PRINCETON PLASMA PHYSICS LABORATORY

ENG-064 - ICD - INTERFACE CONTROL DOCUMENT

Bakeout Systems - Operations & Safety Systems Interface Control Document

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National Spherical Torus eXperiment Upgrade

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Interface Control Document

BAKEOUT SYSTEM: OPERATIONS & SAFETY SYSTEMS

NSTX-U-ICD-BOS-OSS-0

Revision 0
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Change Record

Revision	Date	Description of Change
0	February 14, 2020	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 REQUIREMENTS DOCUMENT, Operations and Safety Systems, NSTX-U-RQMT-SRD-012-00.

[4] NSTX-U Personnel Safety System - Configuration Managed Safeguards, NSTX-U-RQMT-SRD-027-00.

[5] NSTX-U Centralized Control System, NSTX-U-RQMT-SRD-025-00.

1. Purpose

This document describes the various interfaces between the following subsystems: Bakeout System and the Operations & Safety Systems. The interface locations and boundaries that connect the Bakeout System to the Operations & Safety Systems are identified based on different interface types.

2. Scope

The Bakeout System consists of the Helium Heating and Cooling System, Helium Skid, Ex-Vessel Helium Manifolds, In-Vessel Helium Lines, Bakeout Bus Bar, and Helium Feedthroughs. The OSS consists of the Personnel Safety System - Safety Instrumented System, Trapped Key System, Configuration Managed Safeguards, Centralized Control System, Vessel and Diagnostic Ground Systems, Radiation Monitoring System, and Test Cell Oxygen Deficiency Monitor. The scope of this document addresses any defined interfaces between these identified system elements.

3. Responsibilities

The interfaces are managed between the following organizations:

- Bakeout System
- Operations & Safety Systems
- Systems Engineering and Integration

4. Interfaces

Interface requirements in the following sections are identified with a requirement number, ICD, followed by a number [ICD-BOS-OSS-X] where “X” is a sequential count beginning with 001, BOS represents Bakeout System, and OSS represents Operations & Safety Systems. 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 and 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 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, Me		
		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, Me, Di	
					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	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	Si	Si, Me	
		Gf				Si,Gf,Va			Me	Wall Conditioning System			Si,Sw		Me	
		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	Si, Me, Di	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.

Bakeout System	Si, Me
Ep	Operations& Safety Systems

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, location dependent interfaces or areas where penetrations into a wall or floor are required. These are identified independently as interface parameters and 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
1.7.3.10.1-1.3.3.4-S	Trapped key block mounted to control cabinet	See Paragraph 4.2.1, Drawing AE8010

ICD-BOS-OSS-001: The control cabinet has a trapped key mounted to it as shown in Drawing AE8010. The trapped key must be enabled in order to control the Bakeout system.

4.2.2. Spatial Interface

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

Identifier	Interface	References
1.3.3.2.1-1.7.3.2-Sp	Current sensing coils monitor the ground bus bars	See Paragraph 4.2.2.1, Drawing 4F1005
1.3.3.1.1-1.7.3.9.3-Sp	Safeguards are used to prevent individuals from coming in contact with the He piping used to supply hot He to the machine.	See Paragraph 4.2.2.2, Ref. 4
1.3.3.1.1-1.7.3.9.3-Sp	Safeguards are used to prevent individuals from coming in contact with the He manifolds on the machine.	See Paragraph 4.2.2.3, Ref. 4, Drawings AE8350, AE8351

1.3.3.3.2-1.7.3.9.3-Sp	Safeguards are used to prevent individuals from coming in contact with piping used to supply hot water to the machine.	See Paragraph 4.2.2.4, Ref. 4
1.3.3.3.2-1.7.3.9.3-Sp	Safeguards are used to prevent individuals from coming in contact with the water manifolds on the machine.	See Paragraph 4.2.2.5, Ref. 4

4.2.2.1. Vessel Ground Sense Coils – Bakeout Bus Bar

Interface Notes:

- Current design calls for removing one of the two poles of the McBride switch. As a result, the Ground Fault Monitoring system parameters require updating.

ICD-BOS-OSS-002: The Ground System includes a Ground Fault Monitoring system shown in blue in Figure 1.

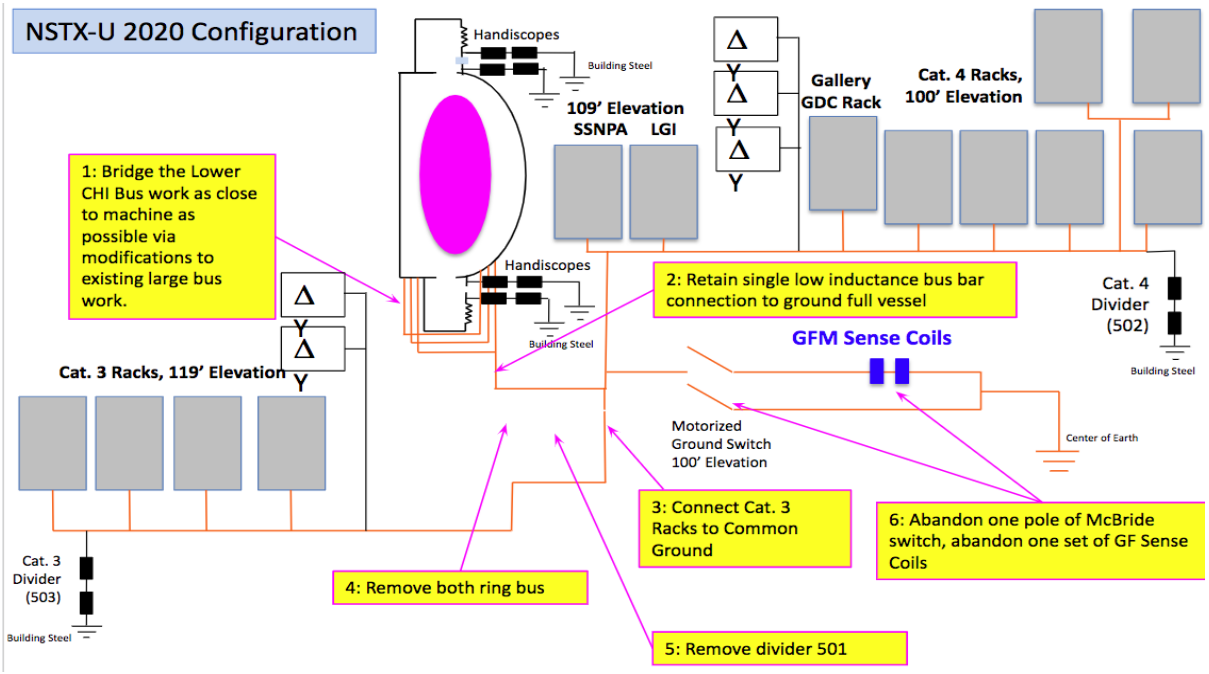


Figure 1. Notional Grounding Block Diagram

4.2.2.2. Helium Pipes – Safeguards

Interface Notes:

- There will be insulation placed under the helium pipe safeguards

ICD-BOS-OSS-003: In order to protect the helium pipes, the current ASJ will be removed and insulation ~3“ as shown on the left of Figure 2. Then for dual pipe applications an additional 1” of insulation will be added.

ICD-BOS-OSS-004: In addition to the pipe covers. A caged area is placed around the helium skid. The wrapping of the pipes with insulation and safeguards will occur in these areas where caged areas or safeguards are not in place.

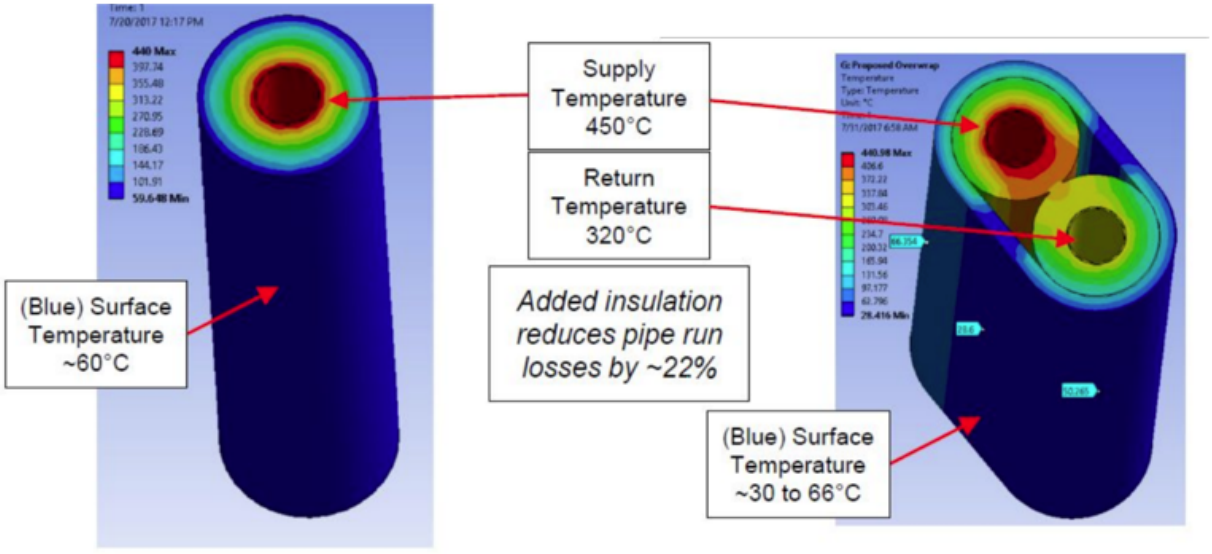


Figure 2. Replacement Pipe Wrap

ICD-BOS-OSS-005: The pipes are additionally safeguarded by adding pipe jackets and pipe jacket elbows as part of the configuration managed safeguards as shown in Figure 3.

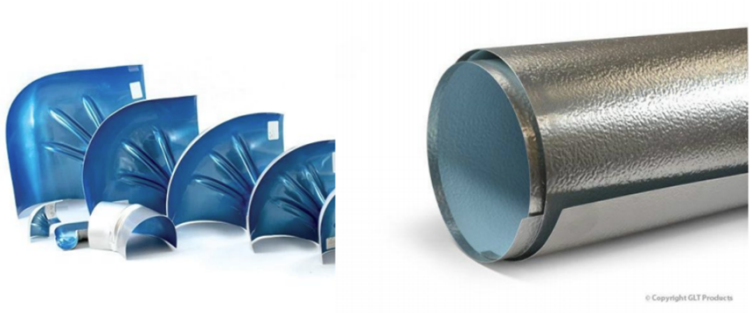
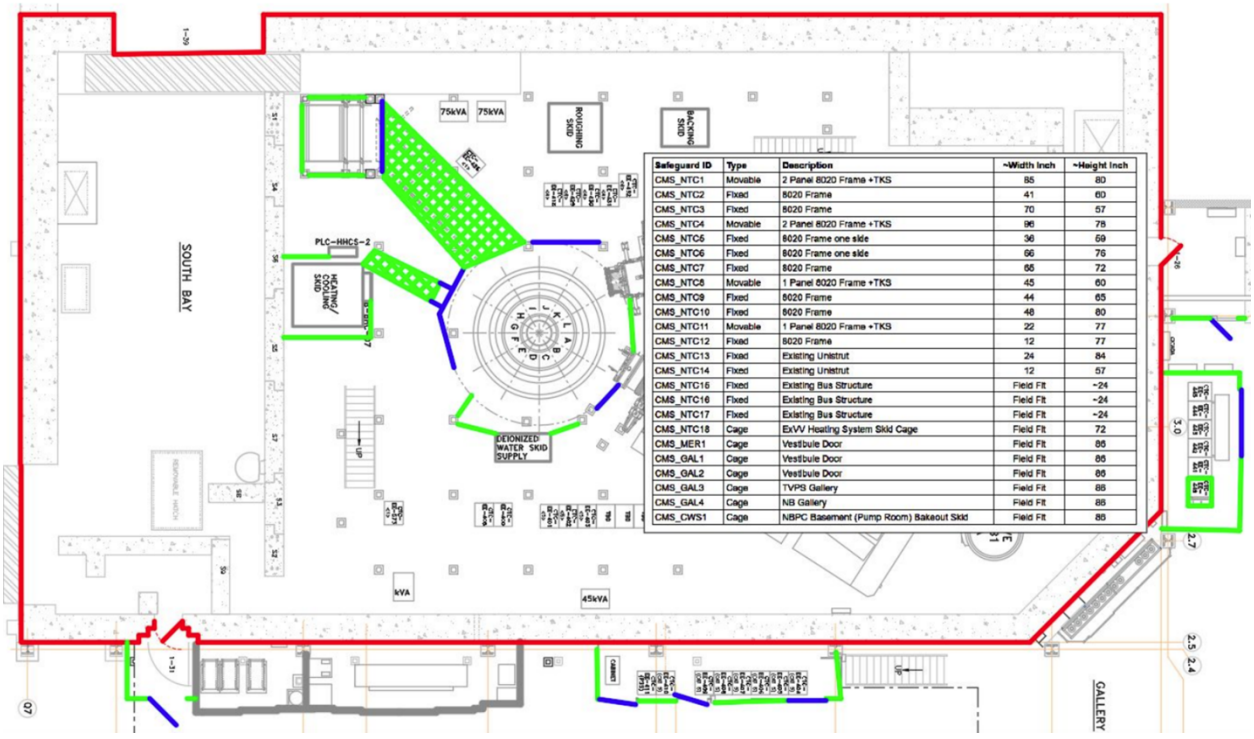


Figure 3. Commercial Pipe Jackets and Elbows.

4.2.2.3. Helium Manifolds – Safeguards

ICD-BOS-OSS-006: The access to the vessel manifolds is prevented by including safeguards around the vacuum vessel. There are movable (blue) and fixed (green) safeguards, as shown in Figure 4 that will be in place when a hazard is present. Figure 5 provides a sample of the safeguard design. Drawing AE8850 provides an overview of this safeguard design presented in Figure 4 while drawing AE8851 provides a drawing of the safeguard represented in Figure 5.



Safeguard ID	Type	Description	~Width Inch	~Height Inch
CMS_NTC1	Movable	2 Panel 8020 Frame +TKS	85	80
CMS_NTC2	Fixed	8020 Frame	41	60
CMS_NTC3	Fixed	8020 Frame	70	57
CMS_NTC4	Movable	2 Panel 8020 Frame +TKS	96	78
CMS_NTC5	Fixed	8020 Frame one side	36	59
CMS_NTC6	Fixed	8020 Frame one side	66	76
CMS_NTC7	Fixed	8020 Frame	66	72
CMS_NTC8	Movable	1 Panel 8020 Frame +TKS	45	60
CMS_NTC9	Fixed	8020 Frame	44	65
CMS_NTC10	Fixed	8020 Frame	46	80
CMS_NTC11	Movable	1 Panel 8020 Frame +TKS	22	77
CMS_NTC12	Fixed	8020 Frame	12	77
CMS_NTC13	Fixed	Existing Unistrut	24	84
CMS_NTC14	Fixed	Existing Unistrut	12	57
CMS_NTC15	Fixed	Existing Bus Structure	Field Fit	~24
CMS_NTC16	Fixed	Existing Bus Structure	Field Fit	~24
CMS_NTC17	Fixed	Existing Bus Structure	Field Fit	~24
CMS_NTC18	Cage	ExVV Heating System Skid Cage	Field Fit	72
CMS_MER1	Cage	Vestibule Door	Field Fit	86
CMS_GAL1	Cage	Vestibule Door	Field Fit	86
CMS_GAL2	Cage	Vestibule Door	Field Fit	86
CMS_GAL3	Cage	TVPS Gallery	Field Fit	86
CMS_GAL4	Cage	NB Gallery	Field Fit	86
CMS_CWS1	Cage	NBPC Basement (Pump Room) Bakeout Skid	Field Fit	86

Figure 4. Safeguards around the vessel

Figure 5. Sample Safeguard

4.2.2.4. Water Pipes – Safeguards

Interface Notes:

- The same insulation is used for water as helium placed under the water pipe safeguards

ICD-BOS-OSS-007: In order to protect water pipes the current and insulation of 3“ as shown on the left of Figure 2.

ICD-BOS-OSS-008: In addition to the pipe covers. A caged area is placed around the water skid. The safeguard is actually represented by the green area on the left of Figure 4. The wrapping of the pipes with insulation and safeguards will occur in these areas where caged areas or safeguards are not in place. This is represented in Figure 2 by the green area between the water skid caged area and the vacuum vessel.

ICD-BOS-OSS-009: The pipes include insulation are additionally safeguarded by adding pipe jackets and pipe packet elbows as shown in Figure 3, similar to the helium pipe interface. This ensures that the accessible pipes are touch safe.

4.2.2.5. Water Manifolds – Safeguards

ICD-BOS-OSS-010: The access to the Ex-vessel Water manifolds is prevented by including safeguards around the vacuum vessel. There are movable (blue) and fixed (green) safeguards, as shown in Figure 4 that will be in place when a hazard is present. Figure 5 provides a sample of the safeguard design.

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
1.7.3.2.3-1.3.3.2.1-P	The ground connection to the vessel is made by connecting to the lower bakeout bus bars.	See Paragraph 4.3.1, Drawing 4F1005

4.3.1. Vessel Ground Bus – Bakeout Bus Bar

ICD-BOS-OSS-011: There are three Bakeout Bus Bar jumpers that connect the vacuum vessel to the center stack. One of these connections will be connected to the ground bus/Ground switch. It will be the bakeout bus bar closest to the ground as shown in Figure 6. Drawing 4F1005 Sheet 1579 provides a drawing on grounding specifics.

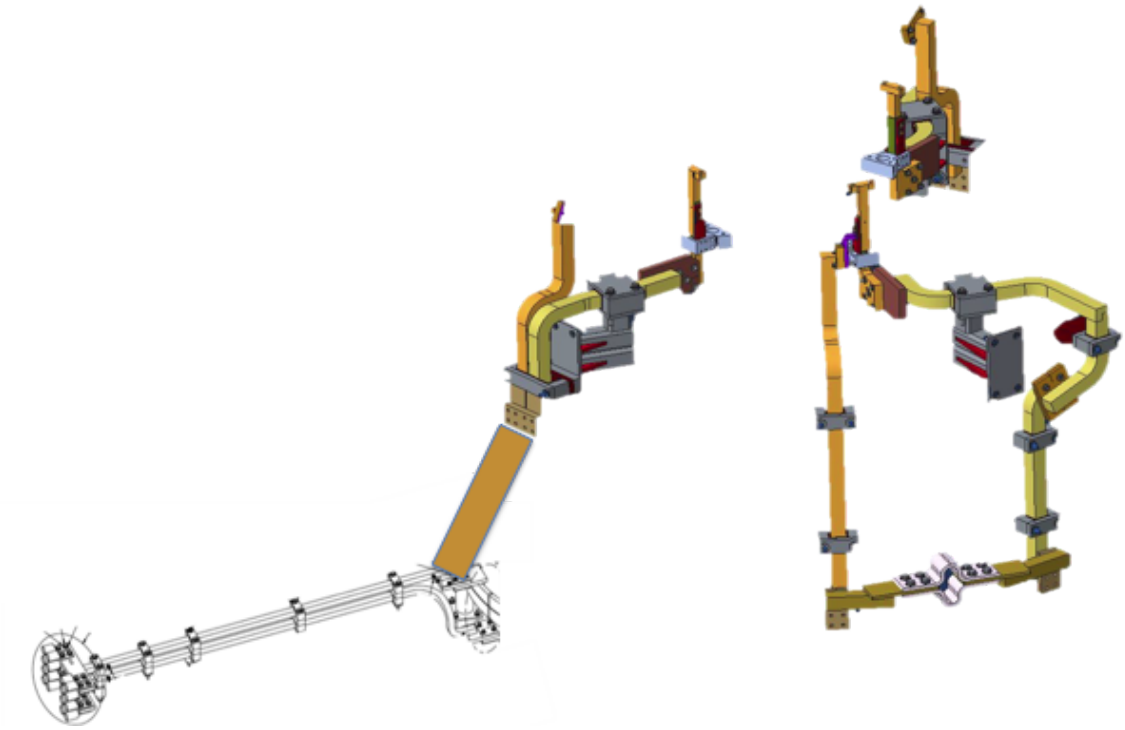


Figure 6. Notional view of Ground Bus Connection

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
1.3.3.4-1.7.3.8-Si	The CCS provides No-ESTOP signal to the bakeout system.	See Paragraph 4.4.1, Drawing D59028-WD

4.4.1. Centralized Control System - Bakeout

Interface Notes:

- The Bakeout PLC controls Helium, MTWS, and DC Heating.
- The No-E-Stop signal is a signal sent in a loop that various PLCs receive and process.

ICD-BOS-OSS-012: The CCS provides a No-ESTOP signal that is sent to the Bakeout PLC. The signal connections at cross connect location 14B & F as shown in Drawing D59028-WD Sheet 1.

ICD-BOS-OSS-013: A 120V signal is used to establish the No-E-stop. A loss of signal creates an E-Stop condition.

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 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.