

Princeton Plasma Physics Laboratory Procedure

Procedure Title: **Modular Coil Fabrication-Winding Form Preparation Activities**

Number:
D-NCSX-MCF-001

Revision:
00

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(2 yrs. unless otherwise stipulated)

Procedure Approvals

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Date: **11/19/04**

Responsible Division: **NCSX Project**

Procedure Requirements Designated by RLM

LABWIDE:

<input checked="" type="checkbox"/>	Work Planning Form # WP-1188 & 1138 (ENG-032)		Lockout/Tagout (ESH-016)
	Confined Space Permit (5008, SEC.8 Chap 5)		Lift Procedure (ENG-021)
	Master Equip. List Mod (GEN-005)	<input checked="" type="checkbox"/>	ES&H Review (NEPA, IH, etc.) NEPA 1283
	RWP (HP-OP-20)		Independent Review
	ATI Walkdown	<input checked="" type="checkbox"/>	Pre-Job Brief
<input checked="" type="checkbox"/>	Post-job Brief *		

D-SITE SPECIFIC:

<input checked="" type="checkbox"/>	D-Site Work Permit (OP-AD-09)		Door Permit (OP-G-93)
	Tritium Work Permit (OP-AD-49)		OSD (OP-AD-63)
<input checked="" type="checkbox"/>	Pre-Job Brief (OP-AD-79)		T-Mod (OP-AD-03)
	** DCA/DCN (OP-AD-104) #		

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- * Required for installations involving internal vacuum installations, critical lifts, and for the initial installation of repetitive work.
- ** OP-AD-104 was voided by procedure ENG-032. However, DCA's that were open at the time of adoption of ENG-032 are still considered valid for work approval purposes.

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TRAINING (designated by RLM)			
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Lead Tech.		X	
Technicians performing task		X	
Field Supervisors		X	
Quality Control Representative		X	
Training Rep.			
RLM Larry Dudek			

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RECORD OF CHANGE

Revision	Date	Description of Change
00	11/22/04	Initial release

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1 Scope

1.1 Introduction

The Modular Coil Manufacturing Facility is divided into 6 workstations. Each workstation has a specific set of tasks that will be performed as part of the overall fabrication process. The fabrication procedures will address the manufacturing, inspection, test and QC inspection points for a specific workstation.

- **Station No. 1...** **Winding Form Preparation & Post VPI Activities**
- Station No. 2... Winding Station A/ Molding and VPI Preparation
- Station No. 3... Winding Station B/ Molding and VPI Preparation
- Station No. 4... Winding Station C/ Molding and VPI Preparation
- Station No. 5... VPI and Autoclave Activities
- Station No. 6... Coil Testing Facility

1.2 Scope

This procedure prepares each Modular Coil Winding Form (MCWF) or Twisted Racetrack Coil winding form (TRC) for winding. It includes:

- Mounting the winding form to the turning fixture
- Verification of electrical integrity of poloidal break
- Winding Form inspection and measurements
- Installation of clamp studs
- Cleaning of winding form
- Installation of winding clamps
- Installation of the inner cladding plates

1.3 Identification of winding form being prepared:

Station Number: _____ (Location where work will be performed)

Winding Form Type: _____ [Type A, B, C or Twisted Racetrack Coil (TRC)]

MC Winding Form ID No: _____

Modular Coil Identification Number: _____

2 Applicable Documents

2.1 NCSX-MIT/QA-142-01:

All applicable documents associated with this procedure, are identified in the MIT/QA Plan, document number NCSX-MIT/QA-142-01.

2.2 NCSX-PLAN-MFOP-00:

All Modular Coil work processes are governed by the "Winding Facility Operations Plan", document number NCSX-PLAN-MFOP-00.

3 Safety Requirements:

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

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3.1 Job Hazard Analysis:

A JHA will be generated for each workstation, identifying 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.

4 Prerequisites and Conditions

4.1 Pre-Job Briefing:

A pre-job briefing will be held, describing the processes and safety issues prior to starting any part of this procedure. Attendance shall be documented via training sign-in sheet.

Pre job Briefing complete: _____
MC Field Supervisor Date

4.2 Daily Operations Startup and Shutdown:

Each working day, it is required to complete and initial the daily operations startup log to ensure that the station is ready to commence work activities for the day. The signoff log is located in the back of this procedure. See section 6.1 and 6.2 for details.

4.3 Torque Values:

The following torque values shall be used for securing hardware unless otherwise specified in the procedure. (Low carbon steel hardware)

3/8-16UNC 18 ft-lbs	3/8-24UNF 19 ft-lbs	1/2 -20 UNF ... 40 ft-lbs
5/8-11 UNC..... 83 ft-lbs	5/8-18 UNF..... 95 ft-lbs	3/4-10 UNC.... 105 ft-lbs
3/4-16 UNF 102 ft-lbs	1-8 UNC ... 236 ft-lbs	1-14 UNF 212 ft-lbs

5 Materials and Parts for his Station

The following materials and/or equipment will be used with this procedure. MSDS's for chemicals will be located in a notebook in the winding facility.

General Description	Material	Reference Document/Product No.
Cladding	Copper	Drawing list to be added as addendum for each coil type as approved
Solvent	Chlorine-Free Degreaser	CRC Product No. 03185 [MSDS #05032]
Solvent	Acetone	MSDS# 00561
Studs for coil clamp to casting stud	Stainless steel grade 316	Drawing SE1405-265P
Mold release	Release agent dry lubricant	"Miller-Stephenson" -PTFE MS122DF
MC Turning Fixture	Equipment	Drawing no. SE144-008
Rolled Ring Assembly	Fixture	Drawing no. SE144-007
Casting to Ring Assy. Fixture	Fixture	Drawing no. SE144-050
Weld stud alignment fixture	Fixture	Drawing no. SE144-085
Stud Welder unit	Equipment- TRW Nelson	Model no. 101 Series 4500
Supports and hardware for MC mounting casting to turning rings	Fixture	See drawing SE144-050
Supports and hardware for TRC mounting casting to turning rings	Fixture	See drawing SE144-200

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Cladding insulation	Kapton-Type HN adhesive back	0.00325 inch thick
Double faced adhesive tape	5 mil thick	Product no. 9485PC-2
Winding clamps	Equipment	Drawing SE144-080
Alcohol	Ethanol	MSDS
Severn Gauge	Equipment	Permeability indicator # 6424

6 Fabrication Process

This fabrication procedure is to be used as guide to complete the station no. 1 activities. Deviation from this procedure can be made during the winding process with the concurrence of the MC Field Supervisor. All deviations shall be documented in the procedure and initialed by the MC Field Supervisor prior to implementing the deviations. Procedure changes need to be incorporated into document via "Minor Procedure Changes" or "Revisions".

6.1 Daily Startup Activities:

- 6.1.1 Check all daily supplies needed:
- 6.1.2 Turn on the Turning Fixture power switch to verify operation.
- 6.1.3 Check stud welder for operation [Only if being used that day]
- 6.1.4 Check station for cleanliness
- 6.1.5 Check that the day's travelers and procedures are in their document holder.
- 6.1.6 Date and initial daily log at the back of procedure

6.2 Daily Shutdown Activities:

- 6.2.1 Turn off power to Turning Fixture.
- 6.2.2 Turn off stud welder and secure for off hours.
- 6.2.3 Clean entire workstation area.
- 6.2.4 Verify that all Traveler and data sheet information is complete.
- 6.2.5 The Lead Technician shall verify that the Station's Log Book has been completed and signed for the day.
- 6.2.6 Cover the Modular coil casting with plastic tarp.
- 6.2.7 Date and initial daily log at the back of procedure

6.3 Transport of Winding Form to the Modular Coil Mfg. Facility (MCMF):

- 6.3.1 Transport a MCWF or TRC from its storage area to the MCMF.
 - 6.3.1.1 Position the winding form on the floor supported by wooden blocks.

6.4 Verification of the Electrical Properties of the Poloidal Break [Not required for TRC]
The electrical integrity of the poloidal break needs to be verified, via a megger test, prior to mounting the MCWF into the support ring. [See Figure 1- Typical Poloidal Break]

6.4.1 Test Criteria

- Test Voltage: 100 volts
- Acceptance criteria for this test: >500 k-ohms
- The Test Director for this test is: _____

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6.4.2 Safety Requirements & Conditions

- 6.4.2.1 The following safety and prerequisites shall be used for performing test of the Poloidal break.
- 6.4.2.2 Technicians and engineers performing these tests shall be familiar with the hazards and work procedure to minimize accidents that may occur.
- 6.4.2.3 There shall be present a second person, "safety watch" monitoring the operator, and capable of removing the power in case of an accident. This person shall be CPR qualified.

Qualified CPR Member: _____ **Recert. Date:** _____

- 6.4.2.4 During the test, the "Test Area" shall be roped-off and suitable "danger high voltage" signs and flashing lights displayed.

Test Director Verify: _____

- 6.4.2.5 The test operator shall stand on an electrical safety mat during the test operation.
- 6.4.2.6 Approved rubber electrical safety gloves shall be worn by test members during grounding operations which occur once the test has been completed, and the test equipment turned off.
- 6.4.2.7 Upon completion of test and before the components are declared safe to touch, (dielectric joint) being tested shall be properly discharged using a "Ground Hook". After a minimum period of 10 seconds, while the ground hook is still in place, attach a ground cable to the casting and poloidal mid-plane. The ground hook may be removed once the ground cable is in place.

6.4.3 Testing of Mid-Plane Insulation:

- 6.4.3.1 Electrically connect (jumper) the poloidal joint mid-plane to the modular coil for this test.
- 6.4.3.2 Measure the insulation resistance between the mid-plane plate and each bolt. The test results shall be in compliance with the requirements noted in Section 6.4.1.

Mid-Plane to Each Bolt- Megger Test Results

Test Components	Voltage Level Volts	Resistance k-Ohms	Remarks
Bolt 1 to Mid	100		
Bolt 2 to Mid	100		
Bolt 3 to Mid	100		
Bolt 4 to Mid	100		
Bolt 5 to Mid	100		
Bolt 6 to Mid	100		
Bolt 7 to Mid	100		

Equipment ID Number: _____ **Calibration Date:** _____

Megger Results: *Acceptable:* _____ *Unacceptable:* _____

Test Director Signoff: _____ **Date:** _____

Quality Control Witness: _____ **Date:** _____

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Remarks:

6.4.4 Testing of Bolt Insulation

6.4.4.1 Electrically connect (jumper) together all of the bolts and the modular coil winding form for this test.

6.4.4.2 Measure the insulation resistance between the electrically connected (jumpered) combination and the mid-plane. The test results shall be in compliance with the requirements noted in Section 6.4.1.

Mid-Plane to Bolts & Winding Form- Megger Test Results

Test Components	Voltage Level Volts	Resistance k-Ohms	Remarks
Mid-plane to Bolts & WF	100		

Equipment ID Number: _____ **Calibration Date:** _____

Megger Results: *Acceptable:* _____ *Unacceptable:* _____

Test Director Signoff: _____ **Date:** _____

Remarks:

6.4.5 If the test results were within the test criteria identified in section 6.4.1 proceed to section 6.5.

6.4.6 If the test results were unacceptable, under the direction of the field supervisor, take corrective action to make repairs, and repeat the electrical tests.



Mid-plane
connection

Figure 1- Typical Poloidal Break

6.5 Mount WF to Support Ring Assembly:

- 6.5.1 Mount the appropriate support brackets to the casting that will allow the winding form to be joined with the Turning Fixture support ring. (Figure 2-Mounting support brackets to casting)

Note: Each coil type (A, B, C, TRC) have different support brackets that will join the MCWF to Turning Fixture support rings.

- 6.5.2 Position the winding form with support brackets into the assembly fixture. (Figure 3-Position Casting in Assy. Fixture) [Note: the TRC will not be assembled in the assembly fixture]
- 6.5.3 Install a support ring into the assembly fixture around the casting, and secure winding form and support ring together. (Figure 4- Install Support Ring)
- 6.5.4 Secure the support/lifting beam to the MCWF /Ring Assembly (MCCRA). (Figure 5-Install Lifting Beam)
- 6.5.5 Verify that all hardware has been torqued and that casting is ready for transport to Turning Fixture.

Verified:

Lead Technician: _____ Date: _____

Field Supervisor: _____ Date: _____

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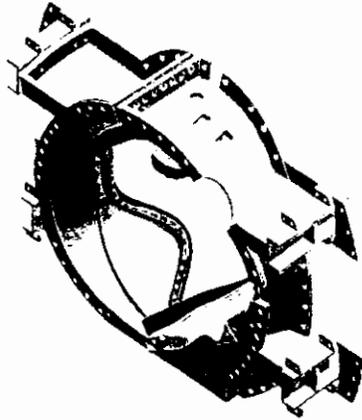


Figure 2-Mounting support brackets to casting



Figure 3-Position Casting in Assy. Fixture



Figure 4- Install Support Ring

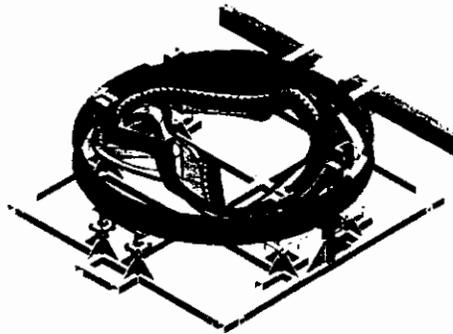


Figure 5-Install Lifting Beam

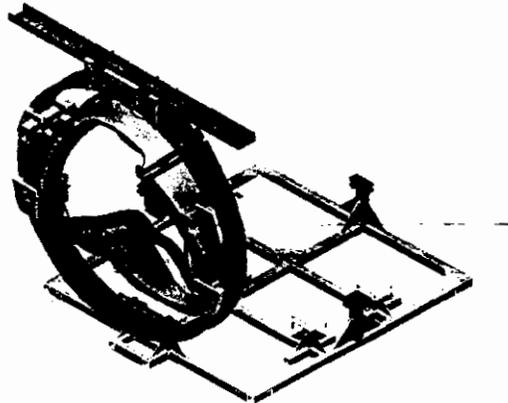


Figure 6-Rotate Casting/Ring Assembly

6.6 Install MCWF in Turning Fixture:

- 6.6.1 Carefully raise the MCCRA until it is in the vertical position. (Figure 6-Rotate Casting/Ring Assembly) Transport and install MCCRA into the Station No. 1 turning fixture using lift procedure D-L-NCSX-983. Secure the MCWF and ring assembly to the turning fixture.

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Verified by: _____ Date: _____
Field Supervisor

- 6.6.2 Install the upper guide rollers, and align all guide rollers to the support ring.
- 6.6.3 Verify that the support ring gear rack is engaged with the drive unit.

Verified by: _____ Date: _____
Lead Technician

- 6.6.4 Verify that the upper support/lift beam is in proper position and secured with appropriate hardware that is torqued to the proper value.

Verified by: _____ Date: _____
Lead Technician

- 6.6.5 Remove the upper support plates between the support ring and lift beam. This operation must be verified prior to operating turning fixture.

Verified by: _____ Date: _____
Lead Technician

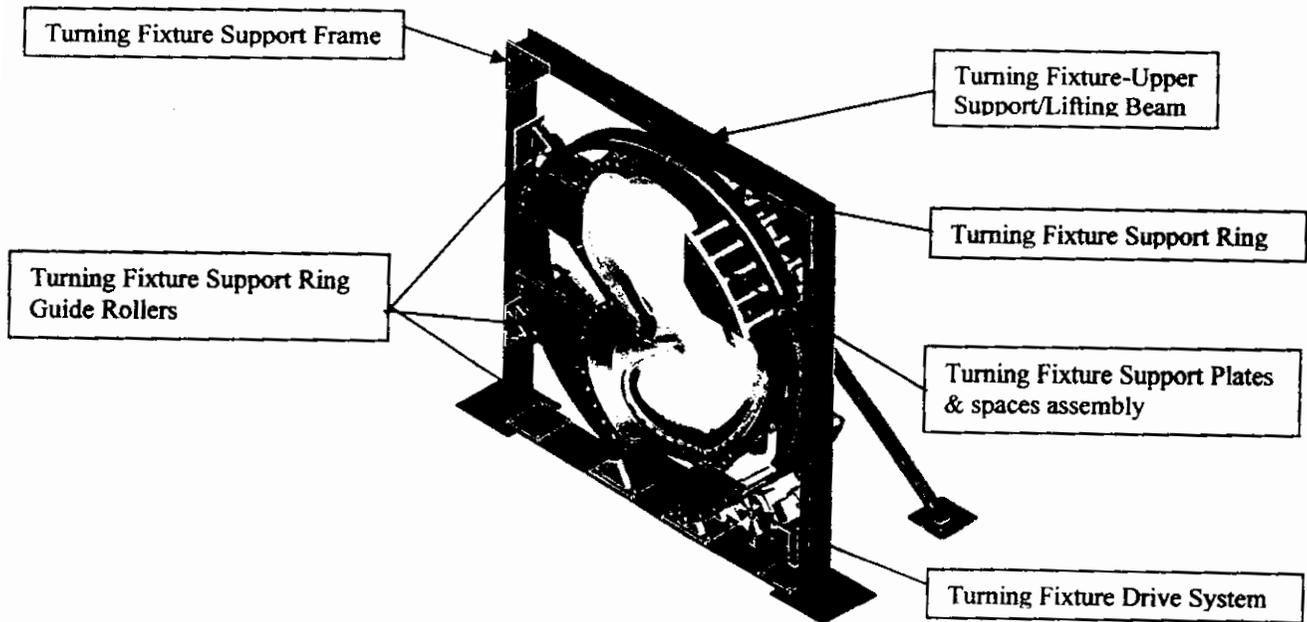


Figure 7- Turning Fixture

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6.9 Dimensional Inspection

- 6.9.1 Using metrology equipment (Romer arm and scanner) thoroughly measure the MCWF winding surfaces. Include all results in the MC traveler package. These measurements should be compared to models which will be provided by NCSX engineering prior to beginning the dimensional inspection. All deviations shall be documented and any deviations dispositioned by the NCSX project prior to proceeding.
- 6.9.2 Procedure D-NCSX-MCF-005 describes the use of the "Romer" measuring arm that will be used. All data will be attached to the back of this procedure

Measurements completed by: _____ Date: _____
--

Summary of Results: ACCEPTANCE CRITERIA
--

Measurements completed and verified by: Field Supervisor: _____ Date: _____ QC Representative: _____ Date: _____

6.10 Seal Poloidal Break

- 6.10.1 Seal the poloidal break seam using RTV 108 sealant. Apply over all seams that will be inside of the Bag mold. Smooth RTV with putty knife. This seal is required for successful VPI operations.

Verified by: _____ Date: _____ Lead Technician
--

6.11 Installation of Clamp Studs

Install stainless steel studs on each side of the castings for the winding and coil clamps. All welding shall be performed by weld certified individuals and requirements of ES&HD 5008, Section 9 Chapter 15 for safe welding must be followed.

- 6.11.1 Notify the ESU and obtain a flame permit prior to starting welding operation.

Lead Technician verify: _____ Date: _____

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- 6.11.2 Position the stud alignment fixture onto the casting using the inner web tapped hole to secure the fixture in place. Check rotational orientation of the fixture with marks on the casting.

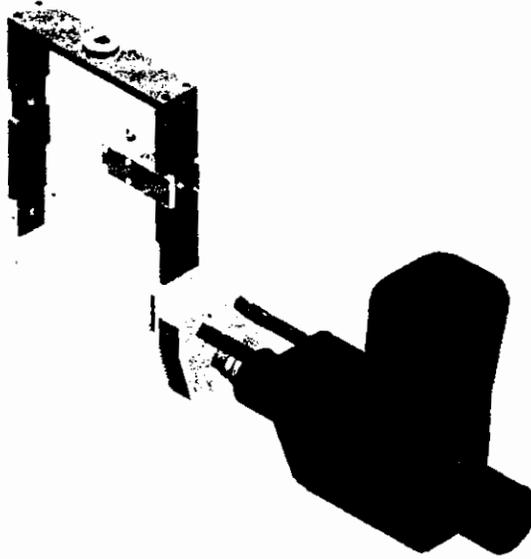


Figure 8- Stud Weld Fixture

- 6.11.3 Using the stud welder, weld grade 316 stainless steel studs (reference drawing SE1405-265P) on each side of the winding. Studs shall be positioned per appropriate coil drawings. In some inaccessible locations it may be necessary to TIG weld the studs in position.

Stud Welder Settings:

- 6.11.4 After welding, remove the alignment fixture and clean the weld. Remove all excess weld material.
- 6.11.5 Repeat process for each clamp position, until all studs have been installed.
- 6.11.6 Permeability Check: Each stud and weld shall be checked with a calibrated Severn permeability indicator to verify that the relative magnetic permeability is below 1.02 μ .

Stud Weld permeability verified by: _____ **Date:** _____
Lead Technician

- 6.11.7 Each welded stud shall be inspected by a QC weld inspector (100% inspection). Welded studs rejected by QC will be removed, surface cleaned and replaced with a new stud. Attach all QC inspection reports to procedure.

Stud Weld performed by: _____ **Date:** _____

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Q.C. Weld Inspector: _____ Date: _____
--

Summary of Results:

6.12 Cleaning:

Using CRC Industrial "Chlor-Free Degreaser and clean cotton cloths thoroughly clean (wipe down) the entire MCWF. Then wipe surface using Ethanol and clean cloths.

Lead Technician verify: _____ Date: _____

6.13 Mold Release:

Mask the surfaces identified in Figure 9 with masking tape. Apply (3) coats of mold release ("Miller-Stephenson"-PTFE MS122DF) to the winding surfaces. Allow each coat to dry to the touch prior to applying the next coat. Figure 9- Mold Release and Masked Surfaces identifies the surfaces to be coated and masked.

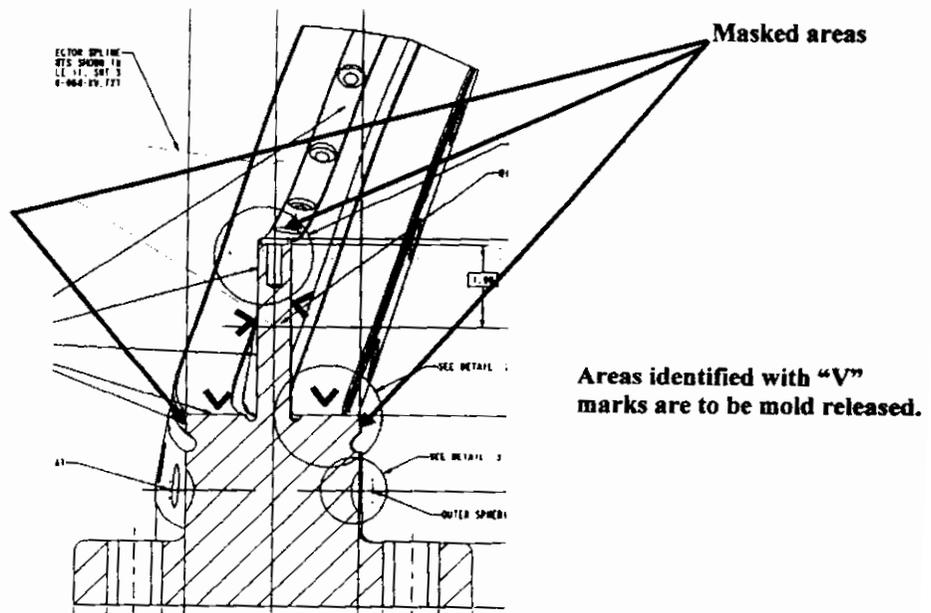


Figure 9- Mold Release and Masked Surfaces

Lead Technician verify: _____ Date: _____

6.14 Winding clamps

Mount the (3) part winding clamps to the MCWF as shown in Figure 10- Winding Clamps. The clamps are located approximately every 3 inches along the entire length of the MCWF. Secure the winding base to the top of the tee using the appropriate hardware. Position the (2) side bars to the winding base, and side studs using the appropriate hardware.

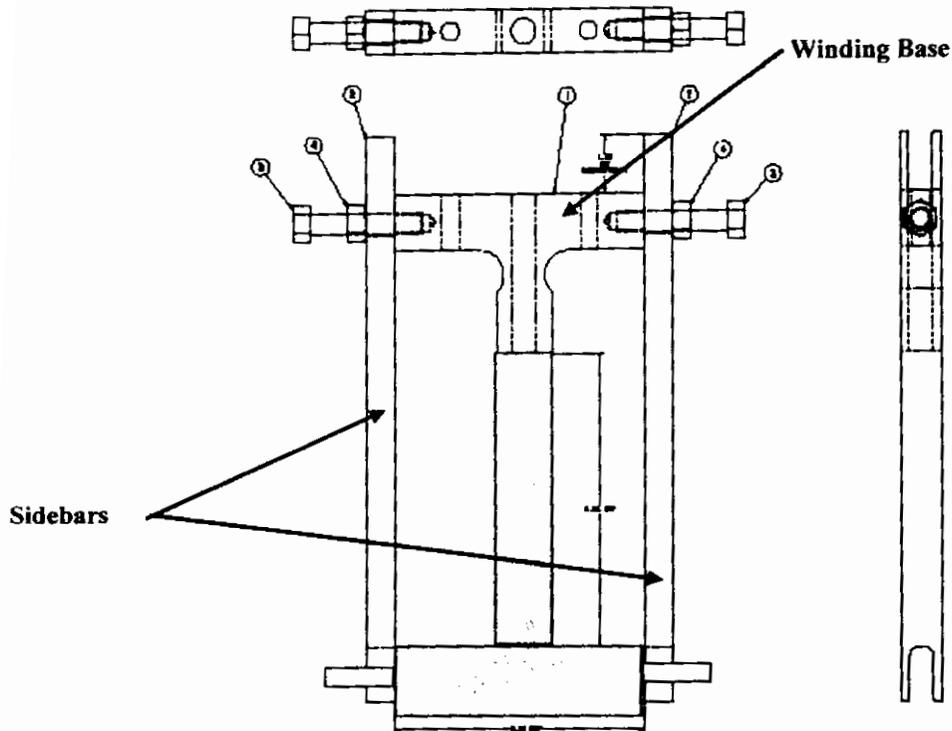


Figure 10- Winding Clamps

6.15 Inner wall copper cladding

- 6.15.1 Select the inner wall copper cladding being used for the coil type being manufactured. [Parts shall be deburred prior to use] Clean the copper plates with CRC Industrial "Chlor-Free Degreaser and clean cotton cloths. EXTREME CARE must be taken during handling of the cladding because of the potential for sharp edges. It is recommended that Kevlar gloves be used during this installation.
- 6.15.2 Fitup each section of copper cladding to the inner wall using the cladding mapping drawings. Customizing of each section of copper cladding will be required. (Figure 11- Inner Copper Cladding)
- 6.15.3 Once all of the cladding have been fit, remove and re-clean the plates. Check that there are no sharp edges or burrs.

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- 6.15.4 Apply (2) layers of adhesive backed Kapton tape (0.00325 in. thick) to the side of the cladding facing the winding surfaces.
- 6.15.5 Secure the insulated cladding to the winding form winding surfaces using double face 3M adhesive tape or adhesive cement. Several types of adhesive may be evaluated on the TRC. Identify the adhesive material used. This will then be incorporated into the final revision of this procedure for the Modular Coils.

Adhesive Material used: _____

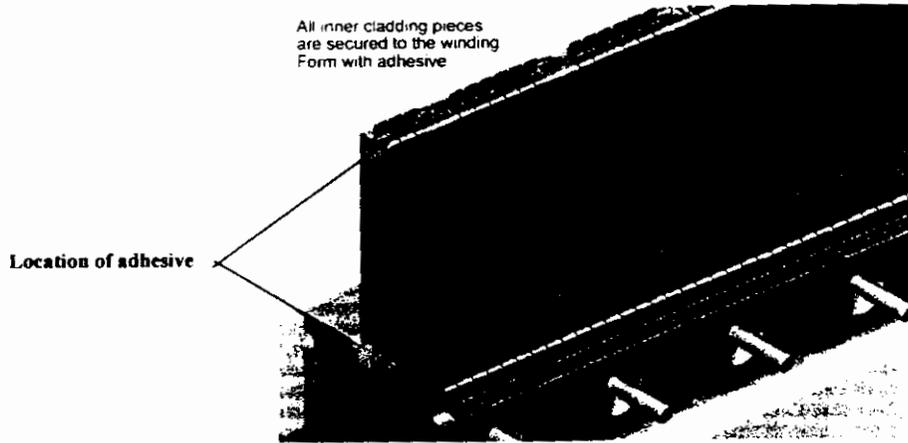


Figure 11- Inner Copper Cladding

- 6.15.6 During the installation of the cladding, continue to verify that the cladding is electrically isolated from the winding form using a multi-meter. Once all of the cladding has been installed, verify that each section of cladding is electrically isolated from its adjacent piece.

Equipment Name & ID Number: _____ **Calibration Date:** _____

Installation of the Inner Copper Cladding is complete and integrity of dielectric break is verified:	
Lead Technician: _____	Date: _____
Field Supervisor: _____	Date: _____
Quality Control: _____	Date: _____

6.16 Dimensional Inspection

- 6.16.1 Once the copper cladding has been installed, remeasure the winding surface using metrology equipment (Romer arm and scanner). Include all results in the MC traveler package. These measurements should be compared to models provided by NCSX engineering.
- 6.16.2 Procedure D-NCSX-MCF-005 describes the use of the "Romer" measuring arm that will be used. All data will be attached to the back of the procedure.

Measurements completed by: _____ Date: _____

Summary of Results:

Measurements verified by:

Field Supervisor: _____ Date: _____

QC Representative: _____ Date: _____

6.17 Lead Terminal Block

6.17.1 Assemble the lead terminal block components to the outside of the casting per the coil drawings.

Terminal Block Installed:

Lead Technician: _____ Date: _____

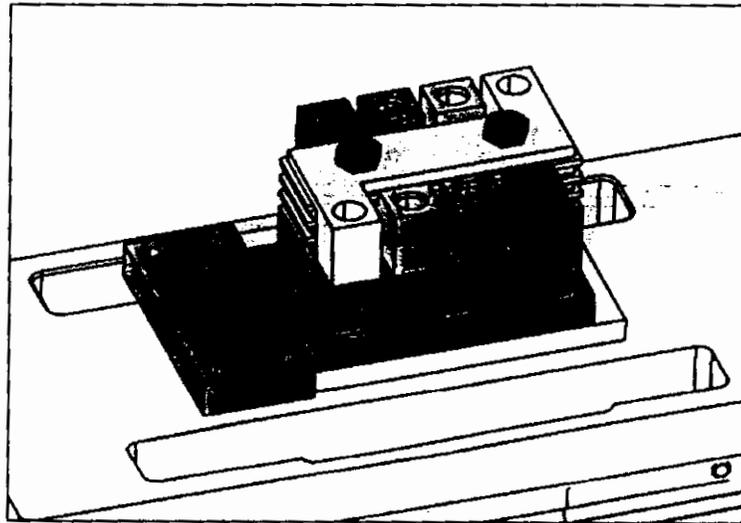


Figure 12- Lead Block

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6.18 Verification of the dielectric insulation at lead block

The electrical integrity of the terminal block needs to be verified, via a megger test, prior to starting the coil winding.

6.18.1 Test Criteria

- **Test Voltage:** _____ volts
- **Acceptance criteria** for this test: > _____ k-ohms
- The Test Director for this test is: _____

6.18.2 Safety Requirements & Conditions

- 6.18.2.1 The following safety and prerequisites shall be used for performing test of the Lead Block components.
- 6.18.2.2 Technicians and engineers performing these tests shall be familiar with the hazards and work procedure to minimize accidents that may occur.
- 6.18.2.3 There shall be present a second person, "safety watch" monitoring the operator, and capable of removing the power in case of an accident. This person shall be CPR qualified.

Qualified CPR Member: _____ **Recertification Date:** _____

- 6.18.2.4 During the test, the "Test Area" shall be roped-off and suitable "danger high voltage" signs and flashing lights displayed.

Test Director Verify: _____

- 6.18.2.5 The test operator shall stand on an electrical safety mat during the test operation.
- 6.18.2.6 Approved rubber electrical safety gloves shall be worn by test members during grounding operations which occur once the test has been completed, and the test equipment turned off.
- 6.18.2.7 Upon completion of test and before the components are declared safe to touch, the dielectric joint being tested shall be properly discharged using a "Ground Hook". After a minimum period of 10 seconds, while the ground hook is still in place, attach a ground cable to the casting and lead blocks. The ground hook may be removed once the ground cable is in place.

6.18.3 Testing of Mid-Plane Insulation:

- 6.18.3.1 Electrically connect (jumper) the inner connectors together for this test.
- 6.18.3.2 Ground (3) of the layers together, and apply the specified voltage to the 4th. Measure the insulation resistance between each layer (terminal set) of connectors. The test results shall be in compliance with the requirements noted in Section 6.18.1.

Megger Test Results

Voltage Level Volts	Resistance k-Ohms	Remarks
Layer 1		
Layer 2		
Layer 3		
Layer 4		

**Modular Coil Fabrication- Casting Preparation Activities
D-NCSX-MCF-001-00**

Equipment ID Number: _____ Calibration Date: _____

Megger Results: *Acceptable:* _____ *Unacceptable:* _____

Test Director Signoff: _____ Date: _____

Quality Control Witness: _____ Date: _____

Remarks:

7 Station No. 1 Completion:

7.1 Document Verification:

Verify that all pertinent data on the procedure and data sheets have been completed.

7.2 Field Package:

Ensure that all data sheets, photographs, QC inspection sheets, etc are included in the Field Package.

7.3 Approval:

Prior to releasing a modular 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 will include signatures from the Station Lead Technician, Field Supervisor and the QC representative.

All winding form preparation activities have been satisfactorily completed.

Lead Technician: _____ Date: _____

Field Supervisor: _____ Date: _____

QC shall verify completion of documentation:

Quality Control Representative: _____ Date: _____

The winding form is ready for transfer to the next station:

Comments:

