

National Compact Stellarator Experiment
NCSX

TEST AND EVALUATION PLAN
NCSX-PLAN-TEP-00

Draft E

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RECORD OF REVISIONS

Revision n	Date	Originator	Description of Change
1		Gentile	modify plan to employ C-Site power supplies

1 PURPOSE AND SCOPE

The purpose of this Test and Evaluation Plan (TEP) is to identify those tasks, documents, actions, reviews required to start up NCSX in a safe, efficient, and compliant manner in accordance with PPPL policies, directives, procedures and DOE orders. It is expected that many of the items required to successfully start up NCSX would occur in parallel with NCSX construction. These tasks include development of NCSX specific procedures and documents including the development of pre-operational test procedures (PTPs) and configuration of existing C-Site and D-Site subsystems to support experimental operations.

Upon completion of construction, a Facility Start Up Integrated Systems Test Procedure will be executed to establish the readiness of the facility for First Plasma and subsequent experimental operations. This plan provides an overview of the Facility Start Up Integrated Systems Testing Program, the approval process to proceed to First Plasma, and cost and schedule estimates for accomplishing that program.

2 DEFINITIONS

2.1 END OF CONSTRUCTION

End of construction is defined as that physical condition when the NCSX device and facility are assembled. **Hi Pots of the coil systems have been completed, the cryostat is fully installed, the ACC has performed it's review and the ORA has been performed. Appropriate sub-systems are available. The hardwired interlock system (HIS) and hardwired control system (HCS) are configured and available to support safe startup activities.**

2.2 START UP

Start up is defined as that condition where the NCSX (Start Up) Test Director has assumed control of NCSX from the NCSX Construction Manager and has configured the device for integrated systems testing. Such configuration should include access control in accordance with subsystem safing procedures.

2.3 E-BEAM MAPPING

NCSX will undergo a series of low power (combined field) e-beam mapping tests for machine characterization and to ensure the proper alignment of field coils. These tests will be limited to $\leq 10\%$ of the rated field coil operating current. No attempt will be made to produce plasmas during the e-beam mapping testing phase.

2.4 ISSUANCE OF SAFETY CERTIFICATE AT THE CONCLUSION OF CONSTRUCTION

The issuance of a First Plasma / Operations Safety Certificate by the PPPL ES&H Executive Board, based on the recommendations of the NCSX ACC should be secured at the conclusion of construction. The NCSX Operational Readiness Assessment (ORA) should follow or closely parallel the ACC review at the end of construction.

Related Documents

This TEP draws on the documents listed below. Documents referenced are the latest issues of the:

- NCSX Facility Start Up Integrated Systems Test Procedure (to be provided)
- NCSX Safety Assessment Document (to be provided)
- PPPL ESHD-5008, "Environmental, Safety, and Health Manual"
- NCSX Systems Engineering Management Plan (NCSX-PLAN-SEMP)

3 NCSX SUBSYSTEMS

Table 3-1 provides the listing of the NCSX subsystems that are required for First Plasma and assumed to be available and properly configured for operation before the start of the Facility Start Up Integrated Systems Test Procedure (ISTP).

Table 3-1 NCSX Subsystems Needed for Facility Start Up ISTP

WBS	Name
WBS 12	Vacuum Vessel Systems
WBS 13	Conventional Coil Systems
WBS 14	Modular Coil Systems
WBS 15	Coil Support Structure Systems
WBS 16	Coil Services
WBS 171	Cryostat
WBS 172	Base Support Structure Systems

WBS 211	Gas Fueling Systems
WBS 22	Torus Vacuum Pumping Systems
WBS 25	Neutral Beam Heating Systems
WBS 26	Electron Cyclotron Heating Systems
WBS 4	C Site Power Systems
WBS 5	Central I&C Systems
WBS 61	Water Cooling Systems
WBS 62	Cryogenic Systems
WBS 63	Utility Systems
WBS 64	Helium Bakeout System (150 C)
WBS 66	Test Cell HVAC
WBS 67	Test Cell Fire Protection

4 DOCUMENTS AND PROCEDURES

Table 4-1 provides a listing of the PPPL and NCSX documents and procedures anticipated to be needed to support the Facility Start Up ISTP.

Table 4-1 Documents and Procedures Needed for Facility Start Up ISTP

Name	Identifier
Safety Documents	
NCSX Safety Assessment Document (SAD)	TBD
PPPL Environmental, Safety, and Health Manual	ESHD-5008
PPPL Engineering & Safety Procedures	
NEPA Review System	ESH-014
Control of Hazardous Energy Sources via Lockout Tagout of Energy Isolation Devices	ESH-016
PPPL Technical Procedures for Experimental Facilities	ENG-030
PPPL Work Planning Procedure	ENG-032
PPPL Engineering Design Verification	ENG-033
NCSX System Engineering Procedures	
NCSX Configuration Control Procedures	NCSX-PROC-002
NCSX Interface Control Procedures	NCSX-PROC-003
NCSX Work Planning Procedures	NCSX-PROC-004
PPPL Operating Procedures	
Control of Workplace Cleanliness Around C-Site Experimental Area	OP-TBD-000
Control Of Temporary Modifications	OP-AD-31D

Conduct of Operations	OP-AD-39
Control of Equipment and System Status (Chain of Command)	OP-AD-56
C-Site Energy Conversion Systems (ECS) High Power Conversion systems (HCS) Input/Output Interface Testing	OP-TBD-000
C-Site ECS Interlock and Level 1 Display Testing	OP-TBD-000
C-Site SDS Pre-operational Testing	OP-TBD-000
C-Site ECS Critical Interlocks	OP-TBD-000
C-Site ECS Ground Fault Testing	OP-TBD-000
C-Site Rectifier Settings	OP-TBD-000
C-Site FCPC Daily Start up/Shutdown Procedure	OP-TBD-000
NCSX Operating Procedures	
Preparations of Experimental Areas for Machine Operations	TBD
Testing the NCSX (High Power Interlock System (HIS) with Areas Safe for Access	TBD
Testing the NCSX Emergency Stop System	TBD
C-Site Safety Lockout Device (SLD) Test Procedure	TBD
Hot Access Requirements	TBD
Operation of the NCSX Access System	TBD
Testing of the Hot Access and HIS Systems with SLD Pressurized	TBD
NCSX Training Matrix	TBD
NCSX Operations Guide for Start up and Shutdown	TBD
High Power Pulsing (HPP) Daily Operations	TBD
Changing the Trip Control Settings of the Rochester Instrument Systems (RIS) Protective Circuit for the NCSX Field Coils	TBD
ACP & PDP Trip Control Settings	TBD
Start up, Operation, and Shutdown of the NCSX Bakeout System	TBD
Verification of Interlock Readiness for Operation of the NB Injection System	TBD
Preparation for NCSX Pumpdown	TBD
Helium Bakeout System Operations Procedure	TBD
Daily Hi-Pot Test of the NCSX Vacuum Vessel	TBD
Leak Checking of NCSX	TBD
Cryostat Operation	TBD
Pre-Operational Test Procedures (PTPs)¹	

¹ Preparation and implementation of Pre-Operational Test Procedures (PTPs) are the responsibility of the individual WBS elements, and is outside scope of the Integrated Systems Test Program.

Coil Energization Tests	TBD
Pre-Op Testing of the NB Power Systems	TBD
HiPot Test of NCSX Coil Sys from SDS in FCPC	TBD
NCSX De-Ionized Water/System Testing	TBD
NCSX Coil System Preoperational Tests	TBD
ECS to NCSX Machine Coil Link Installation	TBD
ECS Continuity, Resistance, Inductance, & Meggar	TBD
Halmar (DCCT) & Shunt System Pre-Op Testing	TBD
RIS Tests	TBD
Analog Coil Protection (ACP) Tests	TBD
PSRTC Simulation Tests	TBD
PSRTC I/O Tests	TBD
Pulse Duration Period Timer Tests	TBD
FCPC Dummy Load Tests	TBD
ECS HiPot Tests	TBD
Cryostat	TBD

5 ELEMENTS OF THE FACILITY START UP ISTP

The Facility Start Up Integrated Systems Test Procedure (ISTP) will be executed to establish the readiness of the device and facility for First Plasma and subsequent experimental operations. The ISTP is expected to include the following steps.

5.1 FACILITY PREPARATIONS

- Machine area scrubs complete.
- Work permits reviewed and closed out as appropriate.

- Installation procedure run copies reviewed and closed out as appropriate.
- Status of temporary modifications to NCSX operating equipment reviewed.
- Bus/coil/power systems walk down complete.
- **C-Site** ECS SLD, HIS, HCS interlock testing complete (OP-TBD-000).
- **C-Site** ECS/SLD system kirk interlock testing complete (OP-TBD-000).
- Testing of the Hardwired Interlock System (HIS) with areas safe for access complete.
- **C-Site** Safety Lockout Device (SLD) testing complete.
- Emergency Stop system testing complete.
- Testing of the Hot Access and HIS systems with **C-Site SLD activated**.

5.2 VACUUM VESSEL PUMPDOWN AND TESTING

- Preliminary vacuum vessel high-pots successfully completed.
- Preparations for NCSX pump down complete.
- Vacuum vessel pump down complete.
- Leak checking of Vacuum Vessel successfully completed in preparation for bakeout.

5.3 WATER SYSTEMS TESTING

- Water systems testing complete.

5.4 C-SITE ENERGY CONVERSION SYSTEMS TESTING

- **C-Site rectifier settings checked (OP-TBD-000).**
- **C-Site SDS pre-operational testing complete (OP-TBD-000).**
- **C-Site ECS HCS input/output interface testing complete (OP-TBD-000).**
- **C-Site ECS interlock and level #1 display testing complete (OP-TBD-000).**
- **C-Site Halmar (DCCT) and shunt systems PTPs complete (OP-TBD-000).**
- **C-Site ECS continuity, resistance, inductance, and meggar measurements complete (PTP-TBD-000).**
- **C-Site ECS ground fault detector testing complete (OP-TBD-000).**

- C-Site ECS high pot testing complete (PTP-TBD-000).
- C-Site Simulation and I/O testing complete (PTP-TBD-000).
- C-Site Dummy load testing complete (PTP-TBD-000).
- C-Site Coil Protection Devices (PTP-TBD-000)

5.5 PREPARATIONS FOR COIL ENERGIZATION

- NCSX prepared for operations per the daily start-up procedure.
- NCSX prepared for high power pulsing (HPP) operations.
- Coil and bus system high pot and circuit resistance measurements from the SDS output complete.
- C-Site ECS start up and high pot of the NCSX coil systems complete.
- Pre-operational testing of coil systems complete.

5.6 COIL ENERGIZATION TESTING

Note that all of the activities identified in Sections 5.1 through Section 5.5 must be completed prior to the commencement of coil energization testing for first plasma. **Section 6.2 is not required for Low Power Physics Testing.**

- Coil energization tests complete.

5.7 BAKEOUT IN PREPARATION FOR FIRST PLASMA

- Bakeout system testing complete.
- Bakeout of vacuum vessel complete.

6 APPROVAL FOR COIL ENERGIZATION AND FIRST PLASMA

The coil energization tests represent the first time the coils have been subject to design-level currents and voltages in situ and the first time there has been the potential for plasma formation with the associated radiation hazards. **Safety Certificate approvals are required for e-beam mapping, normal coil energization testing, and First Plasma as described in section 2.0**

6.1 COIL ENERGIZATION APPROVAL REQUIRMENTS

Prior to coil energization testing, a Safety Certificate for (limited) operation (**as described in section 2.0**) must be issued. The Safety Certificate is issued at **the end of construction** after

the Activity Certification Committee (ACC) has made appropriate presentation and recommendation to the PPPL ES&H Executive Board for the safe start up and operation of the device.

6.2 FIRST PLASMA APPROVAL REQUIREMENTS

The following reviews and approvals will need to occur prior to First Plasma:

- SRC review and approval of NCSX SAD;
- Review and approval of technical documents in Section 4 of this plan;
- Operational Readiness Assessment Review (ORA)
- ACC review and walk-down of NCSX subsystems;
- Approval by ES&H Executive Board for issuance of Safety Certificate;
- Concurrence from the Test Director, NCSX Chief Operating Engineer, and ACC that all subsystem PTP's (for First Plasma) have been successfully completed; and
- Approval by the NCSX Project Manager to commence First Plasma.

7.0 DOCUMENT REQUIREMENTS

Table 7-1 Facility Start Up Documentation Requirements

Document ID	Documents Required for NCSX Start up and Operations	Status	Person-
	*NCSX Safety Assessment Document (SAD)	1	8
*ESHD-5008	Environmental, Safety, and Health Manual	2	0
*ESH-014	NEPA Review System	2	0
*ESH-016	Control of Hazardous Energy Sources Via Lockout Tagout of Energy Isolation Devices	2	0
*ENG-030	PPPL Technical Procedures for Experimental Facilities	2	0
*ENG-032	PPPL Work Planning Procedure	2	0
*ENG-033	PPPL Engineering Design Verification	2	0
*NCSX-XX,	Administrative Control of Procedures	5	4
*OP-AD-39,	Conduct of Operations	6	1
*OP-AD-56,	Control of Equipment and System Status (chain of command)	6	1

*OP-AD-24,	Control of Workplace Cleanliness Around D-Site Experimental	6	1
*OP-TBD-000,	C- Site Fire Watch Requirements	6	1
*OP-TBD-000,	Experimental Proposals for NCSX	6	1
*OP-AD-117	Operation of the NCSX Access System	6	1
*NCSX-OP-XX,	Preparations of Experimental Areas for Machine Operations	5	3
*NCSX-OP-XX,	Operation of the NCSX TVPS	5	3
*NCSX-OP-XX,	Testing the NCSX HIS with Areas Safe for Access	5	3
*NCSX-OP-XX,	Testing the NCSX Emergency Stop System	5	3
*NCSX-OP-XX,	C-Site Safety Lockout Device Test Procedure	5	3
*NCSX-OP-XX,	Hot Access Requirements	5	2
*NCSX-OP-XX,	Testing of the Hot Access and HIS Systems with C-Site SLD activated	5	3
*NCSX-OP-XX,	NCSX Training Matrix	1	3
*NCSX-OP-XX,	NCSX Operations Guide for Start up and Shutdown	5	3
NCSX-OP-XX,	HPP Daily Operations	5	2
*NCSX-OP-XX,	Changing the Trip Control Settings of the C-Site Protective Circuit for the NCSX Field Coils	5	2
*NCSX-OP-XX,	C-Site Trip Control Settings	5	3
NCSX-OP-XX,	Start up, Operation, and Shutdown of the NCSX Bakeout System	5	3
*NCSX-OP-G-XX	Preparation for NCSX pumpdown	5	3
NCSX-OP-XX	Helium Heating and Cooling System Operations Procedure	5	3
*NCSX-OP-G-XX	Daily Hi-Pot Test of the NCSX Inner/Outer Vacuum Vessel	5	3
*ISTP-NCSX-01	Coil Energization Tests	1	4
*OP-KK-28	NCSX C-Site SLD Kirk Key Test	6	1
OP-PC-44	C-Site ECS HCS Input/Output Interface Testing	5	3
*OP-PC-45	C-Site ECS Interlock and Level 1 Display Testing	5	3
*OP-PC-46	C-Site SDS Preoperational Testing	5	3
*OP-PC-48	C-Site ECS Critical Interlocks	5	3
*OP-PC-49	C-Site ECS Ground Fault Testing	5	3
*OP-PC-735	C-Site Rectifier Settings	5	3
*OP-ECS-245	FCPC Daily Start up/Shutdown Procedure	6	2
*NCSX-XX	Leak Checking of NCSX	5	2
*NCSX-PTP-XX	HiPot of NCSX Coil Sys from SDS in FCPC	5	3
NCSX-PTP-XX	HiPot test of CHI Metal Oxide Varistors	5	3
*PTP-ECS- XX	C-Site ECS Continuity, Resistance, Inductance, & Meggar	5	3
*PTP-ECS- XX	Halmar (DCCT) & Shunt System Pre-op testing	5	2
*PTP-ECS- XX	C-Site Coil Protection Tests	5	3
*PTP-ECS- XX	C-Site Pulse Duration Period Timer Tests	5	3
*PTP-ECS- XX	C-Site FCPC Dummy load tests	5	3
*PTP-ECS- XX	C-Site ECS HiPot Tests	5	3

PTP-NCSX-XX	C-Site ECH-PI Pre-Operations Testing	5	2
*PTP-NCSX-XX	NCSX De-Ionized Water/System Testing	5	2
*PTP-NCSX-XX	NCSX Coil System Preoperational Tests	5	4
*PTP-NCSX-XX	C-Site ECS to NCSX Machine Coil Link Installation	5	2

- Legend:
- 1 - Document in development
 - 2 - Current document satisfactory for NCSX start up and operation
 - 3 - Document requires minor revision
 - 4 - Document requires major revision
 - 5 - Document needs to be developed
 - 6 - Need a NCSX Project specific version
 - * - Required for First Plasma