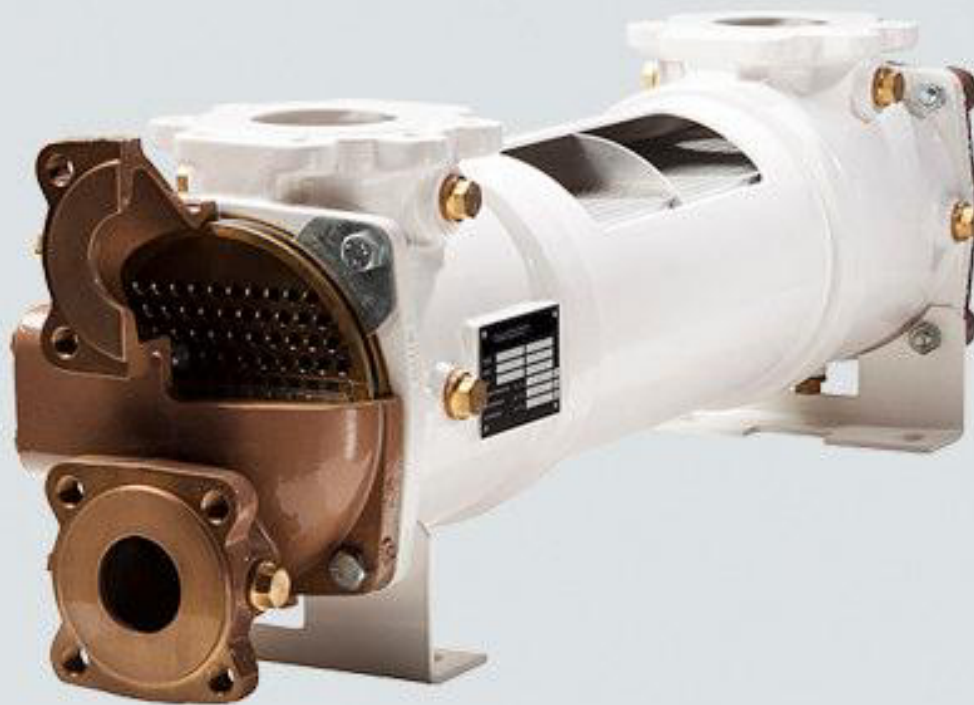


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Shell & Tube Single - Smart



INSTRUCTION MANUAL 200022301
COMPACT HEAT EXCHANGER P-TYPE

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The P-type heat exchanger can be divided into four sizes: P10, P13, P20 and P28. The number indicates the shell size in centimetres. The construction of the P10 is slightly different from the others. When applicable in this manual the difference will be highlighted with the text **“(for P10 Only)”**.

The P-type heat exchanger comes in three executions: the IV (Industrial Version), the MV (Marine Version) and the RV (Refrigeration Version). The main difference is the fact that the MV comes equipped with anodes in the tubeside circuit of the heat exchanger to protect the cooler in unconditioned cooling water conditions. The RV version coolers are thermo syphon coolers with the refrigeration medium in the tube. When there are differences between the models, this is pointed out in the text.

Please note that the P10-type is only available in MV version.

In addition, this manual applies to P-type heat exchangers with plain tubes (PT-type) as well.

1 Introduction

1.1 Notes for the customer

- Read this instruction manual before proceeding.
- Being familiar with the basic safety rules given in the 'Safety' chapter of this manual is a prerequisite for safe and trouble free installation and operation.
- For products with CE marking, the declaration of conformity will be sent separately.



The instructions given in this manual must be observed. Disregard may endanger persons, cause damage to the heat exchanger and lead to warranty and liability claims becoming forfeited.

1.2 Responsibilities of the owner/operator

- If you are in doubt how to proceed, contact Kelvion.
- The owner/operator is responsible for proper installation of the product.
- The design pressures and design temperatures as stated in the specification sheet and on the nameplate may never be exceeded.
- Maintenance of the product is the responsibility of the product owner/operator.
- The product should be maintained according the maintenance instructions in this manual.
- This Instruction Manual is part of the consignment. To guarantee professional handling of the product, it should be preserved in a way, that installation-, maintenance- and operating personnel have access to it.
- The owner is held to supplement this manual by including any provisions required by applicable accident prevention and environmental protection rules and regulations.
- The owner is held to observe the generally accepted rules governing safe and skilled working practices.
- The owner is to observe the skill level and authorizations of the persons installing and operating this product.

1.3 Guarantee and liability

The "General sales conditions of Kelvion Machine Cooling B.V." are applicable.

Also refer to the order confirmation for possible additions.

Liability and warranty claims are excluded:

- If the instructions in this manual are not observed.
- If the heat exchanger is incorrectly operated or handled incorrectly.
- If the heat exchanger is used for a different than the intended application.
- If operating conditions deviate from those used for the thermal calculation.
- If the heat exchanger is being used outside the design limits, including deviation from used media as defined in the specification.
- If the heat exchanger is modified.
- If protective guards are left unused or taken out of service as a whole or partly.
- If equipment functions are changed without Kelvion's prior written consent.
- If applicable safety provisions are not observed.
- If the heat exchanger including pertinent accessories is maintained inexpertly (timewise/expertise).

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- In case of use of non-original parts.
- In case of any kind of corrosion.

For the used materials, in particular but not exclusively polymer seals, the phenomenon of permeation or diffusion of the medium through the material occurs. The escaping quantities depend on the type of apparatus, the used materials, the type of medium, its pressure and its temperature. This fact shall not be considered as a defect and is as such exempted from Kelvion's warranty obligations.

In the case of dangerous media, the operator of the apparatus must ensure for all types of potential leakage of these media that (i) all necessary and suitable safety measures are implemented to discharge escaping permeate, and (ii) that in case of leakages other than permeation a suitable safety concept is in place, that limits possible consequences of such a scenario to maximum extent.

Kelvion is not liable for any losses or damages (i) which result from permeation or diffusion of hazardous media/substances or (ii) which result from or are caused by a missing or improper safety concept on the part of the operator of the equipment.

1.4 Environment

Always respect the environmental laws and rules of the area where the heat exchanger is installed.

If applicable the rules of the classification societies have to be respected.



Always be alert to the possibility of leakage!

1.5 Safety

Some symbols are used in the text to underline safety aspects:



Danger: risk of injury or danger to life.



Danger: risk of damage to the heat exchanger.



Warning that injuries may occur due to suspended loads. Only employ suitable and approved lifting equipment. Secure loads to prevent slipping and overturning during lifting.



Warning against burning hazards caused by hot surfaces.



Warning that personal protective means must be worn when carrying out work on the heat exchanger. Protective clothing, safety goggles, safety shoes, safety gloves, ear protection and/or hard hat should be used depending on the situation, otherwise there will be a risk of injuries.



Warning that safety goggles must be worn when carrying out work on the heat exchanger, otherwise there will be a risk of eye damage/loss of vision.



Warning that compliance with (local) waste disposal regulations is required.



Important information.



Maintenance and repair: cool down to ambient temperature and depressurize the heat exchanger before any work is done on the cooler.



General Note:

Most heat exchangers contain media, which can be irritating or dangerous to humans. These media may cause problems in case of leakage. Since the medium in the heat exchanger is at a raised temperature level, any leaks may cause burns of the skin.



A heat exchanger is a pressure vessel designed for operation at certain specific limits of pressure and temperature. All operating personnel should be made aware of this specific design pressure and temperature, which is stated on the name plate.

1.6 Materials

Always check if the media that flowing through the heat exchanger is consistent with the materials used. Kelvion makes its material choices on the basis of the media types specified by the client, but is often not informed of possible contamination, higher/lower acid levels than normal, additives and other aspects relevant to the choice of materials.

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1.7 Inhibitors

Inhibitors may be added to the cooling medium in the heat exchanger. Contact the supplier of the inhibitor to check for compliance of the inhibitor with the materials of the heat exchanger (see specification sheet). Without proper prevention, micro organisms may grow excessively in the cooling medium and can cause corrosion of metals. Bacteria also give an accumulation of slurry / mud, forming a viscous film on the tube wall and blocking the flow and heat flux, causing insufficient cooling.



Follow the instructions of the supplier for use of the inhibitor and maintenance procedures.

2 Installation and start-up

2.1 Receipt

Upon reception of the heat exchanger check the packaging and the product:

- Report any damage to Kelvion.
- Compare the data on the nameplate, the drawing and the Kelvion order confirmation/packing list.
- Check whether or not the correct instruction manual is present by comparing the article number on the cover sheet with the article number of the instruction manual on the order confirmation/packing list.
- Always store the heat exchanger in its original packing in a dry room at constant temperature. When the heat exchanger is not being put into operation immediately after receipt, follow the “Instructions for storage”.

Kelvion reserves the right to plug off a maximum 1% of the tubes (as per TEMA RGP-RCB-2) (not applicable for parts used in nuclear installations).

2.2 Installation



Corrosion preventive fluid is present inside the heat exchanger. Before installation drain the heat exchanger to remove this fluid. When complete removal of the conservation fluid is necessary, it may be removed by flushing with a mineral solvent like petroleum.



Only use tools and lifting equipment suitable for the task to be performed. Load carrying equipment should be approved, of adequate size and undamaged. Make sure no person pass or stay under the goods lifted during handling.

The P10 heat exchangers are limited in size and weight and can be lifted by two persons by hand. The bigger types can be lifted by using two lifting eye bolts, screwed into a threaded bolt hole in each of the shell side connections (N1 and N2 on the drawing).

Alternatively, use two lifting slings around the shell of the heat exchanger to lift it (always for P13 with shell side BSP connections).

2.3 Start-up



Do not exceed the design temperature and pressure as specified on the nameplate, specification sheet and/or drawing. Avoid abrupt temperature fluctuations; these may cause leaking of the tube-to-tubesheet connections or other connections.

- Make sure that the cold medium circulation is established first, followed by the gradual introduction of the hot medium.
- Vent both circuits.
- Vent both circuits again when the operating temperatures and pressures are reached.
- Check for leakage.

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Respect the flow as specified on the specification sheet. Lower/higher speeds may cause corrosion/erosion.



Avoid standstill: in non-conditioned circuits this may cause corrosion. In case of standstill follow the instructions for shut down periods.

3 Maintenance

If necessary refer to “Assembly and disassembly of the bundle” for (dis-)assembly instructions.

3.1 Cleaning and inspection intervals

The end user is responsible for (preventive) maintenance.

Because the degree of fouling strongly depends on the operating conditions we recommend the following:

- Inspect the tubeside at least quarterly.
- Inspect the shellside at least twice a year.

With the results of these inspections you will be able to determine the required cleaning intervals. Always keep performing regular inspections.

3.2 Galvanic protection

Not applicable for IV models (without anodic protection).

The MV models of P-type heat exchangers are fitted soft iron anodes on the tubeside. When inspecting the tubeside of the heat exchanger, also inspect the condition of the anodes (always drain the tubeside circuit before removing the anodes).

The consumption of the anodes strongly depends on the operating conditions. If most of the anode material is dissolved, they need to be replaced. For spare parts, contact our Service Department at service.almere@kelvion.com.

For example only:



The anode 1 is a new one (for comparison), anode 2 should be replaced if a high consumption of the anodes has been determined. Anode 3 and anode 4 should be replaced immediately. Please note that the above example is indicative only, the user should estimate when the anodes need replacement.

3.3 Cleaning of the heat exchanger

3.3.1 Mechanical cleaning of the tubeside

The tubes can be cleaned with a tube brush. Use original Kelvion brushes only; these have the correct dimensions and are of a suitable material. Other brushes may damage the protective layer that is in the normal course of events present on the tube walls.

3.3.2 Chemical cleaning of the shell-/tubeside

Cleaning of the shellside is normally seldom necessary.

The shell- as well as the tubeside can be cleaned by circulating a chemical solution through the heat exchanger. Another possibility is disassembling of the bundle and submerging the tubebundle in a tank filled with a chemical solution.

There are various international companies (please refer to chapter 7) which can deliver products for the chemical cleaning. They have world-wide offices in many countries and can give you cleaning advice or can clean the heat exchanger for you.



Chemical cleaning can damage the heat exchanger. Let the supplier of the chemical cleaning agent determine whether the agent is suitable in combination with the materials of the heat exchanger (see specification sheet).

3.4 Shut down periods



Avoid the heat exchanger standing still in freezing conditions: this may cause damage to the tubes. Check for the proper glycol content to prevent freezing.



During shut down periods longer than a week the heat exchanger has to be drained completely and dried by means of preheated compressed air.



When a corrosive medium is used in the heat exchanger: during shut down periods longer than 24 hours. After draining a corrosive medium, the heat exchanger has to be rinsed with fresh water.



When not used continuously, the heat exchanger should be drained, rinsed with fresh water and dried for periods longer than 24 hours.



Stopping of the flows, cooling down and draining of the heat exchanger has to be done in a manner to minimize thermal stresses on the heat exchanger.



Never stop one of the flows of the heat exchanger while the other one stays in operation, because of the risk of boiling.

3.5 Assembly and disassembly of the bundle

The circumference of one of the tubesheets is fitted with three grooves (fixed tubesheet). The two outer grooves carry O-rings (sealing between shell- and tubeside). The middle groove of the fixed tubesheet is for the fixation of the position of the tubebundle by means of 'fixation plates'.

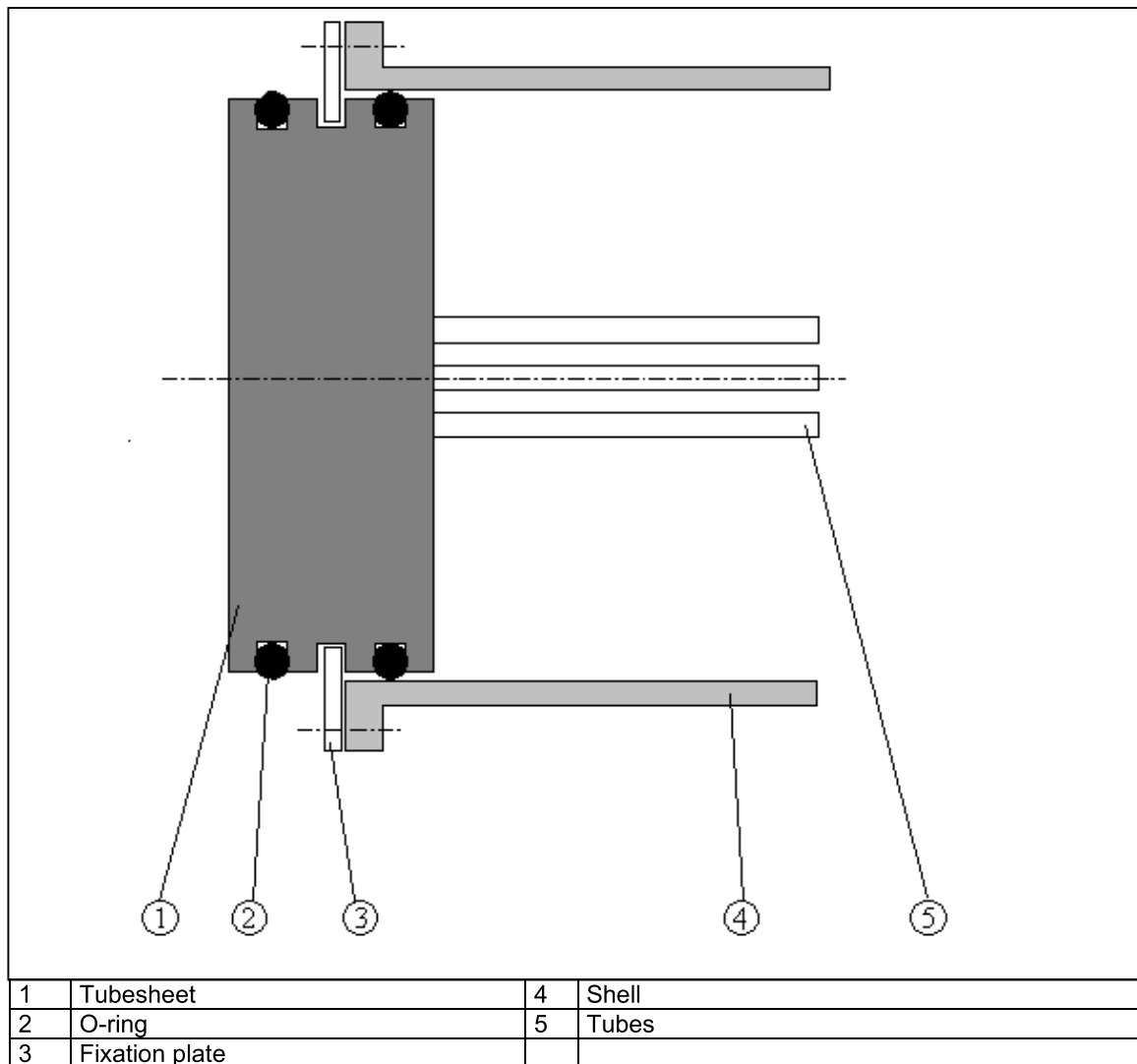


Figure 1: Schematic drawing of tubesheet construction

The other tubesheet (floating tubesheet) will be not fixed and is supposed to slide according to thermal extension.

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For P10 only: instead of fixation plates the P10 has a metal spring ring in the middle groove of the tube sheet. As soon as the bolts are loosened of the tube bundle is no longer fixated. Tubeside inspection or cleaning remains possible, but extra attention is required because the tube bundle is not fixed anymore. Except when performing a pressure test, we recommend to drain both circuits.

Step 1: Disassembly



Cool down to ambient temperature and depressurize the heat exchanger before any work is done on the cooler.

- Depressurize both circuits.
- Drain the tubeside circuit, by opening the drain in the lowest point and the vent in the highest point.
- Mark the position of all parts that will be disassembled, so they can be re-assembled in the correct position later on.



In case the heat exchanger is placed **vertically**, take care the bundle is supported before proceeding with untightening the nuts (fixation plates come loose as well).

- Remove the waterboxes by untightening the nuts (the fixation plates come loose as well)
- Assemble the fixation plates again with the nuts (not necessary when the tubebundle is going to be removed (see step 3))
- 2- or 3-pass heat exchangers have composite (or optional Brass) partitions on the tubesheet(s) for dividing the tubeside circuit; mark their position and remove them
- Remove the outer O-ring from both tubesheets
- Only for a pressure test: pressurize the shellside again. Depressurize the shellside again after the pressure test.



For P10 only: Remember that the tube bundle is not fixed!

Step 2: Removing the tube bundle

- Drain the shellside circuit, by opening the drain in the lowest point and the vent in the highest point.
- Mark the position of the tube bundle.
- Move the tube bundle to one side until the inner O-ring shows (do not move the tube bundle further than necessary) and remove the O-ring.
- Move the tube bundle to the other side and remove the outer O-ring on this side as well.
- Carefully pull the tube bundle from the shell.
- Support the tube bundle under the baffle(s) or support sheet(s) when lifting it, be careful not to bend the baffles (this would affect the thermal performance of the heat exchanger).



The fins are very fragile parts of the heat exchanger and should be handled with care.



For casting design with a blind side, bundle is designed with a small and a big tubesheet. The small tubesheet is inserted at first in the casting with the 4 o-rings already mounted. The fixed tubesheet has to be placed always at the channel side (for 2 pass execution).

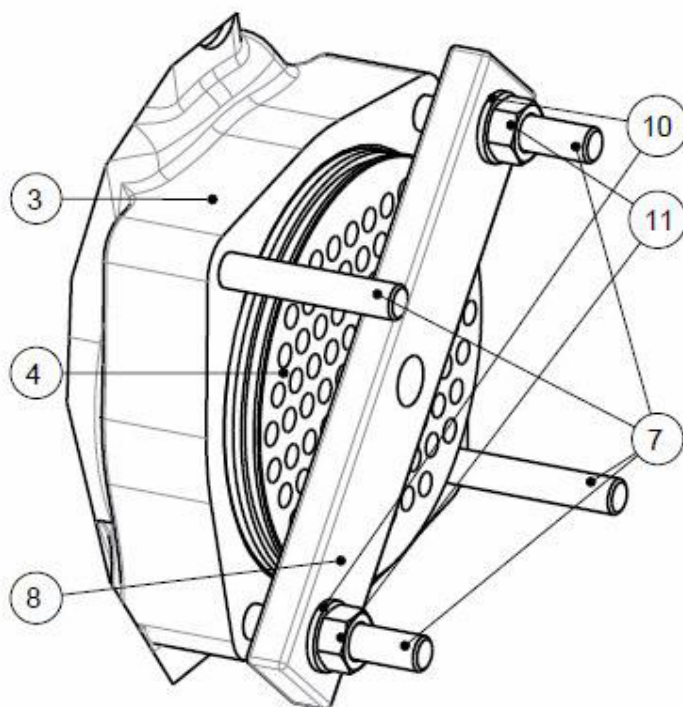
Step 3: Assembly

- Push the tube bundle in the shell. Do not push it completely into the shell. For big bundle sizes, it is preferable (when possible) to insert the bundle vertically in the shell. The tube bundle can be lifted vertically with the help of threaded holes in the tubesheets (1). For horizontal assembly the bundle should be supported under the baffle or support sheet.
- Check the position of the (optional) baffle(s). The position of the first baffle should always be at the same side as oil inlet.
- Assemble the inner O-ring on the first tubesheet.
- Move the tube bundle gently inwards until both O-ring grooves in the other tubesheet are accessible.
- Assemble the inner O-ring on the second tubesheet.



Hint: when it is difficult to move the tube bundle through the shell, you can use a strip between tubesheet and channel and then tighten bolts and nuts.

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3	Shell	8	Strip
4	Tubesheet	10	Washers
7	Stud bolt	11	Nuts

Figure 2: use of tool

- Move the tube bundle in its final position.

Tubeside assembly:

- Assemble the outer O-rings on both sides
- Assemble the composite (or optional Brass) partition(s) on the tubesheets of 2- or 3-pass models.
- Position the fixation plates (3) to secure the bundle in the shell. Note that the fixation plates of the cooler with an even number of tube passes should always be mounted on the same side as the channel.
- Assemble the waterboxes and all connections

Start-up the heat exchanger again:

- Make sure that the cold medium circulation is established first, followed by the gradual introduction of the hot medium
- Vent both circuits
- Vent both circuits again when the operating temperatures and pressures are reached
- Check for leakage.

3.6 Instructions for sealings and bolting

3.6.1 Sealings

One type of sealing is being used in this heat exchanger:

O-rings: After disassembly of the heat exchanger never use the old O-rings again. Replace them with new and original O-rings.



Warning: The O-rings have to be lubricated with a special O-ring lubricant (O-ring silicone paste or Parker O-lube) for easy assembly and a good sealing capacity. Lubricants not suited for O-rings can affect the sealing capacity of the O-ring (for instance never use Vaseline).

3.6.2 Bolting

Check bolts and nuts for damages. Tighten the bolts crosswise (see figure 3).

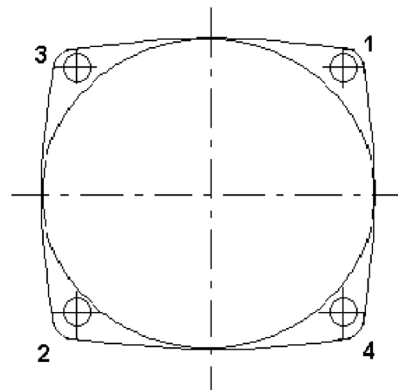


Figure 3: (Un-)bolting sequence

4 Troubleshooting & repairs

4.1 Insufficient thermal performance

In case of insufficient thermal performance check the following items:

- Whether all connections have been made according to the drawing.
- Whether the heat exchanger and the system have been properly vented.
- Whether the flows are according to the specification (check all valves, pipelines and pumps, as well as the flow directions).
- Whether the shell- as well as the tubeside have been cleaned recently (fouling can cause a drop in performance and an increased pressure loss; an increased pressure drop is a good indication that cleaning is necessary).
- Whether the heat exchanger has been re-assembled properly after disassembly. The position of the tube bundle may accidentally be mounted rotated 180° around its axis.

4.2 Leaking tubes / tube-to-tubesheet connection

It is often very hard to determine whether leakage occurs because of a leaking tube or because of a leaking tube-to-tubesheet connection. The shellside of the heat exchanger can be hydrotested, after disassembly of the tubeside. Follow the instructions in "Assembly and disassembly of the bundle". Subsequently pressurize the shellside. After hydrotesting depressurize and drain the shellside again. Assemble the heat exchanger again.

The tubes are expanded into the tubesheet. It is either not possible (finned tubebundles) or relatively complicated (plain tube bundles) to replace a leaking tube, but it can be plugged with soft copper Kelvion plugs (other materials are too hard and may cause leakage of the adjacent tube-to-tubesheet connections) in both tube ends. Contact Kelvion for support when plugging off tubes is necessary.

5 Spare parts & tools

Available spare parts and tools for this type of heat exchangers:

- Set of sealings (four O-rings)
- Set of soft metal rings for drains/vents
- Soft copper plugs
- Nylon tube brush
- Bolts / nuts
- Complete tube bundle
- **For P10 only:** Metal spring ring
- Fixation plates (for types > P10)
- Composite (or optional Brass) partitions (not for 1-pass heat exchangers)
- Waterbox
- Cover
- Anode



When placing orders please specify all data as stated on the nameplate.



Sealings are subject to ageing. Expected lifetime of spare sealings is approx. 5 years when stored according to the rules below.



Rules for storage:

- ✓ Dry, non-freezing environment at a constant temperature of about 20°C
- ✓ Constant humidity level
- ✓ Keep away from direct sunlight
- ✓ Horizontally stored (not hanging on hooks)



Sealing material should be correctly disposed, observing the environmental needs and regulations. Any national rules and directives should be adhered to.

For updated spare parts lists of each Kelvion heat exchanger, please visit www.kelvion.com in order to download an original parts list or contact your local Kelvion supplier.

6 Instructions for storage

6.1 Standard storage (controlled conditions)

Every Kelvion quality product is pressure tested before leaving the factory. The test is performed using a conservation fluid, thus ensuring adequate protection against corrosion during a maximum of six months after delivery. This fluid will protect the heat exchanger when it is stored at controlled conditions, i.e. **inside, in a dry room at constant temperature**. The conservation fluid is a petroleum based fluid.

6.2 Advice for conservation (uncontrolled conditions)

When the above mentioned storage conditions are not met, all openings have to be closed airtight and you will have to fill the heat exchanger with an inert gas at a slight overpressure (additionally silica gel can be added to absorb liquids). Attach a pressure gauge and check the pressure at regular intervals. Alternatively, the heat exchanger can be treated with a rust preventive liquid of a type suited for long term conservation.

When necessary contact a specialised company. Take the materials of the heat exchanger (see specification sheet) into consideration. Be aware that in uncontrolled storage conditions large amounts of water can accumulate in the heat exchanger as a result of condensation.

7 Cleaning of the heat exchanger

7.1 Chemical cleaning

For chemical cleaning several companies offer a comprehensive solution. The table below lists a number of applicable cleaning agents that may be used for chemical cleaning.

manufacturer	product
Drew	HDE-777
Nalfleet	MaxiClean 2
Unitor	Aquabreak
Vecom	Ultrasonic Multi Cleaner



Please refer to the manufacturer's datasheet for specific properties, concentration, duration of cleaning, temperature, etc.

7.2 Post cleaning

After cleaning work on the product has been done:

- Check the condition of the tube surfaces and coating.
- Check and clean all gasket surfaces.
- Replace damaged parts.
- Install new gaskets.

8 Validation

This is to certify this manual has been validated internally by the Kelvion Engineering department.

The validation comprised of checks by a group of engineers, service personnel and users whether the instructions in this manual comply with the tasks to be done by the owner and relevant personnel.

The manual is validated against NEN 5509.

Almere, The Netherlands

M.J. Pieters
Manager Engineering / R&D

9 Glossary

Refer to the figure(s) in the paragraph “ Assembly and disassembly of the bundle” for an explanation of the designation of parts of the heat exchanger in the text.

Conditioned circuit	Closed circuit with a non-corrosive medium.
Unconditioned circuit	Open circuit (for instance seawater) or a closed circuit with a corrosive medium.
Coating	Composite polymer layer that protects the material on which it is applied against corrosion.
Inhibitor	Additive to a medium flowing through the heat exchanger which –expressly tailored to that medium- reduces the speed of chemical reactions like corrosion.
Anodes / galvanic protection	Introducing a soft iron anode in the tubeside circuit that is more reactive to the corrosive medium flowing through the heat exchanger. The anode slowly dissolves and is leaving a corrosion protective layer on the inside of the tubes.

Appendix: Constructional directions for mounting a P-type heat exchanger in a piping design.

Pay attention to the following points:

- Level (horizontal) and square mounting possibility.
- Bends in the piping must be located at a distance of at least three times the nominal diameter of the pipe from the inlet of the heat exchanger.
- When a vaporizing cryogenic medium is used, the heat exchanger has to be placed under an angle of 3° - 10°, in order for the vapour to be able to exit the heat exchanger, aided by natural circulation. For a proper thermosyphon functioning, the height between the oil cooler and the condenser should be at least 3 meters.
- Check if vent and drain connections are present in both circuits of the heat exchanger (when not present on the heat exchanger, then construct them in the piping).
- Put a filter (with a permeability of 3 mm) before the inlet of both circuits of the heat exchanger.
- Stress- and vibration free mounting possibility of the connections and the supports (fit expansion bellows and/or silencer blocks when necessary).
- Disassembling possibility of the tube bundle (and other parts like drain and vent plugs).
- Expansion possibility of lockable liquid circuits.
- Danger of freezing of liquid circuits.
- The design data of the heat exchanger on the specification sheet¹ and the drawing. E.g. the flows: deviating from these can cause unacceptable high or low velocities. A (temporary) lower flow in a conditioned circuit is acceptable when caused by a temperature control valve in the conditioned circuit. Avoid standstill (unless the heat exchanger is drained and flushed according to Kelvion instructions at 3.4).
- When adding an inhibitor to one of the fluids in the heat exchanger, always check whether this inhibitor can be harmful for the materials of the heat exchanger (see specification sheet).
- Make sure that in case of flow control (with conditioned circuits only) this is done gradually (no 'on-off-control').
- To prevent leakages at cold start-ups (especially PF-type oil coolers) the shellside of the heat exchanger must always be completely filled with the operating fluid **before** start up.
- Kelvion reserves the right (according to TEMA RGP-RCB-2) to plug a maximum of 1% of the tubes.
- When selecting a heat exchanger, Kelvion's choice for use of materials is based and judged on the fluids specified by the customer at the time of selection. However, if possible contaminations, higher or lower than normal pH-values and other important properties are exceeding levels as specified at the time of the selection of the heat exchanger, Kelvion cannot be held responsible. Therefore please always check whether both fluids are compatible with the materials of the heat exchanger.
- Check whether the materials of the connecting piping are compatible with the materials of the heat exchanger to prevent galvanic corrosion. E.g. the combination of stainless steel piping running to and from the heat exchanger when CuNi 90/10 tubes are used, might lead to a faster corrosion process than normal.

¹ In connection with the applied materials the instruction manuals refer to the specification sheet of the heat exchanger. Therefore always keep the specification sheet at your documentation.

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