PHE Knowledge

Topics to cover

- PHE evolution
- PHE function & applications
- Current and future PHE range
- Plates & gaskets
- Frames
- Plate gallery tour and Workshop visit
- Plate packs
- Technological and customer benefits
- Product Manual Plates (PMP)

Alfa Laval's Historical Base

1878

The continuous milk separator developed by Gustaf de Laval

1917

The first vacuum-operated milking machine

1931

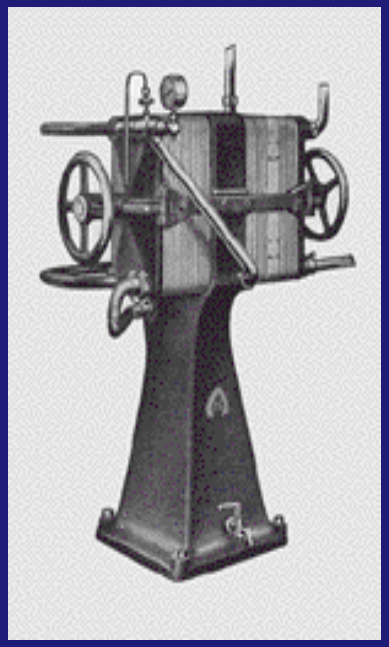
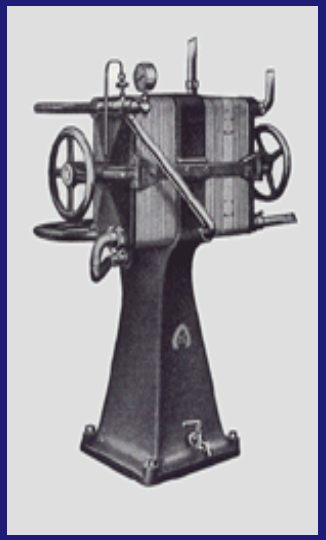


Plate heat exchangers developed to improve pasteurisation process

Plate Heat Exchanger - evolution



2000 Start of the T-series, FrontLine

1999 Vicarb acquisition, Compabloc & V-series

1997 Base-line (Food)

1995 Rolls Laval / Spiral C-serie

1994 AlfaRex

1993 Nickel Brazed

1992 Clip-Line (Food)

1989 Plate evaporator

1987 Graphite plate

1986 M-series, module size & thinner plates, Double-wall

1985 Wide-gap

1983 Copper Brazed

1980 Semi-welded concept, glue-free concepts

1970 A-series with Alfa Flex concept, 0.6 mm

1962 Rosenblad herring-bone pattern

1950 Industrial plates in exotic material

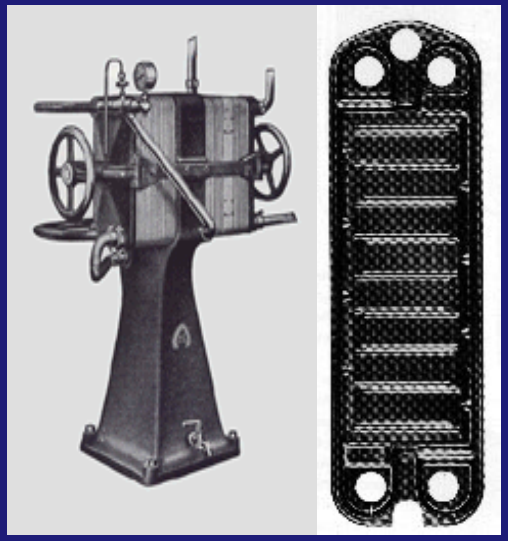
1944 Wash-board pattern

1938 Pressed plates in 1.0 mm

1931 First Plate Heat Exchanger (1878 a German patent)

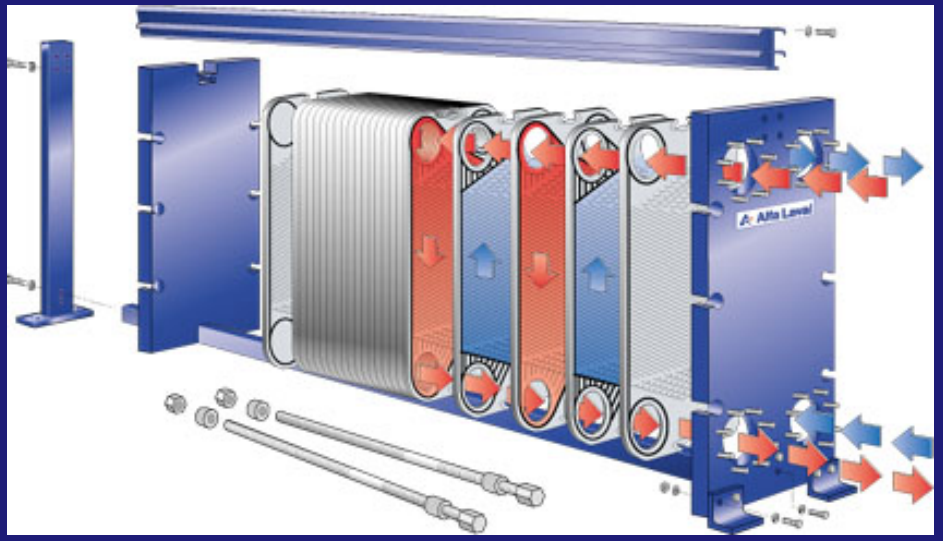
Plate Heat Exchanger - evolution

1931



- 5-10 mm thick plate
- Milled pattern
- Liquids passed the plate horizontally several times
- Stainless steel
- Up to 5 m^2 per unit

2001



- Down to 0.4 mm plates
- Pressed plates
- Liquids passes over the whole plate in one passage
- Various materials
- Up to 2000 m^2 per unit

Plate Heat Exchanger - evolution

Alfa Laval plate development

1955

P2

Free channel: 2.9 mm

AISI 316: 0.8 mm

Max test pressure: 21 barg

1990

M6-M

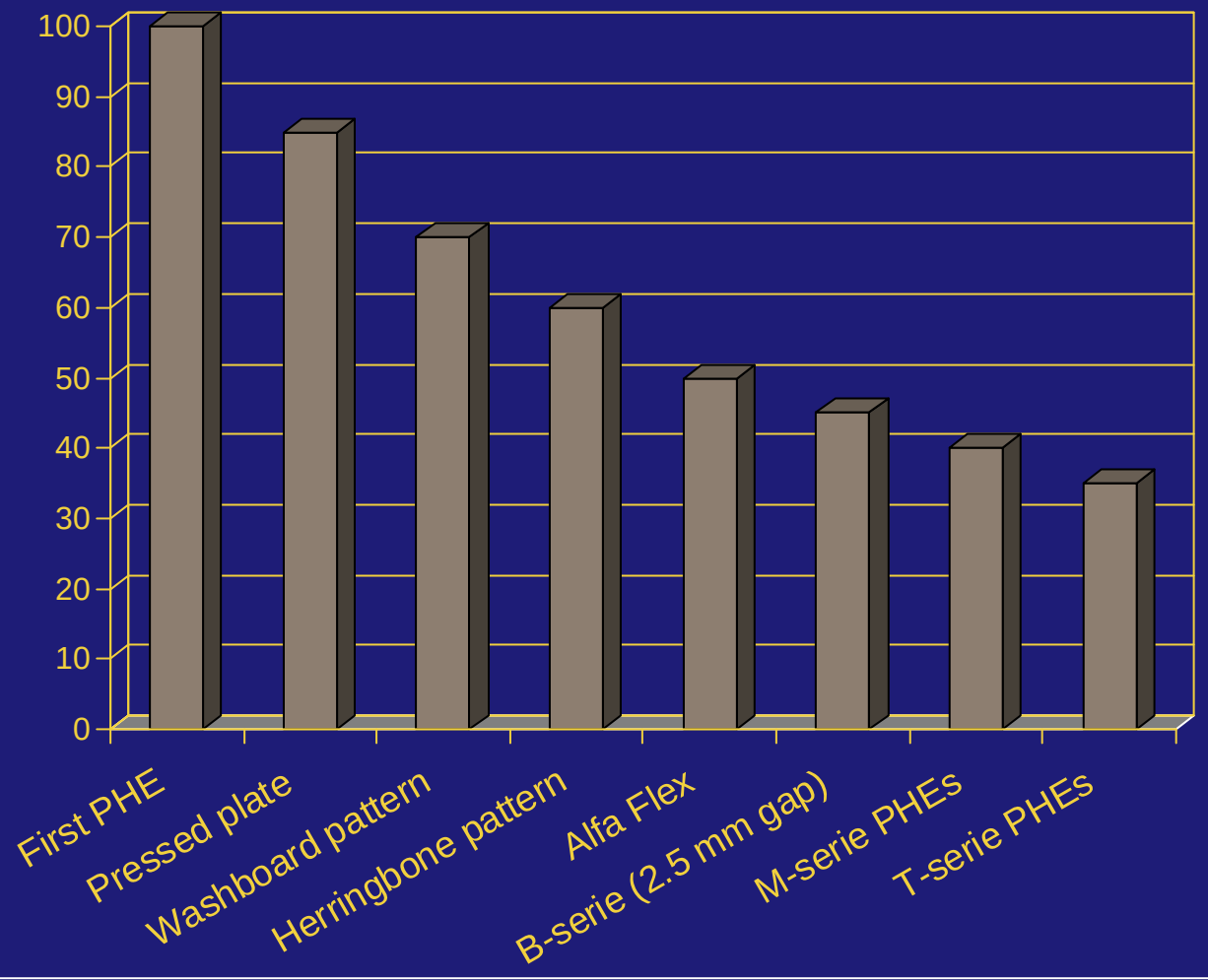
Free channel: 3.0 mm

AISI 316: 0.5 mm

Max test pressure: 31 barg

Plate Heat Exchanger - evolution

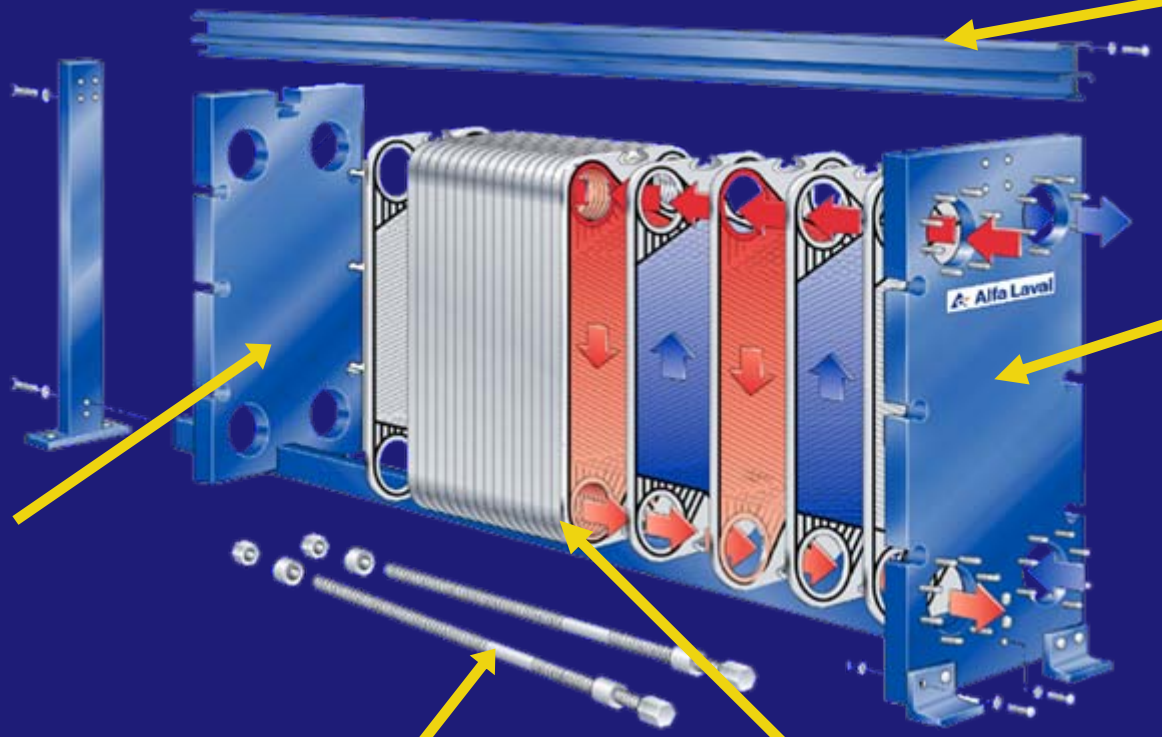
Continuous cost reductions through innovations



PHE - applications

- Steel and metal works
- Power and energy production
- Chemical process industries
- Petroleum industries
- Refrigeration
- Engineering industries
- Central cooling engineering
- Metal recovery industries
- Mineral processing industries
- Sugar, distillery fermentation
- Pulp and paper industries
- Dryers for compressed air
- Heating, ventilation and air conditioning

PHE - main components



Carrying bar

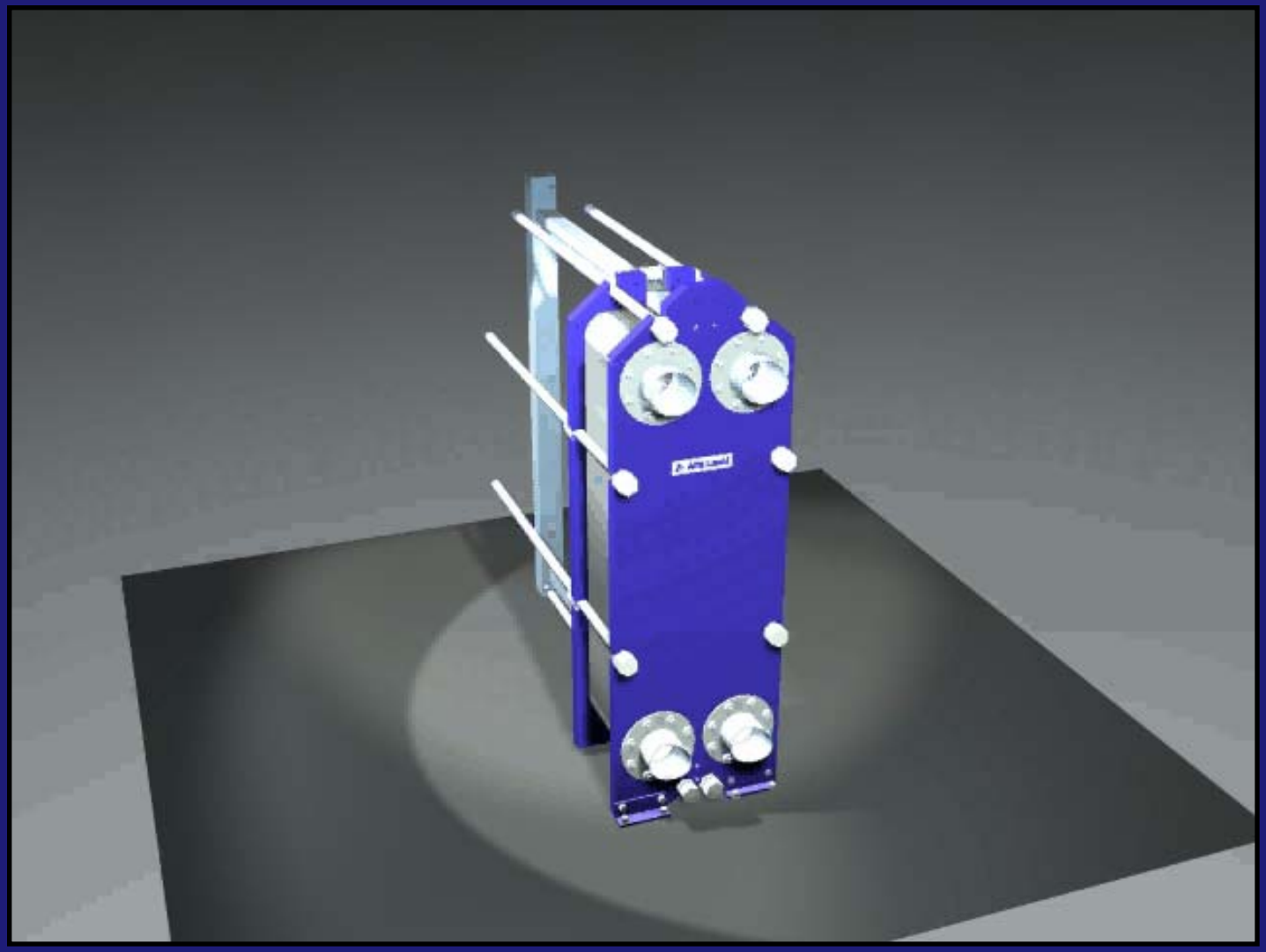
Frame plate

Pressure plate

Tightening bolts

Plate pack

PHE - 3 dimensional tour



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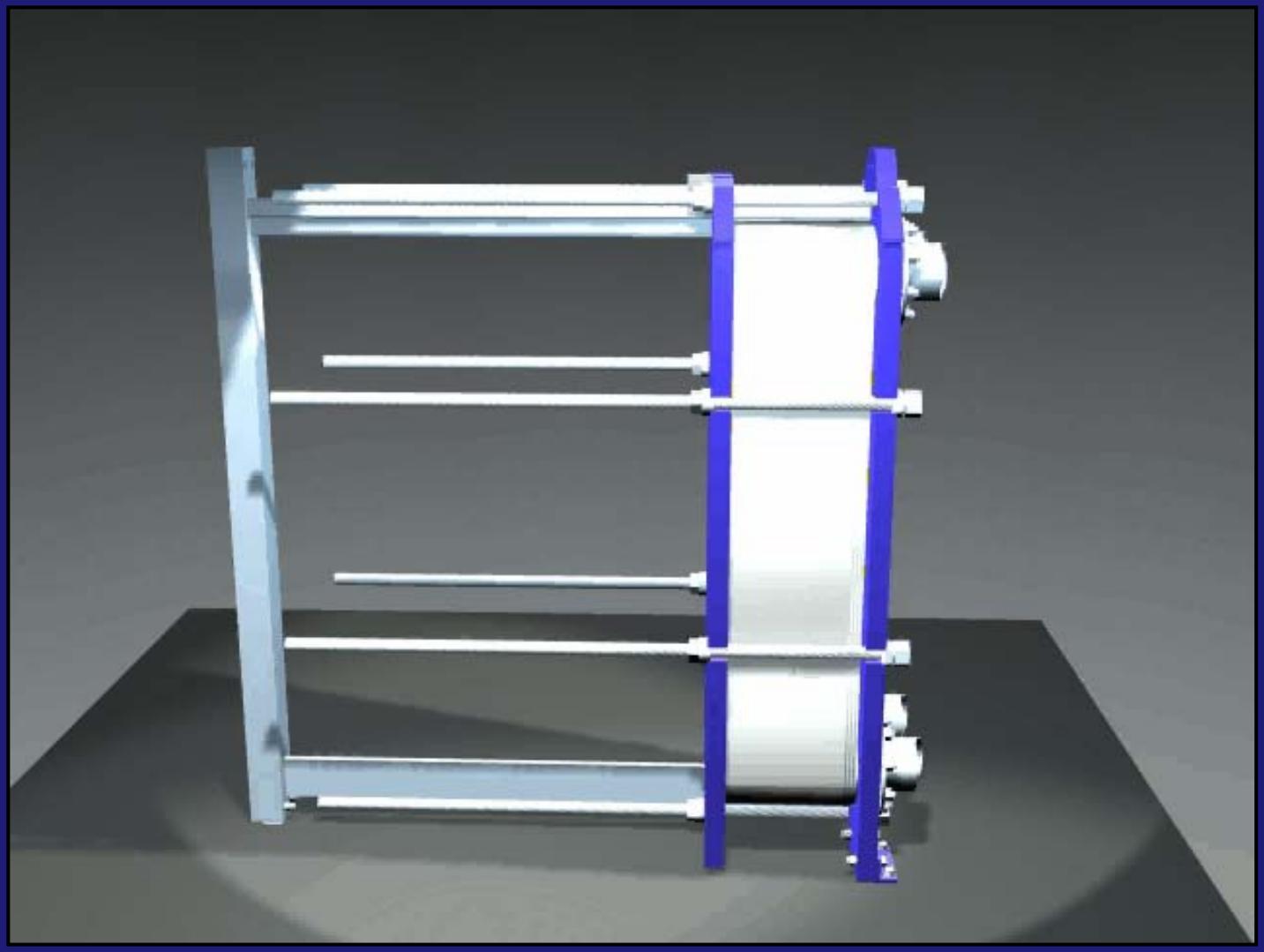
PHE - dismantling



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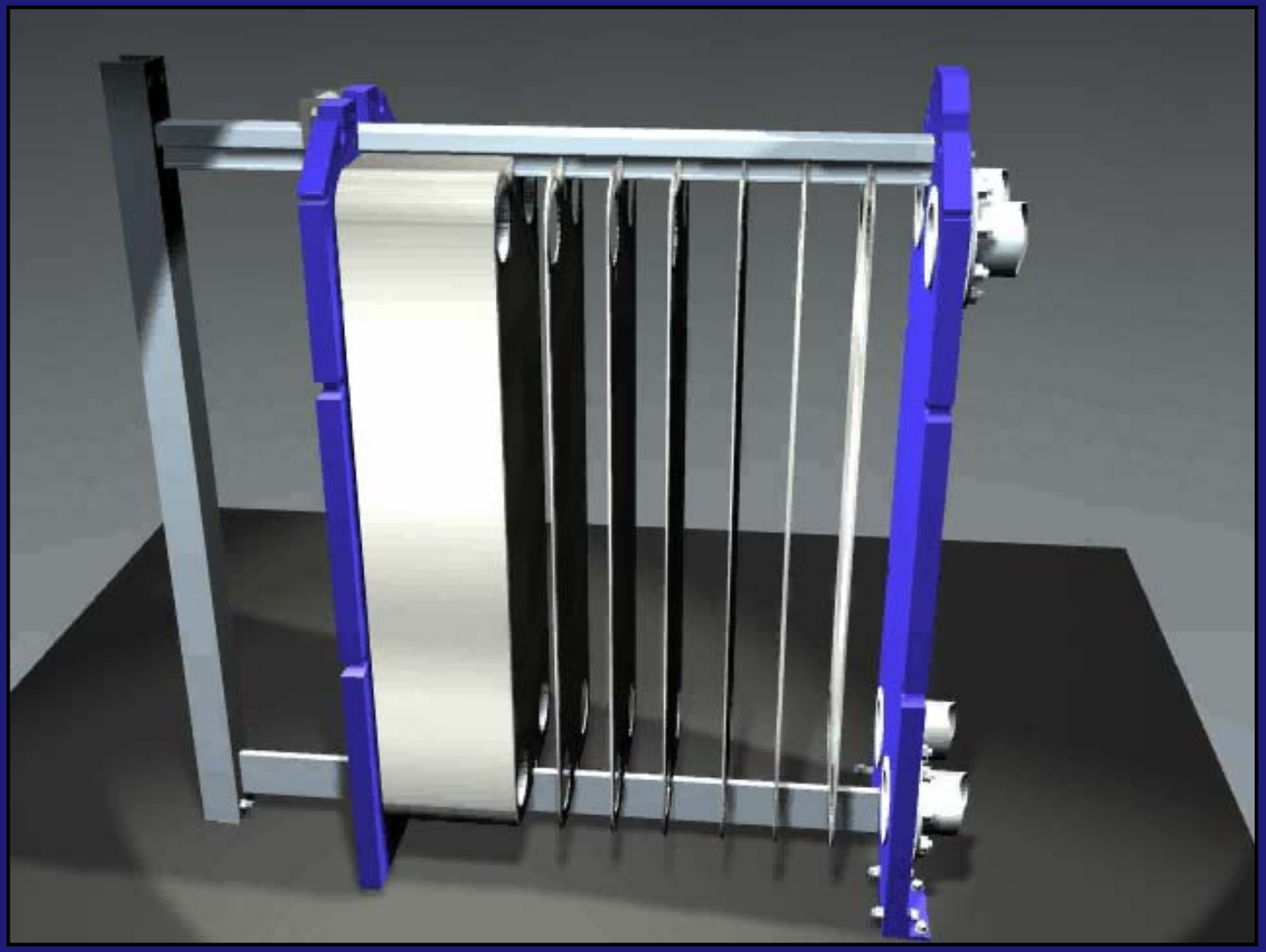
PHE - flow principle



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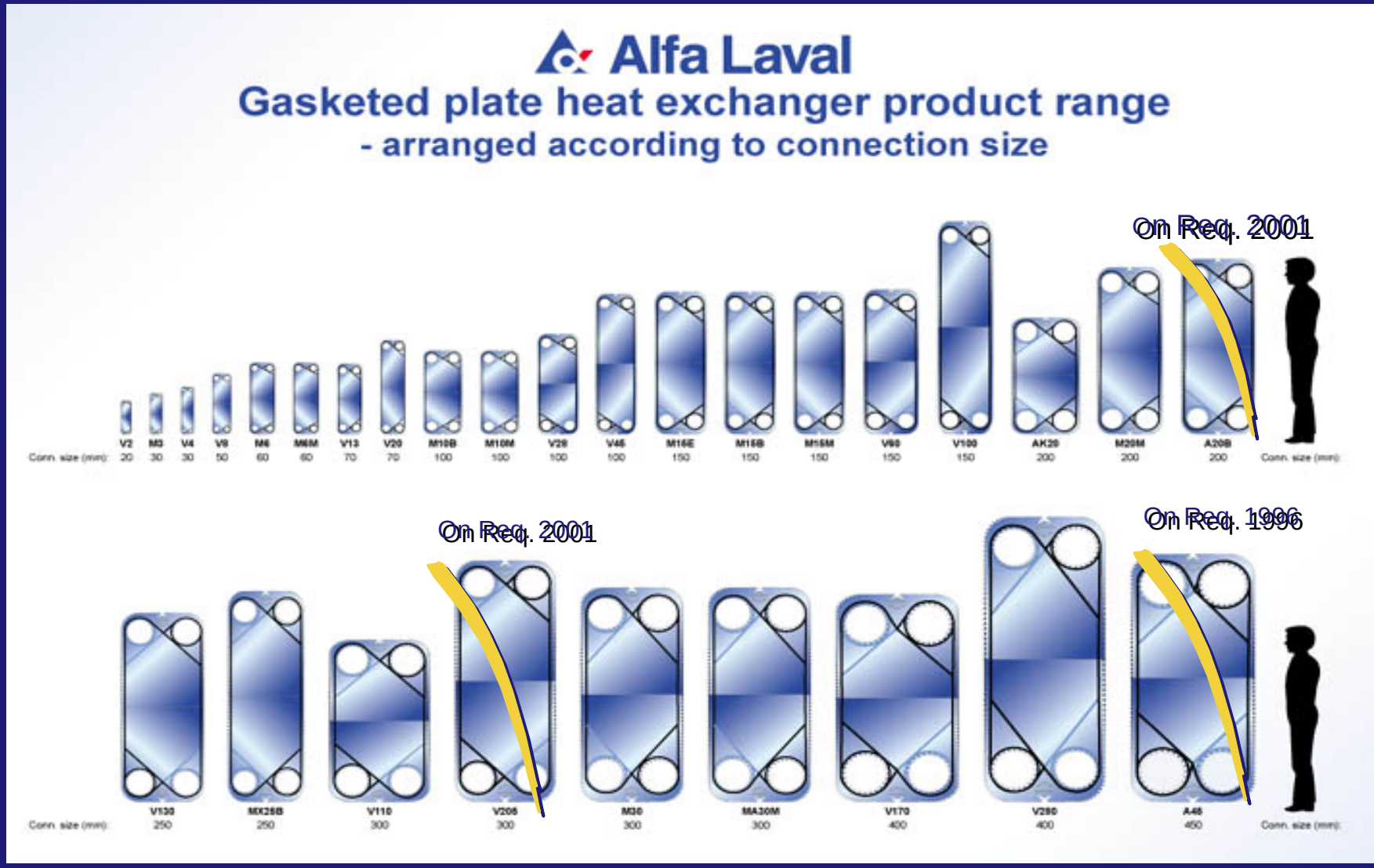
Current PHE range



Current PHE range

- We have three different PHE ranges
  - M-serie PHE
    - The majority of our range
    - Modern types introduced mainly during the 1990s
  - A-serie PHE
    - Some units remaining from an old serie
    - Introduced during the 1970s and 1980s
  - V-series
    - Came through the Vicarb acquisition
    - Separate lecture on this range

M-serie PHEs

- Basic objectives were
  - To replace the A-serie with a smaller number of PHE types
  - To supply each type with the various plates needed
  - To design all plate of a given M-type for same raw sheet material
- Advantages
  - Less inventory and scrap
  - Shorter delivery time
  - Reduced tooling investment
  - Minimised administration

M-serie PHEs

- Features implemented with the M-serie
  - Always parallel flow
  - Chocolate pattern
  - Corner guidance on M10 and smaller models
  - Sheet thickness down to 0.4mm
  - Glue free gaskets
  - Improved pressure and temperature performance
- To a large extent the M-serie has been very success
- We are almost ready with replacing the A-serie
- No time to rest $\Rightarrow$ Move ahead with the future PHE range

Future PHE range

- A brand new series to replace A, M and V-series
- The T-series
  - Already started with one unit released in 2000
  - Next unit to be released end of 2001
- Current range of gasketed PHEs consists of
  - 1 model in the T-serie
  - 11 models in the M-serie
  - 3 models in the A-serie (On Request)
  - 14 models in the V-serie (some will be obsoleted)

T-serie PHEs

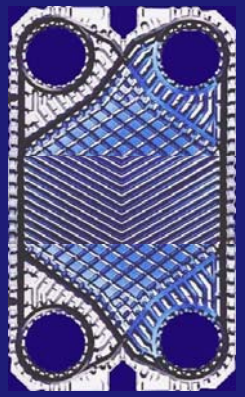
- Technical innovation implementation
  - Existing innovations as well as those made in the future
  - Differentiate performance depending on customer needs
    - State-of-the-art where customers are willing to pay
    - Cost efficient alternatives where customer is price focused
- Total cost optimisation on frames
  - Smart range planning
  - Less frames to be used more frequently
    - Less frame families
    - Less frame types in each family
    - Less components and variants on each frame
  - Allow variation on components customers care about

T-serie PHEs

- Thermal coverage improvements
  - Competition sharpens
  - Good thermal fit is always the best way to ensure competitiveness
  - Larger size PHEs as industrial plants grow larger
  - Maintained low-theta coverage on gasketed units
- Principal schedule has been outlined with the motto:
  - ”A unit per year, keeps customers near, and competitors in fear".
  - All units will be developed based on market requirements

T-serie PHEs

- Theoretical range lay-out is based on
  - Two pressing depths
  - Two plate lengths
  - In each port size



Theta	Low theta	Medium	High
Length	Short	Medium	Long
Pressing depth	4.0 mm	2.5 & 4.0 mm	2.5 mm

Denominations

8 possible positions in PHE name: A B 12 - C D EF

A = PHE serie

- A for A-serie
- M for M-serie
- T for T-serie

B = “Extra” feature if any

- X = Extra high Θ in M-serie (M**X**25-B)
- K = Short in A & M-serie: (A**K**20)
- S = Short in T-serie: (e.g., T**S**20-M)
- L = Long in T-serie: (e.g., T**L**20-B)

12 = Port size

- 10 = 10 cm (4”)
- 20 = 20 cm (8”)
- Ex, M6, M15-B

C = Pressing depth

- B = 2.5 mm
- M = 3.5-4 mm
- = 3-3.5 mm
- Ex, M10-B, M20-M, M30

D = Special feature

- W = semi-welded
- D = double-wall
- S = wide-gap
- Ex, M10-BW, M6-MD

EF = frame design pressure

- FM = 10 barg
- FG = 16 barg
- FD = 25 barg
- FS = 30 barg

Denomination

Naming of connections

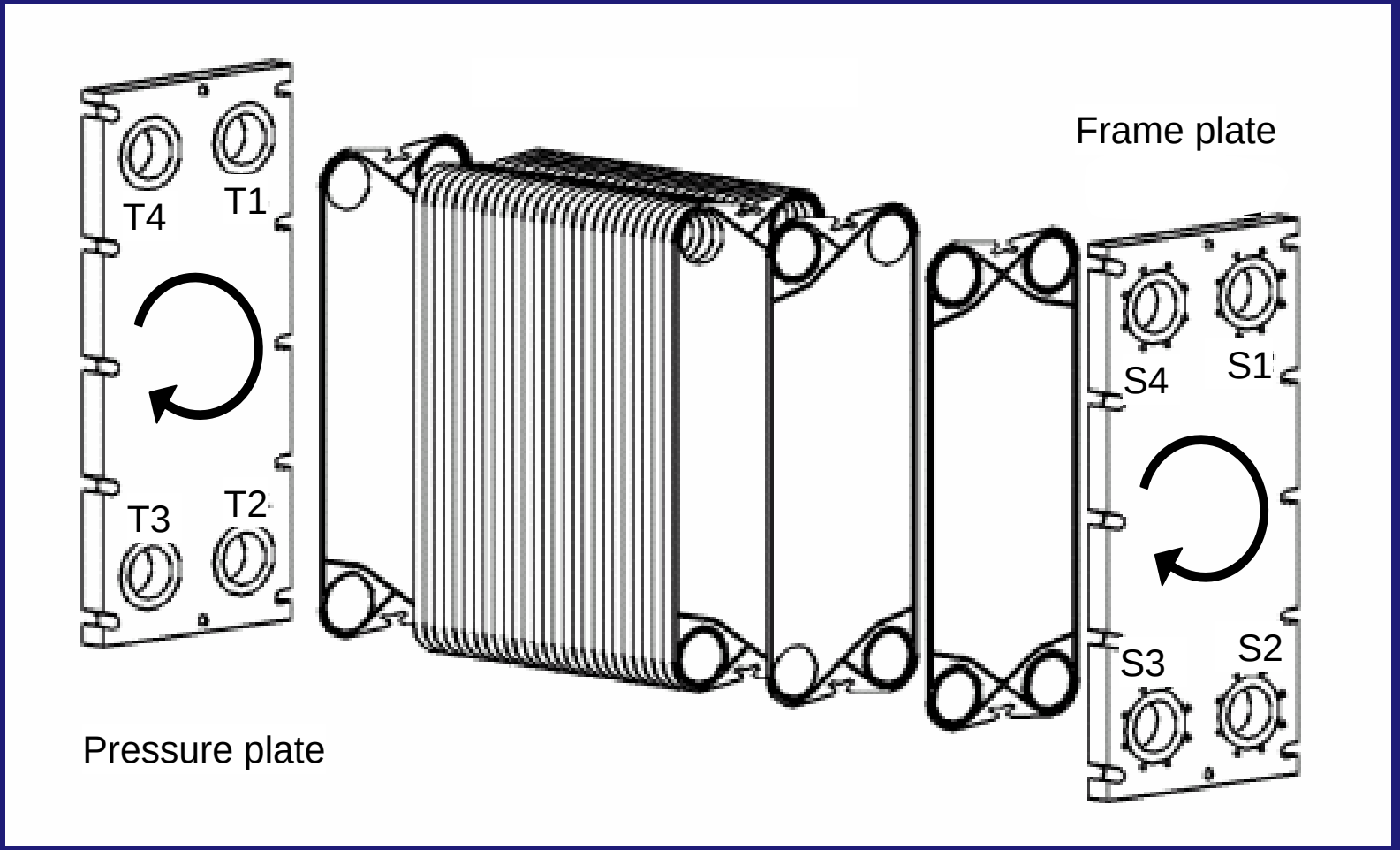
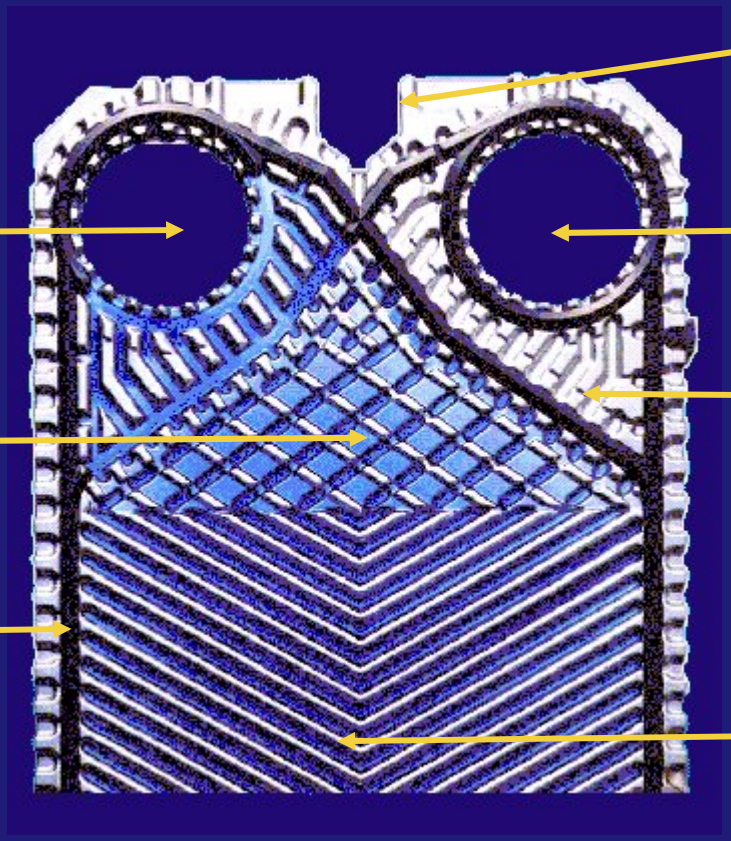


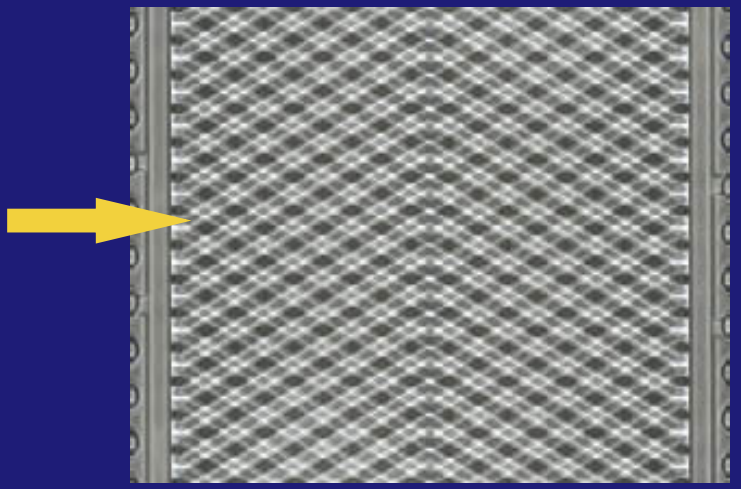
Plate - main components



Thin sheet design, cold formed in single step hydraulic pressing (up to 40000 tons)

Plate - corrugation function

- Mechanical
  - Provide support points
  - Allows thin material



- Flow dynamic
  - Creates high turbulence
  - High efficiency
  - Minimize fouling
  - Cork-screw flow

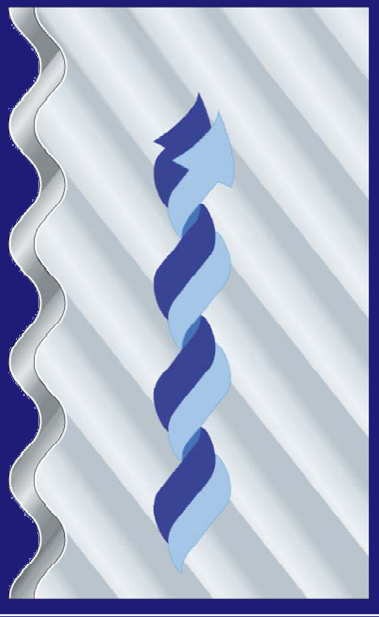


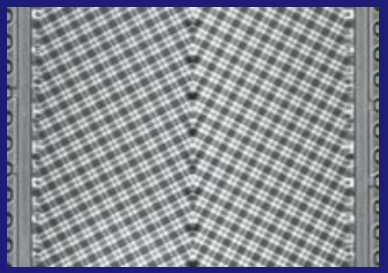
Plate - corrugation and channels

- We have two plate corrugations (L and H)
- These form three different channels (L, M and H)

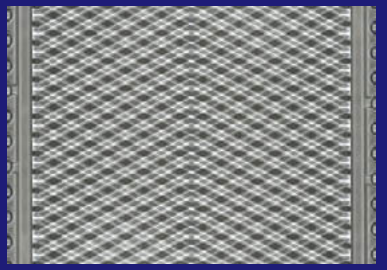
L: Low theta

H: High theta

L + L = L channels



L + H = M channels

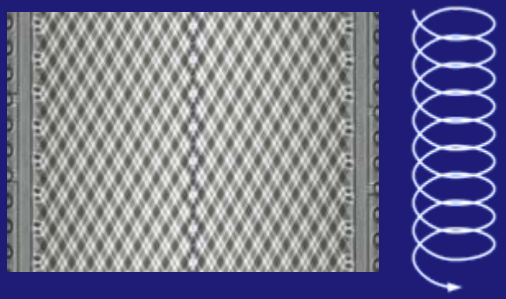


H + H = H channels

- We choose between L, M and H channels
- Tailor-make it for the specific duty

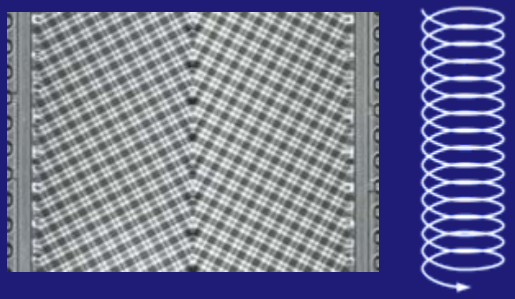
Plate - corrugation and channels

Low turbulence
& pressure drop



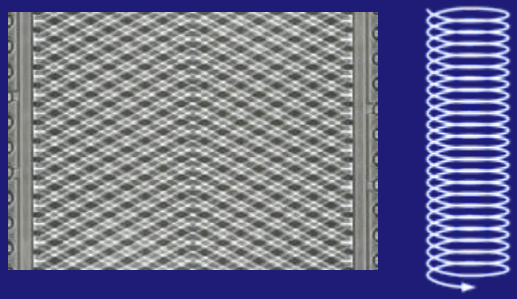
L + L = L channels

Medium turbulence
& pressure drop



L + H = M channels

High turbulence
& pressure drop



H + H = H channels

Advantages

- Efficient heat transfer
- High wall shear stress
- Variable thermal length
- Strong construction

Benefits

- Increased heat recovery
- Low fouling
- Optimal design
- Insensitive to vibration

Plate - pressing depth

- Alfa Laval has a range of pressing depths from 1.5 mm to 11 mm for optimal solution to any duty

There is no good and no bad pressing depth.
Just different ones to fit various duties

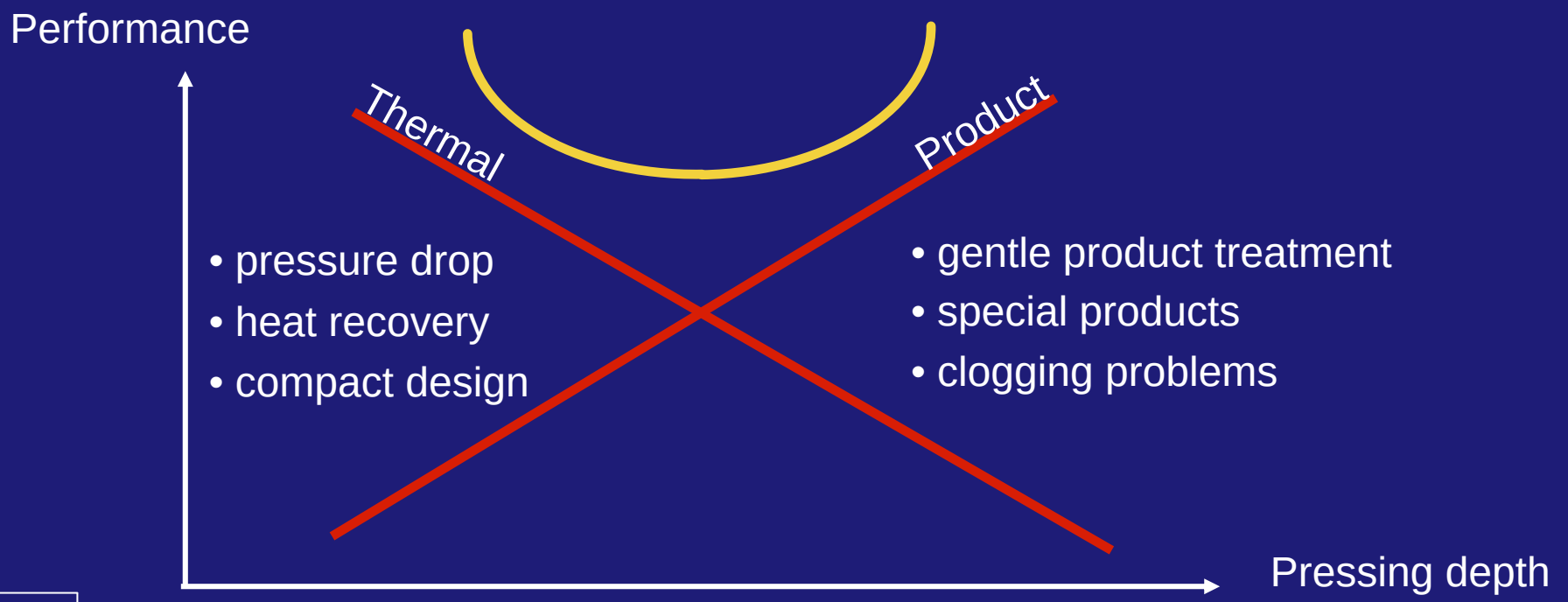


Plate - pressing

- Singles-step pressing of all Alfa Laval plates
- Advantages
  - Plates are totally uniform
    - Gaskets fits to the plates
    - Plates fit together in the plate pack
  - Metal-to-metal contact in all contact points
  - Strong plates that can handle
    - Pressure chocks
    - Vibrations
    - Fatigue
    - High operating pressures
    - High differential pressures

Plate - distribution area

- Chocolate pattern
  - Distributes flow evenly over the plate
  - Same ΔP for distance A and B
  - Uses a minimum of ΔP for distribution
  - Gives more ΔP for efficient heat transfer
  - Allows parallel flow configuration
  - Alfa Laval innovation
    - Patent has expired
    - Competitors has copied us
  - Avoids dead-spots in the far corner
    - Full use of heat transfer area
    - No fouling in stagnant zones

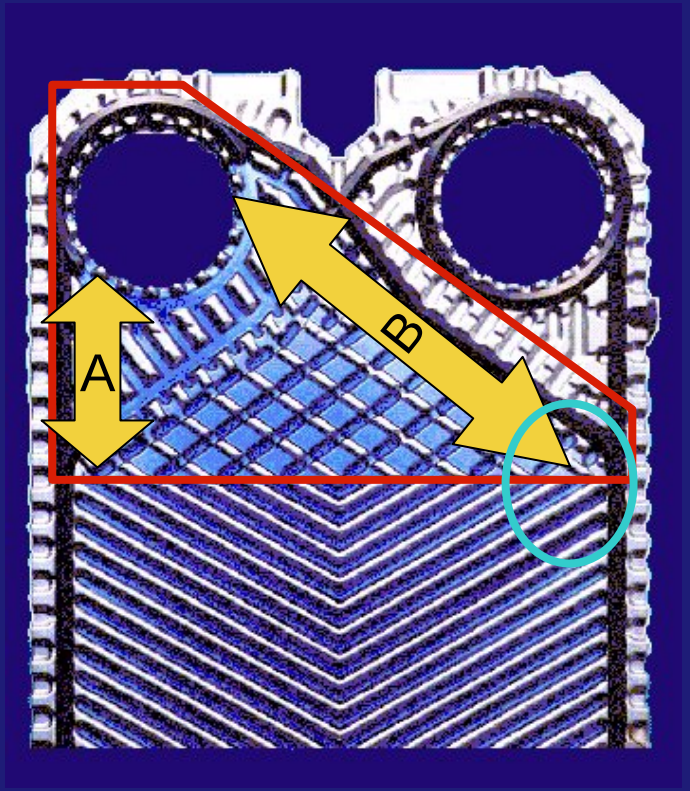
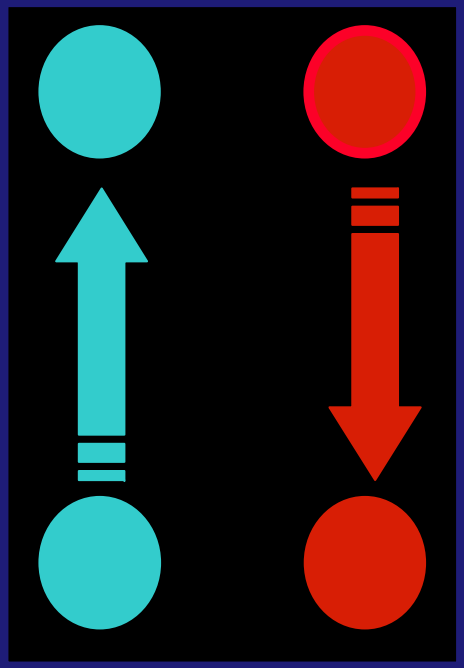
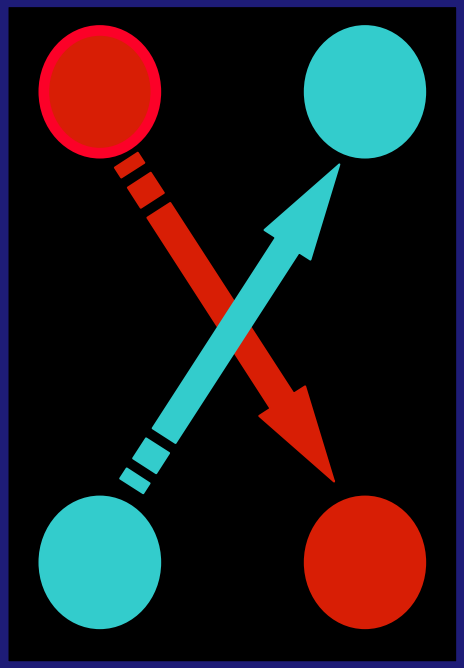


Plate - parallel vs diagonal flow

Parallel



Diagonal



Parallel flow configuration is achieved through the chocolate pattern

Plate - parallel vs diagonal flow

Parallel flow advantages

- One plate & one gasket
  - Identical plates in the plate pack
  - Rotated 180º to achieve both sides
- Less spares required
- Fully supported diagonal
  - Higher design pressure or thinner plate material
- No crossing of nozzles

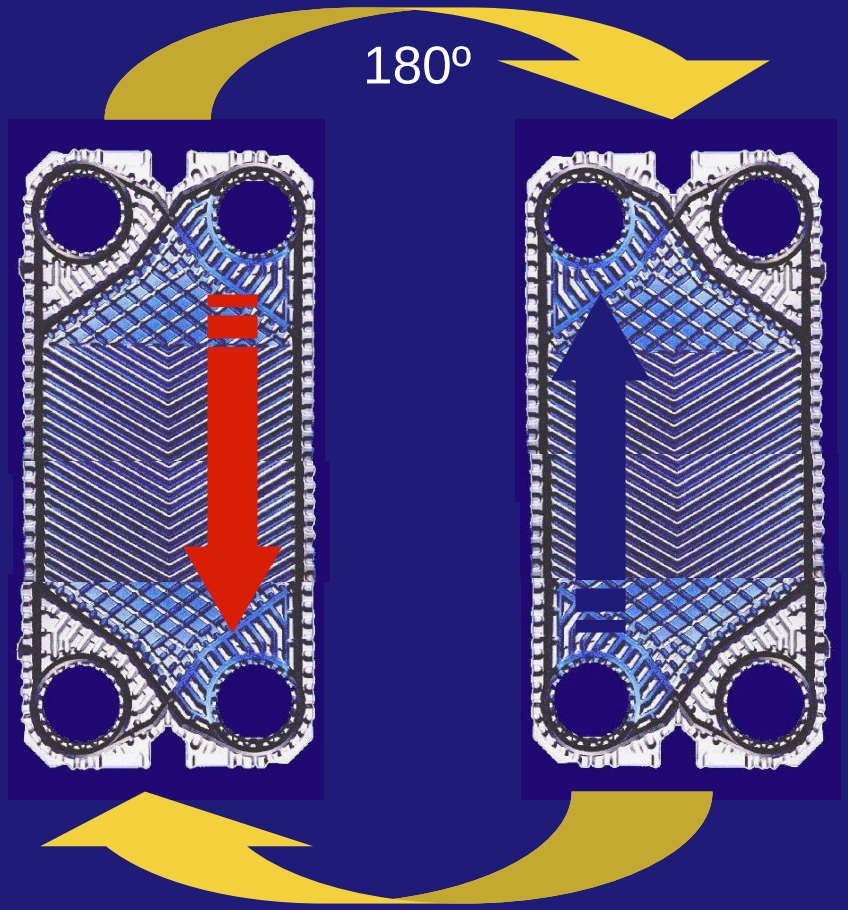


Plate - materials

- Standard materials and thicknesses
  - AISI 304 (stainless steel)
    - Usually 0.4 or 0.5 mm thickness
    - Cheapest possible solution
  - AISI 316 (stainless steel)
    - Always 0.5 and 0.6 mm
    - Some with thicker plates (high-pressure applications)
  - 254 SMO (high-alloy stainless steel)
    - Usually in 0.6 mm to allow stock-keeping
  - Titanium
    - Always 0.5 and 0.6 mm
    - Some with thicker plates (high-pressure applications)
    - Some PHEs with 0.4 mm (low-pressure applications)
  - Alloy C-276 (Nickel alloy)
    - Usually in 0.6 mm to allow stock-keeping

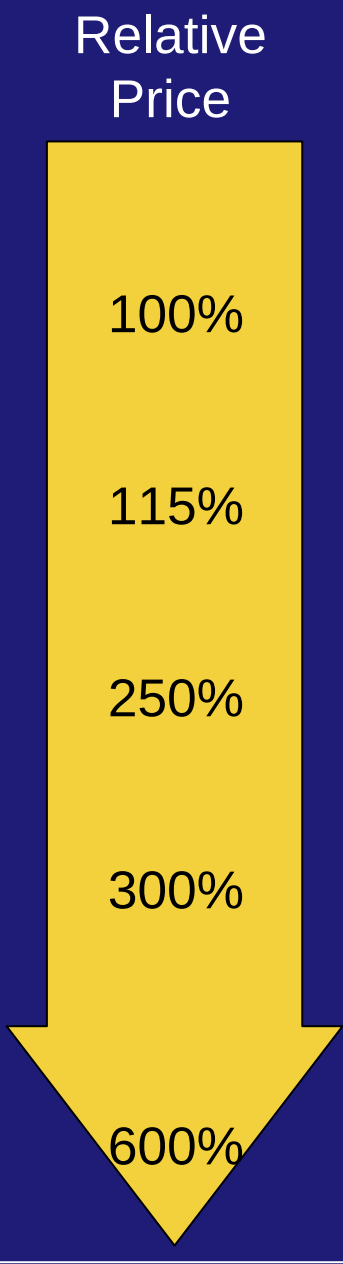


Plate - materials

- Standard materials and typical uses
  - AISI 304
    - Typically in clean water-water duties
    - Example, up to 50 ppm chlorides at 50°C
  - AISI 316
    - Typically in water-water duties
    - Example, up to 250 ppm chlorides at 50°C
  - 254 SMO (high-alloy stainless steel)
    - Many uses including high-chloride water-water duties
    - Example, up to 6000 ppm chlorides at 50°C
  - Titanium
    - Most frequent use is for sea water (3.5% chlorides)
    - Example, up to 130°C in sea water
  - Alloy C-276 (Nickel alloy)
    - Most frequent use is for concentrated sulphuric acid up to 90°C

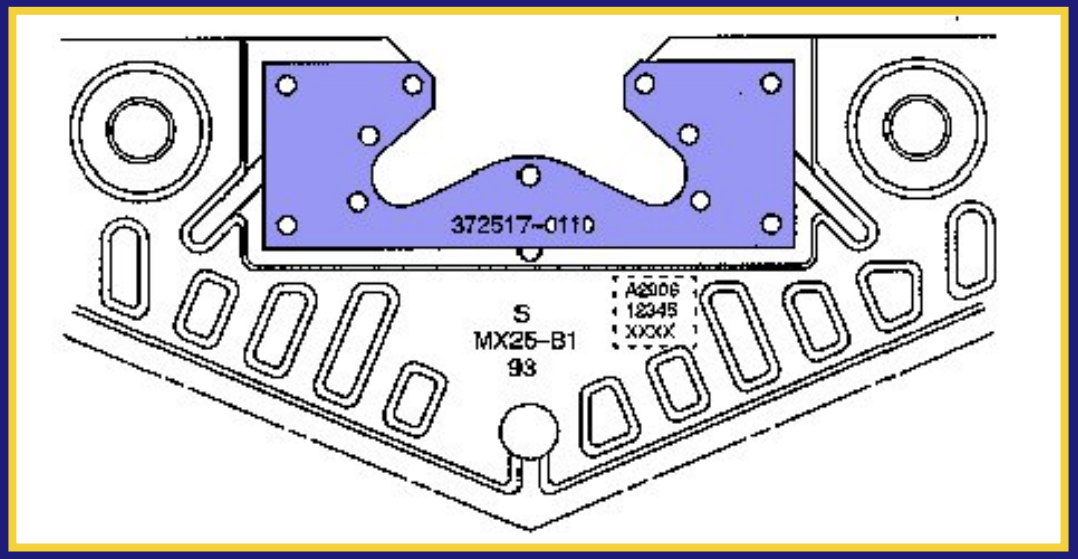
Plate - materials

- Common exotic materials
  - Not always on stock
  - Check with Supply Unit before quoting and confirm before order
  - 904L is an alternative to 254 SMO in some applications
  - Nickel 200/201 is mainly for sodium hydroxide production
  - Titanium Palladium
    - For sea water at high temperature (>130°C)
    - For high concentrated chloride brines at high temperature
  - Alloy G-30 is used in the sulphuric acid application (scrubber)
  - Alloy D-205 is exclusively for concentrated sulphuric acid >90°C
- Many more are used less frequently on a case-by-case basis

Plate - material

- How to know which plate material to use?
  - Application Manual
  - Contact the Market Segment
  - Ask the customer
  - Testing with small test-pieces in the customers process

Plate - hanger slot reinforcement



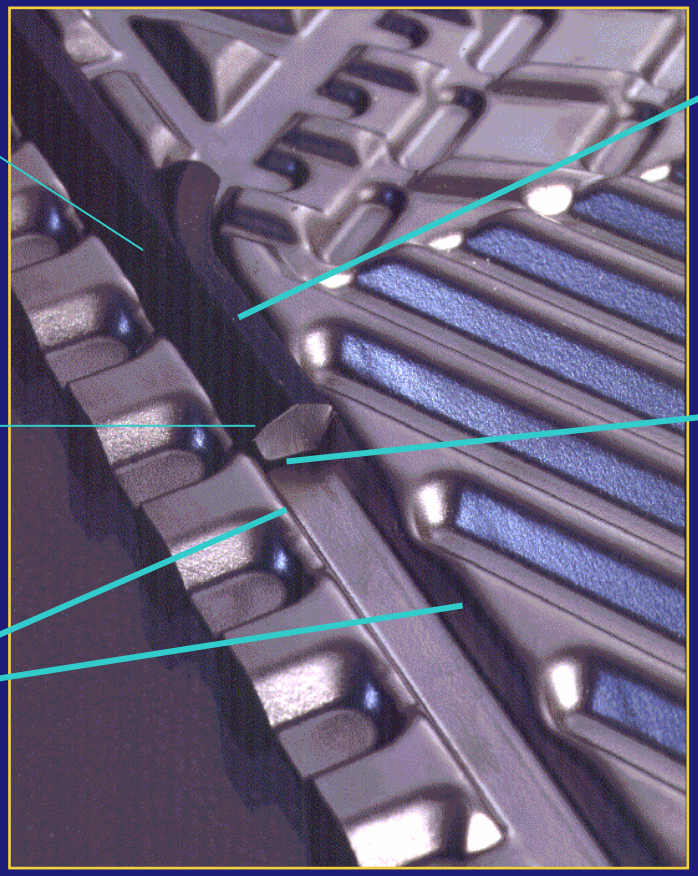
- Reinforces the plate hanging
- Stainless steel spot welded to the plate
- Used on M20 and larger plates

Gasket - advanced sealing system

Homogeneous rubber gasket made in one piece

Gasket material from certified suppliers

Supporting and protecting gasket groove



"Roof-top" gasket profile

Two component oven-cured epoxy glue

...or glue-free gasket that do not mix sealing and fastening function

Long lasting gaskets!

Gasket - profile and groove

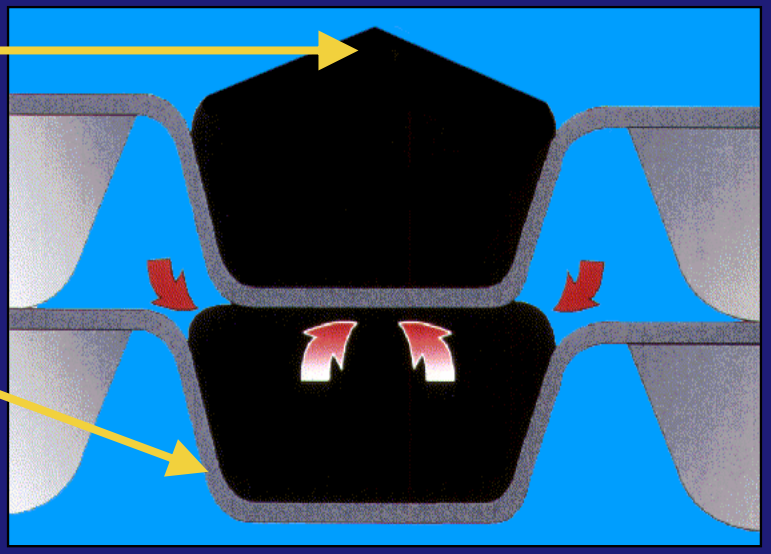
Alfa Laval

Profile

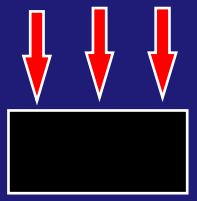
Higher sealing pressure

Groove

Full support to gasket



Competitor



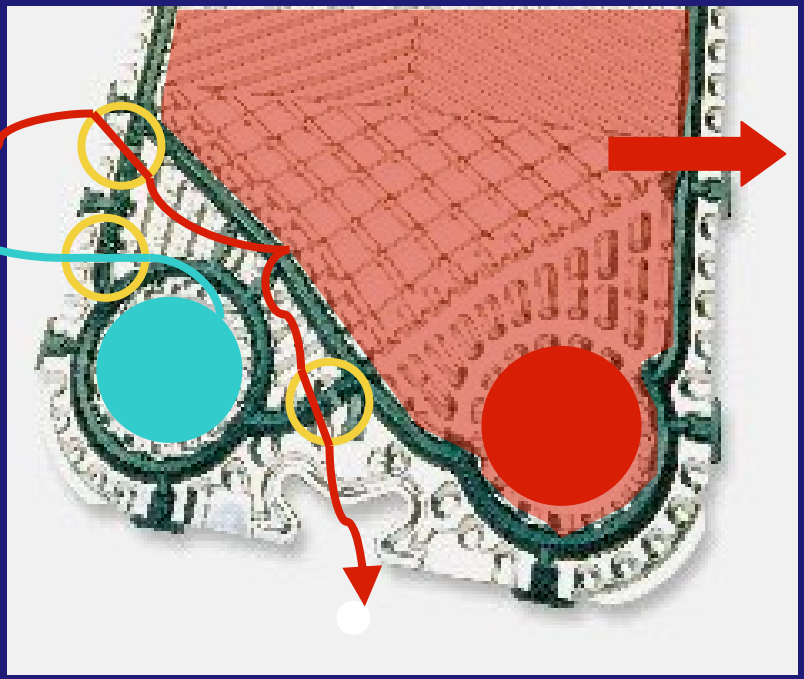
Risk of leakage.

Openings. Risk of gasket blow-out.

The difference is life time and reliability

Gasket - double sealing system

Special venting ports are an integral part of the gasket design to prevent cross contamination



If the gasket fails ⇒ Leakage is detected on the outside

Gasket - materials

- The choice of rubber material depends on
  - Fluids - chemical attack or not
  - The combination of temperature and pressure
- Rubber materials change properties due to
  - Time - the rubber relaxes
  - Temperature - the rubber deteriorates
  - Hardening by attack of oxidising agents (e.g., oxygen in air)
  - Swelling or softening by absorption of chemicals in the fluids
- Common gasket types
  - Nitrile
  - EPDM
  - FKM

Gasket - materials

- Nitrile
  - Inexpensive standard material up to 130°C
    - NBR P (performance) up to 130°C
    - NBR B (base) inexpensive for lower temperatures
  - Application related NBR qualities
    - NBR HTF - food grade for high temperatures
    - NBR LT - for low temperature in refrigeration applications
    - H NBR (hydrogenated) for duties where normal NBR swells and for higher temperatures, more expensive

Gasket - materials

- EDPM
  - Standard material up to 160 °C
  - Standard EPDM qualities
    - EPDM for glued gaskets (“Crushing resistant”)
    - EPDMC for clip-on gaskets at high temperature
    - EPDMCT as above but for thin gaskets in models with low pressing depth (1.5-3 mm)
  - Application related EPDM qualities
    - EPDMF - food grade
    - EPDM AL for increased pressure resistance in certain chemical duties where normal EPDM swells

Gasket - materials

- FKM, Fluorocarbon rubber
  - Often called Viton (DuPont trade name)
  - Used for aggressive chemical compounds
    - Sulphuric acid
    - Aromatic organic compounds
    - Chlorinated organic compounds
  - Two different qualities used
    - FKM G
    - FKM S
- Other types are Neopren, Hypalon, Chloroprene, etc.

Gasket - composition

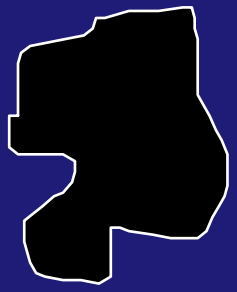
- Typical composition of a PHE gasket

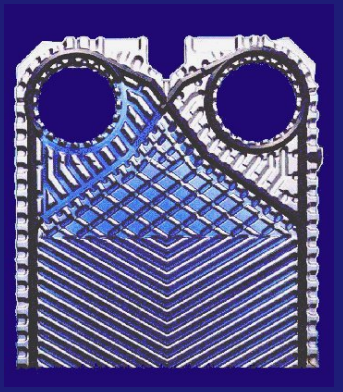
CONSTITUENT	CONTENT	EXAMPLES
Rubber Polymer	~50%	EPDM, NBR
Filler	30-40%	Carbon black
Curing agents	2-10%	Sulphur, peroxides
Metallic oxides	1-5%	ZnO,PbO,CaO
Antidegradants	0-5%	Amines, phenols
Processing Aids	0-5%	Mineral oil

Exact composition is the know-how of the gasket supplier

Gasket - temperature

- Temperature performance of a PHE gasket is lower than that of the rubber compound
  - The rubber compound must not deteriorate
  - The gasket must seal

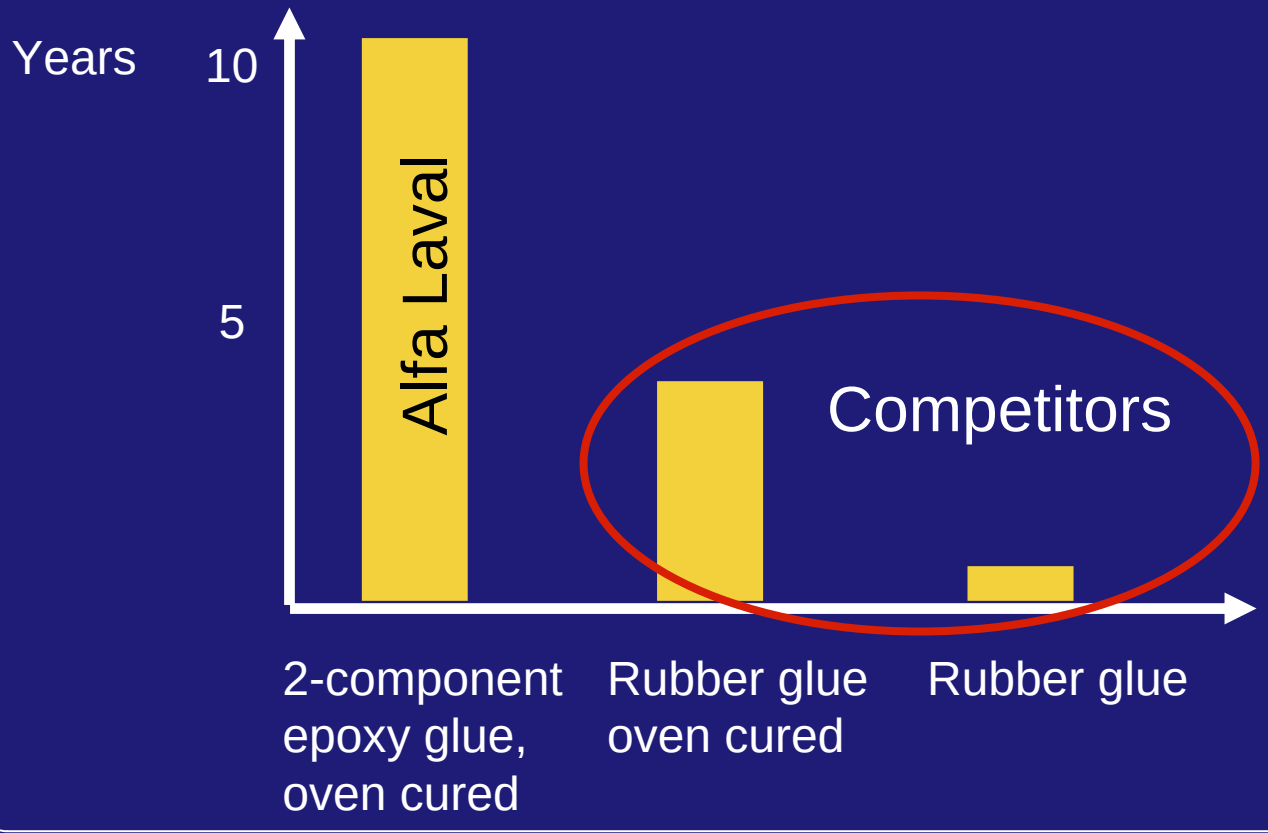




	Rubber compound	Gasket
• NBRB continuous	150 ºC	<130 ºC
• NBRB intermittent	170ºC	<130 ºC

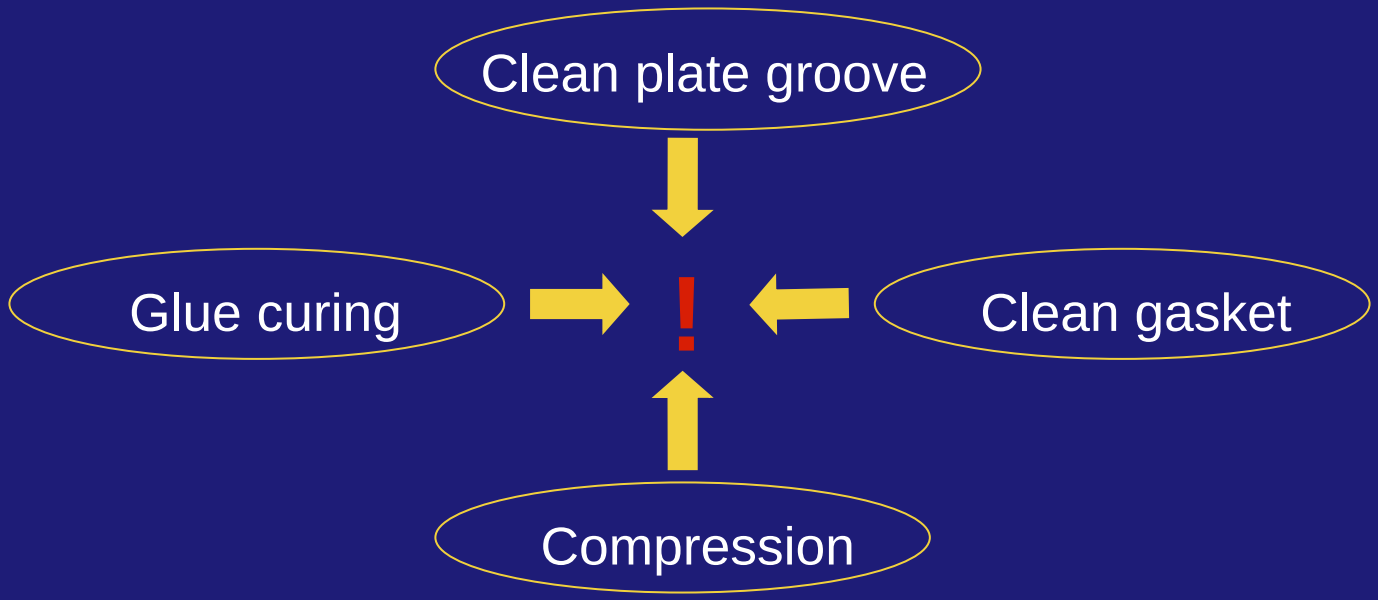
Gasket - glued fastening

- Alfa Laval uses 2-component oven cured epoxy glue
- Average gasket lifetime in years for the same application, opened once a year



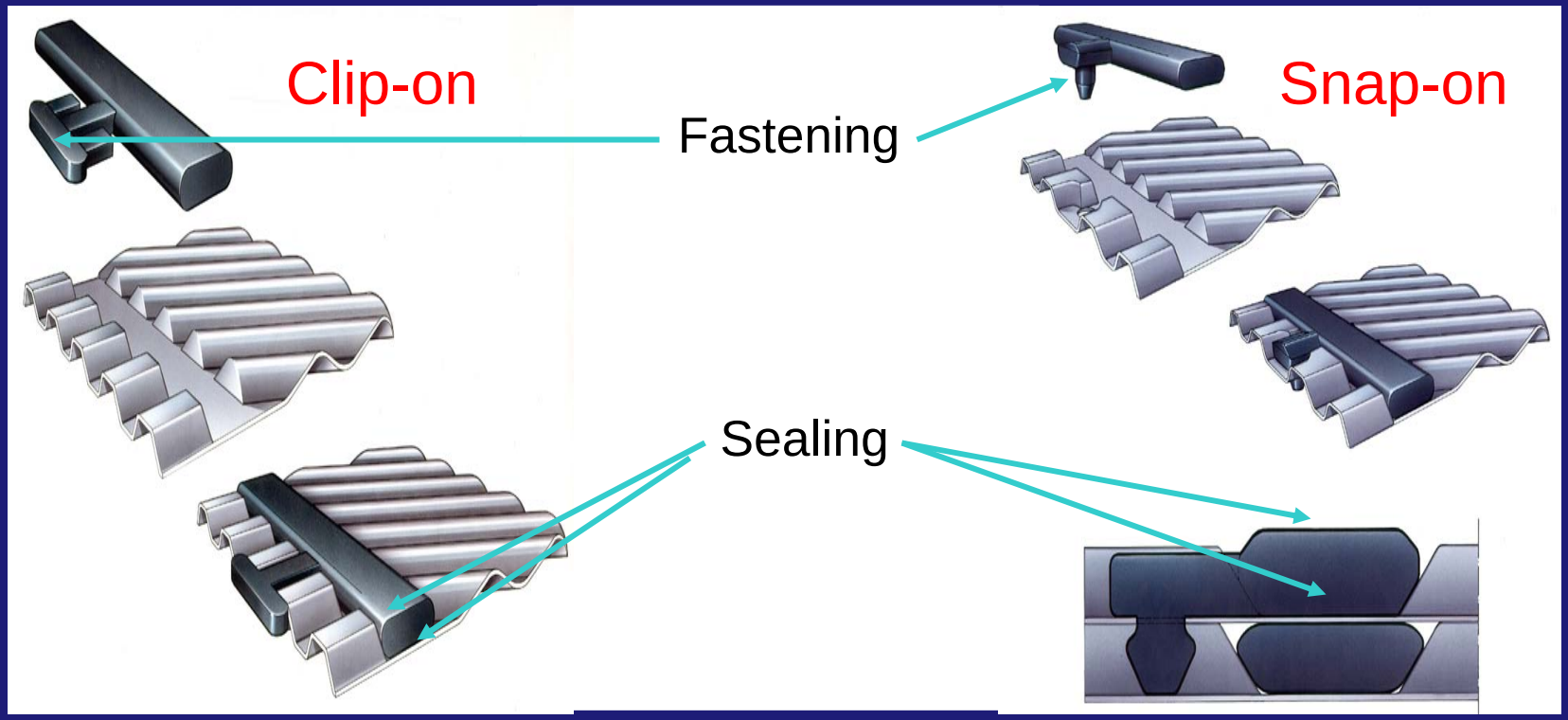
Gasket - glued fastening

- The four parameters creating a perfect glue bond



- A perfect bond with 2-component oven cured epoxy sticks to the plate. Only loosens if the gasket is torn.

Gasket - glue free fastening



- Fastening and sealing are kept separate
- If the one of the fastener breaks, the gasket still stays sealed
- Clip-on is mostly used (snap-on on a few older models)

Gasket - glued versus glue-free

Should be the choice of the customer

...BUT glued is preferred:

- On large plates
- When units are opened frequently
- On high pressure duties
- When the gasket will be swelling due to chemical attack

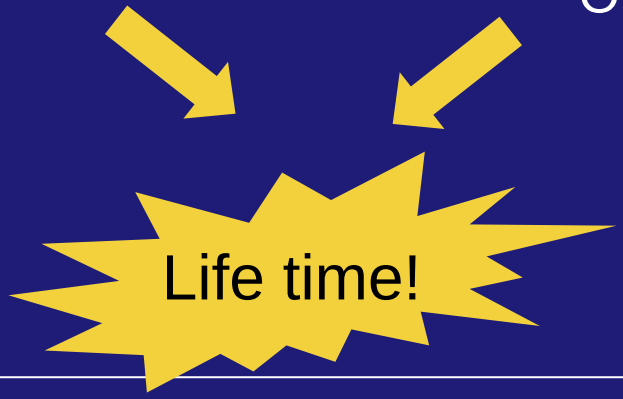
Gasket - sealing lifetime

Product

- Gasket material
- Fastening
  - Glue or glue-free
  - Type of glue
- Gasket geometry
- Gasket groove
- Alignment of plate pack

Duty

- Operating temperature
- Operating pressure
- Media
- Type of operation continuous / cyclic
- Cleaning methods & chemicals
- Opening frequency



Gasket - sealing lifetime

- Maximum temperature in CAS and product manual, for example,
  - NBR up to 130ºC
  - EPDM up to 160ºC

  ⇒ Gives about 1 year lifetime
  When no chemical attack takes place

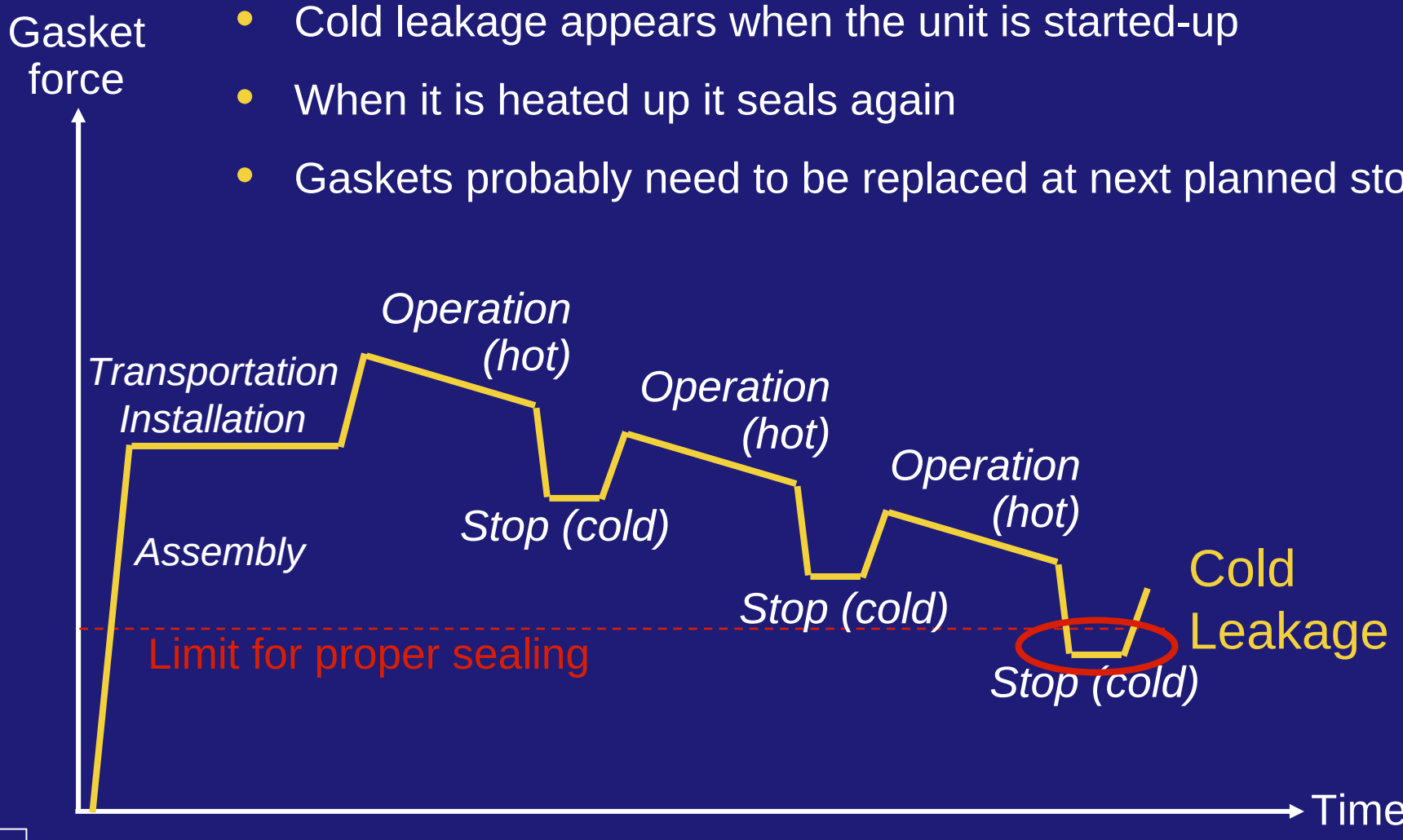
- Rule of thumb:
  - 10ºC lower than max temperature ⇒ 2 years lifetime
  - 10ºC above the max temperature ⇒ 6 months lifetime

Gasket - sealing lifetime

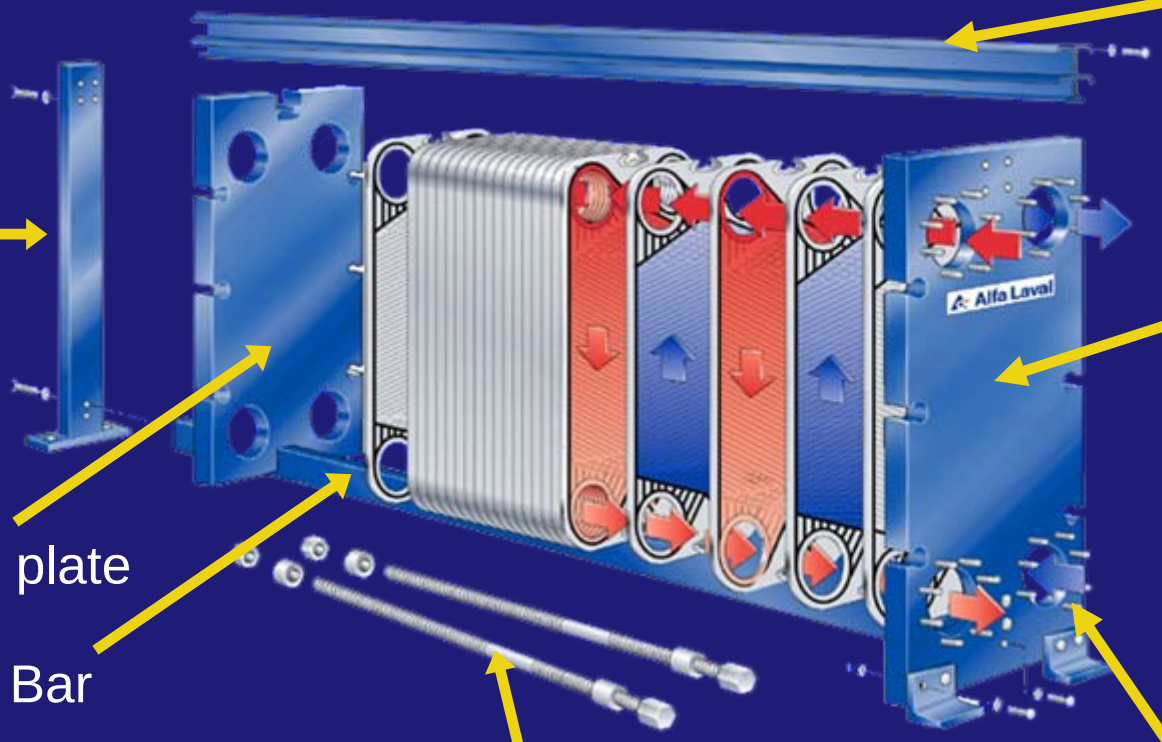
- Temperature
  - Considered in CAS
  - Selects a gasket which gives minimum 1 year lifetime at the design temperature
  - Manual check if other gasket is needed to get longer lifetime
- When aggressive fluids are present
  - Gasket Selection Guide programme
  - Ask the customer
  - Contact the Market Segment
  - Testing with small test-gaskets in the customers process

Gaskets - cold leakage

- Cold leakage appears when the unit is started-up
- When it is heated up it seals again
- Gaskets probably need to be replaced at next planned stop



Frame - components



Carrying bar

Support column

Frame plate

Pressure plate

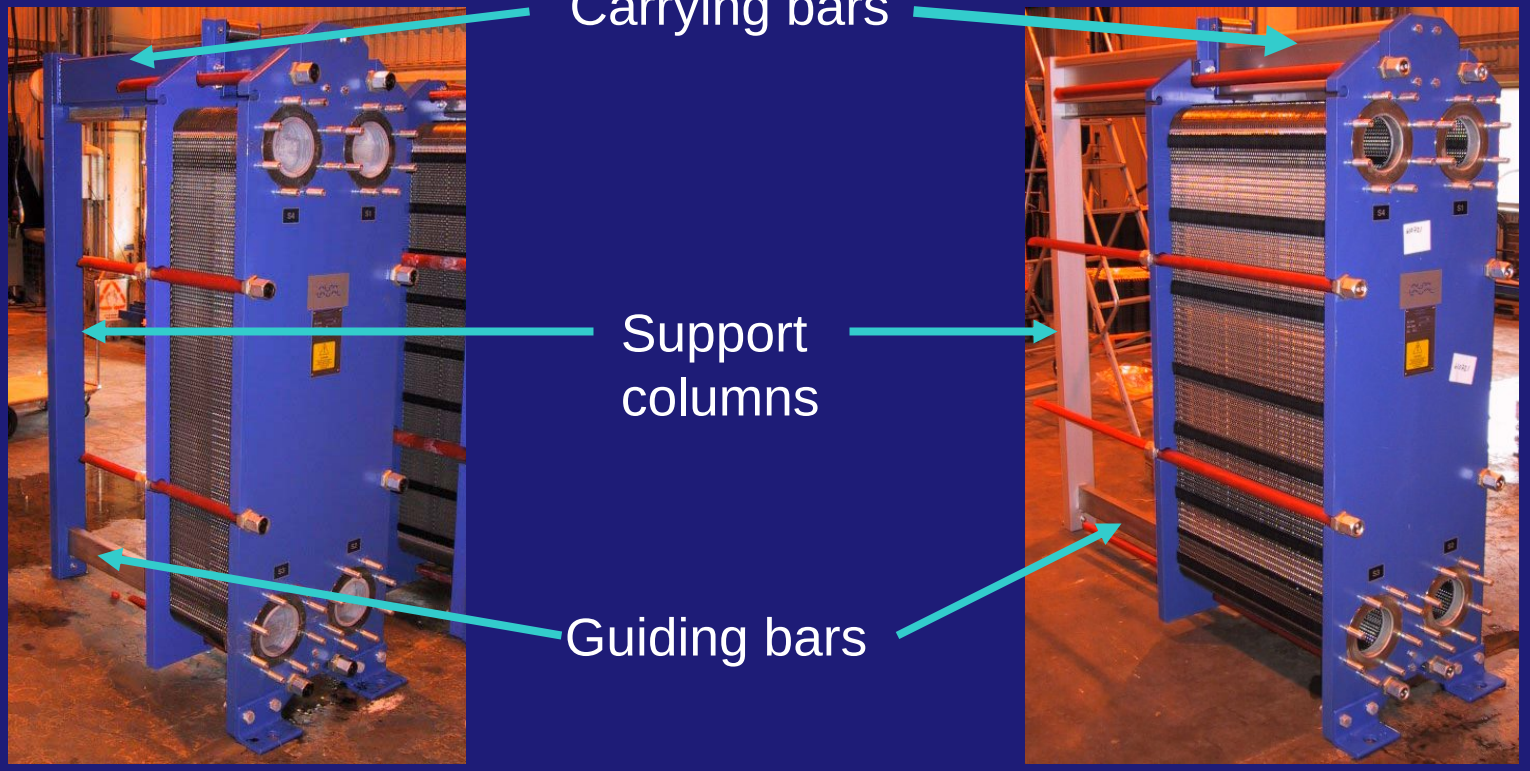
Guiding Bar

Tightening bolts

Studbolt connections

All-bolted construction for easy on site assembly and repair

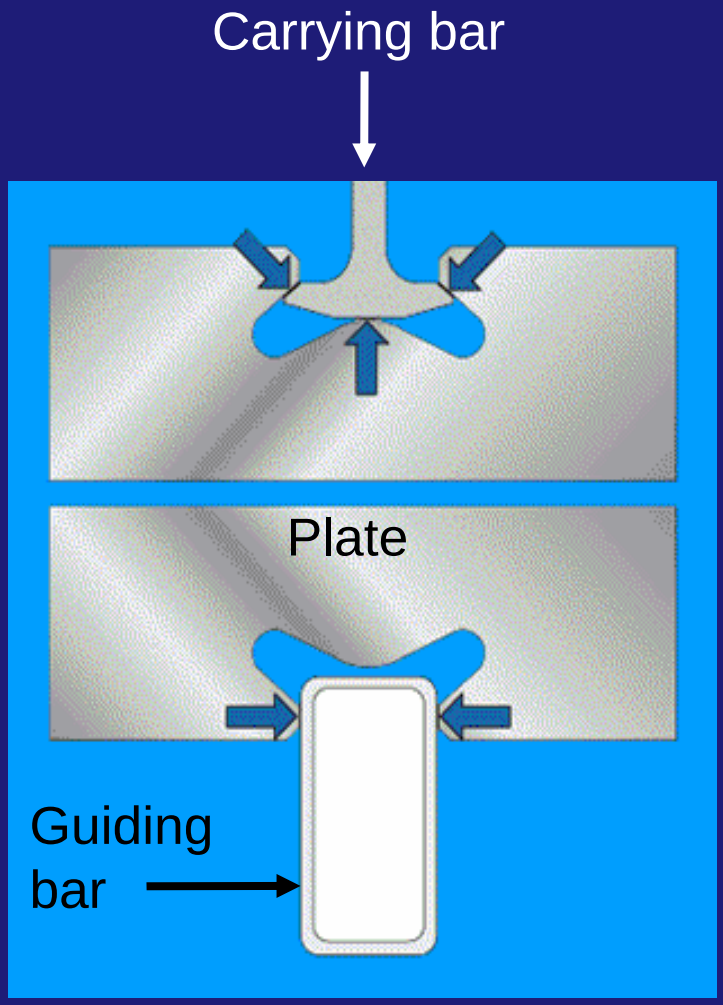
Frame - M15 and larger



- Carryings bar in Aluminium or Painted carbon steel
- Support columns in Aluminium or Painted carbon steel
- Guiding bars in Stainless Steel

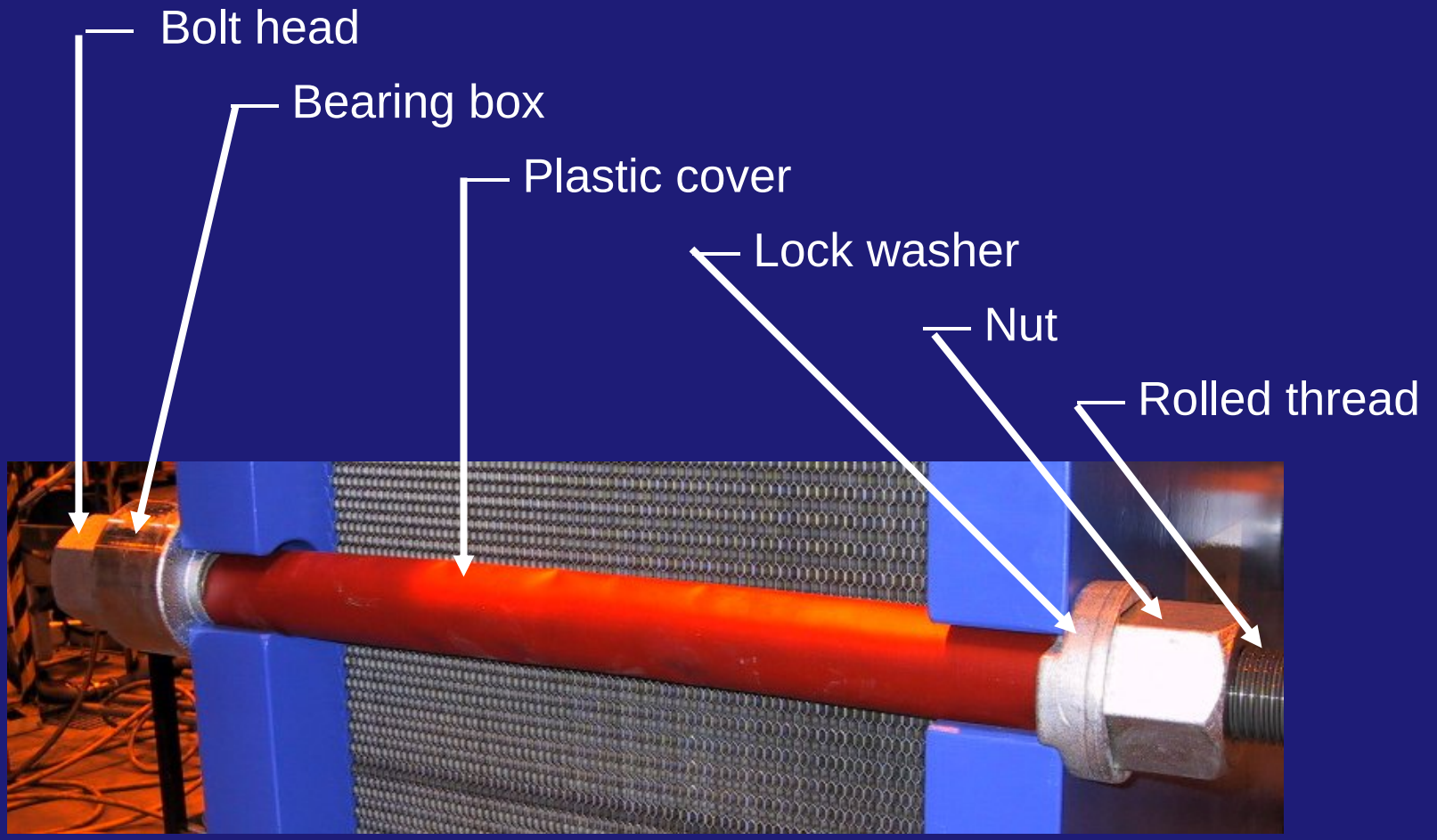
Frame - M15 and larger

- Unique 5-point alignment system
  - Provides exact positioning of the plates horizontally and vertically
  - Ensures good sealing throughout the plate pack



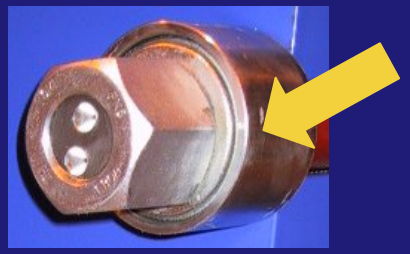
Frame - M15 and larger

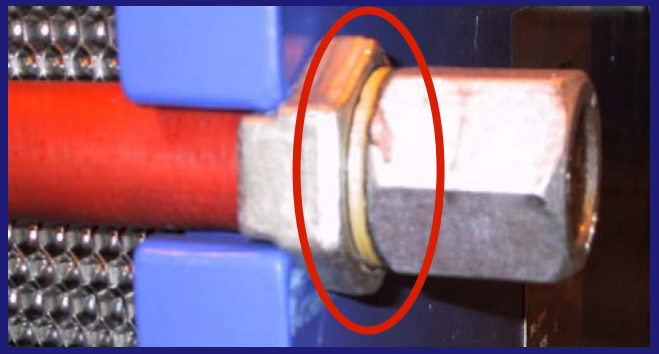
- Tightening bolts to allow easy opening



Frame - M15 and larger

- Tightening bolts to allow easy opening



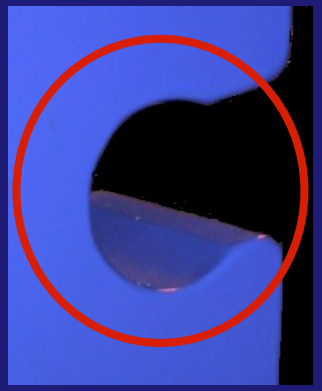


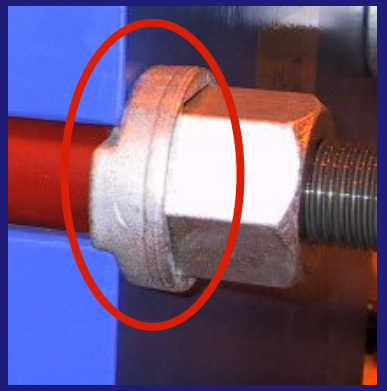
- Four tightening bolts have bearing boxes
- These are used for opening and closing the unit

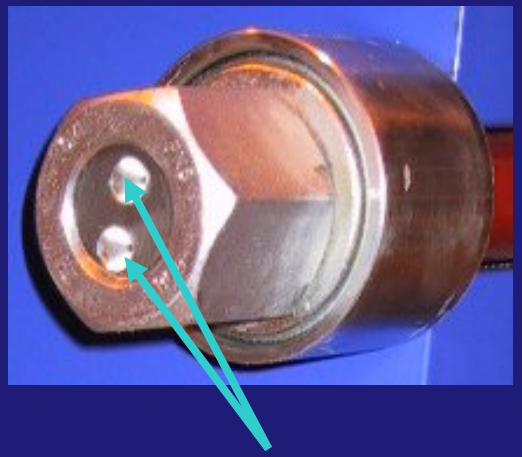
- Remaining bolts with wearing washer
  - When closing these are tightened last
  - When opening these are removed first

Frame - M15 and larger

- Tightening bolts to allow easy opening







- Tilted bolt opening
- Prevents bolts to fall out when loose

- Lock washer
- Prevents bolt to fall out during tightening and opening

- Bolt head fixated
- Does not loosen when opening

Frame - M15 and larger

- Roller on pressure plate to allow easy opening and closing

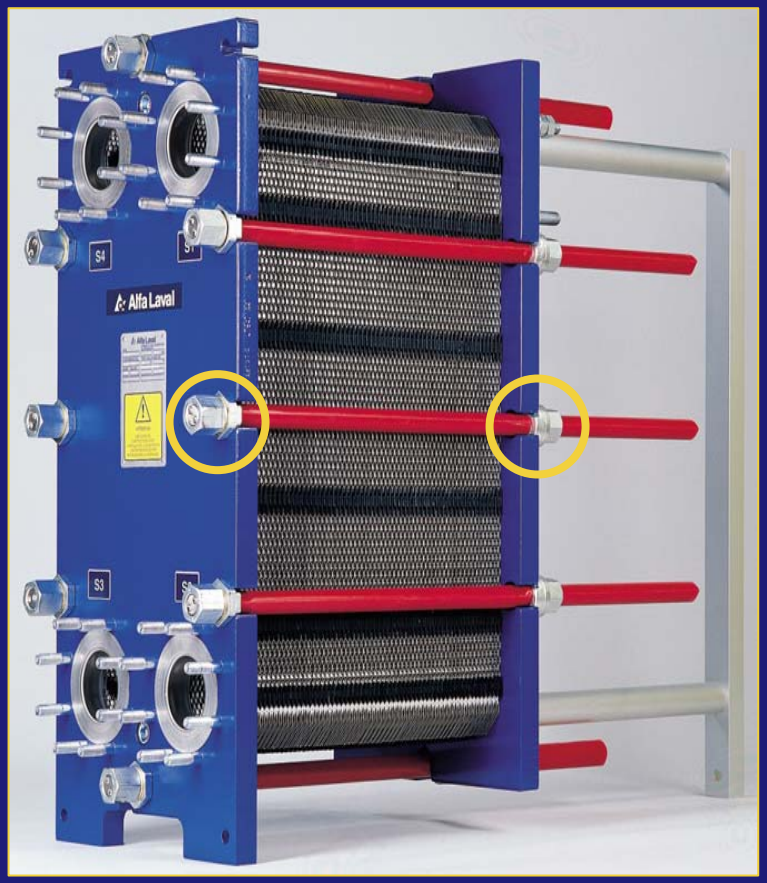
Frame - M15 and larger

- One man can open and close a large PHE using standard tools
- Serviceability
- Less downtime
- Safety
- Longer lifetime

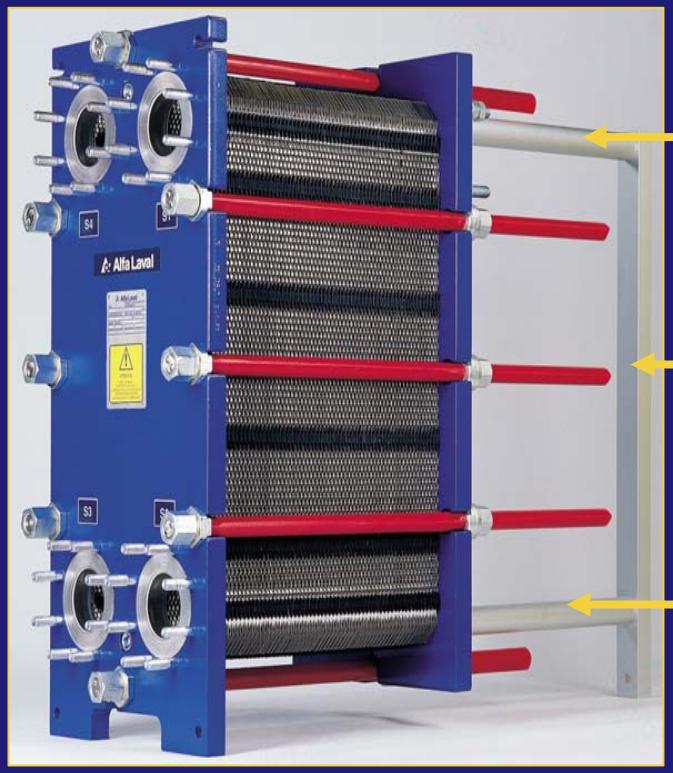
Frame - M10 and smaller

- Smaller units requires less features
- Smaller means easier to handle
- Cost efficiency important

- Appropriate bolting system
  - Less tightening forces required
  - Tilted bolt opening
  - Wearing washer in plastic
  - Lock washer
  - Fixated bolt head



Frame - M10 and smaller



Round carrying bar

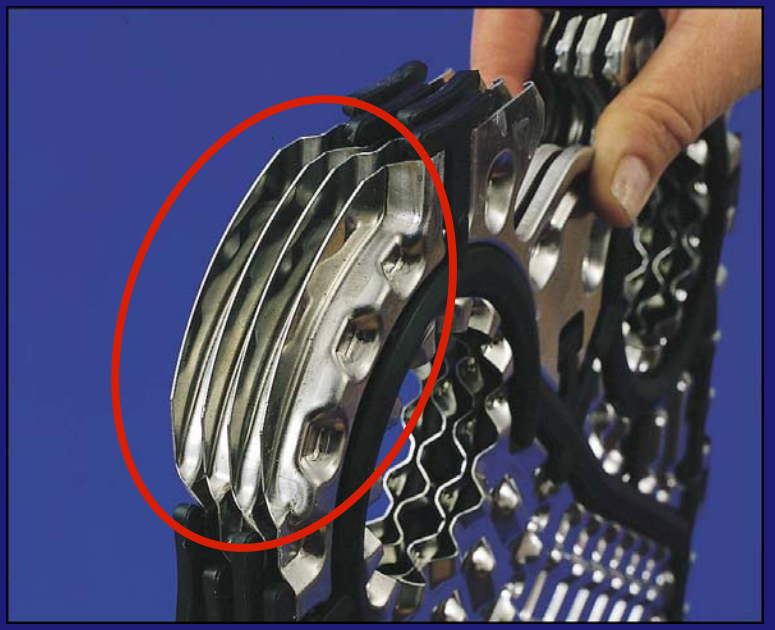
Support column

Round guiding bar

- Carryings bar, Support columns and Guiding bar in Aluminium
- No roller needed due to low weight pressure plate

Frame - M10 and smaller

- First alignment made by the round carrying & guiding bar
- Corner guidance locks the plates in position and fine-tunes the alignment
- Effective and cost efficient



Frame - connections and linings

- Studbolts around the connection
- Connection pipes are bolted to the PHE
- Three different types of linings

Unlined

- Cheapest possible
- Clean water duties

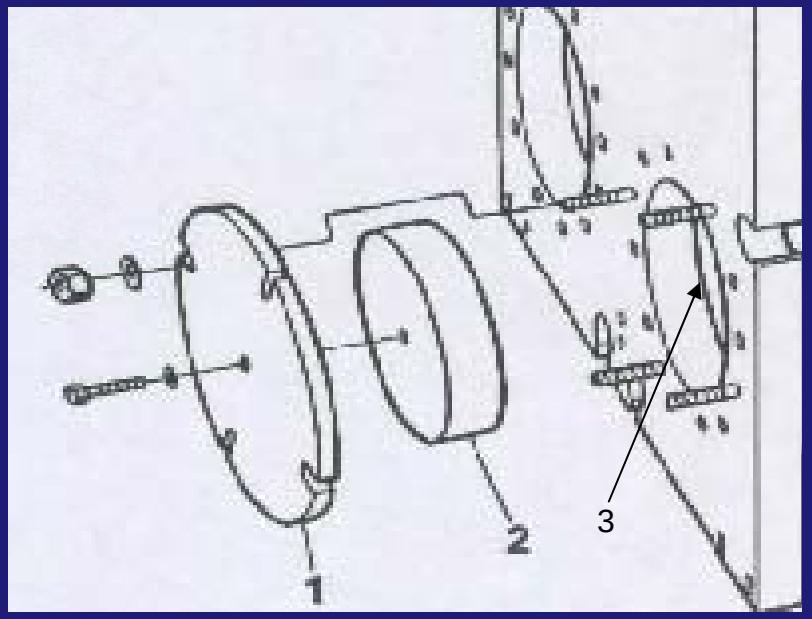
Rubber lining

- Low cost
- Limited in temperature
- NBR and EPDM

Metal lining

- More expensive
- Industrial use
- Same as plate material

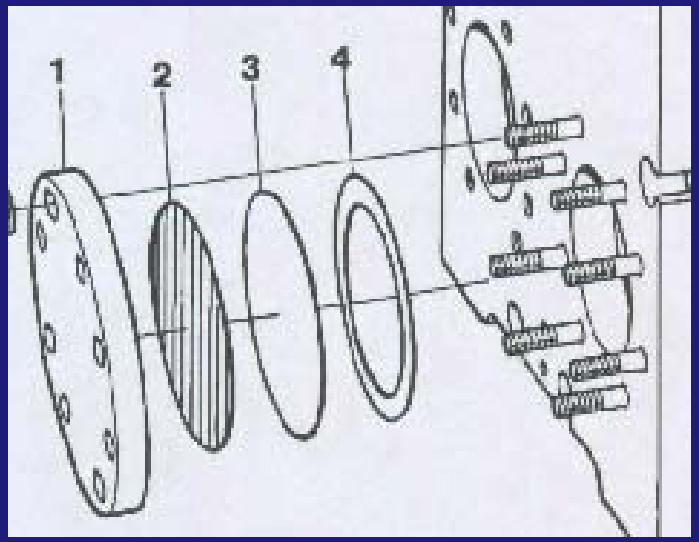
Frame - blind covers



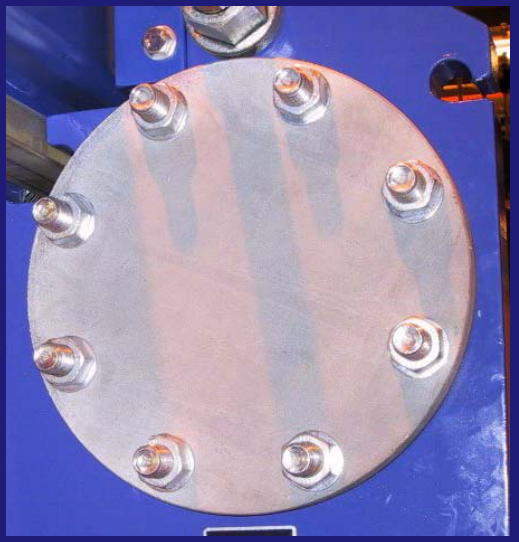
1 External cover
2 Spacing piece
3 Blind cover

- Used in multi-pass to seal off unused connections
- When 2- or 4-holed pressure and frame plates are standard
- M15 and smaller with inside cover only (3)
- M20 and larger blind cover, inside cover and spacing piece (1-3)

Frame - inspection covers



1 Flange
2 Adhesive
3 Metal sheet
4 Gasket



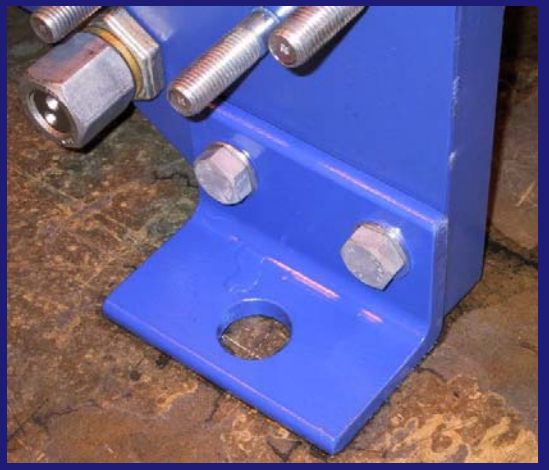
- Used to allow inspection in the port without dismantling the pipes
- Used with holed end plate and pressure plate

Frame - protection sheets

- Safety issue
- Protects personnel in case of leakage
- Stainless steel (M15 and larger)
- High-resistant plastic (M10 and smaller)
- Customers choice
- Recommended for hazardous duties
  - Temperatures over 60°C
  - pH less than 3 (acidic)
  - pH over 10 (alkaline)
  - Toxic, poisonous or flammable fluids under pressure

Frame - feet

- Gives stability
- PHE bolted to foundation
- Standard on M15 and large
- Option on M10 and smaller
- Painted carbon steel
- Hot-dip galvanised



Frame - lifting holes

- For safe and easy lifting of the unit in manufacturing and at site
- On all units except M3

Frame - painting systems

- Specifically developed for PHE
  - Too thick ⇒ Paint is crushed behind end-plates
  - Too thin ⇒ Inadequate protection
  - Alfa Laval system balances hardness & thickness
- Choice of colours
- Choice of tested paint systems
- Examples,
  - Standard
    - Sandblasting
    - Primer - 2 part epoxy
    - Finish - 2 part epoxy
    - 90-135 microns
  - Special
    - Sandblasting
    - Primer - zinc rich epoxy
    - 2 coatings - iron oxide epoxy
    - Finish - 2 part polyurethane
    - 240-315 microns

Frame - pressure vessel codes

- All PHEs available as standard with
  - TUV
    - Always DIN connection standard
  - ASME
    - Always ANSI connections standard
  - SA
    - DIN connections
    - ANSI connections
- Contract orders
  - Various national codes available at extra cost
  - Example, BS5500 (UK), Codap (France) and Ispels (Italy)

Plate gallery & Workshop visit

- Plate gallery tour to view historic PHEs, the evolution and samples of modern PHEs

- Workshop tour to have a hands-on look at the frame components

Plate pack assembly

- Channel Plate
- End Plate II
- End plate I
- Turn Plate
- Transition Plate
- Partition Plate
- Connection Plate

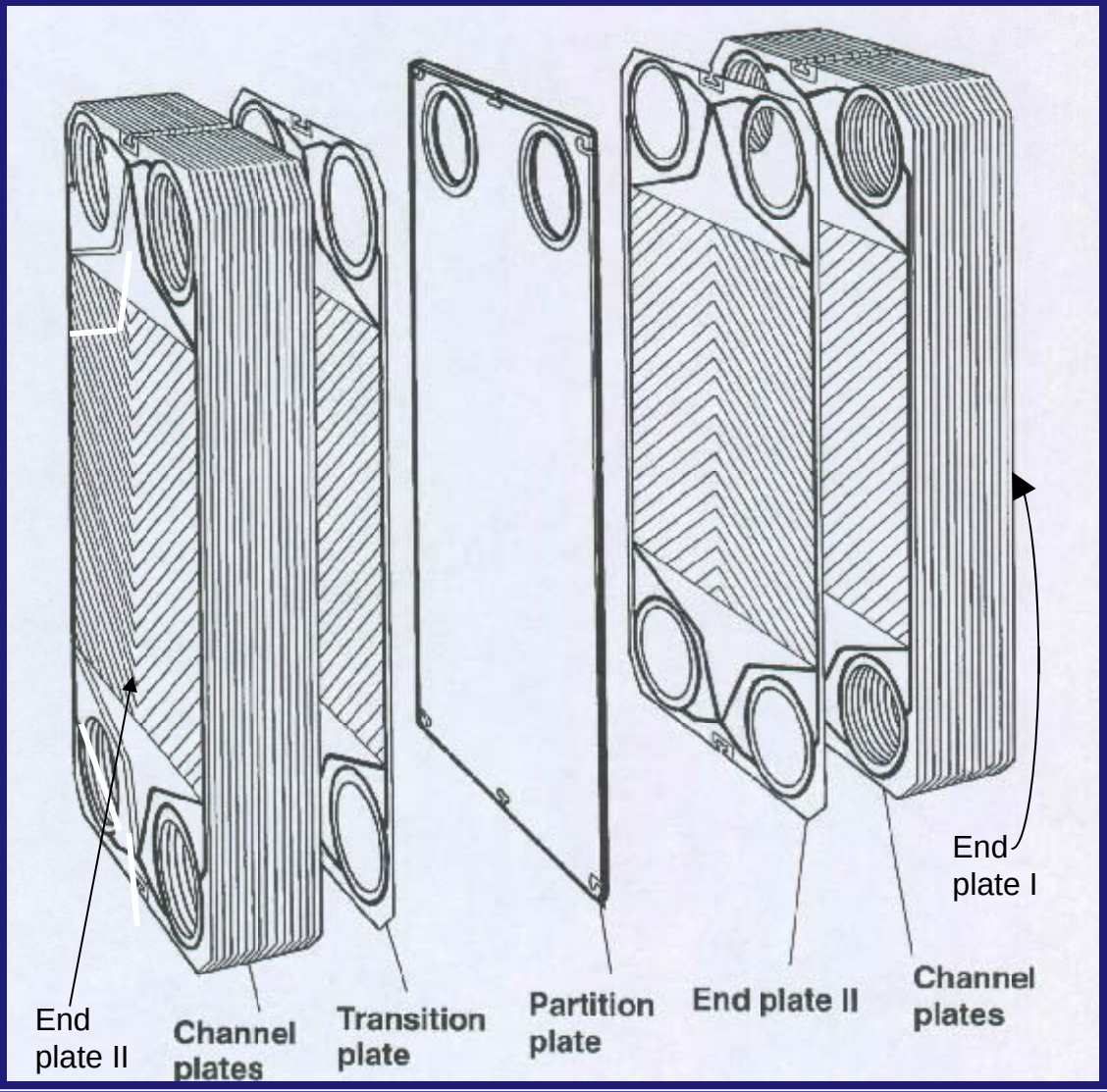


Plate pack - channel plates

- Channel Plates are the heat transfer plates
- They dominate the plate pack
- Most frequently with 4 holes punched

Plate pack - end plate II

- 1st plate at the carbon steel frame plate
- In multi-pass, 1st plate in each pass
- Prevent the fluids from coming in contact with the painted carbon steel frame plate
- All 4 ports sealed off
- Transports the fluids
  - From the connections in the frame plate
  - To the first channel plate
- Usually in 0.6 mm with high-theta

  (On older models the End Plate II is at the end of the plate pack)

Plate pack - end plate I

- In single pass,
  - Stops the fluid at the end of the plate pack
  - Last plate at the carbon steel pressure plate
  - No port holes are cut out
- In multi-pass,
  - Stops one fluid as it reaches the end
  - Allows the other to flow into the plate pack
  - 2nd last plate in the plate pack (transition plate behind it)
  - Hole combination as per pass arrangement
- Normal gasket as on channel plates
- Usually in 0.6 mm with high-theta

(On older models the End Plate I is at front of the plate pack)

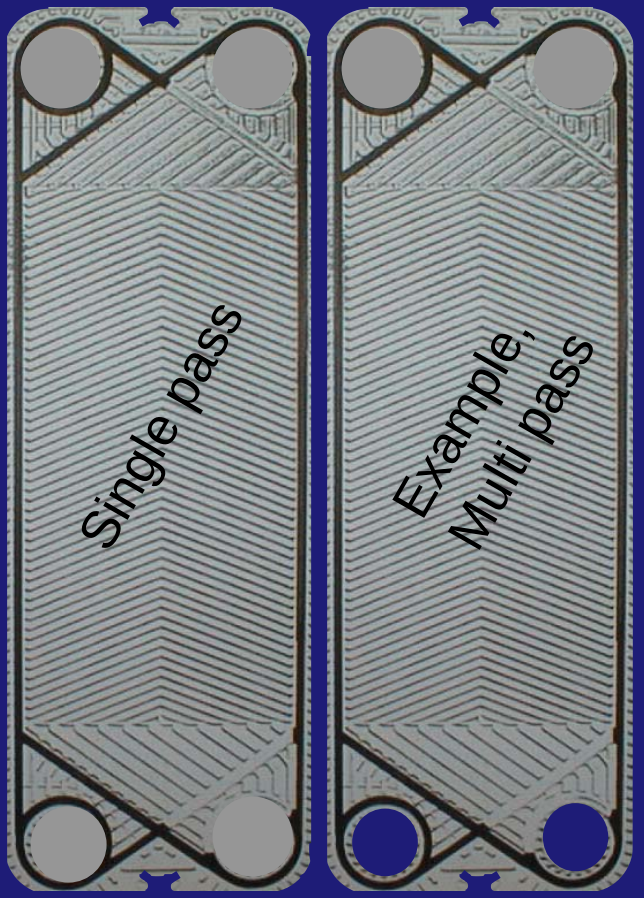
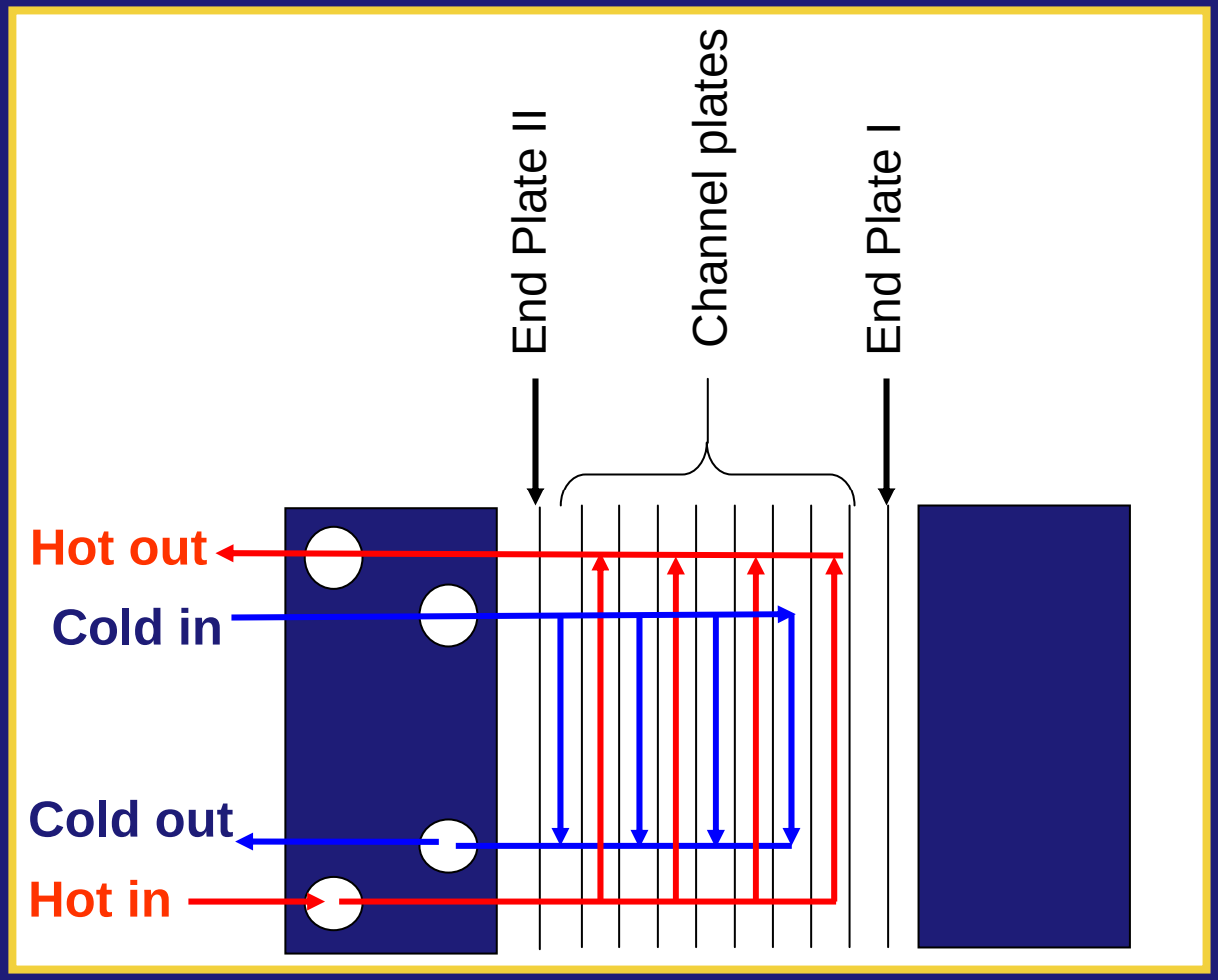


Plate pack - example single pass



Only 2 plates that do not transfer heat - the endplates

Plate pack - turning plate

- Used in multi-pass
- 1, 2 or 3 port can be unholed
- Change the flow direction of one or both fluids in between the passes
- Normal channel plate gasket

Plate pack - partition plate

- Used in multi-pass
- Solid carbon steel plates (6-12 mm thick)
- Metal ring in same material as the plate pack
- Used behind turning plates to support it from the pressure of the flow in the unholed port

Plate pack - transition plate

- Used in multi-pass
- Last plate in each pass (behind Turning plates and End plate I)
- Prevents the fluids to come in contact with partition plates and the pressure plate
- Special port ring-gaskets
  - Protrude through the plate
  - Allows a seal on both sides of the plate
  - Lined on the inside perimeter with a metal ring
- Always, plate in AISI 316 and field gasket in NBR
- Metal ring in the same material as the plate pack
- Ring gaskets in the same material as the plate pack

Plate pack - transition plate

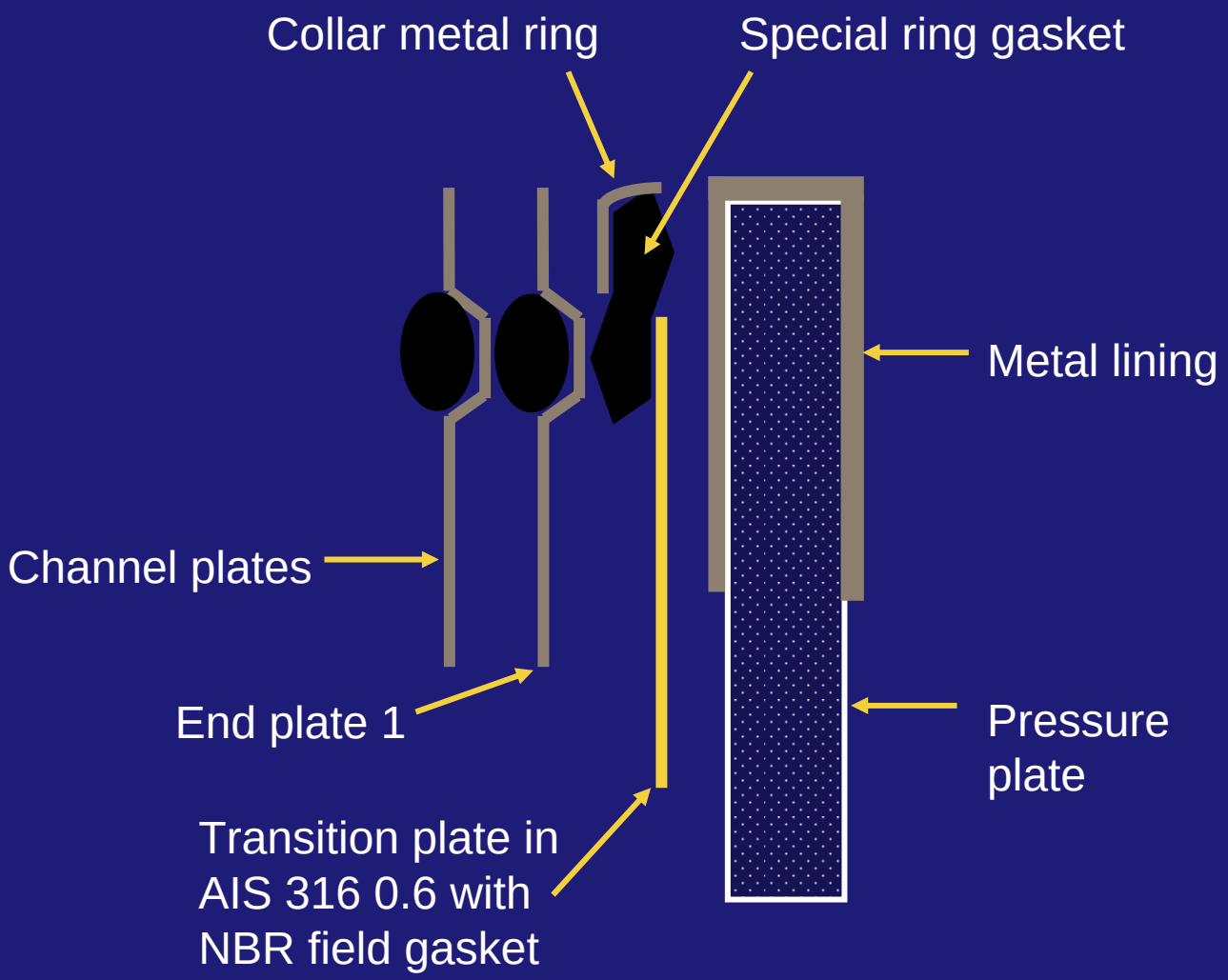
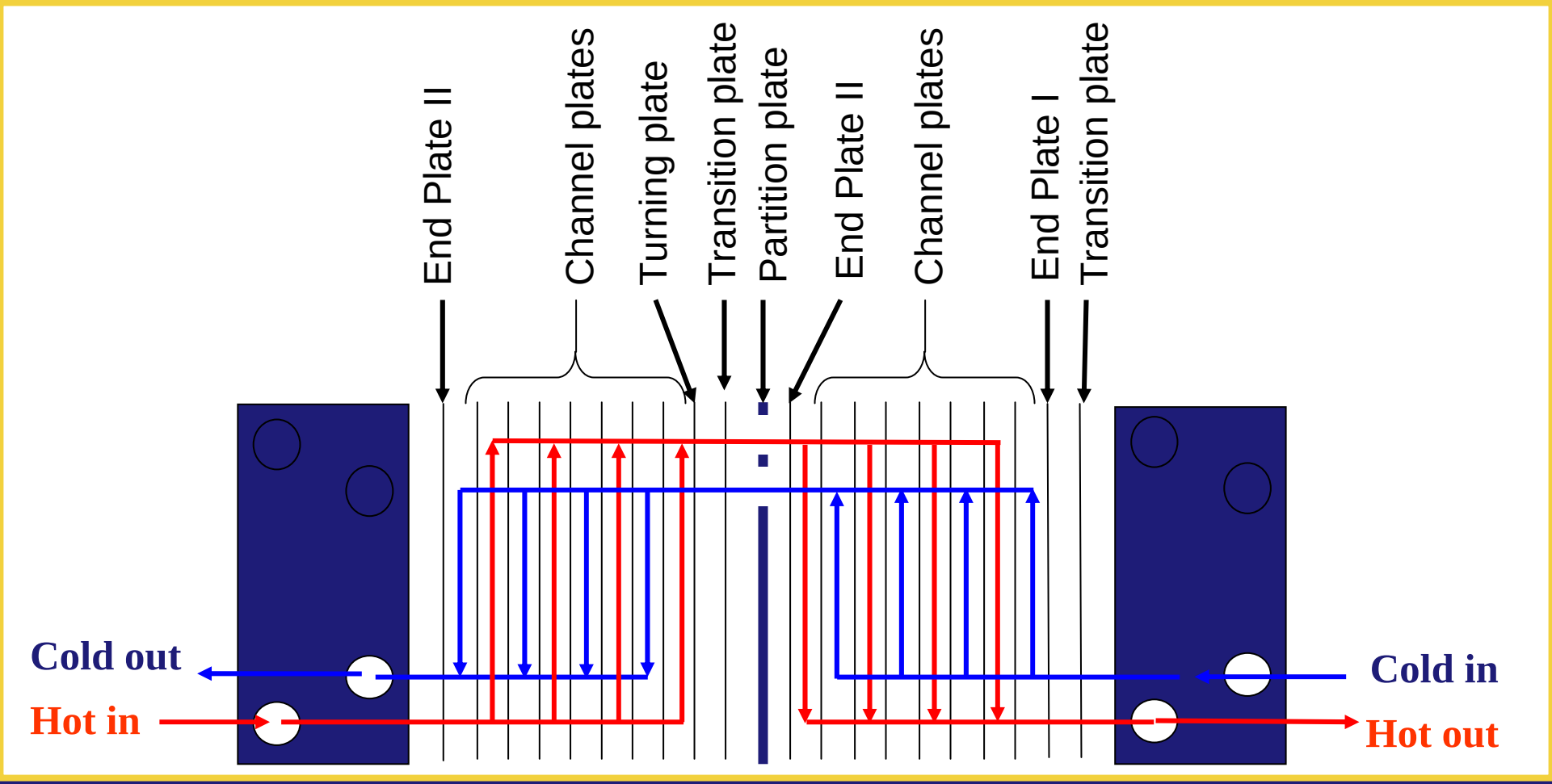


Plate pack - partition plate

- Partition plate rules
  - M20 size and large
    - Always partition plate behind turning plate
  - M15 size
    - Double turning plate if flow rate < 75 kg/s
    - Partition plate if flow rate > 75 kg/s
  - M10 size and smaller
    - Single turning plate is Ok
  - Any unit with 3 fluids or more require partition plate
    - Mainly in Marine applications (combi-coolers)

Plate pack - example two pass



3 plates in each pass that do not transfer heat

Plate pack - the A measure

- A-measurement
  - The length of the compressed plate pack in mm
  - Distance between the inside of the frame and pressure plate
  - No. of plates * (plate pressing depth + plate thickness)

- Very important that the A-measure is correct at each tightening bolt to avoid deformation of plates or leakage

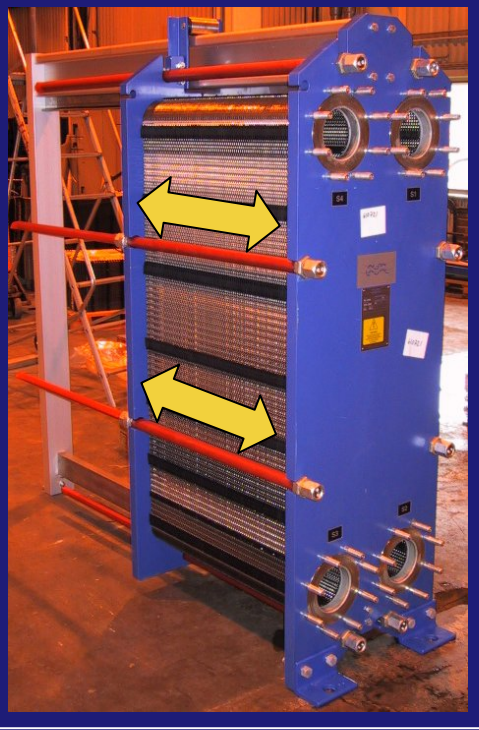


Plate pack - number of plates

- Maximum number of plates is limited due to
  - The more plates, the harder it is to get perfect alignment
  - If the the plates are not aligned, it will leak
  - Max. allowed length of carrying bar and tightening bolts
  - … and of course that ΔP in port can be too high
- Minimum number of plates is limited due to
  - The elongation of tightening bolts when the unit is pressurised
  - Risk of leakage when few gaskets must compensate
  - Min. no. of plates ranges from 10-30 depending on PHE model
  - Option: ¨dummy¨ 0-hole plates can be added at the back of the plate pack minimise the needed compensation of the gaskets
- Considered in CAS and PMP

Alfa Laval technology benefits

Feature	Advantage	Benefit
Herringbone pattern	Promotes turbulence Many contact points	High heat transfer & less fouling Strong plates & thinner plates
Chocolate pattern	No dead spots	Less fouling & corrosion Higher heat transfer
Roof-top gasket & fully supported gasket groove	Higher pressure Gasket stays in place	Lower investment (thin plates) Avoids gasket blow-out Longer gasket lifetime
Single step pressing	Uniform thickness	No weak spots
2-component oven cured epoxy glue	Sticks to the plate	Longer gasket lifetime
Clip-on concept	Easy replacement	Quick replacement

Alfa Laval technology benefits

Feature	Advantage	Benefit
5-point alignment Corner guidance	Exact positioning of the plates	Good sealing throughout the plate pack
Bearing boxes and wearing washers	Easy to open and close the unit	Serviceability, one man can open and close even large units
Tilted bolt openings Lock washers Fixed bolt heads	Tightening bolts stays in place during & after opening & closing	Safety and serviceability

Customer benefits

- Low investment cost
  - Less heat transfer area due to high thermal efficiency and low material consumption
  - Exotic materials $\Rightarrow$ PHE is even more cost efficient
- Low cost for for future expansion
  - Flexible construction
  - Bolted frames
  - Easily to add/remove heat transfer area
- Low installation costs
  - Low weight (up to 125 m^2/ton)
  - Compact design (100 m^2 /m^3)
  - Less space required $\Rightarrow$ More compact process
  - Less investment in piping and foundations

Customer benefits

- Low maintenance costs
  - Speedy cleaning
    - Easy dismantling & full access to heat transfer area
    - High heat transfer ⇒ Less area to clean
    - Low hold up volume ⇒ Chemical cleaning effective
    - Glued gaskets sticks to the plate ⇒ Less downtime for cleaning
    - Glue free concept ⇒ Quick replacement during service
  - Longer operating periods
    - High turbulence ⇒ Low fouling ⇒ Longer operating periods
    - Quality plates, gasket, groove and fastening ⇒ Longer lifetime

Customer benefits

- Improved energy economy
  - High heat transfer
    - ⇒ Close temperature approach
    - ⇒ Higher degree of heat recovery possible
  - Close temperature approach
    - ⇒ Reduced cooling water flow rate
    - ⇒ Reduced cost for water, pumping of water
    - ⇒ Reduced investment in pipe work, pump and valves

Customer benefits

- Improved productivity, quality, safety and reliability
  - Easy to regulate due to low hold up volume (< 0.75 l/m^2)
    - Quick response time
    - Less risk of process problems
  - Less risk of unplanned stops
    - Quality gaskets, gasket groove and gasket fastening
    - Gasket stays in place
    - Less risk of gasket blow-out
- Environmentally efficient
  - High efficiency $\Rightarrow$ High degree of heat recovery
  - Low material consumption
  - Pure materials that are easy to recycle

Product Manual Plates (PMP)

Most of the product information is in CAS

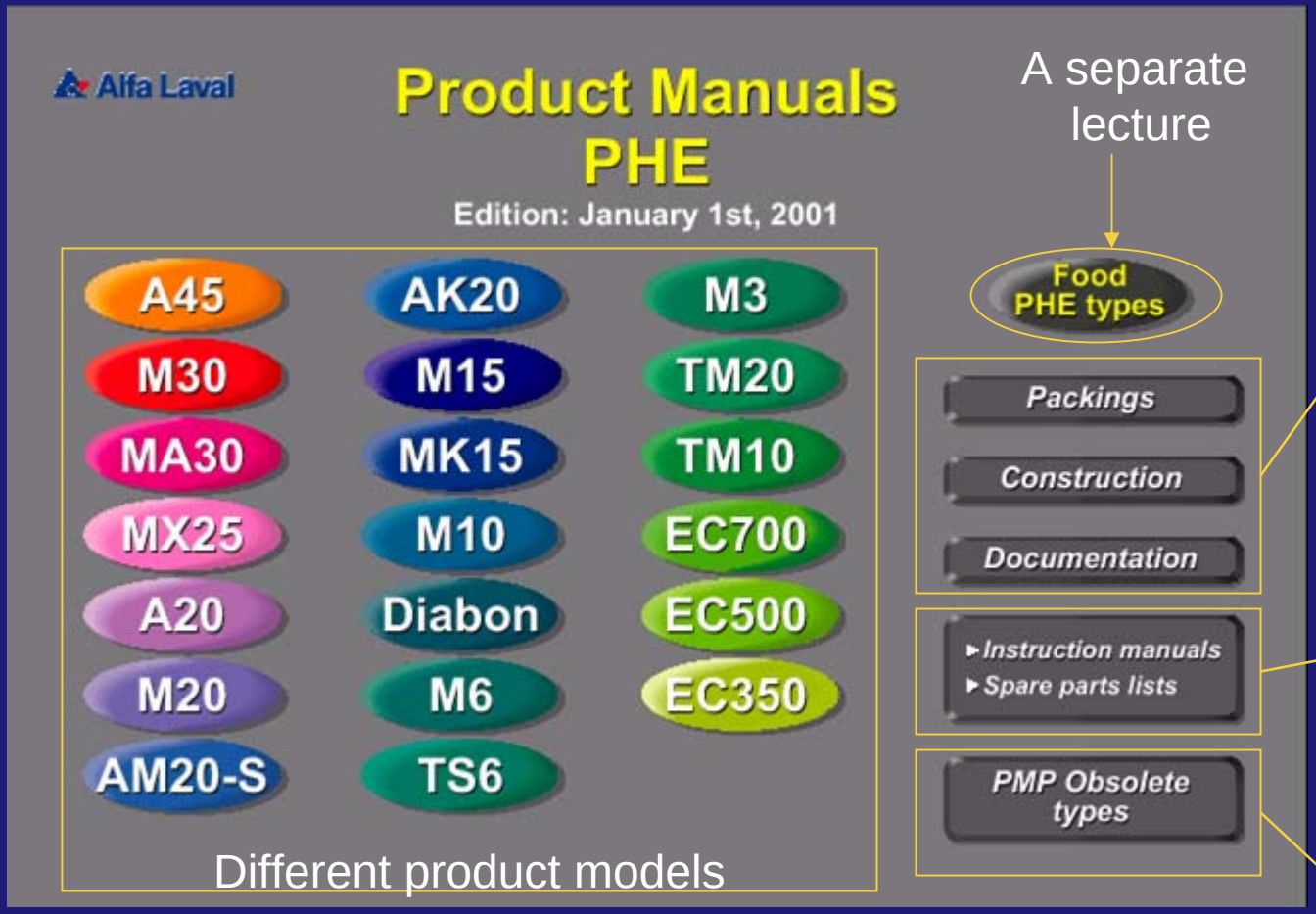
…But CAS only show what is priced

…PMP contains more information

…PMP is the “bible”

- PMP available on
  - ALRound
  - CD software distribution
- Does not contain
  - V-serie PHEs (separate PMP)
  - Compabloc (separate PMP)
- Contains all “Lund” products
  - Gasketed PHEs
  - Wide-gap PHEs
  - Semi-welded PHEs
  - Graphite PHEs
  - Double-wall PHEs
  - Plate Evaporators
  - Food PHE types

PMP - main screen

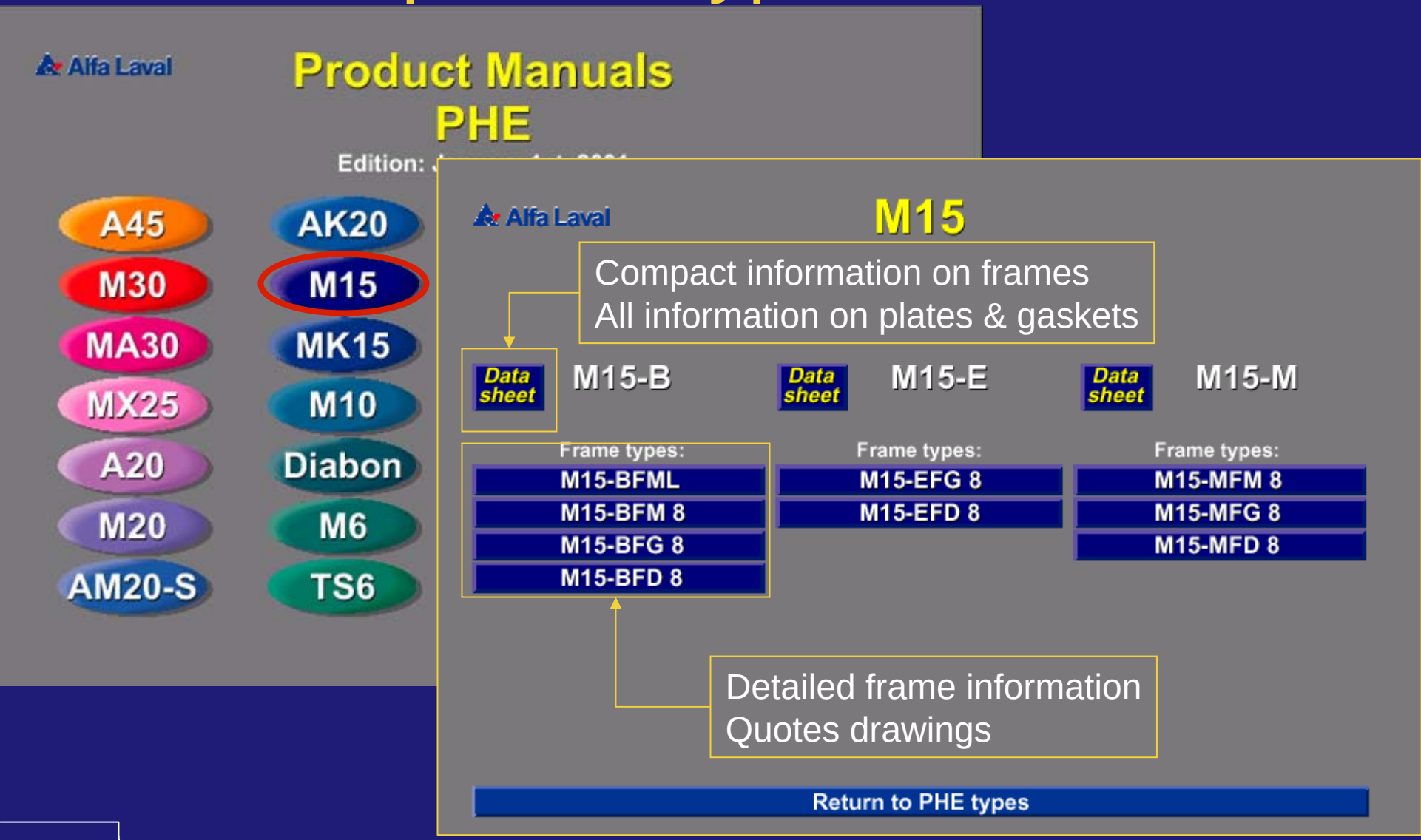


Information about different packaging, construction and documentation

You can generate the manual here

When you need data on an old PHE type

PMP - product types



PMP - data sheet

- Summary of frames

Data sheet

M15-B

Frame types:

- M15-BFML
- M15-BFM 8
- M15-BFG 8
- M15-BFD 8

FRAMES M15–B

CONFIDENTIAL

Frame type	Pressure vessel code	Connect. standard	Frame and pressure plates	Tightening bolts			Design pressure bar (psig)	Design temp. °C	Notes
				Material		Number x size			
			Material	Bolt	Nut				
FML (1)	Uncert.	DIN PN10	1300–00	8.8 SA 193–B7	8 Gr. 2H or 7	8 x M24 4 x M24 + 4 x M30	10	0 – +130	Max. no. of plates: 150
FM8 (1)	SA	DIN PN10 ANSI 150	SA 516–60 H II	8.8 8.8/B7	8 8/2H	8 x M24 4 x M24 + 4 x M30 8 x M30	10	-10 – +160	Max. no. of plates: 250
	TÜV	DIN PN10	H II	8.8/B7	8/2H	8 x M30	10	-10 – +160	
	ASME	ANSI 150	SA 516–60			8 x M30 8 x 1 1/8"	(100)	-40 – +160	
FG8 (1)	SA	DIN PN16 ANSI 150	SA 516–60 H II	8.8/B7	8/2H	4 x M30 + 4 x M39	16	-10 – +160	Max. no. of plates: 600
	TÜV	DIN PN16	H II			4 x M30 + 4 x M39	16	-10 – +160	
	ASME	ANSI 150	SA 516–60			4 x M30 + 4 x M39 4 x 1 1/8" + 4 x 1 1/2"	(150)	-40 – +160	
FD8	SA	DIN PN25/40 ANSI 300	SA 516–60 H II	8.8/B7	8/2H	4 x M39 + 4 x M48	30	-10 – +180	Max. no. of plates: 600
	TÜV	DIN PN25/40	H II			4 x M39 + 4 x M48	30	-10 – +180	
	ASME	ANSI 300	SA 516–60			4 x M39 + 4 x M48 4 x 1 1/2" + 4 x 2"	(300)	-40 – +180	
FD10	ASME	ANSI 400	SA 516–60	8.8/B7	8/2H	4 x M39 + 6 x M48 4 x 1 1/2" + 6 x 2"	(400)	-40 – +160	Max. no. of plates: 600

PMP - data sheet

- Important notes for the frames

Data sheet

M15-B

Frame

M15-E
M15-E
M15-E
M15-E

Notes

All frames:

Carrying bar in aluminium (aluminium may not be suitable in some chemical environments containing fluids like H SO , caustic etc. that would attack aluminium. In case of uncertainties contact application center).
Carrying bar in painted carbon steel on request.

FML: Carrying bar and guiding bar in hot dip galvanized carbon steel.

Guiding bar in stainless steel.

Supporting column in aluminium or in hot dip galvanized carbon steel.

Partition plates required when fluid per unit ≥ 75 kg/s.

The maximum pressure ratings are valid for plate packs with more than 30 plates.

FML

Uncertified frame. Code restrictions may apply (for example not provided for SA, TÜV and ASME). Please check with your local pressure vessel authority if this frame may be used.

FML only single–pass.

(1) Rubber spools in the frame – and pressure plate in NBR (Nitrile) and EPDM are limited to:
Temperature limits: 95°C for NBR
105°C for EPDM

NOTE!

Plates, gaskets and frames may have different pressure and temperature limits. The weakest part determines the performance limit of the PHE.

PMP - data sheet

- Plates & gaskets available as standard

Data sheet

M15-B

PLATES M15–B

Grade	Thick-ness mm	WP weight kg
AISI 304	0.4	2.40
AISI 316	0.5	2.95
AISI 316	0.6	3.45
AISI 316	0.7	3.95
TI	0.5	1.75
TI	0.6	2.05
TI	0.7	2.35
ALLOY 254 SMO	0.6	3.45
ALLOY C276	0.6	3.65

Plate area: 0.62 m2

Volume per channel: 1.55 l

Free channel: 2.5 mm

GASKETS M15–B

Gasket material	Gasket type	Max. oper. temp. °C T(T)	Min. temp. °C	Rec. temp. at max. pressure °C T(P)	Notes
NBR	Clip–On	110	–15	60	
	Glued				
EPDM	Clip–On	160	–25	100	
	Glued	130	–25	80	
EPDMAL	Clip–On	160	–10	100	(3) (4)
	Glued	140	–10	100	
NBRHT	Clip–On	135	–10	70	
HNBR (Hydrogenated nitrile)	Clip–On	160	–5	100	
FPMG	Clip–On	130	–5	90	(2) (3)

Important gasket performance data

Important gaskets notes

Notes

(2) FPMG may cause corrosion on titanium plates.

(3) Do not use FM8 frames.

(4) For plate thickness greater than or equal to:
0.5mm stainless steel
0.6mm titanium

PMP - data sheet

Data sheet **M15-B**

Frame types:

- M15-BFML
- M15
- M15
- M15

- Plate performance table

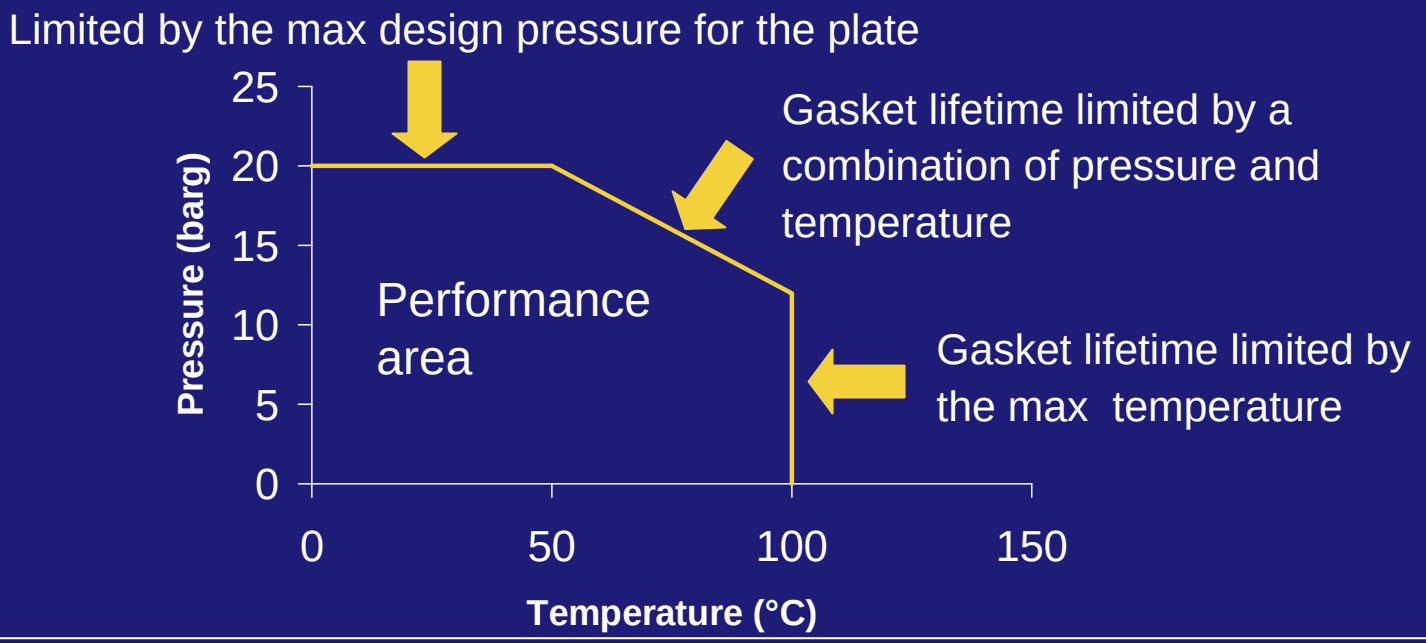
Important plate performance data

PERFORMANCE LIMITS M15–B PLATES See sheet A3–05c in Chapter A3

Plate material	Thickness mm	Max. Test pressure (bar)	Max. Design pressure (bar)		At max. operating temperature	
			SA, TÜV P(P)	ASME P(P)	Recommended max. operating pressure (bar) P(T)	Max. operating differential pressure (bar) DP(T)
AISI 304	0.4	16.0	12.0	10.5	10.0	8.0
AISI 316	0.5	26.0	20.0	17.0	14.0	10.0
AISI 316	0.6	33.0	25.0	22.0	18.0	10.0
AISI 316	0.7	41.0	31.5	27.0	20.0	10.0
TI	0.5	16.0	12.0	10.5	10.0	8.0
TI	0.6	21.0	16.0	14.0	12.0	10.0
TI	0.7	28.0	21.0	18.5	15.0	10.0
ALLOY 254 SMO	0.6	33.0	25.0	22.0	18.0	10.0
ALLOY C276	0.6	33.0	25.0	22.0	18.0	10.0

PMP - pressure/temperature graph

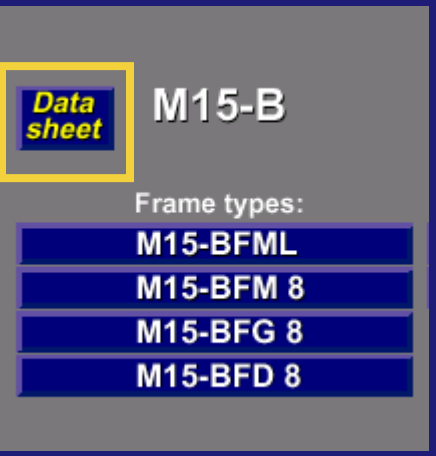
- A P/T graph can be made from data sheet information showing the expected performance of the plate & gasket
  - The design P/T should be inside the performance area
  - If P/T is on the line ⇒ 1 year gasket lifetime
  - If P/T is outside ⇒ Cannot guarantee the performance
  - If the gasket is chemically attacked ⇒ more aspects to be added



PMP - pressure/temperature graph

- The data is found in the data sheet
  - In the gasket performance table
    - T(T) = The maximum allowed operating temperature.
      Above this temperature the gasket will last less than one year.
    - T(P) = Recommended temperature at max pressure.
      Higher pressure ⇒ More strain on the gasket ⇒ We cannot allow the max temperature
  - In the plate performance table
    - P(P) = Maximum design pressure for the plate.
      Above this pressure the plate will deform.
    - P(T) = Recommended max operating pressure at max operating temperature. *Higher pressure ⇒ Softer gasket ⇒ We cannot allow the max pressure*

PMP - pressure/temperature graph



- How to generate the pressures and temperature graph for a certain case
- Example of a quotation
  - German customer
  - Water-water duty with AISI 316 specified
  - Design conditions 110°C and 16 barg
  - Thermal design ⇒ M15-B
- Which plate thickness is needed?
- Which gasket can be used?

PMP - pressure/temperature graph

Data sheet **M15-B**

Frame types:

- M15-BFML
- M15-BFM 8
- M15-BFG 8
- M15-BFD 8

- It is a normal water-water duty
  - I try to use the standard gaskets with lowest price
    ⇒ NBR or EPDM
  - NBR is maximum allowed up to 110°C and the pressure is as high as 16 barg ⇒ Let's try with EPDM
  - We don't expect any frequent cleaning
    ⇒ Clip-on is Ok and with the lowest price

GASKETS M15–B

Gasket material	Gasket type	Max. oper. temp. °C T(T)	Min. temp. °C	Rec. temp. at max. pressure °C T(P)	Notes
NBR	Clip–On	110	–15	60	
	Glued				
EPDM	Clip–On	160	–25	100	
	Glued	130	–25	80	

PMP - pressure/temperature graph

Data sheet **M15-B**

Frame types:

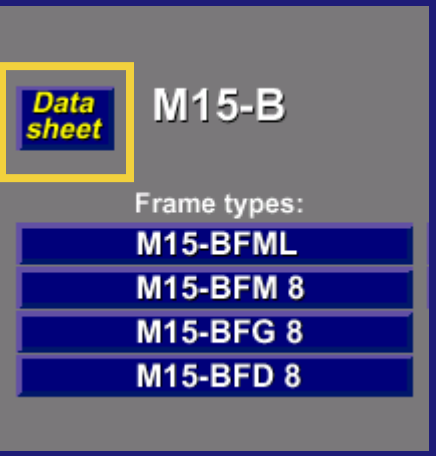
- M15-BFML
- M15-BFM 8
- M15-BFG 8
- M15-BFD 8

- It is AISI 316 specified at 16 barg design pressure
- German customer ⇒ TÜV design
- Let's try with AISI 316 0.5 mm
  - Max design pressure is 20 barg so the plate will not deform
  - Will it support the gasket enough to last?

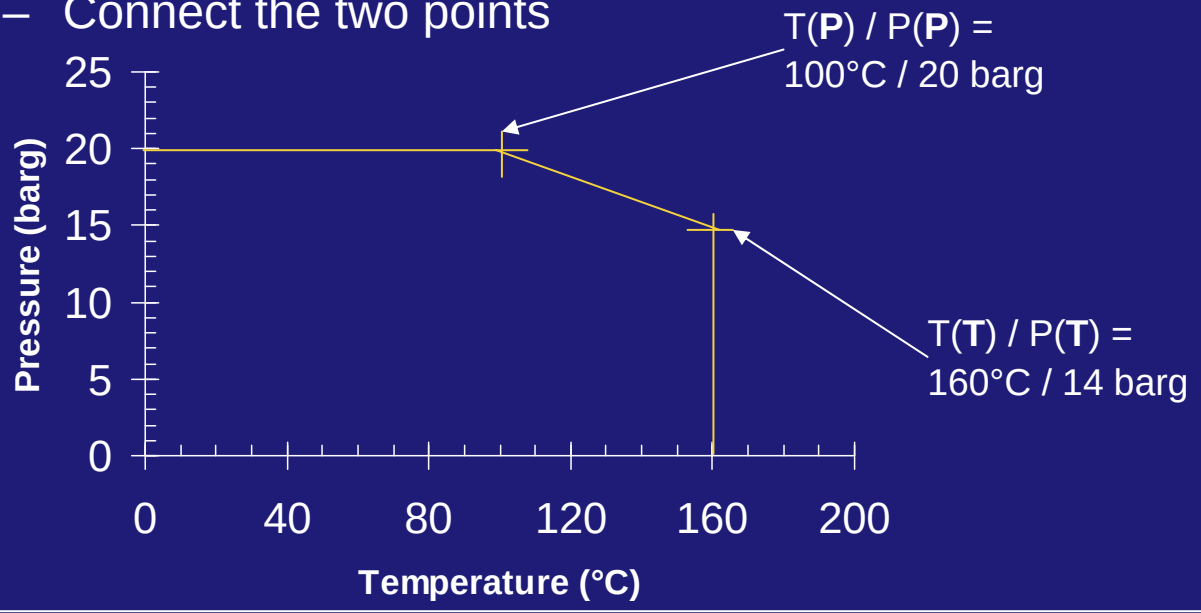
PERFORMANCE LIMITS M15–B PLATES See sheet A3–05c in Chapter A3

Plate material	Thickness mm	Max. Test pressure (bar)	Max. Design pressure (bar)		At max. operating temperature	
			SA, TÜV P(P)	ASME P(P)	Recommended max. operating pressure (bar) P(T)	Max. operating differential pressure (bar) DP(T)
AISI 304	0.4	16.0	12.0	10.5	10.0	8.0
AISI 316	0.5	26.0	20.0	17.0	14.0	10.0
AISI 316	0.6	33.0	25.0	22.0	18.0	10.0
AISI 316	0.7	41.0	31.5	27.0	20.0	10.0
TI	0.5	16.0	12.0	10.5	10.0	8.0

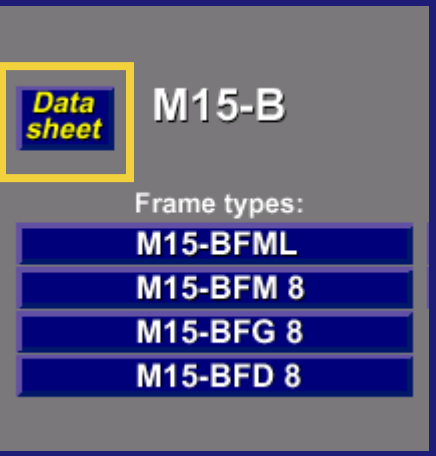
PMP - pressure/temperature graph



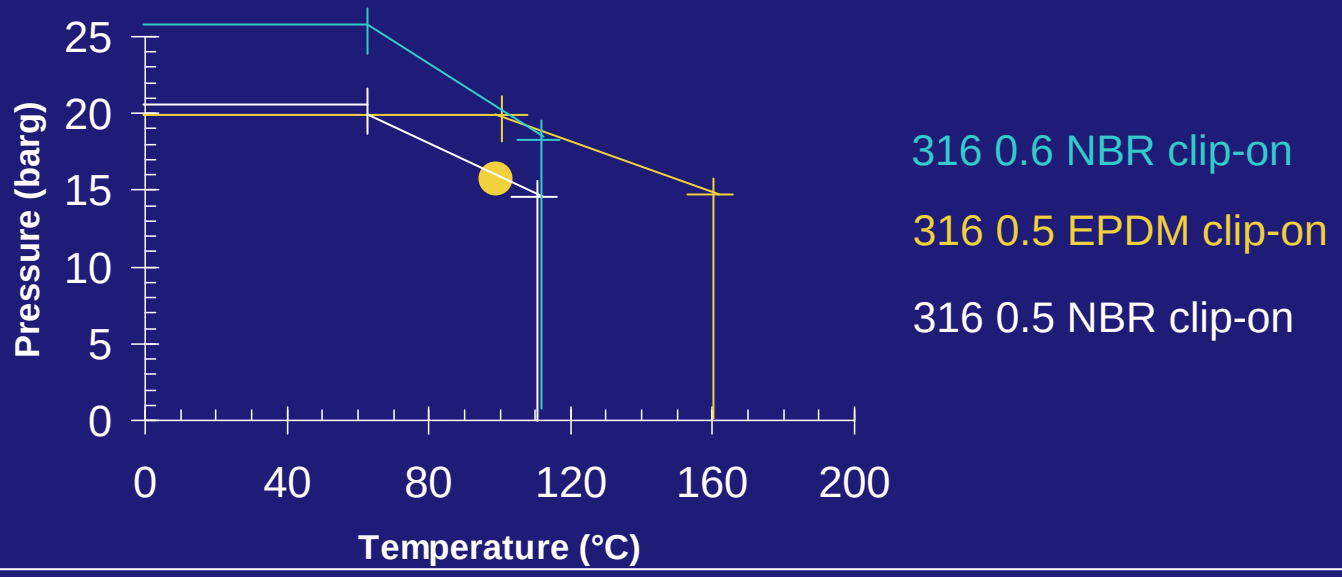
- Now we have the data
- EPDM clip-on, T(T)=160°C and T(P)=100°C
- AISI 316 0.5 mm, P(P)=20 barg and P(T)=14 barg
- Combine it to two data points as per the indices (P) and (T)
- For AISI 316 0.5 mm with EPDM c-o
  - One point is T(**T**) / P(**T**) = 160°C / 14 barg
  - The other point i s T(**P**) / P(**P**) = 100°C / 20 barg
  - Connect the two points



PMP - pressure/temperature graph



- Mark the design P/T, 100°C and 16 barg
- We are well within the limits
- AISI 316 0.5 EPDM clip-on is Ok
- Would it have been Ok with 316 0.5 NBR clip-on?
  - About 1 year lifetime. What does the customer expect?
  - NBR and EDPM about the same price ⇒ EPDM
- 316 0.6 NBR clip-on also Ok but more expensive!



PMP - pressure/temperature graph

- In CAS Mechanical configuration
  - Checks that the duty is inside the performance area
  - Does not check if it is a boarder-line case

- If you are not sure do the P/T graph
  - To see if we are on the boarder-line or not
  - To find out which is the best option

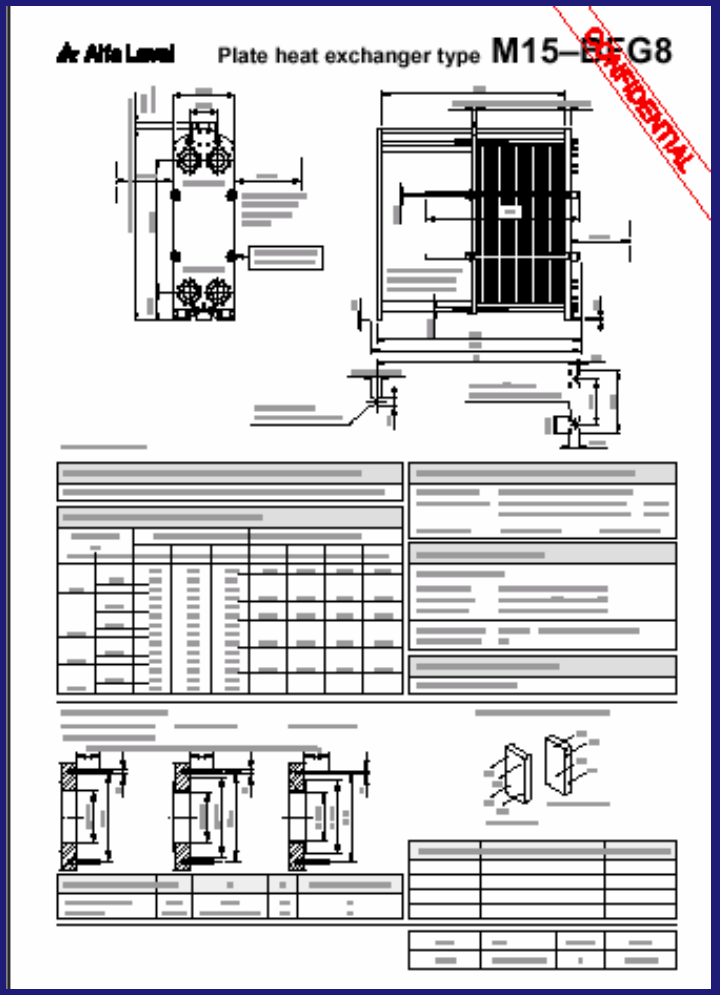
PMP - frame specifications

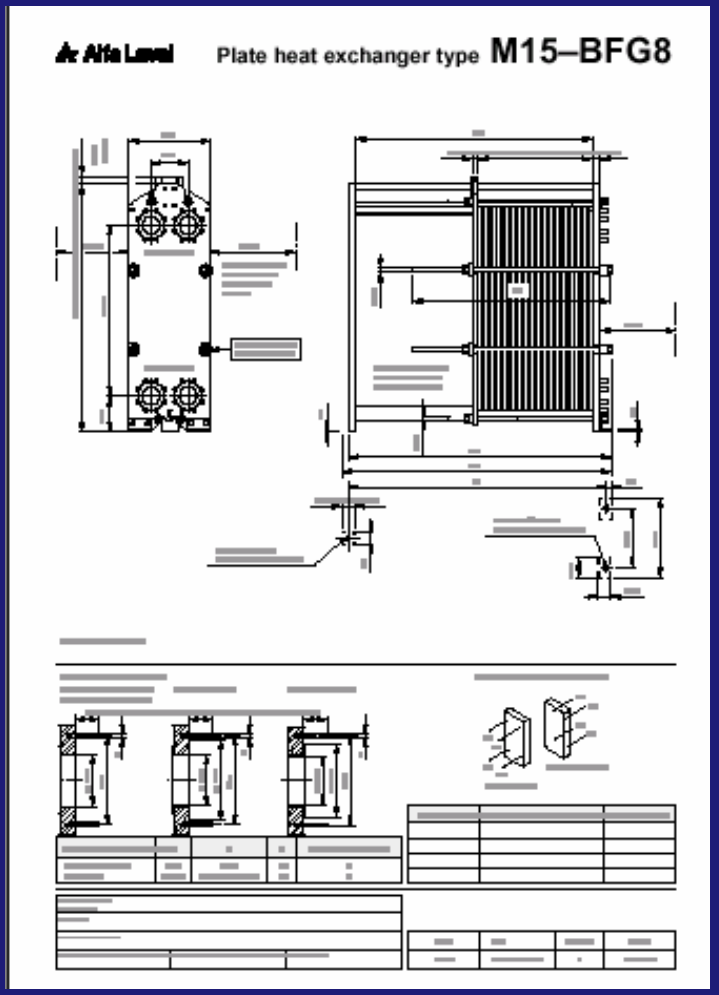
- Detailed frame information & quote drawing

Data sheet **M15-B**

Frame types:

- M15-BFML
- M15-BFM 8
- M15-BFG 8
- M15-BFD 8





PMP - packaging

- Packings
- Construction
- Documentation
- ▸ Instruction manuals
- ▸ Spare parts lists
- PMP Obsolete types

Alfa Laval

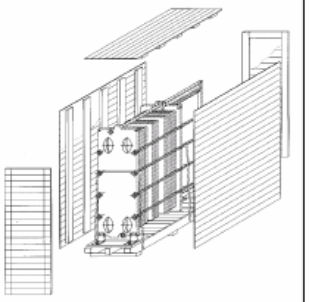
Packing types

- PHE standing on skid base
- PHE standing in case on skid base
- PHE lying on skid base
- PHE lying in case on skid base
- Emballage with gravity centre
- PHE standing in case on skid base (Ocean)
- PHE (hygienic) standing in crate on skid base
- PHE lying in plywood case
- Plates lying in plywood case type 11-15

Retur

PHE Standing in case on skid base

PHE	WP (= width) mm	LP C-measure+300 mm	HP Height PHE+350 mm	Volume (WPxLPxHP)/10m	Q	Packing weight LPxQ kg
A45/AX35	1550		3730		0.37	
A35	1520		3430		0.36	
A35	1520		3700		0.37	
M30/MA30	1350		3400		0.29	
M30/MA30	1350		3450		0.32	
AX30	1200		3130		0.26	
AX30	1200		3360		0.3	
MX25	1090		3300		0.24	
A20	1020		2780		0.23	
A20	1020		2930		0.23	
M20	960		2630		0.21	
M20	960		2830		0.22	
AM20	960		2675		0.21	
AM20	960		2875		0.22	
AK20/T200	925		2025		0.19	
AK20/T200	925		2025		0.2	
M15/A15	890		2475		0.2	
M15/A15	890		2475		0.19	
MK15	716		1875		0.2	
MK15	716		1875		0.19	
M10	620		1290		0.06	
M6	520		1270		0.08	
EC500	1350		3030		0.27	
EC500	1350		3230		0.31	



PMP - construction

- Packings
- Construction
- Documentation
- ▸Instruction manuals
- ▸Spare parts lists
- PMP Obsolete types

Alfa Laval	CONSTRUCTION	PMP A3–1
TI–DS 9612		EDITION 5

3.1.6 Protection Sheets

Most PHEs, are available with protection sheets in stainless steel and/or macro lone

Protection sheets are to be used under the following conditions, and if required are to be specified on the order:

With all units where any form of hazard can occur!

Hazardous duties:
- Temperature ≥60° C
- 3.0 > pH ≥ 10.0
- Toxic, poisonous or flammable fluids under pressure

Check local regulations!

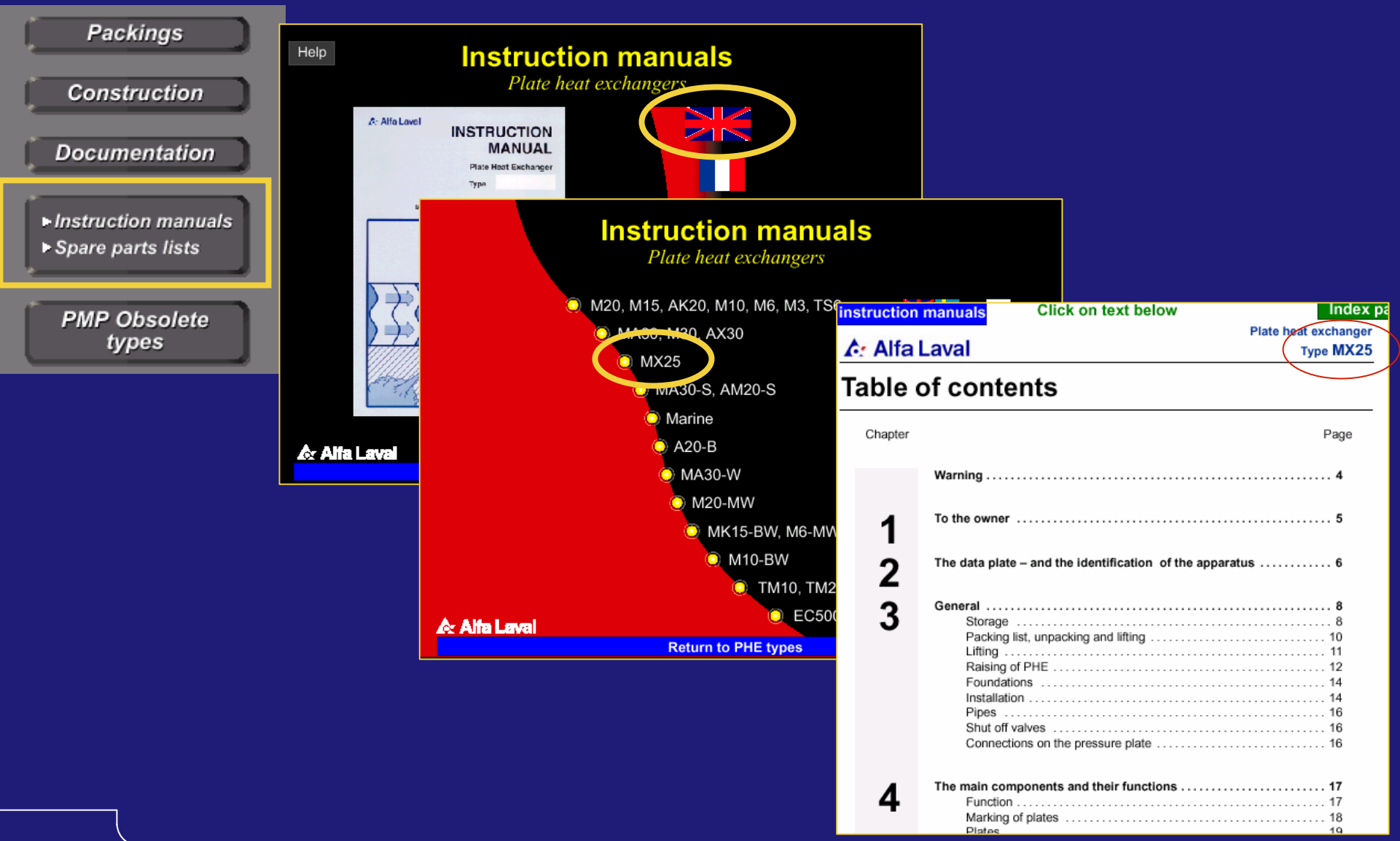
PMP - documentation

- Packings
- Construction
- Documentation
  - ▸ Instruction manuals
  - ▸ Spare parts lists
- PMP Obsolete types

Return to PHE types

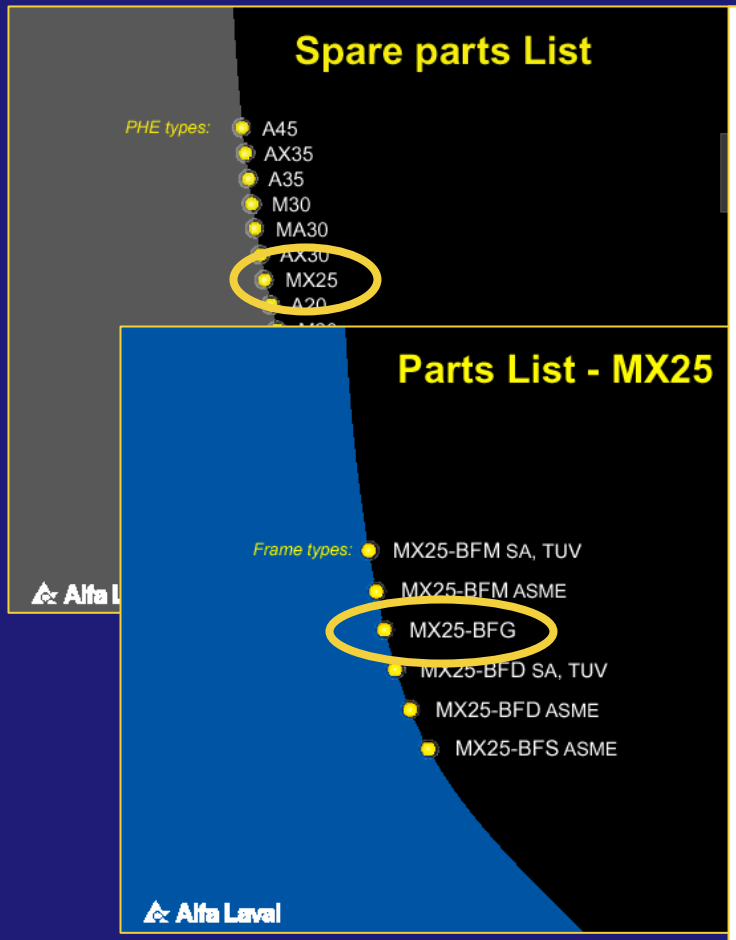
Alfa Laval TI–MS 9612	DOCUMENTATION	PMP A4–01 EDITION 5

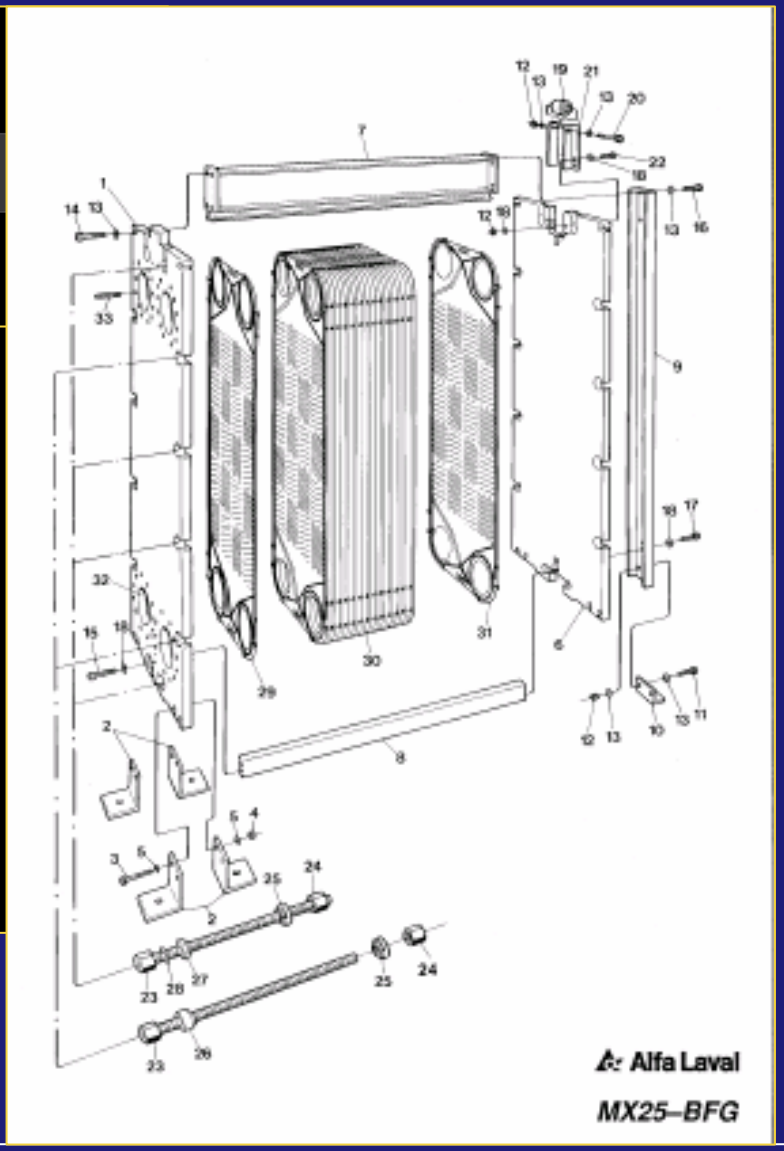
PMP - instruction manuals



PMP - spare parts lists

- Packings
- Construction
- Documentation
- ▸Instruction manuals
- ▸Spare parts lists
- PMP Obsolete types





PMP - obsolete types

Packings

Construction

Documentation

- Instruction manuals
- Spare parts lists

PMP Obsolete types