

THE NEW 2ND-GENERATION SRF R&D FACILITY AT JEFFERSON LAB: TEDF*

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Abstract

The US Department of Energy has funded a near-complete renovation of the SRF-based accelerator research and development facilities at Jefferson Lab. The project to accomplish this, the Technology and Engineering Development Facility (TEDF) Project has completed the first of two phases. An entirely new 3,100 m² purpose-built SRF technical work facility has been constructed and was occupied in summer of 2012. All SRF work processes with the exception of cryogenic testing have been relocated into the new building. All cavity fabrication, processing, thermal treatment, chemistry, cleaning, and assembly work is collected conveniently into a new LEED-certified building. An innovatively designed 800 m² cleanroom/chemroom suite provides long-term flexibility for support of multiple R&D and construction projects as well as continued process evolution. The detailed characteristics of this first 2nd-generation SRF facility are described.

JLAB SRF FACILITY HISTORY

In 1987 the construction of CEBAF began on a green-field site in Newport News, Virginia. Since CEBAF was to be the first major research institution fully dependent on superconducting RF (SRF) technology in the US, a self-contained set of facilities using then-current technology were setup to support construction of CEBAF. To assure project success and on-going support capability, investments were made in chemical, cleanroom, assembly, and testing facilities that have served multiple needs for the subsequent +20 years.

These facilities enabled the construction of the 42 cryomodules for CEBAF, two cryomodules for the JLab FEL, 24 cryomodules for SNS, rework with upgraded techniques of the ten weakest cryomodules from CEBAF as part of the “C50 program” to establish a 6 GeV program, several prototype cryomodules, and most recently ten “C100” cryomodules for the CEBAF 12 GeV Upgrade project. These projects plus additional R&D programs accumulated over 4200 cavity preparation and vertical cryogenic testing cycles.

Participation in the SNS construction project and the ILC R&D program provided opportunities to make some improvement to the cavity cleaning and testing capabilities. The evolution and aging of the infrastructure resulted in adequate, but constrained capabilities and significant on-going maintenance challenges.

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DOE SLI PROGRAM

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 allows 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 completed TEDF project will provide 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 will meet the “green building” standards of LEED Gold™.

TEDF CONCEPTUAL DESIGN

The architectural engineering firm EwingCole was retained to integrate user requirements into a coherent package. The firm took a blank-page approach to facility design, seeking to incorporate improved safety, energy efficiency, and work flow for SRF cavity development, fabrication, processing, assembly, testing, and provide increased build-out space for cryomodule assembly. Replacement of the cryomodule test facility and cavity vertical dewar test facility was briefly considered, but even simple duplication would have been much too expensive.

Lessons learned over the past +30 years of SRF cavity preparation were folded into facility requirements, as was equipment and support systems expertise from the semiconductor industry. This new facility was composed so as to strengthen our support of four parallel missions:

- Reliable on-going support for the CEBAF nuclear physics research program
- Research on performance-limiting aspects of SRF technology to push the net system costs down
- Development of new accelerating structures, improved SRF cavity processing methods, and prototype cryomodules for new applications
- Construction and delivery of SRF-based accelerator modules for Jefferson Lab and partner laboratories.

Anticipating the continued evolution of the designs, materials, and processes used in SRF cryomodules, the

new purpose-built facility was designed with flexibility of use in mind.

NEW FACILITY DESCRIPTION

The Technology and Engineering Development Facility Project has completed the first of two phases. A new 3,100 m² SRF technical work facility has been constructed and occupied in the summer of 2012. This new structure was appended to the south end of the existing Test Lab building, home to all previous SRF work at JLab. Each of the SRF work processes with the exception of cryogenic testing has been relocated into the new building.

The second phase of the TEDF project is now underway, fully renovating the existing Test Lab building. All internal structures and utilities are being demolished and removed with the single exception of the SRF cryogenic test areas, the vertical test area (VTA) and the cryomodule test facility (CMTF). A fully reconstructed office wing will reoccupy areas that were formerly technical work areas. A large concrete shielding wall originally constructed in the 1960s for the NASA synchrocyclotron has been removed from the center of the high bay to allow growth of the VTA staging and support areas. During this second phase construction period SRF staff are temporarily located in a new multi-use building that was also constructed during phase one. A schematic layout of the new facility is presented in Figure 1.

Chemroom/Cleanroom Suite

A unique feature of the new TEDF SRF facility is the ~800 m² 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, supply of standard BCP and EP electrolytes will be provided directly to use locations from a nearby external building. The existing JLab horizontal electropolish cabinet has been relocated into the production chemroom. The air supply to both chemrooms is 100% HEPA filtered. Both chemrooms also have cleaning stations and pass-throughs that connect to the 380 m² cleanroom. All material enters the cleanroom via one of these routes. The cleanroom is ISO Class 5 and meets International Standard 14644. It has 100% HEPA filter coverage with at-grade perforated floor return.

When complete, an appendage from the cleanroom will extend into the Test Lab and under the existing bridge crane. From this horizontal-flow cleanroom SRF cavity vertical dewar test inserts will be 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.

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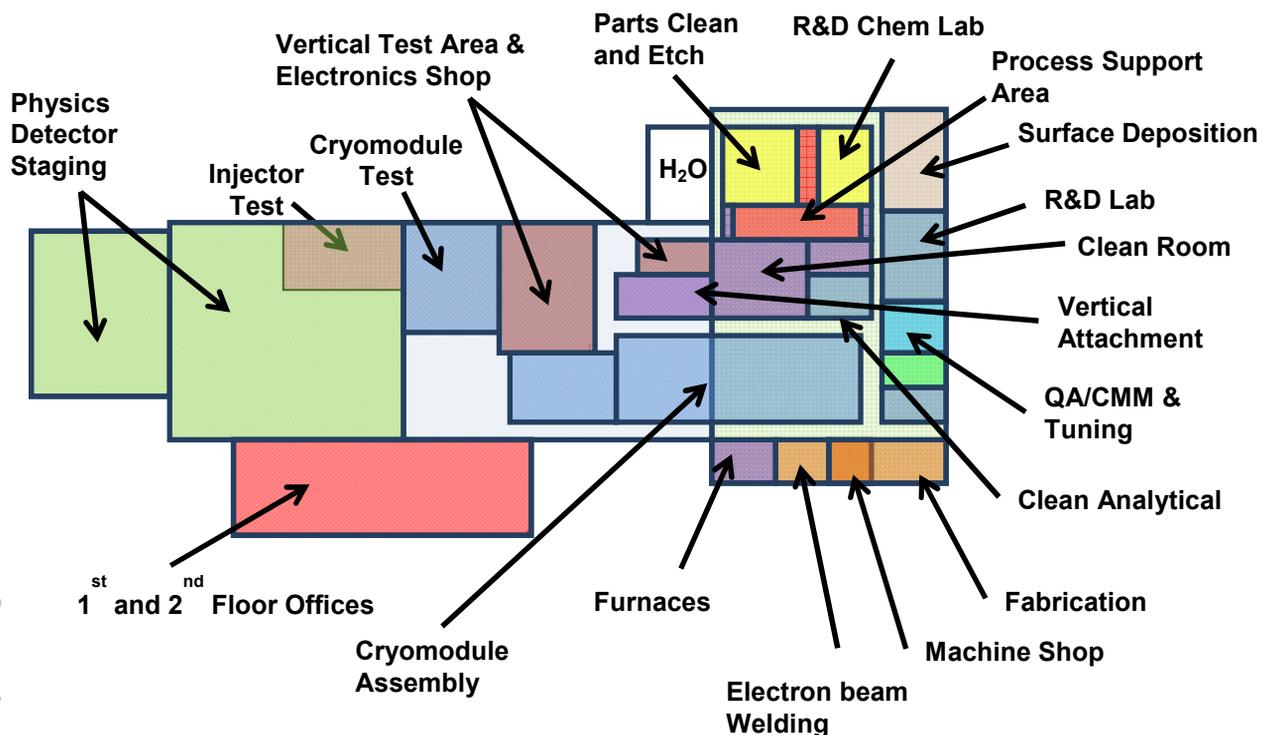


Figure 1: Overview schematic of new Test Lab/TEDF SRF facilities at Jefferson Lab, to be complete summer 2013.

The process tools 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. The acid waste neutralization system has a capacity of 60 gpm.

The TEDF project provides new infrastructure, but not new equipment. The BCP acid etch cavity processing tool, high pressure cavity rinse tool, and vertical electropolish development tool have been relocated into the PSA, with front face open into the new cleanroom. (See Figure 2.) Hook-up and commissioning of the process tools are underway. The horizontal electropolish system, used for the 12 GeV Upgrade cavities and ILC cavity R&D, has been relocated into the production chemroom and is being recommissioned.



Figure 2: BCP and HPR tools bulk-headed into new cleanroom.

Water System

The new SRF ultrapure water (UPW) system has a makeup water capacity of 60 gallons per minute (gpm) and a polish water capacity of 120 gpm (90 gpm ambient loop and a 30 gpm hot UPW loop @ 60°C). The UPW system is designed to produce microelectronics grade

water with a resistivity of 18.2 Mohm-cm, total silica less than 3 ppb, total oxidizable carbon (TOC) below 2 ppb and an overall quality equivalent to type E-1.1 as specified in ASTM D5127-07, with the exception of dissolved gases and boron. This water is plumbed to all chemroom work locations and to each tool in the PSA.

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 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, and a fledgling niobium HIPIMS deposition system. The infrastructure in this lab was also laid out to accommodate eventual addition of thin film coating systems for multi-cell cavities as those techniques mature.

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.

Cryomodule Assembly Facilities

As a result of the need to accommodate the concurrent assembly of 12 GeV cryomodules for CEBAF during the TEDF realization period and also address on-going maintenance and future construction projects, the cryomodule assembly facility is laid out as four parallel assembly lines. During the second phase of the TEDF project, when access to the Test Lab high bay is unavailable, only half of these four lines are available, and two are dedicated to completion of the remaining 12 GeV “C100” cryomodules. These extended assembly rail systems will create the opportunity to serve up to four independent activities/projects simultaneously in 2014 and beyond.

SUMMARY

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