ISBN: 978-3-95450-191-5 doi:10.18429/JACoW-SRF2017-MOPB088

EXPERIENCE ON IN-SITU MODULE REPAIR AND SET UP OF NON XFEL CAVITY STRINGS AT DESY

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Abstract

All components installed to the European XFEL cavity string modules underwent an intensive inspection and quality control before acceptance for installation to cavi-ties or modules. Even though some RF feed throughs for HOM coupler- and Pick Up antennas showed leaks at the ceramic insulation after module test at 2 K. Due to time restriction and continuity of production the exchange of these parts needed to be done without reentering the cleanroom. Successful repair of these modules took place by setting up a local cleanroom onto the cavity string.

In collaboration with Helmholtz-Zentrum Dresden-Rossendorf (HZDR), a cavity string for the ELBE project [1] [2] was assembled at DESY and transported to HZDR for installation to the vacuum vessel.

A spare module with 3.9 GHz resonators for the European XFEL was set up at DESY and will be tested and qualified for the European XFEL. Due to delay in delivery of the power couplers, four power couplers were installed after string assembly.

INTRODUCTION

DESY and the European XFEL had contracted that modules, which failed in the final tests, would be repaired by DESY. For three modules, where the repair could be done by exchange of just one feed through, this repair was done with a local cleanroom on the cantilever system for module assembly.

The cavity string for HZDR was assembled in January 2017 in the DESY cleanroom and afterwards transported to HZDR for the complete installation.

The 3.9 GHz spare module X3M2 was assembled in collaboration between INFN Milano and DESY, comparable to the 3.9 GHz module X3M1 for the European XFEL [3].

REPAIR SEQUENCES

Composition and Qualification of the Clean Room

For the repair of the modules outside the cleanroom, a local cleanroom was needed (Fig. 1). To achieve a sufficient air flow and air quality at the HOM coupler- and Pick Up antennas, the magnetic shielding and the tuners had to be disassembled. For the composition of the local cleanroom a filter fan unit (FFU) was installed and the assembly position was encased with foil. The assembly area in the local cleanroom had to be cleaned with ethanol and lint free tissues.

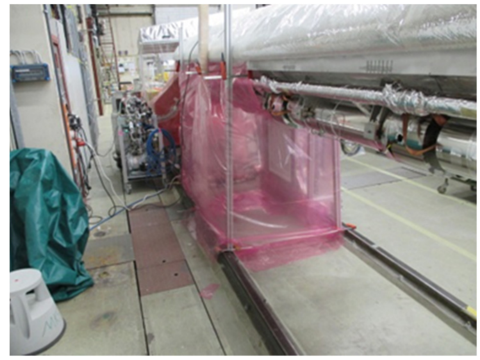

Figure 1: Local cleanroom on the string.

The local cleanroom was reviewed with an anemometer for the air flow speed and a particle counter. The air flow speed was between 0.48 m/s and 0.66 m/s (Fig. 2). The particle counts at the assembly position were better than specified in ISO 4 norm (Fig. 3).

Figure 2: The control of the air flow speed.

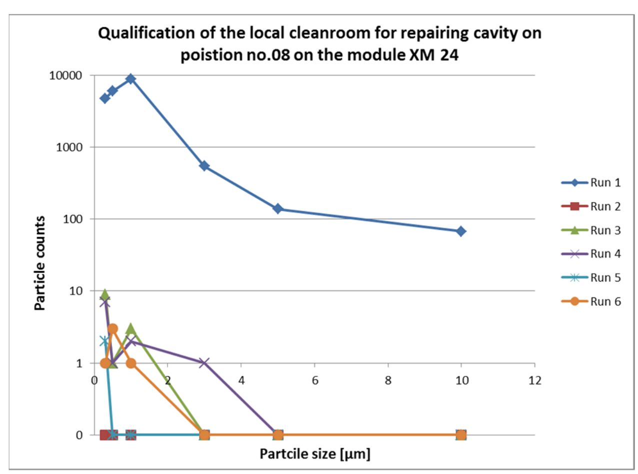

Figure 3: Example of the particle qualification of the local cleanroom for XM24.

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For the assembly a good horizontal air flow without any turbulence at the assembly position is important. This was qualified through the visualization of the air flow with a fog generator (Fig. 4) [4].

Figure 4: Visualization of the air flow.

Change of HOM coupler- or Pick Up Antenna

Before the assembly can start in the local cleanroom, all parts (HOM coupler- or Pick Up antenna, screws, nuts, etc.) had to be cleaned in the cleanroom by ultrasonic cleaning, rinsing and blowing with ionized N2 air gun (counts 0.3-10 µm <10 /min) [5]. All parts were put in double bag for transport to the local cleanroom. The assembly steps are the same as the standard string assembly seen in the list (Table 1) [6].

Table 1: Assembly Steps for the Exchange of HOM Coupler- or Pick Up Antenna

#	Activity
1	String slow venting to air pressure
2	System at normal air pressure start N2 flushing of string
3	Qualification before start by air particle counter and blowing with gas flow from ionized N2 air gun, counts 0.3-10 µm <10 /min
4	Start removing first screws from HOM coupler- or Pick Up antenna and cleaning with gas flow from ionized N2 air gun
5	Remove last screws, remove split backing ring; Remove HOM coupler- or Pick Up antenna with gasket
6	Installation of new HOM coupler- or Pick Up antenna with new gasket
7	Stop N2 flushing of string
8	Start pump down and leak check

Test R*esult XM22, XM24, XM91*

The first module repaired with a local cleanroom was XM22. This module had a beam vacuum leak at the test stand in the AMTF at DESY and could not be tested before one defect HOM coupler antenna on cavity 7 was exchanged. So no test results before the repair can be given. After repair this module has reached an operating gradient of 25.82 MV/m and on the repaired cavity of the module no field emission was observed.

On XM24 one Pick Up antenna on cavity 8 had to be exchanged. The RF test results of this module were identical at the first RF test before and the second RF test after the repair (Fig. 5).

Module XM91 had an operating gradient of 28.79 MV/m before the exchange of one HOM coupler antenna on cavity 7. The module was installed directly in the European XFEL tunnel after the repair. A second RF test in the AMTF at DESY could not be done.

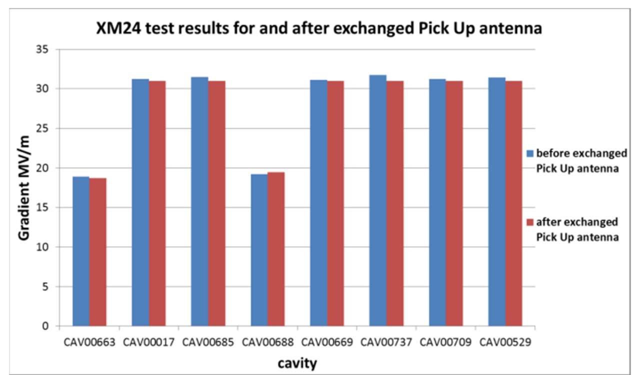

Figure 5: The two test results of XM24.

HZDR STRING FOR ELBE PROJECT

For the string assembly the cavities and other string components are set on posts in the DESY cleanroom. As the HZDR cavities have a different helium tank design than the European XFEL cavities, the post distance had to be adjusted. In consequence the bellow unit and the interconnecting bellows had to be set on separate posts and a new assembly tool for the bellow unit had to be produced (Fig. 6).

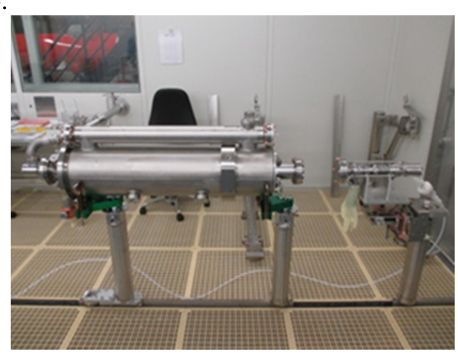

Figure 6: Assembly tool with a bellow unit installed on the extra post.

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The first step of the string assembly was to put the coupler to the cavity. After that the bellow unit was built together. The assembly of the bellow unit started with the connection of the pump bellow to the angel valve and was completed by the connection of the blind flange (Fig. 7). The complete assembly was with N2 flushing. These components were leak checked and a RGA was done before any further steps.

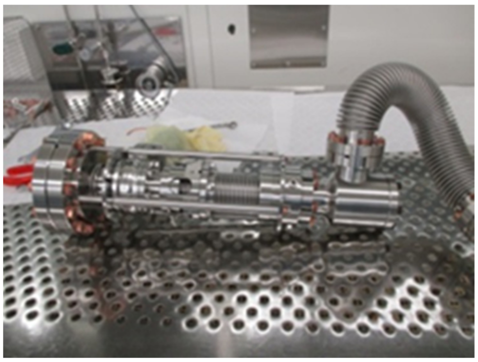

Figure 7: Complete bellow unit for the HZDR-String.

When all components were tested, the string assembly started. At DESY we begin with the connection between the first cavity and the first bellow unit. Then the interconnecting bellow is attached to the first cavity. After that the second bellow unit is put together with the second cavity. This allows us to flush the string with N2 from both sides during the last assembly. Final step is the connection between the interconnecting bellow and the second cavity (Fig. 8). After roll out of the string, the string was transported to HZDR for the next assembly steps into the vacuum vessel.

Figure 8: Complete HZDR-String at the pump station in the cleanroom before roll out.

SPARE MODULE 3.9 GHz

The assembly order for the first 3.9 GHz module X3M1 for the European XFEL was to first connect cavity 8 to the gate valve, join the following 7 cavities and push the string of 8 cavities to the fixed beam quadrupole unit (BQU) to make the last connection between cavity 1 and the BQU. During this procedure we observed that the cavity string could not be moved completely smooth on the slide rail. To prevent the cavity string from jerking on the rail during assembly, we decided to reverse the assembly order. Assembly started with the connection of the beam quadrupole unit (BQU) to the cavity 1 and was completed by the connection of the gate valve to cavity 8. So each time only a single cavity had to be moved on the rail.

In addition we had to change the standard process due to delay in delivery of the power couplers. Four cavities (position 2.4.6.8) had a standard power coupler assembly with leak check and RGA before the connections between the cavities were made. The other four cavities were installed in the string only with High-Q RF antennas (Fig. 9). When the missing power couplers arrived at DESY, we exchanged the High-Q RF antenna with the power coupler on the string (Fig. 10).

Figure 9: String at the pump station before installation of the last four power couplers.

Figure 10: Complete string at the pump station after installed all couplers.

SUMMARY

To save time and stay within the schedule of the European XFEL project, three modules were repaired with a local cleanroom. For exchange of HOM coupler- or Pick Up antennas proper air flow speed and particle counts equal to the ISO-4 norm are important. The procedure for the change of HOM coupler- or Pick Up antennas in the local cleanroom is the same as in the cleanroom.

For the string assembly of the ELBE project at DESY, we have modified the alignment tools and post system. We also changed the standard assembly sequence to ensure that we have a N2 flushing of both sides for all assembly steps. After finishing the string assembly, the string was transported to HZDR for installation into the vacuum vessel.

The spare 3.9 GHz module for the European XFEL was not a standard assembly due to the delay in delivery of the

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power couplers. Before the string assembly started at DESY only four power couplers were installed at the cavities. The other four power couplers had to be installed after string assembly. The test of the spare module 3.9 GHz is planned for autumn 2017.

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