National Spherical Torus eXperiment Upgrade

Trapped Key System and Configuration Managed Safeguards

Part of WBS 1.09.04.01

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

Mike D'Agostino

J. Petrella - Cognizant Engineer

Last edit: 3/10/20

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 1.09.04.01

WBS Title	Personnel Safety System	WBS #	1.09.04.01
Project Cog.	J. Petrella	Assoc. Proj. Man.	T. Jernigan
Design Scope	Install new Trapped Key System and Configuration Managed Safeguards. Labeling/identification of existing Safeguards.		
Technical Impact of Scope	Protect Personnel from Experimental Hazards of NSTX-U		
Design Status	FDR completed on 1/29/20: review link chits: link calculations: link drawings: link		
Fabrication Status	Not Started - Part of CDE-3B ESAAB approval		
Installation Status	Not Started - Will be installed following CDE-3B ESAAB approval		

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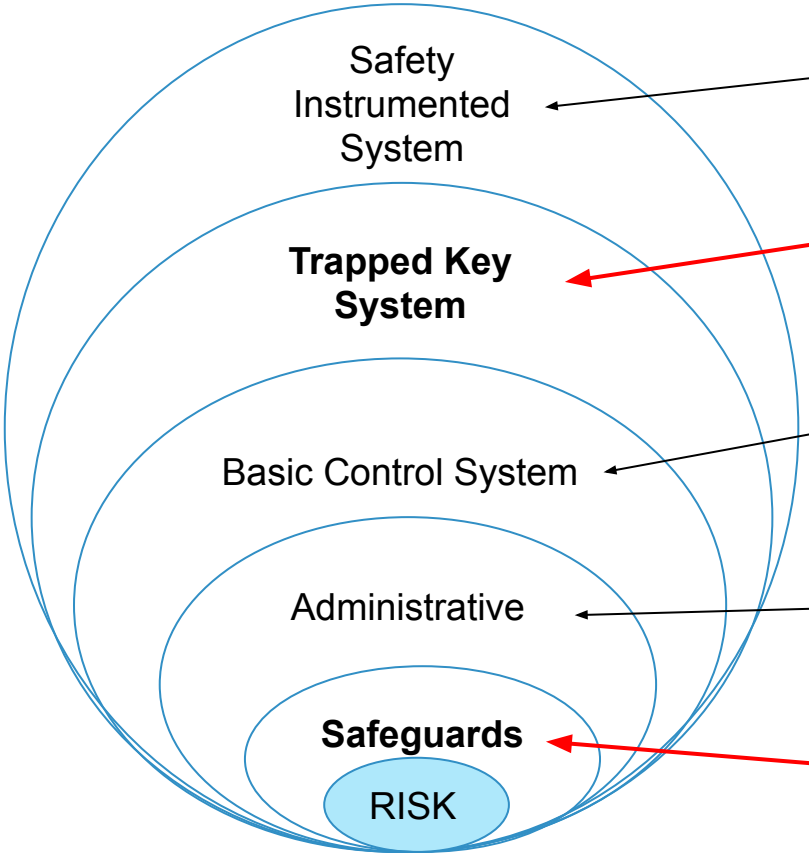
Overview of TKS & CMS

- Trapped Key System (TKS)
  - Design/installation of new Trapped Key System for access control and personnel protection
    - Complements PSS-SIS
    - Enforces safe configuration of the facility, including select movable CMS
    - Interlocks hazardous energy sources to exclusion area access

- Configuration Managed Safeguards (CMS)
  - Design/installation of new cages around the vacuum vessel
    - Protects personnel from contact hazards (electrical & thermal)
    - Allows NTC to be “General-Access” per ESHD 5008 during “Access” state
  - Design/installation of new cage around the Bakeout hot helium skid
    - Protects personnel from thermal hazards
  - Labeling/identification of existing safeguards
    - Streamlines periodic inspections (Configuration Management assurance)
    - Includes new guards on hot helium piping to be installed by Bakeout Recovery job
  - Installation of other cages to improve safety
    - SPA1 power supply

TKS & CMS are each part of Independent Protection Layers designed to reduce risk to personnel



Fail-safe interdiction of breakers independent of BCS interdictions
RRF of 12 needed, RRF of 827 achieved

Enforces select Safeguards and interlocks Hazardous Energy Sources
RRF of 10

Local Control Systems provide interdiction:
FCPC→ Rectifier Suppress/Bypass & Ground Switches
NB → Crowbar & Fast Vacuum Interrupters
RRF of 0 (IEC 61511 allows for up to 10)

Standardized Procedures, Lock out Tag out, Conduct of Operations, Operator Response
RRF of 0

Configuration Managed Safeguards, Shielding, Enclosures, Standard Industrial Covers
RRF of 0

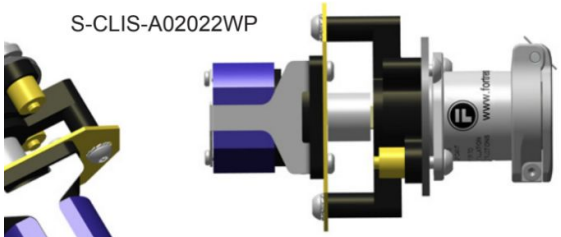
*Risk Reduction Factor (RRF) - discussed in LOPA talk

TKS Provides One of Two Credited* Independent Protection Layers

- The new Trapped Key System is separate and distinct from existing Kirk Keys used for machine protection/sequencing
  - Replaces existing Kirk Keys in access control system
  - Does not replace Kirk Keys in power subsystems
- Fortress Interlocks mGard trapped key interlocks will be used
  - Provides mechanical and electrical interlocks
  - Allows sequential or nonsequential control
  - Expandable, modular, and robust
- Suitable for use in safety applications
  - Certified by independent international safety test agency TUV
  - TUV approved to SIL 3 (EN/IEC 62061), Category 4 and PLe (EN/ISO 13849-1)
  - SIL 3: RRF 1,000-10,000, RRF of 10 required

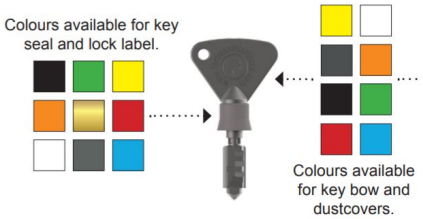
*Incorporated in IEC 61511/61508 LOPA; TKS is *also* expected to be a Credited Control per DOE O 420.2C

Examples of components used in the design

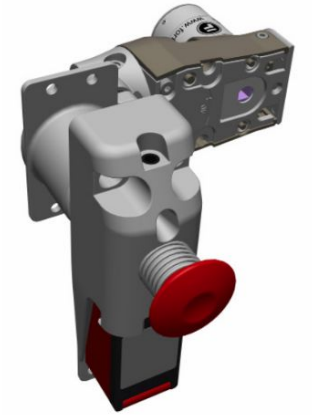


Waterproof Key Switch

Enclosed Solenoid Release Key Switch with Enable Button



Standard Color Coded Keys with Engraving

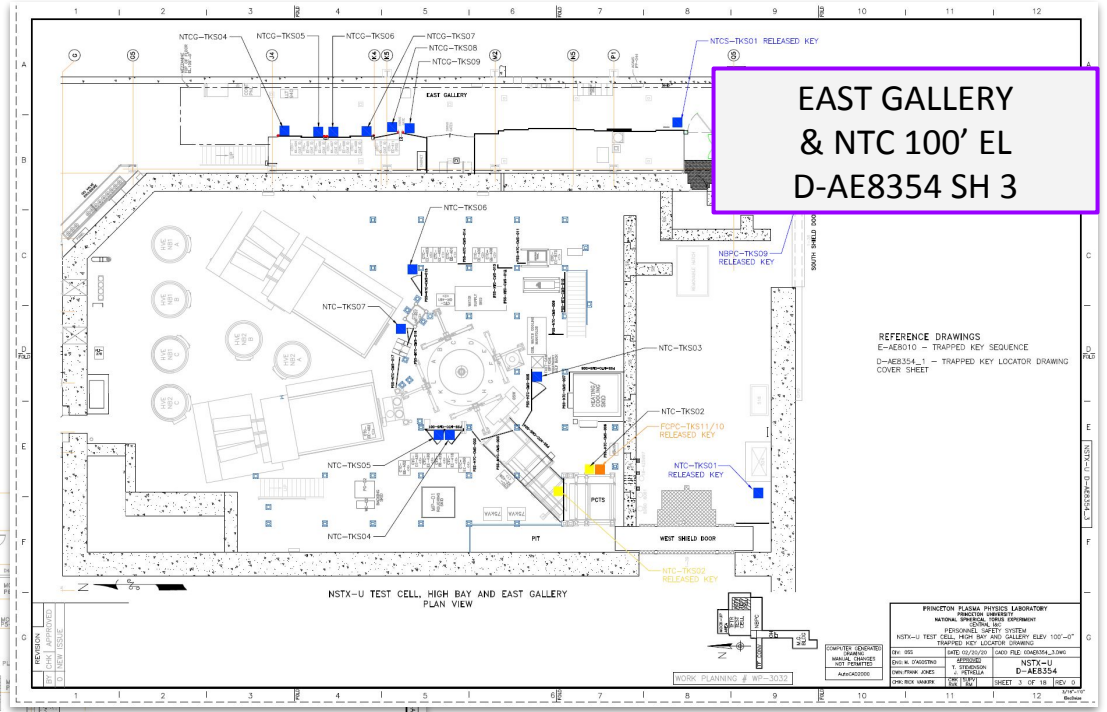


Door Interlock with Internal Release & Monitoring

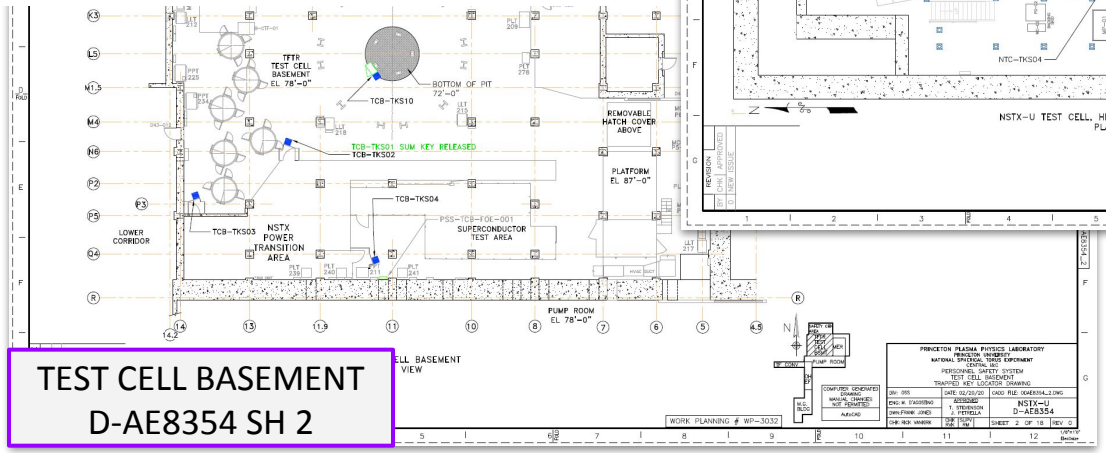
Key Exchange Transfer Block

Physical locations defined by drawing set

- Location of
  - Door Locks
  - Key Exchanges
  - Power & Control Isolation
- Key travel/sequencing
- Relative location to new CMS



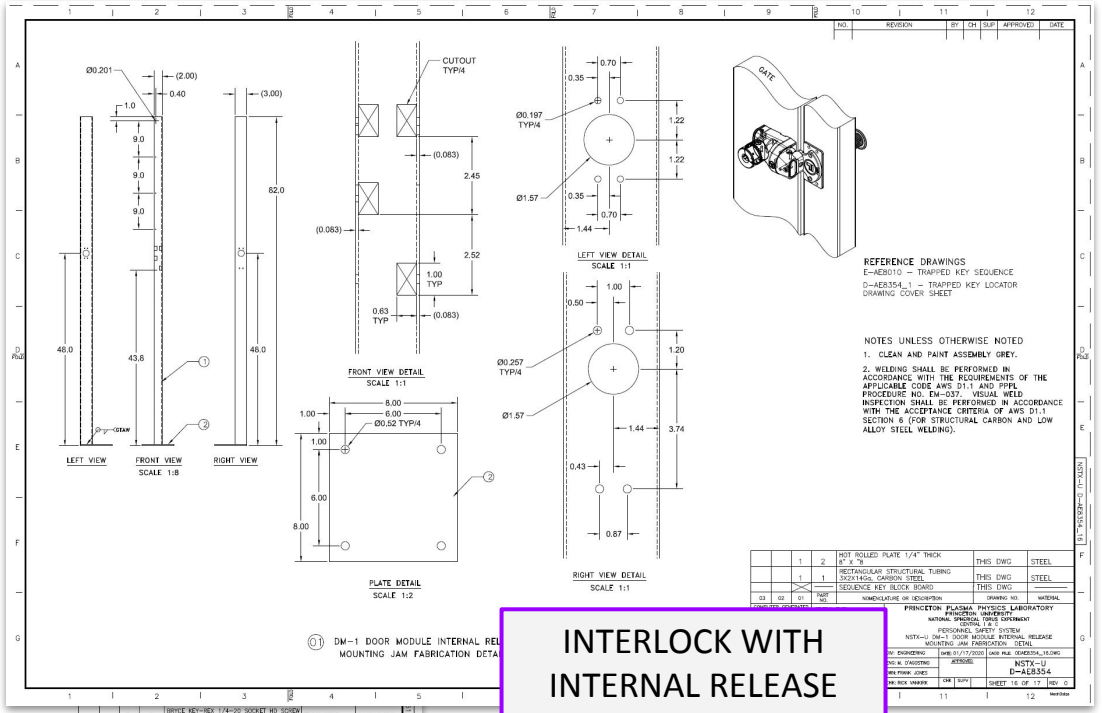
EAST GALLERY
& NTC 100’ EL
D-AE8354 SH 3



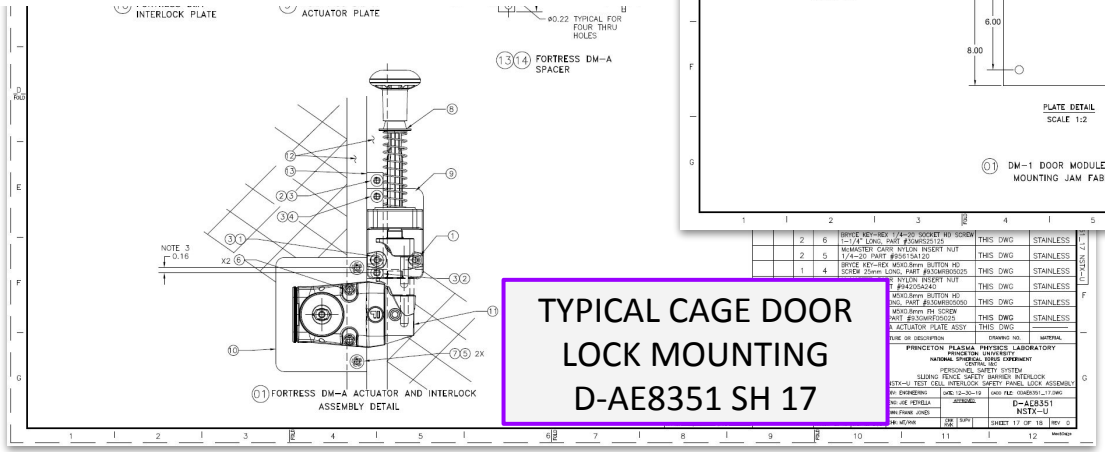
TEST CELL BASEMENT
D-AE8354 SH 2

Mounting details defined by drawing set

- Tamper resistant screws incorporated
- Fabrication of mounting plates as required
- Typical drawings apply to multiple installations



INTERLOCK WITH INTERNAL RELEASE MOUNTING D-AE8354 SH 16

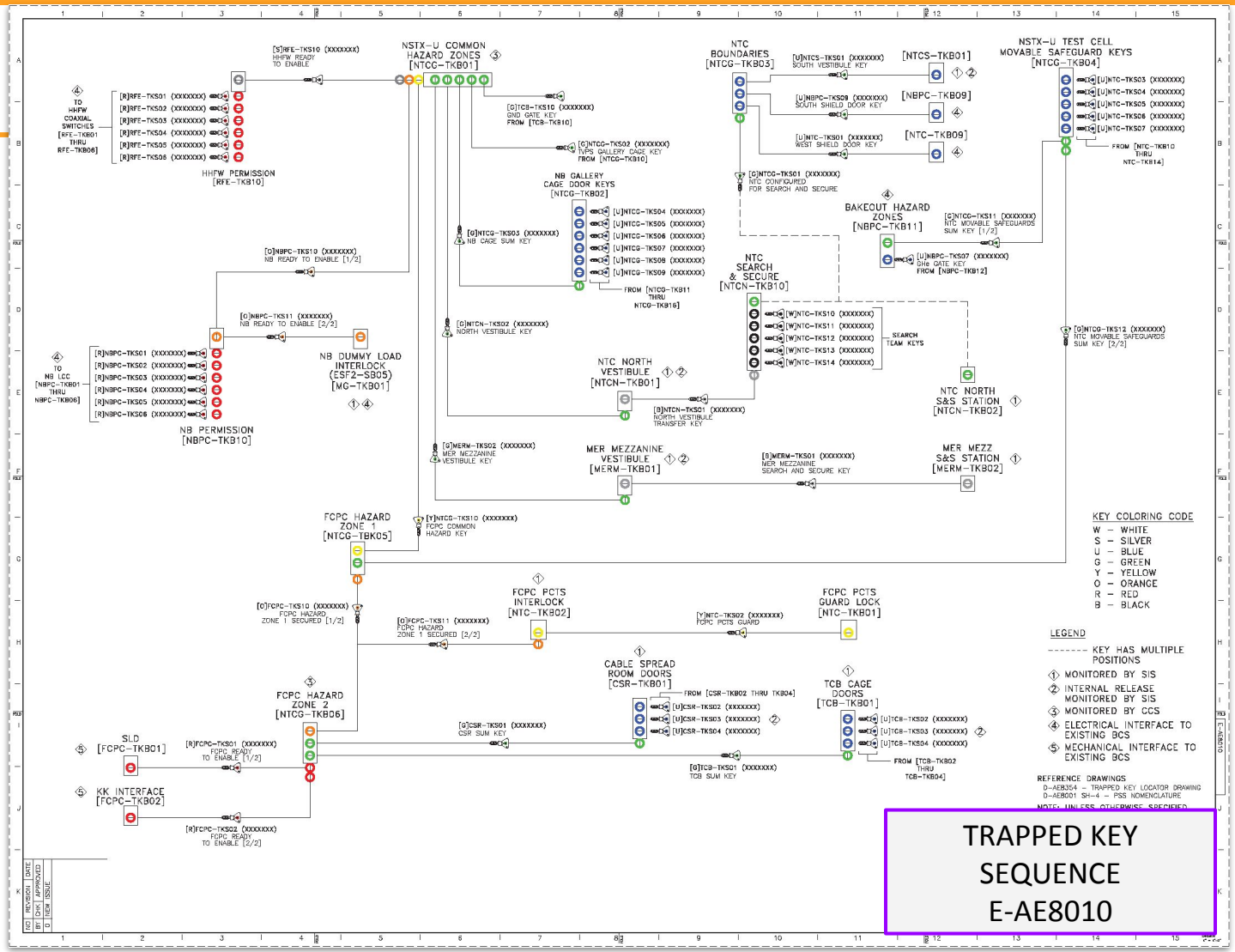


TYPICAL CAGE DOOR LOCK MOUNTING D-AE8351 SH 17

TKS Sequence

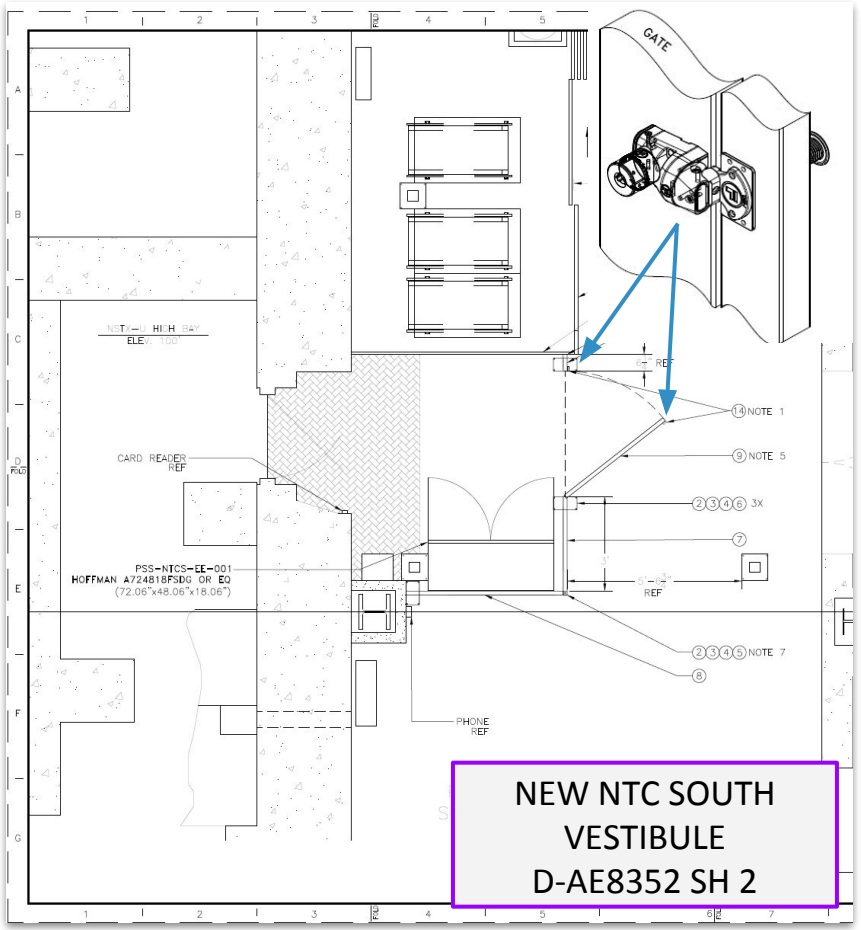
Drawing documents overall TKS sequence and nomenclature

- Key Travel
- Interfaces
  - SIS Monitored
  - CCS Monitored
  - Mechanical/ Electrical to BCS
- Key Colors
- Key & Block Names



TKS installation on new and existing exclusion areas

- Access is interlocked to the hazard producing system(s) specific to that area
- Replaces existing Kirk Keys as required
- Existing:
  - NTC North Door vestibule
  - NB Gallery cage
  - TVPS Gallery cage
  - Ground cage in test cell basement
- New:
  - NTC South Door vestibule
  - MER Mezzanine vestibule
  - Cable Spread Room doors
  - Test Cell Basement cage doors
  - Bakeout cage
  - Movable safeguards in NTC
- All become Configuration Managed Safeguards (CMS)



Configuration Managed Safeguards Scope

- CMS are physical barriers that protect personnel from contact hazards and set the boundaries of exclusion areas
- Safeguards eliminate industrial contact hazards so that experimental areas are General-Access Areas per the ES&H Directive *ESHD-5008* (aka PPPL Safety Manual)
  - Electrocution: Guard exposed electrical conductors > 50 V
  - Thermal Contact Burns: Guard exposed/unprotected surfaces > 60°C*
  - Vacuum: Ensure vacuum windows > 4” in diameter are covered
  - Laser & RF: Ensure Laser Flight Tubes & RF transmission lines are in place
- General-Access Areas are accessible to all personnel without applying LOTO
  - Administrative controls still apply (eg - card reader access)
- Configuration Management method(s) to ensure the engineered CMS solutions are installed properly, maintained, and restored if removed
  - New AND existing CMS identified and labeled for periodic inspections
  - TKS provides Configuration Management of select movable safegaurds

*Recommended limit per ASTM C1055 (Standard Guide for Heated System Surface Conditions That Produce Contact Burn Injuries)

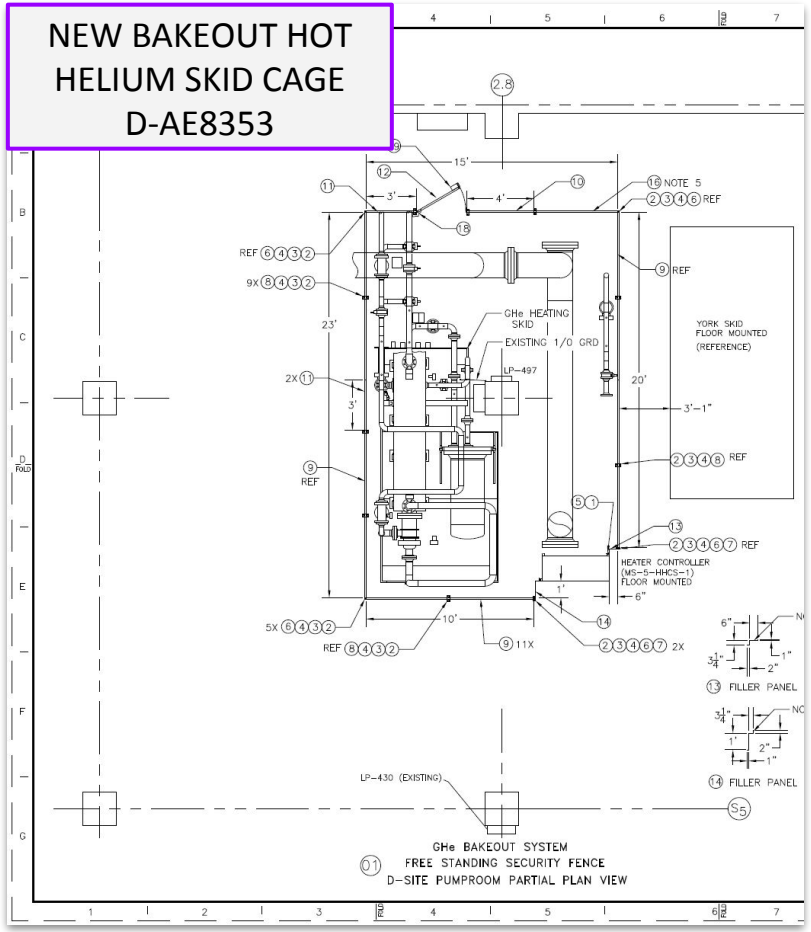
Configuration Management of CMS

- Existing controls are in place:
  - Engineered design documents per *ENG-010* "Control of Drawings" and *ENG-033* "Design Verification"
  - Installation verification and validation per *ENG-030* "PPPL Technical Procedures" and QA procedures
  - Maintenance/removal control via D-Site Work Permit System
  - Work permit required to remove guard per procedure *D-OP-AD-09*
- CMS will have additional administrative controls
  - Labeling for shielded hazard & removal warnings
  - Independent validation of re-installation required
- Select CMS will have additional engineered controls interlocked with hazard source(s)
  - Locked in place via TKS
  - Monitored by PSS-SIS

New CMS have been designed

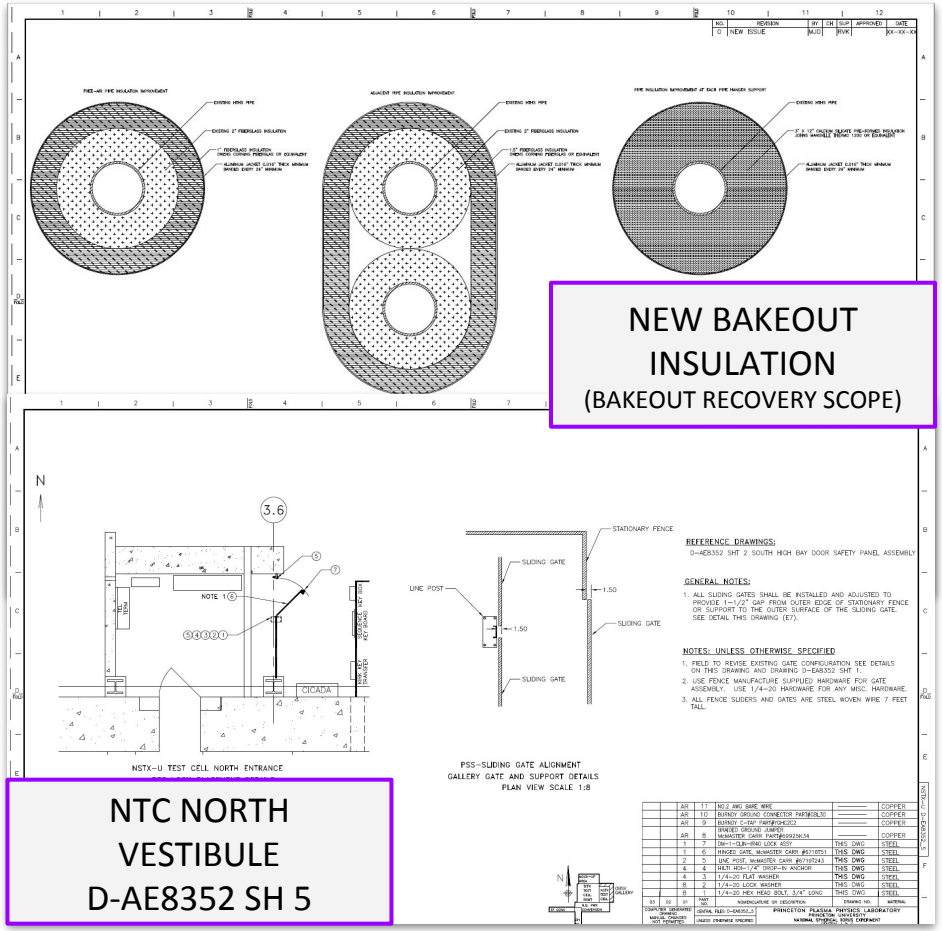
- Guards cover exposed buswork between the PCTS and the Vacuum Vessel
- Exclusion area created by movable safeguards surrounding the Vacuum Vessel at 100’ EL & 109’ EL protect against exposed conductors and exposed Bakeout piping
- Vestibule doors at NTC South entryway & MER Mezzanine provide additional protection from access violations
- Cage around the Bakeout hot helium skid protect against thermal hazards
- New cage doors at Cable Spread Room and Test Cell Basement Cage entryways

NEW BAKEOUT HOT HELIUM SKID CAGE D-AE8353



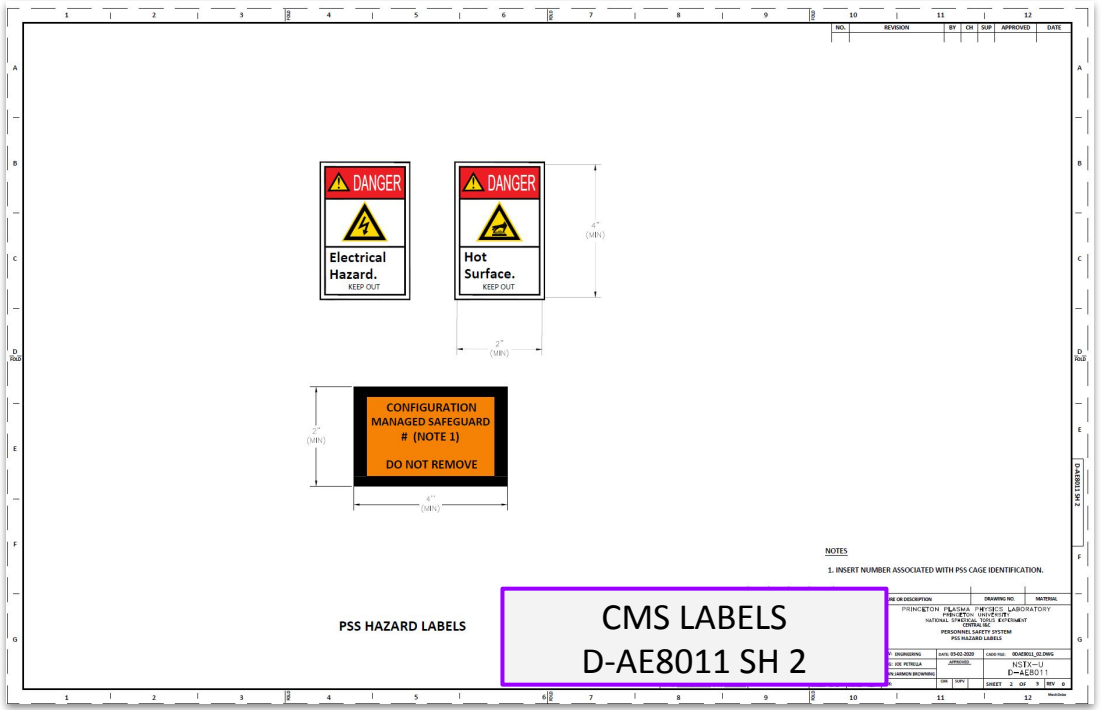
Existing CMS to be labeled and inspected

- NTC North entryway
- TVPS Gallery cage
- NB Gallery cage
- Test Cell Basement Ground cage
- Bakeout hot helium piping insulation/jacket (to be installed by Bakeout Recovery job)
- Physical covers over vacuum windows > 4” in diameter
- Laser Flight Tubes
- RF Transmission Lines & Waveguides



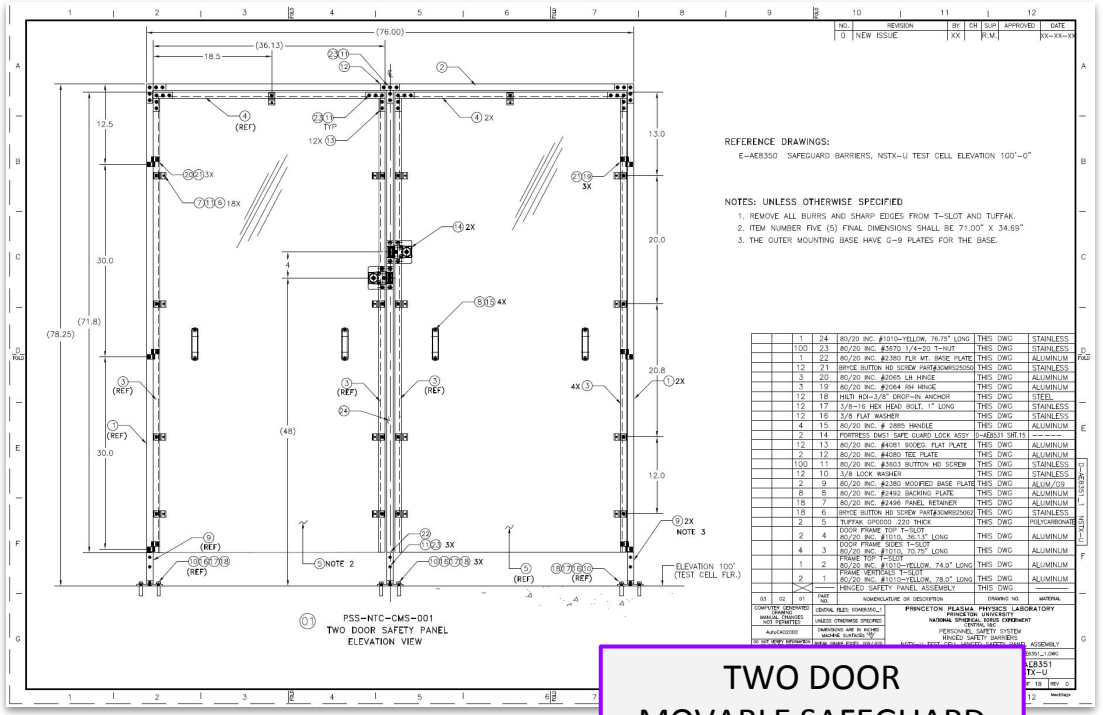
CMS Identification & Labeling

- Labels guided by ANSI/NEMA Z535
  - Reflect the hazard behind the guard
  - Designates the safeguard as part of CMS
  - Provides unique identifier
  - Warns against removal



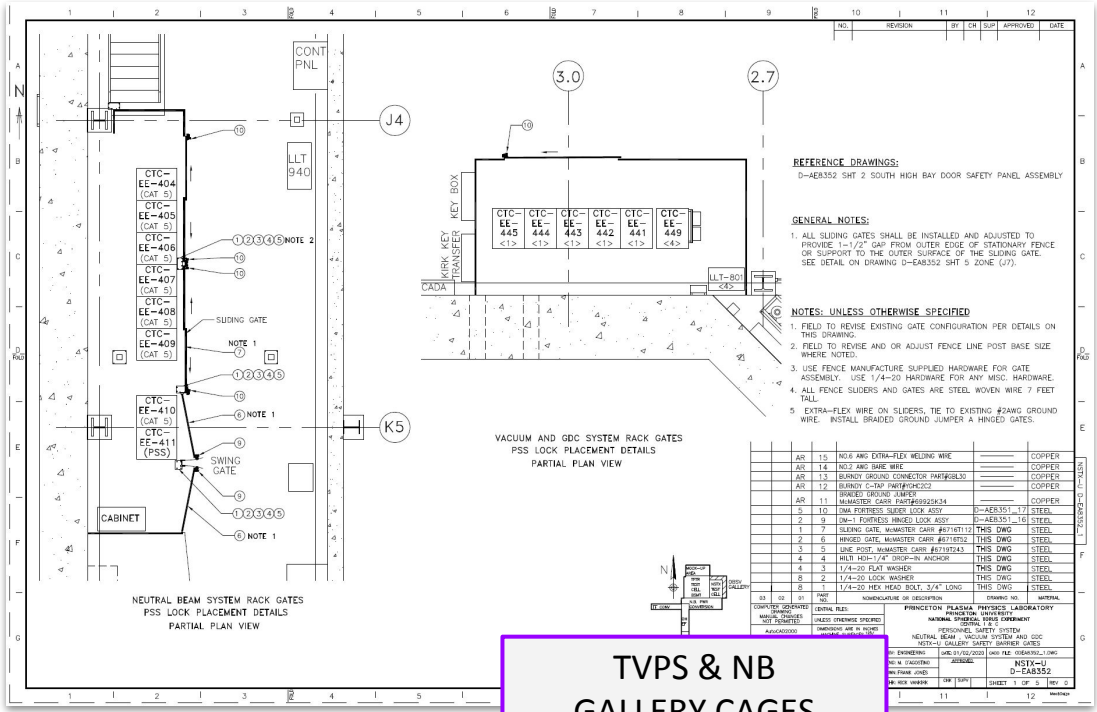
Mechanical assembly of typical movable safeguard

- Uses all COTS material
  - Yellow 80/20 strut for structural framing
  - 80/20 hardware - hinges, handles, retainers, plates, etc.
- Non-conductive features incorporated to not introduce inductive current loops
- Removable/movable safeguards are locked in place via TKS
- Unique fasteners for tamper resistance



Location and assembly of cages defined

- Includes modification of existing cages
- Uses all COTS material
  - McMaster-Carr sliding/hinged gates
  - Standard hardware
- Movable gates are locked in place via TKS
- Unique fasteners for tamper resistance



TVPS & NB GALLERY CAGES D-AE8352 SH 1

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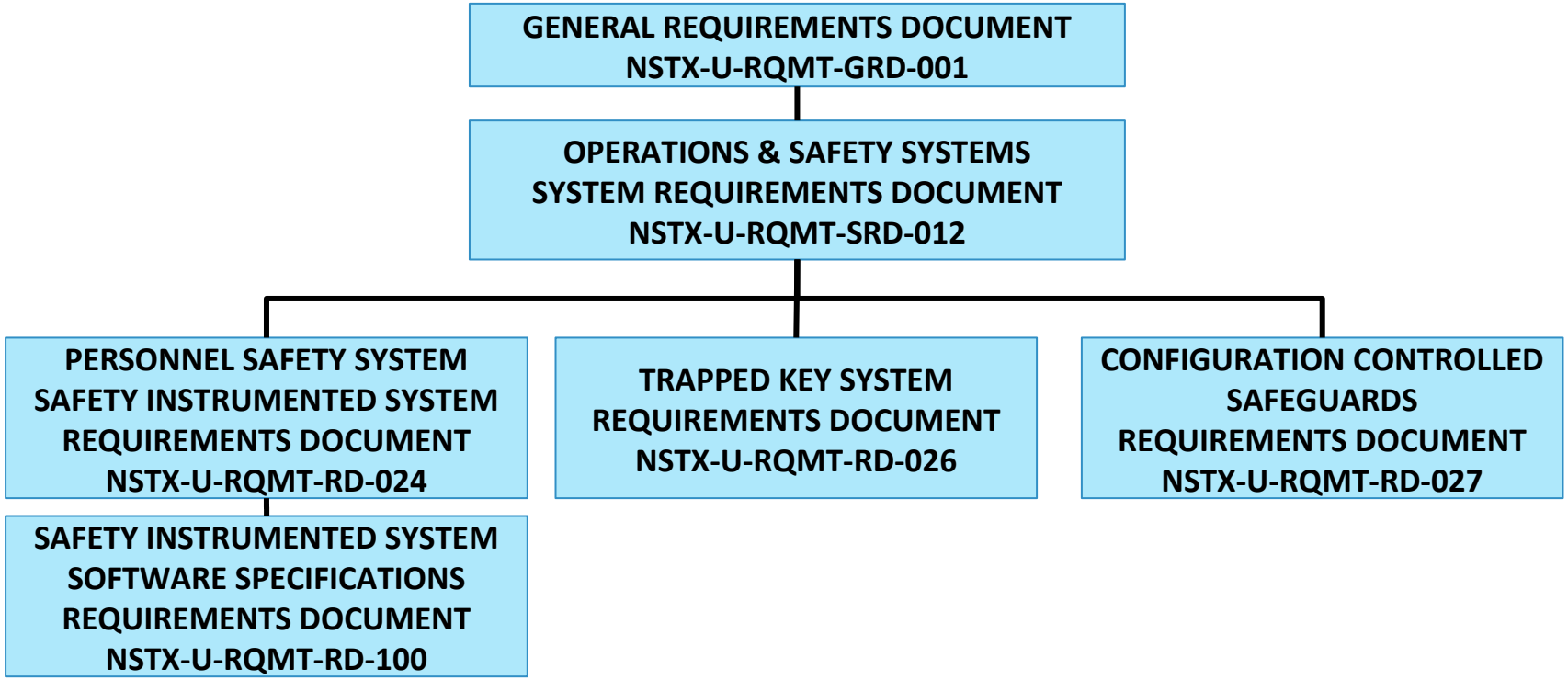
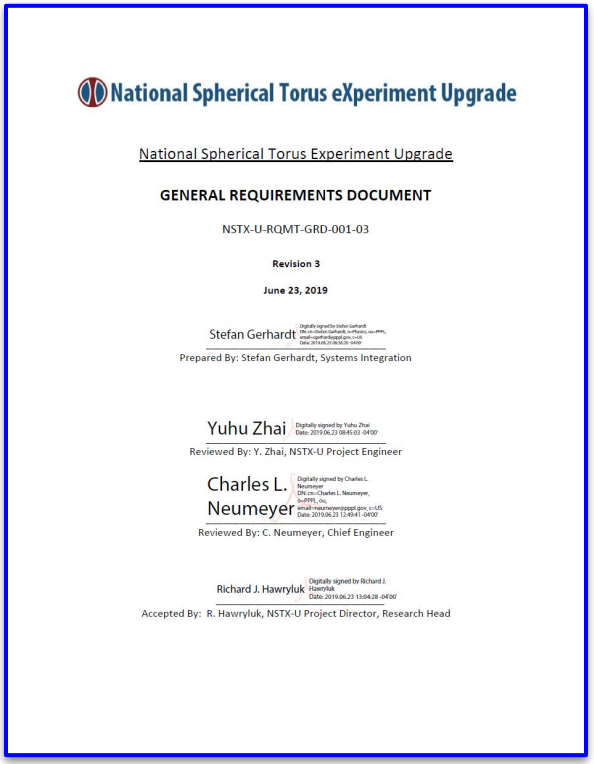
TKS & CMS have individual RDs which flow from the OSS SRD and NSTX-U GRD



Summary of applicable requirements from the GRD

- Comply with the Accelerator Safety Order (DoE Order 420.2c) (6.7.1a)
- Prevent access to the NSTX-U test cell and related areas when they are in an unsafe condition (6.7.3.1a)
- Prevent sources of energy such as neutral beams from turning on when areas allow access (6.7.3.2b)
- Support search and secure (6.7.3.1c)
- Permit multiple layers of protection to achieve the desired risk reduction level (6.7.3.1d)
- ES&H: Complete the project in a way "...protect personnel, visitors, the public, property and the environment from injury."(7)



National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment Upgrade

GENERAL REQUIREMENTS DOCUMENT

NSTX-U-RQMT-GRD-001-03

Revision 3

June 23, 2019

Stefan Gerhardt

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Reviewed By: C. Neumeyer, Chief Engineer

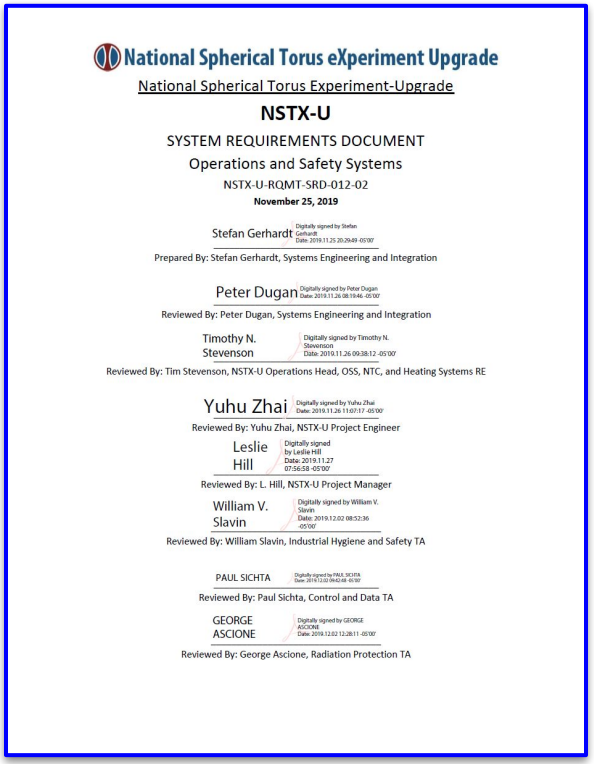
Richard J. Hawryluk

Accepted By: R. Hawryluk, NSTX-U Project Director, Research Head

Summary of requirements from OSS SRD

Trapped Key System

- Functions
  - Ensure that specified areas, safeguards are in proper configuration (4.1 a,b)
- Design
  - Support multi-layer sequences (4.2.2 a,b)
  - Not be bypassable with common tools (4.2.2d)
- Configuration Requirements
  - Provide status to CCS and PSS-SIS (4.3a)
  - Provide means to unlock from the inside of spaces locked by the trapped keys, or provide kick-out panels (4.3c)



National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment-Upgrade

NSTX-U

SYSTEM REQUIREMENTS DOCUMENT

Operations and Safety Systems

NSTX-U-RQMT-SRD-012-02

November 25, 2019

Stefan Gerhardt — Digitally signed by Stefan Gerhardt, Date: 2019.11.25 20:29:49 -05'00'

Prepared By: Stefan Gerhardt, Systems Engineering and Integration

Peter Dugan — Digitally signed by Peter Dugan, Date: 2019.11.26 08:19:46 -05'00'

Reviewed By: Peter Dugan, Systems Engineering and Integration

Timothy N. Stevenson — Digitally signed by Timothy N. Stevenson, Date: 2019.11.26 09:38:12 -05'00'

Reviewed By: Tim Stevenson, NSTX-U Operations Head, OSS, NTC, and Heating Systems RE

Yuhu Zhai — Digitally signed by Yuhu Zhai, Date: 2019.11.26 11:07:17 -05'00'

Reviewed By: Yuhu Zhai, NSTX-U Project Engineer

Leslie Hill — Digitally signed by Leslie Hill, Date: 2019.11.27 07:56:58 -05'00'

Reviewed By: L. Hill, NSTX-U Project Manager

William V. Slavin — Digitally signed by William V. Slavin, Date: 2019.12.02 08:52:36 -05'00'

Reviewed By: William Slavin, Industrial Hygiene and Safety TA

PAUL SICHTA — Digitally signed by PAUL SICHTA, Date: 2019.12.02 09:42:48 -05'00'

Reviewed By: Paul Sichta, Control and Data TA

GEORGE ASCIONE — Digitally signed by GEORGE ASCIONE, Date: 2019.12.02 12:28:11 -05'00'

Reviewed By: George Ascione, Radiation Protection TA

Summary of requirements from OSS SRD

Configuration Managed Safeguards

- Functions - physical safeguards from specific contact hazards (5.1 a,b)
  - Caged Areas
  - Bus Work and Exposed Conductors
  - Helium Piping
  - Laser Flight Tubes
  - Vacuum Windows
- Configuration Requirements
  - Shall not interfere with component functions (5.3a)
  - Placed under configuration management (TKS or Administrative Procedure) (5.3c)
  - Tamper resistant (5.3f)
  - Shall be labelled as such (5.3d)

National Spherical Torus eXperiment Upgrade

National Spherical Torus Experiment-Upgrade

NSTX-U

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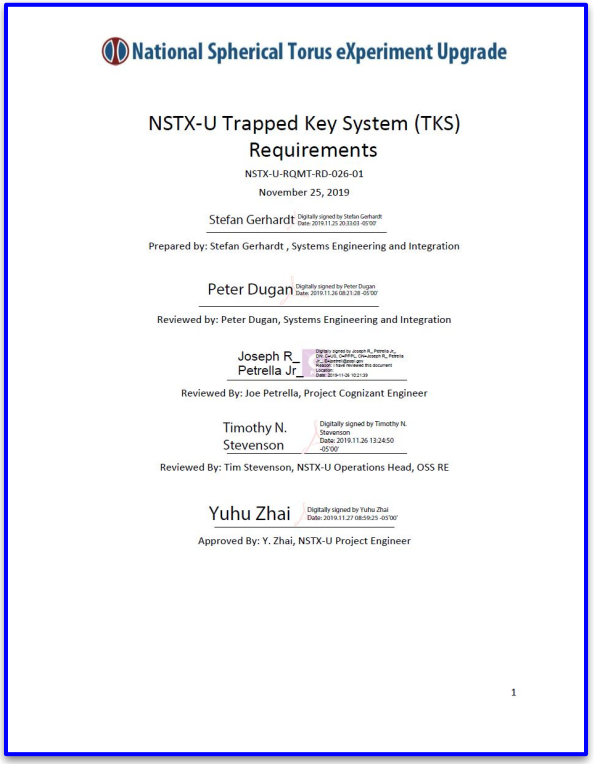
TKS requirements summary from RD-026

RD contains three tables of conditions (example for NB)

a. The trapped key system shall not allow the neutral beam system to transmit high voltage to the test cell , unless the conditions in Table 3.1-1 are met:

***Table 3.1-1**: Conditions required in order to transmit NB high voltage to the test cell*

#	Condition
1	South high bay door closed
2	North door closed and search and secure complete
3	NBPC shield door closed
4	TFTR / South high bay shield door closed
5	TVPS cage closed
6	Neutral beam gallery racks closed.
7	MER door closed and search and secure complete



National Spherical Torus eXperiment Upgrade

NSTX-U Trapped Key System (TKS) Requirements

NSTX-U-RQMT-RD-026-01

November 25, 2019

Stefan Gerhardt Digitally signed by Stefan Gerhardt Date: 2019.11.25 20:33:03 -05'00'

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1

RD contains three statements on TKS interdiction points (example for NB)

a. For the control of neutral beam hazards, the TKS may interdict control circuitry in the local control centers until the conditions of Table 3.1-1 are met. The system may allow high voltage to be armed while test cell access is allowed, if the integrated operation of the beamline that prevents a NB to form is controlled by the TKS.

CMS requirements summary from RD-027

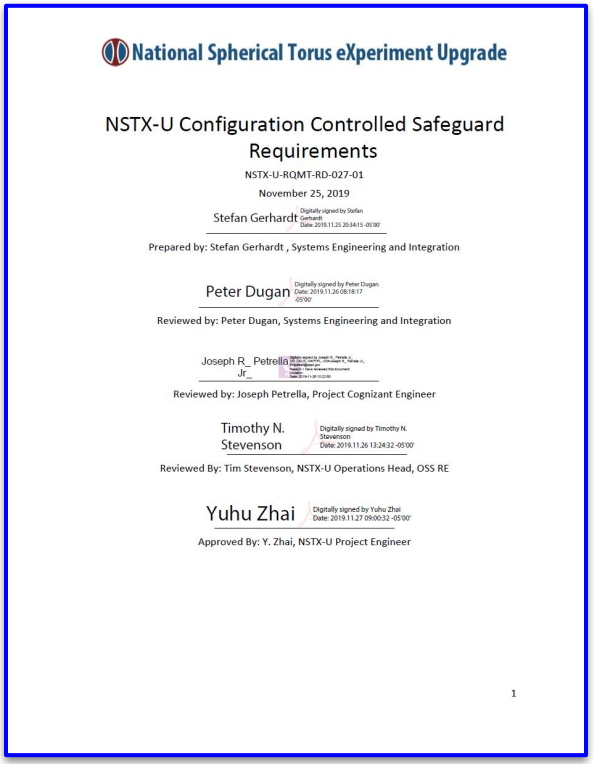
Table 2.1-1 *Cages required as part of the Configuration Managed Safeguards Program*

	Area
1	The TVPS racks in the north gallery
2	The NB racks in the east gallery
3	The gaseous He skid in the pump room
4	TFTR TCB caged area
5	Machine Perimeter Safeguards[1]

Table 2.2-1 *Protection against electrical hazards required as part of the Configuration Managed Safeguards Program*

	System	Configuration Control Method
1	GDC rack in North Gallery	Bolted Safeguards
2	PF-2U coil terminals and exposed bus work components	Bolted Safeguards and/or Flexible Insulating Materials
3	PF-3U coil terminal and exposed bus work components	
4	PF-4U coil terminal and exposed bus work components	
5	PF-5U coil terminal and exposed bus work components	
6	PF-2L coil terminals and exposed bus work components	
7	PF-3L coil terminal and exposed bus work components	
8	PF-4L coil terminal and exposed bus work components	
9	PF-5L coil terminal and exposed bus work components	
10	GDC electrode electrical connections on the NSTX-U vessel	
11	Emissive filament electrical connections on the NSTX-U vessel	
12	PCTS Safeguard	Bolted Safeguards and Movable Safeguards

The exterior surface of any hot-He piping shall be <= 60 C and non-rigid insulating materials shall be protected by a rigid touch-safe cover.



National Spherical Torus eXperiment Upgrade

NSTX-U Configuration Controlled Safeguard Requirements

NSTX-U-RQMT-RD-027-01

November 25, 2019

Stefan Gerhardt

Prepared by: Stefan Gerhardt , Systems Engineering and Integration

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Approved By: Y. Zhai, NSTX-U Project Engineer

1

Summary of TKS & CMS Interfaces

The Trapped Key System…

- locks safeguards in place
  - doors on cages
  - doors on vestibules
  - movable guards (eg - PCTS guard)
- provides personnel accountability during Search & Secure
  - "Team Keys" to be carried by search team during S&S (function of PSS-SIS)
- interlocks breakers (eg - ESF2-SB-05)
- locks the FCPC Safety Lockout Device (SLD)
  - transfers machine control to FCPC Kirk Key sequence
- locks HHFW coaxial switches in safe position
- disables NB primary power at the local control center (LCC)
- provides status switches to PSS-SIS and CCS
  - status of plant
  - operator interaction
- provides egress button status to PSS-SIS to perform emergency stop if released
- disables movable shield wall controls
- disables Bakeout hot helium skid

The Configuration Managed Safeguards…

- are locked in place by TKS
- cover exposed conductors in NTC
- cover vacuum windows in NTC
- cage various locations throughout the facility
- insulate hot process piping

Details of Interfaces Defined in Interface Control Documents

System 1	System 2	ICD Link	Exposition
Operations & Systems Safety	Power Systems	link	Defines interface between the Trapped Key System and Configuration Managed Safeguards and the Power Systems
Operations & Systems Safety	Heating Systems	link	Defines interface between the Configuration Managed Safeguards and the Heating Systems
Operations & Systems Safety	Diagnostics	link	Defines interface between the Configuration Managed Safeguards and Diagnostics
Operations & Systems Safety	Bakeout	link	Defines interface between the Trapped Key System and Configuration Managed Safeguards and the Bakeout

Details of Interfaces Defined in Interface Control Documents

System 1	System 2	ICD Link	Exposition
Operations & Systems Safety	Gas Delivery	link	Defines interface between the Configuration Managed Safeguards and the Gas Delivery Systems
Operations & Systems Safety	Wall Conditioning	link	Defines interface between the Configuration Managed Safeguards and the Wall Conditioning Systems
Operations & Systems Safety	Test Cell	link	Defines interface between the Trapped Key System and Configuration Managed Safeguards and the Test Cell
Operations & Systems Safety	Magnets	link	Defines interface between the Configuration Managed Safeguards and the Magnets

Outline

1. Overview
2. Scope
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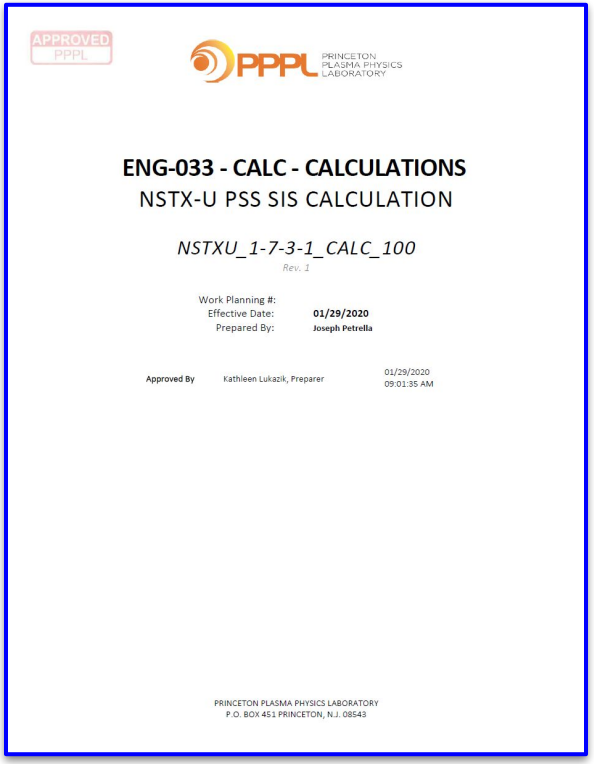
Layer of Protection Analysis (LOPA)

- Layer of Protection Analysis (LOPA) is documented in NSTXU_1-7-3-1_CALC_100
  - LOPA is a method described within IEC 61511 for the determination of Safety Instrumented Function risk reduction requirements
- TKS, as an Independent Protection Layer, provides a Risk Reduction Factor (RRF) of 10 in the LOPA
- No RRF given to CMS

- See LOPA (J. Petrella) talk for further elaboration


APPROVED
PPPL

PPPL PRINCETON PLASMA PHYSICS LABORATORY

ENG-033 - CALC - CALCULATIONS

NSTX-U PSS SIS CALCULATION

NSTXU_1-7-3-1_CALC_100

Rev. 1

Work Planning #:
Effective Date: **01/29/2020**
Prepared By: **Joseph Petrella**

Approved By Kathleen Lukazik, Preparer 01/29/2020 09:01:35 AM

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Selection of prototype mGard assemblies purchased

- Verified switch contact configuration
- Verified part numbers
- Verified ordering process
- Verified physical installation

Prototype Safeguards built

- Small scale prototype built for PDR
  - Includes identification labels
- Full scale prototype built for FDR
  - Includes Fortress Interlocks mGard trapped key hardware

Extensive prototyping of TKS and CMS is not required - these are COTS items with low technical risk

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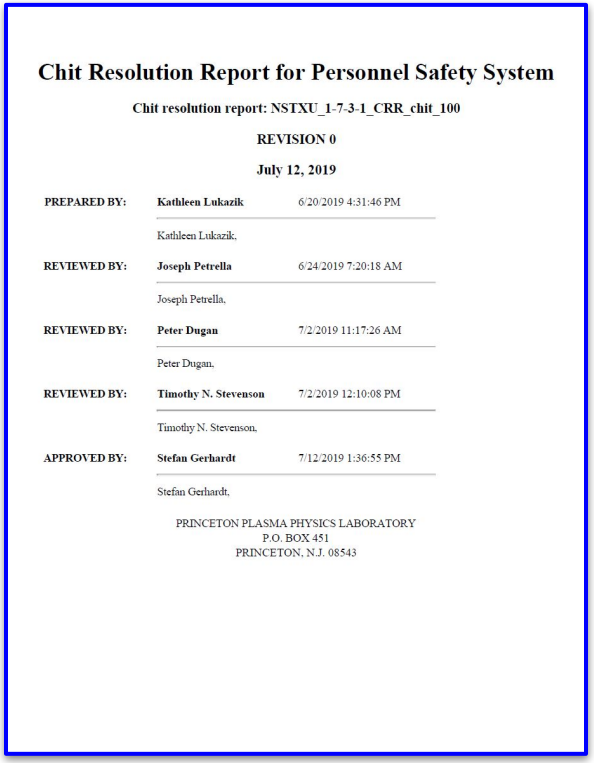
All Chits have been Closed



Chit Resolution Report for Personnel Safety System

Chit resolution report: NSTXU_1-7-3-1_CRR_chit_100

REVISION 0

July 12, 2019

PREPARED BY:	**Kathleen Lukazik**	6/20/2019 4:31:46 PM
	Kathleen Lukazik,	
REVIEWED BY:	**Joseph Petrella**	6/24/2019 7:20:18 AM
	Joseph Petrella,	
REVIEWED BY:	**Peter Dugan**	7/2/2019 11:17:26 AM
	Peter Dugan,	
REVIEWED BY:	**Timothy N. Stevenson**	7/2/2019 12:10:08 PM
	Timothy N. Stevenson,	
APPROVED BY:	**Stefan Gerhardt**	7/12/2019 1:36:55 PM
	Stefan Gerhardt,	

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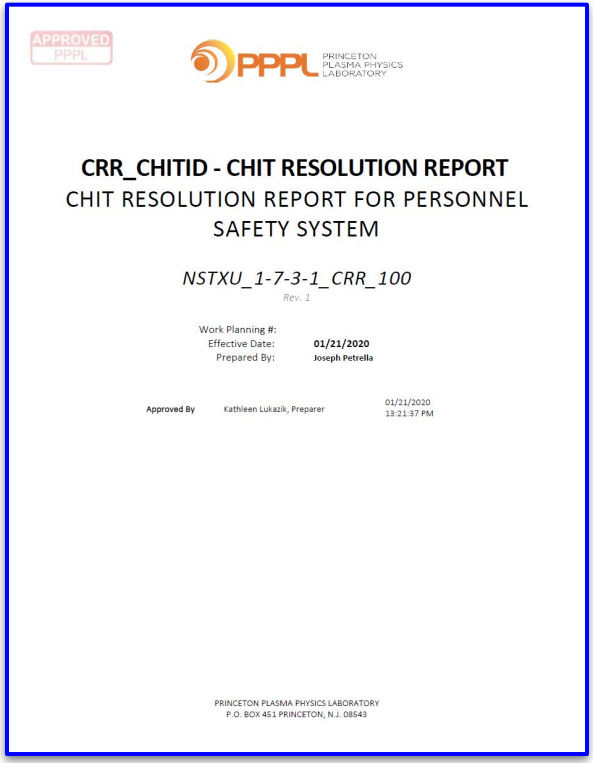
CDR Chit Resolution Report (R0): link



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CRR_CHITID - CHIT RESOLUTION REPORT

CHIT RESOLUTION REPORT FOR PERSONNEL SAFETY SYSTEM

NSTXU_1-7-3-1_CRR_100

Rev. 1

Work Planning #:
Effective Date: **01/21/2020**
Prepared By: **Joseph Petrella**

Approved By Kathleen Lukazik, Preparer 01/21/2020 13:21:37 PM

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PDR Chit Resolution Report (R1): link

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ENG-033 - CRR - CHIT RESOLUTION REPORT

CHIT RESOLUTION REPORT FOR PERSONNEL SAFETY SYSTEM

NSTXU_1-7-3-1_CRR_100

Rev. 2

FDR Chit Resolution Report (R2): link

Chit Resolution Report for *Personnel Safety System*

March 2, 2020

NSTXU_1-7-3-1_CRR_chit_100 Rev 3

Prepared By: Joseph R. Petrella Jr. Digitally signed by Joseph R. Petrella Jr. Date: 2020.03.02 11:34:58 -05'00'

J. Petrella, PSS Cognizant Engineer

Reviewed By: Timothy N. Stevenson Digitally signed by Timothy N. Stevenson Date: 2020.03.03 13:13:51 -05'00'

FDR Chit Resolution Report (R3): link

Outline

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Procurement, Fabrication, Installation, and Test

- Trapped Key System
  - TKS hardware is A-1
  - Vendors have been identified and pre-qualified
  - Prototype parts have been ordered
  - Fasteners, brackets, plates, etc. are A-3
  - Will be PPPL installed per approved drawings

- Configuration Managed Safeguards
  - Raw materials for CMS are A-3, available COTS
  - New cages/safeguards to be PPPL built and installed per approved drawings

- Purchase requisitions will be ready to issue upon CDE-3B authorization
- Will be commissioned and tested in concert with the PSS-SIS

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Project Risks

- Project Risks for TKS and CMS are discussed in the PSS-SIS talk

FMECA - TKS

System	Failure Mode	Failure Cause	Failure Effect	R	Detection/ Mitigation System (1)	Detection/ Mitigation System (2)	Detection/ Mitigation System (3)	R_R
Trapped Key Hardware & Sequencing	Mechanical Lock Failure	Manufacturing Defect	No immediate hazard created; Interlocked Devices potentially allowed to go unsafe when plant configuration is not correct	8	Personnel Safety System (SIS)	None	None	4
Trapped Key Hardware & Sequencing	TKS egress buttons fail to operate	Mechanical Lock Failure	Individual will not be able to egress from caged areas that have egress buttons; potential hazard once interlocked is energized.	8	Personnel Safety System (SIS)	None	None	1
Trapped Key Status Monitoring	TKS position switch indication to PSS-SIS/CCS inaccurate	Lock Feedback Failure	Status of plant not accurate to COE/CCS and PSS-SIS, potential inconsistent state & operational transition	8	Personnel Safety System (SIS)	None	None	4
Trapped Key Device Fasteners and Misc. Hardware	TKS fasteners fail	Rust, bolt failure	No immediate hazard created; Interlocked Devices potentially allowed to go unsafe when plant configuration is not correct	8	Personnel Safety System (SIS)	None	None	4

FMECA - CMS

System	Failure Mode	Failure Cause	Failure Effect	R	Detection/ Mitigation System (1)	Detection/ Mitigation System (2)	Detection/ Mitigation System (3)	R_R
Caged Areas	Cages mechanically fail	Rust, bolt failure; damage from adjacent activities	Cage is no longer present to provide area isolation	8	Trapped Key Hardware & Sequencing	None	None	2
Bus Work Guards & Exposed Conductors >50V Guards	Guards mechanically fail	Fastener failure; damage from adjacent activities	Guard is no longer present to provide area isolation	8	Trapped Key Hardware & Sequencing	None	None	2
Helium Piping Guards	Guards mechanically fail	Fastener failure; damage from adjacent activities	Guard is no longer present to provide area isolation	6	None	None	None	2
Laser Flight Tube Guards	Guards mechanically fail	Fastener failure; damage from adjacent activities	Guard is no longer present to provide area isolation	6	None	None	None	2
NSTX-U Vacuum Window >4" Guards	Guards mechanically fail	Fastener failure; damage from adjacent activities	Guard is no longer present to provide area isolation	8	None	None	None	2
NSTX-U RF Waveguide Guards	Guards mechanically fail	Fastener failure; damage from adjacent activities	Guard is no longer present to provide area isolation	4	None	None	None	2

Inspections as part of CM program are the key element of detecting failure or misconfigured guards

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Quality

- Procurements for A-1 components require QA approval
  - Vendors are pre-approved
  - Receipt Inspection requirements have been established
- All A-1 components are COTS
  - No fabrication oversight plan needed
- PPPL QA & Engineering staff to supervise on-site installations per approved drawings and procedures

ES&H

- Work hazards during installation are standard industrial hazards
  - Hand tools, LOTO, etc.
- Hazards mitigated through PPPL ISM and ES&H procedures
  - Job Hazard Analysis completed prior to the start of planned work
    - Cutting, using power tools, eye protection, etc.
  - Silica Hazard - drilling concrete
    - Air monitoring - as required
    - Respiratory protection - as required
    - Dust minimization controls - vacuum & water
  - Work scheduled via the rollover and work control center to avoid work area conflicts
  - All Lockout/Tagout performed per PPPL procedure ESH-016

SAD/ASE Considerations

- TKS is expected to be a Credited Control per DOE O 420.2C
- CMS are in place according to standard SMPs
  - PPPL ESDH 5008 compliance
  - Protects against standard industrial hazards
- Both will be addressed in the NSTX-U Safety Assessment Document and Accelerator Safety Envelope

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Summary

- Requirements have been met by the design as supported by analysis and an extensive drawing set
- Interfaces are considered in the design and documented in the ICDs
- All chits are closed
- All Design Risks have been mitigated through the design
- Procurement strategy established
- Vendors already QA qualified
- BOAs used for labor augmentation & construction
- SAD/ASE considerations have been addressed
- Environmental, Safety, & Health considerations are standard practices for the laboratory