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PREIRRADIATION DATA FOR THE FUEL SPECIMENS FOR
THE ARMY PM FUEL EXPERIMENT IN THE
ORR PRESSURIZED-WATER LOOP

V. O. Haynes

A. E. Richt

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Reactor Division

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ORR PRESSURIZED-WATER LOOP

V. O. Haynes
A. E. Richt

ABSTRACT

The information in this report describes the preirradiation condition of the fuel specimens for the Army PM (Portable-Medium) Reactor fuel experiment in the Oak Ridge Research Reactor (ORR) pressurized-water loop. A brief description is given of the various instruments and equipment used to perform the measurements and of the analytical techniques. Complete information is given for the specimens which were irradiated for an extended time and, where available, for other specimens fabricated for the fuel irradiation phase of the Army PM advanced-fuel development program.

INTRODUCTION

The information assembled in this report documents the data obtained at ORNL and describes the preirradiation condition of the Army PM fuel specimens. These specimens were produced for the irradiation effects portion of the Martin Company fuel development program sponsored by the Army Reactors Branch of the Atomic Energy Commission and sent to ORNL for the Army PM fuel experiment in the ORR pressurized-water loop. Martin Company reports^{1,2} describe the irradiation program and tabulate the specimen data obtained at the Martin Company plant prior to shipment of the specimens to ORNL. Some of the data reported here merely substantiates similar data obtained by the Martin Company. However, there is some information in each report which cannot be found in the other. Much

¹C. Eicheldinger, et al, Tubular Core Development Program PM Core 3 Materials and Process Status Report, MND-2706-13, Martin Company, Nuclear Division, December 1964.

²Tubular Core Development Program - Tabulation of Fuel Irradiation Specimen Data, MND-2706-15, Martin Company, Nuclear Division, October 1964, (revised January 1965).

of the data developed at ORNL was procured using measuring devices which are available for postirradiation examinations of the specimens. These measuring devices were designed and fabricated at ORNL specifically for measuring these specimens in the ORNL High Radiation Level Examination Laboratory (HRLLEL) at selected positions that could be easily duplicated during a postirradiation examination. Therefore this information is the basic data to be used for discerning changes in the specimens.

As shown by Table 1 the physical characteristics of the specimens varied as to type of starting UO_2 powder, UO_2 loading, UO_2 particle size, matrix stainless steel composition, cladding composition, the fabrication process, and the shape of the specimens.

Documentation of the fuel specimens that were irradiated for an extended time includes all the items discussed in the preirradiation data section of this report. This is not the case for the specimens given the short-duration exposure or for the backup specimens. The information given for the latter specimens is only that which had been performed when the development program was terminated.

PREIRRADIATION DATA

Visual Examination and Documentary Photography

Visual examination of the specimens was performed in three ways - direct and magnified observations, dye penetrant examinations, and boroscopic observations. The boroscopic examinations of the inner surface of the tubes at ORNL were performed with a hand-held device. This was not a precise survey of all of the surface but did establish the inside-diameter surface condition in a general manner.

The Type 1 tubular specimens were quite smooth while the advanced, development types (Types 2, 3, and 4 tubular specimens and all coupons) had smooth ends and had "orange peel" appearance of the surface over the fueled portion. The interface between the fueled core and the dead section was clearly defined visibly by an interruption in the surface characteristics and by a dimensional variation.

Table 1. Nominal Physical Characteristics of the UO₂-Stainless Steel Cermet Fuel Specimens for the Army PM Fuel Experiment in the ORR Pressurized-Water Loop

Specimen		Cermet Characteristics						Cladding Composition (AISI Type)	Fabrication Process
		UO ₂			SS Composition ^a (%)				
Form	Type	Powder Type ^b	Wt %	Particle Size (μ)	Cr	Ni	Fe		
Plate ^c	1	MSC	30	105-149	17.5	12.5	70.0	347	d
Plate ^c	2	MSC	35	105-149	17.5	12.5	70.0	347	d
Plate ^c	3	MSC	40	105-149	17.5	12.5	70.0	347	d
Plate ^c	4	MSC	45	105-149	17.5	12.5	70.0	347	d
Plate ^c	5	MSC	50	105-149	17.5	12.5	70.0	347	d
Plate ^c	6	ASC	40	105-149	17.5	12.5	70.0	347	d
Plate ^c	7	AAC	40	105-149	17.5	12.5	70.0	347	d
Plate ^c	8	MSC	40	105-149	20.0	10.0	70.0	347	d
Plate ^c	10	MSC	40	105-149	17.5	12.5	70.0	318	d
Plate ^c	11	MSU	40	105-149	Type 318 prealloyed			347	d
Plate ^c	12	ASC	40	149-177	17.5	12.5	70.0	347	d
Plate ^c	13	MSCP	40	105-149	17.5	12.5	70.0	347	d
Tube ^e	1	AAU	28	44-105	Type 304L prealloyed			347	f
Tube ^e	2	MSC	35	105-149	17.5	12.5	70.0	347	d
Tube ^e	3	MSC	40	105-149	17.5	12.5	70.0	347	d
Tube ^e	4	MSC	45	105-149	17.5	12.5	70.0	347	d

^a Elemental powder unless noted otherwise.

^b MSC for Martin produced spherical coated powder; ASC for alternate process spherical coated powder; AAC for alternate process angular coated powder; MSU for Martin produced spherical uncoated powder; MSCP for Martin produced spherical coated powder having induced porosity; AAU for alternate process angular uncoated powder.

^c Nominal fueled dimensions are 0.69 × 1.00 × 0.090 in.; nominal overall dimensions are 1.00 × 1.25 × 0.106 in.

^d Cold press, sinter, and isostatic press.

^e Nominal dimensions in in. were

Type	Overall			Clad Thickness	Fuel	
	OD	ID	Length		Thickness	Length
1	0.506	0.416	10.77	0.0075	0.030	9.0
2-4	0.540	0.330	10.77	0.0075	0.090	9.0

^f Martin process for PM Core 1 fuel.

Comments resulting from the visual examination are given for individual specimens in Appendix A. Fig. 1 shows the grids that were established for locating the observations. For convenience Appendix A information for the tubular fuel specimens is displayed as if the tubes were cut axially through the locating notch and flattened.

Numerous dye penetrant indications were observed along the edges of machined surfaces. Such indications were assumed to be caused by roughness resulting from the machining and no attempt was made to document them in detail.

Photographs of types 2, 3, and 4 tubular fuel specimens for long duration irradiation and spare specimens were made at 0°, 90°, 180°, and 270° rotations. The 0°-rotation photographs may be found in Appendix A. Since these show the typical appearance, the other three rotations are not reproduced here.

Photographs of each side of the coupon fuel specimens that were irradiated may be found on the visual information data sheets in Appendix A.

Surface Finish Measurements

Root mean square surface measurements were made on some of the tubular fuel specimens. These measurements were obtained using a Cleveland Instrument Company instrument with a stylus having a spherical top (0.0005 in. radius). The rms values of the clad over the fueled region are as follows:

<u>Element</u>		<u>rms Value (microinches)</u>
<u>Type</u>	<u>No.</u>	
2	7	250
2	9	210
2	10	250
2	11	225
3	7	180
3	8	210
3	9	250
3	10	250
3	12	250
3	13	200

NOTE: Axial position letters have the prefix "O" to indicate the outside diameter surface and "I" to indicate the inside diameter surface.

Scale: 1" = 1 1/2"

Tubular Specimens

Coupons

Fig. 1. Position Reference Scheme for the Fuel Specimens for the Army PM Fuel Experiment in the ORR Pressurized-Water Loop

<u>Element</u>		<u>rms Value (microinches)</u>
<u>Type</u>	<u>No.</u>	
4	6	250
4	7	220
4	8	200
4	9	220

Dimensional Measurements and Density Determinations

Evaluation of the effects of irradiation on the dimensional stability of the Army PM-type fuel specimens requires accurate and reproducible dimensional and density measurements on each fuel specimen both before and after irradiation testing. For this reason, several pieces of equipment designed for the purpose of measuring these particular fuel specimens were built. Use of this equipment for both the pre-and postirradiation measurements will eliminate many of the discrepancies commonly encountered in the comparison of data compiled by different measuring techniques. The equipment permits rapid and reproducible measurements at selected positions on the fuel specimen surfaces.

Accurately measured calibration standards were fabricated for the various pieces of measurement equipment. The equipment was calibrated periodically during the preirradiation measurements on the fuel specimens. These standards will also be used periodically during postirradiation measurements to ascertain that the equipment is functioning properly.

Results of the preirradiation dimensional measurements on the fuel specimens are presented in Appendix B. The remainder of this section describes the measuring devices and presents the density data.

Tubular Fuel Specimen Dimensional Measurement Equipment

Outside Diameter and Bow Measurement Equipment. The equipment for measuring the outer diameter and bow of the tubular fuel specimens is shown in Fig. 2. Two cone-shaped supports, one of which is keyed and geared to indicate the tube orientation, locate the fuel tube. A movable cross-head, indexed to a scale that indicates the axial location, supports two dial-gage micrometers that are equipped with wedge-shaped contact points in a diametrically opposed position. The sum of the two dial-gage readings

Fig. 2. Fuel Tube Diameter and Bow Measuring Equipment

measure the outer diameter of the fuel tube and the individual gage readings measure the deviation of the outer surface from the nominal axis of the tube. Thus, by traversing the length of the specimen, the gage readings can be used to determine the straightness of the tube, i.e., extent of warp or bow.

Length Measurement Equipment. The length of the tubular fuel specimens was measured with the device shown in Fig. 3. The tube is supported horizontally by two V-blocks. At one end a positive stop equipped with a keyway orients the tubes in a fixed position; at the other end a dial gage with a pedestal-type contact point indicates the length of the specimen.

Wall-Thickness Measurement Equipment. The apparatus used for measuring the wall thickness of the tubular fuel specimens is shown in Fig. 4. This unit is designed so that wall thickness measurements may be measured at any location on the tube surface. However, the gage can be used only on fuel tubes which are bowed less than 0.030 in. (erroneous measurements will result if the tube bow exceeds this limit).

Coupon Fuel Specimen Dimensional Measurement Equipment

The length, width, and thickness of the plate-type fuel specimens were measured with the apparatus shown in Fig. 5. Three different specimen holders are used to support the fuel coupon in the proper position for either the length, width, or thickness measurements. Four sliding 1/4-in.-wide bars attached to the specimen holder support-bed are a positioning system that provides for precise duplication of preselected locations for the various measurements. This indexing system is designed to give nine thickness, three length, and three width measurements on each fuel coupon.

Density Determination

The equipment used for measuring the density of the irradiation test specimens is shown in Fig. 6. Basically, this unit consists of a conventional analytical balance mounted upon a lucite case. The balance is fitted with a wire suspension with appropriately-shaped supports to carry either the plate or tubular-type fuel specimens. A glass tank is mounted

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Fig. 3. Fuel Tube Length Measuring Apparatus

Fig. 4. Fuel Tube Wall Thickness Measurement Equipment

Fig. 5. PM Fuel Coupon Length, Width, and Thickness Measurement Apparatus

Fig. 6. Modified Analytical Balance Used For
Density Measurements on the Army PM-Type
Irradiation Test Specimens

upon an elevating mechanism inside the lucite case so that the specimen can be weighed either in air or submerged in a displacement fluid. Distilled water containing a few drops of a wetting agent was used for the immersion fluid during all preirradiation density measurements.

Specimen density data are listed in Tables 2 and 3. The methods used for calculations of the core volume, core density, etc. are described in Appendix C.

Radiographic Examination

Extensive x-ray radiography was performed on the specimens during and following fabrication at the Martin Company plant. Negatives for most of the specimens listed in reference 1 were transferred to and are on file at ORNL along with the as-built x-ray negatives produced at ORNL.

Radiographs were made at two rotations and multiple intensities. In addition to detection of flaws the radiographs were used to determine the size and location of the fuel body.

The examination of the x-ray negatives for each of the fuel specimens listed in reference 1 as sent to ORNL showed the following:

1. The variation of the loading of the coupons was easily detected.
2. The Type 5 coupons appeared to be less dense along the edges than in the central region.
3. The negatives for tubular specimens 2-7, 3-12, 3-13, 4-3, 4-5, and 4-8 had some low density indications (either streaks or spots).

Ultrasonic Examination

Each specimen listed in reference 1 was given an ultrasonic test at the Martin Company to identify non-bond and voids. The traces from these tests were transferred to and are on file at ORNL. Examination of the traces for the specimens listed in reference 1 as sent to ORNL indicated suspect areas in only two tubes (Type 4, No. 3 and Type 4, No. 5). Both of these tubes were irradiated for only one hour.

Table 2. Density Information for the Coupon Fuel Specimens

Coupon (Type) (No.)	UO ₂ Core Loading (wt. %)	Theoretical Core Density ^a (gm/cm ³)	Specimen Weight (gm)	Core Weight (gm)	Specimen Volume (cm ³)	Core Volume ^a (cm ³)	Core Density ^a (gm/cm ³)	% Theoretical Density ^a
1	1	27.6	16.3177	8.5885	2.021	1.046	8.211	95.6
1	3	27.6	16.2819	8.7383	2.011	1.072	8.151	94.9
2	1	34.3	16.6688	8.8245	2.045	1.056	8.357	95.4
2	3	34.3	16.9235	8.8445	2.084	1.065	8.305	94.8
3	2	38.8	16.5391	8.8260	2.016	1.043	8.462	95.3
3	3	38.8	16.7847	8.9399	2.046	1.057	8.458	95.2
4	2	44.4	17.3025	9.2668	2.123	1.110	8.348	92.4
4	3	44.4	17.3021	9.1273	2.108	1.077	8.475	93.9
5	1	47.9	17.4868	9.1789	2.107	1.059	8.668	94.9
5	2	47.9	17.1863	9.0721	2.069	1.046	8.673	95.0
6	1	40.7	16.9293	8.9225	2.034	1.024	8.713	97.6
6	2	40.7	16.9256	8.9740	2.012	1.009	8.894	99.6
7	2	37.3	16.6873	8.8028	2.024	1.030	8.546	96.8
7	3	37.3	16.9378	8.9256	2.040	1.030	8.667	98.2
8	2	38.3	16.7932	8.8950	2.012	1.016	8.775	99.0
8	3	38.3	16.7940	8.8977	2.039	1.043	8.530	96.3
10	2	38.8	17.1341	8.9215	2.089	1.053	8.472	95.4
10	3	38.8	17.3006	8.9124	2.106	1.048	8.504	95.8
11	2	40.0	17.1068	9.1362	2.083	1.078	8.475	95.1
11	3	40.0	17.0997	9.0880	2.071	1.061	8.566	96.1
12	1	38.4	16.8267	8.9023	2.016	1.017	8.753	98.7
12	2	38.4	16.7572	8.8349	2.001	1.002	8.817	99.4
13	1	38.2	16.9570	8.9110	2.070	1.055	8.446	95.4
13	2	38.2	16.7364	8.8932	2.052	1.057	8.414	95.0

^aCalculated values are based on densities of 10.96 and 7.93 gm/cm³ for UO₂ and type 347 stainless steel, respectively.

Table 3. Density Information for the Tubular Fuel Specimens

Tubular Specimens		UO ₂ Core Loading (wt. %)	Theoretical Core Density ^a (gm/cm ³)	Specimen Weight (gm)	Core Weight (gm)	Specimen Volume (cm ³)	Core Volume ^a (cm ³)	Core Density ^a (gm/cm ³)	% Theoretical Density ^a
Type	No.								
1	1	29.9	8.645	92.9809	57.6	11.3550	6.8394	8.422	97.4
1	2	29.9	8.645	92.6259	57.55	11.3171	6.8939	8.348	96.6
1	3	29.9	8.645	92.0630	57.1	11.2463	6.8374	8.351	96.6
1	4	29.9	8.645	91.7614	56.9	11.2088	6.8127	8.352	96.6
1	5	29.9	8.645	92.0537	56.9	11.2707	6.8377	8.322	96.3
1	8	29.9	8.645	92.4264	57.7	11.3993	7.0202	8.219	95.1
2	5	35.0	8.780	202.7470	146.92	24.5737	17.5338	8.379	95.4
2	6	35.0	8.780	202.1833	145.98	24.5166	17.4292	8.376	95.4
2	7	35.48	8.792	204.1524	153.3414	24.4682	18.0608	8.490	96.6
2	9	35.25	8.786	204.1838	150.6217	24.3258	17.5714	8.572	97.6
2	10	35.25	8.786	202.7850	149.7191	24.1587	17.4669	8.572	97.6
2	11	35.25	8.786	204.6951	151.6231	24.3667	17.6742	8.579	97.7
3	4	40.1	8.919	201.1059	149.782	24.0714	17.5991	8.511	95.4
3	5	40.1	8.919	200.6114	148.453	24.0255	17.4478	8.508	95.4
3	6	40.1	8.919	200.7563	149.717	23.9825	17.5467	8.533	95.7
3	7	39.54	8.903	207.1587	155.7043	24.6433	18.1547	8.577	96.3
3	8	39.54	8.903	204.5398	152.6	24.3563	17.8065	8.570	96.3
3	9	39.54	8.903	204.4310	152.8975	24.3715	17.8730	8.555	96.1
3	10	40.09	8.921	203.5011	149.9232	24.1095	17.3531	8.640	96.9
3	12	40.09	8.921	203.0487	150.0226	25.0985	18.4117	8.148	91.3
3	13	39.54	8.903	204.8468	151.2445	24.2450	17.4856	8.650	97.2
4	3	44.6	9.045	203.6740	152.03	24.3440	17.8315	8.526	94.3
4	4	44.6	9.045	201.7305	152.61	24.1580	17.9637	8.496	93.9
4	5	44.6	9.045	200.8414	148.90	24.0067	17.4567	8.530	94.3
4	6	44.54	9.044	201.7046	145.5441	23.9940	17.4794	8.327	92.1
4	7	44.54	9.044	200.7586	147.9080	23.9096	17.2450	8.577	94.8
4	8	44.49	9.042	202.1352	147.4656	23.7976	16.9036	8.724	96.5
4	9	44.49	9.042	203.0875	148.0363	23.9088	16.9667	8.725	96.5

^aCalculated values are based on densities of 10.96 and 7.93 gm/cm³ for UO₂ and type 347 stainless steel, respectively.

Specimen Replication

Because of the rather complex nature of the test specimens, we felt that photographic and descriptive documentation might prove to be inadequate in characterizing the preirradiation condition of the fuel specimen surfaces. Consequently, we developed a method for producing permanent replicas of each individual fuel specimen. This was done by casting a liquid silicon-rubber potting compound³ around the fuel specimens. After the rubber mold was fully cured, the specimens were removed and the resulting cavities back-cast with a room-temperature curing epoxy resin.⁴ The epoxy castings then were shadowed with aluminum by vacuum deposition to render the replica opaque and increase contrast. Typical stages followed in the replication of the tubular fuel specimens are shown in Fig. 7. A similar procedure was used to replicate the plate-type fuel specimens.

Both the specimen molds and the aluminum-shadowed replicas of the fuel specimens are stored at ORNL. Thus, during postirradiation examination program, exact replicas of the preirradiation condition of the test specimens will be available for comparison purposes.

Metallography

Since metallography is expected to be an extremely valuable tool in evaluating the irradiation performance of these fuel specimens, thorough documentation of the preirradiation microstructure of the various fuel specimens was required. The preirradiation metallographic data supplied by the Martin Company was found to be inadequate in this respect; consequently, a more detailed metallographic investigation was made at ORNL. Sections cut from surplus fuel specimens representative of each type of fuel sample were metallographically prepared, examined, and the microstructures photographically documented. Negatives of all preirradiation

³RTV-60 manufactured by the General Electric Company, Waterford, New York.

⁴Araldite 502 manufactured by the Ciba Products Company, Fairlawn, New Jersey.

Fig. 7. Typical Stages in the Replication of the Army TM-Type Tubular Fuel Specimens

- (A) Fuel tubes positioned in a cardboard box for casting the RTV Mold. Note that tube ends are plugged with corks and that small shims are positioned under the ends of the corks to support the specimens above bottom of box.
- (B) Fuel tubes being removed from RTV Mold.
- (C) Comparison of an actual fuel tube and its aluminum-shadowed epoxy replica.

photomicrographs are currently on file in the remote metallography section at ORNL.

A complete set of preirradiation metallographic results are not presented in this report. However, a series of photomicrographs are shown in Figs. 8 through 16 to illustrate the variations in the microstructure of the various types of fuel samples. In general, the microstructure of individual fuel samples can be characterized by (1) the size, shape, and distribution of the UO_2 fuel particles within the stainless steel matrix material, and (2) the microstructure of the UO_2 fuel particles proper. These characteristics of course, are predominately related to the initial selection of materials for the specimens and to the specimen fabrication procedures.

Fig. 8. Typical Microstructure of a Type 1 Tubular Fuel Specimen
(a) As Polished, (b) Etched 100X

Fig. 9. Typical Microstructure of a Type 3 Fuel Coupon
(a) As Polished, (b) Etched 100X

Fig. 10. Typical Microstructure of a Type 6 Fuel Coupon
(a) As Polished, (b) Etched 100X

Fig. 11. Typical Microstructure of a Type 7 Fuel Coupon
(a) As Polished, (b) Etched 100X

Fig. 12. Typical Microstructure of a Type 11 Fuel Coupon
(a) As Polished, (b) Etched 100X

Fig. 13. Typical Microstructure of a Type 12 Fuel Coupon
(a) As Polished, (b) Etched 100X

Fig. 14. Typical Microstructure of a Type 13 Fuel Coupon
(a) As Polished, (b) Etched 100X

Fig. 15. Typical Microstructure of Spherical UO_2 Fuel Particles
Produced by Martin Nuclear Corporation
(a) As Polished, (b) Etched 500X

Fig. 16. Typical Microstructure of Spherical UO₂ Fuel Particles
Produced by United Nuclear Corporation
(a) As Polished, (b) Etched 500X

Appendix A

VISUAL EXAMINATION INFORMATION AND PHOTOGRAPHS

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Inside-Diameter Surface

Outside-Diameter Surface

Remarks: The outside surface has a medium gray color.

Visual Examination Information for Tubular Specimen Type 1, No. 1

Outside-Diameter Surface

Remarks: The outside surface has a medium gray color.

Visual Examination Information for Tubular Specimen Type 1, No. 2

Remarks: The outside surface has a medium gray color.

Visual Examination Information for Tubular Specimen Type 1, No. 3

Inside-Diameter Surface

Outside-Diameter Surface

- Remarks: 1. The inside surface is very reflective.
 2. The outside surface has a uniform, gray color with silver colored axial streaks at 0° and 180°.

Visual Examination Information for Tubular Specimen Type 1, No. 4

Inside-Diameter Surface

Outside-Diameter Surface

- Remarks:
1. The inside surface is very reflective.
 2. The outside surface has a uniform, gray color.

Visual Examination Information for Tubular Specimen Type 1, No. 5

Remarks: The outside surface has a medium gray color.

Visual Examination Information for Tubular Specimen Type 1, No. 8

Inside-Diameter Surface

Outside-Diameter Surface

- Remarks:
1. The inside surface appears dirty but is reflective.
 2. The outside surface has a gray color.

Visual Examination Information for Tubular Specimen Type 2, No. 5

Inside-Diameter Surface

Outside-Diameter Surface

- Remarks:
1. The inside surface has several long scratches - the two worst are in line with the notch.
 2. The outside surface is dark on one side and bright on the other.

Visual Examination Information for Tubular Specimen Type 2, No. 6

Inside-Diameter Surface

Outside-Diameter Surface

- Remarks:
1. The inside surface has a few nicks and scratches, looks dirty but is reflective.
 2. The outside surface appears slightly etched.

Visual Examination Information for Tubular Specimen Type 3, No. 4

Inside-Diameter Surface

Outside-Diameter Surface

- Remarks:
1. The inside surface has a few long scratches.
 2. The outside surface has a dull appearance and is darker on one side than on the other.

Visual Examination Information for Tubular Specimen Type 3, No. 5

- Remarks:
1. The inside surface has numerous axial scratches and has a whitish-colored deposit in a few places.
 2. The outside surface has a mottled greenish-gray color.

Visual Examination Information for Tubular Specimen Type 3, No. 6

Inside-Diameter Surface

Outside-Diameter Surface

- Remarks:
1. The inside surface appears dirty but is reflective. There are six lines running axially which spiral clockwise from the notch end. No scratches evident by eye.
 2. The outside surface has one side which is brighter than the other.

Visual Examination Information for Tubular Specimen Type 4, No. 3

Inside-Diameter Surface

Outside-Diameter Surface

- Remarks:
1. The inside surface has six lines running axially which spiral clockwise from the notched end. The surface is smooth and reflective.
 2. The outside surface appears to be slightly etched.

Visual Examination Information for Tubular Specimen Type 4, No. 5

Inside-Diameter Surface

Outside-Diameter Surface

Remarks:

Visual Examination Information for Tubular Specimen Type 2, No. 7

Inside-Diameter Surface

Outside-Diameter Surface

Remarks:

Visual Examination Information for Tubular Specimen Type 2, No. 9

Inside-Diameter Surface

Outside-Diameter Surface

Remarks:

Visual Examination Information for Tubular Specimen Type 3, No. 7

Inside-Diameter Surface

Outside-Diameter Surface

Remarks: Outside surface quite shiny.

Visual Examination Information for Tubular Specimen Type 3, No. 8

Inside-Diameter Surface

Outside-Diameter Surface

Remarks: The inside surface has numerous scratches.

Visual Examination Information for Tubular Specimen Type 3, No. 9

Inside-Diameter Surface

Outside-Diameter Surface

Remarks: The inside surface has numerous scratches. The inside surface also has numerous pits from 0° to 180° and 300° to 0°.

Visual Examination Information for Tubular Specimen Type 4, No. 6

Inside-Diameter Surface

Outside-Diameter Surface

Remarks: The inside surface has numerous scratches.

Visual Examination Information for Tubular Specimen Type 4, No. 7

Types 2, 3, and 4 Tubular Fuel Specimens for
Long-Duration Irradiation (0° Rotation)

Spare Types 2, 3, and 4 Tubular Fuel Specimens (0° Rotation)

A-25

E Side

Not
Photographed

W Side

Visual Examination Information and Photographs
for Coupon Type 1, No. 1

Remarks: Many small surface marks in the central area.

E Side

Not
Photographed

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 1, No. 3

A-27

Fuel-edge
interface

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 2, No. 1

A-28

E Side

W Side

Visual Examination Information and Photographs
for Coupon Type 2, No. 3

Fuel-edge
interface

E Side

Fuel-edge
interface

W Side

A-30

E Side

W Side

Visual Examination Information and Photographs
for Coupon Type 3, No. 3

A-31

E Side

W Side

Visual Examination Information and Photographs
for Coupon Type 4, No. 2

E Side

W Side

A-33

Fuel-edge
interface

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 5, No. 1

A-34

E Side

W Side

Visual Examination Information and Photographs
for Coupon Type 5, No. 2

Fuel-edge
interface

No record

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 6, No. 1

Fuel-edge
interface

No record

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 6, No. 2

A-37

E Side

W Side

Visual Examination Information and Photographs
for Coupon Type 7, No. 2

E Side

W Side

E Side

W Side

A-40

E Side

W Side

Visual Examination Information and Photographs
for Coupon Type 8, No. 3

A-41

E Side

W Side

Visual Examination Information and Photographs
for Coupon Type 10, No. 2

A-42

Remarks: Surface appearance different from other specimens.

E Side

Remarks: Surface appearance different from other specimens.

W Side

Visual Examination Information and Photographs
for Coupon Type 10, No. 3

A-43

Fuel-edge
interface

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 11, No. 2

A-44

Fuel-edge
interface

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 11, No. 3

A-45

Fuel-edge
interface

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 12, No. 1

A-46

E Side

W Side

Visual Examination Information and Photographs
for Coupon Type 12, No. 2

A-47

Fuel-edge
interface

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 13, No. 1

A-48

Fuel-edge
interface

E Side

Fuel-edge
interface

W Side

Visual Examination Information and Photographs
for Coupon Type 13, No. 2

Appendix B

DIMENSIONAL MEASUREMENT AND DENSITY DATA

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DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1000</u>	1B <u>0.1003</u>	1C <u>0.0991</u>
2A <u>0.1006</u>	2B <u>0.1012</u>	2C <u>0.1002</u>
3A <u>0.1005</u>	3B <u>0.1013</u>	3C <u>0.0999</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.3177</u> g
Total Specimen Volume	<u>2.021</u> cm^3
Specimen Density	<u>8.075</u> g/cm^3

Dimensional and Density Data for Coupon Type 1, No. 1

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1013</u>	1B <u>0.1015</u>	1C <u>0.0995</u>
2A <u>0.1017</u>	2B <u>0.1020</u>	2C <u>0.1005</u>
3A <u>0.1016</u>	3B <u>0.1018</u>	3C <u>0.1002</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.2819</u> g
Total Specimen Volume	<u>2.011</u> gm ³
Specimen Density	<u>8.096</u> g/cm ³

Dimensional and Density Data for Coupon Type 1, No. 3

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A 0.1027	1B 0.1019	1C 0.1029
2A 0.1026	2B 0.1036	2C 0.1023
3A 0.1028	3B 0.1038	3C 0.1025

DENSITY DATA

Total Specimen Wt. in Air	16.6688	g
Total Specimen Volume	2.050	cm ³
Specimen Density	8.132	g/cm ³

Dimensional and Density Data for Coupon Type 2, No. 1

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1045</u>	1B <u>0.1059</u>	1C <u>0.1034</u>
2A <u>0.1053</u>	2B <u>0.1065</u>	2C <u>0.1041</u>
3A <u>0.1032</u>	3B <u>0.1057</u>	3C <u>0.1031</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.9235</u> g
Total Specimen Volume	<u>2.084</u> cm ³
Specimen Density	<u>8.112</u> g/cm ³

Dimensional and Density Data for Coupon Type 2, No. 3

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1006</u>	1B <u>0.1014</u>	1C <u>0.0997</u>
2A <u>0.1013</u>	2B <u>0.1021</u>	2C <u>0.1006</u>
3A <u>0.1012</u>	3B <u>0.1019</u>	3C <u>0.1006</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.5391</u> g
Total Specimen Volume	<u>2.016</u> cm^3
Specimen Density	<u>8.203</u> g/cm^3

Dimensional and Density Data for Coupon Type 3, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1013</u>	1B <u>0.1035</u>	1C <u>0.1025</u>
2A <u>0.1032</u>	2B <u>0.1047</u>	2C <u>0.1038</u>
3A <u>0.1038</u>	3B <u>0.1051</u>	3C <u>0.1039</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.7847</u> g
Total Specimen Volume	<u>2.046</u> cm^3
Specimen Density	<u>8.205</u> g/cm^3

Dimensional and Density Data for Coupon Type 3, No. 3

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1075</u>	1B <u>0.1085</u>	1C <u>0.1069</u>
2A <u>0.1078</u>	2B <u>0.1084</u>	2C <u>0.1076</u>
3A <u>0.1068</u>	3B <u>0.1066</u>	3C <u>0.1066</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>17.3025</u> g
Total Specimen Volume	<u>2.123</u> cm ³
Specimen Density	<u>8.149</u> g/cm ³

Dimensional and Density Data for Coupon Type 4, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1076</u>	1B <u>0.1089</u>	1C <u>0.1066</u>
2A <u>0.1067</u>	2B <u>0.1088</u>	2C <u>0.1066</u>
3A <u>0.1050</u>	3B <u>0.1073</u>	3C <u>0.1052</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>17.3021</u> g
Total Specimen Volume	<u>2.108</u> cm^3
Specimen Density	<u>8.206</u> g/cm^3

Dimensional and Density Data for Coupon Type 4, No. 3

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1052</u>	1B <u>0.1080</u>	1C <u>0.1061</u>
2A <u>0.1055</u>	2B <u>0.1088</u>	2C <u>0.1071</u>
3A <u>0.1052</u>	3B <u>0.1081</u>	3C <u>0.1068</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>17.4868</u>	g
Total Specimen Volume	<u>2.107</u>	cm ³
Specimen Density	<u>8.298</u>	g/cm ³

Dimensional and Density Data for Coupon Type 5, No. 1

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1050</u>	1B <u>0.1067</u>	1C <u>0.1043</u>
2A <u>0.1046</u>	2B <u>0.1083</u>	2C <u>0.1047</u>
3A <u>0.1027</u>	3B <u>0.1055</u>	3C <u>0.1037</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>17.1863</u> g
Total Specimen Volume	<u>2.069</u> cm^3
Specimen Density	<u>8.306</u> g/cm^3

Dimensional and Density Data for Coupon Type 5, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A 0.1007	1B 0.1012	1C 0.0984
2A 0.1008	2B 0.1010	2C 0.1003
3A 0.1007	3B 0.1005	3C 0.1005

DENSITY DATA

Total Specimen Wt. in Air	16.9293 g
Total Specimen Volume	2.034 gm ³
Specimen Density	8.321 g/cm ³

Dimensional and Density Data for Coupon Type 6, No. 1

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1005</u>	1B <u>0.1021</u>	1C <u>0.1001</u>
2A <u>0.1008</u>	2B <u>0.1016</u>	2C <u>0.1000</u>
3A <u>0.0991</u>	3B <u>0.0998</u>	3C <u>0.0986</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.9256</u> g
Total Specimen Volume	<u>2.012</u> cm^3
Specimen Density	<u>8.412</u> g/cm^3

Dimensional and Density Data for Coupon Type 6, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1002</u>	1B <u>0.1018</u>	1C <u>0.1006</u>
2A <u>0.0995</u>	2B <u>0.1005</u>	2C <u>0.0992</u>
3A <u>0.0994</u>	3B <u>0.0994</u>	3C <u>0.0985</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.6873</u>	g
Total Specimen Volume	<u>2.024</u>	cm ³
Specimen Density	<u>8.246</u>	g/cm ³

Dimensional and Density Data for Coupon Type 7, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1017</u>	1B <u>0.1042</u>	1C <u>0.1028</u>
2A <u>0.0993</u>	2B <u>0.1026</u>	2C <u>0.1017</u>
3A <u>0.0969</u>	3B <u>0.0998</u>	3C <u>0.0998</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.9378</u>	g
Total Specimen Volume	<u>2.040</u>	cm ³
Specimen Density	<u>8.304</u>	g/cm ³

Dimensional and Density Data for Coupon Type 7, No. 3

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1012</u>	1B <u>0.1036</u>	1C <u>0.1011</u>
2A <u>0.1024</u>	2B <u>0.1048</u>	2C <u>0.1019</u>
3A <u>0.1022</u>	3B <u>0.1047</u>	3C <u>0.1015</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.7932</u> g
Total Specimen Volume	<u>2.012</u> cm^3
Specimen Density	<u>8.345</u> g/cm^3

Dimensional and Density Data for Coupon Type 8, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1004</u>	1B <u>0.1041</u>	1C <u>0.1022</u>
2A <u>0.1016</u>	2B <u>0.1044</u>	2C <u>0.1020</u>
3A <u>0.1004</u>	3B <u>0.1035</u>	3C <u>0.1017</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.7940</u>	g
Total Specimen Volume	<u>2.039</u>	gm ³
Specimen Density	<u>8.236</u>	g/cm ³

Dimensional and Density Data for Coupon Type 8, No. 3.

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1043</u>	1B <u>0.1074</u>	1C <u>0.1058</u>
2A <u>0.1055</u>	2B <u>0.1077</u>	2C <u>0.1064</u>
3A <u>0.1058</u>	3B <u>0.1069</u>	3C <u>0.1063</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>17.1341</u> g
Total Specimen Volume	<u>2.089</u> cm^3
Specimen Density	<u>8.203</u> g/cm^3

Dimensional and Density Data for Coupon Type 10, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1062</u>	1B <u>0.1080</u>	1C <u>0.1037</u>
2A <u>0.1047</u>	2B <u>0.1077</u>	2C <u>0.1034</u>
3A <u>0.1021</u>	3B <u>0.1043</u>	3C <u>0.1016</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>17.3006</u>	g
Total Specimen Volume	<u>2.106</u>	cm ³
Specimen Density	<u>8.216</u>	g/cm ³

Dimensional and Density Data for Coupon Type 10, No. 3

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1065</u>	1B <u>0.1066</u>	1C <u>0.1036</u>
2A <u>0.1068</u>	2B <u>0.1071</u>	2C <u>0.1049</u>
3A <u>0.1061</u>	3B <u>0.1065</u>	3C <u>0.1052</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>17.1068</u>	g
Total Specimen Volume	<u>2.083</u>	cm ³
Specimen Density	<u>8.212</u>	g/cm ³

Dimensional and Density Data for Coupon Type 11, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1049</u>	1B <u>0.1061</u>	1C <u>0.1038</u>
2A <u>0.1054</u>	2B <u>0.1067</u>	2C <u>0.1045</u>
3A <u>0.1053</u>	3B <u>0.1061</u>	3C <u>0.1047</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>17.0997</u> g
Total Specimen Volume	<u>2.076</u> cm ³
Specimen Density	<u>8.237</u> g/cm ³

Dimensional and Density Data for Coupon Type 11, No. 3

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A	0.0996	1B 0.0993
2A	0.0994	2B 0.0995
3A	0.0983	3B 0.0991
		1C 0.0985
		2C 0.0990
		3C 0.0986

DENSITY DATA

Total Specimen Wt. in Air	16.8267 g
Total Specimen Volume	2.016 cm ³
Specimen Density	8.349 g/cm ³

Dimensional and Density Data for Coupon Type 12, No. 1

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.0981</u>	1B <u>0.0990</u>	1C <u>0.1000</u>
2A <u>0.0984</u>	2B <u>0.0987</u>	2C <u>0.1005</u>
3A <u>0.0988</u>	3B <u>0.0990</u>	3C <u>0.1006</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.7572</u> g
Total Specimen Volume	<u>2.001</u> gm ³
Specimen Density	<u>8.374</u> g/cm ³

Dimensional and Density Data for Coupon Type 12, No. 2

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1038</u>	1B <u>0.1035</u>	1C <u>0.1017</u>
2A <u>0.1048</u>	2B <u>0.1046</u>	2C <u>0.1038</u>
3A <u>0.1044</u>	3B <u>0.1054</u>	3C <u>0.1037</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.9570</u>	g
Total Specimen Volume	<u>2.070</u>	gm ³
Specimen Density	<u>8.190</u>	g/cm ³

Dimensional and Density Data for Coupon Type 13, No. 1

DIMENSIONAL DATA

Specimen Thickness (in.)		
1A <u>0.1026</u>	1B <u>0.1058</u>	1C <u>0.1032</u>
2A <u>0.1021</u>	2B <u>0.1054</u>	2C <u>0.1034</u>
3A <u>0.1003</u>	3B <u>0.1037</u>	3C <u>0.1017</u>

DENSITY DATA

Total Specimen Wt. in Air	<u>16.7864</u>	g
Total Specimen Volume	<u>2.052</u>	cm ³
Specimen Density	<u>8.180</u>	g/cm ³

Dimensional and Density Data for Coupon Type 13, No. 2

DENSITY DATA

Total Specimen Wt. in	
Air	92.9809 g
Total Specimen Volume	11.355 m ³
Specimen Density	8.189 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (290°)			90° Rotation from Peak Flux (20°)			290° Position	20° Position	110° Position	200° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2540	0.2529	0.5069	0.2525	0.2543	0.5068	0.0462	0.0491	0.0498	0.0455
B	0.2534	0.2513	0.5057	0.2530	0.2538	0.5068	0.0455	0.0472	0.0486	0.0454
C	0.2538	0.2511	0.5059	0.2538	0.2531	0.5059	0.0461	0.0459	0.0458	0.0460
D	0.2561	0.2507	0.5058	0.2551	0.2518	0.5069	0.0457	0.0457	0.0458	0.0495
E	0.2561	0.2506	0.5057	0.2557	0.2512	0.5069	0.0464	0.0456	0.0451	0.0490
F	0.2568	0.2500	0.5068	0.2557	0.2512	0.5069	0.0477	0.0484	0.0497	0.0521
G	0.2575	0.2495	0.5070	0.2544	0.2523	0.5067	0.0496	0.0477	0.0459	0.0522
H	0.2573	0.2495	0.5068	0.2527	0.2541	0.5068	0.0529	0.0468	0.0489	0.0532
I	0.2561	0.2507	0.5068	0.2521	0.2547	0.5068	0.0477	0.0462	0.0545	0.0546
J	0.2545	0.2528	0.5073	0.2529	0.2545	0.5074	0.0481	0.0465	0.0477	0.0466

^aSee orientation sketch.

Overall Length (in.)
ORNL Measurement
Z = 10.7661 in.
Martin Measurement
Z = 10.769 in.

Dimensional and Density Data for the Tubular Specimen Type 1, No. 1

B-27

DENSITY DATA

Total Specimen Wt. in
Air 92.6259 g

Total Specimen Volume 11.317 in³

Specimen Density 8.185 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (20°)			90° Rotation from Peak Flux (290°)			20° Position	110° Position	200° Position	290° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2529	0.2531	0.5060	0.2538	0.2528	0.5066	0.0471	0.0498	0.0455	0.0471
B	0.2541	0.2525	0.5066	0.2547	0.2519	0.5066	0.0463	0.0479	0.0454	0.0456
C	0.2544	0.2522	0.5066	0.2549	0.2518	0.5067	0.0456	0.0460	0.0457	0.0456
D	0.2544	0.2521	0.5065	0.2556	0.2510	0.5066	0.0455	0.0457	0.0462	0.0456
E	0.2545	0.2520	0.5065	0.2560	0.2507	0.5067	0.0455	0.0459	0.0458	0.0459
F	0.2543	0.2517	0.5065	0.2560	0.2501	0.5061	0.0457	0.0463	0.0459	0.0459
G	0.2545	0.2520	0.5065	0.2558	0.2508	0.5066	0.0456	0.0463	0.0457	0.0465
H	0.2540	0.2525	0.5065	0.2556	0.2512	0.5068	0.0455	0.0460	0.0458	0.0463
I	0.2531	0.2531	0.5064	0.2553	0.2512	0.5065	0.0455	0.0460	0.0457	0.0460
J	0.2532	0.2538	0.5070	0.2555	0.2517	0.5072	0.0463	0.0467	0.0468	0.0469

^aSee orientation sketch.

Overall Length (in.)
ORNL Measurement
Z = <u>10.7608</u> in.
Martin Measurement
Z = <u>10.766</u> in.

Dimensional and Density Data for the Tubular Specimen Type 1, No. 2

DENSITY DATA

Total Specimen Wt. in _____ g
 Air 92.0630
 Total Specimen Volume 11.246 in.³
 Specimen Density 8.186 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (230°)			90° Rotation from Peak Flux (320°)			230° Position	320° Position	50° Position	140° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2540	0.2534	0.5074	0.2550	0.2526	0.5076	0.0476	0.0452	0.0495	0.0482
B	0.2548	0.2526	0.5074	0.2557	0.2518	0.5075	0.0457	0.0451	0.0465	0.0472
C	0.2548	0.2529	0.5077	0.2565	0.2513	0.5078	0.0458	0.0448	0.0451	0.0458
D	0.2545	0.2532	0.5077	0.2566	0.2512	0.5078	0.0471	0.0467	0.0451	0.0459
E	0.2548	0.2527	0.5075	0.2565	0.2512	0.5077	0.0480	0.0449	0.0452	0.0465
F	0.2557	0.2519	0.5076	0.2560	0.2516	0.5076	0.0497	0.0455	0.0453	0.0472
G	0.2535	0.2521	0.5076	0.2556	0.2522	0.5078	0.0512	0.0470	0.0491	0.0483
H	0.2545	0.2533	0.5078	0.2550	0.2526	0.5076	0.0481	0.0467	0.0470	0.0463
I	0.2542	0.2534	0.5076	0.2548	0.2527	0.5075	0.0452	0.0500	0.0467	0.0466
J	0.2550	0.2531	0.5081	0.2550	0.2533	0.5083	0.0477	0.0500	0.0482	0.0467

^aSee orientation sketch.

Overall Length (in.)	
ORNL Measurement	Z = <u>10.7526</u> in.
Martin Measurement	Z = <u>10.754</u> in.

Dimensional and Density Data for the Tubular Specimen Type 1, No. 3

CIRCUMFERENTIAL ORIENTATION

DENSITY DATA

Total Specimen Wt. in Air 91.7614 g
Total Specimen Volume 11.209 in³
Specimen Density 8.187 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (290°)			90° Rotation from Peak Flux (20°)			290° Position	20° Position	110° Position	200° Position
	Upper Dial	Lower Dial	OI	Upper Dial	Lower Dial	OD				
A	0.2527	0.2529	0.5056	0.2507	0.2518	0.5055	0.0458	0.0472	0.0485	0.0452
B	0.2543	0.2513	0.5056	0.2507	0.2517	0.5054	0.0457	0.0471	0.0472	0.0454
C	0.2553	0.2505	0.5058	0.2508	0.2548	0.5056	0.0456	0.0454	0.0456	0.0457
D	0.2554	0.2503	0.5057	0.2513	0.2543	0.5056	0.0457	0.0453	0.0446	0.0458
E	0.2550	0.2505	0.5055	0.2517	0.2542	0.5059	0.0457	0.0451	0.0448	0.0458
F	0.2548	0.2509	0.5057	0.2512	0.2544	0.5056	0.0461	0.0451	0.0451	0.0473
G	0.2550	0.2507	0.5057	0.2505	0.2551	0.5056	0.0465	0.0453	0.0451	0.0458
H	0.2554	0.2501	0.5055	0.2498	0.2559	0.5057	0.0466	0.0451	0.0452	0.0457
I	0.2543	0.2513	0.5055	0.2496	0.2560	0.5056	0.0460	0.0451	0.0449	0.0456
J	0.2528	0.2533	0.5061	0.2503	0.2562	0.5065	0.0462	0.0462	0.0467	0.0463

^aSee orientation sketch.

Overall Length (in.)	
ORNL Measurement	Z = <u>10.7518</u> in.
Martin Measurement	Z = <u>10.756</u> in.

Dimensional and Density Data for the Tubular Specimen Type 1, No. 4

DENSITY DATA

Total Specimen Wt. in
Air 92.0429 g
Total Specimen Volume 11.247 m³
Specimen Density 8.184 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (230°)			90° Rotation from Peak Flux (320°)			230° Position	320° Position	50° Position	140° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2511	0.2544	0.5055	0.2523	0.2533	0.5056	0.0450	0.0455	0.0453	0.0455
B	0.2522	0.2530	0.5052	0.2533	0.2520	0.5053	0.0451	0.0457	0.0452	0.0460
C	0.2527	0.2528	0.5055	0.2539	0.2519	0.5058	0.0450	0.0459	0.0452	0.0448
D	0.2523	0.2532	0.5055	0.2534	0.2524	0.5058	0.0453	0.0457	0.0458	0.0449
E	0.2515	0.2541	0.5056	0.2530	0.2527	0.5057	0.0452	0.0455	0.0450	0.0452
F	0.2511	0.2544	0.5055	0.2533	0.2525	0.5058	0.0454	0.0455	0.0449	0.0459
Z	0.2509	0.2546	0.5055	0.2537	0.2521	0.5058	0.0456	0.0455	0.0452	0.0455
H	0.2514	0.2542	0.5056	0.2541	0.2515	0.5056	0.0453	0.0453	0.0449	0.0452
I	0.2512	0.2541	0.5053	0.2534	0.2521	0.5055	0.0455	0.0454	0.0447	0.0451
J	0.2513	0.2550	0.5063	0.2528	0.2534	0.5062	0.0458	0.0465	0.0461	0.0457

^aSee orientation sketch.

Overall Length (in.)	
ORNL Measurement	Z = <u>10.7740</u> in.
Martin Measurement	Z = <u>10.776</u> in.

Dimensional and Density Data for the Tubular Specimen Type 1, No. 5

DENSITY DATA

Total Specimen Wt. in	
Air	92.4264 g
Total Specimen Volume	11.399 m ³
Specimen Density	8.108 g/cm ³

DIMENSIONAL DATA

Axial Position	Bcw and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (230°)			90° Rotation from Peak Flux (320°)			230° Position	320° Position	50° Position	140° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2531	0.2529	0.5065	0.2525	0.2538	0.5063	0.0455	0.0495	0.0456	0.0478
B	0.2545	0.2515	0.5065	0.2526	0.2536	0.5062	0.0455	0.0459	0.0456	0.0465
C	0.2567	0.2494	0.5061	0.2531	0.2532	0.5063	0.0457	0.0455	0.0456	0.0456
D	0.2553	0.2510	0.5063	0.2539	0.2522	0.5061	0.0456	0.0454	0.0456	0.0457
E	0.2542	0.2519	0.5061	0.2551	0.2512	0.5063	0.0455	0.0454	0.0455	0.0456
F	0.2539	0.2522	0.5061	0.2552	0.2512	0.5064	0.0456	0.0457	0.0454	0.0461
G	0.2546	0.2514	0.5065	0.2547	0.2517	0.5064	0.0456	0.0456	0.0454	0.0456
H	0.2551	0.2507	0.5058	0.2539	0.2527	0.5066	0.0457	0.0455	0.0452	0.0457
I	0.2542	0.2518	0.5050	0.2534	0.2528	0.5062	0.0459	0.0456	0.0450	0.0455
J	0.2533	0.2538	0.5071	0.2537	0.2532	0.5069	0.0468	0.0465	0.0462	0.0462

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7397 in.
Martin Measurement
Z = 10.737 in.

Dimensional and Density Data for the Tubular Specimen Type 1, No. 8

CIRCUMFERENTIAL ORIENTATION

DENSITY DATA

Total Specimen Wt. in
Air 202.7470 g
Total Specimen Volume 24.574 in³
Specimen Density .8.251 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (160°)			90° Rotation from Peak Flux (250°)			160° Position	250° Position	340° Position	70° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2662	0.2712	0.5394	0.2654	0.2744	0.5398	0.1066	0.1117	0.1066	0.1072
B	0.2661	0.2726	0.5407	0.2645	0.2759	0.5404	0.1072	0.1074	0.1070	0.1065
C	0.2666	0.2712	0.5398	0.2644	0.2745	0.5389	0.1070	0.1073	0.1064	0.1069
D	0.2668	0.2704	0.5392	0.2653	0.2727	0.5385	0.1069	0.1076	0.1056	0.1052
E	0.2665	0.2707	0.5392	0.2663	0.2714	0.5377	0.1076	0.1082	0.1060	0.1052
F	0.2679	0.2710	0.5389	0.2653	0.2714	0.5367	0.1073	0.1080	0.1060	0.1054
G	0.2667	0.2710	0.5377	0.2644	0.2717	0.5361	0.1080	0.1086	0.1054	0.1051
H	0.2663	0.2722	0.5390	0.2637	0.2740	0.5377	0.1086	0.1102	0.1057	0.1052
I	0.2675	0.2739	0.5414	0.2671	0.2731	0.5402	0.1083	0.1099	0.1066	0.1060
J	0.2670	0.2750	0.5420	0.2675	0.2728	0.5403	0.1057	0.1064	0.1055	0.1044

^aSee orientation sketch.

Overall Length (in.)	
ORNL Measurement	Z = <u>10.7567</u> in.
Martin Measurement	Z = <u>10.757</u> in.

Dimensional and Density Data for the Tubular Specimen Type 2, No. 5

DENSITY DATA

Total Specimen Wt. in	
Air	202.1833 g
Total Specimen Volume	24.517 m ³
Specimen Density	.8.247 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (200°)			90° Rotation from Peak Flux (290°)			200° Position	290° Position	20° Position	110° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2678	0.2727	0.5405	0.2649	0.2743	0.5397	0.1076	0.1129	0.1069	0.1141
B	0.2680	0.2705	0.5385	0.2647	0.2733	0.5377	0.1061	0.1071	0.1060	0.1104
C	0.2678	0.2696	0.5374	0.2636	0.2732	0.5368	0.1050	0.1071	0.1059	0.1070
D	0.2695	0.2630	0.5375	0.2635	0.2730	0.5365	0.1049	0.1063	0.1048	0.1059
E	0.2691	0.2631	0.5372	0.2638	0.2725	0.5366	0.1059	0.1063	0.1045	0.1055
F	0.2688	0.2634	0.5372	0.2642	0.2724	0.5366	0.1061	0.1055	0.1044	0.1061
G	0.2689	0.2694	0.5383	0.2645	0.2735	0.5380	0.1066	0.1062	0.1049	0.1083
H	0.2695	0.2699	0.5394	0.2645	0.2751	0.5391	0.1081	0.1076	0.1036	0.1089
I	0.2684	0.2727	0.5411	0.2654	0.2758	0.5412	0.1092	0.1085	0.1061	0.1099
J	0.2711	0.2761	0.5472	0.2696	0.2784	0.5480	0.1122	0.1087	0.1036	0.1124

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7597 in.
Martin Measurement
Z = 10.760 in.

Dimensional and Density Data for the Tubular Specimen Type 2, No. 6

DENSITY DATA

Total Specimen Wt. in
Air 204.1524 g
Total Specimen Volume 24.4682 in³
Specimen Density .8.345 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (200°)			90° Rotation from Peak Flux (290°)			110° Position	20° Position	200° Position	290° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2743	0.2729	0.5472	0.2722	0.2747	0.5469	0.1123	0.1114	0.1079	0.1083
B	0.2736	0.2696	0.5432	0.2696	0.2735	0.5431	0.1077	0.1074	0.1042	0.1037
C	0.2741	0.2694	0.5435	0.2699	0.2720	0.5419	0.1067	0.1072	0.1036	0.1042
D	0.2741	0.2684	0.5425	0.2706	0.2709	0.5415	0.1061	0.1073	0.1025	0.1028
E	0.2737	0.2671	0.5408	0.2709	0.2690	0.5399	0.1070	0.1075	0.1013	0.1028
F	0.2740	0.2685	0.5425	0.2724	0.2695	0.5419	0.1065	0.1084	0.1039	0.1044
G	0.2739	0.2678	0.5417	0.2728	0.2694	0.5422	0.1062	0.1087	0.1037	0.1063
H	0.2750	0.2672	0.5422	0.2714	0.2702	0.5426	0.1061	0.1092	0.1022	0.1064
I	0.2764	0.2684	0.5445	0.2745	0.2718	0.5463	0.1081	0.1101	0.1037	0.1084
J	0.2766	0.2643	0.5369	0.2722	0.2649	0.5371	0.0976	0.1015	0.1019	0.1052

^aSee orientation sketch.

Overall Length (in.)
ORNL Measurement
Z = 10.7507 in.
Martin Measurement
Z = 10.755 in.

Dimensional and Density Data for the Tubular Specimen Type 2, No. 7

DENSITY DATA

Total Specimen Wt. in
Air 204.1838 g

Total Specimen Volume 24.3258 m³

Specimen Density .8.393 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (160°)			90° Rotation from Peak Flux (250°)			70° Position	160° Position	250° Position	340° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2702	0.2706	0.5408	0.2712	0.2697	0.5409	0.1064	0.1038	0.1072	0.1077
B	0.2697	0.2699	0.5396	0.2710	0.2703	0.5413	0.1071	0.1027	0.1043	0.1063
C	0.2704	0.2698	0.5402	0.2721	0.2702	0.5423	0.1054	0.1029	0.1050	0.1063
D	0.2705	0.2696	0.5401	0.2718	0.2705	0.5423	0.1057	0.1041	0.1051	0.1062
E	0.2697	0.2694	0.5391	0.2713	0.2713	0.5426	0.1061	0.1045	0.1049	0.1061
F	0.2691	0.2703	0.5394	0.2700	0.2721	0.5421	0.1068	0.1041	0.1043	0.1063
G	0.2701	0.2710	0.5411	0.2706	0.2715	0.5421	0.1067	0.1037	0.1060	0.1059
H	0.2715	0.2710	0.5425	0.2716	0.2713	0.5434	0.1082	0.1056	0.1064	0.1074
I	0.2717	0.2712	0.5429	0.2732	0.2703	0.5440	0.1081	0.1060	0.1061	0.1064
J	0.2697	0.2685	0.5381	0.2689	0.2690	0.5379	0.1043	0.1012	0.1013	0.1043

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7394 in.

Martin Measurement
Z = 10.764 in.

Dimensional and Density Data for the Tubular Specimen Type 2, No. 9

DENSITY DATA

Total Specimen Wt. in Air	202.7850	g
Total Specimen Volume	24.159	in ³
Specimen Density	8.391	g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (200°)			90° Rotation from Peak Flux (290°)			20° Position	110° Position	200° Position	290° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	GD				
A	0.2704	0.2711	0.5415	0.2698	0.2716	0.5414	0.1077	0.1043	0.1048	0.1071
B	0.2702	0.2711	0.5413	0.2680	0.2721	0.5401	0.1065	0.1033	0.1047	0.1060
C	0.2715	0.2706	0.5422	0.2675	0.2726	0.5401	0.1068	0.1034	0.1044	0.1069
D	0.2719	0.2696	0.5415	0.2661	0.2716	0.5377	0.1063	0.1035	0.1031	0.1056
E	0.2734	0.2688	0.5422	0.2685	0.2704	0.5389	0.1069	0.1032	0.1026	0.1056
F	0.2733	0.2687	0.5420	0.2684	0.2702	0.5386	0.1068	0.1040	0.1033	0.1056
G	0.2729	0.2691	0.5420	0.2694	0.2694	0.5388	0.1073	0.1052	0.1031	0.1060
H	0.2729	0.2688	0.5417	0.2695	0.2697	0.5392	0.1079	0.1036	0.1029	0.1053
I	0.2703	0.2705	0.5414	0.2704	0.2695	0.5399	0.1078	0.1038	0.1035	0.1056
J	0.2669	0.2711	0.5380	0.2700	0.2675	0.5375	0.1072	0.1027	0.0988	0.1025

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement	Z = 10.7589 in.
Martin Measurement	Z = 10.757 in.

Dimensional and Density Data for the Tubular Specimen Type 2, No. 10

B-37

CIRCUMFERENTIAL ORIENTATION

DENSITY DATA

Total Specimen Wt. in
Air 204.6951 g

Total Specimen Volume 24.367 in³

Specimen Density 8.401 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (160°)			90° Rotation from Peak Flux (250°)			70° Position	160° Position	250° Position	340° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2728	0.2697	0.5425	0.2723	0.2692	0.5420	0.1039	0.1042	0.1100	0.1092
B	0.2712	0.2705	0.5417	0.2695	0.2713	0.5409	0.1036	0.1038	0.1075	0.1084
C	0.2749	0.2676	0.5425	0.2693	0.2720	0.5418	0.1029	0.1048	0.1075	0.1080
D	0.2756	0.2658	0.5414	0.2701	0.2713	0.5414	0.1031	0.1054	0.1077	0.1073
E	0.2745	0.2669	0.5414	0.2701	0.2694	0.5395	0.1032	0.1052	0.1073	0.1063
F	0.2738	0.2682	0.5420	0.2713	0.2694	0.5407	0.1032	0.1055	0.1077	0.1064
G	0.2729	0.2686	0.5415	0.2715	0.2680	0.5396	0.1023	0.1046	0.1072	0.1053
H	0.2717	0.2690	0.5407	0.2719	0.2681	0.5400	0.1025	0.1042	0.1074	0.1057
I	0.2708	0.2703	0.5411	0.2713	0.2683	0.5398	0.1031	0.1046	0.1073	0.1061
J	0.2693	0.2681	0.5374	0.2728	0.2653	0.5381	0.0984	0.1019	0.1068	0.1028

^aSee orientation sketch.

Overall Length (in.)	
ORNL Measurement	Z = <u>10.7621</u> in.
Martin Measurement	Z = <u>10.762</u> in.

Dimensional and Density Data for the Tubular Specimen Type 2, No. 11

DENSITY DATA

Total Specimen Wt. in
Air 201.1059 g
Total Specimen Volume 24.071 in³
Specimen Density .8.355 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (50°)			90° Rotation from Peak Flux (140°)			50° Position	140° Position	230° Position	320° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2672	0.2687	0.5359	0.2645	0.2702	0.5347	0.1037	0.1053	0.1065	0.1057
B	0.2693	0.2674	0.5367	0.2662	0.2699	0.5361	0.1056	0.1059	0.1063	0.1052
C	0.2635	0.2680	0.5365	0.2652	0.2712	0.5364	0.1063	0.1065	0.1067	0.1057
D	0.2630	0.2668	0.5348	0.2633	0.2708	0.5341	0.1049	0.1047	0.1056	0.1045
E	0.2679	0.2672	0.5351	0.2630	0.2715	0.5345	0.1052	0.1044	0.1053	0.1043
F	0.2674	0.2672	0.5346	0.2637	0.2710	0.5347	0.1052	0.1042	0.1044	0.1046
G	0.2631	0.2682	0.5363	0.2643	0.2712	0.5355	0.1058	0.1051	0.1060	0.1056
H	0.2678	0.2687	0.5365	0.2646	0.2713	0.5359	0.1061	0.1055	0.1067	0.1058
I	0.2659	0.2699	0.5358	0.2637	0.2713	0.5350	0.1060	0.1051	0.1067	0.1060
J	0.2643	0.2703	0.5346	0.2617	0.2730	0.5347	0.1031	0.1006	0.1023	0.1046

^aSee orientation sketch.

Overall Length (in.)
ORNL Measurement Z = 10.7646 in.
Martin Measurement Z = 10.762 in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 4

DENSITY DATA

Total Specimen Wt. in Air	200.6114 g
Total Specimen Volume	24.0255 m ³
Specimen Density	8.352 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (310°)			90° Rotation from Peak Flux (40°)			310° Position	40° Position	130° Position	220° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2691	0.2654	0.5345	0.2673	0.2633	0.5356	0.1044	0.1073	0.1077	0.1043
B	0.2700	0.2664	0.5364	0.2704	0.2657	0.5371	0.1076	0.1063	0.1056	0.1067
C	0.2693	0.2651	0.5344	0.2711	0.2639	0.5350	0.1061	0.1057	0.1047	0.1054
D	0.2697	0.2644	0.5341	0.2717	0.2628	0.5345	0.1049	0.1042	0.1042	0.1050
E	0.2693	0.2646	0.5339	0.2724	0.2622	0.5346	0.1042	0.1038	0.1048	0.1052
F	0.2694	0.2645	0.5339	0.2720	0.2625	0.5345	0.1045	0.1038	0.1052	0.1064
G	0.2686	0.2650	0.5335	0.2715	0.2627	0.5342	0.1045	0.1037	0.1047	0.1065
H	0.2685	0.2679	0.5364	0.2726	0.2633	0.5359	0.1064	0.1052	0.1069	0.1069
I	0.2684	0.2680	0.5364	0.2708	0.2647	0.5355	0.1062	0.1052	0.1066	0.1073
J	0.2674	0.2677	0.5351	0.2691	0.2655	0.5356	0.1020	0.1035	0.1051	0.1031

^aSee orientation sketch.

Overall Length (in.)
ORNL Measurement
Z = 10.7366 in.
Martin Measurement
Z = 10.736 in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 5

DENSITY DATA

Total Specimen Wt. in
Air 200.7563 g
Total Specimen Volume 23.983 in³
Specimen Density .8.371 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (230°)			90° Rotation from Peak Flux (320°)			230° Position	320° Position	50° Position	140° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2665	0.2690	0.5355	0.2657	0.2692	0.5349	0.1054	0.1067	0.1064	0.1062
B	0.2656	0.2664	0.5360	0.2655	0.2703	0.5358	0.1041	0.1043	0.1058	0.1053
C	0.2708	0.2648	0.5356	0.2636	0.2712	0.5348	0.1040	0.1046	0.1047	0.1046
D	0.2658	0.2660	0.5358	0.2679	0.2671	0.5350	0.1034	0.1034	0.1045	0.1046
E	0.2669	0.2674	0.5361	0.2700	0.2652	0.5352	0.1038	0.1034	0.1044	0.1052
F	0.2655	0.2667	0.5362	0.2682	0.2675	0.5357	0.1046	0.1038	0.1043	0.1063
G	0.2705	0.2669	0.5374	0.2655	0.2713	0.5368	0.1051	0.1056	0.1056	0.1068
H	0.2712	0.2677	0.5389	0.2657	0.2731	0.5388	0.1063	0.1067	0.1063	0.1078
I	0.2698	0.2692	0.5396	0.2675	0.2715	0.5390	0.1063	0.1067	0.1070	0.1072
J	0.2680	0.2691	0.5371	0.2676	0.2700	0.5376	0.1052	0.1046	0.1050	0.1044

^aSee orientation sketch.

Overall Length (in.)	
ORNL Measurement	Z = <u>10.7182</u> in.
Martin Measurement	Z = <u>10.713</u> in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 6

B-41

DENSITY DATA

Total Specimen Wt. in	
Air	207.1587 g
Total Specimen Volume	24.6433 m ³
Specimen Density	8.425 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (310°)			90° Rotation from Peak Flux (40°)			40° Position	130° Position	220° Position	310° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2777	0.2708	0.5485	0.2781	0.2737	0.5488	0.1106	0.1100	0.1118	0.1131
B	0.2779	0.2663	0.5442	0.2766	0.2671	0.5437	0.1058	0.1054	0.1027	0.1026
C	0.2789	0.2647	0.5436	0.2747	0.2669	0.5416	0.1044	0.1053	0.1074	0.1065
D	0.2792	0.2645	0.5437	0.2742	0.2681	0.5423	0.1043	0.1037	0.1073	0.1068
E	0.2785	0.2661	0.5446	0.2734	0.2685	0.5419	0.1038	0.1047	0.1031	0.1068
F	0.2783	0.2661	0.5444	0.2762	0.2669	0.5431	0.1042	0.1055	0.1039	0.1065
G	0.2796	0.2649	0.5445	0.2739	0.2650	0.5439	0.1046	0.1057	0.1035	0.1070
H	0.2764	0.2672	0.5435	0.2779	0.2650	0.5429	0.1043	0.1061	0.1096	0.1068
I	0.2749	0.2721	0.5470	0.2771	0.2691	0.5462	0.1066	0.1088	0.1127	0.1101
J	0.2695	0.2678	0.5373	0.2736	0.2668	0.5374	0.1007	0.1027	0.1038	0.1017

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7669 in.
Martin Measurement
Z = 10.765 in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 7

DENSITY DATA

Total Specimen Wt. in	
Air	204.5398 g
Total Specimen Volume	24.356 in ³
Specimen Density	8.4182 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (230°)			90° Rotation from Peak Flux (320°)			50° Position	140° Position	230° Position	320° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2750	0.2703	0.5453	0.2720	0.2733	0.5453	0.1105	0.1087	0.1106	0.1126
B	0.2748	0.2668	0.5416	0.2694	0.2714	0.5408	0.1053	0.1021	0.1052	0.1077
C	0.2773	0.2658	0.5431	0.2693	0.2716	0.5409	0.1024	0.1029	0.1064	0.1067
D	0.2770	0.2656	0.5426	0.2701	0.2700	0.5401	0.1051	0.1037	0.1059	0.1057
E	0.2773	0.2651	0.5424	0.2712	0.2701	0.5413	0.1041	0.1047	0.1065	0.1053
F	0.2774	0.2646	0.5420	0.2731	0.2692	0.5423	0.1040	0.1048	0.1063	0.1056
G	0.2795	0.2637	0.5432	0.2750	0.2641	0.5391	0.1054	0.1011	0.1064	0.1057
H	0.2787	0.2633	0.5420	0.2734	0.2679	0.5413	0.1043	0.1080	0.1054	0.1034
I	0.2802	0.2659	0.5460	0.2701	0.2707	0.5408	0.1076	0.1097	0.1038	0.1015
J	0.2744	0.2633	0.5377	0.2711	0.2662	0.5373	0.1010	0.1038	0.1041	0.1004

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7613 in.
Martin Measurement
Z = 10.759 in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 8

DENSITY DATA

Total Specimen Wt. in	
Air	204.4310 g
Total Specimen Volume	24.3715 in ³
Specimen Density	8.407 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (50°)			90° Rotation from Peak Flux (140°)			50° Position	140° Position	230° Position	320° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2715	0.2656	0.5471	0.2743	0.2724	0.5467	0.1077	0.1123	0.1149	0.1119
B	0.2776	0.2695	0.5471	0.2723	0.2675	0.5398	0.1029	0.1067	0.1085	0.1056
C	0.2780	0.2647	0.5427	0.2731	0.2664	0.5395	0.1020	0.1062	0.1076	0.1050
D	0.2827	0.2591	0.5415	0.2726	0.2670	0.5396	0.1031	0.1054	0.1073	0.1054
E	0.2865	0.2567	0.5432	0.2719	0.2679	0.5398	0.1030	0.1049	0.1074	0.1046
F	0.2847	0.2579	0.5425	0.2707	0.2700	0.5407	0.1016	0.1044	0.1072	0.1044
G	0.2844	0.2568	0.5412	0.2689	0.2712	0.5401	0.1044	0.1061	0.1081	0.1043
H	0.2860	0.2562	0.5422	0.2683	0.2722	0.5405	0.1038	0.1070	0.1080	0.1046
I	0.2830	0.2594	0.5424	0.2700	0.2738	0.5433	0.1072	0.1090	0.1106	0.1067
J	0.2734	0.2641	0.5375	0.2656	0.2715	0.5371	0.1041	0.1013	0.1021	0.1040

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement	Z = 10.7602 in.
Martin Measurement	Z = 10.760 in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 9

B-44

DENSITY DATA

Total Specimen Wt. in	
Air	203.5011 g
Total Specimen Volume	24.1095 cm ³
Specimen Density	8.4407 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (230°)			90° Rotation from Peak Flux (320°)			50° Position	140° Position	230° Position	320° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2701	0.2695	0.5396	0.2699	0.2709	0.5408	0.1034	0.1071	0.1073	0.1052
B	0.2693	0.2689	0.5387	0.2709	0.2682	0.5391	0.1024	0.1070	0.1067	0.1042
C	0.2696	0.2684	0.5380	0.2760	0.2640	0.5400	0.1030	0.1053	0.1061	0.1035
D	0.2699	0.2685	0.5384	0.2750	0.2646	0.5396	0.1029	0.1059	0.1059	0.1044
E	0.2703	0.2678	0.5381	0.2727	0.2666	0.5393	0.1042	0.1064	0.1052	0.1033
F	0.2701	0.2678	0.5379	0.2726	0.2658	0.5384	0.1026	0.1060	0.1059	0.1016
G	0.2689	0.2691	0.5380	0.2750	0.2634	0.5384	0.1026	0.1068	0.1045	0.1016
H	0.2689	0.2699	0.5383	0.2757	0.2628	0.5385	0.1034	0.1074	0.1042	0.1022
I	0.2690	0.2701	0.5391	0.2744	0.2651	0.5395	0.1052	0.1076	0.1044	0.1023
J	0.2673	0.2702	0.5375	0.2738	0.2643	0.5381	0.1034	0.1015	0.1011	0.1043

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement	Z = 10.7629 in.
Martin Measurement	Z = 10.761 in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 10

B-45

DENSITY DATA

Total Specimen Wt. in
 Air 203.0487 g
 Total Specimen Volume 25.0985 cm³
 Specimen Density 8.0901 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (310°)			90° Rotation from Peak Flux (40°)			40° Position	130° Position	220° Position	310° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2732	0.2682	0.5414	0.2710	0.2702	0.5412	0.1055	0.1059	0.1067	0.1077
B	0.2732	0.2669	0.5401	0.2685	0.2719	0.5404	0.1041	0.1045	0.1065	0.1066
C	0.2770	0.2630	0.5400	0.2626	0.2771	0.5397	0.1040	0.1038	0.1060	0.1057
D	0.2762	0.2629	0.5391	0.2612	0.2775	0.5388	0.1026	0.1037	0.1056	0.1059
E	0.2731	0.2654	0.5385	0.2666	0.2713	0.5379	0.1036	0.1030	0.1055	0.1048
F	0.2728	0.2660	0.5378	0.2691	0.2674	0.5365	0.1023	0.1033	0.1057	0.1052
G	0.2723	0.2671	0.5394	0.2681	0.2692	0.5373	0.1032	0.1040	0.1062	0.1068
H	0.2745	0.2650	0.5395	0.2674	0.2703	0.5382	0.1037	0.1043	0.1073	0.1052
I	0.2746	0.2652	0.5398	0.2708	0.2674	0.5382	0.1031	0.1047	0.1063	0.1062
J	0.2731	0.2643	0.5374	0.2721	0.2652	0.5373	0.1026	0.1003	0.1003	0.1037

^aSee orientation sketch.

Overall Length (in.)	
ORNL Measurement	Z = <u>10.7603</u> in.
Martin Measurement	Z = <u>10.761</u> in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 12

DENSITY DATA

Total Specimen Wt. in Air	204.8468 g
Total Specimen Volume	24.2450 in ³
Specimen Density	8.4490 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (50°)			90° Rotation from Peak Flux (140°)			50° Position	140° Position	230° Position	320° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2675	0.2718	0.5393	0.2718	0.2672	0.5390	0.1060	0.1025	0.1054	0.1096
B	0.2671	0.2719	0.5390	0.2733	0.2662	0.5395	0.1054	0.1019	0.1048	0.1089
C	0.2665	0.2722	0.5387	0.2767	0.2620	0.5387	0.1048	0.1022	0.1054	0.1090
D	0.2687	0.2709	0.5396	0.2779	0.2610	0.5389	0.1049	0.1026	0.1060	0.1080
E	0.2704	0.2692	0.5396	0.2757	0.2622	0.5379	0.1030	0.1026	0.1061	0.1078
F	0.2692	0.2708	0.5400	0.2751	0.2638	0.5389	0.1032	0.1021	0.1072	0.1083
G	0.2684	0.2718	0.5402	0.2749	0.2642	0.5391	0.1036	0.1033	0.1074	0.1094
H	0.2687	0.2712	0.5399	0.2731	0.2659	0.5390	0.1038	0.1032	0.1070	0.1093
I	0.2690	0.2706	0.5396	0.2740	0.2654	0.5394	0.1051	0.1033	0.1074	0.1113
J	0.2706	0.2668	0.5374	0.2718	0.2652	0.5370	0.1049	0.1014	0.1013	0.1028

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement	Z = 10.7678 in.
Martin Measurement	Z = 10.767 in.

Dimensional and Density Data for the Tubular Specimen Type 3, No. 13

B-47

DENSITY DATA

Total Specimen Wt. in	
Air	203.6740 g
Total Specimen Volume	24.3440 m ³
Specimen Density	8.366 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (180°)			90° Rotation from Peak Flux (270°)			180° Position	270° Position	0° Position	90° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2734	0.2650	0.5384	0.2724	0.2554	0.5378	0.1072	0.1090	0.1028	0.1037
B	0.2753	0.2647	0.5400	0.2736	0.2563	0.5395	0.1077	0.1102	0.1044	0.1030
C	0.2746	0.2644	0.5380	0.2729	0.2562	0.5391	0.1082	0.1111	0.1044	0.1021
D	0.2742	0.2646	0.5388	0.2725	0.2553	0.5378	0.1083	0.1093	0.1039	0.1004
E	0.2725	0.2654	0.5379	0.2737	0.2545	0.5382	0.1090	0.1093	0.1043	0.1020
F	0.2710	0.2670	0.5380	0.2745	0.2536	0.5381	0.1068	0.1093	0.1042	0.1043
G	0.2695	0.2684	0.5379	0.2754	0.2526	0.5380	0.1073	0.1095	0.1041	0.1028
H	0.2688	0.2698	0.5386	0.2767	0.2524	0.5391	0.1070	0.1119	0.1042	0.1024
I	0.2698	0.2698	0.5386	0.2777	0.2502	0.5379	0.1073	0.1112	0.1047	0.1042
J	0.2662	0.2752	0.5414	0.2764	0.2551	0.5415	0.1050	0.1090	0.1079	0.1029

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7703 in.
Martin Measurement
Z = 10.772 in.

Dimensional and Density Data for the Tubular Specimen Type 4, No. 3

DENSITY DATA

Total Specimen Wt. in	
Air	201.7305 g
Total Specimen Volume	24.158 m ³
Specimen Density	8.350 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (180°)			90° Rotation from Peak Flux (270°)			180° Position	270° Position	0° Position	90° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2653	0.2701	0.5354	0.2602	0.2752	0.5354	0.1060	0.1063	0.1031	0.1063
B	0.2681	0.2690	0.5371	0.2575	0.2803	0.5378	0.1053	0.1041	0.1051	0.1062
C	0.2671	0.2695	0.5366	0.2567	0.2807	0.5374	0.1054	0.1044	0.1051	0.1067
D	0.2649	0.2706	0.5353	0.2571	0.2793	0.5364	0.1042	0.1041	0.1043	0.1054
E	0.2647	0.2708	0.5355	0.2578	0.2786	0.5364	0.1037	0.1039	0.1043	0.1051
F	0.2657	0.2696	0.5353	0.2575	0.2786	0.5361	0.1057	0.1036	0.1046	0.1053
G	0.2672	0.2687	0.5359	0.2583	0.2784	0.5367	0.1049	0.1038	0.1045	0.1054
H	0.2689	0.2679	0.5368	0.2603	0.2773	0.5376	0.1056	0.1046	0.1058	0.1065
I	0.2693	0.2661	0.5354	0.2624	0.2752	0.5376	0.1055	0.1043	0.1052	0.1061
J	0.2707	0.2701	0.5408	0.2657	0.2753	0.5410	0.1013	0.0958	0.0950	0.1000

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7709 in.
Martin Measurement
Z = 10.764 in.

Dimensional and Density Data for the Tubular Specimen Type 4, No. 4

DENSITY DATA	
Total Specimen Wt. in Air	200.8414 g
Total Specimen Volume	24.007 in ³
Specimen Density	8.366 g/cm ³

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (180°)			90° Rotation from Peak Flux (270°)			180° Position	270° Position	0° Position	90° Position
	Upper Dial	Lower Dial	CD	Upper Dial	Lower Dial	OD				
A	0.2739	0.2545	0.5384	0.2750	0.2546	0.5396	0.1023	0.1036	0.1060	0.1055
B	0.2762	0.2534	0.5396	0.2752	0.2531	0.5383	0.1031	0.1027	0.1064	0.1073
C	0.2775	0.2517	0.5392	0.2766	0.2516	0.5382	0.1027	0.1031	0.1058	0.1069
D	0.2767	0.2517	0.5384	0.2770	0.2504	0.5374	0.1022	0.1008	0.1049	0.1061
E	0.2742	0.2539	0.5381	0.2770	0.2500	0.5370	0.1029	0.1015	0.1047	0.1061
F	0.2714	0.2569	0.5383	0.2762	0.2510	0.5372	0.1023	0.1018	0.1047	0.1057
G	0.2687	0.2592	0.5379	0.2764	0.2515	0.5379	0.1023	0.1022	0.1051	0.1055
H	0.2671	0.2727	0.5398	0.2754	0.2539	0.5393	0.1033	0.1035	0.1066	0.1065
I	0.2634	0.2755	0.5389	0.2735	0.2568	0.5403	0.1026	0.1038	0.1071	0.1067
J	0.2645	0.2798	0.5443	0.2744	0.2597	0.5441	0.1009	0.1062	0.1090	0.1020

^aSee orientation sketch.

Overall Length (in.)	
ORNL Measurement	Z = 10.7722 in.
Martin Measurement	Z = 10.769 in.

Dimensional and Density Data for the Tubular Specimen Type 4, No. 5

DENSITY DATA

Total Specimen Wt. in
Air 201.7046 g

Total Specimen Volume 23.9940 in³

Specimen Density 8.427 g/cm³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (180°)			90° Rotation from Peak Flux (270°)			90° Position	180° Position	270° Position	360° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2720	0.2699	0.5419	0.2732	0.2693	0.5425	0.1099	0.1080	0.1060	0.1055
B	0.2693	0.2681	0.5374	0.2728	0.2668	0.5396	0.1052	0.1052	0.1052	0.1015
C	0.2683	0.2630	0.5363	0.2719	0.2669	0.5388	0.1042	0.1039	0.1044	0.1012
D	0.2694	0.2681	0.5375	0.2718	0.2669	0.5387	0.1042	0.1041	0.1046	0.1022
E	0.2687	0.2685	0.5372	0.2711	0.2673	0.5384	0.1046	0.1051	0.1045	0.1025
F	0.2684	0.2678	0.5362	0.2701	0.2686	0.5387	0.1045	0.1047	0.1051	0.1022
G	0.2689	0.2683	0.5372	0.2716	0.2677	0.5393	0.1046	0.1054	0.1058	0.1017
H	0.2694	0.2696	0.5390	0.2739	0.2641	0.5380	0.1045	0.1073	0.1058	0.1034
I	0.2712	0.2732	0.5454	0.2678	0.2656	0.5334	0.1061	0.1110	0.1047	0.1054
J	0.2653	0.2709	0.5352	0.2740	0.2642	0.5382	0.1010	0.0977	0.1041	0.1057

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7644 in.

Martin Measurement
Z = 10.764 in.

Dimensional and Density Data for the Tubular Specimen Type 4, No. 6

DENSITY DATA

Total Specimen Wt. in Air	200.7586 g
Total Specimen Volume	23.910 cm ³
Specimen Density	.8.417 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (180°)			90° Rotation from Peak Flux (270°)			0° Position	90° Position	180° Position	270° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2721	0.2667	0.5383	0.2683	0.2677	0.5360	0.1033	0.1058	0.1053	0.1025
B	0.2716	0.2660	0.5375	0.2702	0.2636	0.5338	0.1034	0.1040	0.1041	0.1001
C	0.2698	0.2672	0.5370	0.2694	0.2652	0.5346	0.1022	0.1048	0.1032	0.0996
D	0.2707	0.2674	0.5381	0.2691	0.2666	0.5357	0.1035	0.1049	0.1039	0.0996
E	0.2688	0.2700	0.5383	0.2688	0.2664	0.5352	0.1030	0.1045	0.1049	0.0998
F	0.2658	0.2728	0.5385	0.2688	0.2670	0.5358	0.1025	0.1042	0.1051	0.1003
G	0.2652	0.2744	0.5395	0.2702	0.2658	0.5360	0.1037	0.1045	0.1053	0.1015
H	0.2684	0.2719	0.5403	0.2727	0.2653	0.5380	0.1039	0.1057	0.1057	0.1032
I	0.2725	0.2706	0.5431	0.2748	0.2675	0.5423	0.1064	0.1091	0.1099	0.1040
J	0.2695	0.2680	0.5375	0.2749	0.2623	0.5372	0.1028	0.0930	0.1008	0.1054

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement	Z = <u>10.762</u> in.
Martin Measurement	Z = <u>10.762</u> in.

^bNot taken.

Dimensional and Density Data for the Tubular Specimen Type 4, No. 7

DENSITY DATA

Total Specimen Wt. in	
Air	202.1352 g
Total Specimen Volume	23.7976 in ³
Specimen Density	8.4939 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (180°)			90° Rotation from Peak Flux (270°)			90° Position	180° Position	270° Position	0° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	0.2675	0.2678	0.5353	0.2638	0.2673	0.5351	0.1054	0.1005	0.1018	0.1052
B	0.2670	0.2688	0.5358	0.2693	0.2668	0.5351	0.1073	0.1012	0.1012	0.1062
C	0.2697	0.2664	0.5351	0.2681	0.2682	0.5353	0.1050	0.1021	0.1032	0.1056
D	0.2703	0.2649	0.5352	0.2695	0.2670	0.5355	0.1030	0.1022	0.1035	0.1057
E	0.2695	0.2655	0.5354	0.2722	0.2638	0.5360	0.1042	0.1004	0.1024	0.1052
F	0.2705	0.2651	0.5350	0.2750	0.2607	0.5357	0.1034	0.1006	0.1023	0.1054
G	0.2722	0.2638	0.5350	0.2765	0.2606	0.5371	0.1027	0.1024	0.1041	0.1052
H	0.2728	0.2643	0.5371	0.2737	0.2623	0.5360	0.1031	0.1026	0.1048	0.1060
I	0.2716	0.2650	0.5356	0.2709	0.2660	0.5369	0.1049	0.1027	0.1051	0.1073
J	0.2738	0.2638	0.5376	0.2703	0.2674	0.5377	0.1021	0.1058	0.1037	0.0997

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement
Z = 10.7675 in.
Martin Measurement
Z = 10.755 in.

Dimensional and Density Data for the Tubular Specimen Type 4, No. 8

DENSITY DATA

Total Specimen Wt. in Air	203.0875 g
Total Specimen Volume	23.9088 in ³
Specimen Density	.84947 g/cm ³

DIMENSIONAL DATA

Axial Position	Bow and Diameter (in.)						Wall Thickness (in.)			
	Peak Flux Location ^a (180°)			90° Rotation from Peak Flux (270°)			0° Position	90° Position	180° Position	270° Position
	Upper Dial	Lower Dial	OD	Upper Dial	Lower Dial	OD				
A	1.2710	0.2668	0.5378	0.2681	0.2694	0.5375	0.1068	0.1035	0.1059	0.1070
B	1.2738	0.2631	0.5369	0.2668	0.2701	0.5369	0.1045	0.1023	0.1054	0.1060
C	1.2802	0.2554	0.5356	0.2697	0.2651	0.5358	0.1038	0.1020	0.1050	0.1046
D	1.2816	0.2536	0.5352	0.2722	0.2655	0.5377	0.1022	0.1033	0.1061	0.1050
E	1.2775	0.2570	0.5345	0.2669	0.2688	0.5357	0.1027	0.1042	0.1069	0.1050
F	1.2744	0.2617	0.5361	0.2642	0.2702	0.5344	0.1022	0.1028	0.1071	0.1048
G	1.2722	0.2625	0.5351	0.2625	0.2705	0.5334	0.1018	0.1035	0.1056	0.1045
H	1.2728	0.2617	0.5345	0.2637	0.2715	0.5356	0.1024	0.1043	0.1062	0.1043
I	1.2732	0.2616	0.5348	0.2628	0.2729	0.5357	0.1018	0.1044	0.1063	0.1040
J	1.2747	0.2636	0.5383	0.2648	0.2726	0.5374	0.0983	0.1062	0.1070	0.0937

^aSee orientation sketch.

Overall Length (in.)

ORNL Measurement	Z = 10.7608 in.
Martin Measurement	Z = 10.761 in.

Dimensional and Density Data for the Tubular Specimen Type 4, No. 9

Appendix C

CALCULATIONAL METHODS FOR CORE VOLUME AND CORE DENSITY

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METHOD FOR CALCULATING VOLUME AND DENSITY OF UO₂-STAINLESS STEEL DISPERSION FUELS

In order to calculate the core volume and density of stainless steel clad UO₂-stainless steel dispersion fuel plate or tube, it is convenient to consider the specimen as being composed of two regions; the fuel core, and the combined cladding and frame material. The weight, W_t , and volume, V_t , of the entire fuel specimen is first determined by immersion density techniques. The combined weight of the specimen cladding and frame material, W_{cf} , is then determined from the difference

$$W_{cf} = W_t - W_c \quad (1)$$

where W_c is the weight of the core as determined from specimen fabrication records. The volume of the specimen cladding and frame material, V_{cf} , is then calculated from

$$V_{cf} = \frac{W_{cf}}{\rho_{cf}} \quad (2)$$

where

ρ_{cf} = density of cladding and frame material

For these specimens, both the clad and frame material is type 347 stainless steel and $\rho_{cf} = 7.93 \text{ gm/cm}^3$.

The volume of the specimen core, V_c can then be determined by the difference

$$V_c = V_t - V_{cf} \quad (3)$$

and the specimen core density, σ_c , becomes

$$\rho = \frac{W_c}{V_c} \quad (4)$$

The theoretical density of UO₂-stainless steel dispersion fuels can be calculated from the following equation:

$$\rho_{td} = \frac{100}{\frac{L_{UO_2}}{\rho_{UO_2}} + \frac{L_{ss}}{\rho_{ss}}} \quad (5)$$

where

ρ_{td} = theoretical density of fuel core

L_{UO_2} = wt % UO₂ in fuel core

L_{ss} = wt % stainless steel in fuel core

ρ_{UO_2} = theoretical density of UO₂ (10.96 gm/cm³)

ρ_{ss} = theoretical density of ss (7.93 gm/cm³)

The theoretical density of fuel cores containing 25, 30, 35, 40, 45, and 50 wt % UO₂ were calculated from Equation (5). These results are shown graphically on page C-5.

Since the fuel loading (wt % UO₂) of the test specimens is known from specimen fabrication records, the theoretical core density of the specimen can be determined from the graph. The actual core density is calculated from Equation (4) and the percent of theoretical core density (% T.D.) is

$$\% \text{ T.D.} = \frac{\rho_c}{\rho_{td}} \times 100 \quad (6)$$

Theoretical Density of UO₂-Stainless Steel Cermets
as a Function of UO₂ Loading

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