INTERNATIONAL STANDARD

ISO 12211

First edition
2012-08-01

Petroleum, petrochemical and natural gas industries — Spiral plate heat exchangers

Industries du pétrole, de la pétrochimie et du gaz naturel — Échangeurs thermiques à plaques en spirale

Reference number
ISO 12211:2012(E)

Contents

Page

Foreword iv
Introduction v
1 Scope 1
2 Normative reference 1
3 Terms and definitions 1
4 General 4
5 Proposal information required 5
6 Drawings and other data requirements 5
6.1 Outline drawings and other supporting data 5
6.2 Information required after outline drawings are reviewed 6
6.3 Reports and records 7
7 Design 8
7.1 General 8
7.2 Design temperatures 8
7.3 Design pressure 8
7.4 Fouling margin 8
7.5 Corrosion allowance 8
7.6 Components 9
7.7 Supports 14
7.8 Cover gaskets 14
7.9 Handling devices 15
8 Materials 15
8.1 General 15
8.2 Requirements for carbon steel in sour or wet hydrogen sulfide service 16
8.3 Cover gaskets 16
9 Fabrication 16
9.1 Welding 16
9.2 Heat treatment 17
9.3 Gasket contact surfaces other than nozzle flange facings 17
10 Inspection and testing 17
10.1 Quality assurance 17
10.2 Quality control 18
10.3 Pressure testing 19
10.4 Nameplates 19
11 Preparation for shipment 20
11.1 Protection 20
11.2 Identification 20
Annex A (informative) **Recommended practice** 21
Annex B (informative) **Spiral plate heat exchanger checklist** 27
Annex C (informative) **Spiral plate heat exchanger data sheets** 28
Bibliography 37

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 12211 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*.

Introduction

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

This International Standard requires the purchaser to specify certain details and features.

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

In this International Standard, where practical, US Customary (USC) or other units are included in parentheses for information.

Petroleum, petrochemical and natural gas industries — Spiral plate heat exchangers

1 Scope

This International Standard specifies requirements and gives recommendations for the mechanical design, materials selection, fabrication, inspection, testing and preparation for shipment of spiral plate heat exchangers for the petroleum, petrochemical and natural gas industries.

It is applicable to stand-alone spiral plate heat exchangers and those integral with a pressure vessel.

2 Normative reference

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

NACE MR0103[1)] *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

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

3 Terms and definitions

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

3.1
alternate channels welded
ACW
channel closures seal-welded at alternate edges such that each chamber is accessible by removing the corresponding hot or cold side end cover

3.2
centre core
distribution chamber at the centre of the spiral exchanger

3.3
channel
spiral passage formed by strips of metal rolled around a centre core within an outer shell

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

3.4
channel closure
configuration to seal the edge of the internal spiral plate

3.5
spiral plate length
spiral passage length
length of strip(s) in the spiral direction corresponding to the length of each spiral passage

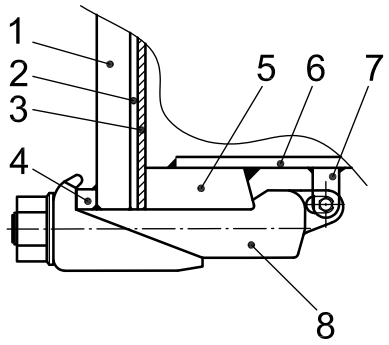
3.6
channel spacing
distance or gap between adjacent spiral plates

3.7
channel width
spiral plate width
width of the strip or plate from which the spiral body is rolled

3.8
clamp-bolting
peripheral hook style bolting used to seal the end cover to the flange ring

NOTE 1 Flange-style bolting and cover design are also possible with stud-bolts and double nuts.

NOTE 2 See Figure 1.



Key

1	end cover	5	flange ring
2	liner (for stainless steel or higher)	6	spiral body
3	full-face sheet gasket	7	U-bracket clip
4	cover ring	8	clamp bolt

Figure 1 — Typical cover clamp-bolting

3.9
cover ring
metal ring welded or integral to the outside face of the end cover that serves as a retaining (grab) ring for the clamp portion of the end cover

3.10
cyclic service
process operation with periodic variation in temperature, pressure and/or flowrate

3.11
distribution manifold
pocket
semi-cylindrical manifold welded to outer shell that allows a fluid to enter or leave the spiral body through corresponding nozzles in the shell

3.12
end cover
cover that seals the fluids in their respective chambers and prevent external leakage

3.13
exchanger orientation
orientation of the cylindrical axis (centre core) of the spiral plate heat exchanger

3.14
heat transfer area
surface area of one side of the spiral plate that is in contact with both hot and cold fluids

NOTE 1 Where multiple plates are used for the channel, then the total area of spiral plates is used to form the spiral body. This equates to the channel width multiplied by the strip length multiplied by the number of strips.

NOTE 2 Areas of outer shell plate and spacer studs are not included.

3.15
hydrogen service
service that contains hydrogen at a partial pressure exceeding 700 kPa (100 psi) absolute

3.16
item number
purchaser's identification number for a spiral plate heat exchanger

3.17
minimum design metal temperature
lowest metal temperature at which pressure-containing elements can be subjected to design pressure

EXAMPLE Minimum ambient temperature or minimum process fluid temperature.

3.18
outer shell
outermost plate welded to the internal spiral plates as the pressure boundary for the spiral body

3.19
pressure design code
recognized pressure vessel standard specified or agreed by the purchaser

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

3.20
flange ring
sealing ring
solid metal ring welded to each end of the spiral body to provide the sealing surface for the gasket, designed to compress the cover and gasket securely against the spiral body using bolts

3.21
spacer stud
pin welded to one spiral plate used to maintain channel spacing

3.22
spiral plate
sheet(s) of metal rolled around a centre core to form a spiral passage

3.23
structural welding code
recognized structural welding code specified or agreed by the purchaser

4 General

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

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

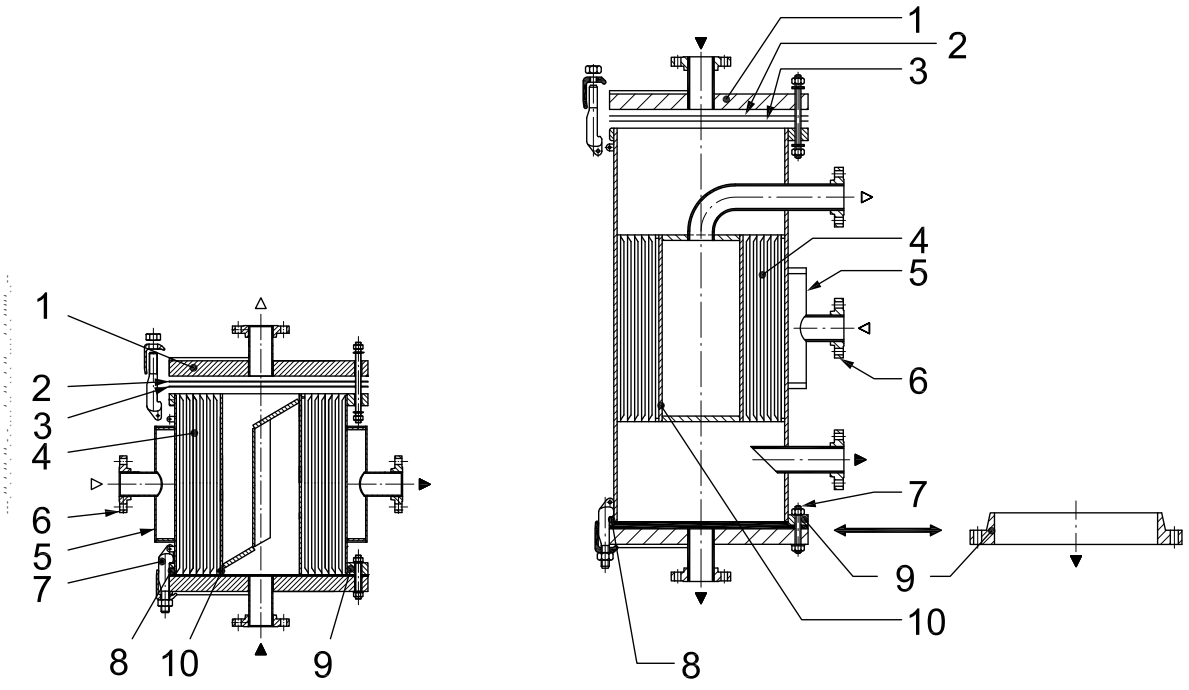
4.3 Typical components of a spiral heat exchanger are shown in Figure 2.

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

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

- **4.6** The purchaser shall specify if the service is designated as sour in accordance with ISO 15156 (all parts) for oil and gas production facilities and natural gas sweetening plants, or designated as wet hydrogen sulfide service in accordance with NACE MR0103 for other applications (e.g. petroleum refineries, LNG plants and chemical plants), in which case all materials in contact with the process fluid shall meet the requirements of the applicable standard to mitigate potential for sulfide stress cracking (SSC). Identification of the complete set of materials, qualification, fabrication, and testing specifications to prevent in-service environmental cracking is the responsibility of the user (purchaser).

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



a) Spiral flow both sides **b) Spiral flow, cross flow**

Key

1	end cover	4	spiral plate	7	cover bolting	10	centre core
2	cover liner	5	distribution manifold	8	flange ring		
3	end cover gasket	6	nozzle flange	9	shell flange		

Figure 2 — Typical components of spiral plate heat exchangers

5 Proposal information required

5.1 The vendor's proposal shall include, for each heat exchanger unit, completed data sheets such as those given in Annex C.

5.2 For components not fully defined by Clause 3, the vendor shall describe the details of construction and assembly.

5.3 The proposal shall include a detailed description of all exceptions to the requirements of the purchaser's inquiry.

5.4 A proposal drawing shall be furnished that shows the major dimensions in plan and elevation, including the nozzle sizes and their orientations, along with those for venting and draining, and approximate mass full of water.

5.5 The vendor's proposal shall include details of the channel closure construction.

5.6 The vendor’s proposal shall include the type of supports.

5.7 The vendor shall supply a recommended spare parts list for each spiral plate heat exchanger.

6 Drawings and other data requirements

6.1 Outline drawings and other supporting data

6.1.1 The vendor shall submit, for review by the purchaser, outline drawings for each heat exchanger unit. The drawings shall include the following information:

a) service, item number, project name and location, purchaser’s order number, vendor's shop order number and other special identification numbers;

b) design pressure, test pressure, design temperature, minimum design metal temperature for each side, and any restrictions on testing or operation of the heat exchanger;

c) maximum allowable working pressure (MAWP) in the corroded condition and at the design temperature for the hot side and cold side;

d) materials specifications and grades for all components;

e) where the heat exchanger is integral with or mounted on a pressure vessel, all mating dimensions, weld preparation details, including connection to the centre core and flange dimensions, gasket and bolting details;

f) connection sizes, location, orientation, projection, direction of flow and, if flanged, the rating and facing;

g) coupling sizes, rating and orientation;

h) dimensions, orientation and location of supports, including bolt holes and slots;

i) overall dimensions of the heat exchanger;

j) detailed information of the heat exchanger, including outer shell thickness, channel width, centre core type, channel spacing and channel closure type (hot and cold sides), channel plate thickness (hot and cold sides), spacer stud diameter and layout, end cover dimensions, shell flange dimensions, distribution manifolds dimensions, cover bolting details, space required for removable components;

k) mass of the heat exchanger, empty and full of water, and of removable components with a mass greater than 25 kg (60 lb), e.g. end covers;

l) maximum allowable forces and moments on each connection;

m) specified corrosion allowance for each side of the heat exchanger;

n) references to the applicable code, standards, and the purchaser's specification;

o) requirements for post-weld heat treatment;

p) hardness test requirements;

q) requirements for non-destructive examination (NDE);

r) requirements for material impact testing;

s) requirements for surface preparation and painting;

t) gasket materials;

u) insulation thickness;

v) location and orientation of nameplates, lifting lugs, grounding clips or other attachments;

w) location of the centre of gravity of the empty exchanger. For units with hinged covers, the centre of gravity shall be shown for one or both covers open.

6.1.2 The review of engineering documents by the purchaser shall not relieve the vendor of the responsibility of meeting the requirements of the purchase order.

6.2 Information required after outline drawings are reviewed

6.2.1 Gasket details, including type and material, shall be provided. Details of any gasket jointing shall be included (see 7.8.2). This information shall not be marked with any restrictions for use.

6.2.2 Upon receipt of the purchaser's review comments on the outline drawings, the vendor shall submit copies of all detailed (non-proprietary) drawings. These shall fully describe the heat exchanger and shall include at least the following information:

a) full views and cross-sectional views with all dimensions and materials sufficient for mechanical design calculations for each part;

b) details of each pressure-retaining weld, including weld material, weld nominal thickness, weld location and applicable non-destructive examination method;

c) details of each weld and weld nominal thickness for non-pressure attachments;

d) complete bills of materials, including the material specification;

e) details of cladding and weld overlay;

f) flange-face finish;

g) installation, operation and maintenance instructions (manual), including lifting and handling.

- **6.2.3** If specified by the purchaser, the vendor shall furnish copies of applicable welding procedure specifications, procedure qualifications and weld map for review or record.

6.2.4 Where sour or wet hydrogen sulfide service is specified, a Certified Material Test Report (CMTR) for all carbon steel materials in contact with the process fluid shall be supplied for the purchaser's review.

- **6.2.5** If specified by the purchaser, the vendor shall furnish for the purchaser's review or record the following documentation:

  a) mechanical design calculations for all the heat exchanger pressure-retaining components. If calculations are made using computer software, all input and output data shall be detailed so as to facilitate an understanding of the calculation procedures. The equations in the applicable sections of the pressure design code shall be referenced;

  b) mechanical calculations shall be provided for deflection of the end covers;

  c) design calculations based on seismic, wind, transportation and/or piping loads, if these loads are provided by the purchaser;

  d) recommended tools and proposed procedures for assembly of flanged joints, if controlled bolt-tightening procedures (such as hydraulic torque wrenches or hydraulic tensioning devices) are used. Any required lubricants shall be stated;

  e) design calculations for loads imposed on nozzles of heat exchangers attached to a vertical vessel.

- **6.2.6** The vendor shall submit design calculations for supports and lifting devices, if specified by the purchaser.

6.2.7 After final review, the vendor shall revise all the required drawings and welding procedures and submit each with the following text marked on every sheet separately and dated: “CERTIFIED FOR CONSTRUCTION”.

6.3 Reports and records

- After the heat exchanger is completed, the vendor shall furnish the purchaser with the following documents in the format and quantities specified by the purchaser:

  a) “as-built” data sheet;

  b) all outline and detail drawings, marked “CERTIFIED AS-BUILT”;

  c) certified record of all impact tests performed;

  d) certified mill test reports for all pressure parts, including channel plates (each material test report shall be identified by a part number);

  e) complete certified bill of materials suitable for obtaining all replacement parts, including quantity, description, material specification and identification of each part;

  f) temperature charts of all post-weld heat treatments;

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

  h) nameplate rubbing or a facsimile;

  i) all mechanical design calculations, marked “CERTIFIED AS-BUILT”;

  j) non-destructive examination (NDE) map;

  k) all associated NDE reports, including radiographic, magnetic-particle, liquid-penetrant, ultrasonic, hardness, impact, positive material identification (PMI) and any other reports as applicable;

  l) hydrostatic test records in the form of a chart or certification.

7 Design

7.1 General

- **7.1.1** The purchaser shall specify if either stream is subject to any of the following: cyclic service; fluid characteristics requiring special considerations (e.g. slurry, entrained particulates, other types of fouling mechanisms); temperature, flowrate and/or pressure fluctuations.

7.1.2 If cyclic service is specified the purchaser shall specify the type and magnitude of variation in pressure, temperature and flowrate, the time for the variation (hours, weeks, etc.) and the number of cycles or frequency for this variation expected during the life of the equipment. The extent and acceptance criteria of any required analysis shall be subject to the agreement of the purchaser. See A.3.1 for guidance on cyclic service.

7.1.3 If fluids are specified as containing particulates, the purchaser shall specify the percentage of particulates in the fluid and the particle size distribution to ensure the proper channel spacing is selected.

- **7.1.4** The purchaser shall specify if internal mechanical cleaning or jetting (i.e. where a lance is inserted within the channels) is required, in which case the minimum channel spacing shall be 10 mm (3/8 in) and the stud layout shall be aligned to allow cleaning lanes.

7.1.5 The exchanger's high and low points shall be capable of being vented and drained in the operating position. The manufacturer shall advise if the equipment is not capable of being fully vented and drained.

7.1.6 A discussion on suitable configurations for spiral heat exchangers is included in A.3.2.

7.2 Design temperatures

- **7.2.1** The purchaser shall specify the design temperature and minimum design metal temperature (MDMT) for each side.

7.2.2 The design temperature of a component (including bolting) influenced by more than one fluid shall be the more severe design temperature.

7.3 Design pressure

Unless otherwise specified or approved by the purchaser, the spiral plate heat exchanger shall be designed for design pressure on either side, with atmospheric pressure or, if specified, vacuum on the other side.

7.4 Fouling margin

- The purchaser shall specify a percentage fouling margin, F, as given in Equation (1):

$$F = \left(U_{\text{clean}} / U_{\text{service}} - 1\right) \times 100 \quad (1)$$

where U is the heat transfer coefficient (overall thermal transmittance).

See A.3.3 for guidance on fouling margins.

7.5 Corrosion allowance

- **7.5.1** Corrosion allowance shall be specified by the purchaser for material in contact with each process fluid.

7.5.2 Corrosion allowance shall not be applied to the spiral plate and spacer studs unless specifically required by the purchaser.

7.6 Components

7.6.1 Spiral plate

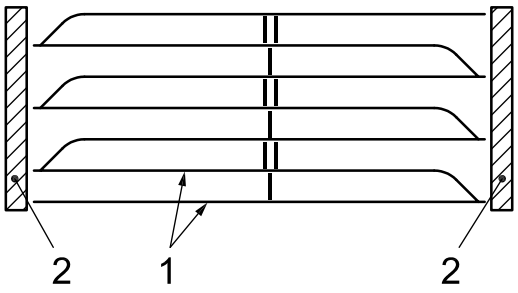
7.6.1.1 The plate thicknesses and stud density (pitch) shall be designed for the higher design temperature of either side. The plate thicknesses and stud density on each side shall take account of the design pressure (or vacuum) on the other side. The stud density may be different on each side.

7.6.1.2 Spiral plate nominal thickness shall not be less than the following:

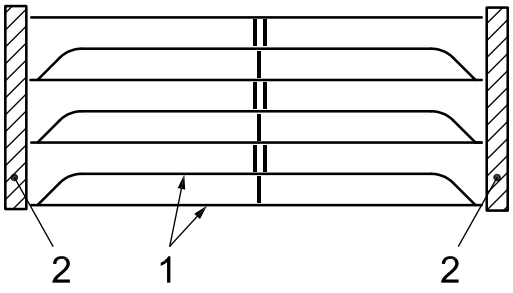
— for carbon steel and low alloys: 4 mm (3/16 in);

— for stainless steels, high alloys and titanium: 2 mm (14 US gauge).

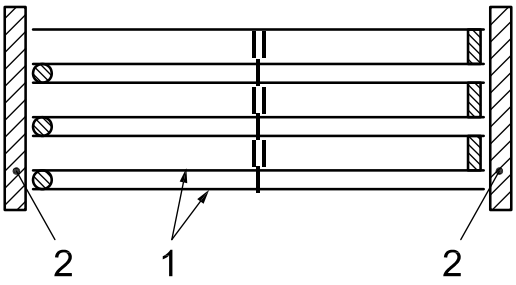
7.6.1.3 The methodology for closing the channels shall be selected to suit the fluids. Typical closure types are shown in Figure 3.



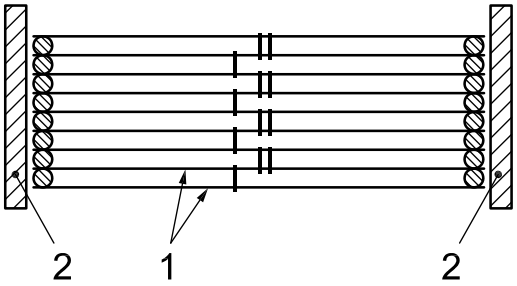
a) Alternate channels with bent edge welded



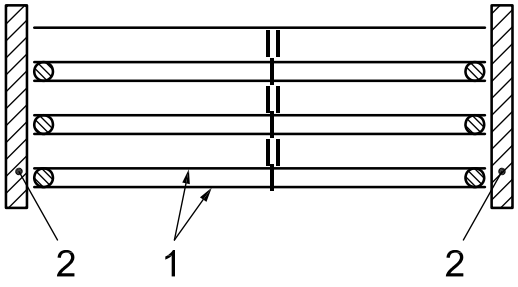
b) One channel side with bent edge welded shut



c) Alternate channels welded using bar closures



d) Fully welded using bar closures



e) One side (hot side) welded using bar closures

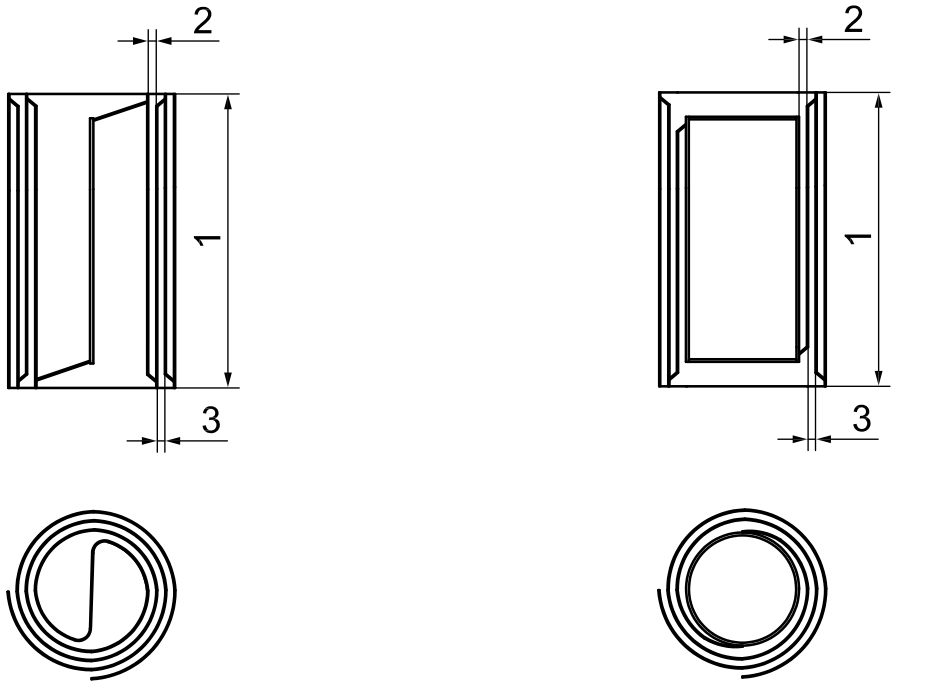
Key

1	spiral plate	I	side one
2	cover plate	II	side two

Figure 3 — Typical designs for channel closure

7.6.2 Centre core

The centre core can be either cylindrical (made from pipe) or split construction (rolled and welded plate or wound type). See Figure 4.



a) Rolled and welded centre core **b) Cylindrical centre core**

Key

1 channel width
2 channel spacing, side I
3 channel spacing, side II

Figure 4 — Typical centre core types

7.6.3 Outer shell

The material of the shell shall be the same as the spiral plate unless otherwise approved by the purchaser.

7.6.4 Outer shell sealing

7.6.4.1 The shell shall be sealed by either shell flanges or flange rings.

7.6.4.2 When shell flange rings are used, they shall be sealed by the use of clamp bolts. Clamp bolts shall be fixed to the shell.

7.6.4.3 The sealing surface of shell flanges and flange rings shall be of the same material type as the shell.

7.6.4.4 When shell flanges are used they shall

a) be of the through bolt type;

b) have through-hardened washers for all bolting.

- **7.6.4.5** The purchaser shall specify if hydraulic bolt-tensioning or torquing devices will be used in the field and the type of equipment or the required space shall be notified to the manufacturer. The manufacturer shall design the flanges to allow adequate space for the use of the devices.

7.6.5 End covers

7.6.5.1 Match marks or dowels shall be provided to prevent mis-assembly of the covers.

- **7.6.5.2** The purchaser shall specify the requirements for hinges, davits or other handling devices.

7.6.5.3 End covers with a liner shall have the liner continuously welded at nozzle openings. The liner shall be at least 1,6 mm (1/16 in) thick.

7.6.5.4 The deflection of the end cover at design pressure and design temperature shall be no greater than the uncompressed thickness of the gasket or 3 mm (1/8 in), whichever is the lesser. The effect of nozzle loading shall be taken into account in this calculation.

7.6.6 Nozzles and other connections

7.6.6.1 Flanges shall be in accordance with the pressure design code unless otherwise specified by purchaser.

7.6.6.2 Connections DN 40 (NPS 11/2) and larger shall be flanged unless otherwise specified by the purchaser.

7.6.6.3 Connection sizes of DN 32 (NPS 1-1/4), DN 65 (NPS 2-1/2), DN 90 (NPS 3-1/2) or DN 125 (NPS 5) shall not be used.

7.6.6.4 If welded connections are specified, they shall be bevelled.

7.6.6.5 Non-flanged connections smaller than DN 40 (NPS 11/2) shall be forged couplings with an with appropriate rating, for example equivalent to ASME B16.11 class 6000, or shall be integrally reinforced welding fittings with appropriate tapered threads, for example equivalent to ASME B1.20.1, and shall comply with the pressure design code. Threaded connections shall not be used in hydrogen, sour, or wet hydrogen sulfide service. This includes auxiliary connections such as vents, drains, instrument connections and chemical cleaning connections.

7.6.6.6 Flanged connections shall be of one of the following types:

a) forged integrally flanged;

b) pipe or forged cylinder welded to forged welding-neck flange;

c) pipe welded to a forged slip-on flange, except as noted in 7.6.6.7.

7.6.6.7 Slip-on flanges shall not be used in any of the following conditions:

a) for design pressure exceeding 2 100 kPa (ga) (300 psig);

b) for design temperature exceeding 400 °C (750 °F);

c) for corrosion allowance exceeding 3 mm (1/8 in);

d) in hydrogen service, sour, or wet hydrogen sulfide service;

e) in cyclic service.

7.6.6.8 The projection of flanged connections shall allow the removal of through-bolting from either side of the flange without removing the insulation. The insulation thickness shall be specified by the purchaser.

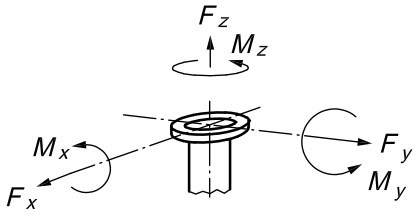
7.6.6.9 Integrally reinforced nozzles shall be designed so that standard spanners (wrenches) fit the nuts without interference from nozzle neck reinforcement.

7.6.6.10 All bolt holes for flanged connections shall straddle centrelines.

7.6.6.11 Alloy nozzles, including any connections fitted into the nozzle necks, shall be solid, lined or clad, as approved by the purchaser.

7.6.6.12 If chemical cleaning connections are specified by the purchaser, their nominal size shall be not less than DN 50 (NPS 2).

7.6.6.13 The heat exchanger, in its design corroded condition, shall be capable of withstanding the simultaneous application of the moments and forces applied to its process connections, as defined in Figure 5 and Tables 1, 2 and 3. Table 1 shall be used where the connection is located on a distribution manifold or where it is on a centrally bolted cover, as shown in Figure 6 a) and 6 b). Table 2 shall be used where the connection is located on a cover that is bolted at its edge as shown in Figure 6 c). Table 3 shall be used where the connection is located on a shell or dished end as shown in Figure 6 d) and 6 e). All the loads and moments specified herein are based on the nozzle necks being set-in.



Key

F forces

M moments

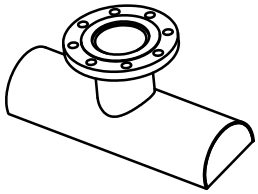
Figure 5 — Directions of forces and moments on connections

Table 1 — Maximum allowable nozzle loading where the connection is on a distribution manifold or a centrally bolted cover

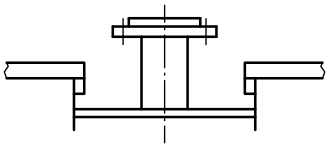
Nom. size		PN 16 – 25 (ASME rating 150)						PN 40 (ASME rating 300)				PN 63 – 100 (ASME rating 600)			
DN	(NPS)	$F_x = F_y = F_z$		$M_x = M_y$		M_z		$F_x = F_y = F_z$		$M_x = M_y = M_z$		$F_x = F_y = F_z$		$M_x = M_y = M_z$	
		N	(lbf)	N·m	(lb·ft)	N·m	(lb·ft)	N	(lbf)	N·m	(lb·ft)	N	(lbf)	N·m	(lb·ft)
50	(2)	250	(56)	50	(37)	150	(111)	250	(56)	100	(74)	350	(79)	150	(111)
80	(3)	500	(112)	150	(111)	250	(184)	500	(112)	250	(184)	650	(146)	300	(221)
100	(4)	500	(112)	200	(148)	500	(369)	750	(169)	400	(295)	800	(180)	500	(369)
150	(6)	750	(169)	200	(148)	500	(369)	1 000	(225)	450	(332)	1 500	(337)	550	(406)
200	(8)	1 000	(225)	200	(148)	750	(553)	1 500	(337)	500	(369)	2 000	(450)	600	(443)
250	(10)	1 500	(337)	250	(184)	750	(553)	1 500	(337)	750	(553)	2 500	(562)	900	(664)
300	(12)	1 500	(337)	300	(221)	750	(553)	2 000	(450)	750	(553)	3 000	(674)	1 000	(738)
350	(14)	2 000	(450)	300	(221)	1 000	(738)	2 500	(562)	1 000	(738)	4 000	(899)	1 500	(1 106)
400	(16)	2 500	(562)	350	(258)	1 000	(738)	3 000	(674)	1 500	(1 106)	4 500	(1 012)	2 000	(1 475)
450	(18)	3 000	(674)	350	(258)	1 500	(1 106)	3 500	(787)	2 000	(1 475)	5 000	(1 124)	3 000	(2 213)
500	(20)	3 000	(674)	500	(369)	1 500	(1 106)	4 000	(899)	2 500	(1 844)	6 000	(1 349)	4 000	(2 950)

Table 2 — Maximum allowable nozzle loading where the connenction is on a cover

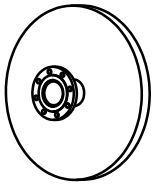
Nom. size		PN 16 – 25 (ASME rating 150)				PN 40 (ASME rating 300)				PN 63 – 100 (ASME rating 600)			
DN	(NPS)	$F_x = F_y = F_z$		$M_x = M_y = M_z$		$F_x = F_y = F_z$		$M_x = M_y = M_z$		$F_x = F_y = F_z$		$M_x = M_y = M_z$	
		N	(lb)	N·m	(lb·ft)	N	(lb)	N·m	(lb·ft)	N	(lb)	N·m	(lb·ft)
50	(2)	250	(56)	100	(74)	250	(56)	150	(74)	350	(79)	150	(111)
80	(3)	500	(112)	250	(148)	500	(112)	250	(184)	650	(146)	300	(221)
100	(4)	500	(112)	500	(258)	750	(169)	500	(295)	800	(180)	600	(332)
150	(6)	750	(169)	750	(553)	1 000	(225)	800	(590)	1 500	(337)	1000	(738)
200	(8)	1 000	(225)	1 000	(738)	1 500	(337)	1 400	(1033)	2 000	(450)	1 700	(1 254)
250	(10)	1 500	(337)	1 700	(1 254)	1 500	(337)	2 000	(1475)	2 500	(562)	2 500	(1 844)
300	(12)	1 500	(337)	2 400	(1 770)	2 000	(450)	3 000	(2213)	3 000	(674)	4 000	(2 950)
350	(14)	2 000	(450)	3 200	(2 360)	2 500	(562)	4 000	(2950)	4 000	(899)	5 500	(4 057)
400	(16)	2 500	(562)	4 000	(2 950)	3 000	(674)	5 000	(3688)	4 500	(1 012)	7 500	(5 532)
450	(18)	3 000	(674)	4 500	(3 319)	3 500	(787)	6 000	(4425)	5 000	(1 124)	9 500	(7 007)
500	(20)	3 000	(674)	5 000	(3 688)	4 000	(899)	7 000	(5163)	6 000	(1 349)	12 000	(8 851)



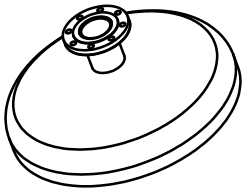
a) On distribution manifold



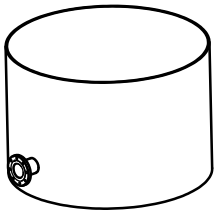
b) On centrally bolted cover



c) On edge bolted (flat) cover



d) On dished cover



e) On outer shell

Figure 6 — Connection locations for use with nozzle loading tables

Table 3 — Maximum allowable nozzle loading on shell or dished end

Nom. size		PN 16 – 25 (ASME rating 150)						PN 40 (ASME rating 300)				PN 63 – 100 (ASME rating 600)			
DN	(NPS)	$F_x = F_y = F_z$		$M_x = M_y$		M_z		$F_x = F_y = F_z$		$M_x = M_y = M_z$		$F_x = F_y = F_z$		$M_x = M_y = M_z$	
		N	(lbf)	N·m	(lb·ft)	N·m	(lb·ft)	N	(lbf)	N·m	(lb·ft)	N	(lbf)	N·m	(lb·ft)
50	(2)	250	(56)	50	(37)	150	(111)	250	(56)	100	(74)	350	(79)	150	(111)
80	(3)	500	(112)	150	(111)	250	(184)	500	(112)	250	(184)	650	(146)	300	(221)
100	(4)	500	(112)	200	(148)	500	(369)	750	(169)	400	(295)	800	(180)	500	(369)
150	(6)	750	(169)	250	(184)	500	(369)	1 000	(225)	450	(332)	1 500	(337)	550	(406)
200	(8)	1 000	(225)	250	(184)	750	(553)	1 500	(337)	500	(369)	2 000	(450)	600	(443)
250	(10)	1 500	(337)	300	(221)	750	(553)	1 500	(337)	750	(553)	2 500	(562)	900	(664)
300	(12)	1 500	(337)	400	(295)	750	(553)	2 000	(450)	750	(553)	3 000	(674)	1 000	(738)
350	(14)	2 000	(450)	400	(295)	1 000	(738)	2 500	(562)	1 000	(738)	4 000	(899)	1 500	(1 106)
400	(16)	2 500	(562)	500	(369)	1 000	(738)	3 000	(674)	1 500	(1 106)	4 500	(1 012)	2 000	(1 475)
450	(18)	3 000	(674)	500	(369)	1 500	(1106)	3 500	(787)	2 000	(1 475)	5 000	(1 124)	3 000	(2 213)
500	(20)	3 000	(674)	700	(516)	1 500	(1106)	4 000	(899)	2 500	(1 844)	6 000	(1 349)	4 000	(2 950)
600	(24)	3 000	(674)	700	(516)	1 500	(1106)	4 000	(899)	2 500	(1 844)	6 000	(1 349)	4 000	(2 950)

7.7 Supports

7.7.1 Acceptable types of supports include (see A.3.6 for guidance on supports)

a) fixed mounting on saddles or feet (horizontal mounting);

b) brackets (horizontal and vertical mounting);

c) turnable mounting on trunnions, either with or without an A-frame.

7.7.2 Supports shall be designed to take account of any loadings that can result from opening of any flanged cover.

7.7.3 All units shall have earthing lug(s) located on the supports.

7.8 Cover gaskets

7.8.1 Where a full-face cover gasket is used, these shall be sheet type, or a combination of sheet type and a metallic peripheral ring gasket. Sheet material shall be non-asbestos compressed fibre, PTFE, graphite or equal, with a minimum thickness of 2 mm (3/32 in). The use of other materials shall be subject to agreement between the vendor and purchaser.

7.8.2 Sheet gaskets shall be single piece up to 1 500 mm (60 in) diameter. For sheet gaskets above this size, the manufacturer shall provide the details of any joint.

7.8.3 A metallic loose liner can be placed over the inner surface of the gasket to protect the gasket from mechanical damage, erosion, etc.

7.8.4 Metallic peripheral ring gaskets shall be provided in hydrocarbon or steam service. Acceptable gaskets types are serrated-metal with soft gasket-seal facing, corrugated metal with soft gasket-seal facing, or spiral-wound.

7.8.5 Where the peripheral ring gasket OD is less than or equal to 610 mm (24 in), the perimeter portion shall be of one piece (non-welded) construction. Where the gasket OD exceeds 610 mm (24 in), the maximum quantity of welds in the perimeter portion shall not exceed the greater of either 2 (two) or the ratio of gasket OD mm/610 mm (OD in/24 in).

7.8.6 Peripheral ring gaskets that are welded shall be as follows.

a) Welds shall be continuous and full penetration. The cross-section, finish and flatness of these welded areas shall match the remainder of the perimeter gasket.

b) Welds shall not inhibit the sealing or compression of the gasket.

7.8.7 When adhesives are used to attach facings to serrated or corrugated metal gaskets, they shall be compatible with the core (e.g. chloride content).

7.8.8 Serrated gaskets shall be as follows.

a) The top of the serrations at the weld shall be flat in comparison with the rest of the gasket. The grooves shall be dressed to match the standard profile.

b) Serrated gaskets shall have a metallic core with thickness variations that do not exceed 0,13 mm (0,005 in) along a 25,4 mm (1 in) band whose centre is defined as the centre of the weld.

c) Where the outside diameter is less than 1 m (40 in), they shall be manufactured with one-piece continuous facing materials (no joints). Facing joints in larger-diameter gaskets shall include a 1,5 mm (1/16 in) to 3 mm (1/8 in) overlap of the facing material. Facing joints shall not be coincident with a facing joint on the opposite sealing face or with any welds in the core.

7.8.9 Corrugated metal gaskets shall be as follows:

a) minimum core thickness of 0,46 mm (0,018 in);

b) corrugations in the weld area that match the gasket profile;

c) where the outside diameter is less than 1 m (40 in), they shall be manufactured with one piece continuous facing materials (no joints). Facing joints in larger-diameter gaskets shall include a 1,5 mm (1/16 in) to 3 mm (1/8 in) overlap of the facing material. Facing joints shall not be coincident with a facing joint on the opposite sealing face or with any welds in the core.

7.8.10 Spiral wound gaskets shall be provided with inner and outer rings.

7.9 Handling devices

7.9.1 The spiral plate heat exchanger shall be provided with suitable lifting lugs, holes or similar devices. The design of the lifting devices shall be based on twice the maximum mass of the spiral plate heat exchanger.

7.9.2 Removable covers shall be provided with suitable lifting lugs, holes or similar devices.

8 Materials

8.1 General

8.1.1 Material for external parts that are welded directly to the heat exchanger, such as pads, brackets and lugs, shall be of the same nominal composition as the material to which they are welded.

8.1.2 Where alloy covers are required, these shall be solid alloy or ferritic steel clad by weld-overlay, integrally clad or explosion-bonded cladding in the same material as the channel. Loose cover liners shall not be used without the approval of the purchaser.

8.1.3 All pressure-containing parts constructed of carbon steel shall be manufactured from fully killed steel unless otherwise approved by the purchaser.

8.1.4 Loose liners or sleeves shall not be used in nozzles without the approval of the purchaser.

8.1.5 The material of the centre core shall be same nominal composition as for the channel.

8.1.6 The material of the studs shall be the same nominal composition as the channel.

8.1.7 Castings for pressure-containing components shall not be used unless approved by the purchaser.

8.1.8 Where clamp bolts are used, they shall be either zinc coated or hot dip galvanized, unless otherwise approved or specified by the purchaser.

8.2 Requirements for carbon steel in sour or wet hydrogen sulfide service

8.2.1 Materials shall be supplied in the normalized condition, unless otherwise approved by the purchaser. The acceptability of hot formed material shall be subject to approval of the purchaser.

8.2.2 Pressure-retaining components shall be supplied with a Certified Material Test Report (CMTR). The CMTR shall include the unspecified elements chromium (Cr), columbium (Cb) (also known [as niobium (Nb)], nickel (Ni), vanadium (V), molybdenum (Mo) and copper (Cu) that are used in the equation to calculate the carbon equivalent (CE) as defined by ISO 15156 (all parts) or NACE MR0103.

8.2.3 The maximum allowable carbon equivalent shall be agreed with the purchaser, prior to purchase of materials used in fabrication. Restrictions on other residual elements and micro-alloying elements can also apply depending on the severity of the service. The purchaser shall specify any such restrictions.

8.3 Cover gaskets

8.3.1 Gaskets shall not contain asbestos.

8.3.2 Material for serrated-metal gaskets shall have a corrosion resistance at least equal to that of the gasket contact surface material.

8.3.3 Metal windings of spiral-wound gaskets shall be of austenitic stainless steel unless otherwise specified or approved by the purchaser. Where materials of construction are a higher alloy, then the metal windings shall be the same alloy material.

8.3.4 Serrated-metal gaskets, including welds, shall be softer than the gasket contact surface.

8.3.5 Gasket material, including filler material, shall be selected to withstand the maximum design temperature.

9 Fabrication

9.1 Welding

9.1.1 All pressure-containing welding shall be in accordance with the pressure design code, and structural welding shall be in accordance with the structural welding code, unless otherwise specified by the purchaser.

9.1.2 Nozzle to shell welds, nozzle to manifold welds and manifold to shell welds shall be full penetration.

- **9.1.3** For nozzles welded to end covers, the purchaser shall specify whether the nozzles shall be set-on with full penetration welds or set-in with fillet welds on the inside and the outside of the end cover.

- **9.1.4** The purchaser shall specify whether weld procedure qualifications for carbon steel in sour or wet hydrogen sulfide service shall include a micro-hardness survey performed on a weld cross-section and transverse to the weld centreline. The micro-hardness testing and acceptance criteria shall be in accordance with NACE SP0472 or ISO 15156 (all parts), as applicable. Any additional restrictions on class, grade, residual elements or micro-alloying elements for the qualification test material shall be specified by the purchaser.

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

9.2 Heat treatment

9.2.1 Heat treatment of fully assembled spiral plate heat exchangers is not recommended due to the risk of distortion. Materials should be selected to avoid the requirement for heat treatment.

9.2.2 Machined contact surfaces, including any threaded connections, shall be suitably protected to prevent scaling or loss of finish during heat treatment.

- **9.2.3** The purchaser shall specify if post-weld heat treatment is required for weld-overlaid components.

9.3 Gasket contact surfaces other than nozzle flange facings

9.3.1 Gasket contact surfaces shall have finishes as shown in Table 4.

Table 4 — Gasket contact surface finishes

Dimensions in micrometres (micro-inches)

Type	Surface roughness R_a[a]
Compressed sheet gaskets	3,2 to 6,3 (125 to 250)
Spiral-wound gaskets	3,2 to 6,3 (125 to 250)
Serrated or corrugated metal gaskets with soft gasket-seal facing	3,2 to 6,3 (125 to 250)

[a] R_a is roughness average.

9.3.2 The flatness tolerance (maximum deviation from a plane) on peripheral gasket contact surfaces shall be 0,8 mm (1/32 in). The flatness of gasket contact surfaces shall be measured with a dial gauge.

9.3.3 Flange flatness tolerance and surface finish shall be measured after the flange has been attached to the component cylinder or the cover and after any post-weld heat treatment.

10 Inspection and testing

10.1 Quality assurance

- The purchaser shall specify if the vendor shall supply information about its quality control system and shall supply a quality control plan.

10.2 Quality control

10.2.1 For pressure-containing welds, inspection shall be performed in accordance with the pressure design code. The following additional requirements apply to external pressure-retaining welds.

a) All accessible butt welds shall have at least one spot-radiograph. The spot radiographs shall be at least 250 mm (10 in) long or shall be full length if the weld is less than 250 mm (10 in) long. Weld porosity limits for spot radiographs shall be as stated in the pressure design code for fully radiographed joints.

b) 100 % radiographic examination shall be performed on any accessible butt welded seam in any component that has been subjected to severe working (ratio of thickness to local radius greater than 5 %) after welding.

c) On pressure parts, all attachment welds (structural attachment, lug, etc.) with a throat greater than 6 mm (1/4 in) shall be examined and evaluated by the liquid penetrant method in accordance with the pressure design code. Any surface irregularities that interfere with the examination shall be removed by grinding or machining.

10.2.2 Production hardness testing of pressure-retaining welds shall be in accordance with the pressure design code, or the following requirements, whichever is the more stringent.

a) Welds in components made of a carbon, Cr-Mo, 11/13/17 % chromium, and duplex stainless steels shall be hardness tested. Hardness testing of the heat-affected zone shall be conducted, if required, by the pressure design code, or when specified by the purchaser.

b) If post-weld heat treatment is required, the examination shall be made after the post-weld heat treatment is completed.

c) Unless otherwise agreed between the vendor and purchaser, the weld hardness shall not exceed the values listed in Table 5.

d) Hardness readings shall be taken with a portable Brinell hardness tester. Other hardness testing techniques can be employed if approved by the purchaser. When access is available, tests shall be performed on the side of the weld in contact with the process fluid.

e) One longitudinal weld, one circumferential weld and each connection-to-component weld if the connection is DN 50 (NPS 2) or larger shall be tested.

f) If more than one welding procedure is used to fabricate longitudinal or circumferential welds, hardness readings shall be made of welds deposited by each procedure.

g) Hardness test results and locations shall be recorded.

Table 5 — Hardness limits

Material	Maximum weld hardness
Carbon steel	225 HBW
Chromium steel (up to 3 % Cr)	225 HBW
Chromium steel (5 % Cr to 17 % Cr)	241 HBW
Duplex stainless steel (22 % Cr)	to be agreed with purchaser
Super duplex stainless steel (25 % Cr)	to be agreed with purchaser
NOTE These hardness values are for general services. More stringent hardness testing and acceptance criteria can be required for special services (e.g. sulfide stress cracking or other types of environmental cracking services as specified in NACE Standards).	

10.2.3 If the plates are not fully examined for laminations by ultrasonic examination and if set-on connections are used, the edge of the hole in the plate to which the connections are attached shall be examined for laminations by the magnetic-particle or liquid-penetrant method. Indications found shall be cleared to sound metal and then back-welded.

10.2.4 For duplex stainless steels, the ferrite content of all accessible completed production welds shall be checked using a ferritescope. The acceptance criteria for the minimum and maximum ferrite content shall be agreed between the purchaser and vendor. The following shall apply.

a) For external pressure boundary welds, a minimum of three tests shall be made on each 1,5 m (5 ft) of weld, with at least three tests made on each circumferential weld, three tests on each longitudinal weld, and three tests on each nozzle weld.

b) For internal welds excluding channel closure welds, a minimum of three tests shall be made on each weld.

c) For channel closure welds, a minimum of three tests on each 15 m (50 ft) of weld shall be made.

d) Spacer stud welds are exempt from testing.

10.3 Pressure testing

10.3.1 One chamber shall be subjected to a pneumatic test with the other filled with water to check the integrity of the internal welds. The air pressure shall be between 50 kPa (ga) (7,5 psig) and 100 kPa (ga) (15 psig).

10.3.2 The hydrostatic test shall be separately applied to the hot side and to the cold side with atmospheric pressure on the other side.

10.3.3 The water used for hydrostatic testing shall be potable and the test pressure shall be maintained for at least 1 h.

10.3.4 The chloride content of the test water used for equipment with austenitic stainless steel materials that can be exposed to the test fluid shall not exceed 50 mg/kg (50 parts per million by mass). Upon completion of the hydrostatic test, the equipment shall be promptly drained.

10.3.5 Any additional requirements for equipment drying or preservation shall be specified by the purchaser.

10.3.6 Nozzle reinforcement pads shall be pneumatically tested between 100 kPa (ga) (15 psig) and 170 kPa (ga) (25 psig).

10.3.7 Joints taken apart after the final pressure test shall be reassembled with new gaskets.

10.4 Nameplates

10.4.1 An austenitic stainless steel nameplate shall be permanently attached to the heat exchanger in such a manner that it is visible after insulation has been installed.

10.4.2 The following parts shall be stamped with the manufacturer's serial number:

a) end cover;

b) shell flange;

c) flange ring.

10.4.3 A warning label shall be permanently attached to the heat exchanger bolted covers to prevent opening a cover with either side under pressure.

11 Preparation for shipment

11.1 Protection

11.1.1 All liquids used for cleaning or testing shall be drained from heat exchangers before shipment.

11.1.2 Heat exchangers shall be free from foreign matter prior to shipment.

11.1.3 All openings in heat exchangers shall be suitably protected to prevent damage and possible entry of water or other foreign material.

11.1.4 All flange-gasket surfaces shall be coated with an easily removable rust preventative and shall be protected by suitably attached durable covers of such material as wood, plastic or gasketed steel.

11.1.5 All threaded connections shall be protected by metal plugs or caps of compatible material.

11.1.6 Connections that are bevelled for welding shall be suitably covered to protect the bevel from damage.

- **11.1.7** The purchaser shall specify if there are requirements for surface preparation and protection (e.g. painting).

11.1.8 Exposed threads of bolts shall be protected with an easily removable rust preventative to prevent corrosion during testing, shipping and storage. Tapped holes shall be plugged with grease.

- **11.1.9** The purchaser shall specify if inert gas purge and fill is required. Positive pressure shall be indicated by a pressure gage. Gages shall be suitably protected from damage during transportaion.

11.2 Identification

11.2.1 The item number, shipping mass and purchaser's order number shall be clearly marked on the heat exchanger.

11.2.2 All boxes, crates or packages shall be identified with the purchaser's order number and the item number.

11.2.3 The words “DO NOT WELD” shall be stencilled on the parts of the equipment that have been post-weld heat-treated.

Annex A
(informative)

Recommended practice

A.1 General

This annex has been prepared to give advice to the designer. The advice is offered for guidance only.

The descriptions and the numbers following are those of subclauses of the main body of this International Standard.

A.2 Reports and records — Guidance to 6.3

In some cases it can be necessary to ask the vendor to provide and/or maintain a detailed manufacturing record book (MRB). A suggested contents list for the MRB is as follows:

a) certificate of conformance;

b) non-conformance report;

c) vendor's data report, as specified by the design code;

d) code calculations;

e) material traceability, certified mill test reports for all pressure parts;

f) weld and non-destructive examination (NDE) documentation;

g) hydrotest report/certificate or chart;

h) nameplate rubbings or photocopy;

i) third-party verification and certification.

A.3 Design

A.3.1 Cyclic design — Guidance to 7.1.2

The following is guidance to assist in identifying a potential cyclic service application:

— 20 % variance in normal operating pressure; and/or

— 20 % variance in process flow rate; and/or

— variations in normal operating temperature that exceed 110 °C (200 °F).

One cycle is where the variance occurs in a time frame of less than 24 h and the number of cycles exceeds 12 per year.

NOTE The variation in the normal operating temperature is suggested by API RP 571-11, Section 4.2.9.3.c, Thermal Fatigue.

A.3.2 Configurations of spiral heat exchangers — Guidance to 7.1.6

A.3.2.1 A spiral heat exchanger can be mounted either vertically or horizontally around its centre axis. The selection of mounting is dependent on the service, fluid properties (fouling, particles, fibres, etc) and requirements for mechanical cleaning.

A.3.2.2 Horizontally mounted spiral heat exchangers, i.e. mounted with the axis horizontally, are recommended for liquids containing solids. In these cases, the design should be such that

a) venting is ensured by a fluid velocity high enough to sweep any entrained gas or residual air through the channel; venting is thus via the external pipe-work or a separate vent connection at the highest practical point;

b) for draining purposes, the lower half of the channel's face is provided with a machined groove from centre to periphery.

NOTE If the channels are alternately welded, the face of each channel can be provided with a draining groove so that both sides can be drained. Venting can be accomplished by similar grooves in the upper half of the body.

A.3.2.3 Vertically mounted spiral heat exchangers, i.e. mounted with the axis vertical, can be used for liquid-to-liquid services where there are low concentrations of solids and minimum requirements for mechanical cleaning.

A.3.2.4 When one medium is a vapour, then a vertical unit should be used and provided with an additional outlet for drainage of condensate.

A.3.2.5 Vertically mounted units are preferred in gas cooling duties, reboilers and condensers.

A.3.2.6 Spiral heat exchangers can be used as column-mounted overhead condensers as shown in Figure A.1. In these cases, the following should be considered.

a) The vapour is fed to the heat-transfer surface via the bottom of the unit.

b) A reflux or product condenser can be placed directly on the top of a column, reactor or vessel, thus avoiding the requirement for intermediate pipe work.

c) The vapour inlet connection is sized to fit the equipment to which the spiral heat exchanger is connected without the requirement for intermediate pipe work.

d) Vapour is directed through a central tube and then flows in full spiral flow, cross flow or a combination of both.

e) The cooling medium enters at the periphery, spirals to the centre, discharging at the top as usual.

f) Condensate can be taken directly from the spiral body or collected in a retention chamber under the spiral body.

g) Condensates and/or inerts can be subcooled.

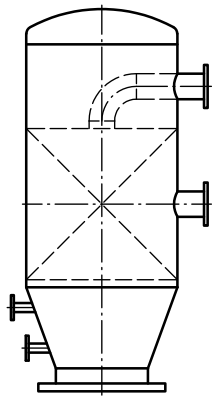


Figure A.1 — A typical column-mounted overhead condenser

A.3.2.7 Where one medium is typically either steam or a condensing vapour/gas stream, or where the exchanger is a reboiler and vaporizer, the covers are replaced with welded or bolted conical or cylindrical extensions at one or both ends of the spiral body.

A.3.2.8 Where one fluid is highly fouling, then both spiral plate edges can be left open, which allows annular access (see-through) into the spiral chamber. In such cases, the other side should be welded on both spiral plate edges.

A.3.2.9 In an application where thermal heat transfer fluids or hot oils are used for heating and/or cooling and where these fluids can cause leakage when gaskets are used, both edges should be welded.

A.3.3 Fouling margin — Guidance to 7.4

Conventional fouling-resistance values used with shell-and-tube heat exchangers should not be used in the thermal design of spiral plate heat exchangers. A 10 % fouling margin is typical. For highly fouling service, it can be necessary to increase this.

It is important to ensure that the addition of the extra margin is taken into account when checking the thermal design of the unit. Wall shear-rate provides a good indication of fouling tendency in a spiral plate heat exchanger. Fouling margin should be introduced by increasing the channel width of the spiral plate and not the units length so as not to reduce the shear rate and hence heat transfer effectiveness of the design. Table A.1 indicates suggested fouling margins for several types of process fluids.

The shear rate, G, expressed in seconds raised to the power -1 (also known as reciprocal seconds) in a spiral heat exchanger (in a rectangular channel) is given by Equation (A.1):

$$G = 6 \times \frac{V}{h} \tag{A.1}$$

where

V is the fluid velocity in the channel, expressed in metres per second (feet per second);

h is the channel spacing, expressed in metres (feet).

Table A.1 — Indicative levels of fouling margin for various process conditions

Shear rate (both channels) s^{-1}	U_{clean} $W/m^2 \cdot K$ (BTU/h·ft^2 F)	**Excess area** % margin	**Fluids**
> 200	1 420 to 2 840 (250 to 500)	10 to 20	Both clean fluids; no scale or similar surface deposition; no suspended solids
	855 to 1 420 (150 to 250)	15 to 25	Either fluid high fouling; risk of scaling or similar deposition; with suspended solids
	285 to 855 (50 to 150)	10 to 15	Both clean fluids; no scale or similar surface deposition; no suspended solids
	142 to 285 (25 to 50)	5 to 10	All other cases
< 200	1 420 to 2 840 (250 to 500)	15 to 25	Both clean fluids; no scale or similar surface deposition; no suspended solids
	855 to 1 420 (150 to 250)	25 to 35	Either fluid high fouling; risk of scaling or similar deposition; with suspended solids
	285 to 855 (50 to 150)	15 to 20	Both clean fluids; no scale or similar surface deposition; no suspended solids
	142 to 285 (25 to 50)	5 to 10	All other cases

A.3.4 Corrosion allowance — Guidance to 7.5

It should be noted that if it is required to apply a corrosion allowance to the spiral plate, then the thickness can become too great to allow fabrication/rolling. In this case, an alternate material selection can be required. In some cases, the purchaser can specify a different corrosion allowance for the spiral plates and studs.

A.3.5 Components

A.3.5.1 End covers — Deflection — Guidance to 7.6.5.4

When an end cover seals a channel (see Figure 2 a) and the fluids are pressurized, a clearance can arise between the channels and the end cover. If this clearance is too large, a considerable portion of the fluid can flow through this gap, rather than following the concentric flow path of the spiral channels. This is referred to as bypassing. Be aware that this is not cross contamination between the hot and cold fluids. Bypassing reduces the thermal performance of the heat exchanger, so deflection of the end covers shall be limited.

Small amounts of deflection are acceptable for many units as small clearances might not lead to appreciable bypassing of a fluid.

A.3.5.2 It is recommended to verify that the contribution of such a nozzle loading to the deflection of the end cover in design conditions is small; otherwise, detailed calculations that take into account all simultaneously applied loads that increase the deflection are required. If nozzle loads and moments are within those specified in Tables 1, 2 and 3, they typically do not significantly impact the deflection calculations.

A.3.5.3 The deflection of an end cover can be reduced by increasing its thickness or by reinforcing it.

A.3.6 Supports — Guidance to 7.7

Spiral plate heat exchangers should be mounted on saddles, feet or brackets for horizontal units. Brackets can also be used for vertically mounted units. Alternatively, units can be mounted on A-frames with trunnions, allowing rotation of unit during servicing. Figure A.2 shows a typical A-frame.

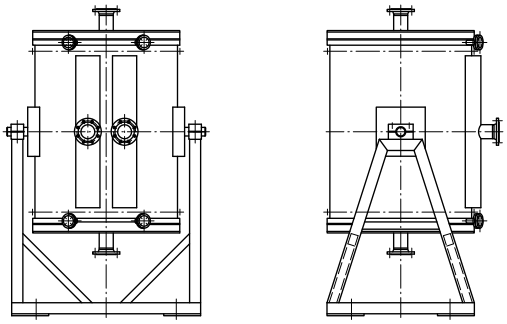


Figure A.2 — Typical A-frame mounted spiral heat exchanger with trunnions

A.4 Preparation for shipment

A.4.1 Protection (cleaning) — Guidance to 11.1

A.4.1.1 If the spiral heat exchanger requires cleaning, this can be done using the methods described in A.4.2.

A.4.1.2 The heat-transfer surfaces should be kept clean to maintain design performance.

A.4.1.3 Cleaning can be undertaken either in place without opening, or by manual cleaning after opening the unit. The entire heat-transfer area is accessible behind the wide-opening, easily removed front cover. Back flushing is very efficient to remove big particles trapped at the channel inlet.

A.4.2 Cleaning methods

A.4.2.1 Cleaning in place by circulation

A.4.2.1.1 Frequently, the most efficient procedure is to flush the unit without removing the covers, using either the process fluid or a suitable solvent such as an acid or alkaline solution.

The pipe work shall be provided with valved branches to enable the circulation of cleaning agents.

A.4.2.1.2 The following is guidance on the methodology.

a) For best results, the flow direction should be in the direction opposite to the normal flow (i.e. back flushing).

b) Cleaning agents should be compatible with the materials of construction and the service fluids.

c) Proprietary cleaning agents, if used, should be handled in accordance with the manufacturer's instructions.

d) The solvent type and frequency of cleaning should be determined for each individual case dependent on the composition of the deposits or scaling. Do not use solutions containing chlorides.

e) The gasket's compatibility with the cleaning agent shall also be checked.

f) The flow of the cleaning solution should normally be equal to the design flow rate or higher. However, flow rates substantially lower than the design flow rate can be acceptable if compensated by a longer cleaning duration.

g) After cleaning, the unit should be completely flushed with water to remove all traces of cleaning agents, particularly if acids have been used. Check the pH and chloride content of the flushing water.

h) The unit should be drained and dried if it is not being put back in operation shortly after cleaning.

A.4.2.1.3 The following is how to back-flush the spiral heat exchanger.

a) Arrange hose connections and valves so that the unit can be operated in reverse for fixed periods of time.

b) Flush the unit with cleaning agent in reverse flow to the normal operation of the circuit.

c) The flow pressure should be higher than normal while flushing.

d) Flush for a duration of 15 min to 30 min.

e) If necessary, flush the other circuit in the same way.

A.4.2.2 Mechanical cleaning

A.4.2.2.1 If cleaning in place is not suitable or possible, then remove the covers and clean the unit either mechanically or manually. During cleaning, keep the unit in a horizontal position (see guidance below on opening the unit). Remove loose accumulations of solids manually. A high-pressure water jet [maximum 100 000 kPa (14 000 psi)] or use of a steam jet can be very effective in removing solids and deposits.

A.4.2.2.2 The following is how to open the spiral heat exchanger.

a) Make sure both sides are de-pressurized before opening.

b) Remove the bolts or clamp bolts from the front cover.

c) Swing the cover open using the handle or the lifting lugs.

A.4.2.2.3 The following is how to undertake mechanical cleaning.

a) Place the unit in horizontal position.

b) Clean the channels, one by one, with high-pressure water [circa 80 000 kPa to 100 000 kPa (11 000 psi to 14 000 psi)].

c) Use a nozzle with a rotating head or a concentrated jet (e.g. hydroblast gun or cleaning bar).

d) Use hot water [circa 50 °C to 60 °C (120 °F to 140 °F)] for enhanced efficiency.

e) Verify the result, either visually or by inserting a bar in the channel.

Annex B
(informative)

Spiral plate heat exchanger checklist

This checklist (Table B.1) is used to record the specific requirements the purchaser makes in response to the clauses and subclauses in this International Standard alongside which bullets (●) are used to indicate that more information is required or it is necessary to make a decision.

Completion of the checklist is the responsibility of the purchaser.

Table B.1 — Checklist for spiral plate heat exchangers

Subclause No.	Requirement	Item		
4.1	Pressure design code to use	Define code requirements		
4.2	Applicable local regulations	Provide regulations		
4.6	Specify if the unit subject to sour service	Yes		No
6.2.3	Supply welding information	For review	For record	Not required
6.2.5.a)	Supply mechanical design calculations for all pressure-retaining components	For review	For record	Not required
6.2.5.b)	Supply mechanical calculations for deflection of the end covers	For review	For record	Not required
6.2.5.c)	Supply design calculations based on seismic, wind, transportation and/or piping loads	For review	For record	Not required
6.2.5.d)	Supply proposed procedures for assembly of flanged joints	For review	For record	Not required
6.2.5.e)	Supply design calculations for loads imposed on nozzles of heat exchangers attached to a vertical vessel	For review	For record	Not required
6.2.6	Supply design calculations for supports or lifting devices	Yes		No
6.3	Format and quantities for the listed documents			
7.1.1	Specify if hot or cold side is subject to cyclic service, fluid characteristics requiring special considerations (e.g. slurry, entrained particulates, other types of fouling mechanisms), temperature and/or pressure fluctuations	Provide detailed information		
7.1.4	Specify if internal mechanical cleaning or jetting is required	Yes		No
7.2.1	Specify design temperature and MDMT for each side	Provide design temperature and MDMT		
7.4	Specify percentage fouling margin to use	Provide fouling margin		
7.5.1	Specify corrosion allowance for each side	Provide corrosion allowance		
7.6.4.5	Specify if bolt-tensioning or torquing devices will be used	Provide type of equipment or bolt spacing requirements		
7.6.5.2	Specify if hinges, davits or other handling devices will be used	Provide end cover handling devices required including types		
7.6.6.8	Specify insulation thickness	Provide insulation requirements		
8.2.3	Maximum allowable carbon equivalent and restrictions on other residual elements and micro-alloying elements	Agree and/or specify		
9.1.3	Specify if nozzles shall be set-on or set-in for nozzles welded to end covers	Set-on		Set-in
9.1.4	Specify if weld procedure qualifications shall include a micro-hardness survey for carbon steel in sour or wet hydrogen sulfide service	Yes		No
9.2.3	Specify if post-weld heat treatment is required for weld-overlaid components	Yes		No
10.1	Specify if quality control system information and quality plan required	Yes		No
10.3.5	Specify additional drying and preservation methods requirements	Define additional requirements for drying and preservation of dry conditions		
11.1.7	Specify requirements for surface preparation and painting	Define surface preparation and protection requirements		
11.1.9	Specify if inert gas purge and fill is required	Yes		No

Annex C
(informative)

Spiral plate heat exchanger data sheets

The following data sheets are provided to assist the designer, vendor and purchaser to specify the data necessary for the design of a spiral plate heat exchanger for petroleum, petrochemical and natural gas services.

Completion of the data sheets is a joint responsibility of the purchaser and the vendor. The purchaser (owner or contractor) is responsible for the process data, which define the purchaser's explicit requirements.

After the exchanger has been fabricated, the vendor should complete the data sheets to make a permanent record that accurately describes the equipment "as-built".

Additional data sheets can be required to define the spiral heat exchanger and the following examples have been included:

— additional process information (see Figures C.1 and C.2, page 3): One or two pages can be necessary if boiling and/or condensing fluids with ranges of physical properties occur;

— additional cyclic service design data (see Figures C.1 and C.2, page 4).

SPIRAL PLATE HEAT EXCHANGER

DATA SHEET (SI UNITS)

Job no. ____ Item No. ____
Page 1 of 4 By ____
Date ____ Revision ____
Proposal No. ____ Contract No. ____
Inquiry No. ____ Order Number ____

Manufacturer		Heat Exchanged, kW	1
Model No.		Surface area per item, m²	2
Customer		MTD, Eff., °C	3
Plant Location		Transfer rate, W/m²-K	4
Service		Number items Parallel / Series	5

Basic design data

Pressure design code		Structural code	6
Code stamped ☐ Yes ☐ No		Flammable service ☐ Yes ☐ No	7
Other specifications		Cyclic service ☐ Yes ☐ No	8
		Fouling margin, %	9

Performance data - Hot side

		IN	OUT	
Fluid name		Temperature, °C		10 / 11
Total fluid entering, kg/h		Total flow rate (liq./vap.), kg/h	/	/ 12
Dew /bubble point, °C /		Water/steam, kg/h	/	/ 13
☐ Pour point ☐ Freeze point, °C		Noncondensables, kg/h	/	/ 14
Latent heat, kJ/kg		Relative molecular mass, (vap./non-cond.)	/	/ 15
Inlet pressure ☐ kPa (ga) ☐ kPa(abs)		Nozzle velocity, m/s		16
Pressure drop (allow./calc.), kP /		Velocity between plates, m/s		17
Max velocity (allow./calc.), m/s /		Maximum velocity entrance area, m/s		18
Strear Rate, s^{-1}				19

Performance data - Cold side

		IN	OUT	
Fluid name		Temperature, °C		20 / 21
Total fluid entering, kg/h		Total flow rate (liq./vap.), kg/h	/	/ 22
Dew /bubble point, °C /		Water/steam, kg/h	/	/ 23
☐ Pour point ☐ Freeze point, °C		Noncondensables, kg/h	/	/ 24
Latent heat, kJ/kg		Relative molecular mass, (vap./non-cond.)	/	/ 25
Inlet pressure ☐ kPa (ga) ☐ kPa(abs)		Nozzle velocity, m/s		26
Pressure drop (allow./calc.), kP /		Velocity between plates, m/s		27
Max velocity (allow./calc.), m/s /		Maximum velocity entrance area, m/s		28
Strear Rate, s^{-1}				29

Design, materials and construction

	Hot Side	Cold Side	
Design pressure, kPa (ga)	/		30 / 31
Test pressure, kPa (ga)	/		32
Design temperature, °C	/		33
Min. design metal temperature, °C	/		34
Vacuum design pressure, kPa (abs)	/		35
Vacuum design temperature, °C	/		36
MAWP, kPa (ga)	/		37
Corrosion allowance, mm	/		38

Coil

Cylinder Outside diameter, mm		39
Plate thickness, mm		40
Cylinder width, mm		41
Cylinder length, mm		42
Distance between plates, mm		43
Stud Arrangement		44
Stud diameter, mm		45
Mechanical Cleaning required Yes ☐ No ☐		46

Nozzle list

Nozzle ID	Number	Size DN	Service	Flange Rating PN	Type	
N1						47
N2						48
N3						49
N4						50
N5						51
N6						52
N7						53
N8						54
						55
						56

Mass of Unit:

Empty, kg	57
Normal Operating, kg	58
Filled with water, kg	59
Lifting, kg	60
Covers, kg	61

Rev. No.	Revision	Date	Prepared by	Reviewed by

Figure C.1 — Spiral plate heat exchanger data sheet — SI units

SPIRAL PLATE HEAT EXCHANGER DATA SHEET (SI UNITS)				
	Job no.		Item No.	
	Page	2 of 4	By	
	Date		Revision	
	Proposal No.		Contract No.	
	Inquiry No.		Order Number	

Design, materials and construction (continued)

Component	Material	Specification	
			1
Shell			2
Spiral Strip			3
Studs			4
Covers			5
Cover liner			6
Nozzles			7
Nozzle flanges			8
Stud bolts			9
Nuts			10
Supports			11
Name plate & fasteners			12
Gaskets			13
			14
			15
			16
			17
			18
			19

Fabrication, Inspection and Testing

				20
Helium Leak Test required	Yes ☐	No ☐	Surface Preparation	21
Post Weld Heat Treatment required	Yes ☐	No ☐	Painting	22
Production Test required	Yes ☐	No ☐	Insulation	23
	Yes ☐	No ☐		24
NDE requirements				25
				26
				27

Notes

1	28
2	29
3	30
4	31
5	32
	33
	34
	35
	36
	37
	38
	39
	40
	41
	42
	43
	44
	45

Rev. No.	Revision	Date	Prepared by	Reviewed by

Figure C.1 (*continued*)

SPIRAL PLATE HEAT EXCHANGER

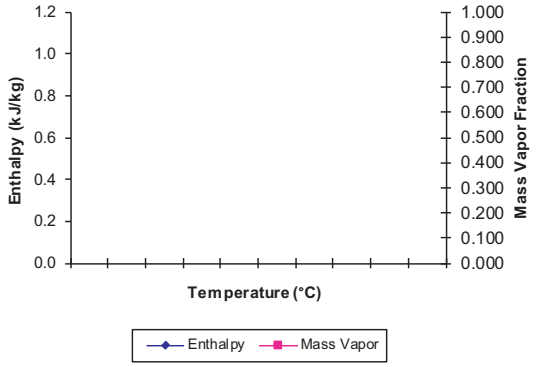
DATA SHEET (SI UNITS)

Job no.		Item No.	
Page	3 of 4	By	
Date		Revision	
Proposal No.		Contract No.	
Inquiry No.		Order Number	

Fluid Name: Reference Pressure 1: kPa (abs)

Pressure kPa (abs)	Temp. °C	Enthalpy kJ/kg	Mass Vapor Fraction

Heat Release Curve

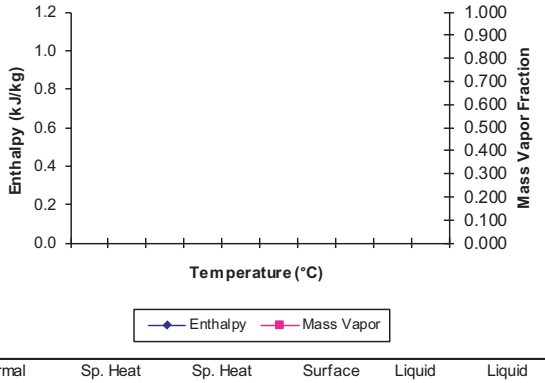


Density Vapor kg/m³	Density Liquid kg/m³	Viscosity Vapor mPa-s	Viscosity Liquid mPa-s	Thermal Cond. Vap. W/m-K	Thermal Cond. Liq. W/m-K	Sp. Heat Vapor kJ/kg-K	Sp. Heat Liquid kJ/kg-K	Surface Tension dyne/cm	Liquid Crit. Press. kPa (abs)	Liquid Crit. Temp. °C

Fluid Name: Reference Pressure 1: kPa (abs)

Pressure kPa (abs)	Temp. °C	Enthalpy kJ/kg	Mass Vapor Fraction

Heat Release Curve



Density Vapor kg/m³	Density Liquid kg/m³	Viscosity Vapor mPa-s	Viscosity Liquid mPa-s	Thermal Cond. Vap. W/m-K	Thermal Cond. Liq. W/m-K	Sp. Heat Vapor kJ/kg-K	Sp. Heat Liquid kJ/kg-K	Surface Tension dyne/cm	Liquid Crit. Press. kPa (abs)	Liquid Crit. Temp. °C

Rev. No.	Revision	Date	Prepared by	Reviewed by

Figure C.1 (*continued*)

SPIRAL PLATE HEAT EXCHANGER

DATA SHEET (SI UNITS)

Job no.		Item No.	
Page	4 of 4	By	
Date		Revision	
Proposal No.		Contract No.	
Inquiry No.		Order Number	

Description of Cyclic Service Operation

Condition	Time (h/m)	Duration (h/m)	**Composition**	**Flow Rate** (kg/h)
Initial	0.0			

Condition	Time (h/m)	Duration (h/m)	**Temperature** (°C)	**Pressure** (kPa(g))
Initial	0.0			

NOTES:

Rev. No.	Revision	Date	Prepared by	Reviewed by

Figure C.1 (*continued*)

SPIRAL PLATE HEAT EXCHANGER

DATA SHEET (US CUSTOMARY UNITS)

Job no. ____ Item No. ____
Page 1 of 4 By ____
Date ____ Revision ____
Proposal No. ____ Contract No. ____
Inquiry No. ____ Order Number ____

Manufacturer		Heat Exchanged, 10^6 Btu/h	1
Model No.		Surface area per item, ft²	2
Customer		MTD, Eff., °F	3
Plant Location		Transfer rate, Btu/h-ft²-°F	4
Service		Number items Parallel / Series	5

Basic design data

Pressure design code		Structural code	6
Code stamped ☐ Yes ☐ No		Flammable service ☐ Yes ☐ No	7
Other specifications		Cyclic service ☐ Yes ☐ No	8
		Fouling margin, %	9

Performance data - Hot side

		IN / OUT	10
Fluid name		Temperature, °F	11
Total fluid entering, lb/h		Total flow rate (liq./vap.), lb/h	12
Dew /bubble point, °F	/	Water/steam, lb/h	13
☐ Pour point ☐ Freeze point, °F		Noncondensables, lb/h	14
Latent heat, Btu/lb		Relative molecular mass, (vap./non-cond.)	15
Inlet pressure ☐ psig ☐ psia		Nozzle velocity, ft/s	16
Pressure drop (allow./calc.), ps	/	Velocity between plates, ft/s	17
Max velocity (allow./calc.), ft/s	/	Maximum velocity entrance area, ft/s	18
Strear Rate, s^{-1}			19

Performance data - Cold side

		IN / OUT	20
Fluid name		Temperature, °F	21
Total fluid entering, lb/h		Total flow rate (liq./vap.), lb/h	22
Dew /bubble point, °F	/	Water/steam, lb/h	23
☐ Pour point ☐ Freeze point, °F		Noncondensables, lb/h	24
Latent heat, Btu/lb		Relative molecular mass, (vap./non-cond.)	25
Inlet pressure ☐ psig ☐ psia		Nozzle velocity, ft/s	26
Pressure drop (allow./calc.), ps	/	Velocity between plates, ft/s	27
Max velocity (allow./calc.), ft/s	/	Maximum velocity entrance area, ft/s	28
Strear Rate, s^{-1}			29

Design, materials and construction

	Hot Side / Cold Side
Design pressure, psig	/
Test pressure, psig	/
Design temperature, °F	/
Min. design metal temperature, °F	/
Vacuum design pressure, psia	/
Vacuum design temperature, °F	/
MAWP, psig	/
Corrosion allowance, inch	/

Coil

Cylinder Outside diameter, inch	
Plate thickness, inch	
Cylinder width, inch	
Cylinder length, inch	
Distance between plates, inch	
Stud Arrangement	
Stud diameter, inch	
Mechanical Cleaning required Yes ☐ No ☐	

Nozzle list 30

Nozzle ID	Number	Size NPS	Service	Flange Rating Class	Type	
N1						33
N2						34
N3						35
N4						36
N5						37
N6						38
N7						39
N8						40
						41
						42

Mass of Unit: 44

Empty, lb	45
Normal Operating, lb	46
Filled with water, lb	47
Lifting, lb	48
Covers, lb	49

Rev. No.	Revision	Date	Prepared by	Reviewed by

Figure C.2 — Spiral plate heat exchanger data sheet — USC units

SPIRAL PLATE HEAT EXCHANGER DATA SHEET (US CUSTOMARY UNITS)				
	Job no.		Item No.	
	Page	2 of 4	By	
	Date		Revision	
	Proposal No.		Contract No.	
	Inquiry No.		Order Number	

Design, materials and construction (continued)

Component	Material	Specification	
			1
Shell			2
Spiral Strip			3
Studs			4
Covers			5
Cover liner			6
Nozzles			7
Nozzle flanges			8
Stud bolts			9
Nuts			10
Supports			11
Name plate & fasteners			12
Gaskets			13
			14
			15
			16
			17
			18
			19

Fabrication, Inspection and Testing

					20
Helium Leak Test required	Yes ☐	No ☐	Surface Preparation		21
Post Weld Heat Treatment required	Yes ☐	No ☐	Painting		22
Production Test required	Yes ☐	No ☐	Insulation		23
	Yes ☐	No ☐			24
NDE requirements					25
					26
					27

Notes

1		28
2		29
3		30
4		31
5		32
		33
		34
		35
		36
		37
		38
		39
		40
		41
		42
		43
		44
		45

Rev. No.	Revision	Date	Prepared by	Reviewed by

Figure C.2 (*continued*)

SPIRAL PLATE HEAT EXCHANGER

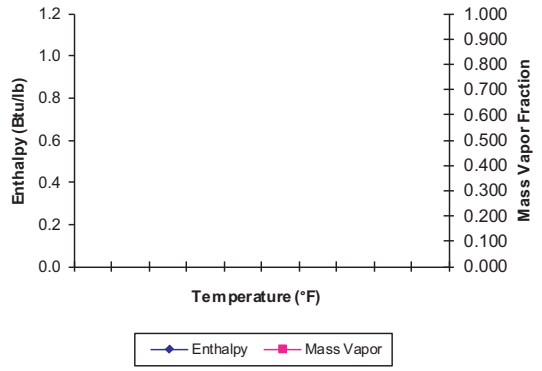
DATA SHEET (US CUSTOMARY UNITS)

Job no.		Item No.	
Page	3 of 4	By	
Date		Revision	
Proposal No.		Contract No.	
Inquiry No.		Order Number	

Fluid Name: Reference Pressure 1: psia

Pressure psia	Temp. °F	Enthalpy Btu/lb	Mass Vapor Fraction

Heat Release Curve

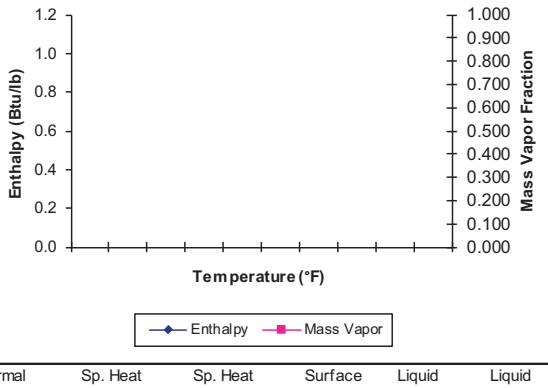


Density Vapor lb/ft³	Density Liquid lb/ft³	Viscosity Vapor cP	Viscosity Liquid cP	Thermal Cond. Vap. Btu/h-ft-°F	Thermal Cond. Liq. Btu/h-ft-°F	Sp. Heat Vapor Btu/lb-°F	Sp. Heat Liquid Btu/lb-°F	Surface Tension dyne/cm	Liquid Crit. Press. psia	Liquid Crit. Temp. °F

Fluid Name: Reference Pressure 1: psia

Pressure psia	Temp. °F	Enthalpy Btu/lb	Mass Vapor Fraction

Heat Release Curve



Density Vapor lb/ft³	Density Liquid lb/ft³	Viscosity Vapor cP	Viscosity Liquid cP	Thermal Cond. Vap. Btu/h-ft-°F	Thermal Cond. Liq. Btu/h-ft-°F	Sp. Heat Vapor Btu/lb-°F	Sp. Heat Liquid Btu/lb-°F	Surface Tension dyne/cm	Liquid Crit. Press. psia	Liquid Crit. Temp. °F

Rev. No.	Revision	Date	Prepared by	Reviewed by

Figure C.2 (*continued*)

SPIRAL PLATE HEAT EXCHANGER

DATA SHEET (US CUSTOMARY UNITS)

Job no.		Item No.	
Page	4 of 4	By	
Date		Revision	
Proposal No.		Contract No.	
Inquiry No.		Order Number	

Description of Cyclic Service Operation

Condition	Time (h/m)	Duration (h/m)
Initial	0.0	

Composition	**Flow Rate** (lb/h)

Condition	Time (h/m)	Duration (h/m)
Initial	0.0	

Temperature (°F)	**Pressure** (psig)

NOTES:

Rev. No.	Revision	Date	Prepared by	Reviewed by

Figure C.2 (*continued*)

Bibliography

[1] EN 13445[2] (all parts), *Unfired pressure vessels*

[2] ASME Boiler and Pressure Vessel Code (BPVC), Section VIII Div. 1[3], *Rules for construction of pressure vessels,* Division 1

[3] ASME Boiler and Pressure Vessel Code (BPVC), Section VIII Div. 2, *Section VIII, Rules for construction of pressure vessels*, Division 2, *Alternative Rules*

[4] ASME B16.11, *Forged Fittings, Socket-Welding and Threaded*

[5] ASME B1.20.1, *Pipe Threads, General Purpose (Inch)*

[6] API RP 571-11, *Damage Mechanisms Affecting Fixed Equipment in the Refining Industry*

[7] NACE MR0175, *Petroleum and Natural Gas Industries — Materials for Use in H_2S-containing Environments in Oil and Gas Production — Parts 1, 2 and 3*

2) Comité Européen de Normalization, 36, rue de Stassart, B-1050 Brussels, Belgium.

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

ICS 27.060.30; 75.180.20
Price based on 37 pages