Interface Control Document PLASMA FACING COMPONENTS : GAS DELIVE

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National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment Upgrade

Interface Control Document

PLASMA FACING COMPONENTS: GAS DELIVERY SYSTEM

NSTX-U-ICD-004-PFC-GDS-00

Revision 0
April 16, 2018

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Change Record

Revision	Date	Description of Change
0		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, AUXILIARY SYSTEMS, NSTX-U-RQMT-SRD-005-01.

[4] In-Vessel Divertor Gas Injection Brief, June 2013.

1. Purpose

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

2. Scope

The Plasma Facing Components consist of the tiles and support structures of the Outboard Divertor, Inboard Divertor Vertical, Center Stack First Wall, Center Stack Angled Section, and Inboard Divertor Horizontal. The Gas Delivery System consists of an Outboard Divertor injections system, Massive Gas Injectors, High Field Side Injectors, and Private Flux Region Fueling. 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
- Gas Delivery System
- 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-GDS-X]. “X” is a sequential count beginning with 001, “PFC” represents Plasma Facing Components, and “GDS” represents Gas Delivery 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. 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, 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.

PFC	Me
	Gas Delivery 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 structural, spatial, and 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
1.1.1.1.5-1.3.4.2.3-Sp	Provision **Outboard Divertor PFC** tile to run tubes to the **Outboard Divertor Injection System** for gas fueling, including provision of an orifice.	See Paragraph 4.2.2.1 Reference 4 Drawings EA3517, ED1384
1.1.1.1.4-1.3.4.3.1-Sp	Provision **Horizontal Target PFCs** tiles or backing structures to run tubes for shoulder and midplane **High Field Side Injection** lines.	See Paragraph 4.2.2.2 Drawings EA3517, 9D11556.ED1391.

1.1.1.1.3-1.3.4.3.1-Sp	Provision **Vertical Target PFC** tiles or backing structures to run tubes for shoulder, midplane, and divertor gas **High Field Side Injection** lines.	See Paragraph 4.2.2.3 Drawings EA3517, 9D11556,ED1391.
1.1.1.1.2-1.3.4.3.1-Sp	Provision **CSAS PFC** tiles for i) shoulder **High Field Side injector** gas lines and outlets ii) midplane **High Field Side injector** gas lines.	See Paragraph 4.2.2.4 Drawings EA3517, 9D11556,ED1391.
1.1.1.1.1-1.3.4.3.1-Sp	**CSFW PFC** tiles shall have provision **High field side injectors** for tube routing and gas deliver orifices.	See Paragraph 4.2.2.5 Drawings EA3517, 9D11556,ED1391.
1.1.1.1.4-1.3.4.2.5-Sp	Gas from **Private Flux Region Fueling injectors** passes through holes in **Horizontal Target PFCs.**	See Paragraph 4.2.2.6. Drawings EA3517, 9D11556, ED1391.
1.1.1.1.4-1.3.4.3.2-Sp	Gas from **Massive Gas Injector** (MGI) valves passes through holes in **Horizontal Target PFCs.**	See Paragraph 4.2.2.7 Drawings EA3517, 9D11556, ED1391.

4.2.2.1. Outboard Divertor to Outboard Divertor Injector

Interface Notes:

- There is a notch cut out of the outboard divertor to allow the clearance for the gas lines.

ICD-PFC-GDS-001: The PFCs need to accommodate the tubing: TUBING, 1/2"O.D. W/.020 WALL MODIFIED TYPE 2 as shown reference 4. There are two lines located: Upper at Bays K, F and G

and Lower at Bays C & I from ED-1384. Figure 1 provides a view of the Gas Delivery Line is marked by the red ellipse.

Figure1. Gas Delivery Line

ICD-PFC-GDS-002: The gas delivery tubing is located between tiles. The current design mechanism is to “puff” gas in the CHI gap.

4.2.2.2. Horizontal Target PFCs to High field side injectors

Interface Notes:

- Tubes run in the existing wireways as shown in Drawing 9D11556 represented as Figure 2.

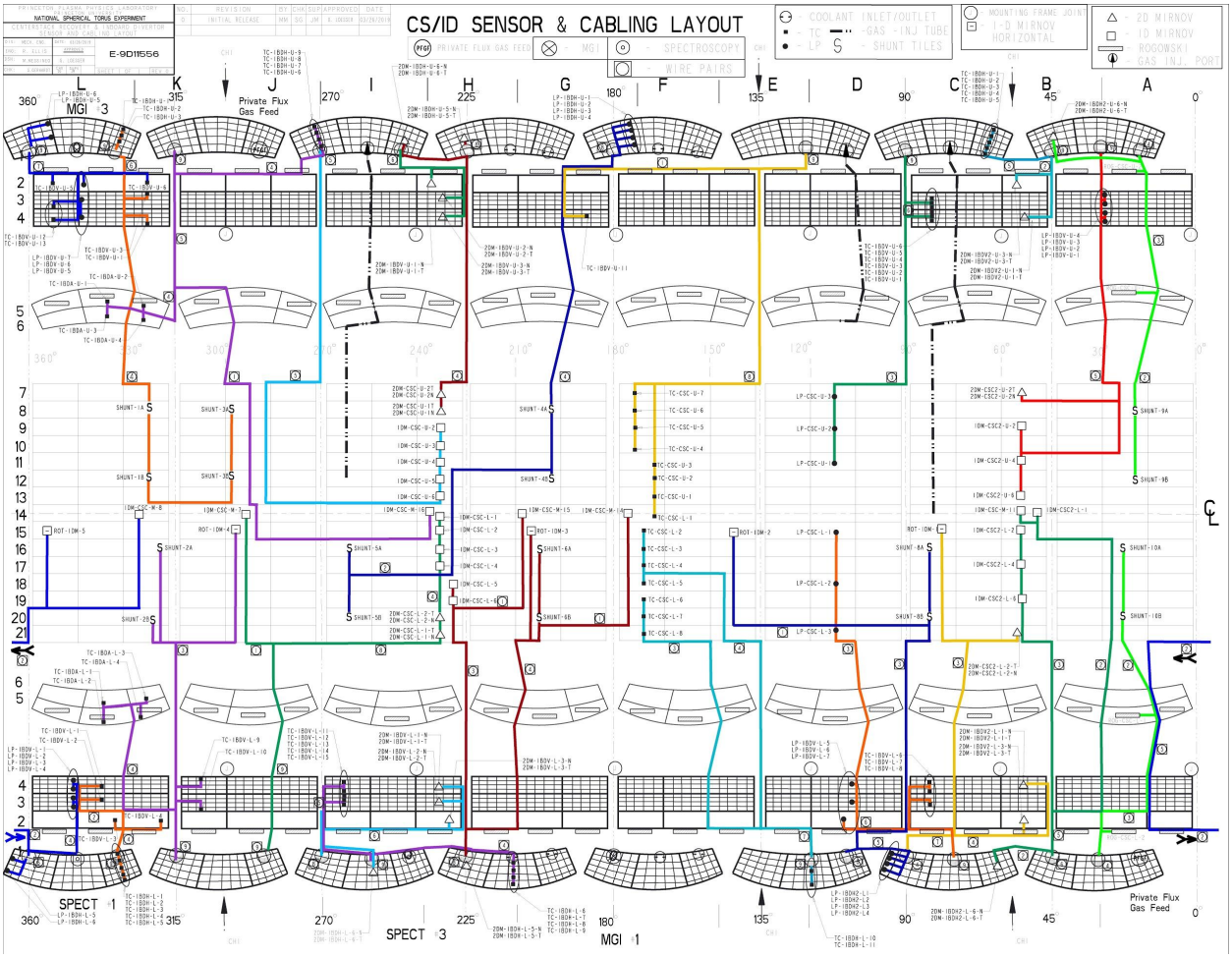

Figure 2. Center Stack Gas Delivery Routing.

ICD-PFC-GDS-004: There needs to be clearance under the assembly structure to allow the ¼" 255 degrees and 1/8" at 75 degrees 316 stainless steel hoses to access to the injection location per Drawing EA3517.

4.2.2.3. Vertical Target PFCs to High field side injectors

Interface Notes:

- The location of the tiles affected by gas delivery is provided as Figure 2. The black dashed lines starting from Upper C and I-ports.
- Tubes run in the existing wireways as shown in Drawing EA3517 and Figure 2.
- There are no special PFC tiles required to delivery gas.

ICD-PFC-GDS-005: There needs to be clearance under the assembly structure to allow the ¼" at 105 degrees 316 Stainless Steel lines to access to the injection location per Drawing EA3517 see in Figure 3.

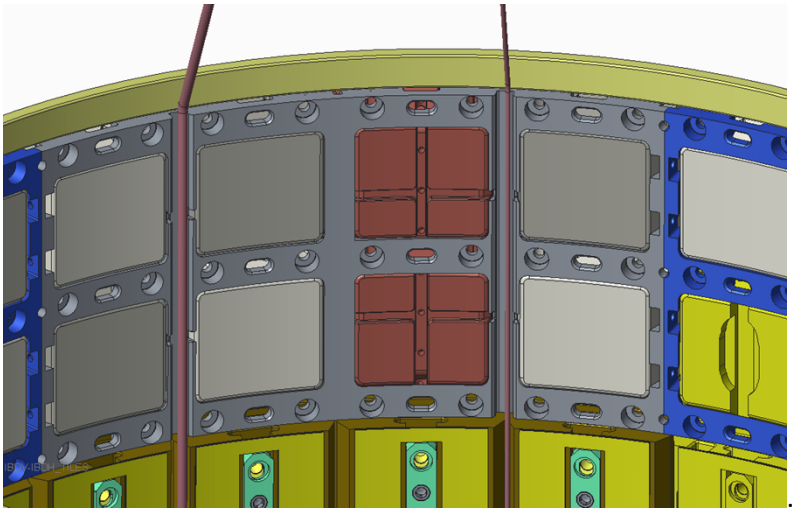

Figure 3. High Field Gas Pipes.

4.2.2.4. CSAS to High field side injectors

ICD-PFC-GDS-006: The CSAS has a special tile to provide gas delivery, as shown in Figure 4.

ICD-PFC-GDS-007: There needs to be clearance under the assembly structure to allow the ¼" at 105 degree and 255 degree and 1/8" at 75 degrees 316 stainless steel hoses to access to the injection location as identified in Drawing EA3517.

ICD-PFC-GDS-008: The location of the CSAS delivery tiles is located in drawing ED-1391.

Figure 4. CSAS Gas Delivery Tile.

4.2.2.5. CSFW to High field side injectors

ICD-PFC-GDS-009: The CSFW has a special tile to provide Gas delivery, as shown in Figure 5. THe High Side injectors are located Bay C mid eighth 75 degree organ pipe, Bay I midquarter 255 degree organ pipe

and Bay E shoulder quarter 105 degree organ pipe

ICD-PFC-GDS-010: There needs to be clearance under the assembly structure to allow the ¼" at 105 degree and 255 degree and 1/8" at 75 degrees 316 Stainless Steel hoses to access to the injection location per Drawing EA3517.

Figure 5. CSFW Gas Delivery Tile.

4.2.2.6. Inboard Divertor Horizontal to Private Flux Region Injectors

Interface Notes:

- **ICD-PFC-GDS-011:** There are two injectors connect to the 285 degree upper organ pipe as well as the 15 degree lower organ pipe. Figure 6 provides the flow of the gas into the vacuum. The gas traverses through the Organ Pipe on the left side of the figure through PFC with a cutout to allow gas injection into the vacuum.

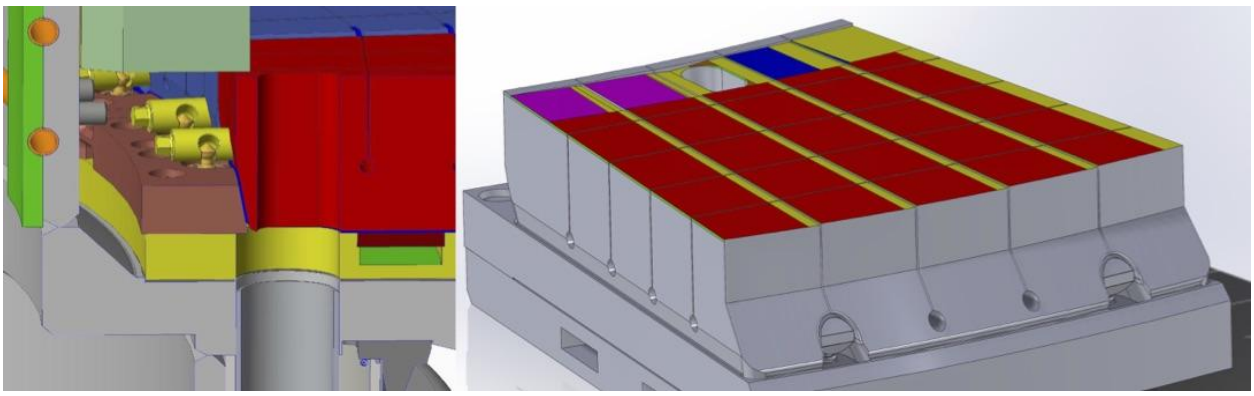

Figure 6. Gas Flow & Tile

4.2.2.7. Inboard Divertor Horizontal to Massive Gas Injectors

ICD-PFC-GDS-012: The Horizontal Target has a special tile aligned with the organ pipes and gas distribution lines through the MGI as shown in Figure 2. Lower MGI 1 uses the organ pipe between F and G (180 degrees), Upper MGI 3 uses the organ pipe Upper L (~345 degrees) as shown in Figure 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 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 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 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 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 Eddie/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 on part of the interface. They are provided for completeness.

There are no external interfaces.