650 MHz $\beta=0.90$ Cavity Jacketing and Procurement of $\beta=0.92$ Jacketed Cavities at FNAL

Chuck Grimm

PIP-II $\beta=0.90$ & 0.92 Jacketed Cavity FDR

1 February 2019

In partnership with:
India/DAE
Italy/INFN
UK/STFC
France/CEA/Irfu, CNRS/IN2P3
650 MHz $\beta=0.90$ Cavity Jacketing and Procurement of $\beta=0.92$ Jacketed Cavities at FNAL

Outline:

• 650 MHz $\beta=0.90$ Cavity Jacketing (Helium Tank Integration)
  – Bare Cavities
  – Helium Vessels
  – Bellows, Bellow Adapter Ring, Endcap
  – Component Legend and Weld Map
  – Dry Fit Components
  – Main Tooling Overview
  – Travelers, Misc. Documents

• 650 MHz $\beta=0.92$ Jacketed Cavity Procurement
  – Dressed Cavity Procurement
  – Technical Criteria
  – Specifications
  – Travelers
650 MHz $\beta=0.90$ Cavity Jacketing

- Bare Cavities, RRR300 Nb and Nb55Ti
  - Four bare cavities purchased with ARRA funds manufactured by AES – Prior to Helium Vessel design
  - Mechanical measurements by IB4 QC Department
  - Processed at Fermilab
  - Vertically tested for qualification in IB1 VT stand
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- Helium Vessels, GR 2 Ti
  - Four Titanium helium vessels manufactured by EMT
  - QC performed by IB4 QC Department
    - CMM measurements, vacuum leak check
  - Design is compatible for both beta version cavities
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- Bellows, GR. 2 Ti
- Four Titanium bellows manufactured by Ameriflex
  - QC performed by IB4 QC Department
    - CMM measurements, vacuum leak check
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- Bellow Adapter Ring, GR. 2 Ti
- Four bellow adapter rings manufactured by EMT
  - QC by IB4 QC Department
    - CMM measurements
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- Endcap, GR. 2 Ti
- Four endcaps manufactured by EMT
  - QC by IB4 QC Department
    - CMM measurements
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- Component Legend

- Bellow Adapter
- Bellow Weldment
- Helium Vessel
- End Cap
- Existing Nb/Ti Transition Ring
- Existing Nb/Ti Transition Ring
- Component Legend

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- **Weld Map**
  - New WPS (Ti/Nb-1) and Welder Qualifications **

**

- Ti to Ti TIG Weld
- Ti to Ti TIG Weld Performed Last
- Ti to Nb55Ti TIG Weld **
- Ti to Nb55Ti TIG Weld **
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- Dry Fit Components

- Bellow Weldment
- End Cap
- Bellow Adapter
- Ring
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- Main Tooling Overview
  - All tooling has been component fit and tested

Insertion Tooling  
Rotation Fixture  
Glovebox Retrofit
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• Travelers

650 MHz Niobium Sheet Inspection Traveler
464033 Rev. A
by Sherry Baker

650 MHz 5-Cell Cavity - RF Measurement Traveler (RFCD)
464280 Rev. NONE
by Jan Stai

Multi-Cell Coordinate Measuring Machine (CMM) Measurement Traveler
333897 Rev. F
by Janie Bisner

650 MHz 5-Cell Cavity Helium Vessel Weldment Leak Check Traveler (RFCD)
464389 Rev. NONE
by Timothy McKenna
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- Travelers
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- Misc. Documents (Pressure Test Procedure)
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- Misc. Documents (Hazzard Analysis Pressure Test)

HAZARD ANALYSIS FORM

This form can be used by Fermilab Employees, Fermilab Supervisors, Fermilab Task Managers and Construction Subcontractors. This is a dynamic document which may require redaction as the project moves from start to finish and should be readily available at the site where the work is being performed.

Note: Not all sections of the first page are applicable to every job or task, complete what is necessary for your specific job or task.

Job Title: Pressure Test of SIF Cored Cylinders

Job Location: MFD

Contract/Order #: Risk

TO BE COMPLETED FOR WORK INVOLVING SUBCONTRACTORS

Subcontractor(s) (if applicable)

Company

Fermilab

Fermilab

Project Rep.

Phone

Fax

EHS Rep.

Phone

EHS Rep.

Phone

Fax

Description of Work:

Pressure test (with dry nitrogen) a dressed SIF cylinder incrementally until it reaches the maximum test pressure of 2.3 bar (35 psig). Frequency measurements of the cavity are taken during the pressure increments to assure the safety of the cavity. A 35.2 psig relief valve is in place so over-pressurization does not occur.

Personal Protective Equipment (Check protective equipment required for the job):

- Safety glasses
- Ear plugs
- Chemical splash goggles
- Hearing protection
- Hard hats
- Protective gloves
- Impact goggles
- Rubber aprons
- Leather gloves
- Chemical resistant gloves (specify type)
- Respirators
- Other required PPE (specify)
- Full protection equipment (specify)
- Safety shoes

Environmental Aspects (Check one):

- Yes, I have thought about the environmental aspects of this job and will document such aspects and mitigation steps within this document.
- Yes, I have thought about the environmental aspects of this job and no such credible aspects exist and therefore do not need to be written in this document.

Equipment required for the job:

- Test 500 L/min, 115V high pressure nitrogen, 0-250 psig regulator, 0-250 psig gage, 0-25 psig test gage, test hose, RF frequency measuring equipment.

Work plan History Information (List any lessons learned from this job. Tips from previous jobs):

This test was conducted in the past with a continuous linear increase of pressure until reaching maximum test pressure. Due to a component failure the procedure was modified to include venting back to 0 psig after reaching each pressure level, measuring frequency if acceptable, moving to the next pressure level. This will allow us to capture a record before it occurs.

Improvement/Feedback: At the conclusion of the job, the Task Manager, Supervisor and/or Project Leader shall work with those involved to consider lessons learned and move to improve future work plans.

Check me:

- Yes, we have considered lessons learned and accepted feedback on this job and will communicate such information so that future work plans may be improved.
- Yes, we have considered lessons learned feedback and determined that future work plans do not need to be improved.

HAZARD ANALYSIS

Description

Minimize the hazards and environmental aspects, and their corresponding safety precautions/precautions to mitigate hazards. Use as many sheets as necessary.

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Minimize the hazards and environmental aspects, and their corresponding safety precautions/precautions to mitigate hazards. Use as many sheets as necessary.

Precautions / Safety Procedures

Setup for the pressure test. Move all the equipment to place and make the necessary connections. Verify there is a signed pressure vessel rate and pressure test permit before starting.

Area around the test pressure test will be roped off. Alert personnel to the danger. A sign on the main entrance will announce a test is in progress and to use an alternative door. This door will be locked for the test.

Additional steps have been added to the test to reduce the likelihood, including venting the vessel after each pressure step and measuring the radio frequency of the cavity before the next pressure limit is tested.

There is a potential to permanently deform the cavity during the test.

Utilizing the format below, identify hazards and environmental aspects, and their corresponding safety precautions/precautions to mitigate hazards. Use as many sheets as necessary.

Fermilab EHS Policy Manual

Fermilab EHS Manual

Fermilab EHS Manual

Fermilab EHS Manual

Fermilab EHS Manual

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- Questions Regarding Cavity Jacketing?
- Next Slides - Jacketed Cavity Procurement
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- **Dressed Cavity Procurement**
  - Procure three dressed cavities, delivered, ready for VTS testing
    - This includes bare cavity fabrication
    - Bare cavity surface treatment and processing (tuning, FF, etc…)
    - Final EP, HPR and helium tank integration
    - VTS hardware installation
    - Shipping
  - Two vendors will receive bid packages
  - Build to print – cavity performance not part of procurement, same model used by LCLS-II 1.3 GHz and 3.9 GHz
  - Cavity Material to be supplied by FNAL. Order is underway, vendor has been selected
    - ED0371037 – RRR300 Niobium material specification
    - ED0008232 – Nb55Ti material specification
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- Dressed Cavity Procurement
  - Deliverable drawing – F10112941
  - Drawing Release in Progress
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- Dressed Cavity Procurement
  - Cavity Processing Flow Chart
  - Hold Points and Hold Point Data
  - Data shared on OneDrive
  - NCR’s also uploaded
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- Specifications
  - Cavity Fabrication Specification - ED0000693
  - Helium Vessel Fabrication Specification – ED0005059
### 650 MHz $\beta=0.92$ Jacketed Cavity Procurement

#### Technical Criteria in Proposals

<table>
<thead>
<tr>
<th>Technical Criteria</th>
<th>Description/elaboration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality assurance plan</td>
<td>Evaluate QA plan in proposal, including dimensional checks, material certifications, RF measurements, tuning. Check if QA done in-house or sub-contractor.</td>
</tr>
<tr>
<td>Delivery schedule</td>
<td>Evaluate if proposed delivery schedule by the vendor shall meet project requirements, including any float provided in vendor schedule. Use prior FNAL experience of deliveries.</td>
</tr>
<tr>
<td>Past experience of similar items</td>
<td>Evaluate if vendors have manufactured satisfactory cavities similar to the ones in the current proposal.</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Examine equipment and process infrastructure present at vendor and their sub-contractors. Equipments including and not limited to laser cutting, water jet cutting, electron-beam welding.</td>
</tr>
<tr>
<td>Capabilities</td>
<td>Evaluate capability of vendor to manufacture cavities per their proposal, including engineering.</td>
</tr>
<tr>
<td>Manufacturing plan</td>
<td>Evaluate proposed manufacturing plan, from sheet format to final product. Take into consideration sequence of each operation, including forming, welding, processing, and shipping.</td>
</tr>
<tr>
<td>Management</td>
<td>Evaluate personnel experience with respect to dressing of RF cavities. Emphasis to be given for understanding of cavity/helium tank integration.</td>
</tr>
<tr>
<td>Technical Merit</td>
<td>Does the vendor demonstrate the ability to successfully dress 650 MHz cavities.</td>
</tr>
</tbody>
</table>
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- Travelers
- 650 MHz Dressed Cavity RF Incoming Inspection - 464491
- 650 MHz Dressed Cavity Incoming Inspection Leak Check - 464492
- 650 MHz Dressed Cavity Incoming Inspection Traveler - 464493
Thank You!

Questions?
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- Back-Up Slides
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- **Bare Cavity Design Review**
  - 30-October-2015
  - Documents are located individually in Teamcenter and packaged in the PIP-II EPDM – ED0001237
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- **Bare Cavity Design Review**
  - Final design review report - ED0003861
  - Additional dataset attached to ED0003861 is teams response to the findings by the review committee. All findings resolved.