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STATUS OF SRF FACILITIES AT SNS*

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Abstract

As a part of an ongoing process to maintain and improve the performance of its Superconducting Linac (SCL) the Spallation Neutron Source(SNS) is building facilities for processing and testing Superconducting Radio Frequency (SRF) cavities. Recently both a High Pressure Rinse (HPR) tool and a Vertical Test Apparatus (VTA) have been built and commissioned. The HPR is a commercially fabricated piece of equipment which is customized for the SNS application. The VTA was specified, designed and developed by the SNS. This paper will outline the design features as well as the commissioning results for both systems.

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. The Superconducting Linac systems group has as a significant priority, developing the capability to process, clean and test SRF structures for use in accelerating equipment. The processed and tested components will be used for research and development of plasma processing and other processes needed to improve the performance of the SNS accelerator. Additionally the repair and maintenance of the SNS superconducting accelerator will periodically require reprocessing of cavities to repair damaged or contaminated surfaces prior to reassembly into a cryomodule. Future upgrades to the SNS accelerator, including the Second Target Station (STS) project will also require the same capabilities. A balanced set of facilities which support processing, assembly, repair, and testing of cavities and cryomodules are currently being placed into service for the SNS SRF test facility. Currently installed items include:

- 5-MW, 805-MHz RF test stand
- A fundamental power coupler processing system
- Four Way Waveguide System
- SRF Test Cave for cryomodules and HTA
- Class 1000 / Class 100 / Class 10 cleanroom
- Cryomodule string and cold mass assembly tooling
- Cryomodule assembly/repair area
- Ultra-pure water system
- Ultrasonic cavity cleaning system
- Cavity High Pressure Rinse System (HPR)
- RF Control Room
- Vertical Test System (VTS)
- Horizontal Test Apparatus (HTA)
- Cryogenic Test Refrigerator
- Plasma Processing R&D system

On-going activities include installation Kinney pumping system for 2K operations of the VTS and Test Cave, and a centrifugal barrel polishing system.

This paper will briefly discuss the design features and commissioning for the SNS high pressure rinse (HPR) tool as well as the Vertical Test System (VTS).

HIGH PRESSURE RINSE

A High Pressure Rinse system, shown in Fig. 1, has been procured and installed in the RF Test Facility cleanroom. This system is a commercially fabricated tool that was specifically 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, 9-cell ILC style cavities and cavities as large as a 650 MHz design. This system was bulkheaded through the cleanroom wall allowing access for preventative maintenance and most repairs of the system from outside of the cleanroom. The HPR is supplied by the existing Ultra high purity water system and utilizes a three head Lewa reciprocating pump. The system can deliver filtered UHP water at up to 100 bar and up to 20 lpm. The system is designed to allow the operator to safely insert the cavity for cleaning and utilize a low mounting height for the cavity. This provides an added measure of safety for the operator. The spray wand is cantilever mounted to the servo-controlled lift mechanism which is mounted in a separate compartment at the rear of the cabinet. The externally mounted lift mechanism ensures a minimal amount of moving parts inside the rinsing compartment providing a cleaner, lower particulate environment for the cavity. The cavity turntable has mounting receptacles for positioning and aligning the cavity in the tool. The table is belt driven by a motor also contained in a separate compartment away from the cavity.

A nitrogen heater is installed in the system for nitrogen drying of the cavity after the rinse cycle is complete.

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Figure 1: SNS high pressure rinse.

A second cabinet located outside of the clean room houses the LEWA pump used to deliver the high pressure water. This system also houses the variable frequency drive and all pump controls and interlocks.

The operator interface is a touch screen located on the side of the rinsing cabinet. Multiple recipes can be programed and stored for use. The system can be operated in manual as well as auto mode and all process parameters including pump speed, table rotation speed, wand position, and speed, as well as rinse duration can be set. The system alarms conditions are easily established and monitored at the machine interface. The system also is able to log key process parameters such as water flow rate and pressure.

COMMISSIONING

The machine has had many cycles performed to optimize process parameters as well as check out tooling and alignment techniques. Developing the operating procedures is very easy, the system can be taught the top of the cavity by moving the spray wand into position in the manual mode. Once the location of top of the cavity is established the spray region is input into the recipe by inputting the start and stop distances from the top of the cavity. This works very well and is easily editable to account for differences in cavity geometry or tooling height. As a part of the commissioning activities, a spray head was designed to provide water to the cavity 30 degrees off horizontal, spraying both upward and downward to ensure complete coverage of the cell walls. The head is equipped with a total of six nozzles which are 15 degree fan nozzles. This symmetrical nozzle design, shown in Fig. 2, has 3 opposing spray jets at each of the two different nozzle heights. This prevents the spray head oscillation that is often induced when a single unopposed spray jet passes by the cavity equator.

Figure 2: Spray head (6 nozzle design).

Initial testing with cavities and Lexan tubes indicated adequate coverage of the interior surfaces and improved wand head oscillation dampening. The current cavity cleaning procedure utilizes approximately 4.5 l/m of 950 psi water and sprays a 0.2” increment every minute. The cavity turntable rotates 2 revolutions per minute. This allows a slight overlap of the water jet at the iris location a significant overlap between steps at the equators. Limited RF testing availability has made it difficult to optimize cleaning parameters but as facility throughput increases additional process validation measures can be taken.

Issues Identified During Commissioning

The overall operation of the machine is quite easy and very intuitive; two areas still require additional attention. The wand mounts a significant distance from the cavity flange, and is held stationary at a single point. This can allow oscillation induced flex in the wand and cause the spray head to move significantly in the horizontal direction. Very little force is required to deflect the wand head off the centreline of its axis. This so far has not posed a significant problem for the SNS style cavities with a greater than 3 inch aperture but for higher frequency cavities with a smaller internal diameter, this design might pose a problem. The new spray head design offers significant improvement by dampening this oscillation.

VERTICAL TEST SYSTEM

The SNS Vertical Test System (VTS), as shown in Fig. 3 is a system to conduct testing and qualification of superconducting radio frequency cavities. The VTS consist of a pit, code stamped dewar, RF system, personnel protection system and radiation shield

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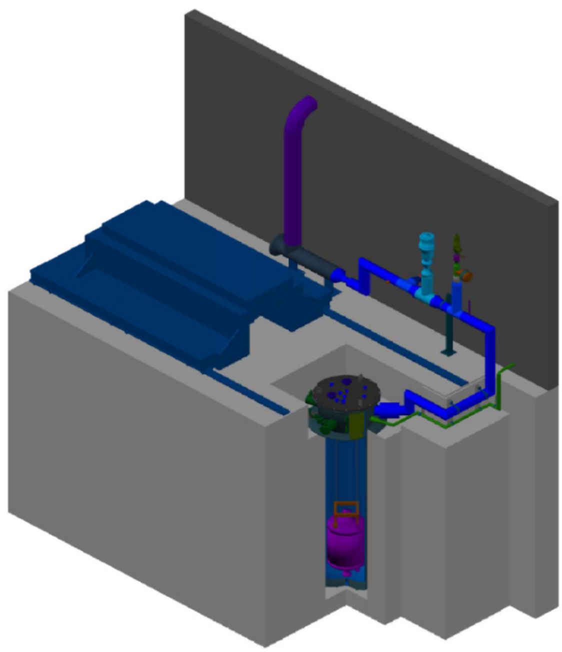

Figure 3: VTS system overview.

Vertical Test System Commissioning

The VTS system has been commissioned and has had three total runs. The purpose of these runs was to perform system check out on the VTS RF system, verify Radiation shielding performance, perform interlock system performance, as well as the test the performance and operability of the cryogenic test facility refrigerator. The systems have all performed very well to date.

RADIATION SHIELD

The Radiation shield has performed as designed. The shield opens and closes smoothly and all interlocks work appropriately. It has been tested at various cavity operating gradients and no significant leaks have been identified. The system is interlocked to prevent the introduction of RF unless the shield is in its fully closed position. The cavities tested thus far have not allowed sufficient gradients to determine radiation protection performance of the shield up to its maximum design basis. Additional testing will be required to determine the shield performance at maximum expected dose rates underneath the shield.

CRYOSTAT

The cryostat is an ASME code stamped pressure vessel. It is designed to a pressure of 3 atm absolute and a temperature of 1.8K. The static load on the cryostat is approximately 30 watts at 4K operation. The system is now connected to the Kinney pumping system and all future tests will have the option of pumping for 2K operation. The new piping design incorporating the Kinney system will still have a bypass allowing 4K operation when desired.

RF SYSTEM

The RF system hardware, shown in Fig. 4, is installed in the existing SNS RFTF control room, and programming was based on existing systems in use at both Jefferson Lab and Fermilab. The system was built using commercially available hardware including National Instruments hardware for data acquisition and processing. The controls are Labview based. A Frequency detection scheme was added to the controls to allow te system to automatically find cavity frequency. The system has also been modified to allow both pulsed and CW operation.

The RF equipment includes a 2KW Tomco solid state amplifier, National Instruments PXIe 8133 (1.73 GHz Quad-Core Controller), Agilent Equipment 53230A Frequency Counter, two Agilent E4416A Power Meters, two Agilent E4417A Power Meters, and a N5181A Signal Generator.

Figure 4: SNS RFTF Control Room.

The Integrated RF system has performed as designed during the initial commissioning tests.

CONCLUSION

The SNS Superconducting Linac Systems Group has made great strides in pursuit of a full complement of SRF processing, assembly, and testing facilities. These facilities when completed will enable the maintenance and repair of the existing linac, process development for future improvements, as well as processing, assembly and testing of cavities and cryomodules for future linac upgrades. The commissioning of the two facilities described above represents two more successful steps toward completion of SRF facilities at SNS fully capable of supporting current and future missions of the accelerator.

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