NCSX

Toroidal Field Coil Manufacturing, Inspection, Test and Quality Assurance Plan

NCSX-MIT/QA-131-01-00

August 2, 2005

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RECORD OF CHANGE

Revision	Date	Description of Change
00	8/2/05	Initial release

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1 Introduction and Scope

1.1 Introduction

The National Compact Stellerator Experiment (NCSX) Toroidal Field coils will be manufactured at Princeton Plasma Physics Laboratory for the NCSX Project. There are a total of 18 Toroidal Field (TF) coils. All (18) coils are identical. Each TF coil is constructed of 12 turns of pre-insulated hollow rectangular copper conductor. Once wound, the entire coil will be ground wrapped and vacuum-pressure impregnated (VPI) with epoxy in the autoclave oven. A structural wedge casting will then be installed on the nose-section of the coil.

1.2 Scope

This document addresses the manufacturing, inspection, test and Quality Assurance (QA) plan to complete and deliver the Toroidal Field Coil (TF) to the NCSX Project. This document includes the following Sections:

2 Applicable Documents
3 Safety Requirements
5 General notes for fabrication of TF Coils.
6 Materials and Parts
7 Fabrication Process
8 Documentation Requirements
9 Quality Assurance/Quality Control Requirements

1.2.1 This document along with the "NCSX Coil Manufacturing Facility Operations Plan" **[NCSX-PLAN-CMFOP-00]** will govern the processes by which the modular coils will be fabricated.

1.2.2 This document meets the requirements of the NCSX Quality Assurance Plan **[NCSX-PLAN-QAP].**

2 Applicable Documents

Identified below are the primary laboratory and project documents that that will be needed to complete the production of the TF coils.

2.1 Laboratory Procedures

Procedure Number (Latest Version)	**Title**
ESH-004	Job Hazard Analysis
ES&H 5008	PPPL Environmental, Safety and Health Manual
ESH-008	Access to Radiological Areas (RCA's)
ENG-014	Hydrostatic and Pneumatic Testing
ENG-021	Hoisting & Rigging Procedure
EM-002	General Welding & Brazing Requirements

2.2 NCSX Project Documents for Toroidal Field Coils

Document No.	Title
NCSX-CSPEC-131-01	Toroidal Field Coil Assembly Specification
NCSX-CSPEC-131-02	Toroidal Field Coil Conductor Specification
NCSX-CSPEC-131-03	Toroidal Field Coil Wedge Castings Specification
NCSX-PLAN-CMFOP-00	NCSX Coil Manufacturing Facility Operations Plan
D-NCSX-OP-EO-41	NCSX Coil Manufacturing Facility Emergency Response
WP-1227	TF Coil Fabrication
NEPA No. 1283	NCSX Coil Development and Production
D-NCSX-OP-G-XXX	TF Coil Cold Test Procedure

2.3 Toroidal Field Coil Manufacturing Procedures

Document No.	Title
D-NCSX-TFCF-001	TF Coil Fab- Coil Winding Activities
D-NCSX-TFCF-002	TF Coil Fab- Groundwrap/Molding Activities
D-NCSX-TFCF-003	TF Coil Fab- VPI Activities
D-NCSX-TFCF-004	TF Coil Fab- Post VPI Activities
D-L-NCSX-995	Lifting TF Coils

2.4 TF Coil Drawings:

2.4.1 Drawings for each TF coil will be provided by the NCSX project. Only signed and "Approved For Fabrication" stamped drawings can be used.

2.4.2 A complete list of coil drawings for the TF coil is located in the table below.

Drawing No.	Title
SE131-003 [shts 1-4]	TF Coil Final Assembly
SE131-005 [shts 1-2]	TF Coil Ground Wrapped Assembly
SE131-007 [shts 1-2]	TF Coil Nose Casting Machining Detail
SE131-013	TF Coil Coolant Tube Fitting Detail
SE131-014	TF Coil Conductor Detail
SE131-031	TF Coil Layer Transition Filler
SE131-032	TF Coil Layer Transition Filler Left/Right Detail
SE131-035 [shts 1-5]	TF Coil Winding Assembly/Details
SE131-041	TF Coil Transition Filler Block
SE131-047 [shts 1-2]	TF Coil Lead Locking Block Central
SE131-053	TF Coil Lead Long Bend
SE131-054	TF Coil Lead Short Bend

SE131-078	TF Coil Locking Block Type "A"
SE131-079	TF Coil Locking Block Type "B"
SE131-081	TF Coil Long Lead Unbent
SE131-082	TF Coil Short Lead Unbent
SE131-084	TF Coil Lead Locking Block Type "B"

2.5 Permits

2.5.1 D-site work permits:
D-site work permits are required whenever work is being performed at D-site. It identifies the type of work and procedures being used.

2.5.2 Confined space permits:
Confined Space permits are required whenever a person is entering a permit required confined space. It identifies any restrictions, requirements and personnel who are authorized for entry. The PPPL Industrial Hygienist (IH) representative issues the permit. [Requires a "safety watch"] (Example: Autoclave entrances when the dome is in position)

2.5.3 Flame/Fire Permit:
Flame/Fire permits are required whenever open flame activities such as welding, soldering, grinding, etc. are being performed. The permit is issued by PPPL's Emergency Service Unit (ESU) and requires a fire watch.

3 Safety Requirements:

3.1 Integrated Safety Management:

All work will be performed in a safe manner in accordance with PPPL Environmental, Safety and Health Manual **ES&H 5008** and the "Integrated Safety Management" (ISM) policy.

3.2 Job Hazard Analysis:

JHA's will be generated for each workstation, identifying existing or potential workplace hazards and evaluating the risk of worker injury or illness associated with job tasks. (Reference document **ESH-004 "Job Hazard Analysis**") The Industrial Hygiene representative will review the JHA's for accuracy as well as completeness. It will be reviewed with all activity participants at the Pre-Job briefings.

4 Training Requirements

Training of personnel working on the TF coil fabrication is "Key" to successfully completing the manufacturing of the TF coils. There are two categories of training requirements, general and specialized.

4.1 General Training Requirements

General training includes all laboratory-training requirements that are required to enter or work in the TF Coil Winding Facility. Examples of this training include:

- General Employee Training [GET]
- Integrated Safety Management [ISM]
- Radiation Safety Training

4.2 Specialized Training Requirements

Specialized training includes specific training or certification required to complete tasks during the fabrication of the modular coils. Examples include:

- Weld or braze certifications
- Confined space
- NCSX Coil Manufacturing Facility Operations Plan [CMFOP]

4.3 Training Matrix

There exists a TF Coil Manufacturing training matrix for the Toroidal Field Coil fabrication which will be posted on the NCSX Web site.

5 General Notes for Toroidal Field Coil Fabrication:

5.1 General Operating Plan:

Document **"NCSX-PLAN-CMFOP-00-01"** describes the general operating plan that will be used for the NCSX coil manufacturing facility.

5.2 Cleanliness/Housekeeping:

See section 8.2 in the Manufacturing Facility Operations Plan **NCSX-PLAN-CMFOP-00-01** for the housekeeping and cleanliness rules.

5.3 Critical Lifts:

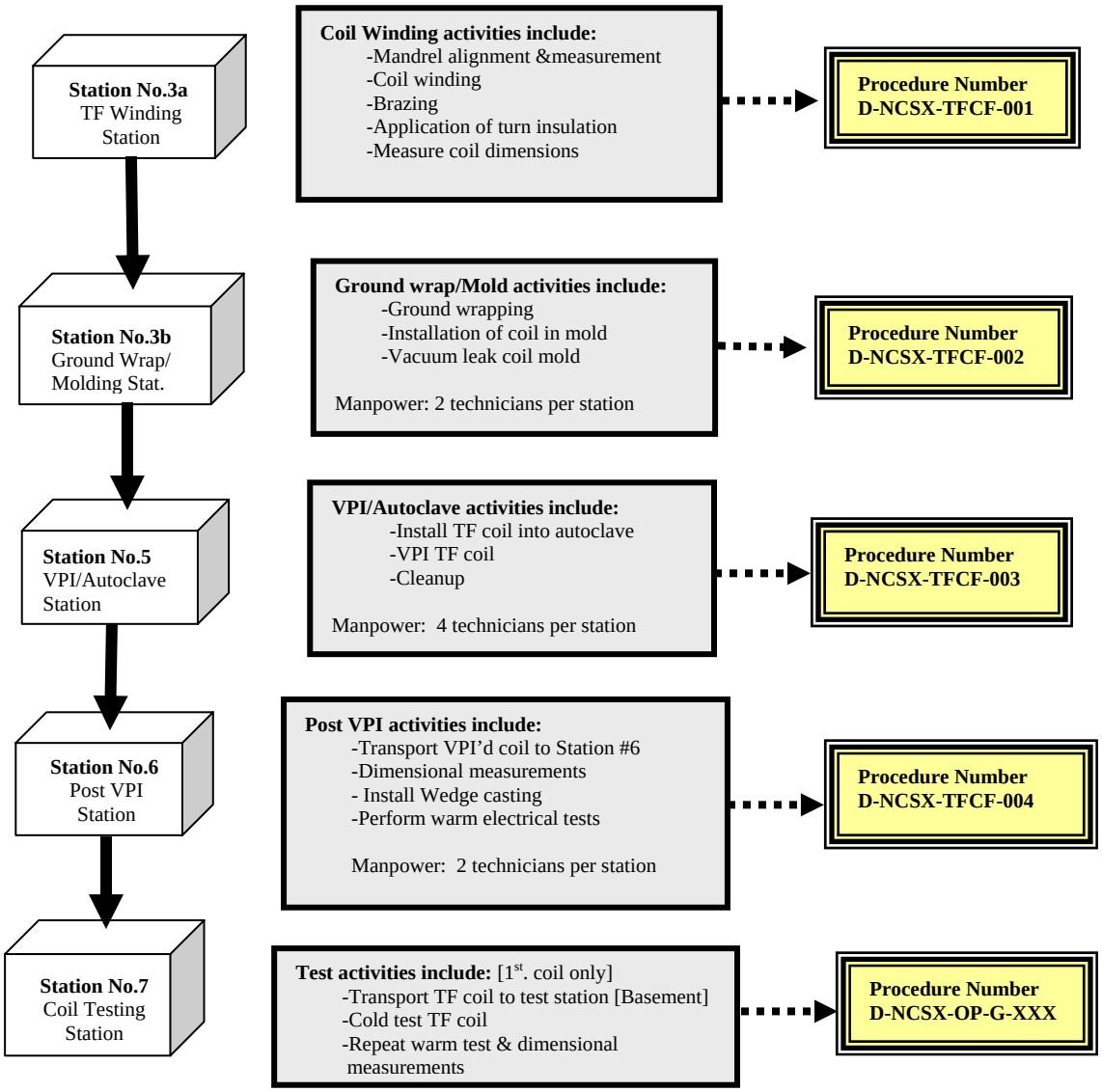
All lifting of TF Coils will be considered a "Critical" lift that requires the presence of a lift engineer. Note: The lift engineer may later identify the lift as repetitive, in which case his presence would not be required.

6 Materials and Parts

Each manufacturing procedure has a table of materials and parts identifying the items needed to complete the activities associated with that procedure. They can be found in section 5.0 of each coil manufacturing procedure.

7 Fabrication Process

This section of the MIT/QA plan outlines the processes that are to be performed and procedures required to complete the fabrication of the Toroidal Field coils. Procedures for performing the activities are covered by the Toroidal Field Coil Fabrication procedures.



Note: In addition to staff called out above, there will be a Field Supervisor, Station Lead Technician(s), metrology engineer and Q.C. representative.

Figure 1- Toroidal Field Coil Fabrication Plan Outline

7.1 Manufacturing Procedures:

There are (4) manufacturing procedures used to fabricate the Toroidal Field Coils (TF). Manufacturing Procedures detail the manufacturing processes, identifies inspection and test points and QC witness points.

7.1.1 D-NCSX-TFCF-001- Winding Activities
Procedure identifies the activities associated with preparation of the winding station; conductor taping; brazing operations; coil winding and metrology activities.

7.1.2 D-NCSX-TFCF-002- Groundwrap/Mold Activities
Procedure identifies the activities associated with ground wrapping and installation of the coil into the VPI mold.

7.1.3 D-NCSX-TFCF-003- Vacuum Impregnation Activities (VPI)
Procedure identifies the activities associated with preparing for and the vacuum-pressure-impregnation of the Toroidal Field coils using the autoclave.

7.1.4 D-NCSX-TFCF-004- Post VPI Activities
Procedure identifies the activities associated with post VPI, final conditioning prior to cold testing. This procedure includes cleanup of the coil following VPI, installation of TF Wedge Castings and room temperature electrical testing.

7.2 Electrical Test Procedure:

D-NCSX-OP-G-XXX- This procedure outlines the details of the testing of each TF coil following fabrication. The coils will be tested at liquid Nitrogen temperatures. [The number of TF coils to be tested will be determined by the NCSX Project Management]

7.3 Emergency Response Procedure:

D-NCSX-OP-EO-41- Details of response are discussed in section 9.7 of the NCSX Coil Facility Operations Plan "**NCSX-PLAN-CMFOP-00**"

8 Documentation Requirements:

8.1 Document Control:

All NCSX associated documents providing instruction for manufacturing the TF coils (e.g. plans and procedures) will be maintained under NCSX Project document control.

8.2 Coil Field Package:

Each coil will have a "Coil Field Package" that will include all coil related documentation associated with the manufacturing of the TF coils. Documentation in this package will include process procedures, QC inspection reports, photographs, test results, and measurements used to document completion of major activities, as well as any ECNs, non–conformance reports (NCR), or other exceptions to or changes in requirements..

8.3 Manufacturing Procedures:

Manufacturing procedures will be used as a signoff/approval document noting that critical manufacturing steps have been completed. Authorized personnel associated with the manufacturing, inspection and test processes will perform the signoff's. In addition, it will provide witness points as well as reference for test results, and measurements.

8.3.1 Procedure Completion:

The Lead Technician or Field Supervisor will document all critical completions on the procedure. This will be completed using the signer's initials or full signature.

The procedures will be filled out in a timely fashion once a particular activity has been completed.

8.3.2 Authorized Signoff's for Manufacturing Completions:

The manufacturing procedures will identify what level of signoff is required for a particular step. The following disciplines are the authorized signatures for the in-process procedures.

-Station Lead Technicians
-Field Supervisors
-Quality Control Representative
-Manufacturing Facility Manager

8.4 Final Document Storage:

All documents (hard copy) associated with the manufacturing will be stored in the PPPL Operations center, electronic documents will be stored on the NCSX Web site for the lifetime of the NCSX Project.

9 Quality Assurance/Quality Control Requirements

9.1 Mission Statement: -TF Coil QA/QC Plan

To observe and obtain any required information as may be necessary to assure that the manufacturing of the TF Coils is being performed in accordance with the Coil Facility Operations plan, TF Coil Specifications, the NCSX TF Coil Manufacturing Procedures and other applicable documents. [See section 2 for document numbers]

9.2 Inspection/Surveillance and Audit:

Authorized representatives of the NCSX project will perform inspection and surveillances all during the manufacturing of TF coils. These representatives will include the Field Supervisors; lead technicians as well as the Quality Control (QC) representatives.

-All measurements and tests will be performed by the field crews and engineering and do not require, unless outlined in the procedures, the presence of a QC representative.

-Independent Audits may be performed by the Quality Assurance Division to ensure that approved manufacturing processes and quality of product is being observed.

9.3 Inspection and Test Procedures:

Inspections and tests shall be performed in accordance with written/approved procedures referencing criteria for acceptance or rejection. Adequate records shall be maintained and available for NCSX Project reviews.

9.4 Document Traceability and Records:

The TF Coil manufacturing team shall maintain a system of documentation whereby objective evidence of required operations, inspections, examinations, and tests is systematically compiled, indexed and stored. Such objective evidence will include "travelers"; and material test, certification, inspection, examination, test and discrepancy reports; which shall be complete and legible and validated by responsible personnel and shall be traceable to subject items.

9.5 Equipment/Material Identification and Status

Material and equipment identification shall be maintained throughout the program and be traceable to the records. Status of acceptability shall be readily discernible through the use of tags, stamps, serial numbers or other positive means.

9.6 Non-conformance & Corrective Actions:

Nonconforming items shall be positively identified, and, where possible, segregated to prevent use. The TF Coil Manufacturing Team shall document each non-conformance in accordance with PPPL procedure **QA-005 "**Control of Non-conformances".

9.7 Calibration of Test and Measuring Equipment:

Inspections and tests shall be performed using properly calibrated measuring and test equipment in accordance with PPPL procedure **ENG-002** "Control of Measurement Test Equipment & Calibration".

9.8 Release for Station Transfer:

Prior to releasing a TF coil from one station to the next it is required that the all-responsible individuals sign the release indicating that all processes at that station have been satisfactorily completed. The release (on the procedure) will include signatures from the Station Lead Technician, Field Supervisor and the QC representative.

9.9 Process History:

The TF Coil Manufacturing team shall provide a Process History for the TF coils that includes a compilation of documents, detailing the objective evidence of the acceptability of the work performed. Process History for each coil records shall be stored in the Operations Center after fabrication is completed. The Process History shall include as a minimum, but not be limited to the following:

9.9.1 Material Certifications:

The TF Coil Manufacturing Team shall compile inspection reports, test data, and/or certifications from vendors, showing relevant chemical, mechanical and electrical properties of materials used, where applicable, as well as documents showing adherence to in-process requirements. Material certifications from sub-tier suppliers shall also be submitted. {Certifications for the insulation, epoxy, conductor as well as chill plates and lead materials are required as a minimum}

9.9.2 Inspection/ Test Documents:

Original or copies of filled in and completed process planning and control documents (procedures, etc.), which verify controlled execution of the required work. Each TF coil will have its own set of process planning and control documents.

9.9.3 Inspection Reports:

Copies of the original reports from all required inspections and examinations, that are properly validated by authorized personnel.

9.9.4 Test Reports:

Copies of the original test data sheets or reports of all required tests, both in-process and acceptance, that are properly validated by authorized personnel.