Plate Heat Exchangers for General Refinery Services

Part 1—Plate-and-Frame Heat Exchangers

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Contents

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.

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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 15547-1 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 6, *Processing equipment and systems*.

This first edition of ISO 15547-1, together with ISO 15547-2, cancels and replaces ISO 15547:2000, of which it constitutes a technical revision.

ISO 15547 consists of the following parts, under the general title *Petroleum, petrochemical and natural gas industries — Plate-type heat exchangers*:

— *Part 1: Plate-and-frame heat exchangers*

— *Part 2: Brazed aluminium plate-fin heat exchangers*

Introduction

Users of this part of ISO 15547 should be aware that further or differing requirements may be needed for individual applications. This part of ISO 15547 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 an innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this part of ISO 15547 and provide details.

This part of ISO 15547 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 part of ISO 15547, where practical, US Customary units are included in parentheses for information.

Petroleum, petrochemical and natural gas industries — Plate-type heat exchangers —

Part 1: Plate-and-frame heat exchangers

1 Scope

This part of ISO 15547 gives requirements and recommendations for the mechanical design, materials selection, fabrication, inspection, testing, and preparation for shipment of plate-and-frame heat exchangers for use in petroleum, petrochemical and natural gas industries. It is applicable to gasketed, semi-welded and welded plate-and-frame heat exchangers.

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 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*

3 Terms and definitions

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

3.1
drip tray
tray that is able to collect droplets from an entire heat exchanger plate pack

3.2
end plate
plate which prevent the fluids in a plate-and-frame heat exchanger from contacting the fixed and removable covers

NOTE There are two end plates, one at each end of the plate-and-frame heat exchanger.

3.3
frame
assembly that provides the structural support and pressure containment of a plate-and-frame heat exchanger

3.4
welded plate pack
plate pack where the gaskets have been replaced by welds

3.5
heat transfer area
sum of the surface areas of one side of all plates in contact with both heat-transfer fluids

NOTE Areas of end plates are not included.

3.6
item number
purchaser's identification number for a plate-and-frame heat exchanger

3.7
minimum design metal temperature
lowest metal temperature at which pressure-containing elements can be subjected to design pressure

EXAMPLE Ambient temperature, process fluid temperature.

3.8
pass plate
plate used to change the direction of flow of a stream in a plate-and-frame heat exchanger with two or more passes

3.9
plate
sheet of material precision-pressed or -formed into a corrugated pattern

3.10
plate chevron angle
angle formed between the corrugated plate pattern and the horizontal

3.11
plate-and-frame heat exchanger
assembly of a gasketed, semi-welded or welded plate pack and its supporting frame

See Figure 1.

3.12
plate gap
b
height to the underside of a corrugation of a plate

See Figure 2.

3.13
plate pack
grouping of all plates contained within a frame

3.14
port
inlet or outlet opening in the plate

3.15
pressure design code
recognized pressure vessel standard specified or agreed by the purchaser

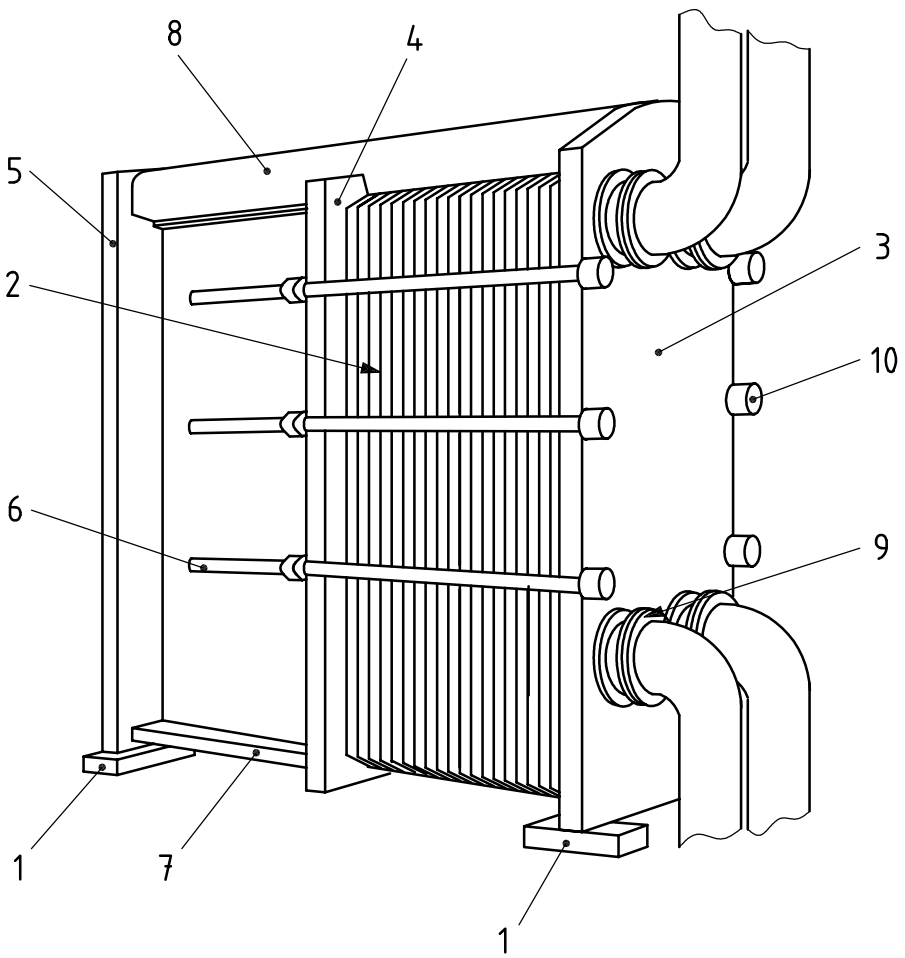
EXAMPLE ASME Section VIII, EN 13445.

3.16
semi-welded plate pair
two adjacent plates welded together where the weld replaces the function of a gasket

NOTE Gaskets are used to seal adjacent semi-welded plate pairs

3.17
shroud
removable covering for the top and sides of the plate pack of the plate-and-frame heat exchanger, which provides protection in the event of a spray leak or fire

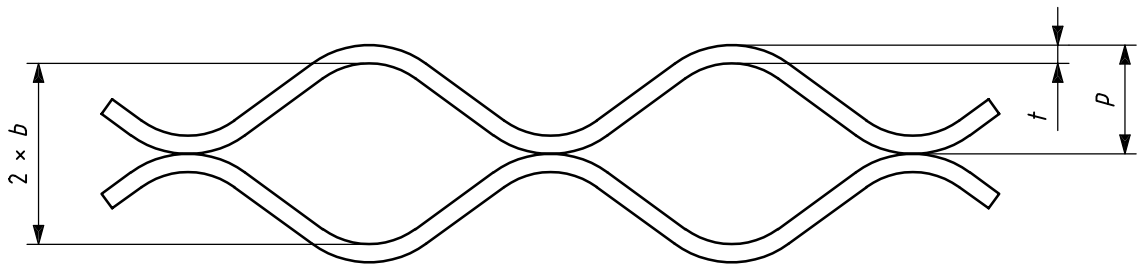
3.18
structural welding code
recognized structural welding code specified or agreed by the purchaser



Key

1	mounting feet	6	tie bolts
2	plate pack	7	guide bar (bottom)
3	fixed cover	8	carrying bar (top)
4	movable cover	9	connections, studded or flanged
5	support column	10	tie nuts

Figure 1 — Typical single-pass plate-and-frame heat exchanger



$b = p - t$

Key

b plate gap
t plate thickness
p compressed pitch per plate

Figure 2 — Plate gap

4 General

- **4.1** The pressure design code shall be specified or agreed by the purchaser. Pressure components (i.e. covers, tie bolts, tie nuts and connections) shall comply with the pressure design code and the supplemental requirements in this part of ISO 15547.

The structural welding code shall be specified or agreed by the purchaser.

Annex A provides some recommended mechanical and design details for information. Annex A also includes some precautions for consideration when specifying fouling margin, fireproof shrouds and plate gaskets.

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

5 Proposal information required

5.1 The vendor shall complete all information requested on the data sheet. Annex C provides suitable formats.

5.2 For components whose terms and definitions are not fully identified by Clause 3, the vendor shall describe the details of construction and assembly.

5.3 The vendor shall include a detailed description of any exception to the specified requirements.

5.4 The first-time use of a plate-and-frame heat exchanger design, component or material by the vendor for the purchaser's intended service shall be clearly indicated by the vendor.

5.5 The vendor shall state the anticipated life of the proposed gaskets in the specified service and in storage. Special requirements for gasket storage to maintain gasket shelf-life shall be specified.

5.6 The vendor shall state the method of support used for the movable cover.

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

5.8 If a fireproof shroud is specified, the plate-and-frame heat exchanger vendor shall submit proof that the proposed design has passed suitable type testing.

6 Drawings and other data requirements

6.1 Drawings

6.1.1 The vendor shall submit general arrangement drawings for each plate-and-frame heat exchanger for review. The drawings shall include the following information:

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

b) design pressure, test pressure, maximum design temperature, minimum design metal temperature and any restrictions regarding testing or operation of the plate-and-frame heat exchanger;

c) dimensions and location of supports;

d) overall exchanger dimensions;

e) maximum and minimum compressed plate pack length;

f) side clearance required for plate removal;

g) mass of the plate-and-frame heat exchanger, both empty and full of water;

h) centre of gravity of the exchanger for empty and operating conditions;

i) corrosion allowance;

j) material specifications for all components;

k) allowable forces and moments on connections;

l) size, flange rating and facing, location, orientation, and flow identification of all connections;

m) applicable design codes;

n) number of plates installed and maximum number of plates for specified frame;

o) gasket materials and attachment method (e.g. glued, clip-on, etc.).

6.1.2 The vendor shall recommend the tools needed for the assembly and maintenance of the plate-and-frame heat exchanger. If torquing of bolts is required, the vendor shall provide torquing procedures.

6.1.3 The review of general configuration drawings by the purchaser shall not relieve the vendor of the responsibility of meeting the requirements of the purchase order.

6.1.4 After receipt of the purchaser's general arrangement drawing review comments, the vendor shall furnish the certified general configuration drawings and the detail drawings.

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

- **6.1.6** If specified by the purchaser, the vendor shall furnish copies of applicable calculations for review or record.

6.2 Final records

6.2.1 The vendor shall furnish the purchaser with a user's manual, which shall contain the following:

a) technical description;

b) assembly instructions;

c) operating instructions;

d) installation and maintenance instructions (including lifting and handling);

e) spare parts list;

f) data sheets and drawings (as-built).

6.2.2 The vendor shall retain, for at least five years, records which confirm compliance of the material and fabrication with the requirements of this part of ISO 15547.

7 Design

7.1 General

7.1.1 The frame and tie bolts of the gasketed or semi-welded plate-and-frame heat exchanger shall be designed to permit the future installation of at least 20 % additional plates.

7.1.2 Gasketed plates shall be replaceable individually, and semi-welded plates in pairs, without having to remove any other plate.

7.1.3 The plate pack shall incorporate means for positive alignment of the plates and gaskets.

7.2 Design temperatures

- **7.2.1** The purchaser shall specify a maximum design temperature and a minimum design metal temperature.

7.2.2 The design temperatures shall be used for the design of all pressure-retaining components.

7.3 Design pressure

Unless otherwise specified or approved by the purchaser, the plate-and-frame 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, calculated by

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

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

7.5 Corrosion allowance

7.5.1 Corrosion allowance, if specified, shall apply to unlined connections only.

7.5.2 The corrosion allowance for plate material shall be zero.

7.6 Components

7.6.1 Plates shall conform to the following:

a) the nominal thickness of gasketed plates before being pressed shall be sufficient to meet design conditions but shall not be less than 0,5 mm (0,02 in);

b) the plates shall be fully supported by the carrying bar;

c) the plates shall be designed to meet the design conditions without the need of additional stiffeners attached to the plate, unless otherwise approved by the purchaser;

d) the thickness of pass plates shall be sufficient to withstand the total stream pressure drop across the port area;

e) the wetted surfaces of supports for pass plates shall be of the same material as the plates;

f) all gasketed and semi-welded plates shall have permanently stamped identification for proper assembly;

g) end plates shall be furnished at the fixed and movable covers.

7.6.2 Fixed and movable covers shall conform to the following:

a) Covers designed with the use of stiffeners shall require approval of the purchaser;

b) Covers shall be furnished with slotted holes for tie bolts. The design shall mechanically restrain the tie bolts or nuts from turning.

7.6.3 Tie bolts and nuts for gasketed and semi-welded plate packs shall conform to the following:

a) the nominal diameter of tie bolts shall be at least 16 mm (5/8 in);

b) each tie bolt shall have one captive nut and at least one running nut. The length of each nut shall be greater than or equal to that of a heavy hexagonal type;

c) hardened steel washers shall be provided under all rotating nuts;

d) each tie bolt shall be supplied greased and with a plastic sleeve to protect it from the environment.

7.6.4 The carrying bar for gasketed and semi-welded plate-and-frame heat exchangers shall conform to the following:

a) the bearing surface shall permit easy sliding of the plates and movable cover along the entire length of the carrying bar;

b) the carrying bar shall be designed to support at least 1,5 times the total mass of the movable cover and plate pack with the maximum number of plates filled with water (or the process fluid if its density is greater than that of water).

7.6.5 Gasketed and semi-welded plate-and-frame heat exchangers shall have a support column with a mounting foot located at the movable cover end. A minimum of two mounting feet shall be provided at the fixed cover. The vendor shall design the supports for the external loads specified in the equipment data sheet

- **7.6.6** If specified by the purchaser, the vendor shall provide details of the reaction at the support points.

- **7.6.7** If specified by the purchaser, plate-and-frame heat exchangers shall be equipped with a shroud to protect against spray leaks.

- **7.6.8** If specified by the purchaser, a suitable fire protection shroud shall be provided. The level of protection shall be specified by the purchaser. For further information see A.6.

- **7.6.9** If specified by the purchaser, plate-and-frame heat exchangers shall be equipped with a drip tray.

7.6.10 All units shall have two earthing lugs, one connected at each end of the frame.

7.7 Connections

7.7.1 Connections shall be bolted and shall be of either studded or flanged design. For flanged design, the connection shall be welded to the cover.

7.7.2 The use of studded and/or flanged connections and facings shall be specified on the data sheet.

7.7.3 Drilled and tapped holes for studded connection bolts shall not pass completely through the cover plate. The hole shall be threaded for a minimum length of one times the stud diameter and the minimum undrilled thickness remaining in the cover shall be no less than one-fourth of its thickness.

7.7.4 The plate-and-frame heat exchanger shall be self-draining and self-venting through the connections for all pass arrangements.

7.7.5 For alloy-lined connections, the minimum thickness of the lining shall not be less than the plate thickness.

7.7.6 The projection of flanged connections shall be of sufficient length to allow installation and removal of the flange bolts from either side of the flange.

7.7.7 All bolt holes for flanged or studded connections shall straddle centrelines.

7.7.8 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.

- **7.7.9** For alloy nozzles, the purchaser shall define requirements for either solid or lined connections, including any connections fitted into the nozzle necks.

7.7.10 Connections shall be designed to withstand suitable forces (F) and moments (M) induced by the piping. Tables 1 and 2 indicate a suitable initial estimate of primary loadings for connections either in standard or severe service. Unless otherwise specified by the purchaser, standard nozzle loadings as shown in Table 1 shall be used. Directions of forces and moments shall be as shown in Figure 3.

Table 1 — Standard-service nozzle loading

Nom. size		PN 20 (ASME rating 150)				PN 50 (ASME rating 300)				PN 110 (ASME rating 600)			
		F		M		F		M		F		M	
DN	(NPS)	N	(lbf)	N·m	(lbf·ft)	N	(lbf)	N·m	(lbf·ft)	N	(lbf)	N·m	(lbf·ft)
25	(1)	90	(20)	0	(0)	119	(27)	1	(1)	167	(37)	2	(2)
40	(1,5)	159	(36)	37	(27)	209	(47)	40	(29)	293	(66)	44	(32)
50	(2)	208	(47)	76	(56)	273	(61)	80	(59)	383	(86)	88	(65)
80	(3)	365	(82)	230	(169)	480	(108)	246	(181)	673	(151)	274	(202)
100	(4)	477	(107)	358	(264)	628	(141)	388	(286)	879	(198)	438	(323)
150	(6)	776	(175)	750	(553)	1 022	(230)	840	(620)	1 430	(322)	990	(730)
200	(8)	1 096	(246)	1 236	(911)	1 443	(324)	1 431	(1 056)	2 020	(454)	1 758	(1 297)
250	(10)	1 433	(322)	1 809	(1 335)	1 886	(424)	2 167	(1 598)	2 640	(593)	2 763	(2 038)
300	(12)	1 784	(401)	2 471	(1 822)	2 347	(528)	3 056	(2 254)	3 286	(739)	4 032	(2 974)
350	(14)	2 146	(482)	3 220	(2 375)	2 824	(635)	4 108	(3 030)	3 953	(889)	5 587	(4 121)
400	(16)	2 519	(566)	4 060	(2 995)	3 314	(745)	5 333	(3 933)	4 640	(1 043)	7 454	(5 498)
450	(18)	2 901	(652)	4 993	(3 683)	3 818	(858)	6 742	(4 973)	5 345	(1 202)	9 658	(7 123)
500	(20)	3 292	(740)	6 021	(4 441)	4 332	(974)	8 346	(6 156)	6 065	(1 363)	12 221	(9 014)

NOTE The data above are based on the following equations:

$$F = \frac{7,5 \cdot \mathrm{DN}^{1,2} + 0,1 \cdot \mathrm{PN} \cdot \mathrm{DN}^{1,2}}{5}$$

$$M = \frac{4(\mathrm{DN} - 25)^{1,4} + (2 \times 10^{-5})\mathrm{PN} \cdot \mathrm{DN}^{2,7}}{5}$$

where $F = F_x = F_y = F_z$; $M = M_x = M_y = M_z$

Table 2 — Severe-service nozzle loading

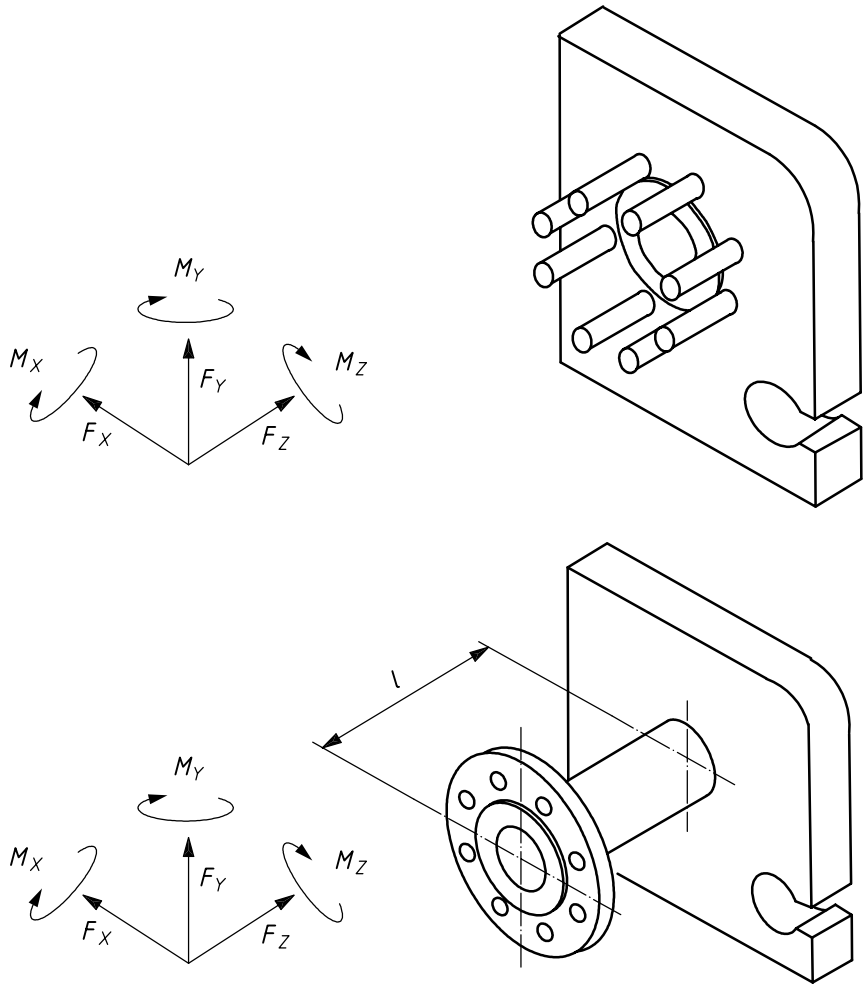
Nom. size		PN 20 (ASME rating 150)				PN 50 (ASME rating 300)				PN 110 (ASME rating 600)			
		F		M		F		M		F		M	
DN	(NPS)	N	(lbf)	N·m	(lbf·ft)	N	(lbf)	N·m	(lbf·ft)	N	(lbf)	N·m	(lbf·ft)
25	(1)	452	(102)	2	(2)	595	(134)	6	(4)	833	(187)	12	(9)
40	(1,5)	795	(179)	186	(137)	1 046	(235)	198	(146)	1 464	(329)	220	(162)
50	(2)	1 039	(234)	378	(279)	1 367	(307)	401	(296)	1 913	(430)	440	(324)
80	(3)	1 826	(410)	1 148	(847)	2 402	(540)	1 230	(907)	3 363	(756)	1 368	(1 009)
100	(4)	2 386	(536)	1 788	(1 318)	3 140	(706)	1 938	(1 430)	4 396	(988)	2 189	(1 615)
150	(6)	3 882	(873)	3 750	(2 766)	5 108	(1 148)	4 200	(3 098)	7 151	(1 608)	4 951	(3 651)
200	(8)	5 482	(1 232)	6 178	(4 556)	7 213	(1 622)	7 157	(5 279)	10 099	(2 270)	8 789	(6 483)
250	(10)	7 166	(1 611)	9 047	(6 673)	9 428	(2 120)	10 836	(7 992)	13 200	(2 967)	13 817	(10 191)
300	(12)	8 918	(2 005)	12 353	(9 111)	11 734	(2 638)	15 280	(11 270)	16 428	(3 693)	20 158	(14 868)
350	(14)	10 730	(2 412)	16 101	(11 876)	14 119	(3 174)	20 539	(15 149)	19 766	(4 444)	27 935	(20 604)
400	(16)	12 595	(2 831)	20 301	(14 973)	16 572	(3 726)	26 665	(19 667)	23 201	(5 216)	37 271	(27 490)
450	(18)	14 507	(3 261)	24 965	(18 413)	19 088	(4 291)	33 711	(24 864)	26 723	(6 008)	48 288	(35 616)
500	(20)	16 462	(3 701)	30 107	(22 206)	21 661	(4 870)	41 732	(30 780)	30 325	(6 817)	61 106	(45 069)

NOTE The data above are based on the following equations:

$$F = 7{,}5 \cdot \mathrm{DN}^{1{,}2} + 0{,}1 \cdot \mathrm{PN} \cdot \mathrm{DN}^{1{,}2}$$

$$M = 4\,(\mathrm{DN} - 25)^{1{,}4} + (2 \times 10^{-5})\,\mathrm{PN} \cdot \mathrm{DN}^{2{,}7}$$

where $F = F_x = F_y = F_z$; $M = M_x = M_y = M_z$



Key

F force
l length of connection
M moment

Figure 3 — Directions of forces on connections

7.8 Plate gaskets

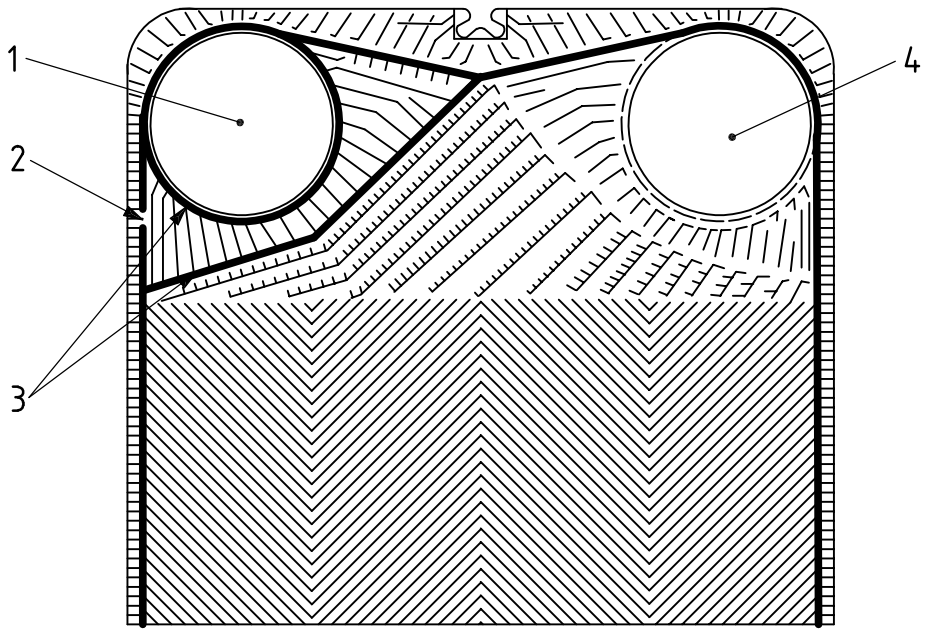
7.8.1 Gaskets shall be positioned in the grooves around the heat transfer surface and around the port holes of the plate as indicated in Figure 4. Gaskets shall be secured to the plate by glue or by mechanical means.

7.8.2 Gaskets shall be compressed to achieve metal contact between plates.

7.8.3 Each sealing gasket shall be one integral piece.

7.8.4 Through-flow port areas of the plates shall be double-gasketed and vented to the atmosphere such that cross-contamination of fluids cannot occur without readily detectable external evidence.

7.8.5 The vendor shall verify the compatibility of the gasket material and glue with the specified fluids, including any specified for chemical cleaning. For further information, see A.8.



Key

1 through-flow port
2 leakage vent
3 double gaskets
4 port hole

Figure 4 — Typical plate gasket

7.9 Handling devices

The plate-and-frame 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 plate-and-frame heat exchanger

8 Materials

8.1 All pressure-containing parts of carbon steel plate shall be manufactured from fully killed fine-grained steel unless otherwise approved by the purchaser.

8.2 Non-pressure-containing parts (such as lifting lugs, clips and supports) that are welded directly to pressure parts shall be weldable mild carbon steel or any steel permitted for pressure parts.

8.3 The plate-contact surface of the guide bar and carrying bar for gasketed and semi-welded plate-and-frame heat exchangers shall be stainless steel.

8.4 All nameplates shall be austenitic stainless steel.

9 Fabrication

9.1 Welding

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.

9.2 Plate gasket installation

9.2.1 Gasket plate surfaces shall be thoroughly cleaned and dried with solvent or detergent solution, before gasketing.

9.2.2 All gaskets shall be checked for adhesion and deformation after curing. All deformed or loose gaskets shall be replaced and cured again.

9.3 Surface finish

9.3.1 Surfaces to be painted shall be degreased and cleaned by wire brushing or a similar means to remove loose scale, dirt and other foreign materials.

9.3.2 Unless otherwise specified, carbon steel covers shall be blast-cleaned in accordance with ISO 8501-1, Grade Sa 2 1/2, and then coated with an inorganic zinc-rich primer to a dry-film thickness of at least 50 µm (0,002 in).

9.4 Assembly

Each component shall be clearly and permanently identified for proper assembly in accordance with the detailed assembly instructions.

10 Inspection and testing

10.1 Quality control

- **10.1.1** The vendor shall supply information on its quality control system and a quality control plan if specified by the purchaser.

- **10.1.2** Any requirement and extent of non-destructive testing of the heat transfer plates in addition to hydrostatic testing, such as a light box, liquid penetrant testing, helium leakage testing or equivalent, shall be specified by the purchaser.

- **10.1.3** Where set-on connections are used on covers fabricated from plate, the purchaser should specify the method of non-destructive testing to be used to detect laminations in the edge zone of the hole cut in the cover plate.

10.2 Hydrostatic testing

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

10.2.2 The hydrostatic test pressure shall be maintained for a sufficient time to permit a thorough inspection and detection of small seepage leaks, but not less than 30 min.

10.2.3 For each hydrostatic test, two indicating gauges (or one indicating gauge and one recording gauge) shall be attached to the plate-and-frame heat exchanger.

10.2.4 The water used for hydrotesting shall be potable.

10.2.5 The minimum water temperature for hydrostatic testing shall be 7 °C (45 °F)

10.2.6 The chloride content of the test water used for equipment with austenitic stainless steel materials that would 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 and cleared of residual test fluid.

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

10.3 Nameplates

10.3.1 A nameplate shall be permanently attached to the plate-and-frame heat exchanger.

10.3.2 Standard nameplate data shall include

a) vendor's name and plate-and-frame heat exchanger serial number,

b) purchaser's item number,

c) year built,

d) pressure design code and, if required, code stamping,

e) maximum design temperature and minimum design metal temperature,

f) maximum design pressure and, if applicable, vacuum,

g) hydrostatic test pressure, and

h) mass (empty).

11 Preparation for shipment

11.1 The plate-and-frame heat exchanger shall be cleaned and all openings sealed before shipment. Any specific requirements for drying will be specified by the purchaser.

11.2 Tie bolt threads shall be coated with an anti-seizing lubricant.

11.3 Exposed machined carbon steel surfaces, including threads extending beyond the nuts, shall be protected with an easily removable rust-preventive coating.

11.4 Exposed flanged connections shall be protected by either of the following:

a) gasketed steel covers fastened by the greater of

   — 50 % of the required flange bolting, or

   — four bolts;

b) commercially available plastic covers specifically designed for flange protection.

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 part of ISO 15547 but are prefixed by the letters RP.

A.2 Reports and records RP 6.2

In some cases it might 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 including plates;

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

g) hydrotest report/certificate or chart;

h) nameplate rubbings or photocopy;

i) third-party verification and certification.

A.3 Design — General RP 7.1

A.3.1 For cyclic service, the fatigue design should conform to ASME Section VIII Div. 2 or an equivalent code specified by the purchaser.

A.3.2 For services containing particles larger than 50 % of the nominal plate gap, strainers should be provided.

A.3.3 The vendor should specify the required clearance around the plate-and-frame heat exchanger for maintenance.

A.4 Design — Fouling margin RP 7.4

Conventional fouling-resistance values used with shell-and-tube heat exchangers should not be used in the thermal design of plate-and-frame heat exchangers. Actual fouling resistances, if known, should be given. In the absence of applicable data, a minimum of 10 % fouling margin should be included. For crude oil service this may need to be increased to 25 %. 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-stress provides a good indication of fouling tendency in a plate-and-frame heat exchanger. A minimum wall shear-stress of 50 Pa (0,007 psi) is recommended.

A.5 Design — Components RP 7.6.2

Single-pass plate-and-frame heat exchangers should have all connections located in the fixed cover in order to ease maintenance and allow the unit to have additional plates added.

If nozzles are located on the movable cover, the design should use piping spools which allow for the retraction of the movable cover for maintenance and future addition of new plates.

A.6 Design — Components RP 7.6.8

A.6.1 A fireproof shroud should

a) be readily removable and replaceable for maintenance,

b) provide convenient access for observation, and

c) be fitted with a suitable vent connection.

A.6.2 If a fireproof shroud is required, a satisfactory type test should conform to the following:

a) type-tested on a plate-and-frame heat exchanger which contains kerosene under pressure with no flow;

b) type-tested at a commercial size and possesses a minimum of 100 plates;

c) demonstrate by test the ability to limit the leakage to no more than 4 l/min (1 gpm) at design pressure or 1 000 kPa (ga) (150 psig) minimum, whilst exposed to a hydrocarbon-spill fire. The test duration should be at least 1 h. The fire should envelop the unit on all sides, with flame temperatures sustained above 760 °C (1 400 °F). Temperature readings at the plate pack should be taken for information.

A.7 Design — Connections RP 7.7.10

A.7.1 The nozzle loads from attached piping are seldom defined at the time of order placement for a plate-and-frame heat exchanger. In addition, the allowable nozzle loads for plate-and-frame heat exchangers are generally lower than the calculated loads for pipe or piping flanges. It is desirable in the design stage that the plate-and-frame heat exchanger vendor and piping designers work on agreed levels of nozzle loadings that can be taken by the plate-and-frame heat exchanger. When actual piping nozzle loads become available, these should be submitted to the vendor to confirm their acceptability.

A.7.2 Nozzle loads affect nozzle attachment design, size of the plate-and-frame heat exchanger's anchor bolts, and the design of the covers and carrier rails; consequently, excessive loads should not be specified. Plate-and-frame heat exchangers located in offshore structures or pre-assembled modules are usually required to withstand higher nozzle loadings than other facilities in which more flexible piping layouts are economical.

A.7.3 It is intended that the standard nozzle loads and moments given in this document be suitable for normal applications. The “severe” levels are intended where space is limited, such as in offshore structures or pre-assembled modules.

A.8 Design — Plate gaskets RP 7.8

A.8.1 The gasket should be selected for the process application and the vendor should provide details of the gasket material and operating limitations, including anticipated gasket life. The purchaser should inform the vendor of any operating, upset or maintenance conditions that could influence the selection of the gaskets.

A.8.2 For services where swelling of the gasket can be expected, e.g. hydrocarbon service, glued gaskets are preferred for maintenance considerations.

A.8.3 If the vendor lacks experience in the use of the proposed gaskets for an application, the gasket should be subjected to an immersion test to measure gasket swelling, hardness and susceptibility to chemical attack. The test should be conducted at the operating temperature with a piece of the specified gasket material with a maximum thickness of 8 mm (0,3 in). The minimum duration of the test is 15 days. The gasket hardness change should not exceed 15 IRHD (international rubber hardness degree) for fluoropolymers and 10 IRHD for others. The volume change should not be more than 15 %.

A.8.4 If the vendor lacks experience in the use of the proposed glue for an application, the glue should be subjected to an immersion test to measure the glue strength and susceptibility to chemical attack. The test should be conducted using a 100 mm (4 in) long piece of the specified gasket at the operating temperature for a duration of 15 days. Half [50 mm (2 in)] of the gasket should be glued to a surface which is equivalent to the gasket-groove surface of the proposed plate, i.e. a smooth surface should be used if the proposed plate's gasket-groove surface is smooth and a corrugated surface if the proposed plate's gasket-groove surface is corrugated. The final peel strength in newtons should be five times the gasket width in millimetres (or, in pounds force, 28 times the gasket width in inches).

A.9 Handling devices RP 7.9

Tools should be provided to facilitate efficient assembly and tensioning of the plate pack. These may consist of a pneumatic spanner with winch attached to the top carrying bar.

A.10 Nameplates RP 10.3.2

A.10.1 Any plate-and-frame heat exchanger that has a lining (e.g. in the nozzles) such as lead, rubber, glass, epoxy, etc. should have warnings printed on the outside of the unit saying “No welding permitted”.

Annex B
(informative)

Plate-and-frame heat exchanger checklist

Completion of the checklist is the responsibility of the purchaser.

This checklist is used for listing the purchaser's specific requirements for which the clauses or subclauses within this part of ISO 15547 include a choice or which designate, by use of a bullet (●) in the margin, that a decision is required.

Subclause	Requirement	Item	
4.1	Specify (or agree) pressure design code	Complete on data sheet	
4.1	Specify (or agree) structural welding code	Complete on data sheet	
4.2	Compliance with applicable local regulations	Complete on data sheet	
6.1.5	Welding procedure specifications and weld map furnished by vendor for review or record	Yes (clarify requirements)	No
6.1.6	Calculations to be furnished by vendor for review or record	Yes (clarify requirements)	No
7.2.1	Specify a maximum design temperature and a minimum design metal temperature	Complete on data sheet	
7.4	Specify fouling margin	Complete on data sheet	
7.6.6	Details of reaction at the support points to be furnished by vendor	Yes	No
7.6.7	Specify if shroud required to protect against spray leaks	Complete on data sheet	
7.6.8	Specify if a fire-protection shroud is required and, if so, level of protection required	Complete on data sheet	
7.6.9	Specify if drip tray required	Complete on data sheet	
7.7.9	For alloy nozzles requirements for solid or lined connections	Complete on data sheet	
10.1.1	Specify if information required on quality control system and if quality control plan required	Yes (clarify requirements)	No
10.1.2	Requirements and extent of non-destructive testing of the heat transfer plates	Complete on data sheet	
10.1.3	Requirements for non-destructive testing where set-on connections are used on covers fabricated from plate	Complete on data sheet	
10.2.7	Any additional requirements for equipment drying or preservation	Complete on data sheet	
11.1	Specific drying requirements	Complete on data sheet	

Annex C
(informative)

Plate-and-frame 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 plate-and-frame heat exchanger for petroleum 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".

Company	PLATE-AND-FRAME HEAT EXCHANGER DATA SHEET (SI UNITS) PROCESS	Engineering contractor
PO No.:	Doc. No.:	Page 1 of

Customer:	Vendor:
Project:	Order/enq. No.:
Location:	Model:
Item No.:	Serial No.:
Service:	

01 **CASE**		HOT SIDE		COLD SIDE	
02 Fluid					
03 Total flow	(kg/s)				
04 Flow per exchanger	(kg/s)				
05 Design temperature (max.)	(°C)				
06 Minimum design metal temp.	(°C)				
07 Design pressure	[kPa (ga)]				
08 Pressure drop allow./calc.-	(kPa)	/		/	
09 Wall temperature min./max.	(°C)	/		/	
10 Fouling margin [a]	(%)				
11 **OPERATING DATA**		INLET	OUTLET	INLET	OUTLET
12 Liquid flow	(kg/s)				
13 Vapour flow	(kg/s)				
14 Non-condensables flow	(kg/s)				
15 Operating temperature	(°C)				
16 Operating pressure	[kPa (ga)]				
17 **LIQUID PROPERTIES**					
18 Density	(kg/m^3)				
19 Specific heat capacity	(kJ/kg·K)				
20 Dynamic viscosity	(mPa·s)				
21 Thermal conductivity	(W/m·K)				
22 Surface tension	(N/m)				
23 **VAPOUR PROPERTIES**					
24 Density	(kg/m^3)				
25 Specific heat capacity	(kJ/kg·K)				
26 Dynamic viscosity	(mPa·s)				
27 Thermal conductivity	(W/m·K)				
28 Relative molecular mass	(kg/kmol)				
29 Relative molecular mass, non-condensables	(kg/kmol)				
30 Dew point/bubble point	(°C)				
31 Solids maximum size	(mm)				
32 Solids concentration (% volume)					
33 Latent heat	(kJ/kg)				
34 Critical pressure	[kPa (abs)]				
35 Critical temperature	(°C)				
36					
37 Total heat exchanged	(kW)				
38 U [a]	($W/m^2·K$)	Clean condition:		Service:	
39 LMTD	(°C)			/	
40 Heat transfer area	(m^2)				
41 Stream heat transfer coefficient	($W/m^2·K$)				

[a] Fouling margin = $[(U_{clean}/U_{service}) - 1] \times 100$ % where U = Overall heat transfer coefficient (thermal transmittance).

Rev. No.	Revision	Date	Prepared by	Reviewed by

Company	PLATE-AND-FRAME HEAT EXCHANGER DATA SHEET (SI UNITS) MECHANICAL	Engineering contractor
PO No.:	Doc. No.:	Page 2 of

01 CONFIGURATION FOR EXCHANGER AND PLATE DETAILS			
02 Number of exchangers in parallel		Heat transfer area/total (m^2)	
03 Number of exchangers in series		Heat transfer area per plate (m^2)	
04 Number of passes, hot side		Number of plates per exchangers	
05 Number of passes, cold side		Max. number of plates per exchangers	
06 Rel. directions of fluids	Cocurrent/countercurrent	Plate chevron angle(s)	
07 Nominal plate gap (mm)		Nominal plate thickness (mm)	

08 DESIGN DATA				
09 Pressure vessel code				
10 Material certificate type				
11 Code stamp	Yes ( )	No ( )		
12 Applicable specifications				
13 Local rules and regulations				
14 Local register of exchanger				
15	HOT SIDE		COLD SIDE	
16 Test pressure [kPa (ga)]				
17 MAWP [kPa (ga)]				
18 Velocity between plates (m/s)				
19 Wall shear stress (Pa)				
20 Volume liquid per exchanger (m^3)				
21 Length/width/height (mm)	/	/		
22 Mass empty/full of water (kg)	/			
23				
24 CONNECTIONS	IN	OUT	IN	OUT
25 Nozzle size (DN)				
26 Flange rating/type	/	/	/	/
27 COMPONENT	MATERIALS			
28 Exchanger type	Gasketed ( )	Semi-welded ( )	Welded ( )	
29 Plates				
30 Gasket fixing	Glued ( )	Not glued ( )		
31 Gaskets hot side/cold side	/			
32 Cover fixed/movable	/			
33 Tie bolts/nuts	/			
34 Connection design	Studded ( )	Flanged nozzle ( )		
35 Nozzle pipes/flanges				
36 Corrosion allow. on connections (mm)				
37 Stud bolts/nuts				
38 Shroud	None ( )	Spray ( )	Fire ( )	
39 Drip tray	Yes ( )	No ( )	By others ( )	
40 Painting specification	Mfg. std. ( )	Purchaser spec. ( )		
41 Insulation	Yes ( )	No ( )	By others ( )	
42				
43 LOADING				
44 Connection loads/moments	Standard ( )	Severe duty ( )	Purchaser spec. ( )	
45 Wind loading				
46 Explosion blast pressure				
47 Earthquake loading				
48 Transport loading at sea				
49				

50 TESTING AND INSPECTION		
51 Specific drying procedure	Yes ( )	No ( )
52 Dried by blowing air	Yes ( )	No ( )
53 Non-destructive testing in addition to the pressure design code		
54 Inspection required	Purchaser ( )	Third party ( )

Company	PLATE-AND-FRAME HEAT EXCHANGER DATA SHEET (SI UNITS) PROCESS	Engineering contractor
PO No.:	Doc. No.:	Page 3 of

PHYSICAL PROPERTIES (INCLUDING WATER IF PRESENT)											
CASE	Temperature (°C)										
	Pressure [kPa (abs)]										
	Heat released (kW)										
LIQUID PHASE	Mass fraction vapour										
	Mass fraction H_2O in liquid										
	Density (kg/m^3)										
	Specific heat capacity (kJ/kg·K)										
	Dynamic viscosity (mPa·s)										
	Thermal conductivity (W/m·K)										
	Surface tension (N/m)										
	Vapour pressure [kPa (abs)]										
VAPOUR PHASE	Density (kg/m^3)										
	Specific heat (kJ/kg·K)										
	Dynamic viscosity (mPa·s)										
	Thermal conductivity (W/m·K)										
	Vapour pressure [kPa (abs)]										
	Relative molecular mass (kg/kmol)										
	Latent heat (kJ/kg)										
	Critical pressure [kPa (abs)]										
	Critical temperature (°C)										

NOTES:

Rev. No.	Revision	Date	Prepared by	Reviewed by

Company	PLATE-AND-FRAME HEAT EXCHANGER DATA SHEET (US CUSTOMARY UNITS) PROCESS	Engineering contractor
PO No.:	Doc. No.:	Page 1 of

Customer:	Vendor:
Project:	Order/enq. No.:
Location:	Model:
Item No.:	Serial No.:
Service:	

01 CASE		HOT SIDE		COLD SIDE	
02 Fluid					
03 Total flow	(lb/h)				
04 Flow per exchanger	(lb/h)				
05 Design temperature (max.)	(°F)				
06 Minimum design metal temp.	(°F)				
07 Design pressure	(psig)				
08 Pressure drop allow./calc.	(psi)	/		/	
09 Wall temperature min./max.	(°F)	/		/	
10 Fouling margin [a]	(%)				
11 OPERATING DATA		INLET	OUTLET	INLET	OUTLET
12 Liquid flow	(lb/h)				
13 Vapour flow	(lb/h)				
14 Non condensables flow	(lb/h)				
15 Operating temperature	(°F)				
16 Operating pressure	(psig)				
17 LIQUID PROPERTIES					
18 Density	(lb/ft^3)				
19 Specific heat capacity	(BTU/lb °R)				
20 Dynamic viscosity	(cP)				
21 Thermal conductivity	(BTU/ft·h·°R)				
22 Surface tension	(Dynes/cm)				
23 VAPOUR PROPERTIES					
24 Density	(lb/ft^3)				
25 Specific heat capacity	(BTU/lb·°R)				
26 Dynamic viscosity	(cP)				
27 Thermal conductivity	(BTU/ft·h·°R)				
28 Relative molecular mass	(lb/lb·mol)				
29 Relative molecular mass, noncondensables	(lb/lb·mol)				
30 Dew point/bubble point	(°F)				
31 Solids maximum size	(in)				
32 Solids concentration (% volume)					
33 Latent heat	(BTU/lb)				
34 Critical pressure	(psia)				
35 Critical temperature	(°F)				
36					
37 Total heat exchanged	(BTU/h)				
38 U [a]	($BTU/h·ft^{2}·°R$)	Clean condition:		Service:	
39 LMTD	(°F)	/			
40 Heat transfer area	(ft^2)				
41 Stream heat transfer coefficient	($BTU/h·ft^{2}·°R$)				

[a] Fouling margin = $[(U_{clean}/U_{service}) - 1] \times 100$ % where U = Overall heat transfer coefficient (thermal transmittance).

Rev. No.	Revision	Date	Prepared by	Reviewed by

Company	PLATE-AND-FRAME HEAT EXCHANGER DATA SHEET (US CUSTOMARY UNITS) MECHANICAL	Engineering contractor
PO No.:	Doc. No.:	Page 2 of

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02 Number of exchangers in parallel		Heat transfer area/total (ft^2)	
03 Number of exchangers in series		Heat transfer area per plate (ft^2)	
04 Number of passes, hot side		Number of plates per exchanger	
05 Number of passes, cold side		Max. number of plates per exchanger	
06 Rel. directions of fluids	Cocurrent/countercurrent	Plate chevron angle(s)	
07 Nominal plate gap (in)		Nominal plate thickness (in)	

08 DESIGN DATA				
09 Pressure vessel code				
10 Material certificate type				
11 Code stamp	Yes ( )	No ( )		
12 Applicable specifications				
13 Local rules and regulations				
14 Local register of exchanger				
15	HOT SIDE		COLD SIDE	
16 Test pressure (psig)				
17 MAWP (psig)				
18 Velocity between plates (ft/s)				
19 Wall shear stress (psi)				
20 Volume liquid per exchanger (ft^3)				
21 Length/width/height (in)				
22 Mass empty/full of water (lb)	/			
23				
24 CONNECTIONS	IN	OUT	IN	OUT
25 Nozzle size (NPS)				
26 Flange rating/type	/	/	/	/
27 COMPONENT	MATERIALS			
28 Exchanger type	Gasketed ( )	Semi-welded ( )	Welded ( )	
29 Plates				
30 Gasket fixing	Glued ( )	Not glued ( )		
31 Gaskets hot side/cold side	/			
32 Cover fixed/movable	/			
33 Tie bolts/nuts	/			
34 Connection design	Studded ( )	Flanged nozzle ( )		
35 Nozzle pipes/flanges				
36 Corrosion allow. on connections (in)				
37 Stud bolts/nuts				
38 Shroud	None ( )	Spray ( )	Fire ( )	
39 Drip tray	Yes ( )	No ( )	By others ( )	
40 Painting specification	Mfg. std. ( )	Purchaser spec. ( )		
41 Insulation	Yes ( )	No ( )	By others ( )	
42				

43 LOADING			
44 Connection loads/moments	Standard ( )	Severe duty ( )	Purchaser spec. ( )
45 Wind loading			
46 Explosion blast pressure			
47 Earthquake loading			
48 Transport loading at sea			
49			

50 TESTING AND INSPECTION		
51 Specific drying procedure	Yes ( )	No ( )
52 Dried by blowing air	Yes ( )	No ( )
53 Non-destructive testing in addition to the pressure design code		
54 Inspection required	Purchaser ( )	Third party ( )

Company	PLATE-AND-FRAME HEAT EXCHANGER DATA SHEET (US CUSTOMARY UNITS) PROCESS	Engineering contractor
PO No.:	Doc. No.:	Page 3 of

PHYSICAL PROPERTIES (INCLUDING WATER IF PRESENT)										
CASE	Temperature (°F)									
	Pressure (psia)									
	Heat released (BTU/h)									
LIQUID PHASE	Mass fraction vapour									
	Mass fraction H_2O in liquid									
	Density (lb/ft^3)									
	Specific heat capacity (BTU/lb·°R)									
	Viscosity (cP)									
	Thermal conductivity (BTU/h·ft·°R)									
	Surface tension (dyn/cm)									
	Vapour pressure (psia)									
VAPOUR PHASE	Density (lb/ft^3)									
	Specific heat capacity (BTU/lb·°R)									
	Viscosity (cP)									
	Thermal conductivity (BTU/h·ft·°R)									
	Vapour pressure (psia)									
	Relative molecular mass (lb/lb·mol)									
	Latent heat (BTU/lb)									
	Critical pressure (psia)									
	Critical temperature (°F)									
NOTES:										

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