AS-BUILT DESCRIPTION OF THE EBR-II, RUN 97 DOSIMETRY EXPERIMENT

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Hanford Engineering Development Laboratory

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Hanford Engineering Development Laboratory

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December 1978

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AS-BUILT DESCRIPTION OF THE EBR-II, RUN 97
DOSIMETRY EXPERIMENT

C. L. Long

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ABSTRACT

A dosimetry experiment has been designed and fabricated for inclusion in the Experimental Breeder Reactor-II (EBR-II) during Run 97 in a Row 2 position. Various types of dosimeter material have been included in the single B-7c pin from 60 cm below midplane to 60 cm above. This report contains the as-built description of irradiation hardware and a detailed description of the dosimetry.

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I. INTRODUCTION

This report contains the as-built description of the Hanford Engineering Development Laboratory (HEDL) Dosimetry Experiment in Experimental Breeder Reactor No. II (EBR-II) to be irradiated during Run 97.* This experiment will produce information that will be useful for analysis of fuels and materials irradiations in EBR-II. The measurements are similar to those made during previous dosimetry tests irradiated during Runs 31F¹, 50H², and 75D³ at EBR-II. Unlike these earlier tests, the present test is more limited in scope and involves only one B-7c pin. The dosimeter encapsulation techniques and container designs used for the previous tests proved successful; therefore, they provide the basis for component design for this experiment.

*This experiment is being conducted in accordance with DOE-RRT Form 189, FF028, HEDL Task Authorization WGTVBA.

I. INTRODUCTION

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II. OBJECTIVES AND SCOPE

In this experiment, a single dosimetry pin will be irradiated in EBR-II, Row 2, for one cycle. The dosimetry pin will contain a variety of dosimeters to meet the following objectives:

- Neutron Fluence Calibration. Measurement of the EBR-II Row 2 flux-spectrum will provide a calibration position for comparison with measurements from previous dosimetry tests to correlate variations due to changes in EBR-II loading. These data will be used, together with EBR-II calculations, to provide better fluence estimates for other EBR-II experiments, including fluence estimates for fuel cladding.
- Dosimetry Testing. Dosimetry types to be applied in the Fast Flux Test Facility (FFTF) will be tested in the high-power irradiation environment, including helium accumulation fluence monitors (HAFM) and niobium foil material of European origin.

In addition, fast-neutron spectrum background measurements will be made on solid state track recorder (SSTR) material proposed to be used for measurements in FFTF.

III. EXPERIMENT DESCRIPTION

A. GENERAL

The experiment requires that one Mark B-7c capsule, designated B-283, be irradiated in any Row 2 position for one reactor cycle. The dosimetry experiment is made up of 30 subcapsules containing different sets of dosimeters that are positioned from approximately 24 in. (61 cm) below to 24 in. (61 cm) above core midplane (see Figure 1). Stainless steel rod is used to position the subcapsules.

The 30 subcapsules consist of 8 fluence/spectral set subcapsules containing passive dosimeters, 16 gradient subcapsules containing Fe and Co passive dosimeters, 3 subcapsules containing HAFMs, and 3 subcapsules containing both SSTR sensors and niobium foil of European origin.

B. PASSIVE DOSIMETERS

Seven of the spectral set subcapsules are 0.746 in. (1.89 cm) in diameter and 0.50 in. (1.27 cm) long (see Figure 2). These cylinders have up to 19 holes of various diameters drilled axially into them. Stainless steel lids 0.060 in. (0.154 cm) thick are held in place by central screws. In this type of subcapsule, dosimeters will be irradiated at the same level for exact comparisons. See Table 1 for a general description of the passive monitor materials.

NOTE 1. THESE DIMENSIONS WERE OBTAINED FROM HEDL H-3-44071 SHEET 1 AND SHEET 2

NOTE 2. G DENOTES GRADIENT SET, F DENOTES FLUENCE SET, AI DENOTES ATOMIC INTERNATIONAL DOSIMETER PACKAGES AND S DENOTES SSTR PACKAGES

FIGURE 1. Run 97 Dosimeter Subcapsule Locations in the B-7c Pin Relative to Reactor Midplane.

FIGURE 2. Run 97 Spectral Set Subcapsules With Hole Numbering System.

TABLE 1
PASSIVE MONITOR MATERIAL DESCRIPTION (NOMINAL)

	Form	Capsule Length (in.)		Bare Length (in.)	Material Mass (mg)
		0.050-in. OD	0.035-in. OD		
$^{235}\text{UO}_2$	Oxide Wire	0.125	0.190	--	1.6
$^{238}\text{UO}_2$	Oxide Wire	0.315	0.310	--	6.0
$^{237}\text{NpO}_2$	Oxide Wire	0.345	0.280	--	4.5
$^{239}\text{PuO}_2$	Oxide Wire	0.285	0.250	--	1.4
^{10}B	Natural Boron Crystals	0.255	0.250	--	0.08
^6LiF	Natural LiF Crystals	0.255	0.250	--	0.10
Sc_2O_3	Ceramic Wire	0.255	0.340	--	1.3
1.0% CoV	Metal Wire	-	0.270	0.10	2.0
0.1% CoMgO	Ceramic Wire	-	0.300	--	1.3
0.1% CoAl	Metal Wire	-	0.240	0.10	1.3
0.1% AgAl	Metal Wire	-	0.210	--	1.3
0.1% AuAl	Metal Wire	-	0.180	--	1.2
MnO_2	Ceramic Wire	-	0.240	--	1.5
0.1% TaAl	Metal Wire	-	0.240	0.10	0.7
0.033-in. diam SS	Metal Wire	-	-	0.10	10.0
Nb	Foil and Wire	-	0.240	0.12	4.5
Fe	Metal Wire	-	0.240	0.10	4.0
Ni	Metal Wire	-	0.180	0.10	2.8
Cu	Metal Wire	-	0.210	0.10	4.0
Ti	Metal Wire	-	0.240	0.10	2.1
V Blank	Welded Tube	0.255	-	--	35.0
0.1% Sc_2O_3	Ceramic Wire	-	0.300	--	1.0
1.0% TaV	Metal Wire	-	-	0.10	3.0

The eighth spectral set subcapsule consists of a hollow wire-wrap tube [0.056-in. (0.142-cm) OD by 0.046-in. (0.117-cm) ID by 13.0-in. (33.0-cm) length] that contains a spectral set composed of 0.035-in. (0.089-cm) vanadium encapsulated monitors (see Figure 3). The dosimeters will be centered at midplane and will be used for direct comparison with a regular spectral set located at midplane. This type of dosimetry has been attached to FFTF fuel pins for Cycle 1 irradiation. The wire-wrap tube passes through 0.140-in. (0.356-cm) diameter holes drilled through all dosimeter, HAFM, and SSTR subcapsules in the core region (see Figure 1). Tables A-1 through A-8 in Appendix A specifically describe the monitors used in each spectral set.

FIGURE 3. Hollow Wire-Wrap Mockup Spectral Set Container and Loading Order.

These tables list the traceability of each material by purchase order and batch number, physical dimensions, material weight, and identification information.

The 16 gradient sets used in this experiment are contained in stainless steel rods that have a central hole drilled into them (see Figure 4). Since these rods also are used as spacers to properly position the other subcapsules, they are of varying lengths as shown. The gradient set subcapsules are shown in Figure 5, which gives the dimension, loading order, and capsule identification method. Table A-9 describes the monitors in each gradient set in greater detail.

GRADIENT SET ID	DIMENSION "X"
G-11	1.600
G-4, G-10	1.900
G-1, G-2 G-3, G-5 G-6, G-8 G-9, G-12 G-13	2.000 ↓
G-0	2.119
G-7, G-14	2.400
G-15	2.520

FIGURE 4. Gradient Set Subcapsule.

0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				

FIGURE 5. Gradient Set Container Dimensions and Identification Scheme.

C. HELIUM ACCUMULATION FLUENCE MONITORS

Specific information for all HAFMs is given in Appendix B. The HAFM subcapsules are right circular cylinders. When capped with an 0.060-in. (0.152-cm) thick stainless steel lid, they are 1.00 in. (2.54 cm) long by 0.746-in. (1.89-cm) diameter, similar to the spectral set dosimetry subcapsules (see Figure B-1). Three holes are drilled axially into the cylinders. Two of the holes are 0.141 in. (0.358 cm) in diameter and contain unsealed containers holding bare wires of vanadium, niobium, platinum, and stainless steel; the larger hole, 0.453-in. (1.15-cm) diameter, contains sealed containers holding material similar to that in the smaller holes. Table 2 lists the positioning and identification of the nine capsules furnished by Atomics International (AI).

TABLE 2
ATOMICS INTERNATIONAL CONTAINER LOADING

<u>Container Identification</u>	<u>Container Hole Number</u>	<u>AI Capsule Identification (a)</u>
AI-1	1	E
	2	N
	3	C
AI-2	1	H
	3	K
	4	A
AI-3	1	O
	3	P
	4	B

(a) See Appendix B for contents of AI capsules.

D. SOLID STATE TRACK RECORDER SUBCAPSULES

Detailed information on the SSTR materials is listed in Appendix C. Each of the SSTR subcapsules (also shown in Figure B-1) contains six natural quartz crystal SSTRs and two pieces of backing material made of high purity nickel. The loading arrangement (listed in Tables C-1 and C-2) gives two quartz-nickel interfaces to monitor the fissionable content of the nickel and several types of quartz-quartz interfaces. The containers are sealed (welded) and placed into the large hole of each subcapsule.

E. EUROPEAN DOSIMETERS

Detailed information on the European niobium dosimeters is listed in Appendix D. Niobium foils of Belgian, French, and German origin [0.0008 in. (0.002 cm) thick by 0.118-in. (0.289-cm) diameter] were interleaved with titanium spacers [0.001 in. (0.0025 cm) thick by 0.125-in. (0.3175-cm) diameter], loaded into a stainless steel container [0.150-in. (0.381-cm) OD by 0.130-in. (0.330-cm) ID], and placed on top of the SSTR containers in two of the SSTR subcapsules, S-1 and S-2 (see Tables D-1 and D-2).

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McElroy, W. N., et al. "EBR-II Dosimetry Test (Reactor Runs 50G and 50H)," HEDL-TME 73-62, Hanford Engineering Development Laboratory, 1973.

APPENDIX A

RUN 97 PASSIVE DOSIMETRY - SPECIFIC DETAILS

TABLE A-1

RUN 97, CONTAINER F-1, SPECTRAL SET DETAILS

Test: Run 97HEDL Capsule Number Container Identification F-1Set Identification: Spectral Set Details

Page 1 of 2

R: Z: -59.4 cm
Distance from Distance from
core centerline reactor midplane

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
1.0% CoV (1)*	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	2.011						
Nb (1)	Fabry	Kawecki	Wire 0.47 mm x 3.0 mm	4.571					83	
Fe (1)	865-777-19046		Wire 0.1-in. L x 0.020-in. D	3.609						Rx Spool 3
Ni (1)	1		Wire 0.1-in. L x 0.020-in. D	4.329						Semi-Elements Roll 2
Cu (1)	19047		Wire 0.1-in. L x 0.020-in. D	4.075						Cominco American Roll 1
Ti (1)	69926		Wire 0.1-in. L x 0.020-in. D	2.154						
Fe (2)	865-777-19046		Wire 0.1-in. L x 0.020-in. D	3.551						
Ni (3)	1		Wire 0.1-in. L x 0.020-in. D	4.332						
²³⁵ U (4)	55047	264C	Oxide Wire	1.597	V	20.724	0.050	0.125	23 : .	Series 3
²³⁷ Np (5)	26534	Np-24-Hp	Oxide Wire	5.477	V	42.700	0.050	0.280	11 : .	Series W
²³⁹ Pu (6)	39407	453-B0	Oxide Wire	1.446	V	50.986	0.050	0.280	7 : .	
Sc ₂ O ₃ (7)	39407	ORNL-1	Oxide Wire	1.364	V	39.505	0.050	0.250	86 : .	
0.1% Sc ₂ O ₃ /MgO (8)	55046	1	Oxide Wire	0.9326	V	21.01	0.035	0.300	6	Sc ₂ O ₃ /MgO
¹⁰ B (9)	44051	AI	Crystal	1.442	V	41.895	0.050	0.250	B-248-W9	

*Number in parentheses = hole number in container.

Container and lid SS heat #68876.

A-1

TABLE A-1 (Continued)

Test: Run 97Page 2 of 2

HEDL Capsule Number _____

Container Identification F-1Set Identification: Spectral Set Details

R: _____

Z: -59.4 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
⁶ LiF (10)	40051	AI	Crystal	2.367	V	40.433	0.050	0.255	L203-Fe	
1.0% CoV (11)	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	2.083						
1.0% CoMgO (11)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.528	V	24.84	0.035	0.300	X	Series 2
0.1% CoAl (11)		SRM-953	Metal Wire 0.100-in. L x 0.020-in. D	1.2856						Roll 4 NBS
1.0% CoV (12)	Fabry		1.0% CoV Wire 0.1-in. L x 0.015-in. D	1.8986						
Ti (12)	69926		Wire 0.1-in. L x 0.020-in. D	2.219						
0.1% AgAl (13)	03783	Rx Wire	Metal Wire	1.2675	V	17.459	0.035	0.210	4	
0.1% AuAl (14)		Rx Wire	Metal Wire	1.2340	V	13.788	0.035	0.210	F	
Mn ₃ O ₄ (15)	55086		Oxide Wire 0.125-in. L x 0.020-in. D	1.4535	V	18.818	0.035	0.240	J	
0.1% TaAl (16)	03783	217W	Metal Wire 0.100-in. L x 0.020-in. D	0.6775						
1.0% TaV (16)	32548	ORNL	0.100-in. L x 0.020-in. D	2.969						
SS Wire (17)			0.1-in. L x 0.033-in. D	9.890						FOTA SS Rod
Cu (18)	19047		Wire 0.100-in. L x 0.020-in. D	4.047						

TABLE A-2

RUN 97, CONTAINER F-2, SPECTRAL SET DETAILS

Test: Run 97

Page 1 of 4

HEDL Capsule Number _____

Container Identification F-2

Set Identification: _____

R: _____ Z: -36.58 m.

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
^{235}U (1)*	55047	264-C	Oxide Wire	1.389	V	21.060	0.050	0.125	1	Series 3
^{238}U (1)	39407	ES-Z	Oxide Wire	7.233	V	51.352	0.050	0.310	37	Series I
^{237}Np (1)	39407	Np-24-Hp	Metal Wire	5.878	V	51.474	0.050	0.345	21	Series 1
1.0% CoV (1)	Fabry		0.1-in. L x 0.015-in. D	2.095						
Nb (1)	Fabry	Kawecki	0.47 mm x 3.0 mm	4.268					79	
Fe (1)	865-777-19046		Metal Wire 0.1-in. L x 0.020-in. D	3.947						
Fe (1)	865-777-19046		Metal Wire 0.1-in. L x 0.020-in. D	4.027						
Ni (1)	1		Metal Wire 0.1-in. L x 0.020-in. D	4.389						
Cu (1)	19047		Metal Wire 0.1-in. L x 0.020-in. D	4.163						
Ti (1)	69926		Metal Wire 0.1-in. L x 0.020-in. D	2.146						
^{235}U (2)	55047	264-C	Oxide Wire	1.583	V	20.874	0.050	0.125	51	Series 3
1.0% CoV (2)	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	1.9117						
Fe (2)	865-777-19046		Metal Wire 0.1-in. L x 0.020-in. D	3.719						
Fe (3)	19046	SC-53	Metal Wire 0.1-in. L x 0.020-in. D	4.047	V	20.55	0.035	0.240	T	Series 5

*Number in parentheses = hole number in container.

A-3

TABLE A-2 (Continued)

Page 2 of 4

Test: Run 97

HEDL Capsule Number

Container Identification F-2

Set Identification:

R:

Z: -36.58 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
Fe (3)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.997						
Sc ₂ O ₃ (4)	39407	ORNL-1	Oxide Wire Metal Wire 0.1-in. L x 0.020-in. D	1.428	V	42.291	0.050	0.255	91 ...	
Fe (4)	19046		Oxide Wire Metal Wire 0.125-in. L x 0.020-in. D	3.754						
0.1% Sc ₂ O ₃ /MgO (5)	55046	1	Metal Wire 0.100-in. L x 0.020-in. D	0.9010	V	21.91	0.035	0.300	1	
Fe (5)	19046			3.694						
¹⁰ B (6)	44051	AI	Crystal Metal Wire 0.1-in. L x 0.020-in. D	1.301	V	41.298	0.050	0.255	8-241-T9	
Fe (6)	19046			3.753						
⁶ LiF (7)	44051	AI	Crystal Metal Wire 0.1-in. L x 0.020-in. D	2.974	V	43.020	0.050	0.255	L215-A1	
Fe (7)	19046			3.983						
Fe (8)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.799						
Cu (8)	19047		Metal Wire 0.1-in. L x 0.020-in. D	4.078						
Ti (8)	69926		Metal Wire 0.1-in. L x 0.020-in. D	2.136						
Fe (9)	19046		Metal Wire 0.1-in. L x 0.020-in. D	4.037						
Ni (9)	1		Metal Wire 0.1-in. L x 0.020-in. D	4.371						

A-4

TABLE A-2 (Continued)

Test: Run 97Page 3 of 4HEDL Capsule Number Container Identification F-2Set Identification: R: Z: -36.58 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
1.0% CoV (10)	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	2.064						
0.1% CoMgO (10)	27940	ORNL Tube 1	Oxide Wire 0.1-in. L x 0.020-in. D	1.171	V	20.16	0.035	0.300	F	Series 4
0.1% CoAl (10)		SRM-953	Metal Wire 0.100-in. L x 0.020-in. D	1.3291						
Fe (10)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.788						
SS (11)			0.1-in. L x 0.033-in. D	9.103						FOTA SS-Wire
Fe (11)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.742						
²³⁸ U (12)	39407	ES-Z	Oxide Wire	7.403	V	50.803	0.050	0.315	13	Series I
²³⁷ Np (13)	39407	Np-24-Hp	Oxide Wire	6.592	V	51.109	0.050	0.345	22	Series 1
0.1% AuAl (14)			Metal Wire	1.3525	V	14.878	0.035	0.180	H	
Fe (14)	19046	Rx Wire	Metal Wire 0.1-in. L x 0.020-in. D	3.987						
0.1% AgAl (15)	03783	Rx Wire	Metal Wire	1.2065	V	16.461	0.035	0.210	2	
Fe (15)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.809						
MnO ₂ (16)	55086		Oxide Wire 0.125-in. L x 0.020-in. D	1.3938	V	18.331	0.035	0.240	K	
Fe (16)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.799						

A-5

TABLE A-2 (Continued)

Test: Run 97Page 4 of 4HEDL Capsule Number Container Identification F-2Set Identification: R: Z: -36.58 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
0.1% TaAl (17)	03783	ORNL	0.1-in. L x 0.020-in. D	0.5660						
1.0% TaV (17)	32548	ORNL	0.1-in. L x 0.020-in. D	2.924						
Fe (17)	19047		Metal Wire 0.1-in. L x 0.020-in. D	3.738						
²³⁹ Pu (18)	14965	453-B0	Oxide Wire	1.280	V	51.235	0.050	0.340	34	Series X
Fe (18)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.641						

TABLE A-3

RUN 97, CONTAINER F-3, SPECTRAL SET DETAILS

Test: Run 97Page 1 of 2

HEDL Capsule Number _____

Container Identification F-3

Set Identification: _____

R: _____

Z: -15.24 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
$^{238}\text{UO}_2$ (1)*	39407	ES-Z	Oxide Wire	7.283	V	51.225	0.050	0.310	28 ..	Series I
Nb (1)	Fabry	Kawecki	0.47 mm x 0.3 mm	4.560	V	20.54	0.035	0.240	0	
Ni (1)	1		Wire 0.1-in. L x 0.020-in. D	4.228						
^{235}U (2)	55047	264-C	Oxide Wire	1.533	V	21.574	0.050	0.125	24 ::	3
^{237}Np (3)	39407	Np-24-Hp	Oxide Wire	5.486	V	51.081	0.050	0.350	16 ..	Series I
Ti (3)	69926		Wire 0.1-in. L x 0.020-in. D	2.133						
Mn (4)	55086		Oxide Wire 0.125-in. L x 0.020-in. D	0.93684	V	17.437	0.035	0.240	F	
SS Wire (4)			0.1-in. L x 0.033-in. D	9.872						FOTA SS Rod
Sc_2O_3 (5)	39407	ORNL-1	Oxide Wire	1.298	V	40.855	0.050	0.250	87 ...	
0.1% $\text{Sc}_2\text{O}_3/\text{MgO}$ (6)	55046	1	Oxide Wire 0.125-in. L x 0.020-in. D	0.7649	V	20.10	0.035	0.300	3	
0.1% AuAl (6)		Rx Wire	Metal Wire	1.3116	V	14.544	0.035	0.180	&	
1.0% CoV (7)	Fabry	Sp-2440	Metal Wire 0.100-in. L x 0.015-in. D	2.006	V	16.544	0.035	0.270	H	
0.1% CoMgO (7)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.299	V	25.56	0.035	0.300	Z	Series 2
0.1% CoAl (7)	HA-69-889-085	SRM 953	Metal Wire 0.100-in. L x 0.020-in. D	1.2518	V	18.259	0.035	0.240	1	

*Number in parentheses = hole number in container.

TABLE A-3 (Continued)

Test: Run 97Page 2 of 2

HEDL Capsule Number _____

Container Identification F-3

Set Identification: _____

R: _____ Z: -15.24 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
0.1% AgAl (8)	03783	Rx Wire	Metal Wire	1.2962	V	15.057	0.035	0.210	6	
²³⁹ Pu (9)	39407	453-B0	Oxide Wire	1.372	V	44.921	0.050	0.280	5	
0.1% TaAl (9)	03783	217 W	Metal Wire 0.100-in. L x 0.020-in. D	0.7025	V	17.336	0.035	0.240	T	
1.0% TaV (9)	32548		Metal Wire 0.100-in. L x 0.020-in. D	2.889						
Fe (10)	19046	Sc 53	Metal Wire 0.100-in. L x 0.020-in. D	3.948	V	20.54	0.035	0.240	S	Series 10
Fe (10)	B65-777-19046		Metal Wire 0.100-in. L x 0.020-in. D	3.758						Rx Spool 3
⁶ LiF (11)	44051	AI	Crystal	2.585	V	43.585	0.050	0.250	L201-HF	
¹⁰ B (12)	44051	AI	Crystal	1.235	V	41.862	0.050	0.250	B245-IL	
Nb (13)	Fabry	Kawecki	Metal Wire 0.47 mm x 0.3 mm	4.571					84	
Cu (13)	19047		Wire 0.100-in. L x 0.020-in. D	4.083						Cominco American Roll 1

TABLE A-4

RUN 97, CONTAINER HWW-1, SPECTRAL SET DETAILS

Test: Run 97Page 1 of 1

HEDL Capsule Number _____

Container Identification Spectral SetSet Identification: HWW-1R: _____ Z: Midplane

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
²³⁵ U	39462	264-C	Oxide Wire	1.519	V	17.073	0.035	0.190	0	Series 2
²³⁸ U	32542	ES-Z	Oxide Wire	8.337	V	25.780	0.035	0.315	2	
²³⁷ Np	39462	Np-24-Hp	Oxide Wire	3.258	V	23.277	0.035	0.280	H	Series 2
Sc ₂ O ₃	39462	ORNL-1	Oxide Wire	1.334	V	25.102	0.035	0.340	S	Series 1
0.1% CoAl	HA-69-889.050	SRM 953	Metal Wire 0.1-in. L x 0.020-in. D	1.2746	V	17.150	0.035	0.240	3	
²³⁹ Pu	39462	453-B0	Oxide Wire	1.542	V	21.654	0.035	0.250	N	Series 6
Fe	19046	Sc 53	Metal Wire 0.100-in. L x 0.020-in. D	4.009	V	19.709	0.035	0.240	J	Series 5
⁶ LiF	50070	AI	Crystal	0.0702	V	18.936	0.035	0.250	LB142-H9	
SS			0.1-in. L x 0.033-in. D	10.851						FOTA SS Rod
¹⁰ B	50070	AI	Crystal	0.0670	V	18.493	0.035	0.250	BB163-1X	
Ni	1		Metal Wire 0.1-in. L x 0.020-in. D	4.399	V	17.95	0.035	0.180	6	Series 3
0.1% CoMgO	27940	ORNL-1	Metal Wire 0.1-in. L x 0.020-in. D	1.102	V	20.70	0.035	0.300	Z	Series 3
Ti	69925	139-W	Metal Wire 0.1-in. L x 0.020-in. D	2.033	V	20.53	0.035	0.240	X	Series 2
Cu	19047	CP0-3054	Metal Wire 0.1-in. L x 0.020-in. D	4.069	V	20.14	0.035	0.210	4	Series 2

See Table 6 for Loading Order

TABLE A-5

RUN 97, CONTAINER F-4, SPECTRAL SET DETAILS

Test: Run 97

Page 1 of 4

HEDL Capsule Number _____

Container Identification F-4

Set Identification: _____

R: _____ Z: 0 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
^{235}U (1)*	55047	264-C	Oxide Wire	1.443	V	20.869	0.050	0.125	31	Series 3
^{238}U (1)	39407	ES-Z	Oxide Wire	7.498	V	51.305	0.050	0.315	34	Series I
$^{237}\text{NpO}_2$	39407	Np-24-Hp	Oxide Wire	5.907	V	49.894	0.050	0.345	17	Series I
1.0% CoV (1)	Fabry	Sp-2440	Metal Wire 0.1-in. L x 0.015-in. D	1.9301						
Nb (1)	Fabry	Kawecki	0.47 mm x 3.0 mm	4.577					86	
Fe (1)	B65-777-19046		Wire 0.100-in. L x 0.020-in. D	4.000						
Ni (1)	1		Wire 0.100-in. L x 0.020-in. D	4.305						
Cu (1)	19047		Wire 0.100-in. L x 0.020-in. D	3.987						Cominco American Roll 1
Ti (1)	69926		Wire 0.100-in. L x 0.020-in. D	2.146						
$^{238}\text{UO}_2$ (2)	32542	ES-Z	Oxide Wire	8.696	V	26.915	0.035	0.310	3	
Nb (2)	Fabry	Kawecki	0.47 mm x 3.0 mm	4.560					80	
^{235}U (3)	55047	264-C	Oxide Wire	1.446	V	20.853	0.050	0.125	33	Series 3
^{235}U (3)	39462	264-C	Oxide Wire	1.529	V	17.491	0.035	0.190	Z	Series 2
^{10}B (3)	44051	AI	Crystal	0.864	V	40.118	0.050	0.250	B24-P5	

*Number in parentheses = hole number in container.

TABLE A-5 (Continued)

Test: Run 97Page 2 of 4HEDL Capsule Number Container Identification F-4Set Identification: R: Z: 0 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
¹⁰ B (3)	50070	AI	Crystal	0.540	V	17.504	0.035	0.250	BB166-8C	
⁶ LiF (3)	44051	AI	Crystal	2.2026	V	41.276	0.050	0.255	L213-V4	
⁶ LiF (3)	50070	AI	Crystal	0.1608	V	18.617	0.035	0.250	LB134-V5	
SS Wire (3)			0.1-in. L x 0.033-in. D	10.074						FOTA SS Wire
²³⁸ U (4)	39407	ES-Z	Oxide Wire	7.918	V	52.185	0.050	0.315	23 :	Series I
Sc ₂ O ₃ (5)	39407	ORNL-1	Oxide Wire	1.396	V	39.924	0.050	0.255	85 ...	
Sc ₂ O ₃ (5)	39462	ORNL-1	Oxide Wire	1.285	V	23.902	0.035	0.340	Z	Series 1
MnO ₂ (5)	55086		Oxide Wire 0.125-in. L x 0.020-in. D	1.3187	V	19.200	0.035	0.240	H	
V Blank (5)	ORNL				V	35.170	0.050	0.255	29 ..	
0.1% Sc ₂ O ₃ /MgO (5)	55046	1	Oxide Wire 0.125-in. L x 0.020-in. D	0.8518	V	19.891	0.035	0.300	4	
Ni (6)	1		Metal Wire 0.100-in. L x 0.020-in. D	4.370	V	17.20	0.035	0.180	0	Series 3
Ni (6)	1		Wire 0.100-in. L x 0.020-in. D	4.303						
1.0% CoV (7)	Fabry	Sp-2440	Metal Wire 0.100-in. L x 0.015-in. D	1.9160	V	16.392	0.035	0.270	&	
1.0% CoV (7)	Fabry	Sp-2440	Metal Wire 0.100-in. L x 0.015-in. D	1.8519						

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TABLE A-5 (Continued)

Test: Run 97

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HEDL Capsule Number

Container Identification F-4

Set Identification:

R: Z: 0 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
0.1% CoMgO (7)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.349	V	25.82	0.035	0.300	T	Series 2
0.1% CoAl (7)	HA-69-889-085	SRM 953	Metal Wire 0.100-in. L x 0.020-in. D	1.2650	V	17.860	0.035	0.240	2	
Cu (8)	19047	CPO 3054	Metal Wire 0.100-in. L x 0.020-in. D	4.142	V	18.60	0.035	0.210	6	Series 2
Cu (8)	19047		Wire 0.100-in. L x 0.020-in. D	4.100						
²³⁷ Np (9)	39407	Np-24-Hp	Oxide Wire	5.840	V	52.083	0.050	0.345	18	Series 1
²³⁷ Np (9)	39462	Hp-24-Hp	Oxide Wire	3.199	V	23.000	0.035	0.280	X	Series 2
²³⁹ Pu (9)	39407	453-B0	Oxide Wire	1.625	V	48.490	0.050	0.285	1	
²³⁹ Pu (9)	39462	453-B0	Oxide Wire	1.257	V	21.264	0.035	0.250	J	Series 6
Fe (9)	19046	Sc 53	Metal Wire 0.100-in. L x 0.020-in. D	4.025	V	20.74	0.035	0.240	V	Series 10
Fe (9)	B65-777-19046		Wire 0.100-in. L x 0.020-in. D	3.808						
Ti (10)	69925	139W	Metal Wire 0.100-in. L x 0.020-in. D	2.162	V	18.71	0.035	0.280	K	Series 3
Ti (10)	69926		Wire 0.100-in. L x 0.020-in. D	2.143						
1.0% TaV (10)	32548	ORNL	0.100-in. L x 0.020-in. D	2.995						
0.1% TaAl (11)	03783	217W	Metal Wire 0.100-in. L x 0.020-in. D	0.7000	V	17.059	0.035	0.240	X	Rx Roll 1

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TABLE A-5 (Continued)

Test: Run 97Page 4 of 4

HEDL Capsule Number _____

Container Identification F-4

Set Identification: _____

R: _____ z: 0 cm

[illegible]

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TABLE A-6

RUN 97, CONTAINER F-5, SPECTRAL SET DETAILS

Test: Run 97Page 1 of 2

HEDL Capsule Number _____

Container Identification F-5

Set Identification: _____

R: _____

Z: +15.24 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
^{238}U (1)*	39407	ES-Z	Oxide Wire	7.556	V	51.455	0.050	0.315	9	Series 1
Nb (1)	Fabry	Kawecki	0.47 mm x 3.0 mm	4.567	V	20.37	0.035	0.240	1	
Ni (1)	1		Wire 0.100-in. L x 0.020-in. D	4.399						
^{235}U (2)	55047	264-C	Oxide Wire	1.535	V	20.909	0.050	0.125	45	Series 3
^{237}Np (3)	39407	Np-24-Hp	Oxide Wire	5.800	V	50.598	0.050	0.345	20	Series 1
Ti (3)	69926		Wire 0.100-in. L x 0.020-in. D	2.124						
Mn_3O_2 (4)	55086		Oxide Wire 0.125-in. L x 0.020-in. D	1.2426	V	17.617	0.035	0.240	S	
SS Wire (4)			0.100-in. L x 0.033-in. D	9.277						FOTA SS Wire
Sc_2O_3 (5)	39407	ORNL Batch 1	Oxide Wire	1.377	V	41.165	0.050	0.255	89	
0.1% $\text{Sc}_2\text{O}_3/\text{MgO}$ (5)	55046	1	Oxide Wire 0.125-in. L x 0.020-in. D	0.8714	V	19.481	0.035	0.300	2	
0.1% AuAl (6)			Metal Wire 0.100-in. L x 0.020-in. D	1.2260	V	14.906	0.035	0.180	J	
1.0% CoV (7)	Fabry	Sp-2440	Metal Wire 0.100-in. L x 0.015-in. D	1.9970	V	17.410	0.035	0.180	F	
0.1% CoMgO (7)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.165	V	20.90	0.035	0.300	6	Series 3
0.1% CoAl (7)	HA-69-889-085	SRM 953	Metal Wire 0.100-in. L x 0.020-in. D	1.2850	V	17.817	0.035	0.240	0	

*Number in parentheses = hole number in container.

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TABLE A-6 (Continued)

Test: Run 97

Page 2 of 2

HEDL Capsule Number _____

Container Identification F-5

Set Identification: _____

R: _____

Z: +15.24 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
0.1% AgAl (8)	03783	Rx Wire	Metal Wire	1.3718	V	16.517	0.035	0.210	3	
²³⁹ Pu (9)	14965	453-B0	Oxide Wire	1.108	V	49.676	0.050	0.285	12 .:	Series X
0.1% TaAl (9)	03783	217W	Metal Wire 1.00-in. L x 0.020-in. D	0.7505	V	17.261	0.035	0.240	V	
1.0% TaV (9)	32548		Metal Wire 0.100-in. L x 0.020-in. D	2.816						
Fe (10)	19046	Sc 53	Metal Wire 0.100-in. L x 0.020-in. D	3.828	V	20.10	0.035	0.240	4	Series 10
Fe (10)	865-777-19046		Wire 0.100-in. L x 0.020-in. D	3.882						
⁶ LiF (11)	44051	AI	Crystal	2.144	V	42.796	0.050	0.255	L211-A2	
¹⁰ B (12)	44051	AI	Crystal	1.110	V	42.605	0.050	0.255	B244-F5	
Nb (13)	Fabry	Kawecki	0.47 mm x 3.0 mm	4.572						
Cu (13)	19047		Wire 0.100-in. L x 0.020-in. D	4.106						

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TABLE A-7

RUN 97, CONTAINER F-6, SPECTRAL SET DETAILS

Test: Run 97Page 1 of 2

HEDL Capsule Number _____

Container Identification F-6

Set Identification: _____

R: _____

Z: +39.37 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
1.0% CoV (1)*	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	1.8333						
Ni (1)	1		Metal Wire 0.1-in. L x 0.020-in. D	4.401						
Fe (1)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.809						
Cu (1)	19047		Metal Wire 0.1-in. L x 0.020-in. D	4.089						
Ti (1)	69926		Wire 0.1-in. L x 0.020-in. D	2.151						
Fe (2)	19046		Metal Wire 0.1-in. L x 0.020-in. D	4.073						
Ni (2)	1		Metal Wire 0.1-in. L x 0.020-in. D	4.380						
²³⁸ U (3)	39407	ES-Z	Oxide Wire	7.354	V	52.506	0.050	0.315	29	Series I
²³⁵ U (4)	55047	264-C	Oxide Wire	1.227	V	21.226	0.050	0.125	56	Series 3
²³⁷ Np (5)	39407	Np-24-Hp	Oxide Wire	6.438	V	52.947	0.050	0.345	23	Series I
²³⁹ Pu (6)	14965	453-B0	Oxide Wire	1.016	V	54.063	0.050	0.285	14	Series X
Sc ₂ O ₃ (7)	39407	PRNL-1	Oxide Wire	1.311	V	42.547	0.050	0.255	92	
0.1% Sc ₂ O ₃ /MgO (8)	55046	1	Oxide Wire 0.125-in. L x 0.020-in. D	0.9603	V	20.04	0.035	0.300	7	
¹⁰ B (9)	44051	AI	Crystal	0.737	V	41.342	0.050	0.255	B250-C7	

*Number in parentheses = hole number in container.

TABLE A-7 (Continued)

Test: Run 97Page 2 of 2HEDL Capsule Number Container Identification F-6Set Identification: R: Z: +39.37 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
⁶ LiF (10)	44051	AI	Crystal	1.892	V	43.517	0.050	0.255	L214-U4	
1.0% CoV (11)	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	1.8110						
0.1% CoMgO (11)	27940	ORNL Tube 1	Oxide Wire 0.1-in. L x 0.020-in. D	1.226	V	20.45	0.035	0.300	J	Series 3
0.1% CoAl (11)		SRM-953	Metal Wire 0.100-in. L x 0.020-in. D	1.2683						
1.0% CoV (12)	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	1.9134						
Ti (12)	69926		Wire 0.1-in. L x 0.020-in. D	2.166						
0.1% AgAl (13)	03783	Rx Wire	Metal Wire	1.2550	V	16.474	0.035	0.210	I	
0.1% AuAl (14)		Rx Wire	Metal Wire	1.1948	V	14.680	0.035	0.180	K	
MnO ₂ (15)	55086		Oxide Wire 0.125-in. L x 0.020-in. D	1.5017	V	17.968	0.035	0.240	T	
0.1% TaAl (16)	03783	217W	Metal Wire 0.100-in. L x 0.020-in. D	0.7340						
1.0% TaU (16)	32548	ORNL	0.100-in. L x 0.020-in. D	2.899						
SS (17)			0.1-in. L x 0.033-in. D	10.307						FOTA SS Rod
Cu (18)	19047		Metal Wire 0.100-in. L x 0.020-in. D	4.112						

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TABLE A-8

RUN 97, CONTAINER F-7, SPECTRAL SET DETAILS

Test: Run 97Page 1 of 2HEDL Capsule Number Container Identification F-7Set Identification: R: Z: +59.44 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
1.0% CoV (1)*	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	1.9979						
Fe (1)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.869						
Ni (1)	1		Metal Wire 0.1-in. L x 0.020-in. D	4.299						
Cu (1)	19047		Metal Wire 0.1-in. L x 0.020-in. D	4.126						
Ti (1)	69926		Metal Wire 0.1-in. L x 0.020-in. D	2.127						
Fe (2)	19046		Metal Wire 0.1-in. L x 0.020-in. D	3.637						
Ni (3)	1		Metal Wire 0.1-in. L x 0.020-in. D	4.340						
²³⁵ U (4)	55047	264-C	Oxide Wire	1.329	V	20.655	0.050	0.125	58 :..	Series 3
²³⁷ Np (5)	39407	Np-24-Hp	Oxide Wire	6.451	V	51.771	0.050	0.345	24 ::	Series I
²³⁹ Pu (6)	39407	453-B0	Oxide Wire	1.467	V	44.869	0.050	0.280	26 ..	
Sc ₂ O ₃ (7)	39407	ORNL-1	Oxide Wire	1.364	V	40.564	0.050	0.255	93 ...	
0.1% Sc ₂ O ₃ /MgO (8)	55046	1	Oxide Wire 0.125-in. L x 0.020-in. D	0.9017	V	21.67	0.035	0.300	F	
¹⁰ B (9)	44051	AI	Crystal	0.980	V	41.167	0.050	0.255	B252-ED	
⁶ LiF (10)	44051	AI	Crystal	2.484	V	41.960	0.050	0.255	L325-X5	

*Number in parentheses = hole number in container.

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TABLE A-8 (Continued)

Test: Run 97Page 2 of 2

HEDL Capsule Number _____

Container Identification F-7

Set Identification: _____

R: _____ Z: +59.44 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
1.0% CoV (11)	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	1.9387						
0.1% CoMgO (11)	27940	ORNL-1	Oxide Wire 0.100-in. L x 0.020-in. D	1.181	V	20.68	0.035	0.300	7	Series 4
0.1% CoAl (11)		SRM-953	Metal Wire 0.100-in. L x 0.020-in. D	1.2030						NBS Roll 1
1.0% CoV (12)	Fabry		Metal Wire 0.1-in. L x 0.015-in. D	1.8080						
Ti (12)	69926		Metal Wire 0.1-in. L x 0.020-in. D	2.164						
0.1% AgAl (13)	03783	Rx Wire	Metal Wire	1.1889	V	16.978	0.035	0.210	0	
0.1% AuAl (14)		Rx Wire	Metal Wire	1.2760	V	14.388	0.035	0.180	V	
Mn ₃ O ₄ (15)	55086		Oxide Wire 0.125-in. L x 0.020-in. D	1.3433	V	17.847	0.035	0.240	N	
0.1% TaAl (16)	03783	217W	Metal Wire 0.1-in. L x 0.020-in. D	0.7136						
1.0% TaV (16)	32548	ORNL	0.1-in. L x 0.020-in. D	2.788						
SS (17)			0.1-in. L x 0.033-in. D	10.264						FOTA SS Rod
Cu (18)	19047		Metal Wire 0.1-in. L x 0.020-in. D	4.016						

TABLE A-9

RUN 97, GRADIENT CONTAINERS 0 THROUGH 15, DOSIMETER DETAILS

Test: Run 97Page 1 of 3

HEDL Capsule Number _____

Container Identification _____

Set Identification: Gradient Set Loading

R: _____ Z: _____

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
0.1% Co/MgO (0)*	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.415	V	19.36	0.035	0.300	F	Series 3
Fe (0)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.896						Rx Wire
0.1% Co/MgO (1)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.247	V	20.15	0.035	0.300	0	Series 4
Fe (1)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.840						Rx Wire
0.1% Co/MgO (2)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.114	V	20.32	0.035	0.300	&	Series 4
Fe (2)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.762						Rx Wire
0.1% Co/MgO (3)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.119	V	21.30	0.035	0.300	V	Series 4
Fe (3)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.743						Rx Wire
0.1% Co/MgO (4)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.222	V	20.67	0.035	0.300	2	Series 4
Fe (4)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.794						Rx Wire
0.1% Co/MgO (5)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.112	V	20.95	0.035	0.300	T	Series 4
Fe (5)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.836						Rx Wire
0.1% Co/MgO (6)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.192	V	21.84	0.035	0.300	S	Series 4
Fe (6)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.691						Rx Wire

*Number in parentheses = Set Number.

TABLE A-9 (Continued)

Test: Run 97Page 2 of 3

HEDL Capsule Number _____

Container Identification _____

Set Identification: Gradient Set Loading

R: _____ Z: _____

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
0.1% Co/MgO (7)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.134	V	21.06	0.035	0.300	3	Series 4
Fe (7)	19046		Metal Wire 0.100-in. L x 0.020-in. D	4.005						Rx Wire
0.1% Co/MgO (8)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.189	V	20.16	0.035	0.300	J	Series 4
Fe (8)	19046		Metal Wire 0.100-in. L x 0.020-in. D	4.079						Rx Wire
0.1% Co/MgO (9)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	0.994	V	19.28	0.035	0.300	N	Series 4
Fe (9)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.948						Rx Wire
0.1% Co/MgO (10)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	0.954	V	20.00	0.035	0.300	K	Series 4
Fe (10)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.696						Rx Wire
0.1% Co/MgO (11)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.053	V	18.62	0.035	0.300	6	Series 4
Fe (11)	19046		Metal Wire 0.100-in. L x 0.020-in. D	4.049						Rx Wire
0.1% Co/MgO (12)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.486	V	20.21	0.035	0.300	4	Series 4
Fe (12)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.615						Rx Wire
0.1% Co/MgO (13)	27940	ORNL Tube 1	Oxide Wire 0.100-in. L x 0.020-in. D	1.071	V	18.89	0.035	0.300	Z	Series 4
Fe (13)	19046		Metal Wire 0.100-in. L x 0.020-in. D	3.944						Rx Wire

TABLE A-9 (Continued)

Test: Run 97Page 3 of 3

HEOL Capsule Number _____

Container Identification

Set Identification: Gradient Set Loading

R: _____ Z: _____

[illegible]

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APPENDIX B

RUN 97 HELIUM ACCUMULATION FLUENCE MONITORS -
SPECIFIC DETAILS

Atomics International Division
8900 De Soto Avenue
Canoga Park, California 91304
(213) 341-1000

June 26, 1978

In reply refer to 78AT-5880

Mr. J. A. Ulseth
Building 325, 300 Area
Hanford Engineering Development Laboratory
Westinghouse Hanford Company
Post Office Box 1970
Richland, Washington 99352

Dear Jim:

Subject: Nine Capsules for Irradiation in the EBR-II
Run 97 Dosimetry Experiment

Enclosed are nine stainless steel capsules to be irradiated at three Row 2 axial locations during the EBR-II Run 97 Dosimetry Experiment. The irradiation capsules contain a variety of helium accumulation fluence monitors (HAFM's), made of vanadium, niobium, platinum, and Type 304 stainless steel, along with a number of pure element wires and metal alloys.

1. Purposes of Tests

The purposes of the experiment are threefold: 1) to demonstrate sets of advanced energy-dependent HAFM's in Row 2 locations, for fluences several times greater than those used before; 2) to determine the effectiveness of vanadium and the alternative materials Nb, Pt, and SS as HAFM encapsulating materials for containing generated helium; and 3) to determine whether HAFM's can be irradiated in an atmosphere of helium (for thermal coupling) without this helium affecting the results.

2. Selection of Reactor Locations

The desire to have several different neutron energy distributions has led to the selection of three locations, each adjacent to a HEDL flux-spectral multiple foil capsule. Emphasis was placed on having the capsules away from any vertical reactor discontinuity so that the flux-spectrum could be determined as well as possible and with minimum gradients. Requested locations in Row 2 are as follows:

<u>Capsule Group</u>	<u>Capsules</u>	<u>Z-Location (cm)</u>	<u>Desired Conditions</u>
AI-1-B	B, P, O	+39.4 cm	Maximum Temperature
AI-2	A, H, K	+1.9 cm	Maximum Flux
AI-3-I	C, E, N	-34.7 cm	Minimum Temperature

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A summary of the masses of all materials in each of the nine capsules is provided in Table 1.

3. Capsule Description

The three capsule groups each contain three capsules. Each group includes an argon-filled 0.44-in. OD capsule, 0.89-in. long, and two 0.128-in. OD capsules, 0.88-in. long with holes to allow the plenum helium to penetrate. The dimensions of the two capsule types are given in the enclosed Figure 1 and are designed to fit within one of your "Specimen Holder, Parts 4 or 5" (HEDL Drawing H-3-44071, April 3, 1978).

We have loaded the nine capsules with a variety of materials described in Sections 4 and 5 of this letter. The three large capsules have been evacuated, back-filled with argon, and TIG-welded under argon. After welding, the capsules were cleaned, heated under vacuum to 500°C for one hour, and leak checked using the boiling water method. The smaller capsules have press-fitted ends, and a hole in the side to allow the helium within the pin to penetrate and bathe the contents during the irradiation. Each capsule has been engraved with an identification letter (on top of the large capsules, on the side of the small capsules) and an arrow which should point toward the zenith while in EBR-II. At HEDL, the capsules are to be inserted into the three HEDL subcapsules, along with HEDL flux gradient wires.

4. Contents of the Large Capsules

The three large capsules have been loaded with materials to study Items 1 and 2 of Section 1. In order to determine the effectiveness of various encapsulating materials for containing generated helium, the large capsules contain a variety of HAFM's with the capsule materials made of vanadium, niobium, platinum, and Type 304 stainless steel. Boron is included in the HAFM's to generate quantities of helium and build up a helium pressure within the HAFM capsules. Many of these four types of HAFM's (having 0.035-in. OD) are also further encapsulated in 0.050-in. OD capsules made of Pt and V. Subsequent shearing of the outer capsules is expected to provide information on possible permeation or leakage of helium through the inner capsule walls. Subsequent helium analyses of the inner capsules might include experiments to heat the HAFM's in steps, or etching experiments to determine the depth of helium penetration into the inner walls of the different capsule materials.

Several special vanadium capsules, also containing boron at one end, also contain 0.020-in. wires of V, Nb, Pt, and stainless steel. Each capsule has a variable (stepped) inside diameter, which provides a different depth of helium surrounding the wire. Measurement of the

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helium at various locations along the wire lengths will show whether the helium is being simply absorbed, or is being knocked into the wire by neutron collisions with the surrounding helium gas.

The other principal experiment included in the midplane large capsule (Capsule A) is the demonstration of a set of advanced energy-dependent HAFM's for fluence levels several times greater than those obtained during the Run 75D dosimetry test. HAFM capsules, made with vanadium, niobium and platinum have been filled with the most promising energy-sensitive helium generation materials. Capsule A contains at least one each of LiF, ^6LiF , ^7LiF , Be, B, C, NaF, NaCl, Al, Si, SiO_2 , KCl, KI, CaF_2 , Ti, TiN, V, V_2O_5 , Fe, FeF_2 , Ni, Cu, Zr, ZrN, Nb, Pt, and PbS. These HAFM's have been sealed by EB-welding, leak checked, and generally fabricated according to the "Specifications for Helium Accumulation Fluence Monitors" by H. Farrar IV, January 10, 1977. Molybdenum, and its seven enriched isotopes, and iron and the enriched isotopes ^{54}Fe , ^{56}Fe and ^{57}Fe are also included in Capsule A in an unsealed inner stainless steel tube.

The results of the helium analyses of these HAFM's will be correlated with ENDF/B cross section data, and compared with the results of HEDL radiometric foil reactions that have equivalent energy responses.

5. Contents of the Small Capsules

The six small capsules are designed to study Item 3) of Section 1. The capsules are not sealed, and this will therefore allow the helium from the pin to enter while they are in the reactor. Since the pin will be loaded at STP, the helium pressure at reactor temperature will be ~3 atmospheres.

All the small capsules were loaded with bare wires of V, Nb, Pt, and stainless steel, having dimensions between 0.020- and 0.050-inches. Some unsealed "stepped" vanadium capsules containing wires were also included. After the irradiation, the wires will undergo various etching procedures to determine the depth of helium penetration, if any. If this penetration is small, it will be feasible to irradiate HAFM's made of that material in a helium atmosphere, which provides a suitable thermal coupling. If there is helium penetration after such an irradiation, the HAFM capsules would be etched to remove the surface material contaminated with helium, so this source of helium would not affect the results.

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This irradiation is a very important part of our plans to develop and demonstrate helium accumulation fluence monitors, and we are particularly pleased to be able to include our capsules at locations close to HEDL's major dosimetry sets.

Yours truly,

James G. Bradley
Applied Nuclear Research
Energy Systems Group

737-E.56/pag

Enclosures

cc w/enclosures:

J. W. Lewellen, DOE-RRT-HQ
E. P. Lippincott, HEDL
W. N. McElroy, HEDL

TABLE 7
SUMMARY OF ROCKWELL INTERNATIONAL MATERIALS FOR RUN 97

Enclosure 1 to
AI Letter 78AT-5880
June 26, 1978

Element or Isotope Chemical or Physical Form		Mass of Element or Isotope (mg)								
		Group AI-2 (Midplane)			Group AI-1 (+39.4 cm)			Group AI-3 (-37.4 cm)		
		A	H	K	B	P	O	C	E	N
⁶ Li	⁶ LiF, ⁶ NiF	0.3								
⁷ Li	⁷ LiF, ⁷ NiF	1.9								
Be	Chunks	6.2								
B	Boron Crystals, Ni Wire	1.9			1.2			1.0		
C	Diamond	1.5								
N	TiN, ZrN	10.2								
O	SiO ₂ , V ₂ O ₅	7.2								
F	LiF, NaF, CaF ₂ , FeF ₂	16.5								
Na	NaF, NaCl	6.8								
Al	Wire	6.0								
Si	Si, SiO ₂	7.3								
S	PbS	2.0								
Cl	NaCl, KCl	5.7								
K	KCl, KI	3.5								
Ca	CaF ₂	3.4								
Ti	Wire, TiN	13.4								
V	Wire, Capsules, V ₂ O ₅	1724.1	190.6	126.1	442.7	166.7	77.2	470.9	188.1	76.7
Fe	Wire, Chunks*, FeF ₂	47.0								
Ni	Wire	16.2			44.7					
Cu	Wire	17.2								
Zr	Wire, ZrN	73.5								
Nb	Wire, Capsules	1590.7	76.8	167.8	120.6	41.7	137.7	138.3	78.3	97.7
Mo	Chunks*	55.8								
I	KI	4.8								
Pt	Wire, Capsules	4868.3	112.2	173.2	1151.3	196.9	258.5	1127.4	111.8	178.8
Pb	PbS	12.9								
SS	Wire, Capsules, Wool	5793.3	558.1	566.40	5371.7	574.0	561.3	5380.7	535.9	604.3

*Includes separated isotopes.

Enclosure 2 to
AI Letter 78AT-5880
June 26, 1978

FIGURE B-1. Large and Small Capsules Containing Rockwell International Materials for EBR-II Run 97.

APPENDIX C

RUN 97 SOLID STATE TRACK RECORDERS -
SPECIFIC DETAILS

RUN 97 SOLID STATE TRACK RECORDERS

Three capsules containing solid state track recorders (SSTR) were included. Each capsule contained a total of six natural quartz crystal SSTR and two pieces of Marz-grade nickel. Quartz crystal SSTR faces were placed next to the nickel wafers to monitor the fissionable element content of the nickel. Quartz-quartz interfaces were also present so that the fissionable element content of the quartz itself could be measured.

Each set of six SSTR consisted of three pieces of natural quartz cut along the 001 plane and three cut along the 100 plane. Three surfaces of each type of quartz were exposed to normally incident ^{252}Cf fission fragments, and three surfaces of each type were exposed to isotopically incident ^{252}Cf fission fragments to study the track relation characteristics of quartz crystal at the elevated temperature and high fluence of EBR-II.

The blank quartz surfaces will be exposed to ^{252}Cf fission fragments after the irradiation to study any possible changes in track recording properties of the SSTR.

TABLE C-1

RUN 97, SSTR SET S-1 DETAILS

Test: Run 97 SSTRPage 1 of 1HEDL Capsule Number S-1Container Identification 1

Set Identification: _____

R: _____ Z: _____

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
Ni		MRC	Marz Grade						T	
Quartz		VALTEC							-0	
Quartz		VALTEC							-1	
Quartz		VALTEC							-2	
Quartz		VALTEC							-3	
Quartz		VALTEC							-4	
Quartz		VALTEC							-5	
Ni		MRC	Marz Grade						B	

C-2

TABLE C-2

RUN 97, SSTR SET S-2 DETAILS

Test: Run 97 SSTRPage 1 of 1HEDL Capsule Number S-2Container Identification 2

Set Identification: _____

R: _____ Z: _____

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
Ni		MRC	Marz Grade						T	
Quartz		VALTEC							0	
Quartz		VALTEC							1	
Quartz		VALTEC							2	
Quartz		VALTEC							3	
Quartz		VALTEC							4	
Quartz		VALTEC							5	
Ni		MRC	Marz Grade						B	

TABLE C-3

RUN 97, SSTR SET 3 DETAILS

Test: Run 97 SSTRPage 1 of 1HEDL Capsule Number S-3Container Identification 3

Set Identification: _____

R: _____ Z: _____

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Remarks
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
Ni		MRC	Marz Grade						T	
Quartz		VALTEC							0	
Quartz		VALTEC							1	
Quartz		VALTEC							2	
Quartz		VALTEC							3	
Quartz		VALTEC							4	
Quartz		VALTEC							5	
Ni		MRC	Marz Grade						B	

C-4

APPENDIX D

EUROPEAN DOSIMETERS - SPECIFIC DETAILS

From: Irradiation Environment

Phone: 2-3710

Date: May 26, 1978

Subject: PROPOSED LOADING AND HANDLING OF EUROPEAN DOSIMETERS FOR THE EBR II
RUN 97 DOSIMETRY TEST

Hanford Engineering Development Laboratory

To: W. N. McElroy

cc: EP Lippincott
JAU/File/LB
Run 97 File/3

The Belgian, French, and German dosimeters will be loaded into the Run 97 Dosimetry Experiment Pin in the following manner:

Distance from Reactor Mid- plane, In.	Foils	Wires	Fission ⁽¹⁾ Monitors	Type of Container
-23.4, 15.5, 23.4	--	Fe, Ni, Cu, Ti Nb, 1% Co/V	--	Dos ⁽²⁾
-14.4, 0	--	Fe, Ni, Cu, Ti Nb, 1% Co/V	²³⁸ U, ²³⁵ U ²³⁷ Np	Dos ⁽²⁾
0, -15.4	10 Nb (MPI) ⁽³⁾ and Ti Spacers ⁽⁵⁾	--	--	SSTR 1 ⁽⁴⁾
0, -15.4	2 Nb (France), Ti Spacers, Cu Ti, Ni, Fe	--	--	SSTR 2 ⁽⁴⁾
0, -15.4	3 Nb (commercial) ⁽⁶⁾ --	--	--	SSTR 3 ⁽⁴⁾

Jim Ulseth
J. A. Ulseth

(1)-(6) See these footnotes on following page.

- (1) The fission monitors are being provided by HEDL, they are an oxide wire encapsulated in 0.050-inch diameter Vanadium.
- (2) DOS refers to a type of container used to hold dosimeter wires and capsules i.e. a right circular cylinder with several small holes drilled to contain the dosimeters. A common lid secured by a threaded screw holds the dosimeter in place.
- (3) MPI - Max Planck Institute.
- (4) SSTR - refers to the dosimeter container system for the foils - see attached figure. The different types of Nb foils will be separated into SSTR 1, 2, and 3 at each axial level. The foils will be stacked into the smaller containers and the positions recorded. After irradiation these small containers will be opened at Mol and the Nb destined for HEDL will be shipped to the US.
- (5) Ti spacers - See drawing.
- (6) Commercial - One Nb foil from three different companies i.e.: Highways Int., Goodfellow Met., and Kawachi Chem.

Nb FOIL SAMPLE CONTAINER

FIGURE D-1. Container and Loading for European Dosimeters.

TABLE D-1

RUN 97, EUROPEAN DOSIMETER SET A - SPECIFIC DETAILS

Test: Run 97 - European DosimetersPage 1 of 2

HEDL Capsule Number _____

Container Identification ASet Identification: S-1, Hole 3R: _____ Z: 0 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Subcontainer
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
Nb*		Max Planok	3.0 mm x 0.020 mm	0.6889					1	1-A
				0.6894					2	
				0.7494					3	
				0.7564					4	
				0.7762					5	
				0.7971					6	
				0.7988					7	
				0.8151					8	
				0.8180					9	
				0.8237					10	

*Foil loaded in same order with Ti spacers.

$$\begin{matrix} \cup & \leftarrow +10 \\ \cup & \leftarrow +1 \end{matrix}$$

TABLE D-1 (Continued)

Test: Run 97 - European Dosimeters

Page 2 of 2

HEDL Capsule Number _____

Container Identification A _____

Set Identification: _____

R: _____ Z: 0 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description				Ident	Subcontainer
					In	Weight (mg)	Diam (in.)	Length (in.)		
Nb*			France						320-568	2-A
Nb*			France						320-572	
Nb*			France						320-576	
Cu*		ASARCO	3.0 mm x 0.28 mm	14.777					47	
Ti*	564.124/61/4897	Baird Atomic	3.0 mm x 0.28 mm	8.728					57	
Ni*			3.0 mm x 0.1 mm	6.94					59	
Fe*	465784/74/6108		3.0 mm x 0.1 mm	5.860					55	
Nb		Good Fellow Metals	3.0 mm x 0.0125 mm	0.7474					37	3-A
Nb		Highways	3.0 mm x 0.0125 mm	0.6215					40	3-A
Nb		Kawecki	3.0 mm x 0.0762 mm	4.7385					45	3-A

*Foil loaded in same order with Ti spacers.

+5.5
+6.8

TABLE D-2

RUN 97, EUROPEAN DOSIMETER SET B - SPECIFIC DETAILS

Test: Run 97 - European DosimetersPage 1 of 2

HEDL Capsule Number _____

Container Identification BSet Identification: S-2, Hole 3

R: _____

Z: -15.4 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Subcontainer
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
Nb*		Max Planck Inst.	3.0 mm x 0.020 mm	0.8882					21	1-B
				0.8897					22	
				0.8997					23	
				0.9024					24	
				0.9027					25	
				0.9032					26	
				0.9089					27	
				0.9339					30	
				0.9350					31	
				0.9367					32	

*Foil loaded in same order with Ti spacers.

TABLE D-2 (Continued)

Test: Run 97 - European Dosimeters

Page 2 of 2

HEDL Capsule Number _____

Container Identification B

Set Identification: _____

R: _____

Z: -15.4 cm

Material	Purchase Order Number	Batch Number	Description	Material Weight (mg)	Encapsulated Monitor Description					Subcontainer
					In	Weight (mg)	Diam (in.)	Length (in.)	Ident	
Nb		France							320-567	2-B
Nb		France							320-571	
Nb		France							320-575	
Cu		ASARCO	3.0 mm x 0.28 mm	14.898					48	
Ti	564.124/61/4897	Baird Atomic	3.0 mm x 0.28 mm	8.768					52	
Ni			3.0 mm x 0.1 mm	6.95					60	
Fe	465784/74G100		3.0 mm x 0.1 mm	5.860					56	
Nb		Good Fellow Metals	3.0 mm x 0.0125 mm	0.7523					38	3-B
Nb		Highways	3.0 mm x 0.0125 mm	0.6360					41	3-B
Nb		Kawecki	3.0 mm x 0.0762 mm	4.7467					46	3-B

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C. L. Long	W/A-39
W. N. McElroy	W/A-39
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