

National Spherical Torus eXperiment Upgrade

Test Plan

HTT Diffusion Bonding Test

**CAT. A-3
REV 0
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1. INTRODUCTION AND SCOPE

The Heat Transfer Tube (HTT) provides a critical function during the operation of the NSTX-U. During operation, the HTT will be used to cool down the center stack vertical casing and tiles. To fabricate the HTT, the Inconel 625 Mandrels and Tubing are heat treated through a vacuum annealing process, and contact points between the parts are the regions of greatest concern. These homogeneous materials must remain separate at all times.

The scope of this specification includes the heat treatment, annealing process, of Inconel 625 material in a vacuum furnace. Two versions of tests will be performed, one without a Stop-off coating and one with Stop-off coating. The results of these tests will validate the material selection process and ensure that diffusion bonding does not occur during the heat treatment process.

2. APPLICABLE DOCUMENTS

I. Standards and Codes

These Standards and Codes set forth the minimum requirements.

ASTM American Society for Testing and Materials

ASTM B444 – Standard Specification for Nickel-Chromium-Molybdenum-Columbium Alloys (UNS N06625 and UNS N06852) and Nickel-Chromium-Molybdenum-Silicon Alloy (UNS N06219) Pipe and Tube

ASME American Society of Mechanical Engineers

ASME BPVC.II.D.M-2015 – 2015 ASME Boiler and Pressure Vessel Code

3. SAFETY AND HAZARDS

Standard operation precautions will be taken before testing to prevent any hazards from occurring. Thus, this plan does not have any safety and hazard mitigation plan.

4. APPLICABLE DRAWINGS

Drawings shall be produced, approved and released by PPPL Engineering Department [1].

5. RESPONSIBILITIES

I. PPPL

All testing and fabrication activities must be coordinated with the PPPL Cognizant Engineer (COG).

A pre-job briefing is to be conducted before the preliminary test procedure, and this briefing brings all involved personnel to meet for an introduction of the tasks.

6. MATERIALS AND FABRICATIONS

I. PPPL Supplied Materials

PPPL will supply Inconel 625 tubing and plate raw materials. Nickel alloy hardware is to be used to conform to a uniform (or near uniform) corresponding coefficient of thermal expansion during the annealing process.

Coating material (STOP-OFF Brazing Aid) to be supplied by PPPL, purchased from Wall Colomonoy. Recommended: Red STOP-OFF; if not available Green, White, or Blue STOP-OFF can be used as replacements.

II. Fixture Design and Fabrication

The fixture shall be designed to “sandwich” a 5in Inconel 625 section of tubing in place, during the annealing and heat treatment process. The Inconel 625 piping is purchased or fabricated to the desired specifications designated by the COG. Material for the fixture shall be Inconel 625. Hardware shall be Nickel Alloy. See [1] for the drawings associated with this fixture.

7. TEST PLAN

The sample shall be placed into Vacuum furnace and complete the four tests described below. All tests shall use the same fixture and Inconel 625 tubing until a failure occurs.

Testing will follow the following conditions:

- I. Installation of the fixture per drawing [1].
- II. Vacuum Furnace is set to 950°C.
- III. Testing Without Coating
 - i. Test 1: 2 hours with Small Load on Bolts (<20lb per bolt)
 - ii. Test 2: 2 hours with Large Load on Bolts (<1000lb per bolt)
- IV. Test with Stop-Off Coating
 - i. Coating is prepared and deposited on Inconel 625 tube
 - ii. Test 1: 2 hours with Small Load on Bolts (<20lb per bolt)
 - iii. Test 2: 2 hours with Large Load on Bolts (<1000lb per bolt)
- V. Modes of Failure:
 - i. Annealing process results in diffusion bonding of the Inconel 625 tube to the Inconel 625 fixture.
- VI. Deliverables:
 - i. Visual results of the tube (Images to be taken over the course of each test).

8. Quality Assurance Requirements

I. Quality Assurance Program

Inspection of manufactured components of the fixture will be completed by PPPL under the direction of the COG. This is done to assure the highest quality of work for testing, identify quality problems, verify conformance of supplied/purchased materials or services to specified requirements and obtain satisfactory resolution of conflicts involving quality.

II. Equipment Calibration

Tests shall be performed using properly calibrated measuring equipment. Calibration standards shall be traceable to the National Institute for Standards and Technology (NIST) or equivalent. Where such standards do not exist, the basis used for calibration shall be documented. Standards used for calibration shall not be used for shop inspections and shall be protected against damage or degradation.

NIST traceable standards used as reference during tested shall be clearly identified in a traceable manner on the test reports.

III. Documentation

All test methods and procedures, including ASTM tests, shall be documented in the Final Report. Any deviation from standard practices shall be noted.

9. Documentation and Deliverables

I. Final Report

A final report detailing the fabrication and test methods will be compiled. Report will include, all test data for each individual test, as well as average values and any pictures. Report shall also include personnel, dates, instrumentation, calibration status, environmental conditions, and results.

10. References

[1] 0DDB1510 Heat Transfer Tube, Inconel Diffusion Test Fixture