Quality Control Update of the Cleanroom for Superconducting Multi Cell Cavities at DESY

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Abstract

The acceleration gradients for superconducting accelerator resonators are improved continuously. The surface electric- and magnetic fields are driven close to the theoretical limits. Nevertheless field emission loading still limits the application of these resonators for accelerator application.

For the preparation of the XFEL Project a quality control system for the cleanroom is set up. Three air particle counters are installed in the class 10 and 100 areas. Two liquid particle counters and an automatic scanning microscope for optical analysis of filter discs are installed to control the ultra-pure water system and the high pressure rinsing process. An N_2-fog generator is installed to visualize the airflow inside the class 10 / 100 clean room.

We report on air particle measurements to qualify the infrastructure and assembly steps, liquid particle measurements and scanning microscope analysis of the high pressure rinsing cycles. In addition, results visualizing the influence on the laminar airflow by the cavity geometry as well as of the personnel during the assembly sequence will be presented.

INTRODUCTION

During the last decade cavity acceleration gradient improved from 5 to 39 MV/m acceleration gradients in 1.3 GHz-multi-cell resonators. To ensure the reproducibility and to reduce field emission loading of resonators, an intensive quality control is set up at DESY. The cavity results especially the field emission onset level are influenced by three major categories: a) emitters origin from contamination of the cleanroom air during assembly and drying b) particulates and bacterial introduced during high pressure rinsing and c) particulates with origin in auxiliary infrastructures like vacuum pump units.

QUALITY CONTROL OF CLEANROOM AIR

a) Air particle concentration and velocity distribution

Four times a year and on demand a general quality check of the cleanroom air is done. All filters are controlled for proper installation on the filter junctions and leakage of particles on the entire filter membranes. The air velocity in class 10 (ASTM) cleanroom should be set to 0,45 m/sec ± 20% to ensure laminar flow conditions

The DESY cleanroom installed in 1992 showed a gradual increase of particles and local turbulences since 2002. An inspection showed that some air velocity distribution flaps were broken and some filter gaskets were aging.

In December 2004 all filter units class 10 / 100 were renewed [4]. After that general reconditioning the particle concentrations went back to less than specified for class 10 ASTM cleanroom (Figure 1)

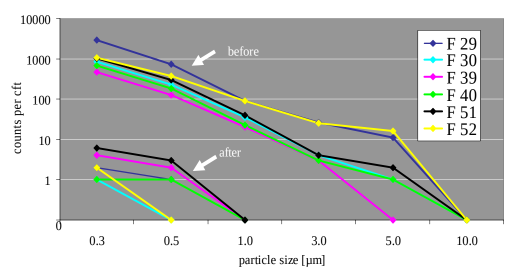

Figure 1: Recovery of the DESY cleanroom after changing of HEPA-filters during shut down. Shown are dedicated filter units (Fx)

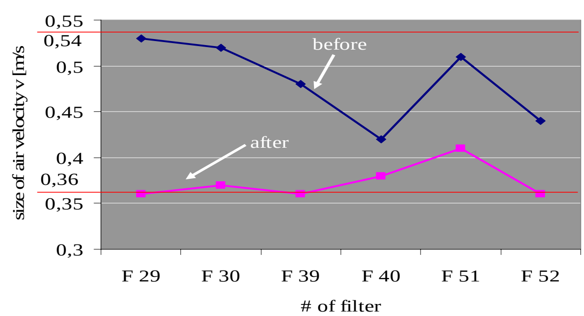

Figure 2: air velocity distribution measured on filter units before / after re adjustment of air distribution flaps

b) N_2-fog-generator for flow visualization in cleanrooms

Mandatory for class 10 / 100 cleanrooms is the laminar air flow condition. Turbulences and velocity gradients are capable to collect and hold particulates. To fullfill these conditions the cleanroom infrastructure has to be designed aerodynamically as well to keep the laminar flow conditions. For visualization of the air flow a water steam fog generator is in use. The contamination free fog is produced by evaporation of ultra pure water by a steam generator. The steam is cooled down with liquid nitrogen and builds up the fog where the water droplets have a size that they follow the air stream without major impact of gravitation. The fog temperature is automatically adapted to room temperature for an isothermal outflow of fog.

The fog generator installed serves for training of personnel as well as design and control of equipment at DESY. Movement of personal and work at the object should be done without producing turbulences and guiding the air-stream towards the object under work. For training of personnel the fog generator allows to visualize the movement of personnel and to examine the individual specifics in different working areas (Figure 3; 4). Each movement close to the cavity is visualized during a test assembly by the fog generator to improve the assembly procedure and to train the personal for optimized handling (Figure 5; 6). To visualize the influence of the equipment like tools, fixtures or the cavity shape itself on the laminar flow pattern, the fog generator is positioned in the laminar flow of class 10. The flow patterns with and without the equipment is monitored (Figure 7) and the design of the equipment can be adapted to laminar flow. For the assembly procedure of power coupler to the resonators the monitoring by the fog generator showed that turbulences appear at the input coupler port. These turbulences guided the air into the cavity beam tube. Installing a constant argon gas overlay from the cavity venting unit towards the resonator set back the flow pattern to laminar conditions at the power coupler port during assembly process (see Figure 8).


movement without turbulences


turbulences produced by fast movememt

Figure 3, 4: Training of cleanroom personnel

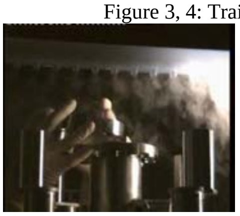
Figure 5: Visualization of the air flow during assembly of cavity top flange


Figure 6: Air flow pattern of laminar flow resulting from the cavity top flange design


Figure 7: Influence of the laminar flow in class 10 area by the cavity geometry


Figure 8: Flow pattern at power coupler port – argon overlay flow from cavity switched on

QUALITY CONTROL OF THE ULTRA PURE WATER SYSTEM

a) Bacteria in ultra pure water

Ultra pure water (UPW) is conditioned by an ion exchanger. Beside the free ions chloride, added to the municipal water to prevent bacterial grow, is removed as well. To prevent bacteria growth in the UPW a UV light is installed in the UPW loop. At a wavelength of 185 nm and an irradiation performance of 250 mJ / cm^2 bacteria passing the UV light cartridge are killed. Even if the UV light is installed, bacteria grow in dead ends and on walls of the UPW system not flushed properly.


Figure 9: Analysis of UPW in the sump of the HP rinse stand


Figure 10: No significant exchange of UP water is available in the sump

To control for bacteria contamination in the UPW water flow, an MILLIFLEXTM-100 test system with filter of 0.45 µm filter is in use. A sample volume of 0.5 litre UPW passes the filter for control. This filter is immersed in culture medium afterwards and stored for 72 hours at 40 °C inside an autoclaved. Living bacteria appear as colonies and are visible as darkened area on the filter surface (Figure 9)

b) Filter analysis after HPR

Rinsing water of the HP rinsing stand is collected in a funnel below the bottom flange of a cavity beam tube. Approximately 10 % of the cavity rinsing water of about 1200 litres UPW is collected and filtered with a 2.0 µm filter. A scanning light microscope allows determining size and numbers of particles. Each HPR rinse following the assembly of cavity auxiliaries is controlled by this filter analysis method. A typical reduction of particulates during six HP rinses done on electro polished cavities is shown in Figure 11.

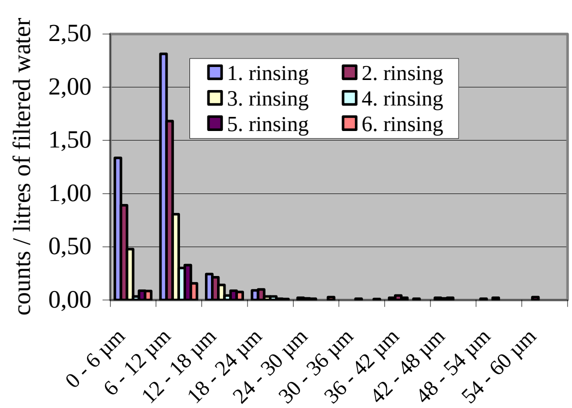

Figure 11: Typical reduction of particle during six HP rinses

c) Online particle measurements

An online liquid particle counter is connected to one of the HP rinse nozzle of the HPR head by a special PVDF adapter (Figure 12). The pressure to the counter is limited to 4 bar [7].

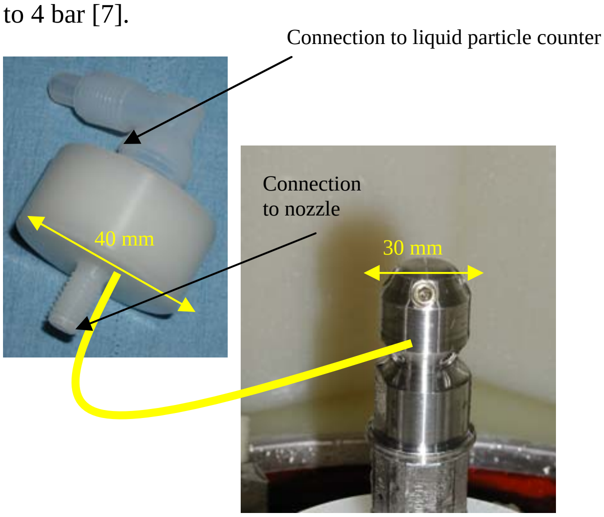

Figure 12: Set up to control particle contamination on the HPR stand. (left: Teflon adapter from nozzle to particle counter / right: HPR Nozzle head

The HPR particle control is done at 4 bar system pressure without the HPR pump running. The flow rate of UPW passing the counter is limited to 100ml/min. The sampling time is set to 10 minutes to get an average particle number of one litre of liquid (Figure 13).

Flush unit for filter cartridge

For quality control and activation of filter cartridges a flushing unit is installed in the UPW line outside of the standard filter housing the cleanroom. The inlet side and the outlet side of standard filter housing are connected to the liquid particle counter. Before installation on to the flushing unit the filter cartridges are immersed into ultra pure alcohol for wetting the surface and removal of air bubbles. After installation the filter is flushed with maximum volume of the UPW towards a draining line. After that flush the unit is switched to an inline mode and continuously flushed like all inline filters of the UPW system. The particle numbers of inlet and outlet line are monitored to get the efficiency of the filter (Figure 14). Parallel to the particle control the contamination by organic carbon is controlled by the TOC monitor. The control of pressure drop over the filter and the passing volume at this pressure drop complete the characteristics of the filter before installation in the DESY UPW. During demounting and transportation to the point of application the cartridge remains immersed in water to prevent post contamination or exposure to bacteria.

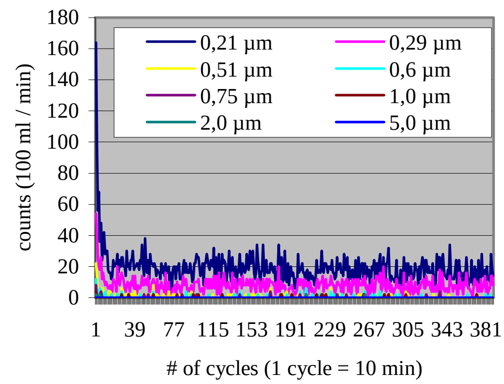

Figure 13: Particle concentration of the HPR filter after 72 h of rinsing

Conclusion

The improved quality control at the DESY infrastructure allows intensive QC and supplies data for correlation analysis of cavity measurements. Air particle control showed aging of all filter units of the DESY cleanroom. Recovery of the cleanroom after renewing the filter units was measured. The N_2-fog generator becomes part of training of personnel and allows optimizing handling and assembly procedures. It is in use to optimize the design of new infrastructure as well. A new online TOC monitor is installed and allows to find correlations between cavity RF measurements and contamination of the UPW line by organic components. With the new quality control equipment changes on processes or material parameters can be made to optimize the infrastructure.

REFERENCES

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[2] A. Matheisen, this conference
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[4] m+w zander, total facility solutions Reinrauminstandsetzung bei DESY, Dezember 2004
[5] VDI Blatt 3 (Messungen in Reinräumen)
[6] K. Escherich, private communication
[7] TESLA Collaboration Meeting, spring 2005: Ultra Pure Water- System: particle control by online liquid particle counters

TRADEMARKS

Air particle counters: Type MetOne, model 3313
Type MetOne model 2408
Hot wire anemometer, TESTO 425
Liquid particle counters: Type:HIAC/ROYCO, model 8000A
TOC monitor, Type ANATEL, model S 10
Scanning microscope: LEICA, DMLP
N_2-fog generator: CCI von Kahlden GmbH