ORNL/TM-2021/2057

Assembly of MiniFuel Targets for Irradiation of TRISO Fuel Compacts in the High Flux Isotope Reactor

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OAK RIDGE National Laboratory

ORNL IS MANAGED BY UT-BATTELLE LLC FOR THE US DEPARTMENT OF ENERGY

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Nuclear Energy and Fuel Cycle Division

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Prepared by
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ABBREVIATIONS

AGR	Advanced Gas Reactor
EABD	experiment authorization bases document
EB	electron beam
FHR	fluoride-salt cooled high-temperature reactor
HFIR	High Flux Isotope Reactor
KP	Kairos Power
ORNL	Oak Ridge National Laboratory
PIE	post-irradiation examination
QA	quality assurance
SiC	silicon carbide
TRISO	tristructural isotropic
VXF	vertical experiment facility

ABSTRACT

To support the development of Kairos Power's fluoride-salt-cooled high-temperature reactor, irradiation testing of tristructural isotropic (TRISO) fuel compacts was performed at the Oak Ridge National Laboratory (ORNL) High Flux Isotope Reactor (HFIR) to collect experimental data on TRISO fuel during high particle-power operation and validate fuel performance models. Fuel compacts containing enriched uranium oxycarbide (UCO), natural UCO (NUCO), or uranium dioxide (UO_2) TRISO particles were fabricated at ORNL and inserted into MiniFuel targets for HFIR irradiation. Five MiniFuel targets were successfully assembled, welded, tested, and delivered to HFIR, along with their quality assurance documentation. The targets were inserted into HFIR's inner vertical experiment facility within the permanent beryllium reflector. Each target contains six fuel compacts and will be irradiated in HFIR for four cycles, with target temperatures of 500, 700, and 900°C. This report summarizes the experiment design, test matrix, and fabrication. This work was performed under the Nuclear Science User Facility program.

1. INTRODUCTION

The fluoride-salt-cooled high-temperature reactor (FHR) concept developed by Kairos Power (KP) leverages tristructural isotropic (TRISO) fuel in pebble form, combined with a low-pressure fluoride salt coolant. The heat transfer properties of molten salt enable high-power density, resulting in high particle powers relative to advanced gas-cooled reactor concepts. Part of the FHR development effort includes collection of experimental data on TRISO fuel during high particle power operation to validate fuel performance models and to predict the particle failure proportion. High-power TRISO particle irradiation testing is expected to demonstrate significant performance margin compared to that shown in current U.S. Advanced Gas Reactor (AGR) irradiation tests, which were performed at significantly higher temperatures (~800-1,300˚C) compared to FHR temperatures (500-700˚C).

KP and Oak Ridge National Laboratory (ORNL) have developed an irradiation campaign to investigate TRISO particle fuel performance at temperatures similar to those in an FHR core. Different kernel compositions are being explored to presumably demonstrate improved fuel performance with uranium oxycarbide (UCO) kernels at very high powers; uranium dioxide (UO_2) particles serve as a test control and have historically been the standard for high performance particle fuels [1][2]. This report summarizes the experiment design, test matrix, and fabrication.

2. EXPERIMENT DESIGN

2.1 IRRADIATION FACILITY

The experiment design is detailed in the report by Gallagher et al. [3] and is summarized in this section. Figure 1 illustrates the components of the MiniFuel experiment design. The experiment facility consists of an aluminum basket with three radial positions (R = 1, 2, 3) and three axial positions (A = 1, 2, 3), for a total of 9 positions. Two of the radial positions face the core (R = 2 and 3), and the middle axial position (A =2) is located around the core's mid-plane. MiniFuel targets can be inserted in each radial position and stacked at each axial position. A MiniFuel target is made of a stainless-steel tube sealed on both ends which contains a stack of six individually sealed subcapsules. The positions of the subcapsules in the target are referred to as S = 1 (bottom position) through S = 6 (top position). Centering thimbles made of titanium alloy are placed at each end of the subcapsules, ensuring that the gas gap between the target tube and the subcapsule is radially uniform and cannot be displaced during irradiation. The target irradiation temperature of the fuel specimens is controlled by the size of the gas gap and the fill gas thermal conductivity, which is a mixture of helium and argon gas. The subcapsule is composed of Mo and contains the fuel specimen, SiC

spacers, a Mo insert tube, SiC passive thermometry, a graphite fission product sink, and grafoil disks. A Mo end cap is welded to the holder to seal the subcapsule. All subcapsules are sealed with pure helium backfill gas.

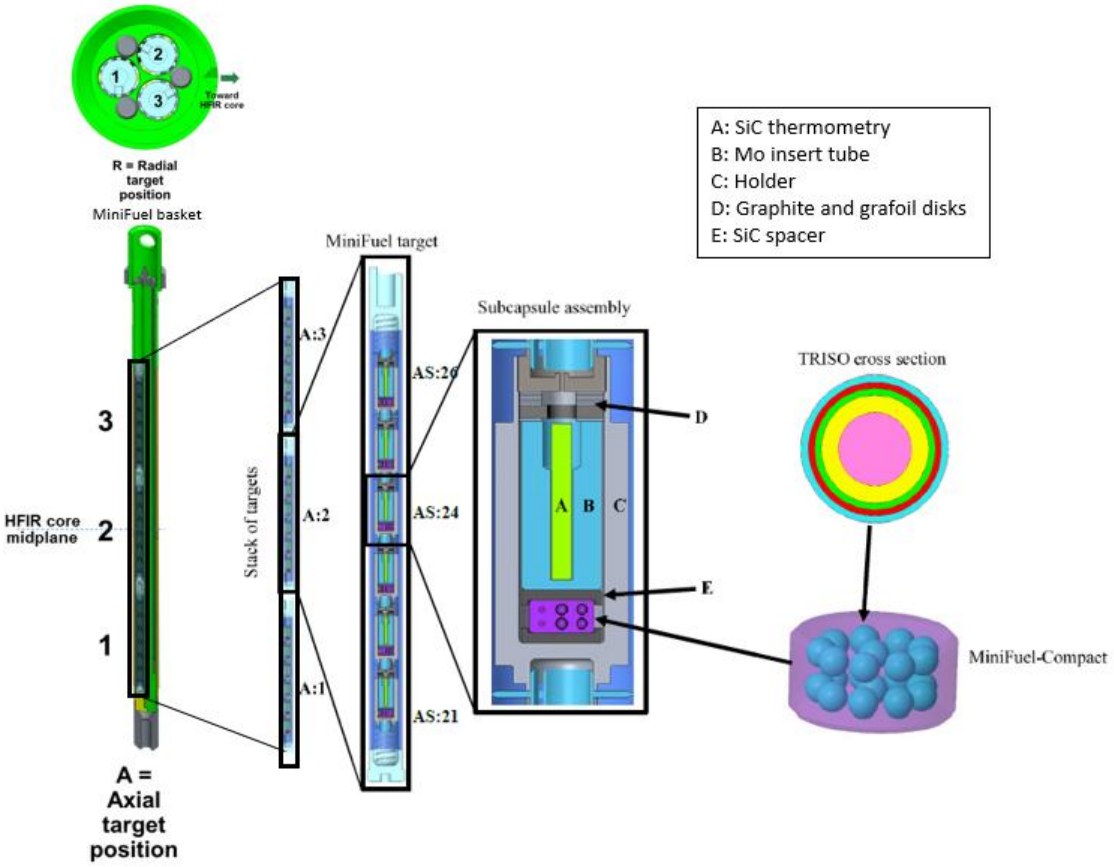

Figure 1. MiniFuel experiment design for Kairos targets [3][1].

2.2 EXPERIMENT TEST MATRIX

Table 1 provides details of the experiment irradiation test matrix, the irradiation conditions, and the specimens being inserted in the targets. Each target contains 6 TRISO compacts, containing UCO, natural UCO (NUCO), or UO_2 kernels (see section 3.1). The irradiation locations specified in Table 1 correspond to the as-inserted in HFIR target location in the MiniFuel basket.

Table 1. Irradiation test matrix

Target ID	Number of irradiation cycles	Target temperature (°C)	Compacts	Irradiation location (R-A)	Target fill gas
KP01	4	900	3 UCO + 3 UO_2	1-2	Ar
KP02		500	3 UCO + 3 NUCO	3-2	Ne equivalent (59.5% Ar/ He bal.)
KP03		500	6 UCO	3-3	Ne equivalent (59.5% Ar/ He bal.)
KP04		700	3 UCO + 3 NUCO	2-2	Ne equivalent (59.5% Ar/ He bal.)
KP05		700	6 UCO	2-3	78% Ar / 22% He

2.3 THERMAL RESULTS

To predict the irradiation temperatures of the MiniFuel compacts, neutronic and thermal analyses were performed [3]. The target temperature for each compact was defined by the time-averaged and volume-averaged irradiation temperature of the specimen TRISO SiC layers. Table 2 summarizes the thermal results [3] for each target. The radial irradiation location of the targets in the MiniFuel basket considered in the neutronic and thermal analyses [3] is different from the actual radial location where the targets were loaded for irradiation in HFIR: targets KP02/KP03 and KP04/KP05 were loaded in radial position R=3 and R=2, respectively, whereas they were considered in radial position R=2 and R=3, respectively, in the numerical analyses [3]. The as-irradiated target thermal analyses will be completed and reported in a future document.

Table 2. Thermal results of TRISO SiC layer for each target

Target ID	Temperature (ºC)		Subcapsule position					
			S=1	S=2	S=3	S=4	S=5	S=6
KP01	TRISO SiC layers	average	885	892	888	888	884	884
		maximum	985	997	996	1001	990	985
		minimum	820	827	822	819	818	820
	SiC thermometry	average	895	899	897	895	892	894
KP02	TRISO SiC layers	average	485	497	489	497	486	493
		maximum	561	516	569	516	565	511
		minimum	437	471	440	472	438	469
	SiC thermometry	average	495	499	499	500	497	501
KP03	TRISO SiC layers	average	485	483	485	487	486	489
		maximum	551	550	552	554	552	553
		minimum	436	435	438	441	442	447
	SiC thermometry	average	493	491	492	494	495	499
KP04	TRISO SiC layers	average	673	690	675	688	676	682
		maximum	764	718	766	715	765	707
		minimum	616	652	620	651	622	647
	SiC thermometry	average	690	699	691	697	693	699
KP05	TRISO SiC layers	average	677	679	678	679	677	675
		maximum	757	760	760	761	759	755
		minimum	618	619	620	621	620	620
	SiC thermometry	average	693	692	692	693	693	695
	UO_2							
	NUCO							
	UCO							

3. EXPERIMENT FABRICATION AND HFIR DELIVERY

3.1 SPECIMEN FABRICATION

ORNL fabricated fuel compacts for this experiment [4]. Each compact contains 20 UCO, NUCO, or UO_2 TRISO particles compacted in a carbon matrix. The TRISO particles were not fabricated as part of this work but were existing AGR-2 particles. Table 3 shows the uranium content per compact, enrichment, and mass of ^{235}U.

Table 3. Characteristic of the fuel for each type of compact

Compact/ kernel type	Batch #	Enrichment	U mass per compact (g)	^{235}U mass per compact (g)
NUCO	NUCO 425-08T	0.71%	0.00761	0.00005
UCO	LEU09	14.029%	0.00762	0.00107
UO_2	LEU11	9.60%	0.01215	0.00117

Pre-characterization of the compacts included dimensional inspection, density measurements, and x-ray computed tomography to provide data on kernel volume and position in the compact. The pre-characterization data are summarized in Gerczak et al. [5].

3.2 SUBCAPSULES ASSEMBLY

A total of 30 subcapsules were assembled. Figure 2 shows the parts layout for one subcapsule. The signed subassembly fabrication request forms are provided in Appendix A.

Figure 2. Subcapsule parts layout (Credit: ORNL, US Department of Energy).

All subcapsule components were dimensionally inspected and cleaned according to HFIR-approved procedures, drawings, and sketches. After internal components were assembled, the subcapsule end caps were welded to the subcapsule bodies using an electron beam (EB) weld. Figure 3 shows the subcapsules after EB welding. The subcapsules assemblies were then placed inside sealed containers that were evacuated and backfilled with ultra-high purity helium three times to ensure a pure environment. The containers were placed inside a glovebox which was also evacuated and backfilled with the same gas that was used in the sealed containers, to a pressure equivalent to local atmospheric pressure. A small hole was seal-welded in each subcapsule end cap using a gas tungsten arc welding procedure. All welds passed visual examination. Each subcapsule was then sent for nondestructive examination, which included a bubble test and a helium leak test. All assemblies passed the nondestructive examination.

Figure 3. Subcapsules after EB welding (Credit: ORNL, US Department of Energy).

3.3 TARGET ASSEMBLY

Five targets were assembled, each containing 6 subcapsules. The parts layout for one target assembly is shown in Figure 4. As can be seen in this figure, the target bottom end cap was welded to the target housing before the subcapsules were loaded. The signed target fabrication request forms are provided in Appendix A. The irradiation locations specified on the fabrication request forms do not correspond to the actual locations where the targets were loaded for HFIR irradiation (see Table 1).

Figure 4. Parts layout of one target assembly: individual parts layout (top) and assembly of centering thimbles and subcapsules (bottom) (Credit: ORNL, US Department of Energy).

All target components were dimensionally inspected and cleaned according to HFIR-approved procedures, drawings, and sketches. After loading the subcapsules, centering thimbles, and compression springs, the target top end caps were orbital welded to the target housings. The targets were then placed inside a sealed container that was evacuated and backfilled with an ultra-high-purity helium/argon mixture (see fill gas in Table 1) three times to ensure a pure environment. The containers were placed inside a glovebox which was also evacuated and backfilled with the same gas that was used in the sealed container, to a pressure equivalent to local atmospheric pressure. A small hole was seal-welded in each target assembly's top end cap using a gas tungsten arc welding procedure. All welds passed visual examination. Each target was then sent for nondestructive examination, which included a helium leak test, hydrostatic compression at a pressure of 7.1 MPa (1,035 psi), mass comparisons before and after hydrostatic compression to ensure that no water penetrated the target assembly, another post-compression helium leak test, dye penetrant inspection, and radiographic inspection. Figure 5 shows a fully welded target, along with a radiographic image of the welds. All target assemblies passed the nondestructive examination.

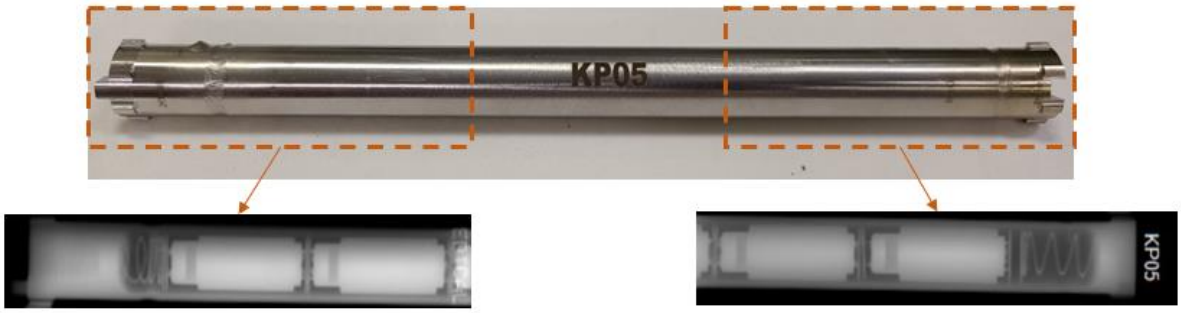

Figure 5. Final target fully welded (top), and radiography of the welds (bottom left and right) (Credit: ORNL, US Department of Energy).

3.4 LOADING IN THE MINIFUEL BASKET

The irradiation targets must be loaded into a basket assembly to keep the targets centered within the flow channel in HFIR's small vertical experiment facility (VXF). A total of 9 targets were assembled inside the basket as shown in Figure 1. For this experiment, the 5 KP targets were loaded in the MiniFuel basket (ID MFB) in the irradiation locations shown in Table 1, along with 4 stainless-steel dummy capsules.

3.5 FABRICATION PACKAGE AND DELIVERY TO HFIR

Each irradiation experiment requires a fabrication package that is reviewed by an independent design engineer, a lead quality assurance (QA) representative, and a HFIR QA representative before it can be accepted for insertion into HFIR. The fabrication package must satisfy the requirements of the experiment authorization bases document (EABD). The irradiation of miniature fuel specimen experiments falls under document EABD-HFIR-2018-001, Rev. 1 [6], which specifies requirements that the rabbits must satisfy in the following areas:

- thermal safety analyses,
- material certification,
- dimensional inspection,
- cleaning,
- assembly procedure,
- sample loading,
- fill gas,
- welding, and
- nondestructive evaluation.

The fabrication packages for the MFB assembly and the KP targets were reviewed and approved by all parties and accepted by HFIR on May 11, 2021 and June 21, 2021, respectively. The final signed acceptance page of the targets' EABD is provided in Appendix A. The loaded MFB was inserted into HFIR's small VXF-11 position starting in cycle 493 (June 2021).

4. SUMMARY AND CONCLUSIONS

Five MiniFuel targets containing TRISO compacts were inserted in HFIR to start irradiation in cycle 493 (commencing on June 29, 2021); the irradiation will be completed after 4 HFIR cycles i.e., at the end of cycle 496, which is expected to end on January 7, 2022. Ultimately, the particle failure proportion and associated failure mechanisms will be determined through well-established post-irradiation examination (PIE) techniques. The failure and fission product release mechanisms may include kernel migration, interaction of fission products with coating layers, and athermal and diffusive release of fission products.

5. REFERENCES

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[2] D.A. Petti, J. Buongiorno, J.T. Maki, R.R. Hobbins, G.K. Miller, *Key differences in the fabrication, irradiation and high temperature accident testing of US and German TRISO-coated particle fuel, and their implications on fuel performance*, Nuclear Engineering and Design, vol. 222, pages 281-297, 2003.

[3] R.C. Gallagher, Z. Wallen, C.M. Petrie, T. Gerczak, A.G. Le Coq, K. Smith, J. Harp, K.D. Linton, B. Collin, and R. Latta, *Analysis and Design of High-Power TRISO Fuel Compact Irradiation in HFIR*, ORNL/TM-2020/1658, Oak Ridge National Laboratory, Oak Ridge, TN, June 2021.

[4] T.J. Gerczak, A.K. Kercher, A.T. Schumacher, G.W. Helmreich, M. Trammell, *Fabrication of MiniFuel Compacts for High-Power Irradiation Testing of TRISO Fuel*, ORNL/SPR-2020/1778, Oak Ridge National Laboratory, Oak Ridge, TN, November 2020.

[5] T.J. Gerczak, G.W. Helmreich, C.A. Hobbs, A.K. Kercher, R. Latta, *Preirradiation Characterization of MiniFuel Compacts for High-Power Irradiation Testing of TRISO Fuel*, ORNL/TM-2021/5, Oak Ridge, TN, January 2021.

[6] Experiment Authorization Bases Document, *Irradiation of Miniature Fuel Specimens in the Inner Small VXF Positions*, EABD-HFIR-2018-001 Rev. 1, May 2021.

APPENDIX A. FABRICATION REQUEST SHEETS

APPENDIX A. FABRICATION REQUEST SHEETS

Target ID:	KP01
Irradiation Conditions	
Irradiation Location (R, A)	1 2
Number cycles	4
First Cycle Goal	491
Fill Gas	Ar
Irradiation Temperature	900°C
Holder assembly drawing	HS-2020-001 Rev. 0
Holder assembly welding drawing	HS-2020-003 Rev. 0

Approvals

	Request	Build
Performed by:	Annabelle Le Coq — Digitally signed by Annabelle Le Coq Date: 2021.05.27 09:02:41 -04'00'	Christopher Hobbs — Digitally signed by Christopher Hobbs Date: 2021.05.27 10:13:08 -04'00'
Checked by:	Ryan C. Gallagher — Digitally signed by Ryan C. Gallagher Date: 2021.05.27 10:31:32 -04'00'	David Bryant — Digitally signed by David Bryant Date: 2021.05.27 09:23:09 -04'00'

Holder Assembly

							S = sub-assembly position												
							1	2	3	4	5	6	1	2	3	4	5	6	
							Component IDs for each holder ID						Component mass (g) for each holder ID						
Component	Drawing	Rev.	Part	Material	MAT IR	FAB IR	KP121	KP122	KP123	KP124	KP125	KP126	KP121	KP122	KP123	KP124	KP125	KP126	All
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21162	20-96	N/A	N/A	N/A	N/A	N/A	7.7307	N/A	N/A	N/A	N/A	N/A	7.7307
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21167	N/A	20-106	20-110	N/A	20-103	20-102	N/A	7.8502	7.8741	N/A	7.8955	7.8223	31.4421
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21168	N/A	N/A	N/A	20-112	N/A	N/A	N/A	N/A	N/A	7.9701	N/A	N/A	7.9701
End cap	S17-14-CER_FUEL	2	2	Moly	21154	21154	20-07	20-08	20-09	20-10	20-11	20-12	0.5057	0.5207	0.5215	0.5018	0.5281	0.5112	3.0890
Tube	HS-2020-001	0	3	Moly	21100	21151	20-04	20-05	20-06	20-07	20-08	20-09	2.6305	2.6450	2.6361	2.6348	2.6227	2.6331	15.8022
Thermometry	HS-2020-001	0	6	SiC	20863	21144	001	002	003	004	005	006	0.0369	0.0371	0.0351	0.0369	0.0370	0.0373	0.2203
Insulator disk (list total # and mass)	HS-2020-001	0	7	Grafoil	19812	19812	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0870
Coated Particle Fuel Compact	HS-2020-001	0	5	UCO	21175	21175	LEU09-M01E	N/A	LEU09-M07E	N/A	LEU09-M09E	N/A	0.0623	N/A	0.0613	N/A	0.0601	N/A	0.1837
				UO2			N/A	LEU11-M01B	N/A	LEU11-M05B	N/A	LEU11-M14B	N/A	0.0673	N/A	0.0673	N/A	0.0667	0.2013
Spacer	HS-2020-001	0	2	SiC	20863	21185	20-07	20-09	20-11	20-13	20-15	20-17	0.0671	0.0641	0.0620	0.0634	0.0578	0.0607	0.3751
							20-08	20-10	20-12	20-14	20-16	20-18	0.0622	0.0617	0.0614	0.0627	0.0629	0.0605	0.3714
Disk	HS-2020-001	0	4	Graphite	21143	21143	20-04	20-05	20-06	20-07	20-08	20-09	0.0382	0.0386	0.0386	0.0379	0.0388	0.0395	0.2316
												Total	11.1481	11.2992	11.3046	11.3894	11.3174	11.2458	67.7045
												Fuel	0.0623	0.0673	0.0613	0.0673	0.0601	0.0667	0.3850

Target ID: KP01

Irradiation Conditions

Irradiation Location (R, A)	1 2
Number cycles	4
First Cycle Goal	493
Fill Gas	Ar
Irradiation Temperature	900°C
Assembly drawing	HS-2020-003 Rev. 0
Welding drawing	HD-2020-007 Rev. 0

Approvals

	Request	Build
Performed by:	Annabelle Le Coq (Digitally signed by Annabelle Le Coq Date: 2021.06.15 10:06:18 -04'00')	David Bryant (Digitally signed by David Bryant Date: 2021.06.15 08:03:59 -04'00')
Checked by:	Ryan Gallagher (Digitally signed by Ryan Gallagher Date: 2021.06.15 08:53:26 -04'00')	Christopher Hobbs (Digitally signed by Christopher Hobbs Date: 2021.06.15 09:09:35 -04'00')

Capsule Fabrication

Component	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Capsule outer tube	X3E020977A520	B	2	304 SS	1		21152	21152	20-03	63.2767
Capsule bottom end cap	X3E020977A520	B	3	304 SS	1		21150	21150	20-03	
Capsule top end cap	X3E020977A520	B	4	304 SS	1		21150	21205	20-03	15.9800
Spring	HS-2020-003	0	3	304 SS	2		20810	21197	001	0.2560
									002	0.2550
Centering thimble	HS-2020-003	0	4	Ti-6Al4V	14		21163	21163	001	0.1369
									002	0.1386
									003	0.1339
									004	0.1360
									005	0.1389
									006	0.1367
									007	0.1362
									008	0.1349
									009	0.1365
									010	0.1344
									011	0.1371
									012	0.1348
									013	0.1397
									014	0.1375
Subcapsule assembly	HS-2020-001	0	1	N/A	6		N/A	21207	KP126	11.2458
									KP125	11.3174
									KP124	11.3894
									KP123	11.3046
									KP122	11.2992
									KP121	11.1481
									Total Mass	149.3843

Holder Sub-Assemblies

Holder ID	S = Sub-Assembly Position	R-A-S (R = Radial target position, A = Axial target position)	Holder diameter (mm)	Initial
KP126	6	1-2-6	9.29	DB
KP125	5	1-2-5	9.31	DB
KP124	4	1-2-4	9.35	DB
KP123	3	1-2-3	9.30	DB
KP122	2	1-2-2	9.30	DB
KP121	1	1-2-1	9.25	DB

Target ID: KP02

Irradiation Conditions

Irradiation Location (R, A)	2 2
Number cycles	4
First Cycle Goal	491
Fill Gas	Ne equivalent
Irradiation Temperature	500°C
Holder assembly drawing	HS-2020-001 Rev. 0
Holder assembly welding drawing	HS-2020-003 Rev. 0

Approvals

	Request	Build
Performed by:	Annabelle Le Coq — Digitally signed by Annabelle Le Coq Date: 2021.05.27 09:04:22 -04'00'	Christopher Hobbs — Digitally signed by Christopher Hobbs Date: 2021.05.27 10:11:51 -04'00'
Checked by:	Ryan C. Gallagher — Digitally signed by Ryan C. Gallagher Date: 2021.05.27 10:35:54 -04'00'	David Bryant — Digitally signed by David Bryant Date: 2021.05.27 09:23:27 -04'00'

Holder Assembly

							$ = sub-assembly position												
							1	2	3	4	5	6	1	2	3	4	5	6	
							Component IDs for each holder ID						Component mass (g) for each holder ID						
Component	Drawing	Rev.	Part	Material	MAT IR	FAB IR	KP221	KP222	KP223	KP224	KP225	KP226	KP221	KP222	KP223	KP224	KP225	KP226	All
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21171	20-135	N/A	N/A	N/A	N/A	N/A	8.5492	N/A	N/A	N/A	N/A	N/A	8.5492
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21168	N/A	20-113	N/A	N/A	N/A	20-117	N/A	8.0505	N/A	N/A	N/A	8.0089	16.0594
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21172	N/A	N/A	20-140	N/A	20-136	N/A	N/A	N/A	8.5704	N/A	8.6332	N/A	17.2036
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21169	N/A	N/A	N/A	20-123	N/A	N/A	N/A	N/A	N/A	7.9940	N/A	N/A	7.9940
End cap	S17-14-CER_FUEL	2	2	Moly	21154	21154	20-13	20-14	20-15	20-16	20-41	20-18	0.5186	0.5217	0.5258	0.5307	0.5268	0.5281	3.1517
Tube	HS-2020-001	0	3	Moly	21100	21151	20-10	20-11	20-12	20-13	20-34	20-15	2.6149	2.6339	2.6360	2.6245	2.6346	2.6160	15.7599
Thermometry	HS-2020-001	0	6	SiC	20863	21144	006	007	008	009	031	011	0.0373	0.0365	0.0372	0.0374	0.0370	0.0375	0.2229
Insulator disk (list total # and mass)	HS-2020-001	0	7	Grafoil	19812	19812	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0870
Coated Particle Fuel Compact	HS-2020-001	0	5	UCO	21175	21175	LEU09-M10E	N/A	LEU09-M14E	N/A	LEU09-M16E	N/A	0.0625	N/A	0.0618	N/A	0.0618	N/A	0.1861
				NUCO			N/A	NUCO425-08T-M02F	N/A	NUCO425-08T-M03F	N/A	NUCO425-08T-M04F	N/A	0.0598	N/A	0.0592	N/A	0.0601	0.1791
Spacer	HS-2020-001	0	2	SiC	20863	21185	20-19	20-21	20-23	20-25	20-68	20-29	0.0627	0.0615	0.0637	0.0610	0.0626	0.0635	0.3750
							20-20	20-22	20-24	20-26	20-69	20-30	0.0621	0.0638	0.0625	0.0629	0.0612	0.0638	0.3763
Disk	HS-2020-001	0	4	Graphite	21143	21143	20-10	20-11	20-12	20-13	20-34	20-15	0.0392	0.0392	0.0387	0.0390	0.0391	0.0383	0.2335
												Total	11.9610	11.4814	12.0106	11.4232	12.0708	11.4307	70.3777
												Fuel	0.0625	0.0598	0.0618	0.0592	0.0618	0.0601	0.3652

Target ID: KP02

Irradiation Conditions

Irradiation Location (R, A)	2 2
Number cycles	4
First Cycle Goal	493
Fill Gas	Ne equivalent
Irradiation Temperature	500°C
Assembly drawing	HS-2020-003 Rev. 0
Welding drawing	HD-2020-007 Rev. 0

Approvals

	Request	Build
Performed by:	Annabelle Le Coq (Digitally signed by Annabelle Le Coq Date: 2021.06.15 10:08:11 -04'00')	David Bryant (Digitally signed by David Bryant Date: 2021.06.15 08:04:08 -04'00')
Checked by:	Ryan Gallagher (Digitally signed by Ryan Gallagher Date: 2021.06.15 08:53:34 -04'00')	Christopher Hobbs (Digitally signed by Christopher Hobbs Date: 2021.06.15 09:09:58 -04'00')

Capsule Fabrication

Component	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Capsule outer tube	X3E020977A520	B	2	304 SS	1		21152	21152	20-07	62.9936
Capsule bottom end cap	X3E020977A520	B	3	304 SS	1		21150	21150	20-07	
Capsule top end cap	X3E020977A520	B	4	304 SS	1		21150	21205	20-07	15.8995
Spring	HS-2020-003	0	3	304 SS	2		20810	21197	003	0.2600
									004	0.2650
Centering thimble	HS-2020-003	0	4	Ti-6Al4V	14		21163	21163	015	0.1358
									016	0.1357
									017	0.1353
									018	0.1353
									019	0.1373
									020	0.1376
									021	0.1389
									022	0.1364
									023	0.1355
									024	0.1383
									025	0.1377
									026	0.1350
									027	0.1357
									028	0.1380
Subcapsule assembly	HS-2020-001	0	1	N/A	6		N/A	21207	KP226	11.4307
									KP225	12.0708
									KP224	11.4232
									KP223	12.0106
									KP222	11.4814
									KP221	11.9610
									Total Mass	151.7083

Holder Sub-Assemblies

Holder ID	S = Sub-Assembly Position	R-A-S (R = Radial target position, A = Axial target position)	Holder diameter (mm)	Initial
KP226	6	2-2-6	9.35	DB
KP225	5	2-2-5	9.60	DB
KP224	4	2-2-4	9.37	DB
KP223	3	2-2-3	9.60	DB
KP222	2	2-2-2	9.37	DB
KP221	1	2-2-1	9.57	DB

Target ID:	KP03
Irradiation Conditions	
Irradiation Location (R, A)	2 3
Number cycles	4
First Cycle Goal	491
Fill Gas	Ne equivalent
Irradiation Temperature	500°C
Holder assembly drawing	HS-2020-001 Rev. 0
Holder assembly welding drawing	HS-2020-003 Rev. 0

Approvals

	Request	Build
Performed by:	Annabelle Le Coq — Digitally signed by Annabelle Le Coq Date: 2021.05.27 08:56:43 -04'00'	Christopher Hobbs — Digitally signed by Christopher Hobbs Date: 2021.05.27 10:11:22 -04'00'
Checked by:	Ryan C. Gallagher — Digitally signed by Ryan C. Gallagher Date: 2021.05.27 10:42:45 -04'00'	David Bryant — Digitally signed by David Bryant Date: 2021.05.27 09:23:40 -04'00'

Holder Assembly

							S = sub-assembly position												
							1	2	3	4	5	6	1	2	3	4	5	6	
							Component IDs for each holder ID						Component mass (g) for each holder ID						
Component	Drawing	Rev.	Part	Material	MAT IR	FAB IR	KP231	KP232	KP233	KP234	KP235	KP236	KP231	KP232	KP233	KP234	KP235	KP236	All
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21158	20-128	N/A	N/A	N/A	N/A	N/A	8.2680	N/A	N/A	N/A	N/A	N/A	8.2680
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21170	N/A	20-124	N/A	N/A	N/A	N/A	N/A	8.1646	N/A	N/A	N/A	N/A	8.1646
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21168	N/A	N/A	20-114	N/A	N/A	N/A	N/A	N/A	7.9140	N/A	N/A	N/A	7.9140
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21166	N/A	N/A	N/A	20-92	N/A	N/A	N/A	N/A	N/A	7.7187	N/A	N/A	7.7187
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21164	N/A	N/A	N/A	N/A	20-81	N/A	N/A	N/A	N/A	N/A	7.3943	N/A	7.3943
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21156	N/A	N/A	N/A	N/A	N/A	20-68	N/A	N/A	N/A	N/A	N/A	6.8537	6.8537
End cap	S17-14-CER_FUEL	2	2	Moly	21154	21154	20-19	20-20	20-21	20-22	20-23	20-24	0.5189	0.5151	0.5230	0.5148	0.5216	0.5126	3.1060
Tube	HS-2020-001	0	3	Moly	21100	21151	20-16	20-17	20-18	20-19	20-20	20-21	2.6360	2.6395	2.6378	2.6527	2.6402	2.6360	15.8422
Thermometry	HS-2020-001	0	6	SiC	20863	21144	013	014	015	016	017	018	0.0365	0.0377	0.0378	0.0367	0.0374	0.0375	0.2236
Insulator disk (list total # and mass)	HS-2020-001	0	7	Grafoil	19812	19812	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0870
Coated Particle Fuel Compact	HS-2020-001	0	5	UCO	21175	21175	LEU09-M17E	LEU09-M19E	LEU09-M21E	LEU09-M22E	LEU09-M24E	LEU09-M25E	0.0614	0.0618	0.0628	0.0607	0.0616	0.0613	0.3696
Spacer	HS-2020-001	0	2	SiC	20863	21185	20-32	20-34	20-36	20-38	20-40	20-42	0.0653	0.0621	0.0640	0.0657	0.0651	0.0576	0.3798
							20-33	20-35	20-37	20-39	20-41	20-43	0.0650	0.0653	0.0635	0.0641	0.0604	0.0635	0.3818
Disk	HS-2020-001	0	4	Graphite	21143	21143	20-16	20-17	20-18	20-19	20-20	20-34	0.0394	0.0389	0.0391	0.0389	0.0388	0.0391	0.2342
												Total	11.7050	11.5995	11.3565	11.1668	10.8339	10.2758	66.9375
												Fuel	0.0614	0.0618	0.0628	0.0607	0.0616	0.0613	0.3696

Target ID: KP03

Irradiation Conditions

Irradiation Location (R, A)	2 3
Number cycles	4
First Cycle Goal	493
Fill Gas	Ne equivalent
Irradiation Temperature	500°C
Assembly drawing	HS-2020-003 Rev. 0
Welding drawing	HD-2020-007 Rev. 0

Approvals

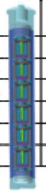
	Request	Build
Performed by:	Annabelle Le Coq Digitally signed by Annabelle Le Coq Date: 2021.06.15 10:10:14 -04'00'	David Bryant Digitally signed by David Bryant Date: 2021.06.15 08:04:16 -04'00'
Checked by:	Ryan Gallagher Digitally signed by Ryan Gallagher Date: 2021.06.15 08:53:42 -04'00'	Annabelle Le Coq Digitally signed by Annabelle Le Coq Date: 2021.06.15 10:10:22 -04'00'

Capsule Fabrication

Component	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Capsule outer tube	X3E020977A520	B	2	304 SS	1		21152	21152	20-04	62.4743
Capsule bottom end cap	X3E020977A520	B	3	304 SS	1		21150	21150	20-04	
Capsule top end cap	X3E020977A520	B	4	304 SS	1		21150	21205	20-04	15.9134
Spring	HS-2020-003	0	3	304 SS	2		20810	21197	005	0.2630
									006	0.2520
Centering thimble	HS-2020-003	0	4	Ti-6Al4V	14		21163	21163	029	0.1375
									030	0.1378
									031	0.1361
									032	0.1337
									033	0.1378
									034	0.1357
									035	0.1369
									036	0.1379
									037	0.1367
									038	0.1364
									039	0.1369
									040	0.1362
									041	0.1340
									042	0.1361
Subcapsule assembly	HS-2020-001	0	1	N/A	6		N/A	21207	KP236	10.2758
									KP235	10.8339
									KP234	11.1668
									KP233	11.3565
									KP232	11.5995
									KP231	11.7050
									Total Mass	147.7499

Holder Sub-Assemblies

Holder ID	S = Sub-Assembly Position	R-A-S (R = Radial target position, A = Axial target position)	Holder diameter (mm)	Initial
KP236	6	2-3-6	8.90	DB
KP235	5	2-3-5	9.13	DB
KP234	4	2-3-4	9.24	DB
KP233	3	2-3-3	9.35	DB
KP232	2	2-3-2	9.43	DB
KP231	1	2-3-1	9.46	DB



Target ID:	KP04

Irradiation Conditions

Irradiation Location (R, A)	3 2
Number cycles	4
First Cycle Goal	491
Fill Gas	Ne equivalent
Irradiation Temperature	700°C
Holder assembly drawing	HS-2020-001 Rev. 0
Holder assembly welding drawing	HS-2020-003 Rev. 0

Approvals

	Request	Build
Performed by:	Annabelle Le Coq — Digitally signed by Annabelle Le Coq Date: 2021.05.27 08:59:05 -04'00'	Christopher Hobbs — Digitally signed by Christopher Hobbs Date: 2021.05.27 10:10:50 -04'00'
Checked by:	Ryan C. Gallagher — Digitally signed by Ryan C. Gallagher Date: 2021.05.27 10:43:32 -04'00'	David Bryant — Digitally signed by David Bryant Date: 2021.05.27 09:26:00 -04'00'

Holder Assembly

							$ = sub-assembly position												
							1	2	3	4	5	6	1	2	3	4	5	6	
							Component IDs for each holder ID						Component mass (g) for each holder ID						
Component	Drawing	Rev.	Part	Material	MAT IR	FAB IR	KP321	KP322	KP323	KP324	KP325	KP326	KP321	KP322	KP323	KP324	KP325	KP326	All
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21155	20-79	N/A	N/A	N/A	N/A	N/A	7.2960	N/A	N/A	N/A	N/A	N/A	7.2960
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21161	N/A	20-55	N/A	N/A	N/A	20-56	N/A	6.0689	N/A	N/A	N/A	6.0707	12.1396
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21165	N/A	N/A	20-86	N/A	20-90	N/A	N/A	N/A	7.5391	N/A	7.5134	N/A	15.0525
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21157	N/A	N/A	N/A	20-61	N/A	N/A	N/A	N/A	N/A	6.2241	N/A	N/A	6.2241
End cap	S17-14-CER_FUEL	2	2	Moly	21154	21154	20-25	20-26	20-27	20-28	20-29	20-31	0.5192	0.5165	0.5209	0.5320	0.5142	0.5208	3.1236
Tube	HS-2020-001	0	3	Moly	21100	21151	20-22	20-23	20-24	20-25	20-26	20-27	2.6530	2.6438	2.6177	2.6398	2.6301	2.6349	15.8193
Thermometry	HS-2020-001	0	6	SiC	20863	21144	019	020	021	022	023	024	0.0369	0.0367	0.0369	0.0366	0.0372	0.0367	0.2210
Insulator disk (list total # and mass)	HS-2020-001	0	7	Grafoil	19812	19812	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0870
Coated Particle Fuel Compact	HS-2020-001	0	5	UCO	21175	21175	LEU09-M26E	N/A	LEU09-M29E	N/A	LEU09-M32E	N/A	0.0615	N/A	0.0624	N/A	0.0612	N/A	0.1851
				NUCO			N/A	NUCO425-08T-M05F	N/A	NUCO425-08T-M07F	N/A	NUCO425-08T-M08F	N/A	0.0594	N/A	0.0599	N/A	0.0607	0.1800
Spacer	HS-2020-001	0	2	SiC	20863	21185	20-44	20-46	20-48	20-50	20-52	20-54	0.0638	0.0653	0.0621	0.0662	0.0656	0.0669	0.3899
							20-45	20-47	20-49	20-51	20-53	20-55	0.0643	0.0650	0.0653	0.0633	0.0619	0.0647	0.3845
Disk	HS-2020-001	0	4	Graphite	21143	21143	20-21	20-22	20-23	20-24	20-25	20-26	0.0391	0.0390	0.0393	0.0388	0.0391	0.0392	0.2345
												Total	10.7483	9.5091	10.9582	9.6752	10.9372	9.5091	61.3371
												Fuel	0.0615	0.0594	0.0624	0.0599	0.0612	0.0607	0.3651

Target ID: KP04

Irradiation Conditions

Irradiation Location (R, A)	3 2
Number cycles	4
First Cycle Goal	493
Fill Gas	Ne equivalent
Irradiation Temperature	700°C
Assembly drawing	HS-2020-003 Rev. 0
Welding drawing	HD-2020-007 Rev. 0

Approvals

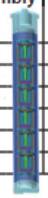
	Request	Build
Performed by:	Annabelle Le Coq Digitally signed by Annabelle Le Coq Date: 2021.06.15 10:10:55 -04'00'	David Bryant Digitally signed by David Bryant Date: 2021.06.15 08:04:24 -04'00'
Checked by:	Ryan Gallagher Digitally signed by Ryan Gallagher Date: 2021.06.15 08:53:49 -04'00'	Annabelle Le Coq Digitally signed by Annabelle Le Coq Date: 2021.06.15 10:11:04 -04'00'

Capsule Fabrication

Component	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Capsule outer tube	X3E020977A520	B	2	304 SS	1		21152	21152	20-05	63.1820
Capsule bottom end cap	X3E020977A520	B	3	304 SS	1		21150	21150	20-05	
Capsule top end cap	X3E020977A520	B	4	304 SS	1		21150	21205	20-05	15.9122
Spring	HS-2020-003	0	3	304 SS	2		20810	21197	007	0.2610
									008	0.2630
Centering thimble	HS-2020-003	0	4	Ti-6Al4V	14		21163	21163	043	0.1372
									044	0.1381
									045	0.1367
									046	0.1332
									047	0.1360
									048	0.1362
									049	0.1378
									050	0.1351
									051	0.1380
									052	0.1381
									053	0.1346
									054	0.1359
									055	0.1369
									056	0.1350
Subcapsule assembly	HS-2020-001	0	1	N/A	6		N/A	21207	KP326	9.5091
									KP325	10.9372
									KP324	9.6752
									KP323	10.9582
									KP322	9.5091
									KP321	10.7483
									Total Mass	142.8641

Holder Sub-Assemblies

Holder ID	S = Sub-Assembly Position	R-A-S (R = Radial target position, A = Axial target position)	Holder diameter (mm)	Initial
KP326	6	3-2-6	8.58	DB
KP325	5	3-2-5	9.17	DB
KP324	4	3-2-4	8.64	DB
KP323	3	3-2-3	9.18	DB
KP322	2	3-2-2	8.58	DB
KP321	1	3-2-1	9.08	DB



Target ID:	KP05
Irradiation Conditions	
Irradiation Location (R, A)	3 3
Number cycles	4
First Cycle Goal	491
Fill Gas	22%He-78% Ar
Irradiation Temperature	700°C
Holder assembly drawing	HS-2020-001 Rev. 0
Holder assembly welding drawing	HS-2020-003 Rev. 0

Approvals

	Request	Build
Performed by:	Annabelle Le Coq — Digitally signed by Annabelle Le Coq Date: 2021.05.27 09:06:04 -04'00'	Christopher Hobbs — Digitally signed by Christopher Hobbs Date: 2021.05.27 10:10:21 -04'00'
Checked by:	Ryan C. Gallagher — Digitally signed by Ryan C. Gallagher Date: 2021.05.27 10:44:29 -04'00'	David Bryant — Digitally signed by David Bryant Date: 2021.05.27 09:28:00 -04'00'

Holder Assembly

							S = sub-assembly position												
							1	2	3	4	5	6	1	2	3	4	5	6	
							Component IDs for each holder ID						Component mass (g) for each holder ID						
Component	Drawing	Rev.	Part	Material	MAT IR	FAB IR	KP331	KP332	KP333	KP334	KP335	KP336	KP331	KP332	KP333	KP334	KP335	KP336	All
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21167	20-105	N/A	N/A	N/A	N/A	N/A	7.8507	N/A	N/A	N/A	N/A	N/A	7.8507
Holder	S17-14-CER_FUEL	2	1	Moly	21093	21166	N/A	20-94	N/A	N/A	N/A	N/A	N/A	7.6926	N/A	N/A	N/A	N/A	7.6926
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21164	N/A	N/A	20-80	N/A	N/A	N/A	N/A	N/A	7.3739	N/A	N/A	N/A	7.3739
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21159	N/A	N/A	N/A	20-73	N/A	N/A	N/A	N/A	N/A	7.0380	N/A	N/A	7.0380
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21160	N/A	N/A	N/A	N/A	20-64	N/A	N/A	N/A	N/A	N/A	6.6055	N/A	6.6055
Holder	S17-14-CER_FUEL	2	1	Moly	21154	21173	N/A	N/A	N/A	N/A	N/A	20-53	N/A	N/A	N/A	N/A	N/A	5.7590	5.7590
End cap	S17-14-CER_FUEL	2	2	Moly	21154	21154	20-32	20-33	20-34	20-35	20-36	20-38	0.5101	0.5148	0.5131	0.5158	0.5209	0.5199	3.0946
Tube	HS-2020-001	0	3	Moly	21100	21151	20-28	20-29	20-30	20-31	20-32	20-33	2.6567	2.6305	2.6133	2.6245	2.6173	2.6375	15.7798
Thermometry	HS-2020-001	0	6	SiC	20863	21144	025	026	027	028	029	030	0.0371	0.0370	0.0372	0.0367	0.0363	0.0372	0.2215
Insulator disk (list total # and mass)	HS-2020-001	0	7	Grafoil	19812	19812	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	5 pcs	0.0145	0.0145	0.0145	0.0145	0.0145	0.0145	0.0870
Coated Particle Fuel Compact	HS-2020-001	0	5	UCO	21175	21175	LEU09-M34E	LEU09-M35E	LEU09-M36E	LEU09-M38E	LEU09-M39E	LEU09-M42E	0.0627	0.0611	0.0620	0.0610	0.0610	0.0621	0.3699
Spacer	HS-2020-001	0	2	SiC	20863	21185	20-56	20-58	20-60	20-61	20-63	20-65	0.0651	0.0659	0.0590	0.0666	0.0651	0.065	0.3867
							20-57	20-59	20-31	20-62	20-64	20-66	0.0632	0.0631	0.0643	0.0633	0.0636	0.0606	0.3781
Disk	HS-2020-001	0	4	Graphite	21143	21143	20-27	20-28	20-29	20-30	20-31	20-32	0.0391	0.0389	0.0392	0.0383	0.0387	0.0384	0.2326
												Total	11.2992	11.1184	10.7765	10.4587	10.0229	9.1942	62.8699
												Fuel	0.0627	0.0611	0.0620	0.0610	0.0610	0.0621	0.3699

Target ID: KP05

Irradiation Conditions

Irradiation Location (R, A)	3 3
Number cycles	4
First Cycle Goal	493
Fill Gas	22%He-78% Ar
Irradiation Temperature	700°C
Assembly drawing	HS-2020-003 Rev. 0
Welding drawing	HD-2020-007 Rev. 0

Approvals

	Request	Build
Performed by:	Annabelle Le Coq Digitally signed by Annabelle Le Coq Date: 2021.06.15 10:14:09 -04'00'	David Bryant Digitally signed by David Bryant Date: 2021.06.15 08:04:33 -04'00'
Checked by:	Ryan Gallagher Digitally signed by Ryan Gallagher Date: 2021.06.15 08:53:57 -04'00'	Christopher Hobbs Digitally signed by Christopher Hobbs Date: 2021.06.15 09:10:18 -04'00'

Capsule Fabrication

Component	Drawing	Rev.	Part	Material	Count	Comment	MAT IR	FAB IR	ID	Mass (g)
Capsule outer tube	X3E020977A520	B	2	304 SS	1		21152	21152	20-08	63.0095
Capsule bottom end cap	X3E020977A520	B	3	304 SS	1		21150	21150	20-08	
Capsule top end cap	X3E020977A520	B	4	304 SS	1		21150	21205	20-08	15.9351
Spring	HS-2020-003	0	3	304 SS	2		20810	21197	009	0.2570
									010	0.2620
Centering thimble	HS-2020-003	0	4	Ti-6Al4V	14		21163	21163	057	0.1386
									058	0.1367
									059	0.1363
									060	0.1364
									061	0.1353
									062	0.1380
									063	0.1369
									064	0.1334
									065	0.1379
									066	0.1378
									067	0.1344
									068	0.1375
									069	0.1363
									070	0.1376
Subcapsule assembly	HS-2020-001	0	1	N/A	6		N/A	21207	KP336	9.1942
									KP335	10.0229
									KP334	10.4587
									KP333	10.7765
									KP332	11.1184
									KP331	11.2992
									Total Mass	144.2466

Holder Sub-Assemblies

Holder ID	S = Sub-Assembly Position	R-A-S (R = Radial target position, A = Axial target position)	Holder diameter (mm)	Initial
KP336	6	3-3-6	8.44	DB
KP335	5	3-3-5	8.80	DB
KP334	4	3-3-4	8.98	DB
KP333	3	3-3-3	9.13	DB
KP332	2	3-3-2	9.23	DB
KP331	1	3-3-1	9.29	DB

APPENDIX B. EXPERIMENT AUTHORIZATION BASES DOCUMENT

APPENDIX B. EXPERIMENT AUTHORIZATION BASES DOCUMENT

Section 6: Acceptance for Use of As-Built Experiment Capsule

Note: This section is used to document acceptance of the as-built experiment for reactor installation and irradiation. This section is completed **after** completion of Section 2. See notes for explanation of signatures.

1. List Applicable Component Identifications:

Basket ID: MFB
Flux monitor IDs for Basket: 1, 2 & 3

Target I.D. (as marked)	Dummy target
KP01	☐
KP02	☐
KP03	☐
KP04	☐
KP05	☐
	☐
	☐
	☐
	☐

2. Approvals (see notes for explanation of signature responsibilities)

Ryan C. Gallagher Lead Experimenter	Ryan C. Gallagher Lead Experimenter (signature)	06/16/2021 Date
MC Vance Lead QA	MC Vance Lead QA (signature)	06/17/2021 Date
DAVID S. KOZLOWSKY RRD NQR	David S Kozlowsky RRD QA (signature)	6/18/2021 Date
Greg Hirtz E&FI Staff	Greg Hirtz E&FI Staff (signature)	6/21/2021 Date
* B. L. Lee RRD Criticality Safety Officer	B. L. Lee RRD Criticality Safety Officer (signature)	06/02/2021 Date
David Stanley HFIR MBA Representative	David Stanley HFIR MBA Representative (signature)	6/21/21 Date
David Stanley HFIR Operations (print name)	David Stanley HFIR Operations (signature)	6/21/21 Date

* RRD Criticality Safety Office item is pre-signed on the basis that the design content will not deviate and conforms to the specifications contained in this EABD. If Att B identifies a NCR or Deviation then the CSO shall be included as party to the specific document or shall acknowledge the change by initial and date in the above signature block.