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Experimental Plan and Irradiation Target Design for FeCrAl Embrittlement Screening Tests Conducted Using the High Flux Isotope Reactor

Kevin G. Field
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June 26, 2015

OAK RIDGE NATIONAL LABORATORY
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Fuel Cycle Reactor and Development (FCRD) Program

Experimental Plan and Irradiation Target Design for FeCrAl Embrittlement Screening Tests Conducted Using the High Flux Isotope Reactor

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ABSTRACT

A need currently exists to develop a database on the change in tensile and fracture toughness properties after irradiation in engineering grade FeCrAl alloys. The development of such a database will provide the necessary information to determine the viability of the use of FeCrAl clad as an accident tolerant fuel form. To meet this need, a series of irradiations will be conducted using two different irradiation capsule configurations in the High Flux Isotope Reactor (HFIR) at three different irradiation temperatures and three different damage doses. The configuration of the irradiation capsules was selected based on the constraints of HFIR irradiation target positions and from the use of miniature or sub-sized testing specimens including the SS-J2 tensile specimens, the SS-2E ultra-miniature tensile specimen, and the M4-PCVVN bend bar specimens. A range of FeCrAl alloys were selected as part of the experimental configuration including FeCrAl alloys with variations in Cr and Al content as well as an oxide-dispersion strengthened (ODS) steel. Currently, the irradiation target capsules are targeted to begin irradiation in cycle 462 in the HFIR on October 6th, 2015. Based on this insertion date, the last capsule will be released in early January 2017.

1. OBJECTIVES

The objective of the FeCrAl embrittlement screening tests being conducted through the use of Oak Ridge National Laboratories (ORNL) High Flux Isotope Reactor is to provide data on the radiation-induced changes in the mechanical properties including radiation-induced hardening and embrittlement through systematic testing and analysis. Data developed on the mechanical properties will be supported by extensive microstructural evaluations to assist in the development of structure-property relationships and provide a sound, fundamental understanding of the performance of FeCrAl alloys in intense neutron radiation fields. Data and analysis developed as part of this effort will be used to assist in the determination of FeCrAl alloys as a viable material for commercial light water reactor (LWR) applications with a primary focus as an accident tolerant cladding.

2. INTRODUCTION

Over the past half-a-decade a significant increase in the development of fuel-clad systems that exhibit properties conducive to enhanced accident tolerance under severe nuclear reactor accidents has occurred. Several unique or novel fuel-clad systems have been proposed and are currently under development including Mo clad, SiC clad, or FeCrAl clad, to name a few. Many of these proposed fuel-clad systems are designed around material systems that exhibit increased high temperature oxidation resistance over the industry standard Zr-based clad-UO_2 fuel system. As part of these development programs, a key component is ensuring not only the accident tolerance of the candidate systems but also verifying limited to no impact on the normal operational performance of the cladding within a commercial light water reactor (LWR) when compared to the Zr-based clad-UO_2 system. As such, portions of these programs are centered on assessing the radiation tolerance of candidate systems with a primary focus on mechanical properties during typical operational lifetimes.

Currently, ORNL has been conducting extensive investigations into the FeCrAl alloy system as a replacement cladding material [1]. The focus is to develop a fully ferritic FeCrAl alloy that can be produced by conventional manufacturing methods (casting and tube drawing) and exhibit high temperature oxidation resistance. Other favorable properties currently being optimized include formability, mechanical properties, weldability, and radiation tolerance [2-10]. Recent work under this program has established preliminary data on the radiation tolerance of four model FeCrAl alloys (Fe-10Cr-4.8Al, Fe-12Cr-4.4Al, Fe-15Cr-3.9Al, and Fe-18Cr-2.9Al) irradiated to 1.8 dpa at 382°C in the HFIR[3]. Based on this study, Field et al. [3] concluded, "…the microstructural and mechanical responses of model FeCrAl alloys to irradiation at LWR-type conditions are similar to the responses of model Fe-Cr alloys. The visible radiation-induced microstructure consisted of Cr-rich α' precipitates, black dots, line dislocations, and $a/2\,\langle 111\rangle$ and $a\langle 100\rangle$ dislocation loops. Limited or a complete absence of voids/bubbles was noted. The observed microstructural features impacted the mechanical properties, and radiation-induced hardening was observed and was highest in the Fe-18Cr-2.9Al alloy."

These conclusions highlight the importance of the radiation-induced microstructural features on the radiation-induced hardening in FeCrAl alloys but did not reveal the impact of radiation on the other mechanical properties such as fracture toughness shift (T_o) or ductile-to-brittle transition temperature (DBTT) shifts. As stated, the responses of the irradiated FeCrAl alloys were qualitatively similar to that of FeCr alloys. Research on FeCr alloys has indicated a proportional link in the change in the fracture properties of alloys to that of the radiation-induced tensile properties. For example, Sokolov et al. [11] has developed a property relationship curve between the T_o shift to the change in yield stress for neutron irradiated commercial reduced activation ferritic/martensitic (RAFM) and reactor pressure vessel (RPV) steel alloys, as shown in Figure 1.

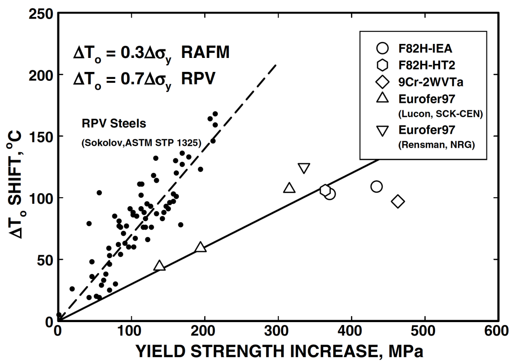

Figure 1: Relationship between fracture toughness shift and radiation-induced hardening in commercial FeCr alloys after irradiation. Figure reproduced from Sokolov et al. [11].

Figure 1 indicates a directly proportional link between the yield strength increase and change in the T_o shift after irradiation. It also highlights the proportionality difference between these two factors can strongly depend on the material system as seen in the difference between the slope of the curves for RAFM and RPV steels. Therefore, it is difficult to infer any change in the fracture toughness shift based on the hardening data presented by Field et al. Furthermore, variances in microstructural features which effect the radiation-induced hardening in FeCrAl alloys, such as dislocation loops or precipitation, could potentially not have a 1-to-1 correlation in the variance in the fracture toughness shift after irradiation.

Previous literature on FeCr alloys has indicated that irradiation temperature can play an important role on determining the microstructural evolution after irradiation. For example, precipitation of the Cr-rich α' is known to strongly depend on temperature and alloy composition for both FeCr and FeCrAl alloys and this precipitation can be a leading factor for hardening and embrittlement [12-14]. Furthermore, dislocation loop morphologies including the size, number density, and Burgers vector have also been known to be influenced by irradiation dose and temperature. Based on these understandings, several schematic design windows have been proposed for FeCr alloys such as the one by Hishinuma et al. reproduced in Figure 2 [15].

Figure 2 shows the influence of radiation on both the hardening and embrittlement where with increasing dose, embrittlement of the alloys (large DBTT shift) can occur at typical operating temperatures for LWR application. Currently, no detailed study has been conducted to systematically evaluate the influence of irradiation dose, temperature, and alloy composition on the radiation-induced microstructural evolution of FeCrAl alloys and assess the influence of these microstructural features on the embrittlement of the FeCrAl alloy class. Therefore, no schematic design window maps, such as the one in Figure 2, can be produced to assist in the assessment of FeCrAl alloys as a candidate material for LWR applications.

The following sections of this report outline the experimental plan and irradiation target design to be used to began establishing the effects of radiation on the hardening and embrittlement of FeCrAl alloys between the irradiation temperatures of 200-600°C and radiation damage doses up to 16 dpa. Following irradiation of candidate alloys, a systematic post irradiation examination (PIE) campaign which includes both mechanical (hardening and fracture toughness) and microstructural (dislocation loop formation and second phase precipitation) will be completed. A full assessment of these alloys after irradiation will assist in developing FeCrAl alloys toward commercialization in LWR reactor applications including as accident tolerant cladding.

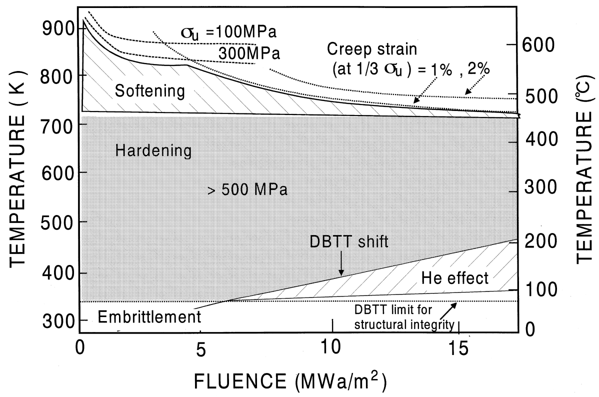

Figure 2: Schematic design window for RAFM steels based on known radiation-induced hardening and embrittlement effects for literature. Schematic is shown for a tokamak fusion reactor and hence the dpa-to-He ratio will be different than LWR application. Figure reproduced from Hishinuma et al. [15].

3. DESIGN METHODOLOGY

The objective of this irradiation campaign is not only to provide the data necessary for the assessment of FeCrAl alloys as an accident tolerant cladding but also to provide such data in a timely manner (<3-5 years from date of target insertion). Based on these criteria, ORNL's HFIR reactor was selected as the materials test reactor for this study. The HFIR, which operates at 85 MW, is the highest flux reactor-based source of neutrons in the United States. With cycle times typically under just a month and the high fast flux, doses of ~1-2 dpa can be achieved per cycle in the central irradiation target positions within the HFIR. With a typical 6 cycle per calendar year run time, total doses can be achieved between 6-12 dpa per year. Such high dose rates will allow for rapid assessment of the effects of neutron irradiation on candidate FeCrAl alloys.

The central target positions within the HFIR accommodate irradiation target capsules, otherwise known as rabbits, that allow for materials experiments. A disadvantage of these positions is the limited space available for test specimens due to the design of the target basket within HFIR. Typically, the use of sub-sized or miniature test specimens are needed if multiple alloys are to be screened within a single irradiation test. Here, three different miniature test specimens have been selected, M4-PCVVN bend bar specimens for fracture toughness, SS-J2 sub-sized tensile specimens for tensile testing, and under the NEET program an experimental configuration designated as the SS-2E ultra-miniature tensile specimen. The M4-PCVVN and SS-J2 tensile specimens have seen extensive use in irradiation campaigns within the HFIR as well as other materials test reactors and hence a rich database for these specimen geometries has been collected for varying materials and irradiation conditions. The SS-2E configuration is a novel design aimed at significantly reducing the volume of a tensile specimen to allow for rapid assessment of mechanical properties post-irradiation without the need for extensive radiological shielding facilities such as a standard hot-cell facility. This series of irradiations will provide the first insight into the validity of using the SS-2E tensile specimen geometry and may allow for future adoption within the FeCrAl materials development program. More detailed specifics on each specimen and their dimensions can be found in Section 4.1.2.

Based on the selected specimen geometries and limited space within the target rabbits it becomes clear that not all geometries will fit within a single rabbit if several or more alloys are to be investigated within a single experimental effort. Currently, over five different engineering grade FeCrAl alloys and one oxide dispersion strengthened (ODS) FeCrAl alloy are under consideration as part of the Fuel Cycle Research and Development (FCRD) campaign. Therefore, experimental configurations must be developed which allow for all specimen geometries and alloys. Here, it was selected that two different rabbit configurations would be pursued: (1) FCAB rabbit series for M4-PCVVN bend bars and (2) FCAT rabbit series for SS-J2 and SS-2E tensile specimens. The partitioning into two different rabbit configurations was selected based on the fact that both rabbit configurations already had near 'off-the-shelf' designs completed from previous irradiation campaigns and that any variance in irradiation temperature between the two configurations would be within the typical gradient observed if a single rabbit configuration was utilized due to the variances in specimen morphologies and heat generation and transfer rates radially and axially. This two-configuration design methodology greatly reduced development costs due to having prototypical geometries ready at the time of design.

The final design or experimental plan decision was based on irradiation conditions. Previous irradiations conducted on FeCrAl [3, 16] were conducted at a singular target temperature with five set dose points. Such irradiations provided detailed dose trends but did not provide a full assessment on the effect of temperature, dose, and alloy chemistry. Hence, three different target temperatures were selected: 200°C, 320°C, and 550°C. The temperatures were selected to place the irradiated alloys in three unique regimes: a dislocation loop dominated regime, a mixed dislocation loop and precipitation dominated regime, and softening or limited dislocation loop dominated regime, respectively. These assumed regimes are based on design window maps such as the one in Figure 2 for typical FeCr alloys. By placing the alloys in different regimes, the assessment of microstructural variation on radiation-induced hardening and embrittlement can be completed. Furthermore, three separate target doses were selected: 2 dpa, 8 dpa, and 16 dpa. These target doses correspond to those studied previously for model FeCrAl alloys [3, 16] allowing for direct assessment on the difference in the radiation tolerance between model and engineered FeCrAl alloys. Due to the splitting of the two rabbit configurations, it was determined that the 2 dpa FCAB rabbit would not be fielded in the HFIR. This decision is based on prior knowledge that the alloys of interest might not hit saturation in the fracture toughness shift and hence would not provide the needed data to meet the objectives of the irradiation campaign.

The described design methodology then establishes the bounding configurations of this irradiation campaign. To summarize, the irradiation campaign will be fielded in the HFIR with two different rabbit configurations allowing for the accommodation of three different specimen configurations at three different irradiation temperatures and doses using over five uniquely different FeCrAl alloy variants. The following sections highlight the activities completed towards developing the experimental plan and irradiation target designs.

4. MATERIALS AND TEST CONDITIONS

4.1.1 Materials

Under the current program, 3 different FeCrAl alloys based on a Fe-13Cr-5Al-2Mo-0.2Si-0.05Y alloy (designated C35M) with variations of Al were fabricated. Additionally, a FeCrAl alloy based on the Fe-10Cr-6Al-2Mo-0.2Si-0.05Y alloy was fabricated and an ODS variant based on the Fe-12Cr-5Al+Y was fabricated. Finally, several other prototype FeCrAl alloys were fabricated under the NEET program and will be irradiated with these alloys but will not be discussed here. The result is three distinct alloy classes: FeCrAl alloys with varying-Al additions, FeCrAl alloys with varying-Cr additions, and FeCrAl alloys with oxide dispersions. The addition of higher-Al contents is suspected to push the phase boundary for

Cr-rich α' formation based on the results of Kobayashi and Takasugi [13] thereby reducing it's propensity to precipitate under irradiation. A similar effect is hypothesized to occur with low Cr FeCrAl alloys. The addition of dispersed nano-clusters in the ODS alloys results in a significantly increased sink strength and could potentially have a positive impact on the radiation tolerance. The nominal compositions of the alloys to be irradiated under this program are presented in Table 1. Analyzed compositions that were completed by an outside vendor can be found in Appendix A.

Table 1: Identified FeCrAl alloys fabricated for irradiation testing.

Name	Nominal Compositions (wt. %)						
	Fe	Cr	Al	Mo	Nb	Si	Y
C35M	Bal.	13	5.2	2	-	0.2	0.05
C36M	Bal.	13	6	2	-	0.2	0.05
C37M	Bal.	13	7	2	-	0.2	0.05
C06M	Bal.	10	6	2	-	0.2	0.05
125YF-ODS	Bal.	12	5	-	-	-	0.2

Two primary processing routes to produce these alloys were taken: vacuum induction melting (VIM) or powder metallurgy followed by extrusion and cross-rolling. VIM production resulted in ~18 kg heats. Thermo-mechanical treatments (TMT) were applied to produce optimized microstructures. ODS FeCrAl alloy was ball milled for 40 h in a Zoz model CM08 Simolayer under an Ar atmosphere with 10:1 ball to charge ratio. The milled powder was extruded in mild steel cans after soaking for 1 h at 950°C. After the extrusion the mild steel can was machined away leaving the consolidated ODS FeCrAl alloy. More detailed discussion on the processing routes, as-received microstructural characterization, and mechanical properties information for each alloy listed in Table 1 can be found in previous reports [17, 18] and will not be discussed here.

4.1.2 Irradiation Specimen Geometries

The main tensile specimen geometry for the irradiations is the SS-J2 flat sheet-type "dog-bone" tensile specimen. As mentioned previously, this geometry has seen extensive use in HFIR irradiation programs. Figure 3 shows a simplified schematic of the SS-J2 specimen while Appendix B provides the detailed engineering drawings. The SS-J2 specimen was selected as it minimizes the total specimen volume while still providing reasonable tensile test results pre- and post-irradiation. Reduced volumes are needed to minimize sample activity. Furthermore, the sheet type specimen allows for efficient stacking within the irradiation capsule geometry and provides effective heat transfer across the stacked faces during irradiation. Here, SS-J2 specimens without pin holes were selected. The elimination of the pin hole provides more material for materials characterization sample preparation such as focused ion beam (FIB) preparation and allows for easier loading into the tensile test frame using typical hot cell manipulator configurations.

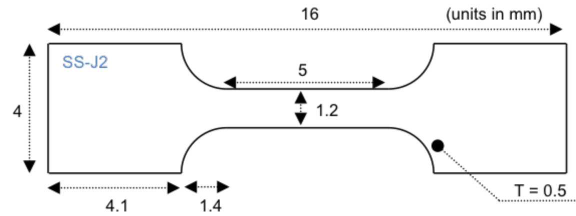

Figure 3: Simplified schematic of the SS-J2 tensile specimen geometry for HFIR irradiations. Figure not to scale.

The secondary tensile specimen geometry is the SS-2E specimen. The SS-2E specimen geometry is currently under development as a novel tensile bar specimen geometry for accelerated materials testing out-of-cell under the Nuclear Energy Enabling Technologies Reactor Materials effort. Details regarding this geometry can be found in the ORNL Report ORNL/TM-2015/192 [19]. To summarize, this geometry is currently in development to significantly reduce the volume of the tensile specimen thereby reducing sample activity. Significant reductions of the sample activity may allow for out-of-cell testing. By testing out of cell, it provides access to higher end mechanical testing configurations such as non-contact extensometry to provide true stress-true strain curves. A schematic of the current SS-2E geometry is provided in Figure 4. The smaller size over the SS-J2 configuration also allows for significantly more specimens to be irradiated at a single time. The overall concern with the SS-2E geometry is no testing database currently exists.

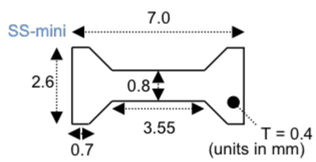

Figure 4: Simplified schematic of the SS-2E tensile specimen geometry for HFIR irradiations. Figure not to scale.

The fracture toughness specimens are M4-PCCVN specimens or (1/4-size pre-cracked Charpy v-notch). Here, the v-notches are placed on alternating sides from left-to-right to limit curvature in the specimens after fatigue pre-cracking, an issue previously observed in similar geometries when all the notches were placed on the same side. Figure 5 provides a simplified schematic of the M4-PCCVN geometry to be used during the irradiation testing. Multiple notches on each bend bar maximize the number of test points per specimen per irradiation capsule.

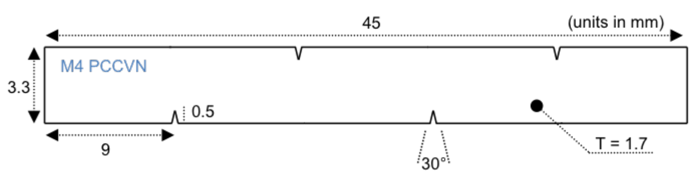

Figure 5: Simplified schematic of the M4-PCCVN bend bar specimen geometry for HFIR irradiations. Figure not to scale.

4.1.3 Sample fabrication from bulk alloys

Samples for irradiation were manufactured at outside vendors to the drawings in Appendix B. All samples were machined from flat sheet product using electric discharge machining (EDM). When possible, EDM burn layers were removed from specimens to limit artifacts in the assessed mechanical properties from the modified layer developed during fabrication. After fabrication, samples were dimensioned using standard quality assurance protocols to determine if specimen meets the dimensional requirements called out in Appendix B.

4.1.4 Sample marking and identification scheme

All samples to be irradiated within the FCAB and FCAT series of rabbits were engraved using a XXXX laser engraver. The specimen marking code can be found in Table 1. "XX" denotes the serial numbering system, i.e. MF01, MF02, etc. One or two digit lettering prefixes the serial numbering system to uniquely identify each alloy composition. Specimens in the SS-2E have a 3 digit alpha-numeric ID system due to the limited area available for engraving on the tensile heads. Care was taken to select prefix letters which do not appear to be similar under microscopic investigation to limit ambiguity during post-irradiation sample sorting. Both SS-J2 and SS-2E specimens are marked on each side on alternating ends of the tensile heads. Bend bar specimens are marked on one side of the specimen with each v-notch being uniquely identified by a letter ("A" – "D"). An example of the C06M series of specimens with sample markings can be found in Figure 6.

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Table 2: Specimen ID marking for specimens that are to be testing in either the irradiated, aged, or as-received condition

Spec.ID. Scheme	Specimen Type	Material Code
MFXX	SS-J2	C35M
M6XX	SS-J2	C36M
MVXX	SS-J2	C37M
ZMXX	SS-J2	C06M
ODXX	SS-J2	125YF-ODS
FXX	SS-2E	C35M
VXX	SS-2E	C37M
ZXX	SS-2E	C06M
IXX	SS-2E	C36M
BM6XX	M4-PCCVN	C36M
BZMXX	M4-PCCVN	C06M

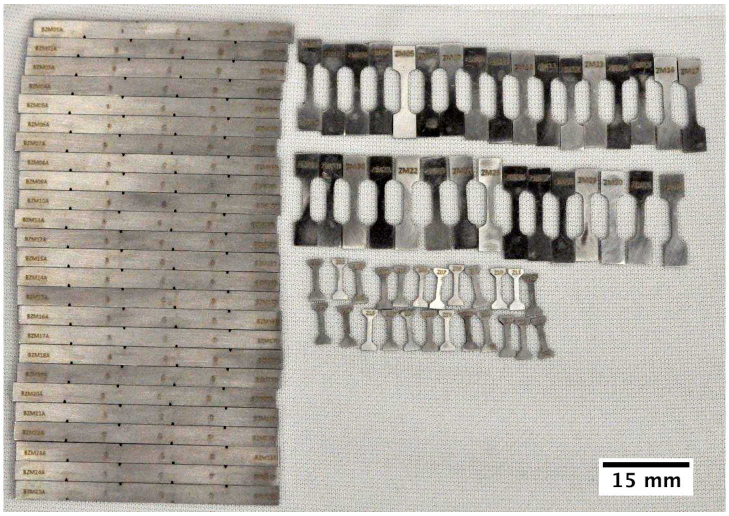

Figure 6: Photograph showing laser-engraving location, size, and designation for the C06M alloy series on all three test specimen irradiation geometries.

5. IRRADIATION TEST CONDITIONS

HFIR is a beryllium-reflected, pressurized, light-water-cooled and moderated flux-trap-type reactor. The core consists of aluminum-clad involute-fuel plates, which currently utilizes highly enriched ^{235}U fuel at a power level of 85 MWt.

The reactor core, illustrated in Figure 7, consists of two concentric annular regions, each approximately 61 cm in height. The flux trap is ~12.7 cm in diameter, and the outer fueled region is ~43.5 cm in diameter. The fuel region is surrounded by a beryllium annular reflector approximately 30.5 cm in thickness. A water reflector of effectively infinite thickness in turn backs up the beryllium reflector. In the axial direction, the reactor is reflected by water. The reactor core assembly is contained in a 2.44 m diameter pressure vessel, which is located in a 5.5 m cylindrical pool of water.

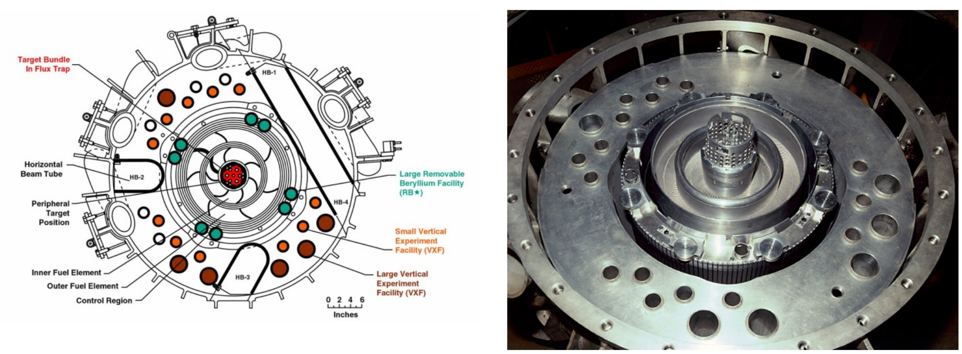

Figure 7: Cross-section Through HFIR Illustrating the Primary Experimental Sites (left) and a Picture of the Reactor Core (right)

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Figure 8 shows the flux trap configuration of HFIR for Cycle 446, which finished in January 2013. The FCAB and FCAT rabbits in this design will be placed in the flux trap of HFIR in the various rabbit holder positions, shown as orange circles in Figure 8. Figure 9 shows the axial neutron flux profile for each of the irradiation positions.

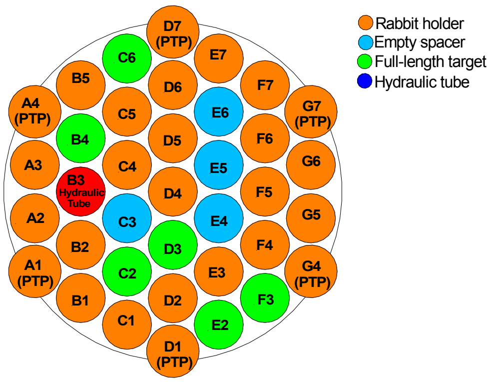

Figure 8: Flux Trap Irradiation Locations in the HFIR

In order to field 9 FCAT rabbits and 6 FCAB rabbits, 15 unique positions are needed within HFIR to begin the irradiation campaign. Table 3 summarizes the selected HFIR irradiation positions and the neutron flux characteristics for all 15 positions. The positions were selected to be near the reactor centerline to limit axial variations along the rabbit. As can be seen in Figure 9, large excursions from the centerline lead to larger variations along the rabbit leading to thermal gradients and inconsistent sample temperatures.

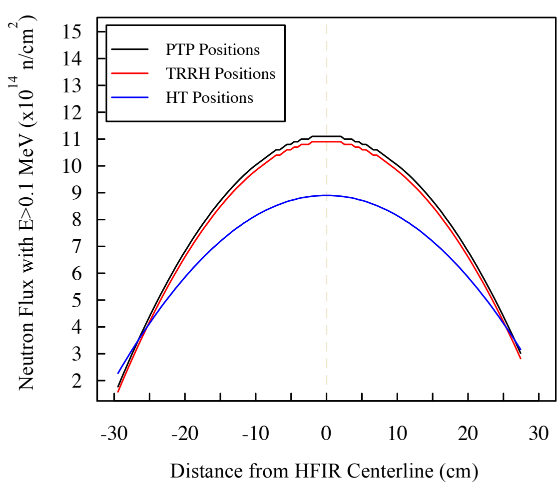

Figure 9: Estimated neutron flux at positions within the HFIR.

Table 3: Position of capsules for irradiation within the HFIR. Nominal dose (dpa) is calculated based on a pure-Fe specimen. Dates are approximant.

FCAB Bend Bar Capsules								
HFIR Position	Capsule ID	Target Temp (°C)	Number of Cycles	Nominal Capsule Avg. Flux ($n/cm^2.s$)	Nominal Capsule Avg. Fluence (n/cm^2)	Nominal Capsule Average Dose (dpa)	Capsule Insertion Date	Capsule Release Date
PTP A1 4	FCAB01	200	4	$1.08x10^{15}$	$8.96x10^{21}$	7.4	10/6/15	3/18/16
PTP A4 4	FCAB02	200	8	$1.08x10^{15}$	$1.79x10^{22}$	14.9	10/6/15	1/10/17
PTP D7 4	FCAB03	325	4	$1.08x10^{15}$	$8.96x10^{21}$	7.4	10/6/15	3/18/16
PTP A1 5	FCAB05	325	8	$1.10x10^{15}$	$9.12x10^{21}$	15.2	10/6/15	1/10/17
PTP A4 6	FCAB03	550	4	$1.04x10^{15}$	$8.63x10^{21}$	7.2	10/6/15	3/18/16
PTP D1 6	FCAB06	550	8	$1.04x10^{15}$	$1.73x10^{22}$	14.3	10/6/15	1/10/17
FCAT Tensile Capsules								
PTP D7 5	FCAT01	200	1	$1.10x10^{15}$	$9.12x10^{21}$	1.9	10/6/15	10/30/15
PTP G4 5	FCAT02	200	4	$1.10x10^{15}$	$9.12x10^{21}$	7.4	10/6/15	3/18/16
PTP G7 5	FCAT03	200	8	$1.10x10^{15}$	$9.12x10^{21}$	15.2	10/6/15	10/30/15
PTP D7 6	FCAT04	325	1	$1.04x10^{15}$	$8.63x10^{21}$	1.8	10/6/15	1/10/17
PTP G4 6	FCAT05	325	4	$1.04x10^{15}$	$8.63x10^{21}$	7.2	10/6/15	3/18/16
PTP G7 6	FCAT06	325	8	$1.04x10^{15}$	$1.73x10^{22}$	14.3	10/6/15	10/30/15
PTP D7 5	FCAT07	550	1	$1.10x10^{15}$	$9.12x10^{21}$	1.9	10/6/15	1/10/17
PTP G4 5	FCAT08	550	4	$1.10x10^{15}$	$9.12x10^{21}$	7.4	10/6/15	3/18/16
PTP G7 5	FCAT09	550	8	$1.10x10^{15}$	$9.12x10^{21}$	15.2	10/6/15	1/10/17

6. DESCRIPTION OF HFIR RABBIT DESIGN

6.1.1 FCAB Rabbit Series for M4-PVCCN bend bars

The overall design of the FCAB rabbit series for M4-PCVVN bend bars is shown in Figure 10, detailed drawings can be found in Appendix B. The capsule contains 4 M4-PCCVN bend bars specimens (gray geometries in Figure 10) and 2 passive SiC thermometry (green geometries in Figure 10) specimens per capsule. Passive SiC thermometry is added as a mode to validate that the modeled target irradiation temperatures have been meet during the PIE phase of the experiment. The primary outer containment is an Al6061 tube with an outer diameter of 10.96 mm (gold geometry in Figure 10). The specimen temperatures are controlled by the axial location within the HFIR, the fill gas, and the radial gap between the specimen holder (blue geometries in Figure 10) and the outer housing. To meet the design temperature specified in Section 3, He was selected as the fill gas.

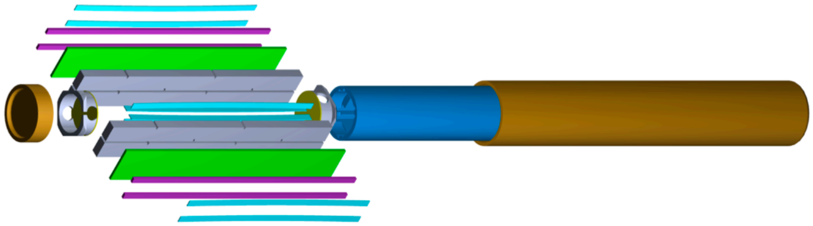

Figure 10: Finalized HFIR rabbit design for the bend bar specimens.

ADD THERMAL ANALYSIS

Kevin Field 6/23/2015 11:12 AM
Comment [3]: Should we add thermal analysis results?

6.1.2 FCAT Rabbit Series for SS-J2 and SS-2E tensile bars

The overall design of the FCAT rabbit series for SS-J2 and SS-2E tensile bars is shown in Figure 11, detailed drawings can be found in Appendix B. The capsule contains 27 SS-J2 tensile bars and 18 SS-2E tensile specimens (gray geometries in Figure 11) and 24 passive SiC thermometry (tan geometries in Figure 11) specimens per capsule. Passive SiC thermometry is added as a mode to validate that the modeled target irradiation temperatures have been meet during the PIE phase of the experiment. The tensile specimens are fitted with stainless steel chevrons or holder plates to provide equal heat generation and heat transfer within the gauge length of both specimen geometries. The specimens, SiC thermometry, and stainless steel components are contained within 3 sub-assemblies to facilitate ease of rabbit deconsolidation during PIE activities. The primary outer containment is an Al6061 tube with an outer diameter of 10.96 mm. The specimen temperatures are controlled by the axial location within the HFIR, the fill gas, and the radial gap between the specimen holder (transparent geometries in Figure 11) and the outer housing. To meet the design temperature specified in Section 3, He was selected as the fill gas.

Kevin Field 6/23/2015 11:12 AM
Comment [4]: Richard, please confirm

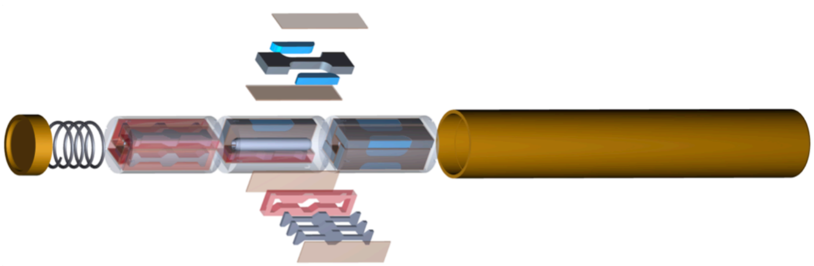

Figure 11: Finalized HFIR rabbit design for the tensile bar specimens.

ADD THERMAL ANALYSIS

Kevin Field 6/23/2015 11:12 AM
Comment [5]: Should we add thermal analysis?

6.1.3 FCAB and FCAT series specimen loading lists

Based on the rabbit designs presented in Section 6.1.1 and 6.1.2, a consolidated specimen-loading list was developed. Typically, 2-3 specimens per sample geometry are fielded in a single irradiation capsule. This allows for tensile testing to be conducted at both room temperature and at irradiation temperature. A third sample provides back up in case of an erroneous data point being generated. A consolidated loading list is presented in Appendix C.

7. SCHEDULE

All irradiation capsules will be inserted in HFIR cycle 462, which starts on October 6, 2015. Depending on the desired fluence the capsules will be irradiated for 1, 4, or 8 cycles. The final capsules will finish being irradiated on January 10, 2017. A summary of the HFIR operating schedule and capsule release schedule can be found in Figure 12.

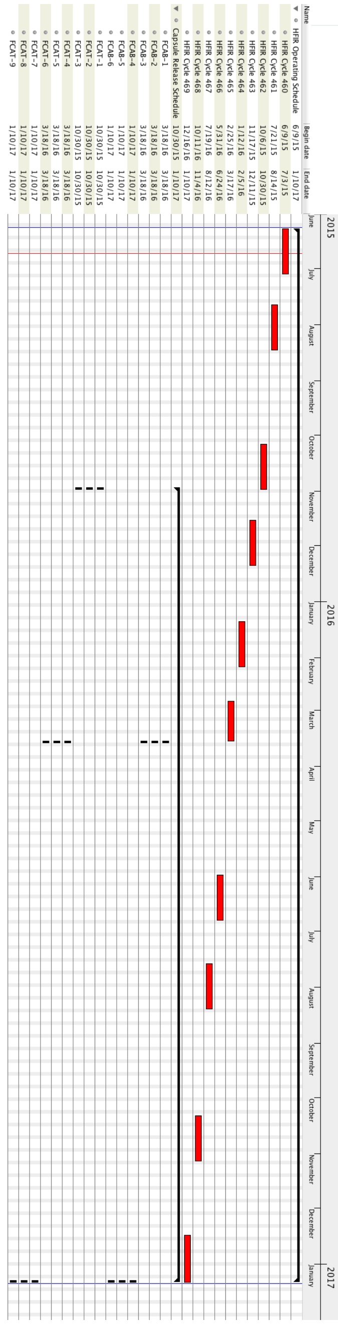

Figure 12: Gantt chart summarizing the HFIR operating schedule and capsule release schedule.

8. REFERENCES

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APPENDIX A: CHEMICAL COMPOSITION REPORTS

DIRATS
LABORATORIES

TEST REPORT

Report Number	**R602519**
Report Date	**26-May-2015**
Page	**1 of 2**
Client Order	**ALS15-0626**
Release	**Sample# 3**

Yong Yan
UT-Battelle, LLC
ORNL Fuel Cycle & Isotopes Division
1 Bethel Valley Road, M/S 6295
Building 3525, Room 103
Oak Ridge, TN 37831

EMAIL yany@ornl.gov

TEL 865-574-9278

FAX 865-241-0215

RECEIVED	1 Sawn Section approx. 1/4" x 1/2" x 1"
IDENTIFICATION	Sample# 3 ID: C36M3
MATERIAL	Fe-Cr-Al
TEST PER	Client Instructions
RETURN	All Material

PROPERTIES AS SUPPLIED

Quantitative Analysis by ICP-OE

Al	6.00	%
B	<0.001	%
Ce	<0.01	%
Co	<0.01	%
Cr	12.98	%
Cu	<0.01	%
Fe	78.80	%
Hf	<0.01	%
La	<0.01	%
Mn	<0.01	%
Mo	1.98	%
Nb	<0.01	%
Ni	<0.01	%
P	<0.002	%
Si	0.18	%
Ti	0.01	%
V	<0.01	%
W	<0.01	%
Y	0.04	%
Zr	<0.01	%

41 AIRPORT ROAD P.O. BOX 39 WESTFIELD, MA 01086-0039 FAX 413-568-1453 413-568-1571

TEST REPORT

DIRATS LABORATORIES

Report Number	R602517
Report Date	26-May-2015
Page	1 of 2
Client Order	ALS15-0626
Release	Sample# 1

Yuki Yamamoto
UT-Battelle, LLC
ORNL Fuel Cycle & Isotopes Division
1 Bethel Valley Road
P.O. Box 2008
Oak Ridge, TN 37831-6083

EMAIL yamamotoy@ornl.gov

TEL 865-574-5153

FAX 865-241-0215

RECEIVED	1 Sawn Section approx. 1/4" x 1/2" x 1"
IDENTIFICATION	Sample# 1 ID: C06M
MATERIAL	Fe-Cr-Al
TEST PER	Client Instructions
RETURN	All Material

PROPERTIES AS SUPPLIED

Quantitative Analysis by ICP-OE

Al	6.00	%
B	<0.001	%
Ce	<0.01	%
Co	<0.01	%
Cr	10.03	%
Cu	<0.01	%
Fe	81.80	%
Hf	<0.01	%
La	<0.01	%
Mn	<0.01	%
Mo	1.96	%
Nb	<0.01	%
Ni	<0.01	%
P	0.003	%
Si	0.18	%
Ti	<0.01	%
V	<0.01	%
W	<0.01	%
Y	0.01	%
Zr	<0.01	%

41 AIRPORT ROAD P.O. BOX 39 WESTFIELD, MA 01086-0039 FAX 413-568-1453 413-568-1571

TEST REPORT

Report Number	**R594861**
Report Date	**16-Dec-2014**
Page	**12 of 14**

UT-Battelle, LLC
ORNL Fuel Cycle & Isotopes Division
Oak Ridge, TN 37831-6083

SAMPLE Sample# 11 ID: C35M3
PROPERTIES AS SUPPLIED

Quantitative Analysis by ICP-OE

Al	5.31	%
B	<3	ppm
Ce	<0.01	%
Co	<0.01	%
Cr	13.06	%
Cu	<0.01	%
Fe	79.43	%
Hf	<0.01	%
La	<0.01	%
Mn	<0.01	%
Mo	2.00	%
Nb	<0.01	%
Ni	<0.01	%
P	0.007	%
Si	0.13	%
Ti	<0.01	%
V	<0.01	%
W	<0.01	%
Y	0.053	%
Zr	<0.01	%

Quantitative Analysis by Combustion

C	0.001	%
S	<3	ppm

Quantitative Analysis by IGF

O	0.0012	%
N	0.0003	%

Disposition of Chemical Analysis

For Information

The < Symbol signifies not detected at the detectability limit indicated.

41 AIRPORT ROAD P.O. BOX 39 WESTFIELD, MA 01086-0039 FAX 413-568-1453 413-568-1571

DIRATS LABORATORIES

TEST REPORT

UT-Battelle, LLC
ORNL Fuel Cycle & Isotopes Division
Oak Ridge, TN 37831-6083

SAMPLE   Sample# 12 ID: C36M2

PROPERTIES AS SUPPLIED

Quantitative Analysis by ICP-OE

Al	6.29	%
B	<3	ppm
Ce	<0.01	%
Co	<0.01	%
Cr	13.00	%
Cu	<0.01	%
Fe	78.40	%
Hf	<0.01	%
La	<0.01	%
Mn	<0.01	%
Mo	1.99	%
Nb	<0.01	%
Ni	<0.01	%
P	0.004	%
Si	0.20	%
Ti	<0.01	%
V	<0.01	%
W	<0.01	%
Y	0.059	%
Zr	<0.01	%

Quantitative Analysis by Combustion

C	0.001	%
S	<3	ppm

Quantitative Analysis by IGF

O	0.0010	%
N	0.0004	%

Disposition of Chemical Analysis

For Information

The < Symbol signifies not detected at the detectability limit indicated.

41 AIRPORT ROAD P.O. BOX 39 WESTFIELD, MA 01086-0039 FAX 413-568-1453 413-568-1571

DIRATS LABORATORIES

TEST REPORT

Report Number	**R594861**
Report Date	**16-Dec-2014**
Page	**14 of 14**

UT-Battelle, LLC
ORNL Fuel Cycle & Isotopes Division
Oak Ridge, TN 37831-6083

SAMPLE Sample# 13 ID: C37M
PROPERTIES AS SUPPLIED

Quantitative Analysis by ICP-OE

Al	7.22	%
B	<3	ppm
Ce	<0.01	%
Co	<0.01	%
Cr	13.01	%
Cu	<0.01	%
Fe	77.49	%
Hf	<0.01	%
La	<0.01	%
Mn	<0.01	%
Mo	1.99	%
Nb	<0.01	%
Ni	<0.01	%
P	0.004	%
Si	0.19	%
Ti	<0.01	%
V	<0.01	%
W	<0.01	%
Y	0.081	%
Zr	<0.01	%

Quantitative Analysis by Combustion

C	0.001	%
S	<3	ppm

Quantitative Analysis by IGF

O	0.0026	%
N	0.0002	%

Disposition of Chemical Analysis

For Information

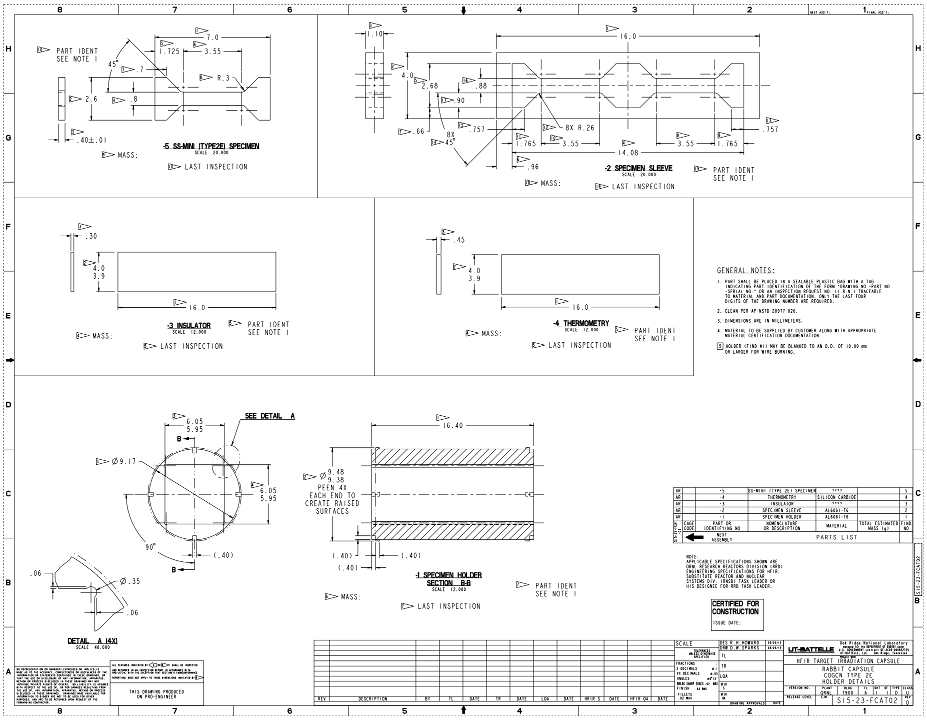
The < Symbol signifies not detected at the detectability limit indicated.

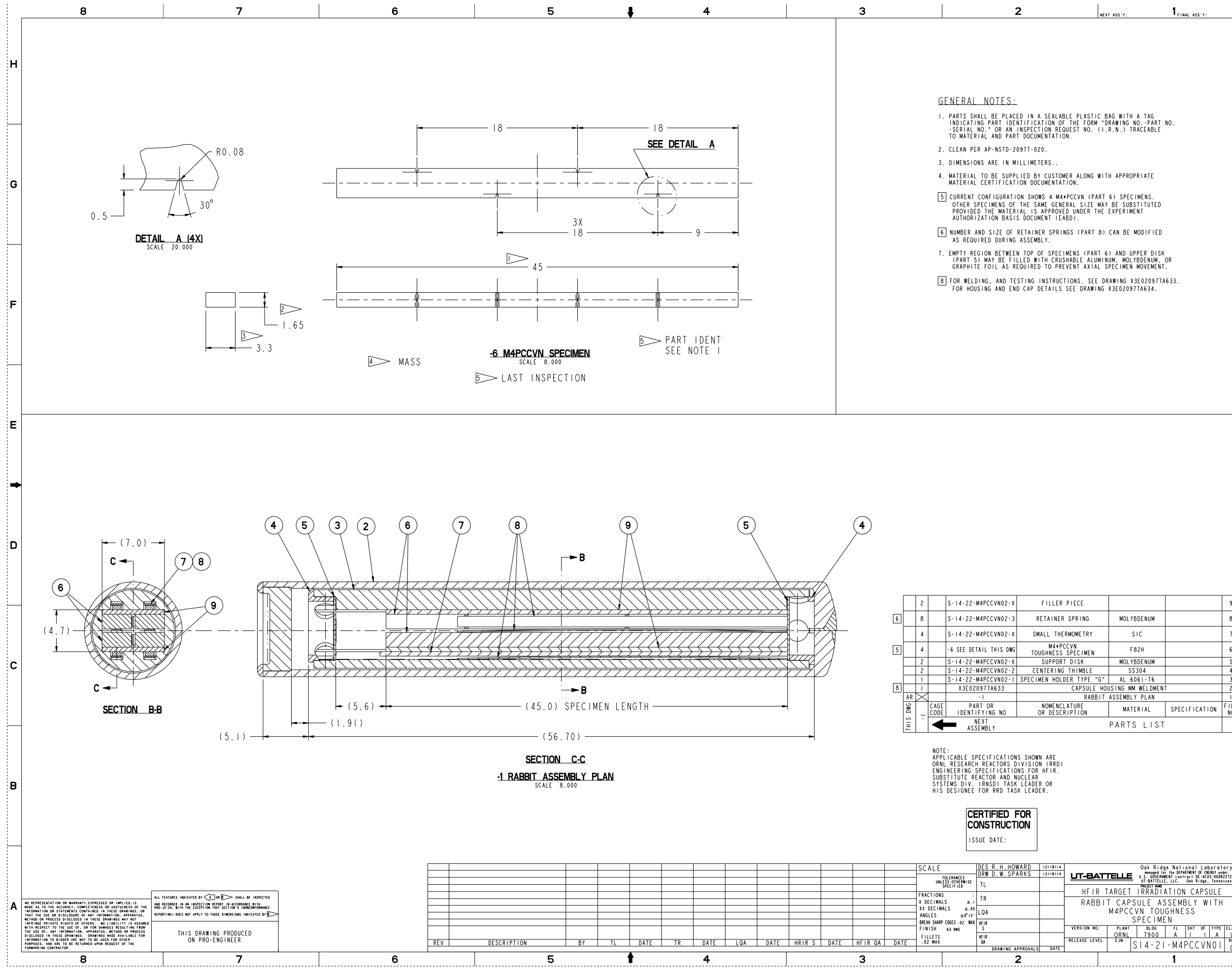
This document, including all Disclosures and Limitations, constitutes the entire report of all test services and results. These tests were performed in accordance with Client and Operations Manual requirements.

Signed by Eric E. Dirats, General Manager.

41 AIRPORT ROAD P.O. BOX 39 WESTFIELD, MA 01086-0039 FAX 413-568-1453 413-568-1571

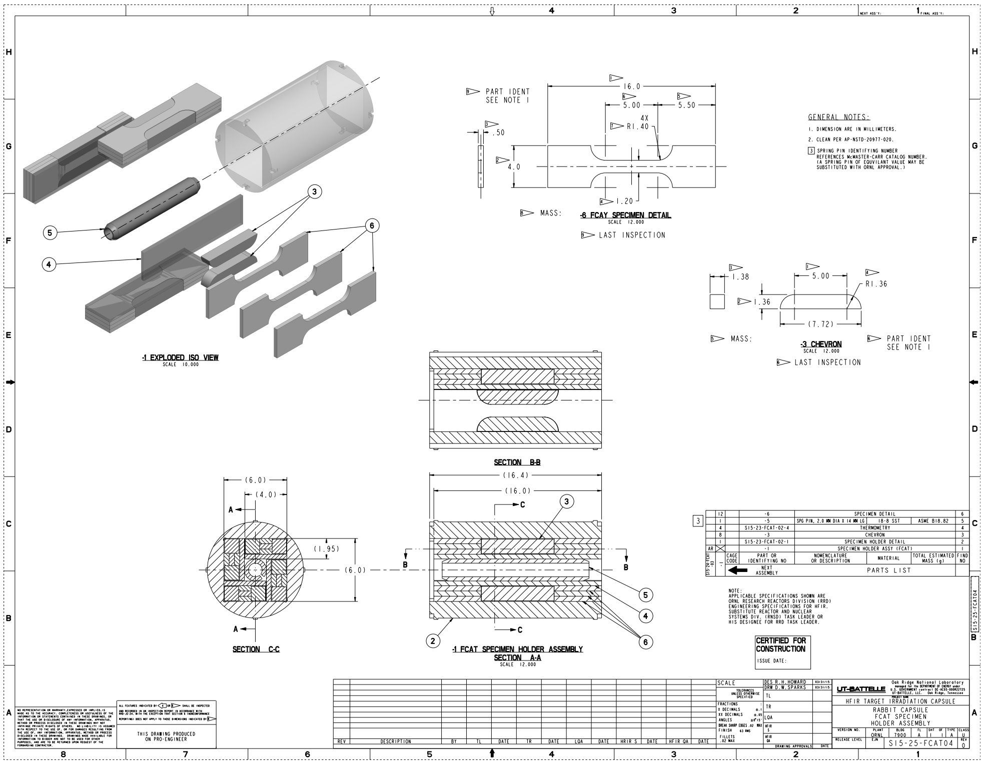
APPENDIX B: CAPSULE ENGINEERING DRAWINGS





Note	QTY	CAGE CODE	PART OR IDENTIFYING NO	NOMENCLATURE OR DESCRIPTION	MATERIAL	SPECIFICATION	FIND NO
	2		S-14-22-M4PCCVN02-X	FILLER PIECE			9
6	8		S-14-22-M4PCCVN02-3	RETAINER SPRING	MOLYBDENUM		8
	4		S-14-22-M4PCCVN02-X	SMALL THERMOMETRY	SIC		7
5	4		-6 SEE DETAIL THIS DWG	M4*PCCVN TOUGHNESS SPECIMEN	F82H		6
	2		S-14-22-M4PCCVN02-X	SUPPORT DISK	MOLYBDENUM		5
	2		S-14-22-M4PCCVN02-2	CENTERING THIMBLE	SS304		4
	1		S-14-22-M4PCCVN02-1	SPECIMEN HOLDER TYPE "G"	AL 6061-T6		3
8	1		X3E020977A633	CAPSULE HOUSING MM WELDMENT			2
	AR		-1	RABBIT ASSEMBLY PLAN			1

PARTS LIST



-1 EXPLODED ISO VIEW
SCALE 10.000
PART IDENT
SEE NOTE 1
-6 FCAY SPECIMEN DETAIL
SCALE 12.000
MASS:
LAST INSPECTION
GENERAL NOTES:
1. DIMENSION ARE IN MILLIMETERS.
-3 CHEVRON
SCALE 12.000
SECTION B-B
SECTION C-C
-1 FCAT SPECIMEN HOLDER ASSEMBLY
SECTION A-A
SCALE 12.000
PARTS LIST
SPECIMEN DETAIL
THERMOMETRY
CHEVRON
SPECIMEN HOLDER DETAIL
SPECIMEN HOLDER ASSY (FCAT)
CERTIFIED FOR
CONSTRUCTION
ISSUE DATE:
THIS DRAWING PRODUCED
ON PRO-ENGINEER
UT-BATTELLE
Oak Ridge National Laboratory
HFIR TARGET IRRADIATION CAPSULE
RABBIT CAPSULE
FCAT SPECIMEN
HOLDER ASSEMBLY
S15-25-FCAT04

APPENDIX C: CAPSULE LOADING LIST

Spec.ID	Specimen Type*	Material Code*	Material or Alloy Composition (Nominal Composition, wt.%)**	Irradiation							
				Target Temp.(°C)	HFIR Position	Avg. Position Flux $x10^{15}$ $n/cm^2.s$ E>0.1 MeV	Cycles	Exposure Time (s)	Estimated Fluence $x10^{20}$ n/cm^2 E>0.1 MeV	Estimated Dose (dpa)	Rabbits ID
BZM01	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP A14	1.08E+15	4	8.29E+06	8.96E+21	7.4	FCAB01
BZM02	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP A14	1.08E+15	4	8.29E+06	8.96E+21	7.4	FCAB01
BM601	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP A14	1.08E+15	4	8.29E+06	8.96E+21	7.4	FCAB01
BM602	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP A14	1.08E+15	4	8.29E+06	8.96E+21	7.4	FCAB01
BZM03	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP A44	1.08E+15	8	1.66E+07	1.79E+22	14.9	FCAB02
BZM04	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP A44	1.08E+15	8	1.66E+07	1.79E+22	14.9	FCAB02
BM603	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP A44	1.08E+15	8	1.66E+07	1.79E+22	14.9	FCAB02
BM604	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP A44	1.08E+15	8	1.66E+07	1.79E+22	14.9	FCAB02
BZM05	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP D74	1.08E+15	4	8.29E+06	8.96E+21	7.4	FCAB01
BZM06	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP D74	1.08E+15	4	8.29E+06	8.96E+21	7.4	FCAB01
BM605	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP D74	1.08E+15	4	8.29E+06	8.96E+21	7.4	FCAB01
BM606	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP D74	1.08E+15	4	8.29E+06	8.96E+21	7.4	FCAB01
BZM07	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP A46	1.10E+15	8	1.66E+07	1.82E+22	15.2	FCAB02
BZM08	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP A46	1.10E+15	8	1.66E+07	1.82E+22	15.2	FCAB02
BM607	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP A46	1.10E+15	8	1.66E+07	1.82E+22	15.2	FCAB02
BM608	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP A46	1.10E+15	8	1.66E+07	1.82E+22	15.2	FCAB02
BZM09	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP A15	1.04E+15	4	8.29E+06	8.63E+21	7.2	FCAB01
BZM10	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP A15	1.04E+15	4	8.29E+06	8.63E+21	7.2	FCAB01
BM609	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP A15	1.04E+15	4	8.29E+06	8.63E+21	7.2	FCAB01
BM610	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP A15	1.04E+15	4	8.29E+06	8.63E+21	7.2	FCAB01
BZM11	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP D16	1.04E+15	8	1.66E+07	1.73E+22	14.3	FCAB02
BZM12	M4-PCCVN	C06M	Fe-10Cr-6Al-2Mo	200	PTP D16	1.04E+15	8	1.66E+07	1.73E+22	14.3	FCAB02
BM611	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP D16	1.04E+15	8	1.66E+07	1.73E+22	14.3	FCAB02
BM612	M4-PCCVN	C36M	Fe-13Cr-6Al-2Mo	200	PTP D16	1.04E+15	8	1.66E+07	1.73E+22	14.3	FCAB02
MF01	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
MF02	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
MF03	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
N501	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
N502	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
M601	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
M602	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
M603	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
MV01	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
MV02	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
MV03	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01

ZM01	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
ZM02	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
ZM03	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
OD01	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
OD02	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
TC01	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
TC02	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
TC03	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
5W01	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
5W02	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
NW01	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
NW02	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
TW01	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
TW02	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
VW01	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
VW02	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
F01	SS-2E	C35M	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
F02	SS-2E	C35M	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
N01	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
N02	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
V01	SS-2E	C37M	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
V02	SS-2E	C37M	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
T01	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
T02	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
A01	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
A02	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
B01	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
B02	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
C01	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
C02	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
C03	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
S01	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
S02	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
S03	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT01
MF10	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
MF11	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
MF12	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
N507	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
N508	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
M610	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
M611	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02

M612	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
MV10	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
MV11	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
MV12	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
ZM10	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
ZM11	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
ZM12	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
OD07	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
OD08	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
TC10	SS-J2	C35M+TC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
TC11	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
TC12	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
5W07	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
5W08	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
NW07	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
NW08	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
TW07	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
TW08	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
VW07	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
VW08	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
F07	SS-2E	C35M	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
F08	SS-2E	C35M	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
N07	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
N08	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
V07	SS-2E	C37M	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
V08	SS-2E	C37M	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
T07	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
T08	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
A07	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
A08	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
B07	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
B08	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
C10	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
C11	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
C12	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
S10	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
S11	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
S12	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT02
MF19	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT03
MF20	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT03
MF21	SS-J2	C35M	Fe-13Cr-5Al-2Mo	200	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT03

N513	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
N514	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
M619	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
M620	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
M621	SS-J2	C36M	Fe-13Cr-6Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
MV19	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
MV20	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
MV21	SS-J2	C37M	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
ZM19	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
ZM20	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
ZM21	SS-J2	C06M	Fe-10Cr-6Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
OD13	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
OD14	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
TC19	SS-J2	C35M+TC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
TC20	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
TC21	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
5W13	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
5W14	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
NW13	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
NW14	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
TW13	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
TW14	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
VW13	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
VW14	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
F13	SS-2E	C35M	Fe-13Cr-5Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
F14	SS-2E	C35M	Fe-13Cr-5Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
N13	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
N14	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
V13	SS-2E	C37M	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
V14	SS-2E	C37M	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
T13	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
T14	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
A13	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
A14	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
B13	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
B14	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
C19	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
C20	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
C21	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
S19	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03
S20	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G7 5	1.08E+1 5	8	1.7E+07	1.8E+22	14.9	FCAT03

S21	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	200	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT03
MV05	SS-J2	C37M	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
MV06	SS-J2	C37M	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
ZM04	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
ZM05	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
ZM06	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
OD03	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
OD04	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
TC04	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
TC05	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
TC06	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
5W03	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
5W04	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
NW03	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
NW04	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
TW03	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
TW04	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
VW03	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
VW04	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
F03	SS-2E	C35M	Fe-13Cr-5Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
F04	SS-2E	C35M	Fe-13Cr-5Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
N03	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
N04	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
V03	SS-2E	C37M	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
V04	SS-2E	C37M	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
T03	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
T04	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
A03	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
A04	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
B03	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
B04	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
C04	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
C05	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
C06	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
S04	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
S05	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
S06	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP D76	9.13E+14	1	2.1E+06	1.9E+21	1.6	FCAT04
MF13	SS-J2	C35M	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
MF14	SS-J2	C35M	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
MF15	SS-J2	C35M	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
N509	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05

N510	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
M613	SS-J2	C36M	Fe-13Cr-6Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
M614	SS-J2	C36M	Fe-13Cr-6Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
M615	SS-J2	C36M	Fe-13Cr-6Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
MV13	SS-J2	C37M	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
MV14	SS-J2	C37M	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
MV15	SS-J2	C37M	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
ZM13	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
ZM14	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
ZM15	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
OD09	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
OD10	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
TC13	SS-J2	C35M+TC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
TC14	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
TC15	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
5W09	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
5W10	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
NW09	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
NW10	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
TW09	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
TW10	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
VW09	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
VW10	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
F09	SS-2E	C35M	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
F10	SS-2E	C35M	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
N09	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
N10	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
V09	SS-2E	C37M	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
V10	SS-2E	C37M	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
T09	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
T10	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
A09	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
A10	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
B09	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
B10	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
C13	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
C14	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
C15	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
S13	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
S14	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05
S15	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G46	9.13E+14	4	8.3E+06	7.6E+21	6.3	FCAT05

MF22	SS-J2	C35M	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
MF23	SS-J2	C35M	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
MF24	SS-J2	C35M	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
N515	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
N516	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
M622	SS-J2	C36M	Fe-13Cr-6Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
M623	SS-J2	C36M	Fe-13Cr-6Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
M624	SS-J2	C36M	Fe-13Cr-6Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
MV22	SS-J2	C37M	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
MV23	SS-J2	C37M	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
MV24	SS-J2	C37M	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
ZM22	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
ZM23	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
ZM24	SS-J2	C06M	Fe-10Cr-6Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
OD15	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
OD16	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
TC22	SS-J2	C35M+TC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
TC23	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
TC24	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
5W15	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
5W16	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
NW15	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
NW16	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
TW15	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
TW16	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
VW15	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
VW16	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
F15	SS-2E	C35M	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
F16	SS-2E	C35M	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
N15	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
N16	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
V15	SS-2E	C37M	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
V16	SS-2E	C37M	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
T15	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
T16	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
A15	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
A16	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
B15	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
B16	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
C22	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
C23	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06

C24	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
S22	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
S23	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
S24	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	325	PTP G76	9.13E+14	8	1.7E+07	1.5E+22	12.6	FCAT06
MF07	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
MF08	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
MF09	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
N505	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
N506	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
M607	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
M608	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
M609	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
MV07	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
MV08	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
MV09	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
ZM07	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
ZM08	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
ZM09	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
OD05	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
OD06	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
TC07	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
TC08	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
TC09	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
5W05	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
5W06	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
NW05	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
NW06	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
TW05	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
TW06	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
VW05	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
VW06	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
F05	SS-2E	C35M	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
F06	SS-2E	C35M	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
N05	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
N06	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
V05	SS-2E	C37M	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
V06	SS-2E	C37M	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
T05	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
T06	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
A05	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
A06	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04

B05	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
B06	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
C07	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
C08	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
C09	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
S07	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
S08	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
S09	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP D75	1.08E+15	1	2.1E+06	2.2E+21	1.9	FCAT04
MF16	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
MF17	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
MF18	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
N511	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
N512	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
M616	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
M617	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
M618	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
MV16	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
MV17	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
MV18	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
ZM16	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
ZM17	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
ZM18	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
OD11	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
OD12	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
TC16	SS-J2	C35M+TC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
TC17	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
TC18	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
5W11	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
5W12	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
NW11	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
NW12	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
TW11	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
TW12	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
VW11	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
VW12	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
F11	SS-2E	C35M	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
F12	SS-2E	C35M	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
N11	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
N12	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
V11	SS-2E	C37M	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
V12	SS-2E	C37M	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05

T11	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
T12	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
A11	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
A12	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
B11	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
B12	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
C16	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
C17	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
C18	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
S16	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
S17	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
S18	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G45	1.08E+15	4	8.3E+06	9.0E+21	7.4	FCAT05
MF25	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
MF26	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
MF27	SS-J2	C35M	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
N517	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
N518	SS-J2	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
M625	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
M626	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
M627	SS-J2	C36M	Fe-13Cr-6Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
MV25	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
MV26	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
MV27	SS-J2	C37M	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
ZM25	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
ZM26	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
ZM27	SS-J2	C06M	Fe-10Cr-6Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
OD17	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
OD18	SS-J2	125YF-ODS	Fe-12Cr-5Al-O-Y	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
TC25	SS-J2	C35M+TC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
TC26	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
TC27	SS-J2	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
5W17	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
5W18	SS-J2	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
NW17	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
NW18	SS-J2	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
TW17	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
TW18	SS-J2	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
VW17	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
VW18	SS-J2	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
F17	SS-2E	C35M	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
F18	SS-2E	C35M	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06

N17	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
N18	SS-2E	C35MN	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
V17	SS-2E	C37M	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
V18	SS-2E	C37M	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
T17	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
T18	SS-2E	C35MTC03	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
A17	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
A18	SS-2E	C35M-Welded	Fe-13Cr-5Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
B17	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
B18	SS-2E	C35MN-Welded	Fe-13Cr-5Al-2Mo-1Nb	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
C25	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
C26	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
C27	SS-2E	C35MTC03-Welded	Fe-13Cr-5Al-2Mo-0.3TiC	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
S25	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
S26	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06
S27	SS-2E	C37M-Welded	Fe-13Cr-7Al-2Mo	550	PTP G75	1.08E+15	8	1.7E+07	1.8E+22	14.9	FCAT06