

COUPLER DEVELOPMENT AND PROCESSING FACILITY AT SLAC*

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Abstract

A new facility to clean, assemble, bake and rf process TTF3 power couplers is in operation at SLAC. This facility includes a class-10 cleanroom, bake station and an L-band source capable of producing up to 4 MW pulses. This paper describes the facility, test results from processing a pair of couplers that will be used in cryomodules at FNAL, and efforts to simplify the manufacturing of the couplers for large scale production for ILC.

INTRODUCTION

The International Linear Collider (ILC) will contain about 16,000 superconducting cavities. Each cavity will have a power coupler that transports ~ 300 kW, 1.6 ms, 1.3 GHz rf pulses at 5 Hz from a waveguide feed at room temperature through a coaxial line to an antenna that protrudes into the 2 °K cavity beam pipe. Figure 1 shows the TTF3 coupler design [1], which was developed by the TESLA Collaboration and is being used for ILC cavity R&D in Europe and the US, and for the European XFEL project. The design is complex due to requirements on thermal expansion, heat load, vacuum, Qext adjustability and high voltage isolation. In particular, four thin bellows are used to allow flexibility and adjustability, the inner stainless surfaces are copper plated to reduce rf losses and better conduct heat and the windows are TiN coated to suppress multipacting.

The cryomodule program for the US ILC effort (and eventually PX) is centered at FNAL and SLAC is providing TTF3 couplers for the cavities that are being 'dressed' there [2]. These couplers are fabricated in industry using brazing and e-beam welding techniques, and then shipped to SLAC where they are inspected, cleaned, assembled in a class 10 room, pumped down, baked at 150 °C and then rf processed. This program has just ramped up and this paper describes the facilities, the procedures used, processing results and ideas for making the coupler fabrication easier, a goal that Orsay is pursuing aggressively for the ~ 800 couplers they will provide for XFEL [3].

CLEANROOM

The SLAC Coupler Cleanroom is a modular built construction located in the High Bay of Building 006 that includes a gowning room, air shower and class 100 and 10 clean areas (US FED-STD-209E standard) that are

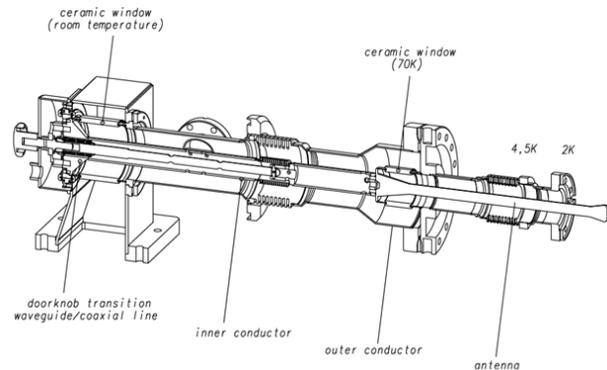


Figure 1: TTF3 L-Band Power Coupler.

operated with 400-560 air changes per hour. An interior view of the clean areas is shown in Figure 2. The class 10 area is 16' by 12' and uses 24 ULPA filters to reduce particulates. It also has an ultrapure (18 MΩ/cm) water rising station and table area for coupler assembly. The class 100 area is 12' by 12' and the air quality is maintained with 13 HEPA filters. This area includes a 56 gallon, 6 kW peak ultrasonic wash station and is mainly used for coupler cleaning and vacuum pump down and leak checking. Personnel entering the clean areas go through a class 1000 air shower for 45 seconds to remove contaminants on their garments after gowning. All the benches are electro-polished 304 stainless steel with perforated tops to maintain a laminar flow in the work areas. The majority of the construction material to fabricate the cleanroom is static dissipative to minimize particle attraction and ease cleaning. The flooring material complies with ANSI/ESD-S20.20 for Electrostatic Discharge (ESD) static dissipative material. A 7.5 ton chiller system maintains the facility air temperature at 68 °F.



Figure 2: SLAC Coupler Cleanroom: the class 10 area is in the foreground and the class 100 area and air shower is in the background.

* Work Supported by DOE Contract DE-AC03-76F00515.

ASSEMBLY AND PROCESSING

After the TTF3 couplers parts are received from the vendor they are inspected in a class 100k cleanroom at Building 33. The two main pieces are the 62 mm ID ‘warm’ coaxial sections that interface to the waveguide and the 40 mm ID ‘cold’ sections that include the antennas. The interior surfaces are examined using a boroscope and alignment fixtures are used to check critical angular orientations of the ports and flanges. Special attention is given when inspecting the welded regions for sharp edges and consistency of the weld. Also, the bellows sections are examined for oxidation and uniformity of the plating. After inspection, the parts are kitted into ESD boxes and moved to Building 006 where they are stored in nitrogen purged cabinets.

The couplers are assembled and rf processed in pairs using procedures similar to those developed at Orsay to prepare TTF3 couplers for the TESLA/XFEL programs [4]. For a given pair, all parts are wiped down and blown off before being brought into the class 100 area. The parts are then placed in an ultrasonic cleaner for 30-45 minutes that is filled with 40-50 °C ultrapure water and a diluted (1:100) cleaning agent (Liquinox). Afterwards, they are rinsed off in the class 10 area using a 40-60 psi hand-held spray nozzle (as seen in Fig. 2). A resistivity meter is used to determine if the part is clean enough, and it usually takes 2-3 minutes of rinsing to achieve an acceptable level ($> 14 \text{ M}\Omega/\text{cm}$). Sterile denatured ethanol (Klervicide 70/30) is then sprayed through the warm and cold sections to help remove water, especially that in the bellows, and all parts are blown dry with filtered nitrogen. The parts are then left on the class 10 laminar flow tables over night to ensure dryness. Prior to assembly, each part is tested for cleanliness by blowing filtered nitrogen (50 psi) across it into a particle counter receptor cup. The count must be below 10 particles of 0.3 microns or larger

during a 10 seconds period for the part to be accepted. If the count remains larger after three blow-off attempts, the part is re-cleaned (washed and rinsed).

During assembly of the warm and cold sections, nitrogen (5 psi) is purged through the instrumentation ports. The couplers are assembled as shown in Fig. 3 where the cold sections are connected rf-wise via a disk shaped Coupler Processing Cavity (CPC), which was designed and built at SLAC (drawings). This cavity geometry allows easier cleaning than the box shaped versions used at Orsay and KEK. With this setup there are three vacuum volumes defined by the windows. Each is first purged through gate valves and verified ‘clean’ by the resulting particle count, then sealed off, pumped down and helium leaked checked.

The assembly is then moved to End Station B where it is placed in a nitrogen-purged box that is put in a forced air oven. The assembly is baked at 150 °C for 24 hours while the vacuum pressure is monitored. This is a critical step to ensure fast rf processing. Afterwards the cold section pressure drops to the low $1\text{e-}9$ Torr scale, and the warm section pressures are so low the ion pumps effectively turn off. The couplers are then moved to a nearby clean-tent area where the waveguides are installed and the antenna positions are adjusted to optimize transmission through the pair ($S_{11} < -30 \text{ dB}$) with low power rf. One of the waveguides is then connected to the L-band power source and other to an rf load in preparation for high power operation. Figure 4 shows the setup and Figure 5 shows the rf processing history data from the first coupler pair sent to FNAL. These couplers processed fairly quickly by historical standards, and there were no pronounced multipacting ‘ledges’ in the ramp up curves as has sometimes been seen. Also, there were no significant jumps in the e-probe signal activity.

After rf processing, the coupler setup is disassembled in the class 100 cleanroom and packaged for shipment to

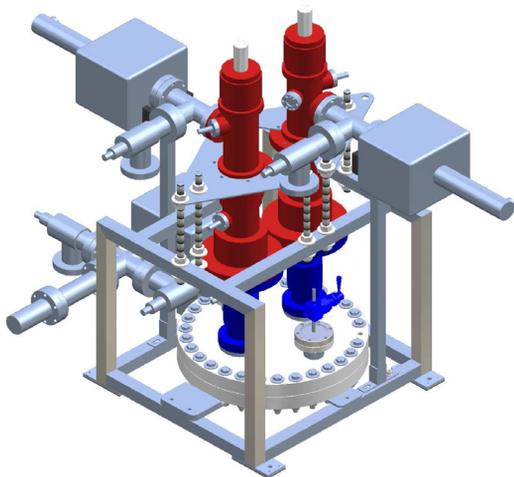


Figure 3: Coupler pair assembly without waveguides showing the warm (red) and cold (blue) sections attached to the Coupler Processing Cavity (bottom disk).

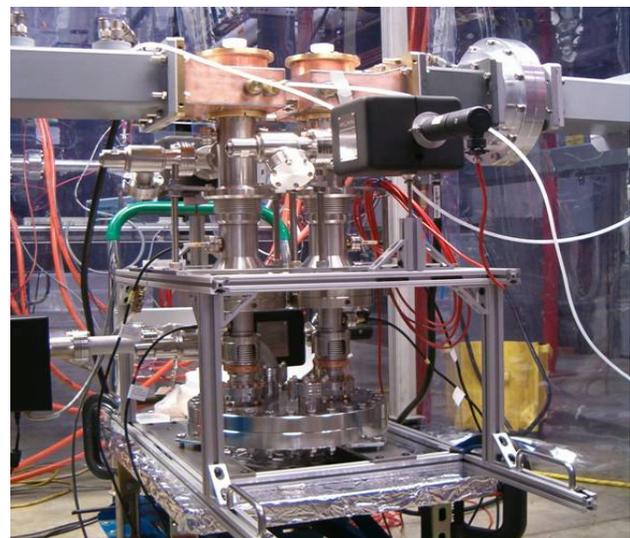


Figure 4: TTF3 Coupler assembly during RF processing.

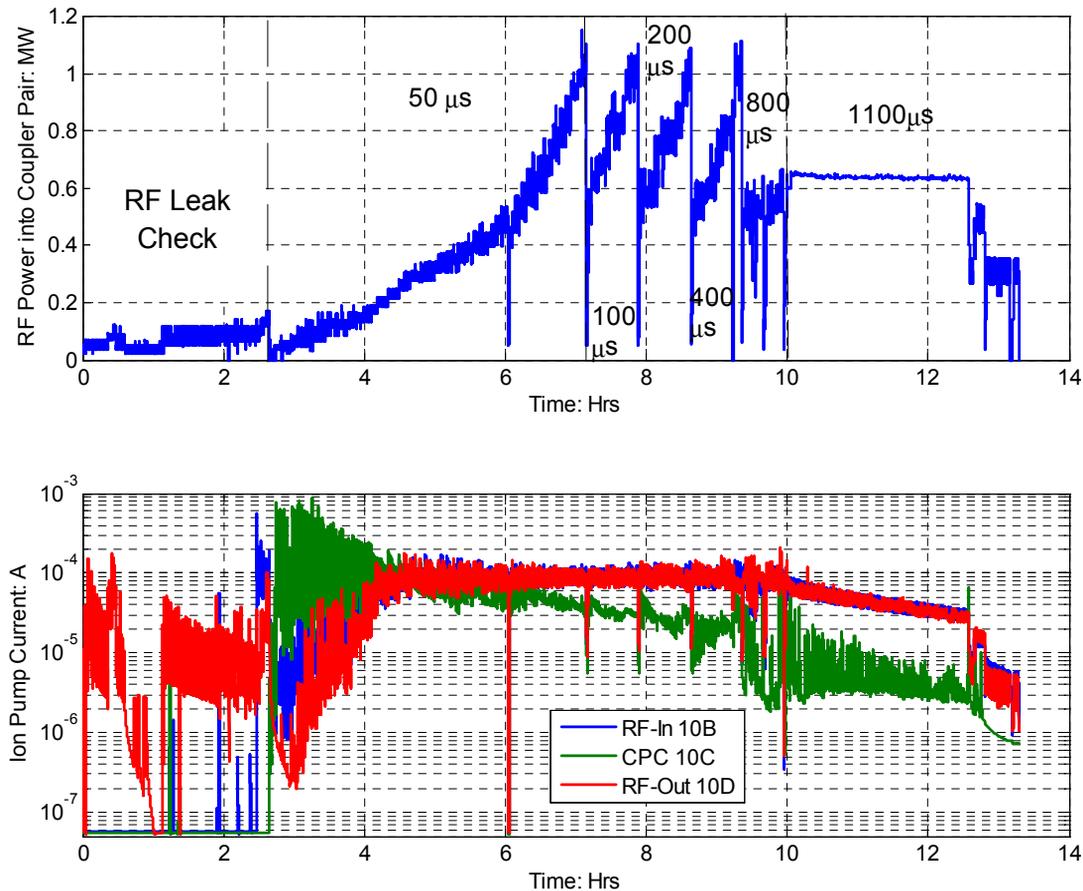


Figure 5: RF processing history of a pair of couplers under automated control. The top plot shows repeated input power ramp ups at progressively longer pulse lengths as paced by the control program's attempt to keep the ion pump currents in each of the three vacuum volumes from exceeding 100 μ A. The associated pump currents are shown in the bottom plot.

FNAL. The cold parts are shipped under vacuum, attached to the CPC and bagged three times for cleanliness. The warm sections are purged with nitrogen and then all ports sealed. All parts are shipped in foam filled Air Transport Association approved shipping cases.

FABRICATION IMPROVEMENTS

The couplers contain a numbers of cylindrical sections that are e-beam welded instead of brazed because the high temperatures would remove the TiN window coating and soften the bellows. A program is underway at SLAC to simplify the fabrication starting with the cold sections. The goals are to plate only sub-assemblies, maintain 'hard' vacuum flanges, eliminate the thin walled e-beam or TIG butt welds, and simplify the TiN coating. SLAC will also evaluate certain aspects of the coupler functional design in support of more substantive changes being considered for future couplers.

ACKNOWLEDGMENTS

We thank W.D. Moeller (DESY), Serge Prat and Laurent Grandsire (Orsay), Brain Rusnak (LLNL) and Tug Arkan and Dan Olis (FNAL) for sharing their extensive knowledge of couplers and cleanrooms with us.

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