Vacuum Pumping System - Gas Delivery System Interface Control Do

Interface Document: NSTXU_1-3-1_IC_101

REVISION 0

September 12, 2019

PREPARED BY:	**Peter Dugan**	9/11/2019 2:49:29 PM
	Peter Dugan,	
REVIEWED BY:	**Yuhu Zhai**	9/11/2019 3:05:09 PM
	Yuhu Zhai,	
REVIEWED BY:	**Dang Cai**	9/11/2019 3:23:45 PM
	Dang Cai,	
REVIEWED BY:	**Peter Dugan**	9/12/2019 7:11:59 AM
	Peter Dugan,	
REVIEWED BY:	**William R. Blanchard**	9/12/2019 9:37:45 AM
	William R. Blanchard,	
APPROVED BY:	**Robert A. Ellis**	9/12/2019 10:58:32 AM
	Robert A. Ellis,	

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

VACUUM PUMPING SYSTEM:
GAS DELIVERY & INJECTION SYSTEM

NSTX-U-ICD-VPS-GDS-0

Revision 0
September 5, 2019

____
Prepared By: P. Dugan, Systems Engineering

____
Reviewed By: D. Cai, Vacuum Pumping RE

____
Reviewed By: W. Blanchard, Gas Delivery COG

____
Reviewed By: Y. Zhai, Project Engineer

____
Approved By: R. Ellis, Chief Engineer

Change Record

Revision	Date	Description of Change
0	September 5, 2019	Initial Release

References

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

[2] SYSTEM REQUIREMENTS DOCUMENT, AUXILIARY SYSTEMS, NSTX-U-RQMT-SRD-005-01

[3] SYSTEM DESIGN DESCRIPTION, Vacuum and Fueling, NSTX-U-SDD-V&F-R0

1. Purpose

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

2. Scope

The Vacuum Pumping System consist of Valves, Vacuum Pumps and Roughing Pumps, Vacuum Gauges and Residual Gas Analyzers, and TIV, Shutter Actuation System, and Interspace Pumping System. The Gas Delivery and Injection System consists of three Low Field Side Injectors, High Field Side Injectors, Lower Divertor Hi Flow injection system, Massive Gas Injectors, Private Flux Region Fueling and Supersonic Gas Injector (future). 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 Pumping System
- Gas Delivery 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-VPS-GDS-X] where "X" is a sequential count beginning with 001, VPS represents Vacuum Pumping System, and GDS represents Gas Delivery & Injection 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 and 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 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 Structures	Me,Di, Pe			Th			Me,Th, Pe	Me		Me, Pe			Di		
		Vacuum Vessel Structure			Me,Va	Me, Va	Me	Me, Th, Pe	Me	Me,Va	Me,Di, Va		Si	Di,Si		
		Va	Centerstack Structures			Va, Th	Me, Gf	Me	Me					Di		
		Me	Me, Th, Ep	Magnets				Me			Di		SI	Di	Me	
Si		Me, Va			Heating Systems		Gf	Th		Me		Si	Si	Si	Si	
					Si, Va, Me, Sw, Gf	Vacuum Pumping System		Si	Si	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							Si, Me	
			Gf,Va			Me, Gf,Si			Gas Delivery System	Gf	Va		Si,Sw		Me	
		Gf				Si,Gf,Va			Me	Wall Conditioning System			Si,Sw		Si	
		Me,Va	Me,Va	Me	Me	Gf,Si	Gf			Va, Ep	Diagnostics		Si,Sw	Si	Si, Me	Si
				Ep	Ep	Ep	Ep	Ep	Ep	Ep	Ep	Power Systems	Ep,Si	Ep, Si	Me, Ep, Si, Di, Gf	Ep
					Si					Me, Si	Si		Centralized Instrumentation and Control	Si, Me		
												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.

Vacuum Pumping System	Si
Me, Si, Gf	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 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.

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
1.3.4.2.1-1.3.1.3-S	Low Field Side Injectors connects to the vacuum system	See Paragraph 4.2.1.1, Drawing EA3517
1.3.4.2.3-1.3.1.3-S	Lower Divertor Injector connects to the vacuum system	See Paragraph 4.2.1.2,Drawing EA3517
1.3.4.3.1-1.3.1.3-S	High Field Side Injector connects to the vacuum system	See Paragraph 4.2.1.3, Drawing EA3517
1.3.4.2.5-1.3.1.3-S	Private Flux Region Injector connects to the vacuum system	See Paragraph 4.2.1.4, Drawing EA3517, EA3543
1.3.4.3.2-1.3.1.3-S	Massive Gas Injector connects to the vacuum system	See Paragraph 4.2.1.5,Drawings EA3517, EA3511, EA3512, EA3513
1.3.4.2.2-1.3.1.3-S	Supersonic Gas Injector connects to the vacuum system	See Paragraph 4.2.1.6,Drawings EA3517

4.2.1.1 Low Field Side Injectors – TIV

ICD-VPS-GDS-001: The Low Field Side Injectors are included in the design and creates the Vacuum interface integrated into the injector assembly. The vacuum component are designated as AV101 (Bay K Upper), AV105 (Bay I Mid), and AV109 (Bay F/G Mid) as shown in Drawing EA3517.

4.2.1.2 Divertor Lower Injector – TIV

ICD-VPS-GDS-002: The Divertor Lower Injectors are included in the design and creates the Vacuum interface integrated into the injector assembly. The vacuum component are designated as AV121 (Bay I) and AV123 (Bay C) as shown in Drawing EA3517.

4.2.1.3 High Field Side Injector– TIV

ICD-VPS-GDS-003: The Low Field Side Injectors are included in the design and creates the Vacuum interface integrated into the injector assembly. The vacuum component are designated as AV113 (75 degrees), AV115 (105 degrees), AV117 (255 degrees),and AV119 (285 degrees) as shown in Drawing EA3517.

4.2.1.4 Private Flux Region – TIV

ICD-VPS-GDS-004: The Private Flux Region Injectors are included in the design and creates the Vacuum interface integrated into the injector assembly. Figure 1 provides a model and drawing (red circles) of the Private flux region and are connected to a G-10 board (grey). The vacuum component are designated as AV125 (Lower) and AV129 (Upper) in Drawing EA3517.

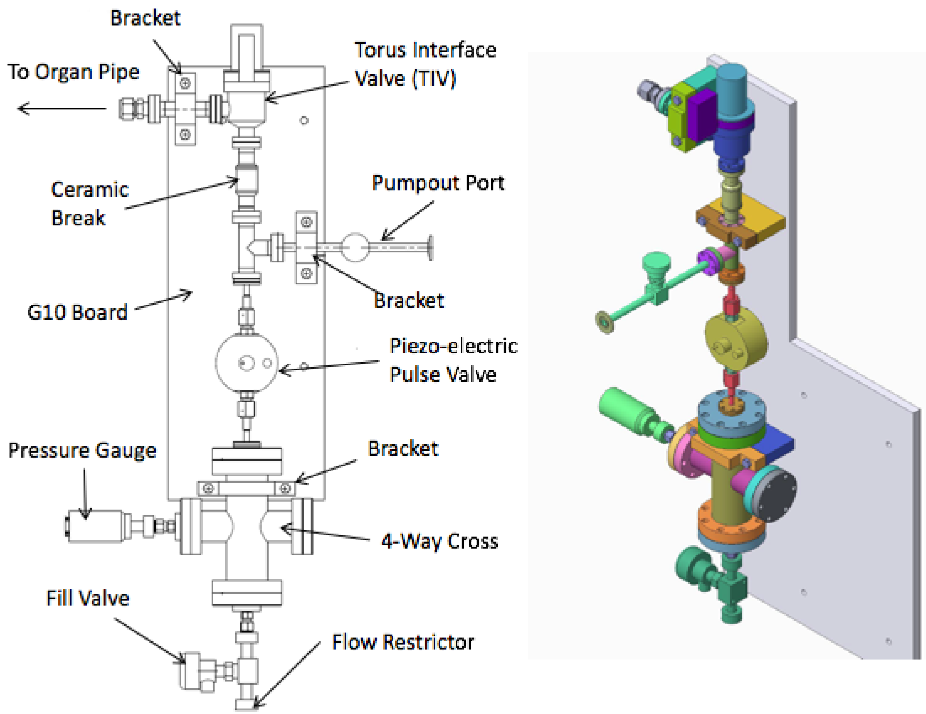

Figure 1. Private Flux Region Interface

4.2.1.5 Massive Gas Injector – TIV

ICD-VPS-GDS-005: The Massive Gas Injectors are included in the design and creates the Vacuum interface integrated into the injector assembly. The vacuum component are designated as AV140 (Bay K/L Upper), AV144 (Bay F Lower), and AV148 (Bay I/J Mid) as shown in Drawing EA3517.

4.2.1.5 Supersonic Gas Injector – TIV

ICD-VPS-GDS-005: The Supersonic Gas Injector (SGI) is a future capability but space and a design has been allocated. The SGI is included in the design and creates the Vacuum interface integrated into the injector assembly. The vacuum component is designated as AV505 (BayI Mid) as shown in Drawing EA3517.

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
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
1.3.1.5-1.3.4.2.2-Si	Control of the supersonic gas injector position	See Paragraph 4.4.1, Drawing EA1500
1.3.1.4-1.3.4.1-Si	Vacuum PLC controls various valves on the gas delivery systems	See Paragraph 4.4.2, Drawing EA1500
1.3.1.3-1.3.4.2.2-Si	Prevent Shutter/TIV movement when probe inserted	See Paragraph 4.4.3, Drawing EA1500
1.3.4.5-1.3.1.4-Si	Vacuum PLC provides permissives, can control valves	See Paragraph 4.4.5, Drawing EA1500
1.3.4.4-1.3.1.4-Si	Argon purge system controlled by the vacuum PLC	See Paragraph 4.4.5, Drawing EA1500

Interface Notes:

- The Vacuum Pumping provides the control for the Gas Delivery Systems. Drawing EA1500 Sheet 106 provides the System CWD. The PLC processor is stored in Rack CTC-EE-443.

4.4.1. Vacuum PLC – SGI

ICD-VPS-GDS-006: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives.

4.4.2. Vacuum PLC – Valves

ICD-VPS-GDS-007: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives.

4.4.3. Vacuum PLC – Shutters/TIV

ICD-VPS-GDS-008: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives.

4.4.4. Vacuum PLC – Permissives

ICD-VPS-GDS-009: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives.

4.4.5. Vacuum PLC – Argon Purge

ICD-VPS-GDS-010: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives.

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
1.3.4.2.1-1.3.1.3-G	TIV and shutter actuation system controls TIV and pneumatic valves on the valve assembly for main chamber fueling	See Paragraph 4.6.1.1
1.3.4.2.2-1.3.1.3-G	TIV and shutter actuation system controls TIV and pneumatic valves on the valve assembly for supersonic Gas injector	See Paragraph 4.6.1.2
1.3.4.2.3-1.3.1.3-G	TIV and shutter actuation system controls TIV and pneumatic valves on the valve assembly for Outboard Divertor Injection Systems	See Paragraph 4.6.1.3
1.3.4.2.4-1.3.1.3-G	TIV and shutter actuation system controls TIV and pneumatic valves on the valve assembly for GPI and Impurity Injectors	See Paragraph 4.6.1.4
1.3.4.2.5-1.3.1.3-G	TIV and shutter actuation system controls TIV and pneumatic valves on the valve assembly for Private Flux Region Fueling	See Paragraph 4.6.1.5
1.3.4.3.2-1.3.1.3-G	TIV and shutter actuation system controls TIV and pneumatic valves on the valve assembly for Massive Gas Injectors	See Paragraph 4.6.1.6
1.3.4.3.1-1.3.1.3-G	TIV and shutter actuation system controls pneumatic valves on the valve assembly for High Field Side injectors	See Paragraph 4.6.1.7

Interface Notes:

- The Vacuum Pumping PLC provide the logic to ensure the Gas Delivery Systems operates correctly.
-

4.6.1.1. TIV and shutter actuation - Main Chamber Fueling

ICD-VPS-GDS-011: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives. The logic within the PLC ensures that the TIV and shutters are in the proper position.

4.6.1.2. TIV and shutter actuation - Supersonic Gas injector

ICD-VPS-GDS-012: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives. The logic within the PLC ensures that the TIV and shutters are in the proper position.

4.6.1.3. TIV and shutter actuation - Outboard Divertor Injection Systems

ICD-VPS-GDS-013: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives. The logic within the PLC ensures that the TIV and shutters are in the proper position.

4.6.1.4. TIV and shutter actuation - GPI and Impurity Injectors

ICD-VPS-GDS-014: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives. The logic within the PLC ensures that the TIV and shutters are in the proper position.

4.6.1.5. TIV and shutter actuation - Private Flux Region Fueling

ICD-VPS-GDS-015: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives. The logic within the PLC ensures that the TIV and shutters are in the proper position.

4.6.1.6. TIV and shutter actuation - Massive Gas Injectors

ICD-VPS-GDS-016: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives. The logic within the PLC ensures that the TIV and shutters are in the proper position.

4.6.1.7. TIV and shutter actuation - High Field Side injectors

ICD-VPS-GDS-017: The Vacuum Gas System PLC is identified in drawing EA1500 Sheet 105. The PLC controls the Gas Injectors, valves and pressure sensors, TIV interlocks and permissives. The logic within the PLC ensures that the TIV and shutters are in the proper position.

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 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.