



National Spherical Torus eXperiment Upgrade

NTC Oxygen Monitoring WBS 1.08.01.02

NSTX-U Recovery Project FDR – March 17-19, 2020

M. Cropper - Cognizant Engineer

Last edit: 3/09/2020

Outline

1. Overview

2. Scope

3. Requirements and Interfaces

4. Analysis/Prototyping

5. Chit Closure

6. Procurement, Fabrication, Installation, and Test

7. Risk - Project Risks and Design FMECA

8. Quality, Environmental, Safety, and Health

9. Summary

Overview - WBS 1.08.01.02

WBS Title	Oxygen Monitor	WBS #	1.09.04.02
Project Cog.	Mark Cropper	Assoc. Proj. Man.	Tom Jernigan
Design Scope	Install redundant oxygen deficiency hazard (ODH) monitors in NSTX-U Test Cell and nearby Gallery		
Technical Impact of Scope	Improves safety by providing warning to individuals of any oxygen deficiency condition in the test cell or adjacent hall (the gallery)		
Design Status	FDR Completed on January 31, 2020: link Drawings: link Chit Reports: link Calculations: link		
Fabrication Status	Closing out FDR issues, awaiting ESAB 3B approval to order monitors and start installation		
Installation Status			

Outline

1. Overview

2. Scope

3. Requirements and Interfaces

4. Analysis/Prototyping

5. Chit Closure

6. Procurement, Fabrication, Installation, and Test

7. Risk - Project Risks and Design FMECA

8. Quality, Environmental, Safety, and Health

9. Summary

Install redundant oxygen deficiency hazard (ODH) monitors to monitor/alarm the NSTX-U Test Cell and nearby gallery spaces

- Install two primary monitors and two redundant monitors
 - Seven locations in these spaces will be monitored for ODH
 - **NSTX-U Test Cell**
 - Under the machine in the vicinity of bays A & L - motivated by leaks of Ar from purge system, N_2 from cryogenic systems
 - At or above the level of the crane cab - motivated by leaks of He from cryogenic systems
 - In the shield door pit - motivated by leaks of SF_6 from NB HV systems
 - Between the NB HVE's - motivated by leaks of SF_6 , from NB HV systems, N_2 from cryogenic systems
 - **Gallery**
 - Low near the LN fill station in the Gallery - motivated by leak of N_2 from fill station
 - High in the NE Gallery
 - High in the SE Gallery
- Motivated by leaks of He from cryogenic system
- These locations was added post FDR is response to the ongoing review of the D-Site ODH hazards
- An ECN will be generated to add this location to the drawings

Remote Annunciators Will Be Installed

- Install remote annunciators at all access points to the Test Cell & Gallery
 - NSTX Test Cell
 - North and South Personnel Doors
 - Neutral Beam Shield Door - will also be used for gallery personnel door
 - Door from Mock-up Vestibule
 - Door from NB Compressor room
 - Door from NB East Stairwell
 - NSTX-U DARM
- Install remote annunciators in the NSTX-U Test Cell
 - NSTX Test Cell
 - East Wall @ ~ 114'
 - West Wall @ ~ 124'
 - South High Bay
 - Pony wall @ ~ 114'

Control Room Status & Backup Power

- Connect system status outputs to the TVPS PLC for display on the control room HMI display
- Install redundant UPS systems
 - One system for the primary monitors
 - M1A - Channels 1 - 4
 - M2A - Channels 5 - 8
 - One system for the redundant monitors
 - M2A - Channels 1 - 4
 - M2B - Channels 5 - 8

ASO Considerations

- This System is expected to become a Credited Control as detailed in the NSTX-U SAD and ASE
 - All components will be labeled in a manner that identifies them as part of a credited control
 - Purple & White Labels
 - Will have a statement that this is a Credited under configuration management per procedure D-NSTXU-OP-AD-134
 - All accessible/removable components will be either locked with a unique lock, or will have tamper resistant fasteners to prevent unauthorized access
- The system will be managed per procedure D-NSTXU-OP-AD-134, *Credited Controls Configuration Management*
- This system has undergone multiple USI screenings
 - Two USID's have been generated
 - 18-008
 - 18-033

NSTX-U Will Use The Same ODH Monitor As The Neutral Beams

- OXIGRAF O2iM

- Up to Four points can be monitored using a single monitor
- Equipped with a secondary high flow pump and valves for long tubing runs
- Uses Laser diode absorption spectroscopy
- Rated for more than 100,000 hours mean time to failure
- Accurate measurement no matter the gas mixture
- Temperature and pressure corrected
- Measures actual oxygen concentration not partial pressure
- Can be set up for auto calibration at user defined intervals
- All functions password protected
- The monitor case is lockable for added security

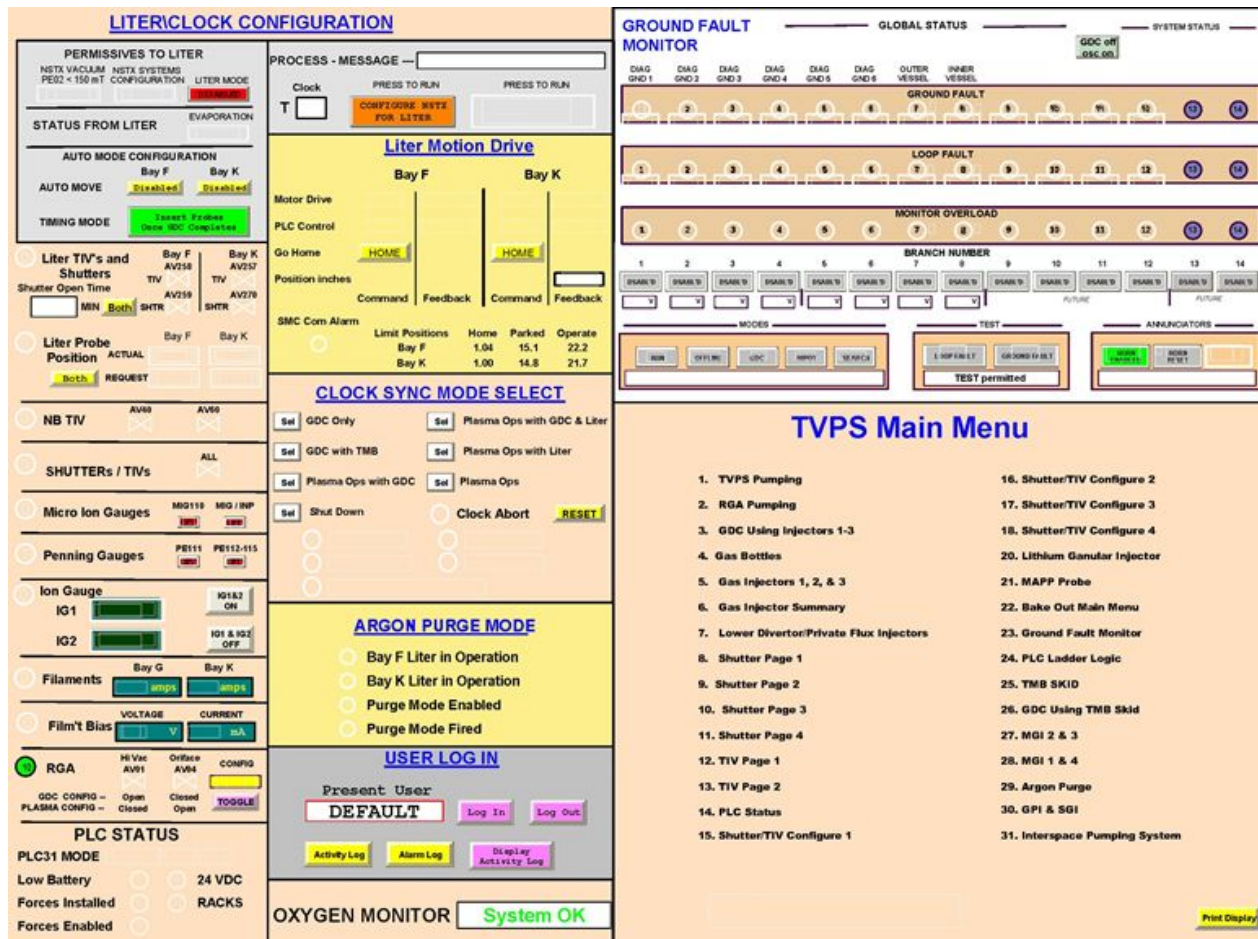


Remote Annunciators

- Have four LED lights to display monitor status
 - Green – System OK
 - Blue – Calibration
 - Yellow – System Faulted
 - Red – System is detecting a Low Oxygen level
 - LED life expectancy 100,000 hours
- Has alarm horn rated @ 90 db at 10 feet

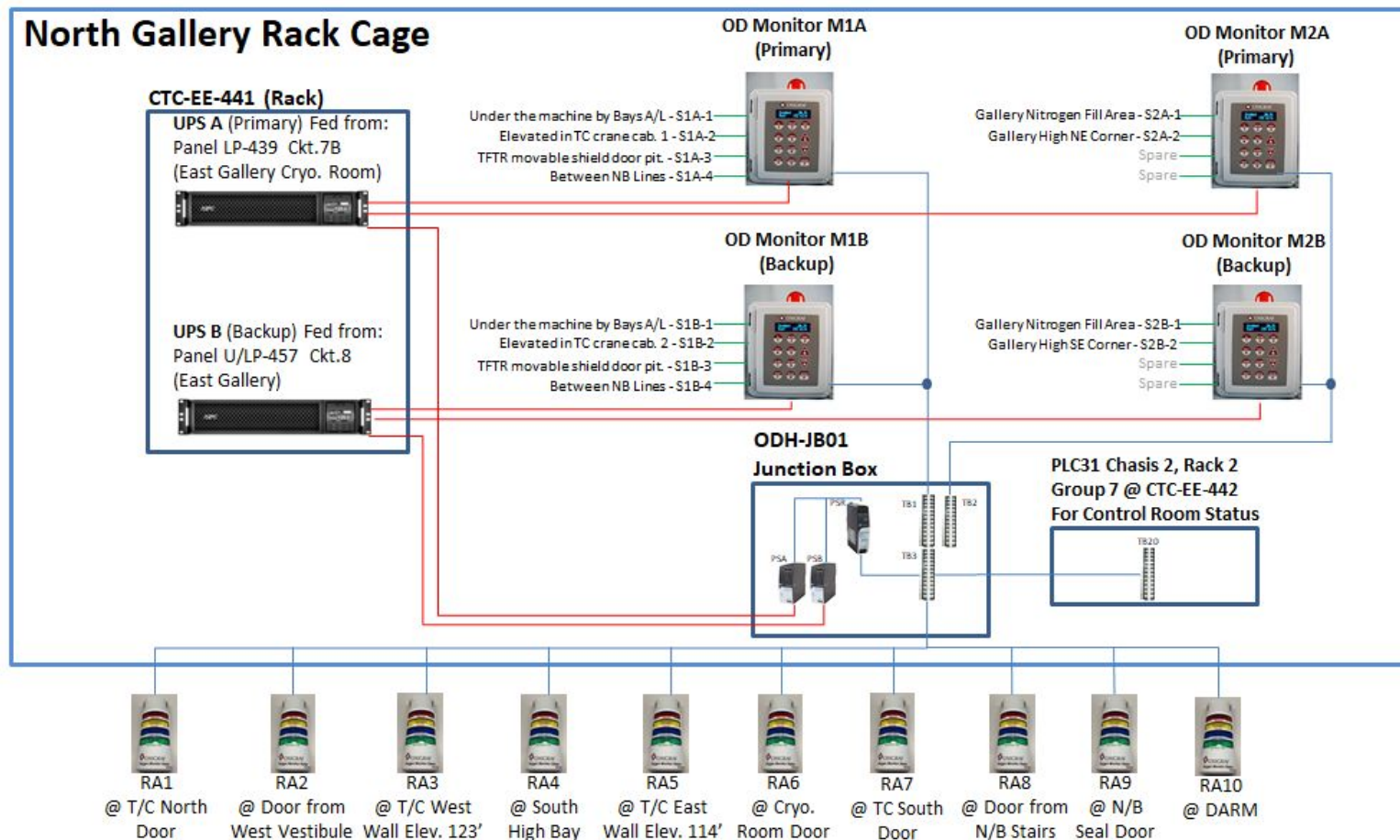


Control Room HMI Display

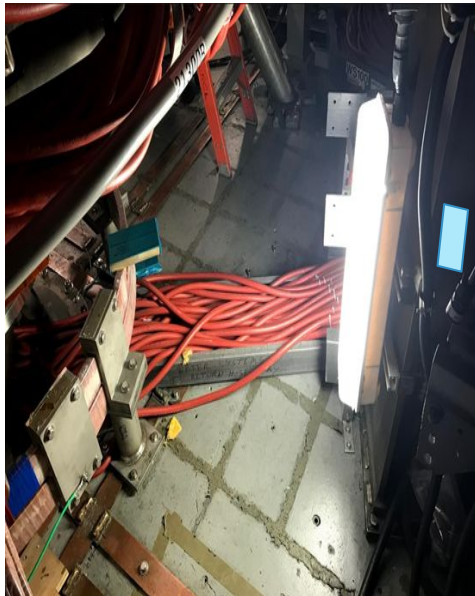


Upper right display.
This display can not be changed.

Design Block Diagram



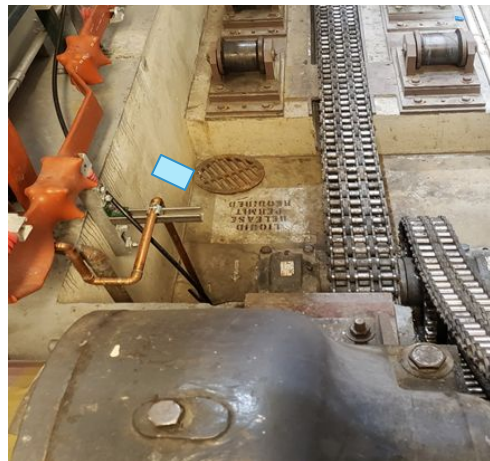
ODH Sampling Locations Test Cell



Bays A/L

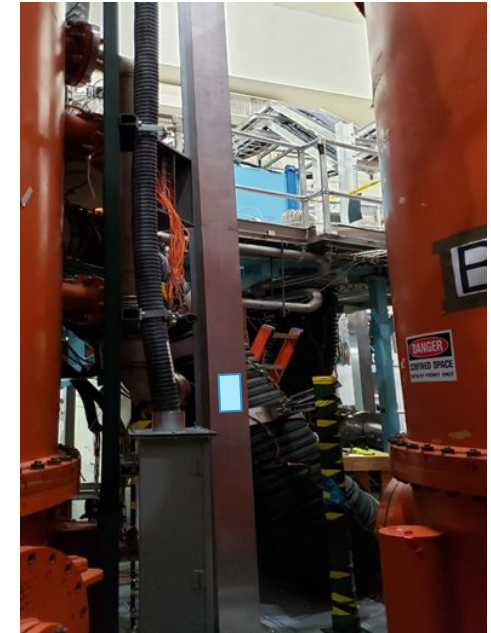


North Wall
Above
Crane Cab



Shield
door pit

 Pick up Tube



HVE's

ODH Sampling Locations Gallery

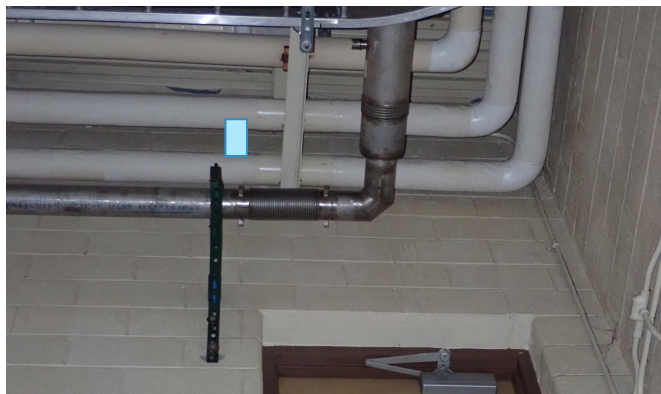
□ Pick up Tube



LN Fill
Station



Northeast Gallery High



Southeast Gallery High

Balance of Plant Considerations

- A comprehensive review of the presently installed Neutral Beam ODH systems and the areas that the NB cryo system transverse is being performed
 - The review is being conducted to ensure that ODH hazards in all areas are re-assessed and addressed in a consistent manner
 - Is a ODH monitor required?
 - Are redundant ODH monitors required?
 - Is the ventilation in the space adequate?
- All presently installed systems will be updated to be consistent with the design principles of the NSTX-U Test Cell design
- Any new installations will follow the same design principles as the NSTX-U Test Cell design

Outline

1. Overview

2. Scope

3. Requirements and Interfaces

4. Analysis/Prototyping

5. Chit Closure

6. Procurement, Fabrication, Installation, and Test

7. Risk - Project Risks and Design FMECA

8. Quality, Environmental, Safety, and Health

9. Summary

Requirements Defined and Met

SOURCE	REQUIREMENT	Met
NSTX-U-RQMT-GRD-01	The test cell shall be provided with an oxygen deficiency hazard (ODH) monitoring system	✓
NSTX-U-RQMT-SRD-012	Oxygen monitor points shall be located at four points	✓
NSTX-U-RQMT-SRD-012	Unless otherwise started, monitor points shall be at or below five feet	✓
NSTX-U-RQMT-SRD-012	The ODH monitors shall have minimum one hour battery backup	✓
NSTX-U-RQMT-SRD-012	The ODH monitors shall be capable of detecting a low oxygen level regardless of the gas mixture.	✓
NSTX-U-RQMT-SRD-012	The monitors shall not be affected by magnetic or radiation fields or shall be capable of being mounted outside the test cell	✓
NSTX-U-RQMT-SRD-012	All remote Status/Alarm indicators mounted inside the NTC shall be electrically isolated from the electronics mounted outside the test cell with isolation as per the GRD	✓
NSTX-U-RQMT-SRD-012	Connections between air sampling sensors and measurement components shall be routed and located in such a manner as to report oxygen deficiencies as efficiently as possible (shortest route)	✓

Requirements Defined and Met

SOURCE	REQUIREMENT	Met
NSTX-U-RQMT-SRD-012	The system shall have redundant ODH monitors for each location	✓
NSTX-U-RQMT-SRD-012	The system shall have remote status/alarm indicators mounted outside the test cell at the two personnel access doors and the two movable shield doors to alert personnel not to enter the test cell	✓
NSTX-U-RQMT-SRD-012	The system shall have remote status/alarm indicators mounted inside the test cell	✓
NSTX-U-RQMT-RD-12	Audible alarms in the test cell and visual status indicators outside the test cell doors shall annunciate when the oxygen level is at or below 19.5% oxygen	✓
NSTX-U-RQMT-RD-12	Audible alarms shall be loud enough that personnel at any location within the NTC, including at entrances, will be able to clearly resolve the alarm above the background noise level.	✓
NSTX-U-RQMT-RD-12	Remote status of the system shall be displayed outside the test cell at the North and South personnel access doors in easily observed locations.	✓

Complete RVTM maintained by Project Systems Engineering

The Design Accommodates Required Interfaces

9.6 Interfaces

Table 9.6-1: Interfaces for the Test Cell Oxygen Monitoring System (SBS 1.7.3.11.1)

Interfacing SBS	Interfacing System	Nature of Interface	Interface Boundary	Interface Description	Required Interface Documentation
1.8.1.1.1	NTC Platforms	Structural	At platform	ODH monitor system suspended/supported from platform	Conduit Drawing
1.5.1.2	D-Site Auxiliary Power	Electrical Power	At panel or plug	AC power provided to oxygen monitor system	Electrical Schematic
1.8.1.1.5	NTC Penetrations	Wall/Floor Penetration	At penetration surface	ODH monitor tubes pass through penetrations in the test cell wall	Conduit Drawing
1.8.1.1.5	NTC Penetrations	Structural	At the wall surface	ODH monitor system suspended/supported from Test Cell Wall	Conduit Drawing
1.8.1.1.5	NTC Penetrations	Wall/Floor Penetration	At penetration surface	ODH monitor tubes pass through penetrations in the test cell wall	Conduit Drawing

Outline

1. Overview
2. Scope
3. Requirements and Interfaces
4. Analysis/Prototyping
5. Chit Closure
6. Procurement, Fabrication, Installation, and Test
7. Risk - Project Risks and Design FMECA
8. Quality, Environmental, Safety, and Health
9. Summary

Analysis/Prototyping

- Calculation of Potential Oxygen Deficient Spaces Associated with the NSTX-U Facility: [NSTXU_1-8-1-1-3_CALC_100](#)
- All Materials are COTS, no prototyping required
- This type of ODH monitor has been in use at this Lab for over ten years
- This ODH monitor is also in use at other National labs

Calculation of Potential Oxygen
Deficient Spaces Associated with the
NSTX-U Facility

Calculation No.: NSTXU_1-8-1-1-3_CALC_100
Revision No.: R1

Preparer: Jessica Guttenfelder

Jessica
Guttenfelder

Digitally signed by Jessica
Guttenfelder
Date: 2020.01.30 13:34:53
-05'00'

Checker: Joseph Petrella

Joseph R.
Petrella Jr.

Digitally signed
by Joseph R.
Petrella Jr.
Date: 2020.01.30
13:54:25 -05'00'

Outline

1. Overview
2. Scope
3. Requirements and Interfaces
4. Analysis/Prototyping
5. Chit Closure
6. Procurement, Fabrication, Installation, and Test
7. Risk - Project Risks and Design FMECA
8. Quality, Environmental, Safety, and Health
9. Summary

Details of Interfaces Defined in Interface Control Documents


System 1	System 2	ICD Link	Exposition
Operations and Systems Safety	Power Systems	link	Defines interfaces between the ODH monitoring system and the Power Sources
Operations and Systems Safety	Test Cell	link	Defines interfaces between the ODH monitors and the test cell to include wall mounts and penetrations

All PDR Chits have been Closed

PDR Chit Resolution Report for ODH Monitoring

[NSTXU_1-8-1-1-3_CRR_100](#)

APPROVED
PPPL

 **PPPL**
PRINCETON
PLASMA PHYSICS
LABORATORY

ENG-033 - CRR - CHIT RESOLUTION REPORT
CHIT RESOLUTION REPORT FOR ODH
MONITORING

NSTXU_1-8-1-1-3_CRR_100
Rev. 1

Work Planning #:
Effective Date: **03/09/2020**
Prepared By: **Peter Dugan**

Reviewed By	Mark B. Cropper, Cognizant Individual	03/06/2020 15:24:59 PM
Reviewed By	Yuhu Zhai, Project Engineer	03/09/2020 08:50:39 AM
Approved By	Robert A. Ellis, Chief Engineer	03/09/2020 09:05:40 AM

PRINCETON PLASMA PHYSICS LABORATORY
P.O. BOX 451 PRINCETON, N.J. 08543

Outline

1. Overview
2. Scope
3. Requirements and Interfaces
4. Analysis/Prototyping
5. Chit Closure
6. Procurement, Fabrication, Installation, and Test
7. Risk - Project Risks and Design FMECA
8. Quality, Environmental, Safety, and Health
9. Summary

Procurements/Installation

- ALL Materials are COTS and will be ordered once ESAB CDE-3B approval is given
- Installation will be performed by a subcontractor under an existing BOA
- A Pre-Operational Test will be completed once the installation is complete

Outline

1. Overview
2. Scope
3. Requirements and Interfaces
4. Analysis/Prototyping
5. Chit Closure
6. Procurement, Fabrication, Installation, and Test
7. Risk - Project Risks and Design FMECA
8. Quality, Environmental, Safety, and Health
9. Summary

FMECA - NTC/Gallery ODH Monitors

System	Failure Mode	Failure Cause	Failure Effect	R	Detection/ Mitigation System (1)	Detection/ Mitigation System (2)	Detection/ Mitigation System (3)	R_R
NTC ODH Monitors	Power loss to monitor	Breaker trip; site wide outage	UPS prevents immediate effect; if power is not restored within an hour, then potential loss of ODH condition detection	0	Vacuum System PLC	NTC ODH Monitors	None	0
NTC ODH Monitors	Cable between monitor and annunciator is disconnected or otherwise fails open	Damage to conduit	Annunciator is not longer capable of indicating an ODH condition	2	Vacuum System PLC	NTC ODH Monitors	None	2
NTC ODH Monitors	Detector failure	electronics failure	Single detector no longer capable of indicating an ODH condition	3	Vacuum System PLC	NTC ODH Monitors	None	3
NTC ODH Monitors	sampling tube flow inadequate	tube pinched, inlet blocked	Single detector no longer capable of indicating an ODH condition	2	Vacuum System PLC	NTC ODH Monitors	None	2
NTC ODH Monitors	Remote annunciator failure	electronics failure	Annunciator is not longer capable of indicating an ODH condition	2	NTC ODH Monitors	None	None	2
NTC ODH Monitors	Calibration source unavailable	empty bottle	Failure to calibrate correctly	3	Vacuum System PLC	NTC ODH Monitors	None	3
NTC ODH Monitors	24 V supply for remote annunciators is lost	power supply failure, wire disconnection	Remote annunciator no longer functional	2	NTC ODH Monitors	None	None	2

Project Risks are Actively Managed

Risk	Score (1-81)	Open/Closed	Risk Retirement Event
No project risks associated with this WBS element			

Outline

1. Overview
2. Scope
3. Requirements and Interfaces
4. Analysis/Prototyping
5. Chit Closure
6. Procurement, Fabrication, Installation, and Test
7. Risk - Project Risks and Design FMECA
8. Quality, Environmental, Safety, and Health
9. Summary

Quality, Environmental, Safety, and Health

- QC & Electrical Safety Specialist will inspect work once completed
- Safety will be at the forefront of work planning
 - Fall protection will be utilized were required
 - Silica hazard - conduit fastener installation
 - Air monitoring - as required
 - respiratory protection - as required
 - dust minimization controls - (vacuum, water)
 - Standard power and hand tools will be used, with appropriate PPE
 - PPPL Lockout/Tagout program will be followed
 - Work will be planned to manage flow of traffic in the work areas
- PPPL employees to supervise all subcontractors

All work Managed by
the PPPL worker
safety program
(ESH-5008)

Outline

1. Overview
2. Scope
3. Requirements and Interfaces
4. Analysis/Prototyping
5. Chit Closure
6. Procurement, Fabrication, Installation, and Test
7. Risk - Project Risks and Design FMECA
8. Quality, Environmental, Safety, and Health
9. Summary

Summary

- All Requirements have been established
- The Design was completed
 - All requirements meet
 - Interfaces have been identified and managed
- An FDR has been held
 - All chits have been closed
 - The Drawings are being update and signed
- No project risks have been identified
- A BCP is being written to add funds and break out planning package
- Areas outside the Test Cell are being reviewed to ensure they follow the same design principles as the Test Cell
- The NSTX-U SAD is being update for ODH hazards
- Awaiting ESAB CDE-3B approval to purchase monitors and start installation