A JOINT ANL/FNAL CAVITY SURFACE PROCESSING FACILITY

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Abstract

Common interest at Argonne and Fermi National Accelerator Laboratories in developing superconducting cavities for projects such as RIA, the ILC and the 8 GeV FNAL Proton Driver has led to a new joint cavity surface processing facility with initial operations to start this fall and full operations in early 2006. This 200 m^2 single cavity processing and assembly area located at Argonne will complement the planned superconducting module and test facility (SMTF) at Fermilab. New infrastructure includes two separate chemical processing rooms each connected to a common use class 1000 anteroom and two separate class 100 clean rooms. Other common facilities include a large exhaust-fume scrubber and an ultrapure water system servicing all chemical and clean rooms. The facility is sized to process a range of elliptical and TEM class cavities at a rate of several per week using modern processing techniques including chemical and electropolishing, ultra-pure high-pressure water rinsing, ultrasonic cleaning and clean room assembly.

INTRODUCTION

A facility for chemically processing and cleaning superconducting niobium RF cavities and for developing cleaning and processing techniques is being built at Argonne National Laboratory (ANL) as a collaborative effort between ANL and Fermi National Accelerator Laboratory (FNAL). The facility design is built upon four decades of experience in cavity electropolishing at ANL and incorporates new and state-of-the-art chemical polishing hardware and techniques.

The costs and effort for construction of this facility are being shared approximately equally by ANL and FNAL. To ensure that the facility's benefits and future operating and maintenance costs are shared equally, a memorandum of understanding between laboratories has been adopted. The ANL Physics Division administrates all safety rules, regulations and procedures and will grant operational approval for the facility following a formal safety review of the electropolishing and chemical polishing processes.

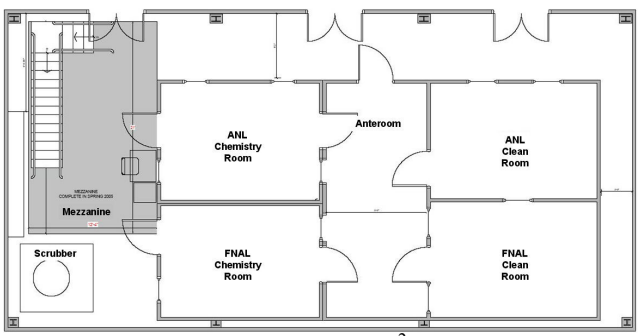

Figure 1: Schematic of the 200 m^2 surface processing facility in room B101 of Building 208 at ANL. This plan view shows the location of the exhaust fume scrubber, mezzanine, processing rooms, anteroom, and clean rooms.

FACILITY DESCRIPTION

The 200 m^2 surface processing facility contains two types of work areas: chemical processing rooms, and two classes of low particulate clean rooms. Figure 1 shows the plan view schematic of the facility with the primary work areas and facility infrastructure indicated.

Figure 2: A pair of large chemical processing rooms (left) and an exhaust fume scrubber (right). These facilities are sized to chemically process several cavities per week.

Chemical Processing Rooms

Two 15 m^2 chemical processing rooms, shown under construction in Figure 2, are available for chemical polishing and electropolishing operations. The chemical room on the left side is configured for buffered chemical polishing (BCP) of 1.3 GHz and 3.9 GHz multi-cell elliptical cavities and will be operated by FNAL personnel. ANL personnel will perform electropolishing and BCP procedures on a variety of cavity types in the other chemistry room.

The two chemical rooms are physically separate with liquid tight and acid impermeable floors and walls so that chemical operations may be performed in one room with assembly work ongoing in the adjacent room. Both rooms also have two access doors, large windows, and an integrated spill trench. To provide ventilation and to remove process fumes, both sides share a controllable 3000 cfm air scrubber. The air scrubber was designed with oversight from ANL Safety and removes 99% of the nitrogen dioxide and 95% of the acid mists generated

during chemistry operations [1].

Clean Rooms

Adjacent to the chemical processing rooms is a low-particulate clean area divided into three rooms:

1. A common class 1000 anteroom will be used for gowning, preliminary pre- and post-process cleaning, and storing parts, equipment, and supplies required for cavity cleaning and assembly.
2. The south-side (bottom of Figure 1.) class 100 area will be configured and used by FNAL. This clean room will primarily be used to do post-process rough rinsing and preparation for high-pressure rinsing at FNAL.
3. The north-side (top of Figure 1.) class 100 area is configured and used by ANL. A high pressure rinse apparatus suitable for essentially all existing cavity geometries will be located here.

Support Facilities

The high-bay area housing the facility also contains storage for drums of acid, and a new mezzanine for power supplies, electronics, and miscellaneous storage. A new dedicated ultra-pure water purification and reservoir system provides water for chemical processing and high-pressure water rinsing. The system produces 10 liter/minute of ultra-pure water with 18 MΩ-cm resistivity and has a 4500 liter storage capacity with a 40 liter/min flow rate to the processing and clean rooms. Figure 3 provides the UPW quality and system specifications.

Ultra-pure Water System Specifications

Contaminant	*Units*	Max. Value
Resistivity	*(Mohm-cm) @ 25 deg C*	> 18
Particulates	*1 (um/ml)*	2
Microorganisms	*(CFU/100 ml)*	1
TOC	*(ppb)*	50
Silica	*(ppb)*	5
Copper	*(ppb)*	1
Chloride	*(ppb)*	2
Potassium	*(ppb)*	2
Sodium	*(ppb)*	1
Residual solids	*(ppb)*	10
Zinc	*(ppb)*	5
Iron	*(ppb)*	2
Heavy Metals	*(ppb)*	10
System Parameters		
Make-up Capacity	*(liters/day) - minimum*	11500
Needed UPW	*(liters/day)*	6000
Flow rate	*(liters/min) (minimum)*	35
Working pressure	*bar (minimum)*	2.4

Figure 3: Joint Facility UPW system specifications and parameters

SURFACE PROCESSING

Electropolishing

Electropolishing has been the standard chemical treatment for processing niobium cavity rf surfaces at Argonne for the past four decades. Nearly 150 cavities operating at facilities around the world have been electropolished at ANL. The approach has been to use a highly adjustable electropolish apparatus to process virtually and desired geometry. An example of an electropolished surface of a beta=0.5 triple spoke cavity for the Rare Isotope Accelerator project is shown in Figure 4 and exhibits the smooth and lustrous surface which may be achieve by this technique.

The size of the new chemistry rooms (~15 m^2 each) and the ancillary electropolishing equipment such as power supplies, acid pumps and water chiller are all suitable to electropolish large cavities with an rf surface area >1 m^2. Efforts are underway to adapt the electropolish capability in the ANL operated chemistry room to the ILC-type 9-cell elliptical cavity geometry.

Figure 4: Electropolished subassemblies of the beta=0.63 triple-spoke resonator after final chemical processing at ANL.

Buffered Chemical Polishing System

Buffered chemical polishing is used throughout the world-wide SRF community to achieve accelerating gradients of 25 MV/m in beta=1 cavities. The BCP system, designed and built for the joint processing facility, is designed to reliably and safely achieve this gradient on ILC style 1.3 GHz cavities. Though sized for 1.3 GHz 9-cell cavities, plans are in place to process several 3.9 GHz 3rd Harmonic 9-cell cavities beginning in early 2006. In the future, the system can be adapted to process other larger volume cavities such as the 1.3 GHz ILC style 9-cell cavities.

The BCP process will be controlled by a semi-automatic gravity feed system that employs redundant safety and operational controls. The users can choose pre-determined recipes for acid/UPW volumes depending on the procedures being performed. These recipes, as well as multiple pH, resistivity, liquid level, and temperature sensors let the user know the status of all fluids in the BCP system in real-time.

High-Pressure Water Rinsing

High-pressure water rinsing (HPR) techniques have been used for several years at Argonne to consistently

achieve some of the best performance obtained in TEM-class drift-tube loaded cavities. A highly configurable HPR system permitting both vertical and horizontal rinsing of virtually any cavity geometry, including the ILC 9-cell cavity, will be operated in the class-100 area administered by ANL.

ACKNOWLEDGEMENTS

The authors wish to acknowledge the efforts of Betsy Grom (Argonne National Laboratory PFS-FEC) for her efforts in coordinating the facility construction and Karl Williams of FNAL AD/MSD for his work on the UPW distribution system layout.

This work was supported by the U. S. Department of Energy, Office of Nuclear Physics, under contract number W-31_109_ENG_38.

REFERENCES

[1] Operating and Maintenance Manual, Chicago Plastics Systems Inc.