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

XFEL
X-Ray Free-Electron Laser

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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. Never the less 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 a 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 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 are influenced by three major categories: Particulates transported by the cleanroom air during exposure of the superconducting surface for assembly and drying, particulates and bacteria introduced by ultra pure water during rinsing and cleaning procedures, and particle contamination resulting from the auxiliary infrastructure like vacuum pump units.

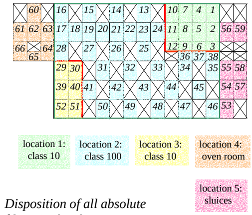
QUALITY CONTROL OF THE TTF CLEANROOM AIR

Air particle concentration

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.

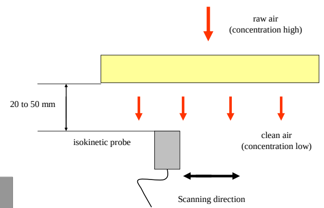
For laminar flow conditions, the standard value of air velocity should be set to 0.45 m/s with a tolerance of ± 20 %.

- Since 2002 a gradual increase of particles was measured
- Air velocity distribution flaps broken (local turbulences)
- Since summer 2004 class 10 had to be closed for cavity assembly
- Renewing filter units class 10 / 100 in December 2004

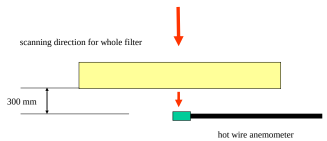


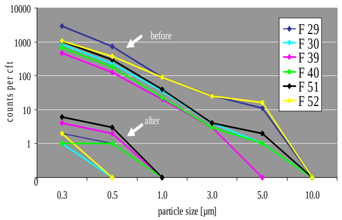
Disposition of all absolute filters in the cleanroom

performance of the leak test



set up for air velocity measurements



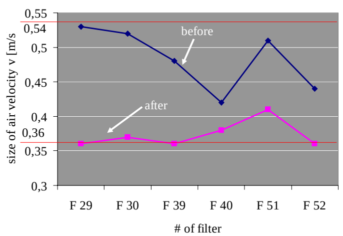


comparison before and after changing absolute filters

Results of the regular quality control check of the cleanroom

Before renewing:
- gaskets become more porous
- filter surfaces were all right

After renewing:
- gaskets are all right
- filter surfaces are all right



comparison of air velocity in the clean room before and after renewing flaps and absolute filters

N_2-fog-generator for flow visualization in cleanrooms

Scope of Application:

- training of cleanroom personnel, air-flow visualization of the movement of personnel in different working area within cleanrooms
- air-flow visualization for acceptable of equipment and installations in cleanrooms
- flow analysis during processing and in production areas
- visualization of first air and exhaust air of the HVAC-System
- the smallest areas with a vortex flow can be visualized
- Flow visualization in cleanrooms with turbulent flow and at the lowest of flow-speeds is possible

Functionary Principle:

mixture UPW-steam and liquid nitrogen

The temperature of the fog is automatically adapted to room temperature for an isothermal outflow of fog. Because of the operating principle of the fog generator, only the smallest amount of water precipitation occurs on surfaces.

training of cleanroom personnel

visualization of the air flow during assembly of cavity top in class 10

disturbing of laminar flow by cavity top flange

change of laminar flow by cavity geometry

flow pattern at power coupler port – argon overlay flow from cavity

QUALITY CONTROL OF THE ULTRA PURE WATER SYSTEM

Bacteria in UPW

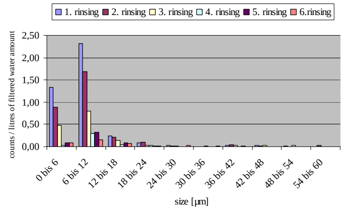
A MILLIFLEXTM-100 test system is in use for bacteria control. Sample size 0.5 liter UPW; filter 0.45µm pore size. Bacteria growth condition: Filter immersed in culture medium; sample autoclaved at 40°C for 72 hours. Bacteria colonies appear as darkened area.

Analysis of UPW in the sump of the HP rinse stand.

No significant exchange of UP water is available in the sump

Filter analysis after HPR

Rinsing water is collected in a funnel below cavity beam tube. Draining water of cavity is filtered by a 2.0 µm filter. Typical volumes of up to 100 litres are analyzed. A scanning light microscope allows to determine size and numbers of particles. Rinsing water analysis is done after assembly of cavity auxiliaries.



Typical reduction of particle concentration measured during 6 HPR sequences

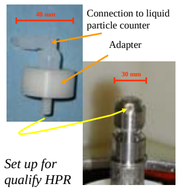
Results from filter analysis

- Particles are found and analyzed
- Origin of particles found
- No significant reduction of particles washed out by the HP rinse found after four HP rinse sequences

Copper particle detected on a filter disc
Origin: Cu seal or CuNiSi nut

Online particle measurements

The online liquid particle counter is connected to one of the HP rinse nozzle of the HP rinse head. Particle counts are defined by sampling 1 liter UPW (100 ml / min for 10 minutes)



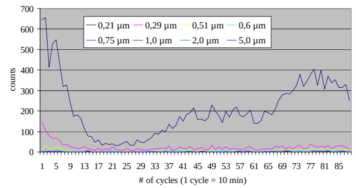
Set up for qualify HPR

Flush unit for filter cartridge

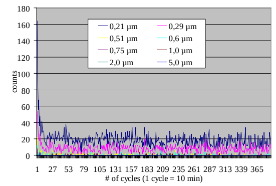
- To minimize time before restart of HPR a filter cartridge flush station is build up outside the clean room
- This system allows to flush and qualify new filter cartridge without contaminating existing clean lines

Sequence:

1. activation of 0.04 µm-filter (alcohol)
2. installation of cartridge into test unit
3. flushing away alcohol / media for activation (to drain line)
4. permanent flushing with maximum volume available for four days
5. dismount and transport to HPR stand
6. installation into HPR housing
7. filter flushed by 6 cubic meter UPW for 6 hours before begin particle measurement
8. start up measurement at HPR nozzle head (system pressure is limited to 4 bar, HPR pump is switched off)
9. three days after installation of this filter in the HPR the particle data showed stable values



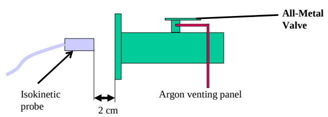
Particles found after installation of a new filter to the HPR stand, total sampling time 16 hours



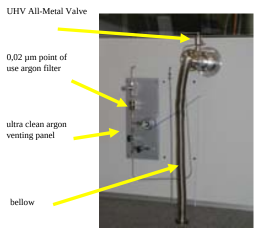
Particle concentration of the HPR filter after 72 h of rinsing

QUALITY CONTROL OF THE CAVITY VENTING UNITS

The DESY ventilation unit is connected to the UHV (Ultra High Vacuum) pumping unit. The 0.02 µm filter is not vacuum applicable. A CF 16 whole metal valve is installed between venting unit and pump line.



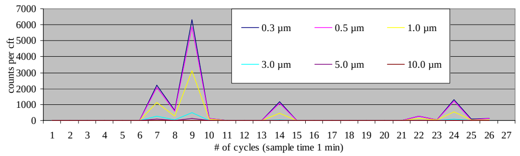
Schematic test set up for CF 16 whole metal valve



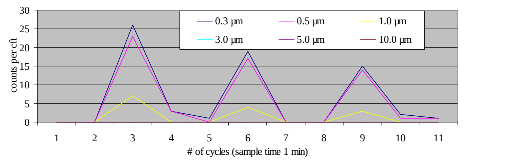
Ultra pure argon venting unit

Quality control steps for the CF 16 valve

1. calibration of counter by class 10 clean room air (zero-measurement)
2. Particulate measurement in the continuous flow of argon (maximum venting speed)
3. shock waves produced by fast open and close of CF16 valve (particulates blown off by shock waves)



Examle for quality control of the UHV All-Metal Valve on particle contamination



Improvement with a new installed UHV All-Metal Valve