|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Traveler Title | CEBAF Upgrade Prototype 1 (P1) Cavity VTA High Power RF Acceptance Test | | | |
| Traveler Abstract | Cryogenic RF testing of 1497MHz 7-cell OC cavities for CEBAF P1 Cryomodule Rebuild | | | |
| Traveler ID | P1-CAV-VTA-HPRF | | | |
| Traveler Revision | R1 | | | |
| Traveler Author | Kirk Davis | | | |
| Traveler Date | 30 Aug, 2020 | | | |
| NCR Emails | kdavis, areilly, reece | | | |
| Approval Names | K. Davis | C. Reece | A. Reilly |  |
| Approval Signatures |  |  |  |  |
| Approval Dates |  |  |  |  |
| Approval Title | Author, VTA Manager | 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](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-27461/A-09-001-SOP%20Operation%20of%20the%20Test%20Lab%20VTA%20Document-21542.pdf) | **1497 VTA RF Testing Procedure** | [**Excel spreadsheet template for VTA RF measurements**](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-98189/SpreadsheetTemplate%20for%20STP-CAV-VTRF_12Nov2014.xlsm) | 7-Cell Quench Analysis |  |
|  |  |  |  |  |

|  |  |
| --- | --- |
| Revision Note |  |
| R1 | Initial release of this Traveler. |
|  |  |
|  |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Step No.** | | **Instructions** | **Data Input** | |
| 1 | | Input 7-cell OC cavity ID, note any special handling, processing (chemistry or bake) or off-normal conditions associated with this cavity test. | [[CAVSN]] <<CAVSN>>  [[Special\_handling]] <<COMMENT>> | |
| 2 | | Record if cavity has SS or NbTi test flanges | [[FlangeType]]{{SS,NbTi}}<<SELECT>> | |
| 3 | Enter the LabView file name, without special characters. (Valid example: JL\_009). | | | [[LabviewFile]] <<TEXT>> |
| 4 | Record Test Date, Dewar No, Top Plate ID and Operator(s). | | | [[TestDate]] <<TIMESTAMP>>  [[Dewar]] {{8,7,5,4,3}} <<SELECT>>  [[VTATSSN]] <<VTATSSN>>  [[TestOperator1]] <<VTAOPS>>  [[TestOperator2]] <<VTAOPS>> |
| 5 | Record cavity vacuum pressure, if so instrumented. If (at 2.07K) cavity vacuum is greater than 5x10-6 mbar chose option **No** in CavityVacuumOK, record pertinent information , abort RF power test and launch NCR. | | | [[CavityVacuum]] <<SCINOT>>  [[VacuumUnits]] {{(mbar),( Torr),(Pa)}} <<SELECT>>  [[CavityVacuumOK]] <<YESNO>>  [[CavityVacuumComment]] <<COMMENT>> |
| 6 | Record dewar helium liquid level, temperature and pressure.  Do not continue unless Dewar LHe level is above the end group.  Start cavity testing at 29 (+/-0.1) Torr (2.07K). | | | [[DewarLHeLevelcm]] <<FLOAT>>(cm)  [[DewarTempK]] <<FLOAT>>(K)  [[DewarPressureTorrInitial]] <<FLOAT>>(Torr) |
| 7 | Per the **1497 VTA RF Testing Procedure**, perform low power measurements using a network analyzer (measure the seven cavity passband mode frequencies). Record measured frequencies. | | | |
| Typical frequency | | | Measured Frequency |
| 7/7Pi = 1496.7075 MHz | | | [[Freq\_7\_7Pi]] <<FLOAT>>(MHz) |
| 6/7Pi = 1495.4688 MHz | | | [[Freq\_6\_7Pi]] <<FLOAT>>(MHz) |
| 5/7Pi = 1492.0414 MHz | | | [[Freq\_5\_7Pi]] <<FLOAT>>(MHz) |
| 4/7Pi = 1487.1299 MHz | | | [[Freq\_4\_7Pi]] <<FLOAT>>(MHz) |
| 3/7Pi = 1481.7767 MHz | | | [[Freq\_3\_7Pi]] <<FLOAT>>(MHz) |
| 2/7Pi = 1476.9200 MHz | | | [[Freq\_2\_7Pi]] <<FLOAT>>(MHz) |
| 1/7Pi = 1473.6405 MHz | | | [[Freq\_1\_7Pi]] <<FLOAT>>(MHz) |
| 8 | | At 29 (+/- 0.1) torr, record Dewar pressure (from VAT valve controller) and cavity 7/7 Pi-mode lock frequency precisely with LLRF frequency counter – per the **1497 VTA RF Testing Procedure**.  **Lock frequency specifications:**   * **Low: 1496.400MHz** * **High: 1496.700 MHz**   If option NO is checked, launch NCR**.** | [[LockFrequency]] <<FLOAT>>(MHz)  [[DewarPressureTorr]] <<FLOAT>>(Torr) | |
| 9 | | At cavity field of 3-5MV/m, determine cavity coupling per the **1497 VTA RF Testing Procedure**. Upload (optional) Tektronics oscilloscope screen (TDS\_.txt) data file. | [[CavityCoupling]] {{Overcoupled,Undercoupled}} <<SELECT>>  [[TDS\_txt]] <<FILEUPLOAD>> | |
| 10 | | Perform decay measurements and record Eacc, Qo, Qext2, Qext1, %error, radiation, QextHOMa**,**  QextHOMb**.** and Decay Time chosen for CW high power tests as specified in **1497 VTA RF Testing Procedure**.  Typical values during decay measurements for: |  | |
|  | | Eacc : (5+/-1) MV/m | [[Eacc]] <<FLOAT>> (MV/m) | |
|  | | Qo : 0.8-1.2 e10 | [[Qo]]<<SCINOT>> | |
|  | | Qext1 : 0.5-0.7 e10 | [[Qextin]]<<SCINOT>> | |
|  | | **Qext2 : 0.8 – 1.8 e12** (launch NCR if not in range) | [[Qextfp]]<<SCINOT>> | |
|  | | % error : 8-13 % | [[Qextfperror]]<<FLOAT>> (%) | |
|  | | Radiation : 1 e-3 mR/hr | [[Rad]]<<SCINOT>> (mR/hr) | |
|  | | **QextHOMa : >= 3.0e12** (launch NCR if not in range) | [[QextHOMa]]<<SCINOT>> | |
|  | | **QextHOMb : >=3.0e12** (launch NCR if not in range) | [[QextHOMb]]<<SCINOT>> | |
|  | | Decay Constant: ~1 second | [[Tau]] <<FLOAT>> (seconds) | |

|  |  |  |
| --- | --- | --- |
| 11 | At 2.07K and in 7/7 Pi mode, test the cavity performance up to its’ maximum operating gradient observing the administrative limits as specified in **1497 VTA RF Testing Procedure**. Increment ~0.5 MV from 2 MV to maximum gradient. | |
| 12 | InitialFEonset: 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 5 MV/m, abort the test. If no field emission is detected up to Emax, record a value of 0mR/hr. Transient radiation due to multipacting should not be recorded here. DO NOT EXCEED 1R/hr without PI approval. | [[Init\_FEonsetMVm]] <<FLOAT>>(MV/m)  [[Init\_FEFree]] <<CHECKBOX>> |
| 13 | **Initial Qo at (12.5+/-0.3) MV/m**. Acceptance criteria Qo >= 8e9 with SS input coupler flange. (launch NCR if not in range) | [[init\_Qo\_12\_5MVm]]<<SCINOT>>(MV/m) |
| Initial value for Radiation at 12.5 MV/m. | [[Init\_Rad\_12\_5MVm]] <<SCINOT>>(mR/h) |
| Initial power rise maximum cavity gradient achieved: Emax. | [[init\_EmaxMVm]] <<FLOAT>>(MV/m) |
| Qo value at maximum cavity gradient. | [[init\_QoAtEmax]] <<SCINOT>> |
| Initial Rmax value for the highest radiation level inside Dewar lid. If Rmax is background up to Emax, insert 1e-3 mR/m for this parameter. | [[init\_Radmax]] <<SCINOT>>(mR/h) |
| Record performance limitation at 2.07K.  If cavity PerformanceLimitAt2\_07K is selected Other, record pertinent information in the Comment box at the right. | [[PerformanceLimitAt2\_07K]] {{Admin,RF power,FE,Quench(non FE),Cable,Operator,Other}} <<SELECT>>  [[PerformLimitAt2\_07K\_Other]] <<COMMENT>> |
| Record Lorentz detuning coefficient (slope of the linear fit frequency vs Eacc2) KLoren.  **Lorentz detuning coefficient specifications:**   * **Low: -4.0** * **High: -6.0 Hz/(MV/m)^2**   If option NO is checked, launch NCR. | [[KLOREN]] <<FLOAT>>(Hz/MVm2)  [[KLORENComment]] <<COMMENT>> |

|  |  |  |
| --- | --- | --- |
| 14 | If the cavity does not meet the acceptance criteria (12.5 MV/m, >= 8e9 for SS flanges) due to quench and/or FE loading, contact the PI (or their designee) before performing this step.  At 2.07K, keeping the same Qextfp as used for the π 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 π-mode (6/7, 5/7 …). | [[EaccUnscaledQuench\_6\_7Pi]] <<FLOAT>>(MV/m)  [[EaccUnscaledQuench\_5\_7Pi]] <<FLOAT>>(MV/m)  [[EaccUnscaledQuench\_4\_7Pi]] <<FLOAT>>(MV/m)  [[EaccUnscaledQuench\_3\_7Pi]] <<FLOAT>>(MV/m)  [[EaccUnscaledQuench\_2\_7Pi]] <<FLOAT>>(MV/m)  [[EaccUnscaledQuench\_1\_7Pi]] <<FLOAT>>(MV/m)  [[QuenchStudyComment]]<<COMMENT>> |
| 15 | 2.07K final “clean” QvsE (1MV/m steps from 2MV to Emax). “Clean” curve should have no new FE processing or FE activation. Repeat power rise until QvsE and FEvsE become static and reproducable. DO NOT EXCEED 1R/hr without PI approval. |  |
| At (4.0 +/-0.3) MV/m, record Eacc and Q0 | [[Eacc\_Grad\_4]] <<FLOAT>>(MV/m)  [[Qo\_Grad\_4]]<<SCINOT>> |
| At (12.5 +/-0.3) MV/m, record Eacc and Q0 | [[Eacc\_Grad\_12\_5]] <<FLOAT>>(MV/m)  [[Qo\_Grad\_12\_5]]<<SCINOT>> |
| Performance note: record information about cavity performance, limitations and other pertinent observations: **Emax >= 12.5 MV/m**  (launch NCR if not in range).  Radiation at Emax | [[CavityPerformance]] <<COMMENT>> |
| [[final\_EaccFEOnset]]<<FLOAT>>(MV/m) |
| [[final\_FEFree]] <<CHECKBOX>> |
| [[final\_EmaxMVm]] <<FLOAT>>(MV/m) |
| [[final\_QoAtEmax]] <<SCINOT>> |
| [[final\_Radmax]] <<SCINOT>>(mR/h) |

|  |  |  |
| --- | --- | --- |
| 16 | Process and upload the VTA RF testing results, using the [Excel file template](https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-27853/Excel%20spreadsheet%20template%20for%20C100-CAV-VTRF.xlsx). | |
| 17 | Upload the raw data file with VTA RF testing results using file name: CavID raw data.txt. | [[RF\_test\_raw\_data]] <<FILEUPLOAD>> |
| 18 | Upload processed (Excel) data file results using file name: CavID processed data.xlsx | [[RF\_test\_processed]] <<FILEUPLOAD>> |
| 19 | Upload processed Qo-and-Rad -vs-Eacc graph (in PDF format) using file name: 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  Above for initial and final power rise (2.0K) | [[UploadFiles1]] <<FILEUPLOAD>> |
| 20 | Upload any additional processed data files collected during this test, in the test using file name: CavID\_OTHER.pdf or any other file name properly describing the CavID and the graph content. | [[UploadFiles2]] <<FILEUPLOAD>> |
| 21 | **Cavity passed all specifications for this traveler: 8, 10, 13, and 15?** If NO option is chosen ensure that appropriate NCR(s) have been issued from this traveler. | [[CavityMeetsSpecifications]] <<YESNO>> |
| 22 | Verify all steps have been completed and all data has been entered. | [[VerifyTraveler]] {{kdavis, reece, areilly}} <<HOLDPOINT>> |