Fermilab

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SRF at Fermilab: Cryomodule Assembly Facility

Fermilab's Cryomodule Assembly Facility consists of two areas: cavity dressing and string assembly in MP9 and cryomodule assembly in Industrial Center Building (ICB). MP9 is a 12,000-square-foot facility that was designed using DESY's Hall 3 facility as a guide. Fermilab's facility consists of a clean room, cavity string assembly rail and cold mass assembly fixture that will support both the 1.3 GHz and 3.9 GHz cavity programs. Fixtures are being developed for 325 MHz and 650 MHz string assembly as well. ICB is an 18,000 square-foot production floor building, which will accommodate two parallel cold mass assembly areas and final assembly areas in order to achieve the ultimate throughput for the facility - one cryomodule per month.

Technicians connecting superconducting cavities together in Fermilab's clean room

Inside the facility at MP9, Fermilab engineers and scientists receive chemically processed bare cavities. These cavities are prepared for the vertical test. If the test is successful, these cavities then are welded inside a helium vessel. The cavities are then dressed with a power coupler in the clean room. A tuner and magnetic shielding are added before heading off for high power radiofrequency testing in the Horizontal Test Stand. If the cavity meets the desired performance criteria in the test stand it returns to the clean room to be assembled into a string of eight cavities for eventual inclusion in a cryomodule.

Fixtures in ICB were used to assemble a 1.3 GHz cryomodule

The string of cavities is then mated with a cold mass and transported to the Industrial Center Building for final assembly. In this area, additional instrumentation is attached and the cavities are aligned. The string assembly is then inserted into a vacuum vessel and the warm couplers are attached, resulting in a completed cryomodule ready for testing in the SRF Test Facility at NML.

A large effort went into constructing the optimal clean room. The 2500-square-foot clean room is divided into three sections to accommodate each stage of the labor intensive assembly process. Rated according to the number of particles per cubic foot, the clean room contains Class 1000, Class 100 and Class 10 areas. The first section, a Class 1000 Ante Clean Room, is a prep room where the

cavities and other peripheral parts are submerged in ultrasonic baths and cleaned with ionized nitrogen to reduce the particle count to less than 10, a critical step before entering the next stage of the assembly process.

The class 10 area, which is used to assemble the dressed cavities to form a string, has more filters and more floor perforations in it to constantly keep air flowing. Every six seconds 100% of the air in the clean room changes with approximately 90 feet per minute laminar air flow speed. While designing the clean room, Fermilab worked closely with DESY scientists and engineers, who described their ideal clean room scenario, and consultants, who specialize in building clean rooms for major corporations. Any person who enters the room must first 'gown up' in special head-to-toe gear – no make-up, perfume or lotion allowed. This is just a small part of the strict clean room protocols that will be enforced for the cavity string assembly clean room.

Cavity string assembly rail inside Fermilab's Cryomodule Assembly Building.

Fermilab used the Cryomodule Assembly Facility to assemble its first cryomodule, CM1. Parts for this cryomodule were supplied by DESY and INFN, essentially as a 'cryomodule kit' that consists of approximately 1200 components. Fermilab worked closely with DESY scientists, engineers and technicians to assemble this first cryomodule, which is now undergoing testing at the SRF Accelerator Test Facility at NML. Fermilab estimates that this first cryomodule will take approximately four months to assemble, but after a learning curve, the goal is to produce one cryomodule per month. In parallel, Fermilab scientists and technical staff built a 3.9 GHz cryomodule for the DESY's FLASH facility. The 3.9 GHz cryomodule used much of the same infrastructure in the Cryomodule Assembly Facility. Work is now underway for the next cryomodule, CM2, to be assembled and tested at Fermilab.