

European

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: research instruments Inspection Sheet V_F01 cavity parts fabrication, Þ 🚱 e. zanon Inspection Sheet V_F02 European XFEL cavity welding, cavity tuning, Measured value Inspection Sheets for RF control: welding in the helium tank, V_F01x16; X_M01; Y_F01; pressure test, V_F02; X_F01; Y_F02; V_F03; X_M02; Y_F03. cavity transport. ■ W_F01x8; ■ X_F02; W_F02; X_M03; W_F03; X_F03; 39 documents x 800 cavities X_HCP; Y_M01;



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.

dX @ B [mm] 0.111

dY @ B [mm] 0.030

Print

RF Control after eq	uator welding										×
ña Fa 🔁 🦘	Marked: 34		🖖 🛛 Details: 💽 🤇	Cavity parts						Prin	t Quit
Cavities			F(D)	Len	igth [mm] a	ccording XF	EL/014	MAX de	eviation	Chainlanna	
- ⊡ CAV00565	<u> </u>	Cavity	[MHz]	After weld	ling Afte	er tuning	Deviation	Trimming	Asym1	snrinkage [mm]	Material
- ⊡ CAV00566		CAV00544	1298 223	1279.9	(ex	1283 40	0.00	0.07	0.07	0.442	T
- 🔽 CAV00567	👼 RE Parts Cor	ntrol inizialization									interior x
- ▽ CAV00568											
- I ⊂ CAV00570	Cavity: CAVU	10544	Produced by : Za	anon			Shrinkag —	e (mm): 0.442			
- 🔽 CAV00571			Frequency [MHz]	Length [mm]	Asym1	Trimming [mm]	1299				
- 🔽 CAV00572	E	GS T00480	1296.525	161.70		0.013	1298-				
	DB1	T01008_T01	076 1294.901	116.47	-0.06	-0.020	1297-				
- I ⊂ CAV00574	DB2	T01079_T01:	225 1294.716	116.57	0.04	0.021		Q			
-⊠ CA¥00575	DB3	T01185_T01:	223 1294.695	116.32	0.02	-0.039	1296-				
	DB4	T00622_T01	045 1294.415	116.38	0.05	0.000	1295				
	DB5	T00783_T00	956 1294.198	116.51	-0.03	0.052		0-0	-a-a		
- 🔽 CAV00577	DB6	T00784_T01	068 1294.156	116.55	-0.01	0.066	1294			<u> </u>	~
- 🔽 CAV00578		T00655_T01	040 1294.145	116.41	0.07	0.032	1293				
- 🔽 CAV00579		101005_101	099 1294.330	116.61	0.03	0.065					
- ⊡ CAV00580		GL 100417	1295.248	198.90		J075	1292-				
- 🔽 CAV00581			Cavity aft	er welding	Ma	ximum	1291 -				
- ⊡ CAV00583			[1298.223]	1279.96	0.07	1 0.075					
- ▼ CAV00584					Ave	erage	1290	EGS DB1 DB	2 DB3 DB4	H H H DB5 DB6 DB7	DB8 EGI
						0.03					
(Remark:										
Accej	ot	Print							Clo	se	

Acceptance Level 2

Values are verified during cavity tuning:

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

r_{ita} I

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.

	21 1/3	361/8	44	PI/9	5Pi/9	6P	1/9	7Pi/9	8Pi/	9	Pi
1272.655	1274.787	1278.178	1282.	307	1286.678	1290.9	04 [12	94.355	1296.648	1	297.393
Remark: TANK_10											
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Cauito	Time										
DESY T	ANK 10		1	o	،						<u> </u>
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100	0.00										
_Air Hum	idity [%]		0.8								
43	.30										
Room Temp	erature [°C]	qe	0.7								
		ji	0.6								
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Pi	v	zed	0.5								
Coll Appolitude	Norm.	mali									
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2 157.66	0.988	_									
4 156.38	0.980	- '	0.2								
5 154.64	0.969		0.1								
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8 156.39	0.980	_		1	2 3	4	5	6	7	8	9
3 <u>1</u> 137.05	1 0.304						CEII #				
XFEL Cavity Ecc	entricity: Reco	nstruction	of axis 🔅								
Cavity: CAV00543				Date: 05.A	pr.2013 16:1	2		C	avity length (mm]: 105 8	3.5
	A-ENd										
	Conn.Flange	e Cell 1	Cell 2	Cell 3	Cell 4	Cell 5	Cell 6	Cell 7	Cell 8	Cell 9	B-l Conn.
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Measured and calculated values:

- pi-mode frequency,
- transmission between high-Q pick-up antennas,

field flatness changes (MSE < 10 kHz)</p>

Spectrum mea	surement under	warm con	ditions at E.	Zanon i	n NWA - s	tation 50	1.00000	••••••••					
Cavity: CAV0054	13	Date:	29.Apr.2013 1		Transmission [dB]: 124								
1Pi/9	2Pi/9	3Pi/9	4Pi/	9	5Pi/9		6Pi/9	7	Pi/9	8Pi/	9	Pi	
1272.950	1275.074	1278.470	1282.59	9	1286.967	12	91.198	1294.	644	1296.940	1	297.680	
Remark: Final spe	ectrum, for Pi-ma	ode referer	nce value mu	st be (1	297.75 +/- (0.1) MHz							
Spectrum	Compare S	pectrum											
Choice fo	or SP2 (Referenc	e): 08.May	/.2013 - Spect	rum (w	arm) @ Di	SY / Hall3	_P2_16/2	ргер					T
Spectrum SP1 1272.950 1P 1275.074 2P 1278.470 3P 1282.599 4P 1286.967 5P 1291.198 6P 1294.644 7P 1296.940 8P 1297.680 1	s to compare SP2 (Reference i/9 1272.938 1275.070 i/9 1278.463 i/9 1282.597 i/9 1286.961 i/9 1291.189 i/9 1294.640 i/9 1296.931 Pi 1297.676 e Results	Relative Spectrum	2.0E-5 1.8E-5 1.5E-5 1.3E-5 1.0E-5 7.5E-6 2.5E-6 0.0E0 2.5E-6 5.0E-6 5.0E-6 5.0E-6 5.0E-6 5.0E-6 5.0E-6 1.2E-5 1.2E-6 1.2E-5	/			<u> </u>					2	
dFp 4.0 MSE	i (Hz) DE+03 [kHz]		1.5E-5 1.8E-5 2.0E-5 2.2E-5 2.5E-5										
	3			Pi/9	2Pi/9	3Pi/9	4Pi/9	5Pi/9 Modes	6Pi/9	7Pi/9	8Pi/9	Pi	
	Print									Clo	ose		

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}, where i = 1...N. Linear Fit is calculated for relative spectrum: $L = {L_i} = linear_fit{R_i}, i = 1...N$ Mean squared error is calculated as: $mse = \frac{\sum_{i=1}^{N} (R_i - L_i)^2}{\sum_{i=1}^{N} (R_i - L_i)^2}$ Mean spectrum frequency deviation is calculated as: $MSE[kHz] = f_{\pi}^{op} \sqrt{mse}$, where $f_{\pi}^{op} = 1.3$ GHz.

			Α	ccep	otano	ce Le	vel 2	/ A	ссер	otanc	e Lev	vel 3
ontrol after Ac	ceptance Leve	13										×
- 🔁 🦘	Marked: 8			Details:	Results	from Protocol	s				Prin	t Quit
es CAV00528			Cavity	Fre Deviation (in HT)	quency (Pi) [in HT (Y. F02)	MHz] with vac (Y. F03)	Transmission [dB]	Spectrum deviation [kHz]	Field flat. (in HT)	Length [mm]	Maximum eccentricity [mm]	Warning

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



			CAV00543	0.037	1297.393	1297.680	124	2.5	0.97	1058.49	0.17		
	- CAV00530	í	CAV00544	0.042	1297.388	1297.680	126	2.5	0.96	1058.58	0.26	Ĭ	
	- CAV00531	Ì	CAV00545	0.055	1297.375	1297.681	126	5.0	0.94	1058.54	0.22	i	
	- 🗖 CAV00534		CAV00546	0.028	1297.458	1297.738	126	1.9	0.97	1058.93	0.28		
	- 🗖 CAV00535 💦 👩		÷					;)			
	- CAV00537												
	- CAV00538	Cavity: CAV00543 Produced by : Zanon											
CAV00539													
	- T CAV00540	Source	[MHz]	flatness	deviation (MHz)	deviation [kHz]			Comment	s / Remarks			
	- 🗖 CAV00541	X_F02	1297.451	0.98	0.001]	OPEN_10						
	- 🔽 CAV00543	X_F03	1297.397	0.99	0.033]	FMS_10						
	- 🔽 CAV00544	Y_F01	1297.408	0.97	0.022]	RB_10						
	- 🔽 CAV00545	Y_F02	1297.393	0.97	0.037	2.5	TANK_10						
	- V CAV00546	[_Y_F03	1297.680		0.070		Final spectrum,	for Pi-mode re	ference value	must be (1297.7	5 +/- 0.1) MHz		
	-V CAV00547		Lenath	Max FCC									
	-IZ CAY00551	Source	[mm]	[mm]				Comment	s / Remarks				
	-W CAV00552] X_M02	1058.53	0.19	OPEN_10								
		X_M03	1058.51	0.17	FMS_10								
	- JA CANOD228	(_Y_M01	1058.49	0.17	RB_10								
			Deiet								1		
	Accept		Print							CI	ose		

- 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.

Referencies:

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