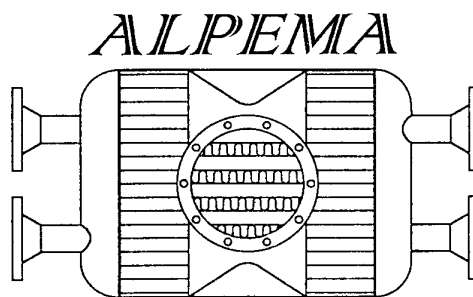


**THE STANDARDS OF THE
BRAZED ALUMINIUM PLATE-FIN HEAT EXCHANGER
MANUFACTURERS' ASSOCIATION**



Second Edition
2000

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PREFACE

This is the Second Edition of the Standards of the Brazed Aluminium Plate-Fin Heat Exchanger Manufacturers' Association (ALPEMA). It is the result of the work by a technical committee of all the Members to meet the objective of the Association to promote the quality and safe use of this type of heat exchanger. The Standards contain all relevant information for the specification, procurement, and use of Brazed Aluminium Plate-Fin Heat Exchangers.

The First Edition, published in 1994, has proved extremely successful and popular. The ALPEMA Members have reviewed the Standards every year since 1994 to consider whether updates are required and what these should be. Changes in the industry, experience with using the Standards and feedback from users has indicated that the time is right for the Second Edition. The additions and amendments which have been made are summarised here.

1. A new Section 3.10 has been added to the end of Chapter 3 on the procedures to follow in rectifying the non-conformities that occasionally occur in manufacture.
2. Chapter 4, previously titled *Installation*, has been re-titled *Installation, Operation and Maintenance* to reflect more accurately its contents. The following changes have also been made to this Chapter:
 - In section 4.9.1, an additional warning to the user has been added on pressure protection.
 - The recommended maximum cool-down and warm-up rates given in Sections 4.9.1 and 4.9.3, respectively, have been increased.
 - Section 4.11 on leak detection on-site, has been extended to give more detail and a new Section 4.12 added on repair of leaks.
3. Section 5.12.2.4 on nozzle loading has been modified with respect both to the point of application of the loads and the corresponding magnitudes of the typical allowable loads.
4. In Chapter 7, Section 7.3, which introduces thermal design, has been modified to emphasise the existence of more advanced and detailed calculation methods than the basic one included in Chapter 7. Also, Figure 7-3 and Figure 7-4, the typical specification sheets, have been tidied up slightly.
5. Section 8.3 on corrosion has been expanded to give more information and guidelines on the use of brazed aluminium plate-fin exchangers in a variety of environments.
6. In addition to the above substantive changes, the wording has been revised in several places to improve clarity and remove typographical errors. Also, minor improvements have been made to a few of the Figures.

Comment by users of The Standards are welcomed.

NO WARRANTY EXPRESSED OR IMPLIED

The Standards herein are recommended by The Brazed Aluminium Plate-Fin Heat Exchanger Manufacturers' Association to assist users, engineers and designers who specify, design and install Brazed Aluminium Plate-Fin Heat Exchangers. These Standards are based upon sound engineering principles, research and field experience in the manufacture, design, installation and use of these exchangers. These Standards may be subject to revision as further investigation or experience may show is necessary or desirable. Nothing herein shall constitute a warranty of any kind, expressed or implied, and warranty responsibility of any kind is expressly denied.

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1 GENERAL DESCRIPTION AND NOMENCLATURE

1.1 GENERAL DESCRIPTION

1.1.1 Introduction

A brazed aluminium plate-fin heat exchanger consists of a block (core) of alternating layers (passages) of corrugated fins. 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.

An illustration of a multi-stream plate-fin heat exchanger is shown in Figure 1-1.

The stacked assembly is brazed in a vacuum furnace to become a rigid core. To complete the heat exchanger, headers with nozzles are welded to the side bars and parting sheets across the ports.

The size of a brazed aluminium plate-fin heat exchanger shall be specified by width W , stacking height H and length L of the rectangular block. (Figure 1-2).

The three dimensions shall be given always in the same sequence as $W \times H \times L$, e.g. $900 \times 1180 \times 6100$ mm.

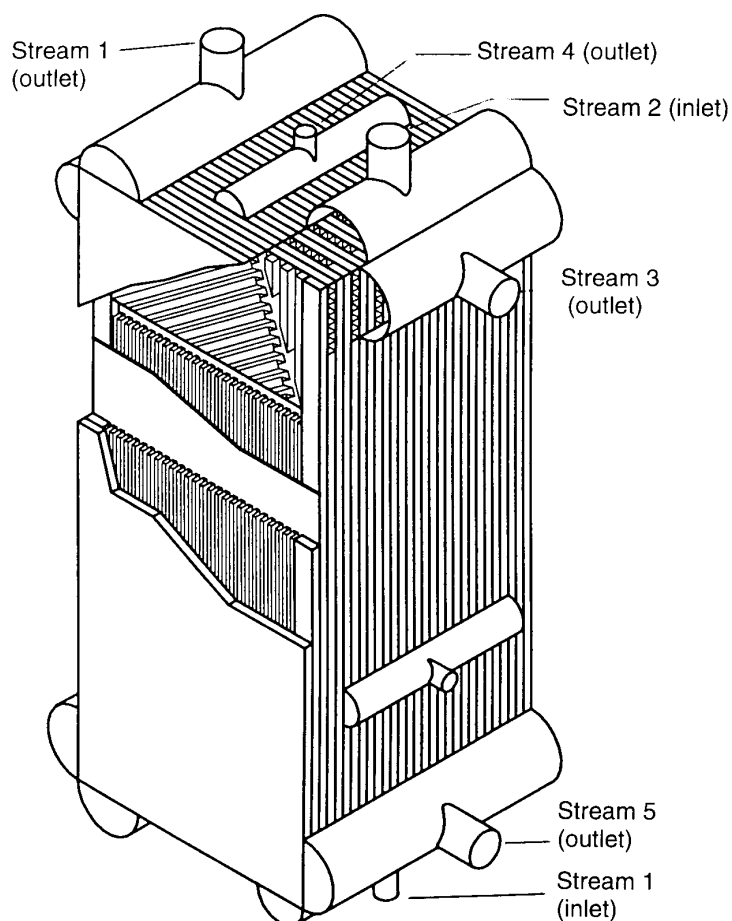


Figure 1-1: Illustration of a Typical Multi-Stream Brazed Aluminium Plate-Fin Heat Exchanger

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1.1.2 Successful Applications for Brazed Aluminium Plate-Fin Heat Exchangers

1.1.2.1 Typical services

Most brazed aluminium plate-fin heat exchangers have been installed in process plants used to separate a feed gas into its constituents, for example by the partial liquefaction of the feed and subsequent distillation and separation. The products and waste streams are then re-warmed against the feed streams. Condensers and reboilers are associated with distillation columns. Often chillers using standard refrigerants are used. Brazed aluminium plate-fin heat exchangers are well suited for these and many other services. A partial listing includes:

Name	Service
Main exchanger	To cool inlet feed streams against return product and residue streams
Reversing exchanger	Air separation application to cool air and remove atmospheric water and CO ₂
Subcooler	To subcool liquid products or other liquid streams
Reboiler	To reboil column bottoms or vaporise tray liquids. Often this exchanger is installed inside the column
Overhead condenser	To condense column overheads, usually against a refrigerant stream
Chiller	To cool a process stream with a vaporising refrigerant
Liquefiers	To liquefy the feed gas in a closed loop
Dephlegmators	To condense overheads and perform simultaneous heat and mass transfer
Aftercooler	To cool vapour coming from a compressor discharge

1.1.2.2 Plant types

Brazed aluminium plate-fin heat exchangers have been successfully used in the above services in a variety of applications. The major applications have been in the cryogenic separation and liquefaction of air (ASU); Natural Gas Processing (NGP) and Liquefaction (LNG); the production of petrochemicals and treatment of offgases; large refrigeration systems. Table 1-1 gives some typical applications where brazed aluminium plate-fin heat exchangers are used extensively and have proven reliable over many years of service.

1.1.3 Limits of Use - Maximum Working Temperature and Pressure

The maximum working pressure for brazed aluminium plate-fin heat exchangers varies from zero to over 100 bar g. It is possible to have over ten process streams, at various pressures, in a single heat exchanger.

The maximum temperature rating is typically specified at 65°C. An upper limit of 65°C is suitable for most applications, and it allows manufacturers to use 5083 aluminium alloy piping which is more economical. However, designs are available for up to +204°C at lower pressures, and design temperatures in excess of 65°C are common. The minimum design temperature is -269°C. See Chapter 6 for a full material listing.

1.1.4 Acceptable Fluids

Brazed aluminium plate-fin heat exchangers are capable of handling a wide variety of fluids in many different types of applications. In general, fluids should be clean, dry, and non-corrosive to aluminium. Trace impurities of H₂S, NH₃, CO₂, SO₂, NO₂, CO, Cl and other acid-forming gases do not create corrosion problem in streams with water dewpoint temperatures lower than the cold-end temperature of the brazed aluminium plate-fin heat exchanger.

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Under specific conditions, mercury can corrode aluminium and therefore caution must be used when handling mercury-containing fluids. However, there are many instances where brazed aluminium plate-fin heat exchangers have been successfully used with fluids containing mercury provided that the proper equipment design and operating procedures are implemented. In all cases, it is recommended that the heat exchanger manufacturer is consulted about specific conditions.

Further information on corrosion guidelines is given in Section 8.3.

Proper filters should be installed upstream of the exchangers to prevent plugging from particulates such as pipe scale or molecular sieve dust. If a brazed aluminium plate-fin heat exchanger is accidentally plugged, proven cleaning procedures are available. Further information on this subject is given in Section 8.2.

Fluids containing compressor lube oils, and other heavy hydrocarbons are acceptable provided these contaminants do not precipitate out on the fin surface. In the event of heavy fouling, chemical solvent cleaning of the exchanger is a proven method of cleaning.

Table 1-1: Plant Types and Applications

<i>Plant Types</i>	<i>Products & Fluids</i>	<i>Typical Temperature Range, °C</i>	<i>Typical Pressure Range, bar.a</i>
Industrial Gas Production - Air Separation - Liquefaction	Oxygen Nitrogen Argon Rare Gases Carbon Dioxide	+65 to -200	1 TO 60
Natural Gas Processing (NGP) - ExpanderType - Nitrogen Rejection Unit (NRU) - Liquefied Petroleum Gas (LPG) - Helium Recovery	Methane Ethane Propane Butane Pentane Nitrogen Helium Hydrogen Hexane Carbon Dioxide	+100 to -130	15 TO 100
Liquefied Natural Gas (LNG) - Base Load - Peakshaver	Liquefied Natural Gas Multi-Component Refrigerants	+65 to -200	5 TO 75
Petrochemical Production - Ethylene - MTBE - Ammonia - Refinery Off-Gas Purification	Ethylene Propylene Ethane Propane MTBE Ammonia Carbon Monoxide Hydrogen	+120 to -200	1 TO 100
Refrigeration Systems - Cascade Cooling - Liquefaction	Helium Freon Ethylene Propane Propylene Nitrogen Hydrogen Multi-Component Refrigerants	+100 to -269	15 TO 45

CHAPTER 1

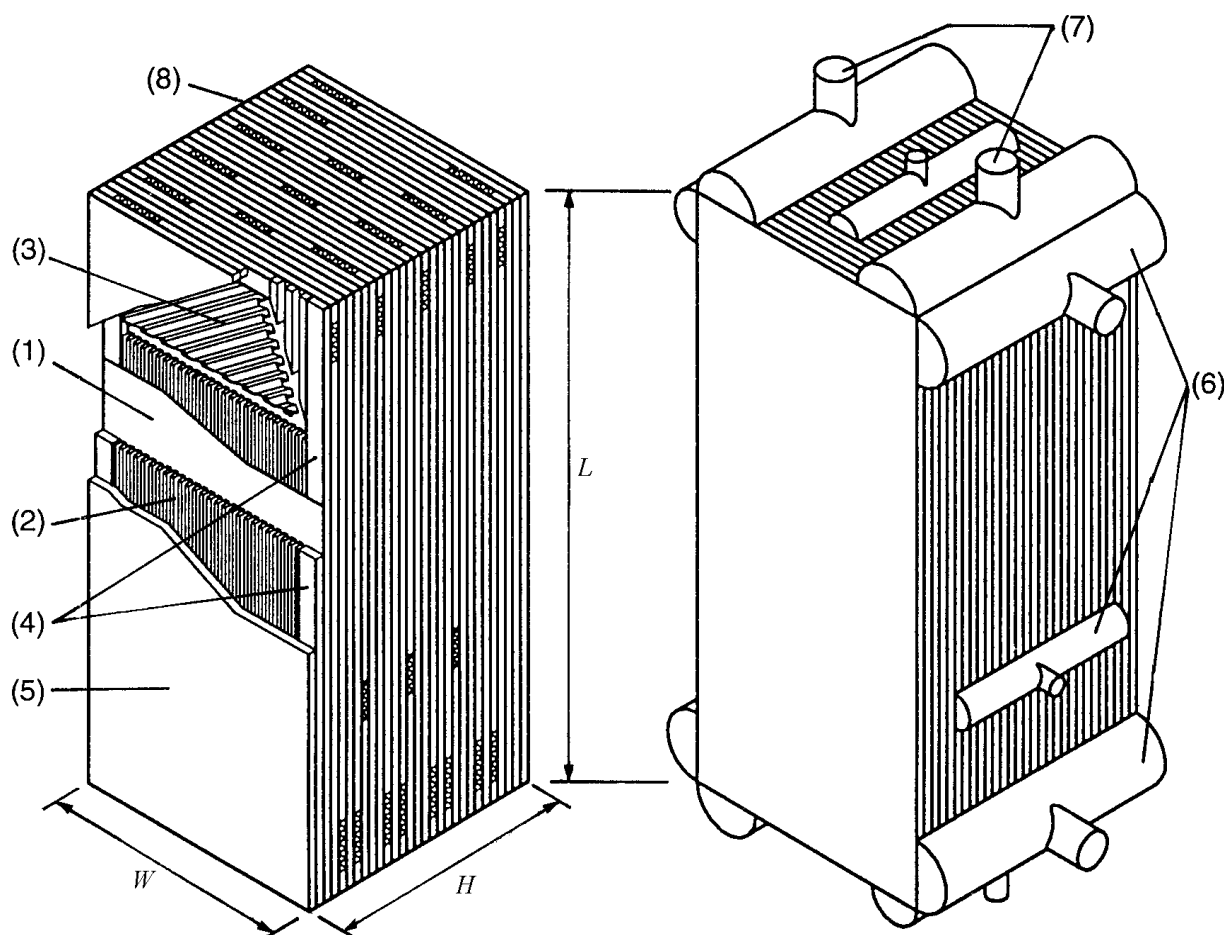
General Description and Nomenclature

1.2 NOMENCLATURE OF THE COMPONENTS

Section 1.2 describes the components which are part of a brazed aluminium plate-fin heat exchanger. Typical geometrical dimensions are included in Chapter 5 of these Standards. Other items are described in the relevant chapters (e.g. supports are illustrated in Chapter 4 of these Standards).

1.2.1 Components of an Exchanger

For the purpose of establishing standard terminology, Figure 1-2 illustrates the components of an exchanger. The components are numbered for identification.



- | | |
|-----------------------|-----------------|
| 1. Parting sheet | 5. Cap sheet |
| 2. Heat transfer fins | 6. Headers |
| 3. Distributor fins | 7. Nozzles |
| 4. Side bars | 8. Block (core) |

L ; Length
 W ; Width
 H ; Height

Figure 1-2: Components of a Brazed Aluminium Plate-Fin Heat Exchanger

1.2.2 Components of Manifolded Exchangers

Multiple brazed aluminium plate-fin exchangers may be connected in parallel, in series, or in parallel-series combination, to form one assembly.

Figure 1-3 illustrates an assembly of three brazed aluminium plate-fin heat exchangers connected in parallel. For this case, each individual stream enters the assembly through a manifold, is distributed to the inlet nozzles on each of the three heat exchangers, flows through the heat exchanger and leaves the assembly through the outlet manifold.

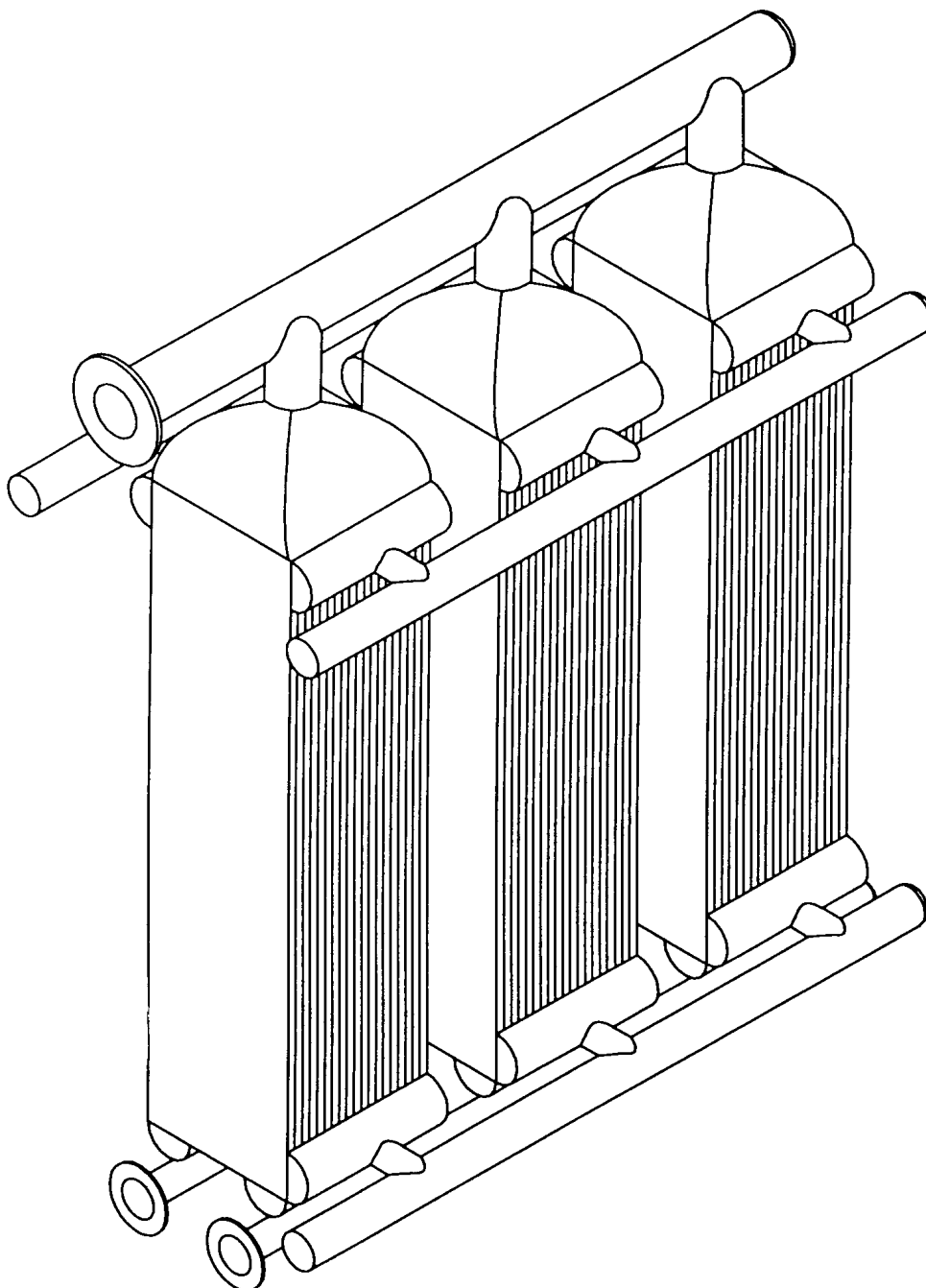


Figure 1-3: Typical Assembly of Three Brazed Aluminium Plate-Fin Heat Exchangers in Parallel

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1.2.3 Module Construction

Two or more individually brazed aluminium plate-fin exchanger blocks may be welded together in parallel to form one composite block. In this way the stacking height of the exchanger can be increased above a dimension limited by the manufacturing process or other restrictions.

1.2.4 Connection Options

Several options are available for connecting a brazed aluminium plate-fin heat exchanger to plant piping.

1.2.4.1 *Stub ends*

This option is selected if the exchanger nozzles are to be directly (butt-) welded to the connecting aluminium pipes.

1.2.4.2 *Flanges*

This option is available if the heat exchanger is to be connected to steel piping or if installation of the heat exchanger without welding is desired. Under this option, the manufacturer provides the heat exchanger with aluminium flanges welded on the nozzles to fit with mating (normally steel) flanges on the piping.

1.2.4.3 *Transition joints*

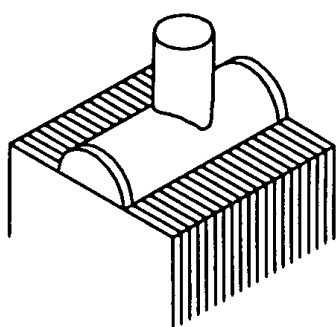
This alternative to flanges is available if the heat exchanger is to be connected to steel piping. Under this option, the manufacturer provides the heat exchanger with transition joints welded to the nozzles. The transition joints are directly (butt-) welded to the connecting steel pipes.

1.2.5 Header/Nozzle Configurations

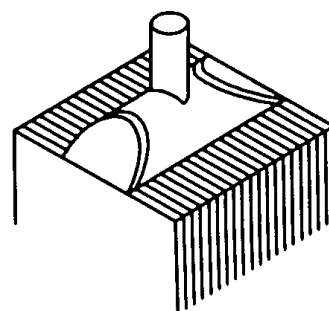
Streams to and from the heat exchanger enter and leave by means of various header/nozzle configurations.

The headers are normally made from half cylinders with flat and/or mitred ends or mitred dome headers. Typical variants are shown in Figure 1-4.

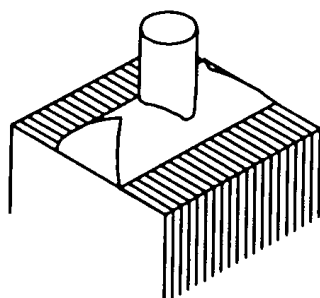
The nozzles may be radial, tangential or inclined to the header and can also be equipped with flanges or transition joints. There are many different and acceptable variations of header/nozzle configurations in use and some typical variations are shown in Figure 1-5.



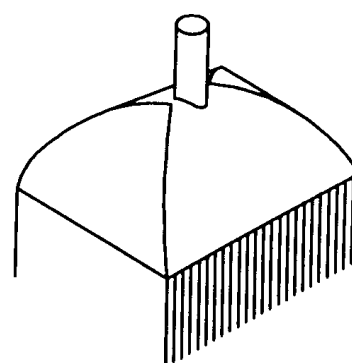
Standard header with flat ends



Header with inclined ends

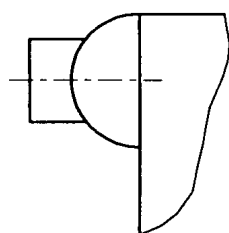


Header with mitred ends

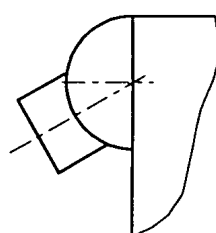


Dome header with mitred ends

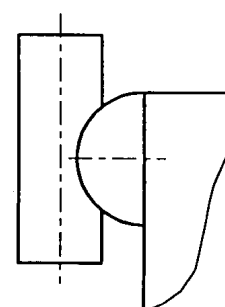
Figure 1-4: Typical Header Configurations



Radial nozzle



Inclined nozzle



Tangential nozzle

Figure 1-5: Typical Header/Nozzle Configurations

CHAPTER 1

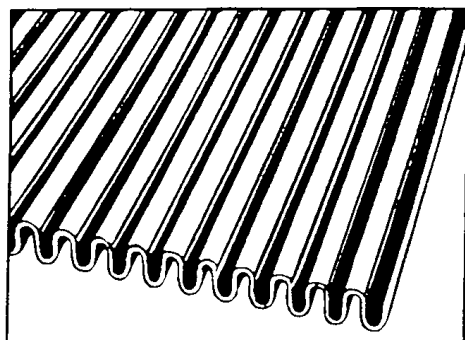
General Description and Nomenclature

1.2.6 Fin Corrugations

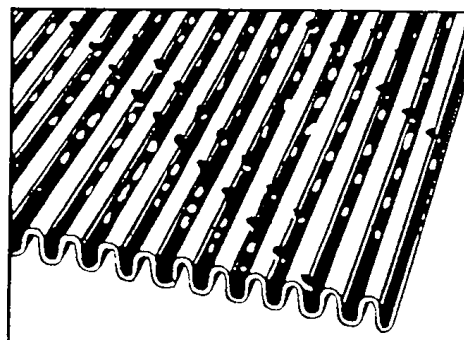
Various shapes of corrugated fins are available.

1.2.6.1 *Principal types of fin*

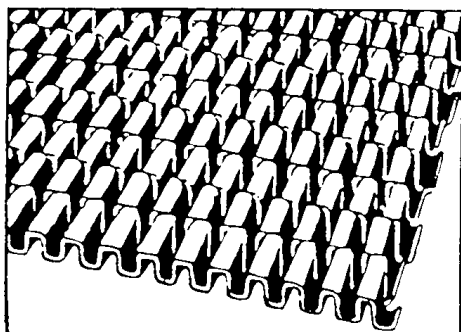
The principal types are plain, serrated and herringbone as illustrated in Figure 1-6. Plain and herringbone fins may also be perforated as illustrated. For the thermal and hydraulic behaviour of each fin-type refer to Chapter 7 of these Standards.



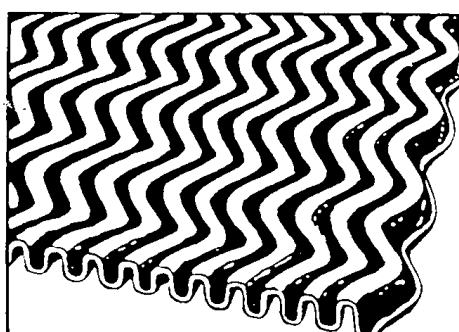
Plain fins



Plain-perforated fins



Serrated fins



Herringbone or wavy fins

Figure 1-6: Principal Types of Fin

1.2.6.2 Dimensions of fins

Each type of fin is characterised by its height, h , thickness, t , and pitch, p , or by the number of fins per inch (FPI) as shown in Figure 1-7. Additionally, specification is required for the percentage perforation of perforated fins, (e.g. 5% of corrugated area); for l_s , the length of the serration of serrated fins, and for the distance between crests on herringbone fins.

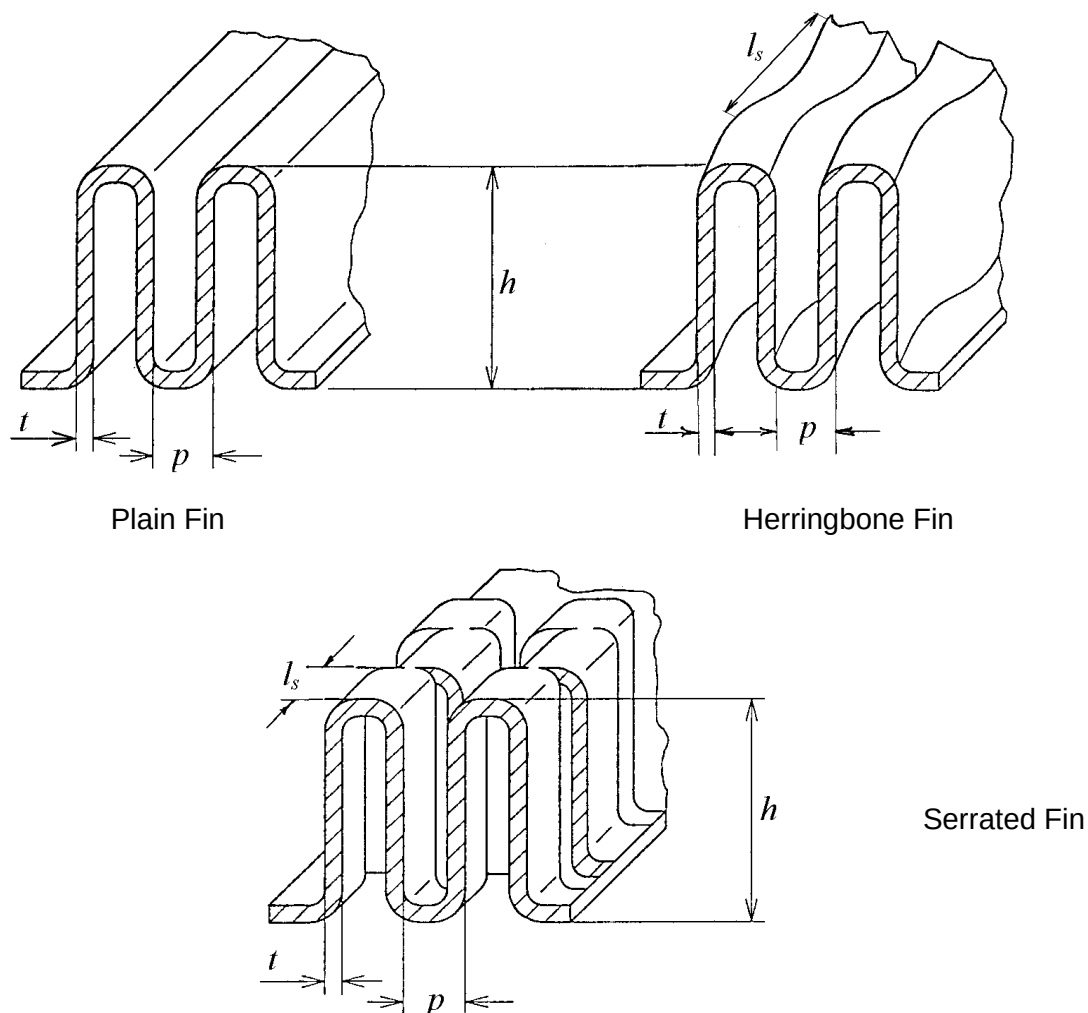


Figure 1-7: Definition of Fin Dimensions

1.2.7 Distributors

There are various distributor types available for streams entering or leaving a block.

The principal distributor types are:

- side distributor (mitred or diagonal)
- end distributor (left, right or central)
- intermediate distributor (special)

Some typical examples are shown in Figure 1-8. Manufacturers may offer other designs.

Special designs of distributor are offered for two-phase streams entering a block (Reference 4).

CHAPTER 1

General Description and Nomenclature

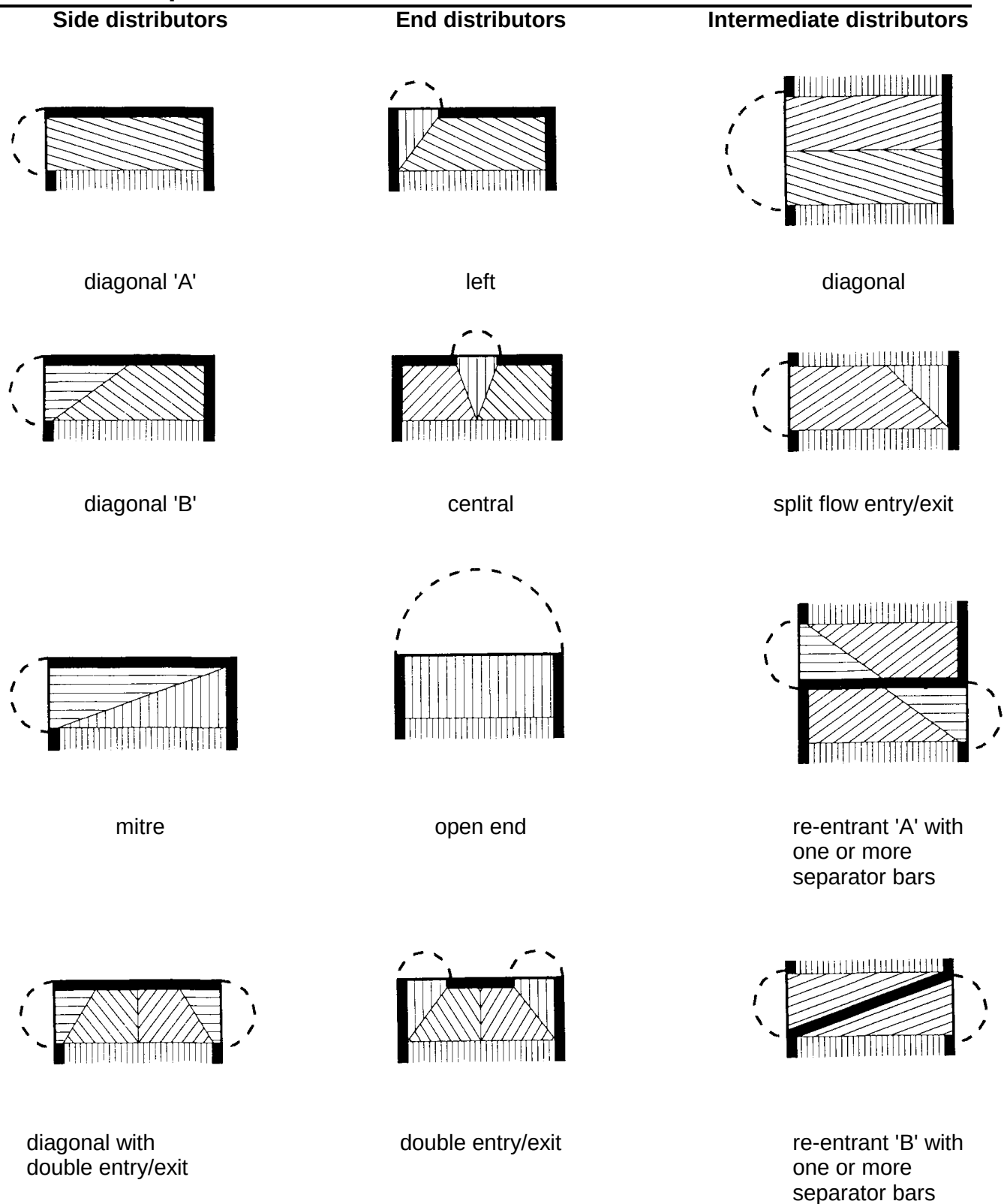


Figure 1-8: Examples of the Principal Distributor Types

1.2.8 Flow Arrangements

Figure 1-9a illustrates the structure of an individual layer. Internal distributor fins (1) conduct the stream from the narrow entry port across the full width of the layer to the heat transfer fins (2). Distribution fins (3) then conduct the stream to the exit port.

Figure 1-9b illustrates the fin arrangement of a layer with an intermediate port (see also Figure 1-8). Various arrangements of the layers for each of the streams provide various possible flow arrangements, as shown in Figure 1-10. Manufacturers may offer further arrangements.

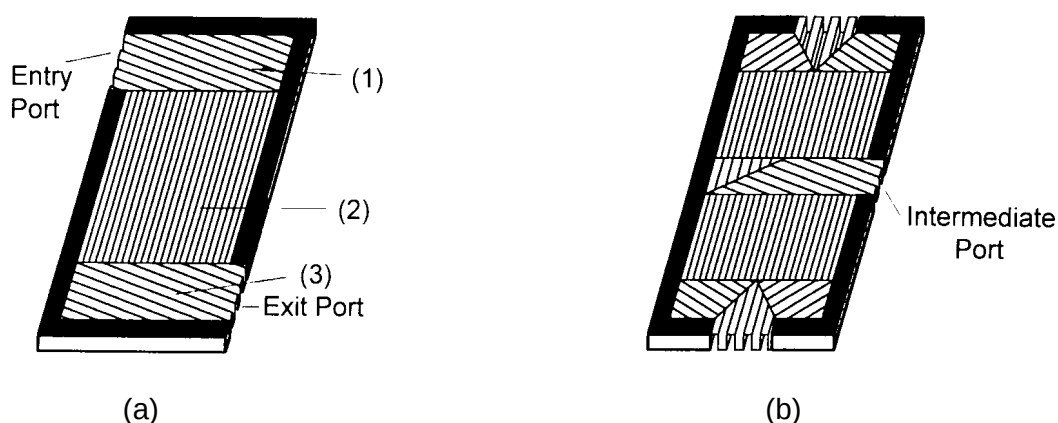


Figure 1-9: Structure of an Individual Layer

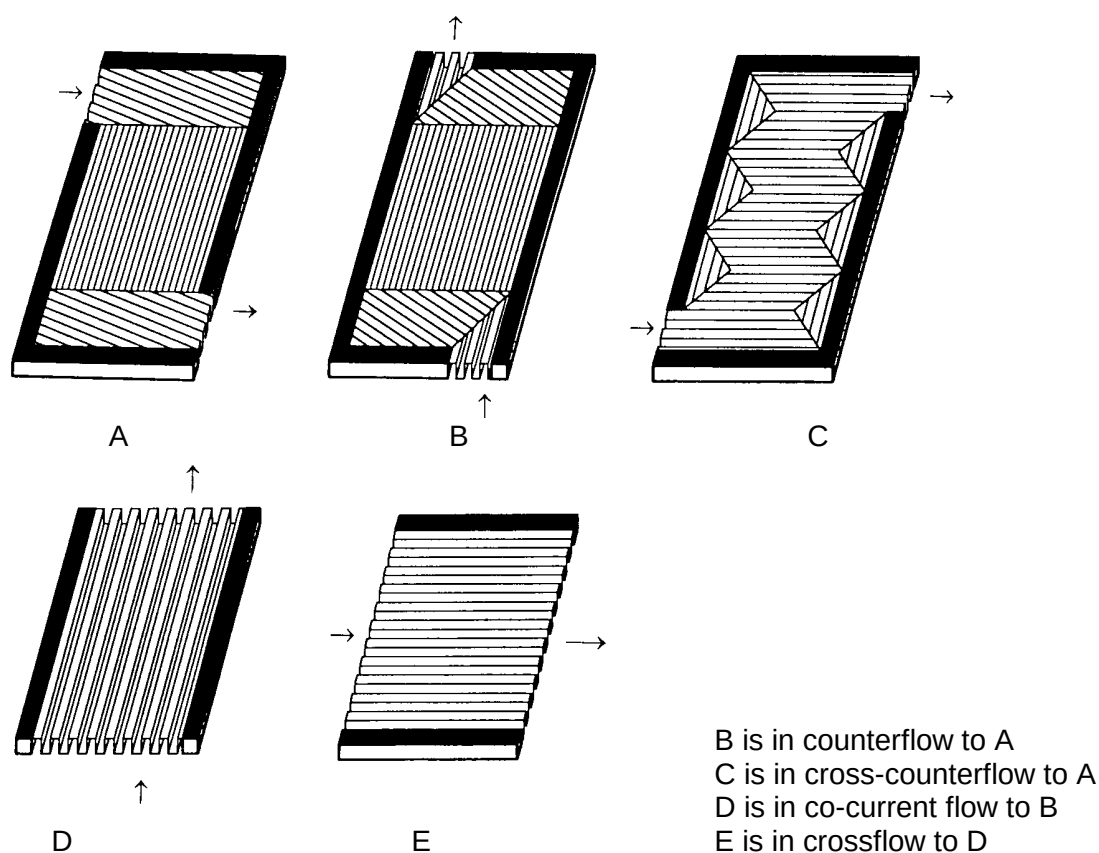


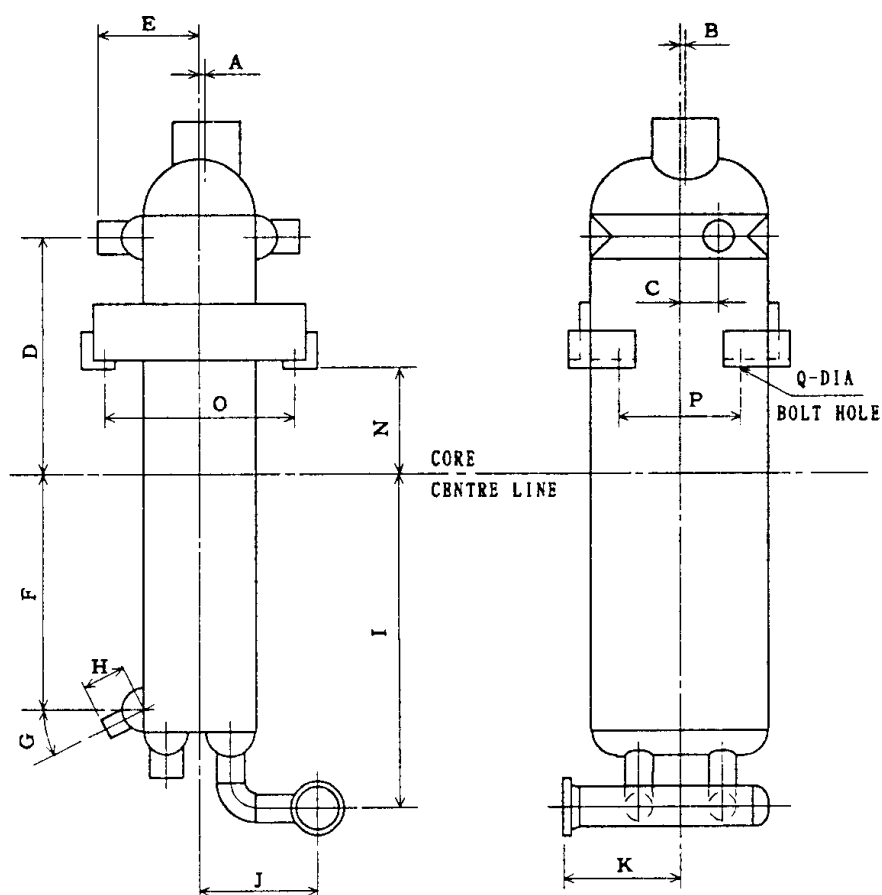
Figure 1-10: Flow Arrangements

2 TOLERANCES

Standard tolerances for the external dimensions of brazed aluminium plate-fin heat exchangers are shown in Figure 2-1 and Figure 2-2. The core centre line (Figure 2-1) and the base line of supports (Figure 2-2) are used here as datum lines to illustrate these dimensions. However, manufacturers may use other reference datum lines. The purchaser and manufacturer may adopt other tolerance values upon agreement.

Figure 2-3 shows the tolerances for a manifolded assembly of two cores. Here, the base line of the supports may also be used as a datum line as shown in Figure 2-2. Details for flanges are also shown in Figure 2-3.

For spare and replacement exchangers these tolerances shall also be applied.

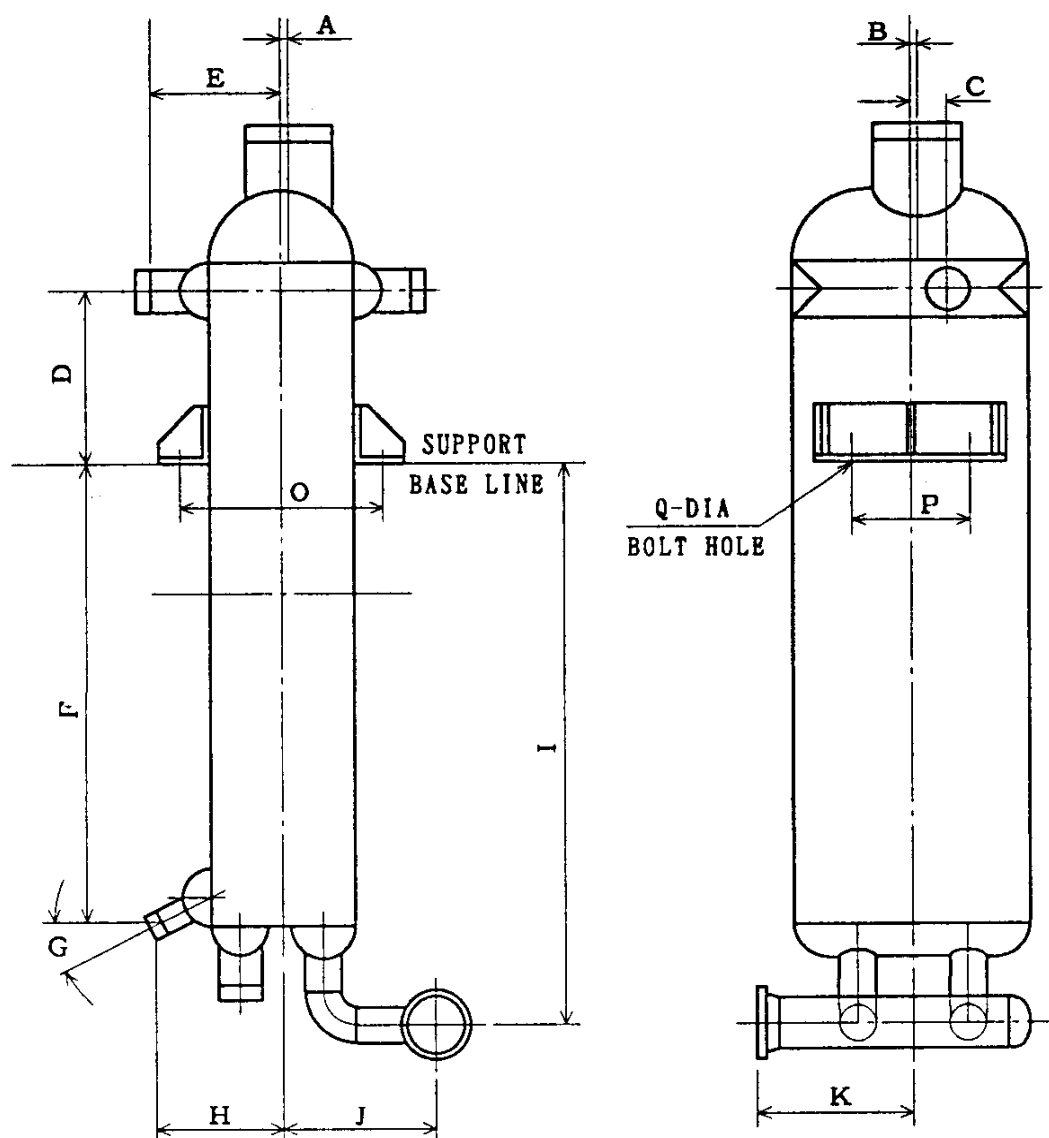


ITEMS	TOLERANCES	ITEMS	TOLERANCES
A, B, C, D, E, F	$\pm 6\text{mm}$ for $\text{Dim} \leq 1000\text{mm}$ $\pm 8\text{mm}$ for $1000\text{mm} < \text{Dim} \leq 2000\text{mm}$ $\pm 10\text{mm}$ for $\text{Dim} > 2000\text{mm}$	H, I, J, K	$\pm 6\text{mm}$ for $\text{Dim} \leq 1000\text{mm}$ $\pm 8\text{mm}$ for $1000\text{mm} < \text{Dim} \leq 2000\text{mm}$ $\pm 10\text{mm}$ for $\text{Dim} > 2000\text{mm}$
G	$\pm 3^\circ$	N, O, P	$\pm 3\text{mm}$
		Q	$\pm 1\text{mm}$

Figure 2-1: Important External Dimensions of One Core using the Core Centre Line

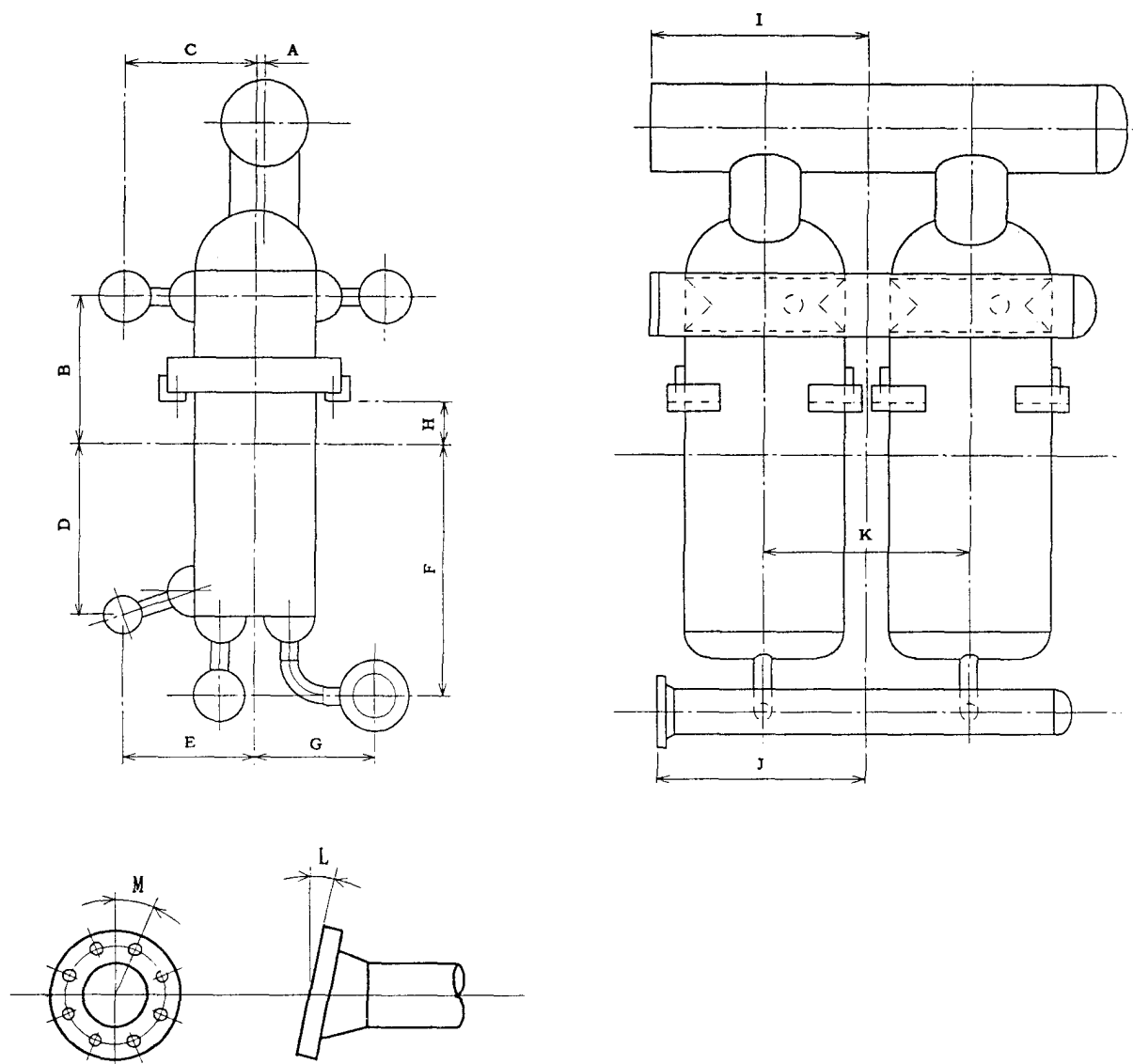
CHAPTER 2

Tolerances



ITEMS	TOLERANCES	ITEMS	TOLERANCES
A, B, C, D, E, F	$\pm 6\text{mm}$ for $\text{Dim} \leq 1000\text{mm}$ $\pm 8\text{mm}$ for $1000\text{mm} < \text{Dim} \leq 2000\text{mm}$ $\pm 10\text{mm}$ for $\text{Dim} > 2000\text{mm}$	H, I, J, K	$\pm 6\text{mm}$ for $\text{Dim} \leq 1000\text{mm}$ $\pm 8\text{mm}$ for $1000\text{mm} < \text{Dim} \leq 2000\text{mm}$ $\pm 10\text{mm}$ for $\text{Dim} > 2000\text{mm}$
G	$\pm 3^\circ$	N, O, P	$\pm 3\text{mm}$
		Q	$\pm 1\text{mm}$

Figure 2-2: Important External Dimensions of One Core using the Support Base Line



ITEMS	TOLERANCES	ITEMS	TOLERANCES
A, B, C, D, E, F, G	$\pm 6\text{mm}$ for $\text{Dim} \leq 1000\text{mm}$ $\pm 8\text{mm}$ for $1000\text{mm} < \text{Dim} \leq 2000\text{mm}$ $\pm 10\text{mm}$ for $\text{Dim} > 2000\text{mm}$	I, J, K	$\pm 6\text{mm}$ for $\text{Dim} \leq 1000\text{mm}$ $\pm 8\text{mm}$ for $1000\text{mm} < \text{Dim} \leq 2000\text{mm}$ $\pm 10\text{mm}$ for $\text{Dim} > 2000\text{mm}$
H	$\pm 3\text{mm}$	L	$\pm 1^\circ$; max 5mm at flange periphery
		Q	$\pm 1^\circ$; max 5mm at bolt circle

Figure 2-3: Important External Dimensions of a
Manifolded Assembly of Two Cores: General Flange Details

