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Development of a Flexible Design for Irradiation of Miniature Tensile and Charpy Test Specimens in the High Flux Isotope Reactor

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OAK RIDGE NATIONAL LABORATORY
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Reactor and Nuclear Systems Division

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ABSTRACT

Fusion promises a sustainable, clean, safe source of energy that could play a major role in solving the great challenge of meeting the world's growing power needs. Much of fusion technology in its current state requires further maturation to support a usable fusion reactor platform. Given that the environment in and around a sustained fusion reaction is very harsh, selecting the best materials for such a reactor is crucial. The European fusion materials community spent many years developing one such material, a low-activation martensitic structural steel named *Eurofer* that is intended primarily for use in the fusion blanket modules. Although this material has reached technological maturity, nuclear performance data are required to qualify Eurofer for these applications. Karlsruhe Institute of Technology (KIT), a member of the EUROfusion consortium, has sponsored an irradiation program to establish irradiation performance data for various forms of the Eurofer alloy family. This document describes the design and development of flexible irradiation capsule designs that can be used to irradiate specimens to temperatures ranging from ~200–400°C. This report also details as-built data for the screening and high dose phases of the KIT irradiation campaign of capsules that were submitted for irradiation in the High Flux Isotope Reactor in FY18.

1. INTRODUCTION

Fusion promises a sustainable, clean, and safe source of energy that could play a major role in solving the great challenge of meeting the world's growing power needs. As such, much of the technology in its current state requires further maturation to support a usable fusion reactor platform. Given that the environment in and around a sustain fusion reaction is very harsh, selecting the right materials for such a reactor is crucial. The European fusion materials community spent many years developing one such material; a low activation martensitic structural steel, dubbed *Eurofer*, that is primarily intended for use in the fusion blanket modules [1]. Although this material has reached technological maturity, nuclear performance data is required to qualify Eurofer for such applications [2] [3]. Karlsruhe Institute of Technology (KIT), a member of the EUROfusion consortium, has sponsored an irradiation program to establish such irradiation performance data for various forms of the Eurofer alloy family. This work describes the design and development of a set of flexible irradiation capsule designs that can be used to irradiate specimens to temperatures that range from ~200°C-400°C. Furthermore, this report details "as-built" data for both the "screening" and "high dose" phases of the KIT irradiation campaign; capsules that were submitted for irradiation in the High Flux Isotope Reactor (HFIR) in FY18.

2. EXPERIMENTAL METHODS

2.1 CAPSULE DESIGN

2.1.1 HFIR Irradiation and Experiment Design Concept

2.1.1.1 HFIR Irradiation

HFIR is a beryllium-reflected, pressurized, light water–cooled and moderated flux trap–type reactor located at Oak Ridge National Laboratory (ORNL). HFIR's core consists of aluminum-clad involute-fuel plates which currently use highly enriched ^{235}U fuel to maintain steady state at a power level of 85 MW [4]. Most of experiments are conducted in the flux trap; typically in small, uninstrumented rabbit capsules. As many as 7–9 rabbits can be stacked axially inside a single peripheral target position (PTP) holder, a target rod rabbit holder (TRRH), or the hydraulic tube (see Figure 1). The target rod and peripheral target holders have orifices that establish capsule heat transfer boundary conditions. Positions are numbered in increasing order from the bottom to the top of a PTP or TRRH. Positions TRRH-4 and PTP-5 are closest to the reactor's midplane.

The goal of this effort was to design a flexible experiment format to irradiate iron-chrome and high nickel content alloys in the flux trap. There are two general capsule formats that accept either (1) miniature single-specimen-J (SSJ2 or SSJ3) tensile specimens and other coupon-style specimens, or (2) miniature (M4CVN) Charpy or bend bar specimens. These two designs are intended for reaching temperatures between ~200–400°C and achieve cumulative irradiation doses up to tens of displacements per atom (dpa).

Neutron and gamma radiation from HFIR fuel cause heating of experiment materials. This heating is accurately determined using neutronics models of the HFIR core and is used as an input to thermal analyses that predict component temperatures during irradiation. As mentioned above, experiments in the flux trap are almost always uninstrumented. Passive silicon carbide (SiC) temperature monitors, or thermometry, can be used to determine the irradiation temperature post irradiation [5]. However, detailed neutronic and thermal analyses are required to ensure that design temperatures are achieved. Experiment designs typically use a small insulating gas gap between the capsule internal components and external housing in contact with reactor coolant. The size of the gap and the choice of fill gas (typically helium, neon, or argon) inside the experiment are chosen so that the heat generated in the experimental components passes through the gas gap and gives the desired temperature drop across the gap. The temperature drop is a function of the heat flux through the gap, thermal conductivity of the fill gas, and size of the gas gap. Each of these parameters is carefully selected and modeled to achieve design temperature in an experiment.

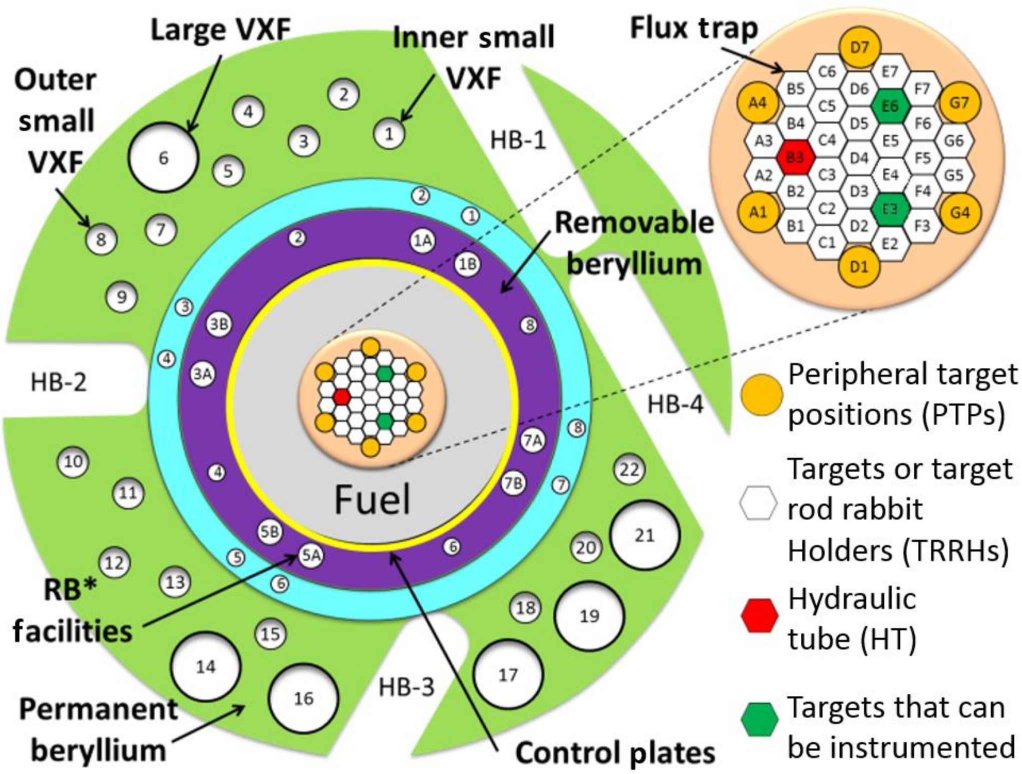

Figure 1. Schematic showing transverse section view of HFIR core, reflector, and experimental positions (not to scale) [6].

2.1.1.2 Experiment Design Concept

This report details two capsule designs (1) the miniature SSJ2 or SSJ3 (generally referred to as "SSJ*" throughout the rest of the document) tensile specimen/MPC coupon shown in Figure 2, and (2) the M4CVN bend bar shown in Figure 3. Design drawings of the experiment assembly and part details are summarized in Table 1. The outer containment for the irradiation experiment is the rabbit capsule housing, which is directly cooled on the outer surface by HFIR's primary coolant. The specimens are placed in aluminum holders with outer diameters (ODs) optimized to create gas gaps to control temperature performance. Centering tabs with a slightly larger diameter are machined into the holders to keep the assemblies centered inside the housing and to maintain a constant gas gap between the holder and the housing. Stainless steel spring pins are used in the tensile specimen design to hold the internal specimen in contact with the holder's inner walls. The chevrons are used as filler pieces that form a rectangular "coupon" shape to produce a uniform thermal load. For the bend bar design, molybdenum wires are used to ensure that the specimens remain captured in the holder. The SiC spring ensures that the specimens remain in contact with the holder wall and maintain constant heat transfer. Stainless steel liners are used to mildly insulate the F82H specimens from the high thermally conductive holder. This feature is meant to reduce thermal gradients in the specimen. Stainless steel wave springs are placed on the ends of the internal assembly between the housing and the holders to minimize axial heat loss. Grafoil insulators are used in both assemblies and are stacked on either end of the holders to reduce axial heat losses.

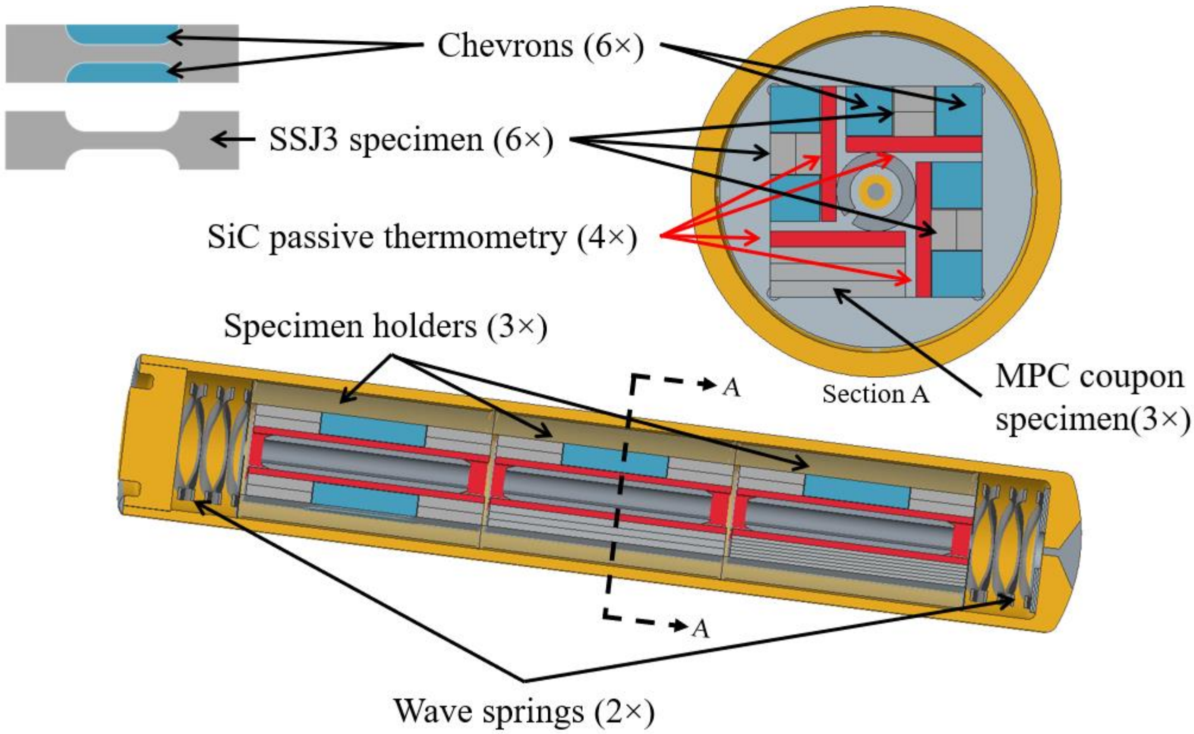

Figure 2. Section view of the single-specimen-J3 (SSJ3)/MPC coupon capsule

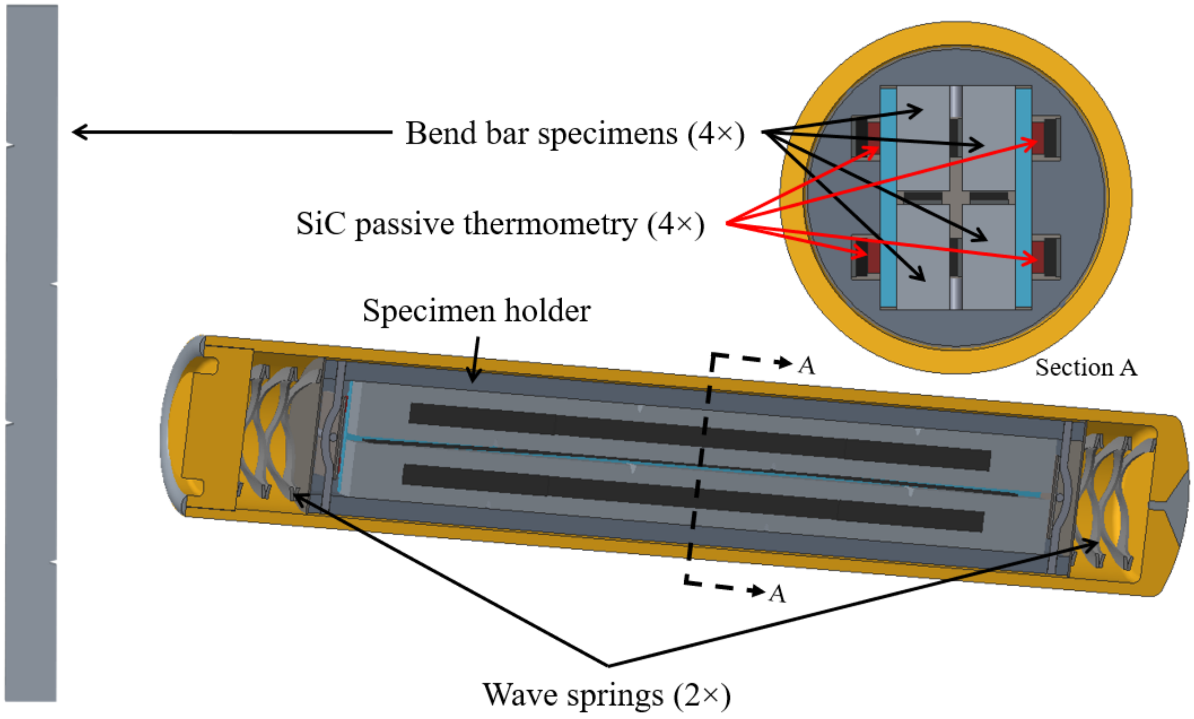

Figure 3. Section view of the M4CVN bend bar capsule showing the design concept.

Table 1. Summary of the experiment assembly and part detail drawings

Drawing	Title
Drawings common to both designs	
X3E020977A633, Rev. 0	Target Capsule Housing Assembly [7]
X3E020977A634, Rev. A	Target Capsule Housing/End Cap Detail [8]
S16-18-FUSSAM01, Rev.1	Chevron-SSJ-MPCCVN-MPC-Thermometry [9]
Drawings that describe the SSJ*/MPC capsule design	
S16-20-ESTEEL, Rev. 1	Rabbit Capsule Assembly [10]
S16-21-ESTEEL, Rev. 2	Rabbit Capsule Holder Assembly [11]
S16-22-ESTEEL, Rev. 1	Rabbit Capsule Part Details [12]
Drawings that describe the M4CVN capsule design	
S16-23-ESTEELB, Rev.1	Rabbit Capsule Assembly [13]
S16-24-ESTEELB, Rev.1	Rabbit Capsule Part Details [14]

3. COMPUTATIONAL METHODS

ANSYS finite element analysis software was used to predict temperature distributions inside the experiments. These analyses use material-dependent heat generation rates (heat per unit mass), which were calculated from previously determined neutronics analyses, as inputs. Custom user-defined macros have been incorporated into ANSYS to determine thermal contact conductance between components either in contact or separated by small gas gaps that expand or contract due to thermal expansion [15]. In this way, gas gaps are not directly meshed, which significantly reduces computational time. Computer aided design (CAD) models are imported into ANSYS and are then meshed. Thermal contacts are defined to allow heat transferred between multiple bodies. Gas gap heat transfer is assumed to only include conduction, as there is very little space available for natural convection to occur. Gaps are typically on the order of microns to a few millimeters in size, and the total internal length of the capsule is less than 60 mm. The solver accounts for thermal expansion using temperature-dependent thermal expansion data and the temperatures of contact and target surface nodes.

The ORNL Nuclear Experiments and Irradiation Testing group (formerly the Thermal Hydraulics and Irradiation Engineering group) maintains a database of design and analysis calculations (DACs) that includes temperature–dependent and some radiation dose–dependent thermophysical material properties used in thermal analyses. Properties are primarily obtained from CINDAS [16], MatWeb [17], and various literature sources. Material thermophysical properties for this calculation are included in the DACs shown in Table 2, which are available upon request.

Table 2. Experiment materials and material property references.

Part	Material	Reference
Housing, end cap, holders	Aluminum	DAC-10-03-PROP_AL6061 [18]
Specimens	F82H steel	DAC-16-02-PROP_F82H [19]
Liners	Stainless steel	DAC-10-16-PROP_SS304 [20]
Insulators	Grafoil	DAC-11-16-PROP_GRAFOIL [21]
Thermometry	Silicon carbide	DAC-10-06-PROP_SIC(IRR) [22]
Wires	Molybdenum	DAC-10-11-PROP_MOLY [23]
Fill gas	Helium	DAC-10-02-PROP_HELIUM [24]

F82H thermophysical properties are used to represent the Eurofer specimen material. Mergia and Boukos show that the F82H and Eurofer 97 have significant overlap in specific heat capacity and relatively good agreement in thermal conductivity in the temperatures of interest [25]. Moreover, Klueh, et. al. show that these two version of reduced-activation ferritic/martensitic steels have virtually the same chemical compositions, with a difference of roughly 1% in chromium and some difference in the minoring alloy, but these two steels have similar mechanical properties [26]. As such, substituting F82H thermophysical properties for the Eurofer samples to estimate capsule thermal performance is valid for this work.

Convection boundary conditions are applied to the outer surface of the housing. Details of the calculation of the convective heat transfer coefficients and bulk coolant temperatures are summarized in DAC-11-01-RAB03 [27]. These parameters were calculated using turbulent flow correlations and the axial power profile (due to neutron and gamma heat generation in the coolant) specific to target rod rabbit holders in the HFIR flux trap. The temperatures calculated in the thermal analyses are not sensitive to the convection heat transfer coefficient, as the housing surface temperatures are typically only ~10°C warmer than the bulk coolant temperature. The heat generation rates vary in each irradiation location and as a function of axial distance from the reactor core midplane. As shown in Figure 1, there are multiple irradiation facilities designation in the HFIR flux trap. The designs discussed in this work focus on the target rod rabbit holder (TRRH) facility. Peak heat generation rates at the core midplane, parameters for determining the axial profile, and convection parameters are summarized in Table 3. Neutronics calculations performed previously for experiments with similar materials to the EUROfusion capsules [28] provided peak heat generation rates for thermal analyses, and are also reported in Table 3.

Table 3. Thermal boundary conditions and input parameters

Parameter	Value in TRRH
Heat transfer coefficient	47.1 kW m^{-2} K^{-1}
Bulk coolant temperature	52°C
Peak heat generation rate for aluminum	31.3 W/g
Peak heat generation rate for F82H steel	38.1 W/g
Peak heat generation rate for Stainless Steel	38.1 W/g
Peak heat generation rate for Molybdenum	42.0 W/g
Peak heat generation rate for SiC	31.7 W/g
Peak heat generation rate for grafoil	32.5 W/g
Correlating parameter (σ)	30.07 cm

Note: TRRH = target rod rabbit holder

The local heat generation rate for each element in the irradiation capsule is estimated with the following profile:

$$\mathrm{q(material, z) = q_{peak}(material) \cdot exp}\left[-\left(\frac{z}{\sigma}\right)^2\right]$$

where:

q	=	local heat generation rate as a function of the material and axial location
q_{peak}	=	heat generation rate at the HFIR midplane as a function of material
z	=	axial location (cm) in the HFIR, where the midplane is at z = 0
σ	=	correlating parameter (cm)

Figure 4 shows an example of a fully meshed 3D finite element model for the bend bar design. The model uses ¼ symmetry to reduce computational time. The wave springs were not modeled, and the model assumes that the ends of the holder assembly are isolated from the housing. Most of the internal components were meshed using 20-node hexagonal elements, and the model mesh size was 0.6 mm.

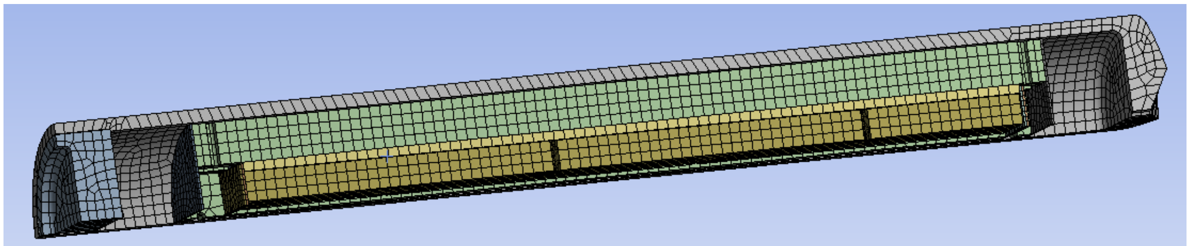

Figure 4. Meshed 3D thermal finite element model for the bend bar design with ¼ symmetry.

Similar mesh sizing was produced for the SSJ*/MPC design, but the model was radially and axially asymmetric, so these simplifications could not be made. However, the internal holder configurations are modular and are essentially equivalent. A specimen set (i.e., MPC coupons, SSJ specimen, and Eurofer chevron sets) can be considered spatially and thermally equivalent. This design flexibility exploits the similar shape footprints shared by the tensile specimens and MPC coupons. The tensile specimen temperatures are roughly equivalent to their MPC* counterparts, but bulk temperature ranges of the MPCs increase due to increased thermal contact resistances caused by stacking multiple parts. SSJ2 specimens are nominally 0.50 mm thick and equivalent to the MPC2 specimens, which allows for a stack of three specimens to be in a holder quadrant. Therefore, these specimen sets will have similar average temperatures and temperature spans. In contrast, the SSJ3 is 0.75 mm thick, and the MPC1 specimen is 0.25 mm thick. This allows space for 2 tensile and 6 MPC1 specimens to fit in a holder quadrant. Given that there are nearly 3 times the number of contact resistances in the MPC1 specimen stack, the average set temperature will be roughly equivalent to the SSJ counter parts, but the span of individual specimen average temperatures will be greater. It is estimated that MPC* average specimen temperature spans will range between 25–45°C, where the SSJ* average specimen temperature spans will be 15–25°C.

The operating temperatures of a single holder subassembly remain relatively consistent, despite specimen configuration. Optimization of the holders' outer diameters can be performed for a single subassembly configuration to establish design target temperatures. This assumption is valid because all holders are contained in a single capsule, are operating at the same temperatures, and are thermally isolated from the axial ends of the capsule. Some uncertainty on specific specimen temperatures may exist given the conditions described in the previous paragraph, but the passive thermometry will provide actual performance data for each quadrant of the as-built capsules. It is unfeasible to establish unique holder diameters for all specimen permutations that may be created from the various specimens available in this design. Therefore, using the single holder module to produce design diameters is the most practical approach to establishing design diameters.

4. RESULTS AND DISCUSSION

4.1 THERMAL ANALYSIS

4.1.1 Test Matrix and Evaluation Cases

Thermal analyses were performed for each capsule configuration requested by the program sponsor to target specific design temperatures (see Table 4 and Table 5). These analyses determine temperature distributions within the experiment using nominal housing and specimen dimensions and the desired fill gas, helium, to produce a specific gas gap to target an average design temperature. The primary sensitivity parameter is the gas gap itself, given that the thermophysical properties and heat generation rates of the solid materials are not greatly affected by small perturbations in temperature. Therefore, once a gas gap is established, the housing's inner diameter and corresponding holder diameter can deviate somewhat from the nominal dimension as long as the target gas gap is maintained. All capsule configurations were designed for positions TRRH 3 and TRRH 5 in the HFIR flux trap to ensure most favorable conditions with the widest availability. The TRRH 3/5 positions are equivalent to the peripheral target position PTP 4 irradiation site. These positions are symmetrically centered around the TRRH center position, which provides the second flattest power profile (91–99% centerline power over the length of the position) and have twice the number of available locations (32) compared to TRRH center positions.

Table 4. Screening or low dose phase test matrix.

Capsule ID	Configuration	Target irradiation condition	Specimen dimensions (Length × width × thickness) mm	Qty.	Material	Pre-irradiation tests	Post-irradiation tests
ES21	20 × SS-J3; 10 × MPC1;	2.5 ± .38 dpa 285°C ± 20	16 × 4 × .75 16 × 4 × .25	2 ea. 1 ea.	10 alloy variants	Photography, metrology	Vickers hardness, tensile test, TEM*
ES22	20 × SS-J3; 10 × MPC1;	2.5 ± .38 dpa 315°C ± 20	16 × 4 × .75 16 × 4 × .25	2 ea. 1 ea.	10 alloy variants	Photography, metrology	Vickers hardness, tensile test, TEM
ES31	4 × M4CVN	2.5 ± .38 dpa 300°C ± 20	45 × 3.3 × 1.65	2 ea.	2 alloy variants	Pre-cracking, photography, metrology	Vickers hardness, fracture toughness
ES32	4 × M4CVN	2.5 ± .38 dpa 300°C ± 20	45 × 3.3 × 1.65	2 ea.	2 alloy variants	Pre-cracking, photography, metrology	Vickers hardness, fracture toughness
ES33	4 × M4CVN	2.5 ± .38 dpa 300°C ± 20	45 × 3.3 × 1.65	2 ea.	2 alloy variants	Pre-cracking, photography, metrology	Vickers hardness, fracture toughness
ES34	4 × M4CVN	2.5 ± .38 dpa 300°C ± 20	45 × 3.3 × 1.65	2 ea.	2 alloy variants	Pre-cracking, photography, metrology	Vickers hardness, fracture toughness
ES35	4 × M4CVN	2.5 ± .38 dpa 300°C ± 20	45 × 3.3 × 1.65	2 ea.	2 alloy variants	Pre-cracking, photography, metrology	Vickers hardness, fracture toughness

*TEM – transmission electron microscopy

Table 5. High dose phase test matrix.

Capsule ID	Configuration	Target irradiation condition	Specimen dimensions (Length × width × thickness) mm	Qty.	Pre-irradiation tests
ES01	12 × SS-J3; 6 × MPC1; 6 × MPC2	20 ± 2 dpa 220°C ± 20	16 × 4 × 0.75 16 × 4 × 0.25, 16 × 4 × 0.5	12 6, 6	Photography, metrology
ES02	12 × SS-J3; 6 × MPC1; 6 × MPC2	20 ± 2 dpa 240°C ± 20	16 × 4 × 0.75 16 × 4 × 0.25, 16 × 4 × 0.5	12 6, 6	Photography, metrology
ES03	12 × SS-J3; 6 × MPC1; 6 × MPC2	20 ± 2 dpa 275°C ± 20	16 × 4 × 0.75 16 × 4 × 0.25, 16 × 4 × 0.5	12 6, 6	Photography, metrology
ES04	12 × SS-J3; 6 × MPC1; 6 × MPC2	20 ± 2 dpa 300°C ± 20	16 × 4 × 0.75 16 × 4 × 0.25, 16 × 4 × 0.5	12 6, 6	Photography, metrology
ES05	12 × SS-J3; 6 × MPC1; 6 × MPC2	20 ± 2 dpa 325°C ± 20	16 × 4 × 0.75 16 × 4 × 0.25, 16 × 4 × 0.5	12 6, 6	Photography, metrology
ES06	12 × SS-J3; 6 × MPC1; 6 × MPC2	20 ± 2 dpa 350°C ± 20	16 × 4 × .75 16 × 4 × .25, 16 × 4 × .5	12 6, 6	Photography, metrology
ES07	12 × SS-J3; 6 × MPC1; 6 × MPC2	20 ± 2 dpa 375°C ± 20	16 × 4 × 0.75 16 × 4 × 0.25, 16 × 4 × 0.5	12 6, 6	Photography, metrology
ES11	4 × M4CVN	20 ± 2 dpa 220°C ± 20	45 × 3.3 × 1.65	4	Pre-cracking, photography, metrology
ES12	4 × M4CVN	20 ± 2 dpa 240°C ± 20	45 × 3.3× 1.65	4	Pre-cracking, photography, metrology
ES13	4 × M4CVN	20 ± 2 dpa 275°C ± 20	45 × 3.3 × 1.65	4	Pre-cracking, photography, metrology
ES14	4 × M4CVN	20 ± 2 dpa 300°C ± 20	45 × 3.3 × 1.65	4	Pre-cracking, photography, metrology
ES15	4 × M4CVN	20 ± 2 dpa 325°C ± 20	45 × 3.3 × 1.65	4	Pre-cracking, photography, metrology
ES16	4 × M4CVN	20 ± 2 dpa 350°C ± 20	45 × 3.3 × 1.65	4	Pre-cracking, photography, metrology
ES17	4 × M4CVN	20 ± 2 dpa 375°C ± 20	45 × 3.3 × 1.65	4	Pre-cracking, photography, metrology

4.1.2 Predicted Temperatures

Figure 5 and Figure 6 show examples of temperature contours for both styles of the rabbit assemblies. The SSJ*/MPC specimen design used the gauge length temperatures of the tensile specimens as the figures of merit. A difference in contour color can be seen between the inner and outer specimens, which is a graphical representation of the contact resistance issue described earlier in Section 3. Otherwise, the calculated temperature of this portion of the specimens is more uniform. There is a slight gradient over the widths and depths of the gauges (observed from left to right and in and out of the page), which comes from the asymmetric loading of the specimens within the holder, as shown in the upper right-hand corner of the figure. This could be corrected by centering the specimens within the cutout, but that would lead to a reduction in the number of specimens loaded into this configuration. Moreover, the gradients are small and generally within the uncertainty of the calculations based on the uncertainties of the heat generation rates, convective heat transfer coefficient, and geometric variations of machined parts.

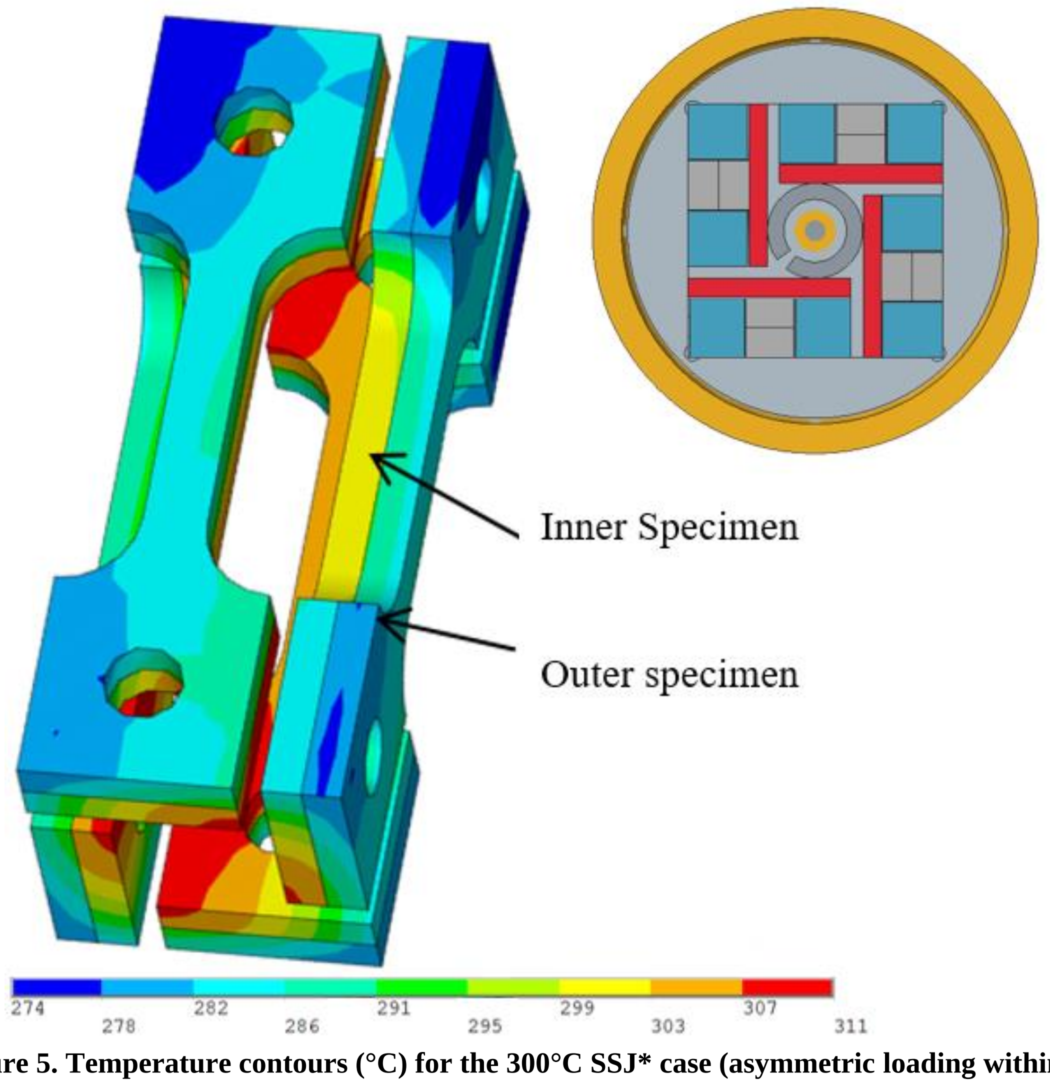

Figure 5. Temperature contours (°C) for the 300°C SSJ* case (asymmetric loading within the holder cutout is shown in the inlayed image)

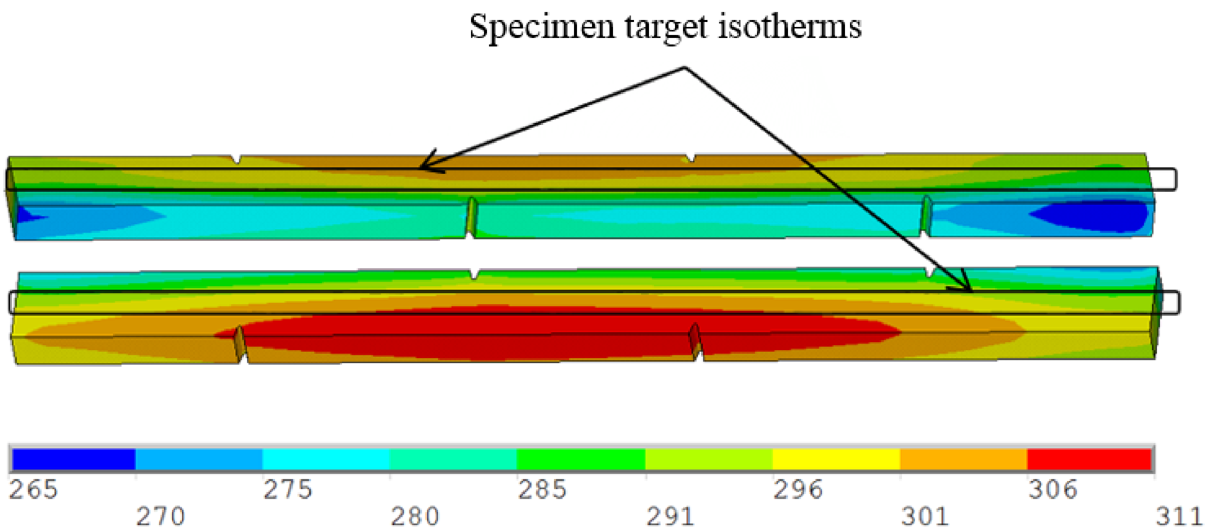

Figure 6. Temperature contours for the 300°C bend bar case (target isotherms outlined in black).

The average temperatures of the central volume located between the bend bar notches were used for the figure of merit for this design configuration (see outlined area in Figure 6). Given the nature of the Charpy test, crack propagation through this region dictates the performance of the specimen, so it was reasonable to select this region for use in identifying the design temperature. Moreover, it is a more central region of the specimen as shown by the reduced magnitude of thermal gradients shown in the thermal contour plots. Note that this calculation employed 90° symmetry, so Figure 6 shows the four lateral sides for a single parallelepiped shape.

Table 6 summarizes average, minimum, and maximum temperatures for the specimens and thermometry of each SSJ style capsule configuration. Likewise, Table 7 summarizes average, minimum, and maximum temperatures for the M4CVN bend bar case. Thermometry data reported in these tables will be compared to temperatures determined post-irradiation using dilatometry on SiC thermometry specimens. More details are provided in the full ANSYS output files in APPENDIX A. Average specimen temperatures fall within the allowable ranges in Table 4 and Table 5. Given the high heat generation rates produced by HFIR and the proximity to the reactor's centerline, it can be problematic to reach lower temperatures. Therefore, the lower temperature cases (200 –-240°C) were established on best effort.

Table 6. Predicted temperatures for the tensile specimens and passive thermometry for each SSJ*/MPC specimen capsule case

Design diameter (mm)	Part name	Material	Fill gas	Irradiation location	Temperature (°C)		
					Average (°C)	Minimum	Maximum
9.40 (200°C)	Inner SSJ tensile	Eurofer	Helium	TRRH 3/5	200	179	212
	Outer SSJ tensile	Eurofer			186	174	195
	Thermometry	SiC			205	169	230
9.38 (220°C)	Inner SSJ tensile	Eurofer			214	193	226
	Outer SSJ tensile	Eurofer			200	188	208
	Thermometry	SiC			219	184	244
9.34 (240°C)	Inner SSJ tensile	Eurofer			241	220	253
	Outer SSJ tensile	Eurofer			227	215	236
	Thermometry	SiC			246	210	271

Design diameter (mm)	Part name	Material	Fill gas	Irradiation location	Temperature (°C)		
					Average (°C)	Minimum	Maximum
9.30 (275°C)	Inner SSJ tensile	Eurofer	Helium	TRRH 3/5	268	247	280
	Outer SSJ tensile	Eurofer			254	242	263
	Thermometry	SiC			272	235	298
9.25 (300°C)	Inner SSJ tensile	Eurofer			304	283	316
	Outer SSJ tensile	Eurofer			290	279	298
	Thermometry	SiC			309	274	335
9.20 (325°C)	Inner SSJ tensile	Eurofer			330	309	341
	Outer SSJ tensile	Eurofer			316	305	324
	Thermometry	SiC			334	300	359
9.15 (350°C)	Inner SSJ tensile	Eurofer			360	339	371
	Outer SSJ tensile	Eurofer			346	334	355
	Thermometry	SiC			364	329	389
9.00 (375°C)	Inner SSJ tensile	Eurofer			388	368	399
	Outer SSJ tensile	Eurofer			374	363	382
	Thermometry	SiC			392	356	417

Table 7. Predicted temperatures for the bend bar specimens and passive thermometry for each SSJ*/MPC specimen capsule case.

Design diameter (mm)	Part name	Material	Fill gas	Irradiation location	Temperature (°C)		
					Average	Minimum	Maximum
9.44 (200°C)	M4CVN	Eurofer	Helium	TRRH 3/5	196	169	210
	Thermometry	SiC			192	185	195
9.40 (240°C)	M4CVN	Eurofer			236	207	251
	Thermometry	SiC			232	223	236
9.35 (275°C)	M4CVN	Eurofer			268	237	282
	Thermometry	SiC			263	253	268
9.30 (300°C)	M4CVN	Eurofer			296	265	311
	Thermometry	SiC			291	280	297
9.27 (330°C)	M4CVN	Eurofer			321	289	337
	Thermometry	SiC			316	304	322
9.23 (350°C)	M4CVN	Eurofer			347	313	363
	Thermometry	SiC			341	328	348
9.19 (375°C)	M4CVN	Eurofer			371	337	387
	Thermometry	SiC			366	352	373

5. AS-BUILT CAPSULE INFORMATION

To June 2018, 21 irradiation capsules have been assembled and inserted into HFIR for irradiation. Out of the total number of capsules, seven (ES21, ES22, ES31–ES35) pertain to the screening phase, and the remaining fourteen capsules (ES01–ES07, ES21–ES27) pertain to the high dose phase. As part of the fabrication process, detailed dimensional, mass, and configuration data were produced to ensure that each capsule met the intended design requirements, the primary metrics being the customer-supplied loading lists and capsule design gas gaps. This report includes essential documentation providing these details (see attachments). More in-depth data such as fabrication and material inspection reports can be found in the fabrication files produce for the individual capsule assembly campaigns. These records are maintained by the Nuclear Engineering and Irradiation Testing group and are available upon request.

6. SUMMARY AND CONCLUSIONS

This work summarizes the capsule design, thermal analyses, and as-built capsule data for the EUROfusion Eurofer irradiation program. This document describes two specific designs: a modular, subsized tensile specimen format and a subsized Charpy test specimen format. These two capsule designs were optimized to produce holder-housing gas gaps that allow a specimen to reach temperatures between 200–400°C. Each capsule configuration contains passive SiC thermometry that will provide temperature performance data during post-irradiation dilatometry to verify individual capsule temperatures. The irradiation program was divided into two phases: (1) low dose screening, and (2) high dose qualification. The former phase targeted ~300°C as the average specimen temperatures at 2.5dpa, and the latter phase targeted the full temperature range established for the program, with a cumulative irradiation dose of 25 dpa. As of the third quarter of the 2018 fiscal year, all requested capsules have been assembled, qualified, and inserted into HFIR for irradiation. Furthermore, at this writing, the screening phase capsule irradiation schedule and preparation of post-irradiation examination are underway.

7. WORKS CITED

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APPENDICES

APPENDIX A. ANSYS DESIGN REPORTS

9.40 mm holder diameter (tensile design)

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    TEMPERATURE DESIGN SOLUTION FOR ESTEEL TENSILE (2016) RABBITS
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  ------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.40 mm

  * Thermal-only solution method
  ------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
 -------------------------------------------------------------------------------
  HEAT GENERATION
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Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOLDER	AL-6061	31300.	45.7	43.1
3) ROLLPIN	SS304	38100.	8.5	8.1
5) SSJ.TENSILE.1	F82H	38100.	9.1	8.6
7) SSJ.TENSILE.2	F82H	38100.	9.1	8.6
9) CHEVRON.1	F82H	38100.	4.4	4.1
11) CHEVRON.2	F82H	38100.	4.4	4.1
13) SSJ.TENSILE.3	F82H	38100.	9.1	8.6
15) SSJ.TENSILE.4	F82H	38100.	9.1	8.6
17) CHEVRON.3	F82H	38100.	4.4	4.1
19) CHEVRON.4	F82H	38100.	4.4	4.1
21) SSJ.TENSILE.5	F82H	38100.	9.1	8.6
23) SSJ.TENSILE.6	F82H	38100.	9.1	8.6
25) CHEVRON.5	F82H	38100.	4.4	4.1
27) CHEVRON.6	F82H	38100.	4.4	4.1
29) SSJ.TENSILE.7	F82H	38100.	9.1	8.6
31) SSJ.TENSILE.8	F82H	38100.	9.1	8.6
33) CHEVRON.7	F82H	38100.	4.4	4.1
35) CHEVRON.8	F82H	38100.	4.4	4.1
37) THERMOMETRY.1	SiC(Irr)	31700.	2.9	2.8
38) THERMOMETRY.2	SiC(Irr)	31700.	2.9	2.8
39) THERMOMETRY.3	SiC(Irr)	31700.	2.9	2.8
40) THERMOMETRY.4	SiC(Irr)	31700.	2.9	2.8
41) HOUSING	AL-6061	31300.	32.1	30.3
			205.5	194.1

CAPSULE TEMPERATURE SUMMARY

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOLDER	AL-6061	158.	154.	166.	155.	161.
3) ROLLPIN	SS304	254.	247.	264.	249.	262.
5) SSJ.TENSILE.1	F82H	200.	179.	212.	185.	210.
7) SSJ.TENSILE.2	F82H	186.	174.	195.	178.	192.
9) CHEVRON.1	F82H	187.	158.	195.	180.	193.
11) CHEVRON.2	F82H	201.	189.	208.	194.	206.
13) SSJ.TENSILE.3	F82H	200.	179.	212.	185.	210.

15) SSJ.TENSILE.4	F82H	186.	174.	194.	178.	192.
17) CHEVRON.3	F82H	188.	180.	195.	184.	193.
19) CHEVRON.4	F82H	200.	188.	207.	194.	206.
21) SSJ.TENSILE.5	F82H	200.	178.	212.	185.	210.
23) SSJ.TENSILE.6	F82H	186.	175.	195.	178.	192.
25) CHEVRON.5	F82H	188.	181.	196.	184.	194.
27) CHEVRON.6	F82H	200.	189.	207.	194.	205.
29) SSJ.TENSILE.7	F82H	199.	178.	211.	184.	209.
31) SSJ.TENSILE.8	F82H	185.	175.	193.	177.	191.
33) CHEVRON.7	F82H	182.	160.	190.	173.	188.
35) CHEVRON.8	F82H	199.	187.	206.	193.	204.
37) THERMOMETRY.1	SiC(Irr)	203.	167.	230.	179.	220.
38) THERMOMETRY.2	SiC(Irr)	205.	169.	230.	180.	221.
39) THERMOMETRY.3	SiC(Irr)	205.	170.	234.	181.	222.
40) THERMOMETRY.4	SiC(Irr)	205.	169.	234.	181.	222.
41) HOUSING	AL-6061	60.	59.	61.	59.	61.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·ºC)	Thermal Exp. Coeff. (µm/m·˚C)	Emis (---)
1) HOLDER	AL-6061	176.000	24.40	0.050
3) ROLLPIN	SS304	18.772	0.00	0.143
5) SSJ.TENSILE.1	F82H	33.231	11.02	0.143
7) SSJ.TENSILE.2	F82H	33.148	10.99	0.143
9) CHEVRON.1	F82H	33.155	10.99	0.143
11) CHEVRON.2	F82H	33.232	11.02	0.143
13) SSJ.TENSILE.3	F82H	33.231	11.02	0.143
15) SSJ.TENSILE.4	F82H	33.149	10.99	0.143
17) CHEVRON.3	F82H	33.162	10.99	0.143
19) CHEVRON.4	F82H	33.231	11.02	0.143
21) SSJ.TENSILE.5	F82H	33.230	11.02	0.143
23) SSJ.TENSILE.6	F82H	33.148	10.99	0.143
25) CHEVRON.5	F82H	33.163	11.00	0.143
27) CHEVRON.6	F82H	33.230	11.02	0.143
29) SSJ.TENSILE.7	F82H	33.223	11.02	0.143
31) SSJ.TENSILE.8	F82H	33.142	10.99	0.143
33) CHEVRON.7	F82H	33.126	10.98	0.143
35) CHEVRON.8	F82H	33.224	11.02	0.143
37) THERMOMETRY.1	SiC(Irr)	6.101	2.95	0.900
38) THERMOMETRY.2	SiC(Irr)	6.101	2.95	0.900
39) THERMOMETRY.3	SiC(Irr)	6.100	2.95	0.900
40) THERMOMETRY.4	SiC(Irr)	6.101	2.95	0.900
41) HOUSING	AL-6061	166.661	24.21	0.050

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (˚C)	Specific Heat (J/kg˚C)	Stored Energy (J)
1) HOLDER	AL-6061	1.459	158.	955.	193.
3) ROLLPIN	SS304	0.224	254.	384.	20.
5) SSJ.TENSILE.1	F82H	0.238	200.	515.	22.
7) SSJ.TENSILE.2	F82H	0.238	186.	510.	20.
9) CHEVRON.1	F82H	0.115	187.	510.	10.
11) CHEVRON.2	F82H	0.115	201.	515.	11.
13) SSJ.TENSILE.3	F82H	0.238	200.	515.	22.
15) SSJ.TENSILE.4	F82H	0.238	186.	510.	20.

17) CHEVRON.3	F82H	0.115	188.	511.	10.
19) CHEVRON.4	F82H	0.115	200.	515.	11.
21) SSJ.TENSILE.5	F82H	0.238	200.	515.	22.
23) SSJ.TENSILE.6	F82H	0.238	186.	510.	20.
25) CHEVRON.5	F82H	0.115	188.	511.	10.
27) CHEVRON.6	F82H	0.115	200.	515.	11.
29) SSJ.TENSILE.7	F82H	0.238	199.	515.	22.
31) SSJ.TENSILE.8	F82H	0.238	185.	509.	20.
33) CHEVRON.7	F82H	0.115	182.	508.	9.
35) CHEVRON.8	F82H	0.115	199.	515.	11.
37) THERMOMETRY.1	SiC(Irr)	0.092	203.	946.	16.
38) THERMOMETRY.2	SiC(Irr)	0.092	205.	947.	16.
39) THERMOMETRY.3	SiC(Irr)	0.092	205.	948.	16.
40) THERMOMETRY.4	SiC(Irr)	0.092	205.	948.	16.
41) HOUSING	AL-6061	1.026	60.	885.	36.
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		5.898			564.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 83: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 µm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (˚C)	156.965	154.363	158.462
Target temperature (˚C)	60.729	60.058	60.906
Geometric gas gap (µm)	59.965	59.689	60.323
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	339.548	327.342	346.952
Radiation heat flux (kW/m²)	0.000	0.000	0.000
Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	339.548	327.342	346.952
Thermal contact conductance (W/m²·C)	3528.169	3487.045	3557.529
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	48.896	48.498	49.375
Contact thermal jump distance (µm)	1.079	1.073	1.082
Target thermal jump distance (µm)	1.020	1.016	1.023
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·˚C)	0.180	0.180	0.180
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	3528.660	3488.720	3557.215

Contact status codes:

0=open/no heat transfer, 1=near-field contact
2=closed and sliding, 3=closed and sticking

9.38 mm holder diameter (tensile design)

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***************************************************************************
    TEMPERATURE DESIGN SOLUTION FOR ESTEEL TENSILE (2016) RABBITS
 ***************************************************************************
  -------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.38 mm

  * Thermal-only solution method
  -------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
 --------------------------------------------------------------------------------
  HEAT GENERATION
```

Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOLDER	AL-6061	31300.	45.2	42.7
3) ROLLPIN	SS304	38100.	8.5	8.0
5) SSJ.TENSILE.1	F82H	38100.	9.1	8.6
7) SSJ.TENSILE.2	F82H	38100.	9.1	8.6
9) CHEVRON.1	F82H	38100.	4.4	4.1
11) CHEVRON.2	F82H	38100.	4.4	4.1
13) SSJ.TENSILE.3	F82H	38100.	9.1	8.6
15) SSJ.TENSILE.4	F82H	38100.	9.1	8.6
17) CHEVRON.3	F82H	38100.	4.4	4.1
19) CHEVRON.4	F82H	38100.	4.4	4.1
21) SSJ.TENSILE.5	F82H	38100.	9.1	8.6
23) SSJ.TENSILE.6	F82H	38100.	9.1	8.6
25) CHEVRON.5	F82H	38100.	4.4	4.1
27) CHEVRON.6	F82H	38100.	4.4	4.1
29) SSJ.TENSILE.7	F82H	38100.	9.1	8.6
31) SSJ.TENSILE.8	F82H	38100.	9.1	8.6
33) CHEVRON.7	F82H	38100.	4.4	4.1
35) CHEVRON.8	F82H	38100.	4.4	4.1
37) THERMOMETRY.1	SiC(Irr)	31700.	2.9	2.8
38) THERMOMETRY.2	SiC(Irr)	31700.	2.9	2.8
39) THERMOMETRY.3	SiC(Irr)	31700.	2.9	2.8
40) THERMOMETRY.4	SiC(Irr)	31700.	2.9	2.8
41) HOUSING	AL-6061	31300.	32.1	30.3
			205.0	193.7

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  CAPSULE TEMPERATURE SUMMARY
```

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOLDER	AL-6061	173.	169.	182.	170.	175.
3) ROLLPIN	SS304	267.	261.	278.	263.	275.
5) SSJ.TENSILE.1	F82H	214.	193.	226.	198.	224.
7) SSJ.TENSILE.2	F82H	200.	188.	208.	192.	206.
9) CHEVRON.1	F82H	200.	171.	208.	193.	206.
11) CHEVRON.2	F82H	214.	202.	221.	208.	219.
13) SSJ.TENSILE.3	F82H	214.	193.	226.	199.	224.

15) SSJ.TENSILE.4	F82H	200.	190.	209.	192.	206.
17) CHEVRON.3	F82H	202.	194.	209.	198.	208.
19) CHEVRON.4	F82H	215.	203.	222.	208.	220.
21) SSJ.TENSILE.5	F82H	214.	192.	226.	199.	224.
23) SSJ.TENSILE.6	F82H	200.	189.	209.	192.	206.
25) CHEVRON.5	F82H	203.	195.	210.	198.	208.
27) CHEVRON.6	F82H	214.	203.	221.	208.	219.
29) SSJ.TENSILE.7	F82H	214.	193.	225.	198.	224.
31) SSJ.TENSILE.8	F82H	200.	189.	208.	191.	206.
33) CHEVRON.7	F82H	202.	193.	209.	197.	207.
35) CHEVRON.8	F82H	214.	199.	221.	208.	219.
37) THERMOMETRY.1	SiC(Irr)	219.	182.	244.	194.	235.
38) THERMOMETRY.2	SiC(Irr)	219.	184.	244.	194.	235.
39) THERMOMETRY.3	SiC(Irr)	219.	184.	248.	195.	236.
40) THERMOMETRY.4	SiC(Irr)	219.	183.	248.	195.	236.
41) HOUSING	AL-6061	60.	59.	61.	59.	61.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (μm/m·°C)	Emis (---)
1) HOLDER	AL-6061	176.000	24.49	0.051
3) ROLLPIN	SS304	18.963	0.00	0.143
5) SSJ.TENSILE.1	F82H	33.304	11.04	0.143
7) SSJ.TENSILE.2	F82H	33.226	11.02	0.143
9) CHEVRON.1	F82H	33.230	11.02	0.143
11) CHEVRON.2	F82H	33.304	11.04	0.143
13) SSJ.TENSILE.3	F82H	33.306	11.04	0.143
15) SSJ.TENSILE.4	F82H	33.229	11.02	0.143
17) CHEVRON.3	F82H	33.241	11.02	0.143
19) CHEVRON.4	F82H	33.308	11.05	0.143
21) SSJ.TENSILE.5	F82H	33.305	11.04	0.143
23) SSJ.TENSILE.6	F82H	33.228	11.02	0.143
25) CHEVRON.5	F82H	33.243	11.02	0.143
27) CHEVRON.6	F82H	33.305	11.04	0.143
29) SSJ.TENSILE.7	F82H	33.303	11.04	0.143
31) SSJ.TENSILE.8	F82H	33.226	11.02	0.143
33) CHEVRON.7	F82H	33.238	11.02	0.143
35) CHEVRON.8	F82H	33.304	11.04	0.143
37) THERMOMETRY.1	SiC(Irr)	6.095	3.00	0.900
38) THERMOMETRY.2	SiC(Irr)	6.095	3.00	0.900
39) THERMOMETRY.3	SiC(Irr)	6.095	3.00	0.900
40) THERMOMETRY.4	SiC(Irr)	6.095	3.00	0.900
41) HOUSING	AL-6061	166.659	24.21	0.050

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOLDER	AL-6061	1.445	173.	965.	213.
3) ROLLPIN	SS304	0.223	267.	385.	21.
5) SSJ.TENSILE.1	F82H	0.238	214.	520.	24.
7) SSJ.TENSILE.2	F82H	0.238	200.	515.	22.
9) CHEVRON.1	F82H	0.115	200.	515.	11.
11) CHEVRON.2	F82H	0.115	214.	520.	12.
13) SSJ.TENSILE.3	F82H	0.238	214.	520.	24.
15) SSJ.TENSILE.4	F82H	0.238	200.	515.	22.

17) CHEVRON.3	F82H	0.115	202.	516.	11.
19) CHEVRON.4	F82H	0.115	215.	520.	12.
21) SSJ.TENSILE.5	F82H	0.238	214.	520.	24.
23) SSJ.TENSILE.6	F82H	0.238	200.	515.	22.
25) CHEVRON.5	F82H	0.115	203.	516.	11.
27) CHEVRON.6	F82H	0.115	214.	520.	12.
29) SSJ.TENSILE.7	F82H	0.238	214.	520.	24.
31) SSJ.TENSILE.8	F82H	0.238	200.	515.	22.
33) CHEVRON.7	F82H	0.115	202.	516.	11.
35) CHEVRON.8	F82H	0.115	214.	520.	12.
37) THERMOMETRY.1	SiC(Irr)	0.092	219.	958.	18.
38) THERMOMETRY.2	SiC(Irr)	0.092	219.	958.	18.
39) THERMOMETRY.3	SiC(Irr)	0.092	219.	958.	18.
40) THERMOMETRY.4	SiC(Irr)	0.092	219.	958.	18.
41) HOUSING	AL-6061	1.026	60.	884.	36.
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		5.884			614.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 83: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 µm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (˚C)	171.241	168.606	172.669
Target temperature (˚C)	60.711	60.079	60.892
Geometric gas gap (µm)	69.965	69.383	70.295
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	339.447	328.766	346.527
Radiation heat flux (kW/m²)	0.000	0.000	0.000
Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	339.447	328.766	346.527
Thermal contact conductance (W/m²·C)	3071.021	3039.348	3109.630
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	57.221	56.530	57.701
Contact thermal jump distance (µm)	1.112	1.106	1.115
Target thermal jump distance (µm)	1.044	1.039	1.046
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·˚C)	0.182	0.182	0.183
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	3072.851	3041.380	3111.320

Contact status codes:

0=open/no heat transfer, 1=near-field contact
2=closed and sliding, 3=closed and sticking

9.34 mm holder diameter (tensile design)

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    TEMPERATURE DESIGN SOLUTION FOR ESTEEL TENSILE (2016) RABBITS
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  -----------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.34 mm

  * Thermal-only solution method
  -----------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
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  HEAT GENERATION
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Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOLDER	AL-6061	31300.	44.4	41.9
3) ROLLPIN	SS304	38100.	8.5	8.0
5) SSJ.TENSILE.1	F82H	38100.	9.1	8.6
7) SSJ.TENSILE.2	F82H	38100.	9.1	8.6
9) CHEVRON.1	F82H	38100.	4.4	4.1
11) CHEVRON.2	F82H	38100.	4.4	4.1
13) SSJ.TENSILE.3	F82H	38100.	9.1	8.6
15) SSJ.TENSILE.4	F82H	38100.	9.1	8.6
17) CHEVRON.3	F82H	38100.	4.4	4.1
19) CHEVRON.4	F82H	38100.	4.4	4.1
21) SSJ.TENSILE.5	F82H	38100.	9.1	8.6
23) SSJ.TENSILE.6	F82H	38100.	9.1	8.6
25) CHEVRON.5	F82H	38100.	4.4	4.1
27) CHEVRON.6	F82H	38100.	4.4	4.1
29) SSJ.TENSILE.7	F82H	38100.	9.1	8.6
31) SSJ.TENSILE.8	F82H	38100.	9.1	8.6
33) CHEVRON.7	F82H	38100.	4.4	4.1
35) CHEVRON.8	F82H	38100.	4.4	4.1
37) THERMOMETRY.1	SiC(Irr)	31700.	2.9	2.8
38) THERMOMETRY.2	SiC(Irr)	31700.	2.9	2.8
39) THERMOMETRY.3	SiC(Irr)	31700.	2.9	2.8
40) THERMOMETRY.4	SiC(Irr)	31700.	2.9	2.8
41) HOUSING	AL-6061	31300.	32.1	30.3
			204.2	192.9

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  CAPSULE TEMPERATURE SUMMARY
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Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOLDER	AL-6061	200.	196.	206.	197.	203.
3) ROLLPIN	SS304	294.	288.	304.	289.	302.
5) SSJ.TENSILE.1	F82H	241.	220.	253.	226.	251.
7) SSJ.TENSILE.2	F82H	227.	215.	236.	219.	233.
9) CHEVRON.1	F82H	227.	199.	235.	220.	233.
11) CHEVRON.2	F82H	241.	229.	248.	235.	246.
13) SSJ.TENSILE.3	F82H	241.	220.	253.	226.	251.

15) SSJ.TENSILE.4	F82H	227.	215.	236.	219.	233.
17) CHEVRON.3	F82H	229.	221.	236.	225.	235.
19) CHEVRON.4	F82H	241.	229.	249.	235.	247.
21) SSJ.TENSILE.5	F82H	241.	219.	252.	226.	251.
23) SSJ.TENSILE.6	F82H	227.	217.	235.	219.	233.
25) CHEVRON.5	F82H	230.	222.	237.	225.	235.
27) CHEVRON.6	F82H	242.	230.	249.	235.	247.
29) SSJ.TENSILE.7	F82H	241.	221.	253.	226.	251.
31) SSJ.TENSILE.8	F82H	227.	216.	236.	219.	233.
33) CHEVRON.7	F82H	230.	221.	237.	225.	235.
35) CHEVRON.8	F82H	242.	230.	249.	235.	247.
37) THERMOMETRY.1	SiC(Irr)	246.	211.	271.	222.	262.
38) THERMOMETRY.2	SiC(Irr)	246.	210.	271.	222.	262.
39) THERMOMETRY.3	SiC(Irr)	246.	209.	275.	222.	262.
40) THERMOMETRY.4	SiC(Irr)	246.	210.	275.	222.	263.
41) HOUSING	AL-6061	60.	59.	61.	59.	61.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (μm/m·°C)	Emis (---)
1) HOLDER	AL-6061	176.000	24.66	0.052
3) ROLLPIN	SS304	19.332	0.00	0.143
5) SSJ.TENSILE.1	F82H	33.448	11.09	0.143
7) SSJ.TENSILE.2	F82H	33.372	11.07	0.143
9) CHEVRON.1	F82H	33.374	11.07	0.143
11) CHEVRON.2	F82H	33.447	11.09	0.143
13) SSJ.TENSILE.3	F82H	33.448	11.09	0.143
15) SSJ.TENSILE.4	F82H	33.373	11.07	0.143
17) CHEVRON.3	F82H	33.385	11.07	0.143
19) CHEVRON.4	F82H	33.449	11.09	0.143
21) SSJ.TENSILE.5	F82H	33.449	11.09	0.143
23) SSJ.TENSILE.6	F82H	33.373	11.07	0.143
25) CHEVRON.5	F82H	33.387	11.07	0.143
27) CHEVRON.6	F82H	33.450	11.09	0.143
29) SSJ.TENSILE.7	F82H	33.449	11.09	0.143
31) SSJ.TENSILE.8	F82H	33.372	11.07	0.143
33) CHEVRON.7	F82H	33.387	11.07	0.143
35) CHEVRON.8	F82H	33.450	11.09	0.143
37) THERMOMETRY.1	SiC(Irr)	6.085	3.09	0.900
38) THERMOMETRY.2	SiC(Irr)	6.085	3.09	0.900
39) THERMOMETRY.3	SiC(Irr)	6.085	3.09	0.900
40) THERMOMETRY.4	SiC(Irr)	6.085	3.09	0.900
41) HOUSING	AL-6061	166.655	24.21	0.050

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOLDER	AL-6061	1.419	200.	983.	252.
3) ROLLPIN	SS304	0.223	294.	387.	24.
5) SSJ.TENSILE.1	F82H	0.238	241.	530.	28.
7) SSJ.TENSILE.2	F82H	0.238	227.	525.	26.
9) CHEVRON.1	F82H	0.115	227.	525.	12.
11) CHEVRON.2	F82H	0.115	241.	530.	13.
13) SSJ.TENSILE.3	F82H	0.238	241.	530.	28.
15) SSJ.TENSILE.4	F82H	0.238	227.	525.	26.

17) CHEVRON.3	F82H	0.115	229.	525.	13.
19) CHEVRON.4	F82H	0.115	241.	530.	13.
21) SSJ.TENSILE.5	F82H	0.238	241.	530.	28.
23) SSJ.TENSILE.6	F82H	0.238	227.	525.	26.
25) CHEVRON.5	F82H	0.115	230.	526.	13.
27) CHEVRON.6	F82H	0.115	242.	530.	13.
29) SSJ.TENSILE.7	F82H	0.238	241.	530.	28.
31) SSJ.TENSILE.8	F82H	0.238	227.	525.	26.
33) CHEVRON.7	F82H	0.115	230.	526.	13.
35) CHEVRON.8	F82H	0.115	242.	530.	13.
37) THERMOMETRY.1	SiC(Irr)	0.092	246.	978.	20.
38) THERMOMETRY.2	SiC(Irr)	0.092	246.	978.	20.
39) THERMOMETRY.3	SiC(Irr)	0.092	246.	978.	20.
40) THERMOMETRY.4	SiC(Irr)	0.092	246.	978.	20.
41) HOUSING	AL-6061	1.026	60.	884.	36.
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		5.858			712.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 83: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 μm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (˚C)	198.948	196.174	200.405
Target temperature (˚C)	60.681	60.077	60.826
Geometric gas gap (μm)	89.963	89.547	90.283
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m^2)	339.339	330.169	344.725
Radiation heat flux (kW/m^2)	0.000	0.000	0.000
Contact conduction heat flux (kW/m^2)	0.000	0.000	0.000
Total heat flux (kW/m^2)	339.339	330.169	344.725
Thermal contact conductance ($W/m^2 \cdot C$)	2454.173	2432.186	2473.726
~~ derived results ~~~~~~~~~~			
Effective gas gap (μm)	73.957	73.412	74.466
Contact thermal jump distance (μm)	1.176	1.170	1.180
Target thermal jump distance (μm)	1.089	1.084	1.092
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·˚C)	0.187	0.187	0.187
Solid spot conductance ($W/m^2 \cdot C$)	0.000	0.000	0.000
Gas gap conductance ($W/m^2 \cdot C$)	2453.703	2432.189	2473.116

Contact status codes:

0=open/no heat transfer, 1=near-field contact
2=closed and sliding, 3=closed and sticking

9.30 mm holder diameter (tensile design)

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TEMPERATURE DESIGN SOLUTION FOR ESTEEL TENSILE (2016) RABBITS

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DESCRIPTION

* HFIR TRRH Axial position 5.
* Helium fill gas
* Holder OD = 9.30 mm

* Thermal-only solution method

BOUNDARY CONDITIONS

Heat transfer coefficient = 47100. W/m²·°C
Bulk coolant temperature = 52.0 °C
Peaking factor = 0.960

HEAT GENERATION

Part	Material	Heat Gen. @Midplane (W/kg)	------ Heat Load ----- @Midplane (W)	@Location (W)
1) HOLDER	AL-6061	31300.	43.6	41.2
3) ROLLPIN	SS304	38100.	8.5	8.0
5) SSJ.TENSILE.1	F82H	38100.	9.1	8.6
7) SSJ.TENSILE.2	F82H	38100.	9.1	8.6
9) CHEVRON.1	F82H	38100.	4.4	4.1
11) CHEVRON.2	F82H	38100.	4.4	4.1
13) SSJ.TENSILE.3	F82H	38100.	9.1	8.6
15) SSJ.TENSILE.4	F82H	38100.	9.1	8.6
17) CHEVRON.3	F82H	38100.	4.4	4.1
19) CHEVRON.4	F82H	38100.	4.4	4.1
21) SSJ.TENSILE.5	F82H	38100.	9.1	8.6
23) SSJ.TENSILE.6	F82H	38100.	9.1	8.6
25) CHEVRON.5	F82H	38100.	4.4	4.1
27) CHEVRON.6	F82H	38100.	4.4	4.1
29) SSJ.TENSILE.7	F82H	38100.	9.1	8.6
31) SSJ.TENSILE.8	F82H	38100.	9.1	8.6
33) CHEVRON.7	F82H	38100.	4.4	4.1
35) CHEVRON.8	F82H	38100.	4.4	4.1
37) THERMOMETRY.1	SiC(Irr)	31700.	2.9	2.8
38) THERMOMETRY.2	SiC(Irr)	31700.	2.9	2.8
39) THERMOMETRY.3	SiC(Irr)	31700.	2.9	2.8
40) THERMOMETRY.4	SiC(Irr)	31700.	2.9	2.8
41) HOUSING	AL-6061	31300.	32.1	30.3
			203.4	192.1

CAPSULE TEMPERATURE SUMMARY

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOLDER	AL-6061	227.	223.	231.	224.	230.
3) ROLLPIN	SS304	319.	313.	330.	314.	327.
5) SSJ.TENSILE.1	F82H	268.	247.	280.	252.	278.
7) SSJ.TENSILE.2	F82H	254.	242.	263.	245.	260.
9) CHEVRON.1	F82H	256.	248.	263.	251.	261.
11) CHEVRON.2	F82H	267.	254.	275.	261.	273.
13) SSJ.TENSILE.3	F82H	268.	247.	279.	252.	277.

15) SSJ.TENSILE.4	F82H	253.	242.	262.	245.	260.
17) CHEVRON.3	F82H	256.	236.	263.	251.	261.
19) CHEVRON.4	F82H	267.	254.	274.	261.	272.
21) SSJ.TENSILE.5	F82H	268.	247.	279.	253.	278.
23) SSJ.TENSILE.6	F82H	254.	241.	262.	245.	260.
25) CHEVRON.5	F82H	256.	248.	263.	251.	261.
27) CHEVRON.6	F82H	267.	255.	274.	260.	272.
29) SSJ.TENSILE.7	F82H	268.	247.	279.	252.	278.
31) SSJ.TENSILE.8	F82H	253.	243.	263.	245.	260.
33) CHEVRON.7	F82H	256.	247.	263.	251.	261.
35) CHEVRON.8	F82H	266.	255.	274.	260.	272.
37) THERMOMETRY.1	SiC(Irr)	272.	236.	298.	249.	288.
38) THERMOMETRY.2	SiC(Irr)	272.	235.	298.	248.	288.
39) THERMOMETRY.3	SiC(Irr)	273.	235.	301.	248.	289.
40) THERMOMETRY.4	SiC(Irr)	273.	237.	301.	248.	289.
41) HOUSING	AL-6061	60.	59.	61.	59.	61.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (μm/m·°C)	Emis (---)
1) HOLDER	AL-6061	176.000	24.83	0.053
3) ROLLPIN	SS304	19.684	0.00	0.143
5) SSJ.TENSILE.1	F82H	33.589	11.14	0.143
7) SSJ.TENSILE.2	F82H	33.513	11.11	0.143
9) CHEVRON.1	F82H	33.525	11.12	0.143
11) CHEVRON.2	F82H	33.585	11.13	0.143
13) SSJ.TENSILE.3	F82H	33.588	11.14	0.143
15) SSJ.TENSILE.4	F82H	33.513	11.11	0.143
17) CHEVRON.3	F82H	33.525	11.12	0.143
19) CHEVRON.4	F82H	33.582	11.13	0.143
21) SSJ.TENSILE.5	F82H	33.590	11.14	0.143
23) SSJ.TENSILE.6	F82H	33.514	11.11	0.143
25) CHEVRON.5	F82H	33.526	11.12	0.143
27) CHEVRON.6	F82H	33.583	11.13	0.143
29) SSJ.TENSILE.7	F82H	33.588	11.14	0.143
31) SSJ.TENSILE.8	F82H	33.512	11.11	0.143
33) CHEVRON.7	F82H	33.526	11.12	0.143
35) CHEVRON.8	F82H	33.580	11.13	0.143
37) THERMOMETRY.1	SiC(Irr)	6.074	3.18	0.900
38) THERMOMETRY.2	SiC(Irr)	6.074	3.18	0.900
39) THERMOMETRY.3	SiC(Irr)	6.074	3.18	0.900
40) THERMOMETRY.4	SiC(Irr)	6.074	3.18	0.900
41) HOUSING	AL-6061	166.651	24.21	0.050

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOLDER	AL-6061	1.393	227.	996.	287.
3) ROLLPIN	SS304	0.223	319.	389.	26.
5) SSJ.TENSILE.1	F82H	0.238	268.	537.	32.
7) SSJ.TENSILE.2	F82H	0.238	254.	533.	30.
9) CHEVRON.1	F82H	0.115	256.	534.	14.
11) CHEVRON.2	F82H	0.115	267.	537.	15.
13) SSJ.TENSILE.3	F82H	0.238	268.	537.	32.
15) SSJ.TENSILE.4	F82H	0.238	253.	533.	30.

17) CHEVRON.3	F82H	0.115	256.	534.	14.
19) CHEVRON.4	F82H	0.115	267.	537.	15.
21) SSJ.TENSILE.5	F82H	0.238	268.	537.	32.
23) SSJ.TENSILE.6	F82H	0.238	254.	533.	30.
25) CHEVRON.5	F82H	0.115	256.	534.	14.
27) CHEVRON.6	F82H	0.115	267.	537.	15.
29) SSJ.TENSILE.7	F82H	0.238	268.	537.	32.
31) SSJ.TENSILE.8	F82H	0.238	253.	533.	30.
33) CHEVRON.7	F82H	0.115	256.	534.	14.
35) CHEVRON.8	F82H	0.115	266.	537.	15.
37) THERMOMETRY.1	SiC(Irr)	0.092	272.	998.	23.
38) THERMOMETRY.2	SiC(Irr)	0.092	272.	998.	23.
39) THERMOMETRY.3	SiC(Irr)	0.092	273.	998.	23.
40) THERMOMETRY.4	SiC(Irr)	0.092	273.	998.	23.
41) HOUSING	AL-6061	1.026	60.	884.	36.
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		5.832			806.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 83: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 µm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (˚C)	225.641	222.676	227.132
Target temperature (˚C)	60.664	60.060	60.786
Geometric gas gap (µm)	109.967	109.646	110.248
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	339.249	330.888	343.630
Radiation heat flux (kW/m²)	0.000	0.000	0.000
Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	339.249	330.888	343.630
Thermal contact conductance (W/m²·C)	2056.309	2039.477	2067.406
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	90.808	90.380	91.338
Contact thermal jump distance (µm)	1.241	1.233	1.245
Target thermal jump distance (µm)	1.134	1.129	1.137
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·˚C)	0.192	0.191	0.192
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	2056.597	2039.564	2067.671

Contact status codes:

0=open/no heat transfer, 1=near-field contact
2=closed and sliding, 3=closed and sticking

9.25 mm holder diameter (tensile design)

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*************************************************************************
    TEMPERATURE DESIGN SOLUTION FOR ESTEEL TENSILE (2016) RABBITS
 *************************************************************************
  -------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.25 mm

  * Thermal-only solution method
  -------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
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  HEAT GENERATION

                                                         Heat Gen.   ------ Heat Load -----
                                                         @Midplane   @Midplane    @Location
   Part                                        Material   (W/kg)        (W)          (W)
 ----------------------------------- --------  ---------   ---------    ---------
   1)  HOLDER                           AL-6061      31300.        42.6         40.2
   3)  ROLLPIN                          SS304        38100.         8.5          8.0
   5)  SSJ.TENSILE.1                    F82H         38100.         9.1          8.6
   7)  SSJ.TENSILE.2                    F82H         38100.         9.1          8.6
   9)  CHEVRON.1                        F82H         38100.         4.4          4.1
  11)  CHEVRON.2                        F82H         38100.         4.4          4.1
  13)  SSJ.TENSILE.3                    F82H         38100.         9.1          8.6
  15)  SSJ.TENSILE.4                    F82H         38100.         9.1          8.6
  17)  CHEVRON.3                        F82H         38100.         4.4          4.1
  19)  CHEVRON.4                        F82H         38100.         4.4          4.1
  21)  SSJ.TENSILE.5                    F82H         38100.         9.1          8.6
  23)  SSJ.TENSILE.6                    F82H         38100.         9.1          8.6
  25)  CHEVRON.5                        F82H         38100.         4.4          4.1
  27)  CHEVRON.6                        F82H         38100.         4.4          4.1
  29)  SSJ.TENSILE.7                    F82H         38100.         9.1          8.6
  31)  SSJ.TENSILE.8                    F82H         38100.         9.1          8.6
  33)  CHEVRON.7                        F82H         38100.         4.4          4.1
  35)  CHEVRON.8                        F82H         38100.         4.4          4.1
  37)  THERMOMETRY.1                    SiC(Irr)     31700.         2.9          2.8
  38)  THERMOMETRY.2                    SiC(Irr)     31700.         2.9          2.8
  39)  THERMOMETRY.3                    SiC(Irr)     31700.         2.9          2.8
  40)  THERMOMETRY.4                    SiC(Irr)     31700.         2.9          2.8
  41)  HOUSING                          AL-6061      31300.        32.1         30.3
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                                                                202.4        191.2

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  CAPSULE TEMPERATURE SUMMARY

 Name                                   Material   Tavg   Tmin   Tmax  T.025  T.975
 ------------------------------------ --------   -----  -----  -----  -----  -----
   1)  HOLDER                           AL-6061    259.   255.   263.   256.   262.
   3)  ROLLPIN                          SS304      350.   344.   361.   346.   358.
   5)  SSJ.TENSILE.1                    F82H       299.   278.   311.   284.   309.
   7)  SSJ.TENSILE.2                    F82H       285.   274.   294.   277.   292.
   9)  CHEVRON.1                        F82H       287.   279.   294.   283.   292.
  11)  CHEVRON.2                        F82H       298.   287.   306.   292.   304.
  13)  SSJ.TENSILE.3                    F82H       299.   279.   311.   284.   309.
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15) SSJ.TENSILE.4	F82H	285.	273.	293.	277.	291.
17) CHEVRON.3	F82H	287.	260.	295.	281.	293.
19) CHEVRON.4	F82H	299.	286.	306.	292.	304.
21) SSJ.TENSILE.5	F82H	300.	279.	311.	284.	309.
23) SSJ.TENSILE.6	F82H	285.	274.	294.	277.	292.
25) CHEVRON.5	F82H	288.	279.	295.	283.	293.
27) CHEVRON.6	F82H	298.	286.	306.	292.	304.
29) SSJ.TENSILE.7	F82H	300.	280.	311.	284.	310.
31) SSJ.TENSILE.8	F82H	286.	274.	294.	277.	292.
33) CHEVRON.7	F82H	288.	280.	295.	283.	293.
35) CHEVRON.8	F82H	299.	286.	307.	292.	305.
37) THERMOMETRY.1	SiC(Irr)	304.	270.	330.	280.	320.
38) THERMOMETRY.2	SiC(Irr)	304.	270.	329.	281.	320.
39) THERMOMETRY.3	SiC(Irr)	304.	268.	333.	280.	320.
40) THERMOMETRY.4	SiC(Irr)	305.	269.	333.	281.	321.
41) HOUSING	AL-6061	60.	59.	61.	59.	60.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·ºC)	Thermal Exp. Coeff. (µm/m·˚C)	Emis (---)
1) HOLDER	AL-6061	176.000	25.09	0.055
3) ROLLPIN	SS304	20.119	0.00	0.143
5) SSJ.TENSILE.1	F82H	33.756	11.19	0.143
7) SSJ.TENSILE.2	F82H	33.681	11.17	0.143
9) CHEVRON.1	F82H	33.693	11.17	0.143
11) CHEVRON.2	F82H	33.751	11.19	0.143
13) SSJ.TENSILE.3	F82H	33.755	11.19	0.143
15) SSJ.TENSILE.4	F82H	33.680	11.17	0.143
17) CHEVRON.3	F82H	33.691	11.17	0.143
19) CHEVRON.4	F82H	33.752	11.19	0.143
21) SSJ.TENSILE.5	F82H	33.758	11.19	0.143
23) SSJ.TENSILE.6	F82H	33.683	11.17	0.143
25) CHEVRON.5	F82H	33.695	11.17	0.143
27) CHEVRON.6	F82H	33.751	11.19	0.143
29) SSJ.TENSILE.7	F82H	33.758	11.19	0.143
31) SSJ.TENSILE.8	F82H	33.683	11.17	0.143
33) CHEVRON.7	F82H	33.695	11.17	0.143
35) CHEVRON.8	F82H	33.754	11.19	0.143
37) THERMOMETRY.1	SiC(Irr)	6.062	3.28	0.900
38) THERMOMETRY.2	SiC(Irr)	6.062	3.28	0.900
39) THERMOMETRY.3	SiC(Irr)	6.062	3.28	0.900
40) THERMOMETRY.4	SiC(Irr)	6.062	3.28	0.900
41) HOUSING	AL-6061	166.647	24.21	0.050

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (˚C)	Specific Heat (J/kg˚C)	Stored Energy (J)
1) HOLDER	AL-6061	1.361	259.	1010.	329.
3) ROLLPIN	SS304	0.223	350.	392.	29.
5) SSJ.TENSILE.1	F82H	0.238	299.	548.	36.
7) SSJ.TENSILE.2	F82H	0.238	285.	542.	34.
9) CHEVRON.1	F82H	0.115	287.	543.	17.
11) CHEVRON.2	F82H	0.115	298.	547.	17.
13) SSJ.TENSILE.3	F82H	0.238	299.	548.	36.
15) SSJ.TENSILE.4	F82H	0.238	285.	542.	34.

17) CHEVRON.3	F82H	0.115	287.	543.	17.
19) CHEVRON.4	F82H	0.115	299.	548.	17.
21) SSJ.TENSILE.5	F82H	0.238	300.	548.	36.
23) SSJ.TENSILE.6	F82H	0.238	285.	542.	34.
25) CHEVRON.5	F82H	0.115	288.	543.	17.
27) CHEVRON.6	F82H	0.115	298.	547.	17.
29) SSJ.TENSILE.7	F82H	0.238	300.	548.	36.
31) SSJ.TENSILE.8	F82H	0.238	286.	542.	34.
33) CHEVRON.7	F82H	0.115	288.	543.	17.
35) CHEVRON.8	F82H	0.115	299.	548.	18.
37) THERMOMETRY.1	SiC(Irr)	0.092	304.	1021.	27.
38) THERMOMETRY.2	SiC(Irr)	0.092	304.	1021.	27.
39) THERMOMETRY.3	SiC(Irr)	0.092	304.	1021.	27.
40) THERMOMETRY.4	SiC(Irr)	0.092	305.	1021.	27.
41) HOUSING	AL-6061	1.026	60.	884.	36.
		--------			--------
		5.800			920.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 83: Frictionless - HOLDER To HOUSING

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   Contact surface material:      AL-6061
   Target surface material:       AL-6061
   Interstitial gas:               Helium
   Effective surface roughness:     2.263 µm
   Effective asperity slope:        0.214 rad
   Effective microhardness:         1.220 GPa
```

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (˚C)	257.661	254.654	259.210
Target temperature (˚C)	60.621	60.036	60.759
Geometric gas gap (µm)	134.963	134.404	135.209
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	339.112	331.735	343.136
Radiation heat flux (kW/m²)	0.000	0.000	0.000
Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	339.112	331.735	343.136
Thermal contact conductance (W/m²·C)	1721.007	1708.361	1732.530
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	111.946	111.277	112.507
Contact thermal jump distance (µm)	1.319	1.312	1.323
Target thermal jump distance (µm)	1.188	1.182	1.190
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·˚C)	0.197	0.196	0.197
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	1720.324	1708.006	1731.731

Contact status codes:

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 0=open/no heat transfer, 1=near-field contact
 2=closed and sliding,    3=closed and sticking
```

9.20 mm holder diameter (tensile design)

****
TEMPERATURE DESIGN SOLUTION FOR ESTEEL TENSILE (2016) RABBITS
****

DESCRIPTION

* HFIR TRRH Axial position 5.
* Helium fill gas
* Holder OD = 9.20 mm

* Thermal-only solution method

BOUNDARY CONDITIONS

Heat transfer coefficient = 47100. W/m^2·°C
Bulk coolant temperature = 52.0 °C
Peaking factor = 0.960

HEAT GENERATION

Part	Material	Heat Gen. @Midplane (W/kg)	------ Heat Load ----- @Midplane (W)	@Location (W)
1) HOLDER	AL-6061	31300.	41.6	39.3
3) ROLLPIN	SS304	38100.	8.5	8.0
5) SSJ.TENSILE.1	F82H	38100.	9.1	8.6
7) SSJ.TENSILE.2	F82H	38100.	9.1	8.6
9) CHEVRON.1	F82H	38100.	4.4	4.1
11) CHEVRON.2	F82H	38100.	4.4	4.1
13) SSJ.TENSILE.3	F82H	38100.	9.1	8.6
15) SSJ.TENSILE.4	F82H	38100.	9.1	8.6
17) CHEVRON.3	F82H	38100.	4.4	4.1
19) CHEVRON.4	F82H	38100.	4.4	4.1
21) SSJ.TENSILE.5	F82H	38100.	9.1	8.6
23) SSJ.TENSILE.6	F82H	38100.	9.1	8.6
25) CHEVRON.5	F82H	38100.	4.4	4.1
27) CHEVRON.6	F82H	38100.	4.4	4.1
29) SSJ.TENSILE.7	F82H	38100.	9.1	8.6
31) SSJ.TENSILE.8	F82H	38100.	9.1	8.6
33) CHEVRON.7	F82H	38100.	4.4	4.1
35) CHEVRON.8	F82H	38100.	4.4	4.1
37) THERMOMETRY.1	SiC(Irr)	31700.	2.9	2.8
38) THERMOMETRY.2	SiC(Irr)	31700.	2.9	2.8
39) THERMOMETRY.3	SiC(Irr)	31700.	2.9	2.8
40) THERMOMETRY.4	SiC(Irr)	31700.	2.9	2.8
41) HOUSING	AL-6061	31300.	32.1	30.3
			201.4	190.2

CAPSULE TEMPERATURE SUMMARY

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOLDER	AL-6061	290.	285.	293.	286.	292.
3) ROLLPIN	SS304	380.	374.	390.	375.	388.
5) SSJ.TENSILE.1	F82H	330.	309.	341.	314.	339.
7) SSJ.TENSILE.2	F82H	316.	305.	324.	308.	322.
9) CHEVRON.1	F82H	318.	310.	325.	313.	323.
11) CHEVRON.2	F82H	329.	316.	337.	322.	334.
13) SSJ.TENSILE.3	F82H	330.	309.	341.	315.	339.

15)	SSJ.TENSILE.4	F82H	315.	303.	324.	307.	322.
17)	CHEVRON.3	F82H	317.	293.	324.	310.	322.
19)	CHEVRON.4	F82H	329.	317.	336.	323.	334.
21)	SSJ.TENSILE.5	F82H	330.	309.	342.	315.	340.
23)	SSJ.TENSILE.6	F82H	316.	305.	325.	308.	322.
25)	CHEVRON.5	F82H	318.	310.	325.	314.	323.
27)	CHEVRON.6	F82H	329.	316.	336.	323.	334.
29)	SSJ.TENSILE.7	F82H	330.	310.	342.	315.	340.
31)	SSJ.TENSILE.8	F82H	316.	305.	325.	308.	322.
33)	CHEVRON.7	F82H	318.	310.	325.	313.	323.
35)	CHEVRON.8	F82H	329.	317.	337.	323.	335.
37)	THERMOMETRY.1	SiC(Irr)	335.	300.	360.	310.	350.
38)	THERMOMETRY.2	SiC(Irr)	334.	300.	359.	311.	350.
39)	THERMOMETRY.3	SiC(Irr)	334.	299.	363.	310.	351.
40)	THERMOMETRY.4	SiC(Irr)	335.	299.	363.	311.	351.
41)	HOUSING	AL-6061	60.	59.	61.	59.	60.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·ºC)	Thermal Exp. Coeff. (μm/m·˚C)	Emis (---)
1) HOLDER	AL-6061	176.000	25.34	0.056
3) ROLLPIN	SS304	20.536	0.00	0.143
5) SSJ.TENSILE.1	F82H	33.752	11.34	0.143
7) SSJ.TENSILE.2	F82H	33.782	11.27	0.143
9) CHEVRON.1	F82H	33.777	11.28	0.143
11) CHEVRON.2	F82H	33.754	11.33	0.143
13) SSJ.TENSILE.3	F82H	33.752	11.34	0.143
15) SSJ.TENSILE.4	F82H	33.783	11.27	0.143
17) CHEVRON.3	F82H	33.780	11.27	0.143
19) CHEVRON.4	F82H	33.753	11.33	0.143
21) SSJ.TENSILE.5	F82H	33.751	11.34	0.143
23) SSJ.TENSILE.6	F82H	33.782	11.27	0.143
25) CHEVRON.5	F82H	33.777	11.28	0.143
27) CHEVRON.6	F82H	33.753	11.33	0.143
29) SSJ.TENSILE.7	F82H	33.751	11.34	0.143
31) SSJ.TENSILE.8	F82H	33.782	11.27	0.143
33) CHEVRON.7	F82H	33.777	11.28	0.143
35) CHEVRON.8	F82H	33.752	11.34	0.143
37) THERMOMETRY.1	SiC(Irr)	6.050	3.37	0.900
38) THERMOMETRY.2	SiC(Irr)	6.050	3.37	0.900
39) THERMOMETRY.3	SiC(Irr)	6.050	3.37	0.900
40) THERMOMETRY.4	SiC(Irr)	6.050	3.37	0.900
41) HOUSING	AL-6061	166.642	24.21	0.050

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (˚C)	Specific Heat (J/kg˚C)	Stored Energy (J)
1) HOLDER	AL-6061	1.329	290.	1024.	367.
3) ROLLPIN	SS304	0.223	380.	394.	32.
5) SSJ.TENSILE.1	F82H	0.238	330.	563.	42.
7) SSJ.TENSILE.2	F82H	0.238	316.	556.	39.
9) CHEVRON.1	F82H	0.115	318.	558.	19.
11) CHEVRON.2	F82H	0.115	329.	563.	20.
13) SSJ.TENSILE.3	F82H	0.238	330.	563.	42.
15) SSJ.TENSILE.4	F82H	0.238	315.	556.	39.

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 17) CHEVRON.3                       F82H        0.115      317.      557.       19.
 19) CHEVRON.4                       F82H        0.115      329.      563.       20.
 21) SSJ.TENSILE.5                   F82H        0.238      330.      564.       42.
 23) SSJ.TENSILE.6                   F82H        0.238      316.      556.       39.
 25) CHEVRON.5                       F82H        0.115      318.      558.       19.
 27) CHEVRON.6                       F82H        0.115      329.      563.       20.
 29) SSJ.TENSILE.7                   F82H        0.238      330.      564.       42.
 31) SSJ.TENSILE.8                   F82H        0.238      316.      556.       39.
 33) CHEVRON.7                       F82H        0.115      318.      558.       19.
 35) CHEVRON.8                       F82H        0.115      329.      563.       20.
 37) THERMOMETRY.1                   SiC(Irr)    0.092      335.     1038.       30.
 38) THERMOMETRY.2                   SiC(Irr)    0.092      334.     1037.       30.
 39) THERMOMETRY.3                   SiC(Irr)    0.092      334.     1037.       30.
 40) THERMOMETRY.4                   SiC(Irr)    0.092      335.     1038.       30.
 41) HOUSING                         AL-6061     1.026       60.      884.       36.
                                              --------                       --------
                                                 5.768                         1034.

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  RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

-------------------------------------------------------------------------------
CONTACT SUMMARY FOR CONTACT ID 83: Frictionless - HOLDER To HOUSING
   Contact surface material:      AL-6061
   Target surface material:       AL-6061
   Interstitial gas:               Helium
   Effective surface roughness:     2.263 µm
   Effective asperity slope:        0.214 rad
   Effective microhardness:         1.220 GPa

                                                Average      Minimum      Maximum
                                              ------------ ------------ ------------
   ~~~~~~~~~~~ direct results ~~~~~~~~~~
   Contact status                                 1.000        1.000        1.000
   Contact temperature (˚C)                     288.531      285.365      290.210
   Target temperature (˚C)                       60.580       59.981       60.703
   Geometric gas gap (µm)                       159.966      159.641      161.334
   Contact pressure (MPa)                         0.000        0.000        0.000
   Gap conduction heat flux (kW/m²)             339.007      332.212      342.637
   Radiation heat flux (kW/m²)                    0.000        0.000        0.000
   Contact conduction heat flux (kW/m²)           0.000        0.000        0.000
   Total heat flux (kW/m²)                      339.007      332.212      342.637
   Thermal contact conductance (W/m²·C)        1487.176     1474.340     1493.550
   ~~~~~~~~~~ derived results ~~~~~~~~~~
   Effective gas gap (µm)                       133.201      132.731      134.477
   Contact thermal jump distance (µm)             1.396        1.387        1.400
   Target thermal jump distance (µm)              1.240        1.234        1.243
   Effective contact pressure (MPa)               0.000        0.000        0.000
   Pressure index                                13.534       13.534       13.534
   Gas thermal conductivity (W/m·˚C)              0.202        0.202        0.202
   Solid spot conductance (W/m²·C)                0.000        0.000        0.000
   Gas gap conductance (W/m²·C)                1486.870     1474.005     1493.240

   Contact status codes:
    ---------------------------------------------
    0=open/no heat transfer, 1=near-field contact
    2=closed and sliding,    3=closed and sticking
```

9.15 mm holder diameter (tensile design)

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***************************************************************************
    TEMPERATURE DESIGN SOLUTION FOR ESTEEL TENSILE (2016) RABBITS
 ***************************************************************************
  -------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.15 mm

  * Thermal-only solution method
  -------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
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  HEAT GENERATION
```

Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOLDER	AL-6061	31300.	40.7	38.4
3) ROLLPIN	SS304	38100.	8.5	8.0
5) SSJ.TENSILE.1	F82H	38100.	9.1	8.6
7) SSJ.TENSILE.2	F82H	38100.	9.1	8.6
9) CHEVRON.1	F82H	38100.	4.4	4.1
11) CHEVRON.2	F82H	38100.	4.4	4.1
13) SSJ.TENSILE.3	F82H	38100.	9.1	8.6
15) SSJ.TENSILE.4	F82H	38100.	9.1	8.6
17) CHEVRON.3	F82H	38100.	4.4	4.1
19) CHEVRON.4	F82H	38100.	4.4	4.1
21) SSJ.TENSILE.5	F82H	38100.	9.1	8.6
23) SSJ.TENSILE.6	F82H	38100.	9.1	8.6
25) CHEVRON.5	F82H	38100.	4.4	4.1
27) CHEVRON.6	F82H	38100.	4.4	4.1
29) SSJ.TENSILE.7	F82H	38100.	9.1	8.6
31) SSJ.TENSILE.8	F82H	38100.	9.1	8.6
33) CHEVRON.7	F82H	38100.	4.4	4.1
35) CHEVRON.8	F82H	38100.	4.4	4.1
37) THERMOMETRY.1	SiC(Irr)	31700.	2.9	2.8
38) THERMOMETRY.2	SiC(Irr)	31700.	2.9	2.8
39) THERMOMETRY.3	SiC(Irr)	31700.	2.9	2.8
40) THERMOMETRY.4	SiC(Irr)	31700.	2.9	2.8
41) HOUSING	AL-6061	31300.	32.1	30.3
			200.4	189.3

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  CAPSULE TEMPERATURE SUMMARY
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Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOLDER	AL-6061	320.	315.	324.	316.	322.
3) ROLLPIN	SS304	409.	403.	419.	404.	416.
5) SSJ.TENSILE.1	F82H	360.	339.	371.	344.	369.
7) SSJ.TENSILE.2	F82H	346.	334.	355.	337.	352.
9) CHEVRON.1	F82H	347.	338.	355.	342.	353.
11) CHEVRON.2	F82H	359.	347.	367.	353.	365.
13) SSJ.TENSILE.3	F82H	358.	339.	370.	344.	369.

15) SSJ.TENSILE.4	F82H	344.	333.	353.	337.	351.
17) CHEVRON.3	F82H	341.	317.	350.	331.	347.
19) CHEVRON.4	F82H	358.	346.	366.	351.	364.
21) SSJ.TENSILE.5	F82H	360.	339.	371.	345.	369.
23) SSJ.TENSILE.6	F82H	346.	335.	354.	338.	351.
25) CHEVRON.5	F82H	348.	339.	355.	343.	353.
27) CHEVRON.6	F82H	359.	348.	366.	353.	365.
29) SSJ.TENSILE.7	F82H	360.	340.	371.	344.	370.
31) SSJ.TENSILE.8	F82H	346.	334.	355.	337.	352.
33) CHEVRON.7	F82H	347.	326.	355.	341.	352.
35) CHEVRON.8	F82H	359.	347.	367.	352.	365.
37) THERMOMETRY.1	SiC(Irr)	364.	329.	390.	341.	380.
38) THERMOMETRY.2	SiC(Irr)	364.	329.	389.	340.	380.
39) THERMOMETRY.3	SiC(Irr)	363.	329.	392.	339.	380.
40) THERMOMETRY.4	SiC(Irr)	365.	330.	393.	341.	381.
41) HOUSING	AL-6061	60.	59.	61.	59.	60.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·ºC)	Thermal Exp. Coeff. (µm/m·˚C)	Emis (---)
1) HOLDER	AL-6061	176.000	25.58	0.058
3) ROLLPIN	SS304	20.942	0.00	0.143
5) SSJ.TENSILE.1	F82H	33.686	11.48	0.143
7) SSJ.TENSILE.2	F82H	33.717	11.41	0.143
9) CHEVRON.1	F82H	33.713	11.42	0.143
11) CHEVRON.2	F82H	33.687	11.48	0.143
13) SSJ.TENSILE.3	F82H	33.689	11.47	0.143
15) SSJ.TENSILE.4	F82H	33.720	11.41	0.143
17) CHEVRON.3	F82H	33.728	11.39	0.143
19) CHEVRON.4	F82H	33.691	11.47	0.143
21) SSJ.TENSILE.5	F82H	33.686	11.48	0.143
23) SSJ.TENSILE.6	F82H	33.716	11.41	0.143
25) CHEVRON.5	F82H	33.712	11.42	0.143
27) CHEVRON.6	F82H	33.687	11.48	0.143
29) SSJ.TENSILE.7	F82H	33.686	11.48	0.143
31) SSJ.TENSILE.8	F82H	33.717	11.41	0.143
33) CHEVRON.7	F82H	33.714	11.42	0.143
35) CHEVRON.8	F82H	33.687	11.48	0.143
37) THERMOMETRY.1	SiC(Irr)	6.039	3.45	0.900
38) THERMOMETRY.2	SiC(Irr)	6.039	3.45	0.900
39) THERMOMETRY.3	SiC(Irr)	6.040	3.44	0.900
40) THERMOMETRY.4	SiC(Irr)	6.039	3.45	0.900
41) HOUSING	AL-6061	166.638	24.21	0.050

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (˚C)	Specific Heat (J/kg˚C)	Stored Energy (J)
1) HOLDER	AL-6061	1.299	320.	1038.	404.
3) ROLLPIN	SS304	0.223	409.	396.	34.
5) SSJ.TENSILE.1	F82H	0.238	360.	577.	47.
7) SSJ.TENSILE.2	F82H	0.238	346.	571.	44.
9) CHEVRON.1	F82H	0.115	347.	572.	21.
11) CHEVRON.2	F82H	0.115	359.	577.	22.
13) SSJ.TENSILE.3	F82H	0.238	358.	577.	46.
15) SSJ.TENSILE.4	F82H	0.238	344.	571.	44.

17) CHEVRON.3	F82H	0.115	341.	569.	21.
19) CHEVRON.4	F82H	0.115	358.	576.	22.
21) SSJ.TENSILE.5	F82H	0.238	360.	577.	47.
23) SSJ.TENSILE.6	F82H	0.238	346.	571.	44.
25) CHEVRON.5	F82H	0.115	348.	572.	21.
27) CHEVRON.6	F82H	0.115	359.	577.	22.
29) SSJ.TENSILE.7	F82H	0.238	360.	577.	47.
31) SSJ.TENSILE.8	F82H	0.238	346.	571.	44.
33) CHEVRON.7	F82H	0.115	347.	572.	21.
35) CHEVRON.8	F82H	0.115	359.	577.	22.
37) THERMOMETRY.1	SiC(Irr)	0.092	364.	1054.	34.
38) THERMOMETRY.2	SiC(Irr)	0.092	364.	1054.	34.
39) THERMOMETRY.3	SiC(Irr)	0.092	363.	1053.	33.
40) THERMOMETRY.4	SiC(Irr)	0.092	365.	1054.	34.
41) HOUSING	AL-6061	1.026	60.	884.	36.
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		5.738			1147.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 83: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 µm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (˚C)	318.390	314.987	320.231
Target temperature (˚C)	60.549	60.056	60.660
Geometric gas gap (µm)	184.970	184.583	185.210
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	338.954	332.675	342.249
Radiation heat flux (kW/m²)	0.000	0.000	0.000
Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	338.954	332.675	342.249
Thermal contact conductance (W/m²·C)	1314.571	1306.429	1320.193
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	154.559	154.018	155.141
Contact thermal jump distance (µm)	1.470	1.461	1.475
Target thermal jump distance (µm)	1.290	1.284	1.293
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·˚C)	0.207	0.206	0.207
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	1313.812	1305.817	1319.370

Contact status codes:

0=open/no heat transfer, 1=near-field contact
2=closed and sliding, 3=closed and sticking

9.00 mm holder diameter (tensile design)

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    TEMPERATURE DESIGN SOLUTION FOR ESTEEL TENSILE (2016) RABBITS
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  -------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.00 mm

  * Thermal-only solution method
  -------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
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  HEAT GENERATION
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Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOLDER	AL-6061	31300.	39.6	37.4
3) ROLLPIN	SS304	38100.	8.5	8.1
5) SSJ.TENSILE.1	F82H	38100.	9.1	8.6
7) SSJ.TENSILE.2	F82H	38100.	9.1	8.6
9) CHEVRON.1	F82H	38100.	4.4	4.1
11) CHEVRON.2	F82H	38100.	4.4	4.1
13) SSJ.TENSILE.3	F82H	38100.	9.1	8.6
15) SSJ.TENSILE.4	F82H	38100.	9.1	8.6
17) CHEVRON.3	F82H	38100.	4.4	4.1
19) CHEVRON.4	F82H	38100.	4.4	4.1
21) SSJ.TENSILE.5	F82H	38100.	9.1	8.6
23) SSJ.TENSILE.6	F82H	38100.	9.1	8.6
25) CHEVRON.5	F82H	38100.	4.4	4.1
27) CHEVRON.6	F82H	38100.	4.4	4.1
29) SSJ.TENSILE.7	F82H	38100.	9.1	8.6
31) SSJ.TENSILE.8	F82H	38100.	9.1	8.6
33) CHEVRON.7	F82H	38100.	4.4	4.1
35) CHEVRON.8	F82H	38100.	4.4	4.1
37) THERMOMETRY.1	SiC(Irr)	31700.	2.9	2.8
38) THERMOMETRY.2	SiC(Irr)	31700.	2.9	2.8
39) THERMOMETRY.3	SiC(Irr)	31700.	2.9	2.8
40) THERMOMETRY.4	SiC(Irr)	31700.	2.9	2.8
41) HOUSING	AL-6061	31300.	32.1	30.3
			199.4	188.3

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  CAPSULE TEMPERATURE SUMMARY
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Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOLDER	AL-6061	348.	344.	352.	345.	351.
3) ROLLPIN	SS304	437.	431.	447.	432.	444.
5) SSJ.TENSILE.1	F82H	388.	368.	399.	373.	397.
7) SSJ.TENSILE.2	F82H	374.	363.	382.	366.	380.
9) CHEVRON.1	F82H	375.	367.	383.	371.	381.
11) CHEVRON.2	F82H	386.	374.	394.	380.	392.
13) SSJ.TENSILE.3	F82H	388.	368.	399.	373.	397.

15) SSJ.TENSILE.4	F82H	374.	363.	382.	366.	380.
17) CHEVRON.3	F82H	375.	357.	383.	369.	381.
19) CHEVRON.4	F82H	387.	373.	395.	380.	393.
21) SSJ.TENSILE.5	F82H	388.	368.	399.	373.	397.
23) SSJ.TENSILE.6	F82H	374.	364.	383.	366.	380.
25) CHEVRON.5	F82H	375.	367.	383.	371.	381.
27) CHEVRON.6	F82H	387.	373.	394.	380.	392.
29) SSJ.TENSILE.7	F82H	388.	368.	399.	373.	397.
31) SSJ.TENSILE.8	F82H	374.	363.	382.	366.	379.
33) CHEVRON.7	F82H	375.	366.	383.	371.	381.
35) CHEVRON.8	F82H	386.	371.	394.	380.	392.
37) THERMOMETRY.1	SiC(Irr)	392.	356.	417.	368.	408.
38) THERMOMETRY.2	SiC(Irr)	392.	356.	417.	368.	408.
39) THERMOMETRY.3	SiC(Irr)	392.	357.	420.	368.	409.
40) THERMOMETRY.4	SiC(Irr)	393.	357.	421.	369.	409.
41) HOUSING	AL-6061	60.	59.	61.	59.	60.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (µm/m·°C)	Emis (---)
1) HOLDER	AL-6061	176.000	25.85	0.060
3) ROLLPIN	SS304	21.324	0.00	0.143
5) SSJ.TENSILE.1	F82H	33.625	11.61	0.143
7) SSJ.TENSILE.2	F82H	33.655	11.55	0.143
9) CHEVRON.1	F82H	33.652	11.56	0.143
11) CHEVRON.2	F82H	33.628	11.61	0.143
13) SSJ.TENSILE.3	F82H	33.625	11.61	0.143
15) SSJ.TENSILE.4	F82H	33.655	11.55	0.143
17) CHEVRON.3	F82H	33.653	11.55	0.143
19) CHEVRON.4	F82H	33.626	11.61	0.143
21) SSJ.TENSILE.5	F82H	33.624	11.62	0.143
23) SSJ.TENSILE.6	F82H	33.655	11.55	0.143
25) CHEVRON.5	F82H	33.652	11.56	0.143
27) CHEVRON.6	F82H	33.627	11.61	0.143
29) SSJ.TENSILE.7	F82H	33.625	11.61	0.143
31) SSJ.TENSILE.8	F82H	33.655	11.55	0.143
33) CHEVRON.7	F82H	33.652	11.55	0.143
35) CHEVRON.8	F82H	33.628	11.61	0.143
37) THERMOMETRY.1	SiC(Irr)	6.028	3.52	0.900
38) THERMOMETRY.2	SiC(Irr)	6.028	3.52	0.900
39) THERMOMETRY.3	SiC(Irr)	6.028	3.53	0.900
40) THERMOMETRY.4	SiC(Irr)	6.028	3.53	0.900
41) HOUSING	AL-6061	166.633	24.21	0.050

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOLDER	AL-6061	1.265	348.	1051.	437.
3) ROLLPIN	SS304	0.224	437.	399.	37.
5) SSJ.TENSILE.1	F82H	0.238	388.	589.	52.
7) SSJ.TENSILE.2	F82H	0.238	374.	583.	49.
9) CHEVRON.1	F82H	0.115	375.	584.	24.
11) CHEVRON.2	F82H	0.115	386.	588.	25.
13) SSJ.TENSILE.3	F82H	0.238	388.	589.	52.
15) SSJ.TENSILE.4	F82H	0.238	374.	583.	49.

17) CHEVRON.3	F82H	0.115	375.	584.	24.
19) CHEVRON.4	F82H	0.115	387.	589.	25.
21) SSJ.TENSILE.5	F82H	0.238	388.	589.	52.
23) SSJ.TENSILE.6	F82H	0.238	374.	583.	49.
25) CHEVRON.5	F82H	0.115	375.	584.	24.
27) CHEVRON.6	F82H	0.115	387.	588.	25.
29) SSJ.TENSILE.7	F82H	0.238	388.	589.	51.
31) SSJ.TENSILE.8	F82H	0.238	374.	583.	49.
33) CHEVRON.7	F82H	0.115	375.	584.	24.
35) CHEVRON.8	F82H	0.115	386.	588.	25.
37) THERMOMETRY.1	SiC(Irr)	0.092	392.	1069.	37.
38) THERMOMETRY.2	SiC(Irr)	0.092	392.	1069.	37.
39) THERMOMETRY.3	SiC(Irr)	0.092	392.	1069.	37.
40) THERMOMETRY.4	SiC(Irr)	0.092	393.	1069.	37.
41) HOUSING	AL-6061	1.026	60.	884.	36.
		5.705			1253.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 83: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 µm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (˚C)	347.127	343.657	348.796
Target temperature (˚C)	60.506	60.021	60.617
Geometric gas gap (µm)	209.964	209.691	210.178
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	338.734	332.727	341.791
Radiation heat flux (kW/m²)	0.000	0.000	0.000
Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	338.734	332.727	341.791
Thermal contact conductance (W/m²·C)	1181.806	1174.516	1186.195
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	175.969	175.522	176.615
Contact thermal jump distance (µm)	1.543	1.534	1.547
Target thermal jump distance (µm)	1.339	1.332	1.342
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·˚C)	0.211	0.211	0.212
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	1181.327	1173.988	1185.726

Contact status codes:

0=open/no heat transfer, 1=near-field contact
2=closed and sliding, 3=closed and sticking

9.44 mm holder diameter (bend bar design)

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TEMPERATURE DESIGN SOLUTION FOR ESTEEL BEND BAR (2016) RABBITS

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DESCRIPTION

* HFIR TRRH Axial position 5.
* Helium fill gas
* Holder OD = 9.44 mm

* Thermal-only solution method

BOUNDARY CONDITIONS

Heat transfer coefficient = 47100. W/m²·°C
Bulk coolant temperature = 52.0 °C
Peaking factor = 0.960

HEAT GENERATION

Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOUSING	AL-6061	31300.	134.1	133.5
3) ENDCAP	AL-6061	31300.	16.5	16.4
5) HOLDER	AL-6061	31300.	133.2	132.8
7) GRAFOIL_SUPPORT.1	GRAFOIL	32500.	0.1	0.1
9) MOLY_SUPPORT.1	Moly	42000.	1.6	1.6
11) SS_LINER.1	SS304	38100.	93.6	93.4
12) SIC_THERMOMETRY.1	SiC(Irr)	31700.	7.3	7.3
13) MOLY_SUPPORT.2	Moly	42000.	1.6	1.6
15) SPECIMEN_BB.4	F82H	38100.	292.9	292.2
17) SIC_SPRING.7	SiC(Irr)	31700.	3.1	3.1
19) GRAFOIL_SPACER.1	GRAFOIL	32500.	0.3	0.3
21) GRAFOIL_SPACER.2	GRAFOIL	32500.	0.3	0.3
23) GRAFOIL_SUPPORT.2	GRAFOIL	32500.	0.1	0.1
			684.8	682.8

CAPSULE TEMPERATURE SUMMARY

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOUSING	AL-6061	59.	54.	62.	55.	61.
3) ENDCAP	AL-6061	82.	80.	84.	81.	83.
5) HOLDER	AL-6061	131.	115.	139.	118.	137.
7) GRAFOIL_SUPPORT.1	GRAFOIL	196.	191.	199.	192.	199.
9) MOLY_SUPPORT.1	Moly	196.	189.	200.	191.	200.
11) SS_LINER.1	SS304	178.	149.	193.	164.	189.
12) SIC_THERMOMETRY.1	SiC(Irr)	192.	185.	195.	187.	194.
13) MOLY_SUPPORT.2	Moly	195.	188.	199.	190.	199.
15) SPECIMEN_BB.4	F82H	196.	169.	210.	179.	208.
17) SIC_SPRING.7	SiC(Irr)	178.	155.	210.	157.	209.
19) GRAFOIL_SPACER.1	GRAFOIL	123.	114.	126.	118.	126.
21) GRAFOIL_SPACER.2	GRAFOIL	117.	109.	120.	113.	119.
23) GRAFOIL_SUPPORT.2	GRAFOIL	195.	189.	198.	192.	198.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (μm/m·°C)	Emis (---)
1) HOUSING	AL-6061	166.589	24.21	0.050
3) ENDCAP	AL-6061	169.242	0.00	0.050
5) HOLDER	AL-6061	174.116	24.23	0.050
7) GRAFOIL_SUPPORT.1	GRAFOIL	38.000	1.00	0.500
9) MOLY_SUPPORT.1	Moly	131.252	0.00	0.047
11) SS_LINER.1	SS304	17.714	0.00	0.143
12) SIC_THERMOMETRY.1	SiC(Irr)	6.106	2.90	0.900
13) MOLY_SUPPORT.2	Moly	131.287	0.00	0.047
15) SPECIMEN_BB.4	F82H	33.207	11.01	0.143
17) SIC_SPRING.7	SiC(Irr)	6.111	2.85	0.900
19) GRAFOIL_SPACER.1	GRAFOIL	38.000	1.00	0.500
21) GRAFOIL_SPACER.2	GRAFOIL	38.000	1.00	0.500
23) GRAFOIL_SUPPORT.2	GRAFOIL	38.000	1.00	0.500

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOUSING	AL-6061	4.286	59.	884.	149.
3) ENDCAP	AL-6061	0.527	82.	902.	29.
5) HOLDER	AL-6061	4.255	131.	937.	441.
7) GRAFOIL_SUPPORT.1	GRAFOIL	0.004	196.	700.	0.
9) MOLY_SUPPORT.1	Moly	0.039	196.	262.	2.
11) SS_LINER.1	SS304	2.457	178.	381.	148.
12) SIC_THERMOMETRY.1	SiC(Irr)	0.231	192.	934.	37.
13) MOLY_SUPPORT.2	Moly	0.039	195.	262.	2.
15) SPECIMEN_BB.4	F82H	7.687	196.	514.	696.
17) SIC_SPRING.7	SiC(Irr)	0.097	178.	918.	14.
19) GRAFOIL_SPACER.1	GRAFOIL	0.009	123.	700.	1.
21) GRAFOIL_SPACER.2	GRAFOIL	0.009	117.	700.	1.
23) GRAFOIL_SUPPORT.2	GRAFOIL	0.004	195.	700.	0.
		19.643			1520.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 25: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 μm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (°C)	128.983	114.642	135.260
Target temperature (°C)	61.199	57.355	62.170
Geometric gas gap (μm)	38.430	17.100	38.473
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	364.449	288.881	934.828
Radiation heat flux (kW/m²)	0.000	0.000	0.000

```
Contact conduction heat flux (kW/m²)        0.000        0.000        0.000
Total heat flux (kW/m²)                   364.449      288.881      934.828
Thermal contact conductance (W/m²·C)     5371.732     5084.671    14705.808
~~~~~~~~~~ derived results ~~~~~~~~~~
Effective gas gap (μm)                     30.672        9.835       31.967
Contact thermal jump distance (μm)          1.016        0.978        1.032
Target thermal jump distance (μm)           0.976        0.944        0.988
Effective contact pressure (MPa)            0.000        0.000        0.000
Pressure index                             13.534       13.534       13.534
Gas thermal conductivity (W/m·°C)           0.175        0.172        0.177
Solid spot conductance (W/m²·C)             0.000        0.000        0.000
Gas gap conductance (W/m²·C)             5376.230     5083.350    14693.840

Contact status codes:
 ----------------------------------------------
 0=open/no heat transfer, 1=near-field contact
 2=closed and sliding,    3=closed and sticking
```

9.40 mm holder diameter (bend bar design)

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    TEMPERATURE DESIGN SOLUTION FOR ESTEEL BEND BAR (2016) RABBITS
 ****************************************************************************
  -------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.40 mm

  * Thermal-only solution method
  -------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
 --------------------------------------------------------------------------------
  HEAT GENERATION
```

Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOUSING	AL-6061	31300.	134.1	133.5
3) ENDCAP	AL-6061	31300.	16.5	16.4
5) HOLDER	AL-6061	31300.	129.9	129.5
7) GRAFOIL_SUPPORT.1	GRAFOIL	32500.	0.1	0.1
9) MOLY_SUPPORT.1	Moly	42000.	1.6	1.6
11) SS_LINER.1	SS304	38100.	93.6	93.4
12) SIC_THERMOMETRY.1	SiC(Irr)	31700.	7.3	7.3
13) MOLY_SUPPORT.2	Moly	42000.	1.6	1.6
15) SPECIMEN_BB.4	F82H	38100.	292.9	292.2
17) SIC_SPRING.7	SiC(Irr)	31700.	3.1	3.1
19) GRAFOIL_SPACER.1	GRAFOIL	32500.	0.3	0.3
21) GRAFOIL_SPACER.2	GRAFOIL	32500.	0.3	0.3
23) GRAFOIL_SUPPORT.2	GRAFOIL	32500.	0.1	0.1
			681.5	679.5

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  CAPSULE TEMPERATURE SUMMARY
```

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOUSING	AL-6061	59.	54.	62.	55.	61.
3) ENDCAP	AL-6061	82.	80.	84.	81.	83.
5) HOLDER	AL-6061	172.	153.	181.	156.	180.
7) GRAFOIL_SUPPORT.1	GRAFOIL	235.	230.	239.	231.	238.
9) MOLY_SUPPORT.1	Moly	235.	228.	239.	230.	239.
11) SS_LINER.1	SS304	218.	189.	234.	204.	231.
12) SIC_THERMOMETRY.1	SiC(Irr)	232.	223.	236.	225.	235.
13) MOLY_SUPPORT.2	Moly	233.	226.	238.	228.	237.
15) SPECIMEN_BB.4	F82H	236.	207.	251.	218.	248.
17) SIC_SPRING.7	SiC(Irr)	218.	196.	249.	198.	249.
19) GRAFOIL_SPACER.1	GRAFOIL	163.	148.	166.	155.	166.
21) GRAFOIL_SPACER.2	GRAFOIL	155.	143.	158.	149.	158.
23) GRAFOIL_SUPPORT.2	GRAFOIL	234.	227.	237.	231.	237.

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  PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE
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Name	Material	Thermal Cond. (W/m·ºC)	Thermal Exp. Coeff. (µm/m·˚C)	Emis (---)
1) HOUSING	AL-6061	166.586	24.21	0.050
3) ENDCAP	AL-6061	169.244	0.00	0.050
5) HOLDER	AL-6061	176.000	24.49	0.051
7) GRAFOIL_SUPPORT.1	GRAFOIL	38.000	1.00	0.500
9) MOLY_SUPPORT.1	Moly	129.681	0.00	0.051
11) SS_LINER.1	SS304	18.281	0.00	0.143
12) SIC_THERMOMETRY.1	SiC(Irr)	6.090	3.04	0.900
13) MOLY_SUPPORT.2	Moly	129.744	0.00	0.051
15) SPECIMEN_BB.4	F82H	33.423	11.08	0.143
17) SIC_SPRING.7	SiC(Irr)	6.095	3.00	0.900
19) GRAFOIL_SPACER.1	GRAFOIL	38.000	1.00	0.500
21) GRAFOIL_SPACER.2	GRAFOIL	38.000	1.00	0.500
23) GRAFOIL_SUPPORT.2	GRAFOIL	38.000	1.00	0.500

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (˚C)	Specific Heat (J/kg˚C)	Stored Energy (J)
1) HOUSING	AL-6061	4.285	59.	884.	149.
3) ENDCAP	AL-6061	0.527	82.	902.	29.
5) HOLDER	AL-6061	4.149	172.	965.	609.
7) GRAFOIL_SUPPORT.1	GRAFOIL	0.004	235.	700.	1.
9) MOLY_SUPPORT.1	Moly	0.039	235.	264.	2.
11) SS_LINER.1	SS304	2.457	218.	382.	186.
12) SIC_THERMOMETRY.1	SiC(Irr)	0.231	232.	967.	47.
13) MOLY_SUPPORT.2	Moly	0.039	233.	263.	2.
15) SPECIMEN_BB.4	F82H	7.687	236.	528.	878.
17) SIC_SPRING.7	SiC(Irr)	0.097	218.	957.	18.
19) GRAFOIL_SPACER.1	GRAFOIL	0.009	163.	700.	1.
21) GRAFOIL_SPACER.2	GRAFOIL	0.009	155.	700.	1.
23) GRAFOIL_SUPPORT.2	GRAFOIL	0.004	234.	700.	1.
		19.537			1925.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 25: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 µm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (˚C)	170.343	152.840	178.297
Target temperature (˚C)	61.093	57.197	61.987
Geometric gas gap (µm)	65.283	18.529	65.478
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	367.136	300.871	1695.468
Radiation heat flux (kW/m²)	0.000	0.000	0.000

Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	367.136	300.871	1695.468
Thermal contact conductance (W/m²·C)	3362.074	3159.420	16403.961
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	52.682	8.878	54.534
Contact thermal jump distance (µm)	1.110	1.063	1.130
Target thermal jump distance (µm)	1.043	1.005	1.058
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·°C)	0.182	0.179	0.184
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	3362.924	3158.830	16373.586

```
Contact status codes:
 ---------------------------------------------
 0=open/no heat transfer, 1=near-field contact
 2=closed and sliding,    3=closed and sticking
```

9.35 mm holder diameter (bend bar design)

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    TEMPERATURE DESIGN SOLUTION FOR ESTEEL BEND BAR (2016) RABBITS
 ****************************************************************************
  ---------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.35 mm

  * Thermal-only solution method
  ---------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
 ---------------------------------------------------------------------------------
  HEAT GENERATION
```

Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOUSING	AL-6061	31300.	134.1	133.5
3) ENDCAP	AL-6061	31300.	16.5	16.4
5) HOLDER	AL-6061	31300.	127.2	126.9
7) GRAFOIL_SUPPORT.1	GRAFOIL	32500.	0.1	0.1
9) MOLY_SUPPORT.1	Moly	42000.	1.6	1.6
11) SS_LINER.1	SS304	38100.	93.6	93.4
12) SIC_THERMOMETRY.1	SiC(Irr)	31700.	7.3	7.3
13) MOLY_SUPPORT.2	Moly	42000.	1.6	1.6
15) SPECIMEN_BB.4	F82H	38100.	292.9	292.2
17) SIC_SPRING.7	SiC(Irr)	31700.	3.1	3.1
19) GRAFOIL_SPACER.1	GRAFOIL	32500.	0.3	0.3
21) GRAFOIL_SPACER.2	GRAFOIL	32500.	0.3	0.3
23) GRAFOIL_SUPPORT.2	GRAFOIL	32500.	0.1	0.1
			678.8	676.8

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 ---------------------------------------------------------------------------------
  CAPSULE TEMPERATURE SUMMARY
```

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOUSING	AL-6061	59.	54.	62.	55.	61.
3) ENDCAP	AL-6061	82.	80.	84.	81.	83.
5) HOLDER	AL-6061	204.	182.	214.	186.	213.
7) GRAFOIL_SUPPORT.1	GRAFOIL	265.	260.	269.	261.	269.
9) MOLY_SUPPORT.1	Moly	265.	259.	270.	260.	270.
11) SS_LINER.1	SS304	250.	219.	266.	234.	262.
12) SIC_THERMOMETRY.1	SiC(Irr)	263.	253.	268.	254.	267.
13) MOLY_SUPPORT.2	Moly	263.	256.	267.	258.	267.
15) SPECIMEN_BB.4	F82H	268.	237.	282.	249.	280.
17) SIC_SPRING.7	SiC(Irr)	249.	228.	280.	230.	279.
19) GRAFOIL_SPACER.1	GRAFOIL	194.	174.	197.	184.	197.
21) GRAFOIL_SPACER.2	GRAFOIL	185.	169.	188.	177.	187.
23) GRAFOIL_SUPPORT.2	GRAFOIL	263.	256.	267.	260.	266.

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  PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE
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Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (μm/m·°C)	Emis (---)
1) HOUSING	AL-6061	166.582	24.21	0.050
3) ENDCAP	AL-6061	169.241	0.00	0.050
5) HOLDER	AL-6061	176.000	24.69	0.052
7) GRAFOIL_SUPPORT.1	GRAFOIL	38.000	1.00	0.500
9) MOLY_SUPPORT.1	Moly	128.462	0.00	0.054
11) SS_LINER.1	SS304	18.719	0.00	0.143
12) SIC_THERMOMETRY.1	SiC(Irr)	6.078	3.15	0.900
13) MOLY_SUPPORT.2	Moly	128.561	0.00	0.054
15) SPECIMEN_BB.4	F82H	33.588	11.14	0.143
17) SIC_SPRING.7	SiC(Irr)	6.083	3.10	0.900
19) GRAFOIL_SPACER.1	GRAFOIL	38.000	1.00	0.500
21) GRAFOIL_SPACER.2	GRAFOIL	38.000	1.00	0.500
23) GRAFOIL_SUPPORT.2	GRAFOIL	38.000	1.00	0.500

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOUSING	AL-6061	4.286	59.	884.	149.
3) ENDCAP	AL-6061	0.527	82.	902.	29.
5) HOLDER	AL-6061	4.063	204.	985.	737.
7) GRAFOIL_SUPPORT.1	GRAFOIL	0.004	265.	700.	1.
9) MOLY_SUPPORT.1	Moly	0.039	265.	265.	3.
11) SS_LINER.1	SS304	2.457	250.	384.	217.
12) SIC_THERMOMETRY.1	SiC(Irr)	0.231	263.	991.	56.
13) MOLY_SUPPORT.2	Moly	0.039	263.	265.	2.
15) SPECIMEN_BB.4	F82H	7.687	268.	537.	1023.
17) SIC_SPRING.7	SiC(Irr)	0.097	249.	981.	22.
19) GRAFOIL_SPACER.1	GRAFOIL	0.009	194.	700.	1.
21) GRAFOIL_SPACER.2	GRAFOIL	0.009	185.	700.	1.
23) GRAFOIL_SUPPORT.2	GRAFOIL	0.004	263.	700.	1.
		19.451			2241.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 25: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 μm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (°C)	202.461	181.931	211.301
Target temperature (°C)	61.077	57.453	61.880
Geometric gas gap (μm)	87.210	20.686	87.470
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	368.885	305.362	2226.203
Radiation heat flux (kW/m²)	0.000	0.000	0.000

Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	368.885	305.362	2226.203
Thermal contact conductance (W/m²·C)	2611.946	2443.363	16694.596
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	70.827	8.878	73.065
Contact thermal jump distance (µm)	1.186	1.130	1.209
Target thermal jump distance (µm)	1.096	1.053	1.113
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·°C)	0.188	0.184	0.189
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	2612.217	2442.627	16627.804

```
Contact status codes:
 ----------------------------------------------
 0=open/no heat transfer, 1=near-field contact
 2=closed and sliding,    3=closed and sticking
```

9.30 mm holder diameter (bend bar design)

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**************************************************************************
    TEMPERATURE DESIGN SOLUTION FOR ESTEEL BEND BAR (2016) RABBITS
 **************************************************************************
  ------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.30 mm

  * Thermal-only solution method
  ------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
 -------------------------------------------------------------------------
  HEAT GENERATION
```

Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOUSING	AL-6061	31300.	134.1	133.5
3) ENDCAP	AL-6061	31300.	16.5	16.4
5) HOLDER	AL-6061	31300.	124.6	124.3
7) GRAFOIL_SUPPORT.1	GRAFOIL	32500.	0.1	0.1
9) MOLY_SUPPORT.1	Moly	42000.	1.6	1.6
11) SS_LINER.1	SS304	38100.	93.6	93.4
12) SIC_THERMOMETRY.1	SiC(Irr)	31700.	7.3	7.3
13) MOLY_SUPPORT.2	Moly	42000.	1.6	1.6
15) SPECIMEN_BB.4	F82H	38100.	292.9	292.2
17) SIC_SPRING.7	SiC(Irr)	31700.	3.1	3.1
19) GRAFOIL_SPACER.1	GRAFOIL	32500.	0.3	0.3
21) GRAFOIL_SPACER.2	GRAFOIL	32500.	0.3	0.3
23) GRAFOIL_SUPPORT.2	GRAFOIL	32500.	0.1	0.1
			676.2	674.3

CAPSULE TEMPERATURE SUMMARY

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOUSING	AL-6061	59.	54.	62.	55.	61.
3) ENDCAP	AL-6061	82.	80.	84.	81.	84.
5) HOLDER	AL-6061	233.	208.	244.	214.	242.
7) GRAFOIL_SUPPORT.1	GRAFOIL	293.	288.	297.	289.	297.
9) MOLY_SUPPORT.1	Moly	293.	287.	298.	288.	298.
11) SS_LINER.1	SS304	278.	246.	295.	262.	291.
12) SIC_THERMOMETRY.1	SiC(Irr)	291.	280.	297.	282.	296.
13) MOLY_SUPPORT.2	Moly	290.	283.	294.	285.	294.
15) SPECIMEN_BB.4	F82H	296.	265.	311.	277.	309.
17) SIC_SPRING.7	SiC(Irr)	278.	257.	308.	259.	307.
19) GRAFOIL_SPACER.1	GRAFOIL	222.	198.	225.	209.	225.
21) GRAFOIL_SPACER.2	GRAFOIL	211.	192.	215.	202.	214.
23) GRAFOIL_SUPPORT.2	GRAFOIL	290.	283.	294.	287.	293.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (µm/m·°C)	Emis (---)
1) HOUSING	AL-6061	166.580	24.21	0.050
3) ENDCAP	AL-6061	169.245	0.00	0.050
5) HOLDER	AL-6061	176.000	24.88	0.053
7) GRAFOIL_SUPPORT.1	GRAFOIL	38.000	1.00	0.500
9) MOLY_SUPPORT.1	Moly	127.342	0.00	0.057
11) SS_LINER.1	SS304	19.120	0.00	0.143
12) SIC_THERMOMETRY.1	SiC(Irr)	6.067	3.24	0.900
13) MOLY_SUPPORT.2	Moly	127.474	0.00	0.056
15) SPECIMEN_BB.4	F82H	33.739	11.18	0.143
17) SIC_SPRING.7	SiC(Irr)	6.072	3.20	0.900
19) GRAFOIL_SPACER.1	GRAFOIL	38.000	1.00	0.500
21) GRAFOIL_SPACER.2	GRAFOIL	38.000	1.00	0.500
23) GRAFOIL_SUPPORT.2	GRAFOIL	38.000	1.00	0.500

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOUSING	AL-6061	4.286	59.	884.	149.
3) ENDCAP	AL-6061	0.527	82.	902.	30.
5) HOLDER	AL-6061	3.982	233.	998.	848.
7) GRAFOIL_SUPPORT.1	GRAFOIL	0.004	293.	700.	1.
9) MOLY_SUPPORT.1	Moly	0.039	293.	266.	3.
11) SS_LINER.1	SS304	2.457	278.	386.	245.
12) SIC_THERMOMETRY.1	SiC(Irr)	0.231	291.	1012.	63.
13) MOLY_SUPPORT.2	Moly	0.039	290.	266.	3.
15) SPECIMEN_BB.4	F82H	7.687	296.	546.	1160.
17) SIC_SPRING.7	SiC(Irr)	0.097	278.	1002.	25.
19) GRAFOIL_SPACER.1	GRAFOIL	0.009	222.	700.	1.
21) GRAFOIL_SPACER.2	GRAFOIL	0.009	211.	700.	1.
23) GRAFOIL_SUPPORT.2	GRAFOIL	0.004	290.	700.	1.
		19.370			2529.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 25: Frictionless - HOLDER To HOUSING

```
   Contact surface material:      AL-6061
   Target surface material:       AL-6061
   Interstitial gas:               Helium
   Effective surface roughness:     2.263 µm
   Effective asperity slope:        0.214 rad
   Effective microhardness:         1.220 GPa
```

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (°C)	231.637	208.259	241.323
Target temperature (°C)	61.041	57.576	61.793
Geometric gas gap (µm)	108.139	23.601	108.475
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	370.065	306.628	2716.815
Radiation heat flux (kW/m²)	0.000	0.000	0.000

```
Contact conduction heat flux (kW/m²)        0.000        0.000        0.000
Total heat flux (kW/m²)                   370.065      306.628     2716.815
Thermal contact conductance (W/m²·C)     2172.779     2022.032    16948.385
~~~~~~~~~~ derived results ~~~~~~~~~~
Effective gas gap (μm)                     88.286        8.878       90.942
Contact thermal jump distance (μm)          1.256        1.194        1.281
Target thermal jump distance (μm)           1.145        1.098        1.163
Effective contact pressure (MPa)            0.000        0.000        0.000
Pressure index                             13.534       13.534       13.534
Gas thermal conductivity (W/m·°C)           0.193        0.188        0.194
Solid spot conductance (W/m²·C)             0.000        0.000        0.000
Gas gap conductance (W/m²·C)             2172.111     2021.650    16838.140

Contact status codes:
 ----------------------------------------------
 0=open/no heat transfer, 1=near-field contact
 2=closed and sliding,    3=closed and sticking
```

9.27 mm holder diameter (bend bar design)

```
****************************************************************************
    TEMPERATURE DESIGN SOLUTION FOR ESTEEL BEND BAR (2016) RABBITS
 ****************************************************************************
  ------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.27 mm

  * Thermal-only solution method
  ------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
 -------------------------------------------------------------------------------
  HEAT GENERATION

                                               Heat Gen.   ------ Heat Load -----
                                               @Midplane   @Midplane    @Location
   Part                               Material  (W/kg)       (W)          (W)
 ----------------------------------- --------  ---------   ---------    ---------
   1) HOUSING                        AL-6061     31300.       134.1        133.5
   3) ENDCAP                         AL-6061     31300.        16.5         16.4
   5) HOLDER                         AL-6061     31300.       122.3        122.0
   7) GRAFOIL_SUPPORT.1              GRAFOIL     32500.         0.1          0.1
   9) MOLY_SUPPORT.1                 Moly        42000.         1.6          1.6
  11) SS_LINER.1                     SS304       38100.        93.6         93.4
  12) SIC_THERMOMETRY.1              SiC(Irr)    31700.         7.3          7.3
  13) MOLY_SUPPORT.2                 Moly        42000.         1.6          1.6
  15) SPECIMEN_BB.4                  F82H        38100.       292.9        292.2
  17) SIC_SPRING.7                   SiC(Irr)    31700.         3.1          3.1
  19) GRAFOIL_SPACER.1               GRAFOIL     32500.         0.3          0.3
  21) GRAFOIL_SPACER.2               GRAFOIL     32500.         0.3          0.3
  23) GRAFOIL_SUPPORT.2              GRAFOIL     32500.         0.1          0.1
 ----------------------------------- --------  ---------   ---------    ---------
                                                              673.9        672.0

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  CAPSULE TEMPERATURE SUMMARY

 Name                                 Material   Tavg   Tmin   Tmax  T.025  T.975
 ------------------------------------ --------   -----  -----  ----- -----  -----
   1) HOUSING                         AL-6061     59.    54.    62.   55.    61.
   3) ENDCAP                          AL-6061     82.    80.    84.   81.    84.
   5) HOLDER                          AL-6061    259.   231.   270.  238.   268.
   7) GRAFOIL_SUPPORT.1               GRAFOIL    318.   312.   322.  314.   321.
   9) MOLY_SUPPORT.1                  Moly       318.   311.   322.  313.   322.
  11) SS_LINER.1                      SS304      303.   270.   320.  287.   317.
  12) SIC_THERMOMETRY.1               SiC(Irr)   316.   304.   322.  306.   321.
  13) MOLY_SUPPORT.2                  Moly       314.   307.   318.  308.   318.
  15) SPECIMEN_BB.4                   F82H       321.   289.   337.  301.   335.
  17) SIC_SPRING.7                    SiC(Irr)   303.   282.   333.  284.   332.
  19) GRAFOIL_SPACER.1                GRAFOIL    246.   218.   250.  231.   250.
  21) GRAFOIL_SPACER.2                GRAFOIL    235.   212.   238.  223.   238.
  23) GRAFOIL_SUPPORT.2               GRAFOIL    314.   307.   318.  311.   317.

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  PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE
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Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (µm/m·°C)	Emis (---)
1) HOUSING	AL-6061	166.577	24.21	0.050
3) ENDCAP	AL-6061	169.246	0.00	0.050
5) HOLDER	AL-6061	176.000	25.09	0.055
7) GRAFOIL_SUPPORT.1	GRAFOIL	38.000	1.00	0.500
9) MOLY_SUPPORT.1	Moly	126.366	0.00	0.059
11) SS_LINER.1	SS304	19.470	0.00	0.143
12) SIC_THERMOMETRY.1	SiC(Irr)	6.058	3.31	0.900
13) MOLY_SUPPORT.2	Moly	126.522	0.00	0.059
15) SPECIMEN_BB.4	F82H	33.770	11.30	0.143
17) SIC_SPRING.7	SiC(Irr)	6.063	3.28	0.900
19) GRAFOIL_SPACER.1	GRAFOIL	38.000	1.00	0.500
21) GRAFOIL_SPACER.2	GRAFOIL	38.000	1.00	0.500
23) GRAFOIL_SUPPORT.2	GRAFOIL	38.000	1.00	0.500

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOUSING	AL-6061	4.286	59.	884.	149.
3) ENDCAP	AL-6061	0.527	82.	902.	30.
5) HOLDER	AL-6061	3.908	259.	1010.	942.
7) GRAFOIL_SUPPORT.1	GRAFOIL	0.004	318.	700.	1.
9) MOLY_SUPPORT.1	Moly	0.039	318.	267.	3.
11) SS_LINER.1	SS304	2.457	303.	388.	270.
12) SIC_THERMOMETRY.1	SiC(Irr)	0.231	316.	1027.	70.
13) MOLY_SUPPORT.2	Moly	0.039	314.	267.	3.
15) SPECIMEN_BB.4	F82H	7.687	321.	559.	1294.
17) SIC_SPRING.7	SiC(Irr)	0.097	303.	1020.	28.
19) GRAFOIL_SPACER.1	GRAFOIL	0.009	246.	700.	1.
21) GRAFOIL_SPACER.2	GRAFOIL	0.009	235.	700.	1.
23) GRAFOIL_SUPPORT.2	GRAFOIL	0.004	314.	700.	1.
		19.296			2794.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 25: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 µm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (°C)	257.003	230.947	267.426
Target temperature (°C)	61.008	57.650	61.722
Geometric gas gap (µm)	127.084	26.988	127.464
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	370.928	307.426	3148.570
Radiation heat flux (kW/m²)	0.000	0.000	0.000

Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	370.928	307.426	3148.570
Thermal contact conductance (W/m²·C)	1896.574	1757.606	17158.719
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	104.162	8.878	107.180
Contact thermal jump distance (µm)	1.318	1.250	1.345
Target thermal jump distance (µm)	1.187	1.137	1.207
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·°C)	0.197	0.192	0.199
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	1895.731	1756.785	17064.052

```
Contact status codes:
 ----------------------------------------------
 0=open/no heat transfer, 1=near-field contact
 2=closed and sliding,    3=closed and sticking
```

9.23 mm holder diameter (bend bar design)

****

TEMPERATURE DESIGN SOLUTION FOR ESTEEL BEND BAR (2016) RABBITS

****

DESCRIPTION

* HFIR TRRH Axial position 5.
* Helium fill gas
* Holder OD = 9.23 mm

* Thermal-only solution method

BOUNDARY CONDITIONS

Heat transfer coefficient = 47100. $W/m^2 \cdot {}^{\circ}C$
Bulk coolant temperature = 52.0 °C
Peaking factor = 0.960

HEAT GENERATION

Part	Material	Heat Gen. @Midplane (W/kg)	------ Heat Load ----- @Midplane (W)	@Location (W)
1) HOUSING	AL-6061	31300.	134.1	133.5
3) ENDCAP	AL-6061	31300.	16.5	16.4
5) HOLDER	AL-6061	31300.	119.9	119.6
7) GRAFOIL_SUPPORT.1	GRAFOIL	32500.	0.1	0.1
9) MOLY_SUPPORT.1	Moly	42000.	1.6	1.6
11) SS_LINER.1	SS304	38100.	93.6	93.4
12) SIC_THERMOMETRY.1	SiC(Irr)	31700.	7.3	7.3
13) MOLY_SUPPORT.2	Moly	42000.	1.6	1.6
15) SPECIMEN_BB.4	F82H	38100.	292.9	292.2
17) SIC_SPRING.7	SiC(Irr)	31700.	3.1	3.1
19) GRAFOIL_SPACER.1	GRAFOIL	32500.	0.3	0.3
21) GRAFOIL_SPACER.2	GRAFOIL	32500.	0.3	0.3
23) GRAFOIL_SUPPORT.2	GRAFOIL	32500.	0.1	0.1
			671.5	669.6

CAPSULE TEMPERATURE SUMMARY

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOUSING	AL-6061	59.	54.	62.	55.	61.
3) ENDCAP	AL-6061	82.	80.	84.	81.	83.
5) HOLDER	AL-6061	285.	255.	297.	262.	295.
7) GRAFOIL_SUPPORT.1	GRAFOIL	343.	338.	347.	339.	347.
9) MOLY_SUPPORT.1	Moly	343.	336.	348.	338.	347.
11) SS_LINER.1	SS304	329.	295.	346.	312.	343.
12) SIC_THERMOMETRY.1	SiC(Irr)	341.	328.	348.	330.	347.
13) MOLY_SUPPORT.2	Moly	339.	331.	343.	333.	343.
15) SPECIMEN_BB.4	F82H	347.	313.	363.	326.	361.
17) SIC_SPRING.7	SiC(Irr)	328.	308.	358.	310.	357.
19) GRAFOIL_SPACER.1	GRAFOIL	270.	239.	275.	254.	275.
21) GRAFOIL_SPACER.2	GRAFOIL	259.	232.	263.	246.	262.
23) GRAFOIL_SUPPORT.2	GRAFOIL	339.	331.	342.	336.	342.

PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (μm/m·°C)	Emis (---)
1) HOUSING	AL-6061	166.574	24.21	0.050
3) ENDCAP	AL-6061	169.243	0.00	0.050
5) HOLDER	AL-6061	176.000	25.29	0.056
7) GRAFOIL_SUPPORT.1	GRAFOIL	38.000	1.00	0.500
9) MOLY_SUPPORT.1	Moly	125.356	0.00	0.062
11) SS_LINER.1	SS304	19.829	0.00	0.143
12) SIC_THERMOMETRY.1	SiC(Irr)	6.048	3.38	0.900
13) MOLY_SUPPORT.2	Moly	125.538	0.00	0.061
15) SPECIMEN_BB.4	F82H	33.714	11.42	0.143
17) SIC_SPRING.7	SiC(Irr)	6.053	3.35	0.900
19) GRAFOIL_SPACER.1	GRAFOIL	38.000	1.00	0.500
21) GRAFOIL_SPACER.2	GRAFOIL	38.000	1.00	0.500
23) GRAFOIL_SUPPORT.2	GRAFOIL	38.000	1.00	0.500

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOUSING	AL-6061	4.286	59.	884.	149.
3) ENDCAP	AL-6061	0.527	82.	902.	29.
5) HOLDER	AL-6061	3.831	285.	1022.	1036.
7) GRAFOIL_SUPPORT.1	GRAFOIL	0.004	343.	700.	1.
9) MOLY_SUPPORT.1	Moly	0.039	343.	268.	3.
11) SS_LINER.1	SS304	2.457	329.	390.	296.
12) SIC_THERMOMETRY.1	SiC(Irr)	0.231	341.	1041.	77.
13) MOLY_SUPPORT.2	Moly	0.039	339.	268.	3.
15) SPECIMEN_BB.4	F82H	7.687	347.	572.	1436.
17) SIC_SPRING.7	SiC(Irr)	0.097	328.	1034.	31.
19) GRAFOIL_SPACER.1	GRAFOIL	0.009	270.	700.	2.
21) GRAFOIL_SPACER.2	GRAFOIL	0.009	259.	700.	1.
23) GRAFOIL_SUPPORT.2	GRAFOIL	0.004	339.	700.	1.
		19.219			3067.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 25: Frictionless - HOLDER To HOUSING

```
   Contact surface material:      AL-6061
   Target surface material:       AL-6061
   Interstitial gas:               Helium
   Effective surface roughness:     2.263 μm
   Effective asperity slope:        0.214 rad
   Effective microhardness:         1.220 GPa
```

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (°C)	282.919	255.470	294.058
Target temperature (°C)	60.959	57.674	61.655
Geometric gas gap (μm)	147.031	32.256	147.475
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	368.641	309.664	2669.851
Radiation heat flux (kW/m²)	0.000	0.000	0.000

Contact conduction heat flux (kW/m²)	0.000	0.000	0.000
Total heat flux (kW/m²)	368.641	309.664	2669.851
Thermal contact conductance (W/m²·C)	1663.425	1551.558	12804.875
~~ derived results ~~~~~~~~~~			
Effective gas gap (μm)	120.945	8.878	124.237
Contact thermal jump distance (μm)	1.382	1.309	1.411
Target thermal jump distance (μm)	1.231	1.178	1.252
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·°C)	0.201	0.196	0.203
Solid spot conductance (W/m²·C)	0.000	0.000	0.000
Gas gap conductance (W/m²·C)	1678.378	1550.318	17235.774

```
Contact status codes:
 ----------------------------------------------
 0=open/no heat transfer, 1=near-field contact
 2=closed and sliding,    3=closed and sticking
```

9.19 mm holder diameter (bend bar design)

```
******************************************************************************
    TEMPERATURE DESIGN SOLUTION FOR ESTEEL BEND BAR (2016) RABBITS
 ******************************************************************************
  ------------------------------------------------------------------------------
  DESCRIPTION

  * HFIR TRRH Axial position 5.
  * Helium fill gas
  * Holder OD = 9.19 mm

  * Thermal-only solution method
  ------------------------------------------------------------------------------
  BOUNDARY CONDITIONS

 Heat transfer coefficient =  47100. W/m²·°C
  Bulk coolant temperature  =    52.0 °C
  Peaking factor            =     0.960
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  HEAT GENERATION
```

Part	Material	Heat Gen. @Midplane (W/kg)	Heat Load @Midplane (W)	Heat Load @Location (W)
1) HOUSING	AL-6061	31300.	134.1	133.5
3) ENDCAP	AL-6061	31300.	16.5	16.4
5) HOLDER	AL-6061	31300.	117.6	117.3
7) GRAFOIL_SUPPORT.1	GRAFOIL	32500.	0.1	0.1
9) MOLY_SUPPORT.1	Moly	42000.	1.6	1.6
11) SS_LINER.1	SS304	38100.	93.6	93.4
12) SIC_THERMOMETRY.1	SiC(Irr)	31700.	7.3	7.3
13) MOLY_SUPPORT.2	Moly	42000.	1.6	1.6
15) SPECIMEN_BB.4	F82H	38100.	292.9	292.2
17) SIC_SPRING.7	SiC(Irr)	31700.	3.1	3.1
19) GRAFOIL_SPACER.1	GRAFOIL	32500.	0.3	0.3
21) GRAFOIL_SPACER.2	GRAFOIL	32500.	0.3	0.3
23) GRAFOIL_SUPPORT.2	GRAFOIL	32500.	0.1	0.1
			669.2	667.3

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  CAPSULE TEMPERATURE SUMMARY
```

Name	Material	Tavg	Tmin	Tmax	T.025	T.975
1) HOUSING	AL-6061	59.	54.	62.	55.	61.
3) ENDCAP	AL-6061	82.	80.	84.	81.	83.
5) HOLDER	AL-6061	309.	277.	322.	286.	320.
7) GRAFOIL_SUPPORT.1	GRAFOIL	367.	361.	371.	362.	370.
9) MOLY_SUPPORT.1	Moly	367.	360.	371.	361.	371.
11) SS_LINER.1	SS304	353.	318.	371.	335.	367.
12) SIC_THERMOMETRY.1	SiC(Irr)	366.	352.	373.	353.	372.
13) MOLY_SUPPORT.2	Moly	362.	354.	366.	356.	366.
15) SPECIMEN_BB.4	F82H	371.	337.	387.	350.	385.
17) SIC_SPRING.7	SiC(Irr)	352.	332.	382.	334.	381.
19) GRAFOIL_SPACER.1	GRAFOIL	294.	258.	299.	275.	299.
21) GRAFOIL_SPACER.2	GRAFOIL	281.	251.	286.	266.	285.
23) GRAFOIL_SUPPORT.2	GRAFOIL	362.	354.	365.	359.	365.

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  PROPERTY SUMMARY AT THE AVERAGE PART TEMPERATURE
```

Name	Material	Thermal Cond. (W/m·°C)	Thermal Exp. Coeff. (µm/m·°C)	Emis (---)
1) HOUSING	AL-6061	166.572	24.21	0.050
3) ENDCAP	AL-6061	169.243	0.00	0.050
5) HOLDER	AL-6061	176.000	25.49	0.057
7) GRAFOIL_SUPPORT.1	GRAFOIL	38.000	1.00	0.500
9) MOLY_SUPPORT.1	Moly	124.406	0.00	0.064
11) SS_LINER.1	SS304	20.168	0.00	0.143
12) SIC_THERMOMETRY.1	SiC(Irr)	6.039	3.45	0.900
13) MOLY_SUPPORT.2	Moly	124.611	0.00	0.064
15) SPECIMEN_BB.4	F82H	33.661	11.53	0.143
17) SIC_SPRING.7	SiC(Irr)	6.044	3.41	0.900
19) GRAFOIL_SPACER.1	GRAFOIL	38.000	1.00	0.500
21) GRAFOIL_SPACER.2	GRAFOIL	38.000	1.00	0.500
23) GRAFOIL_SUPPORT.2	GRAFOIL	38.000	1.00	0.500

STORED ENERGY SUMMARY AT THE AVERAGE PART TEMPERATURE

Name	Material	Mass (g)	Tavg (°C)	Specific Heat (J/kg°C)	Stored Energy (J)
1) HOUSING	AL-6061	4.286	59.	884.	149.
3) ENDCAP	AL-6061	0.527	82.	902.	29.
5) HOLDER	AL-6061	3.756	309.	1033.	1122.
7) GRAFOIL_SUPPORT.1	GRAFOIL	0.004	367.	700.	1.
9) MOLY_SUPPORT.1	Moly	0.039	367.	269.	4.
11) SS_LINER.1	SS304	2.457	353.	392.	321.
12) SIC_THERMOMETRY.1	SiC(Irr)	0.231	366.	1054.	84.
13) MOLY_SUPPORT.2	Moly	0.039	362.	269.	4.
15) SPECIMEN_BB.4	F82H	7.687	371.	582.	1570.
17) SIC_SPRING.7	SiC(Irr)	0.097	352.	1047.	34.
19) GRAFOIL_SPACER.1	GRAFOIL	0.009	294.	700.	2.
21) GRAFOIL_SPACER.2	GRAFOIL	0.009	281.	700.	2.
23) GRAFOIL_SUPPORT.2	GRAFOIL	0.004	362.	700.	1.
		19.144			3321.

RADIAL DIMENSIONS AND GAP SUMMARY FOR THE CORE-HOUSING GAP

CONTACT SUMMARY FOR CONTACT ID 25: Frictionless - HOLDER To HOUSING

Contact surface material: AL-6061
Target surface material: AL-6061
Interstitial gas: Helium
Effective surface roughness: 2.263 µm
Effective asperity slope: 0.214 rad
Effective microhardness: 1.220 GPa

	Average	Minimum	Maximum
~~ direct results ~~~~~~~~~~			
Contact status	1.000	1.000	1.000
Contact temperature (°C)	307.287	277.646	319.192
Target temperature (°C)	60.920	57.740	61.593
Geometric gas gap (µm)	166.485	37.880	166.961
Contact pressure (MPa)	0.000	0.000	0.000
Gap conduction heat flux (kW/m²)	368.154	310.204	2759.516
Radiation heat flux (kW/m²)	0.000	0.000	0.000

Contact conduction heat flux (kW/m^2)	0.000	0.000	0.000
Total heat flux (kW/m^2)	368.154	310.204	2759.516
Thermal contact conductance (W/m^2·C)	1496.825	1395.309	11938.741
~~ derived results ~~~~~~~~~~			
Effective gas gap (µm)	137.414	10.740	140.972
Contact thermal jump distance (µm)	1.443	1.364	1.474
Target thermal jump distance (µm)	1.272	1.216	1.294
Effective contact pressure (MPa)	0.000	0.000	0.000
Pressure index	13.534	13.534	13.534
Gas thermal conductivity (W/m·°C)	0.205	0.200	0.207
Solid spot conductance (W/m^2·C)	0.000	0.000	0.000
Gas gap conductance (W/m^2·C)	1504.668	1394.223	14984.520

Contact status codes:

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 0=open/no heat transfer, 1=near-field contact
 2=closed and sliding,    3=closed and sticking
```

ATTACHMENTS

Capsule Fabrication Request Sheet

Capsule Number: ES02

Irradiation Conditions

Irradiation Location	TRRH	5
Design Temperature		240
First Cycle Goal	479	~~477~~ RMM 5/22/18
Irradiation Time	2	cyc.
Irradiation Charge Number		N/A
Holder diameter	9.10	mm (0.3583 in) at 20°C
Fill Gas		Helium

Approvals

	Request	Build
Performed by:	[signature] 5/4/18	[signature] 5/4/18
Checked by:	[signature] 5/4/18	[signature] 5/4/18

Capsule Fabrication

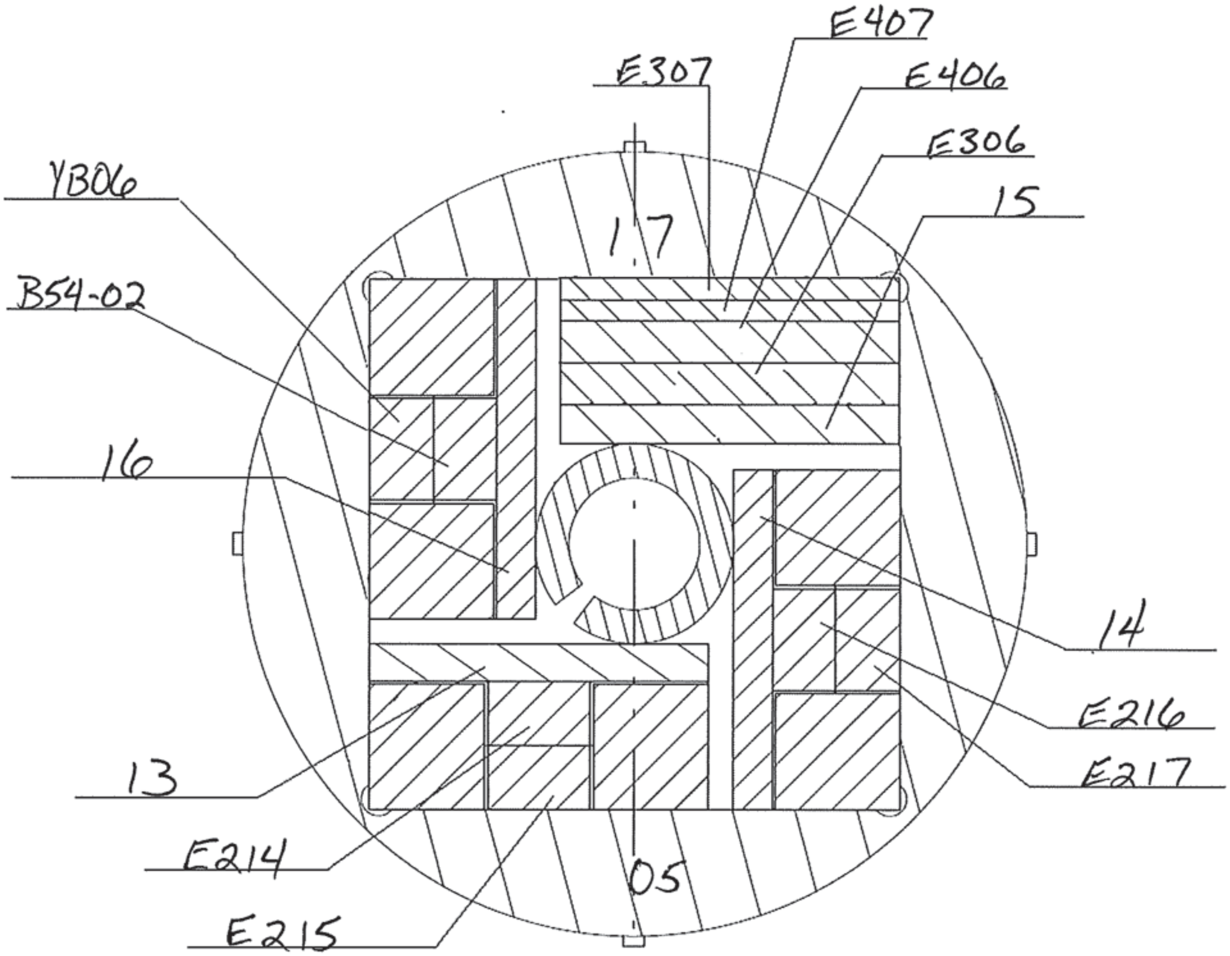
	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		19348	20861	SU2	4.9900
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-29	0.5150
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0570
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2570
Specimen Holder	S16-22-ESTEEL	1	3	Al 6061	3		20825	20784	17-05	1.1341
									17-06	1.1353
									17-07	1.1412
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4130
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	002 004 005 013 014 027 062 063 065 066 068 069 L-1 L-2 L-3 L-4 L-5 L-6	20777	20777	18 Total	1.9633
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	13	0.1005
									14	0.1001
									15	0.0996
									16	0.0997
									17	0.0987
									18	0.1003
									19	0.0995
									20	0.1005
									21	0.0970
									22	0.1002
									23	0.0997
									24	0.1002
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E214	0.2604
							20778	20778	E215	0.2611
							20778	20778	E216	0.2599
							20778	20778	E217	0.2590
							20778	20778	E218	0.2559
							20778	20778	E219	0.2618
							20778	20778	E220	0.2613
							20778	20778	E221	0.2619
							20778	20778	E222	0.2604
							20778	20778	E223	0.2578
							20778	20778	E224	0.2644
							20778	20778	E225	0.2576
							20841	20841	YB06	0.2664
							20841	20841	YB07	0.2665
							20841	20841	YB09	0.2628
							20841	20841	YB10	0.1749
							20841	20841	YB11	0.2747
							20841	20841	B54-02	0.2674
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E306	0.1100
									E307	0.1110
									E308	0.1190
									E309	0.1120
									E310	0.1140
									E311	0.1060
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E406	0.2610
									E407	0.2560
									E408	0.2580
									E409	0.2580
									E410	0.2600
									E411	0.2590
									Total Mass	19.6600
									Specimen Mass	6.8581
									Internal Mass	14.1550

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

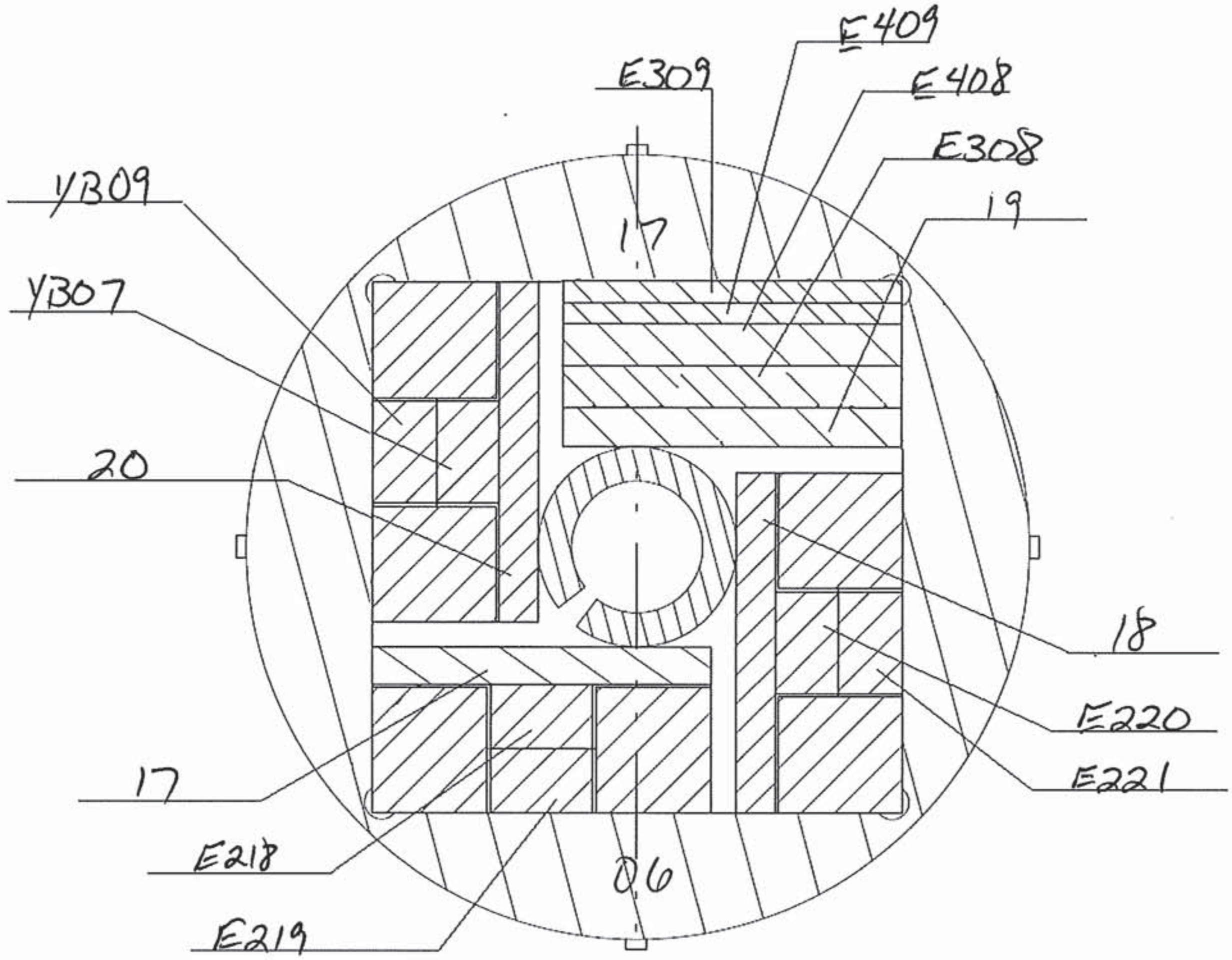
ES02

(17-05)


E407
E307
E406
E306
YB06
15
B54-02
17
16
14
E216
E217
13
E214
05
E215

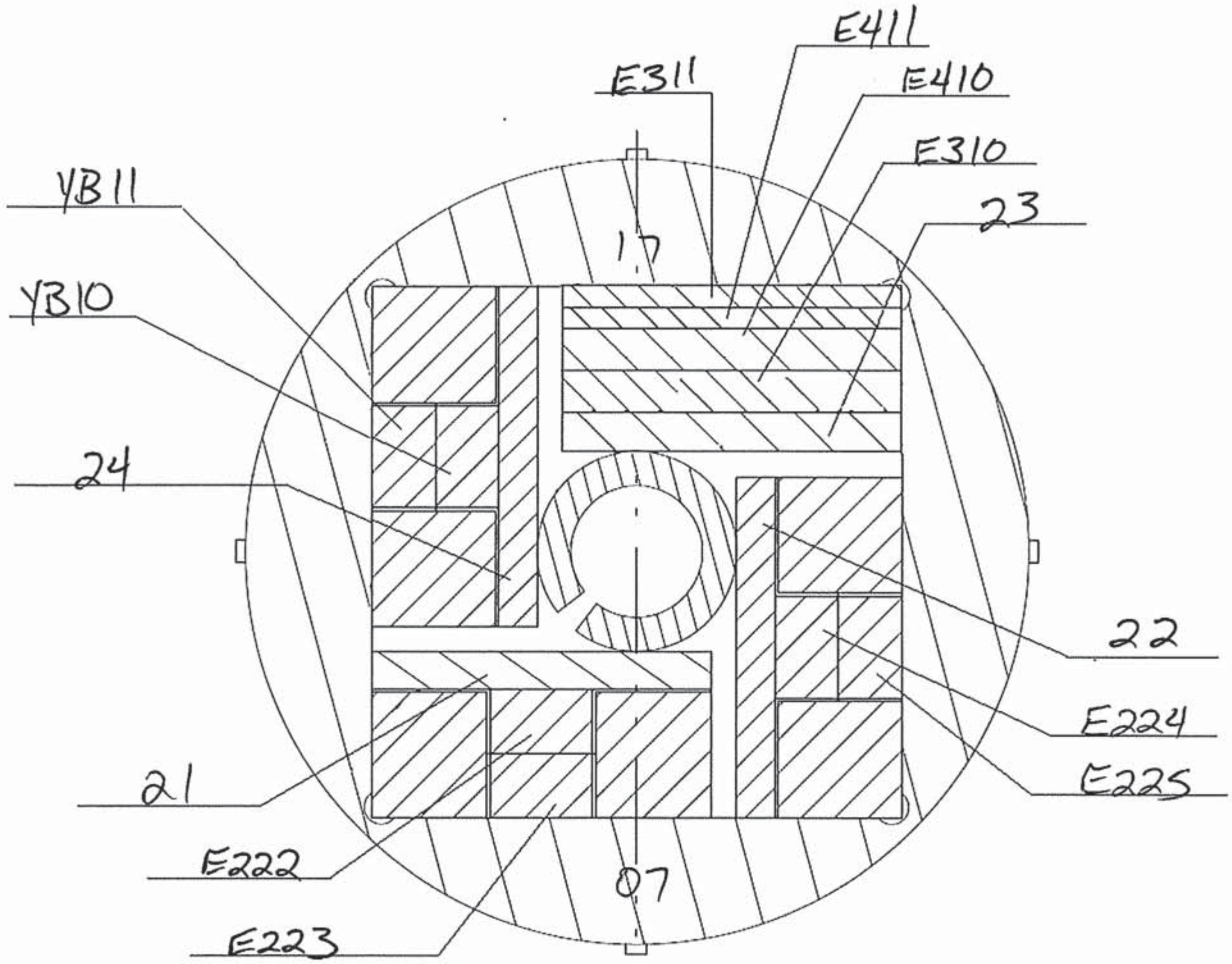
ES02

(17-06)


E409
E309
E408
E308
YB09
19
17
YB07
20
18
E220
17
E221
E218
06
E219

ES02

(17-07)


E411
E311
E410
E310
YB11
23
17
YB10
24
22
E224
21
E225
E222
07
E223

ES02					
Design Diameter (mm)	Tavg (°C)	Tavg (°C)			
9.34	241	227			
	Inner	Outer			Specimen Type
Upper (X - Yc)	E214	E215	14	62	SSJ3 (E)
	E216	E217	5	63	SSJ3 (E)
	E306	E307	E406	E407	MPC1 (E3) / MPC2 (E4)
	B54-02	YB06	L1	L4	SSJ3
Mid (X - Yc)	E218	E219	13	65	SSJ3 (E)
	E220	E221	4	66	SSJ3 (E)
	E308	E309	E408	E409	MPC1 (E3) / MPC2 (E4)
	YB07	YB09	L3	L4	SSJ3
Lower (X - Yc)	E222	E223	2	68	SSJ3 (E)
	E224	E225	27	69	SSJ3 (E)
	E310	E311	E410	E411	MPC1 (E3) / MPC2 (E4)
	YB10	YB11	L5	L6	SSJ3

RABBIT ASSEMBLY: ES02

HOUSING

SN / IR NUMBER:

SU2/20861

INNER DIAMETER:

Ø 9.17mm

HOLDER(S)

SN / IR NUMBER:

17-05/20784

OUTER DIAMETER:

Ø 9.10mm

SN / IR NUMBER:

17-06/20784

OUTER DIAMETER:

Ø 9.11mm

SN / IR NUMBER:

17-07/20784

OUTER DIAMETER:

Ø 9.10

Capsule Fabrication Request Sheet

Date 1/24/2018

Capsule Number: ES03

Irradiation Conditions

Irradiation Location	TRRH	5
Design Temperature		275
First Cycle Goal		477
Irradiation Time	2	cyc.
Irradiation Charge Number		N/A
Holder diameter	9.20	mm (0.3622 in) at 20°C
Fill Gas		Helium

Approvals

	Request	Build
Performed by:	[signature] 1/24/18	[signature] 1/24/18
Checked by:	[signature] 1/31/18	[signature] 1/30/18

Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-07	4.2826
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-32	0.5135
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0560
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2560
Specimen Holder	S16-22-ESTEEL	1	6	Al 6061	3		20825	20787	17-06	1.2690
									17-07	1.2697
									17-08	1.2721
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4130
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	006 007 009 010 024 031 071 072 074 075 077 078 L-7 L-8 L-9 L-10 L-11 L-12	20777	20777		1.9687
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	25	0.0986
									26	0.0994
									27	0.0998
									28	0.1002
									29	0.1002
									30	0.0980
									31	0.0985
									32	0.1006
									33	0.0987
									34	0.1001
									35	0.0990
									36	0.0994
J3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E226	0.2619
							20778	20778	E227	0.2614
							20778	20778	E228	0.2606
							20778	20778	E229	0.2601
							20778	20778	E230	0.2629
							20778	20778	E231	0.2599
							20778	20778	E232	0.2606
							20778	20778	E234	0.2621
							20778	20778	E235	0.2602
							20778	20778	E236	0.2633
							20778	20778	E237	0.2541
							20778	20778	E238	0.2580
							20841	20841	YB12	0.2676
							20841	20841	YB13	0.2668
							20841	20841	YB14	0.2668
							20841	20841	YB16	0.2678
							20841	20841	YB17	0.2713
							20841	20841	B54-05	0.2669
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E312	0.1140
									E313	0.1130
									E314	0.1100
									E315	0.1050
									E316	0.1110
									E317	0.1140
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E412	0.2560
									E413	0.2570
									E414	0.2570
									E415	0.2500
									E416	0.2580
									E417	0.2590
									Total Mass	19.4294
									Specimen Mass	6.9363
									Internal Mass	14.6333

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

Capsule Fabrication Request Sheet

Capsule Number: ES03

Irradiation Conditions

Irradiation Location	TRRH 5
Design Temperature	275
First Cycle Goal	477
Irradiation Time	2 cyc.
Irradiation Charge Number	N/A
Holder diameter	9.20 mm (0.3622 in) at 20°C
Fill Gas	Helium

Approvals

	Request	Build
Performed by:		
Checked by:		[signature] 01/22/18

Capsule Fabrication

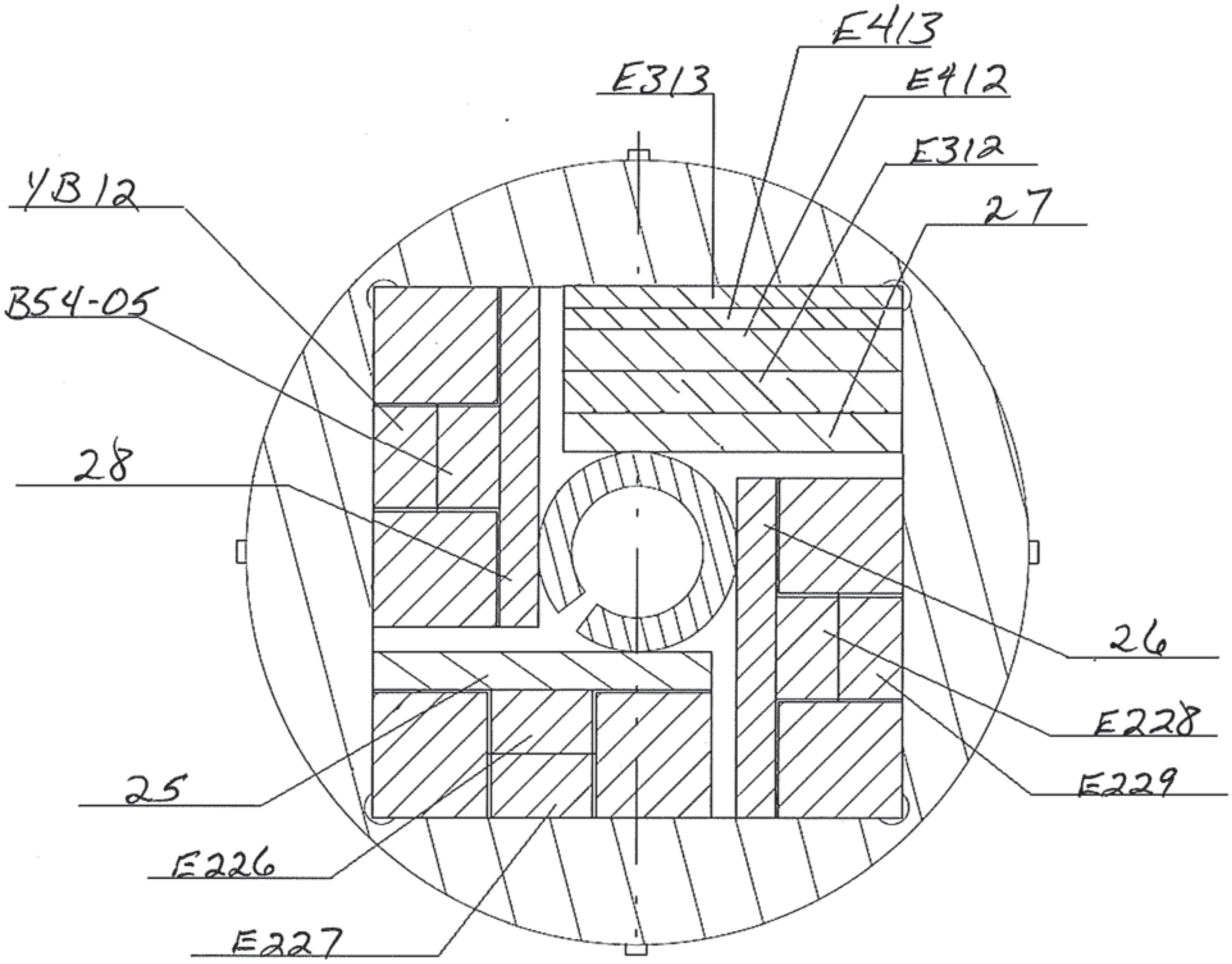
	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-07	
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-32	0.5135
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0560
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2560
Specimen Holder	S16-22-ESTEEL	1	6	Al 6061	3		20825	20787	17-06	1.2690
									17-07	1.2697
									17-08	1.2721
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4130
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	006 007 009 010 024 031 071 072 074 075 077 078 L-7 L-8 L-9 L-10 L-11 L-12	20777	20777		1.9687
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	25	0.0986
									26	0.0994
									27	0.0998
									28	0.1002
									29	0.1002
									30	0.0980
									31	0.0985
									32	0.1006
									33	0.0987
									34	0.1001
									35	0.0990
									36	0.0994
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E226	0.2619
							20778	20778	E227	0.2614
							20778	20778	E228	0.2606
							20778	20778	E229	0.2601
							20778	20778	E230	0.2629
							20778	20778	E231	0.2599
							20778	20778	E232	0.2606
							20778	20778	E234	0.2621
							20778	20778	E235	0.2602
							20778	20778	E236	0.2633
							20778	20778	E237	0.2541
							20778	20778	E238	0.2580
							20841	20841	YB12	0.2676
							20841	20841	YB13	0.2668
							20841	20841	YB14	0.2668
							20841	20841	YB16	0.2678
							20841	20841	YB17	0.2713
							20841	20841	B54-05	0.2669
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E312	0.1140
									E313	0.1130
									E314	0.1100
									E315	0.1050
									E316	0.1110
									E317	0.1140
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E412	0.2560
									E413	0.2570
									E414	0.2570
									E415	0.2500
									E416	0.2580
									E417	0.2590
									Total Mass	15.1468
									Specimen Mass	6.9363
									Internal Mass	14.6333

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

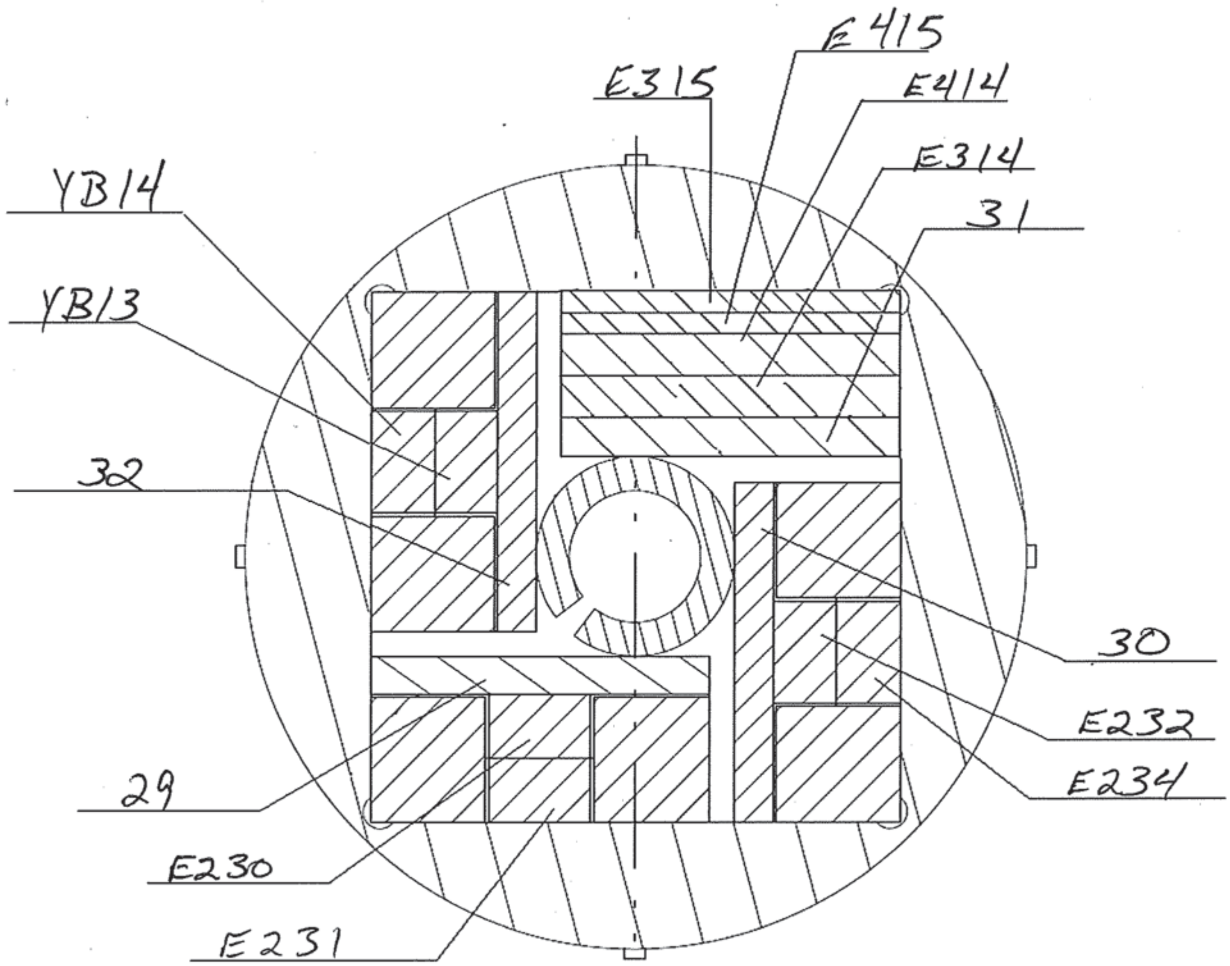
ES03

(17-06)



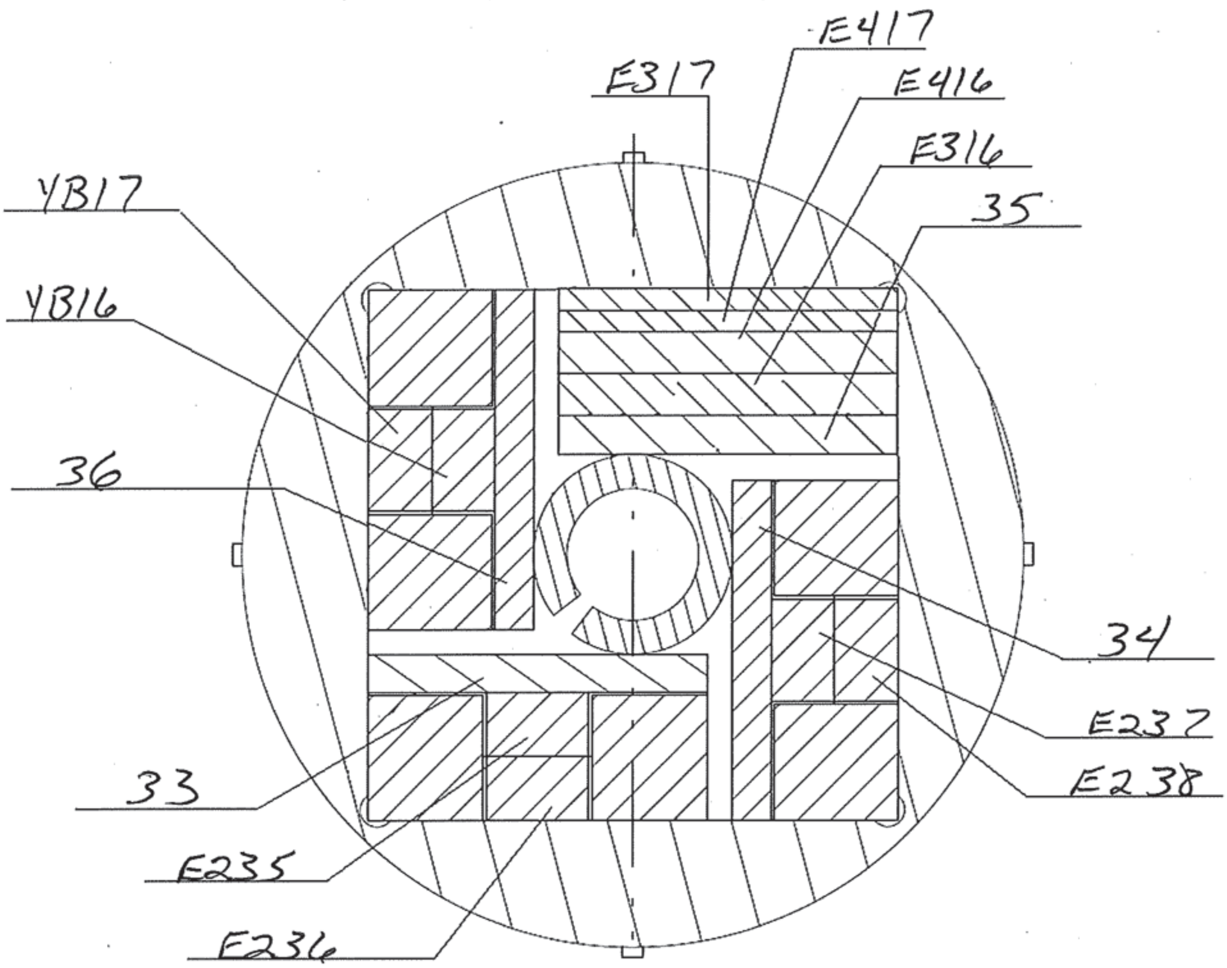
ES03

(17-07)



ES03

(17-08)



ES03					
Design Diameter (mm)	Tavg (°C)	Tavg (°C)			
9.3	268	254			
	Inner	Outer			Specimen Type
Upper (X - Yc)	E226	E227	10	71	SSJ3 (E)
	E228	E229	9	72	SSJ3 (E)
	E312	E313	E412	E413	MPC1 (E3) / MPC2 (E4)
	B54-03	YB12	L7	L8	SSJ3
Mid (X - Yc)	E230	E231	7	74	SSJ3 (E)
	E232	E234	24	75	SSJ3 (E)
	E314	E315	E414	E415	MPC1 (E3) / MPC2 (E4)
	YB13	YB14	L9	L10	SSJ3
Lower (X - Yc)	E235	E236	6	77	SSJ3 (E)
	E237	E238	31	78	SSJ3 (E)
	E316	E317	E416	E417	MPC1 (E3) / MPC2 (E4)
	YB16	YB17	L11	L12	SSJ3

RABBIT ASSEMBLY: ESØ3

HOUSING

SN / IR NUMBER:

18-Ø7/2Ø839

INNER
DIAMETER:

Ø9.52

HOLDER(S)

SN / IR NUMBER:	SN / IR NUMBER:	SN / IR NUMBER:
17-Ø6/2Ø787	17-Ø7/2Ø787	17-Ø8/2Ø787
OUTER DIAMETER:	OUTER DIAMETER:	OUTER DIAMETER:
Ø9.33	Ø9.32	Ø9.33

Capsule Fabrication Request Sheet

Date 1/24/2018

Capsule Number: ES04

Irradiation Conditions

Irradiation Location	TRRH	5
Design Temperature		300
First Cycle Goal		477
Irradiation Time	2	cyc.
Irradiation Charge Number		N/A
Holder diameter	9.20	mm (0.3622 in) at 20°C
Fill Gas		Helium

Approvals

	Request	Build
Performed by:	[signature] 1/24/18	[signature] 1/24/18
Checked by:	[signature] 1/31/18	[signature] 1/30/18

Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-69	4.2969
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-28	0.5157
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0580
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2550
Specimen Holder	S16-22-ESTEEL	1	5	Al 6061	3		20825	20786	17-05	1.2505
									17-06	1.2475
									17-07	1.2426
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4100
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	001 033 034 035 036 037 038 039 040 080 081 082 083 084 085 086 087 088	20777	20777	18 Total	1.9850
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	37	0.0992
									38	0.0995
									39	0.1005
									40	0.1000
									41	0.1001
									42	0.0979
									43	0.1003
									44	0.0997
									45	0.0991
									46	0.0993
									47	0.0994
									48	0.1001
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E239	0.2607
							20778	20778	E240	0.2599
							20778	20778	E241	0.2617
							20778	20778	E242	0.2601
							20778	20778	E243	0.2592
							20778	20778	E245	0.2585
							20778	20778	E247	0.2608
							20778	20778	E248	0.2597
							20778	20778	E249	0.2579
							20778	20778	E250	0.2626
							20778	20778	E251	0.2601
							20778	20778	E252	0.2594
							20841	20841	YB19	0.2679
							20841	20841	YB20	0.2693
							20841	20841	YB21	0.2686
							20841	20841	YB22	0.2678
							20841	20841	YB23	0.2657
							20841	20841	B54-09	0.2573
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E318	0.1090
									E319	0.1110
									E320	0.1050
									E321	0.1090
									E322	0.1120
									E323	0.1080
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E418	0.2480
									E419	0.2520
									E420	0.2550
									E421	0.2580
									E422	0.2540
									E423	0.2340
									Total Mass	19.3286
									Specimen Mass	6.8723
									Internal Mass	14.5160

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

Capsule Fabrication Request Sheet

Date 1/19/2018

Capsule Number: ES04

Irradiation Conditions

Irradiation Location	TRRH 5
Design Temperature	300
First Cycle Goal	477
Irradiation Time	2 cyc.
Irradiation Charge Number	N/A
Holder diameter	9.20 mm (0.3622 in) at 20°C
Fill Gas	Helium

Approvals

	Request	Build
Performed by:		
Checked by:		[signature] 01/22/18

Capsule Fabrication

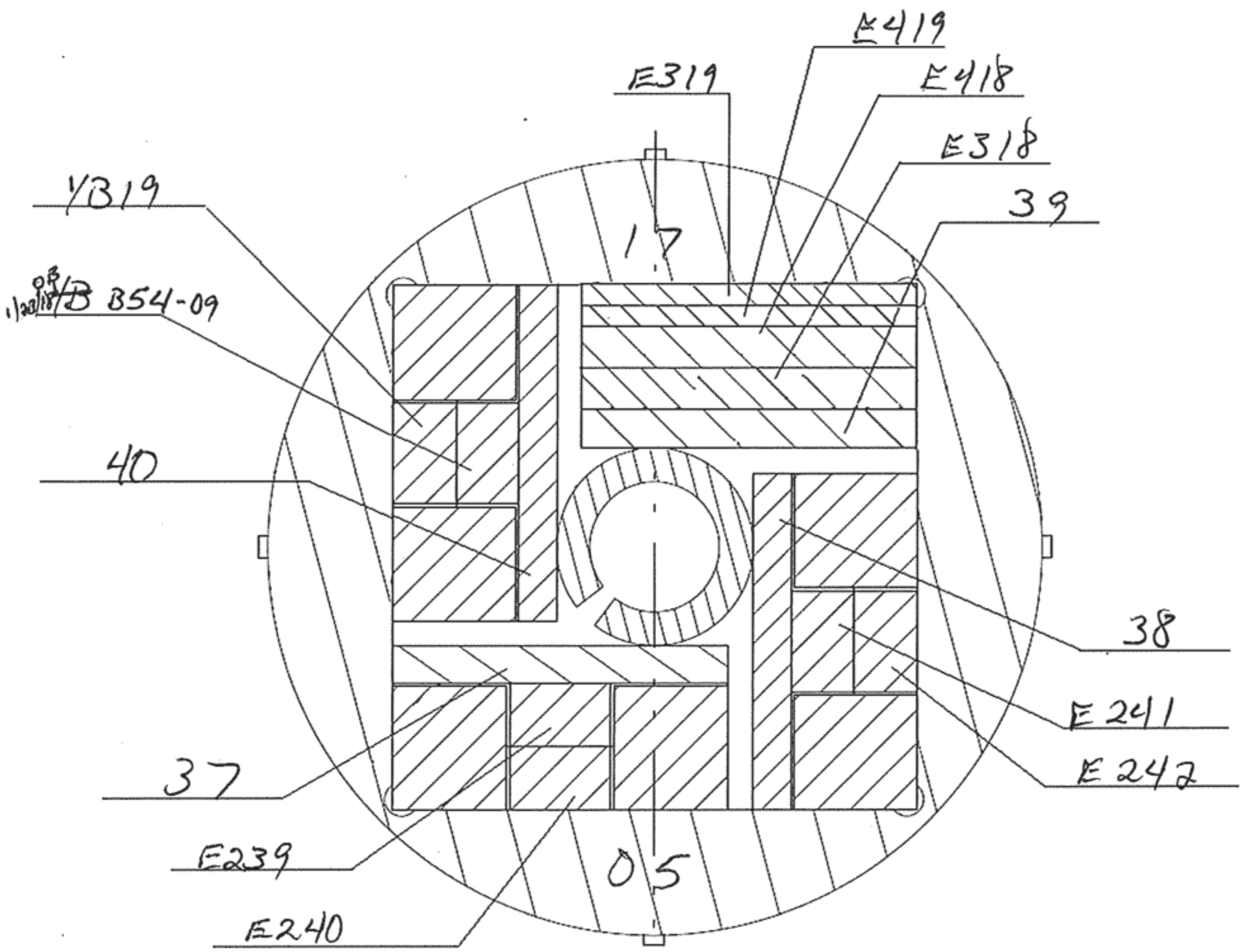
	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-69	
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-28	0.5157
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0580
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2550
Specimen Holder	S16-22-ESTEEL	1	5	Al 6061	3		20825	20786	17-05	1.2505
									17-06	1.2475
									17-07	1.2426
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4100
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	001 033 034 035 036 037 038 039 040 050 051 052 053 054 055 056 057 058	20777	20777	18 Total	1.9850
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	37	0.0992
									38	0.0995
									39	0.1005
									40	0.1000
									41	0.1001
									42	0.0979
									43	0.1003
									44	0.0997
									45	0.0991
									46	0.0993
									47	0.0994
									48	0.1001
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E239	0.2607
							20778	20778	E240	0.2599
							20778	20778	E241	0.2617
							20778	20778	E242	0.2601
							20778	20778	E243	0.2592
							20778	20778	E245	0.2585
							20778	20778	E247	0.2608
							20778	20778	E248	0.2597
							20778	20778	E249	0.2579
							20778	20778	E250	0.2626
							20778	20778	E251	0.2601
							20778	20778	E252	0.2594
							20841	20841	YB19	0.2679
							20841	20841	YB20	0.2693
							20841	20841	YB21	0.2686
							20841	20841	YB22	0.2678
							20841	20841	YB23	0.2657
							20841	20841	B54-09	0.2573
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E318	0.1090
									E319	0.1110
									E320	0.1050
									E321	0.1090
									E322	0.1120
									E323	0.1080
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E418	0.2480
									E419	0.2520
									E420	0.2550
									E421	0.2580
									E422	0.2540
									E423	0.2340
									Total Mass	15.0317
									Specimen Mass	6.8723
									Internal Mass	14.5160

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES04

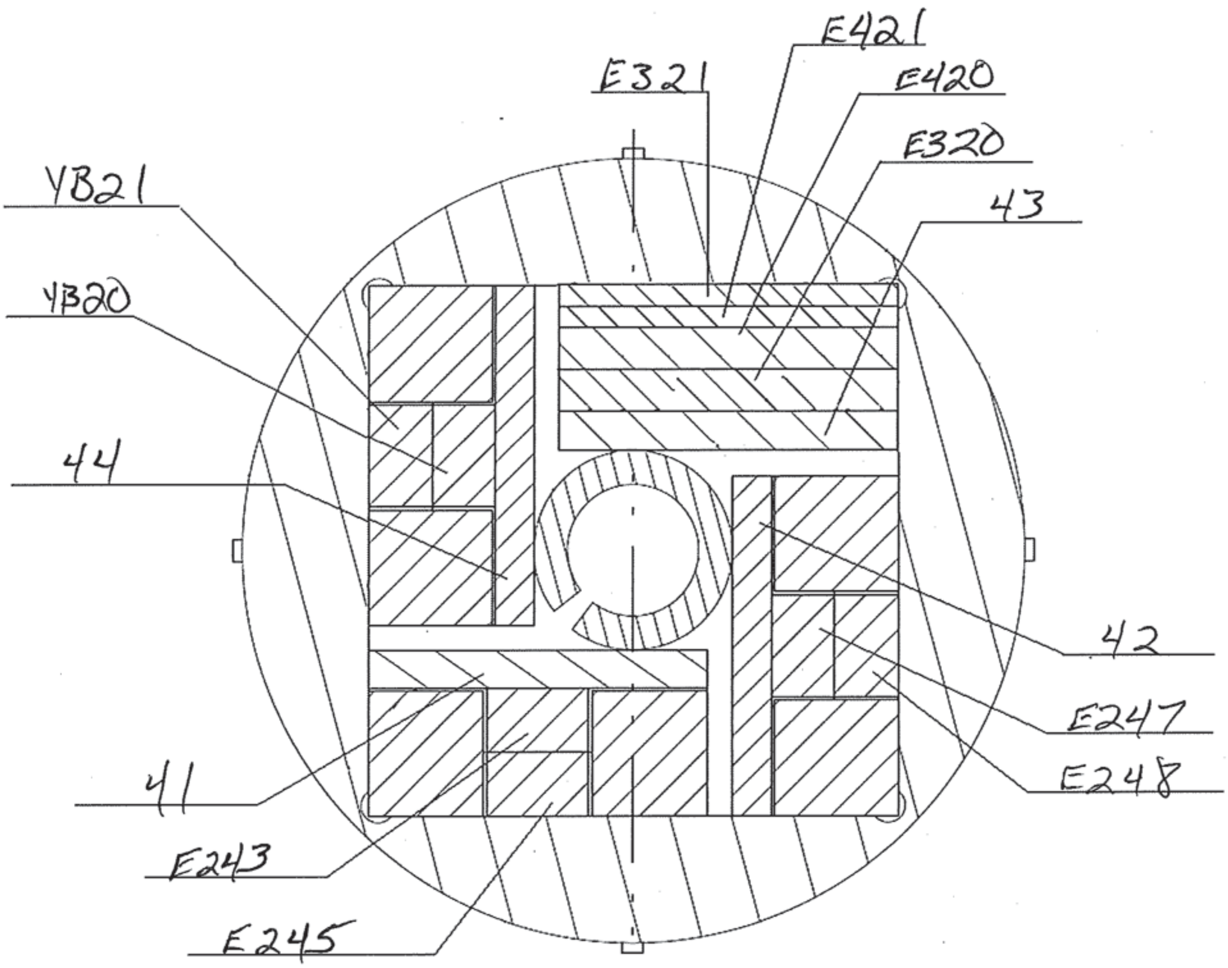
(17-05)



E419
E319
E418
E318
YB19
39
17
B54-09
40
38
E241
E242
37
E239
E240
05

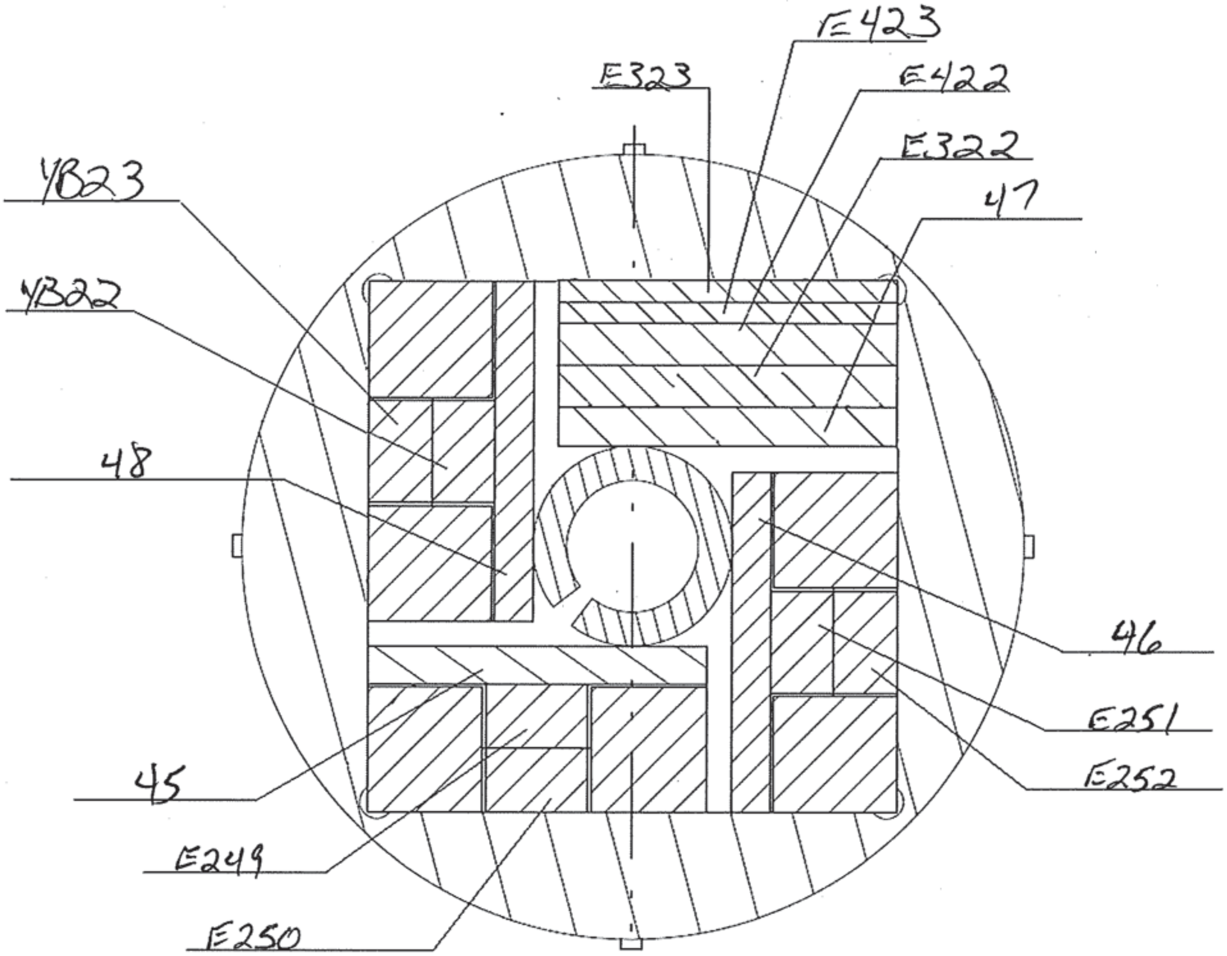
ES04

(17-06)



ES04

(17-07)



ES04					
Design Diameter (mm)	Tavg (°C)	Tavg (°C)			
9.25	304	290			
	Inner	Outer			Specimen Type
Upper (X - Yc)	E239	E240	33	80	SSJ3 (E)
	E241	E242	34	81	SSJ3 (E)
	E318	E319	E418	E419	MPC1 (E3) / MPC2 (E4)
	B54-09	YB19	35	82	SSJ3
Mid (X - Yc)	E243	E245	36	83	SSJ3 (E)
	E247	E248	1	84	SSJ3 (E)
	E320	E321	E420	E421	MPC1 (E3) / MPC2 (E4)
	YB20	YB21	37	85	SSJ3
Lower (X - Yc)	E249	E250	38	86	SSJ3 (E)
	E251	E252	39	87	SSJ3 (E)
	E322	E323	E422	E423	MPC1 (E3) / MPC2 (E4)
	YB22	YB23	40	88	SSJ3

RABBIT ASSEMBLY: ES04

HOUSING

SN / IR NUMBER:

18-69/20839

INNER DIAMETER:

Ø 9.53

HOLDER(S)

SN / IR NUMBER:

17-05/20786

OUTER DIAMETER:

Ø9.30

SN / IR NUMBER:

17-06/20786

OUTER DIAMETER:

Ø9.29

SN / IR NUMBER:

17-07/20786

OUTER DIAMETER:

Ø9.28

Capsule Fabrication Request Sheet

Capsule Number: ES05

Irradiation Conditions

Irradiation Location	TRRH	5
Design Temperature		325
First Cycle Goal		477
Irradiation Time	2	cyc.
Irradiation Charge Number		N/A
Holder diameter	9.20	mm (0.3622 in) at 20°C
Fill Gas		Helium

Approvals

	Request	Build
Performed by:	[signature] 1/29/18	[signature] 1/29/18
Checked by:	[signature] 1/31/18	[signature] 1/30/18

Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-64	4.3411
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-31	0.5151
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0560
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2570
Specimen Holder	S16-22-ESTEEL	1	2	Al 6061	3		20825	20783	17-07	1.2331
									17-08	1.2275
									17-10	1.2262
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4120
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	041 042 043 044 046 047 048 049 050 089 090 091 092 093 094 095 096 097	20777	20777	18 Total	1.9770
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	85	0.0996
									50	0.0978
									51	0.1003
									52	0.0986
									53	0.1009
									54	0.0981
									55	0.0993
									56	0.1005
									57	0.0971
									58	0.0996
									59	0.0983
									60	0.0996
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E253	0.2604
							20778	20778	E254	0.2630
							20778	20778	E255	0.2593
							20778	20778	E256	0.2599
							20778	20778	E257	0.2617
							20778	20778	E258	0.2627
							20778	20778	E259	0.2607
							20778	20778	E260	0.2591
							20778	20778	E261	0.2611
							20778	20778	E263	0.2595
							20778	20778	E264	0.2590
							20778	20778	E265	0.2581
							20841	20841	YB24	0.2668
							20841	20841	YB25	0.2754
							20841	20841	YB26	0.2697
							20841	20841	YB27	0.2721
							20841	20841	B54-06	0.2705
							20841	20841	B54-07	0.2673
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E324	0.1160
									E325	0.1070
									E326	0.1110
									E327	0.1120
									E328	0.1100
									E329	0.1010
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E424	0.2580
									E425	0.2590
									E426	0.2590
									E427	0.2520
									E428	0.2500
									E429	0.2510
									Total Mass	19.3671
									Specimen Mass	6.9324
									Internal Mass	14.5109

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

Capsule Fabrication Request Sheet

Date 1/19/2018

Capsule Number: ES05

Irradiation Conditions

Irradiation Location	TRRH 5
Design Temperature	325
First Cycle Goal	477
Irradiation Time	2 cyc.
Irradiation Charge Number	N/A
Holder diameter	9.20 mm (0.3622 in) at 20°C
Fill Gas	Helium

Approvals

	Request	Build
Performed by:		
Checked by:		[illegible] 01/22/18

Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-64	
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-31	0.5151
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0560
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2570
Specimen Holder	S16-22-ESTEEL	1	2	Al 6061	3		20825	20783	17-07	1.2331
									17-08	1.2275
									17-10	1.2262
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4120
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	041 042 043 044 045 047 048 049 050 089 090 091 092 093 094 095 096 097	20777	20777	18 Total	1.9770
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	~~49~~ 85	0.0996
									50	0.0978
									51	0.1003
									52	0.0986
									53	0.1009
									54	0.0981
									55	0.0993
									56	0.1005
									57	0.0971
									58	0.0996
									59	0.0983
									60	0.0996
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E253	0.2604
							20778	20778	E254	0.2630
							20778	20778	E255	0.2593
							20778	20778	E256	0.2599
							20778	20778	E257	0.2617
							20778	20778	E258	0.2627
							20778	20778	E259	0.2607
							20778	20778	E260	0.2591
							20778	20778	E261	0.2611
							20778	20778	E263	0.2595
							20778	20778	E264	0.2590
							20778	20778	E265	0.2581
							20841	20841	YB24	0.2668
							20841	20841	YB25	0.2754
							20841	20841	YB26	0.2697
							20841	20841	YB27	0.2721
							20841	20841	B54-06	0.2705
							20841	20841	B54-07	0.2673
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E324	0.1160
									E325	0.1070
									E326	0.1110
									E327	0.1120
									E328	0.1100
									E329	0.1010
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E424	0.2580
									E425	0.2590
									E426	0.2590
									E427	0.2520
									E428	0.2500
									E429	0.2510

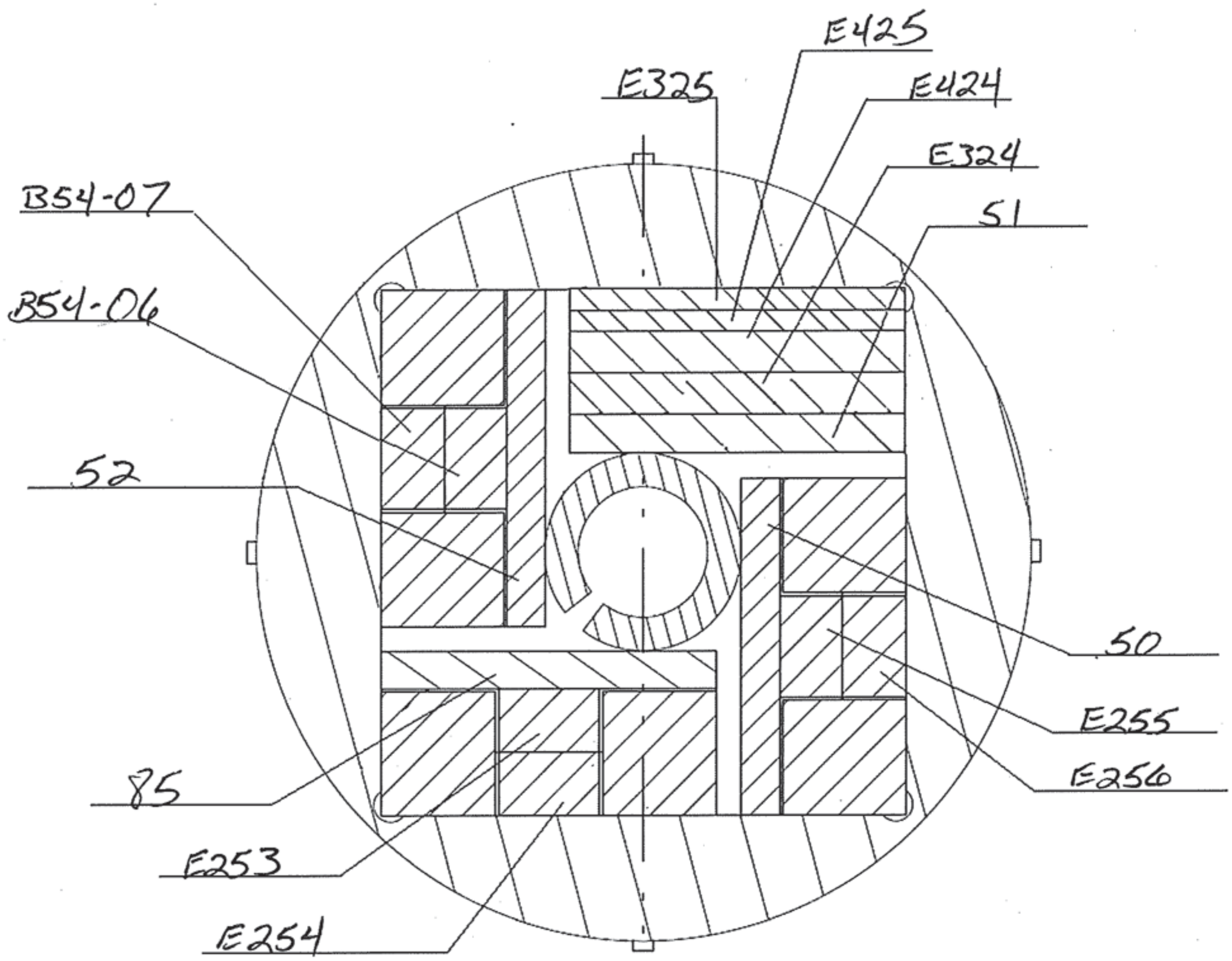
Total Mass	15.0260
Specimen Mass	6.9324
Internal Mass	14.5109

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES05

(17-07)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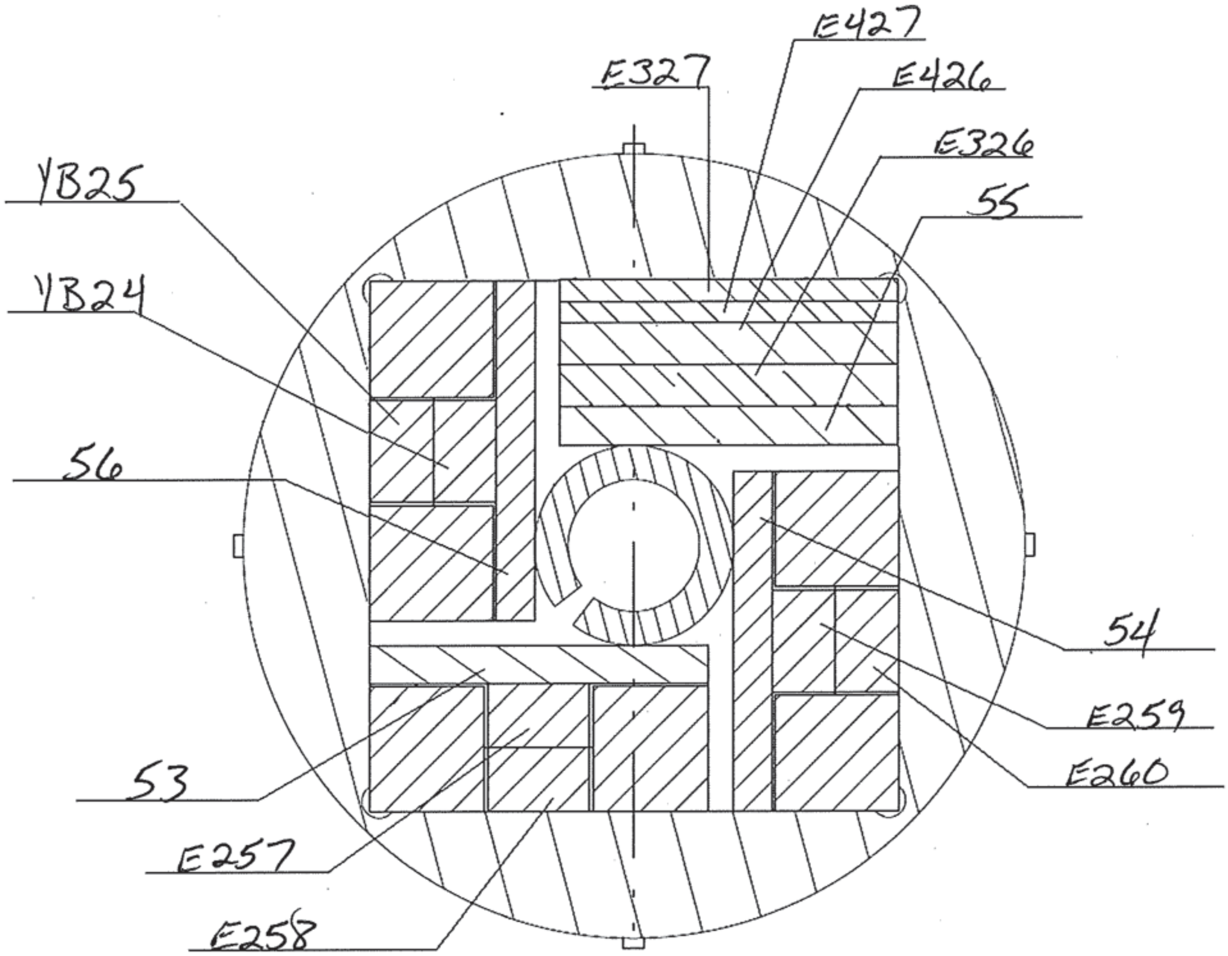
E325
E424
E324
B54-07
51
B54-06
52
50
E255
85
E256
E253
E254

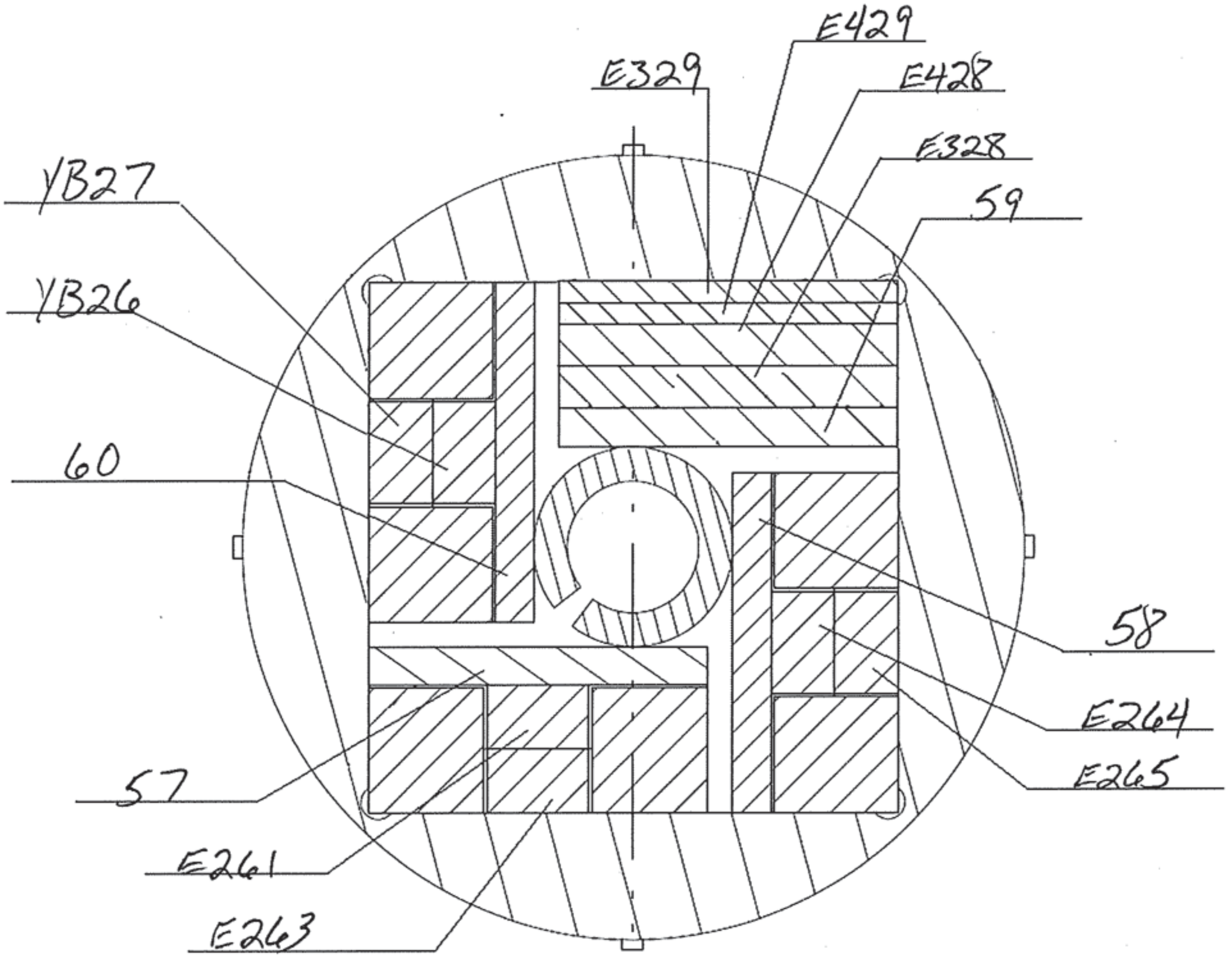
ES05

(17-08)



ES05

(17-10)



ES05					
Design Diameter (mm)	Tavg (°C)	Tavg (°C)			
9.2	330	316			
	Inner	Outer			Specimen Type
Upper (X - Yc)	E253	E254	41	89	SSJ3 (E)
	E255	E256	42	90	SSJ3 (E)
	E324	E325	E424	E425	MPC1 (E3) / MPC2 (E4)
	B54-06	B54-07	43	91	SSJ3
Mid (X - Yc)	E257	E258	44	92	SSJ3 (E)
	E259	E260	46	93	SSJ3 (E)
	E326	E327	E426	E427	MPC1 (E3) / MPC2 (E4)
	YB24	YB25	47	94	SSJ3
Lower (X - Yc)	E261	E263	48	95	SSJ3 (E)
	E264	E265	49	96	SSJ3 (E)
	E328	E329	E428	E429	MPC1 (E3) / MPC2 (E4)
	YB26	YB27	50	97	SSJ3

RABBIT ASSEMBLY: ESØ5

HOUSING

SN / IR NUMBER:

18-64/2Ø839

INNER DIAMETER:

Ø9.52

HOLDER(S)

SN / IR NUMBER:

17-Ø7/2Ø783

OUTER DIAMETER:

Ø9.25

SN / IR NUMBER:

17-Ø8/2Ø783

OUTER DIAMETER:

Ø9.24

SN / IR NUMBER:

17-1Ø/2Ø783

OUTER DIAMETER:

Ø9.25

Capsule Fabrication Request Sheet

Date 1/24/2018

Capsule Number: ES06

Irradiation Conditions

Irradiation Location	TRRH	5
Design Temperature		350
First Cycle Goal		477
Irradiation Time	2	cyc.
Irradiation Charge Number		N/A
Holder diameter	9.20	mm (0.3622 in) at 20°C
Fill Gas		Helium

Approvals

	Request	Build
Performed by:	[signature] 1/24/18	[signature] 1/24/18
Checked by:	[signature] 1/31/18	[signature] 1/30/18

Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-03	4.2759
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-85	0.5122
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0560
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2570
Specimen Holder	S16-22-ESTEEL	1	1	Al 6061	3		20825	20782	17-07	1.1875
									17-10	1.1783
									17-11	1.1826
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4130
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	015 017 021 029 030 051 052 053 054 055 058 061 G-1 G-2 G-7 G-8 G-9 G-10	20777	20777	18 Total	1.9724
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	61	0.1005
									62	0.0985
									63	0.0999
									64	0.1001
									65	0.0978
									66	0.0992
									67	0.0991
									68	0.0997
									69	0.1007
									70	0.0995
									71	0.0993
									72	0.1005
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E266	0.2613
							20778	20778	E267	0.2560
							20778	20778	E268	0.2592
							20778	20778	E269	0.2588
							20778	20778	E270	0.2592
							20778	20778	E271	0.2591
							20778	20778	E272	0.2594
							20778	20778	E273	0.2606
							20778	20778	E274	0.2606
							20778	20778	E275	0.2593
							20778	20778	E276	0.2603
							20778	20778	E277	0.2495
							20841	20841	9-1 LON	0.2606
							20841	20841	9-2 LON	0.2604
							20841	20841	9-1 INL	0.2601
							20841	20841	9-2 INL	0.2590
							20841	20841	9-1 HV	0.2567
							20841	20841	9-2 HV	0.2576
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E330	0.1120
									E331	0.1120
									E332	0.1120
									E333	0.1090
									E334	0.1130
									E335	0.1120
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E430	0.2570
									E431	0.2520
									E432	0.2580
									E433	0.2550
									E434	0.2550
									E435	0.2560
									Total Mass	19.0904
									Specimen Mass	6.8607
									Internal Mass	14.3023

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

Capsule Fabrication Request Sheet

Date 1/19/2018

Capsule Number: ES06

Irradiation Conditions

Irradiation Location	TRRH	5
Design Temperature		350
First Cycle Goal		477
Irradiation Time	2	cyc.
Irradiation Charge Number		N/A
Holder diameter	9.20	mm (0.3622 in) at 20°C
Fill Gas		Helium

Approvals

	Request	Build
Performed by:		
Checked by:		01/22/18

Capsule Fabrication

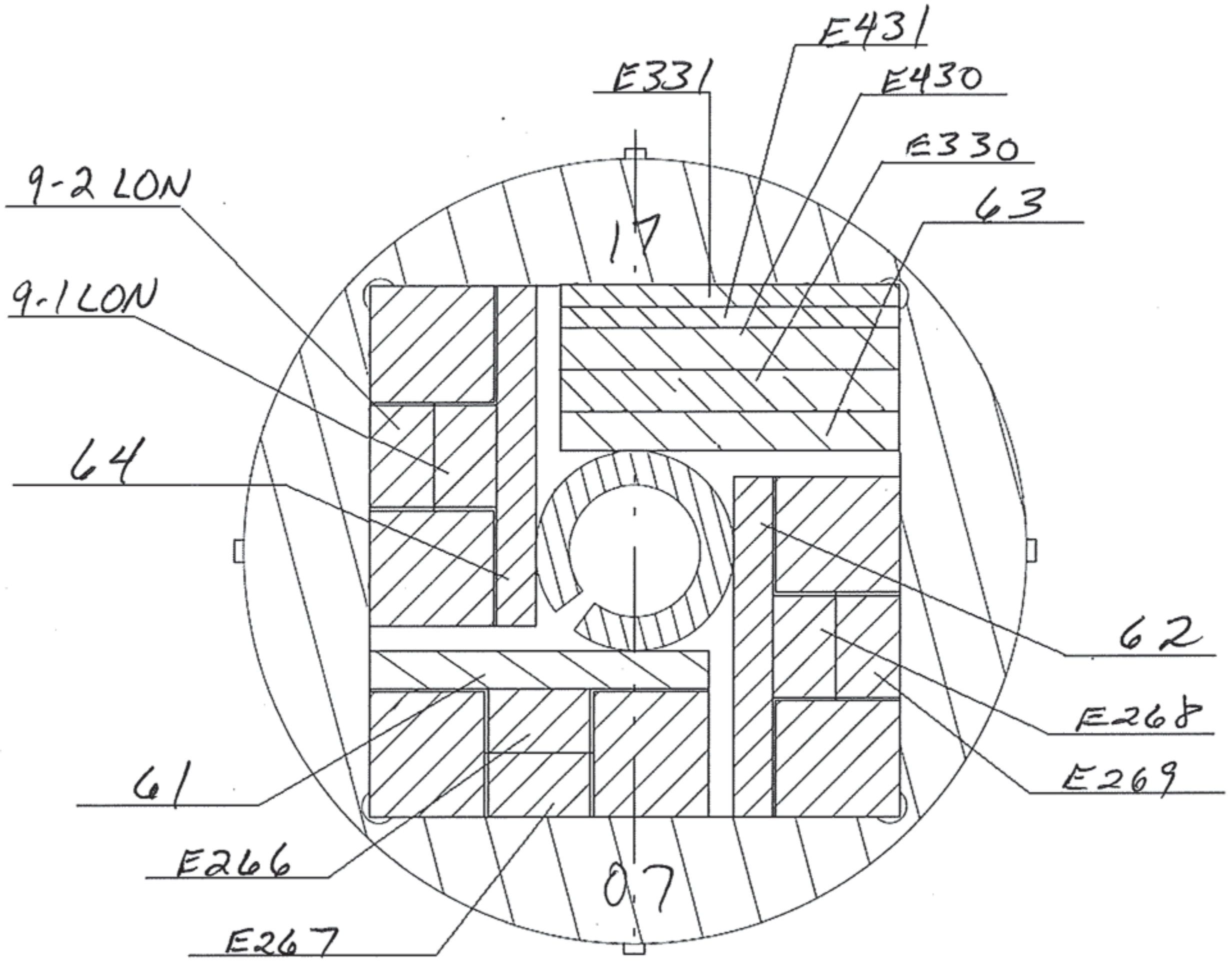
	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-03	
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-85	0.5122
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0560
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2570
Specimen Holder	S16-22-ESTEEL	1	1	Al 6061	3		20825	20782	17-07	1.1875
									17-10	1.1783
									17-11	1.1826
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4130
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	015 017 021 029 030 051 052 053 054 055 058 061 G-1 G-2 G-7 G-8 G-9 G-13	20777	20777	18 Total	1.9724
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	61	0.1005
									62	0.0985
									63	0.0999
									64	0.1001
									65	0.0978
									66	0.0992
									67	0.0991
									68	0.0997
									69	0.1007
									70	0.0995
									71	0.0993
									72	0.1005
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E266	0.2613
							20778	20778	E267	0.2560
							20778	20778	E268	0.2592
							20778	20778	E269	0.2588
							20778	20778	E270	0.2592
							20778	20778	E271	0.2591
							20778	20778	E272	0.2594
							20778	20778	E273	0.2606
							20778	20778	E274	0.2606
							20778	20778	E275	0.2593
							20778	20778	E276	0.2603
							20778	20778	E277	0.2495
							20841	20841	9-1 LON	0.2606
							20841	20841	9-2 LON	0.2604
							20841	20841	9-1 INL	0.2601
							20841	20841	9-2 INL	0.2590
							20841	20841	9-1 HV	0.2567
							20841	20841	9-2 HV	0.2576
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E330	0.1120
									E331	0.1120
									E332	0.1120
									E333	0.1090
									E334	0.1130
									E335	0.1120
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E430	0.2570
									E431	0.2520
									E432	0.2580
									E433	0.2550
									E434	0.2550
									E435	0.2560
									Total Mass	14.8145
									Specimen Mass	6.8607
									Internal Mass	14.3023

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES06

(17-07)


E431
E331
E430
E330
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17
63
9-1 LON
64
62
E268
E269
61
E266
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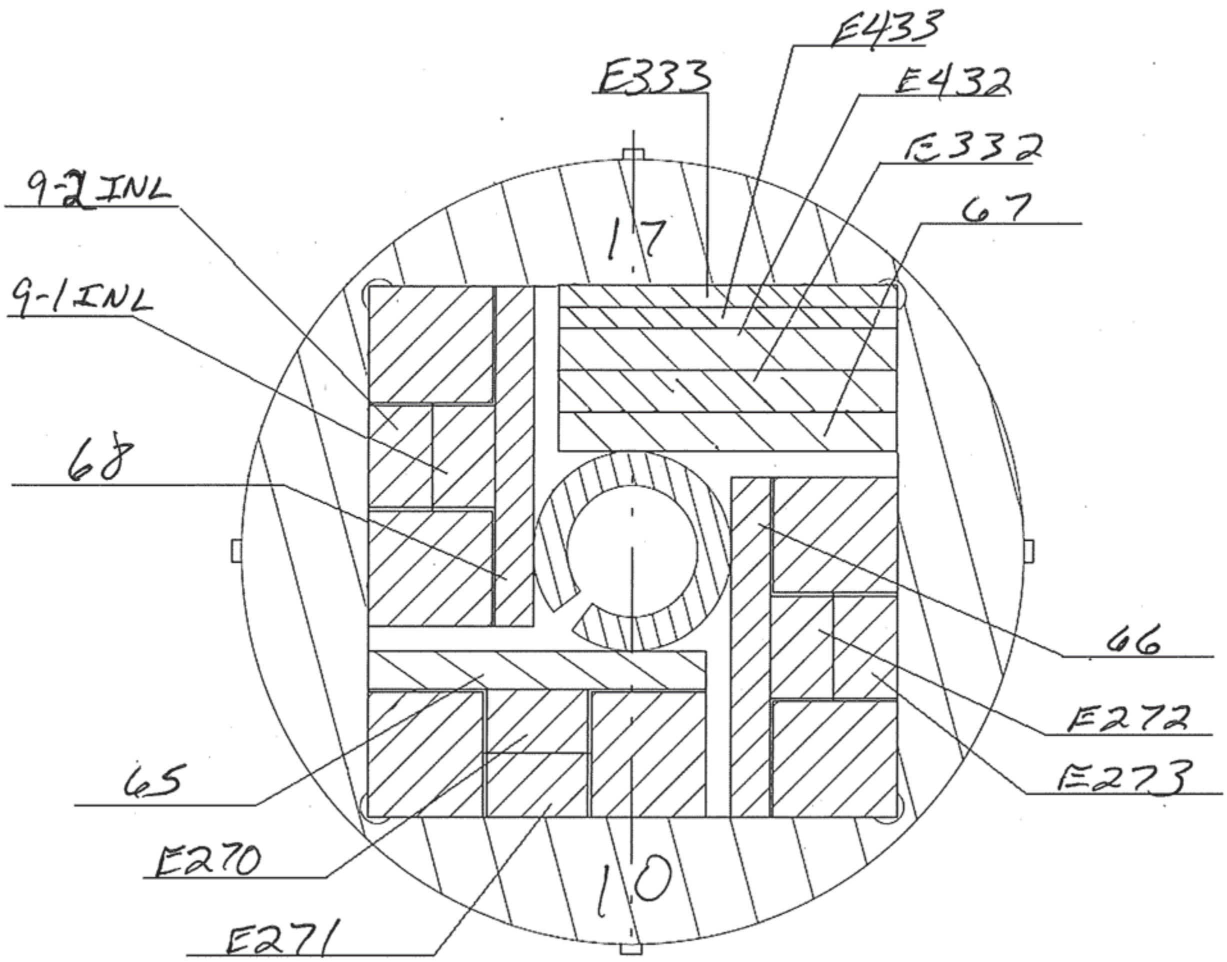
E267

ES06

(17-10)


E433
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E432
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9-1 INL
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68
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E272
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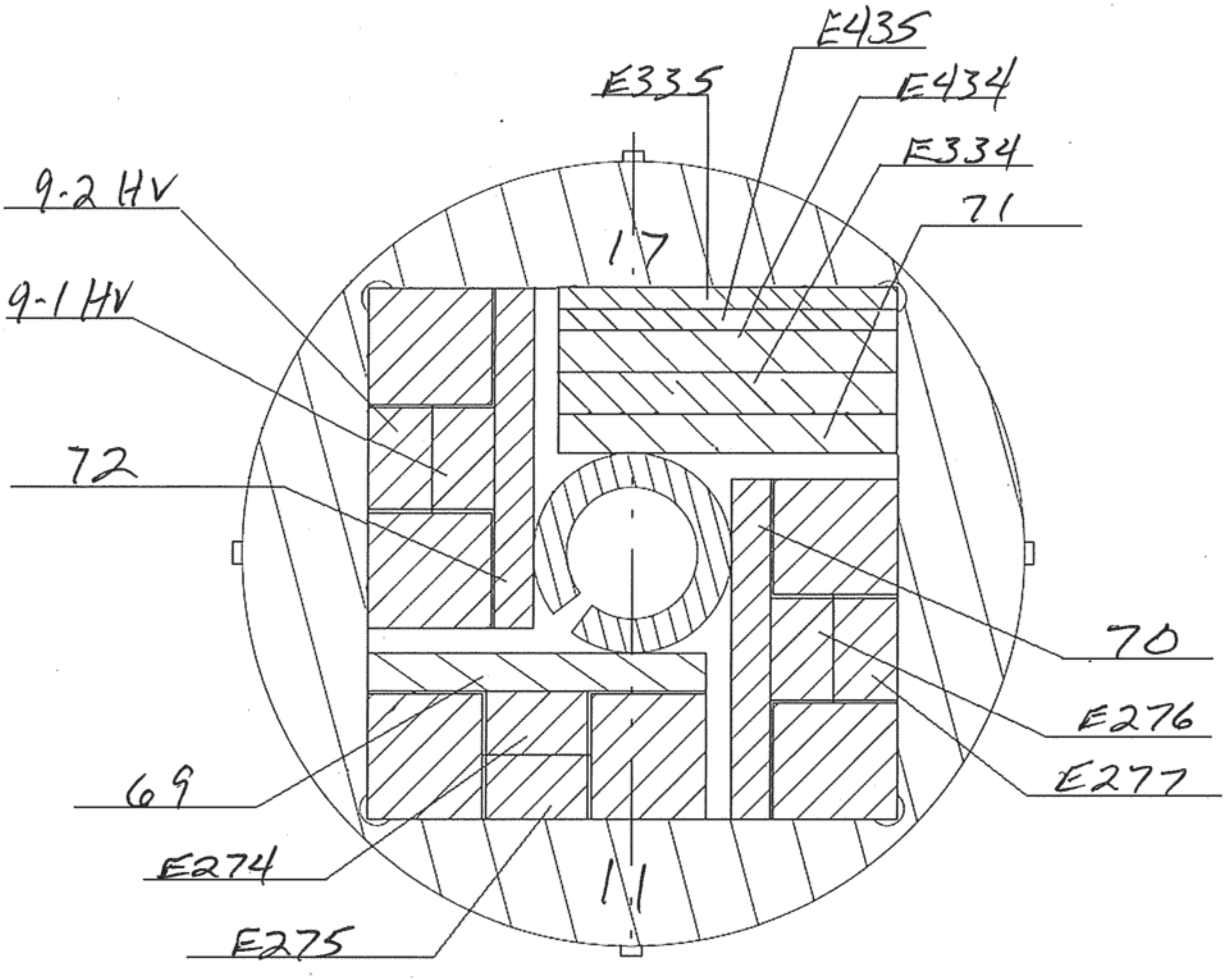
E270
E271
10

ES06

(17-11)



E435
E335
E434
E334
9-2 HV
71
17
9-1 HV
72
70
E276
E277
69
E274
11
E275

ES06					
Design Diameter (mm)	Tavg (°C)	Tavg (°C)			
9.15	360	346	HT9 Kevin Field		
	Inner	Outer			Specimen Type
Upper (X - Yc)	E266	E267	51	17	SSJ3 (E)
	E268	E269	52	21	SSJ3 (E)
	E330	E331	E430	E431	MPC1 (E3) / MPC2 (E4)
	9-1 LON	9-2 LON	G7	G8	SSJ3
Mid (X - Yc)	E270	E271	29	61	SSJ3 (E)
	E272	E273	58	55	SSJ3 (E)
	E332	E333	E432	E433	MPC1 (E3) / MPC2 (E4)
	9-1 INL	9-2 INL	G1	G2	SSJ3
Lower (X - Yc)	E274	E275	53	15	SSJ3 (E)
	E276	E277	54	30	SSJ3 (E)
	E334	E335	E434	E435	MPC1 (E3) / MPC2 (E4)
	9-1 HV	9-2 HV	G9	G10	SSJ3

RABBIT ASSEMBLY: ES06

HOUSING

SN / IR NUMBER:

18-03/20839

INNER DIAMETER:

Ø9.52

HOLDER(S)

SN / IR NUMBER:	SN / IR NUMBER:	SN / IR NUMBER:
17-07/20782	17-10/20782	17-11/20782
OUTER DIAMETER:	OUTER DIAMETER:	OUTER DIAMETER:
Ø9.18	Ø9.19	Ø9.20

Capsule Fabrication Request Sheet

Capsule Number: ES07

Irradiation Conditions

Irradiation Location	TRRH	5
Design Temperature		375
First Cycle Goal		477
Irradiation Time	2	cyc.
Irradiation Charge Number		N/A
Holder diameter	9.20	mm (0.3622 in) at 20°C
Fill Gas		Helium

Approvals

	Request	Build
Performed by:	[signature] 1/24/18	[signature] 1/24/18
Checked by:	[signature] 1/31/18	[signature] 1/30/18

Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-08	4.3401
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-98	0.5149
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0570
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2550
Specimen Holder	S16-22-ESTEEL	1	4	Al 6061	3		20825	20785	17-05	1.1621
									17-07	1.1585
									17-08	1.1603
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4070
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	003 008 011 012 015 032 064 067 070 073 076 079 H-1 H-2 H-3 H-4 H-5 H-6	20777	20777	18 Total	1.9669
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	73	0.0993
									74	0.0987
									75	0.1001
									76	0.1001
									77	0.1005
									78	0.1006
									79	0.1000
									80	0.0980
									81	0.1005
									82	0.1002
									83	0.0988
									84	0.1005
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E279	0.2610
							20778	20778	E280	0.2612
							20778	20778	E281	0.2613
							20778	20778	E282	0.2603
							20778	20778	E283	0.2581
							20778	20778	E284	0.2626
							20778	20778	E285	0.2625
							20778	20778	E286	0.2604
							20778	20778	E287	0.2580
							20778	20778	E288	0.2626
							20778	20778	E289	0.2614
							20778	20778	E290	0.2592
							20841	20841	YB28	0.2681
							20841	20841	YB29	0.2700
							20841	20841	YB30	0.2649
							20841	20841	YB31	0.2667
							20841	20841	YB32	0.2688
							20841	20841	B54-08	0.2675
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E336	0.1210
									E337	0.1100
									E338	0.1130
									E339	0.1130
									E340	0.1120
									E341	0.1100
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E436	0.2530
									E437	0.2590
									E438	0.2550
									E439	0.2590
									E440	0.2550
									E441	0.2600
									Total Mass	19.1739
									Specimen Mass	6.9548
									Internal Mass	14.3189

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

Capsule Fabrication Request Sheet

Capsule Number: ES07

Irradiation Conditions

Irradiation Location	TRRH 5
Design Temperature	375
First Cycle Goal	477
Irradiation Time	2 cyc.
Irradiation Charge Number	N/A
Holder diameter	9.20 mm (0.3622 in) at 20°C
Fill Gas	Helium

Approvals

	Request	Build
Performed by:		
Checked by:		[illegible signature] 01/22/18

Capsule Fabrication

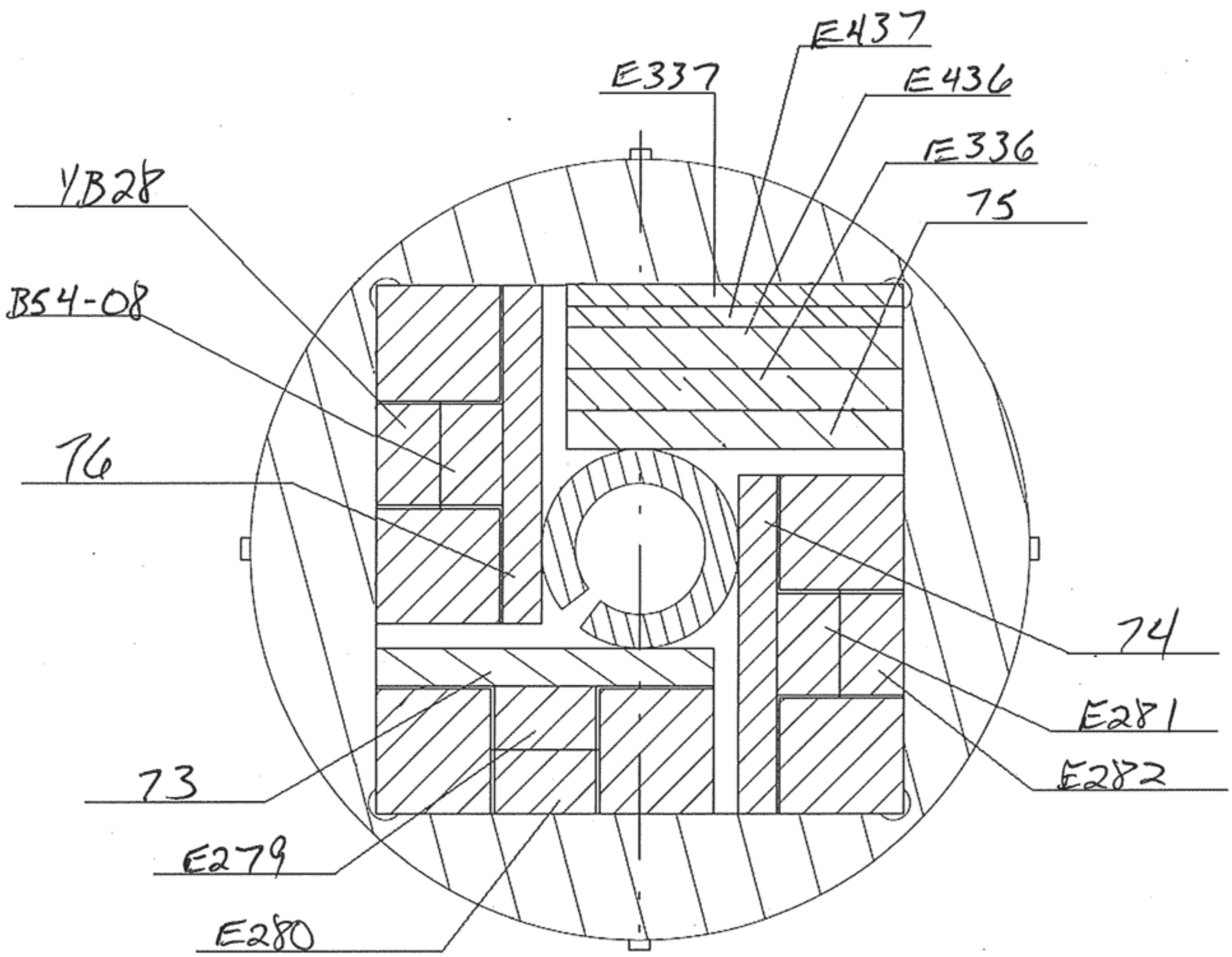
	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-08	
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-98	0.5149
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0570
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2550
Specimen Holder	S16-22-ESTEEL	1	4	Al 6061	3		20825	20785	17-05	1.1621
									17-07	1.1585
									17-08	1.1603
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4070
Chevron	S16-18-FUSSAM01	1	1	EuroFer	18	003 005 011 012 015 032 064 067 073 073 076 079 H-1 H-2 H-3 H-4 H-5 H-6	20777	20777	18 Total	1.9669
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20840	73	0.0993
									74	0.0987
									75	0.1001
									76	0.1001
									77	0.1005
									78	0.1006
									79	0.1000
									80	0.0980
									81	0.1005
									82	0.1002
									83	0.0988
									84	0.1005
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E279	0.2610
							20778	20778	E280	0.2612
							20778	20778	E281	0.2613
							20778	20778	E282	0.2603
							20778	20778	E283	0.2581
							20778	20778	E284	0.2626
							20778	20778	E285	0.2625
							20778	20778	E286	0.2604
							20778	20778	E287	0.2580
							20778	20778	E288	0.2626
							20778	20778	E289	0.2614
							20778	20778	E290	0.2592
							20841	20841	YB28	0.2681
							20841	20841	YB29	0.2700
							20841	20841	YB30	0.2649
							20841	20841	YB31	0.2667
							20841	20841	YB32	0.2688
							20841	20841	B54-08	0.2675
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E336	0.1210
									E337	0.1100
									E338	0.1130
									E339	0.1130
									E340	0.1120
									E341	0.1100
MPC2	S16-18-FUSSAM01	1	6	EuroFer	12		20781	20781	E436	0.2530
									E437	0.2590
									E438	0.2550
									E439	0.2590
									E440	0.2550
									E441	0.2600
									Total Mass	14.8338
									Specimen Mass	6.9548
									Internal Mass	14.3189

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

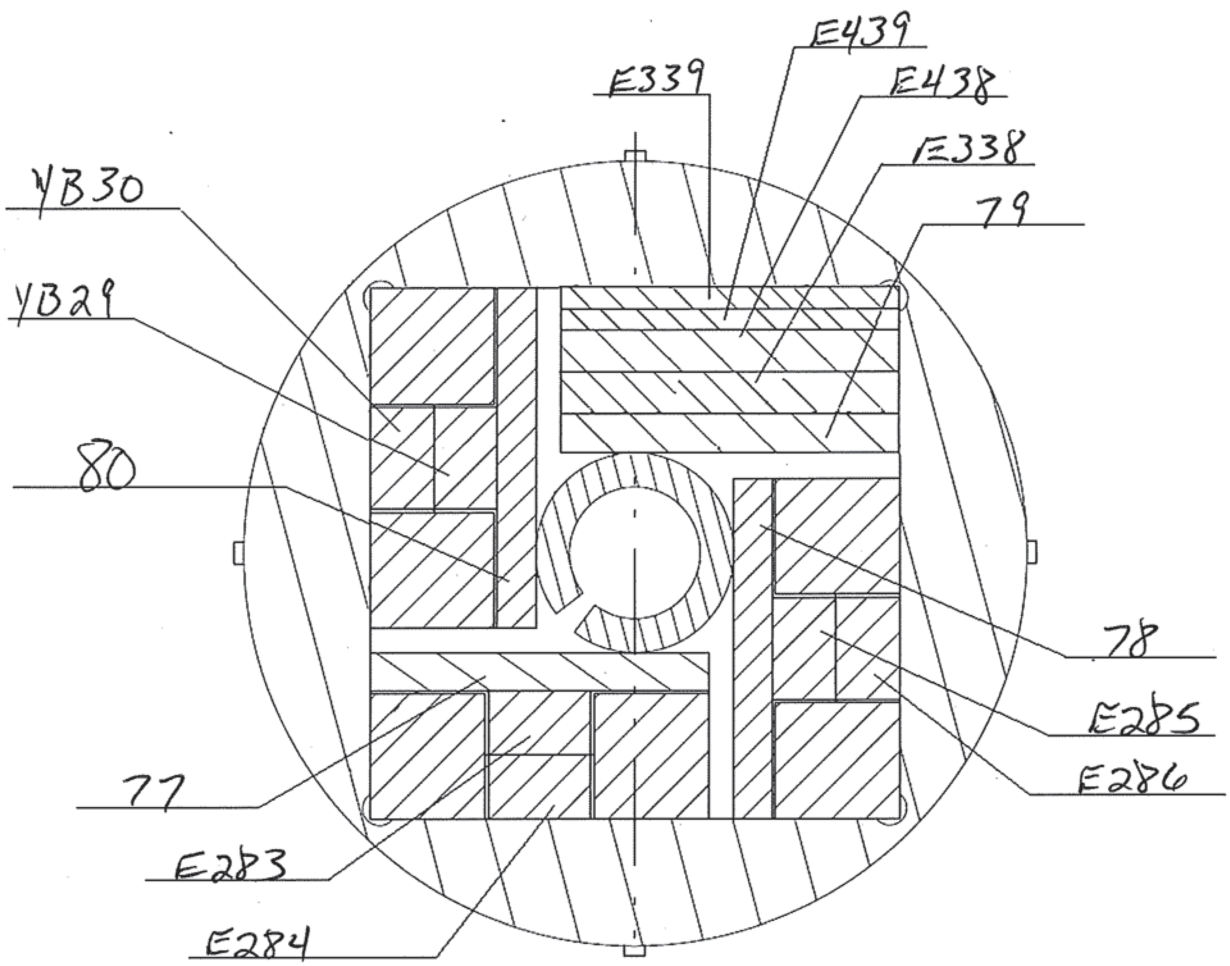
ES07

(17-05)



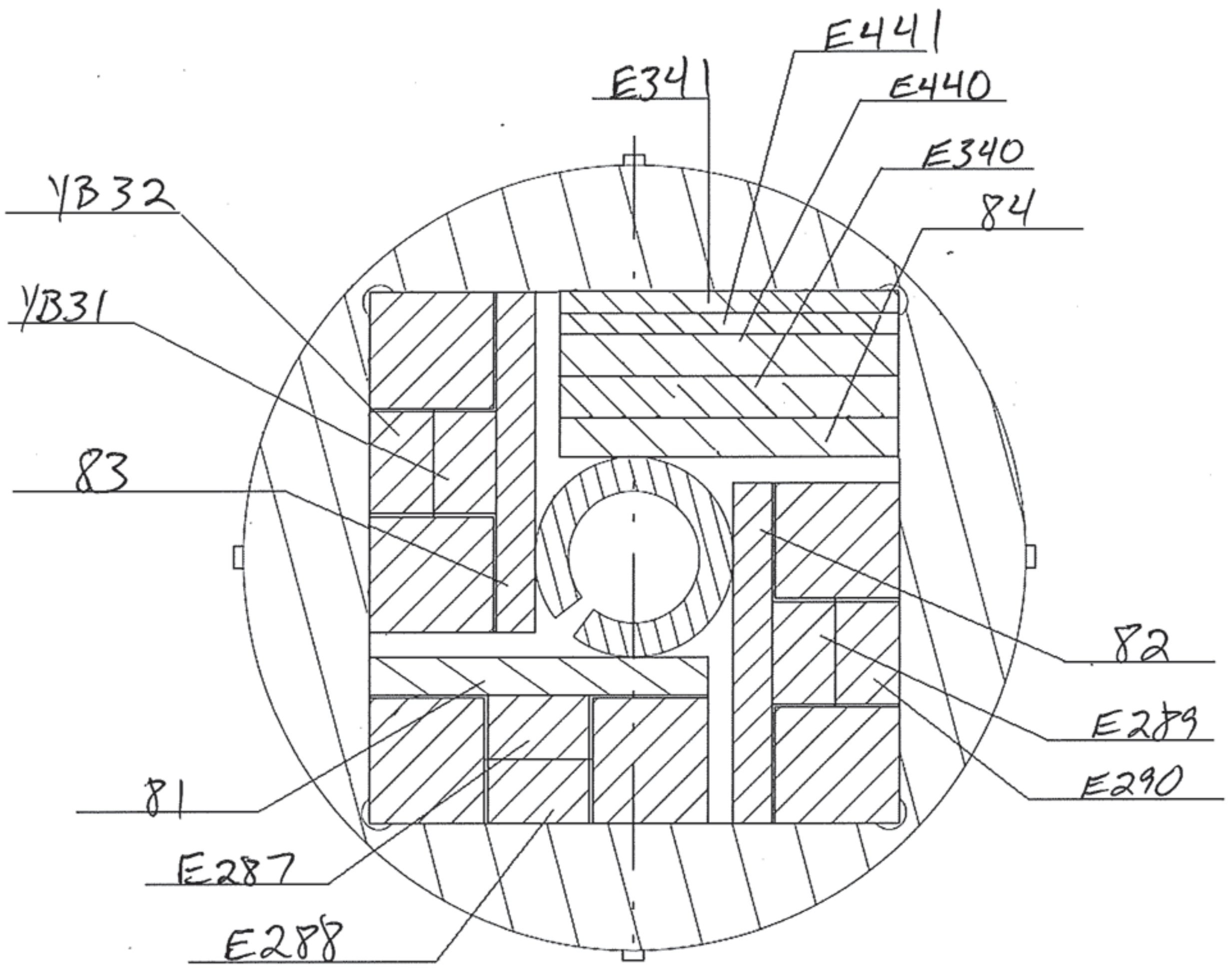
ES07

(17-07)



ES07

(17-08)



ES07					
Design Diameter (mm)	Tavg (°C)	Tavg (°C)			
9	388	374			
	Inner	Outer			Specimen Type
Upper (X - Yc)	E279	E280	12	64	SSJ3 (E)
	E281	E282	3	67	SSJ3 (E)
	E336	E337	E436	E437	MPC1 (E3) / MPC2 (E4)
	B54-08	YB28	H1	H2	SSJ3
Mid (X - Yc)	E283	E284	11	70	SSJ3 (E)
	E285	E286	8	73	SSJ3 (E)
	E338	E339	E438	E439	MPC1 (E3) / MPC2 (E4)
	YB29	YB30	H3	H4	SSJ3
Lower (X - Yc)	E287	E288	18	76	SSJ3 (E)
	E289	E290	32	79	SSJ3 (E)
	E340	E341	E440	E441	MPC1 (E3) / MPC2 (E4)
	YB31	YB32	H5	H6	SSJ3

RABBIT ASSEMBLY: ESØ7

HOUSING

SN / IR NUMBER:

18-Ø8/20839

INNER
DIAMETER:

Ø 9.52

HOLDER(S)

SN / IR NUMBER:	SN / IR NUMBER:	SN / IR NUMBER:
17-Ø5/2Ø785	17-Ø7/2Ø785	17-Ø8/2Ø785
OUTER DIAMETER:	OUTER DIAMETER:	OUTER DIAMETER:
Ø9.15	Ø9.15	Ø9.15

Capsule Fabrication Request Sheet

Date 1/24/2018

Capsule Number: ES11

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	220°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 1/26/18	[signature] 1/26/18
Checked by:	[signature] 1/31/18	[signature] 01/24/18

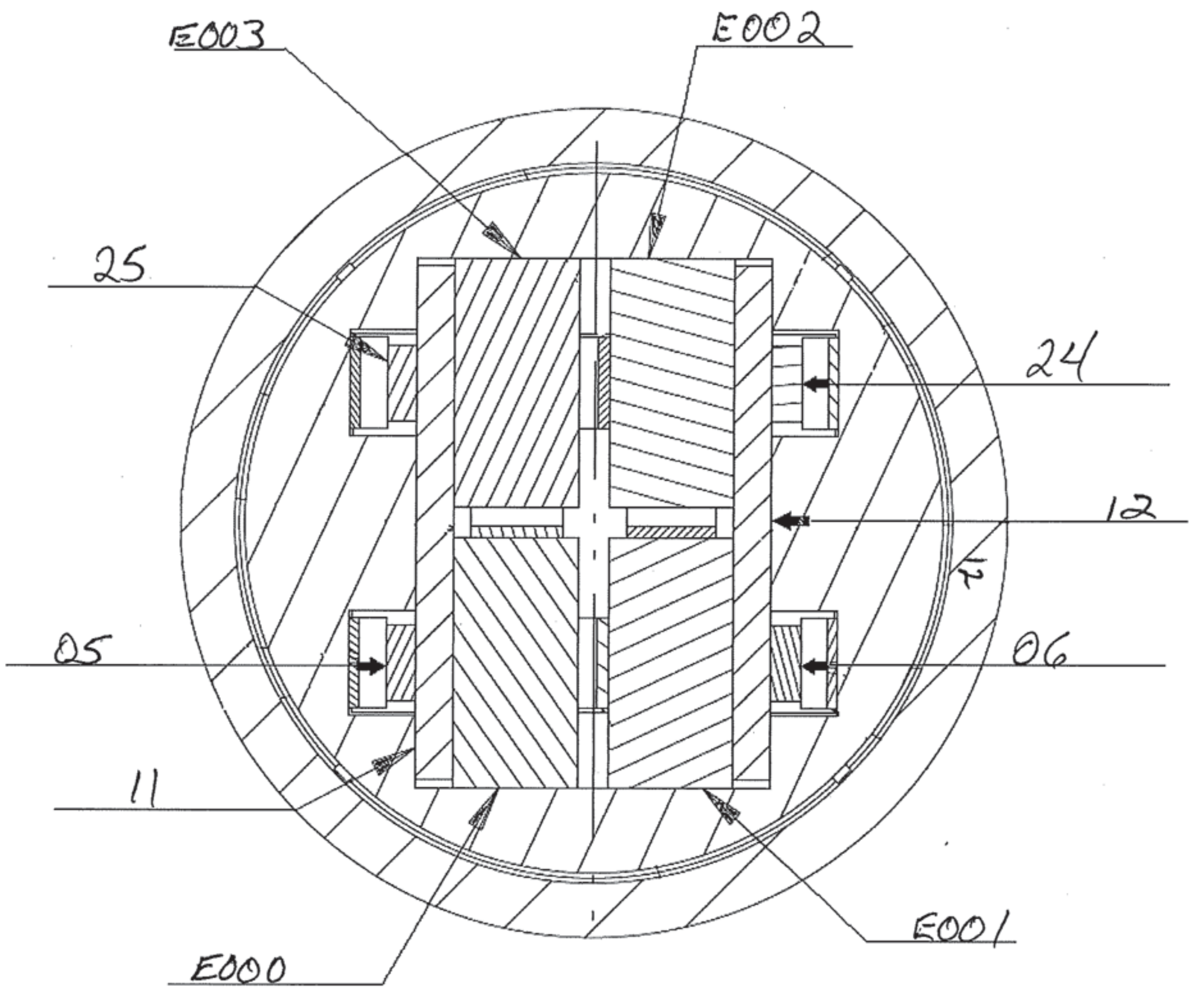
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-52	4.3033
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-30	0.5154
Specimen holder	S16-24-ESTEELB	1	12	Al 6061	1		20825	20776	17-04	4.2110
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.117
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.256
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	4		20710	20710	4 total	0.118
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.011
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.019
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	E000	1.8840
									E001	1.9210
									E002	1.9180
									E003	1.8860
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	5	0.0641
									6	0.0646
									24	0.0646
									25	0.0639
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.219
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2	11, 12	20824	20824	2 total	2.375
									Total Mass	20.0109
									Specimen Mass	7.6090
									Internal Mass	15.1922

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES11



RABBIT ASSEMBLY: ES11

HOUSING

SN / IR NUMBER:

18-52/20839

INNER
DIAMETER:

Ø9.53

HOLDER(S)

SN / IR NUMBER:

17-04/20776

OUTER
DIAMETER:

Ø9.43

Capsule Number: ES12

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	240°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 1/26/18	[signature] 1/26/18
Checked by:	[signature] 1/31/18	[signature] 01/24/18

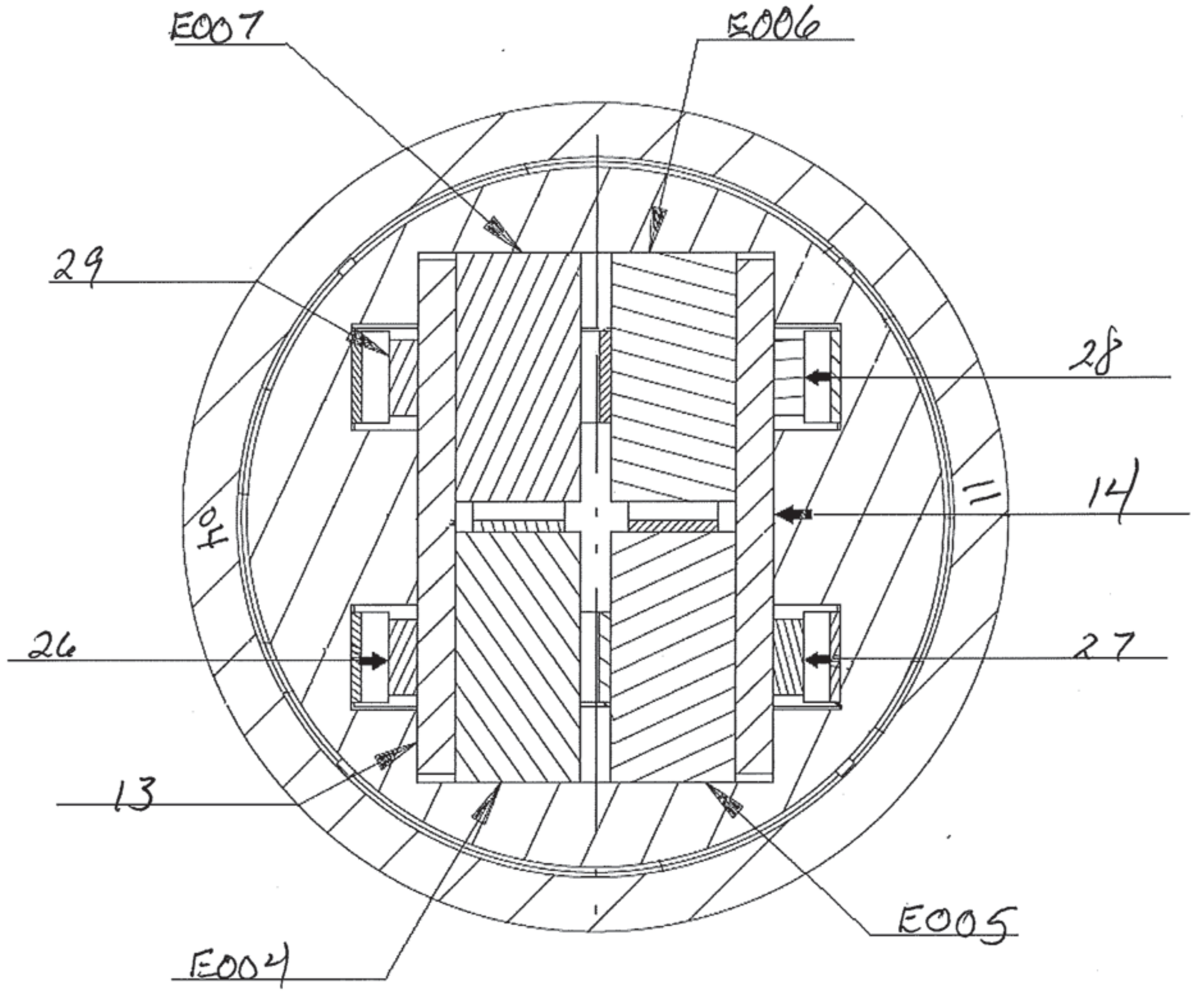
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-11	4.3027
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-67	0.5147
Specimen holder	S16-24-ESTEELB	1	11	Al 6061	1		20825	20775	17-03	4.1443
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.116
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.257
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	2		20710	20710	4 total	0.119
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.011
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.018
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	E004	1.8900
									E005	1.9160
									E006	1.8940
									E007	1.8860
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	26	0.0648
									27	0.0648
									28	0.0631
									29	0.0639
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.219
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2	13, 14	20824	20824	2 total	2.387
									Total Mass	19.9313
									Specimen Mass	7.5860
									Internal Mass	15.1139

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES12



RABBIT ASSEMBLY: ES12

HOUSING

SN / IR NUMBER:

18-11/2Ø839

INNER DIAMETER:

Ø9.51

HOLDER(S)

SN / IR NUMBER:

17-Ø3/2Ø775

OUTER DIAMETER:

Ø9.4Ø

Capsule Number: ES13

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	275°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 1/25/18	[signature] 1/25/18
Checked by:	[signature] 1/31/18	[signature] 01/33/18

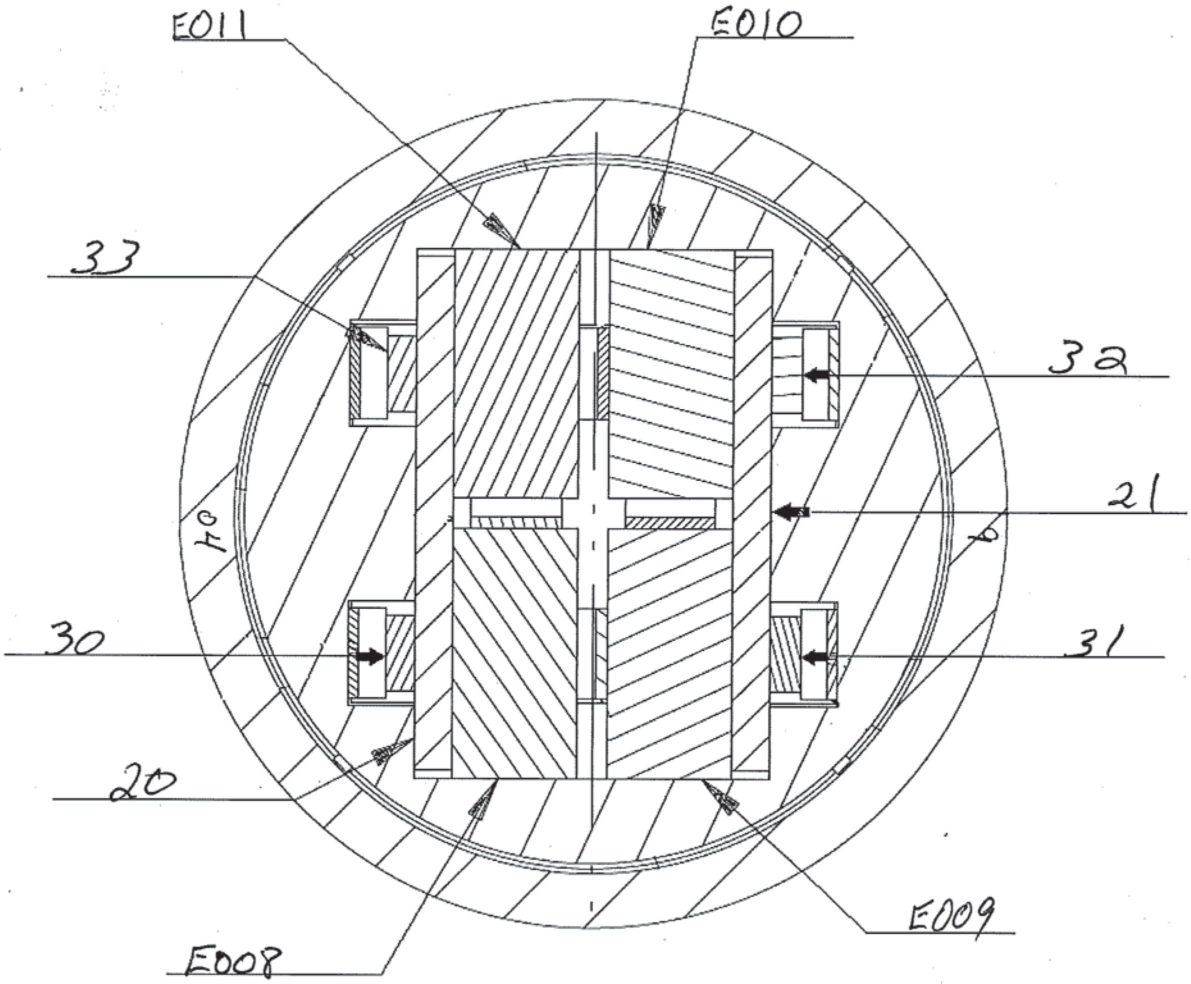
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-13	4.2917
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-71	0.5144
Specimen holder	S16-24-ESTEELB	1	9	Al 6061	1		20825	20774	17-04	4.0442
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.117
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.256
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	4		20710	20710	4 total	0.114
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.011
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.019
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	E008	1.8830
									E009	1.9220
									E010	1.9240
									E011	1.9120
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	30	0.0638
									31	0.0646
									32	0.0645
									33	0.0639
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.218
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2	20, 21	20824	20824	2 total	2.384
									Total Mass	19.8671
									Specimen Mass	7.6410
									Internal Mass	15.0610

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES13



RABBIT ASSEMBLY: ES13

HOUSING

SN / IR NUMBER:

18-13/2Ø839

INNER
DIAMETER:

Ø9.53

HOLDER(S)

SN / IR NUMBER:

17-Ø4/2Ø774

OUTER
DIAMETER:

Ø9.35

Capsule Number: ES14

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	300°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 1/26/18	[signature] 1/26/18
Checked by:	[signature] 1/31/18	[signature] 01/25/18

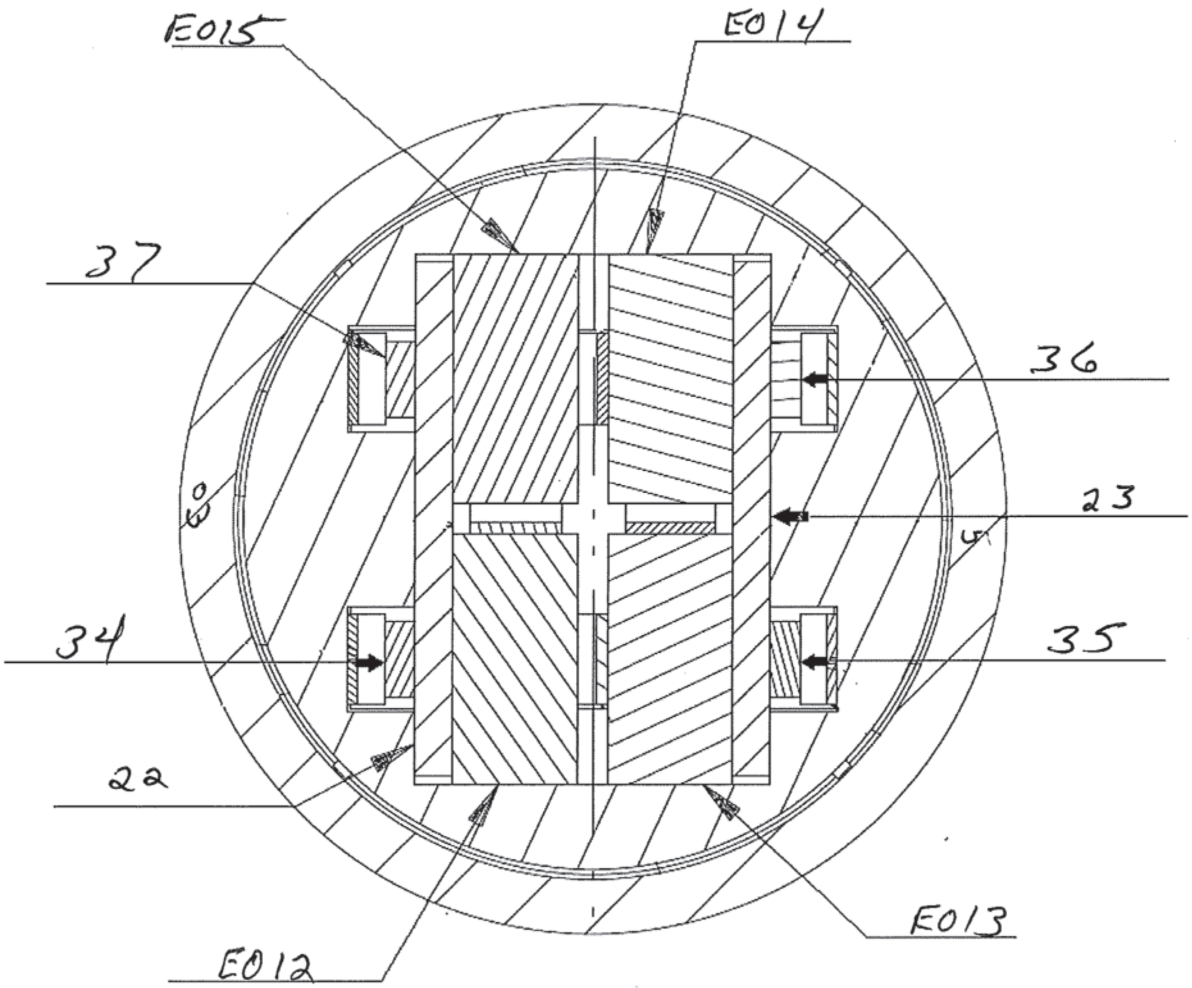
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	17-155	4.2960
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-103	0.5148
Specimen holder	S16-24-ESTEELB	1	5	Al 6061	1		20825	20772	17-03	3.9019
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.117
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.254
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	4		20710	20710	4 total	0.113
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.012
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.019
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	E012	1.9190
									E013	1.8970
									E014	1.8940
									E015	1.8920
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	34	0.0636
									35	0.0643
									36	0.0645
									37	0.0640
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.220
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2	22, 23	20824	20824	2 total	2.373
									Total Mass	19.6791
									Specimen Mass	7.6020
									Internal Mass	14.8683

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES14



RABBIT ASSEMBLY: ES14

HOUSING

SN / IR NUMBER:

17-155/20839

INNER
DIAMETER:

Ø9.53

HOLDER(S)

SN / IR NUMBER:

17-03/20772

OUTER
DIAMETER:

9.28

Capsule Number: ES15

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	325°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 1/26/18	[signature] 1/26/18
Checked by:	[signature] 1/31/18	[signature] 01/25/18

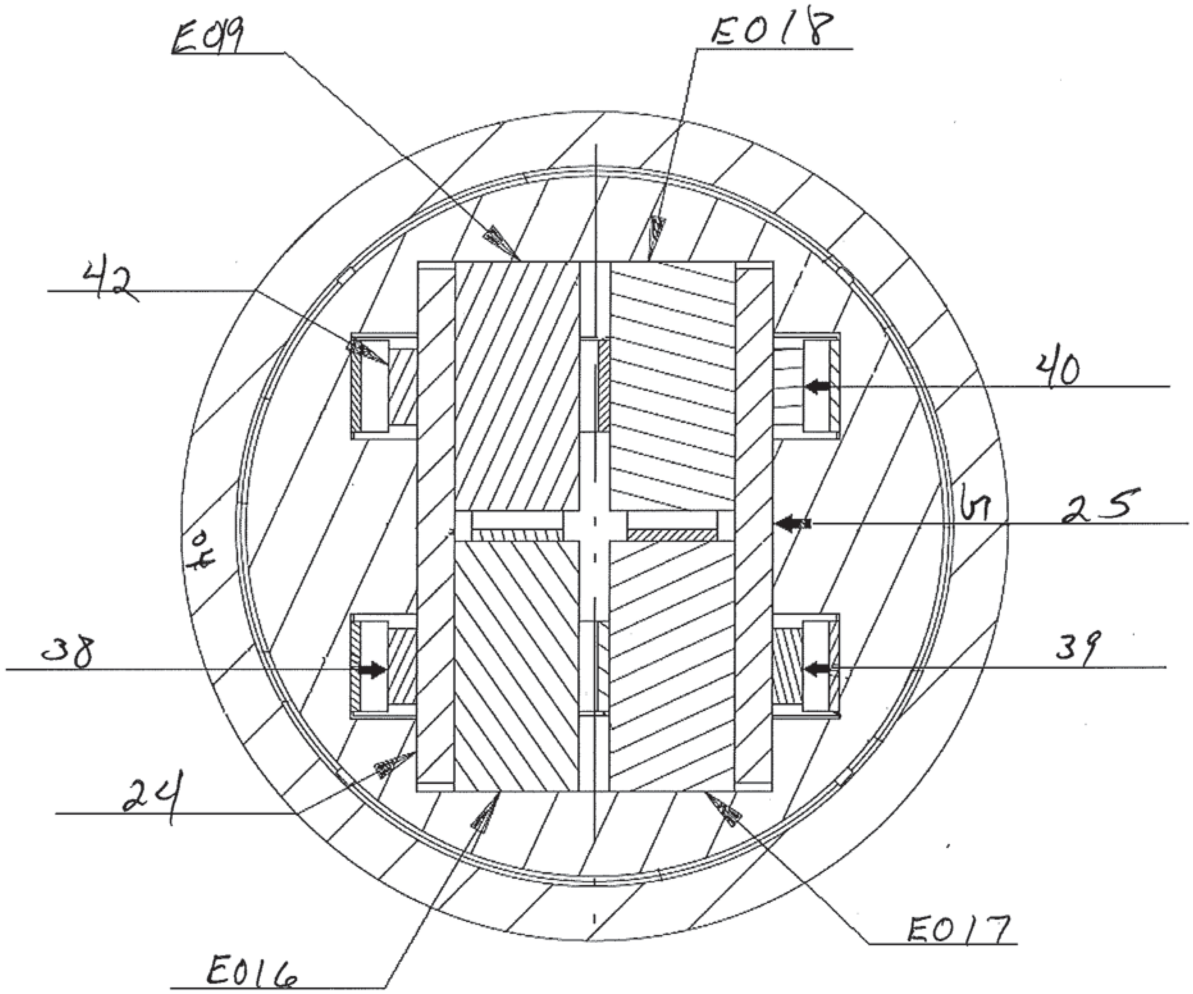
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-16	4.3119
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-110	0.5143
Specimen holder	S16-24-ESTEELB	1	5	Al 6061	1		20825	20772	17-04	3.9040
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.115
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.255
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	4		20710	20710	4 total	0.112
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.010
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.019
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	E016	1.8940
									E017	1.8900
									E018	1.9120
									E019	1.8870
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	38	0.0642
									39	0.0643
									40	0.0638
									42	0.0637
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.216
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2	24, 25	20824	20824	2 total	2.369
									Total Mass	19.6652
									Specimen Mass	7.5830
									Internal Mass	14.8390

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES15



RABBIT ASSEMBLY: ES15

HOUSING

SN / IR NUMBER:

18-16/2Ø839

INNER
DIAMETER:

Ø9.52

HOLDER(S)

SN / IR NUMBER:

17-Ø4/2Ø772

OUTER
DIAMETER:

Ø9.27

Capsule Number: ES16

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	350°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 1/26/18	[signature] 1/26/18
Checked by:	[signature] 1/31/18	[signature] 01/25/18

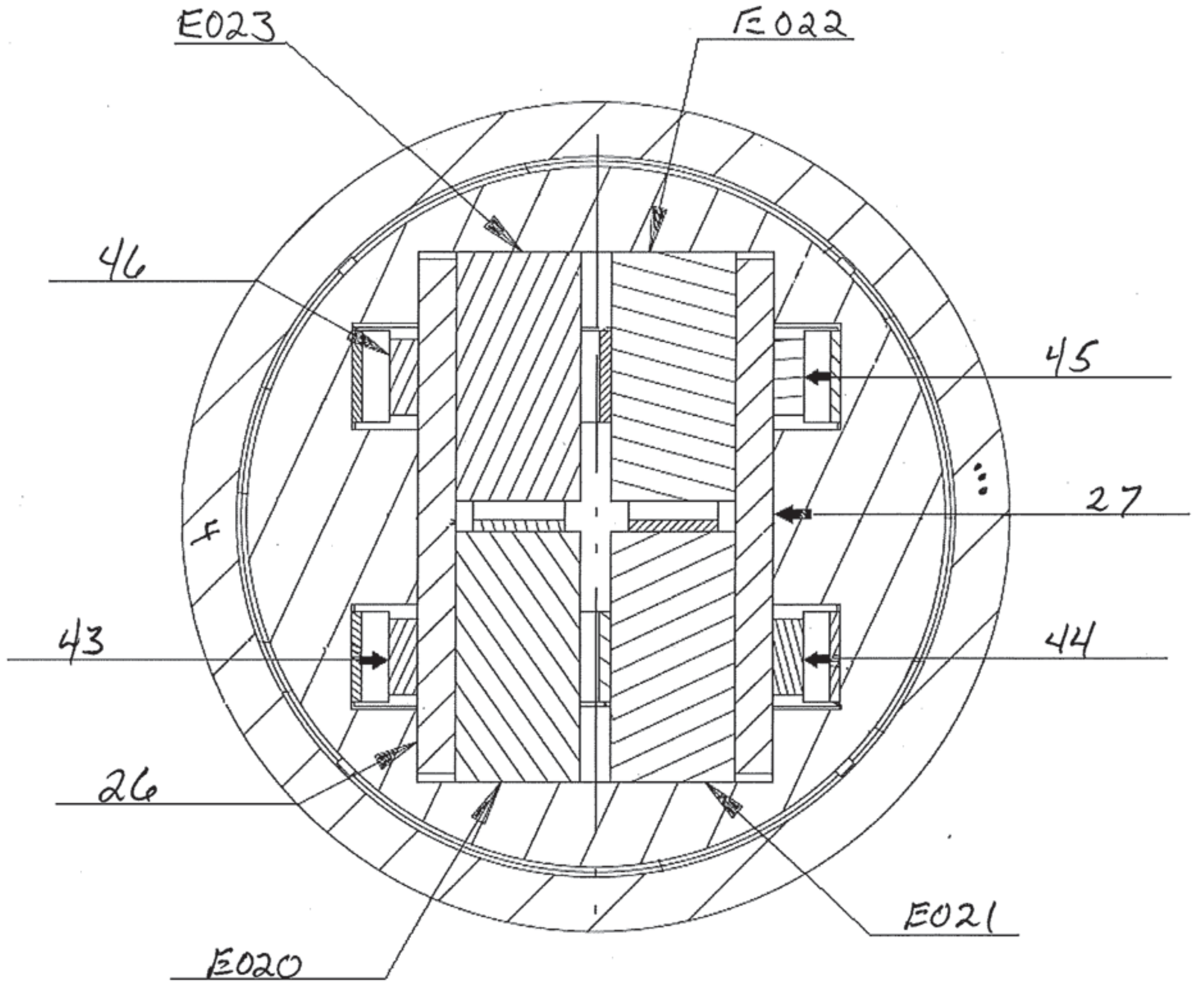
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-68	4.3061
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-128	0.5103
Specimen holder	S16-24-ESTEELB	1	3	Al 6061	1		20825	20771	17-04	3.8016
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.118
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.257
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	4		20710	20710	4 total	0.112
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.011
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.017
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	E020	1.8510
									E021	1.8820
									E022	1.8880
									E023	1.8840
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	43	0.0636
									44	0.0645
									45	0.0646
									46	0.0649
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.221
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2	26, 27	20824	20824	2 total	2.391
									Total Mass	19.5076
									Specimen Mass	7.5050
									Internal Mass	14.6912

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES16



RABBIT ASSEMBLY: ES16

HOUSING

SN / IR NUMBER:

18-68/2Ø839

INNER
DIAMETER:

Ø9.53

HOLDER(S)

SN / IR NUMBER:

17-Ø4/2Ø771

OUTER
DIAMETER:

Ø9.2Ø

Capsule Number: ES17

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	375°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 1/26/18	[signature] 1/26/18
Checked by:	[signature] 1/31/18	[signature] 01/25/18

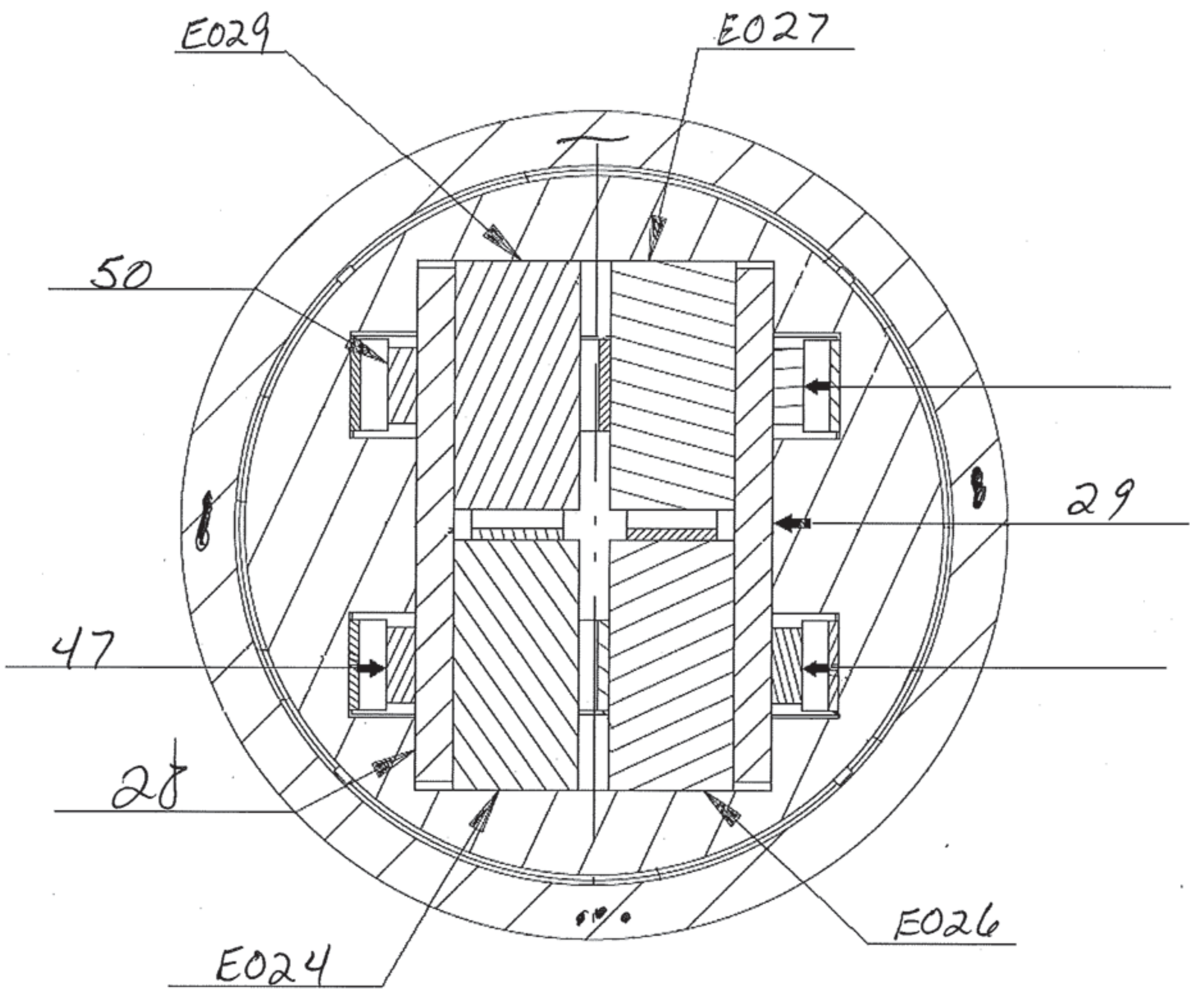
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	18-72	4.3104
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-138	0.5153
Specimen holder	S16-24-ESTEELB	1	3	Al 6061	1		20825	20771	17-03	3.8280
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.136
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.257
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	4		20710	20710	4 total	0.114
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.012
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.018
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	E024	1.9390
									E026	1.9190
									E027	1.8950
									E029	1.8640
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	47	0.0634
									48	0.0634
									49	0.0647
									50	0.0635
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.217
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2	28, 29	20824	20824	2 total	2.384
									Total Mass	19.6637
									Specimen Mass	7.6170
									Internal Mass	14.8380

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES17



RABBIT ASSEMBLY: ES17

HOUSING

SN / IR NUMBER:

18-72/2Ø839

INNER
DIAMETER:

Ø9.53

HOLDER(S)

SN / IR NUMBER:

17-Ø3/2Ø771

OUTER
DIAMETER:

Ø9.22

Capsule Fabrication Request Sheet

Capsule Number: ES21

Irradiation Conditions

Irradiation Location	TRRH	5
Design Temperature		285
First Cycle Goal		477
Irradiation Time	2	cyc.
Irradiation Charge Number		N/A
Holder diameter	9.25	mm (0.3642 in) at 20°C
Fill Gas		Helium

Approvals

	Request	Build
Performed by:	[signature] 12/19/17	[signature] 12/19/17
Checked by:	[signature] 12/19/17	[signature] 12/19/17

Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	17-157	4.2998
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-101	0.5173
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0550
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2570
Specimen Holder	S16-22-ESTEEL	1	2	Al 6061	3		20825	20783	17-05	1.2254
									17-06	1.2279
									17-09	1.2262
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4100
Chevron	S16-18-FUSSAM01	1	1	EuroFer	20	Parts 1-20	20777	20777	20 Total	2.1498
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20657	49	0.1010
									50	0.0980
									51	0.1000
									52	0.0980
									53	0.0980
									54	0.0990
									55	0.0980
									56	0.0970
									57	0.0970
									58	0.0960
									59	0.0970
									60	0.1000
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	E293	0.2575
									E291	0.2622
									H100	0.2624
									H103	0.2617
									I100	0.2612
									I104	0.2613
									J104	0.2685
									J108	0.2674
									K100	0.2697
									K104	0.2704
									L100	0.2582
									L103	0.2588
									M110	0.2580
									M115	0.2576
									N108	0.2562
									N111	0.2623
									O108	0.2537
									O111	0.2598
									P100	0.2633
									P103	0.2627
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E343	0.1170
									H300	0.1247
									I300	0.1239
									O320	0.1265
									P300	0.1225
									I301	0.1239
									J300	0.1129
									K300	0.1170
									L300	0.1257
									M320	0.1271
									N320	0.1243
									M321	0.1261
									Total Mass	19.2519
									Specimen Mass	6.7046
									Internal Mass	14.4348

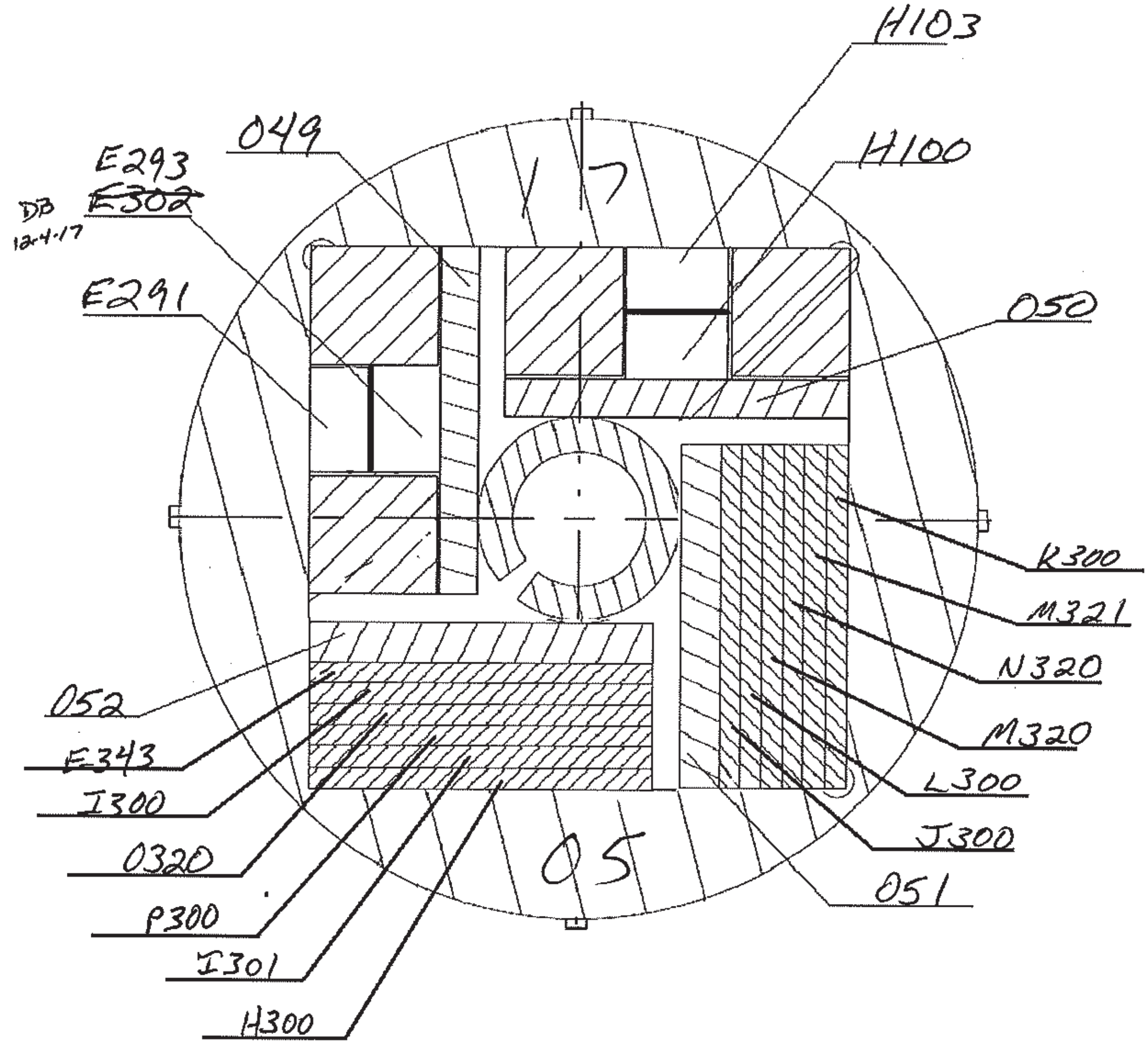
Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES21

17-05

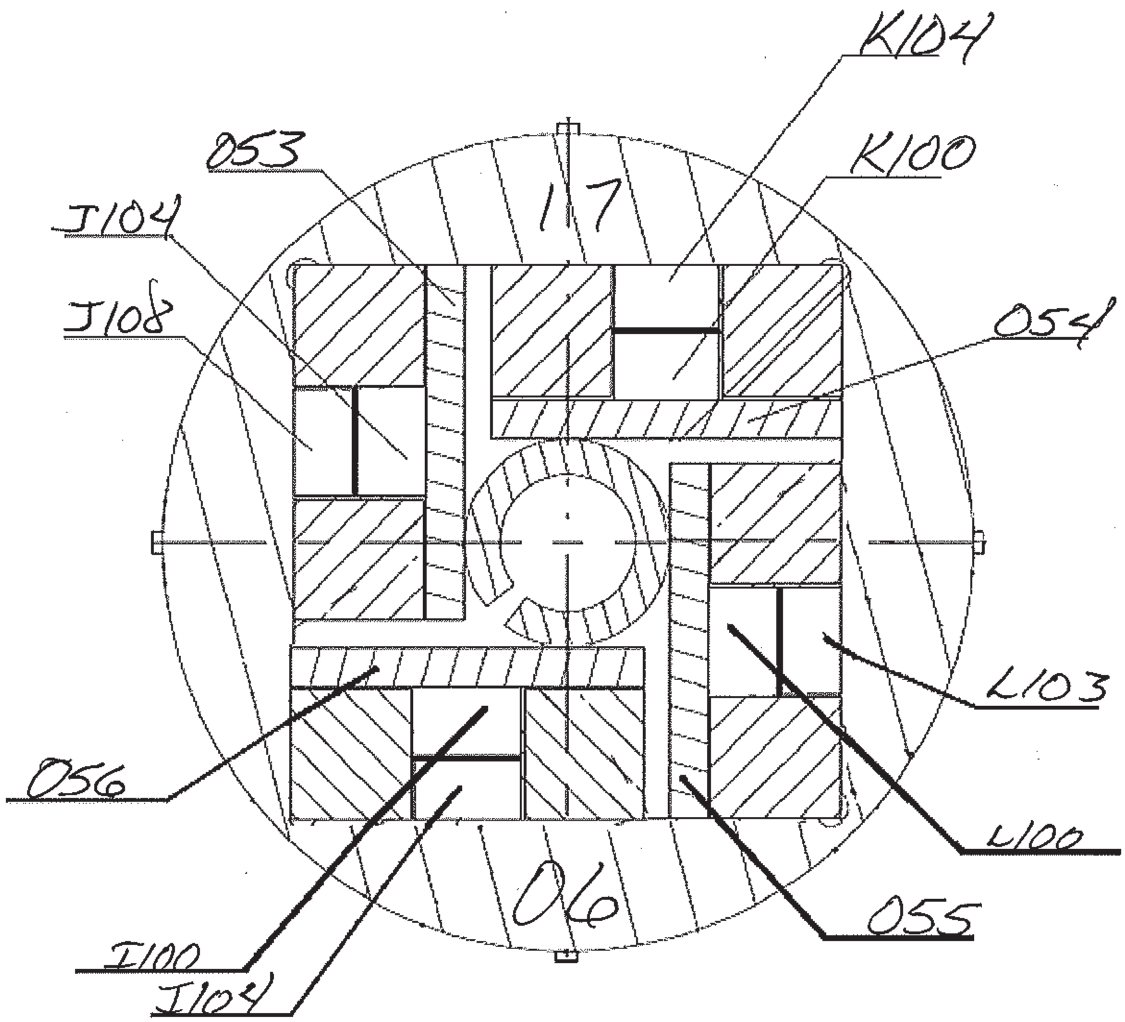
(Top)



ES21

17-06

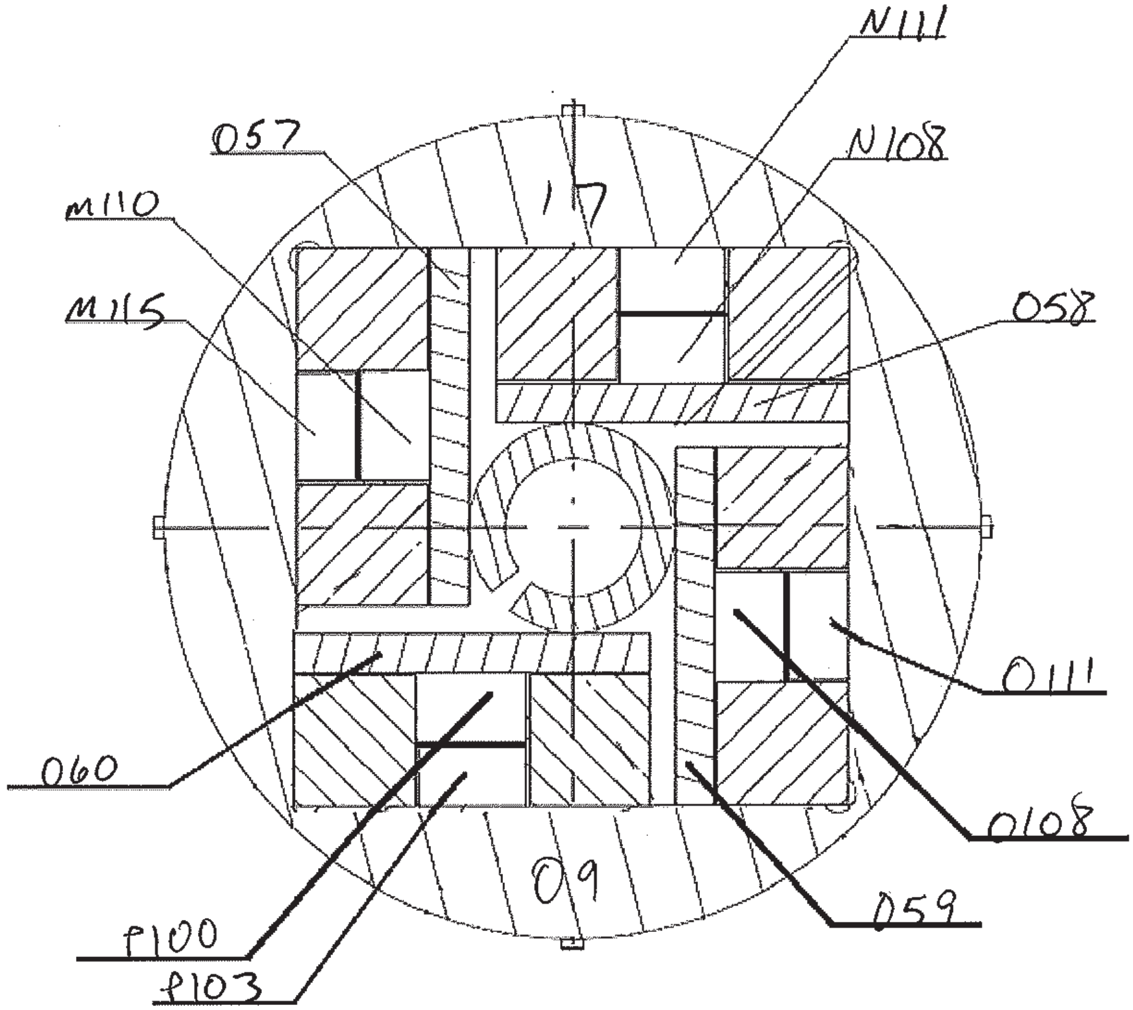
(Middle)



ES21

17-09

(Bottom)



ES21

	Design Diameter (mm)	Tavg (°C)	Tavg (°C)					
	9.25	304	290					
		Inner	Outer					Specimen Type
17-05	Upper (X - Yc)	E293*	E291					SSJ3
		H100*	H103					SSJ3
		J300	K300	L300	M320	N320	M321	MPC1
		E343	H300	I300	O320	P300	I301	MPC1
17-06	Mid (X - Yc)	J104*	J108					SSJ3
		K100*	K104					SSJ3
		L100*	L103					SSJ3
		I100*	I104					SSJ3
17-09	Lower (X - Yc)	M110*	M115					SSJ3
		N108*	N111					SSJ3
		O108*	O111					SSJ3
		P100*	P103					SSJ3

RABBIT ASSEMBLY: ES21

HOUSING

SN / IR NUMBER:

17-157/20838

INNER DIAMETER:

9.53mm

HOLDER(S)

SN / IR NUMBER:

17-05/20783

OUTER DIAMETER:

9.24mm

SN / IR NUMBER:

17-06/20783

OUTER DIAMETER:

9.24mm

SN / IR NUMBER:

17-09/20783

OUTER DIAMETER:

9.25mm

Capsule Fabrication Request Sheet

Date 12/19/2017

Capsule Number: ES22

Irradiation Conditions

Irradiation Location	TRRH 5
Design Temperature	315
First Cycle Goal	477
Irradiation Time	2 cyc.
Irradiation Charge Number	N/A
Holder diameter	9.20 mm (0.3622 in) at 20°C
Fill Gas	Helium

Approvals

	Request	Build
Performed by:	[illegible] 12/19/17	[illegible] 12/19/17
Checked by:	[illegible] 12/19/17	[illegible] 12/19/17

Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	17-156	4.3009
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-72	0.5166
Foil Spacer	S16-20-ESTEEL	1	2	Grafoil	6		19812	19812	6 Total	0.0560
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 Total	0.2560
Specimen Holder	S16-22-ESTEEL	1	1	Al 6061	3		20825	20782	17-05	1.1875
									17-06	1.1906
									17-08	1.1967
Spring Pin	S16-21-ESTEEL	2	91610A207	18-8 SS	3		20548	20548	3 Total	0.4110
Chevron	S16-18-FUSSAM01	1	1	EuroFer	20	Parts 21 - 40	20777	20777	20 Total	2.1500
Thermometry	S16-18-FUSSAM01	1	7	SiC	12		19759	20657	61	0.1000
									62	0.0980
									63	0.1010
									64	0.0990
									65	0.0980
									66	0.0980
									67	0.0990
									68	0.0990
									69	0.0980
									70	0.1000
									71	0.0990
									72	0.1000
SSJ3	S16-18-FUSSAM01	1	2	EuroFer	20		20778	20778	H101	0.2624
									H102	0.2619
									E292	0.2602
									E294	0.2631
									I102	0.2611
									I103	0.2607
									J105	0.2679
									J107	0.2672
									K101	0.2687
									K102	0.2706
									L101	0.2589
									L102	0.2583
									M111	0.2572
									M112	0.2579
									N109	0.2629
									N110	0.2592
									O109	0.2580
									O110	0.2536
									P101	0.2627
									P102	0.2633
MPC1	S16-18-FUSSAM01	1	5	EuroFer	12		20780	20780	E342	0.1130
									H301	0.1249
									I302	0.1241
									O321	0.1258
									P301	0.1227
									H302	0.1250
									J302	0.1133
									K301	0.1154
									L301	0.1237
									M322	0.2518
									N321	0.1247
									O322	0.1263
									Total Mass	19.2807
									Specimen Mass	6.8263
									Internal Mass	14.4632

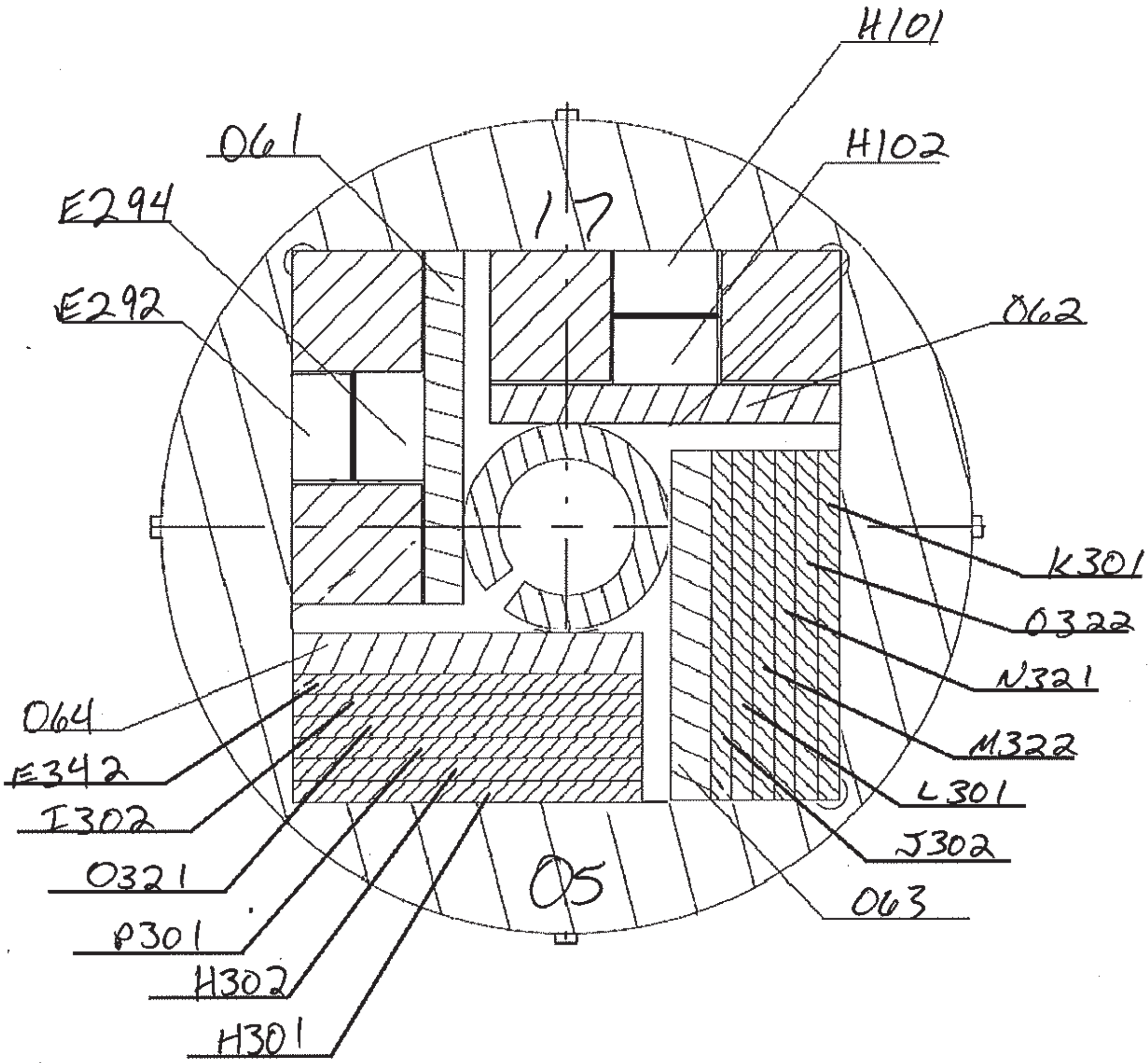
Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-20-ESTEEL	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES22

17-05

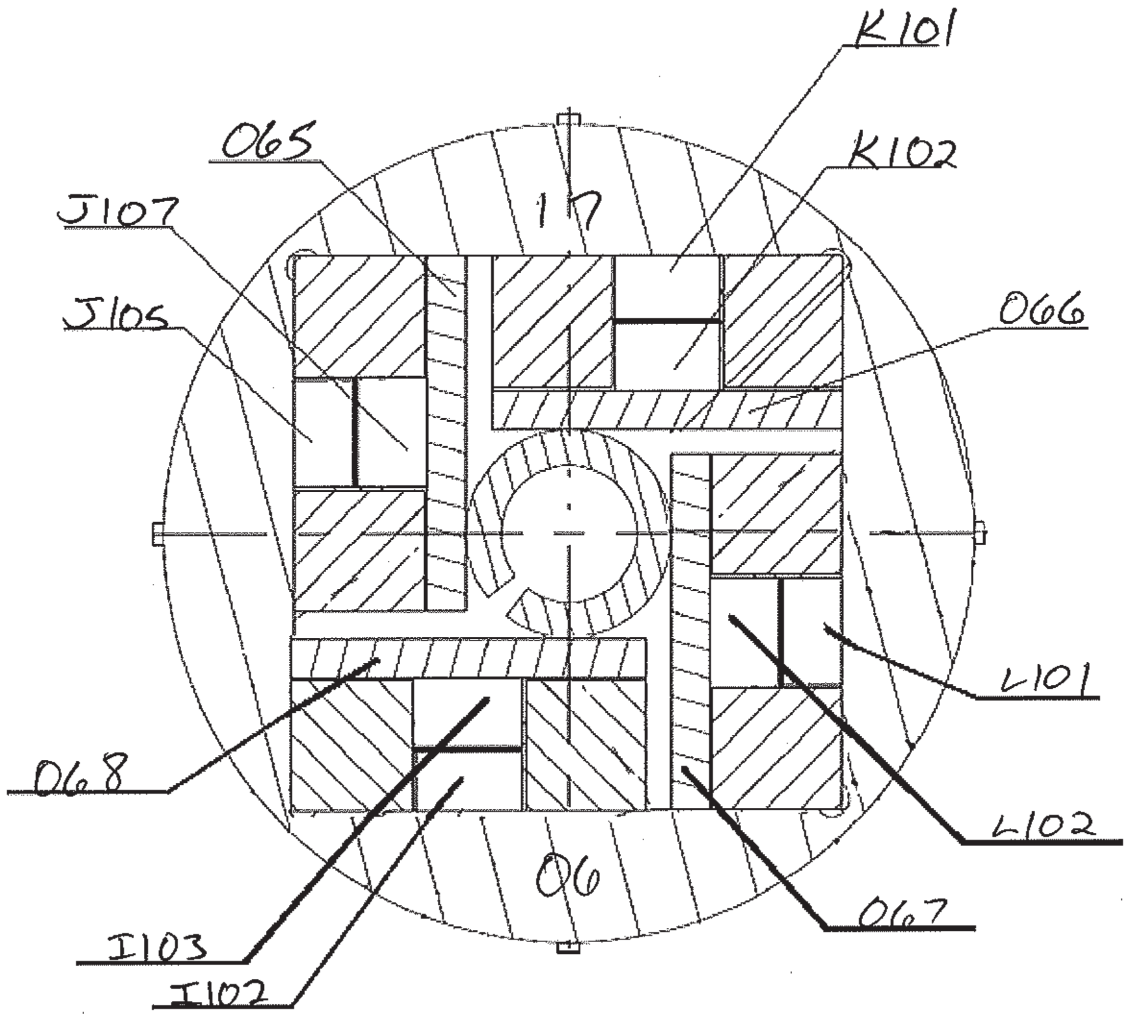
(Top)



ES22

17-06

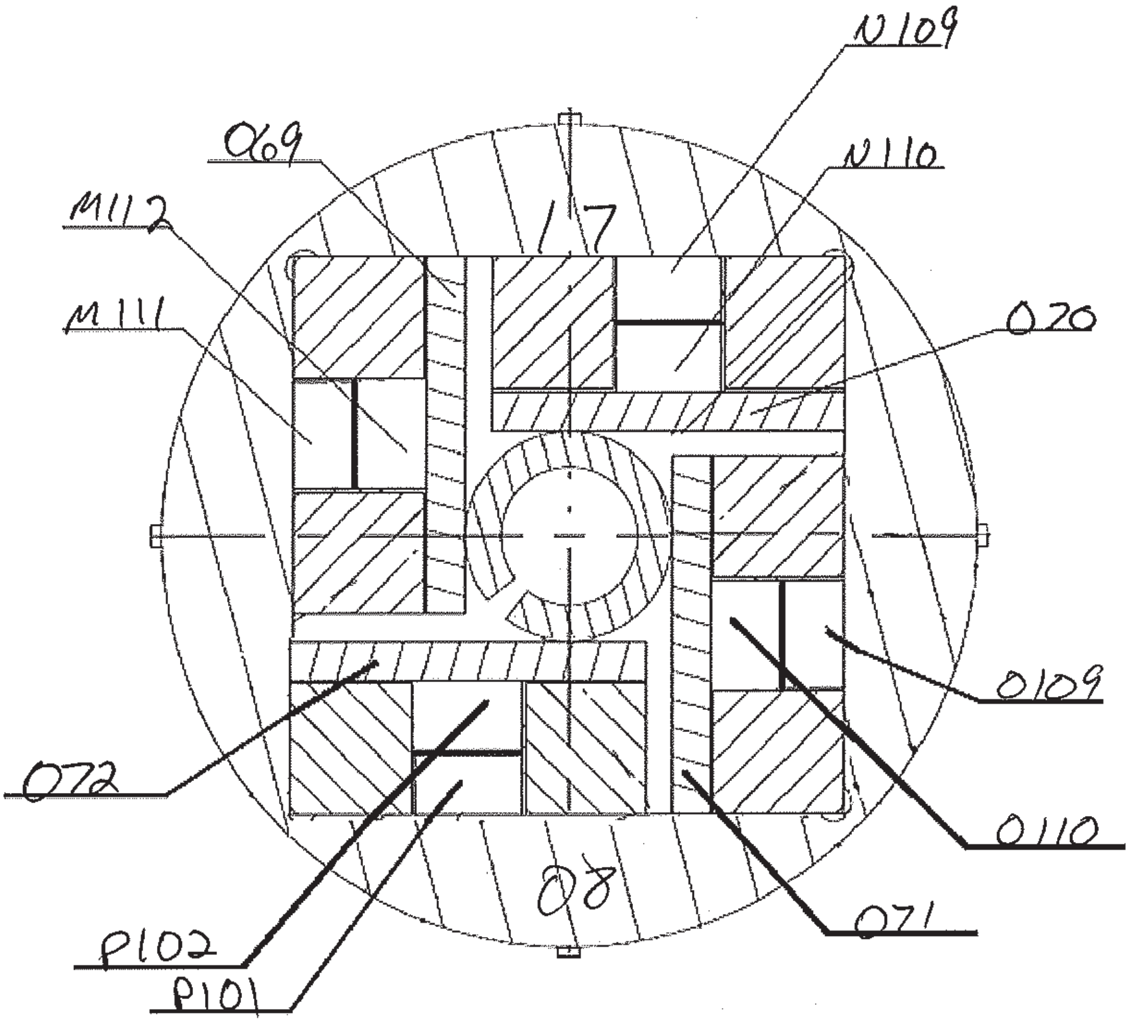
(Middle)



ES22

17-08

(Bottom)



	ES22							
Design Diameter (mm) 9.2	Tavg (°C) 330 Inner	Tavg (°C) 316 Outer						Specimen Type
17-05 Upper (X - Yc)	E294*	E292						SSJ3
	H102	H101*						SSJ3
	J302	K301	L301	M322	N321	O322		MPC1
	E342	H301	I302	O321	P301	H302		MPC1
17-06 Mid (X - Yc)	J107	J105*						SSJ3
	K102	K101*						SSJ3
	L102*	L101*						SSJ3
	I103	I102*						SSJ3
17-08 Lower (X - Yc)	M112	M111*						SSJ3
	N110	N109*						SSJ3
	O110	O109*						SSJ3
	P102	P101*						SSJ3

RABBIT ASSEMBLY: ES22

HOUSING

SN / IR NUMBER:

17-156/20838

INNER DIAMETER:

9.51mm

HOLDER(S)

SN / IR NUMBER:

17-05/20782

OUTER DIAMETER:

9.19mm

SN / IR NUMBER:

17-06/20782

OUTER DIAMETER:

9.18mm

SN / IR NUMBER:

17-08/20782

OUTER DIAMETER:

9.20mm

Caps[illegible] Fabrication Request Sheet

Date [illegible]9/2017

Capsule Number: ES31

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	300°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 12/19/17	[signature] 12/19/17
Checked by:	[signature] 12/19/17	[signature] 12/19/17

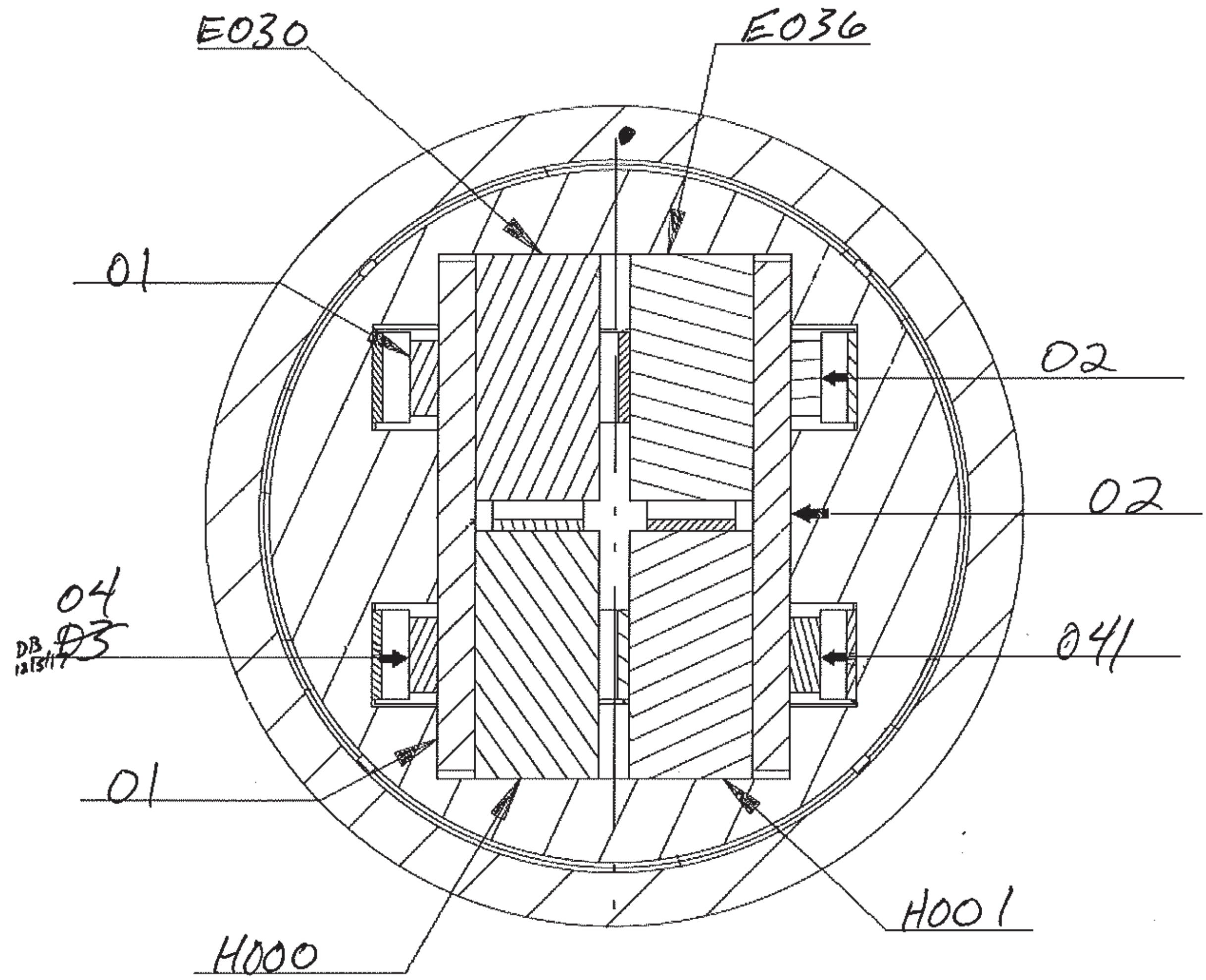
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20713	20713	17-105	4.3344
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-92	0.5147
Specimen holder	S16-24-ESTEELB	1	7	Al 6061	1		20825	20773	17-08	3.9440
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.118
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.256
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	2		20710	20710	4 total	0.110
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.010
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.017
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	E030	1.9220
									E036	1.9220
									H000	1.9090
									H001	1.9119
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	2	0.0635
									1	0.0642
									4	0.0644
									41	0.0641
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.218
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2		20824	20824	2 total	2.392
									Total Mass	19.8352
									Specimen Mass	7.6649
									Internal Mass	14.9861

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

E531



RABBIT ASSEMBLY: ES31

HOUSING

SN / IR NUMBER:

17-1Ø5/2Ø713

INNER
DIAMETER:

9.53mm

HOLDER(S)

SN / IR NUMBER:

17-Ø8/2Ø773

OUTER
DIAMETER:

9.3Ømm

Caps Fabrication Request Sheet

Capsule Number: ES32

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	300°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 12/19/17	[signature] 12/19/17
Checked by:	[signature] 12/19/17	[signature] 12/19/17

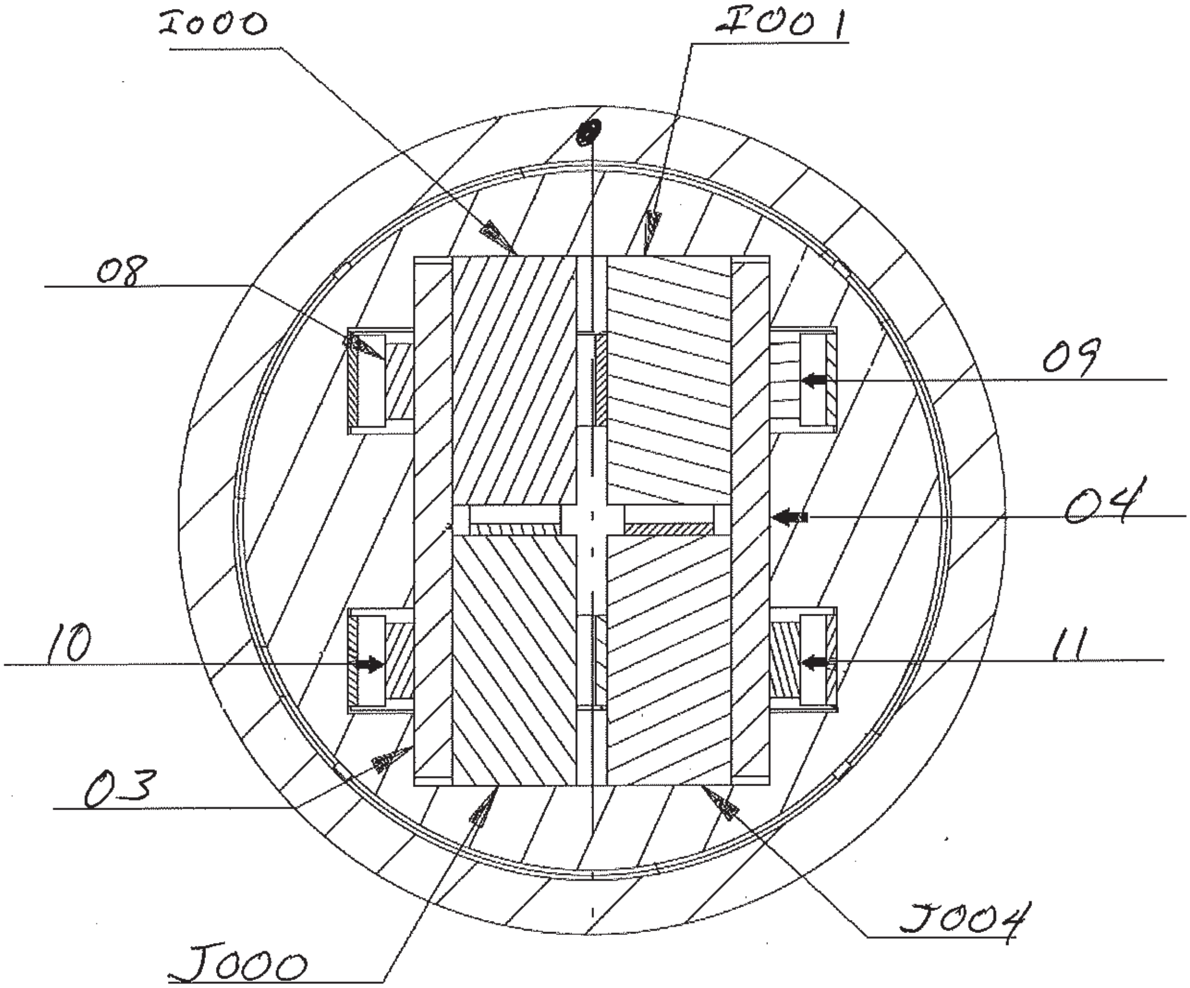
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20713	20713	17-92	4.3324
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-125	0.5108
Specimen holder	S16-24-ESTEELB	1	7	Al 6061	1		20825	20773	17-07	3.9569
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.111
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.256
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	2		20710	20710	4 total	0.015
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.011
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.019
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	I000	1.9088
									I001	1.9109
									J000	1.8994
									J004	1.8939
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	8	0.0580
									9	0.0608
									10	0.0628
									11	0.0625
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.218
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2		20824	20824	2 total	2.381
									Total Mass	19.6681
									Specimen Mass	7.6129
									Internal Mass	14.8249

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES32



RABBIT ASSEMBLY: ES32

HOUSING

SN / IR NUMBER:

17-92/2Ø713

INNER
DIAMETER:

9.52mm

HOLDER(S)

SN / IR NUMBER:

17-Ø7/2Ø773

OUTER
DIAMETER:

9.3Ømm

Caps[illegible] Fabrication Request Sheet

Capsule Number: ES33

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	300°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 12/19/17	[signature] 12/19/17
Checked by:	[signature] 12/19/17	[signature] 12/19/17

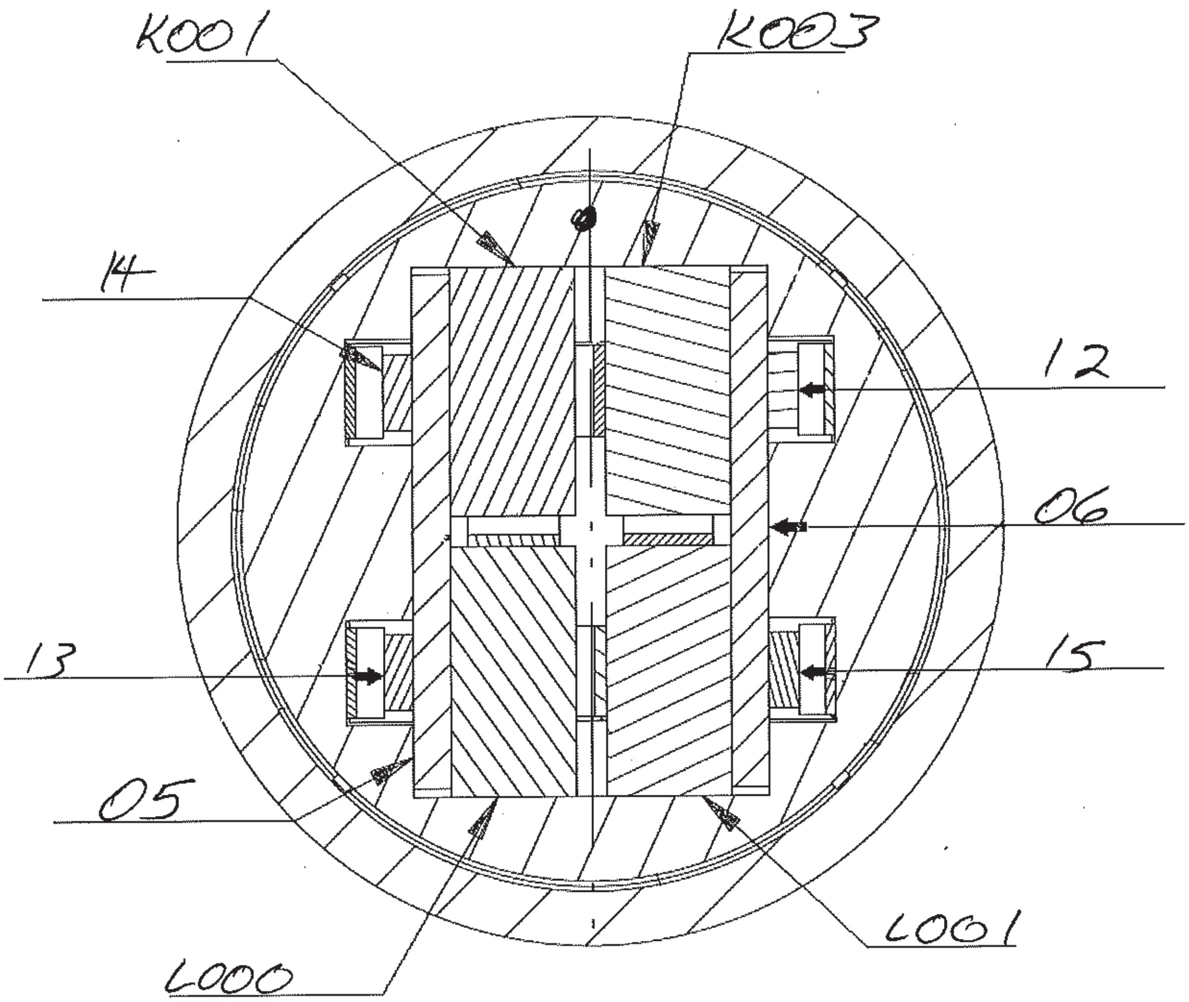
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20838	20839	17-158	4.3137
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-105	0.5155
Specimen holder	S16-24-ESTEELB	1	7	Al 6061	1		20825	20765	17-05	4.0001
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	2		19600	19600	2 total	0.117
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.255
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	2		20710	20710	4 total	0.116
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.011
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.018
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	K001	1.9095
									K003	1.9530
									L000	1.8726
									L001	1.8800
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	12	0.0630
									13	0.0633
									14	0.0629
									15	0.0639
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.219
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2		20824	20824	2 total	2.363
									Total Mass	19.7965
									Specimen Mass	7.6151
									Internal Mass	14.9673

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES33



RABBIT ASSEMBLY: ES 33

HOUSING

SN / IR NUMBER:

17-158/2Ø838

INNER
DIAMETER:

9.53mm

HOLDER(S)

SN / IR NUMBER:

17-Ø5/2Ø773

OUTER
DIAMETER:

9.32

Capsule Fabrication Request Sheet

Capsule Number: ES34

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	300°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 12/19/17	[signature] 12/19/17
Checked by:	[signature] 12/15/17	[signature] 12/19/17

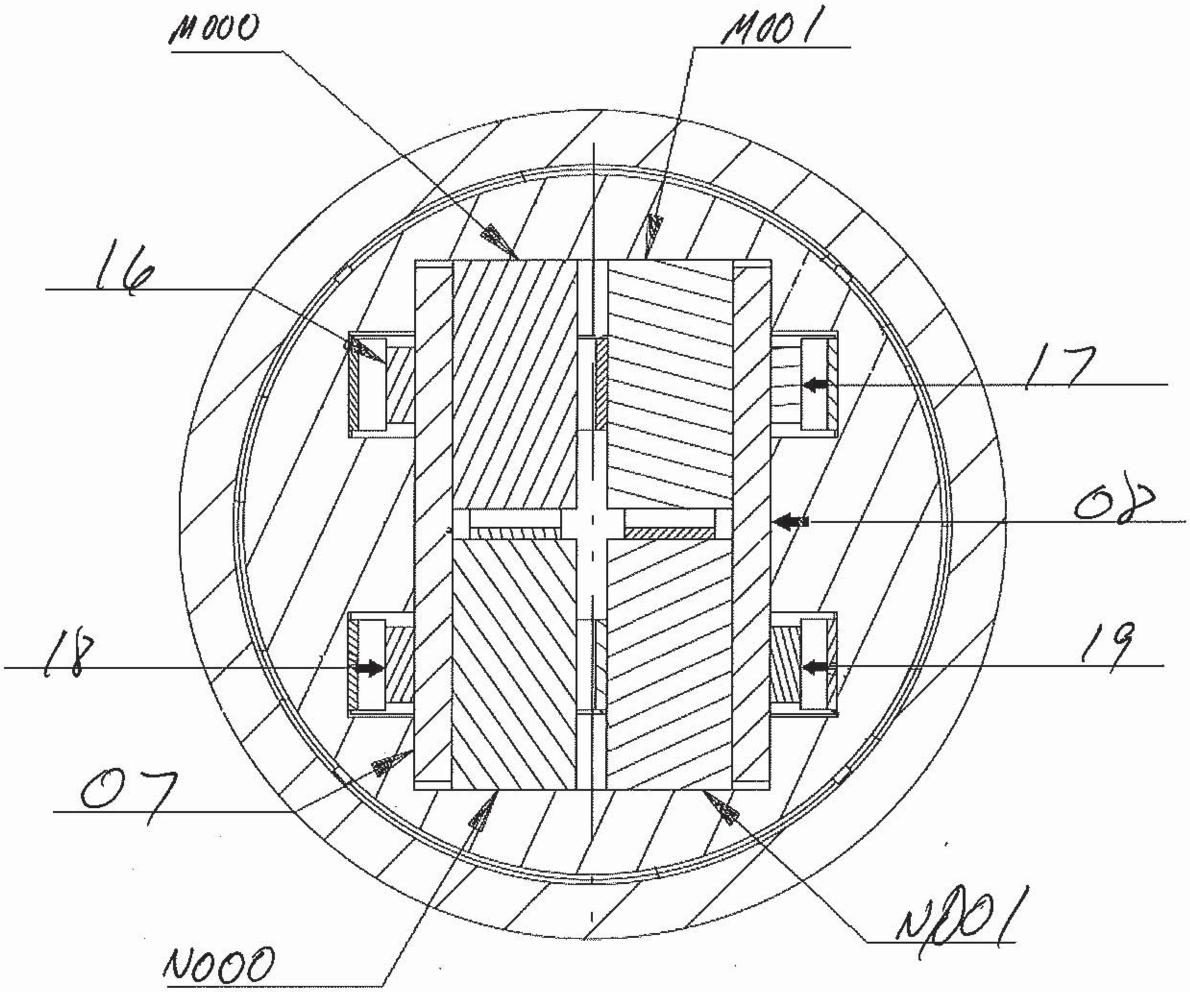
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20713	20713	17-106	4.2956
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-45	0.5145
Specimen holder	S16-24-ESTEELB	1	7	Al 6061	1		20825	20773	17-04	3.9339
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.118
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.254
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	2		20710	20710	4 total	0.117
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.011
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.019
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	M000	1.8833
									M001	1.8753
									N000	1.9121
									N001	1.9101
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	16	0.0633
									17	0.0634
									18	0.0642
									19	0.0639
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.219
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2		20824	20824	2 total	2.378
									Total Mass	19.6956
									Specimen Mass	7.5808
									Internal Mass	14.8855

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

E534



RABBIT ASSEMBLY: ES34

HOUSING

SN / IR NUMBER:

17-106/20713

INNER
DIAMETER:

9.52mm

HOLDER(S)

SN / IR NUMBER:

17-04/20773

OUTER
DIAMETER:

9.29mm

Caps[illegible] Fabrication Request Sheet

Capsule Number: ES35

Irradiation Conditions

Irradiation Location	TRRH 5
Target Fluence	4.5E+21 n/cm^2
First Cycle Goal	477
Irradiation Time	2 cycles
Irradiation Temperature	300°C
Fill Gas	Helium
Holder Design Diameter	9.30 mm

Approvals

	Request	Build
Performed by:	[signature] 12/19/17	[signature] 12/19/17
Checked by:	[signature] 12/19/17	[signature] 12/19/17

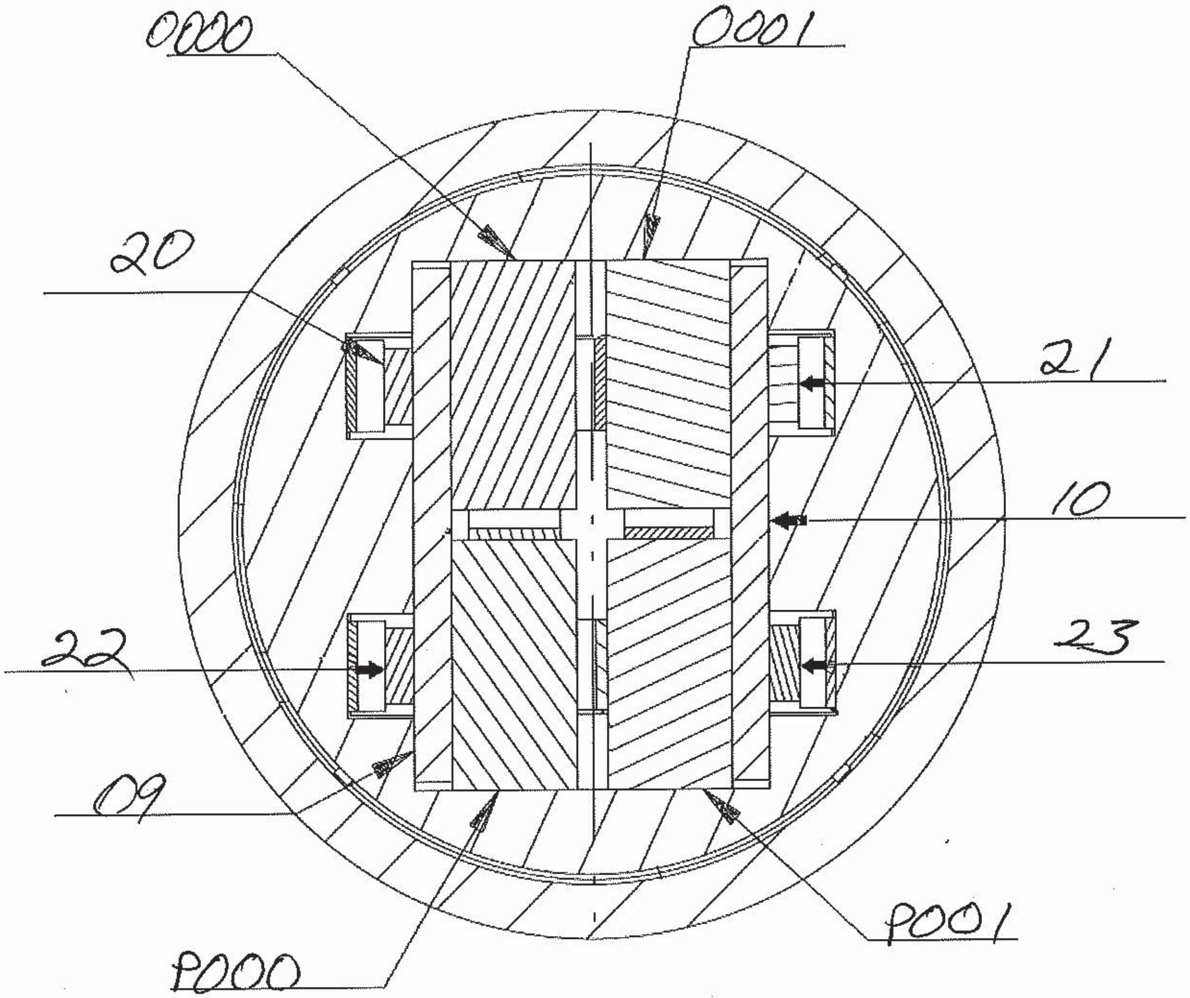
Capsule Fabrication

	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Housing	X3E020977A634	A	1	Al 6061	1		20713	20713	17-136	4.3027
Housing end cap	X3E020977A634	A	2	Al 4047	1		20714	20714	17-55	0.5149
Specimen holder	S16-24-ESTEELB	1	7	Al 6061	1		20825	20773	17-06	3.9260
Molybdenum Wire	S16-23-ESTEELB	1	4	Molybdenum	4		19600	19600	4 total	0.120
Wave Spring	S16-23-ESTEELB	1	CM08-L3-S17	17-7 SS	2		20770	20770	2 total	0.257
Support Disk	S16-23-ESTEELB	1	3	Molybdenum	2		20710	20710	4 total	0.117
Insulator Disk Small	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.011
Insulator Disk Large	S16-23-ESTEELB	1	2	Grafoil	2		19812	19812	2 total	0.018
Bend Bar Specimen	S16-24-ESTEELB	1	14	EuroFer	4		20766	20766	O000	1.8903
									O001	1.8958
									P000	1.9113
									P001	1.9101
Thermometry	S16-24-ESTEELB	1	15	SiC	4		19759	20767	20	0.0638
									21	0.0645
									22	0.0646
									23	0.0646
Retainer Spring	S16-24-ESTEELB	1	16	SiC	8		19759	19759	8 total	0.219
Filler Piece	S16-24-ESTEELB	1	17	18-8 SS	2		20824	20824	2 total	2.376
									Total Mass	19.7266
									Specimen Mass	7.6075
									Internal Mass	14.9090

Assembly

	Drawing	Rev.	Comment
Assembly Drawing	S16-23-ESTEELB	1	
Welding & Cleaning	X3E020977A633	0	
Fill Gas	Helium		

ES35



RABBIT ASSEMBLY: ES35

HOUSING

SN / IR NUMBER:

17-136/20713

INNER
DIAMETER:

9.53mm

HOLDER(S)

SN / IR NUMBER:

17-05/20765

OUTER
DIAMETER:

9.30mm