TECHNICAL SPECIFICATIONS
- MECHANICAL -

1. Static Equipment

3. Heat Exchangers

1. Shell and Tube Heat Exchangers

Contents

1. General description

1.1 Scope
This specification together with other relevant specifications contains the main requirements for design, fabrication and inspection of the tube and shell heat exchangers.

1.2 Alternative designs
If the Vendor offers an alternative design deviating from the project specification or from the inquiry documents but equivalent with that, it can be accepted by a written consent of

In some applications, it is acceptable the heat exchanger not to comply with all of the standards listed in the point 1.5. In this case the manufacturer's standard shall be submitted to the for approval.
These cases can be: flue gas cooler, heater for storage tank, boiler blow down cooler, air heater.

1.3 Conflicting requirements
Should any contradiction exist between this specification and the content of the delivery contract, then the contract is dominant.

1.4 Definition of terms
For purposes of these specifications the determination of terms included in the TEMA, EN and the ASME VIII/1 specifications are accepted.

1.5 Referenced publications

1.5.1 Each heat exchanger as minimum shall conform with the last editions of the following specifications and standards, unless otherwise stipulated in the given specification.

1.5.2 Of the listed standards marks by underlining the standard according to which the equipment has to be designed and fabricated. This standard shall be consistently employed. Deviation from this can be made with approval only.

a) Safety Regulations for Pressure-Containing Vessels (local law)
b) Pressure Equipment Directive PED (2014/68/EC)
c) EN 13445 Unfired Pressure Vessels
d) ASME Boiler and Pressure Vessel Code (in brief: ASME Code)
e) TEMA Standards
   (Standard for Association of Tube-Bundle Heat Exchanger Manufacturers)
f) API 660 / EN ISO 16812 Heat exchangers for general refinery services
g) ASTM or equivalent European (EN) material quality and material tests.
h) Standards stated in chapter MGS-S-REF-M-1.0 General requirements, Requirements for design
i) Requirements of inspection and checking MGS-S-REF-M-6.1, MGS-S-REF-M-6.1.4.3 and MGS-S-REF-M-6.1.4.4

1.6 Design requirements

1.6.1 Unless otherwise specified, each heat exchanger shall meet the requirements of the TEMA Class R.

TEMA Class B is acceptable in case of oil cooler and water cooler at pump, compressor package.

1.6.2 Minimum design pressure on tube bundle is 5 bar.

1.6.3 If more than one heat exchanger is included in an assembly unit, the heat exchangers shall be designed to maximum extent with use of interchangeable components.

1.6.4 Design of heat transfer:

1.6.4.1 Mean Temperature Difference (MTD) is allowable only when heat transfer curves are available.
In case of several series connected heat exchangers the technological design temperature shall be the highest temperature. It is to be considered for strength calculation only.

1.6.4.2 The fouling factors are net values. The tube-side values shall be increased by ratio of the inner and outer surfaces. High-pressure, high-fouling or highly corrosive fluids shall wherever possible be on the tube side of exchangers, though high-fouling fluids should be avoided in U-tubes.

1.6.4.3 On basis of result of preliminary technological calculations the Designer shall define the spacing and arrangement of the deflectors, the cut-out in percentage of the free cross section or the inner diameter and, the type of cut-out for which the jacket-side heat transfer and pressure drop of the heat exchangers have been calculated.

1.6.4.4 Vendor shall check all tube bundles for the stream-caused or sonic vibration and, install mechanical elements as required for reduction of the vibration to minimum. Any modification can be made only with approval. Support or baffle plate distances can be smaller than specified by TEMA, if those are requested for reduction of the vibration.
The heat transfer surface and the heat transfer factor shall be referred always to the effective surface of the tubes.

1.6.5 Specifications correlating with the design

1.6.5.1 Pull out tube bundle shall be used only. For application of any other type Group's consent is required. Below the average 50°C temperature difference rigid tube bundle heat exchangers and below 120°C rigid tube bundle heat exchangers with compensator can also be used, but this also needs consent. The expansion joint shall have a sleeve welded to the upstream end to minimize deposits in the bellows.

1.6.5.2 U-tube heat exchangers may be used only in case of clean, that is least depositing medium. An advantage of this type is the simple construction and for this reasons it can be applied to high pressures and high temperature differences, too. U-tube heat exchanger shall not be used for water coolers due to the high deposition.

1.6.5.3 Floating head heat exchangers can be used also in case of media apt for dirtying, for high temperature and pressure differences as well. Since after dismounting the external head the turning chamber of the floating head is also dismountable, the entire heat exchanger structure is dismountable. By this, the tubes are accessible for cleaning both

inside and outside.

1.6.5.4 For application of heat exchangers exceeding 15 ton mass and 1200 mm tube bundle diameter, consent is required due to the maintenance reason.

1.6.5.5 The designer shall specify the way of how to pull out the bundle considering the available local facilities. The tube bundle removal method shall be designed during the detailed design phase. For all the removing bundle with diameter more than 1000 mm bundle, rollers shall be used.

1.6.5.6 The tube bundle shall be provided with ring bolt, push-off screws, tube bundle flange grooving, required for the pull out operation, and fixed tube sheet fastening bolts (4 - 6 pcs.).

1.6.5.7 Tubes of the tube bundle shall be seamless steel tubes. Tubing shall be furnished from single length pieces, circumferential welds are not allowed.

1.6.5.8 When cleaning of the tube bundle is needed, quadrangular pitch shall be designed and used. Triangular and rotated triangular pattern shall only be used in services where the shell side fluid has a low fouling factor.

1.6.5.9 Where the load on one saddle is higher than 2500 kg or justified by the high temperature difference and supporting length, roller-type saddle shall be used. Fix saddle shall be placed near the bigger pipe connecting nozzle. The sliding plate shall be designed to prevent these support elements from deterioration.

1.6.5.10 The maximal dimensions of tube bundles – maximal diameter – 1.5 m; maximal length – 6 m are allowed.

1.6.5.11 Internal system of exchanges shall allow medium draining from all exchanger spaces.

1.6.5.12 For shell and tube heat exchangers where the design pressure of one side is considerably higher than the other, the design pressure of the lower pressure side shall be made 10/13 of that of the higher side. This will avoid the need for provision of relief facilities on the lower pressure side in the event of a tube rupture.

1.6.5.13 Interchangeable tube bundle shall be designed at heat exchangers (e.g. E-A/B/C) if the technological parameter is the same.

In addition to the mechanical guarantee described in the Purchaser Order, the vendor shall extend a thermal and hydraulic guarantee covering the performance of the unit for conditions shown on the applicable material requisition. Supplier shall also guarantee unit against flow induced and/or sonic vibration damage.

1.7 Corrosion

1.7.1 Corrosion allowance for metal clad (weld overlaying or bimetal) parts is not needed on the carrier metal, under the metal clad. Total thickness of the metal cladding shall be taken into account as corrosion allowance.

Totally welded clad without any gap with the base material can be acceptable only. The

manufacturer shall justify this.

1.7.2 Thickness of the metal cladding may not be taken into account in tensile strength calculation for pressure.

1.8 Body flanges

1.8.1.1 Each body flange shall comply with specifications of ASME Code VIII. Div.1 or relevant EN standards.

1.8.1.2 The flanges shall be of forged design, with welding neck.

1.8.1.3 In case of application of grooved gaskets, the groove shall be on the tube bundle wall, on the inlet chamber lid and on the turning chamber lid.

1.8.1.4 Quality (roughness) of surfaces contacting the gaskets depends on type of the gasket used. For this reason it shall be always specified with a definite roughness value or, reference to a standard.
The surface roughness of the flange face shall be of minimum between 3.2 – 6.3 µm Ra.

1.9 Stacked units

For stacked units, vendor shall shop-assemble and hydro test the units in the stacked position. As a minimum the vendor shall assemble the stacked units to verify proper flange and support fit-up prior to shipping.

1.10 Tube bundle

1.10.1 The pipes of the tube bundles shall be of min 19.1 mm (3/4 inch) outer diameter and 6000 mm length. In water cooler application the pipes shall be of min 25.4 mm (1 inch). Pipes diameter shall be selected to make possible the water cleaning. Min wall thickness shall be BWG14 (2.1 mm)

The tolerance of the tubesheet holes' diameter shall be harmonized with the tolerance of the tubes outside diameter within the tolerances specified in TEMA. The purpose is to avoid a gap between the tubesheet holes and tubes, which can cause corrosion.

The inspection of the welded seam and the acceptance criteria shall be specified by designer.

Calculations for tube vibration and verification of compliance to Standard Drawing shall be submitted to for review.

1.10.2 Each „U" tube shall be fabricated preferably from one piece. Bending of the „U" tubes may not be less than 1.5-fold rated diameter of the pipes. Should extension of the "U" tubes be unavoidable, then place of the weld shall be at least 200 mm from the curved end.

1.10.3 Only seamless tube shall be used.

1.10.4 Protrusion of the pipes from the tube sheet: min. 3 mm.

1.10.5 Where the jacket-side dirtying can be removed by chemicals or solvents, the pipes can be of triangle arrangement design. For other operation mode the pipes shall be designed in squared arrangement, with a minimum spacing of 6 mm between the pipes. The tube pitch shall be defined according to TEMA.

1.10.6 Holes of the tube bundle wall shall be machined with at least two grooves of 3 mm width and 0.4 mm depth each. In case of metal clad tube bundle walls both grooves shall be in the base material.

1.10.7 Pass partition grooves of the cladded (weld overlaying or bimetal) tube sheets shall also be cladded.

1.10.8 In case of high temperature and pressure, integrated tube sheet and chamber can be used, with consent.

1.10.9 Erosion plate shall be used in order to prevent the tubes from direct effects (abrasion, thermal shock, etc.). The use of perforated plate is not permitted. The inlet cross section shall meet the TEMA specifications.

1.10.10 In case of application of shell side with longitudinal deflector (type F), the plans of the deflector and the gasket shall be approved by the .

1.10.11 In case of hydrogen-content medium or if the design pressure is higher than 70 bar and/or the temperature is higher than 530 °C, the tubes shall be fixed by strength weld to the tube bundle wall.

1.10.12 In case of pipes secured into the tube sheet by pressing the distance between edges of the pipe holes and the seal grooves shall be not less than 2.5 mm; for welded-in tubes 1 mm. The tolerance shall be - 0.5 mm.

1.10.13 The tube bundles shall be provided with skid bars. Minimum two skid bars shall be used, inclined at the bottom to about 15 ° angles from the centre line of the apparatus.

1.10.14 Tube-to-tube sheet joints

1.10.14.1 Regardless of the type of the tube-to-tube sheet joint the first step of the manufacturing procedure is the tube contact expanding in the hole. The purpose of this is to fix the tube in the hole of the tube sheet against turning away in the hole to reduce the risk of crevice corrosion from the shell-side fluid. The thinning of the tubes shall be smaller than 0.05mm.

1.10.14.2 In case of strength welded joints, the procedure of expanding the tubes in tube-hole grooves shall follow the welding process.

1.10.14.3 The following selection philosophy of the application of the tube-to-tubesheet joint shall be followed:

1. Strength welded in cylindrical tube-hole[1)]
   The process criteria for application:
   - max. temperature difference between shell and tube side is dT < 60 °C or
   - max. pressure difference between shell and tube side is smaller than 15 barg
2. Expanding in tube-hole grooves
   The process criteria for application:
   - max. temperature difference between shell and tube side is 60 °C<dT<160 °C or
   - max. pressure difference between shell and tube side is 15 barg <dP<20 barg
3. Strength welded and then expanding tubes in the tube-hole grooves
   The process criteria for application:
   - max. temperature difference between shell and tube side is larger than dT>160 °C or
   - max. pressure difference between shell and tube side is smaller than dP>20 barg

Type of third joint shall be applied when the heating medium is steam.

1.10.14.4 In case of rigid tube bundle heat exchangers, the tube-to tube sheet joints shall be allowed to be prepared by using automatic welding machine only. Deviation from this rule is allowed with written consent.

1.10.14.5 For the purpose of verifying by the expanding process for tube-to tubes sheet joints, the probe expanding process shall be applied before commencing the expanding or welding procedure. verification is required in all cases.

1.10.14.6 In case of copper tubes the following manufacturing process shall be applied for tube-to-tube sheet joints:

- brazing for tube wall thickness being up to 1.5 mm
- expanding in tube-hole grooves for tube wall thickness being greater than 1.5 mm

The use of copper tube bundle is allowed only after having the written permit of

1.11 Nozzles, flanges and gaskets

1.11.1 Primarily EN or ANSI type welding neck flanges shall be used.
Unless otherwise specified, the nozzle flanges shall be EN standard design. The minimum nozzle size shall be DN 25. All spaces of the heat exchanger shall be provided with vent and drain nozzles.

1.12 Supports

1.12.1 Bolt holes in the saddle at one of the ends of the heat exchanger shall be elliptic

for assuring of the thermal expansion occurring due to the working temperature. In case of bigger displacement, a slide plate (low-friction pads) shall be installed into the concrete base or, roller-type saddle shall be used.

1.12.2 The vertical heat exchangers shall be provided with support shoes welded to the jacket.
Heavy vertical heat exchanger shall be supported by a skirt.

1.13 Size tolerances

1.13.1 The size tolerances shall meet the TEMA specifications as well as the specifications of the design documents.

Appendix - additional rules valid for refinery:

A. Stiffening collars of the nozzles shall be made of material identical to that of the jacket. Stiffening collars of the nozzles shall be provided with threaded test hole of 10 mm diameter and M10 screw.

B. In case of units mounted on each other the sealing surface of flanges of the connection nozzles shall be raised face type.

C. Substitute materials instead of the specified ASTM or EN materials can be built-in only with Client's approval.

D. Temperature of the medium used for hydro testing shall be from 5 °C to 50 °C range.

E. The Official test for heat exchangers (if applicable) shall be carried out according to Part MGS-S-REF-M-1.0 General requirements.

F. Cladding for inside surface protection is not acceptable. We require applying of bimetal plate or weld overlaying.

G. To point 1.10.14.3

In cases, when the tube-to-tubesheet joint is manufactured by expanding of tube in tubesheet hole only, in all such cases the joint shall be equipped by tightness weld.

H. To point 1.10.1:

I. In water cooler application shall be used pipes with minimal ID 25 mm only.

J. Material of metal gasket shall be made with lower hardness than material of flange (valid for C.S. flanges). Flange hardness shall be ensured by weld overlaying manufacturing. Weld overlaying suitability shall be declared by hardness measurement protocol.