



ENG-060 - SOW - STATEMENT OF WORK

Statement of Work for the NSTX-U Design of Spring Washers for PFC Component Installation

NSTXU_1-1-1-1_SOW_109

Work Planning #: **2317**
Effective Date: **02/28/2020**
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CAT A1

Document Number: NSTXU_1-1-1-1_SOW_109

Reference Work Planning#: 2317

REVISION 0

DATED: 2/20/2020

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1.0 Introduction & Scope

Princeton Plasma Physics Lab (PPPL) is currently performing upgrades as part of the NSTX-U (National Spherical Torus Experiment - Upgrade) Recovery Project. As part of these upgrades PPPL has redesigned eight major sections of the Plasma Facing Components (PFC). The PFC targeted for redesign are the Center Stack First Wall (CSFW), Center Stack Angled (CSA), Outboard Diverter (OBD) rows 1,2,3,4,5, Inboard Diverter Vertical (IBDV), and the Inboard Diverter Horizontal (IBDH). The new PFC tile assemblies will be mounted in various configurations on and around the center stack of the machine.

The combined effect of thermal, electromagnetic and structural loads produced on the PFCs during operation of NSTX has necessitated the establishment of a bolt preload that must be maintained during bakeout and operation of the machine. The design of choice to maintain this preload incorporates the use of Belleville Washers (spring washers) in the mounting of the PFC tiles.

The Scope of the work defined herein is the design of Belleville Washers (spring washers) in accordance with the design inputs provided within this SOW, including the applicable documents and drawings listed in Sections 2.0 and 3.0, respectively.

2.0 Applicable Documents

Below is a listing of Documents the Subcontractor may need to reference for proper completion of the work defined herein:

- 2.1 ASTM B670-07(2018) - Standard Specification for Precipitation-Hardening Nickel Alloy (UNS N07718) Plate, Sheet, and Strip for High-Temperature Service.
- 2.2 AMS 5542, Rev. P – Nickel Alloy, Corrosion and Heat-Resistant, Sheet, Strip, and Plate 72Ni – 15.5 Cr – 0.95Cb(Nb) – 2.5Ti – 0.70Al – 7.0Fe Annealed.
- 2.3 AMS 5598, Rev. F – Nickel Alloy, Corrosion and Heat-Resistant, Sheet, Strip, and Plate, 72Ni - 15.5Cr - 0.95 (Cb (Nb) + Ta) - 2.5Ti - 0.70Al - 7.0Fe, Consumable Electrode, Remelted or Vacuum Induction Melted, Solution Heat Treated, Precipitation-Hardenable.
- 2.4 ISO 19690 – 2: 2018 – Disc Springs, Part 2: Technical Specifications.

Note: Alternative materials may be used with prior PPPL Approval.

3.0 Applicable Drawings

- 3.1 E-ED1416, Rev. 0 – Centerstack Recovery, Inboard Diverter, Angular Section Tile Assembly, Row 5 Style 1.
- 3.2 E-ED1408, Rev. 3 – NSTX Plasma Facing Components, Row 1 &2 Outboard Diverter Tiles Assembly and Parts Detail.
- 3.3 E-ED1432, Rev. 1 – Centerstack Recovery, Inboard Diverter, Vertical and Horizontal Locking Posts Style 1 – 3 Assembly.
- 3.4 E-ED1395, Rev. 2 – Centerstack Recovery, Inboard Diverter Vertical (IBDV) Section, Tile Row 2 Style 1 – 4 Assembly.
- 3.5 E-ED1402, Rev. 2 – NSTX Plasma Facing Component, OBD Plate Tile Ass’y Detail, Row 3 Style 2.

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

The Subcontractor shall conform to all requirements of this Statement of Work. If any portion of this work is to be performed by sub-tier contractors such plans shall be communicated to PPPL with the Contractor’s proposal and shall be subject to PPPL approval. All requirements given in this Statement of Work shall flow down to any PPPL approved sub-tier contractors.

5.0 Requirements

5.1 Performance Requirements

5.1.1 Performance Characteristics

The Subcontractor shall design the spring washers in accordance with the requirements of Table 5.1.1-1, Table 5.2.2-1 and the additional requirements of this SOW.

5.1.2 Operating Environment

The Maximum Operating and Bakeout temperature to which the spring washers will be subjected to is delineated in Table 5.1.1-1.

5.1.3 Design Documentation

The design package shall be provided to PPPL as a hard copy and a CD ROM disc and shall consist of as a minimum the following documentation:

5.1.3.1 One drawing per region defining each washer's height (loaded and unloaded), ID, OD, and thickness. Each drawing shall contain a reference to the calculation number to which it was designed and a Bill of Material defining:

5.1.3.1.1 The Region each spring washer (as defined in Tables 5.1.1-1 and 5.2.2-1).

5.1.3.1.2 Spring Washer Part Number (as defined in Tables 5.1.1-1 and 5.2.2-1).

5.1.3.1.3 The specific material used in the design of each spring washer (including the applicable specification as listed in Section 2.0).

5.1.3.1.4 Design Preload.

5.1.3.1.5 Maximum Bakeout Temperature.

5.1.3.1.6 Maximum Operating Temperature.

5.1.3.2 Design calculations for each specific spring washer cross – referencing the drawing (per Section 5.1.3.1).

Calculations shall be verified by a technically qualified Subcontractor representative independent of the development/preparation of the calculation. Calculations shall be signed by the preparer and the checker. Calculations shall document at a minimum :

5.1.3.2.1 The applicable Region (as defined in Tables 5.1.1-1 and 5.2.2-1).

5.1.3.2.2 Spring Washer Part Number (as defined in Tables 5.1.1-1 and 5.2.2-1).

5.1.3.2.3 The specific material used in the design of each spring washer (including the applicable specification as listed in Section 2.0)

5.1.3.2.4 Design Preload.

5.1.3.2.5 Maximum Bakeout Temperature.

5.1.3.2.6 Maximum Operating Temperature.

5.1.3.2.7 Maximum Stress calculated at Bakeout Temperature.

5.1.3.2.8 Maximum Operating Temperature under the specified Preload.

Table 5.1.1-1
Preload and Temperature Design Input

Region	Spring Washer Part Number	Design Preload (lbs.)	Max Operating Temperature (°C)	Maximum Bakeout Temperature (°C)
CSA(*)	---	---	150	400
OBD 12	ED1408, Items 14	200	200	400
	ED1408, Items 15			
IBDH	E-ED1432 Part No. 3	113	150	400
		169		
IBDV	E-ED1432 Part No. 3	169	250	400
		85		
	E-ED1395 Part No. 7	170		
OBD 345(*)	---	---	150	400

(*) The value of Bellevue Washer Preload and Part Number designation are to be determined with Subcontractor at a later date.

5.2 **Equipment Definitions**

5.2.1 **Specifications and Standards**

The materials defined within the specifications listed in Section 2.0 are to be used in the design of the spring washers.

Note: If the Subcontractor is unable to design the spring washers to the Preload, Temperature, Material and Spatial requirements of this SOW, the Subcontractor is to contact PPPL with his recommendation for a substitute material. Upon PPPL approval the Subcontractor is authorized to use the recommended substitute material in the design of the spring washer.

5.2.2 **General Design Features**

The final design of the spring washers shall meet all requirements of this SOW. The spring washer's nominal inside and maximum outside diameters are given in Table 5.2.2-1. The thickness and dish of the spring washers are to be determined by the Subcontractor during the design phase. The height of all spring washer stacks are to be minimized. Tolerance on the design of the spring washers is to be in accordance with ISO 19690-2-

Note: Spring washer stack – up dimension for Regions IBDH and IBDV shall not exceed .282 inches.

Table 5.2.2-1
Dimensional Design Input

Region	Washer Part Number	Washer Preload (lbs.)	Maximum Outside Diameter (inch)	Inside Diameter (inch)	Number of Washers
CSA (*)	----	---	.551	.252	250
OBD12	ED1408 Item No. 14	200	.344	.168	850
	ED1408 Item No. 15		.630	.317	250
IBDH	E-ED1432 Part No. 3	113	.550	.250	4500
		169			
IBDV	E-ED1432 Part No. 3	169	.550	.250	
		85			
	E-ED1395 Part No. 7	170	.620	.320	500
OBD 345(*)	---	---	.500	.258	2250

(*) The value of Bellevue Washer Preload and Part Number designation are to be determined with Subcontractor at a later date.

6.0 Quality Assurance Requirements

6.1 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. The Subcontractor agrees to insert the paragraph above in each

6.2 Subcontractor's Responsibility for Conformance

6.2.1 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 SOW are imposed on any sub-tier suppliers. Upon completion of design the Subcontractor shall provide a Letter of Conformance certifying that the design has been performed in accordance with the requirements of this SOW. The Letter of Conformance shall be signed by the Subcontractors Manager of Quality Assurance (or equally qualified Subcontractor representative).

6.3 Subcontractor's 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.

- 6.3.1 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.
- 6.3.2 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.
- 6.3.3 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.

6.4 Document Traceability & Records

6.4.1 The Subcontractor shall maintain a system of documentation whereby objective evidence of any required experience, training, examinations, and/or tests is systematically compiled, indexed and stored. Such objective evidence may include resumes, results of tests/examinations, and discrepancy reports, which shall be complete, legible, and validated by responsible personnel and shall be traceable to any work performed. This documentation shall be made available to PPPL upon request.

6.5 Document Review, Approval, and Control

6.5.1 The Subcontractor shall implement a system for review and approval of design documents (drawings, calculations, specifications, etc.), prior to issuance to PPPL for approval and/or for incorporation of changes. The system shall control obsolete documents to prevent inadvertent use. The system shall also control PPPL-furnished documents to ensure that the design of the spring washers are in sync with the applicable document requirements and that obsolete information is not used.

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

7.0 Documentation and Deliverables

Document Deliverables Required	When Deliverable Is Required	Deliverable Format (paper, electronic etc.)	Storage Location	Deliverable Received
Letter of Conformance (Section 6.2.1)	Completion of Order	Electronic	Ops	
Design Package (Section 5.1.3)	Within 20 working days After Receipt of Order	Paper & Electronic	Ops	

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)