

National Spherical Torus eXperiment Upgrade

TECHNICAL SPECIFICATION

FOR

FABRICATION OF THE HEAT TRANSFER TUBE AND HEAT TRANSFER PLATE ASSEMBLIES, AND ASSOCIATED COMPONENTS

CAT: A1 A2 A3

UNIQUE PROJECT IDENTIFIER: NSTX-U-SPEC-VVIH-004-01

REFERENCE WORK PLANNING NO: 2322

REVISION 1

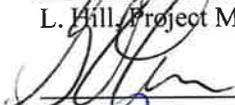
DATED MAY 15TH, 2019

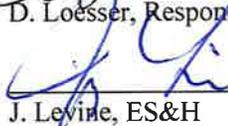
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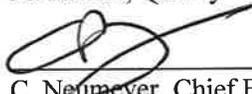
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LIST OF ACRONYMS

AMS	= <u>A</u> erosp <u>a</u> ce <u>M</u> ater <u>i</u> al <u>S</u> pecificat <u>i</u> on	MRR	= <u>M</u> anuf <u>a</u> cturing <u>R</u> eadiness <u>R</u> eview
ASME	= <u>A</u> merican <u>S</u> ociety of <u>M</u> echan <u>i</u> cal <u>E</u> ngineers	NCR	= <u>N</u> on- <u>C</u> onf <u>o</u> rman <u>c</u> e <u>R</u> eport
ASTM	= <u>A</u> merican <u>S</u> ociety for <u>T</u> esting & <u>M</u> aterials	NDT	= <u>N</u> on- <u>D</u> estructive <u>T</u> esting
CMTR	= <u>C</u> ertified <u>M</u> ill <u>T</u> est <u>R</u> eport	NSTX	= <u>N</u> ational <u>S</u> pher <u>i</u> cal <u>T</u> orus <u>e</u> Xperiment
CSC	= <u>C</u> enter <u>S</u> tack <u>C</u> asing	PPPL	= <u>P</u> rin <u>c</u> eton <u>P</u> lasma <u>P</u> hysics <u>L</u> aboratory
GD&T	= <u>G</u> eometric <u>D</u> imensioning & <u>T</u> olerancing	PQR	= <u>P</u> ro <u>c</u> edure <u>Q</u> ualification <u>R</u> ecords
HTT	= <u>H</u> eat <u>T</u> ransfer <u>T</u> ube	PTR	= <u>P</u> rin <u>c</u> eton <u>T</u> echnical <u>R</u> epresentative
HTP	= <u>H</u> eat <u>T</u> ransfer <u>P</u> late	QA	= <u>Q</u> uality <u>A</u> ssurance
JHA	= <u>J</u> ob <u>H</u> azard <u>A</u> nalysis	TA	= <u>T</u> echnical <u>A</u> uthority
MIT	= <u>M</u> anuf <u>a</u> cturing, <u>I</u> nspection & <u>T</u> esting	WPQ	= <u>W</u> elder <u>P</u> erformance <u>Q</u> ualification
		WPS	= <u>W</u> elding <u>P</u> ro <u>c</u> edure <u>S</u> pecifications

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1.0 INTRODUCTION & SCOPE

This Technical Specification provides details on the materials, labor, supervision, equipment, and expertise required to fabricate and test the upper and lower Heat Transfer Tube (HTT) inlet and outlet assemblies, the upper and lower heat transfer plate assemblies, and all associated components and hardware for installation into the Center Stack Casing. These assemblies are used for heating/cooling of the Center Stack assembly as part of the NSTX-U experimental fusion device.

2.0 APPLICABLE DOCUMENTS

- [1] ASME Section IX (2015) – *Welding Brazing and Fusing*
- [2] ASME B31.3 (2014) – *Piping, Pipelines Related Offerings – Process Piping*
- [3] ASTM E498/E498M – *Leaks using Mass Spectrometer Leak Detector or Residual Gas Analyzer*
- [4] ASTM A 342-04 – *Standard Test Methods for Permeability of Feebly Magnetic Materials*
- [5] AMS 2680C – *Electron-Beam Welding for Fatigue Critical Applications*
- [6] ASTM B443 – *Standard Specification for Nickel-Chromium-Molybdenum Columbium Alloy (UNS N06625) Plate, Sheet and Strip*
- [7] ASTM B444 – *Standard Specification for Nickel-Chromium-Molybdenum Columbium Alloy (UNS N06625) Pipe and Tube*
- [8] ASTM B446 – *Standard Specification for Nickel-Chromium-Molybdenum Columbium Alloy (UNS N06625) Rod and Bar*
- [9] ASTM A269 – *Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service*
- [10] ASTM A276 – *Standard Specification for Stainless Steel Bars and Shapes*
- [11] ASTM A240 – *Standard Specification for Chromium and Chromium Nickel Stainless Steel Plate, Sheet and Strip for Pressure Vessels and for General Applications*
- [12] ASTM B700-08 – *Standard Specification for Electrodeposited Coatings of Silver for Engineering Use*

3.0 APPLICABLE DRAWINGS

Table 1. List of PPPL Provided Drawings

Drawing No.	Rev.	Description
E-EB1089	1	Heat Transfer Plate Gas Inlet & Outlet Stub Weldments
E-DC11073	1	Center Stack Heat Transfer Tube Weldment, Top and Bottom
E-DC11124	0	Left & Right Heat Transfer Plate Weldment, Top
E-DC11125	0	Left & Right Heat Transfer Plate Weldment, Bottom
E-DC11126	0	Plastic Jig, Center Stack Heat Transfer Tube Installation
E-DC11173	0	Gasket, HTP
E-DC11174	0	Center Stack Heat Transfer Tube Holding Clamps, Top and Bottom
E-DC11198	1	HTT Clamp Support Welding Fixture
E-DC11211	0	Center Case Weldment, Heat Transfer Parts
E-DC11225	0	Heat Transfer Tube Mandrel Assembly

4.0 RESPONSIBILITIES

4.1 PRINCETON PLASMA PHYSICS LABORATORY

4.1.1 PROJECT MANAGEMENT & OVERSIGHT

- a. PPPL is responsible for this document, and the requirements contained herein.
- b. PPPL will designate a technical contact, the Princeton Technical Representative (PTR) and a Quality Assurance (QA) contact as well as alternate contacts for those individuals at the time of contract award.
- c. PPPL shall have the right to oversee and witness various tests, including all leak tests performed as part of this technical specification. The subcontractor shall provide a minimum one weeks' notice to PPPL of the anticipated date of each test.

4.1.2 PPPL DELIVERABLES TO SUBCONTRACTOR

- a. All drawings outlined in §3.0
- b. PPPL Shipping Release Form (Attachment A)
- c. All components/materials outlined in Table 2.

Table 2. List of PPPL Provided Materials/Components

Part No.	Description	Quantity	Material
E-DC11073-2	Cooling Tube, 3/8" OD	2	Inconel 625
E-DC11073-3	Outlet Tube, 1/4" OD	2	Inconel 625
—	Plate, 48" × 48" × .75" ^[1]	3	Inconel 625

^[1] If thicker raw plate is desired, the subcontractor may use their own material

4.2 SUBCONTRACTOR

4.2.1 PROJECT MANAGEMENT

The subcontractor shall provide a single-point of contact and an alternate for any communication between PPPL and the subcontractor.

4.2.2 DELIVERABLES TO PPPL

The subcontractor is responsible for providing all deliverables outlined in §12.0 to PPPL when noted and as required. For assemblies, the subcontractor is responsible for the fabrication of all sub-components required for the completion of the assembly unless otherwise provided by PPPL, see Table 2.

4.2.3 MATERIAL ACQUISITION

Unless otherwise provided, the subcontractor shall be responsible for purchasing all raw and shop materials necessary for the fabrication of all subcontractor furnished components and assemblies in Table 3.

4.2.4 MANUFACTURING

The subcontractor is responsible for fabricating all subcontractor furnished components/subassemblies in Table 3 per the drawings supplied by PPPL, and any other instructions/standards/etc., referenced on the drawings or in this Technical Specification.

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4.2.5 DOCUMENTATION

The subcontractor shall thoroughly document calibration records, manufacturing plans, personnel certifications and qualifications, and all inspections performed. Inspection reports shall be submitted to PPPL as noted in Table 6 in §12.0. This includes test reports for all non-destructive, leak, pressure and magnetic permeability tests/inspections performed in the completion of the scope of work regardless if a PPPL employee, or designee, is present as a witness. The report shall include type of test, location or test and results and photos of the setup.

4.2.6 START OF WORK

The actual fabrication work shall not start, until the following are met:

- a. PPPL has reviewed, and approved all documents in Table 4 denoted as required prior-to-start ("PS"), including the subcontractors MIT plan.
- b. The subcontractor has successfully completed a Manufacturing Readiness Review per §9.4.
- c. The subcontractor has received PPPL's written approval to proceed with the fabrication.

4.2.7 DIMENSIONAL VERIFICATION

The subcontractor shall verify all dimensions noted in the drawing package and document the results throughout the fabrication process per §6.1.1.

4.2.8 NOTIFICATION REQUIREMENTS

The subcontractor shall immediately contact PPPL regarding non-compliance or damage to any part or assembly. Details of the issue, including pictures, shall be discussed and documented, and a mitigation plan shall be developed. Work shall not resume on the item-in-question, until an NCR is approved and issued by PPPL.

4.2.9 TOOLING ACCOUNTABILITY

Any custom tool/fixture needed in the execution of the scope, including test fixtures, shall be the property of PPPL. The subcontractor shall label, and ship these items to PPPL upon completion of the work in the Technical Specification. The subcontractor shall make a list of this tooling and identify each in the applicable step(s) of the MIT Plan. This list shall include the unique identifier for the tool, where and on which component it was used. Pictures shall be taken of the tool(s), showing how the tool was used to make/hold the part. The general requirements outlined in §9.16 apply to all tooling and fixture materials and hardware.

4.2.10 WEEKLY UPDATES

The subcontractor shall submit weekly updates on the status of fabrication/assembly process. These updates shall include, which part is being worked on, the estimated completion date for each part, any delays, and the reason for the delay. These updates are to be emailed every Monday. The subcontractor shall schedule a weekly meeting with PPPL to discuss these updates as well.

4.2.11 PHOTOGRAPHS OF PROCESSES, HANDLING, PACKAGING & CRATING

Photographs shall be submitted to PPPL of each step of the various processes including welding, inspection, packaging, and crating.

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4.2.12 SHIPPING RELEASE FORM

Before shipping, the subcontractor must complete the Shipping Release Form, see §9.21 and Attachment A, and send it to PPPL's QA department. The subcontractor shall not ship the physical deliverables until PPPL returns the signed form and provides written authorization. The deliverables shall be shipped to PPPL or a separate designated facility located in the continental U.S. per PTR instruction.

Table 3. List of Vendor Fabricated Components/Assemblies

Part No.	Description	Qty	Qty/ Ass'y	Material
E-DC11073-03	Heat Transfer Outlet Tube Weldment Ass'y, Top and Bottom	2		Ass'y
E-DC11073-3	Outlet Tube, Ø1/4" OD		1	Inconel 625 ^[2]
E-DC11073-4	Fitting, Ø1/4" OD × Ø3/8" OD		1	Inconel 625
E-DC11073-6	Extension Tube, Ø3/8" OD		1	Inconel 625 ^[2]
E-DC11073-04	Heat Transfer Cooling Tube Weldment Ass'y, Top and Bottom	2		Ass'y
E-DC11073-2	Cooling Tube, Ø3/8" OD		1	Inconel 625 ^[2]
E-DC11073-5	Fitting, Ø3/8" OD		1	Inconel 625
E-DC11073-6	Extension Tube, Ø3/8" OD		1	Inconel 625 ^[2]
E-DC11073-07	Center Case Cooling Tube Stub Weldment – Type "A"	2		Ass'y
E-DC11073-7	Adapter, Cooling Tube, Ø3/8" OD		1	Inconel 625
E-DC11073-8	Cooling Tube Stub - Type "A"		1	Inconel 625
NS156164	VCR Gland - Swagelok #SS-6-VCR-3 [OR] Equivalent		1	316SST
NS156168	VCR Female Nut - Swagelok #SS-8-VCR-1 [OR] Equivalent		1	316SST
E-DC11073-08	Center Case Cooling Tube Stub Weldment – Type "B"	2		Ass'y
E-DC11073-7	Adapter, Cooling Tube, Ø3/8" OD		1	Inconel 625
E-DC11073-9	Cooling Tube Stub - Type "B"		1	Inconel 625
NS156164	VCR Gland - Swagelok #SS-6-VCR-3 [OR] Equivalent		1	316SST
NS156168	VCR Female Nut - Swagelok #SS-8-VCR-1 [OR] Equivalent		1	316SST
E-DC11073-1	Adapter, Cooling Tube Ø3/8" OD to Ø1/4" OD	2		Inconel 625
E-DC11124-01	Left HT Plate Assembly, Top	1		Ass'y
E-DC11124-1	Left Cooling Plate, Top		1	Inconel 625
E-DC11125-2	HT Plate Channel Cover		1	Inconel 625
E-DC11125-3	Tube Adapter		2	Inconel 625

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Table 3. List of Vendor Fabricated Components/Assemblies (cont'd)

Part No.	Description	Qty	Qty/ Ass'y	Material
E-DC11124-02	Right HT Plate Assembly, Top	1		Ass'y
E-DC11124-4	Right Cooling Plate, Top		1	Inconel 625
E-DC11125-2	HT Plate Channel Cover		1	Inconel 625
E-DC11125-3	Tube Adapter		2	Inconel 625
E-DC11125-01	Left HT Plate Assembly, Bottom	1		Ass'y
E-DC11125-1	Left Cooling Plate, Bottom		1	Inconel 625
E-DC11125-2	HT Plate Channel Cover		1	Inconel 625
E-DC11125-3	Tube Adapter		2	Inconel 625
E-DC11125-02	Right HT Plate Assembly, Bottom	1		Ass'y
E-DC11125-4	Right Cooling Plate, Top		1	Inconel 625
E-DC11125-2	HT Plate Channel Cover		1	Inconel 625
E-DC11125-3	Tube Adapter		2	Inconel 625
E-DC11126	Plastic Jig, Center Stack Heat Transfer Tube Installation	4		Teflon ^[3]
E-DC11173	Gasket, HTP	4		Grafoil, GTA
E-DC11174-1	Clamp, Vertical Tube, Top	7		Inconel 625
E-DC11174-2	Clamp, Vertical Tube, Bottom	6		Inconel 625
E-DC11174-3	Clamp, Tube Holder	8		Inconel 625
E-DC11174-4 thru 7	Upper HTT Clamps (4 Total)	4 (1EA)		Inconel 625
E-DC11174-10 thru 13	Lower HTT Clamps (4 Total)	4 (1EA)		Inconel 625
E-DC11174-01	HTT Shim Clamp Lower Position #6 Weldment Ass'y	1		Ass'y
E-DC11174-15	HTT Clamp, Lower Position #6		1	Inconel 625
E-DC11174-17	HTT Shim, Lower Position #6		1	Inconel 625
E-DC11174-02	HTT Shim Clamp Lower Position #5 Weldment Ass'y	1		Ass'y
E-DC11174-14	HTT Clamp, Lower Position #5		1	Inconel 625
E-DC11174-18	HTT Shim, Lower Position #5		1	Inconel 625
E-DC11174-03	HTT Shim Clamp Upper Position #5 Weldment Ass'y	1		Ass'y
E-DC11174-8	HTT Clamp, Upper Position #5		1	Inconel 625
E-DC11174-19	HTT Shim, Upper Position #5		1	Inconel 625
E-DC11174-04	HTT Shim Clamp Upper Position #6 Weldment Ass'y	1		Ass'y
E-DC11174-9	HTT Clamp, Upper Position #6		1	Inconel 625
E-DC11174-20	HTT Shim, Upper Position #6		1	Inconel 625
E-DC11174-16	Feedthru	5		Inconel 625

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Table 3. List of Vendor Fabricated Components/Assemblies (cont'd)

Part No.	Description	Qty	Qty/ Ass'y	Material
E-DC11198-01	HTP Clamp Support Ring Welding Fixture	1		Ass'y ^[3]
E-DC11198-1	Plate, Fixture		12	304SST
E-DC11198-2	Ring, Fixture		1	Aluminum 6061
E-DC11198-3	Bracket		12	304SST
E-DC11198-4	Chanel, Holding		1	Aluminum 6061
92240A537	HHCS, 1/4-20 × .50L, Drilled HD		24	18-8SST
91847A436	Hex Nut, Thin, 1"-12		12	18-8SST
94210A140	1/2"-13 Threaded Rod, 6' LG		2	B7 Steel
95505A605	Hex Nut, 1/2-13		4	Steel
91375A916	Setscrew, 1-8 UNC × 3" LG		12	Steel
E-EB1089-01	Divertor Flange Coolant Stub Weldment – Type "A1"	1		Ass'y
E-EB1089-1	Tubing, Ø0.625 OD × Ø0.495 ID Upper 1		1	Inconel 625
E-EB1089-2	Tubing, Ø0.625 OD × Ø0.495 ID Upper 2		1	Inconel 625
E-EB1089-3	Union Tee, .625" L3.840"		1	Inconel 625
SS-8-VCR-1	VCR Face Seal Fitting, 1/2" Female Nut		1	316SST
6LV-8-VCR-3-8TB7	Gland, VCR, Butt Weld, Swage, Long Tube .500		1	316SST
E-EB1089-02	Divertor Flange Coolant Stub Weldment – Type "A2"	2		Ass'y
E-EB1089-4	Tubing, Ø0.625 OD × Ø0.495 ID Upper 4		1	Inconel 625
6LV-8-VCR-3-8TB7	Gland, VCR, Butt Weld, Swage, Long Tube .500		1	316SST
SS-8-VCR-1	VCR Face Seal Fitting, 1/2" Female Nut		1	316SST
E-EB1089-03	Divertor Flange Coolant Stub Weldment – Type "A3"	1		Ass'y
E-EB1089-5	Tubing, Ø0.625 OD × Ø0.495 ID Upper 5		1	Inconel 625
E-EB1089-6	Tubing, Ø0.625 OD × Ø0.495 ID Upper 6		1	Inconel 625
E-EB1089-9	Union Tee, .625" L3.170"		1	Inconel 625
SS-8-VCR-1	VCR Face Seal Fitting, 1/2" Female Nut		1	316SST
6LV-8-VCR-3-8TB7	Gland, VCR, Butt Weld, Swage, Long Tube .500		1	316SST
E-EB1089-04	Divertor Flange Coolant Stub Weldment – Type "A4"	2		Ass'y
E-EB1089-8	Tubing, Ø0.625 OD × Ø0.495 ID Upper 8		1	Inconel 625
6LV-8-VCR-3-8TB7	Gland, VCR, Butt Weld, Swage, Long Tube .500		1	316SST
SS-8-VCR-1	VCR Face Seal Fitting, 1/2" Female Nut		1	316SST

^[2] Some components/base materials are provided by PPPL, see Table 2

^[3] NOTE: E-DC11126 and E-DC11198-01 are designated with a low risk categorization (A3) and as such do not require supplier qualification.

5.0 REQUIREMENTS

5.1 DESIGN PERFORMANCE REQUIREMENTS

5.1.1 PERFORMANCE CHARACTERISTICS

- a. All parts fabricated in the execution of this project scope shall meet or exceed all tolerance requirements listed in the provided drawing package.
- b. All welds at the coolant-air boundary shall be subjected to helium leak testing per ASTM E498 standards, as described in §6.1.2, and as noted on the corresponding drawings. Should any of these notes conflict, the subcontractor shall contact the PTR for clarification.
- c. All pressure pipelines shall be subjected to pressure testing as described in §6.1.4.

5.1.2 SPECIFICATION AND STANDARDS

All welds to be performed in accordance with the requirements of ASME. A copy of the most recent calibration certificates for each of the machining, metrology and other appropriate equipment/instruments that will be used for critical measurements or manufacturing processes shall be submitted for PPPL approval, at least a week prior to the beginning of fabrication. The subcontractor must maintain the equipment calibration throughout the duration of the scope of work. The calibration standards must be traceable to the National Institute of Standards and Technology (NIST) or equivalent.

5.1.3 SUBCONTRACTOR SUPPLIED MATERIALS

5.1.3.1 General Requirements

All materials shall meet the magnetic permeability limits outlined in §5.1.4 and pass all required inspections and tests defined in §6.0.

5.1.3.2 Specific Requirements

- a. All Inconel 625 (UNS N06625) sheets and plates used in the execution of this Technical Specification shall meet ASTM B443 Grade 1 (annealed) standards with a yield strength ≥ 60 ksi.
- b. All Inconel 625 (UNS N06625) tubing used in the execution of this Technical Specification shall be seamless and meet ASTM B444 Grade 1 (annealed) standards with a yield strength ≥ 60 ksi.
- c. All Inconel 625 (UNS N06625) bar used in the execution of this Technical Specification shall meet ASTM B446 Grade 1 (annealed) standards with a yield strength ≥ 60 ksi.
- d. All weld Filler shall meet the AWS A5.9 or AWS A5.14 specifications for steel and Inconel 625 weldments respectively.
- e. All Grafoil (E-DC11173-1) shall be grade GTA.

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5.1.4 ELECTROMAGNETIC INTERFERENCE AND SUSCEPTIBILITY

All work performed in the execution of this Technical Specification shall meet the Magnetic Permeability Limits listed on the drawing. If the drawings do not list a magnetic permeability limit, then use the following:

Base Material:

- $\leq 1.04\mu$ for all materials

Machined:

- $\leq 1.2\mu$ for all

Welds:

- $\leq 2.0\mu$ for all

5.1.5 IDENTIFICATION AND MARKING

Add identifications and markings per the supplied drawings.

5.1.6 WORKMANSHIP

- a. General shop cleanliness and housekeeping shall be adequately maintained to prevent contamination of components.
- b. Careful handling of the assemblies is required so as not to damage machined surfaces.
- c. All fabricated parts shall be free from sharp edges and burrs.
- d. All surfaces shall be cleaned to remove all oil, grease, dirt, loose mill scale, residue from protective covering and other foreign substances. Cleaning shall be performed using acetone and then finished with alcohol.
- e. In the event of ferritic contamination of stainless steel, pickling and passivation shall be required.
- f. All parts and assemblies shall be free from weld spatter.
- g. Tubing shall be bent with care to avoid kinking.

5.1.7 SUBCONTRACTOR USE OF EQUIPMENT

Subcontractors must provide their own equipment and not use government equipment. It is the subcontractor's responsibility to qualify/calibrate all equipment necessary to perform the work outlined in this document. Should the use of government equipment become absolutely necessary, that use of equipment will require liability release covering the use of PPPL equipment to be defined in the contract.

5.2 WELDING

- a. Edges or surfaces of parts to be joined by welding shall be prepared by machining, grinding, or plasma arc cutting.
- b. Where thermal cutting is used, all scale must be removed by grinding. Any grinding shall be performed using rubber or resin bonded aluminum oxide or silicon carbide grinding wheels. The grinding wheels shall not have been previously used on other than stainless steel materials and identified accordingly (e.g. color coded).
- c. All filler material must be compatible with the base metals of the components that shall be welded together and have equal or greater strength than the base material and meet the specifications outlined in §5.1.3.2d. Filler material must be added in all weld passes. Filler materials which are dirty, damaged or inadequately identified shall not be used. Filler material shall be stored in a clean and dry space. The filler material shall be properly identified by type or grade.
- d. Magnetic permeability may increase at the base material because of thermal processing. If the permeability increase exceeds the criteria of §5.1.4, additional grinding will be required.
- e. Welding shall be accomplished per the welding standards listed in §2.0, in particular ASME B&PV Code, Section IX (2015).
- f. Welding sequence and techniques shall be closely controlled in order to minimize distortion. The subcontractor's welding sequence and distortion control methodology shall be provided to PPPL for review and approval as part of the Manufacturing/Inspection/Test Plan. The subcontractor may propose alternate methods of welding and weld types (e.g. MIG) other than those indicated on the drawings. These alternate methods must be fully documented and approved by PPPL prior to use. The method proposed should maximize position and tolerance control.
- g. The subcontractor shall submit photos to PPPL of all weld preparation and finished welds for approval. For welds requiring test coupons to qualify their weld process (e.g. all e-beam welds per AMS 2680C) the subcontractor shall submit additional photos of these coupons for approval prior to proceeding.
- h. Prior to welding, the joint edges and immediate weld area of the parts to be joined shall be cleaned of all oil, grease, scale or other foreign materials. For degreasing, swab the weld region with acetone or other PPPL approved solvent. No residual cleaning compounds shall be left on the surfaces prior to welding. These steps shall be documented in the MIT plan described in §9.6.
- i. All welds shall be subject to non-destructive testing per §6.1.2. Additionally, leak and pressure testing shall be performed on vacuum-boundaries and pressure lines as outlined in §6.0.
- j. After successfully passing weld inspections, but prior to the performance of leak and pressure testing, all welds shall be post machined to achieve the features/geometry noted in the GD&T of the associated drawings as specified on the drawings.

5.3 FABRICATION SEQUENCE

The following sequence of operations is the recommended fabrication and assembly sequence for all deliverables to be produced as part of this technical specification. Not all deliverables are components of an assembly and as such may be performed in parallel. The subcontractor shall provide a process flow via their MIT plan which shall be submitted to PPPL for approval prior to the start of work. All welded joints associated with the fabrication below are subject to the testing outlined in §6.0. PPPL required hold points for this process are listed in §6.4.

5.3.1 HEAT TRANSFER TUBE COOLING & OUTLET TUBE ASSEMBLIES

The subcontractor shall fabricate the components and assemble the Heat Transfer Tube Cooling and Outlet Tube Assemblies. The Heat Transfer Cooling Tube (E-DC11073-2) and the Outlet Tube (E-DC11073-3) shall be provided to the subcontractor. Once the weldments are completed, the subcontractor shall perform NDT, leak and pressure testing per §6.0 of this technical specification.

5.3.2 HEAT TRANSFER PLATE

The subcontractor shall fabricate and perform E-beam welding on the HTP components as shown and to the specifications outlined in drawings E-DC11124 and E-DC-11125. These weldments are long lead items and shall have the highest priority. Once assembled, the subcontractor shall perform NDT, leak and pressure testing per §6.0 of this technical specification.

It is required that the tube adapters be installed prior to the installation of the cover plate as the cover plate obscures the tube weldment location. This also requires that the tube adapters be NDT and leak tested prior to the cover plate installation. All the holes features for the HTPs (E-DC11124-01 & -02 and E-DC-11125-01 & -02) should be machined after the cover welding and post machining

5.3.3 DIVERTOR FLANGE COOLANT TUBE STUBS

The subcontractor shall fabricate and assemble the Divertor Flange Coolant Tube Stub weldments per drawing E-EB1089.

5.3.4 ADDITIONAL COMPONENTS AND HARDWARE

The subcontractor shall fabricate the remaining individual components outlined in Table 3.

6.0 TESTING AND INSPECTIONS

6.1 GENERAL REQUIREMENTS

6.1.1 DIMENSIONAL INSPECTION

Tolerances are indicated on the manufacturing drawings. Strict adherence to these dimensions and tolerances are critical to the assembly and performance of the subject equipment. All dimensional measurements shall be performed in a temperature controlled environment of $20 \pm 2^\circ\text{C}$ with $50 \pm 5\%$ relative humidity with the actual values indicated on the inspection report.

The subcontractor shall include the sequence and measurement methodology as part of their MIT Plan. The subcontractor shall also note what best-fit methodology is used to confirm compliance with the drawing tolerances.

Dimensional inspections shall be performed at the following steps:

- a. Pre-Weld/Component Measurements – inspect all components per their respective drawings and document the results.
- b. Post-Weld Measurements – inspect the weldments per their respective drawing and document the results.

6.1.2 NON-DESTRUCTIVE TESTING

All welds performed as part of this work scope shall be subjected to non-destructive testing in accordance with the severe cyclic condition acceptance criteria of ASME B31.3 (2014). All welds shall be subjected to visual inspections.

All electron beam welds are subjected to ultrasonic or radiographic testing per AMS 2680C

6.1.3 LEAK TESTING

All Helium Leak testing shall be performed following ASTM E498/E498M utilizing Test Method A. The maximum allowable helium leak rate, unless otherwise noted, is 1×10^{-9} ATM cc/sec (air equivalent) on all vacuum boundary welds. It is required that a global test of the entire weld with 1 atmosphere of helium be completed (see §10.8 of ASTM E498/498M). Helium detection shall be performed utilizing a Helium Mass Spectrometer Leak Detector (HMSLD).

All leak testing is subjected to witness by a qualified PPPL employee (as designated by PPPL). The subcontractor shall give one week's notice to PPPL for any upcoming leak tests.

This testing shall be performed on all welded joints performed in the execution of this technical specification.

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6.1.4 PRESSURE TESTING

All Pressure testing shall be done to 2 times the maximum expected operating pressure, which exceeds the requirements of ASME BPVC I – XII (2015) and to the acceptance criteria of ASME B31.3 (2014) after performance of any required leak testing. The test shall be conducted for 8 hours, or overnight.

Failure of connections tested cause damage/debris to be ejected to the surround area. The subcontractor shall be required to have a clean work area in which to perform the tests, and include such provisions in their Job Hazard Analysis (JHA).

This testing shall be performed on all joints performed in the execution of this technical specification. The subcontractor shall give one week's notice to PPPL for any upcoming pressure tests.

6.1.5 MAGNETIC PERMEABILITY TESTING

To verify conformance, magnetic permeability shall be measured in accordance with the requirements of ASTM A342, Test Method No. 3.

- a. The magnetic permeability limits shall be per §5.1.4.
- b. Testing shall use a Severn Engineering Low Mu Permeability Indicator ([Available from Severn Engineering Co. Auburn, Alabama](#)), which has been calibrated within the past 12 months.
- c. The drawing shall designate where to measure permeability. If the drawing does not designate where to measure permeability, then contact the PPPL PTR for clarification. Record all measured values, and their locations. Include dimensions to the nearest edge/surface so that it can be double-checked by the PTR or designee.

6.2 COMPONENT TESTING REQUIREMENTS

6.2.1 HEAT TRANSFER INLET & RETURN TUBE

- a. The subcontractor shall perform a visual inspection, leak and pressure testing on all welded joints performed on E-DC11073-03 and -04 (see Figure 1) per §6.1. For all joints of the HTT, pressure testing shall be performed to twice the maximum operating pressure, $120\text{PSIG} \times 2 = 240\text{PSIG}$.
- b. The subcontractor shall test magnetic permeability of the HTT inlet at three locations per §6.1.5: (1) upper turn, (2) lower turn, (3) middle turn. The outlet return line shall be tested for magnetic permeability in three locations as well: (1) upper bend, (2) lower bend and (3) middle section.

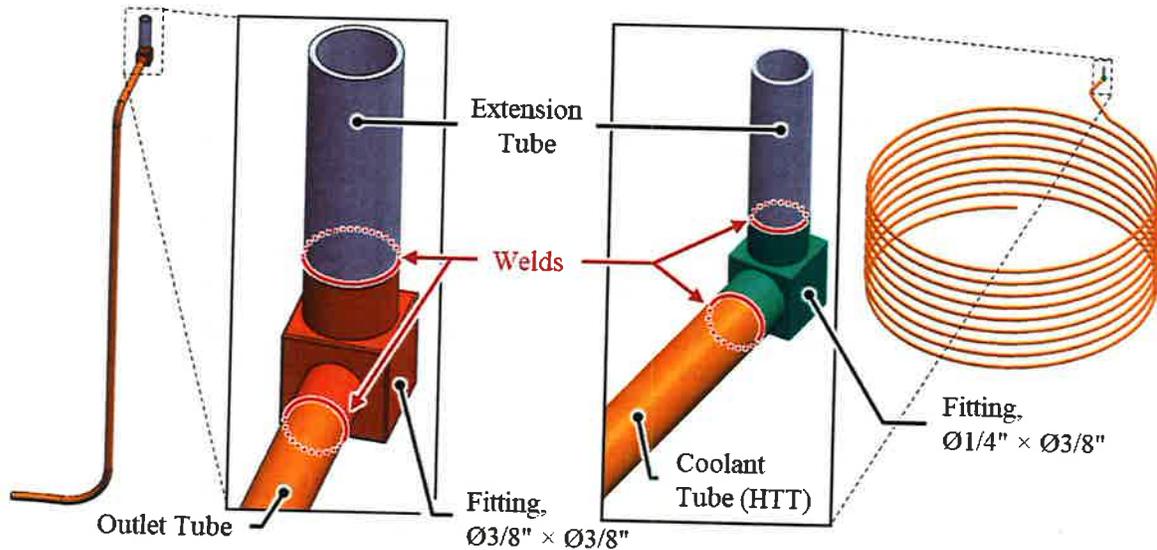


Figure 1. Welds to leak and pressure test on the HTT Return (left) and Inlet (right) Lines

6.2.2 HEAT TRANSFER TUBE STUB WELDMENTS

All the welds on the cooling tube stub weldment, Type "A" (E-DC11073-07) and Type "B" (E-DC11073-08) are subject to leak check and pressure test per §6.1. Pressure testing shall be performed to twice the maximum operating pressure, $120\text{PSIG} \times 2 = 240\text{PSIG}$. They shall be tested with magnetic permeability at three locations per §6.1.5: (1) Upper weld (2) lower weld (3) middle section.

6.2.3 HEAT TRANSFER PLATE

After welding the tube adapters to the HTP base, the subcontractor shall perform leak testing and ultrasonic testing (UT) per AMS 2680 C and §6.1 on the two welds (see left side of Figure 2, for E-DC11124-01 & 02, E-DC11125-03 & 04). Once the tube adapter welds pass, the subcontractor shall weld on the HTP cover and perform UT inspection on the cover.

After post-machining the HTP to the final dimensions specified on the drawing, the HTP cavity shall be subjected to leak and pressure testing per §6.1. For all joints of the HTP, pressure testing shall be performed to 2 times the maximum operating pressure, $300\text{PSIG} \times 2 = 600\text{PSIG}$.

Magnetic permeability shall be tested in a polar grid with spacing 2" radially and 8" circumferentially on face to which the cover plate is welded per §6.1.5.

6.2.4 DIVERTOR COOLANT TUBE STUB WELDMENTS

After assembling the Tube Stub Weldments, the subcontractor shall perform NDT, leak and pressure testing on all joints, per §6.1.2 through §6.1.4 (see Figure 3 for E-EB1089-01, -02, -03, -04). For all joints of the stub weldments, pressure testing shall be performed to 2 times the maximum operating pressure, $300\text{PSIG} \times 2 = 600\text{PSIG}$. Radiographic inspection shall be performed for all the welds per ASME B31.3 with severe cyclic conditions acceptance criteria.

6.2.5 HEAT TRANSFER TUBE SHIM CLAMP WELDMENT ASSEMBLIES

After welding the two-part assemblies for the HTT Clamp (E-DC11174-01) the welds shall be subject to visual inspection per §6.1.2 (see Figure 4 for E-DC11174-01, -02, -03, -04).

6.2.6 ALL REMAINING COMPONENTS/ASSEMBLIES

All remaining components shall be tested for magnetic permeability at a single point on the part per §6.1.5 with the exception of all the non-metal parts and the assembly E-DC11198-01. The location shall be indicated on the drawing or on the inspection report provided to PPPL for verification.

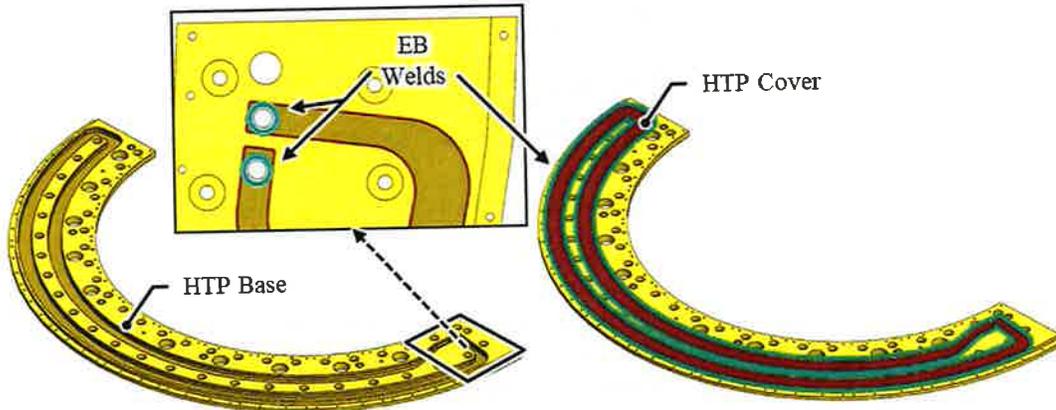


Figure 2. Electron Beam Welds to leak and pressure test on the HTP

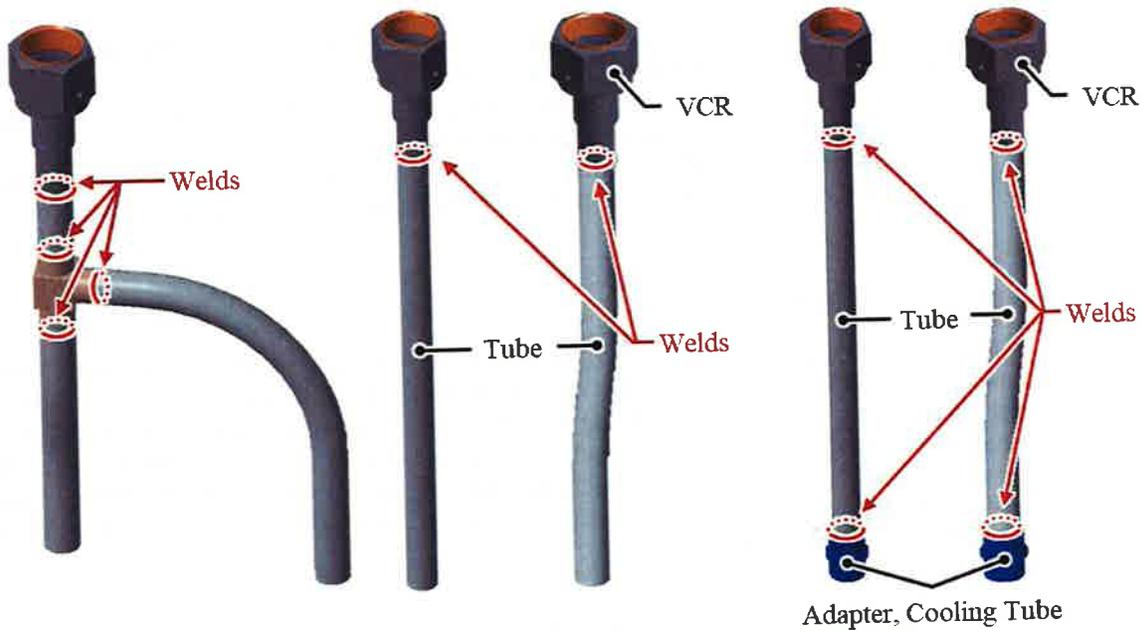


Figure 3. Welds to leak and pressure test on the HTP (Left and Center) & HTT (Right) Stud Weldments

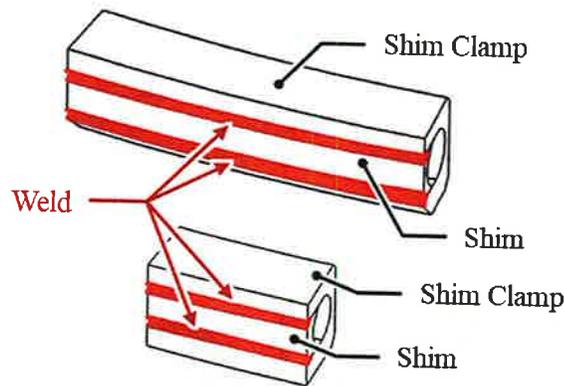


Figure 4. Welds to inspect on the HTT Shim Clamp Weldment Assemblies

6.3 ACCEPTANCE TESTS

- a. PPPL will review all performance tests results for compliance
- b. PPPL will perform a check upon completion but prior to crating
- c. PPPL will perform a check after crating and prior to shipment.
- d. PPPL will perform a visual check upon receiving.
- e. PPPL will verify dimensions and magnetic permeability upon receipt.

6.4 SUPPLIER HOLD POINTS

- a. The subcontractor shall hold and submit dimension inspection reports to PPPL for approval for key components, including the HTP
- b. The subcontractor shall stop work and pause after performing required leak and pressure test. The results of these tests shall be submitted to PPPL.
- c. The subcontractor shall hold once all assemblies/parts are completed prior to crating.
- d. The subcontractor shall hold once all assemblies/parts are crated prior to shipment.

7.0 QUALIFICATIONS

7.1 GENERAL REQUIREMENTS

Personnel are required to be trained in the operation of the equipment such that time is not lost, and material is not damaged, due to preventable mistakes. A copy of training certifications for personnel performing the operations listed below shall be provided, and approved by PPPL, in writing, before the manufacturing work begins. The training must be up-to-date and maintained by each individual throughout the fabrication performed in the execution of this scope. The certifications shall be per the requirements listed in §2.0, or by a PPPL approved alternative.

- a. Welders
- b. Non-Destructive Testing Operators
- c. Magnetic Permeability
- d. Leak Tester
- e. Pressure Tester

7.2 WELDING

7.2.1 SPECIFICATIONS

Welding Procedure Specifications (WPSs), Welding Procedure Qualification Records (PQRs), and Welding Personnel qualifications (WPQs) shall be provided for all work being performed during the execution of the scope of work outlined in this Technical Specification. All documentation must be approved by PPPL prior to the start of welding.

7.2.2 PERSONNEL QUALIFICATIONS

All welders, welder operators and welding procedures shall be qualified in accordance with the requirements of the ASME Boiler and Pressure Vessel Code, Section IX (2015), and this scope of work. Welding procedure qualification test results shall demonstrate that the resulting weldments are compatible with the base materials and meet or exceed the base material mechanical properties, with relative magnetic permeability as outlined in §5.1.4.

8.0 ENVIRONMENT, SAFETY, AND HEALTH

8.1 SAFETY

Work shall be performed under an established safety program including documented policies and procedures subject to PPPL review. Workers shall be trained to these policies and procedures and records of their training shall be auditable.

8.2 NOTIFICATION REQUIREMENTS OFF-NORMAL EVENTS & ISSUES

The subcontractor is required to provide, for PPPL review and approval, a procedure that details subcontractor's process in the case of an off-normal event with safety implications. This procedure may be incorporated into the Quality Assurance Oversight Plan.

8.3 OVERSIGHT

Supplier shall allow scheduled access to their facility to review manufacturing processes and perform inspections at the discretion of PPPL. Supplier shall work with the PPPL PTR and PPPL visitors to identify the hazards of the work to be reviewed and the hazards of unrelated work in the facility that could affect the visitors, and the safety protocols (including but not limited to training and personal protective equipment) that will apply to protect visitors from the hazards. Supplier shall provide any required training to PPPL visitors to assure observance of the supplier's safety rules and prevent exposure to any hazard at supplier's facility.

8.4 SAFETY AND HAZARD MITIGATION PLAN

The subcontractor shall perform a Job Hazard Analysis (JHA) to prior to the execution of the tests outlined in this plan and discuss the results with PPPL. The JHA shall identify the hazards of the test and the safety protocols (including but not limited to training and personal protective equipment) that will apply to protect workers and visitors from the hazards.

9.0 QUALITY ASSURANCE REQUIREMENTS

9.1 INSPECTION/ SURVEILLANCE/AUDIT BY PPPL

Authorized representatives of PPPL and the U.S. Government shall have the right at all reasonable times to visit the subcontractor's premises and those of subcontractor's suppliers during the performance of the procurement for the purposes of inspection, surveillance, audit and/or obtaining any required information as may be necessary to assure that items or services are being furnished in accordance with specified requirements. Such visits shall be coordinated with the subcontractor's personnel to minimize interference with the normal operations of said premises. The subcontractor shall make available records and documentation necessary for this function and shall provide all reasonable facilities and assistance for the safety and convenience of PPPL and/or U.S. Government representatives in the performance of their duties. PPPL and the U.S. Government recognize the subcontractor's right to withhold information concerning proprietary processes.

9.2 SUBCONTRACTOR'S RESPONSIBILITY FOR CONFORMANCE

PPPL's review and/or approval of subcontractor's documents nor PPPL's inspection of subcontractor's items or services shall not relieve the subcontractor of responsibility for full compliance with requirements of the purchase order/contract. The subcontractor is responsible for assuring that all requirements and restrictions are imposed on any sub-tier suppliers. Fabrication processing to be performed by sub-tier subcontractor(s) requires prior notification and concurrence by PPPL.

9.3 SUBCONTRACTOR QUALITY ASSURANCE PROGRAM

The subcontractor shall establish and maintain an effective Quality Assurance Program to assure that the subcontractor's work meets the required level of quality and is performed in accordance with contractual requirements.

Subcontractor's quality assurance function shall be organized to have sufficient authority and independence to identify quality problems, verify conformance of supplied items or services to specified requirements and obtain satisfactory resolution of conflicts involving quality.

9.4 MANUFACTURING READINESS REVIEW

The subcontractor shall prepare for and participate in an on-site Manufacturing Readiness Review at their facility with PPPL prior to the start of work. This review shall include the proposed process in order to effectively execute the tasks outlined in this Technical Specification, including equipment, work flow and scheduling. As part of this review the subcontractor shall be prepared to provide the necessary deliverables, including but not limited to the following:

- Tooling and fixture drawings
- MIT Plan and associated procedures
- Personnel Certifications/Qualifications
- Safety Plan/JHA
- QA Plan
- Packing and Shipping Plan
- List of subcontractor Supplied Materials

After successful completion of this review, PPPL will authorize the start of fabrication in writing.

9.5 QUALITY ASSURANCE PLAN

The subcontractor shall submit a Quality Assurance (QA) plan describing the specific quality assurance and quality control procedures and practices, including special process training and qualifications, which will be in force to meet the requirements of this specification. The QA plan and any revisions require review and approval by PPPL prior to the start of design or manufacturing of the equipment under this specification.

9.6 MANUFACTURING, INSPECTION AND TEST PLAN

The subcontractor shall submit a Manufacturing, Inspection and Test (MIT) plan for PPPL approval prior to the start of manufacture. The MIT must delineate the sequence of all processes and operations affecting quality, including in-process and final acceptance inspections and tests. The plan shall identify parts; show their integrated flow into end items; identify critical manufacturing operations; and show inspections and the characteristics/dimensions to be inspected. The plan may include flow chart(s), Process Sheets, Shop Travelers, and inspection sheets, etc. Equipment to be used for all fabrication, inspections and tests shall be specified, including but not limited to the following:

- Equipment to be used for all fabrication, inspections and tests
- Part(s) being made.
- Integrated flow into end items
- Critical manufacturing operations
- Cleaning steps
- Inspections and the characteristics/dimensions to be inspected
- Sign-off and date by designated inspection personnel at specified process, inspection, and test points.
- How the signoffs are traceable to the items being fabricated.
- PPPL designated Hold/Witness Points

The witness/hold points are steps where the manufacturer will temporarily stop work on this particular part in the Technical Specification, until PPPL has had a chance to review the data, and approves continuing with the fabrication. subcontractor shall notify PPPL a minimum of five (5) working days in advance of these witness points. Revisions or changes to the approved MIT, or its alternate, shall be reviewed and approved by PPPL prior to use including flow chart(s), process and inspection sheets, and shop travelers.

A traveler, whether integral to the MIT Plan or a separate document, shall be used for data entry and operation sign-offs. Relevant data for inspections and tests includes equipment ID and calibration status; acceptance values, actual values obtained, and pass/fail determination. PPPL will designate selected steps as mandatory "witness" points. subcontractor shall notify PPPL a minimum of five (5) working days in advance of these witness points. Revisions or changes to the approved MIT or traveler shall be reviewed and approved by PPPL prior to use.

9.7 CHANGES TO PPPL APPROVED DOCUMENTS

Revisions or changes by the subcontractor to documents approved by PPPL shall be reviewed and approved by PPPL prior to use.

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9.8 NONCONFORMANCE AND CORRECTIVE ACTIONS AND NOTIFICATION OF PPPL

Nonconforming items or services shall be positively identified, and, where possible, segregated to prevent use. The subcontractor shall document each nonconformance. The written approval of PPPL is required in the form of a signed NCR prior to the use or continued fabrication of the nonconforming item or service. The subcontractor's system shall provide not only for timely resolution of nonconformance but also for analysis of nonconformance to determine causes and to implement appropriate and effective corrective actions.

9.9 MEASURING AND TEST EQUIPMENT

Inspections and tests shall be performed using properly calibrated measuring and test 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, but instead shall be protected against damage or degradation.

9.10 SUBMITTAL OF MATERIAL CERTIFICATIONS

The subcontractor shall submit the manufacturer's Certified Material Test Reports (CMTR) showing actual relevant chemical, mechanical, and electrical properties of all parts fabricated by the subcontractor, including raw materials and weld material. Submitted CMTRs must be linked to the specific part by referencing the parts list on the drawing. One copy is to be submitted to PPPL upon subcontractor acceptance for use. Note: For specialty materials, typically non-metals, where test reports are not readily available from the manufacturer, their certificate of analysis or certificate of grade, as appropriate, may suffice, subject to PPPL concurrence.

Subcontractor shall provide high strength fasteners (tensile strength equal to or greater than 100 ksi) in accordance with the Fastener Quality Act. Fasteners shall exhibit grade marks and the manufacturer's identification symbol (head stamp) as specified in the referenced Material Specification. Fasteners having a head mark shown on the suspect fastener list (see ATTACHMENT B) will not be accepted. Certified Mill Test Reports (CMTR), showing actual material composition and physical properties and traceable to the actual fasteners, are required for each lot supplied. Results must be on the original letterhead of the entity performing the tests and not transferred to alternate letterhead. Where high strength fasteners are not required, it is recommended that they not be used. If used, the requirements above shall be implemented.

9.11 DOCUMENT TRACEABILITY AND RECORDS

The subcontractor shall maintain a system of documentation whereby the results of required operations, inspections, examinations, and tests is systematically compiled, indexed and stored. Such objective evidence may include "travelers"; and material test, certification, inspection, examination, test and discrepancy reports; which shall be complete, legible, signed, and dated and shall be traceable to subject items.

9.12 INSPECTION AND TEST CONTROL

Inspections and tests shall be performed by personnel independent of those doing the work inspected or tested. They shall be performed in accordance with written procedures referencing criteria for acceptance or rejection. Adequate records shall be maintained and available for PPPL's review.

9.13 PERFORMANCE AND DOCUMENTATION OF INSPECTIONS AND TESTS

Each item to be delivered to PPPL shall be inspected and tested by the subcontractor to verify that they meet PPPL's requirements. All produced parts must be inspected and tested unless an alternate plan is agreed upon with PPPL in writing. Results shall be documented and reported to PPPL. Any exceptions to PPPL requirements must be approved by PPPL in writing.

The inspection/test report(s) shall indicate the results of all tests and compliance with all drawing notes. Actual values for all drawing dimensions, including Basic, but excluding Reference, must be reported. Either a drawing copy or an inspection report may be used as the report, but the drawing zone and actual measured values must be clearly indicated. Regardless of format, the report must be dated and signed.

The following values should be measured and recorded:

- a. All non-reference drawing dimensions, including Basic Dimensions
- b. Compliance with drawing notes
- c. Measurements taken in §6.1.1

9.14 SUBMITTAL OF COMPLETED INSPECTION AND TEST REPORTS

Reports shall be provided of all required inspections and tests, showing actual values, properly validated by authorized personnel. NDT reports shall meet the requirements of ASME V.

9.15 SUBMITTAL OF ACCEPTANCE TEST PROCEDURES FOR PPPL APPROVAL

The Acceptance Test Procedures (ATPs), including pass/fail criteria, required to demonstrate conformance to PPPL's requirements shall be submitted to PPPL for review and approval prior to use of such procedures.

9.16 GENERAL REQUIREMENTS

Material(s) and/or product(s), including those components, parts, and materials that are permanently installed into systems, sub-systems, and/or assemblies, etc. furnished under this purchase order/subcontract shall be new. Parts and components that have been rebuilt, refurbished, or modified are specifically prohibited unless approved by PPPL in writing. Evidence of deliberate misrepresentation of any item(s)/component(s)/material(s) provided under this order may result in an investigation by the Office of the Inspector General, U.S. Department of Energy. Examples of such misrepresentation include the following:

- Remanufactured, rebuilt, or used parts represented as new
- Counterfeit parts (fraudulently labeled or marked with another manufacturer's name).
- Misrepresented parts.

9.17 PPPL INSPECTION

PPPL reserves the right to inspect items as they are packaged prior to shipment. PPPL will perform Receiving Inspection on items or services supplied by subcontractor, using either a sampling plan or 100% inspection. Discrepant items or services will be rejected and returned to subcontractor or reworked by PPPL.

9.18 PROCESS SEQUENCE

The subcontractor shall maintain a system to define the sequence and document the performance of manufacturing, inspection, installation, and test activities. These shall provide for signoff and date by designated inspection personnel at specified process, inspection, and test points and shall be traceable to the items.

9.19 EQUIPMENT/MATERIAL IDENTIFICATION AND STATUS

Material and equipment identification shall be maintained throughout processing and be traceable to the records. Status of acceptability shall be readily discernible through the subcontractor's use of tags, stamps, serial numbers or other positive means.

9.20 CONTROL OF SPECIAL PROCESSES

Subcontractor shall use trained and qualified personnel and qualified written procedures in accordance with specified requirements for the performance of certain special processes, including but not limited to, soldering, electronic assembly, brazing, welding, plating, heat treatment, nondestructive examination, etc. Copies of special process procedures and qualifications shall be available for review by PPPL and submitted to PPPL for acceptance if requested.

9.21 SUBMITTAL OF COMPLETED RELEASE FOR SHIPMENT FORM

Subcontractor shall not ship without a "Product Quality Certification and Shipping Release" Form (Attachment A) signed by PPPL's Representative. Subcontractor shall complete and sign the certification section, fax or email the form to PPPL's Quality Assurance (QA) Representative, and hold shipment until PPPL signs and returns the form, authorizing shipment. A copy of the fully executed form shall accompany each full or partial shipment.

9.22 SUBMITTAL OF COMPLETED PROCESS HISTORY

Subcontractor's Certificate of Conformance, signed by the Quality Manager, stating that the work performed conforms in every respect to PPPL the physical configuration and functional inspection/test requirements and that personnel performing or interpreting the results of special processes (i.e., welding, soldering, electronic assembly, brazing, nondestructive examination, etc.) were properly trained and qualified. Subcontractor's Quality Assurance (QA) Manager shall sign the Certificate of Conformance. Where the subcontractor has used PPPL-furnished material, such certification shall also include the statement: "Material furnished by PPPL has been inspected by the subcontractor and used by the subcontractor as specified by PPPL with no unauthorized substitutions".

- Copies of completed process planning and control documents (travelers, etc.) that verify controlled execution of the required work.
- Signed and dated reports for all required inspections and tests.
- Copies of Non-Conformance Reports

10.0 SHIPPING STORAGE AND HANDLING

The subcontractor shall be responsible for packing crating and shipping the required deliverables. A Packing and Shipping plan shall be included in the MRR. Crating shall include shock indicators. Once assembly and crating is complete, and PPPL has performed a final inspection, PPPL will sign the Shipping release form (Attachment A).

11.0 ATTACHMENTS

- Product Quality Certification & Shipping Release Form*
- Dept. of Energy Suspect/Counterfeit Headmark List*

12.0 DOCUMENTATION & DELIVERABLES

RFI / PO / Subcontract / BOA / BPA #: _____

Table 4. List of subcontractor Required Deliverables to PPPL or other designated facility

#	Physical Deliverables Required	Date Required	Received (✓)
1	Heat Transfer Outlet Tube Weldment Ass'y, Top and Bottom (E-DC11073-03), Quantity: 2	C	
2	Heat Transfer Cooling Tube Weldment Ass'y, Top and Bottom (E-DC11073-04), Quantity: 2	C	
3	Center Case Coolant Tube Stub Weldment – Type "A" (E-DC11073-07), Quantity: 2	C	
4	Center Case Coolant Tube Stub Weldment – Type "B" (E-DC11073-08), Quantity: 2	C	
5	Adapter, Cooling Tube Ø3/8" O.D. to Ø1/4" O.D. (E-DC11073-1), Quantity: 2	C	
6	Left HT Plate Assembly, Top (E-DC11124-01), Quantity: 1	C	
7	Right HT Plate Assembly, Top (E-DC11124-02), Quantity: 1	C	
8	Left HT Plate Assembly, Bottom (E-DC11125-01), Quantity: 1	C	
9	Right HT Plate Assembly, Bottom (E-DC11125-02), Quantity: 1	C	
10	Plastic Jig, Center Stack Heat Transfer Tube Installation ^[4] (E-DC11126), Quantity: 4	C	
11	Gasket, HTP (E-DC11173), Quantity: 4	C	
12	Clamp, Vertical Tube, Top (E-DC11174-1), Quantity: 7	C	
13	Clamp, Vertical Tube, Bottom (E-DC11174-2), Quantity: 6	C	
14	Clamp, Tube Holder (E-DC11174-3), Quantity: 8	C	
15	Upper HTT Clamps (E-DC11174-4 thru 7), Quantity: 1 EA	C	
16	Lower HTT Clamps (E-DC11174-10 thru 13), Quantity: 1 EA	C	
17	HTT Shim Clamp Lower Position #6 Weldment Ass'y (E-DC11174-01), Quantity: 1	C	
18	HTT Shim Clamp Lower Position #5 Weldment Ass'y (E-DC11174-02), Quantity: 1	C	
19	HTT Shim Clamp Upper Position #5 Weldment Ass'y (E-DC11174-03), Quantity: 1	C	
20	HTT Shim Clamp Upper Position #6 Weldment Ass'y (E-DC11174-03), Quantity: 1	C	
21	Feedthru (E-DC11174-16), Quantity: 5	C	
22	HTP Clamp Support Ring Welding Fixture ^[4] (E-DC11198-01), Quantity: 1	C	

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Table 4. List of subcontractor Required Deliverables to PPPL or other designated facility (cont'd)

#	Physical Deliverables Required	Date Required	Received (✓)
23	Divertor Flange Coolant Stub Weldment – Type "A1" (E-EB1089-01), Quantity: 1	C	
24	Divertor Flange Coolant Stub Weldment – Type "A2" (E-EB1089-02), Quantity: 2	C	
25	Divertor Flange Coolant Stub Weldment – Type "A3" (E-EB1089-03), Quantity: 1	C	
26	Divertor Flange Coolant Stub Weldment – Type "A4" (E-EB1089-04), Quantity: 2	C	
27	All additional jigs/fixtures generated as part of this Technical Specification	C	

^[4] Items 11 and 23 are designated with a low risk categorization (A3) and as such do not require supplier qualification.

Table 5. List of Required Meetings between the subcontractor and PPPL

#	Meetings Required	Date Required	Complete (✓)
1	Manufacturing Readiness Review	PS	
2	NCR Meeting	D	
3	Weekly Status Update (for duration of executing scope)	D	

Exceptions: None

Table 6. List of subcontractor Document Deliverables

#	Document Deliverables Required	Date Required	Format	Storage Location	Rcvd (✓)
1	Training Certifications of Personnel per §7.0	PS	E	Ops Center	
2	Manufacturing, Inspection & Test Plan per §9.6	PS	E	Ops Center	
3	Quality Assurance Plan per §9.5	PS	E	Ops Center	
4	Magnetic Permeability Procedures per §6.1.5	PS	E	Ops Center	
5	Forming and Material Controls Procedures (can be included as part of the MIT plan per §9.6)	PS	E	Ops Center	
6	Cleaning Procedures (can be included as part of the MIT plan per §9.6)	PS	E	Ops Center	
7	Quality Assurance Manual per §9.3	PS	E	Ops Center	
8	Packing and Shipping Plan (can be included as part of the MIT plan per §9.6)	PS	E	Ops Center	
9	Design & Drawing Details for Auxiliary Components (e.g. Lift Fixtures, Leak Test Fixtures/jigs, shipping fixtures/jigs etc.) per §4.2.9	N	E	Ops Center	
10	Dimensional Inspection Reports for all items in Table 3 per §6.1.1	C	E	Ops Center	

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Table 6. List of subcontractor Document Deliverables (cont'd.)

#	Document Deliverables Required	Date Required	Format	Storage Location	Rcvd (✓)
11	Non-conformance Reports per §9.8	D	E	Ops Center	
12	Photos of Testing (Leak, pressure, etc.) per §4.2.5	D	E	Ops Center	
13	Photos of All Tooling per §4.2.9	D	E	Ops Center	
14	Photos of Weld Prep and Finished Welds per §5.2	D	E	Ops Center	
15	Non-Destructive Test Reports for §6.2.1 thru §6.2.6	N	E	Ops Center	
16	Leak Test Reports for §6.2.1, thru §6.2.4	N	E	Ops Center	
17	Pressure Test Reports for §6.2.1, thru §6.2.4	N	E	Ops Center	
18	CMTR – Inconel 625 Tube per §5.1.3.2	PS	E	Ops Center	
19	CMTR – Inconel 625 Bar/ Plate §5.1.3.2	PS	E	Ops Center	
20	CMTR – Inconel 625 Round Bar (Rod) §5.1.3.2	PS	E	Ops Center	
21	CMTR – Inconel 625 Weld Filler §5.1.3.2	PS	E	Ops Center	
22	CMTR – Grafoil, GTA §5.1.3.2	PS	E	Ops Center	
23	Product Quality Certification & Shipping Release Form per §9.2 and §9.21	C	E	Ops Center	
24	Fabrication Drawings per §9.13	C	E	Ops Center	
25	Marked record drawings per §9.13	C	E	Ops Center	
26	Process History per §9.22	C	E	Ops Center	

Legend

*N = Notice to Proceed Requirement
 PS = Prior to Start of Construction
 D = During Construction/As Required*

*C = Project Completion
 P,E = Paper or Electronic*

Princeton Technical Representative: _____

(Sign-off and provide to the Operations Center when job is completed and deliverables are dispositioned and placed/filed in Operations Center (or other Project, Department or Division designated file center).

ATTACHMENT A. PRODUCT QUALITY CERTIFICATION & SHIPPING RELEASE

To be completed by supplier and submitted to PPPL with the Documentation package.
 Shipment (full or partial) is not authorized until PPPL returns this form signed.

Completed by Supplier	PPPL SUBCONTRACT/ ORDER #	ITEM #(s)	QUANTITY SHIPPED
	ITEM DESCRIPTION	SUPPLIER REFERENCE #	SHIPMENT #
	<u>SUPPLIER'S CERTIFICATION</u> This is to certify that the products and services identified herein have been produced under a controlled quality assurance program and are in conformance with the procurement requirements including applicable codes, standards and specifications as identified in the above-referenced documents unless noted below. Any supporting documentation will be retained in accordance with the procurement requirements. SIGNED: _____ DATE: _____ TITLE: _____ COMPANY: _____		

Completed, signed, and returned by PPPL before shipment	<u>PPPL (AUTHORIZED REPRESENTATIVE) SHIPPING RELEASE</u> This is to certify that evidence supporting the above Supplier's Certification statement has been reviewed and no product/service non-conformances from procurement requirements have been identified unless noted below. This product/service is hereby released for shipment. This section serves as the Quality Assurance release for the above described product for shipment. It does not constitute an acceptance thereof and does not relieve the Supplier, Manufacturer or Contractor of any and all responsibility or obligation imposed by the purchase contract. It does not waive any rights the Purchaser may have under the purchase contract, including the Purchaser's right to reject the above described material upon discovery of any deviations from requirements of the purchase contract, drawings and specifications.	
	NONCONFORMANCES FROM PROCUREMENT QUALITY REQUIREMENTS:	
	REMARKS/PRODUCT SERIAL NUMBERS:	
	BY PPPL QA REPRESENTATIVE (OR DESIGNEE)	DATE

Rev. 1 November 15, 2010

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ATTACHMENT B. DEPT. OF ENERGY SUSPECT/COUNTERFEIT HEADMARK LIST

DOE Headmark List

ANY BOLT ON THIS LIST SHOULD BE TREATED AS DEFECTIVE WITHOUT FURTHER TESTING.



ALL GRADE 5 AND GRADE 8 FASTENERS OF FOREIGN ORIGIN WHICH DO NOT BEAR ANY MANUFACTURERS' HEADMARKS:



GRADE 5



GRADE 8

GRADE 5 FASTENERS WITH THE FOLLOWING MANUFACTURERS' HEADMARKS:

<u>MARK</u>	<u>MANUFACTURER</u>	<u>MARK</u>	<u>MANUFACTURER</u>
	J Jlnn Her (TW)		KS Kosaka Kogyo (JP)

GRADE 8 FASTENERS WITH THE FOLLOWING MANUFACTURERS' HEADMARKS:

<u>MARK</u>	<u>MANUFACTURER</u>	<u>MARK</u>	<u>MANUFACTURER</u>
	A Asahi Mfg (JP)		KS Kosaka Kogyo (JP)
	NF Nippon Fasteners (JP)		RT Takai Ltd (JP)
	H Hinomoto Metal (JP)		FM Fastener Co of Japan (JP)
	M Minamida Sleybo (JP)		KY Kysel Mfg (JP)
	MS Minato Kogyo (JP)		J Jlnn Her (TW)
	Hollow Triangle Infasca (CA TW JP YU) (Greater than 1/2 inch dia.)		
	E Dalai (JP)		UNV Unytite (JP)

GRADE 8.2 FASTENERS WITH THE FOLLOWING HEADMARKS:

<u>MARK</u>	<u>MANUFACTURER</u>
	KS Kosaka Kogyo (JP)

GRADE A325 FASTENERS (BENNETT DENVER TARGET ONLY) WITH THE FOLLOWING HEADMARKS:

<u>MARK</u>	<u>MANUFACTURER</u>
Type 1 	A325 KS Kosaka Kogyo (JP)
Type 2 	
Type 3 	

Key: CA-Canada, JP-Japan, TW-Taiwan, YU-Yugoslavia