## Catalogue



# 1. Brief introduction

- **Objective**

This application guide provides installation guidance and typical failure prevention information for brazed plate heat exchangers. Suitable for use by qualified personnel. Please read and follow these instructions to use the brazed plate heat exchangers in a safe and professional manner. Pay special attention to the safety instructions and general warnings provided in this guide and in other documentation supplied with heat exchangers.
Additional materials and manuals are also available from www.danfoss.com.

- **Version**

This manual will be reviewed and updated periodically. Any suggestions for improvement are welcome.

Table 1: version update

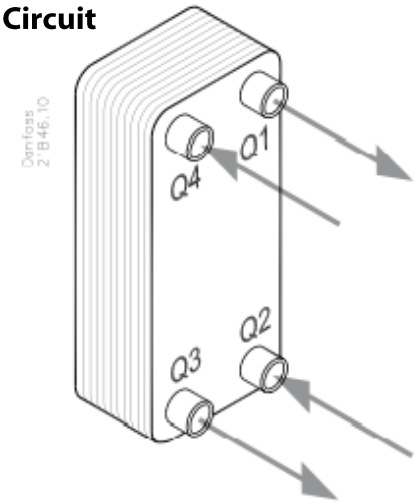
| Version | Updates | Issue date | Remark |
|---|---|---|---|
| A | First edition | 03.01.2022 | |

## 2. Installation Instruction

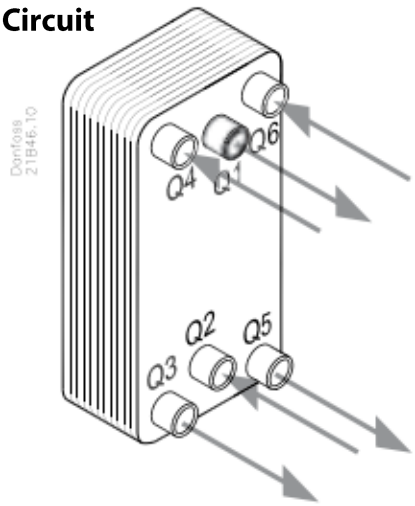
- **Condensers**

Suggest to connecting the refrigerant (gas) to the upper left connection, Q4 (Dual circuit: upper left, Q4, and right, Q6), and the condensate to the lower left connection, Q3 (Dual circuit: lower left, Q3, and lower right, Q5). Connect the water/brine circuit inlet to the lower right connection, Q2, and the outlet to the upper right connection, Q1 (Dual circuit: inlet lower middle, Q2, and outlet upper middle, Q1).

**Single Circuit**



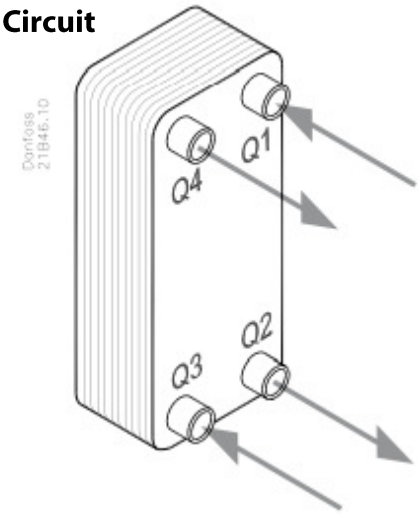

**Dual Circuit**



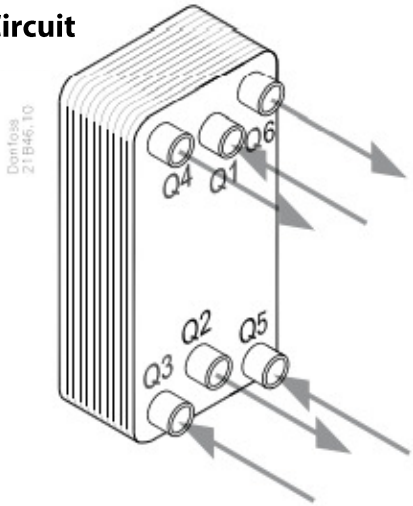

- **Evaporators**

Suggest to connecting the refrigerant (liquid) to the lower left connection Q3 (Dual circuit: lower left Q3 and lower right Q5) and the refrigerant (gas) outlet to the upper left connection Q4 (Dual circuit: upper left Q4 and upper right Q6). Connect the water/brine circuit inlet to the upper right connection, Q1, and the outlet to the lower right connection, Q2 (Dual circuit: inlet upper middle, Q1, and outlet lower middle, Q2).

**Single Circuit**




**Dual Circuit**

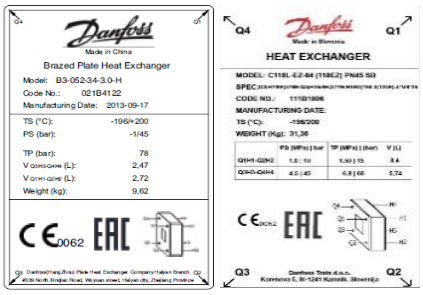


- **Working temperature range (TS):**
  min. -196 °C / max. 200 °C. (Use within the limits only)

- **Maximum operating pressure (PS):**
  refer to the information on product label. (Use within the limits only)

- **Test pressure (TP):**
  refer to the information on product label. (Use within the limits only)

- **Volume (V):**
  refer to the information on product label. (Use within the limits only)



The label samples

- **Fixation:**
  limit vibrations by installing vibration absorbers. For large connection diameters, it is advisable to use an expanding device in the pipeline and a buffer between the BPHE/MPHE and the mounting clamp (e. g. a rubber mounting strip).

- **Start-up and shut-off:**
  when BPHE/MPHE is started up/shut off, the water pressure must be increased/decreased slowly to avoid stress damage to the machine.

- **Connection brazing procedure:**
  insert the copper pipe into the connection and braze using 45% or above silver brazing. Take care to avoid directing the flame at the heat exchanger. Use a wet cloth or cooling water to protect the connection against overheating. Use nitrogen gas to protect the inside of the heat exchanger from oxidation.

## 3. Notice

- Use insulation to create a vapor barrier and prevent heat losses during operation.
- Use a strainer with ≥30 mesh in front of the water inlet pipe.
- The continuous operational temperature range in primary or secondary side should not greater than 80K.
- Ensure constant water flow before/during/after compressor operation – Flow switch and freeze protection thermostat are recommended.
- Use a 5% solution of a weak acid such as phosphoric or citric acid for back flow cleaning (It's best to ask a professional cleaning company to operate). Reverse the normal flow direction and increase the flow rate to 1.5 times normal. After cleaning it is recommended to rinse the heat exchanger carefully with clean water; a solution of 1-2% sodium hydroxide (NaOH) or sodium bicarbonate (NaHCO3) before the last rinse ensures that all acid is neutralized. Hydraulic circuits are recommended to be equipped with connectors and valves dedicate to an easy maintenance.
- When the heat exchanger is not used for a long time (e.g., 2 weeks), drain the water and keep the interior dry.
- DO NOT use open water circulating system.
- The water pump should be turned on first and release the air out of water system, then start the compressor.

- The following guideline is for the water quality of tap water, district heating water, cooling water and industrial water used in plate heat exchangers of stainless steel (EN 1.4404 ~ AISI 316L) brazed with pure copper (Cu), improved copper (CoResist) or Stainless Steel (StS). It is important to point out that the water specification is not a guarantee against corrosion, but it must be considered as a tool to avoid the most critical water applications.

| | | | Plate | Brazing material | | |
|---|---|---|---|---|---|---|
| **Parameter** | **Machine** | **Value or concentration** | **AISI 316L W.Nr. 1.4404** | **Cu** | **CoResist** (product availability to be verified) | **StS** (product availability to be verified) |
| pH | | < 6,0 | o | - | - | o |
| | | 6,0 - 7,5 | + | o/- | o | + |
| | | 7,5 – 10,5 | + | + | + | + |
| | | >10,5 | + | o | o | + |
| Conductivity | µS/cm | <10 | + | + | + | + |
| | | 10 – 500 | + | + | + | + |
| | | 500 – 1.000 | + | o | + | + |
| | | >1.000 | + | - | o | + |
| Free Chlorine | mg/l | <0,5 | + | + | + | + |
| | | 0,5 – 1 | o | + | + | + |
| | | 1 – 5 | - | o | o | o |
| | | >5 | - | - | - | - |
| Ammonia ($NH_3$, $NH_4^+$) | mg/l | <2 | + | + | + | + |
| | | 2 – 20 | + | o | o | + |
| | | >20 | + | - | - | + |
| Alkalinity ($HCO_3$) | mg/l | <60 | + | + | + | + |
| | | 60 – 300 | + | + | + | + |
| | | >300 | + | o | + | + |
| Sulphate ($SO_4^{2-}$) | mg/l | <100 | + | + | + | + |
| | | 100 – 300 | + | o/- | o | + |
| | | >300 | + | - | - | + |
| $HCO_3$ / $SO_4^{2-}$ | mg/l | >1,5 | + | + | + | + |
| | | <1,5 | + | o/- | o | + |
| Nitrate ($NO_3$) | mg/l | <100 | + | + | + | + |
| | | >100 | + | o | + | + |
| Manganese | mg/l | <0,1 | + | + | + | + |
| | | >0,1 | + | o | o | + |
| Iron (Fe) | mg/l | <0,2 | + | + | + | + |
| | | >0,2 | + | o | + | + |
| *Hardness ratio [Ca2+, Mg2+]/[HCO3-] | / | 0 – 0,3 | + | - | - | + |
| | | 0,3 – 0,5 | + | o/- | + | + |
| | | >0,5 | + | + | + | + |

| | |
|---|---|
| **+** | Good corrosion resistance |
| **o** | **Corrosion could happen when more parameters are evaluated with o |
| **o/-** | Risk of corrosion |
| **-** | Use is not recommended |

* Hardness ration limits defined per experience and internal tests in Danfoss laboratory

** In case of three or more parameters evaluated with o consultancy is needed with Consultant for Corrosion & Microbiology or BU HHE Representative

| Application temperature | Chloride concentration |
|---|---|
| ≤ 20°C | ≤ 1000 mg/l |
| ≤ 50°C | ≤ 400 mg/l |
| ≤ 80°C | ≤ 200 mg/l |
| ≥ 100°C | ≤ 100 mg/l |

## 4. Application Failures and Solutions

Failure Mode #1

**Frozen Break:** frozen in water-side cavity leads to expansion of the cavity and cracking of the plate, causing leakage failure.

### Customer side

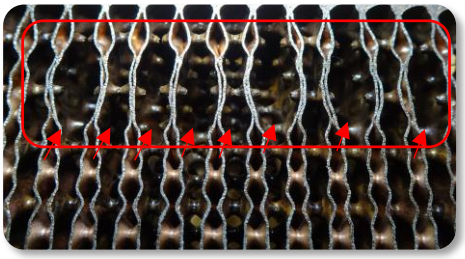
- Machine stop running.
- Collateral damage on compressors and other components.

### Preliminary detection

- Internal leakage

### Deep analysis

- Expansion of product



- Cavity expands and the plates break

### Solutions

**Machine protection:**

- Install a low-pressure switch on refrigerant side, the setting value should be higher than the lowest anti-freeze setting (contact Danfoss technicians for specific setting value).
- Installs a pressure sensor on refrigerant side and the lowest value should be set base on customer needs.
- Installs temperature sensor on the outlet of water side, the more sensitive the better. It must be installed in the water not on the pipe wall.
- The water pump should be turned on before the machine starting, and it should be shut down first, then to turn off the water pump when stop operating.
- The lower limit of water flow switch should not be less than 70% of rated water flow and flow switch should be linked with the machine by PLC.

Failure Mode #2

**Blocked cavity on water side:** if the water contains insoluble particle impurities and without an appropriate filter, the cavity will be blocked after a certain time operation, the heat exchanger and machine may be also damaged.

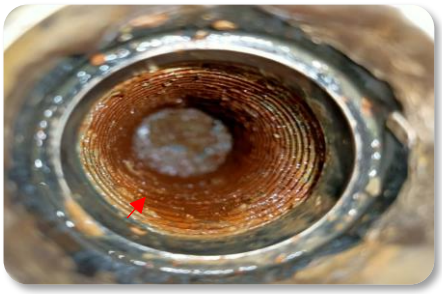
### Customer side

- Low performance of the machine or stop operation.
- Water flow becomes smaller and frozen on water side.
- Corrosion
- Collateral damage on compressors and other components.

### Preliminary detection

- Block inside (dirt)

### Deep analysis



- Block inside (dirt)

- Block inside (dirt)

### Solutions

**Dirt Cleaning**

- Use a strainer with ≥30 mesh to filter the dirty water. The strainer must be maintained regularly to remove the impurities.
- Use a 5% solution of a weak acid such as phosphoric or citric acid for back flow cleaning (It's best to ask a professional cleaning company to operate). Reverse the normal flow direction and increase the flow rate to 1.5 times normal. After cleaning it is recommended to rinse carefully the heat exchanger with clean water; a solution of 1-2% sodium hydroxide (NaOH) or sodium bicarbonate (NaHCO3) before the last rinse ensures that all acid is neutralized. Hydraulic circuits are recommended to be equipped with connectors and valves dedicate to an easy maintenance.

Failure Mode #3

**Water hammer damage:** due to the rapid change of liquid flow rate, the pressure of water reaches dozens or even hundreds of times of normal pressure, resulting in the damage of the plate.

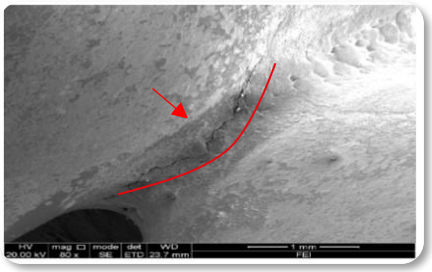
### Customer side

- Machine stop running.
- Collateral damage on compressors and other components.

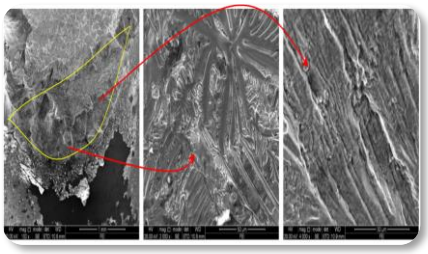
### Preliminary detection

- Internal leakage

### Deep analysis



- Fracture of leak position



- Fracture morphology: low density fatigue mark or dent-shape fracture.

### Solutions

- Slowly opens or closes the valve.
- Installs a relief valve between inlet and outlet water pipes.

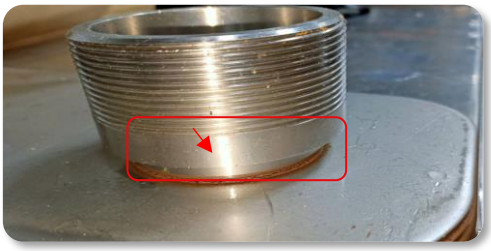
Failure Mode #4

**Vibration fatigue (connector area):** vibration and fatigue crack which acting on external force expand simultaneously, and the interaction between them not only affects the normal operation of the machine, but also seriously affects the reliability.

### Customer side

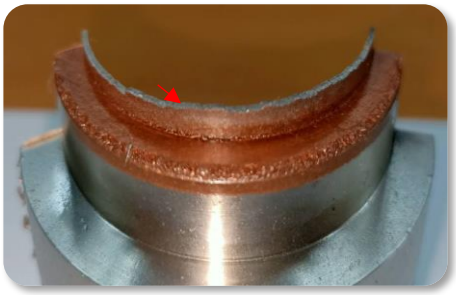
- Low pressure alarm, machine stop running.

### Preliminary detection

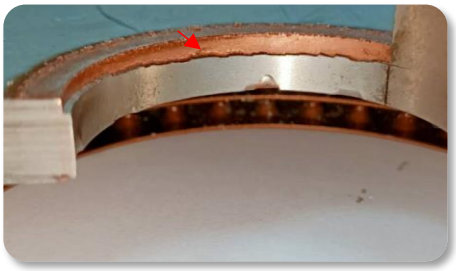


- External leakage

### Deep analysis



- Fatigue fracture



- Fatigue cracks

### Solutions


- The heat exchanger must be fixed by a special bracket, not by the connecting pipes to avoid the stress and vibration on the pipes. It is recommended to place the heat exchanger on the bench and tighten with a metal splint.
- Do not use hoses for water connections as it can easily lead to pressure oscillations.
- The customer needs to consider reducing the vibration of the heat exchanger connecting pipe when designing the machine.

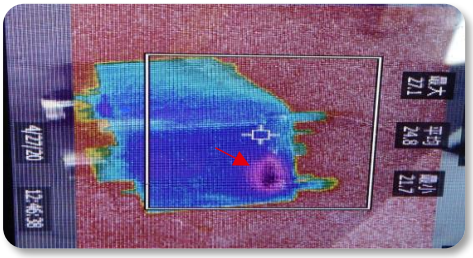
Failure Mode #5

**Corrosion:** components are gradually corroded and fail in the application environment containing corrosive elements.

### Customer side

- Corrosion
- Machine stop running.
- Collateral damage on compressors and other components.

### Preliminary detection



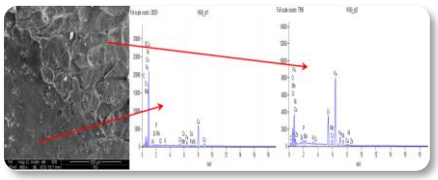
- Internal leakage

### Deep analysis

a

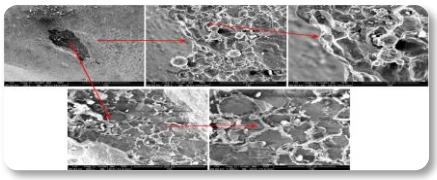
- Corroded and perforated of the plates

b



- EDS analysis: corrosive element Cl

c



- SEM analysis: fracture morphology

### Solutions

- Refers to water guidelines.
- DO NOT use open water circulating system.

Failure Mode #6

Pressure fatigue (inside the heat exchanger): the crack first appeared in the area with stress concentration position, then gradually spread and lead to crack.

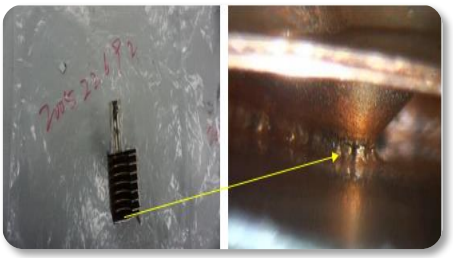
### Customer side

- Machine stop running.
- Collateral damage on compressors and other components.

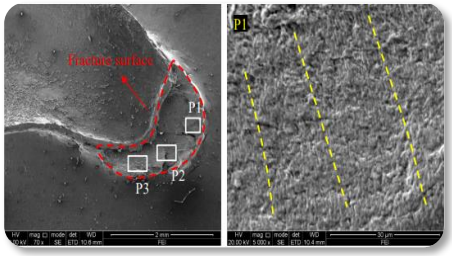
### Preliminary detection

- Internal leakage

### Deep analysis



- Fracture of leak position




- Fracture morphology: regular fatigue striations

### Solutions

- Use pressure shall not exceed the design pressure.
- Fluid use shall not be out of the design scope.

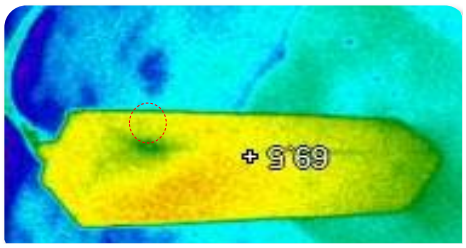
Failure Mode #7

**Thermal fatigue**: the temperature difference of the fluid inside causes circulating strain of the heat exchanger, which leads to cracks and fracture. (Thermal fatigue failure occurs only in the cascade chillers)

### Customer side

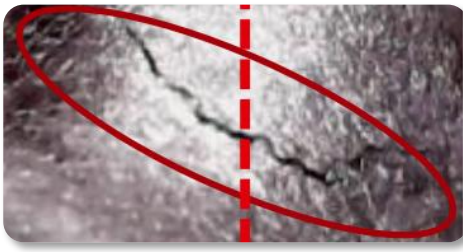
- Machine stop running.
- Collateral damage on compressors and other components.

### Preliminary detection

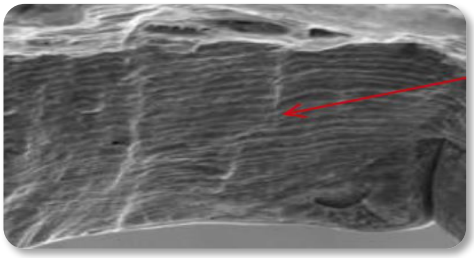


- Internal leakage

### Deep analysis



- Fracture of leak position



- Fracture morphology: regular fatigue striations

### Solutions

- Install the connector correctly.
- The continuous operational temperature range in primary or secondary side should not greater than 80K.
- Optimize the parameters of defrost and minimize the frequency.