

# SRF CAVITY ASSEMBLY IN CLEAN ROOM WITH HORIZONTAL LAMINAR FLOW

Akihiro Miyamoto<sup>†</sup>, Hiroshi Hara, Katsuya Sennyu, Takeshi Yanagisawa, Mitsubishi Heavy Industries Mechatronics Systems, Ltd, Kobe, Japan

## Abstract

Mitsubishi Heavy Industries Mechatronics Systems, LTD. and our group company, hereinafter MHI group, have introduced a clean room for assembling superconducting RF cavity. Unlike a usual clean room with vertical laminar flow, this is a clean room with horizontal laminar flow. We have assembled SRF cavity in this clean room and obtained a good result in vertical test. SRF cavity assembly in clean room with horizontal laminar flow is rare in the world, but it has advantages in improving workability of cryomodule assembly. We report the case of applying clean room with horizontal laminar flow to SRF cavity assembly.

## PROBLEM OF CONVENTIONAL CLEAN ROOM

In order to achieve high accelerating gradient, special attention is required so that the particulates do not contaminate inside of SRF cavity. Therefore, a work that needs to open the flange of the cavity must be performed in a clean room with ISO4 or ISO5 cleanliness.

Generally, in this class of clean room, the HEPA filter is installed on the ceiling, the porous floor is installed on the floor surface, and laminar flow from the ceiling to the floor surface purifies the air. This type of clean room with vertical laminar flow is widely used in the world, but has problems as follows.

- Construction cost of the clean room is expensive.
- Maintenance cost of the clean room is also expensive.
- Once the clean room is contaminated by particulates, it takes a long time to recover the cleanliness.
- It is difficult to handle heavy objects in the clean room because it is restricted to bring a general lifting tool that generates dust into the clean room. Therefore, special lifting tools which do not generate particulates must be designed, manufactured and used at a high cost.

- There are many procedures for the workers before they enter the clean room in order to minimize the contamination of particulates from the outside. The workability is not good.

## FLOOR KOACH

Floor COACH Ez is an advanced clean room developed and manufactured by KOKEN Ltd. This clean room consists of fan filter units, guide screen and collision wall. Fan filter units are constructed by stacking multiple fan filter units, KOACH F 1050-F (See Figure 1). Filtered air has uniform velocity and direction. The air flows horizontally downstream along the guided screen. The space between the downstream end of the guide screen and the collision wall is open. The air flow hitting on the collision wall is discharged from this open part. The air flow can capture particulates in the air and discharged particulates from the clean room. And under ideal condition, ISO1 cleanliness is obtained in the area surrounded by fan filter unit, guide screen and collision wall. (See Figure 2 for outline of the Floor KOACH Ez). This clean room is not sealed at all and it is quite different from a normal clean room. But this characteristic gives us many advantages in SRF cavity assembly.



Figure 1: Fan filter unit KOACH F 1050-F, W1050 × D627 × H929mm, Source of drawing: Product catalogue of KOKEN LTD..

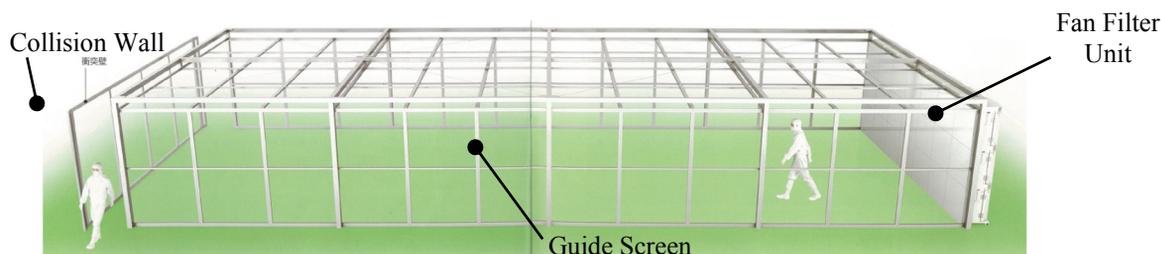


Figure 2: Floor KOACH Ez, source of drawing: product catalogue of KOKEN LTD..

<sup>†</sup> email address akihiro\_miyamoto@mhims.co.jp

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## APPLICATION OF FLOOR KOACH TO SRF CAVITY ASSEMBLY

### Layout

We constructed a clean room for SRF cavity assembly using Floor KOACH Ez. This clean room is installed in the existing clean room of ISO7. High pressure rinsing apparatus is located adjacent to the guide screen of clean room so that cavity after high pressure rinsing can be brought into clean room through opening at guide screen. The interior of the clean room is divided into an assembly area on the upstream side and a preparation area on the downstream side. In the assembly area, assembly work that needs a high cleanliness is performed. And cleaning of parts such as ultrasonic cleaning, rinsing with ultrapure water and blowing with filtered nitrogen is performed in the preparation area.

### Cleanliness

Cleanliness in the Floor KOACH was measured. Intake flow rate of particle counter used for this measurement was 2.83L/min. Particles ( $< 0.3\mu\text{m}$ ) counted by this counter for 10 minutes sampling was below 1020 counts / $\text{m}^3$  for every sampling point in assembly area. Therefore, it is concluded that the cleanliness of the assembly area is ISO4 or higher. And the similar measurement shows that the cleanliness of the preparation area is ISO5. And it is confirmed that sufficient cleanliness is obtained to perform the assembling work of the SRF cavity. Although it is expected that the cleanliness of assembly area is higher than ISO4, further cleanliness cannot be confirmed due to the restriction of the particle counter specification. The cleanliness tends to decrease as the distance from the fan filter unit increases. Although the Floor coach Ez is originally designed to obtain the cleanliness of ISO 1, the result of measurement does not reach this in the preparation area. The guide screen has an opening in order to access HPR apparatus, and there is a small gap between HPR apparatus and guide screen. The outer surface of the HPR apparatus which substitutes the guide screen is not smooth. This incompleteness of the guide screen is considered to be the reason why the degree of cleanliness of ISO1 could not be obtained.

### Preparation Area

A stainless steel sink and ultrasonic cleaning device are installed in the preparation area. And ultrapure water and filtered nitrogen are supplied. The separation between the assembly area and the preparation area is only the line drawn on the floor, and it is easy to move through each area. The parts for cavity assembly are cleaned using ultrasonic bath, rinsed using ultrapure water, blown using filtered nitrogen and dried inside clean room. Therefore, the parts can be prepared in a very clean condition before assembly. On the other hand, the uncleaned parts brought into the clean room may contaminate the clean room. But it is possible to maintain the cleanliness without special care. Of course it is necessary to remove visible dust or

oil on the surface before bringing it into the clean room. But even if invisible residual particulates are brought into the clean room, the air flow from the Floor KOACH capture and discharge them.

### Entrance and Exit

The space between the downstream end of the guide screen and the collision wall is completely opened. And this opening works as an entrance and exit for the parts and workers. Picture of entrance and exit is shown in Figure 3. Workers wear clean wear for ISO 4 clean room outside of entrance and enter the clean room. The worker can enter the predetermined area outside the Floor KOACH even if they wear either ISO4 clean ware of ISO7 clean ware. This allows workers to easily enter and exit the clean room and high workability is obtained. On the other hand, the frequent move between ISO4 and ISO7 cleanroom may contaminates ISO4 clean ware during stay in ISO7 cleanroom. But it is possible to maintain the cleanliness without special care. The air flow of the Floor KOACH capture and exhaust particulates and cleanliness is maintained.

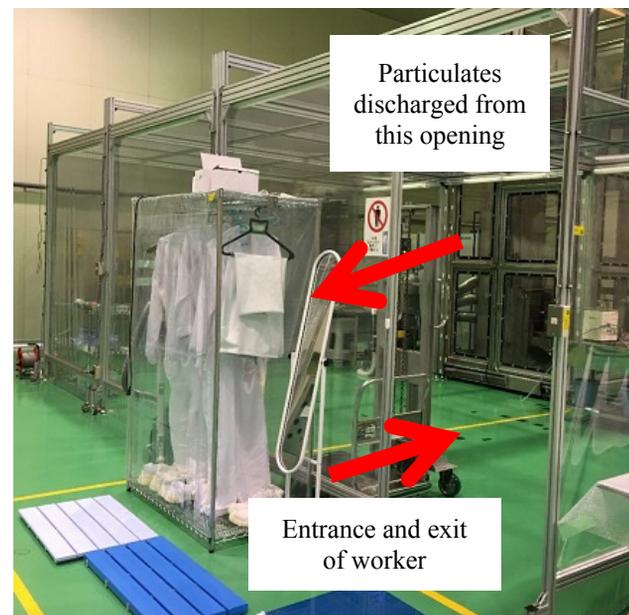


Figure 3: Entrance and exit of the Floor KOACH.

### Handling of Heavy Object

The Floor KOACH makes it easy to handle heavy objects in the clean room. Generally, it is not allowed to bring dust-generating equipment into a clean room of ISO 4 class in order to maintain cleanliness. Therefore, it is not allowed to bring the equipment such as chain block and hand lifter into clean room because a large amount of particulates are generated from movable portion of these equipment. But in case of the Floor KOACH, particulates generated inside clean room are captured and exhausted by the air flow from the Floor KOACH. The cleanliness inside the Floor KOACH is quickly recovered after using this equipment and a good cleanliness can be obtained before the work which really needs a clean condition such

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as opening of the flange of cavity. In order to fully use of this characteristic, the guide screen of the Floor KOACH are made of three divided parts with casters and made movable. Also, a ceiling crane is installed at the Floor KOACH installation site, and moving the guide screen, heavy objects are loaded into the area of ISO4 clean room using crane. After a guide screen is restored, it is possible to quickly recover the cleanliness of ISO4 by turning on FFU again. Figure 4 and Figure 5 are photos of work situation of cryomodule assembly. Workers move a guide screen of the Floor KOACH and lifting a cavity using a crane in Figure 4. The cleanliness inside the Floor KOACH is not ISO4 but ISO7 in this situation. Workers are wearing ISO7 clean ware and helmets and it is not like a work in ISO4 clean room. After placing a cavity on cryomodule, the guide screen is restored and FFU is turned on. And the cleanliness recovers immediately. Workers change their cloth and it is like a work of clean room. The characteristics of this Floor KOACH are a major advantage in special assembly application such as a SRF cavity string assembly and cryomodule assembly, where work requires both a cleanliness and handling of heavy objects.



Figure 4: Heavy parts are brought into clean room using crane. Workers are wearing ISO7 clean ware and helmet.



Figure 5: Workers change their cloths and start the clean work.

## Maintenance

The Floor KOACH's characteristic that cleanliness returns immediately after switching on has advantages not only in handling of heavy objects but also in maintenance of the clean room. During the period when there is no work, the KOACH is turned off for a long time. Before restarting the work, cleaning with a vacuum cleaner and wiping using wet cloth were carried out. After turning on the KOACH, the cleanliness of ISO4 is restored immediately. Unlike conventional clean room, maintenance of the KOACH is very easy.

## Vertical Test of the Cavities Assembled in the Floor KOACH

The results of vertical test of SRF cavity assembled in this Floor KOACH are shown in the Table 1. Accelerating gradient is not as high as the standard electropolished Tesla cavity. However, taking into account that the test cavities are BCP cavities or Low beta cavity, KOACH seems to have more potential in terms of cleanliness. Verification of performance of electropolished Tesla cavity assembled in the Floor KOACH is future task.

Table 1: Vertical Test Result of The Cavities Assembled in The Floor KOACH

Test cavities	Surface treatment	Accelerating gradient Eacc	Cause of limitation
1.3GHz elliptical cavity	BCP + HPR	23MV/m	Thermal breakdown
75.5MHz QWR cavity	BCP + HPR	9.2MV/m	Field emission

[1]

## CONCLUSION

We introduced an advanced clean room, Floor KOACH, for the purpose of assembly of SRF cavity. From the viewpoint of workability, the Floor KOACH has many advantages compared with the conventional clean room and has a great potential in the SRF assembly work.

## ACKNOWLEDGEMENT

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