PERFORMANCE CHARACTERISTICS OF JEFFERSON LAB'S NEW SRF INFRASTRUCTURE*

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Abstract

In the past two years, Jefferson Lab has reconfigured and renovated its SRF support infrastructure as part of the Technology and Engineering Development Facility project, TEDF. The most significant changes are in the cleanroom and chemistry facilities. We report the initial characterization data on the new ultra-pure water systems, cleanroom facilities, describe the reconfiguration of existing facilities and also opportunities for flexible growth presented by the new arrangement.

INTRODUCTION

The US Department of Energy has a program designed to upgrade existing substandard facility infrastructure within the Office of Science laboratory system. Jefferson Lab won a competitive award from this system, the Science Laboratory Infrastructure (SLI) program, to build the Technology and Engineering Development Facility Project (TEDF). The project allowed elimination of substandard structures and provides improved:

- Energy efficiency
- Life-safety code compliance
- Work-flow efficiency
- Facility sustainability
- Human work environment
- Technical quality of facilities for future work

The TEDF project provides new homes for members of several Jefferson Lab organizational units, including the SRF staff, most of the Engineering Division, and Physics Division instrumentation groups. The new building set meets the "green building" standards of LEED Gold™. The TEDF Project is now complete and commissioning of the reworked technical facilities is underway.

We have recently reviewed for the community the history of SRF facilities at JLab and the multi-purpose design strategy for the SRF portion of TEDF project [1]. Here we describe the new infrastructure as presently realized and outline its performance characteristics.

NEW FACILITY DESCRIPTION

A new 3,100 m^2 SRF technical work facility was occupied in the summer of 2012. This new structure is appended to the south end of the existing Test Lab building, home to all previous SRF work at JLab.

The second phase of the TEDF project, now complete, was to fully renovate the existing Test Lab building. All internal structures and utilities were demolished and removed with the exception of the SRF cryogenic test areas, the vertical test area (VTA) and the cryomodule test facility (CMTF). A large concrete shielding wall originally constructed in the 1960s for the NASA synchrocyclotron was removed from the center of the high bay to allow growth of the VTA staging and support areas. A schematic layout of the new facility is presented in Figure 1. A summary of compared characteristics of some of the old and new SRF facilities in the Jefferson Lab Test Lab is presented in Table 1.

Chemroom/Cleanroom Suite

A unique feature of the new TEDF SRF facility is the ~800 m^2 chemroom/cleanroom suite. Two separate chemrooms are provided, one for larger components and more production-style cleaning and chemical processing activities, the other for developmental and research activities. Both of these rooms are outfitted with acid-compatible exhausted wet benches, ultrasonic cleaners, and robust safety systems. To minimize manual handling of acids, standard BCP and EP electrolytes are plumbed directly to use locations from a nearby external building. The existing JLab horizontal electropolish cabinet was relocated into the production chemroom and has been recommissioned. The air supply to both chemrooms is 100% HEPA filtered. Both chemrooms also have cleaning stations and pass-throughs that connect to the 380 m^2 cleanroom. All material enters the cleanroom via one of these routes. The cleanroom meets ISO Class 4 and International Standard 14644. It has 100% HEPA filter coverage with at-grade perforated floor return.

An appendage of the cleanroom extends into the Test Lab and under the existing high bay bridge crane. From this horizontal-flow cleanroom, now called the Vertical Attachment Area (VAA), SRF cavity vertical dewar test inserts are assembled and transferred via the crane to the VTA for cryogenic testing.

Adjoining both chemrooms and one wall of the cleanroom is the Process Support Area (PSA). The PSA contains all process piping for the chemrooms and the cavity processing equipment/tools that are accessed from inside the cleanroom.

The cavity process tools, such as BCP, HPR, and VEP, are bulk-headed into the cleanroom from the PSA. Because of the actual and potential presence of hazardous acids, all effluent drains from the chemrooms and PSA, as well as any potential spills, gravity drain through the PSA to an external collection tank. A new acid neutralization system draws from this tank and increases the pH to an acceptable level before discharge to the sanitary system.

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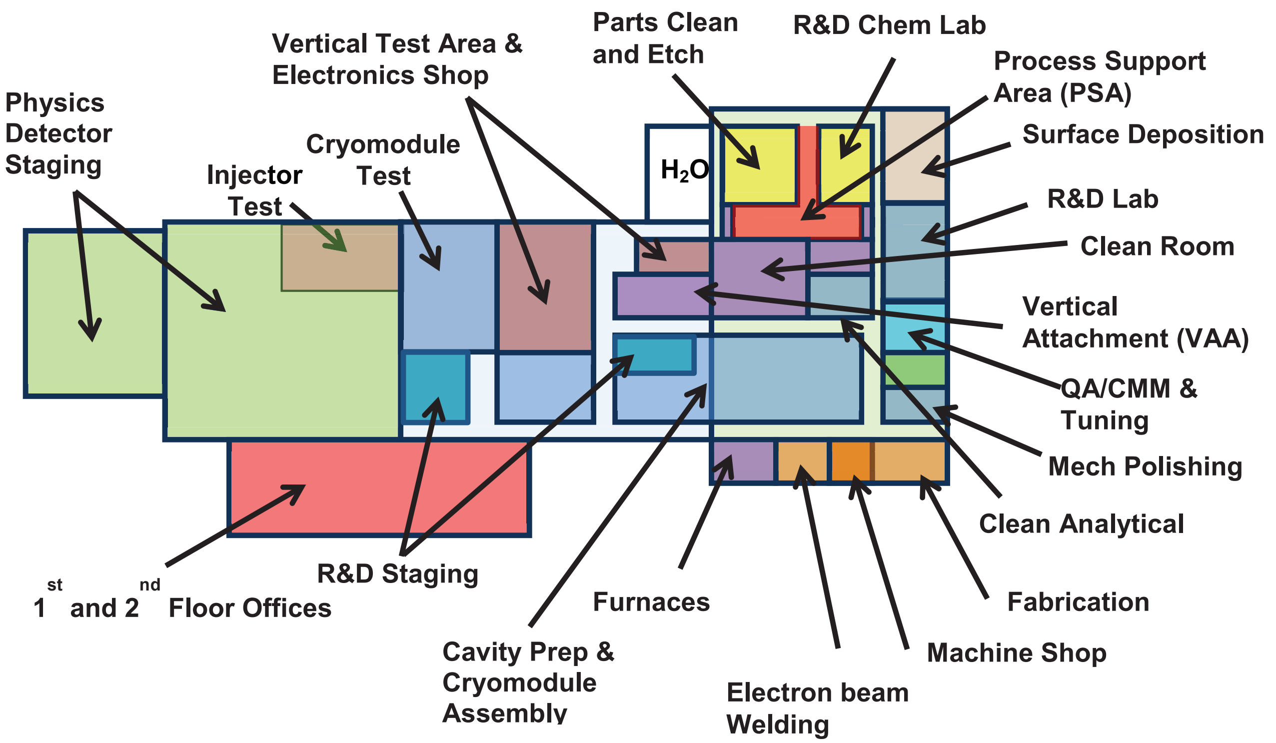

Figure 1: Overview schematic of new Test Lab/TEDF SRF facilities at Jefferson Lab, occupied summer 2013.

There is flexible provision in the cleanroom to accommodate the full spectrum of activities from small research projects to full cryomodule cavity string assemblies. A double "garage-door" cleanroom load lock provides the exit path of completed string assemblies.

The TEDF Project provided new building infrastructure, but not new equipment. The existing BCP acid etch cavity processing tool, high pressure cavity rinse tool, and vertical electropolish development tool have been relocated into the PSA, each with front face open into the new cleanroom. (See Figure 2.) Hook-up and recommissioning of the process tools is nearing completion. The horizontal electropolish system, used for the 12 GeV Upgrade cavities and ILC cavity R&D, has been relocated into the production chemroom and recommissioned for general use. Procurement and installation of a new HPR cabinet is anticipated in the coming year. This will be the first tool able to take advantage of the unique TEDF architecture that allows for significant below-grade structure in the tool. Significant contamination control, ergonomic, and durability improvements are expected from the new design, as well as acceptance of a wider range of cavity sizes.

Figure 2: BCP and HPR tools bulk-headed into the new cleanroom and a view from the PSA.

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Table 1: Jefferson Lab SRF Facility Characteristics

Facility/Utility	Former Test Lab	TEDF Test Lab
Clean Room		
Main cleanroom design	Non-unidirectional	Unidirectional (vertical)
Air returns	Low wall returns	Subfloor return plenum
HEPA coverage	~70%	100%
ISO 4 (m^2)	9.3	227
ISO 5 (m^2)	148	-
ISO 4 assembly bay #	1 @ 9.5 m^2	8
ISO 4 string assembly area	0	1
VAA design	Non-unidirectional	Unidirectional (horizontal)
VAA (ISO 5) (m^2)	41	80
VAA insert stations #	3	6
VSA insert stations #	8	18
Bulkheaded process tool stations #	0	8
Ultrapure Water (UPW)		
Resistivity (Mohm)	17.8	18.2
TOC (ppb)	10-50	< 2
Particles - 0.05-0.1 µm	ASTM E1.1	ASTM E1.1
Particles - 0.1-0.2 µm	ASTM E1.2	ASTM E1.2
Particles - 0.2-0.5 µm	ASTM E1.1	ASTM E1.2
RO makeup rate (lpm)	38	265
Max POU usage rate (lpm)	45	189
POU system pressure (psi)	30	55
Hot UPW temperature (°C)	81	81
HUPW Max POU usage rate (lpm)	15	76
Chemistry		
Wet bench #	3	4
Acid bench/hood #	4	5
Large cavity ultrasonic #	1	3
Production wet room (m^2)	44	91
Production acid (m^2)	34	75
EP room (m^2)	55	N/A
R&D chemistry (m^2)	92	106
CM Assembly		
Rail capacity: # of CM in progress	2	4

Materials Research and Development

Within the large cleanroom an interior room is allocated to analytical equipment focused primarily on particulates that can generate field emission inside of accelerator cavities. The scanning electron microscope/scanning field emission microscope (equipped with EDS and EBSD) and field emission viewer systems have been relocated here. The SEM/EDS/EBSD system has been recommissioned. The Field Emission View suffered damage during the move and awaits re-engineering of the high voltage system.

The other surface material characterization instruments (profilometer, SIMS, and multi-purpose Auger system) were consolidated in a portion of the RF development lab.

The several JLab surface deposition systems have been collected into a common lab in the new facility. These include the general-purpose sputter coating system, the ECR plasma niobium energetic condensation research system, the UHV multi-technique deposition system, all of which have been fully restored to operation. A new furnace for Nb_3Sn reactive coating of single-cell cavities has recently been delivered and will be commissioned soon. A new HiPIMS cavity coating system under construction will also go here[2]. The infrastructure in this lab was laid out to accommodate eventual addition of thin film coating systems for multi-cell cavities as those techniques mature. A view of one system in this consolidated facility is provided in Figure 3.

Figure 3: SRF thin film research station in the new surface deposition laboratory.

Cavity Fabrication Facilities

The TEDF project has enabled JLab to retain and strengthen its SRF cavity development and prototyping capability. The sheet metal forming and machining equipment have been consolidated. The electron beam welder was relocated into a dedicated room in the new facility and its vacuum system was upgraded. The set of brazing and high temperature vacuum furnaces were collected into a common room. The cavity tuning and inspection stations were also collected together conveniently, including the new CYCLOPS cavity internal inspection system [3].

One room in the new facility has been dedicated to mechanical surface polishing operations. This presently includes flange polishing, important for cryogenic vacuum seals using indium wire gaskets, and a centrifugal barrel polisher (CBP) used to polish the interior surface of new cavities.

Vertical Testing Capacity

Cavities processed in the cleanroom must be evacuated and transported to the vertical test area (VTA) for cryogenic testing. This transition takes place between the

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vertical assembly area (VAA) and the vertical support area (VSA). The VAA is a horizontal flow ISO 4 cleanroom with ceiling access holes to receive cryogenic test inserts onto which cavities are mounted for testing. The VSA in the Test Lab highbay is adjoining the VTA and is the location where inserts are serviced, cavities can receive 120°C bakeout prior to test, and instrumentation is mounted and dismounted.

Prior to the renovation, the limited capacity of the VAA and VSA frequently presented a bottleneck in the cavity testing workflow. As part of the TEDF project, both were doubled in size and the environmental quality improved. This arrangement now allows work to flow in and out of the eight vertical cryogenic dewars in the VTA in an uncongested manner. The VTA and new VSA are shown in Figure 4.

As previously, the VTA and the cryomodule test facility (CMTF) are supplied by a dedicated closed-loop helium liquifier facility which has a capacity of 3600 4.5 K liquid liters/day. This supports a sustained test rate of >2 cavity tests per day, depending on dewar size in use and test duration. The larger VTA dewars have a 48 hour cycle time, and the small R&D test dewars can easily cycle daily.

Figure 4: View of VTA and expanded VSA.

Cryomodule Assembly Facilities

The cryomodule assembly facility is laid out as four parallel assembly lines. These extended assembly rail systems create the opportunity to serve up to four independent activities/projects simultaneously, including rework of any type previously built. These facilities include overhead crane systems for each line. See Figure 5.

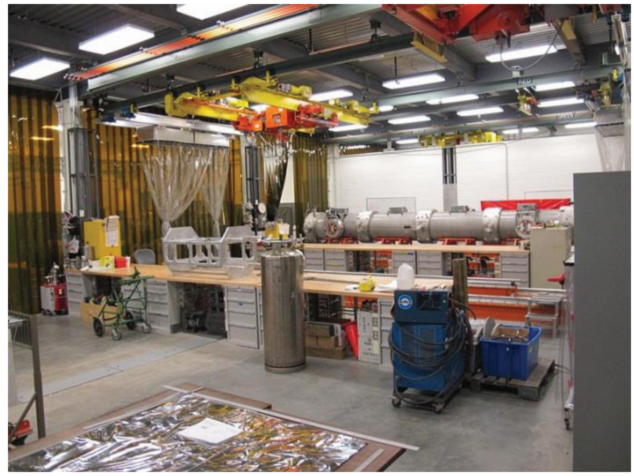

Figure 5: New cryomodule assembly area.

Cryomodule Test Facility

The cryogenic test facilities were the only elements of JLab SRF infrastructure which were unchanged by the TEDF project, although there were extended access interruptions during the construction project. The CMTF retains its ability to perform cryogenic acceptance testing of JLab-built cryomodules, having recently completed such testing for the tenth C100 cryomodule for the CEBAF 12 GeV Upgrade.

SUMMARY

Realization of a new state-of-the-art SRF facility is nearing completion at Jefferson Lab. Its purpose is to provide high-quality support to DOE-supported local, national, and international needs for SRF accelerator system technology research, development, and construction.

ACKNOWLEDGMENTS

The JLab SRF staff owe great debts of gratitude to our colleagues in the Facilities Management department who provided the construction project management for the TEDF Project for enduring the multi-year trauma required to realize this new complex facility. Design elements were gleaned from the accumulated 25 year evolving experience with SRF at JLab, the broader experience of the A/E design company EwingCole, and the construction integration strength of Mortenson Co.

REFERENCES

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