

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 1 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

TABLE OF CONTENTS

1. GENERAL	3
1.1 Scope	3
1.2 Codes and Standards	3
1.3 Specifications	4
1.4 Drawings and Documents	4
2. DESIGN	6
2.1 Design Pressure	6
2.2 Design Temperature	6
2.3 Corrosion Allowance	6
2.4 Material	7
2.5 Tolerances	8
2.6 Strength Calculation	9
2.7 General	9
3. DETAILED DESIGN	10
3.1 Shell and Channels	10
3.2 Tubes and Tube Bundles	12
3.3 Nozzles and Opening Reinforcement	16
3.4 Bolts, Nuts, and Gaskets	18
3.5 Supports	19
3.6 Fittings for Assembly and Disassembly	19
3.7 Test Equipment	20
3.8 Impact test	20
3.9 Hydrogen Service	20
3.10 Wet H ₂ S Service	21
4. FABRICATION	22
4.1 Plate Layout	22
4.2 Forming	22
4.3 Welding	23
4.4 Heat Treatment	26
5. INSPECTION AND TESTING	26
5.1 General	26
5.2 Inspection and Test Records	27
5.3 Inspection & Tests Items, Procedures and Acceptance Standards	28
6. NAMEPLATE, PAINTING AND MARKING	33

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 2 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

6.1	Nameplate	33
6.2	Painting	33
6.3	Marking	34
7.	PACKING AND SHIPPING	34
7.1	General	34
7.2	Packing and Preparation for Shipping	34
7.3	Shipping	34

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 3 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

1. GENERAL

1.1 Scope

1.1.1 Heat exchangers shall be designed, constructed, inspected and tested as per this specification.

The following exchangers are exempted from the application of this Specification:

- a. Heat exchangers which are furnished as a part of proprietary or standardized equipment, surface condensers, air-cooled and plate fin exchangers shall conform to the requirements of the applicable Code and the manufacturer's standards for the design conditions.
- b. Heat exchangers of special of proprietary design or construction shall conform to the manufacturer's design and construction practices and to any Code requirements that are applicable to the design or construction.

1.2 Codes and Standards

1.2.1 The following Codes and Standards and legal requirements form an integral part of this specification. Such Codes and Standards shall be of the latest editions unless otherwise specified.

- 1) Design, Fabrication and Inspection
 - a. ASME Boiler and Pressure Vessel Codes Section VIII, Div. 1
(ASME code stamping is NOT required)
 - b. TEMA Ninth Edition, Class R
- 2) Materials
 - a. ASME Boiler and Pressure Vessel Code Section II

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 4 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

- b. ASTM Standards
 - c. NACE MR 0130
 - d. Other equivalent Codes and Standards subject to OWNER's approval
- 3) Threads
- a. ISO Metric system shall be used except for bolting ANSI Standard flange, which shall be unified thread.

1.2.2 It shall be the responsibility of the VENDOR to ensure that all aspects of the design, materials, fabrication, inspection and testing conform to the requirements of the specified Codes and Standards and legal requirements, including those responsibilities assigned to the manufacturer in specific Codes, as applicable.

1.2.3 Where there are conflicts between OWNER's drawings, specifications, specified codes and standards and legal requirements such as conflicts shall be referred to OWNER. The most stringent shall govern unless approved by OWNER.

1.4 Drawings and Documents

1.4.1 PURCHASERS shall submit to OWNER, drawings, data sheets and documents for approval as required by the ITB.

1.4.2 Drawings and documents to be submitted shall be in SI units, except pipe size which shall be in inches.

1.4.3 Drawings shall contain all information required including but not limited to:

- 1) Title block
- 2) Design Data
- 3) Material list (material specifications and quantities for all parts including spare parts)
- 4) Nozzle list/Orientation/Locations
- 5) All welded seams, weld and surface finish details

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 5 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

- 6) Detailed dimensions and thickness
 - 7) Requirements for post weld heat treatment, non-destructive examination, surface preparation and painting.
 - 8) Empty, operating and test weight
 - 9) Anchor details
- 1.4.4 Calculation shall cover all calculations including but not limited to:
- 1) All pressure containing parts
 - 2) Opening reinforcements
 - 3) Expansion joints
 - 4) Support
 - 5) Pass partition plates
 - 6) Flow induced vibration of bundle
 - 7) Local stress analysis
 - 8) Lifting lugs or other shipment attachments
 - 9) Wind and Seismic
- 1.4.5 All heat exchangers shall be fabricated and assembled in VENDOR's shop. When site assembly is required for practical reason, PURCHASER shall submit to OWNER for approval. PURCHASER shall verify all VENDOR's documentation submit to OWNER for review.
- 1.4.6 OWNER's review of VENDOR's drawings and documentations shall not relieve VENDOR's responsibility to meet all requirements of this specification.

2. DESIGN

2.1 Design Pressure

- 2.1.1 Parts subjected to both shell and tube side fluids shall be designed to withstand the most severe operating condition unless drawings or data sheets explicitly require other design conditions. Design for differential pressure between shell and tube side is prohibited.

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 6 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

2.1.2 The design shall be capable of steamout condition.

2.2 Design Temperature

2.2.1 Parts in contact with both fluids having different temperatures shall normally be designed for the higher temperature of the two. When operating temperatures are 15°C or less, they shall be designed for the lower temperature of the two.

2.3 Corrosion Allowance

2.3.1 The corrosion allowance for main pressure containing parts shall be as specified on drawings or data sheet.

2.3.2 The corrosion allowances for various exchanger parts shall be in accordance with TEMA Class R, Internal baffles, supports and impingement plate thickness shall be equal to at least two corrosion allowances.

2.3.3 In case the corrosion allowance is not specified the following minimum corrosion allowances shall be used, subject to approval of OWNER:

- 1) Carbon Steel & Low Alloy Steel
 - a. Non corrosive service Dry 1.5mm
 Wet 3.0mm
 - b. Corrosive service 6.0mm
- 2) Stainless Steel 0.0mm

2.3.4 Unless otherwise specified in drawing or data sheets, corrosion allowance is not required for tubes.

2.3.5 The corrosion allowance shall not be required for external surfaces of exchangers

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 7 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

- 2.3.6 When the service conditions are such that it is not practical to provide corrosion allowances by added base metal, a solid corrosion-resistant material, or lining, cladding, deposit or coating of the corrosion-resistant material shall be used. The minimum thickness shall be 2 mm for lining and cladding, and 3 mm for weld deposit after machining. The minimum thickness of cladding on tubesheets shall be in accordance with TEMA Class R.
- 2.3.7 When an 18% Cr and 8% Ni steel facing is required, clad plate or a weld deposited overlay shall be used.

2.4 Material

- 2.4.1 The materials for primary parts shall be as specified on drawings and data sheets. Cast iron shall not be used.
- 2.4.2 Materials shall conform to ASTM material specifications and shall normally be limited to those listed in division 1, and TEMA, Substitute materials with equivalent chemical composition and mechanical properties to those listed in Division 1 and TEMA can be used with the approval of Client.
- 2.4.3 Materials subject to welding, including backing ring and strips to be left in place, shall be of weldable quality. Backing ring and strip material, if allowed, shall conform to the nominal chemical composition requirements of the base metal material standard.
- 2.4.4 Baffles may be of commercial quality materials of the specified nominal analysis. Support plates, tie rods and spacer spool materials shall be of a nominal analysis similar to baffle material.
- 2.4.5 The heat treatment required for clad plate conforming to ASME SA-263, SA-264 and SA-265 shall be done at the mill. Explosion-clad plate not conforming to ASME SA-263 or SA-264 shall be stress relieved in accordance with the times and temperatures required by the applicable Code and this specification before commencing fabrication. When required, cold flattening shall be performed before stress relieving.
- 2.4.6 All materials shall conform to ASME/ASTM Specifications.

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 8 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

2.4.7 Tubing

- 1) Tubing shall be in the fully heat treated condition as received from the mill. Heat treatment may be annealed, normalized, or normalized and tempered per the ASTM Specification used.
- 2) Welded tubing conforming to ASTM A 214 or A 226 is an acceptable alternate to seamless tubing, subject to prior approval from OWNER.
- 3) Unless otherwise specified, welded austenitic stainless steel tubes shall be cold drawn to a minimum reduction of 15% in wall thickness prior to a final full solution anneal.
- 4) All welded tubing shall pass a non-destructive electric test per ASTM A 450. When the entire cross section of tube meets the requirements of this test, the hydrostatic test may be waived.

2.4.8 Finned Tubing

- 1) Integral low fin tubing shall conform to ASTM 498 (ferrous) or B 359 (nonferrous).
- 2) Nonferrous tubing shall be supplied in the temper as per B 359 unless otherwise noted. All materials shall conform to ASTM/ASME specifications.

2.5 Tolerances

2.5.1 Unless otherwise specified, tolerances shall be in accordance with Section paragraph 5 Inspection and Testing in this specification.

2.5.2 The thickness after forming of any pressure containing parts shall not be less than the design minimum thickness.

2.6 Strength Calculation

VENDOR shall check, confirm and guarantee that the thickness provides the proper strength under the specified conditions.

2.7 General

KLM Technology Group Project Engineering Standard	 www.klmtechgroup.com	Page : 9 of 34
		Rev: 01
		April 2012
KLM Technology Group #03-12 Block Aronia, Jalan Sri Perkasa 2 Taman Tampoi Utama 81200 Johor Bahru Malaysia	SPECIFICATION FOR SHELL & TUBE HEAT EXCHANGERS (PROJECT STANDARDS AND SPECIFICATIONS)	

- 2.7.1 The exchanger effective surface is the outside tube surface measured between the inner faces of the tubesheets. For U-tube bundles the exposed U-bend portion is admissible, provided the shell nozzle is located past the U-bend tangent point and the velocity of the following fluid makes this surface effective.
- 2.7.2 Data sheets shall be similar to example given in TEMA. Each sheet shall define proposed offering using TEMA nomenclature or by suitable sketch when deviations from standard construction are intended. Each sheet shall show the estimated net effective transfer surface.
- 2.7.3 When alternate operating conditions are specified, the exchanger unit shall be designed to handle either condition without exceeding the allowable pressure drop and the estimated pressure drop shall be stated by VENDOR for all alternates.
- 2.7.4 VENDOR shall be responsible for furnishing equipment that is free of overstressing for any loading within the specified maximum loading.
- 2.7.5 Fouling factors are net. Tube side values shall be increased by ratio of outside to inside surfaces. Pressure drops include entrance and exit losses.
- 2.7.6 When the exchanger unit consists of two or more exchangers, in series flow array, involving exchange between heat profiles having irregular slopes, a heat load vs. temperature profile graph will supplement the item specification sheet. It will contain a weighted estimate of the counter-flow MTD value. VENDOR shall confirm this value and apply proper correction factor as required. The LMTD correction factor shall be 0.80 as a minimum.
- 2.7.7 Use of integral low fin tubing as per ASTM A 498 (ferrous) or B359 (nonferrous) is permitted provided the fluid film coefficients, when corrected fouling, show used when it permits use of increased MTD values due to film temperature limitation of shell side medium.
- 2.7.8 The Maximum shell inside diameter allowed shall be as per TEMA
- 2.7.9 The Maximum tube length allowed shall be 7,200mm for removable type.