SNS TARGET TEST FACILITY FOR Hg OPERATIONS AND REMOTE HANDLING*

P. T. Spampinato, T. W. Burgess, V. B. Graves, T. L. Ray, M. J. Rennich, and S. L. Schrock

Robotics and Process Systems Division
Oak Ridge National Laboratory
P.O. Box 2008, Bldg. 7601, MS-6304
Oak Ridge, TN 37831-6304
Telephone: (423)576-5267

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To be published in the Proceedings of the 1999 Accelerator Applications Conference, November 14-18, 1999, Long Beach, California

* This research was sponsored by the Office of Fusion Energy Sciences, U.S. Department of Energy, under contract DE-AC05-96OR22464 with Oak Ridge National Laboratory, managed by Lockheed Martin Energy Research Corporation.

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ABSTRACT

The Target Test Facility is a full-scale prototype of the mercury-target flow loop for the Spallation Neutron Source. It will be used to study the thermal/hydraulic characteristics of the mercury flow loop, gain experience operating the mercury system, and develop remote handling operations for replacing various target system components. This paper describes the features and status of the TTF.

I. INTRODUCTION

The Target Test Facility (TTF) is a full-scale prototype of the Spallation Neutron Source (SNS) Target Station.[1] It will be used to study the thermal/hydraulic characteristics of the mercury target flow loop, gain experience operating the mercury system, and develop remote handling operations on the various target system components. Since the facility will contain approximately 1.4 m^3 of mercury for flow testing, an enclosure that matches the size of the actual SNS target cell was constructed. The enclosure is a containment structure that meets environmental, safety, and health requirements. Figure 1 shows the enclosure installed in the high bay test facility at Oak Ridge National Laboratory (ORNL).

II. BACKGROUND

Early in the SNS project, it was recognized that R&D would be required to address thermal/hydraulics issues, and issues dealing with remote handling and component maintenance. It was also realized that studying these issues would require use of full-scale systems. By combining the two functions into one mock up facility, and by using an existing high bay facility that already has remote handling equipment, significant cost savings were realized.

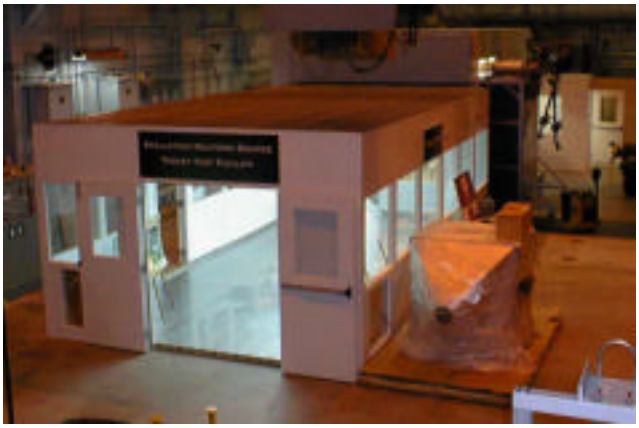

Figure 1. The SNS Target Test Facility enclosure is installed in a high bay test area.

The mercury target flow loop in the TTF is a replica of the actual SNS flow loop[2] and includes components such as the 75 hp centrifugal pump, a mock heat exchanger, a storage tank for 1.4 m^3 of mercury, the "shielded" target module, numerous pipes up to 6 in. diameter, pipe couplings, valves, and various process and diagnostic sensors. Since there will be no radioactivity in the TTF, shielding will be simulated in geometry only. Remote handling tests will be used to verify that optimal arrangements have been designed for the various components, and that all components can be replaced within the time allotted for maintenance operations. Figure 2 shows the TTF equipment assembled at the fabricator's site for acceptance testing.

III. ENCLOSURE

The presence of mercury for thermal/hydraulic testing requires that the flow loop must be operated in an enclosure which provides containment for the facility.[3] The mercury flows in a closed loop system, therefore during normal operations neither mercury fluid nor vapors

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should be present within the enclosure. However, in order to preclude the possibility of personnel exposure to mercury vapors in the event of an accident, the enclosure is connected to the ventilation system of the high bay facility. Five air changes per hour will flow from the high bay into the enclosure, then through the mercury filters, and finally to the building's ventilation stack. Mercury vapor monitors are located downstream of the filters and in each of the two rooms within the enclosure.

Figure 2. TTF equipment fully assembled for testing at the fabricators site.

Both enclosure rooms also have a stainless steel floor liner to contain mercury in the event of a spill. The liners provide full floor coverage and are attached and (silicone) sealed to the enclosure walls. The liners are fabricated from 3 mm stainless steel plate, welded and fully inspected for leak integrity.

The enclosure was constructed in two sections, one to house the pump process equipment, and the other to house the target module. A common wall divides the two rooms. The overall dimensions of the enclosure are 17 m (56 ft.) by 4 m (14 ft.). The height of the process equipment room is 3.6 m (12 ft), and the height of the target room is 2.4 m (8 ft). Mercury will be drained from the flow loop into the TTF storage tank before starting remote handling operations. The storage tank is shown in the foreground of Figure 2.

During remote handling operations the roof of the process equipment room will be removed to allow access for an overhead manipulator system. The bridge manipulator will be used to complement the wall-mounted manipulators, and to accomplish tasks where the wall manipulators can not reach.

IV. MANIPULATOR OPERATIONS

A pair of Central Research Laboratory (CRL) Model F manipulators were mounted onto a movable platform for TTF remote handling operations. The platform includes a simulated shield window and the ability to move slightly along the enclosure wall to remotely work on components. Studies will be done to assess the design of key components relative to the reach and efficiency of manipulator operations. Figure 3 shows the CRL manipulators installed at the west wall of the enclosure for operations on the target module-to-shield interface. Remote handling operations on components that are not adjacent to the "Target Test Cell" wall require using an overhead bridge-mounted (PaR 6000) power arm manipulator. Components such as the centrifugal pump shown in Figure 2 will require overhead operations.

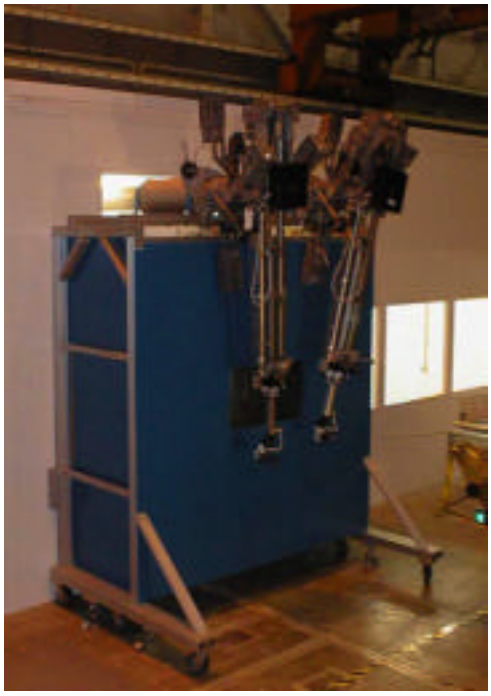

Figure 3. Wall manipulators will be used to develop Target Cell remote handling operations.

V. MERCURY HANDLING

Storing and handling mercury in large quantities requires special consideration to assure that personal safety and environmental concerns are met. Mercury for the TTF was obtained from surplus stores at the Y-12 facility in Oak Ridge, and shipped several miles in wooden pallets to the TTF. Each of the 12 pallets contains 45 steel flasks,

and each flask contains approximately 2.5 liters of mercury. Figure 4 shows a pallet being moved into a special storage building. The pallet weighs approximately 1800 kg (4000 lbs.).

Figure 4. A pallet contains 45 steel flasks of mercury.

Safely loading almost 2000 kg of mercury stored in 540 flasks, into the TTF, required considerable planning. The goal was to demonstrate a safe approach which also minimizes handling time. Several options were considered; the procedure that was chosen uses a peristaltic pump, and does not require that personnel lift or handle any of the flasks except to remove the flask plug. The pump was tested and shown to be a safe, fast method for transferring mercury into the TTF. Figure 5 shows the test set up for transferring mercury using the peristaltic pump. Another advantage of this approach is that only the plastic tubing becomes contaminated with mercury.

VI. NEXT STEPS

The TTF equipment installation will be completed by the end of July, followed by installation of the instrumentation and controls equipment. Leak testing will be done using water, along with gaining preliminary operating experience. Loading the mercury into the storage tank will be performed after completing a readiness review. Operational shakedown and preliminary testing is scheduled to begin in mid-September, 1999.

In addition to “on line” testing using the TTF, other tests that do not require use of mercury will begin. Preliminary remote handling tests will be done using a 4-inch Grayloc remote connector. In particular, handling and replacing the gasket-type seal will be the focus of those activities.

Figure 5. The peristaltic pump transferring mercury under a fume hood.

Testing on the target-seal design interface will also begin. A special fixture capable of supporting a full size replica of the target-seal gasket plates was constructed. It will exert 17,500 N-m (155,000 in-lbs) of bending-moment on the seal face to simulate the weight of the target module full of mercury. These tests will be followed by similar testing next year using pressurized mercury in the TTF. Figure 6 shows the target seal test fixture.

Figure 6. The Target Seal Test Fixture with one of the seal plates installed.

VII. SCHEDULE

Thermal/hydraulic characterization of the flow loop and experience gained operating the flow system will be achieved primarily in the CY2000. Remote handling testing is based on a four-phase program lasting through 2001. Phases 1 and 2 will be completed in CY1999, and include initial operation of the TTF for mercury flow testing, and demonstrating access, manipulator reach, and simple remote handling tasks. Phase 3 will focus on the use of end-effector tools and replacing critical components, as well as constructing and using mock ups for other subsystems. Phase 4 will focus on total remote handling of the target module, including disposal operations.

VIII. CONCLUSIONS

A full-scale prototype of the Spallation Neutron Source Target Station will be constructed. It has two primary test objectives: demonstrate remote handling operations on the components that make up the mercury target flow loop system; and assess the thermal/hydraulic characteristics of the mercury flow loop. In addition to demonstrating the remote replacement of various TTF components, procedures and operations will be developed with this facility to ensure that maintenance operations can be completed in the time allotted to meet the project's availability objectives. The remote handling tests have five objectives: (a) verify the replacement of all subsystems and components, (b) provide feedback to the Target Station design engineers for design improvements, (c) develop and demonstrate appropriate remote handling tools, (d) assess downtime for replacing various components, and (e) provide operator training for actual remote maintenance operations.

REFERENCES

1. Spallation Neutron Source Conceptual Design Report, NSNS/CDR-2, May 1997.
2. M. J. Rennich, T. N. McManamy, "Overview of the SNS Target Station Remote Handling Systems," Proceedings of the Accelerator Applications '98 Conference, Gatlinburg, Tennessee, September 1998.
3. P. T. Spampinato, V. B. Graves, S. L. Schrock, "SNS Target Test Facility for Remote Handling Design and Verification," Proceedings of the Accelerator Applications '99 Conference, Gatlinburg, Tennessee, September 1998.