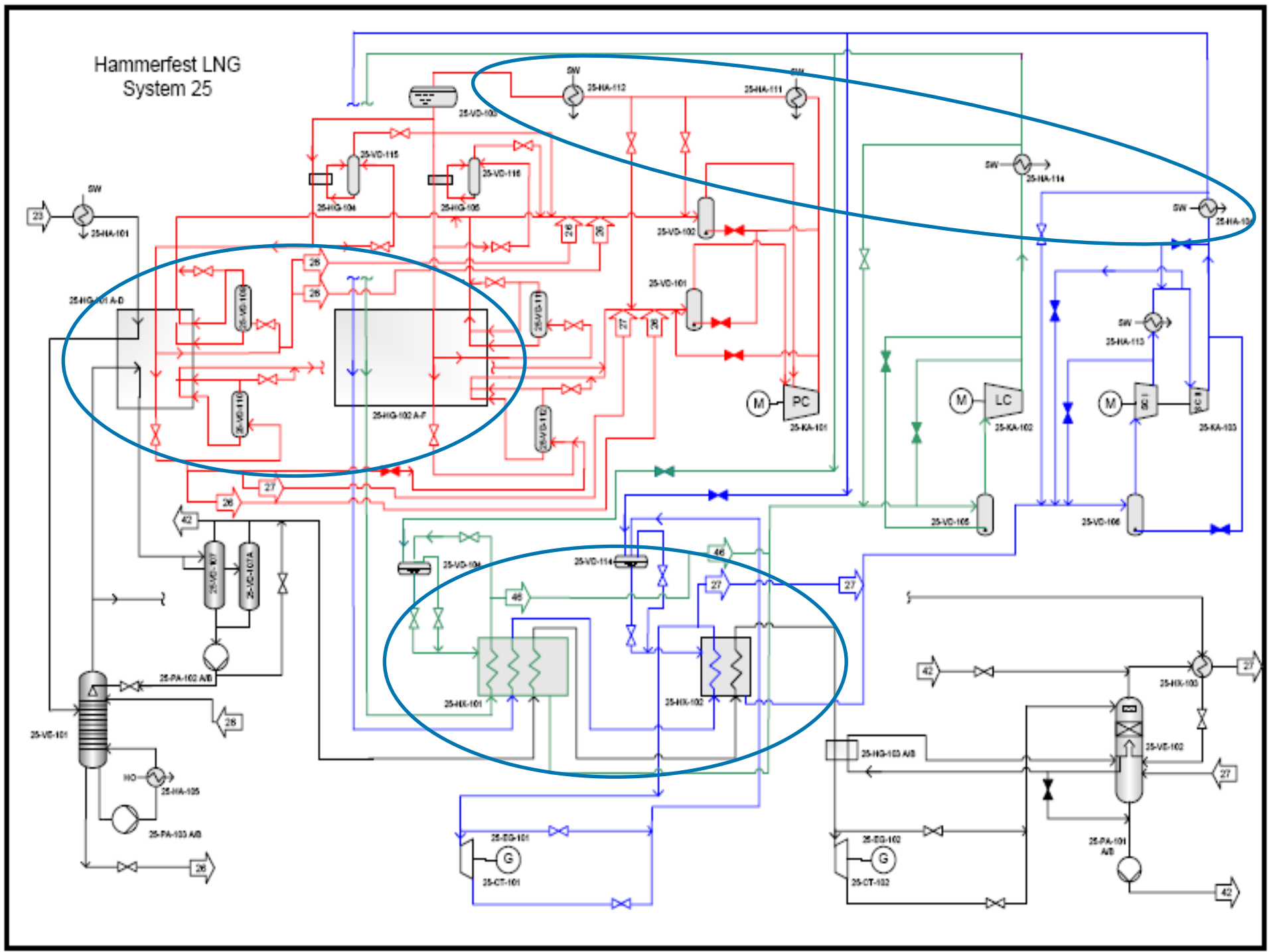
LNG heat exchangers

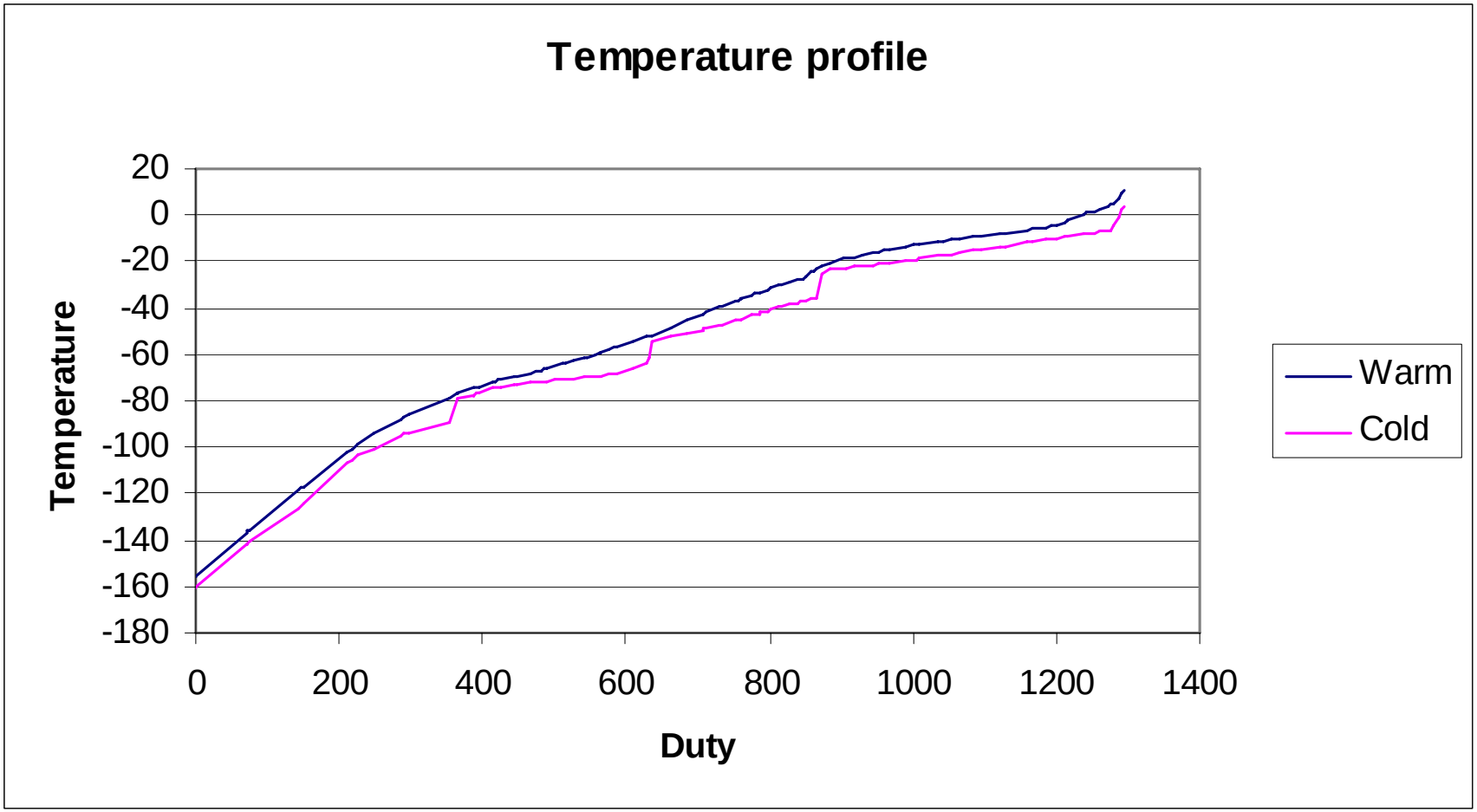
TEP-10

2008

StatoilHydro


Hammerfest LNG
System 25
SW
25-HA-112
25-HA-111
25-HA-114
25-HA-101
25-HA-113
25-VD-103
25-VD-115
25-VD-116
25-HG-104
25-HG-105
25-VD-102
25-VD-101
25-HG-101 A-D
25-HG-102 A-F
25-VD-109
25-VD-110
25-VD-111
25-VD-112
M
PC
25-KA-101
LC
25-KA-102
25-KA-103
25-VD-105
25-VD-106
25-VD-104
25-VD-114
25-VD-107
25-VD-107A
25-PA-102 A/B
25-VE-101
25-HA-105
25-PA-103 A/B
25-HE-101
25-HX-102
25-HX-103
25-HG-103 A/B
25-VE-102
25-PA-101 A/B
25-EG-101
25-CT-101
25-EG-102
25-CT-102
G

MFC - LNG process temperature profile



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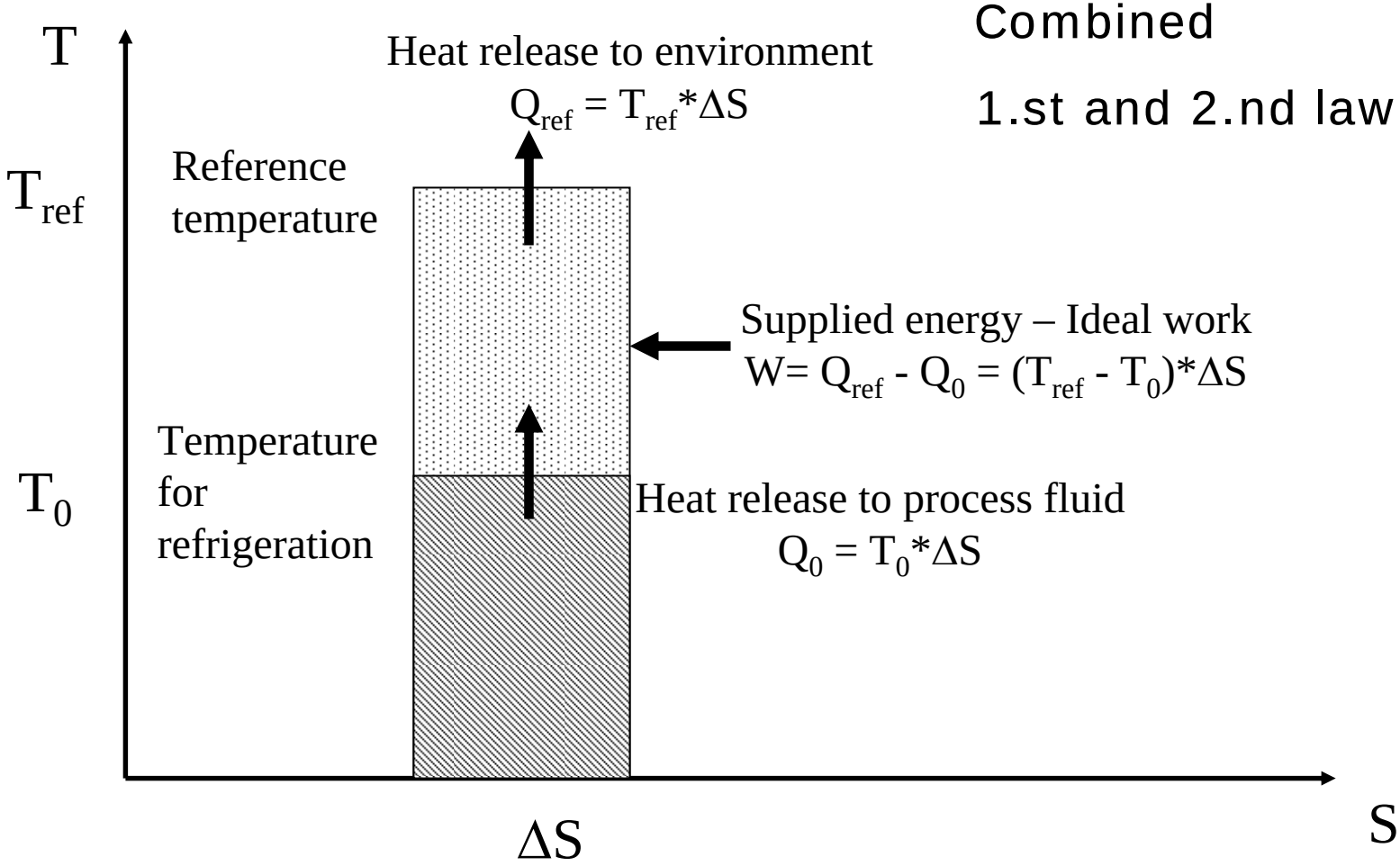
Idle work in refrigeration
The Carnot process



Combined

1.st and 2.nd law

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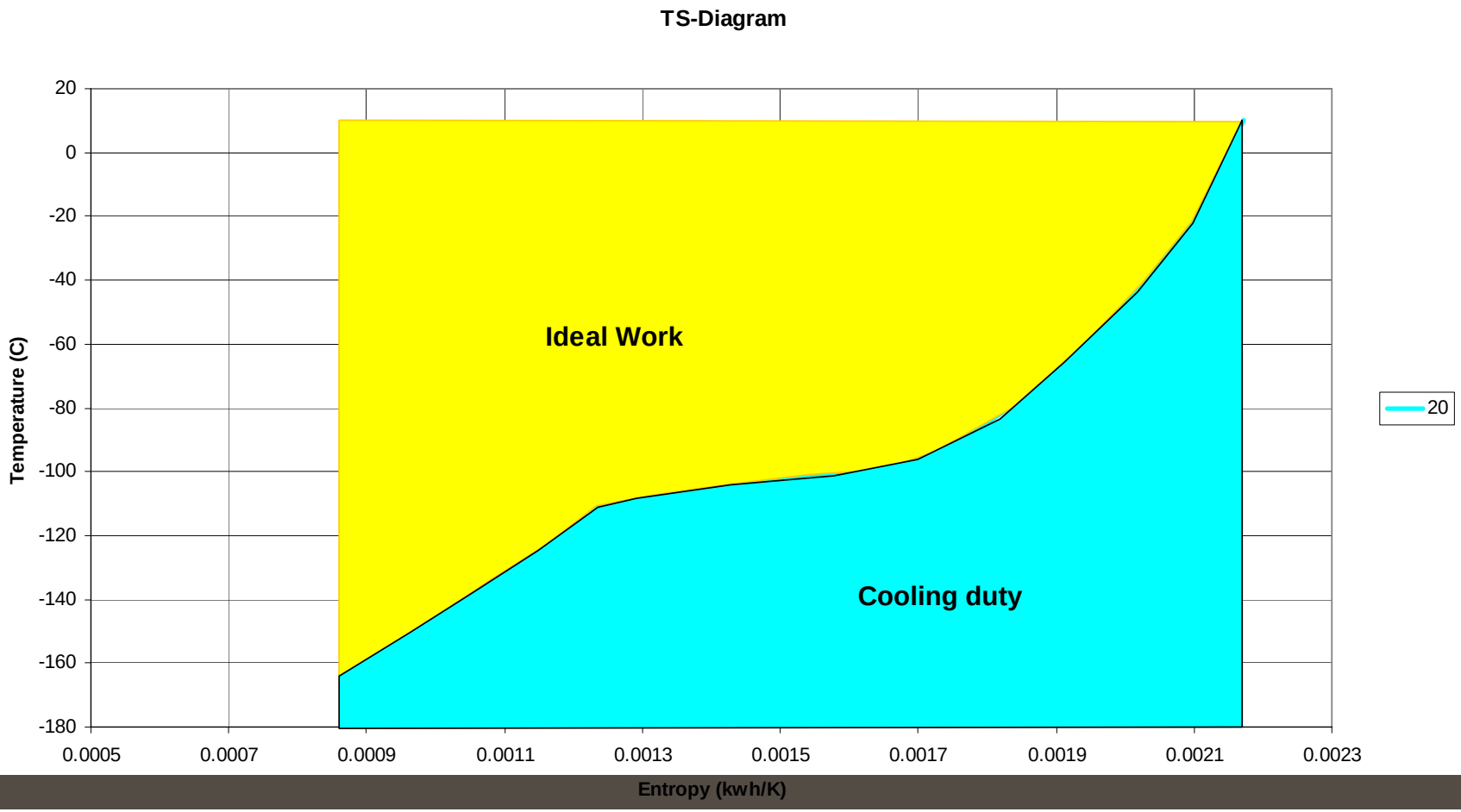
Ideal work – mixed refrigerant
Sum of small Carnot processes



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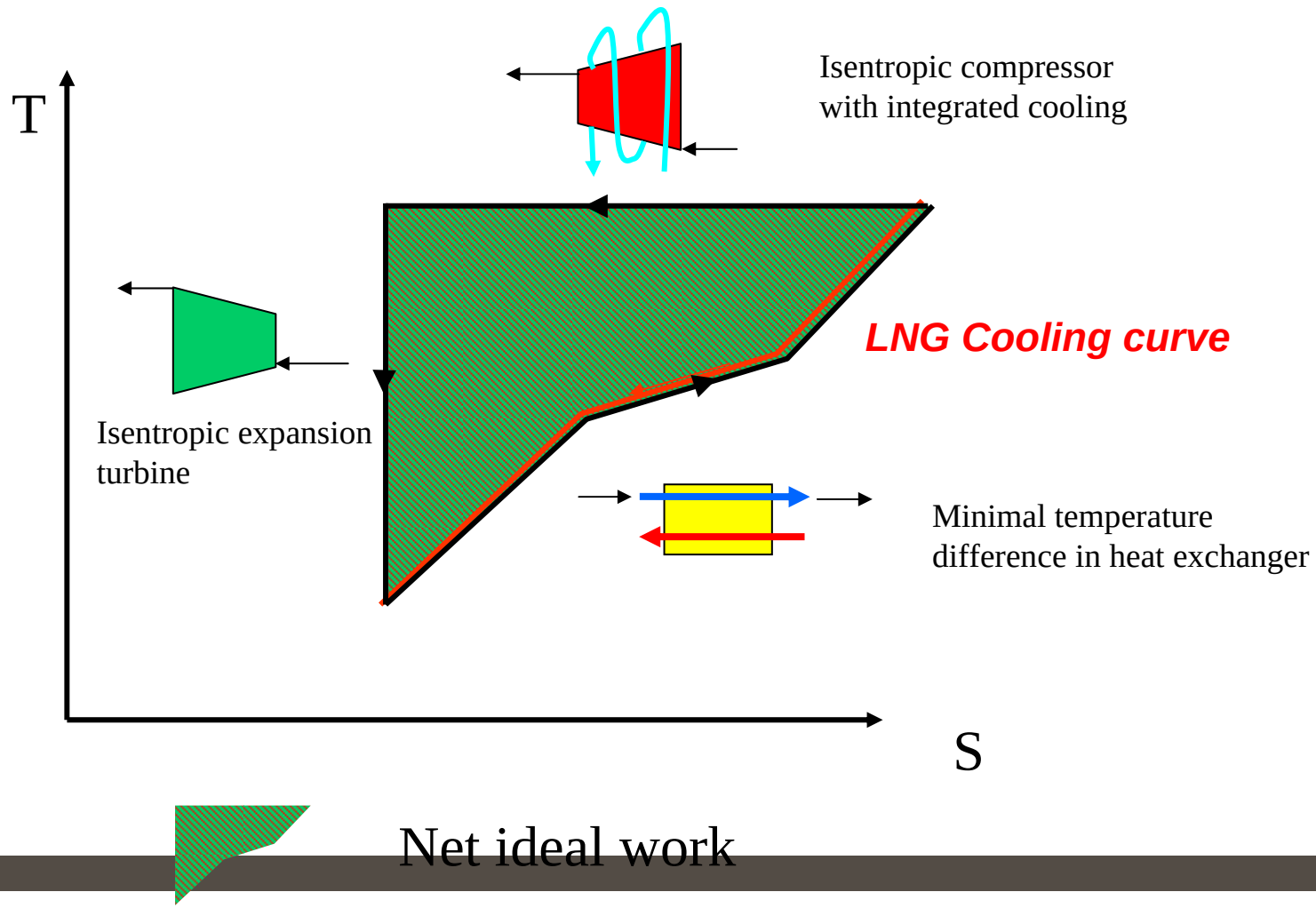
Lowest possible compressor work for natural gas liquefaction



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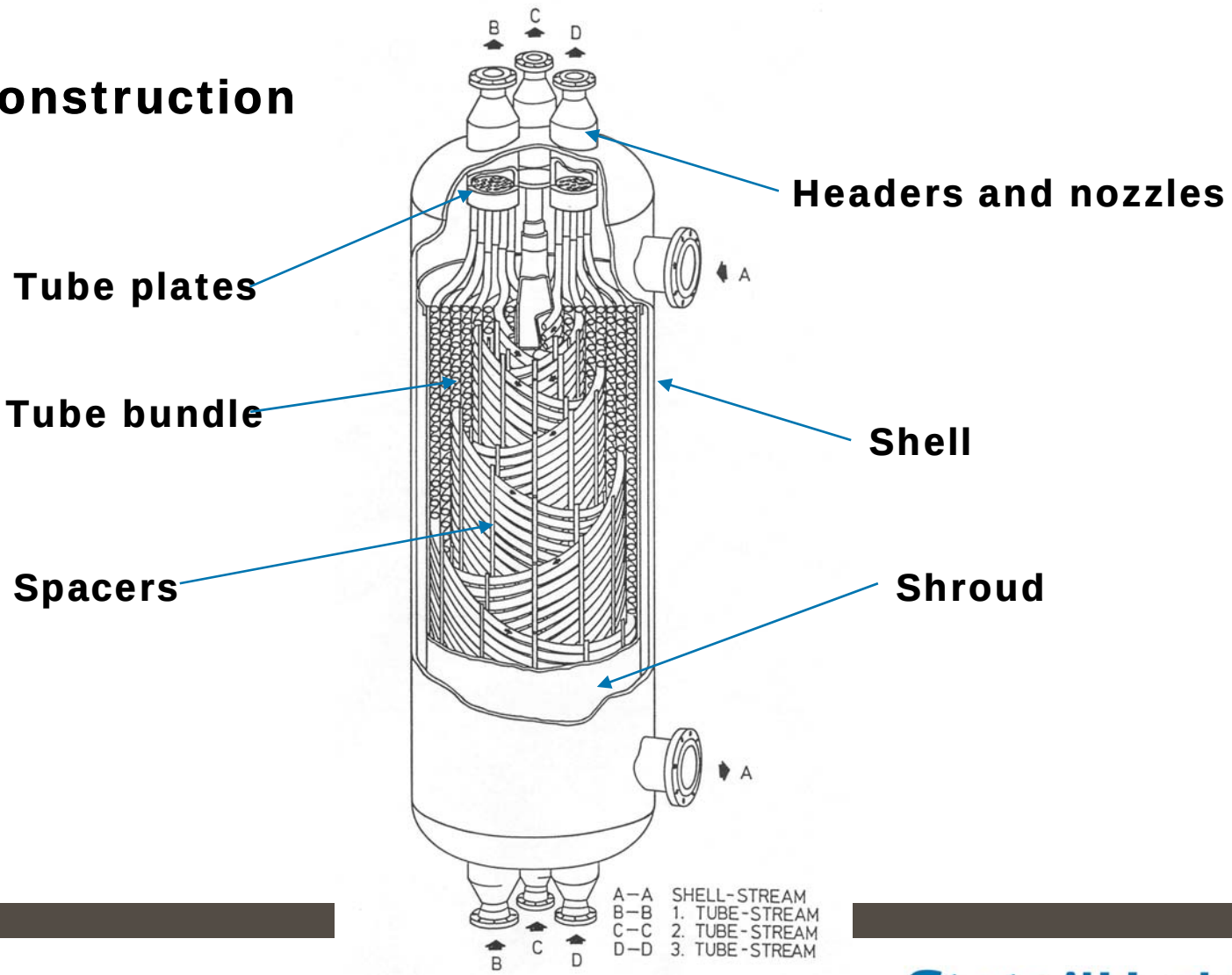
Process impacts

- Relation between process efficiency and heat exchanger efficiency

$$\frac{EXERGY_{loss}}{DUTY} \approx T_{ref} \cdot \frac{T_{hot} - T_{cold}}{T_{hot} \cdot T_{cold}}$$

SWHE – Spiral Wound Heat Exchanger

Principal construction



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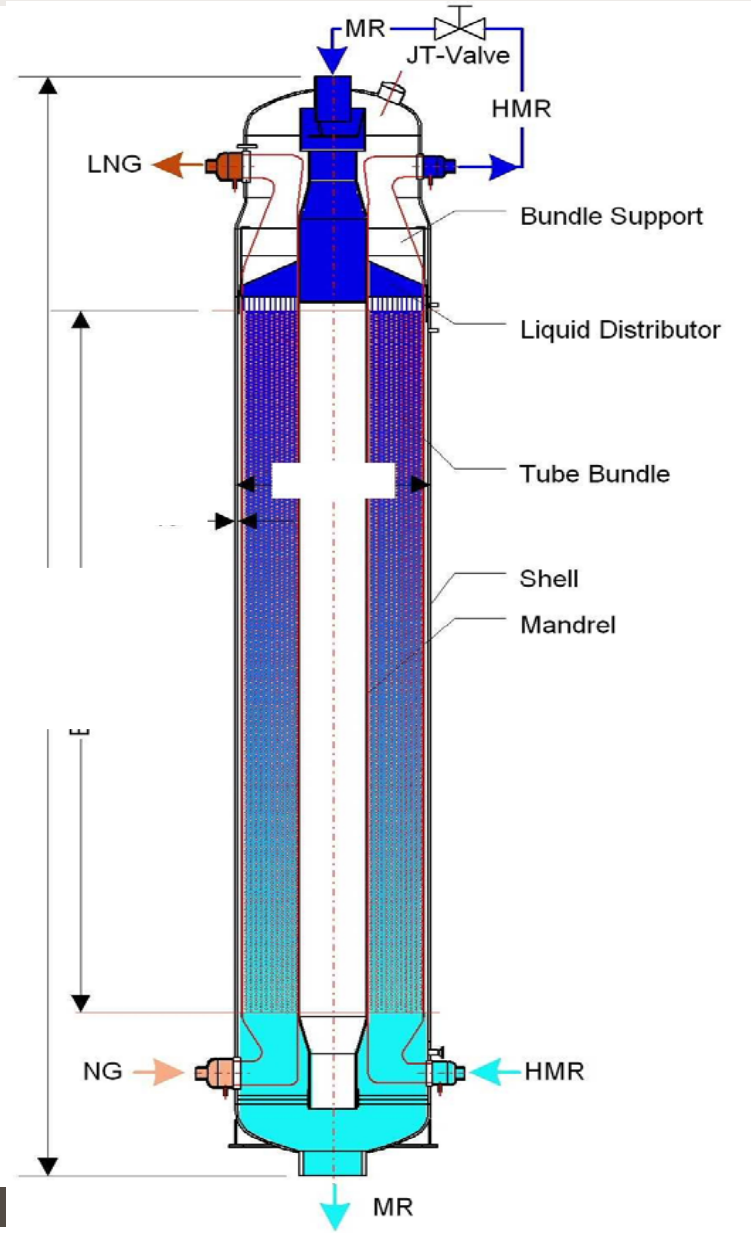
LNG-SWHE

Principal construction



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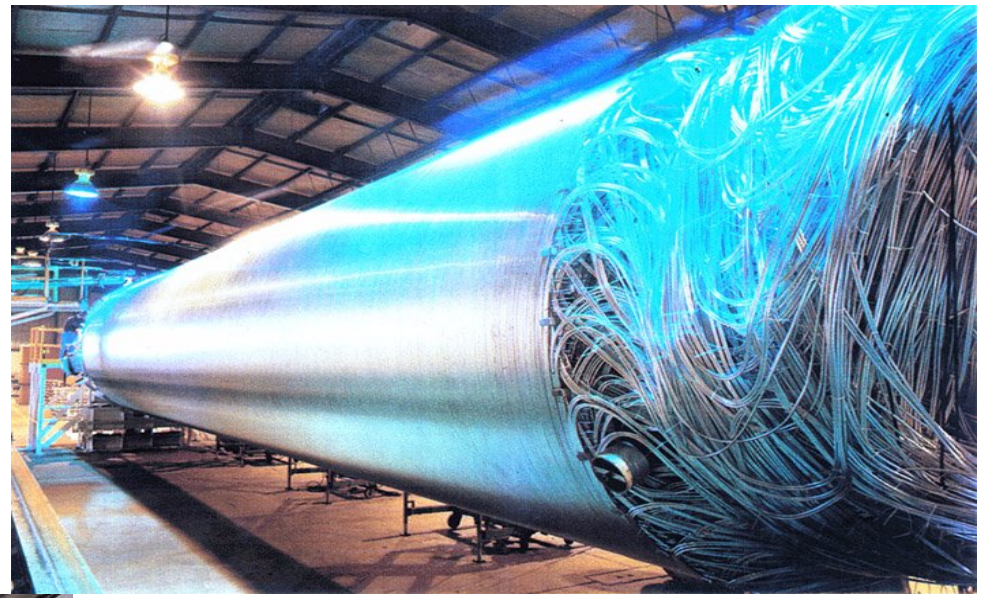
Vendors

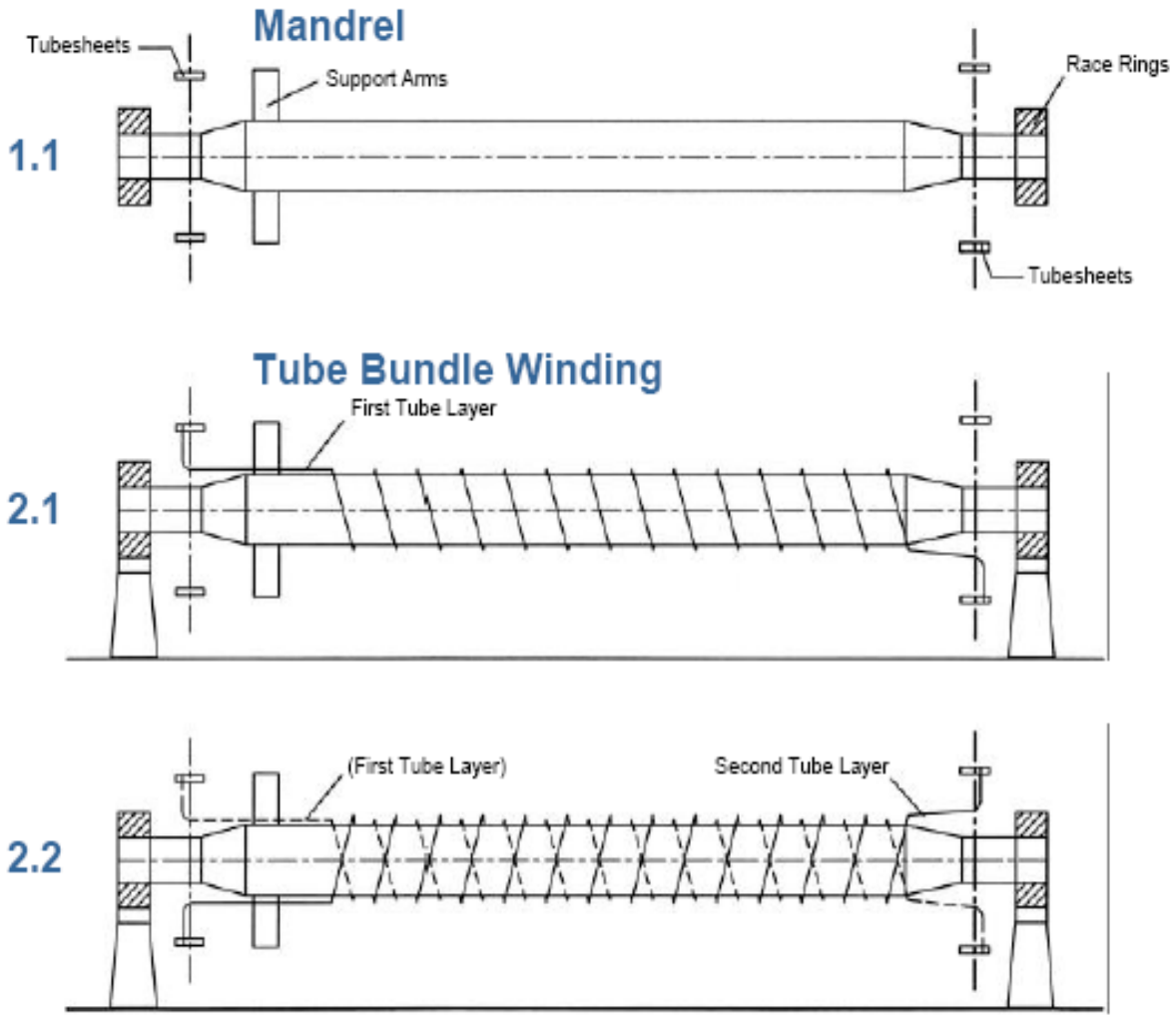


Linde

Air Products

StatoilHydro

Manufacturing Procedure for Spiral Wound Heat Exchangers



SWHE – Fabrication – The mandrel

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SWHE – Fabrication – tube winding

Tube winding with 4 tubes in parallel

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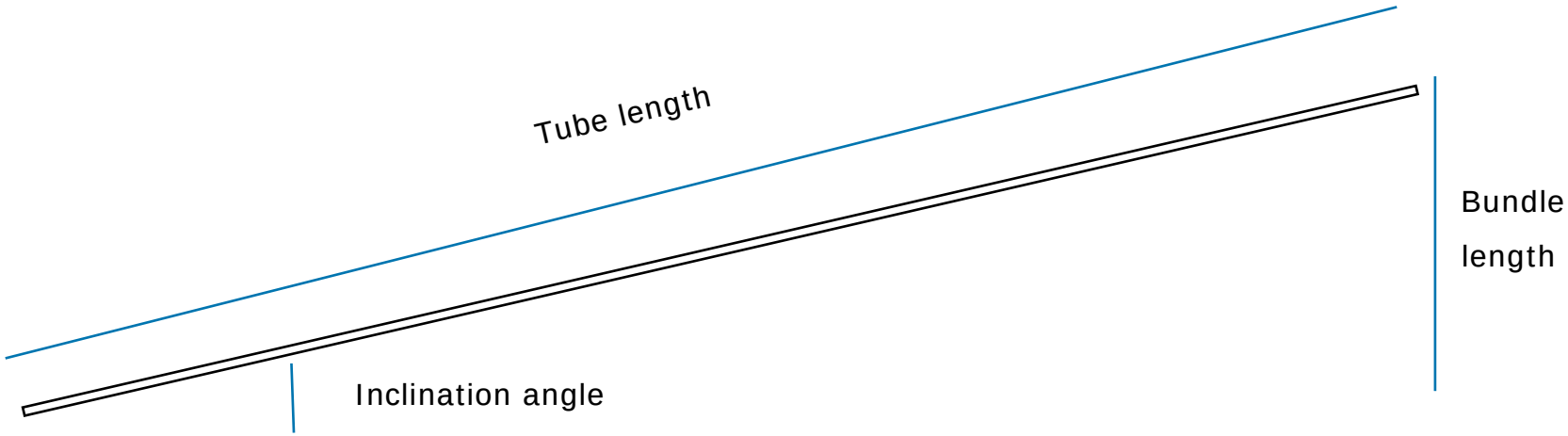
Tube inclination

One single tube straighten out

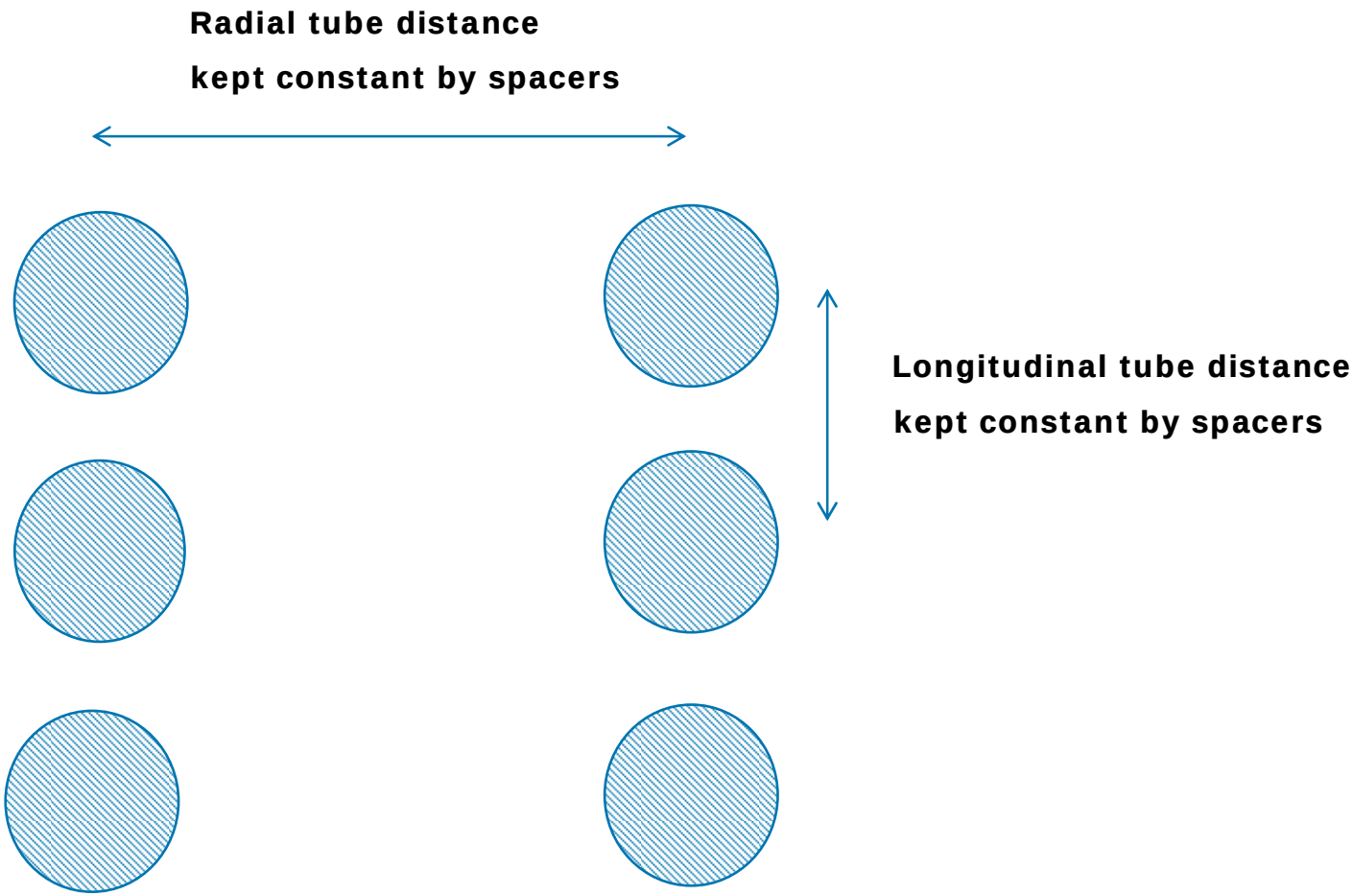


All single tubes connected to the same stream need to have the same length in order to obtain same pressure drop and equal fluid distribution

This is obtained by equal inclination angle.

Different layers may have different angles → Not mixed layers

Tube configuration



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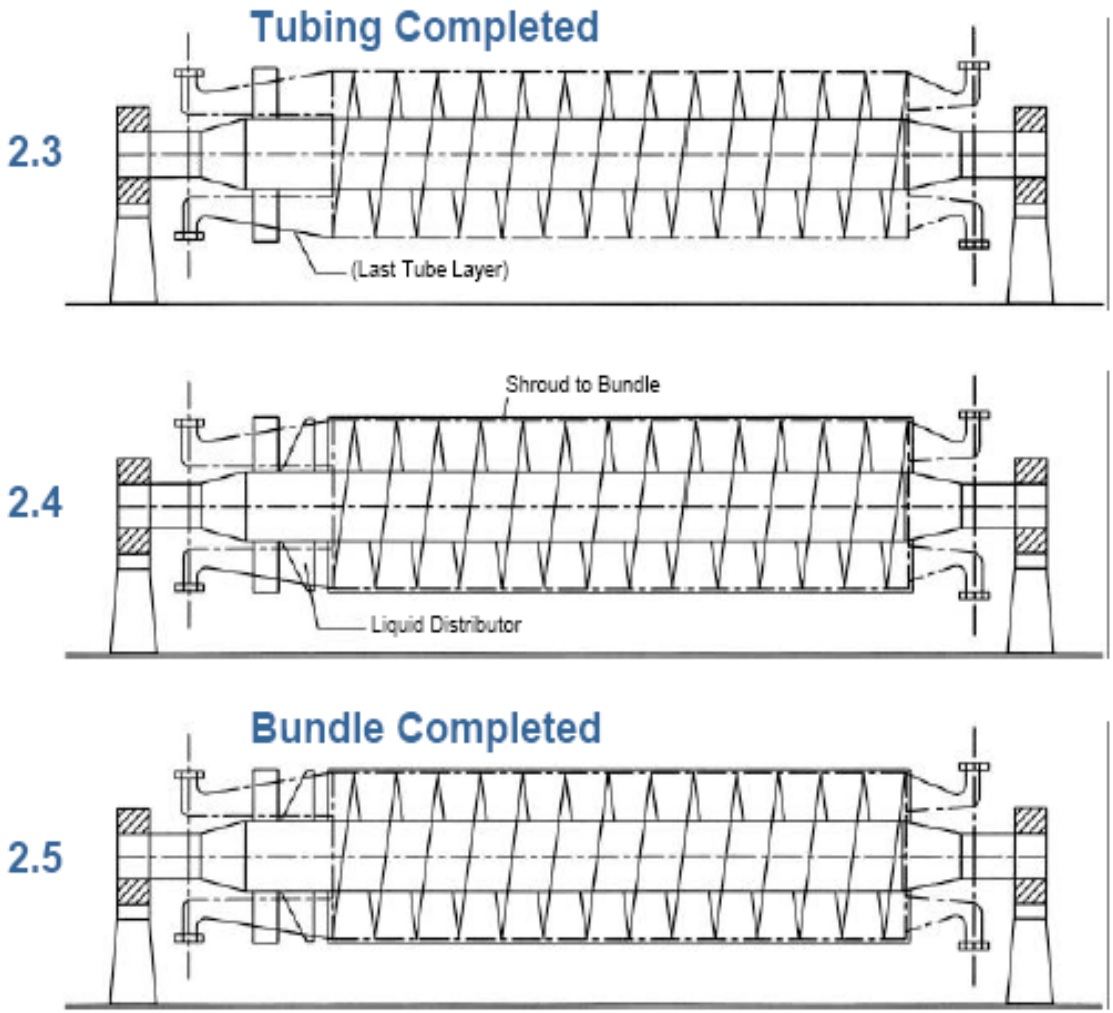
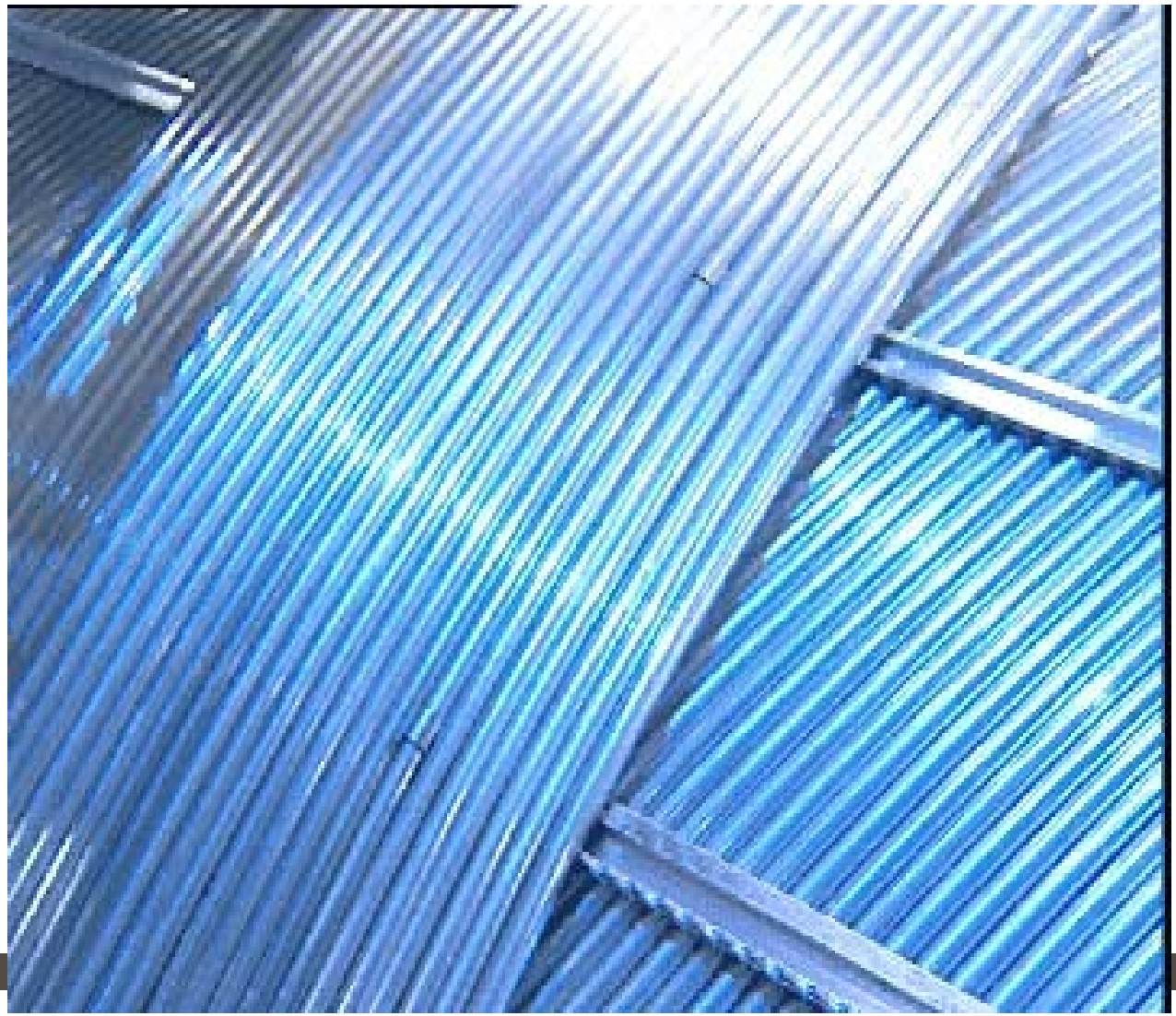
Manufacturing Procedure for Spiral Wound Heat Exchangers



SWHE – Fabrication – tube winding layer by layer



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SWHE – Fabrication – Tube winding complete

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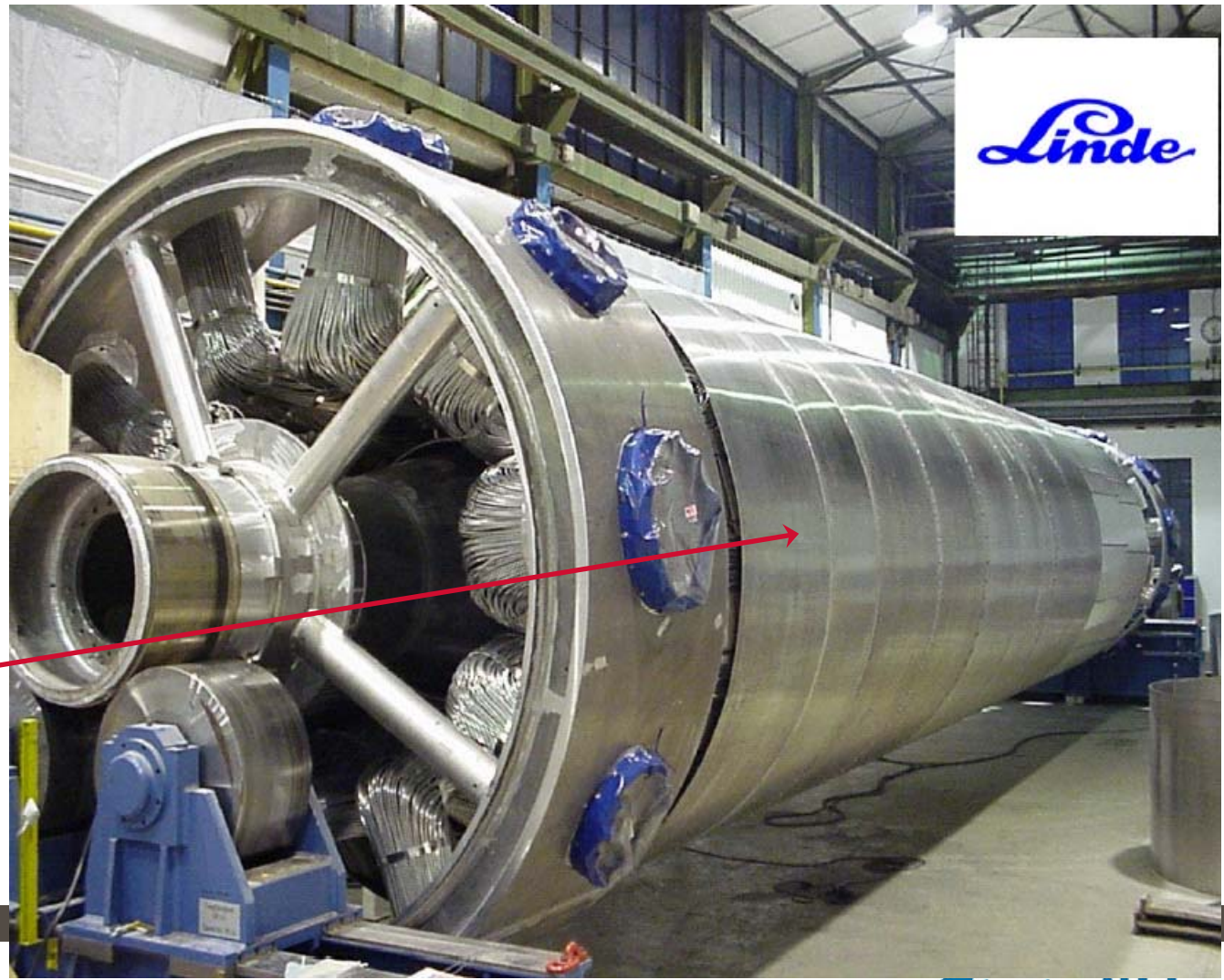
SWHE – Fabrication – The shroud

Avoiding by-pass flow ...

The shroud



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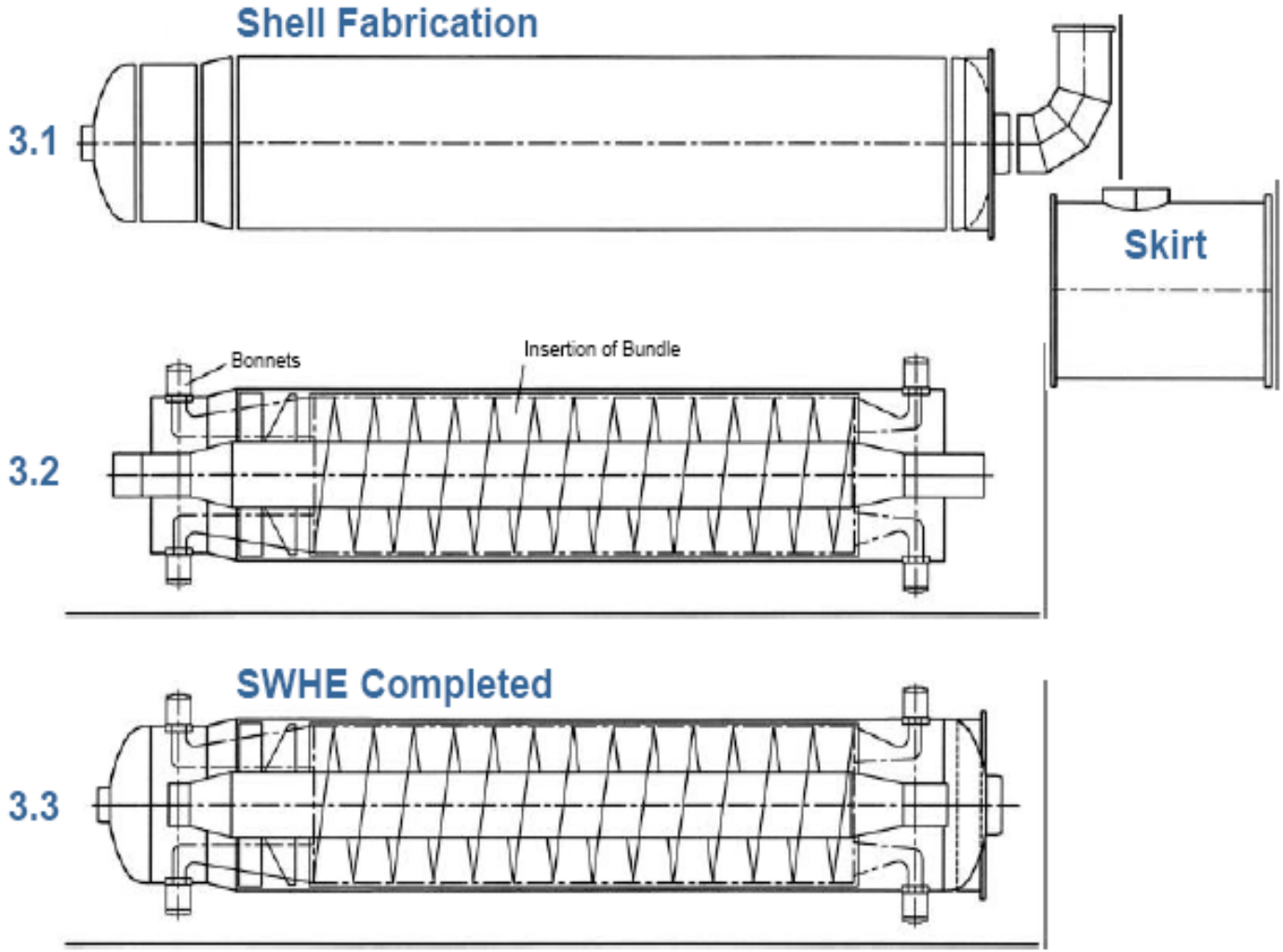
Manufacturing Procedure for Spiral Wound Heat Exchangers



SWHE – Fabrication – Complete

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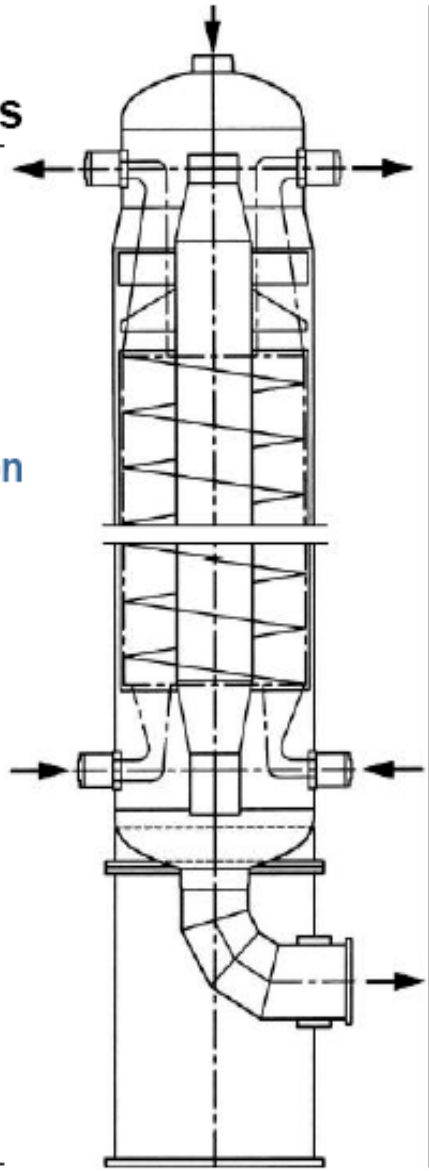
Manufacturing Procedure for Spiral Wound Heat Exchangers

4.

SWHE in Operating Position



SNØHVIT SWHE characteristics

- Liquefier
  - Surface = 11330 m^2
  - Dshell = 3.4 m
  - Lbundle = 10.4 m
- Sub-cooler
  - Surface = 16740 m^2
  - Dshell = 3.7 m
  - Lbundle = 12.7 m

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SWHE starting it’s journey to Melkøya

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Linde LNG SWHE in transportation

The two Snøhvit LNG spiral wound heat exchangers, in transport from Schalchen to Bremen to be installed in the cold box prior to shipment to Hammerfest.

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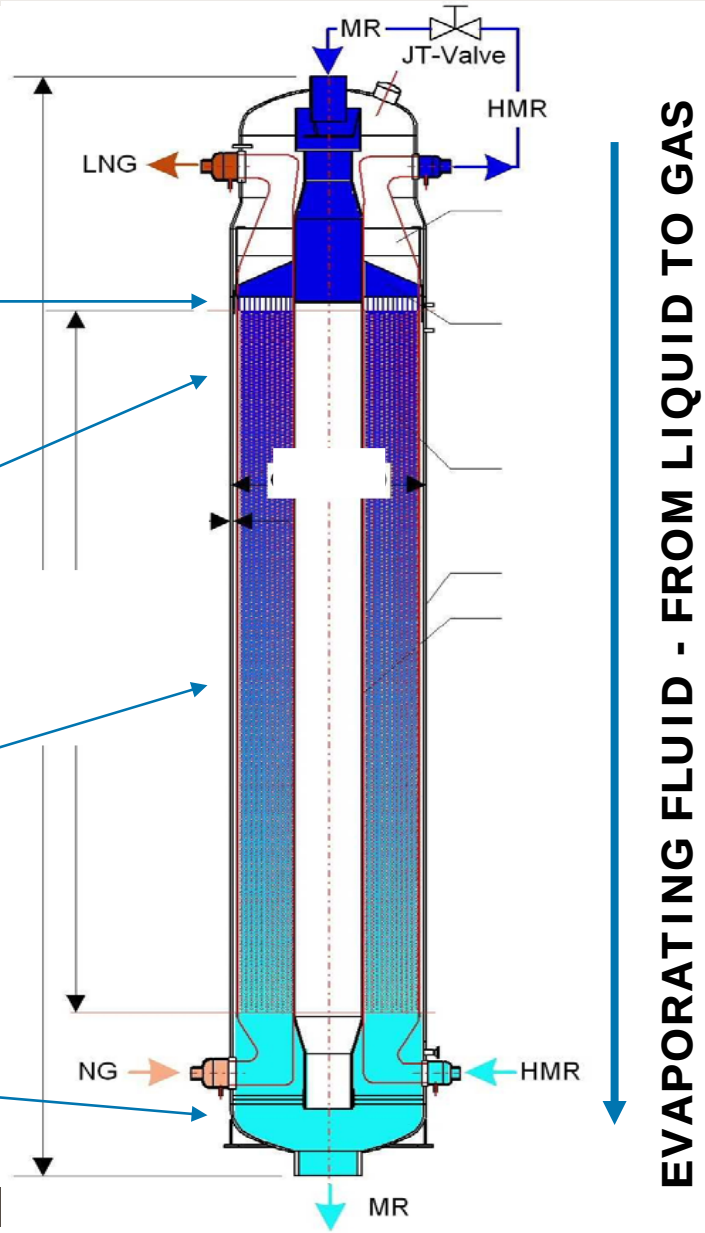
Shell side hydraulic characteristics

Two-phase distribution

Gravity drained liquid

Increased shear flow

Complete evaporated



StatoilHydro

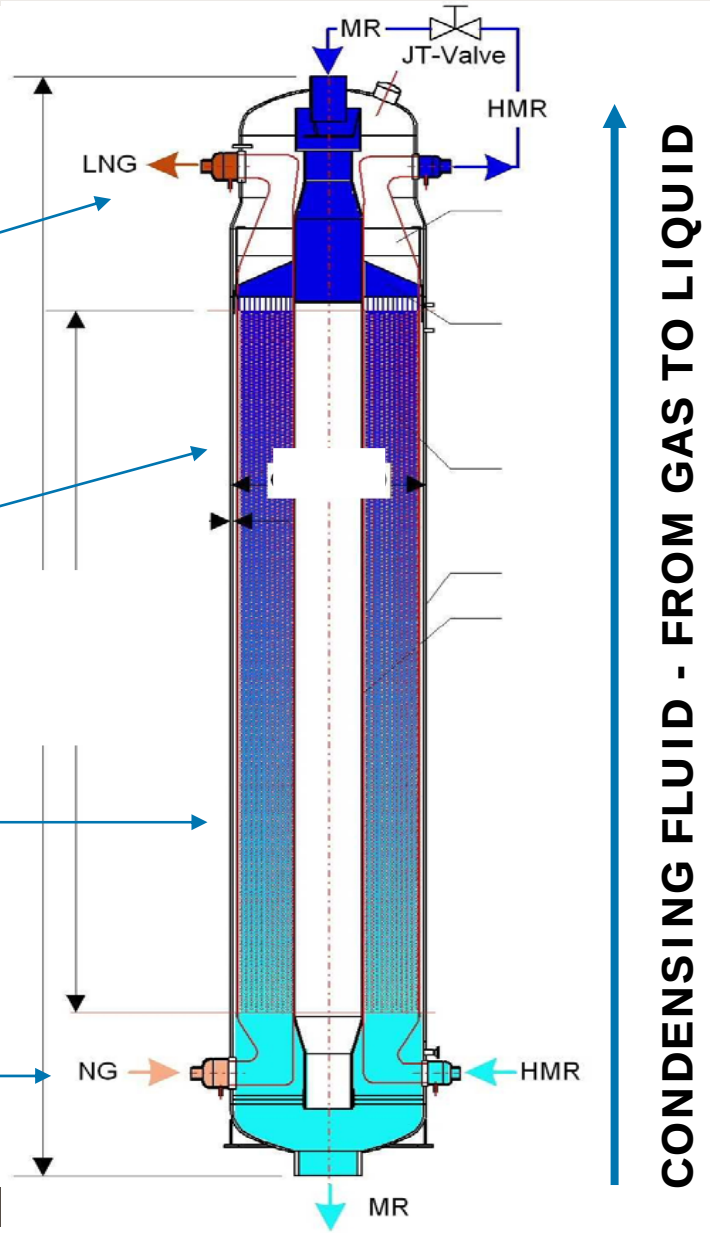
Tube side hydraulic characteristics
Gas feed

Liquid leaving nozzle

Complete condensation

Increased liquid amount transported by gas shear

Gas entering nozzle



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PFHE
Plate-fin heat exchanger

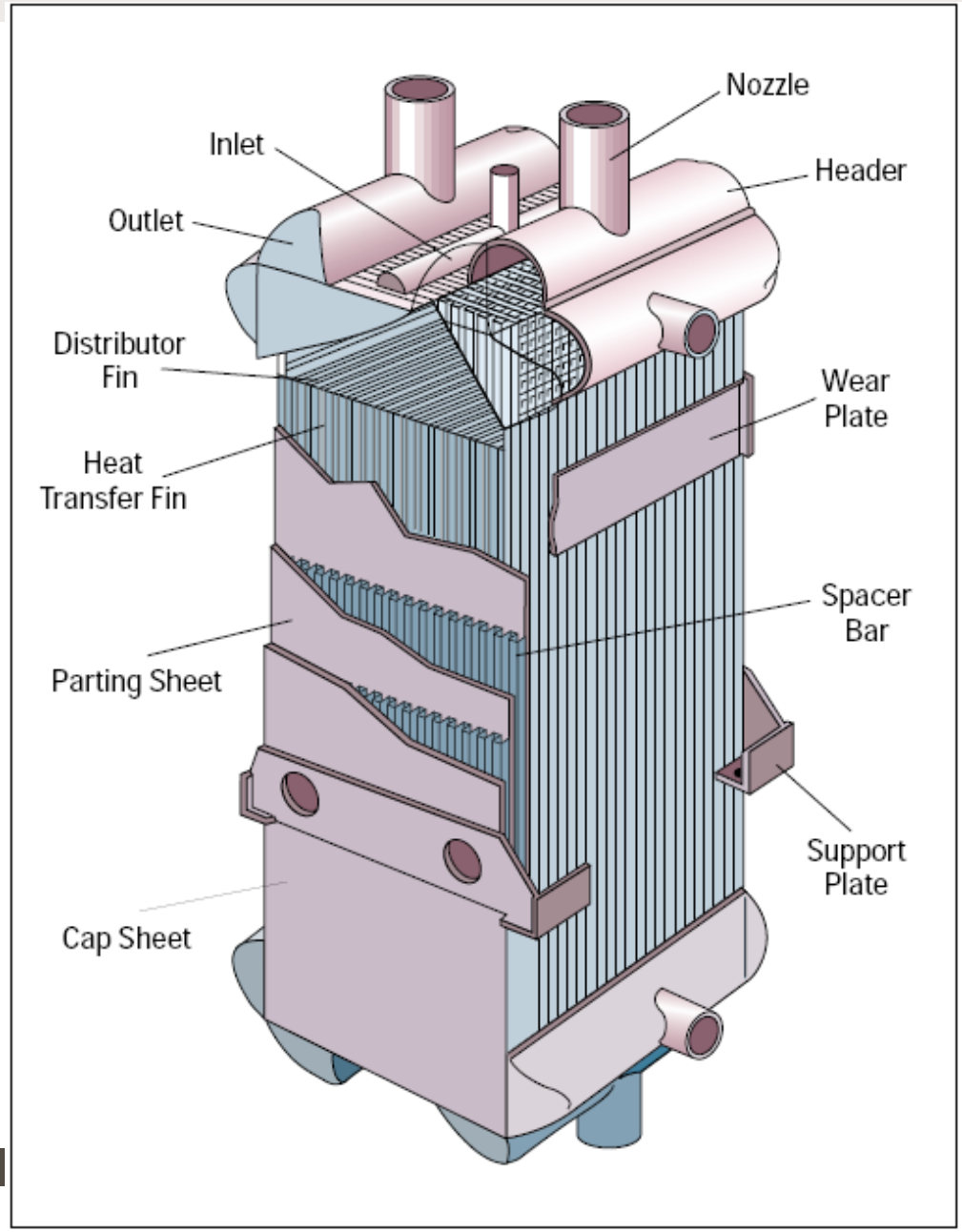

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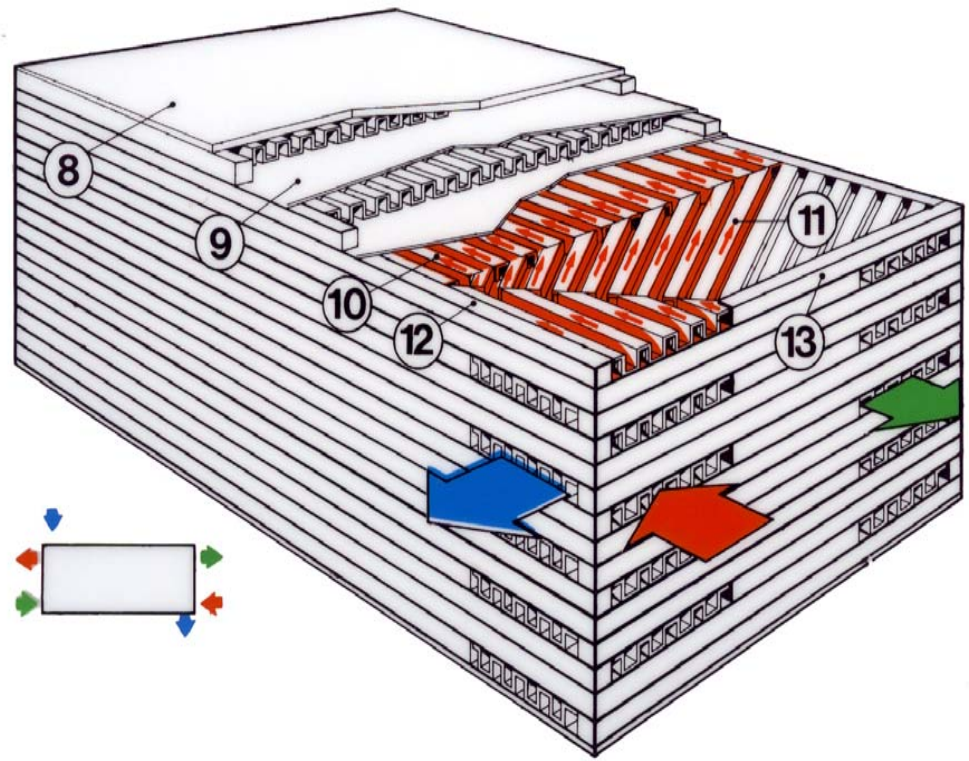
Plate-fin heat exchanger
Principal function



1 Block or Core
2 Header
3 Nozzle
4 Width
5 Stacking height
6 Length
7 Passage outlet
8 Cover sheet
9 Parting sheet
10 Heat transfer fin
11 Distribution fin
12 Side bar
13 End bar

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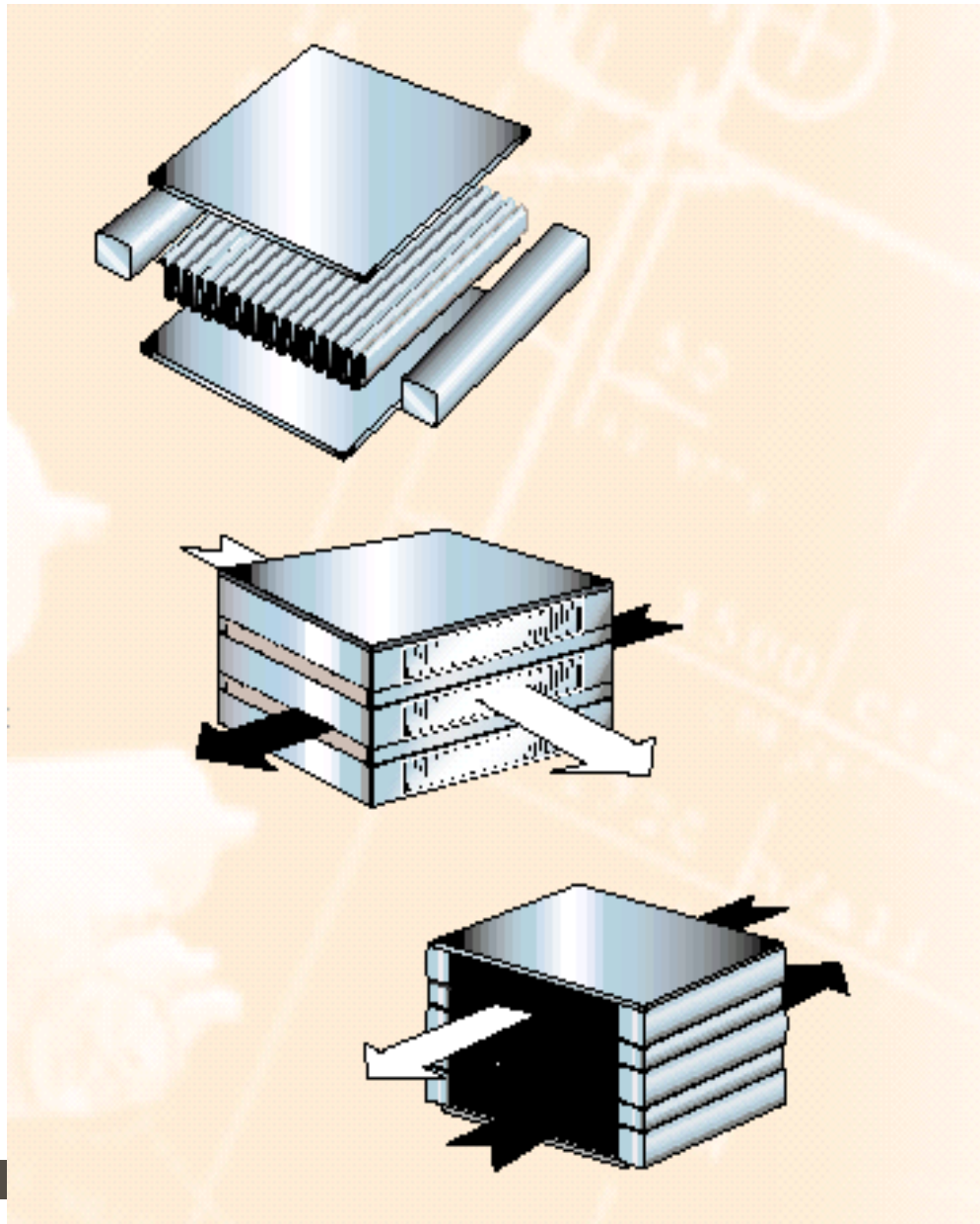
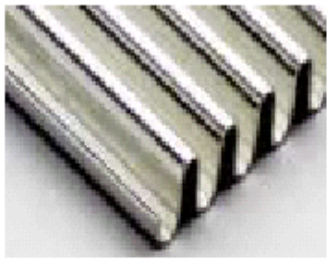


StatoilHydro

Fin patterns

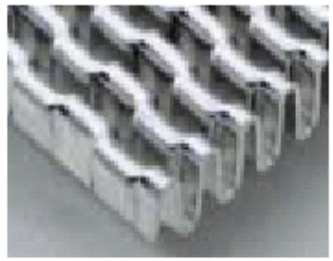
The range comprises four basic fin pattern types:



PLAIN • A sheet of metal with corrugated fins at right angles to the plates.

PERFORATED • A plain fin constructed from perforated material.

HERRINGBONE • Made by displacing the fins sideways at regular intervals to produce a zig-zag effect.



SERRATED • Made by simultaneously folding and cutting alternative sections of fins. These fins are also known as the lanced or multi-entry pattern.

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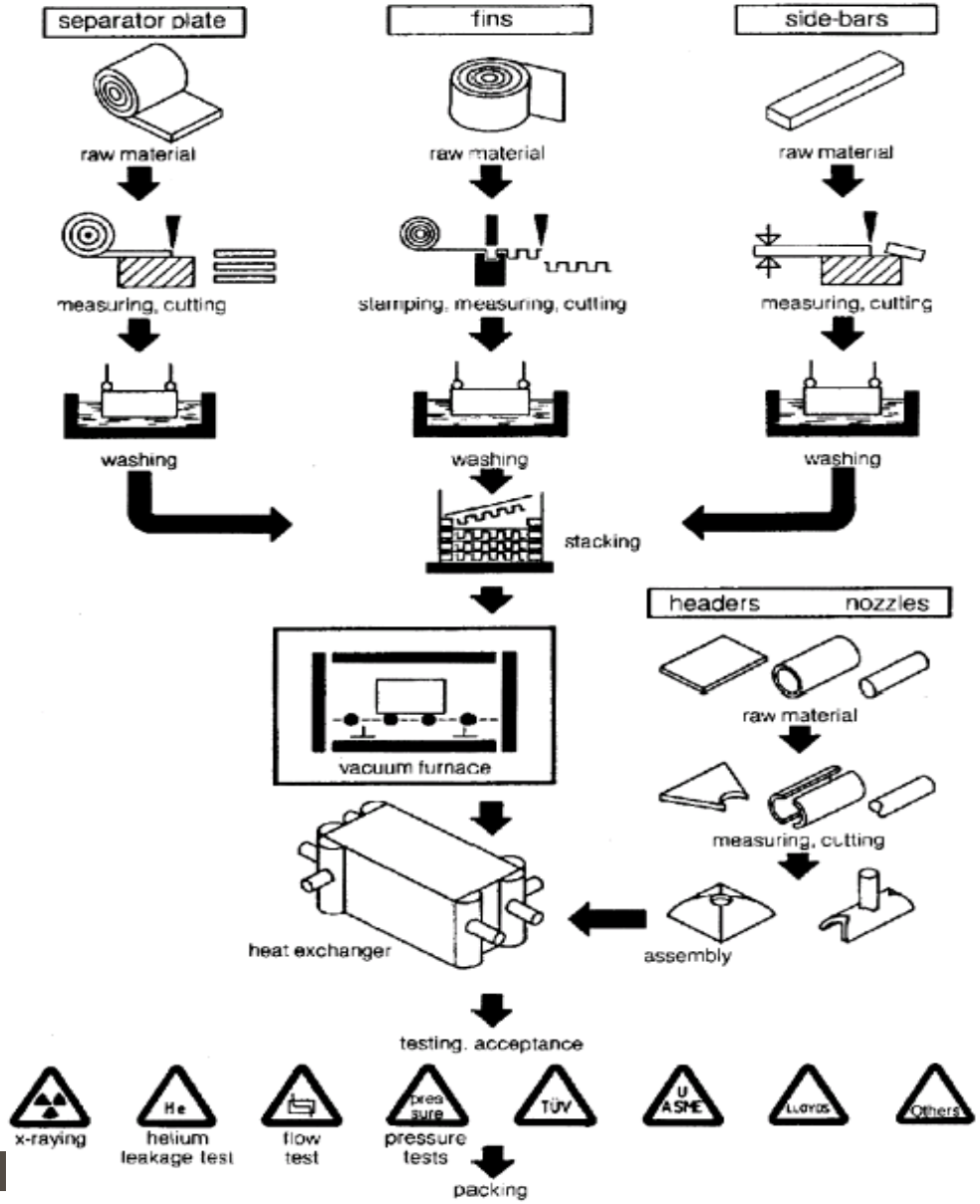

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Manufacturing process

Plate by plate ...

In a stacking platform

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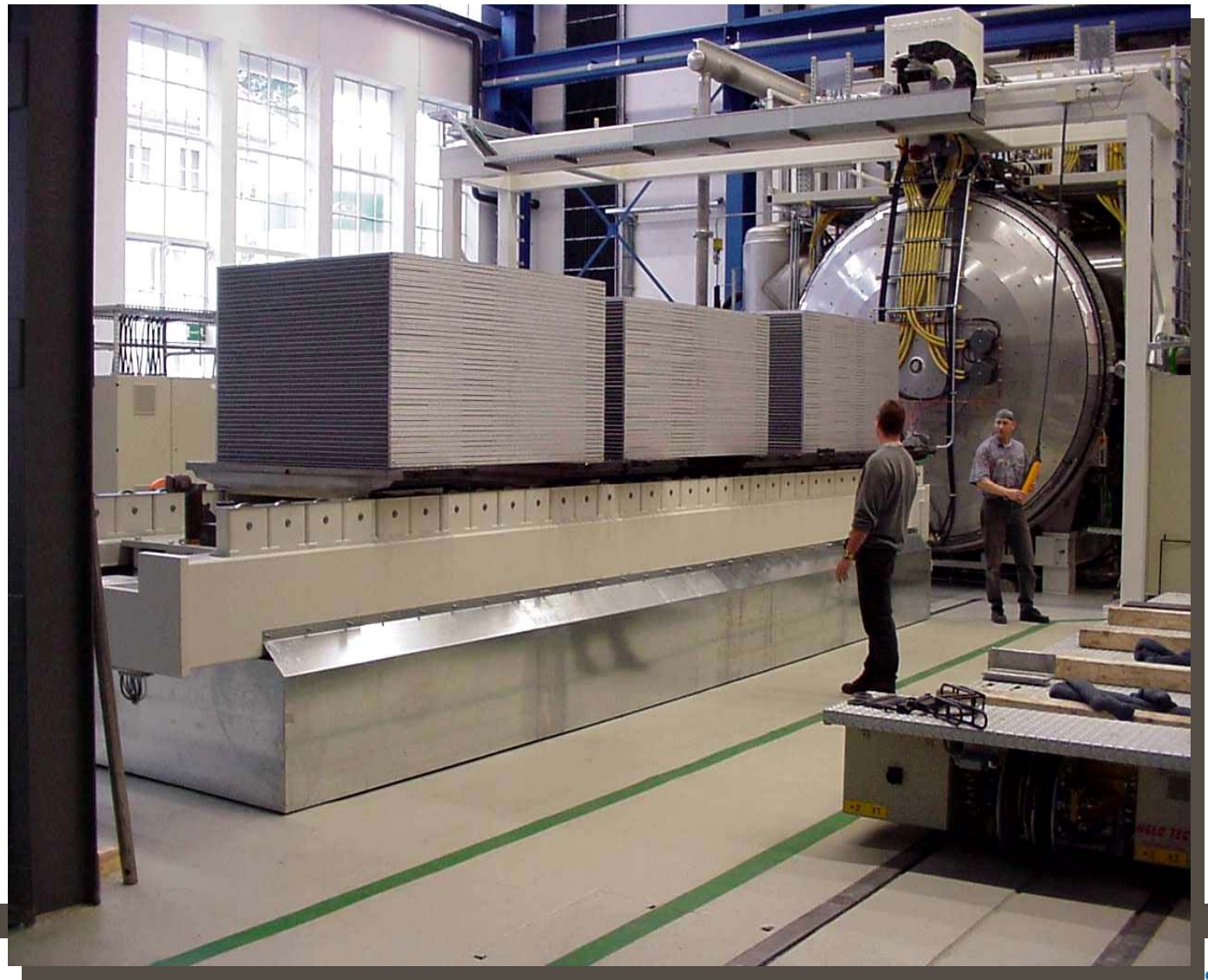
Vacuum brazing of block



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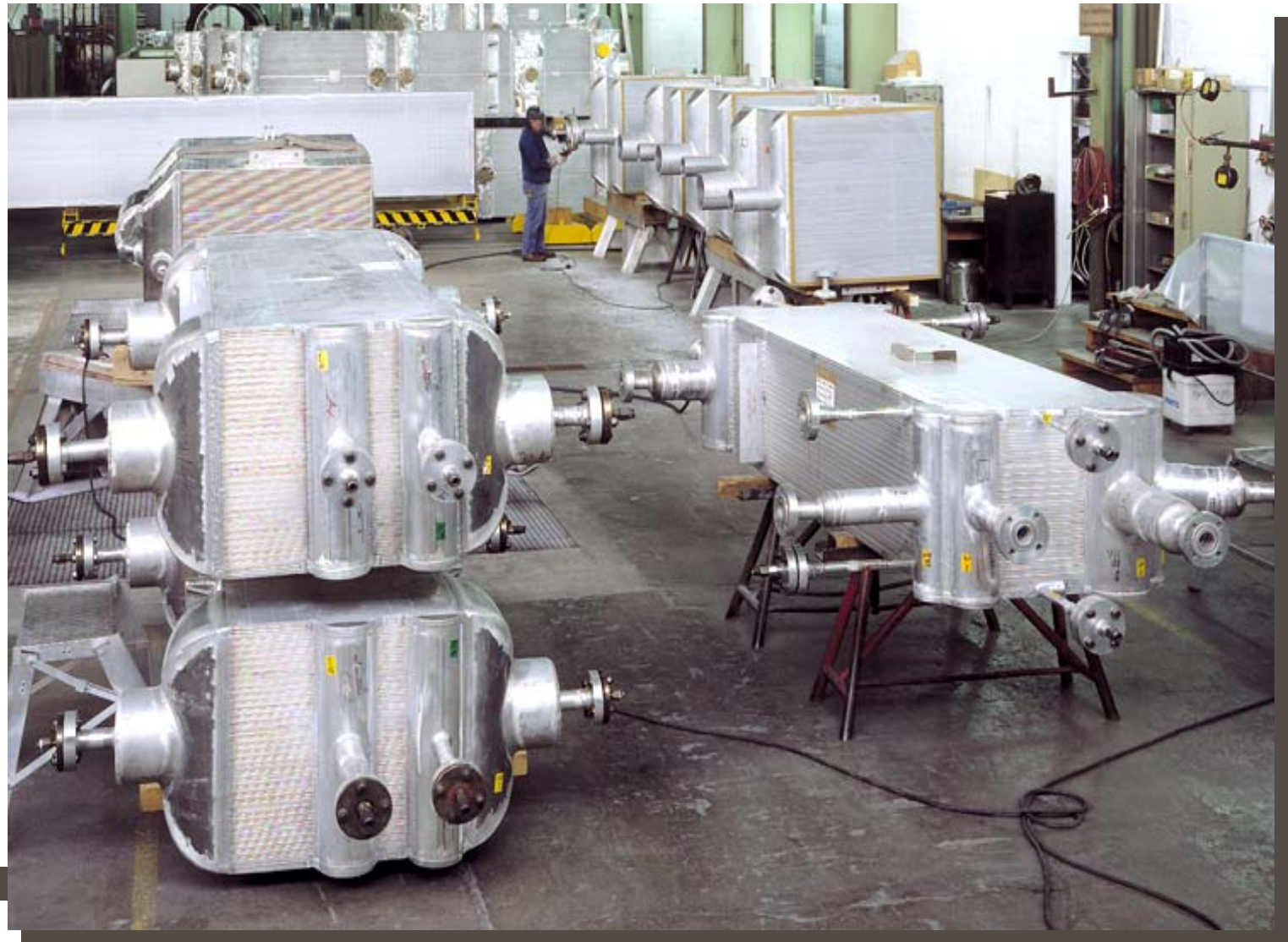
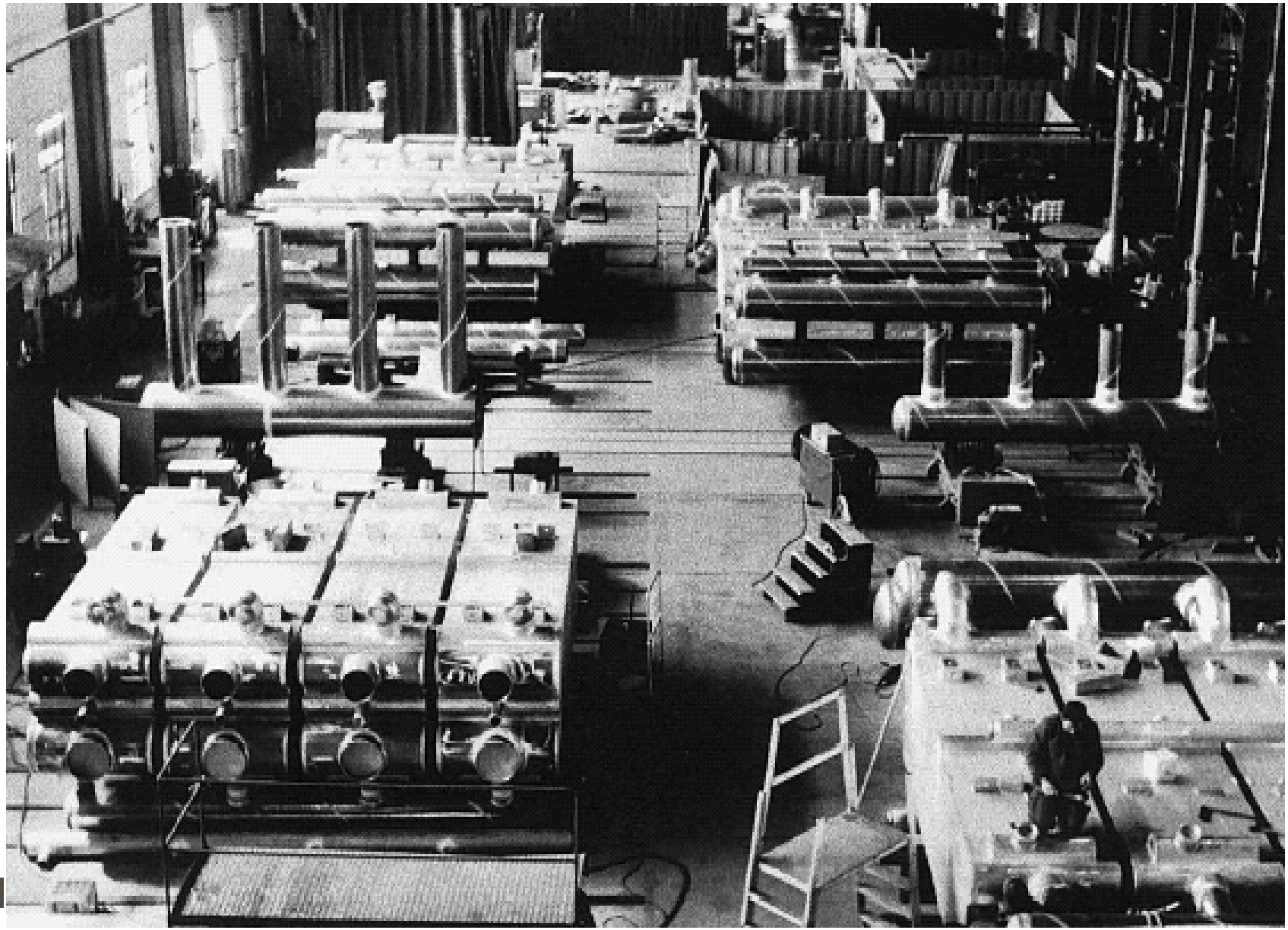
Welding headers and leak testing



StatoilHydro



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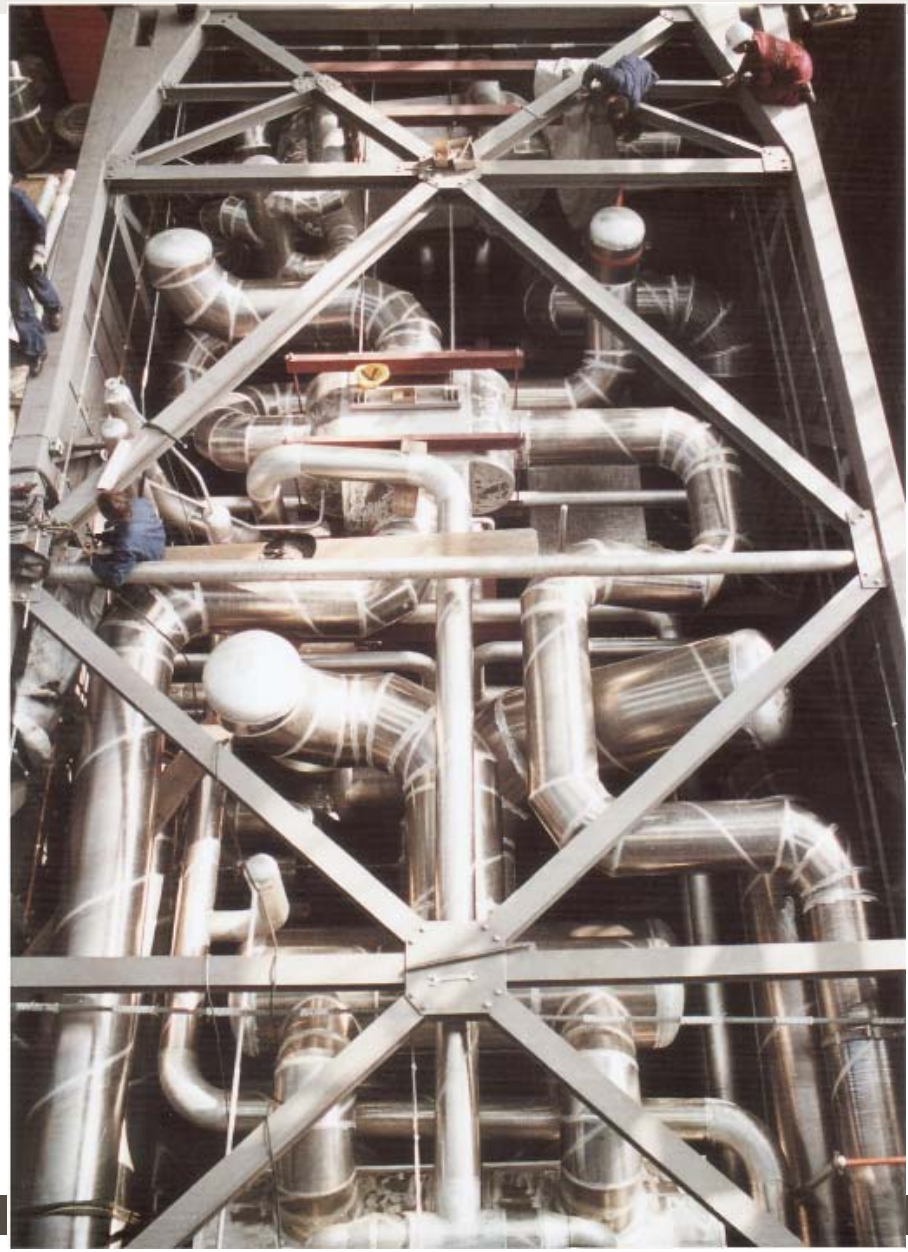
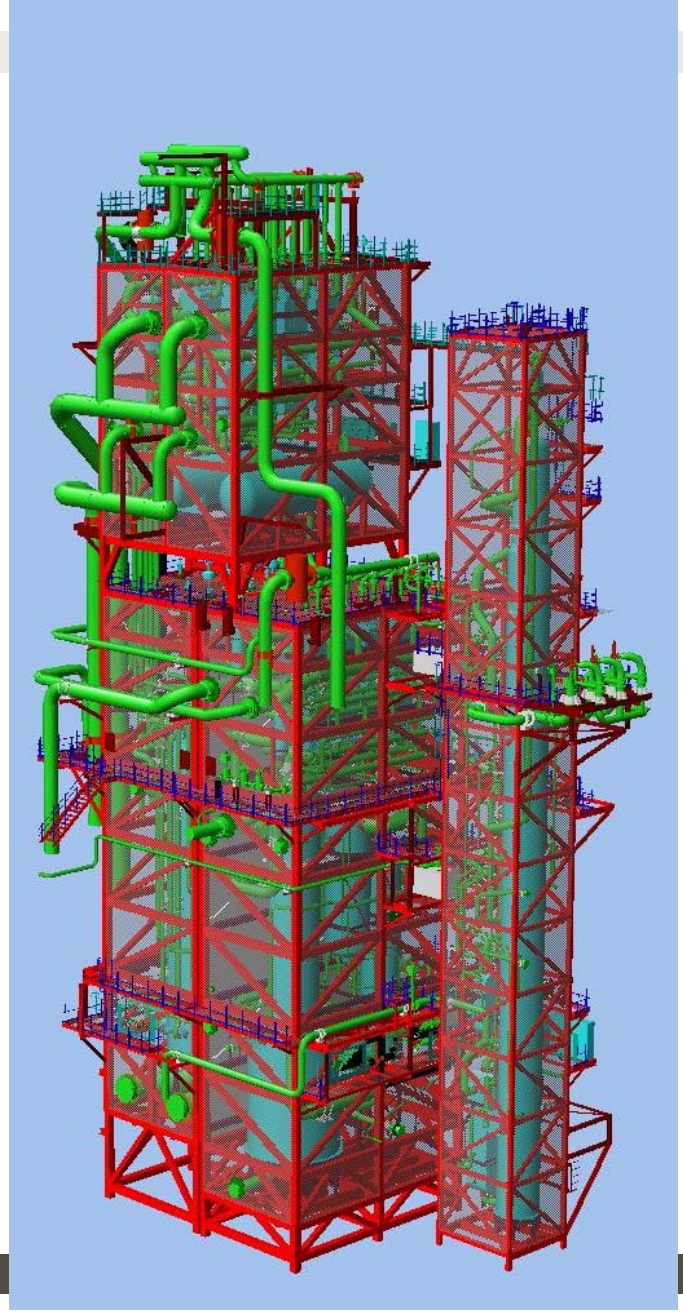
Cold-box



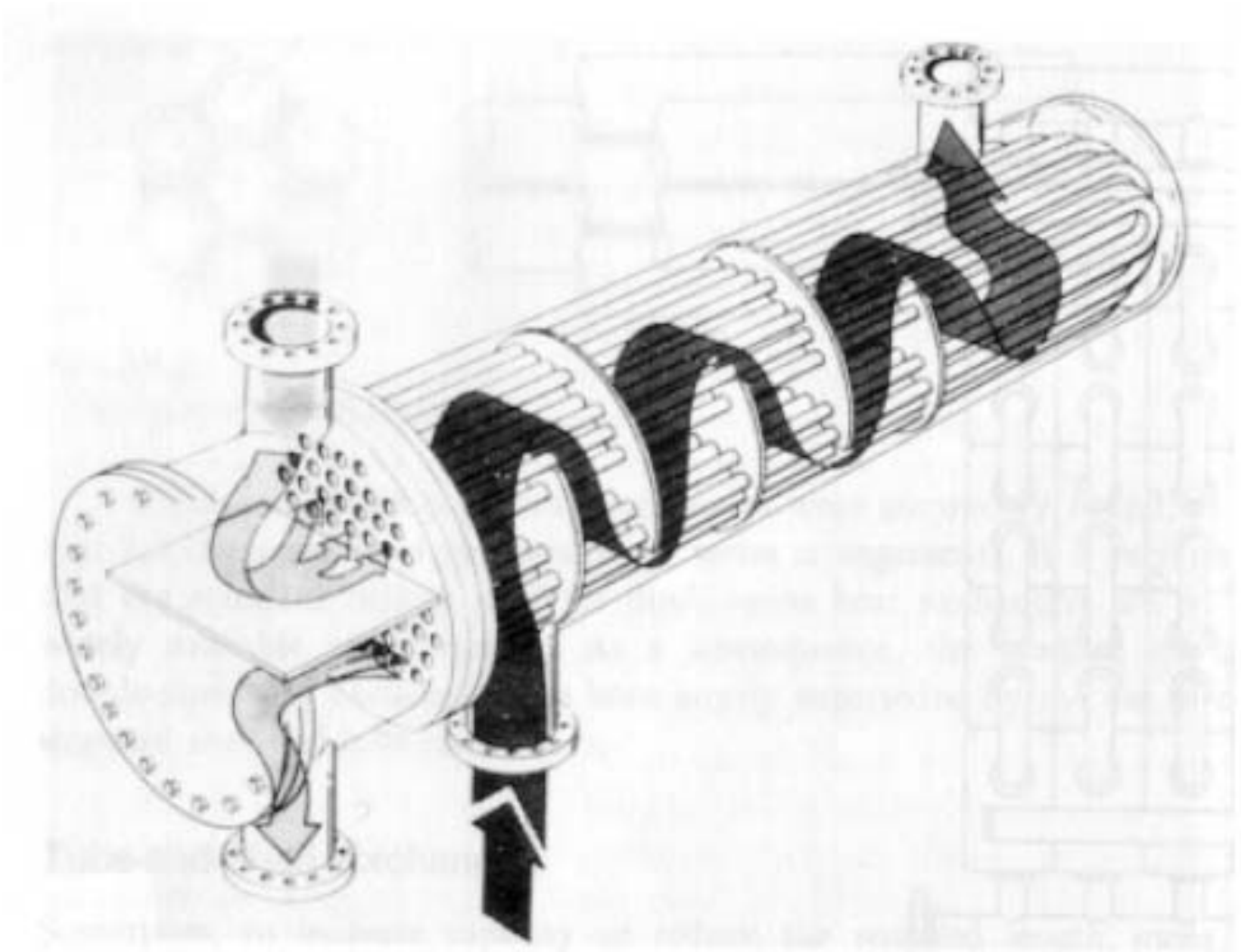
StatoilHydro

Cold-box Hammerfest



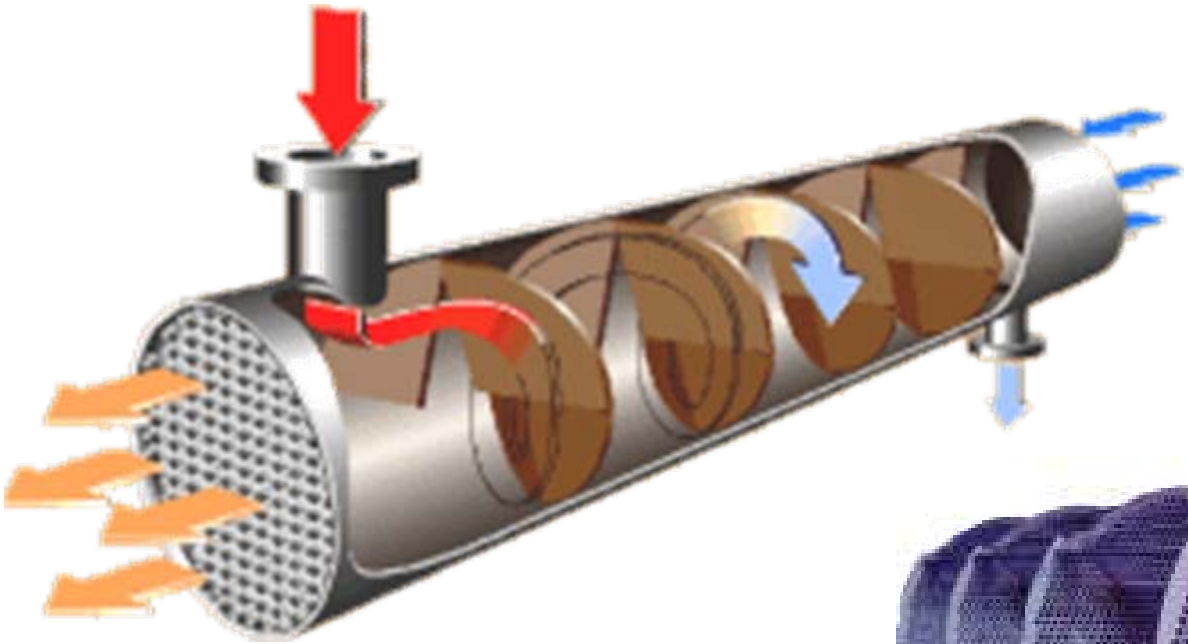
StatoilHydro

Shell-tube



StatoilHydro

Helixchanger – Main sea water cooler



StatoilHydro

Helifin – Helixchanger with low-fin tubing

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Helifin during manufacturing

HELIFIN Heat Exchanger Tube Bundle in Fabrication

StatoilHydro