Center Stack Structures - Bakeout Systems ICD

Interface Document: NSTXU_1-1-3-3_IC_103

REVISION 0

June 28, 2019

PREPARED BY:	**Peter Dugan**	6/27/2019 2:16:27 PM
	Peter Dugan,	
REVIEWED BY:	**George D. Loesser**	6/27/2019 3:05:33 PM
	George D. Loesser,	
REVIEWED BY:	**Joseph Petrella**	6/27/2019 3:35:28 PM
	Joseph Petrella,	
REVIEWED BY:	**Peter Dugan**	6/28/2019 6:46:32 AM
	Peter Dugan,	
APPROVED BY:	**Stefan Gerhardt**	6/28/2019 9:04:57 AM
	Stefan Gerhardt,	

PRINCETON PLASMA PHYSICS LABORATORY
P.O. BOX 451
PRINCETON, N.J. 08543

National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment Upgrade

Interface Control Document

CENTER STACK SYSTEM:
BAKEOUT SYSTEM

NSTX-U-ICD-CSS-BOS-0

Revision 0
June 27, 2019

____

Prepared By: P. Dugan, Systems Engineering

____

Reviewed By: D. Loesser, VVIH RE

____

Reviewed: J. Petrella, Bakeout RE

____

Reviewed By: Y. Zhai, NSTX-U Project Engineer

Change Record

Revision	Date	Description of Change
0	June 27, 2019	Initial Release

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.

1. Purpose

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

2. Scope

The Center Stack Structures include the Center Stack Casing, Pedestal, PF-1a Support Structures, PF-1b Support Structures, and PF-1c Support Structures. The Bakeout System consists of Helium Heating and Cooling System, Helium Skid, Ex-Vessel Helium Manifolds, In-Vessel Helium Lines, and Helium Feedthroughs. The scope of this document addresses any defined interfaces between these identified system elements. Note the Bakeout Bus has not yet undergone a preliminary design review. Most of the interfaces will be designed and this document updated as these interfaces are solidified leading up to the PDR.

3. Responsibilities

The interfaces are managed between the following organizations:

- VVIH
- Bakeout System
- 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-BOS-X], where “X” is a sequential count beginning with 001, CSS represents Center Stack Structure and BOS represents Bakeout System. There is also a unique identifier for all interfaces in the format [#####-#####-X]. The identifier is a concatenation of two level 5 WBS 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,Va	Me	Me	Me, Th, Pe	Me	Me,Va	Me,Di, Va		Si	Di,Si		
		Va	Centerstack Structure			Va	Me, Gf	Me	Me	Me				Di		
		Me	Me, Th, Ep	Magnets			Gf	Me			Di		Si	Di		
Si		Me, 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						Me	Si	
			Gf,Va	Gf,Va	Ep	Gf,Si			Gas Delivery System	Me	Va		Si,Sw	Si	Si	
		Gf	Si			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.

Center Stack Structure	**Me**
Ep, Gf, Th, Pe	**Bakeout System 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.

It must beart numbers used in this document, are subject to change.

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
1.1.3.3.6-1.3.3.2.1-S	Disruption JxB forces reacted at joint between the **Center Stack casing** and the **Bakeout Bus** work.	See Paragraph 4.2.1.1

4.2.1.1. Center Stack Casing – Bakeout Buswork

Interface Notes:

- The Bus Bar is being designed to offload some of the Halo current transitioning through the bellows. A major portion of Halos loads will be carried through the Bakeout Bus bar.
- The disruption J cross B force is calculated at the three bus bar locations, shown in yellow, in Figure 1. The left view is a top down view. The center view is an iso view of the left view. The top part of the machine has been truncated for clarity. Other, miscellaneous parts have also been excluded. Each bus bar location was analyzed at its two bolting locations. One bolting location is at the top, where the bus bar mounts to the flange. The second bolting location is where the bus bar mounts to the collar (the collar is not shown).

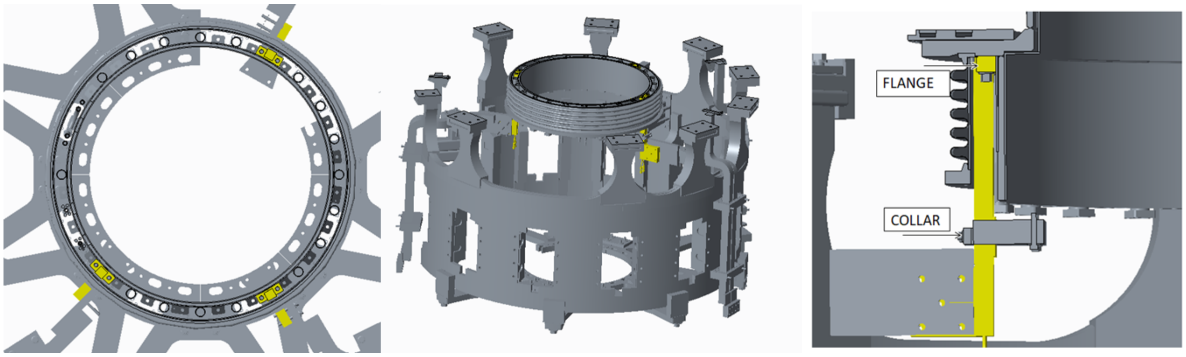

Figure 1: Locations for JxB Force Reactions (Lower Umbrella)

ICD-CSS-BOS-001: The interface is located at the horizontal divertor flange as shown in Figure 2. Figure 2 shows the upper section terminals. The left view gives one quadrant of the upper section. The arrow shows to look down, inside the bellows. The middle section view looks down, along the direction of the left view arrow. The right side picture is shown with multiple parts removed. It is the inside-plan view of the bus-bar. When emplaced the bus bar is surrounded by the coils and the collar. In order to maintain a good electrical contact the horizontal plate will be copper plated/coated to allow better current to flow from the bus bar to the Inconel Horizontal Flange. Plate size is 1.5”x 3.5”.

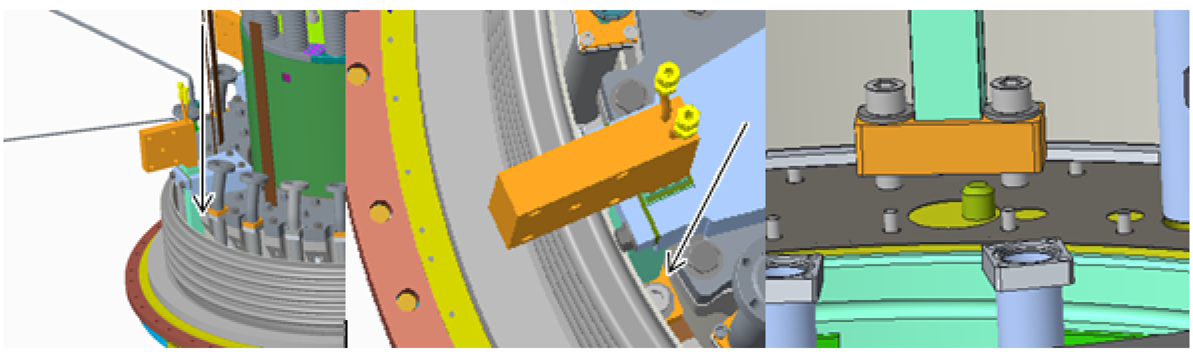

Figure 2. Location of the Bus Bar connection (Upper Umbrella)

ICD-CSS-BOS-002: The interface is connected using ½” Inconel shoulder bolts.

ICD-CSS-BOS-003: The interface has a preload of 20 kN.

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
1.3.3.2.1-1.1.3.3.6-P	The three **bakeout connections** are mounted to the **flange surface** on the air side.	See Paragraph 4.3.1 Drawing , DC1498, lower sub-assembliesDC1495, DC1496, DC1497 DC1861 for the upper sub-assembly
1.3.3.2.1-1.1.3.3.6-P	The **casing** is grounded via the **bakeout bus work**	See Paragraph 4.3.2

4.3.1. Center Stack Casing Flange – Bakeout Connections

Interface Notes:

- See section 4.2.1.1 for the physical location of the flag terminals.

ICD-CSS-BOS-004: The location of the power connection is located on the upper flange and uses flag terminal connections and 16 - 750 MCM cables to create the interface. The power is connected at the top of the terminals as shown in Figures 1 & 2. Note: an intermediate bus bar is needed but not yet designed between the flag that's shown in the picture and the outside of the upper umbrella, where the 750MCM cables will connect.

ICD-CSS-BOS-005: The maximum voltage is 8 V and maximum current is 8kA.

4.3.2. Casing – Bakeout Bus Work Ground

Interface Notes:

- The Backout Bus work will provide more details as a result of the PDR.

ICD-CSS-BOS-006: The casing connected to the vacuum vessel via the bakeout Bus bar to the ground switch. Figure 3 provides a view of a notional connection that connects the bus bar to the grounding switch grounding system.

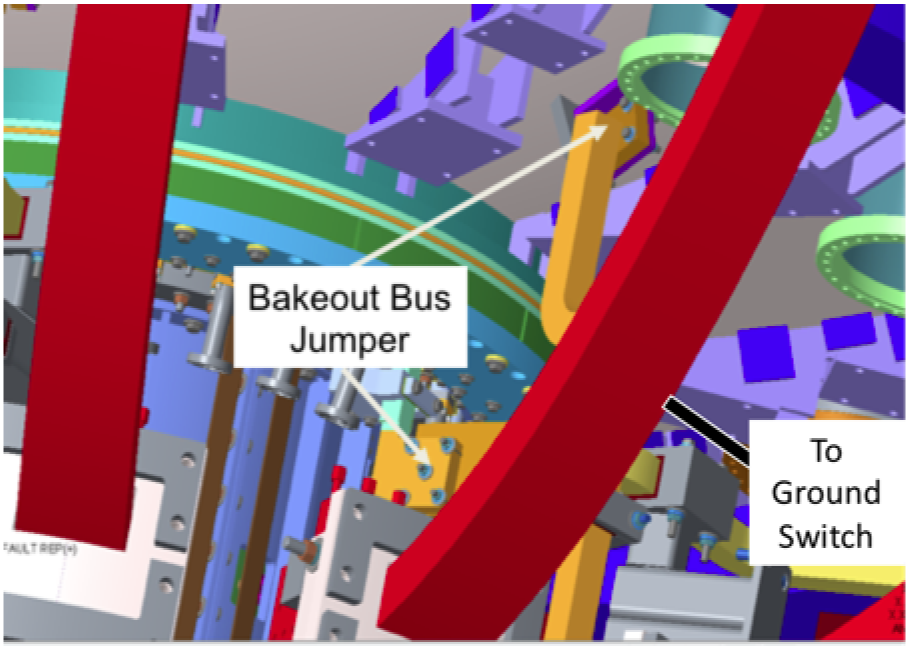

Figure 3. Vessel Grounding

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
1.3.3.1.2-1.1.3.3.9-G	He is fed to the in-vessel **heating/cooling (HTP)** features at the **He distribution system.**	See Paragraph 4.6.1.1

4.6.1.1. Helium Feed to HTP

Interface Notes:

- The physical location for the divertor flange cooling inlet/outlet fittings is shown in Figure 4 below. They connect inside the bellows. The bellows is shown transparent for clarity, and the insulation on the ID of the bellows was hidden. A similar arrangement is used for the lower casing.

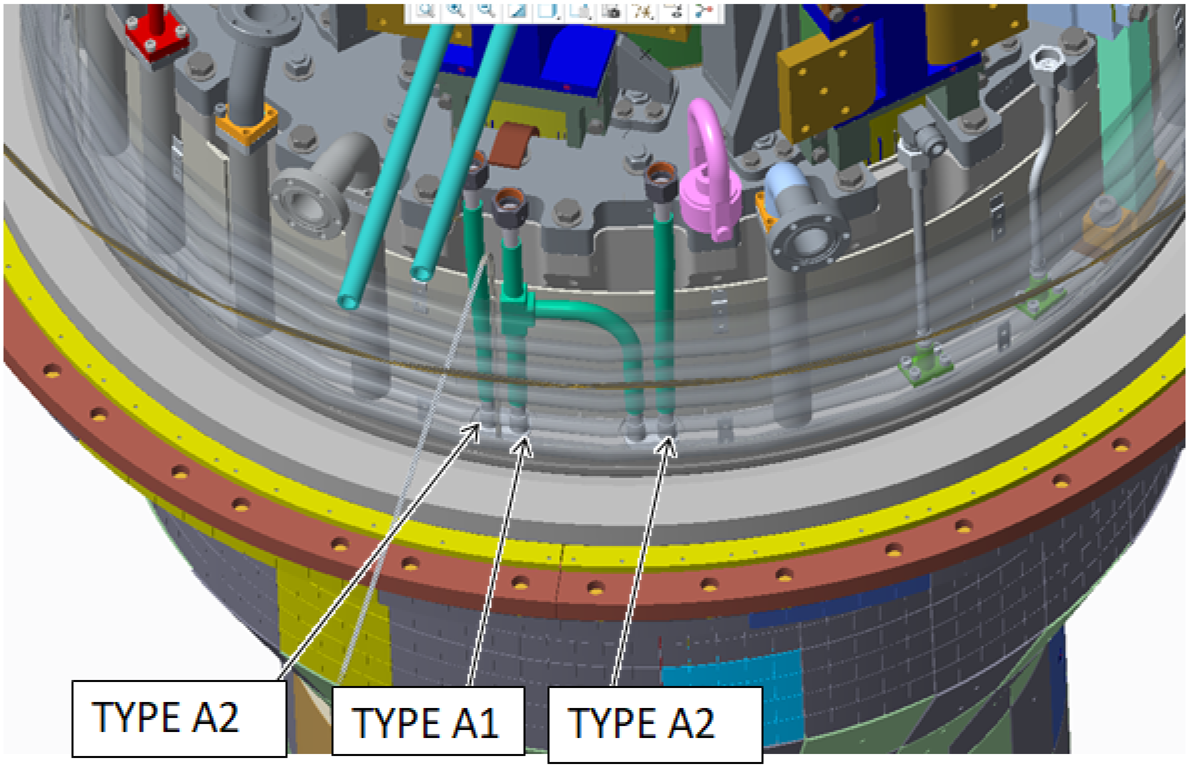

Figure 4: Divertor Flange Cooling Tube, Upper Section.

ICD-CSS-BOS-007: The type of gas is Helium reaching a temperature range of up to 450 deg C.

ICD-CSS-BOS-008: The pressure is up to 300 psi. The actual working pressure will be validated in the field.

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
N/A		

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
1.3.3.2.1-1.1.3.3.6-T	**Water-cooled bus work** components connected to **casing** that will range in temperature from room temperature to bakeout temperature.	See Paragraph 4.9.1

Interface Notes:

- The fittings for the cooling water channels can be clearly seen in the middle view of Figure 2 above. They stick up like two yellow-topped antennae from the orange block with five holes .

4.9.1. Water-Cooled Tubes - Bakeout

ICD-CSS-BOS-009: The water cooling occurs in the Terminal flags both upper and lower. The jumper is not water cooled. A thermal analysis will be conducted for Preliminary Design Review, and signed calculations will be provided for the Bakeout Bus Final Design Review.

4.10. Plasma Interfaces

This paragraph has two different types of interfaces: Plasma and Eddie/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 Eddie/Halo Currents.

Identifier	Interface	References
1.3.3.2.1- 1.1.3.3.6-E	Halo current will flow through **casing** connections bridging inner and outer vessel, applying load to the **bus work.**	See Paragraph 4.10.2.1 Calculation TBP at FDR

4.10.2.1. Casing – Bus Work

Interface Notes:

- Halo Currents are a major driver to the structural design of the Bakeout Bus Bar and will be presented at the FDR.

- A jumper is considered part of the Bakeout Bus Work and connects Center Stack Casing and Vacuum Vessel. A ground is established to the vessel via the bakeout bus bar.

ICD-CSS-BOS-010: The Halo current loads affects the Bakeout Bus Bar and the Bellows as the Halo current flows over the Center Stack to the Vacuum Vessel as shown in Figure 5. The upper arrow in Figure 5 represents the vacuum vessel connection while the lower arrow represents the center stack connection. Because the Bellows has a high resistivity , much of the current will transit through the Bake Out Bus Bar jumper. These loads will be approximated by the Bakeout Bus Work PDR and finalized in a calculation prior to the FDR.

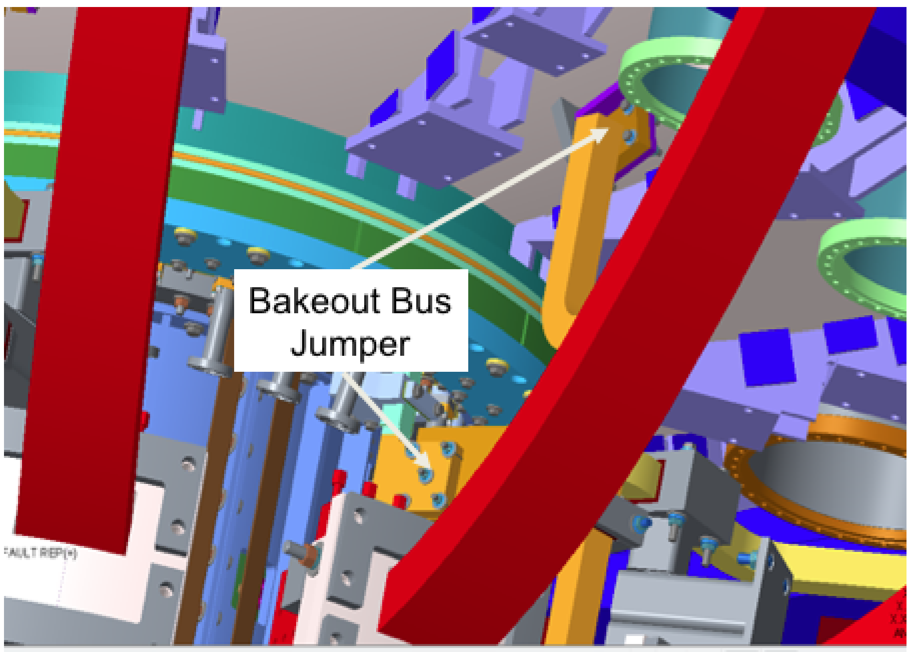

Figure 5. Bakeout Bus Bar Jumper

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 on part of the interface. They are provided for completeness.

There are no external interfaces.