

Brazed Aluminum Plate-fin Heat Exchangers

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Should: As used in a standard, “should” denotes a recommendation or that which is advised but not required in order to conform to the standard.

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Can: As used in a standard, “can” denotes a statement of possibility or capability.

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Contents

	Page
1 Scope	1
2 Normative References	1
3 Terms and Definitions	1
4 General Requirements	4
5 Proposal Information Required	4
6 Drawings and Other Required Data	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 Temperature	8
7.3 Design Pressure	8
7.4 Thermal Stress	8
7.5 Fouling Resistance	9
7.6 Corrosion Allowance	9
7.7 Supports	9
7.8 Connections	10
7.9 Bimetallic Transition Joints	10
7.10 Temperature Monitoring	13
7.11 Handling Devices	13
8 Materials	14
9 Fabrication	14
9.1 Welding and Brazing	14
9.2 Reinforcing Pads and Wear Plates	15
9.3 Dimensional Tolerances	15
10 Inspection and Testing	15
10.1 Quality Control	15
10.2 Pressure and Leak Testing	16
10.3 Rectification	17
10.4 Nameplate	18
11 Preparation for Shipment	18
Annex A (informative) Recommended Practice	19
Annex B (informative) Plate-fin Heat Exchanger Checklist	26
Annex C (informative) Plate-fin Heat Exchanger Datasheets	27
Annex D (informative) Block-in-Shell Heat Exchangers	34
Bibliography	40
Figures	
1 Cross-sectional View of Fin and Parting Sheet	2
2 Typical Components of a Brazed Aluminum Plate-Fin Heat Exchanger	3
3 Bimetallic Transition Joints	12
D.1 Block-in-Shell Heat Exchanger	35

Introduction

It is necessary that users of this standard should be aware that further or differing requirements may be necessary for individual applications. This 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 standard and provide details.

This standard has been re-numbered; it was previously published as API Standard 662, Part 2.

A recommended practice is included within this standard (see Annex A).

This standard requires the purchaser to specify certain details and features.

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

In this standard, where practical, US Customary units are included in parentheses for information.

Brazed Aluminum Plate-fin Heat Exchangers

1 Scope

This standard gives requirements and recommendations for the mechanical design, materials selection, fabrication, inspection, testing, and preparation for shipment of brazed aluminum plate-fin heat exchangers for use in the petroleum, petrochemical, and natural gas industries.

2 Normative References

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any addenda) applies.

ALPEMA¹, *The Standards of the Brazed Aluminum Plate-Fin Heat Exchanger Manufacturers' Association*, 3rd Edition

NOTE In this standard, this normative reference will be referred to in the text as the "ALPEMA Standards" due to its lengthy title and multiple citations.

ASME *Boiler and Pressure Vessel Code (BPVC)*², Section VIII: Rules for construction of pressure vessels; Division 1 or Division 2

ASME B16.25, *Buttwelding Ends*

ASME B16.5, *Pipe Flanges and Flanged Fittings NPS 1/2 through NPS 24 Metric/Inch Standard*

ASME B16.9, *Factory-Made Wrought Buttwelding Fittings*

ASME B31.3, *Process Piping*

3 Terms and Definitions

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

3.1

block core

An assembly consisting of alternating layers (passages) of corrugated fins, separated by parting sheets and sealed along their edges by means of side bars and bounded by cap sheets, which are brazed to become a rigid structure.

3.2

block-in-shell heat exchanger

A heat exchanger system consisting of one or more plate-fin heat exchangers installed within a pressure vessel shell.

3.3

cold box

An enclosure consisting of a carbon steel casing, usually rectangular in shape, that supports and houses plate-fin heat exchangers, pressure vessels, piping, and other cryogenic equipment, filled with insulation and operated under an inert atmosphere.

¹ Brazed Aluminum Plate-Fin Heat Exchanger Manufacturers' Association, www.alpema.org. (Secretariat services provided by Heat Transfer Research Inc., P.O. Box 1390, Navasota, TX 77868, www.htri.net)

² American Society of Mechanical Engineers, Two Park Avenue, New York City, NY 10016-5990, www.asme.org.

3.4**cyclic service**

A process operation with periodic variation in temperature, pressure, and/or flow rate.

3.5**full-penetration weld**

A welded joint that results in weld metal through the entire thickness of the components being joined.

3.6**heat transfer area**

The sum of the primary and secondary heat transfer surface areas of all heat-transfer passages in contact with a stream. See Figure 1.

Key

- 1 primary heat transfer surface
- 2 secondary heat transfer surface
- 3 parting sheet
- 4 fin

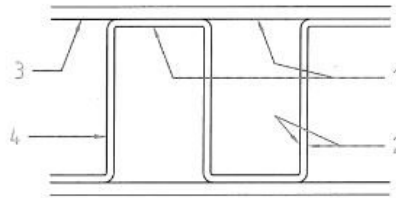


Figure 1—Cross-sectional View of Fin and Parting Sheet
(Figure provided courtesy of ALPEMA)

NOTE 1 The primary heat transfer surface within the plate-fin heat exchanger consists of the bare parting sheet and the fin base directly brazed to the parting sheet.

NOTE 2 The secondary heat transfer surface is provided by the fins. This area includes both sides of the fins where they are in contact with the fluid.

3.7**hydrogen service**

Services that contain hydrogen at a partial pressure exceeding 700 kPa (100 psi) absolute.

3.8**item number**

The purchaser's identification number for a plate-fin heat exchanger.

3.9**minimum design metal temperature**

The lowest metal temperature at which pressure-containing elements can be subjected to design pressure.

EXAMPLES Ambient temperature and process fluid temperature.

3.10**plate-fin heat exchanger**

A heat exchanger consisting of a block to which headers and nozzles have been attached. See Figure 2.

NOTE 1 The layers are separated from each other by parting sheets and sealed along the edges by means of side bars, and are provided with inlet and outlet ports for the streams. The block is bounded by cap sheets at the top and bottom.

NOTE 2 All the layers carrying the same stream are connected together by headers (inlet, outlet, intermediate) directly attached by welding onto the brazed block.

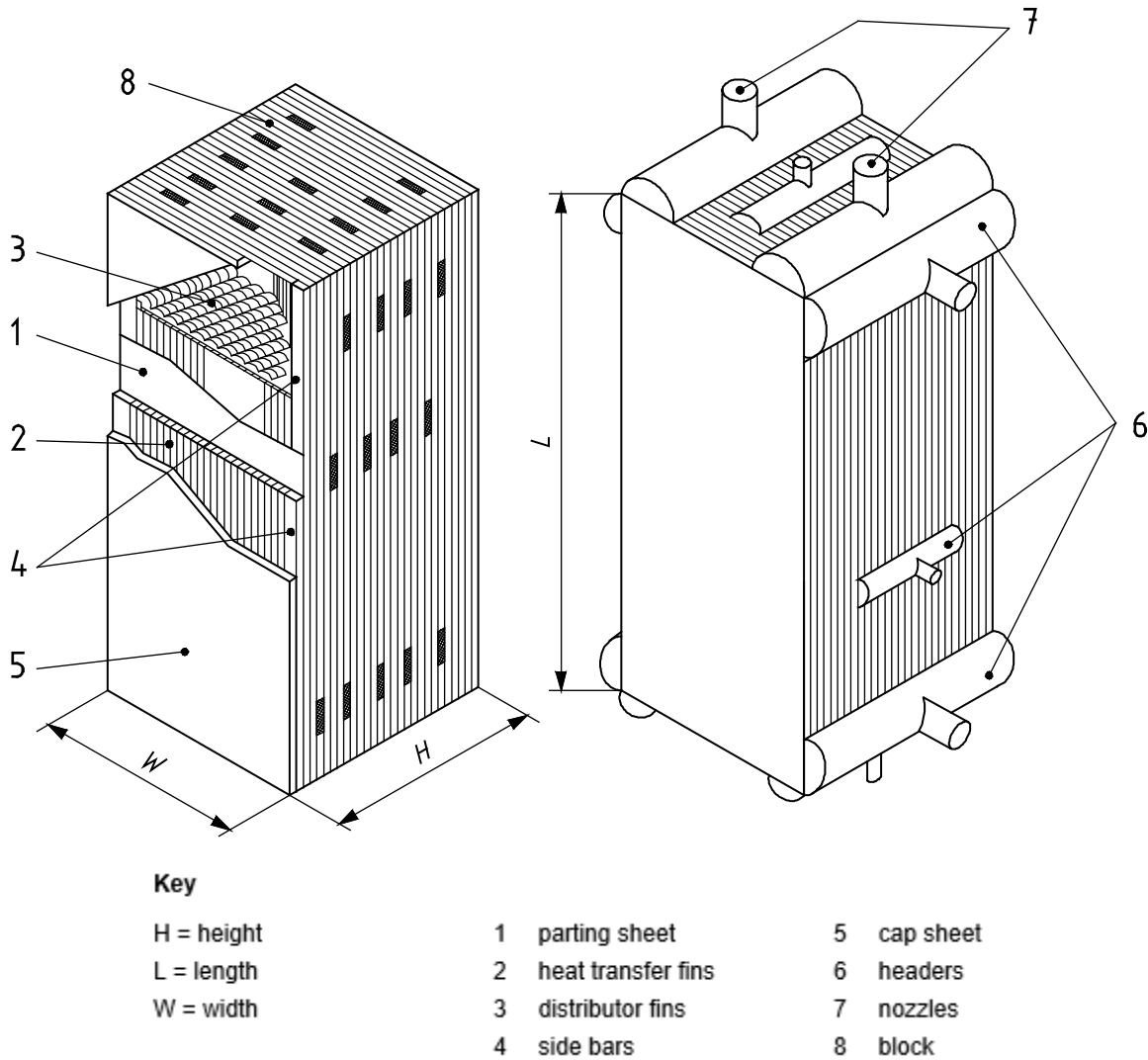


Figure 2—Typical Components of a Brazed Aluminum Plate-Fin Heat Exchanger
(Figure provided courtesy of ALPEMA)

3.11

pressure design code

Recognized pressure vessel standard specified or agreed by the purchaser.

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

3.12

separator vessel

A pressure vessel provided to separate liquid and vapor phases of a two-phase stream prior to the introduction of these phases into a brazed aluminum plate-fin heat exchanger.

3.13

structural welding code

Recognized structural welding code specified or agreed by the purchaser.

3.14

transition joint

A bimetallic piping joint that provides a metallic transition between aluminum piping and other piping materials.

4 General Requirements

- **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 standard.
- **4.2** The structural welding code shall be specified or agreed by the purchaser.
- 4.3** Annex A provides recommended practices for information.
- **4.4** The vendor shall comply with the applicable local regulations specified by the purchaser.
- **4.5** The purchaser shall specify the quantity of mercury, organo-mercuric compounds, and heavy metals that will be present in the fluids in contact with the plate-fin heat exchanger. If water is present, the purchaser shall also specify the quantity of H₂S, NH₃, CO₂, SO₂, NOX, CO, Cl, the presence of halides, and the pH value. The purchaser shall identify any streams for which a mercury-tolerant design is required. See Annex A.2 for additional guidance.
- **4.6** The purchaser shall specify if cyclic service design is required.
- 4.7** If cyclic service is specified, the purchaser shall specify the type and magnitude of variation in pressure, temperature, and flow rate, the time for the variation (hours, weeks, months, 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.
- **4.8** The purchaser shall specify if any of the streams are in hydrogen service.
- **4.9** In addition to the design operating condition(s), the purchaser shall specify all operating conditions that could impose significant thermal stresses on the plate-fin heat exchanger. This shall include any alternative operating cases, turn-down operation, upset-operation cases (with attention to cases where a stream's flowing condition might change or cease abruptly), and the process control philosophy being applied to the plate-fin heat exchanger.
- 4.10** Plate-fin heat exchangers shall comply with the requirements of The ALPEMA *Standards*, unless otherwise specified within this standard.

5 Proposal Information Required

5.1 The vendor shall provide a completed datasheet, including materials of construction. An example of a suitable format is given in Annex C.

NOTE 1 The calculated pressure drops reported on the datasheet shall include all frictional and acceleration losses from the inlet connection to outlet connection, including any losses associated with separator vessels, interconnecting piping, and inlet/outlet manifolds for multi-core exchangers, if these are within the scope of supply of the vendor.

NOTE 2 The static head (gravitational) losses or gains shall be considered in the performance design of the heat exchanger and shall be reported for information. The allowable and calculated pressure drop, however, shall consider only the frictional and acceleration losses.

- **5.2** When specified by the purchaser, the vendor shall provide the following detailed information for all proposed plate-fin heat exchanger designs:
 - a) layer-by-layer plate stacking arrangements;

- b) layer dimensional arrangement for each process stream;
- c) complete fin description, including fin type, fin height, fin thickness, along with perforation percentage/serration length/crest distance (if applicable); and
- d) inlet and outlet distributor fin descriptions, including two-phase distributor details.

5.3 The vendor shall specify in the proposal the operating limitations (e.g. pressure and temperature limits, flow conditions, variations/frequencies/rates of change in flow rate, pressure, and temperature) for normal operating and startup/shutdown/warm-up/cool-down cases.

5.4 When dissimilar metal flanged connections are to be used, the vendor shall specify the type to be provided and the method to be used to prove the adequacy of the design of the joint.

5.5 The first-time use by the vendor of a new technology, design, component, or material shall be clearly indicated by the vendor. See Annex A.3 for additional guidance.

5.6 The vendor shall provide recommended strainer (size of mesh) requirements for each stream. See Annex A.4 for additional guidance.

5.7 For block-in-shell heat exchangers, the vendor's proposal shall indicate the shell dimensions (diameter and length), the design liquid entrainment for the shell exit vapor stream (mass of liquid/mass of vapor), and a general description of any two-phase separation devices to be provided (e.g. de-misting pads).

5.8 If a mercury-tolerant design is specified by the purchaser, the vendor shall provide a general description of the special design, manufacturing techniques, and operating procedures that are to be provided.

6 Drawings and Other Required Data

6.1 Outline Drawings and Other Supporting Data

6.1.1 The vendor shall submit, for review by the purchaser, outline drawings for each plate-fin heat exchanger. The drawings shall include at least the following information:

- a) service, item number, project name and location, vendor's shop order number, and purchaser's order number;
- b) maximum allowable working pressure, design pressure (including vacuum, if applicable), test pressure, maximum design temperature, minimum design metal temperature, and any restrictions regarding testing or operation of the plate-fin heat exchanger;
- c) dimensions and location of supports, including bolt holes and slots, along with reaction loads at each point of support;
- d) overall heat exchanger dimensions;
- e) type and geometric details of fins used;
- f) presence and location of any inactive areas;
- g) mass of the heat exchanger, both empty and full of liquid, with a specific gravity of 1.0;
- h) center of gravity of the heat exchanger for empty and operating conditions;

- i) material specifications for all components;
- j) allowable forces and moments on connections at the header-to-nozzle joint;
- k) connection sizes, location, orientation, projection, direction of flow, and, if flanged, the rating and facing or, if welded to the connecting piping, the thickness and weld bevel preparation;
- l) insulation thickness (when specified by the purchaser);
- m) location and orientation of nameplates, lifting devices, electrical grounding lugs, or other attachments;
- n) recommended liquid levels (normal, minimum, and maximum operating liquid levels) for block-in-shell heat exchangers;
- o) transition joint dimensions and any requirements and instructions for installation; and
- p) references to the applicable code and purchaser's specification.

6.1.2 Torque or bolt tensioning requirements for connection bolting shall be provided for review.

6.1.3 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 Upon receipt of the purchaser's review comments on the outline drawings, the vendor shall furnish detail drawings for the purchaser's review, including header fabrication and connection details, piping fabrication details, and separator vessel details (when provided by the vendor for two-phase distribution purposes). Detailed fabrication drawings for the block need not be provided. The information provided shall include the following:

- a) full views and cross-sectional views with all dimensions and materials sufficient for stress calculations for each part;
- b) details of each pressure-retaining weld, including weld material, weld nominal thickness, weld location, and applicable nondestructive examination method;
- c) details of each weld and weld nominal thickness for non-pressure attachments welded to pressure parts and for all load-bearing attachments;
- d) complete bills of materials, including the materials specification; and
- e) special installation and maintenance instructions, including lifting and handling.

- **6.2.2** If specified by the purchaser, the vendor shall furnish the information necessary to allow the performance of the plate-fin heat exchanger to be modeled using commercially available software. The information provided shall include a stacking sequence or arrangement; dimensional details for each layer, including distributor type and dimensions; identification of fin(s) used; and fin geometry data, including type, height, thickness, fin pitch, fin perforation percentage/serration, length/crest distance (as applicable), and parting sheet thickness.
- **6.2.3** If specified by the purchaser, the vendor shall furnish copies of applicable welding procedure specifications, procedure qualification reports, and weld maps for review or record.
- **6.2.4** If specified by the purchaser, the vendor shall furnish the following calculations for review or record.

- a) pressure design code calculations, which shall include the following as a minimum:
 - 1) header, nozzle, and piping thickness calculations;
 - 2) shell calculations for block-in-shell heat exchangers;
 - 3) aluminum flange thickness calculations for flanges not within the scope of ASME B31.3, Appendix L;
 - 4) dissimilar flange material joint analysis (e.g. stainless steel or low-temperature carbon steel to aluminum), when applicable (see 7.8.9);
 - 5) nozzle reinforcement calculations; and
 - 6) documentation certifying fin strength compliance to the applicable pressure design code. This can be in the form of certified proof test data, calculations, or a statement of compliance.
- b) support calculations, including loads imposed by wind, seismic, and transportation conditions;
- c) lifting device calculations;
- d) transition joint calculations, or other documentation acceptable to the purchaser, to demonstrate the adequacy of the joint;
- e) nozzle load calculations;
- f) internal piping stress calculations for block-in-shell heat exchangers;
- g) entrainment calculations used to size the shell for block-in-shell heat exchangers.

6.2.5 If cyclic service has been specified by the purchaser, the ability of the plate-fin heat exchanger to withstand the operation shall be demonstrated. The method of analysis to be provided and the requirements for review shall be agreed with the purchaser.

- **6.2.6** If specified by the purchaser, the vendor shall furnish procedures for pressure and leak testing and drying for review.

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

6.3 Reports and Records

- **6.3.1** After the plate-fin heat exchanger is completed, the vendor shall furnish the purchaser with the following documents in the format and quantities specified by the purchaser:
 - a) the "as-built" data sheet;
 - b) all outline and detail drawings, marked "CERTIFIED AS-BUILT";
 - c) all mechanical design calculations, marked "CERTIFIED AS-BUILT";
 - d) certified mill test reports for all pressure parts;
 - e) completed manufacturer's data report in accordance with the pressure design code;
 - f) third-party verification and certification;

- g) nonconformance reports and resolutions;
- h) nameplate rubbing or facsimile;
- i) nondestructive examination map;
- j) all associated nondestructive examination reports, including radiographic, magnetic-particle, liquid penetrant, ultrasonic, positive material identification (PMI), and any other reports as applicable;
- k) pressure test records or report;
- l) leak test records or report; and
- m) the user's manual, containing:
 - 1) technical description;
 - 2) operating instructions (including any startup or shutdown constraints); and
 - 3) installation and maintenance instructions (including lifting and handling).

6.3.2 The vendor shall retain, for at least five years, records that confirm compliance of the material and fabrication with the requirements of this standard.

7 Design

7.1 General

The design of the plate-fin heat exchanger, including the suitability of the fins and the block to contain the pressure loadings, shall be in accordance with the pressure design code.

7.2 Design Temperature

- All plate-fin heat exchangers shall have two design temperatures for each stream—a maximum design temperature and a minimum design metal temperature (MDMT)—as specified by the purchaser.

7.3 Design Pressure

- **7.3.1** The purchaser shall specify the design pressure for each stream, including any vacuum condition to be applied. When the plate-fin heat exchanger is to be installed within a pressure vessel, the purchaser shall also specify the design pressure of the environment around the heat exchanger, including vacuum rating.

7.3.2 Each stream of the plate-fin heat exchanger shall be designed for its independent pressure, with coincident atmospheric (or vacuum, if specified) on adjacent streams, as well as any pressure forces from the environment around the heat exchanger as applicable.

7.4 Thermal Stress

7.4.1 The design of the plate-fin heat exchanger shall be suitable for the design operating condition(s) and any other operating conditions identified by the purchaser that could impose significant thermal stresses on the heat exchanger. This shall include startup, shutdown, and turndown conditions, as well as any upset conditions (e.g. sudden changes in stream conditions, loss of process or utility stream flows, emergency shutdown (ESD) operation) and any cyclic temperature conditions specified by the purchaser.