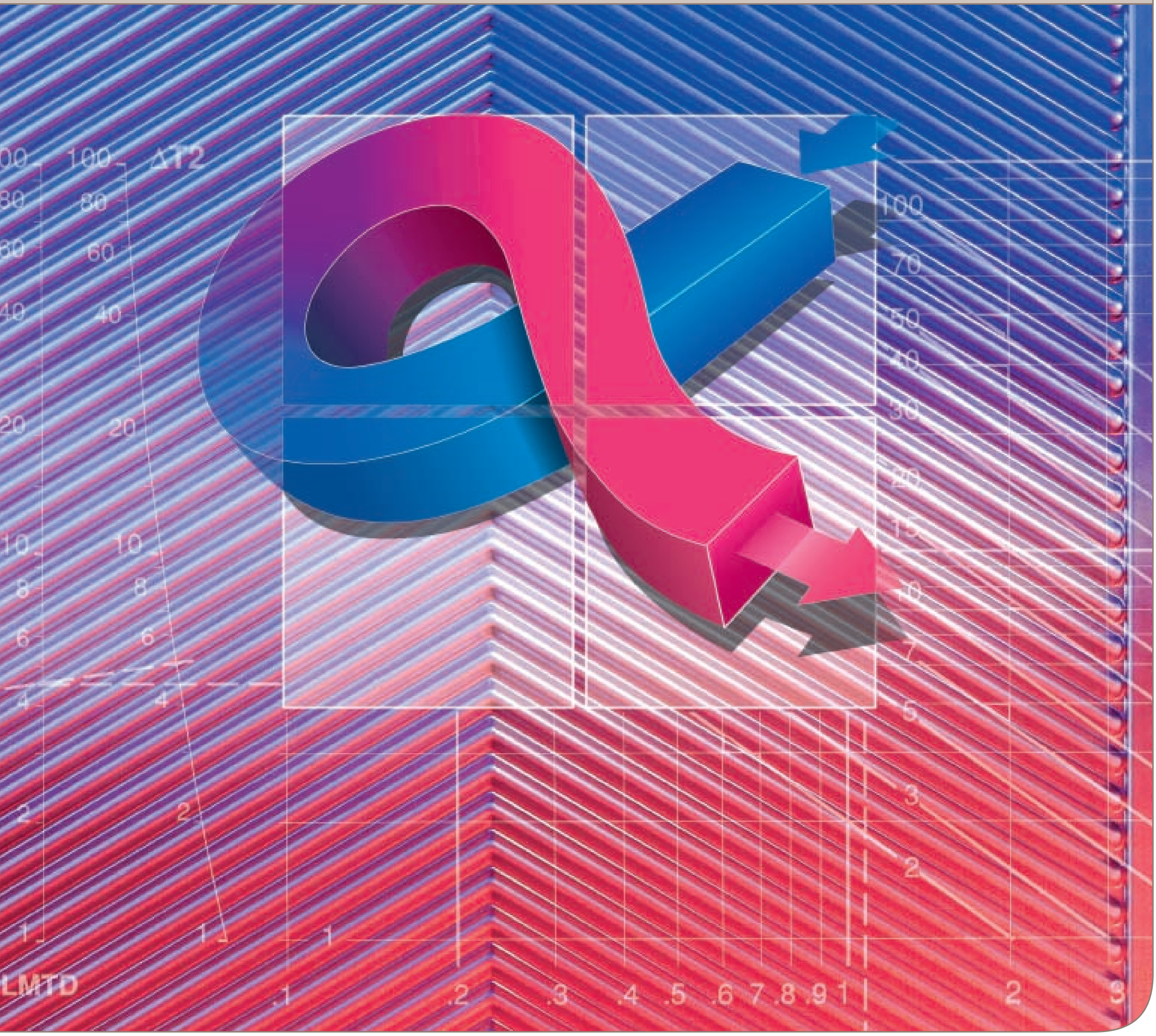
The theory behind heat transfer

Plate heat exchangers



Inside view

Heat transfer theory

The natural laws of physics always allow the driving energy in a system to flow until equilibrium is reached. Heat leaves the warmer body or the hottest fluid, as long as there is a temperature difference, and will be transferred to the cold medium.

A heat exchanger follows this principle in its endeavour to reach equalisation. With a plate type heat exchanger, the heat penetrates the surface, which separates the hot medium from the cold one very easily. It is therefore possible to heat or cool fluids or gases which have minimal energy levels.

The theory of heat transfer from one media to another, or from one fluid to another, is determined by several basic rules.

- Heat will always be transferred from a hot mediumto a cold medium.
- There must always be a temperature difference between the media.
- The heat lost by the hot medium is equal to the amount of heat gained by the cold medium, except for losses to the surroundings.

Heat exchangers

A heat exchanger is a piece of equipment that continually transfers heat from one medium to another in order to carry process energy.
There are two main types of heat exchangers.

- Direct heat exchanger, where both media between which heat is exchanged are in direct contact with each other. It is taken for granted that the media are not mixed together.

An example of this type of heat exchanger is a cooling tower, where water is cooled through direct contact with air.

- Indirect heat exchanger, where both media are separated by a wall through which heat is transferred.

Heat transfer theory

Heat can be transferred by three methods.

Radiation - Energy is transferred by electromagnetic radiation. One example is the heating of the earth by the sun.

Conduction - Energy is transferred between solids or stationary fluids by the movement of atoms or molecules.

Convection - Energy is transferred by mixing part of a medium with another part.

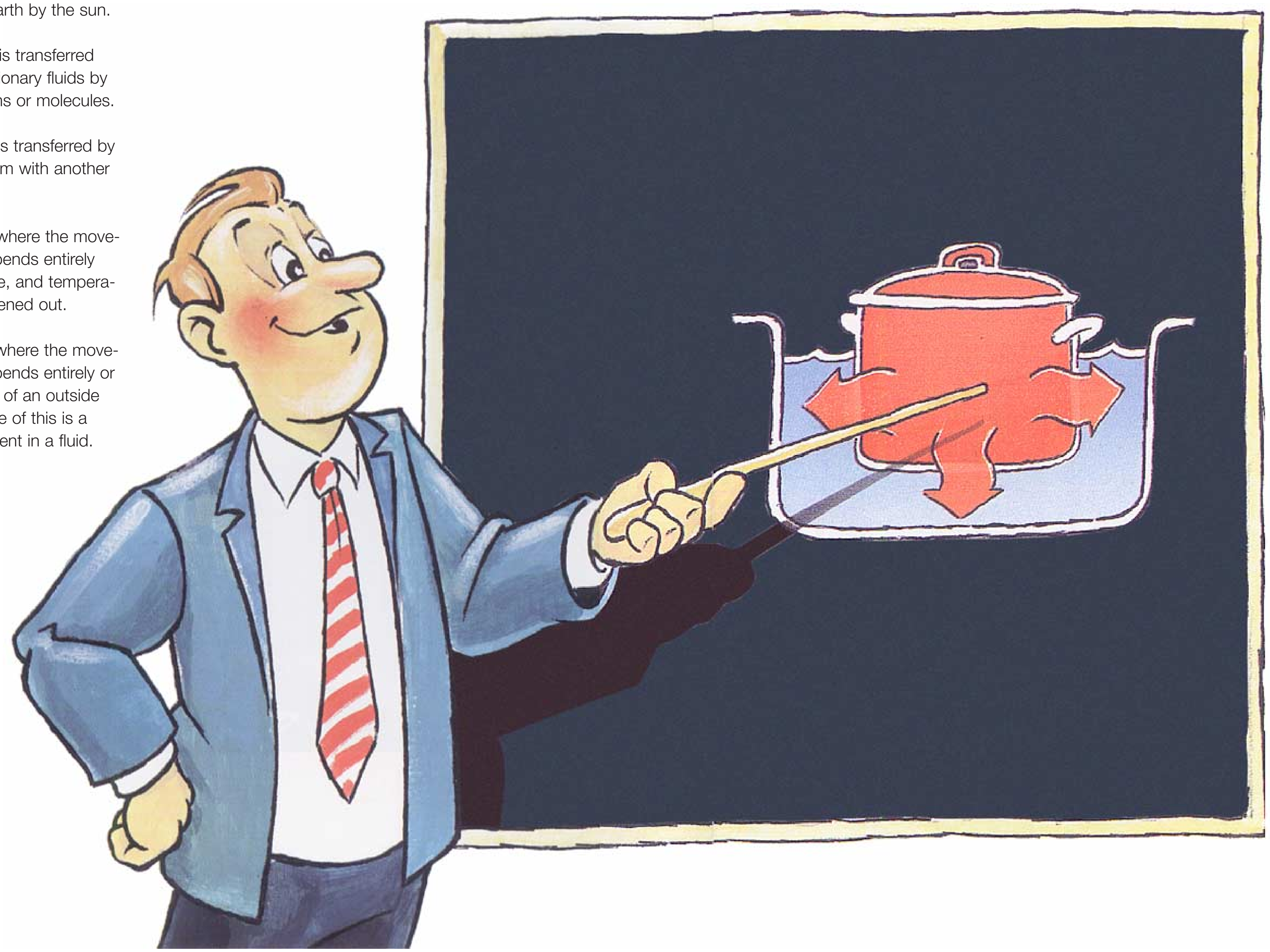
– Natural convection, where the movement of the media depends entirely upon density difference, and temperature differences are evened out.

– Forced convection, where the movement of the media depends entirely or partly upon the results of an outside influence. One example of this is a pump causing movement in a fluid.

Heat exchanger types

In this brochure only indirect heat exchangers are discussed, i.e. those where the media are not mixed, but where the heat is transferred through heat transfer surfaces.

Temperature losses through radiation can be disregarded when considering heat exchangers in this brochure.



Indirect heat exchangers are available in several main types - Plate - Shell&Tube - Spiral etc. In most cases the plate type is the most efficient heat exchanger. Generally it offers the best solution to thermal problems, giving the widest pressure and temperature limits within the constraint of current equipment.

The most notable advantages of a plate heat exchanger are:

Thin material for the heat transfer surface -this gives optimum heat transfer, since the heat only has to penetrate thin material.

High turbulence in the medium -this gives a higher convection, which results in efficient heat transfer between the media. The consequence of this higher heat transfer coefficient per unit area is not only a smaller surface area requirement but also a more efficient plant.

The high turbulence also gives a self-cleaning effect. Therefore, when compared to the traditional shell and tube heat exchanger, the fouling of the heat transfer surfaces is considerably reduced. This means that the plate heat exchanger can remain in service far longer between cleaning intervals.

Flexibility - the plate heat exchanger consists of a framework containing several heat transfer plates. It can easily be extended to increase capacity. Furthermore, it is easy to open for the purpose of cleaning. (This only applies to gasketed heat exchangers, and not to brazed units.)

Variable thermal length - most of the plate heat exchangers manufactured by Alfa Laval are available with two different pressing patterns. When the plate has a narrow pattern, the pressure drop is higher and the heat exchanger is more effective. This type of heat exchanger has a long thermal channel.

When the plate has a wide pattern, the pressure drop is smaller and the heat transfer coefficient is accordingly somewhat smaller. This type of heat exchanger has a short thermal channel.

When two plates of different pressing patterns are placed next to each other, the result is a compromise between long and short channels as well as between pressure drop and effectiveness.

Calculation method

To solve a thermal problem, we must know several parameters. Further data can then be determined. The six most important parameters are as follows:

- The amount of heat to be transferred (heat load).
- The inlet and outlet temperatures on the primary and secondary sides.
- The maximum allowable pressure drop on the primary and secondary sides.
- The maximum operating temperature.
- The maximum operating pressure.

If the flow rate, specific heat and temperature difference on one side are known, the heat load can be calculated. See also page 10.

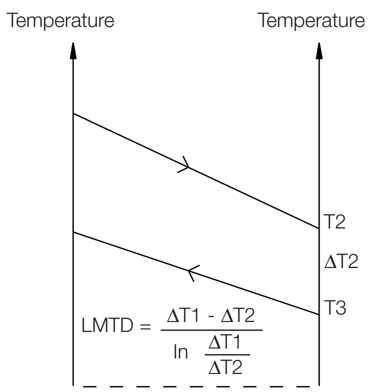
The diagram on page 16 makes selection very simple, giving the type of exchanger required.

Temperature program

This means the inlet and outlet temperatures of both media in the heat exchanger.

T1 = Inlet temperature – hot side
T2 = Outlet temperature – hot side
T3 = Inlet temperature – cold side
T4 = Outlet temperature – cold side

The temperature program is shown in the diagram below.



Heat load

Disregarding heat losses to the atmosphere, which are negligible, the heat lost (heat load) by one side of a plate heat exchanger is equal to the heat gained by the other. The heat load (P) is expressed in kW or kcal/h.

Logarithmic mean temperature difference

Logarithmic mean temperature difference (LMTD) is the effective driving force in the heat exchanger. See diagram on page 6.

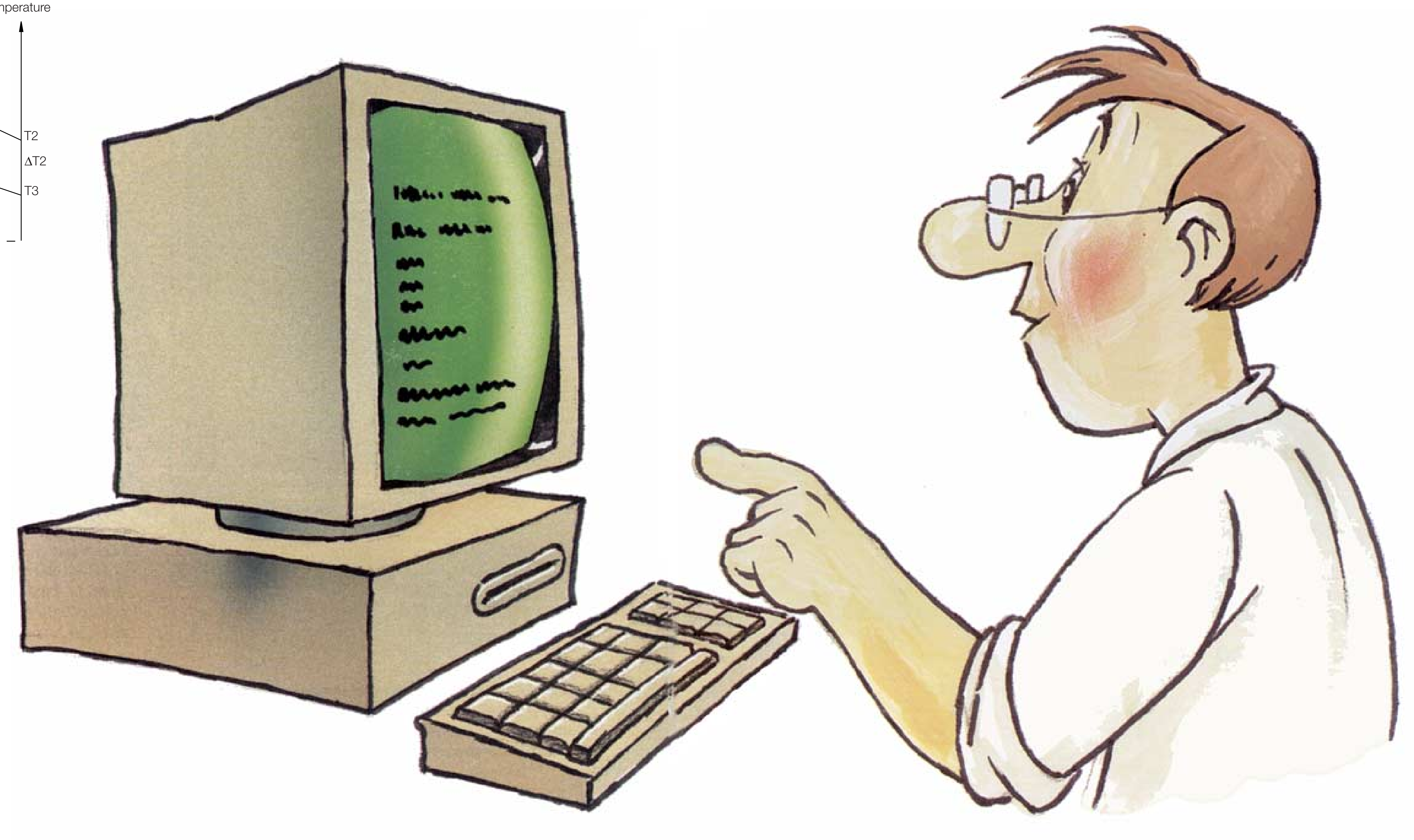
Thermal Length

Thermal length (Θ) is the relationship between temperature difference δt on one side and LMTD.

$$\Theta = \frac{\delta t}{LMTD}$$

Density

Density (ρ) is the mass per unit volume and is expressed in kg/m^3 or kg/dm^3.



Flow rate
This can be expressed in two different terms, either by weight or by volume. The units of flow by weight are in kg/s or kg/h, the units of flow by volume in m^3/h or l/min. To convert units of volume into units of weight, it is necessary to multiply the volume flow by the density. See page 16.

The maximum flow rate usually determines which type of heat exchanger is the appropriate one for a specific purpose. Alfa Laval plate heat exchangers can be used for flow rates from 0.05 kg/s to 1,000 kg/s. In terms of volume, this equates to 0.18 m^3/h to 3,600 m^3/h. The maximum flow for plate heat exchangers in this brochure is 1,000 kg/s or 3,600 m^3/h. If the flow rate is in excess of this, please consult your local Alfa Laval representative.

Pressure drop
Pressure drop (Δp) is in direct relationship to the size of the plate heat exchanger. If it is possible to increase the allowable pressure drop, and incidentally accept higher pumping costs, then the heat exchanger will be smaller and less expensive. As a guide, allowable pressure drops between 20 and 100 kPa are accepted as normal for water/water duties.

Fouling
Fouling allowance (Rf) can be expressed either as an additional percentage of heat transfer area, or as a fouling factor expressed in the units m^2 °C/W or m^2h°C/kcal.

A plate heat exchanger is designed with higher turbulence than a shell and tube exchanger, and this generally means a lower fouling allowance for the same duty. One could say that the margin included in a plate heat exchanger is normally 15%, or 0,000025 m^2 °C/W (0.00003 m^2h°C/kcal).

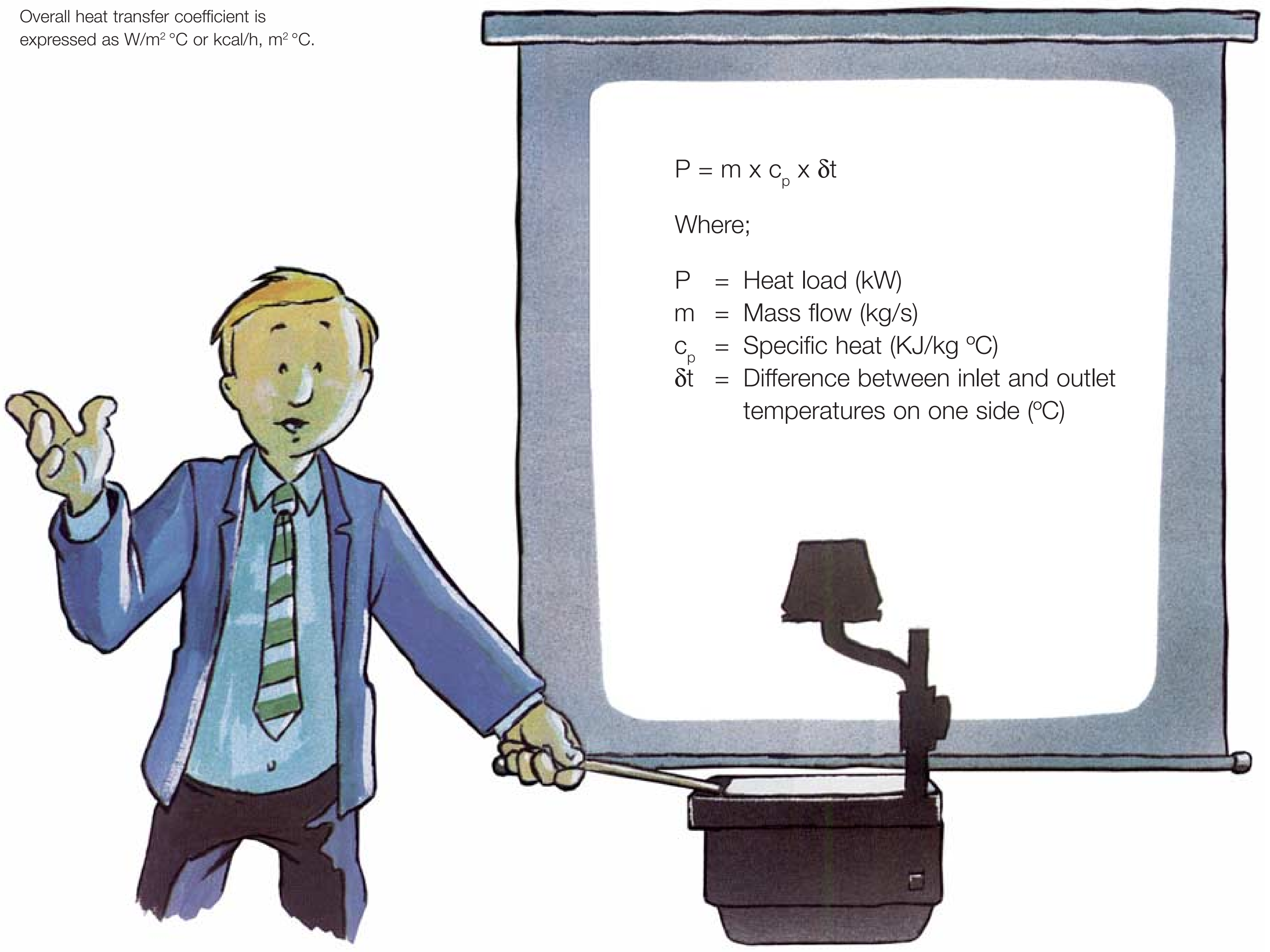
Specific heat
Specific heat (c_p) is the amount of energy required to raise 1 kg of a substance by one degree centigrade. The specific heat of water at 20 °C is 4.182 kJ/kg °C or 1.0 kcal/kg °C.

Viscosity
Viscosity is a measure of the ease of flow of a liquid. The lower the viscosity, the more easily it flows.

Viscosity is expressed in centipoise (cP) or centi-stokes (cSt).

Overall heat transfer coefficient
Overall heat transfer coefficient (k) is a measure of the resistance to heat flow, made up of the resistances caused by the plate material, amount of fouling, nature of the fluids and type of exchanger used.

Overall heat transfer coefficient is expressed as W/m^2 °C or kcal/h, m^2 °C.



Calculation method

Method of Calculation

The heat load of a heat exchanger can be derived from the following two formulas:

$$P = m \cdot c_p \cdot \delta t \quad (m = \frac{P}{c_p \cdot \delta t}\ ;\ \delta t = \frac{P}{m \cdot c_p})$$

$$P = k \cdot A \cdot LMTD$$

Where:

- P = heat load (kW)
- m = mass flow rate (kg/s)
- c_p = specific heat (kJ/kg °C)
- δt = temperature difference between inlet and outlet on one side (°C)
- k = total overall heat transfer coefficient (W/m^2 °C)
- A = heat transfer area (m^2)
- LMTD = log mean temperature difference

$$\Theta = \text{Theta-value} \quad \Theta = \frac{\delta t}{LMTD} = \frac{k \cdot A}{m \cdot c_p}$$

T1 = Temperature inlet – hot side
T2 = Temperature outlet – hot side
T3 = Temperature inlet – cold side
T4 = Temperature outlet – cold side

LMTD can be calculated either by using the diagram on page 17, where ΔT1 = T1–T4 and ΔT2 = T2–T3, or by using the following formula

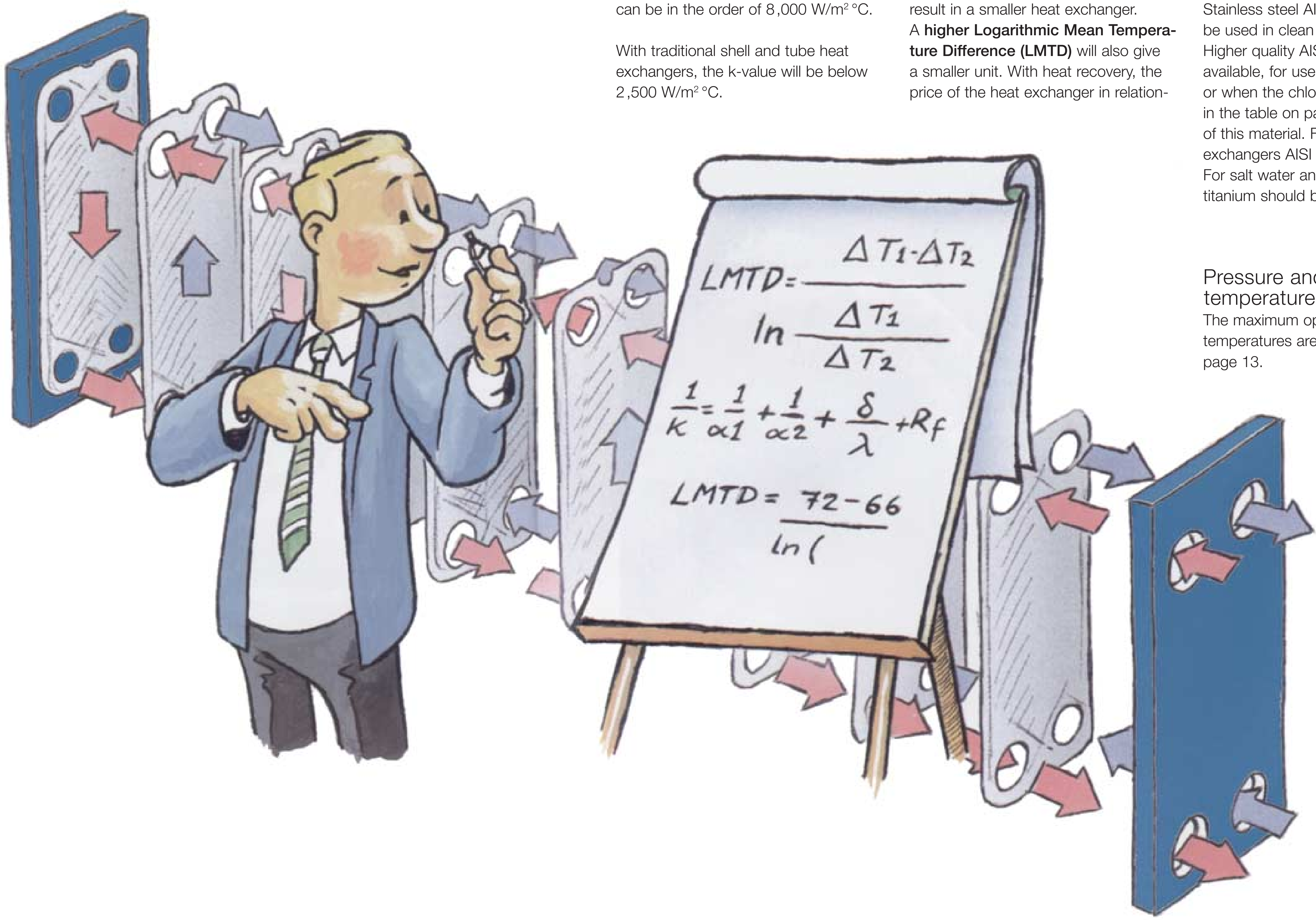
$$LMTD = \frac{\Delta T1 - \Delta T2}{\ln \frac{\Delta T1}{\Delta T2}}$$

The total overall heat transfer coefficient k is defined as:

$$\text{Where:} \quad \frac{1}{k} = \frac{1}{\alpha_1} + \frac{1}{\alpha_2} + \frac{\delta}{\lambda} + Rf$$

- α_1 = The heat transfer coefficient between the warm medium and the heat transfer surface (W/m^2 °C)
- α_2 = The heat transfer coefficient between the heat transfer surface and the cold medium (W/m^2 °C)
- δ = The thickness of the heat transfer surface (m)
- Rf = The fouling factor (m^2 °C/W)
- λ = The thermal conductivity of metal (W/m °C)

Every parameter in the equation beside can influence the choice of heat exchanger. The choice of materials does not normally influence the efficiency, only the strength and corrosion properties of the unit.



In a plate heat exchanger, we have the advantages of small temperature differences and plate thicknesses of between 0.3 and 0.6 mm. The alpha values are a product of the very high turbulence, and the fouling factors are usually very small. This gives a k-value which under favourable circumstances can be in the order of 8,000 W/m^2 °C.

With traditional shell and tube heat exchangers, the k-value will be below 2,500 W/m^2 °C.

An important parameter that can be influenced to reduce the size, and therefore the price, of the heat exchanger is to use the highest possible allowable pressure drop, as well as the LMTD.

A **higher pressure drop** will usually result in a smaller heat exchanger. A **higher Logarithmic Mean Temperature Difference (LMTD)** will also give a smaller unit. With heat recovery, the price of the heat exchanger in relationship to the amount of heat recovered is of great significance, since a profit must be realised to make the project worthwhile.

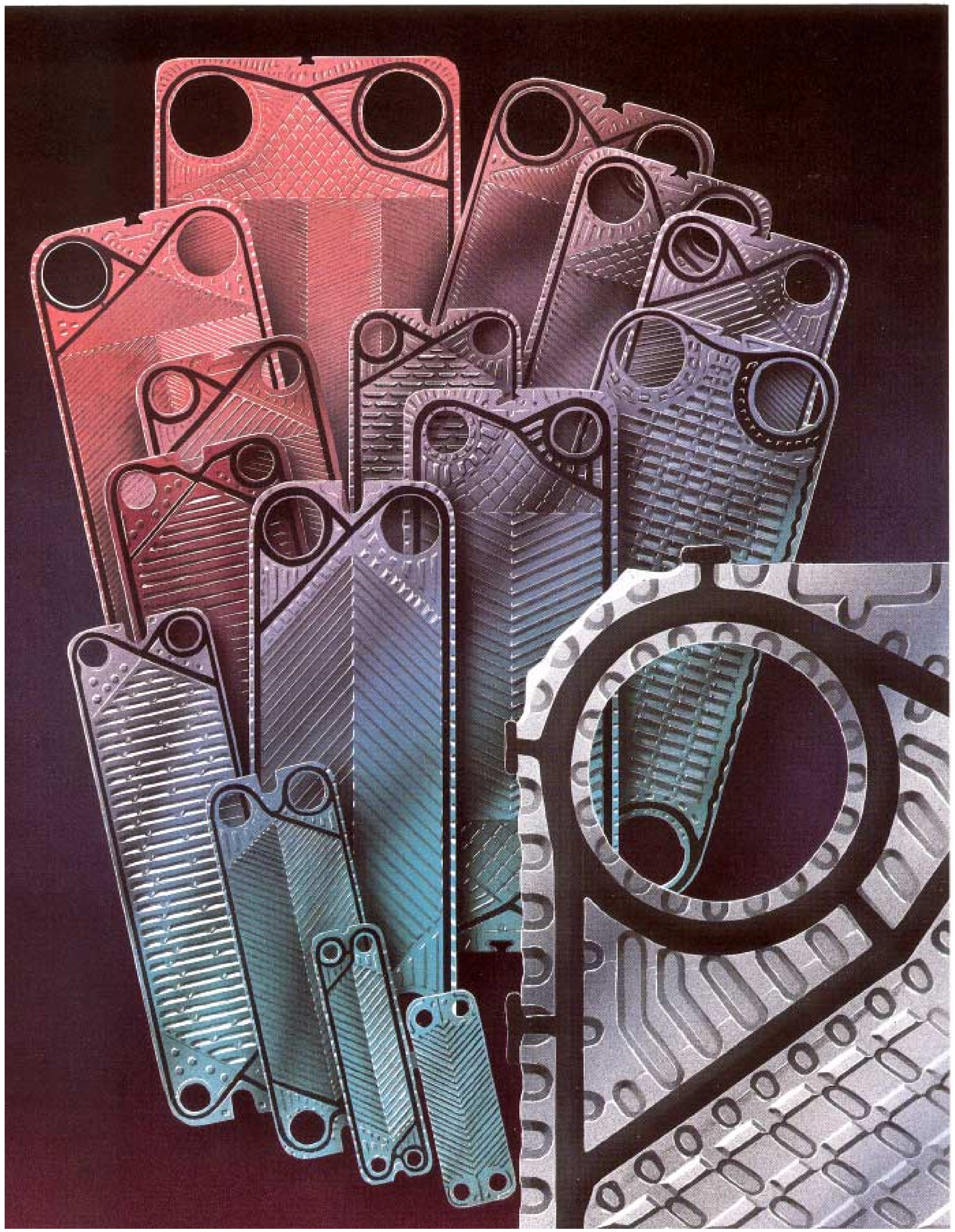
Construction materials

Stainless steel AISI 304 (1.4301) can be used in clean water applications. Higher quality AISI 316 (1.4401) is also available, for use with problem cases, or when the chloride content as shown in the table on page 15 requires the use of this material. For brazed plate heat exchangers AISI 316 is always used. For salt water and brackish water only titanium should be used.

Pressure and temperature limitations

The maximum operating pressure and temperatures are shown in the table on page 13.

Product range



The plate heat exchangers in this brochure are suitable for the majority of relatively uncomplicated heat transfer jobs using water, oil or glycol as the media.

When it comes to the effectiveness of heat transfer and economical operation, the plate heat exchanger is unsurpassed in HVAC, refrigeration, sanitary water heating, district as well as industrial heating and cooling applications.

Our product range of heat exchangers is extensive. The AV280 is the largest unit, with a maximum surface area of 1,700 m^2 and a maximum flow rate of 800 kg/s. This is most suitable for larger jobs such as central cooling applications.

The smallest unit is the CB14, which is brazed, very compact and ideal for jobs involving higher pressures and temperatures, with a maximum heat transfer surface of 0.7 m^2. The unit is suitable for domestic water heating, hydraulic oil cooling and refrigerant evaporation and condensation.

Every single heat exchanger in the catalogue can perform a range of duties. Applications include the heating and cooling of different fluids in factories, process cooling in steelworks, components in air conditioning equipment, heat exchangers in district heating systems or water heating in blocks of flats or hotels. The list of applications is considerable. Not all types of our heat exchangers are included in this brochure. If you require more information, please do not hesitate to contact us.

Heat exchanger	AV280	M30	MX25	M20	TS20
Max. flow rate m^3/h	2,800	1,800	900	720	690
Max. surface area m^2	1,700	1,325	940	510	85
Max. operating pressure MPa	16	2.5	2.5	2.5	30
Max. operating temperature °C	150	130	150	130	180

Heat exchanger type	M15	M10	TS6	M6	M3	CB300*	CB200*	CB77*	CB52*	CB27*	CB14*
Max. flow rate m^3/h	290	180	72	54	14	140/60	102	34/63	7.5/12.7	7.5/12.7	3.6
Max. surface area m^2	390	105	13	38	4	70	44	19	7.5	3.75	0.7
Max. operating pressure MPa	25	25	25	25	16	16/25	16	27/20	30/28	30/28	30
Max. operating temperature °C	150	170	180	170	130	225	225	225	225	225	225

*) Basic brazed heat exchangers. Alfa Laval also have the AlfaChill, Combidryer, Dedicated Oil Cooler (DOC) and the Nickel brazed (NB) heat exchanger.

Applications

Applications

Although the principle of heat transfer is the same irrespective of the medium used, we must differentiate the applications from each other. Most duties fall into three main applications, which are included in our brochure. These applications are described below. This is where your choice of heat exchanger starts.

Water/Water

The largest part of our production of heat exchangers is used for water/water duties, i.e. water heated or cooled with water. This can be achieved by different methods:

Water must be cooled
Here, water with a lower temperature is used, for example from a cooling tower, lake, river or sea.

Water must be heated
Here, water with a higher temperature is used, for example district heating, boiler or hot process water.

Some typical uses of plate heat exchangers
- District heating
- Tap water heating
- Swimming pool heating
- Heat recovery (engine cooling)
- Temperature control of fish farms
- Steel industry – furnace cooling
- Power industry – central cooling
- Chemical – industry – process cooling

Plate material

Chloride content	Maximum temperature 60 °C	80 °C	100 °C	120 °C
10 ppm	304	304	304	316
25 ppm	304	304	316	316
50 ppm	316	316	316	Ti
80 ppm	316	316	316	Ti
150 ppm	316	Ti	Ti	Ti
300 ppm	Ti	Ti	Ti	Ti
> 300 ppm	Ti	Ti	Ti	Ti
Gasket material	Nitrile			
	EPDM			

Water/Oil

In some industries, oil has to be cooled using water. There are two main groups of oils:

- Mineral oil
- Synthetic oil

Mineral oils
Generally, mineral oils do not contain large amounts of aromatics.
Examples of mineral oils are:
- Hydraulic oils
- Lubricating oils
- Motor oils
- Oils used within manufacturing industries

Some typical uses of plate heat exchangers
- Hydraulic oil cooling
- Quench oil cooling
- Cooling of motor oil in engine test beds.

With synthetic oil it may be necessary to use special gaskets. Please contact Alfa Laval for these applications.

Plate heat exchangers can function with oils having viscosities as high as 2,500 centipoise. Emulsions can also be used in plate heat exchangers, and can be treated like water when concentrations are below 5%.

Plate material

Chloride content	Maximum temperature 60 °C	80 °C	100 °C	120 °C
10 ppm	304	304	304	316
25 ppm	304	304	316	316
50 ppm	316	316	316	Ti
80 ppm	316	316	316	Ti
150 ppm	316	Ti	Ti	Ti
300 ppm	Ti	Ti	Ti	Ti
> 300 ppm	Ti	Ti	Ti	Ti
Gasket material	Nitrile			

Water/Glycol

When there is a risk of freezing, add glycol to the water.

Glycol has a different heat capacity from water and therefore needs a somewhat larger heat transfer area to perform the same duty. On the other hand, the physical properties of the various glycols are much the same. Examples of glycols are:

- Ethylene glycol (mono, di or tri)
- Propylene glycol.

Some typical uses of plate heat exchangers
- As an intercooler in a heat pump
- Chilled water production in food factories
- Cooling of air conditioning circuits
- Solar heating systems

Plate material

Chloride content	Maximum temperature 60 °C	80 °C	100 °C	120 °C
10 ppm	304	304	304	316
25 ppm	304	304	316	316
50 ppm	316	316	316	Ti
80 ppm	316	316	316	Ti
150 ppm	316	Ti	Ti	Ti
300 ppm	Ti	Ti	Ti	Ti
> 300 ppm	Ti	Ti	Ti	Ti
Gasket material	Nitrile			
	EPDM			

Heat exchanger selection Water/Water

When the duty of the heat exchanger is known, it is possible to select the most suitable type by following the directions below. The table on the next page will show which type to use.

The following example illustrates the procedure:

Clarification of definitions is given on pages 10-11.

To determine the correct type of heat exchanger, the following information is required:

- The temperature programme °C
- The maximum flow rate (m) kg/s
- The heat load (P) kW.

Note! If only two of the above are known, the other can be found from the chart below. If the units are expressed in anything other than the above, then convert, using tables 1 and 2.

1. From the temperature programme, calculate T1, T2 and dt as follows.

   T1 = Hot water inlet temperature °C
   T2 = Hot water outlet temperature °C
   T3 = Cold water inlet temperature °C
   T4 = Cold water outlet temperature °C

   T1 = T1–T4
   T2 = T2–T3

   δt = T1–T2 (temperature difference of the media being cooled).

2. With the help of the diagram on page 17 using T1 and T2, read off the LMTD.

3. Project a line from the LMTD across to the point where it bisects the calculated δt. Project downwards from this point and read off the Θ-value. Project further downward until within the flow rate range. This will now show which types of heat exchanger will do the job.

4. Calculate $\frac{P}{LMTD} = \phi$

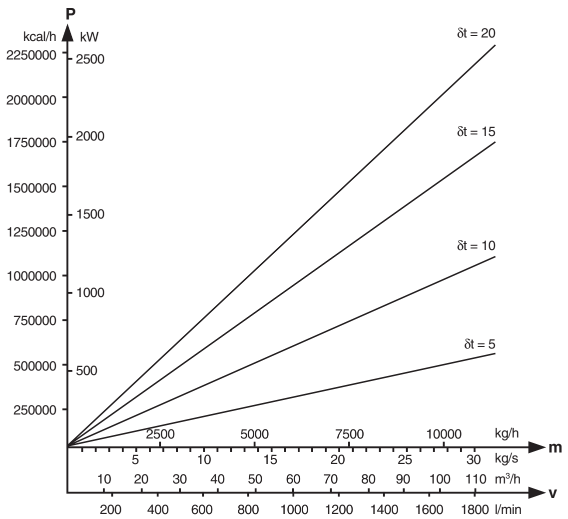
5. Using ϕ, decide whether the smallest size of heat exchanger is suitable from table 3. If not, the next larger type from the diagram on page 17 must be chosen.

1. Heat load

kW	kcal/h
1	8.6×10^2
1.16×10^{-3}	1

2. Water, mass and volume

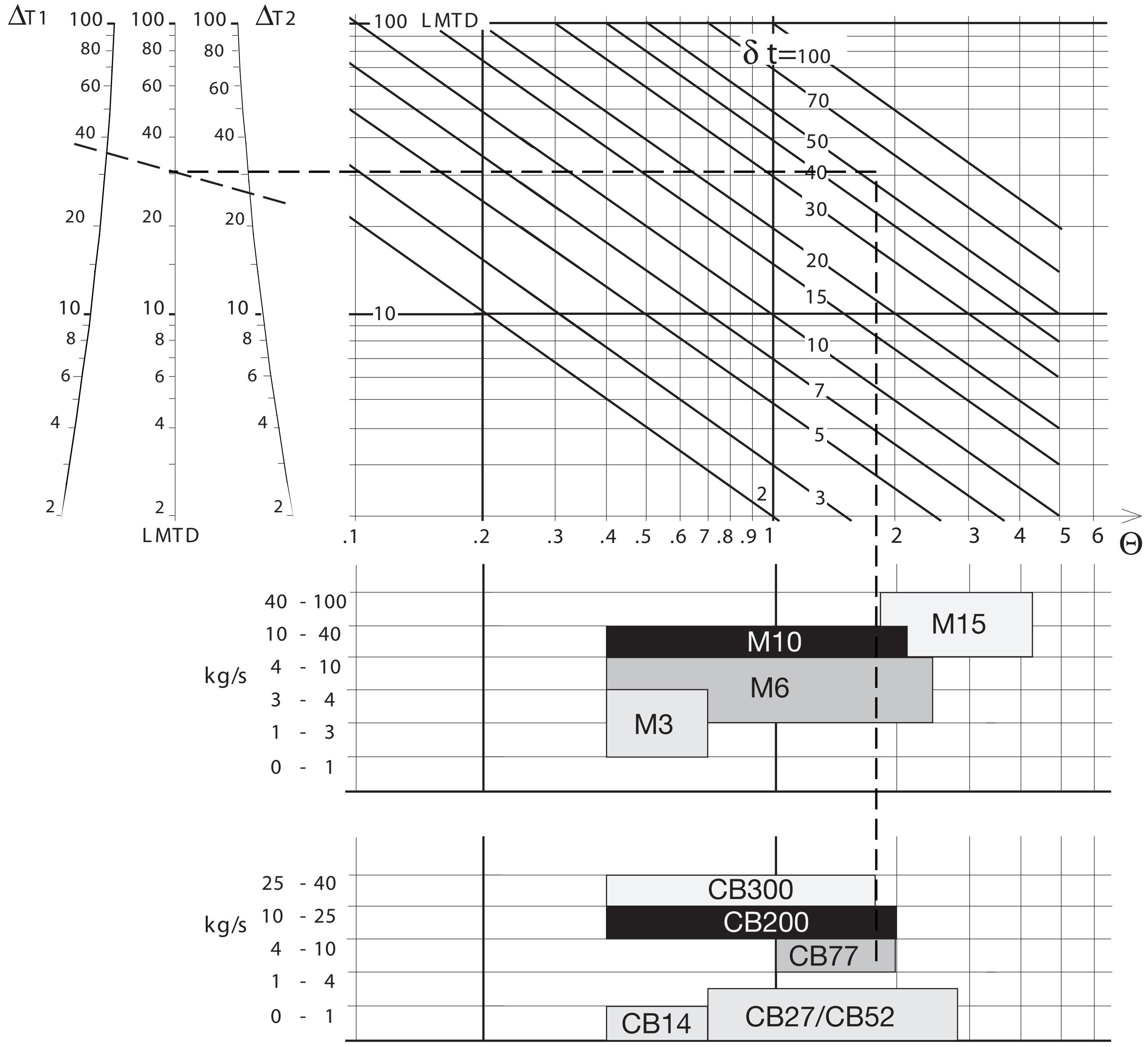
kg/s	Kg/h	m³/h	l/h
1	3,600	3.6	60
2.78×10^{-4}	1	1×10^{-3}	1.67×10^{-2}
0.28	1×10^3	1	16.67
1.67×10^{-2}	60	6.0×10^{-2}	1



Conversion table heat load-flowrate (water)

3.

ϕ Max	3	16	30	80	95	185	300	1,300
smallest size of heat exchanger	CB14	CB27	CB52 M3	CB77	M6	CB200	M10	M15 CB300



Example

Let us assume we are to heat 30 m³/h of water for domestic purposes from 10 °C to 55 °C. The primary supply available is 25 m³/h of boiler water at 90 °C cooled to 36 °C. The amount of heat to be transferred is 1,58l kW (see Page 10). The maximum allowable pressure drop is 35 kPa.

Firstly, the largest of the two flow rates must be expressed in SI-units, from m³/h to kg/s (see page 16).

30 m³/h = 8.4 kg/s.

Set out the temperature program.

T1 = 90 °C
T2 = 36 °C
T3 = 10 °C
T4 = 55 °C

1. ΔT1 = 90 – 55 = 35 °C
   ΔT2 = 36 – 10 = 26 °C
   δt = 90 – 36 = 54 °C

2. Read off the LMTD from the diagram (30.3 °C).

3. $\frac{P}{LMTD} = \frac{1,581}{30.3} = 52.2$: ϕ = 52.2

4. According to Table 3, the smallest possible heat exchanger is the CB77.

5. When Θ = 1.8, δt = 54 °C and m = 8.4 kg/s, it can be seen from the diagram below that types M6 or CB77 are suitable.

Heat exchanger selection Water/Oil

When the duty of the heat exchanger is known, it is possible to select the most suitable type by following the directions below. The table on the next page will show which type to use.

The following example illustrates the procedure:

Clarification of definitions is given on pages 10-11.

To determine the correct type of heat exchanger, the following information is required:

- The temperature programme °C
- The maximum flow rate (m) kg/s
- The heat load (P) kW

Note! If only two of the above are known, the other can be found from the chart below. If the units are expressed in anything other than the above, then convert, using tables 1 and 2.

1. From the temperature programme, calculate ΔT1, ΔT2 and δt as follows.

   T1 = Hot oil inlet temperature °C
   T2 = Hot oil outlet temperature °C
   T3 = Cold water inlet temperature °C
   T4 = Cold water outlet temperature °C

   ΔT1 = T1–T4
   ΔT2 = T2–T3

   δt = T1–T2 (temperature difference of the medium being cooled).

2. With the help of the diagram on page 19 using ΔT1 and ΔT2, read off the LMTD.

3. Project a line from the LMTD across to the point where it bisects the calculated δt. Project downwards from this point and read off the Θ-value. Project further downward until within the flow rate range. This will now show which types of heat exchanger will do the job.

4. Calculate $\frac{P}{LMTD} = \phi$

5. Using ϕ, decide whether the smallest size of heat exchanger is suitable from table 4. If not, the next larger type from the diagram on page 19 must be chosen.

1. Heat load

kW	kcal/h
1	8.6×10^{2}
1.16×10^{-3}	1
2.93×10^{-4}	0.25

2. Oil, mass and volume

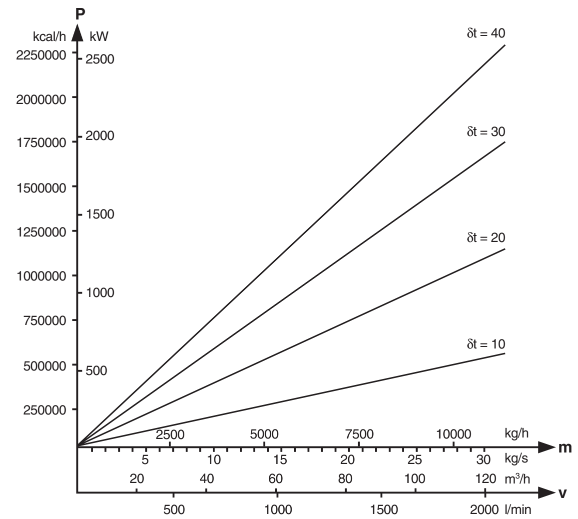
kg/s	Kg/h	g/h	m³/h	l/h
1	3,600	4.0×10^{6}	4.0	66.7
2.78×10^{-4}	1	10^{3}	1.1×10^{-3}	1.85×10^{-2}
2.78×10^{-7}	10^{-3}	1	10^{-6}	1.67×10^{-1}
0.25	0.9×10^{3}	10^{6}	1	16.67
1.5×10^{-2}	54	6×10^{4}	6.0×10^{-2}	1

3. Water, mass and volume

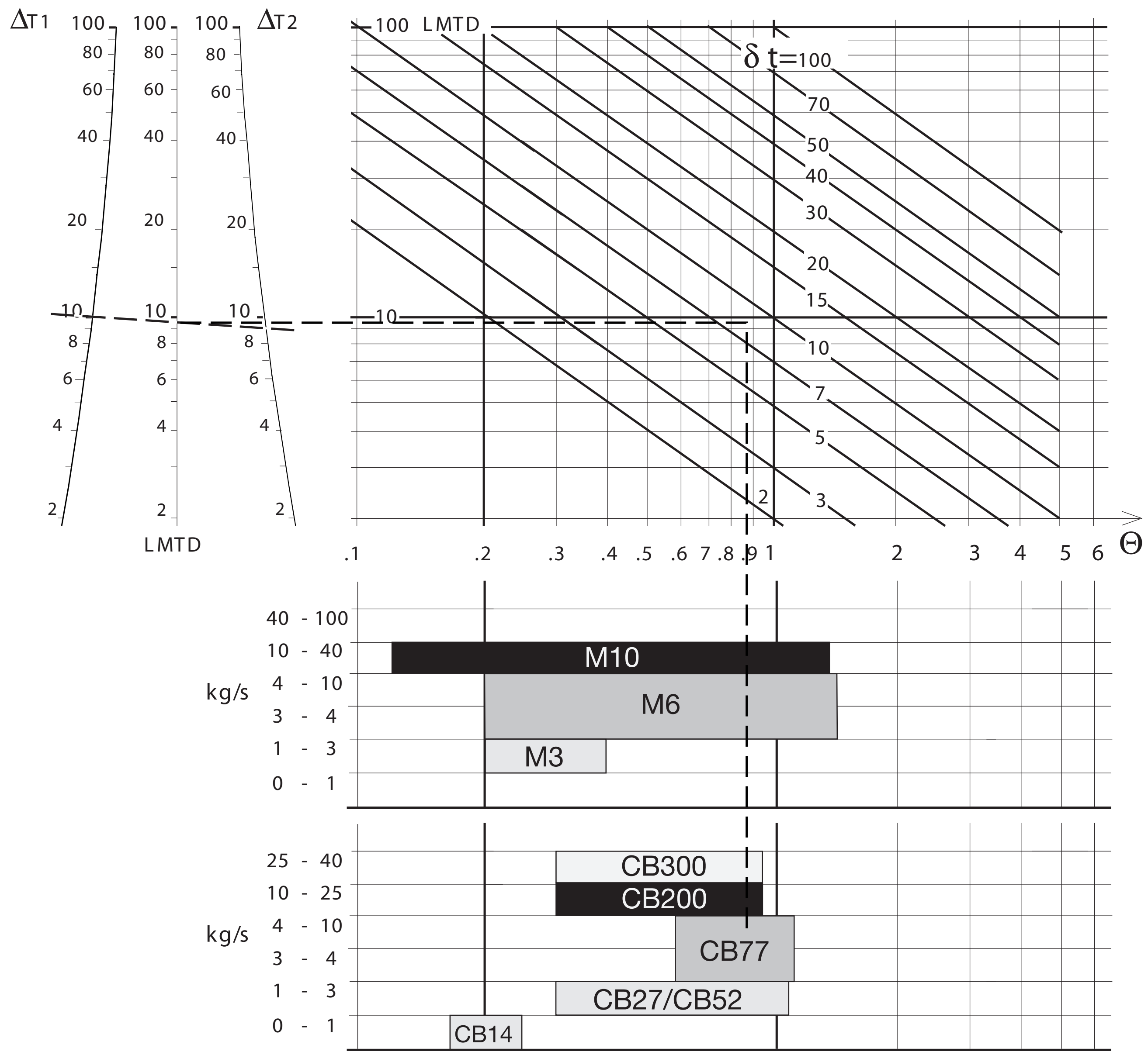
kg/s	Kg/h	g/h	m³/h	l/h
1	3,600	3.6×10^{6}	3.6	60
2.78×10^{-4}	1	10^{3}	1×10^{-3}	1.67×10^{-2}
2.78×10^{-7}	10^{-3}	1	10^{-6}	1.67×10^{-1}
0.28	1×10^{3}	10^{6}	1	16.67
1.67×10^{-2}	60	6×10^{4}	6.0×10^{-2}	1

3.

ϕ Max	1	8	20	50	60	90	170
smallest size of heat exchanger	CB14	CB27 M3	CB52	CB77	M6	CB200	M10 CB300



Conversion table heat load-flowrate (Oil, SAE 10)



Example

Let us assume that we are to cool 400 l/min. of oil* from 50 °C to 42 °C. The density of the oil is 0.858 kg/dm³, and the specific heat is 2.1 kJ/kg °C. Cooling water 205 l/min. is available at 33 °C, which will be heated to 40 °C. The amount of heat to be transferred is 100 kW. The maximum allowable pressure drop is 35 kPa.

Firstly, the largest of two flow rates must be expressed in SI-units, from l/min. to kg/s (see page 18).

400 l/min. x 1.5 x 10 $^{-2}$ = 6 kg/s.

Set out the temperature program.

T1 = 50 °C
T2 = 42 °C
T3 = 33 °C
T4 = 40 °C

* The graphs are valid for oil type SAE10.

1. ΔT1 = 50–40 = 10 °C
   ΔT2 = 42–(–33) = 9 °C
   δt = 50–42 = 8 °C

2. Read off the LMTD from the diagram. (9.5 °C)

3. $\frac{P}{LMTD} = \frac{100}{9.5} = 10.5 \quad \phi = 10.5$

4. According to table 4, the smallest possible heat exchanger is the CB52.

5. When Θ = 0.85 δt = 8 ° C and m = 6 kg/s it can be seen from the diagram that types M6 and CB77 are suitable.

   Please note that CB52 is unsuitable because of too high flow.

Heat exchanger selection Water/Glycol

When the duty of the heat exchanger is known, it is possible to select the most suitable type by following the directions below. The table on the next page will show which type to use.

The following example illustrates the procedure: Clarification of definitions is given on pages 10-11.

To determine the correct type of heat exchanger, the following information is required:

- The temperature programme °C.
- The maximum flow rate (m) kg/s
- The heat load (P) kW

Note! If only two of the above are known, the other can be found from the chart below. If the units are expressed in anything other than the above, then convert, using tables 1 and 2.

The values are based upon water with 40% glycol.

1. From the temperature programme, calculate ΔT1, ΔT2 and δt as follows.

   T1 = Hot water inlet temperature °C
   T2 = Hot water outlet temperature °C
   T3 = Cold glycol inlet temperature °C
   T4 = Cold glycol outlet temperature °C

   ΔT1 = T1–T4
   ΔT2 = T2–T3

   δt = T1–T2 (temperature difference of the medium being cooled).

2. With the help of the diagram on page 21 using ΔT1 and ΔT2, read off the LMTD.
3. Project a line from the LMTD across to the point where it bisects the calculated δt. Project downwards from this point and read off the Θ value. Project further downward until within the flow rate range. This will now show which types of heat exchanger will do the job.
4. Calculate $\frac{P}{LMTD} = \phi$
5. Using ϕ, decide whether the smallest size of heat exchanger is suitable from table 4. If not, the next larger type from the diagram on page 21 must be chosen.

1. Heat load

kW	kcal/h
1	8.6 x 10^2
1.16 x 10^{-3}	1
2.93 x 10^{-4}	0.25

2. Glycol, mass and volume

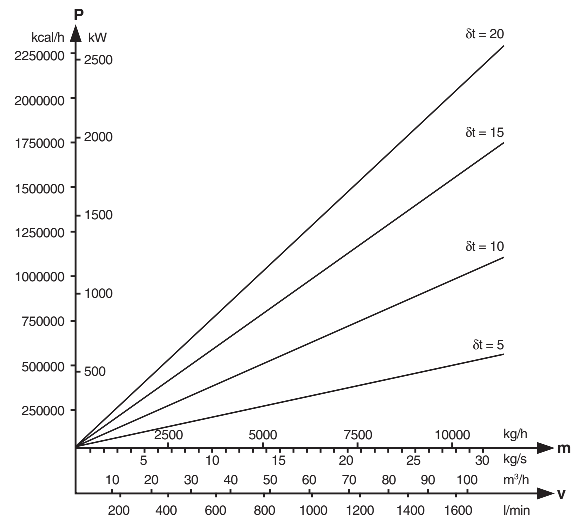
kg/s	Kg/h	g/h	m³/h	l/h
1	3,600	4.0 x 10^6	3.4	66.7
2.78 x 10^{-4}	1	10^3	0.9 x 10^{-3}	1.58 x 10^{-2}
2.78 x 10^{-7}	10^{-3}	1	10^{-6}	1.67 x 10^{-1}
0.29	1.06 x 10^3	10^6	1	16.67
1.76 x 10^{-2}	63.4	6 x 10^4	6.0 x 10^{-2}	1

3. Water, mass and volume

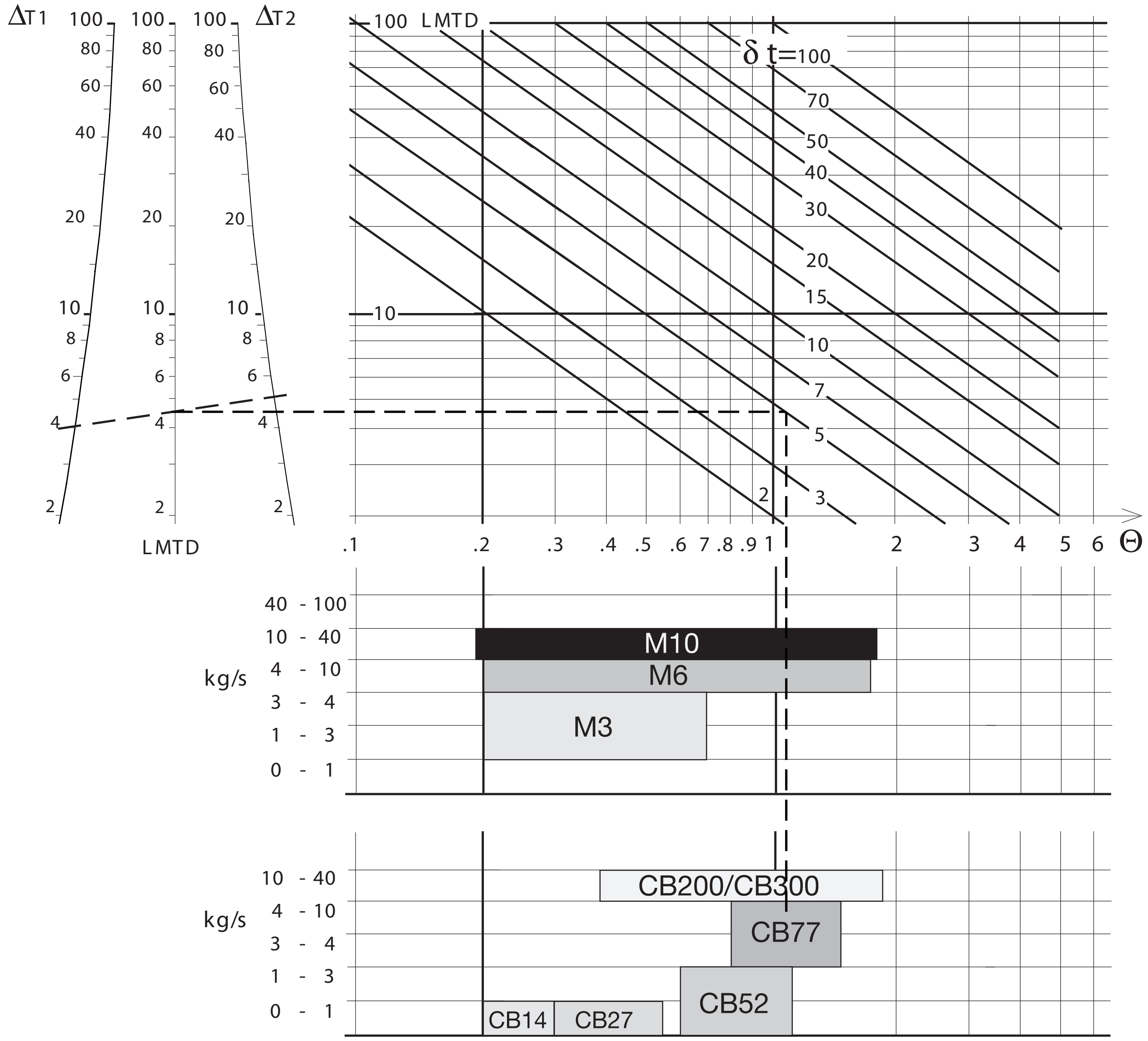
kg/s	Kg/h	g/h	m³/h	l/h
1	3,600	3.6 x 10^6	3.6	60
2.78 x 10^{-4}	1	10^3	1 x 10^{-3}	1.67 x 10^{-2}
2.78 x 10^{-7}	10^{-3}	1	10^{-6}	1.67 x 10^{-1}
0.28	1 x 10^3	10^6	1	16.67
1.67 x 10^{-2}	60	6 x 10^4	6.0 x 10^{-2}	1

4.

ϕ Max	1	8	20	50	60	90	170
smallest size of heat exchanger	CB14	CB27 M3	CB52	CB77	M6	CB200	M10 CB300



Conversion table heat load-flowrate (40% Glycol)



Example

Let us assume that we are to cool Let us assume we are to cool 3.5 kg/s water from 7 °C to 2 °C using 3.5 kg/s of 40% glycol at – 3° C rising to + 3 °C. The amount of heat to be transferred is 73 kW. The maximum allowable pressure drop is 35 kPa.

Set out the temperature program.

T1 = 7 °C
T2 = 2 °C
T3 = –3 °C
T4 = 3 °C

1. ΔT1 = 7–3 = 4 °C
   ΔT2 = 2– (–3) = 5 °C
   δt = 7–2 = 5 °C
2. Read off the LMTD from the diagram. (4.5 °C)
3. $\frac{P}{LMTD} = \frac{100}{9.5} = 16.2$ ϕ = 16.2
4. According to table 4, the smallest possible heat exchanger is the CB52.
5. When Θ = 1.1 δt = 5 °C and m = 3.5 kg/s it can be seen from the diagram that types M6 and CB77 are suitable.

   Please note that CB52 is unsuitable because of too high flow.

Plate heat exchanger construction

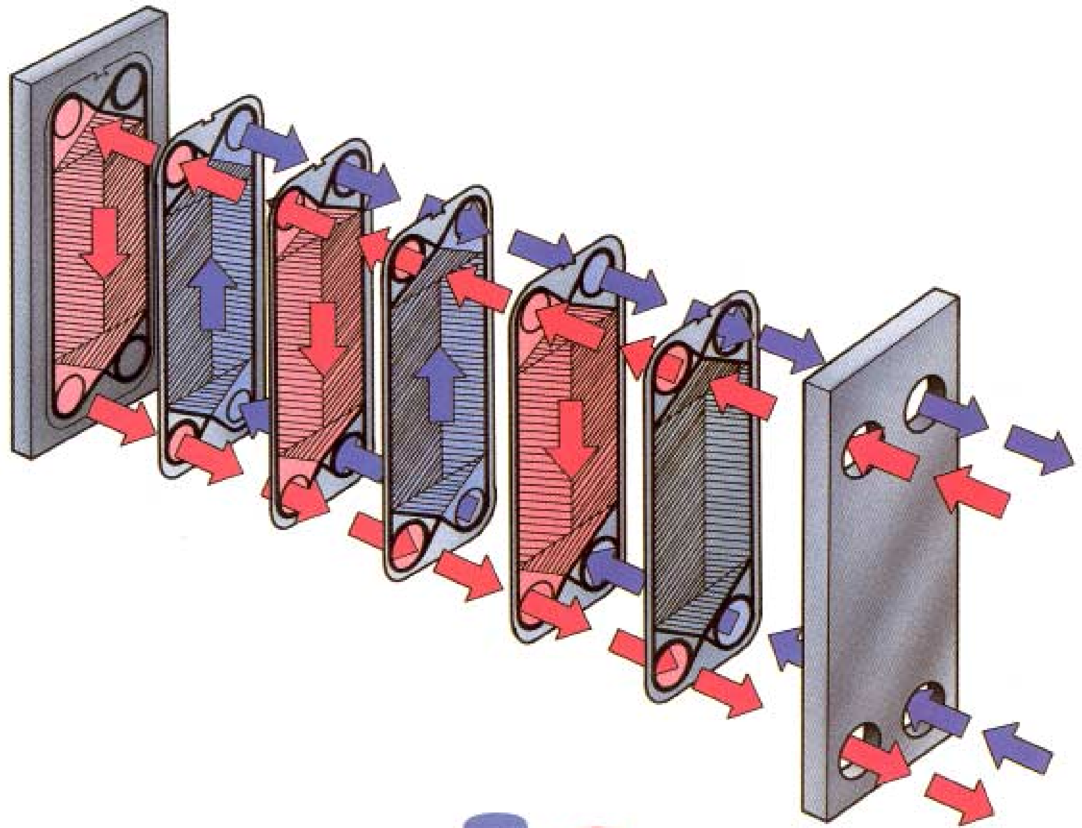
A plate heat exchanger consists of a number of heat transfer plates which are held in place between a fixed plate and a loose pressure plate to form a complete unit. Each heat transfer plate has a gasket arrangement which provides two separate channel systems.

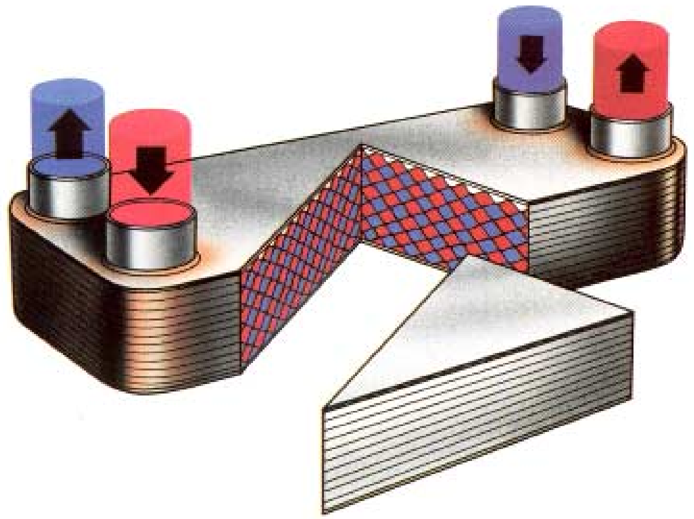
The arrangement of the gaskets (field and ring gaskets) results in through flow in single channels, so that the primary and secondary media are in counter-current flow.

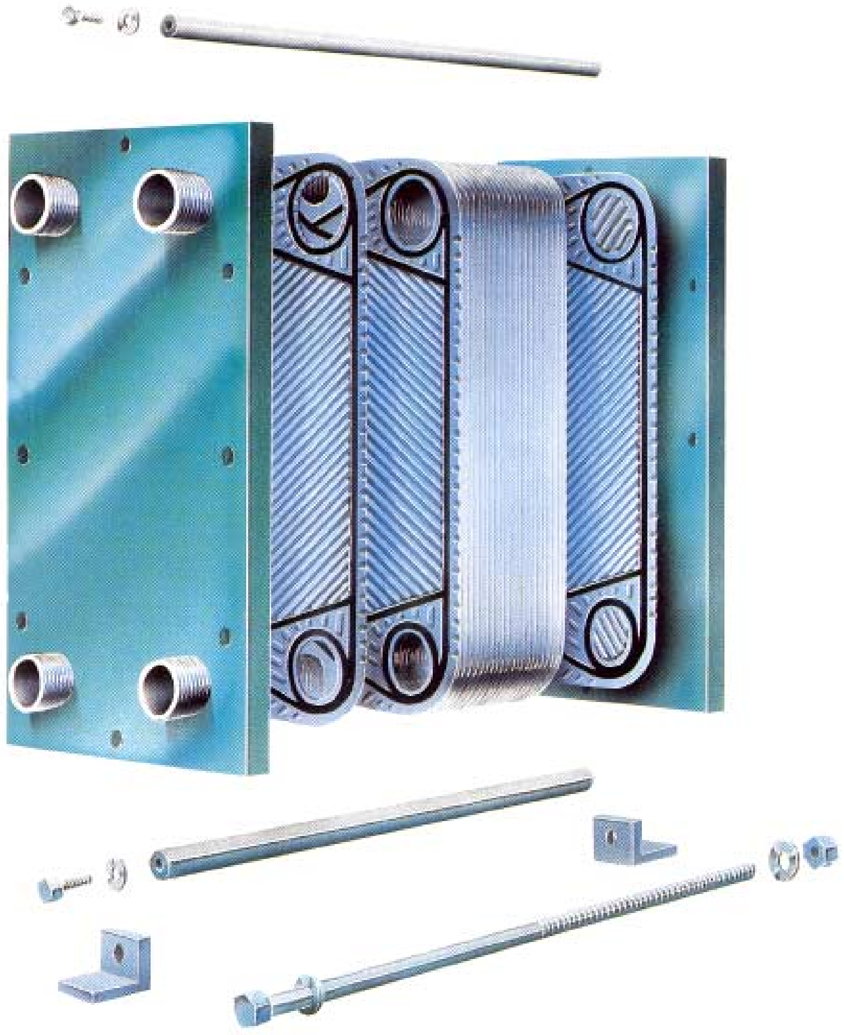
The media cannot be mixed because of the gasket design.

The plates are corrugated, which creates turbulence in the fluids as they flow through the unit. This turbulence, in association with the ratio of the volume of the media to the size of heat exchanger, gives an effective heat transfer coefficient.

A similar principle is employed in the brazed construction heat exchanger types. Instead of the elastomer gasket, special brazing techniques are used to give the same result.







Components

The components consist of a fixed end plate, connections and a loose pressure plate, with carrier bars mounted between them. The plates are hung from the top carrier bar. The carrier bars also serve to position the heat transfer plates. The single plates are pulled together to form a plate pack by means of tightening bolts.

Gasketed plate heat exchangers are available in standard sizes or can be individually prepared.

Brazed plate heat exchangers

A brazed plate heat exchanger is small, light, compact and inexpensive. It does not have gaskets. Instead, it is brazed together to give a strong, compact construction.

This heat exchanger is especially suitable for pressures up to 50 bar and temperatures from -196 °C to + 400 °C.

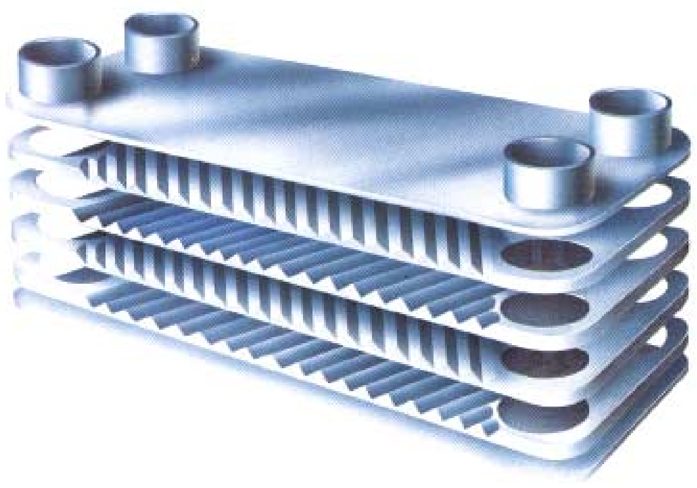
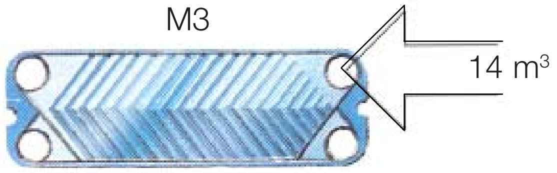


Plate heat exchanger construction

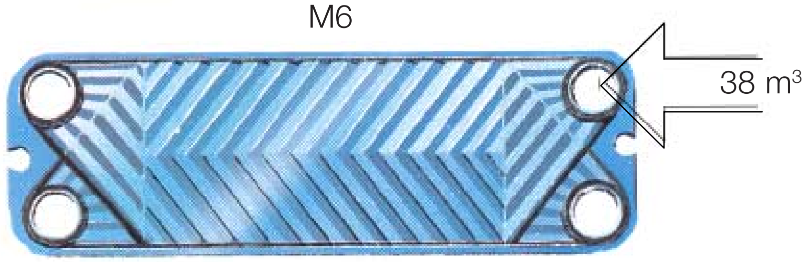
Plates

The plates are available in two standard materials, stainless steel and titanium. Titanium must be selected when the heat exchanger is to be used with salt water. When other corrosive media are involved, consult your Alfa Laval representative. The table below shows what standard plate and gasket materials are available for each type of heat exchanger.

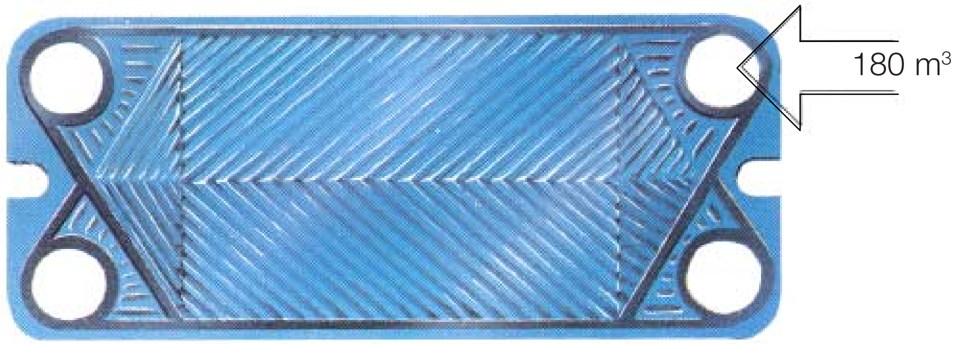
M3



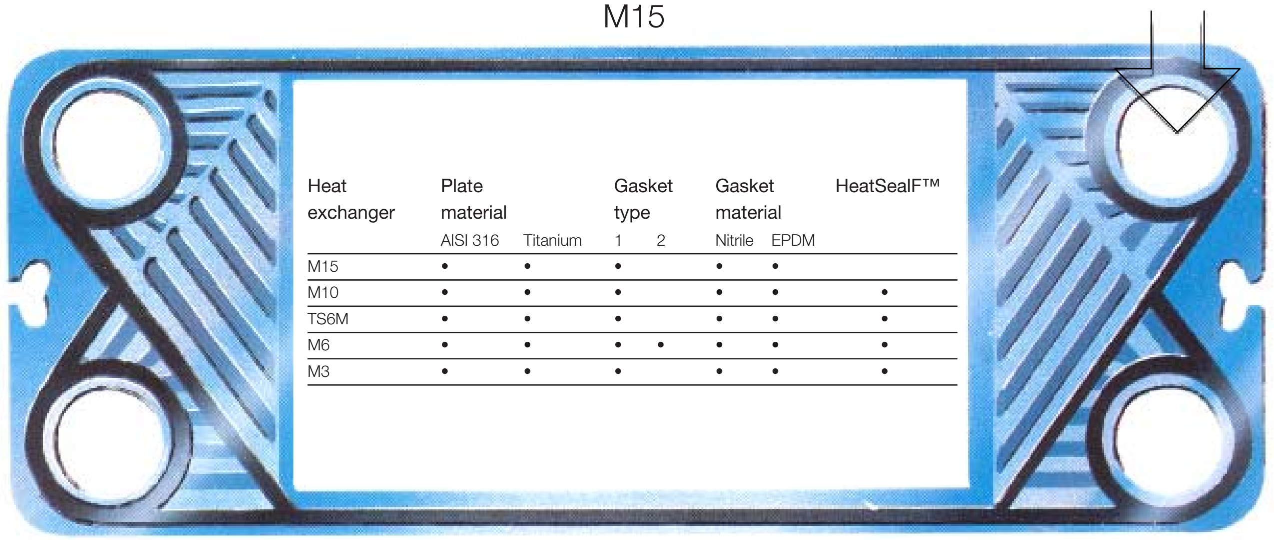
M6



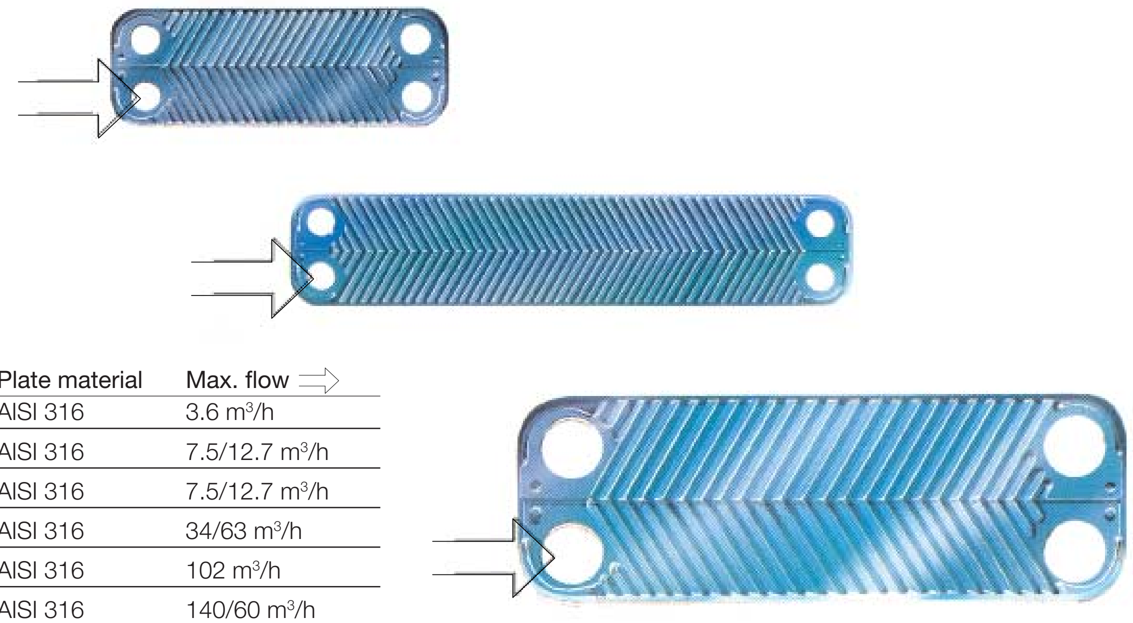
M10



M15



Heat exchanger	Plate material AISI 316	Plate material Titanium	Gasket type 1	Gasket type 2	Gasket material Nitrile	Gasket material EPDM	HeatSealF™
M15	•	•	•		•	•	
M10	•	•	•		•	•	•
TS6M	•	•	•		•	•	•
M6	•	•	•	•	•	•	•
M3	•	•	•		•	•	•



Heat exchanger	Plate material	Max. flow
CB14	AISI 316	3.6 m³/h
CB27	AISI 316	7.5/12.7 m³/h
CB52	AISI 316	7.5/12.7 m³/h
CB77	AISI 316	34/63 m³/h
CB200	AISI 316	102 m³/h
CB300	AISI 316	140/60 m³/h

Brazed heat exchangers available in six sizes

Gaskets

Materials available	
Nitrile rubber	general purpose, oil resistant
EPDM	general purpose, elevated temperatures
HeatSealF™	For high temperatures, specially heating by steam

Type 1
Clip-on gaskets held in place around the plate edge.

Type 2
Super EPDM gaskets are designed to reduce the aging of the gasket caused by the surrounding air.

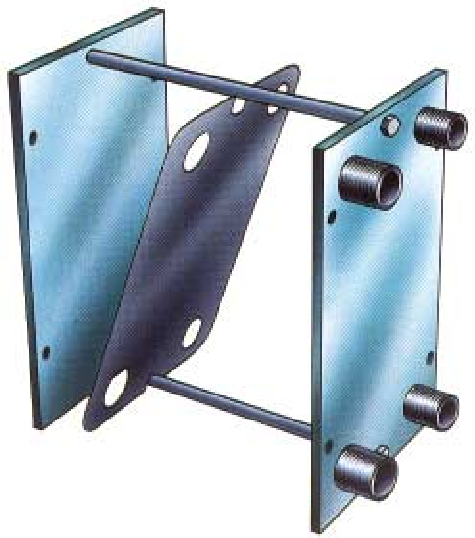
Assembly

Alfa Laval deliver your heat exchanger assembled and pressure tested.

Heat exchangers supplied with gaskets can easily be opened for inspection and cleaning. Should the capacity requirements change in the future, additional plates can easily be hung in the frame on site.

The following sketches show assembly step by step:

1. The frame is put together. It consists of frame and pressure plates, top and bottom carrying bars and connections.



2. The end plate is the first plate to be hung in the frame.

3. Then the plates corresponding to the platage specification are positioned in the frame.

4. The tightening bolts are fitted and the plate pack is tightened by means of a spanner or any other suitable tool to a set measure (specified in the platage specification).

Installation

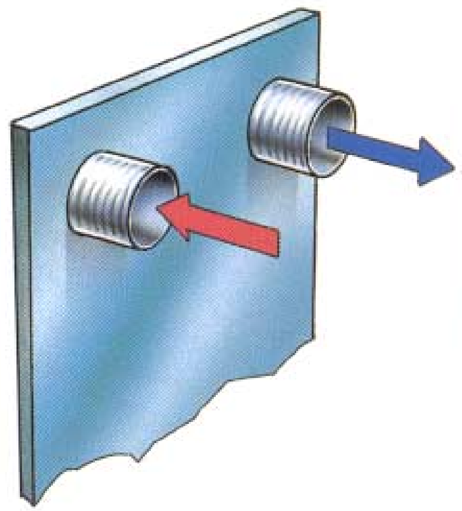
All the heat exchangers in this brochure have the connections in the frame plate. They are referred to as S1, S2, S3 and S4.

The gasketed heat exchanger can be placed directly on the floor. When possible, it is always safer to secure the unit with foundation bolts. The plate heat exchanger is noted for occupying less space than traditional heat exchangers. When planning the space recommended, it is necessary to leave space on one side of the heat exchanger only. The pipe connections can be either screwed or flanged, depending on the type of heat exchanger selected.

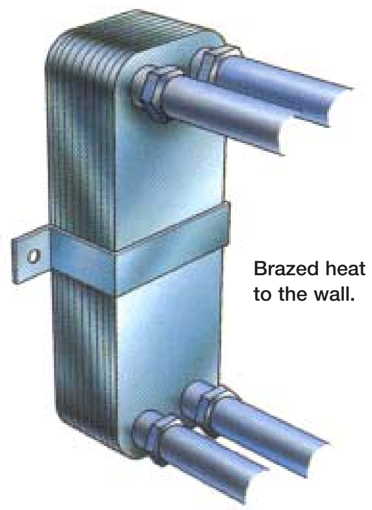
The brazed plate heat exchanger will normally be built into the pipework, or mounted into a small console.

The inlet of one medium is next to the outlet of the other. If S1 is the inlet for medium 1, then S4 is the outlet for medium 2. Every heat exchanger delivered is accompanied by instructions as to which inlet and outlet to use.

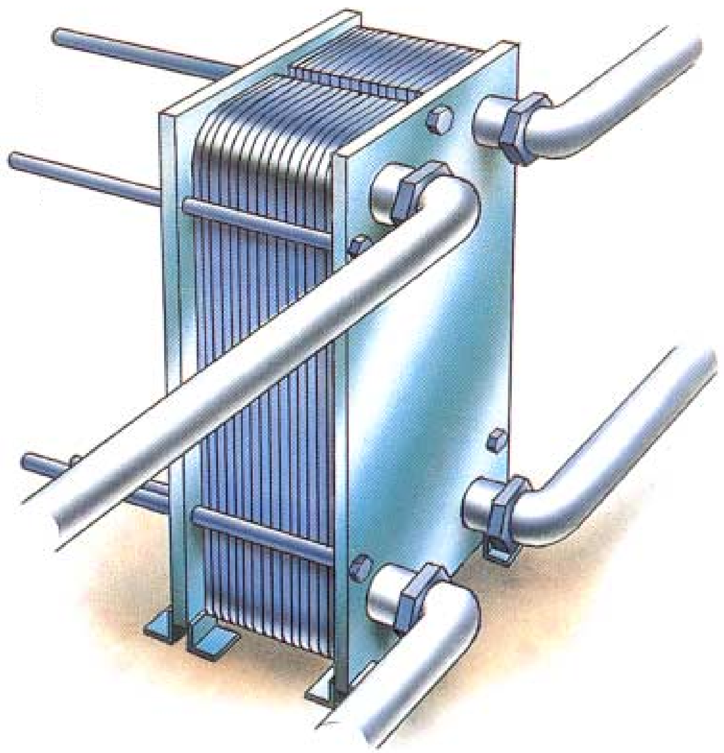
Depending upon the type of connection selected, prepare the pipework with screwed thread ends, fit flanges or prepare for welding.



Entry of the first medium on the left side.
Exit of the second medium on the right side.



Brazed heat exchangers clamped to the wall.



Gasketed plate heat exchanger standing directly on the floor.

Alfa Laval in brief

Alfa Laval is a leading global provider of specialized products and engineering solutions.

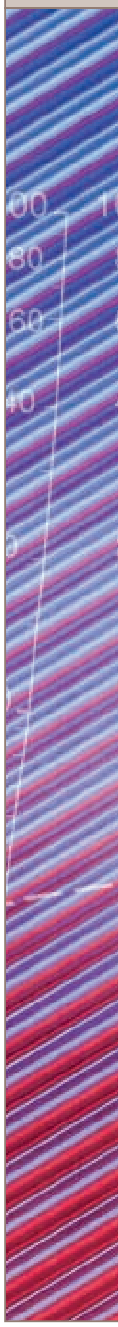
Our equipment, systems and services are dedicated to helping customers to optimize the performance of their processes. Time and time again.

We help our customers to heat, cool, separate and transport products such as oil, water, chemicals, beverages, foodstuff, starch and pharmaceuticals.

Our worldwide organization works closely with customers in almost 100 countries to help them stay ahead.

How to contact Alfa Laval

Contact details for all countries are continually updated on our website. Please visit www.alfalaval.com to access the information.



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