

National Spherical Torus Experiment-Upgrade

**NSTX-U**

**SYSTEM REQUIREMENTS DOCUMENT**

**Test Cell**

**NSTX-U-RQMT-SRD-010-03**

**November 19th, 2019**

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## Change Record

Revision	Date	Description of Change
0	12/20/17	Initial Release
1	7/31/2018	Modified signature block as per new QAPD and ENG-050
		Added 2.3j requiring fire seals in test cell walls
		Added 2.3k requiring penetrations be sealed to maintain negative pressure.
		Added 2.3l requiring the installation of cable trays
		Added 2.3m regarding 19" racks in the NTC
		Added 2.3n, requiring that the test cell accommodate the distribution of various services
		Updated interface tables as per interface spreadsheet
		All statements in 2.2 added or modified
		Removed the statement previously in 4.3d, which was fully redundant with 4.3a and 4.3c.
		Added 4.5a
		Replaced bulleted lists in Section 3.3 with Tables 3.3-1 through 3.3-3
		Remove 2.4d, replace the Structural Design Criteria in 2.2c with the new ES-MECH-019
		Complete rewrite of Section 3 on the Access Control System
2	12/03/18	Moved Sections 3 and 4 to the new SRD for Operations and Safety Systems (NSTX-U-RQMT-SRD-012)
		Changed WBS → SBS
		Updated all the signatures for changed roles
3	11/19/19	Added 2.4e as a temperature requirement
		Updated dewpoint temperature requirement to 41 °F in 2.4a
		Add purge mode requirement to be consistency with legacy requirements in 2.4g, and requirement for outside air circulation in 2.4 h
		Added requirement for test cell fall protection atop NSTX-U in 2.3o
		Updated all the signatures for changed roles
		Added table 2.6-6 and 2.6-7, promoted previous 2.6-6 to new 2.6-8. Added new 2.6-9.

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## References

- [1] NSTX-U-RQMT-GRD-001, NSTX-U General Requirements Document
- [2] ES-MECH-19, PPPL Seismic Design
- [3] NSTX-U-RQMT-RD-010-00, NSTX-U Magnetic Permeability Requirements
- [4] NSTX-U-RQMT-SRD-012-00, NSTX-U Operational and Safety Systems

## **1.0 Scope**

a. The format of this document, including interfaces specifications, is provided in the General Requirements Document [1].

## **2.0 Test Cell**

### **2.1 Functions**

The functions of the NSTX-U Test Cell (NTC) and associated systems are to provide:

- a. Structural support for equipment located there
- b. Fire barriers to adjacent fire zones
- c. Radiation shielding for adjacent areas
- d. Access control during operations, off hours, and working hours
- e. Environmental control for equipment (humidity, temperature, pressure, etc....)
- f. A crane for construction activities within the test cell.

### **2.2 Materials and Design Requirements**

- a. The NSTX-U test cell shall be the former TFTR hot cell; structural design requirements from that design such as floor loading requirements shall continue to apply.
- b. Fire retardant materials shall be used for construction where possible to provide 2 hr rated fire stop for walls and 3 hr rated fire stop for floors.
- c. New structures shall be qualified for seismic events as per Ref. [2].
- d. All relevant life safety and building codes shall apply.
- e. Magnetic materials shall satisfy the requirements described in Ref. [3].
- f. Conducting loops of area greater than  $0.2 \text{ m}^2$  formed by metallic structures within a radius of 3 meters from the centerline of the torus shall be broken by insulating breaks, unless specific exception is granted. The insulation shall be rated to withstand a one minute AC hipot test at 2 kV AC rms.

### **2.3: Configuration Requirements and Essential Features**

- a. Platforms shall be provided for access to the midplane and upper levels of the machine, and for the support of equipment and racks.
- b. An oxygen deficiency monitor shall be installed, with locations at least adjacent to the neutral beamlines and under the NSTX-U device. See Ref. [4] for additional requirements on this system.

- c. Lighting shall be installed both on the ceiling and under platforms where necessary to provide illumination.
- d. Systems for temperature, dew point control and maintenance of negative pressure shall be provided.
- e. Oil-free, dry compressed air service ("Instrument Air") shall be provided for experimental equipment & controls. Additional dry compressed air may be provided for systems not requiring oil-free air.
- f. A pre-action fire protection system shall be installed in the NTC.
- g. Smoke and heat detectors shall be located on the NTC ceiling, and a VESDA<sup>1</sup> system on the ceiling and under all platforms.
- h. Smoke and heat detectors shall report to the communications center.
- i. Penetrations in the test cell walls and floor shall have appropriate neutronics shielding or labyrinths. This shielding shall be designed to satisfy the goals in Table 2.3-1.

**Table 2.3-1:** Requirements for access to D-Site areas surrounding the test cell during neutral beam or plasma operations. Access to the test cell and south high bay are restricted.

	Location	Requirement
1	Neutral Beam Power Conversion Building	Unrestricted access desired during operation
2	MSE/MPTS Mezzanine above the East Gallery	Unrestricted access desired during operation
3	North and East Gallery	Unrestricted access desired during operation
4	TFTR Test Cell	Unrestricted access desired during operation
5	Diagnostics DARM & Cryo Area	Unrestricted access desired during operation
6	MER & MER Mezzanine	Restriction during NSTX-U Operations
7	D-Site Roof	Unrestricted access desired during operation
8	Site Boundary	Shielding shall support a total site boundary limit of 10 mRem/year, as documented in the NSTX-U SAD. Access to the site boundary is unrestricted always.

- j. Penetrations in the test cell walls and floor shall have appropriate fire seals.

<sup>1</sup> VESDA=Very Early Smoke Detection Apparatus, a type of aspirating smoke detector system



- k. Penetrations shall be sealed to facilitate maintenance of negative pressure in the test cell as per 2.3d.
- l. Cable trays shall be provided to route cables from NSTX-U and associated equipment to racks of the appropriate ground class.
- m. Racks for 19" rack mountable equipment shall be provided. These racks shall be electrically isolated from the platform floor. Some racks may be electrically referenced to the NSTX-U vessel.
- n. The test cell shall accommodate the distribution of services such as Instrument Air, House Air, the vacuum exhaust line (which connects to the vent stack), Facility Chilled Water, Potable Water, Deionized Water, and electrical power.
- o. A system shall be installed to provide fall protection for access to the top of NSTX-U.

## **2.4 Baseline Performance and Operational Requirements**

- a. Dewpoint control: The dewpoint setpoint shall be maintained at or below 41 °F using the house steam or dehumidifier system.<sup>2</sup>
- b. Negative pressure: The test cell negative pressure shall be maintained between atmospheric and 0.08 in-H<sub>2</sub>O using the HVAC system.
- c. Per general industrial practice, platforms shall be designed for 150 lb/ft<sup>2</sup>. The main NSTX-U test cell platforms shall be designed for 250 lb/ft<sup>2</sup> in order to provide additional stiffness and account for possible shielding needs around some of the diagnostics.
- d. Removed in Rev. 1.
- e. The HVAC system of the test cell shall maintain a temperature of 70 °F  $\pm$  2 °F, except during purge or bakeout conditions.
- f. Minimum outside air requirements based on occupancy per building code shall be maintained.
- g. A purge mode for the test cell shall be provided with capability of 2 air changes per hour to outside air.

## **2.5 Upgrade Performance and Operational Requirements**

- a. There are no explicit upgrade requirements for the NTC, though platform modifications to support the evolution of the facility should be anticipated.

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<sup>2</sup> Per memo MAG\_191113\_WQ\_1, the insulation quality of the TF bundle improves as the relative humidity gets into the 30-35% range. 35% relative humidity corresponds to a dew point of 41°F at a temperature of 70 degrees.

## 2.6 Interfaces

**Table 2.6-1: Interfaces for the NSTX-U Test Cell Platforms (Incomplete) (SBS 1.8.1.1.1)**

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.5.1.2	D-Site Auxiliary Power	Structural	At platform surface	Transmission lines supported from platforms	Mechanical Drawings
1.1.3.4	Bus Bar Systems and Bus Tower	Structural	NTC Platform	RWM cabling supported from platform.	N/A
1.3.4.1	Gas Storage and Delivery Systems	Spatial	NTC Platforms	Numerous gas delivery tubes are supported from platforms and other structures	Schematic
1.4.1.8	MSE	Structural	At platform surface	MSE DNB is supported by platform.	General Arrangement Drawing
1.4.1.1	Neutron measurements	Structural	At platform surface	Fission chambers installed at various locations on the platform	General Arrangement Drawing
1.2.3	Electron Cyclotron Pre-ionization (ECH)	Structural	Platform floor	ECH system resides in the NSTX-U test cell, on the platform	General Arrangement Drawing
1.4.1.3	Multi-pulse Thompson Scattering (MPTS)	Structural	Test Cell Platform	MPTS TV cameras installed at various locations on the platform	General Arrangement Drawing
1.4.1.15	Vacuum Spectroscopy	Structural	Test Cell platform	EUV spectrometers mounted on stand that is supported from the Test Cell platform	General Arrangement Drawing
1.4.1.3	Multi-pulse Thompson Scattering (MPTS)	Structural	Test Cell platform	MPTS Flight tubes for laser input and exit to the vacuum vessel supported by platform.	General Arrangement Drawing
1.3.5.4	Granule Injector	Structural	At platform floor	Granule injector resides on the platform floor	General Arrangement Drawing
1.6.1.5	Test cell audio/video	Structural	At platform or platform support	Cameras mounted to platforms	N/A
1.3.1.1	Valves, Vacuum Pumps and Roughing Pumps	Structural	At platform support surface	Vacuum lines supported by the platforms	Mechanical Drawing
1.3.4.2.2	Supersonic Gas Injector	Structural	At platform floor	SGI is on a stand that resides on the platform	General Arrangement Drawing
1.3.4.3.2	Massive gas injectors	Structural	Platform floor	MGI valve assembly on outboard side resides on floor	Mechanical Drawing
1.3.4.4	Argon purge system	Structural	At clamps	Argon purge system supported from platforms	N/A
1.4.1.14	Physics Imaging Systems	Structural	Surface of platform	Various cameras and equipment for the physics imaging systems reside on the platforms.	General Arrangement Drawing

1.3.3.3.2	MTWS Manifolds and Vessel-Mounted Piping	Structural	Where support attaches to platform	Manifolds are supported from the test cell platforms	Mechanical Drawing
1.3.3.1.2	Ex-Vessel Helium Manifolds	Structural	Where support attaches to platform	Manifolds are supported from the test cell platforms	Mechanical Drawing
1.8.1.1.2	NTC Cable Trays	Structural	At platform	Cable trays suspended from platform	Mechanical Drawing
1.7.3.11.1	NTC ODH Monitors	Structural	At platform	ODH monitor system suspended/supported from platform	Mechanical Drawing
1.8.1.1.7	NTC Racks	Structural	At platform	NTC racks reside on the platform	General Arrangement
1.8.1.1.10	NTC Lighting	Structural	At platform	NTC lighting suspended from platform	N/A
0.1.1.8	D-Site Vent Stack	Structural	At platform	Exhaust manifold feeding the vent stack is sometimes suspended from the platforms	N/A
0.1.1.9	D-Site Instrument Air	Structural	At platform	Instrument air distribution supported from the platforms	N/A
0.1.1.10	D-Site House Air	Structural	At platform	House air distribution supported from the platform	N/A
1.7.3.1.1	PSS Logic Solver & Logic, I/O, I/O Devices, Interdiction Devices	Structural	At platform	Components of the PSS-SIS are supported by the test cell platforms	N/A
1.7.3.9.1	Caged Areas	Structural	At the brackets mounting the cage components to the platforms and columns	NSTX-U Machine Perimeter Safeguards may mount to NTC platforms and their supports	Mechanical drawings
1.7.3.4.5	TF Twist Measurement	Structural	At the platform	The Camera Needs to be mounted to the platform to provide a view of target	Mechanical Drawing
1.7.3.4.1	Fiber Optic Strain, Temp., Disp. Meas.	Spatial	At the platform	Cable trays attached to the platform require clearance from obstructions	N/A
1.7.3.1.3	PSS Conduit, Wire, Fiber	Structural	Where conduit is clamped to platform or columns	Conduits for PSS-SIS Supported by NTC platforms and platform columns	N/A
1.8.1.1.6	NTC Fire Protection	Structural	Where clamps attach to platform	Fire protection systems supported from platforms	N/A
1.8.1.1.4	NTC Walls	Structural	At NTC wall	NTC Platforms are supported by the test cell wall	Mechanical Drawing
1.8.1.1.5	NTC Penetrations	Structural	At penetration	Conduits of the PSS-SIS are passed through test cell wall penetrations	Conduit run drawing

**Table 2.6-2: Interfaces for the NSTX-U Test Cell Cable Trays (Incomplete) (SBS 1.8.1.1.2)**

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.4.1.1	Neutron measurements	Electrical signal	Cable trays	Cables between detectors and signal processing electronics	N/A
1.4.1.4	Plasma TV	Fiber Optic	Cable trays	Fiber optics bundles between lenses and TV cameras	N/A
1.4.1.13.2	LLNL Filterscope, EIES, VIPS	Fiber Optic	Cable trays	Fiber optics bundles between various windows on the vacuum vessel and detection system	N/A
1.4.1.15	Vacuum Spectroscopy	Fiber Optic	Tray surface	Fibers located in trays	N/A
1.3.4.1	Gas Storage and Delivery Systems	Structural	Surface of trays	Gas lines are run beneath, and supported by, cable trays	N/A
1.8.1.1.1	NTC Platforms	Structural	At platform	Cable trays suspended from platform	Mechanical Drawing
1.4.1.8	MSE	Structural	Tray surface	MSE Fiber optics in cable trays	N/A
1.4.1.2	Magnetics	Structural	Cable trays	Cables between Rogowski Coils, Poloidal Flux Loops, and Mirnov Sensors and signal processing electronics and digitizers located in racks	N/A
1.1.1.1.8	PFC Thermocouples	Structural	Cable trays	PFC Thermocouples cables use cable trays until they reach signal processing electronics and digitizers located in Test Cell racks	N/A
1.4.1.17	Langmuir Probes	Structural	Cable trays	Langmuir Probe Cables between electrical feedthroughs and signal processing electronics and digitizers located in racks	N/A
1.4.1.5.1	Toroidal CHERS	structural	At tray	Toroidal CHERS Fibers reside in cable trays	N/A
1.4.1.5.2	Poloidal CHERS	structural	At tray	Poloidal CHERS Fibers reside in cable trays	N/A
1.7.3.4.1	Fiber Optic Strain, Temp., Disp. Meas.	Structural	At tray	Fibers for sensors reside in cable trays	N/A
1.7.3.4.2	Center Stack Coil Thermocouples	Structural	At tray	Cables reside in cable trays	N/A
1.7.3.4.3	Passive Plate and Vessel Accelerometers	Structural	At tray	Cables reside in cable trays	N/A
1.7.3.6.1	FPDP Data Stream	Structural	At tray	Fibers reside in cable trays	N/A
1.7.3.6.8	Ip Calculator System	Structural	At tray	Fibers reside in cable trays	N/A
1.6.1.1	Control I/O systems	Structural	At tray	Control I/O Fibers or cables reside in cable trays	N/A
1.6.1.2	Plant Control and Monitoring	Structural	At tray	Plant Control and Monitoring Fibers and cables reside in cable trays	N/A
1.6.1.3	Timing and Synchronization System	Structural	At tray	Timing and Synchronization Fibers and cables reside in cable trays	N/A

1.6.1.5	Test cell audio/video	Structural	At tray	Trays support cables for cameras	N/A
1.4.1.6	FIDA	Structural	At tray	FIDA Fibers reside in cable trays	N/A
1.4.1.7	BES	Structural	At tray	BES Fibers reside in cable trays	N/A
1.4.1.13	Visible Spectroscopy	Structural	At tray	Fibers for various spectroscopy systems reside in cable trays	N/A
1.4.1.14	Physics Imaging Systems	Structural	At tray	Physics Imaging Systems Fibers and cables reside in cable trays	N/A
1.4.1.16	SXR Spectroscopy	Structural	At tray	SRX Spectroscopy Cables reside in cable trays	N/A
1.4.1.17	Langmuir Probes	Structural	At tray	Langmuir probe Cables reside in cable trays	N/A
1.4.1.18.1	QMBs	Structural	At tray	QMB Cables reside in cable trays	N/A
1.4.1.18.2	Dust Detectors	Structural	At tray	Dust Detector Cables reside in cable trays	N/A
1.4.1.19	MAPP	Structural	At tray	MAPP Cables reside in cable trays	N/A
1.4.1.20	Bolometers & Vacuum Radiation Sensors	Structural	At tray	Bolometers & Vacuum Radiation Sensors Cables reside in cable trays	N/A
1.4.1.21	IR Cameras for Thermography	Structural	At tray	IR Camera for Thermography Cables reside in cable trays	N/A
1.3.5.4	Granule Injector	Structural	In tray	Granule injector cables reside in trays	N/A
1.2.4.2	Beamlines	Structural	Where any clamps or support structures are fixed to the beamlines	Beamlines support various cable trays	Mechanical Schematic
1.4.1.2.1	Plasma Current Rogowski System	Structural	Surface of tray	Plasma current measurement resides in the NTC trays	N/A
1.4.1.2.3	RWM Sensors	Structural	At surface of tray	RWM Sensor Field cables and similar for sensors use trays to move from the vessel feedthrough to the appropriate racks	N/A
1.4.1.2.2	Mirnov and Flux Loop System	Structural	At surface of tray	Mirnov and Flux Loop Field cables and similar for sensors use trays to move from the vessel feedthrough to the appropriate racks	N/A
1.4.1.2.6	High Frequency MHD Sensors	Structural	At surface of tray	HF MHD Field cables and similar for sensors use trays to move from the vessel feedthrough to the appropriate racks	N/A
1.4.1.2.8	Tile and Rogowski Halo Current Measurements	Structural	At surface of tray	Tile and Rogowski Halo Current Field cables and similar for sensors use trays to move from the vessel feedthrough to the appropriate racks	N/A
1.4.1.2.4	Diamagnetic Loop System	Structural	At surface of tray	Diamagnetic Loop System Field	N/A

				cables and similar for sensors use trays to move from the vessel feedthrough to the appropriate racks	
1.4.1.9.1	SSNPA	Structural	At tray surface	Cables for SSNPA located in cable tray	N/A
1.3.1.2	Vacuum Gauges and Residual Gas Analyzers	Structural	At tray	Signals from gauges use cable trays	N/A
1.3.1.1	Valves, Vacuum Pumps and Roughing Pumps	Structural	At tray	Cables associated with pumps reside in trays	N/A
1.3.1.1	Valves, Vacuum Pumps and Roughing Pumps	Structural	At tray surface	Tubing supported from trays, cables in trays	N/A
1.3.4.4	Argon purge system	Structural	At tray surface	Argon Purge System tubing supported from trays	N/A
1.3.5.1.1	GDC + Filament Power Supplies	Structural	At tray	cabling run in the trays	N/A
1.1.2.2	Vacuum Vessel Thermocouples	Structural	At tray	Trays support cables for thermocouples	N/A
1.5.1.2	D-Site Auxiliary Power	Structural	At tray	trays support cables for sensors on the antenna	N/A
1.2.4.7	Neutral Beam Control Systems	Structural	At tray	Trays support cables for neutral beam controls	N/A
1.3.1.2	Vacuum Gauges and Residual Gas Analyzers	Structural	At tray	Trays support cables for the vacuum gauges and RGA	N/A
1.3.1.5	Probe drive controls	Structural	At tray	Trays support cables for probe drive controls	N/A
1.3.3.4	Bakeout PLC and Controls	Structural	At tray	Trays support cables for bakeout PLC and control cabling	N/A
1.3.3.2.1	Bakeout Bus Work	Structural	At tray	Trays support bakeout cabling	N/A
1.3.4.2.1	Main Chamber Fueling	Structural	At tray	Trays support piezo injector Main Chamber Fueling cables	N/A
1.3.4.2.2	Supersonic Gas Injector	Structural	At tray	Trays support piezo Supersonic Gas Injectors cables	N/A
1.3.4.2.3	Outboard Divertor Injection Systems	Structural	At tray	Trays support piezo Outboard Divertor injector cables	N/A
1.3.4.2.4	GPI and Impurity Injectors	Structural	At tray	Trays support piezo GPI and Impurity injector cables	N/A
1.3.4.2.5	Private Flux Region Fueling	Structural	At tray	Trays support piezo Private Flux Region Fueling injector cables	N/A
1.3.4.3.2	Massive gas injectors	Structural	At tray	Trays support cabling for the MGI system	N/A
0.1.1.3	PPPL Network Infrastructure	Structural	At tray	Trays support ethernet distribution	N/A
1.7.3.4.5	TF Twist Measurement	Structural	TBD	The sensors cables will be run through the Test Cell	Drawing

**Table 2.6-3:** This table eliminated in Rev. 3 of the SRD

**Table 2.6-4: Interfaces for the NSTX-U Test Cell Walls (Incomplete) (SBS 1.8.1.1.4)**

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.5.1.2	D-Site Auxiliary Power	Structural	At NTC wall	Transmissions lines supported from walls	Mechanical Drawings
1.1.3.4	Bus Bar Systems and Bus Tower	Structural	At NTC wall	RWM coil junction box and cables supported from NTC Wall	General Arrangement Drawing
1.7.3.7	Radiation Area Monitors	Structural	At NTC wall	Radiation area monitors mounted to wall.	General Arrangement Drawing
1.4.1.3	Multi-pulse Thompson Scattering (MPTS)	Structural	At NTC wall	MPTS Laser beam optics box supported by south wall of test cell	Mechanical drawing
1.6.1.5	Test cell audio/video	Structural	At NTC wall	Cameras mounted to NTC walls	N/A
1.3.4.4	Argon purge system	Structural	At NTC wall	Argon purge system supported by the NTC walls	General Arrangement
1.8.1.1.1	NTC Platforms	Structural	At NTC wall	NTC Platforms are supported by the test cell wall	Mechanical Drawing
1.7.3.1.1	PSS Logic Solver & Logic, I/O, I/O Devices, Interdiction Devices	Structural	At NTC wall	Components of the PSS-SIS are supported by the test cell wall	N/A
1.5.1.2	D-Site Auxiliary Power	Structural	At NTC wall	Components of the test cell power distribution are supported by the test cell wall	N/A
1.2.4.4	Neutral Beam Services	Structural	At NTC wall	Various neutral beam services are supported by the test cell wall	General Arrangement Drawing
1.7.3.4.5	TF Twist Measurement	Structural	At test cell wall	The Laser is attached to the test cell wall	Mechanical Drawing
1.7.3.4.5	TF Twist Measurement	Structural	At test cell wall	The Target Is attached to the Test Cell wall	Mechanical Drawing
1.7.3.1.3	PSS Conduit, Wire, Fiber	Structural	Where conduit is clamped to wall	Conduits for PSS-SIS Supported by NTC walls	Schematic
1.4.1.3	Multi-pulse Thompson Scattering (MPTS)	Structural	At NTC wall	Flight tube supported from the vessel walls	Mechanical drawing
1.8.1.1.6	NTC Fire Protection	Structural	At NTC wall	Fire protections systems supported from wall	N/A
1.7.3.10.1	Trapped Key Hardware & Sequencing	Structural	TBD	TKS uses components mounted to NTC walls	TBD
1.7.3.10.2	Trapped Key Status Monitoring	Electrical Signal	TBD	TKS disables movable shield wall controls	TBD
1.7.3.4.5	TF Twist Measurement	Structural	At wall surface	System is mounted to NTC walls	Drawings

**Table 2.6-5: Interfaces for the NSTX-U Test Cell Penetrations (Incomplete) (SBS 1.8.1.1.5)**

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.3.3.1	Helium heating and	Wall/Floor	At the	Helium piping basses through	General

	cooling system	Penetration	penetration	penetrations in the NTC wall	Arrangement Drawing
1.3.4.1	Gas Storage and Delivery Systems	Wall/Floor Penetration	At the penetration	Numerous gas delivery tubes come through penetrations in the NTC wall	General Arrangement Drawing
1.5.1.2	D-Site Auxiliary Power	Wall/Floor Penetration	At the penetration	Transmission lines penetrate the NTC wall	General Arrangement Drawing
1.1.3.4	Bus Bar Systems and Bus Tower	Wall/Floor Penetration	At the penetration	Cables from SPAs through NTC Penetrations	N/A
1.3.4.1	Gas Storage and Delivery Systems	Wall/Floor Penetration	At the penetration	Numerous gas delivery tubes come through penetrations in the NTC wall	N/A
1.4.1.8	MSE	Wall/Floor Penetration	At the penetration	MSE Fiber optics pass through NTC walls	N/A
1.5.3	Rectifier DC Systems	Wall/Floor Penetration	At the penetration	Power cables from FCPC come through the NTC floor, are terminated in the power cable termination structure resides in enclosure in corner of NTC	General Arrangement Drawing
1.2.4.4	Neutral Beam Services	Wall/Floor Penetration	NTC walls	Beamline services come through NTC wall penetrations	General Arrangement Drawing
1.5.3.1	TF Convertor DC Systems	Wall/Floor Penetration	At NTC floor, floor penetrations	Power cables from FCPC come through the NTC floor, are terminated in the power cable termination structure resides in enclosure in corner of NTC	N/A
1.5.3.2	OH Convertor DC Systems	Wall/Floor Penetration	At NTC floor, floor penetrations	Power cables from FCPC come through the NTC floor, are terminated in the power cable termination structure which resides in enclosure in corner of NTC	N/A
1.5.3.3	PF Convertor DC Systems	Wall/Floor Penetration	At NTC floor, floor penetrations	Power cables from FCPC come through the NTC floor, are terminated in the power cable termination structure which resides in enclosure in corner of NTC	N/A
1.5.3.4	Switching Power Amplifier DC Systems	Wall/Floor Penetration	At penetration surface	Power cables from the SPAs come through the test cell wall	N/A
1.4.1.15	Vacuum Spectroscopy	Wall/Floor Penetration	Connectors on Fiber to USB converter	Vacuum Spectroscopy Fiber optic USB link to connect detectors to PC located in DARM	N/A
1.4.1.3	Multi-pulse Thompson Scattering (MPTS)	Wall/Floor Penetration	Test Cell wall	Penetrations through Test Cell wall for MPTS laser flight tube and light collection fiber bundles	General Arrangement
1.4.1.5.1	Toroidal CHERS	Wall/Floor Penetration	At penetration	Toroidal CHERS Fiber optics leave NTC via penetrations	N/A
1.4.1.5.2	Poloidal CHERS	Wall/Floor Penetration	At penetration	Poloidal CHERS Fiber optics leave NTC via penetrations	N/A



1.4.1.6	FIDA	Wall/Floor Penetration	At penetration	FIDA Fiber optics leave NTC via penetrations	N/A
1.4.1.7	BES	Wall/Floor Penetration	At penetration	BES Fiber optics leave NTC via penetrations	N/A
1.4.1.10	FIReTIP	Wall/Floor Penetration	At penetration	FIReTIP Laser path passes through penetration in NTC wall	N/A
1.4.1.11	High-K Scattering	Wall/Floor Penetration	At penetration	High-K Scattering Laser path passes through penetration in NTC wall	N/A
1.4.1.13	Visible Spectroscopy	Wall/Floor Penetration	At penetration	Fiber optics for various visible spectroscopy systems leave NTC via penetrations	N/A
1.7.3.4.1	Fiber Optic Strain, Temp., Disp. Meas.	Wall/Floor Penetration	At penetration	Fiber optics leave NTC via penetrations	N/A
1.7.3.6.8	Ip Calculator System	Wall/Floor Penetration	At penetration	Fibers go through penetrations	N/A
1.7.3.6.1	FPDP Data Stream	Wall/Floor Penetration	At penetration	Fibers go through penetrations	N/A
1.3.3.1.1	Helium Skid & Piping	Wall/Floor Penetration	At penetration surface	Helium pipes from the pump room enter the NTC floor.	N/A
1.2.4.6	Neutral Beam Power System	Wall/Floor Penetration	various	Neutral beam power system cables come through various penetrations in the test cell walls	N/A
1.3.1.2	Vacuum Gauges and Residual Gas Analyzers	Spatial	At the penetration	Signals from gauges use NTC penetrations	N/A
1.3.5.1.1	GDC + Filament Power Supplies	Wall/Floor Penetration	At penetration	cabling from North gallery area passes through penetration to enter the NTC	N/A
1.3.4.2.1	Main Chamber Fueling	Wall/Floor Penetration	At the penetration	Main Chamber Fueling cables pass through penetrations	N/A
1.3.4.2.2	Supersonic Gas Injector	Wall/Floor Penetration	At the penetration	Supersonic Gas Injector cables pass through penetrations	N/A
1.3.4.2.3	Outboard Divertor Injection Systems	Wall/Floor Penetration	At the penetration	Outboard Divertor cables pass through penetrations	N/A
1.3.4.2.4	GPI and Impurity Injectors	Wall/Floor Penetration	At the penetration	GPI and Impurity Injectors cables pass through penetrations	N/A
1.3.4.2.5	Private Flux Region Fueling	Wall/Floor Penetration	At the penetration	Private Flux Region cables pass through penetrations	N/A
1.3.4.3.1	High field side injectors	Wall/Floor Penetration	At the penetration	High Field Side Injector cables pass through penetrations	N/A
1.3.4.3.2	Massive gas injectors	Wall/Floor Penetration	At the penetration	Massive Gas Injectors cables pass through penetrations	N/A
0.1.1.3	---	Wall/Floor Penetration	At the penetration	Fiber optics pass through penetrations	N/A
1.7.3.1.3	PSS Conduit, Wire, Fiber	Structural	At penetration	Conduits of the PSS-SIS are passed through test cell wall penetrations	Conduit run drawing
1.7.3.7	Radiation Area Monitors	Spatial	At the penetration	Signals that enable area monitors to illuminate the radiation warning sign pass through	N/A

				penetrations in the NTC wall	
1.7.3.11.1	NTC ODH Monitors	Wall/Floor Penetration	At penetration surface	ODH monitor tubes pass through penetrations in the test cell wall	Mechanical Drawing
1.7.3.11.1	NTC ODH Monitors	Structural	At the wall surface	ODH monitor system suspended/supported from Test Cell Wall	Mechanical Drawing
1.7.3.4.5	TF Twist Measurement	Wall/Floor Penetration	TBD	The cables for the laser and camera require a penetration.	Drawing
1.7.3.1.3	PSS Conduit, Wire, Fiber	Wall/Floor Penetration	At surface of conduits	Conduits for PSS-SIS pass through NTC Penetrations	Schematic
1.8.1.1.6	NTC Fire Protection	Wall/Floor Penetration	Surface of penetration	Fire protection systems utilize penetrations into the NSTX-U test cell	N/A
1.7.3.11.1	NTC ODH Monitors	Wall/Floor Penetration	At penetration surface	ODH monitor tubes pass through penetrations in the test cell wall	Electrical Schematic

**Table 2.6-6: Interfaces for the NSTX-U Fire Protection (Incomplete) (SBS 1.8.1.1.6)**

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.8.1.1.1	NTC Platforms	Structural	Where clamps attach to platform	Fire protection systems supported from platforms	N/A
1.8.1.1.4	NTC Walls	Structural	At NTC wall	Fire protections systems supported from wall	N/A
1.8.1.1.5	NTC Penetrations	Wall/Floor Penetration	Surface of penetration	Fire protection systems utilize penetrations into the NSTX-U test cell	N/A
0.1.1.4	D-Site Tower Water	Fluid	---	Fire protection system uses canal water	As per facilities
1.5.1.2	D-Site Auxiliary Power	Electrical Power	various	Fire protection systems relies on D-site power	Electrical Schematic for Directly Wired Components

**Table 2.6-7: Interfaces for the NSTX-U Test Cell Racks (Incomplete) (SBS 1.8.1.1.7)**

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.1.1.1.8	PFC Thermocouples	Spatial	Racks located in Test Cell	Rack space in Test Cell required for signal processing electronics and digitizers for PFC Thermocouples	N/A
1.4.1.17	Langmuir Probes	Spatial	Racks located in Test Cell	Rack space in Test Cell required for signal processing electronics and digitizers for Langmuir Probes	Mechanical drawing
1.4.1.1	Neutron measurements	Spatial	Rack located in Test Cell	1	Mechanical drawing
1.3.5.4	Granule Injector	Location	at rack	Granule injector electronics in racks	N/A
1.4.1.2.3	RWM Sensors	Location	At cross-connects	RWM Sensors Field cables terminate in cross-connects	N/A

			on rack	located in the racks, interface to electronics located in racks	
1.4.1.2.2	Mirnov and Flux Loop System	Location	At cross-connects on rack	Mirnov/Flux Loop Field cables terminate in cross-connects located in the racks, interface to electronics located in racks	N/A
1.4.1.2.6	High Frequency MHD Sensors	Location	At cross-connects on rack	HF MHD Field cables terminate in cross-connects located in the racks, interface to electronics located in racks	N/A
1.4.1.2.8	Tile and Rogowski Halo Current Measurements	Location	At cross-connects on rack	Tile and Rogowski Halo Current Field cables terminate in cross-connects located in the racks, interface to electronics located in racks Tile and Rogowski	N/A
1.4.1.2.4	Diamagnetic Loop System	Location	At cross-connects on rack	Diamagnetic Loop System Field cables terminate in cross-connects located in the racks, interface to electronics located in racks	N/A
1.4.1.2.1	Plasma Current Rogowski System	Location	At cross-connects on rack	Ip Field cables terminate in cross-connects located in the racks, interface to electronics located in racks	N/A
1.4.1.2.5	Digitizers and Integrators	Location	Front or back of racks	Various electronics modules (Digitizers and Integrators) located in racks	N/A
1.4.1.9.1	SSNPA	Location	N/A	SSNPAS Electronics are located in NTC racks	N/A
1.7.3.4.1	Fiber Optic Strain, Temp., Disp. Meas.	Location	N/A	Some electronics located in NTC racks	N/A
1.4.1.3	Multi-pulse Thompson Scattering (MPTS)	Location	N/A	MPTS Electronics located in NTC racks	N/A
1.7.3.2.3	Vessel Ground Bus & Switch	Electrical Power	Where bus is connected to the rack	Specific NTC racks receive an electrical reference to the vessel ground	Electrical Schematic
1.7.3.2.4	Diagnostic Ground Bus	Electrical Power	Where bus is connected to the rack	Specific NTC racks receive an electrical reference to diagnostic ground	Electrical Schematic
1.8.1.1.1	NTC Platforms	Structural	At platform	NTC racks reside on the platform	General Arrangement

**Table 2.6-8: Interfaces for the NSTX-U Test Cell Floor (Incomplete) (SBS 1.8.1.1.8)**

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.1.3.3.7	Pedestal	Structural	At NTC floor surface	The pedestal sits on the test cell floor	Mechanical Drawing

1.3.1.1	Valves, Vacuum Pumps and Roughing Pumps	Structural	At NTC floor surface	Various pumps are supported on the test cell floor	General Arrangement Drawing
1.1.2.1.3	Vessel Legs	Structural	At NTC floor surface	Gravity, seismic loads, and global torques are transferred to the NTC floor	Calculation, Mechanical Drawings
1.1.3.3.7	Pedestal	Structural	At NTC floor surface	Gravity, seismic loads, and global torques are transferred from the pedestal to the NTC floor	Calculation, Mechanical Drawings
1.1.3.4	Bus Bar Systems and Bus Tower	Structural	At NTC floor surface	Bus tower is supported by NTC floor.	General Arrangement Drawing
1.5.3	Rectifier DC Systems	Structural	At NTC floor surface	Power cables from FCPC come through the NTC floor, are terminated in the power cable termination structure resides in enclosure in corner of NTC	General Arrangement Drawing
1.2.4.2	Beamlines	Structural	At NTC floor surface	Beamlines sit on floor	Drawings
1.4.1.3	Multi-pulse Thompson Scattering (MPTS)	Structural	At NTC floor surface	MPTS Collection optics box supported from Test Cell floor	Mechanical drawing
1.2.4.2	Beamlines	Structural	At NTC floor surface	source platform is supported from the floor	General Arrangement
1.3.1.7	Interspace Vacuum Pumping System	Structural	At NTC floor surface	IVPS pumps reside on the floor of the test cell	General Arrangement
1.2.4.4	Neutral Beam Services	Structural	At NTC floor surface	Various neutral beam services reside on the test cell floor	General Arrangement Drawing
1.7.3.9.1	Caged Areas	Structural	At the brackets mounting the cage components to the floor	NSTX-U Machine Perimeter Safeguards may mount to NTC floor	Mechanical drawings
1.2.4.6	Neutral Beam Power System	Structural	At NTC floor surface	Components such as the high voltage enclosures (HVEs) are supported from the floor	General Arrangement

**Table 2.6-9: Interfaces for the NSTX-U Fall Protection System (SBS 1.8.1.1.11)**

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.1.2.1.2	Umbrella structure & Spoked Lids	Structural	At bolted connection of fall protection anchors	Fall protection anchors are mounted to the umbrella structure	Mechanical drawing

Note: previous material and radiation area monitors and access control systems were moved to the new SRD NSTX-U-RQMT-SRD-12 *Operational and Safety Systems*

