INTERNATIONAL STANDARD

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Petroleum, petrochemical and natural gas industries — Air-cooled heat exchangers

Industries du pétrole, de la pétrochemie et du gaz naturel — Échangeurs de chaleur refroidis à l'air

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 13706 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

This third edition cancels and replaces the second edition (ISO 13706:2005), which has been technically revised.

Introduction

It is necessary that users of this International Standard be aware that further or differing requirements can be needed for individual applications. This International 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, it is the responsibility of the vendor to identify any variations from this International Standard and provide details.

Petroleum, petrochemical and natural gas industries — Air-cooled heat exchangers

1 Scope

This International Standard gives requirements and recommendations for the design, materials, fabrication, inspection, testing and preparation for shipment of air-cooled heat exchangers for use in the petroleum, petrochemical and natural gas industries.

This International Standard is applicable to air-cooled heat exchangers with horizontal bundles, but the basic concepts can also be applied to other configurations.

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.

ISO 76, *Rolling bearings — Static load ratings*

ISO 281, *Rolling bearings — Dynamic load ratings and rating life*

ISO 286 (all parts), *Geometrical product specifications (GPS) — ISO code system for tolerances on linear sizes*

ISO 1081, *Belt drive — V-belts and V-ribbed belts, and corresponding grooved pulleys — Vocabulary*

ISO 1461, *Hot-dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 2491, *Thin parallel keys and their corresponding keyways (dimensions in millimetres)*

ISO 4183, *Belt drives — Classical and narrow V-belts — Grooved pulleys (system based on datum width)*

ISO 4184, *Belt drives — Classical and narrow V-belts — Lengths in datum system*

ISO 5287, *Belt drives — Narrow V-belts for the automotive industry — Fatigue test*

ISO 5290, *Belt drives — Grooved pulleys for joined narrow V-belts — Groove sections 9N/J, 15N/J and 25N/J (effective system)*

ISO 8501-1, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 9563, *Belt drives — Electrical conductivity of antistatic endless synchronous belts — Characteristics and test method*

ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H_2S-containing environments in oil and gas production*

AGMA 6001[1], *Design and Selection of Components for Enclosed Gear Drives*

ANSI/AGMA 6010, *Spur, Helical, Herringbone and Bevel Enclosed Drives*

ASME PTC 30[2], *Air-Cooled Heat Exchangers*

ICC[3], *International Building Code*

NACE MR0103[4], *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

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

3 Terms and definitions

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

3.1
bank
one or more items arranged in a continuous structure

3.2
bare tube surface
total area of the outside surfaces of the tubes, based on the length measured between the outside faces of the header tubesheets

3.3
bay
one or more tube bundles, serviced by two or more fans, including the structure, plenum and other attendant equipment

NOTE Figure 1 shows typical bay arrangements.

3.4
critical process temperature
temperature related to important physical properties of a process stream

EXAMPLES Freezing point, pour point, cloud point, hydrate formation temperature and dew point.

3.5
cyclic service
process operation with periodic variation in temperature, pressure, and/or flowrate

3.6
exhaust air
air that is discharged from the air-cooled heat exchanger to the atmosphere

3.7
external recirculation
process that uses an external duct to carry recirculated air to mix with and heat the inlet air

1) American Gear Manufacturers' Association, 1500 King Street, Suite 201, Alexandria, VA 22314, USA.

2) American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990, USA.

3) International Code Council Foundation, 10624 Indian Woods Drive, Cincinnati, OH 45242, USA.

4) NACE International, P.O. Box 218340, Houston, TX 77218-8340, USA.

3.8
finned surface
<of a tube> total area of the outside surface exposed to air

3.9
forced-draught exchanger
exchanger designed with the tube bundles located on the discharge side of the fan

3.10
geometric centre
location at the centre of a bay on a plane midway between the air inlet and the air outlet for both forced-draft and induced-draft units

NOTE The geometric centre is also considered the acoustic centre of a bay for calculations.

3.11
hydrogen service
services that contain hydrogen at a partial pressure exceeding 700 kPa (100 psi) absolute

3.12
induced-draught exchanger
exchanger designed with the tube bundles located on the suction side of the fan

3.13
inlet air
atmospheric or ambient air that enters the air-cooled heat exchanger

3.14
internal recirculation
process that uses fans (possibly with louvres) to recirculate air from one part of the process bundle to the other part

3.15
item
one or more tube bundles for an individual service

3.16
item number
purchaser's identification number for an item

3.17
measurement surface
surface of the bay or the cylinder or sphere on which sound-pressure level is measured

3.18
minimum design air temperature
specified inlet air temperature that is used for winterization

3.19
minimum design metal temperature
lowest metal temperature at which pressure-containing elements can be subjected to design pressure

3.20
octave bands
preferred frequency bands

3.21
pressure design code
recognized pressure vessel standard specified or agreed by the purchaser

EXAMPLE ASME BPVC VIII.

3.22
recirculated air
air that has passed through the process bundle and is redirected to mix with and heat the inlet air

3.23
specified minimum tube-wall temperature
critical process temperature plus a safety margin

3.24
structural code
recognized structural standard specified or agreed by the purchaser

EXAMPLES AISC M011 and AISC S302.

3.25
tube bundle
assembly of headers, tubes and frames

3.26
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

3.27
sound level
sound-pressure level when frequency is weighted according to the standardized A, B, or C weighting used in sound-level meters

NOTE Only A-weighted readings [dB(A)] are referenced in this International Standard.

3.28
sound-power level
ten times the logarithm to base 10 of the ratio of the total acoustic power radiated by a sound source to the reference power of 10^{-12} W

3.29
sound-pressure level
twenty times the logarithm to base 10 of the ratio of the root mean square sound pressure to the reference sound pressure of 2×10^{-5} N/m^2

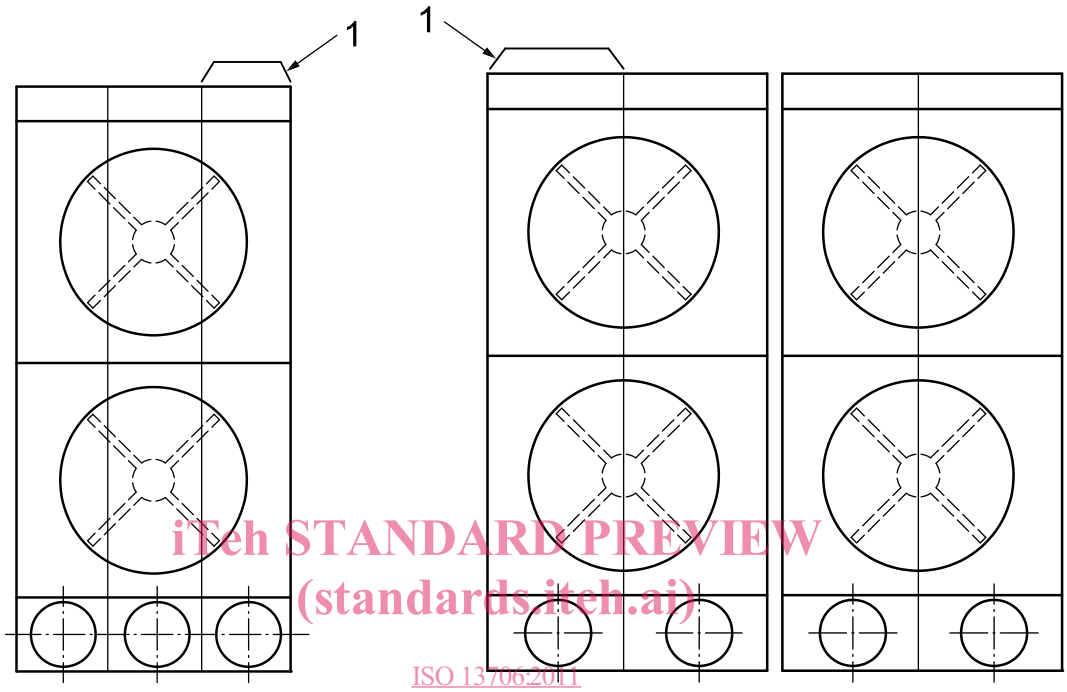
3.30
strength-welded
tube-to-tubesheet joint welded so that the design strength is equal to, or greater than, the axial tube strength specified by the pressure design code

3.31
unit
one or more tube bundles in one or more bays for an individual service

3.32
wind skirt
vertical barrier either above or below an air-cooled heat exchanger that minimizes the effect of wind

3.33
winterization
provision of design features, procedures, or systems for air-cooled heat exchangers to avoid problems with the process fluid as a result of low-temperature inlet air

NOTE Problems related to low-temperature inlet air include fluid freezing, cooling to the pour point, wax formation, hydrate formation, laminar flow, and condensation at the dew point (which can initiate corrosion).



a) One-bay **b) Two-bay**

Key
1 tube bundle

Figure 1 — Typical bay arrangements

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 International Standard.

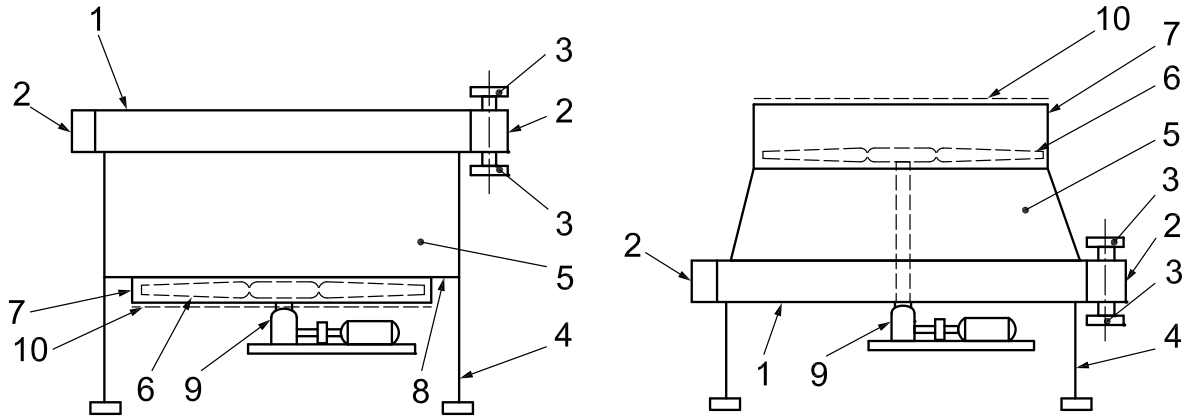
NOTE A bullet (●) at the beginning of a subclause indicates a requirement for the purchaser to make a decision or provide information (see checklist in Annex B).

4.2 The air-cooled heat exchanger shall be either a forced-draught exchanger or an induced-draught exchanger and shall include the components shown in Figure 2 and any auxiliaries such as ladders, walkways and platforms (see A.2).

4.3 Annex A, which may be consulted if required, includes for information some recommended mechanical and design details. Annex A also includes precautions for consideration when specifying certain design aspects, including temperature limitations, type of extended surface, tube support methods, type of air-cooled heat exchanger, materials of gasket construction and operational considerations such as walkway access.

4.4 The vendor shall comply with the applicable local regulations specified by the purchaser.

4.5 In this International Standard, where practical, US Customary (USC) and other commonly used units are included in brackets for information.



a) Forced draught **b) Induced draught**

Key

1	tube bundle	6	fan
2	header	7	fan ring
3	nozzle	8	fan deck
4	supporting column	9	drive assembly
5	plenum	10	fan guard

Figure 2 — Typical components of an air-cooled heat exchanger

4.6 The purchaser shall specify if the service is designated as sour in accordance with ISO 15156 (all parts) for oil and gas production facilities and natural gas sweetening plants, or 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 NACE standard to mitigate the 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).

NOTE For the purpose of this provision NACE MR0175 is equivalent to ISO 15156 (all parts).

4.7 The requirement for winterization and its type shall be specified by the purchaser. Annex C contains guidance on various methods of winterization for air-cooled heat exchangers.

5 Proposals

5.1 The vendor's proposal shall include a completed data sheet for each item (see example in Annex B).

5.2 A proposal drawing that shows the major dimensions in plan and elevation, and the nozzle sizes and their orientation shall be furnished.

5.3 The proposal shall state whether vertically mounted electric motors shall be shaft up or shaft down.

5.4 The proposal shall fully define the extent of shop assembly and include a general description of the components for assembly in the field.

5.5 Any proposal for a design that is not fully described in this International Standard shall include additional drawings sufficient to describe the details of construction.

5.6 The proposal shall include a detailed description of any exceptions to the specified requirements.

● **5.7** The proposal shall include noise data. The proposal shall include a noise data sheet (see example in Annex B) if specified by the purchaser.

5.8 The proposal shall include fan performance characteristic curves with the design point marked on the curves.

5.9 The proposal shall include details of the method used to secure the fin ends; see 7.1.11.7.

5.10 The proposal for an air-cooled exchanger with a recirculation system (as described in Annex C) shall include drawings showing the duct and plenum sizes, net free flow area, louvre type and arrangement, drive location, and proposed control schematic.

6 Documentation

6.1 Approval information

● **6.1.1** For each item number, the vendor shall produce documents that include the following information. The purchaser shall specify which documents shall be submitted and which of them shall be subject to approval.

a) purchaser's item number, service, project name and location, purchaser's order number and vendor's shop order number;

b) design pressure, maximum allowable working pressure, test pressure, maximum and minimum design temperature, and corrosion allowance;

c) fan performance characteristic curves with the design point marked on the curve, including fan critical speeds for use with variable-frequency drives;

d) any applicable codes and purchase specifications of the purchaser;

e) material specifications and grades for all pressure parts;

f) overall dimensions;

g) dimensions and locations of supports and sizes of holding-down bolts;

h) nozzle size, rating, facing, location, projection beyond header surface, allowable loadings (forces and moments) and direction of flow;

i) drive mount details;

j) masses of the tube bundle, the exchanger empty and full of water, and the mass of the heaviest component or combination of components intended by the vendor for handling in a single lift;

k) column reactions for each load type listed in 7.3.3;

l) post-weld heat treatment requirements;

m) U-bend heat treatment or annealing procedure;

n) radiographic and other non-destructive examination requirements;

o) surface preparation and painting requirements;

p) design exposure temperatures for mechanical and instrumentation components;

q) nameplate and its position;

r) tube-to-tubesheet joint and details of joint preparation;

s) maximum and minimum plug torque values with recommended thread lubrication;

t) when sour or wet sulfide service is specified by the purchaser, a certified material test report (CMTR) shall be supplied for all carbon steel materials in contact with the process fluid.

6.1.2 The vendor shall also furnish gasket detail drawings, field assembly drawings, and drawings for all auxiliary equipment and controls furnished. Drawings shall show electrical and control connections, including those of motive and signal air for any pneumatically actuated louvres or fans. The gasket details shall include type and material, and shall be shown on a separate drawing.

- **6.1.3** If specified by the purchaser, calculations required by the pressure design code shall be provided for the design of pressure components, including header boxes, tubes and tube joints. Sufficient detail shall be supplied for any non-standard pressure boundary components, such as swage type transition nozzles. Calculations shall also be provided for restraint relief in accordance with 7.1.6.1.3, and also for the defined external moments and forces on nozzles in accordance with 7.1.10.

- **6.1.4** If specified by the purchaser, weld maps, all proposed welding procedures, including tube to tubesheet welding procedures and qualifications (including impact test results, if applicable) shall be submitted for approval prior to fabrication.

6.1.5 If a hot air recirculation system is utilized for winterization, documents showing duct and plenum sizes, net free flow areas, louvre types and arrangement, louvre drive location(s), heating coil and heating medium consumption, and control scheme schematic shall be provided.

- **6.1.6** Further engineering information required from the vendor for installation, operation, maintenance, or inspection shall be a matter of agreement between the purchaser and the vendor.

6.2 Final records

6.2.1 The vendor shall maintain records of the materials used and fabrication details for at least 10 years.

- **6.2.2** The purchaser shall specify which of the following shall be furnished, and shall specify if any of them shall be in an electronic medium:

a) “as-built” data sheet, including material specifications and grades for all pressure parts;

b) as-built shop drawings including details of headers and tube bundles; as-built shop drawings shall also be provided for any heating coils;

c) calculations as required by the pressure design code, including nozzle load confirmation, restraint relief and any finite element analysis;

d) certified motor drawing and completed motor data sheet for each size and type of motor;

e) manufacturer's data report in accordance with the pressure design code;

f) certified material test reports for all pressure parts;

g) fan and hub data, including shaft bore and keyway dimensions and coupling and sheave data;

h) schematic diagram for automatically controlled fan pitch or louvre blade adjustment, if the controller is furnished by the vendor;

i) installation, operation and maintenance instructions, including the type of lubrication furnished for gears and bearings;

j) parts list;

k) certified noise data sheet for the air-cooled heat exchanger with the fans operating at rated speed and at design conditions;

l) fan performance characteristic curves showing the operating point and shaft power consumption;

m) louvre characteristic performance curve;

n) temperature recorder charts made during postweld heat treatment of the headers;

o) non-destructive testing records;

p) nameplate rubbing or facsimile.

7 Design

7.1 Tube bundle design

7.1.1 General

7.1.1.1 Tube bundles shall be rigid, self-contained, and designed for handling as a complete assembly.

7.1.1.2 The vendor shall make provision for lateral movement of exchanger tube bundles of at least 6 mm ($^1/_4$ in) in both directions or 12,7 mm ($^1/_2$ in) in only one direction, unless the purchaser and the vendor agree on a different value.

7.1.1.3 Provision shall be made to accommodate thermal expansion of tubes.

7.1.1.4 All tubes shall be supported to prevent sagging and meshing or deformation of fins. Tube supports shall be spaced not more than 1,83 m (6 ft) from centre to centre.

7.1.1.5 A hold-down member (tube keeper) shall be provided at each tube support. Hold-down members shall be attached to side frames by bolting.

7.1.1.6 Tubes of single-pass condensers shall be sloped downward at least 10 mm/m ($^1/_8$ in/ft) towards the outlet header.

7.1.1.7 The last pass of tubes in multi-pass condensers shall be sloped downward at least 10 mm/m ($^1/_8$ in/ft) towards the outlet header (see A.3.1).

7.1.1.8 Air seals shall be provided throughout the tube bundle and the bay to minimize air leakage and bypassing. Any air gap that exceeds 10 mm ($^3/_8$ in) in width shall be sealed.

7.1.1.9 The minimum thickness of metal used for air seal construction shall be 2,7 mm (12 gauge USS); 0,105 in) within the bundle side frame and 1,9 mm (14 gauge USS; 0,08 in) outside the bundle side frame.

NOTE USS is US Standard for sheet and plate iron and steel.

7.1.1.10 Bolts for removable air seals shall be at least 10 mm ($^3/_8$ in) nominal diameter.

● **7.1.1.11** The exchanger shall be designed for an internal steam-out operation at the temperature, pressure, and operating conditions if specified by the purchaser.

● **7.1.1.12** The purchaser shall specify if cyclic service design is required. If cyclic service is specified, the purchaser shall specify the type and magnitude of variation in pressure, temperature and flowrate, the time for