

## Pre-Ops Tests and Machine Operations

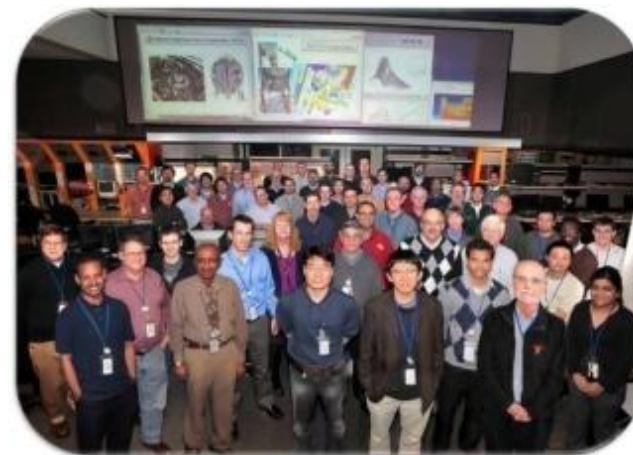
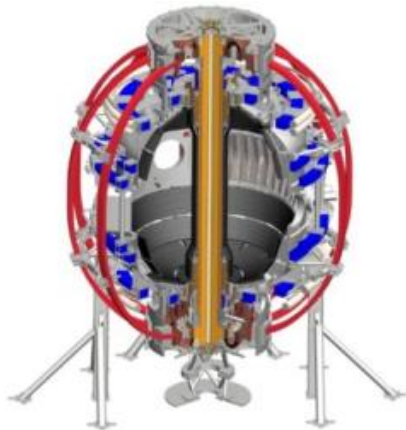
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*Princeton Plasma Physics Laboratory*

*NSTX Upgrade  
Readiness for Operations Review*

*LSB B318*

*December 9-11, 2014*



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# Outline

- **Operations Engineering on NSTX**
- **Assessing Readiness to Operate**
- **Configuration Control**
- **Roles and Responsibilities (Chain of Command)**
- **Operator Training Matrix (OP-NSTX-12)**
- **Managing Work in the Test Cell**
- **Test Cell Access Control**
- **Subsystem Prep for Operations**
- **Overall Start-Up Procedure (OP-NSTX-02)**
- **Allowable Magnet Parameters (ISTP-01)**
- **Maintenance/Repair Planning**
- **Summary**

# Operations Engineering on NSTX

- **Administrative systems utilized for NSTX start-up and operations were originally developed for the TFTR D-T campaign.**
- **The Administrative, Pre-Operational and Operations procedures and controls described in this presentation were used in the initial commissioning of NSTX in February, 1999, and have been updated and exercised for every restart after an extended outage or maintenance/upgrade period.**

# Assessing Readiness to Operate

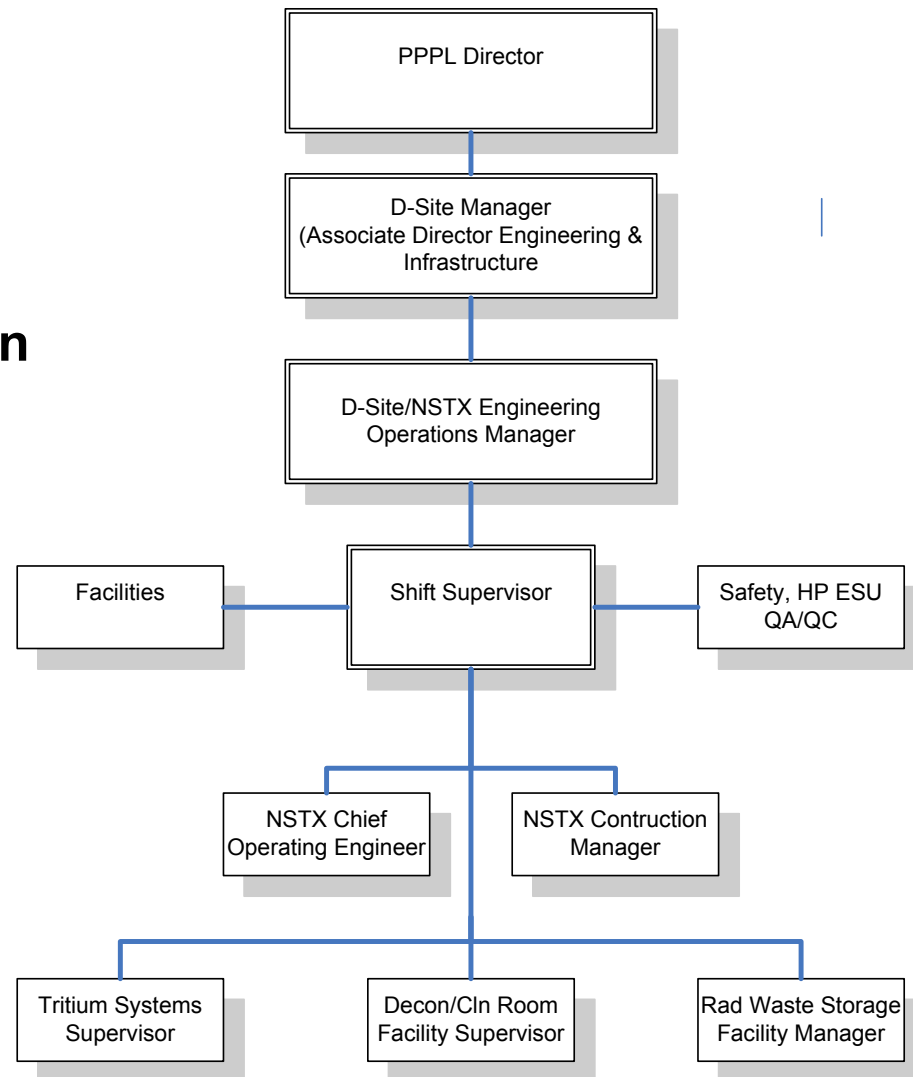
- **Charlie Gentile has described the NSTX-U ACC which has addressed concerns regarding personnel, environmental, and machine safety very early in the planning to start experimental operations.**
- **The ACC has not only proved effective in identifying and addressing potential system problems, but has done so in a timely fashion that allows these problems to be addressed more efficiently than if found just before start-up.**

# Configuration Control

- **Work Planning**      **Web based work planning and approvals.**  
(ENG-032)      **Intended to help staff follow the principles of Integrated Safety Management (ISM) from the earliest part of a design/installation.**
- **Design Verification**      **Documentation of design reviews**  
(ENG-033)      **Calculations**  
   **Chit Resolution**
- **Drawing Control**      **Engineering Change Notice**  
(ENG-010)      **Software Change Notice**
- **Installation/Ops**      **Technical Procedures and Approval Matrix**  
(ENG-030)      **Record of Training**  
   **Run Copy Control**

# Control of Equip. & System Status (OP-AD-56)

**A clear chain of command exists for managing operations, maintenance, construction, and installation activities at D-Site. This structure dates back to the TFTR D-T campaign, and has been utilized to manage field activities in support of NSTX since 1999.**



# Operator Training Matrix

- **Operator Training Matrixes (OP-NSTX-12) developed for:**
  - NSTX-U Chief Operating Engineers (COEs)**
  - Machine Technicians**
  - Vacuum Systems Operator**
  - Water Systems Operator**
  - Field Coil Power Conversion (FCPC) Operator**
  - Motor Generator (MG) Operator**
  - Radio Frequency System Operators**
    - High Harmonic Fast-Wave Source Operator**
    - Electron Cyclotron Heating systems**
  - Neutral Beam Operators**
    - NB Operations Shift Supervisor (NBOS)**
    - Ion Source Operator**
    - Helium refrigerator Operator**
    - Beam-line Subsystem Operator**

# Managing Work in the Test Cell

- **Work Permits, approved by the D-Site Shift Supervisor, ensure that Test Cell configuration control and proper work practices are maintained.**
  - **Defines location of work, tools req' d and responsible workers**
  - **Verifies proper procedures are used (Job specific, Lift, etc.)**
  - **Checks permit requirements (confined space, radiological, etc.)**
  - **Provides record for work for checks before resuming ops**
- **A Job Hazard Analysis (JHA) is performed for each task to help identify existing and potential workplace hazards, and to find ways to control these hazards. The safety controls/equipment needs are defined on the JHA, and reviewed with staff as part of the pre-job brief.**



# Test Cell Access Control

**Approvals and training required for unrestricted access into the NSTX-U test cell:**

- **General Employee training (GET)**
- **Radiation Safety Training**
- **Lockout/Tagout (Control of Energy Sources)**
- **Basic Electric Safety**
- **Knowledge of Administrative Procedures:**
  - Conduct of Operations (OP-AD-39)**
  - Chain of Command (OP-AD-56)**
  - Work Permit System (OP-AD-09)**
  - Control of Temporary Modifications (ENG-036)**
  - Control of Workplace Cleanliness (OP-AD-24)**
  - NSTX Access Controls (OP-AD-117)**

# Subsystem Prep for Operations

Proper system operation is ensured by an approved set of operations procedures (per ENG-030):

- **Preoperational Test Procedures** describe the equipment, methods and steps to bring sub-systems to an operational state. This includes all vendor supplied and project-designed safety/interlock checks.
- **Integrated System Test Procedures** describe the steps to test and document operation or interactions of multiple systems.
- **System Operations Procedures** specify the prerequisites, requirements and actions for operating individual systems.
- **General Operating Procedures** coordinate the operation of multiple systems.

# Overall Start-Up Procedure

- **An Administrative procedure (OP-NSTX-02) is used to list the sub-system and integrated system procedures used to start-up and operate NSTX.**
- **This procedure is managed by the NSTX Chief Operating Engineer (COE), who will get sign-offs from the appropriate cognizant engineers upon the completion of each procedure.**
- **Prerequisites and the order of completion are specified, and “Hold Points” are included when management approvals are needed.**
- **This procedure was used for the initial commissioning of NSTX, and has been revised/used for each restart after an NSTX outage with configuration changes (Currently using Rev. #14)**
- **The procedure includes combined field test shots per the electromagnetic ISTP, the initiation of the 1<sup>st</sup> plasma of the run period, Neutral Beam Inj, and Experimental Ops.**

# Overall Start-Up Procedure

The OP-NSTX-02 procedure is separated into five sections:

1. Pump down, Test Cell Prep, and Initial Bake out.
2. Preparation and authorization for ISTP-001.
3. Preparation and authorization for NSTX-U CD-4 milestone.
4. Preparation and authorization for the Neutral Beam CD-4 milestone
5. Preparations/Approvals for subsystems used for NSTX-U plasma operations.

# OP-NSTX-02 Excerpts

## 2. SCOPE

This procedure defines the criteria for confirming the completion of the preoperational testing of those work elements associated with plasma operations on NSTX:

- Torus Vacuum Pumping System (TVPS)
- Torus pumpdown and testing
- Coil systems and associated hardware
- AC Power Systems
- Motor Generator Sets
- Water Systems
- Bakeout System
- Control Systems
- NTC Safety Interlock Systems
- Energy Conversion Systems (ECS)
- Diagnostic Systems
- Glow Discharge Cleaning (GDC) System
- Vessel Boronization Systems
- Lithium Systems
- RF Systems (HHFW & ECH)
- Neutral Beam Injection Systems
- Preparation of the machine Areas
- Integrated System Testing

# OP-NSTX-02 Excerpts

## 3. REFERENCES (AN EXAMPLE)

### Energy Conversion Systems

OP-KK-26	ECS Kirk key Test
OP-KK-28	NSTX SLD Kirk Key Test
AP-ECS-01	FCPC System Access
AP-NSTX-03	RWM SPA Access Procedure
MP-ECS-09	Rectifier Maintenance
MP-ECS-05	Rectifier Disconnect Maintenance
PTP-ECS-34	PSRTC Simulation Tests
PTP-ECS-35	PSRTC I/O Tests
PTP-ECS-43	Pulse Duration Period Timer Tests
PTP-ECS-39	FCPC Dummy load tests
PTP-ECS-45	ECS HiPot Tests
PTP-ECS-65	RWM PLC to SDS Operation and Kirk Key Test
PTP-ECS-70	ECS HCS Upgrade Preliminary Test procedure
PTP-ECS-71	ECS HCS OH Upgrade Preliminary Test procedure
OP-PC-44	ECS HCS Input/Output Interface testing
OP-PC-45	ECS Interlock and Level 1 Display testing
OP-PC-46	SDS Preoperational testing
OP-PC-48	ECS Critical Interlocks
OP-PC-49	ECS Ground Fault testing
OP-PC-734	Rectifier Reactivation
OP-ECS-245	FCPC Daily Startup/Shutdown Procedure

# OP-NSTX-02 Excerpts

Includes steps with approvals and, when appropriate, prescribes the orders of completion (an example).

## A.3. TEST CELL PREPARATIONS FOR COIL SYSTEM TESTING

- A.3.1 Insulation tests (HiPots) of NSTX-U Coil Systems (PTP-NSTX-CL-28)  
ATI: \_\_\_\_\_
- A.3.2 Vacuum Vessel High-Pots successfully completed (NSTX-OP-G-151)  
ATI: \_\_\_\_\_
- A.3.3 Complete Machine Area scrubs (OP-NSTX-01)  
ATI: \_\_\_\_\_
- A.3.4 Review and close out NSTX-U work permits as appropriate  
Shift Supervisor/COE: \_\_\_\_\_
- A.3.5 Review and close out NSTX-U Installation Procedure Run Copies  
NSTX Eng Ops Head: \_\_\_\_\_
- A.3.6 Review status of temporary modifications to NSTX-U operating equipment  
COE: \_\_\_\_\_
- A.3.7 Bus/Coil/Power System Walkdown complete  
NSTX-U Eng Ops Head: \_\_\_\_\_
- A.3.8 ECS SLD, HIS, HCS Interlock Testing complete (OP-PC-48)  
ATI: \_\_\_\_\_
- A.3.9 ECS/SLD System Kirk Interlock testing complete (OP-KK-28)  
ATI: \_\_\_\_\_

# OP-NSTX-02 Excerpts

Includes “Hold Points” for approvals before energizing any coils, initiating a plasma, or injecting a neutral beam into the NSTX vessel.

(An Example)

**HOLD POINT** (Sections A and B must be completed before proceeding with ISTP-NSTX-001 tests).

The following committee has reviewed the completion of preparations for Coil Energization and concur that systems and procedures are in place and ready.

NSTX-U Project Eng. \_\_\_\_\_

Head, NSTX Ops \_\_\_\_\_

Head, NSTX-U Physics Ops \_\_\_\_\_

Chair, Activity Certification Committee (ACC) \_\_\_\_\_

Head, Engineering & Infrastructure \_\_\_\_\_

**Coil Energization may proceed per ISTP-NSTX-001**



# Allowable Magnet Parameters

- **The electromagnetic ISTP (ISTP-001) defines protection system settings and necessary test shots for any changes to the NSTX electromagnetic configuration and/or operating envelope.**
- **Intended to be repeated multiple times as the operating envelope is adjusted to support the experimental program.**
- **Verifies that planned polarities, power levels and pulse lengths are consistent with design allowables.**
- **Documents, exercises and tests protection circuits, and prescribes test shot levels.**
- **Each iteration approved by Engineering, Research, and Project Management.**

# ISTP-001 Test Shots

- **ISTP-001 prescribes individual magnet coil set test shots to test and set coil protection features.**
- **Important prerequisites for this procedure include:**
  - **that the DCPS be tested and configured per OP-DCPS-779 to verify, exercise, and set protection algorithms.**
  - **that the Power Supply Fault Detectors and AC Protective Relaying be configured/tested per OP-PC-734 (Reactivation of individual rectifiers) and PTP-ECS-39 (individual Rectifier Dummy Load Tests).**

# ISTP-001 Test Shots

- A “portfolio” of test shots will be generated and archived (under a test data sheet #) for each coil set to be qualified for use:
  - Test Shots performed at the 10%, 50% & 100% of the planned operating level, and induced Voltage & Magnetic Diagnostic calibration measurements taken as prescribed.
  - Exercise the overcurrent and I2T trips of the redundant DCPS’s at nominal 10% and 90% of the desired operating level, and the Rectifier Fault Detector Overcurrent and Overtime trips at the 90% level.
  - Set and document the DCPS and Rectifier Fault Detector protection settings at prescribed “headrooms” as defined in ISTP-001 for coil operation at 100% of the planned operating level.
  - Record that coil set’s allowable operating level and protection settings on the summary Test Plan Data Sheet.

# ISTP-001 Test Shots

- **Select appropriate levels for the daily 50% and 100% test shots, and record on the summary Test Plan Data Sheet.**
- **Obtain approvals of the Test Plan Plan Data Sheet results and the daily test shot level selections as shown on the following test plan template.**

# ISTP-001 Test Plan Data Sheet

Test Data Sheet #	OH (kA)	PF1aU (kA)	PF1bU (kA)	PF1cU (kA)	PF2U (kA)	PF3U (kA)	PF4 (kA)	PF5 (kA)	PF3L (kA)	PF2L (kA)	PF1cL (kA)	PF1bL (kA)	PF1aL (kA)	TF (kA)	RWM (kA)	DCPS-FCC OC	DCPS-FCC I2T	DCPS-JA OC	DCPS-JA I2T	FD OC	FD OT	Ind. Volt.	Mag. Diag. Cal.	#Shot
																							Σ	0
Daily Test Shots	OH (kA)	PF1aU (kA)	PF1bU (kA)	PF1cU (kA)	PF2U (kA)	PF3U (kA)	PF4 (kA)	PF5 (kA)	PF3L (kA)	PF2L (kA)	PF1cL (kA)	PF1bL (kA)	PF1aL (kA)	TF (kA)	RWM (kA)									
50%																								
100%																								
Notes:																								
APPROVALS																								
Test Director	-----																							
NSTX-U Project Director	-----																							
NSTX-U Project Engr.	-----																							
Head, PPPL Eng	-----																							
Head, Engr. Ops.	-----																							
Head, Exp. Research Ops.	-----																							

## Example: Test Plan Template

# Maintenance/Repair Planning

- Detailed procedures to safely access vessels, power equipment, diagnostics, etc. are developed before starting up equipment.
- A lab-wide Lockout/Tagout procedure (ESH-016) defines how sources of hazardous energy are controlled.
- Periodic Preventive Maintenance is performed on:
  - Safety Interlock Systems (OP-KK-\*\*, OP-NSTX-\*\*)
  - Control Systems (MP-CCD-\*\*)
  - Energy Conversion Systems (MP-MG-\*\*, MP-ECS-\*\*)
  - AC Power Systems (MP-AC-\*\*\*)
  - Heating Systems (MP-NB-\*\*, MP-RF-\*\*)
  - Water and He Bake-Out Systems (MP-WS-\*\*)
  - Vacuum and Gas Inj Systems (MP-VAC-\*\*)

# Summary

- **NSTX-U has implemented appropriate Administrative Systems and Pre-Operational/ Operations procedures for the safe start-up and operation of this device.**
- **The controls described in this presentation were used in the initial commissioning of NSTX in February, 1999, and have been updated and exercised for every restart after an extended outage or maintenance/upgrade period.**