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Test sequence for superconducting XFEL cavities in the Accelerator Module Test Facility (AMTF) at DESY

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Abstract

The European XFEL is a new research facility currently under construction at DESY in the Hamburg area in Germany. From 2016 onwards, it will generate extremely intense X-ray flashes that will be used by researchers from all over the world. The main part of the superconducting European XFEL linear accelerator consists of 100 accelerator modules with 800 RF-cavities inside. The accelerator modules, superconducting magnets and cavities will be tested in the accelerator module test facility (AMTF) at DESY. This paper gives an overview of the test sequences for the superconducting cavities, applied in the preparation area and at the two cryostats (XATC) of the AMTF-hall, and describes the complete area. In addition it summarizes the tests and lessons learnt until the middle of 2014.

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1. Introduction

In total, 800 cavities have to be integrated in the European XFEL linac. To guarantee adequate cavity shape, verify the performance and to set up the accelerator in an optimal way, all cavities have to undergo a comprehensive control in the Accelerator Module Test Facility (AMTF) before being integrated into the accelerator modules. The

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purpose of this paper is to describe the test sequences from the arrival of the cavities from the manufacturer to the preparation for the shipment for module assembly. The status of the current cavity production for the European XFEL will be briefly described.

Nomenclature

AMTF	Accelerator Module Test Facility
HPR	High Pressure Water Rinsing
BCP	Buffered Chemical Polishing

2. Test sequences

To verify conformity with the specification for manufacture and criteria for the module assembly, several test procedures were defined, which are applied between arrivals of the cavities from the manufacturer until the preparation for shipment for module insertion. The complete test sequence for cavities is divided into three main parts – the incoming inspection, the cold test and the outgoing inspection. An overview of the relevant selection of the AMTF hall, where the tests are done, is given in Fig. 1.

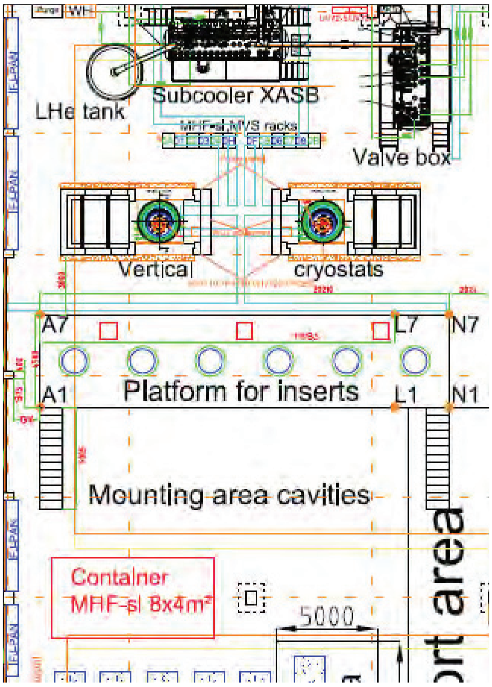

Fig. 1. Cavity test area in the AMTF.

2.1. Incoming inspection

All cavities arrive under vacuum in specially designed transport boxes from the manufacturer, as demonstrated in Fig. 2a, fully equipped with HOM-antennas, pick-up antenna and fixed high Q antenna, ready for the cold test at 2 K. To have an indication, whether the transport complied with the specified maximum disturbances below an acceleration of 3 g, a shock logging system is activated during the entire transport. Immediately after the arrival a brief visual inspection of the cavity inside the transport box is performed. Then the cavity is put on a special support, shown in Fig. 2b, for the mechanical part of the incoming inspection. Here the cavity is checked for completeness, mechanical deviations, such as deep scratches, dents and or other irregularities.

A first RF-test at room temperature verifies the inner shape: the frequency spectrum is compared with the one obtained during the last measurements on the manufacturer site and conformity with the tolerances has to be established.

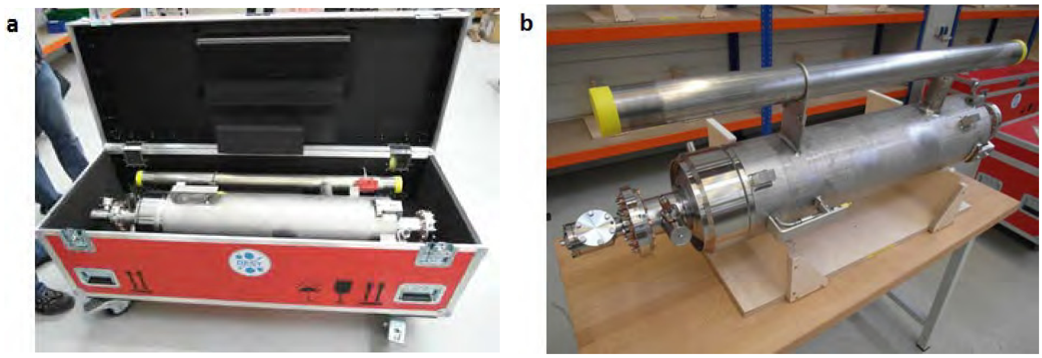

Fig. 2. (a) Cavity in transport box ; (b) cavity support for incoming inspection.

After passing the tests the cavity is installed in the vertical insert (for details see Schaffran at al.), a support structure for placing the cavity inside the vertical test cryostat, which is described by Chorowski at al. Here the cavity is connected to a pumping unit and a leak check and residual gas analysis are carried out. In addition a rejection filter tuning, a plastic deformation of the HOM-antennas, is performed to get an optimal transmission of the fundamental mode and a damping of the higher modes. It is described in detail by Kostin. The setup is depicted in Fig. 3. After that the cavity is ready for the cold test. All observations are recorded in the so called “incoming inspection report”. When the cavity does not pass all criteria of the incoming inspection and an ad-hoc repair is not possible, it will be send back to the manufacturer for remediation.

Fig. 3. Setup for vacuum connection and rejection filter tuning.

2.2. Cold test

The vertical inserts are designed to install four cavities in parallel (see Fig. 4). All cavities have their own vacuum- and RF-connection, so that the measurement can be performed independently. If one cavity fails due to defective RF- or vacuum connection, the tests of the residual three cavities are not affected. To verify the performance of the cavities at a temperature of 2 K, the quality Q is measured as a function of the field (Q vs. E curve) together with the frequency spectrum. Helium leak tightness at 2 K is examined as well. This and an additional radiation measurement for observing the field emission on the top and the bottom of the cryostat allow the determination of the usable gradient E_{usable}. This value helps to decide whether the cavity is ready for installation into a module or whether it needs an additional re-treatment, like an HPR or BCP, for further improvement. The cavity selection for grouping in a module and the positioning of the cavity inside a module depends on the usable gradient.

Fig. 4. Installation of the vertical insert into the cryostat.

Table 1 gives an overview about the status of the cavity production until June 2014:

Table 1. Status of cavity production.

Cavities	Number
Arrived	361
Tested	336
Qualified for module assembly	263
Passed 1st test	209

To meet the requirements for the European XFEL, which is designed for an average usable gradient of 23.6 MV/m all cavities with a gradient above 25 MV/m (an error in the measurement was taken into account) are accepted. The usable gradient is defined by beam dump, the quality factor (gradient E_{acc} at $Q \geq 1E10$) or the field emission, whereby the last one is restricted by measurement of 0.01 mGy/min on the top of the cryostat or 0.12 mGy/min at the bottom. The deviation of the values in different places is explained due to the geometry of the measurement setup.

2.3. Outgoing inspection

Before the cavity will be shipped for module assembly, the outgoing inspection has to be performed. For this investigation the cavity is again installed on the support structure, which was already used for the mechanical part of the incoming inspection (see Fig. 2b). The outgoing inspection includes a detailed and recorded visual inspection as well as an additional measurement of the spectrum and a check of the HOM couplers. The quality of the vacuum is recorded with the help of a leak check and a residual gas analysis.

3. Conclusion

More than 360 out of 800 cavities have arrived at DESY, with more than 330 measured at 2 K. Meanwhile the test sequence has been established as an adequate and manageable tool for the quality control of the XFEL cavities. Performance failures could be reliably detected and often related to variations in the manufacturing process. Direct feedback and communication with the manufacturers proved vital to avoid delivery of defective cavities and additional costs. A test rate of 8-10 cavities/week can be handled currently, so that a suitable stock of cavities for installation in modules with optimal grouping of operating gradient is available. Consequently a steady cavity delivery for module assembly at CEA Saclay can be realized.

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References

Schaffran, J., at al., 2013. Design parameters and commissioning of vertical inserts used for testing the XFEL superconducting cavities, CEC/ICMC 2013, Anchorage, paper 1EPoE1-03.

Chorowski, M., at al., Design and commissioning of vertical test cryostats for XFEL superconducting cavities measurements, CEC/ICMC 2013

Kostin, D., "XFEL Cryomodule Assembly: RF Measurements and Tuning", XFEL String and Cryomodule Assembly Workshop, France, 2008.