STATUS OF THE SPALLATION NEUTRON SOURCE SUPERCONDUCTING RF FACILITIES*

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Abstract

The Spallation Neutron Source (SNS) project was completed without on-site superconducting RF (SRF) facilities for testing, repair and development. An effort to install the infrastructure and equipment necessary to maintain and repair the superconducting Linac and to support power upgrade research and development (R&D) is well underway and for some aspects complete. Installation of a Class10/100/10,000 cleanroom and outfitting of the test cave with RF, vacuum, controls, personnel protection and cryogenics systems is now complete. These systems were recently operated satisfactorily to test a cryomodule that had been removed from the accelerator and repaired in the cleanroom. A horizontal cryostat, has been fabricated and will be soon commissioned. Equipment for cryomodule assembly and disassembly has been installed and used for cryomodule disassembly. Cavity processing equipment is being designed and installed. This effort is providing both high-power test capability as well as long-term maintenance capabilities.

INTRODUCTION

The SNS project was completed in June 2006 with only limited SRF facilities installed as part of the project. Approximately 800 of the nominal 1000 MeV of H^- acceleration is provided by 23 superconducting RF cryomodules, 11 of which are 3 cavity, β=0.61 structures, and 12 are 4 cavity, β=0.81 structures. Operational experience has resulted in the turning off of several cavities due to excessive fundamental power coupling through higher order mode (HOM) antennas, while other cavities performance is limited by field emission [1, 2]. A concerted effort had been initiated to install the infrastructure and equipment necessary to maintain and improve the superconducting Linac [3]. This paper presents the current status and the future plans for the SNS SRF test facility.

The overall layout of the SRF facilities is shown in Figure 1. They are housed in the SNS RF test facility.

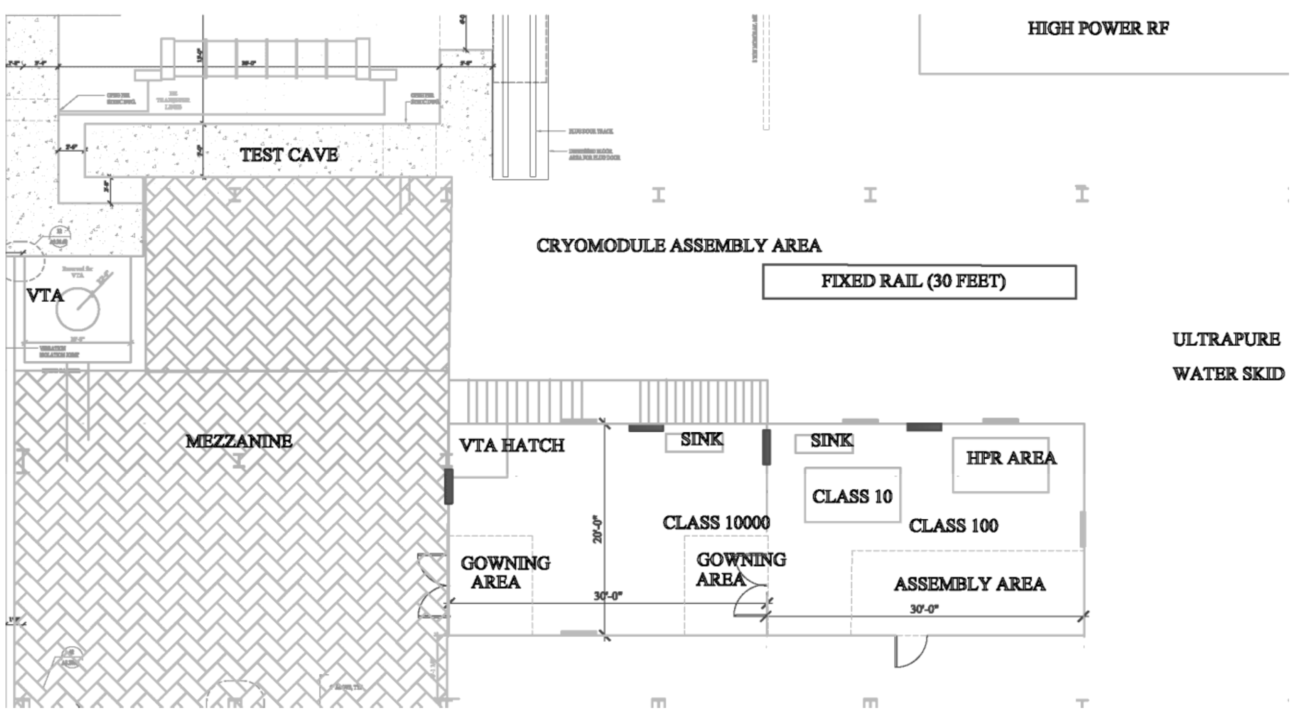

Figure 1: SRF Facility Layout

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The items that have been installed include the 5 MW, 805 MHz RF test stand, a fundamental power coupler processing system, the cleanroom, the cryomodule assembly area and the test cave. Installation of the cryomodule repair area and fabrication of the horizontal cryostat are underway. Future items include a high pressure rinse system, ultra-pure water system, and a vertical test assembly (VTA).

INSTALLED ITEMS

Cleanroom

The cleanroom consists of two rooms: a Class 10,000 room and a Class 100 room, each measuring 20 by 30 feet. The Class 100 room also houses an 8 foot by 8 foot Class 10 assembly area. The rooms employ banks of pipe ducts to facilitate utility routing from the outside and between clean rooms. Figure 2 presents an external view of the cleanroom and the adjacent cryomodule assembly rail.

Figure 2: Exterior view of Cleanroom and Cryomodule Assembly Rail

The Class 10,000 room houses ultrasonic cleaning equipment and general assembly benches. The Class 100 room was recently used to blank off HOM antennas on a cryomodule removed from the tunnel (Serial number H-06). It also will be used for high pressure rinsing, string assembly, and particulate-free assembly within the Class 10 region of the room.

A 2000 square foot mezzanine was constructed as part of the cleanroom project. The mezzanine will provide additional support facilities and laboratory space.

Cryomodule Test Cave

The cryomodule test cave has an interior dimension of 36 feet long, by 13 feet wide, and an interior height of 10 feet. The entire cave is encased in five foot thick concrete shielding.

All components, including the rolling shield door and cryogenic transfer lines, have been installed to test cryomodules. These systems include the high power RF (using a 5 MW klystron), low-level RF, communication, cryogenic controls, vacuum, personnel protection, and oxygen deficiency.

Cryomodule H-06 was tested in December 2007 in the test cave, following the removal of HOM feed-throughs. All systems operated as expected, and all cavities achieved gradients of ~15 MV/m (the design gradient). Recovery of one cavity that had been turned off due to excessive HOM power at the fundamental frequency also confirmed cleanroom repair processes.

Figure 3 shows the interior of the test cave following installation of these systems.

Figure 3: View of Cryomodule Inside Test Cave

The RF power is interlocked with a radiation detector to limit the radiation inside the test cave to 10 R per hour. Simultaneous operation of up to four cavities is planned.

Cryomodule Repair Facilities

The cryomodule repair facilities will be used to separate the end cans from the vacuum vessel, remove the interior space frame from the vessel, and re-assemble these items following cryomodule repairs. The facilities can also be used for spare cryomodule assembly.

The facilities require a substantial amount of tooling to support and align components during assembly or removal. A thirty foot long assembly bench that uses two sets of rails has been installed. Other tooling items include end can benches with rails for use in end can removal and assembly, and a mobile 20 foot transfer bench for transferring items to the assembly bench (i.e. the vacuum vessel assembly less end cans) or for assembling/removing items to the assembly bench (i.e. withdrawing the space frame assembly from the vacuum vessel). All of these items have been fabricated and installed. They were used to disassemble the medium beta prototype cryomodule as part of an effort to rebuild the prototype as a spare cryomodule.

Horizontal Cryostat

The primary purpose of the horizontal cryostat is to support research and development testing for the SNS Power Upgrade Project. The cryostat will house a cavity, helium vessel and fundamental power coupler. After cooling to 2 K or 4 K, the cavity and coupler can be tested with high power RF.

The design is based on one recently developed at Fermilab, although the SNS version is supported at the top. The vacuum vessel and shields of the cryostat have been fabricated and assembled. Figure 4 shows the overall cryostat assembly.

Figure 4: Horizontal Cryostat Assembly

Design of the feed box has been completed and fabrication is underway. Testing of the cryostat is planned in 2008.

CURRENT ACTIVITIES

Initial efforts focused on those significant infrastructure items (i.e. cleanroom and mezzanine) whose installation was disruptive to overall facility use. Current activities are oriented towards establishing a cavity processing capability to repair cryomodules, fabricate spares, and support power upgrade research and development. The items discussed below are part of an approved FY2008 accelerator improvement project.

High Pressure Rinse System

The high pressure rinse system will be similar to those used at other laboratories. The existing ultra-pure water system, used for warm beam pipe cleaning and assembly, will be upgraded to increase storage capacity and provide semiconductor industry Type E-1 water. A diaphragm pump will be used for the rinse fixture. The cleanroom area for the system has a higher ceiling than the rest of the cleanroom to accommodate the high beta SNS cavities. These items are being procured with installation planned for August 2008..

Vertical Test Assembly

The cleanroom and SRF facility have been designed to allow the addition of a vertical test assembly (VTA). The VTA would house a cavity-sized dewar and a research dewar either within a stacked-block radiation shield, or in a pit excavated in the existing building. Although the horizontal cryostat will be used for cavity/coupler qualification, cryomodule testing may prevent access to the test cave, necessitating an independent means for testing cavity processing and of processing quality control samples. In addition to the dewars, the VTA project will include the dewar top plate and inserts, cryogenic transfer lines, instrumentation and controls, RF system, and radiation monitoring.

CONCLUSION

SRF facilities have been installed to support SNS cryomodule repair and testing. Cleanroom and test cave operation was verified by removing a cryomodule from the tunnel, repairing it in the cleanroom, and confirming satisfactory operation in the test cave. Efforts underway will expand cavity processing and research and development capabilities.

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