Cleanroom best practise for SRF assembly

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Outline

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- **General Cleanroom Practices**
    - Design for SRF Cleanrooms
    - Personal behaviour
    - Restricted items
    - Entry of personnel

- **Cleanroom issues specific to CERN**
    - Preparation of fasteners and gaskets
    - Non-beamline component cleaning
    - SRF beamline component cleaning
    - Beamline component storage
    - Site specific considerations

Introduction

- To achieve demanding RF performance required by modern RF cavities, cavity and string assembly must be done in a high quality cleanroom
  - The HL-LHC Crab cavities requires assembly in an ISO4 cleanroom.
    - For reference we adhere to ISO 14644-1 cleanroom standards

Class	maximum particles/m³						FED STD 209E equivalent
	≥0.1 µm	≥0.2 µm	≥0.3 µm	≥0.5 µm	≥1 µm	≥5 µm	
ISO 1	10	2.37	1.02	0.35	0.083	0.0029	
ISO 2	100	23.7	10.2	3.5	0.83	0.029	
ISO 3	1,000	237	102	35	8.3	0.29	Class 1
ISO 4	10,000	2,370	1,020	352	83	2.9	Class 10
ISO 5	100,000	23,700	10,200	3,520	832	29	Class 100
ISO 6	1.0×10^6	237,000	102,000	35,200	8,320	293	Class 1,000

    - Note: size of particle that can be seen on a surface is ~50um

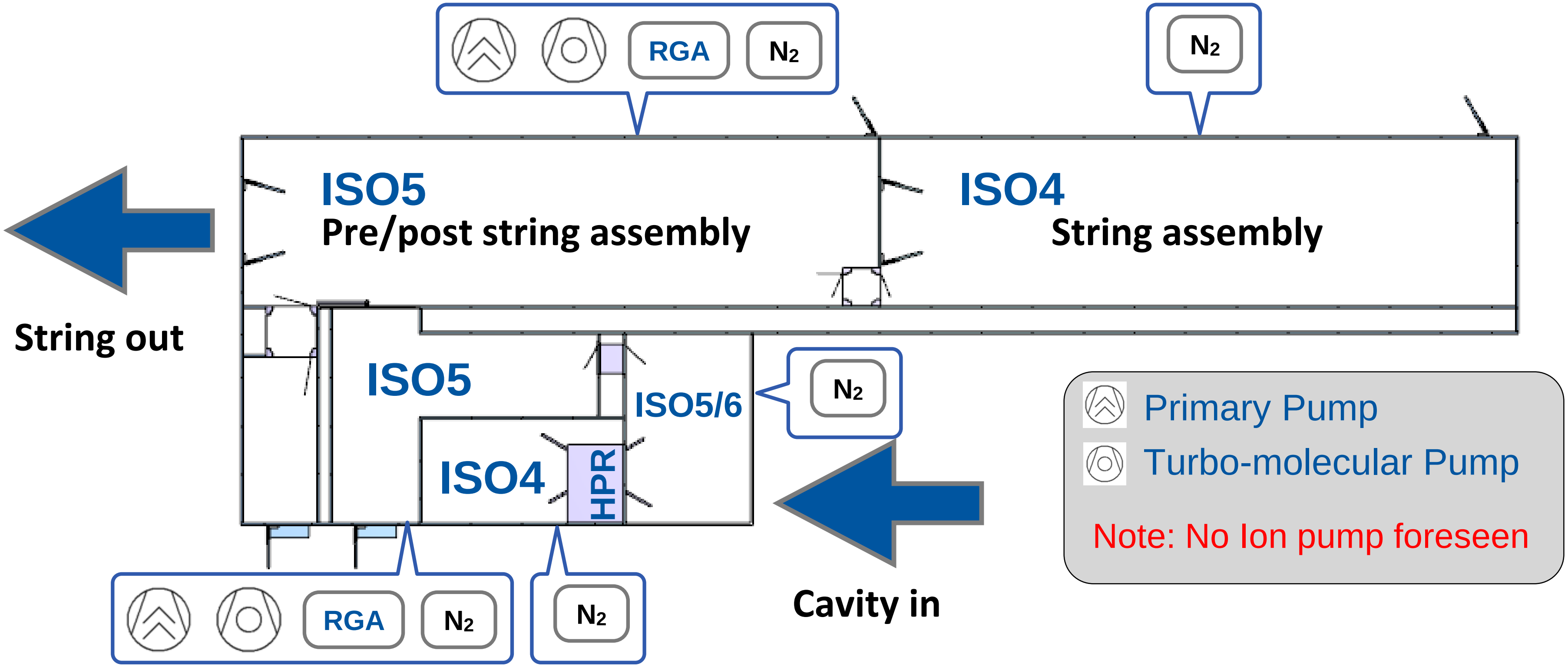
- To ensure the utmost cleanliness during assembly, we need:
  - Procedures to minimise contamination from cavity assembly staff
  - Procedures to minimise contamination from component preparation
  - Assembly sequences that minimise particulate generation

- In short, in addition to the cavity being clean, we must have procedures in place that minimise sources of particulate generation and contamination

SM18 Facilities: Identification of Working Space

- Cleanrooms: ISO5 & ISO4 for Crab Cavity and String Assembly
- External rail system: Cryostating of assembled string
- Horizontal Bunker (M7): Cryomodule Tests @ 2K
- Vertical Test cryostats: 2 stands for bare & dressed cavity tests @ 2K
- Control room: Measurement stands + LLRF

CERN SM18 Cleanroom



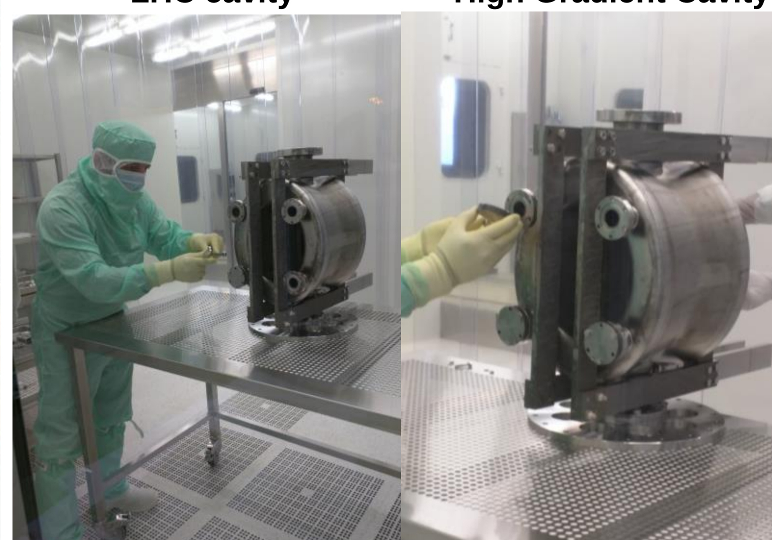
SM18 Cleanroom: Usage up until now

High Pressure Rinse station

LHC Cryomodule on SM18 cleanroom rail system

LHC cavity

High Gradient Cavity



Assembly of Crab DQW_PoP

General Cleanroom Practices

The following best practises reflect the recommendations that we wish to adopt for the Crab Cavity and String assembly in the CERN SM18 Cleanroom

Basic Principles for SRF cleanroom tooling

- Avoid metal on metal sliding surfaces
  - These generate large amounts of particulates.
  - Instead have metal sliding on abrasion resistant, low friction plastics such as Kapton, PVDF.
- All metal tooling should be 300 series stainless steel
  - alternatively, hard anodised aluminium alloy.
- Fasteners should be grade A4-100 stainless steel
- Black oxide coating or zinc plated fasteners are prohibited
- Question to Reviewers
  - What is recommendation for fasteners wrt preventing cold welding?
  - CERN currently use silver plating, but STFC/Cornell using Tungsten Disulphide coating.

Basic Principles for SRF cleanroom tooling - II

- Avoid blind holes in cleanroom & beam line components
  - If present and not directly part of immediate assembly procedure, they must be taped over with kapton.
- Avoid tapped holes; they generate & retain particulates
  - Area around open beam ports particularly critical.
  - Must be taped over with kapton if not under assembly
- Design flanges so through bolts easily accessible
- Always consider air flow over the open ports
  - Laminar flow should draw dirt away from work area.
- Design and choreograph component assembly
  - Simple rule:

    The easier the assembly step, the cleaner it will be.

Personal behaviour - I

Best practises require cleanroom workers adhere to guidelines to ensure reduced contamination within the cleanroom;

- **No fast movements, movement should be as slow as reasonably practicable, especially critical around open ports**
- Minimize the number of persons in the cleanroom
- No talking, coughing or sneezing directly over the product
- Make-up should be removed before entering cleanroom
- **When working with fasteners, don't spin bolt while loosening or tightening. Only turn the nut.**
- Cover unused holes and crevices with Kapton tape
- Masks must cover the nose
- Do not lean on benches, wall, kneel on floor etc as this will transfer/release particulate

Personal behaviour - II

- **Always wear 2 pairs of Nitrile gloves to allow ease of change.**
    - Regular changes improve cleanliness

- **If you drop anything on floor, do not pick up to re-use**
    - If no spare available repeat then re-cleaning item.
        - Only pick-up after assembly work is finished

- **Tool usage:**
    - Wipe before and after use with lint free cloth & propanol.

- **Cleanroom workers should**
    - Not be smokers
    - Shower and use moisturiser before entering cleanroom

- **Cleanroom workers should not wear the following**
    - Cosmetics, jewellery, woollen clothes, handkerchiefs etc

- **Do not re-use gloves, mask, or bouffant**

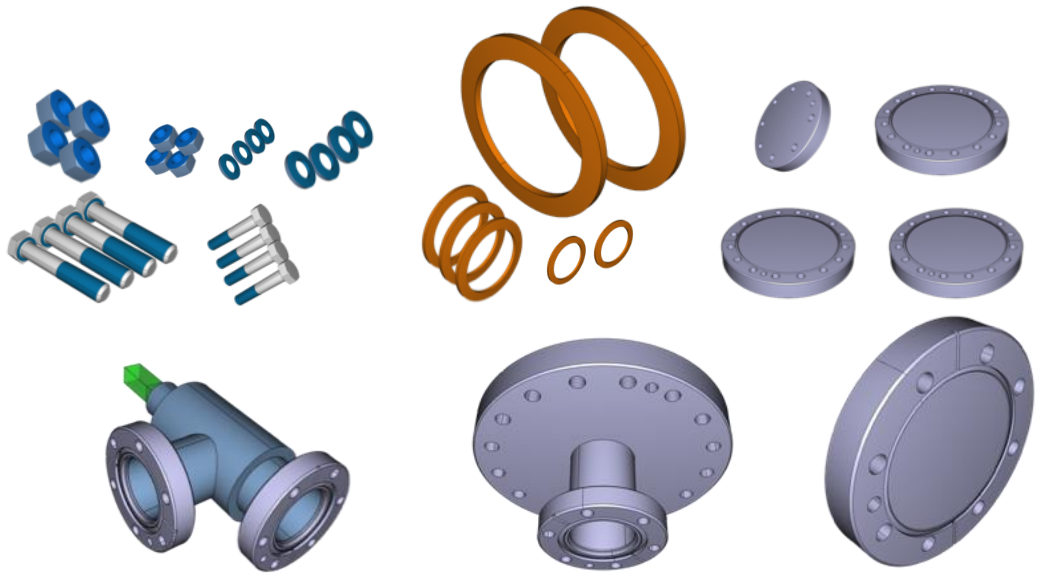
Entering the cleanroom

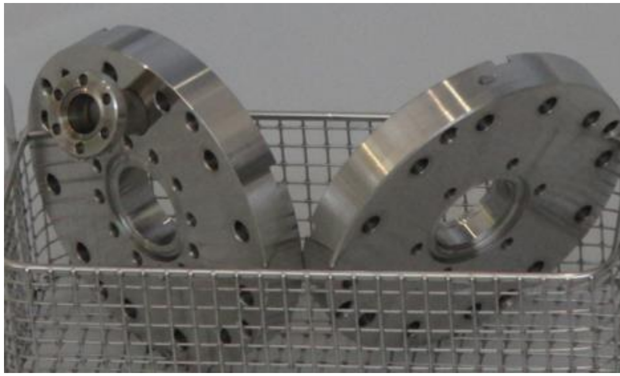
Entering the cleanroom

- **Standard preparation and entry**
  - Duration: ~ 15 minutes
- **Full training of cleanroom workers required**
  - No training => no access
- **Reverse process for exiting cleanroom**

Cleanroom issues specific to CERN

Preparation of fasters & small components





Open issue

- **Fasteners: All assemblies use A4-100 inox nuts & bolts**
  - To avoid cold welding the current CERN solution is where required;
    - silver coated nuts for through holes
    - silver coated bolts for tapped holes
  - Alternative solutions for bolts
    - Tungsten Disulphide coating (Cornell/STFC)
    - Kolsterising (Proposal to be validated)
      - low temp surface carbon diffusion treatment.

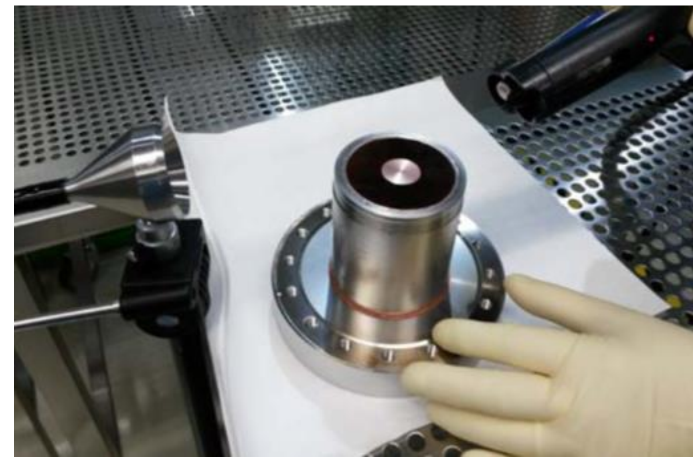
- **Request to review panel**
  - We would appreciate any recommendations on alternatives to silver coating

Preparation of fasters & small components

- **Degreasing: Wash in ultrasonic bath with detergent**
  - Duration: for 30 min at ~50 C
    - Exception: Pieces with ceramic inserts only 2 minutes in bath
- **Rinse with ultra-pure (demineralised) water**
  - 1st rinse done manually above the bath
  - 2nd rinse done by immersion
- **Immerse/Wipe down with cleanroom wipes + alcohol**
  - Wipes: 100% polyester
  - Sterile Alcohol: 70% Isopropanol +30% purified water (by vol)
- **Drying nitrogen**
  - Blow with filtered nitrogen (N-60 bottles: N_2 : 99.9999% by vol)
    - 2 -stage filtering: 0.2um at bottle + 0.05um at gun
  - Question: Should we use filtered air to avoid oxygen depletion issues?
    - Filtered air = N_2 78.9%, O_2 21%, Ar 0.93%, CO_2 0.03%
- **Mount protective caps where appropriate**
  - Mount clean PVDF flange covers with clean A4-100 stainless steel screws (without silver coating)
- **Double bag with LDPE plastic [if not transferring within cleanroom]**
  - Objects sealed in a clean N_2 atmosphere

Particle counting

- **Particle counter: Lighthouse Solair 3200 GenE**
  - Simultaneous measure of 0.3, 0.5, 1.0, 3.0, 5.0,10.0 µm
  - 50 LPM flow rate



- **Ionized Nitrogen gun: Simco-Ion Top Gun**
  - Use filtered nitrogen (99.9999% pure) at 6 Bar pressure
  - Line filter: minimum filter size =0.01um
  - Variable positive/negative ionisation
  - Question: Polarisation best practise?

Non-beamline component cleaning

This is cleaning of external surfaces and components that do not form part of the vacuum system for the SRF beamline.

1. Visually inspect Q:UV inspect (for dust & plastic and organic material)?
2. Removal of loose dust by cleanroom vacuum cleaner
3. Wipe the external parts / vessels with clean lint free cloth and propanol
4. If size permits clean for 30 minutes in Ultrasonic bath with detergent.
5. Rinse with ultra pure water and immerse/wipe with sterile alcohol
6. Blow off items / vessels with filtered nitrogen
7. If prepared in advance then objects are sealed in double bag plastic protection with an clean N_2 atmosphere

Notes

- All internal parts should be sealed before cleaning process.
- Small items which have been cleaned should be placed into a cleaned transport box passing into the controlled environment.
- When the items are transferred to ISO 5 cleanroom they should be left standing in the laminar flow for a minimum of 30 minutes

SRF beamline component cleaning

- **These components should be processed using normal CERN procedures for UHV vacuum components**

- **In addition, for transfer into the cleanroom;**
  1. **Where possible, clean external surfaces as described previously**
  2. **Blow-off internal surfaces with ionising gun**
     - Initial continuous blow-off for at least 3 minutes
  3. **Take a particle count from the item ;**
     a) Position particle counter funnel 10cm from item
     b) Position ionising gun 20cm from item
     c) Set a one minute particle count
     d) After ~15 seconds of counting give 3 short blasts on to the object,
     e) Repeat step d) 2 additional times (total of 60 sec)
     f) Complete 3 full count cycles to eliminate anomalies

Note

- Nitrogen bursts dislodge & remove particles held by static
- Avoid blowing >1 Bar pressure directly at counter funnel.

SRF beamline component cleaning

4. Required particle count should be less than given ISO thresholds
    - Threshold are given by ISO-14644-1 Cleanroom standards

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- For blow-off in ISO4, the threshold for >0.5 um is 352 cnts/m^3
    - Assuming a particle counter flow rate of 50 LPM

threshold(>0.5um) = (352/1000) * 50 = 17.6 counts/min

- For ISO4, require no counts for particle sizes above 1um.

5. If any counts during the blow-off process exceed threshold

   => blow-off repeated until all counts are below threshold

   - If acceptable blow-off not achieved, replace or re-cleaned piece

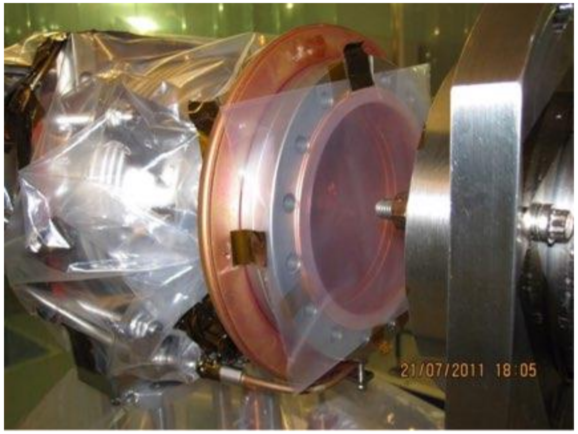
Exception:

Bellows are difficult to clean to the required level using this method.

- If needed, clean by repeated filling & flushing with propanol.

Cleaned Component transfer/storage

- **Cleaned Components are either**
  - Transferred directly into ISO5 cleanroom via SAS
    - Transferred item sit for 30 min (min) in laminar flow
  - **Sealed and under vacuum**
    - CF flanges & stored under vacuum (10^{-3} mBar static)
  - **Stored ready for use – 2 options**
    - Where needed, items capped with PVDF caps which can be secured either by kapton tape or 2 x inox nuts & bolts - finger tightened
    - Sealed with cleanroom grade plastic, or double bagged in N_2 atmosphere



Low density polyethylene sheet

Summary

- **Any recommendations on cleanroom best practise are appreciated.**
- **In particular to the following open questions;**
  - **How to prevent fastener cold welding?**
  - **Filtered nitrogen or filtered air in re-circulating cleanroom?**
  - **Voltage/polarisation settings of blow off gun?**
  - **Is UV inspection of components required?**
  - **Best method of beamline vacuum component storage?**

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