Retreatment of European XFEL Series Cavities at DESY as Part of the Repair of European XFEL Accelerating Modules.

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Abstract

For the European XFEL 102 accelerating modules were built and tested. Several accelerating modules had to be reworked due to different kinds of non-conformities. The extent of this rework varied greatly. At the end of production four accelerating modules could not be qualified in time before the tunnel installation was to be finished in September 2016. Meanwhile the cavity strings of two of these accelerating modules have been disassembled in the DESY clean room. The cavities have been retreated at DESY either by additional high pressure water rinsing or BCP flash chemical treatment. All cavities were vertically tested and 15 out of 16 were qualified for the reassembly of the cavity strings. One accelerating module will be reassembled completely and tested until the end of 2018; the other will follow in the first half of 2019. We report on retreatment procedures and performance of these cavities.

Accelerating Modules Under Repair

XM8
- Leak in 2K area could not be verified
- Module was reassembled
- Disassembly of the cavity string was not necessary

XM46
- Beam vacuum leak
- String disassembled and cavities retreated
- 7 of 8 cavities recovered
- String reassembly in Q1 2019

XM50
- Beam vacuum leak
- String disassembled and cavities retreated
- 8 of 8 cavities recovered
- Reassembly in progress

XM99
- Beam vacuum leak still under investigation
- String disassembly and cavity retreatment planned for 2020

Reassembly of accelerating module XM50.1 (former XM50) in the Accelerator Module Test Facility AMTF

Retreatment Procedures

For the retreatment of superconducting European XFEL series cavities that did not achieve the approval for string installation different retreatment passes were specified. During the repair of the accelerating modules XM46 and XM50 only the retreatment passes RP1 and RP2 were applied.

Retreatment Pass RP1

1. Cleaning by ultrasonic cleaning and ultra-pure water rinsing to enter ISO 4 cleanroom
2. Venting to normal pressure with 3 l/min Nitrogen gas flow rate
3. Dismounting of beam tube flange short side
4. Six times high pressure rinsing and drying for 12 hours in ISO 4 cleanroom area
5. Assembly of beam tube flange
6. Pump down, leak check with standard turbo molecular pumping unit

Retreatment Pass RP2

1. Cleaning by ultrasonic cleaning and ultra-pure water rinsing to enter ISO 4 cleanroom
2. Venting to normal pressure with 3 l/min Nitrogen gas flow rate
3. Dismounting of all cavity accessories
4. Chemical treatment of maximum removal of 10 µm by BCP, ultra-pure water rinsing and one time HPR
5. Drying for 12 hours in ISO 4 cleanroom area
6. Assembly of accessories and beam tube flanges to cavity, leak check
7. Dismounting of beam tube flange short side
8. Six times high pressure rinsing and drying for 12 hours in ISO 4 cleanroom area
9. Assembly of beam tube flange
10. Pump down, leak check and residual gas analysis (RGA) with standard standard turbo molecular pumping unit
11. 120°C baking

High Pressure Rinse (HPR)

High pressure ultra-pure water rinsing (HPR) setup with acrylic plastic cavity model installed above the sprayhead

BCP Flash Chemical Treatment

Buffered chemical polishing cabinet with an undressed nine-cell European XFEL cavity installed

Cavity Performance

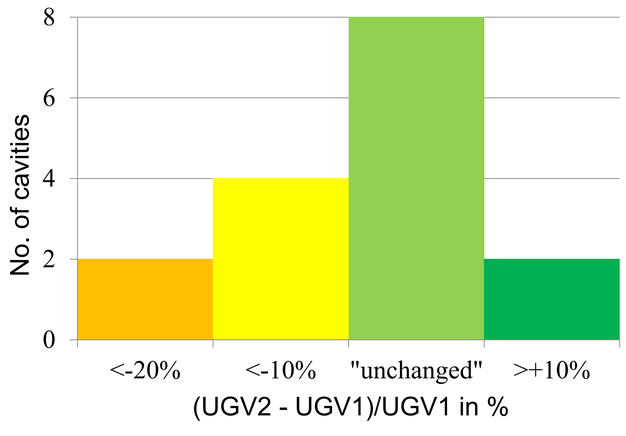
All 16 cavities from the disassembled accelerating modules XM46 and XM50 were retreated by HPR according to retreatment pass RP1. Two of the cavities, CAV00831 and CAV00869, did not recover and were treated additionally by BCP flash chemical treatment, according to retreatment pass RP2. The usable gradients in MV/m of the cavities in the vertical test before accelerating module assembly (UGV1), in the module test (UGM) and after the retreatment (UGV2) together with the retreatment procedure are given in the tables below. The constraint which limits the usable gradient of the cavities is given in brackets. UGV2 for the cavities CAV00831 and CAV00869 were measured after the BCP treatment.

Usable gradients of the cavities from accelerating modules XM46 and XM50 before and after retreatment.
*CAV00831 is not qualified for accelerating module assembly yet. **Sum of the 7 qualified cavities

Position in XM46	Cavity-No	UGV1 in MV/m (limitation)	UGM in MV/m (limitation)	Retreatment Procedure	UGV2 in MV/m (limitation)
C1	CAV00831	30 (Q_0)	17,4 (Xray)	BCP	19 (BD)*
C2	CAV00869	30 (Q_0)	17,6 (BD)	BCP	32 (Q_0)
C3	CAV00051	30 (Q_0)	20,7 (BD)	HPR	31 (BD)
C4	CAV00860	30 (Q_0)	24,5 (Xray)	HPR	30 (Q_0)
C5	CAV00279	30 (Xray)	24,9 (Xray)	HPR	36 (BD)
C6	CAV00261	29 (Q_0)	19,8 (Xray)	HPR	27 (Xray)
C7	CAV00850	29 (Q_0)	17,1 (Xray)	HPR	34 (BD)
C8	CAV00818	30 (Emax)	15,3 (Xray)	HPR	33 (BD)
Sum		238	157,3		223**

Position in XM50	Cavity-No	UGV1 in MV/m (limitation)	UGM in MV/m (limitation)	Retreatment Procedure	UGV2 in MV/m (limitation)
C1	CAV00207	36 (Emax)	20 (Xrays)	HPR	31 (Q_0)
C2	CAV00789	38 (Q_0)	16.4 (Xrays)	HPR	36 (Q_0)
C3	CAV00253	41 (Emax)	29.1 (BD)	HPR	30 (Q_0)
C4	CAV00256	38 (Emax)	31 (PWR)	HPR	34 (Emax)
C5	CAV00257	40 (Emax)	31 (Xrays)	HPR	33 (Emax)
C6	CAV00260	40 (Emax)	25.6 (Xrays)	HPR	39 (FE)
C7	CAV00265	36 (FE)	23.1 (Xrays)	HPR	37 (Q_0)
C8	CAV00267	37 (Q_0)	20.3 (BD)	HPR	32 (FE)
Sum		306	196,5		272

In vertical test 15 of 16 retreated cavities met the acceptance criteria of European XFEL serial production phase and qualified for the reassembly of the cavity string. But some did not recover their original performance. The difference between the usable gradient in vertical test before accelerating module assembly and after the retreatment in the framework of the accelerating module repair efforts is compiled in the figure beside. Due to the typical uncertainties of cold rf measurements, a variation of ±10 % of the previous performance is marked as “unchanged”.



Difference in usable gradient in vertical tests before accelerating module assembly and after retreatment.

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LINAC2018 Beijing 16-21 September 2018
TUPO028