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Process Specification – Magnetic Permeability Inspection 65678 PPPL NCSX Vacuum Vessel Sub Assembly

1. PURPOSE

This specification establishes the process parameters to ensure magnetic permeability testing 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 measuring magnetic permeability of materials used to produce the NCSX VVSA components (using a Severn Engineering High Sensitivity Low-Mu Permeability Indicator) when 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

4. REFERENCE DOCUMENTS

PPPL Product Specification NCSX-CSPEC-121-02
ASTM A800/A800M – Standard Practice for Estimating Ferrite Content
Operating manual – High Sensitivity Low-Mu Permeability Indicator – Severn Engineering
QA-SOP-01 Non-Conformance Control
MTM Mfg. Routing / Inspection Plan / Quality Assurance Plan 65678
PS483 – Cleanliness Control

5. EQUIPMENT AND SUPPLIES

- High Sensitivity Low-Mu Permeability Indicator – Severn Engineering

6. GENERAL INFORMATION / PRECAUTIONS

(obtained from Severn Engineering website)

The operation of the Indicator is based on the mutual attraction of a permanent bar magnet for a known standard and an unknown material. In use, an insert is screwed into the top of the case. The magnet is then attracted to the insert by a force dependent upon the insert's permeability. The end of the magnet projecting from the opening in the bottom of the case is then brought into contact with the material being tested. It is essential that the contact surface be clean and free from oxide scale or foreign material. The Indicator is then moved away in a direction normal to the contact surface. If the material being tested has a permeability higher than that of the insert value, the magnet will first break contact with the insert as the Indicator is moved away. Only full, complete breaks should be considered as indicative of a higher permeability than the test material. On the other hand, if the permeability of the material being tested is lower than that of the insert value, the magnet will first break contact with the test material as the Indicator is moved away. Thus, by interchanging the inserts, it is possible to bracket the permeability of the materials under test.

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Two features of the Indicator deserve special mention. First, the balanced beam to which the magnet is attached permits the use of the Indicator in all positions without correction due to gravity. Secondly, the hemispherical magnet ends provide point contact with the inserts and the test materials.

The High Sensitivity Low-Mu Permeability Indicator must be handled with care. The following precautions should be observed:

- Remove metal filings, chips and dirt from the surface of the material under test. Filings and dirt on the end of the magnet can be removed with masking tape.
- Under no circumstances bring another magnet in contact with the indicator magnet. This will disturb the calibration of the Indicator to such an extent that it will necessitate its return and subsequent recalibration.
- Be sure inserts are screwed firmly in place so as to establish contact with the magnet.
- Do not jerk the Indicator away from the test material, especially with the 1.01 insert in place. This will tend to give a false indication. Smoothly lift the unit straight up. Do not “rock” the unit while removing.
- Avoid as much as possible contacting the Indicator with strongly magnetic materials such as steel, cast iron, or straight chromium steels. This can be accomplished by first screening the materials under test with a hand magnet.
- Do not drop the Indicator
- When not in use keep the Indicator in its box with the highest value insert in place in the Indicator.
- Inserts are not interchangeable between indicators

7. INSTRUCTIONS

- 7.1. Ensure all locations where measurements will be taken are clean and free of any dirt, oil, lint, or any other foreign matter that may affect the readings taken.
 - 7.1.1. If cleaning is necessary, it should be performed in compliance with PS483.
- 7.2. Ensure the part being checked is isolated from ferrous materials (e.g. work tables, bracing, tools, etc...). In addition, any part or material that is suspect of holding residual magnetism must be demagnetized before taking a permeability measurement. Residual magnetism can adversely effect permeability measurements.
- 7.3. If the panel / assembly has not already been laid out for inspection, layout according to the inspection drawing. The layout should cover the entire part evenly, and consist of an approximate 6” grid throughout the body of the component, and an approximate 1” grid near weld seams and edges.
- 7.4. Inspect the magnetic permeability at each inspection point following the directions given within the manufacturer’s operating manual, MTM MIT, above information, and the following:
 - 7.4.1. Screw the insert reflecting the maximum allowable relative permeability into the top of the case. For example, if the area in question cannot exceed 1.2 mu, use the 1.2 mu indicator.
 - 7.4.1.1. Use the following criteria for insert selection:
 - Overall relative magnetic permeability of Inconel 625 components: 1.02 max.
 - Overall relative magnetic permeability of 316SST components: 1.02 max.
 - Overall relative magnetic permeability in welds (and heat affected zones) joining 316 SST to Inconel 625: 1.2 max.
 - 7.4.2. Place the indicator on the piece under test with the exposed magnet making contact within the grid cell.

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- 7.4.3. Smoothly lift the indicator away from the test surface, in a direction perpendicular to the test surface.
- 7.4.4. If the magnet breaks contact with the test piece before breaking contact with the indicator, the test piece has a lower relative magnetic permeability and is acceptable.
- 7.4.5. If the magnet breaks contact with the indicator before breaking contact with the test piece, the test piece has a higher relative magnetic permeability.
 - 7.4.5.1. Recheck the area with successively higher value indicators until a determination can be made that the test piece permeability is greater than one indicator (indicator broke first), but less than another (test piece broke first).
- 7.5. If out-of-tolerance conditions are detected, additional measurements must be taken in the immediate area to adequately define the extent of the non-conformance. Continue checking in all directions in a circular pattern until conforming material is found. The approximate size and location of the nonconformance will be mapped and/or identified on the inspection drawing. The completed map / drawing will be included as an attachment to the resulting NCR.

8. QUALITY ASSURANCE / DOCUMENTATION

- 8.1. 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
 - 8.1.1. 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).
 - 8.1.2. To ensure compliance is maintained throughout the manufacturing process, interim / additional documentation requirements will be provided within the associated MTM IDC, and QAP system
 - 8.1.3. 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
 - 8.1.4. 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.
- 8.2. 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.