FY 2017-Progress Report on the Design and Construction of the Sodium Loop SMT-3

Nuclear Engineering Division

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ABSTRACT

This report provides an update on the design of a forced-convection sodium loop to be used for the evaluation of sodium compatibility of advanced Alloy 709 with emphasis on long term exposures of tensile, creep, fatigue, creep fatigue, and fracture toughness ASTM-size specimens in support of ASME Code qualification and NRC licensing. The report is a deliverable (Level 4) in FY17 (M4AT-17AN1602094), under the Work Package AT-17AN160209, “Sodium Compatibility” performed by Argonne National Laboratory (ANL), as part of the Advanced Materials Program for the Advanced Reactor Technology. This work package enables the development of advanced structural materials by providing corrosion, microstructure, and mechanical property data from the standpoint of sodium compatibility of advanced structural alloys.

The first sodium loop (SMT-1) with a single tank was constructed in 2011 at ANL and has been in operation for exposure of subsize sheet specimens of advanced alloys at a single temperature. The second sodium loop with dual tanks (SMT-2) was constructed in 2013 and has been in operation for the exposure of subsize sheet specimens of advanced alloys at two different temperatures. The current loop (SMT-3) has been designed to incorporate sufficient chamber capacity to expose a large number of ASTM-size specimens to evaluate the sodium effects on tensile, creep, fatigue, creep-fatigue, and fracture toughness properties, in support of ASME Code Qualification and USNRC Licensing.

The design of individual components for the third sodium loop SMT-3 is almost complete. The design also has been sent to an outside vendor for piping analysis to be in compliance with ASME Code. A purchase order has been placed with an outside vendor for the fabrication of major components such as the specimen exposure tanks. However, we have contracted with another vendor to establish the piping design in compliance with ASME design codes. The piping design was completed in FY2017 and the information is being transmitted to the tank fabricator. The SMT-3 loop will be located in Building 206 adjacent to the currently operating SMT-2 loop. In addition, we have demolished the aged power supply system in Building 206 and installed a new transformer, wiring, and power panels for the new loop. Procurement of some of the long lead items such as valves, EM pumps, EM flowmeters, etc. is in progress and will continue in FY 2018. The construction of components such as cold trap, economizers, piping arrangement etc. will be performed in the central shops at ANL. About 150 liters of sodium for the loop will be procured in early FY2018. The loop system is designed to circulate sodium through the sample tanks and the associated loop without an operator for an extended period of time.

With the three sodium loops (with single-tank, dual-tank and four-tanks), materials can be tested at different sodium temperatures, and large tensile, creep, fatigue, creep-fatigue, and fracture toughness specimens can be exposed to sodium for extended periods of time and generate data on mechanical properties in support of ASME Code Qualification and USNRC Licensing of advanced Alloy 709 for use as a structural material in SFRs.

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1 Introduction

The Advanced Reactor Technologies campaign has focused on the sodium-cooled fast reactor concept because of its technical maturity. The current needs are for larger, more reliable, more economical reactors suitable for commercial nuclear power generation. Research and development focuses on three areas including advanced materials, innovative components and systems, and computer models and simulation. Inherent in this research and development is the selection and adequate long-term performance of reactor components that are directly exposed to the sodium coolant at elevated temperatures.

In these reactors, heat is generated from fission reactions in a nuclear-fueled core. The heat is removed by liquid sodium flowing through the core, transferred to a steam system, and the steam is used to drive a turbine. Because of excellent heat transfer properties, liquid sodium has been selected as the coolant and heat transport medium. In general, austenitic stainless steels are used for the fuel cladding, in-core structural components, piping, and intermediate heat exchanger. The selection of a particular structural material and combinations that will be used in both primary and secondary circuits is based upon a number of factors. For in-core applications, the stability of the material in the fast-neutron environment and compatibility with the sodium coolant and the fuel (including possible fission-product interactions) are of primary concern. In the case of the steam generator, the resistance of the material to aqueous chloride and caustic cracking as well as minimization of corrosion wastage rates due to sodium-water reaction products in the event of a tube failure have important bearing on the material selection.

In general, structural materials can undergo a variety of interactions upon exposure to liquid sodium. The extent of interaction depends upon the conditions of temperature, temperature gradient, sodium velocity and purity, the materials of construction, and external sources and sinks for the impurities. The interactions can be broadly classified into either metallic or nonmetallic element mass transfer. Metallic element mass transfer usually establishes a go/no-go type of evaluation of an alloy for use in sodium environment, based upon material wastage or component section loss. A classic example of this is the unacceptable performance of vanadium base alloys in sodium of normal reactor purity. Upon selection of an alloy for sodium service, corrosion allowances that account for metallic element transfer can be incorporated into the design of specific components. Nonmetallic elements, such as oxygen, carbon, nitrogen, and hydrogen, are known to migrate in structural material/sodium systems (under both isothermal and non-isothermal conditions) as a result of chemical activity differences.

A solid metal dissolves in a liquid metal by the diffusion of atoms from the lattice of the solid metal into a boundary layer, followed by transfer of the dissolved atoms from the boundary layer into the bulk liquid. In general, the rate of dissolution depends on the solubility of the solute element in the liquid metal, temperature, and hydrodynamic conditions of the solid/liquid interface. Apart from the atomistic dissolution of metallic elements into sodium, mass transfer can also occur by formation of corrosion products on the metallic surfaces due to interaction between reactants in sodium with the metals to form corrosion products that subsequently erode/spall into the flowing sodium. These corrosion products generally consist of binary or complex oxides of various metals. The dissolution of metallic elements is generally unavoidable especially in systems with temperature gradients, and needs to be minimized to control the metal

wastage in regions at elevated temperatures, limit the deposition of corrosion products in the low temperature regions of the system, and also to control the amount of radioactive corrosion product transport in the primary sodium circuit of the fast reactor. The approach to minimize the problem is to select materials that have 1) relatively low solubility in sodium, and 2) solubility values with small temperature dependence.

Transfer of nonmetallic elements also occurs in systems where combinations of materials of different composition are used. By examining the partitioning of nonmetallic elements between the structural alloy and sodium, the extent to which oxygen, carbon, and nitrogen interact in the structural material-sodium systems can be assessed. From the operation of the sodium-fast-reactor standpoint, the oxygen impurity in sodium can be controlled to ≈ 1 ppm which would result in acceptable corrosion of austenitic and ferritic steels and nickel-base alloys at a typical maximum operating temperature of 600°C for the coolant. The solubility of nitrogen in sodium is low in the reactor anticipated operating temperatures and its effect on the materials performance may not be significant. On the other hand, observations by various investigators, that materials of nominally the same composition with different degrees of decarburization/carburization in sodium loops operating over similar temperature ranges, have resulted in questions regarding the extrapolation of results obtained in small scale sodium loops to large reactor systems. Since carbon concentration in a given system is established by a dynamic equilibrium between the carbon sources and carbon sinks present in the system, it could vary from system to system as well as over time within a system. It is necessary to evaluate the influence of carbon in sodium on the microstructural and mechanical properties of advanced structural materials.

In previous reports [1,2], we addressed the thermodynamics and kinetics of metallic and nonmetallic impurity elements in sodium and their role in the corrosion of structural materials such as austenitic stainless steels and ferritic steels. The reports also presented the available data for the impurity elements, experience on control and maintenance of the impurities in sodium systems, and the impact of various impurity elements, especially nonmetallic elements, on the corrosion performance of various structural components in sodium-cooled reactors. A single-tank forced convection sodium loop was constructed at Argonne National Laboratory for sodium compatibility studies of advanced materials, and has been operating at the maximum temperature of 650°C for materials testing since early 2011. The second sodium loop with dual tanks (SMT-2) was constructed in 2013 and has been in operation for the exposure of subsize sheet specimens of advanced alloys at two different temperatures.

This report presents an update on the design of a third sodium loop (SMT-3) to be constructed at Argonne National Laboratory. This forced convection sodium loop will significantly expand the materials testing capability and will be used for long-term exposure of ASTM-size specimens to evaluate the sodium effects on corrosion, tensile, creep, fatigue, creep-fatigue, and fracture toughness properties of Alloy 709, in support of ASME Code Qualification and USNRC Licensing.

2 Forced Convection Sodium Loops

The first forced convection sodium loop (SMT-1) was constructed, in FY2011 at Argonne National Laboratory, for exposure of subsize tensile specimens of the advanced structural materials. The SMT-1 Loop consists of a single specimen-exposure tank with a heat exchanger, an electromagnetic pump, two electromagnetic flow meters, economizer, and a cold trap. The system was designed to circulate sodium with an argon cover gas through the specimen-exposure tank and the associated loop, for an extended period of time without an operator. The total amount of sodium in the loop is approximately 10 kg. The nominal operating pressure and the temperature for the sample tank in the loop are 3 psig and <650°C. The nominal operating pressure and the temperature for the tubing part of the loops are 3 psig and ~300-400°C, respectively. The maximum allowable working pressure and temperature are rated at 45 psig and 704°C for the sample tank and 1153 psig and 510°C for the tubing part of the loop, except the cold trap where the maximum pressure rating is 953 psig. The loop assembly including the sample tanks is considered under the coverage of ASME Code for process piping B31.3 and its pressure safety is evaluated based on the ASME B31.3. Three specimen ports are available for loading corrosion coupon or sheet-type tensile specimens for sodium compatibility tests.

The second forced convection sodium loop (SMT-2) is a dual-tank sodium loop that has been constructed, in FY2013, for exposure of mechanical test specimens of advanced ferritic-martensitic steels at multiple temperatures [2]. The nominal operating pressure and the temperature for the sample tank in the loop are 3 psig and <700°C. The nominal operating pressure and the temperature for the tubing part of the loops are 3 psig and ~300-400°C, respectively. The maximum allowable working pressure and the temperature of the loop are 75 psig and 800°C. The total amount of sodium in the loop is approximately 20 kg. The loop assembly including the sample tanks is considered under the coverage of ASME Code for pressure piping B31.3 and its pressure safety is evaluated based on the ASME B31.3. The system was designed to circulate sodium through the sample tanks and the associated loop without an operator for an extended period of time.

One significant difference between SMT-1 system and SMT-2 is that there are 2 tanks each containing enough sodium in SMT-2 to flood another tank if improperly distributed. To address this potential issue, the sodium suction point to feed each tank was located just below the sodium level in each tank to ensure that flooding of any of the tanks will never occur. The volume and the location of suction points were designed such that even if an unexpected flow disturbance or blockage occurs in the loop, only a small portion of the sodium in one tank can flow to another as the sodium level goes down, the suction point comes above the sodium level and no more sodium can flow to another tank.

The third forced convection loop (SMT-3), currently in design, incorporates four test tanks with capability to expose as many as 42 ASTM-size specimens in each tank at temperatures of 550 and 600°C for as long as 100,000 hours. The current report presents an update on various aspects of SMT-3 design and planned operation scenarios.

3 SMT-3 Forced Convection Sodium Loop

3.1 Loop Specifications

The loop will incorporate four test tanks capable of ASTM-size specimen exposures without an operator for an extended period of time. Each tank shall meet the requirements of Sec. VIII (Div. 1) of the ASME Boiler and Pressure Tank Code and/or ASME B31.3 Process Pipe Code. The technical requirements for each tank include a maximum allowable working temperature of 750°C, a pressure range of full vacuum to 800 kPa gage, operate with working fluids of sodium and cover gas of Argon. Helium leak test of parent material and welds shall be performed in accordance with the ASME Code Section V Article 10 and its Appendix V. The leak rate should be $<10^{-9}$ std-cc/sec. The pressure boundary materials will be fabricated with either Type 304 or 316 stainless steel with a carbon content in the range of 0.04-0.08 wt.%, and the tanks design will incorporate a corrosion allowance of 15 $\mu\text{m}/\text{year}$ for 20 years. Figure 1 shows an isometric view of SMT-3.

The tanks will be fabricated from 10" dia. Sch. 80 pipe and will be 16" in height with an end cap welded at the bottom. Each tank will contain ~25 liters of sodium and the loop will have ~125-150 liters of sodium, that includes sodium in cold trap and economizers. The sodium flow rate will be in a range of 0.5-1.0 GPM.

Figure 1. Isometric view of SMT-3 forced convection sodium loop.

The cold trap and economizers will also be constructed from stainless steel pipes. The cold trap will be packed with stainless steel mesh, providing a large surface area. The cold trap will have its own heaters/blower and thermocouples. The temperature of the cold trap will be controlled by means of temperature feedback using a commercially available temperature controller. The economizers will be a tube-in-tube type heat exchanger and will have their own heater and thermocouples. The temperatures of the economizers will be controlled by means of temperature feedback using a commercially available temperature controller. The loop sodium will be partially cooled while exchanging heat with outgoing sodium from the cold trap as it flows through the economizer. The partially cooled sodium will enter the cold trap and will be further cooled. The cold sodium leaving the cold trap will be heated as it flows through the economizer. The cold trap temperature will be maintained in the range of 120-140°C which would result in an oxygen concentration in sodium of ~1-2 ppm, that is typical of SFRs.

To prevent undue stresses in the loop, which may arise due to differential thermal expansion, the loop legs and components will be hung from an Unistrut support frame, or otherwise supported loosely on the Unistrut frame. Details of the support configuration will be determined by the result of the piping flexibility analysis, which is currently being performed by an outside vendor.

3.2 Design Specifications

The loop will incorporate the four specimen-exposure tanks in series. Expected operation time will be ~100,000 hours (~12 years). The design temperature (for fabrication and ASME Code purposes) is 650°C. Three of the tanks will be operated at 550°C and the fourth tank at 600°C. There will be a cold trap in the loop to control and maintain the oxygen concentration in the sodium at 1-2 ppm level. An EM pump will circulate the sodium from one of the end tanks through the cold trap back to another end tank. Another EM pump will control the sodium flow distribution between the bypass and the cold trap. Figure 2 shows a schematic of the SMT-3 loop configuration. The major part of the sodium piping will be fabricated using 1/2 in. Sch. 80 pipe of stainless steel. Table 1 lists the various operating scenario, anticipated during the long-term operation of the loop.

Table 1. Conditions for Various Operating Scenarios for SMT-3 Loop

	Case description	EM Pump 021	EM Pump 221	Temp. zone 1		Temp. zone 2		Economizer 1		Temp. zone 3		Economizer 2	
				Cold trap		Cold trap to economizer 1				Main loop piping			
				Temperature	Pressure	Temperature	Pressure	Temperature	Pressure	Temperature	Pressure	Temperature	Pressure
Scenario 1	Initial-cold	OFF	OFF	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig
Scenario 2	Initial-hot	OFF	OFF	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig
Scenario 3	Outgassing	OFF	OFF	300 °C	FV	400 °C	FV	400 °C	FV	500 °C	FV	600 °C	FV
Scenario 4	Sodium filling	ON/OFF	ON/OFF	300 °C	5 psig	300 °C	5 psig	300 °C	5 psig	300 °C	5 psig	300 °C	5 psig
Scenario 5	Nominal operation	ON	ON	Non uniform, linearly from 100 to 145 °C	5 psig	150 °C	5 psig	Non uniform, linearly from 150 to 320 °C	5 psig	335 °C	5 psig	Non uniform, linearly from 350 to 530 °C	5 psig
Scenario 6	High temperature operation	ON	ON	Non uniform, linearly from 100 to 145 °C	5 psig	150 °C	5 psig	Non uniform, linearly from 150 to 320 °C	5 psig	335 °C	5 psig	Non uniform, linearly from 350 to 575 °C	5 psig
Scenario 7	Stand-by-cold	OFF	OFF	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig
Scenario 8	Stand-by-hot	OFF	OFF	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig
Scenario 9	Maximum design condition	ON	ON	500 °C	116 psig	500 °C	116 psig	500 °C	116 psig	500 °C	116 psig	Non uniform, linearly from 500 to 700 °C	116 psig
Scenario 10	Minimum design condition	OFF	OFF	0 °F	FV	0 °F	FV	0 °F	FV	0 °F	FV	0 °F	FV
Temp. zone 4		Temp. zone 5		Economizer 3		Temp. zone 6		Dump tank		Drain piping		Vent piping	
Piping to Tank 1		Tanks 1, 2, 4				Tank 3							
Temperature	Pressure	Temperature	Pressure	Temperature	Pressure	Temperature	Pressure	Temperature	Pressure	Temperature	Pressure	Temperature	Pressure
-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig	-18 °C (0 °F)	0 psig
38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig	38 °C (100 °F)	FV to 10 psig
650 °C	FV	650 °C	FV	675 °C	FV	700 °C	FV	400 °C	FV	400 °C	FV	Ambient	FV
300 °C	5 psig	300 °C	5 psig	300 °C	5 psig	300 °C	5 psig	300 °C	5 psig	300 °C	5 psig	Ambient	5 psig
Non uniform, linearly from 530 to 550 °C	5 psig	550 °C	5 psig	Non uniform, linearly from 555 to 595 °C	5 psig	600 °C	5 psig	150 °C	5 psig	150 °C	5 psig	Ambient	5 psig
Non uniform, linearly from 575 to 600 °C	5 psig	600 °C	5 psig	Non uniform, linearly from 605 to 645 °C	5 psig	650 °C	5 psig	150 °C	5 psig	150 °C	5 psig	Ambient	5 psig
-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig	-18 °C (0 °F)	5 psig
38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig	38 °C (100 °F)	5 psig
700 °C	116 psig	700 °C	116 psig	700 °C	116 psig	700 °C	116 psig	500 °C	116 psig	500 °C	116 psig	500 °C	116 psig
0 °F	FV	0 °F	FV	0 °F	FV	0 °F	FV	0 °F	FV	0 °F	FV	0 °F	FV

Figure 2. A schematic of SMT-3 loop configuration.

3.3 Summary of piping analysis

The piping analysis for the Sodium Loop #3 test facility included four experimental tanks (10" dia. each with two 400-pound flanges on top and a pipe cap serving as the tank bottom). The other components are all made from pipes with pipe caps ends. The dump tank dimension considered is 12 in dia, the cold trap is 6 in dia, and the three economizers are 2 in dia.

The Sodium Loop #3 system is considered as a relatively low pressure (116 psig design pressure) and very high temperature (700°C or 1,292°F design temperature) system with small stainless steel piping (½ in pipe). This temperature for the 316H stainless steel used throughout the system is in fact classified as an "Elevated Temperature Fluid Service," per the ASME B31.3 pipe code. Indeed any temperature above 1,100°F (593°C) is so classified. This classification indicates creep is a factor, and therefore the steel has time-dependent properties.

The design is detailed in the CAESAR II pipe stress analysis software file that was electronically transmitted to ANL by PDS. The detailed isometric drawings of the revised piping layout with the locations of the pipe support were described in the final report. Since the vessels are much more robust and much larger in diameter, off-the-shelf designs were available to meet

the needs of the system. Snubber support locations were also identified. Specifications for the piping supports, including snubbers were also listed. Additionally, ANL worked with the vessel fabricator to increase the robustness of the nozzles to allow the piping system more margin for compliance with allowable loads on the nozzles.

3.4 Loop Design Details

The progress in FY2017 consisted of three major tasks namely, piping analysis, tank design modifications, and EM pump & flowmeter magnetic dipole design.

We worked with Plant Design Solutions (PDS) to perform a piping analysis required by ASME B31.3 pipe code. After performing the first analysis with the operating condition (operating temperatures and pressures), materials of construction, initial piping layout developed at ANL (designed solely for functionality (flow direction, head balance, heat transfer etc, and not for stress, flexibility etc.), it turned out that it was not possible to make the original design to pass the code requirements with reasonable amount of modifications to the loop itself due to the temperature requirement. In the second iteration, the tanks and special supports were included in the piping layout and the entire system was analyzed to pass the requirements. Details are presented in a report delivered to ANL by PDS.

One of the weakest points in the original design was the nozzles (interface between the tanks and the piping). To strengthen the nozzles to meet the code requirements, the nozzle wall thickness had to be increased (from wall thickness of 0.109", schedule 40, 1/2" piping to a wall thickness of 0.147", schedule 80, 1/2" piping), which resulted in redesign of the tanks.

Tank design modifications

For the piping layout to meet the ASME Code requirement, it was necessary to increase the nozzle wall thickness, which made some of the clearances too small and required repositioning some of the nozzles to avoid potential interferences with other structures. The changes were communicated to the tank vendor (Northland Stainless) to make sure the changes would meet the Boiler & Pressure Tank Code with the loading at the nozzles provided from the piping analysis by PDS. Currently, the dimensional consistency is being verified with the piping layout that would meet the piping code requirements.

EM pump & flowmeter magnetic dipoles design

It is planned to use a conventional DC conduction electromagnetic pump and electromagnetic flowmeter (the same type of pumps we have been using in the sodium loops SMT-1 and SMT-2). We have been working with Shin-Etsu Magnetics to come up with a design. To accommodate the larger pipe size, the gap size was increased from the previous designs. Also, to simplify the installation, we incorporated a "C" style dipole. The design has been finalized and plan to request fabrication by a vendor in the FY2018.

3.5 Component Design Details

This Section presents the current design status of various key components for SMT-3 loop. Figure 3 shows the drawing for one of the tanks with sodium-inlet and -outlet piping modifications. All four tanks are identical in design. The tank tops will be secured with flanges and a gasket that is compatible for use in sodium systems. There will be penetrations in the top flange for incorporation of specimen retrieval port, mechanism for specimen support carousel, liquid level indicator, and thermocouple insertion to measure/control the sodium temperature. Figure 4 shows the details on sodium inlet/outlet for the tank in the loop. The central block at the sodium outlet in Fig. 4 is to protect the specimen-holding carousel from separating from the shaft and falling into sodium.

Figure 5 shows the top and front views of tank cover with the flange protrusion locations indicated. Figure 6 shows the details on the valve arrangement for sodium loop isolation as well as for specimen retrieval. Also shown are various protrusions on the cover that were indicated earlier. Figure 7 shows the details of a carousel plate that will support the specimens and will be located above the sodium level in the tank. The carousel ports will be indexed by a sprocket mechanism (shown in Fig. 8) and will be operated from the top of the tank cover to insert/retrieve the specimens.

Figure 3. Details on a specimen-exposure tank in SMT-3 loop.

Figure 4. Details on sodium inlet/outlet in specimen-exposure tank in SMT-3 loop.

Figure 5. Details on tank cover for the specimen-exposure tank in SMT-3 loop.

Figure 6. Details on valve arrangement on the tank cover in SMT-3 loop.

Figure 7. Details on carousel plate in specimen-exposure tank in SMT-3 loop.

Figure 8. Details on sprocket arrangement for specimen-exposure tank in SMT-3 loop.

4 Summary

This report provides update of the progress made in FY 2017 in the design of the new sodium loop SMT-3 at Argonne National Laboratory. The loop will be used for the studies on sodium effects on the advanced Alloy 709 with emphasis on corrosion, tensile, creep, fatigue, creep fatigue, and fracture toughness properties. The loop will have four test tanks that can accommodate as many as 42 ASTM-size specimens in each tank. This system is a forced convection sodium loop in which the oxygen concentration in sodium will be controlled and maintained at 1-2 wppm by a cold trap, during the long-term exposures of mechanical test specimens.

The nominal operating pressure and temperature for the sample tanks in the loop are 3 psig and ~650°C, respectively. The nominal operating pressure and the temperature for the piping part of the loops are 3 psig and ~300-400°C, respectively. The loop will be constructed from Type 304 or 316 stainless steel with associated heaters, fittings, and valves. The total amount of sodium in the loop is approximately <150 kg. The system is designed to circulate sodium through the sample tanks and the associated loop without an operator for an extended period of time. A detailed piping analysis was conducted by a vendor to meet all the essential ASME Code requirements for long term service at elevated temperatures. The long-lead items such as specimen exposure tanks have been ordered and will be fabricated by an outside vendor. The construction of the loop will initiate in FY2018, if funds are allocated.

With the three sodium loops (with single-tank, dual-tank and four-tanks), materials can be tested at different sodium temperatures, and large tensile, creep, fatigue, creep-fatigue, and fracture toughness specimens can be exposed to sodium for extended periods of time and generate data on mechanical properties in support of ASME Code Qualification and USNRC Licensing of advanced Alloy 709 for use as a structural material in SFRs.

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References

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