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Ersatz für
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**Erdöl-, petrochemische und Erdgasindustrie –
Befeuerte Erhitzer für den allgemeinen Einsatz in Raffinerien
(ISO 13705:2012);
Englische Fassung EN ISO 13705:2012, nur auf CD-ROM**

Petroleum, petrochemical and natural gas industries –
Fired heaters for general refinery service (ISO 13705:2012);
English version EN ISO 13705:2012, only on CD-ROM

Industries du pétrole, de la pétrochimie et du gaz naturel –
Réchauffeurs à brûleurs pour usage général dans les raffineries (ISO 13705:2012);
Version anglaise EN ISO 13705:2012, seulement en CD-ROM

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Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN
Normenausschuss Maschinenbau (NAM) im DIN

Nationales Vorwort

Dieses Dokument (EN ISO 13705:2012) wurde vom Technischen Komitee ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“, Subkomitee SC 6 „Processing equipment and systems“ in Zusammenarbeit mit dem Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: AFNOR, Frankreich) erarbeitet.

Für Deutschland hat hieran der Arbeitsausschuss NA 109-00-01 AA „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie — Spiegelausschuss zu CEN/TC 12 und ISO/TC 67“ im Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) des DIN Deutsches Institut für Normung e. V. mitgearbeitet.

Diese europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung der ISO-Norm.

Diese Norm enthält neben den gesetzlichen Einheiten auch die Einheiten „°F“, „BTU/h“, „BTU/scf“, „ft“, „hp“, „in (inch)“, „ksi“, „lb (pound)“, „lb/ft²“, „lb/ft³“, „lbf“, „mph“, „NPS“, „ppm“, „psi (psig)“ und „r/min“ die in Deutschland nicht zugelassen sind. Es wird ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheit im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

Nicht-SI-Einheit	SI-Einheit	Umrechnung	
°F	°C	°C	= (5/9) (°F – 32)
BTU/h	kJ/h	1 BTU/h	= 1,055 kJ/h
BTU/scf	kJ/Nm ³	1 BTU/scf	= 37,25 kJ/Nm ³
ft	m	1 ft	= 0,304 8 m
hp	kW	1 hp	= 0,74 kW
in (inch)	mm	1 inch	= 25,4 mm
ksi	MPa	1 ksi	= 6,894 757 MPa
lb (pound)	kg	1 lb	= 0,453 592 37 kg
lb/ft ²	kg/m ²	1 lb/ft ²	= 4,882 kg/m ²
lb/ft ³	kg/m ³	1 lb/ft ³	= 4,882 kg/m ³
lbf	N	1 lbf	= 4,448 222 N
mph	km/h	1 mph	= 1,6 km/h
NPS	DN	1 NPS	= DN 25
ppm	mg/kg	1 ppm	= 1 mg/kg
psi (psig)	kPa	1 psi	= 6,894 757 kPa
r/min	min ⁻¹	1 r/min	= 1 min ⁻¹

Für die in diesem Dokument zitierten Internationalen Normen wird im Folgenden auf die entsprechenden Deutschen Normen hingewiesen:

ISO 1461	siehe	DIN EN ISO 1461
ISO 1940-1	siehe	DIN ISO 1940-1
ISO 8501-1	siehe	DIN EN ISO 8501-1
ISO 10684	siehe	DIN EN ISO 10684
ISO 13704	siehe	DIN EN ISO 13704
IEC 60079 (all parts)	siehe	DIN EN 60079 (alle Teile)

Änderungen

Gegenüber DIN EN ISO 13705:2007-02 wurden folgende Änderungen vorgenommen:

- a) Aktualisierung der Normativen Verweisungen;
- b) Neuer Abschnitt 3.2 „Abkürzungen und Symbole“;
- c) Neuer Anhang I „Measurement of noise from fired-process heaters“;
- d) Aktualisierung der Literaturhinweise.

Frühere Ausgaben

DIN EN ISO 13705: 2005-09, 2007-02

Nationaler Anhang NA (informativ)

Begriffe, Symbole und Abkürzungen

Die Benummerung der folgenden Begriffe, Symbole und Abkürzungen ist identisch mit der Benummerung in der englischen Fassung.

3 Begriffe, Symbole und Abkürzungen

Für die Anwendung dieses Dokuments gelten die folgenden Begriffe.

ANMERKUNG Die Begriffe in Bezug auf Radialventilatoren sind in Anhang E angegeben.

3.1 Begriffe

3.1.1

Lufterhitzer

Luftvorwärmer

Vorrichtung zur Wärmeübertragung, durch die Verbrennungsluft hindurchströmt und durch ein Medium mit einer höheren Temperatur, wie beispielsweise Verbrennungsprodukte, Wasserdampf oder ein anderes Fluid, erwärmt wird

3.1.2

Verankerung

Zugband

metallische oder feuerfeste Vorrichtung, die den feuerfesten Werkstoff bzw. die Dämmung hält

3.1.3

Brücke

ebener oder schräger Teil des Erhitzer-Strahlungsabschnitts gegenüber dem Boden

3.1.4

Zerstäuber

Vorrichtung, die dazu dient flüssiges Brennöl mit Hilfe von Wasserdampf, Luft oder durch mechanische Hilfsmittel in einen feinen Nebel zu reduzieren

3.1.5

Sicherungsschicht

feuerfeste Schicht hinter der Hochtemperaturschicht

3.1.6

Erhitzer mit Unterdruckfeuerung

Erhitzer, der mittels Druckluft-Gebläse Verbrennungsluft zuführt und mittels Saugzug-Gebläse die Abgase abführt

3.1.7

Rauchgaskanal

Abschnitt des Erhitzers, in dem Abgase nach der letzten Konvektionsrohrschlange für die Transmission zum Schornstein oder zur Abgasleitung gesammelt werden

3.1.8**Brückenkörper****Schwergewichtsmauer**

Mauer, die zwei benachbarte Erhitzerzonen trennt

3.1.9**Brückenkörper-Temperatur**

Temperatur des Abgases, das den Strahlungsabschnitt verlässt

3.1.10**Brenner**

Einrichtung, die Brennstoff und Luft mit der gewünschten Geschwindigkeit, Turbulenz und Konzentration in einen Erhitzer leitet, um die ordnungsgemäße Zündung und Verbrennung zu ermöglichen und aufrechtzuerhalten

ANMERKUNG Brenner werden nach der Art des verfeuerten Brennstoffs klassifiziert, wie beispielsweise Öl, Gas oder eine Mischung aus Gas und Öl, die als „Zweibrennstoff“ oder „Kombination“ bezeichnet wird.

3.1.11**Drosselklappe**

Einblatt-Klappe, die um ihren Mittelpunkt schwenkbar ist

3.1.12**Gehäuse**

Metallplatte, die den befeuerten Erhitzer umschließt

3.1.13**Feuerbeton**

Isolierbeton, der vor Ort vergossen oder gespritzt wird, um eine starre feuerfeste Form oder Struktur zu bilden

3.1.14**Keramikfaser**

faserförmige feuerfeste Dämmung, die in Form einer feuerfesten Keramikfaser (RCF) oder als künstliche Glasfaser (MMVF) vorliegen kann

ANMERKUNG Zu den anwendbaren Formen zählen Bulkware, Decke, Platte, Module, Papier, Beschichtungen, pumpfähige und vakuumgeformte Formen.

3.1.15**Konvektionsabschnitt**

Teilbereich des Erhitzers, in dem die Wärme vor allem durch Konvektion auf die Rohre übertragen wird

3.1.16**Kragstein**

Auskragung der feuerfesten Oberfläche, die im Allgemeinen verhindert, dass Abgase die Rohre des Konvektionsabschnitts umgehen, falls sie versetzt angeordnet sind

3.1.17**Korrosionszuschlag**

hinzugefügte Materialstärke, um Materialverluste während der Gebrauchsdauer des Bauteils zu ermöglichen

3.1.18**Korrosionsgeschwindigkeit**

Geschwindigkeit der Verringerung der Materialstärke infolge des chemischen Angriffs durch Prozessflüssigkeit oder Abgas oder beides

3.1.19

Überleitung

Verbindungsrohrleitung zwischen zwei Rohrschlangenabschnitten des Erhitzers

3.1.20

Drosseleinrichtung

Einrichtung zur Einführung eines veränderlichen Widerstands, um den Durchfluss von Abgas oder Luft zu regeln

3.1.21

Direktluftherhitzer

Wärmeaustauscher, der Wärme direkt zwischen dem Abgas und der Verbrennungsluft überträgt

ANMERKUNG Ein regenerativer Luftvorwärmer verwendet erwärmte rotierende Elemente, und bei einer rekuperativen Konstruktionsweise werden stationäre Rohre, Platten oder Elemente aus Gusseisen eingesetzt, um die beiden Heizmittel zu trennen.

3.1.22

Zug

Unterdruck (Vakuum) der Luft und/oder des Abgases, der an irgendeiner Stelle im Erhitzer gemessen wird

3.1.23

Zugverlust

Druckabfall (einschließlich Auftriebswirkung) durch Rohrkanäle oder Rohrleitungen und Ausrüstungen in Luft- und Abgassystemen

3.1.24

Kanal

Leitungsführung für Luft- oder Abgas-Strömung

3.1.25

Brennstoffnutzungsgrad

aufgenommene Gesamtwärmemenge geteilt durch den Gesamteingang der nur durch die Verbrennung von Brennstoff erzeugten Wärme (auf Grundlage des unteren Heizwerts)

ANMERKUNG Diese Definition schließt fühlbare Wärme der Brennstoffe aus und gilt für den Nettobetrag der von der Einheit abgegebenen Wärme.

3.1.26

thermischer Wirkungsgrad

aufgenommene Gesamtwärmemenge geteilt durch den Gesamteingang der durch die Verbrennung von Brennstoff erzeugten Wärme (h_L) plus der fühlbaren Wärme von Luft, Brennstoff und jeglichem Zerstäubungsmedium

3.1.27

Erosion

Verringerung der Materialstärke infolge des mechanischen Angriffs durch ein Fluid

3.1.28

Luftüberschuss

Luftmenge über der stöchiometrischen Anforderung an eine vollständige Verbrennung

ANMERKUNG Der Luftüberschuss wird als Prozentsatz angegeben.

3.1.29

erweiterte Oberfläche

Oberfläche zur Wärmeübertragung in Form von Rippen oder Noppen, die mit der wärmeaufnehmenden Oberfläche verbunden sind

3.1.30**Erweiterungsquotient**

Verhältnis zwischen der gesamten exponierten Außenfläche und der Außenfläche des Glattrohres

3.1.31**Abgas**

gasförmiges Produkt der Verbrennung einschließlich Luftüberschuss

3.1.32**Druckluft-Erhitzer**

Erhitzer, bei dem Verbrennungsluft mit einem Gebläse oder durch andere mechanische Hilfsmittel zugeführt wird

3.1.33**Verschmutzungszuschlag**

Faktor zur Berücksichtigung einer Rückstandsschicht, die den Druckabfall vergrößert

ANMERKUNG 1 Dieser Rückstand besteht üblicherweise aus einer Ansammlung von Koks oder Zunder auf der Innenfläche der Rohrschlange.

ANMERKUNG 2 Der Verschmutzungszuschlag wird bei der Berechnung des verschmutzungsbedingten Druckabfalls verwendet.

3.1.34**Verschmutzungswiderstand**

Faktor, der zur Berechnung des Gesamt-Wärmedurchgangskoeffizienten verwendet wird

ANMERKUNG Der innere Verschmutzungswiderstand wird bei der Berechnung der maximalen Auslegungswandtemperatur verwendet. Der äußere Verschmutzungswiderstand wird verwendet, um den Leistungsverlust infolge der Ablagerungen auf der Außenfläche der Rohre oder der erweiterten Oberfläche zu kompensieren.

3.1.35**Guillotine****Trennschieber**

Einblatt-Gerät, das zum Trennen von Einrichtungen oder Erhitzern verwendet wird

3.1.36**Sammler****Umkehrbogen**

Guss- oder schmiedeeisernes Formstück, das eine 180°-Krümmung aufweist und dazu dient, zwei oder mehr Rohre miteinander zu verbinden

3.1.37**Endkammer**

innenisolierte Kammer, die vom Abgas-Strom getrennt ist und dazu dient, mehrere Sammler oder Verteilerstücke zu umschließen

ANMERKUNG Der Zugang wird mit Hilfe von Drehflügeltüren oder beweglichen Platten ermöglicht.

3.1.38**Wärmeabsorption**

gesamte von den Rohrschlangen aufgenommene Wärme, außer jeglicher vorerwärmter Verbrennungsluft

3.1.39**durchschnittliche Wärmestromdichte**

aufgenommene Wärme geteilt durch die exponierte Heizfläche des Rohrschlangenabschnitts

ANMERKUNG Die durchschnittliche Wärmestromdichte für ein Rohr mit erweiterter Oberfläche wird auf der Grundlage einer glatten Oberfläche unter Angabe des Erweiterungsquotienten angegeben.

3.1.40

maximale Wärmestromdichte

maximaler lokaler Wärmestrom im Rohrschlangenabschnitt

3.1.41

Gesamtwärmefreisetzung

die vom spezifizierten Brennstoff abgegebene Wärme, unter Verwendung des unteren Heizwertes des Brennstoffs

3.1.42

volumetrische Wärmefreisetzung

abgegebene Wärme geteilt durch das Nettovolumen des Strahlungsabschnitts, unter Ausschluss der Rohrschlangen und feuerfesten Trennwände

3.1.43

oberer Heizwert

Brennwert

gesamte Wärme, die aus der Verbrennung eines festgelegten Brennstoffs bei 15 °C (60 °F) gewonnen wird

3.1.44

unterer Heizwert

Heizwert

oberer Heizwert abzüglich der latenten Kondensationswärme des Wasserdampfs, der bei der Verbrennung von Wasserstoff im Brennstoff entsteht

3.1.45

Hochtemperaturschicht

feuerfeste Schicht, die in einer Mehrschichten- oder Mehrkomponenten-Auskleidung den höchsten Temperaturen ausgesetzt ist

3.1.46

Temperatur der Feuerseite

Temperatur der feuerfesten Oberfläche, die mit dem Abgas oder der erwärmten Verbrennungsluft in Berührung kommt

3.1.47

indirekter Luftvorwärmer

Fluid-Luft-Wärmeübertragungsvorrichtung

ANMERKUNG Die Wärmeübertragung kann durch die Verwendung eines Wärmeträgerfluids, eines Prozess- oder Versorgungsstroms erfolgen, das/der durch das Abgas oder andere Mittel erwärmt wurde. Ein Wärmerohr-Luftvorwärmer verwendet ein Verdampfungs/Kondensierungs-Fluid, um Wärme zwischen dem Abgas und der Luft zu übertragen.

3.1.48

Saugzug-Erhitzer

Erhitzer, der ein Gebläse verwendet, um Abgase zu entfernen und einen Unterdruck im Erhitzer aufrechtzuhalten, um Verbrennungsluft ohne Druckluft-Gebläse einzuleiten

3.1.49

Grenzflächentemperatur

berechnete Temperatur zwischen jeder Schicht einer feuerfesten Mehrschichten- oder Mehrkomponenten-Konstruktion

3.1.50

Übergang

Verbindungsrohr innerhalb eines Rohrschlangenabschnitts des Erhitzers

3.1.51**Jalousieklappe**

Klappe, die aus mehreren Lamellen besteht, die jeweils um ihren eigenen Mittelpunkt drehbar gelagert und miteinander verbunden sind, damit sie gleichzeitig betätigt werden können

3.1.52**Verteiler**

Kammer zum Sammeln und Verteilen von Fluid an bzw. von mehrere(n) parallele(n) Strömungswege(n)

3.1.53**synthetische Glasfaser****MMVF (en: man-made vitreous fibre)**

synthetische amorphe Glasfaser-Dämmung, auf der Grundlage von Calcium, Magnesium und Silicat, die in Körperflüssigkeiten eine erhöhte Löslichkeit aufweist

3.1.54**Metallfaserverstärkung**

Edelstahl-Nadeln, die zum Feuerbeton hinzugefügt werden, um dessen Zähigkeit und Beständigkeit zu verbessern

3.1.55**monolithische Auskleidung**

Einkomponenten-Auskleidungssystem

3.1.56**Mörtel**

Zubereitung aus feuerfestem Material, die zum Vermauern und Verbinden von feuerfesten Steinen verwendet wird

3.1.57**Mehrkomponenten-Auskleidung**

feuerfestes System, das aus zwei oder mehr Schichten unterschiedlicher feuerfester Typen besteht

ANMERKUNG Beispiele für feuerfeste Typen sind Feuerbeton, isolierender feuerfester Ziegel, Schamotteziegel, Block, Platte und Keramikfaser.

3.1.58**mehrschichtige Auskleidung**

feuerfestes System, das aus zwei oder mehr Schichten desselben feuerfesten Typs besteht

3.1.59**Naturzug-Erhitzer**

Erhitzer, in dem ein thermischer Auftrieb die Verbrennungsluft einleitet und die Abgase entfernt

3.1.60**normale Wärmefreisetzung**

Norm-Wärmeabsorption des Erhitzers geteilt durch den berechneten Brennstoffnutzungsgrad

3.1.61**Durchgang****Strom**

Kreislauf, der aus einem oder mehreren, in Reihe angeordneten Rohren besteht

3.1.62**Pilotflamme**

kleiner Brenner, der die Zündenergie zum Entzünden des Hauptbrenners liefert

3.1.63

Plenumkammer

Brennerluftkasten

die Brenner umgebende Kammer, die dazu dient, den Brennern Luft zuzuleiten und das Verbrennungsgeräusch zu dämpfen

3.1.64

Verschlusskopf

gegossener Umkehrbogen, der mit zwei oder mehr Öffnungen für Inspektionen oder für die mechanische Rohrreinigung ausgestattet ist

3.1.65

Berechnungsvorschrift für Druckbehälter

anerkannte, vom Besteller festgelegte oder in Absprache mit ihm ausgewählte Druckbehälter-Norm

BEISPIEL ASME Boiler and Pressure Vessel Code, Section VIII.

3.1.66

Druckabfall

Differenz zwischen dem statischen Eingangs- und Ausgangsdruck zwischen Anschlusspunkten, unter Ausschluss der statischen Druckhöhe

3.1.67

Primärluft

Teil der gesamten Verbrennungsluft, der sich zuerst mit dem Brennstoff vermischt

3.1.68

Schutzbeschichtung

korrosionsbeständiger Werkstoff, der auf eine Metalloberfläche aufgetragen wird

BEISPIEL Beschichtung auf Gehäuseplatten hinter porösen feuerfesten Werkstoffen, um sie gegen Schwefel in den Abgasen zu schützen.

3.1.69

Strahlungsabschnitt

Teil des Erhitzers, in dem Wärme vor allem durch Strahlung in die Rohre übertragen wird

3.1.70

Strahlungsverlust

Abstrahlungsverlust

Wärmeverlust vom Gehäuse des Erhitzers, den Rohrleitungen und Zusatzeinrichtungen an die Umgebung (wenn Wärmerückgewinnungs-Systeme verwendet werden)

3.1.71

Sekundärluft

Luft, die dem Brennstoff zur Ergänzung der Primärluft zugeführt wird

3.1.72

Aufbau

Erhitzer-Gehäuse, Mauerwerk, Feuerfestbereich und Dämmung, einschließlich Zugbänder

3.1.73

Abschirmungsabschnitt

Stoßabschnitt

Rohre, die die übrigen Rohre des Konvektionsabschnitts gegen direkte Flammenstrahlung abschirmen

3.1.74**Rußbläser**

Vorrichtung, die dazu dient, Ruß oder andere Ablagerungen von den wärmeabsorbierenden Oberflächen im Konvektionsabschnitt zu entfernen

ANMERKUNG Üblicherweise wird Dampf als Medium zum Rußblasen verwendet.

3.1.75**Schornstein/Kamin**

vertikaler Abzugskanal, der zum Ableiten von Abgas an die Atmosphäre verwendet wird

3.1.76**Stringer****Luftleitblech**

metallische Einrichtung an einem Schornstein, mit deren Hilfe die Bildung von Karmanschen Wirbeln unterdrückt werden kann, die windinduzierte Schwingungen verursachen können

3.1.77**Bauvorschrift**

vom Besteller festgelegte oder in Absprache mit ihm ausgewählte Norm für die Baukonstruktion

BEISPIEL

International Building Code.

3.1.78**Prallwand****Rückstrahlwand**

vertikale feuerfeste Wand aus Schamottesteinen, die auf einer Seite oder auf beiden Seiten direkter Beflammung ausgesetzt ist

3.1.79**Temperaturzuschlag**

Anzahl der Grad Celsius (Fahrenheit), die zur Prozessfluid-Temperatur hinzuzufügen sind, um Strömungs-Fehlverteilungen und unbekannten Betriebszuständen Rechnung zu tragen

ANMERKUNG Der Temperaturzuschlag wird zur berechneten maximalen Rohrwandtemperatur oder zur äquivalenten Rohrwandtemperatur hinzugefügt, um die Auslegungswandtemperatur zu erhalten.

3.1.80**Aufsatz**

Flansch- oder Schweißverbindung zur oder von der Rohrschlange, um die Zu- und Ableitung von Fluiden zu ermöglichen

3.1.81**Rohrführung**

Vorrichtung, die bei vertikalen Rohren dazu dient, die horizontale Bewegung einzuschränken und die axiale Ausdehnung des Rohres zu ermöglichen

3.1.82**Rohniederhalter**

Vorrichtung, die dazu verwendet wird, das Abheben horizontaler Strahlungsrohre von den Rohrzwischenstützen während des Betriebs einzuschränken

3.1.83**Rrohrhalter****Rrohrboden**

Vorrichtung zum Stützen von Rohren

3.1.84

Dampfsperre

Metallfolie, die zwischen den feuerfesten Schichten als Sperre gegen den Abgasstrom angebracht ist

3.2 Abkürzungen und Symbole

3.2.1 Abkürzungen

APH Luftvorwärmer (en: air preheater)

NO_x Oxide von Stickstoff, d. h. Distickstoffoxid, Stickoxid (en: oxides of nitrogen, i.e. nitrous oxide, nitric oxide)

PMI Materialverwechslungsprüfung (en: positive materials identification)

SCR Selektive Katalytische Reduktion (en: selective catalytic reduction)

3.2.2 Symbole

C Rohrleitungsverlust-Koeffizient aus Tabelle F.2 (en: fitting loss coefficient from Table F.2)

C_1 Druckabfall-Korrekturfaktor für die Temperatur aus Bild F.8b) [en: pressure-drop correction factor for temperature taken from Figure F.8 b)]

C_2 Rauigkeits-Korrekturfaktor, wie folgt:

- sehr rau (z. B. Mauerstein): 1,0
- mittelrau (z. B. Feuerfestbeton): 0,68
- glatt (z. B. unverkleideter Stahl): 0,45

(en: roughness correction factor, as follows:

- very rough (e.g. brick): 1,0
- medium-rough (e.g. castable refractory): 0,68
- smooth (e.g. unlined steel): 0,45)

$d_{\max}$ größter Durchmesser (en: largest diameter)

d ist der Kanal-Innendurchmesser, in Millimeter oder Zoll (en: is the duct inside diameter, in millimetres or inches)

D der Manteldurchmesser, angegeben in Millimeter (Zoll) [en: the shell diameter, expressed in millimetres (inches)]

F_{yr} die Mindest-Streckgrenze der Ringsteife bei der Auslegungsmanteltemperatur, angegeben in Newton je Quadratmillimeter (Pfund je Quadratzoll) [en: the minimum yield strength of ring stiffener at the shell design temperature, expressed in newtons per square millimetre (pounds per square inch)]

F_{ys} die Mindest-Streckgrenze des Mantelwerkstoffs bei Auslegungstemperatur, angegeben in Newton je Quadratmillimeter (Pfund je Quadratzoll) [en: the minimum yield strength of shell material at design temperature, expressed in newtons per square millimetre (pounds per square inch)]

h	die Schornsteinhöhe, angegeben in Meter (Fuß) [en: the stack height, expressed in metres (feet)]
h_H	oberer Heizwert (en: higher heating value)
h_L	unterer Heizwert (en: lower heating value)
H_S	der Ringabstand, angegeben in Millimeter (Zoll) [en: the ring spacing, expressed in millimetres (inches)]
M	das maximale Umfangsmoment je Längeneinheit des Mantels, angegeben in Newtonmeter je Meter (Zoll-Pfund je Zoll) [en: the maximum circumferential moment per unit length of shell, expressed in newton metres per metre (inch-pounds per inch)]
ΔP	ist der korrigierte Druckabfall je 30 Längenmeter (100 Linearfuß), angegeben in mm H ₂ O, (in H ₂ O) [en: is the corrected pressure drop per 30 linear m (100 linear ft), expressed in mm H ₂ O (in H ₂ O)]
ΔP_1	ist der unkorrigierte Druckabfall nach Bild F.8 a) [en: is the uncorrected pressure drop taken from Figure F.8 a)]
$q_{m,a}$	ist der flächenbezogene Massenstrom, in Kilogramm je Quadratmeter je Sekunde (kg/m ² ·s) oder Pfund je Quadratfuß je Sekunde (lb/ft ² ·s) [en: is the areic mass flow rate, in kilograms per square metre per second (kg/m ² ·s) or pounds per square foot per second (lb/ft ² ·s)]
S_C	Scruton-Zahl (en: Scruton number)
t	die korrodierte Manteldicke, angegeben in Millimeter (Zoll) [en: the corroded shell thickness, expressed in millimetres (inches)]
v	Lineargeschwindigkeit, in Meter je Sekunde [Fuß je Sekunde (ft/s)] (en: linear velocity, in metres per second [feet per second (ft/s)])
v_c	kritische Windgeschwindigkeit (en: critical wind velocity)
X	berechneter Wert, angegeben in Meter (Fuß) [en: calculated value, expressed in metres (feet)]
Z	Ring-Widerstandsmoment, angegeben in Kubikmillimeter (Kubikzoll) [en: is the section modulus of ring, expressed in cubic millimetres (cubic inches)]
α_{cr}	kritische Druckspannung, in Newton je Quadratmeter (Pfund je Quadratzoll) [en: critical compressive stress, in newtons per square metre (pounds per square inch)]
δ	die zulässige Abweichung (Ausführungstoleranz) [en: the permitted deviation (execution tolerance)]
ρ	ist die Flusssdichte, in Kilogramm je Kubikmeter (kg/m ³) [Pfund je Kubikfuß (lb/ft ³)] (en: is the flow density, in kilograms per cubic metre (kg/m ³) [pounds per cubic foot (lb/ft ³)])
μ	ist die Viskosität, in Millipascalsekunden (mPa × s) [Centipoise (cP)] (en: is the viscosity, in millipascal seconds (mPa·s) [centipoise (cP)])

Nationaler Anhang NB (informativ)

Literaturhinweise

DIN EN ISO 1461, *Durch Feuerverzinken auf Stahl aufgebrachte Zinküberzüge (Stückverzinken) — Anforderungen und Prüfungen*

DIN ISO 1940-1, *Mechanische Schwingungen — Anforderungen an die Auswuchtgüte von Rotoren in konstantem (starrem) Zustand — Teil 1: Festlegung und Nachprüfung der Unwuchttoleranz*

DIN EN ISO 8501-1, *Vorbereitung von Stahloberflächen vor dem Auftragen von Beschichtungsstoffen — Visuelle Beurteilung der Oberflächenreinheit — Teil 1: Rostgrade und Oberflächenvorbereitungsgrade von unbeschichteten Stahloberflächen und Stahloberflächen nach ganzflächigem Entfernen vorhandener Beschichtungen*

DIN EN ISO 10684, *Verbindungselemente — Feuerverzinkung*

DIN EN ISO 13704, *Erdöl- und Erdgasindustrie — Berechnung der Wanddicke von Heizrohren in Erdölraffinerien*

DIN EN 60079 (alle Teile), *Explosionsfähige Atmosphäre*

English Version

Petroleum, petrochemical and natural gas industries —
Fired heaters for general refinery service
(ISO 13705:2012)

Industries du pétrole, de la pétrochimie et du gaz naturel —
Réchauffeurs à brûleurs pour usage général dans les
raffineries
(ISO 13705:2012)

Erdöl-, petrochemische und Erdgasindustrie —
Befeuerte Erhitzer für den allgemeinen Einsatz in
Raffinerien
(ISO 13705:2012)

This European Standard was approved by CEN on 14 December 2012.

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Foreword

This document (EN ISO 13705:2012) has been prepared by Technical Committee ISO/TC 67 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2013, and conflicting national standards shall be withdrawn at the latest by June 2013.

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

This document supersedes EN ISO 13705:2006.

According to the CEN/CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

Endorsement notice

The text of ISO 13705:2012 has been approved by CEN as a EN ISO 13705:2012 without any modification.

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 checklist (see example in Annex B).

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 heaters (APHs), 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 10025-2:2004¹, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

ABMA Standard 9², *Load Ratings and Fatigue Life for Ball Bearings*

AMCA 210³, *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating*

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

ASME B 17.1⁴, *Keys and Keyseats*

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

ASTM A 36⁵, *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*

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 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 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 and Stainless-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 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*
- 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*

AWS⁶ D 1.1, *Structural Welding Code — Steel*

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

NFPA 70⁷, *National Electrical Code*

SSPC SP 6/NACE No 3⁸, *Commercial Blast Cleaning*

3 Terms, definitions, abbreviated terms and symbols

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.

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

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

8 The Society for Protective Coatings, 40, 24th Street, Pittsburgh, PA 15222-4643, USA.

3.1 Terms and definitions

3.1.1

air heater

air preheater

APH

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

3.1.2

anchor

tieback

metallic or refractory device that holds the refractory or insulation in place

3.1.3

arch

flat or sloped portion of the heater radiant section opposite the floor

3.1.4

atomizer

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

3.1.5

backup layer

refractory layer behind the hot-face layer

3.1.6

balanced-draught heater

heater that uses forced-draught fans to supply combustion air and induced-draught fans to remove flue gases

3.1.7

breeching

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

3.1.8

bridgewall

gravity wall

wall that separates two adjacent heater zones

3.1.9

bridgewall temperature

temperature of flue gas leaving the radiant section

3.1.10

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".

3.1.11

butterfly damper

single-blade damper, which pivots about its centre

3.1.12

casing

metal plate used to enclose the fired heater

3.1.13

castable

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

3.1.14

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.

3.1.15

convection section

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

3.1.16

corbel

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

3.1.17

corrosion allowance

material thickness added to allow for material loss during the design life of the component

3.1.18

corrosion rate

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

3.1.19

crossover

interconnecting piping between any two heater-coil sections

3.1.20

damper

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

3.1.21

direct-APH

heat exchanger that transfers heat directly between the flue gas and the combustion air

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

3.1.22

draught

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

3.1.23

draught loss

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

3.1.24

duct

conduit for air or flue gas flow

3.1.25

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.

3.1.26

thermal efficiency

total heat absorbed divided by the total input of heat derived from the combustion of fuel plus sensible heats from air, fuel and any atomizing medium

3.1.27

erosion

reduction in material thickness due to mechanical attack from a fluid

3.1.28

excess air

amount of air above the stoichiometric requirement for complete combustion

NOTE Excess air is expressed as a percentage.

3.1.29

extended surface

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

3.1.30

extension ratio

ratio of total outside exposed surface to the outside surface of the bare tube

3.1.31

flue gas

gaseous product of combustion including excess air

3.1.32

forced-draught heater

heater for which combustion air is supplied by a fan or other mechanical means

3.1.33

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.

3.1.34

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.

3.1.35

guillotine

isolation blind

single-blade device used to isolate equipment or heaters

3.1.36

header

return bend

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

3.1.37

header box

internally insulated 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.

3.1.38

heat absorption

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

3.1.39

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.

3.1.40

maximum heat flux density

maximum local rate of heat transfer in the coil section

3.1.41

total heat release

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

3.1.42

volumetric heat release

heat released (net) divided by the net volume of the radiant section, excluding the coils and refractory dividing walls

3.1.43

higher heating value

gross heating value

total heat obtained from the combustion of a specified fuel at 15 °C (60 °F)

3.1.44

lower heating value

net heating value

higher heating value minus the latent heat of vaporization of the water formed by combustion of hydrogen in the fuel

3.1.45

hot-face layer

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

3.1.46

hot-face temperature

temperature of the refractory surface in contact with the flue gas or heated combustion air

3.1.47

indirect APH

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 APH uses a vaporizing/condensing fluid to transfer heat between the flue gas and air.

3.1.48

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

3.1.49

interface temperature

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

3.1.50

jump over

interconnecting pipework within a heater coil section

3.1.51

louvre damper

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

3.1.52

manifold

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

3.1.53

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

3.1.54

metal fibre reinforcement

stainless-steel needles added to castable for improved toughness and durability

3.1.55

monolithic lining

single-component lining system

3.1.56

mortar

refractory-material preparation used for laying and bonding refractory bricks

3.1.57

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.

3.1.58

multilayer lining

refractory system consisting of two or more layers of the same refractory type

3.1.59

natural-draught heater

heater in which a stack effect induces the combustion air and removes the flue gases

3.1.60

normal heat release

design heat absorption of the heater divided by the calculated fuel efficiency

3.1.61

pass

stream

flow circuit consisting of one or more tubes in series

3.1.62

pilot

small burner that provides ignition energy to light the main burner

3.1.63

plenum

windbox

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

3.1.64

plug header

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

3.1.65

pressure design code

recognized pressure vessel standard specified or agreed by the purchaser

EXAMPLE ASME Boiler and Pressure Vessel Code, Section VIII.

3.1.66

pressure drop

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

3.1.67

primary air

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

3.1.68

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.

3.1.69

radiant section

portion of the heater in which heat is transferred to the tubes primarily by radiation

3.1.70

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)

3.1.71

secondary air

air supplied to the fuel to supplement primary air

3.1.72

setting

heater casing, brickwork, refractory and insulation, including the tiebacks

3.1.73

shield section

shock section

tubes that shield the remaining convection-section tubes from direct flame radiation

3.1.74

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.

3.1.75

stack

vertical conduit used to discharge flue gas to the atmosphere

3.1.76

strake

spoiler

metal attachment to a stack that can prevent the formation of von Karman vortices that can cause wind-induced vibration

3.1.77

structural design code

structural design standard specified or agreed by the purchaser

EXAMPLE International Building Code.

3.1.78

target wall

reradiating wall

vertical refractory firebrick wall which is exposed to direct flame impingement on one or both sides

3.1.79

temperature allowance

number of degrees Celsius (Fahrenheit) to be added to the process fluid temperature to account for flow maldistribution and operating unknowns

NOTE The temperature allowance is added to the calculated maximum tube-metal temperature or the equivalent tube-metal temperature to obtain the design metal temperature

3.1.80

terminal

flanged or welded connection to or from the coil providing for inlet and outlet of fluids

3.1.81

tube guide

device used with vertical tubes to restrict horizontal movement while allowing the tube to expand axially

3.1.82

tube retainer

device used to restrain horizontal radiant tubes from lifting off the intermediate tube supports during operation

3.1.83

tube support

tube sheet

device used to support tubes

3.1.84

vapour barrier

metallic foil placed between layers of refractory as a barrier to flue gas flow

3.2 Abbreviated terms and symbols

3.2.1 Abbreviated terms

APH air preheater

NO_x oxides of nitrogen, i.e. nitrous oxide, nitric oxide

PMI positive materials identification

SCR selective catalytic reduction

3.2.2 Symbols

C fitting loss coefficient from Table F.2

C_1 pressure-drop correction factor for temperature taken from Figure F.8 b)

C_2 roughness correction factor, as follows:

— very rough (e.g. brick):	1,0
— medium-rough (e.g. castable refractory):	0,68
— smooth (e.g. unlined steel):	0,45

$d_{\max}$ largest diameter

d duct inside diameter, in millimetres or inches

D shell diameter, expressed in millimetres (inches)

F_{yr} minimum yield strength of ring stiffener at the shell design temperature, expressed in newtons per square millimetre (pounds per square inch)

F_{ys} minimum yield strength of shell material at design temperature, expressed in newtons per square millimetre (pounds per square inch)

h stack height, expressed in metres (feet)

h_H higher heating value

h_L lower heating value

H_s ring spacing, expressed in millimetres (inches)

M	maximum circumferential moment per unit length of shell, expressed in newton metres per metre (inch-pounds per inch)
ΔP	corrected pressure drop per 30 linear metres (100 linear feet), expressed in mm H ₂ O (in H ₂ O)
ΔP_1	uncorrected pressure drop taken from Figure F.8 a)
$q_{m,a}$	areic mass flow rate, in kilograms per square metre per second (kg/m ² ·s ⁻¹) or pounds per square foot per second (lb/ft ² ·s ⁻¹)
S_C	Scruton number
t	corroded shell thickness, expressed in millimetres (inches)
v	linear velocity, in metres per second [feet per second (ft/s)]
v_C	critical wind velocity
X	calculated value, expressed in metres (feet)
Z	section modulus of ring, expressed in cubic millimetres (cubic inches)
α_{cr}	critical compressive stress, in newtons per square metre (pounds per square inch)
δ	permitted deviation (execution tolerance)
ρ	flow density, in kilograms per cubic metre (kg/m ³) [pounds per cubic foot (lb/ft ³)]
μ	viscosity, in millipascal-seconds (mPa·s) [centipoise (cP)]

4 General

4.1 Pressure design code

- 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 in this International Standard.

4.2 Regulations

- The purchaser and the vendor shall mutually determine the measures required to comply with any local or national regulations applicable to the equipment.

4.3 Heater nomenclature

In a fired heater, heat liberated by the combustion of fuels is transferred to fluids contained in tubular coils within an internally insulated enclosure. The type of heater is normally described by the structural configuration, radiant-tube coil configuration and burner arrangement. Some examples of structural configurations are cylindrical, box, cabin and multi-cell box. Examples of radiant-tube coil configurations include vertical, horizontal, helical and arbor. Examples of burner arrangements include up-fired, down-fired and wall-fired. The wall-fired arrangement can be further classified as sidewall, endwall and multilevel.

Figure 1 illustrates some typical heater types.

Figure 2 illustrates typical burner arrangements.

Various combinations of Figures 1 and 2 can be used. For example, Figure 1 c) can employ burner arrangements as in Figure 2 a), b) or c). Similarly, Figure 1 d) can employ burner arrangements as in Figure 2 a) or d).

Figure 3 shows typical components.

Annex F gives guidelines for the design, selection and evaluation of air preheat (APH) systems. Figures F.1, F.2 and F.3 show typical APH systems.

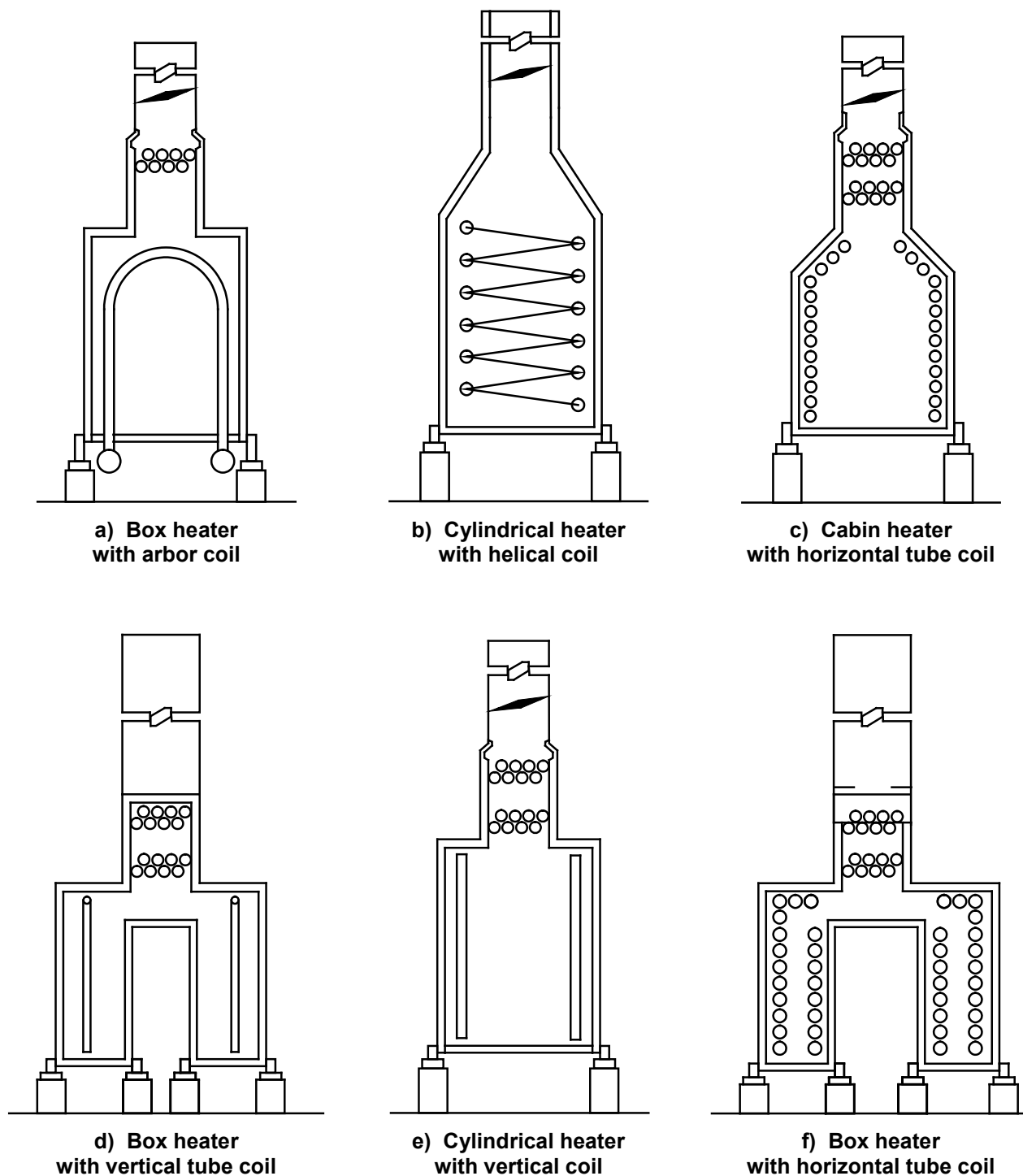
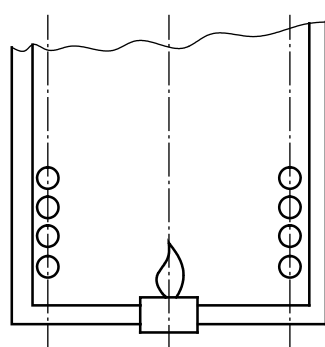
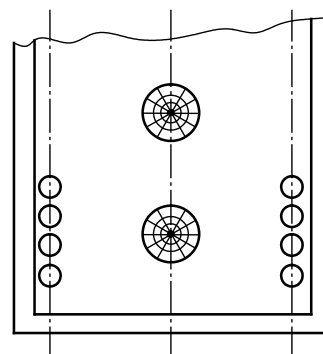


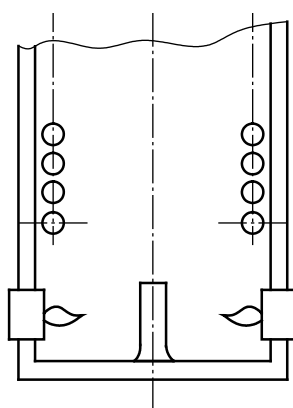
Figure 1 — Typical heater types



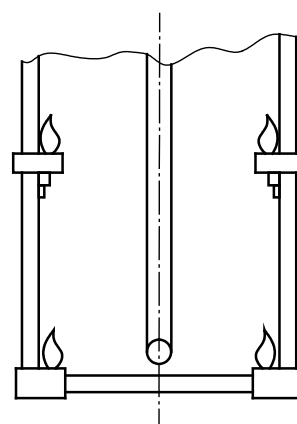
a) Up-fired



b) Endwall-fired

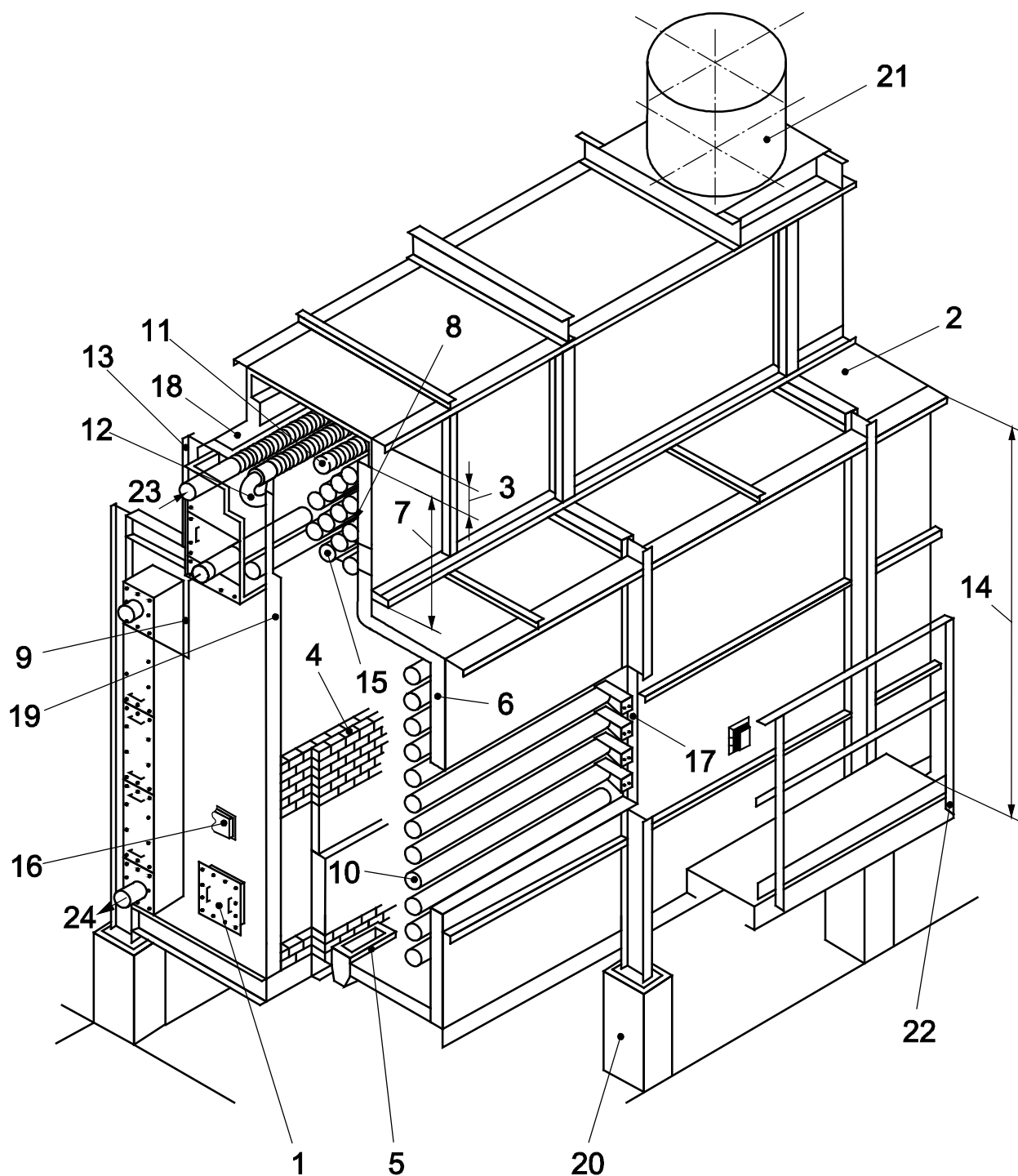


c) Sidewall-fired



d) Sidewall-fired multilevel

Figure 2 — Typical burner arrangements (elevation view)



Key

1 access door	7 convection section	13 header box	19 end-tube sheet
2 arch	8 corbel	14 radiant section	20 pier
3 breeching	9 crossover	15 shield tube	21 stack/duct
4 bridgewall	10 radiant tube	16 observation door	22 platform
5 burner	11 extended surface	17 tube support	23 process in
6 casing	12 return bend	18 refractory lining	24 process out

Figure 3 — Heater components

5 Proposals

5.1 Purchaser's responsibilities

5.1.1 The purchaser's enquiry shall include data sheets, checklists and other applicable information outlined in this International Standard. This information shall include any special requirements or exceptions to this International Standard.

5.1.2 The purchaser is responsible for providing the correct process specification to enable the vendor to prepare the fired-heater design. The purchaser should complete, as a minimum, those items on the data sheet that are designated by an asterisk (*).

5.1.3 The purchaser's enquiry shall state clearly the vendor's scope of supply.

- **5.1.4** The purchaser's enquiry shall specify the number of copies of drawings, data sheets, specifications, data reports, operating manuals, installation instructions, spare parts lists and other data to be supplied by the vendor, as required by 5.2, 5.3 and 5.4.

5.2 Vendor's responsibilities

The vendor's proposal shall include:

- a) completed data sheets for each fired heater and the associated equipment (see examples in Annex A);
- b) an outline drawing showing firebox dimensions, burner layout and clearances, arrangement of tubes, platforms, ducting, stack, breeching, APH and fans;
- c) full definition of the extent of shop assembly (format given in Annex C may be used), including the number, size and mass of prefabricated parts and the number of field welds;
- d) detailed description of any exceptions to the specified requirements;
- e) a completed noise data sheet if specified by the purchaser;
- f) curves for heaters in vaporizing service, showing pressure, temperature, vaporization and bulk velocity as a function of the tube number;
- g) a time schedule for submission of all required drawings, data and documents;
- h) a programme for scheduling the work after receipt of an order; this should include a specified period of time for the purchaser to review and return drawings, procurement of materials, manufacture and the required date of supply;
- i) a list of utilities and quantities required;
- j) if specified by the purchaser, a list of sub-suppliers proposed for the pipes and fittings, coil fabrication, extended surfaces on tubes, castings, steel fabrication, ladders and platforms, refractory supply, refractory installation, APHs, fans, burners and other auxiliary equipment.

5.3 Documentation

5.3.1 Drawings for purchaser's review

The vendor shall submit general arrangement drawings of each heater, for review. The final general arrangement drawings shall include the following information:

- a) heater service, the purchaser's equipment number, the project name and location, the purchase order numbers and the vendor's reference number;
- b) coil terminal sizes, including flange ratings and facings; dimensional locations; direction of process flow; and allowable loads, moments and forces on terminals;
- c) coil and crossover arrangements, tube spacings, tube diameters, tube-wall thicknesses, tube lengths, material specifications, including grades for pressure parts only, and all extended surface data;
- d) coil design pressures, hydrostatic test pressures, design fluid and tube-wall temperatures and corrosion allowance;
- e) a coil design code or recommended practice and fabrication code or specification;
- f) refractory and insulation types, thicknesses and service temperature ratings;
- g) types and materials of anchors for refractory and insulation;
- h) location and number of access doors, observation doors, burners, sootblowers, dampers and instrument and auxiliary connections;
- i) location and dimension of platforms, ladders and stairways;
- j) overall dimensions, including auxiliary equipment.

5.3.2 Foundation-loading diagrams

The vendor shall submit for the purchaser's review foundation-loading diagrams for each heater. The diagram shall include the following information:

- a) number and location of piers and supports;
- b) baseplate dimensions;
- c) anchor bolt locations, bolt diameters and projection above foundations;
- d) dead loads, live loads, wind or earthquake loads, reaction to overturning moments and lateral shear loads.

5.3.3 Documents for purchaser's review

The vendor shall also submit to the purchaser the following documents for review and comment (individual stages of fabrication shall not proceed until the relevant document has been reviewed and commented upon):

- a) structural steel drawings, details of stacks, ducts and dampers and structural calculations;
- b) burner assembly drawings and, if applicable, burner piping drawings;
- c) tube-support details and, if specified by the purchaser, design calculations;
- d) thermowell and thermocouple details;
- e) welding, examination and test procedures;
- f) installation, dry-out and test procedures for refractories and insulation;
- g) refractory thickness calculations, including temperature gradients through all refractory sections and sources of thermal conductivities;

- h) decoking procedures if specified by the purchaser;
- i) installation, operation and maintenance instructions for the heater and for auxiliary equipment such as APHs, fans, drivers, dampers and burners;
- j) performance curves or data sheets for APHs, fans, drivers and burners and other auxiliary equipment;
- k) noise data sheets if specified by the purchaser.

5.3.4 Certified drawings and diagrams

After receipt of the purchaser's comments on the general arrangement drawings and diagrams, the vendor shall furnish certified general arrangement drawings and foundation loading diagrams. The vendor shall furnish design-detail drawings, erection drawings and an erection sequence. Drawings of auxiliary equipment shall also be furnished.

5.4 Final reports

Within a specified time after completion of construction or shipment, the vendor shall furnish the purchaser with the following documents:

- a) data sheets and drawings representing the as-manufactured equipment; in the event field-changes are made, as-built drawings and data sheets shall not be provided unless specifically requested by the purchaser;
- b) certified material reports, mill test reports or ladle analysis for all pressure parts and for alloy extended surfaces;
- c) installation, operation and maintenance instructions for the heater and auxiliary equipment, such as APHs, fans, drivers, dampers and burners;
- d) performance curves or data sheets for APHs, fans, drivers and burners and other auxiliary equipment;
- e) bill of materials;
- f) noise data sheets if specified by the purchaser;
- g) refractory dry-out procedures;
- h) decoking procedures;
- i) test certificates for tube-support castings;
- j) all other test documents, including test reports and non-destructive examination reports.

6 Design considerations

6.1 Process design

6.1.1 Heaters shall be designed for uniform heat distribution. Multi-pass heaters shall be designed for hydraulic symmetry of all passes.

6.1.2 The number of passes for vaporizing fluids shall be minimized. Each pass shall be a single circuit from inlet to outlet.

6.1.3 Average heat flux density in the radiant section is normally based on a single row of tubes spaced at two nominal tube diameters. The first row of shield-section tubes shall be considered as radiant service in determining the average heat flux density if these tubes are exposed to direct flame radiation.

6.1.4 Where the average radiant heat flux density is specified on the basis of two nominal diameters, the vendor may increase the flux rate for other coil arrangements, e.g. for three nominal diameters or double-sided firing, provided the maximum flux, including mal-distribution, does not exceed that based on two nominal diameters.

6.1.5 The maximum allowable inside film temperature for any process service shall not be exceeded anywhere in the specified coil.

6.2 Combustion design

6.2.1 Margins provided in the combustion system are not intended to permit operation of the heater at greater than the design process duty.

6.2.2 Calculated fuel efficiencies shall be based on the lower heating value of the design fuel and shall include a radiation loss of 1,5 % of the calculated normal fuel heat release. Heaters employing flue gas/air preheat systems shall include a radiation loss of 2,5 % of the fuel heat release based on the lower heating value.

6.2.3 Unless otherwise specified by the purchaser, calculated efficiencies for natural-draught operation shall be based upon 20 % excess air if gas is the primary fuel and 25 % excess air if oil is the primary fuel. In the case of forced-draught operation, calculated efficiencies shall be based on 15 % excess air for fuel gas and 20 % excess air for fuel oil.

6.2.4 The heater efficiency and tube-wall temperature shall be calculated using the specified fouling resistances.

NOTE Annex G gives guidance on the measurement of efficiency.

6.2.5 Volumetric heat release of the radiant section shall not exceed 125 kW/m³ (12 000 Btu/h/ft³) for oil-fired heaters and 165 kW/m³ (16 000 Btu/h/ft³) for gas-fired heaters based upon the design heat absorption.

6.2.6 Stack and flue gas systems shall be designed so that a negative pressure of at least 25 Pa (0,10 in of water column) is maintained in the arch section or point of minimum draught location (which is typically below the shield section) at 120 % of normal heat release with design excess air and design stack temperature.

6.3 Mechanical design

6.3.1 Provisions for thermal expansion shall take into consideration all specified operating conditions, including short-term conditions such as steam-air decoking.

- **6.3.2** If specified by the purchaser, the convection-section tube layout shall include space for future installation of sootblowers, water washing or steam-lancing doors.

- **6.3.3** If the heater is designed for heavy fuel-oil firing, sootblowers shall be provided for convection-section cleaning. If light fuel oils such as naphtha are to be fired, the purchaser shall specify whether sootblowers are to be supplied.

6.3.4 The convection-section design shall incorporate space for the future addition of two rows of tubes, including the end and intermediate tube sheets. Placement of sootblowers and cleaning lanes shall be suitable for the addition of the future tubes. Holes in end-tube sheets shall be plugged off to prevent flue gas leakage.

6.3.5 Vertical cylindrical heaters shall be designed with a maximum height-to-diameter ratio of 2,75, where the height is that of the radiant section (inside refractory face) and the diameter is that of the tube circle, both measured in the same units.

6.3.6 For single-fired, box-type, floor-fired heaters with sidewall tubes only, an equivalent height-to-width factor shall be determined by dividing the height of the wall bank (or the straight tube length for vertical tubes) by the width of the tube bank and applying the following limitations:

Design absorption MW (Btu/h $\times 10^6$)	Height-to-width ratio max.	Height-to-width ratio min.
Up to 3,5 (12)	2,00	1,50
3,5 to 7 (12 to 24)	2,50	1,50
Over 7 (24)	2,75	1,50

6.3.7 Shield sections shall have at least three rows of bare tubes.

6.3.8 Except for the first shield row, convection sections shall be designed with corbels or baffles to minimize the amount of flue gas bypassing the heating surface.

6.3.9 The minimum clearance from grade to burner plenum or register shall be 2 m (6,5 ft) for floor-fired heaters, unless otherwise specified by the purchaser.

6.3.10 For vertical-tube, vertical-fired heaters, the maximum radiant straight tube length shall be 18,3 m (60 ft). For horizontal heaters fired from both ends, the maximum radiant straight tube length shall be 12,2 m (40 ft).

6.3.11 Radiant tubes shall be installed with a minimum spacing from refractory or insulation to tube centre-line of 1,5 nominal tube diameters, with a clearance of not less than 100 mm (4 in) from the refractory or insulation. For horizontal radiant tubes, the minimum clearance from floor refractory to tube outside diameter shall be not less than 300 mm (12 in).

6.3.12 The heater arrangement shall allow for replacement of individual tubes or hairpins without disturbing adjacent tubes.

- **6.3.13** If specified by the purchaser, the layout of tubes in the convection section shall incorporate a 450 mm (18 in) fin-tip-to-fin-tip vertical gap or space every eight tube rows to allow access for inspection. Provide a minimum of one access door, having a minimum clear opening of 600 mm $\times$ 600 mm (24 in $\times$ 24 in), in the space between each set of tube sheets in each vertical gap. Permanent platforms are not required.

7 Tubes

7.1 General

7.1.1 Tube-wall thickness for coils shall be determined in accordance with ISO 13704, in which the practical limit to minimum thickness for new tubes is specified. For materials not included, tube-wall thickness shall be determined in accordance with ISO 13704 using stress values mutually agreed upon between purchaser and supplier.

7.1.2 Unless otherwise agreed between the purchaser and supplier, calculations made to determine tube-wall thickness for coils shall include considerations for erosion and corrosion allowances for the various coil materials. The following corrosion allowances shall be used as a minimum:

- carbon steel through C-1/2Mo: 3 mm (0,125 in);
- low alloys through 9Cr-1Mo: 2 mm (0,080 in);
- above 9Cr-1Mo through austenitic steels: 1 mm (0,040 in).

7.1.3 Maximum tube-metal temperature shall be determined in accordance with ISO 13704. The tube-metal temperature allowance shall be at least 15 °C (25 °F).

7.1.4 All tubes shall be seamless. Tubes shall not be circumferentially welded to obtain the required tube length, unless approved by the purchaser, in which case the location of welds shall be agreed by the purchaser. Electric flash welding shall not be used for intermediate welds. Tubes furnished to an average wall thickness shall be in accordance with suitable tolerances so that the required minimum wall thickness is provided.

7.1.5 Tubes, if projected into header box housings, shall extend at least 150 mm (6 in), in the cold position, beyond the face of the end tube sheet, of which 100 mm (4 in) shall be bare.

7.1.6 Tube size (outside diameter in inches) shall be selected from the following sizes: 2,375; 2,875; 3,50; 4,00; 4,50; 5,563; 6,625; 8,625; or 10,75. Other tube sizes should be used only if warranted by special process considerations.

7.1.7 If the shield and radiant tubes are in the same service, the shield tubes shall be of the same material as the connecting radiant tubes.

7.2 Extended surface

- **7.2.1** The extended surface in convection sections may be studded (where each stud is attached to the tube by arc or resistance welding) or finned (where helically wound fins are high-frequency, continuously welded to the tube). The purchaser shall specify or agree the type of extended surface to be provided. In the case of finning, the purchaser shall specify or agree whether the fins shall be solid or segmented (serrated).

7.2.2 Metallurgy for the extended surface shall be selected on the basis of maximum calculated tip temperature as listed in Table 1.

7.2.3 Extended surface dimensions shall be limited to those listed in Table 2.

Table 1 — Extended surface materials

Material	Studs		Fins	
	Maximum tip temperature		Maximum tip temperature	
	°C	(°F)	°C	(°F)
Carbon steel	510	(950)	454	(850)
2 1/4Cr-1Mo, 5Cr-1/2Mo	593	(1 100)	549	(1 000)
11-13Cr	649	(1 200)	593	(1 100)
18Cr-8Ni stainless steel	815	(1 500)	815	(1 500)
25Cr-20Ni stainless steel	982	(1 800)	982	(1 800)

Table 2 — Extended surface dimensions

Fuel	Studs				Fins					
	Minimum diameter		Maximum height		Minimum normal thickness		Maximum height		Maximum number per unit length	
	mm	(in)	mm	(in)	mm	(in)	mm	(in)	per m	(per in)
Gas	12,5	(1/2)	25	(1)	1,3	(0,05)	25,4	(1)	197	(5)
Oil	12,5	(1/2)	25	(1)	2,5	(0,10)	19,1	(3/4)	118	(3)

7.3 Materials

Tube materials shall conform to the specifications listed in Table 3 or their equivalent agreed by the purchaser.

Table 3 — Heater-tube materials specifications

Material	ASTM specifications	
	Pipe	Tube
Carbon steel	A 53, A 106 Gr B	A 192, A 210 Gr A-1
Carbon-1/2Mo	A 335 Gr P1	A 209 Gr T1
1 1/4Cr-1/2Mo	A 335 Gr P11	A 213 Gr T11
2 1/4Cr-1Mo	A 335 Gr P22	A 213 Gr T22
3Cr-1Mo	A 335 Gr P21	A 213 Gr T21
5Cr-1/2Mo	A 335 Gr P5	A 213 Gr T5
5Cr-1/2Mo-Si	A 335 Gr P5b	A 213 Gr T5b
9Cr-1Mo	A 335 Gr P9	A 213 Gr T9
9Cr-1Mo-V	A 335 Gr P91	A 213 Gr T91
18Cr-8Ni	A 312, A 376, TP 304, TP 304H and TP 304L	A 213, TP 304, TP 304H and TP 304L
16Cr-12Ni-2Mo	A 312, A 376, TP 316, TP 316H and TP 316L	A 213, TP 316, TP 316H and TP 316L
18Cr-10Ni-3Mo	A 312, TP 317 and TP 317L	A 213, TP 317 and TP 317L
18Cr-10Ni-Ti	A 312, A 376, TP 321 and TP 321H	A 213, TP 321 and TP 321H
18Cr-10Ni-Nb ^a	A 312, A 376, TP 347 and TP 347H	A 213, TP 347 and TP 347H
Nickel alloy 800 H/800 HT ^b	B 407	B 407
25Cr-20Ni	A 608 Gr HK40	A 213 TP 310H
^a Niobium (Nb) was formerly called columbium (Cb).		
^b Minimum grain size shall be ASTM #5 or coarser.		

8 Headers

8.1 General

8.1.1 The design stress for headers shall be no higher than that allowed for similar materials as given in ISO 13704 and shall be reduced by casting-quality factors if made from castings. Casting-quality factors shall be in accordance with ISO 15649.

NOTE For the purposes of this provision, ASME B 31.3^[15] is equivalent to ISO 15649.

8.1.2 Headers shall be of metallurgy equivalent to the tubes.

8.1.3 Headers shall be welded return bends or welded plug headers, depending on the service and operating conditions.

8.1.4 The specified header wall thickness shall include a corrosion allowance. This allowance shall not be less than that used for the tubes.

8.2 Plug headers

8.2.1 Plug headers shall be located in a header box and shall be selected for the same design pressure as the connecting tubes and for a design temperature equal to the maximum fluid operating temperature at that location, plus a minimum of 30 °C (55 °F).

8.2.2 Tubes and plug headers shall be arranged so that there is sufficient space for field maintenance operations, such as welding and stress relieving.

8.2.3 If plug headers are specified to permit mechanical cleaning of coked or fouled tubes, they shall consist of the two-hole type. Single-hole, 180° plug headers may be installed only for tube inspection and draining.

8.2.4 If plug headers are specified to be used with horizontal tubes that are 18,3 m (60 ft) or longer, two-hole plug headers shall be used for both ends of the coil assembly. For shorter coils, plug headers shall be provided on one end of the coil with welded return bends on the opposite end.

8.2.5 If plug headers are specified for vertical tube heaters, two-hole plug headers shall be installed on the top of the coil and one-hole Y-fittings at the bottom of the tubes.

8.2.6 Headers and corresponding plugs shall be match-marked by 12 mm (0,5 in) permanent numerals and installed in accordance with a fitting-location drawing.

8.2.7 Type 304 stainless-steel thermowells, if required for temperature measurement and control, shall be provided in the plugs of the headers.

8.2.8 Tube centre-to-centre dimensions shall be as shown in Table 4.

Table 4 — Tube centre-to-centre dimensions

Tube outside diameter mm (in)	Header centre-to-centre dimension	
	mm	(in)
60,3 (2,375)	101,6	(4,00) ^a
73,0 (2,875)	127,0	(5,00) ^a
88,9 (3,50)	152,4	(6,00) ^a
101,6 (4,00)	177,8	(7,00) ^a
114,3 (4,50)	203,2	(8,00) ^a
127,0 (5,00)	228,6	(9,00)
141,3 (5,563)	254,0	(10,00) ^a
152,4 (6,00)	279,4	(11,00)
168,3 (6,625)	304,8	(12,00) ^a
193,7 (7,625)	355,6	(14,00)
219,1 (8,625)	406,4	(16,00) ^a
273,1 (10,75)	508,0	(20,00) ^a
NOTE Centre-to-centre dimensions are applicable only to manufacturers' standard header pressure ratings for 5 850 kPa (850 psig) nominal fittings.		
^a This centre-to-centre dimension equals two times the corresponding nominal size and is based on the centre-to-centre dimension for short-radius welded return bends.		

8.2.9 Plugs and screws shall be assembled in the fittings with an approved compound on the seats and screws to prevent galling.

8.3 Return bends

8.3.1 Return bends should be used for the following conditions:

- a) in clean service, where coking or fouling of tubes is not anticipated;
- b) where leakage is a hazard;
- c) where steam-air decoking facilities are provided for decoking of furnace tubes;
- d) where mechanical pigging is the specified cleaning method.

8.3.2 Return bends inside the firebox shall be selected for the same design pressure and temperature as the connecting tubes. Return bends inside a header box shall be selected for the same design pressure as the connecting tubes and for a design temperature equal to the maximum fluid operating temperature at that location plus a minimum of 30 °C (55 °F). Return bends shall be at least the same thickness as the connecting tubes.

8.3.3 Regardless of the location of the welded return bends, the heater design shall incorporate means to permit convenient removal and replacement of tubes and return bends.

8.3.4 Longitudinally welded fittings shall not be used.

8.4 Materials

8.4.1 Plug header and return bend material shall conform to the ASTM specifications listed in Table 5 or to other specifications if agreed by the purchaser.

8.4.2 Cast fittings shall have the material identification permanently marked on the fitting with raised letters or by using low-stress stamps.

Table 5 — Plug header and return bend materials

Material	ASTM specifications		
	Forged	Wrought	Cast
Carbon steel	A 105	A 234, WPB	A 216, WCB
	A 181, class 60 or 70		
C-1/2Mo	A 182, F1	A 234, WP1	A 217, WC1
1 1/4Cr-1/2Mo	A 182, F11	A 234, WP11	A 217, WC6
2 1/4Cr-1Mo	A 182, F22	A 234, WP22	A 217, WC9
3Cr-1Mo	A 182, F21	—	—
5Cr-1/2Mo	A 182, F5	A 234, WP5	A 217, C5
9Cr-1Mo	A 182, F9	A 234, WP9	A 217, C12
9Cr-1Mo-V	A 182, F91	A 234, WP91	A 217, C12A
18Cr-8Ni Type 304	A 182, F304	A 403, WP304	A 351, CF8
18Cr-8Ni Type 304H	A 182, F304H	A 403, WP304H	A 351, CF8
18Cr-8Ni Type 304L	A 182, F304L	A 403, WP304L	A 351, CF8
16Cr-12Ni-2Mo Type 316	A 182, F316	A 403, WP316	A 351, CF8M
16Cr-12Ni-2Mo Type 316H	A 182, F316H	A 403, WP316H	A 351, CF8M
16Cr-12Ni-2Mo Type 316L	A 182, F316L	A 403, WP316L	A 351, CF3M
18Cr-10Ni-3Mo Type 317	A 182, F317	A 403, WP317	—
18Cr-10Ni-3Mo Type 317L	A 182, F317L	A 403, WP317L	—
18Cr-10Ni-Ti Type 321	A 182, F321	A 403, WP321	—
18Cr-10Ni-Ti Type 321H	A 182, F321H	A 403, WP321H	—
18Cr-10Ni-Nb Type 347	A 182, F347	A 403, WP347	A 351, CF8C
18Cr-10Ni-Nb Type 347H	A 182, F347H	A 403, WP347H	A 351, CF8C
Nickel alloy 800H/800HT ^a	B 564	B 366	A 351, CT-15C
25Cr-20Ni	A 182, F310	A 403, WP310	A 351, CK-20 A 351, HK40

^a Minimum grain size shall be ASTM #5 or coarser.

9 Piping, terminals and manifolds

9.1 General

9.1.1 The minimum corrosion allowance shall be in accordance with 7.1.2.

9.1.2 All flanges shall be welding-neck flanges.

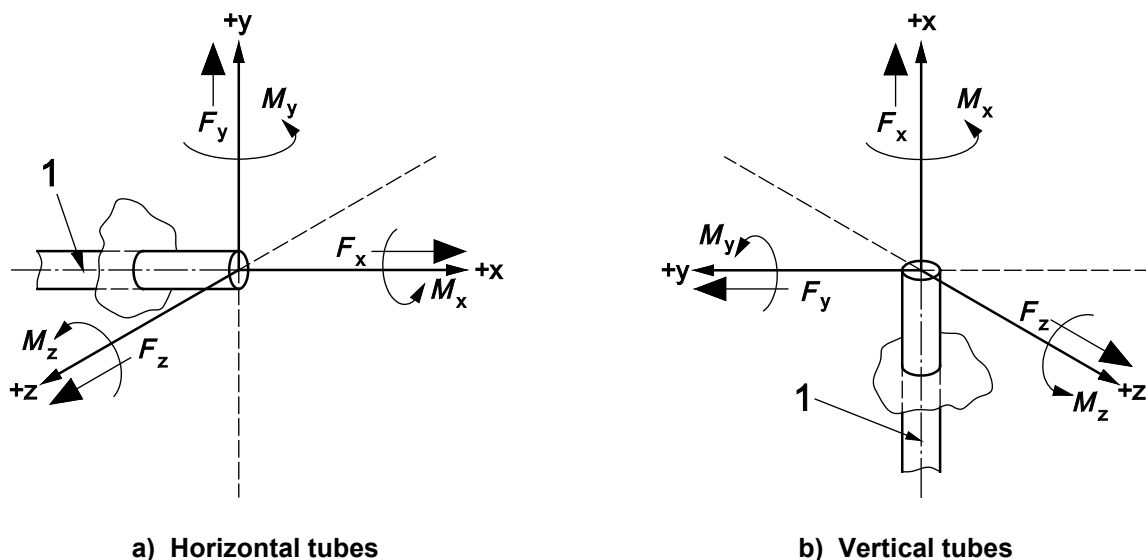
9.1.3 Piping, terminals and manifolds external to the heater enclosure shall be in accordance with ISO 15649.

NOTE For the purposes of this provision, ASME B 31.3^[15] is equivalent to ISO 15649.

- **9.1.4** The purchaser shall specify if inspection openings are required; in which case, if agreed by the purchaser, terminal flanges may be used provided that pipe sections are readily removable for inspection access.
- 9.1.5** Threaded connections shall not be used.
- **9.1.6** The purchaser shall specify if low-point drains and high-point vents are required, in which case they shall be accessible from outside the heater casing.
- 9.1.7** Manifolds and external piping shall be located so as not to block access for the removal of single tubes or hairpins.
- 9.1.8** Manifolds inside a header box shall be selected for the same design pressure as the connecting tubes and for a design temperature equal to the maximum fluid operating temperature at that location plus a minimum of 30 °C (55 °F).

9.2 Allowable movement and loads

Heater terminals shall be designed to accept the moments, M , forces, F , or movements shown in Figure 4, and Tables 6 and 7 for tubes and Figure 5 and Tables 8 and 9 for manifolds.



Key

1 tube centreline

Figure 4 — Diagram of forces for tubes

Table 6 — Allowable forces and moments for tubes

Pipe size DN (NPS)	Force						Moment					
	F_x		F_y		F_z		M_x		M_y		M_z	
	N	(lbf)	N	(lbf)	N	(lbf)	N·m	(ft·lbf)	N·m	(ft·lbf)	N·m	(ft·lbf)
50 (2)	445	(100)	890	(200)	890	(200)	475	(350)	339	(250)	339	(250)
75 (3)	667	(150)	1 334	(300)	1 334	(300)	610	(450)	475	(350)	475	(350)
100 (4)	890	(200)	1 779	(400)	1 779	(400)	813	(600)	610	(450)	610	(450)
125 (5)	1 001	(225)	2 002	(450)	2 002	(450)	895	(660)	678	(500)	678	(500)
150 (6)	1 112	(250)	2 224	(500)	2 224	(500)	990	(730)	746	(550)	746	(550)
200 (8)	1 334	(300)	2 669	(600)	2 669	(600)	1 166	(860)	881	(650)	881	(650)
250 (10)	1 557	(350)	2 891	(650)	2 891	(650)	1 261	(930)	949	(700)	949	(700)
300 (12)	1 779	(400)	3 114	(700)	3 114	(700)	1 356	(1 000)	1 017	(750)	1 017	(750)

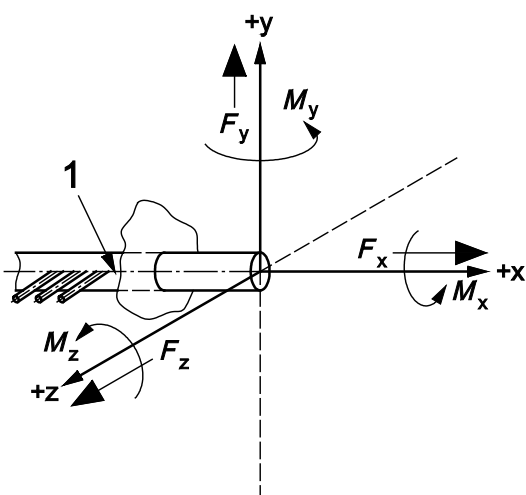
Table 7 — Allowable movements for tubes

Dimensions in millimetres (inches)

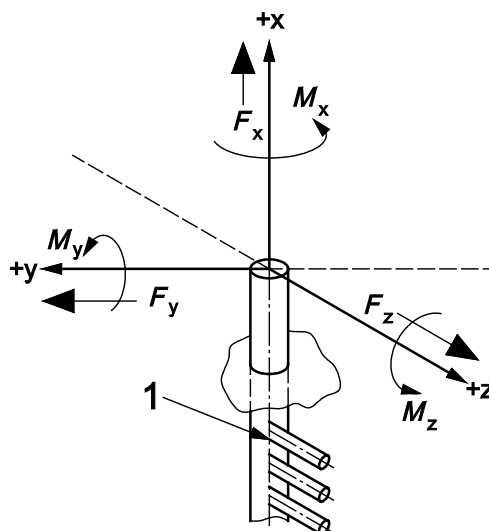
Terminals	Allowable movement											
	Horizontal tubes						Vertical tubes					
	Δx		Δy		Δz		Δx		Δy		Δz	
Radiant	a	a	+ 25	(+ 1)	25	(1)	a	a	25	(1)	25	(1)
Convection	a	a	+ 13	(+ 0,5)	13	(0,5)	—	—	—	—	—	—

NOTE Except where noted, the above movements are allowable in both directions ($\pm$).

^a To be specified by heater vendor.



a) Horizontal manifold



b) Vertical manifold

Key

1 manifold centreline

Figure 5 — Diagram of forces for manifolds

Table 8 — Allowable forces and moments for manifolds

Manifold size DN (NPS)	Force						Moment					
	F_x		F_y		F_z		M_x		M_y		M_z	
	N	(lbf)	N	(lbf)	N	(lbf)	N·m	(ft·lbf)	N·m	(ft·lbf)	N·m	(ft·lbf)
150 (6)	2 224	(500)	4 448	(1 000)	4 448	(1 000)	1 980	(1 460)	1 492	(1 100)	1 492	(1 100)
200 (8)	2 668	(600)	5 338	(1 200)	5 338	(1 200)	2 332	(1 720)	1 762	(1 300)	1 762	(1 300)
250 (10)	3 114	(700)	5 782	(1 300)	5 782	(1 300)	2 522	(1 860)	1 898	(1 400)	1 898	(1 400)
300 (12)	3 558	(800)	6 228	(1 400)	6 228	(1 400)	2 712	(2 000)	2 034	(1 500)	2 034	(1 500)
350 (14)	4 004	(900)	6 672	(1 500)	6 672	(1 500)	2 902	(2 140)	2 170	(1 600)	2 170	(1 600)
400 (16)	4 448	(1 000)	7 117	(1 600)	7 117	(1 600)	3 092	(2 280)	2 305	(1 700)	2 305	(1 700)
450 (18)	4 893	(1 100)	7 562	(1 700)	7 562	(1 700)	3 282	(2 420)	2 441	(1 800)	2 441	(1 800)
500 (20)	5 338	(1 200)	8 006	(1 800)	8 006	(1 800)	3 471	(2 560)	2 576	(1 900)	2 576	(1 900)
600 (24)	5 782	(1 300)	8 451	(1 900)	8 451	(1 900)	3 661	(2 700)	2 712	(2 000)	2 712	(2 000)

Table 9 — Allowable movements for manifolds

Dimensions in millimetres (inches)

Terminals	Allowable movement											
	Horizontal manifolds						Vertical manifolds					
	Δx		Δy		Δz		Δx		Δy		Δz	
Radiant	13	(0,5)	0	(0)	A	a	0	(0)	13	(0,5)	a	a
Convection	13	(0,5)	0	(0)	A	a	—	—	—	—	—	—
NOTE The above movements are allowable in both directions ($\pm$).												
^a Δz is to be specified by heater vendor.												

9.3 Materials

External crossover piping shall be of the same metallurgy as the preceding heater tube; internal crossover piping shall be of the same metallurgy as the radiant tubes.

10 Tube supports

10.1 General

10.1.1 The design temperature for tube supports and guides exposed to flue gas shall be based on design operation of the furnace as follows:

- for the radiant and shock sections and outside the refractory, the flue gas temperature to which the supports are exposed plus 100 °C (180 °F); the minimum design temperature shall be 870 °C (1 600 °F);
- for the convection section, the temperature of the flue gas in contact with the support plus 55 °C (100 °F);
- maximum flue gas temperature gradient across a single convection intermediate tube support shall be 222 °C (400 °F);
- where the radiant tube-support castings are shielded behind a row of tubes, the bridgewall temperature may be used.

No credit shall be taken for the shielding effect of refractory coatings on intermediate supports or guides.

10.1.2 Guides, horizontal radiant-section intermediate tube supports and top supports for vertical radiant tubes shall be designed to permit their replacement without tube removal and with minimum refractory repair.

10.1.3 The unsupported length of horizontal tubes shall not exceed 35 times the outside diameter or 6 m (20 ft), whichever is less.

10.1.4 The minimum corrosion allowance of each side for all exposed surfaces of each tube support and guide contacting flue gases shall be 1,3 mm (0,05 in) for austenitic materials and 2,5 mm (0,10 in) for ferritic materials.

10.1.5 The following shall apply to end-tube sheets for tubes with external headers.

- Tube sheets shall be structural plate. If the tube-sheet design temperature exceeds 425 °C (800 °F), alloy materials shall be used.
- Minimum thickness of tube sheets shall be 12 mm (0,5 in).
- Tube sheets shall be insulated on the flue gas side with a castable having a minimum thickness of 75 mm (3 in) for the convection section and 125 mm (5 in) for the radiant section. (Anchors shall be made from austenitic stainless steel or nickel alloy as listed in Table 11.)
- Sleeves with an inside diameter at least 12 mm (0,5 in) greater than the tube or the extended-surface outside diameter shall be welded to the tube sheet at each tube hole, to prevent the refractory from being damaged by the tubes. The sleeve material shall be austenitic stainless steel.

10.1.6 The following shall apply to the supporting of extended-surface tubes.

- Intermediate supports shall be designed to prevent mechanical damage to the extended surface and shall permit easy removal and insertion of the tubes without binding.
- For studded tubes, a minimum of three rows of studs shall rest on each support.
- For finned tubes, at least five fins shall rest on each support.

10.2 Loads and allowable stress

10.2.1 Tube-support loads shall be determined as follows.

- Loads shall be determined in accordance with acceptable procedures for supporting continuous beams on multiple supports (e.g. AISI^[2]). Friction loads shall be based on a friction coefficient of not less than 0,30.
- Friction loads shall be based on all tubes expanding and contracting in the same direction. Loads shall not be considered to be cancelled or reduced due to movement of tubes in opposite directions.

10.2.2 Tube-support maximum allowable stresses at design temperature shall not exceed the following:

a) dead-load stress:

- 1) one-third of the ultimate tensile strength;
- 2) two-thirds of the yield strength (0,2 % offset);
- 3) 50 % of the average stress required to produce 1 % creep in 10 000 h;
- 4) 50 % of the average stress required to produce rupture in 10 000 h.

b) dead-load plus frictional stress:

- 1) one-third of the ultimate tensile strength;
- 2) two-thirds of the yield strength (0,2 % offset);
- 3) average stress required to produce 1 % creep in 10 000 h;
- 4) average stress required to produce rupture in 10 000 h.

10.2.3 For castings, the allowable stress value shall be multiplied by 0,8 to determine the required casting thickness.

10.2.4 Stress data shall be as presented in Annex D.

10.3 Materials

10.3.1 Tube-support materials shall be selected for maximum design temperatures as shown in Table 10. Other materials and alternative specifications shall be subject to the approval of the purchaser.

- **10.3.2** If the tube-support design temperature exceeds 650 °C (1 200 °F) and the fuel contains more than 100 mg/kg total vanadium and sodium, the supports shall exhibit one of the following design details, as specified or agreed by the purchaser:

- a) constructed of stabilized 50Cr-50Ni metallurgy, without any coating;
- b) for radiant or accessible supports only, covered with 50 mm (2 in) of castable refractory having a minimum density of 2 080 kg/m³ (130 lb/ft³).

Table 10 — Maximum design temperatures for tube-support materials

Material	ASTM specification		Maximum design temperature	
	Casting	Plate	°C	(°F)
Carbon steel	A 216 Gr WCB	A 283 Gr C	425	(800)
2 1/4Cr-1Mo	A 217 Gr WC 9	A 387 Gr 22, Class 1	650	(1 200)
5Cr-1/2Mo	A 217 Gr C5	A 387 Gr 5, Class 1	650	(1 200)
19Cr-9Ni	A 297 Gr HF	A 240, Type 304H	815	(1 500)
25Cr-12Ni	—	A 240, Type 309H	870	(1 600)
25Cr-12Ni	A 447 Type II	—	980	(1 800)
25Cr-20Ni	—	A 240, Type 310H	870	(1 600)
25Cr-20Ni	A 351 Gr HK40	—	1 090	(2 000)
50Cr-50Ni-Nb	A 560 Gr 50Cr-50Ni-Nb	—	980	(1 800)
For exposed radiant and shield-section tube supports, the material shall be 25Cr-12Ni alloy or higher .				

11 Refractories and insulation

11.1 General

11.1.1 Selection of refractory and insulating materials is at least partially based on the anticipated operating temperature and the classification temperature for the material. The following temperature definitions are to be used when making refractory selections.

- Rated temperature is a classification temperature for refractory materials, as defined by each refractory manufacturer, in accordance with specifications such as ASTM. Manufacturers most often use the terms “service temperature”, “maximum temperature rating” and “classification temperature” to describe the rated temperature of the refractory product.
- Design temperature is the calculated hot-face temperature plus the required design margin, and the calculated interface temperature plus that same design margin if there is more than a single layer of refractory. The selected design temperature for each layer of refractory shall be equal to or less than the stated continuous-use limit for the refractory product.
- Continuous-use limit temperature is the manufacturer's stated temperature limit at which the refractory product does not suffer degradation during extended use at that temperature. It is also sometimes referred to as the “recommended use limit”.
- Hot-face temperature is the calculated temperature at the refractory surface in contact with the flue gas or the heated combustion air.
- Interface temperature is the calculated temperature at the intersection of each different layer of refractory material if multilayer or multi-component refractory construction is used.

11.1.2 The temperature of the outside casing of the radiant and convection sections and hot ductwork shall not exceed 82 °C (180 °F) at an ambient temperature of 27 °C (80 °F) with zero wind velocity. Radiant floors shall not exceed 90 °C (195 °F).

11.1.3 Walls, arches and floors shall be designed to allow for proper expansion of all parts. Where multilayer or multi-component linings are used, joints shall not be continuous through the lining.

11.1.4 Each layer of refractory shall be suitable for a design temperature at least 165 °C (300 °F) above the calculated hot-face or calculated interface temperature. The minimum design temperature for refractories used in the radiant and shield sections of the heater is 980 °C (1 800 °F).

11.1.5 The floor hot surface shall be a 63 mm (2,5 in) thick layer of high-duty fireclay brick or a 75 mm (3 in) thick layer of castable with a 1 370 °C (2 500 °F) service temperature and a minimum cold crush strength of 3 450 kN/m² (500 psi) after drying at 110 °C (230 °F).

11.1.6 Burner blocks shall be suitable for a service temperature of at least 1 650 °C (3 000 °F).

11.1.7 Target walls with flame impingement on both sides shall be constructed of high-duty firebrick with at least a 1 540 °C (2 800 °F) rating. Bricks shall be laid dry or with mortared joints. Expansion joints shall be packed with ceramic fibre strips having a rated temperature not less than 1 540 °C (2 800 °F).

11.1.8 Target walls with flame impingement on one side shall be of brick or of plastic refractory with a rated temperature of at least 1 540 °C (2 800 °F). Either may be backed by a castable or ceramic fibreboard.

11.1.9 Expansion joints shall be provided around burner blocks, brick and pre-fired shapes.

11.1.10 Access doors shall be protected from direct radiation by a refractory system of at least the same thermal rating and resistance as the adjacent wall lining.

11.1.11 Refractory anchors are not mandatory for floor castable, unless required for shipping considerations.