10.1 FUSION MATERIALS 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 FY16 effort follows through on FY15 objectives 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 FMITS is a design concept for installation at the SNS Facility. The project 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, which was successfully completed in FY15. The work was continued in FY16 using residual funding. The main goals of the effort are to remove the project technical risks and prepare for a potential future project.

PROGRESS

Seal Mockup

The FMITS-type (double-pillow) seal hardware (Figure 1) was received last year along with a test report from the vendor that shows it successfully tested to 2.9×10^{-6} torr-liter/s. 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 that would modify the inflatable seal test tank at SNS to confirm that the new seal operates to required specifications, and to show robust and repeatable performance. The hardware has not yet been ordered to perform the tests at ORNL, but the testing tank is now ready.

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

Safety Assessment

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 sub-contract was placed with Fike Company (the same company that designed, tested, and supplied HFIR rupture disks) to design and test FMITS tubes that would hold at least 300 psig water pressure, and then fail consistently and without fragmentation in a direction away from the SNS target and moderators. Fike completed the fabrication and testing of 20 tubes with a positive result: The burst pressures ranged from 400 – 800 psig and each tube failed in the pre-determined direction. Also, three of the tubes were precisely weighed before and after rupture, showing that there was no detectable fragmentation. These tests confirm that a rupture tube concept could reliably avert safety issues in an FMITS coolant flow blockage event.

Another concern raised by the 2014 Feasibility Study Review Committee is the reaction with tungsten and water at high temperature leading to deflagration or detonation in the SNS core vessel. An evaluation of the tungsten-steam interaction was previously performed to support the Los Alamos FSAD for a solid tungsten target. The present analysis strategy is based on that Los Alamos approach. Even with extremely conservative assumptions, if the tungsten packing fraction is limited to 50% or less (545 grams) there is insufficient hydrogen production to support deflagration or detonation within the core vessel. This finding alleviates the safety concern raised by the committee.

Assessing FMITS Thermal-hydraulics in the Test Section

A full 3D model of a representative FMITS capsule has been developed and meshed for finite element analysis. A loss-of-flow transient was completed for which the FMITS capsule experiences a sudden

blockage leading to a 50% flow reduction. 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 simulation of the thermal response of the test-section, a sensor has been developed that could verify that actual operational temperatures are managed in FMITS. The instrumentation described in the FMITS feasibility study includes both thermocouples and an RTD-based flow sensor to ensure cooling of the FMITS test section. The compact flow sensor was not currently available for water in 2014, but is now being developed. A sub-contract is 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 near the beginning of calendar year 2016.