# Interface Control Document CENTER STACK STRUCTURE : VACUUM PUMPI

## Interface Document: NSTXU_1-1-3-3-6_IC_101

## REVISION 0

## October 21, 2019

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National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment Upgrade

# Interface Control Document

# CENTER STACK STRUCTURE: VACUUM PUMPING SYSTEM

NSTX-U-ICD-CSS-VPS-0

**Revision 0**
**May 22, 2018**

**Change Record**

| Revision | Date | Description of Change |
|---|---|---|
| 0 | May 22,2019 | Initial Release |
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# References

[1] GENERAL REQUIREMENTS DOCUMENT, NSTX-U-RQMT-GRD-001-01.

[2] SYSTEM REQUIREMENTS DOCUMENT, VACUUM VESSEL AND INTERNAL HARDWARE, NSTX-U-RQMT-SRD-004-01.

[3] SYSTEM REQUIREMENTS DOCUMENT, AUXILIARY SYSTEMS, NSTX-U-RQMT-SRD-005-01.

[4] Polar Region Vacuum Seals Upgrade, Preliminary Design Review, August 2, 2018.

# 1. Purpose

This document describes the various interfaces between the following subsystems: Center Stack Structure and the Vacuum Pumping System. The interface locations and boundaries that connect the Center Stack Structure to the Vacuum Pumping System are identified based on different interface types.

# 2. Scope

The Center Stack Structure components include the Center Stack Casing, the Ceramic Break Assembly, PF 1a/b/c Support Structures, Horizontal Target Cooling System, and Vertical Target Cooling System. The Vacuum Pumping System consists of vacuum pumps, valves, TIV & Shutter Actuation System, and Interspace Vacuum Pumping System. The interfaces in this ICD only pertain to the Interspace vacuum pumping system. These interfaces focus on the IVPS and the ceramic break Center Stack, specifically the bellows flanges. The scope of this document addresses any defined interfaces between these identified system elements.

# 3. Responsibilities

The interfaces are managed between the following organizations:

- VVIH
- Vacuum Pumping
- Systems Engineering and Integration

# 4. Interfaces

Interface requirements in the following sections are identified with a requirement number, ICD, followed by a number [ICD-CSS-VPS-X] where "X" is a sequential count beginning with 001, CSS represents Center Stack Structure, and VPS represents Vacuum Pumping System. There is also a unique identifier for all interfaces in the format [#####-#####-X]. The identifier is a concatenation of two level 5 SBS values and the interface type. This is followed by an interface description and a list of references. References provide evidence pertaining to interfaces include but are not limited to drawings, calculations, or specifications. References also include a reference to a paragraph that identifies the set of interface definitions.

## 4.1. Interface Types

The top-level interface types are defined in Table 1. Within each heading, there are sub-headings to address any special sub-elements that need consideration. For example, the Mechanical has four sub-elements that need to be addressed: Structural, Spatial, Location, and Wall/Floor Penetration. For those interface types with sub-interfaces there are corresponding sub-sections.

Table 1. Interface Types

| Heading | Abbreviation | Name |
|---|---|---|
| 4.2 | Me | Mechanical |
| 4.3 | Ep | Electrical Power |
| 4.4 | Si | Signal |
| 4.5 | Di | Diagnostics |
| 4.6 | Gf | Gas/Fluid |
| 4.7 | Va | Vacuum |
| 4.8 | Sw | Software |
| 4.9 | Th | Thermal |
| 4.10 | Pe | Plasma/Eddy/ Halo Current |

Table 2 provides the N2 Diagram identifying all the interfaces for NSTX-U, while Table 3 provides the specific details of the interface.

Table 2. N2 Diagram Interface types.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plasma Facing Components | Me,Th, Pe | | Me,Th, Va,Pe | | | | | | Me | Me | Me, Pe | | Me | | | |
| | In-Vessel Structure | Me,Di, Pe | | | Th | | | Me,Th, Pe | Me | | Me, Di, Pe | | | Di | | |
| | | Vacuum Vessel Structure | Me | | Me,Va | Me | Me | Me, Th, Pe | Me | Me,Va | Me,Di, Va | | Si | Di,Si | | |
| | | Va | Centerstack Structure | | | Va, Th | Me, Gf | Me | Me | | | | | Di | | |
| | | Me | Me, Th, Ep | Magnets | | | Gf | Me | | | Di | | SI | Di | | |
| Si | | Va | | | Heating Systems | | Gf | Th | | Me | | Gf, Si | Si | Si | Si | |
| | | | | | Si, Va, Me, Sw | Vacuum Pumping System | | Si | Si | Gf, Si | Si | | Si,Va | Si | Si | |
| | | | | Gf,Si | | | Coolant System | Gf | | | | Gf,Sw | Si, Sw | Si | | |
| | Th, Gf | Ep,Di, Th, Va | Ep, Gf, Th, Pe | | Si | | Si | Bakeout System | | | | | | | Si, Me | |
| | | | Gf,Va | | Ep | Gf,Si | | | Gas Delivery System | Me | Va | | Si,Sw | Si | Si | |
| | | Gf | | | | Si,Gf,Va | | | Gf | Wall Conditioning System | | | Si,Sw | Si | Si | |
| | | Me,Va | Me,Va | Me | Me | Gf,Si | Gf | | | Va, Ep | Diagnostics | | Si,Sw | Si | Si | Si |
| | | | | Ep | Ep | Ep | Ep | Ep | Ep | Ep | Ep | Power Systems | Si | Ep, Si | Ep, Si, Di, Gf | Ep |
| | | | | | Si | | | | | Me, Si | Si | | Centralized Instrumentation and Control | Si, Me | | |
| | | | | | | | | | | Sw | | Si | Si,Sw | Integrated Machine Operations | | |
| | | | | | | | | Ep | | | | | | | Operations & Safety Systems | |
| Me | | Me | Me | Me | Me | Me | | Me | Me | Me | Me | Me | Me | Me | Me, Ep | D-Site Locations (Test Cell |

Table 3. Callout.

| | |
|---|---|
| Centerstack Structure | Va, Th |
| | Vacuum Pumping System |

The remainder of this document addresses each of the interfaces. Note the template includes a paragraph heading for each interface and a table for each interface type. In the event there is no interface, the table will remain blank with a blank row.

The following paragraphs in Section 4 address each of the interfaces, and Section 5 addresses any off-project interfaces. Off-project interfaces are those external interfaces that interact with the NSTX-U system.

## 4.2. Mechanical Interfaces

This paragraph addresses any type of mechanical interfaces that include a structural, spatial, location dependent interfaces or areas where penetrations into a wall or floor are required. These are identified independently as interface parameters will likely be different.

### 4.2.1. Structural Interfaces

This identifies any interfaces between system elements that require a structural interface. This could be based on various forces placed on the system and by the system.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

### 4.2.2. Spatial Interface

This identifies any interfaces between the system elements pertaining to spatial restrictions or constraints.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

### 4.2.3. Location Interfaces

This identifies any interfaces between the system elements that have any particular dependencies on element location or location constraints.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

### 4.2.4. Wall/Floor Penetration Interfaces

This identifies any interfaces between the system elements and any penetrations or modifications to the wall or floor of the D-Site building.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

## 4.3. Electrical Power Interfaces

This identifies any interfaces between the system elements requiring AC, DC, rectification, or power conditioning.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

## 4.4. Signal Interfaces

This identifies any interfaces between the system elements and signals that are used to either send or receive control information or data. It explicitly includes the type of physical interface such as Ethernet or Fiber Optic or any specific protocols.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

## 4.5. Diagnostic Interfaces

This identifies any interfaces between the system elements, with any instrumentation or diagnostic equipment to collect performance data.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

## 4.6. Gas/Fluid Interfaces

This paragraph has two different types of interfaces: Gas and Fluid.

### 4.6.1. Gas Interfaces

This identifies any interfaces between the system elements that use any type of gas (e.g., He).

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

### 4.6.2. Fluid Interfaces

This identifies any interfaces between the system elements that use any type of fluid (e.g., ionized water).

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

## 4.7. Vacuum Interfaces

This identifies any interfaces between the system elements that pertain to the Vacuum.

| Identifier | Interface | References |
|---|---|---|
| 1.1.3.3-1.3.1.7-V | Provision for **IVPS** access to interspace via access holes and fittings at vacuum ports on **CSS flanges**. | See Paragraph 4.7.1 Reference 4 |
| 1.1.3.3.8-1.3.1.7-V | **IVPS** pumps out O-rings on the **Ceramic Break assembly**. | See Paragraph 4.7.2 |

**Interface Notes:**

- The SRD requirement is to ensure a vacuum of 2x10-8 Torr.
- The GRD requires a seal leak rate <= 1x10-9 sccs air equivalent.

### 4.7.1. Center Stack Flanges - Interspace Vacuum Pumping System

**ICD-CSS-VPS-001:** The Dual O-Ring Design is shown In Figures 1 & 2. It connects the various flanges labeled flange in Figures 1 & 2. The interface occurs at the interspace vacuum ports. There is only one vacuum pump port for each set of double O-rings. The different O-ring interspace ports are at different toroidal cross-sections.

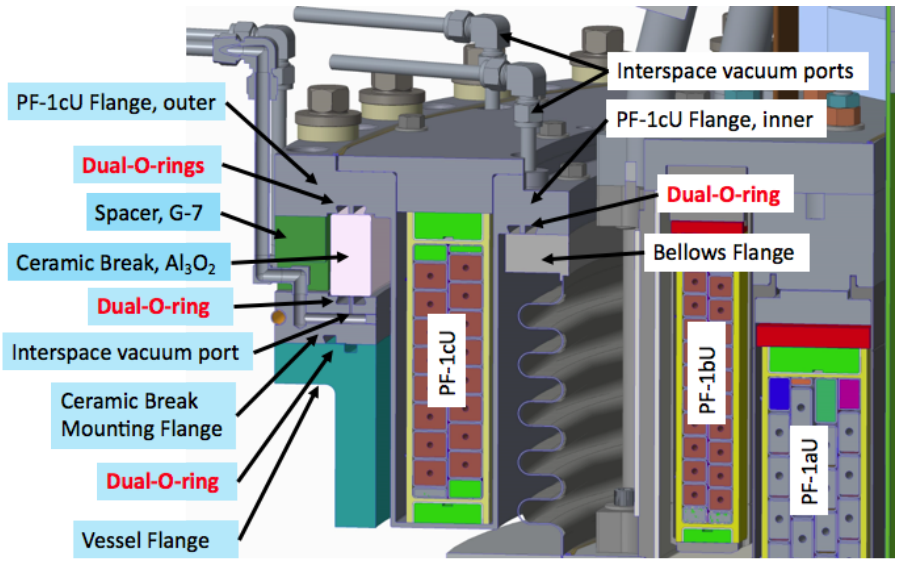

Figure 1. Center Stack Flange Interspace Pumping Vacuum Interface (Upper)

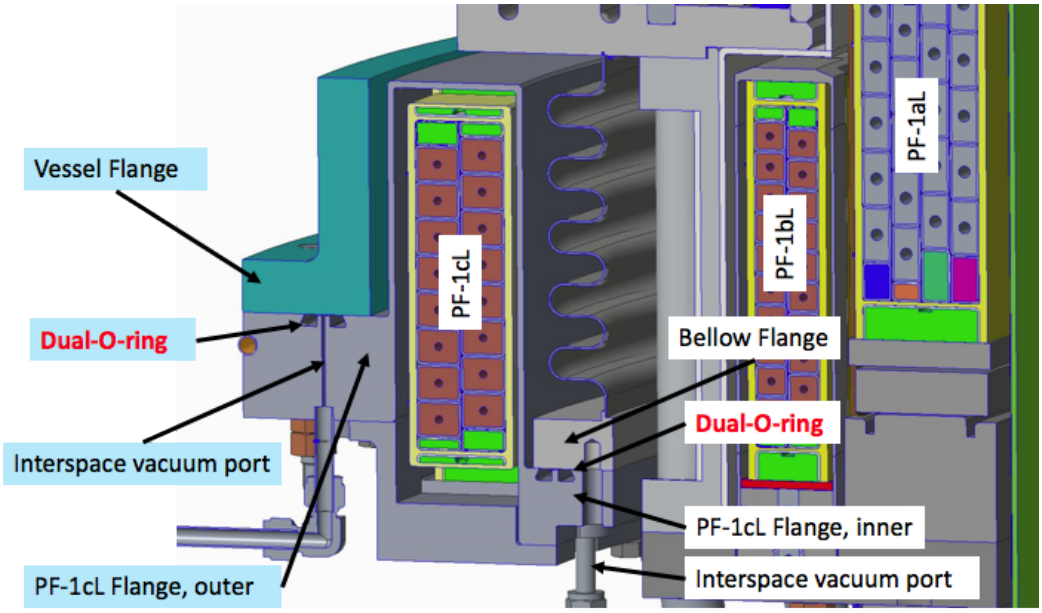


Figure 2. Center Stack Flange Interspace Pumping Vacuum Interface (Lower)

**ICD-CSS-VPS-002:** The vacuum pump port is connected at the elbow using a fitting, e.g., compression fitting.

**ICD-CSS-VPS-003:** There are no allowable gaps between the metal to metal flanges. The maximum tolerance of 0.013" on each flange is to maintain the required compression ratio of between 8 and 22%.

**ICD-CSS-VPS-004:** The flange seal type is a double O-ring and has the minimum dimensions identified in Figure 3. For a given height, 0.02", a min width 1/8" is required for transitional flow status.

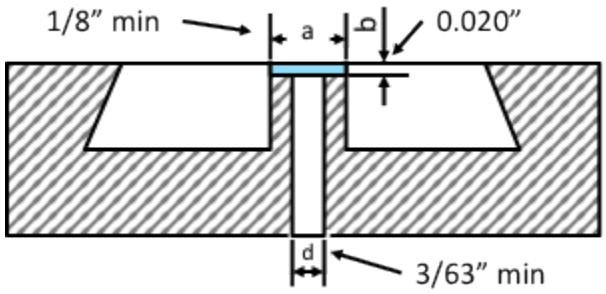


Figure 3. Double O-ring Design.

## 4.7.2. Ceramic Break Assembly - Interspace Vacuum Pumping System

**Interface Notes:**

- The Ceramic Break assembly is only included in the upper Region.

**ICD-CSS-VPS-005:** The Dual O-Ring Design is shown In Figure 2. It connects the ceramic break shown in the upper dual o-ring marker to the PF-1C outer flange where the half dovetail grooves are located. There is also another ceramic break connection to the ceramic break mounting flange on the lower Dual O-Ring. The Vacuum port for the lower is identified in the identified in the figure. There is an upper Interspace Vacuum Port shown on the figure as the grey tube in the left side of the figure. Where the PF1c assembly meets the vacuum vessel, one O-ring groove is in the vacuum flange, and one O-ring groove is in the ceramic break mounting flange. The two together, form one Double O-ring pair.

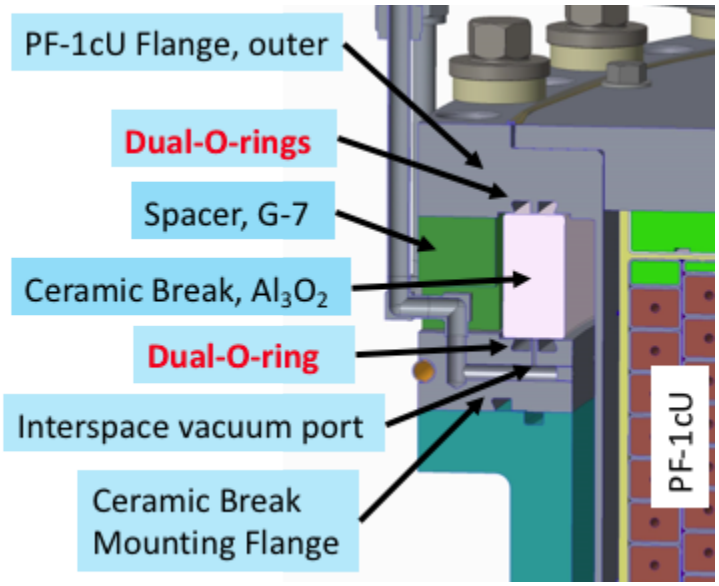


Figure 2. Ceramic Break Flange Vacuum Interface.

**ICD-CSS-VPS-006:** There is an allowable gap of between 0.015”-0.020” between the ceramic break and the metal flanges. The maximum tolerance of 0.013” on each flange is to maintain the required compression ratio of between 8 and 22%.

**ICD-CSS-VPS-007:** The flange seal type is a double O-ring and has the minimum dimensions identified in Figure 2. For a given height, 0.02”, a min width 1/8” is required for transitional flow status.

## 4.8. Software Interfaces

This identifies any interfaces between the system elements that use software that may exchange interfaces with other software components. This includes application programming interfaces (APIs) or any other exchange of information between different software applications.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

## 4.9. Thermal Interfaces

This identifies any interfaces between the system elements that pertain to Thermal characteristics.

| Identifier | Interface | References |
|---|---|---|
| 1.1.3.3-1.3.1.7-T | The double-O Ring seals residing between flanges have thermal limits. | See Paragraph 4.9.1, Reference 4 |

### 4.9.1. Center Stack - IVPS

**Interface Notes:**

- These temperatures apply to all the IVPS double O rings.
- Requirement calls for 180 deg C; however, the design goal is to stay below 150 deg C

**ICD-CSS-VPS-008:** The allowable temperature operating environment is from -20 deg C to 150 deg C.

## 4.10. Plasma Interfaces

This paragraph has two different types of interfaces: Plasma and Eddy/Halo Current.

### 4.10.1. Plasma Interfaces

This identifies any interfaces between the system elements with the Plasma.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

### 4.10.2. Eddy/Halo Current Interfaces

This identifies any interfaces between the system elements with the Eddy/Halo Currents.

| Identifier | Interface | References |
|---|---|---|
| N/A | | |

# 5. Off-Project Interfaces

The off-project interfaces are components that are not specifically part of the NSTX-U system. They may include external systems and interfaces where the program has little control over a part of the interface. They are provided for completeness.

- The IVPS exhausts through the D-Site Stack-Field fit the 1” exhaust line to 4” Test Cell exhaust manifold (SBS 0.1.1.8) at the west side of NB#1.
- Compressed air is provided for the TIV and shutter actuation system where instrument air (SBS 0.1.1.9) connects to the manifolds in the system.