PRINCETON PLASMA PHYSICS LABORATORY

Modular Coil Manufacturing Facility

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RECORD OF CHANGE

Revision	Date	Description of Change
0	8/6/04	Initial release

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 Introduction and General Description

1.1 Introduction

The National Compact Stellerator Experiment (NCSX) Modular Coils will be manufactured at Princeton Plasma Physics Laboratory. The Modular Coil Set consists of three field periods with 6 coils per period for a total of 18 coils. Due to symmetry, only three different coil shapes are required to make up the complete coil set. Each modular coil is constructed by winding pre-insulated rectangular compacted copper cable onto a stainless steel cast winding form. Each coil consists of two, 4-in-hand pancake windings. Once wound, the entire coil will be vacuum-pressure impregnated (VPI) with epoxy. This document describes the facilities, operations, expected hazards and their mitigation for the Modular Coil Manufacturing facility (MCMF). It has been prepared in accordance with PPPL Health and Safety Directives and supports the MCMF designation as a "Moderate Hazard" facility.

1.2 General Description

The Modular Coil 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). It 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.

2 Reference Documents

ESHD 5008 – PPPL Environment, Safety, and Health Directives (“ES&H Manual”)

NCSX-PLAN-WFOP-00 – Modular Coil Winding Facility Operations Plan

3 Facilities and Process Description

3.1 Modular Coil Winding Area

The Coil Winding facility 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. Figure 3-1 below provides a plan view of the Modular Coil Winding Facility layout.

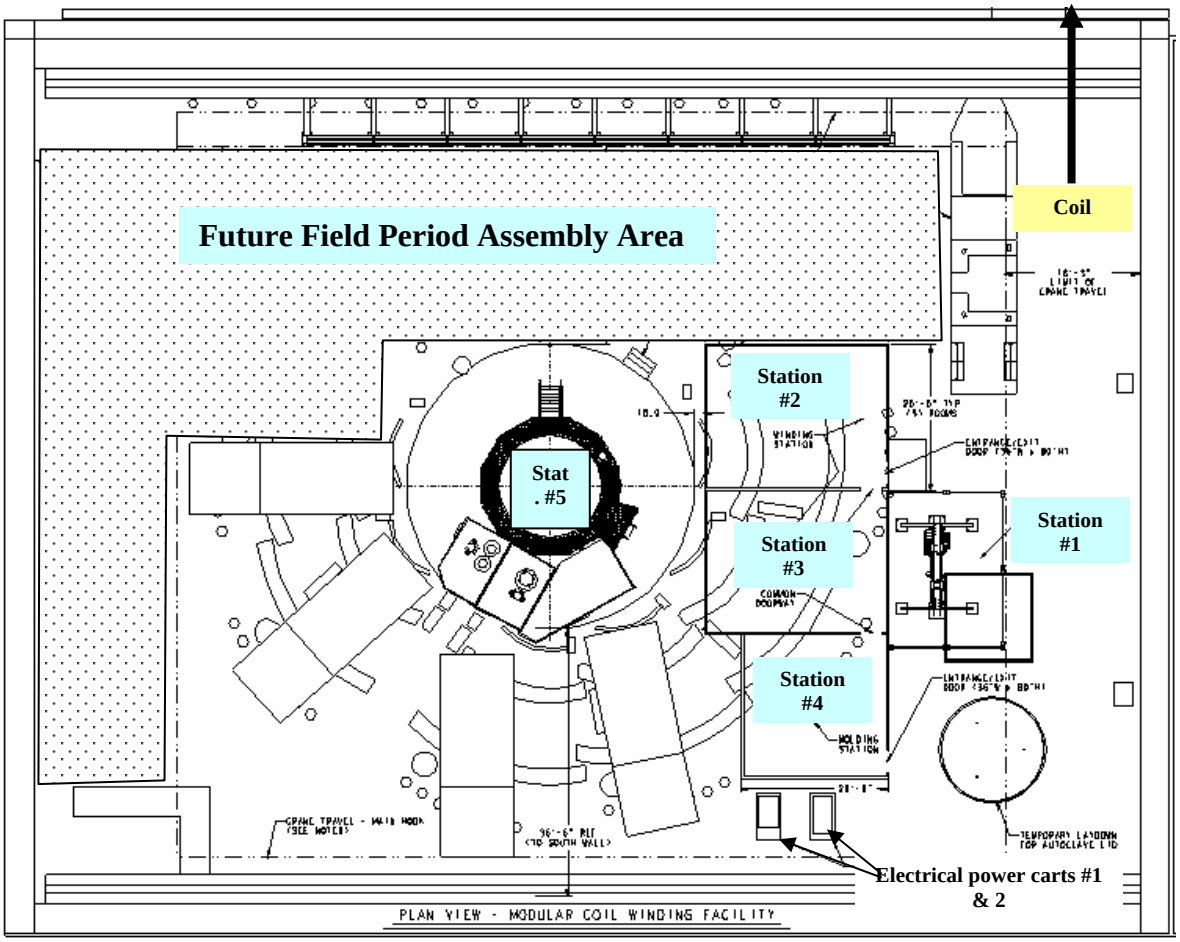

Figure 3-1 Modular Coil Winding Facility Layout

3.2 Overhead Cranes

The coil 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.

3.3 Climate Control

The coil manufacturing facility environment will be maintained at a constant 75 degrees F +/- 5 degrees with 50% relative humidity +/- 10%

3.4 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.

3.4.1 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.

3.4.2 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)

3.4.3 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 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.

3.6 Emergency Planning

3.6.1 E-Stop

There are no high voltage power supplies used in the MCMF. 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 MCMF.

3.6.2 Emergency Egress

All areas of the MCMF 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.

3.6.3 Phones

There will be numerous phones in the MCMF 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.

3.6.4 Working Alone

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

3.7 General Safety Requirements:

3.7.1 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

3.7.2 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.

3.7.3 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.

3.7.4 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. Provides IH technical support to the field supervisors, lead technicians and field crews.

3.8 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 Modular Coil Manufacturing Facility (MCMF). 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.

3.8.1 Station No. 1- Casting Preparation

Station No.1 is not located in a clean room and contains (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 and inner diagnostics will be installed. Cleaning solvents such as acetone and Chlorine free degreasers will be utilized.

3.8.2 Stations 2 & 3- 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. 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.

3.8.3 Station No. 4- Mold Preparation

This station contains a turning fixture to which the MC casting is mounted. Details of the units are described in station no. 1. At this station, the outer chill plates, outer diagnostics, coil clamps and "Bag Mold" are installed. This station will be enclosed with a ceiling and walls to better control the cleanliness of the winding environment. Materials used in this station include RTV, 2-part epoxy formulations, vulcanized rubber tape and felt sheets. 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. 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.

3.8.4 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 MCWF has been declared a "Moderate Hazard" activity.

3.8.4.1 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 temperature of 125 degrees C. Table 3-1 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

4 Hazard Analysis

4.1 Material Hazards

No materials of significant toxicity or carcinogenicity are used in MC winding/fabrication operations. 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 MCWF 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 coil and castings 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 MCWF is located in a Radiologically 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. 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 constitutes a permit-required confined space hazard upon personnel entry due to the vessel geometry and 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 MCMF 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 MCMF 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 MCMF 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 exceeds the minimum NCSX seismic requirements. Therefore, the seismic risk for the MCMF facility is considered to be acceptable.

4.7.2 Tornadoes and Extreme Wind

The building housing the MCMF 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 MCMF 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.