INTERNATIONAL STANDARD

ISO 13705

Second edition
2006-11-15

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

Industries du pétrole, de la pétrochimie et du gaz naturel — Réchauffeurs à brûleurs pour usage général dans les raffineries

Reference number
ISO 13705:2006(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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 13705 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 second edition cancels and replaces the first edition (ISO 13705:2001), which has been technically revised.

Introduction

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 (USC) 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, petrochemical 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.

This International Standard is not intended to apply to the design of steam reformers or pyrolysis furnaces.

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

ISO 1940-1:2003, *Mechanical vibration — Balance quality requirements for rotors in a constant (rigid) state — Part 1: Specification and verification of balance tolerances*

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 10684, *Fasteners — Hot dip galvanized coatings*

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

ISO 15649, *Petroleum and natural gas industries — Piping*

IEC 60079 (all parts), *Electrical apparatus for explosive gas atmospheres*

EN 10025-2:2004[1)], *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

ABMA Standard 9[2)], *Load Ratings and Fatigue Life for Ball Bearings*

AMCA 210[3)], *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating*

AMCA 801:2001, *Industrial Process/Power Generation Fans — Specifications and Guidelines*

API 673[4)], *Centrifugal Fans for Petroleum, Chemical and Gas Industry Services*

---

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

2) American Bearing Manufacturers Association, 2025 M. Street, NW, Suite 800, Washington, DC 20036, USA.

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

4) American Petroleum Institute, 1220 L Street NW, Washington, DC 20005-4070, USA.

ASME B 17.1[5], *Keys and Keyseats*

ASME Boiler and Pressure Vessel Code, Section VIII, *Pressure Vessels*

ASTM A 36[6], *Standard Specification for Carbon Structural Steel*

ASTM A 53, *Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless*

ASTM A 105, *Standard Specification for Carbon Steel Forgings for Piping Applications*

ASTM A 106, *Standard Specification for Seamless Carbon Steel Pipe for High-Temperature Service*

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 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 or High-Pressure Service and Other Special Purpose Applications*

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 Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels and for General Applications*

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*

---

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

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

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 312, *Standard Specification for Seamless, Welded, and Heavily Cold Worked Austenitic Stainless Steel Pipes*

ASTM A 320, *Standard Specification for Alloy Steel and Stainless 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 335, *Standard Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service*

ASTM A 351, *Standard Specification for Castings, Austenitic, for Pressure-Containing Parts*

ASTM A 376, *Standard Specification for Seamless Austenitic Steel Pipe for High-Temperature Central-Station Service*

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[7)] D 1.1, *Structural Welding Code — Steel*

AWS D 14.6, *Welding of Rotating Elements of Equipment*

---

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

MSS SP-53[8], *Quality Standard for Steel Castings and Forgings for Valves, Flanges and Fittings and Other Piping Components — Magnetic Particle Exam Method*

MSS SP-55, *Quality Standard for Steel Castings for Valves, Flanges and Fittings and Other Piping Components — Visual Method for Evaluation of Surface Irregularities*

MSS SP-93, *Quality Standard for Steel Castings and Forgings for Valves, Flanges, and Fittings and Other Piping Components — Liquid Penetrant Examination Method*

NFPA 70[9], *National Electrical Code*

SSPC SP 6[10], *Commercial Blast Cleaning — NACE No. 3*

3 Terms and definitions

For the purposes of this document, 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 combustion products, steam or other fluid

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 a liquid fuel oil to a fine mist, using steam, air or mechanical means

3.5
backup layer
refractory layer behind the hot-face layer

3.6
balanced draught heater
heater that uses forced-draught fans to supply combustion air and uses induced-draught 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

---

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

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

10) The Society for Protective Coatings, 40, 24th Street, Pittsburg, PA 15222-4643, USA.

3.8
bridgewall
gravity wall
wall that separates two adjacent heater zones

3.9
bridgewall temperature
temperature of flue gas leaving the radiant section

3.10
burner
device that 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 which can be in the form of refractory ceramic fibre (RCF) or man-made vitreous fibre (MMVF)

NOTE Applicable forms include bulk, blanket, board, modules, paper, coatings, pumpables 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 during the design life of the component

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

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 that 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 the 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
guillotine
isolation blind
single-blade device used to isolate equipment or heaters

3.36
header
return bend
cast or wrought fitting shaped in a 180° bend and used to connect two or more tubes

3.37
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.

3.38
heat absorption
total heat absorbed by the coils, excluding any combustion-air preheat

3.39
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.

3.40
maximum heat flux density
maximum local rate of heat transfer in the coil section

3.41
total heat release
heat liberated from the specified fuel, using the lower heating value of the fuel

3.42
volumetric heat release
heat released divided by the net volume of the radiant section, excluding the coils and refractory dividing walls

3.43
higher heating value
h_H
gross heating value
total heat obtained from the combustion of a specified fuel at 15 °C (60 °F)

3.44
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

3.45
hot-face layer
refractory layer exposed to the highest temperatures in a multilayer or multi-component lining

3.46
hot-face temperature
temperature of the refractory surface in contact with the flue gas or heated combustion air

3.47
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 that 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.

3.48
induced-draught heater
heater that uses a fan to remove flue gases and to maintain a negative pressure in the heater to induce combustion air without a forced-draught fan

3.49
interface temperature
calculated temperature between each layer of multilayer or multi-component refractory construction

3.50
jump over
interconnecting pipework within a heater coil section

3.51
louvre damper
damper consisting of several blades, each of which pivots about its centre and is linked to the other blades for simultaneous operation

3.52
manifold
chamber for the collection and distribution of fluid to or from multiple parallel flow paths

3.53
man-made vitreous fibre
MMVF
synthetic amorphous glass insulation fibre, based on a calcium, magnesium and silicate chemistry, that has enhanced solubility in body fluids

3.54
metal fibre reinforcement
stainless steel needles added to castable for improved toughness and durability

3.55
monolithic lining
single-component lining system

3.56
mortar
refractory-material preparation used for laying and bonding refractory bricks

3.57
multi-component lining
refractory system consisting of two or more layers of different refractory types

NOTE Examples of refractory types are castable, insulating firebrick, firebrick, block, board and ceramic fibre.

3.58
multilayer lining
refractory system consisting of two or more layers of the same refractory type

3.59
natural-draught heater
heater in which a stack effect induces the combustion air and removes the flue gases

3.60
normal heat release
design heat absorption of the heater divided by the calculated fuel efficiency

3.61
pass
stream
flow circuit consisting of one or more tubes in series

3.62
pilot
small burner that provides ignition energy to light the main burner

3.63
plenum
windbox
chamber surrounding the burners that is used to distribute air to the burners or reduce combustion noise

3.64
plug header
cast return bend provided with one or more openings for the purpose of inspection or mechanical tube cleaning

3.65
pressure design code
recognized pressure vessel standard specified or agreed by the purchaser

EXAMPLE ASME Boiler and Pressure Vessel Code, Section VIII.

3.66
pressure drop
difference between the inlet and the outlet static pressures between termination points, excluding the static differential head

3.67
primary air
portion of the total combustion air that first mixes with the fuel