10.1 FUSION MATERIAL IRRADIATION TEST STATION (FMITS) AT SNS — Mark Wendel, Phil Ferguson (Oak Ridge National Laboratory)

OBJECTIVE

The Fusion Materials Irradiation Test Station (FMITS) is a plan for an irradiation facility at the Spallation Neutron Source (SNS). The objective of the FY15 effort is to address comments by the reviewers of the 2014 feasibility study and to reduce the technical risks to a potential project by analysis and by building and testing hardware mockups. The 2014 effort produced a Feasibility Study Report, 30% Design Review, and a Preliminary Safety Assessment. The 2014 estimate for implementation of the FMITS at SNS was $13.4 M including a 25% contingency.

SUMMARY

The Fusion Materials Irradiation Test Station (FMITS) is a design concept for installation at the Spallation Neutron Source (SNS) Facility. The project has received funding from OFES during FY15 for (1) performing a mockup test on an FMITS-type target seal, (2) augmenting the safety assessment based on the 2014 technical review, (3) analyzing thermal-hydraulic off-normal transients with a full 3D model to assess the performance of the FMITS sensor array, and (4) remote-handling electrical connector operational mock-up. The main goals of the effort are to remove the project technical risks and prepare for a potential future project.

PROGRESS

1. Seal mockup

FMITS-type (double-pillow) seal hardware (Figure 1) has been received along with a test report from the vendor. This seal is a prototype of the assembly that could be used between the target module and the core vessel flange for an FMITS harness. It would replace the single-sided version currently in use at SNS. Hardware has also been designed and ordered that would modify the inflatable seal test tank (Figure 2) at SNS to confirm that the new seal operates to required specifications, and to show robust and repeatable performance. The vendor (KSM Corporation) completed a leak test on the double pillow seal with the apparatus shown in Figure 3. The test report indicates that the seal design is highly successful, holding 2.9×10^{-6} torr-liter/s against helium gas. If the ORNL mockup test results confirm, then the technical risk to a proposed FMITS project would be greatly reduced, according to the Feasibility Study Report of 2014.

2. Safety assessment

As mentioned in the previous semi-annual report, deterministic analysis does not seem feasible that can rule out possible FMITS test-section tube rupture severe consequences. It is likely that the FMITS plan will have to keep the engineering control safeguard of a calibrated containment tube with directional failure bias. To that end, a contract has been placed with Fike Company (the same company that designed, tested, and supply HFIR rupture disk) to design and test FMITS tubes that would hold up to 300 psig water pressure, and then fail consistently and without fragmentation in a direction away from the SNS target and moderators. Fike has material on order for their first tests which should begin around August 1, 2015.

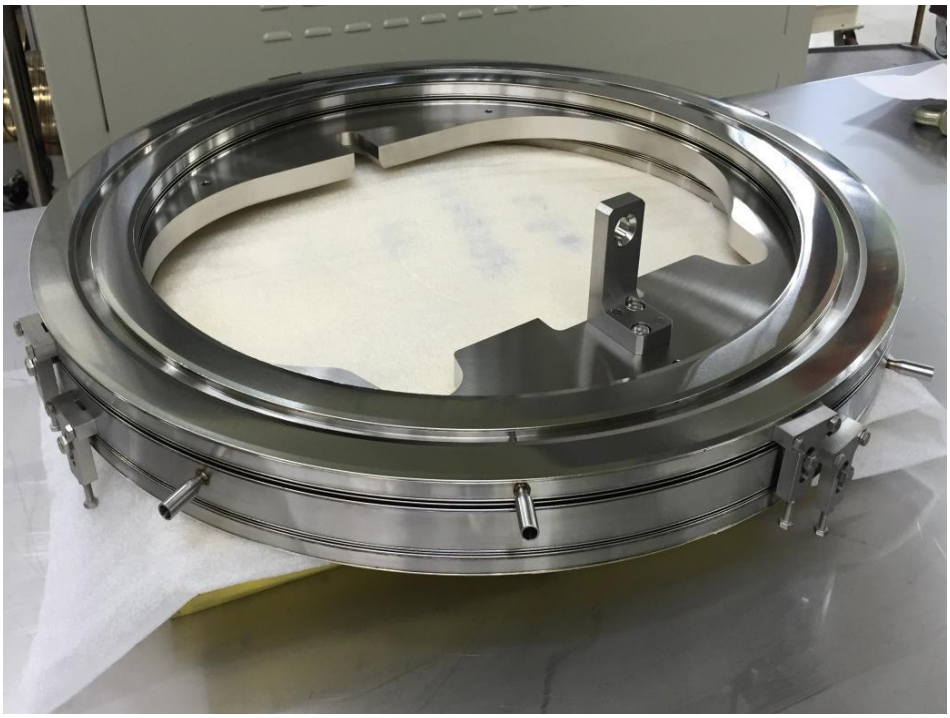

Figure 1. Double-inflatable seal ring received at ORNL from KSM Corporation. Outside diameter is 0.65 meters.

Figure 2. Test tank that will be used to assure robust functional performance of prototype double-inflatable pillow seal. Outside diameter of the tank is 0.91 m.

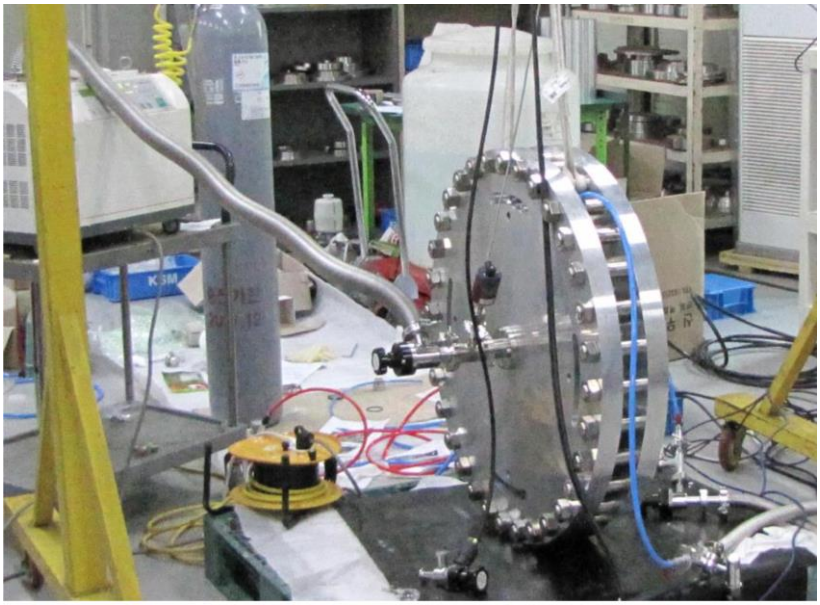

Figure 3. Set-up for double-inflatable seal leak test performed at KSM Corporation.

3. Finite element analysis (FEA) model of FMITS test section

A full 3D model of a representative FMITS capsule has been developed and meshed for finite element analysis. The model includes the outer containment, which is cooled by 37°C water at 5 GPM from the SNS light water system 2, and five sub-capsules containing steel bend bar specimens. As a representative experiment, all five sub-capsules are set to operate between 500°C to 550°C. However, because the axial heat generation profile is strongly peaked at the center, a series of calculations were performed to find individual design diameters that would produce the design temperature in each sub-capsule.

A loss-of-flow transient was completed for which the FMITS capsule experiences a sudden blockage leading to a 50% flow reduction. As shown in Figure 4, within 5 s of the flow blockage event, the hottest thermocouples indicate a 10°C temperature rise. This type of results will be useful in formulating the strategy and timing for machine protection at SNS.

In addition to the thermocouples, the instrumentation described in the FMITS feasibility study includes an RTD-based flow sensor to ensure cooling of the FMITS test section. The flow sensor is not currently available for water, but requires some development. A sub-contract is now in place with Delta M Corporation to test and deliver a prototype water flow sensor that would stand up to the harsh radioactive environment of the FMITS seal ring. The water sensor is scheduled for delivery to ORNL at the beginning of calendar year 2016.

4. Remote-handling connector mockup

Remote handling mockup tests showed that the FMITS electrical connections could be reliably made up using the SNS master-slave manipulators within the available confined space on the back end of the target carriage. Prototypical connectors were used in the mock-up testing, and these results can now be used to confidently move ahead with a preliminary design for the FMITS-specific vent line shield block.

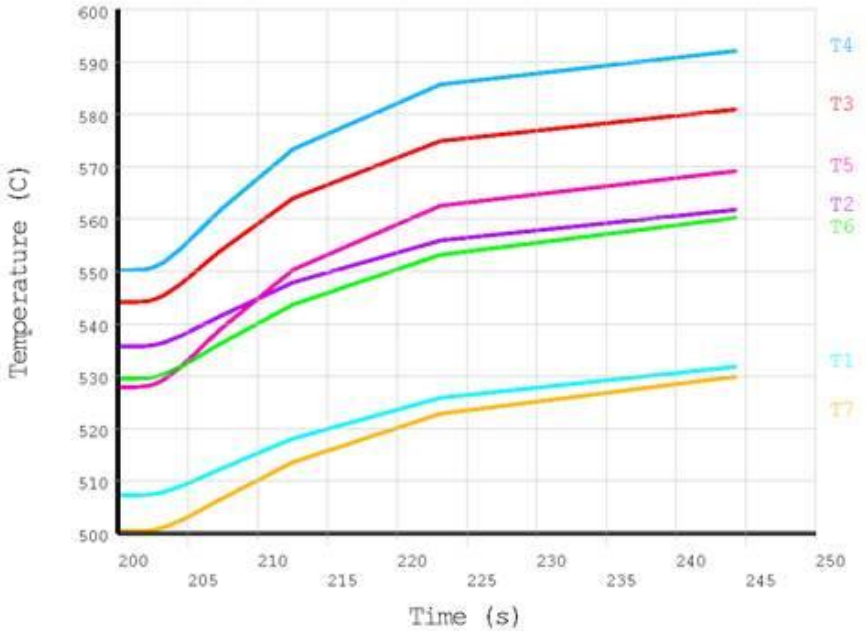

Figure 4. Simulated temperature responses of thermocouples in FMITS test section following an abrupt 50% flow reduction event.