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1 SCOPE:

This specification establishes the requirements for weld qualification and testing of LHC D2 & D4 Separation Dipoles.

2 APPLICABLE DOCUMENTS:

The following documents, of the issue in effect on the date of invitation to quote, form a part of this specification to the extent specified herein:

ASME VIII, Div 2

ASTM E1032 Standard Test Method for Radiographic Examination of Weldments

ASTM E-190 Standard Test Method for Guided Bend Test for Ductility of Welds

ASTM E8 Standard Test Methods for Tension Testing of Metallic Materials

AWS D1.6:1999

EN 10045-1

EN 1435 Non destructive examination of welds: Radiographic examination of welded joints

EN 25817

EN 875

EN 895

EN 910

EN 970 Non destructive examination of fusion welds: Visual examination

EN10002-1

ISO 148 Charpy impact test (V-notch)

ISO 5617

ISO 5817 Arc-welded joints in steel - Guidance on quality levels for imperfections

ISO 7438 Metallic Materials - Bend Test

RHIC-CR-E-4703-0041 Leak Checking Specification, Magnets, Cryostats and Associated Equipment

3 REQUIREMENTS:

3.1 Qualification Testing

The D1 and D3 magnets designed and fabricated by Brookhaven National Laboratory (BNL) were previously qualified on the basis of their similarity to RHIC magnets. The cold mass skins of the D2 and D4 beam separation dipoles employ the same weld materials and weld process as the RHIC magnets. However, they differ from

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the RHIC magnets in the geometry of the welds plus the use of a stainless steel backing strip behind the welds. For these reasons, additional testing will be conducted on the longitudinal welds of the D2 and D4 cold masses.

Qualification of the welding procedure and welders will be according to the requirements of ASME Section IX. Additional qualification testing will be performed during the D4 prototype fabrication. Testing will be performed on coupons taken from weld samples that are prepared at the time of D4 prototype welding and submitted to destructive and non-destructive tests as described in Table 1. The samples and coupons will be flat but otherwise will be of the same geometry as the longitudinal weld joint of the cold mass skin.

3.2 Production Testing:

Additional weld samples of the longitudinal weld joint will be made at the time each of the D2 and D4 magnets are welded. The materials used to make the weld samples will be the same as those of the skin and backing strip they represent. The samples will be flat but otherwise will be of the same geometry as the longitudinal weld joint of the cold mass skin, and will be welded using the same technique. The samples will be at least 600 mm along the weld and 200 mm across the weld, long enough to obtain the test coupons necessary for the required tests as well as for possible re-testing.

3.3 Procedure:

Before cutting the weld samples into coupons, the magnet ID number shall be marked on each coupon. The weld coupons shall be tested as indicated in Table 1.

4 QUALITY ASSURANCE PROVISIONS:

N/A

5 PREPARATION FOR DELIVERY:

N/A

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Table 1

Weld Qualification and production tests for D2 and D4 production twin aperture dipoles. Tests will be conducted on the D4 prototype and all D2/D4 production magnets unless otherwise noted. CERN test standards, which are comparable but not necessarily identical, are listed for reference. All tests are conducted at room temperature unless otherwise noted.

Tests	CERN Standard (for reference only)	BNL Standard	Note
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Tests on Weld Coupons

Visual inspection <i>D4 prototype</i> <i>All D2 production units</i> <i>All D4 production units</i>	EN 970 (test) ISO 5817 (acpt)	AWS D1.6:1999 (test/acpt)	1
Radiography X-ray <i>D4 prototype</i> <i>All D2 production units</i> <i>All D4 production units</i>	EN 1435 (test) ISO 5817 (acpt) EN 25817 (acpt)	ASTM E1032 (test) ISO 5817 (acpt)	2
Transverse tensile test <i>D4 prototype</i> <i>1st D2 production unit</i> <i>1st D4 production unit</i>	EN 895 (test) EN10002-1 (acpt)	ASTM E8 (test) ASME VIII, Div 2 (acpt)	3
Impact test (4.2K) <i>D4 prototype</i> <i>1st D2 production unit</i> <i>1st D4 production unit</i> <i>3 required in heat-affected zone</i> <i>3 required in welded metal</i>	EN 875 (test) ISO 148 (test) EN 10045-1 (test)	EN 875 (test) ISO 148 (test) EN 10045-1 (test)	4
Bend Test <i>D4 prototype</i> <i>1st D2 production unit</i> <i>1st D4 production unit</i>	EN 910 (test) ISO 7438 (test)	ASTM E-190 (test/acpt)	5

Table 1 (Cont'd)

**Tests on Deliverable
Magnet Units**

Tests	CERN Standard (for reference only)	BNL Standard	Note
Visual inspection	EN 970 (test) ISO 5617 (acpt)	AWS D1.6:1999 (test/acpt)	6
Leak check		RHIC-CR-E-4703-0041	7
Pressure test		ASME VIII, Div 2	8

Notes on tests listed in Table 1

1. Visual inspection of weld sample: The root pass and final pass of each weld will be inspected along its full length. BNL will specify the requirement to inspect in the Magnet Assembly Procedure and in the Traveler.
2. Radiographic x-ray: A 200mm long coupon will be cut from each weld sample and 100% inspected by x-ray.
3. Tensile test: Test coupons will be prepared from the D4 prototype, D2 first series production unit, and D4 first series production unit. Three specimens will be tested from each. Ultimate Tensile Strength (U.T.S.) must be at least equal to the minimum value specified by the ASME code (70 ksi).
4. Impact test: Test coupons will be prepared from the D4 prototype, D2 first series production unit, and D4 first series production unit. Three specimens from the weld and three from the heat-affected zone will be tested from each. The specimens will be taken from the flat plate weld samples and will measure 10 mm x 5 mm in cross section. The specimens will be impact tested at 4.2 K. The average impact energy will be 40 J/cm².
5. Bend test: Test coupons will be prepared from the D4 prototype, D2 first series production unit, and D4 first series production unit. The test will be conducted according to the standards listed in the table.
6. Visual inspection of production units: The root pass and final pass of each weld will be inspected along the full length of the magnet. BNL will specify the requirement to inspect in the Magnet Assembly Procedure and in the Traveler.
7. Leak check: Each production cold mass will be leak checked in accordance with RHIC-CR-E-4703-0041.

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8. Pressure test: Each production cold mass will be pneumatically pressurized to 25 bar (1.25 times design pressure).