PS-491

Process Specification – General Welding Requirements
65678 PPPL NCSX Vacuum Vessel Sub Assembly

1. PURPOSE

This specification establishes the process parameters to ensure that all welding performed on the NCSX SE120-002 Vacuum Vessel Sub Assembly is maintained within the guidelines required by PPPL product specification NCSX-CSPEC-121-02

2. SCOPE

This specification defines the minimum requirements for welding processes and fabrication practices required by the MTM MIT.

3. DEFINITIONS

PPPL – Princeton Plasma Physics Laboratory
MTM – Major Tool & Machine, Inc.
NCSX – National Compact Stellarator Experiment
VVSA - Vacuum Vessel Sub Assembly
MIT – Manufacturing, Inspection, and Test plan (MTM Mfg. Routing)
IDC – MTM Inspection Data Checklist system
QAP – MTM Quality Assurance Planning system
NCR – Non-Conformance Report
WPS – Welding Procedure Specification
PQR – Procedure Qualification Record

4. REFERENCE DOCUMENTS

PPPL Product Specification NCSX-CSPEC-121-02
ASME Boiler and Pressure Vessel Code, Section V-03 (Articles 2 and 9)
ASME SFA-97 5.14 Nickel and Nickel Alloy Bare Welding Rods Electordes.
AWS D1.6-99: Structural Welding Code – Stainless Steel, (Paragraph 6.29.1)
AWS QC1, Standard and Guide for Qualification and Certification of Welding Inspectors, 1996
ASNT 2055, Recommended Practice SNT-TC-1A, 2001
QA-SOP-01 Non-Conformance Control
MTM Mfg. Routing / Inspection Plan / Quality Assurance Plan 65678
PS480 – Visual Weld Inspection
PS481 – Radiographic Weld Inspection
PS482 – Dimensional Inspection (Laser Tracker)
PS483 – Cleanliness / Contamination Control
PS484 – Magnetic Permeability measurement
PS485 – Ultrasonic Thickness Testing
PS487 – Surface Finish Inspection
PS490 – Part Identification / Serialization

5. PRODUCT SPECIFICATION NCSX-CSPEC-121-02-03 CORRELATION

- 2.1 b, 2.1 j, 2.1 q, 2.1 r, 2.1 (no ASME Code stamping)
- 3.2.2.1, 3.3.2.8
- 4.1.3, 4.2.6.1

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6. REQUIREMENTS

6.1. ASME Code stamping of the VVSA is not required.

6.2. Weld Filler Material

6.2.1. Weld Filler metal shall meet the requirements of the applicable AWS A series specifications or ASME SFA specifications. Certified material test reports shall be supplied for all materials.

6.3. Weld joint identification; weld mapping; traceability

6.3.1. Each weld joint will be individually identified / serialized throughout the welding and inspecting process per PS490. The primary method of individual weld identification will be using the manufacturing routing serial number (work order, lot, sub-id, sequence numbers) appended with a weld number. For example, a serial number 65678-1-15-20W1-2 would indicate the subject weld is joining panels 1 & 2 together, and can be traced to the MIT job number 65678, lot 1, sub ID 15, Sequence 20. A map will be completed that will show the general location of the panels, the adjoining weld, and its respective film number and location.

6.4. Weld Joint preparation.

6.4.1. Prior to fit-up, each weld joint preparation will be visually inspected by a Team Leader, or CWI for the following prior to fitting and welding.
- 6.4.1.1. Verify the weld joint preparation / joint prep angle are of optimum configuration.
- 6.4.1.2. Verify the weld joint preparation is clean and smooth, with no heavy grinding marks.
- 6.4.1.3. Verify any dross / oxidation / recast layer resulting from panel trimming has been completely removed.
- 6.4.1.4. Verify material thickness is adequate to allow for anticipated local reduction which will result from grinding / blending / and polishing the welds.

6.5. Fit-up

6.5.1. All fabrication fixturing designed to support vacuum facing surfaces, and manufactured under this work order is produced to nominal profile geometry. It is preferred that at the time of fit-up, the weld joints are at least slightly raised above the fixture surfaces to better facilitate unavoidable weld shrinkage.

6.5.2. During fitting and attaching components to fixturing, tabs made of the same material as the component must be used (e.g. Inconel 625, and 300 Series SST). Specific WPS information will be included within the MIT. Components are not to be welded directly to dissimilar fixturing materials.

6.5.3. Necessary fixturing manufactured under this work order will be specified for use within the first operation sequence which it is required. Parts will remain with the fixture until the following removal instructions are provided (within later operation sequences)

6.5.4. After each component has been positioned and installed onto it's respective assembly fixture, the Team Leader will verify fit-up and joint alignment per the following criteria:
- 6.5.4.1. When possible, the weld joint should be gapped away from the fixture surfaces.
- 6.5.4.2. Mating parts should be aligned to within approximately 1/32" of their shared profile.
- 6.5.4.3. The included weld prep angle should be even and consistent throughout the entire length of the joint.

6.5.4.4. Parts should be secured (via. Fixturing and/or tack welding) adequately to ensure fit-up and alignment is maintained during welding.

6.6. Welding Processes / Techniques

6.6.1. All welding shall be performed only by personnel qualified to welding procedures identified within the MIT. Weld procedures will be in accordance with ASME Code, Section IX. GMAW and GTAW are the only approved processes. Individual welding operation sequences will identify the specific process / WPS information for each welding requirement.

6.6.2. Weld sequencing and back stepping will be utilized to inhibit excessive weld shrinkage and distortion.

6.6.3. Details / sub-components will be grouped, and welded as sub-assemblies where possible to provide the opportunity to compensate for welding shrinkage while fitting to the primary fabrication.

6.7. Purging / Back Purging

6.7.1. Each weld joint will be purged with 100% argon.

6.7.2. Purge dam material must be either 625 Inconel or 300 Series Stainless Steel.

6.7.3. Back purging must be maintained through a minimum of two weld layers (root pass, and at least one stringer / inter pass). Once the purge material is removed, the back side of the weld joint is to be monitored for oxidation / discoloration. If the back surface turns gray during welding, back purging will resume, and continue until enough weld thickness is deposited until excessive oxidation is discontinued. Some discoloring (e.g. straw to blue colors) on the back side is normal, and will be removed during subsequent blasting, blending, or polishing operations.

6.8. Inspections

6.8.1. Visual Inspection

6.8.1.1. All visual weld inspections will be performed in accordance with PS480 and the following:

- Each weld pass requires 100% visual inspection prior to beginning the next (covering) weld pass. The MTM MIT will include inspection data checklist records for each visual inspection step required within a given welding operation sequence. The visual inspection verification (IDC(s)) must be completed prior to beginning a covering weld pass on all structural weld joints. The number of IDCs provided within each manufacturing operation is based on an estimated number of weld passes required to complete a given weld joint. If more (or less) IDC records are required than have been provided, the welding operation will halt until engineering is notified, and the records are added (or removed).
- Each completed weld joint will be 100% visually inspected under a minimum of 8X magnification in accordance with PS480.

6.8.2. Radiographic Inspection

6.8.2.1. Each welded sub-assembly will require 10% radiographic inspection of structural welding as required by the MIT in accordance with PS481.

6.8.3. Cleanliness / Contamination control

6.8.3.1. Cleanliness will be maintained throughout the fabrication process as required by the MIT in accordance with PS483.

6.8.4. Material thickness

6.8.4.1. Material thickness will be audited throughout the process of preparation, fit-up, inter-pass, and final grinding, blending, and polishing as required by the MIT in accordance with PS485.

6.8.5. Magnetic Permeability

6.8.5.1. Magnetic permeability will be audited throughout the process of fit-up, inter-pass, and final grinding, blending, and polishing as required by the MIT in accordance with PS484.

7. QUALITY ASSURANCE / DOCUMENTATION

7.1. The MTM MIT will specify all in-process and final inspection documentation requirements. All quality documentation will be compiled electronically utilizing MTM's integrated IDC and QAP systems

7.1.1. At a minimum, the MTM MIT will require documentation for all contractual features and/or physical requirements (e.g. final component features / final material condition).

7.1.2. To ensure compliance is maintained throughout the manufacturing process, interim / additional documentation requirements will be provided within the associated MTM IDC, and QAP system

7.1.3. When an IDC record, or QAP document is completed, reference to the specific area being tested will be clearly discernable. The record will include the following information (as applicable):

- MTM Work Order Number
- Part Identification Number
- Part Description
- Part Serial Number
- Date of Inspection
- Gage Serial Number
- Reference Standard Serial Number
- Inspector Signature / Acknowledgement, Initials, or Stamp

7.1.4. For all MIT operation sequences that include this document as a task requisite, but do not specify physical inspection records or documentation, the electronic completion ("clocking out") of each sequential manufacturing operation within the MTM (Visual Manufacturing®) routing confirms compliance to the applicable requirements. The MTM employee completing the electronic transaction (which completes and closes the operation sequence) personally acknowledges completeness and compliance to the routing instructions.

7.2. All un-authorized exceptions / out of tolerance conditions according to MTM MIT will be documented within the MTM Non-Conformance system per QA-SOP-01.