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GP 26-10

Heat Exchangers

Group Practice

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This issue of Engineering Technical Practice (ETP) GP 26-10 incorporates a new Figure A-1 because the previous figure was used inadvertently in violation of copyright.

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1. Scope

This GP provides guidance for the selection, design, and installation of heat exchangers.

2. Normative references

The following referenced documents may, to the extent specified in subsequent clauses and normative annexes, be required for full compliance with this GP:

- For dated references, only the edition cited applies.
- For undated references, the latest edition (including any amendments) applies.

BP

GIS 26-101	Shell and Tube Heat Exchangers (ISO 16812 or API 660).
GIS 26-102	Double Pipe Heat Exchangers.
GIS 26-103	Air-Cooled Heat Exchangers (ISO 13706 or API 661).
GIS 26-104	Plate Heat Exchangers.
GIS 26-106	Steam Surface Condensers.
GIS 36-101	Pressure Equipment Bolting.
GIS 46-010	Pressure Vessels.
GP 04-20	Civil Engineering.
GP 06-14	Erosion Control.
GP 06-33	Cathodic Protection of Onshore Structures and Equipment.
GP 12-01	Power System Design.
GP 12-10	Switchgear and Controlgear.
GP 12-20	Motors.
GP 36-10	Metallic Materials Selection.
GP 42-10	Piping Systems (ASME B31.3).
GP 44-10	Plant Layout.
GP 60-10	Cooling Water Systems and Treatment.

American Petroleum Institute (API)

API Std 660	Shell-and-Tube Heat Exchangers for General Refinery Services.
API Std 661	Air-Cooled Heat Exchangers for General Refinery Service.
API Std 662	Plate Heat Exchangers for General Refinery Services.

American Society of Mechanical Engineers (ASME)

ASME Boiler and Pressure Vessel Code	
Sec II	Section II Materials
	Part A Ferrous Material Specifications.
	Part B Nonferrous Material Specifications.

Heat Exchange Institute (HEI)

Heat Exchange Institute Standards for Steam Surface Condensers.



International Standardisation Organisation (ISO)

ISO 13706	Petroleum and natural gas industries – Air-cooled heat exchangers.
ISO 15547	Petroleum and natural gas industries – Plate heat exchangers.
ISO 16812	Petroleum and natural gas industries – Shell-and-tube heat exchangers.

Tubular Exchanger Manufacturers Association (TEMA)

Standards of the Tubular Exchanger Manufacturers Association.

3. Symbols and abbreviated terms

For the purpose of this GP, the following abbreviations apply:

DBHE	Diffusion bonded heat exchanger.
HTFS	Heat Transfer Fluid Flow Services.
HTRI	Heat Transfer Research Inc.
MAWP	Maximum allowable working pressure.
MDMT	Minimum design metal temperature.
MOP	Maximum operating pressure.
NTIW	No tube in window.
PFHE	Plate fin heat exchanger.
TMTD	True mean temperature difference.

4. General**4.1. Heat exchanger selection**

Table A-1 in Annex A provides typical process design limits for common types of heat exchangers.

4.2. Data sheets

Information contained in this GP should be used to complete the appropriate heat exchanger data sheet provided in ISO documents, or equivalent. Double pipe or multitube hairpin type heat exchangers can be specified on shell and tube heat exchanger data sheets. HTRI and HTFS software provide electronic data sheets.

4.3. Design performance

- a. Utilities shall be specified by BP.
- b. For any group of exchangers, units shall be designed to permit interchangeability of components, if feasible.
- c. Cooling water treatment shall comply with GP 60-10.
- d. Normal and alternate operating conditions affecting the design of the exchanger shall be specified on separate data sheets.



- e. Exchangers shall be designed for maximum operating conditions that impact exchanger performance, including:
 - 1. Duties.
 - 2. Flow rates.
 - 3. Fluid properties.
 - 4. Temperatures.
 - 5. Pressures.
- f. Typical alternate operating conditions include:
 - 1. Start of run.
 - 2. End of run.
 - 3. Loss of flow.
 - 4. Steam out.
- g. Heat exchangers should be designed for proper venting and draining.
- h. If extra performance is required, said conditions should be specified in percent of increase in flow rates and duty.
- i. Thermal and hydraulic designs shall be evaluated using the latest versions of computer programs from HTRI or HTFS. The use of other software shall be subject to BP approval.
- j. Special services that affect material selection, fabrication, inspection, and testing shall be clearly specified on the data sheet.

4.4. Guarantees

- a. Vendors shall guarantee the thermal and hydraulic performance of the unit. Vibration analysis shall be an integral part of the performance guarantee.
- b. Vendors shall be responsible for and guarantee the mechanical design.

4.5. Process data requirements

4.5.1. All process streams

- a. Property data shall be provided in tabular form at the inlet and expected outlet pressure for the complete temperature range of exchanger operation, and include:
 - 1. Density.
 - 2. Heat capacity.
 - 3. Thermal conductivity.
 - 4. Viscosity.
 - 5. Enthalpy.
 - 6. Weight fraction vapour.
- b. For boiling streams, also include:
 - 1. Liquid surface tension.
 - 2. Pseudo-critical temperature.
 - 3. Pseudo-critical pressure.
- c. For thermosyphon reboilers, pressure references shall be at the column bottoms and expected inlet to the reboiler including liquid static head.



4.5.2. Condensing and boiling process streams

- a. Heat release data shall be provided in tabular form at the inlet and expected outlet pressure for the complete temperature range of condensing and boiling streams including dew point and bubble point (if applicable).
- b. For thermosyphon reboilers a sketch shall be provided that shows:
 1. Tower and reboiler relative locations/elevations.
 2. Interconnecting piping with line sizes, elbows, fittings, and lengths.
 3. Tower liquid level(s).
 4. Type of reboiler required (recirculating or once through).

4.6. Pressure drop

- a. If available, pressure drop (and resultant higher heat transfer due to increased velocity) should be made available for heat exchanger design instead of dissipating pressures in valves.
- b. In general, pressure drop through single phase exchangers is set between, 35 kPa to 70 kPa (5 psi to 10 psi) as this generally provides a reasonable trade off between pumping power and heat transfer area costs.
- c. Condensers are usually specified for approximately 7 kPa to 35 kPa (1 psi to 5 psi) drop and should not exceed about 10% of the operating pressure.
- d. Reboiler pressure drop ranges from 2 kPa to 7 kPa (0,25 psi to 1 psi).
 1. For vertical thermosyphon reboilers, the liquid level is generally located at the top tubesheet. At operating pressures less than 200 kPa (30 psia), the liquid level may be located below the top tubesheet to ensure the high static head does not adversely affect performance.
 2. For horizontal thermosyphon reboilers, the elevation of the reboiler relative to the column should be set to limit the weight fraction vapour out of the reboiler no greater than 0,5.
- e. Vertical thermosiphon reboilers normally are designed for a weight fraction vapour out of 0,2-0,4. In no case shall the circulation rate generate a weight fraction vapour out of the reboiler greater than 0,5.
- f. Exchangers in viscous service require special attention because significant pressure drop may be required to achieve turbulent flow. A heat exchanger specialist should be consulted.

4.7. Design pressure and temperatures**4.7.1. General**

Design Pressure and Design Temperature should be determined using the pressure vessel and relief system GIS guidelines.

4.7.2. Design pressure

- a. Maximum Operating Pressure (MOP) and highest service temperature shall be determined from process design.
- b. MOP shall be highest operating pressure for a given process condition, excluding unpredicted pressure excursions.
- c. Maximum Allowable Working Pressure (MAWP) shall be equal to or greater than design pressure.



- d. For vacuum service, design vacuum shall be full vacuum.
- e. For the low pressure side Design Pressure, consider failure of the boundary between the high pressure and low pressure sides.

4.7.3. Minimum design metal temperature

Minimum Design Metal Temperature (MDMT) shall be specified.

4.8. Materials

- a. Materials for pressure containing parts shall be chosen from GP 36-10.
- b. For hydrogen service or other onerous (sour water, wet H₂S, amine, caustic, hydrofluoric acid, wet CO₂, or polythionic acid) services, tubes shall be seamless.

4.9. Fouling

Fouling factors should be based on satisfactory BP operating experience for similar services. If no data is available, then those recommended by TEMA may be used.

4.10. Vibration

Heat exchangers shall be free of any potential damage from mechanical or acoustic vibration. All possible operating conditions shall be considered.

4.11. Design velocities

Vendor shall be advised of any minimum or maximum velocity requirements.

4.12. Piping

Piping and flanges associated with heat exchangers shall comply with GP 42-10.

4.13. Connections

- a. Flange connection bolting meeting the conditions of Table 1 (below) shall have sufficient clearance and access to allow the use of hydraulic tensioning equipment.

Table 1 – Design requiring bolt tensioning

Nominal bolt diameter	Condition
50 mm (2 in) and over	All joints
38 mm (1 1/2 in) and over	(a) Joints of PN 100 (Class 600) and over (b) Joints in hydrogen service
25 mm (1 in) and over	(a) Joints subject to high temperatures or cyclic duties (b) Joints with leakage history (c) Joints where high accuracy of bolt load is required

- b. Stud bolts and nuts shall be compatible with the chosen bolt tensioner.
- c. Flange faces shall be consistent with connected piping.

4.14. Threaded connections

Threaded connections shall not be used unless approved by BP.

5. Shell and tube heat exchangers

5.1. General

- a. Requirements stated below shall be used to complete the shell and tube data sheet.



- b. Shell and tube heat exchangers shall comply with GIS 26-101. Specific designs are classified to TEMA standard Figure N-1.2.
- c. If a shell might be over-pressured in the event of a burst tube, a review of the need for overpressure protection shall be performed in accordance with 4.7.1.
- d. For reboiler special requirements, refer to Clause 5.13.
- e. Access for bundle removal at operating site is required.

5.2. TEMA classes

Use of TEMA Class B or Class C exchangers shall be subject to BP approval.

5.3. Types

- a. If shell side fluid is clean and no mechanical cleaning of shell side is required, a fixed tubesheet exchanger may be used (Type L, M, or N rear head).
- b. If shell side requires mechanical cleaning but tube side does not, a U tube bundle (Type U rear head) may be used.
- c. If both sides of the exchanger need to be mechanically cleaned, a Type S floating rear head should be specified.
- d. If frequent shell side cleaning is required (severe fouling) a Type T rear head may be selected.
- e. TEMA Type P and Type W rear head for removable bundles shall not be used.
- f. Use of shell Type F shall be subject to BP approval (see 5.5.3.d.).

5.4. Tubes

5.4.1. General

- a. Material grades for shell and tube heat exchangers shall comply with GP 36-10.
- b. GIS 46-010 contains Appendices with BP requirements for fabrication in different materials. This guide also provides information on material requirements if the design temperature is below 0°C (32°F).
- c. Materials for use in sour water service shall comply with GP 36-10.
- d. If the use of salt water or other aggressive water on the shell side of an exchanger is unavoidable, the shell shall be of corrosion resistant material. Materials for the tube bundle and shell shall be selected to ensure galvanic compatibility.

5.4.2. Water cooled exchangers with water on tube side

- a. If the cooling water is treated to be noncorrosive to carbon steel, carbon steel tubes and tubesheets should be considered.
- b. If cooling water is not treated to be noncorrosive to carbon steel, the following materials should be considered for the tubes, subject to their compatibility with the process side fluids:
 - 1. Admiralty brass with fresh and recirculated fresh cooling water.
 - 2. Aluminium brass with seawater and other corrosive waters; 90-10 Cu-Ni and 70-30 Cu-Ni may be used as alternatives.
 - 3. Titanium for use with seawater and other corrosive waters.

