In-Vessel Structures - Diagnostics ICD

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REVISION 0

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National Spherical Torus eXperiment Upgrade

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Interface Control Document

IN-VESSEL STRUCTURE–
DIAGNOSTICS

NSTX-U-ICD-IVS-DIA-0

Revision 0
June 18, 2019

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Change Record

Revision	Date	Description of Change
0	June 18, 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, Diagnostics, NSTX-U-RQMT-SRD-011-01

[4] Halo Current Shunt Analysis, NSTXU_1-4-1_CALC_088

1. Purpose

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

2. Scope

The In-Vessel Structures consists of consist of the Passive Plates, Outboard Divertors, and Neutral Beam Armor. The Diagnostics consists Thermocouples, Mirnov sensors and Langmuir probes.. 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
- Diagnostics
- 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-DIA-X] where X is a sequential count beginning with 001, IVS represents In-Vessel Structures and DIA represents Diagnostics. 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 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.

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		
		Me,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, Va, Me, Sw	Vacuum Pumping System		Si	Si	Gf, Si	Si		Si,Va	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		
			Gf,Va	Gf,Va	Ep	Gf,Si			Gas Delivery System	Me	Va		Si,Sw	Si		
		Gf	Si			Si,Gf,Va			Gf	Wall Conditioning System			Si,Sw	Si		
		Me,Va	Me,Va	Me	Me	Gf,Si	Gf			Va, Ep	Diagnostics		Si,Sw	Si		Si
				Ep	Ep	Ep	Ep	Ep	Ep	Ep	Ep	Power Systems	Si	Ep, Si		Ep
					Si					Me, Si	Si		Centralized Instrumentation and Control	Si, Me		
										Sw		Si	Si,Sw	Integrated Machine Operations		
															Operations & Safety Systems	
Me		Me	Me	Me	Me	Me		Me	Me	Me	Me	Me	Me	Me		D-Site Locations (Test Cell

Table 3. Callout

In-Vessel Structures	Me, Di, Pe
	Diagnostics

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
1.1.1.2.1-1.4.1.2.3-S	The **RWM** poloidal field **Sensors** (BP) sensors are supported at the tabs that hold the sensor boxes from the primary **Passive Plates**.	See Paragraph 4.2.1.1, 9D1471, 9D1095, 9D1227
1.1.1.2.1-1.4.1.2.2-S	**Mirnov Sensors** mounted behind and between the **Passive Plates**	See Paragraph 4.2.1.2, Drawing 9D1227

4.2.1.1. RWM Sensors to Passive Plates

ICD-IVS-DIA-001: The RWM Sensors are located on the Primary passive Plates as shown in red on Figure 1. Drawing 9d1095 Sheets 242 provides the Wiring diagram. Drawing 9D1227 provides the backing plate for the B_z coil.

ICD-IVS-DIA-002: The coils will be run in under camfers between the passive plate tiles and the passive plates as shown in red Br sensor in Figure 2 while Bz sensors are shown in green arrows.

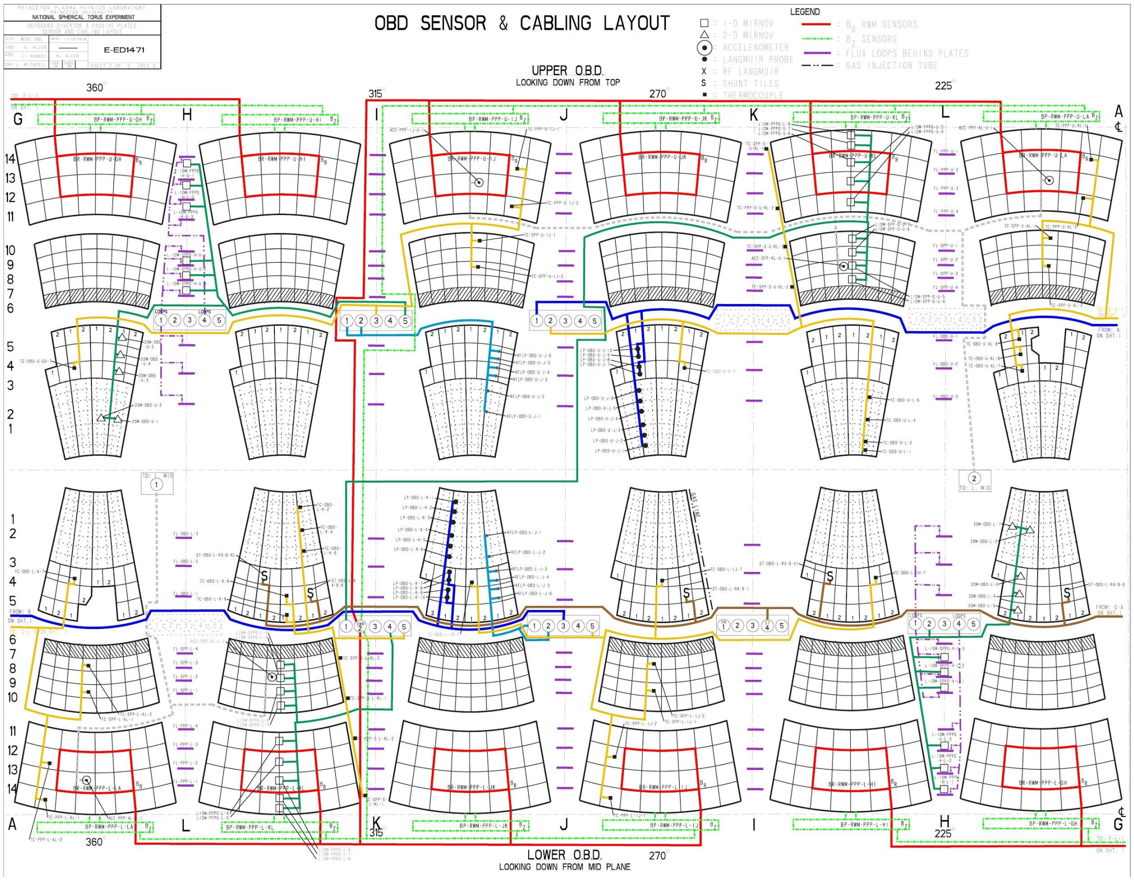

Figure 1. Passive Plate and OBD Sensor Wiring Diagram

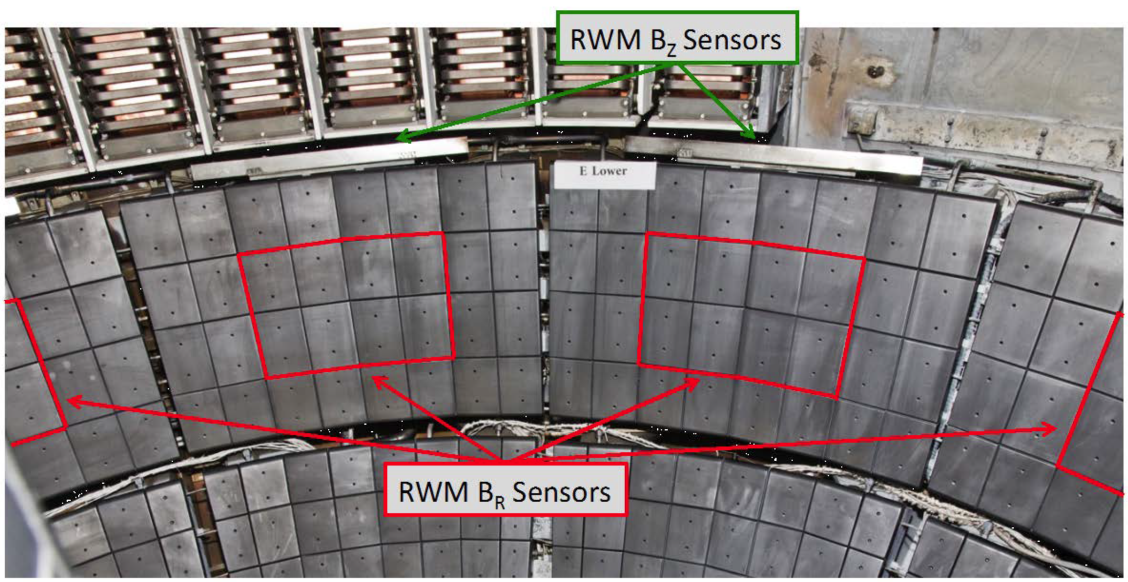

Figure 2. RWM Sensor locations photos

4.2.1.2. Mirnov Sensors to Passive Plates

ICD-IVS-DIA-003: The Large 1D Mirnov Sensors are located behind th3 passive plates as shown in Figure 3.

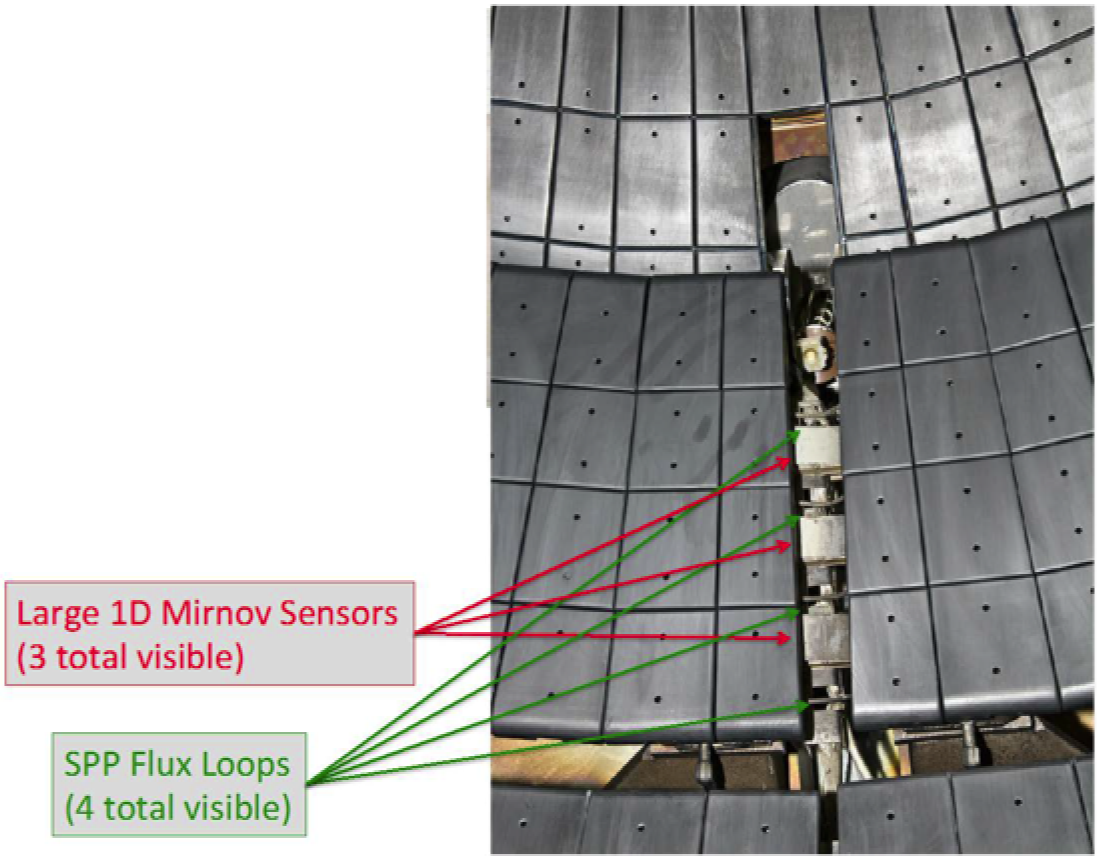

Figure 3. Mirnov sensors and Flux Loops mounted behind the Passive Plates

4.2.2. Spatial Interface

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

Identifier	Interface	References
1.1.1.2.1-1.4.1.14.3	The **Divertor Tangential Imaging (DTI) camera** functions between the primary **Passive plates**	See Paragraph 4.2.2.1, Drawing 9D11323

1.1.1.2.3-1.4.1.8-Sp	Line-of-sight access via Neutral Beam Armor is provided to enable the MSE-LIF neutral beam to enter the plasma	See Paragraph 4.2.2.2
1.1.1.2.2-1.4.1.19-Sp	**Outboard Divertor** gap at large radius into which the **MAPP** probe is inserted for surface science measurements	See Paragraph 4.2.2.3, Drawing ED1384
1.1.1.2.2-1.4.1.5.2-Sp	Cut-out in the **Outboard Divertor** allows diagnostic views of the plasma for the **PCHERS** system	See Paragraph 4.2.2.4, ED1384
1.1.1.2.2-1.4.1.6-Sp	Cut-out in the **Outboard Divertor** allows diagnostic views of the plasma using **FIDA**	See Paragraph 4.2.2.5, ED1384
1.1.1.2.2-1.4.1.13-Sp	Cut-out in the **Outboard Divertor** allows diagnostic views of the plasma using **Visible Spectroscopy**	See Paragraph 4.2.2.6, ED1384
1.1.1.2.2-1.4.1.13.1-Sp	Cut-out in the **Outboard Divertor** allows diagnostic views of the plasma using **Filterscopes**	See Paragraph 4.2.2.7,ED1384
1.1.1.2.2-1.4.1.19-Sp	Cut-out in the **Outboard Divertor** allows **MAPP** probe insertion	See Paragraph 4.2.2.8,ED1384
1.1.1.2.2-1.4.1.20-Sp	Cut-out at the **Outboard Divertors** allows diagnostic views using **Bolometers & Vacuum Radiation Sensors** of the plasma	See Paragraph 4.2.2.9,ED1384
1.1.1.2.2-1.4.1.21.Sp	Cut-out in the **Outboard Divertor** allows diagnostic views using **IR Cameras for Thermography** of the plasma	See Paragraph 4.2.2.10, ED1384

- The Diagnostics pertaining make use of ports on the vessel. The port assignments with the various diagnostic are identified in Figure 4. These gaps in the Outboard Divertor need to remain open to allow diagnostics this include not only outboard divertor locations but cabling runs, and heating/cooling pipes.

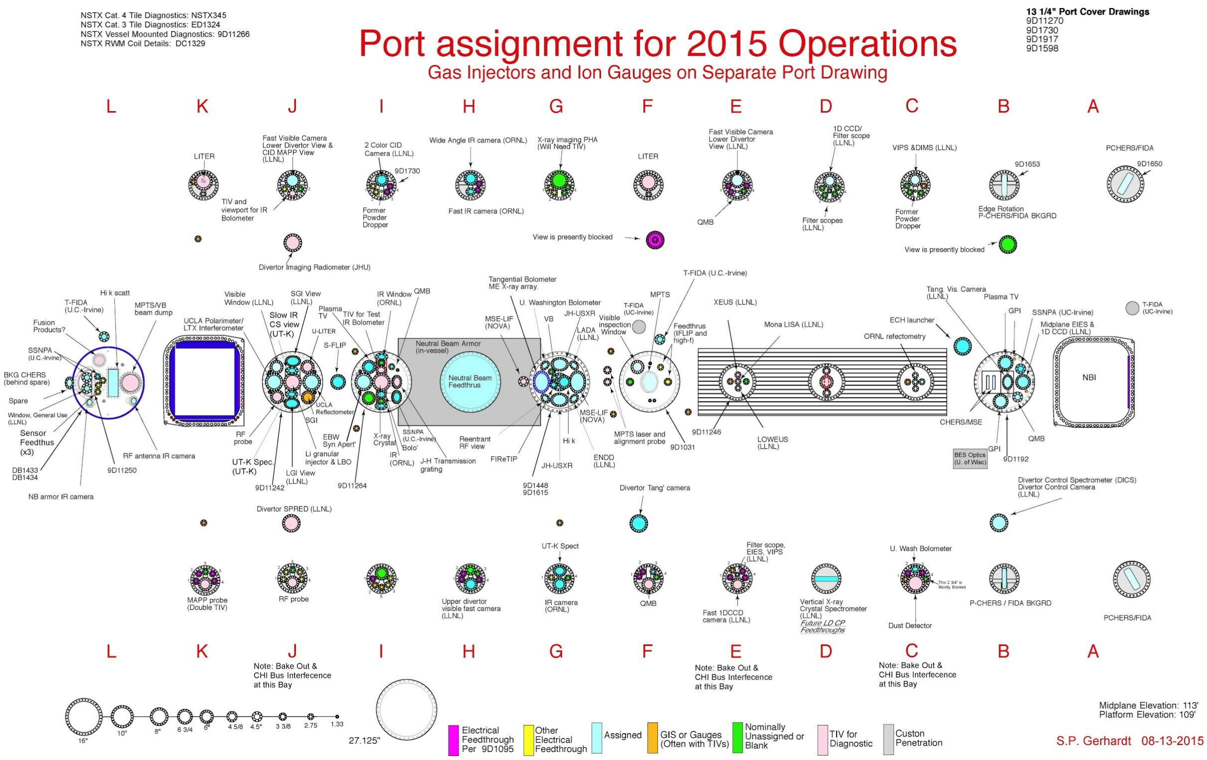

Figure 4. Port Assignments

- Drawing ED1384 is an OBD tile assembly drawing bus is very useful for identifying the gaps between the tiles.

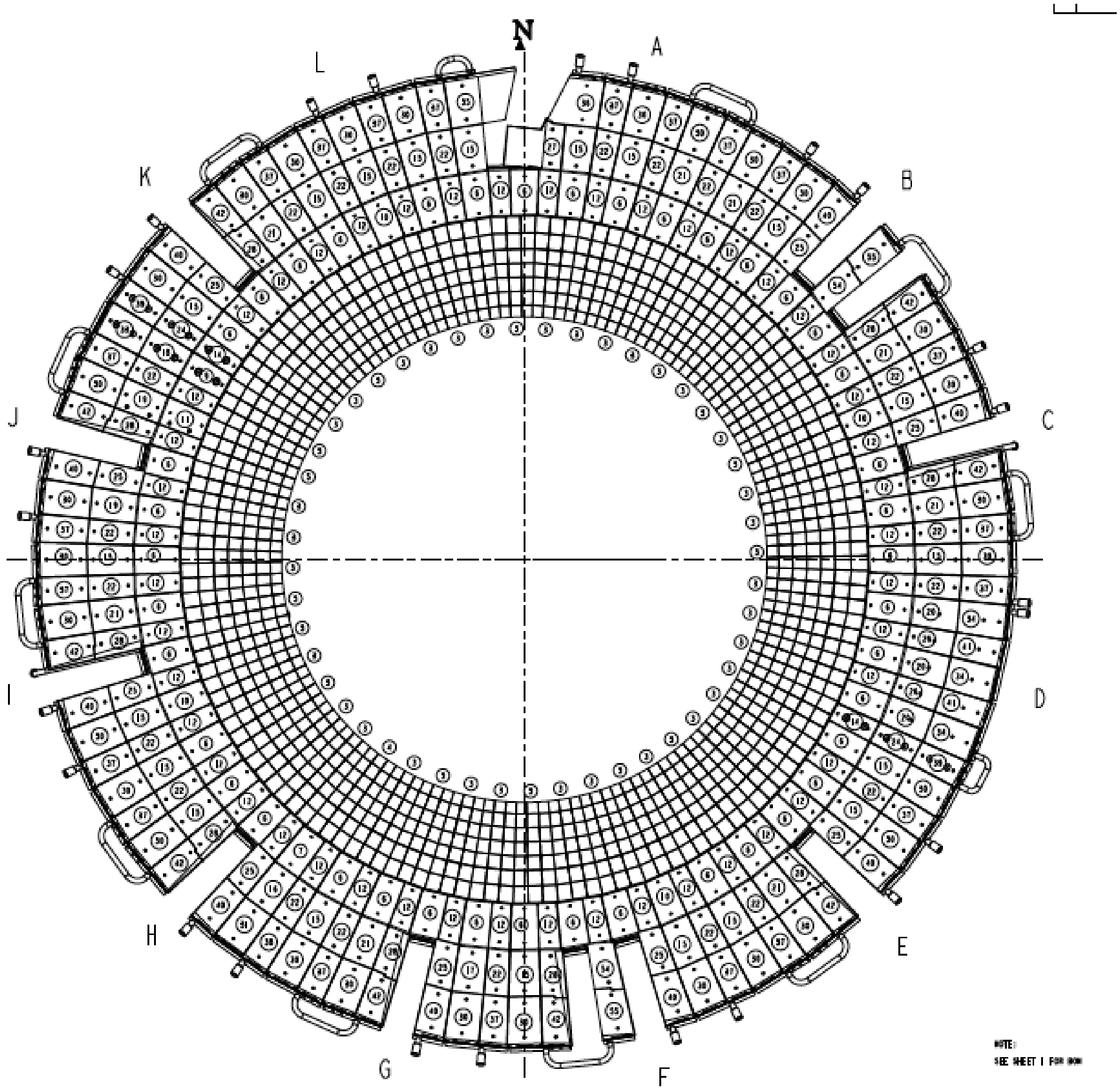

Figure 5. OBD Lower Gaps

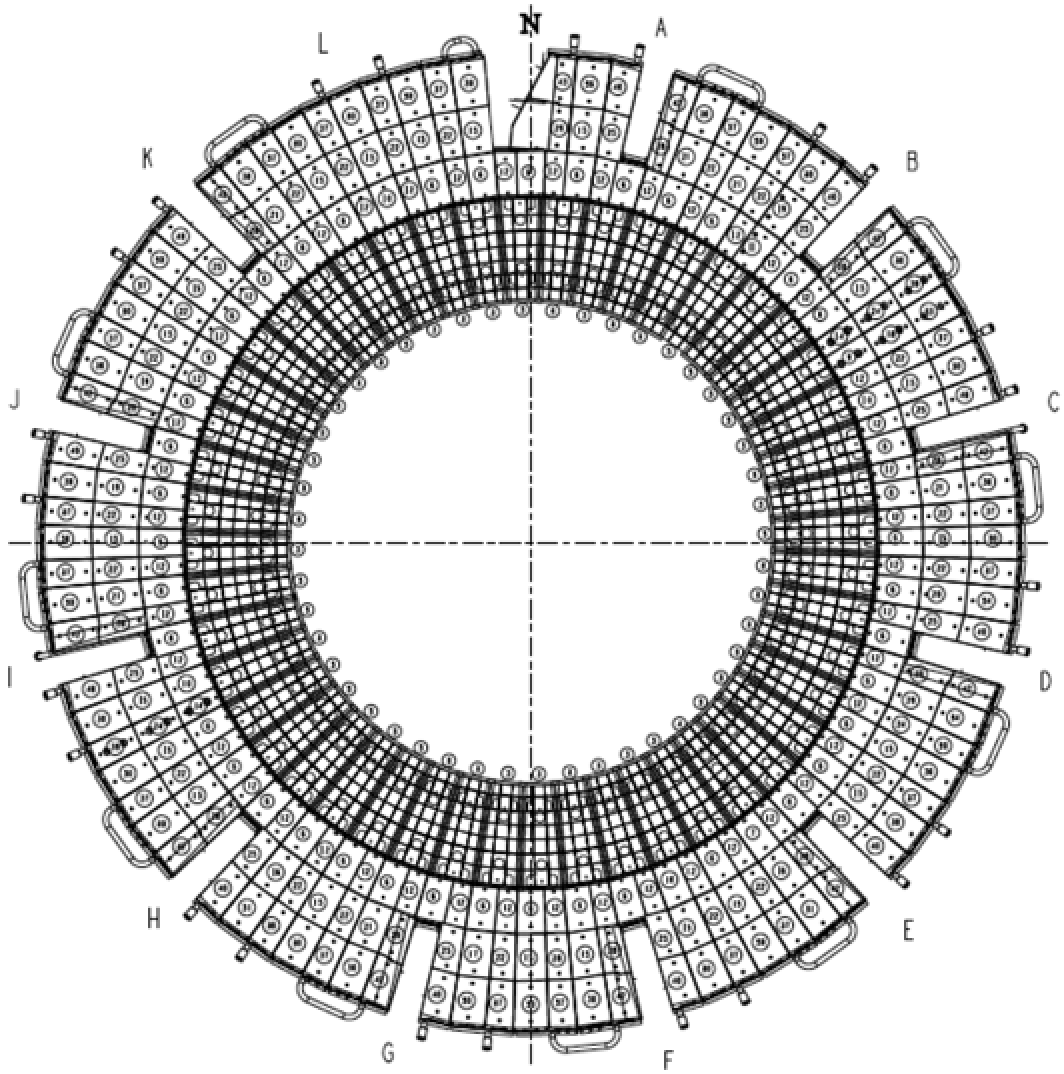

Figure 6. OBD Upper Gaps

- Figure 7 provides a photo of an Outboard Divertor component with a diagnostics cutout.

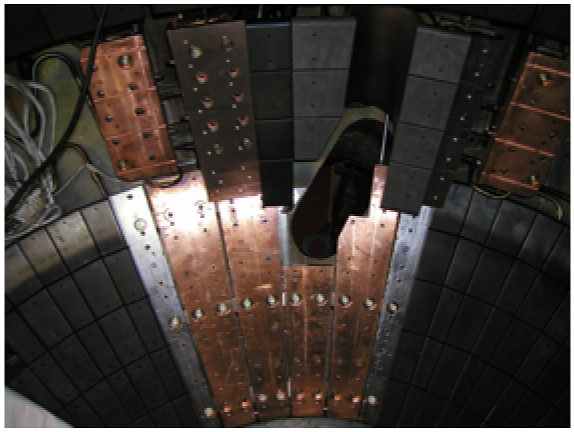

Figure 7. Outboard Divertor w/Cut Out

4.2.2.1. Passive Plates - DTI Camera

Interface Notes:

- The DTI camera is not part of recovery scope but included since the camera interacts with the passive plate component design that is part of Recovery Scope.

ICD-IVS-DIA-004: The DTI enter the vessel aligned to Port F between the midplane and lower ports as shown in Figure 4. The DTI camera fits between the passive plate and a tile gap as shown in Figure 8. Drawing 9D11323 provides a drawing of the DTI camera Assembly

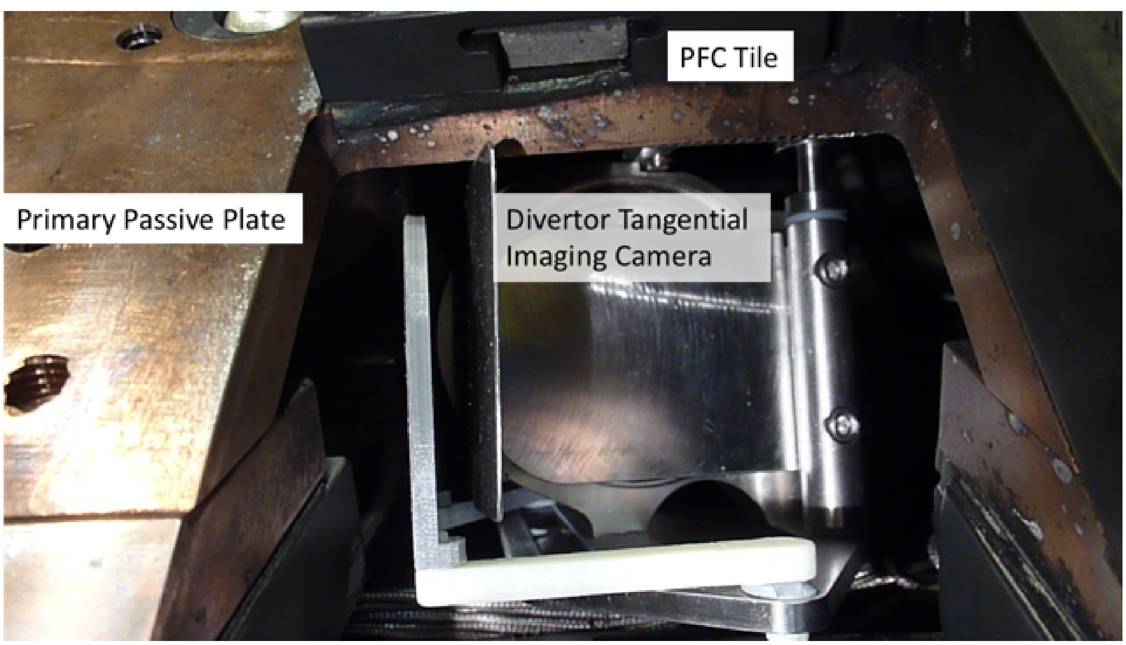

Figure 8. DTI Camera mounted between the passive plates

4.2.2.2. NB Armor to MSE LIF

Interface Notes:

- This is not part of recovery scope but included for completeness.

ICD-IVS-DIA-005: The MSE LIF need to allow gaps to access the NB Armor as shown as Figure 9 in Center Bay H, G, &I. Figure 10 is a photo of the MSE LIF gap (inside the red circle) within the neutral beam armor.

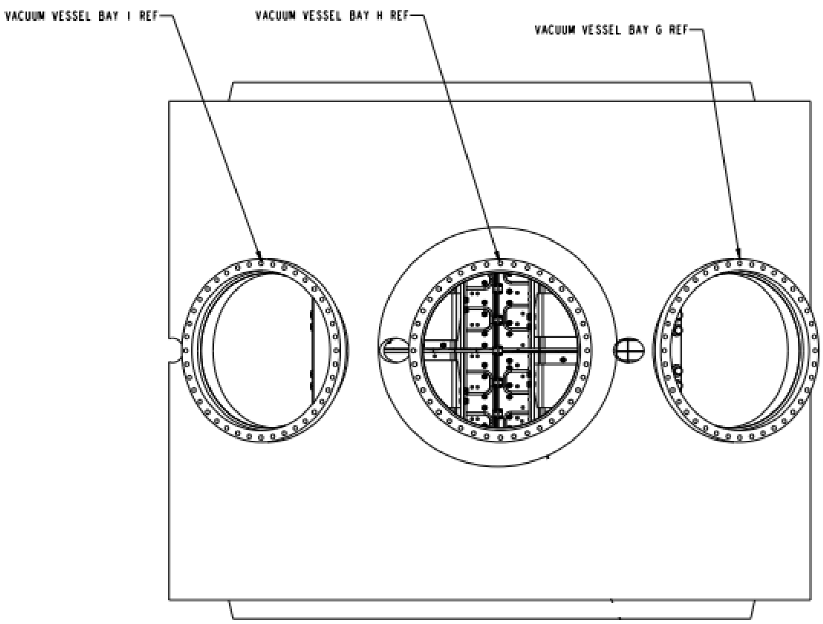

Figure 9. Neutral Beam Armor through the Vessel Ports

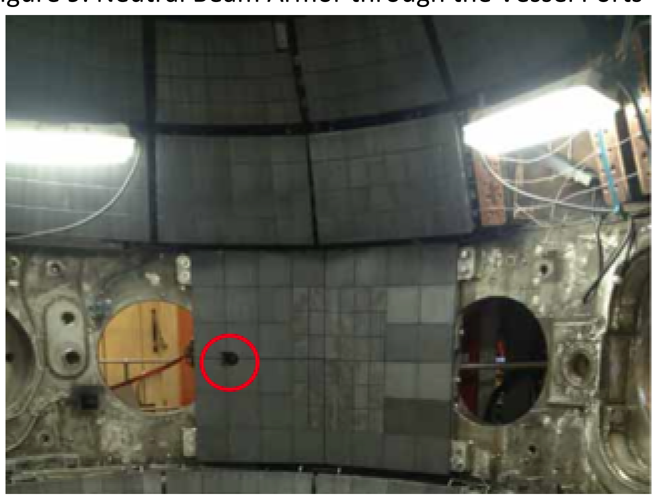

Figure 10. MSE-LIF Gap in Neutral Beam Armor

4.2.2.3. Outboard Divertor to MAPP Probe

Interface Notes:

- This is not part of recovery scope but included for completeness.

ICD-IVS-DIA-006: The Outboard Divertors need to allow gaps in the areas of as shown as Figures 4, 5, & 6 in lower Bay K.

4.2.2.4. Outboard Divertor to PCHERS

Interface Notes:

- This is not part of recovery scope but included for completeness.

ICD-IVS-DIA-007: The Outboard Divertors need to allow gaps in the areas of as shown as Figures 4,5,&6 in lower Bays A&B and Upper Bay A&B.

4.2.2.5. Outboard Divertor to FIDA

Interface Notes:

- This is not part of recovery scope but included for completeness.

ICD-IVS-DIA-008: The Outboard Divertors need to allow gaps in the areas of as shown as Figures 4, 5, & 6 in lower Bays A&B and Upper Bay A&B.

4.2.2.6. Outboard Divertor to Spectroscopy

Interface Notes:

- This is not part of recovery scope but included for completeness.

ICD-IVS-DIA-009: The Outboard Divertors need to allow gaps in the areas of as shown Figures 4, 5, & 6 in lower Bay G.

4.2.2.7. Outboard Divertor to Filterscope

Interface Notes:

- There is likely bakeout interference at the Lower Bay E

ICD-IVS-DIA-010: The Outboard Divertors need to allow gaps in the areas of as shown as Figures 4, 5, & 6 in lower Bay E and Upper Bay D.

4.2.2.8. Outboard Divertor to MAPP

Interface Notes:

- This is not part of recovery scope but included for completeness.

ICD-IVS-DIA-011: The Outboard Divertors need to allow gaps in the areas of as shown Figures 4, 5, & 6 in lower Bay K.

4.2.2.9. Outboard Divertors to Bolometers

Interface Notes:

- This is not part of recovery scope but included for completeness.

ICD-IVS-DIA-012: The Outboard Divertors need to allow gaps in the areas of as shown as Figures 4, 5, & 6 in lower Bay C and Upper Bay J.

4.2.2.10. Outboard Divertor to IR Cameras for Thermography

Interface Notes:

- This is not part of recovery scope but included for completeness.

ICD-IVS-DIA-013: The Outboard Divertors need to allow gaps in the areas of lower Bay G and Upper Bay H as shown as Figures 4, 5, & 6.

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 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
1.1.1.2.1-1.4.1.2.2-D	Poloidal **Flux Loops** mounted in grooves behind the primary and secondary passive plates, used to estimate current flowing in **Passive Plates**	See Paragraph 4.5.1, Drawing 9D1227

4.5.1. Flux Loops to Passive Plates

ICD-IVS-DIA-014: The Flux Loops are mounted the backing plate as shown in drawing 9D1227. Figure 3 provides a photo of the passive plates.

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
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
N/A		

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
1.1.1.2.2-1.4.1.2.8-E	Shunt **Outboard Divertor** tiles measure **Halo Current** flowing through tiles to the divertor slats at surface of divertor	See Paragraph 4.10.2.1, Ref 4

4.10.2.1. Outboard Divertor - Shunt Tiles

ICD-IVS-DIA-015: The Halo Currents that will interact OBD are captured in the Shunt Tiles. The Halo Current are captured in the Halo Current Shunt Analysis [Ref 4].

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.