

# NCSX

## Product Specification

### TF Coil Wedge Castings

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Prepared By: \_\_\_\_\_

M. Kalish, WBS Manager for TF Coils (WBS 13)

Concurred By: \_\_\_\_\_

B. Nelson, Project Engineer for Stellarator Core Systems (WBS 1)

Concurred By: \_\_\_\_\_

Irving Zatz, QA Representative

Approved by: \_\_\_\_\_

W. Reiersen, NCSX Engineering Manager

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### Record of Revisions

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**Table of Contents**

**1 Scope ..... 1**

**2 Applicable Documents..... 1**

2.1 PPPL Drawing ..... 1

    2.1.1 TF Coil Nose Casting Machining Detail Drawing # SE131-007-00 Sheets 1 and 2 ..... 1

2.2 Codes and Standards..... 1

    2.2.1 American Society for Testing and Materials (ASTM) Documents ..... 1

    2.2.2 Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry Documents ..... 2

    2.2.3 British Standard ..... 2

    2.2.4 American Welding Standard..... 2

**3 Requirements ..... 2**

3.1 Item Definition ..... 2

3.2 Characteristics ..... 2

    3.2.1 Performance..... 2

        3.2.1.1 Chemical Composition ..... 2

            3.2.1.1.1 Casting Alloy ..... 2

            3.2.1.1.2 Weld Wire..... 3

        3.2.1.2 Mechanical Properties..... 3

        3.2.1.3 Surface Finish ..... 4

        3.2.1.4 Relative Magnetic Permeability..... 4

        3.2.1.5 External Defects..... 4

            3.2.1.5.1 Visual Examination..... 4

            3.2.1.5.2 Liquid Penetrant Inspection ..... 4

        3.2.1.6 Internal Defects..... 4

3.3 Design and Construction..... 4

    3.3.1 Production Drawings ..... 4

    3.3.2 Dimensions and Tolerances..... 4

    3.3.3 Standards of Manufacture..... 5

        3.3.3.1 Heat Treatment and Stress Relieving..... 5

        3.3.3.2 Repairs ..... 5

            3.3.3.2.1 Non Weld Repairs ..... 5

            3.3.3.2.2 Weld Repairs..... 5

            3.3.3.2.3 Major Weld Repairs ..... 5

    3.3.4 Method of Construction..... 5

**4 Quality Assurance Provisions ..... 5**

4.1 General ..... 5

4.1.1 Responsibility for Inspection .....5

4.2 Quality Conformance Inspections .....6

4.2.1 Verification of Chemical Composition .....6

4.2.1.1 Casting Alloy .....6

4.2.1.2 Weld Wire.....6

4.2.2 Verification of Mechanical Properties .....6

4.2.2.1 Verification of Yield Strength and Elastic Modulus .....6

4.2.2.2 Verification of Ultimate Tensile Strength and Elongation.....6

4.2.2.3 Verification of Charpy V-Notch Energy.....6

4.2.2.4 Additional Test Material.....6

4.2.3 Verification of Surface Finish.....6

4.2.4 Verification of Relative Magnetic Permeability .....7

4.2.5 Verification of Dimensions and Tolerances.....7

4.2.6 Inspection for External Defects .....7

4.2.6.1 Visual Inspection .....7

4.2.6.2 Liquid Penetrant Inspections.....7

4.2.6.2.1 General Liquid Penetrant Inspection.....7

4.2.6.2.2 Post Machining Liquid Penetrant Inspection .....7

4.2.7 Inspection for Internal Defects.....7

**5 Preparation for delivery .....8**

5.1 Marking .....8

5.2 Cleaning.....8

5.3 Crating .....8

5.4 Shipping.....8

**List of Tables**

**Table 3-1 Weight % of Chemical Constituents in Casting Alloy.....2**

**Table 3-2 Weight % of Chemical Constituents in Casting Alloy (Alternate).....3**

**Table 3-3 Weight % of Chemical Constituents in Weld Wire.....3**

**Table 3-4 Minimum Mechanical Properties.....3**

## 1 SCOPE

This specification defines the Toroidal Field (TF) Coil Wedge Castings (Wedge Castings) and requirements for its manufacture. There are two (2) identical Wedge Castings per TF coil and thirty-six (36) altogether. An illustration of the Wedge Castings with a TF coil is shown in Figure 1 - TF Coil With Wedge Castings

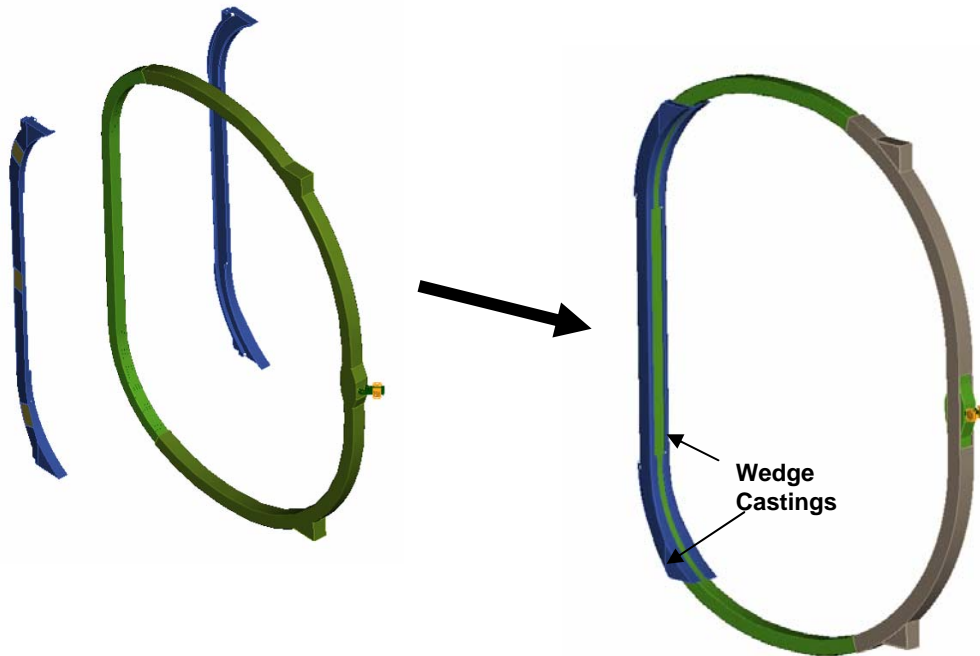


Figure 1 - TF Coil With Wedge Castings

## 2 APPLICABLE DOCUMENTS

### 2.1 PPPL Drawing

#### 2.1.1 TF Coil Nose Casting Machining Detail Drawing # SE131-007-00 Sheets 1 and 2

### 2.2 Codes and Standards

#### 2.2.1 American Society for Testing and Materials (ASTM) Documents 1

A703/A703M-03 “Standard Specification for Steel Castings, General Requirements for Pressure Containing Parts”.

A800/A800M-01 “Standard Practice for Steel Casting, Austenitic Alloy, Estimating Ferrite Content Thereof”.

A802/A802M-95 “Standard Practice for Steel Castings, Surface Acceptance Standards, Visual Examination”.

A903/A903/M-99 “Standard Specification for Steel Castings, Surface Acceptance Standards, Magnetic Particle, and Liquid Penetrant Inspection”.

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1 Publications are available from <http://www.astm.org/cgi-bin/SoftCart.exe/index.shtml?E+mystore>.

### 2.2.2 Manufacturers Standardization Society (MSS) of the Valve and Fittings Industry Documents 2

MSS SP-54-2001: “Quality Standard for Steel Castings for Valves, Flanges, Fittings, and Other Piping Components; Radiographic Inspection Method”.

### 2.2.3 British Standard

BS EN 12072:2000 “Welding consumables – Wire Electrodes, Wires and Rods For Arc Welding of Stainless and Heat-Resisting Steels-Classifications”

### 2.2.4 American Welding Standard

AWS D1.6 “Structural Welding Code – Stainless Steel”

## 3 REQUIREMENTS

### 3.1 Item Definition

The item covered in this specification is the TF wedge casting. This specification defines the TF wedge casting and requirements for its fabrication.

### 3.2 Characteristics

#### 3.2.1 Performance

##### 3.2.1.1 Chemical Composition

###### Background

The chemical composition for two acceptable casting alloys is provided below. The vendor may select from these alloys based on their compatibility with the manufacturing process. The vendor may propose alternate casting alloys and weld wire if they meet the requirements of this specification. All alternate alloys shall be subject to review and approval by PPPL.

##### 3.2.1.1.1 Casting Alloy

The chemical composition shall be in accordance with Table 3-1 or Table 3-2.

**Table 3-1 Weight % of Chemical Constituents in Casting Alloy**

	<u>C</u>	<u>Mn</u>	<u>Si</u>	<u>Cr</u>	<u>Ni</u>	<u>Mo</u>	<u>P</u>	<u>S</u>	<u>N</u>
Min. %	.040	2.3	--	18.0	13.0	2.1	--	--	.24
Max.%	.070	2.8	0.7	18.5	13.5	2.5	.04	.04	.28

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2 Publications are available from Manufacturers Standardization Society of the Valve and Fittings Industry, Inc., 127 Park Street, NE, Vienna, Virginia 22180p, Tel. (703)-281-6613.

**Table 3-2 Weight % of Chemical Constituents in Casting Alloy (Alternate)**

	<u>C</u>	<u>Mn</u>	<u>Si</u>	<u>Cr</u>	<u>Ni</u>	<u>Mo</u>	<u>P</u>	<u>S</u>	<u>N</u>
Min. %	0	.5	0	17.0	14.0	2.0	--	--	--
Max.%	.080	1.5	1.0	18.5	18.0	3.0	.04	.04	--

**3.2.1.1.2 Weld Wire**

The chemical composition of the weld wire shall comply with Standard BS EN 12072:2000 (British Standard / Welding consumables – Wire Electrodes, Wires and Rods For Arc Welding of Stainless and Heat-Resisting Steels- Classifications). Chemical requirements from this standard are reproduced in Table 3-3.

**Table 3-3 Weight % of Chemical Constituents in Weld Wire (BS EN 12072:2000)**

	<u>C</u>	<u>Mn</u>	<u>Si</u>	<u>Cr</u>	<u>Ni</u>	<u>Mo</u>	<u>P</u>	<u>S</u>	<u>Cu</u>	<u>N</u>
Min. %	-	5.0	-	19.0	15.0	2.5	--	--	-	-
Max. %	.030	9.0	1.0	22.0	18.0	4.5	.03	.02	0.3	-

**3.2.1.2 Mechanical Properties**

The properties of the casting alloy shall meet or exceed the mechanical properties requirements stated in Table 3-4.

**Table 3-4 Minimum Mechanical Properties**

<b>Temperature</b>	<b>77K</b>	<b>293K</b>
Elastic Modulus	21 Msi (144.8 GPa)	20 Msi (137.9 GPa)
0.2% Yield Strength	72 ksi (496.4 MPa)	30 ksi (206.8 MPa)
Tensile Strength	95 ksi (655 MPa)	78 ksi (537.8 MPa)
Elongation	32%	36%
Charpy V – notch Energy	35 ft-lbs (47.4 J)	50 ft-lbs (67.8 J)

### 3.2.1.3 Surface Finish

Unless otherwise specified machined surfaces must have an RMS (root mean square) surface finish <125  $\mu$ -inches. Uniform “scallops” which exceed 125  $\mu$ -inches, which may result from some machining processes, may be acceptable, subject to PPPL approval of the non-conformance that would be generated in this case. The finished part shall be free of sharp edges and burrs.

### 3.2.1.4 Relative Magnetic Permeability

The local relative magnetic permeability shall not exceed 1.02.

### 3.2.1.5 External Defects

#### 3.2.1.5.1 Visual Examination

- a. Cast surfaces shall be free of visual external defects as defined in ASTM A802/A802M Level III.
- b. Machined surfaces shall be free of visual external defects as defined in ASTM A802/A802M Level II.
- c. Discontinuities not meeting the evaluation criteria shall be repaired per Section 3.3.3.2.

#### 3.2.1.5.2 Liquid Penetrant Inspection

- a. Each casting, shall be free of external defects as defined in ASTM A903/A903M Level I when checked by liquid penetrant inspection.
- b. Discontinuities not meeting the evaluation criteria shall be repaired per Section 3.3.3.2.

### 3.2.1.6 Internal Defects

- a. Each casting shall be free of internal defects as defined in MSS SP 54 for radiography.
- b. Discontinuities not meeting the evaluation criteria shall be repaired per Section 3.3.3.2.

## 3.3 Design and Construction

### 3.3.1 Production Drawings

The castings shall be fabricated in accordance with the TF Coil Nose Casting Machining Detail Drawing SE131-007-00

### 3.3.2 Dimensions and Tolerances

The Wedge Castings shall conform to the dimensions and tolerances defined in the production drawings referenced in Section 3.3.1. All dimensions are for 20 C; actual measurements shall be temperature compensated for 20 C.



### **3.3.3 Standards of Manufacture**

#### **3.3.3.1 Heat Treatment and Stress Relieving**

The castings shall be heat treated prior to final measurements of mechanical properties and relative magnetic permeability. In addition, unless heat treatment is performed after all foundry upgrading, stress relieving shall be performed after all upgrading is completed at the foundry. If the final part was fabricated by welding two individual halves together stress relief must occur at a point after this welding operation. The temperature and duration of the heat treatment and stress relieving processes shall be reviewed and approved by PPPL. Heat treatment records shall be prepared and maintained as defined in S21 of ASTM Spec. A703/A703M, and supplied to PPPL.

#### **3.3.3.2 Repairs**

##### **3.3.3.2.1 Non Weld Repairs**

When defects are removed by grinding without violating minimum wall thickness requirements, the ground area shall be re-inspected by the original inspection method to verify complete defect removal. Discontinuities that will be removed during subsequent machining processes do not need to be weld repaired

##### **3.3.3.2.2 Weld Repairs**

Weld repairs may be necessitated to (1) repair casting defects when defect removal involves excavation beyond wall thickness limitations or (2) to repair gouges or other machining errors. Welding procedure qualification tests shall include evidence of compliance with the magnetic permeability requirements of Section 3.2.1.4. Weld preparation shall be per Section S10 of ASTM A703/A703M. Weld repairs must meet the inspection criteria of Sections 3.2.1.5 and 3.2.1.6

##### **3.3.3.2.3 Major Weld Repairs**

Repairs shall be considered major when the depth of the cavity prepared for welding exceeds 20 % of the actual wall thickness or when the extent of the cavity exceeds approximately 1 in<sup>2</sup>. Weld Maps (showing size and location as required by ASTM A703/A703M S20) shall be prepared for each major weld repair cycle. The weld map shall be delivered to PPPL no later than 24 hours after the start of welding. Major weld repairs during machining operations shall necessitate the issuance of a Non-Conformance Report to address the conditions that led to the need for welding. The weld repairs may proceed while the NCR is being dispositioned

### **3.3.4 Method of Construction**

The final part may be constructed by joining two identical parts using a full penetration weld provided that the final part meets all of the criteria established in this specification. The full penetration weld is to meet the requirements of AWS D1.6 Structural Welding Code – Stainless Steel.

## **4 QUALITY ASSURANCE PROVISIONS**

### **4.1 General**

#### **4.1.1 Responsibility for Inspection**

The responsibility for performing all tests and verifications rests with the supplier. PPPL reserves the right to witness or separately perform all tests specified or otherwise inspect any or all tests and inspections.

## **4.2 Quality Conformance Inspections**

### **4.2.1 Verification of Chemical Composition**

#### **4.2.1.1 Casting Alloy**

The material chemical composition shall be measured for compliance with the requirements stated in Section 3.2.1.1.1 and shall be provided for each ladle used in each casting.

#### **4.2.1.2 Weld Wire**

Vendor to supply manufacturer's material certifications showing that the chemistry of the weld wire meets the requirements of Section 3.2.1.1.2

### **4.2.2 Verification of Mechanical Properties**

The mechanical properties of the casting alloy for each heat of material must be verified for compliance with Section 3.2.1.1 by testing of specimens poured from that heat. The specimen material shall be heat treated simultaneously and in close proximity with the Wedge Castings. Each specimen shall be permanently marked to permit traceability. Test data must be referenced to the test specimen identifiers. The mechanical properties data of castings shall be supplied to PPPL within 30 days of the casting date.

#### **4.2.2.1 Verification of Yield Strength and Elastic Modulus**

The yield strength at 0.2% offset strain and the elastic (Young's) modulus shall be verified for the casting alloy in the as heat-treated condition at room temperature and 77K for each heat of material. Test specimen coupons shall be tested in accordance with ASTM A703/A703M-03, Paragraphs 6 and 7.

#### **4.2.2.2 Verification of Ultimate Tensile Strength and Elongation**

The ultimate tensile strength and elongation for the cast stainless steel in the as heat-treated condition at room temperature and 77K shall be verified for each heat of material. Tensile test specimen coupons shall be tested in accordance with ASTM A703/A703M-03, Paragraphs 6 and 7.

#### **4.2.2.3 Verification of Charpy V-Notch Energy**

The Charpy V-Notch energy of the casting alloy at room temperature and 77K shall be measured for each heat of material. Specimen coupons shall be cast and heat treated with the wedge castings and tested in accordance with ASTM A703/A703M-03, Paragraph 6.

#### **4.2.2.4 Additional Test Material**

Sufficient additional heat treated material shall be provided from every fourth wedge casting to allow NCSX to fabricate (3) specimens sized 3" x 3" x 3/4" thick. Supplied material shall be permanently marked with identification linked to the casting with which it was poured.

### **4.2.3 Verification of Surface Finish**

All machined surfaces shall be inspected for compliance with surface finish requirements specified in Section 3.2.1.3. Either a surface profilometer or comparator can be used.

#### 4.2.4 Verification of Relative Magnetic Permeability

Relative magnetic permeability shall be checked with a calibrated Severn Permeability Indicator for compliance with Section 3.2.1.4. Permeability measurements shall be per Supplementary Requirements S24 of ASTM Spec. A703/A703M and S1 of ASTM A800/A800M, except that the results shall be expressed as relative permeability,  $\mu$ ,  $\mu_r$ , rather than ferrite content (FN). Relative magnetic permeability that exceeds 1.02 must be documented on a nonconformance report and will require approval on a case-by-case basis. Permeability checks shall, at minimum, provide the following coverage:

- Cast surfaces at locations approximately 6 inches apart (to approximate a 6" x 6" grid).
- Machined surfaces at locations approximately 2 inches apart (to approximate a 2 x 2" grid).
- Accessible weld repairs at a minimum of 1 point per every 2 sq. in. of surface area.

#### 4.2.5 Verification of Dimensions and Tolerances

All cast surfaces, machined surfaces, and features shall be dimensionally checked to assure compliance with Section 3.3.2.

#### 4.2.6 Inspection for External Defects

##### 4.2.6.1 Visual Inspection

All cast surfaces shall be visually inspected to assure compliance with Section 3.2.1.5.1.

##### 4.2.6.2 Liquid Penetrant Inspections

###### 4.2.6.2.1 General Liquid Penetrant Inspection

All cast surfaces of the casting shall be liquid penetrant inspected to assure compliance with Section 3.2.1.5.2 (Liquid Penetrant Examination of Casting). Certified test reports shall be per ASTM A903, Supplementary Requirement S1. Surfaces may be prepared by abrasive blast per standard foundry procedures.

###### 4.2.6.2.2 Post Machining Liquid Penetrant Inspection

All machined surfaces shall be inspected to assure to assure compliance with Section 3.2.1.5.2 (Liquid Penetrant Examination of Casting). Certified test reports shall be per ASTM A903, Supplementary Requirement S1.

#### 4.2.7 Inspection for Internal Defects

Each casting shall be examined for internal defects as defined in ASTM Spec. A703/A703M using radiographic inspection per Supplementary Requirement S5 Acceptance criteria shall be as defined in Section 3.2.1.6.

## **5 PREPARATION FOR DELIVERY**

### **5.1 Marking**

Each casting shall have the supplier's name, a serial number (drawing number and a unique identifier), marked or stamped with characters  $\frac{1}{4}$  inches high. The marking shall be located as shown in the part drawing.

### **5.2 Cleaning**

The casting shall be degreased/cleaned using a solvent which must be able to dissolve grease, oils and other soils, and leave the casting residue free. No chips, burrs, oil, etc. shall remain in any of the tapped holes.

### **5.3 Crating**

The crate shall protect the casting from shock and weather conditions, including precipitation. The crate shall be constructed to protect the casting from being bent or warped and so that the straightness of the part is maintained. The crate shall be built for moving on rollers, handling with slings from overhead cranes, and transport by forklifts. The part shall be totally wrapped with a plastic protective film.

### **5.4 Shipping**

Supplier is responsible for arranging shipment, and for the safe arrival of the casting at PPPL in Princeton, New Jersey, USA. Subcontractor's name, shipper, purchase order number, contents and gross weight shall be marked on the shipping container.