In-Vessel Structures - Bakeout System ICD

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National Spherical Torus eXperiment Upgrade

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Interface Control Document

IN-VESSEL STRUCTURES – BAKEOUT SYSTEMS

NSTX-U-ICD-IVS-BOS-0

Revision 0
June 27, 2019

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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

[4] NSTXU Recovery Global Heat Balance Calculations, NSTXU-CALC-10-6-00

1. Purpose

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

2. Scope

The In-Vessel Structure consists of the Passive Plates, Outboard Divertor, and Neutral Beam Armor. The Bakeout System consists 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.

3. Responsibilities

The interfaces are managed between the following organizations:

- Vacuum Vessel & Internal Hardware
- Bakeout and Cooling
- Systems Engineering and Integration

4. Interfaces

Interface requirements in the following sections are identified with a requirement number, ICD followed by a number [ICD-IVS-BOS-X] where X is a sequential count beginning with 001, IVS represents In-Vessel 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. Reference also includes 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

In-Vessel Structure	Me, Th, Pe
Th, Gf	Bakeout 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 that 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 to include a structural, spatial, location dependent interfaces or areas where penetrations in a wall or floor are required. These are identified independently as the interface parameters will likely be different.

4.2.1. Structural Interfaces

This identifies any interfaces between the 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
1.1.1.2.2-1.3.3.1.3.S	**OBD** provide structural support for the **In-Vessel Helium Lines** at surface of heating/cooling line.	See Paragraph 4.2.1.3 Drawing NSTX093
1.1.1.2.2-1.3.3.1.3.S	**OBD Plate brackets** provide structural support of the tubes, and motion of plates can transfer load to the **In-Vessel Helium Line** tubes at surface of tubes.	See Paragraph 4.2.1.3, Drawing NSTX091
1.1.1.2.1-1.3.3.1.3-S	**Passive Plates** provide structural support for the **In-Vessel Helium Lines** at surface of heating/cooling line.	See Paragraph 4.2.1.3, Drawing DB1509

4.2.1.1. Outboard Divertor to In-Vessel Helium Lines

Interface Notes:

- This capability is not included in recovery scope but included for completeness.

ICD-IVS-BOS-001: Figure 1 shows the flow of helium for In-Vessel Helium Lines.
The helium lines are run in sections with the passive plates from the manifold. Brackets on the manifold are included and shown in red ellipse in Figure 2.

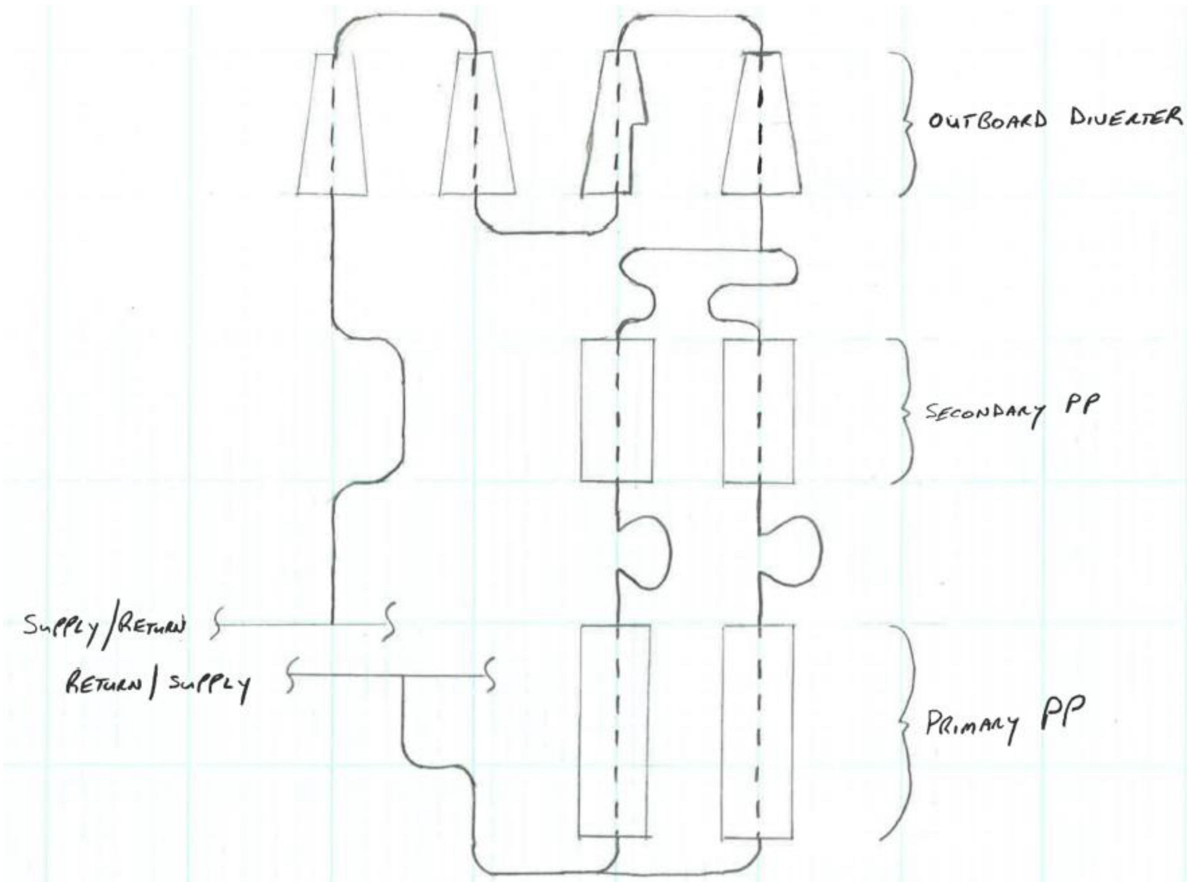

Figure 1. In- Vessel Helium Lines Section

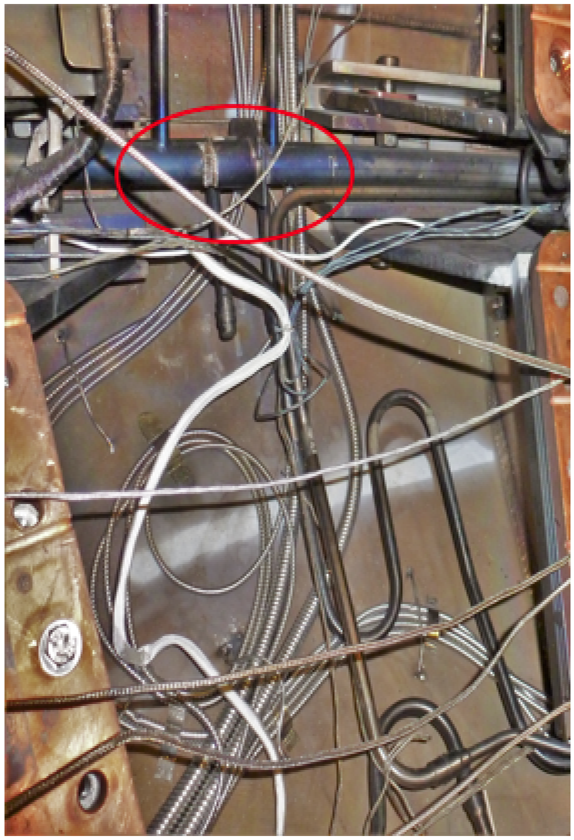

Figure 2. Existing Helium Pipes

4.2.1.2. Outboard Divertor Brackets to In-Vessel Helium Lines

Interface Notes:

- This capability is not included in Recovery Scope but included for completeness.

ICD-IVS-BOS-002: The OBD backplates are assembled in groups of 4, and brazed to a serpentine cooling line. The helium lines are placed in the channel of the Passive Plate backplane as shown In Figure 3.

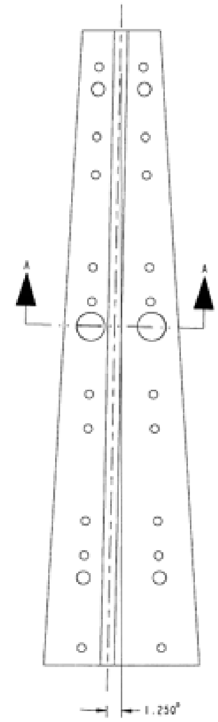

Figure 3. OBD Backplate with Helium Line channel

4.2.1.3. Passive Plates to In-Vessel Helium Lines

Interface Notes:

- The Passive Plates will be finalizing the design and FDR and the models and drawings will be updated.

ICD-IVS-BOS-003: The helium lines tubes are embedded in jumpers that reside between shims and the plate as per Figure 4. In addition, clamps are included to secure the tubes (purple) as they enter the passive plate region as shown in Figure 5.

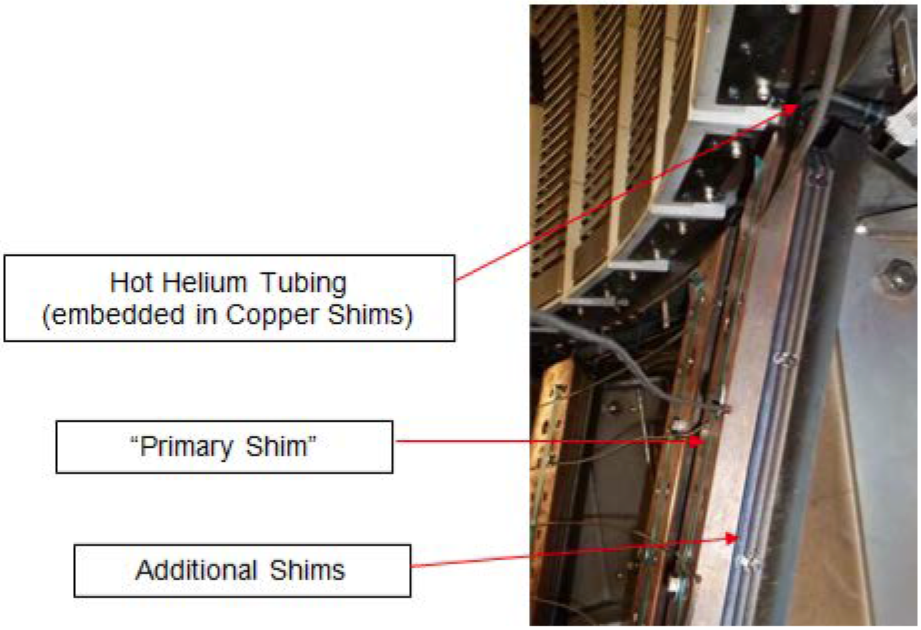

Figure 4 . Photo of passive plate cooling tube.

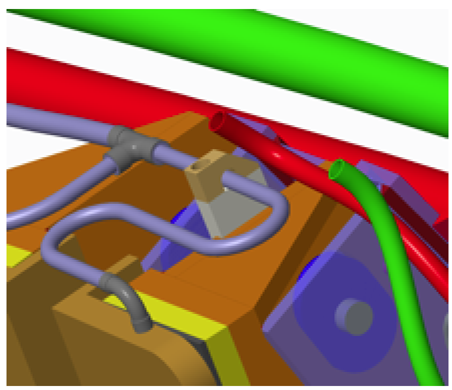

Figure 5 . Photo of passive plate cooling tube.

4.2.2. Spatial Interfaces

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 Penetrations Interfaces

This identifies any interfaces between the system elements 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
1.3.3.1.2-1.1.1.2.3-G	The **hot helium** distribution system feeds helium to the **Neutral Beam armor structures** during bakeout.	See Paragraph 4.6.1.1., Drawing DB1482
1.3.3.1.2-1.1.1.2.3-G	The **hot helium** distribution system feeds helium to the **OBD structures** during bakeout.	See Paragraph 4.6.1.2., Drawing DB1008, DB1077
1.3.3.1.2-1.1.1.2.3-G	The **hot helium** distribution system feeds helium to the **Passive Plate structures** during bakeout.	See Paragraph 4.6.1.3., Drawing DB1008, DB1077

4.6.1.1. Hot Helium - Neutral Beam Armor Structure

Interface Notes:

- This capability is not included in Recovery Scope but included for completeness.

ICD-IVS-BOS-004: The type of Gas is Helium and the flow rate will be verified by the field. Drawing DB1482 defines the details of the cooling tubes. Two Feed Thrus, 6" and 8", 316 Stainless Steel Flanges provide input and output lines on the Bay H Port Cover.

4.6.1.2. Hot Helium - Outboard Divertor

Interface Notes:

- This capability is not included in Recovery Scope but included for completeness.

ICD-IVS-BOS-005: The type of Gas is Helium and the flow rate will be verified by the field. Drawing DB1482 defines the details of the cooling tubes.

4.6.1.3. Hot Helium - Passive Plates

Interface Notes:

- This capability is not included in Recovery Scope but included for completeness.

ICD-IVS-BOS-006: The type of Gas is Helium and the flow rate will be verified by the field. Drawing DB1482 defines the details of the cooling tubes.

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
1.1.1.2.2-1.3.3.1.3.T	**In Vessel Helium Lines** are used to bring heat into the **OBD** plates during bakeout at surface of helium line, and may in the future be used to extract heat between discharges	See Paragraph 4.9.1, Ref4
1.3.3.1.3-1.1.1.2.1-T	**Heating tubes** used to transfer heat to the **passive plates** during bakeout	See Paragraph 4.9.2, Ref 4

4.9.1. In Vessel Helium Lines - OBD

Interface Notes:

- This capability is not included in Recovery Scope but included for completeness.

ICD-IVS-BOS-007: The temperature in the hot helium tubes exceed 350 degrees C. Based on data in Ref 4 the tiles during bakeout including the ohmic heating reach between from 269 - 281 degrees C.

4.9.2. In Vessel Helium Lines - Passive Plates

ICD-IVS-BOS-008: The temperature in the hot helium tubes exceed 350 degrees C. Based on data in Ref 4 the tiles during bakeout including the ohmic heating reach between from 263 - 282 degrees C.

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. Thermal Eddy/Halo Current Interfaces

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

Identifier	Interface	References
1.1.1.2.1-1.3.3.1.3.E	During disruptions and other transients, current can transfer between the **In-Vessel Helium Lines** and the **Passive Plate** brackets at surface of tubes	See Paragraph 4.10.2.1
1.1.1.2.2-1.3.3.1.3.E	Currents during disruptions can transfer to/from the **OBD** plates and **In-Vessel Helium heating/cooling lines** at surface of heating/cooling line	See Paragraph 4.10.2.2

4.10.2.1. In-Vessel Helium Lines – Passive Plates

Interface Notes:

- A Passive Plate FDR will provide some of the detailed data

ICD-IVS-BOS-009: There is a Halo current that will cross the interface for the Passive plate into the Helium Tube. A calculation is being created and will be included as part of the Passive Plate FDR addressing the loads on the helium tube support structures on the vessel wall.

4.10.2.2. In-Vessel Helium Lines - OBD

Interface Notes:

- This capability is not included in Recovery Scope but included for completeness.

ICD-IVS-BOS-010: There is a Halo current that will cross the interface from the OBD and effect the helium tubes.

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.