

Magnets - Integrated Machine Operations Interface Control Docume

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REVISION 0

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National Spherical Torus Experiment Upgrade

Interface Control Document

MAGNETS : INTEGRATED MACHINE OPERATIONS

NSTX-U-MAG-IMO-ICD-0

**Revision 0
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Change Record

Revision	Date	Description of Change
0	October 25, 2019	Initial Release

References

- [1] GENERAL REQUIREMENTS DOCUMENT, NSTX-U-RQMT-GRD-001-01
- [2] SYSTEM REQUIREMENTS DOCUMENT, MAGNET SYSTEMS, NSTX-U-RQMT-SRD-002-02
- [3] SYSTEM REQUIREMENTS DOCUMENT, Diagnostics, NSTX-U-RQMT-SRD-011-01.
- [4] NSTX-U Machine Instrumentation, NSTX-U-RQMT-RD-008-03.

1. Purpose

This document describes the various interfaces between the following subsystems: Magnets and the Integrated Machine Operations. The interface locations and boundaries that connect the Magnets to the Integrated Machine Operations are identified based on different interface types.

2. Scope

The Magnets address the TF Inner Legs, OH Solenoid, Outer PF Coils, PF-1a Coils, PF-1b Coils, and PF-1c Coils. The Integrated Machine Operations consists of the Machine Instrumentation and Real-Time Control and Protection Systems such as the Digital Coil Protection System, and the Shorted Turn Protection System. The scope of this ICD focuses on Machine Instrumentation and this document addresses any defined interfaces between these identified system elements.

3. Responsibilities

The interfaces are managed between the following organizations:

- Magnets
- 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-MAG-IMO-X] where X is a sequential count beginning with 001, MAG represents Magnets and IMO represents Integrated Machine Operations. 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 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	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	
		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

Magnets	Di
	Integrated Machine Operations

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
N/A		

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 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

1.1.3.3.2- 1.7.3.4.2-D	Thermocouples are installed on the surface of the OH coil to measure temperature during normal operations and bakeout	See Paragraph 4.5.1
1.1.3.3.3- 1.7.3.4.2-D	Thermocouples applied to surface of PF1a coil	See Paragraph 4.5.2, Drawing DC11112
1.1.3.3.4- 1.7.3.4.2-D	Thermocouples applied to surface of PF1b coil	See Paragraph 4.5.3, Drawing DC11113
1.1.3.3.5- 1.7.3.4.2-D	Thermocouples applied to surface of PF1c coil	See Paragraph 4.5.4, Drawing DC11114, 9D1095
1.1.3.2- 1.7.3.4.1-D	Sensors measures strain in the TF outer leg	See Paragraph 4.5.5, Drawing 9D11557
1.1.3.3.2- 1.7.3.4.1-D	Sensors measure displacements of the belleville stack that provides preload to the OH coil	See Paragraph 4.5.6
1.1.3.3.1- 1.7.3.4.1-D	Sensors measure strain in multiple directions on the surface of the TF bundle	See Paragraph 4.5.7

4.5.1. Thermocouples – OH

ICD-MAG-IMO-001: There are several thermocouples attached to the OH coil. These coil connected per drawing Drawing 9D1095 Sheets 25, 35, 40,45.

ICD-MAG-IMO-002: The leads of the thermocouples will be connected to allow the signals to be digitized and processed as defined in Drawing 1095 Sheets 35 & 45.

4.5.2. Thermocouples – PF-1a

Interface Notes:

- The application of the thermocouples is the responsibility of the Magnet RE but is included for completeness.

ICD-MAG-IMO-003: Three thermocouples as shown in Figure 3, within the red ellipse, are included in the upper, mid, and lower portion of the OD of the coil per drawing DC11112. Drawing 9D1095 Sheet 20 provide the CWD for the lower coils and Sheet 35 for the upper coils.

ICD-MAG-IMO-004: The leads of the thermocouples will be connected to allow the signals to be digitized and processed as defined in Drawing 1095 Sheets 20 & 35.

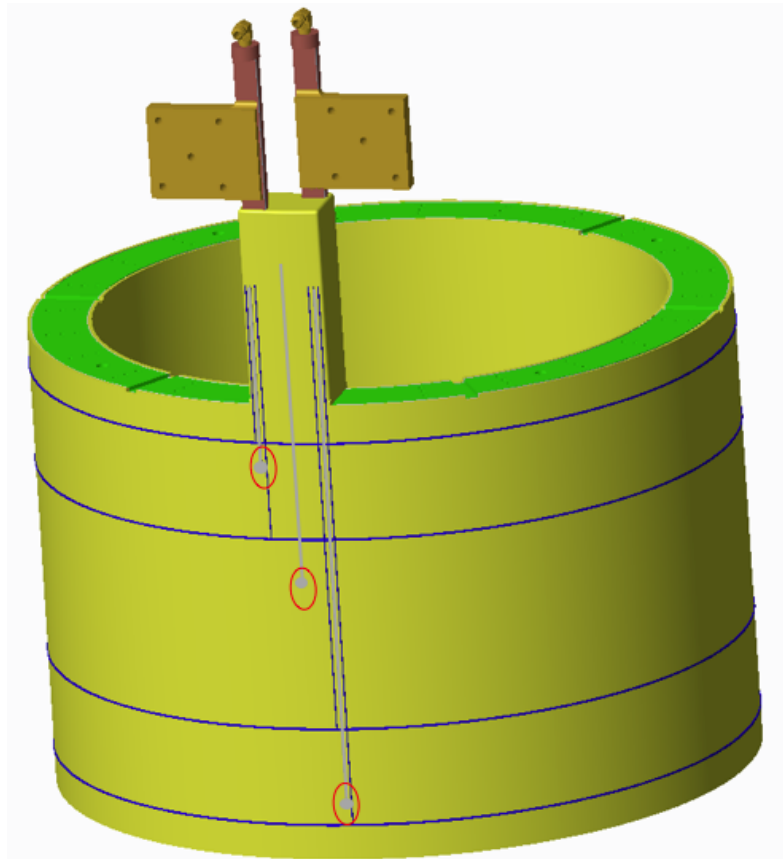


Figure 1. Thermocouples located on the PF-1b coil

4.5.3. Thermocouples – PF-1b

Interface Notes:

- The application of the thermocouples is the responsibility of the Magnet RE but is included for completeness.
- Drawing 9D1095 needs to be updated to include the PF-1B thermocouples

ICD-MAG-IMO-005: Two thermocouples as shown in Figure 2, within the red ellipse, are included in the upper and lower portion of the OD of the coil per drawing DC11113.

ICD-MAG-IMO-006: The leads of the thermocouples will be connected to allow the signals to be digitized and processed as defined in Drawing 1095 Sheet TBD.

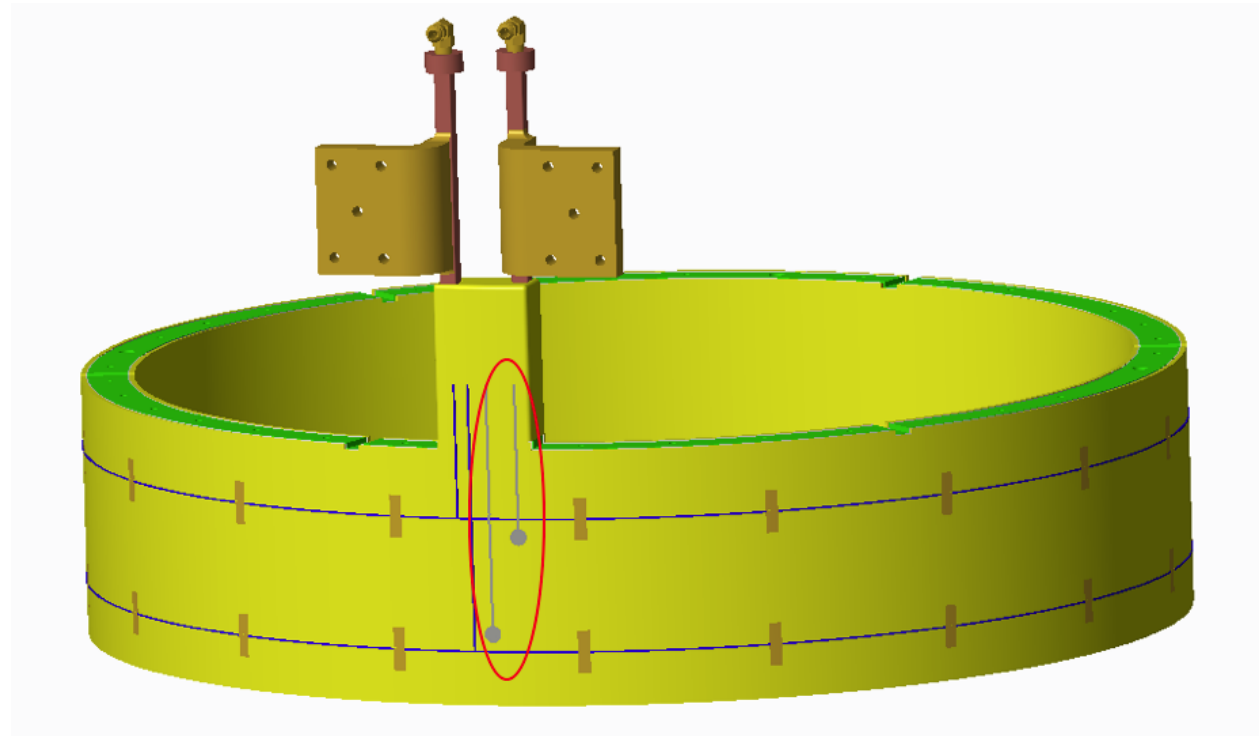


Figure 2. Thermocouples located on the PF-1b coil

4.5.4. Thermocouples – PF-1c

Interface Notes:

- The application of the thermocouples is the responsibility of the Magnet RE but is included for completeness.

ICD-MAG-IMO-007: Three thermocouples as shown in Figure 3, within the red ellipse, are included in the upper, mid, and lower portion of the OD of the coil per drawing DC11114. Drawing 9D1095 Sheet 37 provide the CWD for the lower coils and Sheet 36 for the upper coils.

ICD-MAG-IMO-008: The leads of the thermocouples will be connected to allow the signals to be digitized and processed as defined in Drawing 1095 Sheets 36 & 37.

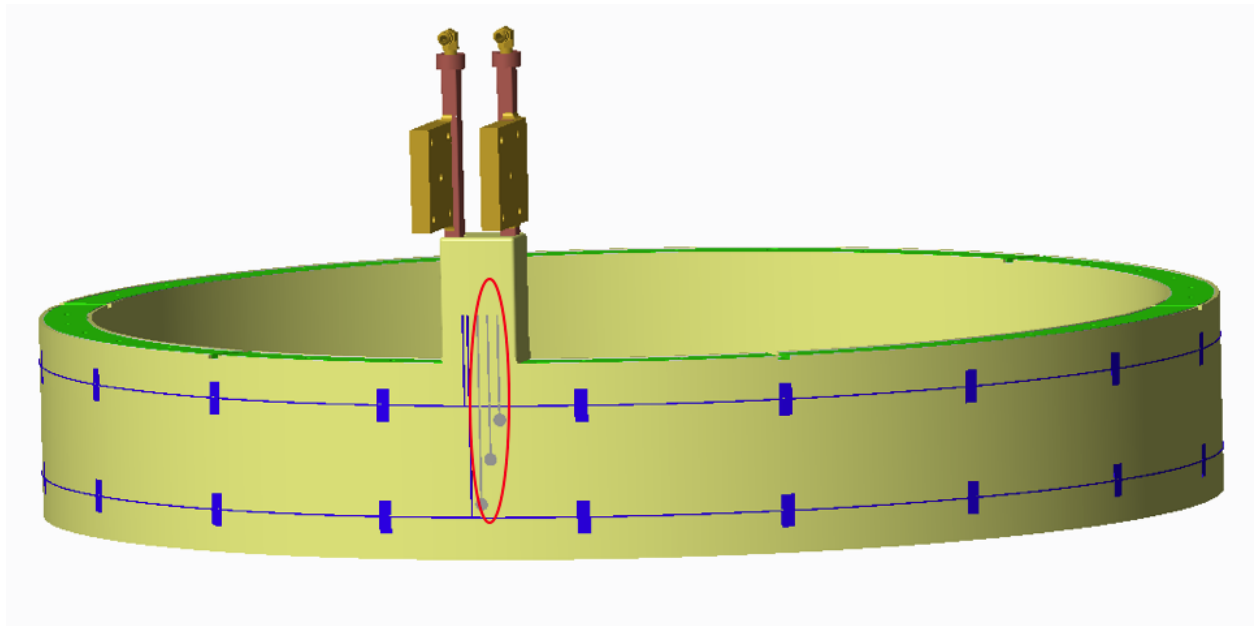


Figure 3. Thermocouples located on the PF-1c coil

4.5.5. Strain Sensors – TF Coils

ICD-MAG-IMO-009: The strain gauges identified in Drawing 9D11557 are located in several places as identified in blue in Figure 4. In addition to strain gauges, the drawing also identifies several temperature sensors that are coupled with the strain gauges. Drawing 9D11557 provides a table that identifies the type of sensor on 13 locations across 12 Outer TF legs (A-L).



Figure 4. TF Outer Leg with attached strain gauges

4.5.6. Preload Sensor – OH Coil

ICD-MAG-IMO-010: The preload sensor are located in two locations between the Belleville washer stack as indicated in drawing DC1887. The sensor assembly is shown in Figure DC1888. Figure 5 shows the location of the preload displacement sensor.

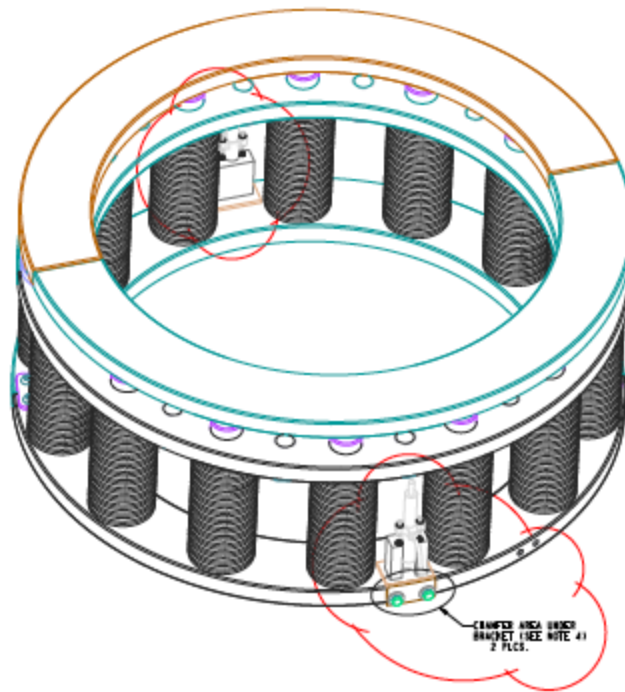


Figure 5. Location of the OH displacement sensor

4.5.7. Strain Sensors – TF Bundle

ICD-MAG-IMO-011: The rosettes are based on Fiber Bragg Gratings will be attached via a field fit at various locations on the face of the TF Bundle in accordance with drawing 9D11574. Figure 6 provides a sample of the Rosettes that will be attached to the TF Bundle.



Figure 6. Sample Rosette

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
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.