TRAVELERS
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L2HE

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L2HE-CHEM-CAV-HEP-R1 -- L2HE Cavity Horizontal Electropolish
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L2HE-CHEM-CAV-LAP-R1 -- LCLS-II HE Cavity flange Final lapping traveler

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SerialNum: 0 **Traveler ID: L2HE-VTA-CAV-VTRF** **Rev: R3** **Page:0** **Traveler Seq Number: 0**

Traveler Title	**LCLS-II HE Vertical Cavity Test**			
Traveler Abstract	**Cryogenic RF testing of 1300MHz 9-cell cavities for LCLS-II HE Production Cryomodules**			
Traveler ID	**L2HE-VTA-CAV-VTRF**			
Traveler Revision	**R3**			
Traveler Author	**T. Ganey**			
Traveler Date	**25-Oct-21**			
NCR Informative Emails	**areilly,forehand,kwilson,hogan**			
NCR Dispositioners	**hannesv,ganey,kdavis**			
D3 Emails	**areilly,kdavis,ganey,forehand,hannesv**			
Approval Names	**T. Ganey**	**J. Vennekate**	**K. Davis**	**J. Hogan**
Approval Signatures				
Approval Dates				
Approval Title	**Author**	**Reviewer**	**Reviewer**	**Project Manager**
References	**List and Hyperlink all documents related to this traveler. This includes, but is not limited to: safety (THAs, SOPs, etc.), drawings, procedures, and facility related documents.**			
VTA SOP	LCLS-II HE VTA RF Testing Procedure R1	VTA Cavity Test Data Processing Template	9-Cell Quench Analysis	Cavity Drawing Package F10023864_RevM

Revision Note	
R1	**Initial release of this Traveler.**
R2	**Updated References, clarified instructions and cavity acceptance criteria, and added checkbox for if initial cavity performance results do not require a second power rise and/or RF processing, added data fields for cavity switching to 7/9-pi mode during test.**
R3	**Updated pi mode acceptance criteria from 1300.250 +/- 0.1 MHz to 1300.3 +/- 0.2 MHz. in steps 8 and 13 in accordance with LCLS-II-HE VT Acceptance Test Procedure and Criteria, LCLSII-HE-1.2-PP-0356-R1.**

	Clarified FE Free up to peak gradient (no admin limit) acceptance criteria in steps 11, 12, and 19.

Step No.	Instructions	Data Input
0	Was cavity kept under vacuum since it was shipped from the vendor?	CavVacuum ○ Yes ○ No
1	Input LCLS-II HE 9-cell cavity ID, Epk/Eacc, and Bpk/Eacc. Note any special handling, processing (chemistry or bake) or off-normal conditions associated with this cavity before test.	CAVSN -0- EpkEaccRatio BpkEaccRatio SpecialHandling

Step No.	Instructions	Data Input
2	Enter the LabView file name, without special characters. (Valid example: CAV_0045_YYMMDD.txt).	Must submit traveler before attaching files.
3	Record Test Date, Dewar No, Top Plate ID and Operator(s). If the test is in Dewar 5, record the cavity position on the Dewar 5 test stand. The cavity position can be found in L2HE-CLNRM-CAV-TSTD5.	TestDate NOW (ex format 18-Jun-2005 16:30) Dewar -0- D5CavPosition -0- VTATSSN -0- TestOperator1 -0- TestOperator2 -0-
4	Record cavity vacuum pressure, if so instrumented. If after cooling down to 2K, a lambda leak of $5x10^{-6}$ mbar or greater is identified:	CavityVacuum Vacuum_Unit -0-

	- choose option No for Cavity Vacuum OK - record pertinent information in the Cavity Vacuum Comment - abort RF power test - launch NCR	CavityVacuumOK ○ Yes ○ No CavityVacuumComment
5	Record Dewar helium bath liquid level, temperature and baratron pressure. Do not continue unless Dewar LHe level is above the end group. Start cavity testing at (23+/-0.1) Torr, which corresponds to about 2.0K with a liquid level > 171 cm for dewars 5, 7 and 8.	DewarLHeLevelcm (cm) DewarTempK (K) DewarPressureTorrInitial (Torr)
6	Zero power meters then calibrate cables at cavity fundamental frequency as specified in the LCLS-II HE VTA RF Testing Procedure. If the NO radio button is chosen, launch D3 and record pertinent information.	PowermetersZeroed ○ Yes ○ No CableCalibrationOK ○ Yes ○ No CableCalibrationComment

Step No	Instructions	Data Inputs
7	Perform Pi Mode measurements using a network analyzer in accordance with the LCLS-II VTA RF Testing Procedure. Record the cavity mode frequencies at the right. Example of cavity mode frequencies:	
	9_9Pi = 1300.250 MHz	Freq_9_9Pi (MHz)
	8_9Pi = 1299.448 MHz	Freq_8_9Pi (MHz)
	7_9Pi = 1297.121 MHz	Freq_7_9Pi (MHz)

	6_9Pi = 1293.613 MHz	**Freq_6_9Pi** _____ **(MHz)**
	5_9Pi = 1289.376 MHz	**Freq_5_9Pi** _____ **(MHz)**
	4_9Pi = 1284.892 MHz	**Freq_4_9Pi** _____ **(MHz)**
	3_9Pi = 1280.721 MHz	**Freq_3_9Pi** _____ **(MHz)**
	2_9Pi = 1277.307 MHz	**Freq_2_9Pi** _____ **(MHz)**
	1_9Pi = 1275.087 MHz	**Freq_1_9Pi** _____ **(MHz)**
8	**At 2.0 K, record dewar pressure and lock frequency displayed on the frequency counter.** **Lock frequency specifications:** **- Low: 1300.100 MHz** **- High: 1300.500 MHz** **If the cavity does not meet the lock frequency specification, select NO and launch an NCR. Continue the test.**	**LockFrequency** Criteria #1 **(MHz)** **DewarPressure_Torr** _____ **(Torr)** **LockFreqMeetsSpec** ○ **Yes** ○ **No**
9	**At a cavity field of 6-8 MV/m, determine the cavity coupling.** **If the cavity appears to be critically coupled, perform the steps in the procedure to determine coupling. If the cavity is critically coupled, select Overcoupled.** **Optional: Upload oscilloscope data.**	**CavityCoupling** -0- **Must submit traveler before attaching files.**
10	**Perform decay measurements and record Eacc, Qo, Qext1, Qext2, %error, radiation, QextHOMa, QextHOMb, and Decay Time.** **If any values do not meet the acceptance criteria, launch an NCR.** **Typical values during decay measurements for:**	
	Eacc: (7+/-1) MV/m	**Eacc** _____ **(MV/m)**
	Qo: ~2.2 e10	

		Qo
	Qext1 Acceptance Criteria: 1.1e10</=Qext1</=1.9e10	**Qextin** Criteria # 7
	Qext2 Acceptance Criteria: >/= 7 e11	**Qextfp** Criteria # 8
	%error: 8-13	**Qextfperror** **(%)**
	Radiation: </= 0.03 mR/hr	**Rad** **(mR/hr)**
	QextHOMa Acceptance Criteria: >/= 2 e11	**QextHOMa** Criteria # 9
	QextHOMb Acceptance Criteria: >/= 2 e11	**QextHOMb** Criteria # 9
	Decay Constant: ~ 1 second	**Tau** **(seconds)**

Step No	Instructions	Data Inputs
11	**Initial Power Rise** **Test the cavity performance over its full dynamic range per the LCLS-II VTA RF Testing Procedure. Increment ~0.5 MV from 2 MV to quench.** • **LCLS-II HE cavity performance does not have an Eacc administrative limit.** • **MP may be present from 17 to 22 MV/m.** **Observe the administrative limits:** • **FE Limit 1 R/hr** • **FE onset < 10 MV/m** • **Incident Power < 100 W to avoid overheating cables** • **HOM Power limit of 10 W** • **Power absorbed by HOMs at 20.8 MV/m is </= 1.7 W** **Be sure to capture a clean data set from which to generate a Qo-vs-Eacc-Rad and f-vs-Eacc2 curves.** **Also observe the cavity frequency during the auto ramp-up, as some cavities might jump to the 7/9 Pi-mode (~1297 MHz).**	**Traveler Step 11 may be repeated in Step 12. When Step 12 is blank, then Step 11 is used to evaluate acceptance Criteria. When Step 12 has values, then Step 12 is used to evaluate acceptance criteria.**

Record the follow values from the initial power rise.

At 4.0+/-0.3 MV/m: Initial Eacc and Qo	**Init_EaccAt4MVm** (MV/m) **Init_QoAt4MVm**
At 20.8+/-0.3 MV/m: Initial Eacc, Qo , and Rad **Acceptance criteria Qo at 20.8+/-0.1 MV/m >/= 2.5 e10**	**Init_EaccAt21MVm** (MV/m) **Init_QoAt21MVm** Criteria #3 **Init_RadAt21MVm** (mR/h) New field will be Criteria #10
At 23+/-0.3 MV/m: Initial Eacc and Qo	**Init_EaccAt23MVm** (MV/m) **Init_QoAt23MVm**
Initial maximum cavity gradient achieved (Emax) **Acceptance criteria is Emax >/= 23 MV/m**	**Init_EmaxMVm** Criteria #2 (MV/m)
Initial Q_o value at maximum cavity gradient.	**Init_QoAtEmax**
Initial FE onset: onset of field emission (FE onset, defined to be the first measured gradient where sustained radiation is >/= 3e-2 mR/hr). **If FE onset occurs below 10 MV/m, abort the test.** **Acceptance criteria is FE free up to the peak gradient (no admin. limit).**	**Init_FEonsetMVm** (MV/m) **Init_FEFree (Yes?)** ☐ Criteria #4 **Init_MP_Present (Yes?)** ☐ Criteria #5
Initial Rmax value for the highest radiation level inside Dewar lid. If Radmax is background up to the operating limit, insert 1e-3 mR/m for this parameter. **DO NOT EXCEED 1R/hr without PI approval.**	**Init_Radmax** (mR/h)
Did the cavity jump into the 7/9 Pi-mode (~1297 MHz) during the initial power rise? **If the main mode shifts to the 7/9 Pi-mode, check the checkbox and record the approximate Eacc at which the mode shift occurred.**	**Init_ModeShift (Yes?)** ☐ **Init_ModeShiftEacc** (MV/m)

		Init_ModeShiftComment
	Are additional power rise(s) required and/or RF processing? **If yes, continue to the next step.** **If no, select the checkbox and skip the Final Power Rise section. This will copy the initial power rise data into the final power rise data fields.**	**AdditionalRun (Yes?)** ☐

Step No	Instructions	Data Inputs
12	**Final Power Rise** **Test the cavity performance over its full dynamic range per the LCLS-II HE VTA RF Testing Procedure. Increment ~0.5 MV from 2 MV to quench.** • **LCLS-II HE cavity performance does not have an Eacc administrative limit.** • **MP may be present from 17 to 22 MV/m.** **Observe the administrative limits:** • **FE Limit 1 R/hr** • **FE onset < 10 MV/m** • **Incident Power < 100 W to avoid overheating cables** • **HOM Power limit of 10 W** • **Power absorbed by HOMs at 20.8 MV/m is </= 1.7 W** **Be sure to capture a clean data set from which to generate a Qo-vs-Eacc-Rad and f-vs-Eacc2 curves.** **Also observe the cavity frequency during the auto ramp-up, as some cavities might jump to the 7/9 Pi-mode (~1297 MHz).** **Record the follow values from the final power rise.**	**Traveler Step 12 is only done sometimes. When Step 12 is blank, then Step 11 is used to evaluate acceptance Criteria. When Step 12 has values, then Step 12 is used to evaluate acceptance criteria.**
	At 4.0+/-0.3 MV/m: Final Eacc and Qo	**Final_EaccAt4MVm** (MV/m) **Final_QoAt4MVm**

	At 20.8+/-0.3 MV/m: Final Eacc, Qo , and Rad **Acceptance criteria Q_o at 20.8+/-0.1 MV/m >/= 2.5 e10**	**Final_EaccAt21MVm** (MV/m) **Final_QoAt21MVm** Criteria #3 **Final_RadAt21MVm** (mR/h) New field will be Criteria #10
	At 23+/-0.3 MV/m: Final Eacc and Qo	**Final_EaccAt23MVm** (MV/m) **Final_QoAt23MVm**
	Final maximum cavity gradient achieved (Emax) **Acceptance criteria is Emax >/= 23 MV/m**	**Final_EmaxMVm** Criteria #2 (MV/m)
	Final Q_o value at maximum cavity gradient.	**Final_QoAtEmax**
	Final FE onset: onset of field emission (FE onset, defined to be the first measured gradient where sustained radiation is >/= 3e-2 mR/hr). **If FE onset occurs below 10 MV/m, abort the test.** **Acceptance criteria is FE free up to the peak gradient (no admin. limit).**	**Final_FEonsetMVm** (MV/m) **Final_FEFree (Yes?)** ☐ Criteria #4 **Final_MP_Present (Yes?)** ☐ Criteria #5
	Final Rmax value for the highest radiation level inside Dewar lid. If Radmax is background up to the operating limit, insert 1e-3 mR/m for this parameter. **DO NOT EXCEED 1R/hr without PI approval.**	**Final_Radmax** (mR/h)
	Did the cavity jump into the 7/9 Pi-mode (~1297 MHz) during the initial power rise? **If the main mode shifts to the 7/9 Pi-mode, check the checkbox and record the approximate Eacc at which the mode shift occurred.**	**Final_ModeShift (Yes?)** ☐ **Final_ModeShiftEacc** (MV/m) **Final_ModeShiftComment**

Step No	Instructions	Data Inputs

13	**Record cavity performance limitation. If the performance limit is Other, record performance limit description in the comment box.** **If any cavity performance value does not meet the acceptance criteria in by the final power rise, launch an NCR.**	**PerformancLimitAt2_0K** -0- **PerformanceLimitAt2_0K_Other**
14	**Final Record Lorentz detuning coefficient (slope of the linear fit frequency vs Eacc2).** **Lorentz detuning coefficient expected range:** • **Low: -0.8** • **High: -1.2 Hz/(MV/m)^2**	**KLOREN** **(Hz/MVm2)** **KLORENComment**
15	**If the cavity does not meet the acceptance criteria of Emax ≥ 23 MV/m with Qo at 20.8+/-0.1 MV/m >/= 2.5 e10, due to quench and/or FE loading, contact the PI (or their designee) before performing this step.** **At 2.0K, keeping the same Qextfp as used for the Pi mode, attempt to find the related unscaled Quench fields for each member of the fundamental passband. Use caution since HOM filters can pass excessive power at frequencies lower than Pi-mode (8/9, 7/9, ...).**	**EaccUnscaledQuench_9_9Pi (MV/m)** **EaccUnscaledQuench_8_9Pi (MV/m)** **EaccUnscaledQuench_7_9Pi (MV/m)** **QuenchStudyComment**

Step No	Instructions	Data Inputs
16	**Upload the raw data file with VTA RF testing results using file name: CavID raw data.txt.**	**Must submit traveler before attaching files.**
17	**Process the raw data file using the Excel file template and upload the data file results using the file name: CAVID processed data.xlsx.**	**Must submit traveler before attaching files.**
18	**Upload processed Qo and Rad-vs-Eacc graph (in PDF format) using file**	**Must submit traveler before attaching files.**

	name: CavID_ QoAndRadvsEacc.pdf. **Upload processed HOMa and HOMb vs Eacc graph (in PDF format) using file name: CavID_HOMaHOMbvsEacc.pdf.** **Upload processed f-vs-Eacc2 graph (in PDF format) using file name:** **CavID_FreqvsEacc2.pdf.** **Upload any additional processed data files collected during this test, in the test at the right (e.g. HOM power as a function of gradient, data mining) using a file name that includes the CavID and properly describes the graph content.**	**Must submit traveler before attaching files.** **Must submit traveler before attaching files.** **Must submit traveler before attaching files.**

19	**Record if the cavity passed all specifications in this traveler. If the cavity does not meet any specification, ensure an NCR is launched.**
	
	<u>Cavity Acceptance Criteria:</u>
	• **Lock Frequency @ dewar pressure of 23 +/- 0.1 Torr**
	  ○ **Low: 1300.100 MHz**
	  ○ **High: 1300.500 MHz**
	• **Qext1: 1.1e10</=Qext1</=1.9e10**
	• **Qext2: >/= 7 e11**
	• **QextHOMa: >/= 2 e11**
	• **QextHOMb: >/= 2 e11**
	• **Emax >/= 23 MV/m**
	• **Q_o at 20.8+/-0.1 MV/m >/= 2.5 e10**
	• **FE free to the peak gradient (no admin. limit)**
		CavityMeetsSpecifications ○ Yes ○ No