STATUS OF SRF FACILITIES AT SNS*

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Abstract

The Spallation Neutron Source (SNS) has recognized the need for developing in-house capability to ensure long term sustainability of the superconducting linac (SCL). SNS has made substantial gains in the last 6 years in understanding SCL operation, including system and equipment limiting factors, and resolution of system and equipment issues. Significant effort and focus is required to assure on-going success in the operation, maintenance, and improvement of the SCL and to address the requirements of the upgrade project for the Second Target Station. These interdependent efforts include implementation of demonstrated improvements, fabrication of spare cryomodules, cavity R&D to enhance machine performance, and related SRF facility developments. Cryomodule and vertical cavity testing facilities are being developed to demonstrate process capabilities and to further understand the collective limitations of installed cavities. The status and future plans for SRF facilities at SNS will be presented.

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 cryomodules, 11 of which are β=0.61 structure with 3-cavities, and 12 are β=0.81 structure with 4-cavity. Sustained operation has required repairs of cryomodules for multiple reasons. A concerted effort had been initiated to install the infrastructure and equipment necessary to maintain, improve and ensure the long-term sustainability of the SCL. 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 (RFTF). Currently installed items include a 5-MW, 805-MHz RF test stand, a fundamental power coupler processing system, cleanroom, cryomodule assembly/repair area, ultra-pure water system.

On-going activities include installation of a high pressure rinse system, vertical test system, cryogenic test facility (CTF) system, RF System, and a horizontal test apparatus (HTA).

CRYODMODULE STATUS

Operation of the SNS superconducting Linac has proven to be very stable. The availability of the machine is about 95% for FY2012, and SCL portion including all related systems about 99 %. Critical to maintaining this exemplary performance is the ability to perform maintenance and repairs quickly, predictably, and economically, along with the well-balanced operating parameters of SCL systems as a whole based on the lessons learned in past 6 years [1]. A very successful proactive cryomodule repair program has been also employed to assure linac reliability. Most cryomodule repairs performed thus far have been in-situ. In these cases cryomodules have been repaired and returned to service during a regularly scheduled maintenance interval. Two cryomodule have been taken out from the tunnel for repair, successfully repaired and back to service [2]: These cryomodules have had HOM feedthroughs removed in the RFTF clean room and had leaking feedthroughs removed in the end cans.

Several additional cryomodules have been identified as in need of repair. A spare high beta cryomodule has been built and successfully tested at SNS as well. [3]. This spare cryomodule will allow removal and repair of lower performing cryomodules in the linac without compromising the overall performance of the accelerator. Cryomodule 20 and cryomodule 6 both show abnormal vacuum reading on the fundamental power coupler cold cathode gage. Cryomodule 13 has a superfluid leak. Cryomodule 9 has a large air leak on an end plate o-ring, and cryomodule 11 cavity B has never operated due to a high coupling of fundamental power through the HOM. Cryomodule 20 will be removed from the linac in the summer of 2012 and replaced with the spare High Beta cryomodule. Troubleshooting and repair of cryomodule 20 will occur in the RFTF cleanroom

Operating gradients of high beta cavities are lower than design value due to the electron loadings and collective effect from the electron loadings. In-situ plasma processing is expected to improve the performance of these cavities. Development of SRF facilities which will support the R&D and implementation of these processes is critical to the continued successful performance of the linac [4].

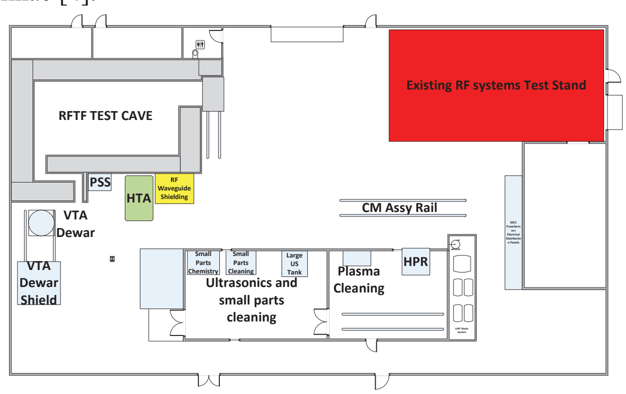

Figure 1: SRF Facilities at SNS.

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SRF FACILITY DEVELOPMENT

The SNS has established as a priority developing capability of performing in house repairs to SCL systems, providing R&D focused on improving our application, and supporting our Second Target Station, and other future upgrades with increased capability. Critical to the success of this group is building facilities and equipment that can provide a balance among all four functions of processing, assembly, R&D and, testing: 1) Processing: Chemistry (BCP, EP, Small Parts), Ultrasonic Cleaning, High Pressure Rinse, 2) Assembly: Clean Room, Assembly Rails and Tooling, 3) R&D: Plasma Processing, cavity and fundamental power coupler development for upgrade project, 4) Testing: CTF refrigerator, cryomodule test in test cave, vertical test system, HTA, 4-way waveguide system, RF control room.

Additional facilities identified as needed to support this mission are currently under development and commissioning.

High Pressure Rinse

A High Pressure Rinse system has been procured and is currently undergoing installation in the RF Test Facility cleanroom. This system is designed to rinse internal surfaces of SNS style cavities as well as retain the capability to rinse multiple other structures including smaller single or multi-cell cavities for plasma processing testing. This system will bulkhead through the cleanroom wall allowing access for maintenance from outside of the cleanroom. The HPR will be supplied by the existing Ultra high purity water system and will utilize a three head Lewa reciprocating pump.

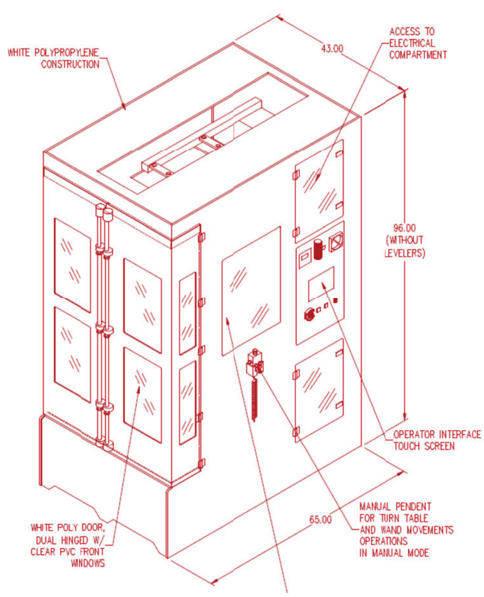

Figure 2: SNS high pressure rinse.

Vertical Test Area

The SNS Vertical Test System (VTS) is a system to conduct testing and qualification of superconducting radio frequency cavities. The VTS consist of a pit, code stamped dewar, and radiation shield. The pit is below the floor and has a square opening 5.5' x 5.5' x 2' deep. Below the square pit the dewar fits in a cylindrical 3' diameter x 12' deep shaft. A 1.5' x 2' deep trench allows access to the dewar for the piping, rf-cables, and instrumentation. The dewar is an ASME code stamped pressure vessel. It is designed to a pressure of 3 atm absolute and a temperature of 1.8K. The helium vessel has an inside diameter of 26.5". The radiation shield is moveable lid with stacked lead. The radiation shield is designed for 20MeV 200 nA. The radiation shield has varying thickness from 6"-10" of lead based on the radiation analysis. The radiation shield lid rolls on a track and Hillman rollers. The lid is opened and closed with a push-pull chain system. The weight of the shield lid is 44 tons.

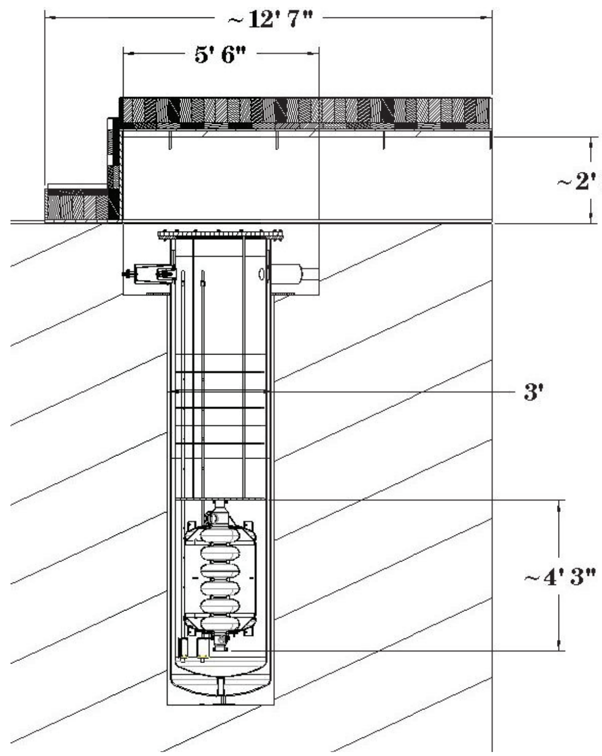

Figure 3: SNS Vertical Test system.

Cryogenic Test Facility (CTF)

A dedicated helium cryogenic system is being built at the SNS to support the Superconducting RF Testing Facility (SRFTF) at 4K. FIGURE 4 shows the block diagram that depicts the process flow diagram of the CTF system. The system is designed such that it can be upgraded to 2K system by adding a Kinney process pump system and 2K refrigeration recovery cold box. The system is designed to support any single testing activity including a cryomodule in the Test Cave, cavities in the HTA, VTA or in portable dewars. The system is also designed to be part of the backup system of the current CHL to keep the LINAC at 4K during the CHL maintenance in the future. Currently the cryogenic storage dewar and oil removal system are installed. The cold box, distribution box, and compressor for this system are scheduled for delivery May 2013.

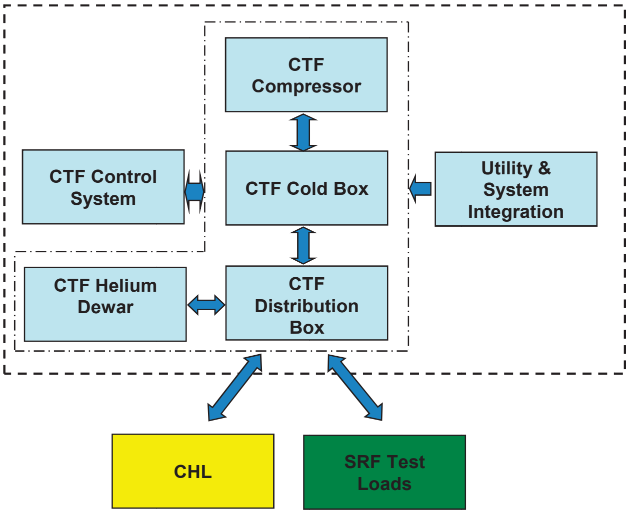

Figure 4: CTF Block Diagram.

SRF Facility RF System

The new facility utilizes the existing Radio Frequency Klystron Test Stand for the RF power source along with dual low level radio frequency (LLRF) control systems capable of testing both 402.5 MHz and 805 MHz systems simultaneously. One of the control systems is based on the standard SNS Linac LLRF control system (shown in Figure 5) that is fully compatible with the normal operating conditions experienced by the cavities in the linac. While the second control system only provides open-loop operation. Full personnel protection safety (PPS) and oxygen deficiency hazard (ODH) systems have been installed to ensure safe operation of the facility.

A four-way waveguide RF power distribution system for testing the SNS multi-cavity cryomodule to investigate the collective behavior has been developed [5]. A single klystron operating at 805MHz in 60Hz 8% duty cycle powers the 4-way waveguide splitter to deliver up to 600 kW to Individual cavities. Each cavity is fed through a waveguide vector modulator at each splitter output with magnitude and phase control.

Figure 5: SRF Facilities Control Room.

Horizontal Test Apparatus (HTA)

A Horizontal Test Apparratus is being built to enable testing of a cavity in a helium vessel while integrated with the Fundamental Power Coupler. This will allow testing of the cavity in the same RF and thermal configuration as in the cryomodule. This will allow validation of endgroup design, enable testing with high power pulsed operation, as well as provide a flexible instrumentation platform and support plasma processing R&D. The vacuum vessel and internal shielding has been fabricated and the cryogenic piping and pressure vessel compliance upgrades are currently in ongoing.

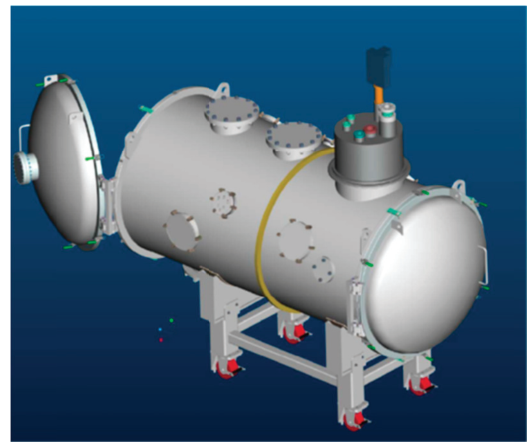

Figure 6: SNS Horizontal Test Apparatus.

SUMMARY

The SNS is taking a multi-faceted approach to maintaining and improving its linac. A balanced set of facilities which support processing, assembly, and testing of cavities are currently being placed into service. Additionally an aggressive R&D program which will develop new test cavity designs, and develop and test in-situ plasma processing techniques is under way. Multiple cryomodule repairs are planned for the future. The high beta spare cryomodule will allow comprehensive repairs to be performed on cryomodules with minimal impact on accelerator operations. Development of a medium beta spare will also be critical to supporting this program.

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