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Volume I of II

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Experimental Criticality Benchmarks for SNAP 10A/2 Reactor Cores

April 2005

Prepared by
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ORNL Nuclear Criticality Safety

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EXPERIMENTAL CRITICALITY BENCHMARKS FOR SNAP 10A/2 REACTOR CORES
VOLUME I OF II

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April 2005

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ABSTRACT

This report describes computational benchmark models for nuclear criticality derived from descriptions of the Systems for Nuclear Auxiliary Power (SNAP) Critical Assembly (SCA)-4B experimental criticality program conducted by Atomics International during the early 1960's. The selected experimental configurations consist of fueled SNAP 10A/2–type reactor cores subject to varied conditions of water immersion and reflection under experimental control to measure neutron multiplication.

SNAP 10A/2-type reactor cores are compact volumes fueled and moderated with the hydride of highly enriched uranium–zirconium alloy. Specifications for the materials and geometry needed to describe a given experimental configuration for a model using MCNP5 are provided. The material and geometry specifications are adequate to permit user development of input for alternative nuclear safety codes, such as KENO. A total of 73 distinct experimental configurations are described.

1. INTRODUCTION

Atomics International (AI), a Division of North American Aviation, Inc., contributed to the development of several Systems for Nuclear Auxiliary Power (SNAP) reactors during the 1950's and 1960's under contract to the Atomic Energy Commission. Many of these systems were envisioned as compact nuclear reactors designed for remote or automated operation to generate electrical power for earth satellites, such as the SNAP 10A/2 system. Integral to the development of these systems were the experimental criticality programs to support nuclear safety analyses. This report studies the SNAP Critical Assembly-4B (SCA-4B) program in which fueled SNAP 10A/2 reactor cores and assemblies were subjected to experiments involving water flooding and reflection. The results of the SCA-4B program are principally described in NAA-SR-8490[1] and NAA-SR-9871.[2]

The configuration of the reactor core for the SCA-4B experimental program is illustrated in Fig. 1. The reactor core is characterized by a cylindrical thin-walled stainless steel vessel that contains a pseudo-cylindrical array of 37 closely spaced fuel elements. The fuel elements are about 1.250 in. (3.175 cm) in diameter, 12.450 in. (31.623 cm) long, and are positioned on a triangular pitch of 1.260 in. (3.2004 cm). Six beryllium metal inserts are shaped to fit the spaces between the element array and the cylindrical vessel wall. The fuel elements and beryllium metal inserts are supported and held laterally within the core vessel at both ends by grid plates.

Each element is fueled and moderated by the hydride of highly enriched uranium and zirconium alloy in the form of a solid cylindrical rod housed within a thin-walled Hastelloy® N cladding tube. The tubes are closed by solid plugs and indexing pins at both ends, as seen in Fig. 2. The alloy is nominally 10 wt % uranium (enriched to at least 93 wt % ^{235}U) and 90 wt % zirconium, with a mass density of about 6.06 g/cm^3. The resulting hydride contains about 6.5×10^{22} H atoms/cm^3, comparable to the hydrogen content of ordinary water. Each fuel element contains approximately 128.5 g ^{235}U with an H/^{235}U ratio of about 45. The total fissile content of a 37-element full-core complement would be about 4.75 kg ^{235}U.

To prevent the hydrogen from diffusing out of the element at operating temperatures, the internal surface of the cladding tube is thinly coated with a small but variable amount of the burnable neutron absorber samarium as samarium oxide (Sm_2O_3). A 37-element full-core complement might contain about 2.7 to 4.0 total grams of Sm_2O_3, depending on the fabrication specifications of the fuel elements used in a given application.

For the SCA-4B experimental program, the reactor core vessel was mounted inside combinations of nesting cylindrical water tanks. The core vessel and the water tanks were remotely filled and drained to provide varied conditions of water flooding and reflection for the purpose of neutron multiplication measurements. The tanks were also sufficiently large to permit the placement of additional sleeves and mechanical reflector assemblies around the core vessel. The sleeve assemblies allowed the reactor to be surrounded radially by various materials such as void, Binal (borated aluminum), steel, and boron carbide powder. The Binal and steel sleeves were made from sheets of Binal or steel surrounding the core vessel. The void and boron carbide (absorber) sleeves were made from thin shells of steel surrounding the void or boron carbide. A more complicated reflector assembly made from beryllium was also used (see case *fig12*).

Descriptions of the selected benchmark experiments are presented in Sections 3 and 4 for those configurations derived from NAA-SR-8490 and NAA-SR-9871, respectively. Descriptions contain sufficient detail for independent analysis by any computational tool that is capable of numerical analysis of nuclear criticality. Appendix A of this report provides documentation of the technical review performed for this work. Derivations of the properties for all materials used in these benchmark calculations are provided in Appendix B and Appendix C shows geometry details for the MCNP5 input files. Appendix D provides sample input files, while Volume II of this report provides a complete input file listing for all MCNP5 calculations this report.

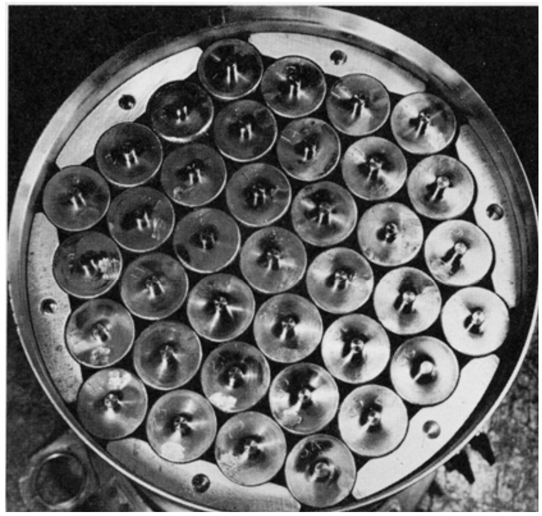


Fig. 1. View into a SNAP 10A/2 reactor core vessel, showing the fuel elements and Be inserts internal reflectors.

(reproduced from Fig.3, ORNL-4058)

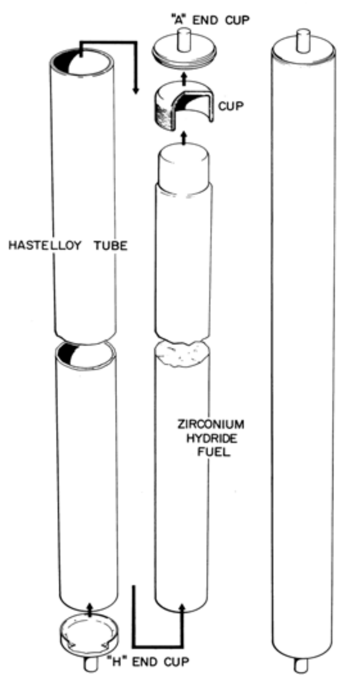


Fig. 2. Illustrated anatomy of a SNAP 10A/2–type fuel element.

(reproduced from Fig.1, NAA-SR-6794)

2. SUMMARY OF RESULTS

The SCA-4B experiments were performed in three phases for the SNAP program to evaluate the water immersion of SNAP 10A/2 cores. The experiments from Phases I and III are used to derive a total of 73 distinct benchmark models for calculation of k_{eff} with MCNP5. Of these, 56 represent experimental configurations where the k_{eff} was at or very near critical. For these critical and near-critical configurations, the calculated results are normalized to experiment by dividing the calculated k_{eff} (k_{calc}) by the experimentally derived k_{eff} (k_{exp}). The remaining 17 subcritical experimental configurations are only known to be sub-critical by an unspecified margin, but remain useful for qualitative comparisons. The results are summarized in Table 1 and Table 2 and illustrated in Fig. 3.

The MCNP5 results for all calculations indicate that approximately 73% of all fissions occur due to neutrons whose incident energy is less than 0.625 eV (i.e., thermal), that about 24% of all fissions occur due to neutrons whose incident energy is between 0.625 eV and 100 keV (i.e., intermediate), and that less than 3% of all fissions occur due to neutrons whose incident energy is greater than 100 keV (i.e., fast). The average energy of all neutrons causing fission for each benchmark model ranges from about 37 keV to about 50 keV. The results are based on no fewer than two million active neutron histories per benchmark.

All calculations were performed by or under the direction of qualified ORNL Nuclear Criticality Safety staff in April 2005, using a Dell Precision Workstation 650N equipped with two 3.06 GHz XEON processors. The workstation operating system is "Red Hat Enterprise Linux WS Release 3 (Taroon Update 2)." The workstation (*ws6*) is accessed over the ORNL internal Ethernet network as *ossws6.ornl.gov*. The computer is maintained under the administrative control of the ORNL Nuclear Criticality Safety staff. ENDF B-VI neutron cross section libraries are specified for all isotopes, except for a very small number of minor isotopes for which only ENDF B-V data is available. Also, the $S(\alpha,\beta)$ thermal neutron treatment for selected elements is specified as appropriate.

MCNP5 was initially installed on *ws6* in August 2004. Formal verification and approval for safety-related usage occurred in February 2005, prior to execution of all computational cases reported herein. The software verification effort is documented in Refs. 8-10. Initial verification of the computer and computer code was in accordance with recommendations provided by the code developers at Los Alamos National Laboratory. A quarterly reverification program exists for MCNP5 on *ws6*, but all computations reported have been executed prior to the first required occurrence of reverification.

As shown in Fig. 3, the calculated results demonstrate good agreement with the experiments, for both critical and subcritical configurations. No strong bias is evident from inspection of these results. A rigorous treatment of the combined uncertainties associated with each individual calculation has not been performed. The computational uncertainty for each benchmark case is less than 0.00075. The most important parameters associated with geometry and compositions are well-defined. The modeling details are physically realistic and consistent with the experimental configurations with very few simplifications or approximations. The uncertainty for each k_{eff} inherent to the derived benchmark calculation is conservatively judged to be less than 0.008. It is evident that MCNP5 may be reliably applied to criticality predictions of water immersed and reflected SNAP 10A/2 reactor cores.

Table 1. Summary of calculated results for Phase I experiments

Case name	Be inserts	Water flooded core	Upper tank water level, in. (cm)	Number of fuel elements	Lucite rods	Binal sleeves*	B_4C sleeves*	kg Ammonium Pentaborate in 39 gal. of water	Calculated k_{eff}, k_{calc}	Computa-tional uncertainty, σ	Normalized result, k_{calc}/k_{exp}
8490a	no	yes	9.0 (22.86)	28	0	no	no	n/a	1.00491	0.00069	1.0051
8490b	no	yes	9.0 (22.86)	28	0	no	no	n/a	1.00774	0.00067	1.0056
8490c	no	yes	3.8 (9.652)	28	9	no	no	n/a	1.00192	0.00070	1.0019
8490d	yes	yes	5.4 (13.72)	25	12	no	no	n/a	1.00498	0.00067	1.0050
8490e	yes	no	9.0 (22.86)	31	6	no	no	n/a	1.00135	0.00070	1.0006
8490e1	yes	no	7.0 (17.78)	31	6	no	no	n/a	0.99890	0.00070	0.9997
8490e2	yes	no	6.0 (15.24)	31	6	no	no	n/a	0.99677	0.00067	1.0004
8490e3	yes	no	5.5 (13.97)	31	6	no	no	n/a	0.99416	0.00067	0.9985
8490e4	yes	no	4.938 (13.54)	31	6	no	no	n/a	0.98920	0.00068	0.9995
8490e5	yes	no	3.5 (8.89)	31	6	no	no	n/a	0.98681	0.00070	0.9971
8490e6	yes	no	2.0 (5.08)	31	6	no	no	n/a	0.98174	0.00068	1.0022
8490e7	yes	no	empty	31	6	no	no	n/a	0.96020	0.00070	0.9928
8490f	yes	no	5.2 (13.21)	32	5	no	no	n/a	1.00198	0.00068	1.0020
8490g	yes	no	2.7 (6.86)	33	4	no	no	n/a	0.99940	0.00071	0.9994
8490h	yes	no	1.7 (4.32)	34	3	no	no	n/a	0.99889	0.00068	0.9989
8490h1	yes	no	1.4 (3.56)	34	3	no	no	n/a	0.99603	0.00069	0.9976
8490h2	yes	no	0.9 (2.286)	34	3	no	no	n/a	0.99239	0.00067	1.0011
8490h3	yes	no	0.4 (1.016)	34	3	no	no	n/a	0.98545	0.00070	1.0000
8490h4	yes	no	empty	34	3	no	no	n/a	0.98147	0.00070	0.9999
8490i	yes	no	0.6 (1.524)	35	2	no	no	n/a	0.99631	0.00067	0.9963
8490i1	yes	no	empty	35	2	no	no	n/a	0.98888	0.00070	1.0007
8490j	yes	no	0.1 (0.254)	36	1	no	no	n/a	0.99753	0.00069	0.9975
8490j1	yes	no	empty	36	1	no	no	N/A	0.99671	0.00068	1.0007
8490k	yes	no	5.2 (13.208)	36	1	no	L-1/3-0.50	N/A	0.99415	0.00069	0.9942

* Explanation of symbols: U = upper, M= middle, L = lower, F = full; in the case of the partial sleeves, this symbol is followed by the axial fraction of the core vessel covered by the sleeve, which is in turn followed by the thickness of the sleeve in inches. For example, L-2/3-0.25 refers to a 0.25 in.-thick sleeve, surrounding the lower two-thirds of the core vessel.

Table 1. (continued)

Case name	Be inserts	Water flooded core	Upper tank water level, in. (cm)	Number of fuel elements	Lucite rods	Binal sleeves*	B_4C sleeves*	kg Ammonium Pentaborate in water	Calculated k_{eff}, k_{calc}	Computa-tional uncertainty, σ	Normalized result, k_{calc}/k_{exp}
8490k1	yes	no	9.0 (22.86)	36	1	no	M-1/3-0.50	N/A	0.96428	0.00070	n/a
8490ℓ	yes	no	5.0 (12.7)	36	1	no	L-1/3-0.25	N/A	0.99488	0.00071	0.9949
8490ℓ1	yes	no	9.0 (22.86)	36	1	no	L-2/3-0.25	N/A	0.94555	0.00070	n/a
8490ℓ2	yes	no	9.0 (22.86)	36	1	no	F-0.25	N/A	0.92092	0.00069	n/a
8490ℓ3	yes	yes	9.0 (22.86)	29	8	F-0.75	no	N/A	0.97173	0.00068	n/a
8490ℓ4	yes	no	9.0 (22.86)	29	8	F-0.75	no	N/A	0.88255	0.00068	n/a
8490ℓ5	yes	yes	9.0 (22.86)	29	8	M-1/3-0.25	no	N/A	0.99879	0.00070	n/a
8490m	yes	yes	empty	28	8	no	no	N/A	1.00623	0.00070	1.0050
8490n	yes	yes	9.0 (22.86)	29	8	no	U-1/3-0.50 + L-1/3-0.25	N/A	1.00081	0.00068	1.0006
8490n1	yes	yes	9.0 (22.86)	29	8	no	F-0.50	N/A	0.96128	0.00068	n/a
8490o	yes	yes	9.0 (22.86)	29	8	L-1/3-0.25	U-1/3-0.50	N/A	1.00105	0.00069	1.0009
8490p	yes	yes	9.0 (22.86)	29	8	L-1/3-0.50	U-1/3-0.50	N/A	1.00068	0.00068	1.0024
8490q	yes	yes	9.0 (22.86)	29	8	L-1/3-0.75	U-1/3-0.50	N/A	1.00006	0.00071	1.0025
8490r	yes	yes	9.0 (22.86)	29	8	L-1/3-1.00	U-1/3-0.50	N/A	1.00040	0.00070	1.0022
8490s1	yes	yes	full	32	0	no	no	2.00	0.98391	0.00071	n/a
8490s2	yes	yes	full	31	0	no	no	2.00	0.97508	0.00068	n/a
849s3	yes	yes	full	30	0	no	no	2.00	0.96689	0.00069	n/a
8490t	yes	yes	full	35	0	no	no	3.24	0.99614	0.00071	0.9949
8490t1	yes	yes	full	33	0	no	no	3.24	0.97566	0.00070	n/a
8490t2	yes	yes	full	32	0	no	no	3.24	0.96326	0.00070	n/a
8490u	yes	yes	full	37	0	no	no	4.54	1.00387	0.00073	1.0039
8490u1	yes	yes	full	36	0	no	no	4.54	0.99463	0.00071	n/a
8490u2	yes	yes	full	35	0	no	no	4.54	0.98240	0.00069	n/a

* Explanation of symbols: U = upper, M= middle, L = lower, F = full; in the case of the partial sleeves, this symbol is followed by the axial fraction of the core vessel covered by the sleeve, which is in turn followed by the thickness of the sleeve in inches. For example, L-2/3-0.25 refers to a 0.25 in.-thick sleeve, surrounding the lower two-thirds of the core vessel.

Table 2. Summary of calculated results for Phase III experiments

Case name	Fuel type*	Water flooded core	Water level†, in. (cm)	Number of fuel elements	Lucite rods	Binal or steel sleeves	Void sleeve	Absorber sleeve	Calculated k_{eff}, k_{calc}	Computational uncertainty, σ	Normalized result, k_{calc}/k_{exp}
fig12‡	4	no	9.5 (24.13)	26	11	no	no	no	0.99602	0.00067	0.9960
fig14a	4	yes	*1.8 (4.572)*§	25	12	no	no	no	1.00381	0.00069	1.0038
fig14b	4	yes	*2 (5.08)*	25	12	no	no	no	1.00247	0.00067	1.0021
fig14c	4	yes	*2.25 (5.715)*	25	12	no	no	no	1.00348	0.00067	1.0026
fig14d	4	yes	*2.5 (6.35)*	25	12	no	no	no	1.00387	0.00067	1.0026
fig16**	4	no	19 (48.26)	37	0	no	no	no	1.01666	0.00067	1.0023
p34	4	no	19 (48.26)	32	5	no	no	no	1.00784	0.00066	1.0045
p35	4	no	19 (48.26)	37	0	no	no	no	1.04568	0.00065	1.0100
p49	4	yes	10.25 (26.035)	35	2	Binal	no	no	0.99744	0.00072	0.9974
p58	4	yes	14.88 (37.7952)	36	1	steel	yes	yes	0.99102	0.00072	0.9910
p58gap	4	yes	14.88 (37.7952)	36	1	steel	yes	yes	0.99584	0.00072	0.9958
p59	4	yes	12.41 (31.5214)	37	0	steel	yes	yes	0.98559	0.00071	0.9856
p59gap	4	yes	12.41 (31.5214)	37	0	steel	yes	yes	0.99278	0.00072	0.9928
tbl1a	T	no	14.9375 (37.9413)	33	4	no	no	no	1.01205	0.00065	1.0083
tbl1b	T	no	12.06 (30.6324)	34	3	no	no	no	1.00407	0.00067	1.0006
tbl1c	T	no	11.06 (28.0924)	35	2	no	no	no	1.00787	0.00067	1.0046
tbl1d	T	no	10.31 (26.1874)	36	1	no	no	no	1.01109	0.00069	1.0060
tbl1e	T	no	9.88 (25.0952)	37	0	no	no	no	1.01244	0.00069	1.0075
fig19	T	no	14.9375 (37.9413)	37	0	no	no	no	1.00294	0.00068	1.0013
p45	T	no	5.96†† (15.1384)	37	0	Binal	no	no	0.93874	0.00070	n/a
p46a	T	no	5.96 (15.1384)	37	0	Binal	no	no	0.96092	0.00070	n/a
p46b	T	no	10.4 (26.416)	37	0	Binal	no	no	0.99610	0.00068	0.9961

* 4 indicates SCA-4 fuel , while T indicates SNAPTRAN fuel.
† Water level is measured from the bottom of the active fuel region unless otherwise noted.
‡ This case uses the external beryllium reflector.
§ Values in italics indicate level of water above the vessel, or axial reflection.
** Case *fig16* uses 12 absorber splines and case *fig19* uses 15 absorber splines.
†† Cases *p45* and *p46a* measure the amount of water over the top grid plate.

Table 2. (continued)

Case Name	Fuel type*	Water flooded core	Water level†, in. (cm)	Number of fuel elements	Lucite rods	Binal or steel sleeves	Void sleeve	Absorber sleeve	Calculated k_{eff}, k_{calc}	Computational uncertainty, σ	Normalized result, k_{calc}/k_{exp}
tbl4a	T	no	18.25 (46.355)	37	0	Binal	no	no	0.98014	0.00070	n/a
tbl4b	T	no	14.13 (35.8902)	37	0	Binal	no	no	0.99320	0.00071	0.9932
tbl4c	T	no	14.75 (37.465)	37	0	Binal	no	no	0.99718	0.00071	0.9951
tbl4d	T	no	18.25 (46.355)	37	0	Binal	no	no	0.99883	0.00069	0.9988
p50a	T	yes	10.5 (26.67)	36	1	Binal	no	no	0.99909	0.00073	0.9991
p50b	T	yes	9.13 (23.1902)	36	1	Binal	no	no	1.00034	0.00070	1.0003

* 4 indicates SCA-4 fuel , while T indicates SNAPTRAN fuel.
† Water level is measured from the bottom of the active fuel region unless otherwise noted.

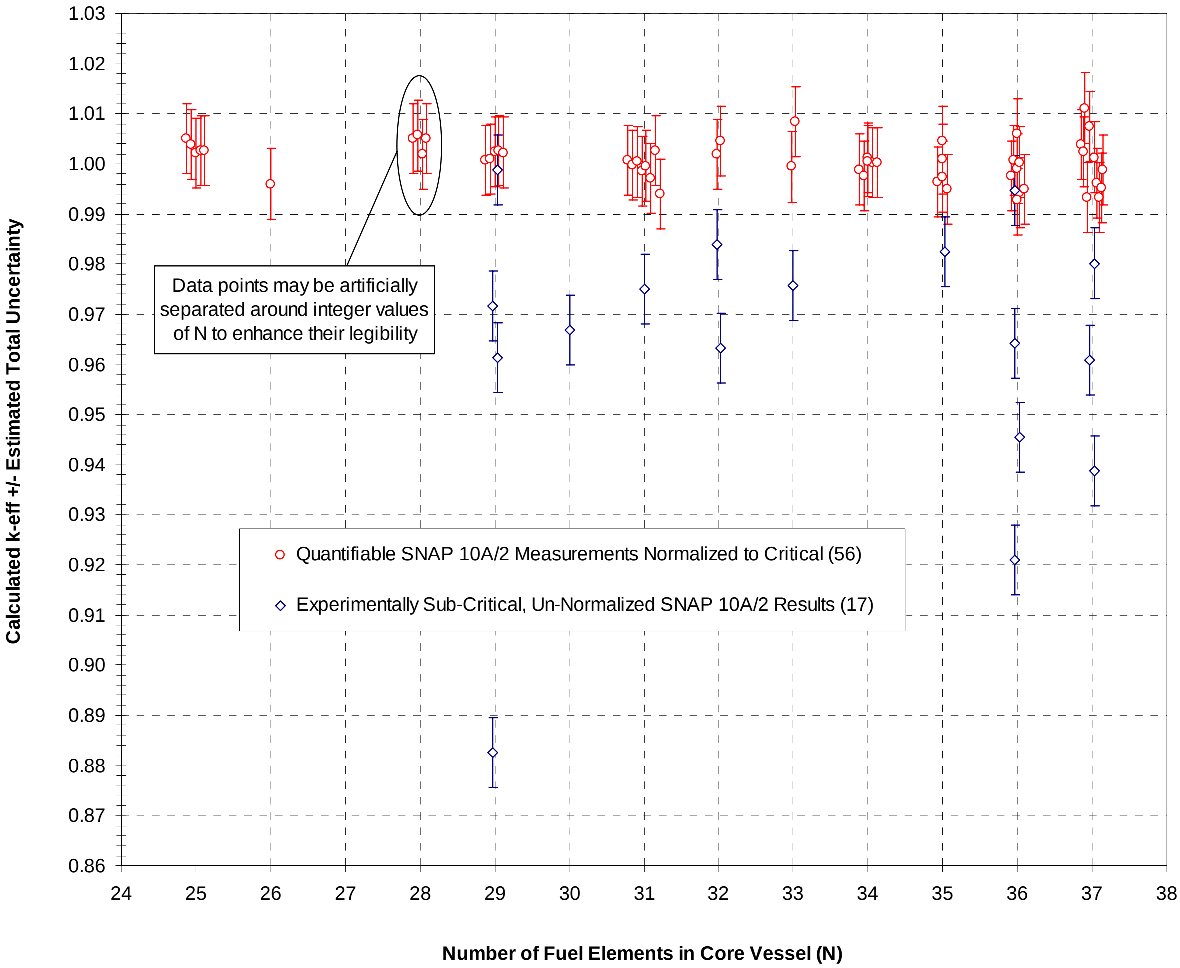


Fig. 1. Benchmark results-plot of the normalized k_{eff} vs. number of fuel elements present in core.

Note: The error bars depicted here show the uncertainty assigned to all cases, 0.008, as described in Section 2.

3. NAA-SR-8490 EXPERIMENTS

NAA-SR-8490 describes Phases I and II of the SCA-4B experimental campaign by AI. A total of 57 benchmarks are derived in this report, all of which are from Phase I. The nuclear reactivity is reported for 33 of the 57 benchmarks, and is used to estimate the experimental k_{eff} (k_{exp}) for direct comparison to computational results. The value of β_{eff} used by AI to convert reactivity to units of dollars throughout this work is 0.008 and is determined valid by both experiment and analysis.[1]

An additional 14 benchmarks are sub-critical by an unknown margin. These still prove useful to test the benchmark models as a whole by comparison to the 57 results that are quantifiably normalized to the critical condition (i.e., is $k_{eff,\ sub\text{-}critical} < k_{eff,\ critical}$?).

3.1 CRITICAL ASSEMBLY DESCRIPTION

3.1.1 Reactor Core Vessel

Figs. 4 and 5, reproduced from Fig. 1 of NAA-SR-8490, depict the reactor core vessel used in Phase I of the SCA-4B experimental program. It is a cylindrical shell of 316-series stainless steel that is closed at the bottom end and has a flange at the open top end. A removable aluminum cover plate mates with the flange, presumably with bolts. The flange diameter and cover plate diameter are not indicated, and are assumed to be 4.0 in. (10.16 cm) larger than the 8.900-in. (22.606-cm) inside diameter of the core vessel body. The inside diameter of the reactor core is sufficiently large to accommodate up to 37 SNAP 10A/2-type fuel elements on a triangular pitch of 1.260 in. (3.2004 cm) and up to six beryllium inserts. The fuel elements and beryllium inserts were supported and held laterally by aluminum grid plates at the top and bottom, 0.375 in. (0.9525 cm) thick and 0.312 in. (0.79248 cm) thick, respectively. Each grid plate is approximated as a solid right circular cylinder of aluminum whose diameter matches the inside diameter of the reactor core vessel. All other dimensions shown are converted to metric and used directly for input to MCNP5.

The reactor core vessel could be remotely filled with water to simulate a “flooded” core, or could be drained and sealed to simulate a “dry” core. Experimental measurements of a “dry” core also employed low-density (i.e., less than 2 lb/ft^3) Styrofoam™ pieces to fill the volume between the fuel elements and prevent water intrusion should water inadvertently leak into the core vessel. The total reactivity effect of Styrofoam in the reactor core vessel within an otherwise “dry” core is estimated by AI to be about 10¢ with respect to void, but no specific dimensional information is provided. As a simplification, the benchmark models described herein neglect the explicit effect of Styrofoam and assume that the space between the fuel elements is truly void.

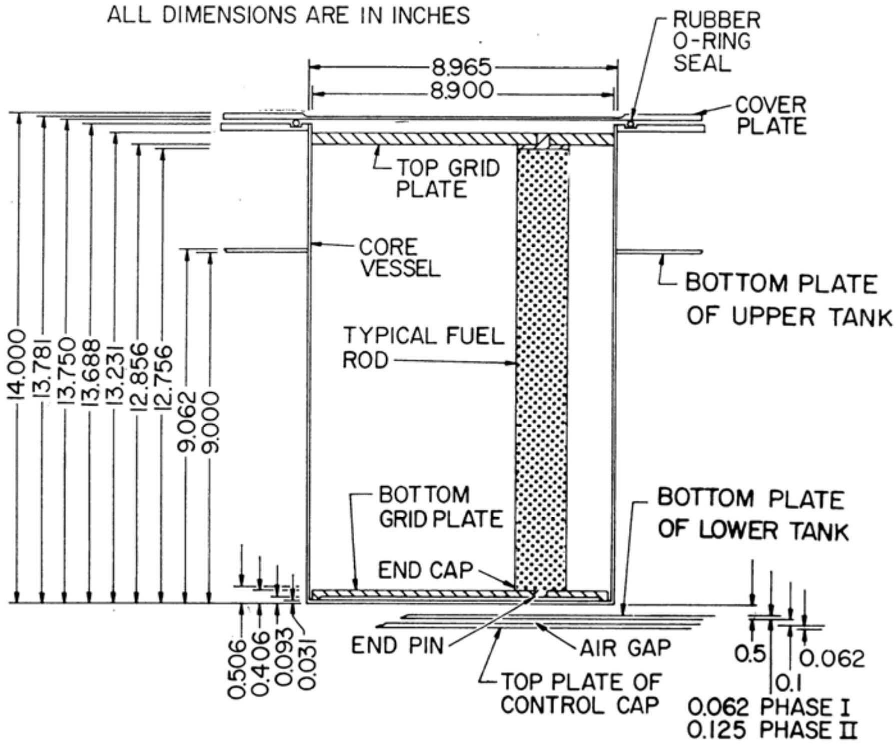


Fig. 4. Side view of reactor core vessel configuration for SCA-4B experimental program.

(reproduced from Fig. 1 of NAA-SR-8490)

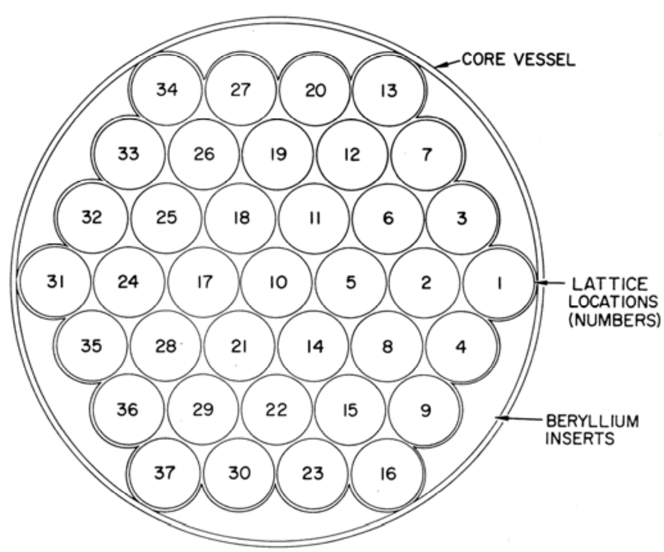


Fig. 5. Plan view of reactor core vessel configuration for SCA-4B experimental program.

(reproduced from Fig. 1 of NAA-SR-8490)

3.1.2 Reflector Tanks and Water Supply

The SCA-4B machine and its operation are briefly described in the text of NAA-SR-8490. The machine consists of a C-frame support structure with three separate cylindrical stainless-steel water tanks. The tanks are remotely filled or drained, as required, with a closed-loop water system connected to a 55-gallon drum that serves as a water supply tank. Fig. 6 through Fig. 8 illustrate the physical configuration of the system components and are reproduced from Fig. 4 through Fig. 6 of NAA-SR-8490. Explicit dimensions for the water tanks forming the core reflector are not provided by NAA-SR-8490, but the principal dimensions can be inferred from the descriptive text and indexed to the relative axial position of the core vessel. The error associated with the inferred dimensions is negligible since the worth of reflection on either side of the nominal values described in NAA-SR-8490 would only be a very few cents. Fig. 11 and Fig. 13 of NAA-SR-8490 show the reactivity worth of the upper tank water as a function of water level, and these curves flatten out as the water level approaches the top of the tank.

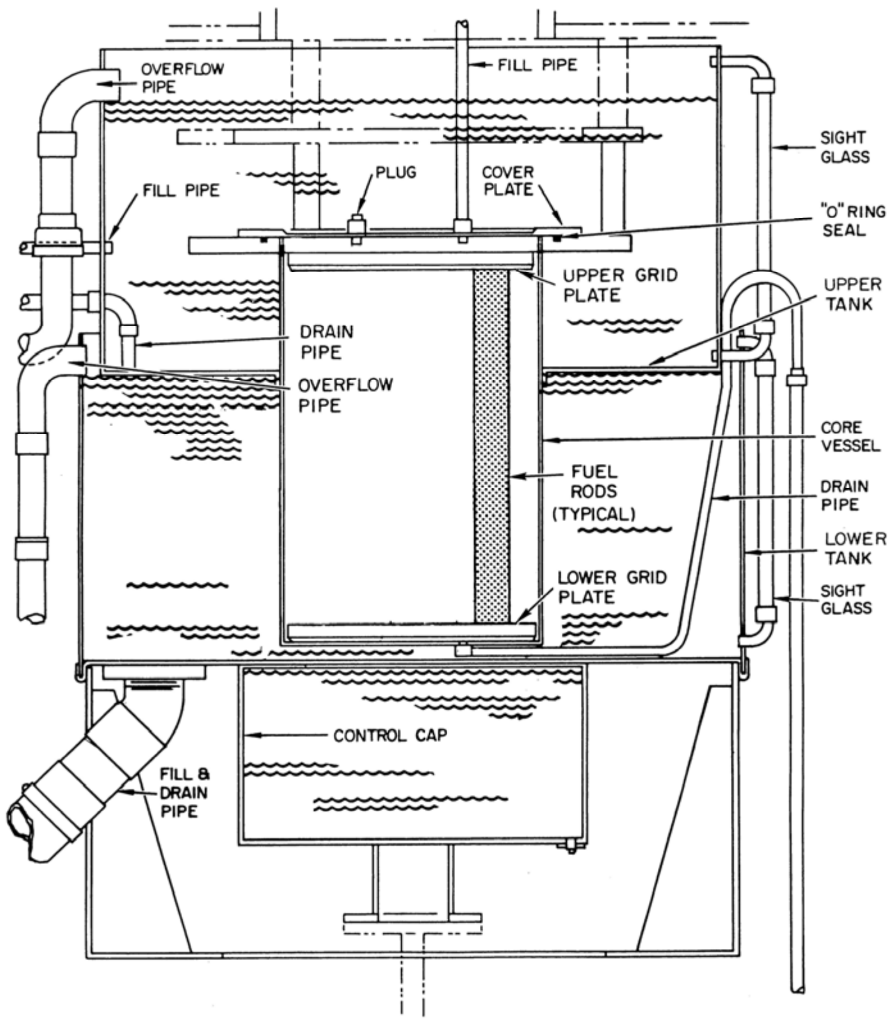


Fig. 6. Schematic diagram of the SCA-4B core vessel and water tank assembly.

(reproduced from Fig. 4 of NAA-SR-8490)

The reactor core vessel and upper tank are welded together and fixed to the upper support structure of the C-frame. The upper tank is remotely filled or drained to provide about 6 in. of radial water reflection over the upper one-third of the reactor core vessel, plus up to 6 in. of axial water reflection above the top of the reactor core vessel. The reactor core vessel is remotely filled or drained separately, based on the requirements for a “flooded” or “dry” core condition for a given experimental measurement.

The upper tank is assumed to be fabricated of 316-series stainless steel, just like the reactor core vessel to which it is welded. The bottom of the upper tank is explicitly shown to be 0.062 in. (0.15748 cm) thick, so this value is also assumed to be valid for the side wall of the tank. The tank is assumed to be open at the top. The inside diameter of the upper tank is taken to be 12 in. (30.48 cm) larger than the 8.965-in. (22.7711-cm) outside diameter of the core vessel. The maximum water depth reported for any experiment is 9.0 in. (22.86 cm), presumably limited by the elevation of the overflow pipe above the bottom inside surface of the upper tank. The side wall of the upper tank is arbitrarily assumed to exceed the maximum water height by one inch (2.54 cm).

The lower tank is stainless steel (i.e., assumed to mean 316-series), and is bolted to a movable section of the C-frame assembly. The bottom of the lower tank is explicitly known to be 0.062 in. (0.15748 cm) thick for Phase I experiments, which is assumed to be valid for the side wall thickness of the tank. It is remotely filled or drained to provide 0.5 in. (1.27 cm) of axial reflection below the bottom of the reactor core vessel, inclusive of the lower tank bottom steel thickness. The lower tank also provides about 6.5 in. (16.51 cm) of radial water reflection over the lower two-thirds of the reactor core vessel. Thus, the inside diameter of the lower tank is assumed to be 13 in. (33.02 cm) larger than the 8.965-in. (22.7711-cm) outside diameter of the core vessel.

Finally, the third tank is the control cap tank. It is a sealed water-filled tank that is raised and lowered by another movable section of the C-frame assembly to add about 6 in. (15.24 cm) of axial reflection to the bottom of the lower tank, but with a 0.062-in. (0.15748-cm)-thick air gap in between. Thus, the inside height of the control cap tank is assumed to be 6 in. (15.24 cm). The top plate of this tank is explicitly described as being 0.031 in. (0.07874 cm) thick and made of aluminum. The side wall and bottom of the control cap tank are assumed to be 0.062 in. (0.15748 cm) thick and fabricated of 316-series stainless steel. This is consistent with the material and construction of the upper and lower tanks. Since it is unspecified, the inside diameter of the control cap is arbitrarily assumed to be the average value of the inside diameter of the lower tank and the outside diameter of the reactor core vessel.

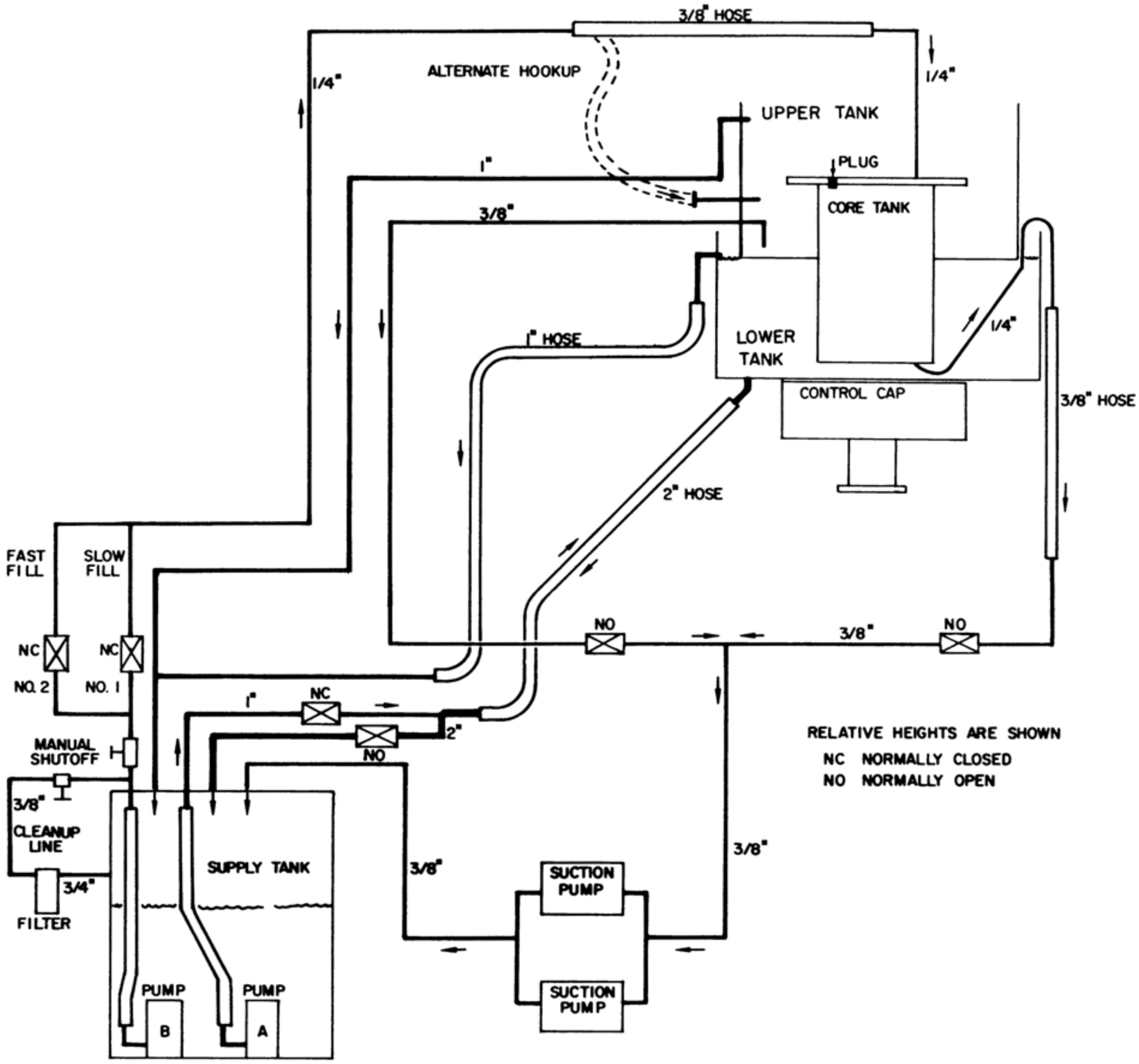


Fig. 7. Schematic diagram of the SCA-4B water supply system.

(reproduced from Fig. 5 of NAA-SR-8490)

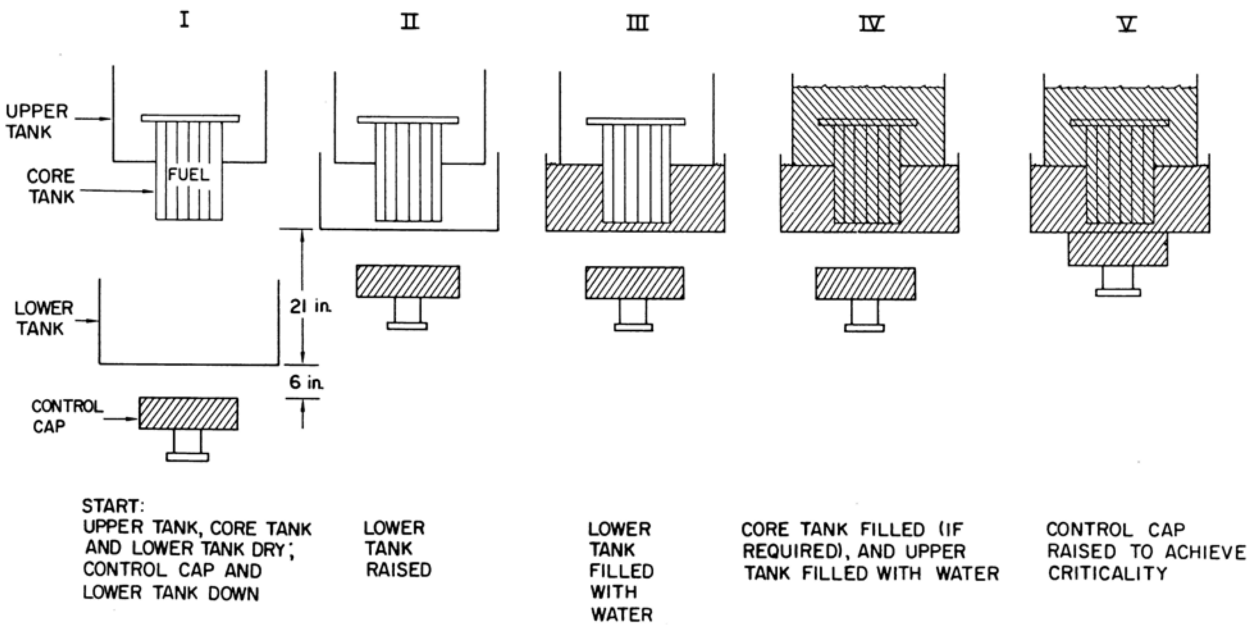


Fig. 8. Sequence of SCA-4B assembly machine operations.

(reproduced from Fig. 6 of NAA-SR-8490)

3.1.3 SCA-4 Fuel Elements

The fuel elements are designated as SCA-4 fuel and were originally fabricated by AI to fuel the SNAP 2 Development Reactor. The fuel consists of the hydride of a highly enriched uranium and zirconium alloy that is common to the SNAP 10A/2 program. The composition of the SCA-4 fuel data is provided in Appendix A of NAA-SR-8490. This data has been used to define an "average" fuel element with respect to its mass density and ^{235}U, U, Zr, and H content (see Appendix A of this report). Corrections of a few very minor arithmetic errors were made, but the most significant correction is identified by NAA-SR-8613[3] in which the values previously given for N_H were overestimated. The core-averaged value of N_H derived from the NAA-SR-8490 data is about 6.48×10^{22} H atoms/cm^3, while the core-averaged value of 6.40×10^{22} H atoms/cm^3 is specified in NAA-SR-8613 as the correct value. Thus, the revised core-averaged value of 6.40×10^{22} H atoms/cm^3 is the more appropriate value and is used accordingly for application to these benchmarks.

Otherwise, the fuel element is modeled as it is described by NAA-SR-8490. The fuel rod is a solid right circular cylinder with a diameter of 1.212 in. (3.07848 cm) and a length of 12.225 in. (31.0515 cm). The fuel rod is axially centered within a Hastelloy N cladding tube with an outside diameter of 1.250 in. (3.175 cm) and a wall thickness of 0.010 in. (0.0254 cm). The Hastelloy N cladding tube extends over each end of the fuel rod to simulate the plugs and end caps of the fuel elements such that the overall length of a fuel element is 12.450 in. (31.623 cm). There is no axial gap between the end plugs and the fuel rod, but the radial gap between the cladding tube and the fuel rod is occupied by the hydrogen diffusion barrier coating that contains Sm_2O_3. This material is averaged over the entire radial gap volume rather than model an explicit thickness of the barrier coating on the inside wall of the cladding tube that is separate from a smaller gap.

3.1.4 Lucite® Rods

Most experimental configurations did not use all 37 fuel elements for a given measurement. The vacant fuel positions were either left empty or were occupied by a solid Lucite® rod. The Lucite rod major dimensions match those of a fuel element, and are represented as a solid right circular cylinder of $C_5H_8O_2$ with a density of 1.18 g/cm^3 that has a diameter of 1.250 in. (3.175 cm) and length of 12.450 in. (31.623 cm). Indexing pins at either end are neglected.

3.1.5 Beryllium Inserts

The beryllium inserts are not explicitly dimensioned in NAA-SR-8490. However, the dimensions shown in Appendix C of this report are derived from AI Drawing Number 10FSM2-15006[4] which was originally issued in November 1961, a time period that is consistent with the conduct of Phase I of the SCA-4B experimental program. Thus, there is no doubt that this drawing is an accurate depiction of the beryllium inserts employed throughout the AI SNAP 10A/2 programs. While the AI drawing does specify the allowed impurities of the inserts, these values are very small. The material is modeled as beryllium metal with a mass density of 1.82 g/cm^3. This value is consistent with densities of commercially available forms of pure beryllium metal.

3.1.6 Absorber Sleeves

Several experimental configurations investigate the reactivity effect of various neutron absorber sleeve configurations at the radial surface of the reactor core vessel subject to water immersion. However, the sleeve dimensions are not explicitly described in NAA-SR-8490. The sleeve is intended to contact the outside radial surface of the core vessel, so the inside diameter of the sleeve is assumed to equal the 8.965-in. (22.7711-cm) outside diameter of the reactor core vessel. Also, the SCA-4B assembly machine separates the axial length of the reactor core vessel into the upper one-third in the upper tank and the lower two-thirds in the lower tank. Thus, the overall axial length of the sleeve components are assumed be either 4.5 in. (11.43 cm) or 9.0 in. (22.86 cm).

One type of absorber sleeve is a cylindrical annular canister that is filled with boron powder of natural isotopic distribution. The walls of the canister are made from 0.031-in. (0.07874-cm)-thick 304-series stainless steel and the boron powder is packed to 22% of theoretical density (i.e., assumed to be ^{nat}B at 0.45 g/cm^3). Fig. 9 is reproduced from Fig. 17 of NAA-SR-8490 to illustrate the configuration of a canned boron sleeve. The example shown is that of a sleeve whose annular thickness is 0.50 in. (1.27 cm), but some experiments are described as having used a 0.25-in. (0.635-cm)-thick sleeve. The stated sleeve thickness for a given experiment is taken to be the combined radial thickness of the boron powder-filled annulus plus the thickness of the inside and outside sleeve walls.

The second type of absorber sleeve is a cylindrical annulus formed by 0.25-in. (0.635-cm)-thick rolled sheet of borated aluminum (i.e., Binal). Annular sleeve thicknesses up to one inch (2.54 cm) are formed by nesting multiple sleeves around the reactor core vessel, as illustrated by Fig. 9 and Fig. 10 (reproduced from Fig. 17 and Fig. 18 of NAA-SR-8490). Binal is described as a dispersion of boron carbide in aluminum that contains 10.2 wt % boron. The isotopic distribution is modeled as that of natural boron and Binal is assumed to be an idealized volume-additive mixture consisting of ~13 wt % $^{nat}B_4C$ (ρ_{th} = 2.52 g/cm^3) and ~87 wt % aluminum (ρ_{th} = 2.70 g/cm^3).

Fig. 9. Photograph of sleeve components consisting of canned boron powder.

(reproduced from Fig. 17 of NAA-SR-8490)

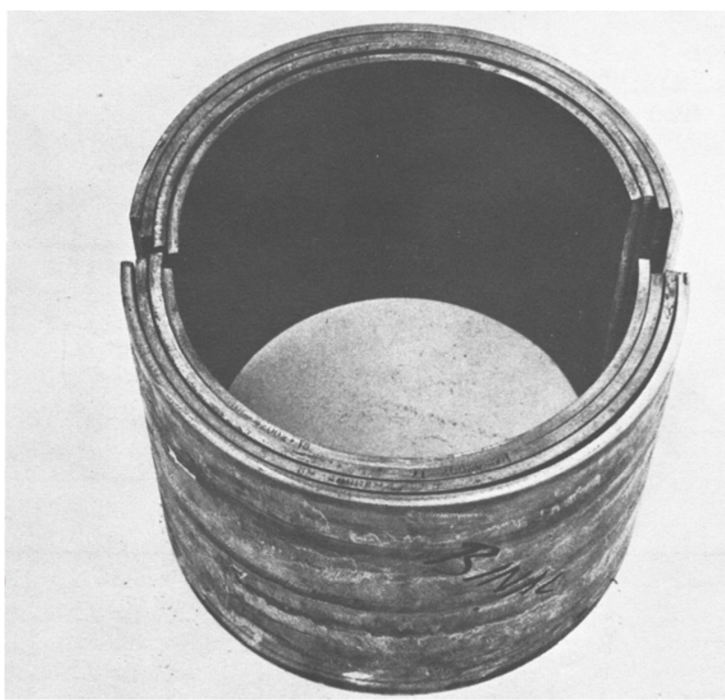


Fig. 10. Photograph of sleeve components consisting of borated aluminum sheet.

(reproduced from Fig. 18 of NAA-SR-8490)

3.2 PHASE I EXPERIMENT DESCRIPTIONS

While NAA-SR-8490 documents experiments performed for both Phase I and Phase II of the campaign, this benchmark report focuses on those experiments that were performed during Phase I. These experiments determined critical configurations with water in the core, critical configurations without water in the core, and the effects of absorber sleeves at the core-reflector interface. The effects of adding soluble boron to the water tanks were also examined.

3.2.1 Cases *8490a* through *8490d*

Phase I of the SCA-4B program began with an initial assembly of SCA-4 fuel elements within the reactor core vessel. The vacant fuel positions in the core vessel were left empty so that they would fill with water when flooded. Likewise, there were no beryllium inserts. The case identified herein as *8490a* is derived from the description on page 22 of NAA-SR-8490 in which the core vessel was completely water reflected and flooded. With 28 fuel elements in each of the first 28 positions of the reactor core vessel, the assembly was subcritical by approximately 2¢. The MCNP5 plot of this case is shown in Fig. 11.

This configuration was altered slightly to determine the effect of fuel element position on core reactivity and gives rise to case *8490b* (see Fig. 12). For this experiment (also described on page 22 of NAA-SR-8490), a single fuel element was relocated from lattice position 16 to lattice position 29 to create a slightly more compact array of fuel elements. The same 28 fuel elements in this configuration with full water reflection and internal flooding increased the total core reactivity to +26¢.

Case *8490c* is similar to case *8490a*, except that Lucite rods were used to occupy the vacant fuel positions, as described on page 23 of NAA-SR-8490. There were no beryllium inserts and the assembly was otherwise flooded and reflected with water. With the 9 Lucite rods and 28 fuel elements in the reactor core vessel, the critical water height was 3.8 in. (9.562 cm) in the upper tank. This configuration is shown in Fig. 13.

The final assembly (case *8490d*-see Fig. 14) of the initial SCA-4B Phase I experiments (page 23 of NAA-SR-8490) included 25 fuel elements, 12 Lucite rods, and 6 beryllium inserts in a water flooded core vessel with significant, but less than full, water reflection. The system was critical when 5.4 in. (13.716 cm) of water had been added to the upper tank.

The results are summarized In Table 3. All calculated results are based on no fewer than two million active neutron histories per benchmark case.

Table 3. Summary Table of Initial Experimental Benchmarks from NAA-SR-8490

Case name	Number of fuel elements	Lucite rods	Be inserts	Upper tank water level, in. (cm)	Reported excess reactivity, ρ($)	Estimated experimental $k_{eff,}$, k_{exp}	Calculated $k_{eff,}$, k_{calc}	Computati-onal uncertainty, σ	Normalized Result, k_{calc}/k_{exp}
8490a	28	no	No	9.0 (22.86)	-0.02	0.99984	1.00491	0.00069	1.0051
8490b	28	no	No	9.0 (22.86)	+0.26	1.00208	1.00774	0.00067	1.0056
8490c	28	yes	No	3.8 (9.562)	critical	1.00000	1.00192	0.00070	1.0019
8490d	25	yes	Yes	5.4 (13.716)	critical	1.00000	1.00498	0.00067	1.0050

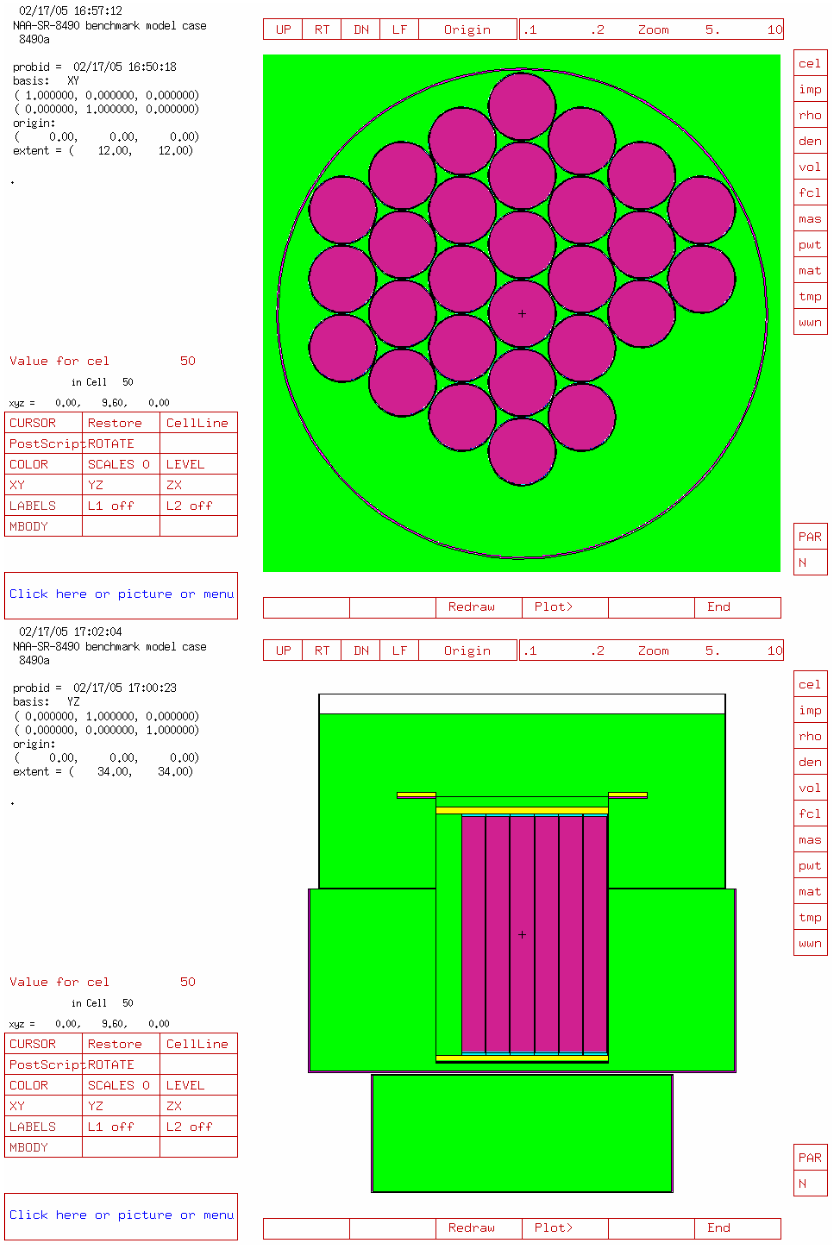


Fig. 11. Case *8490a* MCNP5 plot.

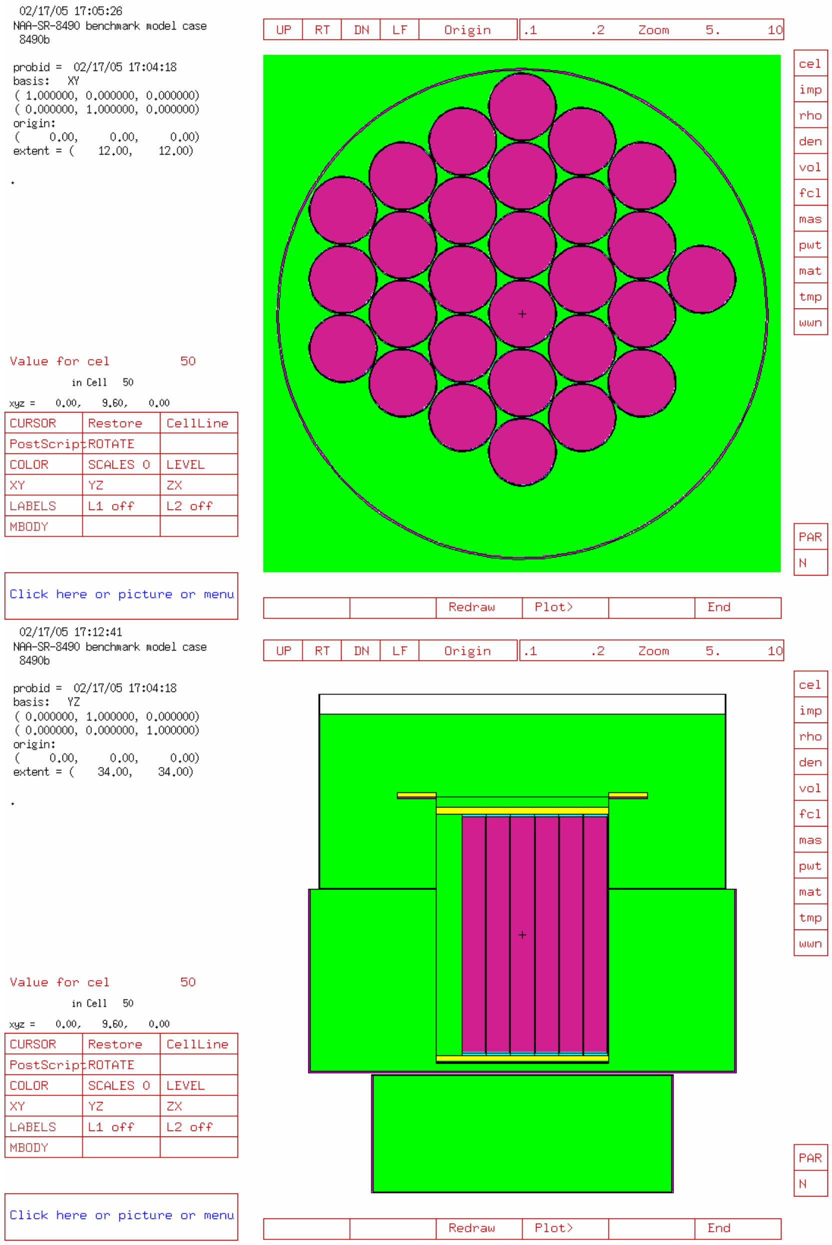


Fig. 12. Case *8490b* MCNP5 plot.

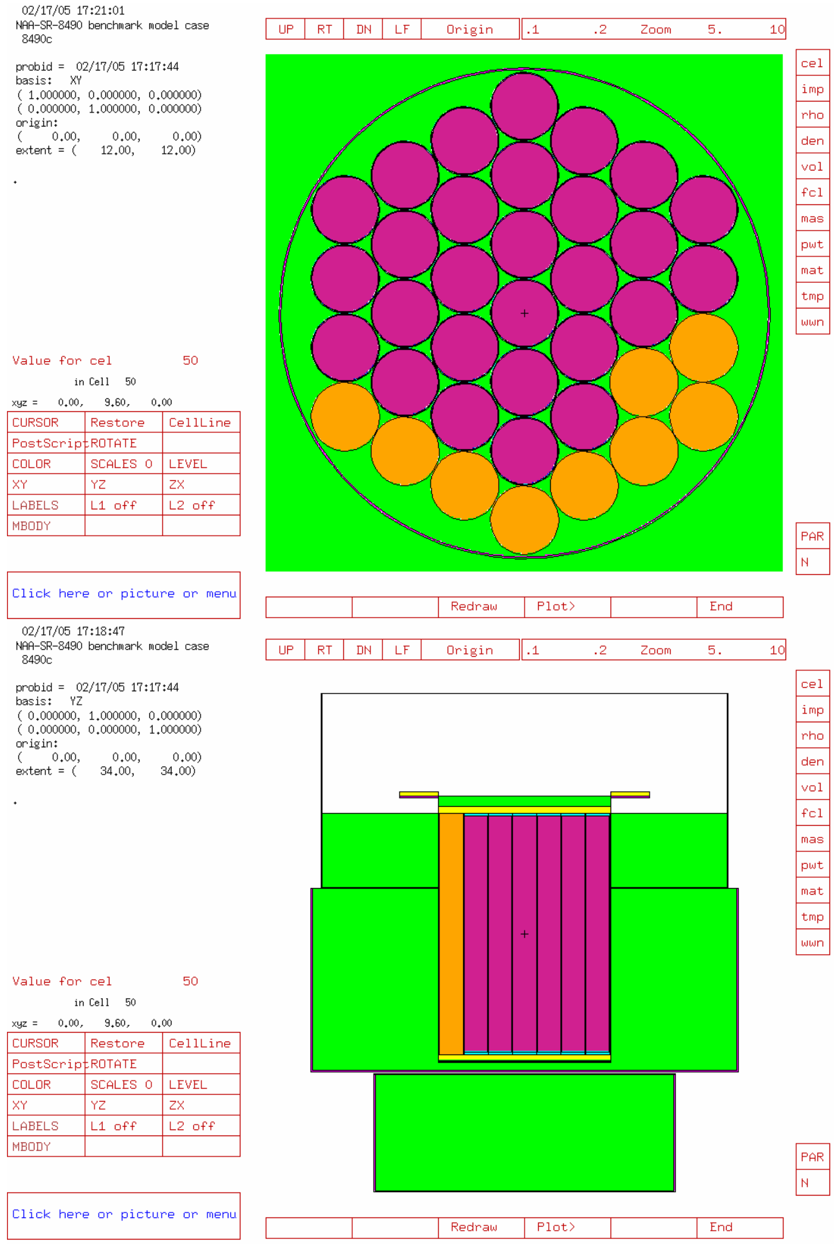


Fig. 13. Case *8490c* MCNP5 plot.

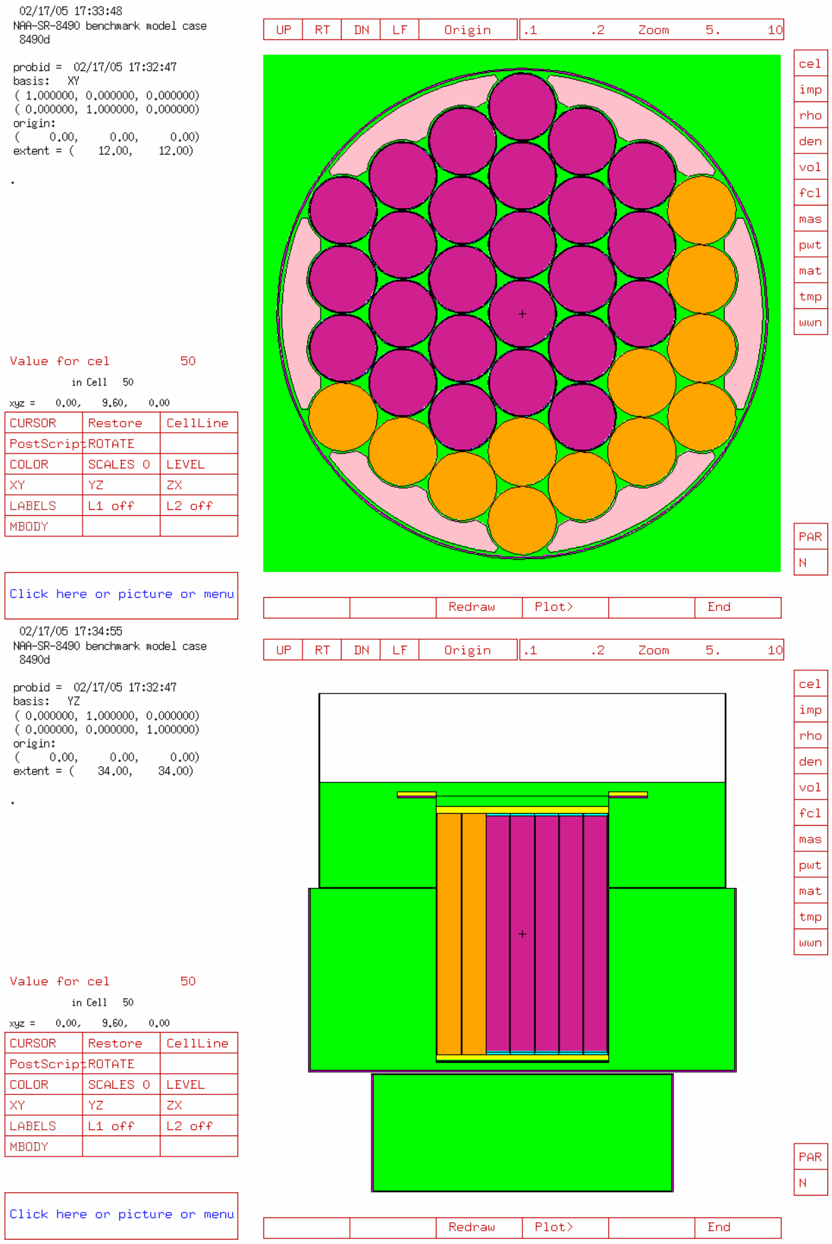


Fig. 14. Case *8490d* MCNP5 plot.

3.2.2 Cases *8490e* through *8490j*

There are 19 distinct benchmarks in this group that are derived from the experimental results presented in Fig. 15. Within this group, the principal distinction is the height of water in the upper tank required to produce a critical condition for a given number of SCA-4 fuel elements within the reactor core vessel. The negative reactivity is estimated at lesser water heights during each approach to the critical condition. In all cases, the lower tank and control cap are full of water, but the core vessel itself is not flooded. None of the experimental measurements involve the full complement of 37 fuel elements. Lucite rods occupy the positions in the core that do not otherwise contain a fuel element and all six beryllium inserts are present. The results are summarized in Table 4, and the MCNP5 plots of all the configurations are shown in Fig. 16 through Fig. 34. All calculated results are based on no fewer than two million active neutron histories per benchmark case.

Table 4. Summary table of experimental benchmarks from approach to the critical for Phase I*

Case name	Number of fuel elements	Upper tank water level, in. (cm)	Reported excess reactivity, $\rho(\$)$	Experimental k_{eff}, k_{exp}	Calculated k_{eff}, k_{calc}	Computat-ional uncertainty, σ	Normalized result, k_{calc}/k_{exp}
8490e	31	9.0 (22.86)	+0.09	1.00072	1.00135	0.00070	1.0006
8490e1	31	7.0 (17.76)	-0.10	0.99920	0.99890	0.00070	0.9997
8490e2	31	6.0 (15.24)	-0.45	0.99641	0.99677	0.00067	1.0004
8490e3	31	5.5 (13.97)	-0.55	0.99562	0.99416	0.00067	0.9985
8490e4	31	4.938 (12.5425)	-1.30	0.98971	0.98920	0.00068	0.9995
8490e5	31	3.5 (8.89)	-1.30	0.98971	0.98681	0.00070	0.9971
8490e6	31	2.0 (5.08)	-2.60	0.97962	0.98174	0.00068	1.0022
8490e7	31	empty	-4.25	0.96712	0.96020	0.00070	0.9928
8490f	32	5.2 (13.208)	critical	1.00000	1.00198	0.00068	1.0020
8490g	33	2.7 (6.858)	critical	1.00000	0.99940	0.00071	0.9994
8490h	34	1.7 (4.318)	critical	1.00000	0.99889	0.00068	0.9989
8490h1	34	1.4 (3.556)	-0.20	0.99840	0.99603	0.00069	0.9976
8490h2	34	0.9 (2.286)	-1.10	0.99128	0.99239	0.00067	1.0011
8490h3	34	0.4 (1.016)	-1.85	0.98542	0.98545	0.00070	1.0000
8490h4	34	empty	-2.35	0.98155	0.98147	0.00070	0.9999
8490i	35	0.6 (1.524)	critical	1.00000	0.99631	0.00067	0.9963
8490i1	35	empty	-1.50	0.98814	0.98888	0.00070	1.0007
8490j	36	0.1 (0.254)	critical	1.00000	0.99753	0.00069	0.9975
8490j1	36	empty	-0.50	0.99602	0.99671	0.00068	1.0007

* The number of fuel elements, water level, and reactivity are determined from Fig. 15.

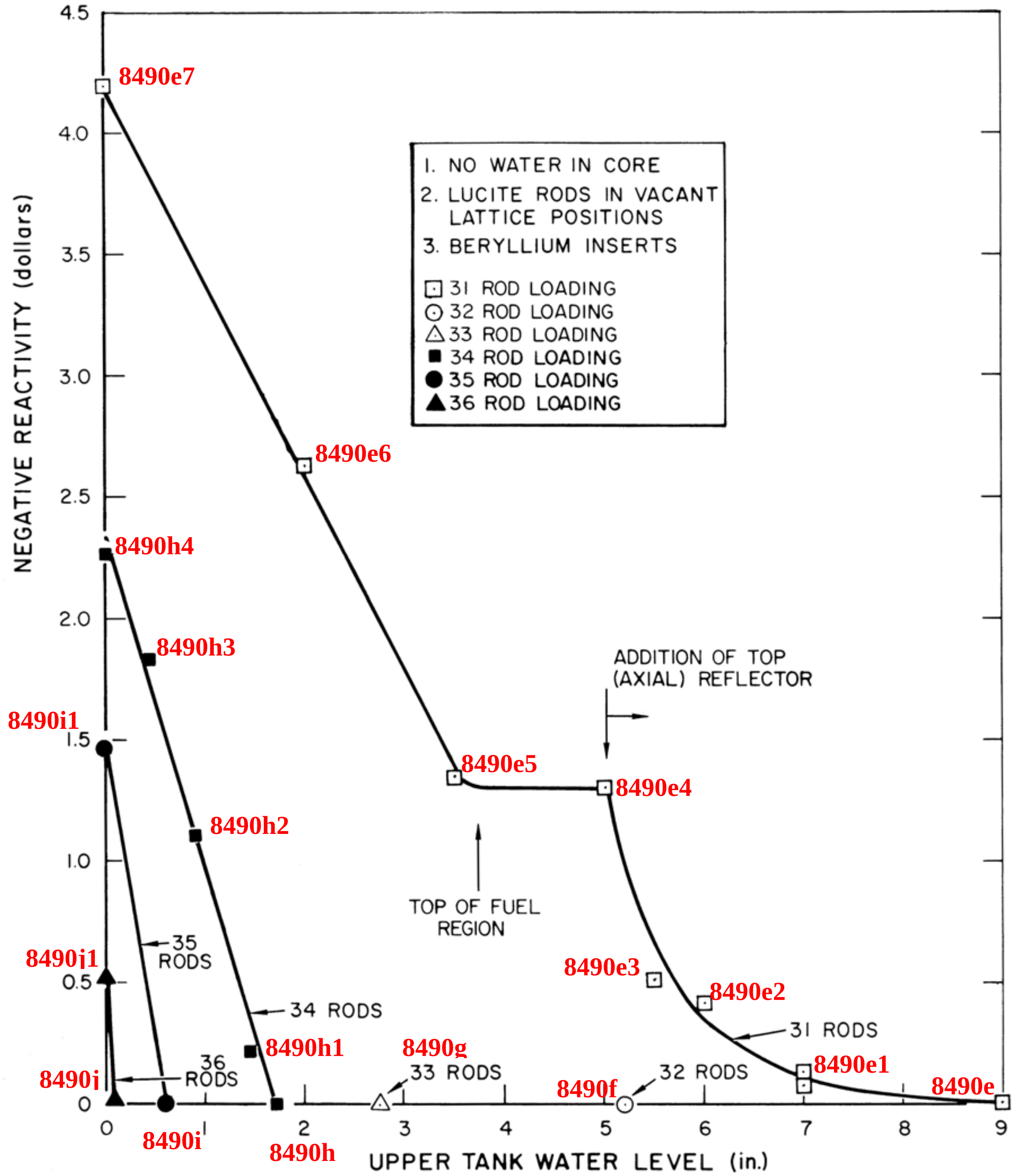


Fig. 15. Reactivity measurements for various "dry core" configurations from SCA-4B Phase I

(reproduced from Fig. 10 of NAA-SR-8490)

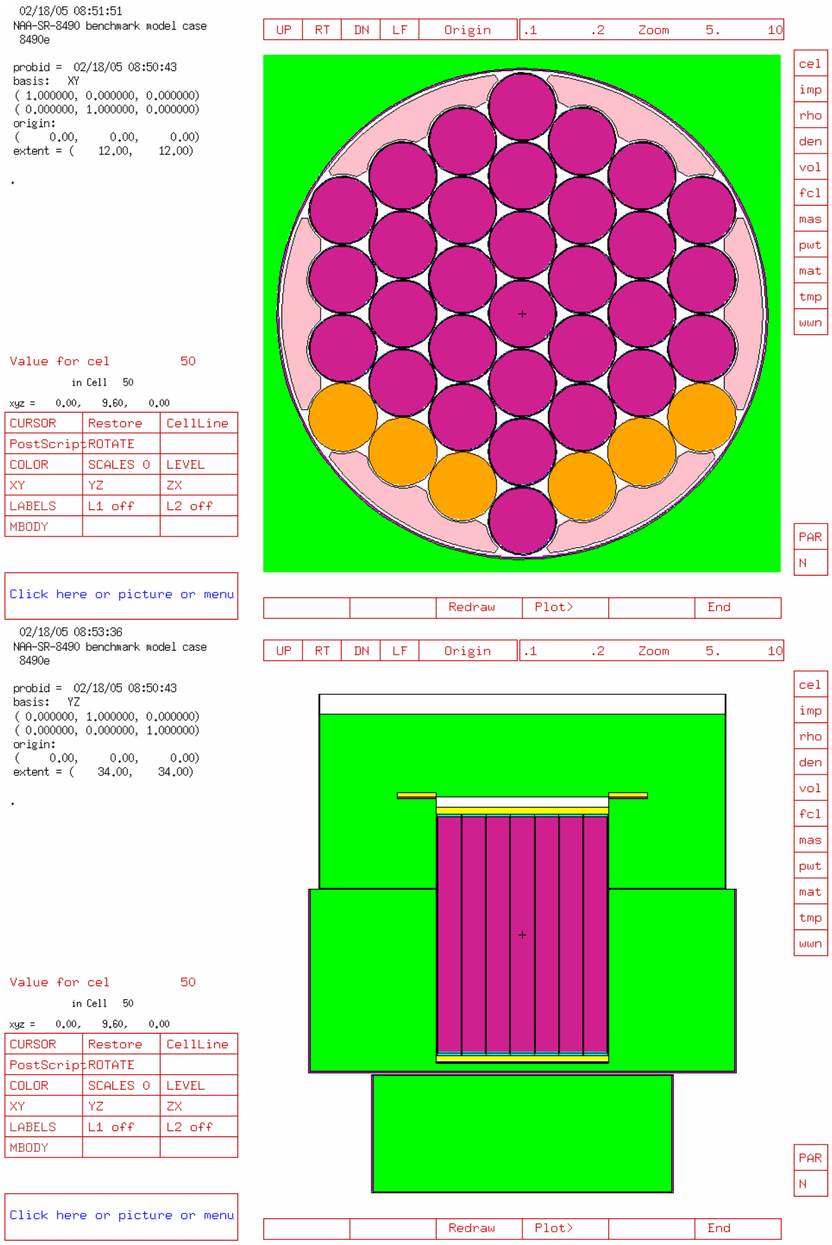


Fig. 16. Case *8490e* MCNP5 plot.

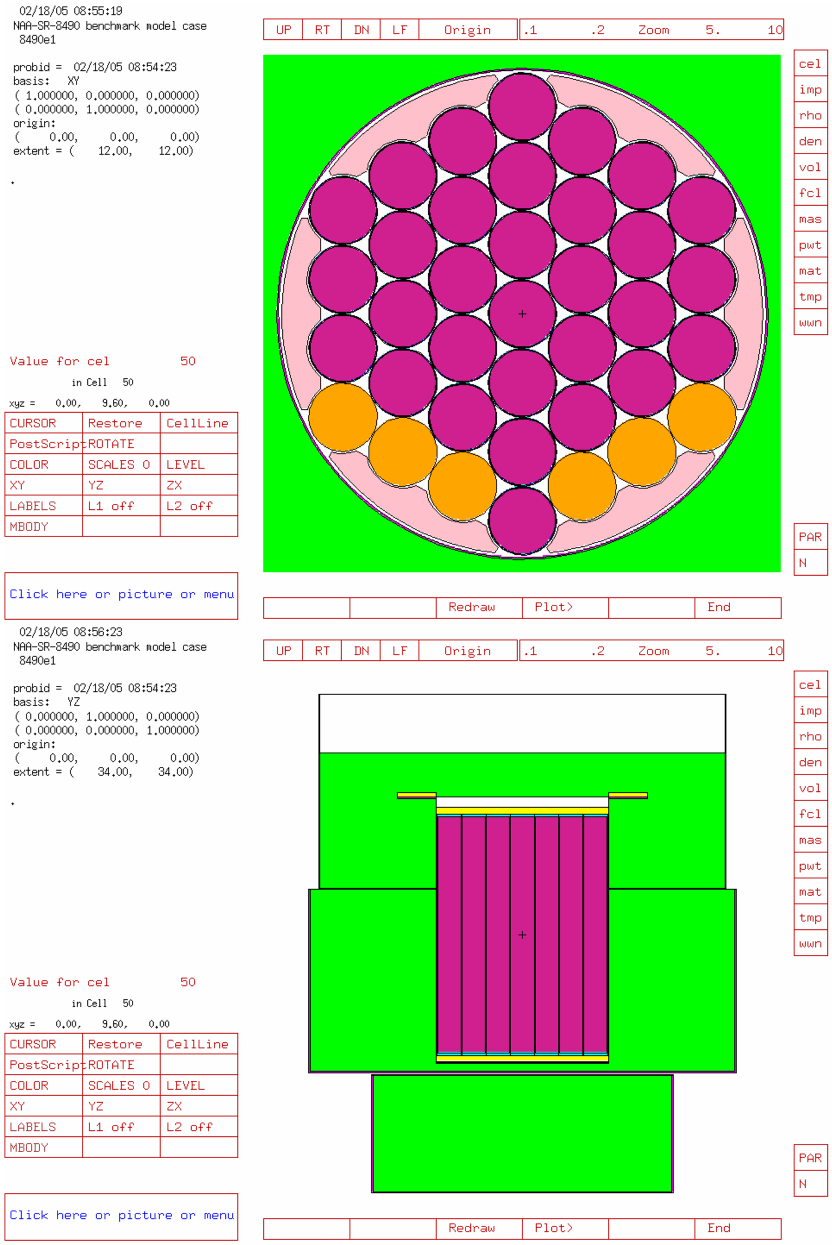


Fig. 17. Case *8490e1* MCNP5 plot.

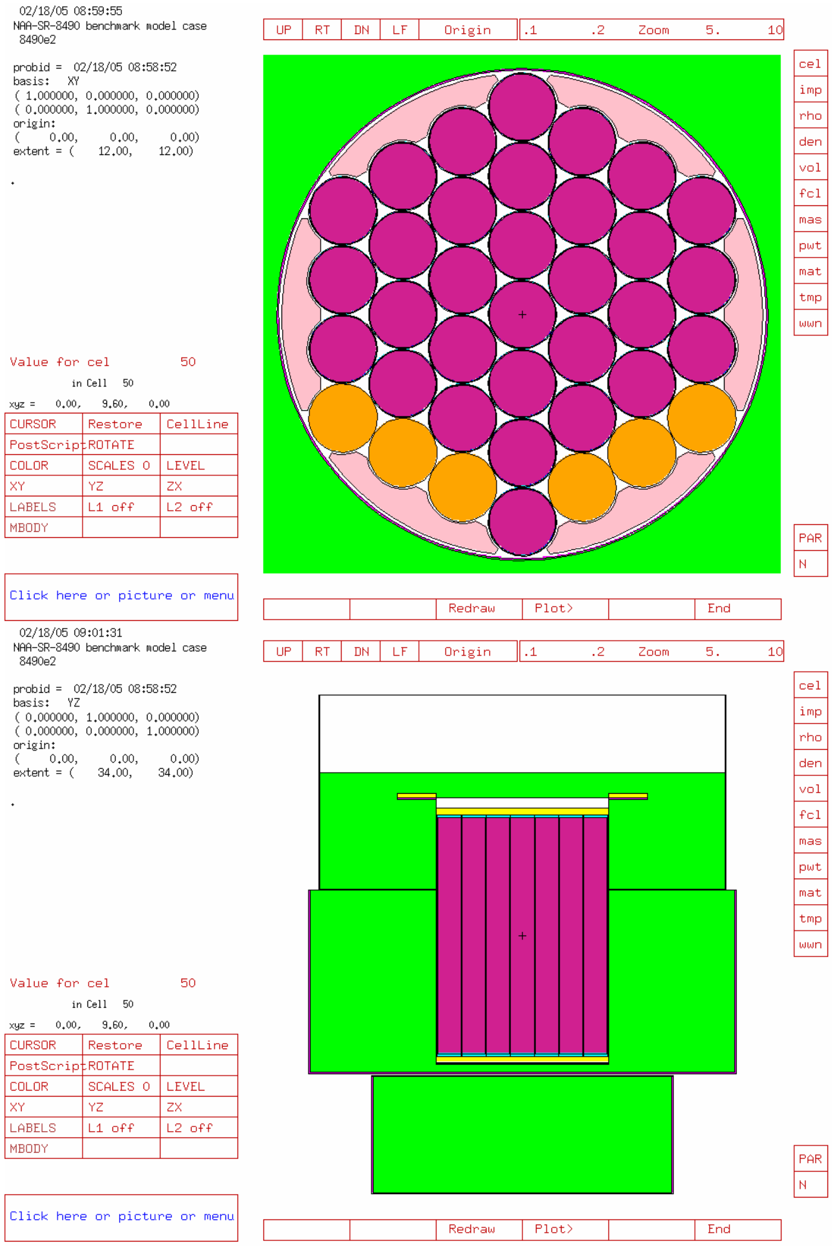


Fig. 18. Case *8490e2* MCNP5 plot.

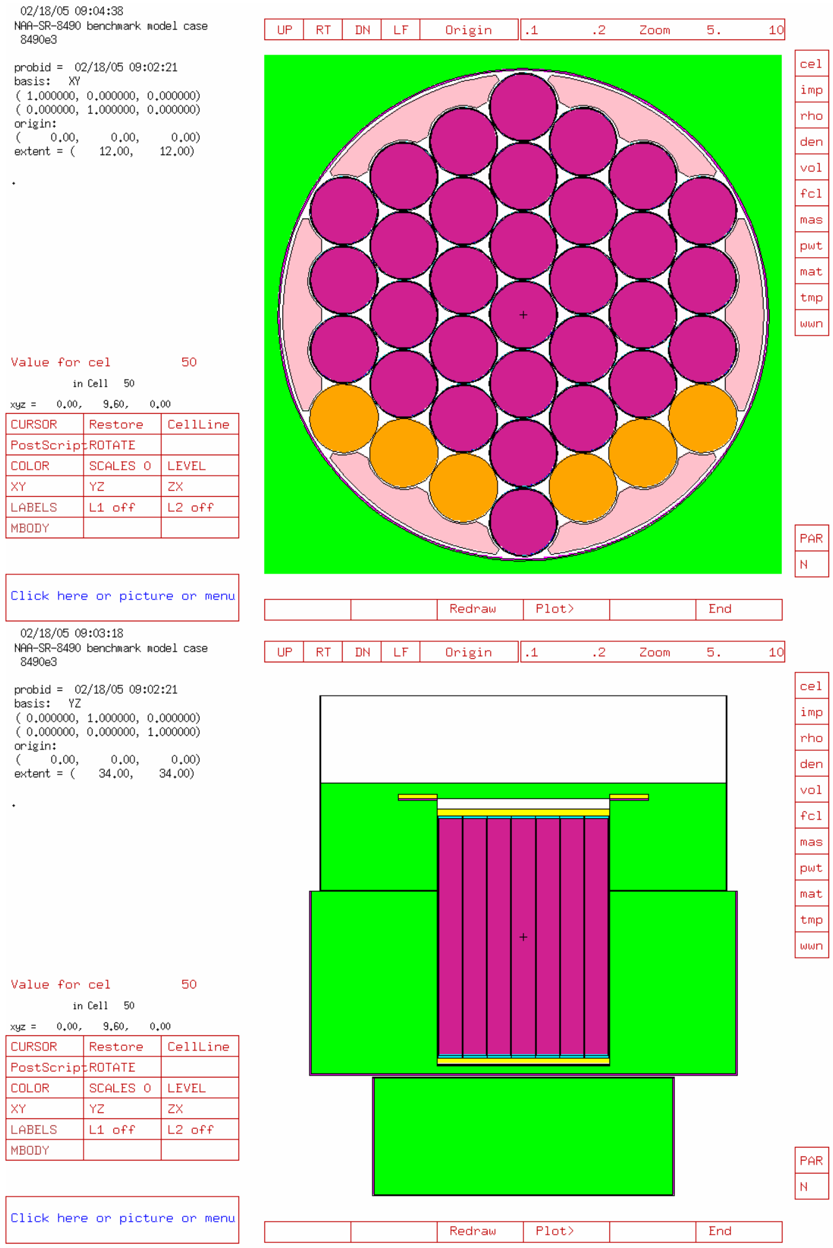


Fig. 19. Case *8490e3* MCNP5 plot.

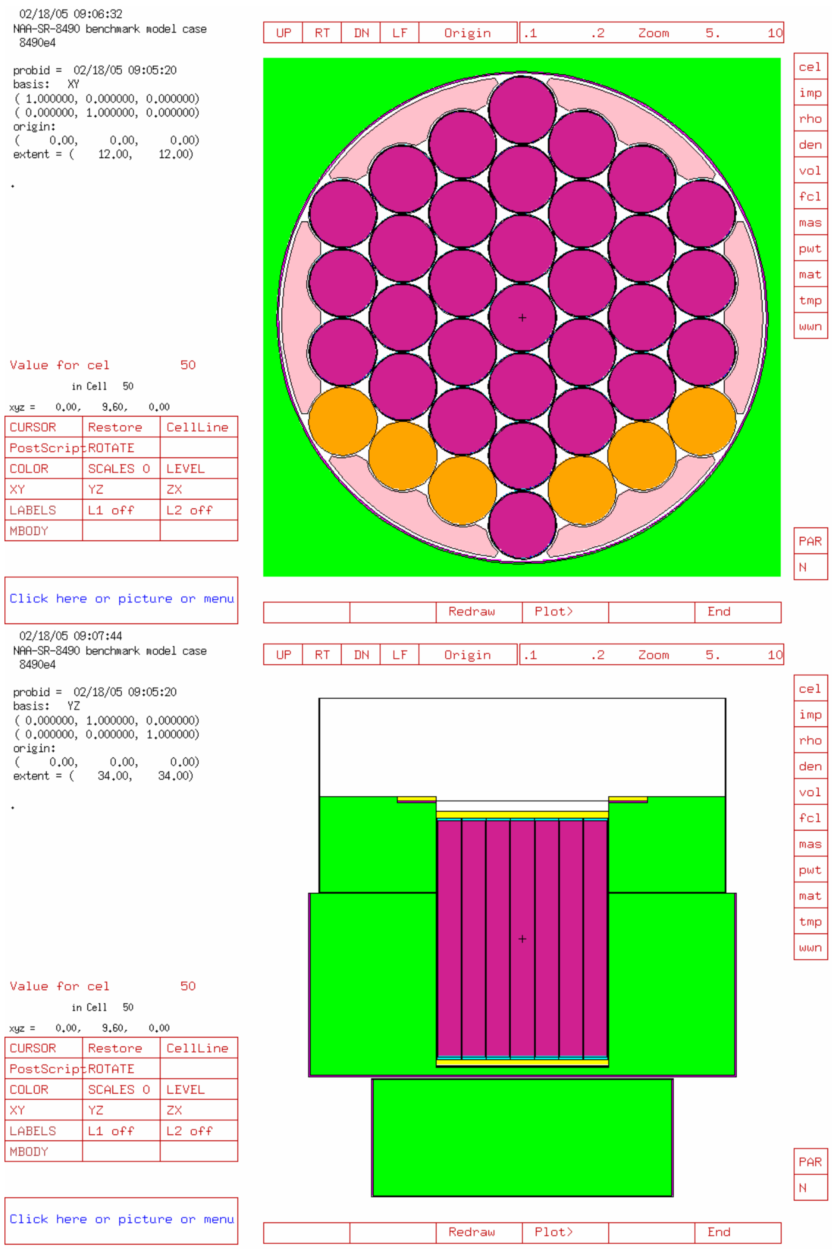


Fig. 20. Case *8490e4* MCNP5 plot.

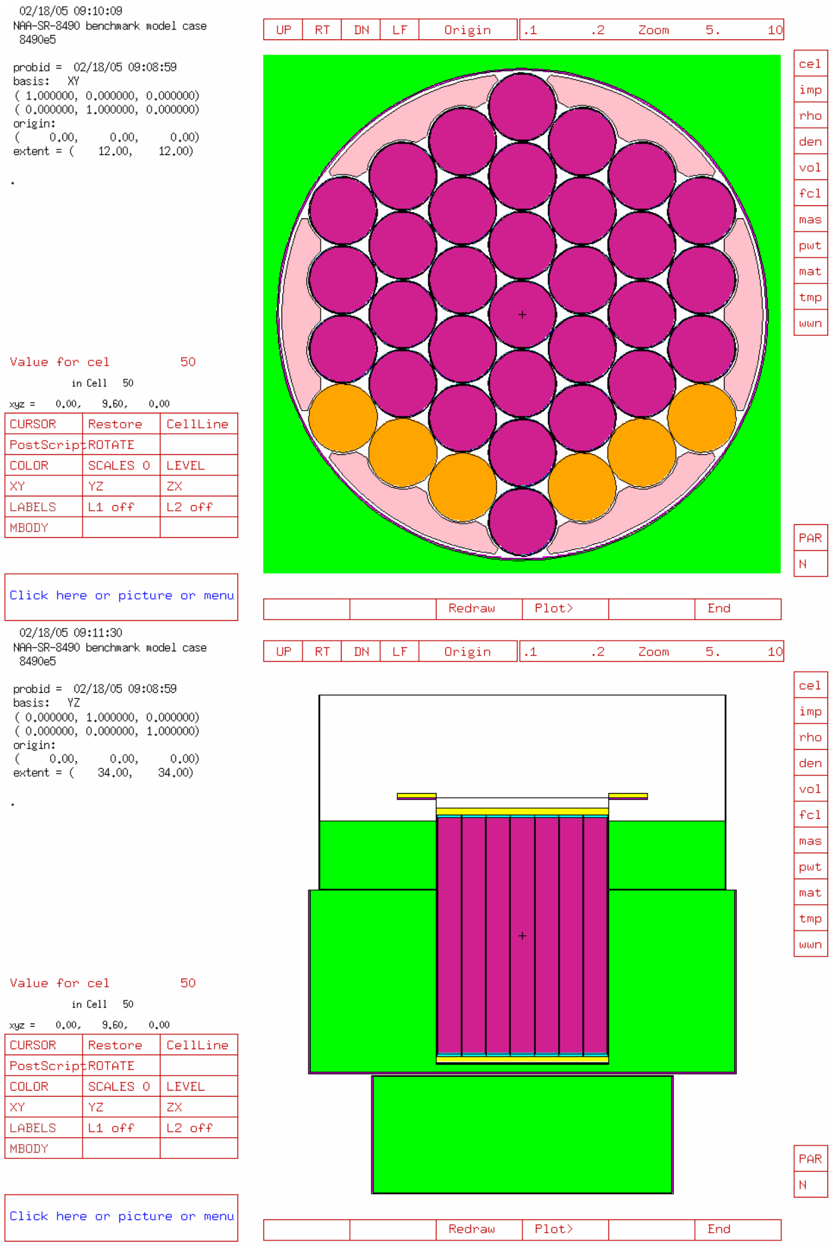


Fig. 21. Case *8490e5* MCNP5 plot.

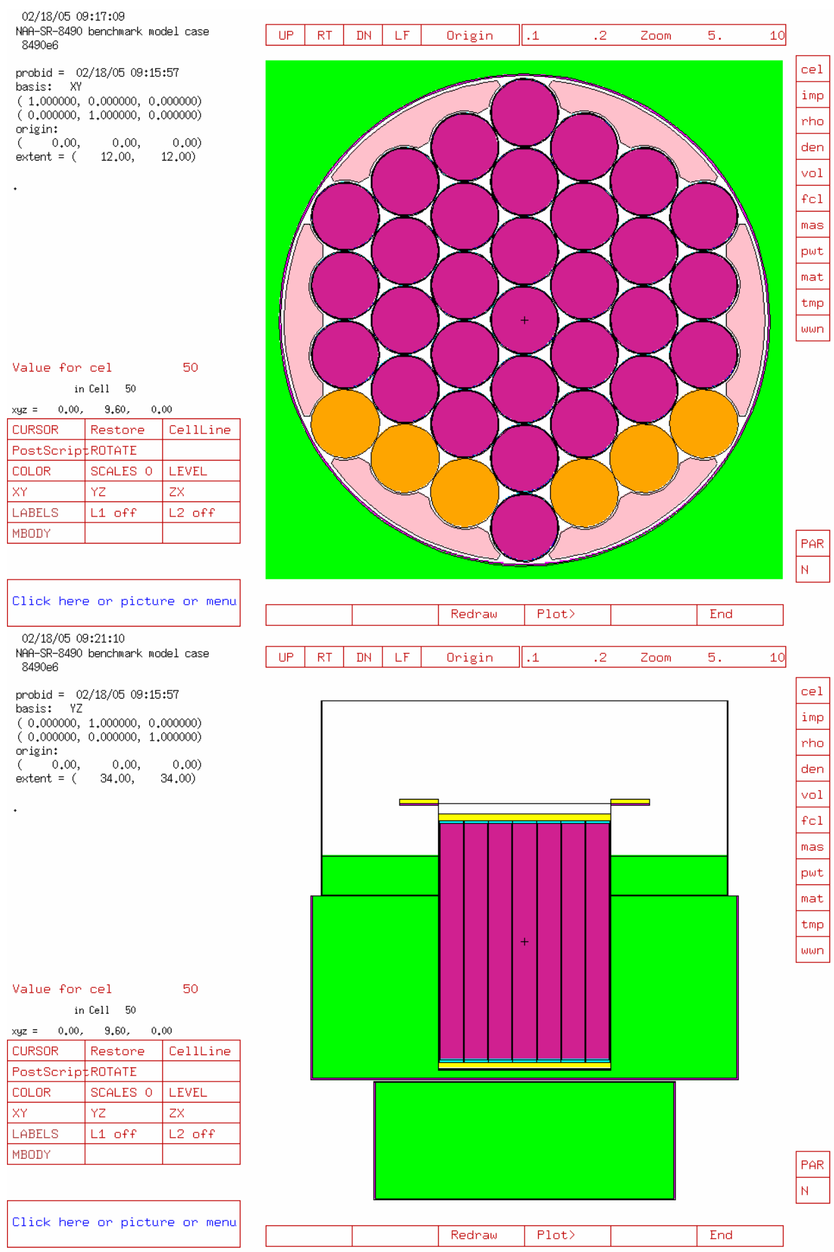


Fig. 22. Case *8490e6* MCNP5 plot.

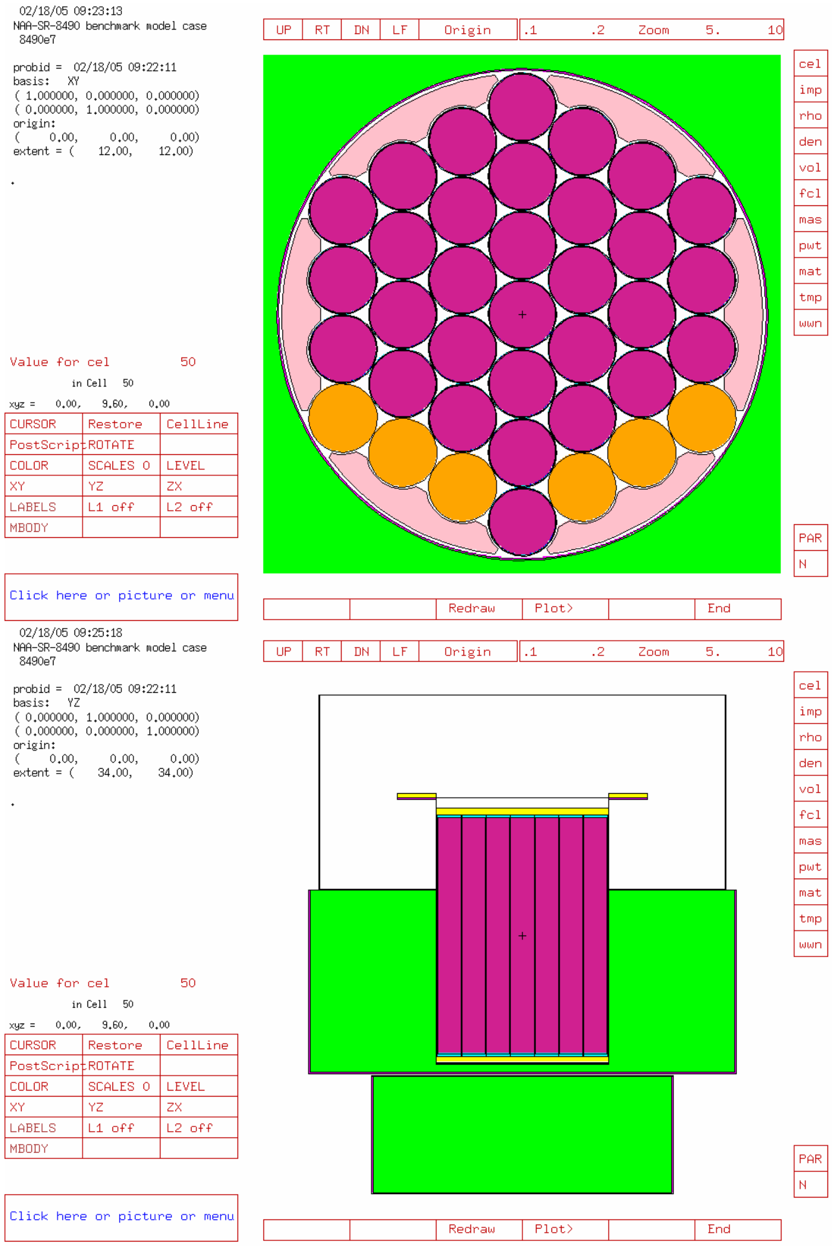


Fig. 23. Case *8490e7* MCNP5 plot.

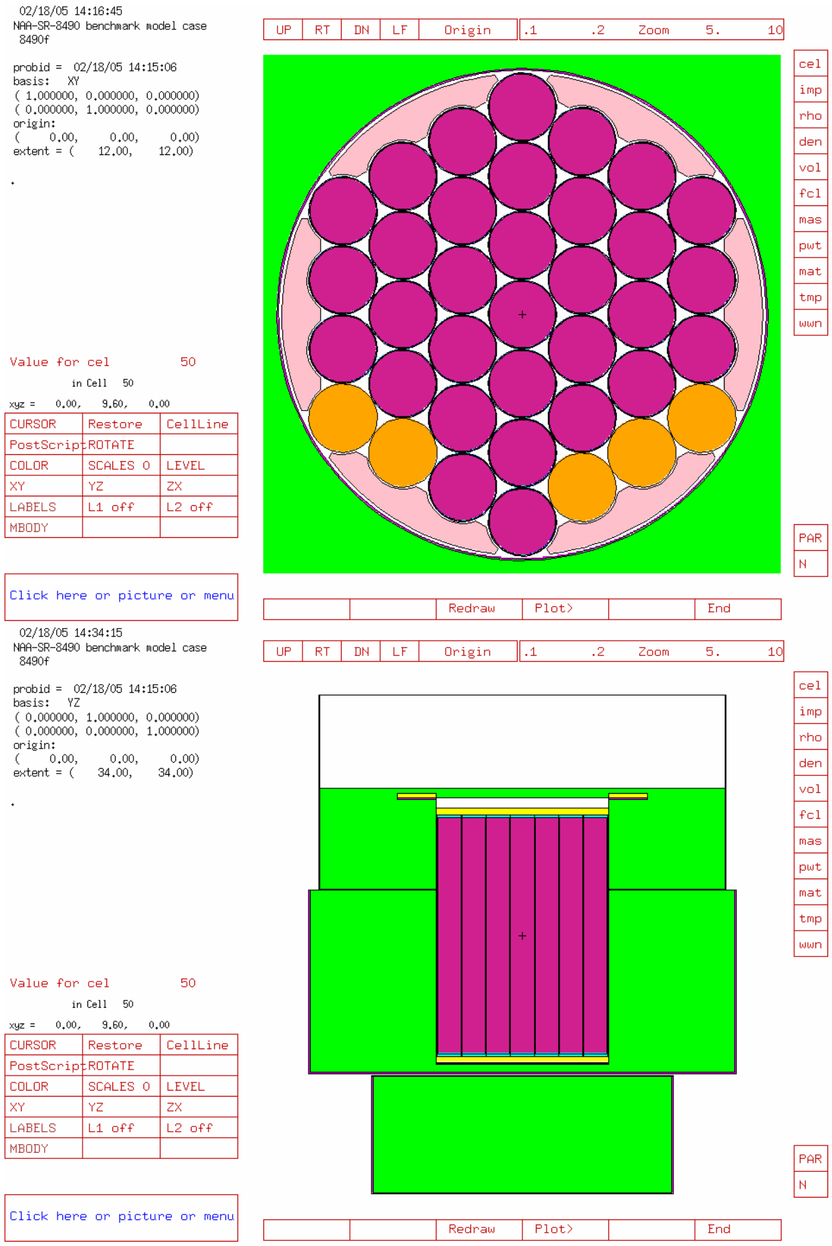


Fig. 24. Case *8490f* MCNP5 plot.

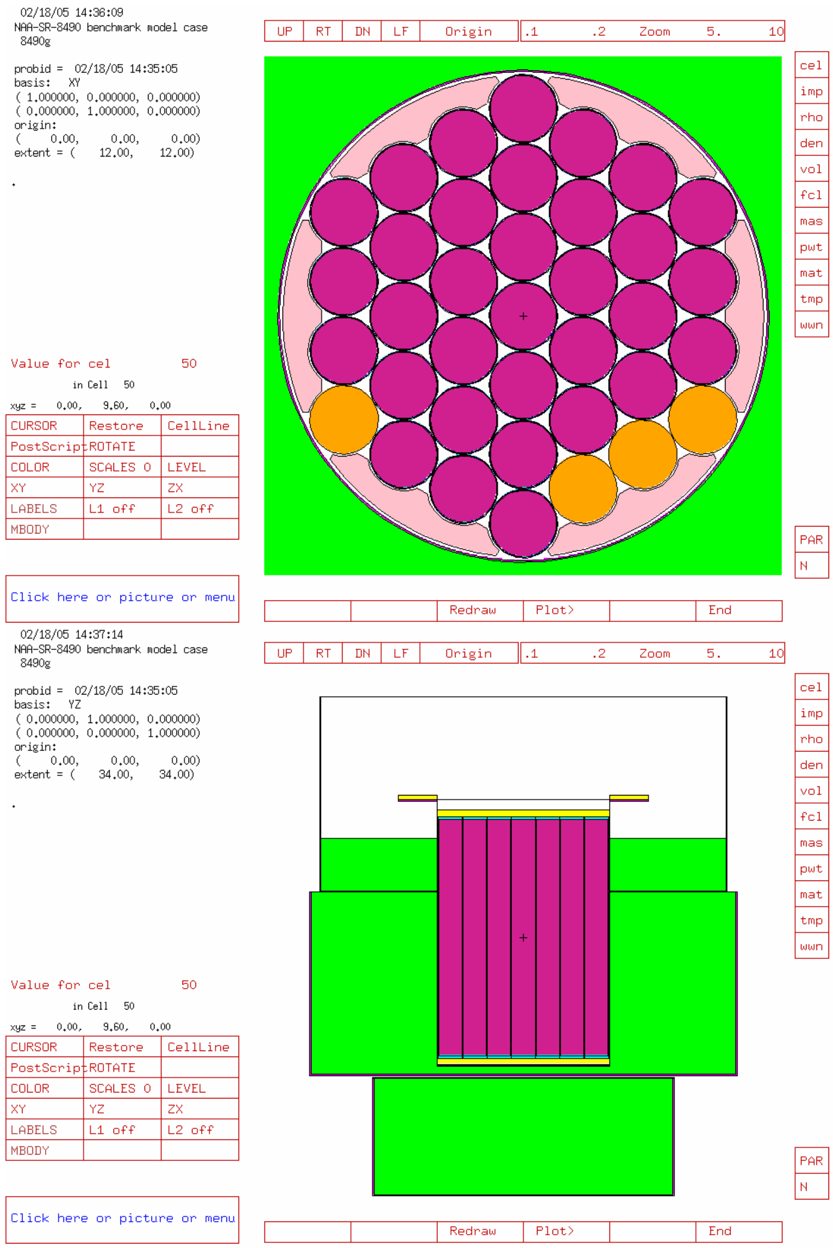


Fig. 25. Case *8490g* MCNP5 plot.

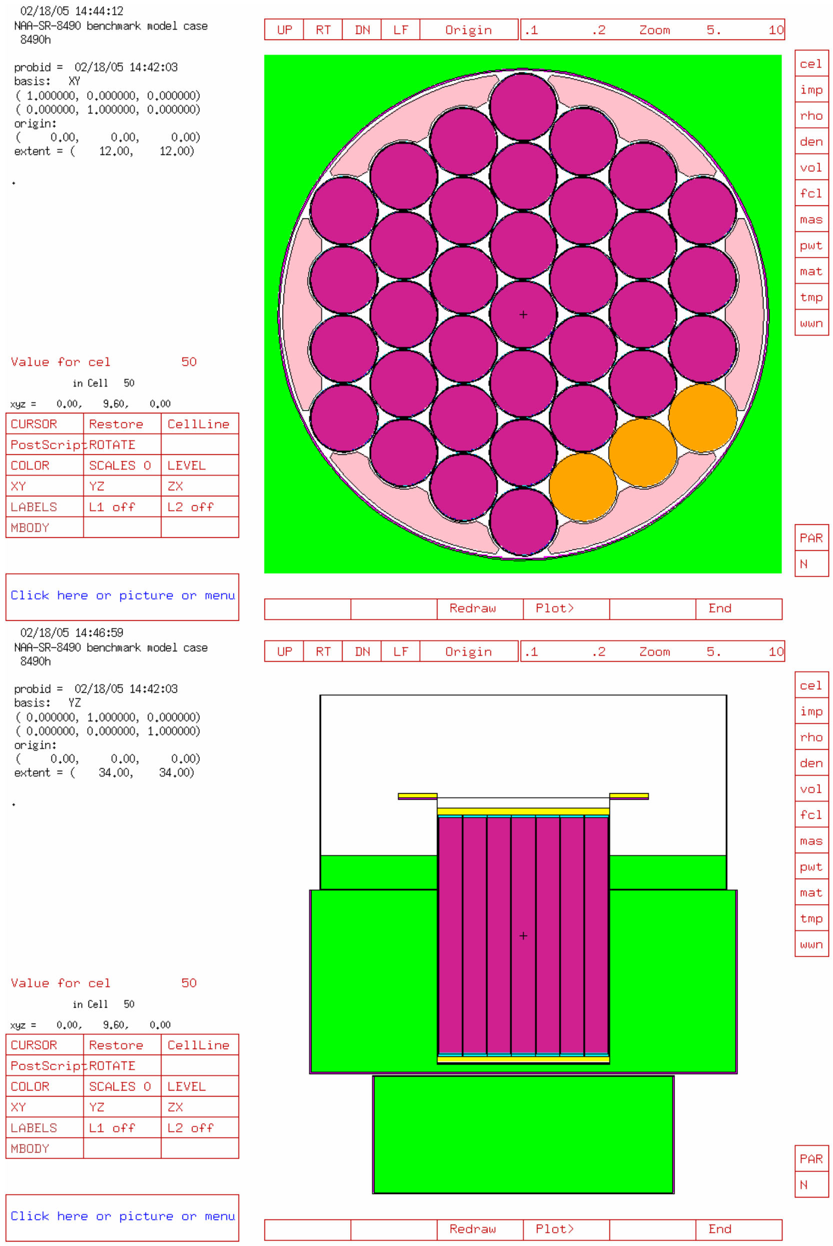


Fig. 26. Case *8490h* MCNP5 plot.

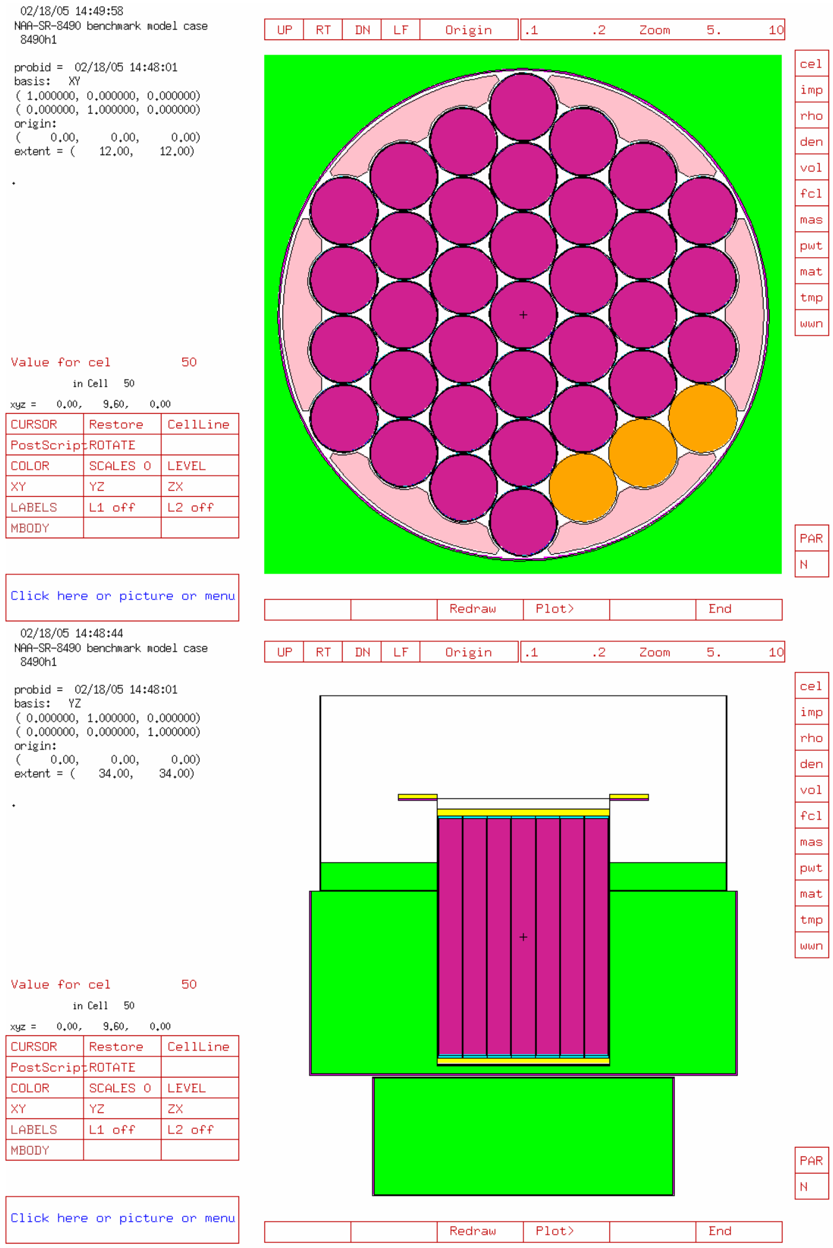


Fig. 27. Case *8490h1* MCNP5 plot.

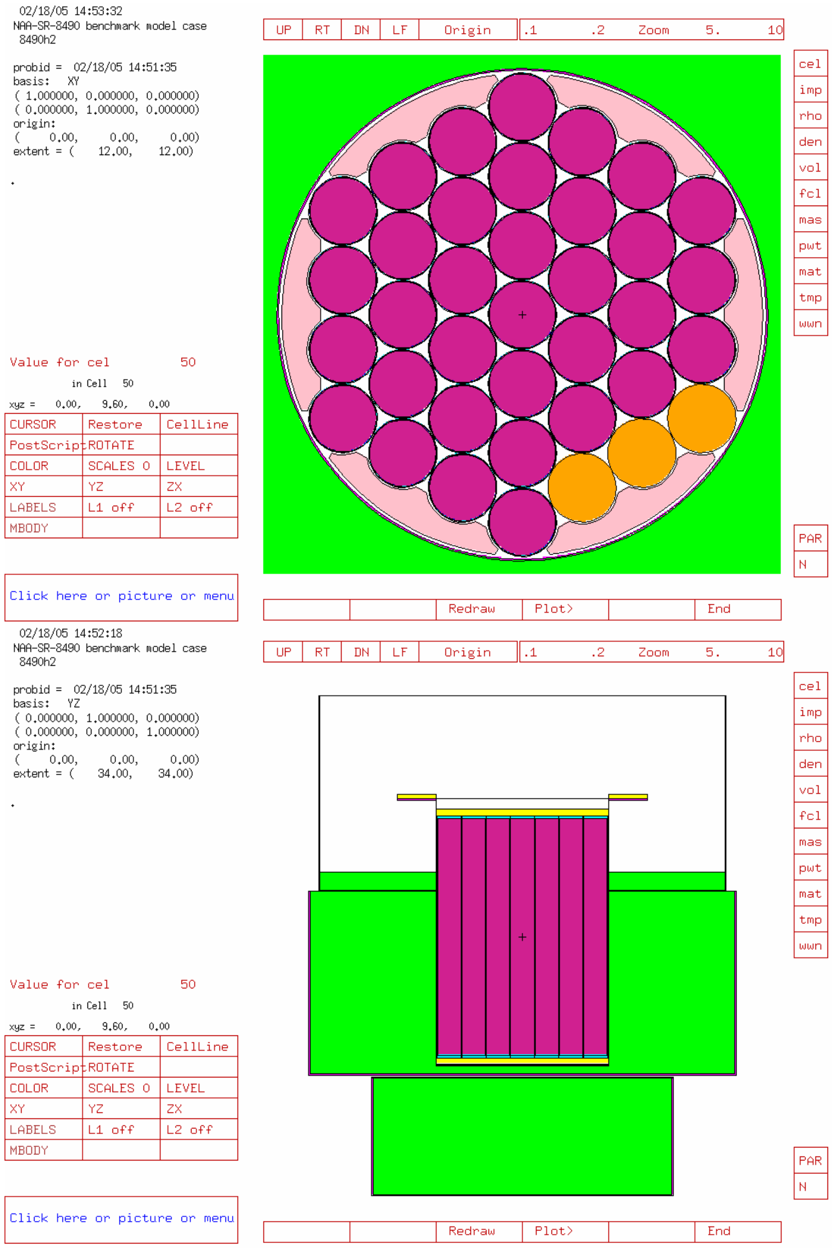


Fig. 28. Case *8490h2* MCNP5 plot.

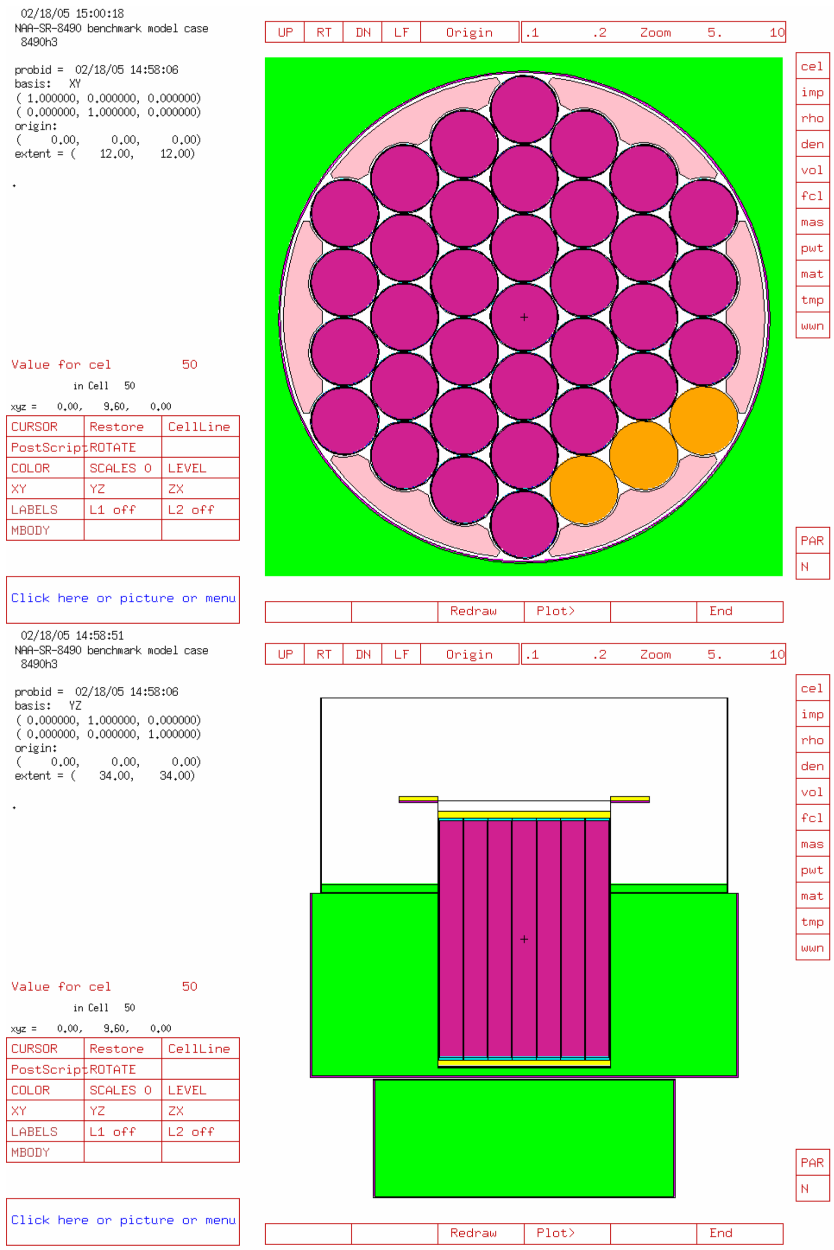


Fig. 29. Case *8490h3* MCNP5 plot.

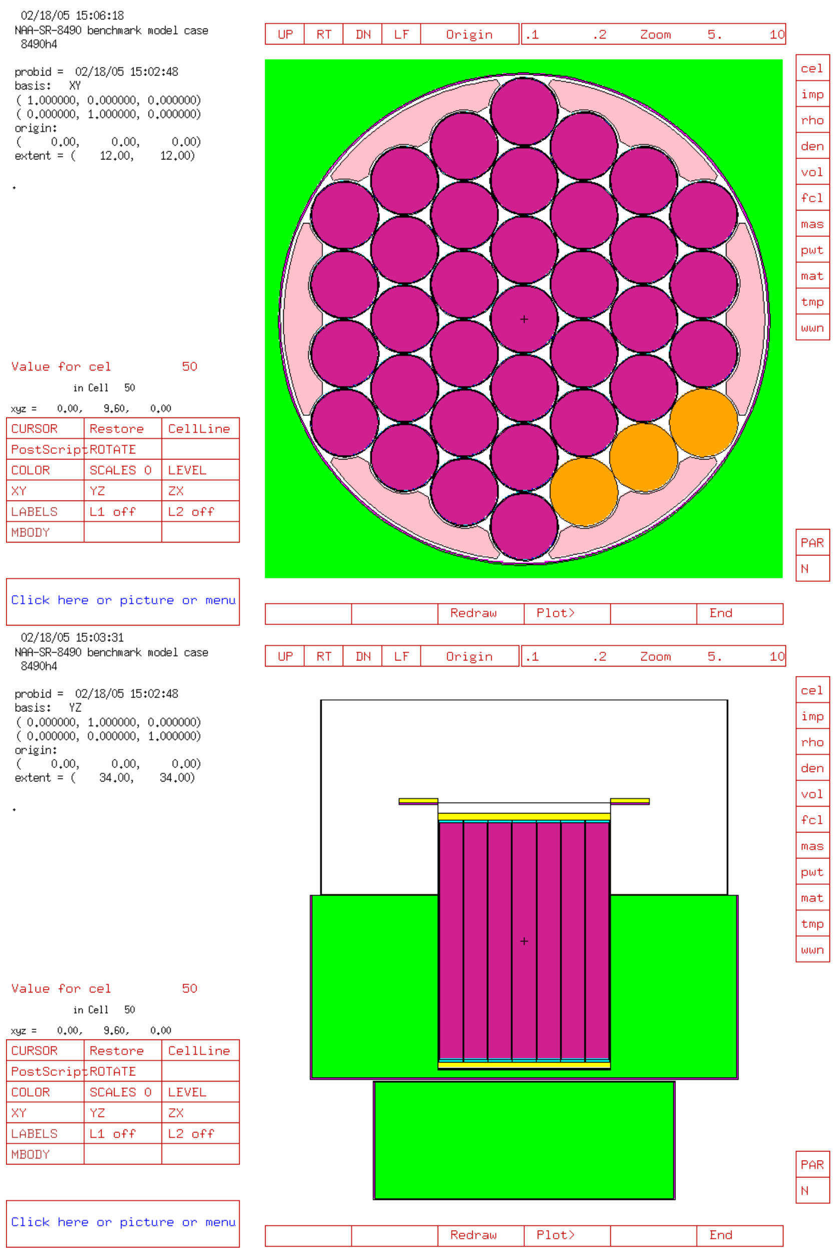


Fig. 30. Case *8490h4* MCNP5 plot.

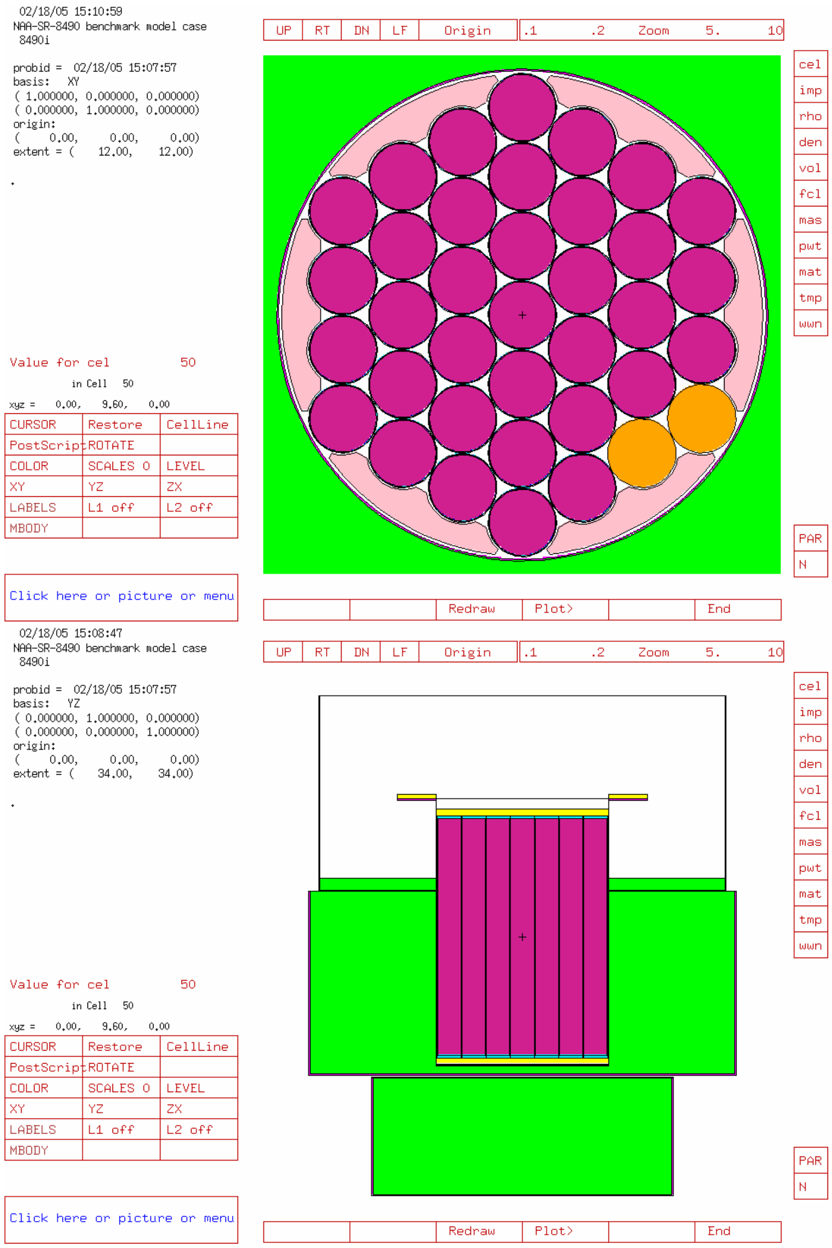


Fig. 31. Case *8490i* MCNP5 plot.

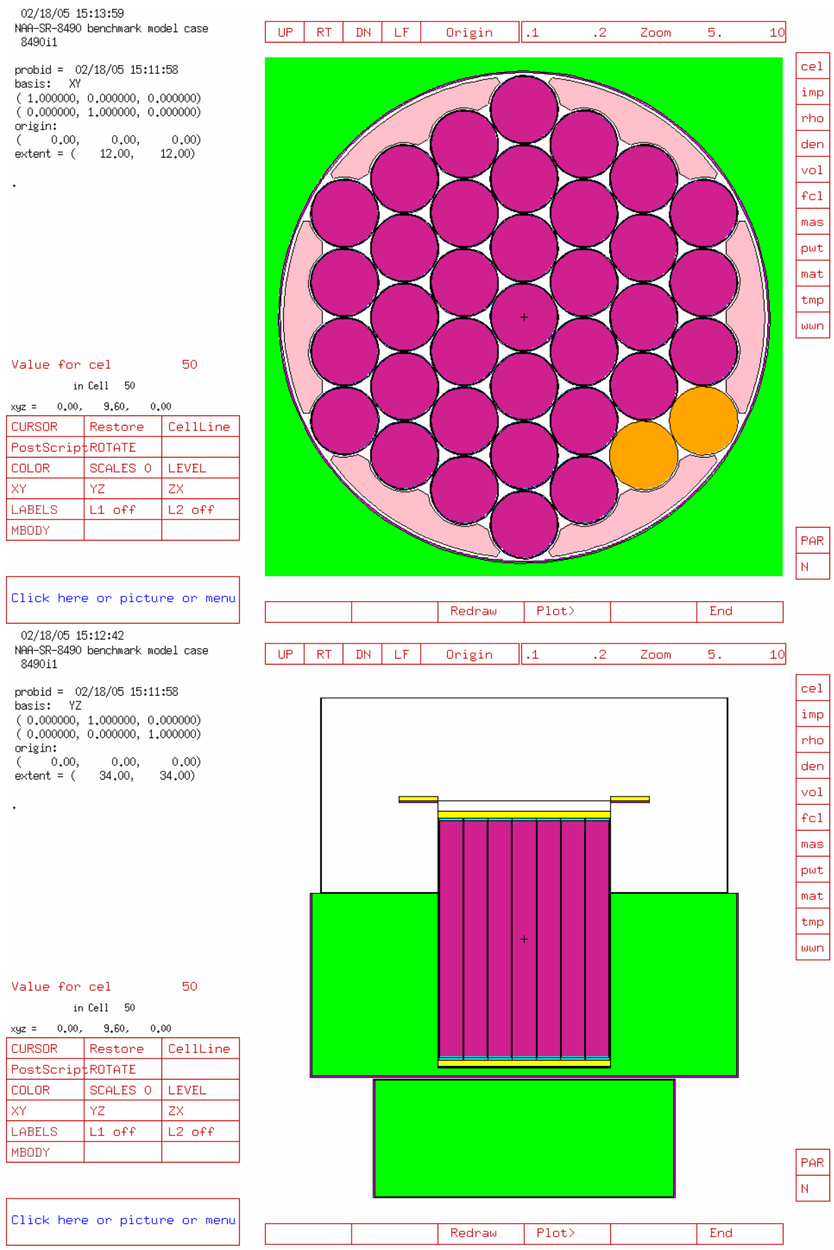


Fig. 32. Case *8490i1* MCNP5 plot.

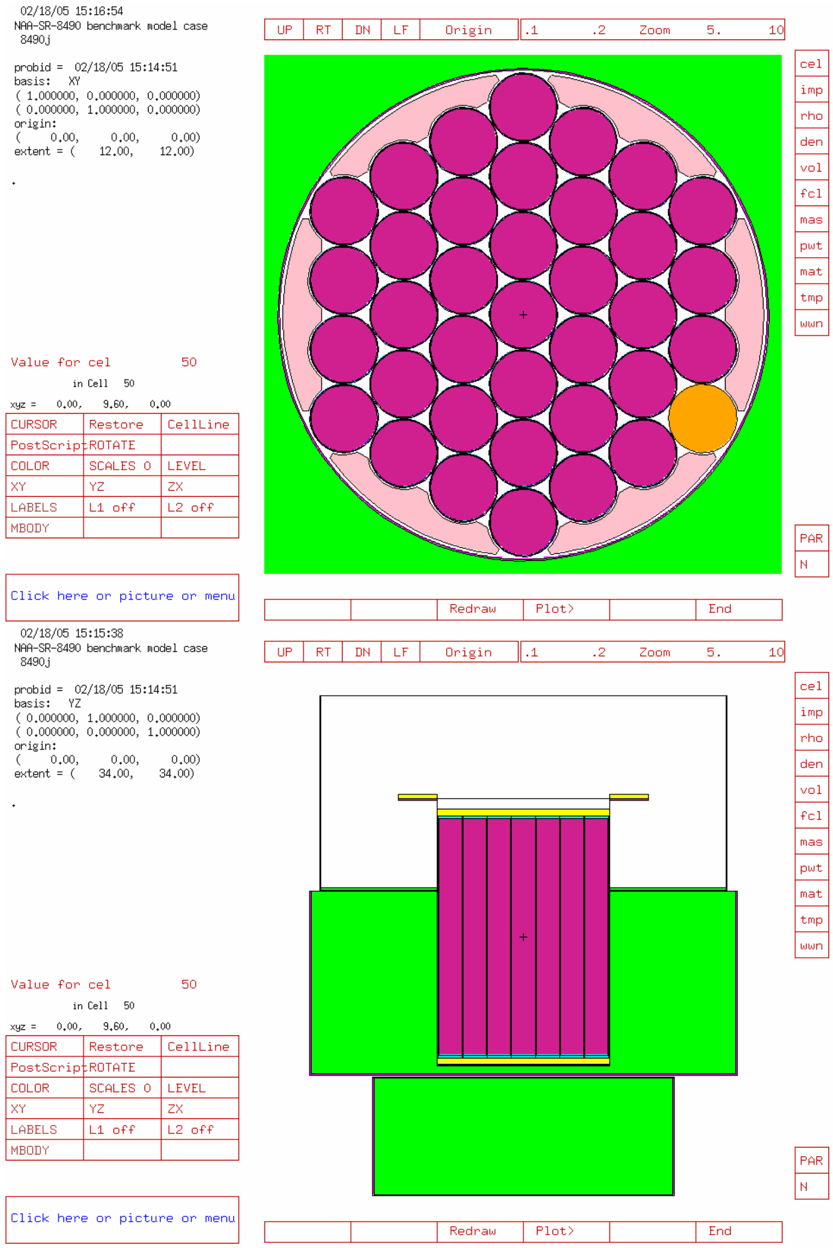


Fig. 33. Case *8490j* MCNP5 plot.

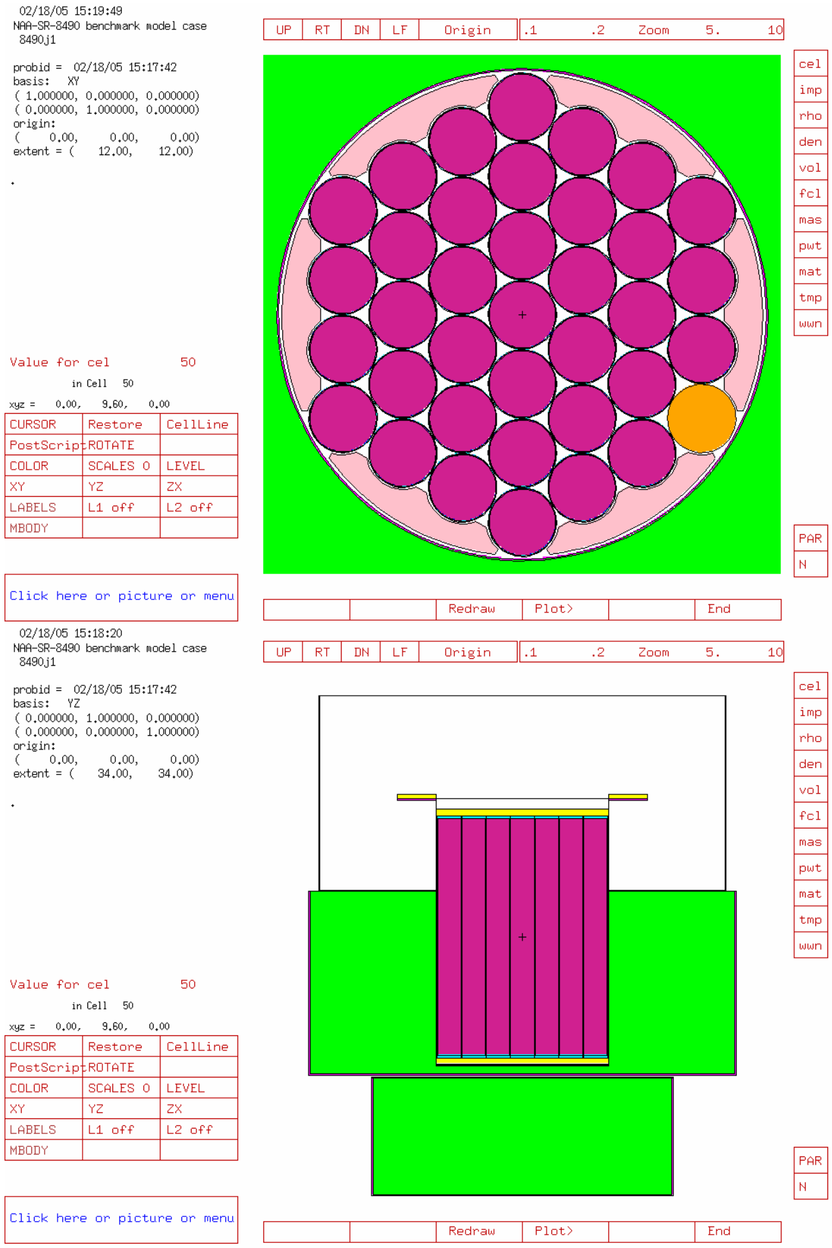


Fig. 34. Case *8490j1* MCNP5 plot

3.2.3 Cases *8490k* through *8490r*

There are 15 distinct benchmarks in this group that are derived from the experimental results presented in Table III of NAA-SR-8490 (summarized here in Table 5). Seven configurations are only qualitatively known to be subcritical by an undetermined margin, so their calculated results cannot be quantitatively normalized. These measurements illustrate the reactivity effect of absorber sleeves around the reactor core vessel in various configurations. The sleeves used were made from stainless-steel-encased boron carbide powder or borated aluminum, as discussed in Section 3.1.6. The sleeves were made in several different thicknesses, and were positioned to cover various amounts of the radial surface of the core vessel.

Table 5 provides the sleeve configurations for this series of experiments. The reference number of the sleeve configuration noted in Table 5 corresponds to the reference number of the configuration as noted in Table III of NAA-SR-8490. None of the experimental measurements involve the full complement of 37 fuel elements. The reactor core vessel is flooded with water in some cases, but not in others. Lucite rods occupy the positions in the core that do not otherwise contain a fuel element and all six beryllium inserts are present. In all cases, the lower tank and control cap are full of water while the water level of the upper tank is varied from case to case.

Table 5. Absorber sleeve configurations for Phase I experiments

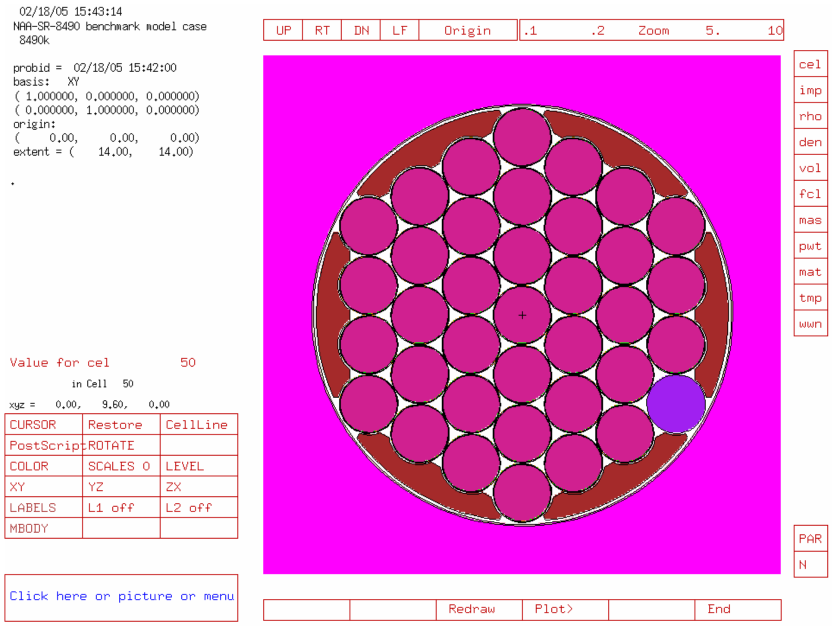
Case name	Reference no. of configuration	Fuel Rods*	Sleeve geometry and material†	Flooded core interstices‡	Upper tank water height (in.)	Measurement
8490ℓ1	2	36	L–2/3–0.25–bc	voided	9.0	far subcritical
8490k1	3	36	M–1/3–0.50–bc	voided	9.0	far subcritical
8490k	4	36	L–1/3–0.50–bc	voided	5.2	ρ/β = \$0.00
8490ℓ	5	36	L–1/3–0.25–bc	voided	5.0	ρ/β = \$0.00
8490ℓ2	6	36	F–0.25–bc	voided	9.0	far subcritical
8490m	7	28	No sleeve	water	0.0	ρ/β = \$0.15
8490n	8	29	U–1/3–0.50–bc and L–1/3–0.25–bc	water	9.0	ρ/β = \$0.02
8490n1	9	29	F–0.50–bc	water	9.0	far subcritical
8490o	10	29	U–1/3–0.50–bc and L–1/3–0.25–bi	water	9.0	ρ/β = \$0.02
8490p	11	29	U–1/3–0.50–bc and L–1/3–0.50–bi	water	9.0	ρ/β = -\$0.21§
8490q	12	29	U–1/3–0.50–bc and L–1/3–0.75–bi	water	9.0	ρ/β = -\$0.31§
8490r	13	29	U–1/3–0.50–bc and L–1/3–1.00–bi	water	9.0	ρ/β = -\$0.23§
8490ℓ5	14	29	M–1/3–0.25–bi	water	9.0	subcritical
8490ℓ3	15	29	F–0.75–bi	water	9.0	far subcritical
8490ℓ4	16	29	F–0.75–bi	voided	9.0	far subcritical

* Vacant fuel rod position are occupied by lucite rods.
† Explanation of symbols: U = upper, M= middle, L = lower, F = full; in the case of the partial sleeves, this symbol is followed by the axial fraction of the core vessel covered by the sleeve, which is in turn followed by the thickness of the sleeve in inches. The last symbol gives the type of sleeve material: bc = natural boron powder, packed to 22% of theoretical density, and canned in 0.031-in.-thick 304 stainless steel; bi = Binal containing 10.2 wt % boron. For example, L-2/3-0.25-bi refers to a Binal sleeve, 0.25 in. thick, surrounding the lower two-thirds of the core vessel.
‡ "Voided" signifies the presence of low density (less than 2 lb/ft^3) styrofoam in the interstices in the experiments.
§ Measured with an inverse multiplication technique, using as a reference the control cap worth of \$0.15.

The configurations described in Table 5 are illustrated in Fig. 35 through Fig. 49. The calculated results presented in Table 6 are based on no fewer than two million active neutron histories per benchmark case.

Table 6. Summary Table of Experimental Benchmarks from Table III of NAA-SR-8490

Case name	Reference no. of configuration	Reported excess reactivity, ρ($)	Estimated experimental k_{eff}, k_{exp}	Calculated k_{eff}, k_{calc}	Computa-tional uncertainty, σ	Normalized result, k_{calc}/k_{exp}
8490k	4	0.00	1.00000	0.99415	0.00069	0.9942
8490k1	3	far subcritical	unknown	0.96428	0.00070	n/a
8490ℓ	5	0.00	1.00000	0.99488	0.00071	0.9949
8490ℓ1	2	far subcritical	unknown	0.94555	0.00070	n/a
8490ℓ2	6	far subcritical	unknown	0.92092	0.00069	n/a
8490ℓ3	15	far subcritical	unknown	0.97173	0.00068	n/a
8490ℓ4	16	far subcritical	unknown	0.88255	0.00068	n/a
8490ℓ5	14	subcritical	unknown	0.99879	0.00070	n/a
8490m	7	+0.15	1.00120	1.00623	0.00070	1.0050
8490n	8	+0.02	1.00016	1.00081	0.00068	1.0006
8490n1	9	far subcritical	unknown	0.96128	0.00068	n/a
8490o	10	+0.02	1.00016	1.00105	0.00069	1.0009
8490p	11	-0.21	0.99832	1.00068	0.00068	1.0024
8490q	12	-0.31	0.99753	1.00006	0.00071	1.0025
8490r	13	-0.23	0.99816	1.00040	0.00070	1.0022



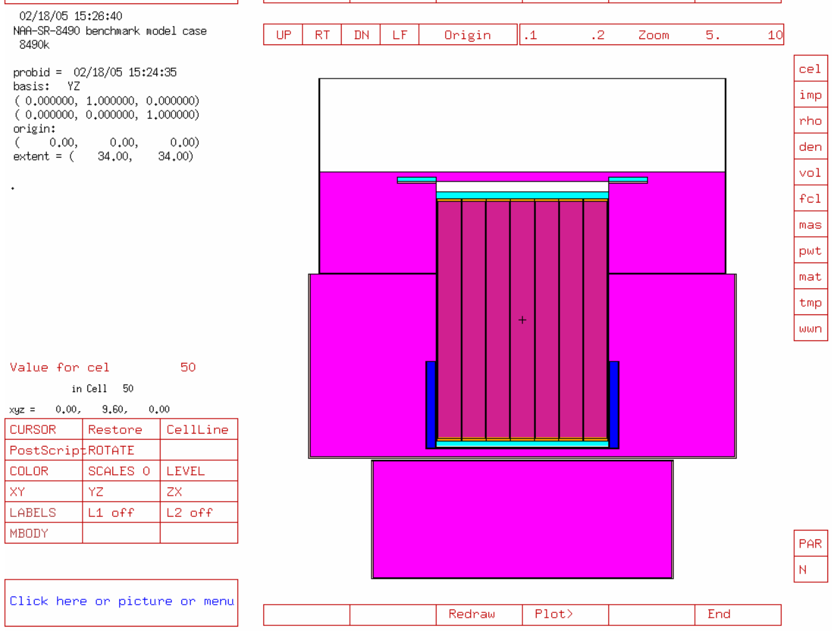


Fig. 35. Case *8490k* MCNP5 plot.

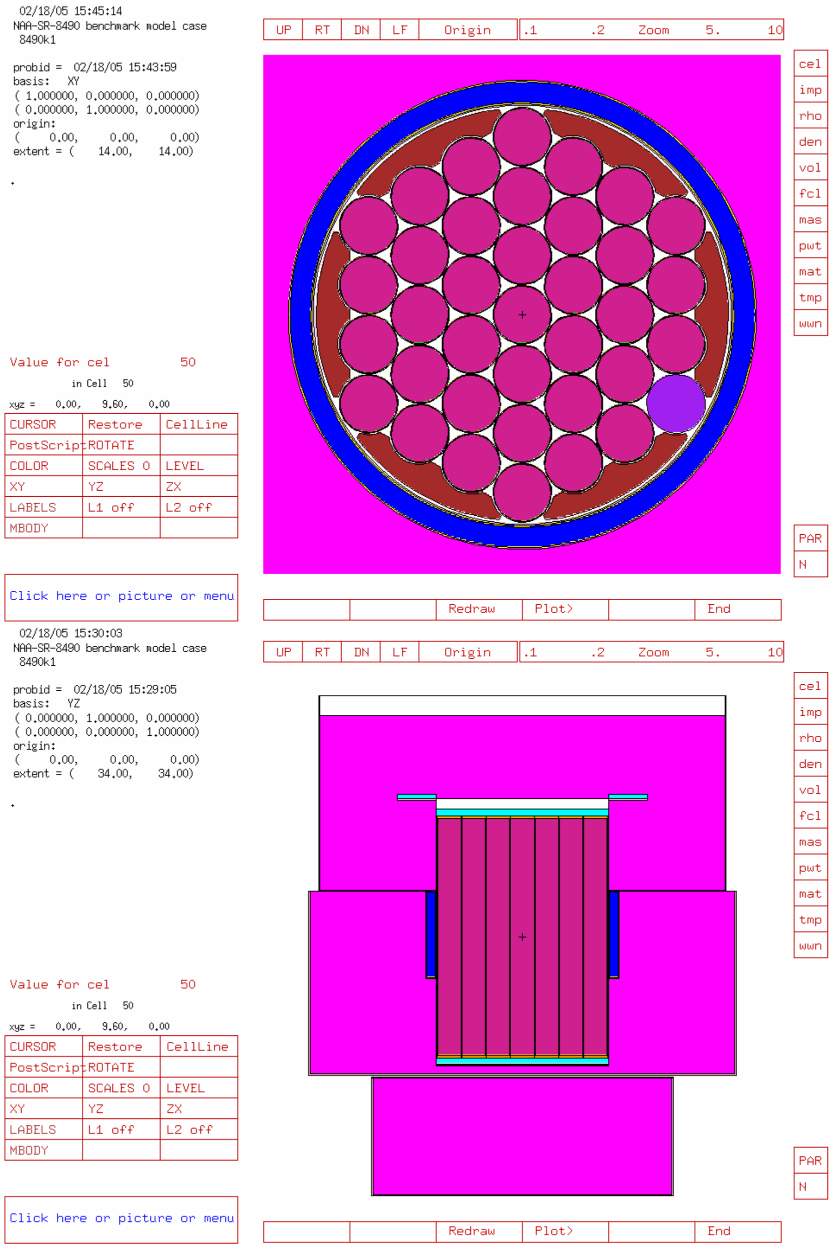


Fig. 36. Case *8490k1* MCNP5 plot.

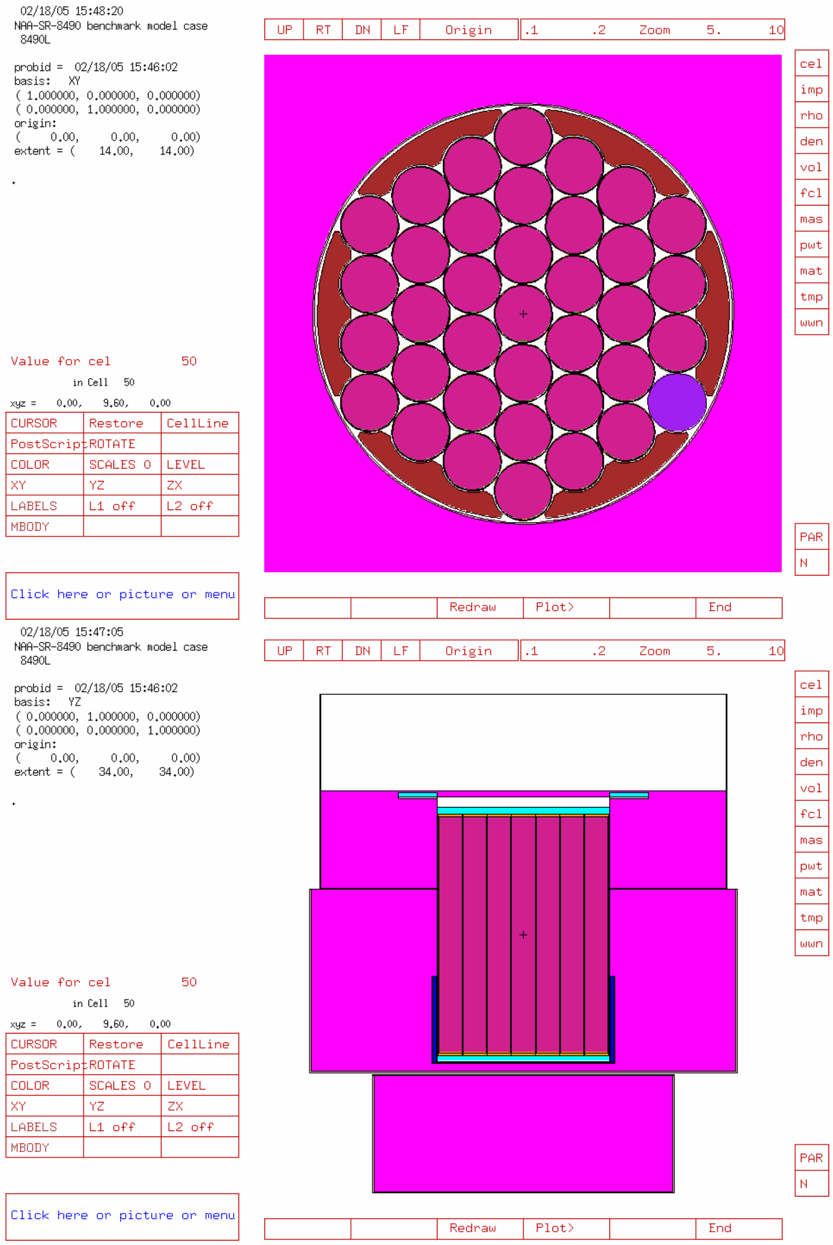


Fig. 37. Case *8490ℓ* MCNP5 plot.

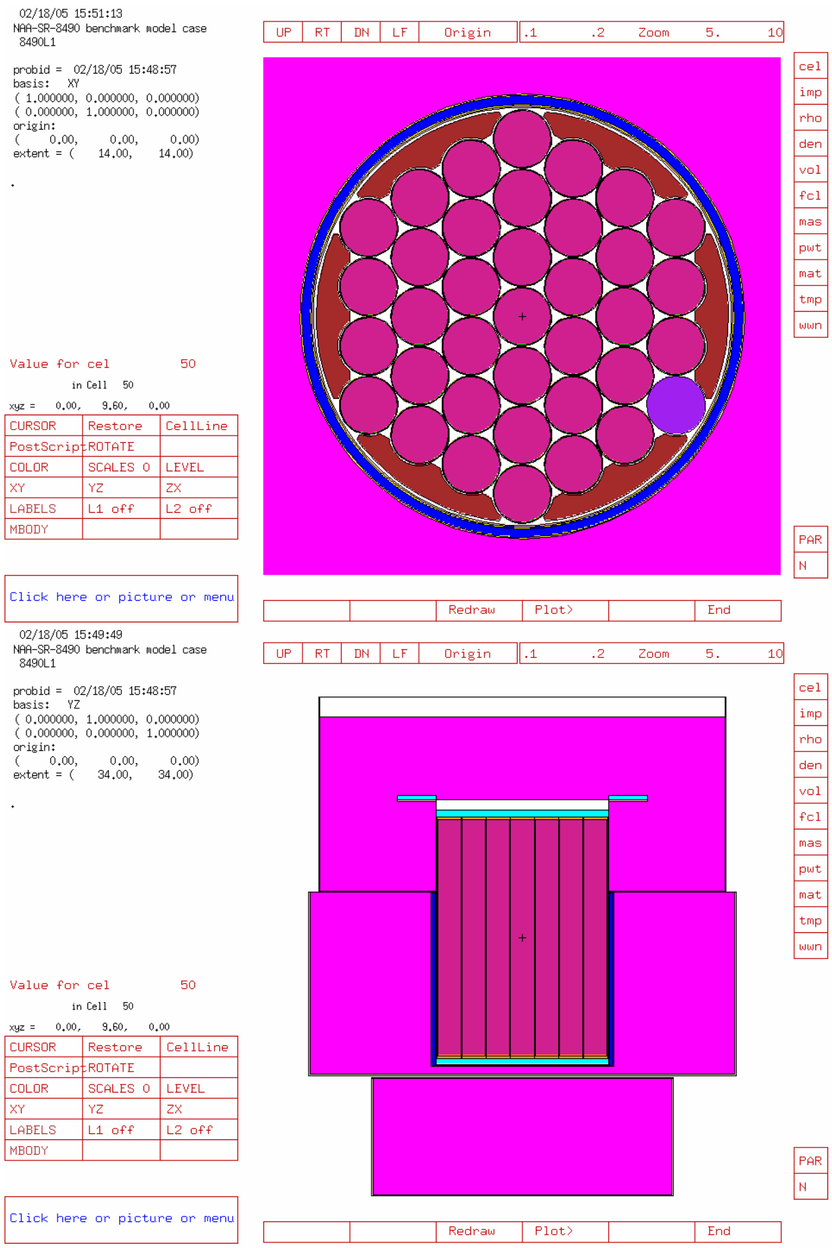


Fig. 38. Case *8490ℓ1* MCNP5 plot.

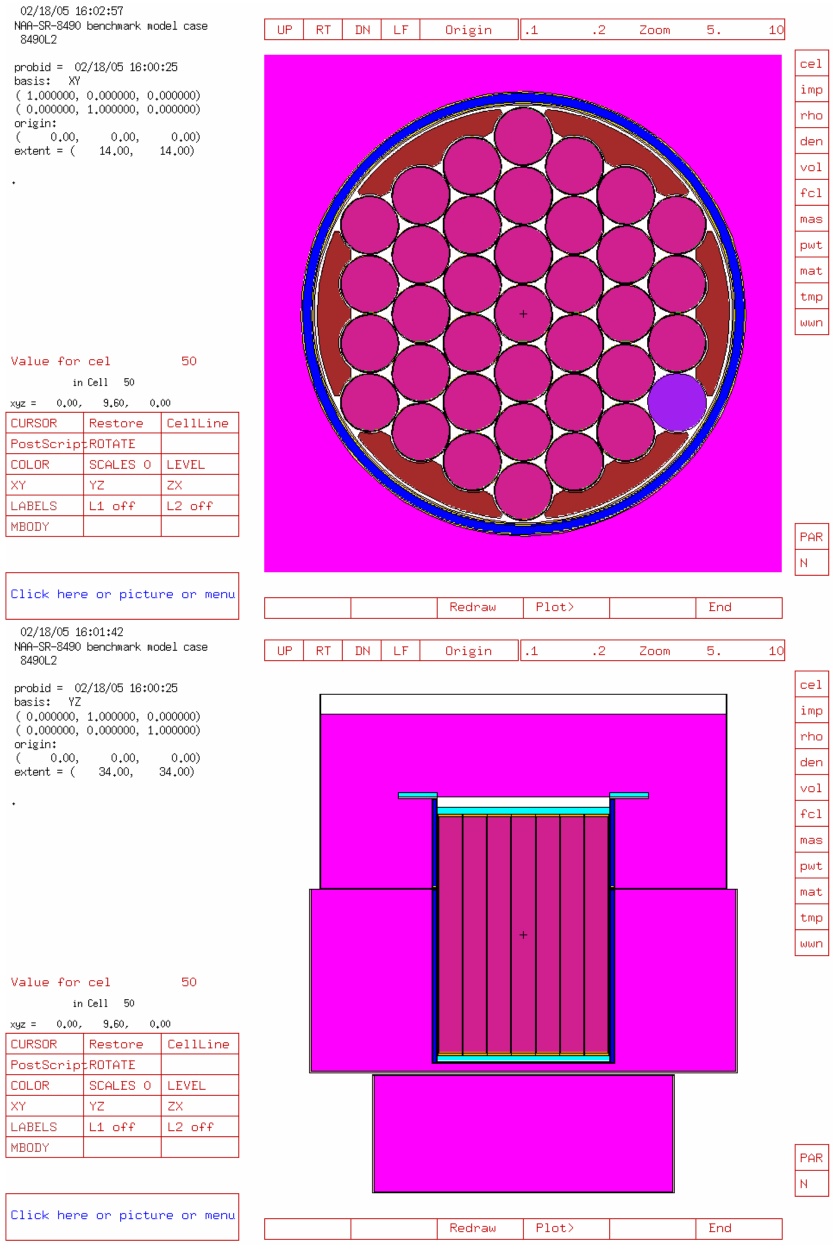


Fig. 39. Case *8490ℓ2* MCNP5 plot.

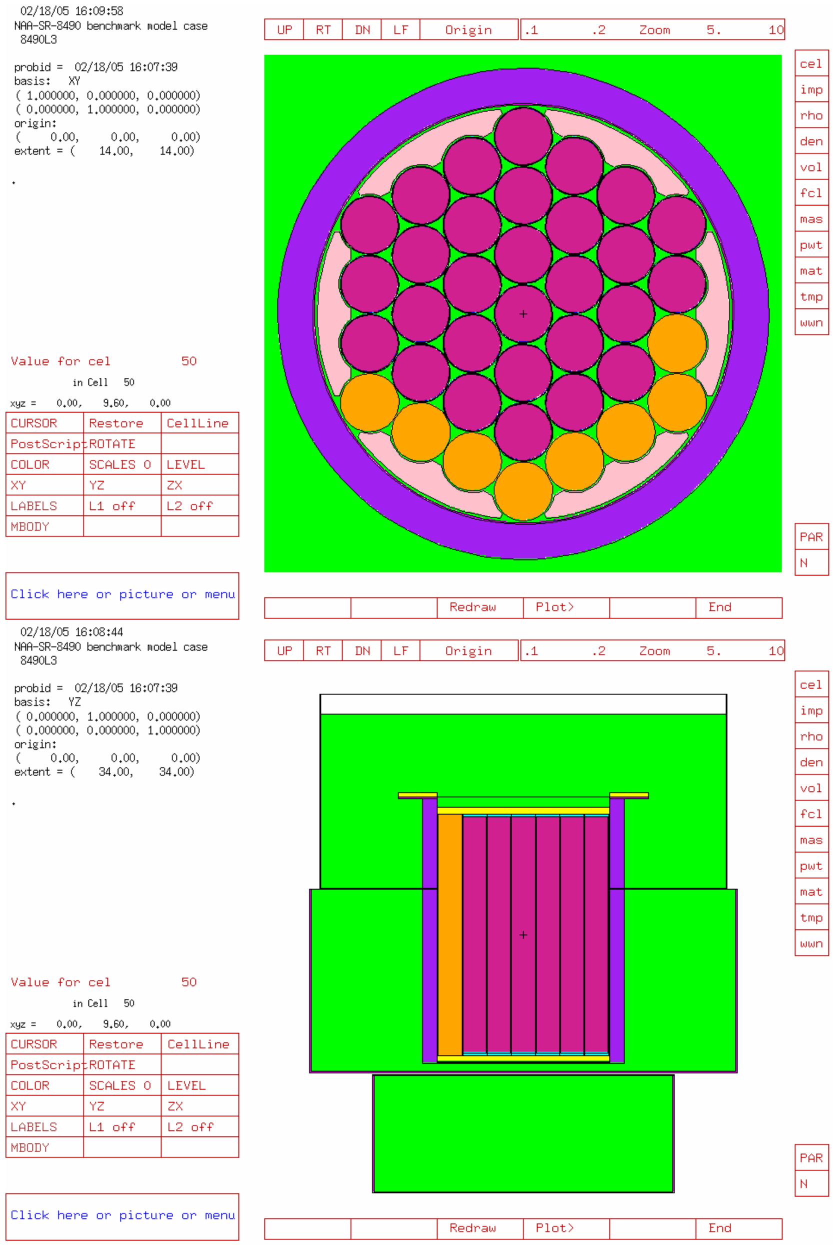


Fig. 40. Case *8490L3* MCNP5 plot.

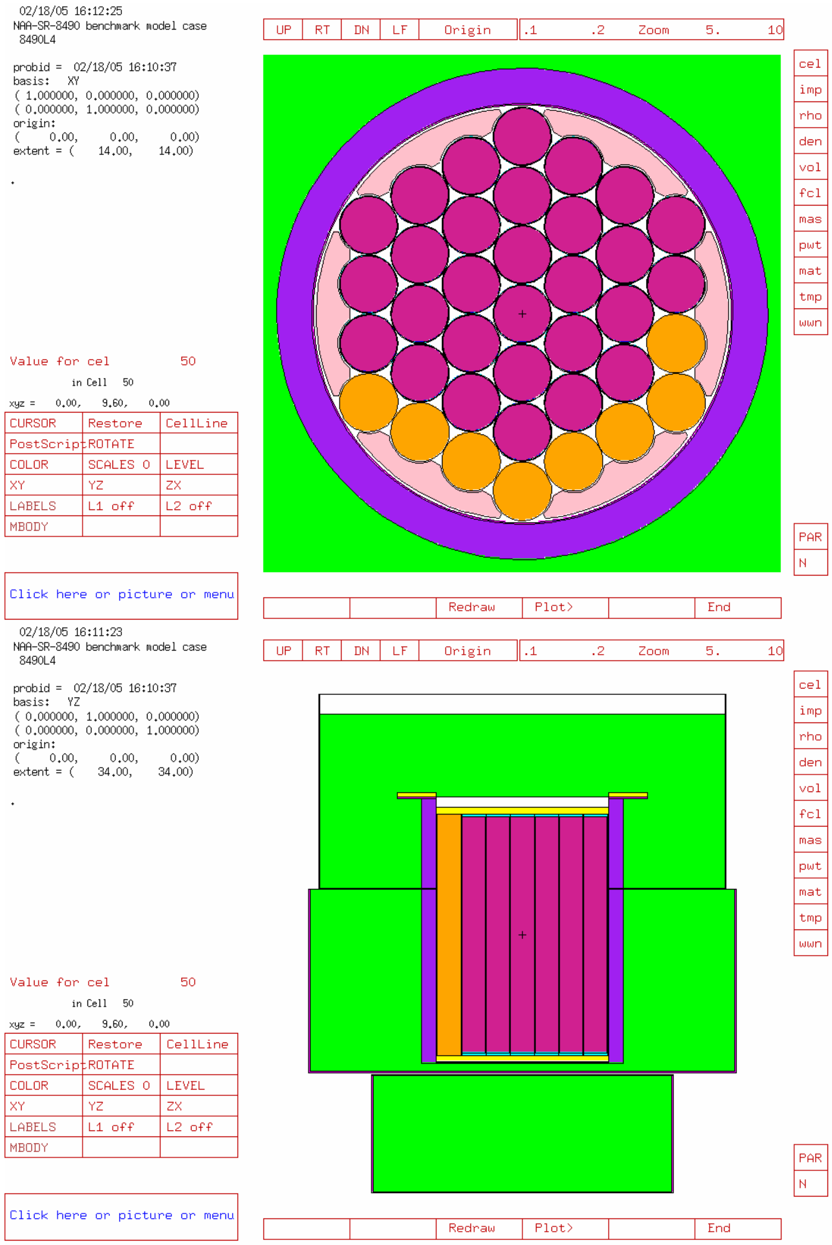


Fig. 41. Case *8490ℓ4* MCNP5 plot.

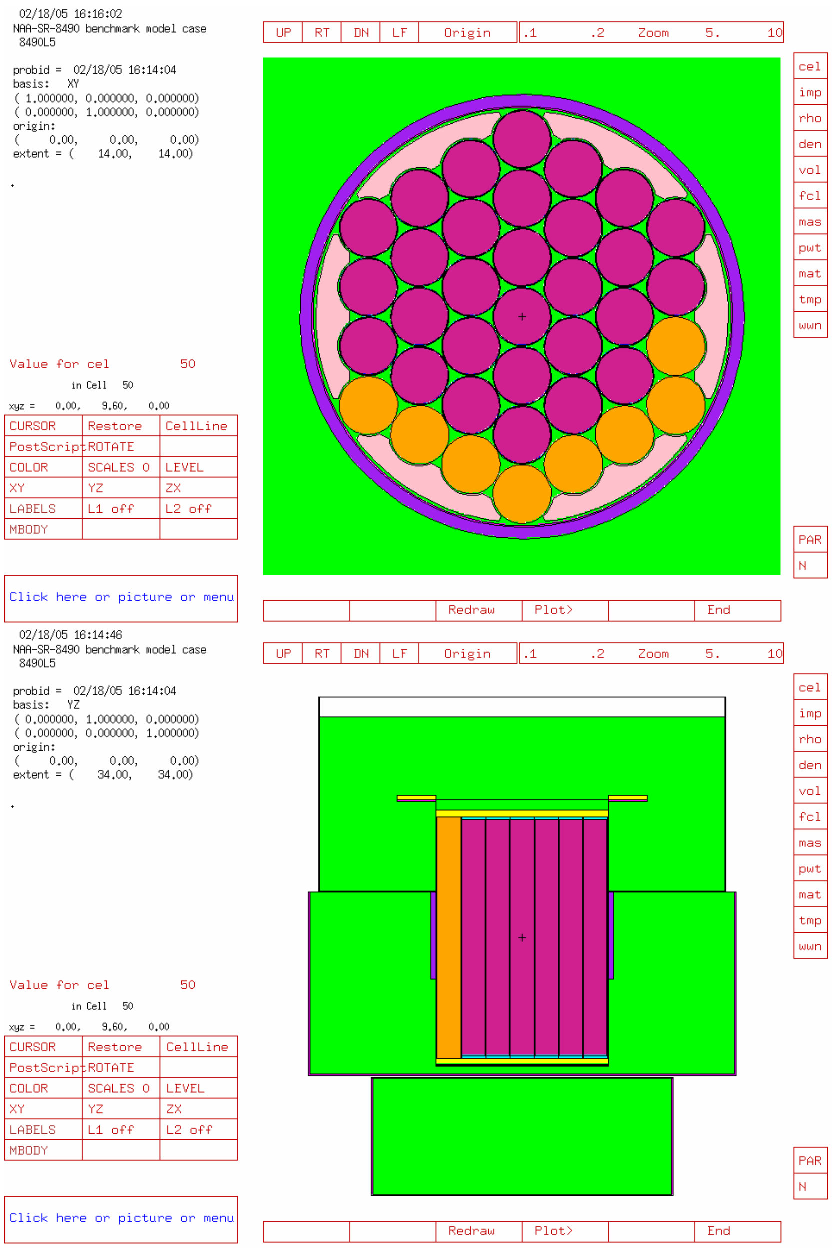


Fig. 42. Case *8490L5* MCNP5 plot.

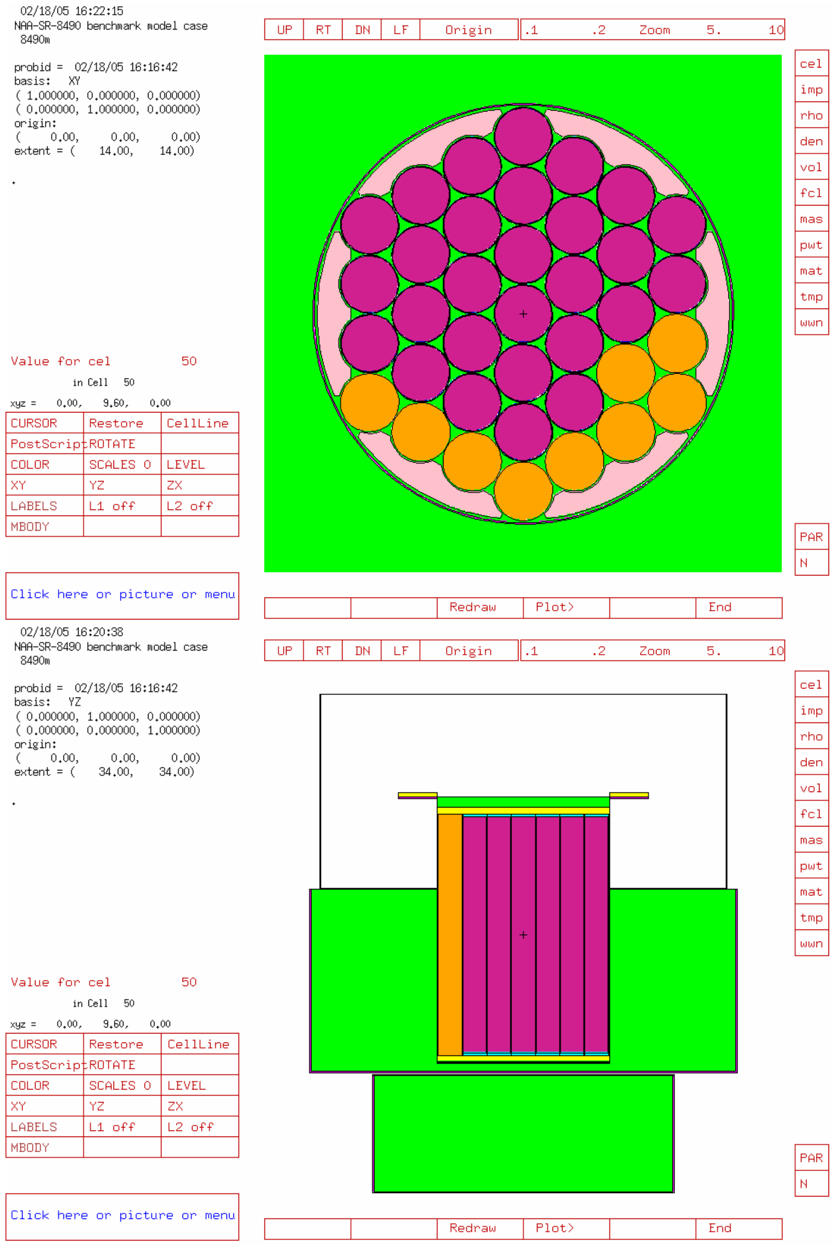


Fig. 43. Case *8490m* MCNP5 plot.

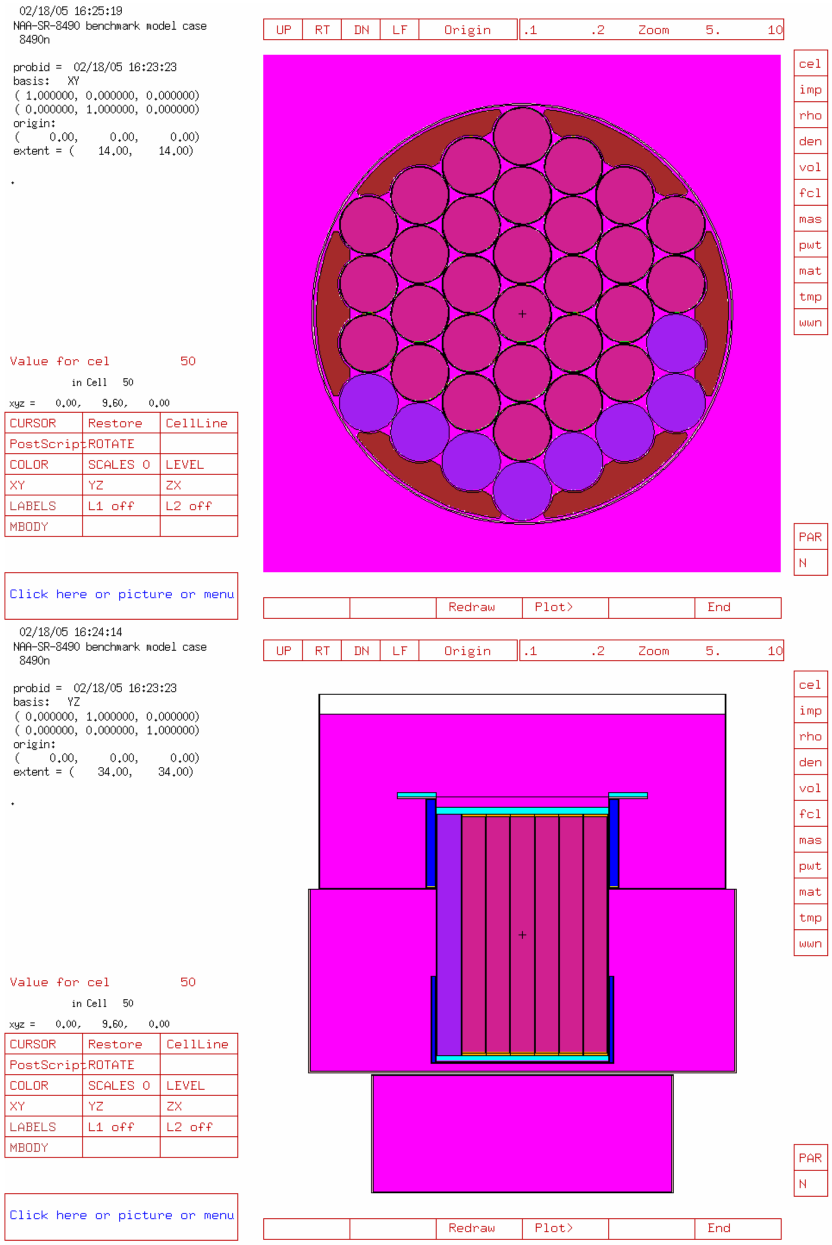


Fig. 44. Case *8490n* MCNP5 plot.

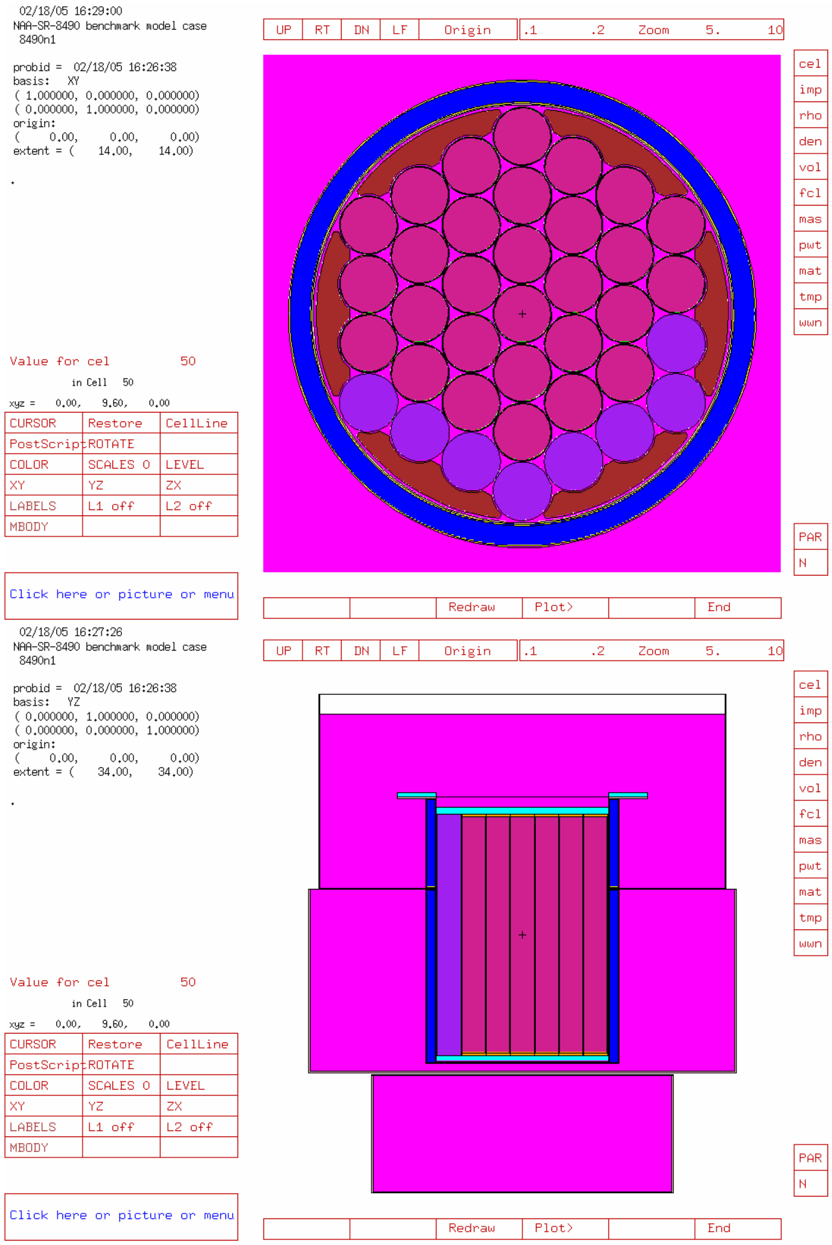


Fig. 45. Case *8490n1* MCNP5 plot.

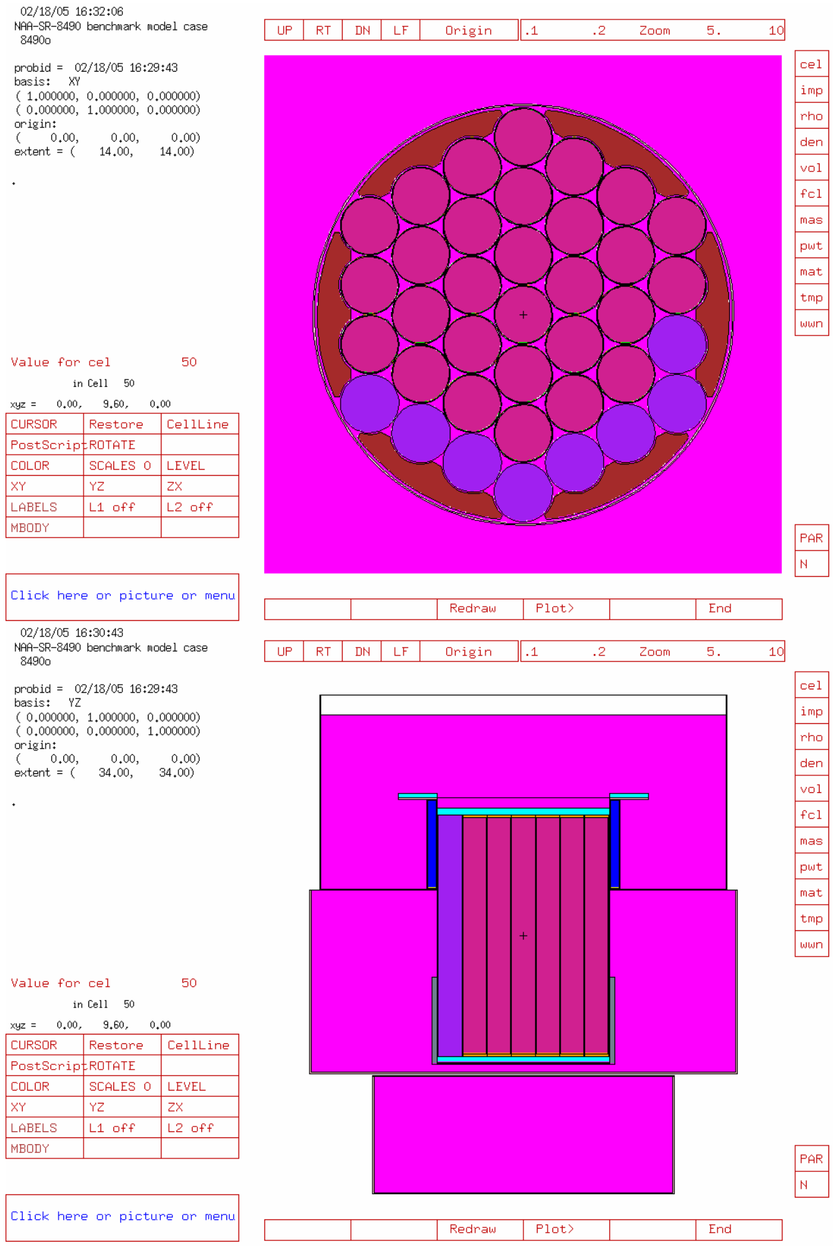


Fig. 46. Case *8490o* MCNP5 plot.

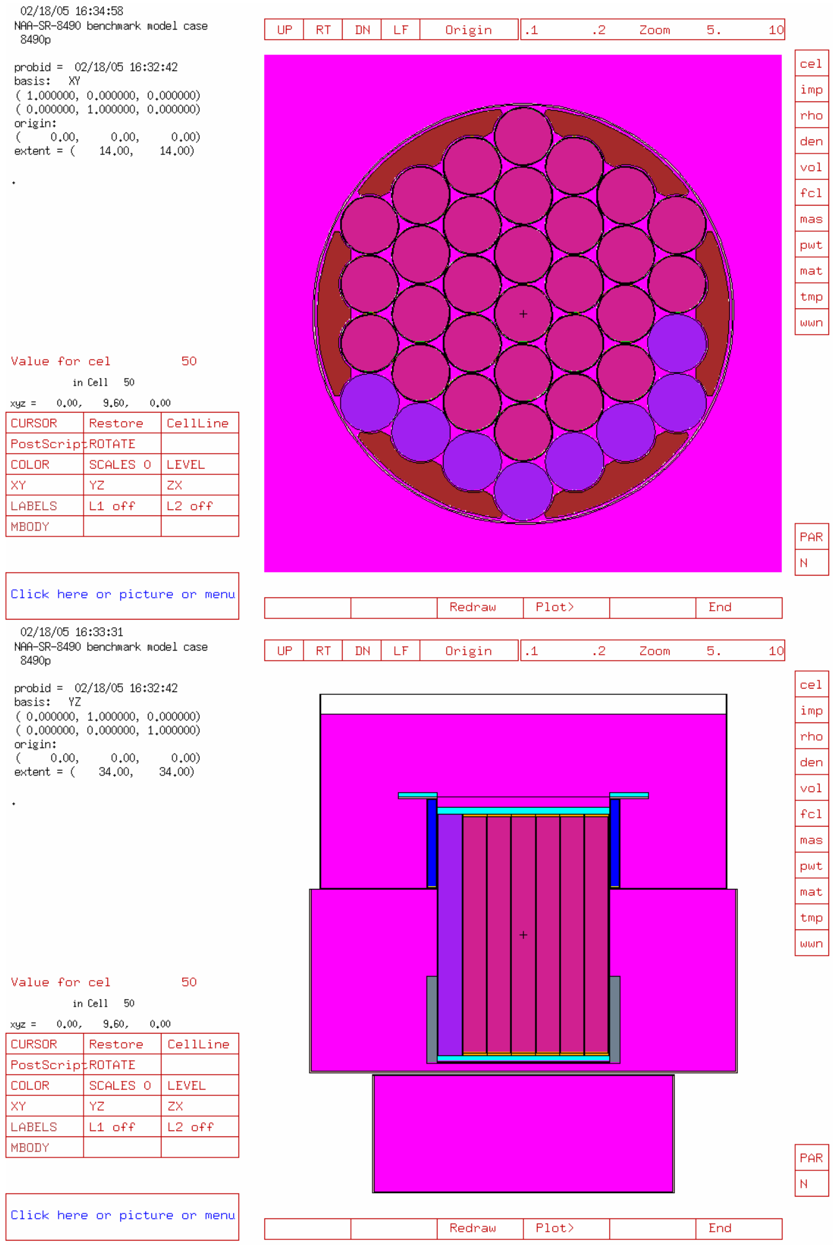


Fig. 47. Case *8490p* MCNP5 plot.

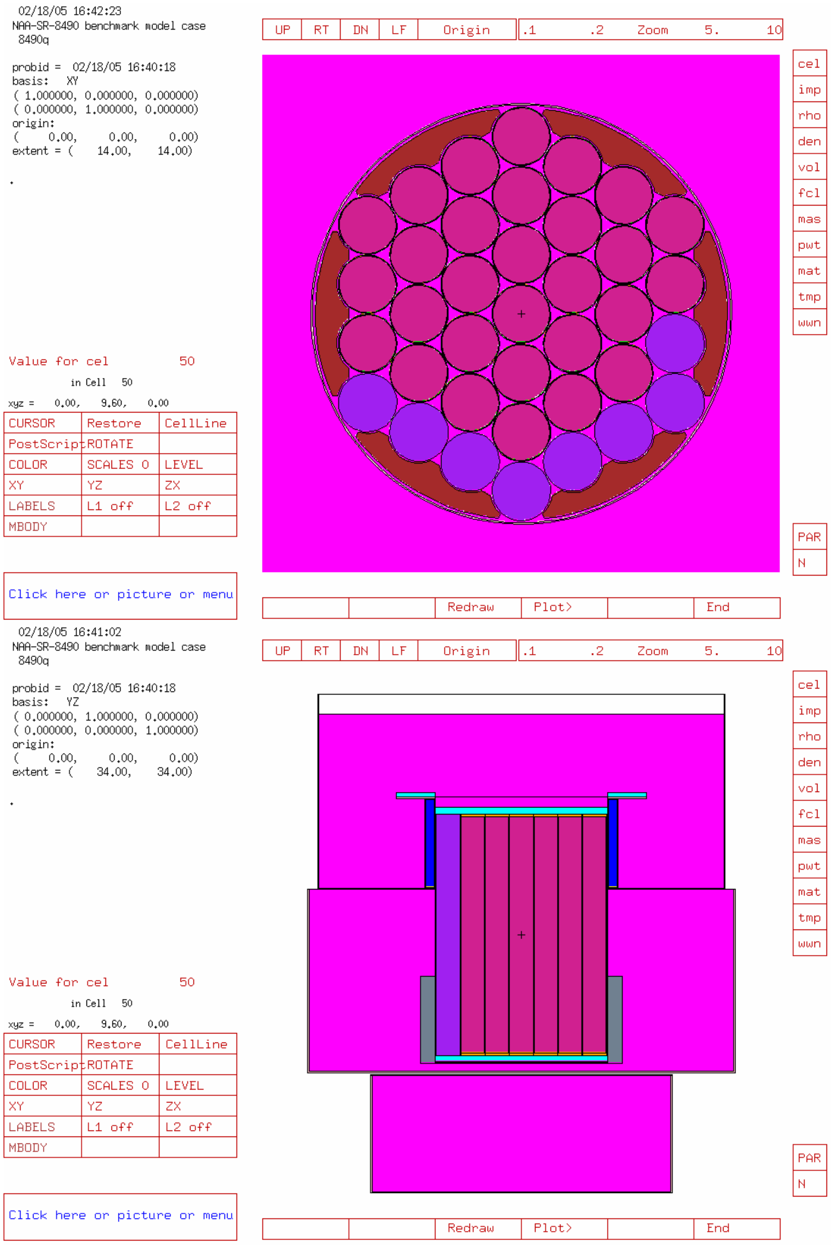
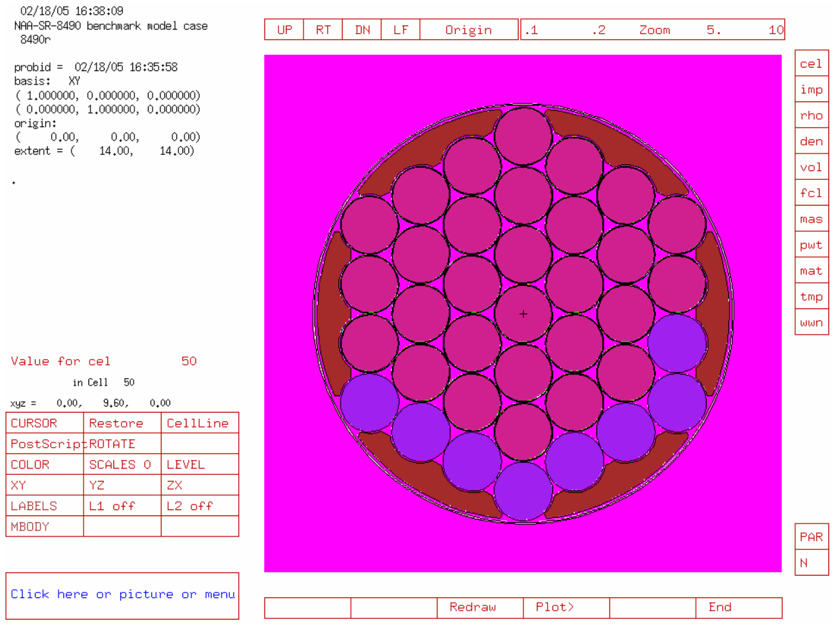


Fig. 48. Case *8490q* MCNP5 plot.



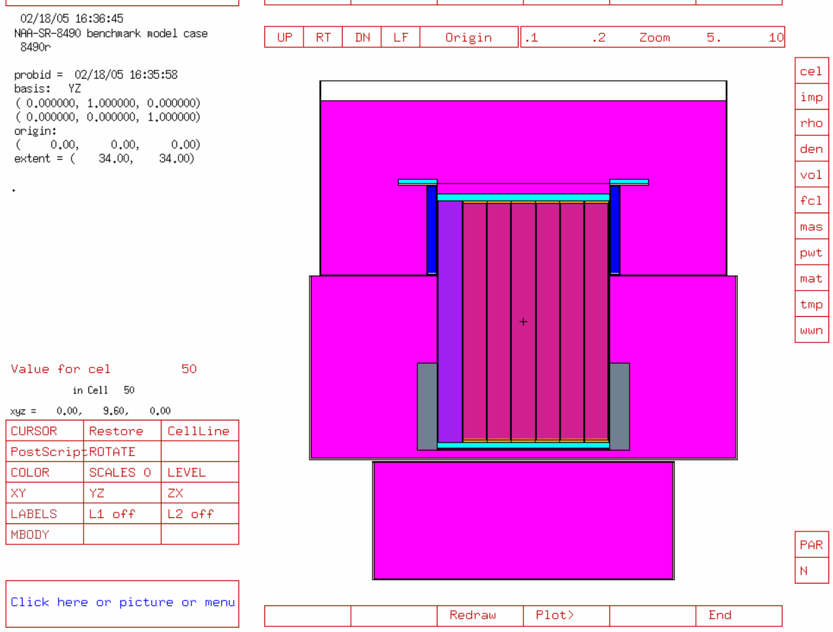


Fig. 49. Case *8490r* MCNP5 plot.

3.2.4 Cases *8490s1* through *8490u2*

There are nine distinct benchmarks in this group that are derived from the experimental results presented in Fig. 20 of NAA-SR-8490 (see Fig. 50). The reactivity is only quantified for two of the configurations. The remaining seven are only qualitatively known to be subcritical by an undetermined margin, so their calculated results cannot be normalized.

These experiments illustrate the reactivity effect of soluble boron in the water supply (i.e., flooded and reflected by borated water). The boron is present in the form of ammonium pentaborate ($NH_4B_5O_8{\cdot}4H_2O$), for which the boron isotopic distribution is natural. The water in the control cap tank is assumed be ordinary water since it is not connected to the water supply (see Fig. 7). This is further supported by the nature of the AI description concerning the boron content of the water (e.g., 3.24 kg of ammonium pentaborate in 39 gallons of water). The reference to 39 gallons is consistent with the fact that a 55–gallon drum functions as the water supply tank for the SCA–4B assembly machine.

Though not explicitly stated in NAA-SR-8490, it is assumed that the six beryllium inserts are present in the core vessel to be consistent with the experiments described thus far. Only one experimental configuration employs the full complement of 37 fuel elements. In cases where fewer than 37 fuel elements are present in the core vessel, it is assumed that the remaining fuel element positions are left vacant so that they would fill with the borated water when flooded. This is based on the reasoning that the Lucite rods contain no boron and that their presence in the core vessel is contrary to the stated purpose of these particular measurements. In all cases, the core vessel is flooded and all three reflector tanks are full. The results are summarized in Table 7 and the MCNP5 plots are shown in Fig. 51 through Fig. 59. Each calculated result is based on no fewer than two million active neutron histories.

Table 7. Summary Table of Experimental Benchmarks from Table III of NAA-SR-8490

Case name	Ammonium pentaborate content (kg in 39 gal. of water)*	Number of fuel elements	Reported excess reactivity, ρ($)	Estimated experimental k_{eff}, k_{exp}	Calculated k_{eff},, k_{calc}	Computational uncertainty, σ	Normalized Result, k_{calc}/k_{exp}
8490s1	2.00	32	unknown	unknown	0.98391	0.00071	n/a
8490s2	2.00	31	unknown	unknown	0.97508	0.00068	n/a
849s3	2.00	30	unknown	unknown	0.96689	0.00069	n/a
8490t	3.24	35	+0.15	1.00120	0.99614	0.00071	0.9949
8490t1	3.24	33	unknown	unknown	0.97566	0.00070	n/a
8490t2	3.24	32	unknown	unknown	0.96326	0.00070	n/a
8490u	4.54	37	critical	1.00000	1.00387	0.00073	1.0039
8490u1	4.54	36	unknown	unknown	0.99463	0.00071	n/a
8490u2	4.54	35	unknown	unknown	0.98240	0.00069	n/a

* The amount of ammonium pentaborate and the number of fuel rods are determined from Fig. 50.

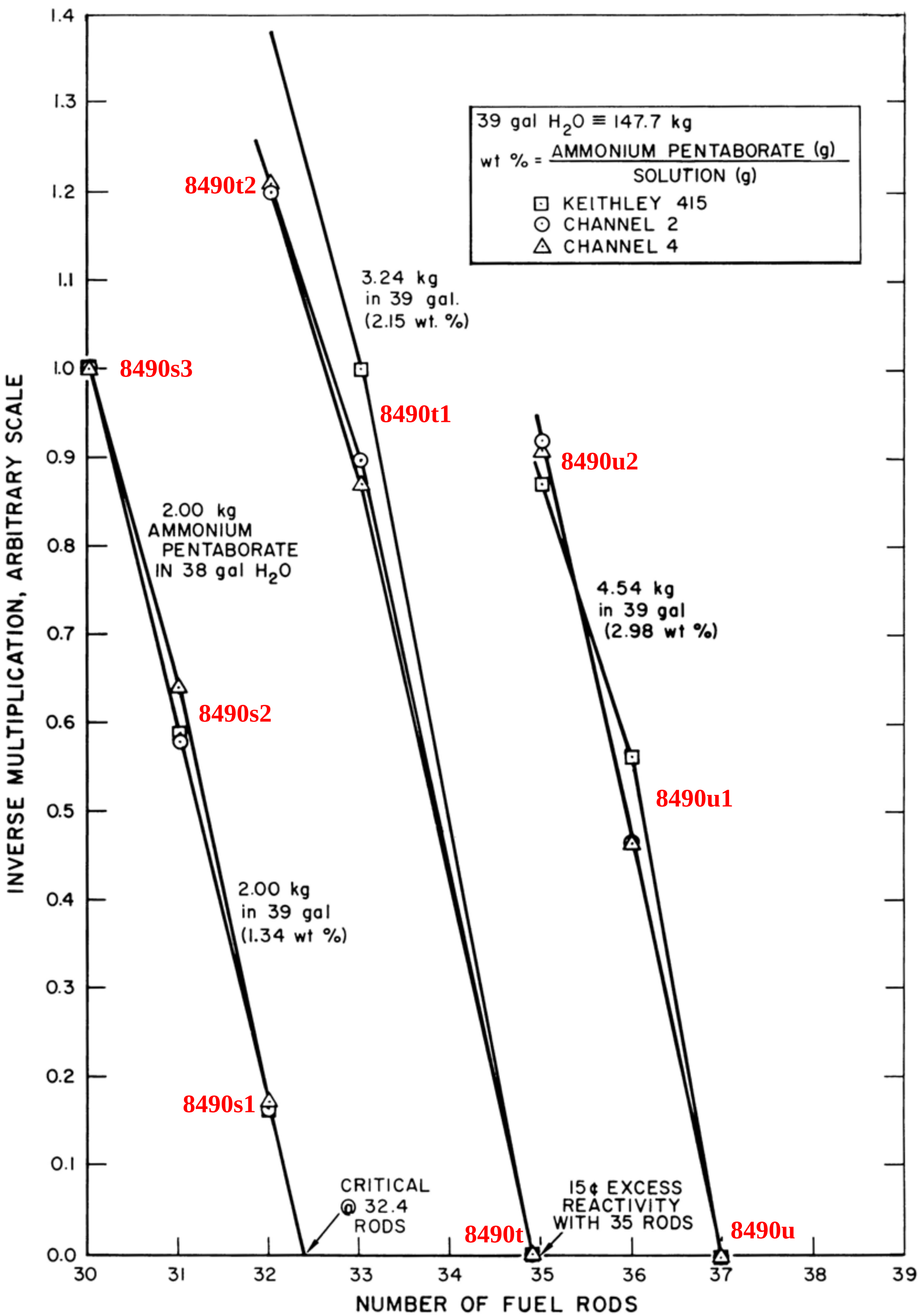


Fig. 50. Loading approaches to critical with various concentrations of ammonium pentaborate in water.

(reproduced from Fig. 20 of NAA-SR-8490)

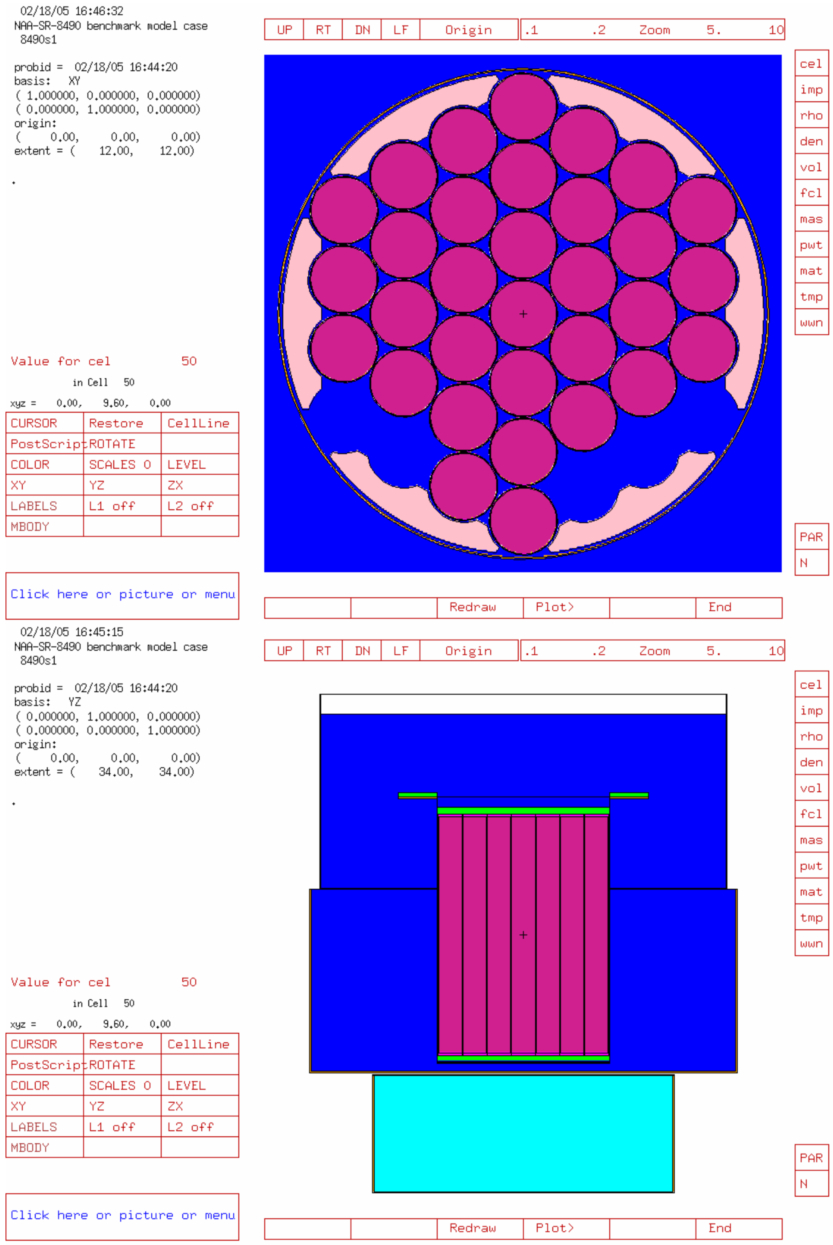


Fig. 51. Case *8490s1* MCNP5 plot.

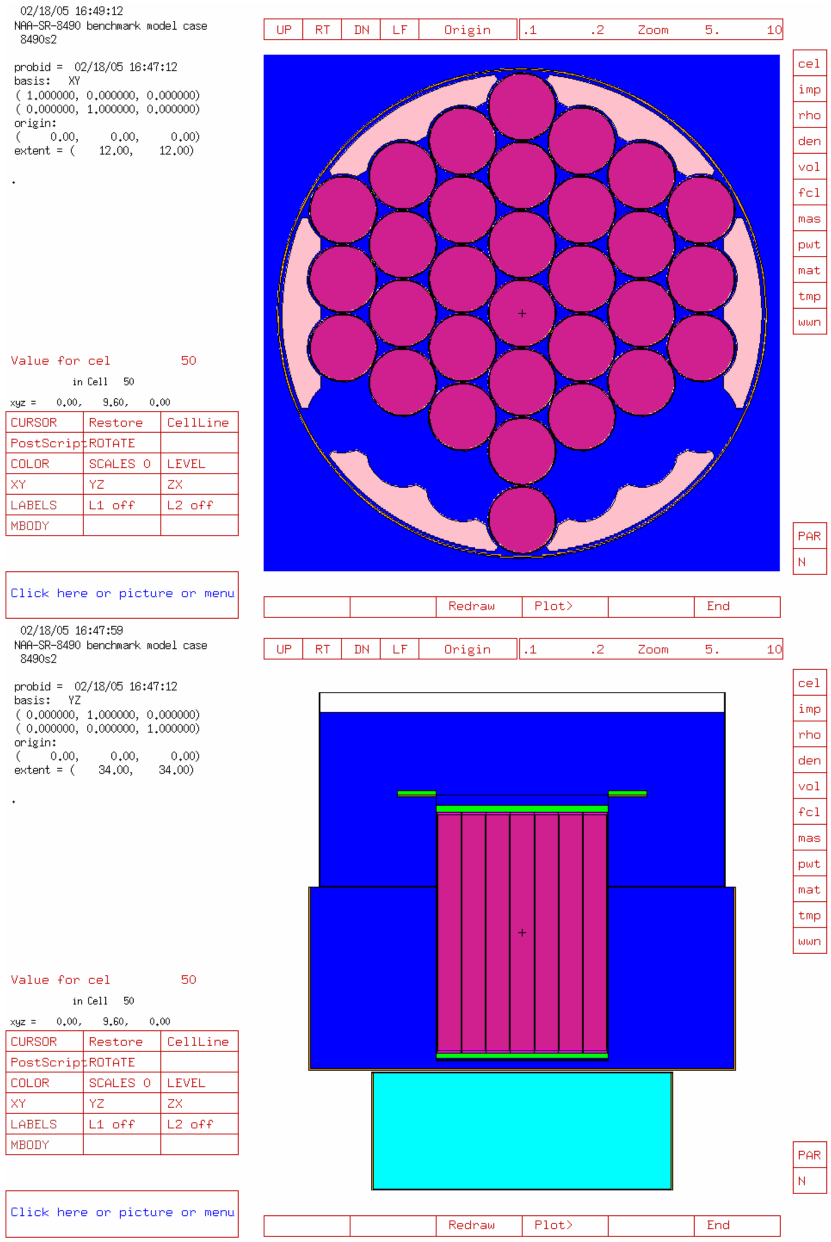


Fig. 52. Case *8490s2* MCNP5 plot.

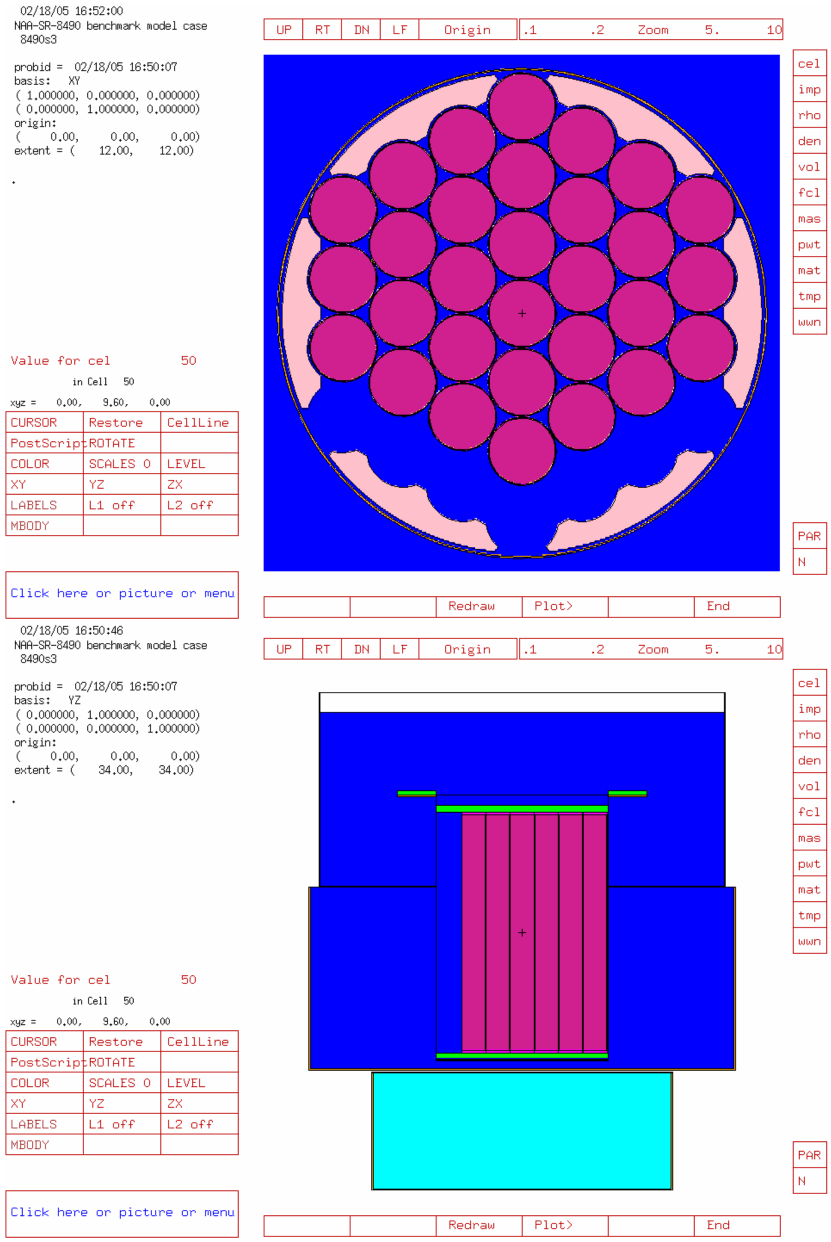


Fig. 53. Case *8490s3* MCNP5 plot.

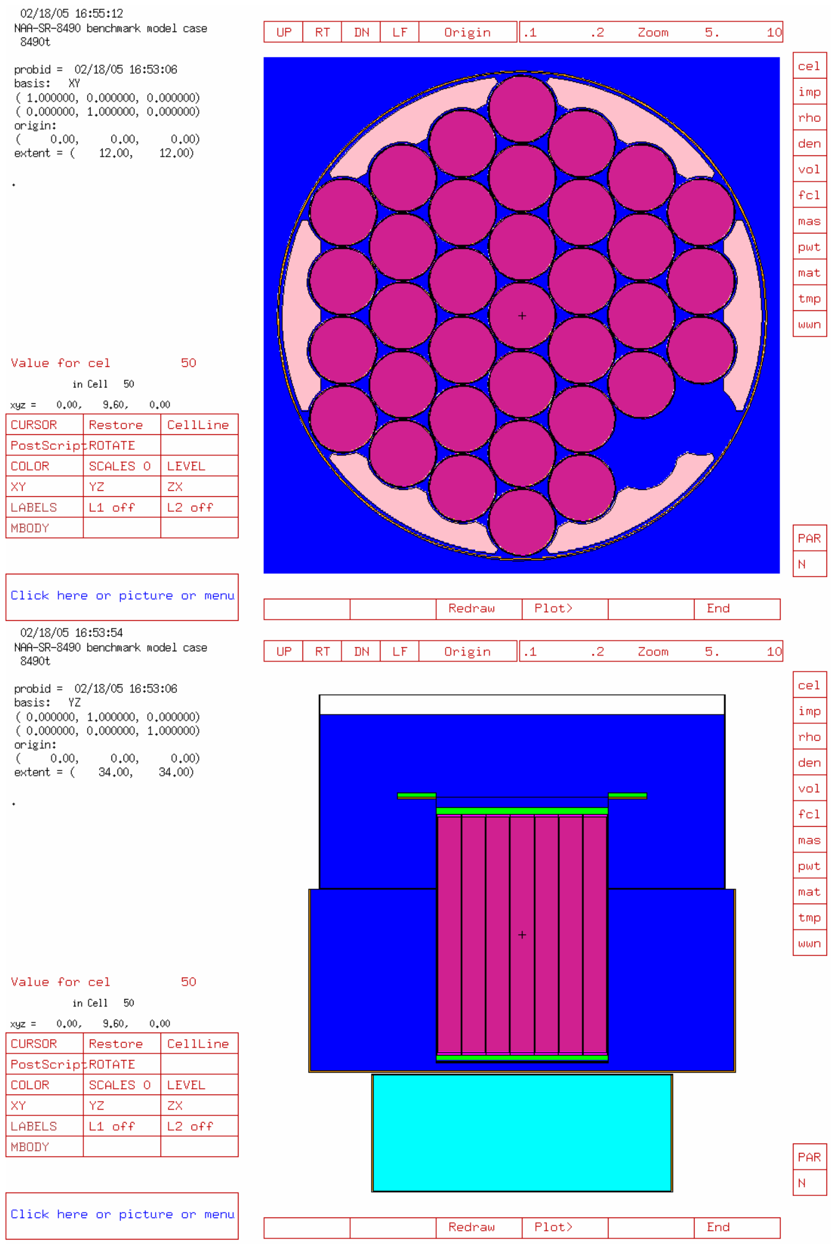


Fig. 54. Case *8490t* MCNP5 plot.

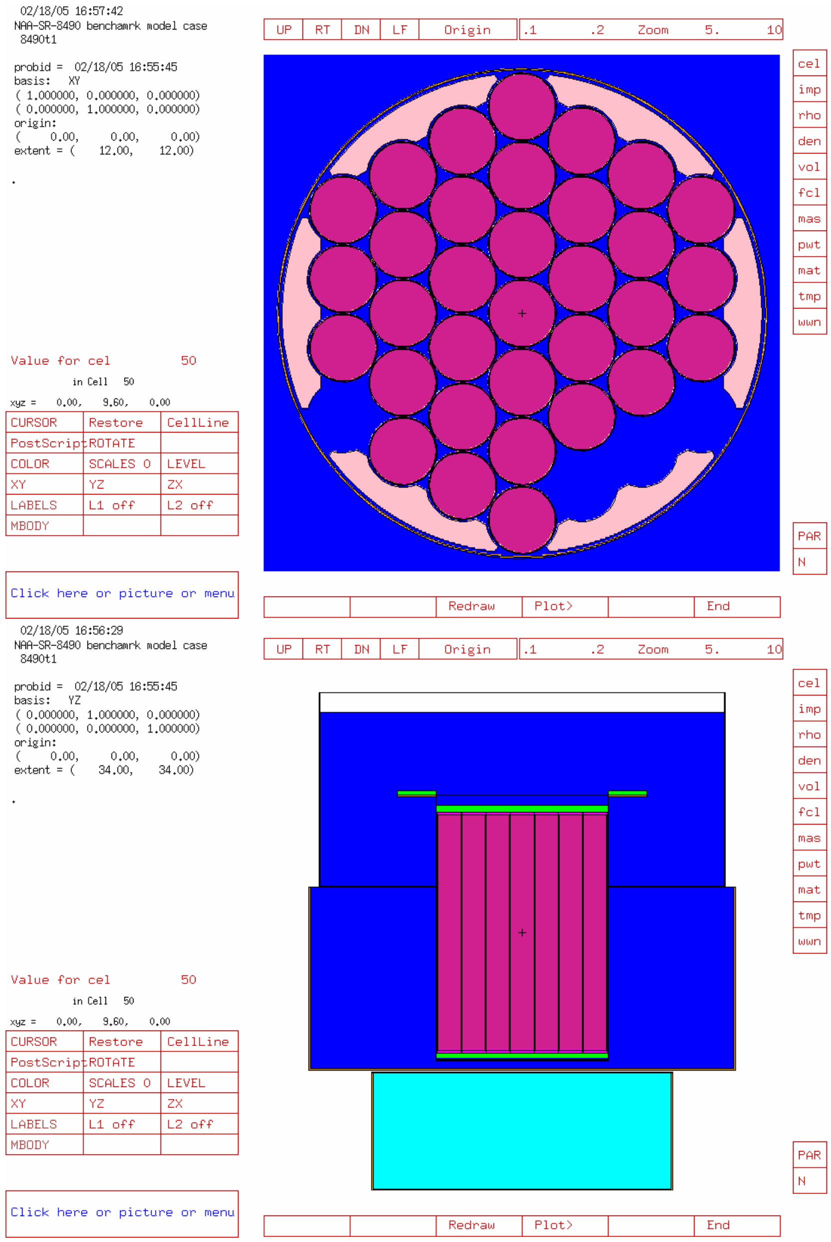


Fig. 55. Case *8490t1* MCNP5 plot.

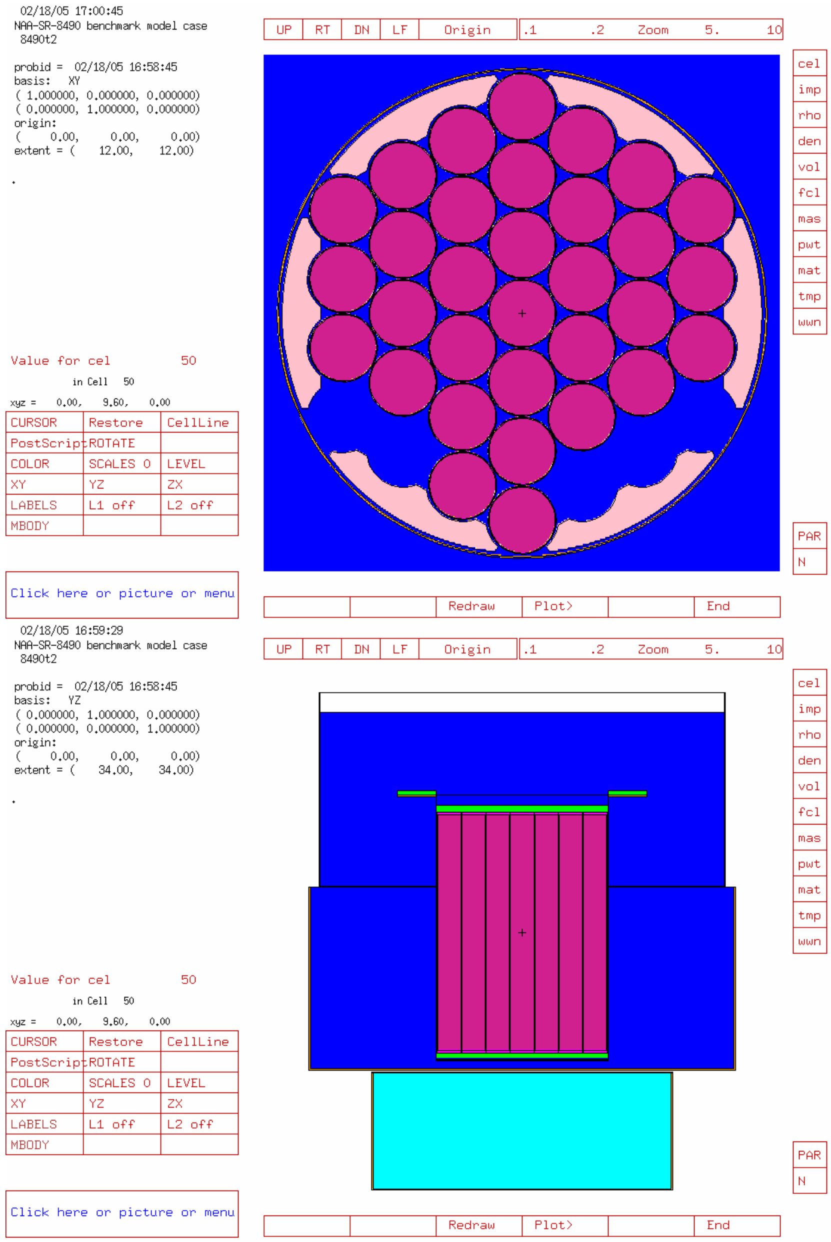


Fig. 56. Case *8490t2* MCNP5 plot.

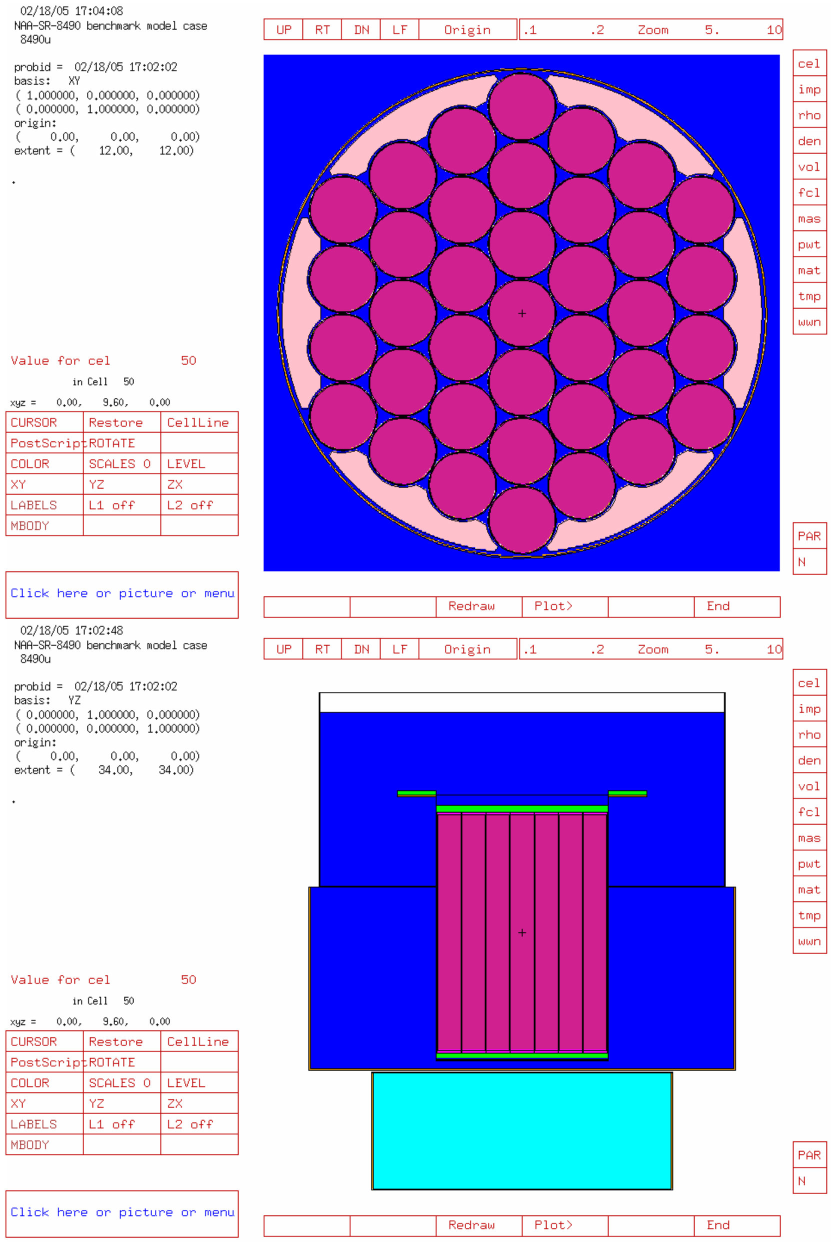


Fig. 57. Case *8490u* MCNP5 plot.

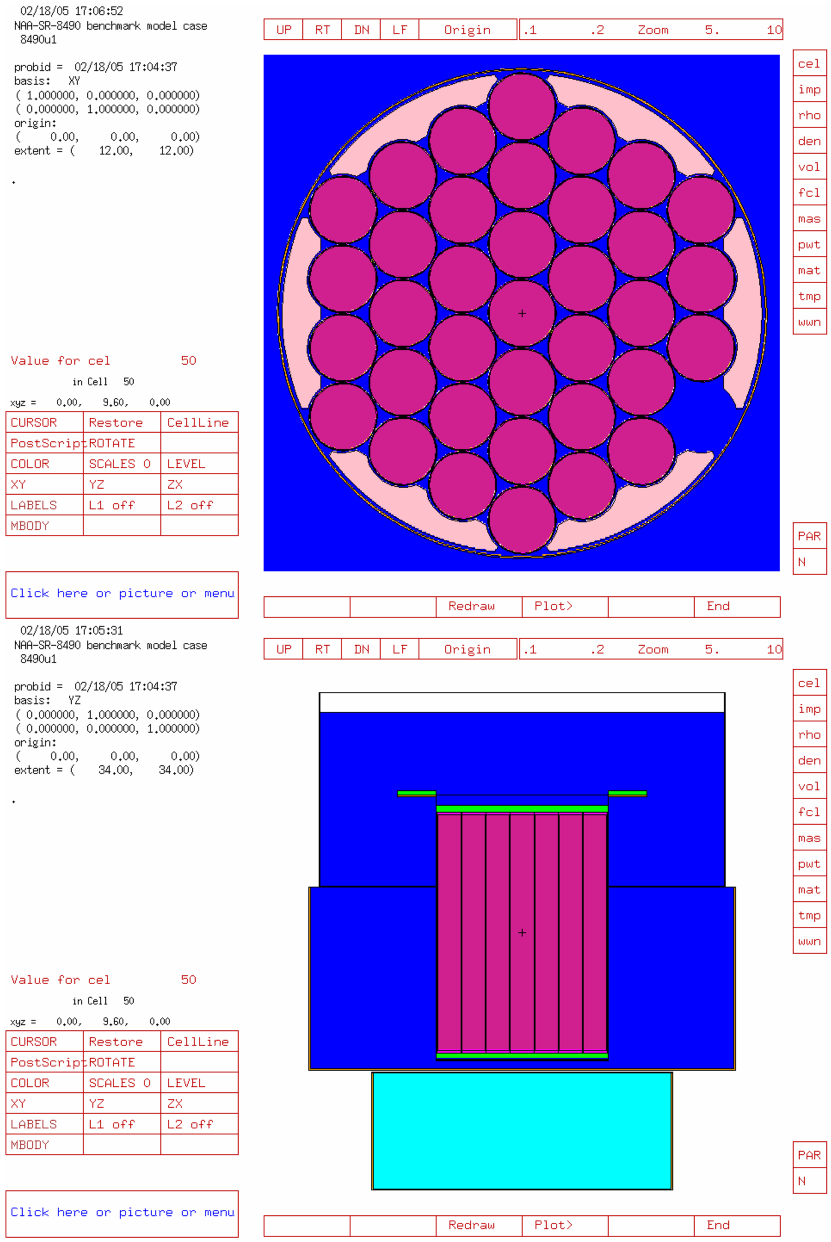


Fig. 58. Case *8490u1* MCNP5 plot.

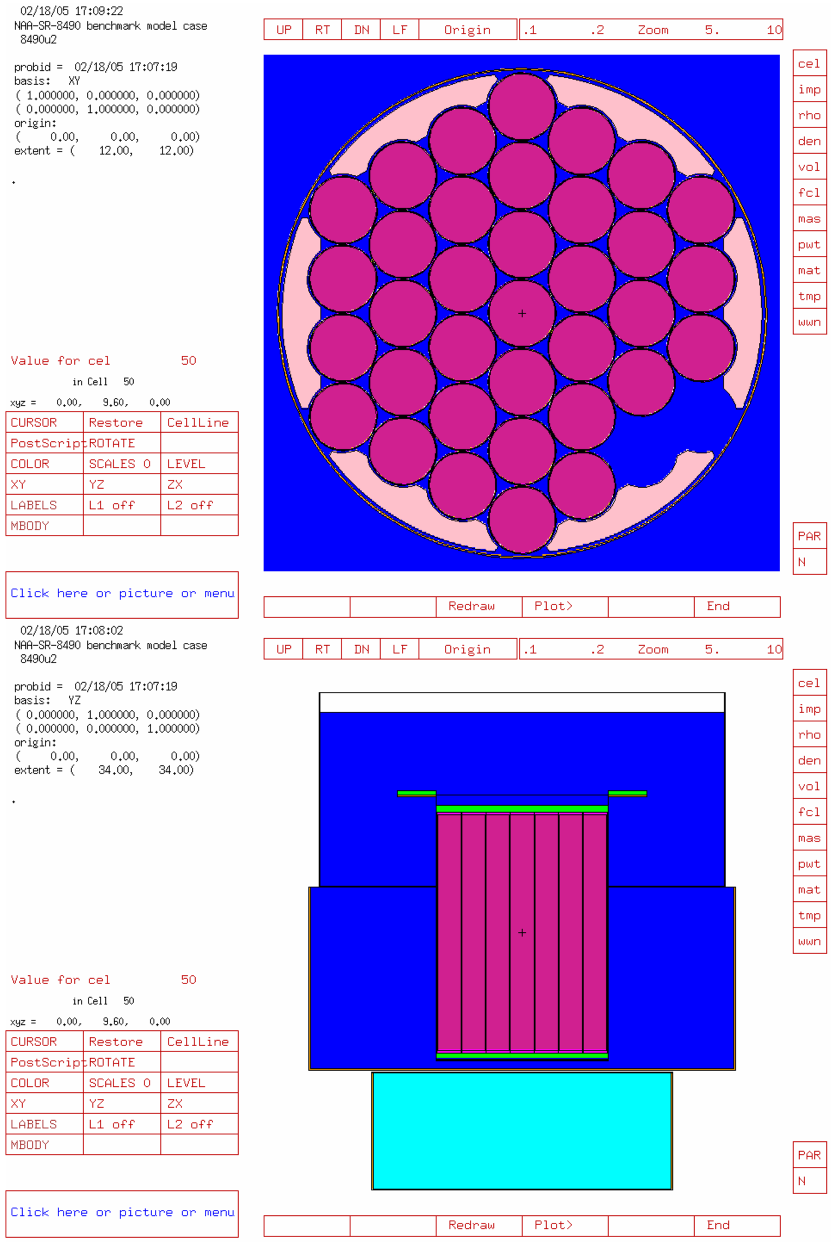


Fig. 59. Case *8490u2* MCNP5 plot.

4. NAA-SR-9871 EXPERIMENTS

Phase III of the SCA–4B experimental program is reported in NAA-SR-9871, *SNAP Critical Assembly–4B, Phase III Water Immersion Experiments*. The nuclear reactivity is reported for 23 experimental configurations and is used to estimate the experimental k_{eff} (k_{exp}) for direct comparison with calculated results. For the remaining three cases, it is only known that they were subcritical. Phase I, documented in NAA-SR-8490, was completed prior to the conduct of the experiments in Phase III.

4.1 DESCRIPTION OF THE EXPERIMENTAL APPARATUS

4.1.1 SCA–4B Critical Assembly Machine

Overall, the SCA–4B critical assembly machine used in this series of experiments was the same as that described in the Phase I experiments. In Phase III, however, the water tank system was changed from a three–tank system to a two–tank system. The general tank concept is shown in Fig. 60 and Fig. 61.

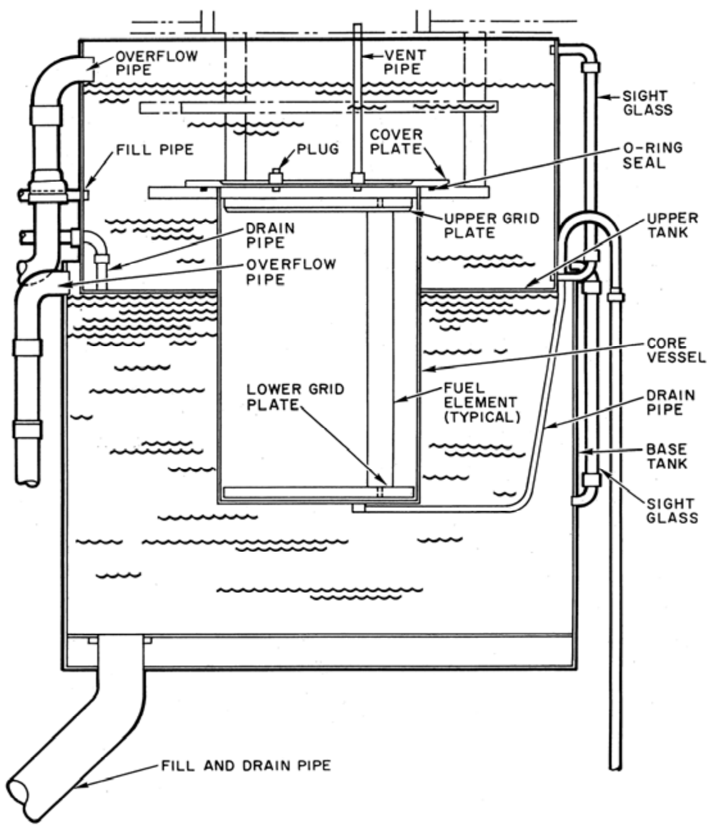


Fig. 60. Sketch of the water tank assembly for Phase III experiments.

(reproduced from Fig. 3 of NAA-SR-9871)

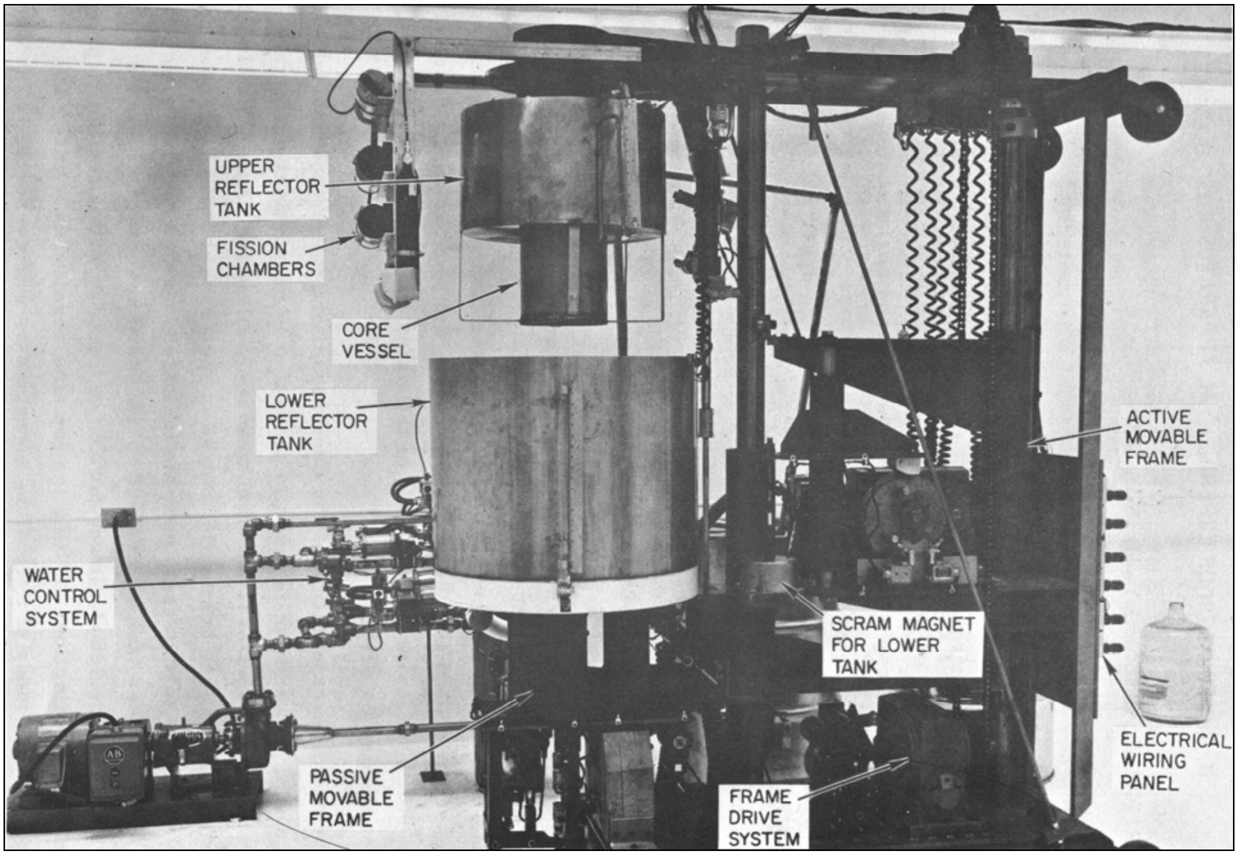


Fig. 61. Photograph of the water tank assembly for Phase III experiments.

(reproduced from Fig. 1 of NAA-SR-9871)

The system was composed of two stainless–steel water tanks. The upper reflector tank was welded to the top of the core vessel, and these were then fixed to a support structure. The larger lower reflector tank was attached to a moveable frame that allowed it to be raised to cover the core vessel and the lower section of the top reflector tank. The tops of both tanks were open. The walls were made from 0.031-in. (0.07874-cm)–thick stainless steel, with the bottom of the lower tank being 0.125 in. (0.3175 cm) thick in order to support the weight of the water in the tank. The wall thicknesses can be seen in Fig. 4.

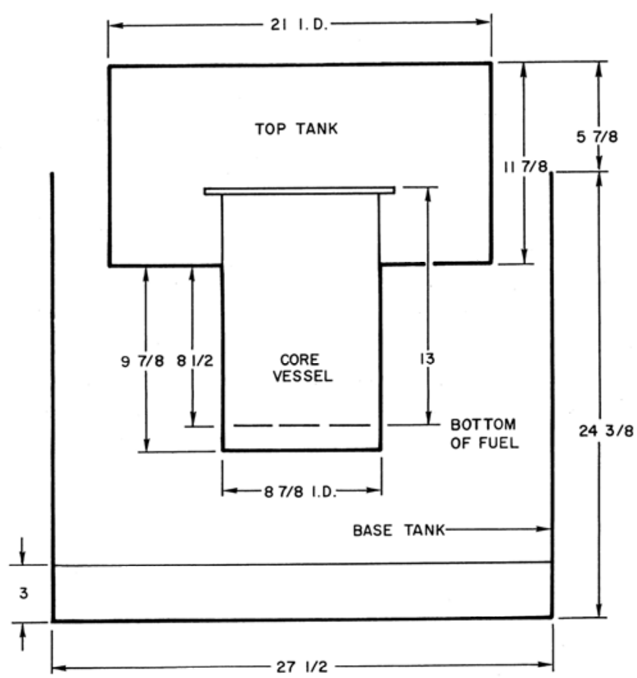
Water levels described in NAA–SR–9871 as "in. above the bottom of the fuel" are actually the height of the water above the bottom of the active fuel region (not the fuel element). This measure refers to the amount of radial reflection of the core–the height above the bottom of the fuel is a measure of the fraction of the fuel height that has radial reflection. For most of the Phase III experiments, it is obvious that it is the water level in the top tank that is adjusted, as the bottom of the top tank intersects the top half of the active fuel region. There is, however, one experiment where the water level is adjusted in the lower tank. This is a case where the top reflector tank bottom is higher, just below the vessel flange (case *fig12*), as opposed to intersecting the top half of the active fuel region as it does for the other configurations. The top reflector tank for this case is assumed to be full. In all cases where the lower tank is full, the water level is assumed to extend to the very top of the lower tank, rather than being even with the bottom of the top tank. This assumption has very little influence on the calculated k_{eff}.

The experiments also refer to the amount of "axial water reflector." This is the height of the water above the top of the fuel, not the top of the tank. In NAA–SR–8490, this same measure is more directly referred to as the height of water in the top tank, and is measured from the bottom of the top reflector tank. The core vessel flange, rather than being flat, had a small circular indentation created by the difference in height between the top of the core vessel and the top of the vessel flange (see Fig. 4). During experiments involving variation of top tank water height, the presence of the indentation sometimes caused discrepancies. When the water was being added to the tank, it would take more water to achieve criticality (because the indentation was empty), than it would when the water was being removed from the core (because the indentation would be filled with water).

As can be seen from Fig. 62, the top tank divided the axial surface of the core vessel into two segments. Some of the experiments used combinations of void, boron carbide, Binal (borated aluminum), or steel sleeves. These experiments used the split water tank system shown in Fig. 62. For the experiment requiring the external beryllium reflector, the configuration in Fig. 68 was used. These sketches are shown in Appendix B of NAA–SR–9871. The tank system shown in Fig. 62 , with the top tank dividing the core vessel, was used for most of the Phase III experiments. The only experiment modeled in this report that used the tank system shown in Fig. 68 is case *fig12*, where the external beryllium reflector was attached.

With the exception of the tank system that allowed the attachment of the beryllium reflector, the top water tank surrounded the top section of the core vessel. This generated the need to fabricate the void and absorber sleeves in two halves–one that fit in the bottom tank and on that fit in the top half. The interface between the top tank and the reactor vessel is simply modeled as the bottom of the top tank intersecting the side wall of the vessel rather than as a complete shell surrounding the water.

As can be seen in Fig. 60, it was inferred from the sketch and pictures of the assembly provided in the report that the three in. at the bottom of the lower tanks were actually an enclosed void, rather than a skirt. This results in an extra steel plate at the very bottom of the lower tank. It is shown in Fig. 3 of NAA-SR-9871.



Note: All dimensions are in inches.
Lower reflector tank shown in up position.

Fig. 62. Sketch of the water tank (with dimensions) used for Phase III experiments

(reproduced from Fig. 48 of NAA–SR–9871)

4.1.2 SNAP 10A/2 Core

Two fuel types were used for the Phase III experiments–the SNAPTRAN fuel and SCA–4 fuel. The SCA-4 fuel is the same as described in Sect. 3. For the Phase III experiments, rather than using an average fuel model, the MCNP5 model uses individual definitions for each fuel rod for both the SCA–4 fuel elements described in Sect. 3 and the SNAPTRAN fuel elements. Fuel element position is shown in Fig. 83 for the SCA–4 fuel and Fig. 85 for the SNAPTRAN fuel. The number density calculations for the individual SCA–4 and SNAPTRAN fuel elements are provided in detail in Appendix B.

The SNAPTRAN fuel is described in Table 11 of NAA–SR–9871. It should be noted that the SNAPTRAN fuel includes carbon, while the SCA–4 fuel does not. During fuel fabrication it was noticed that during the hydriding process, as much as 80% of the fuel would crack, usually down the entire length of the rod. This problem was investigated and documented by AI in NAA–SR–7305.[7] Various amounts of carbon were studied, and it was initially decided that ~0.4 wt % carbon would sufficiently address the problem of the cracking. After several experiments, however, it was determined that 0.15 wt % was enough carbon to prevent cracking, and this was the amount in use at the time the SNAPTRAN fuel was fabricated. This is the amount assumed for the MCNP5 model.

NAA–SR–9871 states that the SNAPTRAN fuel is for the most part the same as the SCA–4 fuel, varying only slightly in composition and dimensions. Like the SCA–4 elements, the fuel rods were 12.225 in. (31.0515 cm) long and 1.212 in. (3.07848 cm) in diameter. Hastelloy N was used as the fuel cladding, with a 1.25–in. (3.175–cm) outer diameter and a 0.010–in. (0.0254–cm) wall thickness. The same hydrogen diffusion barrier and burnable absorber used for the SCA–4 fuel was used for the SNAPTRAN fuel, and was applied to the inside of the cladding tube and the end caps. As previously discussed this coating consisted of aluminum and silicon oxides, followed by Sm_2O_3. In these calculations, the coating is considered to use the entire fuel–cladding gap, relying on the weight of Sm_2O_3 provided in Table 11 of NAA–SR–9871.

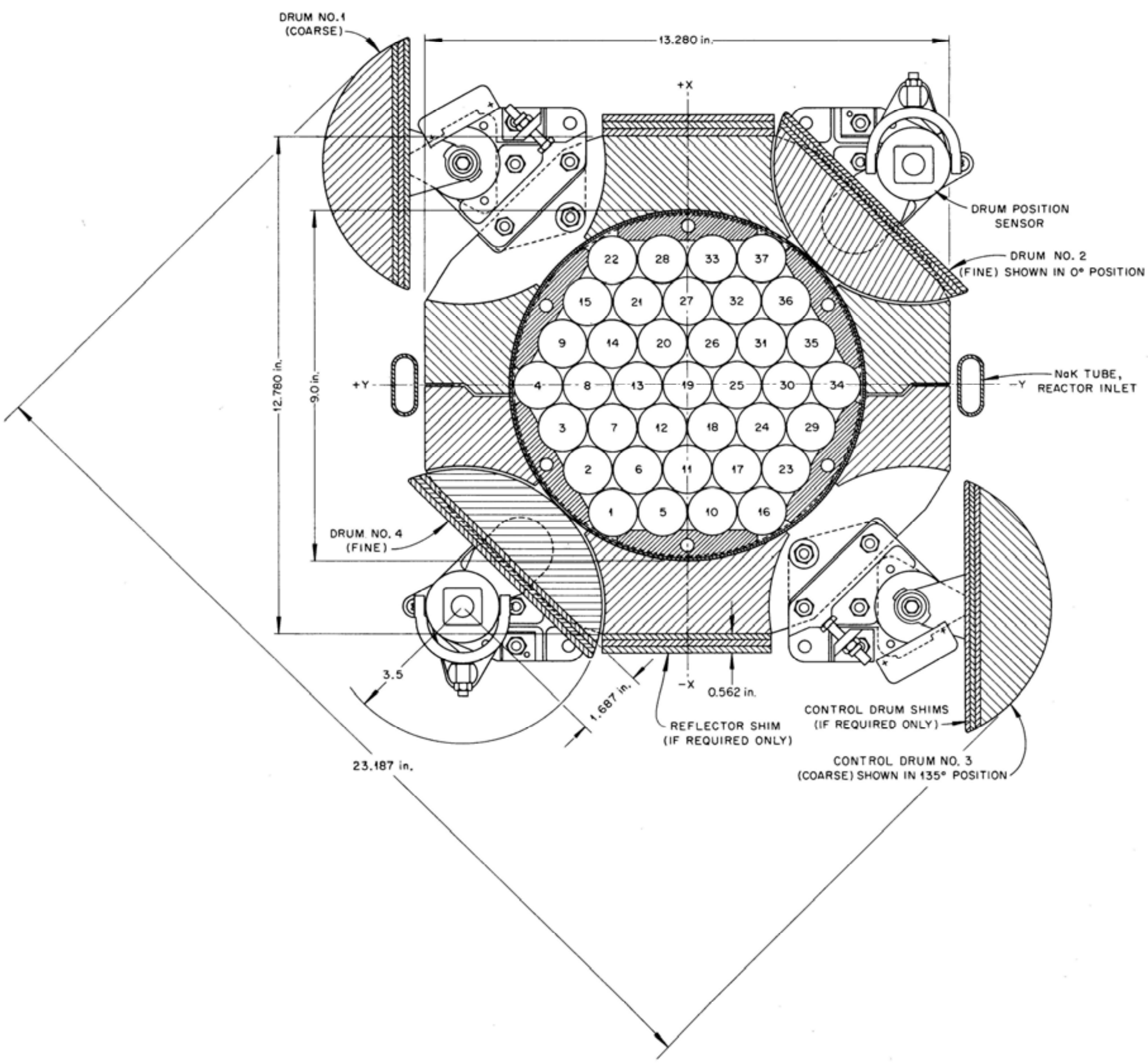
The weights of the other constituents (aluminum oxide and silicon oxide) are determined from the data available for the SNAPTRAN V fuel. The fuel specifications for SNAPTRAN V (provided by NAA-SR-MEMO–9946) indicate, for each cladding tube, a value for the total Sm_2O_3 in the tube and a total absorber coat weight. The absorber coat weight per tube was divided by the area inside the tube to be covered to yield a coat weight per unit area that would provide the hydrogen barrier needed for the fuel. The amount of Sm_2O_3 in the elements is provided in Table 11 of NAA–SR–9871.

It is important to note that the amount of hydrogen reported in NAA–SR–8490 and NAA–SR–9871 overestimates the hydrogen content of the fuels. A later report, NAA–SR–8613 (Ref. 3, in the appendix) notes this correction, that while the average hydrogen content is reported to be 6.48×10^{22} H atoms/cm^3, it was in fact 6.4×10^{22} H atoms/cm^3. This correction is applied to the fuel model used for the SCA–4 and SNAPTRAN fuels.

The dimensions for the core vessel used with the SNAPTRAN and SCA–4 fuels and the intersection of the vessel with the bottom of the top tank are taken from Fig. 4 and from Fig. 48 and Fig. 49 of NAA-SR-9871. The core vessel is not exactly the same as was used for the Phase I experiments. The core vessel for most of the experiments had a larger gap at the bottom of the core, and less of a gap at the top. The basic shape of the core vessel as presented in Fig. 4 is used to model the core vessel for the NAA-SR-9871 experiments. These differences are briefly mentioned on p. 35 of NAA–SR–9871–"the assembly configuration was not identical [to that from 8490], with differences in the top cover plate and the bottom of the core vessel." The same flange configuration is used for the Phase III models, but the grid plates are assumed to be 0.25–in. (0.635–cm)–thick aluminum. The description of the geometry used is provided in detail in Appendix C.

4.1.3 External Beryllium Reflector Assembly

While the SNAP 10A/2 cores used internal beryllium reflector pieces, an external beryllium reflector was also used for one of the SNAP 10A/2 core experiments. The reflector assembly fit closely around the core vessel and completely covered the fuel region. The assembly had several pieces: a reflector main block that remained attached to the core vessel, and four control drums that could be rotated into various positions. The control drums were sections of cylinders that had been sliced vertically, and were attached to a drive mechanism at the center of the cylinder. The axes of the control drums were parallel to the reactor vessel. When rotated into place to provide maximum reflection, the control drums and the main block approximated a complete radial reflector. A top view of the reflector assembly is shown in Fig. 63. A photograph of the assembly is shown in Fig. 64.



Note: All dimensions are specified in inches.

Fig. 63. Detailed sketch of the top view of the external beryllium reflector assembly.

(reproduced from Fig. 5 of ORNL–4058)

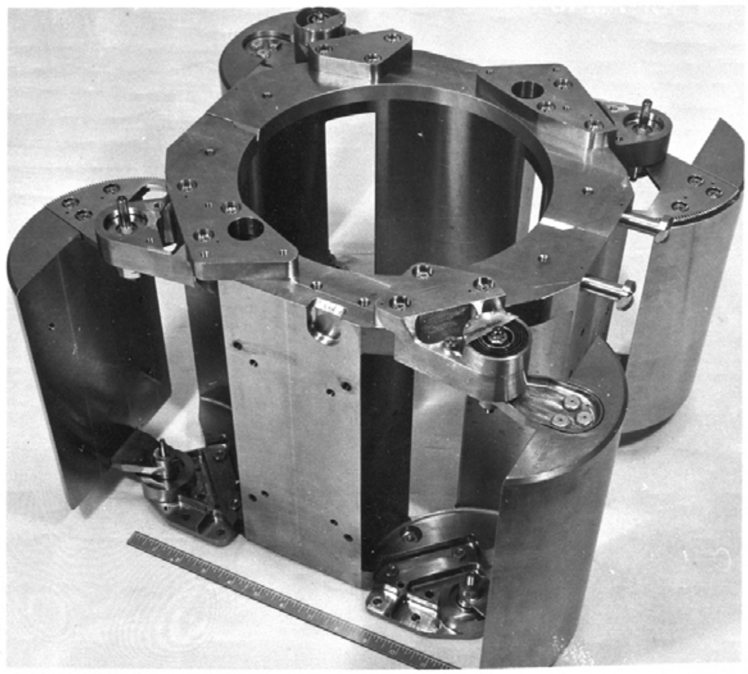


Fig. 64. Photograph of the external beryllium reflector assembly.

(reproduced from Fig. 3 of ORNL–4058)

The control drums did not extend the length of the reflector. Apparatus to hold and move the control drums into place created two ledges roughly 1.63 in. (4.1402 cm) thick, at the top and bottom of the main reflector block. When rotated into place, the control drums, ledges, and the rest of the main reflector block provided a roughly cylindrical reflector lateral to the core. The control drum position sensors shown in the middle of the control drums in Fig. 63 only extended roughly half of the length of the control drum. The axial extent of the control drums and position sensors can be seen in Fig. 65 and Fig. 66.

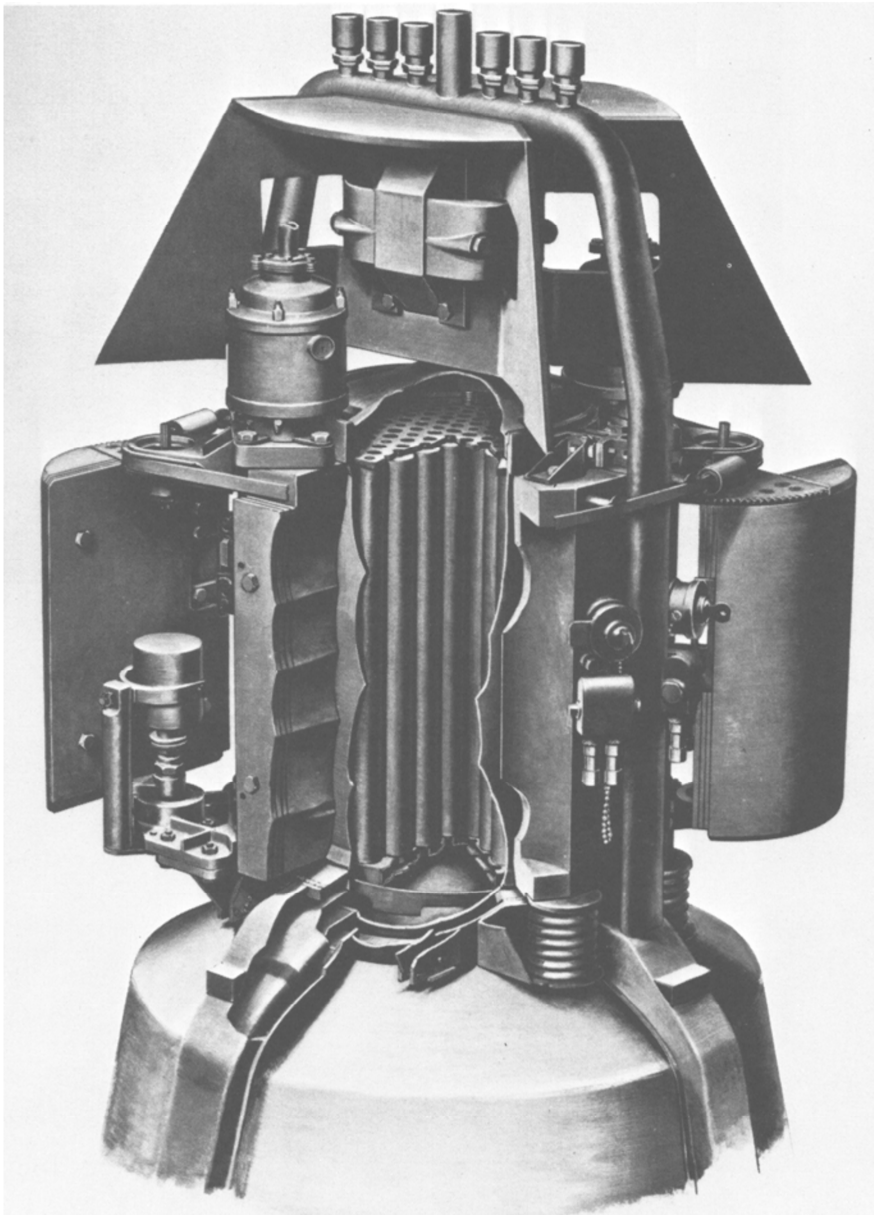
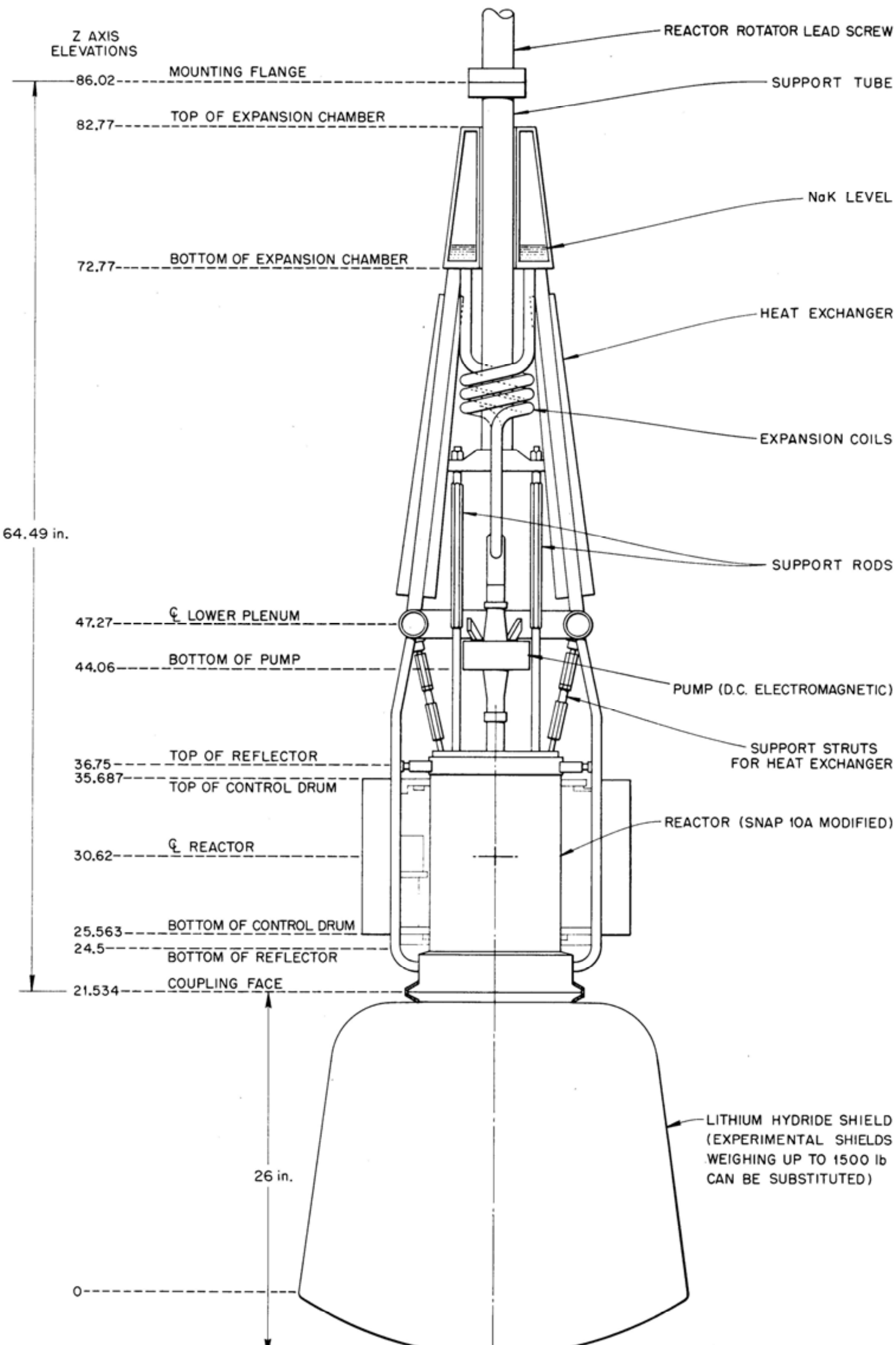


Fig. 65. Artist's drawing of the external beryllium reflector assembly.

(reproduced from Fig. 1 of ORNL–4058)



Note: All dimensions are specified in inches.

Fig. 66. Schematic of the external beryllium reflector assembly on the complete SNAP reactor.

(reproduced from Fig. 4 of ORNL–4058)

4.2 CRITICAL ASSEMBLIES OF SNAP 10A/2 CORES

4.2.1 Water–Reflected Cores

The first experiments discussed in NAA–SR–9871 deal with cores that are water reflected but without water in the core.

4.2.1.1 SCA–4 fuel loadings

Case *fig12*. This experiment used a core filled with SCA–4 fuel and the external beryllium reflector attached to the core vessel. The water tank system used is shown in Fig. 68. This special tank system allowed for the attachment of the beryllium reflector in one piece. The water in the bottom tank was 9.5 in. (24.13 cm) above the bottom of the active fuel region. The core contained 26 fuel elements and 11 Lucite rods, as shown in Fig. 67. The thick side of the reflector main block, where the reflector measures 13.28 in. (33.7312 cm) across, is assumed to be adjacent to lattice location 1. This assumption is based on the orientation shown in Fig. 63 coupled with the positions of the control drums shown in Fig. 67. While the lattice numbering may differ between the two drawings, it can be seen that the first position shown in Fig. 67 corresponds to lattice element 34 in Fig. 63.

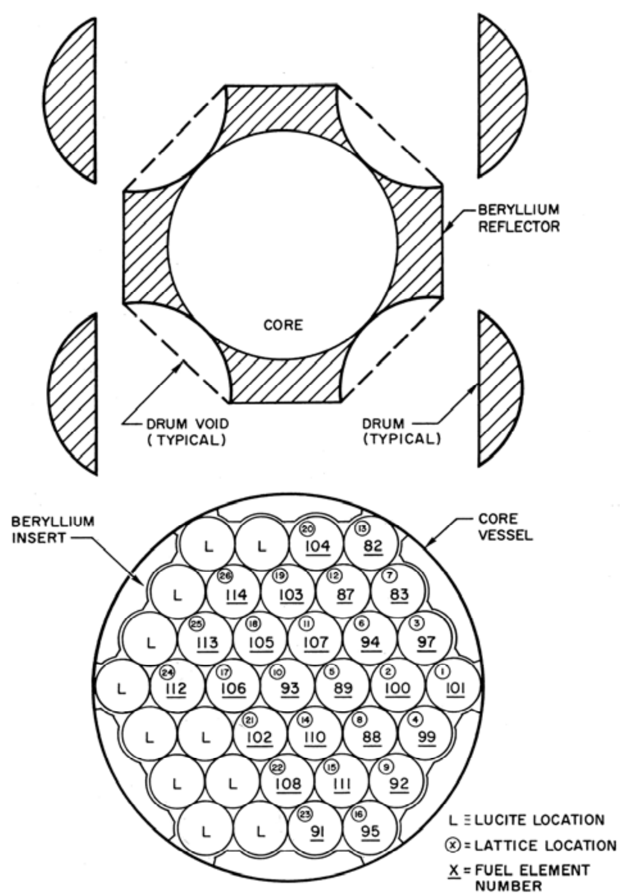
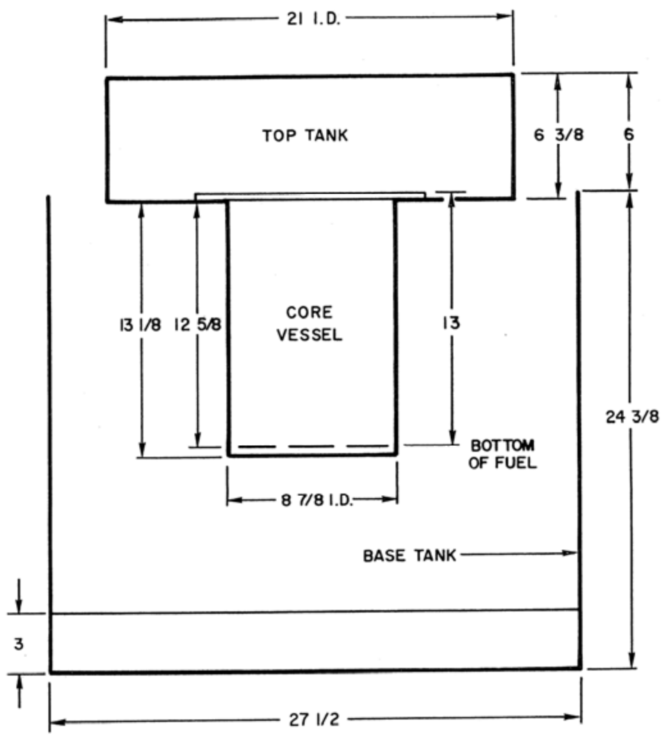


Fig. 67. External beryllium reflector position and orientation around the core.

(reproduced from Fig. 12 of NAA–SR–9871)

The top and bottom of the reflector had ledges such that when the control drums were rotated into place around the core, a rough cylinder of beryllium reflector was formed. These ledges are modeled by arcs of a circle, along with the regular surfaces of the reflector main block.

The beryllium reflector was unshimmed, meaning that the control drums measured 1.83 in. (4.6482 cm) at their thickest point. The main block of the reflector, closely attached to the core, measured 13.28 in. (33.7312 cm) wide in one direction, and 12.78 in. (32.4612 cm) in the other. The shape and dimensions of the core and the reflector are shown in Fig. 63 and Fig. 66. This is the only experiment modeled with the external beryllium reflector attached, and therefore the only experiment modeled using the tank system shown in Fig. 68. The calculated k_{eff} (k_{calc}) for this case is 0.99602±0.00067. The experiment was reported to be critical. The calculated results are based on no fewer than two million active neutron histories. The MCNP5 plots illustrating this case are provided in Figs. 69–71.



Note: All dimensions are specified in inches.

Fig. 68. Water tank system used with the external beryllium reflector.

(reproduced from Fig. 49 of NAA–SR–9871)

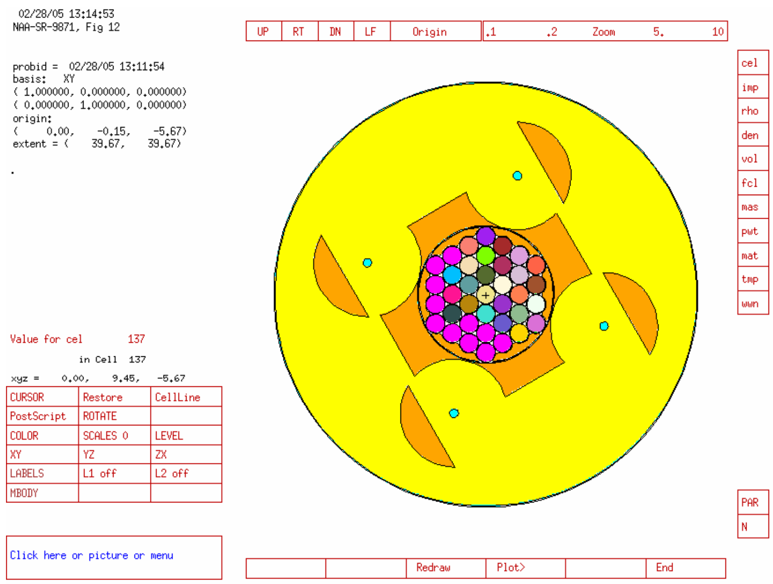


Fig. 69. Top view of MCNP5 model for case *fig12*

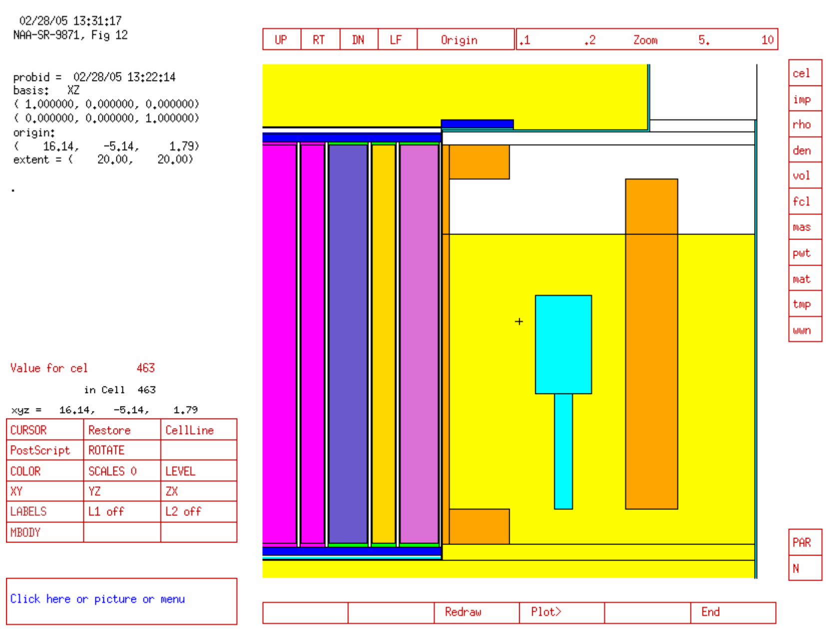


Fig. 70. Side view of MCNP5 model for case *fig12*, showing the external beryllium reflector

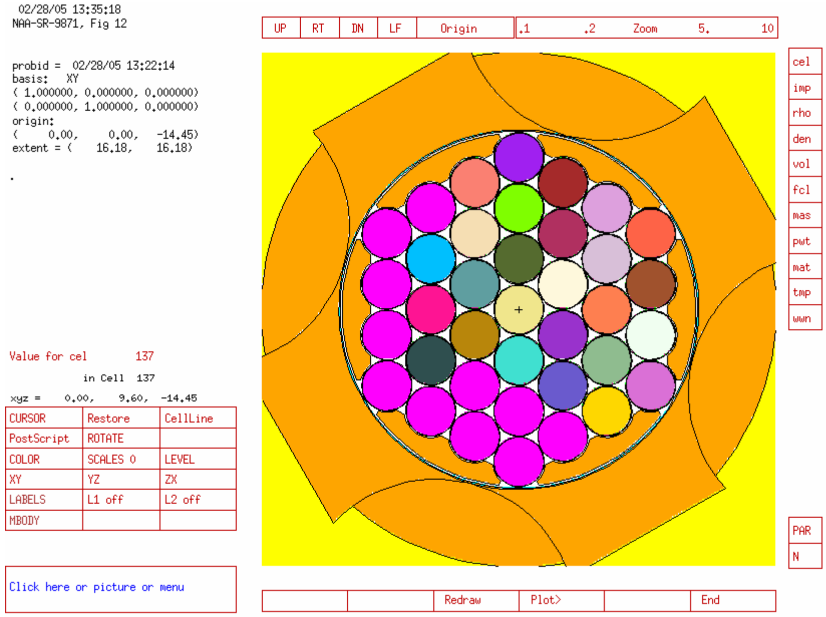


Fig. 71. Top view detail of MCNP5 model for case fig12, showing the external beryllium reflector.

(shown at z=-14.45 cm)

Cases *tbl1a–tbl1e*. The SNAPTRAN core was made critical with 33 fuel elements and 4 Lucite rods. The core was dry, and the water reflector extended 14.94 in. (37.9476 cm) above the bottom of the active fuel region. The full core loading was achieved by replacing Lucite rods with fuel rods, one at a time, and adjusting the water level. The lattice locations were filled in order, so that the 33–element loading filled the first 33 lattice element positions. For the fuel elements used, the positioning was as shown in Fig. 85. The configurations are shown in Figs. 72–76.

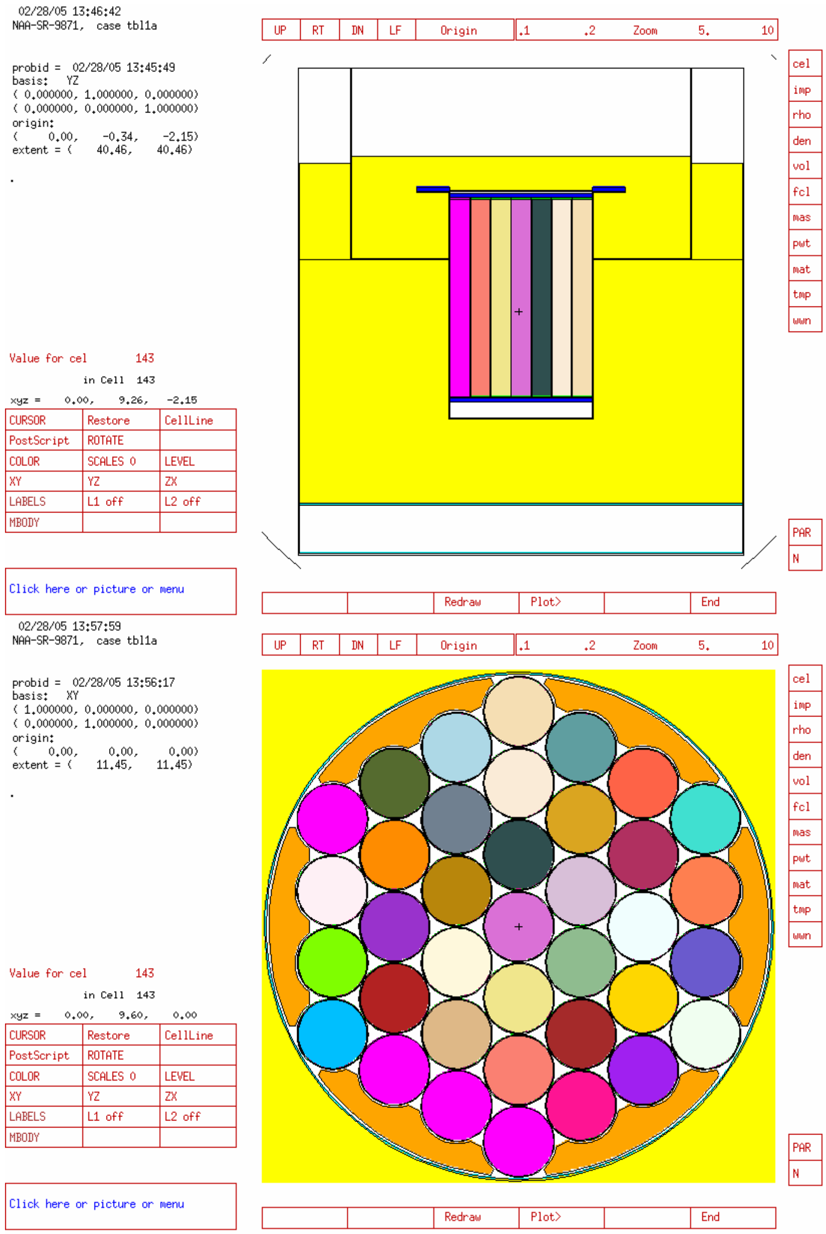


Fig. 72. Case *tbl1a* MCNP5 plot.

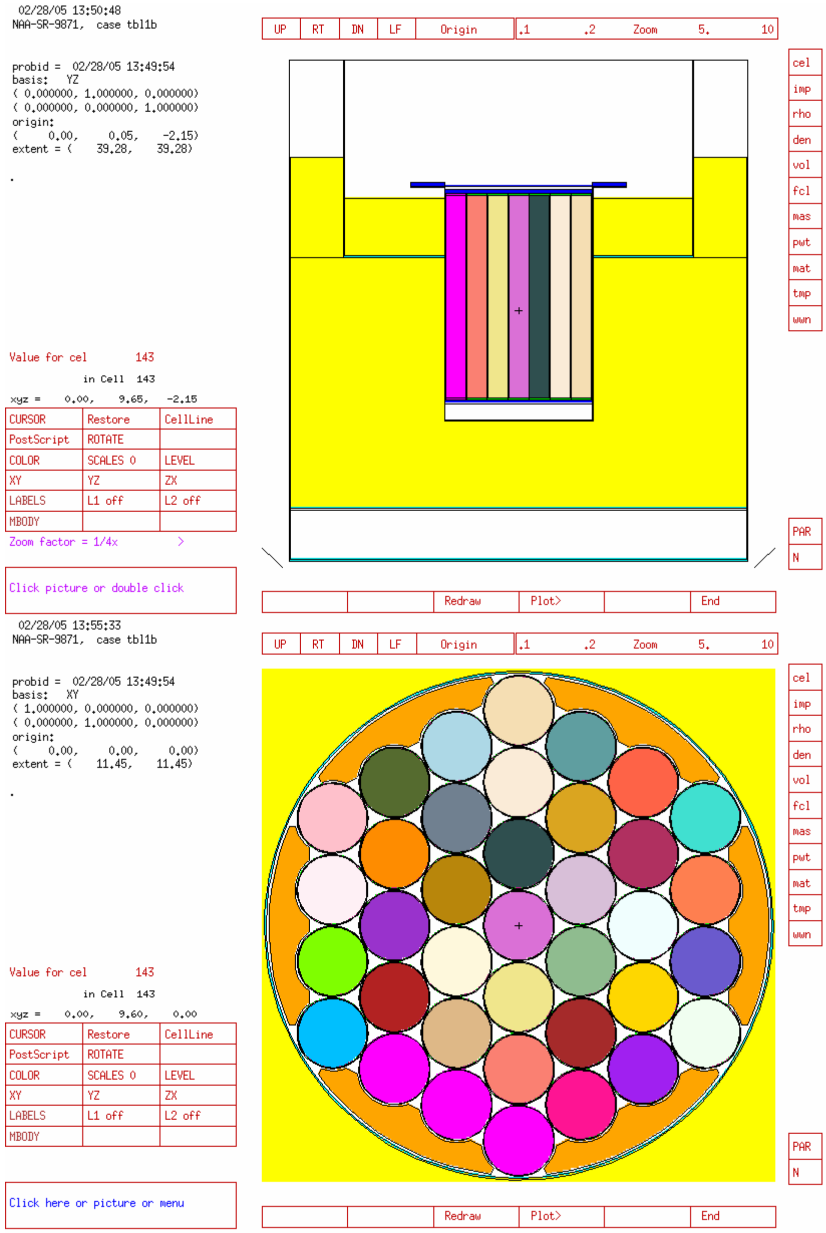


Fig. 73. Case *tbl1b* MCNP5 plot.

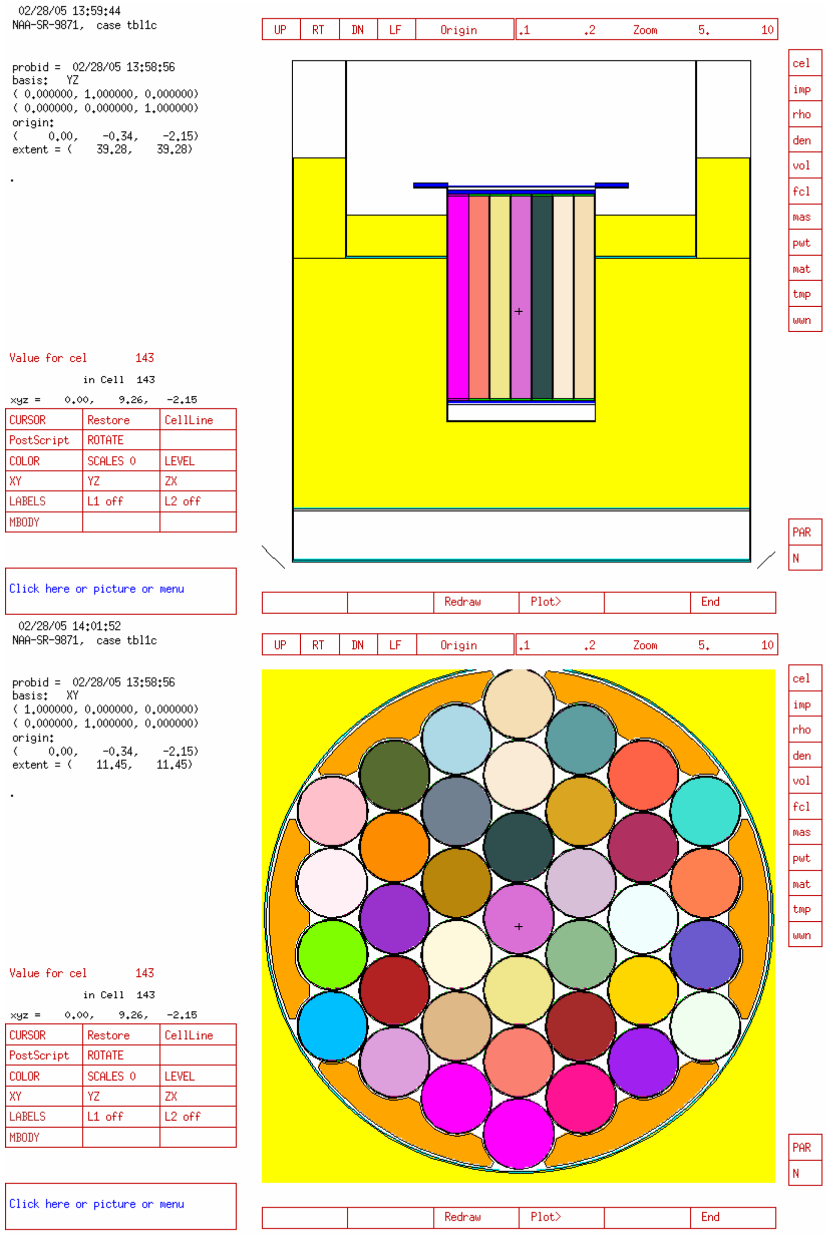


Fig. 74. Case *tbl1c* MCNP5 plot.

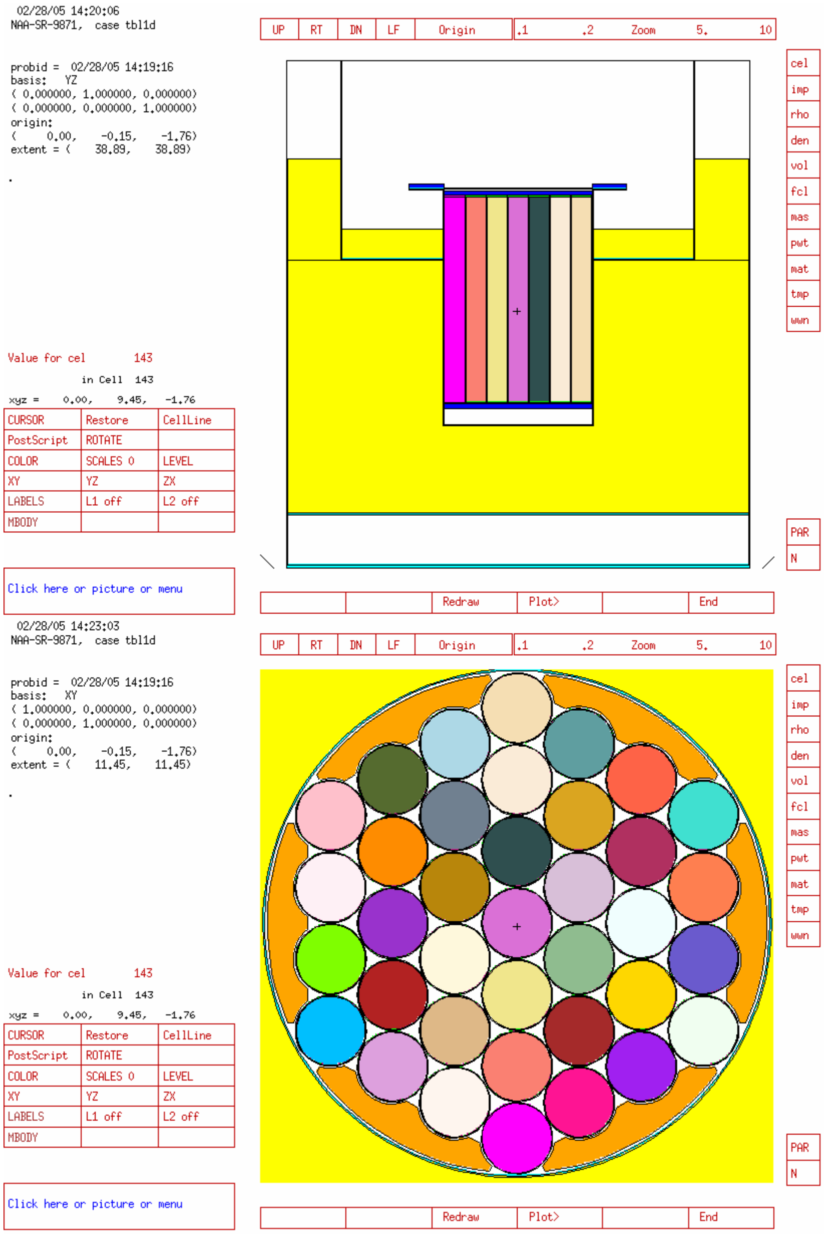


Fig. 75. Case *tbl1d* MCNP5 plot.

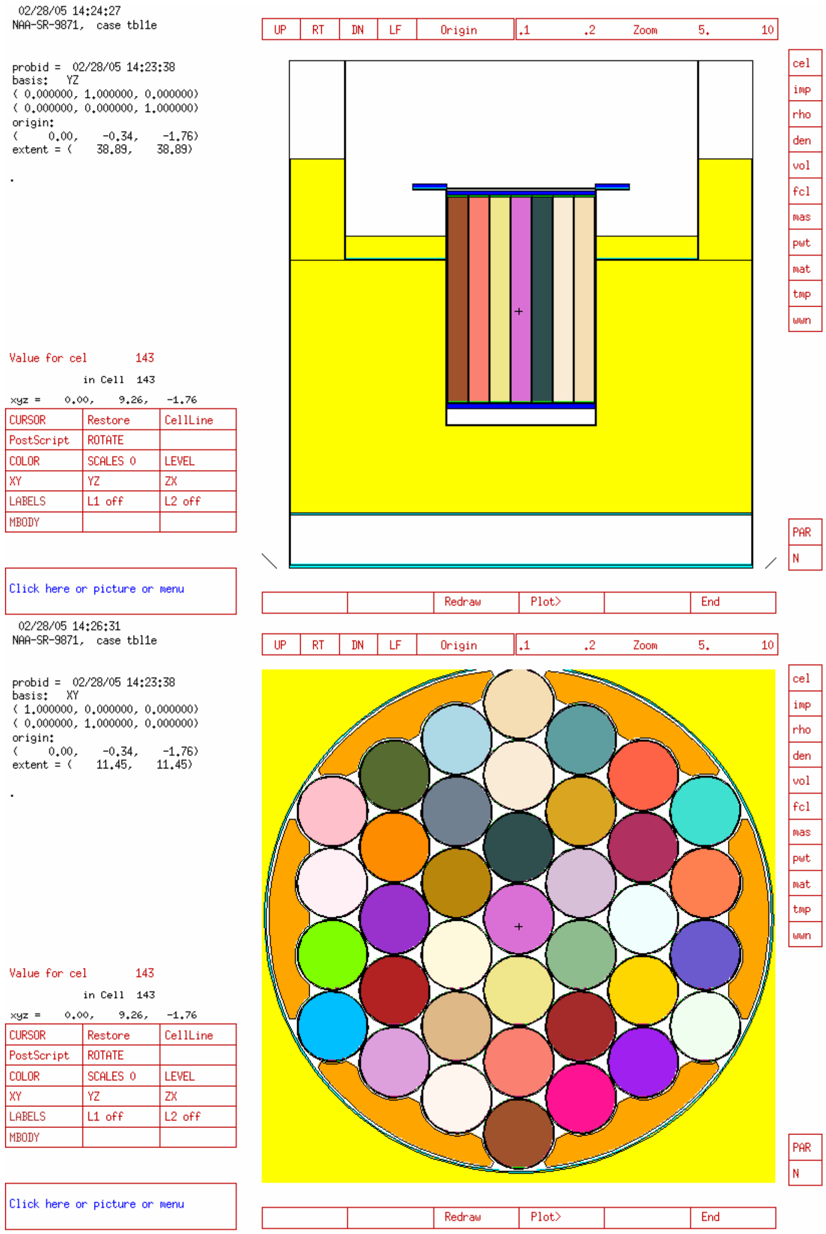


Fig. 76. Case *tbl1e* MCNP5 plot.

The documentation of the series of experiments used to determine the upper water reflector calibration curve (see p. 36 of Ref. 2) noted that the initial loading of 33 elements (case *tbl1a*) actually had 46.4¢ of excess reactivity, as opposed to being exactly critical as reported Table 1 of NAA–SR–9871. This was in fact true for all the configurations listed in Table 8. However, only the excess reactivity for the case *tbl1a* is reported, and several sources of information had to be used to estimate the excess reactivity for each configuration.

The excess reactivity is determined by assuming that the reactivity worths of the various components are additive. This assumption that the reactivity worths are additive was used by the experimenters to determine the excess reactivity for several experiments (see p. 47 of Ref. 2 and p. 33 of Ref. 1 for examples). The worth of the added fuel rods, the decrease in the height of the water reflector, and the removal of Lucite rods from the core are all accounted for in estimating the excess reactivity for cases *tbl1a–tbl1e*. The procedure begins with the information in Table 8 (reproduced from Table I of Ref. 2), which provides the core loading and water level in the top reflector tank. As previously stated, the initial amount of excess reactivity was documented as 46.4¢, and the other cases are calculated from this beginning value.

Table 8. Water level at critical for cases *tbl1a–tbl1e*

Case name	Number of fuel elements	Number of Lucite rods	Water level above the bottom of the active fuel region at critical, in. (cm)
tbl1a	33	4	14.94 (37.9476)
tbl1b	34	3	12.06 (30.6324)
tbl1c	35	2	11.06 (28.0924)
tbl1d	36	1	10.31 (26.1874)
tbl1e	37	0	9.88 (25.0952)

Fig. 77, the water reflector calibration curve for the SNAPTRAN fuel, is used to estimate the amount of reactivity removed by decreasing the water height. While the curve does not extend down to the lowest water level reported for the experiments, below a water height of 12 in. (30.48 cm) the graph is almost linear, and can reasonably be extended. The linear trend is also demonstrated by the calibration curve for the top reflector for the SCA–4 core shown in Fig. 78.

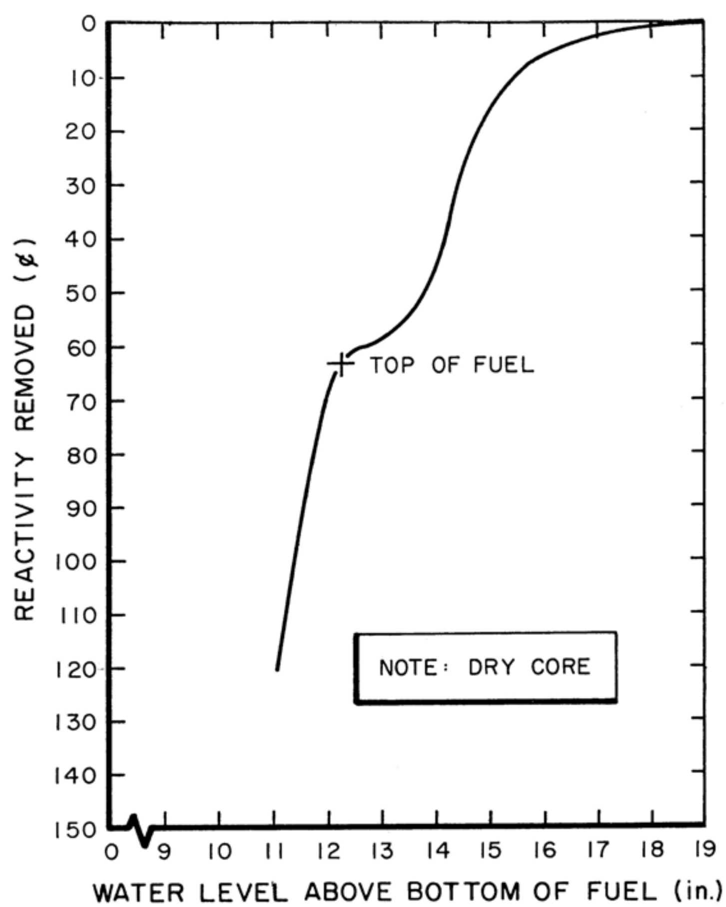


Fig. 77. Top reflector tank calibration curve for Phase III experiments using SNAPTRAN fuel.

(reproduced from Fig. 18 of NAA–SR–9871)

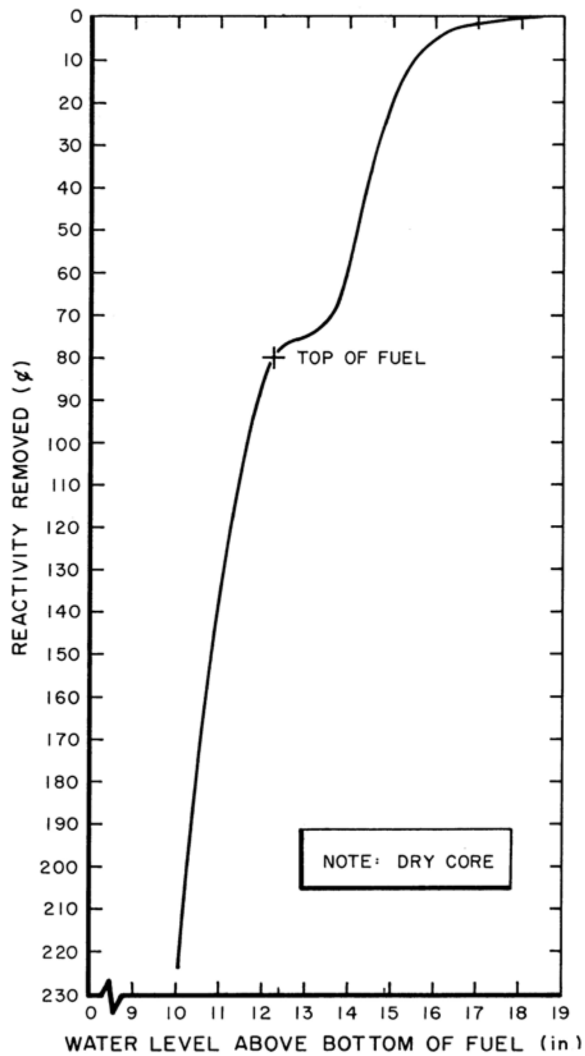


Fig. 78. Top reflector tank calibration curve for Phase III experiments using SCA–4 fuel.

(reproduced from Fig. 17 of NAA–SR–9871)

The experimenters noted that going from core–vessel–voided to core–vessel–flooded would not appreciably alter the reflector calibration curve (p.23, Ref.1). From the reflector calibration curve and the water heights provide in Table 8, the reactivity removed from the system by the decreased water level was determined. The values are presented in Table 9.

Table 9. Reactivity removed by decreasing the water height for cases *tbl1b–tbl1e*

Case name	Fuel element number	Reactivity worth (¢) for each fuel rod (same for all cases)	Reactivity removed by decreased water level (¢) estimated from Fig. 77
tbl1b	19	75.7	50
tbl1c	83	84.3	55
tbl1d	84	84.5	30
tbl1e	85	61.4	40

The reactivity contribution of the Lucite rods is also be accounted for. NAA–SR–8613 discussed experiments that examined the hydrogen worth in the core. These experiments determined that Lucite rods themselves contributed significant amounts of reactivity, since the cores of the SNAP reactors were very sensitive to the hydrogen content. Table 6 of NAA–SR–8613 reports that replacing a Lucite rod with a fuel rod in one of the outer lattice positions results in a reactivity insertion of 49.3 ¢ (averaged over the data provided). The Lucite–to–fuel worth of rod number 116 (Fig. 1, Ref. 3) is reported as 47 ¢ (p. 43, Ref. 3), while the worth of the fuel rod alone is 76.7 ¢ (Ref. 2). This results in the Lucite–to–fuel worth being roughly 62% of the fuel rod worth. The position of rod 116 in the experiments discussed in NAA-SR-8613 is the same as rod 85 in cases *tbl1a–tbl1e* (see Fig. 85). The reactivities reported in Table 8 do not account for the reactivity of the Lucite rod being replaced, and therefore overestimate the reactivities of the inserted rods by ~38%. Accounting for the Lucite rod worth allows the determination of the excess reactivity for the configurations reported in Table 1 of NAA–SR–9871 as shown in Table 10.

Table 10. Excess reactivity calculations for cases *tbl1b–tbl1e*

Case name	Initial excess reactivity (¢)	Reactivity added by replacing Lucite with fuel (¢)= 62% of fuel rod worth	Reactivity removed by lowering water level (¢)	Final excess reactivity (¢)
tbl1a	N/A	N/A	N/A	46.4
tbl1b	46.4	46.9	50	43.3
tbl1c	43.3	52.3	55	40.6
tbl1d	40.6	52.4	30	63
tbl1e	63	38.1	40	61.1

The final calculated k_{eff} for cases *tbl1a–tbl1e* are presented in Table 11. The calculated k_{eff} is normalized to the experimental k_{eff} with the excess reactivities calculated in Table 10 accounted for. All calculated results are based on no fewer than two million active neutron histories per benchmark case.

Table 11. Calculated results for cases *tbl1b–tbl1e*

Case name	Estimated experimental k_{eff}, k_{exp}	Calculated k_{eff}, k_{calc}	Computational uncertainty, σ	Normalized result k_{calc}/k_{exp}
tbl1a	1.00373	1.01205	0.00065	1.0083
tbl1b	1.00348	1.00407	0.00067	1.0006
tbl1c	1.00326	1.00787	0.00067	1.0046
tbl1d	1.00507	1.01109	0.00069	1.0060
tbl1e	1.00491	1.01244	0.00069	1.0075

4.2.2 Water–Immersed and Reflected Core

Cases *fig14a–fig14d*. Figure 14 of NAA–SR–9871 depicts the loading for a flooded and water reflected core. The SCA–4 fuel was loaded into the first 25 lattice positions (see Fig. 83), with the remaining positions filled with Lucite rods. The amount of axial reflection was varied, and the reactivity worth of the axial reflector thus determined. The system was critical with 25 elements and 1.88 in. (4.7752 cm) of axial water reflection. The various axial reflector heights are shown in Table 12. These configurations are shown in Fig. 79 through Fig. 82. The lower water tank was full for these experiments.

Table 12. Amount of axial water reflection used for cases *fig14a–fig14d*

Case name	Axial water reflector height, in. (cm)	Reported excess reactivity, ρ(¢)
fig14a	1.88 (4.7752)	0
fig14b	2.00 (5.08)	4.9
fig14c	2.25 (5.715)	10.5
fig14d	2.50 (6.35)	15.5

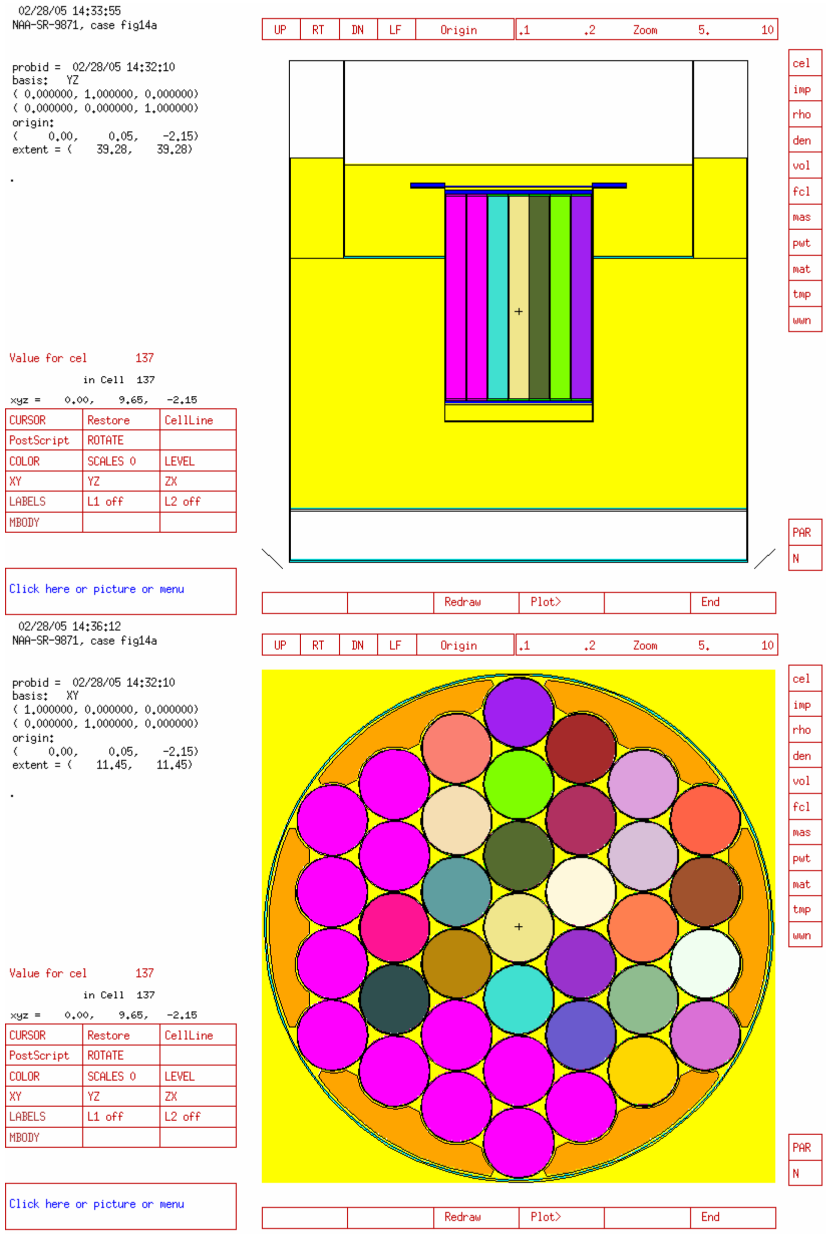


Fig. 79. Case *fig14a* MCNP5 plot.

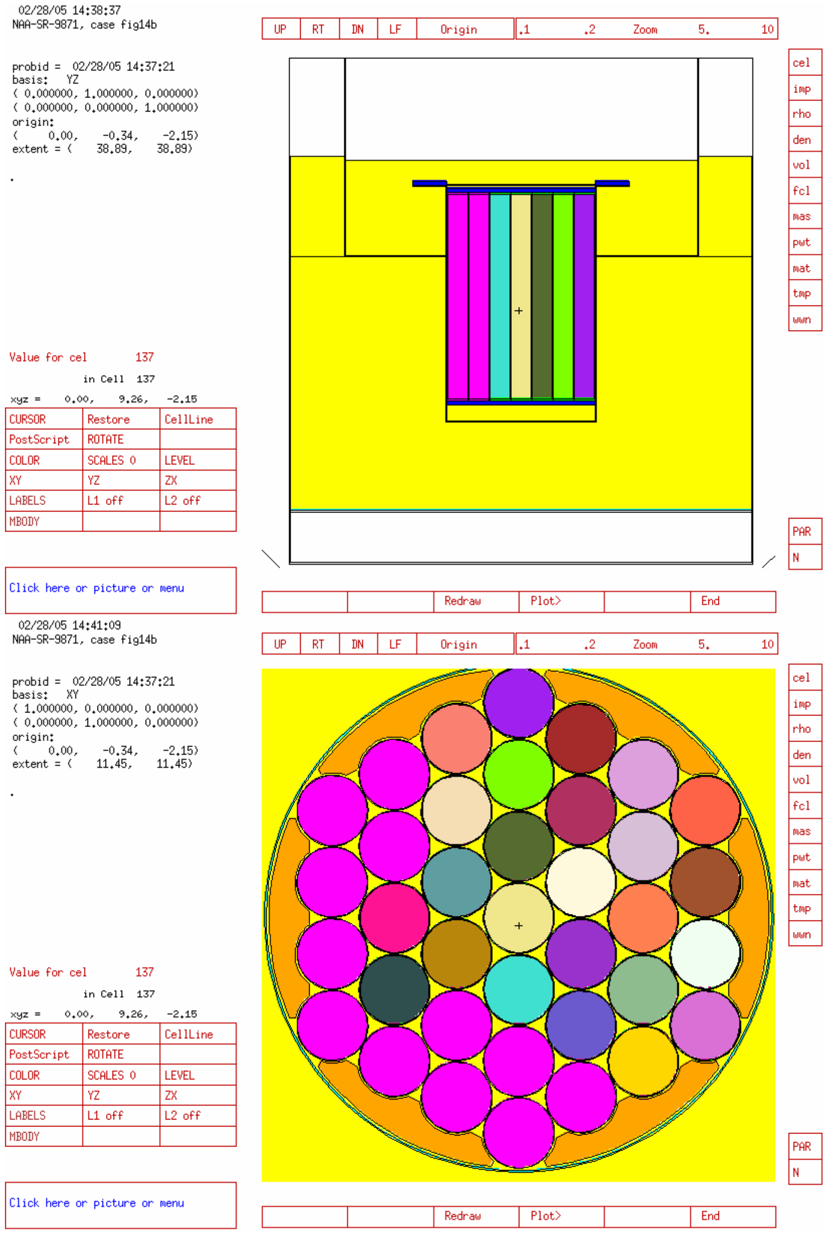


Fig. 80. Case *fig14b* MCNP5 plot.

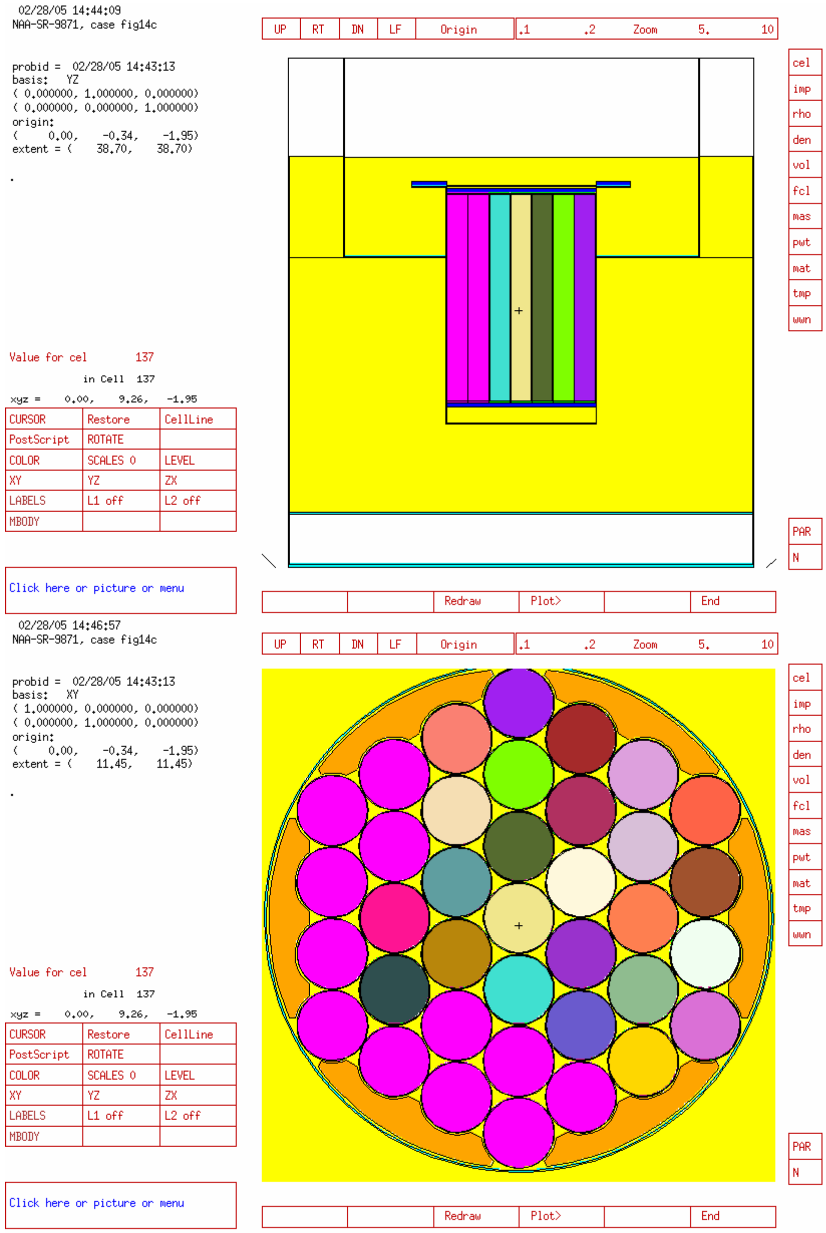


Fig. 81. Case *fig14c* MCNP5 plot.

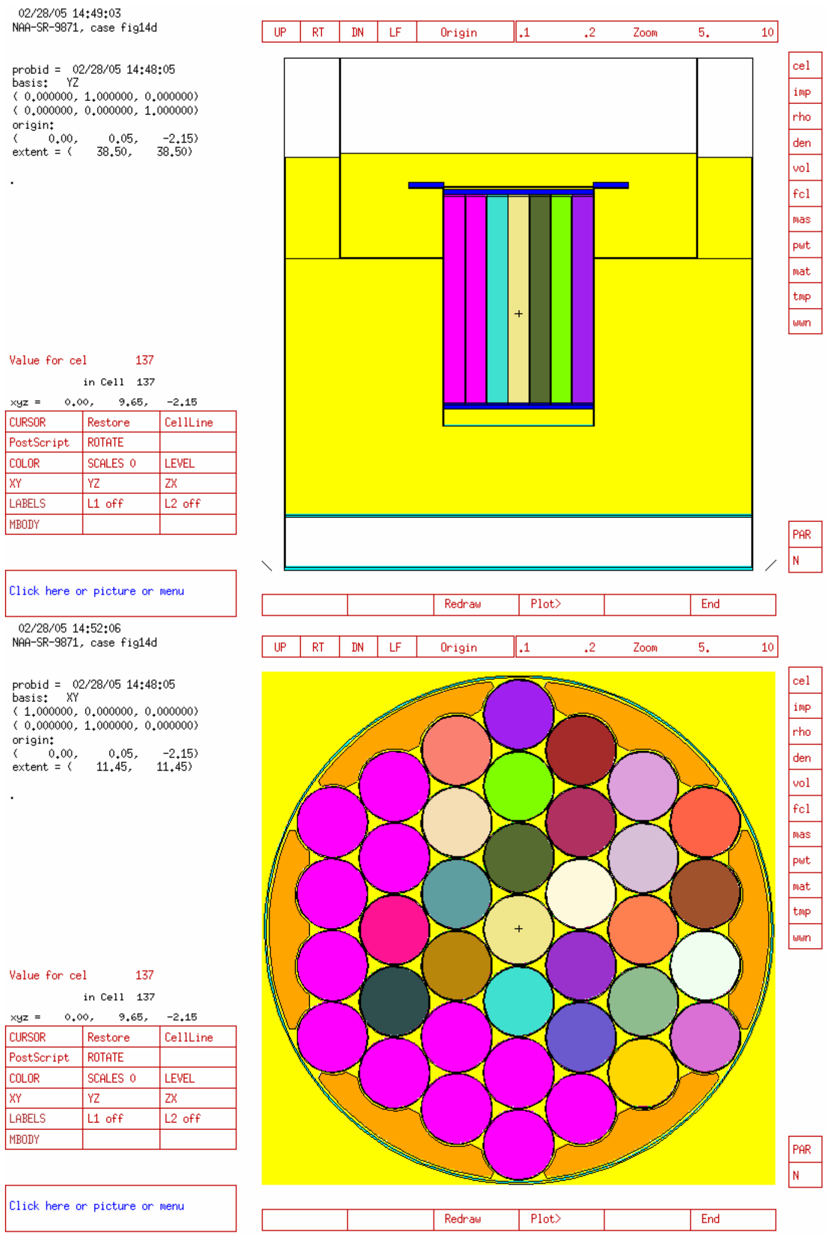


Fig. 82. Case *fig14d* MCNP5 plot.

The final calculated k_{eff} for cases *fig14a–fig14d* are presented in Table 13. The calculated k_{eff} (k_{calc}) is normalized to the experimental k_{eff} (k_{exp}) with the reported excess reactivities accounted for. All calculated results are based on no fewer than two million active neutron histories per benchmark case.

Table 13. Calculated results for cases *fig14a–fig14d*

Case name	Reported excess reactivity (¢)	Estimated experimental k_{eff}, k_{exp}	Calculated k_{eff}, k_{calc}	Computational uncertainty, σ	Normalized result, k_{calc}/k_{exp}
fig14a	0	1.00000	1.00381	0.00069	1.0038
fig14b	4.9	1.00039	1.00247	0.00067	1.0021
fig14c	10.5	1.00084	1.00348	0.00067	1.0026
fig14d	15.5	1.00124	1.00387	0.00067	1.0023

4.2.3 Determination of the Total Excess Reactivity of a Fully–Loaded Core

4.2.3.1 SCA–4 fuel loading

Cases *fig16, p34,* and *p35*. Case *fig16* models full, dry core loaded with SCA–4 fuel and 12 absorber splines. The fuel and spline positions are as shown in Fig. 83. This series of experiments was used to generate the water reflector curve, showing the worth of the water in the top tank as a function of water height above the top of the fuel (see Fig. 78). The absorber splines were described as right circular cylinders that fit between the fuel elements and the internal beryllium reflectors. The diameter of the splines was estimated using sketches made with a drafting program. The splines were filled with natural boron powder. The weight of boron powder in each spline was provided (see Table 14). From this, the number densities for the splines could be determined.

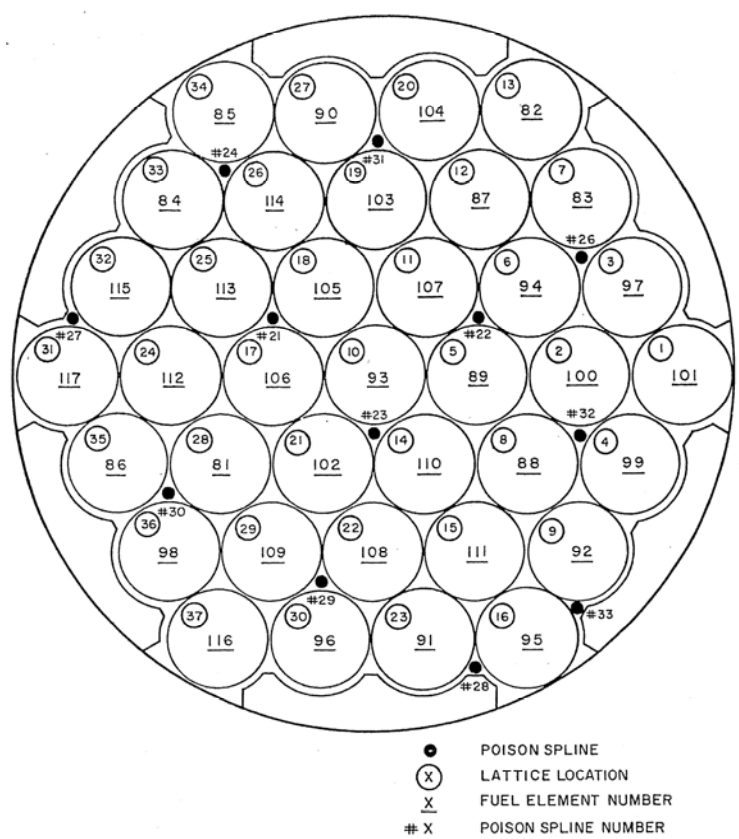


Fig. 83. Fuel element and absorber spline loading for the SCA–4 fuel loading

(reproduced from Fig. 16 of NAA–SR–9871)

Table 14. Absorber spline worths in SCA–4 fuel loading

Absorber spline number	Reactivity worth (¢)	Boron weight (g)
31	-19	1.40
32	-17	1.42
27	-13	1.60
21	-49	1.11
23	-49	1.18
22	-43	0.99
29	-43	1.38
33	-21	1.21
28	-18	1.72
26	-21	1.66
30	-26	1.44
24	-22	1.58

Table 15. Fuel element worth for SCA–4 absorber spline experiment

Fuel element number	Reactivity worth (¢)
84	+73
85	+65
86	+86
98	+86
116	+76

Only three of the configurations used to generate the calibration curve were described in enough detail to allow the excess reactivity to be determined. The loading for the absorber spline experiment (case *fig16*) began with 32 elements and no absorber splines. The empty fuel positions were filled with Lucite rods. As each fuel element was added, some number of absorber splines were added to compensate for the added reactivity. The initial 32–element loading was determined to have an excess reactivity of 41¢ (case *p34*). The worth of the added fuel elements was provided, as was the average worth per spline. By summing the fuel rod worths (provided in Table 15), subtracting the spline worths (provided in Table 14), and adding this to the reactivity of the initial loading, the excess reactivity was determined to be $1.77 for case *fig16*. The excess reactivity for the fuel core without the splines, case *p35*, is estimated to be $4.27, by similar calculation. It should be noted that the reactivity for case *p35* does not represent an experimental configuration, but was an estimate by the experimenters. The results of these calculations are shown in Table 16, and the MCNP5 plot for case *fig16* is provided in Fig. 84. Each calculated result is based on no fewer than two million active neutron histories.

Table 16. Calculated results for cases *fig16*, *p34*, and *p35*

Case name	Reported excess reactivity, ρ($)	Estimated experimental k_{eff}, k_{exp}	Calculated k_{eff}, k_{calc}	Computational uncertainty, σ	Normalzed result, k_{calc}/k_{exp}
fig16	+1.77	1.01436	1.01666	0.00067	1.0023
p34	+0.41	1.00329	1.00784	0.00066	1.0045
p35	+4.27	1.03537	1.04568	0.00065	1.0100

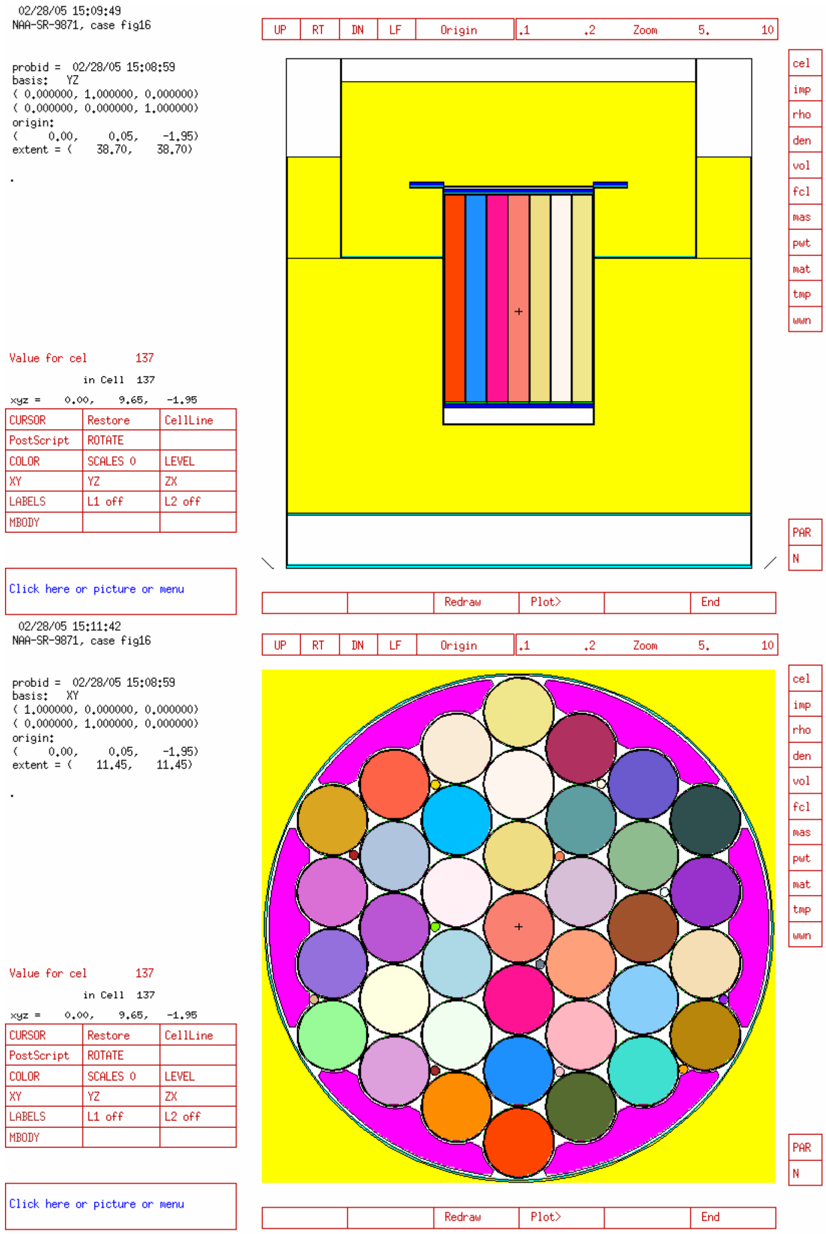


Fig. 84. Case *fig16* MCNP5 plot.

4.2.3.2 SNAPTRAN fuel loading

Case *fig19.* Fifteen absorber splines were added to a dry core fully loaded with SNAPTRAN fuel. Twelve of the splines were used with the SCA–4 core; Table 17 provides the spline number and boron weight for the additional three splines. The position of the splines and fuel elements are as shown in Fig. 85. The figure also notes the position of ^{235}U foils used to generate flux maps. These foils were not included in the MCNP5 model. This series of experiments was used to generate the water reflector curve, showing the worth of the water in the top tank as a function of water height above the top of the fuel (see Fig. 77). Only one configuration in this series of experiments was described in enough detail to determine the excess reactivity. The absorber splines are reported to be worth roughly -22.1¢ in reactivity each (as opposed to the average worth of -28.4¢ average for the twelve splines used with the SCA–4 core), and the experimenters determined the individual fuel rod worth to be as reported in Table 18. The excess reactivity of the core with 33 fuel elements and no absorber splines was measured to be 46.4¢ (see case *tbl1a*). Based on the worth of the fuel rods, the worth of the absorber splines, and the excess reactivity of the 33–element loading, the excess reactivity for this case is 20.8¢ (k_{exp}=1.00166). The calculated k_{eff} for this case is 1.00294±0.00068, with a normalized k_{eff} (k_{calc}/k_{exp}) of 1.0013. The calculated result is based on no fewer than two million active neutron histories. This configuration is shown in Fig. 86.

Table 17. Absorber spline loadings for SNAPTRAN core

Absorber spline number	Boron weight (g)
25	1.63
34	1.70
35	1.62

Table 18. Fuel element worth for SNAPTRAN absorber spline experiment

Fuel element number	Reactivity worth (¢)
19	+75.7
83	+84.3
84	+84.5
85	+61.4

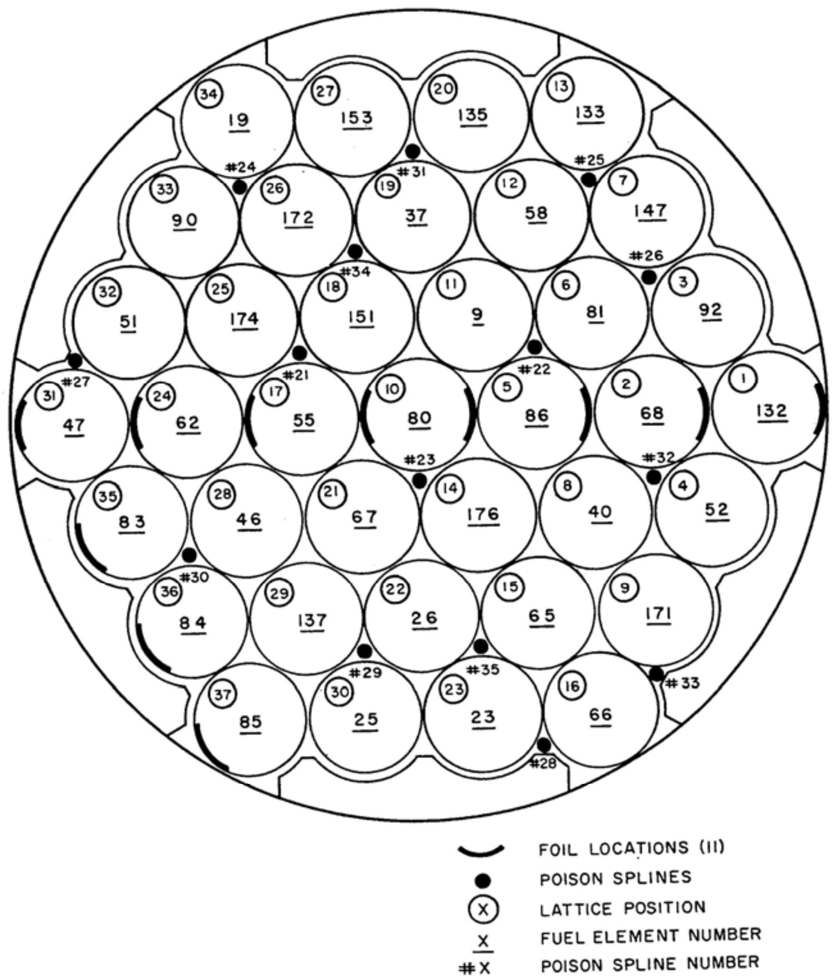


Fig. 85. Fuel element and absorber spline loading for the SNAPTRAN fuel loading.

(reproduced from Fig. 19 of NAA–SR–9871)

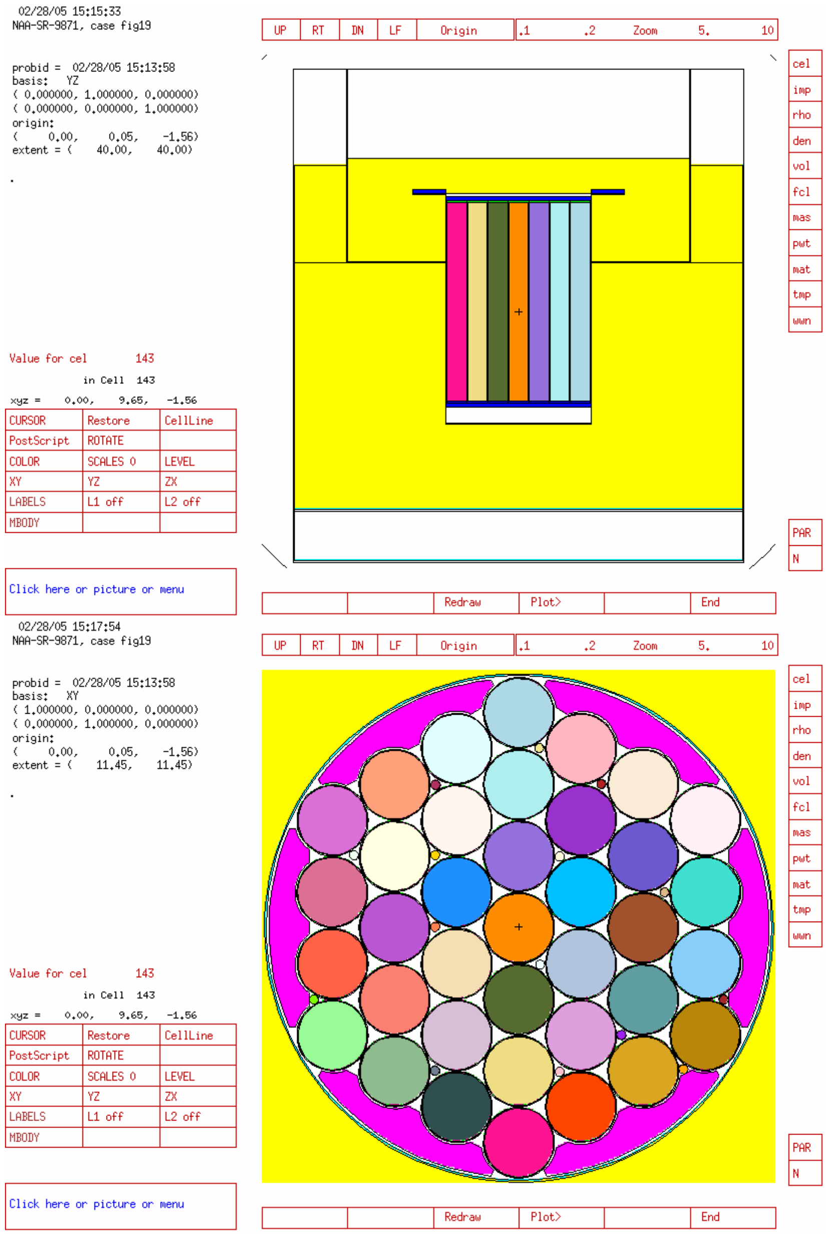


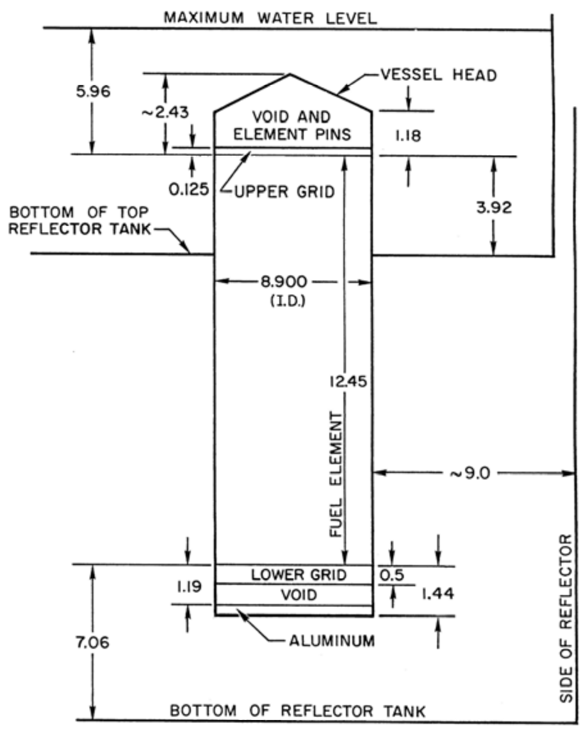
Fig. 86. Case *fig19* MCNP5 plot.

4.3 VOID AND ABSORBER SLEEVE EXPERIMENTS

4.3.1 Absorber Sleeves

4.3.1.1 Water reflection only

A set of experiments to provide data for the SNAPTRAN program used a water tank and reactor vessel system that were of a different design than the remainder of the NAA–SR–9871 experiments. These configurations examined a voided core with water reflection. The tank system is shown in Fig. 87.



SNAPTRAN-3
SCA-4B CONFIGURATION

Note: All dimensions are specified in inches.

Fig. 87. Water tank and core vessel configuration for void–absorber sleeve experiments.

(reproduced from Fig. 27 of NAA–SR–9871)

The core was fully loaded with the SNAPTRAN fuel, and no absorber splines were used. The position of the elements in the core was consistent with the configuration shown in Fig. 85. The core vessel was made from 0.031–in. (0.07874–cm)–thick 316-series stainless steel. The bottom of the core vessel in these cases is aluminum, as shown in Fig. 87. For this series of experiments, Binal (10.2 wt % boron in aluminum) sleeves were used to cover varying amounts of the core radial surface and the water height was adjusted. The sleeves were 0.25 in. (0.635 cm) thick, and were placed 0.25 in. (0.635 cm) from the vessel surface. The Binal sleeves completely surrounded the core radial surface. These experiments are modeled in cases *p45, p46a, p46b,* and *tbl4a–tbl4d.*

Case *p45*. This core was loaded to critical using a full core compliment and Binal sleeves that covered the entire core. The Binal sleeves were formed in two parts, one for the section of the core in the top tank, and one for the bottom. The sleeves were 0.25 in. (0.635 cm) thick, and a 0.25–in. (0.635–cm) thick water gap existed between the sleeves and the core vessel. With no water in the core and the core vessel fully water–reflected, the assembly was far subcritical. The calculated k_{eff} (k_{calc}) for this case is 0.93874±0.00070. The calculated result is based on no fewer than two million active neutron histories. This configuration is shown in Fig. 88.

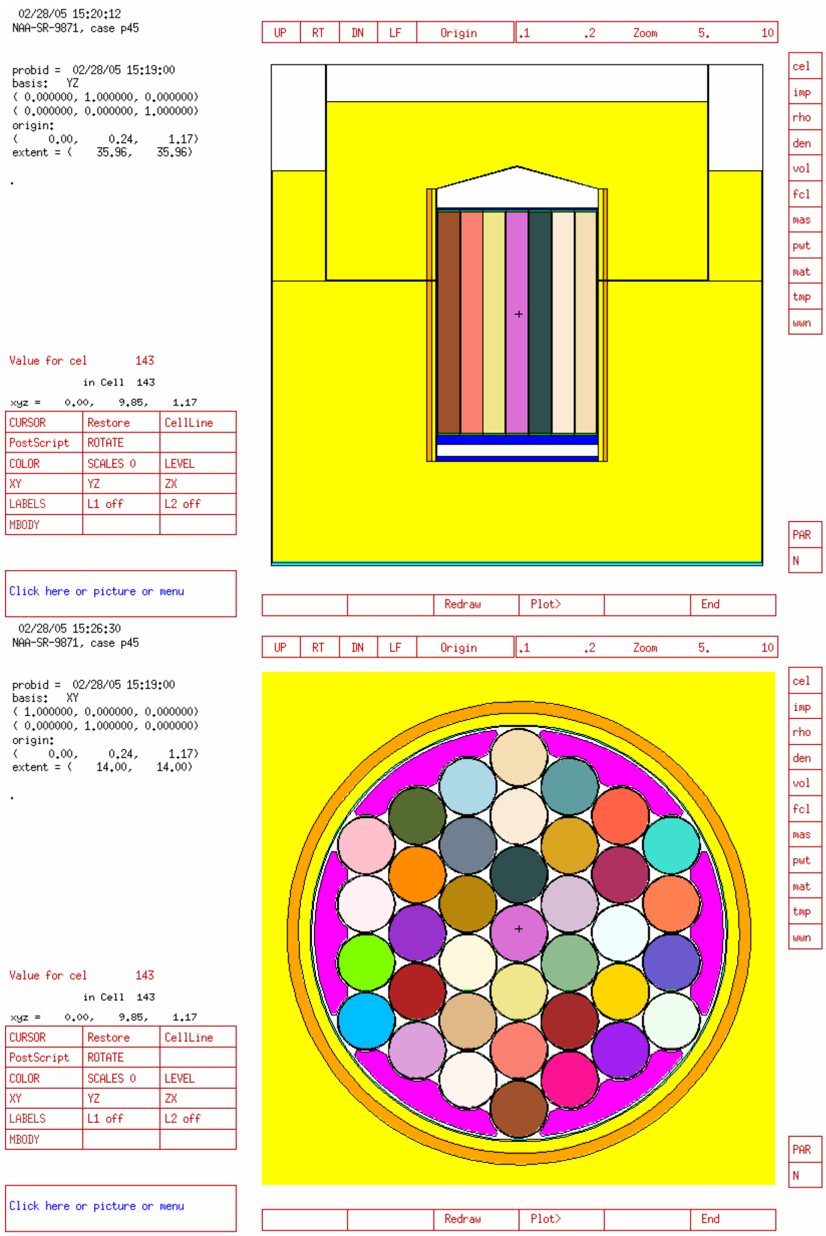


Fig. 88. Case *p45* MCNP5 plot.

Case *p46a*. This case is very similar to case *p45*, except that the Binal sleeve configuration for this experiment covered the bottom two–thirds of the core. This was accomplished by removing the Binal sleeve that was situated in the top water tank for case *p45* while leaving the lower sleeve in place. The system was fully water reflected. While this configuration was more reactive than case *p45*, the assembly was still subcritical. The calculated k_{eff} (k_{calc}) for this case is 0.96092±0.00070. The calculated result is based on no fewer than two million active neutron histories. This configuration is shown in Fig. 89.

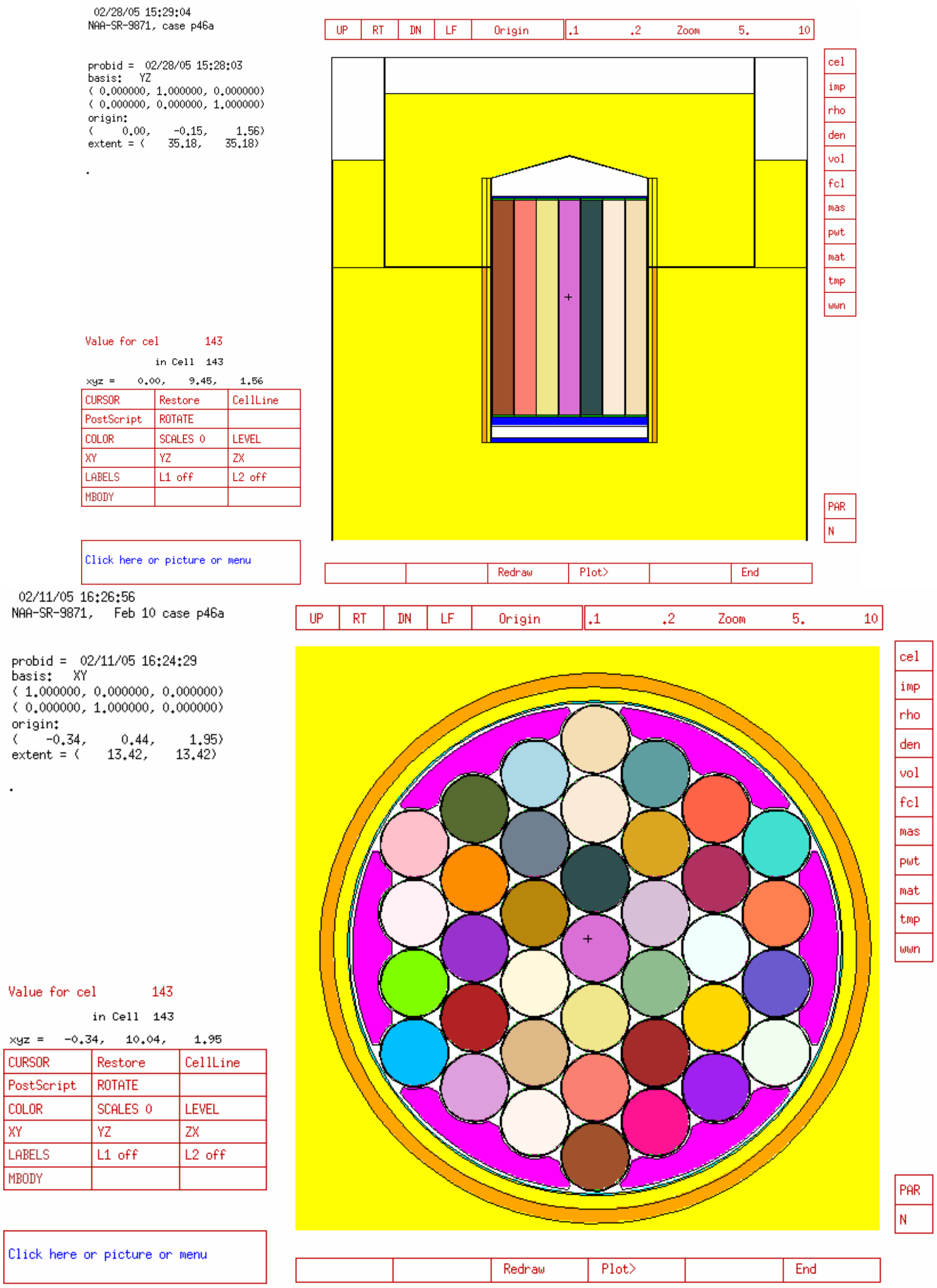


Fig. 89. Case *p46a* MCNP5 plot.

Case *p46b.* The bottom Binal sleeve used for cases *p45* and *p46a* was removed and replaced with the sleeve built for the top section of the reactor for the experiment modeled by case *p46b*. The sleeve position was adjusted such that it covered the bottom 2.7 in. (6.858 cm) of the fuel. The water level was also adjusted, to a height of 10.4 in. (26.416 cm) above the bottom of the active fuel region. This configuration was critical. The experimenters extrapolated the upper water tank calibration curve (see Fig. 77) to estimate that this change in the water height (from fully reflected) inserted roughly -$1.70 in reactivity. Since the full core excess reactivity was determined to be $3.52, the worth of the Binal sleeve covering the bottom 2.7 in. (6.858 cm) of fuel was calculated to be ~$1.80. The experiment was reported as critical, and the calculated k_{eff} (k_{calc}) is 0.99610±0.00068. The calculated result is based on no fewer than two million active neutron histories. This configuration is shown in Fig. 90.

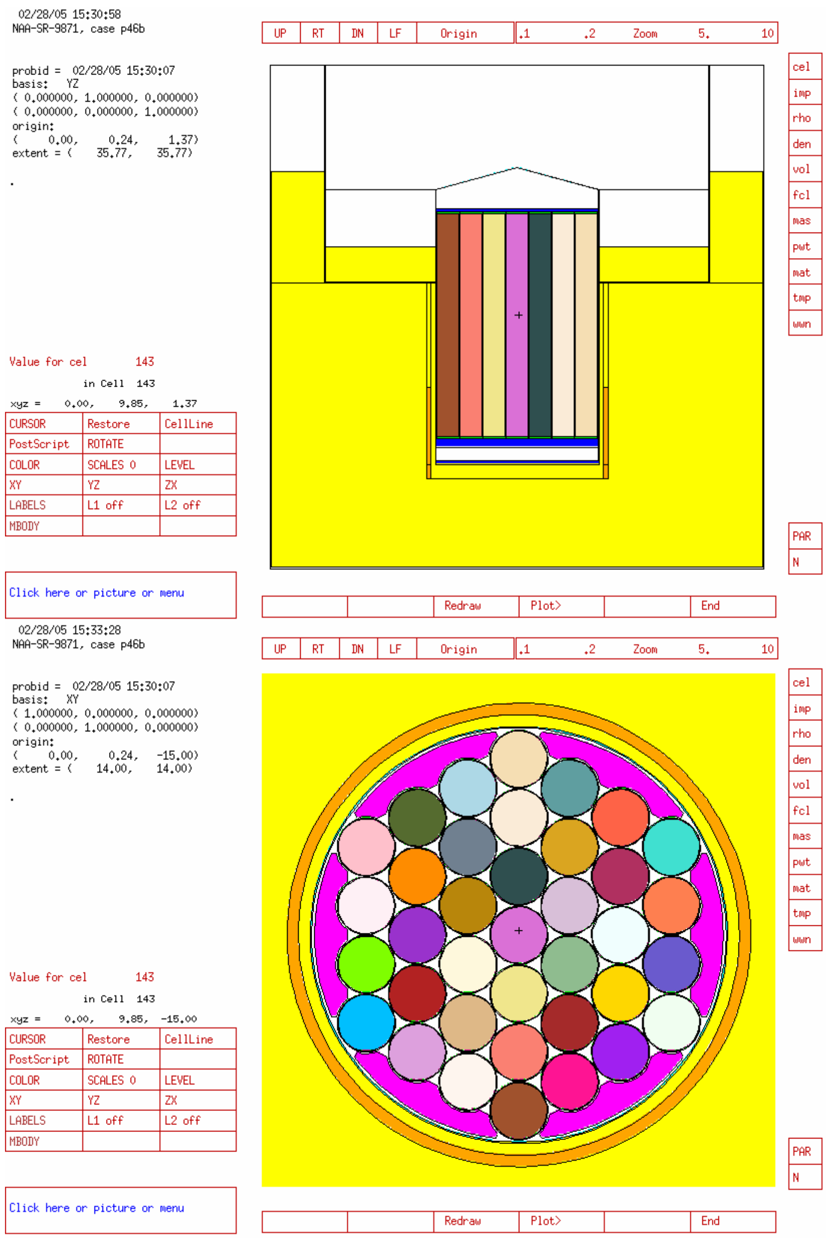


Fig. 90. Case *p46b* MCNP5 plot.

Cases *tbl4a–tbl4d.* A series of experiments was performed to determine a sleeve configuration that would balance the full excess reactivity of the core (~$3.52). The lower Binal sleeve was positioned to cover various heights of the core vessel, and the water height in the top tank adjusted (the lower tank was always full). The Binal sleeves for all cases were held 0.25 in. (0.635 cm) away from the core vessel, creating a layer of water next to the core vessel. The positions of the Binal sleeves and the heights of the water are summarized in Table 19. The MCNP5 configurations for these cases are shown in Fig. 91 through Fig. 94. The calculated results for these cases are shown in Table 20 and each result is based on no fewer than two million active neutron histories.

Table 19. Determination of Binal sleeve effectiveness with SNAPTRAN core

Case name	Lower fuel element length surrounded by Binal sleeve, in. (cm)	Water level above the bottom of the active fuel region, in. (cm)	Reported excess reactivity (¢)
tbl4a	6.5 (16.51)	18.25 (46.355)	subcritical
tbl4b	4.5 (11.43)	14.13 (35.8902)	0 (critical)
tbl4c	4.5 (11.43)	14.75 (37.465)	25.7
tbl4d	4.93 (12.52)	18.25 (46.355)	0 (critical)

Table 20. Calculated results for cases *tbl4a–tbl4d*

Case name	Estimated experimental k_{eff}, k_{exp}	Calculated k_{eff}, k_{calc}	Computational uncertainty, σ	Normalized result, k_{calc}/k_{exp}
tbl4a	subcritical	0.98014	0.00070	n/a– subcritical
tbl4b	1.00000	0.99320	0.00071	0.9932
tbl4c	1.00206	0.99718	0.00071	0.9951
tbl4d	1.00000	0.99883	0.00069	0.9988

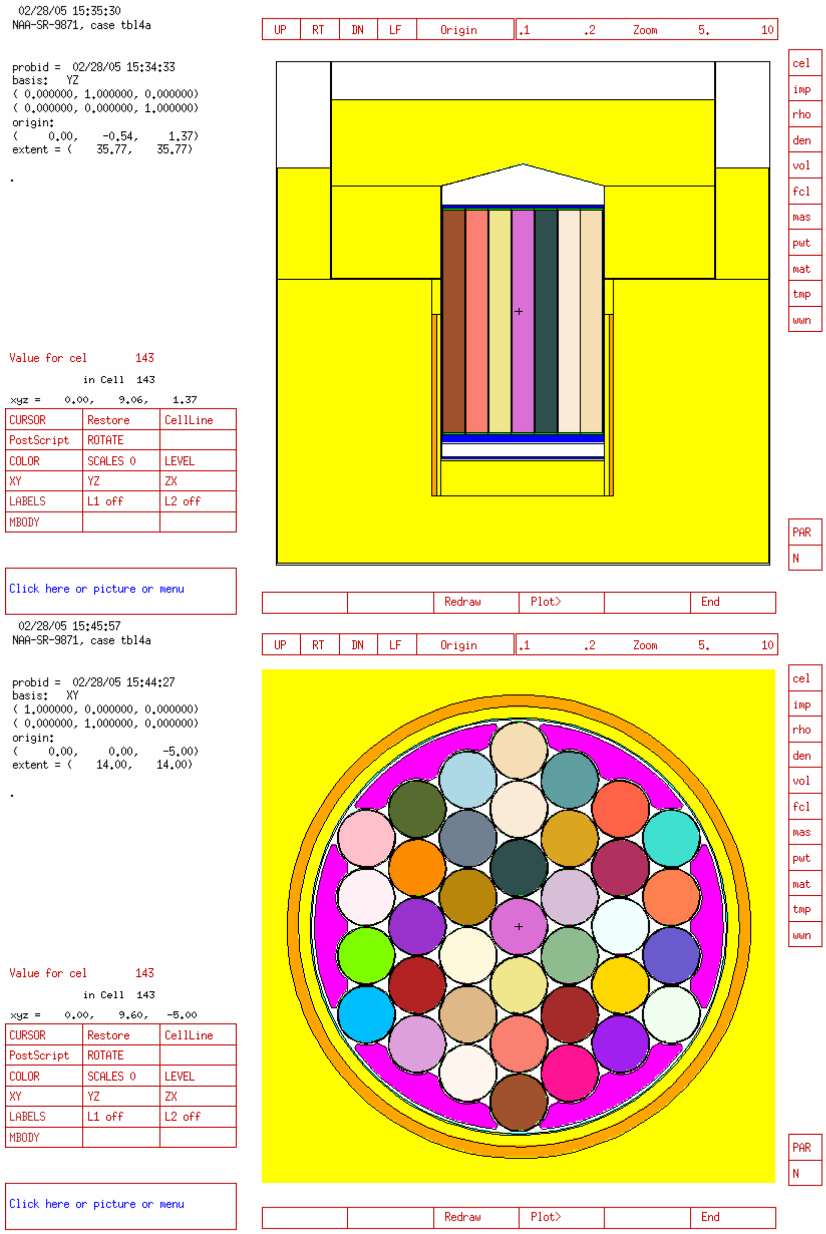


Fig. 91. Case *tbl4a* MCNP5 plot.

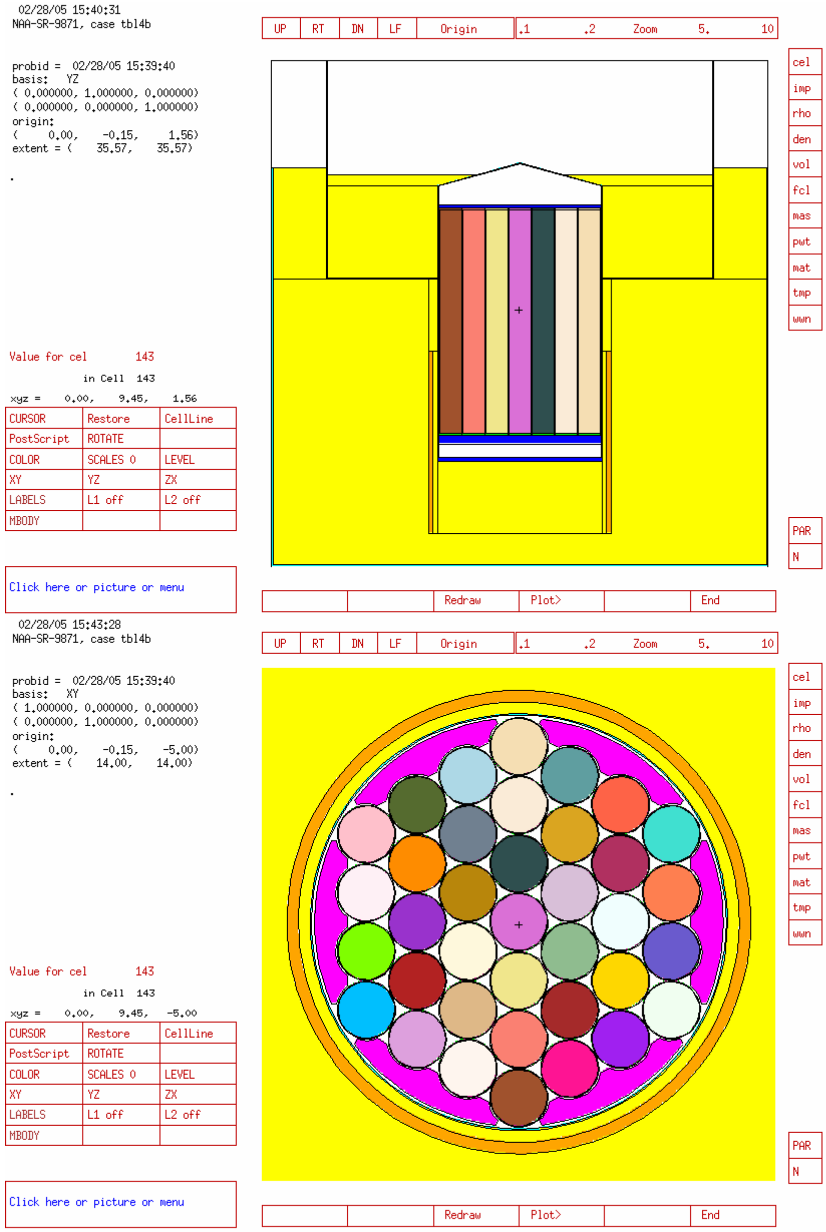


Fig. 92. Case *tbl4b* MCNP5 plot.

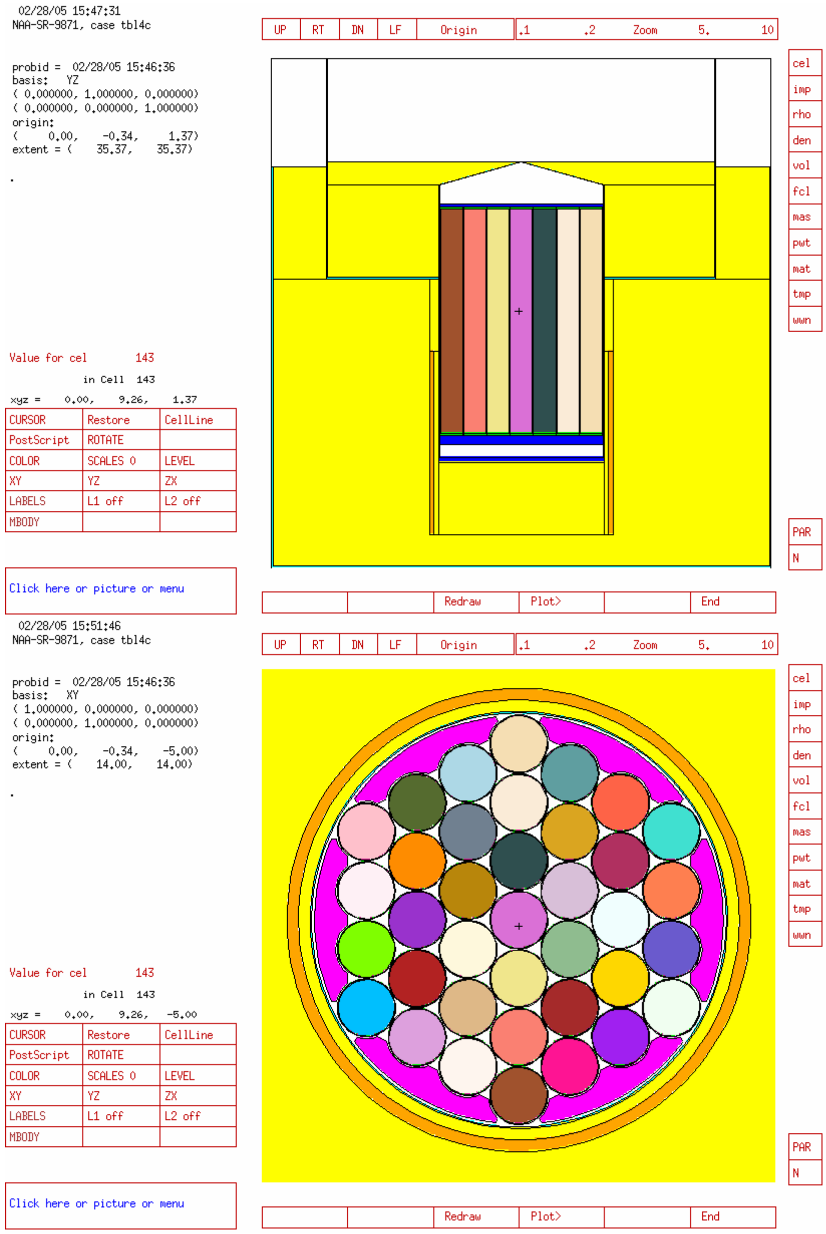


Fig. 93. Case *tbl4c* MCNP5 plot.

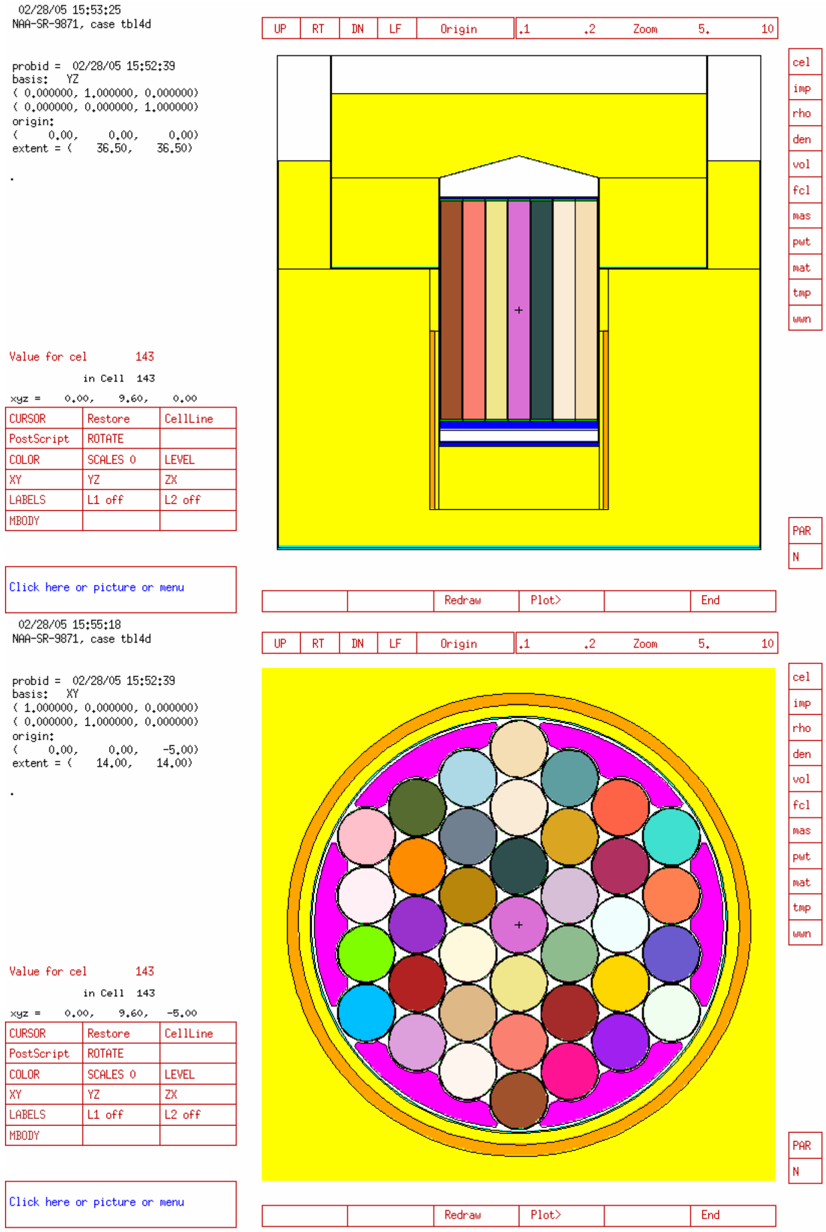


Fig. 94. Case *tbl4d* MCNP5 plot.

4.3.1.2 Water immersion and reflection

Experiments were performed using Binal (10.2 wt % boron in aluminum) sleeves for water–reflected and flooded cores. These experiments were done with cores loaded with SCA–4 and SNAPTRAN fuels. The water tank configuration was that shown in Fig. 62, where the top tank divided the core vessel into two axial regions. The sleeves were again constructed in two sections–one for the top tank and one for the lower tank. The sleeves for these experiments were constructed such that there was no gap between the sleeves and the core vessel for a water gap.

Case *p49*. For the experiment with SCA–4 fuel, a 0.75–in. (1.905–cm)–thick Binal sleeve was used. The core was loaded with 35 fuel elements (lattice position 36 and 37 loaded with Lucite rods). The water level was 10.25 in. (26.035 cm) above the bottom of the active fuel region. This configuration is shown in Fig. 95. This experiment was reported as critical, and the calculated k_{eff} (k_{calc}) is 0.99744±0.00072. The calculated result is based on no fewer than two million active neutron histories.

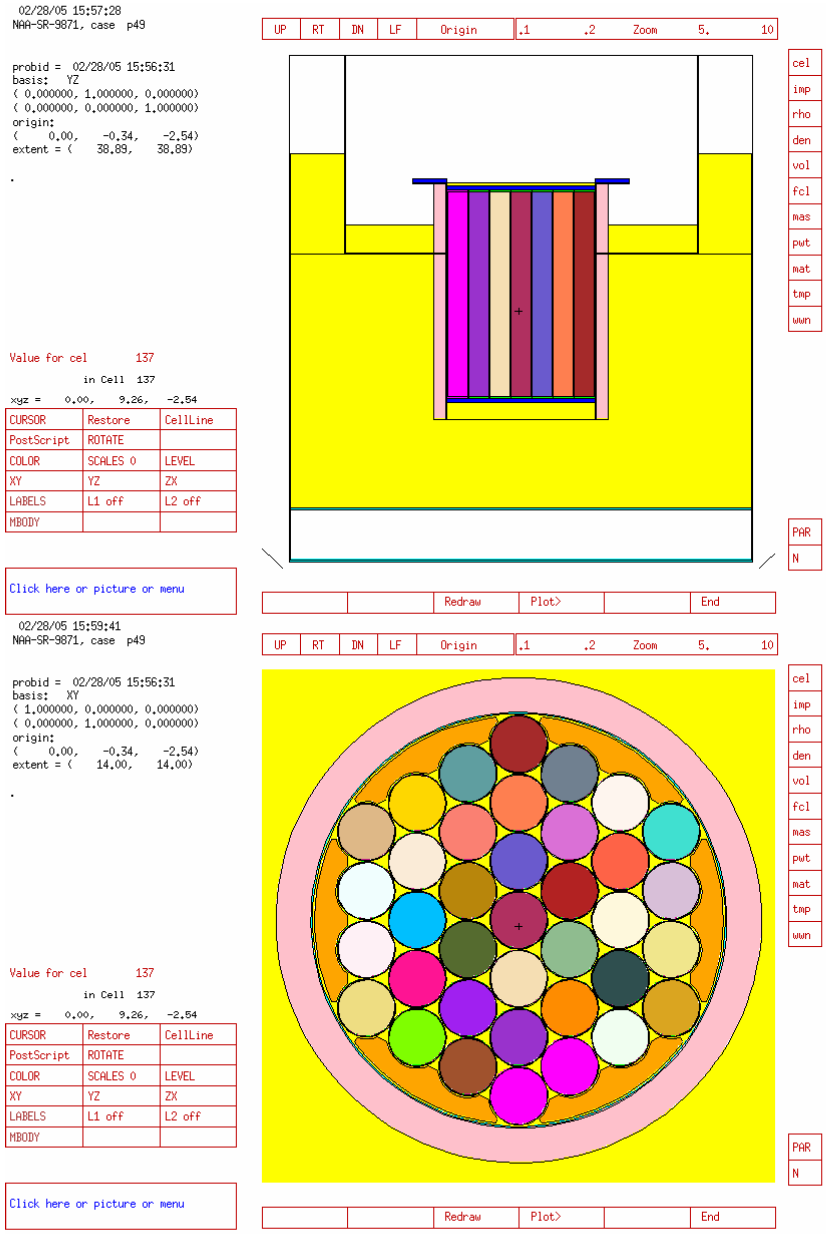


Fig. 95. Case *p49* MCNP5 plot.

Cases *p50a* and *p50b*. The SNAPTRAN fuel was used for cases *p50a* and *p50b*. Two different Binal sleeve configurations were used for these experiments: 0.25 in. (0.635 cm) for case *p50a* and 0.75 in. (1.905 cm) for case *p50b*. There was no water gap between the core vessel and the sleeves. The critical loading for case *p50a* was 36 fuel elements, with a Lucite rod in lattice position 37. The water level above the bottom of the active fuel region was 10.5 in. (26.67 cm). For the case with 0.75–in. (1.905–cm) thick Binal sleeves, *p50b*, the core loading was again 36 elements with one Lucite rod, with a water height 9.13 in. (23.1902 cm) above the bottom of the active fuel region. The configuration for *p50a* is shown in Fig. 96, while case *p50b* is illustrated in Fig. 97. The critical experiments have calculated k_{eff} (k_{calc}) values of 0.99909±0.00073 for case *p50a*, and 1.00070±0.00070 for case *p50b*.

These experiments demonstrated that the thicker sleeve was less effective than the thinner sleeve, and this was determined to be due partially to how well the sleeves fit around the core vessel. Another effect was also indicated, that the extra half inch of Binal was reflecting neutrons of sufficient energy to pass through the ¼–inch Binal back into the core. A similar thickness of water would thermalize the neutrons such that they would be absorbed in the ¼–inch Binal on the way back into the core. These experiments indicated an optimal absorber thickness.

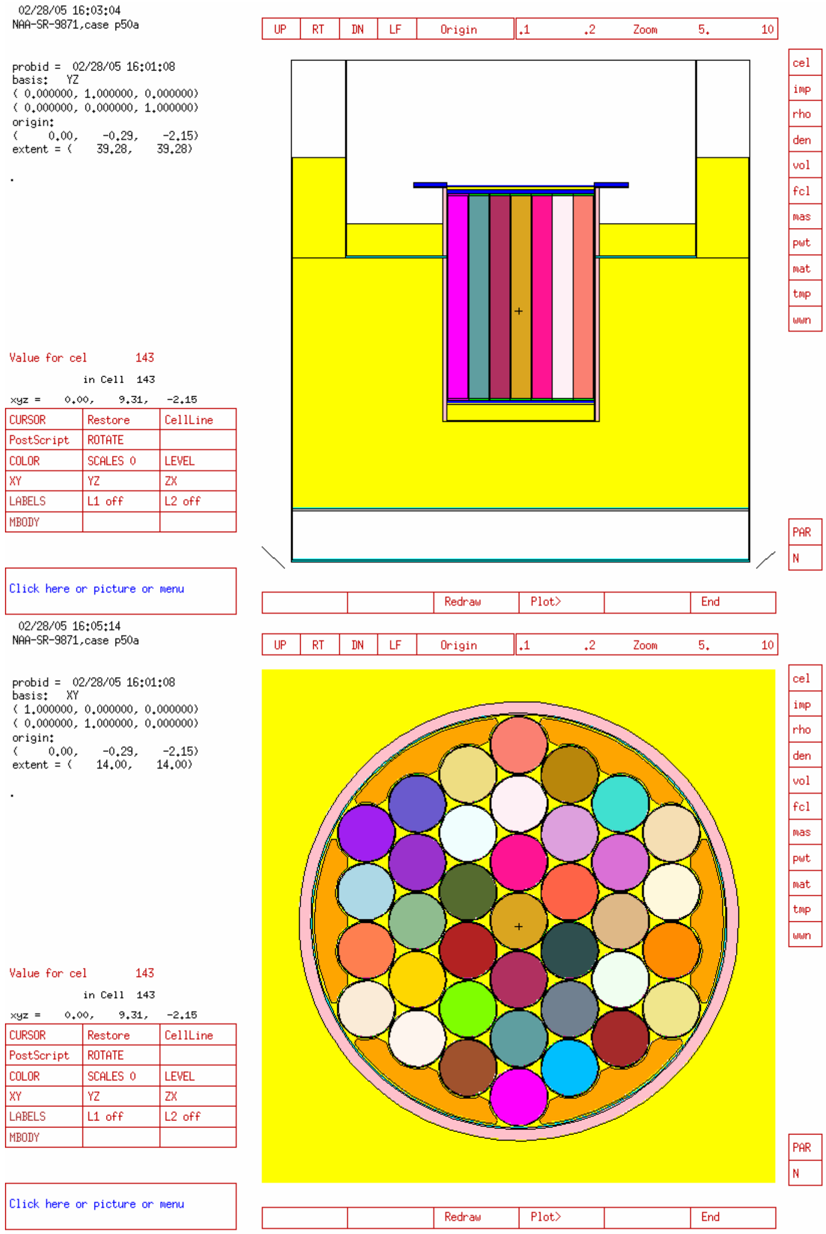


Fig. 96. Case *p50a* MCNP5 plot.

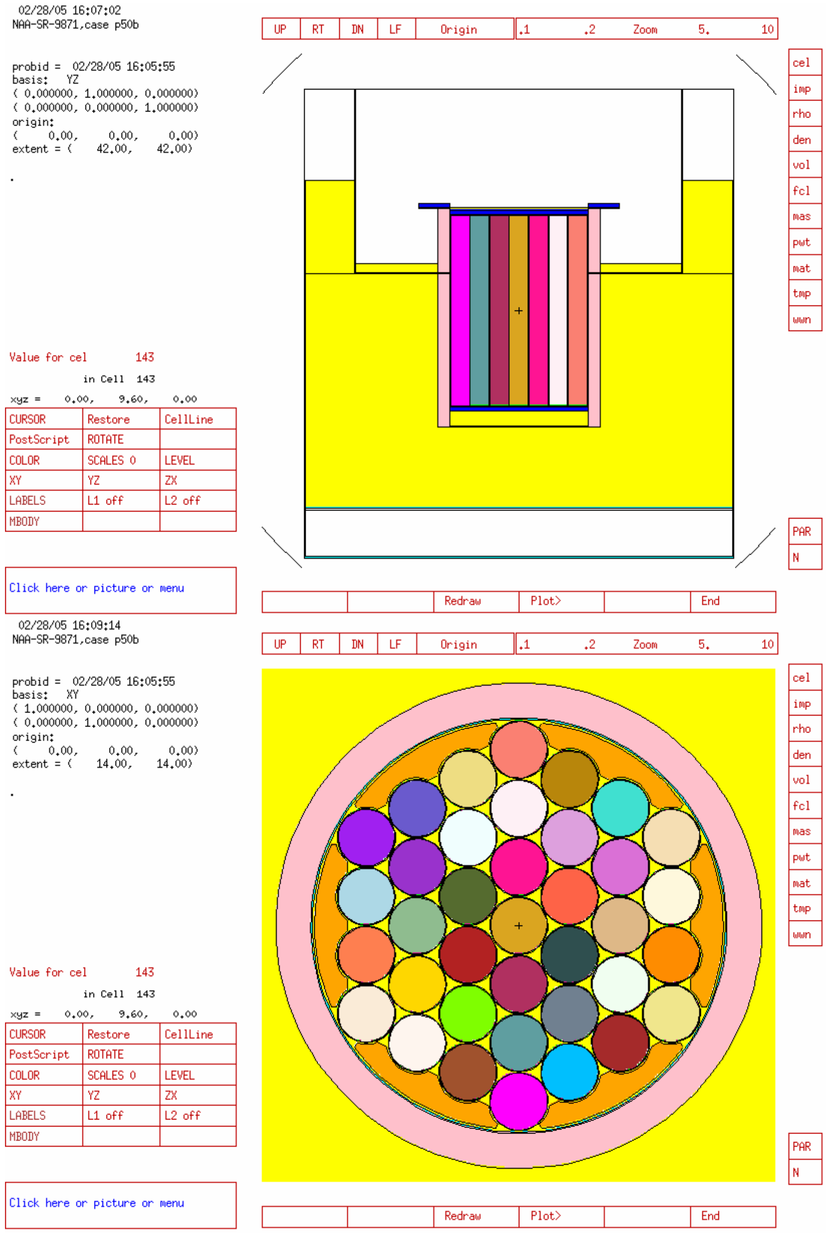


Fig. 97. Case *p50b* MCNP5 plot.

4.3.2 Void–Absorber Sleeve Combination

Several experiments were performed with a combination void/absorber sleeve in place to determine design criteria for a sleeve that would maintain subcritical conditions for a fully–flooded and reflected core. The void/absorber sleeve was comprised of a 3–in. (7.62–cm)–thick void sleeve, a 1–in. (2.54–cm)–thick absorber sleeve, and a 0.25–in. (0.635–cm)–thick steel sleeve. The sleeve assembly was described as covering the fuel region, and is therefore modeled as extending between the upper and lower grid plates. Based on the design criteria for a sleeve assembly specified as a result of these experiments, the void and absorber sleeves are assumed to have 0.031–inch–thick stainless steel walls. The interior of the void sleeve measures 3 in. (7.62 cm) in the radial direction, and the interior of the absorber sleeve measures 1 in. (2.54 cm). In some cases, two thin cadmium sheets (0.02–in. [0.0508–cm]–thick) were placed over the ends of the sleeve assembly. A photograph of a portion of the sleeve assembly is shown in Fig. 98, without the cadmium sheet.

The importance of the fit of a sleeve around the assembly was noted by the experimenters during the experiments discussed in Sect. 4.3.1.2. Noting this effect of possible water gaps created by poorly fitting sleeves, the cases modeling the void–absorber sleeve combination were calculated two ways. The first method (cases *p58* and *p59*) assumes that the sleeve components fit perfectly together and around the core, such that there are no water gaps to provide reflection. The second method (cases *p58gap* and *p59gap*) assumes a large gap exists between all the components, equal to 1/16 in. (0.15875 cm), which is assumed to be a bounding value for any possible gaps in the construction. The true construction of the sleeve is assumed to be bounded by these two models.

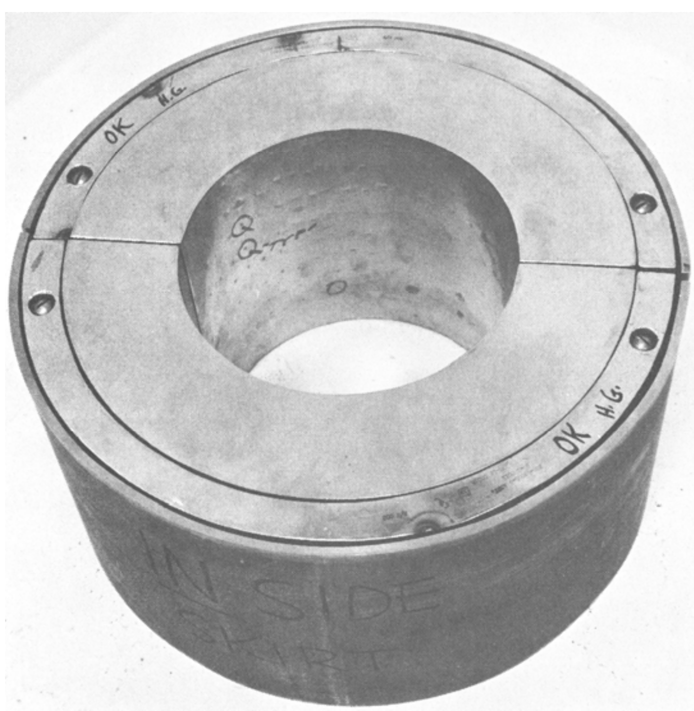


Fig. 98. Photograph of void/absorber sleeve assembly

(reproduced from Fig. 38 of NAA–SR–9871)

Cases *p58gap* and *p58*. For cases *p58* and *p58gap*, two thin cadmium sheets (0.02-in. [0.0508-cm]-thick) were placed over the ends of the sleeve assembly. The core was loaded with 36 fuel elements and one Lucite rod in the vacant position. The water level above the bottom of the active fuel region was 14.88 in. (37.7952 cm). This experiment was reported as critical. As previously noted, the difference between the *p58* and *p58gap* models is that the *p58gap* case accounts for a small water gap between each sleeve component, while *p58* does not. The configuration for p58gap is shown in Fig. 99 and Fig. 100. The water gap between the sleeve components can be seen in Fig. 100. A close–up of the sleeve assembly modeled for *p58* is shown in Fig. 101. The calculated k_{eff} (k_{calc}) value for *p58gap* is 0.99584±0.00072. The calculated k_{eff} (k_{calc}) value for *p58* is 0.99102±0.00072. Each calculated result is based on no fewer than two million active neutron histories.

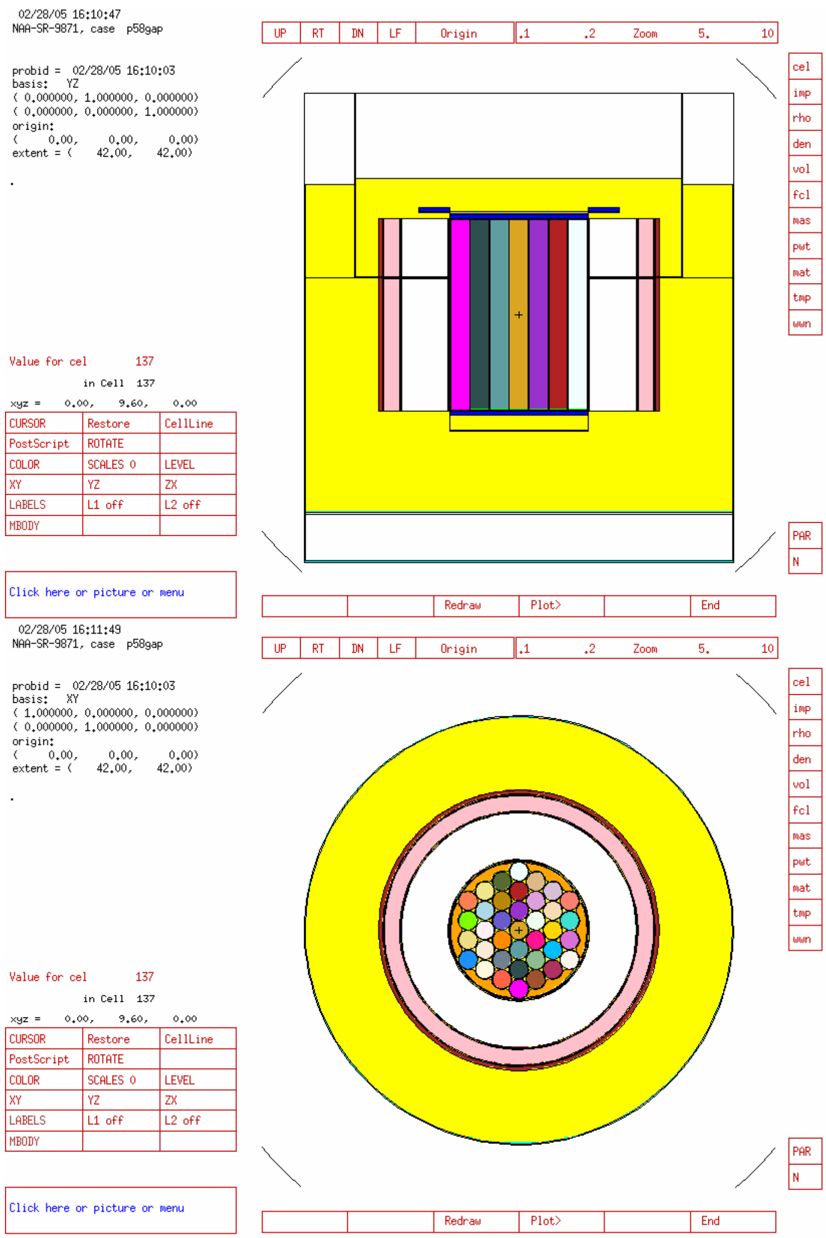


Fig. 99. Case *p58gap* MCNP5 plot.

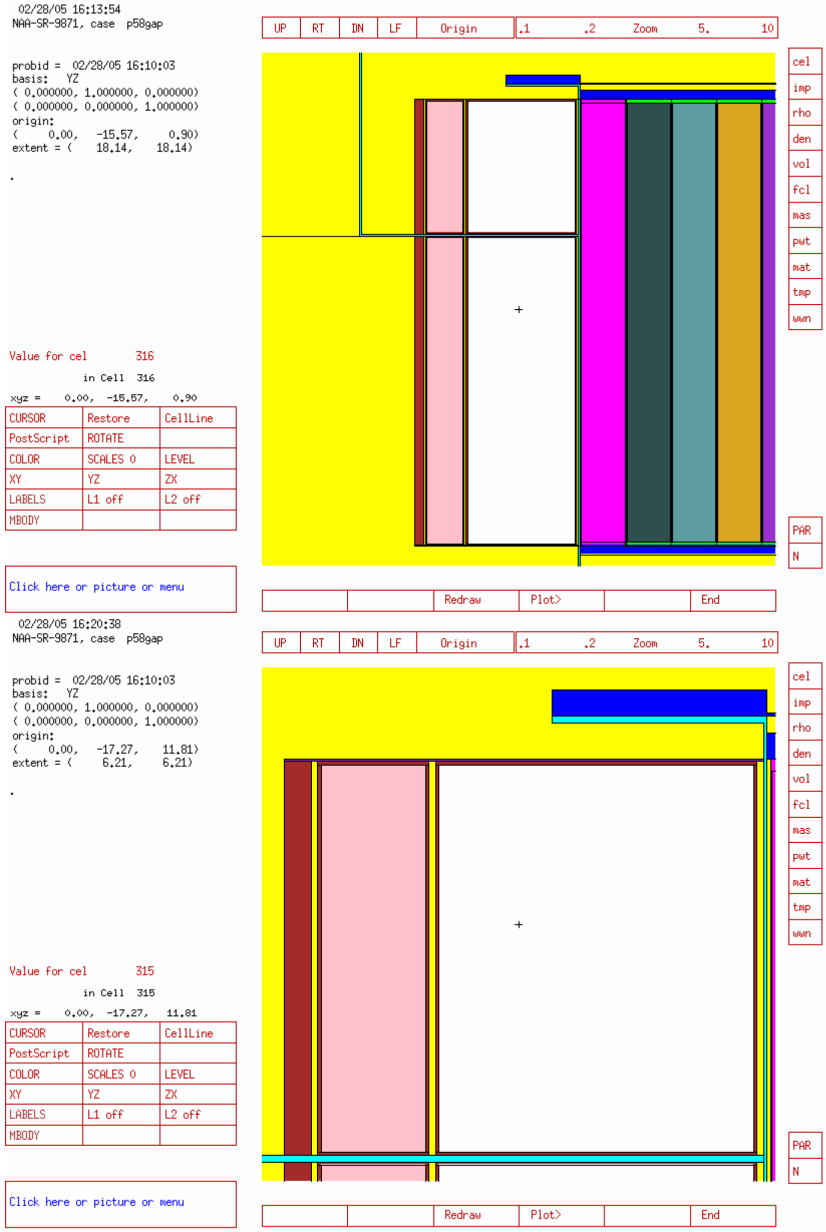


Fig. 100. Case *p58gap* side view–close–up of the void–absorber sleeve

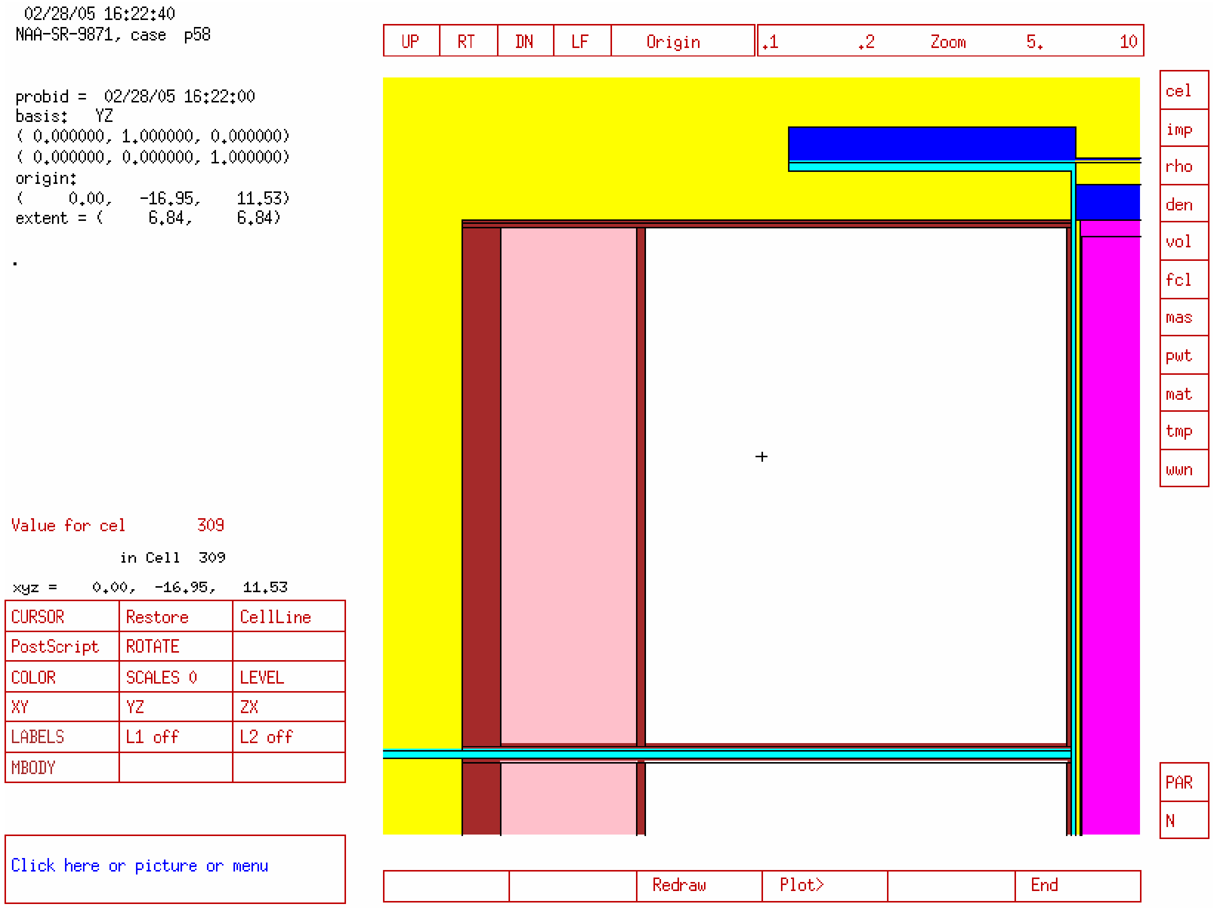


Fig. 101. Case *p58* side view–close–up of the void–absorber sleeve

Cases *p59gap* and *p59*. For cases *p59* and *p59gap*, the cadmium sheet was removed, and the water level was lowered to 12.41 in. (31.5215 cm) above the bottom of the active fuel region. The Lucite rod was removed, and the core was fully loaded. This experiment was reported to be critical. As with the cases *p58* and *p58gap*, the difference between the *p59* and *p59gap* models is that the *p59gap* case accounts for a small water gap between each sleeve component, while *p59* does not. The MCNP5 plots for *p59gap* are shown in Figs. 102–103. The calculated k_{eff} (k_{calc}) value for *p59gap* is 0.99278±0.00072. The calculated k_{eff} (k_{calc}) value for *p59* is 0.98559±0.00071. Each calculated result is based on no fewer than two million active neutron histories.

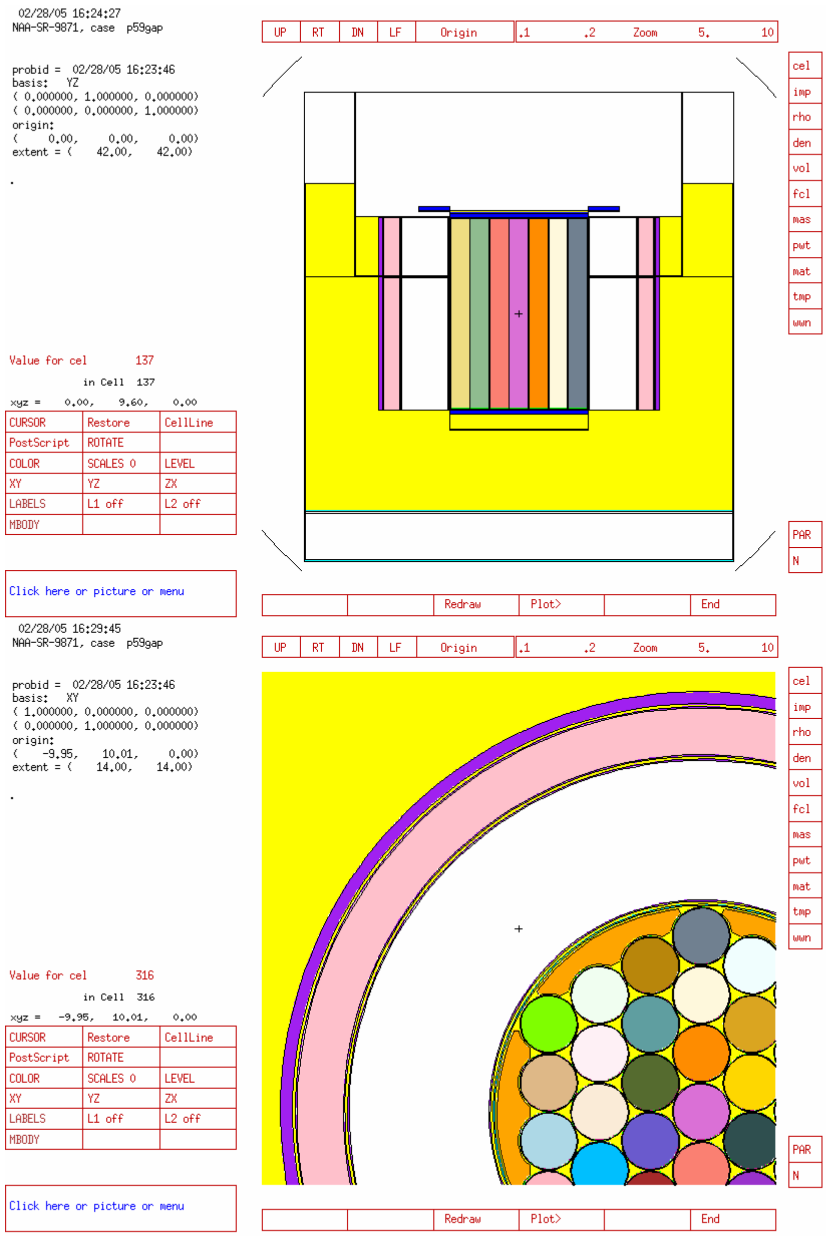


Fig. 102. Case ***p59gap*** **MCNP5 plot.**

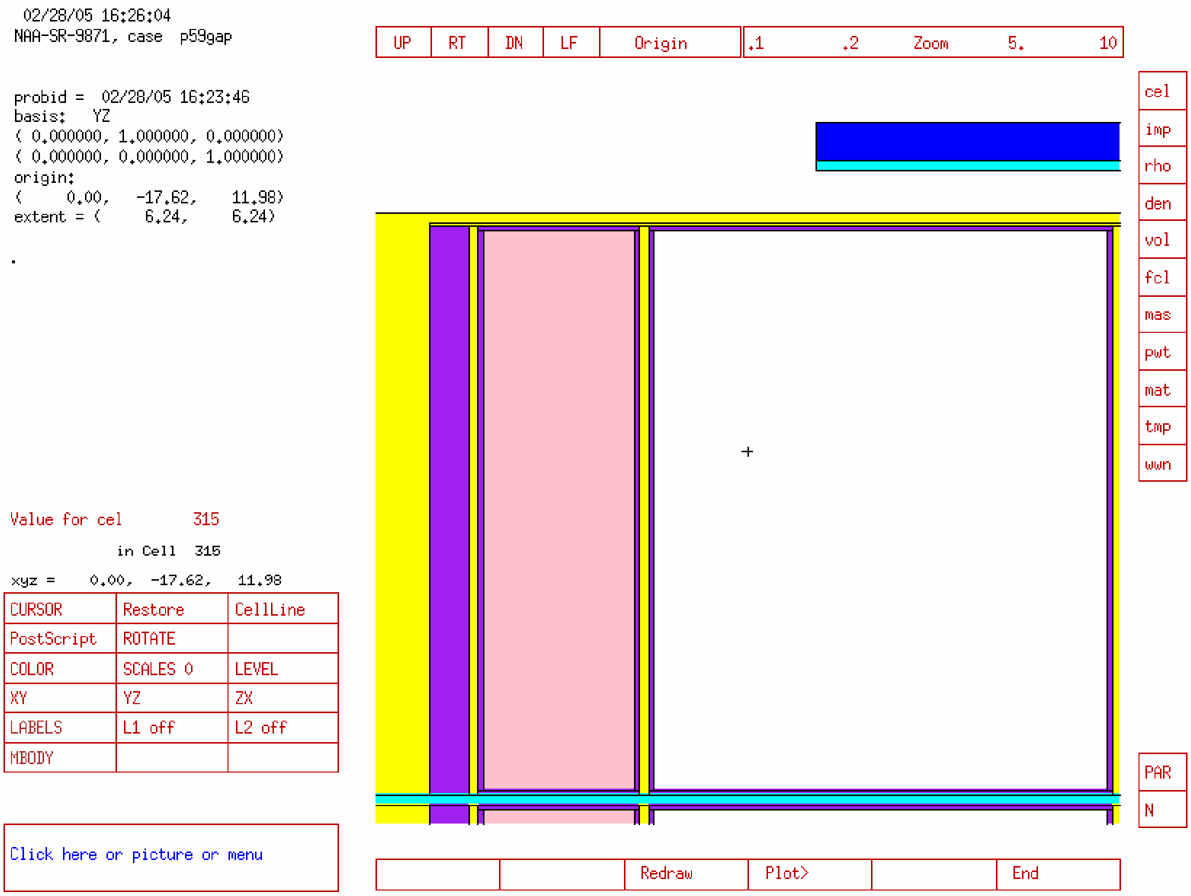


Fig. 103. Case *p59gap* side view–detail of the void–absorber sleeve

5. CONCLUSION

A total of 73 distinct configurations of SNAP 10A/2–type reactor fuel elements from the SCA-4B experimental criticality program conducted by Atomics International during the 1960's have been evaluated. Details sufficient to describe their materials and geometry are provided to permit the computation of the effective neutron multiplication factor (k_{eff}) for these configurations. The MCNP5 computed results indicate generally good agreement with the experimental results. Therefore, these configurations and their associated models for computation constitute valid benchmark candidates for prediction of critical conditions in SNAP 10A/2 applications, specifically, and for prediction of critical conditions in hydrogen–moderated systems of highly enriched uranium, generally.

6. REFERENCES

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9. D. A. Reed, *Software Quality Assurance Plan*, Operational Safety Services Division, Oak Ridge National Laboratory, Oak Ridge, TN, April 2005.

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11. Correspondence from D. A. Reed (UT–Battelle) to OSSD NCS Staff Files (UT–Battelle), “Reverification of SCALE 5.0 on Workstation *ossws6*,” Operational Safety Services Division, Oak Ridge National Laboratory, Oak Ridge, TN, April 1, 2005.

APPENDIX A

NUCLEAR CRITICALITY SAFETY RECORD OF COMPUTATIONAL REVIEW

RECORD OF NCS COMPUTATIONS TECHNICAL REVIEW

Application Scope and Description

Application/Document/Work Calculations Support
Validation of MCNP5 estimates of k_{eff} *for SNAP 10A/2 type reactor fuels and cores.*

List/Identify The Particular Calculations Reviewed
All cases were reviewed for consistency with presented assumptions and information.

Calculations Reviewed Were Performed by:
Allan W. Krass and Katherin L. Goluoglu

For The Indicated Application, Calculations And Conclusions Based On Those Calculations Were Verified As Correct:

By: Richard G. Taylor Date: 04/26/05
Richard G. Taylor

Description of Calculational Method

Controlled Codes/Data Sets Used
MCNP5 with ENDF B-V and ENDF B-VI neutron cross section libraries

Identify Computing Platform(s)
ORNL NCS staff workstation ossws6

Date(s) Verification Problem Set Last Executed
February 2005

Applicable Validation Reference(s)
N/A -- These cases constitute criticality benchmarks for validation.

Description of Review

Geometry and Atom Density Inputs Were Verified Using the Following Information:
The geometry and material inputs of the reviewed cases were reviewed for consistency with information presented within the report. Calculated results were also reviewed for consistency with experimental results.

Did the Review Include Verification of Code Input Options and Cross Section Treatments? *Yes*

Were Calculational Results Appropriately Corrected For Bias and Bias Uncertainty? *N/A*
Or, For Reviews of Validation Calculations,
Were Bias and Bias Uncertainty Appropriately Determined/Area of Applicability Defined? *Yes*

Were Independent Calculations Made As Part of the Review? *No - not required*
If Yes, Please Describe: *N/A*

Elaboration on Answers to Parts A, B, or C or Other Review Recommendations
None

APPENDIX B

MATERIAL MODELS FOR MCNP5 SNAP BENCHMARK CALCULATIONS

CONTENTS

B-1. SCA-4 FUEL (NAA-SR-8490)

Density (weighted average for all 37 fuel rod assemblies): 6.036 g/cm^3

Hydrogen content:
As determined by a weighted average from data in NAA-SR-8490 for all 37 fuel element assemblies, the hydrogen content is 6.483 x 10^{22} H atoms/cm^3; however, the hydrogen content is subsequently described in Ref. B-2 as having been over-stated due to an analytical laboratory bias by AI and revised downward to 6.40 x 10^{22} H atoms/cm^3.

Constituent masses (total for all 37 fuel rod assemblies):
51,722.59 grams fuel, total. The uranium is assumed to be ^{235}U and ^{238}U, which are the only isotopes reported in Ref. B-1. (The ^{234}U contribution is assumed to be negligible, and any uncertainty associated with it is accounted for in the total combined uncertainty of the benchmark model [0.008]. This is based on sensitivity calculations reported in Ref. B-16 for other benchmark applications. The study varied the ^{234}U content by ±20%. In all cases, the resultant change in k_{eff} was less than 0.0007 Δk, and the effect was judged to be insignificant.)

4,760.38 grams ^{235}U (5,104.02 grams total U)
917.79 grams H (based on 6.40 x 10^{22} H atoms/cm^3 and 6.036 g/cm^3)
45,700.78 grams Zr (by difference)
(Ref's B-1 and B-3)

Therefore:
$N_{U\text{-}235}$ = (4,760.38/51,722.59)(6.036)(0.60221367)/(235.043924)
= 0.0014234 ^{235}U atom/bn·cm
$N_{U\text{-}238}$ = [(5,104.02 – 4,760.38)/ 51,722.59](6.036)(0.60221367)/(238.050785)
= 0.0001015 ^{238}U atom/bn·cm
N_{Zr} = (45,700.78/ 51,722.59)(6.036)(0.60221367)/(91.224)
= 0.0352074 Zr atom/bn·cm
N_H = 0.0640000 H atom/bn·cm (p. 61, NAA-SR-8613)

Thus:
$N_{Total} = \sum N$ = 0.1007323 atom/bn·cm

B-2. BERYLLIUM METAL

Density: 1.82 g/cm^3 (Ref. B-4)
Composition: 100 percent Be, by weight
Atomic weight (Be): 9.01218 g/mole (Ref. B-3)

Thus:
$N_{Total} = N_{Be}$ = (1.82)(0.60221367)/(9.01218) = 0.1216164 Be atom/bn·cm

B-3. LUCITE®

Density: 1.18 g/cm^3 (Ref. B-5)
Composition: $C_5H_8O_2$ (Ref. B-5)
Molecular weight ($C_5H_8O_2$): 100.117 g/mole

Therefore:
N_{C5H8O2} = (1.18)(0.60221367)/(100.117) = 7.097817e-3 $C_5H_8O_2$ molecule/bn·cm

Where:
$N_C = 5N_{C5H8O2}$ = 0.0354891 C atom/bn·cm
$N_H = 8N_{C5H8O2}$ = 0.0567825 H atom/bn·cm
$N_O = 2N_{C5H8O2}$ = 0.0141956 O atom/bn·cm

Thus:
$N_{Total} = \sum N$ = 0.1064672 atom/bn·cm

B-4. TYPE 1100 ALUMINUM

Density: 2.7 g/cm^3 (Ref. B-6)
Composition: 100 percent Al, by weight
Atomic weight (Al): 26.98154 g/mole

Thus:
$N_{Total} = N_{Al}$ = (2.7)(0.60221367)/(26.98154) = 0.0602626 Al atom/bn·cm

B-5. BORATED ALUMINUM (BINAL) FOR AI SLEEVES

Description: A dispersion of $^{nat}B_4C$ in aluminum (i.e., a volume-additive mixture) (Ref. B-1)
Composition: $^{nat}B_4C$ plus Al, 10.2% B by weight
Density of $^{nat}B_4C$: 2.52 g/cm^3
Density of Al: 2.70 g/cm^3

Therefore:

Information taken from Ref. B-3:
Atomic weight of Al: 26.98154 g Al/mole
Isotopic abundance of ^{nat}B: 19.9 atom percent ^{10}B plus 80.1 atom percent ^{11}B
Molecular weight of $^{nat}B_4C$= (4)(10.8110687)+(12.0107)=55.255 g $^{nat}B_4C$/mole
Fraction of $^{nat}B_4C$ that is carbon=12.0107/55.255=0.217369
Fraction of $^{nat}B_4C$ that is boron=(4)(10.8110687)/55.255=0.782631
(0.102)(wt. of Binal)=(0.782631)(wt. of $^{nat}B_4C$ only)
(0.102)/(0.782631)= (wt. of $^{nat}B_4C$ only)/ (wt of Binal)=0.13032

Final density of the Binal $=[(0.13032/2.51)+(0.869682/2.7)]^{-1}=2.6736$ g/cc

Thus:
$N_C = N_{natB4C} = 3.79734e\text{-}3$ C atom/bn·cm
$N_{B\text{-}10} = (0.199)\ (3.79734e\text{-}3)(4) = 0.0030227$ ^{10}B atom/bn·cm
$N_{B\text{-}11} = (0.801)(3.79734e\text{-}3)(4)=0.00121667$ ^{11}B atom/bn·cm
$N_{Al} = (0.869682)(2.6736)(0.60221367)/(26.98538)=5.18894e\text{-}2$ Al atoms/bn·cm

Where:
$N_{Total} = N_{Al} + N_C + N_{B\text{-}10} + N_{B\text{-}11} = 0.0708762$ atom/bn·cm

B-6. HYDROGEN BARRIER COATING FOR SCA-4 FUEL

AI Specification (ca.1961): 6.6 ± 0.66 mg Sm_2O_3/inch of fuel (Ref. B-7)
AI Specification (ca.1964): 8.0 ± 0.8 mg Sm_2O_3/inch of fuel (Ref. B-8)

The poison coat content is unspecified for SCA-4 fuel, specifically, but it is assumed to follow the AI specification ca.1961 (Ref. B-6). The total poison coat weight is fully detailed for fuel fabricated to the AI specification ca.1964 in the form of SNAPTRAN V fuel (Ref. B-9).

Mass of Sm_2O_3 (for all 37 SNAPTRAN V elements): 3.5919 g Sm_2O_3
Mass of coating (for all 37 SNAPTRAN V elements): 220.57 g = sum of the total poison coat weights for the individual elements

Thus, the SNAPTRAN V fuel actually contains:
[(1000 mg/g)(3.5919 g Sm_2O_3)/[(37)(12.25-inches)] = 7.9 mg Sm_2O_3/inch of fuel

It will be assumed that the poison coat for the SNAPTRAN V fuel is the same in every respect as that of the SCA-4 fuel, except for the proportion of Sm_2O_3 in the coating. It is also assumed that the poison coat occupies the entire radial gap volume between the fuel rod and the cladding tube.

So, 37 SCA-4 fuel elements are estimated to proportionally contain:
= [(6.6 mg Sm_2O_3/in.)$_{\text{SCA-4}}$ /(7.9 mg Sm_2O_3/in.)$_{\text{SNAPTRAN V}}$](3.5919 g Sm_2O_3)$_{\text{SNAPTRAN V}}$
= 3.00 g Sm_2O_3

It is assumed that 37 SCA-4 fuel elements require the same total coat weight (220.57 g) as do the 37 SNAPTRAN V fuel elements, so the remainder (217.57 g) is ". . . oxides of Al, Si, Ti, Mn, and Ba with smaller amounts of Na, Li, and K." (Ref. B-7, pp. 51-52); however, the composition is simplified as a 50/50 mixture of Al_2O_3 and SiO_2, by weight.

Occupied volume (gaps for all 37 SCA-4 fuel elements):
$V = 37\pi(12.225\text{ in})[(0.615\text{ in})^2 – (0.606\text{ in})^2](2.54\text{ cm/in})^3 = 255.894\text{ cm}^3$

Using atomic data taken from Ref. B-3:
Molecular weight of Sm_2O_3: 348.7982 g Sm_2O_3/mole
Molecular weight of Al_2O_3: 101.96128 g Al_2O_3/mole
Molecular weight of SiO_2: 60.0843 g SiO_2/mole

N_{Sm2O3} = (3.00/255.894)(0.60221367)/(348.7982) = 2.024e-5 Sm_2O_3 molecule/bn·cm
N_{Al2O3} = ½(217.57/255.894)(0.60221367)/(101.96128) = 2.51087e-3 Al_2O_3 molecule/bn·cm
N_{SiO2} = ½(217.57/225.894)(0.60221367)/(60.0843) = 4.2609e-3 SiO_2 molecule/bn·cm

Isotopic abundance of Sm (by atom percent):
~~3.1% ^{144}Sm~~ + 15.0% ^{147}Sm + ~~11.3% ^{148}Sm~~ + 13.8% ^{149}Sm + 7.4% ^{150}Sm +
26.7% ^{152}Sm + ~~22.7% ^{154}Sm~~
NOTE: ~~Strikethrough~~ text indicates isotopes omitted due to lack of neutron cross section data in MCNP5. They have low/negligible neutron absorption cross sections so the abundance of the remaining isotopes remains unadjusted.
Therefore:
$N_{Sm\text{-}147} = (0.150)2N_{Sm2O3}$ = 0.0000061 ^{147}Sm atom/bn·cm
$N_{Sm\text{-}149} = (0.138)2N_{Sm2O3}$ = 0.0000056 ^{149}Sm atom/bn·cm

$N_{Sm-150} = (0.074)2N_{Sm2O3} = 0.0000030$ ^{150}Sm atom/bn·cm
$N_{Sm-152} = (0.267)2N_{Sm2O3} = 0.0000108$ ^{152}Sm atom/bn·cm
$N_{Al} = 2N_{Al2O3} = 0.0050217$ Al atom/bn·cm
$N_{Si} = N_{SiO2} = 0.0042609$ Si atom/bn·cm
$N_{O} = 3N_{Sm2O3} + 3N_{Al2O3} + 2N_{SiO2} = 0.0161151$ O atom/bn·cm

Thus:
$N_{Total} = \sum N = 0.0254232$ atom/bn·cm

B-7. HASTELLOY® N

Density: 8.86 g/cm^3 (Ref. B-10)
Composition (by weight fraction):
0.71 Ni
0.07 Cr
0.16 Mo
0.05 Fe
0.01 Si
(contributions from other elements neglected)
Isotopic abundance for selected elements (by atom percent):
Ni = 68.27% ^{58}Ni + 26.10% ^{60}Ni + 1.13% ^{61}Ni + 3.59% ^{62}Ni + 0.91% ^{64}Ni
Cr = 4.345% ^{50}Cr + 83.790% ^{52}Cr + 9.500% ^{53}Cr + 2.365% ^{54}Cr
Fe = 5.90% ^{54}Fe + 91.72% ^{56}Fe + 2.10% ^{57}Fe + 0.28% ^{58}Fe

Therefore:
$N_{Ni-58} = (0.6827)(0.71)(8.86)(0.60221367)/(58.70) = 0.0440590$ ^{58}Ni atom/bn·cm
$N_{Ni-60} = (0.2610)(0.71)(8.86)(0.60221367)/(58.70) = 0.0168440$ ^{60}Ni atom/bn·cm
$N_{Ni-61} = (0.0113)(0.71)(8.86)(0.60221367)/(58.70) = 0.0007293$ ^{61}Ni atom/bn·cm
$N_{Ni-62} = (0.0359)(0.71)(8.86)(0.60221367)/(58.70) = 0.0023169$ ^{62}Ni atom/bn·cm
$N_{Ni-64} = (0.0091)(0.71)(8.86)(0.60221367)/(58.70) = 0.0005873$ ^{64}Ni atom/bn·cm
$N_{Cr-50} = (0.04345)(0.07)(8.86)(0.60221367)/(51.996) = 0.0003121$ ^{50}Cr atom/bn·cm
$N_{Cr-52} = (0.83790)(0.07)(8.86)(0.60221367)/(51.996) = 0.0060187$ ^{52}Cr atom/bn·cm
$N_{Cr-53} = (0.09500)(0.07)(8.86)(0.60221367)/(51.996) = 0.0006824$ ^{53}Cr atom/bn·cm
$N_{Cr-54} = (0.02365)(0.07)(8.86)(0.60221367)/(51.996) = 0.0001699$ ^{54}Cr atom/bn·cm
$N_{Mo} = (0.16)(8.86)(0.60221367)/(95.94) = 0.0088982$ Mo atom/bn·cm
$N_{Fe-54} = (0.0590)(0.05)(8.86)(0.60221367)/(55.847) = 0.0002818$ ^{54}Fe atom/bn·cm
$N_{Fe-56} = (0.9172)(0.05)(8.86)(0.60221367)/(55.847) = 0.0043815$ ^{56}Fe atom/bn·cm
$N_{Fe-57} = (0.0210)(0.05)(8.86)(0.60221367)/(55.847) = 0.0001003$ ^{57}Fe atom/bn·cm
$N_{Fe-58} = (0.0028)(0.05)(8.86)(0.60221367)/(55.847) = 0.0000134$ ^{58}Fe atom/bn·cm
$N_{Si} = (0.01)(8.86)(0.60221367)/(28.0855) = 0.0018998$ Si atom/bn·cm

Thus:
$N_{Total} = \sum N = 0.0872946$ atom/bn·cm

B-8. HASTELLOY® C

Density: 8.27 g/cm^3
Composition (by weight fraction): (Ref. B-11, Note 8)
0.4200 Ni
0.5715 Fe
0.0050 Mn
0.0025 Si
0.0010 C
Isotopic abundance for selected elements (by atom percent):
Ni = 68.27% ^{58}Ni + 26.10% ^{60}Ni + 1.13% ^{61}Ni + 3.59% ^{62}Ni + 0.91% ^{64}Ni
Fe = 5.90% ^{54}Fe + 91.72% ^{56}Fe + 2.10% ^{57}Fe + 0.28% ^{58}Fe

Therefore:
N_{Ni-58} = (0.6827)(0.4200)(8.27)(0.60221367)/(58.70) = 0.0243275 ^{58}Ni atom/bn·cm
N_{Ni-60} = (0.2610)(0.4200)(8.27)(0.60221367)/(58.70) = 0.0093005 ^{60}Ni atom/bn·cm
N_{Ni-61} = (0.0113)(0.4200)(8.27)(0.60221367)/(58.70) = 0.0004027 ^{61}Ni atom/bn·cm
N_{Ni-62} = (0.0359)(0.4200)(8.27)(0.60221367)/(58.70) = 0.0012793 ^{62}Ni atom/bn·cm
N_{Ni-64} = (0.0091)(0.4200)(8.27)(0.60221367)/(58.70) = 0.0003243 ^{64}Ni atom/bn·cm
N_{Fe-54} = (0.0590)(0.5715)(8.27)(0.60221367)/(55.847) = 0.0030069 ^{54}Fe atom/bn·cm
N_{Fe-56} = (0.9172)(0.5715)(8.27)(0.60221367)/(55.847) = 0.0467451 ^{56}Fe atom/bn·cm
N_{Fe-57} = (0.0210)(0.5715)(8.27)(0.60221367)/(55.847) = 0.0010703 ^{57}Fe atom/bn·cm
N_{Fe-58} = (0.0028)(0.5715)(8.27)(0.60221367)/(55.847) = 0.0001427 ^{58}Fe atom/bn·cm
N_{Mn} = (0.0050)(8.27)(0.60221367)/(54.9380) = 0.0004533 Mn atom/bn·cm
N_{Si} = (0.0025)(8.27)(0.60221367)/(28.0855) = 0.0004433 Si atom/bn·cm
N_C = (0.0010)(8.27)(0.60221367)/(12.011) = 0.0004146 C atom/bn·cm

Thus:
$N_{Total} = \sum N$ = 0.0879105 atom/bn·cm

B-9. SS304

Density: 7.92 g/cm^3 (Ref. B-4)
Composition (by weight fraction):
0.695 Fe
0.190 Cr
0.095 Ni
0.020 Mn
Isotopic abundance for selected elements (by atom percent):
Fe = 5.90% ^{54}Fe + 91.72% ^{56}Fe + 2.10% ^{57}Fe + 0.28% ^{58}Fe
Cr = 4.345% ^{50}Cr + 83.790% ^{52}Cr + 9.500% ^{53}Cr + 2.365% ^{54}Cr
Ni = 68.27% ^{58}Ni + 26.10% ^{60}Ni + 1.13% ^{61}Ni + 3.59% ^{62}Ni + 0.91% ^{64}Ni

Therefore:
$N_{Fe\text{-}54}$ = (0.0590)(0.695)(7.92)(0.60221367)/(55.847) = 0.0035020 ^{54}Fe atom/bn·cm
$N_{Fe\text{-}56}$ = (0.9172)(0.695)(7.92)(0.60221367)/(55.847) = 0.0544408 ^{56}Fe atom/bn·cm
$N_{Fe\text{-}57}$ = (0.0210)(0.695)(7.92)(0.60221367)/(55.847) = 0.0012465 ^{57}Fe atom/bn·cm
$N_{Fe\text{-}58}$ = (0.0028)(0.695)(7.92)(0.60221367)/(55.847) = 0.0001662 ^{58}Fe atom/bn·cm
$N_{Cr\text{-}50}$ = (0.04345)(0.190)(7.92)(0.60221367)/(51.996) = 0.0007573 ^{50}Cr atom/bn·cm
$N_{Cr\text{-}52}$ = (0.83790)(0.190)(7.92)(0.60221367)/(51.996) = 0.0146033 ^{52}Cr atom/bn·cm
$N_{Cr\text{-}53}$ = (0.09500)(0.190)(7.92)(0.60221367)/(51.996) = 0.0016557 ^{53}Cr atom/bn·cm
$N_{Cr\text{-}54}$ = (0.02365)(0.190)(7.92)(0.60221367)/(51.996) = 0.0004122 ^{54}Cr atom/bn·cm
$N_{Ni\text{-}58}$ = (0.6827)(0.095)(7.92)(0.60221367)/(58.70) = 0.0052698 ^{58}Ni atom/bn·cm
$N_{Ni\text{-}60}$ = (0.2610)(0.095)(7.92)(0.60221367)/(58.70) = 0.0020147 ^{60}Ni atom/bn·cm
$N_{Ni\text{-}61}$ = (0.0113)(0.095)(7.92)(0.60221367)/(58.70) = 0.0000872 ^{61}Ni atom/bn·cm
$N_{Ni\text{-}62}$ = (0.0359)(0.095)(7.92)(0.60221367)/(58.70) = 0.0002771 ^{62}Ni atom/bn·cm
$N_{Ni\text{-}64}$ = (0.0091)(0.095)(7.92)(0.60221367)/(58.70) = 0.0000702 ^{64}Ni atom/bn·cm
N_{Mn} = (0.020)(7.92)(0.60221367)/(54.9380) = 0.0017363 Mn atom/bn·cm

Thus:
$N_{Total} = \sum N$ = 0.0862393 atom/bn·cm

B-10. SS316

Density: 8.03 g/cm^3 (calculated from isotopic distribution)
Composition (by weight fraction): (Ref. B-4)
0.655 Fe
0.170 Cr
0.120 Ni
0.025 Mo
0.020 Mn
0.010 Si
Isotopic abundance for selected elements (by atom percent):
Fe = 5.90% ^{54}Fe + 91.72% ^{56}Fe + 2.10% ^{57}Fe + 0.28% ^{58}Fe
Cr = 4.345% ^{50}Cr + 83.790% ^{52}Cr + 9.500% ^{53}Cr + 2.365% ^{54}Cr
Ni = 68.27% ^{58}Ni + 26.10% ^{60}Ni + 1.13% ^{61}Ni + 3.59% ^{62}Ni + 0.91% ^{64}Ni

Therefore:
$N_{Fe\text{-}54}$ = (0.0590)(0.655)(8.03)(0.60221367)/(55.847) = 0.0033463 ^{54}Fe atom/bn·cm
$N_{Fe\text{-}56}$ = (0.9172)(0.655)(8.03)(0.60221367)/(55.847) = 0.0520202 ^{56}Fe atom/bn·cm
$N_{Fe\text{-}57}$ = (0.0210)(0.655)(8.03)(0.60221367)/(55.847) = 0.0011910 ^{57}Fe atom/bn·cm
$N_{Fe\text{-}58}$ = (0.0028)(0.655)(8.03)(0.60221367)/(55.847) = 0.0001588 ^{58}Fe atom/bn·cm
$N_{Cr\text{-}50}$ = (0.04345)(0.170)(8.03)(0.60221367)/(51.996) = 0.0006870 ^{50}Cr atom/bn·cm
$N_{Cr\text{-}52}$ = (0.83790)(0.170)(8.03)(0.60221367)/(51.996) = 0.0132476 ^{52}Cr atom/bn·cm
$N_{Cr\text{-}53}$ = (0.09500)(0.170)(8.03)(0.60221367)/(51.996) = 0.0015020 ^{53}Cr atom/bn·cm
$N_{Cr\text{-}54}$ = (0.02365)(0.170)(8.03)(0.60221367)/(51.996) = 0.0003739 ^{54}Cr atom/bn·cm
$N_{Ni\text{-}58}$ = (0.6827)(0.120)(8.03)(0.60221367)/(58.70) = 0.0067490 ^{58}Ni atom/bn·cm
$N_{Ni\text{-}60}$ = (0.2610)(0.120)(8.03)(0.60221367)/(58.70) = 0.0025802 ^{60}Ni atom/bn·cm
$N_{Ni\text{-}61}$ = (0.0113)(0.120)(8.03)(0.60221367)/(58.70) = 0.0001117 ^{61}Ni atom/bn·cm
$N_{Ni\text{-}62}$ = (0.0359)(0.120)(8.03)(0.60221367)/(58.70) = 0.0003549 ^{62}Ni atom/bn·cm
$N_{Ni\text{-}64}$ = (0.0091)(0.120)(8.03)(0.60221367)/(58.70) = 0.0000900 ^{64}Ni atom/bn·cm
N_{Mo} = (0.025)(8.03)(0.60221367)/(95.94) = 0.0012601 Mo atom/bn·cm
N_{Mn} = (0.020)(8.03)(0.60221367)/(54.9380) = 0.0017604 Mn atom/bn·cm
N_{Si} = (0.010)(8.03)(0.60221367)/(28.0855) = 0.0017218 Si atom/bn·cm

Thus:
$N_{Total} = \sum N$ = 0.0871549 atom/bn·cm

B-11. NAK

Density: 0.866 g/cm^3 (Ref. B-12)
Composition: 22% Na plus 78% K, by weight (Ref. B-13)

N_{Na} = (0.22)(0.866)(0.60221367)/(22.98977) = 0.0049906 Na atom/bn·cm
N_K = (0.78)(0.866)(0.60221367)/(39.0983) = 0.0104041 K atom/bn·cm

Thus:
$N_{Total} = N_{Na} + N_K$ = 0.0153947atom/bn·cm

B-12. WATER

Density: 0.9982 g/cm^3
Molecular weight (H_2O): 18.0152 g/mole

N = (0.9982)(0.60221367)/(18.0152) = 0.0333679 H_2O molecule/bn·cm
Where:
N_O = N = 0.0333679 O atom/bn·cm
N_H = 2N = 0.0667358 H atom/bn·cm

Thus:
N_{Total} = N_O + N_H = 0.1001037 atom/bn·cm

B-13. BORON POWDER FOR AI SLEEVE

Density: 20-22% of theoretical=0.45 g/cm^3 (Ref. B-7)
Atomic weight: 10.81 g/mole
Isotopic abundance of ^{nat}B: 19.9 atom percent ^{10}B plus 80.1 atom percent ^{11}B

N_{Total} = (0.45)(0.60221367)/(10.81) = 0.0250690 B atom/bn·cm

Where:
$N_{B\text{-}10}$ = (0.199)N_{Total} = 0.0049887 ^{10}B atom/bn·cm
$N_{B\text{-}11}$ = (0.801)N_{Total} = 0.0200803 ^{11}B atom/bn·cm

B-14. BORATED WATER (4.54 KG $NH_4{}^{NAT}B_5O_8{\cdot}4H_2O$ IN 39 GAL. OF WATER)

Information is taken from Ref. B-1.
39 gallons of water = 147.7 kg of water
Molecular weight of $NH_4{}^{nat}B_5O_8{\cdot}4H_2O$ (borate): 272.1443 g/mole
Molecular weight of H_2O (water): 18.0152 g/mole
Total mass of borated solution: 4.54 kg borate + 147.7 kg water = 152.24 kg solution
$N_B = 3.33 \times 10^{20}$ B atoms/cm^3 = 0.0003330 B atoms/bn·cm
Isotopic abundance of ^{nat}B: 19.9 atom percent ^{10}B plus 80.1 atom percent ^{11}B

By definition:

wf_{borate} = (4.54 kg borate/152.24 kg solution)
$N_{borate} = N_B/5 = 6.66 \times 10^{19}$ molecules/cm^3
$N_{borate} = (wf_{borate})(\rho_{solution})(N_{Avogadro}/MW_{borate}) = (4.54/152.24)(\rho_{solution})(6.0221367 \times 10^{23})/(272.1443)$

Thus:

$\rho_{solution} = 1.0092$ g/cm^3
$N_{borate} = (4.54/152.24)(1.0092)(0.60221367)/(272.1443) = 6.65971565e\text{-}5$ molecule/bn·cm
$N_{H2O} = (147.7/152.24)(1.0092)(0.60221367)/(18.0152) = 3.27295839e\text{-}2$ molecule/bn·cm

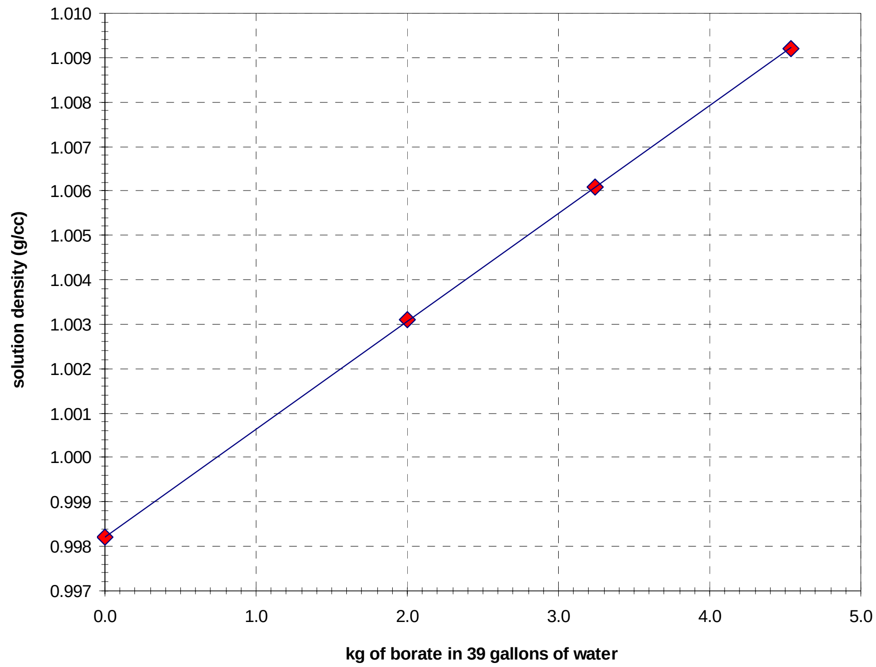
Therefore:

$N_H = 2N_{H2O} + 12N_{borate} = 0.0662583$ H atom/bn·cm
$N_{B\text{-}10} = (0.199)5N_{borate} = 0.0000663$ ^{10}B atom/bn·cm
$N_{B\text{-}11} = (0.801)5N_{borate} = 0.0002667$ ^{11}B atom/bn·cm
$N_N = N_{borate} = 0.0000666$ N atom/bn·cm
$N_O = N_{H2O} + 12N_{borate} = 0.0335287$ O atom/bn·cm

Where:

$N_{Total} = \sum N = 0.1001866$ atom/bn·cm

The densities of similarly borated solutions are estimated by linear interpolation between the density of pure water (0.9982 g/cm^3) and the density of solution with 4.54 kg of $NH_4{}^{nat}B_5O_8{\cdot}4H_2O$ in 39 gallons of water (1.0092 g/cm^3), as illustrated below. Specifically, the density of a solution with 3.24 kg of $NH_4{}^{nat}B_5O_8{\cdot}4H_2O$ in 39 gallons of water is estimated to be about 1.0061 g/cm^3, and the density of a solution with 2.00 kg of $NH_4{}^{nat}B_5O_8{\cdot}4H_2O$ in 39 gallons of water is estimated to be about 1.0031 g/cm^3.



B-15. BORATED WATER (3.24 KG $NH_4{}^{NAT}B_5O_8{\cdot}4H_2O$ IN 39 GAL. OF WATER)

Information is taken from Ref. B-1.
39 gallons of water = 147.7 kg of water
Molecular weight of $NH_4{}^{nat}B_5O_8{\cdot}4H_2O$ (borate): 272.1443 g/mole
Molecular weight of H_2O (water): 18.0152 g/mole
Total mass of borated solution: 3.24 kg borate + 147.7 kg water = 150.94 kg solution
Solution density: 1.0061 g/cm^3
Isotopic abundance of ^{nat}B: 19.9 atom percent ^{10}B plus 80.1 atom percent ^{11}B

Thus:

N_{borate} = (3.24/150.94)(1.0061)(0.60221367)/(272.1443) = 4.77895764e-5 molecule/bn·cm
N_{H2O} = (147.7/150.94)(1.0061)(0.60221367)/(18.0152) = 3.29100711e-2 molecule/bn·cm

Therefore:

$N_H = 2N_{H2O} + 12N_{borate}$ = 0.0663936 H atom/bn·cm
$N_{B-10} = (0.199)5N_{borate}$ = 0.0000475 ^{10}B atom/bn·cm
$N_{B-11} = (0.801)5N_{borate}$ = 0.0001914 ^{11}B atom/bn·cm
$N_N = N_{borate}$ = 0.0000478 N atom/bn·cm
$N_O = N_{H2O} + 12N_{borate}$ = 0.0334835 O atom/bn·cm

Where:

$N_{Total} = \sum N$ = 0.1001638 atom/bn·cm

B-16. BORATED WATER (2.00 KG $NH_4{}^{NAT}B_5O_8{\cdot}4H_2O$ IN 39 GAL. OF WATER)

Information is taken from Ref. B-1.
39 gallons of water = 147.7 kg of water
Molecular weight of $NH_4{}^{nat}B_5O_8{\cdot}4H_2O$ (borate): 272.1443 g/mole
Molecular weight of H_2O (water): 18.0152 g/mole
Total mass of borated solution: 2.00 kg borate + 147.7 kg water = 149.7 kg solution
Solution density: 1.0031 g/cm^3
Isotopic abundance of ^{nat}B: 19.9 atom percent ^{10}B plus 80.1 atom percent ^{11}B

Thus:

N_{borate} = (2.00/149.7)(1.0031)(0.60221367)/(272.1443) = 2.96554004e-5 molecule/bn·cm
N_{H2O} = (147.7/149.7)(1.0031)(0.60221367)/(18.0152) = 3.30837284e-2 molecule/bn·cm

Therefore:

$N_H = 2N_{H2O} + 12N_{borate}$ = 0.0665233 H atom/bn·cm
$N_{B\text{-}10} = (0.199)5N_{borate}$ = 0.0000295 ^{10}B atom/bn·cm
$N_{B\text{-}11} = (0.801)5N_{borate}$ = 0.0001188 ^{11}B atom/bn·cm
$N_N = N_{borate}$ = 0.0000297 N atom/bn·cm
$N_O = N_{H2O} + 12N_{borate}$ = 0.0334396 O atom/bn·cm

Where:

$N_{Total} = \sum N$ = 0.1001409 atom/bn·cm

B-17. CADMIUM

Density: 8.65 g/cm^3 (Ref. B-2)
Composition: 100 percent Cd, by weight
Atomic weight (Cd): 112.411 g/mole

Thus:
$N_{Total} = N_{Cd}$ = (8.65)(0.60221367)/(112.411) = 0.0463402 Cd atom/bn·cm

B-18. SNAPTRAN FUEL

The individual fuel elements were modeled for the Phase III experiments.

The uranium is assumed to be ^{235}U and ^{238}U, which are the only isotopes reported in Ref. B-1. The ^{234}U contribution is assumed to be negligible, and any uncertainty associated with it is accounted for in the total combined uncertainty of the benchmark model (0.008). This is based on sensitivity calculations reported in Ref. B-16 for other benchmark applications. The study varied the ^{234}U content by ±20%. In all cases, the resultant change in k_{eff} was less than 0.0007 Δk, and the effect was judged to be insignificant.

As determined by a weighted average from data in Ref. B-1 for all 37 fuel element assemblies, the hydrogen content is 6.483 x 10^{22} H atoms/cm^3; however, the hydrogen content is subsequently described in Ref. B-2 as having been over-stated due to an analytical laboratory bias by AI and revised downward to 6.40 x 10^{22} H atoms/cm^3.

Carbon content.
The carbon content was estimated based on the description provided in Ref. B-14, p. 5.

Tables B-1 through B-3 show the calculations performed to determine the number densities used to model the SNAPTRAN fuel. Each fuel rod is defined as a new material for these calculations. The material number and universe number for the fuel rods are specified in MCNP5 such that they easily relate to the number of the fuel element.

- $\text{rod volume} = \pi\left(\frac{1.212}{2} * \frac{2.54cm}{inch}\right)^2\left(12.225 * \frac{2.54cm}{inch}\right)$
- $\text{H content per rod} = \left(\frac{6.4}{6.483}\right)\left(\frac{\text{reported H content}, atoms}{cm^3 * 10^{-22}}\right)$
- $\text{Total U content per rod} = \frac{^{235}\text{U}(g/rod)}{93.2\%}$
- $^{238}\text{U content per rod} = \text{Total U content per rod-}^{235}\text{U}(g/rod)$
- $\text{Total (U + Zr + ZrC) content per rod} = \frac{\text{Total U content per rod}}{10\%}$

Table B-1. Calculations to support number density determinations for SNAPTRAN fuel

Fuel element number	Reported ^{235}U content per rod (g)	Reported H content per rod (atoms/cm^3*10^{-22})	Adjusted H content per rod, (atoms/cm^3*10^{-22})	Total U content per rod (g)	^{238}U content per rod (g)	Total (Zr+U+ZrC) content per rod (g)
19	128.5	6.48	6.397056	137.8755	9.3755	1378.7554
23	126.7	6.36	6.278592	135.9442	9.2442	1359.4421
26	125.8	6.55	6.46616	134.9785	9.1785	1349.7854
37	126.5	6.39	6.308208	135.7296	9.2296	1357.2961
40	128.3	6.36	6.278592	137.6609	9.3609	1376.6094
46	126.5	6.55	6.46616	135.7296	9.2296	1357.2961
51	126.4	6.58	6.495776	135.6223	9.2223	1356.2232
52	128.6	6.52	6.436544	137.9828	9.3828	1379.8283
55	126.3	6.56	6.476032	135.5150	9.2150	1355.1502
62	126.2	6.55	6.46616	135.4077	9.2077	1354.0773
65	126.3	6.54	6.456288	135.5150	9.2150	1355.1502
66	126.7	6.39	6.308208	135.9442	9.2442	1359.4421
67	128.2	6.49	6.406928	137.5536	9.3536	1375.5365
68	127.2	6.55	6.46616	136.4807	9.2807	1364.8069
80	128.4	6.48	6.397056	137.7682	9.3682	1377.6824
81	127.5	6.52	6.436544	136.8026	9.3026	1368.0258
83	126.7	6.63	6.545136	135.9442	9.2442	1359.4421
84	128.3	6.32	6.239104	137.6609	9.3609	1376.6094
85	126.8	6.44	6.357568	136.0515	9.2515	1360.5150
86	127.7	6.59	6.505648	137.0172	9.3172	1370.1717
92	125.5	6.41	6.327952	134.6567	9.1567	1346.5665
132	126.8	6.36	6.278592	136.0515	9.2515	1360.5150
133	126.7	6.53	6.446416	135.9442	9.2442	1359.4421
137	125	6.51	6.426672	134.1202	9.1202	1341.2017
147	125.3	6.45	6.36744	134.4421	9.1421	1344.4206
151	127.9	6.46	6.377312	137.2318	9.3318	1372.3176
153	127.6	6.46	6.377312	136.9099	9.3099	1369.0987
171	128.2	6.58	6.495776	137.5536	9.3536	1375.5365
173	126.5	6.35	6.26872	135.7296	9.2296	1357.2961
174	128.7	6.54	6.456288	138.0901	9.3901	1380.9013
176	127.8	6.58	6.495776	137.1245	9.3245	1371.2446
9	128.8	6.28	6.199616	138.1974	9.3974	1381.9742
25	128.3	6.35	6.26872	137.6609	9.3609	1376.6094
47	128.3	6.3	6.21936	137.6609	9.3609	1376.6094
58	128.2	6.51	6.426672	137.5536	9.3536	1375.5365
90	125.5	6.38	6.298336	134.6567	9.1567	1346.5665
135	126.7	6.58	6.495776	135.9442	9.2442	1359.4421

- C content per rod = (Total (U + Zr + ZrC) content per rod)($0.15wt\%$)

  Zr content per rod = Total (U + Zr + ZrC) content per rod
- - Total U content per rod

  - C content per rod
- $$N_{Zr} = \left(\frac{Zr(g)}{volume, cm^3}\right) * \left(\frac{1 mole}{91.224 g}\right) * \left(\frac{6.0221367 \times 10^{23}\, atoms}{mole}\right)$$
- $$\text{H content per rod, (g)} = \left(volume, cm^3\right) * \left(\frac{H \text{ content per rod} \times 10^{-22}}{6.0221367 \times 10^{23}}\right)\left(\frac{1.0079 g}{mole}\right)$$

Table B-2. Calculations to support number density determinations for SNAPTRAN fuel

Fuel element number	Total (Zr+U+ZrC) content per rod (g)	(Zr+ZrC) content per rod (g)	C content per rod (g)	Zr only content per rod (g)	N_{Zr}	H content per rod (g)
19	1378.7554	1240.8798	2.0681	1238.8117	3.5384E+22	24.75
23	1359.4421	1223.4979	2.0392	1221.4587	3.4888E+22	24.29
26	1349.7854	1214.8069	2.0247	1212.7822	3.4640E+22	25.01
37	1357.2961	1221.5665	2.0359	1219.5306	3.4833E+22	24.40
40	1376.6094	1238.9485	2.0649	1236.8836	3.5328E+22	24.29
46	1357.2961	1221.5665	2.0359	1219.5306	3.4833E+22	25.01
51	1356.2232	1220.6009	2.0343	1218.5665	3.4805E+22	25.13
52	1379.8283	1241.8455	2.0697	1239.7758	3.5411E+22	24.90
55	1355.1502	1219.6352	2.0327	1217.6025	3.4778E+22	25.05
62	1354.0773	1218.6695	2.0311	1216.6384	3.4750E+22	25.01
65	1355.1502	1219.6352	2.0327	1217.6025	3.4778E+22	24.97
66	1359.4421	1223.4979	2.0392	1221.4587	3.4888E+22	24.40
67	1375.5365	1237.9828	2.0633	1235.9195	3.5301E+22	24.78
68	1364.8069	1228.3262	2.0472	1226.2790	3.5026E+22	25.01
80	1377.6824	1239.9142	2.0665	1237.8476	3.5356E+22	24.75
81	1368.0258	1231.2232	2.0520	1229.1711	3.5108E+22	24.90
83	1359.4421	1223.4979	2.0392	1221.4587	3.4888E+22	25.32
84	1376.6094	1238.9485	2.0649	1236.8836	3.5328E+22	24.13
85	1360.5150	1224.4635	2.0408	1222.4227	3.4915E+22	24.59
86	1370.1717	1233.1545	2.0553	1231.0992	3.5163E+22	25.17
92	1346.5665	1211.9099	2.0198	1209.8900	3.4557E+22	24.48
132	1360.5150	1224.4635	2.0408	1222.4227	3.4915E+22	24.29
133	1359.4421	1223.4979	2.0392	1221.4587	3.4888E+22	24.94
137	1341.2017	1207.0815	2.0118	1205.0697	3.4420E+22	24.86
147	1344.4206	1209.9785	2.0166	1207.9619	3.4502E+22	24.63
151	1372.3176	1235.0858	2.0585	1233.0274	3.5218E+22	24.67
153	1369.0987	1232.1888	2.0536	1230.1352	3.5136E+22	24.67
171	1375.5365	1237.9828	2.0633	1235.9195	3.5301E+22	25.13
173	1357.2961	1221.5665	2.0359	1219.5306	3.4833E+22	24.25
174	1380.9013	1242.8112	2.0714	1240.7398	3.5439E+22	24.97
176	1371.2446	1234.1202	2.0569	1232.0633	3.5191E+22	25.13
9	1381.9742	1243.7768	2.0730	1241.7039	3.5466E+22	23.98
25	1376.6094	1238.9485	2.0649	1236.8836	3.5328E+22	24.25
47	1376.6094	1238.9485	2.0649	1236.8836	3.5328E+22	24.06
58	1375.5365	1237.9828	2.0633	1235.9195	3.5301E+22	24.86
90	1346.5665	1211.9099	2.0198	1209.8900	3.4557E+22	24.36
135	1359.4421	1223.4979	2.0392	1221.4587	3.4888E+22	25.13

- $$\mathrm{N}_{U-235} = \left(\frac{U_{235},(g)}{volume, cm^3}\right)\left(\frac{0.60221367, atoms}{cm^3 * 10^{-22}}\right)\left(\frac{mole}{235.043924g}\right)$$
- $$\mathrm{N}_{U-238} = \left(\frac{U_{238},(g)}{volume, cm^3}\right)\left(\frac{0.60221367, atoms}{cm^3 * 10^{-22}}\right)\left(\frac{mole}{238.050785g}\right)$$
- $$\mathrm{N}_{Zr} = \left(\frac{Zr(g)}{volume, cm^3}\right)\left(\frac{0.60221367, atoms}{cm^3 * 10^{-22}}\right)\left(\frac{mole}{91.224g}\right)$$
- $$\mathrm{N}_{H} = \left(\frac{H(g)}{volume, cm^3}\right)\left(\frac{0.60221367, atoms}{cm^3 * 10^{-22}}\right)\left(\frac{mole}{1.0079g}\right)$$
- $$\mathrm{N}_{C} = \left(\frac{C(g)}{volume, cm^3}\right)\left(\frac{0.60221367, atoms}{cm^3 * 10^{-22}}\right)\left(\frac{mole}{12.011g}\right)$$

Table B-3. Number densities for individual SNAPTRAN fuel rods

Fuel element number	^{235}U	^{238}U	Zr	H	C	Total
19	0.0014245	0.0001026	0.0353836	0.0639706	0.0004486	0.1013299
23	0.0014045	0.0001012	0.0348879	0.0627859	0.0004424	0.0996219
26	0.0013946	0.0001005	0.0346401	0.0646616	0.0004392	0.1012359
37	0.0014023	0.0001010	0.0348329	0.0630821	0.0004417	0.0998599
40	0.0014223	0.0001025	0.0353285	0.0627859	0.0004479	0.1000871
46	0.0014023	0.0001010	0.0348329	0.0646616	0.0004417	0.1014395
51	0.0014012	0.0001009	0.0348053	0.0649578	0.0004413	0.1017065
52	0.0014256	0.0001027	0.0354111	0.0643654	0.0004490	0.1017538
55	0.0014001	0.0001009	0.0347778	0.0647603	0.0004410	0.1014800
62	0.0013990	0.0001008	0.0347502	0.0646616	0.0004406	0.1013522
65	0.0014001	0.0001009	0.0347778	0.0645629	0.0004410	0.1012826
66	0.0014045	0.0001012	0.0348879	0.0630821	0.0004424	0.0999181
67	0.0014212	0.0001024	0.0353010	0.0640693	0.0004476	0.1013414
68	0.0014101	0.0001016	0.0350256	0.0646616	0.0004441	0.1016430
80	0.0014234	0.0001025	0.0353560	0.0639706	0.0004483	0.1013008
81	0.0014134	0.0001018	0.0351082	0.0643654	0.0004452	0.1014340
83	0.0014045	0.0001012	0.0348879	0.0654514	0.0004424	0.1022874
84	0.0014223	0.0001025	0.0353285	0.0623910	0.0004479	0.0996922
85	0.0014056	0.0001013	0.0349155	0.0635757	0.0004427	0.1004408
86	0.0014156	0.0001020	0.0351633	0.0650565	0.0004459	0.1021832
92	0.0013912	0.0001002	0.0345575	0.0632795	0.0004382	0.0997666
132	0.0014056	0.0001013	0.0349155	0.0627859	0.0004427	0.0996510
133	0.0014045	0.0001012	0.0348879	0.0644642	0.0004424	0.1013002
137	0.0013857	0.0000998	0.0344198	0.0642667	0.0004364	0.1006085
147	0.0013890	0.0001001	0.0345024	0.0636744	0.0004375	0.1001034
151	0.0014178	0.0001021	0.0352184	0.0637731	0.0004466	0.1009580
153	0.0014145	0.0001019	0.0351357	0.0637731	0.0004455	0.1008708
171	0.0014212	0.0001024	0.0353010	0.0649578	0.0004476	0.1022299
173	0.0014023	0.0001010	0.0348329	0.0626872	0.0004417	0.0994651
174	0.0014267	0.0001028	0.0354386	0.0645629	0.0004493	0.1019804
176	0.0014167	0.0001021	0.0351908	0.0649578	0.0004462	0.1021136
9	0.0014278	0.0001029	0.0354662	0.0619962	0.0004497	0.0994427
25	0.0014223	0.0001025	0.0353285	0.0626872	0.0004479	0.0999884
47	0.0014223	0.0001025	0.0353285	0.0621936	0.0004479	0.0994948
58	0.0014212	0.0001024	0.0353010	0.0642667	0.0004476	0.1015388
90	0.0013912	0.0001002	0.0345575	0.0629834	0.0004382	0.0994705
135	0.0014045	0.0001012	0.0348879	0.0649578	0.0004424	0.1017938

B-19. HYDROGEN BARRIER/ABSORBER COATING FOR THE SNAPTRAN FUEL ELEMENTS

The content of the hydrogen barrier/absorber coating on the inside of the fuel cladding is fully detailed for fuel fabricated to the AI specification ca. 1964 in the form of SNAPTRAN V fuel (Ref. B-9). It will be assumed that the absorber coating for the SNAPTRAN V fuel is very similar to that of the SNAPTRAN fuel used for the experiments document in Ref. B-15. The coating weight per unit for the SNAPTRAN V fuel was determined, and applied to the SNAPTRAN fuel of Ref. B-15. It is also assumed that the absorber coating occupies the entire radial gap volume between the fuel rod and the cladding tube.

The SNAPTRAN V fuel coating: (Ref. B-9)

- Total coating weight=214.95 g
- number of rods=36
- length coated=30.6990908 cm
- diameter coated=3.073572861 cm
- coated area, one rod=296.4277782 cm^2
- area coated, total=10671.40002 cm^2
- coating weight per unit area=0.020142624 g/cm^2

Note: Data for rod E-0500 was not used.

For SNAPTRAN: (Ref. B-15)

- 12.225=length of the fuel rod, inches
- 1.5621=clad inner radius, cm
- 1.53924=fuel radius, cm
- number of rods =37
- Element Length (only fuel length used; caps disregarded)=31.0515

From these values, the following are calculated:
inside surface area of 1 element=(2π)*(clad inner radius)*(element length)=304.7693475 cm^2
Total area to be coated for the 37 rods=(304.7693475)*(37)=11276.46586 cm^2
coat weight per unit area, g/cm^2=0.020142624 (based on the SNAPTRAN V fuel)
Total coating weight= coat weight per unit area* Total area to be coated for the 37 rods =227.1376138 g

Atomic weights used:

- 15.9994=atomic weight of oxygen
- 150.36=atomic weight of samarium
- 26.981538=atomic weight of aluminum
- 28.0855=atomic weight of silicon

Table B-4. Sm_2O_3 content (mg) per rod for SNAPTRAN fuel (Ref. B-15)

Rod	Total/Rod determined from tube sample
1	125.9175
2	113.6925
3	108.8025
4	90.465
5	95.355
6	99.0225
7	95.355
8	92.91
9	97.8
10	101.4675
11	118.5825
12	106.3575
13	90.465
14	117.36
15	102.69
16	100.245
17	89.2425
18	111.2475
19	111.2475
20	107.58
21	97.8
22	99.0225
23	100.245
24	103.9125
25	95.355
26	108.8025
27	86.7975
28	95.355
29	86.7975
30	90.465
31	90.465
32	116.1375
33	118.5825
34	95.355
35	92.91
36	97.8
37	92.91
weight of Sm_2O_3 for 37 elements (mg)	3744.5175

The coating is assumed to fill the fuel-cladding gap:

- volume of the fuel gap=6.916049034 cm^3
- Volume for 37 elements=255.89381427cm^3
- Density of the Sm_2O_3=

  mass of Sm_2O_3 from Table B-4/ volume of the fuel gap=0.01463309 g/cm^3
- Density of the Al_2O_3 and SiO_2=mass of Al_2O_3 and SiO_2/ fuel gap volume=0.88762448 g/cm^3

Molecular weight of Sm_2O_3=348.7182 g/mole
Molecular weight of Al_2O_3=101.961276 g/mole
Molecular weight of SiO_2=60.0843 g/mole

Number density of Sm_2O_3=2.527039743E-05 molecule/bn·cm
Number density of Al_2O_3=2.621287300E-03 molecule/bn·cm
Number density of SiO_2=4.448246844E-03 molecule/bn·cm

Combining these to determine number density by element:

N_O=0.0168362 O atom/bn·cm
N_{Sm}=0.0000505 Sm atom/bn·cm
N_{Al}=0.0052426 Al atom/bn·cm
N_{Si}=0.0044482 Si atom/bn·cm

As previously stated, not all the Sm isotopes are used. Those with low absorption cross-sections are neglected:

MCNP5 isotope identifier	Isotopic abundance, atom percent	Low or high absorption cross section?	Number density
62144	3.1	n/a	=not used
62147	15	medium	=0.0000076
62148	11.3	low	=not used
62149	13.8	very high	=0.0000070
62150	7.4	medium	=0.0000037
62152	26.7	high	=0.0000135
62154	22.7	low	=not used

The total number density of the coating is the sum of the used Sm isotopes and the O, Si, and Al contributions:

Total number density for coating=0.0265588 atom/bn·cm

B-20. ABSORBER SPLINES USED FOR THE PHASE III EXPERIMENTS

The largest possible radius of a absorber spline was determined with the assistance of drafting software, and was found to be 0.208 cm. While these splines are clad in a thin aluminum tubing, this material was neglected, and the reported boron content was modeled to fill the whole volume of the spline. The density of each spline is calculated according to the equation below and reported in Table B-5.

$$\text{density}\frac{\text{g}}{\text{cm}^3} = \frac{\text{boron weight(g)}}{\pi * (0.208\text{cm})^2 * (31.0515\text{cm})}$$

Table B-5. Absorber spline content and calculated densities

Spline number	boron weight (g)	density
28	1.72	0.4075
29	1.38	0.3270
35*	1.62	0.3838
33	1.21	0.2867
30	1.44	0.3412
23	1.18	0.2796
32	1.42	0.3365
27	1.6	0.3791
21	1.11	0.2630
22	0.99	0.2346
26	1.66	0.3933
34*	1.7	0.4028
24	1.58	0.3744
25*	1.63	0.3862
31	1.4	0.3317

* These splines were only used for case fig19. All other splines were used in cases fig16 and fig19.

The following data was used to calculated the absorber spline number densities:
Element weight: 10.811
Atom fractions of the isotopes:
B_{10} 0.199
B_{11} 0.801

The number densities were calculated using the following formula:

$$N_{isotope} = \frac{(\text{atom fraction of the isotope}) * (\text{density}) * (0.602201367)}{\text{element weight}}$$

These calculations are shown in Table B-6.

Table B-6. Number densities for absorber splines

Spline number	B_{10} number density (at/barn-cm) (MCNP5 identifier 5010.60c)	B_{11} number density (at/barn-cm) (MCNP5 identifier 5011.60c)	Total
28	0.004517593	0.018183881	0.022702
29	0.003624581	0.014589393	0.018214
35	0.004254943	0.017126679	0.021382
33	0.003178074	0.012792149	0.015970
30	0.003782171	0.015223714	0.019006
23	0.003099279	0.012474988	0.015574
32	0.003729641	0.015012274	0.018742
27	0.004202412	0.016915238	0.021117
21	0.002915424	0.011734946	0.014650
22	0.002600243	0.010466304	0.013066
26	0.004360003	0.017549559	0.021910
34	0.004465063	0.01797244	0.022438
24	0.004149882	0.016703798	0.020854
25	0.004281208	0.017232399	0.021514
31	0.003677111	0.014800833	0.018478

B-21. INDIVIDUAL SCA-4 FUEL ROD DEFINITIONS USED FOR THE PHASE III EXPERIMENTS

The following tables document the calculations of the number densities for each of the SCA-4 fuel rods used for the modeling of the Phase III experiments. The information shown in Table B-7 was taken from Ref. B-1. In some cases, two pieces of fuel rod were used to make the fuel element, a long rod and a short rod, and these are noted in Table B-7. The equations used to determine the number densities for the fuel rods are shown below.

- Total Wt of ^{238}U (g)= Total Wt of U (g)- Total Wt of ^{235}U (g)
- total weight of H =volume*(avg. N_H adjusted for overprediction /100)*1.0079/0.60221367
- Total Wt of Zr (g)= Total Wt of U-ZrHx (g)- Total Wt of U (g)- total weight of H
- $N_{U\text{-}235}$ = (Total Wt of ^{235}U (g)/volume)*0.60221367/235.043924 ^{235}U atom/bn·cm
- $N_{U\text{-}238}$ = (Total Wt of ^{238}U (g)/ volume)*0.60221367/238.050785 ^{238}U atom/bn·cm
- N_{Zr} = (Total Wt of Zr (g)/ volume)*0.60221367/91.224 Zr atom/bn·cm
- N_H = (total weight of H (g)/ volume)*0.60221367/1.0079 H atom/bn·cm

The uranium is assumed to be ^{235}U and ^{238}U, which are the only isotopes reported in Ref. B-1. (The ^{234}U contribution is assumed to be negligible, and any uncertainty associated with it is accounted for in the total combined uncertainty of the benchmark model [0.008]. This is based on sensitivity calculations reported in Ref. B-16 for other benchmark applications. The study varied the ^{234}U content by ±20%. In all cases, the resultant change in k_{eff} was less than 0.0007 Δk, and the effect was judged to be insignificant.)

Table B-7. Data and calculations supporting the determination of individual fuel rod number densities for SCA-4 fuel elements

Element No.	Long rod No.	Short rod No.	Weight (g)	Wt.% U	Wt. of U	Wt.% of ^{235}U (g)	Total Wt of ^{235}U (g)	Total Wt of rod (g)	Total Wt of U (g)	Total Wt of ^{235}U (g)
	524-8		1141.16	9.91	113.09	93.15	105.34			
81		519-5D	256.88	9.91	25.46	93.15	23.72	1398.04	138.55	129.06
	510-3		1137.51	9.96	113.30	93.15	105.54			
82		510-1A	256.44	9.91	25.41	93.15	23.67	1393.95	138.71	129.21
	520-4		1131.97	9.92	112.29	93.26	104.72			
83		519-5B	256.59	9.91	25.43	93.15	23.69	1388.56	137.72	128.41
	519-3		1142.38	9.91	113.21	93.15	105.45			
84		519-5A	256.64	9.91	25.43	93.15	23.69	1399.02	138.64	129.14
	525-7		1142.41	9.91	113.11	93.15	105.37			
85		516-1D	255.98	9.92	25.39	93.15	23.65	1398.39	138.50	129.02
	517-2		1140.67	9.91	113.04	93.15	105.30			
86		516-1B	256.97	9.92	25.49	93.15	23.75	1397.64	138.53	129.05
	520-6		1142.31	9.92	113.32	93.26	105.68			
87		511-1C	255.87	9.92	25.38	93.15	23.64	1398.18	138.70	129.32
	511-2		1140.35	9.89	113.09	93.15	105.35			
88		516-1C	256.90	9.92	25.48	93.15	23.74	1397.25	138.57	129.09
	520-1		1155.47	9.82	113.47	93.21	105.76			
89		511-1B	241.80	9.92	24.08	93.15	22.44	1397.27	137.55	128.20
	513-2		1140.87	9.92	113.17	93.15	105.42			
90		511-1D	256.08	9.92	25.40	93.15	23.66	1396.95	138.57	129.08
	513-4		1142.42	9.92	113.33	93.15	105.57			
91		512-2B	255.91	9.92	25.39	93.15	23.65	1398.33	138.72	129.22
	513-7		1156.6	9.94	114.97	93.15	107.09			
92		512-2D	242.47	9.92	24.05	93.15	22.4	1399.07	139.02	129.49
	511-5		1156.54	9.94	114.96	93.15	107.09			
93		512-2C	242.53	9.92	24.05	93.15	22.41	1399.07	139.01	129.5
	516-7		1143.42	9.92	113.43	93.21	105.73			
94		512-2A	256.24	9.92	25.42	93.15	23.68	1399.66	138.85	129.41
	516-4		1130.95	9.92	112.19	93.21	104.57			
95		519-5C	256.56	9.91	25.42	93.15	23.68	1387.51	137.61	128.25
	515-2		1133.95	9.92	112.49	93.21	104.85			
96		516-1A	256.69	9.92	25.46	93.15	23.72	1390.64	137.95	128.57
97	529-3		1397.57	9.86	137.8	93.17	128.38	1397.57	137.8	128.38
98	545-7		1407.57	9.86	138.79	93.17	129.31	1407.57	138.79	129.31
99	528-2		1398.91	9.81	137.23	93.17	127.86	1398.91	137.23	127.86
100	529-2		1389.68	9.8	136.19	93.17	126.89	1389.68	136.19	126.81
101	542-5		1398.68	9.83	137.49	93.17	128.1	1398.68	137.49	128.1
102	542-7		1396.97	9.82	137.18	93.17	127.81	1396.97	137.18	127.81
103	547-2		1404.21	9.79	137.47	93.13	128.03	1404.21	137.47	128.03
104	548-7		1403.04	9.76	136.94	93.13	127.53	1403.04	136.94	127.53
105	542-4		1388	9.84	135.79	93.17	127.25	1388	135.79	127.25
	509-5		1132.49	9.93	112.46	93.15	104.75			
106		510-1B	256.44	9.91	25.41	93.15	23.67	1388.93	137.87	128.42
	510-6		1144.26	9.96	113.97	93.15	106.16			
107		510-1C	256.44	9.91	25.41	93.15	23.67	1400.70	139.38	129.83
	509-6		1122.49	9.93	111.46	93.15	103.82			
108		510-1D	256.44	9.91	25.41	93.15	23.67	1378.93	136.87	127.49
109	552-4		1410	9.84	138.74	93.13	129.21	1410	138.7	129.2
110	551-3		1410	9.82	138.7	93.13	129.2	1410	138.7	129.2
111	542-2		1393	9.82	136.8	93.17	127.5	1393	136.8	127.5
	526-6		1149.62	9.88	113.56	93.18	105.84			
112		551-1AE	256.12	9.92	25.41	93.15	23.67	1405.74	138.97	129.51

Table B-7. (continued)

Element No.	Long rod No.	Short rod No.	Weight (g)	Wt.% U	Wt. of U	Wt.% of ^{235}U (g)	Total Wt of ^{235}U (g)	Total Wt of rod (g)	Total Wt of U (g)	Total Wt of ^{235}U (g)
113	513-3		1142.37	9.92	113.32	93.15	105.57	1398.87	138.56	129.08
		552-3A	256.5	9.84	25.24	93.15	23.51			
114	518-5		1138.9	9.92	112.97	93.15	105.24	1395.4	138.21	128.75
		552-3B	256.5	9.84	25.24	93.15	23.51			
115	547-5		1402.82	9.8	137.48	93.13	128.04	1402.82	137.48	128.04
116	545-6		1406.29	9.85	138.52	93.17	129	1406.29	138.52	129
117	551-4		1407.75	9.86	133.88	93.13	129.26	1407.75	133.88	129.26

Table B-8. Determination of individual fuel rod material weights for SCA-4 fuel elements

Element No.	N_H (x 10^{22} atoms/cm^3), long and short rods	Weighted avg. N_H (x 10^{22} atoms/cm^3)	avg. N_H adjusted for overprediction (x 10^{22} atoms/cm^3)	Total Wt of U-ZrHx (g)	Total Wt of U (g)	Total Wt of ^{235}U (g)	Total Wt of ^{238}U (g)	Total weight of H (g)	Total Wt of Zr (g)
81	6.62 6.60	6.62	6.534642	1398.04	138.55	129.06	9.49	25.27747	1234.213
82	6.44 6.38	6.43	6.349592	1393.95	138.71	129.21	9.5	24.56166	1230.678
83	6.55 6.60	6.56	6.478261	1388.56	137.72	128.41	9.31	25.05938	1225.781
84	6.51 6.60	6.53	6.445936	1399.02	138.64	129.14	9.5	24.93434	1235.446
85	6.53 6.52	6.53	6.447575	1398.39	138.5	129.02	9.48	24.94068	1234.949
86	6.52 6.52	6.52	6.439506	1397.64	138.53	129.05	9.48	24.90947	1234.201
87	6.53 6.47	6.52	6.438538	1398.18	138.7	129.32	9.38	24.90572	1234.574
88	6.52 6.52	6.52	6.439506	1397.25	138.57	129.09	9.48	24.90947	1233.771
89	6.47	6.47	6.390123	1397.27	137.55	128.2	9.35	24.71844	1235.002
90	6.52 6.45	6.51	6.426833	1396.95	138.57	129.08	9.49	24.86044	1233.52
91	6.42 6.40	6.42	6.337126	1398.33	138.72	129.22	9.5	24.51344	1235.097
92	6.39 6.40	6.39	6.31282	1399.07	139.02	129.49	9.53	24.41943	1235.631
93	6.38 6.40	6.38	6.30466	1399.07	139.01	129.5	9.51	24.38785	1235.672
94	6.43 6.40	6.42	6.34519	1399.66	138.85	129.41	9.44	24.54464	1236.265
95	6.57 6.60	6.58	6.49437	1387.51	137.61	128.25	9.36	25.12168	1224.778
96	6.38 6.52	6.41	6.32676	1390.64	137.95	128.57	9.38	24.47333	1228.217
97	6.43	6.43	6.35062	1397.57	137.8	128.38	9.42	24.56563	1235.204
98	6.57	6.57	6.48889	1407.57	138.79	129.31	9.48	25.10049	1243.68
99	6.46	6.46	6.38025	1398.91	137.23	127.86	9.37	24.68024	1237
100	6.49	6.49	6.40988	1389.68	136.19	126.89	9.3	24.79485	1228.695
101	6.50	6.50	6.41975	1398.68	137.49	128.1	9.39	24.83306	1236.357
102	6.34	6.34	6.26173	1396.97	137.18	127.81	9.37	24.22178	1235.568
103	6.57	6.57	6.48889	1404.21	137.47	128.03	9.44	25.10049	1241.64
104	6.42	6.42	6.34074	1403.04	136.94	127.53	9.41	24.52742	1241.573
105	6.42	6.42	6.34074	1388	135.79	127.25	8.54	24.52742	1227.683
106	6.45 6.38	6.44	6.35761	1388.93	137.87	128.42	9.45	24.59266	1226.467
107	6.54 6.38	6.51	6.43033	1400.7	139.38	129.83	9.55	24.87396	1236.446
108	6.37 6.38	6.37	6.29319	1378.93	136.87	127.49	9.38	24.3435	1217.716
109	6.55	6.55	6.46914	1410	138.74	129.21	9.53	25.02408	1246.236
110	6.40	6.40	6.32099	1410	138.7	129.2	9.5	24.45101	1246.849
111	6.69	6.69	6.60741	1393	136.8	127.5	9.3	25.55895	1230.641
112	6.55 6.47	6.54	6.45474	1405.74	138.97	129.51	9.46	24.9684	1241.802
113	6.30 6.38	6.31	6.23671	1398.87	138.56	129.08	9.48	24.12501	1236.185

Table B-8. (continued)

Element No.	N_H (x 10^{22} atoms/cm^3), long and short rods	Weighted avg. N_H (x 10^{22} atoms/cm^3)	avg. N_H adjusted for overprediction (x 10^{22} atoms/cm^3)	Total Wt of U-ZrHx (g)	Total Wt of U (g)	Total Wt of ^{235}U (g)	Total Wt of ^{238}U (g)	Total weight of H (g)	Total Wt of Zr (g)
114	6.41 6.45	6.42	6.33813	1395.4	138.21	128.75	9.46	24.51731	1232.673
115	6.53	6.53	6.44938	1402.82	137.48	128.04	9.44	24.94767	1240.392
116	6.56	6.56	6.47901	1406.29	138.52	129	9.52	25.06229	1242.708
117	6.54	6.54	6.45926	1407.75	133.88	129.26	4.62	24.98588	1248.884

Table B-9. Individual fuel rod number densities for SCA-4 fuel

Element No.	^{235}U (atoms/barn-cm)	^{238}U (atoms/barn-cm)	Zr (atoms/barn-cm)	H (atoms/barn-cm)	Total (atoms/barn-cm)
81	0.0014307	0.0001039	0.0352522	0.0653464	0.1021332
82	0.0014324	0.0001040	0.0351513	0.0634959	0.1001835
83	0.0014235	0.0001019	0.0350114	0.0647826	0.1013194
84	0.0014316	0.0001040	0.0352874	0.0644594	0.1012824
85	0.0014303	0.0001038	0.0352733	0.0644757	0.1012830
86	0.0014306	0.0001038	0.0352519	0.0643951	0.1011813
87	0.0014336	0.0001027	0.0352625	0.0643854	0.1011842
88	0.0014310	0.0001038	0.0352396	0.0643951	0.1011694
89	0.0014212	0.0001023	0.0352748	0.0639012	0.1006995
90	0.0014309	0.0001039	0.0352324	0.0642683	0.1010355
91	0.0014325	0.0001040	0.0352775	0.0633713	0.1001852
92	0.0014355	0.0001043	0.0352927	0.0631282	0.0999607
93	0.0014356	0.0001041	0.0352939	0.0630466	0.0998802
94	0.0014346	0.0001033	0.0353108	0.0634519	0.1003007
95	0.0014217	0.0001024	0.0349827	0.0649437	0.1014506
96	0.0014253	0.0001027	0.0350810	0.0632676	0.0998765
97	0.0014232	0.0001031	0.0352805	0.0635062	0.1003130
98	0.0014335	0.0001038	0.0355226	0.0648889	0.1019487
99	0.0014174	0.0001026	0.0353318	0.0638025	0.1006542
100	0.0014066	0.0001018	0.0350946	0.0640988	0.1007018
101	0.0014201	0.0001028	0.0353135	0.0641975	0.1010338
102	0.0014168	0.0001026	0.0352909	0.0626173	0.0994276
103	0.0014193	0.0001033	0.0354643	0.0648889	0.1018758
104	0.0014137	0.0001030	0.0354624	0.0634074	0.1003866
105	0.0014106	0.0000935	0.0350657	0.0634074	0.0999772
106	0.0014236	0.0001034	0.0350310	0.0635761	0.1001341
107	0.0014392	0.0001045	0.0353160	0.0643033	0.1011631
108	0.0014133	0.0001027	0.0347810	0.0629319	0.0992290
109	0.0014324	0.0001043	0.0355956	0.0646914	0.1018237
110	0.0014323	0.0001040	0.0356131	0.0632099	0.1003593
111	0.0014134	0.0001018	0.0351502	0.0660741	0.1027395
112	0.0014357	0.0001035	0.0354690	0.0645474	0.1015556
113	0.0014309	0.0001038	0.0353086	0.0623671	0.0992103
114	0.0014273	0.0001035	0.0352082	0.0633813	0.1001203
115	0.0014194	0.0001033	0.0354287	0.0644938	0.1014453
116	0.0014300	0.0001042	0.0354949	0.0647901	0.1018192
117	0.0014329	0.0000506	0.0356713	0.0645926	0.1017473

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APPENDIX C

GEOMETRY CALCULATIONS FOR MCNP5 MODELS

CONTENTS

C-1. GENERAL

This appendix provides details on how the MCNP5 inputs were developed. The material models are discussed in detail in Appendix B. This appendix deals with the geometries of the systems modeled. The first section describes those elements that are the same for all the models- the fuel elements, their positioning in the core, and the internal beryllium reflector pieces. Section C-2 details the geometry used for the Phase I experiments. Sections C-3, C-4, and C-5 detail the geometries for the various Phase III experiments. This general section covers those items common to all the MCNP5 models, namely the fuel elements and internal reflector pieces. The geometry for these items is the same in all the input files.

C-1.1. Fuel Element Model and Positioning

While the material definitions for the fuel elements vary from case to case, the geometry of the element does not. The geometries of the SCA-4 and SNAPTRAN fuels are the same. While there is some indication that the SNAPTRAN elements may have been slightly longer (12.25 in. vs. 12.225 in.), NAA-SR-9871 states that physically the SNAPTRAN elements are the same as the SCA-4 elements. The fuel masses are provided in NAA-SR-9871 and NAA-SR-8490 for both fuels, and are the basis for the number density calculations. A sketch of a fuel element is shown in Fig. C-1, and the definitions of the fuel materials are provided in Appendix B.

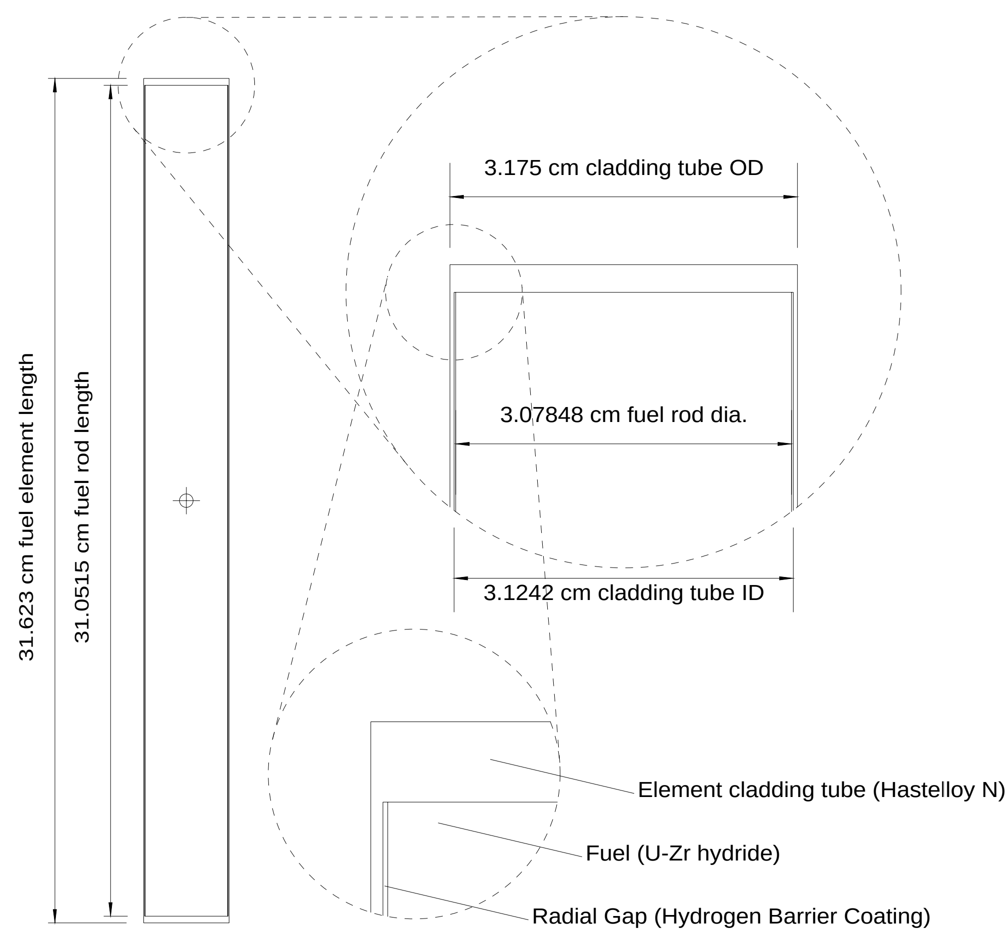


Fig. C-1. CAD sketch of fuel element

Determining the dimensions for the fuel elements:

$$\text{radius of fuel rod} = 1.53924\ cm = \left(2.54\,\frac{cm}{inch}\right) * \left(\frac{1.212\ inches}{2}\right)$$

$$\text{IR of fuel element tube} = 1.5621\ cm = \left(2.54\,\frac{cm}{inch}\right) * \left(\frac{(1.25 - 0.02)\ inches}{2}\right)$$

$$\text{OR of fuel element tube} = 1.5875\ cm = \left(2.54\,\frac{cm}{inch}\right) * \left(\frac{1.25\ inches}{2}\right)$$

$$\text{top and bottom of the active fuel region} = \pm 15.52575\ cm = \pm\left(2.54\,\frac{cm}{inch}\right) * \left(\frac{12.225\ inches}{2}\right)$$

$$\text{top and bottom of the fuel element} = \pm 15.8115\ cm = \pm\left(2.54\,\frac{cm}{inch}\right) * \left(\frac{12.45\ inches}{2}\right)$$

The coordinates for the center points of the elements were determined with the assistance of a CAD drawing. The first rod is positioned at (0, 9.610). The positions of the other rods are measured relative to this in order to use the TRCL option in MCNP5. The coordinates for the remaining 36 positions are shown, relative to the first rod, in Table C-1.

Table C-1. Coordinates for Fuel Elements

Position Number	X(cm)	Y(cm)
2	0.0	-3.2004
3	-2.7716	-1.6002
4	2.7716	-1.6002
5	0.0	-6.4008
6	-2.7716	-4.8006
7	-5.5432	-3.2004
8	2.7716	-4.8006
9	5.5432	-3.2004
10	0.0	-9.6012
11	-2.7716	-8.0010
12	-5.5432	-6.4008
13	-8.3149	-4.8006
14	2.7716	-8.0010
15	5.5432	-6.4008
16	8.3149	-4.8006
17	0.0	-12.8016
18	-2.7716	-11.2014
19	-5.5432	-9.6012
20	-8.3249	-8.0010
21	2.7716	-11.2014
22	5.5432	-9.6012
23	8.3149	-8.0010
24	0.0	-16.0020
25	-2.7716	-14.4018
26	-5.5432	-12.8016
27	-8.3149	-11.2014
28	2.7716	-14.4018
29	5.5432	-12.8016
30	8.3149	-11.2014
31	0.0	-19.2024
32	-2.7716	-17.6022
37	8.3149	-14.4018
36	5.5432	-16.002
35	2.7716	-17.6022
34	-8.3149	-14.4018
33	-5.5432	-16.002

C-1.2. Internal Beryllium Reflectors

The internal beryllium reflector pieces were designed to fit snugly into the periphery of the reactor vessel, outside the fuel element array. Specific dimensions were not provided, so CAD software was used to estimate the surfaces required for the MCNP5 model. The CAD drawing is provided in Fig. C-2.

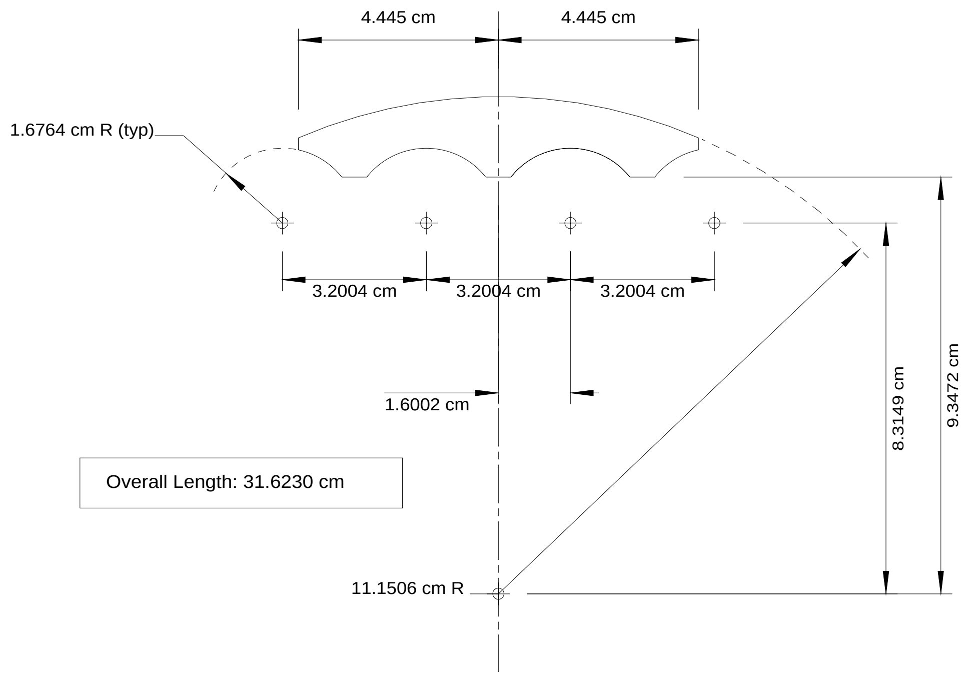


Fig. C-2. CAD sketch of internal beryllium reflector piece

Internal reflector pieces were at the 1, 3, 5, 7, 9, and 11 o'clock positions. This positioning can be seen in Fig. C-3.

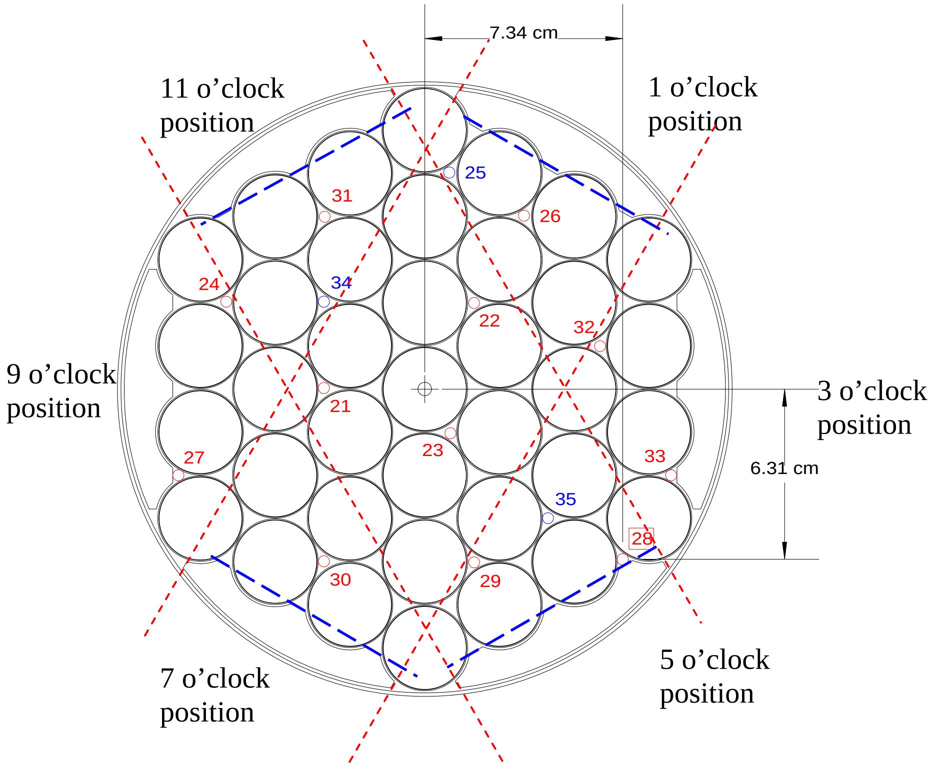


Fig. C-3. MCNP5 plot showing internal reflector piece positioning

The outside radius of the reflector pieces is approximated to be 11.1506 cm. The curved portions around the fuel elements are modeled with cylindrical surfaces of 1.6764 cm radius centered on the outer ring of fuel elements in the lattice.

The remaining surfaces defining the reflectors are straight lines. For the pieces at 3 and 9 o'clock, these are lines parallel to the x and y axes:

$$\mathrm{y} = \pm 4.445\ cm = \text{side flat of internal reflector piece}$$

$$\mathrm{x} = \pm 9.3472\ cm = \text{inside flat of internal reflector piece}$$

The lines to create the flat insides for the pieces at 1, 5, 7, and 11 o'clock are illustrated in Fig. C-3 with blue dashed lines. To construct these lines, a point on the line is needed. The center point of the reflector piece was chosen.

For the piece in the 1 o'clock position, the coordinates of this point are:

$$x = 9.3472 \cos 60° = 4.6736$$

$$y = 9.3472 \sin 60° = 8.0949$$

Inside flat of internal Be piece @ 1 o'clock:

$$AX + BY + CZ - D = 0$$

$$(1)(4.6736) + (1.73205)(8.0949) + (0)(Z) = D = 18.6944$$

$$\mathrm{A} = 1 \quad \mathrm{B} = 1.73205 \quad \mathrm{C} = 0 \quad \mathrm{D} = 18.6944$$

Inside flat of internal Be piece @ 5 o'clock:

$$AX + BY + CZ - D = 0$$

$$(-1)(4.6736) + (1.73205)(-8.0949) + (0)(Z) = D = -18.6944$$

$$\mathrm{A} = -1 \quad \mathrm{B} = 1.73205 \quad \mathrm{C} = 0 \quad \mathrm{D} = -18.6944$$

Inside flat of internal Be piece @ 7 o'clock

$$AX + BY + CZ - D = 0$$

$$(1)(-4.6736) + (1.73205)(-8.0949) + (0)(Z) = D = -18.6944$$

$$\mathrm{A} = 1 \quad \mathrm{B} = 1.73205 \quad \mathrm{C} = 0 \quad \mathrm{D} = -18.6944$$

Inside flat of internal Be piece @11 o'clock

$$AX + BY + CZ - D = 0$$

$$(-1)(-4.6736) + (1.73205)(8.0949) + (0)(Z) = D = 18.6944$$

$$\mathrm{A} = -1 \quad \mathrm{B} = 1.73205 \quad \mathrm{C} = 0 \quad \mathrm{D} = 18.6944$$

The lines to create the flat sides for the pieces at 1, 5, 7, and 11 o'clock are illustrated in Fig. C-3 with red dashed lines.

The angle subtended by half of a reflector piece is:

$$\arcsin\left(\frac{4.445}{11.1506}\right) = 23.49276$$

The ends of the reflector pieces then pass through a line that is (30° - 23.49276° = 6.50724) off the vertical. Using this angle and the outer radius of the reflector piece as a hypotenuse, points on the lines defining the sides of the reflectors are determined:

$$11.1506 * \sin(6.50724) = 1.26368 = x$$

$$y = \sqrt{11.1506^2 - 1.26368^2} = 11.07876$$

The lines defining the ends of the reflectors can then be determined:

Side flat of internal be piece @ 1 & 7 o'clock:

$$AX + BY + CZ - D = 0$$

$$(-1.73205)(1.26368) + (1)(11.07876) + (0)(Z) = D = 8.89$$

$$\mathrm{A} = -1.73205 \quad \mathrm{B} = 1 \quad \mathrm{C} = 0 \quad \mathrm{D} = 8.89$$

Side flat of internal be piece @ 1 & 7 o'clock

$$AX + BY + CZ - D = 0$$

$$(-1.73205)(1.26368) + (1)(-11.07876) + (0)(Z) = D = -8.89$$

$$\mathrm{A} = -1.73205 \quad \mathrm{B} = 1 \quad \mathrm{C} = 0 \quad \mathrm{D} = -8.89$$

Side flat of internal be piece @ 5 & 11 o'clock

$$AX + BY + CZ - D = 0$$

$$(1.73205)(-1.26368) + (1)(11.07876) + (0)(Z) = D = 8.89$$

$$\mathrm{A} = 1.73205 \quad \mathrm{B} = 1 \quad \mathrm{C} = 0 \quad \mathrm{D} = 8.89$$

Side flat of internal be piece @ 5 & 11 o'clock

$$AX + BY + CZ - D = 0$$

$$(1.73205)(1.26368) + (1)(-11.07876) + (0)(Z) = D = -8.89$$

$$\mathrm{A} = 1.73205 \quad \mathrm{B} = 1 \quad \mathrm{C} = 0 \quad \mathrm{D} = -8.89$$

C-2. PHASE I CONFIGURATIONS

The reactor vessel and grid plates are consistent throughout the Phase I experiments. Fig. C-4 provides the dimensions for the reactor vessel, and the surfaces required to describe the vessel in MCNP5 are determined in this section. For the experiments performed during Phase I, the geometry for the water reflector tanks is inferred from the text describing the experiments, rather than a dimensioned drawing. The description of the tanks is discussed in Section 3.1.2 of this report. The dimensions in Fig. C-5 are calculated in this section and are based on the text description. These dimensions are common to all the Phase I cases, as this tank system was used for all the experiments.

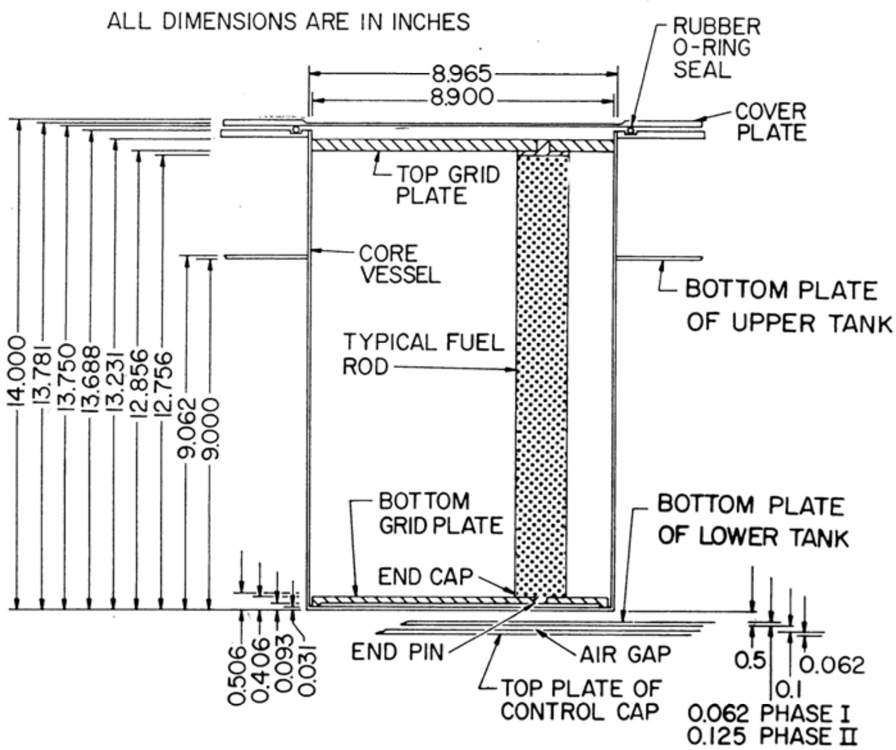


Fig. C-4. Phase I reactor vessel configuration

As was previously determined, the top and bottom of the fuel elements are determined to be ±15.8115 cm. From these dimensions the top and bottom of the grid plates are calculated:

$$\text{top of the upper grid plate} = 16.764\ cm = 15.8115\ cm + \left(2.54\frac{cm}{inch}\right)*\left(0.375\ inch\right)$$

$$\text{bottom of the lower grid plate} = -16.60652\ cm = -15.8115\ cm - \left(2.54\frac{cm}{inch}\right)*\left(0.312\ inch\right)$$

From Fig. C-4, the following dimensions are determined:

$$\text{IR of vessel} = 11.303\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.9\ inches}{2}\right)$$

$$\text{OR of vessel} = 11.38555\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.965\ inches}{2} + 0.031\ inch\right)$$

No dimensions are provided for the diameter of the flange. It is assumed to be 2 in. larger than the outer diameter of the vessel:

$$\text{OR of vessel flange} = 16.46555\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.965\ inches}{2}+2\ inches\right)$$

$$\text{top of the cover plate flange} = 18.71726\ cm = 15.8115\ cm + \left(2.54\frac{cm}{inch}\right)*\left((14-12.856)\ inches\right)$$

$$\text{top of the vessel cover indent} = 18.161\ cm = 18.71726\ cm - \left(2.54\frac{cm}{inch}\right)*\left((14-13.781)\ inches\right)$$

$$\text{vessel cover /flange interface} = 18.08226\ cm = 18.161\ cm - \left(2.54\frac{cm}{inch}\right)*\left((13.781-13.75)\ inches\right)$$

$$\text{bottom of the vessel flange} = 17.92478\ cm = 18.08226\ cm - \left(2.54\frac{cm}{inch}\right)*\left((13.75-13.688)\ inches\right)$$

$$\text{top of the vessel bottom} = -16.84274\ cm = 18.71726\ cm - \left(2.54\frac{cm}{inch}\right)*\left(14\ inches\right)$$

$$\text{top of the vessel bottom} = -16.764\ cm = -16.84274\ cm - \left(2.54\frac{cm}{inch}\right)*\left(0.031\ inch\right)$$

$$\text{bottom of the bottom plate for the top tank} = 6.01726\ cm = -16.84274\ cm + \left(2.54\frac{cm}{inch}\right)*\left(9\ inches\right)$$

$$\text{top of the bottom plate for the top tank} = 6.17474\ cm = 6.01726\ cm + \left(2.54\frac{cm}{inch}\right)*\left(0.062\ inch\right)$$

The maximum water height reported for the experiments is 9 in. (22.86 cm) in the top tank. From the sketch shown in Fig. C-5, the top tank extends a short amount over the water, and this is arbitrarily taken to be 10 in. (25.4 cm):

$$\text{top edge of the top tank} = 31.57474\ cm = 6.17474\ cm + \left(2.54\frac{cm}{inch}\right)*\left(10\ inches\right)$$

$$\text{bottom of the bottom plate for the lower tank} = -18.11274\ cm = -16.84274\ cm - \left(2.54\frac{cm}{inch}\right)*\left(0.5\ inch\right)$$

$$\text{top of the bottom plate for the lower tank} = -17.95526\ cm = -18.11274\ cm + \left(2.54\frac{cm}{inch}\right)*\left(0.062\ inch\right)$$

$$\text{top of the top plate for the control cap tank} = -18.36674\ cm = -18.11274\ cm - \left(2.54\frac{cm}{inch}\right)*\left(0.1\ inch\right)$$

$$\text{bottom of the top plate for the control cap tank} = -18.52422\ cm = -18.36674\ cm - \left(2.54\frac{cm}{inch}\right)*\left(0.062\ inch\right)$$

$$\text{top of the bottom plate for the control cap tank} = -33.76422\ cm = -18.52422\ cm - \left(2.54\frac{cm}{inch}\right)*\left(6\ inches\right)$$

$$\text{bottom of the bottom plate for the control cap tank} = -33.9217\ cm = -33.76422\ cm - \left(2.54\frac{cm}{inch}\right)*\left(0.062\ inch\right)$$

As discussed in Section 3.1.2, the inner radius of the upper tank is assumed to be 6 in. larger than the outside diameter of the reactor vessel, providing 6 in. of radial reflection to the top portion of the vessel. The bottom wall of the upper tank is explicitly shown in Fig. C-4 to be 0.062 in. (0.15748 cm) thick, and this wall thickness is assumed for the walls of all the tanks.

$$\text{IR of upper tank} = 26.62555\,cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.965\,inches}{2}+6\,inches\right)$$

$$\text{OR of upper tank} = 26.78303\,cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.965\,inches}{2}+6.062\,inches\right)$$

$$\text{IR of lower tank} = 27.89555\,cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.965\,inches}{2}+6.5\,inches\right)$$

$$\text{OR of lower tank} = 28.05303\,cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.965\,inches}{2}+6.562\,inches\right)$$

$$\text{IR of control cap tank} = 19.64055\,cm = \left(2.54\frac{cm}{inch}\right)\left(\frac{8.965+6.5}{2}inches\right)$$

$$\text{OR of control cap tank} = 19.64055\,cm = \left(2.54\frac{cm}{inch}\right)\left(\frac{8.965+6.5}{2}inches+0.062\,inch\right)$$

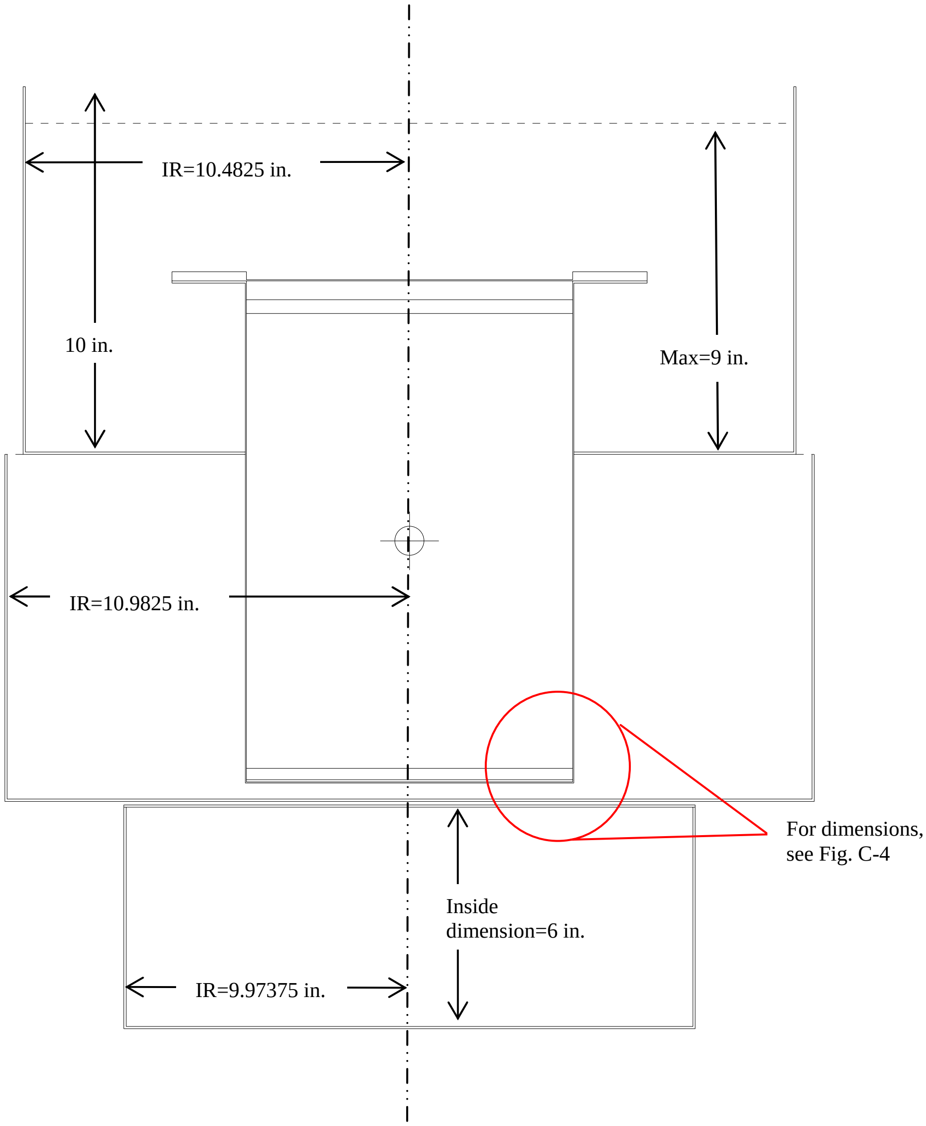


Fig. C-5. Phase I water tank configuration

In the Phase I experiments, the amount of water in the reflector tanks was varied. The water levels in the upper tank reported in NAA-SR-8490 and the top surfaces of the water are listed in Table C-2 for the Phase I experiments.

Table C-2. Top surface of water in top tank, Phase I cases

Case name	Upper tank water level, in. (cm)	Top surface of water (=6.17474cm+water level(cm))- surface 21	Case name	Upper tank water level, in. (cm)	Top surface of water (=6.17474cm+water level(cm))- surface 21
8490a	9.0 (22.86)	29.03474	8490k1	9.0 (22.86)	29.03474
8490b	9.0 (22.86)	29.03474	8490ℓ	5.0 (12.7)	18.87474
8490c	3.8 (9.652)	15.82674	8490ℓ1	9.0 (22.86)	29.03474
8490d	5.4 (13.72)	19.89074	8490ℓ2	9.0 (22.86)	29.03474
8490e	9.0 (22.86)	29.03474	8490ℓ3	9.0 (22.86)	29.03474
8490e1	7.0 (17.78)	23.95474	8490ℓ4	9.0 (22.86)	29.03474
8490e2	6.0 (15.24)	21.41474	8490ℓ5	9.0 (22.86)	29.03474
8490e3	5.5 (13.97)	20.14474	8490m	Empty	-
8490e4	4.938 (13.54)	18.71726	8490n	9.0 (22.86)	29.03474
8490e5	3.5 (8.89)	15.06474	8490n1	9.0 (22.86)	29.03474
8490e6	2.0 (5.08)	11.25474	8490o	9.0 (22.86)	29.03474
8490e7	Empty	-	8490p	9.0 (22.86)	29.03474
8490f	5.2 (13.21)	19.38274	8490q	9.0 (22.86)	29.03474
8490g	2.7 (6.86)	13.03274	8490r	9.0 (22.86)	29.03474
8490h	1.7 (4.32)	10.49274	8490s1	9.0 (22.86)	29.03474
8490h1	1.4 (3.56)	9.73074	8490s2	9.0 (22.86)	29.03474
8490h2	0.9 (2.286)	8.46074	849s3	9.0 (22.86)	29.03474
8490h3	0.4 (1.016)	7.19074	8490t	9.0 (22.86)	29.03474
8490h4	Empty	-	8490t1	9.0 (22.86)	29.03474
8490i	0.6 (1.524)	7.69874	8490t2	9.0 (22.86)	29.03474
8490i1	Empty	-	8490u	9.0 (22.86)	29.03474
8490j	0.1 (0.254)	6.42874	8490u1	9.0 (22.86)	29.03474
8490j1	Empty	-	8490u2	9.0 (22.86)	29.03474
8490k	5.2 (13.21)	19.38274			

Absorber Sleeve Experiments.

Absorber sleeves were used for the experiments modeled in cases *8490k-8490r*. These sleeves were annular cylinders that fit around the core vessel, and were made from absorber material in 0.031-in. (0.07874-cm)-thick stainless steel cans. Several thicknesses of sleeves were used, as well as different heights. The core vessel was divided into three sections- upper, middle, and lower. Sleeves were constructed to fit these axial regions of the core. The middle and lower sections divided the portion of the core vessel in the lower reflector tank into two equal sections, each 4.5 in. (11.43 cm) long. The upper section extends from the top of the bottom plate for the upper tank to the bottom of the core vessel flange (4.626 in. [11.75 cm]) long. The experimental configurations are detailed in Section 3.2.3.

For the axial surfaces of the lower sleeve:

$$\text{Bottom of lower sleeve} = \text{bottom of reactor vessel} = -16.84274\ cm$$

$$\text{Top edge of lower sleeve} = -5.41274\ cm = -16.84274\ cm + \left(2.54\frac{cm}{inch}\right) * \left(\frac{9\ inches}{2}\right)$$

$$\text{Inside top surface of lower sleeve} = -5.49148\ cm = -5.41274\ cm - \left(2.54\frac{cm}{inch}\right) * (0.031\ inch)$$

$$\text{Inside bottom surface of lower sleeve} = -16.68526\ cm = -16.764\ cm + \left(2.54\frac{cm}{inch}\right) * (0.031\ inch)$$

For the axial surfaces of the middle sleeve:

$$\text{Bottom of middle sleeve} = \text{top of the lower sleeve} = -5.41274\ cm$$

$$\text{Top edge of middle sleeve} = \text{bottom of top tank} = 6.01726\ cm$$

$$\text{Inside top surface of lower sleeve} = 5.93852\ cm = 6.01726\ cm - \left(2.54\frac{cm}{inch}\right) * (0.031\ inch)$$

$$\text{Inside bottom surface of lower sleeve} = -5.334\ cm = -5.41274\ cm + \left(2.54\frac{cm}{inch}\right) * (0.031\ inch)$$

For the axial surfaces of the upper sleeve:

$$\text{Bottom of upper sleeve} = \text{top of the top tank bottom plate} = 6.17474\ cm$$

$$\text{Top edge of upper sleeve} = \text{bottom of vessel flange} = 17.92478\ cm$$

$$\text{Inside top surface of upper sleeve} = 17.84604\ cm = 17.92478\ cm - \left(2.54\frac{cm}{inch}\right) * (0.031\ inch)$$

$$\text{Inside bottom surface of upper sleeve} = 6.25348\ cm = 6.17474\ cm + \left(2.54\frac{cm}{inch}\right) * (0.031\ inch)$$

Four different sleeve thicknesses are used: 0.25 in., 0.5 in., 0.75 in., and 1 in. The thickness of the sleeve is assumed to refer to the outside dimension, and the sleeves are assumed to fit tightly against the vessel wall. As previously mentioned, the sleeves are constructed of steel shells with 0.031-in.-thick walls.

The inner radial surfaces for all the sleeves then are:

$$\text{Inside surface of sleeve} = \text{OR of vessel} = 11.38555\ cm$$

$$\text{Inside surface of sleeve inner wall} = 11.46429\ cm = 11.38555\ cm - \left(2.54\frac{cm}{inch}\right) * (0.031\ inch)$$

The remaining radial surfaces for the various sleeves are calculated below.

For the 0.25-in. thick sleeves:

$$\text{Outside surface of sleeve} = 12.02055\, cm = 11.38555\ \text{cm} + \left(2.54\frac{cm}{inch}\right) * (0.25\, inch)$$

$$\text{Inside surface of sleeve outer wall} = 11.94181\, cm = 12.02055\ \text{cm} - \left(2.54\frac{cm}{inch}\right) * (0.031\, inch)$$

For the 0.5-in. thick sleeves:

$$\text{Outside surface of sleeve} = 12.65555\, cm = 11.38555\, cm + \left(2.54\frac{cm}{inch}\right) * (0.5\, inch)$$

$$\text{Inside surface of sleeve outer wall} = 12.57681\, cm = 12.65555\, cm - \left(2.54\frac{cm}{inch}\right) * (0.031\, inch)$$

For the 0.75-in. thick sleeves:

$$\text{Outside surface of sleeve} = 13.29055\, cm = 11.38555\, cm + \left(2.54\frac{cm}{inch}\right) * (0.75\, inch)$$

$$\text{Inside surface of sleeve outer wall} = 12.21181\, cm = 13.29055\, cm - \left(2.54\frac{cm}{inch}\right) * (0.031\, inch)$$

For the 1-in. thick sleeves:

$$\text{Outside surface of sleeve} = 13.92555\, cm = 11.38555\, cm + \left(2.54\frac{cm}{inch}\right) * (1\, inch)$$

$$\text{Inside surface of sleeve outer wall} = 13.84681\, cm = 13.92555\, cm - \left(2.54\frac{cm}{inch}\right) * (0.031\, inch)$$

C-3. PHASE III CORE VESSEL AND COMMON DIMENSIONS

Details regarding the vessel closure and grid plates were not provided in NAA-SR-9871. These tank details then are taken from the Phase I description. As the grid plates from the Phase I configuration would not practically fit into all the vessels used for the Phase III experiments, a thickness on 0.25 in. was assumed for the top and bottom grid plates. The plate materials were assumed to be the same from Phase I, type 1100 aluminum. It is important to note that in Fig. C-4, a gap between the cover plate and vessel flange is shown, and appears to be dimensioned. This is somewhat misleading, as the gap does not exist, and the dimensioning lines in fact are for the positioning and thickness of the Phase I grid plate.

$$\text{IR of vessel} = 11.27125\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.875\ inches}{2}\right)$$

$$\text{OR of vessel} = 11.34999\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.875\ inches}{2}+0.031\ inch\right)$$

$$\text{top of the vessel cover} = 17.49425\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right)*\left(13\ inches\right)$$

$$\text{top of the vessel cover indent} = 16.93799\ cm = 17.49425\ cm - \left(2.54\frac{cm}{inch}\right)*\left(\left(14-13.781\right)inch\right)$$

$$\text{vessel cover /flange interface} = 16.85925\ cm = 16.93799\ cm - \left(2.54\frac{cm}{inch}\right)*\left(\left(13.781-13.75\right)inch\right)$$

$$\text{bottom of the vessel flange} = 16.70177\ cm = 16.85925\ cm - \left(2.54\frac{cm}{inch}\right)*\left(\left(13.75-13.688\right)inch\right)$$

$$\text{bottom of the lower grid plate} = -16.4465\ cm = -15.8115\ cm - \left(2.54\frac{cm}{inch}\right)*\left(\left(0.25\right)inch\right)$$

$$\text{top of the upper grid plate} = 16.4465\ cm = 15.8115\ cm + \left(2.54\frac{cm}{inch}\right)*\left(0.25\ inch\right)$$

The outer radius of the vessel flange was not provided, so an estimate consistent with the MCNP5 models for the Phase I experiments is used. This allowed for a ~2-in. flange (the dimension is slightly different due to the minor change in vessel diameter):

$$\text{OR of the vessel flange} = 16.46555\ cm$$

The Phase III experiments used three different water tank systems. One of these systems, used for case *fig12*, was designed to accommodate the large external beryllium reflector assembly on the outside of the core vessel. The split tank water system used a top water tank that divided the core vessel into two sections. Sleeve assemblies used with the split tank were made in two sections, one to fit the section of the core vessel in the top tank, and the second to fit the section of vessel in the bottom tank. The third configuration was for those experiments modeling the SNAPTRAN-3 configuration. The radii and materials of the *fig12* and split tank configurations were the same. The remaining dimensions for these tank systems are discussed in Sections C-4 and C-5.

$$\text{IR of top tank} = 26.67\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{21\,inches}{2}\right)$$

$$\text{OR of top tank} = 26.82743\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{21\,inches}{2}+0.062\ inch\right)$$

$$\text{IR of bottom tank} = 34.925\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{27.5\ inches}{2}\right)$$

$$\text{OR of bottom tank} = 35.08248\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{27.5\ inches}{2}+0.062\ inch\right)$$

C-4. PHASE III-WATER TANK SYSTEM FOR THE EXTERNAL BERYLLIUM REFLECTOR

This case *(fig12)* models the experiment described in Fig. 12 of NAA-SR-9871. This case uses SCA-4 fuel, with 26 fuel elements, full reflection/dry core, with the external beryllium reflector shown in this section. The tank configuration used is shown in Fig. C-6. The water in the reflector is 9.5 inches above fuel bottom. **Case *fig12* is the only case that uses this external beryllium reflector and this water tank configuration.** The input file for case *fig12* is provided in Appendix D as well as Volume II of this report.

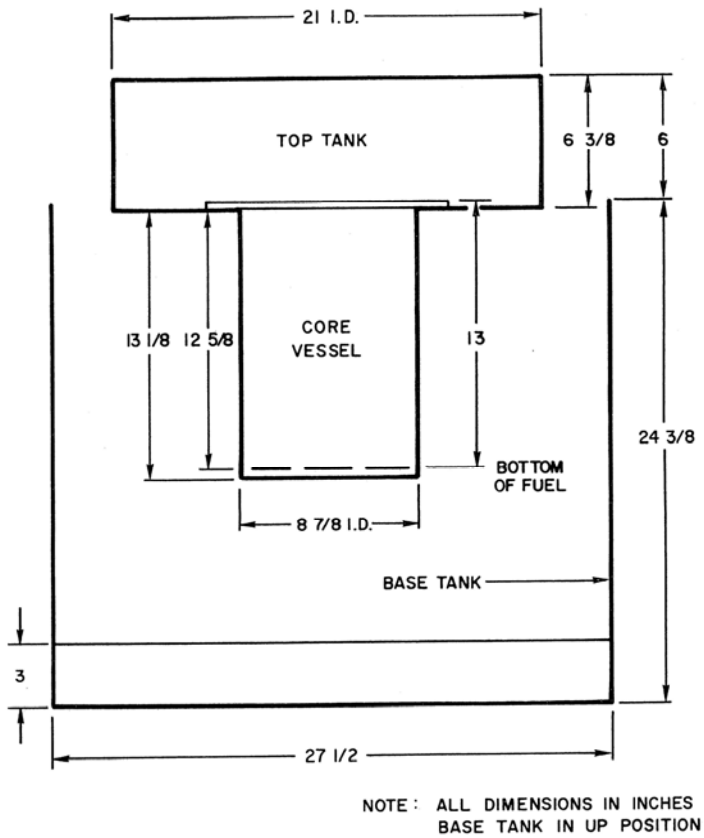


Fig. C-6. Sketch of water tank system for case *fig12*

$$\text{bottom of the top tank} = 16.54429\ cm = 16.70177\ cm - \left(2.54\frac{cm}{inch}\right)*(0.062\ inch)$$

$$\text{bottom of the vessel bottom} = -16.79231\ cm = 16.54429\ cm - \left(2.54\frac{cm}{inch}\right)*(13.125\ inches)$$

$$\text{top of the vessel bottom} = -16.71447\ cm = -16.79231\ cm - \left(2.54\frac{cm}{inch}\right)*(0.031\ inch)$$

$$\text{top edge of top tank} = 32.73769\ cm = 16.79231\ cm + \left(2.54\frac{cm}{inch}\right)*([13.125 + 6.375]\ inches)$$

$$\text{top of the bottom tank} = 17.49769\ cm = 32.73769\ cm - \left(2.54\frac{cm}{inch}\right)*(6\ inches)$$

$$\text{bottom of the bottom plate for the lower tank} = -44.41481\ cm = 32.73769\ cm - \left(2.54\frac{cm}{inch}\right)*(30.375\ inches)$$

$$\text{top of the bottom plate for the lower tank} = -44.09731\,cm = -44.41825\,cm + \left(2.54\frac{cm}{inch}\right)*(0.125\,inch)$$

$$\text{top of the top plate for the lower tank} = -36.47731\,cm = -44.09731\,cm + \left(2.54\frac{cm}{inch}\right)*(3\,inches)$$

$$\text{bottom of the top plate for the lower tank} = -36.15981\,cm = -36.47731\,cm + \left(2.54\frac{cm}{inch}\right)*(0.125\,inch)$$

$$\text{water level in the lower tank} = 8.60425\,cm = -15.52575\,cm + \left(2.54\frac{cm}{inch}\right)*(9.5\,inches)$$

$$\text{water level in the top tank} = 32.73425\,cm = -15.52575\,cm + \left(2.54\frac{cm}{inch}\right)*(19\,inches)$$

In the MCNP model, the orientation of the beryllium reflector main block is such that the picture shown in Fig. C-7 is rotated counterclockwise 30°.

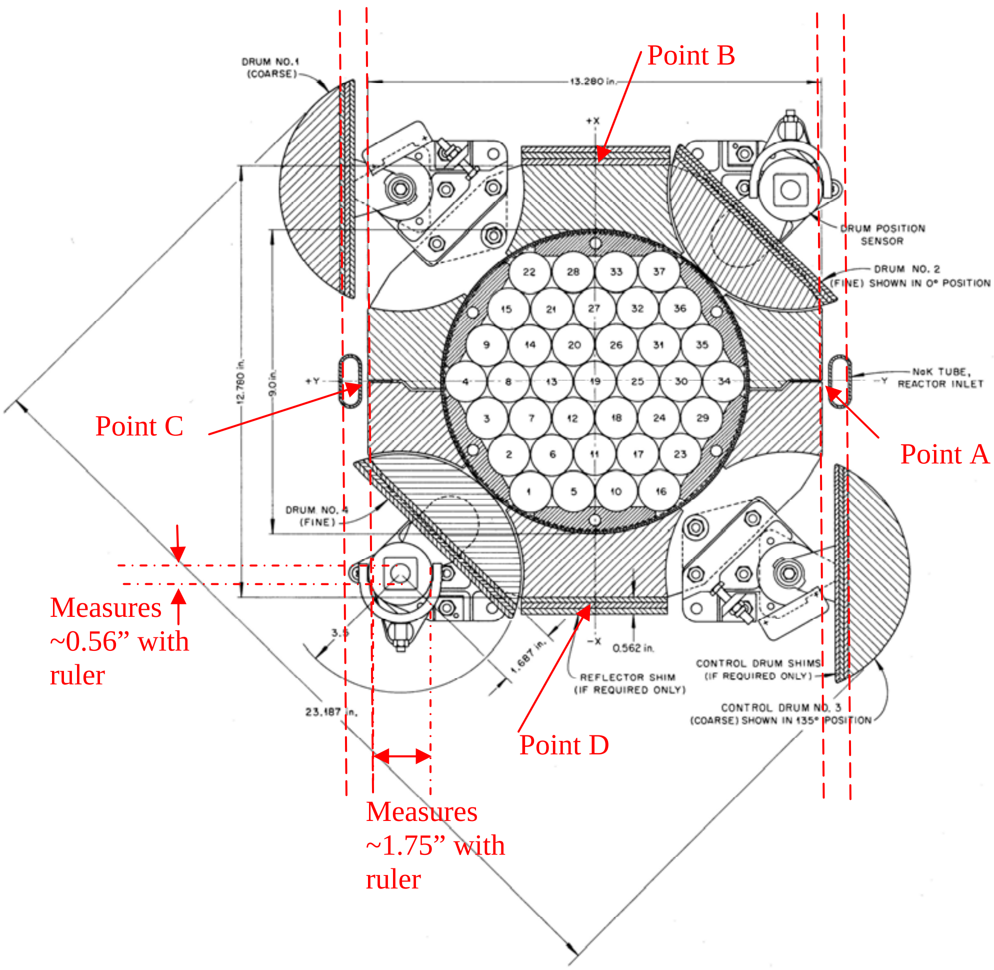


Fig. C-7. Sketch used to determine the dimensions for the external beryllium reflector

The unshimmed reflector has two dimensions for the main block. As shown in Fig. C-7, these dimensions are:

$$16.8656\ cm = \left(\frac{13.28\ inches}{2}\right)\left(2.54\frac{cm}{inch}\right) \quad \text{and} \quad 16.2306\ cm = \left(\frac{12.78\ inches}{2}\right)\left(2.54\frac{cm}{inch}\right)$$

Looking at the reflector main block in the sketch above, the center point of each side was determined (recall that in the model, the sketch is rotated 30°). The letters A, B, C, and D note the distance from the midpoint of the side of the reflector to the origin (and the point itself):

- A=16.8656 (side will be in first quadrant- shown as the –y axis in the sketch)
- B=16.2306 (side will be in the second quadrant)
- C=16.8656 (side will be in third quadrant)
- D=16.2306 (side will be in the fourth quadrant)

The coordinates of these center points are:

$$A_X = A\sin 30° = 14.6060$$
$$A_Y = A\cos 30° = 8.4328$$

$$B_X = A\sin 30° = -8.1153$$
$$B_Y = A\cos 30° = 14.056$$

$$C_X = A\sin 30° = -14.6060$$
$$C_Y = A\cos 30° = -8.4328$$

$$D_X = A\sin 30° = 8.1153$$
$$D_Y = A\cos 30° = -14.056$$

Determine the line that passes through (A_X, A_Y):

$$slope = -\tan 60° = -1.732$$
$$8.4328 = (-1.732)(14.6060) + b; b = 33.730392$$
$$\text{A} = \text{-1.732} \quad \text{B} = \text{-1} \text{C} = 0 \quad \text{D} = 33.730392$$

Determine the line that passes through (B_X, B_Y):

$$slope = \tan 30° = 0.57735$$
$$14.056 = (0.57735)(-8.1153) + b; b = 18.74137$$
$$\text{A} = 0.57735 \qquad \text{B} = \text{-1} \qquad \text{C} = 0 \qquad \text{D} = 18.74137$$

Determine the line that passes through (C_X, C_Y):

$$
\begin{aligned}
&slope = -\tan 60° = -1.732 \\
&-8.4328 = (-1.732)(-14.6060) + b; b = -33.730392 \\
&\mathrm{A} = -1.732 \quad \mathrm{B} = \text{-}1 \quad \mathrm{C} = 0 \quad \mathrm{D} = -33.730392
\end{aligned}
$$

Determine the line that passes through (D_X, D_Y):

$$
\begin{aligned}
&slope = \tan 30° = 0.57735 \\
&-14.056 = (0.57735)(8.1153) + b; b = -18.74137 \\
&\mathrm{A} = 0.57735 \quad \mathrm{B} = \text{-}1 \quad \mathrm{C} = 0 \quad \mathrm{D} = -18.74137
\end{aligned}
$$

The planes used to cut off the control drums are calculated in much the same way. These two lines will be parallel to the lines through points A and D. The centers of the drive shafts are 3.5 in. beyond the outer radius of the core vessel.

$$
\begin{aligned}
&11.38555 + 8.89 = 20.27555 \\
&20.27555 \cos 15° = 19.584677 \\
&20.27555 \sin 15° = 5.247698
\end{aligned}
$$

The center points for the control drums are then:

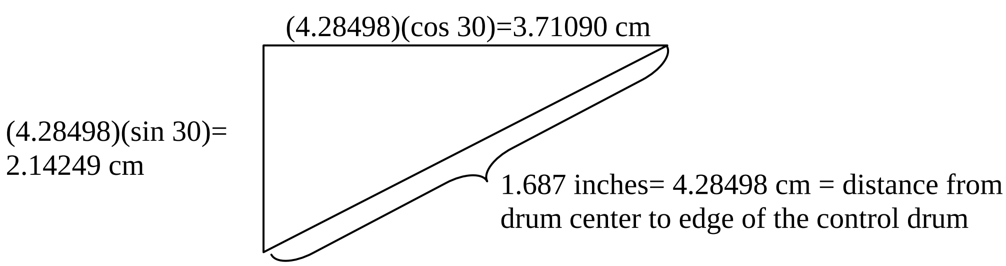
(-19.584677, 5.247698)

(19.584677, -5.247698)

(5.247698, 19.584677)

(-5.247698, -19.584677)

Two lines are used to cut off the control drums, and these lines are parallel to the edge of the reflector main block (lines running through points A and D above). The points on these lines are determined from the control drum center point and the distance to the line:



The point on the line to cut off the control drum is:

$$
\begin{aligned}
&19.5846677 + 3.71090 = 23.295577 \\
&-5.247698 + 2.14249 = -3.105208
\end{aligned}
$$

The equation line to cut off the control drums is given by:

$$slope = -\tan 60° = -1.732$$
$$-3.105208 = (-1.732)(-23.295577) + b; b = -37.2427$$
$$\text{A} = -1.732 \quad \text{B} = -1 \quad \text{C} = 0 \quad \text{D} = -37.2427$$

The procedure is repeated for the second line needed to cut off the other two control drums:

$$-5.247698 - 3.71090 = -8.958598$$
$$-19.584677 - 2.14249 = -21.727167$$
$$slope = -\tan 60° = -1.732$$
$$-21.727167 = (-1.732)(-8.958598) + b; b = -37.2434$$
$$\text{A} = -1.732 \quad \text{B} = -1 \quad \text{C} = 0 \quad \text{D} = -37.2434$$

The radii for the control drum assembly are:

$$\text{OR of control drum} = 8.89\ cm = \left(2.54\frac{cm}{inch}\right) * (3.5\ inches)$$
$$\text{OR of drive shaft} = 2.2225\ cm = \left(2.54\frac{cm}{inch}\right) * \left(\frac{1.75}{2}inch\right)$$
$$\text{IR of drive shaft} = 0.7112\ cm = \left(2.54\frac{cm}{inch}\right) * \left(\frac{0.56}{2}inch\right)$$

Determining the axial dimensions for the external beryllium reflector.

The axial dimensions of the reflector are taken from Fig. C-8.

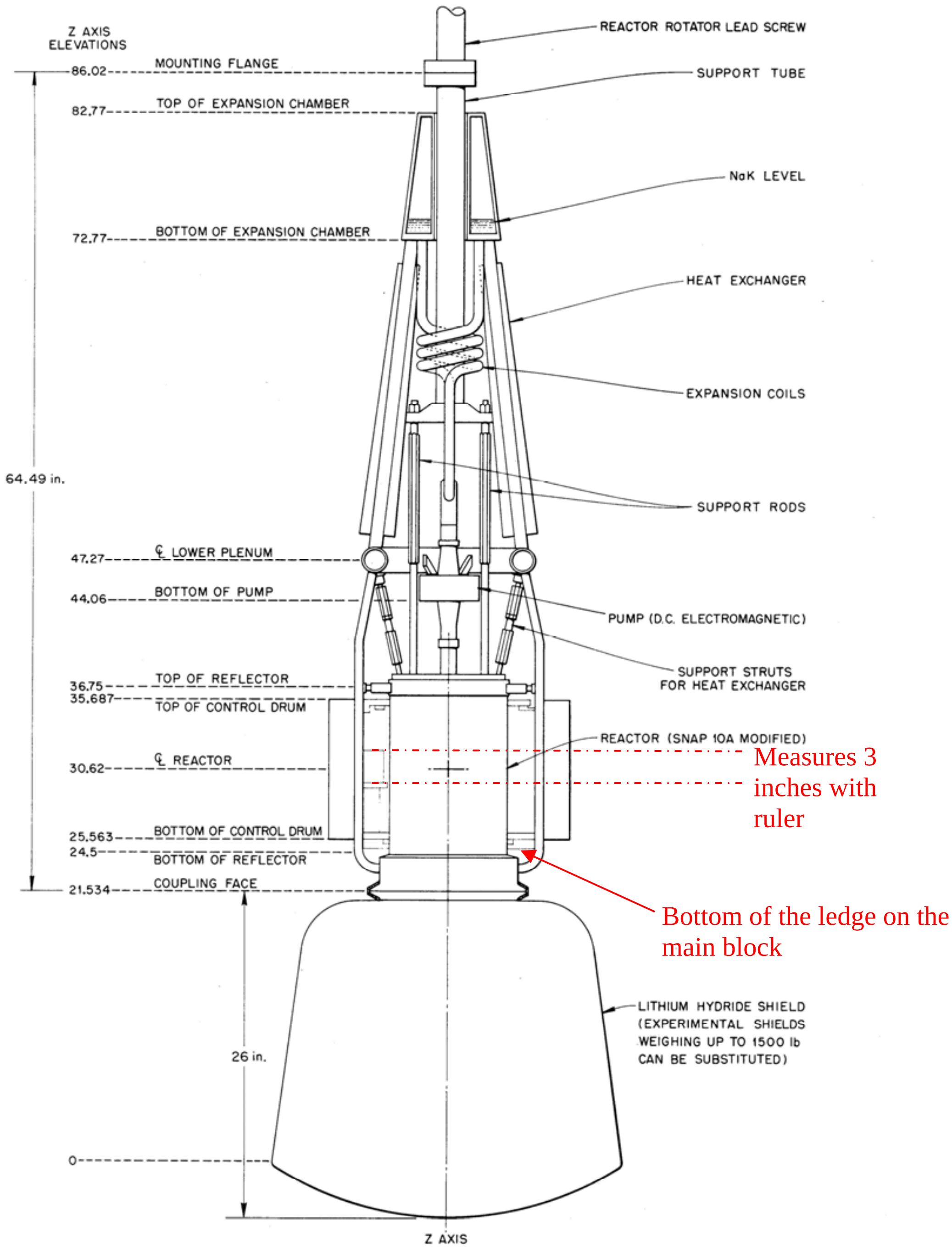


Fig. C-8. Sketch illustrating the axial dimensions of the external beryllium reflector

$$\text{top of the control drums} = 12.87018\ cm = 0\ cm + \left(2.54\,\frac{cm}{inch}\right) * \left((35.687 - 30.62)\ inches\right)$$

$$\text{bottom of the control drums} = -12.84478\ cm = 0\ cm - \left(2.54\,\frac{cm}{inch}\right) * \left((30.62 - 25.563)\ inches\right)$$

$$\text{bottom of the reflector main block} = -15.5448\ cm = 0\ cm - \left(2.54\,\frac{cm}{inch}\right) * \left((30.62 - 24.5)\ inches\right)$$

$$\text{top of the reflector main block} = 15.5702\ cm = 0\ cm + \left(2.54\,\frac{cm}{inch}\right) * \left((36.75 - 30.62)\ inches\right)$$

$$\text{top and bottom of the large cylinder of the drive shaft} = 0\ cm \pm \left(2.54\,\frac{cm}{inch}\right) * \left(3\ inches\right)$$

$$\text{circle used for the ledges of the reflector main block} = \left(2.54\,\frac{cm}{inch}\right) * \left(\frac{12.78}{2}\,inches\right)$$

C-5. PHASE III- SPLIT TANK CONFIGURATIONS

The experiments described in this appendix all used the split tank configuration shown in Fig. 48 of NAA-SR-9871. This water tank system used a top tank whose bottom divided the reactor vessel into two axial segments. Binal, void, and absorber sleeves used with this assembly had to be fabricated in two sections. The top section fit around the section of the reactor vessel in the top section, and the lower portion covered the section of the tank in the lower water tank.

The following is a list of the cases described in this appendix. The MCNP5 inputs for cases shown in red bold text in Table C-3 are provided in Appendix D. They are a representative sample of the inputs required for this report. MCNP5 input files for all cases discussed in this report are available in Volume II of this report.

Table C-3. Case names for experiments using the split tank configuration

Case name	Fuel type	Water flooded	Water level, inches above fuel bottom	Fuel elements	Lucite rods	Absorber splines	Binal or steel sleeves	Void sleeve	Absorber sleeves
Fig16	SCA-4	no	19	37	0	12	no	no	no
Fig14a	SCA-4	yes	1.88* (axial reflection)	25	12	0	no	no	no
Fig14b	SCA-4	yes	2 (axial reflection)	25	12	0	no	no	no
Fig14c	SCA-4	yes	2.25 (axial reflection)	25	12	0	no	no	no
Fig14d	SCA-4	yes	2.5 (axial reflection)	25	12	0	no	no	no
p49	SCA-4	yes	10.25	35	2	0	yes	no	no
p58gap and p58	SCA-4	yes	14.88	36	1	0	yes	yes	yes
p59gap and p59	SCA-4	yes	12.41	37	0	0	yes	yes	yes
Tbl1a	SNAPTRAN	no	14.9375	33	4	0	no	no	no
Tbl1b	SNAPTRAN	no	12.06	34	3	0	no	no	no
Tbl1c	SNAPTRAN	no	11.06	35	2	0	no	no	no
Tbl1d	SNAPTRAN	no	10.31	36	1	0	no	no	no
Tbl1e	SNAPTRAN	no	9.88	37	0	0	no	no	no
Fig19	SNAPTRAN	no	14.9375	37	0	15	no	no	no
p50a	SNAPTRAN	yes	10.5	36	1	0	yes	no	no
p50b	SNAPTRAN	yes	9.13	36	1	0	yes	no	no

* “Axial reflection” indicates measurement is given in inches above the top of the reactor vessel.

Cases *fig16* and *fig19*.

These cases model the experiments described in Figs. 16 and 19 of NAA-SR-9871.

These cases use a full core complement (SCA-4 fuel for *fig16* and SNAPTRAN fuel for *fig19*), full reflection/dry core, with absorber splines. The tank configuration used is that shown in Fig. C-9, reproduced from Fig. 48 of NAA-SR-9871. The absorber spline materials and fuel elements are modeled individually.

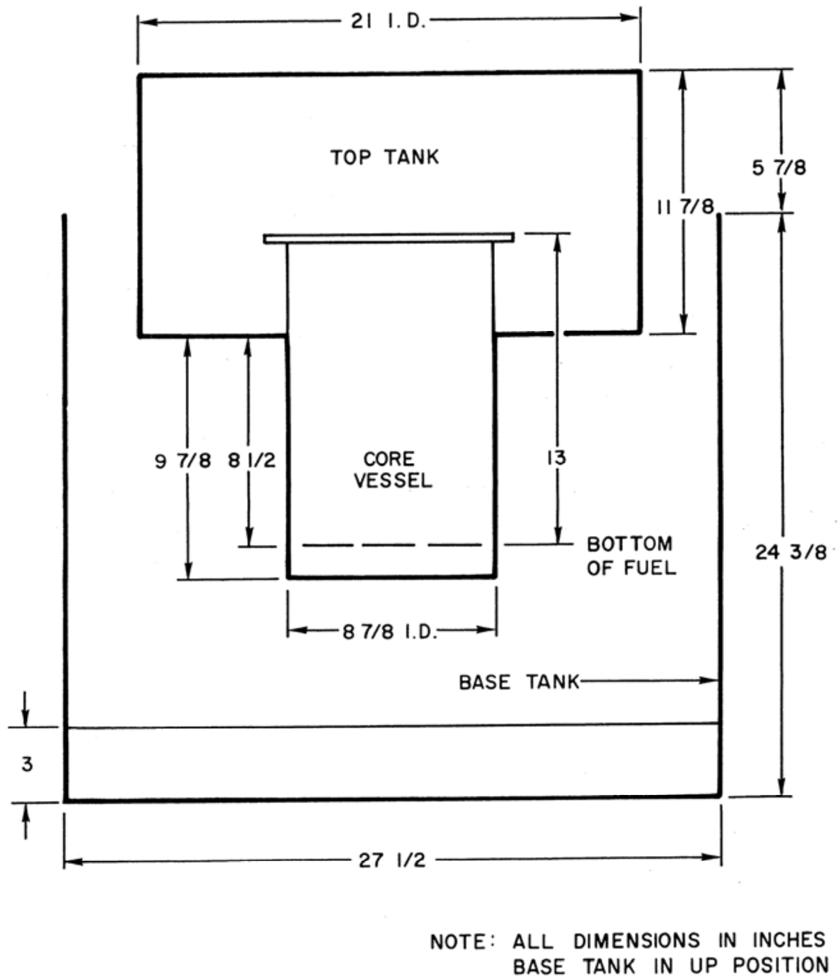


Fig. C-9. Sketch of split water tank system

Fig. C-9 provides dimensions for the reactor vessel:

$$\text{bottom of the vessel bottom} = -19.01825\ cm = 6.06425\ cm - \left(2.54\frac{cm}{inch}\right)*(9.875\ inches)$$

$$\text{bottom of the top tank} = 6.06425\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right)*(8.5\ inches)$$

The thickness of the bottom plate of the core vessel, 0.062 in., is taken from Fig. C-4:

$$\text{top of the top tank bottom} = 6.22173\ cm = 6.06425\ cm + \left(2.54\frac{cm}{inch}\right)*(0.062\ inch)$$

$$\text{top edge of the top tank} = 36.22675\ cm = 6.06425\ cm + \left(2.54\frac{cm}{inch}\right)*(11.875\ inches)$$

$$\text{top of the bottom tank} = 21.30425\ cm = 36.22675\ cm - \left(2.54\frac{cm}{inch}\right)*(5.875\ inches)$$

$$\text{bottom of the bottom plate for the lower tank} = -40.60825\ cm = 21.30425\ cm - \left(2.54\frac{cm}{inch}\right)*(24.375\ inches)$$

$$\text{top of the bottom plate for the lower tank} = -40.29075\ cm = -40.60825\ cm + \left(2.54\frac{cm}{inch}\right)*(0.125\ inch)$$

$$\text{bottom of the top plate for the lower tank} = -32.67075\ cm = -40.29075\ cm + \left(2.54\frac{cm}{inch}\right)*(3\ inches)$$

$$\text{top of the top plate for the lower tank} = -32.5325\ cm = -32.67075\ cm + \left(2.54\frac{cm}{inch}\right)*(0.125\ inch)$$

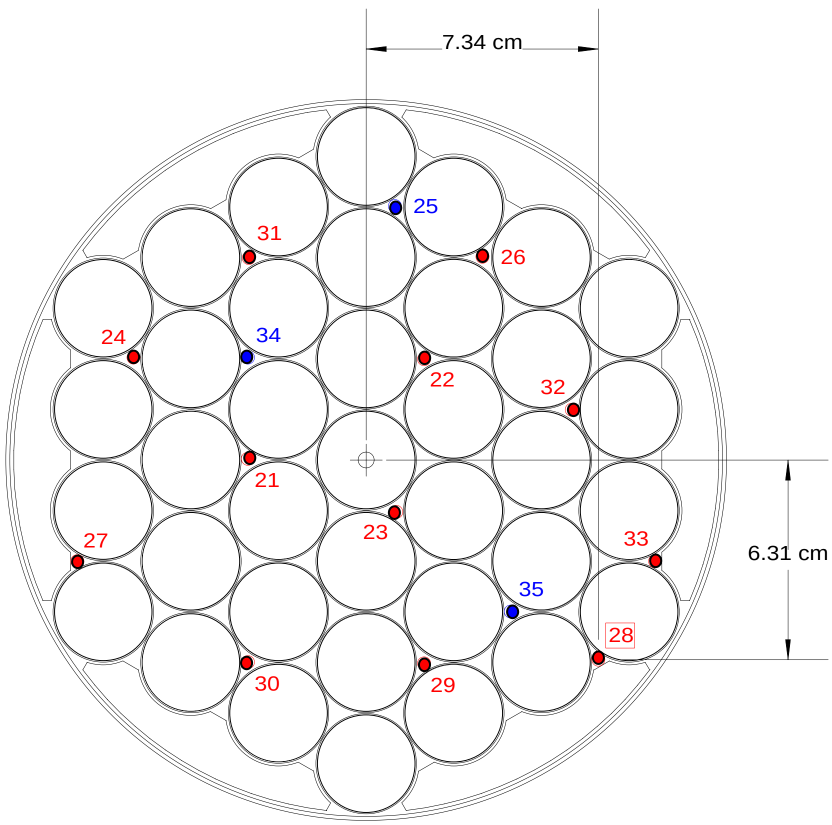
The water level for this experiment is reported simply as full reflection. It is inferred from this and the calibration curve that this corresponds to 19 in. of water above the bottom of the active fuel region.

$$\text{water level in the top tank} = 32.73425\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right)*(19\ inches)$$

Absorber spline positions.

The positions of the splines were determined using simple CAD software. The figure below uses a spline with an outer diameter of 1/8 in. For the final MCNP5 case, the spline diameter was increased to the maximum amount that would fit into the interstitial spaces (0.416 cm outer diameter). For this reason, the coordinates for the center points of the splines had to be adjusted from what is shown in the sketch to fit into each position. The thin aluminum wall of the tube is neglected. The CAD sketch is provided in Fig. C-10.

$$\text{OR of poison spline} = 0.208\,cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{0.16378}{2}inch\right)$$



NOTE: Splines shown in blue are NOT used in case *fig16*; these splines are used only in case *fig19*

Fig. C-10. Spline positions for cases *fig16* and *fig19*

Spline #28 was the first defined, and the remaining splines were positioned in the MCNP5 model relative to this spline. The coordinates of the remaining splines, using spline #28 as the origin, are provided in the table below.

Table C-4. Absorber spline positions relative to spline #28

Spline Number	X displacement (cm)	Y displacement (cm)
29	-5.51	-0.12
35	-2.77	1.52
33	1.795	3.11
30	-11.08	-0.08
23	-6.39	4.67
32	-.84	7.90
27	-16.475	3.11
21	-11.08	6.35
22	-5.51	9.5
26	-3.66	12.74
34	-11.08	9.55
24	-14.7	9.55
25	-6.43	14.34
31	-11.05	12.7

Surfaces required for sleeve assemblies.

Several cases modeled use Binal sleeves or a combination of void/absorber sleeves.

Case *p49* uses a close-fitting Binal sleeve 0.75 in. thick that covers the core. The water level in the bottom tank is 10.25 in. above the fuel bottom.

13.25499 *cm* = OR of the Binal sleeve=11.34999 *cm* + (0.75 *inch*)(2.54 *cm/inch*)

10.50925 *cm* =water level in the top tank=-15.52575 *cm* + (10.25 *inches*)(2.54 *cm/inch*)

Case *p58* uses a void/absorber sleeve assembly that is also surrounded by a stainless steel sleeve. The entire sleeve assembly has cadmium sheets covering the top and bottom. It is assumed for this case that there are no gaps between the sleeve components that could be filled with water. The water level is 14.88 in. above the bottom of the fuel.

22.26945 *cm* = -15.52575 *cm* + (14.88 *inches* above the bottom of the fuel)(2.54 *cm/inch*)

The radial sleeve surfaces are determined as follows:

11.42873 *cm* = 11.34999 *cm* (OR of vessel) + (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

18.89125 *cm* = 11.42873 *cm* + (3-*inch* thick void sleeve-(2*0.031-*inch* thick walls))(2.54 *cm/inch*)

18.96999 *cm* = 18.89125 *cm* + (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

19.04873 *cm* = 18.96999 *cm* + (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

21.43125 *cm* = 19.04873 *cm* +

(1-*inch* thick absorber sleeve-(2*0.031-*inch* thick walls))(2.54 *cm/inch*)

21.50999 *cm* = 21.43125 *cm* + (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

22.14499 *cm* = 21.50999 *cm* + (0.25-*inch* thick wall steel sleeve)(2.54 *cm/inch*)

The axial sleeve surfaces are determined as follows:

15.7607 *cm* = 15.8115 *cm* -(2.54 *cm/inch*)(0.02-*inch* thick cadmium sheet)

15.68196 *cm* =15.7607 *cm* -(2.54 *cm/inch*)(0.031-*inch* thick steel shell)

6.30047 *cm* = 6.22173 *cm* + (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

5.98551 *cm* = 6.06425 *cm* - (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

-15.7607 *cm* = -15.8115 *cm* + (2.54 *cm/inch*)(0.02-*inch* thick cadmium sheet)

-15.68196 *cm* = -15.7607 *cm* + (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

For case *p58gap*, the same void/absorber sleeve assembly is modeled, but with water gaps between the sleeve components. The water gap is assumed to be a maximum of 1/16 in. in all cases. The axial sleeve surfaces are the same as for case *p58*.

11.50874 *cm* = 11.34999 *cm* (OR of vessel) + (1/16-*inch* water gap)(2.54 *cm/inch*)

11.58748 *cm* = 11.50874 *cm* + (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

19.05 *cm* = 11.58748 *cm* + (3-*inch* thick void sleeve-(2*0.031-*inch* thick walls))(2.54 *cm/inch*)

19.12874 *cm* = 19.05 *cm* + (2.54 *cm/inch*)(0.031-*inch* thick steel shell)

19.28749 *cm* = 19.12874 *cm* + (1/16-*inch* water gap)(2.54 *cm/inch*)

19.36623 *cm* = 19.28749 *cm* + (0.031-*inch* thick wall for absorber sleeve)(2.54 *cm/inch*)

21.74875 *cm* = 19.36623 *cm* +

(1-*inch* thick absorber sleeve-(2*0.031-*inch* thick walls))(2.54 *cm/inch*)

21.82749 *cm* = 21.74875 *cm* + (0.031-*inch* thick wall for absorber sleeve)(2.54 *cm/inch*)

21.98624 *cm* = 21.82749 *cm* + (1/16-*inch* water gap)(2.54 *cm/inch*)

22.62124 *cm* = 21.98624 *cm* + (0.25-*inch* thick wall steel sleeve)(2.54 *cm/inch*)

For the case *p59* and *p59gap*, the sleeve assemblies are the same as described for *p58* and *p58gap*. The difference between the cases, other than the fuel loading, is that the cadmium sheets have been removed and the water level in the tank has been changed:

15.99565 *cm* = -15.52575 *cm* + (12.41 *inches* above the bottom of the fuel)(2.54 *cm/inch*)

Case *p50a* uses a 0.25-in. thick close-fitting Binal sleeve with a water level 10.5 in. above the bottom of the fuel.

11.98499 *cm* = 11.34999 *cm* (OR of vessel) + (0.25-*inch* thick sleeve)(2.54 *cm/inch*)

11.14425 *cm* = -15.52575 *cm* + (10.5 *inches* above the bottom of the fuel)(2.54 *cm/inch*)

Case *p50b* uses a 0.75-in. thick close-fitting Binal sleeve with a water level 9.13 in. above the bottom of the fuel.

13.25499 *cm* = 11.34999 *cm* (OR of vessel) + (0.25-*inch* thick sleeve)(2.54 *cm/inch*)

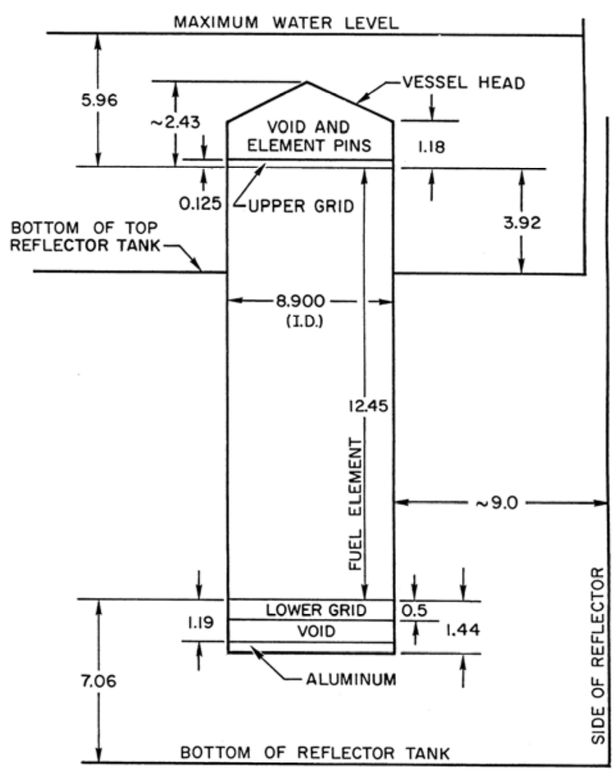
7.66445 *cm* = -15.52575 *cm* + (10.5 *inches* above the bottom of the fuel)(2.54 *cm/inch*)

C-6. PHASE III- SNAPTRAN-3 TANK CONFIGURATIONS

This section describes the geometry for the models of the experiments described in Table 4, NAA-SR-9871, beginning with case ***tbl4a***. These cases use SNAPTRAN fuel, with the SNAPTRAN-3 tank configuration shown in Fig. 27 of NAA-SR-9871. These cases use a full core loading, and the core is voided. No absorber splines are used. Case *p45* is provided in Appendix D, and all cases are provided in Volume II. The water level for these experiments is provided in Table C-5, and the tank configuration in shown in Fig. C-11.

Table C-5. Case names for experiments using the SNAPTRAN-3 tank configuration

Case name	water level, inches above fuel bottom
tbl4a	18.25
tbl4b	14.13
tbl4c	14.75
tbl4d	18.25
p45	5.69 (above top grid plate)
p46a	5.69 (above top grid plate)
p46b	10.4



Note: All dimensions are in inches.

Fig. C-11. Sketch used to determine vessel and water tank dimensions for SNAPTRAN -3 tank configurations

Fig. C-11 provides dimensions for the reactor vessel and the water tanks:

$$\text{IR of rx vessel} = 11.303\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.9\ inches}{2}\right)$$

$$\text{OR of rx vessel} = 11.38174\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{8.9\ inches}{2}+0.031\ inch\right)$$

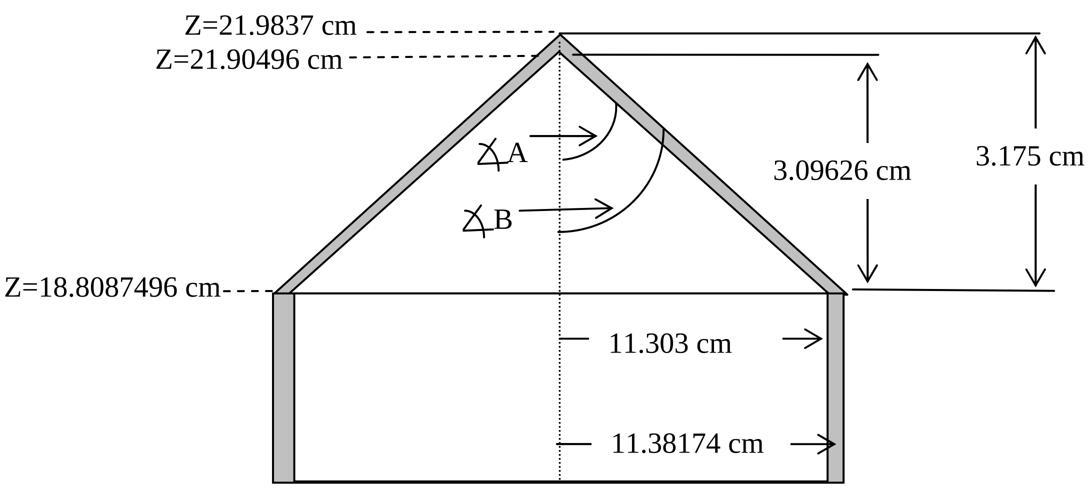
$$\text{top of the upper grid plate} = 16.129\ cm = 15.8115\ cm + \left(2.54\frac{cm}{inch}\right)*(0.125\ inch)$$

$$\text{bottom of the lower grid plate} = -17.0815\ cm = -15.8115\ cm - \left(2.54\frac{cm}{inch}\right)*(0.5\ inch)$$

The top of the reactor vessel for this experiment is a conical cap that meets the side walls of the vessel. For a cone parallel to the z-axis, the z coordinate of the vertex must be determined as well as the square of the tangent of the opening angle of the cone. Two conical surfaces were required- one for the inside surface of the cap, and one for the outside. Determining the vertices of the cones:

$$\text{Vertex of outside surface of the reactor's conical top} = 21.9837\ cm$$
$$= 15.8115\ cm + \left(2.54\frac{cm}{inch}\right)*(2.43\ inches)$$
$$\text{Vertex of inside surface of the reactor's conical top} = 21.90496\ cm$$
$$= 21.9837\ cm - \left(2.54\frac{cm}{inch}\right)*(0.031\ inch)$$

The opening angle of the cone at the top of the reactor vessel is determined using the vertex of each cone, and the point where the surface meets the vessel wall. This is illustrated in the sketch below:



The squares of the tangents of the angles shown in the above sketch are required to define the cones:

$$\tan^2 A = \left(\frac{11.303}{3.0926}\right)^2 = 13.326$$

$$\tan^2 B = \left(\frac{11.38174}{3.175}\right)^2 = 12.8508$$

$$\text{beginning of the conical cap} = 18.8087\ cm = 15.8115\ cm + \left(2.54\frac{cm}{inch}\right)*(1.18\ inches)$$

$$\text{top of the vessel bottom} = -18.8341\ cm = -15.8115\ cm - \left(2.54\frac{cm}{inch}\right)*(1.19\ inches)$$

$$\text{bottom of the vessel bottom} = -19.4691\ cm = -15.8115\ cm - \left(2.54\frac{cm}{inch}\right)*(1.44\ inches)$$

The remaining axial dimensions for the water tanks are determined as follows:

$$\text{bottom of the top tank} = 5.8547\ cm = 15.8115\ cm - \left(2.54\frac{cm}{inch}\right)*(3.92\ inches)$$

$$\text{top of the top tank bottom} = 6.01218\ cm = 5.8547\ cm + \left(2.54\frac{cm}{inch}\right)*(0.062\ inches)$$

$$\text{top edge of the top tank} = 36.22675\ cm = 6.06425\ cm + \left(2.54\frac{cm}{inch}\right)*(11.875\ inches)$$

$$\text{top of the bottom tank} = 21.30425\ cm = 36.22675\ cm - \left(2.54\frac{cm}{inch}\right)*(5.875\ inches)$$

$$\text{bottom of the lower tank} = -34.0614\ cm = -33.22675\ cm - \left(2.54\frac{cm}{inch}\right)*(0.125\ inch)$$

$$\text{top of the bottom plate for the lower tank} = -33.7439\ cm = -15.8115\ cm + \left(2.54\frac{cm}{inch}\right)*(7.06\ inches)$$

The radii of the water tanks are determined below:

$$\text{IR of top tank} = 26.67\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{21\ inches}{2}\right)$$

$$\text{OR of top tank} = 26.82743\ cm = \left(2.54\frac{cm}{inch}\right)*\left(\frac{21\ inches}{2} + 0.062\ inch\right)$$

$$\text{IR of bottom tank} = 34.24174\ cm = 11.38174\ cm + \left(2.54\frac{cm}{inch}\right)*(9\ inches)$$

$$\text{OR of bottom tank} = 34.3992\ cm = 34.24174\ cm + \left(2.54\frac{cm}{inch}\right)*(0.062\ inches)$$

These cases also use a Binal (borated aluminum) sleeve around the core vessel. The radial surfaces for all these cases are the same. Case *p45* uses this sleeve along the entire length of the core. Case *p46a* surrounds only the lower two thirds of the core (the section of the sleeve in the top tank was removed). The Binal sleeve is ¼ in. from the vessel surface, and is ¼ inch thick. The radial surfaces for the sleeve are:

$$\text{IR of Binal sleeve} = 12.01674\ cm = 11.38174\ cm + \left(2.54\frac{cm}{inch}\right)*(0.25\ inch)$$

$$\text{OR of Binal sleeve} = 12.65174\ cm = 12.01674\ cm + \left(2.54\frac{cm}{inch}\right)*(0.25\ inch)$$

Case *p46b* removes the lower sleeve, and puts the top section of the sleeve around the bottom of the core.

top of Binal sleeve =-8.66775 *cm* = -15.52572 *cm* + (2.7 *inches*)(2.54 *cm/inch*)

bottom of sleeve = -21.46427 *cm* = -8.66775 *cm* – (5.038 *inches*)(2.54 *cm/inch*)

water level in the top tank = 10.89025 *cm* =-15.52575 *cm* + (10.4 *inches*)(2.54 *cm/inch*)

The remaining cases (*tbl4**) place the Binal sleeve at different heights and use different water levels. The sleeve is long enough to cover the core in the bottom tank.

$$\text{Length of Binal sleeve} = 25.3238\ cm = \left(2.54\frac{cm}{inch}\right) * \left((12.45 - 3.92 + 1.44)\ inches\right)$$

The following calculations determine the change in the position of the Binal sleeve and the water height for the *tbl4** MCNP5 models.

Case *tbl4a*:

$$\text{top of Binal sleeve} = 0.98425\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right) * (6.5\ inches)$$

$$\text{bottom of Binal sleeve} = -24.33955\ cm = 0.98425\ cm - 25.3238\ cm$$

$$\text{water level in the top tank} = 30.82925\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right) * (18.25\ inches)$$

Case *tbl4b*:

$$\text{top of Binal sleeve} = -4.09575\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right) * (4.5\ inches)$$

$$\text{bottom of Binal sleeve} = -29.41955\ cm = -4.09575\ cm - 25.3238\ cm$$

$$\text{water level in the top tank} = 20.36455\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right) * (14.13\ inches)$$

Case *tbl4c*:

$$\text{top of Binal sleeve} = -4.09575\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right) * (4.5\ inches)$$

$$\text{bottom of Binal sleeve} = -29.41955\ cm = -4.09575\ cm - 25.3238\ cm$$

$$\text{water level in the top tank} = 21.93925\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right) * (14.75\ inches)$$

Case *tbl4d*:

$$\text{top of Binal sleeve} = -3.00355\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right) * (4.93\ inches)$$

$$\text{bottom of Binal sleeve} = -28.32735\ cm = -3.00355\ cm - 25.3238\ cm$$

$$\text{water level in the top tank} = 30.82925\ cm = -15.52575\ cm + \left(2.54\frac{cm}{inch}\right) * (18.25\ inches)$$

APPENDIX D.

MCNP5 SAMPLE INPUT FILES

CONTENTS

Page

D-1. CASE 8490O

```
NAA-SR-8490 benchmark model case 8490o
c
c  derived from Table III, configuration 10
c  water flooded core, 9.0-inches (full) water in upper tank
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts
c  critical ($0.02) measurement
c  upper 1/3 core surrounded by 0.50-inch thick sleeve of canned boron powder
c        plus
c  lower 1/3 core surrounded by 0.25-inch thick sleeve of borated aluminum
c
c  model setup by a.w. krass
c
c ----- complete fuel element assembly ----------
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1
c ----- additional fuel elements ----------------
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29
c ----- lucite rods -----------------------------
37  10 0.1064672     -35 -8 9                imp:n=1  $ position 37
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30
c ----- internal be reflector pieces ------------
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock
c ----------------------------------------------
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps
c ----------------------------------------------
100 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled
c ----- tbd -------------------------------------
```

```
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate
103 7  0.1001037     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
water filled
104 7  0.1001037     -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
water filled
c ----- tbd ------------------------------------
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate
107 3  0.0862393  (7 -84 -82 83)                            imp:n=1  $ inside wall of sleeve
108 2  0.0250690  -85 84 -82 83                             imp:n=1  $ nat boron powder in upper
sleeve
109 3  0.0862393  (7 -86 19 -83):(7 -86 82 -14):&
                  (85 -86 83 -82)                           imp:n=1  $ ss304 of upper sleeve
110 7  0.1001037  (-23 86 -14 19):(-23 16 -18 14): &
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank
111 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank
112 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls
113 12 0.0708762   -81 7 -75 78                             imp:n=1  $ binal of lower sleeve
114 7  0.1001037  (-27 -15 25):(-27 81 -75 15):(-27 7 -20 75)  imp:n=1  $ water filled volume of
lower tank
115 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls
116 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank
117 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank
118 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank walls
c ----- tbd ------------------------------------
119 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell
120 0     999                                               imp:n=0  $ rest of the universe

1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod
2   pz  15.52575                $ top end of fuel rod
3   pz -15.52575                $ bottom end of fuel rod
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube
6   cz  11.303                  $ IR of rx vessel
7   cz  11.38555                $ OR of rx vessel
8   pz  15.8115                 $ bottom of upper grid plate
9   pz -15.8115                 $ top of lower grid plate
10  pz  16.764                  $ top of upper grid plate
11  pz -16.60652                $ bottom of lower grid plate
12  pz  18.08226                $ vessel cover/flange interface
13  pz -16.764                  $ top of vessel bottom
14  pz  17.92478                $ bottom of vessel flange
15  pz -16.84274                $ bottom of vessel bottom
16  cz  16.46555                $ OR of vessel flange
17  pz  18.161                  $ top of cover plate indent
18  pz  18.71726                $ top of cover plate flange
19  pz   6.17474                $ top of bottom plate for upper tank
20  pz   6.01726                $ bottom of bottom plate for upper tank
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches
22  pz  31.57474                $ top edge of upper tank
23  cz  26.62555                $ IR of upper tank
24  cz  26.78303                $ OR of upper tank
25  pz -17.95526                $ top of bottom plate for lower tank
26  pz -18.11274                $ bottom of bottom plate for lower tank
27  cz  27.89555                $ IR of lower tank
28  cz  28.05303                $ OR of lower tank
29  pz -18.52422                $ bottom of top plate for control cap tank
30  pz -33.76422                $ top of bottom plate for control cap tank
31  pz -18.36674                $ top of top plate for control cap tank
32  pz -33.9217                 $ bottom of bottom plate for control cap tank
33  cz  19.64055                $ IR of control cap tank
34  cz  19.79803                $ OR of control cap tank
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37
c ----- begin internal be piece surfaces -----------------
```

```
44  cz  11.1506     $ outside radius of internal be piece
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element
c ----- begin sleeve surfaces -----------------
75  pz   -5.41274        $ top edge of lower sleeve
78  pz  -16.84274        $ bottom edge of lower sleeve
81  cz   12.02055        $ outside surface of outer edge of lower sleeve
82  pz   17.84604        $ inside top edge of upper sleeve
83  pz    6.25348        $ inside bottom edge of upper sleeve
84  cz   11.46429        $ inside surface of inner edge of upper sleeve
85  cz   12.57681        $ inside surface of outer edge of upper sleeve
86  cz   12.65555        $ outside surface of outer edge of upper sleeve
c ----- tbd -----------------------------------
999 so  50

mode  n
c ------npg----k----nsk---gen----
kcode  1000   1.0  1000  3000
ksrc    0  9.6012  0
c --- uzrhx ------------
m1   92235.60c 0.0014234 &
     92238.60c 0.0001015 &
     40000.60c 0.0352074 &
      1001.60c 0.0640000
mt1   zr/h.01t &
      h/zr.01t
c --- nat boron powder ----
m2    5010.60c 0.0049887 &
      5011.60c 0.0200803
c --- ss304 ------------
m3   26054.60c 0.0035020 &
     26056.60c 0.0544408 &
     26057.60c 0.0012465 &
     26058.60c 0.0001662 &
     24050.60c 0.0007573 &
     24052.60c 0.0146033 &
     24053.60c 0.0016557 &
     24054.60c 0.0004122 &
     28058.60c 0.0052698 &
     28060.60c 0.0020147 &
     28061.60c 0.0000872 &
     28062.60c 0.0002771 &
     28064.60c 0.0000702 &
```

```
     25055.60c 0.0017363
c --- sm2o3 coating ----
m5    8016.60c 0.0161151 &
     13027.60c 0.0050217 &
     14000.60c 0.0042609 &
     62147.66c 0.0000061 &
     62149.66c 0.0000056 &
     62150.50c 0.0000030 &
     62152.50c 0.0000108
c --- type 1100 aluminum ---------
m6   13027.60c 0.0602626
c --- water -----------
m7    1001.60c 0.0667358 &
      8016.60c 0.0333679
mt7   lwtr.01t
c --- Hastelloy N -----
m8   28058.60c 0.0440590 &
     28060.60c 0.0168440 &
     28061.60c 0.0007293 &
     28062.60c 0.0023169 &
     28064.60c 0.0005873 &
     26054.60c 0.0002818 &
     26056.60c 0.0043815 &
     26057.60c 0.0001003 &
     26058.60c 0.0000134 &
     24050.60c 0.0003121 &
     24052.60c 0.0060187 &
     24053.60c 0.0006824 &
     24054.60c 0.0001699 &
     42000.60c 0.0088982 &
     14000.60c 0.0018998
c --- ss316 ------------
m9   26054.60c 0.0033463 &
     26056.60c 0.0520202 &
     26057.60c 0.0011910 &
     26058.60c 0.0001588 &
     24050.60c 0.0006870 &
     24052.60c 0.0132476 &
     24053.60c 0.0015020 &
     24054.60c 0.0003739 &
     28058.60c 0.0067490 &
     28060.60c 0.0025802 &
     28061.60c 0.0001117 &
     28062.60c 0.0003549 &
     28064.60c 0.0000900 &
     42000.60c 0.0012601 &
     25055.60c 0.0017604 &
     14000.60c 0.0017218
c --- lucite -----------
m10   6000.60c 0.0354891 &
      1001.60c 0.0567825 &
      8016.60c 0.0141956
mt10  poly.01t
c --- Be metal ---------
m11   4009.60c 0.1216164
mt11    be.01t
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------
m12   5010.60c 0.0030227 &
      5011.60c 0.0121667 &
      6000.60c 0.0037973 &
     13027.60c 0.0518894
c ---total=0.07087616
print
```

D-2. CASE 8490T

```
NAA-SR-8490 benchmark model case 8490t
c
c  derived from Figure 20 on p.34
c  core vessel flooded and reflected with borate water
c  3.24 kg ammonium pentaborate in 39 gal of water
c  ordinary water in control cap
c  35 fuel rods plus 6 Be inserts (no lucite rods)
c  critical ($0.15) measurement
c
c  model setup by a.w. krass
c
c ----- complete fuel element assembly ----------
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1
c ----- additional fuel elements ----------------
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35
c ----- internal be reflector pieces ------------
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock
c ----------------------------------------------
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel
51 5   0.0254232    -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps
c ----------------------------------------------
100 2  0.1001638   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 &
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water
c ----- tbd ------------------------------------
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate
```

```
103 2  0.1001638     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
borated water
104 2  0.1001638     -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
borated water
c ----- tbd -------------------------------------
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate
107 2  0.1001638  (-23 7 -14 19):(-23 16 -18 14): &
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank - borated water
108 0              -23 -22 21                               imp:n=1  $ void filled volume of upper
tank
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls
110 2  0.1001638  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank - borated water
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank walls
c ----- tbd -------------------------------------
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell
116 0     999                                               imp:n=0  $ rest of the universe

1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod
2   pz  15.52575                $ top end of fuel rod
3   pz -15.52575                $ bottom end of fuel rod
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube
6   cz  11.303                  $ IR of rx vessel
7   cz  11.38555                $ OR of rx vessel
8   pz  15.8115                 $ bottom of upper grid plate
9   pz -15.8115                 $ top of lower grid plate
10  pz  16.764                  $ top of upper grid plate
11  pz -16.60652                $ bottom of lower grid plate
12  pz  18.08226                $ vessel cover/flange interface
13  pz -16.764                  $ top of vessel bottom
14  pz  17.92478                $ bottom of vessel flange
15  pz -16.84274                $ bottom of vessel bottom
16  cz  16.46555                $ OR of vessel flange
17  pz  18.161                  $ top of cover plate indent
18  pz  18.71726                $ top of cover plate flange
19  pz   6.17474                $ top of bottom plate for upper tank
20  pz   6.01726                $ bottom of bottom plate for upper tank
21  pz  29.03474                $ fill height of upper tank @ 9 inches
22  pz  31.57474                $ top edge of upper tank
23  cz  26.62555                $ IR of upper tank
24  cz  26.78303                $ OR of upper tank
25  pz -17.95526                $ top of bottom plate for lower tank
26  pz -18.11274                $ bottom of bottom plate for lower tank
27  cz  27.89555                $ IR of lower tank
28  cz  28.05303                $ OR of lower tank
29  pz -18.52422                $ bottom of top plate for control cap tank
30  pz -33.76422                $ top of bottom plate for control cap tank
31  pz -18.36674                $ top of top plate for control cap tank
32  pz -33.9217                 $ bottom of bottom plate for control cap tank
33  cz  19.64055                $ IR of control cap tank
34  cz  19.79803                $ OR of control cap tank
c ----- begin internal be piece surfaces -----------------
44  cz  11.1506     $ outside radius of internal be piece
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock
```

```
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element
c ----- tbd -----------------------------------
999 so  50

mode  n
c ------npg----k----nsk---gen----
kcode  1000   1.0  1000  3000
ksrc    0  9.6012  0
c --- uzrhx ------------
m1   92235.60c 0.0014234 &
     92238.60c 0.0001015 &
     40000.60c 0.0352074 &
      1001.60c 0.0640000
mt1   zr/h.01t &
      h/zr.01t
c --- 3.24 kg borate in 39 gal of water ----
m2    1001.60c 0.0663936 &
      5010.60c 0.0000475 &
      5011.60c 0.0001914 &
      7014.60c 0.0000478 &
      8016.60c 0.0334835
mt2   lwtr.01t
c --- sm2o3 coating ----
m5    8016.60c 0.0161151 &
     13027.60c 0.0050217 &
     14000.60c 0.0042609 &
     62147.66c 0.0000061 &
     62149.66c 0.0000056 &
     62150.50c 0.0000030 &
     62152.50c 0.0000108
c --- type 1100 aluminum ---------
m6   13027.60c 0.0602626
c --- water -----------
m7    1001.60c 0.0667358 &
      8016.60c 0.0333679
mt7   lwtr.01t
c --- Hastelloy N -----
m8   28058.60c 0.0440590 &
     28060.60c 0.0168440 &
     28061.60c 0.0007293 &
     28062.60c 0.0023169 &
     28064.60c 0.0005873 &
     26054.60c 0.0002818 &
     26056.60c 0.0043815 &
     26057.60c 0.0001003 &
     26058.60c 0.0000134 &
     24050.60c 0.0003121 &
     24052.60c 0.0060187 &
     24053.60c 0.0006824 &
     24054.60c 0.0001699 &
```

```
     42000.60c 0.0088982 &
     14000.60c 0.0018998
c --- ss316 ------------
m9   26054.60c 0.0033463 &
     26056.60c 0.0520202 &
     26057.60c 0.0011910 &
     26058.60c 0.0001588 &
     24050.60c 0.0006870 &
     24052.60c 0.0132476 &
     24053.60c 0.0015020 &
     24054.60c 0.0003739 &
     28058.60c 0.0067490 &
     28060.60c 0.0025802 &
     28061.60c 0.0001117 &
     28062.60c 0.0003549 &
     28064.60c 0.0000900 &
     42000.60c 0.0012601 &
     25055.60c 0.0017604 &
     14000.60c 0.0017218
c --- Be metal ---------
m11   4009.60c 0.1216164
mt11   be.01t
print
```

D-3. CASE FIG12

```
NAA-SR-9871, Fig 12
c Feb 24, 2005
c Model setup by a.w. krass and k.l.goluoglu
c This case models the experiment described in Figure 12, NAA-SR-9871
c This case uses SCA-4 fuel, with 26 fuel elements, full reflection/
c dry core, with the external reflector as shown in Fig12.
c The tank configuration used is that shown in
c Fig 49, of 9871.  The water in the reflector is 9.5" above fuel bottom.
c ----- complete fuel element assembly ----------
1  0        -5 -8 9  fill=582                     imp:n=1  $ position 1
c ----- additional fuel elements ----------------
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6
7  like 1 but fill=2    trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12
13 like 1 but fill=2    trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19
20 like 1 but fill=2    trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23
24 like 1 but fill=2    trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24
25 like 1 but fill=2    trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26
27 like 1 but fill=2    trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31
32 like 1 but fill=2    trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36
35 like 1 but fill=2    trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35
34 like 1 but fill=2    trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34
33 like 7 but fill=2    trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33
c ----- internal be reflector pieces ------------
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock
c -------- define the lucite rods -----------------
98 10 0.1064672  -4 -2 3   u=2   imp:n=1   $  lucite rod
99 10 0.1064672  4:2:-3    u=2   imp:n=1   $  lucite
c ------- define the individual fuel rods
c The fuel rod universe is the number of the fuel rod
c with either a 5 in front or the first digit replaced with 5.
c For example, U=581 is for rod #81. u=501 is for rod #101.
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps
```

```
c ---------
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating
```

```
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps
c -------------------------------------------------------
300 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &
```

```
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &
         #41 #42 #43 #44 #45 #46    &      $ fuel elements
         imp:n=1  $ vessel interior between elements - void filled
401 6  0.0602626     -6   8 -10              imp:n=1  $ type 1100 aluminum upper gridplate
402 6  0.0602626     -6  -9  11              imp:n=1  $ type 1100 aluminum lower gridplate
403 0                -6  10 -12              imp:n=1  $ vessel interior above upper gridplate
404 0                -6 -11  13              imp:n=1  $ vessel interior above upper gridplate
c ----- tbd ------------------------------------
405 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls
406 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ aluminum cover plate
c ----- Main block of the extrnal reflector:
407 11 0.1216164 (7 -301 302 -300 303 -20 502 208 202 211 205) imp:n=1 $external Be reflector
408 11 0.1216164 (7 -301 302 -300 303 -503 20 208 202 211 205) imp:n=1 $external Be reflector
409 11 0.1216164 (7 -504 500 -503 -202) imp:n=1
410 11 0.1216164 (7 -504 500 -503 -205) imp:n=1
411 11 0.1216164 (7 -504 500 -503 -208) imp:n=1
412 11 0.1216164 (7 -504 500 -503 -211) imp:n=1 $ledge of Be ref. to support drums
413 11 0.1216164 (7 -504 502 -501 -202) imp:n=1
414 11 0.1216164 (7 -504 502 -501 -205) imp:n=1
415 11 0.1216164 (7 -504 502 -501 -208) imp:n=1
416 11 0.1216164 (7 -504 502 -501 -211) imp:n=1  $ledge of Be ref. to support drums
c ----- Steel drive shafts and water-filled interiors:
420 9  0.0871549 (501 -506 -200)     imp:n=1             $drive shaft
422 9  0.0871549 (-505 506 -201)    imp:n=1             $drive shaft
c
423 9  0.0871549 (501 -506 -203)     imp:n=1             $drive shaft
425 9  0.0871549 (-505 506 -204)    imp:n=1             $drive shaft
c
426 9  0.0871549 (501 -506 -206)     imp:n=1             $drive shaft
428 9  0.0871549 (-505 506 -207)    imp:n=1             $drive shaft
c
429 9  0.0871549 (501 -506 -209)     imp:n=1             $drive shaft
431 9  0.0871549 (-505 506 -210)    imp:n=1             $drive shaft
c
c ---- Control Drums:
440 11 0.1216164  (401 -205 501 -20 204) imp:n=1                        $control drum
441 11 0.1216164  (-202 -403 501 -20 201) imp:n=1                       $control drum
442 11 0.1216164  (-208 -403 501 -20 207) imp:n=1                       $control drum
443 11 0.1216164  (-211 401 501 -20  210) imp:n=1                       $control drum
c
444 11 0.1216164  (401 -205 20 -500 204) imp:n=1                        $control drum
445 11 0.1216164  (-202 -403 20 -500 201) imp:n=1                       $control drum
446 11 0.1216164  (-208 -403 20 -500 207) imp:n=1                       $control drum
447 11 0.1216164  (-211 401 20 -500 210) imp:n=1                        $control drum
c -----bottom tank:
460 7  0.1001037  (29 -15 -27  ) imp:n=1      $ water volume below the RX vessel
461 7  0.1001037  (7 -27 -502 15) imp:n=1     $ water below reflector main block
c 462 7  0.1001037  (504 -27 502 -501) imp:n=1  $ water outside bottom ledge of main block
463 7  0.1001037  (7 -27 502 -20) &
                  #407 &
                  #413 #414 #415 #416 &
                  #440 #441 #442 #443 &       $ water around the core except the control drums
                  #420 #422 &                 $ and the drive shafts
                  #423 #425 &
                  #426 #428 &
                  #429 #431  imp:n=1
464 0           (20 -503 -27 7)  &
                #408&                         $ void above the water in the lower tank
                #409 #410 #411 #412 &
                #444 #445 #446 #447   &       $ around the control drums
                  imp:n=1
466 0 (-19 503 -27 7) imp:n=1           $void outside the top ledge of the reflector main block
467 0 (19 -31 24 -27) imp:n=1           $void above the water in the lower tank
c
470 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell
471 0              -27 25 -30                   imp:n=1  $ void at the bottom of lower tank
472 9 0.0871549   -29 30 -27                    imp:n=1  $ steel plate in lower tank above void
473 0             31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank
c -------top tank
481 9  0.0871549  (-14 19 7 -24):(-24 23 19 -22) imp:n=1 $upper tanks wall
```

```
482 7 0.1001037    (14 -18 16 -23):&
    (17 -18 -6):(18 -36 -23) imp:n=1                 $water  inside top tank
483 0           (-23 36 -22)  imp:n=1                $ void over the water in top tank
c
c ----- tbd -------------------------------------
500 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1
501 0 999  imp:n=0

1 c/z  0.0  9.6012   1.53924    $ radius of fuel rod = (2.54)(1.212/2)
2 pz  15.52575                  $ top of the active fuel region= (2.54)(12.225/2)
3 pz -15.52575                  $ bottom of active fuel region
4 c/z  0.0  9.6012   1.5621     $ IR of fuel element tube=((1.25-0.02)/2)2.54
5 c/z  0.0  9.6012   1.5875     $ OR of fuel element tube=(1.25/2)(2.54)
6 cz  11.27125                  $ IR of rx vessel=(8.875/2)(2.54)
7 cz  11.34999                  $ OR of rx vessel=((8.875/2)+0.031)(2.54)
8 pz  15.8115                   $ top of the fuel element=(12.45/2)(2.54)
9 pz -15.8115                   $ bottom of fuel element
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)
12  pz  16.85925                $ vessel cover/flange interface
13  pz -16.71357                $ top of vessel bottom:-16.79231+(2.54)(.031)
14  pz  16.70177                $ bottom of vessel flange
15  pz -16.79231                $ bottom of vessel bottom=16.54429-(2.54)(13.125)
16  cz  16.46555                $ OR of vessel flange
17  pz  16.93799                $ top of cover plate indent
18  pz  17.49425                $ top of cover plate flange=-15.52575+(2.54)(13)
19  pz  16.54429                $ bottom of the top tank:16.70177-(.062)(2.54)
20  pz  8.60425                 $ water in the lower tank- 9.5" above the bottom of the fuel
22  pz  32.73769                $ top edge of upper tank:-16.79231+(13.125+6.375)(2.54)
36  pz  32.73425                $ top of the water 19" inches above the bottom of the fuel
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)
25  pz -44.09731                $ top of bottom plate for lower tank=-44.41481+(2.54)(0.125)
26  pz -44.41481                $ bottom of bottom plate for lower tank=32.73769-(2.54)(30 3/8)
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.062)(2.54)
29  pz -36.15981                $ bottom of top plate for lower tank=-36.47731+(2.54)(0.125)
30  pz -36.47731                $ top of bottom plate for lower tank=-44.09731+(2.54)(3)
31  pz  17.49769                $ top of the bottom tank=32.73769-(2.54)(6)
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37
c ----- begin internal be piece surfaces ----------------
44  cz  11.1506     $ outside radius of internal be piece
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element
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74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element
c -----------------------------------------------
c external reflector surfaces
200 c/z 19.584677 -5.247698  0.7112 $IR of drive shaft
201 c/z 19.584677 -5.247698  2.2225 $OR of drive shaft
202 c/z 19.584677 -5.247698  8.89   $OR of control drum
c
203 c/z -19.584677 5.247698  0.7112 $IR of drive shaft
204 c/z -19.584677 5.247698  2.2225 $OR of drive shaft
205 c/z -19.584677 5.247698  8.89   $OR of control drum
c
206 c/z 5.247698   19.584677 0.7112 $IR of drive shaft
207 c/z 5.247698   19.584677 2.2225 $OR of drive shaft
208 c/z 5.247698   19.584677 8.89   $OR of control drum
c
209 c/z -5.247698  -19.584677 0.7112 $IR of drive shaft
210 c/z -5.247698  -19.584677 2.2225 $OR of drive shaft
211 c/z -5.247698  -19.584677 8.89   $OR of control drum
c
300 p 0.57735 -1 0  18.74137         $line to  bound reflector
301 p -1.732  -1 0  33.730392        $line to bound reflector
302 p 0.57735 -1 0 -18.74137         $line  to bound reflector
303 p -1.732  -1 0 -33.73092         $line to bound reflector
c
401 p -1.732  -1 0  37.2427          $line to cut off control drums
403 p -1.732  -1 0 -37.2434          $line to cut off control drums
c
500 pz 12.87018                      $ top of the control drums
501 pz -12.84478                     $ bottom of the control drums
502 pz -15.5448                      $ bottom of the reflector main block
503 pz 15.5702                       $ top of the reflector main block
504 cz 16.2306                       $ surface used for the ledges of the main block
505 pz 3.81                          $ top of the large cylinder of the drive shaft
506 pz -3.81                         $ bottom of the large cylinder of the drive shaft
c
999 so  58

mode  n
c ------npg----k----nsk---gen----
kcode   1000  1.0  1000  3000
ksrc    0  9.6012  0
c --- sm2o3 coating ----
m5    8016.60c 0.0161151 &
     13027.60c 0.0050217 &
     14000.60c 0.0042609 &
     62147.66c 0.0000061 &
     62149.66c 0.0000056 &
     62150.50c 0.0000030 &
     62152.50c 0.0000108
c --- type 1100 aluminum ---------
m6   13027.60c 0.0602626
c --- water -----------
m7    1001.60c 0.0667358 &
      8016.60c 0.0333679
mt7   lwtr.01t
c --- Hastelloy N -----
m8   28058.60c 0.0440590 &
     28060.60c 0.0168440 &
     28061.60c 0.0007293 &
     28062.60c 0.0023169 &
     28064.60c 0.0005873 &
     26054.60c 0.0002818 &
     26056.60c 0.0043815 &
     26057.60c 0.0001003 &
     26058.60c 0.0000134 &
     24050.60c 0.0003121 &
     24052.60c 0.0060187 &
     24053.60c 0.0006824 &
     24054.60c 0.0001699 &
     42000.60c 0.0088982 &
     14000.60c 0.0018998
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c --- ss316 ------------
m9   26054.60c 0.0033463 &
     26056.60c 0.0520202 &
     26057.60c 0.0011910 &
     26058.60c 0.0001588 &
     24050.60c 0.0006870 &
     24052.60c 0.0132476 &
     24053.60c 0.0015020 &
     24054.60c 0.0003739 &
     28058.60c 0.0067490 &
     28060.60c 0.0025802 &
     28061.60c 0.0001117 &
     28062.60c 0.0003549 &
     28064.60c 0.0000900 &
     42000.60c 0.0012601 &
     25055.60c 0.0017604 &
     14000.60c 0.0017218
c --- lucite ----------
m10  6000.60c  0.0354891 &
     1001.60c  0.0567825 &
     8016.60c  0.0141956
mt10 poly.01t
c --- Be metal ---------
m11   4009.60c 0.1216164
mt11   be.01t
c --- Definitions for the fuel elements:
m81   92235.60c   0.001430699   &
      92238.60c   0.000103873   &
      40000.60c   0.035252214   &
       1001.60c   0.065346421
mt81   zr/h.01t   h/zr.01t
m82   92235.60c   0.001432362   &
      92238.60c   0.000103982   &
      40000.60c   0.035151269   &
       1001.60c   0.063495921
mt82   zr/h.01t   h/zr.01t
m83   92235.60c   0.001423493   &
      92238.60c   0.000101903   &
      40000.60c   0.035011378   &
       1001.60c   0.064782612
mt83   zr/h.01t   h/zr.01t
m84   92235.60c   0.001431586   &
      92238.60c   0.000103982   &
      40000.60c   0.035287436   &
       1001.60c   0.064459356
mt84   zr/h.01t   h/zr.01t
m85   92235.60c   0.001430255   &
      92238.60c   0.000103763   &
      40000.60c   0.035273259   &
       1001.60c   0.064475748
mt85   zr/h.01t   h/zr.01t
m86   92235.60c   0.001430588   &
      92238.60c   0.000103763   &
      40000.60c   0.035251872   &
       1001.60c   0.064395062
mt86   zr/h.01t   h/zr.01t
m87   92235.60c   0.001433581   &
      92238.60c   0.000102669   &
      40000.60c   0.035262547   &
       1001.60c   0.064385381
mt87   zr/h.01t   h/zr.01t
m88   92235.60c   0.001431031   &
      92238.60c   0.000103763   &
      40000.60c   0.03523959   &
       1001.60c   0.064395062
mt88   zr/h.01t   h/zr.01t
m89   92235.60c   0.001421165   &
      92238.60c   0.000102341   &
      40000.60c   0.035274751   &
       1001.60c   0.063901235
mt89   zr/h.01t   h/zr.01t
```

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m90   92235.60c   0.00143092   &
      92238.60c   0.000103873   &
      40000.60c   0.035232421   &
       1001.60c   0.064268326
mt90   zr/h.01t   h/zr.01t
m91   92235.60c   0.001432472   &
      92238.60c   0.000103982   &
      40000.60c   0.035277465   &
       1001.60c   0.063371257
mt91   zr/h.01t   h/zr.01t
m92   92235.60c   0.001435466   &
      92238.60c   0.000104311   &
      40000.60c   0.035292717   &
       1001.60c   0.063128228
mt92   zr/h.01t   h/zr.01t
m93   92235.60c   0.001435576   &
      92238.60c   0.000104092   &
      40000.60c   0.035293905   &
      1001.60c   0.063046588
mt93   zr/h.01t   h/zr.01t
m94   92235.60c   0.001434579   &
      92238.60c   0.000103326   &
      40000.60c   0.035310848   &
       1001.60c   0.063451929
mt94   zr/h.01t   h/zr.01t
m95   92235.60c   0.001421719   &
      92238.60c   0.00010245   &
      40000.60c   0.03498275   &
       1001.60c   0.064943676
mt95   zr/h.01t   h/zr.01t
m96   92235.60c   0.001425267   &
      92238.60c   0.000102669   &
      40000.60c   0.035080958   &
       1001.60c   0.063267573
mt96   zr/h.01t   h/zr.01t
m97   92235.60c   0.001423161   &
      92238.60c   0.000103107   &
      40000.60c   0.035280544   &
       1001.60c   0.063506173
mt97   zr/h.01t   h/zr.01t
m98   92235.60c   0.00143347   &
      92238.60c   0.000103763   &
      40000.60c   0.035522615   &
       1001.60c   0.064888889
mt98   zr/h.01t   h/zr.01t
m99   92235.60c   0.001417396   &
      92238.60c   0.000102559   &
      40000.60c   0.035331825   &
       1001.60c   0.063802469
mt99   zr/h.01t   h/zr.01t
m100  92235.60c   0.001406643   &
      92238.60c   0.000101793   &
      40000.60c   0.035094624   &
       1001.60c   0.064098765
mt100   zr/h.01t   h/zr.01t
m101  92235.60c   0.001420057   &
      92238.60c   0.000102778   &
      40000.60c   0.035313464   &
       1001.60c   0.064197531
mt101   zr/h.01t   h/zr.01t
m102  92235.60c   0.001416842   &
      92238.60c   0.000102559   &
      40000.60c   0.035290936   &
       1001.60c   0.062617284
mt102   zr/h.01t   h/zr.01t
m103  92235.60c   0.001419281   &
      92238.60c   0.000103326   &
      40000.60c   0.035464348   &
       1001.60c   0.064888889
mt103   zr/h.01t   h/zr.01t
m104  92235.60c   0.001413738   &
```

```
      92238.60c   0.000102997   &
      40000.60c   0.035462436   &
       1001.60c   0.063407407
mt104   zr/h.01t   h/zr.01t
m105   92235.60c   0.001410634   &
       92238.60c   9.34746E-05   &
       40000.60c   0.035065703   &
        1001.60c   0.063407407
mt105   zr/h.01t   h/zr.01t
m106   92235.60c   0.001423604   &
       92238.60c   0.000103435   &
       40000.60c   0.035030992   &
        1001.60c   0.063576057
mt106   zr/h.01t   h/zr.01t
m107   92235.60c   0.001439235   &
       92238.60c   0.00010453   &
       40000.60c   0.035316009   &
        1001.60c   0.064303281
mt107   zr/h.01t   h/zr.01t
m108   92235.60c   0.001413294   &
       92238.60c   0.000102669   &
       40000.60c   0.034781046   &
        1001.60c   0.062931948
mt108   zr/h.01t   h/zr.01t
m109   92235.60c   0.001432362   &
       92238.60c   0.000104311   &
       40000.60c   0.035595633   &
        1001.60c   0.064691358
mt109   zr/h.01t   h/zr.01t
m110   92235.60c   0.001432251   &
       92238.60c   0.000103982   &
       40000.60c   0.035613144   &
        1001.60c   0.063209877
mt110   zr/h.01t   h/zr.01t
m111   92235.60c   0.001413405   &
       92238.60c   0.000101793   &
       40000.60c   0.035150204   &
        1001.60c   0.066074074
mt111   zr/h.01t   h/zr.01t
m112   92235.60c   0.001435687   &
       92238.60c   0.000103545   &
       40000.60c   0.035468978   &
        1001.60c   0.064547401
mt112   zr/h.01t   h/zr.01t
m113   92235.60c   0.00143092   &
       92238.60c   0.000103763   &
       40000.60c   0.035308553   &
        1001.60c   0.062367101
mt113   zr/h.01t   h/zr.01t
m114   92235.60c   0.001427262   &
       92238.60c   0.000103545   &
       40000.60c   0.035208233   &
        1001.60c   0.063381262
mt114   zr/h.01t   h/zr.01t
m115   92235.60c   0.001419392   &
       92238.60c   0.000103326   &
       40000.60c   0.035428725   &
        1001.60c   0.064493827
mt115   zr/h.01t   h/zr.01t
m116   92235.60c   0.001430034   &
       92238.60c   0.000104201   &
       40000.60c   0.035494858   &
        1001.60c   0.064790123
mt116   zr/h.01t   h/zr.01t
m117   92235.60c   0.001432916   &
       92238.60c   5.05682E-05   &
       40000.60c   0.035671272   &
        1001.60c   0.064592593
mt117   zr/h.01t   h/zr.01t
print
```

D-4. CASE P58GAP

```
NAA-SR-9871, case  p58gap
c Feb24, 2005
c Model setup by a.w. krass and k.l.goluoglu
c This case models the experiment described on p58, NAA-SR-9871
c This case uses SCA4 fuel, with 36 fuel rods and 1 lucite rod,
c flooded core., water 14.88 inches above bottom of the fuel.
c The tank configuration used is that shown in
c Fig 48, of 9871.
c NOTE:  This model examines the effects of water gaps in the
c        sleeve assembly.
c ----- complete fuel element assembly ----------
1  0        -5 -8 9  fill=582                    imp:n=1  $ position 1
c ----- additional fuel elements ----------------
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12
13 like 1 but fill=585  trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19
20 like 1 but fill=584  trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31
32 like 1 but fill=598  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36
35 like 1 but fill=596  trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34
33 like 7 but fill=586  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33
c ----- internal be reflector pieces ------------
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock
c -------- define the lucite rod -----------
80 10 0.1064672  -4 -2 3 u=2 imp:n=1   $ lucite
81 10 0.1064672     4:2:-3  u=2 imp:n=1   $ lucite
c ------- define the individual fuel rods
c The fuel rod universe is the number of the fuel rod
c with either a 5 in front or the first digit replaced with 5.
c For example, U=581 is for rod #81. u=501 is for rod #101.
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel
```

```
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
```

```
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps
```

```
c ----------------------------------------------------
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &
         #41 #42 #43 #44 #45 #46    &      $ fuel elements
         imp:n=1  $ vessel interior between elements
c ----- rest of vessel interior------------------
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate
303 7 0.1001037      -6  10 -12                imp:n=1  $ vessel interior above upper gridplate
304 7 0.1001037      -6 -11  13                imp:n=1  $ vessel interior above upper gridplate
c ----- rx vessel------------------------------
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)   imp:n=1  $ type 1100 aluminum cover plate
c --------sleeve assembly-----------------------
311 7  0.1001037  (7 -500  19  -600)           imp:n=1  $ water gap at the outside of vessel
312 7  0.1001037  (7 -500  -20  604)           imp:n=1  $ water gap at the outside of vessel
c
313 35 0.0862393  (500 -501 -601 602)          imp:n=1  $ inner sheel of void sleeve
314 35 0.0862393  (500 -501 605 -603)          imp:n=1  $ inner shell of the void sleeve
c
315 0             (501 -502 602 -601)          imp:n=1  $ void sleeve
316 0             (501 -502 605 -603)          imp:n=1  $ void sleeves
c
317 35 0.0862393  (502 -503 602 -601)          imp:n=1  $ outer sheel of void sleeve
318 35 0.0862393  (502 -503 605 -603)          imp:n=1  $ outer shell of void sleeves
c
319 35 0.0862393  (500 -503 601 -600)          imp:n=1  $ top of top sleeve
320 35 0.0862393  (500 -503 19  -602)          imp:n=1  $ bottom of the top sleeve
321 35 0.0862393  (500 -503 -605 604)          imp:n=1  $ top of top sleeve
322 35 0.0862393  (500 -503 -20  603)          imp:n=1  $ bottom of the top sleeve
c
331 7  0.1001037  (503 -504  19 -600)          imp:n=1  $ water gap outside of void sleeve
332 7  0.1001037  (503 -504 -20  604)          imp:n=1  $ water gap outside of void sleeve
c
333 35 0.0862393  (504 -505 602 -601)          imp:n=1  $ steel inside boron sleeve
334 35 0.0862393  (504 -505 605 -603)          imp:n=1  $ steel inside boron sleeve
c
335 20 0.0250690  (505 -506 602 -601)          imp:n=1  $ boron power sleeve
336 20 0.0250690  (505 -506 605 -603)          imp:n=1  $ boron powder sleeve
c
337 35 0.0862393  (506 -507 602 -601)          imp:n=1  $ outer shell boron sleeve
338 35 0.0862393  (506 -507 605 -603)          imp:n=1  $ outer shell boron sleeve
c
339 35 0.0862393  (504 -507 601 -600)          imp:n=1  $ top of top sleeve
340 35 0.0862393  (504 -507 19  -602)          imp:n=1  $ bottom of the top sleeve
341 35 0.0862393  (504 -507 -605 604)          imp:n=1  $ top of top sleeve
342 35 0.0862393  (504 -507 -20  603)          imp:n=1  $ bottom of the top sleeve
c
351 7  0.1001037  (507 -508 19  -600)          imp:n=1  $ water outside boron sleeve
352 7  0.1001037  (507 -508 -20  604)          imp:n=1  $ water outside boron sleeve
c
353 35 0.0862393  (19  -600  508 -509)         imp:n=1  $ steel sleeve
354 35 0.0862393  (604 -20   508 -509)         imp:n=1  $ steel sleeve
c
355 30 0.0463402  (7 -509 600 -8)              imp:n=1  $ Cd sheet
356 30 0.0463402  (7 -509 9 -604)              imp:n=1  $ Cd sheet
c
c ----------- water tanks ----------------------------------
407 7  0.1001037  (29 -15 -27):(9 -20 -27 509):(-27 7 15 -9) imp:n=1 $ water
408 7  0.1001037  (20 -31 24 -27)              imp:n=1  $ volume of lower tank around top tank
409 9  0.0871549  (26 -25 -28):(27 -28 -31 25) imp:n=1  $ bottom tank shell
410 0              -27 25 -30                  imp:n=1  $ void at the bottom of lower tank
411 9  0.0871549  -29 30 -27                   imp:n=1  $ steel plate in lower tank above void
412 0             31 -22 24 -28                imp:n=1  $ void over lower tank outside top tank
c
413 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall
414 7  0.1001037  (19 -8 509 -23):(8 -14 -23 7):&
                  (14 -18 16 -23):(17 -18 -6):(18 -21 -23)  imp:n=1   $water inside top tank
415 0             (21 -22 -23)                 imp:n=1   $ void above the top tank water
c ----- tbd -------------------------------------
```

```
416 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1
417 0 999           imp:n=0

1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)
3   pz -15.52575                $ bottom of active fuel region
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)
9   pz -15.8115                 $ bottom of fuel element
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)
12  pz  16.85925                $ vessel cover/flange interface
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)
14  pz  16.70177                $ bottom of vessel flange
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)
16  cz  16.46555                $ OR of vessel flange
17  pz  16.93799                $ top of cover plate indent=
18  pz  17.49425                $ top of cover plate flange
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)
21  pz  22.26945                $ top of the water :14.88" above the bottom of the fuel
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37
c ----- begin internal be piece surfaces -----------------
44  cz  11.1506     $ outside radius of internal be piece
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element
c ----- radial sleeve surfaces -----------------
500 cz 11.50874  $ surface 7 + 1/16"
501 cz 11.58748  $ +0.031"
502 cz 19.05
```

```
503 cz 19.12874
504 cz 19.28749
505 cz 19.36623
506 cz 21.74875
507 cz 21.82749
508 cz 21.98624
509 cz 22.62124
c ---- axial sleeve surfaces ------------------
600 pz 15.7607     $ 15.8115-(2.54)(0.02)=cd sheet
601 pz 15.68196    $ 15.7607-(2.54)(0.031)=steel shell
602 pz 6.30047
603 pz 5.98551
604 pz -15.7607    $ -15.8115 +(2.54)(0.02)=cd sheet
605 pz -15.68196     $ -15.7607 +(2.54)(0.031)=steel shell
c ------------------------------------------------
999 so  55

mode  n
c ------npg----k----nsk---gen----
kcode   1000  1.0  1000  3000
ksrc    0  9.6012  0
c --- sm2o3 coating ----
m5    8016.60c 0.0161151 &
     13027.60c 0.0050217 &
     14000.60c 0.0042609 &
     62147.66c 0.0000061 &
     62149.66c 0.0000056 &
     62150.50c 0.0000030 &
     62152.50c 0.0000108
c --- type 1100 aluminum ---------
m6   13027.60c 0.0602626
c --- water -----------
m7    1001.60c 0.0667358 &
      8016.60c 0.0333679
mt7   lwtr.01t
c --- Hastelloy N -----
m8   28058.60c 0.0440590 &
     28060.60c 0.0168440 &
     28061.60c 0.0007293 &
     28062.60c 0.0023169 &
     28064.60c 0.0005873 &
     26054.60c 0.0002818 &
     26056.60c 0.0043815 &
     26057.60c 0.0001003 &
     26058.60c 0.0000134 &
     24050.60c 0.0003121 &
     24052.60c 0.0060187 &
     24053.60c 0.0006824 &
     24054.60c 0.0001699 &
     42000.60c 0.0088982 &
     14000.60c 0.0018998
c --- ss316 ------------
m9   26054.60c 0.0033463 &
     26056.60c 0.0520202 &
     26057.60c 0.0011910 &
     26058.60c 0.0001588 &
     24050.60c 0.0006870 &
     24052.60c 0.0132476 &
     24053.60c 0.0015020 &
     24054.60c 0.0003739 &
     28058.60c 0.0067490 &
     28060.60c 0.0025802 &
     28061.60c 0.0001117 &
     28062.60c 0.0003549 &
     28064.60c 0.0000900 &
     42000.60c 0.0012601 &
     25055.60c 0.0017604 &
     14000.60c 0.0017218
c --- lucite -----------
m10   6000.60c 0.0354891 &
      1001.60c 0.0567825 &
```

```
      8016.60c 0.0141956
mt10 poly.01t
c --- Be metal ---------
m11   4009.60c 0.1216164
mt11   be.01t
c --- natural B for poison sleeves
m20  5010.60c  0.0049887   &
     5011.60c  0.0200803
c ----cadmium -----------
m30  48000.50c 0.0463402
c ---- Steel 304---------
m35  26054.60c  0.0035020 &
     26056.60c  0.0544408 &
     26057.60c  0.0012465 &
     26058.60c  0.0001662 &
     28058.60c  0.0052698 &
     28060.60c  0.0020147 &
     28061.60c  0.0000872 &
     28062.60c  0.0002771 &
     28064.60c  0.0000702 &
     24050.60c  0.0007573 &
     24052.60c  0.0146033 &
     24053.60c  0.0016557 &
     24054.60c  0.0004122 &
     25055.60c  0.0017363
c --- Definitions for the fuel elements:
m81   92235.60c   0.001430699   &
      92238.60c   0.000103873   &
      40000.60c   0.035252214   &
       1001.60c   0.065346421
mt81   zr/h.01t   h/zr.01t
m82   92235.60c   0.001432362   &
      92238.60c   0.000103982   &
      40000.60c   0.035151269   &
       1001.60c   0.063495921
mt82   zr/h.01t   h/zr.01t
m83   92235.60c   0.001423493   &
      92238.60c   0.000101903   &
      40000.60c   0.035011378   &
       1001.60c   0.064782612
mt83   zr/h.01t   h/zr.01t
m84   92235.60c   0.001431586   &
      92238.60c   0.000103982   &
      40000.60c   0.035287436   &
       1001.60c   0.064459356
mt84   zr/h.01t   h/zr.01t
m85   92235.60c   0.001430255   &
      92238.60c   0.000103763   &
      40000.60c   0.035273259   &
       1001.60c   0.064475748
mt85   zr/h.01t   h/zr.01t
m86   92235.60c   0.001430588   &
      92238.60c   0.000103763   &
      40000.60c   0.035251872   &
       1001.60c   0.064395062
mt86   zr/h.01t   h/zr.01t
m87   92235.60c   0.001433581   &
      92238.60c   0.000102669   &
      40000.60c   0.035262547   &
       1001.60c   0.064385381
mt87   zr/h.01t   h/zr.01t
m88   92235.60c   0.001431031   &
      92238.60c   0.000103763   &
      40000.60c   0.03523959   &
       1001.60c   0.064395062
mt88   zr/h.01t   h/zr.01t
m89   92235.60c   0.001421165   &
      92238.60c   0.000102341   &
      40000.60c   0.035274751   &
       1001.60c   0.063901235
mt89   zr/h.01t   h/zr.01t
```

```
m90   92235.60c   0.00143092   &
      92238.60c   0.000103873   &
      40000.60c   0.035232421   &
       1001.60c   0.064268326
mt90   zr/h.01t   h/zr.01t
m91   92235.60c   0.001432472   &
      92238.60c   0.000103982   &
      40000.60c   0.035277465   &
       1001.60c   0.063371257
mt91   zr/h.01t   h/zr.01t
m92   92235.60c   0.001435466   &
      92238.60c   0.000104311   &
      40000.60c   0.035292717   &
       1001.60c   0.063128228
mt92   zr/h.01t   h/zr.01t
m93   92235.60c   0.001435576   &
      92238.60c   0.000104092   &
      40000.60c   0.035293905   &
      1001.60c   0.063046588
mt93   zr/h.01t   h/zr.01t
m94   92235.60c   0.001434579   &
      92238.60c   0.000103326   &
      40000.60c   0.035310848   &
       1001.60c   0.063451929
mt94   zr/h.01t   h/zr.01t
m95   92235.60c   0.001421719   &
      92238.60c   0.00010245   &
      40000.60c   0.03498275   &
       1001.60c   0.064943676
mt95   zr/h.01t   h/zr.01t
m96   92235.60c   0.001425267   &
      92238.60c   0.000102669   &
      40000.60c   0.035080958   &
       1001.60c   0.063267573
mt96   zr/h.01t   h/zr.01t
m97   92235.60c   0.001423161   &
      92238.60c   0.000103107   &
      40000.60c   0.035280544   &
       1001.60c   0.063506173
mt97   zr/h.01t   h/zr.01t
m98   92235.60c   0.00143347   &
      92238.60c   0.000103763   &
      40000.60c   0.035522615   &
       1001.60c   0.064888889
mt98   zr/h.01t   h/zr.01t
m99   92235.60c   0.001417396   &
      92238.60c   0.000102559   &
      40000.60c   0.035331825   &
       1001.60c   0.063802469
mt99   zr/h.01t   h/zr.01t
m100  92235.60c   0.001406643   &
      92238.60c   0.000101793   &
      40000.60c   0.035094624   &
       1001.60c   0.064098765
mt100   zr/h.01t   h/zr.01t
m101  92235.60c   0.001420057   &
      92238.60c   0.000102778   &
      40000.60c   0.035313464   &
       1001.60c   0.064197531
mt101   zr/h.01t   h/zr.01t
m102  92235.60c   0.001416842   &
      92238.60c   0.000102559   &
      40000.60c   0.035290936   &
       1001.60c   0.062617284
mt102   zr/h.01t   h/zr.01t
m103  92235.60c   0.001419281   &
      92238.60c   0.000103326   &
      40000.60c   0.035464348   &
       1001.60c   0.064888889
mt103   zr/h.01t   h/zr.01t
m104  92235.60c   0.001413738   &
```

```
      92238.60c   0.000102997   &
      40000.60c   0.035462436   &
       1001.60c   0.063407407
mt104   zr/h.01t   h/zr.01t
m105   92235.60c   0.001410634   &
       92238.60c   9.34746E-05   &
       40000.60c   0.035065703   &
        1001.60c   0.063407407
mt105   zr/h.01t   h/zr.01t
m106   92235.60c   0.001423604   &
       92238.60c   0.000103435   &
       40000.60c   0.035030992   &
        1001.60c   0.063576057
mt106   zr/h.01t   h/zr.01t
m107   92235.60c   0.001439235   &
       92238.60c   0.00010453   &
       40000.60c   0.035316009   &
        1001.60c   0.064303281
mt107   zr/h.01t   h/zr.01t
m108   92235.60c   0.001413294   &
       92238.60c   0.000102669   &
       40000.60c   0.034781046   &
        1001.60c   0.062931948
mt108   zr/h.01t   h/zr.01t
m109   92235.60c   0.001432362   &
       92238.60c   0.000104311   &
       40000.60c   0.035595633   &
        1001.60c   0.064691358
mt109   zr/h.01t   h/zr.01t
m110   92235.60c   0.001432251   &
       92238.60c   0.000103982   &
       40000.60c   0.035613144   &
        1001.60c   0.063209877
mt110   zr/h.01t   h/zr.01t
m111   92235.60c   0.001413405   &
       92238.60c   0.000101793   &
       40000.60c   0.035150204   &
        1001.60c   0.066074074
mt111   zr/h.01t   h/zr.01t
m112   92235.60c   0.001435687   &
       92238.60c   0.000103545   &
       40000.60c   0.035468978   &
        1001.60c   0.064547401
mt112   zr/h.01t   h/zr.01t
m113   92235.60c   0.00143092   &
       92238.60c   0.000103763   &
       40000.60c   0.035308553   &
        1001.60c   0.062367101
mt113   zr/h.01t   h/zr.01t
m114   92235.60c   0.001427262   &
       92238.60c   0.000103545   &
       40000.60c   0.035208233   &
        1001.60c   0.063381262
mt114   zr/h.01t   h/zr.01t
m115   92235.60c   0.001419392   &
       92238.60c   0.000103326   &
       40000.60c   0.035428725   &
        1001.60c   0.064493827
mt115   zr/h.01t   h/zr.01t
m116   92235.60c   0.001430034   &
       92238.60c   0.000104201   &
       40000.60c   0.035494858   &
        1001.60c   0.064790123
mt116   zr/h.01t   h/zr.01t
m117   92235.60c   0.001432916   &
       92238.60c   5.05682E-05   &
       40000.60c   0.035671272   &
        1001.60c   0.064592593
mt117   zr/h.01t   h/zr.01t
print
```

D-5. CASE FIG19

```
NAA-SR-9871, case fig19
c Feb 25, 2005
c Model setup by a.w. krass and k.l.goluoglu
c This case models the experiment described by Fig 19, NAA-SR-9871
c This case uses SNAPTRAN fuel, with a full core compliment, full reflection/
c dry core, with 15 poison splines.  The tank configuration used is that shown in
c Fig 48, of 9871.  The poison spline materials are modeled individually.
c ----- complete fuel element assembly ----------
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1
c ----- additional fuel elements ----------------
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33
c ----- internal be reflector pieces ------------
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock
c -------define the makeup of each poison spline-------------------------
51 28 .022702 -100 -2 3 u=28 imp:n=1
52 0 100:2:-3 u=28 imp:n=1
c
53 29 .018214 -100 -2 3 u=29 imp:n=1
54  0 100:2:-3 u=29 imp:n=1
c
55 35 .021382 -100 -2 3 u=35 imp:n=1
56 0 100:2:-3 u=35 imp:n=1
c
57 33 .015970 -100 -2 3 u=33 imp:n=1
58 0 100:2:-3 u=33 imp:n=1
c
59 30 .019006 -100 -2 3 u=30 imp:n=1
60 0 100:2:-3 u=30 imp:n=1
```

```
c
61 23 .015574 -100 -2 3 u=23 imp:n=1
62 0 100:2:-3 u=23 imp:n=1
c
63 32 .018742 -100 -2 3 u=32 imp:n=1
64 0 100:2:-3 u=32 imp:n=1
c
65 27 .021117 -100 -2 3 u=27 imp:n=1
66 0 100:2:-3 u=27 imp:n=1
c
67 21 .014650 -100 -2 3 u=21 imp:n=1
68 0 100:2:-3 u=21 imp:n=1
c
69 22 .013066 -100 -2 3 u=22 imp:n=1
70 0 100:2:-3 u=22 imp:n=1
c
71 26 .021910 -100 -2 3 u=26 imp:n=1
72 0 100:2:-3 u=26 imp:n=1
c
73 34 .022437 -100 -2 3 u=34 imp:n=1
74 0 100:2:-3 u=34 imp:n=1
c
75 24 .020854 -100 -2 3 u=24 imp:n=1
76 0 100:2:-3 u=24 imp:n=1
c
77 25 .021513 -100 -2 3 u=25 imp:n=1
78 0 100:2:-3 u=25 imp:n=1
c
79 31 .018478 -100 -2 3 u=31 imp:n=1
80 0 100:2:-3 u=31 imp:n=1
c ------ fill each spline position with the correct spline:
81 0 -101 9 -8 fill=28 imp:n=1
82 like 81 but fill=29 trcl ( -5.51    -0.12    0) imp:n=1
83 like 81 but fill=35 trcl ( -2.77    1.52     0) imp:n=1
84 like 81 but fill=33 trcl ( 1.795    3.11     0) imp:n=1
85 like 81 but fill=30 trcl ( -11.08   -0.08    0) imp:n=1
86 like 81 but fill=23 trcl ( -6.39    4.67     0) imp:n=1
87 like 81 but fill=32 trcl ( -.84     7.90     0) imp:n=1
88 like 81 but fill=27 trcl ( -16.475   3.11    0) imp:n=1
89 like 81 but fill=21 trcl ( -11.08   6.35     0) imp:n=1
90 like 81 but fill=22 trcl ( -5.51    9.5      0) imp:n=1
91 like 81 but fill=26 trcl ( -3.66    12.74    0) imp:n=1
92 like 81 but fill=34 trcl ( -11.08   9.55     0) imp:n=1
93 like 81 but fill=24 trcl ( -14.7    9.55     0) imp:n=1
94 like 81 but fill=25 trcl ( -6.43    14.34    0) imp:n=1
95 like 81 but fill=31 trcl ( -11.05   12.7     0) imp:n=1
c ------- define the individual fuel rods
c The fuel rod universe is the number of the fuel rod
c with either a 5 in front or the first digit replaced with 5.
c For example, U=581 is for rod #81. u=501 is for rod #101.
c -----------------------------------------------
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
```

```
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
```

```
c ---------
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps
c -------------------------------------------------------
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &
         #41 #42 #43 #44 #45 #46    &      $ fuel elements
         #81 #82 #83 #84 #85 #86 #87 #88 #89 #90 #91 #92 #93&
         #94 #95      imp:n=1  $ vessel interior between elements - void filled
c ----- tbd -------------------------------------
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate
303 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate
c ----- tbd -------------------------------------
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ aluminum cover plate
```

```
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7)            imp:n=1  $ water
308 7  0.1001037  (20 -31 24 -27)                          imp:n=1  $ top of lower tank h2o
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)             imp:n=1  $ bottom tank shell
310 0              -27 25 -30                              imp:n=1  $ void bottom of lower tank
311 9 0.0871549   -29 30 -27                               imp:n=1  $ steel plate in lower tank
312 0             31 -22 24 -28                            imp:n=1  $ tank outside top tank
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22)           imp:n=1  $ upper tanks wall
314 7  0.1001037  (19 -14 7 -23):&
    (14 -18 16 -23):(17 -18 -6):(18 -21 -23)               imp:n=1  $ water inside top tank
315 0             (21 -22 -23)                             imp:n=1  $ void over top tank water
c
c ----- tbd ------------------------------------
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1
317 0 999           imp:n=0

1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)
3   pz -15.52575                $ bottom of active fuel region
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)
9   pz -15.8115                 $ bottom of fuel element
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)
12  pz  16.85925                $ vessel cover/flange interface
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)
14  pz  16.70177                $ bottom of vessel flange
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)
16  cz  16.46555                $ OR of vessel flange
17  pz  16.93799                $ top of cover plate indent=
18  pz  17.49425                $ top of cover plate flange
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)
21  pz  22.4155                 $ top of the water in the top tank :14 15/16 "
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37
c ----- begin internal be piece surfaces -----------------
44  cz  11.1506     $ outside radius of internal be piece
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element
```

```
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element
c ----- tbd ------------------------------------
c  surfaces for splines
100 c/z 7.34 -6.31 0.208
101 c/z 7.34 -6.31 0.208001
c -----------------------------------------------
999 so  55

mode  n
c ------npg----k----nsk---gen----
kcode   1000  1.0  1000  3000
ksrc    0  9.6012  0
c --- sm2o3 coating ----
m5    8016.60c 0.0168362 &
     13027.60c 0.0052426 &
     14000.60c 0.0044482 &
     62147.66c 0.0000076 &
     62149.66c 0.0000070 &
     62150.50c 0.0000037 &
     62152.50c 0.0000135
c --- type 1100 aluminum ---------
m6   13027.60c 0.0602626
c --- water -----------
m7    1001.60c 0.0667358 &
      8016.60c 0.0333679
mt7   lwtr.01t
c --- Hastelloy N -----
m8   28058.60c 0.0440590 &
     28060.60c 0.0168440 &
     28061.60c 0.0007293 &
     28062.60c 0.0023169 &
     28064.60c 0.0005873 &
     26054.60c 0.0002818 &
     26056.60c 0.0043815 &
     26057.60c 0.0001003 &
     26058.60c 0.0000134 &
     24050.60c 0.0003121 &
     24052.60c 0.0060187 &
     24053.60c 0.0006824 &
     24054.60c 0.0001699 &
     42000.60c 0.0088982 &
     14000.60c 0.0018998
c --- ss316 ------------
m9   26054.60c 0.0033463 &
     26056.60c 0.0520202 &
     26057.60c 0.0011910 &
     26058.60c 0.0001588 &
     24050.60c 0.0006870 &
     24052.60c 0.0132476 &
     24053.60c 0.0015020 &
     24054.60c 0.0003739 &
     28058.60c 0.0067490 &
     28060.60c 0.0025802 &
     28061.60c 0.0001117 &
     28062.60c 0.0003549 &
     28064.60c 0.0000900 &
     42000.60c 0.0012601 &
     25055.60c 0.0017604 &
     14000.60c 0.0017218
c --- Be metal ---------
m11   4009.60c 0.1216164
mt11   be.01t
c --- natural B for poison splines
m28  5010.60c  0.004518 &
```

```
     5011.60c  0.018184
c --- natural B for poison splines
m29  5010.60c  0.003625 &
     5011.60c  0.014589
c --- natural B for poison splines
m35  5010.60c  0.004255 &
     5011.60c  0.017127
c --- natural B for poison splines
m33  5010.60c  0.003178 &
     5011.60c  0.012792
c --- natural B for poison splines
m30  5010.60c  0.003782 &
     5011.60c  0.015224
c --- natural B for poison splines
m23  5010.60c  0.003099 &
     5011.60c  0.012475
c --- natural B for poison splines
m32  5010.60c  0.003730 &
     5011.60c  0.015012
c --- natural B for poison splines
m27  5010.60c  0.004202 &
     5011.60c  0.016915
c --- natural B for poison splines
m21  5010.60c  0.002915 &
     5011.60c  0.011735
c --- natural B for poison splines
m22  5010.60c  0.002600 &
     5011.60c  0.010466
c --- natural B for poison splines
m26  5010.60c  0.004360 &
     5011.60c  0.017550
c --- natural B for poison splines
m34  5010.60c  0.004465 &
     5011.60c  0.017972
c --- natural B for poison splines
m24  5010.60c  0.004150 &
     5011.60c  0.016704
c --- natural B for poison splines
m25  5010.60c  0.004281 &
     5011.60c  0.017232
c --- natural B for poison splines
m31  5010.60c  0.003677 &
     5011.60c  0.014801
c  Definitions for the fuel elements:
c  --------------rod number:  19
m519 92235.60c 0.0014245 &
     92238.60c 0.0001026 &
     40000.60c 0.0353836 &
      1001.60c 0.0639706 &
      6000.60c 0.0004486
mt519     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  23
m523 92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0627859 &
      6000.60c 0.0004424
mt523     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  26
m526 92235.60c 0.0013946 &
     92238.60c 0.0001005 &
     40000.60c 0.0346401 &
      1001.60c 0.0646616 &
      6000.60c 0.0004392
mt526     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  37
m537 92235.60c 0.0014023 &
     92238.60c 0.0001010 &
```

```
     40000.60c 0.0348329 &
      1001.60c 0.0630821 &
      6000.60c 0.0004417
mt537     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  40
m40  92235.60c 0.0014223 &
     92238.60c 0.0001025 &
     40000.60c 0.0353285 &
      1001.60c 0.0627859 &
      6000.60c 0.0004479
mt40     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  46
m46  92235.60c 0.0014023 &
     92238.60c 0.0001010 &
     40000.60c 0.0348329 &
      1001.60c 0.0646616 &
      6000.60c 0.0004417
mt46     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  51
m51  92235.60c 0.0014012 &
     92238.60c 0.0001009 &
     40000.60c 0.0348053 &
      1001.60c 0.0649578 &
      6000.60c 0.0004413
mt51     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  52
m52  92235.60c 0.0014256 &
     92238.60c 0.0001027 &
     40000.60c 0.0354111 &
      1001.60c 0.0643654 &
      6000.60c 0.0004490
mt52     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  55
m55  92235.60c 0.0014001 &
     92238.60c 0.0001009 &
     40000.60c 0.0347778 &
      1001.60c 0.0647603 &
      6000.60c 0.0004410
mt55     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  62
m62  92235.60c 0.0013990 &
     92238.60c 0.0001008 &
     40000.60c 0.0347502 &
      1001.60c 0.0646616 &
      6000.60c 0.0004406
mt62     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  65
m65  92235.60c 0.0014001 &
     92238.60c 0.0001009 &
     40000.60c 0.0347778 &
      1001.60c 0.0645629 &
      6000.60c 0.0004410
mt65     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  66
m66  92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0630821 &
      6000.60c 0.0004424
mt66     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  67
m67  92235.60c 0.0014212 &
```

```
     92238.60c 0.0001024 &
     40000.60c 0.0353010 &
      1001.60c 0.0640693 &
      6000.60c 0.0004476
mt67     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  68
m68  92235.60c 0.0014101 &
     92238.60c 0.0001016 &
     40000.60c 0.0350256 &
      1001.60c 0.0646616 &
      6000.60c 0.0004441
mt68     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  80
m80  92235.60c 0.0014234 &
     92238.60c 0.0001025 &
     40000.60c 0.0353560 &
      1001.60c 0.0639706 &
      6000.60c 0.0004483
mt80     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  81
m81  92235.60c 0.0014134 &
     92238.60c 0.0001018 &
     40000.60c 0.0351082 &
      1001.60c 0.0643654 &
      6000.60c 0.0004452
mt81     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  83
m83  92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0654514 &
      6000.60c 0.0004424
mt83     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  84
m84  92235.60c 0.0014223 &
     92238.60c 0.0001025 &
     40000.60c 0.0353285 &
      1001.60c 0.0623910 &
      6000.60c 0.0004479
mt84     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  85
m85  92235.60c 0.0014056 &
     92238.60c 0.0001013 &
     40000.60c 0.0349155 &
      1001.60c 0.0635757 &
      6000.60c 0.0004427
mt85     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  86
m86  92235.60c 0.0014156 &
     92238.60c 0.0001020 &
     40000.60c 0.0351633 &
      1001.60c 0.0650565 &
      6000.60c 0.0004459
mt86     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  92
m92  92235.60c 0.0013912 &
     92238.60c 0.0001002 &
     40000.60c 0.0345575 &
      1001.60c 0.0632795 &
      6000.60c 0.0004382
mt92     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  132
```

```
m132 92235.60c 0.0014056 &
     92238.60c 0.0001013 &
     40000.60c 0.0349155 &
      1001.60c 0.0627859 &
      6000.60c 0.0004427
mt132     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  133
m133 92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0644642 &
      6000.60c 0.0004424
mt133     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  137
m137 92235.60c 0.0013857 &
     92238.60c 0.0000998 &
     40000.60c 0.0344198 &
      1001.60c 0.0642667 &
      6000.60c 0.0004364
mt137     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  147
m147 92235.60c 0.0013890 &
     92238.60c 0.0001001 &
     40000.60c 0.0345024 &
      1001.60c 0.0636744 &
      6000.60c 0.0004375
mt147     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  151
m151 92235.60c 0.0014178 &
     92238.60c 0.0001021 &
     40000.60c 0.0352184 &
      1001.60c 0.0637731 &
      6000.60c 0.0004466
mt151     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  153
m153 92235.60c 0.0014145 &
     92238.60c 0.0001019 &
     40000.60c 0.0351357 &
      1001.60c 0.0637731 &
      6000.60c 0.0004455
mt153     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  171
m171 92235.60c 0.0014212 &
     92238.60c 0.0001024 &
     40000.60c 0.0353010 &
      1001.60c 0.0649578 &
      6000.60c 0.0004476
mt171     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  173
m173 92235.60c 0.0014023 &
     92238.60c 0.0001010 &
     40000.60c 0.0348329 &
      1001.60c 0.0626872 &
      6000.60c 0.0004417
mt173     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  174
m174 92235.60c 0.0014267 &
     92238.60c 0.0001028 &
     40000.60c 0.0354386 &
      1001.60c 0.0645629 &
      6000.60c 0.0004493
mt174     zr/h.01t  &
  h/zr.01t
```

```
c  --------------rod number:  176
m176 92235.60c 0.0014167 &
     92238.60c 0.0001021 &
     40000.60c 0.0351908 &
      1001.60c 0.0649578 &
      6000.60c 0.0004462
mt176     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  9
m559 92235.60c 0.0014278 &
     92238.60c 0.0001029 &
     40000.60c 0.0354662 &
      1001.60c 0.0619962 &
      6000.60c 0.0004497
mt559     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  25
m525 92235.60c 0.0014223 &
     92238.60c 0.0001025 &
     40000.60c 0.0353285 &
      1001.60c 0.0626872 &
      6000.60c 0.0004479
mt525     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  47
m47  92235.60c 0.0014223 &
     92238.60c 0.0001025 &
     40000.60c 0.0353285 &
      1001.60c 0.0621936 &
      6000.60c 0.0004479
mt47     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  58
m58  92235.60c 0.0014212 &
     92238.60c 0.0001024 &
     40000.60c 0.0353010 &
      1001.60c 0.0642667 &
      6000.60c 0.0004476
mt58     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  90
m90  92235.60c 0.0013912 &
     92238.60c 0.0001002 &
     40000.60c 0.0345575 &
      1001.60c 0.0629834 &
      6000.60c 0.0004382
mt90     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  135
m135 92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0649578 &
      6000.60c 0.0004424
mt135     zr/h.01t  &
  h/zr.01t
print
```

D-6. CASE P45

```
NAA-SR-9871, case p45
c Feb 25, 2005
c Model setup by a.w. krass and k.l.goluoglu
c This case models the experiment described on p45, NAA-SR-9871
c This case uses SNAPTRAN fuel, with the tank configuration shown in
c Fig 27 of 9871.  It has a full core loading, and the core is voided.
c ----- complete fuel element assembly ----------
1  0        -5 -8 9  fill=133                     imp:n=1  $ position 1
c ----- additional fuel elements ----------------
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33
c ----- internal be reflector pieces ------------
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock
c ----------------------------------------------
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
```

```
c ---------
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating
```

```
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
c ---------
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps
c -----------------------------------------------------
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &
         #41 #42 #43 #44 #45 #46    &      $ fuel elements
         imp:n=1  $ vessel interior between elements - void filled
c ----- vessel interior spaces  -----------------------------------
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate
303 0                (-6  10 -14):(14 -16)     imp:n=1  $ vessel interior above upper gridplate
```

```
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate
c ----- reactor vessel -----------------------------------
400 9  0.0871549  (-7 6 -14 13):(-12 16 14)             imp:n=1  $ ss316 vessel walls
401 6  0.0602626  (-7 15 -13)                            imp:n=1  $ aluminum bottom of vessel
402 7  0.1001037  (7 -17 19 -14)                         imp:n=1  $ upper water gap
403 7  0.1001037  (7 -17 -20 15)                         imp:n=1  $ lower water gap
407 12 0.0708762  (17 -18 19 -14)                        imp:n=1  $ binal sleeve
408 12 0.0708762  (17 -18 -20 15)                        imp:n=1  $ lower binal sleeve
c ----- water tanks ----------------------------
500 7  0.1001037  (29 -15 -27):(15 -20 -27 18 )          imp:n=1  $ water in the lower tank
501 7  0.1001037  (-27 24 20 -31)                        imp:n=1  $ void between top/bottom
502 9  0.0871549  (-29 -28 30):(27 -28 29 -31)          imp:n=1  $ bottom tank shell
c
506 9  0.0871549  (-19 20 7  -24):(-24 23 19 -22)       imp:n=1  $ upper tanks wall
507 7  0.1001037  (19 -14 18  -23):(14 12 -21 -23)      imp:n=1  $ water inside top tank
508 0             (21 -22 -23)                           imp:n=1  $ void above top tank water
509 0             (-22 31 -28 24)                        imp:n=1  $ void outside top tank
c
c ----- outside world ------------------------------------
516 0   (22 -999):(-22 31 28 -999):(28 -999 30 -31):(-30 -999) imp:n=1
517 0 999           imp:n=0

1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)
3   pz -15.52575                $ bottom of active fuel region
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)
6   cz  11.303                  $ IR of rx vessel=(8.9/2)(2.54)
7   cz  11.38174                $ OR of rx vessel=((8.9/2)+0.031)(2.54)
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)
9   pz -15.8115                 $ bottom of fuel element
10  pz  16.129                  $ top of upper grid plate =15.8115+(2.54)(0.125)
11  pz -17.0815                 $ bottom of lower grid plate=-15.8115-(2.54)(0.5)
12  kz 21.9837 12.8508 -1       $ top of rx vessel: vertex at 0,0,21.9837.
c                                 tan^2 of the opening angle=12.8508
13  pz -18.8341                 $ top of vessel bottom=-15.8115-(2.54)(1.19)
14  pz  18.8087                 $ beginning of conical top=15.8115+1.18"
15  pz -19.4691                 $ bottom of vessel bottom=-15.8115-1.44"
16  kz 21.90496 13.3262 -1      $ inside top of rx vessel: vertex at 0,0,21.90496.
17  cz 12.01674                 $ inside surface of binal sleeve
18  cz 12.65174                 $ outside surface of binal sleeve
19  pz  6.01218                 $ top of bottom plate for upper tank=15.8115-3.92"+0.062"
20  pz  5.8547                  $ bottom of bottom plate for upper tank=15.8115-3.92"
21  pz  30.9499                 $ top of the water in the top tank=15.8115+5.96"
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)
c
27  cz  34.24174                $ IR of lower tank=(surface 7)+9"
28  cz  34.3992                 $ OR of lower tank=
29  pz -33.7439                 $ top of bottom plate for lower tank=-15.8115-7.06"
30  pz -34.0614                 $ bottom of lower tank=-33.7439-0.125"
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37
c ----- begin internal be piece surfaces -----------------
44  cz  11.1506     $ outside radius of internal be piece
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element
```

```
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element
c --------------------------------------------------
999 so  55

mode  n
c ------npg----k----nsk---gen----
kcode   1000  1.0  1000  3000
ksrc    0  9.6012  0
c --- sm2o3 coating ----
m5    8016.60c 0.0168362 &
     13027.60c 0.0052426 &
     14000.60c 0.0044482 &
     62147.66c 0.0000076 &
     62149.66c 0.0000070 &
     62150.50c 0.0000037 &
     62152.50c 0.0000135
c --- type 1100 aluminum ---------
m6   13027.60c 0.0602626
c --- water -----------
m7    1001.60c 0.0667358 &
      8016.60c 0.0333679
mt7   lwtr.01t
c --- Hastelloy N -----
m8   28058.60c 0.0440590 &
     28060.60c 0.0168440 &
     28061.60c 0.0007293 &
     28062.60c 0.0023169 &
     28064.60c 0.0005873 &
     26054.60c 0.0002818 &
     26056.60c 0.0043815 &
     26057.60c 0.0001003 &
     26058.60c 0.0000134 &
     24050.60c 0.0003121 &
     24052.60c 0.0060187 &
     24053.60c 0.0006824 &
     24054.60c 0.0001699 &
     42000.60c 0.0088982 &
     14000.60c 0.0018998
c --- ss316 ------------
m9   26054.60c 0.0033463 &
     26056.60c 0.0520202 &
     26057.60c 0.0011910 &
     26058.60c 0.0001588 &
     24050.60c 0.0006870 &
     24052.60c 0.0132476 &
     24053.60c 0.0015020 &
     24054.60c 0.0003739 &
     28058.60c 0.0067490 &
     28060.60c 0.0025802 &
     28061.60c 0.0001117 &
     28062.60c 0.0003549 &
     28064.60c 0.0000900 &
     42000.60c 0.0012601 &
     25055.60c 0.0017604 &
     14000.60c 0.0017218
c --- Be metal ---------
m11   4009.60c 0.1216164
```

```
mt11   be.01t
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------
m12   5010.60c 0.0030227 &
      5011.60c 0.0121667 &
      6000.60c 0.0037973 &
     13027.60c 0.0518894
c ---total=0.07087616
c  Definitions for the fuel elements:
c  --------------rod number:  19
m519 92235.60c 0.0014245 &
     92238.60c 0.0001026 &
     40000.60c 0.0353836 &
      1001.60c 0.0639706 &
      6000.60c 0.0004486
mt519     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  23
m523 92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0627859 &
      6000.60c 0.0004424
mt523     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  26
m526 92235.60c 0.0013946 &
     92238.60c 0.0001005 &
     40000.60c 0.0346401 &
      1001.60c 0.0646616 &
      6000.60c 0.0004392
mt526     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  37
m537 92235.60c 0.0014023 &
     92238.60c 0.0001010 &
     40000.60c 0.0348329 &
      1001.60c 0.0630821 &
      6000.60c 0.0004417
mt537     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  40
m40  92235.60c 0.0014223 &
     92238.60c 0.0001025 &
     40000.60c 0.0353285 &
      1001.60c 0.0627859 &
      6000.60c 0.0004479
mt40     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  46
m46  92235.60c 0.0014023 &
     92238.60c 0.0001010 &
     40000.60c 0.0348329 &
      1001.60c 0.0646616 &
      6000.60c 0.0004417
mt46     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  51
m51  92235.60c 0.0014012 &
     92238.60c 0.0001009 &
     40000.60c 0.0348053 &
      1001.60c 0.0649578 &
      6000.60c 0.0004413
mt51     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  52
m52  92235.60c 0.0014256 &
     92238.60c 0.0001027 &
     40000.60c 0.0354111 &
      1001.60c 0.0643654 &
      6000.60c 0.0004490
mt52     zr/h.01t  &
```

```
  h/zr.01t
c  --------------rod number:  55
m55  92235.60c 0.0014001 &
     92238.60c 0.0001009 &
     40000.60c 0.0347778 &
      1001.60c 0.0647603 &
      6000.60c 0.0004410
mt55     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  62
m62  92235.60c 0.0013990 &
     92238.60c 0.0001008 &
     40000.60c 0.0347502 &
      1001.60c 0.0646616 &
      6000.60c 0.0004406
mt62     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  65
m65  92235.60c 0.0014001 &
     92238.60c 0.0001009 &
     40000.60c 0.0347778 &
      1001.60c 0.0645629 &
      6000.60c 0.0004410
mt65     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  66
m66  92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0630821 &
      6000.60c 0.0004424
mt66     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  67
m67  92235.60c 0.0014212 &
     92238.60c 0.0001024 &
     40000.60c 0.0353010 &
      1001.60c 0.0640693 &
      6000.60c 0.0004476
mt67     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  68
m68  92235.60c 0.0014101 &
     92238.60c 0.0001016 &
     40000.60c 0.0350256 &
      1001.60c 0.0646616 &
      6000.60c 0.0004441
mt68     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  80
m80  92235.60c 0.0014234 &
     92238.60c 0.0001025 &
     40000.60c 0.0353560 &
      1001.60c 0.0639706 &
      6000.60c 0.0004483
mt80     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  81
m81  92235.60c 0.0014134 &
     92238.60c 0.0001018 &
     40000.60c 0.0351082 &
      1001.60c 0.0643654 &
      6000.60c 0.0004452
mt81     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  83
m83  92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0654514 &
      6000.60c 0.0004424
```

```
mt83     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  84
m84  92235.60c 0.0014223 &
     92238.60c 0.0001025 &
     40000.60c 0.0353285 &
      1001.60c 0.0623910 &
      6000.60c 0.0004479
mt84     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  85
m85  92235.60c 0.0014056 &
     92238.60c 0.0001013 &
     40000.60c 0.0349155 &
      1001.60c 0.0635757 &
      6000.60c 0.0004427
mt85     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  86
m86  92235.60c 0.0014156 &
     92238.60c 0.0001020 &
     40000.60c 0.0351633 &
      1001.60c 0.0650565 &
      6000.60c 0.0004459
mt86     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  92
m92  92235.60c 0.0013912 &
     92238.60c 0.0001002 &
     40000.60c 0.0345575 &
      1001.60c 0.0632795 &
      6000.60c 0.0004382
mt92     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  132
m132 92235.60c 0.0014056 &
     92238.60c 0.0001013 &
     40000.60c 0.0349155 &
      1001.60c 0.0627859 &
      6000.60c 0.0004427
mt132     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  133
m133 92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0644642 &
      6000.60c 0.0004424
mt133     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  137
m137 92235.60c 0.0013857 &
     92238.60c 0.0000998 &
     40000.60c 0.0344198 &
      1001.60c 0.0642667 &
      6000.60c 0.0004364
mt137     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  147
m147 92235.60c 0.0013890 &
     92238.60c 0.0001001 &
     40000.60c 0.0345024 &
      1001.60c 0.0636744 &
      6000.60c 0.0004375
mt147     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  151
m151 92235.60c 0.0014178 &
     92238.60c 0.0001021 &
     40000.60c 0.0352184 &
      1001.60c 0.0637731 &
```

```
      6000.60c 0.0004466
mt151     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  153
m153 92235.60c 0.0014145 &
     92238.60c 0.0001019 &
     40000.60c 0.0351357 &
      1001.60c 0.0637731 &
      6000.60c 0.0004455
mt153     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  171
m171 92235.60c 0.0014212 &
     92238.60c 0.0001024 &
     40000.60c 0.0353010 &
      1001.60c 0.0649578 &
      6000.60c 0.0004476
mt171     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  173
m173 92235.60c 0.0014023 &
     92238.60c 0.0001010 &
     40000.60c 0.0348329 &
      1001.60c 0.0626872 &
      6000.60c 0.0004417
mt173     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  174
m174 92235.60c 0.0014267 &
     92238.60c 0.0001028 &
     40000.60c 0.0354386 &
      1001.60c 0.0645629 &
      6000.60c 0.0004493
mt174     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  176
m176 92235.60c 0.0014167 &
     92238.60c 0.0001021 &
     40000.60c 0.0351908 &
      1001.60c 0.0649578 &
      6000.60c 0.0004462
mt176     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  9
m559 92235.60c 0.0014278 &
     92238.60c 0.0001029 &
     40000.60c 0.0354662 &
      1001.60c 0.0619962 &
      6000.60c 0.0004497
mt559     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  25
m525 92235.60c 0.0014223 &
     92238.60c 0.0001025 &
     40000.60c 0.0353285 &
      1001.60c 0.0626872 &
      6000.60c 0.0004479
mt525     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  47
m47  92235.60c 0.0014223 &
     92238.60c 0.0001025 &
     40000.60c 0.0353285 &
      1001.60c 0.0621936 &
      6000.60c 0.0004479
mt47     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  58
m58  92235.60c 0.0014212 &
     92238.60c 0.0001024 &
     40000.60c 0.0353010 &
```

```
      1001.60c 0.0642667 &
      6000.60c 0.0004476
mt58     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  90
m90  92235.60c 0.0013912 &
     92238.60c 0.0001002 &
     40000.60c 0.0345575 &
      1001.60c 0.0629834 &
      6000.60c 0.0004382
mt90     zr/h.01t  &
  h/zr.01t
c  --------------rod number:  135
m135 92235.60c 0.0014045 &
     92238.60c 0.0001012 &
     40000.60c 0.0348879 &
      1001.60c 0.0649578 &
      6000.60c 0.0004424
mt135     zr/h.01t  &
  h/zr.01t
print
```

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ORNL/TM-2005/54
Volume II of II

Experimental Criticality Benchmarks for SNAP 10A/2 Reactor Cores: MCNP5 Input Files in Support of ORNL/TM-2005/54

April 2005

Prepared by
A.W. Krass and K.L. Goluoglu
ORNL Nuclear Criticality Safety

ORNL/TM-2005/54
Volume II of II

Operational Safety Services Division

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CONTENTS

CONTENTS (continued)

1. RECORD OF NCS COMPUTATIONS TECHNICAL REVIEW

This record of review is provided as Appendix A of Volume I. It is reproduced here for information purposes.

Appendix A. Record of NCS Computations Technical Review

Application Scope and Description

Application/Document/Work Calculations Support
Validation of MCNP5 estimates of k_{eff} for SNAP 10A/2 type reactor fuels and cores.

List/Identify The Particular Calculations Reviewed
All cases were reviewed for consistency with presented assumptions and information.

Calculations Reviewed Were Performed by:
Allan W. Krass and Katherin L. Goluoglu

For The Indicated Application, Calculations And Conclusions Based On Those Calculations Were Verified As Correct:

By: Richard G. Taylor Date: 04/26/05
Richard G. Taylor

Description of Calculational Method

Controlled Codes/Data Sets Used
MCNP5 with ENDF B-V and ENDF B-VI neutron cross section libraries

Identify Computing Platform(s)
ORNL NCS staff workstation ossws6

Date(s) Verification Problem Set Last Executed
April 2005

Applicable Validation Reference(s)
N/A -- These cases constitute criticality benchmarks for validation.

Description of Review

Geometry and Atom Density Inputs Were Verified Using the Following Information:
The geometry and material inputs of the reviewed cases were reviewed for consistency with information presented within the report. Calculated results were also reviewed for consistency with experimental results.

Did the Review Include Verification of Code Input Options and Cross Section Treatments? *Yes*

Were Calculational Results Appropriately Corrected For Bias and Bias Uncertainty? *N/A*
Or, For Reviews of Validation Calculations,
Were Bias and Bias Uncertainty Appropriately Determined/Area of Applicability Defined? *Yes*

Were Independent Calculations Made As Part of the Review? *No - not required*
If Yes, Please Describe: *N/A*

Elaboration on Answers to Parts A, B, or C or Other Review Recommendations
None

2. INTRODUCTION

Atomics International (AI), a Division of North American Aviation, Inc., contributed to the development of several Systems for Nuclear Auxiliary Power (SNAP) during the 1950's and 1960's under contract to the Atomic Energy Commission. Many of these systems were envisioned as compact nuclear reactors designed for remote or automated operation to generate electrical power for earth satellites, such as the SNAP 10A/2 system. Integral to the development of these systems were the experimental criticality programs to support nuclear safety analyses. The input files presented in this volume model the SNAP Critical Assembly-4B (SCA-4B) program in which fueled SNAP 10A/2 reactor cores and assemblies are subject to water flooding and reflection. The results of the SCA-4B program are principally described in NAA-SR-8490 and NAA-SR-9871. Volume I of this report provides the detailed descriptions of how these input files were developed.

The configuration of the reactor core of the SCA-4B experimental program mimics the configuration of a SNAP 10A/2 reactor core. In both cases, the reactor core is characterized by a cylindrical thin-walled stainless steel vessel that contains a pseudo-cylindrical array of 37 closely spaced fuel elements. The fuel elements are about 1.250-inches in diameter (3.175 cm) and 12.450-inches long (31.623 cm) and are positioned on a triangular pitch of 1.260-inches (3.2004 cm). Six beryllium metal inserts are shaped to fit the spaces between the element array and the cylindrical vessel wall. The fuel elements and beryllium metal inserts are supported and held laterally within the core vessel at both ends by grid plates.

Each element is fueled and moderated by the hydride of highly enriched uranium (at least 93 percent ^{235}U, by weight) and zirconium alloy in the form of a solid cylindrical rod housed within a thin-walled Hastelloy® N cladding tube with solid plugs and indexing pins at both ends. The internal surface of the cladding tube is also thinly coated with a ceramic glass barrier that includes a small, but variable, amount of samarium oxide (Sm_2O_3). A 37-element full-core complement might contain about 2.7 to 4.0 total grams of Sm_2O_3, dependant on the fabrication specifications of the fuel elements used in a given application.

The alloy is nominally 10 percent uranium and 90 percent zirconium, by weight, with a mass density of about 6.06 g/cm^3. The resulting hydride contains about 6.5 x 10^{22} hydrogen atoms per cm^3, comparable to the hydrogen content of ordinary water. Thus, each fuel element contains approximately 128.5 g ^{235}U with an $H/^{235}U$ ratio of about 45. The total fissile content of a 37-element full-core complement would be about 4.75 kg ^{235}U.

For the SCA-4B experimental program, the reactor core vessel was mounted inside a combination of nesting cylindrical water tanks. The core vessel and the water tanks were remotely filled and drained to provide varied conditions of water flooding and reflection for the purpose of neutron multiplication measurements. The tanks were also sufficiently large to permit the placement of additional sleeves and mechanical reflector assemblies around the core vessel.

3. INPUT FILES

3.1 Phase I MCNP5 Input Files

3.1.1 Case 8490a

```
NAA-SR-8490 benchmark model case 8490a$
c$
c  p. 22, Figure 9 as shown$
c  -2 cents excess reactivity$
c  28 fuel rods, fully water reflected and water flooded core$
c  no lucite rods, no Be inserts$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl   (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl   (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl   (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl  (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl   (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl   (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl  (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl   (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl   (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl   (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl  (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl   (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl   (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl   (2.7716 -14.4018  0)  imp:n=1  $ position 28$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7  0.1001037  (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28     imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
```

```
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                              imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
```

```
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
print$
$
```

3.1.2 Case 8490b

```
NAA-SR-8490 benchmark model case 8490b$
c$
c  p. 22, Figure 9 as shown, except one fuel element moved from position 16 to position 29$
c  +26 cents core reactivity$
c  28 fuel rods, fully water reflected and water flooded core$
c  no lucite rods, no Be inserts$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl   (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl   (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl   (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl  (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl   (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl   (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl  (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl   (5.5432  -6.4008  0)  imp:n=1  $ position 15$
c$
17 like 1 but trcl   (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl  (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl   (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl   (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl   (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 28$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7  0.1001037  (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15     #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29    imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10              imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11              imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12              imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13              imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
```

```
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)             imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
```

```
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
print$
$
```

3.1.3 Case 8490c

```
NAA-SR-8490 benchmark model case 8490c$
c$
c  p. 23, Figure 9 as shown, except vacant positions occupied by lucite rods$
c  criticality at upper water tank height of 3.8 inches$
c  28 fuel rods plus 9 lucite rods, but no Be inserts$
c  water reflected and water flooded core$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl   (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl   (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl   (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl  (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl   (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl   (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl  (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl   (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl   (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl   (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl  (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl   (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl   (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl   (2.7716 -14.4018  0)  imp:n=1  $ position 28$
c ------ lucite rods in vacant positions ------------$
29 10 0.1064672   -35 -8 9                  imp:n=1  $ position 29$
30 like 29 but trcl   (2.7716   1.6002  0)  imp:n=1  $ position 30$
31 like 29 but trcl  (-5.5432  -6.4008  0)  imp:n=1  $ position 31$
32 like 29 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 32$
33 like 29 but trcl (-11.0864  -3.2004  0)  imp:n=1  $ position 33$
34 like 29 but trcl (-13.858   -1.6002  0)  imp:n=1  $ position 34$
35 like 29 but trcl  (-2.7716  -4.8006  0)  imp:n=1  $ position 35$
36 like 29 but trcl   (0.0     -3.2004  0)  imp:n=1  $ position 36$
37 like 29 but trcl   (2.7716  -1.6002  0)  imp:n=1  $ position 37$
c -----------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7  0.1001037  (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
      #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
      #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37  imp:n=1  $ vessel interior between
elements - water filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
```

```
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  -23 7 -21 19                            imp:n=1  $ water filled volume of upper
tank$
108 0   (-23 7 -14 21):(-23 16 -18 14):(-6 -18 17):(-23 -22 18)   imp:n=1  $ void filled volume of
upper tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  15.82674                $ fill height of upper tank @ 3.8 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  5.5432  -3.2004   1.5875  $ OR of lucite rod $
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
```

```
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t $
print$
$
```

3.1.4 Case 8490d

```
NAA-SR-8490 benchmark model case 8490d$
c$
c  p. 23 description, as shown in Figure 12 on p. 25$
c  water reflected and water flooded core$
c  25 fuel rods plus 12 lucite rods plus 6 Be inserts$
c  criticality at an upper tank water level of 5.4 inches$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl   (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl   (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl   (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl  (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl   (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl   (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl  (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl   (5.5432  -6.4008  0)  imp:n=1  $ position 15$
c $
17 like 1 but trcl   (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl  (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl   (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$
c$
c  $
25 like 1 but trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl   (2.7716 -14.4018  0)  imp:n=1  $ position 28$
c ----- lucite rods ----------------------------$
16  10 0.1064672    -35 -8 9                imp:n=1  $ position 16$
23 like 16 but trcl   (0.0     -3.2004  0)  imp:n=1  $ position 23$
24 like 16 but trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 24$
29 like 16 but trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 29$
30 like 16 but trcl   (0.0     -6.4008  0)  imp:n=1  $ position 30$
31 like 16 but trcl  (-8.3149 -14.4018  0)  imp:n=1  $ position 31$
32 like 16 but trcl (-11.0864 -12.8016  0)  imp:n=1  $ position 32$
33 like 16 but trcl (-13.858  -11.2014  0)  imp:n=1  $ position 33$
34 like 16 but trcl (-16.6296  -9.6012  0)  imp:n=1  $ position 34$
35 like 16 but trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 35$
36 like 16 but trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 36$
37 like 16 but trcl   (0.0     -9.6012  0)  imp:n=1  $ position 37$
c ----- internal be reflector pieces -----------$
41  11 0.1216161  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216161  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216161  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216161  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216161  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216161  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7  0.1001037  (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
```

```
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  19.89074                $ fill height of upper tank @ 5.4 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149  4.8006 1.5875  $ OR of lucite rod in position 16$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
```

```
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd ----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
```

```
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.5 Case 8490e

```
NAA-SR-8490 benchmark model case 8490e$
c$
c  p. 26 description, as shown in Figure 14 on p. 27$
c  31 fuel rods plus 6 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core $
c  9 cents supercritical at full (9 inches) water in upper tank$
c  family of results shown in Figure 10 on p. 24 $
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd ------------------------------------$
```

```
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                              imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
```

```
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd ----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
```

```
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.6 Case 8490e1

```
NAA-SR-8490 benchmark model case 8490e1$
c$
c  derived from Figure 10 on p. 24 $
c  31 fuel rods plus 6 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  10 cents subcritical at 7-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10                 imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                              imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  23.95474                $ fill height of upper tank @ 7 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k-0--nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.7 Case 8490e2

```
NAA-SR-8490 benchmark model case 8490e2$
c$
c  derived from Figure 10 on p. 24$
c  31 fuel rods plus 6 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  45 cents subcritical at 6-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- lucite rods -----------------------------$
37  10 0.1064672     -35 -8 9                imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  21.41474                $ fill height of upper tank @ 6 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.8 Case 8490e3

```
NAA-SR-8490 benchmark model case 8490e3$
c$
c  derived from Figure 10 on p. 24$
c  31 fuel rods plus 6 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  55 cents subcritical at 5.5-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- lucite rods -----------------------------$
37  10 0.1064672     -35 -8 9                imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ----------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ----------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                              imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  20.14474                $ fill height of upper tank @ 5.5 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
NAA-SR-8490 benchmark model case 8490e4$
c$
c  derived from Figure 10 on p. 24$
c  31 fuel rods plus 6 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  $1.30 subcritical at 4.938-inches (top of cover plate) of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
```

```
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ------------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ------------------------------------------------$
100 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14)          imp:n=1  $ water filled volume of upper
tank$
108 0             (-6 -18 17):(-23 -22 18)                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  18.71726                $ fill height of upper tank @ 4.938 inches$
22  pz  31.57474                $ top edge of upper tank$
```

```
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
```

```
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.9 Case 8490e5

```
NAA-SR-8490 benchmark model case 8490e5$
c$
c  derived from Figure 10 on p. 24$
c  31 fuel rods plus 6 lucite rods plus Be inserts$
c  water reflected, but NO water in core$
c  $1.30 subcritical at 3.5-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -21 19)                            imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  15.06474                $ fill height of upper tank @ 3.5 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.10 Case 8490e6

```
NAA-SR-8490 benchmark model case 8490e6$
c$
c  derived from Figure 10 on p. 24$
c  31 fuel rods plus 6 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  $2.60 subcritical at 2.0-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)               imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -21 19)                           imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                 imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)           imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)              imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)             imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                              imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                              imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)             imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)          imp:n=1  $ spherical void shell$
116 0     999                                              imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  11.25474                $ fill height of upper tank @ 2.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.11 Case 8490e7

```
NAA-SR-8490 benchmark model case 8490e7$
c$
c  derived from Figure 10 on p. 24$
c  31 fuel rods plus 6 luctie rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  $4.25 subcritical at 0.0-inches (empty) of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9                imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -----------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
c$
108 0             (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -----------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   6.17474                $ fill height of upper tank @ 0.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
```

```
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.12 Case 8490f

```
NAA-SR-8490 benchmark model case 8490f$
c$
c  derived from Figure 10 on p. 24$
c  32 fuel rods plus 5 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  critical at 5.2-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9                imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)               imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                 imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                               imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)           imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)              imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)             imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                              imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                              imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)             imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)          imp:n=1  $ spherical void shell$
116 0     999                                              imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  19.38274                $ fill height of upper tank @ 5.2 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.13 Case 8490g

```
NAA-SR-8490 benchmark model case 8490g$
c$
c  derived from Figure 10 on p. 24$
c  33 fuel rods plus 4 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  critical at 2.7-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  -23 7 -21 19                            imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  13.03274                $ fill height of upper tank @ 2.7 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.14 Case 8490h

```
NAA-SR-8490 benchmark model case 8490h$
c$
c  derived from Figure 10 on p. 24$
c  34 fuel rods plus 3 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  critical at 1.7-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  -23 7 -21 19                              imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  10.49274                $ fill height of upper tank @ 1.7 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.15 Case 8490h1

```
NAA-SR-8490 benchmark model case 8490h1$
c$
c  derived from Figure 10 on p. 24$
c  34 fuel rods plus 3 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  20 cents subcritical at 1.4-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
c ----- lucite rods -----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10              imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  -23 7 -21 19                              imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   9.73074                $ fill height of upper tank @ 1.4 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.16 Case 8490h2

```
NAA-SR-8490 benchmark model case 8490h2$
c$
c  derived from Figure 10 on p. 24$
c  34 fuel rods plus 3 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  $1.10 subcritical at 0.9-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  -23 7 -21 19                              imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   8.46074                $ fill height of upper tank @ 0.9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.17 Case 8490h3

```
NAA-SR-8490 benchmark model case 8490h3$
c$
c  derived from Figure 10 on p. 24$
c  34 fuel rods plus 3 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  $1.85 subcritical at 0.4-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  -23 7 -21 19                              imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   7.19074                $ fill height of upper tank @ 0.4 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.18 Case 8490h4

```
NAA-SR-8490 benchmark model case 8490h4$
c$
c  derived from Figure 10 on p. 24$
c  34 fuel rods plus 3 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  $2.35 subcritical at 0.0-inches (empty) of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
c$
108 0             (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   6.17474                $ fill height of upper tank @ 0.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506      $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
```

```
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.19 Case 8490i

```
NAA-SR-8490 benchmark model case 8490i$
c$
c  derived from Figure 10 on p. 24$
c  35 fuel rods plus 2 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  critical at 0.6-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
c ----- lucite rods -----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  -23 7 -21 19                            imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   7.69874                $ fill height of upper tank @ 0.6 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.20 Case 8490i1

```
NAA-SR-8490 benchmark model case 8490i1$
c$
c  derived from Figure 10 on p. 24$
c  35 fuel rods plus 2 lucite rods plus 6 Be inserts$
c  water reflected, but NO water in core$
c  $1.50 subcritical at 0.0-inches (empty) of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
c$
108 0             (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   6.17474                $ fill height of upper tank @ 0.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
```

```
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.21 Case 8490j

```
NAA-SR-8490 benchmark model case 8490j$
c$
c  derived from Figure 10 on p. 24$
c  36 fuel rods plus 1 lucite rod plus 6 Be inserts, as shown in Figure 15 on p. 27$
c  water reflected, but NO water in core$
c  critical at 0.1-inches of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
c ----- lucite rods -----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  -23 7 -21 19                              imp:n=1  $ water filled volume of upper
tank$
108 0             (-23 7 -14 21):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   6.42874                $ fill height of upper tank @ 0.1 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.22 Case 8490j1

```
NAA-SR-8490 benchmark model case 8490j1$
c$
c  derived from Figure 10 on p. 24$
c  36 fuel rods plus 1 lucite rod plus 6 Be inserts, as shown in Figure 15 on p. 27$
c  water reflected , but NO water in core$
c  50 cents subcritical at 0.0-inches (empty) of water in upper tank$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
c ----- lucite rods -----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
c$
108 0             (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   6.17474                $ fill height of upper tank @ 0.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
```

```
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.23 Case 8490k

```
NAA-SR-8490 benchmark model case 8490k$
c$
c  derived from Table III, configuration 4$
c  NO water in core, 5.2-inches of water in upper tank$
c  36 fuel rods plus 1 lucite rod plus 6 Be inserts$
c  critical ($0.00) measurement  $
c  lower 1/3 core surrounded by 0.50-inch thick sleeve of canned boron powder$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -----------------------------------$
```

```
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -----------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 3  0.0862393  (7 -79 77 -76)                            imp:n=1  $ wall of bc sleeve next to
vessel$
111 2  0.0250690  -80 79 -76 77                             imp:n=1  $ nat boron powder in sleeve$
112 3  0.0862393  (7 -81 76 -75):(-76 80 -81 77):&$
                  (7 -81 78 -77)             imp:n=1  $ ss304 of sleeve$
113 7  0.1001037  (-27 -15 25):(-27 81 -75 15):(-27 7 -20 75)  imp:n=1  $ water filled volume of
lower tank$
114 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
115 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
116 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
117 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -----------------------------------$
118 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
119 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  19.38274                $ fill height of upper tank @ 5.2 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
```

```
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces -----------------$
75  pz   -5.41274        $ top edge of sleeve$
76  pz   -5.49148        $ inside top edge of sleeve$
77  pz  -16.764          $ inside bottom edge of sleeve$
78  pz  -16.84274        $ bottom edge of sleeve$
79  cz   11.46429        $ inside surface of inner edge of sleeve$
80  cz   12.57681        $ inside surface of outer edge of sleeve$
81  cz   12.65555        $ outside surface of outer edge of sleeve$
c ----- tbd ----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
```

```
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.24 Case 8490k1

```
NAA-SR-8490 benchmark model case 8490k1$
c$
c  derived from Table III, configuration 3$
c  NO water in core, 9.0-inches (full) of water in upper tank$
c  36 fuel rods plus 1 lucite rod plus 6 Be inserts$
c  far subcritical measurement$
c  middle 1/3 core surrounded by 0.50-inch thick sleeve of canned boron powder$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c  QUALITATIVE USE ONLY$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
```

```
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 3  0.0862393  (7 -79 77 -76)                            imp:n=1  $ wall of bc sleeve next to
vessel$
111 2  0.0250690  -80 79 -76 77                             imp:n=1  $ nat powder in sleeve$
112 3  0.0862393  (7 -81 76 -75):(-76 80 -81 77):&$
                               (7 -81 78 -77)               imp:n=1  $ ss304 of sleeve   $
113 7  0.1001037  (-27 -15 25):(-27 7 -78 15):(-27 81 -20 78)  imp:n=1  $ water filled volume of
lower tank$
114 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
115 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
116 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
117 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
118 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
119 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
```

```
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
75  pz    6.01726        $ top edge of sleeve$
76  pz    5.93852        $ inside top edge of sleeve$
77  pz   -5.334          $ inside bottom edge of sleeve$
78  pz   -5.41274        $ bottom edge of sleeve$
79  cz   11.46429        $ inside surface of inner edge of sleeve$
80  cz   12.57681        $ inside surface of outer edge of sleeve$
81  cz   12.65555        $ outside surface of outer edge of sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
```

```
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.25 Case 8490l

```
NAA-SR-8490 benchmark model case 8490L$
c$
c  derived from Table III, configuration 5$
c  NO water in core, 5.0-inches of water in upper tank$
c  36 fuel rods plus 1 lucite rod plus 6 Be inserts$
c  critical ($0.00) measurement$
c  lower 1/3/core surrounded by 0.25-inch thick sleeve of canned boron powder$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ----------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ----------------------------------------------$
100 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd ------------------------------------$
```

```
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)             imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)               imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                             imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)         imp:n=1  $ ss316 upper tank walls$
110 3  0.0862393  (7 -79 77 -76)                         imp:n=1  $ wall of bc sleeve next to
vessel$
111 2  0.0250690  -80 79 -76 77                          imp:n=1  $ nat boron powder in sleeve$
112 3  0.0862393    (7 -81 76 -75):(-76 80 -81 77):&$
                                 (7 -81 78 -77)          imp:n=1  $ ss304 of sleeve$
113 7  0.1001037  (-27 -15 25):(-27 81 -75 15):(-27 7 -20 75)  imp:n=1  $ water filled volume of
lower tank$
114 9  0.0871549  (-28 -25 26):(-28 27 -20 25)           imp:n=1  $ ss316 lower tank walls$
115 7  0.1001037   -33 -29 30                            imp:n=1  $ water filled volume of
control cap tank$
116 6  0.0602626   -34 -31 29                            imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
117 9  0.0871549  (-34 -30 32):(-34 33 -29 30)           imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
118 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)        imp:n=1  $ spherical void shell$
119 0     999                                            imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  18.87474                $ fill height of upper tank @ 5.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
```

```
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
75  pz   -5.41274        $ top edge of sleeve$
76  pz   -5.49148        $ inside top edge of sleeve$
77  pz  -16.764          $ inside bottom edge of sleeve$
78  pz  -16.84274        $ bottom edge of sleeve$
79  cz   11.46429        $ inside surface of inner edge of sleeve$
80  cz   11.94181        $ inside surface of outer edge of sleeve$
81  cz   12.02055        $ outside surface of outer edge of sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
```

```
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.26 Case 8490l1

```
NAA-SR-8490 benchmark model case 8490L1$
c$
c  derived from Table III, configuration 2$
c  NO water in core, 9.0-inches (full) of water in upper tank$
c  36 fuel rods plus 1 lucite rod plus 6 Be inserts$
c  far subcritical measurement$
c  lower 2/3 core surrounded by 0.25-inch thick sleeve of canned boron powder$
c$
c  INDETERMINATE SUB_CRITICAL MARGIN$
c  QUALITATIVE USE ONLY$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
```

```
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank$
108 0             -23 -22 21                              imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 3  0.0862393  (7 -79 77 -76)                          imp:n=1  $ wall of bc sleeve next to
vessel$
111 2  0.0250690  -80 79 -76 77                           imp:n=1  $ nat boron powder in sleeve$
112 3  0.0862393  (7 -81 76 -75):(-76 80 -81 77):&$
                  (7 -81 78 -77)             imp:n=1  $ ss304 of sleeve$
113 7  0.1001037  (-27 -15 25):(-27 81 -75 15)            imp:n=1  $ water filled volume of lower
tank$
114 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
115 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
116 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
117 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
118 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
119 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
```

```
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces -----------------$
75  pz    6.01726       $ top edge of sleeve$
76  pz    5.93852       $ inside top edge of sleeve$
77  pz  -16.764         $ inside bottom edge of sleeve$
78  pz  -16.84274       $ bottom edge of sleeve$
79  cz   11.46429       $ inside surface of inner edge of sleeve$
80  cz   11.94181       $ inside surface of outer edge of sleeve$
81  cz   12.02055       $ outside surface of outer edge of sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
```

```
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.27 Case 8490l2

```
NAA-SR-8490 benchmark model case 8490L2$
c$
c  derived from Table III, configuration 6$
c  NO water in core, 9.0-inches (full) of water in upper tank$
c  36 fuel rods plus 1 lucite rod plus 6 Be inserts$
c  far subcritical measurement$
c  full length of core surrounded by 0.25-inch thick sleeve of canned boron powder$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c  QUALITATIVE USE ONLY$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
```

```
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 3  0.0862393  (7 -79 -82 83)                            imp:n=1  $ inside wall of sleeve$
108 2  0.0250690  -80 79 -82 83                             imp:n=1  $ nat boron powder in upper
sleeve$
109 3  0.0862393  (7 -81 -14 82):(7 -81 19 -83)&$
                  :(80 -81 -82 83)                          imp:n=1  $ ss304 of upper sleeve$
110 7  0.1001037  (-23 81 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
111 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
112 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
113 3  0.0862393  (7 -79 -76 77)                            imp:n=1  $ inside wall of sleeve$
114 2  0.0250690  -80 79 -76 77                             imp:n=1  $ nat boron powder in lower
sleeve$
115 3  0.0862393  (7 -81 78 -77):(7 -81 76 -75):&$
                  (80 -81 77 -76)                           imp:n=1  $ ss304 of lower sleeve$
116 7  0.1001037  (-27 -15 25):(-27 81 -75 15)              imp:n=1  $ water filled volume of lower
tank$
117 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
118 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
119 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
120 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
121 0    (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
       (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
122 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
```

```
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces -----------------$
75  pz    6.01726        $ top edge of lower sleeve$
76  pz    5.93852        $ inside top edge of lower sleeve$
77  pz  -16.764          $ inside bottom edge of lower sleeve$
78  pz  -16.84274        $ bottom edge of lower sleeve$
79  cz   11.46429        $ inside surface of inner edge of lower sleeve$
80  cz   11.94181        $ inside surface of outer edge of lower sleeve$
81  cz   12.02055        $ outside surface of outer edge of lower sleeve$
82  pz   17.84604        $ inside top edge of upper sleeve$
83  pz    6.25348        $ inside bottom edge of upper sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
```

```
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.28 Case 8490l3

```
NAA-SR-8490 benchmark model case 8490L3$
c$
c  derived from Table III, configuration 15$
c  water flooded core, 9.0-inches (full) of water in upper tank$
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  far subcritical measurement$
c  full length of core surrounded by 0.75-inch thick sleeve of borated aluminum $
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c  QUALITATIVE USE ONLY$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7 0.1001037     (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
```

```
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 12 0.0708762  -81 7 -14 19                              imp:n=1  $ binal of upper sleeve$
109 7  0.1001037  (-23 81 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
110 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
111 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
112 12 0.0708762   -81 7 -20 15                             imp:n=1  $ binal of lower sleeve$
113 7  0.1001037  (-27 -15 25):(-27 81 -20 15)              imp:n=1  $ water filled volume of lower
tank$
114 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
115 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
116 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
117 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
118 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
119 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
```

```
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
81  cz   13.29055        $ outside surface of sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
```

```
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
c --- borated aluminum @ 10.2 w/o boron as natB4C -----------$
m12   5010.60c 0.0030227 &$
      5011.60c 0.0121667 &$
      6000.60c 0.0037973 &$
     13027.60c 0.0518894$
c ---total=0.07087616$
print$
```

3.1.29 Case 8490l4

```
NAA-SR-8490 benchmark model case 8490L4$
c$
c  derived from Table III, configuration 16$
c  NO water in core, 9.0-inches (full) of water in upper tank$
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  far subcritical measurement$
c  full length of core surrounded by 0.75-inch thick sleeve of borated aluminum $
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c  QUALITATIVE USE ONLY$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
```

```
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
void filled$
104 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
void filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 12 0.0708762  -81 7 -14 19                              imp:n=1  $ binal of upper sleeve$
108 7  0.1001037  (-23 81 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
109 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
110 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
111 12 0.0708762   -81 7 -20 15                             imp:n=1  $ binal of lower sleeve$
112 7  0.1001037  (-27 -15 25):(-27 81 -20 15)              imp:n=1  $ water filled volume of lower
tank$
113 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
114 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
115 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
116 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
117 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
118 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
```

```
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
81  cz   13.29055        $ outside surface of sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
```

```
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
c --- borated aluminum @ 10.2 w/o boron as natB4C -----------$
m12   5010.60c 0.0030227 &$
      5011.60c 0.0121667 &$
      6000.60c 0.0037973 &$
     13027.60c 0.0518894$
c ---total=0.07087616$
print$
$
```

3.1.30 Case 8490l5

```
NAA-SR-8490 benchmark model case 8490L5$
c$
c  derived from Table III, configuration 14$
c  water flooded core, 9.0-inches (full) of water in upper tank $
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  subcritical measurement$
c  middle 1/3 core surrounded by 0.25-inch thick sleeve of borated aluminum $
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c  QUALITATIVE USE ONLY $
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7 0.1001037     (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
```

```
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
109 7  0.1001037  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
110 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
111 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
112 12 0.0708762   -81 7 -20 78                             imp:n=1  $ binal of lower sleeve$
113 7  0.1001037  (-27 -15 25):(-27 7 -78 15):(-27 81 -20 78)  imp:n=1  $ water filled volume of
lower tank$
114 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
115 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
116 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
117 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
118 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
119 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
```

```
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
78  pz   -5.41274        $ bottom edge of sleeve$
81  cz   12.02055        $ outside surface of sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
```

```
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
c --- borated aluminum @ 10.2 w/o boron as natB4C -----------$
m12   5010.60c 0.0030227 &$
      5011.60c 0.0121667 &$
      6000.60c 0.0037973 &$
     13027.60c 0.0518894$
c ---total=0.07087616$
print$
$
```

3.1.31 Case 8490m

```
NAA-SR-8490 benchmark model case 8490m$
c$
c  derived from Table III, configuration 7$
c  water flooded core, 0.0-inches (empty) of water in upper tank$
c  28 fuel rods plus 9 lucite rods plus 6 Be inserts$
c  critical ($0.15) measurement$
c  NO sleeve$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
29 like 37 but trcl  (-2.7716   1.6002  0)  imp:n=1  $ position 29$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd ------------------------------------$
```

```
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
c$
108 0             (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -22 18)                  imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 7  0.1001037  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz   6.17474                $ fill height of upper tank @ 0.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1  92235.60c 0.0014234 &$
    92238.60c 0.0001015 &$
    40000.60c 0.0352074 &$
     1001.60c 0.0640000$
mt1 zr/h.01t &$
    h/zr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
```

```
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.32 Case 8490n

```
NAA-SR-8490 benchmark model case 8490n$
c$
c  derived from Table III, configuration 8$
c  water flooded core, 9.0-inches (full) of water in upper tank$
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  critical ($0.02) measurement$
c  upper 1/3 core surrounded by 0.50-inch thick sleeve of canned boron powder$
c        plus$
c  lower 1/3 core surrounded by 0.25-inch thick sleeve of canned boron powder$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
```

```
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)               imp:n=1  $ type 1100 aluminum cover
plate$
107 3  0.0862393  (7 -84 -82 83)                            imp:n=1  $ inside wall of sleeve$
108 2  0.0250690  -85 84 -82 83                             imp:n=1  $ nat boron powder in upper
sleeve$
109 3  0.0862393  (7 -86 19 -83):(7 -86 82 -14):&$
                  (83 -82 85 -86)                           imp:n=1  $ ss304 of upper sleeve$
110 7  0.1001037  (-23 86 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
111 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
112 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
113 3  0.0862393  ( 7 -79 77 -76)                           imp:n=1  $ inside wall of sleeve$
114 2  0.0250690  -80 79 -76 77                             imp:n=1  $ nat boron powder in lower
sleeve$
115 3  0.0862393  (7 -81 78 -77):(7 -81 76 -75):&$
                  (80 -81 77 -76)                           imp:n=1  $ ss304 of lower sleeve$
116 7  0.1001037  (-27 -15 25):(-27 81 -75 15):(-27 7 -20 75)  imp:n=1  $ water filled volume of
lower tank$
117 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
118 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
119 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
120 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
121 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
122 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
```

```
30  pz -33.76422               $ top of bottom plate for control cap tank$
31  pz -18.36674               $ top of top plate for control cap tank$
32  pz -33.9217                $ bottom of bottom plate for control cap tank$
33  cz  19.64055               $ IR of control cap tank$
34  cz  19.79803               $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
75  pz   -5.41274        $ top edge of lower sleeve$
76  pz   -5.49148        $ inside top edge of lower sleeve$
77  pz  -16.764          $ inside bottom edge of lower sleeve$
78  pz  -16.84274        $ bottom edge of lower sleeve$
79  cz   11.46429        $ inside surface of inner edge of lower sleeve$
80  cz   11.94181        $ inside surface of outer edge of lower sleeve$
81  cz   12.02055        $ outside surface of outer edge of lower sleeve$
82  pz   17.84604        $ inside top edge of upper sleeve$
83  pz    6.25348        $ inside bottom edge of upper sleeve$
84  cz   11.46429        $ inside surface of inner edge of upper sleeve$
85  cz   12.57681        $ inside surface of outer edge of upper sleeve$
86  cz   12.65555        $ outside surface of outer edge of upper sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
```

```
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.33 Case 8490n1

```
NAA-SR-8490 benchmark model case 8490n1$
c$
c  derived from Table III, configuration 9$
c  water flooded core, 9.0-inches (full) of water in upper tank$
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  far subcritical measurement$
c  full length of core surrounded by 0.50-inch thick sleeve canned boron powder $
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c  QUALITATIVE USE ONLY$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
```

```
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)               imp:n=1  $ type 1100 aluminum cover
plate$
107 3  0.0862393  (7 -79 -82 83)                           imp:n=1  $ inside wall of sleeve$
108 2  0.0250690  -80 79 -82 83                            imp:n=1  $ nat boron powder in upper
sleeve$
109 3  0.0862393  (7 -81 19 -83):(7 -81 82 -14):&$
                  (83 -82 80 -81)                          imp:n=1  $ ss304 of upper sleeve$
110 7  0.1001037  (-23 81 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                 imp:n=1  $ water filled volume of upper
tank$
111 0             -23 -22 21                               imp:n=1  $ void filled volume of upper
tank$
112 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)           imp:n=1  $ ss316 upper tank walls$
113 3  0.0862393  (7 -79 77 -76)                           imp:n=1  $ inside wall of sleeve$
114 2  0.0250690  -80 79 -76 77                            imp:n=1  $ nat boron powder in lower
sleeve$
115 3  0.0862393  (7 -81 78 -77):(7 -81 76 -75):&$
                  (80 -81 77 -76)                          imp:n=1  $ ss304 of lower sleeve$
116 7  0.1001037  (-27 -15 25):(-27 81 -75 15)             imp:n=1  $ water filled volume of lower
tank$
117 9  0.0871549  (-28 -25 26):(-28 27 -20 25)             imp:n=1  $ ss316 lower tank walls$
118 7  0.1001037   -33 -29 30                              imp:n=1  $ water filled volume of
control cap tank$
119 6  0.0602626   -34 -31 29                              imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
120 9  0.0871549  (-34 -30 32):(-34 33 -29 30)             imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
121 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)          imp:n=1  $ spherical void shell$
122 0     999                                              imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
```

```
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces -----------------$
75  pz    6.01726        $ top edge of lower sleeve$
76  pz    5.93852        $ inside top edge of lower sleeve$
77  pz  -16.764          $ inside bottom edge of lower sleeve$
78  pz  -16.84274        $ bottom edge of lower sleeve$
79  cz   11.46429        $ inside surface of inner edge of lower sleeve$
80  cz   12.57681        $ inside surface of outer edge of lower sleeve$
81  cz   12.65555        $ outside surface of outer edge of lower sleeve$
82  pz   17.84604        $ inside top edge of upper sleeve$
83  pz    6.25348        $ inside bottom edge of upper sleeve$
c ----- tbd ----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
```

```
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
print$
$
```

3.1.34 Case 8490o

```
NAA-SR-8490 benchmark model case 8490o$
c$
c  derived from Table III, configuration 10$
c  water flooded core, 9.0-inches (full) water in upper tank$
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  critical ($0.02) measurement$
c  upper 1/3 core surrounded by 0.50-inch thick sleeve of canned boron powder$
c        plus$
c  lower 1/3 core surrounded by 0.25-inch thick sleeve of borated aluminum$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9                imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ----------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ----------------------------------------------$
100 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
```

```
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 3  0.0862393  (7 -84 -82 83)                            imp:n=1  $ inside wall of sleeve$
108 2  0.0250690  -85 84 -82 83                             imp:n=1  $ nat boron powder in upper
sleeve$
109 3  0.0862393  (7 -86 19 -83):(7 -86 82 -14):&$
                  (85 -86 83 -82)                           imp:n=1  $ ss304 of upper sleeve$
110 7  0.1001037  (-23 86 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
111 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
112 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
113 12 0.0708762   -81 7 -75 78                             imp:n=1  $ binal of lower sleeve$
114 7  0.1001037  (-27 -15 25):(-27 81 -75 15):(-27 7 -20 75)  imp:n=1  $ water filled volume of
lower tank$
115 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
116 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
117 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
118 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
119 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
120 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
```

```
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces -----------------$
75  pz   -5.41274       $ top edge of lower sleeve$
78  pz  -16.84274       $ bottom edge of lower sleeve$
81  cz   12.02055       $ outside surface of outer edge of lower sleeve$
82  pz   17.84604       $ inside top edge of upper sleeve$
83  pz    6.25348       $ inside bottom edge of upper sleeve$
84  cz   11.46429       $ inside surface of inner edge of upper sleeve$
85  cz   12.57681       $ inside surface of outer edge of upper sleeve$
86  cz   12.65555       $ outside surface of outer edge of upper sleeve$
c ----- tbd ----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
```

```
     28061.60c 0.0000872 &$
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$
m12   5010.60c 0.0030227 &$
      5011.60c 0.0121667 &$
      6000.60c 0.0037973 &$
     13027.60c 0.0518894$
c ---total=0.07087616$
print$
$
```

3.1.35 Case 8490p

```
NAA-SR-8490 benchmark model case 8490p$
c$
c  derived from Table III, configuration 11$
c  water flooded core, 9.0-inches (full) of water in upper tank$
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  critical (-$0.21) measurement$
c  upper 1/3 core surrounded by 0.50-inch thick sleeve of canned boron powder$
c        plus$
c  lower 1/3 core surrounded by 0.50-inch thick sleeve of borated aluminum$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
```

```
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 3  0.0862393  (7 -84 -82 83)                            imp:n=1  $ inside wall of sleeve$
108 2  0.0250690  -85 84 -82 83                             imp:n=1  $ nat boron powder in upper
sleeve$
109 3  0.0862393  (7 -86 19 -83):(7 -86 82 -14):&$
                  (85 -86 83 -82)                           imp:n=1  $ ss304 of upper sleeve$
110 7  0.1001037  (-23 86 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank$
111 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
112 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
113 12 0.0708762   -81 7 -75 78                             imp:n=1  $ binal of lower sleeve$
114 7  0.1001037  (-27 -15 25):(-27 81 -75 15):(-27 7 -20 75)  imp:n=1  $ water filled volume of
lower tank$
115 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
116 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
117 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
118 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
119 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)          imp:n=1  $ spherical void shell$
120 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
```

```
34  cz  19.79803                $ OR of control cap tank$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
75  pz   -5.41274        $ top edge of lower sleeve$
78  pz  -16.84274        $ bottom edge of lower sleeve$
81  cz   12.65555        $ outside surface of outer edge of lower sleeve$
82  pz   17.84604        $ inside top edge of upper sleeve$
83  pz    6.25348        $ inside bottom edge of upper sleeve$
84  cz   11.46429        $ inside surface of inner edge of upper sleeve$
85  cz   12.57681        $ inside surface of outer edge of upper sleeve$
86  cz   12.65555        $ outside surface of outer edge of upper sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 ------------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
```

```
     28061.60c 0.0000872 &$
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$
m12   5010.60c 0.0030227 &$
      5011.60c 0.0121667 &$
      6000.60c 0.0037973 &$
     13027.60c 0.0518894$
c ---total=0.07087616$
print$
$
```

3.1.36 Case 8490q

```
NAA-SR-8490 benchmark model case 8490q$
c$
c  derived from Table III, configuration 12$
c  water flooded core, 9.0-inches (full) of water in upper tank$
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  critical (-$0.31) measurement$
c  upper 1/3 core surrounded by 0.50-inch thick sleeve of canned boron powder$
c        plus$
c  lower 1/3 core surrounded by 0.75-inch thick sleeve of borated aluminum $
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
```

```
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)             imp:n=1  $ type 1100 aluminum cover
plate$
107 3  0.0862393  (7 -84 -82 83)                         imp:n=1  $ inside wall of sleeve$
108 2  0.0250690  -85 84 -82 83                          imp:n=1  $ nat boron of upper sleeve$
109 3  0.0862393  (7 -86 19 -83):(7 -86 82 -14):&$
                  (85 -86 83 -82)                        imp:n=1  $ ss304 of upper sleeve$
110 7  0.1001037  (-23 86 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)               imp:n=1  $ water filled volume of upper
tank$
111 0             -23 -22 21                             imp:n=1  $ void filled volume of upper
tank$
112 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)         imp:n=1  $ ss316 upper tank walls$
113 12 0.0708762   -81 7 -75 78                          imp:n=1  $ binal of lower sleeve$
114 7  0.1001037  (-27 -15 25):(-27 81 -75 15):(-27 7 -20 75)  imp:n=1  $ water filled volume of
lower tank$
115 9  0.0871549  (-28 -25 26):(-28 27 -20 25)           imp:n=1  $ ss316 lower tank walls$
116 7  0.1001037   -33 -29 30                            imp:n=1  $ water filled volume of
control cap tank$
117 6  0.0602626   -34 -31 29                            imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
118 9  0.0871549  (-34 -30 32):(-34 33 -29 30)           imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
119 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)        imp:n=1  $ spherical void shell$
120 0     999                                            imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
```

```
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
75  pz   -5.41274       $ top edge of lower sleeve$
78  pz  -16.84274       $ bottom edge of lower sleeve$
81  cz   13.29055       $ outside surface of outer edge of lower sleeve$
82  pz   17.84604       $ inside top edge of upper sleeve$
83  pz    6.25348       $ inside bottom edge of upper sleeve$
84  cz   11.46429       $ inside surface of inner edge of upper sleeve$
85  cz   12.57681       $ inside surface of outer edge of upper sleeve$
86  cz   12.65555       $ outside surface of outer edge of upper sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
```

```
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
c --- borated aluminum @ 10.2 w/o boron as natB4C -----------$
m12   5010.60c 0.0030227 &$
      5011.60c 0.0121667 &$
      6000.60c 0.0037973 &$
     13027.60c 0.0518894$
c ---total=0.07087616$
print$
$
```

3.1.37 Case 8490r

```
NAA-SR-8490 benchmark model case 8490r$
c$
c  derived from Table III, configuration 13$
c  water flooded core, 9.0-inches (full) of water in upper tank$
c  29 fuel rods plus 8 lucite rods plus 6 Be inserts$
c  upper 1/3 core surrounded by 0.50-inch thick sleeve of canned boron powder$
c        plus$
c  lower 1/3 core surrounded by 1.00-inch thick sleeve of borated aluminum$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
c ----- lucite rods ----------------------------$
37  10 0.1064672     -35 -8 9               imp:n=1  $ position 37$
36 like 37 but trcl  (-2.7716  -1.6002  0)  imp:n=1  $ position 36$
35 like 37 but trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 35$
34 like 37 but trcl (-16.6298   0.0     0)  imp:n=1  $ position 34$
33 like 37 but trcl (-13.8581  -1.6002  0)  imp:n=1  $ position 33$
32 like 37 but trcl (-11.0865  -3.2004  0)  imp:n=1  $ position 32$
31 like 37 but trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 31$
30 like 37 but trcl   (0.0      3.2004  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1  0.1007323   -1 -2 3    u=1   imp:n=1  $ UZrHx fuel$
51 5  0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8  0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - water filled$
```

```
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 7  0.1001037     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
water filled$
104 7  0.1001037     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
water filled$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 3  0.0862393  (7 -84 -82 83)                          imp:n=1  $ inside wall of sleeve$
108 2  0.0250690  -85 84 -82 83                           imp:n=1  $ nat boron powder in upper
sleeve$
109 3  0.0862393  (7 -86 19 -83):(7 -86 82 -14):&$
                  (85 -86 83 -82)                         imp:n=1  $ ss304 of upper sleeve$
110 7  0.1001037  (-23 86 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank$
111 0             -23 -22 21                              imp:n=1  $ void filled volume of upper
tank$
112 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
113 12 0.0708762   -81 7 -75 78                           imp:n=1  $ binal of lower sleeve$
114 7  0.1001037  (-27 -15 25):(-27 81 -75 15):(-27 7 -20 75)  imp:n=1  $ water filled volume of
lower tank$
115 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
116 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
117 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
118 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
119 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
120 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9.0 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
```

```
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- begin sleeve surfaces ------------------$
75  pz   -5.41274       $ top edge of lower sleeve$
78  pz  -16.84274       $ bottom edge of lower sleeve$
81  cz   13.92555       $ outside surface of outer edge of lower sleeve$
82  pz   17.84604       $ inside top edge of upper sleeve$
83  pz    6.25348       $ inside bottom edge of upper sleeve$
84  cz   11.46429       $ inside surface of inner edge of upper sleeve$
85  cz   12.57681       $ inside surface of outer edge of upper sleeve$
86  cz   12.65555       $ outside surface of outer edge of upper sleeve$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- nat boron powder ----$
m2    5010.60c 0.0049887 &$
      5011.60c 0.0200803$
c --- ss304 -----------$
m3   26054.60c 0.0035020 &$
     26056.60c 0.0544408 &$
     26057.60c 0.0012465 &$
     26058.60c 0.0001662 &$
     24050.60c 0.0007573 &$
     24052.60c 0.0146033 &$
     24053.60c 0.0016557 &$
     24054.60c 0.0004122 &$
     28058.60c 0.0052698 &$
     28060.60c 0.0020147 &$
     28061.60c 0.0000872 &$
```

```
     28062.60c 0.0002771 &$
     28064.60c 0.0000702 &$
     25055.60c 0.0017363$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10  poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11    be.01t$
c --- borated aluminum @ 10.2 w/o boron as natB4C -----------$
m12   5010.60c 0.0030227 &$
      5011.60c 0.0121667 &$
      6000.60c 0.0037973 &$
     13027.60c 0.0518894$
c ---total=0.07087616$
print$
$
```

3.1.38 Case 8490s1

```
NAA-SR-8490 benchmark model case 8490s1$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borated water$
c  2.00 kg ammonium pentaborate in 39 gal of water$
c  32 fuel rods plus 6 Be inserts (no lucite rods)$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 2  0.1001409   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 2  0.1001409     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
borated water$
```

```
104 2  0.1001409     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
borated water$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)               imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001409  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                 imp:n=1  $ water filled volume of upper
tank - borated water$
108 0              -23 -22 21                              imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)           imp:n=1  $ ss316 upper tank walls$
110 2  0.1001409  (-27 7 -20 15):(-27 -15 25)              imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)             imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                              imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                              imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)             imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)          imp:n=1  $ spherical void shell$
116 0     999                                              imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
```

```
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd ----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 2.00 kg borate in 39 gal of water ----$
m2    1001.60c 0.0665233 &$
      5010.60c 0.0000295 &$
      5011.60c 0.0001188 &$
      7014.60c 0.0000297 &$
      8016.60c 0.0334396$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
```

```
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.39 Case 8490s2

```
NAA-SR-8490 benchmark model case 8490s2$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borated water$
c  2.00 kg ammonium pentaborate in 39 gal of water$
c  ordinary water in control cap$
c  31 fuel rods plus 6 Be inserts (no lucite rods)$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1                imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 2  0.1001409   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 2  0.1001409     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
borated water$
```

```
104 2  0.1001409     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
borated water$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001409  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank - borated water$
108 0              -23 -22 21                               imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 2  0.1001409  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
```

```
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd ----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 2.00 kg borate in 39 gal of water ----$
m2    1001.60c 0.0665233 &$
      5010.60c 0.0000295 &$
      5011.60c 0.0001188 &$
      7014.60c 0.0000297 &$
      8016.60c 0.0334396$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
```

```
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.40 Case 8490s3

```
NAA-SR-8490 benchmark model case 8490s3$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borated water$
c  2.00 kg ammonium pentaborate in 39 gal of water$
c  ordinary water in control cap$
c  30 fuel rods plus 6 Be inserts (no lucite rods)$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 2  0.1001409   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 2  0.1001409     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
borated water$
104 2  0.1001409     -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
borated water$
```

```
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001409  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank - borated water$
108 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 2  0.1001409  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
```

```
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352103 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 2.00 kg borate in 39 gal of water ----$
m2    1001.60c 0.0665233 &$
      5010.60c 0.0000295 &$
      5011.60c 0.0001188 &$
      7014.60c 0.0000297 &$
      8016.60c 0.0334396$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
```

```
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.41 Case 8490t

```
NAA-SR-8490 benchmark model case 8490t$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borate water$
c  3.24 kg ammonium pentaborate in 39 gal of water$
c  ordinary water in control cap$
c  35 fuel rods plus 6 Be inserts (no lucite rods)$
c  critical ($0.15) measurement$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ----------------------------------------------$
50 1   0.1007323      -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232    -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3     u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ----------------------------------------------$
100 2  0.1001638   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
```

```
103 2  0.1001638     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
borated water$
104 2  0.1001638     -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
borated water$
c ----- tbd -----------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001638  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank - borated water$
108 0             -23 -22 21                                imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 2  0.1001638  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -----------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
```

```
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 3.24 kg borate in 39 gal of water ----$
m2    1001.60c 0.0663936 &$
      5010.60c 0.0000475 &$
      5011.60c 0.0001914 &$
      7014.60c 0.0000478 &$
      8016.60c 0.0334835$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
```

```
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.42 Case 8490t1

```
NAA-SR-8490 benchamrk model case 8490t1$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borated water$
c  3.24 kg ammonium pentaborate in 39 gal of water$
c  ordinary water in control cap$
c  33 fuel rods plus 6 Be inserts (no lucite rods)$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ----------------------------------------------$
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ----------------------------------------------$
100 2  0.1001638   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd -------------------------------------$
101 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
```

```
103 2  0.1001638     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
borated water$
104 2  0.1001638     -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
borated water$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001638  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank - borated water$
108 0              -23 -22 21                             imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 2  0.1001638  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
```

```
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 3.24 kg borate in 39 gal of water ----$
m2    1001.60c 0.0663936 &$
      5010.60c 0.0000475 &$
      5011.60c 0.0001914 &$
      7014.60c 0.0000478 &$
      8016.60c 0.0334835$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
```

```
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.43 Case 8490t2

```
NAA-SR-8490 benchmark model case 8490t2$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borated water$
c  3.24 kg ammonium pentaborate in 39 gal of water$
c  ordinary water in control cap$
c  32 fuel rods plus 6 Be inserts (no lucite rods)$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 2  0.1001638   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd ------------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 2  0.1001638     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
borated water$
```

```
104 2  0.1001638     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
borated water$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001638  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank - borated water$
108 0              -23 -22 21                             imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 2  0.1001638  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
```

```
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 3.24 kg borate in 39 gal of water ----$
m2    1001.60c 0.0663936 &$
      5010.60c 0.0000475 &$
      5011.60c 0.0001914 &$
      7014.60c 0.0000478 &$
      8016.60c 0.0334835$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
```

```
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.44 Case 8490u

```
NAA-SR-8490 benchmark model case 8490u$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borated water$
c  4.54 kg ammonium pentaborate in 39 gal of water$
c  ordinary water in control cap$
c  37 fuel rods (full core) plus 6 Be inserts$
c  crtical (1/M=0) measurement$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
37 like 1 but trcl    (8.3149 -14.4018  0)  imp:n=1  $ position 37$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ----------------------------------------------$
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ----------------------------------------------$
100 2  0.1001866   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd -------------------------------------$
```

```
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 2  0.1001866     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
borated water$
104 2  0.1001866     -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
borated water$
c ----- tbd ------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001866  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                  imp:n=1  $ water filled volume of upper
tank - borated water$
108 0               -23 -22 21                              imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)            imp:n=1  $ ss316 upper tank walls$
110 2  0.1001866  (-27 7 -20 15):(-27 -15 25)               imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)              imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                               imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                               imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)              imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd ------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)           imp:n=1  $ spherical void shell$
116 0     999                                               imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 4.54 kg borate in 39 gal of water ----$
m2    1001.60c 0.0662583 &$
      5010.60c 0.0000663 &$
      5011.60c 0.0002667 &$
      7014.60c 0.0000666 &$
      8016.60c 0.0335287$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
```

```
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.45 Case 8490u1

```
NAA-SR-8490 benchmark model case 8490u1$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borated water$
c  4.54 kg ammonium pentaborate in 39 gal of water$
c  ordinary water in control cap$
c  36 fuel rods plus 6 Be inserts (no lucite rods)$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
36 like 1 but trcl    (5.5432 -16.0020  0)  imp:n=1  $ position 36$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 2  0.1001866   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36  &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd -----------------------------------$
```

```
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
102 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
103 2  0.1001866     -6  10 -12               imp:n=1  $ vessel interior above upper gridplate -
borated water$
104 2  0.1001866     -6 -11  13               imp:n=1  $ vessel interior above upper gridplate -
borated water$
c ----- tbd -----------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001866  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)                imp:n=1  $ water filled volume of upper
tank - borated water$
108 0              -23 -22 21                             imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)          imp:n=1  $ ss316 upper tank walls$
110 2  0.1001866  (-27 7 -20 15):(-27 -15 25)             imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)            imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                             imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                             imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)            imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -----------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)         imp:n=1  $ spherical void shell$
116 0     999                                             imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx ------------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 4.54 kg borate in 39 gal of water ----$
m2    1001.60c 0.0662583 &$
      5010.60c 0.0000663 &$
      5011.60c 0.0002667 &$
      7014.60c 0.0000666 &$
      8016.60c 0.0335287$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
```

```
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.1.46 Case 8490u2

```
NAA-SR-8490 benchmark model case 8490u2$
c$
c  derived from Figure 20 on p.34$
c  core vessel flooded and reflected with borate water$
c  4.54 kg ammonium pentaborate in 39 gal of water$
c  ordinary water in control cap$
c  35 fuel rods plus 6 Be inserts (no lucite rods)$
c$
c  INDETERMINATE SUB-CRITICAL MARGIN$
c$
c  model setup by a.w. krass$
c$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=1               imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
33 like 1 but trcl   (-5.5432 -16.0020  0)  imp:n=1  $ position 33$
34 like 1 but trcl   (-8.3149 -14.4018  0)  imp:n=1  $ position 34$
35 like 1 but trcl    (2.7716 -17.6022  0)  imp:n=1  $ position 35$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ---------------------------------------------$
50 1   0.1007323     -1 -2 3  u=1   imp:n=1  $ UZrHx fuel$
51 5   0.0254232   -4 1 -2 3  u=1   imp:n=1  $ radial rod surface coating$
52 8   0.0872946    4:2:-3    u=1   imp:n=1  $ Hastelloy N fuel element tubing/caps$
c ---------------------------------------------$
100 2  0.1001866   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 &$
         #41 #42 #43 #44 #45 #46      imp:n=1  $ vessel interior between elements - borated water$
c ----- tbd -----------------------------------$
101 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
```

```
102 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
103 2  0.1001866     -6  10 -12                imp:n=1  $ vessel interior above upper gridplate -
borated water$
104 2  0.1001866     -6 -11  13                imp:n=1  $ vessel interior above upper gridplate -
borated water$
c ----- tbd -------------------------------------$
105 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
106 6  0.0602626  (-6 -17 12):(-16 6 -18 12)             imp:n=1  $ type 1100 aluminum cover
plate$
107 2  0.1001866  (-23 7 -14 19):(-23 16 -18 14): &$
                  (-6 -18 17):(-23 -21 18)               imp:n=1  $ water filled volume of upper
tank - borated water$
108 0             -23 -22 21                            imp:n=1  $ void filled volume of upper
tank$
109 9  0.0871549  (-24 7 -19 20):(-24 23 -22 19)         imp:n=1  $ ss316 upper tank walls$
110 2  0.1001866  (-27 7 -20 15):(-27 -15 25)            imp:n=1  $ water filled volume of lower
tank - borated water$
111 9  0.0871549  (-28 -25 26):(-28 27 -20 25)           imp:n=1  $ ss316 lower tank walls$
112 7  0.1001037   -33 -29 30                           imp:n=1  $ water filled volume of
control cap tank$
113 6  0.0602626   -34 -31 29                           imp:n=1  $ type 1100 aluminum top plate
for control cap tank$
114 9  0.0871549  (-34 -30 32):(-34 33 -29 30)           imp:n=1  $ ss316 control cap tank
walls$
c ----- tbd -------------------------------------$
115 0   (-999 22):(-999 24 -22 20):(-999 28 -20 26): &$
        (-999 -26 31):(-999 34 -31 32):(-999 -32)        imp:n=1  $ spherical void shell$
116 0     999                                           imp:n=0  $ rest of the universe$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod$
2   pz  15.52575                $ top end of fuel rod$
3   pz -15.52575                $ bottom end of fuel rod$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube $
6   cz  11.303                  $ IR of rx vessel$
7   cz  11.38555                $ OR of rx vessel $
8   pz  15.8115                 $ bottom of upper grid plate$
9   pz -15.8115                 $ top of lower grid plate $
10  pz  16.764                  $ top of upper grid plate$
11  pz -16.60652                $ bottom of lower grid plate$
12  pz  18.08226                $ vessel cover/flange interface$
13  pz -16.764                  $ top of vessel bottom$
14  pz  17.92478                $ bottom of vessel flange$
15  pz -16.84274                $ bottom of vessel bottom$
16  cz  16.46555                $ OR of vessel flange$
17  pz  18.161                  $ top of cover plate indent $
18  pz  18.71726                $ top of cover plate flange $
19  pz   6.17474                $ top of bottom plate for upper tank$
20  pz   6.01726                $ bottom of bottom plate for upper tank$
21  pz  29.03474                $ fill height of upper tank @ 9 inches$
22  pz  31.57474                $ top edge of upper tank$
23  cz  26.62555                $ IR of upper tank$
24  cz  26.78303                $ OR of upper tank$
25  pz -17.95526                $ top of bottom plate for lower tank$
26  pz -18.11274                $ bottom of bottom plate for lower tank$
27  cz  27.89555                $ IR of lower tank$
28  cz  28.05303                $ OR of lower tank$
29  pz -18.52422                $ bottom of top plate for control cap tank$
30  pz -33.76422                $ top of bottom plate for control cap tank$
31  pz -18.36674                $ top of top plate for control cap tank$
32  pz -33.9217                 $ bottom of bottom plate for control cap tank$
33  cz  19.64055                $ IR of control cap tank$
34  cz  19.79803                $ OR of control cap tank$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd -----------------------------------$
999 so  50    $
$
mode  n$
c ------npg----k----nsk---gen----$
kcode  1000   1.0  1000  3000$
ksrc    0  9.6012  0$
c --- uzrhx -----------$
m1   92235.60c 0.0014234 &$
     92238.60c 0.0001015 &$
     40000.60c 0.0352074 &$
      1001.60c 0.0640000$
mt1   zr/h.01t &$
      h/zr.01t$
c --- 4.54 kg borate in 39 gal of water ----$
m2    1001.60c 0.0662583 &$
      5010.60c 0.0000663 &$
      5011.60c 0.0002667 &$
      7014.60c 0.0000666 &$
      8016.60c 0.0335287$
mt2   lwtr.01t$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 & $
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
```

```
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
print$
$
```

3.2 Phase III Experiments MCNP5 Input Files

3.2.1 Case fig12

```
NAA-SR-9871, Fig 12$
c Feb 24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described in Figure 12, NAA-SR-9871$
c This case uses SCA-4 fuel, with 26 fuel elements, full reflection/$
c dry core, with the external reflector as shown in Fig12. $
c The tank configuration used is that shown in$
c Fig 49, of 9871.  The water in the reflector is 9.5" above fuel bottom.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                     imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=2    trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=2    trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=2    trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=2    trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=2    trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=2    trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=2    trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=2    trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=2    trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=2    trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rods ------------------$
98 10 0.1064672  -4 -2 3   u=2   imp:n=1   $  lucite rod$
99 10 0.1064672  4:2:-3    u=2   imp:n=1   $  lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
```

```
c ---------                     $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
```

```
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
```

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210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------------------------------------------------$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements - void filled$
401 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
402 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
403 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate$
404 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$
c ----- tbd ------------------------------------$
405 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
406 6  0.0602626  (-6 -17 12):(-16 6 -18 12)                imp:n=1  $ aluminum cover plate$
c ----- Main block of the extrnal reflector:$
407 11 0.1216164 (7 -301 302 -300 303 -20 502 208 202 211 205) imp:n=1 $external Be reflector$
408 11 0.1216164 (7 -301 302 -300 303 -503 20 208 202 211 205) imp:n=1 $external Be reflector$
409 11 0.1216164 (7 -504 500 -503 -202) imp:n=1$
410 11 0.1216164 (7 -504 500 -503 -205) imp:n=1$
411 11 0.1216164 (7 -504 500 -503 -208) imp:n=1$
412 11 0.1216164 (7 -504 500 -503 -211) imp:n=1 $ledge of Be ref. to support drums$
413 11 0.1216164 (7 -504 502 -501 -202) imp:n=1$
414 11 0.1216164 (7 -504 502 -501 -205) imp:n=1$
415 11 0.1216164 (7 -504 502 -501 -208) imp:n=1$
416 11 0.1216164 (7 -504 502 -501 -211) imp:n=1  $ledge of Be ref. to support drums$
c ----- Steel drive shafts and water-filled interiors:$
420 9  0.0871549 (501 -506 -200)     imp:n=1             $drive shaft$
422 9  0.0871549 (-505 506 -201)    imp:n=1             $drive shaft$
c$
423 9  0.0871549 (501 -506 -203)     imp:n=1             $drive shaft$
425 9  0.0871549 (-505 506 -204)    imp:n=1             $drive shaft$
c$
426 9  0.0871549 (501 -506 -206)     imp:n=1             $drive shaft$
428 9  0.0871549 (-505 506 -207)    imp:n=1             $drive shaft$
c$
429 9  0.0871549 (501 -506 -209)     imp:n=1             $drive shaft$
431 9  0.0871549 (-505 506 -210)    imp:n=1             $drive shaft$
c$
c ---- Control Drums:$
440 11 0.1216164  (401 -205 501 -20 204) imp:n=1                       $control drum$
441 11 0.1216164  (-202 -403 501 -20 201) imp:n=1                      $control drum$
442 11 0.1216164  (-208 -403 501 -20 207) imp:n=1                      $control drum$
443 11 0.1216164  (-211 401 501 -20  210) imp:n=1                      $control drum$
c$
444 11 0.1216164  (401 -205 20 -500 204) imp:n=1                       $control drum$
445 11 0.1216164  (-202 -403 20 -500 201) imp:n=1                      $control drum$
446 11 0.1216164  (-208 -403 20 -500 207) imp:n=1                      $control drum$
447 11 0.1216164  (-211 401 20 -500 210) imp:n=1                       $control drum$
c -----bottom tank: $
460 7  0.1001037  (29 -15 -27  ) imp:n=1      $ water volume below the RX vessel$
461 7  0.1001037  (7 -27 -502 15) imp:n=1     $ water below reflector main block$
c 462 7  0.1001037  (504 -27 502 -501) imp:n=1  $ water outside bottom ledge of main block$
463 7  0.1001037  (7 -27 502 -20) &           $
                  #407 &$
                  #413 #414 #415 #416 &$
                  #440 #441 #442 #443 &       $ water around the core except the control drums$
                  #420 #422 &                 $ and the drive shafts$
                  #423 #425 &     $
                  #426 #428 &$
                  #429 #431  imp:n=1$
464 0           (20 -503 -27 7)  &$
                #408&                         $ void above the water in the lower tank$
                #409 #410 #411 #412 &$
                #444 #445 #446 #447   &       $ around the control drums$
                  imp:n=1 $
466 0 (-19 503 -27 7) imp:n=1           $void outside the top ledge of the reflector main block$
467 0 (19 -31 24 -27) imp:n=1           $void above the water in the lower tank$
c$
470 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
471 0              -27 25 -30                   imp:n=1  $ void at the bottom of lower tank$
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472 9 0.0871549   -29 30 -27                    imp:n=1  $ steel plate in lower tank above void$
473 0             31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank$
c -------top tank$
481 9  0.0871549  (-14 19 7 -24):(-24 23 19 -22) imp:n=1 $upper tanks wall$
482 7 0.1001037    (14 -18 16 -23):&$
    (17 -18 -6):(18 -36 -23) imp:n=1                 $water  inside top tank$
483 0           (-23 36 -22)  imp:n=1                $ void over the water in top tank$
c$
c ----- tbd -----------------------------------$
500 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1 $
501 0 999  imp:n=0$
$
1 c/z  0.0  9.6012   1.53924    $ radius of fuel rod = (2.54)(1.212/2)$
2 pz  15.52575                  $ top of the active fuel region= (2.54)(12.225/2)$
3 pz -15.52575                  $ bottom of active fuel region$
4 c/z  0.0  9.6012   1.5621     $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5 c/z  0.0  9.6012   1.5875     $ OR of fuel element tube=(1.25/2)(2.54)$
6 cz  11.27125                  $ IR of rx vessel=(8.875/2)(2.54)$
7 cz  11.34999                  $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8 pz  15.8115                   $ top of the fuel element=(12.45/2)(2.54)$
9 pz -15.8115                   $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -16.71357                $ top of vessel bottom:-16.79231+(2.54)(.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -16.79231                $ bottom of vessel bottom=16.54429-(2.54)(13.125)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent$
18  pz  17.49425                $ top of cover plate flange=-15.52575+(2.54)(13)$
19  pz  16.54429                $ bottom of the top tank:16.70177-(.062)(2.54)$
20  pz  8.60425                 $ water in the lower tank- 9.5" above the bottom of the fuel$
22  pz  32.73769                $ top edge of upper tank:-16.79231+(13.125+6.375)(2.54)$
36  pz  32.73425                $ top of the water 19" inches above the bottom of the fuel    $
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -44.09731                $ top of bottom plate for lower tank=-44.41481+(2.54)(0.125)$
26  pz -44.41481                $ bottom of bottom plate for lower tank=32.73769-(2.54)(30 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.062)(2.54)$
29  pz -36.15981                $ bottom of top plate for lower tank=-36.47731+(2.54)(0.125)$
30  pz -36.47731                $ top of bottom plate for lower tank=-44.09731+(2.54)(3)$
31  pz  17.49769                $ top of the bottom tank=32.73769-(2.54)(6)                $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
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70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c -------------------------------------------------$
c external reflector surfaces$
200 c/z 19.584677 -5.247698  0.7112 $IR of drive shaft$
201 c/z 19.584677 -5.247698  2.2225 $OR of drive shaft$
202 c/z 19.584677 -5.247698  8.89   $OR of control drum$
c$
203 c/z -19.584677 5.247698  0.7112 $IR of drive shaft$
204 c/z -19.584677 5.247698  2.2225 $OR of drive shaft$
205 c/z -19.584677 5.247698  8.89   $OR of control drum$
c$
206 c/z 5.247698   19.584677 0.7112 $IR of drive shaft$
207 c/z 5.247698   19.584677 2.2225 $OR of drive shaft$
208 c/z 5.247698   19.584677 8.89   $OR of control drum$
c$
209 c/z -5.247698  -19.584677 0.7112 $IR of drive shaft$
210 c/z -5.247698  -19.584677 2.2225 $OR of drive shaft$
211 c/z -5.247698  -19.584677 8.89   $OR of control drum$
c$
300 p 0.57735 -1 0  18.74137         $line to  bound reflector$
301 p -1.732  -1 0  33.730392        $line to bound reflector$
302 p 0.57735 -1 0 -18.74137         $line  to bound reflector$
303 p -1.732  -1 0 -33.73092         $line to bound reflector$
c$
401 p -1.732  -1 0  37.2427          $line to cut off control drums$
403 p -1.732  -1 0 -37.2434          $line to cut off control drums$
c$
500 pz 12.87018                      $ top of the control drums$
501 pz -12.84478                     $ bottom of the control drums$
502 pz -15.5448                      $ bottom of the reflector main block$
503 pz 15.5702                       $ top of the reflector main block$
504 cz 16.2306                       $ surface used for the ledges of the main block$
505 pz 3.81                          $ top of the large cylinder of the drive shaft$
506 pz -3.81                         $ bottom of the large cylinder of the drive shaft$
c$
999 so  58$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
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     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10  6000.60c  0.0354891 &$
     1001.60c  0.0567825 &$
     8016.60c  0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
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      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
```

```
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
```

```
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.2 Case fig14a

```
NAA-SR-9871, case fig14a             $
c Feb 24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described by fig 14, NAA-SR-9871$
c This case uses SCA4 fuel, with 25 fuel rods and the rest lucites,$
c flooded core.  The amount of axial reflection is varied for the$
c fig14 cases.  The tank configuration used is that shown in$
c Fig 48, of 9871.$
c ----- complete fuel element assembly ----------$
1  0       -5 -8 9  fill=582                    imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=2    trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=2    trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=2    trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=2    trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=2    trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=2    trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=2    trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=2    trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=2    trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=2    trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=2    trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rods -----------------$
98 10 0.1064672  -4 -2 3   u=2   imp:n=1   $  lucite rod$
99 10 0.1064672  4:2:-3    u=2   imp:n=1   $  lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
```

```
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
```

```
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -----------------------------------------------------$
```

```
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements $
c ----- tbd ------------------------------------$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$
304 7 0.1001037      -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$
c ----- tbd ------------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)    imp:n=1  $ type 1100 aluminum cover plate$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7) imp:n=1  $ water $
308 7  0.1001037  (20 -31 24 -27)                imp:n=1  $ volume of lower tank around top tank$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
310 0             -27 25 -30                     imp:n=1  $ void at the bottom of lower tank$
311 9 0.0871549   -29 30 -27                     imp:n=1  $ steel plate in lower tank above void$
312 0             31 -22 24 -28                  imp:n=1  $ void over lower tank outside top tank$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
314 7  0.1001037  (19 -14 7 -23):(14 -18 16 -23):(17 -18 -6):&$
                  (18 -21 -23)                   imp:n=1  $ Water in the top tank$
315 0             (21 -22 -23)                   imp:n=1  $ void in the top tank$
c$
c ----- tbd ------------------------------------$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
317 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  20.30095                $ top of the water in the top tank :1.88" above fuel top  $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)              $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
```

```
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ------------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
```

```
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10  6000.60c  0.0354891 &$
     1001.60c  0.0567825 &$
     8016.60c  0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
```

```
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
```

```
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.3 Case fig14b

```
NAA-SR-9871, case fig14b             $
c Feb 24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described by fig 14, NAA-SR-9871$
c This case uses SCA4 fuel, with 25 fuel rods and the rest lucites,$
c flooded core.  The amount of axial reflection is varied for the$
c fig14 cases.  The tank configuration used is that shown in$
c Fig 48, of 9871.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                    imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=2    trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=2    trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=2    trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=2    trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=2    trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=2    trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=2    trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=2    trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=2    trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=2    trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=2    trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rods -----------------$
98 10 0.1064672  -4 -2 3   u=2   imp:n=1   $  lucite rod$
99 10 0.1064672  4:2:-3    u=2   imp:n=1   $  lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
```

```
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
```

```
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -----------------------------------------------------$
```

```
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements $
c ----- tbd -------------------------------------$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$
304 7 0.1001037      -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$
c ----- tbd -------------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)    imp:n=1  $ type 1100 aluminum cover plate$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7) imp:n=1  $ water $
308 7  0.1001037  (20 -31 24 -27)               imp:n=1  $ volume of lower tank around top tank$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
310 0              -27 25 -30                   imp:n=1  $ void at the bottom of lower tank$
311 9 0.0871549   -29 30 -27                    imp:n=1  $ steel plate in lower tank above void$
312 0             31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
314 7  0.1001037  (19 -14 7 -23):(14 -18 16 -23):(17 -18 -6):&$
                  (18 -21 -23)                  imp:n=1  $ Water in the top tank$
315 0             (21 -22 -23)                  imp:n=1  $ void in the top tank$
c$
c ----- tbd -------------------------------------$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
317 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  20.60575                $ top of the water in the top tank :2" above fuel top  $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)               $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
```

```
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c -----------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
```

```
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10  6000.60c  0.0354891 &$
     1001.60c  0.0567825 &$
     8016.60c  0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
```

```
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
```

```
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.4 Case fig14c

```
NAA-SR-9871, case fig14c             $
c Feb 24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described by fig 14, NAA-SR-9871$
c This case uses SCA4 fuel, with 25 fuel rods and the rest lucites,$
c flooded core.  The amount of axial reflection is varied for the$
c fig14 cases.  The tank configuration used is that shown in$
c Fig 48, of 9871.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                    imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=2    trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=2    trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=2    trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=2    trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=2    trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=2    trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=2    trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=2    trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=2    trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=2    trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=2    trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rods ------------------$
98 10 0.1064672  -4 -2 3   u=2   imp:n=1   $  lucite rod$
99 10 0.1064672  4:2:-3    u=2   imp:n=1   $  lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                         $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
```

```
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
```

```
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -----------------------------------------------------$
```

```
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements $
c ----- tbd -------------------------------------$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$
304 7 0.1001037      -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$
c ----- tbd -------------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)    imp:n=1  $ type 1100 aluminum cover plate$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7) imp:n=1  $ water $
308 7  0.1001037  (20 -31 24 -27)               imp:n=1  $ volume of lower tank around top tank$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
310 0              -27 25 -30                   imp:n=1  $ void at the bottom of lower tank$
311 9 0.0871549   -29 30 -27                    imp:n=1  $ steel plate in lower tank above void$
312 0             31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
314 7  0.1001037  (19 -14 7 -23):(14 -18 16 -23):(17 -18 -6):&$
                  (18 -21 -23)                  imp:n=1  $ Water in the top tank$
315 0             (21 -22 -23)                  imp:n=1  $ void in the top tank$
c$
c ----- tbd -------------------------------------$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
317 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  21.24075                $ top of the water in the top tank :2.25" above fuel top  $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)                $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
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54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c -----------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
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     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10  6000.60c  0.0354891 &$
     1001.60c  0.0567825 &$
     8016.60c  0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
```

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       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
```

```
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.5 Case fig14d

```
NAA-SR-9871, case fig14d            $
c Feb 24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described by fig 14, NAA-SR-9871$
c This case uses SCA4 fuel, with 25 fuel rods and the rest lucites,$
c flooded core.  The amount of axial reflection is varied for the$
c fig14 cases.  The tank configuration used is that shown in$
c Fig 48, of 9871.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                    imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=2    trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=2    trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=2    trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=2    trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=2    trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=2    trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=2    trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=2    trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=2    trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=2    trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=2    trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rods ------------------$
98 10 0.1064672  -4 -2 3   u=2   imp:n=1   $  lucite rod$
99 10 0.1064672  4:2:-3    u=2   imp:n=1   $  lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
```

```
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
```

```
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -----------------------------------------------------$
```

```
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements $
c ----- tbd -------------------------------------$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$
304 7 0.1001037      -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$
c ----- tbd -------------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)    imp:n=1  $ type 1100 aluminum cover plate$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7) imp:n=1  $ water $
308 7  0.1001037  (20 -31 24 -27)               imp:n=1  $ volume of lower tank around top tank$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
310 0             -27 25 -30                    imp:n=1  $ void at the bottom of lower tank$
311 9 0.0871549   -29 30 -27                    imp:n=1  $ steel plate in lower tank above void$
312 0             31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
314 7  0.1001037  (19 -14 7 -23):(14 -18 16 -23):(17 -18 -6):&$
                  (18 -21 -23)                  imp:n=1  $ Water in the top tank$
315 0             (21 -22 -23)                  imp:n=1  $ void in the top tank$
c$
c ----- tbd -------------------------------------$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
317 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  21.87575                $ top of the water in the top tank :2.5" above fuel top  $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)              $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
```

```
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c -----------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
```

```
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10  6000.60c  0.0354891 &$
     1001.60c  0.0567825 &$
     8016.60c  0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
```

```
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
```

```
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.6 Case fig16

```
NAA-SR-9871, case fig16                $
c Feb 24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described by fig 16, NAA-SR-9871$
c This case uses SCA4 fuel, with a full core compliment, full reflection/$
c dry core, with 12 poison splines.  The tank configuration used is that shown in$
c Fig 48, of 9871.  The poison spline materials are modeled individually.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                    imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=585  trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=584  trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=516  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=598  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=596  trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=586  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------define the makeup of each poison spline-------------------------$
51 28 .022702 -100 -2 3 u=28 imp:n=1$
52 0 100:2:-3 u=28 imp:n=1$
c$
53 29 .018214 -100 -2 3 u=29 imp:n=1$
54  0 100:2:-3 u=29 imp:n=1$
c$
c 55 35 .021382 -100 -2 3 u=35 imp:n=1$
c 56 0 100:2:-3 u=35 imp:n=1$
c$
57 33 .015970 -100 -2 3 u=33 imp:n=1$
58 0 100:2:-3 u=33 imp:n=1$
c$
59 30 .019006 -100 -2 3 u=30 imp:n=1$
```

```
60 0 100:2:-3 u=30 imp:n=1$
c$
61 23 .015574 -100 -2 3 u=23 imp:n=1$
62 0 100:2:-3 u=23 imp:n=1$
c$
63 32 .018742 -100 -2 3 u=32 imp:n=1$
64 0 100:2:-3 u=32 imp:n=1$
c$
65 27 .021117 -100 -2 3 u=27 imp:n=1$
66 0 100:2:-3 u=27 imp:n=1$
c$
67 21 .014650 -100 -2 3 u=21 imp:n=1$
68 0 100:2:-3 u=21 imp:n=1$
c$
69 22 .013066 -100 -2 3 u=22 imp:n=1$
70 0 100:2:-3 u=22 imp:n=1$
c$
71 26 .021910 -100 -2 3 u=26 imp:n=1$
72 0 100:2:-3 u=26 imp:n=1$
c$
c 73 34 .022438 -100 -2 3 u=34 imp:n=1$
c 74 0 100:2:-3 u=34 imp:n=1$
c$
75 24 .020854 -100 -2 3 u=24 imp:n=1$
76 0 100:2:-3 u=24 imp:n=1$
c$
c 77 25 .021514 -100 -2 3 u=25 imp:n=1$
c 78 0 100:2:-3 u=25 imp:n=1$
c$
79 31 .018478 -100 -2 3 u=31 imp:n=1$
80 0 100:2:-3 u=31 imp:n=1$
c ------ fill each spline position with the correct spline:$
81 0 -101 9 -8 fill=28 imp:n=1$
82 like 81 but fill=29 trcl ( -5.51    -0.12    0) imp:n=1$
84 like 81 but fill=33 trcl ( 1.795    3.11     0) imp:n=1$
85 like 81 but fill=30 trcl ( -11.08   -0.08    0) imp:n=1$
86 like 81 but fill=23 trcl ( -6.39    4.67     0) imp:n=1$
87 like 81 but fill=32 trcl ( -.84     7.90     0) imp:n=1$
88 like 81 but fill=27 trcl ( -16.475   3.11    0) imp:n=1$
89 like 81 but fill=21 trcl ( -11.08   6.35     0) imp:n=1$
90 like 81 but fill=22 trcl ( -5.51    9.5      0) imp:n=1$
91 like 81 but fill=26 trcl ( -3.66    12.74    0) imp:n=1$
93 like 81 but fill=24 trcl ( -14.7    9.55     0) imp:n=1$
95 like 81 but fill=31 trcl ( -11.05   12.7     0) imp:n=1$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
```

```
c ---------                      $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
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```
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ----------------------------------------------------$
300 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         #81 #82 #84 #85 #86 #87 #88 #89 #90 #91 #93&$
         #95      imp:n=1  $ vessel interior between elements - void filled$
c ----- tbd ------------------------------------$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
303 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$
c ----- tbd ------------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)    imp:n=1  $ type 1100 aluminum cover plate$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7) imp:n=1  $ water $
308 7  0.1001037  (20 -31 24 -27)               imp:n=1  $ volume of lower tank around top tank$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
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```
310 0              -27 25 -30                    imp:n=1  $ void at the bottom of lower tank$
311 9 0.0871549   -29 30 -27                     imp:n=1  $ steel plate in lower tank above void$
312 0             31 -22 24 -28                  imp:n=1  $ void over lower tank outside top tank$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
314 7  0.1001037  (19 -14 7 -23):&$
    (14 -18 16 -23):(17 -18 -6):(18 -21 -23)    imp:n=1  $ water inside top tank$
315 0 21 -22 -23                                 imp:n=1  $ void above the top tank water$
c$
c ----- tbd ------------------------------------$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
317 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  32.73425                $ top of the water  :19" inches above the bottom of the fuel    $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)               $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
```

```
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- tbd ----------------------------------$
c  surfaces for splines$
100 c/z 7.34 -6.31 0.208  $
101 c/z 7.34 -6.31 0.208001$
c ---------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water ----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- natural B for poison splines$
m28  5010.60c  0.004518 &$
     5011.60c  0.018184$
c --- natural B for poison splines$
m29  5010.60c  0.003625 &$
```

```
     5011.60c  0.014589$
c --- natural B for poison splines$
m33  5010.60c  0.003178 &$
     5011.60c  0.012792$
c --- natural B for poison splines$
m30  5010.60c  0.003782 &$
     5011.60c  0.015224$
c --- natural B for poison splines$
m23  5010.60c  0.003099 &$
     5011.60c  0.012475$
c --- natural B for poison splines$
m32  5010.60c  0.003730 &$
     5011.60c  0.015012$
c --- natural B for poison splines$
m27  5010.60c  0.004202 &$
     5011.60c  0.016915$
c --- natural B for poison splines$
m21  5010.60c  0.002915 &$
     5011.60c  0.011735$
c --- natural B for poison splines$
m22  5010.60c  0.002600 &$
     5011.60c  0.010466$
c --- natural B for poison splines$
m26  5010.60c  0.004360 &$
     5011.60c  0.017550$
c --- natural B for poison splines$
m24  5010.60c  0.004150 &$
     5011.60c  0.016704$
c --- natural B for poison splines$
m31  5010.60c  0.003677 &$
     5011.60c  0.014801$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
```

```
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
```

```
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
```

```
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.7 Case p34

```
NAA-SR-9871, case p34              $
c Feb24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described on p34, NAA-SR-9871$
c This case uses SCA4 fuel, with 32 fuel rods and 5 lucites, full reflection/$
c dry core.  The tank configuration used is that shown in$
c Fig 48, of 9871.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                     imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=2    trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=2    trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=2    trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=596  trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=2    trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rods -----------------$
98 10 0.1064672  -4 -2 3   u=2   imp:n=1   $  lucite rod$
99 10 0.1064672  4:2:-3    u=2   imp:n=1   $  lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
```

```
c ---------                     $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
```

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160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                   $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                   $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -------------------------------------------------------$
300 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
```

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         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements$
c ----- tbd ------------------------------------$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
303 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$
c ----- tbd ------------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)    imp:n=1  $ type 1100 aluminum cover plate$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7) imp:n=1  $ water $
308 7  0.1001037  (20 -31 24 -27)               imp:n=1  $ volume of lower tank around top tank$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
310 0              -27 25 -30                   imp:n=1  $ void at the bottom of lower tank$
311 9 0.0871549   -29 30 -27                    imp:n=1  $ steel plate in lower tank above void$
312 0             31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
314 7  0.1001037  (19 -14 7 -23):&$
    (14 -18 16 -23):(17 -18 -6):(18 -21 -23)    imp:n=1  $ water inside top tank$
315 0 21 -22 -23                                imp:n=1  $ void above the top tank water$
c$
c ----- tbd ------------------------------------$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
317 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  32.73425                $ top of the water :19" inches above the bottom of the fuel    $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)                $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
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55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c -----------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
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     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10  6000.60c  0.0354891 &$
     1001.60c  0.0567825 &$
     8016.60c  0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
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mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
```

```
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.8 Case p35

```
NAA-SR-9871, case p35             $
c Feb 24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described on p35, NAA-SR-9871$
c This case uses SCA4 fuel, with a full core compliment, full reflection/$
c dry core.  The tank configuration used is that shown in$
c Fig 48, of 9871.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                     imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=585  trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=584  trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=516  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=598  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=596  trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=586  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces -----------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
```

```
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
```

```
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                        $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------------------------------------------------$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
```

```
         imp:n=1  $ vessel interior between elements$
c ----- tbd -------------------------------------$
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
303 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate$
304 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$
c ----- tbd -------------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)    imp:n=1  $ type 1100 aluminum cover plate$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7) imp:n=1  $ water $
308 7  0.1001037  (20 -31 24 -27)               imp:n=1  $ volume of lower tank around the top
tank$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
310 0              -27 25 -30                   imp:n=1  $ void at the bottom of lower tank$
311 9 0.0871549   -29 30 -27                    imp:n=1  $ steel plate in lower tank above void$
312 0             31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
314 7  0.1001037  (19 -14 7 -23):&$
    (14 -18 16 -23):(17 -18 -6):(18 -21 -23)    imp:n=1  $ water inside top tank$
315 0 21 -22 -23                                imp:n=1  $ void above the top tank water$
c$
c ----- tbd -------------------------------------$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
317 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  32.73425                $ top of the water :19" inches above the bottom of the fuel    $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)             $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
```

```
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c --------------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
```

```
     14000.60c 0.0017218$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
```

```
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
```

```
        40000.60c   0.034781046   &$
         1001.60c   0.062931948   $
mt108    zr/h.01t   h/zr.01t$
m109    92235.60c   0.001432362   &$
        92238.60c   0.000104311   &$
        40000.60c   0.035595633   &$
         1001.60c   0.064691358   $
mt109    zr/h.01t   h/zr.01t$
m110    92235.60c   0.001432251   &$
        92238.60c   0.000103982   &$
        40000.60c   0.035613144   &$
         1001.60c   0.063209877   $
mt110    zr/h.01t   h/zr.01t$
m111    92235.60c   0.001413405   &$
        92238.60c   0.000101793   &$
        40000.60c   0.035150204   &$
         1001.60c   0.066074074   $
mt111    zr/h.01t   h/zr.01t$
m112    92235.60c   0.001435687   &$
        92238.60c   0.000103545   &$
        40000.60c   0.035468978   &$
         1001.60c   0.064547401   $
mt112    zr/h.01t   h/zr.01t$
m113    92235.60c   0.00143092   &$
        92238.60c   0.000103763   &$
        40000.60c   0.035308553   &$
         1001.60c   0.062367101   $
mt113    zr/h.01t   h/zr.01t$
m114    92235.60c   0.001427262   &$
        92238.60c   0.000103545   &$
        40000.60c   0.035208233   &$
         1001.60c   0.063381262   $
mt114    zr/h.01t   h/zr.01t$
m115    92235.60c   0.001419392   &$
        92238.60c   0.000103326   &$
        40000.60c   0.035428725   &$
         1001.60c   0.064493827   $
mt115    zr/h.01t   h/zr.01t$
m116    92235.60c   0.001430034   &$
        92238.60c   0.000104201   &$
        40000.60c   0.035494858   &$
         1001.60c   0.064790123   $
mt116    zr/h.01t   h/zr.01t$
m117    92235.60c   0.001432916   &$
        92238.60c   5.05682E-05   &$
        40000.60c   0.035671272   &$
         1001.60c   0.064592593   $
mt117    zr/h.01t   h/zr.01t$
print$
```

3.2.9 Case p49

```
NAA-SR-9871, case  p49            $
c Feb 24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described on p49, NAA-SR-9871$
c This case uses SCA4 fuel, with 35 elements, 2 lucites, full reflection/$
c flooded core.  The tank configuration used is that shown in$
c Fig 48, of 9871.  A close-fitting Binal sleeve 0.75" thick covers the core.$
c The water level in the bottom tank is 10.25 inches aboe the fuel bottom.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                    imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=585  trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=584  trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=598  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=2    trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=586  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c --------define lucite rods -------------------$
80 10 0.1064672 -4 -2 3 u=2 imp:n=1 $
81 10 0.1064672 4:2:-3 u=2  imp:n=1$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                         $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
```

```
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                 $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
```

```
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -----------------------------------------------------$
```

```
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements - flooded    $
c ----- tbd ------------------------------------$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12               imp:n=1  $ vessel interior above upper gridplate $
304 7 0.1001037      -6 -11  13               imp:n=1  $ vessel interior above upper gridplate $
c ----- tbd ------------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 12 0.0708762  (15 -20 7 -36)               imp:n=1  $ binal sleeve$
307 12 0.0708762  (19 -14 7 -36)               imp:n=1  $ binal sleeve$
308 6  0.0602626  (-6 -17 12):(-16 6 -18 12)    imp:n=1  $ type 1100 aluminum cover plate$
309 7  0.1001037  (29 -15 -27):(15 -20 -27 36)  imp:n=1  $ water in the lower tank$
310 7  0.1001037  (20 -31 24 -27)              imp:n=1  $ volume of lower tank around top tank$
311 9  0.0871549  (26 -25 -28):(27 -28 -31 25)  imp:n=1  $ bottom tank shell$
312 0              -27 25 -30                  imp:n=1  $ void at the bottom of lower tank$
313 9 0.0871549   -29 30 -27                   imp:n=1  $ steel plate in lower tank above void$
314 0             31 -22 24 -28                imp:n=1  $ void over lower tank outside top tank$
315 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
316 7 0.1001037  (19 -37 36 -23)               imp:n=1  $ water in the top tank$
317 0            (37 -14 36 -23):&$
    (14 -18 16 -23):(17 -18 -6):(18 -22 -23)    imp:n=1  $void  inside top tank$
c$
c ----- tbd ------------------------------------$
318 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
319 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  32.73425                $ water in top tank 19" inches above the bottom of the fuel    $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ top of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ bottom of bottom plate for lower tank$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)            $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
36  cz 13.25499                 $ OR of the binal sleeve=11.34999+(0.75)(2.54)$
37  pz 10.50925                 $ water level in the top tank=-15.52575 +(10.25)(2.54)$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
```

```
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c --------------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
```

```
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$
m12   5010.60c 0.0030227 &$
      5011.60c 0.0121667 &$
      6000.60c 0.0037973 &$
     13027.60c 0.0518894$
c ---total=0.07087616$
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
```

```
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
```

```
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.10 Case p58

```
NAA-SR-9871, case  p58             $
c Feb24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described on p58, NAA-SR-9871$
c This case uses SCA4 fuel, with 36 fuel rods and 1 lucite rod,$
c flooded core., water 14.88 inches above bottom of the fuel.$
c The tank configuration used is that shown in$
c Fig 48, of 9871. $
c ----- complete fuel element assembly ----------$
1  0       -5 -8 9  fill=582                     imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=585  trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=584  trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=598  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=596  trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=586  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rod ----------$
80 10 0.1064672  -4 -2 3 u=2 imp:n=1   $ lucite$
81 10 0.1064672     4:2:-3  u=2 imp:n=1   $ lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                       $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
```

```
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
```

```
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                    $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -----------------------------------------------------$
```

```
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements $
c ----- rest of vessel interior------------------$
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12                imp:n=1  $ vessel interior above upper gridplate$
304 7 0.1001037      -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$
c ----- rx vessel------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)   imp:n=1  $ type 1100 aluminum cover plate$
c --------sleeve assembly----------------------$
307 35 0.0862393  (7 -500 -601 602)           imp:n=1  $ inner sheel of void sleeve$
308 35 0.0862393  (7 -500 605 -603)           imp:n=1  $ inner shell of the void sleeve$
c$
309 0             (500 -501 602 -601)          imp:n=1  $ void sleeve$
310 0             (500 -501 605 -603)          imp:n=1  $ void sleeves$
c$
311 35 0.0862393  (501 -503 602 -601)          imp:n=1  $ outer sheel of void sleeve$
312 35 0.0862393  (501 -503 605 -603)          imp:n=1  $ outer shell of void sleeves$
c$
313 20 0.0250690  (503 -504 602 -601)          imp:n=1  $ boron power sleeve$
314 20 0.0250690  (503 -504 605 -603)          imp:n=1  $ boron powder sleeve$
c$
315 35 0.0862393  (504 -506 602 -601)          imp:n=1  $ outer shell+steel sleeve$
316 35 0.0862393  (504 -506 605 -603)          imp:n=1  $ outer shell+steel sleeve$
c$
317 35 0.0862393  (-605 604 7 -506)            imp:n=1  $ steel sheet$
318 35 0.0862393  (19 -602 7 -506)             imp:n=1  $ steel sheet$
c$
319 35 0.0862393  (601 -600 7 -506)            imp:n=1  $ steel sheet$
320 35 0.0862393  (603 -20 7 -506)             imp:n=1  $ steel sheet on the ends of sleeves$
c$
321 30 0.0463402  (7 -506 600 -8)              imp:n=1  $ Cd sheet$
322 30 0.0463402  (7 -506 9 -604)              imp:n=1  $ Cd sheets on ends of sleeves$
c$
c ----------- water tanks ----------------------------------$
407 7  0.1001037  (29 -15 -27):(9 -20 -27 506):(-27 7 15 -9) imp:n=1 $ water $
408 7  0.1001037  (20 -31 24 -27)              imp:n=1  $ volume of lower tank around top tank$
409 9  0.0871549  (26 -25 -28):(27 -28 -31 25) imp:n=1  $ bottom tank shell$
410 0              -27 25 -30                  imp:n=1  $ void at the bottom of lower tank$
411 9  0.0871549  -29 30 -27                   imp:n=1  $ steel plate in lower tank above void$
412 0             31 -22 24 -28                imp:n=1  $ void over lower tank outside top tank$
413 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
414 7  0.1001037  (19 -8 506 -23):(8 -14 -23 7):&$
                  (14 -18 16 -23):(17 -18 -6):(18 -21 -23)  imp:n=1   $water inside top tank$
415 0             (21 -22 -23)                 imp:n=1   $ void above the top tank water$
c ----- tbd -------------------------------------$
416 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
417 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
```

```
19  pz  6.22173               $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425               $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  22.26945              $ top of the water :14.88" above the bottom of the fuel    $
22  pz  36.22675              $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                 $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743              $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075              $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825              $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248              $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325              $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075              $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425              $ top of the bottom tank=36.22675-(2.54)(5.875)                $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- radial sleeve surfaces -----------------$
500 cz 11.42873$
501 cz 18.89125$
502 cz 18.96999$
503 cz 19.04873$
504 cz 21.43125$
505 cz 21.50999$
506 cz 22.14499$
c ---- axial sleeve surfaces ------------------$
600 pz 15.7607     $ 15.8115-(2.54)(0.02)=cd sheet $
601 pz 15.68196    $ 15.7607-(2.54)(0.031)=steel shell$
602 pz 6.30047$
603 pz 5.98551$
604 pz -15.7607    $ -15.8115 +(2.54)(0.02)=cd sheet$
605 pz -15.68196     $ -15.7607 +(2.54)(0.031)=steel shell$
c ---------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
```

```
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- natural B for poison sleeves$
m20  5010.60c  0.0049887   &$
     5011.60c  0.0200803  $
c ----cadmium -----------$
m30  48000.50c 0.0463402   $
c ---- Steel 304---------$
m35  26054.60c  0.0035020 &$
     26056.60c  0.0544408 &$
     26057.60c  0.0012465 &$
     26058.60c  0.0001662 &$
     28058.60c  0.0052698 &$
     28060.60c  0.0020147 & $
     28061.60c  0.0000872 &$
     28062.60c  0.0002771 &$
     28064.60c  0.0000702 &$
     24050.60c  0.0007573 &$
     24052.60c  0.0146033 & $
     24053.60c  0.0016557 &$
     24054.60c  0.0004122 &$
```

```
     25055.60c  0.0017363 $
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
```

```
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
```

```
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.11 Case p58gap

```
NAA-SR-9871, case  p58gap             $
c Feb24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described on p58, NAA-SR-9871$
c This case uses SCA4 fuel, with 36 fuel rods and 1 lucite rod,$
c flooded core., water 14.88 inches above bottom of the fuel.$
c The tank configuration used is that shown in$
c Fig 48, of 9871. $
c NOTE:  This model examines the effects of water gaps in the$
c        sleeve assembly.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                    imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=585  trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=584  trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=2    trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=598  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=596  trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=586  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rod ----------$
80 10 0.1064672  -4 -2 3 u=2 imp:n=1   $ lucite$
81 10 0.1064672     4:2:-3  u=2 imp:n=1   $ lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
```

```
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
```

```
c ---------                      $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
```

```
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------------------------------------------------$
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements $
c ----- rest of vessel interior------------------$
301 6  0.0602626     -6   8 -10              imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11              imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12              imp:n=1  $ vessel interior above upper gridplate$
304 7 0.1001037      -6 -11  13              imp:n=1  $ vessel interior above upper gridplate$
c ----- rx vessel------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)   imp:n=1  $ type 1100 aluminum cover plate$
c --------sleeve assembly-----------------------$
311 7  0.1001037  (7 -500  19  -600)         imp:n=1  $ water gap at the outside of vessel$
312 7  0.1001037  (7 -500  -20  604)         imp:n=1  $ water gap at the outside of vessel$
c$
313 35 0.0862393  (500 -501 -601 602)        imp:n=1  $ inner sheel of void sleeve$
314 35 0.0862393  (500 -501 605 -603)        imp:n=1  $ inner shell of the void sleeve$
c$
315 0             (501 -502 602 -601)        imp:n=1  $ void sleeve$
316 0             (501 -502 605 -603)        imp:n=1  $ void sleeves$
c$
317 35 0.0862393  (502 -503 602 -601)        imp:n=1  $ outer sheel of void sleeve$
318 35 0.0862393  (502 -503 605 -603)        imp:n=1  $ outer shell of void sleeves$
c$
319 35 0.0862393  (500 -503 601 -600)        imp:n=1  $ top of top sleeve$
320 35 0.0862393  (500 -503 19  -602)        imp:n=1  $ bottom of the top sleeve$
321 35 0.0862393  (500 -503 -605 604)        imp:n=1  $ top of top sleeve$
322 35 0.0862393  (500 -503 -20  603)        imp:n=1  $ bottom of the top sleeve$
c$
331 7  0.1001037  (503 -504  19 -600)        imp:n=1  $ water gap outside of void sleeve$
332 7  0.1001037  (503 -504 -20  604)        imp:n=1  $ water gap outside of void sleeve$
c$
333 35 0.0862393  (504 -505 602 -601)        imp:n=1  $ steel inside boron sleeve$
334 35 0.0862393  (504 -505 605 -603)        imp:n=1  $ steel inside boron sleeve$
c$
335 20 0.0250690  (505 -506 602 -601)        imp:n=1  $ boron power sleeve$
336 20 0.0250690  (505 -506 605 -603)        imp:n=1  $ boron powder sleeve$
c$
337 35 0.0862393  (506 -507 602 -601)        imp:n=1  $ outer shell boron sleeve$
338 35 0.0862393  (506 -507 605 -603)        imp:n=1  $ outer shell boron sleeve$
c$
339 35 0.0862393  (504 -507 601 -600)        imp:n=1  $ top of top sleeve$
340 35 0.0862393  (504 -507 19  -602)        imp:n=1  $ bottom of the top sleeve$
341 35 0.0862393  (504 -507 -605 604)        imp:n=1  $ top of top sleeve$
342 35 0.0862393  (504 -507 -20  603)        imp:n=1  $ bottom of the top sleeve$
c$
351 7  0.1001037  (507 -508 19  -600)        imp:n=1  $ water outside boron sleeve$
352 7  0.1001037  (507 -508 -20  604)        imp:n=1  $ water outside boron sleeve$
c$
353 35 0.0862393  (19  -600  508 -509)       imp:n=1  $ steel sleeve$
354 35 0.0862393  (604 -20   508 -509)       imp:n=1  $ steel sleeve                      $
c$
355 30 0.0463402  (7 -509 600 -8)            imp:n=1  $ Cd sheet$
356 30 0.0463402  (7 -509 9 -604)            imp:n=1  $ Cd sheet$
c$
c ----------- water tanks ----------------------------------$
407 7  0.1001037  (29 -15 -27):(9 -20 -27 509):(-27 7 15 -9) imp:n=1 $ water $
408 7  0.1001037  (20 -31 24 -27)            imp:n=1  $ volume of lower tank around top tank$
409 9  0.0871549  (26 -25 -28):(27 -28 -31 25) imp:n=1  $ bottom tank shell$
410 0              -27 25 -30                imp:n=1  $ void at the bottom of lower tank$
411 9  0.0871549  -29 30 -27                 imp:n=1  $ steel plate in lower tank above void$
412 0             31 -22 24 -28              imp:n=1  $ void over lower tank outside top tank$
c$
413 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
414 7  0.1001037  (19 -8 509 -23):(8 -14 -23 7):&$
                  (14 -18 16 -23):(17 -18 -6):(18 -21 -23)  imp:n=1   $water inside top tank$
415 0             (21 -22 -23)               imp:n=1   $ void above the top tank water$
```

```
c ----- tbd -------------------------------------$
416 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
417 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  22.26945                $ top of the water :14.88" above the bottom of the fuel    $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)                $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- radial sleeve surfaces -----------------$
500 cz 11.50874  $ surface 7 + 1/16"$
501 cz 11.58748  $ +0.031"$
```

```
502 cz 19.05$
503 cz 19.12874$
504 cz 19.28749$
505 cz 19.36623$
506 cz 21.74875$
507 cz 21.82749$
508 cz 21.98624$
509 cz 22.62124$
c ---- axial sleeve surfaces ------------------$
600 pz 15.7607     $ 15.8115-(2.54)(0.02)=cd sheet $
601 pz 15.68196    $ 15.7607-(2.54)(0.031)=steel shell$
602 pz 6.30047$
603 pz 5.98551$
604 pz -15.7607    $ -15.8115 +(2.54)(0.02)=cd sheet$
605 pz -15.68196     $ -15.7607 +(2.54)(0.031)=steel shell$
c -----------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 ------------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
```

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      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- natural B for poison sleeves$
m20  5010.60c  0.0049887   &$
     5011.60c  0.0200803  $
c ----cadmium -----------$
m30  48000.50c 0.0463402   $
c ---- Steel 304---------$
m35  26054.60c  0.0035020 &$
     26056.60c  0.0544408 &$
     26057.60c  0.0012465 &$
     26058.60c  0.0001662 &$
     28058.60c  0.0052698 &$
     28060.60c  0.0020147 & $
     28061.60c  0.0000872 &$
     28062.60c  0.0002771 &$
     28064.60c  0.0000702 &$
     24050.60c  0.0007573 &$
     24052.60c  0.0146033 & $
     24053.60c  0.0016557 &$
     24054.60c  0.0004122 &$
     25055.60c  0.0017363 $
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
```

```
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
```

```
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.12 Case p59

```
NAA-SR-9871, case  p59            $
c Feb24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described on p58, NAA-SR-9871$
c This case uses SCA4 fuel, with 37 fuel rods and $
c flooded core., water 12.41 inches above bottom of the fuel.$
c The tank configuration used is that shown in$
c Fig 48, of 9871. $
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                     imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=585  trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=584  trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=516  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=598  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=596  trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=586  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rod ----------$
80 10 0.1064672  -4 -2 3 u=2 imp:n=1   $ lucite$
81 10 0.1064672     4:2:-3  u=2 imp:n=1   $ lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                          $
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
```

```
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
```

```
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                      $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -----------------------------------------------------$
```

```
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements $
c ----- rest of vessel interior------------------$
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12                imp:n=1  $ vessel interior above upper gridplate$
304 7 0.1001037      -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$
c ----- rx vessel------------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)   imp:n=1  $ type 1100 aluminum cover plate$
c --------sleeve assembly----------------------$
307 35 0.0862393  (7 -500 -601 602)            imp:n=1  $ inner sheel of void sleeve$
308 35 0.0862393  (7 -500 605 -603)            imp:n=1  $ inner shell of the void sleeve$
c$
309 0             (500 -501 602 -601)          imp:n=1  $ void sleeve$
310 0             (500 -501 605 -603)          imp:n=1  $ void sleeves$
c$
311 35 0.0862393  (501 -503 602 -601)          imp:n=1  $ outer sheel of void sleeve$
312 35 0.0862393  (501 -503 605 -603)          imp:n=1  $ outer shell of void sleeves$
c$
313 20 0.0250690  (503 -504 602 -601)          imp:n=1  $ boron power sleeve$
314 20 0.0250690  (503 -504 605 -603)          imp:n=1  $ boron powder sleeve$
c$
315 35 0.0862393  (504 -506 602 -601)          imp:n=1  $ outer shell+steel sleeve$
316 35 0.0862393  (504 -506 605 -603)          imp:n=1  $ outer shell+steel sleeve$
c$
317 35 0.0862393  (-605 604 7 -506)            imp:n=1  $ steel sheet$
318 35 0.0862393  (19 -602 7 -506)             imp:n=1  $ steel sheet$
c$
319 35 0.0862393  (601 -600 7 -506)            imp:n=1  $ steel sheet$
320 35 0.0862393  (603 -20 7 -506)             imp:n=1  $ steel sheet on the ends of sleeves$
c$
321 7 0.1001037   (7 -506 600 -8)              imp:n=1  $ water replacing CD sheet$
322 7 0.1001037   (7 -506 9 -604)              imp:n=1  $ water replacing CD sheet    $
c$
c ----------- water tanks ---------------------------------$
407 7  0.1001037  (29 -15 -27):(9 -20 -27 506):(-27 7 15 -9) imp:n=1 $ water $
408 7  0.1001037  (20 -31 24 -27)              imp:n=1  $ volume of lower tank around top tank$
409 9  0.0871549  (26 -25 -28):(27 -28 -31 25) imp:n=1  $ bottom tank shell$
410 0              -27 25 -30                  imp:n=1  $ void at the bottom of lower tank$
411 9  0.0871549  -29 30 -27                   imp:n=1  $ steel plate in lower tank above void$
412 0             31 -22 24 -28                imp:n=1  $ void over lower tank outside top tank$
413 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
414 7  0.1001037  (19 -8 506 -23):(8 -21 -23 7) imp:n=1 $ water in the top tank$
415 0             (21 -14 7 -23):(14 -18 16 -23):&$
                  (18 -22 -23):(17 -18 -6)     imp:n=1   $ void above the top tank water$
c ----- tbd -------------------------------------$
416 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
417 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
```

```
19  pz  6.22173                $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  15.99565               $ top of the water :12.41" above the bottom of the fuel    $
22  pz  36.22675               $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                  $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743               $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075               $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825               $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                 $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248               $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325               $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075               $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425               $ top of the bottom tank=36.22675-(2.54)(5.875)               $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces -----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- radial sleeve surfaces -----------------$
500 cz 11.42873$
501 cz 18.89125$
502 cz 18.96999$
503 cz 19.04873$
504 cz 21.43125$
505 cz 21.50999$
506 cz 22.14499$
c ---- axial sleeve surfaces ------------------$
600 pz 15.7607     $ 15.8115-(2.54)(0.02)=cd sheet $
601 pz 15.68196    $ 15.7607-(2.54)(0.031)=steel shell$
602 pz 6.30047$
603 pz 5.98551$
604 pz -15.7607    $ -15.8115 +(2.54)(0.02)=cd sheet$
605 pz -15.68196     $ -15.7607 +(2.54)(0.031)=steel shell$
c ---------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
```

```
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite -----------$
m10   6000.60c 0.0354891 &$
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- natural B for poison sleeves$
m20  5010.60c  0.0049887   &$
     5011.60c  0.0200803  $
c ----cadmium -----------$
m30  48000.50c 0.0463402   $
c ---- Steel 304---------$
m35  26054.60c  0.0035020 &$
     26056.60c  0.0544408 &$
     26057.60c  0.0012465 &$
     26058.60c  0.0001662 &$
     28058.60c  0.0052698 &$
     28060.60c  0.0020147 & $
     28061.60c  0.0000872 &$
     28062.60c  0.0002771 &$
     28064.60c  0.0000702 &$
     24050.60c  0.0007573 &$
     24052.60c  0.0146033 & $
     24053.60c  0.0016557 &$
     24054.60c  0.0004122 &$
```

```
     25055.60c  0.0017363 $
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
```

```
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
```

```
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.13 Case p59gap

```
NAA-SR-9871, case  p59gap            $
c Feb24, 2005$
c Model setup by a.w. krass and k.l.goluoglu$
c This case models the experiment described on p58, NAA-SR-9871$
c This case uses SCA4 fuel, with 37 fuel rods and$
c flooded core., water 12.41 inches above bottom of the fuel.$
c The tank configuration used is that shown in$
c Fig 48, of 9871. $
c NOTE:  This model examines the effects of water gaps in the$
c        sleeve assembly.$
c ----- complete fuel element assembly ----------$
1  0        -5 -8 9  fill=582                    imp:n=1  $ position 1$
c ----- additional fuel elements ----------------$
2  like 1 but fill=587  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$
3  like 1 but fill=504  trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$
4  like 1 but fill=583  trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$
5  like 1 but fill=507  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$
6  like 1 but fill=503  trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$
7  like 1 but fill=590  trcl   (-5.5432  -3.2004  0)  imp:n=1  $ position 7$
8  like 1 but fill=594  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$
9  like 1 but fill=597  trcl    (5.5432  -3.2004  0)  imp:n=1  $ position 9$
10 like 1 but fill=593  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$
11 like 1 but fill=505  trcl   (-2.7716  -8.0010  0)  imp:n=1  $ position 11$
12 like 1 but fill=514  trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$
13 like 1 but fill=585  trcl   (-8.3149  -4.8006  0)  imp:n=1  $ position 13$
14 like 1 but fill=589  trcl    (2.7716  -8.0010  0)  imp:n=1  $ position 14$
15 like 1 but fill=500  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$
16 like 1 but fill=501  trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$
17 like 1 but fill=502  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$
18 like 1 but fill=506  trcl   (-2.7716 -11.2014  0)  imp:n=1  $ position 18$
19 like 1 but fill=513  trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$
20 like 1 but fill=584  trcl   (-8.3249  -8.0010  0)  imp:n=1  $ position 20$
21 like 1 but fill=510  trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$
22 like 1 but fill=588  trcl    (5.5432  -9.6012  0)  imp:n=1  $ position 22$
23 like 1 but fill=599  trcl    (8.3149  -8.0010  0)  imp:n=1  $ position 23$
24 like 1 but fill=509  trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$
25 like 1 but fill=581  trcl   (-2.7716 -14.4018  0)  imp:n=1  $ position 25$
26 like 1 but fill=512  trcl   (-5.5432 -12.8016  0)  imp:n=1  $ position 26$
27 like 1 but fill=515  trcl   (-8.3149 -11.2014  0)  imp:n=1  $ position 27$
28 like 1 but fill=508  trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$
29 like 1 but fill=511  trcl    (5.5432 -12.8016  0)  imp:n=1  $ position 29$
30 like 1 but fill=592  trcl    (8.3149 -11.2014  0)  imp:n=1  $ position 30$
31 like 1 but fill=516  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$
32 like 1 but fill=598  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$
37 like 1 but fill=595  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$
36 like 1 but fill=591  trcl    (5.5432 -16.002   0)  imp:n=1  $ position 36$
35 like 1 but fill=596  trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$
34 like 1 but fill=517  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$
33 like 7 but fill=586  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$
c ----- internal be reflector pieces ------------$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$
c -------- define the lucite rod ----------$
80 10 0.1064672  -4 -2 3 u=2 imp:n=1   $ lucite$
81 10 0.1064672     4:2:-3  u=2 imp:n=1   $ lucite$
c ------- define the individual fuel rods $
c The fuel rod universe is the number of the fuel rod$
c with either a 5 in front or the first digit replaced with 5.$
c For example, U=581 is for rod #81. u=501 is for rod #101.$
101   81  0.1021332    -1 -2 3     u=  581    imp:n=1  $ UZrHx fuel   $
102   5   0.0254232    -4 1 -2 3   u=  581    imp:n=1  $ radial rod surface coating   $
103   8   0.0872946    4:2:-3      u=  581    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
```

```
104   82  0.1001835    -1 -2 3     u=  582    imp:n=1  $ UZrHx fuel   $
105   5   0.0254232    -4 1 -2 3   u=  582    imp:n=1  $ radial rod surface coating   $
106   8   0.0872946    4:2:-3      u=  582    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
107   83  0.1013194    -1 -2 3     u=  583    imp:n=1  $ UZrHx fuel   $
108   5   0.0254232    -4 1 -2 3   u=  583    imp:n=1  $ radial rod surface coating   $
109   8   0.0872946    4:2:-3      u=  583    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
110   84  0.1012824    -1 -2 3     u=  584    imp:n=1  $ UZrHx fuel   $
111   5   0.0254232    -4 1 -2 3   u=  584    imp:n=1  $ radial rod surface coating   $
112   8   0.0872946    4:2:-3      u=  584    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
113   85  0.1012830    -1 -2 3     u=  585    imp:n=1  $ UZrHx fuel   $
114   5   0.0254232    -4 1 -2 3   u=  585    imp:n=1  $ radial rod surface coating   $
115   8   0.0872946    4:2:-3      u=  585    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
116   86  0.1011813    -1 -2 3     u=  586    imp:n=1  $ UZrHx fuel   $
117   5   0.0254232    -4 1 -2 3   u=  586    imp:n=1  $ radial rod surface coating   $
118   8   0.0872946    4:2:-3      u=  586    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
119   87  0.1011842    -1 -2 3     u=  587    imp:n=1  $ UZrHx fuel   $
120   5   0.0254232    -4 1 -2 3   u=  587    imp:n=1  $ radial rod surface coating   $
121   8   0.0872946    4:2:-3      u=  587    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
122   88  0.1011694    -1 -2 3     u=  588    imp:n=1  $ UZrHx fuel   $
123   5   0.0254232    -4 1 -2 3   u=  588    imp:n=1  $ radial rod surface coating   $
124   8   0.0872946    4:2:-3      u=  588    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
125   89  0.1006995    -1 -2 3     u=  589    imp:n=1  $ UZrHx fuel   $
126   5   0.0254232    -4 1 -2 3   u=  589    imp:n=1  $ radial rod surface coating   $
127   8   0.0872946    4:2:-3      u=  589    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
128   90  0.1010355    -1 -2 3     u=  590    imp:n=1  $ UZrHx fuel   $
129   5   0.0254232    -4 1 -2 3   u=  590    imp:n=1  $ radial rod surface coating   $
130   8   0.0872946    4:2:-3      u=  590    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
131   91  0.1001852    -1 -2 3     u=  591    imp:n=1  $ UZrHx fuel   $
132   5   0.0254232    -4 1 -2 3   u=  591    imp:n=1  $ radial rod surface coating   $
133   8   0.0872946    4:2:-3      u=  591    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
134   92  0.09996072   -1 -2 3     u=  592    imp:n=1  $ UZrHx fuel   $
135   5   0.0254232    -4 1 -2 3   u=  592    imp:n=1  $ radial rod surface coating   $
136   8   0.0872946    4:2:-3      u=  592    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
137   93  0.09988016   -1 -2 3     u=  593    imp:n=1  $ UZrHx fuel   $
138   5   0.0254232    -4 1 -2 3   u=  593    imp:n=1  $ radial rod surface coating   $
139   8   0.0872946    4:2:-3      u=  593    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
140   94  0.1003007    -1 -2 3     u=  594    imp:n=1  $ UZrHx fuel   $
141   5   0.0254232    -4 1 -2 3   u=  594    imp:n=1  $ radial rod surface coating   $
142   8   0.0872946    4:2:-3      u=  594    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
143   95  0.1014506    -1 -2 3     u=  595    imp:n=1  $ UZrHx fuel   $
144   5   0.0254232    -4 1 -2 3   u=  595    imp:n=1  $ radial rod surface coating   $
145   8   0.0872946    4:2:-3      u=  595    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
146   96  0.09987647   -1 -2 3     u=  596    imp:n=1  $ UZrHx fuel   $
147   5   0.0254232    -4 1 -2 3   u=  596    imp:n=1  $ radial rod surface coating   $
148   8   0.0872946    4:2:-3      u=  596    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
149   97  0.1003130    -1 -2 3     u=  597    imp:n=1  $ UZrHx fuel   $
150   5   0.0254232    -4 1 -2 3   u=  597    imp:n=1  $ radial rod surface coating   $
151   8   0.0872946    4:2:-3      u=  597    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
152   98  0.1019487    -1 -2 3     u=  598    imp:n=1  $ UZrHx fuel   $
153   5   0.0254232    -4 1 -2 3   u=  598    imp:n=1  $ radial rod surface coating   $
154   8   0.0872946    4:2:-3      u=  598    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                     $
155   99  0.1006542    -1 -2 3     u=  599    imp:n=1  $ UZrHx fuel   $
156   5   0.0254232    -4 1 -2 3   u=  599    imp:n=1  $ radial rod surface coating   $
157   8   0.0872946    4:2:-3      u=  599    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
```

```
c ---------                  $
158   100 0.1007018    -1 -2 3     u=  500    imp:n=1  $ UZrHx fuel   $
159   5   0.0254232    -4 1 -2 3   u=  500    imp:n=1  $ radial rod surface coating   $
160   8   0.0872946    4:2:-3      u=  500    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
161   101 0.1010338    -1 -2 3     u=  501    imp:n=1  $ UZrHx fuel   $
162   5   0.0254232    -4 1 -2 3   u=  501    imp:n=1  $ radial rod surface coating   $
163   8   0.0872946    4:2:-3      u=  501    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
164   102 0.09942762   -1 -2 3     u=  502    imp:n=1  $ UZrHx fuel   $
165   5   0.0254232    -4 1 -2 3   u=  502    imp:n=1  $ radial rod surface coating   $
166   8   0.0872946    4:2:-3      u=  502    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
167   103 0.1018758    -1 -2 3     u=  503    imp:n=1  $ UZrHx fuel   $
168   5   0.0254232    -4 1 -2 3   u=  503    imp:n=1  $ radial rod surface coating   $
169   8   0.0872946    4:2:-3      u=  503    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
170   104 0.1003866    -1 -2 3     u=  504    imp:n=1  $ UZrHx fuel   $
171   5   0.0254232    -4 1 -2 3   u=  504    imp:n=1  $ radial rod surface coating   $
172   8   0.0872946    4:2:-3      u=  504    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
173   105 0.09997722    -1 -2 3     u=  505    imp:n=1  $ UZrHx fuel   $
174   5   0.0254232    -4 1 -2 3   u=  505    imp:n=1  $ radial rod surface coating   $
175   8   0.0872946    4:2:-3      u=  505    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
176   106 0.1001341    -1 -2 3     u=  506    imp:n=1  $ UZrHx fuel   $
177   5   0.0254232    -4 1 -2 3   u=  506    imp:n=1  $ radial rod surface coating   $
178   8   0.0872946    4:2:-3      u=  506    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
179   107 0.1011631    -1 -2 3     u=  507    imp:n=1  $ UZrHx fuel   $
180   5   0.0254232    -4 1 -2 3   u=  507    imp:n=1  $ radial rod surface coating   $
181   8   0.0872946    4:2:-3      u=  507    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
182   108 0.09922896   -1 -2 3     u=  508    imp:n=1  $ UZrHx fuel   $
183   5   0.0254232    -4 1 -2 3   u=  508    imp:n=1  $ radial rod surface coating   $
184   8   0.0872946    4:2:-3      u=  508    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
185   109 0.1018237    -1 -2 3     u=  509    imp:n=1  $ UZrHx fuel   $
186   5   0.0254232    -4 1 -2 3   u=  509    imp:n=1  $ radial rod surface coating   $
187   8   0.0872946    4:2:-3      u=  509    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
188   110 0.1003593    -1 -2 3     u=  510    imp:n=1  $ UZrHx fuel   $
189   5   0.0254232    -4 1 -2 3   u=  510    imp:n=1  $ radial rod surface coating   $
190   8   0.0872946    4:2:-3      u=  510    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
191   111 0.1027395    -1 -2 3     u=  511    imp:n=1  $ UZrHx fuel   $
192   5   0.0254232    -4 1 -2 3   u=  511    imp:n=1  $ radial rod surface coating   $
193   8   0.0872946    4:2:-3      u=  511    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
194   112 0.1015556    -1 -2 3     u=  512    imp:n=1  $ UZrHx fuel   $
195   5   0.0254232    -4 1 -2 3   u=  512    imp:n=1  $ radial rod surface coating   $
196   8   0.0872946    4:2:-3      u=  512    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
197   113 0.09921034   -1 -2 3     u=  513    imp:n=1  $ UZrHx fuel   $
198   5   0.0254232    -4 1 -2 3   u=  513    imp:n=1  $ radial rod surface coating   $
199   8   0.0872946    4:2:-3      u=  513    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
200   114 0.1001203    -1 -2 3     u=  514    imp:n=1  $ UZrHx fuel   $
201   5   0.0254232    -4 1 -2 3   u=  514    imp:n=1  $ radial rod surface coating   $
202   8   0.0872946    4:2:-3      u=  514    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
203   115 0.1014453    -1 -2 3     u=  515    imp:n=1  $ UZrHx fuel   $
204   5   0.0254232    -4 1 -2 3   u=  515    imp:n=1  $ radial rod surface coating   $
205   8   0.0872946    4:2:-3      u=  515    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
206   116 0.1018192    -1 -2 3     u=  516    imp:n=1  $ UZrHx fuel   $
207   5   0.0254232    -4 1 -2 3   u=  516    imp:n=1  $ radial rod surface coating   $
208   8   0.0872946    4:2:-3      u=  516    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c ---------                  $
209   117 0.1017473    -1 -2 3     u=  517    imp:n=1  $ UZrHx fuel   $
210   5   0.0254232    -4 1 -2 3   u=  517    imp:n=1  $ radial rod surface coating   $
```

```
211   8   0.0872946    4:2:-3      u=  517    imp:n=1  $ Hastelloy N fuel element tubing/caps   $
c -----------------------------------------------------$
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$
         imp:n=1  $ vessel interior between elements $
c ----- rest of vessel interior------------------$
301 6  0.0602626     -6   8 -10              imp:n=1  $ type 1100 aluminum upper gridplate$
302 6  0.0602626     -6  -9  11              imp:n=1  $ type 1100 aluminum lower gridplate$
303 7 0.1001037      -6  10 -12              imp:n=1  $ vessel interior above upper gridplate$
304 7 0.1001037      -6 -11  13              imp:n=1  $ vessel interior above upper gridplate$
c ----- rx vessel-----------------------------$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)   imp:n=1  $ type 1100 aluminum cover plate$
c --------sleeve assembly----------------------$
311 7  0.1001037  (7 -500  19  -600)          imp:n=1  $ water gap at the outside of vessel$
312 7  0.1001037  (7 -500  -20  604)          imp:n=1  $ water gap at the outside of vessel$
c$
313 35 0.0862393  (500 -501 -601 602)         imp:n=1  $ inner sheel of void sleeve$
314 35 0.0862393  (500 -501 605 -603)         imp:n=1  $ inner shell of the void sleeve$
c$
315 0             (501 -502 602 -601)         imp:n=1  $ void sleeve$
316 0             (501 -502 605 -603)         imp:n=1  $ void sleeves$
c$
317 35 0.0862393  (502 -503 602 -601)         imp:n=1  $ outer sheel of void sleeve$
318 35 0.0862393  (502 -503 605 -603)         imp:n=1  $ outer shell of void sleeves$
c$
319 35 0.0862393  (500 -503 601 -600)         imp:n=1  $ top of top sleeve$
320 35 0.0862393  (500 -503 19  -602)         imp:n=1  $ bottom of the top sleeve$
321 35 0.0862393  (500 -503 -605 604)         imp:n=1  $ top of top sleeve$
322 35 0.0862393  (500 -503 -20  603)         imp:n=1  $ bottom of the top sleeve$
c$
331 7  0.1001037  (503 -504  19 -600)         imp:n=1  $ water gap outside of void sleeve$
332 7  0.1001037  (503 -504 -20  604)         imp:n=1  $ water gap outside of void sleeve$
c$
333 35 0.0862393  (504 -505 602 -601)         imp:n=1  $ steel inside boron sleeve$
334 35 0.0862393  (504 -505 605 -603)         imp:n=1  $ steel inside boron sleeve$
c$
335 20 0.0250690  (505 -506 602 -601)         imp:n=1  $ boron power sleeve$
336 20 0.0250690  (505 -506 605 -603)         imp:n=1  $ boron powder sleeve$
c$
337 35 0.0862393  (506 -507 602 -601)         imp:n=1  $ outer shell boron sleeve$
338 35 0.0862393  (506 -507 605 -603)         imp:n=1  $ outer shell boron sleeve$
c$
339 35 0.0862393  (504 -507 601 -600)         imp:n=1  $ top of top sleeve$
340 35 0.0862393  (504 -507 19  -602)         imp:n=1  $ bottom of the top sleeve$
341 35 0.0862393  (504 -507 -605 604)         imp:n=1  $ top of top sleeve$
342 35 0.0862393  (504 -507 -20  603)         imp:n=1  $ bottom of the top sleeve$
c$
351 7  0.1001037  (507 -508 19  -600)         imp:n=1  $ water outside boron sleeve$
352 7  0.1001037  (507 -508 -20  604)         imp:n=1  $ water outside boron sleeve$
c$
353 35 0.0862393  (19  -600  508 -509)        imp:n=1  $ steel sleeve$
354 35 0.0862393  (604 -20   508 -509)        imp:n=1  $ steel sleeve                         $
c$
355 7 0.1001037   (7 -509 600 -8)             imp:n=1  $ water replaces Cd sheet$
356 7 0.1001037   (7 -509 9 -604)             imp:n=1  $ water replaces Cd sheet$
c ----------- water tanks ---------------------------------$
407 7  0.1001037  (29 -15 -27):(9 -20 -27 509):(-27 7 15 -9) imp:n=1 $ water $
408 7  0.1001037  (20 -31 24 -27)             imp:n=1  $ volume of lower tank around top tank$
409 9  0.0871549  (26 -25 -28):(27 -28 -31 25) imp:n=1  $ bottom tank shell$
410 0              -27 25 -30                 imp:n=1  $ void at the bottom of lower tank$
411 9  0.0871549  -29 30 -27                  imp:n=1  $ steel plate in lower tank above void$
412 0             31 -22 24 -28               imp:n=1  $ void over lower tank outside top tank$
c$
413 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1 $ upper tanks wall$
414 7  0.1001037  (19 -8 509 -23):(8 -21 -23 7) imp:n=1 $ water in the top tank$
415 0             (21 -14 7 -23):&$
                  (14 -18 16 -23):(17 -18 -6):&$
                  (18 -22 -23)                imp:n=1  $water inside top tank$
```

```
c ----- tbd ----------------------------------$
416 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$
417 0 999           imp:n=0$
$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$
3   pz -15.52575                $ bottom of active fuel region$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$
9   pz -15.8115                 $ bottom of fuel element$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$
12  pz  16.85925                $ vessel cover/flange interface$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$
14  pz  16.70177                $ bottom of vessel flange$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$
16  cz  16.46555                $ OR of vessel flange$
17  pz  16.93799                $ top of cover plate indent=$
18  pz  17.49425                $ top of cover plate flange$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$
21  pz  15.99565                $ top of the water :12.41" above the bottom of the fuel    $
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)               $
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$
c ----- begin internal be piece surfaces ----------------$
44  cz  11.1506     $ outside radius of internal be piece$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$
c ----- radial sleeve surfaces ----------------$
500 cz 11.50874  $ surface 7 + 1/16"$
501 cz 11.58748  $ +0.031"$
```

```
502 cz 19.05$
503 cz 19.12874$
504 cz 19.28749$
505 cz 19.36623$
506 cz 21.74875$
507 cz 21.82749$
508 cz 21.98624$
509 cz 22.62124$
c ---- axial sleeve surfaces ------------------$
600 pz 15.7607     $ 15.8115-(2.54)(0.02)=cd sheet $
601 pz 15.68196    $ 15.7607-(2.54)(0.031)=steel shell$
602 pz 6.30047$
603 pz 5.98551$
604 pz -15.7607    $ -15.8115 +(2.54)(0.02)=cd sheet$
605 pz -15.68196     $ -15.7607 +(2.54)(0.031)=steel shell$
c ---------------------------------------------$
999 so  55$
$
mode  n$
c ------npg----k----nsk---gen----$
kcode   1000  1.0  1000  3000$
ksrc    0  9.6012  0$
c --- sm2o3 coating ----$
m5    8016.60c 0.0161151 &$
     13027.60c 0.0050217 &$
     14000.60c 0.0042609 &$
     62147.66c 0.0000061 &$
     62149.66c 0.0000056 &$
     62150.50c 0.0000030 &$
     62152.50c 0.0000108$
c --- type 1100 aluminum ---------$
m6   13027.60c 0.0602626$
c --- water -----------$
m7    1001.60c 0.0667358 &$
      8016.60c 0.0333679$
mt7   lwtr.01t$
c --- Hastelloy N -----$
m8   28058.60c 0.0440590 &$
     28060.60c 0.0168440 &$
     28061.60c 0.0007293 &$
     28062.60c 0.0023169 &$
     28064.60c 0.0005873 &$
     26054.60c 0.0002818 &$
     26056.60c 0.0043815 &$
     26057.60c 0.0001003 &$
     26058.60c 0.0000134 &$
     24050.60c 0.0003121 &$
     24052.60c 0.0060187 &$
     24053.60c 0.0006824 &$
     24054.60c 0.0001699 &$
     42000.60c 0.0088982 &$
     14000.60c 0.0018998$
c --- ss316 -----------$
m9   26054.60c 0.0033463 &$
     26056.60c 0.0520202 &$
     26057.60c 0.0011910 &$
     26058.60c 0.0001588 &$
     24050.60c 0.0006870 &$
     24052.60c 0.0132476 &$
     24053.60c 0.0015020 &$
     24054.60c 0.0003739 &$
     28058.60c 0.0067490 &$
     28060.60c 0.0025802 &$
     28061.60c 0.0001117 &$
     28062.60c 0.0003549 &$
     28064.60c 0.0000900 &$
     42000.60c 0.0012601 &$
     25055.60c 0.0017604 &$
     14000.60c 0.0017218$
c --- lucite ----------$
m10   6000.60c 0.0354891 &$
```

```
      1001.60c 0.0567825 &$
      8016.60c 0.0141956$
mt10 poly.01t$
c --- Be metal ---------$
m11   4009.60c 0.1216164$
mt11   be.01t$
c --- natural B for poison sleeves$
m20  5010.60c  0.0049887   &$
     5011.60c  0.0200803  $
c ----cadmium -----------$
m30  48000.50c 0.0463402   $
c ---- Steel 304---------$
m35  26054.60c  0.0035020 &$
     26056.60c  0.0544408 &$
     26057.60c  0.0012465 &$
     26058.60c  0.0001662 &$
     28058.60c  0.0052698 &$
     28060.60c  0.0020147 & $
     28061.60c  0.0000872 &$
     28062.60c  0.0002771 &$
     28064.60c  0.0000702 &$
     24050.60c  0.0007573 &$
     24052.60c  0.0146033 & $
     24053.60c  0.0016557 &$
     24054.60c  0.0004122 &$
     25055.60c  0.0017363 $
c --- Definitions for the fuel elements:$
m81   92235.60c   0.001430699   &  $
      92238.60c   0.000103873   &  $
      40000.60c   0.035252214   &  $
       1001.60c   0.065346421   $
mt81   zr/h.01t   h/zr.01t$
m82   92235.60c   0.001432362   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035151269   &$
       1001.60c   0.063495921   $
mt82   zr/h.01t   h/zr.01t$
m83   92235.60c   0.001423493   &$
      92238.60c   0.000101903   &$
      40000.60c   0.035011378   &$
       1001.60c   0.064782612   $
mt83   zr/h.01t   h/zr.01t$
m84   92235.60c   0.001431586   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035287436   &$
       1001.60c   0.064459356   $
mt84   zr/h.01t   h/zr.01t$
m85   92235.60c   0.001430255   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035273259   &$
       1001.60c   0.064475748   $
mt85   zr/h.01t   h/zr.01t$
m86   92235.60c   0.001430588   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035251872   &$
       1001.60c   0.064395062   $
mt86   zr/h.01t   h/zr.01t$
m87   92235.60c   0.001433581   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035262547   &$
       1001.60c   0.064385381   $
mt87   zr/h.01t   h/zr.01t$
m88   92235.60c   0.001431031   &$
      92238.60c   0.000103763   &$
      40000.60c   0.03523959   &$
       1001.60c   0.064395062   $
mt88   zr/h.01t   h/zr.01t$
m89   92235.60c   0.001421165   &$
      92238.60c   0.000102341   &$
      40000.60c   0.035274751   &$
       1001.60c   0.063901235   $
```

```
mt89   zr/h.01t   h/zr.01t$
m90   92235.60c   0.00143092   &$
      92238.60c   0.000103873   &$
      40000.60c   0.035232421   &$
       1001.60c   0.064268326   $
mt90   zr/h.01t   h/zr.01t$
m91   92235.60c   0.001432472   &$
      92238.60c   0.000103982   &$
      40000.60c   0.035277465   &$
       1001.60c   0.063371257   $
mt91   zr/h.01t   h/zr.01t$
m92   92235.60c   0.001435466   &$
      92238.60c   0.000104311   &$
      40000.60c   0.035292717   &$
       1001.60c   0.063128228   $
mt92   zr/h.01t   h/zr.01t$
m93   92235.60c   0.001435576   &$
      92238.60c   0.000104092   &$
      40000.60c   0.035293905   &$
      1001.60c   0.063046588   $
mt93   zr/h.01t   h/zr.01t$
m94   92235.60c   0.001434579   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035310848   &$
       1001.60c   0.063451929   $
mt94   zr/h.01t   h/zr.01t$
m95   92235.60c   0.001421719   &$
      92238.60c   0.00010245   &$
      40000.60c   0.03498275   &$
       1001.60c   0.064943676   $
mt95   zr/h.01t   h/zr.01t$
m96   92235.60c   0.001425267   &$
      92238.60c   0.000102669   &$
      40000.60c   0.035080958   &$
       1001.60c   0.063267573   $
mt96   zr/h.01t   h/zr.01t$
m97   92235.60c   0.001423161   &$
      92238.60c   0.000103107   &$
      40000.60c   0.035280544   &$
       1001.60c   0.063506173   $
mt97   zr/h.01t   h/zr.01t$
m98   92235.60c   0.00143347   &$
      92238.60c   0.000103763   &$
      40000.60c   0.035522615   &$
       1001.60c   0.064888889   $
mt98   zr/h.01t   h/zr.01t$
m99   92235.60c   0.001417396   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035331825   &$
       1001.60c   0.063802469   $
mt99   zr/h.01t   h/zr.01t$
m100  92235.60c   0.001406643   &$
      92238.60c   0.000101793   &$
      40000.60c   0.035094624   &$
       1001.60c   0.064098765   $
mt100   zr/h.01t   h/zr.01t$
m101  92235.60c   0.001420057   &$
      92238.60c   0.000102778   &$
      40000.60c   0.035313464   &$
       1001.60c   0.064197531   $
mt101   zr/h.01t   h/zr.01t$
m102  92235.60c   0.001416842   &$
      92238.60c   0.000102559   &$
      40000.60c   0.035290936   &$
       1001.60c   0.062617284   $
mt102   zr/h.01t   h/zr.01t$
m103  92235.60c   0.001419281   &$
      92238.60c   0.000103326   &$
      40000.60c   0.035464348   &$
       1001.60c   0.064888889   $
mt103   zr/h.01t   h/zr.01t$
```

```
m104  92235.60c   0.001413738   &$
      92238.60c   0.000102997   &$
      40000.60c   0.035462436   &$
       1001.60c   0.063407407   $
mt104   zr/h.01t   h/zr.01t$
m105   92235.60c   0.001410634   &$
       92238.60c   9.34746E-05   &$
       40000.60c   0.035065703   &$
        1001.60c   0.063407407   $
mt105   zr/h.01t   h/zr.01t$
m106   92235.60c   0.001423604   &$
       92238.60c   0.000103435   &$
       40000.60c   0.035030992   &$
        1001.60c   0.063576057   $
mt106   zr/h.01t   h/zr.01t$
m107   92235.60c   0.001439235   &$
       92238.60c   0.00010453   &$
       40000.60c   0.035316009   &$
        1001.60c   0.064303281   $
mt107   zr/h.01t   h/zr.01t$
m108   92235.60c   0.001413294   &$
       92238.60c   0.000102669   &$
       40000.60c   0.034781046   &$
        1001.60c   0.062931948   $
mt108   zr/h.01t   h/zr.01t$
m109   92235.60c   0.001432362   &$
       92238.60c   0.000104311   &$
       40000.60c   0.035595633   &$
        1001.60c   0.064691358   $
mt109   zr/h.01t   h/zr.01t$
m110   92235.60c   0.001432251   &$
       92238.60c   0.000103982   &$
       40000.60c   0.035613144   &$
        1001.60c   0.063209877   $
mt110   zr/h.01t   h/zr.01t$
m111   92235.60c   0.001413405   &$
       92238.60c   0.000101793   &$
       40000.60c   0.035150204   &$
        1001.60c   0.066074074   $
mt111   zr/h.01t   h/zr.01t$
m112   92235.60c   0.001435687   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035468978   &$
        1001.60c   0.064547401   $
mt112   zr/h.01t   h/zr.01t$
m113   92235.60c   0.00143092   &$
       92238.60c   0.000103763   &$
       40000.60c   0.035308553   &$
        1001.60c   0.062367101   $
mt113   zr/h.01t   h/zr.01t$
m114   92235.60c   0.001427262   &$
       92238.60c   0.000103545   &$
       40000.60c   0.035208233   &$
        1001.60c   0.063381262   $
mt114   zr/h.01t   h/zr.01t$
m115   92235.60c   0.001419392   &$
       92238.60c   0.000103326   &$
       40000.60c   0.035428725   &$
        1001.60c   0.064493827   $
mt115   zr/h.01t   h/zr.01t$
m116   92235.60c   0.001430034   &$
       92238.60c   0.000104201   &$
       40000.60c   0.035494858   &$
        1001.60c   0.064790123   $
mt116   zr/h.01t   h/zr.01t$
m117   92235.60c   0.001432916   &$
       92238.60c   5.05682E-05   &$
       40000.60c   0.035671272   &$
        1001.60c   0.064592593   $
mt117   zr/h.01t   h/zr.01t$
print$
```

3.2.14 Case tbl1a

```
NAA-SR-9871,  case tbl1a            $$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described in Table 1, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with 33 fuel rods, 4 lucite rods and a$$
c dry core.  The water is 14.3975" above active fuel region bottom.$$
c The tank configuration used is that shown in$$
c Fig 48, of 9871.  The poison spline materials are modeled individually.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=2   trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=2   trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=2   trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=2   trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces ------------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ---------------------------------------------$$
80    10  0.1064672    -4 -2 3       u=2         imp:n=1  $ lucite rod$$
81    10  0.1064672    4:2:-3        u=2         imp:n=1  $ lucite$$
c ------- define the individual fuel rods $$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel         $$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating         $$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel         $$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating         $$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
```

```
c ---------                         $$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel         $$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating         $$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel         $$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating         $$
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel         $$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating         $$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel         $$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating         $$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel         $$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating         $$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel         $$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating         $$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel         $$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating         $$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel         $$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating         $$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel         $$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating         $$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel         $$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating         $$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel         $$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating         $$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel         $$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating         $$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel         $$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating         $$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel         $$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating         $$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
```

```
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel         $$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating         $$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel         $$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating         $$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel         $$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating         $$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel         $$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating         $$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel         $$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating         $$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel         $$
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating         $$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel         $$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating         $$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel         $$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating         $$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel         $$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating         $$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel         $$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating         $$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel         $$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating         $$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel         $$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating         $$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel         $$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating         $$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel         $$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating         $$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel         $$
```

```
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating         $$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel      $$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating      $$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel      $$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating      $$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel      $$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating      $$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel      $$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating      $$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel      $$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating      $$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                      $$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel      $$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating      $$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c -------------------------------------------------------$$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- tbd -------------------------------------$$
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$$
303 0                -6  10 -12                imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$$
c ----- tbd -------------------------------------$$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)              imp:n=1  $ aluminum cover plate$$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7)           imp:n=1  $ water $$
308 7  0.1001037  (20 -31 24 -27)                         imp:n=1  $ water of lower tank$$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)            imp:n=1  $ bottom tank shell$$
310 0              -27 25 -30                             imp:n=1  $ void bottom of lower tank$$
311 9 0.0871549   -29 30 -27                              imp:n=1  $ steel plate in lower tank$$
312 0             31 -22 24 -28                           imp:n=1  $ void over lower tank$$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22)          imp:n=1  $ upper tanks wall$$
314 7  0.1001037  (19 -14 7 -23):&$$
    (14 -18 16 -23):(17 -18 -6):(18 -21 -23)              imp:n=1  $ water inside top tank$$
315 0             (21 -22 -23)                            imp:n=1  $ void above top tank water$$
c$$
c ----- tbd -------------------------------------$$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$$
317 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$$
```

```
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$$
12  pz  16.85925                $ vessel cover/flange interface$$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$$
14  pz  16.70177                $ bottom of vessel flange$$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$$
16  cz  16.46555                $ OR of vessel flange$$
17  pz  16.93799                $ top of cover plate indent=$$
18  pz  17.49425                $ top of cover plate flange$$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$$
21  pz  22.4155                 $ top of the water in the top tank :14 15/16 "     $$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)                 $$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -------------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
```

```
c --- water -----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 ------------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c ---- lucite ----------$$
m10  6000.60c  0.0354891 &$$
     1001.60c  0.0567825 &$$
     8016.60c  0.0141956 $$
mt10 poly.01t            $$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19 $$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486 $$
mt519     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  23 $$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424 $$
mt523     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  26 $$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392 $$
mt526     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  37 $$
```

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m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417 $$
mt537     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  40 $$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479 $$
mt40     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  46 $$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  51 $$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413 $$
mt51     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  52 $$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490 $$
mt52     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  55 $$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410 $$
mt55     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  62 $$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406 $$
mt62     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  65 $$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410 $$
mt65     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  66 $$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424 $$
mt66     zr/h.01t  & $$
  h/zr.01t $$
```

```
c  --------------rod number:  67 $$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476 $$
mt67     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  68 $$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441 $$
mt68     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  80 $$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483 $$
mt80     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  81 $$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452 $$
mt81     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  83 $$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424 $$
mt83     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  84 $$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479 $$
mt84     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  85 $$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427 $$
mt85     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  86 $$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459 $$
mt86     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  92 $$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382 $$
mt92     zr/h.01t  &$$
```

```
  h/zr.01t $$
c  --------------rod number:  132 $$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427 $$
mt132     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  133 $$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424 $$
mt133     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  137 $$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364 $$
mt137     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  147 $$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375 $$
mt147     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  151 $$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466 $$
mt151     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  153 $$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455 $$
mt153     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  171 $$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476 $$
mt171     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  173 $$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417 $$
mt173     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  174 $$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493 $$
```

```
mt174     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  176 $$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462 $$
mt176     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  9 $$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497 $$
mt559     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  25 $$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479 $$
mt525     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  47 $$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479 $$
mt47     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  58 $$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476 $$
mt58     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  90 $$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382 $$
mt90     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  135 $$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424 $$
mt135     zr/h.01t  & $$
  h/zr.01t $$
print$$
```

3.2.15 Case tbl1b

```
NAA-SR-9871,  case tbl1b            $$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described in Table 1, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with 34 fuel rods, 3 lucite rods and a$$
c dry core.  The water is 12.06" above active fuel region bottom.$$
c The tank configuration used is that shown in$$
c Fig 48, of 9871.  The poison spline materials are modeled individually.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=2   trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=2   trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=2   trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces ------------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ----------------------------------------------$$
80    10  0.1064672    -4 -2 3       u=2         imp:n=1  $ lucite rod$$
81    10  0.1064672    4:2:-3        u=2         imp:n=1  $ lucite$$
c ------- define the individual fuel rods $$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel         $$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating         $$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel         $$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating         $$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
```

```
c ---------                         $$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel         $$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating         $$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel         $$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating         $$
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel         $$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating         $$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel         $$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating         $$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel         $$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating         $$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel         $$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating         $$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel         $$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating         $$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel         $$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating         $$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel         $$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating         $$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel         $$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating         $$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel         $$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating         $$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel         $$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating         $$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel         $$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating         $$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel         $$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating         $$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
```

```
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel         $$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating         $$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel         $$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating         $$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel         $$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating         $$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel         $$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating         $$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel         $$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating         $$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel         $$
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating         $$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel         $$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating         $$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel         $$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating         $$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel         $$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating         $$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel         $$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating         $$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel         $$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating         $$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel         $$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating         $$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel         $$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating         $$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel         $$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating         $$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel         $$
```

```
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating         $$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel      $$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating      $$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel      $$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating      $$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel      $$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating      $$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel      $$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating      $$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel      $$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating      $$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel      $$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating      $$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c -------------------------------------------------------$$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- tbd -------------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
303 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$$
c ----- tbd -------------------------------------$$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)               imp:n=1  $ aluminum cover plate$$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7)            imp:n=1  $ water $$
308 7  0.1001037  (20 -31 24 -27)                          imp:n=1  $ water of lower tank$$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)             imp:n=1  $ bottom tank shell$$
310 0              -27 25 -30                              imp:n=1  $ void bottom of lower tank$$
311 9 0.0871549   -29 30 -27                              imp:n=1  $ steel plate in lower tank$$
312 0             31 -22 24 -28                            imp:n=1  $ void over lower tank$$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22)           imp:n=1  $ upper tanks wall$$
314 7  0.1001037  (19 -21 7 -23)                           imp:n=1  $ water in top tank$$
315 0             (21 -14 7 -23):&$$
                  (14 -18 16 -23):(17 -18 -6):(18 -22 -23)  imp:n=1  $ void inside top tank$$
c ----- tbd -------------------------------------$$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$$
317 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$$
```

```
12  pz  16.85925                $ vessel cover/flange interface$$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$$
14  pz  16.70177                $ bottom of vessel flange$$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$$
16  cz  16.46555                $ OR of vessel flange$$
17  pz  16.93799                $ top of cover plate indent=$$
18  pz  17.49425                $ top of cover plate flange$$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$$
21  pz  15.10665                $ top of the water in the top tank :12.06"         $$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)               $$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces ----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -----------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water ----------$$
```

```
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c ---- lucite ----------$$
m10  6000.60c  0.0354891 &$$
     1001.60c  0.0567825 &$$
     8016.60c  0.0141956 $$
mt10 poly.01t             $$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19 $$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486 $$
mt519     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  23 $$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424 $$
mt523     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  26 $$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392 $$
mt526     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  37 $$
m537 92235.60c 0.0014023 &$$
```

```
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417 $$
mt537     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  40 $$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479 $$
mt40     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  46 $$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  51 $$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413 $$
mt51     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  52 $$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490 $$
mt52     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  55 $$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410 $$
mt55     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  62 $$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406 $$
mt62     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  65 $$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410 $$
mt65     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  66 $$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424 $$
mt66     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  67 $$
```

```
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476 $$
mt67     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  68 $$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441 $$
mt68     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  80 $$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483 $$
mt80     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  81 $$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452 $$
mt81     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  83 $$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424 $$
mt83     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  84 $$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479 $$
mt84     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  85 $$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427 $$
mt85     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  86 $$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459 $$
mt86     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  92 $$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382 $$
mt92     zr/h.01t  &$$
  h/zr.01t $$
```

```
c  --------------rod number:  132 $$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427 $$
mt132     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  133 $$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424 $$
mt133     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  137 $$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364 $$
mt137     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  147 $$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375 $$
mt147     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  151 $$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466 $$
mt151     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  153 $$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455 $$
mt153     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  171 $$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476 $$
mt171     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  173 $$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417 $$
mt173     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  174 $$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493 $$
mt174     zr/h.01t  & $$
```

```
  h/zr.01t $$
c  --------------rod number:  176 $$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462 $$
mt176     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  9 $$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497 $$
mt559     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  25 $$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479 $$
mt525     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  47 $$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479 $$
mt47     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  58 $$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476 $$
mt58     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  90 $$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382 $$
mt90     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  135 $$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424 $$
mt135     zr/h.01t  & $$
  h/zr.01t $$
print$$
```

3.2.16 Case tbl1c

```
NAA-SR-9871,  case tbl1c            $$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described in Table 1, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with 35 fuel rods, 2 lucite rods and a$$
c dry core.  The water is 11.06" above active fuel region bottom.$$
c The tank configuration used is that shown in$$
c Fig 48, of 9871.  The poison spline materials are modeled individually.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=2   trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=2   trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces ------------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ---------------------------------------------$$
80    10  0.1064672    -4 -2 3       u=2         imp:n=1  $ lucite rod$$
81    10  0.1064672    4:2:-3        u=2         imp:n=1  $ lucite$$
c ------- define the individual fuel rods $$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel         $$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating         $$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel         $$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating         $$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
```

```
c ---------                         $$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel         $$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating         $$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel         $$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating         $$
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel         $$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating         $$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel         $$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating         $$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel         $$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating         $$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel         $$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating         $$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel         $$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating         $$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel         $$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating         $$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel         $$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating         $$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel         $$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating         $$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel         $$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating         $$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel         $$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating         $$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel         $$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating         $$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel         $$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating         $$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
```

```
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel         $$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating        $$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel         $$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating        $$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel         $$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating        $$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel         $$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating        $$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel         $$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating        $$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel         $$
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating        $$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel         $$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating        $$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel         $$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating        $$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel         $$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating        $$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel         $$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating        $$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel         $$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating        $$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel         $$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating        $$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel         $$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating        $$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel         $$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating        $$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel         $$
```

```
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating         $$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel      $$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating      $$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel      $$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating      $$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel      $$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating      $$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel      $$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating      $$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel      $$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating      $$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel      $$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating      $$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c -------------------------------------------------------$$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- tbd -------------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
303 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$$
c ----- tbd -------------------------------------$$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)             imp:n=1  $ aluminum cover plate$$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7)          imp:n=1  $ water $$
308 7  0.1001037  (20 -31 24 -27)                        imp:n=1  $ water of lower tank$$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)           imp:n=1  $ bottom tank shell$$
310 0              -27 25 -30                            imp:n=1  $ void bottom of lower tank$$
311 9 0.0871549   -29 30 -27                             imp:n=1  $ steel plate in lower tank$$
312 0             31 -22 24 -28                          imp:n=1  $ void over lower tank$$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22)         imp:n=1  $ upper tanks wall$$
314 7  0.1001037  (19 -21 7 -23)                         imp:n=1  $ water in top tank$$
315 0             (21 -14 7 -23):&$$
                  (14 -18 16 -23):(17 -18 -6):(18 -22 -23)  imp:n=1  $ void inside top tank$$
c ----- tbd -------------------------------------$$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$$
317 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$$
```

```
12  pz  16.85925                $ vessel cover/flange interface$$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$$
14  pz  16.70177                $ bottom of vessel flange$$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$$
16  cz  16.46555                $ OR of vessel flange$$
17  pz  16.93799                $ top of cover plate indent=$$
18  pz  17.49425                $ top of cover plate flange$$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$$
21  pz  12.56665                $ top of the water in the top tank :11.06"         $$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)                $$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -----------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water ----------$$
```

```
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c ---- lucite ----------$$
m10  6000.60c  0.0354891 &$$
     1001.60c  0.0567825 &$$
     8016.60c  0.0141956 $$
mt10 poly.01t             $$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19 $$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486 $$
mt519     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  23 $$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424 $$
mt523     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  26 $$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392 $$
mt526     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  37 $$
m537 92235.60c 0.0014023 &$$
```

```
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417 $$
mt537     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  40 $$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479 $$
mt40     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  46 $$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  51 $$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413 $$
mt51     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  52 $$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490 $$
mt52     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  55 $$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410 $$
mt55     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  62 $$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406 $$
mt62     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  65 $$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410 $$
mt65     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  66 $$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424 $$
mt66     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  67 $$
```

```
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476 $$
mt67     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  68 $$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441 $$
mt68     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  80 $$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483 $$
mt80     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  81 $$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452 $$
mt81     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  83 $$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424 $$
mt83     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  84 $$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479 $$
mt84     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  85 $$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427 $$
mt85     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  86 $$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459 $$
mt86     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  92 $$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382 $$
mt92     zr/h.01t  &$$
  h/zr.01t $$
```

```
c  --------------rod number:  132 $$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427 $$
mt132     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  133 $$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424 $$
mt133     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  137 $$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364 $$
mt137     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  147 $$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375 $$
mt147     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  151 $$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466 $$
mt151     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  153 $$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455 $$
mt153     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  171 $$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476 $$
mt171     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  173 $$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417 $$
mt173     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  174 $$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493 $$
mt174     zr/h.01t  & $$
```

```
  h/zr.01t $$
c  --------------rod number:  176 $$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462 $$
mt176     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  9 $$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497 $$
mt559     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  25 $$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479 $$
mt525     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  47 $$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479 $$
mt47     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  58 $$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476 $$
mt58     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  90 $$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382 $$
mt90     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  135 $$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424 $$
mt135     zr/h.01t  & $$
  h/zr.01t $$
print$$
```

3.2.17 Case tbl1d

```
NAA-SR-9871,  case tbl1d            $$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described in Table 1, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with 36 fuel rods, 1 lucite rods and a$$
c dry core.  The water is 10.31" above active fuel region bottom.$$
c The tank configuration used is that shown in$$
c Fig 48, of 9871.  The poison spline materials are modeled individually.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=2   trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces ------------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ---------------------------------------------$$
80    10  0.1064672    -4 -2 3       u=2         imp:n=1  $ lucite rod$$
81    10  0.1064672    4:2:-3        u=2         imp:n=1  $ lucite$$
c ------- define the individual fuel rods $$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel         $$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating         $$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel         $$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating         $$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
```

```
c ---------                           $$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel         $$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating         $$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel         $$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating         $$
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel         $$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating         $$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel         $$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating         $$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel         $$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating         $$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel         $$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating         $$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel         $$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating         $$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel         $$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating         $$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel         $$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating         $$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel         $$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating         $$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel         $$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating         $$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel         $$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating         $$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel         $$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating         $$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel         $$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating         $$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
```

```
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel         $$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating         $$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel         $$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating         $$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel         $$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating         $$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel         $$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating         $$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel         $$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating         $$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel         $$
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating         $$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel         $$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating         $$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel         $$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating         $$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel         $$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating         $$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel         $$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating         $$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel         $$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating         $$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel         $$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating         $$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel         $$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating         $$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel         $$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating         $$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel         $$
```

```
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating         $$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel      $$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating      $$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel      $$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating      $$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel      $$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating      $$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel      $$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating      $$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel      $$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating      $$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel      $$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating      $$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c -------------------------------------------------------$$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- tbd -------------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
303 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$$
c ----- tbd -------------------------------------$$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)             imp:n=1  $ aluminum cover plate$$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7)          imp:n=1  $ water $$
308 7  0.1001037  (20 -31 24 -27)                        imp:n=1  $ water of lower tank$$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)           imp:n=1  $ bottom tank shell$$
310 0              -27 25 -30                            imp:n=1  $ void bottom of lower tank$$
311 9 0.0871549   -29 30 -27                             imp:n=1  $ steel plate in lower tank$$
312 0             31 -22 24 -28                          imp:n=1  $ void over lower tank$$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22)         imp:n=1  $ upper tanks wall$$
314 7  0.1001037  (19 -21 7 -23)                         imp:n=1  $ water in top tank$$
315 0             (21 -14 7 -23):&$$
                  (14 -18 16 -23):(17 -18 -6):(18 -22 -23)  imp:n=1  $ void inside top tank$$
c ----- tbd -------------------------------------$$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$$
317 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$$
```

```
12  pz  16.85925                $ vessel cover/flange interface$$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$$
14  pz  16.70177                $ bottom of vessel flange$$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$$
16  cz  16.46555                $ OR of vessel flange$$
17  pz  16.93799                $ top of cover plate indent=$$
18  pz  17.49425                $ top of cover plate flange$$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$$
21  pz  10.66165                $ top of the water in the top tank :10.31"         $$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)               $$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -----------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water ----------$$
```

```
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c ---- lucite ----------$$
m10  6000.60c  0.0354891 &$$
     1001.60c  0.0567825 &$$
     8016.60c  0.0141956 $$
mt10 poly.01t            $$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19 $$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486 $$
mt519     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  23 $$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424 $$
mt523     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  26 $$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392 $$
mt526     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  37 $$
m537 92235.60c 0.0014023 &$$
```

```
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417 $$
mt537     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  40 $$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479 $$
mt40     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  46 $$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  51 $$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413 $$
mt51     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  52 $$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490 $$
mt52     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  55 $$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410 $$
mt55     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  62 $$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406 $$
mt62     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  65 $$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410 $$
mt65     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  66 $$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424 $$
mt66     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  67 $$
```

```
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476 $$
mt67     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  68 $$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441 $$
mt68     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  80 $$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483 $$
mt80     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  81 $$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452 $$
mt81     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  83 $$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424 $$
mt83     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  84 $$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479 $$
mt84     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  85 $$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427 $$
mt85     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  86 $$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459 $$
mt86     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  92 $$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382 $$
mt92     zr/h.01t  &$$
  h/zr.01t $$
```

```
c  --------------rod number:  132 $$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427 $$
mt132     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  133 $$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424 $$
mt133     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  137 $$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364 $$
mt137     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  147 $$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375 $$
mt147     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  151 $$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466 $$
mt151     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  153 $$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455 $$
mt153     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  171 $$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476 $$
mt171     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  173 $$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417 $$
mt173     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  174 $$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493 $$
mt174     zr/h.01t  & $$
```

```
  h/zr.01t $$
c  --------------rod number:  176 $$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462 $$
mt176     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  9 $$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497 $$
mt559     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  25 $$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479 $$
mt525     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  47 $$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479 $$
mt47     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  58 $$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476 $$
mt58     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  90 $$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382 $$
mt90     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  135 $$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424 $$
mt135     zr/h.01t  & $$
  h/zr.01t $$
print$$
```

3.2.18 Case tbl1e

```
NAA-SR-9871,  case tbl1e            $$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described in Table 1, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with 37 fuel rods and a$$
c dry core.  The water is 9.88" above active fuel region bottom.$$
c The tank configuration used is that shown in$$
c Fig 48, of 9871.  The poison spline materials are modeled individually.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces ------------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ---------------------------------------------$$
80    10  0.1064672    -4 -2 3       u=2         imp:n=1  $ lucite rod$$
81    10  0.1064672    4:2:-3        u=2         imp:n=1  $ lucite$$
c ------- define the individual fuel rods $$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel         $$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating         $$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel         $$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating         $$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
```

```
c ---------                          $$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel         $$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating         $$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel         $$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating         $$
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel         $$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating         $$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel         $$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating         $$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel         $$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating         $$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel         $$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating         $$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel         $$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating         $$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel         $$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating         $$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel         $$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating         $$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel         $$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating         $$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel         $$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating         $$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel         $$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating         $$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel         $$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating         $$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel         $$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating         $$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                          $$
```

```
149   83  0.1022874    -1 -2 3        u=   83    imp:n=1  $ UZrHx fuel         $$
150   5   0.0265588    -4 1 -2 3      u=   83    imp:n=1  $ radial rod surface coating         $$
151   8   0.0872946    4:2:-3         u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
152   84  0.0996922    -1 -2 3        u=   84    imp:n=1  $ UZrHx fuel         $$
153   5   0.0265588    -4 1 -2 3      u=   84    imp:n=1  $ radial rod surface coating         $$
154   8   0.0872946    4:2:-3         u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
155   85  0.1004408    -1 -2 3        u=   85    imp:n=1  $ UZrHx fuel         $$
156   5   0.0265588    -4 1 -2 3      u=   85    imp:n=1  $ radial rod surface coating         $$
157   8   0.0872946    4:2:-3         u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
158   86  0.1021832    -1 -2 3        u=   86    imp:n=1  $ UZrHx fuel         $$
159   5   0.0265588    -4 1 -2 3      u=   86    imp:n=1  $ radial rod surface coating         $$
160   8   0.0872946    4:2:-3         u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
161   92  0.0997666    -1 -2 3        u=   92    imp:n=1  $ UZrHx fuel         $$
162   5   0.0265588    -4 1 -2 3      u=   92    imp:n=1  $ radial rod surface coating         $$
163   8   0.0872946    4:2:-3         u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
164   132 0.0996510    -1 -2 3        u=   132    imp:n=1  $ UZrHx fuel         $$
165   5   0.0265588    -4 1 -2 3      u=   132    imp:n=1  $ radial rod surface coating         $$
166   8   0.0872946    4:2:-3         u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
167   133 0.1013002    -1 -2 3        u=   133    imp:n=1  $ UZrHx fuel         $$
168   5   0.0265588    -4 1 -2 3      u=   133    imp:n=1  $ radial rod surface coating         $$
169   8   0.0872946    4:2:-3         u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
170   137 0.1006085    -1 -2 3        u=   137    imp:n=1  $ UZrHx fuel         $$
171   5   0.0265588    -4 1 -2 3      u=   137    imp:n=1  $ radial rod surface coating         $$
172   8   0.0872946    4:2:-3         u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
173   147 0.1001034    -1 -2 3        u=   147    imp:n=1  $ UZrHx fuel         $$
174   5   0.0265588    -4 1 -2 3      u=   147    imp:n=1  $ radial rod surface coating         $$
175   8   0.0872946    4:2:-3         u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
176   151 0.1009580    -1 -2 3        u=   151    imp:n=1  $ UZrHx fuel         $$
177   5   0.0265588    -4 1 -2 3      u=   151    imp:n=1  $ radial rod surface coating         $$
178   8   0.0872946    4:2:-3         u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
179   153 0.1008708    -1 -2 3        u=   153    imp:n=1  $ UZrHx fuel         $$
180   5   0.0265588    -4 1 -2 3      u=   153    imp:n=1  $ radial rod surface coating         $$
181   8   0.0872946    4:2:-3         u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
182   171 0.1022299    -1 -2 3        u=   171    imp:n=1  $ UZrHx fuel         $$
183   5   0.0265588    -4 1 -2 3      u=   171    imp:n=1  $ radial rod surface coating         $$
184   8   0.0872946    4:2:-3         u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
185   173 0.0994651    -1 -2 3        u=   173    imp:n=1  $ UZrHx fuel         $$
186   5   0.0265588    -4 1 -2 3      u=   173    imp:n=1  $ radial rod surface coating         $$
187   8   0.0872946    4:2:-3         u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
188   174 0.1019804    -1 -2 3        u=   174    imp:n=1  $ UZrHx fuel         $$
189   5   0.0265588    -4 1 -2 3      u=   174    imp:n=1  $ radial rod surface coating         $$
190   8   0.0872946    4:2:-3         u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                            $$
191   176 0.1021136    -1 -2 3        u=   176    imp:n=1  $ UZrHx fuel         $$
```

```
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating         $$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel      $$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating      $$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel      $$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating      $$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel      $$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating      $$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel      $$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating      $$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel      $$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating      $$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel      $$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating      $$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ----------------------------------------------------$$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- tbd ------------------------------------$$
301 6  0.0602626     -6   8 -10              imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11              imp:n=1  $ type 1100 aluminum lower gridplate$$
303 0                -6  10 -12              imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13              imp:n=1  $ vessel interior above upper gridplate$$
c ----- tbd ------------------------------------$$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)             imp:n=1  $ aluminum cover plate$$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7)          imp:n=1  $ water $$
308 7  0.1001037  (20 -31 24 -27)                        imp:n=1  $ water of lower tank$$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)           imp:n=1  $ bottom tank shell$$
310 0              -27 25 -30                            imp:n=1  $ void bottom of lower tank$$
311 9 0.0871549   -29 30 -27                             imp:n=1  $ steel plate in lower tank$$
312 0             31 -22 24 -28                          imp:n=1  $ void over lower tank$$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22)         imp:n=1  $ upper tanks wall$$
314 7  0.1001037  (19 -21 7 -23)                         imp:n=1  $ water in top tank$$
315 0             (21 -14 7 -23):&$$
                  (14 -18 16 -23):(17 -18 -6):(18 -22 -23)  imp:n=1  $ void inside top tank$$
c ----- tbd ------------------------------------$$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$$
317 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$$
```

```
12  pz  16.85925               $ vessel cover/flange interface$$
13  pz -18.93951               $ top of vessel bottom=-19.01825+(2.54)(0.031)$$
14  pz  16.70177               $ bottom of vessel flange$$
15  pz -19.01825               $ bottom of vessel bottom=6.06425-(2.54)(9.875)$$
16  cz  16.46555               $ OR of vessel flange$$
17  pz  16.93799               $ top of cover plate indent=$$
18  pz  17.49425               $ top of cover plate flange$$
19  pz  6.22173                $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$$
20  pz  6.06425                $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$$
21  pz  9.569455               $ top of the water in the top tank :9.88"         $$
22  pz  36.22675               $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                  $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743               $ OR of upper tank=((21/2)+0.062)(2.54)$$
25  pz -40.29075               $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$$
26  pz -40.60825               $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$$
27  cz  34.925                 $ IR of lower tank=(27.5/2)(2.54)$$
28  cz  35.08248               $ OR of lower tank=((27.5/2)+0.06)(2.54)$$
29  pz -32.35325               $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$$
30  pz -32.67075               $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$$
31  pz  21.30425               $ top of the bottom tank=36.22675-(2.54)(5.875)               $$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -------------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water ----------$$
```

```
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c ---- lucite ----------$$
m10  6000.60c  0.0354891 &$$
     1001.60c  0.0567825 &$$
     8016.60c  0.0141956 $$
mt10 poly.01t            $$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19 $$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486 $$
mt519     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  23 $$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424 $$
mt523     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  26 $$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392 $$
mt526     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  37 $$
m537 92235.60c 0.0014023 &$$
```

```
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417 $$
mt537     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  40 $$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479 $$
mt40     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  46 $$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  51 $$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413 $$
mt51     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  52 $$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490 $$
mt52     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  55 $$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410 $$
mt55     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  62 $$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406 $$
mt62     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  65 $$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410 $$
mt65     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  66 $$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424 $$
mt66     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  67 $$
```

```
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476 $$
mt67     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  68 $$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441 $$
mt68     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  80 $$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483 $$
mt80     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  81 $$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452 $$
mt81     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  83 $$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424 $$
mt83     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  84 $$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479 $$
mt84     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  85 $$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427 $$
mt85     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  86 $$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459 $$
mt86     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  92 $$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382 $$
mt92     zr/h.01t  &$$
  h/zr.01t $$
```

```
c  --------------rod number:  132 $$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427 $$
mt132     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  133 $$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424 $$
mt133     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  137 $$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364 $$
mt137     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  147 $$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375 $$
mt147     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  151 $$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466 $$
mt151     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  153 $$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455 $$
mt153     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  171 $$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476 $$
mt171     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  173 $$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417 $$
mt173     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  174 $$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493 $$
mt174     zr/h.01t  & $$
```

```
  h/zr.01t $$
c  --------------rod number:  176 $$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462 $$
mt176     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  9 $$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497 $$
mt559     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  25 $$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479 $$
mt525     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  47 $$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479 $$
mt47     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  58 $$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476 $$
mt58     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  90 $$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382 $$
mt90     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  135 $$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424 $$
mt135     zr/h.01t  & $$
  h/zr.01t $$
print$$
```

3.2.19 Case fig19

```
NAA-SR-9871, case fig19              $$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described by Fig 19, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with a full core compliment, full reflection/$$
c dry core, with 15 poison splines.  The tank configuration used is that shown in$$
c Fig 48, of 9871.  The poison spline materials are modeled individually.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces -----------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c -------define the makeup of each poison spline-------------------------$$
51 28 .022702 -100 -2 3 u=28 imp:n=1$$
52 0 100:2:-3 u=28 imp:n=1$$
c$$
53 29 .018214 -100 -2 3 u=29 imp:n=1$$
54  0 100:2:-3 u=29 imp:n=1$$
c$$
55 35 .021382 -100 -2 3 u=35 imp:n=1$$
56 0 100:2:-3 u=35 imp:n=1$$
c$$
57 33 .015970 -100 -2 3 u=33 imp:n=1$$
58 0 100:2:-3 u=33 imp:n=1$$
c$$
59 30 .019006 -100 -2 3 u=30 imp:n=1$$
```

```
60 0 100:2:-3 u=30 imp:n=1$$
c$$
61 23 .015574 -100 -2 3 u=23 imp:n=1$$
62 0 100:2:-3 u=23 imp:n=1$$
c$$
63 32 .018742 -100 -2 3 u=32 imp:n=1$$
64 0 100:2:-3 u=32 imp:n=1$$
c$$
65 27 .021117 -100 -2 3 u=27 imp:n=1$$
66 0 100:2:-3 u=27 imp:n=1$$
c$$
67 21 .014650 -100 -2 3 u=21 imp:n=1$$
68 0 100:2:-3 u=21 imp:n=1$$
c$$
69 22 .013066 -100 -2 3 u=22 imp:n=1$$
70 0 100:2:-3 u=22 imp:n=1$$
c$$
71 26 .021910 -100 -2 3 u=26 imp:n=1$$
72 0 100:2:-3 u=26 imp:n=1$$
c$$
73 34 .022437 -100 -2 3 u=34 imp:n=1$$
74 0 100:2:-3 u=34 imp:n=1$$
c$$
75 24 .020854 -100 -2 3 u=24 imp:n=1$$
76 0 100:2:-3 u=24 imp:n=1$$
c$$
77 25 .021513 -100 -2 3 u=25 imp:n=1$$
78 0 100:2:-3 u=25 imp:n=1$$
c$$
79 31 .018478 -100 -2 3 u=31 imp:n=1$$
80 0 100:2:-3 u=31 imp:n=1$$
c ------ fill each spline position with the correct spline:$$
81 0 -101 9 -8 fill=28 imp:n=1$$
82 like 81 but fill=29 trcl ( -5.51    -0.12    0) imp:n=1$$
83 like 81 but fill=35 trcl ( -2.77    1.52     0) imp:n=1$$
84 like 81 but fill=33 trcl ( 1.795    3.11     0) imp:n=1$$
85 like 81 but fill=30 trcl ( -11.08   -0.08    0) imp:n=1$$
86 like 81 but fill=23 trcl ( -6.39    4.67     0) imp:n=1$$
87 like 81 but fill=32 trcl ( -.84     7.90     0) imp:n=1$$
88 like 81 but fill=27 trcl ( -16.475   3.11    0) imp:n=1$$
89 like 81 but fill=21 trcl ( -11.08   6.35     0) imp:n=1$$
90 like 81 but fill=22 trcl ( -5.51    9.5      0) imp:n=1$$
91 like 81 but fill=26 trcl ( -3.66    12.74    0) imp:n=1$$
92 like 81 but fill=34 trcl ( -11.08   9.55     0) imp:n=1$$
93 like 81 but fill=24 trcl ( -14.7    9.55     0) imp:n=1$$
94 like 81 but fill=25 trcl ( -6.43    14.34    0) imp:n=1$$
95 like 81 but fill=31 trcl ( -11.05   12.7     0) imp:n=1$$
c ------- define the individual fuel rods $$
c The fuel rod universe is the number of the fuel rod$$
c with either a 5 in front or the first digit replaced with 5.$$
c For example, U=581 is for rod #81. u=501 is for rod #101.$$
c -----------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel         $$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating         $$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel         $$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating         $$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel         $$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating         $$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel         $$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating         $$
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
```

```
c ---------                           $$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel         $$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating        $$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel         $$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating        $$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel         $$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating        $$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel         $$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating        $$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel         $$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating        $$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel         $$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating        $$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel         $$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating        $$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel         $$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating        $$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel         $$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating        $$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel         $$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating        $$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel         $$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating        $$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel         $$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating        $$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel         $$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating        $$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel         $$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating        $$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
```

```
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel         $$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating         $$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel         $$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating         $$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel         $$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating         $$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel         $$
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating         $$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel         $$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating         $$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel         $$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating         $$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel         $$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating         $$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel         $$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating         $$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel         $$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating         $$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel         $$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating         $$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel         $$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating         $$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel         $$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating         $$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel         $$
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating         $$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
194   559 0.0994427    -1 -2 3        u=   559    imp:n=1  $ UZrHx fuel      $$
195   5   0.0265588    -4 1 -2 3      u=   559    imp:n=1  $ radial rod surface coating      $$
196   8   0.0872946    4:2:-3         u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
197   525 0.0999884    -1 -2 3        u=   525    imp:n=1  $ UZrHx fuel      $$
```

```
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating      $$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel      $$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating      $$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel      $$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating      $$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                         $$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel      $$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating      $$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel      $$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating      $$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c -------------------------------------------------------$$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         #81 #82 #83 #84 #85 #86 #87 #88 #89 #90 #91 #92 #93&$$
         #94 #95      imp:n=1  $ vessel interior between elements - void filled$$
c ----- tbd -------------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
303 0                -6  10 -12               imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$$
c ----- tbd -------------------------------------$$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)             imp:n=1  $ aluminum cover plate$$
307 7  0.1001037  (29 -15 -27  ):(15 -20 -27 7)          imp:n=1  $ water $$
308 7  0.1001037  (20 -31 24 -27)                        imp:n=1  $ top of lower tank h2o$$
309 9  0.0871549  (26 -25 -28):(27 -28 -31 25)           imp:n=1  $ bottom tank shell$$
310 0              -27 25 -30                            imp:n=1  $ void bottom of lower tank$$
311 9 0.0871549   -29 30 -27                             imp:n=1  $ steel plate in lower tank$$
312 0             31 -22 24 -28                          imp:n=1  $ tank outside top tank$$
313 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22)         imp:n=1  $ upper tanks wall$$
314 7  0.1001037  (19 -14 7 -23):&$$
    (14 -18 16 -23):(17 -18 -6):(18 -21 -23)             imp:n=1  $ water inside top tank$$
315 0             (21 -22 -23)                           imp:n=1  $ void over top tank water$$
c$$
c ----- tbd -------------------------------------$$
316 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$$
317 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$$
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$$
12  pz  16.85925                $ vessel cover/flange interface$$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$$
14  pz  16.70177                $ bottom of vessel flange$$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$$
16  cz  16.46555                $ OR of vessel flange$$
17  pz  16.93799                $ top of cover plate indent=$$
18  pz  17.49425                $ top of cover plate flange$$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$$
```

```
20  pz  6.06425                $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$$
21  pz  22.4155                $ top of the water in the top tank :14 15/16 "     $$
22  pz  36.22675               $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                  $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743               $ OR of upper tank=((21/2)+0.062)(2.54)$$
25  pz -40.29075               $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$$
26  pz -40.60825               $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$$
27  cz  34.925                 $ IR of lower tank=(27.5/2)(2.54)$$
28  cz  35.08248               $ OR of lower tank=((27.5/2)+0.06)(2.54)$$
29  pz -32.35325               $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$$
30  pz -32.67075               $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$$
31  pz  21.30425               $ top of the bottom tank=36.22675-(2.54)(5.875)               $$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces ----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c ----- tbd ------------------------------------$$
c  surfaces for splines$$
100 c/z 7.34 -6.31 0.208  $$
101 c/z 7.34 -6.31 0.208001$$
c ------------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water ----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
```

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m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 ------------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- natural B for poison splines$$
m28  5010.60c  0.004518 &$$
     5011.60c  0.018184$$
c --- natural B for poison splines$$
m29  5010.60c  0.003625 &$$
     5011.60c  0.014589$$
c --- natural B for poison splines$$
m35  5010.60c  0.004255 &$$
     5011.60c  0.017127$$
c --- natural B for poison splines$$
m33  5010.60c  0.003178 &$$
     5011.60c  0.012792$$
c --- natural B for poison splines$$
m30  5010.60c  0.003782 &$$
     5011.60c  0.015224$$
c --- natural B for poison splines$$
m23  5010.60c  0.003099 &$$
     5011.60c  0.012475$$
c --- natural B for poison splines$$
m32  5010.60c  0.003730 &$$
     5011.60c  0.015012$$
c --- natural B for poison splines$$
m27  5010.60c  0.004202 &$$
     5011.60c  0.016915$$
c --- natural B for poison splines$$
m21  5010.60c  0.002915 &$$
     5011.60c  0.011735$$
c --- natural B for poison splines$$
m22  5010.60c  0.002600 &$$
     5011.60c  0.010466$$
c --- natural B for poison splines$$
m26  5010.60c  0.004360 &$$
     5011.60c  0.017550$$
c --- natural B for poison splines$$
m34  5010.60c  0.004465 &$$
     5011.60c  0.017972$$
```

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c --- natural B for poison splines$$
m24  5010.60c  0.004150 &$$
     5011.60c  0.016704$$
c --- natural B for poison splines$$
m25  5010.60c  0.004281 &$$
     5011.60c  0.017232$$
c --- natural B for poison splines$$
m31  5010.60c  0.003677 &$$
     5011.60c  0.014801$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19 $$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486 $$
mt519     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  23 $$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424 $$
mt523     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  26 $$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392 $$
mt526     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  37 $$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417 $$
mt537     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  40 $$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479 $$
mt40     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  46 $$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  51 $$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413 $$
mt51     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  52 $$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
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      6000.60c 0.0004490 $$
mt52     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  55 $$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410 $$
mt55     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  62 $$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406 $$
mt62     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  65 $$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410 $$
mt65     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  66 $$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424 $$
mt66     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  67 $$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476 $$
mt67     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  68 $$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441 $$
mt68     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  80 $$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483 $$
mt80     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  81 $$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452 $$
mt81     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  83 $$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
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      1001.60c 0.0654514 &$$
      6000.60c 0.0004424 $$
mt83     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  84 $$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479 $$
mt84     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  85 $$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427 $$
mt85     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  86 $$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459 $$
mt86     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  92 $$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382 $$
mt92     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  132 $$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427 $$
mt132     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  133 $$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424 $$
mt133     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  137 $$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364 $$
mt137     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  147 $$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375 $$
mt147     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  151 $$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
```

```
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466 $$
mt151     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  153 $$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455 $$
mt153     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  171 $$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476 $$
mt171     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  173 $$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417 $$
mt173     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  174 $$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493 $$
mt174     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  176 $$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462 $$
mt176     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  9 $$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497 $$
mt559     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  25 $$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479 $$
mt525     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  47 $$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479 $$
mt47     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  58 $$
m58  92235.60c 0.0014212 &$$
```

```
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476 $$
mt58     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  90 $$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382 $$
mt90     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  135 $$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424 $$
mt135     zr/h.01t  & $$
  h/zr.01t $$
print$$
```

3.2.20 Case p45

```
NAA-SR-9871, case p45$$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described on p45, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with the tank configuration shown in$$
c Fig 27 of 9871.  It has a full core loading, and the core is voided.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces -----------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ----------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel$$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating$$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel$$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating$$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel$$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating$$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel$$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating$$
```

```
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel$$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating$$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel$$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating$$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel$$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating$$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel$$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating$$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel$$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating$$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel$$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating$$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel$$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating$$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel$$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating$$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel$$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating$$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel$$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating$$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel$$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating$$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel$$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating$$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel$$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating$$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel$$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating$$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel$$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating$$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel$$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating$$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel$$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating$$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel$$
```

```
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating$$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel$$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating$$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel$$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating$$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel$$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating$$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel$$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating$$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel$$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating$$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel$$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating$$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel$$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating$$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel$$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating$$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel$$
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating$$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel$$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating$$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel$$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating$$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel$$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating$$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel$$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating$$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel$$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating$$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel$$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating$$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------------------------------------------------$$
300 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- vessel interior spaces  -----------------------------------$$
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$$
```

```
303 0               (-6  10 -14):(14 -16)     imp:n=1  $ vessel interior above upper gridplate$$
304 0               -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$$
c ----- reactor vessel ------------------------------------$$
400 9  0.0871549  (-7 6 -14 13):(-12 16 14)             imp:n=1  $ ss316 vessel walls$$
401 6  0.0602626  (-7 15 -13)                           imp:n=1  $ aluminum bottom of vessel$$
402 7  0.1001037  (7 -17 19 -14)                        imp:n=1  $ upper water gap$$
403 7  0.1001037  (7 -17 -20 15)                        imp:n=1  $ lower water gap$$
407 12 0.0708762  (17 -18 19 -14)                       imp:n=1  $ binal sleeve$$
408 12 0.0708762  (17 -18 -20 15)                       imp:n=1  $ lower binal sleeve$$
c ----- water tanks ----------------------------$$
500 7  0.1001037  (29 -15 -27):(15 -20 -27 18 )         imp:n=1  $ water in the lower tank$$
501 7  0.1001037  (-27 24 20 -31)                       imp:n=1  $ void between top/bottom$$
502 9  0.0871549  (-29 -28 30):(27 -28 29 -31)          imp:n=1  $ bottom tank shell$$
c$$
506 9  0.0871549  (-19 20 7  -24):(-24 23 19 -22)       imp:n=1  $ upper tanks wall$$
507 7  0.1001037  (19 -14 18  -23):(14 12 -21 -23)      imp:n=1  $ water inside top tank$$
508 0             (21 -22 -23)                          imp:n=1  $ void above top tank water$$
509 0             (-22 31 -28 24)                       imp:n=1  $ void outside top tank$$
c$$
c ----- outside world ------------------------------------$$
516 0   (22 -999):(-22 31 28 -999):(28 -999 30 -31):(-30 -999) imp:n=1$$
517 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.303                  $ IR of rx vessel=(8.9/2)(2.54)$$
7   cz  11.38174                $ OR of rx vessel=((8.9/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.129                  $ top of upper grid plate =15.8115+(2.54)(0.125)$$
11  pz -17.0815                 $ bottom of lower grid plate=-15.8115-(2.54)(0.5)$$
12  kz 21.9837 12.8508 -1       $ top of rx vessel: vertex at 0,0,21.9837.$$
c                                 tan^2 of the opening angle=12.8508$$
13  pz -18.8341                 $ top of vessel bottom=-15.8115-(2.54)(1.19)$$
14  pz  18.8087                 $ beginning of conical top=15.8115+1.18"$$
15  pz -19.4691                 $ bottom of vessel bottom=-15.8115-1.44"$$
16  kz 21.90496 13.3262 -1      $ inside top of rx vessel: vertex at 0,0,21.90496.$$
17  cz 12.01674                 $ inside surface of binal sleeve$$
18  cz 12.65174                 $ outside surface of binal sleeve$$
19  pz  6.01218                 $ top of bottom plate for upper tank=15.8115-3.92"+0.062"$$
20  pz  5.8547                  $ bottom of bottom plate for upper tank=15.8115-3.92"$$
21  pz  30.9499                 $ top of the water in the top tank=15.8115+5.96"$$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
c$$
27  cz  34.24174                $ IR of lower tank=(surface 7)+9"$$
28  cz  34.3992                 $ OR of lower tank=$$
29  pz -33.7439                 $ top of bottom plate for lower tank=-15.8115-7.06"$$
30  pz -34.0614                 $ bottom of lower tank=-33.7439-0.125"$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)$$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
```

```
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -------------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water -----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c --- Be metal ---------$$
```

```
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C -----------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19$$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486$$
mt519     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  23$$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424$$
mt523     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  26$$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392$$
mt526     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  37$$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417$$
mt537     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  40$$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479$$
mt40     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  46$$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  51$$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413$$
mt51     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  52$$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490$$
```

```
mt52     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  55$$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410$$
mt55     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  62$$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406$$
mt62     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  65$$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410$$
mt65     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  66$$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424$$
mt66     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  67$$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476$$
mt67     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  68$$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441$$
mt68     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  80$$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483$$
mt80     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  81$$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452$$
mt81     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  83$$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
```

```
      6000.60c 0.0004424$$
mt83     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  84$$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479$$
mt84     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  85$$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427$$
mt85     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  86$$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459$$
mt86     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  92$$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382$$
mt92     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  132$$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427$$
mt132     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  133$$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424$$
mt133     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  137$$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364$$
mt137     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  147$$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375$$
mt147     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  151$$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
```

```
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466$$
mt151     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  153$$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455$$
mt153     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  171$$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476$$
mt171     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  173$$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417$$
mt173     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  174$$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493$$
mt174     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  176$$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462$$
mt176     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  9$$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497$$
mt559     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  25$$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479$$
mt525     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  47$$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479$$
mt47     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  58$$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
```

```
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476$$
mt58     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  90$$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382$$
mt90     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  135$$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424$$
mt135     zr/h.01t  &$$
  h/zr.01t$$
print$$
```

3.2.21 Case p46a

```
NAA-SR-9871, case p46a$$
c Feb 25, 2005$$
c model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described on p46, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with the tank configuration shown in$$
c Fig 27 of 9871.  It has a full core loading, and the core is voided.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces -----------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ----------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel$$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating$$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel$$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating$$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel$$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating$$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel$$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating$$
```

```
112   8   0.0872946    4:2:-3         u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
113   40  0.1000871    -1 -2 3        u=   40    imp:n=1  $ UZrHx fuel$$
114   5   0.0265588    -4 1 -2 3      u=   40    imp:n=1  $ radial rod surface coating$$
115   8   0.0872946    4:2:-3         u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
116   46  0.1014395    -1 -2 3        u=   46    imp:n=1  $ UZrHx fuel$$
117   5   0.0265588    -4 1 -2 3      u=   46    imp:n=1  $ radial rod surface coating$$
118   8   0.0872946    4:2:-3         u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
119   51  0.1017065    -1 -2 3        u=   51    imp:n=1  $ UZrHx fuel$$
120   5   0.0265588    -4 1 -2 3      u=   51    imp:n=1  $ radial rod surface coating$$
121   8   0.0872946    4:2:-3         u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
122   52  0.1017538    -1 -2 3        u=   52    imp:n=1  $ UZrHx fuel$$
123   5   0.0265588    -4 1 -2 3      u=   52    imp:n=1  $ radial rod surface coating$$
124   8   0.0872946    4:2:-3         u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
125   55  0.1014800    -1 -2 3        u=   55    imp:n=1  $ UZrHx fuel$$
126   5   0.0265588    -4 1 -2 3      u=   55    imp:n=1  $ radial rod surface coating$$
127   8   0.0872946    4:2:-3         u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
128   62  0.1013522    -1 -2 3        u=   62    imp:n=1  $ UZrHx fuel$$
129   5   0.0265588    -4 1 -2 3      u=   62    imp:n=1  $ radial rod surface coating$$
130   8   0.0872946    4:2:-3         u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
131   65  0.1012826    -1 -2 3        u=   65    imp:n=1  $ UZrHx fuel$$
132   5   0.0265588    -4 1 -2 3      u=   65    imp:n=1  $ radial rod surface coating$$
133   8   0.0872946    4:2:-3         u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
134   66  0.0999181    -1 -2 3        u=   66    imp:n=1  $ UZrHx fuel$$
135   5   0.0265588    -4 1 -2 3      u=   66    imp:n=1  $ radial rod surface coating$$
136   8   0.0872946    4:2:-3         u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
137   67  0.1013414    -1 -2 3        u=   67    imp:n=1  $ UZrHx fuel$$
138   5   0.0265588    -4 1 -2 3      u=   67    imp:n=1  $ radial rod surface coating$$
139   8   0.0872946    4:2:-3         u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
140   68  0.1016430    -1 -2 3        u=   68    imp:n=1  $ UZrHx fuel$$
141   5   0.0265588    -4 1 -2 3      u=   68    imp:n=1  $ radial rod surface coating$$
142   8   0.0872946    4:2:-3         u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
143   80  0.1013008    -1 -2 3        u=   80    imp:n=1  $ UZrHx fuel$$
144   5   0.0265588    -4 1 -2 3      u=   80    imp:n=1  $ radial rod surface coating$$
145   8   0.0872946    4:2:-3         u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
146   81  0.1014340    -1 -2 3        u=   81    imp:n=1  $ UZrHx fuel$$
147   5   0.0265588    -4 1 -2 3      u=   81    imp:n=1  $ radial rod surface coating$$
148   8   0.0872946    4:2:-3         u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
149   83  0.1022874    -1 -2 3        u=   83    imp:n=1  $ UZrHx fuel$$
150   5   0.0265588    -4 1 -2 3      u=   83    imp:n=1  $ radial rod surface coating$$
151   8   0.0872946    4:2:-3         u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
152   84  0.0996922    -1 -2 3        u=   84    imp:n=1  $ UZrHx fuel$$
153   5   0.0265588    -4 1 -2 3      u=   84    imp:n=1  $ radial rod surface coating$$
154   8   0.0872946    4:2:-3         u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
155   85  0.1004408    -1 -2 3        u=   85    imp:n=1  $ UZrHx fuel$$
156   5   0.0265588    -4 1 -2 3      u=   85    imp:n=1  $ radial rod surface coating$$
157   8   0.0872946    4:2:-3         u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
158   86  0.1021832    -1 -2 3        u=   86    imp:n=1  $ UZrHx fuel$$
159   5   0.0265588    -4 1 -2 3      u=   86    imp:n=1  $ radial rod surface coating$$
160   8   0.0872946    4:2:-3         u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
161   92  0.0997666    -1 -2 3        u=   92    imp:n=1  $ UZrHx fuel$$
162   5   0.0265588    -4 1 -2 3      u=   92    imp:n=1  $ radial rod surface coating$$
163   8   0.0872946    4:2:-3         u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
164   132 0.0996510    -1 -2 3        u=   132    imp:n=1  $ UZrHx fuel$$
```

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165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating$$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel$$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating$$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel$$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating$$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel$$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating$$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel$$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating$$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel$$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating$$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel$$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating$$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel$$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating$$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel$$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating$$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel$$
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating$$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel$$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating$$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel$$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating$$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel$$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating$$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel$$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating$$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel$$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating$$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel$$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating$$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ----------------------------------------------------$$
300 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- vessel interior spaces  ------------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
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303 0                (-6  10 -14):(14 -16)     imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$$
c ----- reactor vessel -----------------------------------$$
400 9  0.0871549  (-7 6 -14 13):(-12 16 14)              imp:n=1  $ ss316 vessel walls$$
401 6  0.0602626  (-7 15 -13)                            imp:n=1  $ aluminum bottom of vessel$$
402 7 0.1001037   (7 -17 19 -14)                         imp:n=1  $ upper water gap$$
403 7  0.1001037  (7 -17 -20 15)                         imp:n=1  $ lower water gap$$
407 7 0.1001037   (17 -18 19 -14)                        imp:n=1  $ water$$
408 12 0.0708762  (17 -18 -20 15)                        imp:n=1  $ lower binal sleeve$$
c ----- water tanks ----------------------------$$
500 7  0.1001037  (29 -15 -27):(15 -20 -27 18 )          imp:n=1  $ water in the lower tank$$
501 7  0.1001037  (-27 24 20 -31)                        imp:n=1  $ void between top/bottom$$
502 9  0.0871549  (-29 -28 30):(27 -28 29 -31)           imp:n=1  $ bottom tank shell$$
c$$
506 9  0.0871549  (-19 20 7  -24):(-24 23 19 -22)        imp:n=1  $ upper tanks wall$$
507 7  0.1001037  (19 -14 18  -23):(14 12 -21 -23)       imp:n=1  $ water inside top tank$$
508 0             (21 -22 -23)                           imp:n=1  $ void above top tank water$$
509 0             (-22 31 -28 24)                        imp:n=1  $ void outside top tank$$
c ----- outside world -----------------------------------$$
516 0   (22 -999):(-22 31 28 -999):(28 -999 30 -31):(-30 -999) imp:n=1$$
517 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.303                  $ IR of rx vessel=(8.9/2)(2.54)$$
7   cz  11.38174                $ OR of rx vessel=((8.9/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.129                  $ top of upper grid plate =15.8115+(2.54)(0.125)$$
11  pz -17.0815                 $ bottom of lower grid plate=-15.8115-(2.54)(0.5)$$
12  kz 21.9837 12.8508 -1       $ top of rx vessel: vertex at 0,0,21.9837.$$
c                                 tan^2 of the opening angle=12.8508$$
13  pz -18.8341                 $ top of vessel bottom=-15.8115-(2.54)(1.19)$$
14  pz  18.8087                 $ beginning of conical top=15.8115+1.18"$$
15  pz -19.4691                 $ bottom of vessel bottom=-15.8115-1.44"$$
16  kz 21.90496 13.3262 -1      $ inside top of rx vessel: vertex at 0,0,21.90496.$$
17  cz 12.01674                 $ inside surface of binal sleeve$$
18  cz 12.65174                 $ outside surface of binal sleeve$$
19  pz  6.01218                 $ top of bottom plate for upper tank=15.8115-3.92"+0.062"$$
20  pz  5.8547                  $ bottom of bottom plate for upper tank=15.8115-3.92"$$
21  pz  30.9499                 $ top of the water in the top tank=15.8115+5.96"$$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
c$$
27  cz  34.24174                $ IR of lower tank=(surface 7)+9"$$
28  cz  34.3992                 $ OR of lower tank=$$
29  pz -33.7439                 $ top of bottom plate for lower tank=-15.8115-7.06"$$
30  pz -34.0614                 $ bottom of lower tank=-33.7439-0.125"$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)$$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
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60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -------------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water -----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
```

```
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C -----------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19$$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486$$
mt519     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  23$$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424$$
mt523     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  26$$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392$$
mt526     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  37$$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417$$
mt537     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  40$$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479$$
mt40     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  46$$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  51$$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413$$
mt51     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  52$$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490$$
mt52     zr/h.01t  &$$
```

```
  h/zr.01t$$
c  --------------rod number:  55$$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410$$
mt55     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  62$$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406$$
mt62     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  65$$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410$$
mt65     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  66$$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424$$
mt66     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  67$$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476$$
mt67     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  68$$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441$$
mt68     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  80$$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483$$
mt80     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  81$$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452$$
mt81     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  83$$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424$$
```

```
mt83     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  84$$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479$$
mt84     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  85$$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427$$
mt85     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  86$$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459$$
mt86     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  92$$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382$$
mt92     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  132$$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427$$
mt132     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  133$$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424$$
mt133     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  137$$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364$$
mt137     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  147$$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375$$
mt147     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  151$$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
```

```
      6000.60c 0.0004466$$
mt151     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  153$$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455$$
mt153     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  171$$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476$$
mt171     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  173$$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417$$
mt173     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  174$$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493$$
mt174     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  176$$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462$$
mt176     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  9$$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497$$
mt559     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  25$$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479$$
mt525     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  47$$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479$$
mt47     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  58$$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
```

```
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476$$
mt58     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  90$$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382$$
mt90     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  135$$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424$$
mt135     zr/h.01t  &$$
  h/zr.01t$$
print$$
```

3.2.22 Case p46b

```
NAA-SR-9871, case p46b$$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described on p46, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with the tank configuration shown in$$
c Fig 27 of 9871.  It has a full core loading, and the core is voided.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces -----------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ----------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel$$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating$$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel$$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating$$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel$$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating$$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel$$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating$$
```

```
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel$$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating$$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel$$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating$$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel$$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating$$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel$$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating$$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel$$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating$$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel$$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating$$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel$$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating$$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel$$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating$$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel$$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating$$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel$$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating$$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel$$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating$$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel$$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating$$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel$$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating$$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel$$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating$$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel$$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating$$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel$$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating$$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel$$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating$$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel$$
```

```
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating$$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel$$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating$$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel$$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating$$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel$$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating$$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel$$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating$$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel$$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating$$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel$$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating$$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel$$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating$$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel$$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating$$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel$$
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating$$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel$$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating$$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel$$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating$$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel$$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating$$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel$$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating$$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel$$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating$$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel$$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating$$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------------------------------------------------$$
300 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- vessel interior spaces  -----------------------------------$$
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$$
```

```
303 0              (-6  10 -14):(14 -16)     imp:n=1  $ vessel interior above upper gridplate$$
304 0               -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$$
c ----- reactor vessel -----------------------------------$$
400 9  0.0871549  (-7 6 -14 13):(-12 16 14)              imp:n=1  $ ss316 vessel walls$$
401 6  0.0602626  (-7 15 -13)                            imp:n=1  $ aluminum bottom of vessel$$
403 7  0.1001037  (7 -17 -20 15):(-17 101 -15)           imp:n=1  $ water below vessel$$
408 7  0.1001037  (17 -18 -20 100)                       imp:n=1  $ water above lower sleeve$$
409 12 0.0708762  (17 -18 -100 15)                       imp:n=1  $ lower binal sleeve$$
410 12 0.0708762  (17 -18 -15 101)                       imp:n=1  $ binal sleeve below vessel$$
c ----- water tanks ----------------------------$$
500 7  0.1001037  (29 -101 -27):(101 -20 -27 18 )        imp:n=1  $ water in the lower tank$$
501 7  0.1001037  (-27 24 20 -31)                        imp:n=1  $ water between top/bottom$$
502 9  0.0871549  (-29 -28 30):(27 -28 29 -31)           imp:n=1  $ bottom tank shell$$
c$$
506 9  0.0871549  (-19 20 7  -24):(-24 23 19 -22)        imp:n=1  $ upper tanks wall$$
507 7  0.1001037  (19 -102 7  -23)                       imp:n=1  $ water inside top tank$$
508 0             (102 -14 7  -23)                       imp:n=1  $$
509 0             (14 12 -22 -23)                        imp:n=1  $ void inside top tank$$
510 0             (-22 31 -28 24)                        imp:n=1  $ void outside  top tank$$
c ----- outside world -----------------------------------$$
516 0   (22 -999):(-22 31 28 -999):(28 -999 30 -31):(-30 -999) imp:n=1$$
517 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.303                  $ IR of rx vessel=(8.9/2)(2.54)$$
7   cz  11.38174                $ OR of rx vessel=((8.9/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.129                  $ top of upper grid plate =15.8115+(2.54)(0.125)$$
11  pz -17.0815                 $ bottom of lower grid plate=-15.8115-(2.54)(0.5)$$
12  kz 21.9837 12.8508 -1       $ top of rx vessel: vertex at 0,0,21.9837.$$
c                                 tan^2 of the opening angle=12.8508$$
13  pz -18.8341                 $ top of vessel bottom=-15.8115-(2.54)(1.19)$$
14  pz  18.8087                 $ beginning of conical top=15.8115+1.18"$$
15  pz -19.4691                 $ bottom of vessel bottom=-15.8115-1.44"$$
16  kz 21.90496 13.3262 -1      $ inside top of rx vessel: vertex at 0,0,21.90496.$$
17  cz 12.01674                 $ inside surface of binal sleeve$$
18  cz 12.65174                 $ outside surface of binal sleeve$$
19  pz  6.01218                 $ top of bottom plate for upper tank=15.8115-3.92"+0.062"$$
20  pz  5.8547                  $ bottom of bottom plate for upper tank=15.8115-3.92"$$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
c$$
27  cz  34.24174                $ IR of lower tank=(surface 7)+9"$$
28  cz  34.3992                 $ OR of lower tank=$$
29  pz -33.7439                 $ top of bottom plate for lower tank=-15.8115-7.06"$$
30  pz -34.0614                 $ bottom of lower tank=-33.7439-0.125"$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)$$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
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60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -----------------------------------------------$$
c  surfaces for sleeve $$
100 pz -8.66775    $top of binal sleeve:-15.52572+2.7"$$
101 pz -21.46427   $bottom of sleeve=-8.66775-5.038"$$
102 pz 10.89025    $water level in the top tank:10.4" above -15.52575$$
c ------------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water ----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
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     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19$$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486$$
mt519     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  23$$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424$$
mt523     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  26$$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392$$
mt526     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  37$$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417$$
mt537     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  40$$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479$$
mt40     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  46$$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  51$$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413$$
mt51     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  52$$
m52  92235.60c 0.0014256 &$$
```

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     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490$$
mt52     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  55$$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410$$
mt55     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  62$$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406$$
mt62     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  65$$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410$$
mt65     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  66$$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424$$
mt66     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  67$$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476$$
mt67     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  68$$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441$$
mt68     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  80$$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483$$
mt80     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  81$$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452$$
mt81     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  83$$
```

```
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424$$
mt83     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  84$$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479$$
mt84     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  85$$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427$$
mt85     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  86$$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459$$
mt86     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  92$$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382$$
mt92     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  132$$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427$$
mt132     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  133$$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424$$
mt133     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  137$$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364$$
mt137     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  147$$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375$$
mt147     zr/h.01t  &$$
  h/zr.01t$$
```

```
c  --------------rod number:  151$$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466$$
mt151     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  153$$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455$$
mt153     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  171$$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476$$
mt171     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  173$$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417$$
mt173     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  174$$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493$$
mt174     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  176$$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462$$
mt176     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  9$$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497$$
mt559     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  25$$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479$$
mt525     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  47$$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479$$
mt47     zr/h.01t  &$$
```

```
  h/zr.01t$$
c  --------------rod number:  58$$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476$$
mt58     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  90$$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382$$
mt90     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  135$$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424$$
mt135     zr/h.01t  &$$
  h/zr.01t$$
print$$
```

3.2.23 Case tbl4a

```
NAA-SR-9871, case tbl4a$$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described by Table 4, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with the tank configuration shown in$$
c Fig 27 of 9871.  It has a full core loading, and the core is voided.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                     imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces -----------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ----------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel$$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating$$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel$$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating$$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel$$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating$$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel$$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating$$
```

```
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel$$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating$$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel$$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating$$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel$$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating$$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel$$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating$$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel$$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating$$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel$$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating$$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel$$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating$$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel$$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating$$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel$$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating$$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel$$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating$$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel$$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating$$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel$$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating$$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel$$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating$$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel$$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating$$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel$$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating$$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel$$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating$$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel$$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating$$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel$$
```

```
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating$$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel$$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating$$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel$$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating$$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel$$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating$$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel$$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating$$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel$$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating$$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel$$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating$$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel$$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating$$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel$$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating$$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel$$
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating$$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel$$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating$$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel$$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating$$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel$$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating$$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel$$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating$$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel$$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating$$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel$$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating$$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------------------------------------------------$$
300 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- vessel interior spaces  -----------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
```

```
303 0               (-6  10 -14):(14 -16)     imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$$
c ----- reactor vessel ------------------------------------$$
400 9  0.0871549  (-7 6 -14 13):(-12 16 14)    imp:n=1  $ ss316 vessel walls$$
401 6  0.0602626  (-7 15 -13)                  imp:n=1  $ aluminum bottom of vessel$$
403 7  0.1001037  (7 -18 -20 100)              imp:n=1  $ lower water gap and water below vessel$$
409 12 0.0708762  (17 -18 -100 101)            imp:n=1  $ lower binal sleeve outside vessel$$
410 7  0.1001037  (7 -17 -100 101)             imp:n=1  $ water outside vessel$$
411 7 0.1001037   (-7  101 -15)                imp:n=1  $ water below binal sleeve$$
c ----- water tanks ----------------------------$$
500 7  0.1001037  (29 -101 -27):(101 -20 -27 18)  imp:n=1  $ water in the lower tank$$
501 7  0.1001037  (-27 24 20 -31)              imp:n=1  $ water between top and bottom tank$$
502 9  0.0871549  (-29 -28 30):(27 -28 29 -31) imp:n=1  $ bottom tank shell$$
c$$
506 9  0.0871549  (-19 20 7  -24):(-24 23 19 -22) imp:n=1  $ upper tanks wall$$
507 7  0.1001037  (19 -14  7  -23)             imp:n=1  $ water inside top tank$$
509 7  0.1001037  (14 12 -102 -23)             imp:n=1  $ water inside top tank$$
510 0             (102 -22 -23)                imp:n=1  $ void in the top tank$$
511 0             (-22 31 -28 24)              imp:n=1  $ void outside radial surface top tank$$
c ----- outside world ------------------------------------$$
516 0   (22 -999):(-22 31 28 -999):(28 -999 30 -31):(-30 -999) imp:n=1$$
517 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.303                  $ IR of rx vessel=(8.9/2)(2.54)$$
7   cz  11.38174                $ OR of rx vessel=((8.9/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.129                  $ top of upper grid plate =15.8115+(2.54)(0.125)$$
11  pz -17.0815                 $ bottom of lower grid plate=-15.8115-(2.54)(0.5)$$
12  kz 21.9837 12.8508 -1       $ top of rx vessel: vertex at 0,0,21.9837.$$
c                                 tan^2 of the opening angle=12.8508$$
13  pz -18.8341                 $ top of vessel bottom=-15.8115-(2.54)(1.19)$$
14  pz  18.8087                 $ beginning of conical top=15.8115+1.18"$$
15  pz -19.4691                 $ bottom of vessel bottom=-15.8115-1.44"$$
16  kz 21.90496 13.3262 -1      $ inside top of rx vessel: vertex at 0,0,21.90496.$$
17  cz 12.01674                 $ inside surface of binal sleeve$$
18  cz 12.65174                 $ outside surface of binal sleeve$$
19  pz  6.01218                 $ top of bottom plate for upper tank=15.8115-3.92"+0.062"$$
20  pz  5.8547                  $ bottom of bottom plate for upper tank=15.8115-3.92"$$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
c$$
27  cz  34.24174                $ IR of lower tank=(surface 7)+9"$$
28  cz  34.3992                 $ OR of lower tank=$$
29  pz -33.7439                 $ top of bottom plate for lower tank=-15.8115-7.06"$$
30  pz -34.0614                 $ bottom of lower tank=-33.7439-0.125"$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)$$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
```

```
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c ----- tbd ----------------------------------$$
c  surfaces for sleeve $$
100 pz 0.98425     $top of binal sleeve:-15.52575+6.5"$$
101 pz -24.33955   $bottom of sleeve=0.98425-25.3238$$
102 pz 30.82925    $water level in the top tank:18.25" above -15.52575$$
c -----------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water -----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
```

```
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19$$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486$$
mt519     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  23$$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424$$
mt523     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  26$$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392$$
mt526     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  37$$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417$$
mt537     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  40$$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479$$
mt40     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  46$$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  51$$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413$$
mt51     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  52$$
m52  92235.60c 0.0014256 &$$
```

```
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490$$
mt52     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  55$$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410$$
mt55     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  62$$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406$$
mt62     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  65$$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410$$
mt65     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  66$$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424$$
mt66     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  67$$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476$$
mt67     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  68$$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441$$
mt68     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  80$$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483$$
mt80     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  81$$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452$$
mt81     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  83$$
```

```
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424$$
mt83     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  84$$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479$$
mt84     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  85$$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427$$
mt85     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  86$$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459$$
mt86     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  92$$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382$$
mt92     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  132$$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427$$
mt132     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  133$$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424$$
mt133     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  137$$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364$$
mt137     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  147$$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375$$
mt147     zr/h.01t  &$$
  h/zr.01t$$
```

```
c  --------------rod number:  151$$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466$$
mt151     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  153$$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455$$
mt153     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  171$$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476$$
mt171     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  173$$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417$$
mt173     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  174$$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493$$
mt174     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  176$$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462$$
mt176     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  9$$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497$$
mt559     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  25$$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479$$
mt525     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  47$$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479$$
mt47     zr/h.01t  &$$
```

```
  h/zr.01t$$
c  --------------rod number:  58$$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476$$
mt58     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  90$$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382$$
mt90     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  135$$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424$$
mt135     zr/h.01t  &$$
  h/zr.01t$$
print$$
```

3.2.24 Case tbl4b

```
NAA-SR-9871, case tbl4b$$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described by Table 4, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with the tank configuration shown in$$
c Fig 27 of 9871.  It has a full core loading, and the core is voided.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces -----------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ----------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel$$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating$$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel$$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating$$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel$$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating$$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel$$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating$$
```

```
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel$$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating$$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel$$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating$$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel$$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating$$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel$$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating$$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel$$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating$$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel$$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating$$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel$$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating$$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel$$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating$$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel$$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating$$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel$$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating$$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel$$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating$$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel$$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating$$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel$$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating$$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel$$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating$$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel$$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating$$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel$$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating$$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel$$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating$$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel$$
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165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating$$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel$$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating$$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel$$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating$$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel$$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating$$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel$$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating$$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel$$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating$$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel$$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating$$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel$$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating$$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel$$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating$$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel$$
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating$$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel$$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating$$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel$$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating$$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel$$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating$$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel$$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating$$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel$$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating$$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel$$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating$$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ------------------------------------------------------$$
300 0             (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- vessel interior spaces  -----------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
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303 0               (-6  10 -14):(14 -16)     imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$$
c ----- reactor vessel -----------------------------------$$
400 9  0.0871549  (-7 6 -14 13):(-12 16 14)    imp:n=1  $ ss316 vessel walls$$
401 6  0.0602626  (-7 15 -13)                  imp:n=1  $ aluminum bottom of vessel$$
403 7  0.1001037  (7 -18 -20 100)              imp:n=1  $ lower water gap and water below vessel$$
409 12 0.0708762  (17 -18 -100 101)            imp:n=1  $ lower binal sleeve outside vessel$$
410 7  0.1001037  (7 -17 -100 101)             imp:n=1  $ water outside vessel$$
411 7 0.1001037   (-7  101 -15)                imp:n=1  $ water below binal sleeve$$
c ----- water tanks ----------------------------$$
500 7  0.1001037  (29 -101 -27):(101 -20 -27 18)  imp:n=1  $ water in the lower tank$$
501 7  0.1001037  (-27 24 20 -31)              imp:n=1  $ water between top and bottom tank$$
502 9  0.0871549  (-29 -28 30):(27 -28 29 -31) imp:n=1  $ bottom tank shell$$
c$$
506 9  0.0871549  (-19 20 7  -24):(-24 23 19 -22) imp:n=1  $ upper tanks wall$$
507 7  0.1001037  (19 -14  7  -23)             imp:n=1  $ water inside top tank$$
509 7  0.1001037  (14 12 -102 -23)             imp:n=1  $ water inside top tank$$
510 0             (102 12 -22 -23)             imp:n=1  $ void in the top tank$$
511 0             (-22 31 -28 24)              imp:n=1  $ void outside radial surface top tank$$
c ----- outside world ------------------------------------$$
516 0   (22 -999):(-22 31 28 -999):(28 -999 30 -31):(-30 -999) imp:n=1$$
517 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.303                  $ IR of rx vessel=(8.9/2)(2.54)$$
7   cz  11.38174                $ OR of rx vessel=((8.9/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.129                  $ top of upper grid plate =15.8115+(2.54)(0.125)$$
11  pz -17.0815                 $ bottom of lower grid plate=-15.8115-(2.54)(0.5)$$
12  kz 21.9837 12.8508 -1       $ top of rx vessel: vertex at 0,0,21.9837.$$
c                                 tan^2 of the opening angle=12.8508$$
13  pz -18.8341                 $ top of vessel bottom=-15.8115-(2.54)(1.19)$$
14  pz  18.8087                 $ beginning of conical top=15.8115+1.18"$$
15  pz -19.4691                 $ bottom of vessel bottom=-15.8115-1.44"$$
16  kz 21.90496 13.3262 -1      $ inside top of rx vessel: vertex at 0,0,21.90496.$$
17  cz 12.01674                 $ inside surface of binal sleeve$$
18  cz 12.65174                 $ outside surface of binal sleeve$$
19  pz  6.01218                 $ top of bottom plate for upper tank=15.8115-3.92"+0.062"$$
20  pz  5.8547                  $ bottom of bottom plate for upper tank=15.8115-3.92"$$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
c$$
27  cz  34.24174                $ IR of lower tank=(surface 7)+9"$$
28  cz  34.3992                 $ OR of lower tank=$$
29  pz -33.7439                 $ top of bottom plate for lower tank=-15.8115-7.06"$$
30  pz -34.0614                 $ bottom of lower tank=-33.7439-0.125"$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)$$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
```

```
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c ----- tbd -----------------------------------$$
c  surfaces for sleeve $$
100 pz -4.09575    $top of binal sleeve:-15.52575+4.5"$$
101 pz -29.41955   $bottom of sleeve=-4.09575-25.3238$$
102 pz 20.36455    $water level in the top tank:14.13" above -15.52575$$
c -----------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water -----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
```

```
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19$$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486$$
mt519     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  23$$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424$$
mt523     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  26$$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392$$
mt526     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  37$$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417$$
mt537     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  40$$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479$$
mt40     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  46$$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  51$$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413$$
mt51     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  52$$
m52  92235.60c 0.0014256 &$$
```

```
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490$$
mt52     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  55$$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410$$
mt55     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  62$$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406$$
mt62     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  65$$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410$$
mt65     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  66$$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424$$
mt66     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  67$$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476$$
mt67     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  68$$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441$$
mt68     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  80$$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483$$
mt80     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  81$$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452$$
mt81     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  83$$
```

```
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424$$
mt83     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  84$$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479$$
mt84     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  85$$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427$$
mt85     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  86$$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459$$
mt86     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  92$$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382$$
mt92     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  132$$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427$$
mt132     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  133$$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424$$
mt133     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  137$$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364$$
mt137     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  147$$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375$$
mt147     zr/h.01t  &$$
  h/zr.01t$$
```

```
c  --------------rod number:  151$$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466$$
mt151     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  153$$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455$$
mt153     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  171$$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476$$
mt171     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  173$$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417$$
mt173     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  174$$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493$$
mt174     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  176$$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462$$
mt176     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  9$$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497$$
mt559     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  25$$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479$$
mt525     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  47$$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479$$
mt47     zr/h.01t  &$$
```

```
  h/zr.01t$$
c  --------------rod number:  58$$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476$$
mt58     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  90$$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382$$
mt90     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  135$$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424$$
mt135     zr/h.01t  &$$
  h/zr.01t$$
print$$
```

3.2.25 Case tbl4c

```
NAA-SR-9871, case tbl4c$$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described by Table 4, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with the tank configuration shown in$$
c Fig 27 of 9871.  It has a full core loading, and the core is voided.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces -----------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ---------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel$$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating$$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel$$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating$$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel$$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating$$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel$$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating$$
```

```
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel$$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating$$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel$$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating$$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel$$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating$$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel$$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating$$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel$$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating$$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel$$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating$$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel$$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating$$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel$$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating$$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel$$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating$$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel$$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating$$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel$$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating$$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel$$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating$$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel$$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating$$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel$$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating$$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel$$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating$$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel$$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating$$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel$$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating$$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel$$
```

```
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating$$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel$$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating$$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel$$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating$$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel$$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating$$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel$$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating$$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel$$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating$$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel$$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating$$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel$$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating$$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel$$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating$$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel$$
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating$$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel$$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating$$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel$$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating$$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel$$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating$$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel$$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating$$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel$$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating$$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel$$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating$$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------------------------------------------------$$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- vessel interior spaces  -----------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
```

```
303 0                (-6  10 -14):(14 -16)     imp:n=1  $ vessel interior above upper gridplate$$
304 0                 -6 -11  13               imp:n=1  $ vessel interior above upper gridplate$$
c ----- reactor vessel ------------------------------------$$
400 9  0.0871549  (-7 6 -14 13):(-12 16 14)    imp:n=1  $ ss316 vessel walls$$
401 6  0.0602626  (-7 15 -13)                  imp:n=1  $ aluminum bottom of vessel$$
403 7  0.1001037  (7 -18 -20 100)              imp:n=1  $ lower water gap and water below vessel$$
409 12 0.0708762  (17 -18 -100 101)            imp:n=1  $ lower binal sleeve outside vessel$$
410 7  0.1001037  (7 -17 -100 101)             imp:n=1  $ water outside vessel$$
411 7 0.1001037   (-7  101 -15)                imp:n=1  $ water below binal sleeve$$
c ----- water tanks ----------------------------$$
500 7  0.1001037  (29 -101 -27):(101 -20 -27 18)  imp:n=1  $ water in the lower tank$$
501 7  0.1001037  (-27 24 20 -31)              imp:n=1  $ water between top and bottom tank$$
502 9  0.0871549  (-29 -28 30):(27 -28 29 -31) imp:n=1  $ bottom tank shell$$
c$$
506 9  0.0871549  (-19 20 7  -24):(-24 23 19 -22) imp:n=1  $ upper tanks wall$$
507 7  0.1001037  (19 -14  7  -23)             imp:n=1  $ water inside top tank$$
509 7  0.1001037  (14 12 -102 -23)             imp:n=1  $ water inside top tank$$
510 0             (102 12 -22 -23)             imp:n=1  $ void in the top tank$$
511 0             (-22 31 -28 24)              imp:n=1  $ void outside radial surface top tank$$
c ----- outside world ------------------------------------$$
516 0   (22 -999):(-22 31 28 -999):(28 -999 30 -31):(-30 -999) imp:n=1$$
517 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.303                  $ IR of rx vessel=(8.9/2)(2.54)$$
7   cz  11.38174                $ OR of rx vessel=((8.9/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.129                  $ top of upper grid plate =15.8115+(2.54)(0.125)$$
11  pz -17.0815                 $ bottom of lower grid plate=-15.8115-(2.54)(0.5)$$
12  kz 21.9837 12.8508 -1       $ top of rx vessel: vertex at 0,0,21.9837.$$
c                                 tan^2 of the opening angle=12.8508$$
13  pz -18.8341                 $ top of vessel bottom=-15.8115-(2.54)(1.19)$$
14  pz  18.8087                 $ beginning of conical top=15.8115+1.18"$$
15  pz -19.4691                 $ bottom of vessel bottom=-15.8115-1.44"$$
16  kz 21.90496 13.3262 -1      $ inside top of rx vessel: vertex at 0,0,21.90496.$$
17  cz 12.01674                 $ inside surface of binal sleeve$$
18  cz 12.65174                 $ outside surface of binal sleeve$$
19  pz  6.01218                 $ top of bottom plate for upper tank=15.8115-3.92"+0.062"$$
20  pz  5.8547                  $ bottom of bottom plate for upper tank=15.8115-3.92"$$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
c$$
27  cz  34.24174                $ IR of lower tank=(surface 7)+9"$$
28  cz  34.3992                 $ OR of lower tank=$$
29  pz -33.7439                 $ top of bottom plate for lower tank=-15.8115-7.06"$$
30  pz -34.0614                 $ bottom of lower tank=-33.7439-0.125"$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)$$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
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60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c ----- tbd ----------------------------------$$
c  surfaces for sleeve $$
100 pz -4.09575    $top of binal sleeve:-15.52575+4.5"$$
101 pz -29.41955   $bottom of sleeve=-4.09575-25.3238$$
102 pz 21.93925    $water level in the top tank:14.75" above -15.52575$$
c ----------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water -----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
```

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     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19$$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486$$
mt519     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  23$$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424$$
mt523     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  26$$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392$$
mt526     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  37$$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417$$
mt537     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  40$$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479$$
mt40     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  46$$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  51$$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413$$
mt51     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  52$$
m52  92235.60c 0.0014256 &$$
```

```
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490$$
mt52     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  55$$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410$$
mt55     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  62$$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406$$
mt62     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  65$$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410$$
mt65     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  66$$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424$$
mt66     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  67$$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476$$
mt67     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  68$$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441$$
mt68     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  80$$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483$$
mt80     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  81$$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452$$
mt81     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  83$$
```

```
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424$$
mt83     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  84$$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479$$
mt84     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  85$$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427$$
mt85     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  86$$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459$$
mt86     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  92$$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382$$
mt92     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  132$$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427$$
mt132     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  133$$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424$$
mt133     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  137$$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364$$
mt137     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  147$$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375$$
mt147     zr/h.01t  &$$
  h/zr.01t$$
```

```
c  --------------rod number:  151$$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466$$
mt151     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  153$$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455$$
mt153     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  171$$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476$$
mt171     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  173$$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417$$
mt173     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  174$$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493$$
mt174     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  176$$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462$$
mt176     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  9$$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497$$
mt559     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  25$$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479$$
mt525     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  47$$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479$$
mt47     zr/h.01t  &$$
```

```
  h/zr.01t$$
c  --------------rod number:  58$$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476$$
mt58     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  90$$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382$$
mt90     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  135$$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424$$
mt135     zr/h.01t  &$$
  h/zr.01t$$
print$$
```

3.2.26 Case tbl4d

```
NAA-SR-9871, case tbl4d$$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described by Table 4, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with the tank configuration shown in$$
c Fig 27 of 9871.  It has a full core loading, and the core is voided.$$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                     imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=85  trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces -----------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ---------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel$$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating$$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel$$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating$$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel$$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating$$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel$$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating$$
```

```
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel$$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating$$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel$$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating$$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel$$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating$$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel$$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating$$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel$$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating$$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel$$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating$$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel$$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating$$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel$$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating$$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel$$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating$$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel$$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating$$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel$$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating$$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel$$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating$$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel$$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating$$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel$$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating$$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel$$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating$$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel$$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating$$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel$$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating$$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel$$
```

```
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating$$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel$$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating$$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel$$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating$$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel$$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating$$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel$$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating$$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel$$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating$$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel$$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating$$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel$$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating$$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel$$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating$$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel$$
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating$$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel$$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating$$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel$$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating$$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel$$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating$$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel$$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating$$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel$$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating$$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ---------$$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel$$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating$$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c ------------------------------------------------------$$
300 0            (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- vessel interior spaces  ------------------------------------$$
301 6  0.0602626     -6   8 -10               imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11               imp:n=1  $ type 1100 aluminum lower gridplate$$
```

```
303 0                (-6  10 -14):(14 -16)     imp:n=1  $ vessel interior above upper gridplate$$
304 0                -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$$
c ----- reactor vessel ------------------------------------$$
400 9  0.0871549  (-7 6 -14 13):(-12 16 14)    imp:n=1  $ ss316 vessel walls$$
401 6  0.0602626  (-7 15 -13)                  imp:n=1  $ aluminum bottom of vessel$$
403 7  0.1001037  (7 -18 -20 100)              imp:n=1  $ lower water gap and water below vessel$$
409 12 0.0708762  (17 -18 -100 101)            imp:n=1  $ lower binal sleeve outside vessel$$
410 7  0.1001037  (7 -17 -100 101)             imp:n=1  $ water outside vessel$$
411 7 0.1001037   (-7  101 -15)                imp:n=1  $ water below binal sleeve$$
c ----- water tanks ----------------------------$$
500 7  0.1001037  (29 -101 -27):(101 -20 -27 18)  imp:n=1  $ water in the lower tank$$
501 7  0.1001037  (-27 24 20 -31)              imp:n=1  $ water between top and bottom tank$$
502 9  0.0871549  (-29 -28 30):(27 -28 29 -31) imp:n=1  $ bottom tank shell$$
c$$
506 9  0.0871549  (-19 20 7  -24):(-24 23 19 -22) imp:n=1  $ upper tanks wall$$
507 7  0.1001037  (19 -14  7  -23)             imp:n=1  $ water inside top tank$$
509 7  0.1001037  (14 12 -102 -23)             imp:n=1  $ water inside top tank$$
510 0             (102 -22 -23)                imp:n=1  $ void in the top tank$$
511 0             (-22 31 -28 24)              imp:n=1  $ void outside radial surface top tank$$
c ----- outside world ------------------------------------$$
516 0   (22 -999):(-22 31 28 -999):(28 -999 30 -31):(-30 -999) imp:n=1$$
517 0 999            imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.303                  $ IR of rx vessel=(8.9/2)(2.54)$$
7   cz  11.38174                $ OR of rx vessel=((8.9/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.129                  $ top of upper grid plate =15.8115+(2.54)(0.125)$$
11  pz -17.0815                 $ bottom of lower grid plate=-15.8115-(2.54)(0.5)$$
12  kz 21.9837 12.8508 -1       $ top of rx vessel: vertex at 0,0,21.9837.$$
c                                 tan^2 of the opening angle=12.8508$$
13  pz -18.8341                 $ top of vessel bottom=-15.8115-(2.54)(1.19)$$
14  pz  18.8087                 $ beginning of conical top=15.8115+1.18"$$
15  pz -19.4691                 $ bottom of vessel bottom=-15.8115-1.44"$$
16  kz 21.90496 13.3262 -1      $ inside top of rx vessel: vertex at 0,0,21.90496.$$
17  cz 12.01674                 $ inside surface of binal sleeve$$
18  cz 12.65174                 $ outside surface of binal sleeve$$
19  pz  6.01218                 $ top of bottom plate for upper tank=15.8115-3.92"+0.062"$$
20  pz  5.8547                  $ bottom of bottom plate for upper tank=15.8115-3.92"$$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
c$$
27  cz  34.24174                $ IR of lower tank=(surface 7)+9"$$
28  cz  34.3992                 $ OR of lower tank=$$
29  pz -33.7439                 $ top of bottom plate for lower tank=-15.8115-7.06"$$
30  pz -34.0614                 $ bottom of lower tank=-33.7439-0.125"$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)$$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445               $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
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60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c ----- tbd -----------------------------------$$
c  surfaces for sleeve $$
100 pz -3.00355    $top of binal sleeve:-15.52575+4.93"$$
101 pz -28.32735  $bottom of sleeve=-3.00355-25.3238$$
102 pz 30.82925    $water level in the top tank:18.25" above -15.52575$$
c -----------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water -----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
```

```
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19$$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486$$
mt519     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  23$$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424$$
mt523     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  26$$
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392$$
mt526     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  37$$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417$$
mt537     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  40$$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479$$
mt40     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  46$$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  51$$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413$$
mt51     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  52$$
m52  92235.60c 0.0014256 &$$
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     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490$$
mt52     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  55$$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410$$
mt55     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  62$$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406$$
mt62     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  65$$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410$$
mt65     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  66$$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424$$
mt66     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  67$$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476$$
mt67     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  68$$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441$$
mt68     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  80$$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483$$
mt80     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  81$$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452$$
mt81     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  83$$
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m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424$$
mt83     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  84$$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479$$
mt84     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  85$$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427$$
mt85     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  86$$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459$$
mt86     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  92$$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382$$
mt92     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  132$$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427$$
mt132     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  133$$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424$$
mt133     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  137$$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364$$
mt137     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  147$$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375$$
mt147     zr/h.01t  &$$
  h/zr.01t$$
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c  --------------rod number:  151$$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466$$
mt151     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  153$$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455$$
mt153     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  171$$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476$$
mt171     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  173$$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417$$
mt173     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  174$$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493$$
mt174     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  176$$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462$$
mt176     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  9$$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497$$
mt559     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  25$$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479$$
mt525     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  47$$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479$$
mt47     zr/h.01t  &$$
```

```
  h/zr.01t$$
c  --------------rod number:  58$$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476$$
mt58     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  90$$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382$$
mt90     zr/h.01t  &$$
  h/zr.01t$$
c  --------------rod number:  135$$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424$$
mt135     zr/h.01t  &$$
  h/zr.01t$$
print$$
```

3.2.27 Case p50a

```
NAA-SR-9871,case p50a           $$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described on p.50, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with36 fuel rods, 1 lucite rod, and a$$
c flooded core.  The tank configuration used is that shown in$$
c Fig 48, of 9871.  A 0.25" close fitting Binal sleeve is attached$$
c and the water level is 10.5" above the bottom of the fuel. $$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=2   trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces ------------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ---------------------------------------------$$
80    10  0.1064672    -4 -2 3       u=2         imp:n=1  $ lucite rod$$
81    10  0.1064672    4:2:-3        u=2         imp:n=1  $ lucite$$
c -------------------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel         $$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating         $$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel         $$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating         $$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
```

```
c ---------                           $$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel         $$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating         $$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel         $$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating         $$
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel         $$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating         $$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel         $$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating         $$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel         $$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating         $$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel         $$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating         $$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel         $$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating         $$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel         $$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating         $$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel         $$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating         $$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel         $$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating         $$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel         $$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating         $$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel         $$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating         $$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel         $$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating         $$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel         $$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating         $$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
```

```
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel         $$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating        $$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel         $$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating        $$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel         $$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating        $$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel         $$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating        $$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel         $$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating        $$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel         $$
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating        $$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel         $$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating        $$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel         $$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating        $$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel         $$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating        $$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel         $$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating        $$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel         $$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating        $$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel         $$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating        $$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel         $$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating        $$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel         $$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating        $$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel         $$
```

```
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating         $$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel      $$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating      $$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel      $$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating      $$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel      $$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating      $$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel      $$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating      $$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel      $$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating      $$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel      $$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating      $$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c -------------------------------------------------------$$
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- tbd -------------------------------------$$
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$$
303 7 0.1001037      -6  10 -12                imp:n=1  $ vessel interior above upper gridplate$$
304 7 0.1001037      -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$$
c ----- tbd -------------------------------------$$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)   imp:n=1  $ type 1100 aluminum cover plate$$
307 12 0.0708762  (7 -500 19 -14)              imp:n=1  $ binal sleeve$$
308 12 0.0708762  (7 -500 -20 15)              imp:n=1  $ binal sleeve$$
309 7  0.1001037  (29 -15 -27  ):(15 -20 -27 500) imp:n=1  $ water $$
310 7  0.1001037  (20 -31 24 -27)              imp:n=1  $ water filled volume of lower tank$$
311 9  0.0871549  (26 -25 -28):(27 -28 -31 25) imp:n=1  $ bottom tank shell$$
312 0             -27 25 -30                   imp:n=1  $ void at the bottom of lower tank$$
313 9 0.0871549   -29 30 -27                   imp:n=1  $ steel plate in lower tank above void$$
314 0            31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank$$
315 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1  $upper tanks wall$$
316 7  0.1001037  (19 -21 500 -23)             imp:n=1  $ water in the upper tank$$
317 0  (21 -14 500 -23):(17 -18 -6):(14 -18 16 -23):(18 -22 -23) imp:n=1 $void inside top tank$$
c ----- tbd -------------------------------------$$
318 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$$
319 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$$
```

```
11  pz -16.4465                $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$$
12  pz  16.85925               $ vessel cover/flange interface$$
13  pz -18.93951               $ top of vessel bottom=-19.01825+(2.54)(0.031)$$
14  pz  16.70177               $ bottom of vessel flange$$
15  pz -19.01825               $ bottom of vessel bottom=6.06425-(2.54)(9.875)$$
16  cz  16.46555               $ OR of vessel flange$$
17  pz  16.93799               $ top of cover plate indent=$$
18  pz  17.49425               $ top of cover plate flange$$
19  pz  6.22173                $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$$
20  pz  6.06425                $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$$
21  pz  11.14425               $ top of the water in the top tank :10.5" above fuel bottom    $$
22  pz  36.22675               $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                  $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743               $ OR of upper tank=((21/2)+0.062)(2.54)$$
25  pz -40.29075               $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$$
26  pz -40.60825               $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$$
27  cz  34.925                 $ IR of lower tank=(27.5/2)(2.54)$$
28  cz  35.08248               $ OR of lower tank=((27.5/2)+0.06)(2.54)$$
29  pz -32.35325               $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$$
30  pz -32.67075               $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$$
31  pz  21.30425               $ top of the bottom tank=36.22675-(2.54)(5.875)              $$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -----Binal sleeve outer radius----------------$$
500 cz 11.98499$$
c ----------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
```

```
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water -----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 ------------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c ---- lucite ----------$$
m10  6000.60c  0.0354891 &$$
     1001.60c  0.0567825 &$$
     8016.60c  0.0141956 $$
mt10 poly.01t            $$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C ------------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19 $$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486 $$
mt519     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  23 $$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424 $$
mt523     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  26 $$
```

```
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392 $$
mt526     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  37 $$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417 $$
mt537     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  40 $$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479 $$
mt40     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  46 $$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  51 $$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413 $$
mt51     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  52 $$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490 $$
mt52     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  55 $$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410 $$
mt55     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  62 $$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406 $$
mt62     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  65 $$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410 $$
mt65     zr/h.01t  & $$
  h/zr.01t $$
```

```
c  --------------rod number:  66 $$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424 $$
mt66     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  67 $$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476 $$
mt67     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  68 $$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441 $$
mt68     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  80 $$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483 $$
mt80     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  81 $$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452 $$
mt81     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  83 $$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424 $$
mt83     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  84 $$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479 $$
mt84     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  85 $$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427 $$
mt85     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  86 $$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459 $$
mt86     zr/h.01t  & $$
```

```
  h/zr.01t $$
c  --------------rod number:  92 $$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382 $$
mt92     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  132 $$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427 $$
mt132     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  133 $$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424 $$
mt133     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  137 $$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364 $$
mt137     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  147 $$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375 $$
mt147     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  151 $$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466 $$
mt151     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  153 $$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455 $$
mt153     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  171 $$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476 $$
mt171     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  173 $$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417 $$
```

```
mt173     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  174 $$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493 $$
mt174     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  176 $$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462 $$
mt176     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  9 $$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497 $$
mt559     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  25 $$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479 $$
mt525     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  47 $$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479 $$
mt47     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  58 $$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476 $$
mt58     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  90 $$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382 $$
mt90     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  135 $$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424 $$
mt135     zr/h.01t  & $$
  h/zr.01t $$
print$$
```

3.2.28 Case p50b

```
NAA-SR-9871,case p50b           $$
c Feb 25, 2005$$
c Model setup by a.w. krass and k.l.goluoglu$$
c This case models the experiment described on p.50, NAA-SR-9871$$
c This case uses SNAPTRAN fuel, with36 fuel rods, 1 lucite rod, and a$$
c flooded core.  The tank configuration used is that shown in$$
c Fig 48, of 9871.  A 0.75" close fitting Binal sleeve is attached$$
c and the water level is 9.13" above the bottom of the fuel. $$
c ----- complete fuel element assembly ----------$$
1  0        -5 -8 9  fill=133                    imp:n=1  $ position 1$$
c ----- additional fuel elements ----------------$$
2  like 1 but fill=58  trcl    (0.0     -3.2004  0)  imp:n=1  $ position 2$$
3  like 1 but fill=135 trcl   (-2.7716  -1.6002  0)  imp:n=1  $ position 3$$
4  like 1 but fill=147 trcl    (2.7716  -1.6002  0)  imp:n=1  $ position 4$$
5  like 1 but fill=559  trcl    (0.0     -6.4008  0)  imp:n=1  $ position 5$$
6  like 1 but fill=537 trcl   (-2.7716  -4.8006  0)  imp:n=1  $ position 6$$
7  like 1 but fill=153 trcl  (-5.5432  -3.2004  0)  imp:n=1  $ position 7$$
8  like 1 but fill=81  trcl    (2.7716  -4.8006  0)  imp:n=1  $ position 8$$
9  like 1 but fill=92  trcl   (5.5432  -3.2004  0)  imp:n=1  $ position 9$$
10 like 1 but fill=80  trcl    (0.0     -9.6012  0)  imp:n=1  $ position 10$$
11 like 1 but fill=151 trcl  (-2.7716  -8.0010  0)  imp:n=1  $ position 11$$
12 like 1 but fill=173 trcl   (-5.5432  -6.4008  0)  imp:n=1  $ position 12$$
13 like 1 but fill=519 trcl  (-8.3149  -4.8006  0)  imp:n=1  $ position 13$$
14 like 1 but fill=86  trcl   (2.7716  -8.0010  0)  imp:n=1  $ position 14$$
15 like 1 but fill=68  trcl    (5.5432  -6.4008  0)  imp:n=1  $ position 15$$
16 like 1 but fill=132 trcl    (8.3149  -4.8006  0)  imp:n=1  $ position 16$$
17 like 1 but fill=67  trcl    (0.0    -12.8016  0)  imp:n=1  $ position 17$$
18 like 1 but fill=55  trcl  (-2.7716 -11.2014  0)  imp:n=1  $ position 18$$
19 like 1 but fill=174 trcl   (-5.5432  -9.6012  0)  imp:n=1  $ position 19$$
20 like 1 but fill=90  trcl  (-8.3249  -8.0010  0)  imp:n=1  $ position 20$$
21 like 1 but fill=176 trcl    (2.7716 -11.2014  0)  imp:n=1  $ position 21$$
22 like 1 but fill=40  trcl   (5.5432  -9.6012  0)  imp:n=1  $ position 22$$
23 like 1 but fill=52  trcl   (8.3149  -8.0010  0)  imp:n=1  $ position 23$$
24 like 1 but fill=137 trcl    (0.0    -16.0020  0)  imp:n=1  $ position 24$$
25 like 1 but fill=46  trcl  (-2.7716 -14.4018  0)  imp:n=1  $ position 25$$
26 like 1 but fill=62  trcl  (-5.5432 -12.8016  0)  imp:n=1  $ position 26$$
27 like 1 but fill=51  trcl  (-8.3149 -11.2014  0)  imp:n=1  $ position 27$$
28 like 1 but fill=526 trcl    (2.7716 -14.4018  0)  imp:n=1  $ position 28$$
29 like 1 but fill=65  trcl   (5.5432 -12.8016  0)  imp:n=1  $ position 29$$
30 like 1 but fill=171 trcl   (8.3149 -11.2014  0)  imp:n=1  $ position 30$$
31 like 1 but fill=2   trcl    (0.0    -19.2024  0)  imp:n=1  $ position 31$$
32 like 1 but fill=84  trcl   (-2.7716 -17.6022  0)  imp:n=1  $ position 32$$
37 like 1 but fill=66  trcl   (8.3149  -14.4018  0)  imp:n=1  $ position 37$$
36 like 1 but fill=523 trcl   (5.5432 -16.002   0)  imp:n=1  $ position 36$$
35 like 1 but fill=525 trcl  (2.7716    -17.6022 0)  imp:n=1  $ position 35$$
34 like 1 but fill=47  trcl  (-8.3149   -14.4018 0)  imp:n=1  $ position 34$$
33 like 7 but fill=83  trcl  (-5.5432   -16.002  0)  imp:n=1  $ position 33$$
c ----- internal be reflector pieces ------------$$
41  11 0.1216164  -44 -45 46  51 57 58 59 60 -8 9  imp:n=1  $  1 o'clock$$
42  11 0.1216164  -44 -47 48  52 60 61 62 63 -8 9  imp:n=1  $  3 o'clock$$
43  11 0.1216164  -44 -49 50 -53 63 64 65 66 -8 9  imp:n=1  $  5 o'clock$$
44  11 0.1216164  -44 -45 46 -54 66 67 68 69 -8 9  imp:n=1  $  7 o'clock$$
45  11 0.1216164  -44 -47 48 -55 69 70 71 72 -8 9  imp:n=1  $  9 o'clock$$
46  11 0.1216164  -44 -49 50  56 72 73 74 57 -8 9  imp:n=1  $ 11 o'clock$$
c ---------------------------------------------$$
80    10  0.1064672    -4 -2 3       u=2         imp:n=1  $ lucite rod$$
81    10  0.1064672    4:2:-3        u=2         imp:n=1  $ lucite$$
c ----------------------------------------------------------$$
101   519 0.1013299    -1 -2 3       u=   519    imp:n=1  $ UZrHx fuel         $$
102   5   0.0265588    -4 1 -2 3     u=   519    imp:n=1  $ radial rod surface coating         $$
103   8   0.0872946    4:2:-3        u=   519    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
104   523 0.0996219    -1 -2 3       u=   523    imp:n=1  $ UZrHx fuel         $$
105   5   0.0265588    -4 1 -2 3     u=   523    imp:n=1  $ radial rod surface coating         $$
106   8   0.0872946    4:2:-3        u=   523    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
```

```
c ---------                           $$
107   526 0.1012359    -1 -2 3       u=   526    imp:n=1  $ UZrHx fuel         $$
108   5   0.0265588    -4 1 -2 3     u=   526    imp:n=1  $ radial rod surface coating         $$
109   8   0.0872946    4:2:-3        u=   526    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
110   537 0.0998599    -1 -2 3       u=   537    imp:n=1  $ UZrHx fuel         $$
111   5   0.0265588    -4 1 -2 3     u=   537    imp:n=1  $ radial rod surface coating         $$
112   8   0.0872946    4:2:-3        u=   537    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
113   40  0.1000871    -1 -2 3       u=   40    imp:n=1  $ UZrHx fuel         $$
114   5   0.0265588    -4 1 -2 3     u=   40    imp:n=1  $ radial rod surface coating         $$
115   8   0.0872946    4:2:-3        u=   40    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
116   46  0.1014395    -1 -2 3       u=   46    imp:n=1  $ UZrHx fuel         $$
117   5   0.0265588    -4 1 -2 3     u=   46    imp:n=1  $ radial rod surface coating         $$
118   8   0.0872946    4:2:-3        u=   46    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
119   51  0.1017065    -1 -2 3       u=   51    imp:n=1  $ UZrHx fuel         $$
120   5   0.0265588    -4 1 -2 3     u=   51    imp:n=1  $ radial rod surface coating         $$
121   8   0.0872946    4:2:-3        u=   51    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
122   52  0.1017538    -1 -2 3       u=   52    imp:n=1  $ UZrHx fuel         $$
123   5   0.0265588    -4 1 -2 3     u=   52    imp:n=1  $ radial rod surface coating         $$
124   8   0.0872946    4:2:-3        u=   52    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
125   55  0.1014800    -1 -2 3       u=   55    imp:n=1  $ UZrHx fuel         $$
126   5   0.0265588    -4 1 -2 3     u=   55    imp:n=1  $ radial rod surface coating         $$
127   8   0.0872946    4:2:-3        u=   55    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
128   62  0.1013522    -1 -2 3       u=   62    imp:n=1  $ UZrHx fuel         $$
129   5   0.0265588    -4 1 -2 3     u=   62    imp:n=1  $ radial rod surface coating         $$
130   8   0.0872946    4:2:-3        u=   62    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
131   65  0.1012826    -1 -2 3       u=   65    imp:n=1  $ UZrHx fuel         $$
132   5   0.0265588    -4 1 -2 3     u=   65    imp:n=1  $ radial rod surface coating         $$
133   8   0.0872946    4:2:-3        u=   65    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
134   66  0.0999181    -1 -2 3       u=   66    imp:n=1  $ UZrHx fuel         $$
135   5   0.0265588    -4 1 -2 3     u=   66    imp:n=1  $ radial rod surface coating         $$
136   8   0.0872946    4:2:-3        u=   66    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
137   67  0.1013414    -1 -2 3       u=   67    imp:n=1  $ UZrHx fuel         $$
138   5   0.0265588    -4 1 -2 3     u=   67    imp:n=1  $ radial rod surface coating         $$
139   8   0.0872946    4:2:-3        u=   67    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
140   68  0.1016430    -1 -2 3       u=   68    imp:n=1  $ UZrHx fuel         $$
141   5   0.0265588    -4 1 -2 3     u=   68    imp:n=1  $ radial rod surface coating         $$
142   8   0.0872946    4:2:-3        u=   68    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
143   80  0.1013008    -1 -2 3       u=   80    imp:n=1  $ UZrHx fuel         $$
144   5   0.0265588    -4 1 -2 3     u=   80    imp:n=1  $ radial rod surface coating         $$
145   8   0.0872946    4:2:-3        u=   80    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
146   81  0.1014340    -1 -2 3       u=   81    imp:n=1  $ UZrHx fuel         $$
147   5   0.0265588    -4 1 -2 3     u=   81    imp:n=1  $ radial rod surface coating         $$
148   8   0.0872946    4:2:-3        u=   81    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
```

```
149   83  0.1022874    -1 -2 3       u=   83    imp:n=1  $ UZrHx fuel         $$
150   5   0.0265588    -4 1 -2 3     u=   83    imp:n=1  $ radial rod surface coating         $$
151   8   0.0872946    4:2:-3        u=   83    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
152   84  0.0996922    -1 -2 3       u=   84    imp:n=1  $ UZrHx fuel         $$
153   5   0.0265588    -4 1 -2 3     u=   84    imp:n=1  $ radial rod surface coating         $$
154   8   0.0872946    4:2:-3        u=   84    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
155   85  0.1004408    -1 -2 3       u=   85    imp:n=1  $ UZrHx fuel         $$
156   5   0.0265588    -4 1 -2 3     u=   85    imp:n=1  $ radial rod surface coating         $$
157   8   0.0872946    4:2:-3        u=   85    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
158   86  0.1021832    -1 -2 3       u=   86    imp:n=1  $ UZrHx fuel         $$
159   5   0.0265588    -4 1 -2 3     u=   86    imp:n=1  $ radial rod surface coating         $$
160   8   0.0872946    4:2:-3        u=   86    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
161   92  0.0997666    -1 -2 3       u=   92    imp:n=1  $ UZrHx fuel         $$
162   5   0.0265588    -4 1 -2 3     u=   92    imp:n=1  $ radial rod surface coating         $$
163   8   0.0872946    4:2:-3        u=   92    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
164   132 0.0996510    -1 -2 3       u=   132    imp:n=1  $ UZrHx fuel         $$
165   5   0.0265588    -4 1 -2 3     u=   132    imp:n=1  $ radial rod surface coating         $$
166   8   0.0872946    4:2:-3        u=   132    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
167   133 0.1013002    -1 -2 3       u=   133    imp:n=1  $ UZrHx fuel         $$
168   5   0.0265588    -4 1 -2 3     u=   133    imp:n=1  $ radial rod surface coating         $$
169   8   0.0872946    4:2:-3        u=   133    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
170   137 0.1006085    -1 -2 3       u=   137    imp:n=1  $ UZrHx fuel         $$
171   5   0.0265588    -4 1 -2 3     u=   137    imp:n=1  $ radial rod surface coating         $$
172   8   0.0872946    4:2:-3        u=   137    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
173   147 0.1001034    -1 -2 3       u=   147    imp:n=1  $ UZrHx fuel         $$
174   5   0.0265588    -4 1 -2 3     u=   147    imp:n=1  $ radial rod surface coating         $$
175   8   0.0872946    4:2:-3        u=   147    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
176   151 0.1009580    -1 -2 3       u=   151    imp:n=1  $ UZrHx fuel         $$
177   5   0.0265588    -4 1 -2 3     u=   151    imp:n=1  $ radial rod surface coating         $$
178   8   0.0872946    4:2:-3        u=   151    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
179   153 0.1008708    -1 -2 3       u=   153    imp:n=1  $ UZrHx fuel         $$
180   5   0.0265588    -4 1 -2 3     u=   153    imp:n=1  $ radial rod surface coating         $$
181   8   0.0872946    4:2:-3        u=   153    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
182   171 0.1022299    -1 -2 3       u=   171    imp:n=1  $ UZrHx fuel         $$
183   5   0.0265588    -4 1 -2 3     u=   171    imp:n=1  $ radial rod surface coating         $$
184   8   0.0872946    4:2:-3        u=   171    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
185   173 0.0994651    -1 -2 3       u=   173    imp:n=1  $ UZrHx fuel         $$
186   5   0.0265588    -4 1 -2 3     u=   173    imp:n=1  $ radial rod surface coating         $$
187   8   0.0872946    4:2:-3        u=   173    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
188   174 0.1019804    -1 -2 3       u=   174    imp:n=1  $ UZrHx fuel         $$
189   5   0.0265588    -4 1 -2 3     u=   174    imp:n=1  $ radial rod surface coating         $$
190   8   0.0872946    4:2:-3        u=   174    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                           $$
191   176 0.1021136    -1 -2 3       u=   176    imp:n=1  $ UZrHx fuel         $$
```

```
192   5   0.0265588    -4 1 -2 3     u=   176    imp:n=1  $ radial rod surface coating         $$
193   8   0.0872946    4:2:-3        u=   176    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
194   559 0.0994427    -1 -2 3       u=   559    imp:n=1  $ UZrHx fuel      $$
195   5   0.0265588    -4 1 -2 3     u=   559    imp:n=1  $ radial rod surface coating      $$
196   8   0.0872946    4:2:-3        u=   559    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
197   525 0.0999884    -1 -2 3       u=   525    imp:n=1  $ UZrHx fuel      $$
198   5   0.0265588    -4 1 -2 3     u=   525    imp:n=1  $ radial rod surface coating      $$
199   8   0.0872946    4:2:-3        u=   525    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
200   47  0.0994948    -1 -2 3       u=   47    imp:n=1  $ UZrHx fuel      $$
201   5   0.0265588    -4 1 -2 3     u=   47    imp:n=1  $ radial rod surface coating      $$
202   8   0.0872946    4:2:-3        u=   47    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
203   58  0.1015388    -1 -2 3       u=   58    imp:n=1  $ UZrHx fuel      $$
204   5   0.0265588    -4 1 -2 3     u=   58    imp:n=1  $ radial rod surface coating      $$
205   8   0.0872946    4:2:-3        u=   58    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                        $$
206   90  0.0994705    -1 -2 3       u=   90    imp:n=1  $ UZrHx fuel      $$
207   5   0.0265588    -4 1 -2 3     u=   90    imp:n=1  $ radial rod surface coating      $$
208   8   0.0872946    4:2:-3        u=   90    imp:n=1  $ Hastelloy N fuel element tubing/caps
$$
c ---------                       $$
209   135 0.1017938   -1 -2 3       u=   135    imp:n=1  $ UZrHx fuel      $$
210   5   0.0265588    -4 1 -2 3     u=   135    imp:n=1  $ radial rod surface coating      $$
211   8   0.0872946    4:2:-3        u=   135    imp:n=1  $ Hastelloy N fuel element tubing/caps$$
c -------------------------------------------------------$$
300 7 0.1001037   (-6 5 -8 9) #2  #3  #4  #5  #6  #7  #8  #9 &$$
         #10 #11 #12 #13 #14 #15 #16 #17 #18 #19 #20 #21 #22 #23 &$$
         #24 #25 #26 #27 #28 #29 #30 #31 #32 #33 #34 #35 #36 #37 &$$
         #41 #42 #43 #44 #45 #46    &      $ fuel elements$$
         imp:n=1  $ vessel interior between elements - void filled$$
c ----- tbd -------------------------------------$$
301 6  0.0602626     -6   8 -10                imp:n=1  $ type 1100 aluminum upper gridplate$$
302 6  0.0602626     -6  -9  11                imp:n=1  $ type 1100 aluminum lower gridplate$$
303 7 0.1001037      -6  10 -12                imp:n=1  $ vessel interior above upper gridplate$$
304 7 0.1001037      -6 -11  13                imp:n=1  $ vessel interior above upper gridplate$$
c ----- tbd -------------------------------------$$
305 9  0.0871549  (-7 -13 15):(-7 6 -14 13):(-16 6 -12 14)  imp:n=1  $ ss316 vessel walls$$
306 6  0.0602626  (-6 -17 12):(-16 6 -18 12)   imp:n=1  $ type 1100 aluminum cover plate$$
307 12 0.0708762  (7 -500 19 -14)              imp:n=1  $ binal sleeve$$
308 12 0.0708762  (7 -500 -20 15)              imp:n=1  $ binal sleeve$$
309 7  0.1001037  (29 -15 -27  ):(15 -20 -27 500) imp:n=1  $ water $$
310 7  0.1001037  (20 -31 24 -27)              imp:n=1  $ water filled volume of lower tank$$
311 9  0.0871549  (26 -25 -28):(27 -28 -31 25) imp:n=1  $ bottom tank shell$$
312 0            -27 25 -30                    imp:n=1  $ void at the bottom of lower tank$$
313 9 0.0871549   -29 30 -27                   imp:n=1  $ steel plate in lower tank above void$$
314 0            31 -22 24 -28                 imp:n=1  $ void over lower tank outside top tank$$
315 9  0.0871549  (-19 20 7 -24):(-24 23 19 -22) imp:n=1  $upper tanks wall$$
316 7  0.1001037  (19 -21 500 -23)             imp:n=1  $ water in the upper tank$$
317 0  (21 -14 500 -23):(17 -18 -6):(14 -18 16 -23):(18 -22 -23) imp:n=1 $void inside top tank$$
c ----- tbd -------------------------------------$$
318 0   (22 -999):(-22 31 28 -999):(28 -999 26 -31):(-26 -999) imp:n=1$$
319 0 999           imp:n=0$$
$$
1   c/z  0.0  9.6012   1.53924  $ radius of fuel rod = (2.54)(1.212/2)$$
2   pz  15.52575                $ top of the active fuel region= (2.54)(12.225/2)$$
3   pz -15.52575                $ bottom of active fuel region$$
4   c/z  0.0  9.6012   1.5621   $ IR of fuel element tube=((1.25-0.02)/2)2.54$$
5   c/z  0.0  9.6012   1.5875   $ OR of fuel element tube=(1.25/2)(2.54)$$
6   cz  11.27125                $ IR of rx vessel=(8.875/2)(2.54)$$
7   cz  11.34999                $ OR of rx vessel=((8.875/2)+0.031)(2.54)$$
8   pz  15.8115                 $ top of the fuel element=(12.45/2)(2.54)$$
9   pz -15.8115                 $ bottom of fuel element$$
10  pz  16.4465                 $ top of upper grid plate =15.8115+(2.54)(0.25)$$
```

```
11  pz -16.4465                 $ bottom of lower grid plate=-15.8115-(2.54)(0.25)$$
12  pz  16.85925                $ vessel cover/flange interface$$
13  pz -18.93951                $ top of vessel bottom=-19.01825+(2.54)(0.031)$$
14  pz  16.70177                $ bottom of vessel flange$$
15  pz -19.01825                $ bottom of vessel bottom=6.06425-(2.54)(9.875)$$
16  cz  16.46555                $ OR of vessel flange$$
17  pz  16.93799                $ top of cover plate indent=$$
18  pz  17.49425                $ top of cover plate flange$$
19  pz  6.22173                 $ top of bottom plate for upper tank=6.06425+(2.54)(0.062)$$
20  pz  6.06425                 $ bottom of bottom plate for upper tank=-15.52575+(2.54)(8.5)$$
21  pz  7.66445                 $ top of the water in the top tank :9.13" above fuel bottom    $$
22  pz  36.22675                $ top edge of upper tank=6.06425+(2.54)(11.875)$$
23  cz  26.67                   $ IR of upper tank=(21/2)(2.5)$$
24  cz  26.82743                $ OR of upper tank=((21/2)+0.062)(2.54)$$
25  pz -40.29075                $ top of bottom plate for lower tank=-40.60825+(2.54)(0.125)$$
26  pz -40.60825                $ bottom of bottom plate for lower tank=21.30425-(2.54)(24 3/8)$$
27  cz  34.925                  $ IR of lower tank=(27.5/2)(2.54)$$
28  cz  35.08248                $ OR of lower tank=((27.5/2)+0.06)(2.54)$$
29  pz -32.35325                $ bottom of top plate for lower tank=-32.67075+(2.54)(0.125)$$
30  pz -32.67075                $ top of bottom plate for lower tank=-32.67075+(2.54)(0.125)$$
31  pz  21.30425                $ top of the bottom tank=36.22675-(2.54)(5.875)               $$
35  c/z  8.3149 -4.8006 1.5875  $ OR of lucite rod in position 37$$
c ----- begin internal be piece surfaces -----------------$$
44  cz  11.1506     $ outside radius of internal be piece$$
45  p -1.73205   1  0   8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
46  p -1.73205   1  0  -8.89 $ side flat of internal be piece @ 1 &  7 o'clock$$
47  py   4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
48  py  -4.445              $ side flat of internal be piece @ 3 &  9 o'clock$$
49  p  1.73205  1  0   8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
50  p  1.73205  1  0  -8.89  $ side flat of internal be piece @ 5 & 11 o'clock$$
51  p   1  1.73205  0   18.6944  $ inside flat of internal be piece @  1 o'clock$$
52  px   9.3472                  $ inside flat of internal be piece @  3 o'clock$$
53  p  -1  1.73205  0  -18.6944  $ inside flat of internal be piece @  5 o'clock$$
54  p   1  1.73205  0  -18.6944  $ inside flat of internal be piece @  7 o'clock$$
55  px  -9.3472                  $ inside flat of internal be piece @  9 o'clock$$
56  p  -1  1.73205  0   18.6944  $ inside flat of internal be piece @ 11 o'clock$$
57  c/z   0.0      9.6012  1.6764   $ inside be piece clearance for element$$
58  c/z   2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
59  c/z   5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
60  c/z   8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
61  c/z   8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
62  c/z   8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
63  c/z   8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
64  c/z   5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
65  c/z   2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
66  c/z   0.0     -9.6012  1.6764   $ inside be piece clearance for element$$
67  c/z  -2.7716  -8.0010  1.6764   $ inside be piece clearance for element$$
68  c/z  -5.5432  -6.4008  1.6764   $ inside be piece clearance for element$$
69  c/z  -8.3149  -4.8006  1.6764   $ inside be piece clearance for element$$
70  c/z  -8.3149  -1.6002  1.6764   $ inside be piece clearance for element$$
71  c/z  -8.3149   1.6002  1.6764   $ inside be piece clearance for element$$
72  c/z  -8.3149   4.8006  1.6764   $ inside be piece clearance for element$$
73  c/z  -5.5432   6.4008  1.6764   $ inside be piece clearance for element$$
74  c/z  -2.7716   8.0010  1.6764   $ inside be piece clearance for element$$
c -----Binal sleeve outer radius----------------$$
500 cz 13.25499$$
c ---------------------------------------------------$$
999 so  55$$
$$
mode  n$$
c ------npg----k----nsk---gen----$$
kcode   1000  1.0  1000  3000$$
ksrc    0  9.6012  0$$
c --- sm2o3 coating ----$$
m5    8016.60c 0.0168362 &$$
     13027.60c 0.0052426 &$$
     14000.60c 0.0044482 &$$
     62147.66c 0.0000076 &$$
     62149.66c 0.0000070 &$$
     62150.50c 0.0000037 &$$
     62152.50c 0.0000135$$
```

```
c --- type 1100 aluminum ---------$$
m6   13027.60c 0.0602626$$
c --- water ----------$$
m7    1001.60c 0.0667358 &$$
      8016.60c 0.0333679$$
mt7   lwtr.01t$$
c --- Hastelloy N -----$$
m8   28058.60c 0.0440590 &$$
     28060.60c 0.0168440 &$$
     28061.60c 0.0007293 &$$
     28062.60c 0.0023169 &$$
     28064.60c 0.0005873 &$$
     26054.60c 0.0002818 &$$
     26056.60c 0.0043815 &$$
     26057.60c 0.0001003 &$$
     26058.60c 0.0000134 &$$
     24050.60c 0.0003121 &$$
     24052.60c 0.0060187 &$$
     24053.60c 0.0006824 &$$
     24054.60c 0.0001699 &$$
     42000.60c 0.0088982 &$$
     14000.60c 0.0018998$$
c --- ss316 -----------$$
m9   26054.60c 0.0033463 &$$
     26056.60c 0.0520202 &$$
     26057.60c 0.0011910 &$$
     26058.60c 0.0001588 &$$
     24050.60c 0.0006870 &$$
     24052.60c 0.0132476 &$$
     24053.60c 0.0015020 &$$
     24054.60c 0.0003739 &$$
     28058.60c 0.0067490 &$$
     28060.60c 0.0025802 &$$
     28061.60c 0.0001117 &$$
     28062.60c 0.0003549 &$$
     28064.60c 0.0000900 &$$
     42000.60c 0.0012601 &$$
     25055.60c 0.0017604 &$$
     14000.60c 0.0017218$$
c ---- lucite ----------$$
m10  6000.60c  0.0354891 &$$
     1001.60c  0.0567825 &$$
     8016.60c  0.0141956 $$
mt10 poly.01t            $$
c --- Be metal ---------$$
m11   4009.60c 0.1216164$$
mt11   be.01t$$
c --- borated aluminum @ 10.2 w/o boron as natB4C -----------$$
m12   5010.60c 0.0030227 &$$
      5011.60c 0.0121667 &$$
      6000.60c 0.0037973 &$$
     13027.60c 0.0518894$$
c ---total=0.07087616$$
c  Definitions for the fuel elements:$$
c  --------------rod number:  19 $$
m519 92235.60c 0.0014245 &$$
     92238.60c 0.0001026 &$$
     40000.60c 0.0353836 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004486 $$
mt519     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  23 $$
m523 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004424 $$
mt523     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  26 $$
```

```
m526 92235.60c 0.0013946 &$$
     92238.60c 0.0001005 &$$
     40000.60c 0.0346401 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004392 $$
mt526     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  37 $$
m537 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004417 $$
mt537     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  40 $$
m40  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004479 $$
mt40     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  46 $$
m46  92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004417$$
mt46     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  51 $$
m51  92235.60c 0.0014012 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0348053 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004413 $$
mt51     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  52 $$
m52  92235.60c 0.0014256 &$$
     92238.60c 0.0001027 &$$
     40000.60c 0.0354111 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004490 $$
mt52     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  55 $$
m55  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0647603 &$$
      6000.60c 0.0004410 $$
mt55     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  62 $$
m62  92235.60c 0.0013990 &$$
     92238.60c 0.0001008 &$$
     40000.60c 0.0347502 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004406 $$
mt62     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  65 $$
m65  92235.60c 0.0014001 &$$
     92238.60c 0.0001009 &$$
     40000.60c 0.0347778 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004410 $$
mt65     zr/h.01t  & $$
  h/zr.01t $$
```

```
c  --------------rod number:  66 $$
m66  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0630821 &$$
      6000.60c 0.0004424 $$
mt66     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  67 $$
m67  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0640693 &$$
      6000.60c 0.0004476 $$
mt67     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  68 $$
m68  92235.60c 0.0014101 &$$
     92238.60c 0.0001016 &$$
     40000.60c 0.0350256 &$$
      1001.60c 0.0646616 &$$
      6000.60c 0.0004441 $$
mt68     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  80 $$
m80  92235.60c 0.0014234 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353560 &$$
      1001.60c 0.0639706 &$$
      6000.60c 0.0004483 $$
mt80     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  81 $$
m81  92235.60c 0.0014134 &$$
     92238.60c 0.0001018 &$$
     40000.60c 0.0351082 &$$
      1001.60c 0.0643654 &$$
      6000.60c 0.0004452 $$
mt81     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  83 $$
m83  92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0654514 &$$
      6000.60c 0.0004424 $$
mt83     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  84 $$
m84  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0623910 &$$
      6000.60c 0.0004479 $$
mt84     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  85 $$
m85  92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0635757 &$$
      6000.60c 0.0004427 $$
mt85     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  86 $$
m86  92235.60c 0.0014156 &$$
     92238.60c 0.0001020 &$$
     40000.60c 0.0351633 &$$
      1001.60c 0.0650565 &$$
      6000.60c 0.0004459 $$
mt86     zr/h.01t  & $$
```

```
  h/zr.01t $$
c  --------------rod number:  92 $$
m92  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0632795 &$$
      6000.60c 0.0004382 $$
mt92     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  132 $$
m132 92235.60c 0.0014056 &$$
     92238.60c 0.0001013 &$$
     40000.60c 0.0349155 &$$
      1001.60c 0.0627859 &$$
      6000.60c 0.0004427 $$
mt132     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  133 $$
m133 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0644642 &$$
      6000.60c 0.0004424 $$
mt133     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  137 $$
m137 92235.60c 0.0013857 &$$
     92238.60c 0.0000998 &$$
     40000.60c 0.0344198 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004364 $$
mt137     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  147 $$
m147 92235.60c 0.0013890 &$$
     92238.60c 0.0001001 &$$
     40000.60c 0.0345024 &$$
      1001.60c 0.0636744 &$$
      6000.60c 0.0004375 $$
mt147     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  151 $$
m151 92235.60c 0.0014178 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0352184 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004466 $$
mt151     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  153 $$
m153 92235.60c 0.0014145 &$$
     92238.60c 0.0001019 &$$
     40000.60c 0.0351357 &$$
      1001.60c 0.0637731 &$$
      6000.60c 0.0004455 $$
mt153     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  171 $$
m171 92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004476 $$
mt171     zr/h.01t  &$$
  h/zr.01t $$
c  --------------rod number:  173 $$
m173 92235.60c 0.0014023 &$$
     92238.60c 0.0001010 &$$
     40000.60c 0.0348329 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004417 $$
```

```
mt173     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  174 $$
m174 92235.60c 0.0014267 &$$
     92238.60c 0.0001028 &$$
     40000.60c 0.0354386 &$$
      1001.60c 0.0645629 &$$
      6000.60c 0.0004493 $$
mt174     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  176 $$
m176 92235.60c 0.0014167 &$$
     92238.60c 0.0001021 &$$
     40000.60c 0.0351908 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004462 $$
mt176     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  9 $$
m559 92235.60c 0.0014278 &$$
     92238.60c 0.0001029 &$$
     40000.60c 0.0354662 &$$
      1001.60c 0.0619962 &$$
      6000.60c 0.0004497 $$
mt559     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  25 $$
m525 92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0626872 &$$
      6000.60c 0.0004479 $$
mt525     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  47 $$
m47  92235.60c 0.0014223 &$$
     92238.60c 0.0001025 &$$
     40000.60c 0.0353285 &$$
      1001.60c 0.0621936 &$$
      6000.60c 0.0004479 $$
mt47     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  58 $$
m58  92235.60c 0.0014212 &$$
     92238.60c 0.0001024 &$$
     40000.60c 0.0353010 &$$
      1001.60c 0.0642667 &$$
      6000.60c 0.0004476 $$
mt58     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  90 $$
m90  92235.60c 0.0013912 &$$
     92238.60c 0.0001002 &$$
     40000.60c 0.0345575 &$$
      1001.60c 0.0629834 &$$
      6000.60c 0.0004382 $$
mt90     zr/h.01t  & $$
  h/zr.01t $$
c  --------------rod number:  135 $$
m135 92235.60c 0.0014045 &$$
     92238.60c 0.0001012 &$$
     40000.60c 0.0348879 &$$
      1001.60c 0.0649578 &$$
      6000.60c 0.0004424 $$
mt135     zr/h.01t  & $$
  h/zr.01t $$
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```

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