# INTERNATIONAL STANDARD

# ISO 13705

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# Petroleum and natural gas industries — Fired heaters for general refinery service

*Industries du pétrole et du gaz naturel — Réchauffeurs à brûleurs pour usage général dans les raffineries*



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## Foreword

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International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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 International Standard may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13705 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

Annexes D and E form a normative part of this International Standard. Annexes A, B, C, F, G and H are for information only.

## Introduction

This International Standard is based on API standard 560, second edition, September 1995.

Users of this International Standard should be aware that further or differing requirements may 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 may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this International Standard and provide details.

In International Standards, the SI system of units is used. Where practical in this International Standard, US Customary units are included in brackets for information.

A bullet (●) at the beginning of a clause or subclause indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on data sheets (see examples in annex A) or stated in the enquiry or purchase order. Decisions should be indicated on a check list (see example in annex B).

# Petroleum and natural gas industries — Fired heaters for general refinery service

## 1 Scope

This International Standard specifies requirements and gives recommendations for the design, materials, fabrication, inspection, testing, preparation for shipment, and erection of fired heaters, air preheaters, fans and burners for general refinery service.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.



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 13704, *Petroleum and natural gas industries — Calculation of heater-tube thickness in petroleum refineries*

EN 10025[1)], *Hot rolled products of non-alloy structural steels — Technical delivery conditions*

AFBMA Standard 9[2)], *Load ratings and fatigue life for ball bearings*

AMCA 99-2404-78[3)], *Drive arrangements for centrifugal fans*

AMCA 201, *Fans and systems*

AMCA 210, *Laboratory methods of testing fans for aerodynamic performance rating*

ASME B17.1[4)], *Keys and keyseats*

ASME B31.3, *Process piping*

ASME Boiler and pressure vessel code, Section VIII, *Rules for construction of pressure vessels*

ASTM A 36[5)], *Standard specification for carbon structural steel*

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1) European Committee for Standardization (CEN), Rue de Stassart 36, B-1050 Brussels, Belgium.

2) Anti-Friction Bearing Manufacturers Association, 1200 19th Street NW, Suite 300, Washington, DC 20036-2412, USA.

3) Air Movement and Control Assocation, 30 West University Drive, Arlington Heights, IL 60004, USA.

4) American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10017, USA.

5) American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA.

ASTM A 105, *Standard specification for carbon steel forgings for piping applications*

ASTM A 123, *Standard specification for zinc (hot-dip galvanized) coatings on iron and steel products*

ASTM A 143, *Standard practice for safeguarding against embrittlement of hot-dip galvanized structural steel products and procedure for detecting embrittlement*

ASTM A 153, *Standard specification for zinc coating (hot-dip) on iron and steel hardware*

ASTM A 161, *Standard specification for seamless low-carbon and carbon-molybdenum steel still tubes for refinery service*

ASTM A 181, *Standard specification for carbon steel forgings, for general-purpose piping*

ASTM A 182, *Standard specification for forged or rolled alloy-steel pipe flanges, forged fittings, and valves and parts for high-temperature service*

ASTM A 192, *Standard specification for seamless carbon steel boiler tubes for high-pressure service*

ASTM A 193, *Standard specification for alloy-steel and stainless steel bolting materials for high-temperature service*

ASTM A 194, *Standard specification for carbon and alloy steel nuts for bolts for high-pressure or high-temperature service, or both*

ASTM A 209, *Standard specification for seamless carbon-molybdenum alloy-steel boiler and superheater tubes*

ASTM A 210, *Standard specification for seamless medium-carbon steel boiler and superheater tubes*



ASTM A 213, *Standard specification for seamless ferritic and austenitic alloy-steel boiler, superheater and heat-exchanger tubes*



ASTM A 216, *Standard specification for steel castings, carbon, suitable for fusion welding, for high-temperature service*

ASTM A 217, *Standard specification for steel castings, martensitic stainless and alloy, for pressure-containing parts, suitable for high-temperature service*

ASTM A 234, *Standard specification for piping fittings of wrought carbon steel and alloy steel for moderate and high temperature service*

ASTM A 240, *Standard specification for heat-resisting chromium and chromium-nickel stainless steel plate, sheet, and strip for pressure vessels*

ASTM A 242, *Standard specification for high-strength low-alloy structural steel*

ASTM A 283, *Standard specification for low and intermediate tensile strength carbon steel plates*

ASTM A 297, *Standard specification for steel castings, iron-chromium and iron-chromium-nickel, heat resistant, for general application*

ASTM A 307, *Standard specification for carbon steel bolts and studs, 60 000 psi tensile strength*

ASTM A 320, *Standard specification for alloy steel bolting materials for low-temperature service*

ASTM A 325, *Standard specification for structural bolts, steel, heat treated, 120/105 ksi minimum tensile strength*

ASTM A 351, *Standard specification for castings, austenitic, austenitic-ferritic (duplex), for pressure-containing parts*

ASTM A 384, *Standard practice for safeguarding against warpage and distortion during hot-dip galvanizing of steel assemblies*

ASTM A 385, *Standard practice for providing high-quality zinc coatings (hot-dip)*

ASTM A 387, *Standard specification for pressure vessel plates, alloy steel, chromium-molybdenum*

ASTM A 403, *Standard specification for wrought austenitic stainless steel piping fittings*

ASTM A 447, *Standard specification for steel castings, chromium-nickel-iron alloy (25-12 class), for high-temperature service*

ASTM A 560, *Standard specification for castings, chromium-nickel alloy*

ASTM A 572, *Standard specification for high-strength, low alloy columbium-vanadium structural steel*

ASTM A 608, *Standard specification for centrifugally cast iron-chromium-nickel high-alloy tubing for pressure application at high temperatures*

ASTM B 366, *Standard specification for factory-made wrought nickel and nickel alloy fittings*

ASTM B 407, *Standard specification for nickel-iron-chromium alloy seamless pipe and tube*

ASTM B 564, *Standard specification for nickel alloy forgings*

ASTM B 633, *Standard specification for electrodeposited coatings of zinc on iron and steel*

ASTM C 27, *Standard classification of fireclay and high-alumina refractory brick*

ASTM C 155, *Standard classification of insulating firebrick*



ASTM C 332, *Standard specification for lightweight aggregates for insulating concrete*

ASTM C 401, *Standard classification of alumina and alumina-silicate castable refractories*



ASTM C 612, *Standard specification for mineral fiber block and board thermal insulation*

AWS[6] D1.1, *Structural welding code — Steel*

AWS D14.6-96, *Specification for welding of rotating elements of equipment*

MSS SP-55[7], *Quality standard for steel castings for valves, flanges and fittings, and other piping components — Visual method*

NFPA 70[8], *National electrical code*

## 3 Terms and definitions

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

NOTE Terms and definitions related to centrifugal fans are given in annex E.

**3.1**
**air heater**
**air preheater**
heat transfer apparatus through which combustion air is passed and heated by a medium of higher temperature, such as the combustion products, steam or other fluid

6) American Welding Society, 550 NW Le Jeune Road, Miami, FL 33126, USA.

7) Manufacturers Standardization Society, 127 Park Street NE, Vienna, VA 22180, USA.

8) National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101, USA.

**3.2**
**anchor**
**tieback**
metallic or refractory device that holds the refractory or insulation in place

**3.3**
**arch**
flat or sloped portion of the heater radiant section opposite the floor

**3.4**
**atomizer**
device used to reduce liquid fuel to a fine mist

**3.5**
**backup layer**
refractory layer behind the hot face layer

**3.6**
**balanced draught heater**
heater which uses forced-draught fans to supply combustion air and uses induced fans to remove flue gases

**3.7**
**breeching**
heater section where flue gases are collected after the last convection coil for transmission to the stack or the outlet ductwork



**3.8**
**bridgewall**
**gravity wall**
wall which separates two adjacent heater zones



**3.9**
**bridgewall temperature**
temperature of flue gas leaving the radiant section

**3.10**
**burner**
device which introduces fuel and air into a heater at the desired velocities, turbulence and concentration to establish and maintain proper ignition and combustion

NOTE Burners are classified by the type of fuel fired, such as oil, gas, or a combination of gas and oil, which may be designated as “dual fuel” or “combination”.

**3.11**
**butterfly damper**
single-blade damper which pivots about its centre

**3.12**
**casing**
metal plate used to enclose the fired heater

**3.13**
**castable**
insulating concrete poured or gunned in place to form a rigid refractory shape or structure

**3.14**
**ceramic fibre**
fibrous refractory insulation composed primarily of silica and alumina

NOTE Applicable forms include blanket, board, module, rigidized blanket, and vacuum-formed shapes.

**3.15**
**convection section**
portion of the heater in which the heat is transferred to the tubes primarily by convection

**3.16**
**corbel**
projection from the refractory surface generally used to prevent flue gas bypassing the tubes of the convection section if they are on a staggered pitch

**3.17**
**corrosion allowance**
additional material thickness added to allow for material loss due to corrosion

**3.18**
**corrosion rate**
rate of reduction in the material thickness due to chemical attack from the process fluid or flue gas or both

NOTE Corrosion rate is expressed in millimetres per year (mils per year).

**3.19**
**crossover**
interconnecting piping between any two heater-coil sections

**3.20**
**damper**
device for introducing a variable resistance in order to regulate the flow of flue gas or air



**3.21**
**direct air preheater**
heat exchanger which transfers heat directly between the flue gas and the combustion air



NOTE A regenerative air preheater uses heated rotating elements and a recuperative design uses stationary tubes, plates, or cast iron elements to separate the two heating media.

**3.22**
**draught**
negative pressure (vacuum) of the air and/or flue gas measured at any point in the heater

**3.23**
**draught loss**
pressure drop (including buoyancy effect) through duct conduits or across tubes and equipment in air and flue gas systems

**3.24**
**duct**
conduit for air or flue gas flow

**3.25**
**fuel efficiency**
total heat absorbed divided by the total input of heat derived from the combustion of fuel only (lower heating value basis)

NOTE This definition excludes sensible heat of the fuels and applies to the net amount of heat exported from the unit.

**3.26**
**thermal efficiency**
total heat absorbed divided by the total input of heat derived from the combustion of fuel ($h_L$) plus sensible heats from air, fuel and any atomizing medium

**3.27**
**erosion**
reduction in material thickness due to mechanical attack from a fluid

**3.28**
**excess air**
amount of air above the stoichiometric requirement for complete combustion

NOTE Excess air is expressed as a percentage.

**3.29**
**extended surface**
heat-transfer surface in the form of fins or studs attached to the heat-absorbing surface

**3.30**
**extension ratio**
ratio of total outside exposed surface to the outside surface of the bare tube

**3.31**
**flue gas**
gaseous product of combustion including excess air

**3.32**
**forced-draught heater**
heater for which combustion air is supplied by a fan or other mechanical means



**3.33**
**fouling allowance**
factor to allow for a layer of residue that increases pressure drop



NOTE 1 This residue is usually a build-up of coke or scale on the inner surface of a coil.

NOTE 2 The fouling allowance is used in calculating the fouled pressure drop.

**3.34**
**fouling resistance**
factor used to calculate the overall heat transfer coefficient

NOTE The inside fouling resistance is used to calculate the maximum metal temperature for design. The external fouling resistance is used to compensate the loss of performance due to deposits on the external surface of the tubes or extended surface.

**3.35**
**header**
**return bend**
cast or wrought fitting shaped in a 180° bend and used to connect two or more tubes

**3.36**
**header box**
internally insulated structural compartment, separated from the flue-gas stream, which is used to enclose a number of headers or manifolds

NOTE Access is afforded by means of hinged doors or removable panels.

**3.37**
**heat absorption**
total heat absorbed by the coils, excluding any combustion-air preheat

**3.38**
**average heat flux density**
heat absorbed divided by the exposed heating surface of the coil section

NOTE Average flux density for an extended-surface tube is indicated on a bare surface basis with extension ratio noted.

**3.39**
**maximum heat flux density**
maximum local rate of heat transfer in the coil section

**3.40**
**total heat release**
heat liberated from the specified fuel, using the lower heating value of the fuel

**3.41**
**volumetric heat release**
heat released divided by the net volume of the radiant section, excluding the coils and refractory dividing walls

**3.42**
**higher heating value**
$h_H$
**gross heating value**
total heat obtained from the combustion of a specified fuel at 15 °C (60 °F)

**3.43**
**lower heating value**
$h_L$
**net heating value**
higher heating value minus the latent heat of vaporization of the water formed by combustion of hydrogen in the fuel



**3.44**
**hot face layer**
refractory layer exposed to the highest temperatures in a multilayer or multicomponent lining

**3.45**
**hot face temperature**
temperature of the refractory surface in contact with the flue gas or heated combustion air

NOTE The hot face temperature is used to determine refractory or insulation thickness and heat transmitted.

**3.46**
**indirect air preheater**
fluid-to-air heat transfer device

NOTE The heat transfer can be accomplished by using a heat-transfer fluid, process stream or utility stream which has been heated by the flue gas or other means. A heat pipe air preheater uses a vaporizing/condensing fluid to transfer heat between the flue gas and air.

**3.47**
**induced-draught heater**
heater which uses a fan to remove flue gases and maintain a negative pressure in the heater to induce combustion air without a forced-draught fan

**3.48**
**jump over**
interconnecting pipework within a heater coil section

**3.49**
**louvre damper**
damper consisting of several blades, each of which pivots about its centre and is linked to the other blades for simultaneous operation

**3.50**
**manifold**
chamber for the collection and distribution of fluid to or from multiple parallel flow paths

**3.51**
**metal fibre reinforcement**
stainless steel needles added to castable for improved toughness and durability

**3.52**
**monolithic lining**
single-component lining system

**3.53**
**mortar**
refractory material preparation used for laying and bonding refractory bricks

**3.54**
**multicomponent lining**
refractory system consisting of two or more layers of different refractory types

NOTE Examples of refractory types are castable and ceramic fibre.



**3.55**
**multilayer lining**
refractory system consisting of two or more layers of the same refractory type



**3.56**
**natural-draught heater**
heater in which a stack effect induces the combustion air and removes the flue gases

**3.57**
**normal heat release**
design heat absorption of the heater divided by the calculated fuel efficiency

**3.58**
**pass**
**stream**
flow circuit consisting of one or more tubes in series

**3.59**
**pilot**
small burner that provides ignition energy to light the main burner

**3.60**
**plenum**
**windbox**
chamber surrounding the burners that is used to distribute air to the burners or reduce combustion noise

**3.61**
**plug header**
cast return bend provided with one or more openings for the purpose of inspection or mechanical tube cleaning

**3.62**
**pressure design code**
recognized pressure vessel standard specified or agreed by the purchaser

EXAMPLE ASME Boiler and Pressure Vessel Code, Section VIII.

**3.63**
**pressure drop**
difference between the inlet and the outlet static pressures between termination points, excluding the static differential head

**3.64**
**primary air**
portion of the total combustion air that first mixes with the fuel

**3.65**
**protective coating**
corrosion-resistant material applied to a metal surface

EXAMPLE Coating on casing plates behind porous refractory materials to protect against sulfur in the flue gases.

**3.66**
**radiant section**
portion of the heater in which heat is transferred to the tubes primarily by radiation

**3.67**
**radiation loss**
**setting loss**
heat lost to the surroundings from the casing of the heater and the ducts and auxiliary equipment (when heat recovery systems are used)



**3.68**
**secondary air**
air supplied to the fuel to supplement primary air

**3.69**
**setting**
heater casing, brickwork, refractory and insulation, including the tiebacks

**3.70**
**shield section**
**shock section**
tubes that shield the remaining convection-section tubes from direct radiation

**3.71**
**sootblower**
device used to remove soot or other deposits from heat-absorbing surfaces in the convection section

NOTE Steam is normally the medium used for soot blowing.

**3.72**
**stack**
vertical conduit used to discharge flue gas to the atmosphere

**3.73**
**strake**
**spoiler**
metal attachment to a stack which can prevent the formation of von Karman vortices that can cause wind-induced vibration