Shell-and-Tube Heat Exchangers

API STANDARD 660
NINTH EDITION, MARCH 2015

AMERICAN PETROLEUM INSTITUTE

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Introduction

It is necessary that users of this standard be aware that further or differing requirements can be needed for individual applications. This standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This can be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this standard and provide details.

This standard requires the purchaser to specify certain details and features.

A bullet (●) at the beginning of a section indicates a requirement for the purchaser to make a decision or provide information (for information, a checklist is provided in Annex B).

In this standard, where practical, U.S. Customary (USC) or other units are included in parentheses for information.

Shell-and-Tube Heat Exchangers

1 Scope

This standard specifies requirements and gives recommendations for the mechanical design, material selection, fabrication, inspection, testing, and preparation for shipment of shell-and-tube heat exchangers for the petroleum, petrochemical, and natural gas industries.

This standard is applicable to the following types of shell-and-tube heat exchangers: heaters, condensers, coolers, and reboilers.

This standard is not applicable to vacuum-operated steam surface condensers and feed-water heaters.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ASME B16.5 [1], *Pipe Flanges and Flanged Fittings: NPS 1/2 through NPS 24 Metric/Inch Standard*

ASME PCC-1-2013, *Guidelines for Pressure Boundary Bolted Flange Joint Assembly*

EJMA [2], *Standards of the Expansion Joint Manufacturers Association*

NACE MR0103 [3], *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

NACE MR0175, *Petroleum and natural gas industries—Materials for use in H_2S containing environments in oil and gas production—Parts 1, 2 and 3*

NACE SP0472, *Methods and Controls to Prevent In-Service Environmental Cracking of Carbon Steel Weldments in Corrosive Petroleum Refining Environments*

TEMA [4], Ninth Edition, *Standards of the Tubular Exchanger Manufacturers Association*

3 Terms and Definitions

For the purposes of this document, the following definitions apply.

3.1
annular distributor
An additional chamber incorporated into a shell side nozzle to evenly distribute shell side fluids entering or exiting the tube bundle.

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1 ASME International, 2 Park Avenue, New York, New York 10016-5990, www.asme.org.
2 Expansion Joint Manufacturers Association, 25 North Broadway, Tarrytown, New York 10591, www.ejma.org.
3 NACE International (formerly the National Association of Corrosion Engineers), 1440 South Creek Drive, Houston, Texas 77084-4906, www.nace.org.
4 Tubular Exchanger Manufacturers Association, 25 North Broadway, Tarrytown, New York 10591, www.tema.org.

3.2
category A welded joint
Longitudinal welded joint within the main shell, communicating chambers, nozzles, or transitions in diameter; or any welded joint within a sphere or within a formed or flat head; or circumferential welded joint connecting hemispherical heads to main shells, to transitions in diameters, or to communicating chambers.

3.3
category B welded joint
Circumferential welded joint within the main shell, communicating chambers, nozzles, or transitions in diameter including joints between the transitions and a cylinder at either the large or small end; or circumferential welded joint connecting formed heads, other than hemispherical to main shells, to transitions in diameter, to nozzles, or to communicating chambers.

3.4
communicating chamber
Heat exchanger appurtenance that intersects the shell or heads of the heat exchanger and forms an integral part of the pressure-containing envelope.

EXAMPLE Sump, Annular Distributor.

3.5
cyclic service
Process operation with periodic variation in temperature, pressure, and/or flow rate.

3.6
effective heat transfer area
Outside surface area of the tubes that contributes to heat transfer including finned surface (if any).

3.7
full-penetration weld
Welded joint which results in weld metal through the entire thickness of the components being joined.

3.8
heat exchanger unit
One or more heat exchangers arranged in series or parallel for a specified service that operate together to perform the intended duty.

3.9
hydrogen service
Services that contain hydrogen at a partial pressure exceeding 700 kPa (100 psi) absolute.

3.10
item number
Purchaser’s identification number for a heat exchanger unit.

3.11
minimum design metal temperature
MDMT
Lowest metal temperature at which pressure-containing elements can be subjected to design pressure.

EXAMPLE Ambient temperature or process fluid temperature.

3.12
nubbin
Projection on the flange gasket surface, positioned at the center of the gasket, used to concentrate the bolt load on the gasket.

3.13
pressure design code
Recognized pressure vessel standard specified or agreed by the purchaser.

EXAMPLE ASME *BPVC, Section VIII*, EN 13445 (all parts).

3.14
seal-welded
Tube-to-tubesheet joint weld of unspecified strength applied between the tubes and tubesheets for the sole purpose of reducing the potential for leakage.

3.15
strength-welded
Tube-to-tubesheet joint welded so that the design strength is equal to, or greater than, the axial tube strength specified by the pressure design code.

4 General

- **4.1** The pressure design code shall be specified or agreed by the purchaser. Pressure components shall comply with the pressure design code and the supplemental requirements given in this standard.

4.2 Heat exchanger construction shall conform to TEMA, Class R, unless another TEMA class is specified.

- **4.3** The vendor shall comply with the applicable local regulations specified by the purchaser.

4.4 Annex A includes some recommended mechanical and design details for information.

4.5 Annex B provides a checklist that can be used by the purchaser to ensure that bulleted items in this standard are addressed.

4.6 Annex C provides examples of data sheets.

- **4.7** The purchaser shall specify if either stream has fluid characteristics requiring special considerations (e.g. slurry, entrained particulates, or other certain types of fouling mechanisms).

- **4.8** The purchaser shall specify if cyclic service design is required.

4.9 If cyclic service is specified, the purchaser shall specify the type and magnitude of variation in pressure, temperature and flow rate, the time for the variation (hours, weeks, months, etc.) and the number of cycles or frequency for this variation expected during the life of the equipment. The extent and acceptance criteria of any required analysis shall be subject to the agreement of the purchaser. See A.2.1 for guidance on cyclic service.

- **4.10** The purchaser shall specify if the service is designated as sour in accordance with NACE MR0175 (all parts) for oil and gas production facilities and natural gas processing plants or is designated as wet hydrogen sulfide service in accordance with NACE MR0103 for other applications (e.g. petroleum refineries, LNG plants, and chemical plants), in which case all materials in contact with the process fluid shall meet the requirements of the applicable standard to mitigate potential for sulfide stress cracking (SSC). Identification of the complete set of materials, qualification, fabrication, and testing specifications to prevent in-service environmental cracking is the responsibility of the user (purchaser). See A.2.2 for guidance on sour or wet hydrogen sulfide service.