n_TOF target #3 Production readiness review – Prototyping activities & manufacturing aspects

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Outline

• Overview of challenging designs
• Moderator and Bi-metallic transition
• Vessel
• Tests and inspections
• Anti creep plate
• Instrumentation
• Mounting procedure
Challenging designs

- Nitrogen circuit
- Demineralized water circuit
- Borated water circuit
- Beam

Lead wedge (Pur lead 99.99%)

Moderator support (Aluminium 6082)

Cradle assembly (Aluminium 6082 + Pur lead 99.99%)

Cover (St Steel 316L Low cobalt <0.1%)

Thermo-couples

Anti-creep plates

Vessel (St Steel 316L)

Moderators (Aluminium 5083)

Bi-metallic transition

Total weight: 1800 Kg

Dimensions:
- Height: 760 mm
- Width: 700 mm
- Depth: 626 mm

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Moderator and Bi-metallic transition

H. Moderator

Deep milling for central insert Ø40 over 300mm (minimising deformations)
Moderator and Bi-metalllic transition

H. Moderator

Precise machining of interface for EB weld on insert (Localisation 0.1mm).
Moderator and Bi-metallic transition

H. Moderator

Body machined according to metrology on insert to achieve a perfect fit for EB weld. Maximum tolerated gap: **0.1mm**
Moderator and Bi-metallic transition

Extra thickness to be machined according to metrology on vessel to achieve maximum gap of 0.1mm
Moderator and Bi-metallic transition

H. Moderator

Production strategy:

1. Production of full scale prototype at CERN has started.

2. Insert has been produced and is conform. (See part)

3. EB Welding tests will start in September 2019.


5. If successful the moderator will be used in final target.

• Conforms in terms of dimensional tolerances
• Passes vacuum and pressure leak tests.
• inspections conformity (Visual, X-ray, PT)
Moderator and Bi-metallic transition

H. Moderator material considerations

H. Moderator insert considerations

- Material EN AW-5083 H111
- 2 products were considered
  - 3D forged plates: Most isotropic properties and random distribution of precipitates (Mg and Si based). Non-standard products → Uncertain supply delays and cost
  - Rolled plates: Anisotropic properties and precipitates aligned in the rolling direction → Readily available products

H. Moderator Insert prototype

Material: 3x rolled plates of EN AW-5083 H111, due to material availability
- Dimensions:
  - 3x: 650 mm x 650 mm → Moderator insert fabrication (1x) and spares (2x)
  - 2x: 200 mm x 300 mm → Material qualification (1x) and machining / welding qualification (1x)
- Certificates: Specific inspection (type 3.1) certificate from supplier, concerning mechanical properties and chemical composition
Moderator and Bi-metallic transition

H. Moderator material considerations

Material qualification for prototype:

Inspection at CERN (ongoing)

- Ultrasonic testing before insert machining to reveal bulk defects
  - Inspection carried out the 29/04/19
  - Sensibility of defects equivalent to Flat bottom hole (FBH) of 1.2 mm
  - Inspection was conform $\rightarrow$ plate shipped for machining
- Metallographic inspection:
  - Reference microstructure images, specifically from the precipitates, for corrosion considerations
  - To be compared with 3D forged Al plates
Moderator and Bi-metallic transition

Upstream part – Closing plate

Central part - Vessel

Downstream part – Multilayer plate

ERA2 moderator support

N2 outlet (DN80)

End stopper / cradle fixe point

Foot

Front view (without cover)
Moderator and Bi-metallic transition

Bi-metallic transition

Following the leak detected in the bi-metallic transition used to test the vertical moderator prototype in 2018 (EDMS-1995057)

New design with 28mm bi-metallic transition wall thickness

Other materials proposed but ruled out. Copper, (not good for galvanic coupling with Al). Nickel (ferromagnetic)

Use of explosion bonded plates not abandoned as suggested in IEDR 2018!!
Moderator and Bi-metallic transition

Production of a bimetallic transition prototype

- Supplied by NEYCO See certificates (EDMS-2068498) and UT-PT inspection at CERN (EDMS-2047350, EDMS-2080662)

Vacuum and pressure tests EDMS-2143635:

PT at the bimetallic transition, for inner and outer surfaces was conform, no delamination observed

Machined in steps of 5mm down to final thickness of 8mm
No leak detected:

Resulting specification EDMS-2150802

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**Vessel**

No prototypes will be produced however all welds will be qualified carrying out tests on samples followed by UT&PT.
Vessel

TIG lip weld (After insertion of the target)

Step machined after welding

EB Butt weld

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<table>
<thead>
<tr>
<th>Weld number</th>
<th>Description</th>
<th>Weld process</th>
<th>Weld type</th>
<th>Material</th>
<th>Standard pressure weld</th>
<th>Qualification process</th>
<th>Pressure/Vacuum test</th>
<th>Final inspection</th>
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</thead>
<tbody>
<tr>
<td>W01</td>
<td>Wedge support to vessel</td>
<td>EB</td>
<td>Butt weld</td>
<td>304V/316L</td>
<td>Yes</td>
<td>Existing WPQR</td>
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<td>W02.1</td>
<td>N2 outlets to vessel</td>
<td>TIG</td>
<td>Corn weld</td>
<td>316L/316L</td>
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<td>W02.2</td>
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<td>W03</td>
<td>Vessel Long. Weld</td>
<td>TIG</td>
<td>Butt weld</td>
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<td>W04</td>
<td>Bi-mellic transition to vessel</td>
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<td>W05</td>
<td>H moderator to bi-metallic transition</td>
<td>EB</td>
<td>Step Butt</td>
<td>5083H111/5083H111</td>
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<td>Based on representative samples</td>
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<td>Yes</td>
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<td>W06.1</td>
<td>N2 tube to Front plate</td>
<td>TIG</td>
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<td>W06.2</td>
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<td>W07</td>
<td>Vessel front plate to vessel body</td>
<td>TIG</td>
<td>Edge weld</td>
<td>316L/316L</td>
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<td>Existint WPQR</td>
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<td>W08</td>
<td>feedthrough to front plate</td>
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<td>W09.1</td>
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<td>Vacuum brazing</td>
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<td>Inconel/316L</td>
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<td>Based on full scale Prototype</td>
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<td>E01</td>
<td>Bi-metallic transition</td>
<td>Exp. Bonding</td>
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<td>5083/Al-1050/TiG/316L</td>
<td>No</td>
<td>Based on representative Prototype</td>
<td>Yes</td>
<td>Yes</td>
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</table>
Tests & inspection

Particular care must be taken for qualifying joints which are limited in terms of inspections (ex: Unable to locate spikes in the weld W05).
### Tests & inspection

#### n_TOF target #3 Weld qualifications and tests

<table>
<thead>
<tr>
<th>Weld number</th>
<th>Description</th>
<th>Weld process</th>
<th>Weld type</th>
<th>Material</th>
<th>Standard pressure weld</th>
<th>Qualification process</th>
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<th>Final inspection</th>
<th>Comment</th>
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</thead>
<tbody>
<tr>
<td>W10</td>
<td>Moderator nozzles to body</td>
<td>EB</td>
<td>Step butt weld</td>
<td>5083H111/5083H111</td>
<td>No</td>
<td>Based on representative samples</td>
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<td>W11</td>
<td>Bi-metallic pipe transition H&amp;V moderator</td>
<td>TIG</td>
<td>Butt weld</td>
<td>5083H111/5083H111</td>
<td>Yes</td>
<td>Existing WPQR</td>
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<td>W12.1</td>
<td>H moderator insert to body</td>
<td>EB</td>
<td>Step butt weld</td>
<td>5083H111/5083H111</td>
<td>No</td>
<td>Based on representative samples</td>
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<tr>
<td>W12.2</td>
<td>V moderator insert to body</td>
<td>EB</td>
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<td>5083H111/5083H111</td>
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<td>W13.1</td>
<td>Vertical moderator to moderator support</td>
<td>EB</td>
<td>Edge weld</td>
<td>5083H111/5083H111</td>
<td>No</td>
<td>Existing WPQR</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

**Inspection unable to locate spikes in W13.2 and W12.2 and W10**
Anti creep plate

New design with respect to what was shown in IEDR in May 2018.

Machined from both sides on vacuum table for limited deformations and controlled thickness.

Material
Al 6082 T6

20mm x 4mm grooves

580 x 620mm

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Anti creep plate

Prototype

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Instrumentation

Probe tip

Spring

Brazing

Flange – replace the cover of the vessel

Spring: St Steel 304L, Thickness 0.5 mm
Compression: 2 mm

Integration in anti-creep plate

to be protected, weld without isolate

Brazing Area: Oxy Acetylene or equivalent

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Instrumentation

Induction brazing failed. Inconel sheath melded on one of the probes. Surprising the probes still work and the feedthrough is leak tight. However new brazing will be carried out in a Furness at 850oC.
Mounting procedure – Pb slices

Discussion ongoing with MTH (Pb producer) to find best way of installing Pb blocks inside the anti-creep cradle.

Challenges:

- Handling the Pb blocks without drilling holes or using inserts.
- Mounting the thermocouples inside the anti-creep plates while installing the Pb blocks.
- Securing position of Pb block during mounting.
Mounting procedure

Possible fabrication & mounting challenges

Assembly step 1

- Setting up the cradle on its support
  - Material: 34 CrNi Mo4
  - Max deflection: <0.8 mm
  - Max Stress: 105 Mpa

- Setting up the vessel on its support
  - Weight: 200 Kg

- Upper tie rods already installed
- Positioning end stoppers

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Mounting procedure
Possible fabrication & mounting challenges

Assembly step 2

Insertion of the vessel around the cradle

Gap: 2 mm

Height adjustment made with 4 screws

Gap: 3 mm

Adjustment / Positionning

Lateral & longitudinal positionning made by the end stoppers

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Mounting procedure
Possible fabrication & mounting challenges

Assembly step 3

Removal from the support

Fixation of the cradle inside the vessel
Thankyou for your attention

Questions ?