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| Traveler Title | C75 Cavities VTA RF Test | | | |
| Traveler Abstract | Cryogenic RF testing of C75 5-cell CEBAF cavities. Cavities can be tested single or as part of a hermetic pair.  Cavity | | | |
| Traveler ID | ER5C-VTA-CPR-VTRF | | | |
| Traveler Revision | R7 | | | |
| Traveler Author | C. Wilson | | | |
| Traveler Date | 29-Jul-2024 | | | |
| NCR Informative Emails | areilly | | | |
| NCR Dispositioners | kdavis,gciovati,grenoble,weaksmc | | | |
| D3 Emails | kdavis,areilly,gciovati,grenoble,weaksmc | | | |
| Approval Names | C. Wilson | G. Ciovati | K. Davis | T. Reilly |
| Approval Signatures |  |  |  |  |
| Approval Dates |  |  |  |  |
| Approval Title | Author | Reviewer | Group Lead | Project Representative |

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| 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 OSP SRF-23-158113-OSP](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-283699/VTA_operational_safety_procedure_form_158113.pdf) | [C75-PR-CPR-VTRF-R4](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-272511/C75-PR-CPR-VTRF-R4.pdf) – VTA cryogenic RF test procedure for C75 cavities |  |  |  |
|  | [Excel macro for C75-CPR-VTRF](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-254362/VTRF_Data_Processing_Spreadshet_Templete.xlsm) |  |  |  |

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| Revision Note |  |
| R1 | Initial release of this Traveler. |
| R2 | Added performance limit |
| R3 | Updated link to the test procedure and added fields for Multipacting and Lorentz force detuning coefficient |
| R4 | Updated the high and low frequency specifications |
| R5 | Add: Hold point, highlight in yellow item that will cause an NCR to be created, administrative limit of 21 MV/m, list all cavity qualifications, correct link to RF data processing macro. |
| R6 | Step 18 updated step for performing an Unscaled Quench field Measurement with the step number in the procedure. |
| R7 | Updated References, Updated steps 19 and 24 to consolidate cavity test specification values, Modified hold point for cavity or cavity pair acceptance to new step 25 |

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| Step No. | Instructions | Data Input |
| 1 | Select C75 5-cell cavity serial number (SN). (ex. 5C75-RI-001)  Note any special handling, processing (chemistry or bake) or off-normal conditions associated with this cavity before test. | [[CAVSN]] <<CAVSN>>  [[SpecialHandling]] <<COMMENT>> |
| 2 | Is this cavity part of a hermetic pair? If YES, note cavity serial number and cavity position on the test stand. | [[PartOfPair]] <<YESNO>>  [[DuplicateOnLastPageStep25]]<<NOTE>>  [[CPRSN]] <<CPRSN>>  [[C75CavPosition]] {{Top,Bottom}} <<SELECT>> |
| 3 | Record if cavity is mechanically constrained (i.e. tuner attached, etc.). | [[TunerAttached]] <<YESNO>> |
| 4 | Enter the LabView file name, without special characters. | [[LabviewFile]] <<TEXT>> |
| 5 | Record Test Date, Dewar No, VTA Test Stand Serial Number and Operator(s). | [[TestDate]] <<TIMESTAMP>>  [[AddToEveryPage]]<<NOTE>>  [[Dewar]]{{8,4,7,3}} <<SELECT>>  [[TSTDSN]]<<TSTDSN>>  [[TestOperator1]] {{KDavis,CWilson,Liang,POwen,Powers,GCiovati,AdamG,None}} <<SELECT>>  [[TestOperator2]] {{KDavis,CWilson,Liang,POwen,Powers,GCiovati,AdamG,None}} <<SELECT>>  [[PTeamToSeeIfVTATesterListCreatedIfSoReplacePrior2Lists]]<<NOTE>> |
| 6 | If testing a single cavity, record cavity vacuum pressure. Cavity pairs are isolated per procedure and are not instrumented for vacuum readback. If the cavity pressure is <2e-5 mbar an RF test can be attempted. | [[CavityVacuum]] <<SCINOT>>  [[CavityVacuumUnits]]{{(mbar),(Torr),(Pa)}} <<SELECT>>  [[CavityVacuumOK]] <<YESNO>>  [[CavityVacuumComment]] <<COMMENT>> |

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| **Step No** | **Instructions** | **Data Inputs** |
| 7 | Record Dewar helium bath liquid level, temperature and baratron pressure.  Start cavity testing at (29 +/-0.1) Torr. | [[DewarLHeLevelcm]] <<FLOAT>> (cm)  [[DewarTempK]]<<FLOAT>>(K)  [[DewarPressureTorr]]<<FLOAT>>(Torr) |
| 8 | Zero power meters then calibrate cables at cavity fundamental frequency. If NO option is chosen launch D3 and record pertinent information. | [[PowermetersZeroed]] <<YESNO>>  [[CableCalibrationOK]] <<YESNO>>  [[CableCalibrationComment]] <<COMMENT>> |
| 9 | Perform low power measurements using a network analyzer (measure the five cavity mode frequencies).  Record the cavity mode frequencies at the right.  Example of cavity mode frequencies:  Pi = 1497.388 MHz  4Pi5 = 1492.711 MHz  3Pi5 = 1480.413 MHz  2Pi5 = 1466.088 MHz  1Pi5 = 1454.720 MHz | [[Freq\_Pi]] <<FLOAT>> MHz  [[Freq\_4Pi5]] <<FLOAT>> MHz  [[Freq\_3Pi5]] <<FLOAT>> MHz  [[Freq\_2Pi5]] <<FLOAT>> MHz  [[Freq\_1Pi5]] <<FLOAT>> MHz |
| 10 | At 2.07 K determine and record dewar pressure (baratron) and cavity Pi-mode lock frequency precisely with LLRF frequency counter.  Lock frequency specifications: Low: 1497.375 MHz  High: 1497.575 MHz  Launch NCR if frequency specification is not met | [[LockFrequency]] <<FLOAT>> (MHz)  [[LockFreqMeetsSpec]] <<YESNO>> |
| 11 | At 2.07 K and cavity field of 4-5 MV/m, determine cavity coupling state. | [[CavityCoupling]] {{Overcoupled,Undercoupled,Critically\_coupled}} <<SELECT>> |
| 12 | Perform decay measurements and record Eacc, Qo, Qext2, Qext1, %error, Tau, radiation, chosen for CW high power tests as specified. More information regarding these parameters can be found in CavID raw data.txt or CavID processed data.xlsx.  Typical values during decay measurements for:  Eacc: (4-5) MV/m  Qo: 1.0-1.6 e10  Qext1: 0.5-2.4 e10  Qext2: 0.8-3 e12  error: 8-13%  Tau : 0.3-1.2 s  Radiation : 1e-3 mR/hr | [[Eacc]] <<FLOAT>> MV/m  [[Qo]] <<SCINOT>>  [[QextIn]] <<SCINOT>>  [[QextFp]] <<SCINOT>>  [[QextFpError]] <<FLOAT>> %  [[Tau]] <<FLOAT>> Seconds  [[Rad]] <<SCINOT>> mR/hr |

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| **Step No** | **Instructions** | **Data Inputs** |
| 13 | In Pi mode, test the cavity performance over its full dynamic range at 2.07 K. Be sure to capture a clean final-state data set from which to generate the post-processing Qo-vs-Eacc, Rad-vs-Eacc and f-vs-Eacc2 curves.  At 2.07 K record:  Final Maximum cavity gradient stably achieved Emax.  Final Qo value at maximum cavity gradient.  Final Qo at (20.5+/-0.3) MV/m. Acceptance criteria Qo >= 8e9.  Cavity gradient at Qo specification (8e9)  Initial value for Radiation at (20.5+/-0.3) MV/m.  Initial FEonset: onset of field emission (FE onset, defined to be the first measured gradient where measured radiation is >= 3e-2 mR/hr).  RadMax: value for the highest radiation level inside Dewar lid.  Final Qo at Eacc= (4 +/- 0.3)MV/m. | [[EmaxMVm]] <<FLOAT>> MV/m  [[QoAtEmax]] <<SCINOT>>  [[QoAt20\_5MVm]] <<SCINOT>>  [[EmaxAtQo\_Spec]] <<SCINOT>> MV/m  [[Init\_RadAt20\_5MVm]] <<SCINOT>> mR/h  [[Init\_FEonsetMVm]] <<FLOAT>> MV/m  [[RadMax]] <<SCINOT>> mR/h  [[QoAt4MVm]] <<SCINOT>> |
| 14 | Enter the value of the Lorentz force coefficient KL. Acceptable range: -3.7 to -4.2 Hz/(MV/m)2 | [[LorentzForceCoeff]] <<FLOAT>> Hz/(MV/m)^2 |
| 15 | Record if multipacting (MP) was found during the test, the Eacc at which occurred and if it was successfully processed.  The C75 cavities have a "soft" MP barrier at 12-15 MV/m and a strong MP barrier at 17-24 MV/m. | [[MultipactingFound]] <<YESNO>>  [[MultipactingGradient]] <<FLOAT>> MV/m  [[MultipactingProcessed]] <<YESNO>>  [[MultipactingComment]] <<COMMENT>> |
| 16 | At 2.07 K, was cavity RF processed to achieve performances over 20.5 MV/m. Record pertinent information at the right and lunch NCR if cavity RF processing was unsuccessful in achieving 20.5 MV/m with a Qo of 8e9. | [[RFProcessing]] <<YESNO>>  [[RFProcessingComment]] <<COMMENT>> |
| 17 | Record after RF processing at 2.07 K:  Post-processing Radiation at (20.5+/-0.3) MV/m.  Post-processing FEonset: onset of field emission (FE onset, defined to be the first measured gradient where measured radiation is >= 3e-2 mR/hr).  Post-processing RadMax value for the highest radiation level inside Dewar lid. | [[PP\_RadAt20\_5MVm]] <<SCINOT>> mR/h  [[PP\_FEonsetMVm]] <<FLOAT>> MV/m  [[PP\_RadMax]] <<SCINOT>> mR/h |
| 18 | At 2.07 K, if cavity is quench limited below Eacc 20.5 MV/m, find the unscaled Quench fields for each member of the fundamental passband as described in Section 8, Step 10 of C75-PR-CPR-VTRF and Launch NCR. | [[EaccQuench\_4Pi5]] <<FLOAT>> MV/m  [[EaccQuench\_3Pi5]] <<FLOAT>> MV/m  [[EaccQuench\_2Pi5]] <<FLOAT>> MV/m  [[EaccQuench\_1Pi5]] <<FLOAT>> MV/m  [[QuenchStudyComment]] <<COMMENT>> |

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| **Step No** | **Instructions** | **Data Inputs** |
| 19 | Record performance limitation. Definition of performance limitation terms:   * Administrative Gradient: 21 MV/m * Administrative Radiation: 1R/h admin limit * FieldEmission: FE loaded Qo curve * Quench: non-FE related quench limit * Multipacting * RF power: test limited by available RF power * Cable: test aborted due to cable breakdown or broken cable * Other: RF Tester defined   If Other is selected, record pertinent information in the Comment box at the right. | [[PerformanceLimit]] {{Quench,FieldEmission,Multipacting,RFPower,Cable,Admin,Other}} <<SELECT>>  [[PerformanceLimitComment]] <<COMMENT>> |
| 20 | Upload the raw data file with VTA RF testing results using file name: CavID raw data.txt. | [[RF\_test\_raw\_data]] <<FILEUPLOAD>> |
| 21 | Upload processed (Excel) data file results using file name: CavID processed data.xlsx | [[RF\_test\_processed]] <<FILEUPLOAD>> |
| 22 | Upload processed Qo-and-Rad -vs-Eacc graph (in PDF format) using file name: QoandRadvsEacc.pdf  Upload processed f-vs-Eacc2 graph (in PDF format) using file name: CavID\_FreqvsEacc2.pdf | [[UploadQvsE\_Rad]] <<FILEUPLOAD>>  [[UploadFvsE2]] <<FILEUPLOAD>> |
| 23 | For a cavity pair test, measure the frequencies and loaded Q of all HOMs in the frequency range 1.74 GHz – 2.20 GHz for each cavity of the pair.  Upload an Excel Spreadsheet with the HOM data using filename: CavID\_HOM.xlsx. | [[UploadHOMFile]] <<FILEUPLOAD>> |
| 24 | VTRF Tester to determine if the cavity meets the specifications listed below.  For a single cavity, only the Emax, Qo, Radiation dose rate and Lorentz detuning coefficient are applicable. For a cavity pair, all listed specfications are applicable.  Cavity test specifications:  \* Lock Frequency @ dewar pressure of 29 +/- 0.1 Torr (applies only to cavity in a pair)  Low: 1497.375 MHz  High: 1497.575 MHz  \* QextFP: 4 e11 to 1.2 e12 (applies only to a cavity in a pair)  Emax >= 20.5 MV/m Eacc >= 20.5 MV/m with a Qo >= 8e9  Radiation dose rate at Eacc = 19.1 MV/m <= 100 mR/h  Lorentz detuning coefficient: -3.7 to -4.2 -4.2 Hz/(MV/m)2  Cavity passed all specifications for this traveler?  If NO option is chosen issue an NCR from this traveler. | [[CavityMeetsSpecifications]] <<YESNO>>  [[MakeMandatoryField]]<<NOTE>> |
| 25 | **C75 Cavity SME to determine if the cavity is acceptable to progress to next stage of assembly.**  **For a single cavity, is the cavity accepted to progress to cavity pair assembly?**  **For a cavity in a pair, is the cavity pair accepted to progress to cryomodule assembly group?**  If cavity is accepted to progress to the next stage of assembly, disposition and close all NCRs on this traveler.  Add comment for exceptions | [[duplicatePartOfPairYESNOFromStep2]]<<NOTE>>  [[AcceptableToProgress]]<<YESNO>>  [[AcceptanceComment]] <<COMMENT>>  [[HOLDPOINT]] {{gciovati,areilly,kdavis,weaksmc}} <<HOLDPOINT>> |