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DESCRIPTION OF EBR-II SUBASSEMBLY X-100

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J. W. Woods
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METALS AND CERAMICS DIVISION

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E. E. Bloom J. W. Woods
A. F. Zulliger[1]

ABSTRACT

The experiment described in this document was designed to investigate the effects of preirradiation microstructure, alloy composition, irradiation temperature, and fast neutron fluence on the physical and mechanical properties of austenitic steels. Alloys included in the experiment are types 304, 316, and 318 stainless steels, types 304 and 316 stainless steels modified by altering the amounts of Mo, Ti, and C, SANDVIK 12R72HV, and 19-9-DL. The experiment has been installed in the reactor grid position 2D1 of the EBR-II and is designated subassembly X-100.

INTRODUCTION

Subassembly X-100 is a Mark B-7 subassembly designed for the irradiation of cladding and structural materials test specimens in a row-2 position of the EBR-II at a reactor power level of 62.5 MW(t). The subassembly was installed in grid position 2D1 on October 7, 1970. This report summarizes the objectives of the irradiation experiment, the design of the irradiation subassembly, and the plan for postirradiation examination.

EXPERIMENTAL OBJECTIVES

The primary objective of this experiment is to establish the effects of preirradiation heat treatment (i.e., microstructure) on the swelling resistance and postirradiation mechanical properties of type 316 stainless steel, which is the reference cladding material for FFTF, and titanium-modified type 316 stainless steel, an alloy that exhibits

[1]General Engineering Division.

significant improvements in strength and resistance to elevated-temperature embrittlement due to transmutation-produced helium.

Other objectives of the experiment are:

1. Investigation of the effects of certain compositional variations on the swelling and postirradiation mechanical properties of type 316 stainless steel. The compositional variations include (1) molybdenum (0.2 to 5.0%), (2) titanium (0 to 0.6%), and (3) carbon (0.2 and 0.6%).

2. Determination of the effects of fast-neutron irradiation on the swelling and postirradiation mechanical properties of a number of alloys that are of interest to the overall LMFBR Program. Alloys included in the experiment are SANDVIK 12R72HV, 19-9-DL, type 318 stainless steel, and titanium-modified type 304 stainless steel.

3. Determination of the effects of irradiation on the mechanical properties of type 304 stainless steel weldments.

4. Determination by Atomics International of the effects of microstructure, fluence, and irradiation temperature on void formation and high-temperature mechanical properties of type 316 stainless steel samples contained in six capsules included in this experiment.

DESIGN OF IRRADIATION SUBASSEMBLY

Specimen Holders

Mechanical property test specimens having the dimensions shown in Fig. 1 are irradiated in specimen holders shown schematically in Fig. 2. A gas gap is provided between the specimen holder surface and the inside surface of the Mark B-7 tube element to provide a barrier to radial heat flow.

Heat Transfer Calculations

Nuclear heating rates used in the experimental design are shown as a function of axial position in Fig. 3. For the design of each tube of

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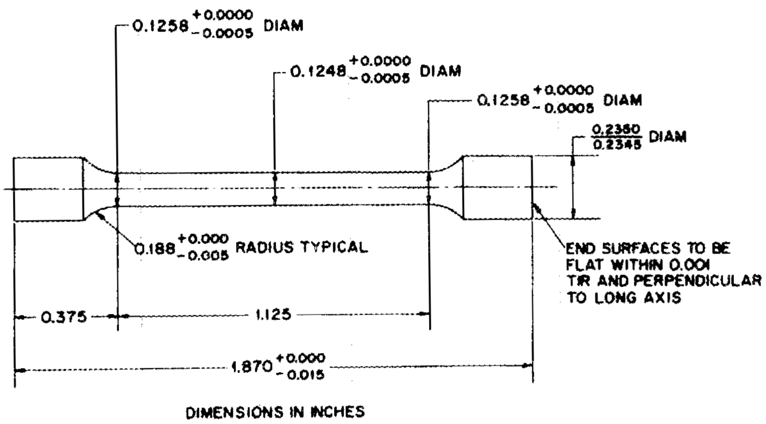

Fig. 1. Mechanical Property Test Specimen Used in EBR-II Irradiation Experiments.

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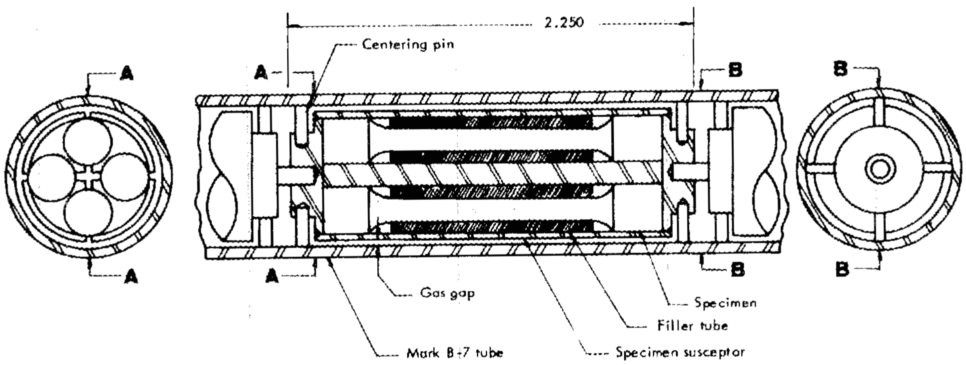

Fig. 2. Schematic Drawing of a Specimen Holder Used in EBR-II Materials Irradiation Experiment. The length shown is in inches.

the seven-tube subassembly a computer program called Little MAMU,[2] written for the IBM 360-91, was used. Briefly the technique was:

1. The materials and desired irradiation temperature for each specimen holder within a given element were determined.

2. The above information, along with inlet sodium temperature, sodium flow rate, sodium film coefficient, the dimensions of the tube

[2]D. A. Dyslin, Little MAMU – A Radial Steady State Heat Transfer Computer Program, ORNL-TM report in preparation.

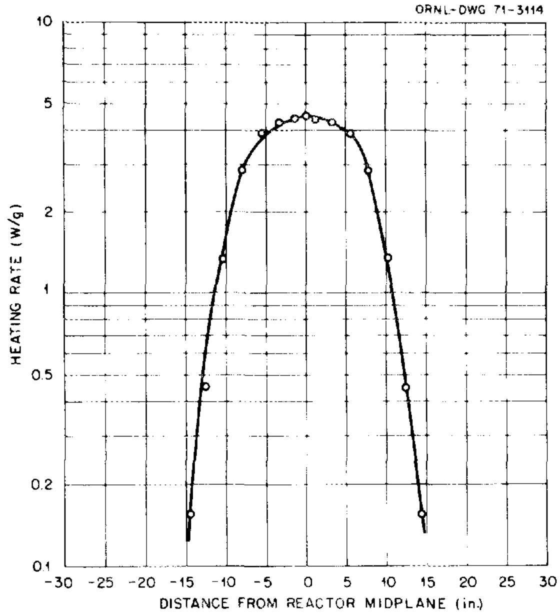

Fig. 3. Nuclear Heating Rate as a Function of Distance from the Reactor Midplane.

element, material properties as listed in Table 1, and nuclear heating rate as a function of axial position were inputs to the computer.

3. The computer was programmed to calculate the cold gas annulus required to attain the specified irradiation temperatures. Calculations for the gas annulus were performed at three places (bottom, middle, and top) on each of the 2.25-in.-long specimen holders.

It was assumed that at steady state all heat transfer within the capsule tube was radial and that the total heat transferred across the gas annulus was the sum of the amounts transferred by conduction and radiation. The inside surface of each capsule tube was gold plated to enable one to more accurately calculate the amount of heat transferred across the gas gap by radiation. Standard equations applicable to these conditions and this geometry were used. On the basis of initial computer calculations, the sodium flow rates for each element were adjusted to attain exit coolant temperatures of approximately 425°C. Next the required gas annulus was calculated for each specimen holder within a given element. Starting at the bottom end of the element, where the sodium inlet temperature is 370°C, heat was added to the sodium at each calculated position. The heat added included all that generated within

Table 1. Properties of Materials Used in Irradiation Experiment

Property	Material	Temperature (°C)	Value
Emissivity	Gold-plated surface	T^a	$0.01118 + 0.000038T$
	Type 304 stainless steel	T^a	$0.2458 + 0.0000612T$
Density	Helium		~ 0
	Type 304 stainless steel		7.9
Thermal expansion coefficient	Type 304 stainless steel	T	$(1.645 \times 10^{-5} + 3.7 \times 10^{-9}T)/°C$
Thermal conductivity	Helium	−17.7	0.0014 W cm^{-1} $°C^{-1}$
		204	0.00206
		371	0.00251
		593	0.00303
		815	0.00353
	Type 304 stainless steel	−17.7	0.147
		538	0.221
		1093	0.296

[a]Surface temperature.

both the element and the coolant. In each of the six outside elements (A, B, C, E, F, and G), one sixth of the heat generated in the hexagonal can of the subassembly plus some heat flowing radially from adjacent driver fuel assemblies were added to the sodium. This was accomplished on the computer program by inputting the coolant density as a composite density of coolant and hexagonal can and by adjusting the sodium flow rate to attain an exit coolant temperature of about 425°C. The sodium coolant temperature at each calculation position was then determined, and the calculation for gas annulus was based upon the transfer of heat to sodium at this temperature.

Subassembly Layout

So that the effect of a given metallurgical variable upon both the amount of swelling and the postirradiation mechanical properties can be determined, the standard tensile specimen will serve as both a density specimen and a mechanical property test specimen. To supplement these density measurements and provide additional material for postirradiation transmission electron microscopy, those specimen holders located within the reactor core were fabricated from selected alloys (e.g., type 316 and titanium-modified type 316 stainless steels in both the annealed and 20% cold-worked conditions).

The contents of each of the seven pins of the subassembly are listed in detail in the Appendix. This list shows (1) the material (and its metallurgical condition) used in the fabrication of each specimen holder and its location; (2) the specimen number, location, material, and heat treatment of each mechanical property test specimen; (3) the design irradiation temperature for each specimen holder; and (4) the projected goal fluence at the center of each specimen holder. The locations of specimens and specimen holders within each element are numbered from 2 at the top to 23 at the bottom. The orientation of the subassembly with respect to the reactor center line is shown in Fig. 4. Figure 5 shows the approved schedule for the removal and replacement of elements from the subassembly. The materials, heat treatments, and design irradiation temperatures for those specimen holders and specimens located within ±10 in. of the core midplane (positions 9 through 16) are duplicated in each set of two elements with the same irradiation schedule. The three sets will be removed during two scheduled changeouts and at termination of the subassembly, thus giving three fluence levels for a given alloy and preirradiation heat treatment. Element G contains primarily type 318 stainless steel, 19-9-DL, and SANDVIK 12R72HV. This element will be removed during the second changeout.

At each changeout the outside diameters of the elements will be measured and the effect of capsule swelling on the irradiation temperatures will be estimated. If these estimates indicate that the temperatures of the specimen holders either have increased significantly (50°C)

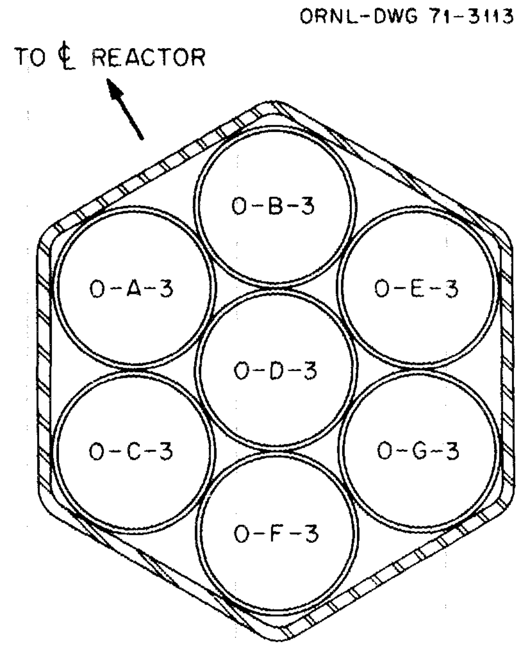

Fig. 4. Capsule Arrangement in the Wrapper. ORNL EBR-II Subassembly X-100.

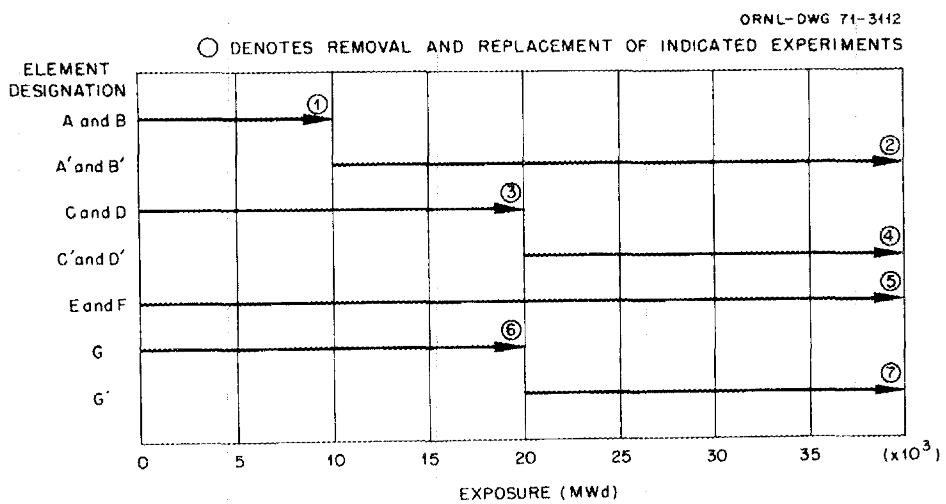

Fig. 5. Goal Exposures for Original and Replacement Elements of EBR-II Subassembly X-100.

or would during the next portion of the experiment, then reencapsulation of the highest priority specimens will be recommended.

A listing of the materials to be included in the changeout capsules (A′, B′, C′, D′, and G′) will be submitted to AEC-RDT before the capsules are constructed. Materials will be selected on the basis of the following criteria:

1. alloys and/or heat treatments that, on the basis of then-available results, exhibit improved resistance to irradiation-induced swelling or improved mechanical properties,
2. reencapsulation of selected specimens to obtain high fluence data over a wide range of irradiation temperatures (370–750°C),
3. irradiation of "new" materials (e.g., FV548) that are of interest for LMFBR's.

DOSIMETRY

Dosimetry for EBR-II subassembly X-100 consists of 30 sets of flux monitors and four fission monitor sets. Each flux monitor set consists of one wire each of Fe, Ni, Ti, and Co, and each fission set consists of ^{238}U, ^{235}U, Sc, and ^{237}Np. Tables 2 and 3 and Fig. 6 show the location and weight of each flux monitor. The dosimetry program was planned such that one element in each set of two elements contains a sufficient number of flux monitors (7 sets with 4 flux monitors in each set) to allow a determination of fluence as a function of axial position upon removal of the element. The remaining element of each set contains 3 flux monitor sets, which will establish the fluence variation from element to element.

Table 2. Fission Flux Monitor Location and Weights in EBR-II Subassembly X-100

Tube Position	Weight (mg) of			
	^{238}U	^{235}U	Sc	^{237}Np
A6	2.842	0.235	3.566	a
A13	2.748	0.253	3.567	0.722
E13	2.573	0.266	3.560	0.422
E19	2.892	0.259	3.502	0.745

[a]The ^{237}Np sample was omitted from position A6.

Table 3. Wire Flux Monitor Location and Weights in EBR-II Subassembly X-100

Tube Position	Weight (mg) of			
	Fe	Ni	Ti	Co
A7	5.480	6.868	6.905	6.170
A9	6.010	7.357	6.435	5.813
A11	5.923	6.440	5.602	6.470
A12	6.088	7.340	6.165	6.183
A14	6.300	7.288	6.453	5.990
A16	5.685	7.544	6.319	6.437
A18	5.585	7.271	6.179	6.153
B7	6.078	5.725	6.585	6.028
B13	5.345	7.102	6.530	6.481
B18	5.570	6.715	6.079	5.964
C7	5.640	6.910	5.921	6.195
C9	5.625	5.735	6.195	6.403
C11	5.206	6.856	6.205	6.469
C13	6.135	6.846	5.323	5.812
C14	6.431	7.439	6.290	6.064
C16	6.465	7.140	6.380	6.228
C18	5.490	7.512	4.585	6.209
D7	5.900	6.668	6.663	6.225
D13	6.065	6.595	7.005	6.265
D18	5.395	6.810	6.722	6.175
E7	6.275	6.761	6.335	5.985
E9	5.990	6.810	6.424	6.470
E11	5.480	6.845	6.410	6.370
E12	6.031	7.265	6.675	5.925
E14	5.967	7.743	6.751	6.090
E16	5.590	7.490	5.385	6.230
E18	6.232	6.284	5.895	6.740
F7	6.068	6.995	6.595	6.998
F13	6.130	7.400	6.420	5.460
F18	7.090	6.528	6.555	6.164

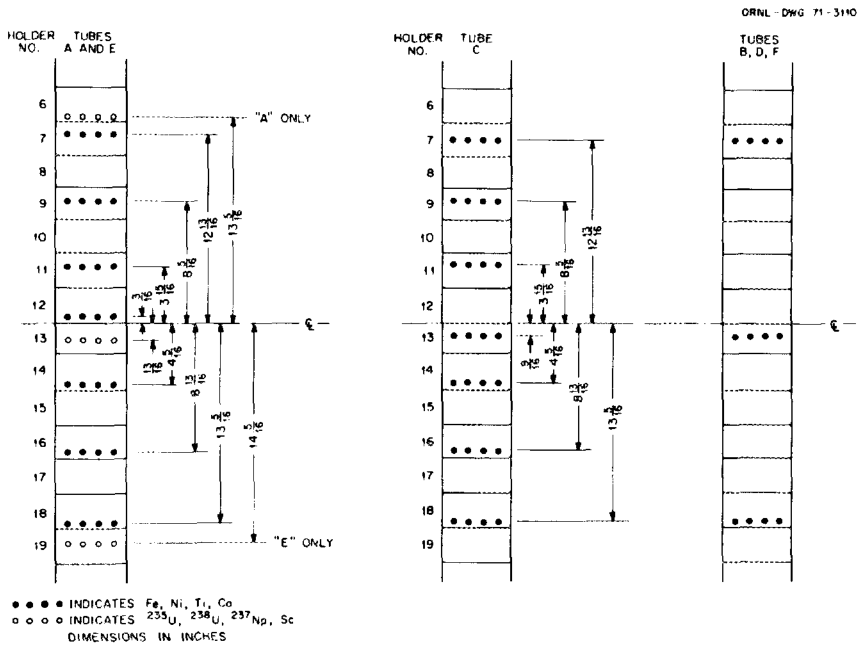

Fig. 6. Axial Positions of Dosimeters.

POSTIRRADIATION TESTING

The general plan for postirradiation examination is as follows.

1. Postirradiation dimensions of each specimen holder will be determined. This information will be used along with dimensions of the outer containment tube to establish the end-of-life irradiation temperatures.

2. Upon disassembly of specimen holders, the length of each tensile specimen will be measured and compared to preirradiation measurements. Length changes will serve as a check on immersion density measurements.

3. The density and density change of each specimen (and specimen holder) irradiated in positions 9 through 16 (within the core) will be determined. Density measurements will be made on selected specimens irradiated in positions further removed from the reactor core.

4. To establish the postirradiation microstructure, transmission electron microscopy samples will be removed from the shoulder of selected mechanical property specimens before testing.

5. A tensile or creep-rupture test will be conducted on each mechanical property specimen. These tests will be conducted in the range 400 to 750°C, and each specimen will be tested at or near its irradiation temperature.

6. Transmission electron, scanning electron, and optical microscopy will be used to determine the effects of irradiation on the microstructure.

7. Tensile tests and a few selected creep-rupture tests will be conducted on the weld specimens for weld development of FTR components.

FABRICATION PROCEDURES

The fabrication procedures for encapsulation of the mechanical property test specimens involve fabrication of the specimen holder, positioning the holders within the Mark B-7 tubes, and sealing the pins.

Specimen Holders

The body of the holder is constructed by drilling four holes into a stainless steel cylinder and then splitting it into four quarters to facilitate assembly and disassembly. A hole is drilled in each quadrant of those holders designated to contain flux monitors. Mechanical property test specimens with a split filler piece around the gage section of each specimen and the dosimeters are loaded into the body of the holder. End caps are then welded into the specimen holder body to hold it together as well as to retain the specimens in the holder. The outside of the specimen holder is then machined by "centerless grinding" to the correct dimensions (as determined by the heat transfer calculations described above in the design section). Those specimen holders located at positions with a large gradient in the nuclear heating rate are tapered to obtain a uniform temperature along the specimen. The specimen holders are ultrasonically cleaned in hot soapy water, rinsed in alcohol, and the axial spacers (to minimize axial heat transfer from one holder to another) and the centering pins (to center the holder in the tube) are installed. The centering pins are ground to the correct dimensions to center the holder within the tube so that the desired temperature is obtained during irradiation. A final ultrasonic cleaning in alcohol is given the specimen holder just before insertion in the housing tube.

Assembly of Pin

The bottom end plug of the pin is welded in place. The fabricated specimen holders are then laid out on a table according to the loading diagram. Each holder is lowered into the pin (starting with the bottom holder) by a nylon thread looped around the holder's centering pins. After all holders have been inserted, the top plug with its fill tube is placed in position and welded.

Pin Sealing

The pin is placed in a heater and the fill tube connected to a vacuum system. The assembly is twice evacuated and filled with helium. During the third evacuation the assembly is baked out at 200°C for 1 hr, cooled to room temperature, and refilled with helium. The fill tube is clamped, cut off, and sealed by welding. The top end cap is added to the pin and welded in place.

ACKNOWLEDGMENTS

The authors wish to acknowledge the contribution of J. D. Jenkins who planned the dosimetry program. We also thank W. W. Davis and C. K. Thomas for their assistance in the assembly of the experiment.

APPENDIX

Contents of EBR-II Subassembly X-100

In the pages that follow is a complete list of specimens in the irradiation experiment. Since efficient tabulation requires terse designations of materials and conditions, an explanation of the designations follows.

Materials

Stainless steels of AISI types are designated by the type number. Experimental modifications of AISI types are designated as indicated by these examples: 304 + 0.2 Ti means type 304 except that 0.2% Ti has been added; 316 (2.4 Mo) means type 316 except that the molybdenum content has been altered to 2.4%. High-purity 316 is a special heat of type 316 stainless steel with the following analysis:

Ni, 14.4; Cr, 17.46; Mo, 2.79; Si 0.01 wt %;
Mn, < 10; P, 65; Cu < 10; S, 20; B, < 1; C, 50; O, 25; N, 3 ppm.

The letter-number weld designation (F07, SA4, etc.) denote different welding conditions. These will be identified when the results on the specimens are reported. Specimen orientations are as follows.

TW indicates transverse all-weld-metal specimen.
TFL indicates transverse fusion-line specimen.
LBM indicates longitudinal base-metal specimen.
LWM indicates longitudinal weld-metal specimen.

LBM or LWM specimens may be base metal, weld metal, or fusion line specimens; the actual specimen type will be determined metallographically after test.

Preirradiation Treatments

"Mill anneal" designates material that had been annealed at the mill and was used as received. Heat treatments are designated a/b where a is the time in hours and b is the temperature in °C. Mechanical deformation is indicated by the percent strain; room-temperature deformation is implied unless a temperature (in °C) is indicated. Successive treatments are given in order. For example, specimen D2-152 in position A15 was annealed 1 hr at 1050°C, strained 20% at room temperature, and then heated 24 hr at 482°C and 100 hr at 700°C. Specimen Z4-1 in A17 was annealed 1 hr at 1050°C and then strained 40% at 450°C. For welded specimens the solution anneal was 2 hr at 1063°C and aging was 10 hr at 800°C.

Specimens in Irradiation Experiment

Position	Design Temperature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder		Specimen		
			Material	Preirradiation Condition	Number	Material	Preirradiation Treatment
		$\times 10^{22}$					
A2	450	0.12	304	Mill anneal	F10191	308 weld F10, TW	As welded
					F10192	308 weld F10, TW	Solution anneal
					F101921	308 weld F10, TFL	As welded
					F101922	308 weld F10, TFL	Solution anneal
A3	450	0.20	304	Mill anneal	F11192	308 weld F11, TW	As welded
					F11174	308 weld F11, TW	Solution anneal
					F111921	308 weld F11, TFL	As welded
					F111922	308 weld F11, TFL	Solution anneal
A4	450	0.31	304	Mill anneal	F12191	308 weld F12, TW	As welded
					F12192	308 weld F12, TW	Solution anneal
					F121921	308 weld F12, TFL	As welded
					F121922	308 weld F12, TFL	Solution anneal
A5	450	0.47	304	Mill anneal	F07162	308 weld F07, TW	As welded
					F07161	308 weld F07, TW	Solution anneal
					F071621	308 weld F07, TFL	As welded
					F071622	308 weld F07, TFL	Solution anneal
A6			Spacer				
A7	450	1.0	304	Mill anneal	MS-18	High-purity 316	1/1050
					S1-38	316 + 0.33 Ti	1/1050
					T1-39	316 + 0.46 Ti	1/1050
					U1-39	316 + 0.60 Ti	1/1050
A8	500	1.4	304	Mill anneal	R1-170	316 + 0.23 Ti	1/1050 + 10/800
					R1-171	316 + 0.23 Ti	1/1050 + 10/800
					R1-172	316 + 0.23 Ti	1/1050 + 10/800
						Silicon carbide	
A9	500	1.9	304	Mill anneal	MS-1	High-purity 316	1/1050
					S1-30	316 + 0.33 Ti	1/1050
					T1-31	316 + 0.46 Ti	1/1050
					U1-31	316 + 0.60 Ti	1/1050
A10	500	2.4	316	1/1050	R2-80	316 + 0.23 Ti	1/1050 + 20% ϵ + 10/550
					R2-81	316 + 0.23 Ti	1/1050 + 20% ϵ + 10/550
					R2-92	316 + 0.23 Ti	1/1050 + 20% ϵ + 10/650
					R2-93	316 + 0.23 Ti	1/1050 + 20% ϵ + 10/650
A11	500	2.8	316	1/1050 + 20% ϵ	R1-159	316 + 0.23 Ti	1/1050
					R1-160	316 + 0.23 Ti	1/1050
					D0-260	316 + 0.23 Ti	1/1050
					D0-261	316 + 0.23 Ti	1/1050

Specimens (continued)

Position	Design Temperature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirradiation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
A12	500	3.3	316 + 0.23 Ti	1/1050	MS-3	High-purity 316	1/1050
					V1-286	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
						Silicon carbide AI capsule	
A13	443	3.3	316 + 0.23 Ti	1/1050	MS-7	High-purity 316	1/1050
					D2-133	316	1/1050 + 20% ε + 10/650
					UFG tube	Ultrafine-grain 316 tube	
					V1-285	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
A14	500	2.8	316 + 0.23 Ti	1/1050 + 20% ε	D2-104	316	1/1050 + 20% ε + 10/550
					D2-105	316	1/1050 + 20% ε + 10/550
					D2-116	316	1/1050 + 20% ε + 10/650
					D2-117	316	1/1050 + 20% ε + 10/650
A15	500	2.4	304 + 0.2 Ti	1/1050 + 20% ε	D0-196	316	1/1050 + 100/700 + 20% ε
					D2-155	316	1/1050 + 20% ε
					R1-71	316 + 0.23 Ti	1/1050 + 20% ε
					D2-152	316	1/1050 + 20% ε + 24/482 + 100/700
A16	500	1.9	304 + 0.2 Ti	1/1050	A2-1	316 (0.2 Mo)	1/1050
					M2-1	316 (0.5 Mo)	1/1050
					O2-1	316 (2.4 Mo)	1/1050
					P2-1	316 (4.8 Mo)	1/1050
A17	500	1.4	304	Mill anneal	Z1-1	316 + 0.25 Ti	1/1050
					Z2-1	316 + 0.25 Ti	1/1050 + 20% ε
					Z4-1	316 + 0.25 Ti	1/1050 + 40% ε at 450°C
						Silicon carbide	
A18	400	1.0	304	Mill anneal	D0-209	316	1/1050 + 100/700 + 10% ε
					D0-214	316	1/1050 + 100/700 + 10% ε
					D3-7	316	1/1050 + 10% ε
					D3-8	316	1/1050 + 10% ε
A19			Spacer				
A20	370	0.47	304	Mill anneal	F07163	308 weld F07, TW	As welded
					F07164	308 weld F07, TW	Solution anneal
					F071624	308 weld F07, TFL	As welded
					F071623	308 weld F07, TFL	Solution anneal
A21	370	0.31	304	Mill anneal	F12194	308 weld F12, TW	As welded
					F12193	308 weld F12, TW	Solution anneal
					F121923	308 weld F12, TFL	As welded
					F121924	308 weld F12, TFL	Solution anneal

Specimens (continued)

Position	Design Temperature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirradiation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
A22	370	0.20	304	Mill anneal	F11194	308 weld F11, TW	As welded
					F11193	308 weld F11, TW	Solution anneal
					F111923	308 weld F11, TFL	As welded
					F111924	308 weld F11, TFL	Solution anneal
A23	370	0.12	304	Mill anneal	F10193	308 weld F10, TW	As welded
					F10194	308 weld F10, TW	Solution anneal
					F101923	308 weld F10, TFL	As welded
					F101924	308 weld F10, TFL	Solution anneal
B2		0.12	304	Mill anneal	SA4251	308 weld SA4, TW	As welded
					SA4273	308 weld SA4, TW	Solution anneal
					SA42521	308 weld SA4, TFL	As welded
					SA42522	308 weld SA4, TFL	Solution anneal
B3		0.20	304	Mill anneal	SA5271	308 weld SA5, TW	As welded
					SA5276	308 weld SA5, TW	Solution anneal
					SA52321	308 weld SA5, TFL	As welded
					SA52322	308 weld SA5, TFL	Solution anneal
B4		0.31	304	Mill anneal	SA6301	308 weld SA6, TW	As welded
					SA6302	308 weld SA6, TW	Solution anneal
					SA63022	308 weld SA6, TFL	As welded
					SA63021	308 weld SA6, TFL	Solution anneal
B5		0.47	304	Mill anneal	F13172	308 weld F13, TW	As welded
					F13171	308 weld F13, TW	Solution anneal
					F131722	308 weld F13, TFL	As welded
					F131721	308 weld F13, TFL	Solution anneal
B6			Spacer				
B7	450	1.0	304	Mill anneal	D0-215	316	1/1050 + 100/700 + 10% ε
					D0-216	316	1/1050 + 100/700 + 10% ε
					D2-157	316	1/1050 + 20% ε + 24/482 + 100/700
					D2-158	316	1/1050 + 10% ε + 24/482 + 100/700
B8	500	1.4	304	Mill anneal	V1-220	304 + 0.2 Ti	1/1050
					V1-226	304 + 0.2 Ti	1/1050 + 100/800
					V1-289	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
					V1-217	304 + 0.2 Ti	1/925
B9	600	1.9	304	Mill anneal	MS-2	High-purity 316	1/1050
					S1-31	316 + 0.33 Ti	1/1050
					T1-32	316 + 0.46 Ti	1/1050
					U1-32	316 + 0.60 Ti	1/1050
B10	600	2.4	316	1/1050	R2-82	316 + 0.23 Ti	1/1050 + 20% ε + 10/550
					R2-83	316 + 0.23 Ti	1/1050 + 20% ε + 10/550
					R2-94	316 + 0.23 Ti	1/1050 + 20% ε + 10/650
					R2-95	316 + 0.23 Ti	1/1050 + 20% ε + 10/650
B11	600	2.8	316	1/1050 + 20% ε	R1-161	316 + 0.23 Ti	1/1050
					R1-162	316 + 0.23 Ti	1/1050
					D0-262	316 + 0.23 Ti	1/1050
					D0-263	316 + 0.23 Ti	1/1050

Specimens (continued)

Position	Design Temper-ature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirradiation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
B12	600	3.3	316 + 0.23 Ti	1/1050	MS-4	High-purity 316	
					D2-134	316	1/1050 + 20% ε + 10/650
					V1-287	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
						AI capsule	
B13	700	3.3	316 + 0.23 Ti	1/1050	D2-135	316	1/1050 + 20% ε + 10/650
					D2-136	316	1/1050 + 20% ε + 10/650
					V1-288	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
					UFG tube	Ultrafine-grain 316 tube	
B14	600	2.8	316 + 0.23 Ti	1/1050 + 20% ε	D2-106	316	1/1050 + 20% ε + 10/550
					D2-107	316	1/1050 + 20% ε + 10/550
					D2-118	316	1/1050 + 20% ε + 10/650
					D2-119	316	1/1050 + 20% ε + 10/650
B15	600	2.4	304 + 0.2 Ti	1/1050 + 20% ε	D2-145	316	1/1050 + 20% ε
					D0-197	316	1/1050 + 100/700 + 20% ε
					D2-156	316	1/1050 + 20% ε + 24/482 + 100/700
						Silicon carbide	
B16	600	1.9	304 + 0.2 Ti	1/1050	A2-2	316 (0.2 Mo)	1/1050
					M2-2	316 (0.5 Mo)	1/1050
					O2-2	316 (2.4 Mo)	1/1050
					P2-2	316 (4.8 Mo)	1/1050
B17	500	1.4	304	Mill anneal	Z2-2	316 + 0.25 Ti	1/1050 + 20% ε
					Z2-3	316 + 0.25 Ti	1/1050 + 20% ε
					Z4-2	316 + 0.25 Ti	1/1050 + 40% ε at 450°C
					Z4-3	316 + 0.25 Ti	1/1050 + 40% ε at 450°C
B18	400	1.0	304	Mill anneal	V1-221	304 + 0.2 Ti	1/1050
					V1-231	304 + 0.2 Ti	1/1050 + 100/800
					V1-290	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
					V1-213	304 + 0.2 Ti	1/925
B19			Spacer				
B20		0.47	304	Mill anneal	F13174	308 weld F13, TW	As welded
					F13173	308 weld F13, TW	Solution anneal
					F131723	308 weld F13, TFL	As welded
					F131724	308 weld F13, TFL	Solution anneal
B21		0.31	304	Mill anneal	SA6304	308 weld SA6, TW	As welded
					SA6303	308 weld SA6, TW	Solution anneal
					SA63023	308 weld SA6, TFL	As welded
					SA63024	308 weld SA6, TFL	Solution anneal
B22		0.20	304	Mill anneal	SA5273	308 weld SA5, TW	As welded
					SA5274	308 weld SA5, TW	Solution anneal
					SA52323	308 weld SA5, TFL	As welded
					SA52324	308 weld SA5, TFL	Solution anneal

Specimens (continued)

Position	Design Temperature (°C)	Goal Fluence (neutrons/cm^2)	Specimen Holder Material	Specimen Holder Preirradiation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
B23		0.12	304	Mill anneal	SA4254	308 weld SA4, TW	As welded
					SA4274	308 weld SA4, TW	Solution anneal
					SA42524	308 weld SA4, TFL	As welded
					SA42523	308 weld SA4, TFL	Solution anneal
C2		0.2		Spacer			
C3		0.4	304	Mill anneal	SA393	308 weld SA3, TW	As welded
					SA351	308 weld SA3, TW	Solution anneal
					SA3321	308 weld SA3, TFL	As welded
					SA3521	308 weld SA3, TFL	Solution anneal
C4		0.6	304	Mill anneal	SA355	308 weld SA3, TW	As welded
					SA353	308 weld SA3, TW	Solution anneal
					SA3322	308 weld SA3, TFL	As welded
					SA3926	308 weld SA3, TFL	Solution anneal
C5		0.9	304	Mill anneal	F071611	308 weld F07, LBM	Anneal and aged
					F101911	308 weld F10, LBM	Anneal and aged
					F111911	308 weld F11, LBM	Anneal and aged
					F121911	308 weld F12, LBM	Anneal and aged
C6	450	1.4	304	Mill anneal	CO-195	304L	1/1050
					XO-22	304L + 0.2 Ti	1/1050
					UO-18	304L + 0.1 Ti	1/1050
					VO-16	304L + 0.5 Ti	1/1050
C7	450	2.0	304	Mill anneal	S1-37	316 + 0.33 Ti	1/1050
					T1-38	316 + 0.46 Ti	1/1050
					MS-17	High-purity 316	1/1050
					U1-38	316 + 0.60 Ti	1/1050
C8	500	2.8	304	Mill anneal	R1-173	316 + 0.23 Ti	1/1050 + 10/800
					R1-174	316 + 0.23 Ti	1/1050 + 10/800
					R1-175	316 + 0.23 Ti	1/1050 + 10/800
					R1-176	316 + 0.23 Ti	1/1050 + 10/800
C9	500	3.8	304	Mill anneal	MS-8	High-purity 316	1/1050
					S1-32	316 + 0.33 Ti	1/1050
					T1-33	316 + 0.46 Ti	1/1050
					U1-33	316 + 0.60 Ti	1/1050
C10	500	4.8	316	1/1050	R2-84	316 + 0.23 Ti	1/1050 + 20% ϵ + 10/550
					R2-85	316 + 0.23 Ti	1/1050 + 20% ϵ + 10/550
					R2-96	316 + 0.23 Ti	1/1050 + 20% ϵ + 10/650
					R2-97	316 + 0.23 Ti	1/1050 + 20% ϵ + 10/650
C11	500	5.7	316	1/1050 + 20% ϵ	R1-163	316 + 0.23 Ti	1/1050
					R1-164	316 + 0.23 Ti	1/1050
					DO-264	316 + 0.23 Ti	1/1050
					DO-265	316 + 0.23 Ti	1/1050
C12	500	6.7	316 + 0.23 Ti	1/1050	D2-203	316	1/1050 + 100/700 + 20% ϵ
					D2-146	316	1/1050 + 20% ϵ + 1/700
					D2-147	316	1/1050 + 20% ϵ + 1/700
						AI capsule	

Specimens (continued)

Position	Design Temperature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirradiation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		× 10^{22}					
C13	443	6.7	316 + 0.23 Ti	1/1050	D2-143	316	1/1050 + 20% ε + 10/650
					D2-144	316	1/1050 + 20% ε + 10/650
					D0-202	316	1/1050 + 100/700 + 20% ε
					R2-104	316 + 0.23 Ti	1/1050 + 20% ε + 1/700
C14	500	5.7	316 + 0.23 Ti	1/1050 + 20% ε	D2-108	316	1/1050 + 20% ε + 10/550
					D2-109	316	1/1050 + 20% ε + 10/550
					D2-120	316	1/1050 + 20% ε + 10/650
					D2-121	316	1/1050 + 20% ε + 10/650
C15	500	4.8	304 + 0.2 Ti	1/1050 + 20% ε	A2-3	316 (0.2 Mo)	1/1050
					M2-3	316 (0.5 Mo)	1/1050
					O2-3	316 (2.4 Mo)	1/1050
					P2-3	316 (4.8 Mo)	1/1050
C16	500	3.8	304 + 0.2 Ti	1/1050	D0-210	316	1/1050 + 100/700 + 10% ε
					D0-211	316	1/1050 + 100/700 + 10% ε
					D0-198	316	1/1050 + 100/700 + 20% ε
					D0-199	316	1/1050 + 100/700 + 20% ε
C17	500	2.8	304	Mill anneal	MS-15	High-purity 316	1/1050
					D0-206	316	1/1050 + 100/700 + 20% ε
					D0-207	316	1/1050 + 100/700 + 20% ε
					D0-208	316	1/1050 + 100/700 + 20% ε
C18	400	2.0	304	Mill anneal	V1-251	304 + 0.2 Ti	1/1050 + 10% ε
					V1-252	304 + 0.2 Ti	1/1050 + 10% ε
					V1-266	304 + 0.2 Ti	1/1050 + 20% ε
					V1-267	304 + 0.2 Ti	1/1050 + 20% ε
C19		1.4	304	Mill anneal	V1-253	304 + 0.2 Ti	1/1050 + 10% ε
					V1-254	304 + 0.2 Ti	1/1050 + 10% ε
					V1-268	304 + 0.2 Ti	1/1050 + 20% ε
					V1-269	304 + 0.2 Ti	1/1050 + 20% ε
C20		0.9	304	Mill anneal	F101718	308 weld F10, LBM	As welded
					F101917	308 weld F10, LBM	Annealed and aged
					SA42718	308 weld SA4, LBM	As welded
					SA42517	308 weld SA4, LBM	Annealed and aged
C21		0.6	304	Mill anneal	F101711	308 weld F10, LBM	As welded
					F101712	308 weld F10, LBM	As welded
					F101713	308 weld F10, LBM	As welded
					F101912	308 weld F10, LBM	Annealed and aged
C22		0.4	304	Mill anneal	F101714	308 weld F10, LBM	As welded
					F101715	308 weld F10, LBM	As welded
					F101913	308 weld F10, LBM	Annealed and aged
					F101914	308 weld F10, LBM	Annealed and aged
C23		0.2	304	Mill anneal	F101716	308 weld F10, LBM	As welded
					F101717	308 weld F10, LBM	As welded
					F101915	308 weld F10, LBM	Annealed and aged
					F101916	308 weld F10, LBM	Annealed and aged

Specimens (continued)

Position	Design Temper-ature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirra-diation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
D2		0.2	304	Mill anneal	F18111	308 weld F18, TW	As welded
					F18113	308 weld F18, TW	Solution anneal
					F18921	308 weld F18, TFL	As welded
					F18924	308 weld F18, TFL	Solution anneal
D3		0.4	304	Mill anneal	F18112	308 weld F18, TW	As welded
					F18115	308 weld F18, TW	Solution anneal
					F18922	308 weld F18, TFL	As welded
					F18925	308 weld F18, TFL	Solution anneal
D4		0.6	304	Mill anneal	SA354	308 weld SA3, TW	As welded
					SA352	308 weld SA3, TW	Solution anneal
					SA3323	308 weld SA3, TFL	As welded
					SA3925	308 weld SA3, TFL	Solution anneal
D5		0.9	304	Mill anneal	F131711	308 weld F13, LBM	Annealed and aged
					SA42511	308 weld SA4, LBM	Annealed and aged
					SA52711	308 weld SA5, LBM	Annealed and aged
					SA63011	308 weld SA6, LBM	Annealed and aged
D6	450	1.4	304	Mill anneal	B0-233	304	1/1050
					C1-13	304 + 0.15 Ti	1/1050
					B1-13	304 + 0.15 Ti	1/1050
					S0-115	304 + 0.27 Ti	1/1050
D7	450	2.0	304	Mill anneal	L2-9	316L + 0.20 Ti	1/1050 + 20% ε
					L2-10	316L + 0.20 Ti	1/1050 + 20% ε
					L2-11	316L + 0.20 Ti	1/1050 + 20% ε
					L2-12	316L + 0.20 Ti	1/1050 + 20% ε
D8	450	2.8	304	Mill anneal	MS-13	High-purity 316	1/1050
					E2-9	316L	1/1050 + 20% ε
					E2-10	316L	1/1050 + 20% ε
					E2-11	316L	1/1050 + 20% ε
D9	600	3.8	304	Mill anneal	MS-9	High-purity 316	1/1050
					S1-33	316 + 0.33 Ti	1/1050
					T1-34	316 + 0.46 Ti	1/1050
					U1-34	316 + 0.60 Ti	1/1050
D10	600	4.8	316	1/1050	R2-86	316 + 0.23 Ti	1/1050 + 20% ε + 10/550
					R2-87	316 + 0.23 Ti	1/1050 + 20% ε + 10/550
					R2-98	316 + 0.23 Ti	1/1050 + 20% ε + 10/650
					R2-99	316 + 0.23 Ti	1/1050 + 20% ε + 10/650
D11	600	5.7	316	1/1050 + 20% ε	R1-165	316 + 0.23 Ti	1/1050
					R1-166	316 + 0.23 Ti	1/1050
					D0-266	316 + 0.23 Ti	1/1050
					D0-267	316 + 0.23 Ti	1/1050
D12	600	6.7	316 + 0.23 Ti	1/1050	D0-204	316	1/1050 + 100/700 + 20% ε
					D2-148	316	1/1050 + 20% ε + 1/700
					D2-149	316	1/1050 + 20% ε + 1/700
						AI capsule	
D13	700	6.7	316 + 0.23 Ti	1/1050	D2-137	316	1/1050 + 20% ε + 10/650
					D2-138	316	1/1050 + 20% ε + 10/650
					D2-205	316	1/1050 + 100/700 + 20% ε
					R2-105	316	1/1050 + 100/700 + 20% ε

Specimens (continued)

Position	Design Temperature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirradiation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
D14	600	5.7	316 + 0.23 Ti	1/1050 + 20% ε	D2-110	316	1/1050 + 20% ε + 10/550
					D2-112	316	1/1050 + 20% ε + 10/550
					D2-122	316	1/1050 + 20% ε + 10/650
					D2-123	316	1/1050 + 20% ε + 10/650
D15	600	4.8	304 + 0.2 Ti	1/1050 + 20% ε	A2-4	316 (0.2 Mo)	1/1050
					M2-4	316 (0.5 Mo)	1/1050
					02-4	316 (2.4 Mo)	1/1050
					P2-4	316 (4.8 Mo)	1/1050
D16	600	3.8	304 + 0.2 Ti	1/1050	D5-10	316	1/1050 + 20% ε at 250°C
					D5-30	316	1/1050 + 20% ε at 450°C
					D5-40	316	1/1050 + 40% ε at 450°C
					D5-90	316	1/1050 + 40% ε at 650°C
D17	500	2.8	304	Mill anneal	D5-11	316	1/1050 + 20% ε at 250°C
					D5-31	316	1/1050 + 20% ε at 450°C
					D5-41	316	1/1050 + 40% ε at 450°C
					D5-91	316	1/1050 + 40% ε at 650°C
D18	400	2.0	304	Mill anneal	V1-281	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
					V1-282	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
					V1-283	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
					V1-284	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
D19				Spacer			
D20		0.9		Spacer			
D21		0.6	304	Mill anneal	SA42711	308 weld SA4, LBM	As welded
					SA42712	308 weld SA4, LBM	As welded
					SA42713	308 weld SA4, LBM	As welded
					SA42512	308 weld SA4, LBM	Annealed and aged
D22		0.4	304	Mill anneal	SA42714	308 weld SA4, LWM	As welded
					SA42715	308 weld SA4, LWM	As welded
					SA42513	308 weld SA4, LWM	Annealed and aged
					SA42514	308 weld SA4, LWM	Annealed and aged
D23		0.2	304	Mill anneal	SA42716	308 weld SA4, LBM	As welded
					SA42717	308 weld SA4, LBM	As welded
					SA42515	308 weld SA4, LBM	Annealed and aged
					SA42516	308 weld SA4, LBM	Annealed and aged
E2		0.4	304	Mill anneal	F10196	308 weld F10, TW	As welded
					F10195	308 weld F10, TW	Solution anneal
					F101925	308 weld F10, TFL	As welded
					F101926	308 weld F10, TFL	Solution anneal
E3		0.8	304	Mill anneal	F11195	308 weld F11, TW	As welded
					F11196	308 weld F11, TW	Solution anneal
					F111925	308 weld F11, TFL	As welded
					F111926	308 weld F11, TFL	Solution anneal

Specimens (continued)

Position	Design Temperature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirradiation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
E4		1.2	304	Mill anneal	F12195	308 weld F12, TW	As welded
					F12196	308 weld F12, TW	Solution anneal
					F121925	308 weld F12, TFL	As welded
					F121926	308 weld F12, TFL	Solution anneal
E5		1.8	304	Mill anneal	F07166	308 weld F07, TW	As welded
					F07165	308 weld F07, TW	Solution anneal
					F071625	308 weld F07, TFL	As welded
					F071626	308 weld F07, TFL	Solution anneal
E6	500	2.8	Tungsten		MS-6	High-purity 316	1/1050
					E1-149	304L + 0.2 Ti	1/1040
					E1-155	304L + 0.2 Ti	1/1040
						Silicon carbide	
E7	450	4.0	304	Mill anneal	D0-276	316	1/1050 + 50% ε
					R1-184	316 + 0.23 Ti	1/1050 + 50% ε
					R2-52	316 + 0.23 Ti	1/1050 + 20% ε
					D2-32	316	1/1050 + 20% ε
E8	500	5.6	304	Mill anneal	R1-177	316 + 0.23 Ti	1/1050 + 10/800
					R1-178	316 + 0.23 Ti	1/1050 + 10/800
					R1-179	316 + 0.23 Ti	1/1050 + 10/800
					R1-180	316 + 0.23 Ti	1/1050 + 10/800
E9	500	7.6	304	Mill anneal	MS-12	High-purity 316	1/1050
					S1-34	316 + 0.33 Ti	1/1050
					T1-35	316 + 0.46 Ti	1/1050
					U1-35	316 + 0.60 Ti	1/1050
E10	500	9.6	316	1/1050	R2-88	316 + 0.23 Ti	1/1050 + 20% ε + 10/550
					R2-89	316 + 0.23 Ti	1/1050 + 20% ε + 10/550
					R2-100	316 + 0.23 Ti	1/1050 + 20% ε + 10/650
					R2-101	316 + 0.23 Ti	1/1050 + 20% ε + 10/650
E11	500	1.1	316	1/1050 + 20% ε	R1-167	316 + 0.23 Ti	1/1050
					R1-168	316 + 0.23 Ti	1/1050
					D0-268	316 + 0.23 Ti	1/1050
					D0-269	316 + 0.23 Ti	1/1050
E12	500	1.3	316 + 0.23 Ti	1/1050	D2-150	316	1/1050 + 20% ε + 1/700
					D2-151	316	1/1050 + 20% ε + 1/700
					R2-72	316 + 0.23 Ti	1/1050 + 20% ε + 1/700
						AI capsule	
E13	443	1.3	316 + 0.23 Ti	1/1050	D2-139	316	1/1050 + 20% ε + 10/650
					D2-140	316	1/1050 + 20% ε + 10/650
					UFG tube	Ultrafine-grain 316 tube	
					R2-74	316 + 0.23 Ti	1/1050 + 20% ε + 1/700
E14	500	1.1	316 + 0.23 Ti	1/1050 + 20% ε	D2-113	316	1/1050 + 20% ε + 10/550
					D2-114	316	1/1050 + 20% ε + 10/550
					D2-124	316	1/1050 + 20% ε + 10/650
					D2-125	316	1/1050 + 20% ε + 10/650
E15	500	9.6	304 + 0.2 Ti	1/1050 + 20% ε	A2-5	316 (0.2 Mo)	1/1050
					M2-5	316 (0.5 Mo)	1/1050
					O2-5	316 (2.4 Mo)	1/1050
					P2-5	316 (4.8 Mo)	1/1050

Specimens (continued)

Position	Design Temperature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder: Material	Specimen Holder: Preirradiation Condition	Specimen: Number	Specimen: Material	Specimen: Preirradiation Treatment
		$\times 10^{22}$					
E16	500	7.6	304 + 0.2 Ti	1/1050	DO-200	316	1/1050 + 100/700 + 20% ϵ
					DO-201	316	1/1050 + 100/700 • 20% ϵ
					DO-212	316	1/1050 + 100/700 + 10% ϵ
					DO-213	316	1/1050 + 100/700 + 10% ϵ
E17	500	5.6	304	Mill anneal	Z1-2	316 + 0.25 Ti	1/1050
					Z2-4	316 + 0.25 Ti	1/1050 + 20% ϵ
					Z2-5	316 + 0.25 Ti	1/1050 + 20% ϵ
					Z2-6	316 + 0.25 Ti	1/1050 + 20% ϵ
E18	400	4.0	304	Mill anneal	DO-275	316	1/1050 + 50% ϵ
					R1-183	316 + 0.23 Ti	1/1050 + 50% ϵ
					R3-8	316 + 0.23 Ti	1/1050 + 10% ϵ
					R2-54	316 + 0.23 Ti	1/1050 + 20% ϵ
E19	370	2.8	304	Mill anneal	CO-194	304L	1/1050
					XO-21	304L + 0.2 Ti	1/1050
					UO-17	304L + 0.1 Ti	1/1050
					VO-15	304L + 0.5 Ti	1/1050
E20		1.8	304	Mill anneal	F07141	308 weld F07, TW	As welded
					F07142	308 weld F07, TW	Solution anneal
					F071421	308 weld F07, TFL	As welded
					F071422	308 weld F07, TFL	Solution anneal
E21		1.2	304	Mill anneal	F12172	308 weld F12, TW	As welded
					F12171	308 weld F12, TW	Solution anneal
					F121722	308 weld F12, TFL	As welded
					F121721	308 weld F12, TFL	Solution anneal
E22		0.8	304	Mill anneal	F11173	308 weld F11, TW	As welded
					F11172	308 weld F11, TW	Solution anneal
					F111722	308 weld F11, TFL	As welded
					F111721	308 weld F11, TFL	Solution anneal
E23		0.4	304	Mill anneal	F10171	308 weld F10, TW	As welded
					F10172	308 weld F10, TW	Solution anneal
					F101721	308 weld F10, TFL	As welded
					F101722	308 weld F10, TFL	Solution anneal
F2		0.4	304	Mill anneal	SA4275	308 weld SA4, TW	As welded
					SA4276	308 weld SA4, TW	Solution anneal
					SA42525	308 weld SA4, TFL	As welded
					SA42526	308 weld SA4, TFL	Solution anneal
F3		0.8	304	Mill anneal	SA5275	308 weld SA5, TW	As welded
					SA5276	308 weld SA5, TW	Solution anneal
					SA52326	308 weld SA5, TFL	As welded
					SA52325	308 weld SA5, TFL	Solution anneal
F4		1.2	304	Mill anneal	SA6305	308 weld SA6, TW	As welded
					SA6306	308 weld SA6, TW	Solution anneal
					SA63026	308 weld SA6, TFL	As welded
					SA63025	308 weld SA6, TFL	Solution anneal
F5		1.8	304	Mill anneal	F13175	308 weld F13, TW	As welded
					F13176	308 weld F13, TW	Solution anneal
					F131726	308 weld F13, TFL	As welded
					F131725	308 weld F13, TFL	Solution anneal
F6	450	2.8	304	Mill anneal	MS-14	High-purity 316	1/1050
					CO-82	304L	1/1050
					MS-19	High-purity 316	1/1050
					BO-189	304	1/1200
F7	450	4.0	304	Mill anneal	S1-36	316 + 0.33 Ti	1/1050
					T1-37	316 + 0.46 Ti	1/1050
					U1-37	316 + 0.60 Ti	1/1050
					MS-16	High-purity 316	1/1050

Specimens (continued)

Position	Design Temper-ature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirra-diation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		× 10^{22}					
F8	500	5.6	304	Mill anneal	V1-224	304 + 0.2 Ti	1/1050
					V1-232	304 + 0.2 Ti	1/1050 + 100/800
					V1-291	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
					V1-214	304 + 0.2 Ti	1/925
F9	600	7.6	304	Mill anneal	MS-11	High-purity 316	1/1050
					S1-35	316 + 0.33 Ti	1/1050
					T1-36	316 + 0.46 Ti	1/1050
					U1-36	316 + 0.60 Ti	1/1050
F10	600	9.6	316	1/1050	R2-90	316 + 0.23 Ti	1/1050 + 20% ε + 10/550
					R2-91	316 + 0.23 Ti	1/1050 + 20% ε + 10/550
					R2-102	316 + 0.23 Ti	1/1050 + 20% ε + 10/650
					R2-103	316 + 0.23 Ti	1/1050 + 20% ε + 10/650
F11	600	1.1	316	1/1050 + 20% ε	R1-169	316 + 0.23 Ti	1/1050
					R2-108	316 + 0.23 Ti	1/1050 + 20% ε + 24/482 + 100/700
					D0-270	316 + 0.23 Ti	1/1050
					D0-271	316 + 0.23 Ti	1/1050
F12	600	1.3	316 + 0.23 Ti	1/1050	D2-153	316	1/1050 + 20% ε + 1/700
					D2-154	316	1/1050 + 20% ε + 1/700
					R2-73	316 + 0.23 Ti	1/1050 + 20% ε + 1/700
						AI capsule	
F13	700	1.3	316 + 0.23 Ti	1/1050	D2-141	316	1/1050 + 20% ε + 10/650
					D2-142	316	1/1050 + 20% ε + 10/650
					UFG tube	Ultrafine-grain 316 tube	
					R2-75	316 + 0.23 Ti	1/1050 + 20% ε + 1/700
F14	600	1.1	316 + 0.23 Ti	1/1050 + 20% ε	D2-115	316	1/1050 + 20% ε + 10/550
					D2-126	316	1/1050 + 20% ε + 10/650
					D2-127	316	1/1050 + 20% ε + 10/650
					D2-128	316	1/1050 + 20% ε + 10/650
F15	600	9.6	304 + 0.2 Ti	1/1050 + 20% ε	A2-6	316 (0.2 Mo)	1/1050
					M2-6	316 (0.5 Mo)	1/1050
					O2-6	316 (2.4 Mo)	1/1050
					P2-6	316 (4.8 Mo)	1/1050
F16	600	7.6	304 + 0.2 Ti	1/1050	318-3	318	1/1050
					R2-109	316 + 0.23 Ti	1/1050 + 20% ε + 24/482 + 100/700
					R2-110	316 + 0.23 Ti	1/1050 + 20% ε + 24/482 + 100/700
					R2-111	316 + 0.23 Ti	1/1050 + 20% ε + 24/482 + 100/700

Specimens (continued)

Position	Design Temper-ature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirradiation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
F17	500	5.6	304	Mill anneal	Z4-4	316 + 0.25 Ti	1/1050 + 40% ε at 450°C
					Z4-5	316 + 0.25 Ti	1/1050 + 40% ε at 450°C
					Z4-6	316 + 0.25 Ti	1/1050 + 40% ε at 450°C
					Z1-3	316 + 0.25 Ti	1/1050
F18	400	4.0	304	Mill anneal	V1-223	304 + 0.2 Ti	1/1050
					V1-292	304 + 0.2 Ti	1/1050 + 100/700 + 10% ε
					V1-233	304 + 0.2 Ti	1/1050 + 100/800
					V1-218	304 + 0.2 Ti	1/925
F19	370	2.8	304	Mill anneal	B0-234	304	1/1050
					C1-12	304 + 0.35 Ti	1/1050
					B1-12	304 + 0.12 Ti	1/1050
					S0-114	304 + 0.27 Ti	1/1050
F20		1.8	304	Mill anneal	F13152	308 weld F13, TW	As welded
					F13151	308 weld F13, TW	Solution anneal
					F131521	308 weld F13, TFL	As welded
					F131522	308 weld F13, TFL	Solution anneal
F21		1.2	304	Mill anneal	SA6282	308 weld SA6, TW	As welded
					SA6281	308 weld SA6, TW	Solution anneal
					SA62822	308 weld SA6, TFL	As welded
					SA62821	308 weld SA6, TFL	Solution anneal
F22		0.8	304	Mill anneal	SA5255	308 weld SA5, TW	As welded
					SA5256	308 weld SA5, TW	Solution anneal
					SA52721	308 weld SA5, TFL	As welded
					SA52722	308 weld SA5, TFL	Solution anneal
F23		0.4	304	Mill anneal	SA4272	308 weld SA4, TW	As welded
					SA4271	308 weld SA4, TW	Solution anneal
					SA42722	308 weld SA4, TFL	As welded
					SA42721	308 weld SA4, TFL	Solution anneal
G7	450	1.0	304	Mill anneal	I0-3	SANDVIK 12R72HV	1/1150
					I0-5	SANDVIK 12R72HV	1/1150
					318-7	318	1/1050
					318-8	318	1/1050
G8	500	1.4	304	Mill anneal	I0-8	SANDVIK 12R72HV	1/1150
					I2-11	SANDVIK 12R72HV	1/1150 + 20% ε
					I2-12	SANDVIK 12R72HV	1/1150 + 20% ε
					I2-6	SANDVIK 12R72HV	1/1150 + 20% ε
G9	500	1.9	304	Mill anneal	DL-4	19-9-DL	1/1150
					DL-5	19-9-DL	1/1150
					318-1	318	1/1050
					318-2	318	1/1050
G10	600	2.4	304	Mill anneal	DL-3	19-9-DL	1/1150
					DL-22	19-9-DL	1/1150 + 20% ε
					DL-31	19-9-DL	1/1150 + 20% ε at 450°C
					DL-32	19-9-DL	1/1150 + 20% ε at 450°C
G11	700	2.8	316	1/1050 + 50% ε	DL-2	19-9-DL	1/1150
					DL-21	19-9-DL	1/1150 + 20% ε
					I0-7	SANDVIK 12R72HV	1/1150
					I2-3	SANDVIK 12R72HV	1/1150 + 20% ε
G12	600	3.3	304 + 0.2 Ti	1/1050 + 50% ε	318-6	318	1/1050
					I0-6	SANDVIK 12R72HV	1/1150
					I2-10	SANDVIK 12R72HV	1/1150 + 20% ε
					I2-2	SANDVIK 12R72HV	1/1150 + 20% ε

Specimens (continued)

Position	Design Temper-ature (°C)	Goal Fluence (neutrons/cm²)	Specimen Holder Material	Specimen Holder Preirra-diation Condition	Specimen Number	Specimen Material	Specimen Preirradiation Treatment
		$\times 10^{22}$					
G13	500	3.3	304	Mill anneal	318-4	318	1/1050
					I0-4	SANDVIK 12R72HV	1/1050
					I2-9	SANDVIK 12R72HV	1/1050 + 20% ε
					I2-1	SANDVIK 12R72HV	1/1050 + 20% ε
G14	500	2.8	316	1/1050 + 50% ε	DL-1	19-9-DL	1/1150
					DL-20	19-9-DL	1/1150 + 20% ε
					DL-30	19-9-DL	1/1150 + 20% ε at 450°C
					DL-33	19-9-DL	1/1150 + 20% ε at 450°C
G15	450	2.4	304 + 0.2 Ti	1/1050 + 50% ε	I2-7	SANDVIK 12R72HV	1/1150 + 20% ε
					I2-8	SANDVIK 12R72HV	1/1150 + 20% ε
					I2-4	SANDVIK 12R72HV	1/1150 + 20% ε
					I2-5	SANDVIK 12R72HV	1/1150 + 20% ε
G16	450	1.9	304	Mill anneal	DL-6	19-9-DL	1/1150
					DL-7	19-9-DL	1/1150
					I0-1	SANDVIK 12R72HV	1/1150
					I0-2	SANDVIK 12R72HV	1/1150
G17	450	1.4	304	Mill anneal	S0-17	304 + 0.27 Ti	1/1040
					S0-20	304 + 0.27 Ti	1/1040
					S0-95	304 + 0.27 Ti	1/1040 + 100/800
					S0-99	304 + 0.27 Ti	1/1040 + 100/800

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