वेन्डर परिकल्पित शेल एवं ट्यूब हीट एक्सचेन्जर्स के लिए विनिर्देश

STANDARD SPECIFICATION FOR VENDOR-DESIGNED SHELL AND TUBE HEAT EXCHANGERS

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Abbreviations:

TEMA	Tubular Exchangers Manufacturers Association
ASME	American Society of Mechanical Engineers
IBR	Indian Boiler Regulations
ASTM	American Society of Testing Materials
EJMA	Expansion Joint Manufacturer Association
CS	Carbon steel
SS	Stainless steel
NB	Nominal bore
EIL	Engineers India Limited
NDT	Non destructive testing
BHN	Brinell hardness number
OD	Outer diameter
MDMT	Mean design metal temperature
FV	Full vacuum
LAS	Low alloy steel
CAF	Compressed aramide fibre
HTRI	Heat Transfer Research Institute

CONTENTS

1.0 GENERAL

1.1 Scope

1.1.1 This specification is intended to cover minimum requirements for thermal and mechanical design of Vendor designed shell & tube heat exchangers. It shall be read in conjunction with EIL specification 6-15-0001, which covers requirements for materials, fabrication, workmanship, inspection, testing and supply of unfired shell and tube type heat exchangers.

In case thermal design is furnished by Purchaser, clause 2.2 on Thermal Design is not to be considered.

1.1.2 The intent of this specification is to supplement amend or limit the reference codes and standards mentioned.

1.1.3 This specification shall not be considered limiting and it shall be Vendor's responsibility to comply with all requirements of Material/Purchase Requisition/Bid documents to which this specification is attached.

1.2 References

Following codes and standards etc. shall be followed in their latest editions and addenda, errata, amendments unless specified otherwise:

1.2.1 TEMA

1.2.2 ASME Section II part A, B, C and D

1.2.3 ASME Boiler and Pressure Vessel Code Section VIII, Division 1, Unfired Pressure Vessels

1.2.4 National, State and local laws and codes such as IBR etc.

1.2.5 EJMA Standards

1.2.6 Design Basis

2.0 DESIGN

2.1 General Requirements

2.1.1 Vendor shall strictly follow the design information issued by the Purchaser. Any comment and/or reservations shall be resolved with the Purchaser at the bidding stage. Reservations/ deviations not accepted during bidding stage shall not be reopened during the job execution.

2.1.2 Material of construction may be specified in the requisition/datasheets in general terms. Material shall conform to relevant ASME Specification or equivalent. Castings shall not be used.

2.1.3 DESIGN PRESSURE

(a) The design pressure shall be as indicated on respective drawings/data sheets. However, minimum design pressure shall be 5 kg/cm^{2}g.

(b) Parts subjected to both shell & tube side fluids shall be designed for higher of two pressures, unless specified otherwise. In case of FV on any one side, the design pressure on other side shall be increased to account for negative pressure of side under vacuum.

(c) When design pressure is specified as FV the same shall be taken as external pressure of 1.04 kg/cm^{2}g.

(d) Where tube bundles are designed for the differential pressure, Vendor shall provide visible warning plate adjacent to name plate outlining test pressure regulations.

2.1.4 DESIGN TEMPERATURE

(a) The design temperature shall be as indicated on respective drawings/data sheets.

(b) Parts in contact with both shell & tube side fluids, shall be designed for more severe of the temperature conditions.

(c) MDMT shall be taken as lower of 0°C or the design temperature unless lower MDMT is specified elsewhere. The equipment shall comply with all the code/specification requirements for MDMT such as impact test, heat treatment, radiography etc.

2.1.5 TUBE TO TUBESHEET JOINTS

Tube to tube sheet joints shall preferably be expanded type except that the tube-to-tube sheet joint shall be welded for following cases:

(a) When specified in Process Licensors' requirements/Datasheets.

(b) Service requirements such as lethal service, product quality contamination not tolerable, hazards of intermixing of shell and tube fluids.

(c) Tube OD/thk. ratio < 6 for non ferrous and < 8 for ferrous materials.

(d) For H_2 service with partial pressure > 7 kg/cm^{2}g (except when brass material is used).

(e) For duplex materials where reliable expanded joints are difficult to achieve.

(f) Where tube hardness/yield strength exceeds that of tube sheet.

(g) Low temperature service, design temperature below 0 °C.

(h) When shell or tube side design pressure >50 kg/cm^{2}g & design temperature > 400°C.

(i) When shell or tube side design pressure > 70 kg/cm^{2}g & design temperature is > 300°C.

(j) For different co-efficient of thermal expansions of tube and tube sheet materials, the limitation of design temperature as per ASME Sec. VIII Div. 1, Appendix-`A' para A-1 (d) (3) shall apply, and may warrant welded joints.

2.1.6 Extended type tube sheet shall be used with stab in bundles, with bolt holes of tube sheet threaded. Also the studs in this case shall be square ended for holding/tightening.

2.2 **Thermal Design**

Vendor's thermal designs shall be vetted by EIL on HTRI's ST, CST, RKH and RTF computer software (latest version) for adequacy, including safety against failure due to flow-induced vibration and acoustic vibration. This is the minimum requirement and Vendor shall make necessary changes in design to ensure compliance to HTRI. However, Vendor can provide

higher area/more conservative design as per their design practices and shall submit the thermal design calculations/computer outputs for EIL review.

2.2.1 Maximum overall heat transfer coefficients may be specified for certain services based on operating experience. For these items, the allowable pressure drops on shell side and tube side should be utilised as fully as possible. However, the Vendor is responsible for performance of the equipment as per the requisition.

2.2.2 The minimum velocity of cooling water inside tubes shall be 1.0 m/sec. Cooling water velocity inside tubes shall be kept as high as the allowable pressure drop permits, but not greater than 4.0 m/sec for Titanium, 2.0 m/sec for Admiralty Brass & Cu-Ni and 2.5 m/sec for CS, LAS and SS tubes.

2.2.3 BAFFLES

Baffles should be either single segmental or double segmental. Triple-segmental baffles shall not be used. "No tubes in window" design may be used to avoid flow-induced vibrations.

2.2.4 IMPINGEMENT PLATE

Impingement plate shall be no closer to the inlet nozzle than is required for escape height and flow area.

(a) It shall be of sufficient size so that the distance from the projected inside of the nozzle to the edge of the plate, in any direction, is at least equal to the distance of the plate from the nozzle opening.

(b) Perforated impingement plates are not permitted.

2.2.5 For other special applications such as kettle reboilers, kettle steam generators, slurry handling, HF acid service, Hydrogen service etc. applicable special constructional features shall be indicated in the requisition.

2.3 Mechanical Design

During the design of shell & tube heat exchangers, consideration must be given to the stresses induced at operating, alternate operating, start-up, shutdown and other upset conditions.

For design temperature below 0°C, all requirements of code applicable for equipments below --29°C such as heat treatment, full radiography etc. shall be complied with. Further all materials and welds shall be impact tested at -29°C or as per relevant code requirements, whichever is lower.

2.3.1 NOZZLES

a) All flanges shall be of weld neck type.

b) Integral reinforced nozzles are required if any of the following conditions is applicable:

i) The design pressure exceeds 50 kg/cm^2g.

ii) The design temperature is $\leq$ -10°C or $\geq$ 400 °C.

iii) Plate thickness in case of CS exceeds 50 mm and in case of LAS exceeds 25 mm.

c) Exchanger units shall be designed for the additional external loading from the connected piping etc. The allowable loading on process nozzles will not be less than those levels defined by the maximum allowable stress in adjacent piping, given by:

Connected pipe size	Allowable stress of Calculation of Resultant force	Allowable stress for the Calculation of Resultant Moment
2"-18"	21.1 kg/cm^2	425 kg/cm^2
20"-24"	21.1 kg/cm^2	280 kg/cm^2

Vendor shall check the exchanger including nozzle flanges for these nozzle loads and verify these loads by calculations.

d) Where exchanger centre line is sloping with respect to horizontal, the flange faces shall be true horizontal.

2.3.2 GIRTH FLANGE JOINTS

a) All girth flanges shall be of forged hub type and shall have confined gasketed joints.

b) All girth flanges, floating head & other internal flanges (such as for single pass floating head) flanges shall be designed for full bolt load. In gasket seating conditions bolting area provided shall have the following minimum design margin over the code requirements:

i) 10% for floating head flange and other internal flanged joints.

ii) 5% for girth flanges.

2.3.3 BOLTING AND FLANGE CLOSURES

a) All bolting shall conform to ASTM A193 B7 with nuts in accordance with ASTM A-194 2H unless otherwise specified, or better grades required for other consideration.

b) For floating head flanges and other pressure holding internal joints, the bolts shall conform to ASTM A-193 B7M with nuts in accordance with ASTM A-194 2HM.

c) Vendor of exchanger unit shall guarantee tightness compatibility of their closure designs. This, especially, pertains to closures where designer amalgamates components having different thermal expansion properties.

2.3.4 BAFFLES/SUPPORT PLATES

Minimum thickness of baffles and support plates shall be as per TEMA or twice the shell side corrosion allowance whichever is more. A suitable notch cut shall be provided at the top and bottom of each baffle and support plate for venting and draining of shell side of exchanger.

2.3.5 SLIDING STRIPS/RAILS

Sliding strips shall be provided for removable exchanger bundle with shell diameter greater than 450 mm, to facilitate insertion & pulling out of the bundle. Vendor may provide the same in smaller diameters also.

In kettle type shells, provide sliding rails continuously welded to shell for removable bundle, in order to facilitate sliding of bundle while being pulled out. Also, bundle retainer shall be provided during transportation and erection.

2.3.6 ACCESSORIES FOR TESTING

For testing of exchangers with removable bundle, following testing accessories shall be supplied:

a) Provide test ring for testing tube-to-tube sheet joint for all floating head type exchangers. The test ring shall be generally as per TEMA type, refer para E-4.13-1 & FIG. E-4.13-2.

b) Test flange shall be provided for the following cases:

i) For floating head exchanger when tube side test pressure is higher.

ii) For exchanger with U-tube bundle and non-extended tube sheet when channel is B-type and shell side test pressure is higher.

iii) For exchanger with U-tube bundle and non-extended tube sheet when tube side test pressure is greater than shell side test pressure.

iv) For stab in bundle & non-extended tube sheet.

c) Dummy shell shall be provided for the following cases.

i) For stab in bundle when shell side test pressure is higher than tube side.

ii) For AKT or AET exchangers when shell side test pressure is higher than tube side.

d) For stacked exchangers, hydro test shall be carried out with all required interconnections made. This will require as many number of test rings as the number of exchangers in one stack, and in case of U-tube or BES type exchangers, as many test flanges as number of exchangers in stack.

2.3.7 EXPANSION JOINTS/BELLOWS

For fixed tube sheet heat exchangers, whenever required, thick expansion joints shall preferably be used. Thin expansion joints shall be avoided as far as possible. Written approval from EIL/Purchaser shall be taken prior to use of the expansion bellows. Requirements as noted below shall be followed with regard to expansion joints/bellows:

i) All CS expansion joints shall be stress-relieved. SS bellows/joints need not be solution annealed.

ii) For SS bellows/joints, use only low carbon or stabilized grade of steel.

iii) All expansion joints/bellows shall be provided with internal sleeve and shall have suitable venting/draining provision.

iv) Vendor shall submit design calculations showing actual spring load, actual deflection, total combined stresses and calculated cycle life based on actual dimensions, and also fabrication procedure for review.

v) Thick expansion joints shall be designed per TEMA, while thin expansion joints shall be designed as per EJMA.

vi) Material of thick expansion joint, sleeve, transition piece etc. shall be same as that of shell.

vii) All welds shall be 100% radiographed.

viii) Design cycle life shall be 500 startup/shut down cycles and 7000 operating cycles, in the case of thin bellows & 750 operating cycles in case of thick expansion joints.

ix) The expansion joints shall be flanged and flued type and Appendix CC of ASME Section VIII Div.1 shall be mandatory for expansion joints.

For single pass floating head exchangers, thin internal bellows shall be provided to take care of bundle movement. Internal expansion bellows shall be hydraulically or mandrill formed type and such that permit easy replacement at site. Such bellows shall be of Inconel 600, Inconel 625, Incoloy 800 or Incoloy 825 material.

The expansion joint/bellow shall be procured from reputed manufacturers only with adequate experience.

2.3.8 EQUIPMENT SUPPORTS

When EIL standards for equipment supports are not furnished to Vendor, equipment supports for horizontal heat exchangers shall be designed to withstand a pulling force of not less than 1.5 times the bundle weight, taken at the centre line of the exchanger. Analysis shall be based on L.P Zick's criterion. The exchanger supports shall also be adequate to ensure structural stability of the exchanger in basic configuration as required considering all superimposed loads. Detailed calculations shall be submitted to this effect. Vertical exchangers shall be supported by lugs welded to wrapper plate in such a way that the shell is not overstressed or deformed. Alternate methods such as skirts, lugs or trunnions may be considered where necessary. The shear stress for support shall be limited to 40% of the material yield strength.

In case of stacked exchangers, the lower shell(s) of stacked exchangers shall be designed to appropriately consider the load of upper shell(s) without distorting the lower shell and causing bending of tube bundles.

2.3.9 VENTS, DRAINS AND OTHER CONNECTIONS

a) When tube side fluid is steam, a 40 NB (flanged) operating vent connection shall be provided in the channel cover or bonnet head at high point of second pass.

b) When shell side fluid is steam, 40 NB (flanged) shell side operating vent connections shall be provided as follows:

   i) Horizontal units - one vent, located below centerline at the end opposite the inlet.

   ii) Vertical units - two vents required, one below horizontal centerline at the end of steam travel and one near the top.

c) For total condensing service, provide a flanged 40 NB vent nozzle on top of shell at end opposite to shell inlet. For stacked units, provide a vent nozzle in each shell. Rating, flange facing etc. shall be equal to that provided for main shell side nozzles.

d) All vertical fixed tube sheet exchangers shall additionally be provided with proper vent/drain through tapped holes in tube sheets.

2.3.10 GASKETS

Gaskets shall be made in one piece. This shall however not mean exclusion of gaskets made integral by welding, provided the weld area is not harder than the adjoining material and has the same corrosion resistance. Hardness of the gasket shall be at least 15 BHN lower than the gasket seating face. SS jacketed gaskets shall not be used unless specific approval of Purchaser is taken. Where galvanic corrosion is envisaged, gasket material shall be compatible with or nobler than the surrounding materials.

a) Copper/brass gaskets are not permitted when fluids contain H_2S or amines.

b) Aramide filler used for jacketed gaskets is not to be of compressed type.

c) Asbestos is not to be used when project specification prohibits use of it.

d) CAF gaskets when used shall be 2 thk and shall be used only in utility services like air, water, steam up to 150°C and with nozzle flange rating of up to 150 psig. CAF gaskets shall not be used at temperature less than 0°C, and for vacuum service (except in steam). These gaskets shall not be used in internal joints/flanges.

e) Solid metal gaskets & metal of jacketed gaskets shall be dead soft annealed.

2.3.11 RADIOGRAPHY AND OTHER NDT REQUIREMENTS

a) The minimum extent of radiography shall be spot.

b) Heat exchangers which fall under the following categories shall be fully (100%) radiographed:

i) For exchangers under IBR

ii) Where the relevant design code/specification does not permit a lower class of construction.

iii) Lethal service

iv) Low temperature service below 0°C

v) Special services such as Hydrogen service, wet H_2S (Sour gas service) etc.

vi) All Cr-Mo steels and C- ½ Mo steels.

3.0 DESIGN REVIEW & VENDOR DATA REQUIREMENT

The Vendor shall submit the mechanical & thermal design calculations for EIL review. EIL's review of calculation shall not relieve the Vendor of his responsibility in any manner. The fabrication drawings and other documents shall also be submitted in accordance with the requisition/bid document.

4.0 VENDOR'S LIABILITIES AND GUARANTEES

Following provisions in conjunction with clause 10.0 of 6-15-0001 shall apply.

The Vendor shall guarantee the equipment for design, workmanship, material and specified performance. Defects/short falls, if any, shall be made good by the Vendor as per General Purchase Condition of the requisition/order to which this specification has been attached.

5.0 PATENT INFRINGEMENT

Vendor shall defend any and all infringement suits in which the Purchaser and/ or EIL is made a defendant, alleging patent infringement on equipment purchased from Vendor. Vendor shall pay all costs and expenses incident to any such litigation. It being further agreed and understood, however, that Purchaser and/or EIL shall have the right to be represented therein by counsel, of their own selection and paid by them. Vendor shall pay all damages, profits and/or cost which may be awarded to the plaintiff in any such litigation; and, in general, shall defend Purchaser and/or EIL against all claim or demand of every kind to which they may be subjected under the patent laws, in connection with equipment purchased under this specification.

6.0 REFERENCE LIST

Vendor shall furnish reference list of heat exchangers designed & supplied by him giving technical details such as Purchaser/plant, type, service, metallurgy, size, tube sheet thickness, weight, year of completion and highlighting Vendor's scope like thermal design, mechanical design, fabrication etc