Interface Control Document PLASMA FACING COMPONENT : DIAGNOSTICS

Interface Document: NSTXU_1-1-1-1_IC_104

REVISION 0

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National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment Upgrade

Interface Control Document

PLASMA FACING COMPONENT: DIAGNOSTICS

NSTX-U-ICD-006-PFC-DIAG-00

Revision 0
May 9, 2018

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Change Record

Revision	Date	Description of Change
0	May 9, 2018	Initial Release

References

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

[2] SYSTEM REQUIREMENTS DOCUMENT, Plasma Facing Components, NSTX-U-RQMT-SRD-003-01.

[3] SYSTEM REQUIREMENTS DOCUMENT, Diagnostics, NSTX-U-RQMT-SRD-011-01.

[4] Halo Current Shunt Analysis, NSTXU_1_4_1_CALC_012

1. Purpose

This document describes the various interfaces between the following subsystems: Plasma Facing Components and the Diagnostics. The interface locations and boundaries that connect the Plasma Facing Component to the Diagnostics are identified based on different interface types.

2. Scope

The Plasma Facing Components consist of Center Stack First Wall, Center Stack Angle Section, Vertical and Horizontal Targets, Outboard Divertor, Passive Plates, and Neutral Beam Armor. The Diagnostics consists of Neutron measurements, Magnetics, Multi-pulse Thompson Scattering (MPTS), Plasma TV, CHERS, Langmuir probes, spectroscopy, FIDA, BES, MSE, High-K Scattering, and microwave diagnostics, among other instrumentation and diagnostics. The diagnostics consist of those embedded within the PFC and those where gaps are required between the PFCs. The scope of this document addresses any defined interfaces between these identified system elements.

3. Responsibilities

The interfaces are managed between the following organizations:

- Plasma Facing Components
- Diagnostics
- Systems Engineering and Integration

4. Interfaces

Interface requirements in the following sections are identified with the requirement prefix, ICD followed by a number [ICD-PFC-DIA-X]. “X” is a sequential count beginning with 001, “PFC” represents Plasma Facing Components, 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 that 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.

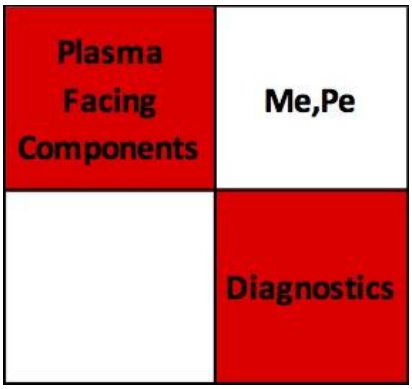
Heading	Abbreviation	Name
4.2	Me	Mechanical
4.3	Ep	Electrical Power
4.4	Si	Signal
4.5	Di	Diagnostics
4.6	Gf	Gas/Fluid
4.7	Va	Vacuum
4.8	Sw	Software
4.9	Th	Thermal
4.10	Pe	Plasma/Eddy/Halo Current

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, Va	Me	Me, Th, Pe	Me	Me,Va	Me,Di, Va		Si	Di,Si		
		Va	Centerstack Structure			Va, Th	Me, Gf	Me	Me	Me				Di		
		Me	Me, Th, Ep	Magnets				Me			Di		SI	Di		
Si		Me, Va			Heating Systems		Gf	Th		Me		Gf, Si	Si	Si	Si	
					Si, Va, Me, Sw, Gf	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, Me	
			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.



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 interface to include a structural, spatial, location, dependent interfaces, or areas where penetrations into 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
N/A		

4.2.2. Spatial Interface

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

Identifier	Interface	References
1.1.1.1.6- 1.4.1.2.3-Sp	**RWM BR sensors** on primary **Passive Plate** front surface, supported by machined features in tiles; RWM Bp sensors supported tab inserted under T-bars that support the tiles.	See 4.2.2.1. Drawing ED1471
1.1.1.1.5- 1.4.1.2.2-Sp	**Mirnov coil**s are installed in the **Outboard Divertor PFCs** tiles.	See 4.2.2.2 Drawing ED1471

1.1.1.1.5-1.4.1.17.0-Sp	**Langmuir Probes** are installed in the **Outboard Divertor PFC** tiles.	See 4.2.2.3 Drawing ED1471
1.1.1.1.5-1.4.1.13.0-Sp	Many plasma **Visible Spectroscopy** diagnostics view through gaps in the **OBD** in rows 4 & 5, having their field of view set by the edges of tiles.	See 4.2.2.4. Drawing ED1384
1.1.1.1.5-1.4.1.14.0-Sp	Many plasma **Physics Imaging System** diagnostics view through gaps in the **OBD** in rows 4 & 5, having their field of view set by the edges of tiles.	See 4.2.2.5, Drawing ED1384
1.1.1.1.4-1.4.1.2.2-Sp	**Mirnov Coils** installed in or between the **Horizontal Target PFC** tiles.	See 4.2.2.6 Drawing 9D11556,ED1469 .
1.1.1.1.4-1.4.1.17.0-Sp	**Langmuir Probes** are installed in or between the **Horizontal Target PFC** tiles.	See 4.2.2.7 Drawing 9D11556, ED1442.
1.1.1.1.3-1.4.1.2.2-Sp	**Mirnov Coils** embedded in **Vertical Target PFC** tiles.	See 4.2.2.8 Drawing 9D11556, ED1395 .
1.1.1.1.3-1.4.1.17.0-Sp	**Langmuir Probes** embedded in or in between **Vertical Target PFC** tiles.	See 4.2.2.9 Drawing 9D11556, 9D11170, ED1447, ED1395, 9D11170, ED1474
1.1.1.1.1-1.4.1.2.2-Sp	**Mirnov Coils** are embedded in **Center Stack First Wall PFC** tiles.	See 4.2.2.10 Drawing 9D11556, ED1391.
1.1.1.1.1-1.4.1.17.0-Sp	**Langmuir Probes** are located in or between **Center Stack First Wall PFC** tiles.	See 4.2.2.11 Drawing 9D11556, ED1391.

1.1.1.1.1- 1.4.1.2.8-Sp	Current **Shunt Tile** added to the **CSFW** set of tiles	See 4.2.2.12 Drawing 9D11556,9D11553 .
1.1.1.1.5- 1.4.1.5.2-Sp	Cut-out allows diagnostic views of the plasma for the **PCHERS** system in the **Outboard Divertor PFCs**.	See 4.2.2.13, Drawing ED1384
1.1.1.1.5- 1.4.1.6.0-Sp	Cut-out allows **FIDA** diagnostic views of the plasma at the **Outboard Divertor PFCs**.	See 4.2.2.14, Drawing ED1384
1.1.1.1.5- 1.4.1.13.1-Sp	Cut-out allows **Filterscope** diagnostic views of the plasma through the **Outboard Divertor PFCs**.	See 4.2.2.15, Drawing ED1384
1.1.1.1.5- 1.4.1.19-Sp	Cut-out allows **MAPP** probe insertion **Outboard Divertor PFCs**.	See 4.2.2.16, Drawing ED1384, 9D11059
1.1.1.1.5 -1.4.1.20.0-Sp	Cut-out allows **Bolometers & Vacuum Radiation Sensors** diagnostic views of the plasma at the **Outboard Divertor PFCs**.	See 4.2.2.17, Drawing ED1384
1.1.1.1.5- 1.4.1.21.0-Sp	Cut-out around **Outboard Divertor** PFCS allows diagnostic views of the plasma using **IR Cameras for Thermography**.	See 4.2.2.18, Drawing ED1384
1.1.1.1.2- 1.4.1.2.8.0-Sp	Space behind **CSAS PFC** tiles for the **Halo Rogowskis** to reside.	See 4.2.2.19 Drawing 9D11556 .
1.1.1.1.3- 1.4.1.2.8.0-Sp	Space behind **Vertical Target PFC** tiles for the **Halo Rogowskis** to reside.	See 4.2.2.20 Drawing 9D11556, 9D11550.
1.1.1.1.5- 1.4.1.2.8-Sp	**Halo Current Shunts** are embedded in **Outboard Divertor** tiles.	See 4.2.2.21 Drawing 9D11556,

1.1.1.1.4-1.4.1.13-Sp	**Spectroscopy diagnostics** view through cutouts in some **horizontal target tiles.**	See 4.2.2.22, Drawing ED1384

Interface Notes:

- Drawing 9D11556 (shown as Figure 1) provides the sensor types and locations for all Center Stack sensors and is used for many interfaces. It is included one time at the beginning to provide a reference rather than repeating the figure multiple times.
- The OBD sensor locations are captured in Drawing ED1471, as shown in Figure 2.
- Many of the interfaces require clearance at the OBD to allow sensors to access to the plasma in the vessel. Figure 3 provides the port assignments for the diagnostic access.

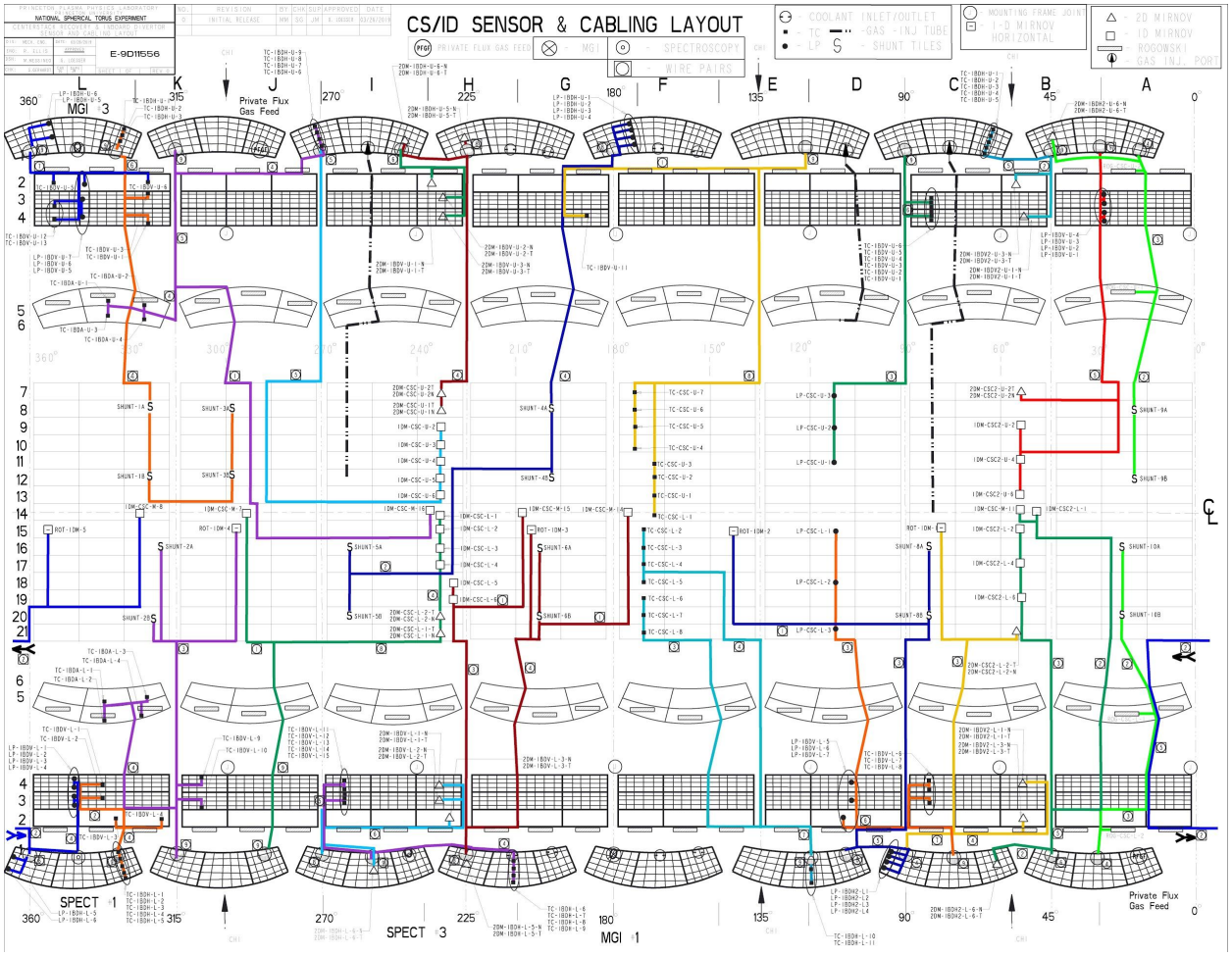


Figure 1. Center Stack Sensor Locations.

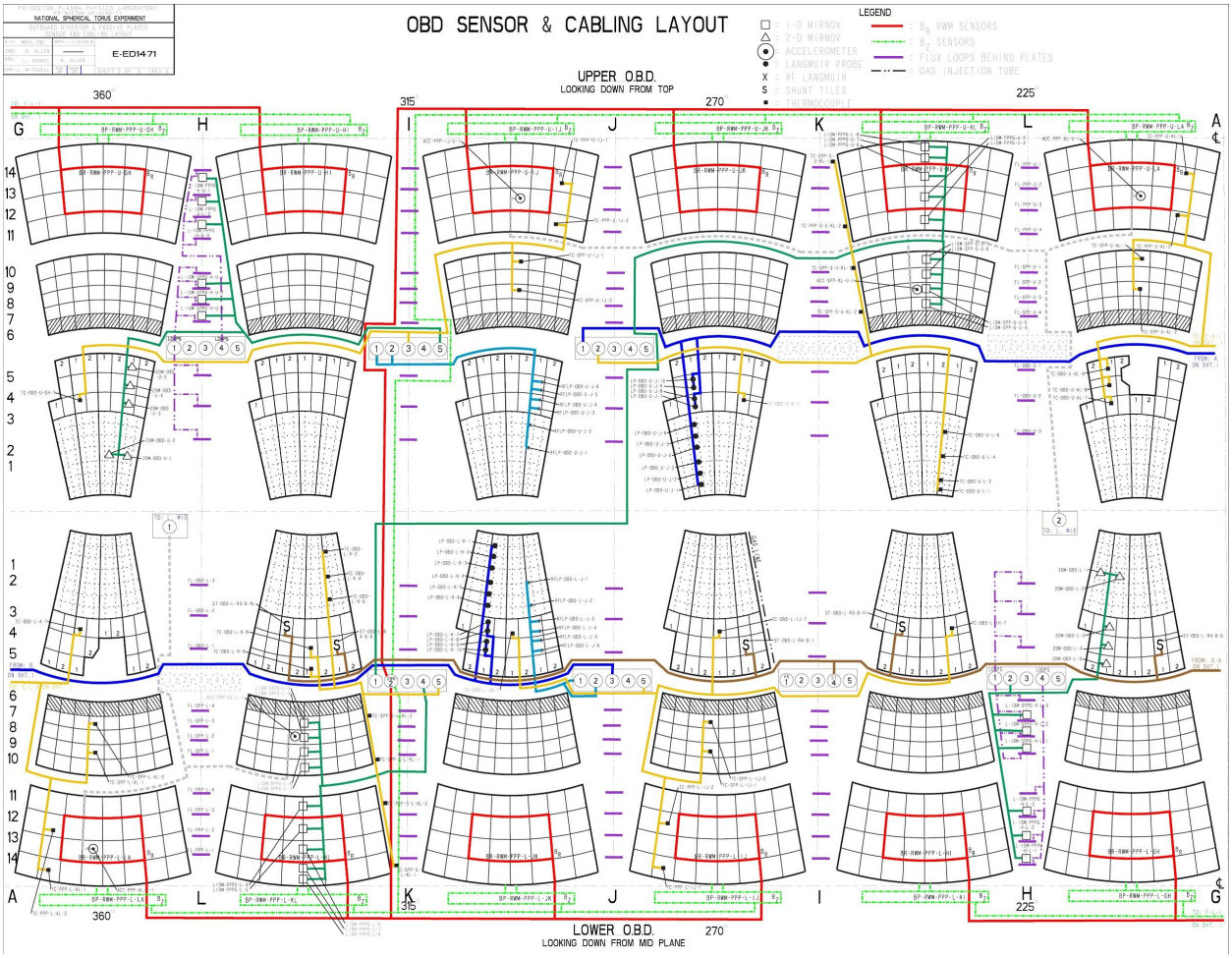


Figure 2. OBD Upper and Lower Sensor Locations.

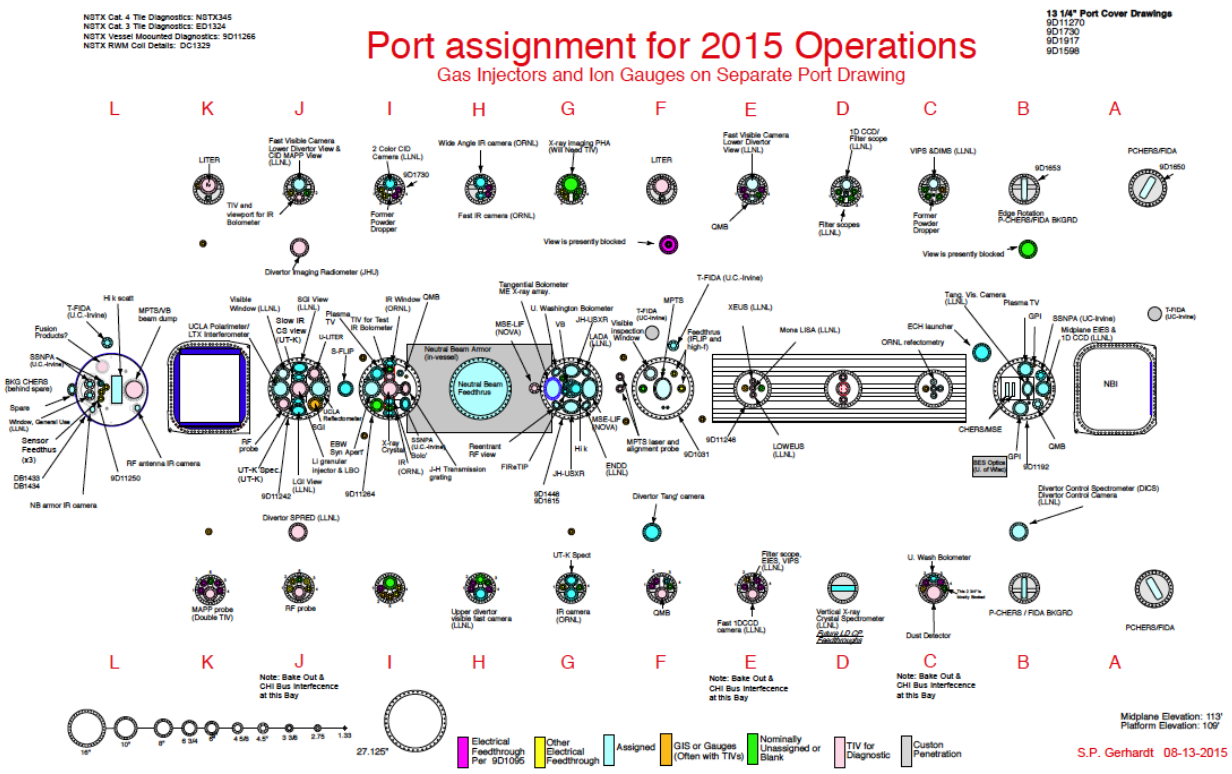


Figure 3. Port Assignment.

4.2.2.1. RWM BR - Passive Plates

ICD-PFC-DIA-001: The RWM BR sensors are located in red in Figure 2.

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4.2.2.2. Mirnov - Outboard Divertor

ICD-PFC-DIA-002: The Mirnov sensors are identified on the OBD as outlined in Drawing ED1471, shown in Figure 2. The 2D Mirnov assembly for Rows 1 & 2 shown in drawing ED1408 Sheet 1 Section QQ is included in Drawing 1408. Row 3 is represented in Drawing 1402 & 1403. Row 4&5 is represented in Drawing 1404 & 1406, respectively Drawing 1401 Is the tile assembly including diagnostics.

ICD-PFC-DIA-003: A pocket exists to house the Mirnov tiles as shown in Figure 4.

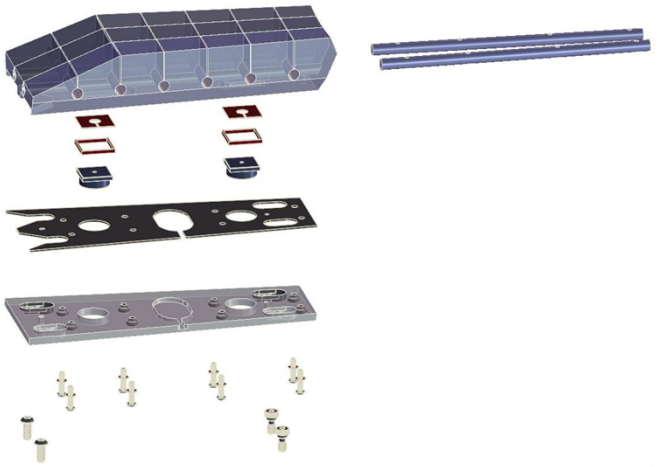

Figure 4. Mirnov Space for OBD.

4.2.2.3. Langmuir Probes - Outboard Divertor

ICD-PFC-DIA-004: The Langmuir Probe sensors are identified on the OBD as outlined in Drawing Drawing ED1471, shown in Figure 2. Drawing 1401 Is the tile assembly including diagnostics.

ICD-PFC-DIA-005: The Langmuir Probe sensor tiles for OBD Rows 1/2 uses a rail type design as shown in Figure 5. For the low Heat flux regions of OBD rows 3/4, threaded plug screws into tile and the plug and probe are made from isotropic graphite.

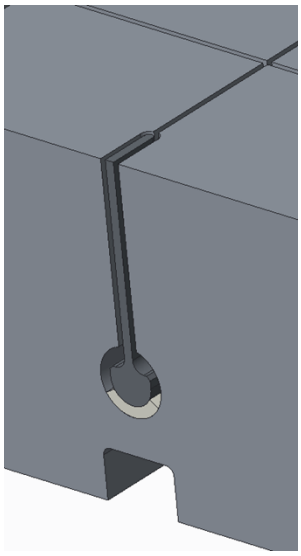

Figure 5. Langmuir probe to OBD Rows 1/2.

4.2.2.4. Visible Spectroscopy - Outboard Divertor

ICD-PFC-DIA-006: The Visible Spectroscopy will access the plasma in G lower as shown in Figure 3. Drawing ED1384 provides the layout of the Outboard Divertor.

4.2.2.5. Physics imaging - Outboard Divertor

ICD-PFC-DIA-007: The X-ray Imaging G upper will access the plasma as shown in Figure 3. Drawing ED1384 provides the layout of the Outboard Divertor with the various gaps labeled.

4.2.2.6. Mirnov - IBDH

ICD-PFC-DIA-008: The 2D Mirnov sensor locations are identified by triangles in Drawing 9D11556, as shown in Figure 1. Drawing ED1469 provides the assembly.

ICD-PFC-DIA-009: The 2D Mirnov sensors have pockets for the sensor as shown in Figure 6.

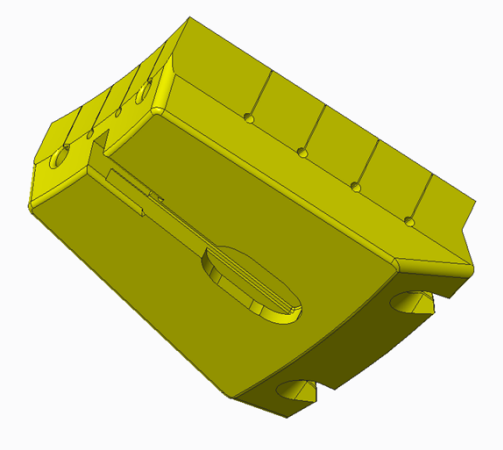

Figure 6. Mirnov IBDH Tile.

4.2.2.7. Langmuir Probe - IBDH

ICD-PFC-DIA-010: The Langmuir Probe sensor locations are indicated by black dots in Drawing 9D11556

as shown in Figure 1. The Assembly is shown in Drawing ED1442.

ICD-PFC-DIA-011: The Langmuir Probe sensor tiles uses a rail type design as shown in Blue in Figure 7.

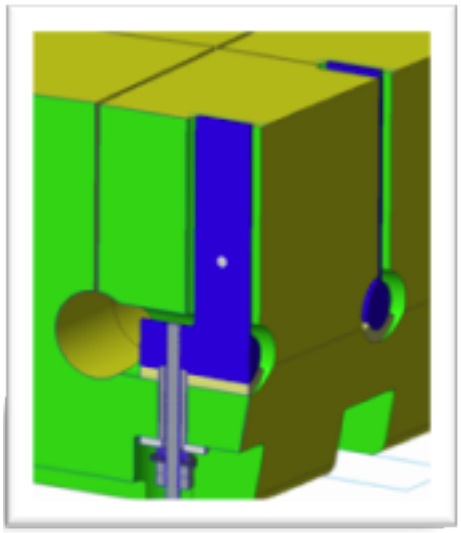

Figure 7. Langmuir Probe tile for IBDH.

4.2.2.8. Mirnov - IBDV

ICD-PFC-DIA-012: The 2D Mirnov sensor locations are identified by triangles in Drawing 9D11556, as shown in Figure 1.

ICD-PFC-DIA-013: The 2D Mirnov sensor tile (Blue) fits the sensor (Black) into the tile as shown in Figure 8.

Figure 8. Mirnov Sensor Tiles for IBDV.

4.2.2.9. Langmuir Probe - IBDV

ICD-PFC-DIA-014: The Langmuir Probe sensor locations are by black dots in Drawing 9D11556 as shown in Figure 1. Drawing 9D11170, ED1474 provides the Assembly.

ICD-PFC-DIA-015: The Langmuir Probe sensor tiles are shown in Figure 9.

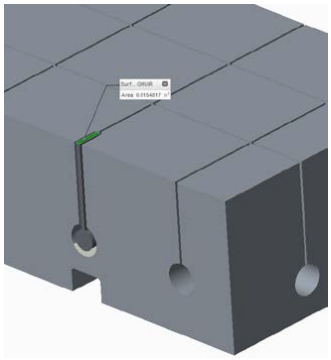

Figure 9. Langmuir Probe tile for IBDV.

4.2.2.10. Mirnov - CSFW

ICD-PFC-DIA-016: The 2D Mirnov sensor locations are identified by triangles, 1D identified by square, and ROT Mirnov Sensors represented by a square box with a dash in the center in Drawing 9D11556, as shown in Figure 1. Drawings ED1389 & ED1390 define the various first wall tiles.

ICD-PFC-DIA-017: The Mirnov sensor, Both 1D and 2D tiles are shown in Figure 10. The left tile represents the tile two two Mirnovs. The center tile represents Mirnov ROT, and the right represents the single Mirnove. Note: there is another tile that contains both a Mirnov sensor and a thermocouple.

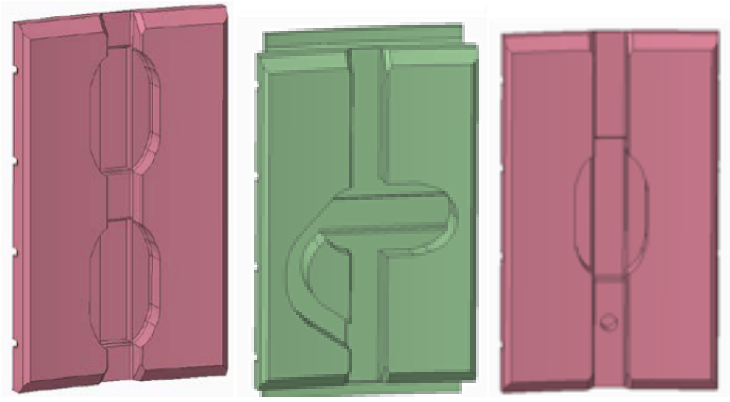

Figure 10. CSFW 2-Mirnov.

4.2.2.11. Langmuir Probe - CSFW

ICD-PFC-DIA-018: The Langmuir Probe sensor locations are indicated by black dots in Drawing 9D11556, as shown in Figure 1. Drawings ED1389 & ED1390 define the various first wall tiles.

4.2.2.12. Shunt - CSFW

ICD-PFC-DIA-019: The Shunt tile locations are indicated in Drawing 9D11556, as shown in Figure 1. Drawing 9D11553 provides the Center Stack Shunt Assembly.

4.2.2.13. PCHERS - OBD

ICD-PFC-DIA-020: The PCHERS will view the plasma via Bays A upper and A lower as shown in Figure 3. Drawing ED1384 provides the layout of the Outboard Divertor with the various gaps labeled.

4.2.2.14. FIDA - OBD

ICD-PFC-DIA-021: The FIDA will view the plasma via Bays A upper and B lower as shown in Figure 3. Drawing ED1384 provides the layout of the Outboard Divertor with the various gaps labeled.

4.2.2.15. Filterscope - OBD

ICD-PFC-DIA-022: The Filterscope will view the plasma via Bay D upper as shown in Figure 3. Drawing Drawing ED1384 provides the layout of the Outboard Divertor with the various gaps labeled.

4.2.2.16. MAPP - OBD

ICD-PFC-DIA-023: The MAPP will view the plasma via Bays J upper and K lower as shown in Figure 3. Drawing ED1384 provides the layout of the Outboard Divertor with the various gaps labeled. Drawing 9D11059 provides the MAPP Top Level Assembly.

4.2.2.17. Bolometers & Vacuum Rad Sensors - OBD

ICD-PFC-DIA-024: The bolometer will access the plasma via Port C lower and J Upper and a Radiometer J Mid upper as shown in Figure 3. Drawing ED1384 provides the layout of the Outboard Divertor with the various gaps labeled.

4.2.2.18. IR Camera - OBD

ICD-PFC-DIA-025: The IR camera views the lower divertor through the Wide and Fast IR cameras in the vessel via Port H upper, the lower divertor through the Port G lower IR Camera, as shown in Figure 3. Drawing ED1384 provides the layout of the Outboard Divertor with the various gaps labeled.

4.2.2.19. Center Stack Halo Current Rogowski Coil - CSAS

Interface Notes:

- Rogowski coil resides under the CSAS tiles and against the Center Stack.

ICD-PFC-DIA-026: The Rogowski is represented by a rectangle with a diagonal line fill in Drawing 9D11556 as shown in Figure 1. The CSAS has Rogowski coils that are routed under the CSAS tile as shown by the yellow circle in Figure 11 and 12. Similarly, Figure 12 provides a plan view gold band in the center of the figure shows the view from the top with the tiles removed how the coil connects to the center stack caning in the mauve color at the bottom of the figure.

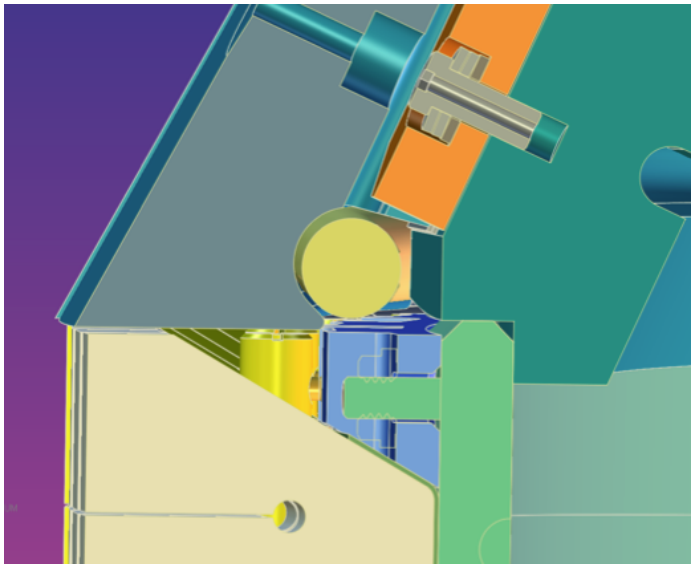

Figure 11. CSAS Rogowski Cutaway View.

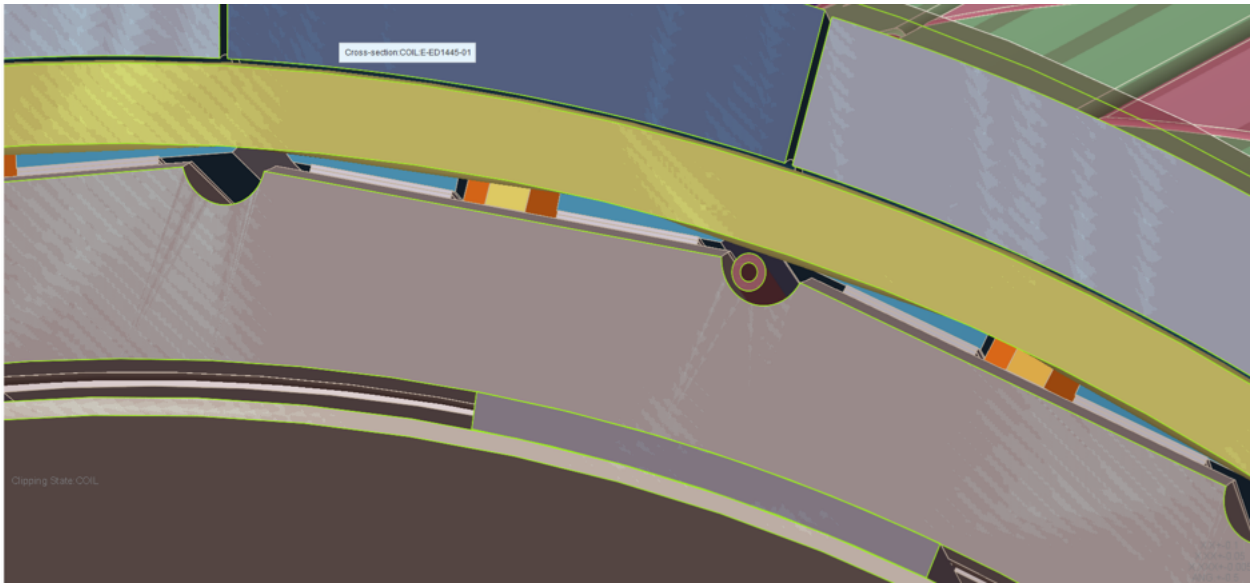

Figure 12. CSAS Rogowski Plan View.

4.2.2.20. Center Stack Halo Current Rogowski Coil and IBDV

ICD-PFC-DIA-027: The Rogowski is represented by a rectangle with a diagonal line fill in Drawing 9D11556 as shown in Figure 1. The Rogowski coils that are routed under the IBDV and adjacent

to the IBDH as shown in Figure 13. Drawing 9D11550 provides a clamp (shown in Figure 12 in Red and Green) that is secured to the stud on the Center Stack shown in grey.

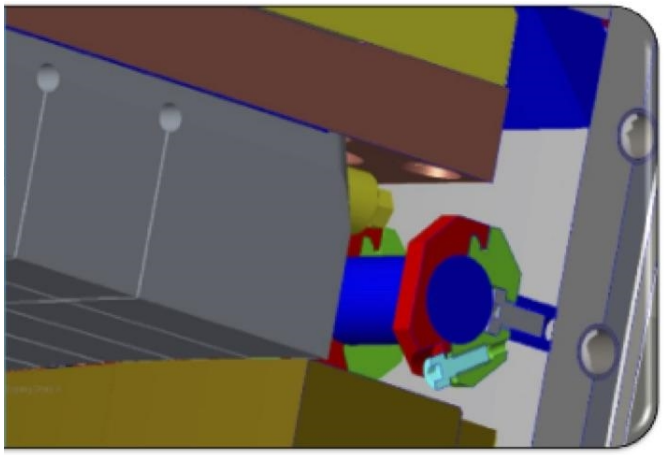

Figure 13. Rogowski located between the IBDV and IBDH

4.2.2.21. Shunt Tiles - IBDV

ICD-PFC-DIA-028: The Shunt Tiles are located in Rows 3-4 of the OBD Tile in Drawing ED1471. The Shunt Tile is shown in Figure 14.

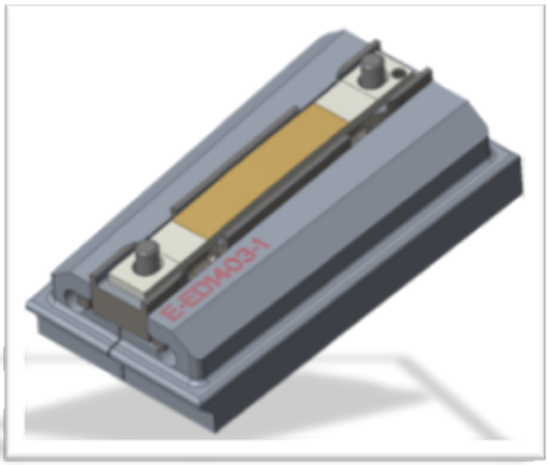

Figure 14. Shunt Tile

4.2.2.22. Spectroscopy and IBDH

ICD-PFC-DIA-029: There Spectroscopy represented by SPEC 1 and SPAC 3 in Drawing 9D11556.

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 gas (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 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 Eddy/Halo Currents.

Identifier	Interface	References
1.1.1.1.5-1.4.1.2.8.E	Shunt **Outboard Divertor PFC** tiles are installed in or under select tiles to measure **Tile Halo Current.**	See Paragraph 4.10.2.1, Ref 4

4.10.2.1. OBD PFCs

ICD-PFC-DIA-030: The expected Halo current expected at the interface is identified in the Halo Current Shunt Analysis Ref 4.

1. 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.