

TECHNICAL SPECIFICATION RADIANT COILS

Project title : Brahmaputra Petrochemical Complex Project
Location : Lepetkata, Dibrugarh, Assam, India
Owner : Brahmaputra Cracker and Polymer Ltd. (BCPL)
Owner Ref. : -
Customer : Engineers India Limited
Customer Reference : BCPL-BPCP
Heater : 4 Gas/ Naptha Cracking Furnaces
Unit : Ethylene Cracker Unit
Item : 113-FF-101 Thru 113-FF-104
LHT Reference : 62559
Attached : PAGE 2 thru 10

Distribution	
cli	Fi/e
Kht	fa/e
Pjhb	Fi/e
At	Fi/h/ A4
Jp	Fi/e
Ompr ak	Fi/e

1	2009-11-20	Revised & issued for BDEP	OPS	AT	pjhb	 Lummus Technology a CB&I company	Lummus Technology HeatTransfer BA62559SPC1200
0	2009-09-16	Approved for design	AT	GHH	pjhb		

HEATER RADIANT TUBE COIL FABRICATION

1. SCOPE

- 1.1 This specification covers the fabrication and inspection of coils for the radiant section of heaters, including outlet parts, constructed from high alloy cast materials.

Coils will be exposed to oxidizing atmosphere of flue gases at high temperatures and may be subjected to carburizing environment of ethylene pyrolysis heaters.

- 1.2 Acceptance of this specification does not relieve the manufacturer of his responsibility to produce material to accepted industry standards and his manufacturing experience.

- 1.3 Any deviation to the design is not permitted without written approval from lummus.

2. REFERENCE SPECIFICATIONS

Applicable paragraphs of the latest revisions of the following specifications shall be followed (Vendor is deemed to be in possession of complete copies of the referenced specifications, codes and standards).

2.1 ASTM Standards:

- | | |
|-------|--|
| A 351 | Standard Specification for AUSTENITIC STEEL CASTINGS FOR HIGH TEMPERATURE SERVICES. |
| A 370 | Standards Methods and Definitions for MECHANICAL TESTING OF STEEL PRODUCTS. |
| A 608 | Standard Specification for CENTRIFUGALLY CAST IRON-CHROMIUM-NICKEL HIGH-ALLOY TUBING FOR PRESSURE APPLICATION AT HIGH TEMPERATURE. |
| E 94 | Standard guide for RADIOGRAPHIC TESTING. |
| E 142 | Standard Method for CONTROLLING QUALITY OF RADIOGRAPHIC TESTING. |
| E 165 | Standard Recommended Practice for LIQUID PENETRANT INSPECTION METHOD. |
| E 433 | Standard Reference Photographs for LIQUID PENETRANT INSPECTION. |
| E 446 | Standard Reference Radiographs for STEEL CASTINGS UP TO TWO INCHES (51 mm) IN THICKNESS. |

2.2 ASME Section V, Article 2, RADIOGRAPHIC EXAMINATION.

2.3 ASME Section VIII, Div. 1, PRESSURE VESSEL CODE.

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2.4 ASME IX WELDING AND BRAZING QUALIFICATIONS.

2.5 SNT-TC-1A PERSONNEL QUALIFICATION AND CERTIFICATION in
NONDESTRUCTIVE TESTING

2.6 EN 473 General Principles for Qualification and Certification of NDT Personnel.

3. GENERAL

3.1 The intent of this specification is to control the quality of the end product. Except for the special requirements, stated in this specification, the manufacturer has the freedom of and responsibility for selecting safe production, fabrication and inspection methods to provide satisfactory end product. However, interim Lummus inspection must be permitted.

3.2 The values stated in SI units or English units are to be regarded separately as standard. Within the text, the English units are shown in brackets. The values stated in each system are not exact equivalent; therefore, each system must be used independently of the other.

The system to be used shall be as specified in the applicable requisition.

4. MATERIAL AND MANUFACTURING REQUIREMENTS

All materials not furnished by Lummus shall be manufactured or purchased in accordance with the appropriate LUMMUS specification.

4.1 Material

4.11 All materials offered shall have proven reliability in the ethylene pyrolysis service and all materials shall be virgin.

A. ALLOY 35 Cr-45 Ni+Nb+ MICRO ALLOYED CAST TUBES AND FITTINGS

A.I. This specification covers the requirements for centrifugally cast tubes and statically cast fittings containing 35% Chromium-45% Nickel and strengthened with Niobium (Nb) and additional elements.

A.II. Chemical Composition in Weight Percent

	Cr*	Ni*	Nb	W*	Si	C	Mn	S	P	Mo	Pb As Zn Sn	Cu	Al
MIN	30	40	0.5	--	1.2	0.40	**	--	--	--	(each)	--	--
MAX	37	47	1.5	0.3	1.8	0.60	1.5	0.03	0.03	0.5	100ppm	0.25	0.05

* LUMMUS recognizes that different suppliers prefer and have experience with different ranges for chromium, nickel, titanium, tungsten, zirconium and micro elements. Bidders shall submit the composition they prefer and recommend to LUMMUS for approval.

Bidder's proprietary alloys, including their chemical composition range, may be accepted after LUMMUS approval.

** Ten times amount of lower case sulfur.

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Alloy for both tubes and fittings shall satisfy requirements of the following tests. Specimens for tests of tube alloy shall be taken from centrifugally cast tubes:

A.IV. Room Temperature Tension Test in accordance with ASTM A 370.

Ultimate Tensile Stress Min.	: 440 MPa (64000 psi)
Yield Stress Min.	: 235 MPa (34000 psi)
Elongation Percent Min. (L = 4 D)	: Centrifugal castings: 5 Static castings: 3.

A.V. Testing required shall be done on the first 10 production heats for both centrifugal and static castings. Thereafter, 10% of all heats used for centrifugally cast tubes shall be tested and 20% of all heats for static castings. If a specimen fails to meet the requirements, then two retests shall be performed. If either retest fails to meet the requirements of this specification, then the heat is rejected and the frequency of testing shall be doubled. If two heats are rejected, then 100% testing is required.**A.VI. Stress-rupture test shall be performed on 5% of the heats, (unless agreed otherwise with vendor) used for centrifugally cast tubes and static castings (minimum one each) in accordance with ASTM A 608 S3 modified as follows:**

Test condition shall be 1100°C (2012°F) and constant stress of 16 MPa (2320 psi).

Test duration to be minimum 120 hrs. Rupture shall not occur before 100 hrs. In case of failure before 100 hrs the test frequency shall be doubled and the failed heat shall be rejected.

The actual time to rupture of all tests shall be documented (if rupture occurs within 120 hrs)

B. ALLOY 25 Cr-35 Ni+Nb MICRO ALLOYED CAST TUBES AND FITTINGS**B.I. This specification covers the requirements for centrifugally cast tubes and statically cast fittings containing 25% Chromium - 35% Nickel and strengthened with Niobium (Nb) and micro-alloys.****B.II. Chemical Composition*(weight percent)**

	Cr	Ni	Nb*	W*	Si	C	Mn	S	P	Mo*	Pb As Zn Sn	Cu	Al
MIN	24.0	34.0	0.8	---	**	0.37	***	--	--	--	(each)	--	--
MAX	27.0	37.0	1.2	0.3		0.5	1.5	0.03 0	0.030	0.5	100ppm	0.25	0.05

* LUMMUS recognizes that different suppliers prefer and have experience with different ranges for niobium, titanium, tungsten, zirconium, molybdenum and micro elements. Bidders shall submit the composition they prefer and recommend to LUMMUS for approval and agreement.
Bidders proprietary alloy, including their chemical composition range, may be accepted after LUMMUS approval.

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- ** Silicon content for radiant tubes shall be from 1.5 to 2.0%.
Silicon content for static castings may be from 1.25 to 1.75%.
Silicon content for reformer tubes shall be from 1.0 to 1.75%.

*** Ten times amount of lower case sulfur.

B.III. Testing

Alloy for both tubes and fittings shall satisfy requirements of the following tests. Specimens for tests of tube alloy shall be taken from centrifugally cast tubes:

B.IV. Room Temperature Tension Test in accordance with ASTM A 370.

Ultimate Tensile Stress Min.	:	450 MPa (65000 psi)
Yield Stress Min.	:	240 MPa (35000 psi)
Elongation Percent Min.	:	Centrifugal castings: 8
(L = 4 D)		Static castings: 6

B.V. Testing required shall be done on the first 10 production heats for both centrifugal and static castings. Thereafter, 10% of all heats used for centrifugally cast tubes shall be tested and 20% of all heats for static castings. If a specimen fails to meet the requirements, then two retests shall be performed. If either retest fails to meet the requirements of this specification, then the heat is rejected and the frequency of testing shall be doubled. If two heats are rejected, then 100% testing is required.

B.VI. Stress rupture test shall be performed on 5% of the heats (unless agreed otherwise with Vendor) used for centrifugal cast tubes and static castings (minimum one each) in accordance with ASTM A 608 S3 modified as follows:

Test condition shall be 1100⁰C (2012⁰C) and constant stress of 17 Mpa (2465 psi).

Test duration to be 120 hrs. Rupture shall not occur before 100 hrs. In case of failure before 100 hrs the test frequency shall be doubled and the failed heat shall be rejected.

The actual time to rupture of all tests shall be documented (if rupture occurs within 120 hrs)

4.2 Tubes

4.2.1 Tubes covered by this specification shall be made by centrifugally cast method in accordance with the requirements of ASTM A 608.

4.2.2 All tubes shall be furnished with machined or honed bores. The preferred method of metal removal may be either pull bar boring or honing at the manufacturer's option. The boring or honing tool shall pilot on the as-cast bore to assure equal metal removal from each side of the tube and concentric boring. The amount of metal removal shall not be less than 1.2 mm (0.05 inch) and shall be adequate to assure an inside surface essentially free of shrinkage porosity. Inspection shall be by liquid penetrant in accordance with Paragraph 9.

4.2.3 Tubes for ethylene heaters shall have maximum columnar structure (to be discussed with Vendor). Macro examination of the etch-ring shall be performed on 10% of all tube heats. The rings shall be taken from the cold end.

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4.3 Fittings

4.3.1 Fittings shall be statically cast in accordance with the requirements of ASTM A 351.

4.3.2 Modifications to the design of the fittings required by the intended casting technique must be outlined and approved by LUMMUS.

4.4 Qualification

4.4.1 Casting manufacturer shall be qualified and approved by LUMMUS.

4.4.2 Vendor must include technical data and application references with his quotation to obtain qualifications, unless the quoted alloy has previously been satisfactorily supplied to this specification.
Technical data shall include actual stress rupture test results, at different temperatures and stresses and the chemical composition range (min. and max. values) of his proprietary alloy.

4.5 DESIGN OF FITTINGS AND WELD BEVEL

4.5.1 Fittings with support lugs shall have the lugs integrally cast with the fitting. Where lug and fitting are of such a size requiring welding to join the two components, the design of the butt weld shall be such that a valid radiograph can be made.

4.5.2 The back wall of the U-bend and elbow fittings shall be within the tolerances as specified.

4.5.3 The weld preparation shown on the design drawing are for information only. The vendor shall use his preferred weld preparation depending on his standard and welding process to be used subject to LUMMUS approval. The thickness at the weld preparation shall not be less than the required minimum sound wall thickness.

4.5.4 The weld bevel for field welded joints shall be as detailed on design drawings. If not indicated, it shall consist of 37.5° bevel with 1.6 mm (1/16 inch) land for wall thickness up to 16 mm (5/8 inch). For thickness over this limit, the weld bevel dimension shall be provided by Lummus.

4.5.5 Vendor design drawings must be approved by LUMMUS for each of the proposed fittings before production begins. The drawings shall include the estimated weight of each fitting.

4.6 All material substitutes must be approved in writing by LUMMUS.

4.7 Allowable stresses of applied materials at design temperature shall be such that the specified wall thickness is respected.

4.8 All materials offered shall have proven reliability in the ethylene pyrolysis service and all materials shall be virgin

5. DIMENSIONAL TOLERANCES

5.1 Dimensional tolerances not indicated on the design drawings and/or defined by Technical Specifications shall be within limits indicated by the referenced ASTM Specifications.

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- 5.2. The maximum tube wall thickness shall not exceed the specified minimum wall thickness by more than 1.6 mm (1/16 inch).
- 5.3 The tolerance on the outside diameter of tubes shall be as follows:
+ 2.0/-0 mm (+0.08/-0 inch) for OD $\leq$ 152 mm (6 inch)
+ 2.5/-0 mm (+0.10/-0 inch) for OD > 152 mm (6 inch)
- 5.4 The surface finish of internally machined tubes shall be Ra 3.2 μ m (125 rms) or smoother.
- 5.5 Eccentricity for machined tubes (maximum wall thickness minus minimum wall thickness) shall not exceed 0.8 mm (0.03 inch).
- 5.6 The roughness depth on the outside surface of the tube shall not exceed 0.8 mm (0.03 inch) Peak to valley. the finish shall have a uniform appearance throughout the full length of the tube and the tolerance on eccentricity shall not exceed 0.05 time the wall thickness
- 5.7 Smooth surface is required for statically cast parts.
- 5.8 Bow (deviation from straight line) in any tube shall not exceed 6 mm (1/4 inch) for each 3 m (10 ft) of length.
- 6.0 WELDING
- 6.1 All welds shall have complete fusion at the root. The internal surface shall be free of oxide and have smooth contour. Where possible the root shall be machined flush with the ID. Minor concavity not exceeding the crown reinforcement or up to 1.6 mm (1/16 inch) projection is acceptable. Completed welds shall have a maximum crown reinforcement of 1.6 mm (1/16 inch). The cover pass and the base metal adjacent to all welds shall be suitable for liquid penetrant examination. When the outside surface of the tubes is not suitable, it may be machined to sound metal when making the weld preparation (see 6.6).
- 6.2. All welding, including nonpressure welds and tackwelding, shall be performed by welders qualified under ASME IX and paragraph 6.1 of this specification.
- 6.3 The deposited weld metal for welds of similar metals shall be as close as possible to the chemical requirements and to the physical characteristics of the base metal, except that the silicon content (and for alloy 20 Cr-32Ni-0.1C the Mn content) may be varied as required to produce sound welds.
- 6.3.1 Weld metal used for welding 20 Cr-32 Ni-0.1C) should preferably have 4-5% Mn to prevent hot cracking.
- 6.4 The deposited metal for welds between dissimilar metals shall provide the ductility required by differential thermal expansion of the parent metals and still provide the strength required for the joint.
- 6.4.1 For dissimilar welds of nozzles or guides, ERNiCr-3/ENiCrFe-2 type filler metals shall be used.
- 6.4.2 For dissimilar welds requiring full strength at high temperature (over 760°C/1400°F) such as coil support lugs, a filler metal shall be used which develops a higher strength at temperature of the weaker of the two parent metals.

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6.4.4 Filler metals type ERNiCrMo-3/ENiCrMo-3 and type ERNiCrCoMo-1/EniCrCoMo-1 shall not be used in the temperature range of 600° - 800°C (1100° - 1480°F).

6.5 The weld preparations shown on the design drawing are for information only. The vendor, , shall use his preferred weld preparation based on the application and welding process. The thickness at the weld preparation shall not be less than the required minimum sound wall thickness.

The weld bevel for field welded joints shall be as detailed on design drawings. If not indicated, it shall consist of 37-1/2° bevel with 1.6 mm (1/16 inch) land and assumed 3.2 mm (1/8 inch) land gap for wall thickness up to 16 mm (5/8 inch). For thickness over this limit, the dimensions of the weld bevel shall be provided by Lummus.

6.6 The back-machining of the outside of tubes at the location of the weld bevels shall not go beyond the minimum sound wall thickness specified (minimum wall minus 0.8 mm (0.03 inch)).

6.7 Permanent backing ring shall not be used.

6.8 Repair welding shall be performed in accordance with an approved repair procedure.

7. INSPECTION – GENERAL

7.1 The intent of all inspection and testing during manufacturing is to assure conformance to this specification and to sound engineering practice. Responsibility for quality shall remain with the manufacturer.

7.2 The inspection and testing required by this specification are the minimum to be performed by the vendor. The Inspector must be permitted to witness any or all of this inspection and testing. The Inspector will, at all times, conduct these examinations with the least possible interruption of the vendor's shop activities.

7.3 The inspector has the right to have additional inspection performed ,If a rejectable defect is found, the vendor shall bear the cost for this additional inspection, the cost of repair or replacement and any additional inspection and repair/ replacement required by this specification.

7.4 Cancelled.

7.5 Documentation certifying that all of the required inspections and tests have been performed by the vendor must be made available to the Inspector.

7.6 All non-destructive examinations shall be performed by personnel qualified in accordance with SNT-TC-1A or EN 473. Interpretations shall only be performed by personnel qualified in accordance with SNT-TC-1A level 2 or 3 or EN 473 level 2 or 3.

8. VISUAL INSPECTION

8.1 The inside surfaces of all welds shall be examined by borescope. If incomplete or excessive penetration or lack of fusion is found, the welds shall be rejected.

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- 8.2 Visual and dimensional inspection of the coil shall be performed in conformance with Purchase Order, special requirements, design drawing and dimensional tolerances of paragraph 5 of this technical specification.
9. LIQUID PENETRANT INSPECTION
- 9.1 The root pass of all pressure retaining full penetration manual welds and all completed welds, including attachment of drains, guides, thermowells and support lugs shall be examined by liquid penetrant inspection. This examination may be in the as-welded condition if surface condition is smooth enough. Questionable areas may be ground to give clear results.
- 9.2 Testing method shall be in accordance with ASTM E 165.
- Acceptance criteria shall be as per ASME VIII, Div. 1, Appendix 8.
10. RADIOGRAPHY
- 10.1 All pressure retaining butt joint welds shall be 100% radiographed in accordance with ASTM E 94. Sensitivity shall be sufficient to display the Image Quality Indicator (IQI) and specified hole or equivalent wire. IQI selection shall be in accordance with ASME, section V, article 2.
- 10.2 If panoramic exposure arrangement, with Ir 192 is used, the source size shall be limited to 1 x 1 mm (0.04 x 0.04 inch) maximum.
- 10.3 Film used shall be fine grain type like Kodak M, Agfa D4 or equivalent (E 94 – 83 type 1).
- 10.4 Acceptance criteria shall be as per ASME VIII, Div. 1, paragraph UW-51.
- 11.0 CANCELLED
12. HYDROSTATIC TEST
- 12.1 Each completed assembly shall be hydrostatically tested before shipment. The test pressure shall be as specified by design drawings.
- 12.2 Test pressure shall be held for a minimum of 15 minutes. Where there is any doubt of casting quality, the time shall be increased to 30 minutes.
- 12.3 Where a coil contains connections or flanges which are not suitable for the required test pressure, they shall be isolated with test plugs or other suitable means. the test pressure shall not be reduced to accommodate such conditions.
- 12.4 Test shall be performed at normal ambient temperature, using clean water containing no more than 25 ppm of chlorides or other contaminants which may cause stress corrosion in stainless steel.

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13. CLEANING

- 13.1 The exterior of the completed coil shall be cleaned by shotblasting or equivalent means to ensure complete removal of all welding splatter, flux, slag and dye-penetrant developer.
- 13.2 The interior of the coil shall be clean and free of all test water or any foreign material. All openings shall be closed to prevent entry of any foreign objects.
- 13.3 All surfaces shall be free of coatings, lubricants and markings, which may be detrimental to metal exposed to high temperatures.

14. MARKING

- 14.1 Each coil or coil section shall be permanently identified by legible stamping its unique number on the bottom end of one of the guide tubes, the inlet manifold lug or the outlet T-piece.
Unique numbers shall enable full traceability to the manufacturer Data Books.

In addition, each coil section shall be conspicuously marked with its piece mark number for temporary identification. The marking paint, chalk or crayon shall be free of ingredients such as sulfur compounds, lead compounds, aluminum pigments, vanadium compounds (vanadates), metallic zinc and chlorides which are injurious to austenitic metal at high temperature. Commonly, acceptable marking paints have a titanium oxide pigment in an alkyd base (nonsulfur) and frequently have a calcium carbonate filler.

15. PACKING

- 15.1 The shipper, normally the fabricator, shall ensure that the coil is adequately supported and packaged for the method of shipping intended and safe, normal handling. This shall include adequate protection of all appendages such as guide tubes and thermowells and all machined surfaces and field weld bevels.
- 15.2 The packaging and shipment intended shall be reviewed with Lummus. Responsibility for adequate packaging remains with the shipper.
- 15.3 Shipping requirements as specified in the purchase order shall be adhered to.