PRINTED CIRCUIT HEAT EXCHANGER

Installation, Operation and Maintenance Manual

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This manual describes the design, installation, operation, and maintenance of the Printed Circuit Heat Exchanger (PCHE). This document is the English version.

Please read this manual before commencing any work. Alfa Laval is not responsible for any damage due to incorrect installation, operation, or maintenance of the PCHE due to non-compliance with this manual.

This manual is intended to acquaint the maintenance personnel with the construction, operation and service conditions of the PCHE whatever shell material and whatever core material.

Only qualified personnel, after studying this manual and corresponding safety instructions, are allowed to operate and maintain the Alfa Laval PCHE.

Specific information in the General Arrangement (GA) drawing or other specific documents provided by Alfa Laval with the equipment takes precedence over information in this document.

If there is a QR Code on the nameplate (*see Appendix 1*) of your PCHE, scan it to access to this Instruction Manual and to other valuable information.

Publication and Revisions:

01	MAR2023	First issue for project
REV.	**DATE**	**COMMENTS**

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1. Introduction

1.1 General Description

A Printed Circuit Heat Exchanger (PCHE) is a compact plate type heat exchanger. It typically consists of a heat exchanger core to which distribution assemblies are welded.

The heat exchanger core is comprised of metal sheet plates which have fluid flow channels chemically etched into them. After etching, the metal sheet plates are stacked on top of each other and then diffusion-bonded together to form a solid block of metal. Depending on the required heat transfer area, several blocks can be manufactured and then welded together to form a complete heat exchanger core.

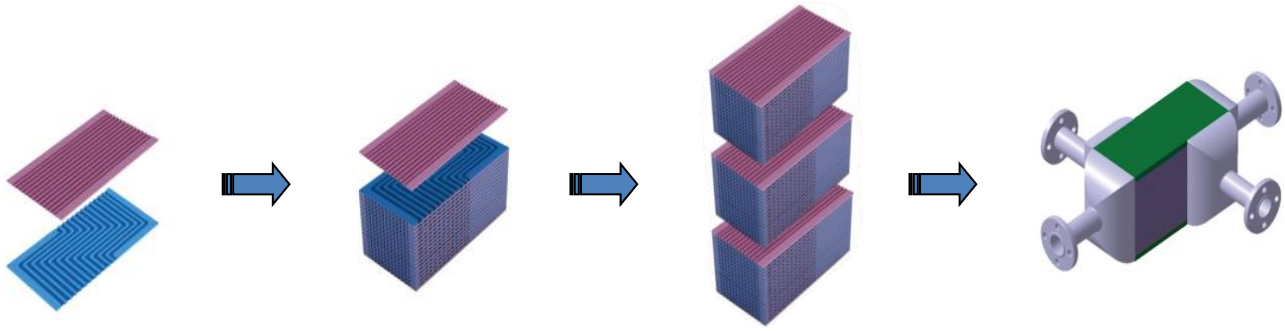

Figure1: PCHE manufacturing process

A few words about diffusion Bonding…

Diffusion bonding is a solid-state welding process wherein the principal mechanism of joining is movement of grain boundaries across the interface of the plates. No welding or brazing consumables are used.

Unlike traditionally welded and brazed products, diffusion-bonded components have the same physical and mechanical properties as the base material.

After the core is manufactured, distribution assemblies are welded to it via traditional welding methods. The assemblies typically consist of a nozzle welded to a distribution header. The nozzles can be provided as stub ends or with flanges to enable connection of the pipework.

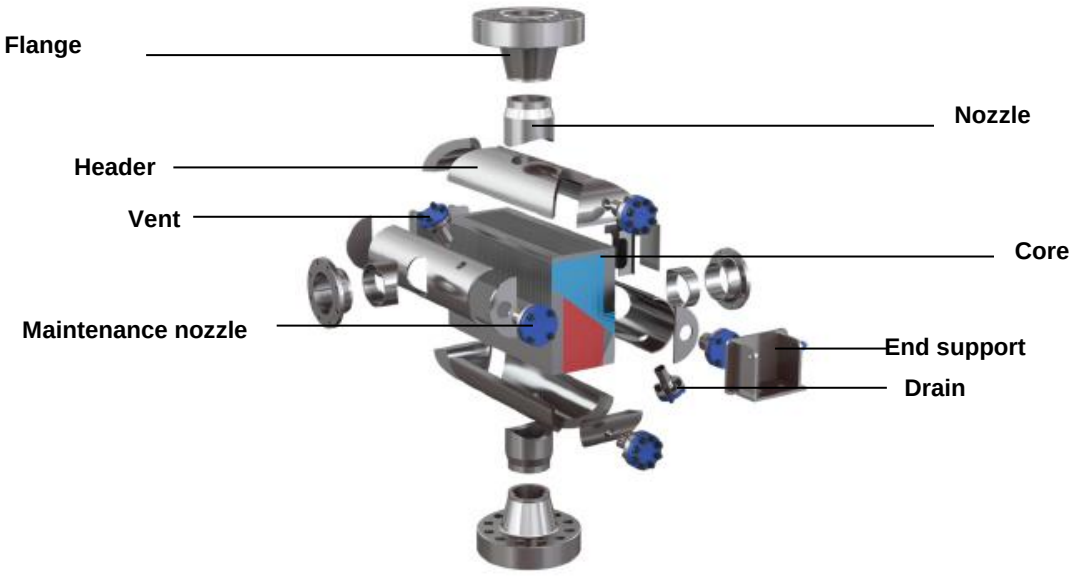

Figure 1. Exploded view of typical PCHE.

PCHEs are custom designed for each application and heat transfer duty. The design form or shape may be different to the depiction in the figure above. Please refer to the General Arrangement (GA) drawing for the project specific PCHE design.

Specific process or design conditions may result in the substitution of external headers with internal distribution ports in the core. Where internal ports are used, nozzles are welded directly onto the heat exchanger core.

PCHEs are also supplied with lifting lugs, a nameplate (see *Appendix 1*), earthing bosses and supports. Supports are normally end-type but may be designed as saddle-type or others depending on project requirement.

Vents, drains and maintenance nozzles can be provided. Vents and drains facilitate adequate venting and draining of the exchanger. Maintenance nozzles are attached to header ends for effective cleaning, to remove fouling or clogging.

1.2 Design Codes & local regulations

PCHEs are designed and manufactured in accordance with a Pressure Vessel Code (typically ASME Sec. VIII Div. 1) and for defined working conditions. The minimum and maximum design conditions are noted on the pressure vessel nameplate (see *Appendix 1*).

The design and manufacture of the PCHEs are in accordance with Alfa Laval's Quality Management System, which is certified to ISO 9001.

PED & Risk analysis

All units delivered in the EEC (European Economic Community) follow the PED (Pressure Equipment Directive) with a level of risk depending on parameters such as nature of the fluid (gas, liquid, steam, fluid vapour pressure), and the danger level of the fluid, Design Pressure, Volume of each circuit or Design temperature.
These parameters will determine a PED Category to which is linked to a risk analysis as per the PED. Make sure that the category of your unit matches your operating conditions.

1.3 Function and Duty

A PCHE is a compact plate type heat exchanger with a high heat transfer area per unit volume. Compared to other heat exchanger technologies such as shell-and-tube heat exchangers, PCHEs are significantly smaller. Typical applications for PCHEs include cooling, heating, evaporating and/or condensing of relatively clean fluids, high temperature and pressure applications, high pressure gas processing, compact reactors, compact recuperators for gas turbines, re-liquefaction units…

Each application, or duty, requires a specific installation which must be in conformity with the PCHE Data Sheet and General Arrangement (GA) drawing of the unit.

- **Pressure and temperature limits**
  Never operate the PCHE outside of the limits (design pressure and design temperature) indicated on the nameplate (*see Appendix 1*).

- **Duty**
  To ensure optimal efficiency, it is strongly recommended to operate your PCHE as close as possible to the conditions and the fluids used initially for designing the heat exchanger.

- **Corrosion risk**
  The materials of the parts in contact with the used medium have been specified or chosen based on data supplied by the customer (fluid, composition, temperature, etc.). If the media passing through the unit and the operating temperatures are different from those specified in the data sheet, the customer is responsible for ensuring that the corrosion resistance is suitable.

  Special attention shall be given to the chloride content of the streams, as this is a frequent cause of corrosion of stainless-steel materials.

If not otherwise agreed with Alfa Laval, responsibility regarding the duty or cleaning medium, and checking its compatibility with the materials used in the heat exchanger is with the customer or contractor. The quality of medium can considerably affect the operation and lifetime of the heat exchanger.

- **Applicability of specific conditions (on request only)**
  Specific allowable external loads (nozzle loads, wind, seismic…) can be calculated on request. It is customer's responsibility to inform Alfa Laval about these specific conditions to make sure that the design of the PCHE is suitable with these specific conditions. Check on the General Arrangement drawing and/or on the calculation note which specific conditions can be applied on your Alfa Laval PCHE.

- **Cyclical duty**
  If the heat exchanger must hold a certain number of cycles (thermal and/or mechanical cycles), the user shall provide the manufacturer with data relating to the cyclic conditions. This will permit Alfa Laval to evaluate the suitability of the design of the PCHE with such conditions. In this case, the theorical number of cycles would be found on the General Arrangement drawing.

- **Utilities (recommendations in case of water-based coolant)**
  If the application uses a water-based coolant on the cold side, there are specific requirements that need consideration early in the project during design of the coolant system, and later during operation of the coolant system.

  Typical descriptions given to water-based utilities used within PCHEs are inhibited fresh water, closed-loop cooling medium or glycol water of varying concentration.

  Although the name may vary, recommendations for the utility fluid chemistry are as follows:
  - Use of corrosion inhibitors appropriate to the expected operating temperature range in service
  - Low chloride level (up to 500 ppm where oxygen scavenger is present)
  - Low salinity and hardness
  - Alkaline pH (pH 9-10)
  - Low oxygen level (<0.2 ppm using additives)
  - Non-scaling throughout its expected operating temperature range

  Permanent, operating strainers are recommended for use in these applications; please refer to Section 2.9 and 4.2.1 for information about strainers.

2. Installation

2.1 General requirements and precautions

Personnel protection should be considered, and appropriate warning signage put in place to make sure that no one can touch the PCHE once in operation (risk of personnel injury). If also required, to avoid significant heat loss, suitable insulation or a cold box is recommended. Significant heat loss affects the performance of the PCHE and may influence the temperature of the fluids. Alfa Laval can provide clips for installation of insulation or personnel protection.

Similarly, for cryogenic or very cold services, thermal breaks should be installed between the PCHE support and its installation frame/foundation, to reduce heat loss.

Safety device shall be installed by the user to protect the PCHE against over-pressure.

Alfa Laval does not supply safety devices with PCHE: they must be incorporated with the pressure relief device of the system by the customer. Ensure that the pressure relief device is installed in the mating pipework and that there is no dangerous discharge of pressure relief blow off.

2.2 Site Preparation

The unit is supplied with supports that can be bolted on to a frame, a foundation or others; these are project-specific, and the relevant project-specific drawings should be referred to for method of installation. The installation method must be able to withstand the entire weight of the unit once filled with liquid. The weight and dimensions are shown in the GA drawing.

The PCHE's maximum allowable nozzle loads have been calculated as specified on the GA drawing. Do not exceed these loads as it may cause damage and deformation to the heat exchanger. Heavy on-site piping systems may need additional support to ensure the loads are not exceeded.

2.3 Receiving

Upon initial delivery, check the packing list to ensure all items have been delivered as expected and inspect the nameplate (see *Appendix* 1) to ensure the information (material, design conditions, etc.) complies with the order.

Upon delivery, remove the protective coverings.

Before throwing away the packaging accordingly to the applicable local regulations regarding the protection of the environment, verify that it does not contain any parts, such as spare bolts or gaskets, delivered with the equipment.

If the PCHE is shipped with nitrogen preservation (filled with nitrogen gas), unlock the valve to release the nitrogen and then disassemble the blank flanges. To avoid moisture ingress, the PCHE should be installed and connected to its pipework promptly.

2.4 Handling and Lifting

The handling of the PCHE should be done by qualified and competent personnel using certified lifting equipment and by appropriate lifting means. A lifting plan should be prepared so that hazards can be identified and managed. Ensure that the capacity of the lifting means correspond to the lift weight.
When handling the PCHE, avoid physical shocks to the core, nozzles, and headers as they can cause deformation and damage its structural integrity.

Lift the PCHE using the provided lifting lugs. Never lift the heat exchanger by its nozzles.

Lifting lugs position and design are depending on how the PCHE will be installed in your process (vertically or horizontally). Use Dee-type shackles to connect to the lifting lugs and lift using slings. Where provided, reference drawings or documentation will contain information such as unit weight, lift points and centre of gravity.

Figure 3. Dee-type shackles connected to lifting lugs for vertical unit (left) or horizontal unit (right).

The lifting load should be distributed evenly during lifting. Ensure the heat exchanger has safety landed on the intended location before removing the lifting devices.

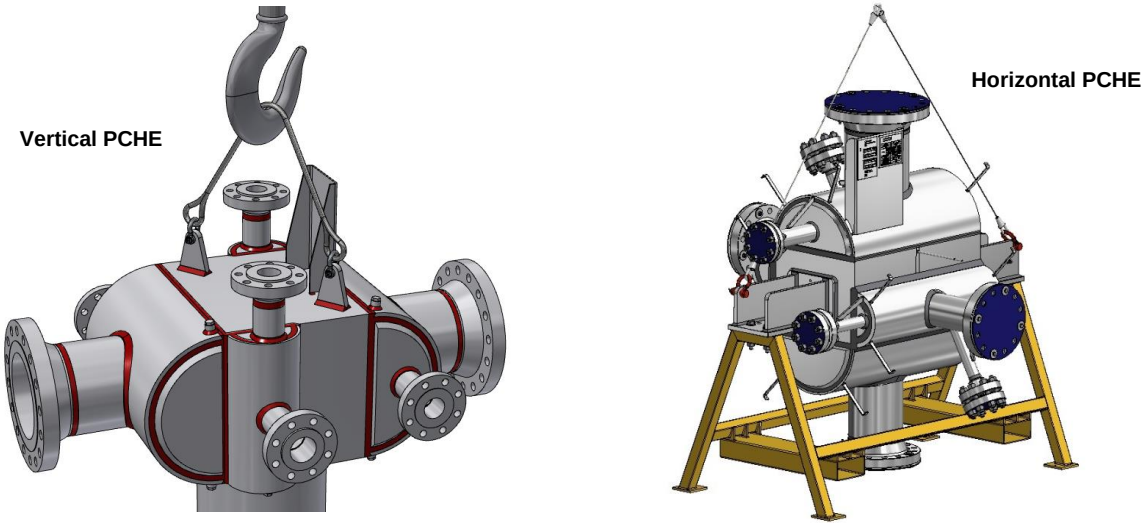

Figure 4. PCHEs with single-point lifting - vertical unit (left) or horizontal unit (right).

For safety reasons, never stand or work under suspended loads. Maintain a safe distance from the PCHE during lifting. Relevant personal protective equipment and safety equipment should be used.

2.5 Test and Inspection

If carrying out a pressure test, the test pressures shall not exceed those stated on the nameplate (see *Appendix 1*). For routine testing, use the design pressure (unless local regulation says otherwise).

If performing a hydrotest, ensure that the test medium is drained immediately after the test. Water quality for inspection or testing should be clean, with a low chloride content (recommended content <50ppm). Never use sea water.

2.6 Installation and connection

Installation must conform with the General Arrangement (GA) drawing of the unit. The PCHE should be installed in the right direction as designed (vertical or horizontal) for optimal operation. Flow direction (inlet and outlet) and nozzles of the hot and cold side are not interchangeable. They must be connected as per the GA drawing.

Ensure there are no packing materials or other loose parts around the PCHE before installation. Where possible, prepare adequate space around the PCHE to allow easy access for maintenance and inspection.

Clean all mating pipework and ensure they are drained and dry prior to hook-up. Commissioning or other debris and any scale in the piping system should be removed; see Section 2.9 for guidance on commissioning strainers.

During hook-up, ensure there is no leakage around connection points such as sensor ports, drain or vent ports, nozzles, and flanges. Piping flanges should be correctly aligned, and all connections should be correctly tightened.

All connections/nozzles are marked and should be piped accordingly. In case of doubt, check with the general arrangement drawing. Standard nozzle load limits are indicated on the General Arrangement drawing. For piping connections, Alfa Laval strongly recommends using bolting with material and gasket with properties (gasket factor / seating load). appropriate for performance required for this joint. Alfa Laval may set minimum requirements for bolting and/or gaskets for high performing joints. Where this occurs, notification will be made within the strength calculation notes provided with the product.

2.7 Grounding Connection

The connection of the PCHE to Earth is mandatory prior to operation start-up. Please use the earthing bosses provided for this purpose.

2.8 Storage

The PCHE needs to be stored indoors and the internals should not be directly exposed to air or moisture.

Prior to storage, the PCHE should be cleaned, rinsed, fully drained, and dried to avoid corrosion and to maintain its thermal performance. Connections must be closed with blind flanges, wooden covers, or plastic tape to prevent contamination.

For long-term storage, nitrogen preservation can be used to maintain dry internals and prevent rust formation. Regular visual inspection is recommended to monitor the nitrogen level and to detect any formation of rust.

If the PCHE is delivered with spare parts, these spare parts must be stored without time limitation in their original packing an in a dry indoor area. Gaskets must be stored in horizontal position.

2.9 Strainers or Filters

It is recommended to ensure that any particles or contaminants are removed from the fluid channels, and that they are prevented from entering the channels by installing the right strainers or filters to prevent clogging, fouling or erosion.

Ensure that the proper mesh size is installed. The maximum aperture opening is noted on the PCHE Data Sheet.

Even if fluids are expected to be clean while the exchanger is in operation, in our experience, we have found that even in clean applications, debris or other foulants can be introduced during commissioning.

Therefore, it is recommended to install temporary strainers in a removable spool leg upstream of all inlets to the exchanger during commissioning. The temporary strainer can be removed after commissioning and replaced with a spool pipe, or a permanent strainer if desired.

Where there is a liquid utility fluid entering the heat exchanger, such as water, an automatic self-cleaning strainer is recommended for continuous operation. Non-automatic self-cleaning strainers, such as tee-type or bucket-type strainers, may be used instead, with potentially more frequent operational maintenance stops should the strainers need to be cleaned.

To avoid fouling due to corrosion of pipes, it is recommended that stainless steel piping is used. If carbon steel, aluminised piping or other material is used, it is highly recommended that permanent or in-service strainers be utilised, and all pipework in between the inlet strainer and the heat exchanger should be made from stainless steel.

When sizing your installation, please consider the pressure drop related to the strainer or the filter (not included in the heat exchanger pressure drop indicated on the PCHE Data Sheet).

For more information on strainer monitoring during operation, please refer to Section 4.2.1.

3. Operation

3.1 Start-Up

3.1.1 Before Start-Up

Check that the actual operating conditions do not exceed the limits noted on the nameplate (see *Appendix 1*).

The heat exchanger in operation can operate with high or very cold temperatures and with aggressive media. It is necessary to provide personnel protection measures in accordance with the applicable safety regulations and work safety codes at the customer site.

Ensure the unit has appropriate personnel protection or insulation for operator safety.

Ensure that all the blind flanges are sealed. During shipment or prolongated periods of shutdown, gaskets and/or bolting may loosen. Torque all bolts. The maintenance/service point bolts (and any vents/drains) should be tightened in a diagonally opposite sequence.

Connect the PCHE to Earth.

3.1.2 Venting

Venting can be carried out via the process nozzles or dedicated vent nozzle.

Ensure venting during the start-up process. Remaining air pockets can cause air locks, reducing the heat transfer capacity and increasing the risk of corrosion.

3.1.3 During Start-Up

To extend the lifetime of the unit, start-up must be gradual and smooth. Flow rate increase must be slow to avoid the risk of water hammer or fatigue effects. Rapid temperature changes can also reduce the lifetime of the PCHE.

The fluid that is the closest to room temperature shall be introduced first. Our recommendation is to have a temperature ramp-up lower than 180°C per hour.

It is recommended that once the flowrate on the first side is at 100%, that the other fluid is gradually introduced. Our recommendation is to have a temperature ramp-up lower than 180°C per hour.

Temperature control valves shall be open progressively.

Commissioning is a critical period where you have the highest likelihood of process instability. Subsequently, it is recommended that the temperature control valve is set to manual to avoid/limit unstable flow (rapid temperature change) during commissioning.

3.2 In Service

3.2.1 During Operation

The operating pressures and temperatures must not exceed the maximum or minimum design values stated on the nameplate (*see Appendix 1*).

Maintain flow rates at or near to the designed values as much as possible. Flow rates much lower than design values may result in accelerated fouling and reduced thermal efficiency. In installations with multiple units or trains in parallel, variations in capacity are best handled by varying the number of units in operation rather than by major variations in flow per unit.

The PCHE is designed to be operated with the specified fluids on the PCHE Data Sheet. Process stream compositions should be maintained for compliance with the specified process data. Should the compositions change, ensure they are stable (i.e., will not decompose over time or at the operating temperature and pressure) and suitable for use (non-reactive) with the heat exchanger material of construction.

Operate at nominal steady state; keep fluctuations within or better than +/- 5% for both temperatures and flows.

Never touch the heat exchanger directly while it is operating. Ensure personnel protective insulation is provided and do not enter within proximity of the PCHE without any protection or safety clothes.

The exchanger must not be exposed to open flame.

3.2.2 Process Control

Control equipment is not provided with the PCHE. This is generally installed later by the package builder or the plant contractor.

The control system must not introduce substantial instabilities when applying performance control to the exchanger.

A PCHE's internal metal temperature reacts very quickly to changes in conditions, such as changes in flow. This is due to its low thermal mass, a feature in common with other compact exchangers.

Temperature sensing devices and transmitters, in comparison, have a slower thermal response time. Hence, there is a time delay between the fluid's actual temperature in the conveying piping, and the measured temperature.

The control system must consider this and make allowances to be adjusted. Its response should be dampened to avoid overshooting and to prevent resulting cycling. If the control system is poorly tuned or responding too quickly, the resulting harmful instability will create thermal stresses inside the core. Thermal fatigue cracks may form within the metal between hot and cold plates, leading to inter-stream leakage.

3.2.3 Gas Cooler Applications

How to avoid thermal fatigue in gas coolers:

- **Consider the preliminary control valve controller settings carefully.**

  Review the settings early, during test and commissioning, to confirm they are suitable for long term operation. Tune the control valve. Monitor the control system for stability.

- **Avoid sudden changes in fluid flow rates or flow instabilities.**

  The control system should be tuned to avoid large amplitude, high frequency flow variation. The exchanger should be operated at nominal steady state; that is, keep fluctuations within or better than ±5% for temperature and flow, which should be readily achievable in the field.

  The paragraph above applies to nominal steady operation. Outside of that, the PCHE can withstand instantaneous flow rate changes during the brief periods of changing operating mode such as during normal start-up and shutdown, and process upsets.

- **Install a physical minimum stop on the control valve.**

  For utility streams that have a control valve fitted, it is recommended that a minimum stop is included on the flow control valve. This stop prevents undesired full closure of the valve and flow. This can occur if the valve is not tuned.

  Minimum stops of 20-30% are recommended.

  Ideally, once operating, this stop should be raised to as high a level as possible which still allows control during operation. The flow stop is recommended to be a physical stop rather than a digital (software) limit.

  Ensure the minimum stop provides adequate coolant flow during start-up. There may be a minimum flow to ensure gas cooling to a specific temperature requirement, or minimum flow to avoid particulate settlement and wall shear.

- **Ensure coolant pressure is high enough to avoid boiling.**

  Boiling can be highly unstable, damaging the exchanger with fluctuation wall temperatures during this process.

3.2.4 System Monitoring

Instrumentation is not provided with the unit. This is generally installed later by the package builder or the plant contractor.

Regular inspections should be carried out on instrumentation such as pressure transmitters, flow meters and temperature gauges to secure that they work correctly.

To ensure trouble free operation, it is recommended that the following parameters are monitored and preferably recorded for both sides:

- Stream flow rate
- Stream inlet and outlet temperatures
- Stream pressure drop
- Control valve output

Recorded measurements should be taken over a period of two hours, at intervals of 15 seconds. Raw measurements should be recorded. Do not average measurements as these can reduce peaks and troughs.

If applicable, take measurements during different operating modes. A different operating mode can be any large operational change or significant change in process conditions, including but not limited to:

- Turndown conditions
- Changes in gas flow
- Significant changes in gas compositions
- Start-up / shut-down

The critical recording period is during the first 3 months of operation.

System stability should be reassessed once a year or whenever there are changes to the process.

3.3 Shut Down

3.3.1 During Shut Down

It is the reverse procedure of start-up. Ideally, flow rates should be reduced slowly and gradually.

The fluid with the operating temperature the furthest of the ambient temperature shall be reduced first and shut down prior to the fluid the closest to the ambient temperature.

To avoid injury to operators, do not touch the unit until its external temperature is the same as the ambient temperature.

3.3.2 Draining

Draining can be carried out via the process nozzles or dedicated drain nozzle (when they exist).

If the planned stoppage period is of a short duration and if the unit will not be opened, the unit need not be drained to facilitate restart.

For longer stoppage periods or if the PCHE is shut down for several days, it should be drained. Draining must also be done if the process is shut down and the ambient temperature is below the freezing temperature of the fluid.

If the fluids are hot, allow the unit to cool down to ambient temperature before draining, to prevent possible injury to operators.

Make sure that pressure has been removed on both sides before opening or draining.

Make sure toxic, hazardous, lethal vapours or liquids are not released to the atmosphere or to the ground. These could cause injury to people and/or damage to the environment. Any toxic or hazardous fluids should be treated as per local environmental, health and safety regulations.

Depending on the process fluids used, it is also recommended to clean, rinse, drain, and dry the unit if the shutdown is of a longer duration.

4. Maintenance

Before any examination requiring to be in contact with the inside of a heat exchanger, both circuits shall be drained and rinsed to avoid any risk of injury due to toxic or corrosive fluid.

4.1 Inspection

It is recommended that the heat exchanger is visually inspected at regular intervals such as during regular plant shutdowns and maintenance periods.

External inspection should check for intactness of the surface finishing (paint or other coatings) and any signs of corrosion.

Internal inspection can be used to check for signs of fouling (with borescope at the inlet of the channels via service connections).

Mandatory inspections must be achieved according to local regulations with the periodicity required by local authorities.

4.2 Fouling and Clogging

Due to the size of the fluid flow channels, the PCHE should be used with clean fluids.

If topping up utilities such as water or water-glycol mixtures, ensure that the make-up fluid is clean, and the concentration of any inhibitors are maintained as per the original specification.

Any carry-over of oil, lubricant or other foulants from upstream equipment should be minimised as far as practicable, as they will result in fouling of the heat exchanger.

4.2.1 Strainer or Filter

Where filters and strainers are installed, they should be checked and cleaned at regular intervals to prevent clogging and to ensure optimal performance. Check-up periods will be dependent on the size of contaminant, cleanliness of fluid, flow rate, etc.

It is recommended to visually inspect the strainers. This is mostly likely to occur during any convenient shutdown period of the process.

The pressure drop across the strainer must be monitored. It is an indicator for scheduling strainer maintenance and cleaning.

Do not allow excessive build-up of particulates in the strainer and ensure that the pressure drop does not exceed its burst pressure. If a strainer becomes so clogged that it bursts, foulant and strainer mesh parts will enter and clog the heat transfer channels, resulting in a longer production stop to clean the heat exchanger instead of the strainer.

4.2.2 Heat Exchanger

During operation, temperatures, flow rates, and pressure drops should be checked regularly. Differential pressure drop monitoring across both sides of the heat exchanger is recommended. Increased pressure drops or falling temperatures and flow rates indicate that there is restriction and fouling inside the unit.

If the pressure drop is higher than that specified on the PCHE Data Sheet, first check that the pressure transmitter is working properly and that the flow rate is within limits. Make sure that no other equipment in your line also causes unexpected pressure drop.

If fouling is suspected, please contact Alfa Laval for further investigation to assess whether the heat exchanger is fouled or whether the pressure drop level is expected for the process conditions at the time operation.

If a heat exchanger becomes fouled, as part of preventative maintenance it is important to clean sooner rather than later as a heavily fouled exchanger will be more difficult to clean.

4.3 Cleaning

The more often cleaning is carried out, the better the heat transfer performance is maintained at original levels. Delaying cleaning makes the recovery of initial heat transfer performances more difficult.

While cleaning, the correct safety procedures should always be followed. Personnel shall wear protection gear and clothes before entering the cleaning area.

Install PCHE within a spill containment tray to avoid any pollution in case of run-offs during cleaning. All applicable health, safety, and local environmental code shall be followed by the operator while cleaning is carried out.

4.3.1 Gas Puffing or Flushing

If fouling is not severe, gas puffing or flushing can remove light fouling or small particles which are stuck in the channels.

Gas puffing is a mechanical cleaning method that uses sudden high pressure gas depressurisation against the direction of normal flow (i.e., from outlet to inlet). Alfa Laval does not propose gas puffing service; it is just evoked here as a possible efficient way to clean your PCHE.

A calibrated bursting disc is located on the inlet of the exchanger. The heat exchanger is then slowly pressurised from the outlet, with nitrogen or service air, up to but not higher than either 15 barg or the design pressure of the side being cleaned, whichever is lower.

The bursting disc is typically calibrated to burst at no higher than 15 barg or 80% of the design pressure. When the bursting disc ruptures, particulates in the heat exchanger are expelled along with the nitrogen or service air.

Cleaning by flushing involves flushing the heat exchanger with a large volume of water, either in the same direction as during operation or in the opposite direction.

Water quality should be clean and non-scaling, with a low chloride concentration. Never use dirty water or sea water for flushing as they may cause corrosion inside the unit.

4.3.2 Ultra-High Pressure (UHP) Water Jetting

UHP water jetting uses high pressure water to break up and expel foulant from the internals of the heat exchanger. Fouling can be removed efficiently using this method.

UHP water jetting can be performed if the heat exchanger is fitted with maintenance nozzles, or if the process nozzle is large enough. It can be performed in-place, or the exchanger can be taken offline for cleaning. If cleaning in-place, ensure there is at least 1.5m clearance at the maintenance nozzles to provide UHP working access to direct flow into the PCHE.

UHP water jetting must be performed by authorized and qualified personnel. Personnel shall wear protection gear and clothes before entering the cleaning area.

Before cleaning a PCHE, make sure it is empty.
Collect the fluid to avoid any pollution of the environment.

4.3.3 Chemical Cleaning

Fouling can usually efficiently dissolve in chemical solvents or acids. The correct chemicals shall be chosen: the selected cleaning fluid shall be compatible with, and not affect, the integrity of the heat exchanger. PCHEs are generally made from stainless steel. The material(s) of parts in contact with the fluids are indicated on the GA Drawing.

Chemical cleaning can be performed in-place (CIP) or the exchanger can be taken offline for cleaning. When cleaning, ensure that there is sufficient space for cleaning equipment.

Use an adapted container to collect the cleaning effluents.

Never use hydrochloric acid or other cleaning substances containing chlorides as their presence will inevitably lead to corrosion of stainless-steel alloy components

The chemical cleaning must be carried out by an authorized and qualified operator.

4.4 Leak Detection

Periodic pressure retaining test

Alfa Laval recommends conducting periodic leak tests, typically once every two years. These will disclose the presence of any inter-stream leakage and allow the operator to act before it becomes problematic.

Real-time leak detection

In the case of high-pressure hydrocarbon streams paired with lower pressure utilities such as water, monitoring for leakage during operation is possible and recommended. If the lower pressure utility has an expansion tank, any leakage will bubble or dissolve from the hydrocarbon stream into the lower pressure utility flowing out of the exchanger. The hydrocarbon will collect in the expansion tank high point. It is recommended that the expansion tank is blanketed using an inert gas such as nitrogen so that a hydrocarbon sensing device can be installed to detect leakage.

4.5 Recommended Spare Parts

It is recommended to keep a supply of spare bolts and gaskets for the flanges.
Refer to the chapter 2.8 for the storage of the spare parts.

5. Waste management and scrapping

Throughout the lifecycle of the PCHE, the owner is responsible for managing the waste related to any equipment or material delivered by Alfa Laval (e.g., packing material of the delivered PCHE, packaging of spare parts, used spare parts like gaskets, etc.) according to the applicable local regulations regarding the protection of the environment.

The PCHE can be subject to scrapping if, according to results of a technical inspection, the end of life of the PCHE is confirmed. The owner is responsible for carrying out the disposal of the scrap-metal in accordance with the applicable local legislation and regulations regarding protection of the environment.

Appendix 1: Nameplate

A nameplate is fixed to the frame of the heat exchanger with the following data (*see drawing below*):

- 1: manufacturer
- 2: type of heat exchanger
- 3: serial number
- 4: year of built
- 5: fluid group : 1 for dangerous fluid and 2 for non-dangerous fluid
  This field is related to PED regulation filled only for units submitted to PED
- 6: identification of nozzle (please refer to General arrangement drawing)
- 7: volume per side including nozzles
- 8: design pressure for both media (maximum pressure for which the equipment is designed (FV = Full Vacuum))
- 9: design temperatures for both media (maximum and minimum temperatures for which the equipment is designed)
- 10: differential / simultaneous test pressure per side
- 11: maximum operating temperature per side
- 12: date of pressure test
- 13: weight of the unit (empty/full)
- 14: Tag Number or other customer identification information (if specified and required by customer)
- 15: maximum differential pressure between both sides
  Please notice that this information is only indicated when this restriction is applicable Differential pressure across sides A and B shall never exceed this value when this value is specified!
- 16: “CE” tag - when required by PED.
  A paper copy of filled nameplate is attached to documentation accompanying physically the unit when PED applicable. Customer’s values are engraved on the nameplate of each.
- 17: core material (when indicated)
- 18: other information (like QR code for example…)
- 19: warning reminder: always read Instruction Manual before any activity regarding installation, operation and maintenance of the heat exchanger!
- 20: construction code (and local regulation if applicable) used for designing the unit

Example of nameplate: