NCSX
Product Specification
For The Station Three Assembly

NCSX-CSPEC-185-03-00

October 3, 2008

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Controlled Document

This is a controlled document. Check the NCSX Engineering Web prior to use to assure that this document is current.

Record of Revisions

Revision	Date	ECP	Description of Change
Rev. 0	10/3/2008	---	Initial Release

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1 OVERVIEW AND SCOPE

1.1 Overview

The assembly of the NCSX machine is accomplished at 5 stations. Stations 1 – 3 and Station 5 are located in the NCSX Manufacturing Facility and Station 6 is located in the NCSX Test Cell. Station 4 activities have now been combined into Station 5.

This document details the specifications for the assembly of two half-period modular coil assemblies, Station Two, over the vacuum vessel components, Station 1, for the National Compact Stellarator Experiment (NCSX). The NCSX machine assembly sequence can be summarized as follows (refer to the Assembly Sequence Plan, AssySeqPlan, for more details):

- Station One – Assembly of the Vacuum Vessel components (covered in NCSX-CSPEC-185-01)
- Station Two – Assembly of the Modular Coil Half Period, MCHP, Type-A, B, and C coils (covered in NCSX-CSPEC-185-02).
- Station Three – Assembly of two MCHP assemblies over the vacuum vessel.
- Station Four –not used.
- Station Five – Final full period assembly. Completes the FPA assembly process by assembling two MCHP over the vacuum vessel, attaching VV ports, the external trim coils, modular coil lead and coolant connections, and 4 of the 6 TF coils per period.
- Station Six Assembly – full machine assembly, joining three full periods. This also includes the PF coils.

1.2 Scope

This station three specification defines the product requirements for the assembly of the MCFP.

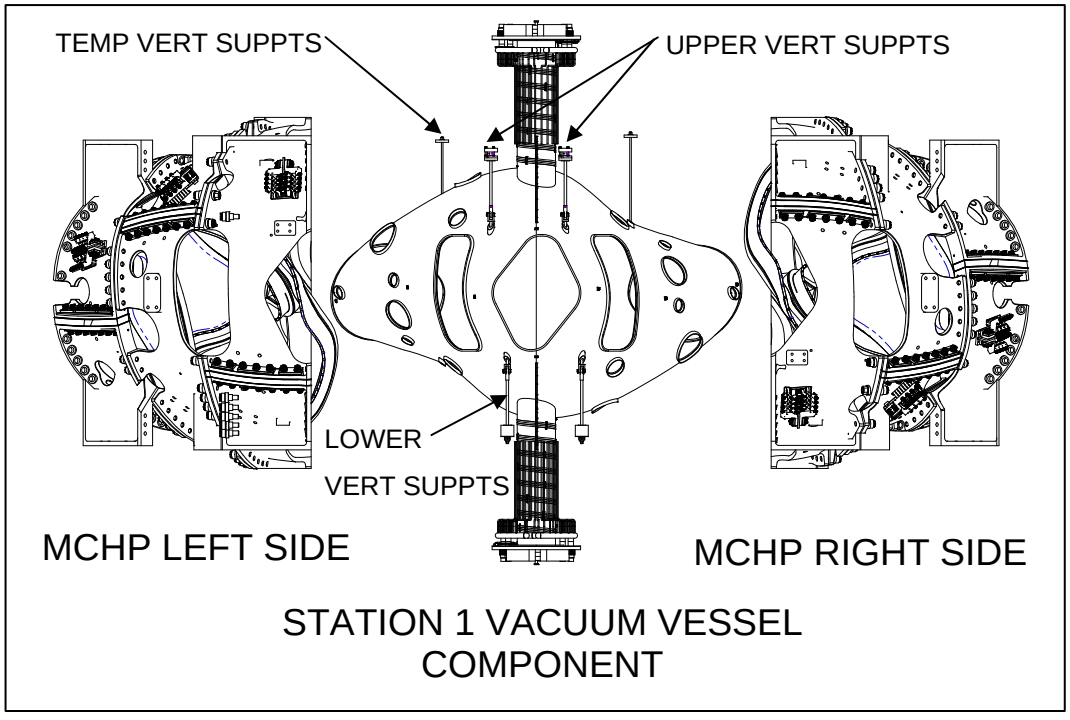


Figure 1-1 Station Three Assembly

2 APPLICABLE DOCUMENTS

2.1 NCSX Documents

[1] NCSX-CSPEC-142-05-01, Product Specification for the Modular Coil Assemblies (Type A, B, C)

NCSX-BSPEC-14-01, System Requirements Document (SRD) for the Modular Coil

NCSX-PLAN-FPA3DC-00-SIGNED.pdf

AssySeqPlan

2.2 Drawings

Dwg No.	Title
SE100-003	FIELD PERIOD ASSEMBLY STATION 3
SE121-009	VACUUM VESSEL ASSY STATION 1 PHASE 3
SE124-051	VERTICAL UPPER SUPPORT ASSEMBLY
SE124-054	VERTICAL LOWER SUPPORT ASSEMBLY
SE140-003	MODULAR COIL ASSEMBLY ½ FIELD PERIOD
SE140-045	A-A MOD COIL SHIM AND SHEAR PLATE KIT
SE140-190	MCWF FLANGE STUD KITS

2.3 Other Documents

ENG-037, PPPL WELD PROCEDURE

3 REQUIREMENTS

3.1 Item Definition

a. Modular Coil Flange. The Modular Coil Flanges are rims cast into the perimeter of each side of the winding form which support the Modular coil and interface with shims located between the different types of Modular Coils. Flange holes match up between adjoining flanges, and are either countersunk or tapped. Studs inserted in the holes during assembly attach the Modular Coils together and clamp against the shims.

b. Shims. Shims of various thicknesses are placed between adjacent Modular Coil Flanges, and serve to position coils properly, transfer shear loads between flanges, and electrically isolate adjacent coils. Two types of shims are utilized: a) single hole shims which consist of a sandwich of G10, stainless steel, and G10. b) circular shims (also referred to as pucks) that are retained in holes through shear plates that are welded along the inner and outer surface of the inboard flange.

c. Stud Assembly Kits. Studs are used for attaching modular coils together at the modular coil flanges. Stud assembly kits exist in two types – tapped studs and through studs. A large pre-load is applied to the studs in order to transfer transverse magnetic loading to the shims. The pre-load is applied by a Supernut torqued onto a series of insulating washers, load bearing washers, sleeves, and insulating bushings.

d. A modular coil half period assembly (MCHP) consists of three modular coils: one each of type A, B, and C. The coils are joined by bolts and shims at the hole locations in the flanges, and welded together in the nose region.

e. A modular coil field period assembly (MCFP) consist of two MCHPs, joined together at the “A” coils in Stellarator symmetry with a bolted and welded joint.

3.2 Characteristics

3.2.1 Performance

3.2.1.1 Coil Positioning

The monuments as defined in NCSX-PLAN-FPA3DC-00-SIGNED.PDF, of the MCFP assembly shall be located within +/-0.020in of the desired locations as defined by the global coordinate system shown on the drawings in section 2.2.

3.2.1.2 Electrical Isolation

a. Bolted joints shall electrically isolate adjacent MCHP assemblies. (It is recognized that the welded shims joining adjacent modular coils will indeed provide a conducting path between adjacent modular coils.)

b. There shall be no continuous electrical paths poloidally between two MCHP assemblies, i.e. the poloidal electrical break on the outboard side of the one MCHP will not be shorted by the other MCHP.

c. Electrical requirements in the Modular Coil Assembly product specification [1] shall not be compromised during assembly of MCHP assemblies.

3.2.2 Physical Characteristics

3.2.2.1 Bolted Joints

3.2.2.1.1 Stud Engagement

The studs shall be inserted into the tapped holes in the flange by advancing the stud to the bottom of the thread then reversing direction ¼ turn. Studs shall be installed per drawing SE140-190, MCWF FLANGE STUD KITS.

In all cases, at least the minimum thread engagement specified on drawing, SE100-003, FIELD PERIOD ASSEMBLY STATION 3, shall be obtained.

3.2.2.1.2 Stud Pre-Load

The studs shall be pre-loaded to 72,000 pounds force ±5,000lbs (77,000/67,000). The Supernut shall be torqued using the manufacturer's recommended procedure shown in Appendix A. The preload shall be verified by use of a ultrasonic bolt tension determination device.

3.2.2.1.3 Shim Length

The shim must not extend beyond the flange in such a way that it will interfere with the winding form or wings of the adjacent modular coil or TF coils. The shim length shall be as shown in drawing SE140-045, MODULAR COIL SHIM AND SHEAR PLATE LAYOUT.

3.2.2.1.4 Shim Contact

Shim assemblies shall be in good contact with both sides of adjacent flanges. After sizing all shims and applying a preload of 50% of the stud pre-load as specified in Section 3.2.2.1.2 to the studs each shim shall be tested by performing a "wiggle test" to determine if the shim is loose. Any movement of the shim shall

require the shim to be resized and a new shim installed. This test shall be repeated until all shims have successfully met this requirement simultaneously.

3.2.2.1.5 Insulated Bushing Clearance

Bushings shall be machined to minimize the clearance between the busing and stud and between the bushing and the coil flange holes. The maximum clearance between the stud and bushing shall not exceed .002in. For the bushing to coil flange hole the clearance shall not exceed .004in. In cases where the clearance can not be minimized the gaps shall be filled with epoxy.

3.2.2.1.6 Welded Joints

Welds shall be applied to the inboard shims as specified in the drawings listed in Sect. 2.2.

Welds shall be completed in accordance with PPPL procedure ENG-037. Deflections produced by the welding must not exceed the requirements of 3.2.1.1 above.

3.3 Design and Construction

3.3.1 Production Drawings

Station 3 assemblies shall be assembled in accordance with the production drawings shown in Section 2.2.

3.3.2 Interchangeability

Design tolerances shall permit Assemblies of the same part number to be used as replacement parts without degrading the specified performance of the parent item, except for custom fit shims and bushings. [Ref. SRD Section 3.3.5 Interchangeability]

3.3.3 Magnetic Permeability

The magnetic permeability of all components and welded areas must be less than 1.02 unless otherwise authorized by the project.

4 QUALITY ASSURANCE PROVISIONS

4.1 General

This section identifies the methods to be used for verification of requirements in Section 3.2 of this specification.

4.2 Verification Methods

Verification of qualification shall be by analysis, inspection, or test. Definition of analysis, inspection, and test is as follows:

Analysis: Verification of conformance with required characteristics by calculation or simulation, including computer modeling based on established material or component characteristics.

Inspection: Verification of conformance by measuring, examining, testing, and gauging one or more characteristics of a product or service and comparing the results with specified requirements.

Test: Verification by physically exercising a component or system under appropriate loads or simulated operating conditions, including measurement and analysis of performance data.

4.3 Quality Conformance

This section establishes the specific methods for verification of requirements in Section 3.

4.3.1 Verification of Physical Characteristics

4.3.1.1 Verification of Coil Positioning

Upon completion of Station 3 Assembly, the placement of the MCFP assembly shall be confirmed to be as specified in Section3.2.1.1. This will be measured using the position of the monuments on each MCHP. Final verification shall be performed after all assembly operations, e.g. welding and analysis has been completed.

4.3.1.2 Verification of Electrical Isolation

A megger test shall be performed to verify the requirements as specified in Section 3.2.1.2 The megger test shall be conducted at 150 volts with a leakage current <100 micro amps.

4.3.1.3 Verification of Magnetic Permeability

Magnetic permeability of components (shims, studs, etc.) and welds shall be verified by use of a calibrated Severn gauge to verify compliance with the magnetic permeability requirement in Section 3.3.3.

4.3.1.4 Verification of Stud Placement

The required minimum thread length for the stud shall be as specified in Section 3.2.2.1.1. Assurance that the stud threads are fully engaged shall be determined by measuring the stud length before installation and comparing to the exposed length of stud.

4.3.1.5 Verification of Stud Pre-Load

The stud pre-load will be confirmed by ultrasonic inspection using calibrated equipment per requirements in Section 3.2.2.1.2

4.3.1.6 Verification of Shim Contact

The shim shall be tested in accordance with Section 3.2.2.1.4 to show that each side of the shim is in good contact with the adjacent modular coil flanges.

4.3.1.7 Verification of Shim Length

Interference with winding form or coil wings should be checked, and shims cut as specified in Section 3.2.2.1.3 to avoid any interference.

4.3.1.8 Verification of Shim Welding

All welds shall be visually inspected to verify that weld standards are met as specified in the drawings containing the welding requirements.

4.3.1.9 Verification of bushing fit

The bushing clearance will be determined by measurements of the stud, modular coil flange hole, and bushing after machining.

Appendix A

Air Impact Tool Selection

Helpful Tips

Prior to Tightening:

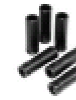
For Tightening:

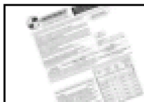
For Removal:

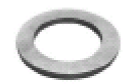
4

SUPERBOLT® Installation and Removal Instructions

Installation Preparation:







Further Preparation Steps:

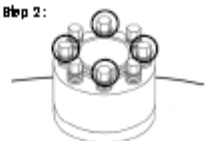
1

Installation

Step 1:

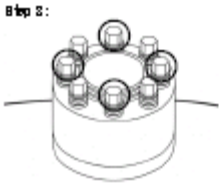
Spin the tensioner onto the main thread until it seats against the washer. You may want to back off the tensioner slightly as mentioned in Helpful Tip #3 on page 4.

Step 2:



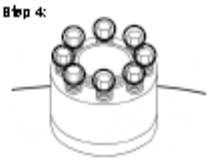
Tighten (4) pickballs at 90° apart (12:00, 6:00, 9:00, and 3:00) on all studs with a pistol torque (50-70%). This serves to seat the flange. If using an air impact, use a reduced setting or lightly pulse the trigger at the full setting.

Step 3:



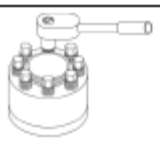
At 100% target torque, tighten the same (4) pickballs on all studs.

Step 4:



At 100% target torque, tighten all pickballs in a circular pattern. Do this for all studs (1 round only). See Helpful Tip #7 about using up to 120% torque.

Step 6:



Repeat "STEP 4" until all pickballs are saturated (less than 10° rotation). This usually requires 2-4 additional passes. If using air tools, switch to a torque wrench when socket rotation is small. Use the torque wrench to stabilize at the target torque.

NOTE: Product with 4 or 8 pickballs - use a star pattern for all steps.

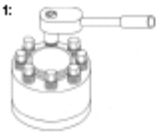
Removal

CAUTION! [illegible]

Service Under 250°F

Preparation: Spray pickballs with penetrating oil or hydraulic oil prior to unit especially if present in corrosive environment.

Step 1:



Loosen each pickball 1/8 turn following a circular pattern around the tensioner (1 round only). As you move around and get back to the first pickball, it will be tight again. Do this for all studs on the joint prior to the next step.

Step 2: Repeat a 2nd round as above for all studs, now loosening each pickball 1/4 turn in a circular pattern.

Step 3: Continue loosening 1/4 turn for 3rd and successive rounds until all pickballs are loose. (NOTE: Usually after the 3rd or 4th round, an impact can be used to completely unload the pickballs, one by one. For long bolts or tie rods, additional rounds may be required before removing the pickballs with an impact tool.

Step 4: Remove, clean and relubricate the pickballs prior to next use with coated Superball lubricant (JL-G or JL-M).

Service Over 250°F

Preparation: Above 350°F the petroleum base of the lubricant burns off. Dilper STEP 1 below to remove the remaining grease.

Step 1:

As the equipment is cooling down (around 300°F), apply hydraulic oil to the pickballs and washer and let sit for several hours. Thoroughly "wet-down" all components and re-apply during equipment cool down period. If the tensioner is inverted, squirt oil in the gap between the nut body and the washer. Synthetic oil can be used to cling above 300°F.

Step 2: Wait for tensioner to cool below 200°F. Using a circular pattern, "crack" each pickball only enough to ensure movement. Do not turn beyond the back loose point. Do this for all studs.

Step 3: Now begin with "STEP 1" of the procedure for service under 250°F.

NOTE: Heating Rods can be used to reduce the removal torque required.