Reestablishing Capability at PNNL and Aging and Testing Schedule

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Background: This work package aims to build a systematic knowledge base for the thermal aging behavior of cast stainless steels (CASSs) within a limited time of five years. Facility for the long-term aging treatment is a key component of the project. The aging treatment for model CASS materials had been started at ORNL in FY 2014 and the shortest term aging for 1500 h had been completed and some model alloy blocks to be aged for longer terms have achieved aging of 2100 h. The aging capability has been reestablished at Pacific Northwest National Laboratory (PNNL) since the principal investigator moved to the laboratory. The aging of model CASS materials are about to be continued, and the blocks and specimens of the EPRI CASS materials are expected to be delivered in February, 2015 and will be loaded in the furnaces soon after. This memo report presents the current status of the project.

Aging station setup: Establishment of long-term aging capability has been completed at PNNL as four (4) large muffle furnaces (MTI Co. Model KSL-1200X-L) were purchased and installed. Each of these furnaces has a large chamber size of 40×40×40 cm^3 (64 L) and capacity to heat up to 1100 °C at a maximum heating rate of 20 °C/ min. The chamber temperature is controlled by a UDIAN programmable controller at an accuracy of ±1°C using K-type thermocouple. The spatial variation of temperature in chamber is claimed to be ±5 ^oC (it will be reevaluated with materials loaded and the temperature setting will be adjusted accordingly). These furnaces use AC 208 – 240 V single phase electricity and are operated at < 34 A (< 7.5 kW).

Figure-A: Aging station with four muffle furnaces, which will be set at 290, 330, 360, and 400 °C, respectively. The furnace with open door (right) show its chamber space.

Materials allocation and aging schedule: The test run up to 800 ^{o}C was successfully completed for all four furnaces, and currently, the model CASS blocks and wrought 316L and 304L bars are being loaded. Figure-B shows an example for stacking blocks/specimens. The aging schedule for CASS materials is summarized in Table-A. In FY 2015, the 4500 h aging time will be achieved for model alloys and the 1500 h and 4500 h aging times for the EPRI CASS and wrought SS materials.

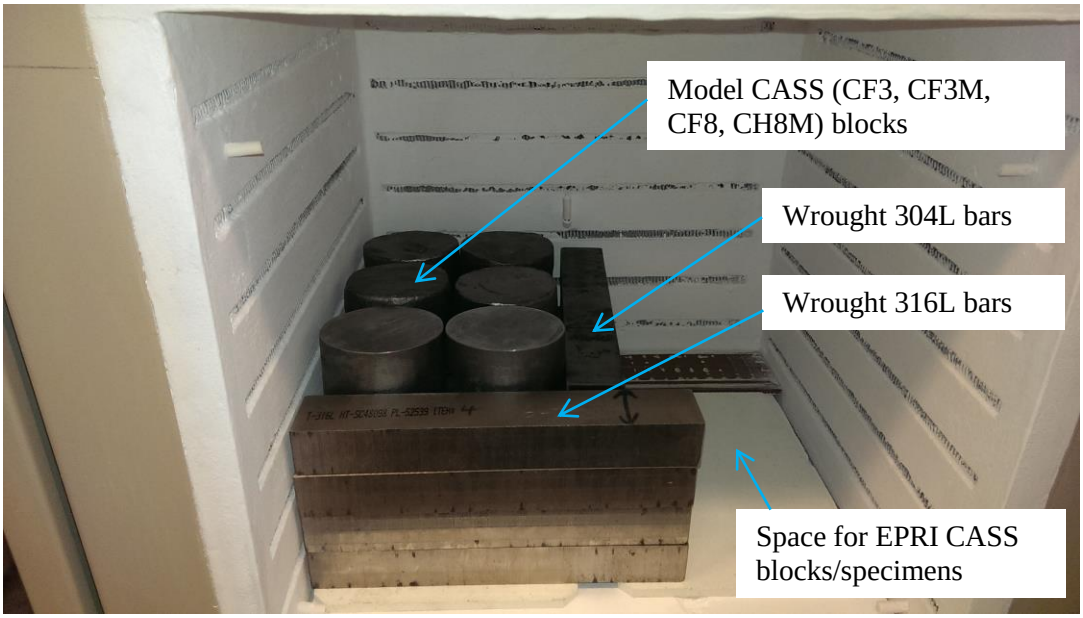

Figure-B: CASS and stainless steels loaded in the furnace (seen is the furnace for 360 °C aging).

Table-A: Aging schedule set for CASS materials

CASS	FY 2014	FY 2015	FY 2016	FY 2017	FY 2018	FY 2109+
Model Alloys (4 alloys)	CF3, CF3M, CF8, CF8M					
	1500 h	4500 h	15000 h		30000 h	45000 h
EPRI CASS (4 alloys)	K10(523&525 rings)-simulated, Z12(21&43 rings, CF3)-vintage, 3(-4043&14352 rings)-vintage, Elbow block					
		1500 h 4500 h		15000 h		30000 h, 45000 h(?)
Wrought SS (2 alloys)	304L, 316L					
		1500 h 4500 h		15000 h		30000 h, 45000 h(?)
Weld (3 alloys)	316L, 308L, 347 vessel clad simulation (KHNP) – to be decided					

Note: the aging periods are 1500 h (0.17 yr), 4500 h (0.51 yr), 15000 h (1.71 yr), 30000 h (3.43 yr), 45000 h (5.17), and were decided based on Aging Parameter (aging effect) estimation. The longer term aging schedules may be changed in request of collaborators or by project schedule.

Characterization Tasks for FY 2015:

- Mechanical tests (tensile, Charpy impact, and J-R tests) will be carried out for the 1500 h aged model alloys. Machining specimens about 90% complete as of today. The Instron 8801 servohydraulic system at the 3410 materials research facility will be used for both static tension and fracture tests. Equipment for Charpy impact testing is undecided.
- The same mechanical testing will be carried out for the pristine EPRI materials.
- Chemistry analysis will be made for the EPRI materials. Grain structure will be also examined in SEM-EBSD.
- Microscopy on the 1500 h aged model alloys will be performed, focusing on precipitation analysis on CF3 and CF8 alloys using TEM.