Alfa Laval

- Compact Heat Exchangers Advantages & Limitations

Phillip Siggery
Alfa Laval was founded in 1883 by Gustav de Laval
Currently the Headquarters are based in Lund, Sweden
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval Introduction – Global Presence

- 39 production units*
- More than 100 service centres
- Sales companies in 55 countries
- Other sales representation in 45 countries
To optimize the performance of our customers’ processes.
Time and time again.

We help customers to heat, cool, separate and transport products such as oil, water, chemicals, beverages, foodstuff, starch and pharmaceuticals.
Our key technologies are adapted to each customer segment and offered separately or combined into optimized solutions.

**HEAT TRANSFER**
- ENERGY DIVISION
  - Brazed & Fusion bonded heat exchangers
  - Gasketed plate heat exchangers
  - Welded heat exchangers
- FOOD & WATER DIVISION
  - Food heat transfer
  - Food systems
- MARINE DIVISION
  - Marine separation & Heat transfer equipment
  - Boilers & Gas systems

**SEPARATION**
- ENERGY DIVISION
  - Energy separation
- FOOD & WATER DIVISION
  - High speed separators
  - Decanters
  - Food systems
- MARINE DIVISION
  - Marine separation & Heat transfer equipment

**FLUID HANDLING**
- FOOD & WATER DIVISION
  - Food systems
  - Hygienic fluid handling
- MARINE DIVISION
  - Pumping systems
Widest HE range in Industry

- **Pressure**
  - 650 barg
  - 110 barg
  - 100 barg
  - 55 barg
  - 42 barg
  - 37 barg
  - 30 barg

- **Temperature**
  - -196°C
  - -100°C
  - -50°C
  - 180°C
  - 350°C
  - 400°C
  - 550°C
  - 800°C

**Types of Compact Heat Exchangers**
- AlfaNova
- Semi-welded
- Spiral
- Compabloc
- Duroshell
- PCHE

- [www.alfalaval.com](http://www.alfalaval.com)
The design of **plate heat exchangers** gives much higher turbulence, and thereby **thermal efficiency**, than a **shell-and-tube exchanger**. A typical **k-value** (water/water) for a **plate heat exchanger** is 6,000-7,500 W/m² °C while a typical **shell-and-tube exchanger** gives only 2,000-2,500 W/m² °C.

\[ U = k \times A \times \text{LMTD} \]
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – What Makes a Compact Heat Exchanger Compact?

Mechanical:

- Provides support points
- Allows thin material (0.3mm)

Flow Dynamic:

- Creates High Turbulence
- High Efficiency
  - Small Laminar Wall film
- Minimizes Fouling
- Cork Screw Flow
Compact Heat Exchangers Advantages & Limitations

– Alfa Laval – What Makes a Compact Heat Exchanger Compact?

Designed for:

Temperature-cross and close temperature approach

Close temperature approach: down to 3°C

Temperature cross

In

Out

• High efficiency in Heat recovery
Compact Heat Exchangers Advantages & Limitations
- Alfa Laval – Gasketed Industries

Biofuels
Biotech and pharmaceutical
Chemicals
Crude oil refinery
Engine and transport
Fluid power
Food and beverages
HVAC
Industrial fermentation
Latex
Machinery
Marine and diesel
Metal working
Mining and mineral processing
Oil and gas
Power
Pulp and paper
Refrigeration and air-conditioning
Semiconductor systems
Steel and coke oven gas
Sugar
Wastewater treatment
All gasketed plate-and-frame heat exchangers have a similar construction.
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval – Gasketed Plate Heat Exchangers – Pass Arrangement

- Close approach
- Increase pressure drop
- For high capacity duties

1-pass
Low capacity

2-pass
Medium capacity

3-pass
High capacity
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval Gasketed Plate Heat Exchanger

Limitations:
• Temperature & Pressure limits due to gasket materials.
• Gasket replacement.

Flexibility & Benefits:
• Different channel plate materials available. (including 304, 316, Hastelloy’s, 904L, Nickel 200/201, SMO, Titanium & D205)
• Different gasket materials dependant on fluid compatibility: Nitrile, EPDM, Viton etc.
• Easy to open within own footprint
  • Mechanically clean
  • Maintenance
• Can change plate pack configuration to suit duty changes
• Semi-welded construction allows different gaskets to be used.
• Can withstand cyclic duties due to gasket material. (Crude production)
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Copper Brazed Heat Exchanger

Brazed plate heat exchangers offer multiple benefits. The brazing technology eliminates the need for seals and thick frame plates and the design offers excellent resistance to pressure and thermal fatigue in a wide range of heating and cooling applications.
Benefits:
Low capital investment.
Small footprint.
Low installation costs.

Disadvantages:
Non-openable.
Some processes/fluids not compatible with copper.
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Copper Brazed Plate Heat Exchanger

Residential heating
Heat pumps
Engine cooling
• Alfa Laval has developed a heat exchanger range of 100% stainless steel.

• This means:
  - Stainless steel fusion bonded heat exchangers
  - Patented technology - AlfaFusion

• High temperature performance
• Chemical resistance like stainless steel
• High pressure fatigue resistance
• High operating pressure at high temperatures
• Low hold up volume compared to Shell & Tube
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Alfa Nova (Fusion Bonded) Heat Exchanger

- District Heating systems with corrosive liquids
- Tap Water Heating systems with specific demands
- Compressor oil coolers in Ammonia Chillers
- Clean Water Chillers
- Drink dispensing equipment
- Intercooler in compressor systems
- Ground source Heat Pumps
- High temperature gas Heat Exchanger
- Absorption Systems
- Hygienic applications
- Industrial cooling
- High temperature applications
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Alfa Nova Heat Exchanger - Metallurgy

D: Original plate material
E: Original filler material
F: Homogenisation
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval - Alfa Nova - Mechanical Performance

Example ΔP = 30 bar
- Alfa Nova
- Copper brazed
- Nickel brazed
- All-welded

Example ΔT = 125°C
- Alfa Nova
- Copper brazed
- Nickel brazed
- All-welded
Compabloc is a fully openable welded compact heat exchanger.

The two media in the Compabloc heat exchanger flow in alternately welded channels between the plates.
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Compabloc (Welded Bloc) Heat Exchanger

- Panels
- Top and Bottom heads
- Heat transfer plate pack
- Baffles
- Gaskets
- Girders
- Support
- Customer connections
Heat transfer plate pack

The heart of Compabloc is a stack of corrugated heat-transfer plates in stainless steel or exotic materials.

The corrugations are angled at 45° to form channels.

This results in high amounts of contact points and therefore increased turbulence and thermal efficiency.

- Standard plate materials are:
  - 316L SS
  - 254 SMO
  - Titanium
  - C276
  - C22
  - 904L
• It works as a cooler, heater, interchanger, reboiler or condenser.

• Proven in applications such as:
  - Refinery
  - Petrochemicals
  - Fine Chemicals
  - Power

• Over 35,000 units sold
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Compabloc (Welded Bloc) Heat Exchanger

• Vertical multipass condenser

Allows for sub-cooling of condensate
Requires higher pressure drop on vapour side
Pass-sizes can be optimized for condensing and sub-cooling
The baffles are adjusted to increase the turbulence and velocity of the liquid at the bottom of the unit to optimize the sub-cooling.
High degree of heat recovery from vapour
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval – Compabloc (Welded Bloc) Heat Exchanger – The Range

There are seven Compabloc models covering a large range of pressures, temperatures, and sizes

<table>
<thead>
<tr>
<th>Model</th>
<th>Standard design pressures**</th>
<th>Standard design temperatures**</th>
<th>Max. width (in vertical position)</th>
<th>Max. height (in vertical position)</th>
<th>Max. weight</th>
<th>Max. Heat transfer area</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP15</td>
<td>FV* / 30 bar (435 psi)</td>
<td>-46 °C (-51 °F) / 343°C (649 °F)</td>
<td>280 mm (11&quot;)</td>
<td>540 mm (21&quot;)</td>
<td>250 kg (551 lbs)</td>
<td>2 m² (21 ft²)</td>
</tr>
<tr>
<td>CP20</td>
<td>FV* / 30 bar (435 psi)</td>
<td>-46 °C (-51 °F) / 343°C (649 °F)</td>
<td>430 mm (17&quot;)</td>
<td>730 mm (29&quot;)</td>
<td>550 kg (1,212 lbs)</td>
<td>5 m² (54 ft²)</td>
</tr>
<tr>
<td>CP30</td>
<td>FV* / 30 bar (435 psi)</td>
<td>-46 °C (-51 °F) / 343°C (649 °F)</td>
<td>500 mm (20&quot;)</td>
<td>1070 mm (42&quot;)</td>
<td>1160 kg (2,557 lbs)</td>
<td>17 m² (183 ft²)</td>
</tr>
<tr>
<td>CP40</td>
<td>FV* / 30 bar (435 psi)</td>
<td>-46 °C (-51 °F) / 343°C (649 °F)</td>
<td>600 mm (24&quot;)</td>
<td>1400 mm (55&quot;)</td>
<td>2330 kg (5,136 lbs)</td>
<td>33 m² (355 ft²)</td>
</tr>
<tr>
<td>CP50</td>
<td>FV* / 38 bar (551 psi)</td>
<td>-46 °C (-51 °F) / 343°C (649 °F)</td>
<td>840 mm (33&quot;)</td>
<td>2050 mm (81&quot;)</td>
<td>5940 kg (13,095 lbs)</td>
<td>81 m² (872 ft²)</td>
</tr>
<tr>
<td>CP75</td>
<td>FV* / 38 bar (551 psi)</td>
<td>-46 °C (-51 °F) / 343°C (649 °F)</td>
<td>1240 mm (49&quot;)</td>
<td>3500 mm (130&quot;)</td>
<td>17760 kg (39,196 lbs)</td>
<td>320 m² (3,444 ft²)</td>
</tr>
<tr>
<td>CP120</td>
<td>FV* / 42 bar (609 psi)</td>
<td>-46 °C (-51 °F) / 343°C (649 °F)</td>
<td>2190 mm (86&quot;)</td>
<td>3500 mm (138&quot;)</td>
<td>60000 kg (132,277 lbs)</td>
<td>840 m² (9,042 ft²)</td>
</tr>
</tbody>
</table>

* FV = Full Vacuum
** Standard maximum design conditions for ASME design
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Compabloc – Customer Values

• High thermal performance -> reduction in size and number of heat exchangers
• Close temperature approach and crossing temperatures -> improved heat recovery
• Compact design -> reduced size and weight
• Gasket free construction -> handling of aggressive media and high-pressure/high-temperature duties
• High wall shear stress -> reduced fouling tendency
• Cost-efficient in corrosion resistant materials -> eliminated corrosion problems
• Heat transfer area fully accessible facilitating inspection, maintenance and repair
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval – Compabloc (Welded Bloc) Heat Exchanger Cleaning

Fouling flushed out in side channels
Cleaning the Compabloc heat exchanger mechanically is done quickly and conveniently by hydro blasting the channels.

The unit’s compact size allows the water jet to reach every corner with equally high pressure.

Access is facilitated by the easily removed side panels.
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval – Compabloc (Welded Bloc) Heat Exchanger – Maintenance

- Repair and service

Every weld in the compabloc is accessible for maintenance and repair

It is recommended to use Alfa Laval Onsite service technicians
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Compabloc (Welded Bloc) Heat Exchanger Limitations

• Fully welded block.
• Duty should be stable – cyclic duties will fatigue welds.
• Requires 2 to 3 bar dP between circuits to avoid pressure inversion.
Nyas Refinery has total of 14 Compablocs:

- Gas oil cooling
- Gasoline cooling
- Vapour condensing
- Bitumen heating
- Bitumen cooling
- Steam heaters

Original S&Ts needed cleaning every year (1 week operation / S&T)
CPs need chemical cleaning every third year (<1 day operation / CP)

**Total maintenance cost reduction:**

96%!!!
Condenser (once-through)

Queensland Alumina replaced a shell and-tube unit with a Compabloc condenser to decrease maintenance costs.

Utilizing only a quarter of the space of the old shell-and-tube installation, the Compabloc also solved severe corrosion and fouling problems.
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval – Compabloc (Welded Bloc) Heat Exchanger
Condenser (once-through)

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Reflux Condenser

Alfa Laval Compabloc reflux condensers take up very little space, so they were a natural contender when a new stripper tower was required for the gas sweetening process at the Syzran oil refinery.

The decision to install the extremely compact Compabloc solution instead of traditional shell-and-tube units enabled YUKOS to save both money and space.

The Syzran refinery is very happy with the way the Compabloc units work.
DuroShell is a very versatile heat exchanger, with flexibility that makes it suitable for numerous applications that have high-temperature or high-pressure demands.

Operating modes include liquid-to-liquid heating and cooling duties, gas-to-gas, condensing and reboiling.
DuroShell can operate with a large range of different temperatures and pressures depending on the material and size of the model.

<table>
<thead>
<tr>
<th>Design pressure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CE/PED</td>
<td>Vacuum to 100 barG (1,450 psiG)</td>
</tr>
<tr>
<td>ASME</td>
<td>Vacuum to 100 barG (1,450 psiG)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Design temperature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon steel shell:</td>
<td>-45 °C to 450 °C (-49 °F to 842 °F)</td>
</tr>
<tr>
<td>316L SST shell:</td>
<td>-160 °C to 350 °C (-256 °F to 662 °F)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Maximum heat transfer surface</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>DuroShell S</td>
<td>15 m² (161 ft²)</td>
</tr>
<tr>
<td>DuroShell M</td>
<td>56 m² (603 ft²)</td>
</tr>
<tr>
<td>DuroShell L</td>
<td>235 m² (2,530 ft²)</td>
</tr>
</tbody>
</table>
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval DuroShell – Plate & Shell Heat Exchanger

Going into the details
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval – Duroshell (Plate & Shell) Heat Exchanger

**Petrochemicals**
- Batch reactor cooler/heater
- Overhead condensers
- Interchangers
- Preheaters
- Reboiler

**Power**
- District heating condenser
- Boiler feed water heating
- Air heating (gas turbines)
- Gland steam condensers
- Performance heater

**Oil & Gas**
- TEG interchangers
- Gas compression
- Gas pressure reduction
- LPG heating
Compact Heat Exchangers Advantages & Limitations

– Alfa Laval – Duroshell (Plate & Shell) Heat Exchanger

Steam heater

When building a new power plant, a Chinese power company installed an Alfa Laval DuroShell to preheat boiler feedwater.

The compact size and high thermal efficiency were the main reasons for the company to choose DuroShell.

The unit is easy to operate and control with traditional liquid-level control systems.
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval – Duroshell (Plate & Shell) Heat Exchanger – Cleaning

Materials limited to 316 SS

Unit fully closed, cleaning by CIP only
Compact Heat Exchangers Advantages & Limitations
– Alfa Laval – Spiral Heat Exchanger

The range

SpiralPro
- Liquid-Liquid
- Steam Heater

SpiralCond
- Condenser
- Stacked condenser
Compact Heat Exchangers Advantages & Limitations
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• IF cleaning is needed - Easily accessible means service-friendly
Compact Heat Exchangers Advantages & Limitations

- Alfa Laval – Spiral Heat Exchanger – Customer Values

- Customer tailor-made to match the needs of a specific application and duty
- High thermal performance -> reduction in size and number of heat exchangers
- Close temperature approach and crossing temperatures -> improved heat recovery
- Compact design -> reduced size and weight
- Gasket free construction -> handling of aggressive media and high-pressure/high-temperature duties
- Tailor-made for fouling applications (sludges, fibrous liquids or solids in suspension) as well as a wide range of viscous fluids self-cleaning effect -> Reduced or eliminated fouling
- Heat transfer area fully accessible facilitating inspection, maintenance and repair
Compact Heat Exchangers Advantages & Limitations

– Alfa Laval – Spiral Heat Exchanger – Space Saving

• Compact design – requires only a fraction of the floor space of a S&T
The PCHE is designed to deliver unparalleled compactness and thermal efficiency compared to shell-and-tube heat exchangers in clean and high-pressure duties. Typical applications are high pressure vaporizers in marine applications and high pressure gas coolers for offshore gas compression.
Compact Heat Exchangers Advantages & Limitations

- PCHE - Advantages – Compactness lower cost

- Structural and support – light weight
- Installation – single lifting possible
- Transportation – compact size
- Performance – high heat efficiency
- Fluid inventory – small volume leads to safety
- Pressure relief – small leak rate resulting small relief connection
- Retrofit/upgrade capability – easily fit into existing space or future upgrade
Compact Heat Exchangers Advantages & Limitations

– PCHE - Limitations

- Suitable only for clean fluids
- Strainers protection required
- Fully welded heat exchangers (maintenance can be carried out through cleaning connections)
- Stable operation