DCM: Manufacturing & Inspection Plan


*Engineering Design Review of the D1-DFX Connection Module (DCM) 15.04.2021
Contents

- Manufacturing & Inspection plan overview
- Main sub-assemblies overview
- Assembly procedure and QC checks
Manufacturing & Inspection Plan overview

Inputs for the manufacturing

- DCM sub-models assembly and QC
- DCM final assembly and QC
Manufacturing & Inspection Plan overview

- DCM is split in 3 sub-modules
- Each sub-module is pre-assembled and tested out of the tunnel
- The sub-modules will be connected only in the tunnel (string test)
- Tests on the whole assembled DCM will be carried only in the tunnel (string test)

**Main stream**
- Vacuum vessel
- Helium vessel
- Thermal shield
- Diode stack
- Instrumentations

**D1 module**
- Vacuum vessel
- Helium vessel
- Thermal shield
- Connecting flexible to D1
- Frame interface

**Frame**
- Main structure
- Connections to Vacuum vessel
- Connection to ground
Assembly and quality procedure overview

**Phase 0:**
- Deliverable sub-assemblies
- Check and upload of requested documentation

**Phase 1:**
- Sub-modules assembly procedure
- QC Tests to be performed
- Final acceptance test
- Reports of the test
- Upload of documentation

**Phase 2:**
- Sub-modules assembly in the string
- Tests to be performed
- Reports of the test
- Upload of documentation
Phase 0 - Main stream

Vacuum Vessel Components
- Technical specification: EDMS 2515149
- Drawing Folder: EDMS 2471237
- Dimensional control report
- Leak test report (TE-VSC St.)
- Material certificate
- Welding book
- Packing/shipping requirements

Helium Vessel Components
- Technical specification: EDMS 2519812
- Drawing Folder: EDMS 2495226
- Dimensional control report
- Leak test report (TE-VSC St.)
- Material certificate
- Welding book (PED cat. IV)
- Weld inspection (PED cat. IV)
- Individual label for traceability
- Packing/shipping requirements

Thermal Shield Components
- Technical specification: In progress
- Dimensional control report
- Material certificate
- Welding book
- Individual label for traceability
- Packing/shipping requirements

Plugs, cables, Instrumentation, MLI, ancillaries and diode stack
- Documentation

MTF
Phase 0 – D1 module

Vacuum Vessel Components

- Technical specification: EDMS 2515149
- Drawing Folder EDMS 2471237
- Dimensional control report
- Individual label for traceability
- Leak test report
- Material certificate
- Welding book
- Packing/shipping requirements

Helium Vessel Components

- Technical specification: EDMS 2519812
- Drawing Folder EDMS 2495226
- Dimensional control report
- Individual label for traceability
- Leak test report
- Material certificate
- Welding book
- Welding book (PED cat. IV)
- Weld inspection (PED cat. IV)
- Packing/shipping requirements

Thermal Shield Components

- Technical specification: In progress
- Dimensional control report
- Material certificate
- Cleaning of surfaces
- Welding book
- Packing/shipping requirements
Phase 0 – Frame

Frame - structure

Technical specifications:
In progress

- Dimensional control report
- Material certificate
- Welding book

MTF
Ph.1 - Main Stream – Assembly & QA

- Procedure qualification (EDMS document)
- Procedure Assembly Drawing
- Weld + Welders qualifications (WPS)

- Cables and plugs connected to lambda plate
- Main helium vessel aligned to position
- Main helium vessel is butt welded to the lambda plate chamber

- Visual inspection
- Dimensional control
- Helium leak test

- Report
- Report
- Report

Main operations

Phase 0
Lambda plate chamber
- Leak tested
- Dimensions checked
- Documentation

Phase 0
Main helium vessel
- Leak tested
- Dimensions checked
- Documentation

Main operations

Helium leak test
Ph.1 - Main Stream – Assembly & QA

- Thermal shield assembly
- Vacuum vessel connection with vacuum barrier
- Visual & dimensional inspections and report
Ph.1 - Main Stream – Assembly & QA

Copper cables are inserted in the T of the main helium vessel → Visual inspection → Report

HV elbow oriented & welded to the main HV → Helium leak test → Dimensional check → Report

Copper cables are bent → Insulation of copper cables → Visual inspection → Dimensional check → Report

Helium vessel elbow
- Leak tested
- Dimensions checked
- Documentation

Copper cables
- Dimensions checked
- Documentation

Main operations
Ph. 1 - Main Stream – Assembly & QA

- Insertion, positioning and welding of thermal shield and VV elbow
- Welding of sliding support and connection of the TS cooling line
- He Volume Leak test, dimensional check and report
- Pressure and leak test of the TS cooling line
- Welding of VV extension
- VV volume Leak test and report
- Assembly of vacuum vessel elbow

**Main operations**

- Vacuum vessel elbow
  - Leak tested
  - Dimensions checked
  - Documentation

- Sliding support
  - Leak tested
  - Dimensions checked
  - Documentation

- VV extension
  - Leak tested
  - Dimensions checked
  - Documentation

- VV bellow
  - Leak tested
  - Dimensions checked
  - Documentation
Ph.1 - Main Stream – Assembly & QA

- Insertion of the diode stack in HV – Diode
- Cable are passed through the not bended IFS pipe
- Bending of the IFS pipe
- Assembly of the thermal shield
- Assembly of the diode vacuum vessel
- Welding and electrical connections
- IFS intermediate electrical test
- Leak test
- Assembly of the VV Diode elbow
Ph.1 - Main Stream – Assembly & QA

- Electrical connections Cu-NbTi
- Report documentations
- Diode electrical connections
- Diode intermediate electrical test
- HV closure welds
- Leak test
- Assembly of the thermal shield and VV Diode
- Final acceptance tests
- Protection of leak tight interfaces
- Sealing and Packing for storage
Ph.1 – Main Stream Final acceptance tests

- Final acceptance tests sequence
  - Pressure Test acc. to PED harmonized standards (30 bar)
  - Dimensional controls
  - Leak test acc. to TE-VSC requirements EDMS 2228665
  - Electrical tests
    - Instrumentation tests
    - Busbars tests (as defined in functional specification, 4 kV, max leakage current 10 mA)
    - Cryogenic instrumentation test

EDMS 2228665

ENGINEERING SPECIFICATION

Leak Tightness of LHC Cold Vacuum Systems

Abstract:
This document provides the leak tightness requirements for all equipment to be installed in the cold vacuum system of the LHC accelerator. Leak tightness tests shall be validated by TE-VSC prior to installation in the LHC accelerator.

- Helium to insulation vacuum \( < 1 \times 10^{-9} \text{ mbar-1/s} \)
- Air to insulation vacuum \( < 1 \times 10^{-8} \text{ mbar-1/s} \)
Ph.1 – D1 interface and frame – Assembly & QA

- Same procedure for the other 2 sub models and for the DCM assembly in the string:

Qualifications of:
- Procedure
- Tools
- Materials

Clear definition of assembly procedure

Definition and performance of intermediate tests

Creation and upload of report

Safe storage

Manufacturing & Inspection Plan overview

DCM is split in 3 sub-models:
- Each sub-model is pre-assembled and tested out of the tunnel.
- The sub-models will be connected only in the tunnel.
- Tests on the whole DCM will be carried out only in the tunnel.

Main stream:
- Vacuum vessel
- Helium vessel
- Thermal shield
- Dode stack
- Instrumentations

D1 Interface:
- Vacuum vessel
- Helium vessel
- Thermal shield
- Connecting flexible to D1
- Frame interface

Frame:
- Main structure
- Connections to vacuum vessel
- Connection to ground
Ph.2 - Installation sequence in the tunnel

1. Cables are pulled with frame installed

2. Installation & positioning of D1 side sub-assembly

3. Main stream assembled using the adjustment boxes

4. Electrical connections

5. Closure of the helium vessel (weld sleeve)

6. Finalize assembly of thermal shield and closure of the vacuum vessel
- EDMS structure created
- Definition of items & assets to be started ➔ MTF structure
- Production of detailed MIP document for the DCM assembly in progress
- Production of detailed workflow in progress
Conclusions

- Quality controls requirements of the DCM device are defined in the specifications
  - Technical Specifications for sub-elements are being produced to comply with the requirements to qualify the assembled DCM device
  - The MIP of the assembly is being produced identifying quality controls and inspections to comply with the requirements of the DCM
  - Quality controls for pressure, leak test and dimensions already defined, electrical tests to be validated

- Next steps:
  - Trigger qualification for welds procedure and welders
  - Define electrical quality controls
  - Set-up with HL-LHC QA the MTF structure
  - Complete the MIP document
Spare slides
Ph.1 – Main Stream Final acceptance documentation

- The DCM main stream shall be delivered with the following documentation:

<table>
<thead>
<tr>
<th>For CAT IV PED assessment of Helium vessel*</th>
<th>Assembly &amp; qualification documentation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Design report acc. to standards</td>
<td>• Manufacturing drawings</td>
</tr>
<tr>
<td>• Material certificates pressure compliant</td>
<td>• Material Certificates (all parts)</td>
</tr>
<tr>
<td>• Welding Procedure Qualification Record (WPQR)</td>
<td>• Welds qualification for non pressure vessel elements</td>
</tr>
<tr>
<td>• Welding Procedure Specification (WPS)</td>
<td>• Dimensional controls report</td>
</tr>
<tr>
<td>• Welds inspection reports (visual &amp; NDT) &amp; associated personnel qualifications</td>
<td>• Instrumentation electric test report</td>
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<tr>
<td>• Pressure test report (HSE)</td>
<td>• Leak testing personnel qualification</td>
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<tr>
<td></td>
<td>• Leak test report using CERN template</td>
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<tr>
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<td>• Leak detector calibration report</td>
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<tr>
<td></td>
<td>• Electrical test reports</td>
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</tbody>
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*covering activities performed in industry and at CERN