ENGINEERING SPECIFICATION

1320.000-ES- 296471

Revision: - 1

NOvA ME Mark II:

Target Specification

Preparer:	MICHAEL McGEE / *(Michael W. McGee)*	*(Sign)*	Date: 11 SEP 2012
Reviewer:	KRIS ANDERSON / *(Kris Anderson)*	Kris E. Anderson *(Sign)*	Date: 12-Sept-2012
Reviewer:	JAMES HYLEN / *(Jim Hylen)*	*(Sign)*	Date: 14 Sep 2012
Approver:	PATRICK HURH / *(Patrick G. Hurh)*	*(Sign)*	Date: 9-18-12
Approver:	Craig Moore *(Craig Moore)*	Craig Moore *(Sign)*	9/19/12

Introduction: This Engineering Specification provides requirements and guidelines related to the Fabrication and Assembly of the NOvA Medium Energy (ME) Mark II Target at STFC-Rutherford Appleton Laboratory. Exceptions and substitutions to the provisions listed herein are allowed over the course of manufacture subject to Fermilab review and approval.

Design Modifications: It is currently expected that some modifications will be investigated and prototyped where necessary by RAL for this target. The modifications expected to be investigated include:

- Rail development including plug welds for water channel turn-around
- Consideration of change of rail aluminum alloy from 6000 to 5000 series
- Eliminate internal welded joint on target vessel (outer cooling tube)
- Change thin walled bellows to more robust bellows type

Modifications associated with these engineering design changes will be subject to Fermilab approval.

Fermilab Provided Parts/Assemblies: Fermilab will provide the tooling balls (dwg# MB-433656) to STFC/RAL including shipping charges (as applicable). Fermilab will provide and install the Downstream Beryllium Window Assembly (dwg # MC-433714), the Upstream Beryllium Window Assembly (dwg # MB-363049) and the budal monitor signal wire electrical insulation after delivery of the target to Fermilab. STFC/RAL shall provide an appropriate port closure (vacuum flange) in place of the US and DS Be Window Assemblies to enable leak checking and safe shipment. Other parts or assemblies may be provided by Fermilab if required and mutually agreed to by both parties. Any resulting changes in compensation or schedule terms will require approved modification (change order) to the existing Purchase Order.

Documentation of the Manufacturing Process: Manufacturing processes regarding the NOvA ME Target shall be documented including, at minimum, documentation of required Quality Assurance steps, any processes that deviate from drawings or specification, and material procurement documentation/certificates. All documentation shall be provided with the Target upon delivery.

Materials: All materials substitutions are subject to Fermilab approval prior to manufacture.

Target Fin Fabrication and Alignment: Target segments to be baked out in a vacuum furnace before assembly, under the following conditions; 400 degrees C at a pressure of 1e-4 mbar for 4 hours. Surfaces of target segments shall be carefully cleaned after machining with ethyl alcohol (200 proof).

Coatings and Special Processes: "Hard coat" anodized coatings for aluminum NOvA ME Mark II Target components shown in Table 1 are generally 0.025 mm – 0.05 mm total thickness layer achieved by standard industrial type III Class 1 anodization process.

Table 1. List of ME Mark II Target anodized parts.

Target Drawing #	Component	Quantity
MB-433747	BUDAL Fin Pressing Plate	1
MC-433750	Vertical Budal Fin Bracket	1
MB-433753	Cooling Tube Weldment	1
MB-433771	Cooling Rail Support Bracket DS	1
MB-433772	Rail Support Bracket US Locking	1
MB-433773	Rail Support Bracket US Sliding	1
MB-433774	Cooling Rail Support Rod	3
MB-433776	M10 Spherical Washer Bottom	6
MB-433777	M10 Spherical Washer Top	6
MB-433785	Rail Support Base Plate DS	1
MB-433786	Rail Support Base Plate US	1
MB-433865	M10 Aluminum Venting Screw	4
MB-433868	8mm Dia x 10mm lg Shoulder Screw	4

Vacuum and Preparation: All parts should be cleaned according to industry standards for high vacuum (degrease/ultra-sonic bath, ethyl alcohol wipe, and pure water rinse) prior to assembly. All assembly shall be done in a manner consistent with high vacuum practices (with the use of appropriate gloves, clean area and clean tools). Leak check of completed assembly shall be performed using a helium (He) mass spectrometer (no detectable leak at a sensitivity of 1e-9 atm-cc/sec or equivalent). During leak check apply blank-off flanges using o-rings. Note that the Beryllium window with vacuum flanges and aluminum gaskets will be installed only at Fermilab upon final assembly for operation. Also, note that the final target cooling tube weld to US endwall flange stub to be done at Fermilab upon final assembly.

Target Cooling Circuit Fabrication and Assembly: Target cooling tube inlet and outlet bellows shall be purchased in accord with drawing MD-433732. The bimetallic adaptor (aluminum to stainless steel) shall be purchased in accord with drawing MB-433737. However, a substitution for the Target cooling tube bellows and bimetallic adaptor is permissible and subject to Fermilab approval prior to manufacture. Each welded joint shall be tested using a He mass spectrometer to vacuum standard specified.

Quality Assurance: STFC/RAL will provide documentation for certain critical quality assurance examinations as specified:

A) Radiographic examination of all welded joints in the target fin water cooling circuit is required. Joints shall satisfy the acceptance criteria for NAS-1514 Class II under Table 1, as applicable to the fusion and penetration zones for each weld type (see Welding Procedure Guidelines below). Note that for plug welds, concave areas along the top surface above the plug are not acceptable. However a convex layer is allowed. Deviation from NAS-1514, Class II may be acceptable, subject to Fermilab review and approval. In addition, the finished cooling circuit shall pass a pneumatic and hydrostatic pressure test of 200 psig. Note that a fixture must be used to restrain each bellows during the pressure test.

B) Non-destructive examination of target vessel cooling jacket welded/brazed joints including, at minimum, in-process examination (as per ASME B31.3 (2004) Para. 344.2) and hydrostatic pressure test of 90 psig, and visual inspection (as per ASME B31.3 (2004) Para. 344.2).

C) Leak check of completed assembly using He mass spectrometer (no detectable leak at a sensitivity of 1E-9 atm-cm^3/sec). Note that during leak check apply blank-off flanges using o-rings.

D) Budal monitor electrical circuit connectivity (less than 1 ohm resistance) and isolation to ground (greater than 1 M-ohm resistance at 100 v).

E) Graphite target fin tip alignment of +/- 0.3 mm relative to a theoretical straight line extending from the first target tip edge to the last target tip edge.

Welding Procedure Guidelines:

- All welds are hermetic
- Maintain a minimum of 1 scfh of Argon inside of tube during welding
- Stainless Steel Welding
  - Stainless TIG welding using 316L welding rod
  - Use either μ-TIG or e-beam welding process for target bellows. Due to joint geometry (socket type), full penetration is not required
- Aluminum Welding
  - Aluminum TIG welding using welding rod ER4043
  - Scraping parts prior to welding highly recommended to minimize weld porosity
  - Plug joint welding
    - Maintain a chamfer of 1.6 mm [1/16"] at 82 degrees with an additional 1.6 mm [1/16"] gap above the plug as shown in Figure 1
    - Use minimum of ϕ2.4 mm [ϕ3/32"] 2% thoriated Tungsten rod (ZrW optional); use of truncated tip to prevent W contamination acceptable
    - Suggested Parameters:
      - Root pass 70% Ar/30% He high purity gas mix (18 scfh minimum flow)
      - Cover/fill pass using high purity Ar only with ER4043 filler

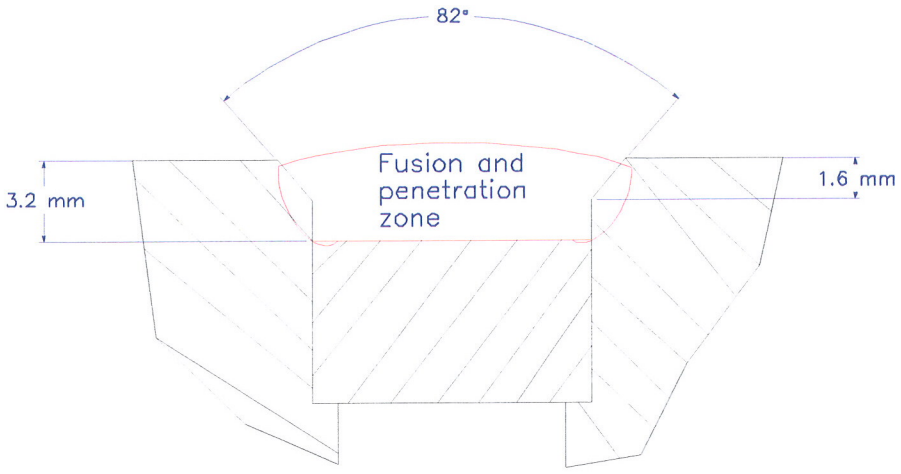

Figure 1. Aluminum plug weld design.

- Socket joint welding
  - Provide a 1.6 mm [1/16"] gap within the socket for future expansion as shown in Figure 2

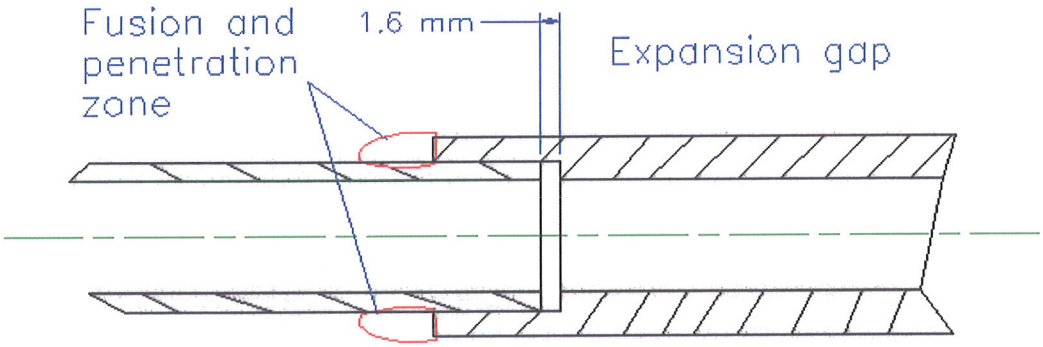

Figure 2. Aluminum socket weld design.

  - Purge welding cup 75% He/25% Argon high purity gas at (18 scfh minimum flow)
  - Use minimum of ϕ2.4 mm [ϕ3/32"] 2% thoriated Tungsten rod (ZrW optional); use of truncated tip to prevent W contamination acceptable
  - All welds should undergo X-ray inspection to assure welds meet NAS-1514 Class II criteria

Shipment to Fermilab: The Manufacturer is responsible for the proper packing or crating to ensure that damage will not occur during shipment. The water passages shall be purged with clean compressed air to ensure that the water passage is clear of any and all contaminants and moisture prior to shipment. The

water passages of the target shall be properly capped to prevent contamination, which would subsequently degrade the low conductivity nature of the target cooling system.

Fermilab Guidance: In addition to the above, Fermilab will provide Target operating parameters and best practices as needed to enable the fabrication efforts. Fermilab will provide direction and guidance as efforts proceed to resolve any issues that may arise. This may include visits of Fermilab personnel (at Fermilab expense) to the STFC/RAL site for the purposes of quality assurance and problem resolution.