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Alloy 709 Procurement and ASTM Standardization Status

June 2022

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U.S. DEPARTMENT OF ENERGY | Office of NUCLEAR ENERGY

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Advanced Reactor Technologies Program

Advanced Materials R&D Program Review

June 7 and 8, 2022

Richard N. Wright

Structural Alloys, LLC

Introduction

- Alloy 709 ASME Code qualification requires property characterization for three commercial scale heats
- One heat was obtained from G. O. Carlson in FY 2017
- An additional heat was obtained from ATI Flat Rolled Products in FY 21 and the third procurement, also from ATI, will be complete by the end of this fiscal year
- A pre-requisite for ASME qualification is to have ASTM standards in place for the desired product form

ATI Flat Rolled Product Heats

- Two heats approximately 40,000 pounds each melted using electro-slag remelt process
- Plates rolled to 1.75- and 2.0-inch thickness
- Solution annealed above 1150˚C – specific temperature determined based on experience of vendor
- Grain size between ASTM grain sizes of 4-7

Desired chemistry of ATI Heats

Table 1. Product Chemistry

wt %	C	Mn	P	Si	Cr	Ni	Mo	N	Nb	Ti	B	Fe
Max or Range	0.04-0.10	1.5	Note (1)	1.00	19.5-23	23-26	1.0-2.0	Note (2)	0.1-0.4	0.2	0.002-0.010	Note (3)
Aim	0.07	0.9	Note (4)	0.40	20	25	1.5	0.15	0.25	<0.2	Note (5)	

Note (1): The P not to exceed 0.025 wt %
Note (2): The N controlled to the range 0.13 – 0.17 wt %
Note (3): Balance
Note (4): Less than 0.015 wt % or as low as possible
Note (5): Boron aim is 0.004 wt %

Additionally, the residual elements are restricted to:

- S controlled to 0.002 wt % or less
- Cu controlled to 0.50 wt % or less
- Co controlled to 0.10 wt % or less
- Al not to exceed 0.05 wt %

Actual Chemistry of Heats

		C	Mn	P	Si	Cr	Ni	Mo	N
SOW	Min	0.04				19.5	23.0	1.0	0.13
	Max	0.10	1.5	0.025	1.00	23.0	26.0	2.0	0.17
FY-21		0.08	0.9	0.003	0.39	19.9	24.6	1.5	0.15
FY-22		0.07	0.9	0.008	0.42	19.8	25.1	1.5	0.15

		Nb	Ti	B	S	Cu	Co	Al	Fe
SOW	Min	0.1		0.002					
	Max	0.4	0.2	0.010	0.002	0.50	0.10	0.05	Balance
FY-21		0.17	<0.01	0.004	<0.001	0.06	0.02	0.02	Balance
FY-22		0.18	<0.01	0.004	<0.001	0.04	0.01	0.03	Balance

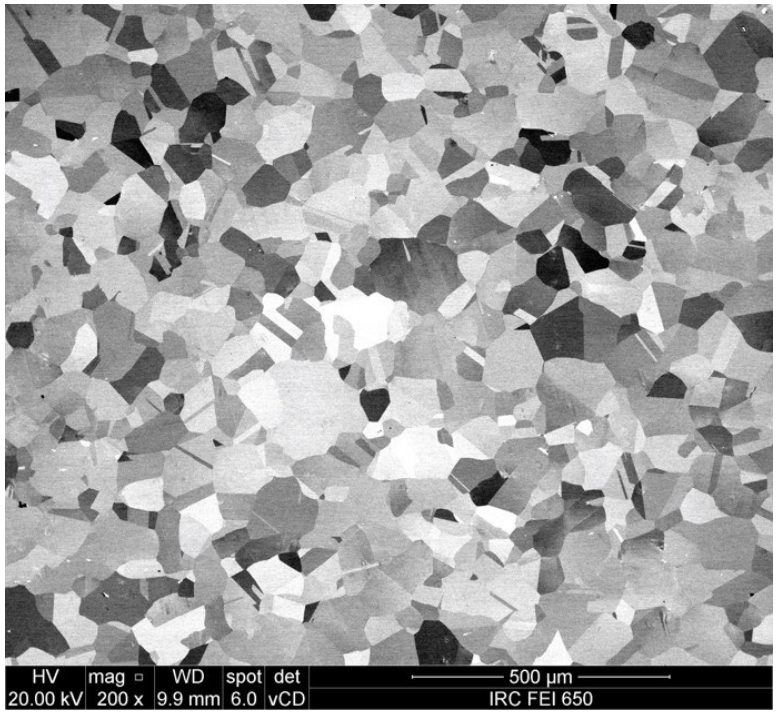
Note: in wt%

Alloy 709 heat procured in FY-22

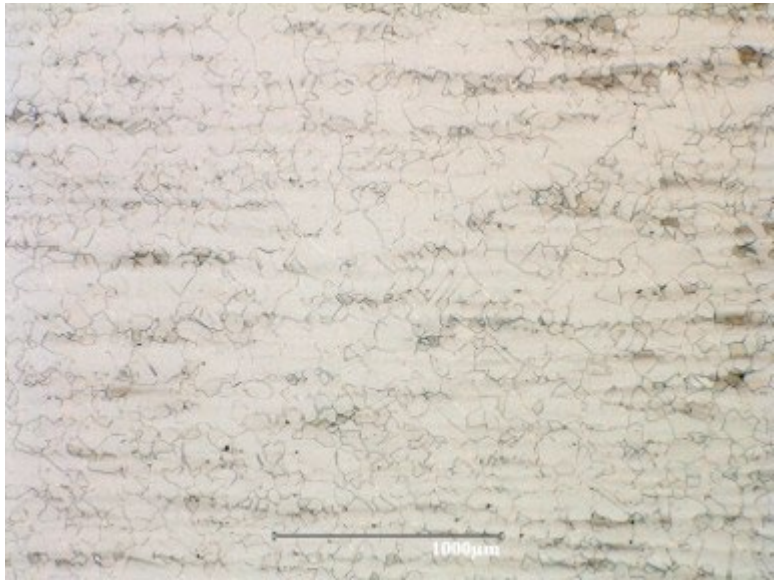
Microstructure of heat(s)

	ASTM Grain Size
SOW	4 - 7
FY-21	4 - 7
FY-22	4 - 7

FY-21 Center 1.75” thick



FY-21 Center 2.0” thick



ASTM Standards Status

- Alloy 709 conforms to UNS 31025 with slight modifications
- ASTM Standards define specific characteristics the alloy must meet, these definitions are the basis for receiving inspection for material from a vendor as part of a NQA-1 quality program
- The alloy has been approved under standard ASTM A213/213M-21b, “Standard Specification for Seamless Ferritic and Austenitic Alloy-Steel Boiler, Superheater, and Heat-Exchanger Tubes”

ASTM Standards Status

- There are existing standards for austenitic steels into which Alloy 709
- ASTM A240/A240M-20a, “Standard Specification for Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications”
- ASTM A480/480M-20A, “Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip”
- Additional requirements or modifications will be required for Alloy 709 in these standards

ASTM Standards Path Forward

- A consultant with considerable experience standardizing austenitic stainless steels will be sub-contracted to aid with this effort
- Necessary modifications on chemistry and microstructure will be defined
- Acceptance criteria will be determined; this will likely include a creep-fatigue acceptance test for elevated temperature applications

Acknowledgements

- The members of the Alloy 709 ART program team are:

  Ryann Bass, Mark Messner, Mike McMurtrey, Xuan Zhang, Yanli Wang, and Sam Sham

- We gratefully acknowledge the extensive contributions of Dr. Matt Bender from ATI Flat Rolled Products. His team has made critical contributions to the hot rolling and solution annealing schedules that allow tight control of the grain size and properties in the desired ranges.

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