

PRINCETON PLASMA PHYSICS LABORATORY

**NCSX Manufacturing Facility
Project Hazard Analysis**

NCSX-PHA-142-01-01

April 21, 2006

PREPARED BY:

Jim Chrzanowski, Modular Coil Manufacturing Facility Manager

REVIEWED BY:

M. Viola, Field Period Assembly

APPROVED BY:

Larry Dudek, Responsible Line Manager

Wayne Reiersen, Project Engineering

Jerry Levine, Chairman, Safety Review Committee

RECORD OF CHANGE

Revision	Date	Description of Change
0	8/6/04	Initial release
1	4/21/06	Added Field Period Assembly

TABLE OF CONTENTS

1	Introduction and General Description.....	1
1.1	Introduction.....	1
1.2	General Description	1
2	Reference Documents	1
3	Facilities and Work Station Descriptions	1
3.1	Work Space.....	1
3.2	Work Stations.....	1
3.3	Overhead Cranes.....	2
3.4	Climate Control.....	2
3.5	AC Power.....	2
3.5.1	Winding Facility Power: (Stations 1-4).....	2
3.5.2	Autoclave Power System: (Station 5).....	2
3.5.3	Autoclave Control System	2
3.5.4	Field Period Assembly Power (Station V1 – V5).....	2
3.6	Grounding	3
3.7	Emergency Planning	3
3.7.1	E-Stop	3
3.7.2	Emergency Egress.....	3
3.7.3	Phones.....	4
3.7.4	Working Alone.....	4
3.8	General Safety Requirements:	4
3.8.1	Integrated Safety Management (ISM)	4
3.8.2	Job Hazard Analysis Surveys (JHA’s).....	4
3.8.3	Construction Safety Engineer (CSE)	4
3.8.4	Industrial Hygiene Representative (IH).....	5
3.9	Coil Manufacturing Work Station and Activity Descriptions	5
3.9.1	Station No. 1a and 1b- Winding Form Preparation	5
3.9.2	Stations 2 & 4- Coil Winding	5
3.9.3	Station No. 3- TF Winding Station.....	5
3.9.4	Station No. 5- Autoclave/VPI.....	6
3.10	Field Period Assembly Workstation and Activity Descriptions.....	7
3.10.1	Station No. V1 – VVSA receipt Inspection, diagnostic loop and cooling tube installation Facility	7
3.10.2	Station No. V2 – Modular Coil Assembly.....	7
3.10.3	Station No. V3 – Modular Coil and Port Extension Installation	7
3.10.4	Station No. V4 – TF Coil and Trim Coil Installation	7
3.10.5	Station No. V5 – Storage and Transportation Preparation	7
4	Hazard Analysis.....	7
4.1	Material Hazards.....	7
4.2	Electrical Hazards	8
4.3	Mechanical Hazards.....	8
4.3.1	Lifting and Rigging.....	8
4.3.2	Elevated Workspace:	8
4.3.3	Gas Cylinders:.....	8
4.4	Radiation Hazards.....	8

4.5	Autoclave-Vacuum Oven Chamber Hazards.....	9
4.5.1	Vacuum/Pressure Hazards:.....	9
4.5.2	Oxygen Deficiency	9
4.5.3	Hot Surface Hazards	9
4.6	Fire Safety.....	9
4.6.1	Fire Detection	9
4.6.2	Fire Suppression	9
4.7	Natural Phenomena.....	10
4.7.1	Earthquakes.....	10
4.7.2	Tornadoes and Extreme Wind	10
4.7.3	Floods.....	10

TABLE OF FIGURES

Figure 3-1	Manufacturing Facility Layout	3
------------	-------------------------------------	---

TABLE OF TABLES

Table 3-1-	Autoclave Operations and Conditions	6
------------	---	---

1 Introduction and General Description

1.1 Introduction

The National Compact Stellarator Experiment (NCSX) will be assembled and built at Princeton Plasma Physics Laboratory. The modular coils will be fabricated and the stellarator core will be preassembled into three 120° field period assemblies in the TFTR Test Cell which has been renamed the NCSX Manufacturing Facility. There will be ten (10) stations to accomplish this task. Once completed, the Field Period Assemblies (FPA) will be moved into the NCSX test cell at C-Site.

This document describes the facilities, operations, expected hazards and their mitigation to fabricate (18) modular coils and to assemble and deliver three (3) Field Period Assemblies for the NCSX Project to the NCSX test cell.

It has been prepared in accordance with PPPL ES&HD 5008 and supports the MCMF designation as a "Moderate Hazard" facility.

1.2 General Description

The NCSX Manufacturing Facility consists of two assembly areas the Modular Coil Manufacturing Facility and the Field Period assembly area. The NCSX Manufacturing Facility will occupy the area formerly known as the TFTR Test Cell at D-Site. This area is a Radiologically Controlled Area (RCA) as a result of past operations (see Section 4.4). The Modular Coil Manufacturing Facility will be comprised of five (5) workstations including three (3) clean rooms as well as a vacuum oven (autoclave). Each station will have a separate procedure detailing the manufacturing processes; use of travelers; inspection points and test plan for that station.

The Field Period Assembly area occupies the north end of the building and is comprised of five (5) workstations to assemble the VVSA and Field Period Assemblies.

2 Reference Documents

ESHD 5008 – PPPL Environment, Safety, and Health Directives (“ES&H Manual”)
NCSX-PLAN-MFOP-01 – NCSX Manufacturing Facility Operations Plan

3 Facilities and Work Station Descriptions

3.1 Work Space

Test Cell has over 14,000 square feet of floor space that will be shared between the coil manufacturing facility, field period assembly activities plus the remaining neutral beams from TFTR. The coil winding facility will need a minimum of 3500 square feet of floor space.

3.2 Work Stations

The Twisted Racetrack (TRC), Modular Coils and TF coils will be fabricated on the ground floor of the NCSX Manufacturing Facility (NMF). The NMF has adequate climate control needed for comfort and tolerance control and crane capabilities. There are a total of six [5] workstations associated with the manufacturing of the modular and TRC coils.

In addition to Coil Manufacturing the building will be used to assemble parts to the NCSX vacuum Vessel segments and then to assemble the Coils onto the segments to create 3 complete field period assemblies. This work will be performed in the area north and west of

the NCSX Coil Manufacturing Facility. This area is called the “NCSX Field Period Assembly Area”.

3.3 Overhead Cranes

The manufacturing facility has (2) overhead bridge cranes rated at 110 Ton and 25 Ton loads capacity. These cranes are part of PPPL’s crane inspection, maintenance and qualification programs and are operated by trained, qualified personnel.

3.4 Climate Control

The manufacturing facility environment will be maintained at a constant 70 degrees F +/- 5 degrees with 50% relative humidity +/- 10%

3.5 AC Power

All wiring and equipment is installed in accordance with the National Electrical Code (NEC). During the VPI activities, stand-by (diesel) power will be available. This will be identified as a pre-requisite in the VPI procedure.

3.5.1 Winding Facility Power: (Stations 1-4)

Station #1 located outside the clean rooms is powered from panel board LP-501. Stations #2-4 (Clean rooms) are powered from panel board LP-502. The panel boards are located on the East side of the pedestal.

3.5.2 Autoclave Power System: (Station 5)

All Autoclave power comes from two existing 480-volt receptacles that are located on the south wall of the Test Cell. Power is distributed via two system carts (located behind station #4). One circuit is for 480-volts and one circuit is stepped down to 208/120v. (Reference drawing SD144E014)

3.5.3 Autoclave Control System

The Autoclave heating, vacuum and blower system are all controlled from cart #2. Thermocouple meters with visual displays & PC interface are at cart #2.

3.5.4 Field Period Assembly Power (Station V1 – V5)

These areas are located for easy reach by the overhead crane to facilitate assembly of the larger components and access to local power outlets to supply 480-volts for welding equipment to be used during diagnostic loop and Heating and Cooling tube installation.

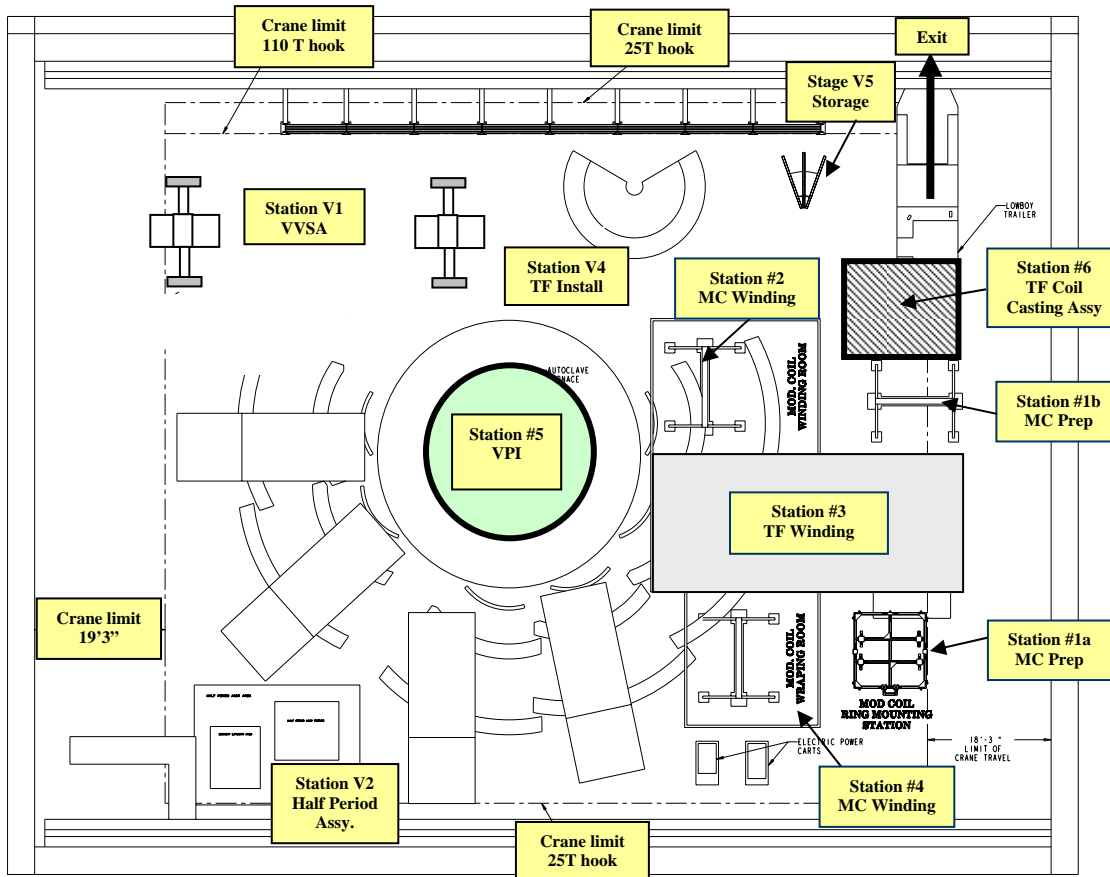


Figure 3-1 Manufacturing Facility Layout

3.6 Grounding

As stated above, all electrical installations are done in accordance with the NEC latest edition. In addition to the VPI steel platforms, the autoclave and any operating panels shall be bonded to the building steel for equipment grounding.

3.7 Emergency Planning

3.7.1 E-Stop

There are no high voltage power supplies used in the NMF. All the power units have "dead front operation" with front panel disconnects. They are easily and quickly shutdown by the operator should an emergency arise. Therefore no global area E-Stop is required for the NMF.

3.7.2 Emergency Egress

All areas of the NMF meet the life safety code for emergency egress. As equipment is installed in the area, this issue will be reviewed to assure that compliance is maintained.

3.7.3 Phones

There will be several phones in the NMF area. They are located at the main door and in the clean rooms. All will be posted with emergency call information. In addition there are phones in adjoining areas.

3.7.4 Working Alone

For purposes of personnel safety, operation of the turning fixtures and or other major equipment in the NMF will not be allowed without a second person present. This requirement will be highlighted in the procedures.

3.8 General Safety Requirements:

3.8.1 Integrated Safety Management (ISM)

ISM principles will be used throughout the coil manufacturing process. It is a “Common sense approach to Doing Work Safely”. There are seven guiding principles for safety management:

- Line management responsibility for safety
- Clear roles and responsibilities
- Competence commensurate with responsibilities
- Balanced priorities
- Identification of safety standards and requirements
- Hazard controls tailored to work being performed
- Operations authorization

3.8.2 Job Hazard Analysis Surveys (JHA's)

JHA's will be generated to identify existing or potential workplace hazards and to evaluate the risk of worker injury or illness associated with job tasks. (Reference document ESH-004 Job Hazard Analysis). The IH 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.

3.8.3 Construction Safety Engineer (CSE)

A Construction Safety Engineer (CSE) will be assigned to support the manufacturing activities. He/she will be responsible for reviewing and ensuring that all field activities are being performed safely and in accord with PPPL safety requirements. Responsibilities include working with field supervisors, lead technicians and field crews, making recommendations for types of safety equipment to be used and how to perform work more safely.

3.8.4 Industrial Hygiene Representative (IH)

The Industrial Hygiene (IH) Representative is responsible for reviewing and approving Job Hazard Analysis (JHA) surveys and issuing Confined Space Work Permits. IH representative provides IH related technical support to the field supervisors, lead technicians and field crews.

3.9 Coil Manufacturing Work Station and Activity Descriptions

There are a total of [5] workstations associated with the production of the Modular Coils. Stations 1 thru 5 are located in the NCSX Manufacturing Facility. The fabrication of the modular coils involves a production line in which the coils under construction move from station to station via the overhead crane.

3.9.1 Station No. 1a and 1b- Winding Form Preparation

Stations No.1a and 1b are not located in a clean room and contain (2) fixtures. One fixture will be used for mounting the castings to the turning fixture ring supports. The second is a turning fixture that will be used for completing the balance of the station's activities. Most station activities will be performed on the casting while it is mounted in the turning fixture. The rotational speed will be limited by internal controls and the off-on is controlled via a deadman foot pedal. Adequate guards will be provided in pinch areas to eliminate personnel risks. At this station the modular coil castings are inspected, measured and cleaned. Coil clamp studs will be welded onto the castings using a stud weld machine. In addition, inner copper chill plates will be installed. Cleaning solvents such as acetone and Chlorine free degreasers will be utilized.

3.9.2 Stations 2 & 4- Coil Winding

These stations each contain a turning fixture to which the MC casting is mounted. Details of the units are described in station no. 1. At these (2) stations the insulated cable conductors are wound onto the stainless steel winding forms. Work at this station includes the installation of the fiberglass/Kapton Groundwrap insulation as well as completion of the coil leads. In addition, the outer chill plates, outer diagnostics, coil clamps and "Bag Mold" are installed. Materials used in this station include RTV, 2-part epoxy formulations and glass fibers and vulcanized rubber tape. All chemicals and materials used have been reviewed and approved by PPPL IH. Additional ventilation will be provided to minimize any fumes from the epoxy work being performed inside of the enclosure. These stations will be enclosed with a ceiling and walls to better control the cleanliness of the winding environment. A filtered airflow system will be incorporated to provide adequate air changes for personnel comfort and to remove any epoxy fumes that may exist from the molding operations.

3.9.3 Station No. 3- TF Winding Station

At this station the TF coils are wound onto a winding mandrel using insulated extruded copper conductor. Work at this station includes application of turn insulation, conductor brazing, joint testing as well as completion of the coil leads. Once the coil has been wound, the coil is then moved to stands within the cleanroom, for application of the groundwrap insulation. The coil is then placed into a vacuum mold in preparation for VPI activities. This station is enclosed with a ceiling and walls to better control the cleanliness of the winding environment. The room is provided with positive pressure that may be used to reduce any outside contamination.

Note: This station is presently dormant but could be used if necessary to wind the TF coils.

3.9.4 Station No. 5- Autoclave/VPI

This station is comprised of the autoclave [vacuum/pressure oven], epoxy mixing station and epoxy control station for performing the epoxy vacuum-pressure-impregnation of the modular coils. A confined space permit will establish prerequisites for access and entry, and only trained personnel with a safety watch will be authorized to enter the vessel. This designation of the vessel as a confined space and the need for periodic entries to the vessel during operations is the primary reason the NCSX Manufacturing Facility has been declared a "Moderate Hazard" activity.

3.9.4.1 General Operation of Autoclave

An autoclave is a pressure chamber used to cure materials at elevated temperatures and pressures, and/or vacuum during the process and cure cycles. The application and sequence of heating, cooling, pressure and vacuum are predetermined by the process specifications that detail the fabrication and treatment of parts. In our application, the modular coils will be placed in the autoclave where they will be vacuum filled with epoxy resin. Once filled the coil will be heated to a cure [GEL] temperature of 110° C then elevated to 125° C for a 15 hour Post Cure.

identifies the autoclave operations plus condition during each activity.

Table 3-1- Autoclave Operations and Conditions

Activity	Chamber entry status	Temperature	Vacuum/ Pressure	Crane Use
Remove lid	Confined space	RT	Atmospheric	Yes
Insert modular coil	Confined space	RT	Atmospheric	Yes
Reposition lid	Confined space	RT	Atmospheric	Yes
Chamber- vacuum and heat	No entry	50 deg. C	Milli Torr	No
VPI modular coil	No entry	50 deg. C	Milli Torr to 10 psig	No
Final oven cure	No entry	125 deg. C	Atmospheric	No
Cool down	No entry	125 deg. C to RT	Atmospheric	No
Remove lid	Confined space	RT	Atmospheric	Yes
Remove modular coil	Confined space	RT	Atmospheric	Yes

3.10 Field Period Assembly Workstation and Activity Descriptions

3.10.1 Station No. V1 – VVSA receipt Inspection, diagnostic loop and cooling tube installation Facility

The Field Period Assembly will begin with the assembly of the vacuum vessel. This station is comprised of two trunions that will support the VVSA in a rotisserie style. The Diagnostic loops will be installed using small tabs spot welded to the vessel surface and then the cooling tubes will be installed with studs welded to the surface and clamps applied.

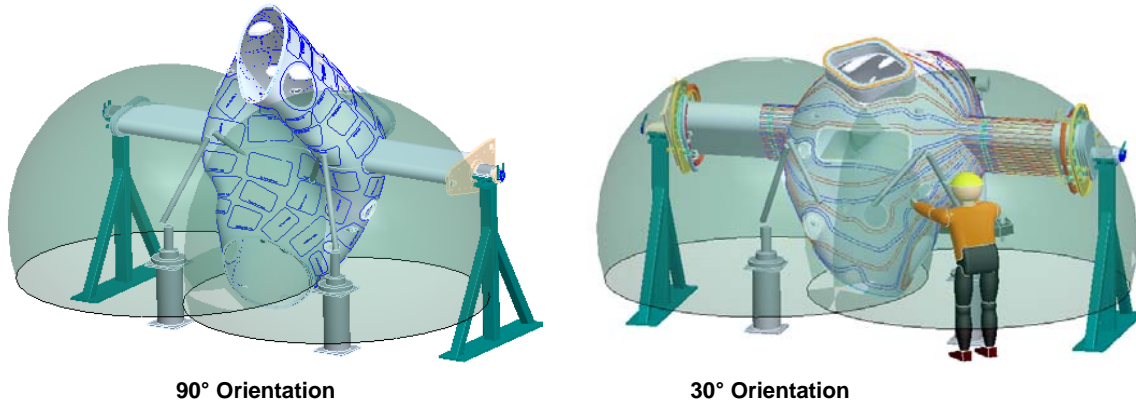


Figure 3.2 Vacuum Vessel Support

3.10.2 Station No. V2 – Modular Coil Assembly

This station is comprised of a tilting platform that will allow the modular coils to be aligned and bolted together.

3.10.3 Station No. V3 – Modular Coil and Port Extension Installation

This station is comprised of a support that will hold the vacuum vessel vertical and allow the modular coils to be rotated (screwed) onto each end of the VVSA, one at a time. Then the ports will be aligned and welded on. From this point forward, the Assembly will be called the Field Period Assembly.

3.10.4 Station No. V4 – TF Coil and Trim Coil Installation

This station is comprised of a support for the Field Period Assembly and a large column that will be used to support the TF Coils and rotate them onto the Field Period Assembly.

3.10.5 Station No. V5 – Storage and Transportation Preparation

This station is space set aside for minor intermediate operations or storage both between stations and in preparation for transportation to the NCSX Test Cell.

4 Hazard Analysis

4.1 Material Hazards

No materials of significant toxicity or carcinogenicity are used in MC winding/fabrication operations or field period assembly. A number of chemical agents, ethanol, acetone, vacuum

grease, leak sealant, solder fluxes and lubricants, etc., will be used in small quantities during fabrication. ES&H personnel are consulted with regard to safe handling and utilization of hazardous materials and all materials are handled in accordance with the procedures recommended in the MSDS's and stored in labeled containers. Flammable solvents will be stored in listed or approved safety containers and cabinets not in the immediate area. Flammable materials are store away from oxidizers and sources of flame. Any waste material that may be generated from the use of hazardous materials is handled in accordance with PPPL Environmental Restoration and Waste Management procedures for hazardous waste management (EWM-001, Hazardous Waste Management).

4.2 Electrical Hazards

There are no unusual electrical hazards in the NMF area, no exposed conductors, and no hazards that would restrict access to the area. The AC power for the general MCWF area and the power for the autoclave constitute the only electrical hazards in the area. As mentioned above, all AC power circuits are designed and installed in accordance with the NEC. All operating personnel will be trained on Basic Electrical Safety and Lockout/Tagout procedures.

4.3 Mechanical Hazards

4.3.1 Lifting and Rigging

During the modular fabrication activities, the overhead crane will be required to transport the modular coils, vacuum vessel segments and field period sub-assemblies from station to station. Only qualified crane operators will be utilized. Certified lifting beams as well as a lift procedure will be used during the critical lifts. A lift engineer will be present during all designated critical lifts. (ENG-021 Critical Lift Procedure)

4.3.2 Elevated Workspace:

The upper catwalk around the top of the autoclave will be restricted (chained) during the removal/installation of the autoclave lid, or a modular coil. An observation area on the catwalk will be provided to allow the crane operator and/or lift engineer to observe the lift. This observation area will have guardrails to protect the crane operator from falls into the open chamber. There will be no restrictions on use of the upper catwalks by personnel while the autoclave lid is in position or while the space between the lid and vessel is less than 12 inches.

4.3.3 Gas Cylinders:

Nitrogen gas will be used during the epoxy impregnation activities (VPI) to provide positive pressure. All gas cylinders will be handled and secured in accordance with the requirements of ES&H Directive 5008, Section 9, and Chapter 2.

4.4 Radiation Hazards

The NMF is located in a Radiological Controlled Area (RCA). The RCA designation is a result of the NB boxes (internal contamination) remaining in the area from TFTR, and from locations of low level activity throughout the former TFTR Test Cell. Health Physics performs daily surveys, and all personnel entering the facility must be Radiation Safety

qualified or be escorted by a Rad Safety qualified individual. Activities in the RCA, including removal of materials from the room, are controlled by an approved Radiation Work Permit (RWP). No significant HP issues have been identified.

4.5 Autoclave-Vacuum Oven Chamber Hazards

The autoclave-oven/ vacuum chamber poses several potential hazards. These hazards are identified as oxygen deficiency, hot surfaces, elevated workspaces and vacuum related hazards. The elevated workspaces hazard has already been discussed in the Mechanical Hazards section.

4.5.1 Vacuum/Pressure Hazards:

The autoclave chamber is a vacuum/pressure (15 psig max.) chamber and contains viewing ports. To prevent personal injury in an unlikely situation of a window breaking, protective plastic outer covers will be installed on each view port. A pressure relief valve (15 psig) will be installed on the chamber lid to control over pressure and are relieved directly into the Manufacturing Facility.

4.5.2 Oxygen Deficiency

The autoclave chamber with or without the lid in position and the NCSX VVSA each constitutes a permit-required confined space hazard upon personnel entry due to the vessel geometry. In addition the autoclave is a possible oxygen deficient atmosphere from nitrogen. All entries will be in accordance with an approved confined space entry procedure, including appropriate oxygen monitoring, and all entry and safety watch personnel will be confined space trained. This is the primary reason the NMF has been declared a "Moderate Hazard" activity.

4.5.3 Hot Surface Hazards

As part of the VPI operation every modular coil will be cured at a temperature of 125 degrees C. To prevent personnel injury due to hot surfaces, the outer surface of the chamber is covered in an insulating blanket. The outer blanket surface during oven use will be < 38 degrees C (100 degrees F). Personnel awareness and caution will still be observed to prevent any heat/burn related injuries. Warning signs as well as a blue flashing light will indicate that the autoclave is being heated.

4.6 Fire Safety

4.6.1 Fire Detection

Fire detection in the NMF area is by overhead ceiling mounted smoke detectors. Additional smoke detectors are installed in the (3) clean rooms. The smoke detectors are part of the building Pyrotronics system which is tied into the Laboratory wide Simplex reporting and recording system. All systems are tested in accordance with NFPA codes.

4.6.2 Fire Suppression

Fire suppression in the NMF areas is by overhead pre-action sprinklers, supplied from the Laboratory's fire protection water system and tower. All systems are tested in accordance

with NFPA codes. No fire suppression systems will be installed in the clean rooms. However, fire extinguishers will be positioned in the Modular Coil Manufacturing Facility.

4.7 Natural Phenomena

4.7.1 Earthquakes

PPPL is in a low probability earthquake region (a 1 in 1000-year earthquake). The NCSX Project seismic requirements state that rigid steel structures mounted in the TFTR Test Cell, which could present a physical hazard to personnel in the event of an earthquake, must be able to withstand a static lateral load of 0.11Gs applied at the center of gravity of the structure.

The design for the autoclave and field period assembly fixtures exceeds the minimum NCSX seismic requirements. Therefore, the seismic risk for the NMF facility is considered to be acceptable.

4.7.2 Tornadoes and Extreme Wind

The building housing the NMF is designed to withstand low probability tornado and extreme wind events defined for the PPPL site (see D-site Facilities Safety Assessment Document, Section 2.3.1.2, 11/16/01). No special tornado/wind proofing of the NMF facility is required.

4.7.3 Floods

PPPL is not in a flood plain, and studies done for the TFTR facility indicate that the site is not subject to floods up to and including the Probable Maximum Flood (PMF) associated with streams near the site.