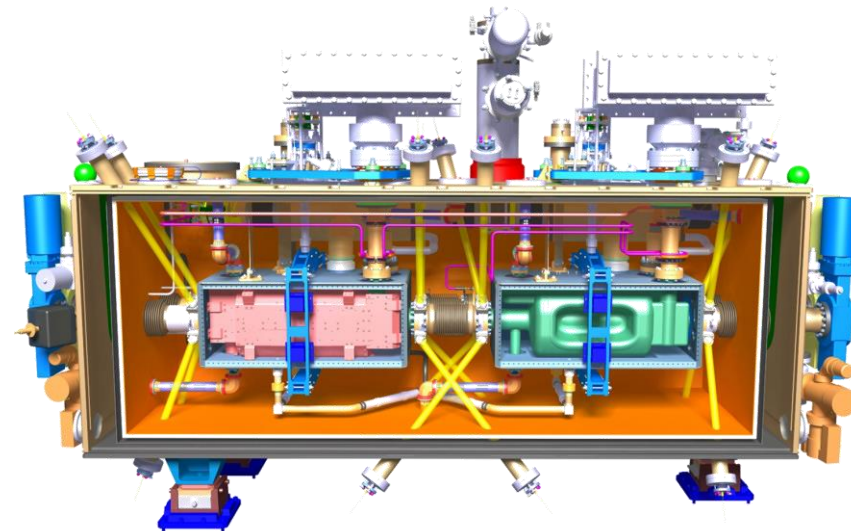


# RFD Engineering Issues – Interpreting European standards for North America manufacture

Oliver Law

Project Engineer – TRIUMF contribution to HL-LHC collaboration

TRIUMF



## Project Overview

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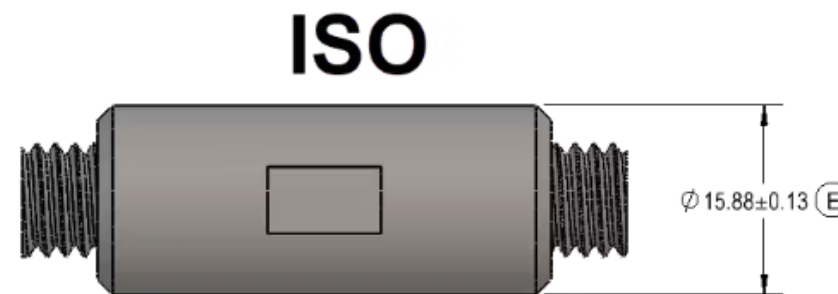
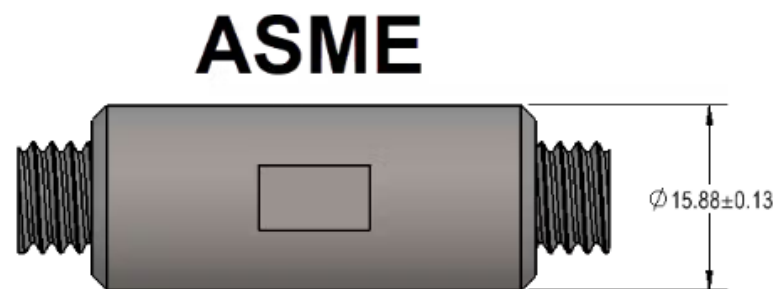
- TRIUMF is to assemble and qualify 5 cryomodules for the Hi-Lumi upgrade under the WP4 collaboration and ship to CERN
- Current project status:
  - TCM0 - Outer Vacuum Chamber (OVC) has been awarded to a local company (est. March 2024) and pre-fabrication documentation is in progress
  - Clean room & Mu-Metal (series) contracts awarded
  - In-house tooling and fixtures in design/manufacturing phase
  - Material for the OVC series has been procured (est. mid-October 2023)
- Future outlook:
  - Series OVC will be contracted out following the successful site acceptance tests and approval of TCM0 OVC
  - MLI, Cryo lines, Thermal shield, etc. contracts

# OVC Documentation

Pre-Fabrication Phase					
Document Name	Type	Standard	Action	Status	Notes
3D Models	Design	N/A	N/A	Completed	
2D drawings	Manufacturing	ASME Y14.5	N/A	Completed	
Manufacturing drawings	Manufacturing	ASME Y14.5	TRIUMF	In Progress	Under internal review prior to EDMS/MTF
Manufacturing and Inspection Plan (MIP)	Manufacturing	Axton	Axton	In Progress	Document in progress
Welder Certification	Certification	ISO 9606-1	Axton	In Progress	Certification in progress
Welding Procedure Specifications (WPS)	Certification	ISO 15609-1	Axton	In Progress	Document in progress
Welding Procedure Qualifications Records (WPQR)	Certification	ISO 15613 ISO 15614-1	Axton	In Progress	Document in progress
Raw material certificates	Material	EN 10204 Type 3.1	TRIUMF	In Progress	Expected mid-October 2023
Filler material certificates	Material	EN 10204 Type 2.2 (or higher)	CERN	In Progress	<a href="https://edms.cern.ch/document/2953464/1">https://edms.cern.ch/document/2953464/1</a>
Material samples	Material	N/A	TRIUMF	In Progress	Waiting for material to be received
Scheduling (incl. preliminary dates)	Project	Axton	Axton	In Progress	Document in progress
Traceability procedure	Manufacturing	Axton	Axton	In Progress	Procedure document in progress
Cleaning procedure	Manufacturing	TRIUMF	TRIUMF	In Progress	Draft document in progress
Leak test procedure	Manufacturing	TRIUMF	TRIUMF	In Progress	Draft document in progress

## Engineering Challenges – North American Manufacturing Manufacturing Drawings Interpretation - ASME Y14.5 vs ISO GPS

- Interpreting ISO GPS-compliant drawings for North American manufacturers
- Symbology and intent generally identical but unfamiliarity with ISO GPS standards can lead to reluctance to bid or manufacturing errors
- Example: Envelope vs Independency Principle
  - ASME Y14.5 Rule #1: Envelope Principle
    - The form of a regular feature of size is controlled by its “limits of size.”
    - Boundary prescribed by feature of perfect form at MMC
  - ISO GPS: Independency Principle
    - Each dimensional or geometric tolerance is met independently unless a relationship is specified on the drawing

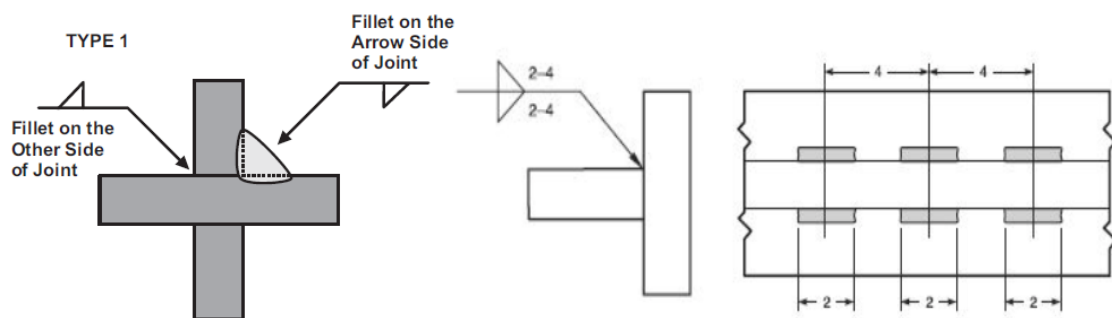


# Engineering Challenges – North American Manufacturing

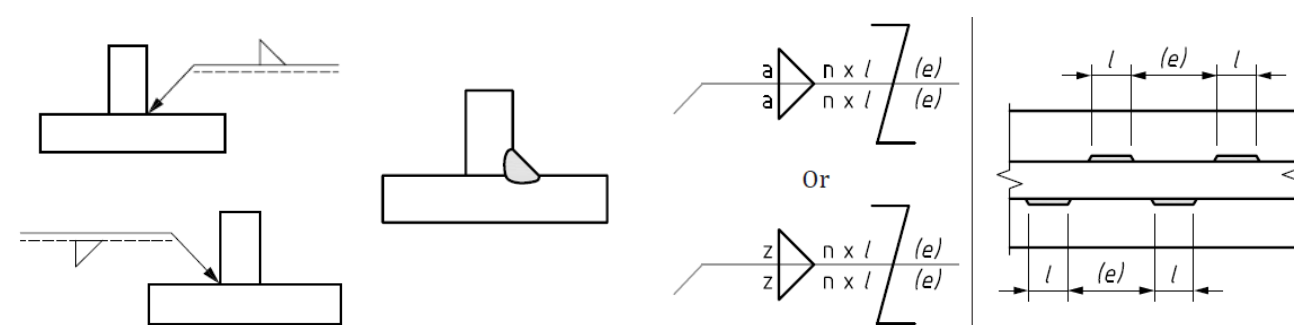
## Manufacturing Drawings Interpretation – AWS A2.4 vs ISO 2553

- AWS A2.4: Standard Symbols for Welding, Brazing, and Nondestructive Examination
- ISO 2553: Welding and allied processes – Symbolic representation on drawings
- Symbology and intent generally identical but without knowledge of specific differences can lead to misinterpretation of resulting welds

### AWS A2.4



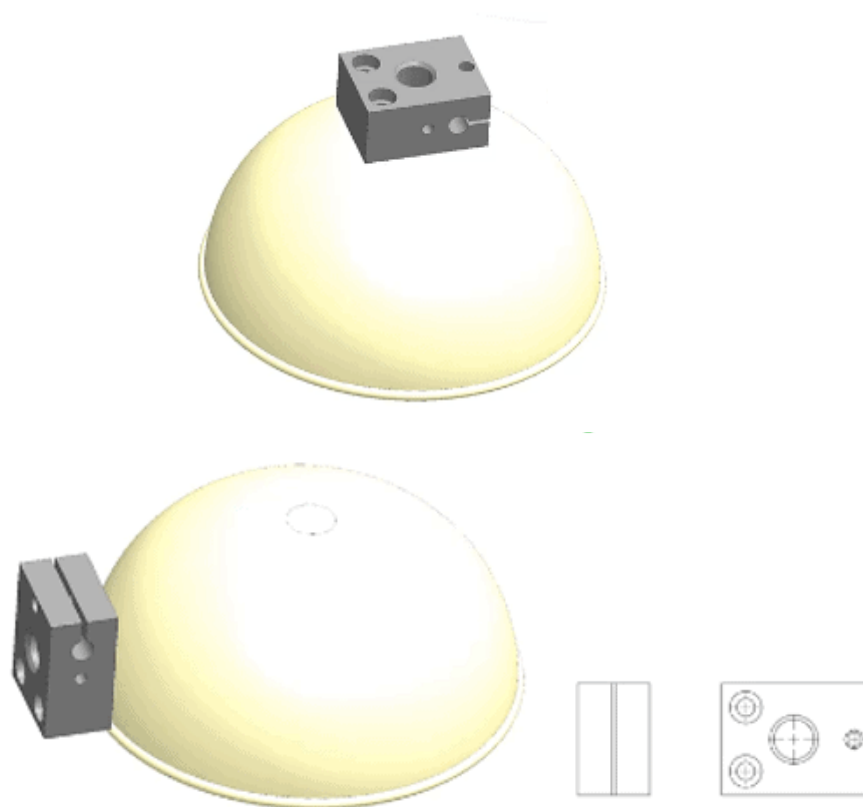
### ISO 2553 – System A



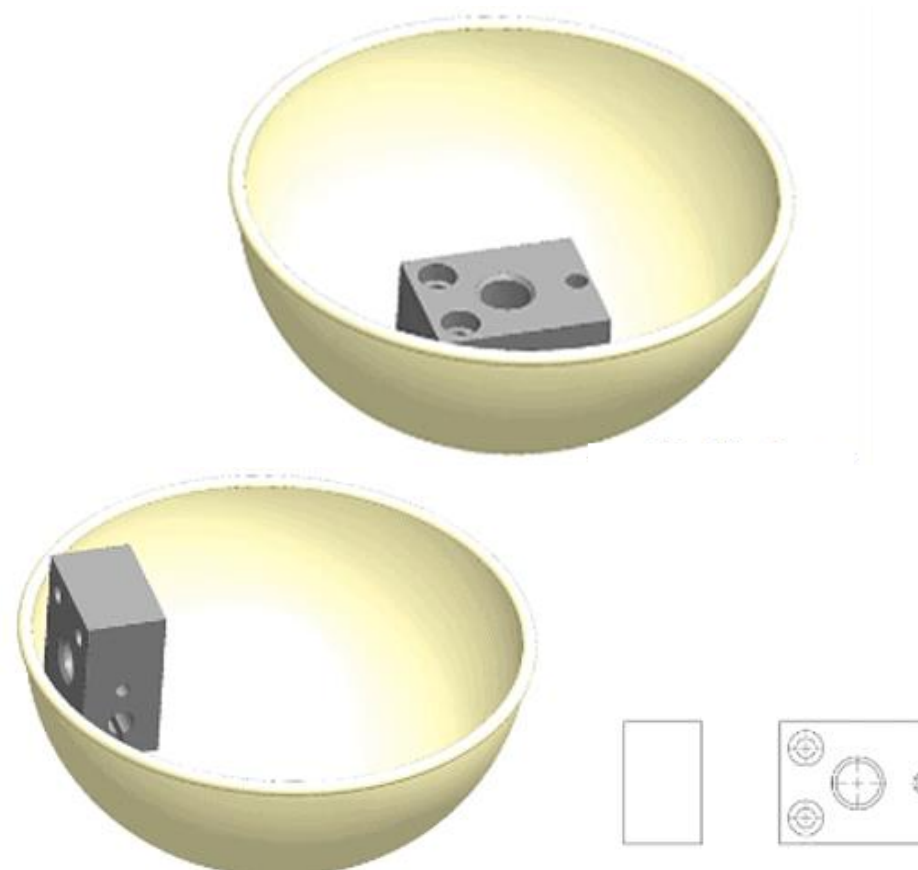
# Engineering Challenges – North American Manufacturing

## Manufacturing Drawings Interpretation – First vs Third Angle

### First Angle Projection



### Third Angle Projection



## Material Requirements and Procurement

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- TRIUMF is responsible for the procurement of all material for the series OVC
- Current status: Production series ordered (Outokumpu). Expected delivery mid-October 2023.
- Approval for EN 1.4307 (304L) to be used with additional chemical composition requirements:
  - Co < 0.3 wt%
  - P < 0.03 wt%
  - S < 0.015 wt%
- Challenges:
  - Metric sizing – specifically plate thicknesses and availability
    - 35mm vs 38.1mm (1.5in)
    - 30mm vs 31.75mm (1.25in)
  - Cobalt content restriction

## Challenges – Weld Qualifications

### ISO/TR 15608 and Qualification of Non-Standard Joints

- ISO/TR 15608: Welding – Guidelines for a metallic materials grouping system
  - Provides guidelines for grouping materials for welding purposes
  - Group 8, Subgroup 8.1: Austenitic stainless steels with  $\text{Cr} \leq 19\%$
- EDMS 2706475: Welded Joints for DQW & RFD Crab Cryomodule
  - Section 2: Qualification of Non-Standard Joints
    - The 304L (1.4306, 1.4307) / 316L (1.4404, 1.4435) / 316LN (1.4429) being in the same material group 8.1, it is accepted to use the **316L** as the base material for the samples required by the qualification process
    - Corrected to: “it is accepted to use **any** of these alloys as the base material for the samples required by the qualification process”
- Weld filler material: ER317L (mod.) / EN ISO 14343-A – W Z 18 16 5 Mn N L
  - Production series received – inspection certificate 3.1 (EN 10204) under review
  - <https://edms.cern.ch/document/2953464/1>



## Challenges - Welder Qualifications

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### CSA W47.1 vs ISO 9606-1

- No reciprocal agreement exists between CSA and ISO allowing the acceptance of either standard to the other
- Canadian Welding Bureau (CWB) is permitted to test welders to ISO 9606-1 provided the appropriate WPS are submitted
- Local third-party certification companies available to create WPS and WPQR according to ISO 15609-1 and ISO 15613/15614-1 – suggestions given to supplier



## Leak Testing Procedure & Personnel Qualifications

- TRIUMF personnel will perform the leak tests on the OVC using TRIUMF equipment
- Leak check procedure document draft in progress
- Laboratories under WP4 Collaboration are given 3 options:
  - Personnel shall be qualified to EN ISO 9712 or Recommended Practice No. SNT-TC-1A (minimum level 2, for both)
  - Leak-testing personnel provide the following documents:
    - Copy of at least 2x leak tests performed in the last 6 months and on equipment with comparable vacuum levels
    - Proven experience in comparable vacuum level (ex. 2-3 representative reports spanning the last 3 years)
  - Auto-certification of consistent experience (years + vacuum level) must be signed by leak-testing personnel and the project leader
- Correction to requirements: No deviation request required

**OPTION 2!**

## Conclusion

- TCM0 OVC pre-fabrication documents in progress or waiting for approval
- TRIUMF has translated or retained ISO specifications and requirements where applicable
- TRIUMF has taken on some of the responsibilities to alleviate the requirements for NA manufacturers (ex. Material procurement & leak checking)
- Corrections to specification documents that aid TRIUMF and suppliers in compliance with the requirements have been discussed and approved with CERN
- TCM0/Series procurement is ongoing and TRIUMF expects to issue tender contracts within the coming months

**CERN/TRIUMF/UK teams' collaboration  
has proven to be very helpful**



**Keep your ducks in a row!**



Thank you  
Merci

[www.triumf.ca](http://www.triumf.ca)

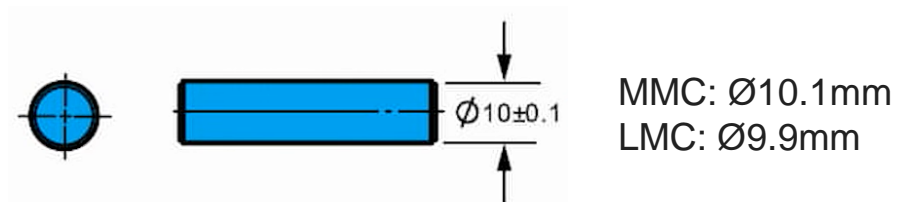
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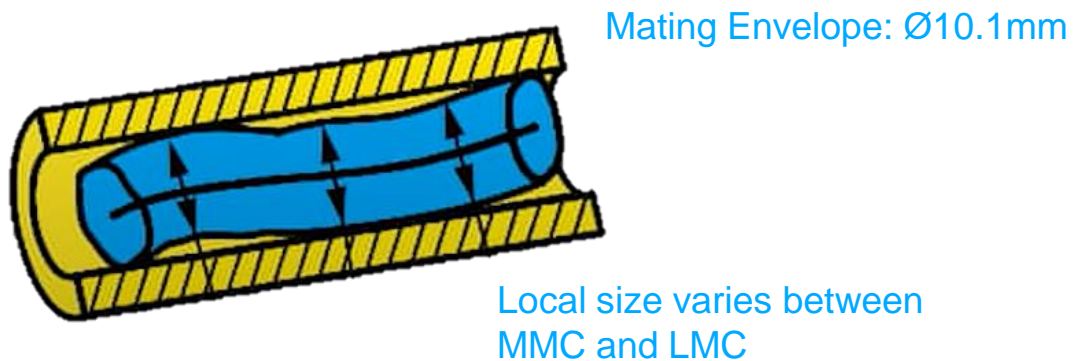
## References

- ASME Y14.5 vs ISO GPS:
  - <https://www.gdandtbasics.com/>
  - GeoTolPro
- First angle vs third angle projection: <https://www.gdandtbasics.com/>
- AWS A2.4: Welding for Design Engineers (CWB – 2006)
- ISO 2553: <https://www.iso.org/standard/72740.html>
- CSA W47.1: <https://www.cwbgroup.org/certification-and-qualification/csa-w471-fusion-welding-steel-company-certification>
- ISO 9606-1: <https://www.iso.org/standard/54936.html>

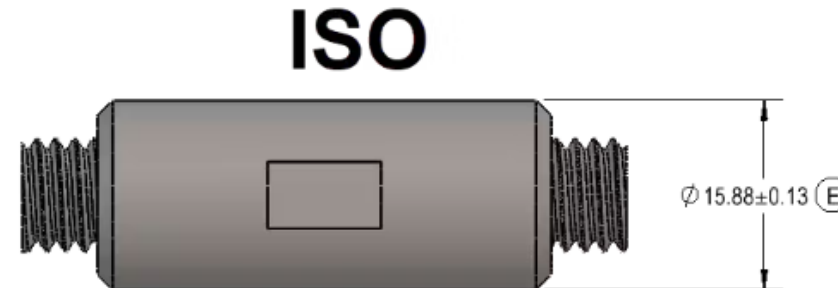
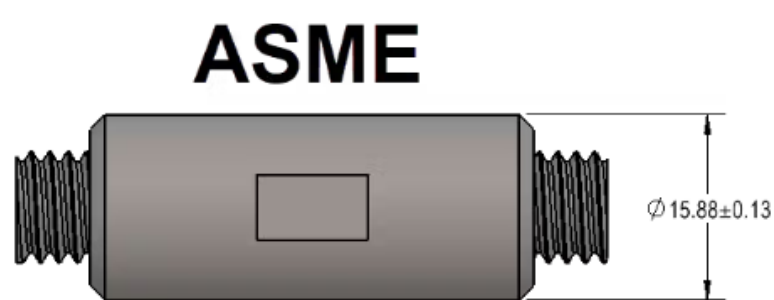
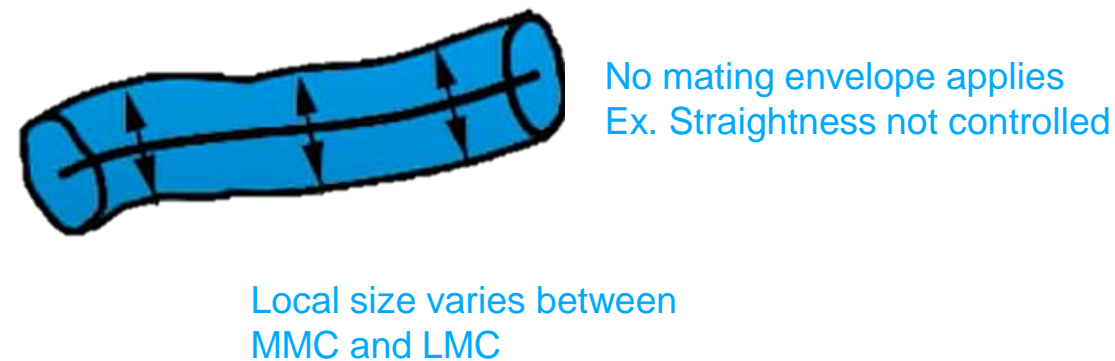
# Extra Slides – ASME Y14.5 Rule #1 vs ISO GPS Envelope



## Rule #1/Envelope Requirement



## Without Envelope Requirement



# Extra Slides – ASME Y14.5 Rule #1 vs ISO GPS Envelope

