

## Princeton Plasma Physics Laboratory Procedure

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

Number: <b>D-NCSX-MCF-001</b>	Revision: <b>05</b>	Effective Date: February 28, 2007  Expiration Date: <i>(2 yrs. unless otherwise stipulated)</i>
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### Procedure Approvals

Author: James H. Chrzanowski:

ATI: James H. Chrzanowski:

RLM: Larry Dudek:

Responsible Division: **NCSX Project**

### Procedure Requirements Designated by RLM

**LABWIDE:**

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

**D-SITE SPECIFIC:**

<b>X</b>	D-Site Work Permit (OP-AD-09)		Door Permit (OP-G-93)
	Tritium Work Permit (OP-AD-49)		USQD (OP-AD-63)
<b>X</b>	Pre-Job Brief (OP-AD-79)		T-Mod (OP-AD-03)
	** DCA/DCN (OP-AD-104) # _____		

\* 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.

<b>REVIEWERS (designated by RLM)</b>	<b>Rec'd/ Incorp. Comments</b>
Accountable Technical Individual. .... <b>J. Chrzanowski</b>	
Test Director	
Independent Reviewer	
D-Site Shift Supervisor	
Dimensional Control Coordinator .....	
NCSX Field Supervisors..... <b>Tom Meighan, Steve Raftopoulos</b>	X
Vacuum	
Project Engineer for Stellerator Systems (WBS 1) Manager.....	
NCSX .....	
Quality Assurance/Quality Control. .... <b>Colin Phelps</b>	X
Maintenance and Operations Division	
Energy Conversion System/Motor Control Division	
Engineering .....	
Environmental Restoration & Waste Management Division	
Environmental, Safety & Health..... <b>Jerry Levine</b>	X
Industrial Hygiene..... <b>Bill Slavin</b>	X
Health Physics.....	
RLM .....	

<b>TRAINING (designated by RLM)</b>			
No training required _____		Instructor <b><u>Jim Chrzanowski</u></b>	
Personnel (group, job title or individual name)	Read Only	Instruction <b>Pre-job Briefing</b>	Hands On
<b>Lead Tech.</b>		X	
<b>Technicians performing task</b>		X	
<b>Field Supervisors</b>		X	
<b>Quality Control Representative</b>		X	
<b>Training Rep.</b>			
RLM Larry Dudek			

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**RECORD OF CHANGE**

<b>Revision</b>	<b>Date</b>	<b>Description of Change</b>
00	11/22/04	Initial release
01	5/19/05	Release for Revision 1
02	8/2/05	Release for Revision 2 -General description of changes: 1)Included the fitup and installation of the lead terminal and filler blocks [6.19] 2)More detail for winding form inspection [6.7] 3)Addition of Kapton tape on edges of casting [6.15] 4)Added reference to winding form product specification
03	1/3/06	General description of changes 1) Added new figure 1 of poloidal break arrangement 2) Added safety note 6.7.3 using scaffolding 3) Section 6.12.1 Tapped hole ID rewritten 4) Section 6.15- Lead block fitup rewritten 5) Section 6.22- Cladding installation rewritten 6) General reformatting and rearrangement of some sections in proper order 7) Added new figures throughout
04	6/1/06	1) Relocated surface inspections and magnetic permeability to winding form delivery [section 7.1.] 2) Added safety notes throughout procedure identifying PPE's 3) Added welding of prosthetic section into position. [section 7.8] 4) Added Kapton insulation under terminal block assembly and G-10 plugs [section 7.20]
05	2/28/07	1) Add Safety Notes about blocking hinge during assembly of coil to ring- includes signoff [Sect 7.4] 2) Modified safety note: gloves & steel tip shoes during rigging [Sect. 7.4] 3) Changed description of stations 3 & 4 [sect 1.1] 4) During electrical test- change QC witness to QC verify [7.7.4] 5) Added inspection cladding notes during installation [page 29] 6) Shifted sequence not technical content of activities in procedure to reflect actual operations 7) Added temperature measurements during metrology measurements [paragraph 7.9]

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## **1 Scope**

### **1.1 Introduction**

The Modular Coil Manufacturing Facility is divided into 5 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... Post VPI Activities
- Station No. 2... Winding/Bag Mold Station
- Station No. 3... Winding/Bag Mold Station
- **Station No. 4... Winding Form Preparation Station**
- Station No. 5... VPI and Autoclave Activities

### **1.2 Scope**

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

- Mounting and balancing the winding form to the turning fixture
- Verification of electrical integrity of poloidal break
- Installation of measurement monuments
- Winding Form inspection and measurements
- Installation of clamp studs
- Cleaning of winding form
- Fitup and installation of terminal blocks
- 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: \_\_\_\_\_

## **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 “Manufacturing Facility Operations Plan”, document number **NCSX-PLAN-MFOP-00**.

2.3 **D-L-NCSX-983** Lifting Modular Coil Winding Forms

2.4 **D-L-NCSX-984** Lifting Modular Coil Assemblies

2.5 **NCSX-CSPEC-141-03** Product Specification for MC Winding Forms

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- 2.6 **D-NCSX-MCF-005** Dimensional Control & Metrology for the NCSX MC
- 2.7 **D-NCSX-PLAN-MCWDC** Modular Coil Dimensional Control Plan

**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.

**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 prior to the first time that revision of the procedure is used or if being performed by a new crew. The briefing will describe the processes and safety issues [JHA] associated with 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 Daily Station Log. See section 6.1 and 6.2 for details.

**4.3 Torque Values:**

Unless a torque value is specified or the fastening material is something other than low carbon steel, the following values shall be used whenever the procedure requires a torquing operation:

3/8-16UNC .....	18 ft-lbs	3/8-24UNF .....	19 ft-lbs	1/2-13 UNC .....	38 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	1 1/4 UNC .....	432 ft-lbs	1 1/2-6 UNC .....	732 ft-lbs

**5 Materials and Parts for Station No. 1**

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.

<b>General Description</b>	<b>Material</b>	<b>Reference Document/Product No.</b>
Cladding	Copper	See coil drawings
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 And/or Inconel 625	3/8-16 UNC x 2.5 inches long [other lengths may be required in tight areas]
Mold release	Release agent dry lubricant	“Miller-Stephenson” -PTFE MS122DF
MC Turning Fixture	Equipment	Drawing no. SE144-008

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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
Cladding and edge insulation	Kapton-Type HN adhesive back	0.00325 inch thick
Cement- for adhering cladding	Adhesive cement	3M Product no. CA40H
Adhesive accelerator for cement	Accelerator	3M Pronto Surface Activator
Winding clamps	Equipment	Drawing SE144-080
RTV sealer for poloidal break	Sealant	RTV108
Alcohol	Ethanol	MSDS
Severn Gauge	Equipment	Permeability indicator # 6424
Thread-locker	Loctite	Loctite 2440 medium strength thread-locker

## 6 Daily Station Activities

### 6.1 Daily Startup Activities:

- Check all daily supplies needed:
- Turn on the Turning Fixture power switch to verify operation.
- Check stud welder for operation [Only if being used that day]
- Check station for cleanliness
- Check that the day's travelers and procedures are in their document holder.
- Date and initial daily Startup Log located at the back of Station Log Book.

### 6.2 Daily Shutdown Activities:

- Turn off power to Turning Fixture.
- Turn off stud welder and secure for off hours.
- Clean entire workstation area.
- Verify that all Traveler and data sheet information is complete.
- The Lead Technician shall verify that the Station's Log Book has been completed and signed for the day.
- Cover the Modular coil casting with plastic tarp [After final cleaning operation has occurred]
- Date and initial daily Shutdown log located at the back of Station Log Book

## 7 Fabrication Process

This fabrication procedure is to be used as guide to complete the preparation of the winding form for coil winding. Deviation from this procedure for processes that DO NOT affect the design of the coil can be made with the concurrence of the MC Field Supervisor. These deviations shall be documented in the procedure and initialed by the MC Field Supervisor prior to implementing the deviations. Deviations that may effect the design of the coil requires a Request for Deviation "RFD" approval. The RFD must be approved prior to proceeding. Procedure changes need to be incorporated into the document via "Minor Procedure Changes" or "Revisions".

*Deviation from the sequence of activities is at the discretion of the Field Supervisor as long as it does not affect the quality or design of the final product.*



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**7.1 Winding Form Delivery**

- 7.1.1 Visual Inspection [All delivery inspections are made in RESA Building]  
Upon receipt of a winding form, perform a visual inspection of the shipping crate and casting.  
Look for any obvious defects or damage as a result of shipment.

<b>Inspection Findings:</b>          
---

<b>Inspection Performed by:</b> _____ <b>Date:</b> _____  Findings Verified: <b>QC Representative:</b> _____ <b>Date:</b> _____
--

- 7.1.2 Surface Inspection: [CSPEC section 4.2.4]  
Spot inspect the surface finish of the machined tee section using either a surface profilometer or comparator. The two “L” machined surfaces of the tee must have a RMS (root mean square) **surface finish <125 μ-inches**. Also verify that the part is free of sharp edges and burrs.

<b>Surface Inspection Findings:</b>          
---

<b>Surface Finish verified by:</b>  <b>Field Supervisor:</b> _____ <b>Date:</b> _____  <b>QC Representative:</b> _____ <b>Date:</b> _____
---

- 7.1.3 Relative Magnetic Permeability [CSPEC section 4.2.5]  
Spot check the relative magnetic permeability of the winding form surface and poloidal break hardware using a Severn gauge. The **Acceptance Criteria:** < 1.02μ.

<b>Magnetic Permeability verified by:</b>  <b>Field Supervisor:</b> _____ <b>Date:</b> _____  <b>QC Representative:</b> _____ <b>Date:</b> _____
--

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<b>Permeability Inspection Findings:</b>
--

7.1.4 VPI Groove

Inspect the edges of the VPI groove to ensure that there not sharp edges that could cut the bag mold.

<b>Inspection Performed by:</b> _____ <b>Date:</b> _____
Findings Verified: <b>QC Representative:</b> _____ <b>Date:</b> _____

7.2 **Winding Form Rework Activities:**

It may be necessary to modify or rework portions of the winding form prior to starting the casting preparation activities. These modifications or changes need to be identified and documented in this procedure. All Non-conformance documents shall also be identified in this procedure.

- Winding form does not require any rework or modifications

<b>Verified:</b>
<b>Field Supervisor:</b> _____ <b>Date:</b> _____
<b>QC Representative:</b> _____ <b>Date:</b> _____

- Winding form does require modifications or rework.

<b>Verified:</b>
<b>Field Supervisor:</b> _____ <b>Date:</b> _____

- Identify all rework or modifications that need to be performed on winding form. Include reference NCR numbers.

<b>Rework Activities:</b>
---------------------------

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- Modifications have been completed:

<b>Verified:</b>	
<b>Field Supervisor:</b> _____	<b>Date:</b> _____
<b>QC Representative:</b> _____	<b>Date:</b> _____

**7.3 Transport Winding Form to the Modular Coil Mfg. Facility (MCMF):**

Transport a MCWF or TRC from its storage area to the MCMF using either a folk lift or lift procedure **D-L-NCSX-983**. Position the winding form on the floor supported by wooden blocks.

**7.4 Mount WF to Support Ring Assembly:**

Mount the appropriate support brackets to the casting that will allow the winding form (MCWF) to be joined with the Turning Fixture support ring. (**Error! Reference source not found.**)  
[Reference drawing SE-144-050]

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

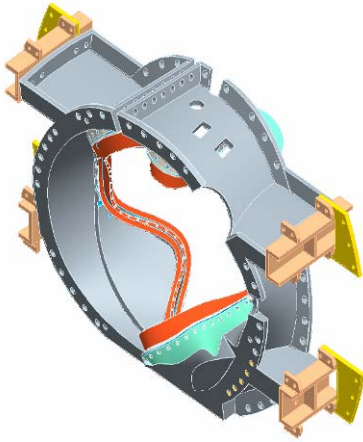
- **SAFETY NOTE 1:** Safety glasses **MUST** be worn when operating the pneumatic impact wrenches
- **SAFETY NOTE 2:** The use of leather gloves and steel tipped shoes is required during the assembly of the support brackets and during **ALL** rigging operations associated with joining the winding form and ring assembly.
- Transport the MCWF to station 1a using lift procedure **D-L-NCSX-983**. Position the MCWF with lower support brackets into the assembly fixture [station 1a]. (**Figure 2-Position Casting in Assy. Fixture**) [Note: the TRC will not be assembled in the assembly fixture]
- Position a support ring into the assembly fixture around the casting, and secure the winding form and support ring together with support brackets. Note the orientation of the ring in relation to the lifting beam and pivot locations. (**Figure 3- Install Support Ring**)
- **SAFETY NOTE 3:** Verify that the hinge assembly at station 1a is properly blocked to prevent the hinge from swinging down and possibly injuring the assembly and rigging personnel prior to being secured to the ring assembly.
- **Verify that safety block is in position prior to installing support ring**

<b>Verified by:</b> _____	<b>Date:</b> _____
<b>Lead Technician</b>	

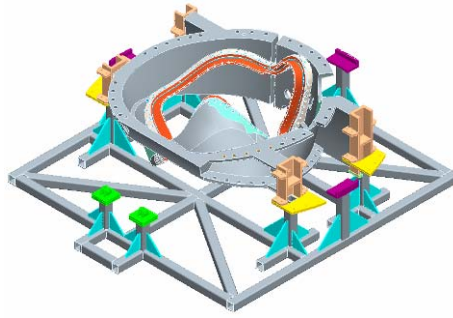
- Position and secure the support/lifting beam to the joined MCWF and ring support using pneumatic impact wrenches [MCWFA]. (**Figure 4-Install Lifting Beam**)

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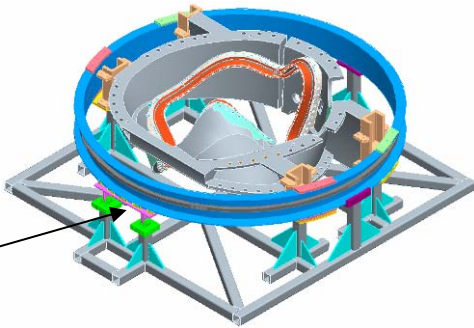
- Verify that all hardware has been torqued [see section 4.3 for torque values] and that the MCWFA is ready for transport to the Station No. 1b Turning Fixture.



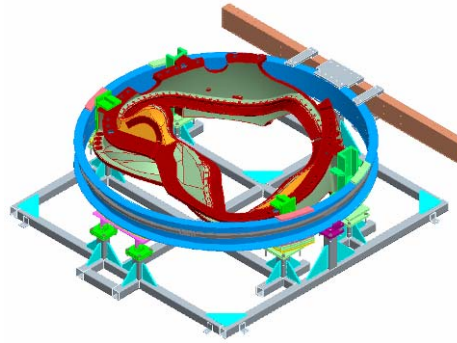
**Figure 1-**Mounting support brackets to casting



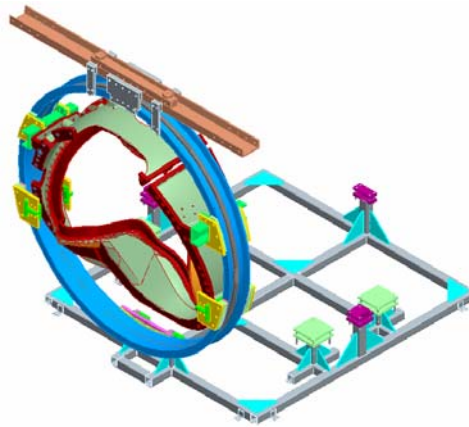
**Figure 2-**Position Casting in Assy. Fixture



**Figure 3-** Install Support Ring



**Figure 4-**Install Lifting Beam



**Figure 5-**Rotate Casting/Ring Assembly

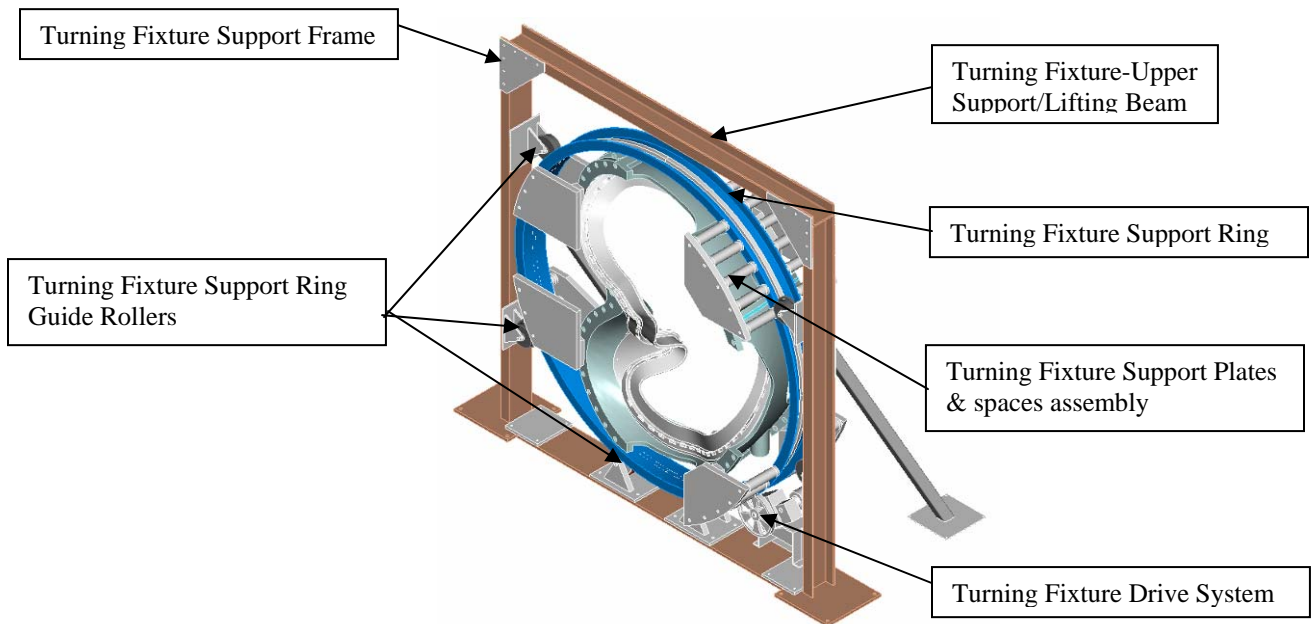
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<b>Verified:</b>	
<b>Lead Technician:</b> _____	<b>Date:</b> _____
<b>Field Supervisor:</b> _____	<b>Date:</b> _____

**7.5 Install MCWFA in Turning Fixture:**

Using lift procedure **D-L-NCSX-984**, carefully raise the MCWFA until it is in the vertical position. (Figure 5-**Rotate Casting/Ring Assembly**) Transport and install MCWFA into the Station No. 1b turning fixture. (Figure 6- **Turning Fixture**) Secure the MCWFA to the turning fixture per steps below.

<b>Verified by:</b> _____	<b>Date:</b> _____
<b>Field Supervisor</b>	



**Figure 6- Turning Fixture**

**7.5.1 Station 1b Preparations:**

Activities associated with receiving modular coil at station 1b.

- **SAFETY NOTE 1:** Use scaffolding or appropriate ladders while working on upper section of turning fixture. Scaffolding must be inspected prior to use per Section 9 Chapter 5 in PPPL ES&H Manual.
- **SAFETY NOTE 2:** Safety glasses **MUST** be worn when operating the pneumatic impact wrenches
- Prior to installing the MCWF compress the springs under the gear box (drive system) until they are bottomed.

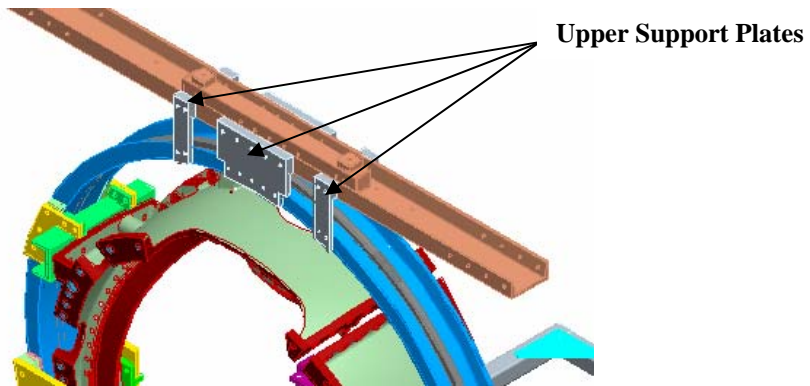
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- Measure the inside width of the winding form ring (where the roller guide wheels engage) and record the smallest value. \_\_\_\_\_ [Narrowest dimension].
- Adjust the lower wheels on the winding station so that they are centered in the frame and are set at a width that is one-half inch greater than the value recorded in the previous step.
- Lower the MCWF and ring assembly into the turning fixture using the corner brackets for alignment. Bolt up one end loosely (use spud wrenches to align holes).
- Install the upper guide rollers and align all of the guide rollers to the support ring. NOTE: The rollers are hinged and swing into position. Lifting is not required.
- Verify that the upper support/lift beam is in proper position. Then secure the appropriate hardware using a pneumatic impact wrench. Hardware shall be torqued to the proper value. [See section 4.3]

<b>Verified by:</b> _____ <b>Date:</b> _____ <p align="center"><b>Lead Technician</b></p>
--

- Using a pneumatic impact wrench remove the upper support plates between the support-ring and lift beam. Figure 7- Upper Support Plates This operation must be verified prior to operating turning fixture.

<b>Verified by:</b> _____ <b>Date:</b> _____ <p align="center"><b>Lead Technician</b></p>
--



**Figure 7- Upper Support Plates**

- The modular coil/ring assembly needs to be balanced by adding weights to the lower section of the ring assembly [hinge point]. [Figure 8-Modular Coil Counter Balance Assembly]

<b>Weight of winding form:</b> _____ lbs. <b>Est. balance weight to be added:</b> _____ lbs. <b>Field Supervisor verify:</b> _____ <b>Date:</b> _____
--

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- Once the balancing weights have been added, the technician should be able to free spin the assembly by hand. Make any wheel adjustments or add additional weights as needed.

<b>Balancing completed:</b>
Verified by: _____ Date: _____ <b>Lead Technician</b>



**Figure 8-Modular Coil Counter Balance Assembly**

- Decompress springs under the gear box (drive unit) until gear is fully engaged with ring gear rack. **The upper set of springs MUST be completely disengaged.** This must be verified prior to proceeding.

Verified by: _____ Date: _____ <b>Lead Technician</b>
--

- To ensure proper alignment and operation of the turning fixture, rotate the MCWFA a full **two** revolutions [in both directions] using the foot-pedal control. Re-adjust the alignment rollers as required. Alignment of MCWFA to the turning fixture is complete.

Verified by: _____ Date: _____ <b>Lead Technician</b>
--

**7.6 MC Winding Form Acceptance Inspections:**

There are a number of inspections in section 7.1 and 7.6 that need to be made of the winding form prior to final acceptance of the winding form from the vendor. These need to be completed prior to starting winding preparation activities. These inspections are based upon the requirements identified in the MC Product Specification “NCSX-CSPEC-141-03”.

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7.6.1 Dimensional Inspection for Winding Form Acceptance

Per section 4.2.6 of the Modular Coil Winding Form Product specification NCSX-CSPEC-141-03-08, a thorough measurement of the MCWF machined winding surfaces, flange surfaces, and bolt holes shall be made to verify the dimensions and tolerances of the winding form. The NCSX project may perform spot measurements besides that provided by the vendor to verify the dimensional integrity of the delivered winding form.

<p><b>Additional measurements have been made by PPPL and verified as being acceptable:</b> Verified By: <b>Metrology Engineer:</b> _____ <b>Date:</b> _____ <b>QC Representative:</b> _____ <b>Date:</b> _____</p>
--

- Acceptance inspections and measurements have been completed and have verified that the winding form is acceptable for use on NCSX.

<p><b>Winding Form has been accepted:</b> Verified By: <b>Metrology Engineer:</b> _____ <b>Date:</b> _____ <b>Dimensional Control Coordinator:</b> _____ <b>Date:</b> _____ <b>QC Representative:</b> _____ <b>Date:</b> _____</p>
--

<p><b>Comments:</b></p>
-------------------------

**7.7 Verification of the Electrical Properties of the Poloidal Break**

Verify the electrical integrity of the poloidal break, via a megger test. [See Figure 9- Typical Poloidal Break] [Not required for TRC]

7.7.1 Test Criteria

<p>- <b>Test Voltage:</b> <u>250 volts</u>      - <b>Acceptance criteria</b> for this test: <b>&gt;500 k-ohms</b></p>
---

7.7.2 Test Director:

The Test Director for this test is: \_\_\_\_\_



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**7.7.3 Safety Requirements & Conditions**

The following safety and prerequisites shall be used for performing test of the Poloidal break.

- All personnel involved with these tests shall be familiar with the hazards and work procedure to minimize accidents that may occur.
- A “Safety Watch” shall be appointed by the Test Director. The Test Director shall clearly describe to the Safety Watch his/her responsibilities.

<b>Name of Safety Watch:</b> _____  Responsibilities have been clearly discussed with Safety Watch:  <b>Verified:</b> _____ <b>Date:</b> _____ <p style="text-align: center;">Test Director</p>
--

- Responsibilities of a Safety Watch include as a minimum:
  - a) Monitoring the operations in an attempt to prevent careless or unsafe activities.
  - b) Shutting down the power in case of an accident.
  - c) Contacting ESU in case of accident
  - d) Additional responsibilities of a Safety Watch can be found in the ES&H Manual Section 2, Chapter 2.2.6.
- During the test, the “Test Area” shall be roped-off and suitable “danger high voltage” signs and flashing lights displayed.

Test Area has been safed:  <b>Verified by:</b> _____ <b>Date:</b> _____ <p style="text-align: center;">Test Director</p>
---

- The test operator shall stand on an electrical safety mat during the test operation.
- 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.
- Upon completion of test and before the components are declared safe to touch, the coil 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 coil. The ground hook may be removed once the ground cable is in place.

**7.7.4 Testing of Mid-Plane Insulation:**

- Electrically connect (jumper) the poloidal joint mid-plane to the modular coil for this test.
- 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 7.7.1.

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**Mid-Plane to Each Bolt- Megger Test Results**

<b>Test Components</b>	<b>Voltage Level Volts</b>	<b>Resistance k-Ohms</b>	<b>Remarks</b>
Bolt 1 to Mid	250		
Bolt 2 to Mid	250		
Bolt 3 to Mid	250		
Bolt 4 to Mid	250		
Bolt 5 to Mid	250		
Bolt 6 to Mid	250		
Bolt 7 to Mid	250		

**Casting Temperature** \_\_\_\_\_ **deg. C**

**Equipment ID Number:** \_\_\_\_\_ **Calibration Date:** \_\_\_\_\_

**Megger Results: Acceptable:** \_\_\_\_\_ **Unacceptable:** \_\_\_\_\_

**Test Director Signoff:** \_\_\_\_\_ **Date:** \_\_\_\_\_

**Quality Control Verify:** \_\_\_\_\_ **Date:** \_\_\_\_\_

<b>Remarks:</b>	
-----------------	--

**7.7.5 Testing of Bolt Insulation**

- Electrically connect (jumper) together all of the bolts and the modular coil winding form for this test.
- Measure the insulation resistance between the electrically connected (jumped) combination and the mid-plane. The test results shall be in compliance with the requirements noted in Section 7.7.1.

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

Test Components	Voltage Level Volts	Resistance k-Ohms	Remarks
Mid-plane to Bolts & WF	250		

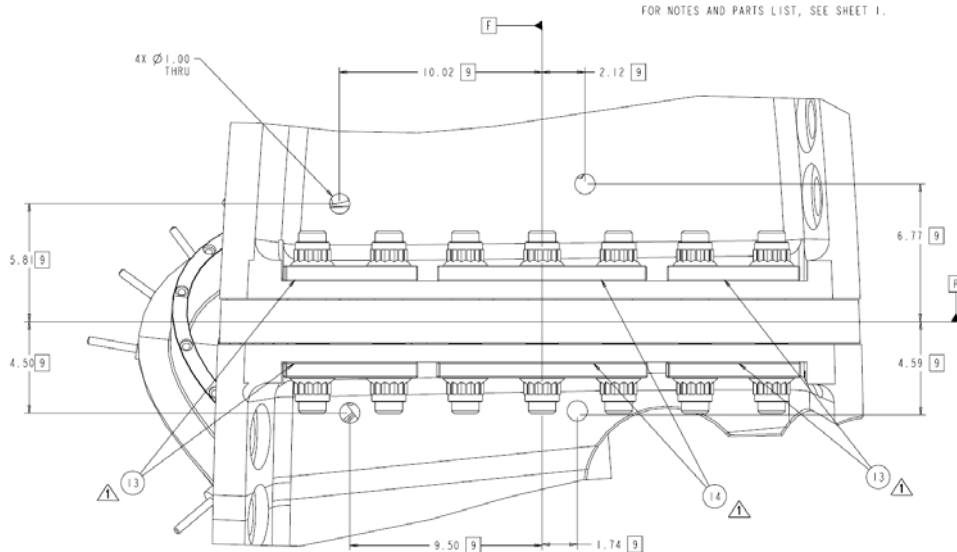
Equipment ID Number: \_\_\_\_\_ Calibration Date: \_\_\_\_\_

Megger Results: *Acceptable*: \_\_\_\_\_ *Unacceptable*: \_\_\_\_\_

Test Director Signoff: \_\_\_\_\_ Date: \_\_\_\_\_

Quality Control Verify: \_\_\_\_\_ Date: \_\_\_\_\_

**Remarks:**



**Figure 9- Typical Poloidal Break**

- If the test results were within the test criteria identified in section 7.7.1 proceed to section 7.8.
- If the test results are unacceptable, the field supervisor shall review the test results with NCSX project management to determine corrective action. All corrective actions shall be performed under the direction of the Field Supervisor. Once completed repeat the electrical tests. All corrective actions shall be documented and added to the RUN copy.

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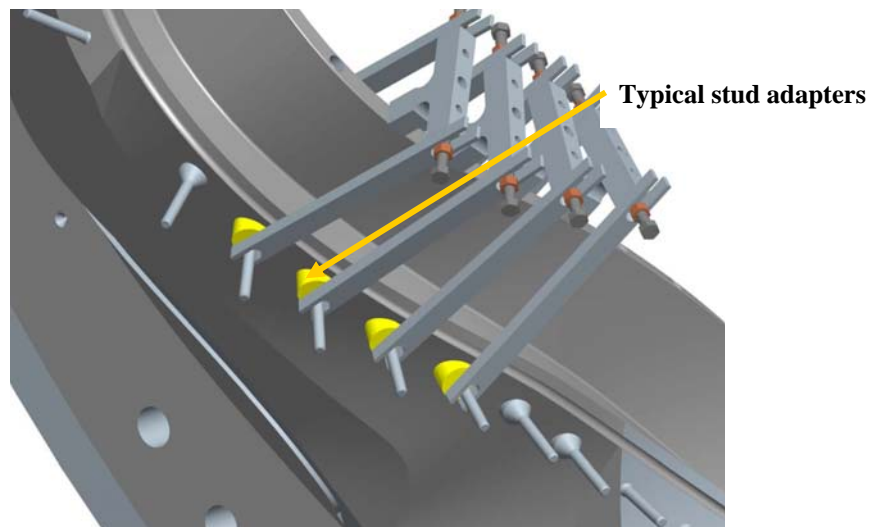
**7.8 Installation of Additional Monuments, Stud Adapters and Prosthetic Section- TIG Welding**

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.

7.8.1 Installation Steps:

- **SAFETY NOTE:** Welders shall wear welding eye protection, fire retardant clothing plus welder's gloves.
- Notify the ESU and obtain a flame permit daily prior to starting welding operation.
- On some castings, due to the geometry of the winding form, it may be necessary to add stud adapters [Type C] or prosthetic section [type A and B] directly to the casting prior to the installation of studs. This information will be identified on the appropriate casting drawings. These adapters shall be Tig welded directly to the casting. See Figure 10- Typical Stud Adapters
- Stud Adapters are required for this casting: **YES:** \_\_\_\_\_ **NO:** \_\_\_\_\_  
[Lead Technician verify:]
- Prosthetic section required for this casting: **YES:** \_\_\_\_\_ **NO:** \_\_\_\_\_  
[Lead Technician verify:]
- Installation of stud adapters and/or prosthetic section has been completed.

<b>Weld Date:</b> _____ <b>Obtain Flame Permit:</b> _____
<b>Weld Operator:</b> _____ <b>Fire Watch:</b> _____



**Figure 10- Typical Stud Adapters**

- The metrology engineer shall determine the location of additional monuments that need to be added to the MCWF. These monuments will be used by the metrology group for measuring the location of the winding surfaces and coil turns.

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<b>Location verified by:</b> _____ <b>Date:</b> _____ <b>Metrology Engineer</b>
--

- Installation [TIG weld] of additional monuments has been completed.

<b>Weld Date:</b> _____ <b>Obtain Flame Permit:</b> _____ <b>Weld Operator:</b> _____ <b>Fire Watch:</b> _____
---

<b>Installation of stud adapters, monuments and prosthetic pieces have been completed and inspected by:</b> <b>Field Supervisor:</b> _____ <b>Date:</b> _____ <b>QC Representative:</b> _____ <b>Date:</b> _____ (Weld inspect)  File name and location of additional reference monuments:
---

**7.9 Establish Winding Surface Baseline Values:**

The Metrology engineer shall measure the winding surfaces and establish reference values to be used during coil manufacturing using procedure **D-NCSX-MCF-005**. A summary of all data shall be inserted into Section 9 of the Coil Field Package.

**Record the room temperature during metrology measurements:** \_\_\_\_\_ degrees F |

**Record the winding form temperature during metrology measurements:** \_\_\_\_\_ degrees F |

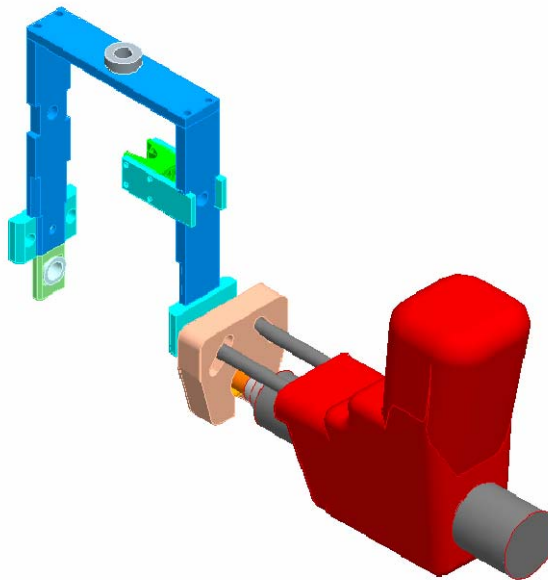
<b>Measurements completed and reference values established.</b> File name and location of additional reference monuments:   <b>Verified by:</b> <b>Metrology Engineer:</b> _____ <b>Date:</b> _____ <b>Dimensional Control Coordinator:</b> _____ <b>Date:</b> _____ <b>QC Representative:</b> _____ <b>Date:</b> _____
--

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**7.10 Installation of Winding Clamp Weld Studs:**

Install Inconel studs for the winding clamps on each side of the winding form. 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.

- Notify the ESU and obtain a flame permit daily prior to starting welding operation.
- Position the stud alignment fixture Figure 11- Stud Weld Fixture onto the casting using the tapped hole in the septum to secure the fixture in place. Check the orientation of the fixture to the casting prior to welding.
- **SAFETY NOTE:** Technician **MUST** wear fire retardant clothing, safety glasses and leather gloves during the stud welding operation.



**Figure 11- Stud Weld Fixture**

- Using the stud welder, weld Inconel studs on each side of the winding form. Studs shall be positioned per appropriate coil drawings. In some inaccessible locations it may be necessary to use shorter studs and they may need to be TIG welded into position.
- [The stud weld operator shall fill out and submit to the Coil Facility Manager a “Filler Request Form” which is required to maintain their certification. The Coil Facility Manager is responsible for submitting the forms to the weld engineer and training group]

**Stud Welder Settings:**

**Stud Weld Model:** “TRW Nelson” Series 4500 Model 101

**Time:** approximately 3.1 to 4.0 seconds

**Current:** 6.5 to 7.0 amps

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Verified by Lead Technician  <b>Stud Weld Date:</b> _____ <b>Obtain Flame Permit:</b> _____  Stud Weld Operators: _____ Fire Watch: _____ *****  <b>Stud Weld Date:</b> _____ <b>Obtain Flame Permit:</b> _____  Stud Weld Operators: _____ Fire Watch: _____ *****  <b>Stud Weld Date:</b> _____ <b>Obtain Flame Permit:</b> _____  Stud Weld Operators: _____ Fire Watch: _____ *****  <b>Stud Weld Date:</b> _____ <b>Obtain Flame Permit:</b> _____  Stud Weld Operators: _____ Fire Watch: _____ *****
---

- After welding, remove the alignment fixture and clean the weld. Remove all excess weld material.
- Repeat process for each clamp position, until all studs have been installed.
- Each welded stud that will not be removed during the post VPI operation 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. [Field supervisor shall identify those studs that need to be inspected]

Inspection and acceptance of welded studs that will remain after winding has been completed  <b>Q.C. Weld Inspector: Not required Date:</b> _____
---

<b>Summary of Results:</b> [Add additional QC reports to back of procedure]
---

- If weld spatter is observed on the studs, chase stud threads with a die

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**7.11 Installation of Lead Block Mounting Pucks**

- Temporarily install the cladding and groundwrap in the lead area sides A & B for fitup of the lower fillers.
- Install the lead block alignment fixture for positioning the bosses (pucks) and tack weld the bosses to the winding form.
- Remove alignment fixture and finish Tig welding the bosses to the winding form.

Verified by Lead Technician
<b>Weld Date:</b> _____ <b>Obtain Flame Permit:</b> _____
Weld Operator: _____ Fire Watch: _____

- Using a Sevrn permeability indicator measure the relative magnetic permeability of the welds. **Acceptance criteria:** <1.02  $\mu$ .

<b>Weld permeability verified by:</b> _____ <b>Date:</b> _____ <b>QC Inspector</b>
---

- Each welded bosses shall be inspected by a QC weld inspector (100% inspection). Welded bosses rejected by QC will have their welds ground out and re-welded. Attach all QC inspection reports to procedure.

<b>Installation completed and inspected by:</b>
<b>Field Supervisor:</b> _____ <b>Date:</b> _____
<b>QC Representative:</b> _____ <b>Date:</b> _____ (Weld inspect)

**7.12 Initial Lead Block Fitups**

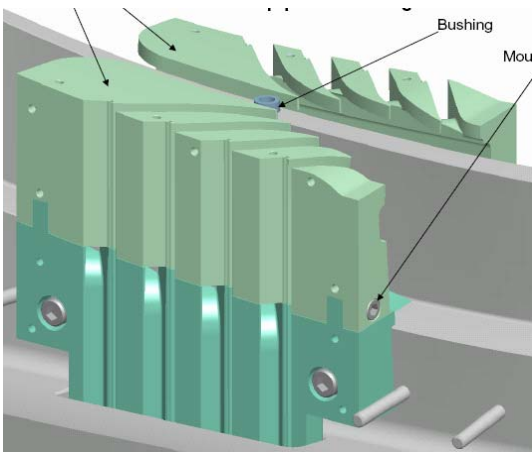
If the final G-11 lead block components are not available, use the sterolithophy components for fitup.

- Loosely mount the lower lead blocks with 1/2" socket head bolts with 2 special washers that fit in the counter bored holes. Tilt the lower lead blocks backward away from the tee and slip (2) "shim" washers onto the 1/2" bolts that will screw into the bosses. [4/block, 8 total] Carefully tilt the lower blocks up straight and push against the bosses. Leave the bolts loose not tight.
- Attach the upper lead blocks on each side and position them so the upper and lower block faces are flush and the triangular insert grooves are aligned. Insert a temporary filler strip into the 4 grooves and tighten the 3/8" socket head bolts into each end to secure the upper and lower blocks as a single unit. [Figure 12-Upper Lead Blocks & Bushing]

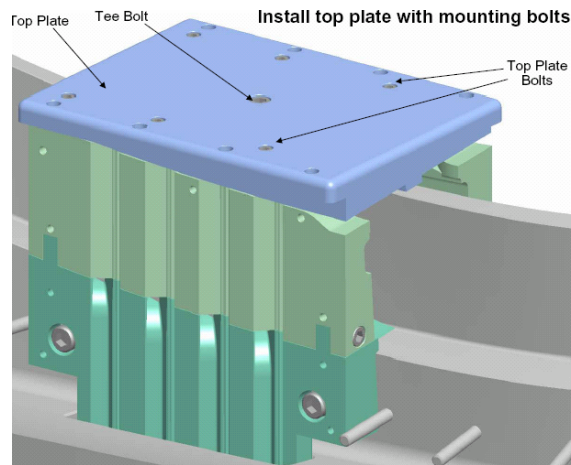


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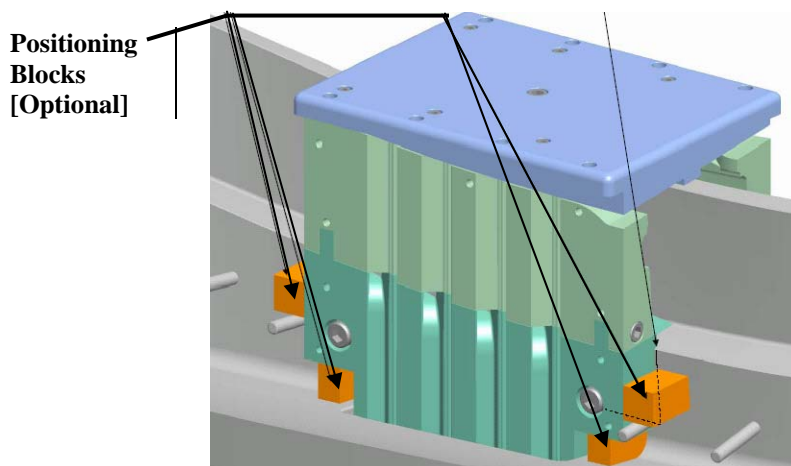
- Insert a bushing into the #1 hole in the top of the tee and fit the top plate onto the bushing (there is a recessed hole in the bottom of the top plate that seats the bushing) and insert the 3/8" bolt into the middle hole of the top plate and lightly tighten. [Figure 13- Install Top Plate]
- Position, push, tap on, whatever the upper winding blocks to line up with the 3 inner holes on each side of the top plate and insert the 1/4" screws and lightly tighten.
- Once all bolts have been engaged, tighten the top, center bolt first to seat the box to the top of the tee. Then tighten the 1/2" bolts in the lower winding blocks and snug it against the welded bosses. If it appears that the upper and lower winding blocks are not flush on each side of the front surface, the box needs to be disassembled and either remove or add a shim to the side that seems to be either protruding or recessing.
- Once the lead block components are tight, the surfaces are flush, and the grooves aligned, tighten down on the 1/2" bolts on the lower winding blocks.



**Figure 12-Upper Lead Blocks & Bushing**



**Figure 13- Install Top Plate**



**Figure 14- Install Lead Positioning Blocks**

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- Glue small positioning blocks (G-10 or phenolic) to the tee as they are pressed firmly against the sides of the lower winding blocks using the same glue as was used for the cladding, only be liberal with the amount so that the blocks will stay put until knocked or chipped off before the bagging operation. [Figure 14- Install Lead Positioning Blocks] **Optional**
- The top plate and the upper/lower winding blocks can now be disassembled and removed.

7.12.1 Install Base Studs:

- Using the G-11CR mounting base locate the position of the (2) 3/8-16 studs. [Figure 15- Electrical Insulator and Adjustment Studs] **[Note: The type A & B base plates are identical, Type B is not. See NCSX drawings for appropriate base plate.**
- Notify the ESU and obtain a flame permit daily prior to starting welding operation.
- **SAFETY NOTE:** Welders shall wear welding eye protection, fire retardant clothing plus welder's gloves.
- TIG weld the (2) 3/8-16 studs to the winding form.

<b>Weld Date:</b> _____ <b>Obtain Flame Permit:</b> _____ <b>Weld Operator:</b> _____ <b>Fire Watch:</b> _____
---

7.12.2 Quality Control Inspection:

- Each of the welded studs 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.

Inspection and acceptance of welded studs complete . <b>Q.C. Weld Inspector:</b> _____ <b>Date:</b> _____
---

<b>Summary of Results:</b> [Add additional QC reports to back of procedure]
---

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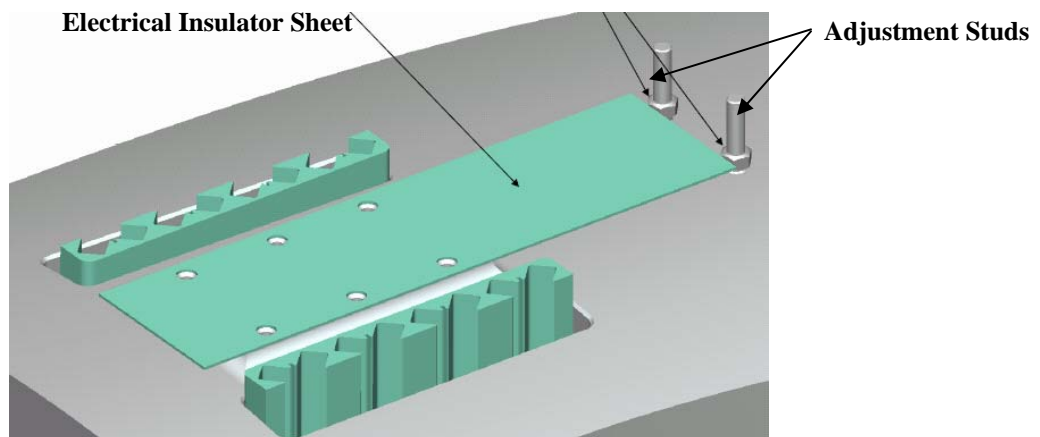
- Permeability Check: Each stud and weld shall be checked with a Severn permeability indicator to verify that the relative magnetic permeability is below the acceptance criteria. If the permeability exceeds the acceptance criteria the stud must be removed and replaced and/or the Field Supervisor must approve the variation via a non-conformance report (NCR).  
**Acceptance Criteria:** 1.02 $\mu$ .

<b>Permeability Inspection Findings:</b>
--

<b>Stud Weld permeability verified by:</b> _____ <b>Date:</b> _____ <b>QC Representative</b>
---

7.12.3 Component Installation Sequence:

- Install the electrical insulator sheet and height adjustment nuts onto the studs just welded. [Figure 15- Electrical Insulator and Adjustment Studs]

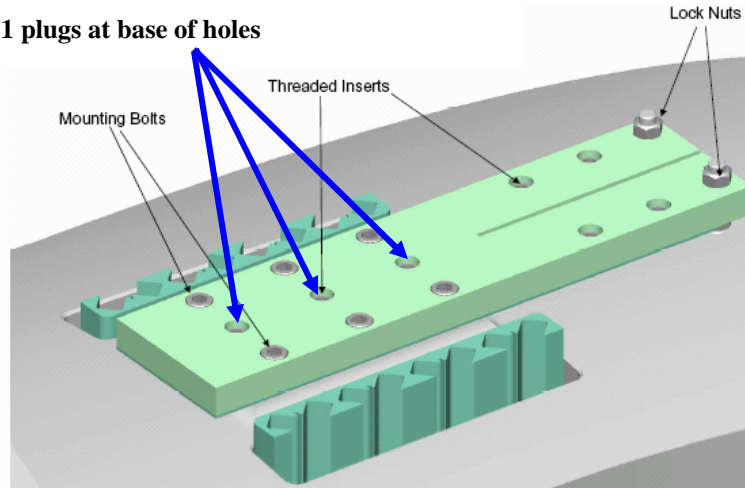


**Figure 15- Electrical Insulator and Adjustment Studs**

- Install the G-11CR base plate and secure in place with 0.375 mounting hardware and Loctite 2440. [Figure 16-Installation of Lead Terminal Base] Install G-11 plugs at bottom of threaded holes.

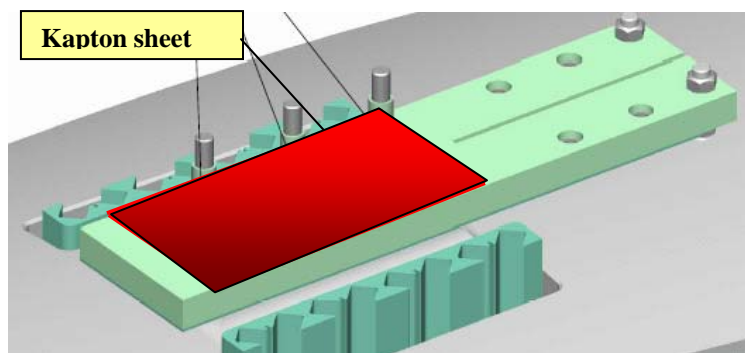
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**Insert G-11 plugs at base of holes**



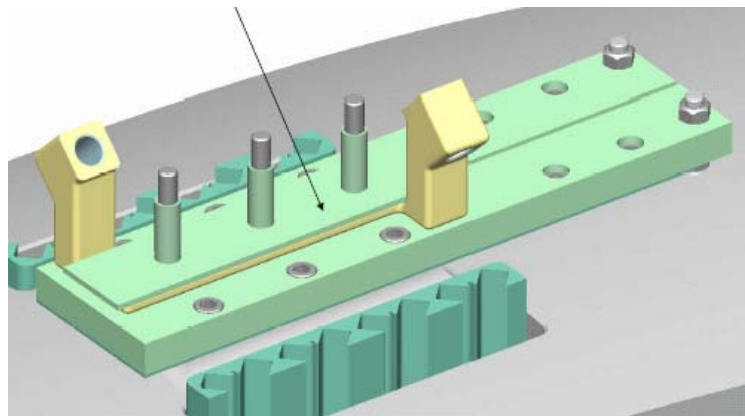
**Figure 16-Installation of Lead Terminal Base**

- Install the (3) studs and insulating sleeves into the G-11CR base plate using Loctite 2440 on the threads per manufacturer's instructions. Figure 17-Install Studs, Insulating Sleeves and Kapton sheets



**Figure 17-Install Studs, Insulating Sleeves and Kapton sheets**

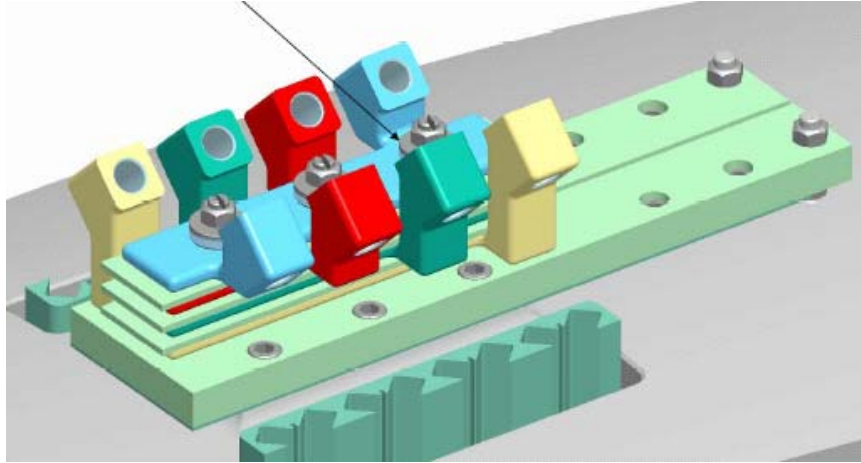
- Begin by positioning Kapton sheet [0.002 in. minimum thickness] onto the G-11 base-plate in the areas where the jumpers interface with the plate. The Kapton sheet shall extend over the mounting hardware that secures the G-11 plate to the winding form. This will improve the electrical tracking distance. [See Figure 17-Install Studs, Insulating Sleeves and Kapton sheets]



**Figure 18-Jumper #1 and Insulating Plate Installed**

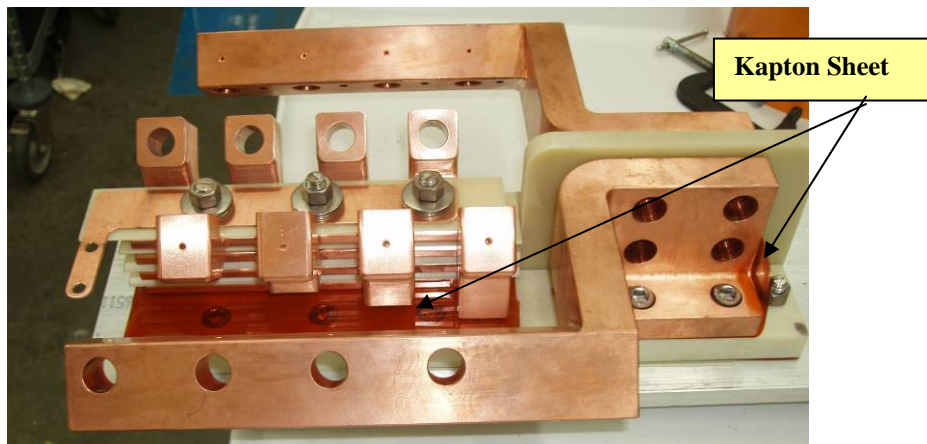
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- Install jumper #1 then an insulating plate. Continue to alternate between jumpers and insulators until Jumper #4 has been installed. Then secure in place with Belleville washers, flat washer and nut. Do not torque the jumper hardware at this time. [Figure 18-Jumper #1 and Insulating Plate Installed and Figure 19-Final Jumper#4 Installed and Secured]



**Figure 19-Final Jumper#4 Installed and Secured**

- Install and epoxy in-place the insulating divider plate in the groove provided in the G-11 base. Mount the terminal lugs to the G-11 base plate and secure in position with appropriate hardware. Figure 20- Install Terminal Lugs
- **SAFETY NOTE:** Technician **MUST** wear safety glasses and Nitrile gloves while working with epoxy.
- Install a Kapton sheet [0.002 in. minimum thickness] between the G-11 base-plate and the Terminal lugs extending over the mounting hardware that secures the G-11 plate to the winding form. This will improve the electrical tracking distance. [See Figure 20- Install Terminal Lugs]



**Figure 20- Install Terminal Lugs**

- Installation of the Lead Terminal Assembly is complete. Note: it will be necessary to disassemble some of these components during the mounting of the copper leads to the terminal lugs.

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<b>Verified:</b>	
<b>Lead Technician:</b> _____	<b>Date:</b> _____
<b>Field Supervisor:</b> _____	<b>Date:</b> _____

**7.13 Cleaning/inspecting Tapped Holes**

Inspect the tapped holes in the MCWF for evidence of metal chips or oil residue. Using a bottlebrush, clean cotton rags and acetone/ethanol; thoroughly clean any chips or oil residue remaining from the casting manufacturing process. After cleaning, check each threaded hole using a **brass or bronze** thread plug or bolt. Re-tap and clean as required RECORD FINDINGS.

- **SAFETY NOTE:** Technician MUST wear chemical goggles and Nitrile gloves during the cleaning operation.

<b>Tapped Hole Inspection Findings:</b>
---

<b>Verified by:</b> _____ <b>Date:</b> _____ <b>Lead Technician</b>
--

**7.14 Identification Numbers:**

- Verify that the winding form vendor has properly identified the clamp locations on top of the septum next to the tapped holes. The clamp location numbers will be provided on the appropriate coil winding form drawings. See Figure 22- Mold Release and Masked Surfaces

<b>Verified by:</b> _____ <b>Date:</b> _____ <b>Lead Technician</b>
--

- Identify each coil side of the MCWF with either an “A” or “B”. This information will be provided from the coil drawings. Use large stick-on letters that can be clearly seen.

**7.15 Seal Poloidal Break**

- Wipe the outside surface of the poloidal break seams using clean lint free wipe with acetone and ethanol. Do not saturate the cloth.
- **SAFETY NOTE:** Technician MUST wear chemical goggles and Nitrile gloves during the cleaning operation.

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

Poloidal Break has been sealed:

Verified by: \_\_\_\_\_ Date: \_\_\_\_\_  
**Lead Technician**

**7.16 Cleaning:**

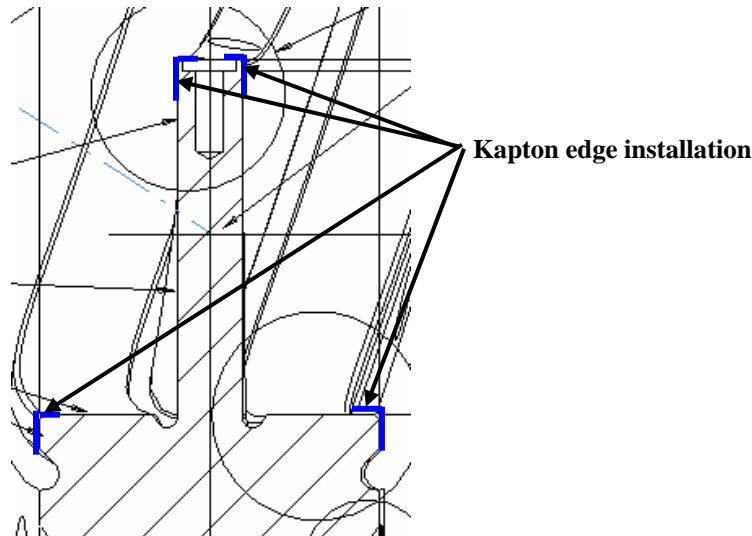
Thoroughly clean (wipe down) the entire MCWF using acetone and clean lint free wipes. Then wipe surface using Ethanol and lint free wipes.

- **SAFETY NOTE:** Technician MUST wear chemical goggles and Nitrile gloves during the cleaning operation.

Lead Technician verify: \_\_\_\_\_ Date: \_\_\_\_\_

**7.17 Kapton Edging:**

Prior to mold releasing, install (1) layer of 0.00325 inch thick adhesive back Kapton tape onto the edges of the tee casting where the cladding bends around corners. [Figure 21-Kapton Edge Installation]

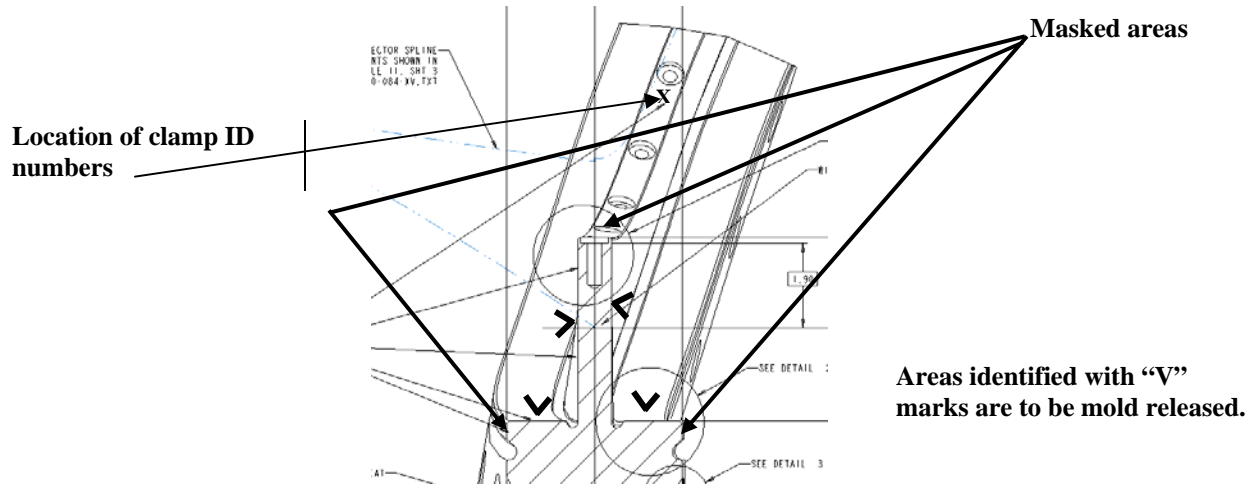


**Figure 21-Kapton Edge Installation**

- The installation of the Kapton edging tape has been completed:

Verified:  
Lead Technician: \_\_\_\_\_ Date: \_\_\_\_\_

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**Figure 22- Mold Release and Masked Surfaces**

**7.18 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 22- Mold Release and Masked Surfaces identifies the surfaces to be coated and masked.

- **SAFETY NOTE:** Technician MUST wear safety glasses during the application of mold release.

<b>Lead Technician verify:</b> _____ <b>Date:</b> _____
---

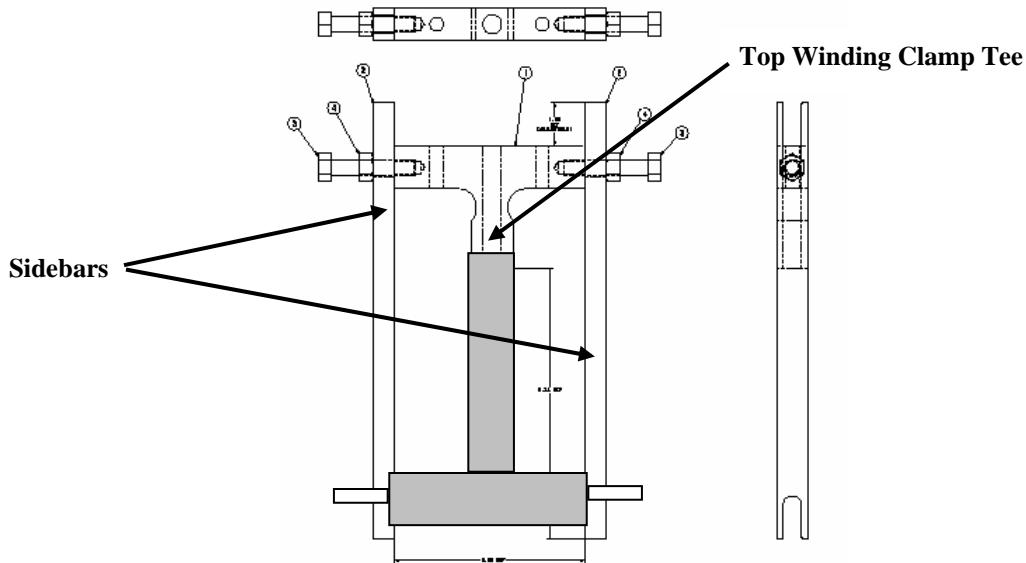
**7.19 Winding clamps**

Mount the top tee section of the winding clamps to the MCWF as shown in Figure 23- Winding Clamps. The clamps are located approximately every 3 inches along the entire length of the MCWF. Secure the winding clamp tee to the top of the septum using the appropriate hardware. Use the (2) side bars to assist in the positioning of the top section, but do not leave in place. [This operation can be performed at either Casting Prep station 4 or in the winding stations 2 or 3]

Installation of winding clamp tees is complete:  <b>Lead Technician verify:</b> _____ <b>Date:</b> _____
--



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**Figure 23- Winding Clamps**

## 7.20 Inner wall copper cladding

### 7.20.1 Cladding Preparation:

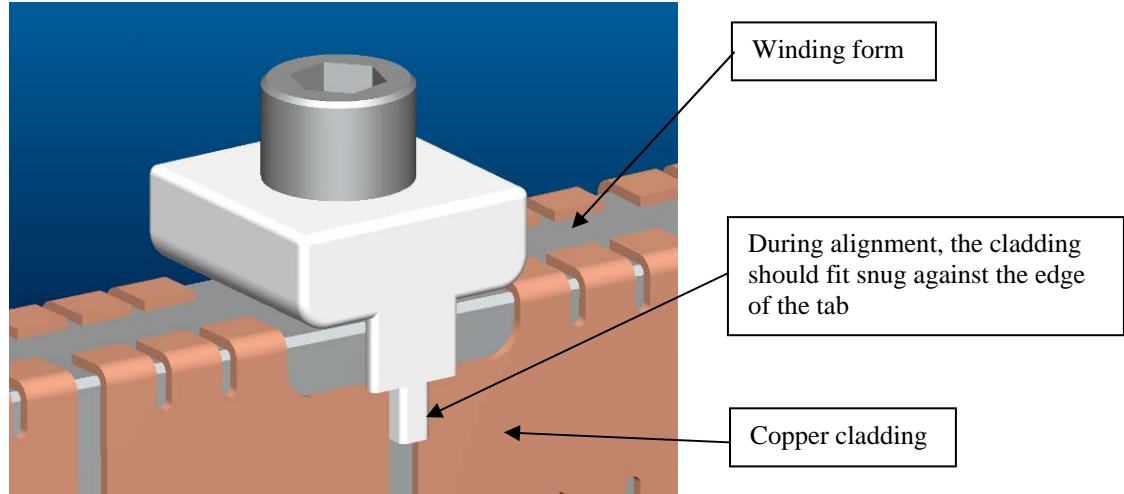
- Select the inner wall copper cladding being used for the coil type being manufactured. [Parts shall be deburred prior to use] Clean the copper plates with ethanol and clean lint free wipes. EXTREME CARE must be taken during handling of the cladding because of the potential for sharp edges. It is recommended that Kevlar gloves be used if possible during this installation.
- Apply (1) layer of adhesive backed Kapton tape (0.00325 in. thick) to the backside of the cladding that is facing the winding surfaces. Trim the Kapton insulation to the cladding profile. Slit the Kapton between fingers.

### 7.20.2 Cladding Installation- General Notes:

- **Note: The cladding may be installed at either station 4 [Winding Form Prep] or in one of the winding clean rooms, at the discretion of the Field Supervisor.**
- 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. Some pre-forming can be performed, but final fitup will be performed with cladding piece in position. Install cladding on both sides "A" and "B".
- Use the cladding positioning block [Figure 24- Cladding Positioning Block, to fitup and align the vertical cladding strips.
- The copper cladding in the lead area both vertical and horizontal plus the poloidal break are to be replaced with G-11 CR spacers [0.040 inch thick]

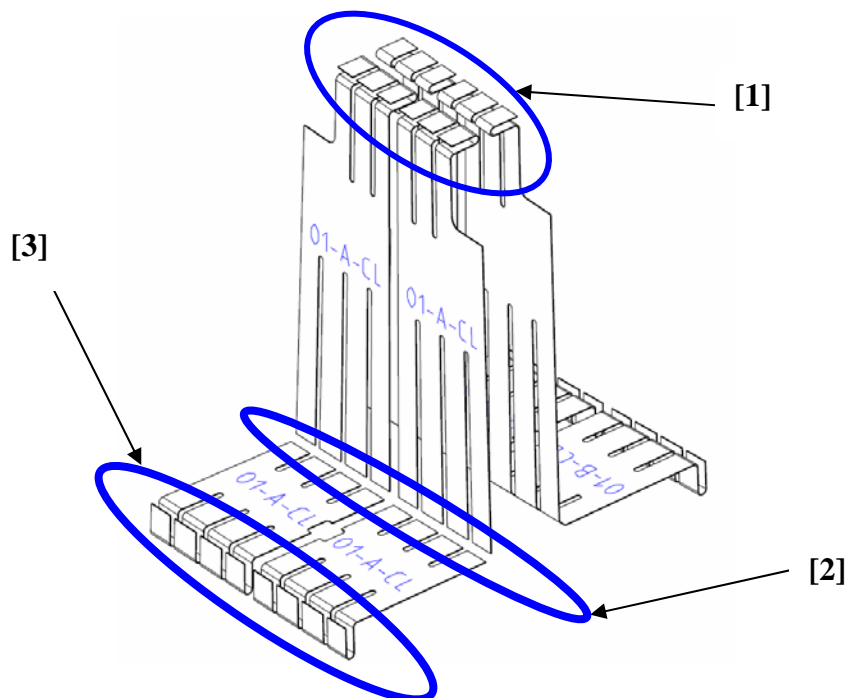
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- Secure the cladding positioning block to the winding form. The positioning block helps to align and position the vertical cladding strips. Use the positioning block to fit up each piece of cladding to the winding form. The cladding should fit snug to the positioning guide. Once the cladding has been fit, remove and re-clean if necessary. Check that there are no sharp edges or burrs.



**Figure 24- Cladding Positioning Block**

- During the fit up of the cladding the following inspections should be made: [See figure below]
  - Check that the cladding edge closest to the septum is clear of the corner radius [cladding should not roll up the radius [use G-10 spacers to verify] [1]
  - Trim the upper fingers to ¼ inch after they are bent [2]
  - On the horizontal cladding, the U-bend should be in contact with the winding form to avoid movement during the later staking operation. [3]



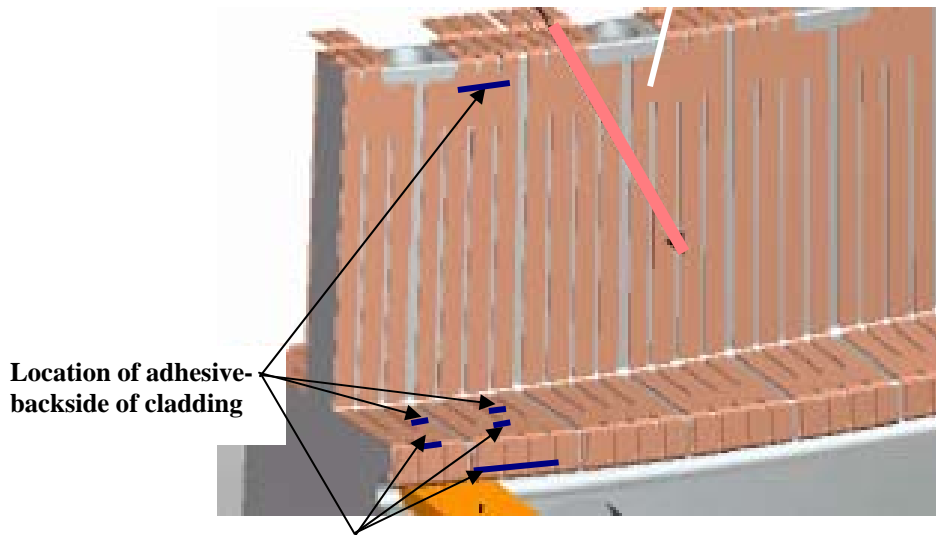
**Figure 25A- Cladding Inspections**

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- Secure the insulated cladding to the winding form winding surfaces using 3M adhesive cement #CA40H. CARE should be taken to avoid any buildup of cement under cladding.
- **SAFETY NOTE:** Technician **MUST** wear safety glasses and Nitrile gloves while working with the 3M adhesive cement and accelerator.

7.20.3 Installation of Vertical Cladding Strips:

- Apply a minimal quantity [drop] to the back of the cladding at the top bend and on the back of the outside fingers of the strip on the bottom. Evenly spread out the adhesive to a thin film avoiding any thick areas on the cladding. See Figure 26- Installation of Cladding for location of adhesive. Figure 27-Applying Adhesive to Vertical Cladding. Do not apply adhesive to the upper - sections of the cladding.
- Prior to placing the cladding in its final position, apply by brush 3M Accelerator “Pronto Surface Activator” to small area of MCWF where the adhesive on the cladding will mate with the winding form. [Figure 28-Applying Accelerator]
- Place the cladding into position and hold in place for 5 seconds. Then continue with remaining cladding pieces. [Figure 29- Positioning Vertical Cladding]



**Figure 26- Installation of Cladding**



**Figure 27-Applying Adhesive to Vertical Cladding**

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**Figure 28-Applying Accelerator**



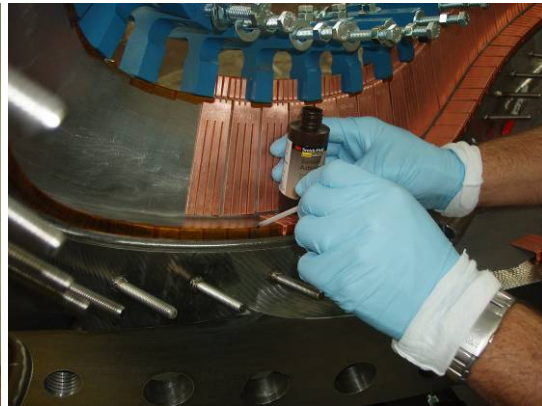
**Figure 29- Positioning Vertical Cladding**

**7.20.4 Installation of Horizontal Cladding Strips:**

- Apply a minimal quantity [drop] to the back of the cladding at the edge bend and on the back of the outside fingers of the strip on the short leg of the cladding. Evenly spread out the adhesive to a thin film avoiding any thick areas on the cladding. See Figure 26- Installation of Cladding for location of adhesive. Figure 30- Applying Adhesive to Horizontal Cladding].
- Prior to placing the cladding in its final position, apply by brush 3M Accelerator “Pronto Surface Activator” to small area of MCWF where the adhesive on the cladding will mate with the winding form. [Figure 31- Applying Accelerator [Horizontal]]
- Place the cladding into position and hold in place for 5 seconds. Then continue with remaining cladding pieces. [Figure 32-Positioning Horizontal Cladding]

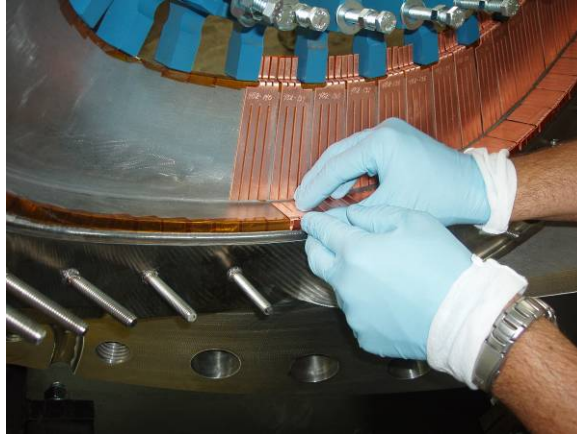


**Figure 30- Applying Adhesive to Horizontal Cladding**



**Figure 31- Applying Accelerator [Horizontal]**

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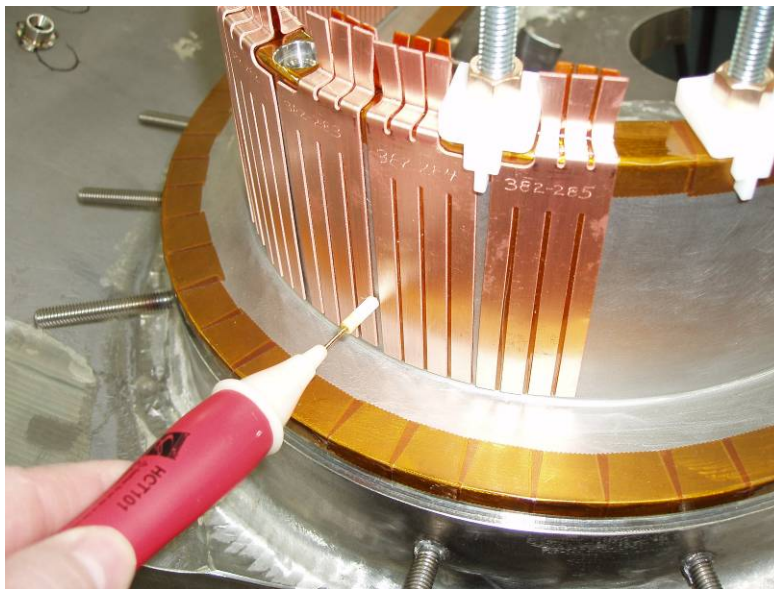


**Figure 32-Positioning Horizontal Cladding**

- 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:** \_\_\_\_\_

- Under the oversight of a Quality Control representative a final check shall be made to verify that the cladding is positioned to the winding form with minimal buildup between cladding and the form. Using a voltage probe or multi-meter with a depth stop [ $<0.060$  inch] insert the probe between each pair of cladding until the stop rests on the cladding surface. If the probe light is on, it indicates that the cladding is acceptable and within the required buildup. If the probe does not light, then the cladding piece must be removed and reapplied. These measurements may also be performed using Verniers. [Figure 33-Verifying Cladding standoff w/Voltage Probe] Quality Control shall sign off that the cladding has been satisfactorily inspected.



**Figure 33-Verifying Cladding standoff w/Voltage Probe**

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- Installation of the cladding has been satisfactorily completed.

Installation of the Inner Copper Cladding is complete (sides “A” and “B”) including verification of the integrity of dielectric break and the cladding positions are satisfactory.	
<b>Lead Technician:</b> _____	<b>Date:</b> _____
<b>Field Supervisor:</b> _____	<b>Date:</b> _____
<b>Quality Control:</b> _____	<b>Date:</b> _____

**8 Station No. 1 MCWF Preparation Completion:**

**8.1 Document Verification:**

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

**8.2 Field Package:**

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

**8.3 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.	
<b>Lead Technician:</b> _____	<b>Date:</b> _____
<b>Field Supervisor:</b> _____	<b>Date:</b> _____
QC shall verify completion of documentation:	
<b>Quality Control Representative:</b> _____	<b>Date:</b> _____

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