QUALITY CONTROL AT THE TTF– CLEANROOM INFRASTRUCTURE FOR CAVITY - PROCESSING

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Abstract

At DESY Hamburg the Tesla Test Facility (TTF) was set up in the year 1992. One major facility of the TTF infrastructure is the cleanroom [Ref. 1] where the preparation of about 70 superconducting (s.c.) TESLA/TTF-cavities took place. A strong variation of results in the cavity performances in respect to field emission onset level was observed. To minimize the spread and to dedicate the origin of field emitters a quality control (QC) system has been set up.

The TTF-cleanroom is divided in 3 classes of air quality (class 10, class 100 and class 10 000) specified by Federal Standard 209E, ISO 14 644 and VDI 2083. The preparation of cavities by ultrasonic cleaning, chemical surface treatment, pure water rinse is done in class 10 000 environment while the high pressure rinsing station (HPR) and assembly areas are located in the class 10 and 100 laminar air flow region. For pumping and drying of cavities three oil free vacuum-pump stations (VPS) are connected to the class 10 assembly areas.

Three air particle counters are located in class 10 and 100 area. A liquid particle counter, located in the gray room, and an automatic scanning microscope for optical filter analysis in the class 10 000 area, are installed for QC.

This is a report about QC established in the preparation sequences. Results of routine check of cleanroom air and ultra pure water (UPW) as well as the qualification of components after system break down will be presented. In addition, the analysis of datasets of contamination control measurements and cavity performance will be shown [Ref. 2].

INTRODUCTION

For the optimum performance of the s.c. cavities it is essential to work under very clean and very controlled conditions. As any particle on the surface can influence the maximum achievable gradient, a contamination by particulates has to be avoided. To ensure reproducibility, an efficient QC system has to be set up. It has to be guarantied that the means of labour like air; water and acid in use will fulfil the highest standards at any time and will not influence the cavity results.

TTF CLEANROOM EQUIPMENT

The equipment for QC on particle contamination in the TTF cleanroom consist of three air particle counters [trademarks 1;2], one liquid particle counter [trademark 3], one hot-wire anemometer [trademark 4] and a scanning microscope for filter analysis [trademark 5].

STANDARD QUALITY CONTROL CHECK OF CLEANROOM AIR

a) Filter units- leak testing and air velocity

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. These measurements are done in a distance of 20 to 50 mm underneath the filter unit (Picture 1) [Ref. 3, 4].

To confirm the laminar flow conditions, the air velocity of every absolute filter has to be measured. About 300 mm below the filter outlet plan, the standard value of air velocity should be set to 0.45 m/s with a tolerance of ± 20 % for laminar flow conditions.

Typical data taken during these measurements are shown in Figure 4.

b) Particle concentration

For cleanroom QC the German norm VDI 2083 [reference 7] determinates the minimum numbers of the independent measurement points by:

$$n = \sqrt{A}$$

n = numbers of measurement points
A = area in m^2

For the class 100 area of the TTF cleanroom a total of 16 measurement points are defined. The location of these points is shown in Figure 1.

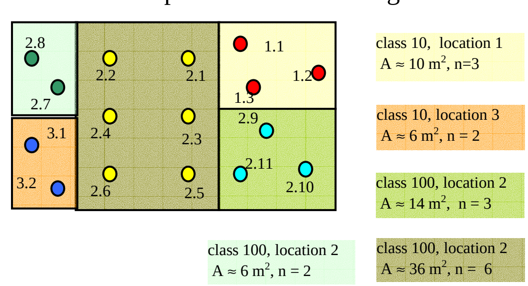


Figure 1: Location and number of measurement points at the TTF class 10 / 100 area

The measurements of particle concentration have to be done under laminar airflow conditions in a volume of 1 cubic foot (cft) = 28.3 litres. For relevant measurements in assembly areas for TTF Cavities, the ISO-KINETIC probe has to be placed at work height for assembly, about 1.2 m above floor level. The general check of the cleanroom is done four times a year, specific controls at the assembly areas are done before any critical assembly.

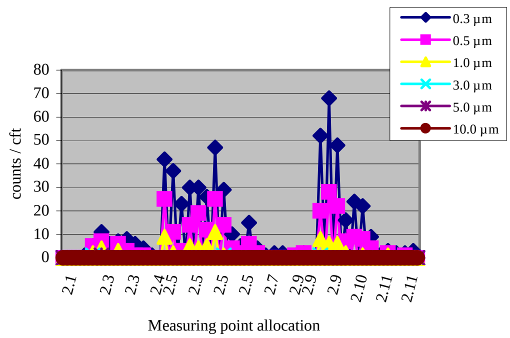


Figure 2: Typical results of a complete measurement in class 10 area, location

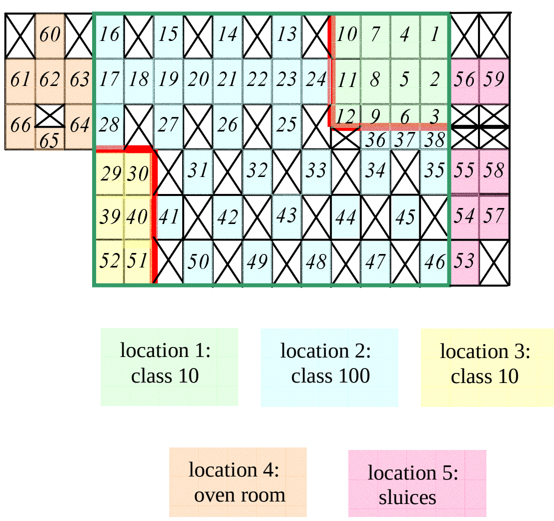
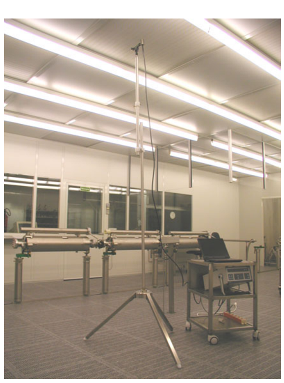
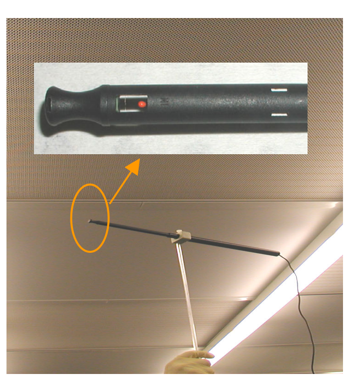


Figure 3: Filter unit number and location of all absolute filters in the TTF cleanroom

Picture 1:
Set up for filter
Leak test

Picture 2:
Detailed view on set up for air velocity measurements





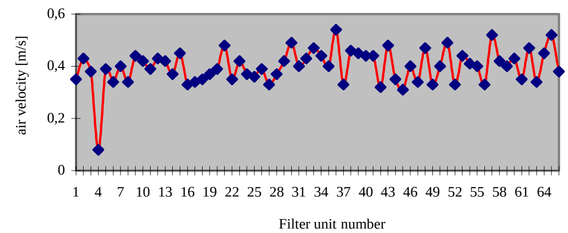


Figure 4: Air velocity distribution of the TTF cleanroom with broken butterfly valve on filter unit Nr. 4

Results

During the regular measurements of the last years no specific problems on particle contamination or leakage were found. Never the less from the analysis of the data it can be stated that aging of the infrastructure takes place. In summer of this year one class 10 filter in assembly area (see Figure 4 / filter Nr. 4) showed no airflow. The examination of the air distribution system showed that one butterfly valve was broken and the flap was closed. After repair of the valve the class 10 area fulfilled the laminar flow conditions again.

During the frequently necessary shutdown of the cleanroom fan unit for maintenance, the particle concentration is monitored continuously (see Figure 5).

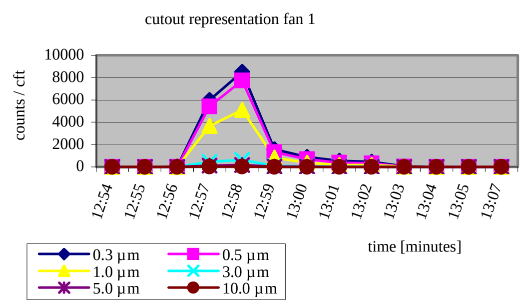


Figure 5: Typical cleanroom recovery time after shut down of the fan units (fan is working again at 12:56)

If the fan unit is cut off, the laminar flow changed into turbulences. Particles from the bottom of the cleanroom went up to the top. After the restart of the fan unit the laminar flow is ensured again.

cleanliness classes	permissible number / size [µm]	actually measured values / size [µm]
10	10 / 0.5	1 - 2
100	100 / 0.5	15 - 35
10 000	10 000 / 0.5	4300 - 5500

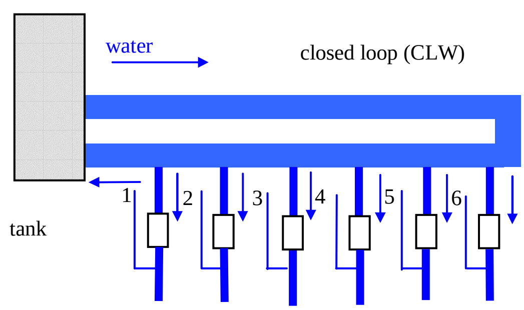
Table 1: Typical values of particle concentrations in a volume of 1 cft [Ref. 5 ,6]

QUALITY CONTROL OF THE ULTRA PURE WATER SYSTEM

The TTF UPW supply system purifies about 1200 l/h city water to ultra pure water with a resistance of 18 MΩ/cm [Ref. 7]. About 20 l/min UPW circulate continuously in the closed loop water (CLW) supply line of the cleanroom. The particle concentration in the primary CLW line is monitored continuously, while the resistance is controlled once a day.

Point of Use

Each POU is equipped with a 0.02 µm inline filter and a sampling line connector at the filter outlet side. For QC of the TTF UPW system one-inline liquid particle counter is installed. The particle contamination of each POU can be controlled individually via a switchboard connection (tableau) to the particle counter (Figure 7). This system allows high flexibility and short response time after changing the measurement points even if there is only one inline counter available.



0,02 µm filters
A feed-line high pressure rinsing pump
B chemistry supply line/fine rinse
C chemistry supply line
D electro polishing fine rinse
E ultrasonic cleaning and fine rinse station
F cleanroom primary supply line

1 – 6 Point of Use-places

Figure 6: UPW-circulation

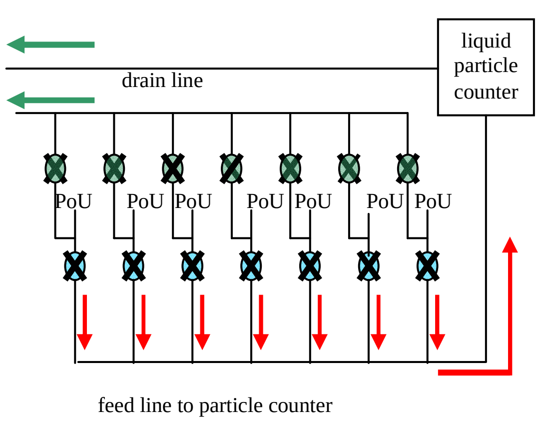


Figure 7: Schematics of the UPW switchboard connection to the inline liquid particle counter

The setup of the tableau guaranties a continuous flushing of all lines due to the permanent open connection towards the drain. Closing the draining valve and opening the feed line towards the particle counter allows starting individual measurements.

Standard particle concentrations in the CLW lines are in the order of <=500 particles per litre (size: 0.05 microns) [Ref. 8]. On the individual POU a strong increase of particulates numbers is observed when the full capacity of water flow is started (Figure 8). The decay time towards standard concentrations is <u>about 24 hours</u>. This enhanced particle numbers cannot be correlated with real particles. Up to now it looks more likely that water bubbles, which result in stray light inside the counter like particles, are colleted in the filter units may be the origin of this effect. More studies with different set up will be done to understand this phenomenon.

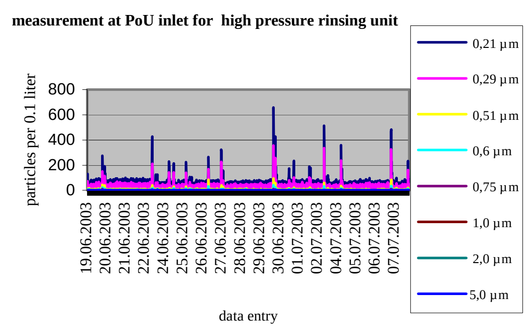


Figure 8: Representative measurements of particles detected at the Point of Use HPR inlet filter.

Filter Analysis

Standard inline particle counters are designed for a pressure of 2-4-bar abs. To control the high-pressure line of the HPR stand (up to 200 bar), two different methods are developed.

A) Low pressure control of the 100 bar inline filter (size 0.02 µm): The standard 100 bar nozzle head is removed from the HPR cane and a direct feed line is connected to the liquid particle counter. The system pressure in the HP line is limited to 4 bars.

B) High pressure control: A funnel installed underneath the HPR cane [Ref. 9] collects up to 10 % of the HPR water coming out of the nozzle head. This sampling water is guided via a pipe to a 2 µm filter. After a test sequence this filter is scanned under a scanning microscope. Beside the particle numbers the particulates can be analysed with SEM or similar analysis. The system pressure can be set up to the pressure limit of the HPR system (200 bars abs).

Qualification of the HPR System

To qualify the HPR system the low-pressure control is made to ensure the integrity of the filter. After this a glass cylinder is installed in the HP stand and a complete HPR sequence (2 h HPR rinse / 2000 litres of UPR water at 100 bar) is done and the filter, installed in the funnel extraction line, is analysed.

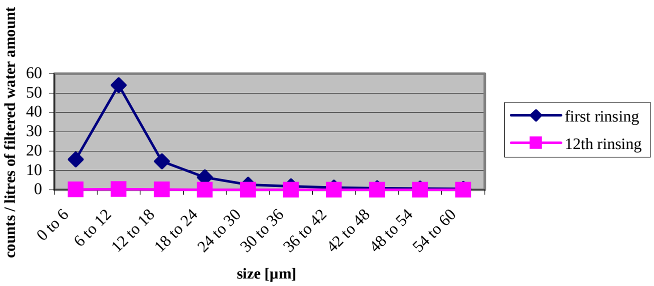


Figure 9: Qualifying the HPR

Results

Typical results of a QC on the low pressure UPW system show about 120 particles (size 0.21 µm) per 0.1 liter
After system maintenance, done once a year, the UPW supply line needs about 24 hours (5760 Liter) to recover from filter exchange (see Figure 9).

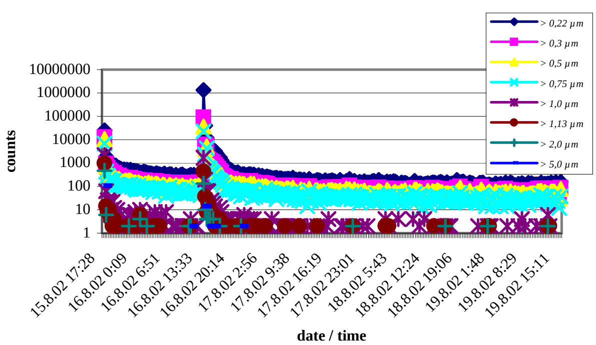


Figure 10: Example for recovery of the UPW after changing one of the 0.02 µm filters

VACUUM-PUMP-STATIONS

During the preparation sequence all cavities are connected to one of the three oil free pumping-stations at the TTF cleanroom. The pump units are equipped with integrated ultra clean argon gas venting panels [Ref. 10]. For pump down and especially for venting of cavities to normal air pressure particle and residue free conditions have to be guarantied.

GASKET CONTROL

The vacuum components (valves, pipes and bellows) are standard components sealed with Cu gaskets. They are exposed to high humidity during pump-down of resonators after HP rinse and drying in the cleanroom. A control for corrosion on those gaskets, origin of Cu particulates in the pump line, is done by visual inspection with a borescope.

Picture 3: Control set up for vacuum pump stands

PARTICLE MEASUREMENT

Each venting unit of the vacuum pump is equipped with a 0.02 µm inline particle filter. Via this filter the resonators are vented to air pressure. The integrity of these filters has to be controlled four times a year.
About two hours before the measurement is started, as first order the whole piping will be flushed by the maximum stream of argon.
For a zero-measurement of the particle counter the argon valve is closed slowly and a measurement has to be done. In a second control order the cleanliness of the pipes has to be controlled by carefully opening and closing the needle valve and the main gate valve of the venting unit. Inside the pipes are laminar and turbulent flow conditions, so the particle contaminations can be controlled precisely. By introducing a shock wave in the pipe, remaining particles will be blown off by the turbulent flow.
In the third order the normal condition of the filter can be controlled. The maximum argon flow over the filter is manufactured and measured for some minutes. On the basis of these particle numbers it can be recognized whether the origin comes from possibly remained particles in the piping or from defects of the filter.

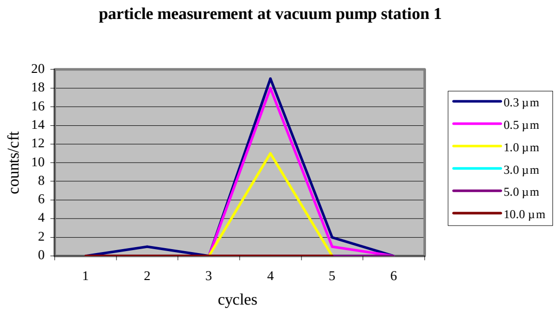


Figure 11: Particle control on a TTF Pump/Venting unit:
cycles 1 – 3: Variation from laminar to turbulent flow
cycles 3 – 5: Introduction of a shock wave

CONCLUSION

Due to the set up of quality control at the TTF infrastructure more information on the infrastructures are gained and can be correlated to results of the RF measurements. Information on early aging of infrastructure as well as recoveries after breakdown, are available and can reduce the number of costly tests and improve the reproducibility of cavity results. More over the particulates can be extracted from filters and analysed to dedicate the origin. With this information, changes on processes or material parameters can be set to optimise the infrastructure.

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[2] A. Matheisen, see this conference

[3] magazin forschung 2/1999: Christian Stief, Axel Grabowski „Nicht nur sauber, sondern rein“- Reine Räume zur Herstellung kleinster Strukturen

[4] FEDERAL STANDARD 209 E: Airborne Particulate Cleanliness Classes in Cleanrooms and Clean Zones

[5] SYNTAS EnergieManagement, Reinraumüberprüfung bei DESY am 02/03.04.2002

[6] VDI Blatt 3 (Messungen in Reinräumen)

[7] K. Escherich, private communication

[8] PMT-Seminar: Grundlagen der Partikelzählung

[9] D. Reschke, private communication

[10] K. Zapfe: “Oil free pumpstations for pumping of the s.c. cavities of the TTF”, SRF Workshop 2001 Tsukuba

TRADEMARKS

Air particle counters: Type MetOne, model 3313
Type MetOne model 2408

Liquid particle counters: Type:HIAC/ROYCO, model 8000A

Hot-wire anemometer: TESTO, type designation-model 425

Scanning microscope: LEICA, DMLP