

STATUS OF U.S./JAPAN COLLABORATIVE PROGRAM PHASE II HFIR TARGET AND RB* CAPSULES – J. E. Pawel, K. E. Lenox, A. W. Longest, R. L. Senn, (Oak Ridge National Laboratory), and K. Shiba (Japan Atomic Energy Research Institute)

OBJECTIVE

The objective of the HFIR irradiations is to determine the response of various U.S. and Japanese austenitic and ferritic steels with different pretreatments and alloy compositions to the combined effects of displacement damage and helium generation. Specimen temperatures during irradiation range from 60 to 600°C and fluences range up to 60 dpa. The RB* experiments are a continuation of the ORR spectrally tailored experiments in which the spectrum is modified with a hafnium shield to simulate the expected fusion helium to damage (He/dpa) ratio. In the HFIR target capsules, many specimens have been isotopically tailored in order to achieve fusion helium generation rates.

SUMMARY

Capsules HFIR-MFE-JP9 through 16 were installed in the High Flux Isotope Reactor (HFIR) target July 20, 1990 for irradiation beginning with HFIR fuel cycle 289. Of these eight target capsules, JP10, 11, 13, and 16 accumulated 18 dpa and were removed from the reactor in September 1991. JP14 was removed from the reactor at the end of cycle 310 (September 1992) after achieving a peak of 34 dpa. Capsules JP9, 12, and 15 completed 35 cycles on April 1, 1994 and were removed from the target region. Each capsule had accumulated a peak of approximately 57 dpa.

Three additional capsules, HFIR-MFE-JP20, 21, and 22, have been designed to complete the original experiment matrix of the JP9 through JP16 series capsules. Irradiation began in December 1993 with the start of cycle 322. Capsule JP20 was removed from the reactor on June 3, 1994, after accumulating a peak of 8 dpa. As of September 16, 1994 (end of cycle 329), each of the other two capsules had achieved approximately 9.5 dpa.

The RB* experiments are the continuation of the ORR spectrally tailored experiments. In this stage, a hafnium liner is used to modify the spectrum to simulate the fusion helium to displacements per atom (He/dpa) ratio in the austenitic steel specimens. Of the four capsules in this set, two (60J-1 and 330J-1) have been disassembled and testing is in progress. Two capsules (200J-1 and 400J-1) are in the reactor and have accumulated 8 dpa.

PROGRESS AND STATUS

Target Capsules JP9 through JP16

Capsules HFIR-MFE-JP9 through 16 were installed in the High Flux Isotope Reactor (HFIR) target July 20, 1990 for irradiation beginning with HFIR fuel cycle 289. A complete description and details of the design, construction, and installation of capsules JP9 through JP16 have been previously reported [1,2,3]. The as-built specimen matrix can be found in a previous report [3]. These capsules contain primarily transmission electron microscopy disks (TEM) and SS-3 flat tensile specimens. A wide variety of alloys and thermomechanical conditions are included. Many of the TEM disks were made from isotopically tailored alloys to produce a range of He/dpa ratios (<0.1, 10, 20, 70 appm/dpa). Details of the irradiation history of these capsules are shown in Table 1. Capsules JP10, 11, 13, and 16 were removed at the end of Cycle 300 (September 1991) after achieving a total of 18 dpa. Capsule JP14 was removed at the end of Cycle 310 (September 1992), after accumulating 34 dpa. Capsules JP9, 12, and 15 completed 35 cycles and achieved a peak fluence of 57 dpa on April 1, 1994 and were removed from the reactor target region. These three capsules were disassembled in September 1994 and specimen testing is scheduled to begin during the next reporting period.

Table 1. Irradiation History of HFIR Target Capsules JP-9, -12, and -15

Cycle No.	HFIR Operation			JP-9, -12, -15†	
	Start Date	End Date	MWd/Cycle	MWd	dpa*
289	7/20/90	9/7/90	1879	1879	1.64
290	9/19/90	10/11/90	1852	3731	3.26
291	10/17/90	11/13/90	1838	5569	4.86
292	11/25/90	12/10/90	1847	7416	6.47
293	12/27/90	1/23/91	1965	REMOVED FOR 1 CYCLE	
294	2/1/91	2/25/91	1906	9322	8.14
295	3/1/91	3/24/91	1908	11230	9.80
296	4/6/91	4/28/91	1874	13104	11.44
297	5/19/91	6/15/91	1845	14949	13.05
298	6/20/91	7/11/91	1747	16696	14.58
299	7/25/91	8/15/91	1741	18437	16.10
300	8/28/91	9/17/91	1724	20161	17.60
301	9/27/91	10/19/91	1851	22012	19.22
302	10/27/91	11/21/91	1829	23841	20.81
303	12/1/91	12/22/91	1821	25662	22.40
304	12/31/91	1/24/92	1826	27488	24.00
305	1/30/92	2/27/92	1876	29364	25.63
306	3/31/92	4/27/92	1845	31209	27.25
307	5/1/92	5/28/92	1842	33051	28.85
308	6/2/92	6/30/92	1938	34989	30.55
309	7/3/92	8/1/92	1949	36938	32.25
310	8/27/92	9/18/92	1848	38786	33.86
311	9/25/92	10/12/92	1856	40642	35.48
312	10/22/92	11/14/92	1834	42476	37.08
313	11/21/92	12/15/92	1858	44334	38.70
314	12/20/92	1/12/93	1867	46201	40.33
315	1/19/93	2/11/93	1861	48062	41.96
316	2/17/93	4/3/93	1807	49869	43.54
317	4/23/93	5/14/93	1841	51710	45.14
318	5/20/93	6/13/93	1878	53588	46.78
319	6/18/93	7/10/93	1863	55451	48.41
320	7/15/93	8/7/93	1934	57385	50.10
321	8/12/93	9/4/93	1884	59269	51.74
322	12/16/93	1/7/94	1854	61123	53.36
323	1/23/94	2/14/94	1874	62997	55.00
324	3/5/94	4/1/94	1907	64904	56.66
				REMOVED EOC 324	

†JP-10, -11, -13, and -16 removed at End of Cycle 300; JP-14 removed at End of Cycle 310

*dpa levels based on 0.000873 dpa/MWd in the target capsules

Target Capsules JP20 through 22

Three additional capsules, HFIR-MFE-JP20, 21, and 22, were designed to complete the original experiment matrix of the JP9 through JP16 series capsules [4]. Specimen temperatures in each capsule are 300, 400, 500, or 600°C. The complete test matrix is described in Reference 5. Irradiation began December 16, 1993 with the start of cycle 322. Capsule JP20 was removed from the reactor on June 3, 1994, after accumulating a peak dose of 8 dpa, and was disassembled in September 1994. As of September 16, 1994 (end of cycle 329), each of the other two capsules had achieved approximately 9.5 dpa (see Table 2).

Table 2. Irradiation History of HFIR Target Capsules JP-20, 021, and -22

Cycle No.	HFIR Operation			JP-20, -21, -22†	
	Start Date	End Date	MWd/Cycle	MWd	dpa*
322	12/16/93	1/7/94	1854	1854	1.62
323	1/23/94	2/14/94	1874	3728	3.25
324	3/5/94	4/1/94	1907	5635	4.92
325	4/10/94	5/3/94	1907	7542	6.58
326	5/8/94	6/3/94	1825	9367	8.18
327	6/26/94	7/18/94	1903	REMOVED FOR 2 CYCLES	
328	7/31/94	8/21/94	1922		
329	8/27/94	9/16/94	1513‡	10880	9.50

†JP-20 removed at End of Cycle 326

*dpa levels based on 0.000873 dpa/MWd in the target capsules

‡Due to power variations over this cycle, this number is not exact

RB* Capsules HFIR-MFE-60J-1, 200J-1, 330J-1 and 400J-1

The RB* capsules are irradiated in the removable beryllium positions of the HFIR. These experiments are a continuation of the ORR spectrally tailored experiments ORR-MFE-6J and 7J. At this stage in the experiment, a hafnium liner surrounds the capsules in order to harden the spectrum and achieve the expected fusion helium generation rate in the austenitic steel specimens. Capsule design, assembly and details of specimen loading have been previously described [6-9]. Capsules 60J-1 and 330J-1 were removed from the reactor in November 1992 after accumulating approximately 11 dpa in the HFIR. Details concerning the performance of these capsules can be found in Reference 10. Most of the specimens had also been irradiated to approximately 7 dpa in the ORR (for a total of 18 dpa in these specimens). These capsules were disassembled in February 1994. Capsules 200J-1 and 400J-1 have completed 17 of the scheduled 20 irradiation cycles, as shown in Table 3. The capsules are performing as designed, with the temperatures holding within the expected ranges. Details of the capsule performances have been described [11].

Gamma counting was conducted on four of the 24 flux monitors from each of 60J-1 and 330J-1. These data have been analyzed and are reported in Reference 12. In addition to the flux analysis, helium analysis was performed on one TEM disk, irradiated in both the 7J and 330J-1 experiments. The results indicate that these experiments were successful in producing fusion relevant helium/dpa levels. The maximum helium (appm)/dpa ratio is 10.2 for 60J-1 and 11.8 for 330J-1.

Tensile testing of J316 alloy specimens, in either the solution annealed or cold-worked condition, was conducted during this reporting period. Details of these tests and the results are described elsewhere [13].

Table 3. Irradiation History of HFIR-MFE-200J-1 and 400J-1

Cycle No.	HFIR Operation			200J-1 and 400J-1	
	Start Date	End Date	MWd/Cycle	MWd	dpa*
313	11/21/92	12/15/92	1858	1858	0.46
314	12/20/92	1/12/93	1867	3725	0.91
315	1/19/93	2/11/93	1861	5586	1.37
316	2/17/93	4/3/93	1807	7393	1.81
317	4/23/93	5/14/93	1841	9234	2.26
318	5/20/93	6/13/93	1878	11112	2.72
319	6/18/93	7/10/93	1863	12975	3.18
320	7/15/93	8/7/93	1934	14909	3.65
321	8/12/93	9/4/93	1884	16793	4.11
322	12/16/93	1/7/94	1854	18647	4.57
323	1/23/94	2/14/94	1874	20521	5.03
324	3/5/94	4/1/94	1907	22428	5.49
325	4/10/94	5/3/94	1907	24335	5.96
326	5/8/94	6/3/94	1825	26160	6.41
327	6/26/94	7/18/94	1903	28063	6.88
328	7/31/94	8/21/94	1922	29985	7.35
329	8/27/94	9/16/94	1513‡	31498	7.72

*dpa levels based on 0.000245 dpa/MWd

‡Due to power variations over this cycle, this number is not exact

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