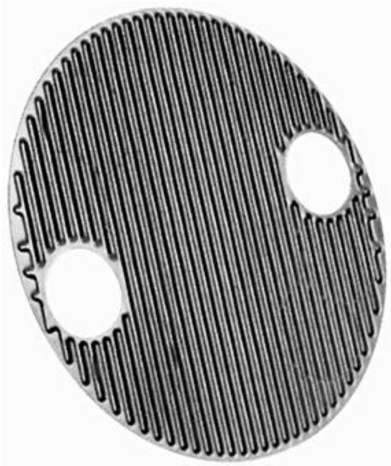
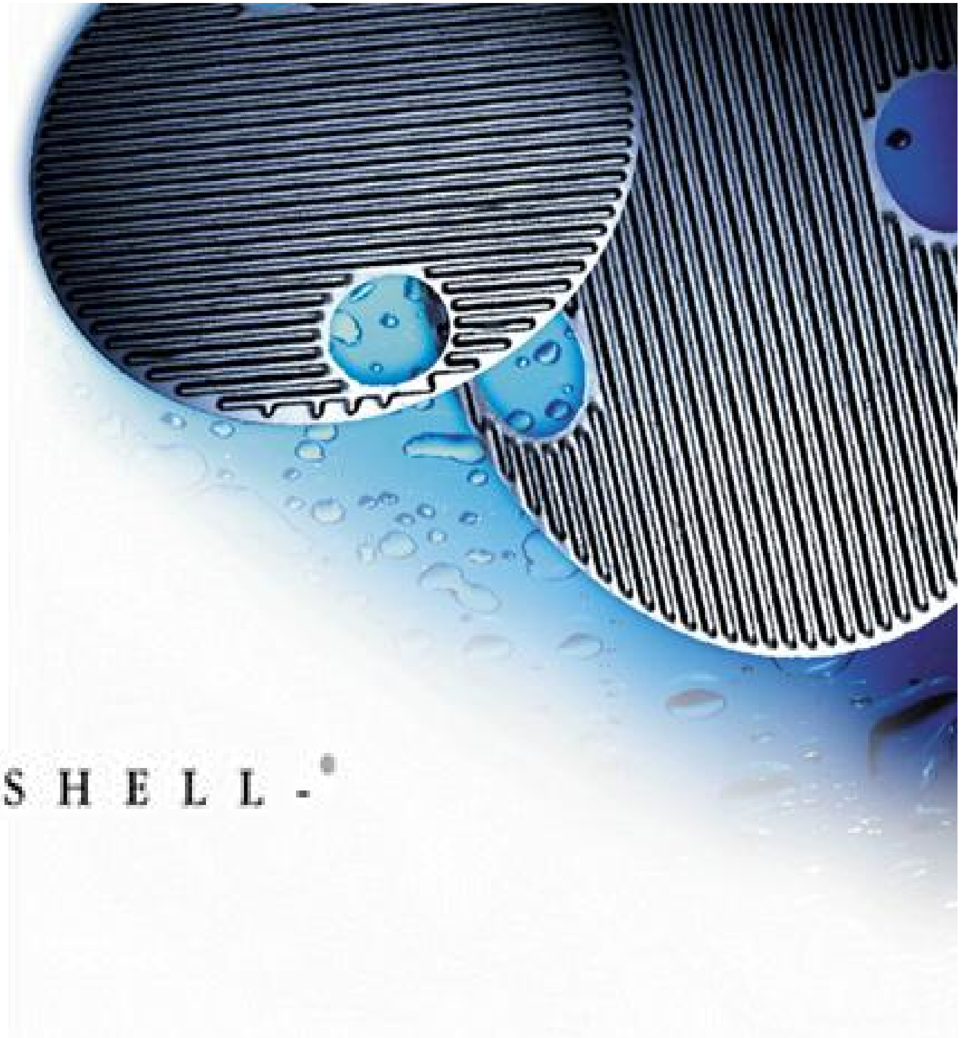


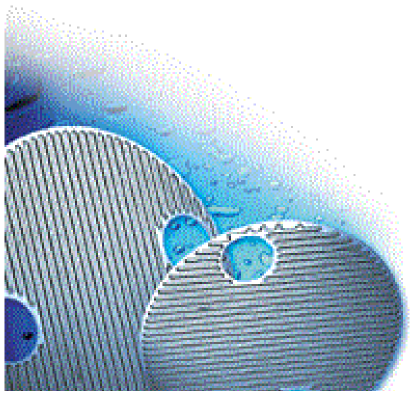


- P L A T E & S H E L L -®

**Vahterus Plate & Shell® Heat Exchangers I 2010**

Heat exchangers

# Company History




FINLAND
Barents Sea
Norway
Inari
Lapland
0 200 km
0 120 miles
Lemmenjoki
National Park
Pallas-Ounastunturi
National Park
ARCTIC
OCEAN
Arctic Circle
Oulanka
National Park
White Sea
Luleå
Oulu
SWEDEN
Kajaani
Kuhmo
RUSSIA
Umeå
Pietarsaari
Koupio
Joensuu
Vaasa
Seinäjori
Kolovesi
National Park
Onega
Jyväsklyä
Olavinlinna
Kristinestad
Imatra
Castle
Golf of
Bothnia
Pori
Tampere
Ladoga
VAHTERUS
NORWAY
Rauma
Kotka
Gulf of
Finland
Turku
(Åbo)
Helsinki
(Helsingfors)
Oslo
Stockholm
Estonia

Vahterus Plate & Shell® Heat Exchangers I 2010

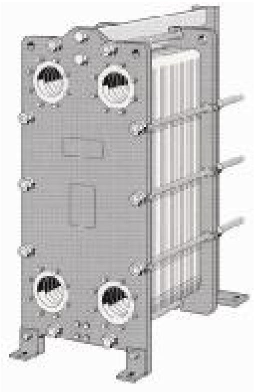
VAHTERUS

# Introduction

- Independent company
- Founded 1990
- Inventor of Plate&Shell® technologies
- Head office and manufacturing center in Finland
- Sales offices in UK & Germany
- Global distribution network

# WORLDWIDE

# Best of Both Worlds…



R Compact

R Low Fouling

R Close Approach Temps

S Pressure Limitations

S Temperature Limitations

S Gasket - Leaks

R High Pressure

R High Temperature

R No Gaskets

S Large size/ weight

S High Fouling


R High Pressure

R High Temperature

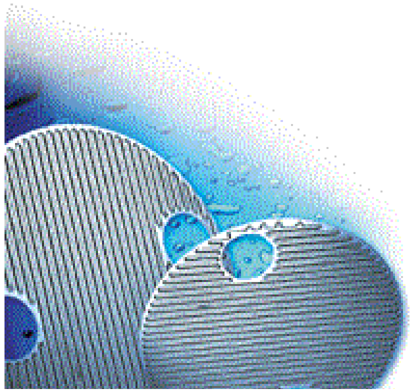
R No Gaskets

R Compact

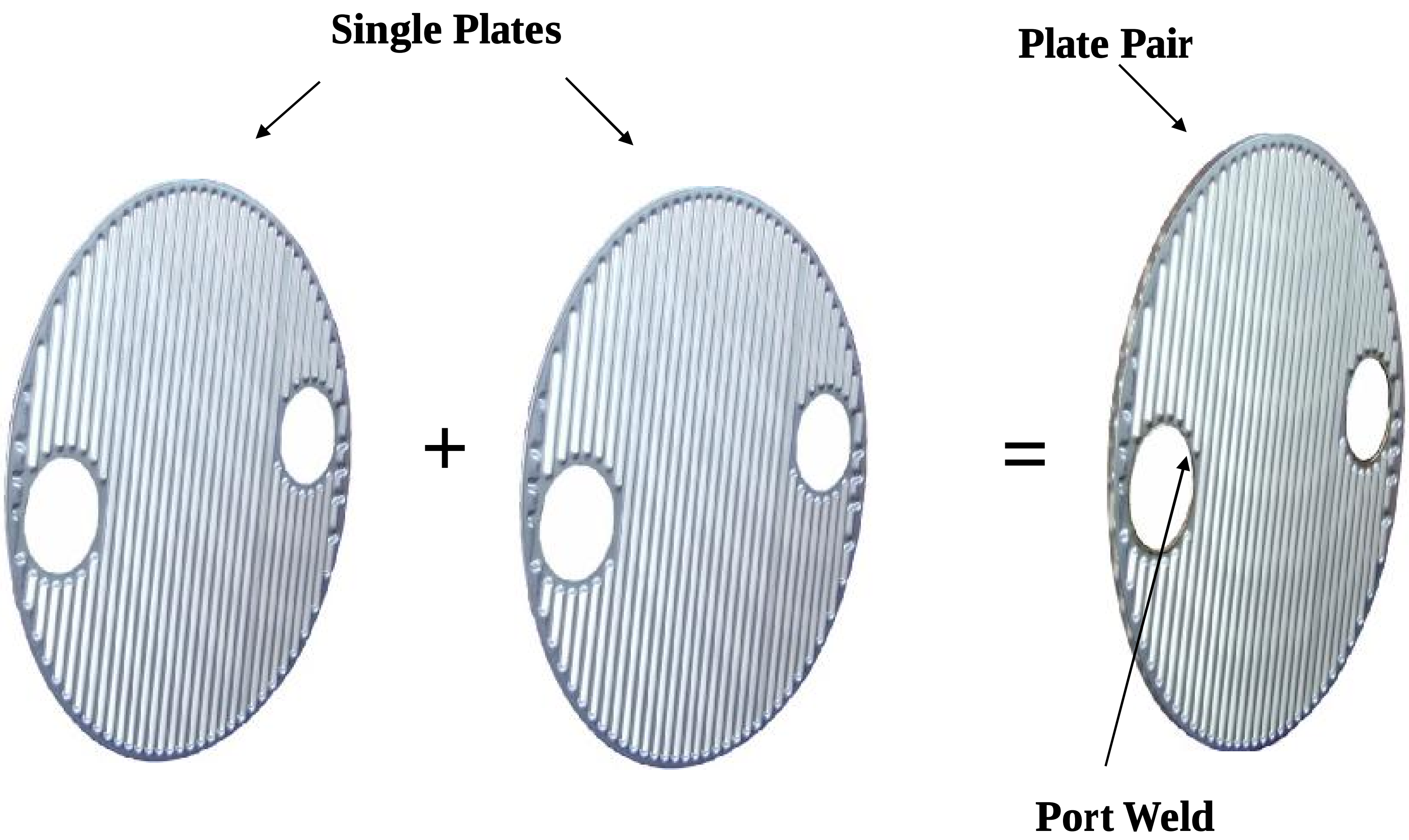
R Low Fouling

R Close Approach Temps

# Construction of a Vahterus Plate and Shell



# Plate Pair Welding



# Plate Pack

**Plate Pair**

**Plate Pack**

**x N**

**=**

**Perimeter Welds**

# Materials of construction

- AISI 316L
- Titanium Gr. 1
- Hastelloy (C22 & C276)
- Nickel
- SMO 254
- AISI 904
- Duplex

0.7 – 1.0 mm


- Carbon Steel
- AISI 316L
- Hastelloy
- SMO 254
- AISI 904
- Duplex

# Products

**Plate & Shell® (PSHE)**


**Plate & Shell® compact**

**Plate & Ring® (PRHE)**

**Plate & Shell® openable**

**Plate & Shell® systems**

VAHTERUS

# MARKING OF PSHE HEAT EXCHANGER

Size

Number of plates

Number of passes on shell side

**PSHE 7HH-400 / 1 / 1**

Plate & Shell Heat Exchanger

Plate type

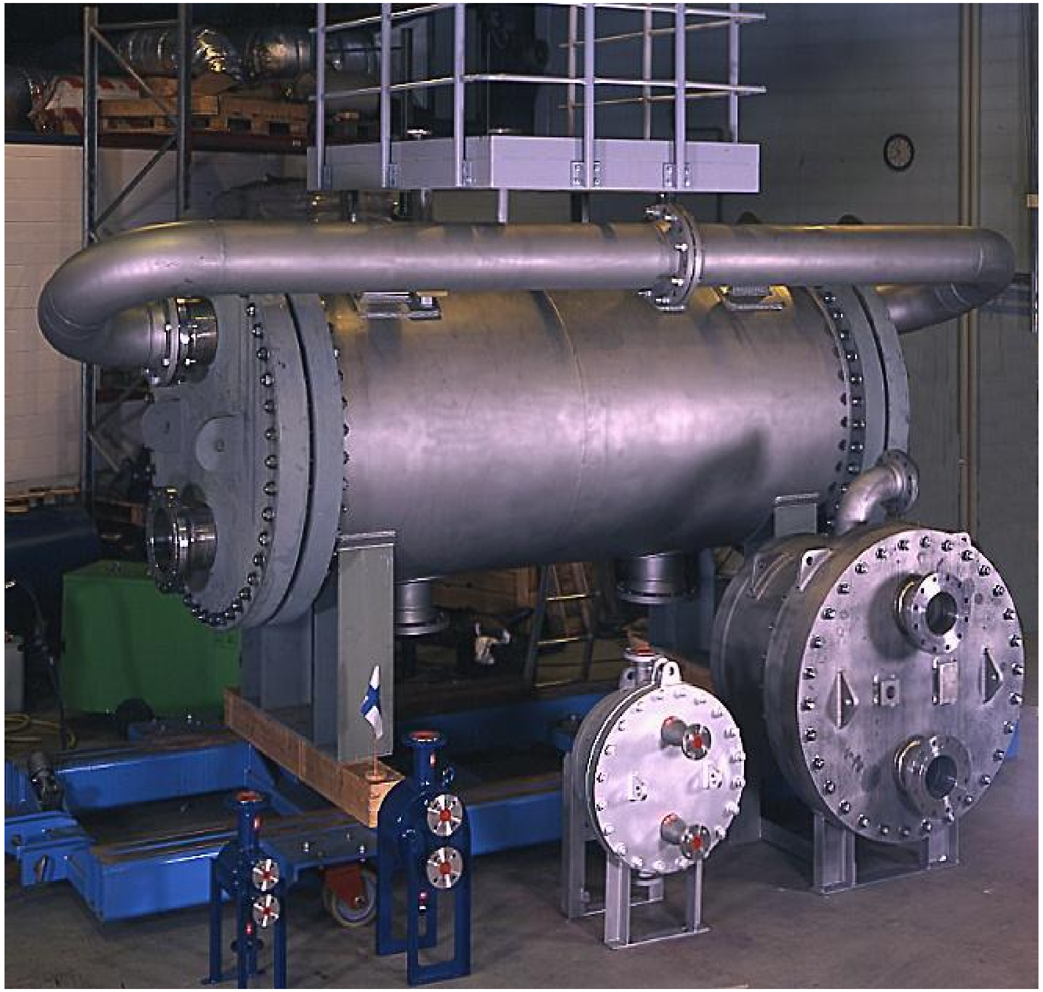
Number of passes on plate side

# TECHNICAL SPECIFICATIONS

| | Area / plate $m^2$ | Plate Ø | Plate side nozzles, DN | Shell side nozzles, DN |
|---|---|---|---|---|
| PSHE 2 | 0,032 | 190 | 25 | 20-80 |
| PSHE 3 | 0,076 | 300 | 50 | 25-250 |
| PSHE 4 | 0,15 | 440 | 80 | 25-300 |
| PSHE 5 | 0,26 | 556 | 100 | 25-350 |
| PSHE 7 | 0,46 | 740 | 150 | 25-500 |
| PSHE 9 | 0,80 | 998 | 200 | 25-700 |
| PSHE 12 | 1,00 | 1214 | 200 | 600 |
| PSHE 14 | 1,55 | 1358 | 300 | 25-1000 |

# Product Range

- 200mm
- 300mm
- 500mm
- 900mm
- 1400mm



# Capabilities

**PRESSURE**

- ü Standard range 16 / 25 / 40 bar
- ü In excess of 150 bar

**TEMPERATURE**

- ü -190°C to +600°C
- ü Shock differential 480°C

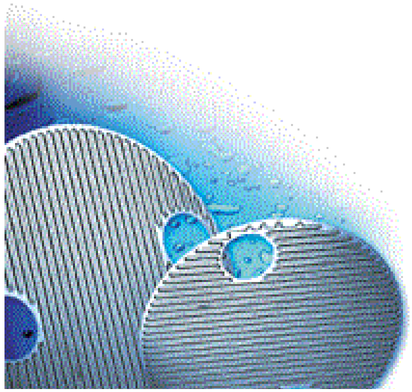
**POWER**

- ü Up to 200 MW
- ü 0.5m² to 2000m²

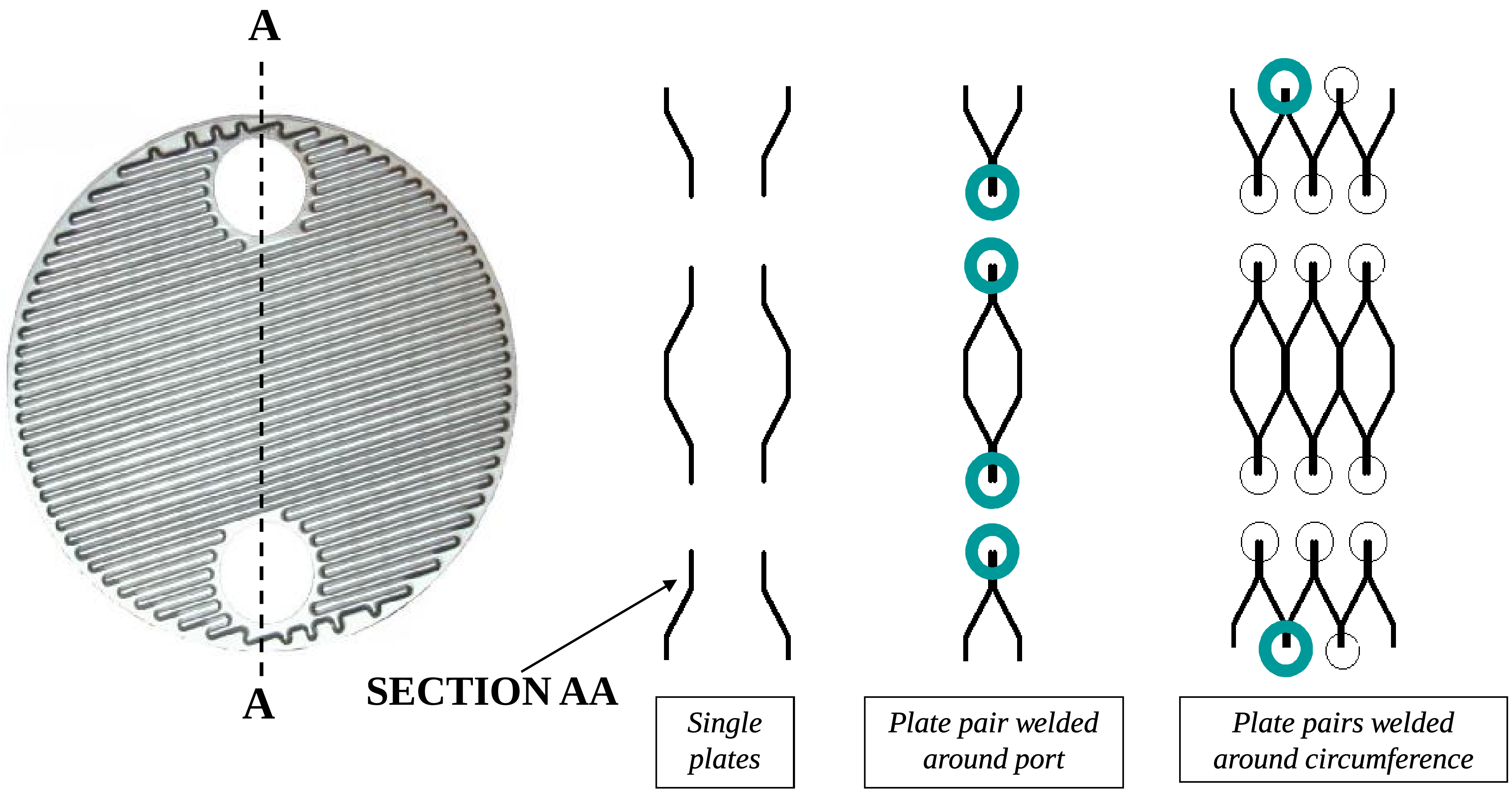
# Some advantages of construction,

# Design Codes, Inspection

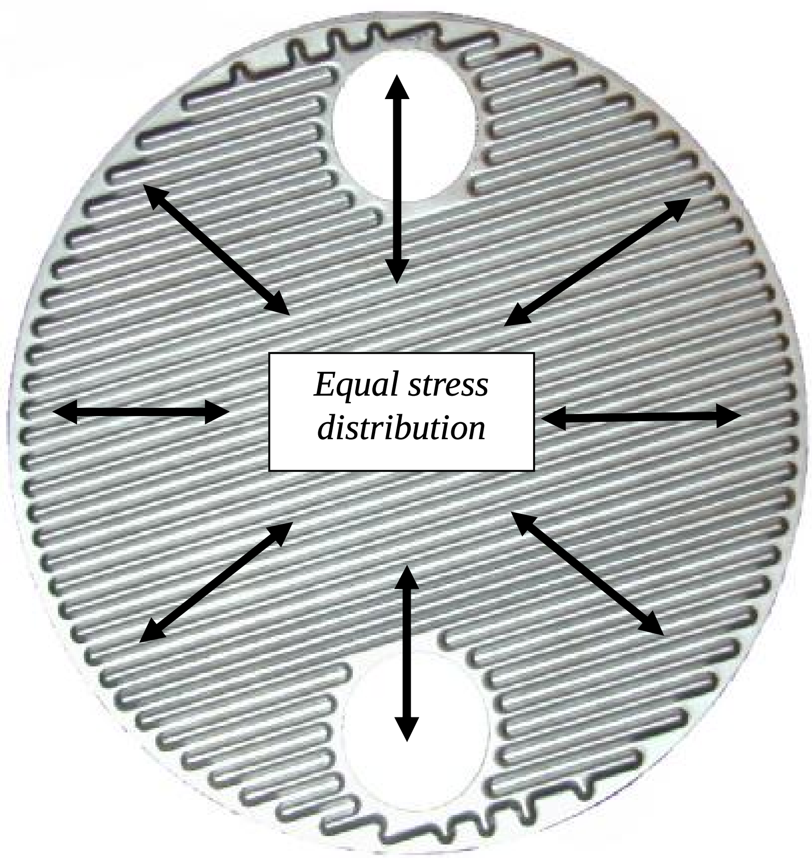
# and Testing

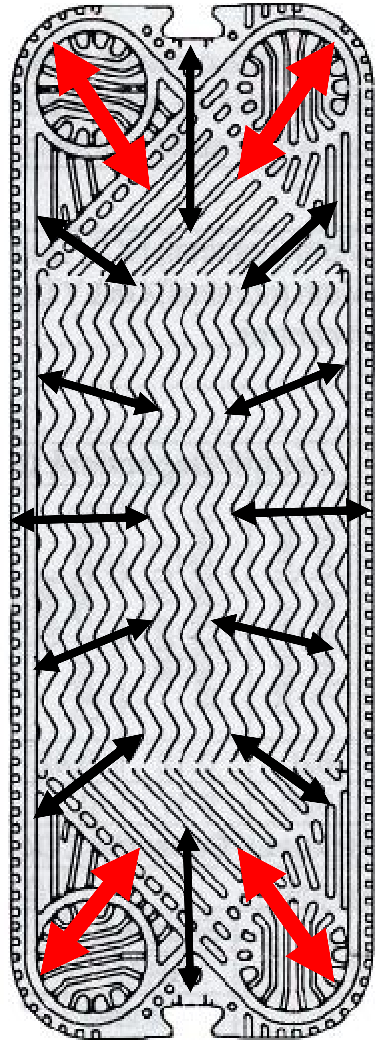


# Resistance to Thermal and Mechanical Stress



# Resistance to Thermal and Mechanical Stress



*Stress Concentration at Corners*

# Quality

### Quality control system:

- ISO 9001:2000 + EN 729-:1994 (welding)
- PED Module B + D
- ASME U-stamp
- AD-2000-Merkblatt HPO
- CBPVI, China

### Welding procedures:

- EN ISO 15614-1
- EN 288-3
- AD-2000
- PED 97/23/EC requirements
- ASME IX

ISO 9001

DNV

CERTIFIED ORGANISATION

### Design:

- PED 97 / 23 / EC – CE-marking
- ASME VIII, div. 1
- AD-2000 Merkblatt
- PD5500
- Lloyd’s Register
- ABS Europe Ltd.
- Germanischer Lloyd
- Bureau Veritas
- RINA
- Det Norske Veritas (DNV)
- GOST-R
- Other approvals by request

# Inspection

We carry out the following inspections as standard

Visual on each weld

Dye penetration on sample basis

Air under water pressure test

Helium leak test by vacuum or pressure

Random inspection weld thickness by macrograph

For special cases we can also carry out the following additional tests

100% LPE

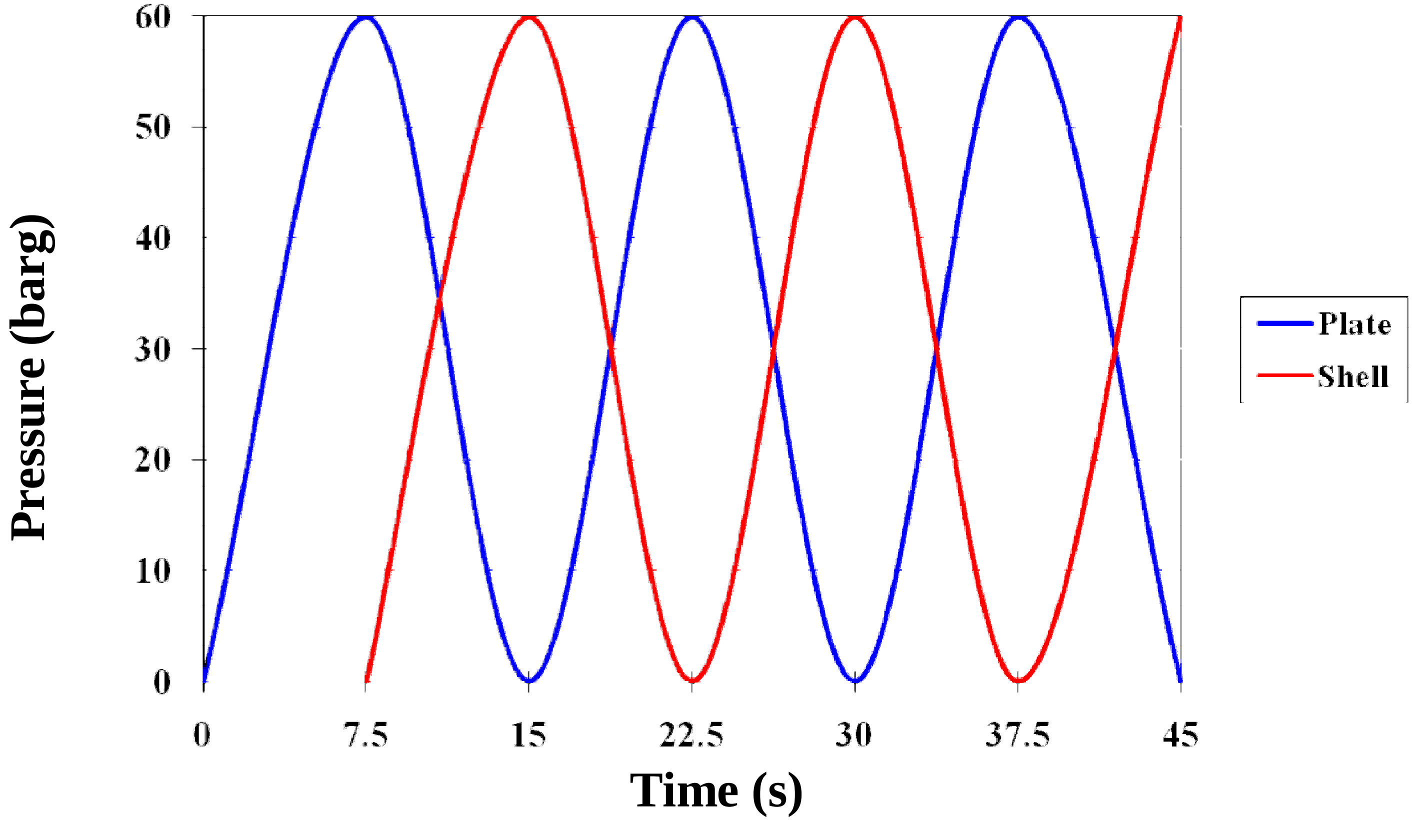
RTG normally 2% of welding seam or at least 400mm effective film length (inspected in the same plane as welding)

Manufacture of production samples for more detailed examination

Weld examination by macrograph

# Pressure Cycling Test

- Duration 15 seconds each cycle
- Plate side & Shell side tested simultaneously
- Pressure Cycling 0-60 Bar G (870 psi)
- 80000 Cycles completed successfully



# Freeze Testing

DNV Id. No.:
TUR02-2064

DET NORSKE VERITAS

## *SURVEY REPORT*

This is to confirm that at the request of **VAHTERUS OY, Kalanti, Finland,** the Surveyor of Det Norske Veritas attended the Manufacturer's workshop and subsequent inspections of freezing test of heating plate stack of heat exchanger.

***Place of test:***
Test specimen was erected to the Manufacturer's Test room to Kalanti, Finland.

***Date of test:***
Freezing test was carried out from 11.01.2002 to 31.01.2002.

***Freezing test purpose:***
Purpose of this test was to ensure that plate stacking made of titanium and filled with water do not damage when this construction without pressure (0 bar) will temporary freeze.

***Construction of test specimen:***
Plate stack was collected from ten (10) together welded plates. Stack was installed to open steel frame. Plate diameter was 300 mm. The Stack was tightly welded construction. Plates were Manufacturer's standard plates.

***The Freezing test:***
After the Test specimen stack was fully filled with water, hole assembly was frozen in deep-freezer, and unit temperature was measured with thermocouples. Desired value for freezing was -20 °C, and during freezing period it was reach. This was verified time to time by the undersigned DNV surveyor.
After the freezing period deep-frozen packet was warmed with hot water until all the water in the stack was melted.
This was made 40 times sequentially.
Finally the plate stack was water pressure tested with 24 bars. Test duration time was a. 30 min. Testing record is enclosed.

***Results of the test***
It was not found defects or damages in the Heat Exchanger stack after the above-described tests.

**Place:** Turku, Finland

**Date:** 2002-02-12

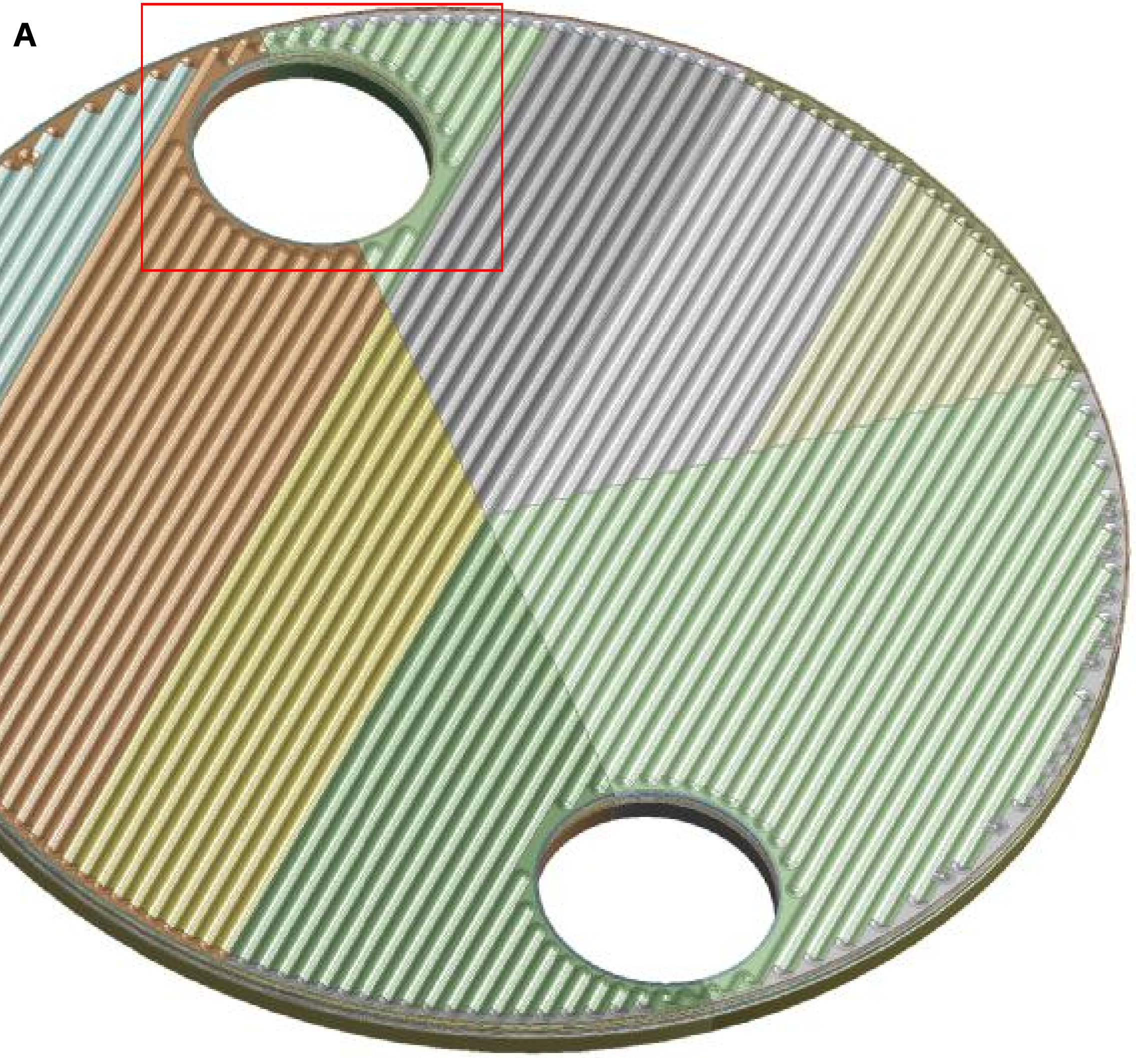
**Surveyor:** Jouko Putro

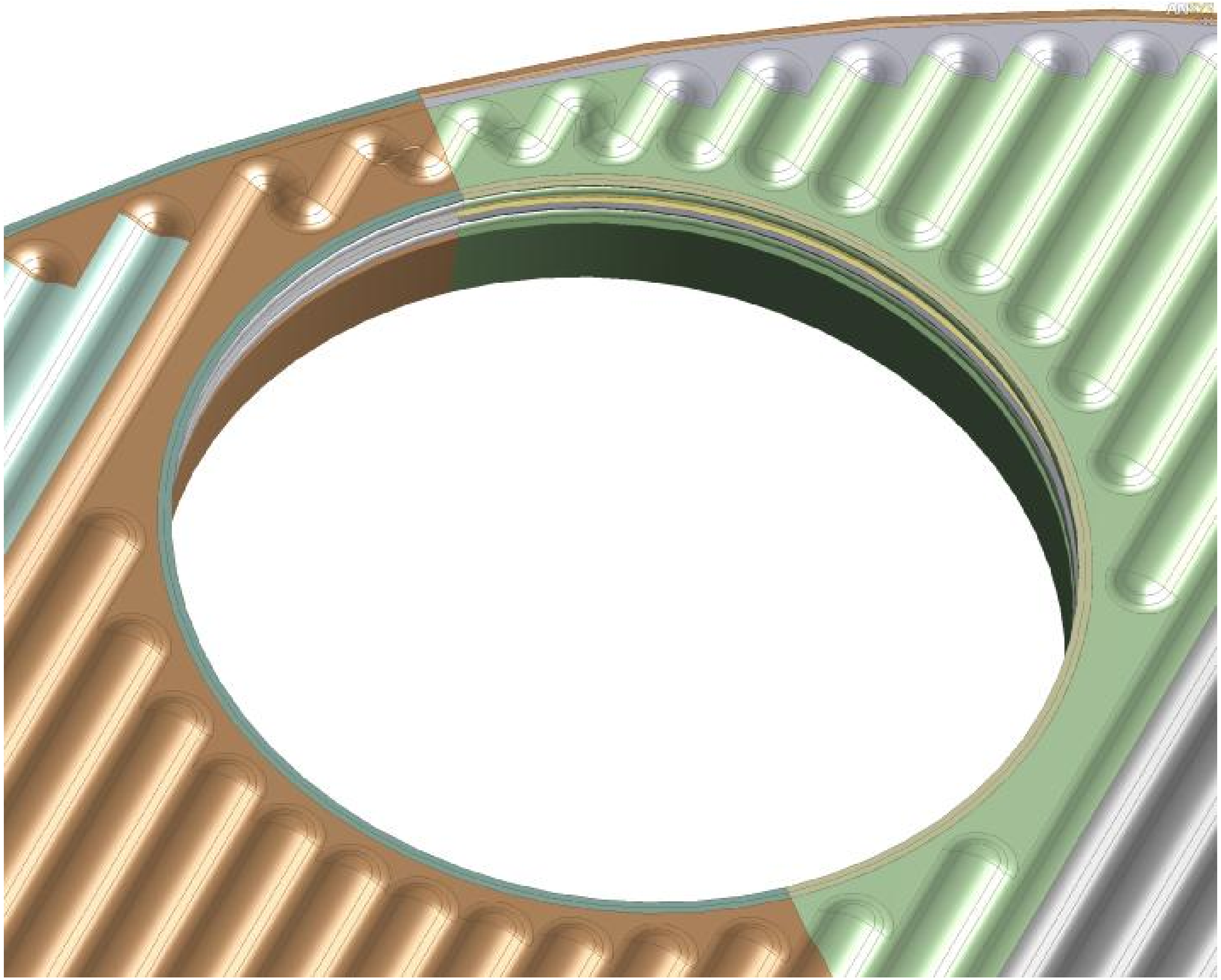
NORSKE VERITAS * 1864 * TURKU

DET NORSKE VERITAS AS, VERITASVEIEN 1, N-1363 HØVIK NORWAY TEL INT: +47 67 57 99 00, TELEFAX. +47 67 57 99 11
Page 1 of 1

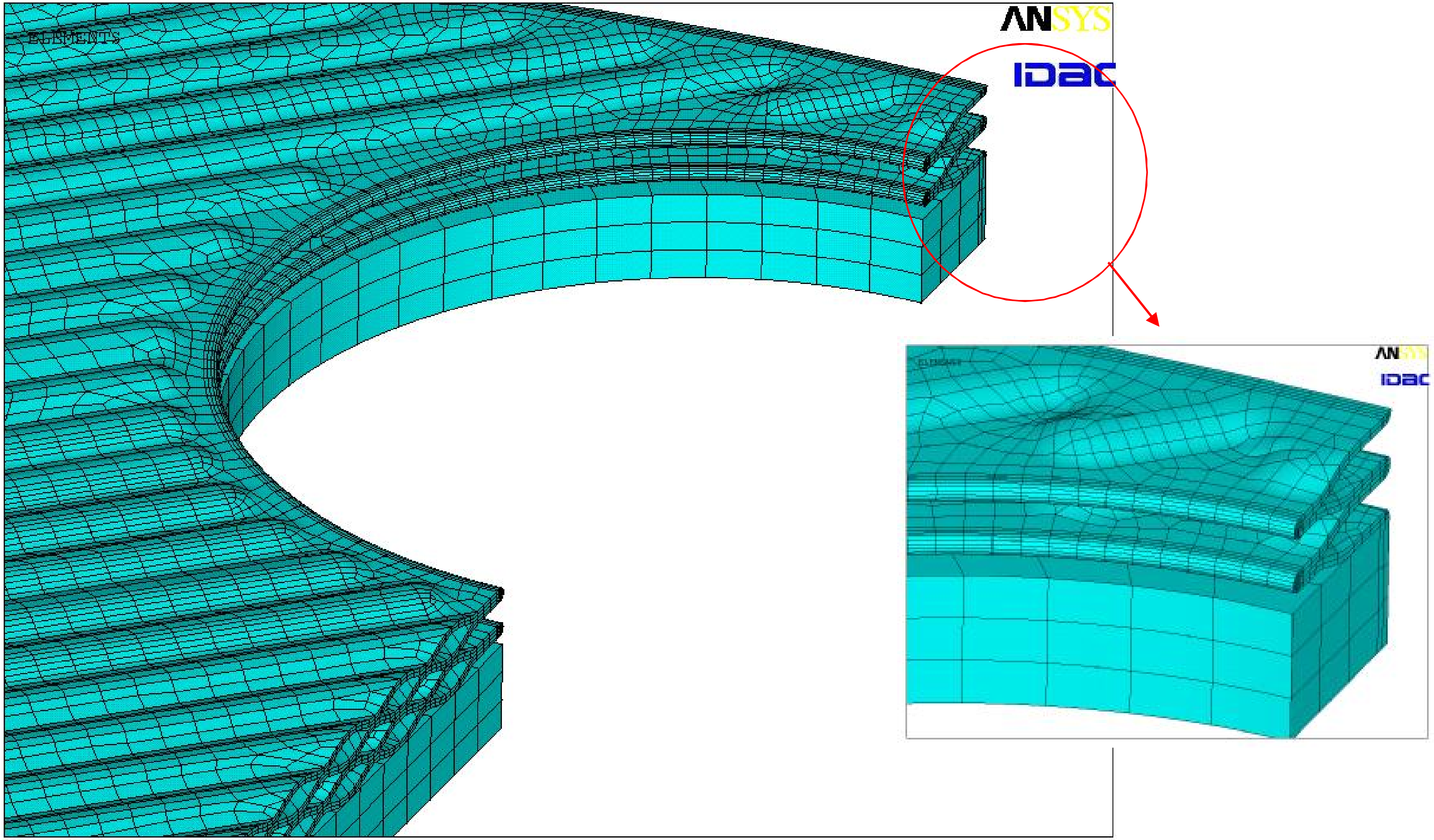
# FEA Analysis

## Solid Model



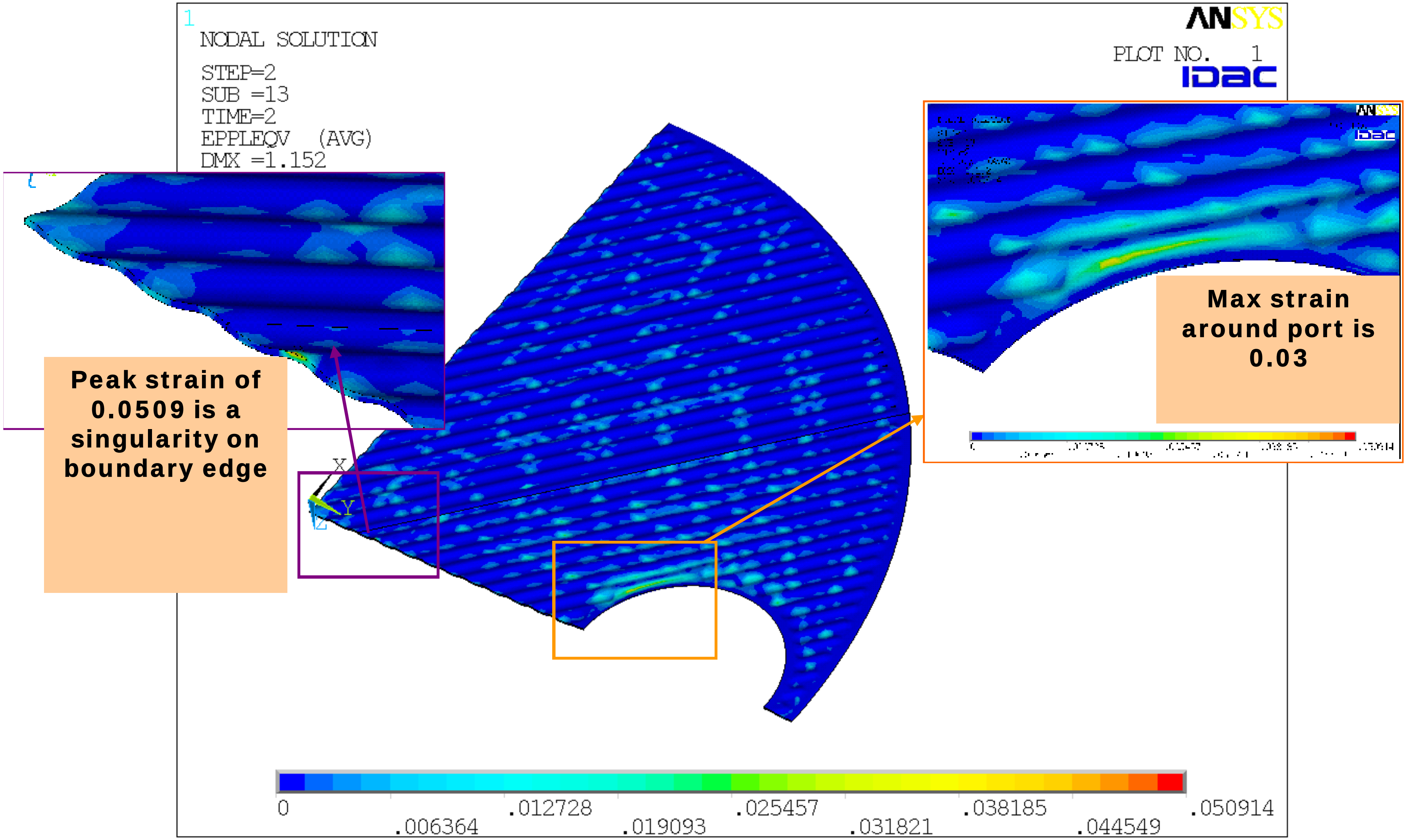


## Finite Element Mesh near the port hole

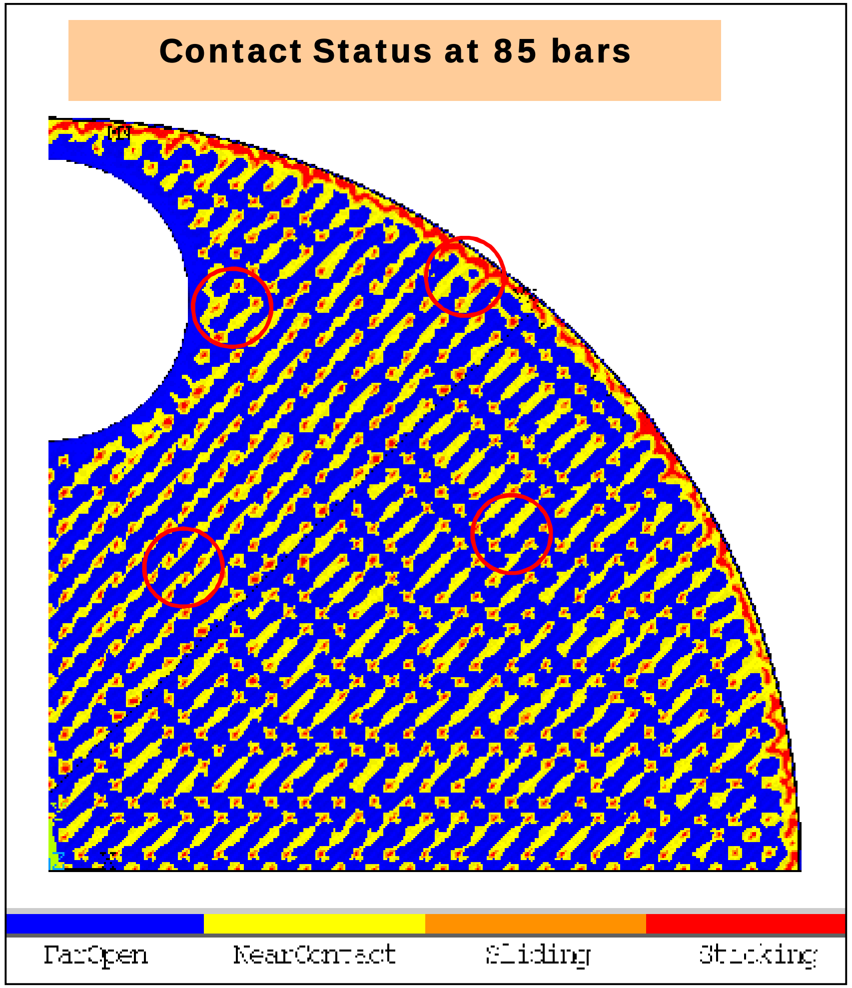


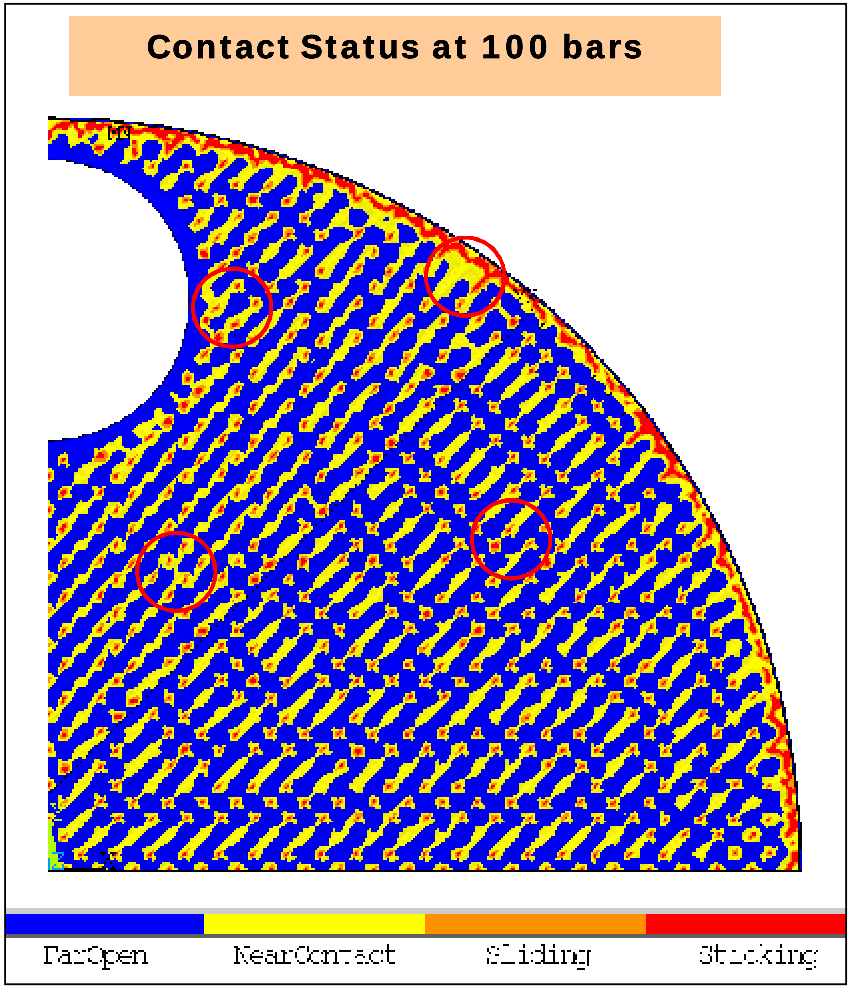
## Plastic Strain

## Plate 3 Preload+Pressure of 70bar (1029psi)



## Preload + Pressure Incremented to 100 bars (1470 psi)



# Research & Development

**Software Fully designed by Vahterus**

**continuous research and development process**


**Own test laboratory**

•Membership in: C-Dig group

HTFS

IIAR (International Institute of Ammonia Refrigeration)

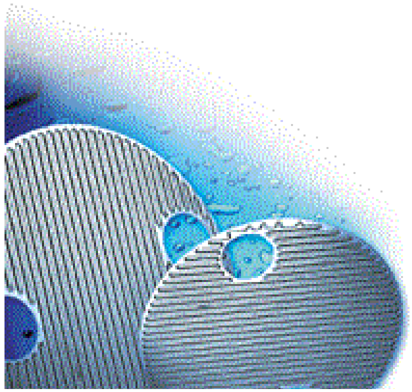
Ashrae

TNO (netherlands Institute of Applied Geoscience

VTT Technical Research Centre of Finland

# Heat Transfer Coefficents

# Why PSHE are so effective



# Thermal Performance

In the Plate & Shell Heat Exchanger the heat transfer can best be described by a Dittus Boelter type equation:

$$Nu = A(Re)^n (Pr)^m \left\{ \frac{\mu}{u_w} \right\}^x$$

Reported values of the constant and exponents are:

A = 0.15 to 0.4 m = 0.3 to 0.45

N = 0.65 t0 0.85 x = 0.05 to 0.2

Where $Nu = \frac{hd}{k}$ $Re = \frac{Vd\rho}{\mu}$ $Pr = \frac{Cp\mu}{k}$

D is the equivalent diameter defined in the case of the plate heat exchanger as 2 x the mean gap.

Typical velocities in plate heat exchangers for water like fluids in turbulent flow are normally in the range of 0.3 to 0.9 m/s but true velocities in certain regions will be higher due to the effect of the corrugations. All heat transfer and pressure drop relationships are, however, based on either a velocity calculation from the average plate gap or on the flow rate per passage.

One particular important feature of the Plate & Shell is that the turbulence induced by the troughs reduces the Reynolds number at which the flow becomes lamina. If the characteristic length dimension in the Reynolds number is taken as twice the average gap between the plates, the Re number at which the flow becomes laminar varies from about 100 to 400 according to plate geometry used.

To achieve these high coefficients it is necessary to expend energy. With the Plate & Shell unit, the friction factors normally encountered are in the range of 10 to 400times those inside a tube for the same Reynolds number. However, nominal velocities are low and plate lengths do not exceed 1m so that the term $\frac{V^2L}{2g}$

in the same pressure drop equation is very much smaller than one would normally encounter in tubulars. In addition, single pass operation will achieve most duties so that the pressure drop is efficiently used and not wasted on losses due to flow direction changes.

The friction factor is correlated with an equation:

$$\delta p = \frac{f.L\rho\, v^2}{2g.d}$$

where $f = \frac{B}{Re^y}$

Where y varies from 0.1 to 0.4 according to the plate and B is a constant characteristic of the plate. If the overall heat transfer equation $H = US\delta T$ is used to calculate the heat duty, it is necessary to know the overall coefficient U (sometimes known as the K factor), the surface area S and the mean temperature difference $\delta T$.

The overall coefficient U can be calculated from

$$\frac{1}{U} = r_{fh} + r_{tc} + r_w + r_{dh} + r_{dc}$$

The values of $r_{fh}$ and $r_{fc}$ (the film resistances for the hot and cold fluids respectively) can be calculated from the Dittus Boelter equations previously described and the wall metal resistance $r_w$ can be calculated from the average metal thickness and thermal conductivity. The fouling resistances of the hot and cold fluids $r_{dh}$ and $r_{dc}$ are often based on experience but a more detailed discussion of this is available separately.

The value taken for S is the developed area after pressing. That is the total area available for heat transfer and, due to the corrugations, will be greater than the projected area of the plate.

The value of $\delta T$ is calculated from the logarithmic mean temperature difference multiplied by a correction factor. With single pass operation, this factor is about 1 for counter flow operation. This can be a significant difference compared to tubulars where the fluids tend to operate in crossflow where the factor can be as low as 0.6.

# 1 Geometry.

Part of the heat transfer equation to determine the amount of surface area required to perform a given duty is in establishing the turbulence created, which in turn helps us establish the overall heat transfer coefficient.

Shell & Tubes utilise a very poor geometry for this –fluid flowing through round tubes is not very effective in producing turbulence. Similarly, fluid flowing over a bank of tubes on the shell side of the exchanger is an inefficient way of producing turbulence. Therefore, the resultant overall heat transfer coefficients are correspondingly poor.

Plate & Shell Heat Exchangers employ a corrugated plate surface, which create thin streams in the fluid, which are constantly changing direction. This in turn leads to high turbulence and thus, high heat transfer coefficients.

## 2 Efficient use of Heat Transfer Surface

Within the Shell side of a Shell & Tube heat exchanger there are dead spots, areas of low velocity and areas for fluid to bypass the tubes – all this contributes to reducing the overall effectiveness of the exchanger.

In contrast, the Plate & Shell Heat Exchanger has no dead spots, all the surface area is utilised in the heat transfer process, and there is no possibility of fluid bypassing the heat transfer surfaces. This, again, ensures high heat transfer coefficients.

VAHTERUS

3. Temperature Difference

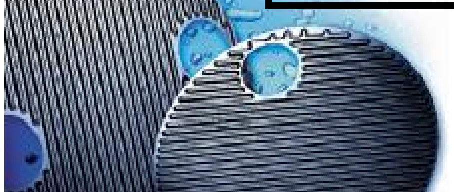
To achieve a high level of effectiveness it is important to make the best use of the driving force of hot to cold. We all refer to this as the “Log Mean Temperature Difference” (LMTD). To achieve the full use of the LMTD it is necessary to have the fluids flowing in opposite directions in adjacent passages.

This cannot be achieved by a Shell & Tube design as by its very nature of construction the fluids on opposing sides of the exchanger flow at 90 degrees to each other. This is called “cross flow” and can de-rate the potential effect of the LMTD by as much 35%.

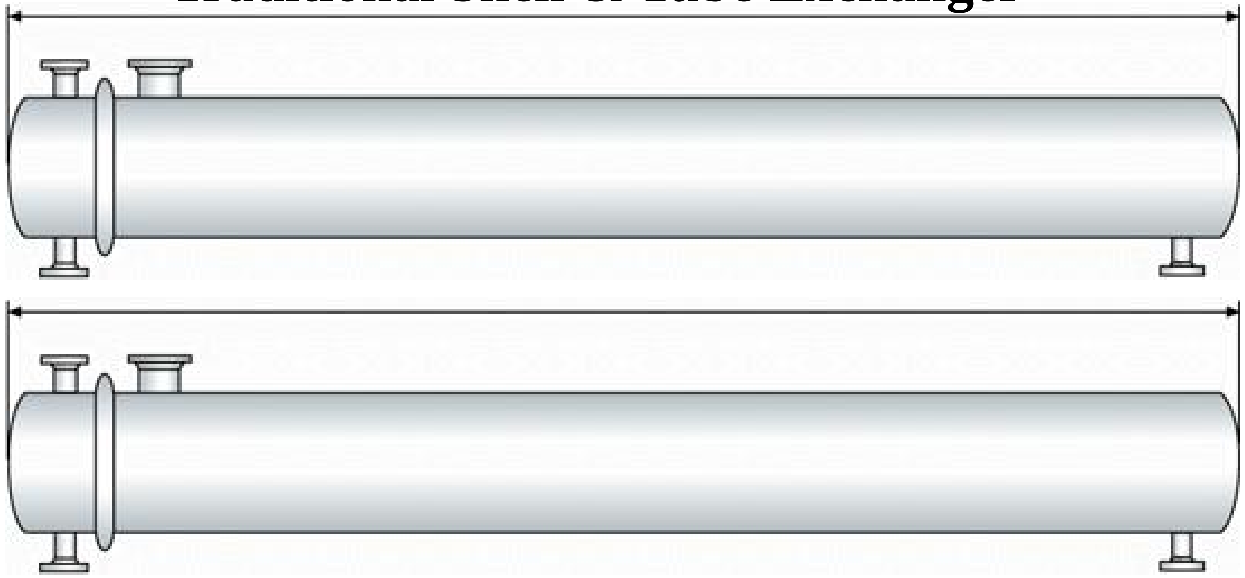
Compare this with a Plate & Shell heat exchanger, which has fluids flowing in opposing directions (counter flow).

## To Cool 392000 kg/h of water from 42 to 28 deg C using 350000 kg/h of seawater at 22 deg C

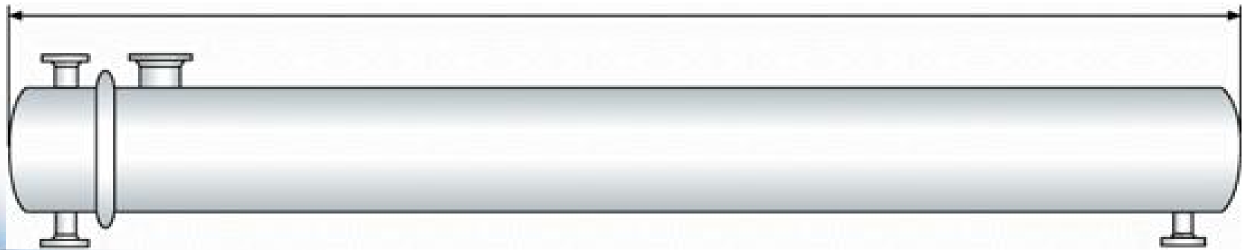
| | Shell & Tube | PSHE |
|---|---|---|
| Surface Area | 3 Shells in series<br>1120 sq.m | 1 off 9LL<br>402 sq.m |
| Footprint | 1.3m x 8m | 1.1m x 1.9m |
| Volume | 34 cubic m. | 3.2 cubic m. |
| HTC | 1318 kcal/sq.m.h.deg C | 2662 Kcal/sq.m.h.deg C |
| MTD | 4.3 deg C | 5.1 deg C |
| Pressure Loss | 0.7/1.3 Bar | 0.65/1.11 Bar |



## Traditional Shell & Tube Exchanger



8500mm

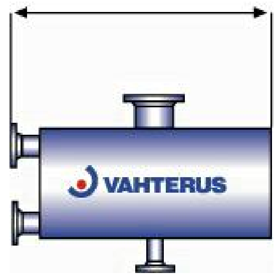


Weight: Dry – 26717 kg Wet - 35698 kg

Total gross weight
= **107094 kg**

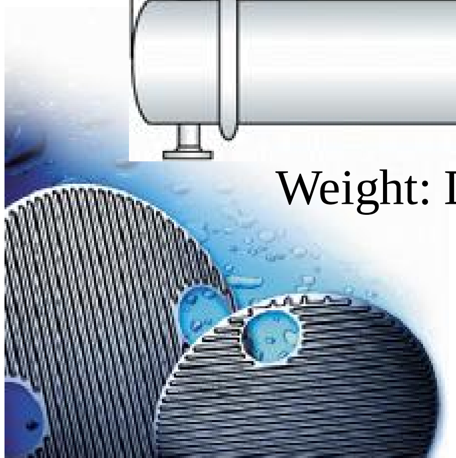
## Vahterus Plate & Shell Heat Exchanger

1750mm

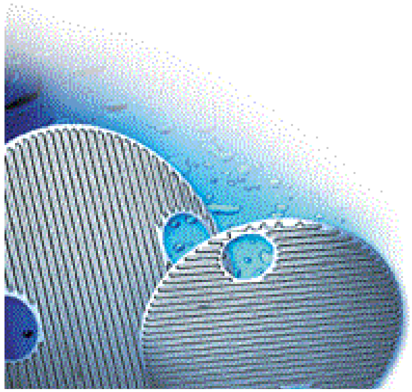



Weight: Dry – 4707 kg

Wet – 5172 kg



# Fouling and design considerations



# Fouling

**Fouling of a heat exchanger, consisting of the accumulation of dirt or other materials on the wall of a heat exchanger, causing corrosion, roughness, and ultimately leading to a lowered rate of efficiency.**

# Types of fouling

- Crystallization and suspended solid fouling
- Sedimentation
- Chemical reaction & polymerisation
- Organic material growth
- Biological growth
- Corrosion
- Coking

# Fouling Mechanisms

- *Initiation* - most critical period - when temperature, concentration and velocity gradients, oxygen depletion zones and crystal nucleation sites are established - a few minutes to a few weeks

- *Migration* - most widely studied phenomenon - involving transport of foulant to surface and various diffusion transport mechanisms

- *Attachment* - begins the formation of the deposit

- *Transformation or Aging* - another critical period when physical or chemical changes can increase deposit strengthh and tenacity

- *Removal or Re-entrainment* - dependent upon deposit strength - removal of fouling layers by dissolution, erosion or spalling - or by . . . *"randomly distributed turbulent bursts"*

# A function of time

**Crystallization and suspended solid fouling**

**Sedimentation**

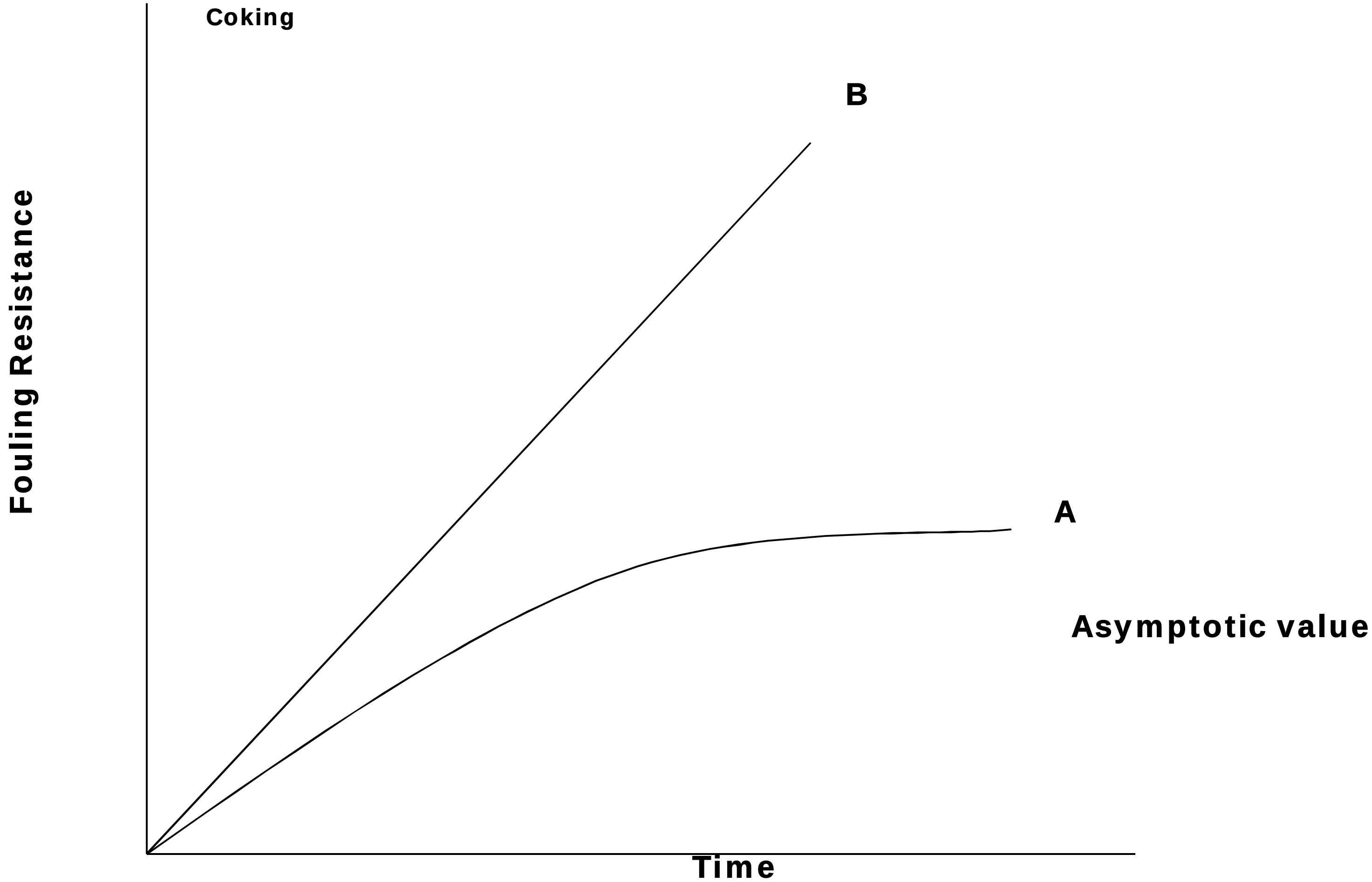
**Chemical reaction & polymerisation**

**Organic material growth**

**Biological growth**

**Corrosion**

**Coking**



# Effects of fouling

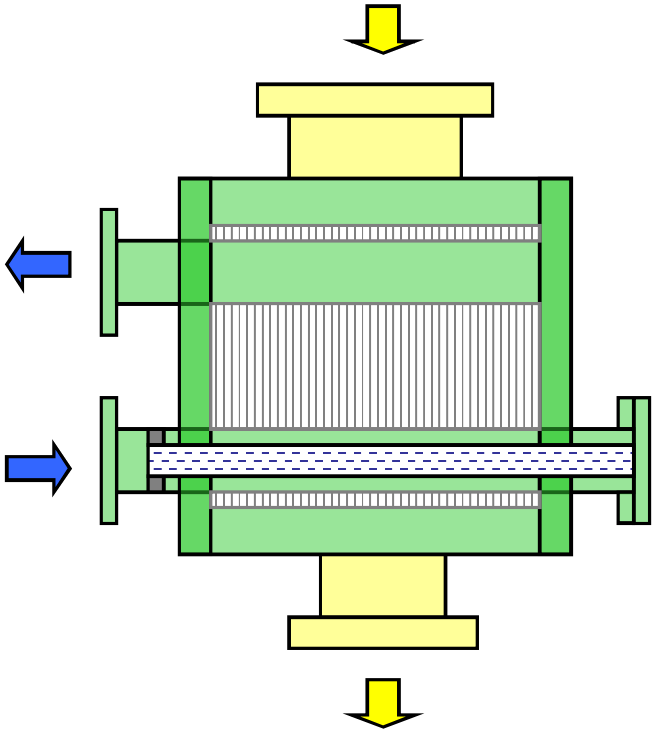
- Oversizing
- Special materials and/or design considerations
- Added cost of cleaning equipment & chemicals
- Loss of plant capacity and/or efficiency
- Higher operating costs
- Loss of waste heat recovery options
- Eventual failure of equipment

# Designing lower resistance to fouling By using PSHE

- Correct sizing of Heat exchanger – using correct fouling factor
- Maintain a high degree of turbulence, increases foulant removal rate
- Good velocity profile across a plate (in the range of 0.3 to 0.9 m/s)
- Exchanger flow configuration-Wall temperatures
- Smooth heat transfer surface
- Materials of construction  - Corrosion resistance
- Filtration - Suspended solids

# Ammonia Condenser in Chemical Plant

- **Type: 14HH-202/1/1**
- **Strainers at cooling water inlet**



# Case Study – Engen Petroleum South Africa

## UOP Solvent Extraction Plant

**Benzene, Toluene, Xylene production (BTX)**

**S & T used for Heating – 2 stages**

**Feed / Effluent exchanger & Heater**

# Case Study – Engen Petroleum South Africa

## Serious Fouling Problem

Thermal degradation of olefins to form polymer

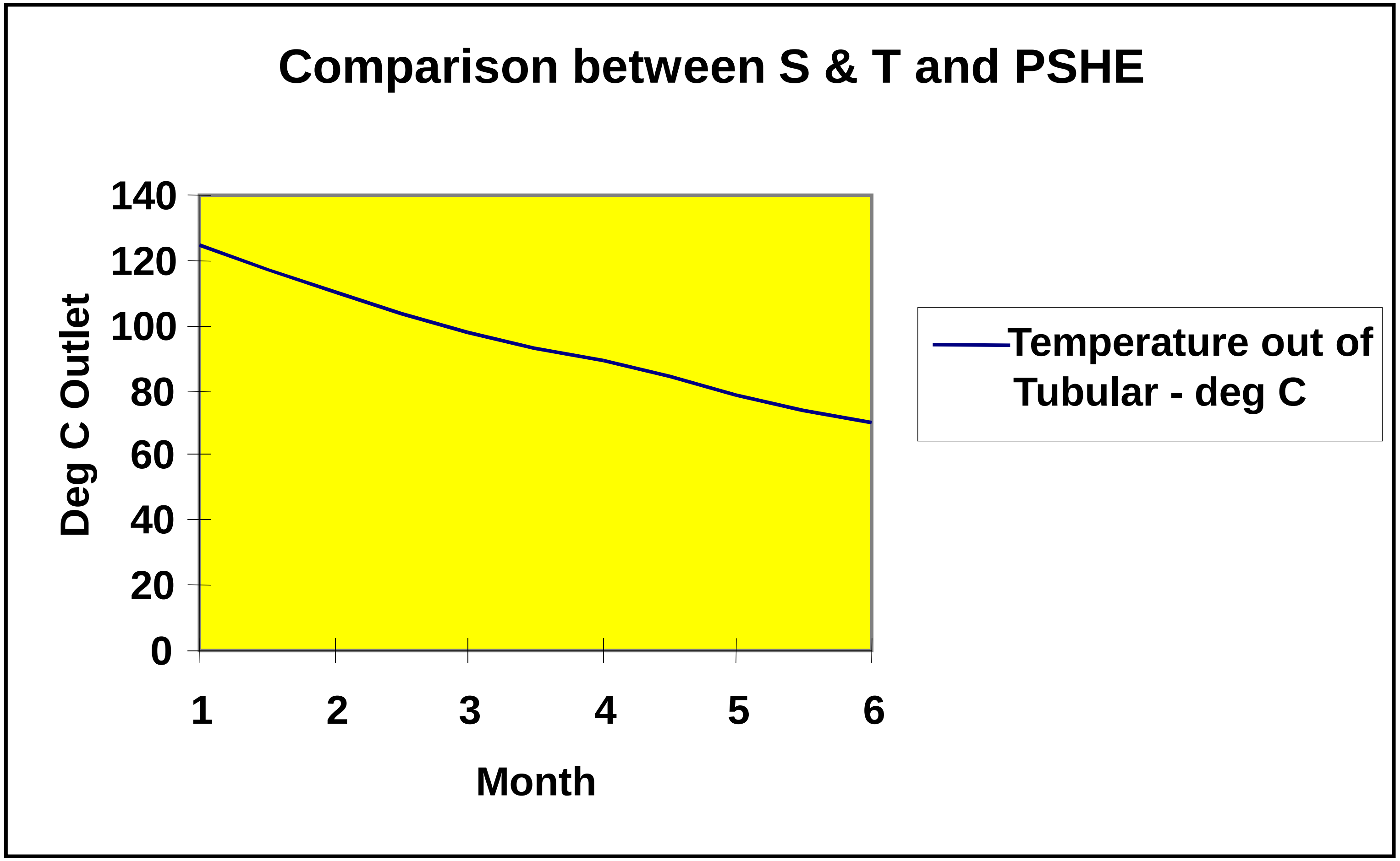
Reduce the tendency to degrade by reducing residence time in heat exchanger

Reduce exposure to high wall temperature by increasing turbulence / reducing laminar sub-layer

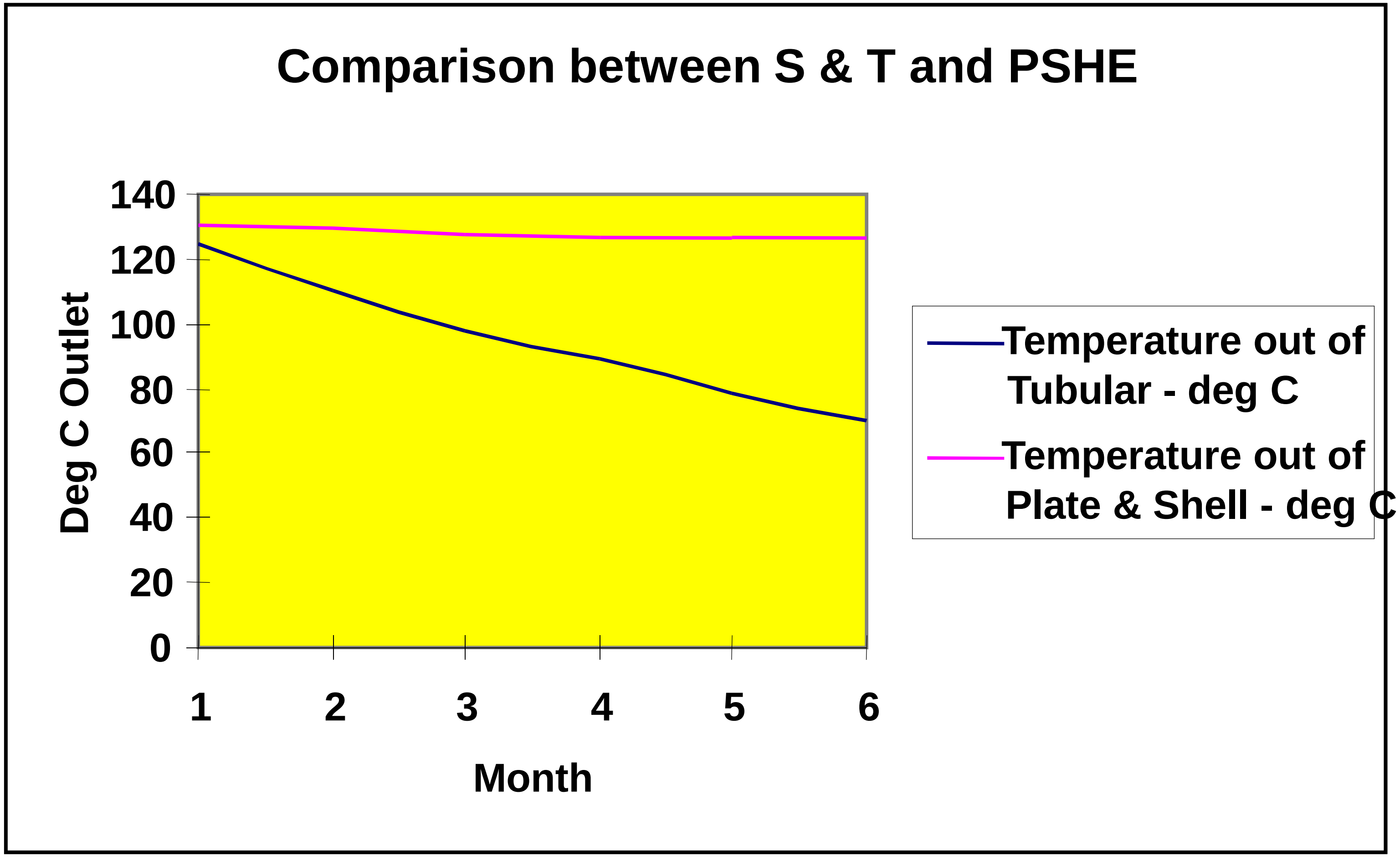
Polymers bonding to surface of tubes

Increase turbulence which in turn increases Shear Stress which helps prevents polymers sticking to surface

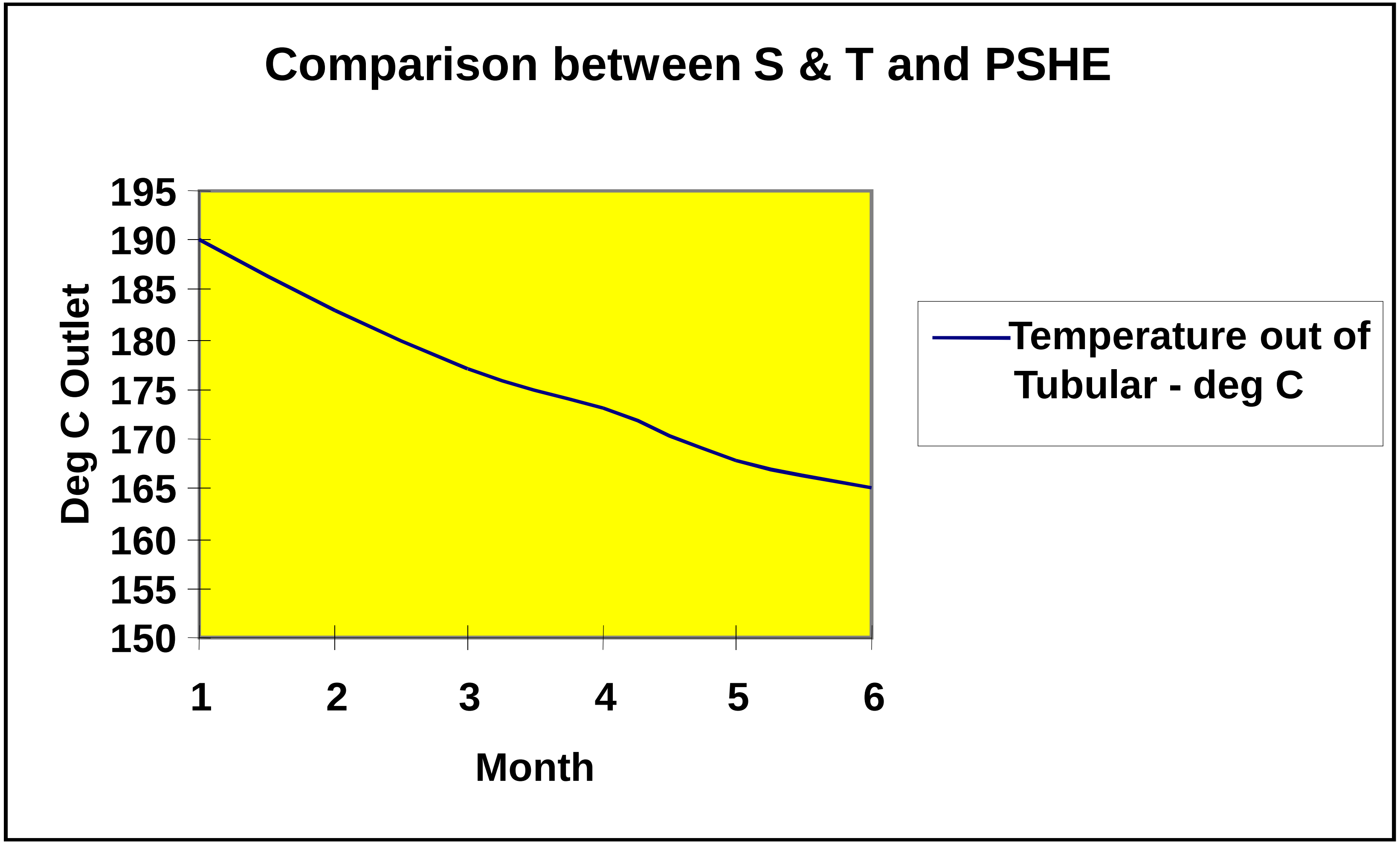
# Engen – Feed/Effluent Exchanger



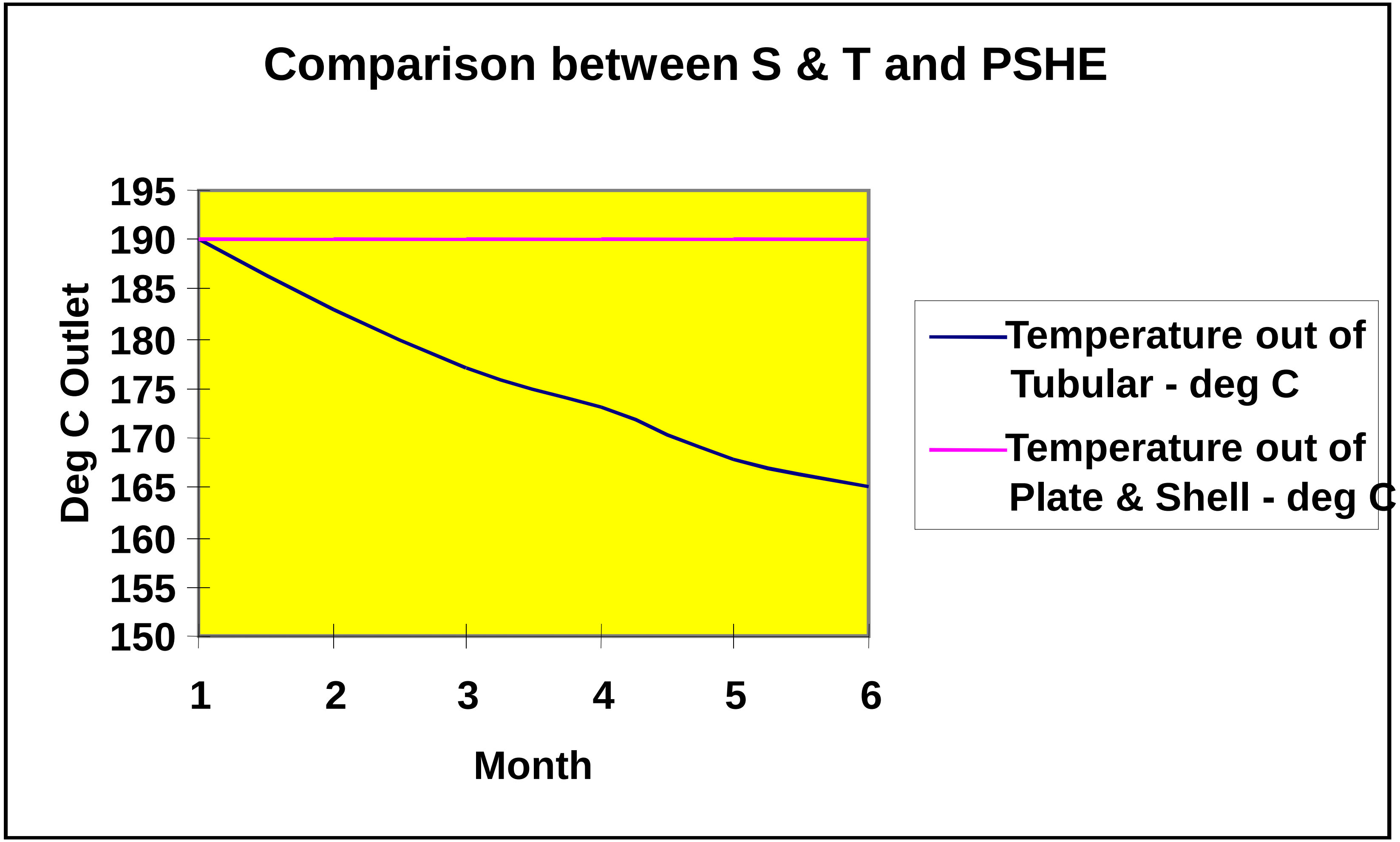
# Engen – Feed / Effluent Exchanger



# Engen – Feed Heater



# Engen – Feed Heater



# Case Study – Engen Petroleum South Africa

## Benefits

1. Stable performance which has led to a 25% increase in the efficiency and reliablity of Engen's process

2. Reduced maintenance costs

3. No retubing costs

4. Lower energy costs – Less energy required to heat process

   - Lower pumping costs

5. Smaller footprint – allows easy access around the equipment

6. Capital cost of PSHE 35% of cost of longitudinal finned tubular

# Crude Oil Cooler

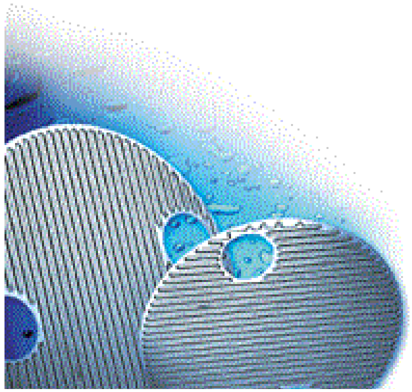
# BP – Mad Dog & Holstein

- **Application: Crude Oil Cooler with sea water (Duty: 5528kW)**
  - **Type: 9HH-324/1/1 (titanium plates)**

# Applications for

# Plate and shell

# and reference examples



# References

- Akzo Nobel
- Arizona Chemicals
- Atofina
- BASF
- Bayer / Lanxess
- Bechtel
- Borealis
- British Petroleum (BP)
- Ciba-Geigy
- Clariant
- Degussa
- Daewoo
- DOW
- Expro
- ExxonMobile
- Evonik

- Fortum
- Frames Process Systems
- Gas de France
- GE Advanced Materials
- GlaxoSmithKline
- Halliburton
- Hamworthy
- Jacobs Engineer
- Kanfa Process Systems and services
- Kemira
- KerrMcGee
- Kvaerner
- Lurgi
- Mars / Masterfoods
- Mustang Engineering
- Metso
- Nestlé

- Neste Oil
- Petreco (Cameron)
- Pemex
- Pfaudler
- Propak
- Rhodia
- Sinopec
- Stora Enso
- Sasol
- Sadra Samsung
- Saudi Aramco
- Shering Plough
- Shell
- Sinopec
- Talisman
- TDE
- Technip
- Total Final Elf
- UPM

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# Solutions in Oil&Gas Industries

- **UPSTREAM**



- **DOWNSTREAM**
  - **Refineries**
  - **Petrochemical production**


# Gas Compression Solution 1

## 2nd stage suction cooler with PSHE

- Type 7HH-256/1/1
- Design pressure 55 bar
- Cooling media: sea water
- Operating Offshore platform in North Sea (Tweedsmuir)

# 3rd Stage Suction Cooler

- Type 4HH-264/1/1
- Design pressure 91 bar
- Cooling media: sea water
- Duty 1506kW (=5140 kBTU/h)
- Installation on offshore platform (GOM)

# Lean/Rich TEG Interchanger & TEG Cooler

- **Contractor: Petreco**
- **Design pressure: -1/99 bar and -1/91 bar**
- **Application: glycol/glycol interchangers and TEG Cooler**

# Heavy crude heater

# Well Testing application for Statoil Hydro

**Crude at high Viscosity – 22,000Cp**

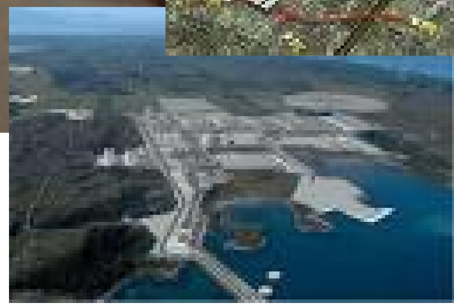
**100 barG operating pressure**

# Dump Condenser

# Dump Condenser AMEC – Milford Haven

# Liquid Ring Water Cooler & Lean/Rich TEG Exchanger

## End User: Norsk Hydro (Today Statoil-Hydro), Ormen Lange



# Amine / Amine Interchanger

**Designed to ASME VIII div 1 Lethal Service with U-Stamp**

# Treatment of Crude Oil

## Crude oil heating with PSHE in FPSO vessel - Interstage Heater

- **Type 5LL-142/1/1**
- **Design pressure 45 bar**
- **Heating media: Essotherm 500**
- **Operating in GOM**

# Treatment of Crude Oil

## Crude oil cooling in floating production platform – Export pipeline cooler

- Type 9HH-324/1/1
- Cooling medea: Sea Water
- Duty 5525 kW (=18852kBTU/h)
- Cocurrent design to avoid waxing in overcooling situation
- Operating in GOM

# Produced Water Cooler

- Type 9HH-824/1/1
- Cooling media: Sea Water
- Duty: 36 MW
- Ti plates, 254 SMO Shell
- Operating in Norway

# Propylene Condenser


**Type: 9LL-222/1/1 openable**

**Duty: 1290kW**

**Propylene vapour / sea water**

**(LPG-tanker) Design code R.I.N.A.**

# Propylene Heater

**Type: 9LL-222/1/1 openable**

**Propylene / sea water 4800 kW**

**(LPG-tanker) Design code R.I.N.A**

# Gas Heater in LNG Import Facility

**LP Boil Off Gas Heater**

**-Type: 5LL-124/1/1**

**-Heating media: Steam @ 165.2 ºC**

**-Gas heating from –97 to +2 ºC**

**-Design code: PD5500/PED**

**-Design Temp: -125/200 ºC**

**-Design Pressure: FV/18.9 bar(g)**

**-Materials: 316L/316L**

# Crude Oil Heating in pumping station in Russia

- 3 x Type 9HH-398/1/1
- Design pressure 40 bar
- Duty: 17.62 MW each
- Heating media: Hot water
- Dirty process (including sand)

# Gasoline Cooler

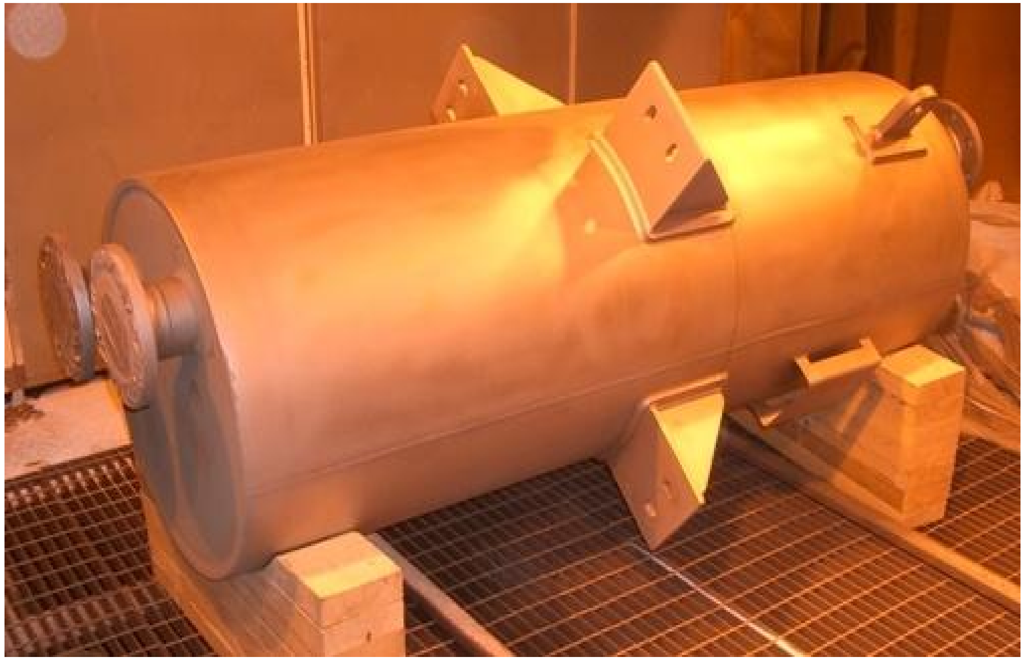
**End customer: Largest refinery in Europe**

- **Application: Gasoline Cooler 1700 kW (=5801 kBTU/h)**
- **Cooling media: River Water (Rhein)**
- **Type: 7HH-354/1/1**

# Feed Effluent Heat Exchanger

**Customer: German Oil Refinery**

- **Application: Feed Effluent Heat Exchanger**
- **Type PSHE 5HH-544/4/4**
- **Duty: 5500 kW**
- **All material in Alloy 59 (UNS N06059)**



# Effluent Economizer at EO Plant

- **Type: 14HH-968/2/2**
- **Customer: German Chemical Company**
- **Application: Effluent economizer at ethylene oxide plant**
- **Capacity: 30MW**

# Project for Petrochemical Plants

## Applications

- Condensate cooler
- Acidic feed cooler
- Condensate precooler
- Iso-Alkohol Cooler
- Octane Cooler
- Syngas Interchanger
- Vaporizer Tails cooler
- Aldehyde Cooler
- Regeneration Gas Cooler
- Tempered water cooler
- Octanol Cooler
- Vacuum Pump Liquid Ring Cooler
- Heavies return cooler
- Feed Cooler
- Turbo rundown cooler
- Tempered water start up heater

# Solutions in Chemical and Pharmaceutical Industry

# Economizer at Fertilizer Plant

- **Application: Liquid/Liquid (Stripped Condensate/ Contamined Condensate (Heat recovery)**
- **Type: 5LL-206/1/1**
- **Contractor: Kvaerner**
- **End Customer: Terra Nitrogen (UK)**
- **Design pressure: -1/56 bar**
- **Design Temperature: 0 / 400°C**

# Hydrolizer Heat Exchanger at Fertilizer Plant

- **Type: 5HH-192/2/2**
- **Contractor: UHDE**
- **End Customer: Helwan Fertilizer Plant, Cairo-Egypt**
- **Design pressure: -1/29 bar**
- **Design Temperature: 0 / 230°C**
- **Application: 1438 kW - Liquid/Liquid (Ammonia&Water/ Ammonia&Water)**
- **Same applications in 5 other UHDE plants**
- **Further information:** http://www.chemicals-technology.com/projects/helwanfertiliserco/

# Air Heater at Fertilizer Plant

- **Type: PRHE-12R-50/1/1**
- **End Customer: Yara Sluiskill, NL**
- **Application:** ***950 kW Waste Gas Heater using water steam as a heating media. Plate side superheated 3.5 bar(g) steam 210 °C, waste gas inlet temperature -2 °C outlet 100 °C.***

# PSHE in H2O2 application in South Korea

# Kettle Type Nonanol Evaporator at Chemical Plant

- **Type: 3HH-380/1/1 in size 5 shell (Kettle type)**
- **Customer: BASF, Germany**
- **Application: Nonanol (alcohol) evaporator, heating medium water steam**
- **Capacity: 438 kW**

# Head Condenser in Chemical Plant

- **Type: 12R-260/1/2**
- **Application: low pressure (0,2bar) steam condenser**
- **Capacity: 5MW**
- **Materials: AISI316L**
- **Replacing a Shell&Tube**

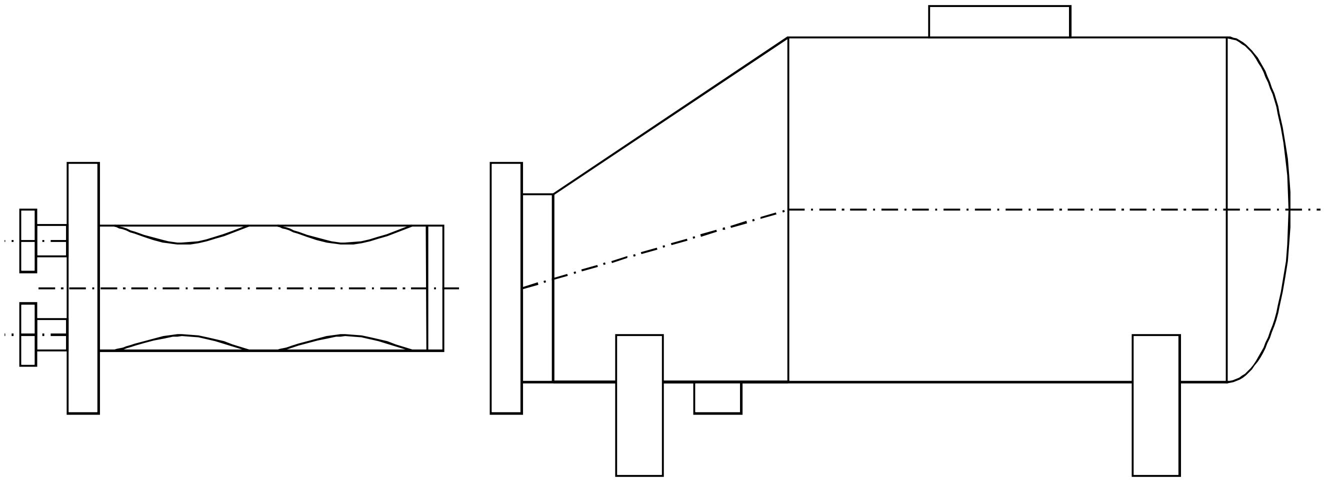
# Process Condensers in Chemical Plant in China

**Type: 2 x 14LL-240/1/1**

**Chemical vapor / Water**
**Capacity: 2 x 12,5 MW**
**(condensing plate side)**

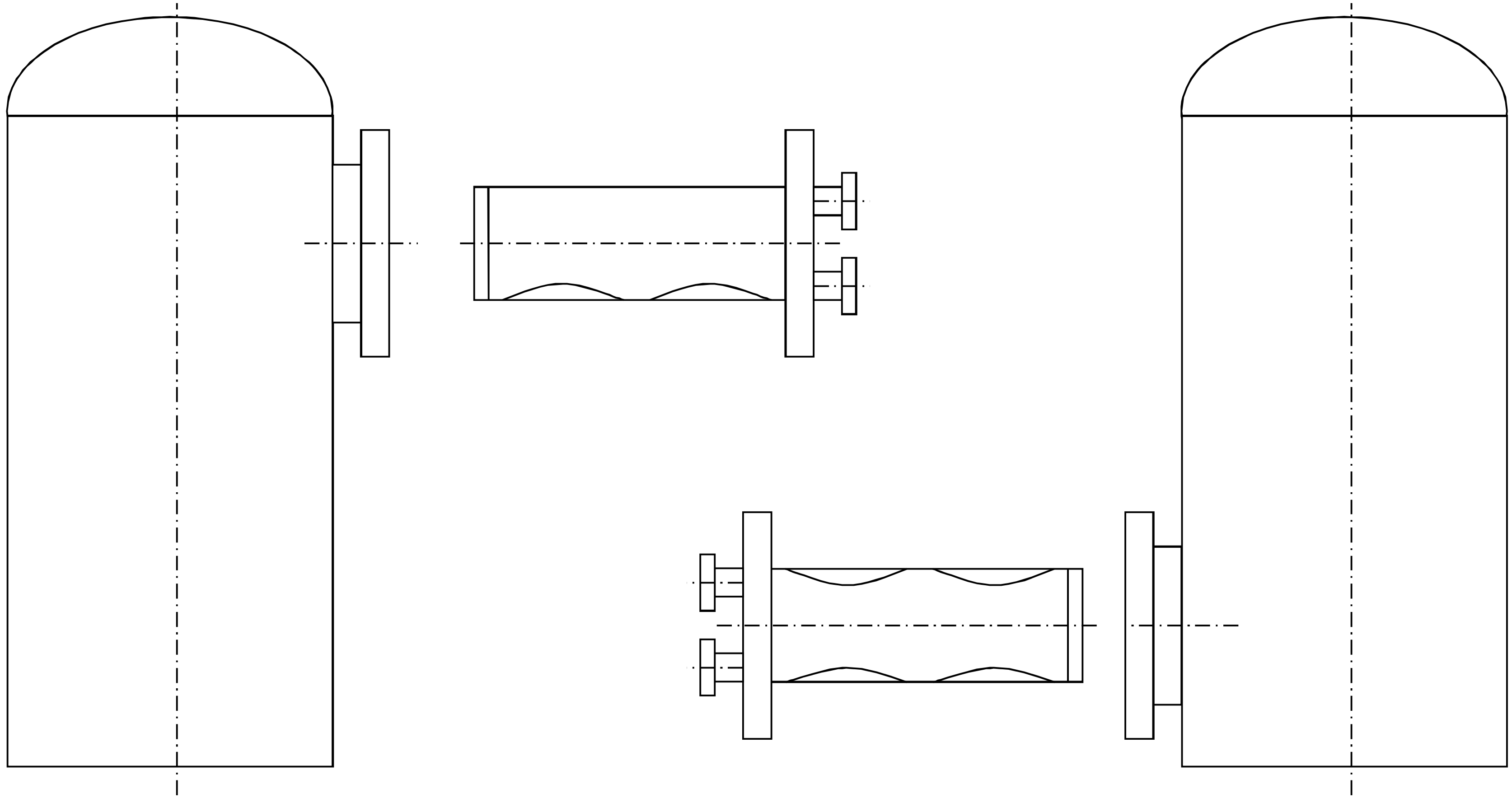
**Design pressure: – 1/10 bar**
**Design temperature: 0/110 ºC**

# Kettle type reboiler



**PSHE 7 Plates / Size 14 Shell, Kettle type Steam Transformer (at Car tyre Factory) 23MW**

# Reactor overhead consensers and reboilers



# Reboiler Plate Pack for Reactor

# Reboiler Plate Pack for Reactor

# Polyol Cooler at BASF, Geismar (USA)

# Lean / Rich ABS Exchanger

- **Type: 9HH-1160/1/1**
- **Customer: BASF, Ethylene Oxide Plant, Germany**
- **Application: Liquid/Liquid (Lean ABS/Rich ABS (heat recovery))**
- **Capacity: 29MW**
- **Heat Transfer Area: 923m2**
- **Design Pressure -1/18 bar**
- **Mounted 30m of the ground level – Low weight high benefit**

# Applications in Refrigeration Industry

Cascades (especially $NH_3/CO_2$)

Flooded evaporators

Flooded evaporators + droplet separ

DX-evaporators

Condensers

Oil coolers

De-superheaters

Ammonia absorption plants

Special designs / applications by customer request

# Flooded Cascade

- Type: 5HH-440/1/1
- $NH_3$ / $CO_2$
- Capacity: 580 kW
- Design pressure: 40 bar
- Design temperature: –50/110 °C

# De-superheater

- Type: 3LL-116/2/2
- $NH_3$ / $H_2O$
- Capacity: 60 kW
- Design pressure: –1/25 bar
- Design temperature: 0/110 °C

# Auxiliary cooler

- Type: 3HH-184/4/1
- 404a / $CO_2$
- Dx-evaporator

Lugano Ice Rink, Switzerland

# ICE STADIUM, SWEDEN

- 3HH-80/2/2
- 65 kW de-superheater
- $NH_3$ / water
- Design specs: –1/25 bar, –50/110°C

- 5LL-240/1/1
- 450 kW condenser
- $NH_3$ / Et. glycol 35 %
- Design specs: –1/25 bar, –50/110°C

# ICE BREAKER LABORATORY

- PSHE 7HH-2 x 214/3/1
- 2 x 240 kW DX-cascade
- $CO_2$-tank, -16°C / -8°C
- R404A / $CO_2$, -16°C / -8°C
- Design specs: -1/40 bar and -50/110°C

# CASCADE ($CO_2$-CONDENSER)

- 9HH-464/1/1
- 1500 kW cascade
- Cold storage in the Netherlands $NH_3$ / $CO_2$
- Design pressure: – 1/40 bar
- Design temp.: – 50/110°C

# FLOODED EVAPORATOR

- Type: PSHE 9HH–520/1/1
- $NH_3$ / Water
- Capacity: 4350 kW
- Design pressure: –1/25 bar
- Design temperature: –50/110 ºC
- Evaporation temperature: 3 ºC

# DIRECT

# EXPANSION EVAPORATOR

- Type: 5HH-260/4/1
- Ammonia / Et. glycol 25 %
- Capacity: 480 kW
- Design pressure: –1/25 bar
- Design temperature:–50/110 ºC
- Evaporation temperature: –1 ºC

# CONDENSER

- Type: 5LL-240/1/1
- $NH_3$ / Et. glycol 35 %
- Capacity: 450 kW
- Design pressure: –1/25 bar
- Design temperature: –50/110 ºC

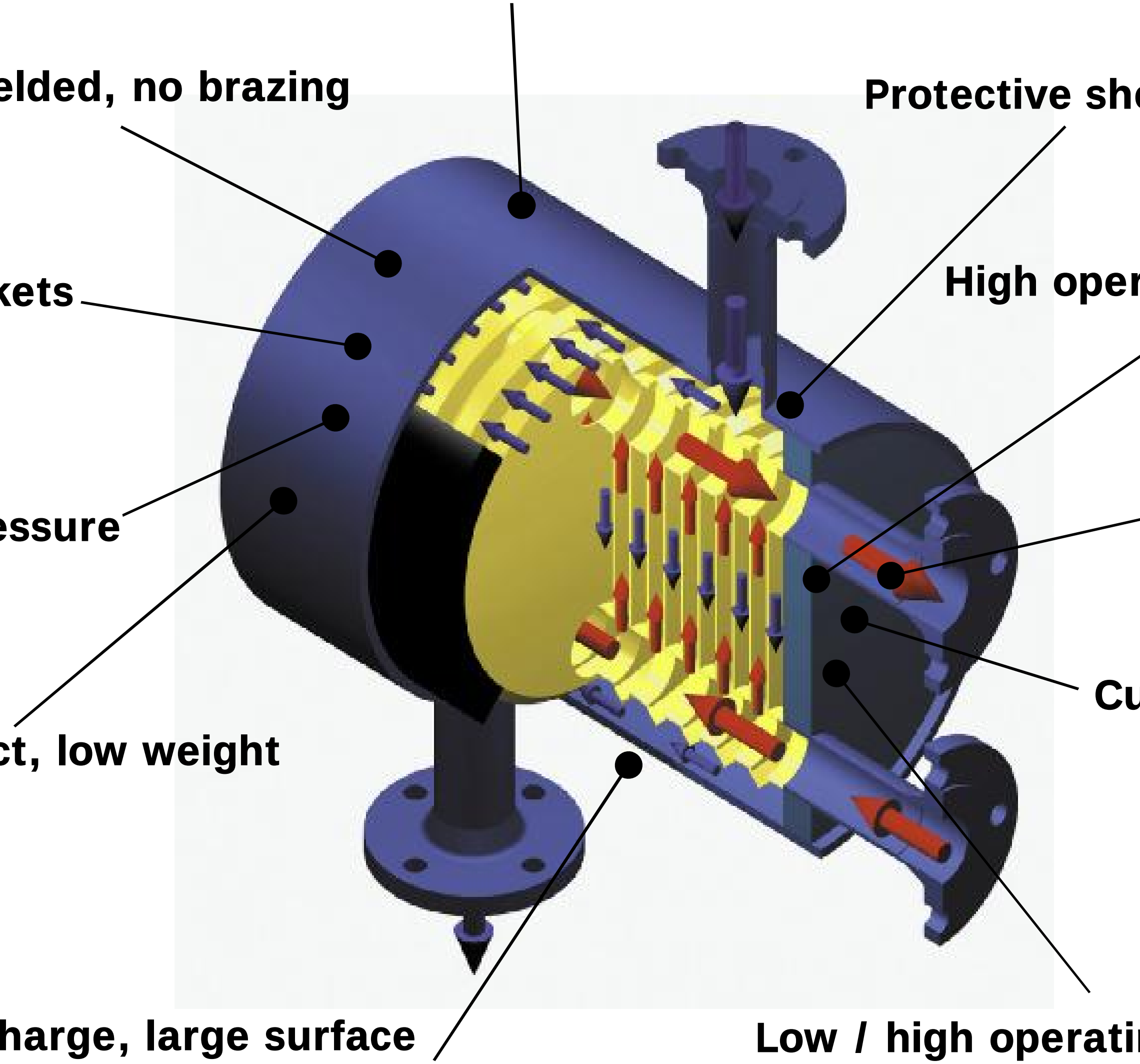
# DE-SUPERHEATER

- Type: 3HH-80/2/1
- $NH_3$ / Water
- Capacity: 65 kW
- Design pressure: –1/25 bar
- Design temperature:–50/110 ºC

# OIL COOLER

- **Capacity: 20 - 180 kW**
- **Design pressure: – 1 / 28 bar**
- **Design temperature: 0 / 150 ºC**

# Benefits


Low noise – no vibration
Fully welded, no brazing
Protective shell construction
No gaskets
High operating pressure
Low pressure drop
Easy chemical cleaning
Customised shell construction
Compact, low weight
Small charge, large surface
Low / high operating temperature

# Conclusions

•Proven Reliable Technology

•Compact  Alternative to Shell & Tube

•Maintenance Free Plate Exchanger

•Excellent Resistance to Thermal and Pressure shock

•Space Saving, Low Weight, Easy Installation

• Flexible Design

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