9.1 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, 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 upcoming viability review by DOE.

PROGRESS

Seal mockup

FMITS-type (double-pillow) seal hardware (Fig. 1) is on order. Finite element analysis was completed and the design specification was approved and archived. The fabrication contract was awarded to bellows manufacturer KSM, Inc., and should be delivered to ORNL in March, 2015. This seal is a prototype of the assembly that could be used between the target module and the core vessel flange for an FMITS installation. It would replace the single-sided version currently in use at SNS. Once the prototype seal is received, it will be tested in the seal test tank (Fig. 2) at SNS to determine it operates to required specifications, shows robust and repeatable performance, and compares favorably to the quality of the original design. If these mockup test results are positive, then the technical risk to a proposed FMITS project would be greatly reduced, according to the Feasibility Study Report of 2014.

Safety assessment

Two meetings have been held to discuss the 30% Design Review comments on safety. The outstanding issues are: possible tungsten/water reaction and subsequent detonation of hydrogen, removing the rupture tube mitigation concept to avoid complicating the fabrication, and radiolysis and shock wave risks. The hydrogen production due to the tungsten water reaction is limited by tungsten availability, and a simple calculation should provide an acceptable bound. A deterministic analysis that can rule out possible tube rupture severe consequences does not seem feasible. It is likely that the FMITS plan will have to keep the engineering control safeguard of a calibrated containment tube with directional failure bias.

Finite element analysis (FEA) model of FMITS test section

The FMITS team met on December 17, 2014, to discuss the off-normal analysis plan for 2015. The purpose of the analysis is to comply with recommendation of the 30% Design Review Committee to strengthen the case for operational reliability by understanding how the proposed sensor array protects the SNS facility. These concerns will be addressed by thermal modeling of an actual FMITS experiment with inclusion of realistic thermocouple details. Transient conditions will be performed with a three-dimensional transient model. The sensitivity of each thermocouple to the changing thermal conditions will be quantified, thus providing the necessary information to optimize a machine protection voting logic that would be effective to protect the SNS facility.

The team selected 5 off-normal events to consider:

- beam/power generation drift
- diminished or loss of flow
- flow redistribution or flow blockage
- primary gas transients (e.g., 100% argon flow)
- startup and shutdown sequences

A representative three-dimensional FEA model of the FMITS has been constructed. A simple, but commonly used, specimen configuration of bend bars was selected, as shown in Fig. 3. Figure 4 shows this same configuration contained inside a specimen holder.

Currently, there are 5 holder assemblies contained within a single FMITS capsule. Figure 5 shows the complete FMITS capsule with the 5 holder assemblies.

As shown in Fig. 5, a TCAT assembly runs through the center of the capsule and is used to measure temperature at various locations in the assembly. A close-up view of the TCAT is shown in Fig. 6. This device is a combination of seven individual thermocouples into one wire. Each of the seven thermocouples will measure the temperature at whatever location the wires come together: nominally, one at the center of each assembly, plus two that can be located at arbitrary points. It is necessary to model the TCAT in detail in order to get the proper thermal time response from the transient conditions.

Currently, the Creo solid model is about 98% complete. The next stage is to import the design into the ANSYS FEA software and begin the process of meshing and defining contact between parts.

Remote-handling connector mockup

A wooden mockup was created of the electrical connector pocket that is located at the front of the target carriage (Fig. 7). This pocket houses the fixed half of the mercury leak detector jumper connector, which is very difficult to access remotely due to its location relative to the shoulder joint of the thru-wall-manipulators. Implementing FMITS would require a second connector in this region, and perhaps a third, so the mockup was developed using the proposed electrical connectors. Initial tests showed the first mockup configuration was manageable, but a lower connector location within the pocket could enhance the ability to remotely manipulate the connectors. Because the proposed FMITS-style electrical connectors have more pins than the current connector, the insertion force required to mate the connectors will increase. The next step is to procure some prototype connectors with identical pin configurations and test them with the manipulators. Once the mockup is complete, the results can be used in a preliminary design for the FMITS-specific Vent Line Shield Block.

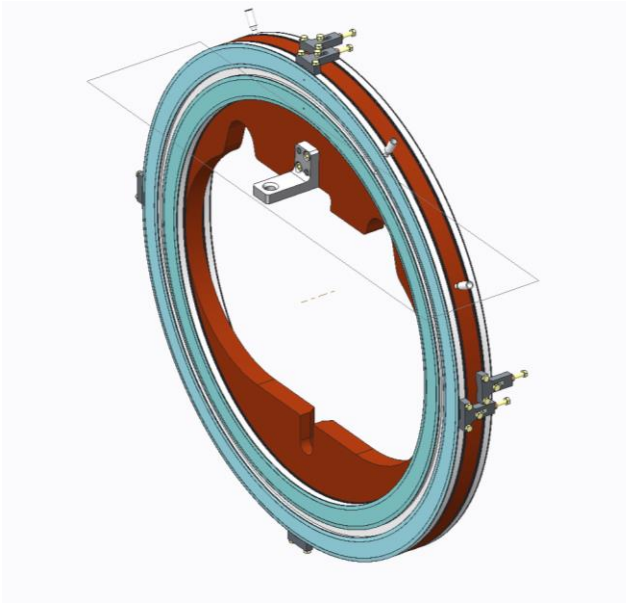

Figure. 1. Double-inflatable seal ring under fabrication.

Figure 2. Target seal test tank which will be adapted to test FMITS-type core vessel seal.

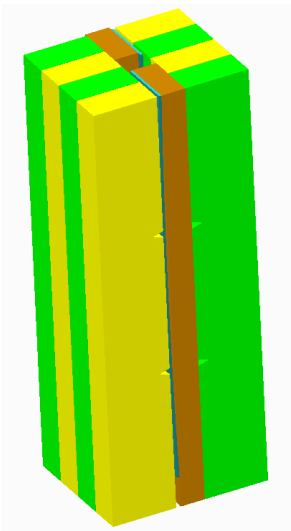

Figure. 3. Specimen configuration showing 8 bend bars (yellow and green), 2 thermometry elements (brown) and springs (blue).

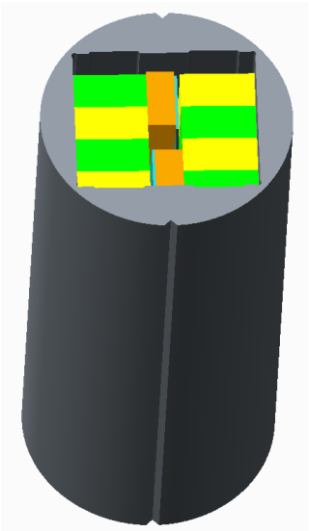

Figure 4. Standard specimen configuration shown inside a holder**.**

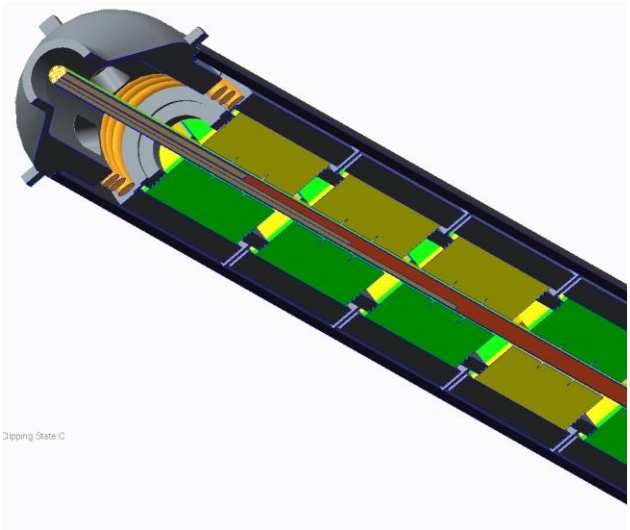

Figure 5. FMITS Assembly

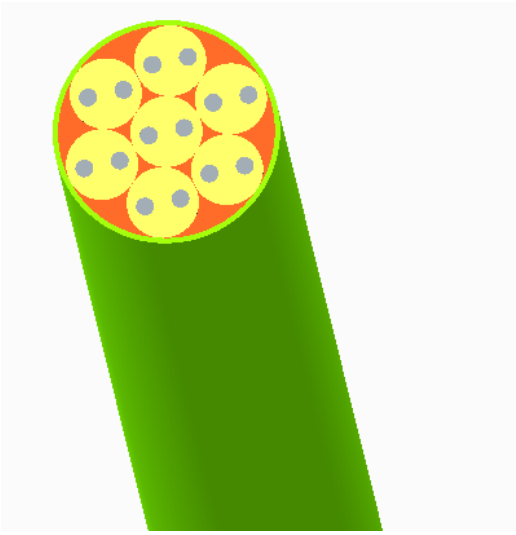

Figure 6 . TCAT Assembly Showing 7 Individual Thermocouples

Figure 7. Remote handling mockup for FMITS electrical connections.