ENGINEERING AND MATERIAL STANDARD

FOR

DOUBLE PIPE HEAT EXCHANGERS

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0. INTRODUCTION

Double pipe heat exchangers or otherwise called hairpin heat exchangers are used in various applications in most any industry. The units normally operate in true counter current flow. This allows the design to be based on the full log mean temperature difference without considering the reducing correction factor generally necessary in shell and tube heat exchangers.

As the shells are relatively small the hairpin sections lend themselves to high pressure applications. Shellside design pressures are available to 14.1 Mpag (2000 psig) and tubeside pressure to 70.5 Mpag (10000 psig). All sections meet or exceed the requirements of the ASME Code.

Generally hairpin sections utilize extended heat transfer surface. This is accomplished by welding several fin to the tubes. Steel or steel alloy fins are welded to the tubes with continuous electric resistance weld which assures high heat transfer efficiency. In case of copper alloys a continuous brazing process is used.

1. SCOPE

1.1 This Standard Specification covers the minimum requirements for design, material, fabrication, inspection and testing of double pipe heat exchangers.

1.2 This Standard together with Iranian Petroleum Standard for pressure vessels IPS-G-ME-150 shall apply to double pipe heat exchangers.

2. SOURCES AND REFERENCES

2.1 Sources

In preparation of this Standard, in addition to the referenced codes and standards mentioned in 2.2, the following standards and publications have also been considered:

NIOC (NATIONAL IRANIAN OIL COMPANY)

SP-45-12 "Double Pipe Heat Exchangers", July 1976

IPS (IRANIAN PETROLEUM STANDARDS)

G-ME-220 "Engineering and Material Standard for Shell and Tube Heat Exchangers", Rev.0, 1992

2.2 References

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor:

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

Pressure Vessel Code

Section VIII "Unfired Pressure Vessels"
Section IX "Welding and Brazing Qualification"

IPS (IRANIAN PETROLEUM STANDARDS)

G-ME-150 "Towers Reactors, Pressure Vessels and Internals"
E-TP-100 "Paints"

TEMA (TUBULAR EXCHANGER MANUFACTURERS ASSOCIATION)

ANSI (AMERICAN NATIONAL STANDARDS INSTITUTE)

B 16.5 "Pipe Flanges and Flange Fittings"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

BSI (BRITISH STANDARDS INSTITUTION)

BS-1133
Sub. section 6.2-91 "Temporary Protection of Metal Surfaces against Corrosion"

3. UNITS

International System of Units (SI) in accordance with IPS-E-GN-100 shall be used.

4. DESIGN

4.1 Design Data

4.1.1 Design codes

4.1.1.1 Double pipe heat exchangers shall be designed according to the ASME Code Section VIII and the supplemental requirements contained in this Specification.

4.1.1.2 Design of tube sheet and tube expansion jointing shall be per TEMA (Tubular Exchanger Manufacturers Association) Standard.

4.1.1.3 Nozzles, flanges, tapered pipe threads, pipe fittings, bolts, nuts and gaskets shall be in accordance with appropriate ANSI Codes.

4.1.2 Design pressure

4.1.2.1 Double pipe heat exchangers shall be designed to conform to specified shell side or tube side design pressure. Designs based on differential pressure of shell side and tube side are not acceptable.

4.1.2.2 If design pressure is not specified in the exchanger specification sheet, the minimum design pressure shall be 1.75 bar or 5% above the maximum operating pressure, whichever is the greater.

4.1.3 Design temperature

4.1.3.1 If design temperature is not specified in the exchanger specification sheet, then the minimum design temperature shall be taken as 28°C or 10%, whichever is the greater, above the maximum operating temperature.

4.1.4 Corrosion allowance

4.1.4.1 The minimum corrosion allowance for the shell side and tube side components (except tubes) shall be 1.6 mm for carbon steel.

4.2 Shell Design

4.2.1 The shell shall be made of seamless pipe, the minimum thickness of which shall be schedule 40 for carbon steel and 10 S for stainless steel.

4.2.2 Design of shell tube closure and return bend housing is normally left to the manufacturer. However the design shall be approved by the Company.

4.2.3 Tube bundle shall be removable through the use of bolted closure joints.

4.3 Tube (Tube Bundle) Design

4.3.1 One end of tube bundle shall be free-floating for thermal expansion.

4.3.2 No internal screwed connections shall be allowed.

4.3.3 Tube bundle maximum overall length shall be 10 meters.

4.3.4 Fins shall be longitudinal and should be attached to the outside of the tube by welding or mechanical bonding. Minimum thickness of the fins shall be 0.8 mm.

4.3.5 The bent portion of the following U-tubes shall be stress re-lieved after bending:

a) Carbon steel, carbon-molybdenum, chrominum-molybdenum and ferritic stainless steel tubes which have been bent to a radius smaller than five times their outside diameter.

b) For U-tubes of Austenitic stainless steel and non-ferrous material, heat treatment will be specified to avoid stress corrosion cracking.

c) Copper alloy and cupronickel tubes which have been annealed in straight condition.

4.4 Nozzles and Connections Design

4.4.1 Unless specified otherwise, shellside connections shall be flanged. The type of termination for the tube side connections to process piping will be specified.

4.4.2 Pipe threads connecting to process, if permitted, shall be taper pipe thread.

4.4.3 Steel flanges outside the scope of ANSI B16.5 shall be designed per ASME pressure vessel code.

4.4.4 All nozzles 40 mm NPS (1½ inches) and larger shall be provided with one horizontal connection of 19 mm NPS (¾ in.) for pressure gage.

4.4.5 All nozzles 100 mm NPS (4 in.) and larger shall be provided with one horizontal connection of 25 mm NPS (1 in.) for a thermowell.

4.4.6 Couplings shall be used for threaded connections. All couplings shall be installed with full penetrated welds.

4.4.7 All unpiped threaded openings shall be fitted with bar stock, round-head type plugs of the same material as the connection.

4.5 Support Design

4.5.1 A minimum of two supports shall be provided on the shell pipe. On stacked units, the design shall prevent shell distortion which might cause bending of the tube.

4.5.2 Supports shall be free to move along the length of the shell for thermal expansion.

5. MATERIAL

5.1 The materials not specified shall conform to the specification given in Section II of the ASME boiler and pressure vessel code or other governing code. Materials of construction are subject to approval by the Company.

5.2 All materials must be new and unused.

5.3 All materials used in the manufacture of pressure parts of double pipe heat exchangers constructed to this standard shall have available test certificates of chemical analysis and physical properties. Materials for which test certificates are not available may be used for supporting lugs, baffles, spacers and other similar non-pressure parts.

5.4 Carbon steel, ferritic alloy, and austenitic alloy steel tubes shall meet the requirements of ASTM A-450 "General requirements for carbon, ferritic, and austenitic alloy steel tubes".

5.5 Tube wall thicknesses specified shall be considered as "minimum wall thickness".

5.6 Compressed asbestos gaskets shall be graphited both sides or contain an anti-stick release agent.

Note:

Due to health hazards , materials equivalent to asbestos may be used provided prior approval of the Company is obtained.

5.7 Materials equivalent to ASTM standard may be used with prior approval of the purchaser.

5.8 All pipes and tubes used in the construction of double pipe heat exchangers shall be seamless.

5.9 Appendix B of this Standard lists typical materials of construction for double pipe heat exchangers in normal services. This Appendix is given as a guide and does not cover all materials of construction. Other materials which are equally suitable may be selected.

6. FABRICATION

6.1 In multitube double pipe heat exchangers, tube holes in tube-sheets shall be furnished to the diameters and tolerances shown in Table. RCB-7.41, Column (a) of TEMA Standard.

6.2 Inside edges of tube holes in tubesheets (in multitube exchangers) shall be free of burrs to prevent cutting of the tubes. Internal surfaces shall be given a workmanlike finish.

6.3 For non-ferrous tubes, the said tolerances shall be in accordance with the appropriate heat exchanger tube specification.

6.4 When U-tubes are specified, cold work forming shall be employed for bending of the tubes. The minimum radius of U-bends shall not be less than 1½ times the nominal O.D. of the tubes.

6.5 Manufacturing tolerances of U-tubes shall be as follows:

6.5.1 Wall thickness at the bent portion shall not be reduced more than 17 percent of the specified thickness.

6.5.2 Flattening at the bent portion shall not exceed 10 percent of the nominal outside diameter of straight portion.

6.5.3 The tolerances for the center to center dimension between parallel legs of U-tubes shall be ± 1.0 mm for the radius having less than five times the outside diameter and ± 1.5 mm for those more than five times.

6.6 Gasket contact faces shall be machined and free of surface scale.

6.7 Gasket contact faces shall be true planes within 1 mm. The flatness of the tube sheet gasket faces (in multitube type) shall be measured after expanding or welding of tube joints.

7. WELDING

7.1 All welding of pressure parts shall conform to the requirements of ASME Code, Section VIII, Division 1 and Section IX.

7.2 All butt welds shall be full penetration welds.

7.3 Prior to commencing fabrication, the vendors proposed welding procedure specification (WPS) and its supporting PQR shall be submitted for approval. After approval, this welding procedure shall be strictly adhered to unless written approval is obtained covering deviations.

7.4 Preheating and post weld heat treatment is required when so specified in the applicable code for:

- The service conditions.
- The particular material.
- The material thickness.
- Weld configuration.
- Consumables.

The preheat temperature is to be checked and maintained throughout welding.

7.5 If post-weld heat treatment is specified, temperature graph and hardness measurement results are required.

8. INSPECTION AND TESTING

8.1 The term inspector, used in this Standard, refers to the Company's representative.

8.2 The inspection and testing of the heat exchanger at the manufacturer's shop shall be performed in accordance with ASME Code Section VIII Div.1 and the following requirements.

8.3 All parts and tools necessary for inspection and testing shall be prepared by the manufacturer.

8.4 Spot radiographic examination according to ASME Code Section VIII Div.1 shall be as a minimum requirement for the welds of double pipe heat exchanger. Acceptance criteria shall be per par. UW-51 of the above mentioned code.

8.5 Unless specified otherwise,scope of inspection for double pipe heat exchangers shall be as follows:

8.5.1 Material inspection:

a) Review of material certificates.
b) Identification of material.

8.5.2 Welding procedure and welders'/welding operator's performance qualification tests:

a) Review of welding procedure specification (WPS).
b) Review of welding procedure qualification records (PQR).
c) Review of welder's/welding operator's performance qualification records.

8.5.3 Random witness in fabrication process, such as edge preparation, fit-up, welding, tube hole preparation and finish, tube expansion, seal welding etc.

8.5.4 Review of records of post weld heat treatment (if any).

8.5.5 Non-destructive examination (where applicable):

a) Monitoring of radiographic examination and review of radiographs.
b) Witness of ultrasonic examination.
c) witness of magnetic particle examination.

8.5.6 Check of hardness test on welds if specified.

8.5.7 Pressure tests:

a) Witness of hydrostatic test.
b) Witness of pneumatic test if any.

8.5.8 Final inspection:

a) Visual inspection.
b) Check of dimensions.

8.5.9 Painting inspection if applicable.

8.5.10 Review and endorsement of inspection reports issued by manufacturers.

8.6 Unless agreed otherwise, the applicable references for inspection and tests shall be as follows:

8.6.1 The standards specified in this Specification and others specified in the purchase order.

8.6.2 ASME Code, ASTM Standards, ANSI and TEMA Standards.

8.6.3 Approved manufacturer's specifications and drawings.

9. SUPPLEMENTARY REQUIREMENTS

9.1 Inquiries and Quotations

9.1.1 Inquiries

9.1.1.1 An inquiry to a supplier will include the double pipe heat exchanger specification sheet (Appendix A) partially-completed as appropriate.

9.1.1.2 All necessary data including any special requirements or exceptions to this Standard will be provided.

9.1.1.3 In the case of conflict between this Standard and the inquiry or order, the inquiry or order shall govern.

9.1.2 Quotation

9.1.2.1 The Vendor's proposal shall include, for each unit, a completed specification sheet (see Appendix A) or, when a specification sheet is included in the inquiry, a statement indicating complete compliance with that specification sheet.

9.1.2.2 The quotation shall be in accordance with technical specification of this Standard, and the specific requirements for each unit as specified in the data sheet or purchase order.

9.1.2.3 The proposal shall include a detailed description of all exceptions to the specified requirements, together with the reasons for deviations.

9.2 Drawings and Documentation

9.2.1 In the event of an order, the vendor shall furnish all engineering documents as specified in this Section.

9.2.2 Four copies of each drawing shall be submitted.

9.2.3 The engineering documents shall be in English.

9.2.4 Drawings for approval

9.2.4.1 Within the time specified after receipt of the purchase order, the Vendor shall submit general arrangement and/or detailed workshop drawings for approval by the Company. These drawings shall show the complete unit to be supplied and shall give the technical information required.

9.2.4.2 Shop fabrication of the parts shall not be started before the relevant Vendor's and/or sub-contractor's drawings have been approved by the Company.

9.2.4.3 Approval of drawings by the Company shall not relieve the Vendor of his responsibility to meet the requirements of the Purchase order.

9.2.5 Information required after approval of drawings:

9.2.5.1 Upon receipt of the Company's approval of the drawings, the Vendor shall furnish one reproducible copy of the approved drawings.

9.2.5.2 Qualified welding procedure, as required by the ASME Boiler and Pressure Vessel Code, shall be submitted for review and approval or for record purposes.

9.2.6 Drawings and reports for record

9.2.6.1 After satisfactory completion of fabrication and inspection, the Vendor shall furnish the Company with four copies of the following documents:

- As built specification sheet that includes material specifications and grades for all pressure parts.
- As built drawings.
- Manufacturer's data report (see form U-1, Section VIII, Division 1 of the ASME Code).
- Nameplate rubbing.
- Certified material test reports or certificates of compliance, as required by the ASME Code.

- The temperature recorder charts made during post-weld heat treatment.
- Inspection reports and records, when applicable.

9.2.6.2 Unless otherwise agreed, the drawings, specification and the design are to be considered as property of the Company and the Company shall have the right to use these drawings, etc., for any purpose without obtaining permission of the Vendor.

9.3 Spare Parts

9.3.1 Manufacturer shall include with his quotation a list of recommended spare parts and special tools if needed for two years operation.

9.3.2 Two sets of gaskets for each double pipe heat exchanger shall, as a minimum, be included in the spare parts list.

9.4 Preparation for Shipment

9.4.1 Internal and external surfaces of the exchanger shall be free from loose scale and other foreign material that is readily removable.

9.4.2 Water, oil, or other liquids used for cleaning or hydrostatic testing shall be drained from all sections before shipment.

9.4.3 Surface preparation and painting shall be as specified in the relative purchase order.

9.4.4 Machined surfaces and flange faces shall be temporary protected against corrosion during shipment and subsequent storage, by coating with a rust preventive which is easily removable with a petroleum solvent. Temporary protection against corrosion shall be in accordance with IPS-E-TP-100 or BS 1133, subsection 6.2-1991.

9.4.5 All threads of bolts including exposed parts shall be coated with a metallic base waterproof coating to prevent galling in use and aqueous corrosion during testing, shipping and storage.

9.4.6 Flange connections shall be blanked with bolted wood or metal covers. Beveled ends shall be protected with suitable covers. Threaded connections shall be fitted with a cap or plug.

9.4.7 Exchangers shall be shipped completely assembled and shall be clearly identified by painting or dye stenciling the equipment number in a conspicuous location.

APPENDICES

APPENDIX A
SPECIFICATION SHEET FOR
DOUBLE PIPE HEAT EXCHANGER

FOR VENDOR	b MULTI-TUBE	b SINGLE TUBE SERVICE	b FINNED TUBE	b BARE TUSE

DUTY kj/s	SHELL SIDE				TUBE SIDE			
FLUID								
TOTAL FLOW kg/s								
LIQUID. kg/s	INLET		OUTLET		INLET		OUTLET	
SP-GR	@	°C	@	°C	@	°C	@	°C
THERMAL COND W/m °C	@	°C	@	°C	@	°C	@	°C
SPECIFIC HEAT kj/kg°C	@	°C	@	°C	@	°C	@	°C
VISCOSITY Pa.s	@	°C	@	°C	@	°C	@	°C
VAPOR kg/s								
MOLECULAR WEIGHT								
THERMAL COND W/m °C	@	°C	@	°C	@	°C	@	°C
SPECIFIC HEAT kj/kg °C	@	°C	@	°C	@	°C	@	°C
VISCOSITY Pa.s	@	°C	@	°C	@	°C	@	°C
ADDITIONAL DATA ON SHEET NO								
OPERATING TEMPERATURES °C								
PRESSURES bar (ga)								
VELOCITIES m/s								
PRESSURE DROP (NOTE A) bar	ALLOW		CALC		ALLOW		CALC	
DESIGN TEMPERATURE °C								
PRESSURE bar (ga)	MIN.		ACTUAL	TEST	MIN.		ACTUAL	TEST
MIN. CORROSION ALLOWANCE mm	MIN.		CALC.		MIN.		CALC.	
FOUL. RESIST m^2h °C/kj	SHELL FOUL. ( ) +TUB FOUL. ( ) ×		TOT. OUT SURF / TOT. IN SURF.		( )= TOT. FOUL ( )			

NO. OF SECTIONS	SHELL DIA. × LENGTH mm. NOM.× m.	NOZZLES (ANS1)	TUBE SIDE SIZE RATING
AREA PER SECT. (NOTE B) . m^2	SCHEDULE	INLET	
OUT. AREA (NOTE B) . m^2	NO. TUBES PER SHELL	OUTLET	
LMTD	TUBE DIA. × LENGTH IN × m.		SHELL SIDE SIZE RATING
CORRECTED MTD	SCHED, OR GAUGE. BWG	INLET	
TRANSFER COEF. CLEAN	FINS PER TUBE	OUTLET	
KW/m^2 °C SERVICE	FIN HT.× THICKNESS mm × mm		
CODE REQUIREMENTS ASME (YES) (NO)	FIN CUTS PER SECT	TOTAL WEIGHT THIS ITEM	
CODE STAMP (YES) (NO)	WEIGHT PER SECT kg	EMPTY	kg
REMOVABLE TUBES (YES) (NO)	WEIGHT PER ELEMENT kg	FLOODED	kg

MATERIALS (MARK STRESS RELIEVED. SM. RADIOGRAPHED- X.R.)

TUBES
FINS
SHELL
SHELL COVER
TUBE CONNECTORS
SHELL CONNECTORS
GASKETS
SHELL NOZZ FLGS
HOOK UP SHELL SIDE
TUBE SIDE
STACKING ARRANGEMENT
REMARKS:

SKETCH SHOWING ARRANGEMENT OF SECTIONS

NOTE A, FOR CONDENSERS AND THERMOSYPHON REBOILERS PRESSURE DROP STATED SHALL INCLUDE STATIC HEAD BETWEEN CENTERLINES OF INLET AND CUTLET FLANGES.
NOTE B: OUTSIDE TUBE AND FIN AREA.

PARALLEL BANKS OF SECTIONS IN SERIES
PARALLEL BANKS OF SECTIONS IN SERIES
WIDE HIGH

APPENDIX B
TYPICAL MATERIALS OF CONSTRUCTION FOR DOUBLE PIPE HEAT EXCHANGERS IN NORMAL SERVICES

Shell (Pipe)	Seamless Carbon Steel, Open-hearth or Electric Furnance ASTM A-106, Gr. A or B ASTM A-53 , Gr. A or B
Shell Return	Carbon Steel Casting ASTM A=216, Gr. WCA or WCB
Shell Cover Plate	Carbon Steel Plate ASTM A-285, Gr., C ASTM A-515, & 516
Fittings, Flanges	Forged Steel ASTM A-105
Exchanger Tubes, also Connectors	Carbon Steel Tube ASTM A-179 Ferritic Alloys, Tubes ASTM A-199 Austenitic Alloys ASTM-A-213 Admiralty Metal ASTM B-111 Type B, C or D (Cooling Water Service)
Exchanger Pipe, also Connectors	Seamless Carbon Steel Pipe ASTM A-106, Gr, A or B Ferritic Alloys ASTM A-335 Austenitic Alloys-Seamless ASTM A-312 Copper Alloys, Admiralty Metal ASTM B-111 Type B, C or D Nickel Copper Alloys Monel ASTM B-163
Fins (Strip)	(Material to be compatible with tube metallurgy and shellside fluid).
Support Brackets	Steel ASTM A-36
Nuts	Steel ASTM A-194, Class 211
Bolts	Steel ASTM A-193, Gr, B7 or B14