



SHELL AND TUBE HEAT EXCHANGER SPECIFICATION ADDENDA TO ANSI/API STANDARD 660

FOR THE CARTAGENA REFINERY EXPANSION PROJECT

CB&I CONTRACT NO. 166000

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	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refineria de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 2 of 18

TABLE OF CONTENTS

1	SCOPE.....	3
3	TERMS AND DEFINITIONS	3
4	GENERAL	3
5	PROPOSALS.....	4
6	DRAWINGS AND OTHER REQUIRED DATA.....	4
7	DESIGN.....	4
8	MATERIALS	14
9	FABRICATION.....	14
10	INSPECTION FOR TESTING	16
11	PREPARATION FOR SHIPMENT	17
12	SUPPLEMENTAL REQUIREMENTS.....	18

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 3 of 18

1 SCOPE

(Add) This "SHELL AND TUBE HEAT EXCHANGER SPECIFICATION ADDENDA TO ANSI/API STANDARD 660", 000-SP-ME07-0005 (addenda) modifies SHELL-AND-TUBE HEAT EXCHANGERS ANSI/API STANDARD 660 EIGHTH EDITION, AUGUST 2007 (standard). Subclauses in the standard which are not modified shall be read in conjunction.

Instructions shall be interpreted as follows:

(Add)	This subclause shall be read as a continuation of the referenced subclause.
(Substitute)	This subclause replaces the referenced subclause.
(Revise)	This subclause revises the referenced subclause or a phrase.
(Delete)	This deletes the reference subclause or phrase.
(New)	This is an added subclause.
(Decision)	This subclause makes an API required decision or provides information.

3 TERMS AND DEFINITIONS

3.11 (Substitute) The pressure design code is the 2007 Edition of ASME Section VIII Div. 1.

4 GENERAL

4.1 (Decision) The pressure design code is the 2007 Edition of ASME Section VIII Div. 1.

4.3 (Decision) Local regulations are the current Laws of the Republic of Colombia.

4.8 (New) The seller shall guarantee the thermal and hydraulic performance of the heat exchanger. In all cases, the thermal performance shall be the seller's responsibility, even when the exchanger was initially designed by the purchaser. If, in the opinion of the purchaser, the heat exchanger does not meet the requirements, a performance test will be conducted. The seller will be advised of the test, and may witness, or participate. If the heat exchanger does not meet the requirements, it shall be modified or replaced, FOB the job site, to the satisfaction of, and at no cost to, the purchaser.

The seller shall guarantee that no damage will occur due to flow-induced vibration. The seller shall modify, repair, or replace without charge any damage due to flow-induced vibration found within the guarantee period.

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 4 of 18

- 4.9 (New) The seller shall guarantee the heat exchanger against defects of material and workmanship and warrant that the materials used in the manufacture of the heat exchanger, meet the physical and chemical requirements, and are free from injurious defects. All defects shall be repaired or replaced to the satisfaction of, and at no cost to, the purchaser.

5 PROPOSALS

- 5.7 b) (Substitute) Two spare sets of gaskets per heat-exchanger unit plus 10% spare bolts/nuts per unit.

6 DRAWINGS AND OTHER REQUIRED DATA

6.1 Outline Drawings and Other Supporting Data

- 6.1.2 (Decision) The seller shall submit calculations to verify that the exchanger will not have damage caused by flow-induced vibration.

6.2 Information Required after Outline Drawings are Reviewed

- 6.2.2 (Decision) Qualified welding procedure specifications and procedure qualification records as required by the pressure design code shall be submitted for review.

- 6.2.5 (Decision) Seller shall submit design calculations for supports or lifting and pulling devices.

- 6.3 (Decision) Formats and quantities of the following documents will be specified on the seller Data Requirements form in the requisition package.

7 DESIGN

7.1 Design Temperature

- 7.1.1 (Decision) Maximum design temperatures and minimum design metal temperatures shall be specified on data sheet.

- 7.1.3 (Decision) If purchaser requires an expansion joint, purchaser shall supply input data needed for expansion joint design.

- 7.1.4 (New) The maximum metal temperature in contact with cooling water is 130 °F (266 °C).

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	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 5 of 18

7.1.5 (New) Design temperature for cooling water service is 366 °F (185.6 °C).

7.1.6 (New) Cooling water design pressure shall be 120 psig (827.37 kPag), if not considering the 1/1.3 rule.

7.2 Cladding for Corrosion Allowance

7.2.2 (Revise) Cladding thickness shall be per 166000-000-SP-ME07-0006, Heat Exchanger Material Specification.

7.2.3 (New) The method of lining of nozzles and manways shall be integrally bonded cladding or weld deposit overlay, unless otherwise agreed by the contractor.

7.2.4 (New) Minimum nozzle size for cladding is NPS 2 (DN 50).

7.2.5 (New) The weld overlay of nozzles shall be made of 2 passes minimum.

7.3 Shell Supports

7.3.5 (Add) Slotted holes shall be located opposite the channel inlet end unless otherwise noted on the outline drawings.

By usage of UBC-1997 and "Structural Design Criteria, document No. 000-SP-CS07-0001", civil design shall be in full compliance with the Colombian Norm NSR-98.

7.3.6 (New) Prevailing winds are from north to south. Wind design shall be in accordance with the provisions of UBC 1997.

Basic wind speed = 80 mph (35.76 m/s)

Importance factor, I = 1.15

Exposure = D

7.3.7 (New) Seismic design shall be in accordance with the provisions of the Uniform Building Code, 1997 Edition. By usage of UBC-1997 and "Structural Design Criteria, document No. 000-SP-CS07-0001", civil design will be in full compliance with the Colombian Norm NSR-98.

Soils Profile Type = SD

Seismic Zone Factor Z = 0.15 (Zone 2A)

Importance Factor, I = 1.25, Ip = 1.5

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 6 of 18

- 7.3.8 (New) Stresses for horizontal vessel supports shall be calculated in accordance with TEMA (8th edition), Section 10, Paragraph RGP-G-7.11. Stresses for vertical vessel supports shall be calculated in accordance with TEMA (8th edition), Section 10, RGP-G-7.12.
- 7.3.9 (New) Lug-supported exchangers shall have stresses in the shell evaluated for the effects of local loadings from the support lugs using WRC Bulletin 107. Acceptance criteria shall be in accordance with the 2004 Edition of ASME Section VIII with 2006 addendum, Division 2, Appendix 4, Figure 4-130.1. Also include seismic and wind loads.
- 7.3.10 (New) Electrical grounding lugs shall be furnished on each support. Fabricate lug from 0.375 in (9 mm) plate, with a 0.56 in (14 mm) hole.
- 7.3.11 (New) For design temperatures lower than -20.2 °F (-29 °C), the support saddles and brackets shall be made of the same material as the exchanger.
- 7.3.12 (New) Equipment working at a temperature below 14 °F (-10 °C) shall be provided with wooden pillows to prevent direct contact with foundations.

7.6 Tube Bundle

7.6.1 Tubes

- 7.6.1.1 (Substitute) The outside diameter of the tubes shall be 3/4 in (19.05 mm) unless otherwise specified or approved by the purchaser.
- 7.6.1.2 (Substitute) Minimum tube outside diameter is given in Table 1. The tube-wall thickness shall be as listed in Table 1, or thicker if required by the design conditions, such as high pressure applications:

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 7 of 18

Table 1 – Minimum Outside Diameter And Wall Thickness Of Tubes

Dimensions in inches (millimetres)

Tube material	Tube OD	Minimum wall thickness ^a
Carbon steel and low-alloy steel (up to and including 5 Cr – ½ Mo)	¾ (19.05)	0.083 (2.11)
		0.109 (2.77) ^b
Non-ferrous (Admiralty, Cu-Ni, etc.)	¾ (19.05)	0.083 (2.11)
High alloy (above 5 Cr – ½ Mo and up through austenitic stainless steel), super high alloys (Incoloy, Titanium, etc.)	¾ (19.05)	0.065 (1.65)
^a For low-fin tubing, this shall be the minimum thickness at the root diameter		
^b Minimum wall thickness for 1 in (25.4 mm) OD CS or low-alloy steel tube		

- 7.6.1.4 (New) Maximum and preferred nominal straight tube length is 20 ft (6.10 m). Shorter tube lengths may be specified to meet design constraints.
- 7.6.1.5 (New) Seamless tubes are required for lethal service, or with design pressures exceeding 1 000 psig (6 894 kPag).
- 7.6.1.6 (New) Welded Hastelloy tubes shall be cold-drawn; “bead working” is not permitted.
- 7.6.1.7 (New) Do not fin the U-bend section of low fin tubes when the bend radius is less than 4 times the tube’s outside diameter.
- 7.6.1.8 (New) Preferred tube metallurgy for treated and inhibited fresh cooling water service is killed carbon steel.
- 7.6.1.9 (New) Maximum tube wall temperature in cooling water service is limited to 130 °F (54.4 °C).
- 7.6.1.10 (New) Square tube pitch may be specified when the shell side fouling factor is equal or greater than 0.002 h-ft²-°F/Btu (0.000352 m²-K/W), low shell side pressure drop services, boiling services, or the strength welded tube-to-tubesheet joint is required. Triangular pitch may be specified for certain clean services when the shell side fouling factor is less than 0.002 h-ft²-°F/Btu (0.000352 m²-K/W).

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refineria de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 8 of 18

7.6.1.11 (New) U-tubes may be specified when the fouling factor on the tube side is less than 0.002 h-ft²-°F/Btu (0.000352 m²-K/W) or if required by the process fluid on the shell side, such as hydrogen and HF acid services. For fouling services [tube side fouling > 0.002 h-ft²-°F/Btu (0.000352 m²-K/W)] and cooling water services in the tube side, floating head construction will normally be specified.

7.6.1.12 (New) Flow induced vibration analysis shall be performed on all high alloy tube bundles.

7.6.1.13 (New) Minimum acceptable tube pitch for ¾ in (19.05 mm) tubes shall be 1 in (25.4 mm) for square pitch and 15/16 in (19.05 mm) for triangular pitch.

7.6.2 Tubesheets

7.6.2.4 (Delete) “Or tapped tubesheet holes”

7.6.2.5 (New) For forged hubs on tubesheets, the minimum diametral distance between the inside diameter of the cylinder and the outermost tube, in inches, is:

- a) $(2) (R_h) + 0.5$ (Expanded joint, hub on tube side of tubesheet)
 - b) $(2) (R_h) + 0.5 + (2 \times tw)$ (Welded joint, hub on tube side of tubesheet)
 - c) $(2) (R_h) + 0.5$ (hub on shell side of tubesheet)
- R_h = Radius of hub, inches
 tw = Minimum tube wall thickness, inches

7.6.3 Baffles and Support Plates

7.6.3.4 (New) For welded-in longitudinal baffles, use the equation in TEMA (8th edition), Section 5, Paragraph RCB-9.132 to calculate the baffle thickness. Multiply calculated thickness by 1.2 as a safety factor. Longitudinal baffles shall not be less than ¼ in (6.4 mm) nominal metal thickness.

7.6.3.5 (New) For low fin tubes, the tube holes in the baffles shall be 1/64 in (0.4 mm) larger than the nominal tube diameter.

7.6.3.6 (New) The end baffle spaces shall be greater than or equal to the central baffle spaces.

7.6.3.7 (New) When baffle cuts include a portion of the inlet/outlet nozzle knockout areas, ears shall be provided to block bypass.

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 9 of 18

7.6.4 Impingement Protection

7.6.4.7 (New) If impingement rods are specified, a minimum of two offset rows of rods are required.

7.6.5 Bypass-Sealing Devices

7.6.5.9 (New) Dummy tubes shall be sealed at one end.

7.6.6 Bundle Skid Bars

7.6.6.3 (New) Sliding surfaces shall be properly seated in the baffles, secured with a complete seal weld and attached to the stationary tube sheet with a fillet weld. Sliding strips shall protrude 0.075 in (1.91 mm) beyond the periphery of the baffles. Vertical exchangers shall be provided with four sliding strips evenly placed around the circumference of the bundle. When mechanical cleaning is required on the shell side (square pitch patterns), the sliding strips shall not obstruct the tube lanes or pass partition.

7.6.7 Tube-to-Tubesheet Joint

7.6.7.1 (New) "Rolled-only" tubes shall project 1/8 in (3.175 mm) beyond the tube side face of the tubesheet of horizontal units.

7.7 Nozzles and Other Connections

7.7.1 (Decision) Minimum connection size shall be NPS 2 (DN 50) 150# minimum. All connections shall be flanged. The required flange design code is ASME B16.5.

7.7.4 Flanged connections shall be one of the following types:

7.7.4 b) (Substitute) Seamless pipe or forged cylinder welded to forged welding-neck flange;

7.7.4 c) (Substitute) Seamless pipe welded to a forged slip-on flange, except as noted in 7.7.5.

7.7.5 Slip-on flanges shall not be used in any of the following conditions:

7.7.5 f) (New) flange ratings greater than 150#.

7.7.9 (Decision) The design of connections shall be suitable to withstand the loads and moments specified in the following table:

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 	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
		Revision: 4
		Date: 07-Jan-11
		Page: Page 10 of 18

The designations and directions of forces and moments are referred to TEMA (8th edition), Section 5, Paragraph RGP-RCB 10.

NS = Nozzle Size

Nozzle Size NPS (DN)	Forces lbf (N)			Moments ft·lbf (N·m)		
	<i>P</i>	<i>V_L</i>	<i>V_c</i>	<i>M_r</i>	<i>M_L</i>	<i>M_c</i>
2 (50) and 3 (80)	600 (2 669)	600 (2 669)	600 (2 669)	600 (814)	600 (814)	600 (814)
4 (100)	1 000 (4 448)	1 000 (4 448)	1 000 (4 448)	1 200 (1 627)	1 200 (1 627)	1 000 (1 356)
6 (150)	1 800 (8 007)	1 500 (6 672)	1 500 (6 672)	3 000 (4 067)	3 150 (4 271)	2 700 (3 661)
8 (200)	3 000 (13 345)	2 400 (10 676)	2 400 (10 676)	6 000 (8 135)	4 500 (6 101)	4 500 (6 101)
10 (250)	4 000 (17 793)	3 000 (13 345)	3 000 (13 345)	6 000 (8 135)	6 000 (8 135)	5 000 (6 779)
12 (300)	4 500 (20 017)	4 000 (17 793)	4 000 (17 793)	6 000 (8 135)	7 500 (10 169)	6 200 (8 406)
14 (350)	5 000 (22 241)	5 000 (22 241)	5 000 (22 241)	7 000 (9 491)	8 000 (10 847)	7 500 (10 169)
16 (400)	5 800 (25 800)	5 800 (25 800)	5 800 (25 800)	7 500 (10 169)	9 000 (12 202)	8 500 (11 524)
18 (450)	6 500 (28 913)	6 500 (28 913)	6 500 (28 913)	8 300 (11 253)	9 800 (13 287)	9 300 (12 609)
20 (500)	7 000 (31 138)	7 000 (31 138)	7 000 (31 138)	9 200 (12 474)	10 500 (14 236)	10 200 (13 829)
24 (600)	7 700 (34 251)	7 700 (34 251)	7 700 (34 251)	10 500 (14 236)	12 500 (16 948)	11 900 (16 134)
26 (650)	9 240 (41 102)	9 240 (41 102)	9 240 (41 102)	12 600 (17 083)	15 000 (20 337)	14 200 (19 253)
Larger than 26 (650)	355 x NS (63.2 x NS)	355 x NS (63.2 x NS)	355 x NS (63.2 x NS)	485 x NS (86.3 x NS)	577 x NS (102.7 x NS)	546 x NS (97.15 x NS)

a) All the loadings are acting simultaneously on nozzles.

b) The maximum combined stresses, including the pressure stress, shall not exceed 0.8 x yield strength at the design temperature or the specified temperatures for the special cases.

c) If reinforcement pads are required, seller shall also include the calculations at the OD of the pads, but the combined stresses shall not exceed 3 x allowable stress.

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	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 11 of 18

d) Seller to submit their nozzle loading calculations of WRC-107 for review and approval.

e) Seller to submit their nozzle loading calculations of WRC-107 for the special cases requested with the specified pressures and temperatures.

- 7.7.10 (New) Flanged nozzle projection shall be at least 8 in (203.2 mm) from outside of shell/channel to the flange face. This distance shall be increased to allow the sufficient clearance when insulation is required. The projection of auxiliary nozzles shall extend beyond the insulation. The bolts at auxiliary nozzles shall not interfere with insulation when being installed or removed.
- 7.7.11 (New) Unless otherwise required by the Licensor or Reficar, for single shell, one pressure gauge connection NPS 2 (DN 50) 150# minimum RFLWN shall be installed on the connecting pipe.
- 7.7.12 (New) Unless otherwise required by the Licensor or Reficar, for single shell, one thermowell connection NPS 2 (DN 50) 300# minimum RFLWN shall be installed on the connecting pipe.
- 7.7.13 (New) Hillside nozzles shall have the minimum projection measured on the short side.
- 7.7.14 (New) Unless otherwise required by the Licensor or Reficar, for stacked shells, vendor to provide pressure gauge and thermowell connections on the intermediate nozzles of the bottom shell. All other process nozzles in the stacked unit shall have the pressure gauge and thermowell connections in the connecting pipes.
- 7.7.15 (New) Reinforcing pads shall not be used for cyclic service.
- 7.7.16 (New) For vertical exchangers, high point vents and low point drains shall be provided on the shell side of the stationary tubesheets. Connections shall be $\frac{3}{4}$ in (19.05 mm) flanged with blind.
- 7.7.17 (New) When a corrosion allowance greater than 1/8 in (3.18 mm) is specified, the seller shall verify the thickness of standard blind flanges.
- 7.7.18 (New) Reinforcing plates and pads shall have rounded corners. Minimum radius shall be 2 in (50.8 mm).
- 7.7.19 (New) All nozzles shall be set-in type, unless otherwise specifically accepted.
- 7.7.20 (New) Nozzles thicker than 1.5 in (38.1 mm) shall be self-reinforcing type.

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	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 12 of 18

7.8 Flanged External Girth Joints

- 7.8.4 (Add) To facilitate breaking of the gasket joint of the main girth flanges when the assembled flanges have a clearance less than 3/16 in (4.77 mm) at their periphery, either of the two following methods shall be employed:

Jack screws shall be provided on one of each pair of main girth flanges. At the periphery of the male flange, a cutback of 3/16 in (4.77 mm) to a depth of approximately 5/16 in (7.94 mm) shall be made.

- 7.8.7 (Decision) Flanges with 1.5 in (38.1 mm) or larger bolts shall be designed with bolt tensioner. The studs shall extend at least one stud diameter beyond the nut.
- 7.8.10 (New) The pass rib contact area shall be in accordance with TEMA (8th edition), Section 10, Paragraph RGP-RCB-11.7.

7.9 Expansion Joints

- 7.9.1 (Substitute) Expansion joints shall be thin-wall bellows only at the internal floating head of one tube pass units. Shell side expansion joints on fixed tubesheet exchangers shall be flanged and flued.
- 7.9.2 c) (Revise sentence 2) In no case shall the cycle life, as calculated by EJMA, be less than 3 000 normal operating cycles.
- 7.9.3 (New) Normal operation in the clean or fouled condition, start-up, upset, shutdown, and failure of fluid on the shell side shall be the conditions investigated to justify the necessity of an expansion joint.

7.10 Gaskets

- 7.10.10 (New) The gasket for the floating tubesheet shall be solid flat metal or kammprofile. Nubbins shall not be used.

7.11 Handling Devices

- 7.11.15 (New) Based on available pulling and lifting equipment, maximum bundle size should not exceed 60 in (1.524 m) diameter with a maximum weight of 44 000 lb (19 958 kg). These limitations do not apply to vertical combined feed exchangers, vertical reboilers, or fixed tubesheet type exchangers.

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 13 of 18

7.12 Hydrogen Service

(Decision) Hydrogen service will be specified on data sheet.

7.13 (New) Kettle Type Shells

- 7.13.1 (New) If a weir plate is required, the weir plate shall be continuously welded to the shell inside diameter and shall contain no drain holes. For kettle exchangers with a shell side fouling factor greater than 0.001 h-ft²-°F/Btu (0.000176 m²-K/W), provide a manway [24 in (609.6 mm) minimum inside diameter] in the shell beyond the weir. The manway shall be provided on the side of the vessel below the centre horizontal line.
- 7.13.2 (New) For kettle type exchangers with the tubesheet welded to the shell, provide a 3 in (75 mm) minimum cylindrical section between the tubesheet and the conical transition. The crevice between the tubesheet and the cylindrical section shall be seal welded.
- 7.13.3 (New) Skid bars welded to the shell inside diameter shall be provided to support and guide the tube bundle. For fixed tubesheet and U-tube kettles, the skid bars shall be designed to keep the bundle from rotating during tube installation and/or shipment.
- 7.13.4 (New) For kettles with removable bundles, a bundle hold-down shall be provided to protect the bundle from damage during shipment and erection. Refer to TEMA (8th edition), Section 5 Paragraph RCB-4.9.
- 7.13.5 (New) Horizontal kettles 10 ft (3.05 m) and longer shall have one NPS 6 (DN 150) blinded ventilation nozzle on the top near the head.
- 7.13.6 (New) Liquid level transmitter connections are required on all kettles and shall be NPS 2 (DN 50) minimum 300# RF flanged.
- 7.13.7 (New) Maximum tube wall temperature in cooling service is 130 °F (54.4 °C) in normal operation.

7.14 (New) Fouling Resistances

- 7.14.1 (New) The typical fouling resistance for fresh water cooling should be 0.003 h-ft²-°F/Btu (0.000528 m²-K/W).
- 7.14.2 (New) The typical fouling resistance for sea water or brackish water cooling should be 0.003 h-ft²-°F/Btu (0.000528 m²-K/W).

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	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refineria de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 14 of 18

8 MATERIALS

8.1 General

- 8.1.1 (Decision) Sour service will be specified on the data sheet to comply with NACE MR103.

9 FABRICATION

9.1 Shells

- 9.1.4 (New) Whenever possible, dished heads shall be made of a single piece.

9.5 Welding

- 9.5.1 (Decision) When tube end welding is to be performed, the following procedure shall be followed:

- a) The tube holes and tube outside diameter shall be cleaned and degreased.
- b) Light contact roll performed without lubrication to set the tube.
- c) Tube end welding.
- d) Liquid dye penetrant examination.
- e) Pneumatic soap solution test and 15 psig (103.42 kPag)
- f) Tube end expansion (omitted for strength welds unless otherwise full expansion is specified on the data sheet).
- g) Liquid dye penetrant examination if tube ends are expanded.
- h) Hydrotest.

- 9.5.11 (New) Subclause A.3.1 Shell -- guidance to 9.1 shall apply.

- 9.5.12 (New) High pressure TEMA type D heads use a special diaphragm gasket that is welded to the flange. When the gasket is replaced in the field, the old one is cut out and the new one welded in. When a vessel that is heat treated is welded on, the vessel must be re-heat treated after welding. The flange needs to be designed so that the welding does not take place directly on the flange itself. Therefore, the flange shall have a ¼ inch (6 mm) minimum thickness high alloy or non-ferrous weld overlay deposited on the flange face. The gasket can be welded to the weld overlay and avoid the requirement for a field post-weld heat treatment.

- 9.5.13 (New) ASME Section VIII Div 1 Nonmandatory Appendix R shall apply for P4 or P5 materials.

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 	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
		Revision: 4
		Date: 07-Jan-11
		Page: Page 15 of 18

9.5.14 (New) Temporary attachments shall be welded to the base material using the same welding material of the main welds.

9.5.15 (New) Subclause A.3.1 in Annex A of API 660 applies.

9.6 Heat Treatment

9.6.2 (Decision) Solution anneal the bend portion of U-tubes plus 1 ft (305 mm) straight length of austenitic stainless steel. U-bends of copper and copper alloy tubes shall not be heat treated.

9.6.5 (Decision) Post-weld heat treatment (PWHT) of weld-overlaid channels and bonnets will be specified on data sheet.

9.6.7 (Decision) Heat treatment for process reasons, if any, will be shown on the data sheet.

9.6.8 (New) Subclause A.3.2.1 in Annex A of API 660 applies.

9.6.9 (New) No welding shall be performed after PWHT without the approval of the Purchaser. Buttering (method for building up a work piece by deposit welding) to avoid subsequent PWHT is also not allowed, except for the case of subclause 9.5.12 of this specification.

9.6.10 (New) Vent holes on reinforcing plates, pads, and slip-on flanges, shall be open and dirt free during heat treatment.

9.8 Gasket Contact Surfaces Other Than Nozzle-Flange Facings

9.8.3 (Decision) The flatness tolerance in Table 3 shall be used for Hydrogen service or when the design pressure exceeds 1 000 psig (6.9 MPa).

9.9 Tube Holes

9.9.2 (Add) The special close-fit tolerance is also required for welded tube-to-tubesheet joints.

9.10 Tube-to-Tubesheet Joints

9.10.5 (New) Provide tube expansion within the limits of subclause A.2.5.1 in Annex A of API 660.

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refinería de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 16 of 18

9.10.6 (New) Where clad tubesheets are used, pulling lugs or tapped holes shall be located on the outside edge, not in the cladding.

9.11 Assembly

9.11.3 (New) If a bolt tensioner shall be used, required tension for each bolt shall be marked as required for tightening torque.

10 INSPECTION AND TESTING

10.1.1 (Decision) As a minimum, inspection includes witnessing of hydrostatic testing.

10.1.3 (New) The fabricator shall notify the purchaser a minimum of five working days prior to the start of fabrication, and before all tests.

10.1.4 (New) A stamp and signature marking the review or approval of drawings, procedures, calculations, or other supporting data for review by the purchaser shall in no way relieve the seller of the guarantee, the responsibility for carrying out the provisions of this specification, or for failure in service resulting from non-adherence to this specification or applicable codes specified herein.

10.2 Quality Control

10.2.1 3) (New) Radiography shall be performed after any required post weld heat treatment.

10.2.12 (New) Welds which are subjected to severe working (ratio of thickness to local radius greater than 5%) shall be fully radiographed after working.

10.2.13 (New) When a nozzle will be welded into the neck of another nozzle (branch connection) and the thickness of the nozzle neck is equal to or greater than 2 in (50.8 mm), the edge of the bevelled opening shall be examined by UT before welding.

10.3 Pressure Testing

10.3.4 (Revise) "The chloride content of the test water used for equipment with austenitic stainless steel materials that are exposed to the test fluid shall not exceed 30 parts per million by mass (30 mg/kg). If chloride content is greater than 30 ppm (30 mg/kg) up to 250 ppm (250 mg/kg), a sufficient quantity of sodium nitrate shall be added to provide a test medium of 0.5% by weight sodium nitrate solution."

	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
 Refineria de Cartagena S.A.		Revision: 4
		Date: 07-Jan-11
		Page: Page 17 of 18

10.3.12 (New) The test pressure value shall be read at the top of the exchanger, erected as for operation. For a vertical exchanger, the test can be performed in horizontal position, but in this case, the missing water head shall be taken into account by increasing the test pressure value.

10.3.13 (New) Vertical exchangers tested in the horizontal position shall be supported by saddles adequately designed to avoid local stress values in the shell exceeding 90% of the yield strength of the material.

10.4 Nameplates and Stampings

10.4.1 (Add) If the shell side normal operating temperature is less than 32 °F (0 °C) provide a stainless steel nameplate bracket. Bracket shall extend 2 in (50.8 mm) beyond insulation.

11 PREPARATION FOR SHIPMENT

11.1 Protection

11.1.1 (Add) For ocean freight, subclause A.4 in Annex A of API 660 applies.

11.1.4 (Substitute) All flange-gasket surfaces shall be coated with an easily removable rust preventative and shall be protected by suitably attached durable covers of gasketed steel. A minimum of four machine bolts shall be used for flange size 12 in (305 mm) and smaller and eight bolts for larger flange sizes.

11.1.7 (Decision) Additional requirements for surface preparation and protection can be found in the coatings and insulation specs attached to the requisition package.

11.1.10 (New) The seller shall provide the exchanger with adequate wood skids or domestic type wood crates for shipment and protection against damage. Export shipments will be covered by special instructions.

11.2 Identification

11.2.1 (Substitute) The item number, empty weight, center of gravity, and the purchaser's offer number shall be painted on the heat exchanger.

11.2.4 (New) The metal stamp on tubes, pipes, and rolled surfaces shall be made by a low stress type.

 	SHELL AND TUBE HEAT EXCHANGER SPECIFICATION	Document No.: 000-SP-ME07-0005
		Revision: 4
		Date: 07-Jan-11
		Page: Page 18 of 18

12 Supplemental Requirements

- 12.1 (Decision) These supplemental requirements shall apply if the cylinder thickness of a heat exchanger component exceeds NPS 2 (DN 50) or for lethal service, cyclic service, hydrogen service, or critical service.