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Preparation & shipping of ten neutron irradiated Eurofer97 steel variants to HFIR for SANS experiments

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December 2022

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Materials Science and Technology Division

Preparation & shipping of ten neutron irradiated Eurofer97 steel variants to HFIR for SANS experiments

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1.1 Introduction

At ORNL, ten variants of Eurofer97 steel were irradiated in the high flux isotope reactor (HFIR) to ~2.94 – 3.24 dpa at 300 ± 30 °C, as part of the EUROfusion Lot-IV collaboration. The irradiations were performed in non-instrumented rabbit capsules in the flux trap region, which included SS-J3 type tensile samples and M4-CVN multi-notch bend bars. Their full set of microstructure and mechanical properties were previously reported in multiple previous publications [1,2,3]. In this project, half-broken irradiated and nonirradiated SS-J3 tensile samples from ten alloys, code-named H, I, J, K, L, M, N, O, P and E, were prepared and shipped for facilitating small angle neutron scattering (SANS) experiments at the HFIR general purpose (GP)-SANS beam line. This report summarizes the completed tasks which included canister moves at the Irradiated Materials Examination and Testing (IMET) hot-cell facility to retrieve the samples from long-term storage, loading of the ten irradiated samples at IMET inside lead (Pb) piglets that were specifically provided by ORNL for SANS experiments and radiological shipment from IMET facility to the HFIR hot cells for performing SANS experiments. In addition to the irradiated samples, ten nonirradiated half-broken pieces from the Eurofer97 variants were also provided to HFIR for SANS.

1.2 Materials

Tables 1 and 2 summarizes the chemistries and processing conditions for the ten Eurofer97 steel variants that were irradiated in HFIR.

Table 1. Summary of different Eurofer-97 steel variants. AQ: air quenched, WQ: water quenched, LT: low temperature application, HT: high temperature application.

Code	Material type	Heat	Processing Details	Provider
E	EUROFER97/2	993391	980°C/0.5h + AQ + 760°C + AC	KIT
H	EUROFER-LT	J362A	1000°C/0.5h + WQ + 820°C + AC	KIT
I	EUROFER-LT	J363A	1000°C/0.5h + WQ + 820°C + AC	KIT
P	EUROFER-LT	J361A	1000°C/0.5h + WQ + 820°C + AC	KIT
L	EUROFER97/2	994578	1150°C/0.5h + AQ + 700°C + AC	CEA
J	EUROFER-LT	I196C	TMT:1250°C/1h and then rolling to a final rolling temperature of 850°C in 6 rolling steps with a reduction of 20-30% for each rolling pass, then AC. Q&T: 880°C/0.5h+WQ+750°C/2h+AC	SCK.CEN
K	EUROFER-HT	I427A	TMT:1250°C/1h and then rolling to a final rolling temperature of 850°C in 6 rolling steps with a reduction of 20-30% for each rolling pass, then AC. Q&T: 1050°C/15min + WQ + 675°C/1.5h + AC	SCK.CEN
M	EUROFER97/2	993391	1020°C/0.5h + AQ + 1020°C/0.5h + AQ +760°C/1.5h + AC (double austenitization)	ENEA
O	EUROFER-LT	VM2991	TMT: 1080°C/1h, cooling to 650°C and rolling, reduction 40% (from 30 mm to 18mm) Tempering: 760°C/1h + AC	ENEA
N	EUROFER-LT	VM2897	920°C/1.5h + AQ + 920°C/1.5h + AQ + 760°C/1h + AC (double austenitization)	ENEA

Table 2. Chemical compositions of different Eurofer-97 steel variants. All values are in wt.%.

Element	P	H	I	E, M	L	J	K	O	N
Cr	8.7	8.7	8.73	8.83	9.14	9	7.84	8.8	9.04
C	0.105	0.0583	0.11	0.107	0.106	0.107	0.017	0.06	0.092
Mn	0.021	0.0223	0.0189	0.527	0.54	0.39	<0.03	0.5	0.11
V	0.2	0.353	0.351	0.2	0.2	0.22	0.2212	0.3	<0.05
N	0.0445	0.0465	0.0422	0.019	0.038	0.022	0.022	0.07	0.0024
W	1.14	1.07	1.08	1.081	1.11	1.1	0.99	0.97	0.99
Ta	0.093	0.1	0.0918	0.117	0.12	0.11	0.1265	0.05	0.092
Si	0.032	0.0362	0.0363	0.0352	0.025	<0.04	<0.04	0.15	0.037
S	0.0015	0.0014	0.0011	0.0009	0.0037	0.0011	0.0011	0.003	0.001
B	<0.0005	<0.0005	<0.0005	<0.0005	0.0011	<0.0005	<0.0005	<0.001	<0.001

Ti	<0.0001	<0.0001	<0.0001	<0.0001	0.001	<0.0001	<0.0001	<0.01	<0.01
O	0.0036	0.0022	0.0052	0.0043	<0.001	0.007	0.0043	0.006	<0.004
Nb	<0.0004	<0.0004	<0.0004	<0.0004	0.004	<0.0004	<0.0004	<0.01	<0.01
Mo	0.0012	0.0009	0.0009	0.0009	0.002			<0.01	<0.01
Ni	0.0057	0.004	0.0036	0.0034	0.01			<0.02	<0.02
Cu	0.0075	0.0077	0.0072	0.007	0.003			<0.01	<0.01
Al	0.0016	0.0017	0.0014	0.0012	0.002			<0.01	<0.01
Co	0.0021	0.0017	0.0017	0.0017	0.003			<0.01	<0.01
As,Zr,Sn,Sb					<0.007			<0.005	<0.005
P					0.0015			<0.006	<0.005

1.3 Background on Irradiation Conditions

Neutron irradiations were performed at 85 MW_{th} mixed spectrum HFIR at ORNL, in the flux trap rabbit facility. For irradiations on tensile samples, the experiments were conducted using two general purpose tensile (GENTEN) rabbit capsules that were designed to target temperatures of 285±20 °C and 315±20 °C. Type SS-J3 flat tensile specimens having the dimensions: 16 mm (length) x 4 mm (width) x 0.75 mm (thickness) and gauge dimensions of 5 mm (length) and 1.2 mm (width) were irradiated inside the sealed non-instrumented GENTEN capsule. Capsule design for the SS-J3 samples and FEM predictions of temperature distribution, as previously reported by Howard and Smith [4], are given in Figure 1. The capsules were inserted in HFIR cycle 477A (4 days), stayed in for cycle 477B (20 days) and cycle 478 (24 days) for a total of 48 days of irradiation. This corresponded to ~4063 MWD (megawatt days) at nominal operating power. The accumulated fast neutron fluence (E > 0.1 MeV) in the two capsules were: 4.15×10^{25} n/m^2 and 4.57×10^{25} n/m^2. Using a displacement threshold energy of 40 eV for Fe and Cr, the estimated doses were 2.94 and 3.24 dpa, respectively. The axial fast flux variation for the two radial positions used in the HFIR flux trap and the fast flux variation across the two capsules are shown in Figure 2. The center of the two rabbit capsules was located ~5 cm above and ~7 cm below the midplane of the reactor, thereby providing relatively flat axial flux profile with less than ~7% variation across the holders. The samples were held in three smaller cylindrical holders located inside each capsule. Because the length of an SS-J3 sample/holder is significantly smaller as compared to the length of a capsule, the neutron flux/dose variation along the length of a single SS-J3 sample was <2%. In addition to SS-J3 samples, the capsules contained a total of twenty-four SiC thermometry pieces (twelve inside each capsule) for sample irradiation temperature estimation. More details about the irradiation capsule geometry, including the arrangement of the samples inside the capsules, can be found Refs. [1,4].

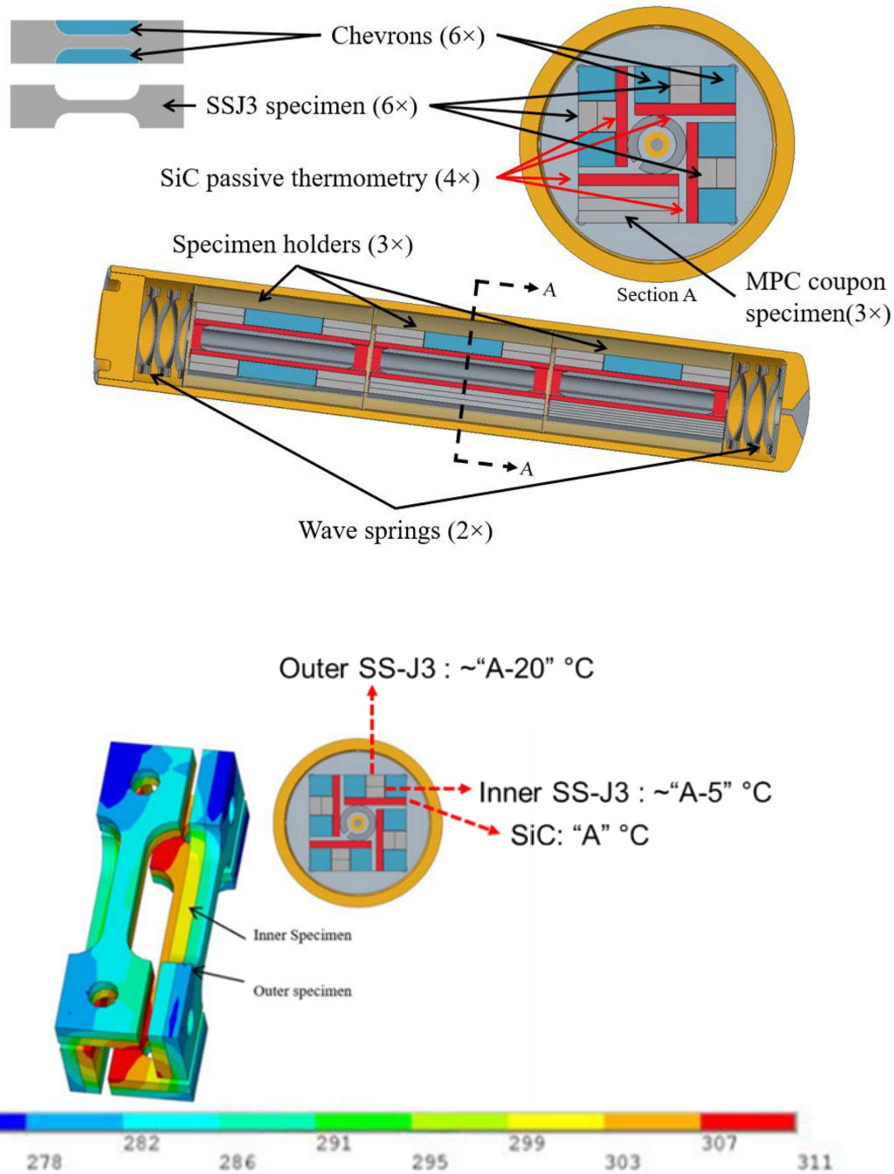


Figure 1: Capsule design for the SS-J3 samples as detailed in Ref. [2], FEM temperature distribution and the expected sample temperatures based on SiC thermometry. Adapted from Ref. [4].

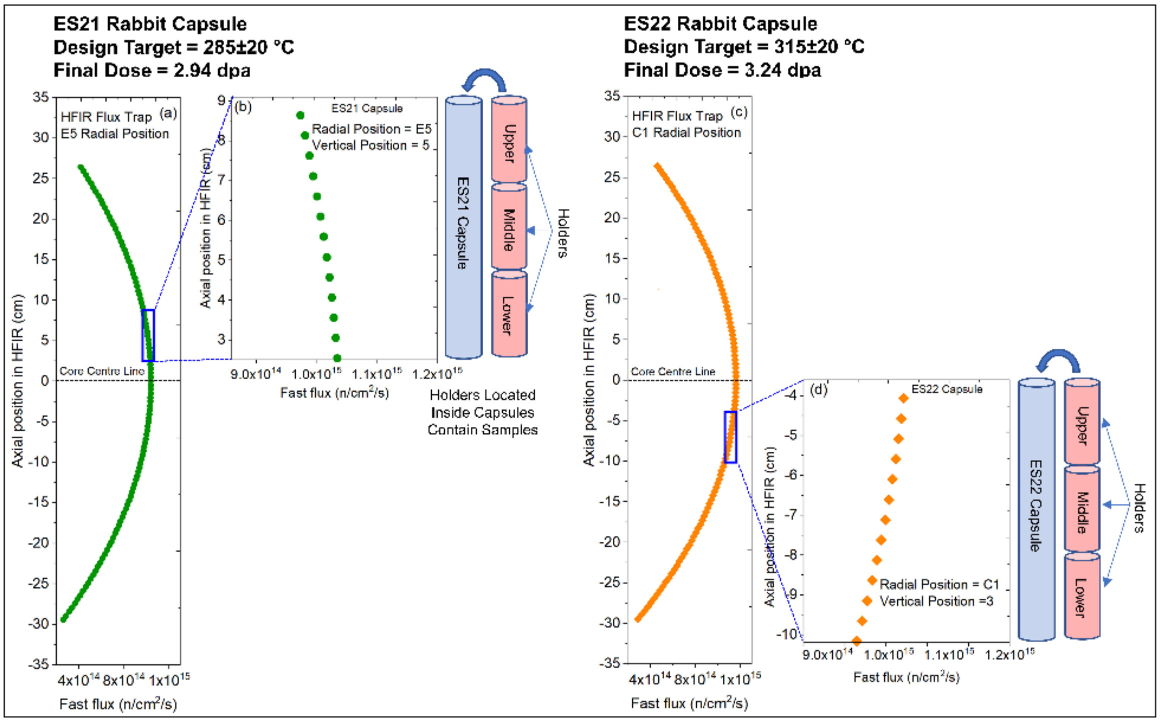


Figure. 2. Fast neutron (*E*>0.1 MeV) axial flux profiles for the HFIR rabbit capsule irradiations. (a). Axial flux profile for radial position E5 in the flux trap of HFIR. (b) Axial flux profile for the vertical position #5 in E5 where the first capsule (id = ES21) was located. (c) Axial flux profile for the radial position C1 in the flux trap. (d) Axial flux profile for the vertical position #3 in C1 where the second capsule (id = ES22) was located. The SS-J3 samples were located inside the holders. Blue squares represent the capsule & its vertical location. Adapted from Bhattacharya et al. [1].

1.4 Specimen irradiation temperatures

As detailed in previous reports [1,4], the specimen temperatures inside the capsules depend upon the axial location inside the reactor, holder material, fill gas and gap size between the specimen holder and outer housing. The temperature contour plots of the SS-J3 samples predicted using finite element modeling (FEM) by the HFIR design team are provided in Figure 1, which show uniform calculated temperatures across the gauge length, and the temperatures of the opposing grip sections constant within ±10-15 °C. In addition to FEM modeling, passive SiC thermometry analysis was performed after irradiation to measure the capsule temperature distribution using the dilatometry based standard procedures. The estimated temperatures of each tensile sample that was examined by SANS are tabulated in Table 3, where exact sample ids are reported for future traceability using ORNL's hot-cell database.

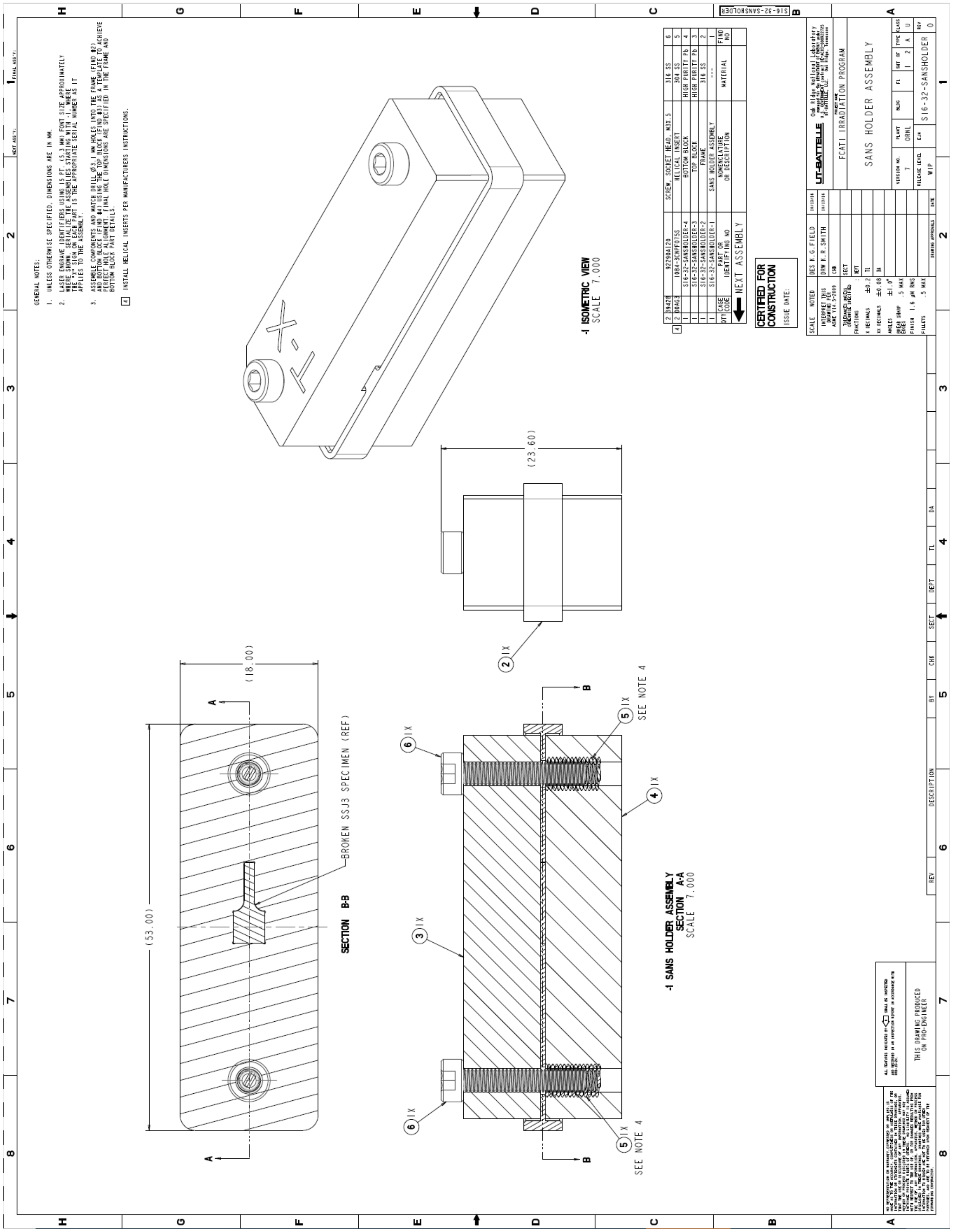
Table 3: Estimated irradiation temperatures of samples on which SANS was performed. The temperatures were deduced using the combination of SiC thermometry data and FEM.

Capsule	Design Temperature	Sample id	Estimated temperature (°C)
ES21	285 ± 20		
ES21	285 ± 20	E293	321
ES21	285 ± 20	J104	270
ES21	285 ± 20	L100	291
ES21	285 ± 20	N111	266
ES22	315 ± 20	H101	319
ES22	315 ± 20	K102	337
ES22	315 ± 20	I102	334
ES22	315 ± 20	M111	331
ES22	315 ± 20	O109	331
ES22	315 ± 20	P102	345

1.5 Hot-cell activities: canister moves, loading of samples into Pb piglets and shipping

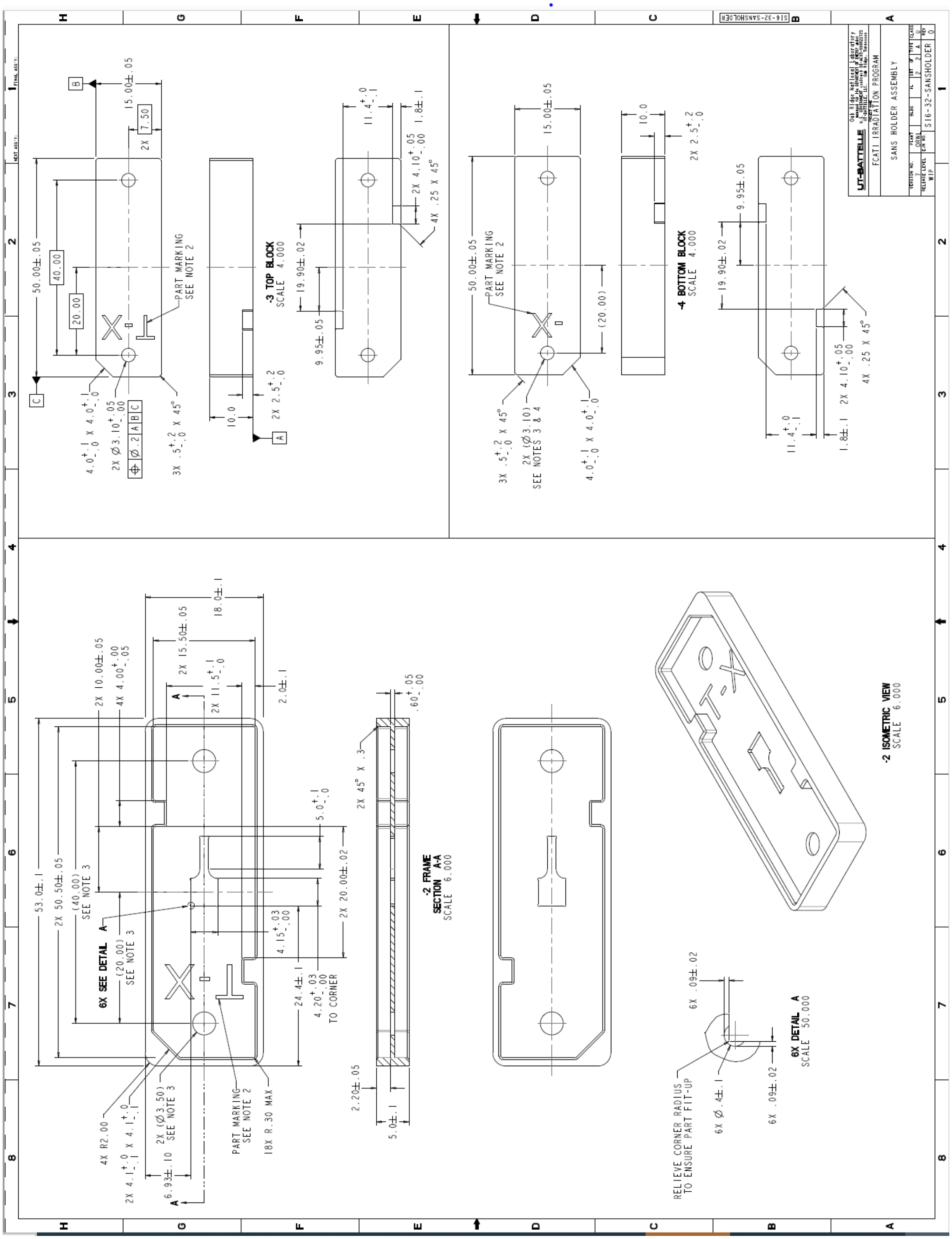
The irradiated samples were stored in the long-term storage of the IMET facility. As part of this SPP, we performed canister moves to locate the samples inside the long-term storage containers. Following this step, the half-broken tensile samples were loaded into specially designed Pb piglets. The specific design dimensions and photographs of this type of unique piglets available at ORNL are show in Figure 3. These piglets are ideal for performing SANS experiments because Pb is transparent to neutrons but acts as effective shield from radioactivity emanating from radioactive materials including HFIR irradiated RAFM steels. Figure 4, shows pictures of a holder, representing the loading scheme followed to insert the samples inside the holders. Figure 4a, represents the holder that is fully disassembled, Figure 4b shows the configuration when the bottom portion of the folder is screwed in while Figure 4c depicts the geometry of the setup when the half-broken tensile samples are loaded into the holders. For the irradiated samples, this activity was performed inside the cell using remote manipulators. Each piglet is engraved with unique ID for traceability, starting with TX-1 to TX-11.

Following the specimen loading onto holders, details of the radiological survey from the 10 irradiated samples and from the loaded holders are provided in Table 4. The surveys were performed using the standard procedures mandated by DOE regarding radiological safety at ORNL. For the purpose of shipping, the samples were secured in lead containers which were then transported in drums. Seven irradiated samples were stored in container ID: Pig FY22-AAAA and three irradiated samples were secured in container ID: Pig FY22-BBBB. Figure 5 gives a snapshot of how these containers are prepared. These drums are initially lined with protective tissue material. Then the primary lead containers that hold the radioactive samples are stored central to the drum. The drum was then protected with additional layer of protective tissue, sealed, checked by smears for contamination and shipped to HFIR hotcells.



SANS HOLDER ASSEMBLY
FCATI IRRADIATION PROGRAM
S16-32-SANSHOLDER
-1 ISOMETRIC VIEW
SCALE 7.000
-1 SANS HOLDER ASSEMBLY
SECTION A-A
SCALE 7.000
SECTION B-B
BROKEN SSJ3 SPECIMEN (REF)
(53.00)
(18.00)
(23.60)
SEE NOTE 4
CERTIFIED FOR CONSTRUCTION
THIS DRAWING PRODUCED ON PRO-ENGINEER
UT-BATTELLE

(a)


UT-BATTELLE
FCATI IRRADIATION PROGRAM
SANS HOLDER ASSEMBLY
S16-32-SANSHOLDER
-3 TOP BLOCK
SCALE 4.000
-4 BOTTOM BLOCK
SCALE 4.000
-2 FRAME
SECTION A-A
SCALE 6.000
-2 ISOMETRIC VIEW
SCALE 6.000
6X DETAIL A
SCALE 50.000
PART MARKING
SEE NOTE 2
6X SEE DETAIL A
RELIEVE CORNER RADIUS
TO ENSURE PART FIT-UP

(b)

Figure 3a-3b: Design of the Pb piglets used at ORNL for loading of half-broken neutron irradiated SS-J3 specimens from EUROfusion Lot-IV irradiations, for SANS study.

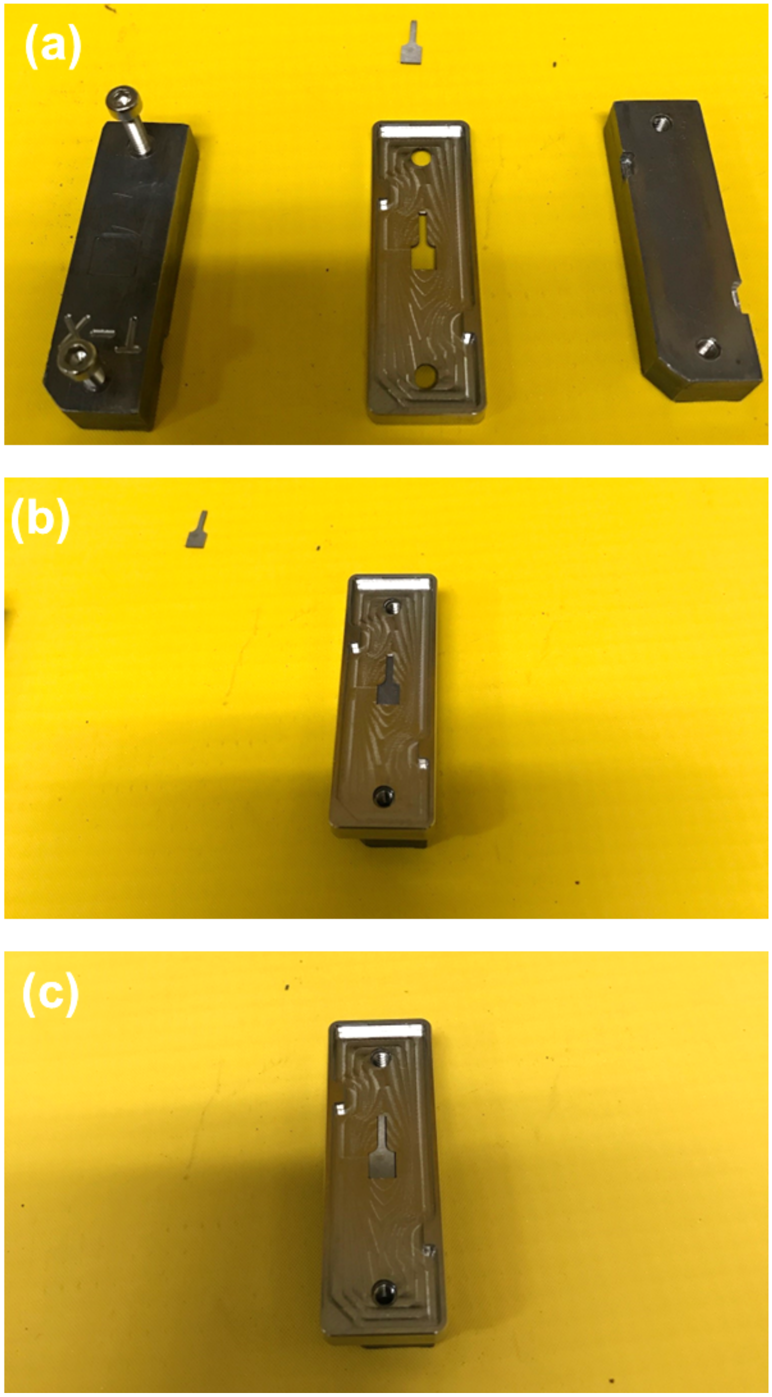


Figure 4: Photographs showing a Pb piglet and the loading steps to insert the half-broken SS-J3 samples into piglet. Photo courtesy: Clay Morris (IMET facility). (a) Fully disassembled configuration, (b) Plate loaded onto the holder bottom, (c) Configuration showing the sample loaded into the holder, following which the top portion is screwed later.

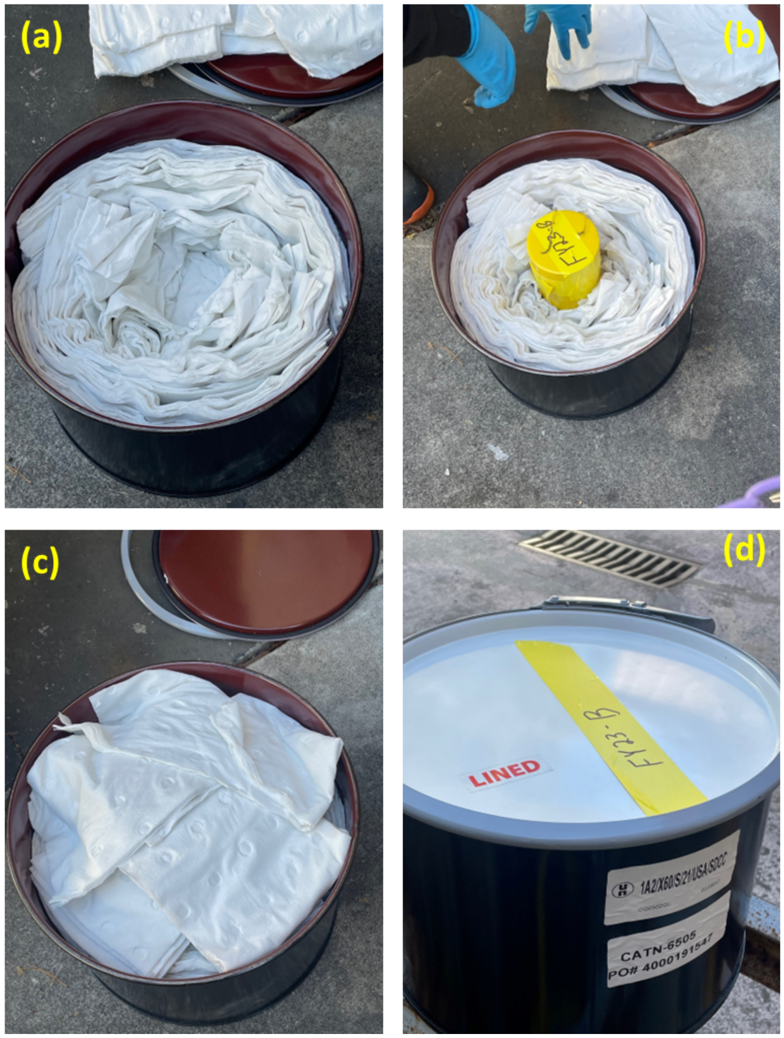


Figure 5: Examples of shipping drums. (a) Drum prepared with tissue liners to hold the primary lead container that holds the radioactive samples. (b) Lead container that has samples is then loaded in the drum. (c) The drum is lined with protective tissue. (d) Example of the fully sealed drum.

1.6 Dose rates and sample activities

Table 4: Dose rates from the specimens and from the loaded Pb piglets recorded in the ORNL Radiological Survey number 3025-589754.

Specimen holder (Pb piglet) ID	Specimen ID	Specimen mRem/h γ (on contact)	Specimen mRem/h γ (at 30 cm)	Secimen mRad/h β (on contact)	Holder mRem/h γ (on contact)	Holder mRem/h γ (at 30 cm)
TX-1	H101-A	240	16	3,420	140	8
TX-2	E293-A	400	24	4,500	240	12
TX-3	O109-A	800	22	5,400	300	14
TX-4	M111-A	600	28	4,500	210	12
TX-5	L100-A	340	18	3,780	160	8
TX-6	K102-A	300	20	3,150	120	8
TX-7	P102-A	260	12	3,300	160	8
TX-8	N111-A	340	20	3,870	180	10
TX-9	I102-A	300	20	3,150	120	6
TX-10	Empty	N/A	N/A	N/A	N/A	N/A
TX-11	J104-A	800	28	4,500	340	20

Table 5: Estimated isotopic composition and activity values of the 10 irradiated steels. These estimates will change with time as different isotopes decay.

SpecimenID	SpecimenType	Description		Isotope1
Pig FY22-AAAA				
L100 A	Tensile	EuroFer-L SSJ3		Cr-51
N111 A	Tensile	EuroFer-N SSJ3		Cr-51
H101 A	Tensile	EuroFer-H SSJ3		Cr-51
I102 A	Tensile	EuroFer-I SSJ3		Cr-51
K102 A	Tensile	EuroFer-K SSJ3		Cr-51
M111 A	Tensile	EuroFer-G SSJ3		Cr-51
O109 A	Tensile	EuroFer-O SSJ3		Cr-51
		Total Pig FY22-AAAA		**Cr-51**
		Total Ci	**1.39E+01**	
Pig FY22-BBBB				
E293 A	Tensile	EuroFer-G SSJ3		Cr-51
J104 A	Tensile	EuroFer-J SSJ3		Cr-51
P102 A	Tensile	EuroFer-P SSJ3		Cr-51
		Total Pig FY22-BBBB		**Cr-51**
		Total Ci	**6.26E+00**	
			2.01E+01	**Cr-51**
			2.01E+01	

Curies1	Isotope2	Curies2	Isotope3	Curies3	Isotope4	Curies4
1.47E+00	Fe-55	4.14E-01	Fe-59	8.84E-02	W-185	7.29E-02
1.44E+00	Fe-55	4.22E-01	Fe-59	9.01E-02	W-185	6.46E-02
1.30E+00	Fe-55	3.87E-01	Fe-59	8.21E-02	W-185	6.83E-02
1.29E+00	Fe-55	3.84E-01	Fe-59	8.16E-02	W-185	6.86E-02
1.20E+00	Fe-55	4.04E-01	Fe-59	8.57E-02	W-185	6.52E-02
1.29E+00	Fe-55	3.77E-01	Fe-59	7.99E-02	W-185	6.77E-02
1.32E+00	Fe-55	3.80E-01	Fe-59	8.06E-02	W-185	6.21E-02
9.32E+00	**Fe-55**	**2.77E+00**	**Fe-59**	**5.88E-01**	**W-185**	**4.69E-01**
1.42E+00	Fe-55	4.15E-01	Fe-59	8.85E-02	W-185	7.08E-02
1.51E+00	Fe-55	4.32E-01	Fe-59	9.22E-02	W-185	7.51E-02
1.30E+00	Fe-55	3.88E-01	Fe-59	8.24E-02	W-185	7.30E-02
4.22E+00	**Fe-55**	**1.24E+00**	**Fe-59**	**2.63E-01**	**W-185**	**2.19E-01**
1.35E+01	**Fe-55**	**4.00E+00**	**Fe-59**	**8.51E-01**	**W-185**	**6.88E-01**

Isotope5	Curies5	Isotope6	Curies6	Isotope7	Curies7	Isotope8
Re-188	4.08E-02	W-188	4.04E-02	Mn-54	1.56E-02	Ta-182
Re-188	3.62E-02	W-188	3.58E-02	Mn-54	1.59E-02	Ta-182
Re-188	3.79E-02	W-188	3.75E-02	Mn-54	1.83E-02	Ta-182
Re-188	3.81E-02	W-188	3.77E-02	Mn-54	1.82E-02	Ta-182
Re-188	3.62E-02	W-188	3.58E-02	Mn-54	1.91E-02	Ta-182
Re-188	3.75E-02	W-188	3.71E-02	Mn-54	1.79E-02	Ta-182
Re-188	3.45E-02	W-188	3.41E-02	Mn-54	1.80E-02	Ta-182
Re-188	**2.61E-01**	**W-188**	**2.58E-01**	**Mn-54**	**1.23E-01**	**Ta-182**
Re-188	3.96E-02	W-188	3.92E-02	Mn-54	1.57E-02	Ta-182
Re-188	4.20E-02	W-188	4.16E-02	Mn-54	1.63E-02	Ta-182
Re-188	4.05E-02	W-188	4.01E-02	Mn-54	1.84E-02	Ta-182
Re-188	**1.22E-01**	**W-188**	**1.21E-01**	**Mn-54**	**5.03E-02**	**Ta-182**
Re-188	**3.83E-01**	**W-188**	**3.79E-01**	**Mn-54**	**1.73E-01**	**Ta-182**

Curies8	Isotope9	Curies9	Isotope10	Curies10	Isotope11	Curies11
4.04E-03	Ta-183	3.94E-03	Co-60	2.19E-03	W-183m	2.01E-04
1.71E-03	Ta-183	1.67E-03	Co-60	6.91E-03	W-183m	8.50E-05
3.76E-03	Ta-183	3.31E-03	Co-60	1.24E-03	W-183m	1.69E-04
3.44E-03	Ta-183	3.03E-03	Co-60	1.23E-03	W-183m	1.54E-04
4.91E-03	Ta-183	4.32E-03	Co-60	1.91E-04	W-183m	2.20E-04
4.32E-03	Ta-183	3.80E-03	Co-60	1.21E-03	W-183m	1.94E-04
3.40E-03	Ta-183	3.00E-03	Co-60	6.27E-03	W-183m	1.53E-04
2.56E-02	**Ta-183**	**2.31E-02**	**Co-60**	**1.92E-02**	**W-183m**	**1.18E-03**
3.93E-03	Ta-183	3.83E-03	Co-60	1.33E-03	W-183m	1.95E-04
3.85E-03	Ta-183	3.75E-03	Co-60	2.22E-04	W-183m	1.91E-04
3.51E-03	Ta-183	3.09E-03	Co-60	1.49E-03	W-183m	1.58E-04
1.13E-02	**Ta-183**	**1.07E-02**	**Co-60**	**3.04E-03**	**W-183m**	**5.44E-04**
3.69E-02	**Ta-183**	**3.37E-02**	**Co-60**	**2.23E-02**	**W-183m**	**1.72E-03**

Isotope12	Curies12	Isotope13	Curies13	Isotope14	Curies14	Isotope15
W-181	7.04E-05	V-49	2.00E-05	Ir-191m	1.73E-05	Os-191
W-181	6.19E-05	V-49	1.96E-05	Ir-191m	1.53E-05	Os-191
W-181	7.93E-05	V-49	2.22E-05	Ir-191m	1.40E-05	Os-191
W-181	7.95E-05	V-49	2.22E-05	Ir-191m	1.40E-05	Os-191
W-181	7.61E-05	V-49	2.06E-05	Ir-191m	1.33E-05	Os-191
W-181	7.87E-05	V-49	2.21E-05	Ir-191m	1.38E-05	Os-191
W-181	7.21E-05	V-49	2.27E-05	Ir-191m	1.27E-05	Os-191
W-181	**5.18E-04**	**V-49**	**1.49E-04**	**Ir-191m**	**1.00E-04**	**Os-191**
W-181	6.84E-05	V-49	1.93E-05	Ir-191m	1.68E-05	Os-191
W-181	7.25E-05	V-49	2.05E-05	Ir-191m	1.78E-05	Os-191
W-181	8.46E-05	V-49	2.23E-05	Ir-191m	1.49E-05	Os-191
W-181	**2.25E-04**	**V-49**	**6.21E-05**	**Ir-191m**	**4.95E-05**	**Os-191**
W-181	**7.44E-04**	**V-49**	**2.12E-04**	**Ir-191m**	**1.50E-04**	**Os-191**

Curies15	Isotope16	Curies16	Isotope17	Curies17	Isotope18	Curies18
1.73E-05	Re-186	1.20E-05	Nb-95	7.96E-05	P-32	6.24E-05
1.53E-05	Re-186	1.06E-05	Nb-95	2.02E-04	P-32	1.25E-04
1.40E-05	Re-186	1.10E-05	Nb-95	7.36E-06	P-32	6.64E-06
1.40E-05	Re-186	1.10E-05	Nb-95	7.32E-06	P-32	5.20E-06
1.33E-05	Re-186	1.04E-05	Nb-95	7.54E-06	P-32	5.39E-06
1.38E-05	Re-186	1.08E-05	Nb-95	7.21E-06	P-32	4.19E-06
1.27E-05	Re-186	9.96E-06	Nb-95	1.80E-04	P-32	4.67E-06
1.00E-04	**Re-186**	**7.58E-05**	**Nb-95**	**4.92E-04**	**P-32**	**2.13E-04**
1.68E-05	Re-186	1.16E-05	Nb-95	7.96E-06	P-32	3.70E-06
1.78E-05	Re-186	1.24E-05	Nb-95	8.26E-06	P-32	4.71E-06
1.49E-05	Re-186	1.17E-05	Nb-95	7.40E-06	P-32	7.14E-06
4.95E-05	**Re-186**	**3.57E-05**	**Nb-95**	**2.36E-05**	**P-32**	**1.55E-05**
1.50E-04	**Re-186**	**1.12E-04**	**Nb-95**	**5.15E-04**	**P-32**	**2.29E-04**

Isotope7	Curies19	Isotope19	Curies20	Isotope20	Curies20	Isotope21
S-35	1.52E-05	C-14	5.18E-06	Zn-65	9.34E-07	Ni-63
S-35	1.25E-04	C-14	9.69E-06	Zn-65	3.16E-06	Ni-63
S-35	5.30E-06	C-14	5.83E-06	Zn-65	2.06E-06	Ni-63
S-35	4.12E-06	C-14	5.27E-06	Zn-65	1.92E-06	Ni-63
S-35	4.27E-06	C-14	2.85E-06			
S-35	3.33E-06	C-14	2.34E-06	Zn-65	1.84E-06	Ni-63
S-35	3.66E-06			Zn-65	2.63E-06	Ni-63
S-35	**1.61E-04**	**C-14**	**3.12E-05**	**Zn-65**	**1.25E-05**	**Ni-63**
S-35	3.69E-06	C-14	2.58E-06	Zn-65	2.17E-06	Ni-63
S-35	4.69E-06	C-14	3.12E-06			
S-35	5.65E-06	C-14	5.60E-06	Zn-65	2.01E-06	Ni-63
S-35	**1.40E-05**	**C-14**	**1.13E-05**	**Zn-65**	**4.19E-06**	**Ni-63**
S-35	**1.75E-04**	**C-14**	**4.25E-05**	**Zn-65**	**1.67E-05**	**Ni-63**

Curies21	Isotope22	Curies22	Isotope23	Curies23	Isotope24	Curies24
4.59E-06	Hf-181	1.23E-06	H-3	1.42E-06	Co-58	3.18E-06
9.36E-06	Hf-181	5.81E-07	H-3	1.86E-06	Co-58	6.49E-06
1.74E-06	Hf-181	1.12E-06	H-3	1.71E-06	Co-58	1.62E-06
1.56E-06	Hf-181	1.03E-06	H-3	1.65E-06	Co-58	1.45E-06
	Hf-181	1.41E-06	H-3	1.41E-06		
1.45E-06	Hf-181	1.26E-06	H-3	1.30E-06	Co-58	1.35E-06
8.42E-06	Hf-181	1.01E-06	H-3	1.13E-06	Co-58	7.94E-06
2.71E-05	**Hf-181**	**7.65E-06**	**H-3**	**1.05E-05**	**Co-58**	**2.20E-05**
1.58E-06	Hf-181	1.20E-06	H-3	1.15E-06	Co-58	1.09E-06
	Hf-181	1.18E-06	H-3	1.24E-06		
2.48E-06	Hf-181	1.06E-06	H-3	1.69E-06	Co-58	2.31E-06
4.06E-06	**Hf-181**	**3.44E-06**	**H-3**	**4.07E-06**	**Co-58**	**3.40E-06**
3.12E-05	**Hf-181**	**1.11E-05**	**H-3**	**1.45E-05**	**Co-58**	**2.54E-05**

Isotope25	Curies25	Isotope26	Curies26	Isotope27	Curies27	Isotope28	Curies28	Isotope29	Curies29
Ir-192	1.02E-06	Ta-179	6.85E-07	Co-57	8.36E-07				
Ir-192	9.07E-07			Co-57	1.70E-06	P-33	2.76E-06	Sc-46	1.11E-06
Ir-192	8.38E-07	Ta-179	6.69E-07						
Ir-192	8.42E-07	Ta-179	6.11E-07						
Ir-192	8.00E-07	Ta-179	8.73E-07						
Ir-192	8.30E-07	Ta-179	7.67E-07						
Ir-192	7.62E-07	Ta-179	6.05E-07	Co-57	1.94E-06			Sc-46	1.24E-06
Ir-192	**6.00E-06**	**Ta-179**	**4.21E-06**	**Co-57**	**4.47E-06**	**P-33**	**2.76E-06**	**Sc-46**	**2.35E-06**
Ir-192	9.92E-07	Ta-179	6.67E-07						
Ir-192	1.05E-06	Ta-179	6.53E-07						
Ir-192	8.96E-07	Ta-179	6.24E-07	Co-57	5.63E-07				
Ir-192	**2.94E-06**	**Ta-179**	**1.94E-06**	**Co-57**	**5.63E-07**	**P-33**	**0.00E+00**	**Sc-46**	**0.00E+00**
Ir-192	**8.94E-06**	**Ta-179**	**6.15E-06**	**Co-57**	**5.04E-06**	**P-33**	**2.76E-06**	**Sc-46**	**2.35E-06**

1.7 Conclusions

Ten HFIR irradiated Eurofer97 variants that were irradiated in EUROfision Lot-IV campaign at ORNL (and their nonirradiated counterparts) were successfully prepared, packaged and shipped from ORNL's IMET hotcells to hotcell facility of HFIR. Following this shipping activity, SANS data collection has been completed recently on all the samples (using a HFIR user proposal).

1.8 References

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