MOP052

RF Aspects of Quality Control for Industrial XFEL Cavities Fabrication

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Abstract

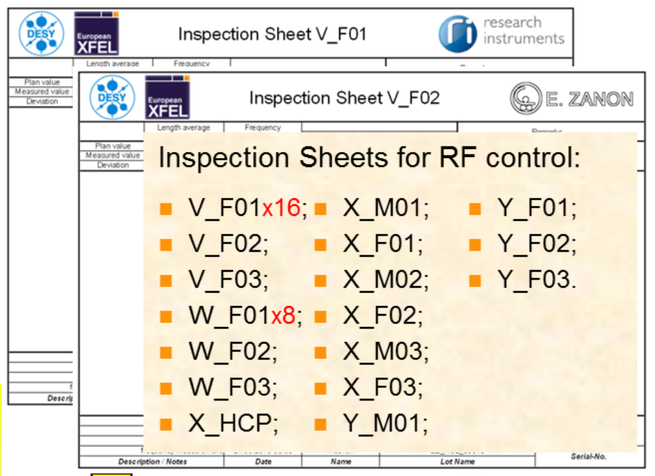
Quality control of European XFEL serial cavities allows us not only exception of the use of rejected cavities for the linac, but also giving a feedback to industry in case of cavity parameters come to their limits. RF check assays not only the electro dynamical characteristics (as frequencies, Q-factors and fields), but also provides the mechanical revise with a very high accuracy.

Automation of this quality control in XFEL data base gave us a powerful tool necessary for big projects such as the European XFEL.

Production sequence:

- cavity parts fabrication,
- cavity welding,
- cavity tuning,
- welding in the helium tank,
- pressure test,
- cavity transport.

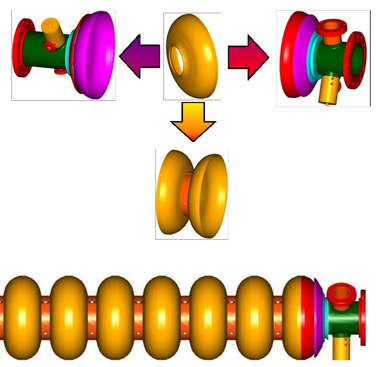
39 documents x 800 cavities
=
31 200 documents
312 documents / week



Cavity parts fabrication:

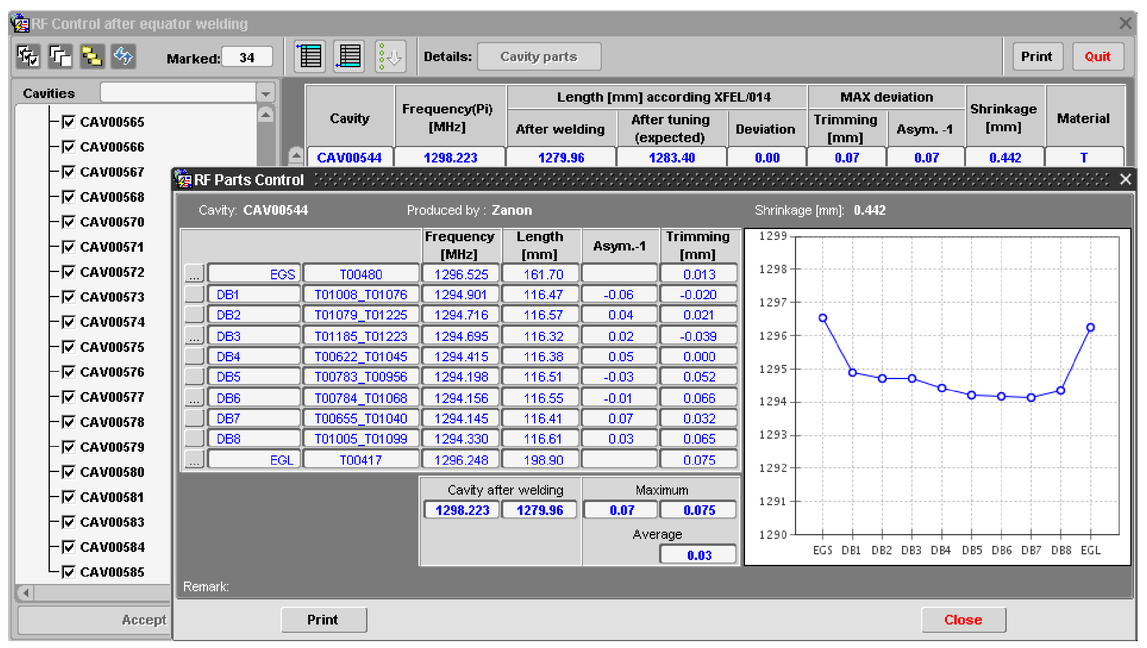
- shape control for half cells (HC), end groups (EG) and dumb-bells (DB);
- DBs asymmetry control;
- calculation of optimal parts lengths;
- DBs sorting in cavity;
- estimation of cavity length in the helium tank.

Acceptance Level 1



After cavity welding:

- measure the pi-mode frequency and cavity length;
- verifying the welding parameters (shrinkage and deformation);
- calculate the cavity length in the helium tank.



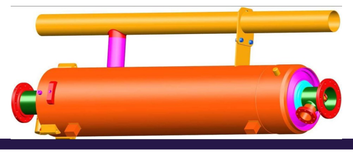
Acceptance Level 2

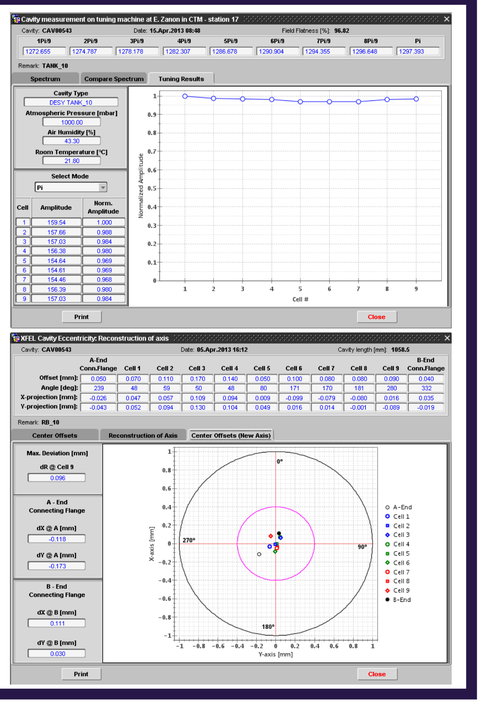
Values are verified during cavity tuning:

- pi-mode frequency,
- field flatness (FF),
- cavity length,
- cavity cells eccentricity.

Welding in the helium tank , pressure test :

- checking of pi-mode frequency during the welding of rings with bellow and helium tank;
- checking of RF parameters (Fpi, FF) before and after HT welding and pressure test.

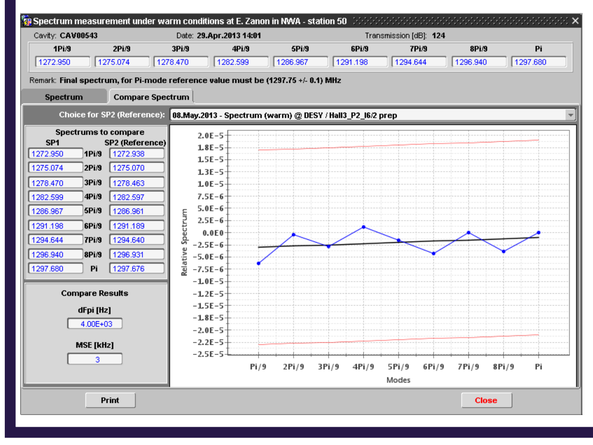




Acceptance Level 3

Measured and calculated values:

- pi-mode frequency,
- transmission between high-Q pick-up antennas,
- field flatness changes (MSE < 10 kHz)



Acceptance Level 3

To estimate deviation of field flatness two spectra have to be compared:

- Reference spectrum SP2 can be downloaded from XFEL DB (it's a spectrum with known value of FF^{ref})
- N = 9 – number of cavity cells, measured spectrum SP1 = $\{f_i\}$, SP2 = $\{F_i\}$, where i = 1…N.
- Relative spectrum is calculated as:

$$RS = \{R_i\} = \{F_i/f_i - F_N/f_N\}, \text{ where } i = 1\ldots N.$$

- Linear Fit is calculated for relative spectrum:

$$L = \{L_i\} = \text{linear\_fit}\{R_i\}, \; i = 1\ldots N$$

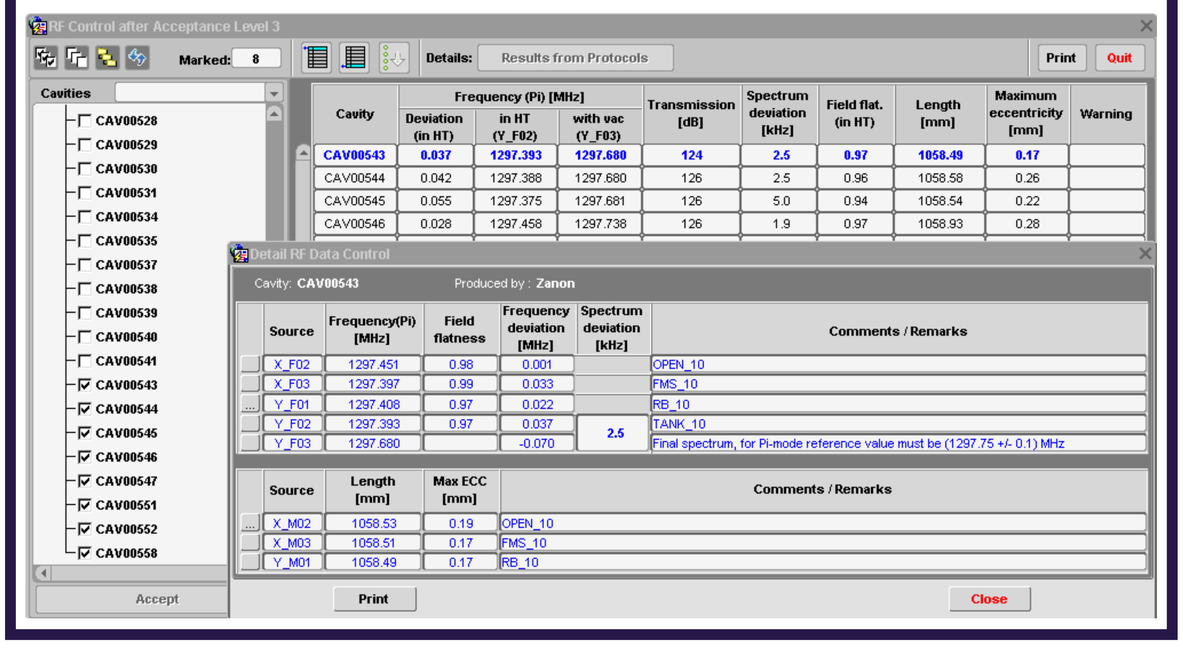
- Mean squared error is calculated as:

$$mse = \frac{\sum_{i=1}^{N}(R_i - L_i)^2}{N}$$

- Mean spectrum frequency deviation is calculated as:

$$MSE[kHz] = f_\pi^{\,op}\sqrt{mse}\,, \text{ where } f_\pi^{\,op} = 1.3 \text{ GHz}.$$

Acceptance Level 2 / Acceptance Level 3



Summary

- The RF quality control for European XFEL cavities requires checking of 31 200 inspection sheets only from cavity producers. Automation of this process in the XFEL data base gave us a powerful tool which is required for such a big project.
- The access to the fabrication data in the XFEL data bese is limited – only for cavity producers and DESY experts. So this paper will be interesting mostly for them. But the analysis will be published and our experience can be used also for others projects.

References:

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[2] http://xfel.desy.de/cavity_database/cavity_production
[3] A. Sulimov et al., "Description and First Experience with the RF Measurement Procedure for the European XFEL SC Cavity Production", 2nd IPAC'11, San Sebastian, Spain, 2011, pp. 277-279.
[4] A. Sulimov et al., "First RF Measurement Results for the European XFEL SC Cavity Production" Proceedings of LINAC2012, Tel-Aviv, Israel, 2012, p. 195.
[5] J. Iversen et al., "Development and Design of an RF measurement Machine for the European XFEL Cavity Fabrication", 14th SRF Conference, Berlin, 2009, p.786.
[6] J.-H. Thie et al., "Commissioning and Upgrade of Automatic Cavity Tuning Machines for the European XFEL", 15th SRF Conference, Chicago, 2011

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