

Statement of Work for Fabrication of NSTX-U Recovery Tiles

Statement of Work: NSTXU_1-1-1-1_SOW_101

REVISION 1

October 1, 2019

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**STATEMENT OF WORK
FOR
FABRICATION OF NSTX-U RECOVERY TILES**

PLASMA FACING COMPONENTS

NSTXU_1-1-1-1_SOW_101

CAT: ☒ A1 ☐ A2 ☐ A3

Reference Work Planning #: 2317

REVISION 0

DATED *September 26th, 2019*

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Table of Contents

1.0	INTRODUCTION & SCOPE	4
2.0	APPLICABLE DOCUMENTS	4
3.0	APPLICABLE DRAWINGS	4
4.0	RESPONSIBILITIES	4
4.1	PRINCETON PLASMA PHYSICS LABORATORY	4
4.1.1.	<i>PPPL CONTACTS</i>	4
4.2	SUBCONTRACTOR	4
4.2.1.	<i>SUBCONTRACTOR CONTACTS</i>	4
5.0	REQUIREMENTS	5
5.1	PERFORMANCE REQUIREMENTS	5
5.1.1.	<i>PERFORMANCE CHARACTERISTICS</i>	5
5.1.2.	<i>HANDLING & CLEANLINESS REQUIREMENTS</i>	5
5.1.3.	<i>DESIGN LIFE</i>	7
5.1.4.	<i>RELIABILITY</i>	7
5.1.5.	<i>MAINTAINABILITY</i>	7
5.1.6.	<i>HUMAN FACTORS</i>	7
5.1.7.	<i>SUSTAINABILITY</i>	7
5.2	EQUIPMENT DEFINITIONS	7
5.2.1.	<i>SPECIFICATION AND STANDARDS</i>	7
5.2.2.	<i>GENERAL DESIGN FEATURES</i>	7
5.2.3.	<i>MATERIALS</i>	11
5.2.4.	<i>ELECTROMAGNETIC INTERFERENCE AND SUSCEPTIBILITY</i>	12
5.2.5.	<i>IDENTIFICATION AND MARKING</i>	12
5.2.6.	<i>WORKMANSHIP</i>	12
5.2.7	<i>SUBCONTRACTOR EQUIPMENT USE</i>	12
6.0	TEST & INSPECTION REQUIREMENTS	13
6.1	PERFORMANCE TESTS	13
6.2	ACCEPTANCE TESTS	13
6.2.1	<i>FIRST-ARTICLE INSPECTION (FAI) PROCESS</i>	13
6.2.2	<i>SAMPLING AND INSPECTION PLANNING</i>	14
6.3	SUPPLIER HOLD POINTS	15
7.0	QUALIFICATIONS	15
8.0	ENVIRONMENT, SAFETY, AND HEALTH	15
9.0	QUALITY ASSURANCE REQUIREMENTS	16
9.1	INSPECTION/ SURVEILLANCE/AUDIT BY PRINCETON	16

9.2	SUBCONTRACTOR’S RESPONSIBILITY FOR CONFORMANCE	16
9.3	SUBCONTRACTOR QUALITY ASSURANCE PROGRAM	16
9.4	DOCUMENT TRACEABILITY AND RECORDS	17
9.5	ACCEPTIBILITY OF PURCHASED ITEMS AND SERVICES	17
9.6	DOCUMENT REVIEW, APPROVAL, AND CONTROL	17
9.7	MATERIAL IDENTIFICATION AND STATUS	17
9.8	NONCONFORMANCES & CORRECTIVE ACTIONS	18
9.9	CALIBRATION OF MEASURING AND TEST EQUIPMENT	18
9.10	SUBMITTAL OF COMPLETED RELEASE FOR SHIPMENT FORM.....	18
9.11	SUBMITTAL OF MANUFACTURING/INSPECTION/TEST (MIT) PLAN.....	19
9.12	PROCESS HISTORY	19
9.12.1.	<i>CERTIFICATE OF CONFORMANCE</i>	19
9.12.2.	<i>INSPECTION & TEST REPORTS</i>	19
9.12.3.	<i>NONCONFORMANCE REPORTS</i>	19
9.13	PPPL RECEIVING/INSPECTION	19
10.0	SHIPPING, STORAGE, AND PACKAGING	19
11.0	WARRANTY	20
12.0	ATTACHMENTS	20
13.0	DOCUMENTATION & DELIVERABLES	20
14.0	DELIVERABLES LIST	22
	ATTACHMENT I: "PRODUCT QUALITY CERTIFICATION & SHIPPING RELEASE"	23
	ATTACHMENT II: "PPPL DIMENSIONAL INSPECTION FORM"	24

1.0 INTRODUCTION & SCOPE

This document establishes the manufacturing and acceptance requirements for the Plasma Facing Components (PFC) graphite tiles that will be used within the National Spherical Torus eXperiment Upgrade (NSTX-U) device. NSTX-U is an innovative magnetic fusion device that was constructed by PPPL in collaboration with the Oak Ridge National Laboratory, Columbia University, and the University of Washington at Seattle. NSTX-U will include an internal plasma facing wall that will be mainly constructed out of graphite tiles. These tiles are intended to survive extremely large pulsed heat fluxes, while cooling within a short amount of time to allow for multiple consecutive shots.

The scope of this document covers the manufacturing of the various graphite tiles used in the assembly of the PFC's. The Subcontractor's strict conformance to the manufacturing and material grade requirements given in this specification is essential. However, the subcontractor is encouraged to submit, with their proposal, suggestions to improve product quality, reduce cost, or improve schedule, subject to approval by PPPL.

The graphite grade and quantities required for PFC components to be fabricated are listed in Tables 1 through 6 in Section 5.2.2. The PFC components (i.e. tiles) are to be made from several grades of graphite based on the expected loading where they are installed; it is of critical importance that the PFC tiles be made from the specified grade of graphite listed on their applicable drawings. All graphite raw stock will be provided to the Subcontractor by PPPL to ensure strict material conformance.

2.0 APPLICABLE DOCUMENTS

- 2.1 ASME Y14.5-2009, Dimensioning and Tolerancing
- 2.2 PPPL Attachment I – “Product Quality Certification and Shipping Release”
- 2.3 PPPL Attachment II – “PPPL Dimensional Inspection Form”

3.0 APPLICABLE DRAWINGS

Tables 1 through 6 within Section 5.2.2 indicate the grade of graphite as well as the quantity required for all PFC tiles within the scope of this SOW.

4.0 RESPONSIBILITIES

4.1 PRINCETON PLASMA PHYSICS LABORATORY

4.1.1 PPPL CONTACTS

PPPL shall designate a technical contact referred to as the Princeton Technical Representative (PTR), a Quality Assurance (QA) contact, as well as back-up contacts for each.

4.2 SUBCONTRACTOR

4.2.1 SUBCONTRACTOR CONTACTS

- 4.2.1.1 The Subcontractor shall designate and provide contact information for a primary technical contact, a Quality Assurance contact, and a back-up contact for each.
- 4.2.1.2 The Subcontractor shall ensure their appointed contacts are available to attend regularly scheduled status update meetings (biweekly at a minimum). Dates and times for these meetings will be established with the PTR prior to starting work. Additional status update meetings may be requested by PPPL or by the Subcontractor as needed based on project progress and/or identified issues.

4.2.2 *SUBCONTRACTOR CONFORMANCE*

- 4.2.2.1 The Subcontractor shall conform to all requirements of this document and process the components in full conformance with this specification.
- 4.2.2.2 The Subcontractor shall accommodate PPPL representatives during on-site visits (per Section 9.1), including the provision of any requisite safety related training and PPE (per Section 8.0).
- 4.2.2.3 The Subcontractor shall promptly document and report any Non-Conformances to PPPL (per Section 9.8).
- 4.2.2.4 The Subcontractor shall submit their Manufacturing, Inspection, and Testing (MIT) plan within 10 working days of the award of contract, subject to PPPL approval (per Section 9.12).
- 4.2.2.5 Diagnostic tile manufacturing and shipping shall precede the manufacturing and shipping of all Base tile designs. Specific details regarding Diagnostic vs Base tile variations can be found within Tables 1 through 6 in Section 5.2.2.
- 4.2.2.6 The Subcontractor shall address any questions or concerns regarding the requirements of this Statement of Work “SOW” to any of the designated PPPL representatives (per Section 4.1.1).

5.0 REQUIREMENTS

PFC tile designs have been qualified based on the dimensions and tolerancing shown on the fabrication drawings. The performance of the PFC tiles is dependent upon their conformance to the provided drawings. Therefore, strict conformance to the below requirements is paramount.

5.1 PERFORMANCE REQUIREMENTS

5.1.1 *PERFORMANCE CHARACTERISTICS*

All components fabricated shall conform to the dimensions and tolerancing shown on the applicable fabrication drawing. All Handling & Cleanliness requirements contained within Section 5.1.2 shall be followed to prevent potential contamination of the material/part surface. All workmanship requirements within Section 5.2.6 shall be followed to ensure dimensional and quality conformance of Subcontractor produced parts.

5.1.2 *HANDLING & CLEANLINESS REQUIREMENTS*

All tiles shall be produced under an operating environment which prevents external

contaminants from contacting the graphite stock during all stages of manufacturing by following the below handling and cleanliness procedures, in addition to any methods utilized by the Subcontractor (as defined in the MIT plan and approved by PPPL):

- 5.1.2.1 Under no circumstances shall the graphite stock or parts (both prior, during, and after manufacturing) be handled bare-handed as it will contaminate the surface.
- 5.1.2.2 All graphite stock and parts shall only be handled by personnel wearing silicone-free latex gloves at all stages of production.
- 5.1.2.3 Under no circumstances shall the graphite stock or tiles be exposed to any type of grease, cutting fluid, oil, sealant, solvent, or any other external contaminants present within the Subcontractor's operating environment.
- 5.1.2.4 All machining operations shall be done without lubricant.
- 5.1.2.5 All tooling, measurement/inspection devices, and fixtures shall be cleaned in high-purity solvent and allowed to completely air-dry prior to usage, any drying through blowing/heating will re-contaminate the device.
- 5.1.2.6 Any machinery, tooling, or equipment used for the manufacturing of the graphite tiles shall be contained within a controlled working area dedicated to the work being performed on this contract.
- 5.1.2.7 To prevent inadvertent contamination from the sharing of controlled equipment the Subcontractor shall maintain a sign-out/sign-in inventory on all machinery, tooling, or equipment used within the controlled working area. The method of inventory control is to be outlined within the Subcontractor's MIT plan and subject to PPPL approval.
- 5.1.2.8 All machinery, tooling, or equipment being controlled through the sign-out/sign-in inventory shall be cleaned with a high purity solvent and allowed to completely air-dry after being signed back into the controlled working area to prevent contamination prior to further usage.
- 5.1.2.9 Cleaning of machining debris shall be done either via compressed air with a Desiccant filter attached at the point of use; or by brushing the surface with a Polypropylene bristle brush that has been cleaned in high-purity solvent and allowed to completely air-dry prior to usage. The Subcontractor may also submit their own alternatives to this approach which would prevent contamination in their MIT plan subject to PPPL approval.
- 5.1.2.10 Completed parts shall be marked as per their respective applicable fabrication drawing; the Subcontractor may submit with their MIT plan alternative or equivalent marking options subject to PPPL Approval.
- 5.1.2.11 Finished parts shall be placed in a (new) clear polyethylene bag tagged with its unique tile number (i.e., its part number) as specified on the fabrication drawing. Each individual tile shall be bagged separately. Alternate bagging methods may be suggested by the Subcontractor in their MIT plan, and are subject to PPPL approval.

5.1.3 *DESIGN LIFE*

Not Applicable.

5.1.4 *RELIABILITY*

Not Applicable.

5.1.5 *MAINTAINABILITY*

Not Applicable.

5.1.6 *HUMAN FACTORS*

Not Applicable.

5.1.7 *SUSTAINABILITY*

Not Applicable.

5.2 EQUIPMENT DEFINITIONS

5.2.1 *SPECIFICATION AND STANDARDS*

5.2.1.1 ASME Y14.5-2009, Dimensioning and Tolerancing

5.2.2 *GENERAL DESIGN FEATURES*

Tiles shall meet geometry, orientation, dimensions, tolerances, and surface finishes called out on the approved drawings. The dimensions and tolerances of the components are defined within the respective drawings as listed in Tables 1 through 6.

The different tiles to be manufactured are delineated in Tables 1 through 6 below and detail the different tiles with their respective tile groups. The Tables below also indicate the applicable drawing, part, description, and material grade.

5.2.2.1 Table 1: Outboard Divertor Tiles, Rows 3, 4, 5

5.2.2.2 Table 2: Outboard Divertor Tiles, Rows 1 & 2

5.2.2.3 Table 3: Center-Stack First Wall Tiles, Rows 7 – 21

5.2.2.4 Table 4: Center-Stack Angled Tiles, Rows 5 & 6

5.2.2.5 Table 5: Inboard Divertor Horizontal Tiles, Row 1

5.2.2.6 Table 6: Inboard Divertor Vertical Tiles, Rows 3 & 4

Every tile produced shall be inspected per the sampling plan outlined within Section 6.2.2. Certain tiles (OBD 1-2, IBDH, & IBDV) have selected features that shall require 100% inspection of those specific features as outlined below Tables 2, 5, and 6.

The basic geometry of the tiles listed below is based on the “Base tile” designs, with the “Diagnostic tile” variants representing modifications to the “Base tile” designs. Please note that the Tables are color coded white and grey. Tiles in white represent the “Base tile” designs; tiles shaded in grey represent the “Diagnostic tile” variants.

Note: Any quantities listed on the fabrication drawings are for reference only. The Subcontractor shall manufacture the quantities listed within the Purchase Order. Purchase order quantities shall supersede all other quantities.

Table 1: Outboard Divertor Tiles Rows 3, 4, and 5 all Styles (OBD 3,4, and 5)									
Item No.	Row & Style	Tile Type	DWG No.	Sheet No.	Part No.	Description	Graphite Grade	Qty	Sample Size Total (Breakdown)
1	OBD Row 3, Style 1	Base	E-ED1403	4 of 6	E-ED1403-1	Base tile	T953	75	13 (FAI, Last unit, 11 Random)
2		Diagnostic		4 of 6	E-ED1403-2	Mirnov		6	8 (four FAIs, Last unit, & 3 random)
3		Diagnostic		4 of 6	E-ED1403-3	Thermocouple		20	
4		Diagnostic		4 of 6	E-ED1403-4	Langmuir Probe (2x)		6	
5		Diagnostic		5 of 6	E-ED1403-6	RF Langmuir Probe		4	
6	OBD Row 3, Style 2	Base	E-ED1402	3 of 3	E-ED1402-1	Base tile	T953	100	20 (FAI, Last unit, & 18 random)
7	OBD Row 4, Style 1	Base	E-ED1404	1 of 7	E-ED1404-1	Base tile	T953	60	13 (FAI, Last unit, & 11 random)
8		Diagnostic		2 of 7	E-ED1404-2	Mirnov		6	8 (five FAIs, Last unit, & 2 random)
9		Diagnostic		3 of 7	E-ED1404-3	Thermocouple		8	
10		Diagnostic		4 of 7	E-ED1404-7	Langmuir Probe (2x)		6	
11		Diagnostic		5 of 7	E-ED1404-8	RF Langmuir Probe		4	
12		Diagnostic		6 of 7	E-ED1404-10	X-Ray Crystal Spectrometer M-1		5	
13	OBD Row 4, Style 2	Base	E-ED1405	1 of 9	E-ED1405-1	Base tile	T953	50	8 (FAI, Last unit, & 6 random)
14		Diagnostic		4 of 9	E-ED1405-6	Diagnostic Gap - Ramped Tile		25	13 (six FAIs, Last unit, & 6 random)
15		Diagnostic		5 of 9	E-ED1405-9	X-Ray Crystal Spectrometer M-1		4	
16		Diagnostic		6 of 9	E-ED1405-10	Bay A Lower Custom	CFC	2	
17		Diagnostic		7 of 9	E-ED1405-11	Receiving Ramp		24	
18		Diagnostic		8 of 9	E-ED1405-12	Bay A Upper Custom		2	
19		Diagnostic		9 of 9	E-ED1405-13	14 Degree Ramp		4	
20	OBD Row 5, Style 1	Base	E-ED1406	1 of 7	E-ED1406-1	Base tile	T953	65	13 (FAI, Last unit, & 11 random)
21		Diagnostic		2 of 7	E-ED1406-2	Mirnov		6	5 (five FAIs)
22		Diagnostic		3 of 7	E-ED1406-3	Thermocouple		6	
23		Diagnostic		5 of 7	E-ED1406-9	X-Ray Crystal Spectrometer M-1		5	
24		Diagnostic		6 of 7	E-ED1406-10	PCHERS Lower Tile - Ramp		3	
25		Diagnostic		7 of 7	E-ED1406-11	PCHERS Lower Tile - Chamfer		3	
26	OBD Row 5, Style 2	Base	E-ED1407	1 of 8	E-ED1407-1	Base tile	T953	50	8 (FAI, Last unit, & 6 random)
27		Diagnostic		4 of 8	E-ED1407-6	Ramp tile	CFC	24	13 (five FAIs, Last unit, & 7 random)
28		Diagnostic		5 of 8	E-ED1407-8	X-Ray Crystal Spectrometer M-1	T953	5	
29		Diagnostic		6 of 8	E-ED1407-9	Receiving Ramp	CFC	24	
30		Diagnostic		7 of 8	E-ED1407-10	Bay A Upper Custom		2	
31		Diagnostic		8 of 8	E-ED1407-11	14 Degree Ramp		4	

Inspected as per the sampling plan outlined within section 6.2.2.

Table 2: Outboard Divertor Tiles Rows 1 and 2 all Styles (OBD 1-2)									
Item No.	Row & Style	Tile Type	DWG No.	Sheet No.	Part No.	Description	Graphite Grade	Qty	Sample Size Total (Breakdown)
32	OBD Rows 1-2, All Styles	Base	E-ED1408	6 of 8	E-ED1408-3	Base tile & Mirnov	6510	92	13 (FAI, Last unit, & 11 random)
33		Diagnostic		7 of 8	E-ED1408-11	Langmuir		10	5 (two FAIs, Last unit, & 2 random)
34		Diagnostic		7 of 8	E-ED1408-25	Thermocouple		8	

Inspected as per the sampling plan outlined within section 6.2.2. The following features require 100% inspection for the OBD 1-2 Tiles:

- 1) The applicable fabrication drawings for OBD 1-2 tiles detail 21 individual castellated surfaces, called out on the drawing by note 6, that require 100% inspection to the applicable model dimensions and tolerance.
- 2) For all tile variations and for each tile produced, the 0.390” through-holes, which have applied straightness and true-position tolerance modifiers, shall be 100% inspected per the Subcontractor’s preferred method.

Methods for inspection shall be detailed in the Subcontractor’s MIT plan and shall be reviewed and subject to PPPL approval. Any Non-conformances per these critical inspection dimensions shall be communicated to PPPL as per Section 9.8.

Table 3: Center-Stack First Wall Tiles Rows 7-21, All Styles (CSFW)									
Item No.	Row & Style	Tile Type	DWG No.	Sheet No.	Part No.	Description	Graphite grade	Qty	Sample Size Total (Breakdown)
35	CSFW Style 3	Base	E-ED1389	1 of 3	E-ED1389-1	Base tile	ET10	70	13 (FAI, Last unit, & 11 random)
36		Diagnostic		2 of 3	E-ED1389-3	Mirnov		19	8 (four FAIs, Last unit, & 3 random)
37		Diagnostic		2 of 3	E-ED1389-5	Mirnov Horizontal		7	
38		Diagnostic		2 of 3	E-ED1389-4	Langmuir		7	
39		Diagnostic		2 of 3	E-ED1389-2	Thermocouple		10	
40	CSFW Style 4	Base	E-ED1390	1 of 3	E-ED1390-1	Base tile	ET10	50	8 (FAI, Last unit, & 6 random)
41		Diagnostic		2 of 3	E-ED1390-3	Mirnov		11	13 (seven FAIs, Last unit, & 5 random)
42		Diagnostic		2 of 3	E-ED1390-5	Double Mirnov		4	
43		Diagnostic		3 of 3	E-ED1390-6	Mirnov/Thermo		3	
44		Diagnostic		2 of 3	E-ED1390-4	Langmuir		3	
45		Diagnostic		2 of 3	E-ED1390-2	Thermocouple		8	
46		Diagnostic		3 of 3	E-ED1390-7	Gas INJ Nozzle		4	
47		Diagnostic		3 of 3	E-ED1390-9	Shunt		25	
48	CSFW Style 5 (Over)	Base	E-ED1449	1 of 1	E-ED1449-1	Base tile	ET10	100	20 (FAI, Last unit, & 18 random)
49	CSFW Style 5 (Under)	Base	E-ED1450	1 of 2	E-ED1450-1	Base tile	ET10	90	13 (FAI, Last unit, & 11 random)

Inspected as per the sampling plan outlined within section 6.2.2.

Table 4: Center-Stack Angled Tiles Rows 5 & 6, All Styles (CSA)									
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Item No.	Row & Style	Tile Type	DWG No.	Sheet No.	Part No.	Description	Graphite Grade	Qty	Sample Size Total (Breakdown)
50	CSA Row 5 (Over)	Base	E-ED1420	1 of 2	E-ED1420-1	Base tile	6510	25	5 (FAI, Last unit, & 3 random)
51		Diagnostic		2 of 2	E-ED1420-2	Thermocouple		3	2 (FAI & Last)
52	CSA Row 5 (Under)	Base	E-ED1421	1 of 2	E-ED1421-1	Base tile	6510	25	5 (FAI, Last unit, & 3 random)
53		Diagnostic		2 of 2	E-ED1421-2	Thermocouple		3	2 (FAI & Last)
54	CSA Row 6 (Over)	Base	E-ED1422	1 of 2	E-ED1422-1	Base tile	6510	24	5 (FAI, Last unit, & 3 random)
55		Diagnostic		2 of 2	E-ED1422-2	Thermocouple		3	2 (FAI & Last)
56	CSA Row 6 (Under)	Base	E-ED1423	1 of 2	E-ED1423-1	Base tile	6510	21	5 (FAI, Last unit, & 3 random)
57		Diagnostic		2 of 2	E-ED1423-2	Thermocouple		3	3 (three FAI's)
58		Diagnostic		2 of 2	E-ED1423-3	Gas Injection Shoulder Tube		2	
59		Diagnostic		2 of 2	E-ED1423-4	Gas Injection Midplane Tube		3	

Inspected as per the sampling plan outlined within section 6.2.2.

Table 5: Inboard Divertor Horizontal Tiles Row 1, all Styles (IBDH)									
Item No.	Row & Style	Tile Type	DWG No.	Sheet No.	Part No.	Description	Graphite Grade	Qty	Sample Size Total (Breakdown)
60	IBDH Row 1, All Styles	Base	E-ED1434	1,2,3 of 7	E-ED1434-1	Generic	6510	30	8 (FAI, Last unit, & 6 random)
61		Diagnostic		4 of 7	E-ED1434-2	Mirnov		7	8 (four FAIs, Last unit, & 3 random)
62		Diagnostic		5 of 7	E-ED1434-3	Line Of Sight		7	
63		Diagnostic		6 of 7	E-ED1434-4	Thermocouple		7	
64		Diagnostic		7 of 7	E-ED1434-5	LP5		5	

Inspected as per the sampling plan outlined within section 6.2.2. The following features require 100% inspection for the IBDH Tiles.

- 1) The applicable fabrication drawings for IBDH tiles detail 25 individual castellated surfaces, called out on the drawing by note 5, that require 100% inspection to the applicable model dimensions and tolerance.
- 2) For all tile variations and for each tile produced, the 0.456" through-holes, which have applied total runout tolerance modifiers, shall be 100% inspected per the Subcontractor's preferred method.

Methods for inspection shall be detailed in the Subcontractor's MIT plan and shall be reviewed and subject to PPPL approval. Any Non-conformances per these critical inspection dimensions shall be communicated to PPPL as per Section 9.8.

Table 6: Inboard Divertor Vertical Tiles Rows 2, 3, and 4, all Styles (IBDV)

Item No.	Row & Style	Tile Type	DWG No.	Sheet No.	Part No.	Description	Graphite Grade	Qty	Sample Size Total (Breakdown)
65	IBDV Row 2, LHF Style	Base	E-ED1430	1 of 4	E-ED1430-1	Base tile	6510	43	8 (FAI, Last unit, & 6 random)
66		Diagnostic		2 of 4	E-ED1430-2	Mirnov		5	3 (three FAIs)
67		Diagnostic		3 of 4	E-ED1430-3	Thermocouple		5	
68		Diagnostic		4 of 4	E-ED1430-4	LP1		3	
69	IBDV Row 3, HHF Style	Base	E-ED1441	1 of 5	E-ED1441-1	Base tile	6510	39	8 (FAI, Last unit, & 6 random)
70		Diagnostic		2 of 5	E-ED1441-2	Mirnov		3	5 (four FAIs & Last unit)
71		Diagnostic		3 of 5	E-ED1441-3	Thermocouple		8	
72		Diagnostic		4 of 5	E-ED1441-4	LP1		3	
73		Diagnostic		5 of 5	E-ED1441-5	LP2		3	
74	IBDV Row 4, HHF Style	Base	E-ED1440	1 of 5	E-ED1440-1	Base tile	6510	36	8 (FAI, Last unit, & 6 random)
75		Diagnostic		2 of 5	E-ED1440-2	Mirnov		5	5 (four FAIs & Last unit)
76		Diagnostic		3 of 5	E-ED1440-3	Thermocouple		9	
77		Diagnostic		4 of 5	E-ED1440-4	LP1		3	
78		Diagnostic		5 of 5	E-ED1440-5	LP2		3	

Inspected as per the sampling plan outlined within section 6.2.2. The following features require 100% inspection for the IBDV Tiles.

- 1) The applicable fabrication drawings for IBDV tiles detail 20 individual castellated surfaces, called out on the drawing by note 5, that require 100% inspection to the applicable model dimensions and tolerance.
- 2) For all tile variations and for each tile produced, the 0.456” through-holes, which have applied total runout tolerance modifiers, shall be 100% inspected per the Subcontractor’s preferred method.

Methods for inspection shall be detailed in the Subcontractor’s MIT plan and shall be reviewed and subject to PPPL approval. Any Non-conformances per these critical inspection dimensions shall be communicated to PPPL as per Section 9.8.

Note: Sample sizes provided in Tables 1 through 6 are for reference only and assume single lots/batches of each part number. See Note 1 in Section 6.2.2 for lot/batch definition.

5.2.3 MATERIALS & TRACEABILITY

5.2.3.1 All graphite will be supplied by PPPL to ensure strict material conformance. Material may be supplied to the Subcontractor in near-nominal blocks ready for machining, or in a single billet with a provided PPPL cutting plan (or cutting nest). The T953 and ET10 materials will be provided in billets. The 6510 and CFC materials will be provided in block form. The Subcontractor shall be responsible for the cutting of any provided raw-billets per their respective cutting plans.

5.2.3.2 The Subcontractor shall detail within their MIT plan their process for maintaining material traceability between any single billets and any near-nominal blocks cut from said billet(s), through all stages of manufacturing.

5.2.3.3 The Subcontractor shall ensure that their awarded parts are produced from the

required grade of graphite listed in Tables 1 through 6. Handling & Cleanliness controls shall be implemented and followed at all stages of manufacturing to prevent the contamination of any material or part; outlines of these controls are found within Section 5.1.2.

5.2.4 ELECTROMAGNETIC INTERFERENCE AND SUSCEPTIBILITY

Not Applicable.

5.2.5 IDENTIFICATION AND MARKING

Marking shall be per the fabrication drawings unless otherwise specified by PPPL. For parts whose drawing does not indicate marking on the part surface then only the standard bag-and-tag process outlined within Section 10.0 shall apply. The Subcontractor may suggest alternative marking processes from what is on the applicable fabrication drawings within their MIT plan subject to PPPL review and approval.

Under no circumstances shall the graphite tiles/parts be marked with any type of ink-marker or paint-stick as it will contaminate the surface and render the part unusable.

5.2.6 WORKMANSHIP

Separate from the Handling and Cleanliness outlined within Section 5.1.2, the Subcontractor's manufacturing shall meet, at minimum, the following expectations for workmanship:

- 5.2.6.1 Gouged, pitted, chipped, or corroded material will not be acceptable under any circumstances.
- 5.2.6.2 All machining debris and sharp edges shall be cleaned. Holes, channels, slots, and grooves shall be clear of any machining debris that could affect form, fit, and function.
- 5.2.6.3 Chatter, cutter, and vibrational marks shall be minimized through proper tooling care, usage, and inspection. Extra care should be taken to ensure that all surface finish requirements are met during manufacturing.
- 5.2.6.4 Threads shall be fully formed and of the correct size. Acceptable threads shall be free of tears, cracks, loose debris, and other contaminants. All threads shall be protected from potential damage and free of dirt, grease, or debris which could lead to poor assembly.
- 5.2.6.5 Cross-threading or rolling of any threads is only acceptable for stock materials, such as fasteners, and is not acceptable for fabricated components.
- 5.2.6.6 Counter sinks and counter bores shall be free from chatter and meet the surface finish requirements of the applicable tile drawing. Any "witness marks", ragged edges, or oblong holes on countersinks are unacceptable.
- 5.2.6.7 Although fixture and clamping marks are inherently unavoidable, care should be taken to ensure that any fixture/clamping marks accrued on a part during manufacturing do not conflict with any of the above workmanship requirements.

5.2.7 SUBCONTRACTOR EQUIPMENT USE

Not Applicable.

6.0 TEST & INSPECTION REQUIREMENTS

6.1 PERFORMANCE TESTS

- 6.1.1 The Subcontractor shall verify conformance of purchased and/or PPPL-furnished items, materials, or services to drawings and specification requirements and shall provide documented evidence of such verifications to PPPL if requested.
- 6.1.2 The Subcontractor shall perform a visual inspection of each graphite billet upon receipt to ensure no damage (e.g. cracking, chipping, etc.) occurred during shipment. Any damage identified shall be documented and reported to PPPL within 2 business days of discovery at the Subcontractor's facility.
- 6.1.3 All produced parts shall be inspected and tested per Section 6.2.2 requirements unless an alternate plan is agreed upon with PPPL in writing.

Note: Results shall be documented and reported to PPPL in the Subcontractor's Process History (per Section 9.12). Any exceptions to PPPL requirements shall be approved by PPPL in writing.

6.2 ACCEPTANCE TESTS

6.2.1 FIRST-ARTICLE INSPECTION (FAI) PROCESS

The Subcontractor will be provided a standard "PPPL Dimensional Inspection Form" (Attachment II) to be used for reporting all inspection results.

The Subcontractor is required to complete a First-Article Inspection "FAI" (inspect, verify, and record dimensional accuracy) for the first unit of each unique part number using the "PPPL Dimensional Inspection Form". FAI approval is a Hold Point (per Section 6.3).

The FAI approval process is as follows:

- 6.2.1.1 The dimensions and tolerances indicated on the applicable drawings are to be interpreted by the Subcontractor in accordance with ASME Y14.5-2009, Dimensioning and Tolerancing.
- 6.2.1.2 The Subcontractor is responsible for conducting the FAI inspection and providing the completed FAI (using the "PPPL Dimensional Inspection Form") to their respective PPPL QA contact once complete.
- 6.2.1.3 PPPL will review the FAI and indicate acceptance by signing and returning the Dimensional Inspection Form.
- 6.2.1.4 Following acceptance of the FAI by PPPL, the Subcontractor may continue manufacturing subsequent units of the same part number in accordance with the approved MIT plan (per Section 9.11).

After acceptance of the FAI by PPPL, the remaining units required by the purchase order shall be produced using the same design, materials, processes, methods, and tooling that were used to manufacture the approved FAI components. Any changes to the approved process require PPPL approval prior to implementation.

Note: PPPL reserves the right to designate the FAI a mandatory witness point.

6.2.2 SAMPLING AND INSPECTION PLANNING

Tables 1 through 6 within Section 5.2.2. list the number of applicable samples to be taken from each production lot of tiles. Table 7 serves as supplemental information for determining the inspection sample size listed within Tables 1 through 6.

All Critical Dimensions & Features, as identified in the notes following Tables 1 through 6, shall be inspected on 100% of the tiles. The remaining features shall be inspected in accordance with the sampling plan identified in Table 7, below:

Table 7: Sampling Plan for Non-Critical Features

Lot or Batch Size	Sample Size
2 to 8	2
9 to 15	3
16 to 25	5
26 to 50	8
51 to 90	13
91 to 150	20
151 to 280	32
281 to 500	50

Sampling plan based on ANSI/ASQ Z1.4-2003, single sampling plan for normal inspection, general inspection level II.

Samples shall be chosen such that the inspected units are approximately evenly distributed through the manufacturing run. Each sampled lot shall include inspection of the first unit of each part (FAI per Section 6.2.1) and the last unit.

Sampling inspection and FAI documentation shall be completed with the provided “PPPL Dimensional Inspection Form” listed within Section 12.0 (Attachment II).

Note 1: For the purposes of executing the above defined sampling plan, a lot/batch shall be defined as a series of components of the same part number manufactured under a continuous process using the same material (same material heat/lot number), fixturing, tooling, and machine. Any change in any of these four characteristics of the machining process shall constitute the end of a lot/batch.

Note 2: For the purposes of determining lot or batch size, diagnostic variants of a given base tile may be considered a single lot. For example, OBD Row 3, Style 1 (Items # 1 through 5 of Table 1) consists of 75 base tiles and a total of 36 diagnostic variants (Mirnov, Thermocouple, Langmuir Probe, Shunt, & RF Langmuir Probe). There are, therefore, two lots: 75 base tiles requiring a sample size of 13, and 36 diagnostic variants requiring a sample size of 8. The 8 sampled units from the diagnostic variants will consist of the 4 FAI units, the last unit of the lot, and three additional units selected to minimize the number of consecutively manufactured units without inspection.

6.3 SUPPLIER HOLD POINTS

The following hold points require written PPPL approval prior to continuance of work:

- 6.3.1 Approval of MIT plan (per Section 9.11) – Initial MIT plan, as well as revisions to previously approved MIT plan shall be approved prior to implementation. Approval will be provided by the PPPL Responsible Engineer (RE) and communicated to Subcontractor by the PTR or QA Representative.
- 6.3.2 Approval of FAI Forms (per Section 6.2.1) – Subcontractor shall submit FAI forms for the first of each part number manufactured per this SOW for approval prior to manufacturing subsequent components of the same part number being reported. Approval will be provided by the PTR.
- 6.3.3 Approval of Nonconformance Disposition and Corrective Action (As applicable, per Section 9.8) – Subcontractor shall submit Nonconformance Reports for PPPL review and approval of Disposition and Corrective Action for any non-conforming items. Approval shall be provided prior to manufacturing subsequent components. Approval will be provided by the PTR.
- 6.3.4 Approval of Process History documentation (per Section 9.12) – Subcontractor shall submit Process History documentation for approval prior to shipment of product. Approval will be provided by PPPL QA representative via the “Product Quality Certification & Shipping Release” (per Section 9.10).

7.0 QUALIFICATIONS

Personnel performing work to this SOW are required to have been trained in the operation of the equipment being used. Training records shall be maintained on file and shall be available for review upon PPPL request.

The Subcontractor shall maintain documentation outlining the training of their employees responsible for completing the contract manufacturing with the MIT plan and all requirements of this SOW. Documentation of training to the MIT plan and SOW requirements shall include, at minimum, the following:

- 7.1 A Pre-Production Kick-Off meeting with any Subcontractor employees responsible for completing work to this contract and SOW in attendance (either physically or remotely).
- 7.2 A formal sign-in sheet recording the names and dates of employees present for the meeting (physical or electronic signatures are acceptable).
- 7.3 A formal Presentation in the Subcontractors preferred format (Microsoft Slides, Word, Excel, etc.) detailing the training covered during the meeting.

Documentation of these training records shall be presented to PPPL upon request; it is established that the PTR shall review this documentation during Subcontractor Audit(s).

8.0 ENVIRONMENT, SAFETY, AND HEALTH

PPPL may request information deemed necessary to evaluate the Subcontractor’s safety record at any time.

The Subcontractor shall:

- 8.1 Comply with all OSHA regulations to ensure the safety of any potential PPPL visitors to the Subcontractor's facility.
- 8.2 Be responsible for ensuring the safety of PPPL visitors; and providing any necessary personal protective equipment (PPE) and safety related training to PPPL visitors who have been tasked with overseeing the Subcontractor's manufacturing.

9.0 QUALITY ASSURANCE REQUIREMENTS

9.1 INSPECTION/ SURVEILLANCE/AUDIT BY PRINCETON

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. The Subcontractor agrees to insert the paragraphs above in each lower tier procurement issued hereunder.

Note: PPPL plans to have a representative at the Subcontractor's facility one day per month to review project progress/status and verify conformance to requirements. PPPL may modify the frequency of visits at any time and will provide the Subcontractor with as much notification as possible for planning purposes.

9.2 SUBCONTRACTOR'S RESPONSIBILITY FOR CONFORMANCE

Neither PPPL's review and/or approval of the Subcontractor's documents nor PPPL's inspection of Subcontractor's items or services shall relieve the Subcontractor of responsibility for full compliance with the requirements of the purchase order/contract. If any portion of this work is planned to be performed by sub-tier contractors, such plans shall be communicated to PPPL with the contractor's quotation proposal and shall be approved by PPPL prior to execution of work. The Subcontractor is responsible for ensuring that all requirements and restrictions within this specification are imposed on any sub-tier suppliers.

9.3 SUBCONTRACTOR QUALITY ASSURANCE PROGRAM

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

- 9.3.1 The Subcontractor's Quality Assurance function shall be actively involved in the planning, processing, oversight, problem resolution, and determination of the acceptability of all work covered under this SOW.
- 9.3.2 The 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.
- 9.3.3 The Subcontractor shall perform planned, periodic audits of the various aspects of its QA Program by persons not directly responsible for the area being audited. Written reports of these audits shall be made available to PPPL upon request.
- 9.3.4 The Subcontractor shall submit with the proposal, a copy of its Quality Assurance Program Manual, describing the Subcontractor's quality capability and general approach to quality assurance. The manual shall be subject to PPPL's review and acceptance prior to contract award.

9.4 DOCUMENT TRACEABILITY AND RECORDS

The Subcontractor shall maintain a system of documentation whereby objective evidence of required operations, examinations, and tests is systematically compiled, indexed and stored. Such objective evidence may include "travelers", certification, examination, and discrepancy reports, which shall be complete, legible, and validated by responsible personnel and shall be traceable to subject items. This documentation shall be made available to PPPL upon request.

9.5 ACCEPTIBILITY OF PURCHASED ITEMS AND SERVICES

The Subcontractor shall inspect any PPPL provided material upon receipt and notify PPPL of any damage within 2 business days prior to usage. Documentation of any damaged PPPL material shall be maintained by the Subcontractor and made available to PPPL upon request (see Section 6.1).

9.6 DOCUMENT REVIEW, APPROVAL, AND CONTROL

The Subcontractor shall implement a system for review and approval of design documents (drawings, specifications, etc.), prior to issuance for use, and for approval and incorporation of changes in a formal and orderly manner. The system shall control obsolete documents to prevent inadvertent use. The system shall also control PPPL-furnished design documents to ensure that any models are in sync with the applicable drawings, and that obsolete information is not used.

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

9.7 MATERIAL IDENTIFICATION AND STATUS

Material 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 as approved by PPPL. See Section 5.2.5 for specific instructions regarding identification and marking; and Section 5.2.3 regarding material traceability.

Revisions or changes by the Subcontractor to documents approved by PPPL shall be reviewed and

approved by PPPL prior to use.

9.8 NONCONFORMANCES & CORRECTIVE ACTIONS

The Subcontractor shall promptly identify and control nonconforming items or services. Nonconforming items or services shall be positively identified, and segregated where possible, to prevent use. The Subcontractor shall document each non-conformance on a Non-Conformance Report "NCR".

Non-Conformance Reports (NCRs) shall, at a minimum, contain the following information:

- 9.8.1 A description of the non-conformance.
- 9.8.2 A determination of the cause of the non-conformance.
- 9.8.3 A proposed resolution/disposition of the non-conformance.
- 9.8.4 A corrective action plan to preclude recurrence.

(Note: The determination of cause and corrective action plan may be waived by PPPL).

Upon the discovery of any non-conforming parts, all work by the Subcontractor on the applicable part/drawing number being produced shall be halted and shall not resume until an NCR has been processed and a corrective action plan has been established and approved by PPPL.

PPPL shall be notified within 2 business days if upon inspection, the dimensions of any part are found to be noncompliant with the dimensions and tolerances specified on the applicable fabrication drawing, and the Subcontractor shall begin the process of filing a Non-Conformance report following the above minimum requirements. NCRs shall be submitted to PPPL for review within 7 business days of the discovery of the non-conformance.

9.9 CALIBRATION OF 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.

The usage of reference standards for Subcontractor self-calibration of equipment shall be detailed in the Subcontractor's submitted MIT plan. Examples of this can include: The use of externally calibrated gauge blocks to internally calibrate their own calipers; or the usage of machinery manuals/guides to internally calibrate their own machining equipment. The Subcontractor shall submit calibration records for all externally calibrated equipment and reference standards used to execute the work defined within this SOW. These records shall be submitted with the MIT plan.

9.10 SUBMITTAL OF COMPLETED RELEASE FOR SHIPMENT FORM

The Subcontractor shall not ship without a "Product Quality Certification and Shipping Release" (Attachment I) form signed by PPPL's Representative. The 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.

9.11 SUBMITTAL OF MANUFACTURING/INSPECTION/TEST (MIT) PLAN

The Subcontractor shall submit a Manufacturing/Inspection/Test Plan within 10 working days after receipt of order for PPPL approval prior to start of manufacture. 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. PPPL may designate selected operations as mandatory "witness" points based on the MIT plan. The Subcontractor shall provide PPPL, within 5 working days, notice of such witness points. Revisions or changes to the approved MIT plan shall be reviewed and approved by PPPL prior to use.

9.12 PROCESS HISTORY

Subcontractor shall provide PPPL, along with the completed "Product Quality Certification and Shipping Release" (per Section 9.10), a digital copy of the Process History. The Process History is a compilation of documents, detailing the objective evidence of the acceptability of the work performed, and shall include as a minimum the following:

9.12.1 CERTIFICATE OF CONFORMANCE

Subcontractor's Certificate of Conformance, signed by the Subcontractor's Quality Manager (or equally authorized Subcontractor Representative), stating that the work performed conforms in every respect to PPPL requirements. Where the Subcontractor has used PPPL furnished material, such certification shall also include a statement certifying that the material furnished by PPPL has been inspected by the Subcontractor and used as specified by PPPL with no unauthorized substitutions.

9.12.2 INSPECTION & TEST REPORTS

The Subcontractor shall submit all FAI (per Section 6.2.1) and in-process sampling inspection reports (per Section 6.2.2).

9.12.3 NONCONFORMANCE REPORTS

The Subcontractor shall submit copies of processed NCRs (per Section 9.8).

9.13 PPPL RECEIVING/INSPECTION

PPPL will perform Receiving Inspection on items or services supplied by Subcontractor, using either a sampling plan or 100% inspection.

10.0 SHIPPING, STORAGE, AND PACKAGING

The Subcontractor shall control items during shipping, handling, and storage. Release from storage shall be controlled to prevent accidental or inadvertent use of incorrect or unacceptable items. The following packaging requirements shall be followed for each part being fabricated at the Subcontractor and delivered to PPPL:

- 10.1 Each tile is to be individually bagged into a clear (new) polyethylene bag; and the bag is to be tagged with the parts unique tile number (i.e. its part number) as

specified on the applicable fabrication drawing.

- 10.2 Tiles which share the same part/drawing number (identical parts) may be combined into one shipment for delivery to PPPL. The tiles shall still be individually bagged as per above. Parts of differing part/drawing numbers may be combined into the same packaging if a dozen or fewer are being produced (Ex. Multiple parts of quantities 12 or fewer can be packaged onto 1 singular skid, rather than a separate skid per part.).
- 10.3 All parts are to be packaged in such a way that the parts cannot freely move and potentially incur damage while in-transit. This can be achieved through the Subcontractor's preferred methods. Methods may include but are not limited to: metal-tension banding, clear plastic wrap, or movement restrictive packaging. The method of packaging for shipment used by the Subcontractor shall be detailed in their MIT plan. PPPL reserves the right to review the Subcontractor's packaging method.
- 10.4 Graphite is an inherently brittle material which can easily chip or crack when subject to impacts, thus special packaging considerations shall be made by the Subcontractor to prevent the potential of impact damage affecting the shipment while in-transit. These special packaging considerations shall be submitted with the Subcontractor's MIT plan subject to PPPL approval.
- 10.5 A copy of the Process History documentation (per Section 9.12) shall be enclosed within a weather-safe shipping label accompanying the shipment.

The Subcontractor is encouraged to ship completed total quantities of each tile being produced as per the quantities listed on the purchase order. Completed "Product Quality Certification and Shipping Release" and Process History forms shall accompany each shipment as per Sections 9.10 and 9.12 requirements.

11.0 WARRANTY

Not Applicable.

12.0 ATTACHMENTS

Attachment I – "Product Quality Certification and Shipping Release"

Attachment II – "PPPL Dimensional Inspection Form"

13.0 DOCUMENTATION & DELIVERABLES

- 13.1 PPPL Attachment I, the "Product Quality Certification and Shipping Release", is to be completed, reviewed and approved by PPPL prior to shipment. Physical copies of the form are to be included in all shipments to PPPL made by the Subcontractor.
- 13.2 PPPL Attachment II, the "PPPL Dimensional Inspection Form", shall serve as the documentation the Subcontractor shall use to report any FAI or sampling inspection results.

- 13.3 Documentation shall be provided to PPPL for approval as delineated in the following Deliverables List (one original and one duplicate copy of each document shall be provided unless otherwise specified herein). Process History (Section 9.12) documentation shall be supplied with each individual shipment.

14.0 DELIVERABLES LIST

PO / Subcontract / BOA / BPA #: _____

#	Document Deliverables Required	When Deliverable Is Required	Format (paper, electronic etc.)	Storage Location	Deliverable Received (X)
1	Calibration of Test and Measuring Equipment (Section 9.9)	With Proposal	Electronic	Ops	
2	Quality Assurance Program Manual (Section 9.3.4)	With Proposal	Electronic	Ops	
3	Manufacturing, Inspection, and Testing (MIT) plan (Section 9.11)	Within 10 days of Contract Award	Electronic	Ops	
4	First-Article Inspection Reports (Section 6.2.1)	Upon completion of First-Article	Electronic	Ops	
5	Non-Conformance Reports (Section 9.8)	Within 2 days of Discovery	Electronic	Ops	
6	Product Quality Certification and Shipping Release (Section 9.10)	Prior to Shipment(s)	Electronic	Ops	
7	Process History (Section 9.12)	Prior to Shipment(s)	Electronic	Ops	
Exceptions (Add justification for any missing document deliverables that will not be received):					

Princeton Technical Representative or COG: _____
(Sign-off and provide to the Operations Center when the job is complete, and deliverables are dispositioned and placed/filed in Operations Center (or other Project, Department or Division designated file center)

PRINCETON PLASMA PHYSICS LABORATORY—PPPL
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 #
	<p align="center"><u>SUPPLIER'S CERTIFICATION</u></p> <p>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.</p>		
	<p>SIGNED: _____ DATE: _____</p> <p>TITLE: _____ COMPANY: _____</p>		

Completed, signed, and returned by PPPL before shipment	<p align="center"><u>PPPL (AUTHORIZED REPRESENTATIVE) SHIPPING RELEASE</u></p> <p>This is to certify that evidence supporting the above Supplier's Certification statement has been reviewed and no product/service nonconformances from procurement requirements have been identified unless noted below. This product/service is hereby released for shipment.</p> <p>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 54rpurchase contract, drawings and specifications.</p>	
	NONCONFORMANCES FROM PROCUREMENT QUALITY REQUIREMENTS:	
	REMARKS/PRODUCT SERIAL NUMBERS:	
	BY PPPL QA REPRESENTATIVE (OR DESIGNEE)	DATE

Rev. 1 November 15, 2010

Page 24 of 25



The PPPL Dimensional Inspection form is used to document results of inspections and any applicable nonconformances. The following are instructions for the completion of each field. Fields marked **(R)** are required. Fields marked **(CR)** are conditionally required, with the fields' instructions providing guidance regarding the applicability of the requirement. Fields marked **(O)** are optional.

1. **(R) Subcontractor/Company:** Name of the organization performing the inspection.
2. **(R) Purchase Order#:** Customer purchase order number.
3. **(R) Line Item:** Purchase order line item of the component being inspected.
4. **(R) Drawing# & Rev.:** Drawing number (including revision) of the drawing identifying the dimensions and tolerances of the component being inspected.
5. **(R) Part Name:** Part name/description as identified on the drawing's title block, part list, or purchase order line item.
6. **(R) FAI/In-Process:** Identification of type of dimensional inspection being reported. Only one option may be selected to indicate whether the inspection is an FAI or In-Process inspection.
7. **(R) Sheet#:** Multiple sheets may be used as necessary to document all applicable requirements. Each sheet is marked to indicate its sheet number and the total number of sheets comprising the report.
8. **(R) Feature Number:** Unique number assigned to each design characteristic. This number shall match the corresponding number assigned to the feature on the accompanying bubbled drawing.
9. **(CR) Reference Location:** Location of the feature on the drawing (sheet number and zone). This field is optional in cases where features are identified via a bubbled drawing. In the event that, with PPPL approval, a bubbled drawing is not included, this field is required.
10. **(R) Requirement:** Specified requirement for the design characteristic (e.g. drawing dimensional characteristic with associated nominal dimension and tolerances, drawing notes, specification requirements).
11. **(R) Results:** A listing of the measurement(s) obtained for the design characteristics.
 - In the event that a single Feature Number covers multiple features, the results may either be reported individually or as a range identifying the minimum and maximum measured values. Any features that are found to be nonconforming shall be listed separately.
 - When pin gages are used to verify hole diameters, the largest "go" pin and smallest "no-go" pin diameters shall be reported.
 - When qualified tooling (e.g. radius gage) is used as a go/no-go gage, the results are identified on an attribute basis (e.g. pass/fail).
12. **(R) M&TE Identification:** The unique identification assigned to the tooling used to take the reported measurements.
13. **(CR) Nonconformance Number:** As applicable, reference number of any nonconformance document.
14. **(O) Comments:** This field is used to document any noteworthy observations or comments.
15. **(R) Inspected and Documented by:** Printed name and signature of the person who prepared and approved the form. The signature may be in electronic format only if the signature is uniquely, positively, and securely associated with the approving individual.
16. **(CR) Date:** The date when field 15 was signed. If an electronic signature with a date stamp was used in field 15, this field is optional.
17. **(CR) Reviewed and Approved by:** Printed name and signature or electronic signature (as defined for field 15) of the PPPL representative who reviewed and approved the form. When First Article Inspection is indicated in field 6, this field is required.
18. **(CR) Date:** The date when field 17 was signed. If an electronic signature with a date stamp was used in field 17, this field is optional.