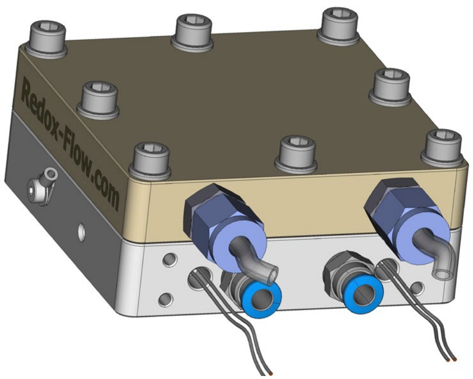
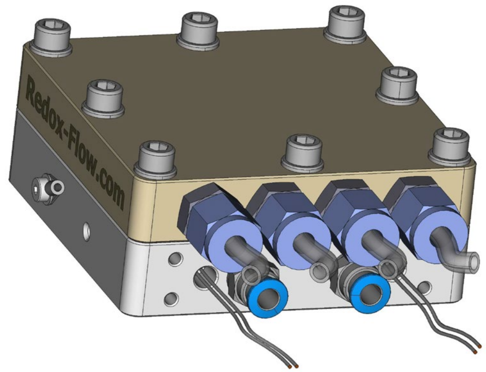
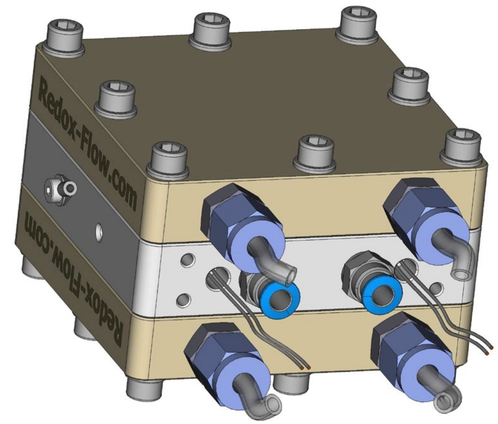
Electrolyte heating & cooling unit

Overview & assembly manual







Version date	December 18 – 2025
Manual version	2.0 - visit www.redox-flow.com for updated versions and spare parts
Notes	This equipment is intended for research purposes only and can be applied for different purposes. There is no guarantee on performance, corrosion or lifetime of the equipment. See https://redox-flow.com/termsandconditions/ for more information.

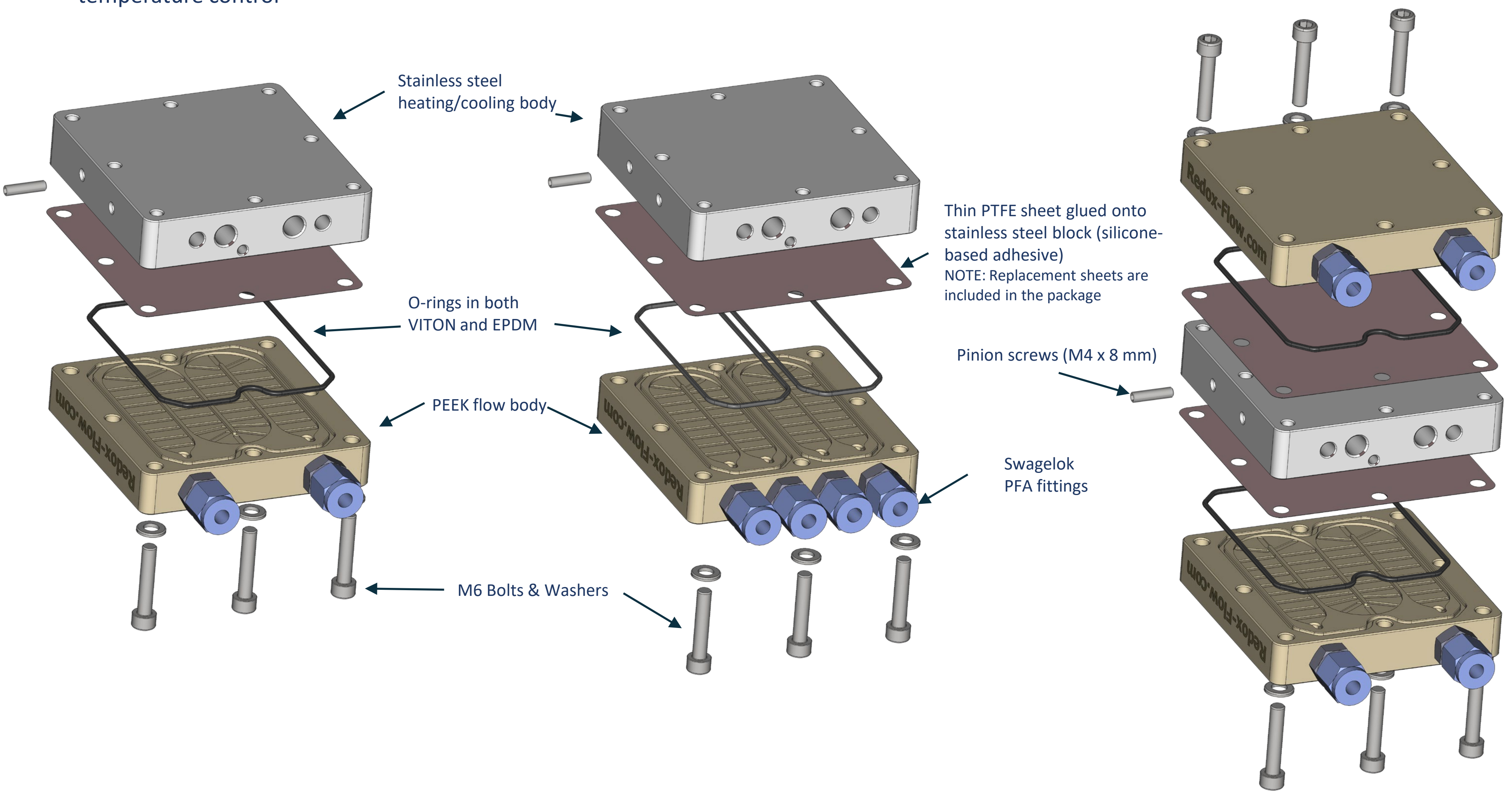
Overview of variants & components

Electrolyte heating & cooling unit comes in three different variants

1. Single electrolyte flow temperature control

2. Double electrolyte flow temperature control

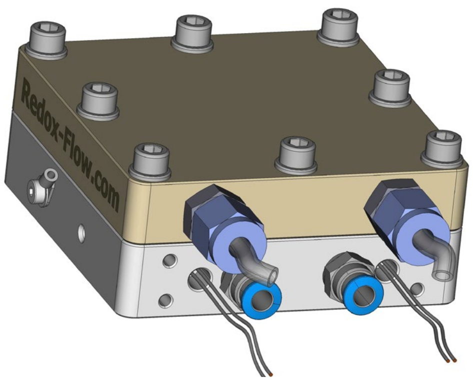
3. High power electrolyte temperature control



Working principles

Based on the three main components, the electrolyte heating & cooling unit comes in three different variants

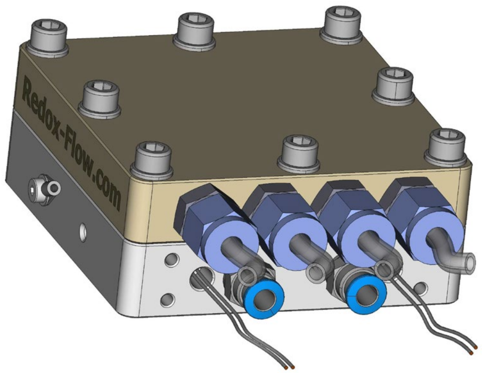
1. Single electrolyte flow temperature control



This unit can control a single electrolyte temperature by

- Heating plate (only heating)
- Heat cartridges (only heating)
- Heating/Cooling liquid (heating & cooling)

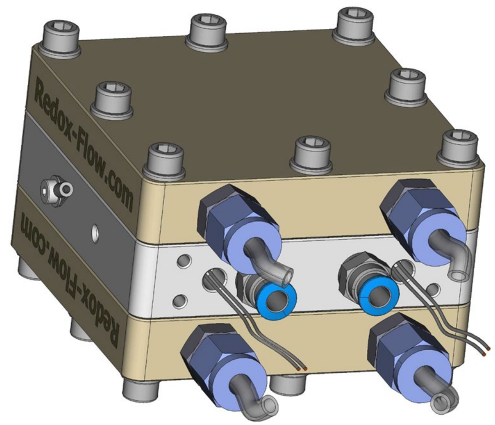
2. Double electrolyte flow temperature control



This unit can control a double electrolyte temperature by

- Heating plate (only heating)
- Heat cartridges (only heating)
- Heating/Cooling liquid (heating & cooling)

3. High power electrolyte temperature control

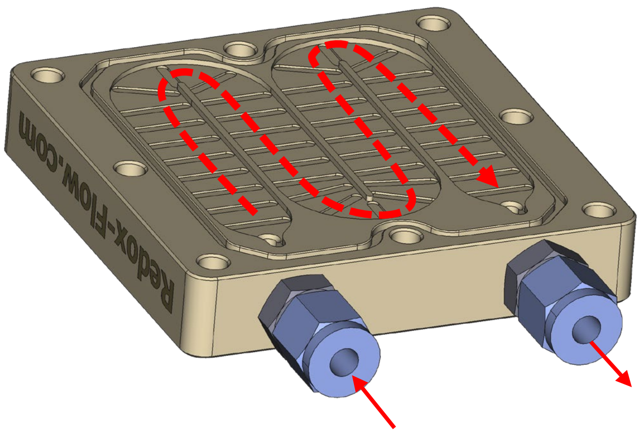


This unit can control a double electrolyte temperature by

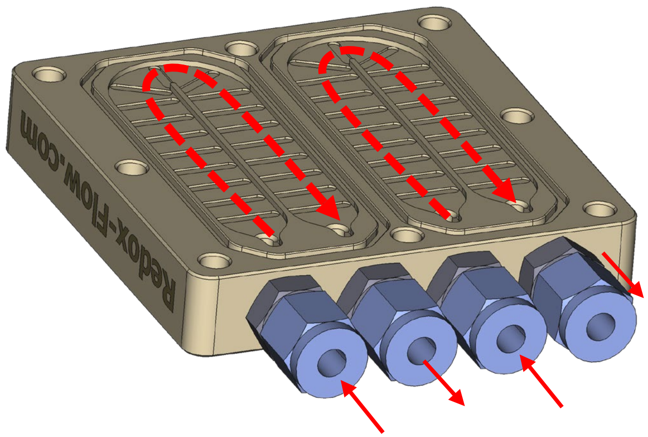
- Heat cartridges (only heating)
- Heating/Cooling liquid (heating & cooling)

Working principles

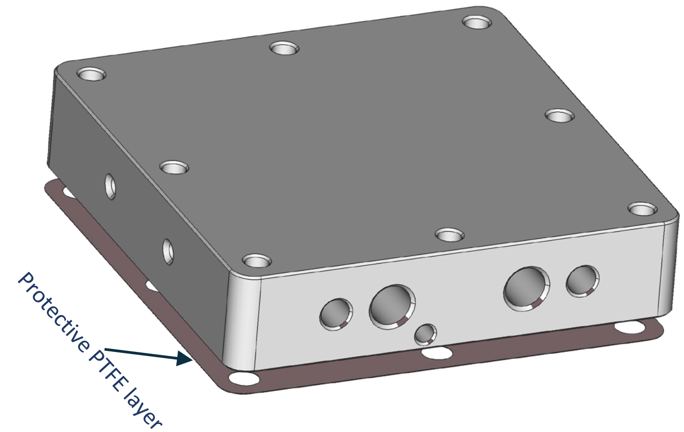
All three variants are based on combinations of three components

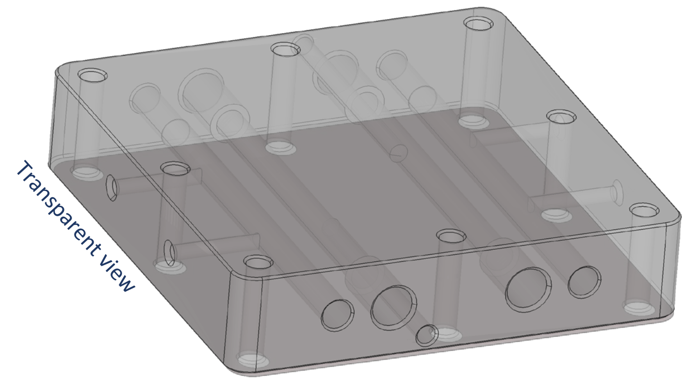


1. Single electrolyte PEEK flow body



2. Double electrolyte PEEK flow body





All options are based on a PEEK flow body and stainless steel block shown in the pictures. The PEEK body comes in two variants, one that can heat a single electrolyte/flow (part **1**) and one that can heat two independent electrolytes/flows (part **2**). The liquids in the experimental setup are circulated through the PEEK flow body and placed up against a stainless steel heating/cooling plate (part **3**), whereby heat is transferred to or from the liquids in the PEEK flow body. The stainless steel plate is separated from the liquids in the experimental setup by a thin PTFE layer that is glued on to the stainless steel block.

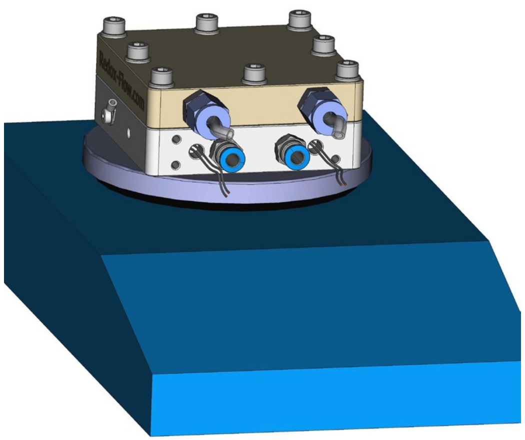
3. Stainless steel heating/cooling block

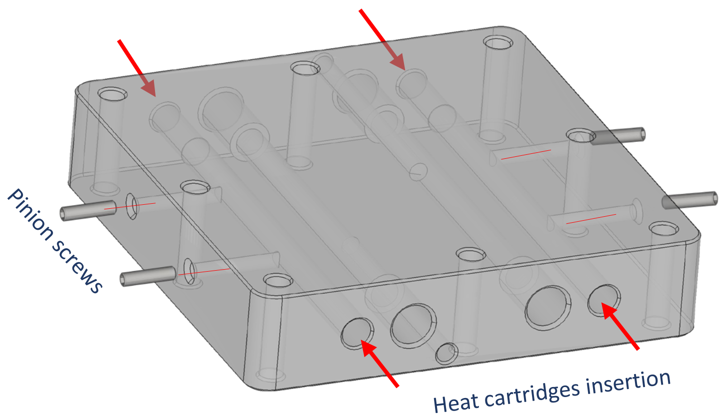
The heating/cooling unit is temperature controlled by either (i) heating plating (ii) heating cartridge or (iii) cooling heating liquid.
NOTE: The stainless steel block is corrosion protected from the electrolyte by a thing PTFE layer that is glued to the stainless steel block

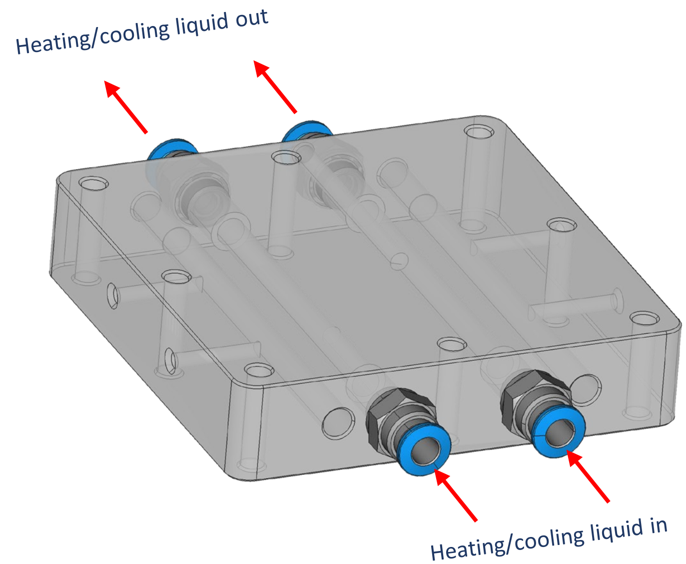
Working principles

Heating & Cooling options - The stainless steel block can be heated/cooled by either

- Hotplate (heating only)
- Heat cartridges (heating only)
- Heating/cooling liquid (heating and cooling)







1. Hotplate operation - When heating unit is assembled it is placed on the hotplate and the liquid flowing through the unit is temperature controlled by the hotplate

NOTE: Hotplate operation is not possible for the high power heating unit where the stainless steel block is surrounded by PEEK blocks on both sides.

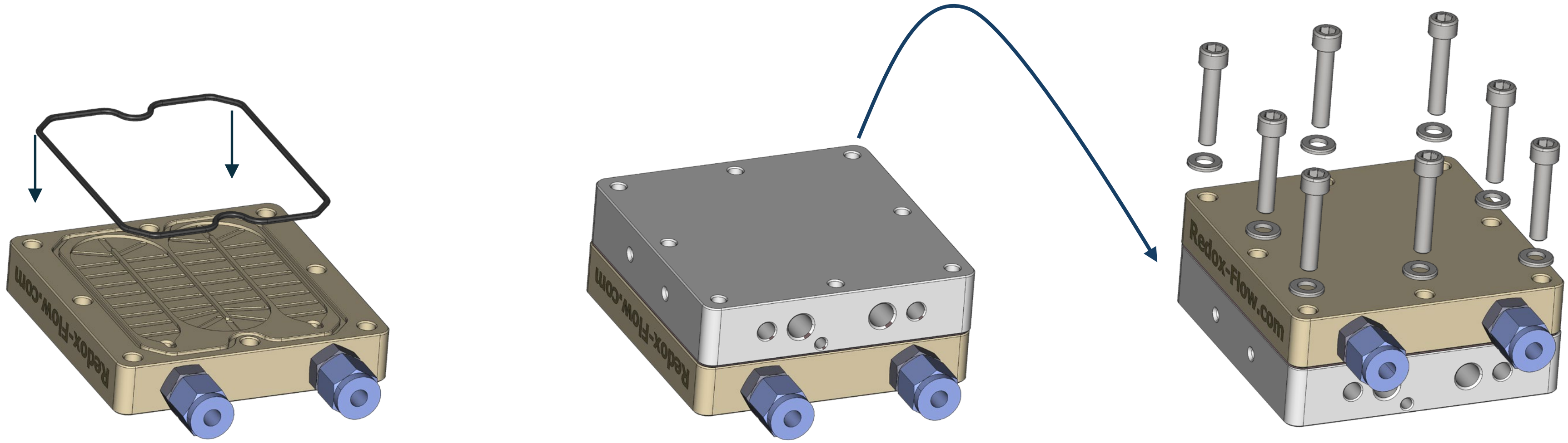
2. Heat cartridge operation – ¼´´ (or 6.35 mm) heat cartridges can be placed inside the holes in the stainless steel block. Depending on the length of the heat cartridges between one and four heat cartridges can be mounted. The cartridges are kept in place by pinion screws from the side.

3. Heating/cooling liquid operation – The two middle holes have threads for 1/8´´ BSPP fittings that can used for circulating a heating or cooling liquid in the stainless steel block to control the temperature.

NOTES: Picture is shown with push-in fittings, but any type can be used (including barbed) but depends on the specific liquid type and temperature.

Due to the many different types of heating/cooling liquids and external devices, fittings are not supplied with the unit.

Assembly below is shown for single flow PEEK body, but is similar for the other two variant and is not explicitly shown



1. O-ring (EPDM or VITON) is mounted in PEEK flow body

2. Stainless steel block is placed on top of PEEK flow body

3. Stainless steel block and PEEK flow body is turned 180° and M6 bolt and washers are screwed into stainless steel block.

Important notes:

- Cross-tighten bolts
- Do not overtighten bolts
- Once O-ring starts to be compressed the tightening becomes harder
- Once PEEK flow body has contact with stainless steel block tightening becomes very hard. This is a signal to STOP TIGHTENING.

General notes: Before use with electrolytes, it is recommended to do a leak test, by circulating pure water at high flow rates. If leaks appear

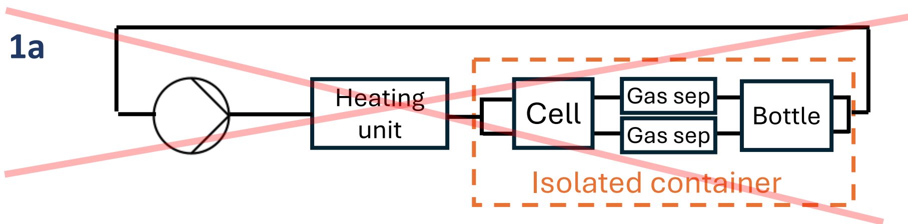
- this can be caused by wrong cross-tightening (e.g. measure assembly with caliber at all four corners (should be within 0.1 mm or less).
- Tiny amounts of silicone-based grease can be applied to the O-ring(s). Remember to wipe of the O-ring with a (fiber free) cloth after applying the grease

Hydraulic circuits

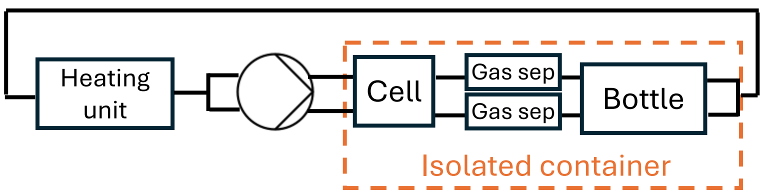
Heating & Cooling options – The hydraulic circuit and order of unit can be done in many ways and depends on the specific application. Descriptions below are general considerations and users must make their own evaluations and design of the circuits.

Single electrolyte PEEK flow body

1a

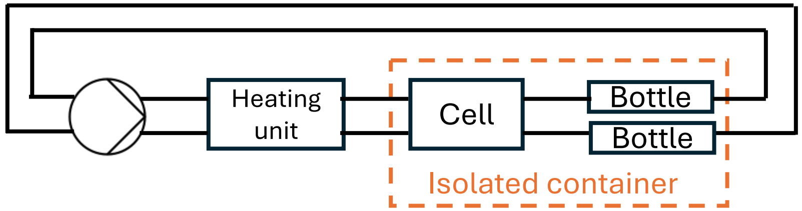


1b



Double electrolyte PEEK flow body

2



Circuit 2 - Here a *double electrolyte PEEK flow body* is used and is the recommend default circuit for electrochemical systems with two separate electrolytes (e.g. flow batteries). But it can also be used for electrolyser with one common electrolyte (no T connections are needed in this case).

Circuits 1a-1b - Here a *single electrolyte PEEK flow body* is used and is typically intended for electrolysers with one common electrolyte. In all cases two T connections are need.

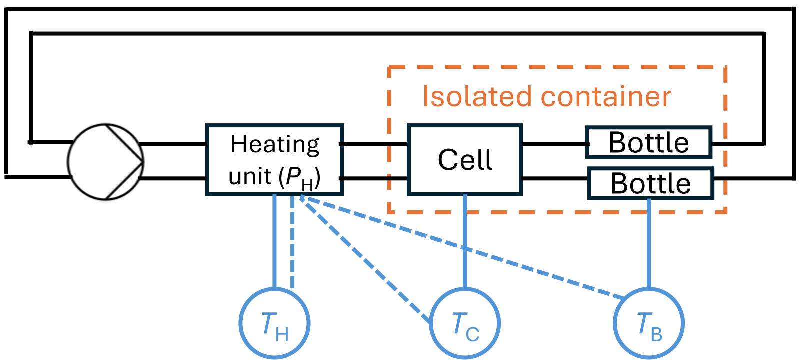
- Circuit 1a is not recommend for any application – The issue is that there is only a single flow/strem from the pump that is being split into to two flows/streams. Any (small) difference in the hydraulic resistance of the two streams will lead to significant difference in the flow rates in the two streams
- Circuit 1b is the recommended circuit – Here the pump (e.g. 2 channel peristaltic pump) has two individual flows for each side of the electrochemical cell. This ensures that the flow rates are approximately the same and approximately independent of differences in the hydraulic resistances. NOTE: Variants of 1b can be made, e.g. placing the 2nd T fitting close to the heating unit or having combined bottles/gas separators etc

General notes

- When the cell and bottle(s) are placed in a common isolated container/box, the heat dissipation from the bottle heats up the container and helps to heat the outside of the cell and reach 'absolute' temperature stability faster. However, cell and bottle can be placed in separate isolated boxes, but here the outside temperature of the cell will take much longer to reach stability (still the inside electrode and current collector temperature may be stable)
- Bottle must be placed after the cell otherwise pressure can be built up inside it

Temperature control strategy and safety considerations

Temperature control can be done in several ways and depends on the specific application. Descriptions below are general considerations; feasibility depends on specific capabilities of external heating/cooling equipment.



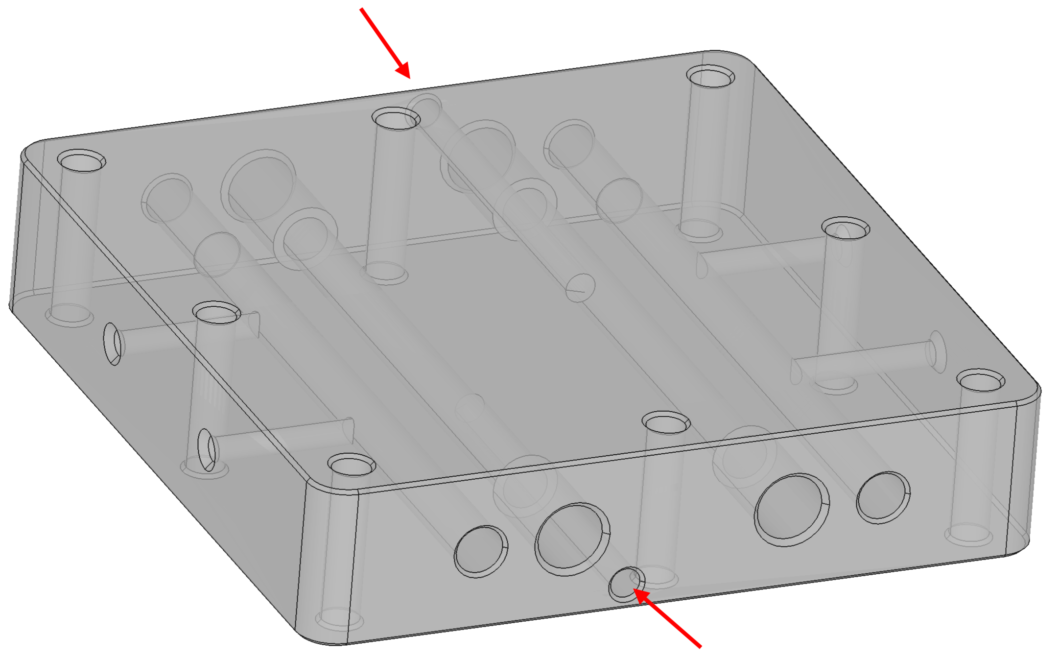
Temperature control strategies - Schematic figure to the left shows a general outline of a setup with a heating/cooling unit. Here the temperature can be measured in the stainless steel block of the heating unit (T_H), a thermometer in the cell (T_C) or electrolyte bottle (T_B). The dotted lines show possible feedback to the (PID) control of the heating/cooling power (P_H) of the heating unit.
The advantages and disadvantage of each is summarized in the table below.
As stated, in the table temperature control by T_C gives the fastest time to temperature stability, but it requires more considerations on safety measures.

	Advantages	Disadvantages
T_H	- Highest safety - Can be integrated with most/all external temperature control units through internal thermometer	- Longer time for temperature stability in cell
T_C	- Fastest to reach temperature stability in the cell/electrode (provided that the thermometer is placed close to current collector/electrode as in the Redox-Flow cells)	- Some external temperature control units cannot be controlled by external thermometers - For safety reason there must be a thermometer in the temperature control unit that ensures that temperature in the stainless steel block does not reach excessive levels. E.g. in the case where the pump malfunctions and there is no flow and T_C remains constant
T_B	- An alternative to control by T_C, however, temperature stability in the cell/electrode will be slower	- Same as above

Important notes: For safety reasons, it is recommended that stainless steel block temperature does not exceed significantly above the boiling points of the electrolytes pumped through the heating unit. It is to prevent dangerous pressure increase in the hydraulic circuit. The maximum temperature also depends on the flow rates, where high flow rates will permit higher temperatures in the stainless steel block.

Thermometers

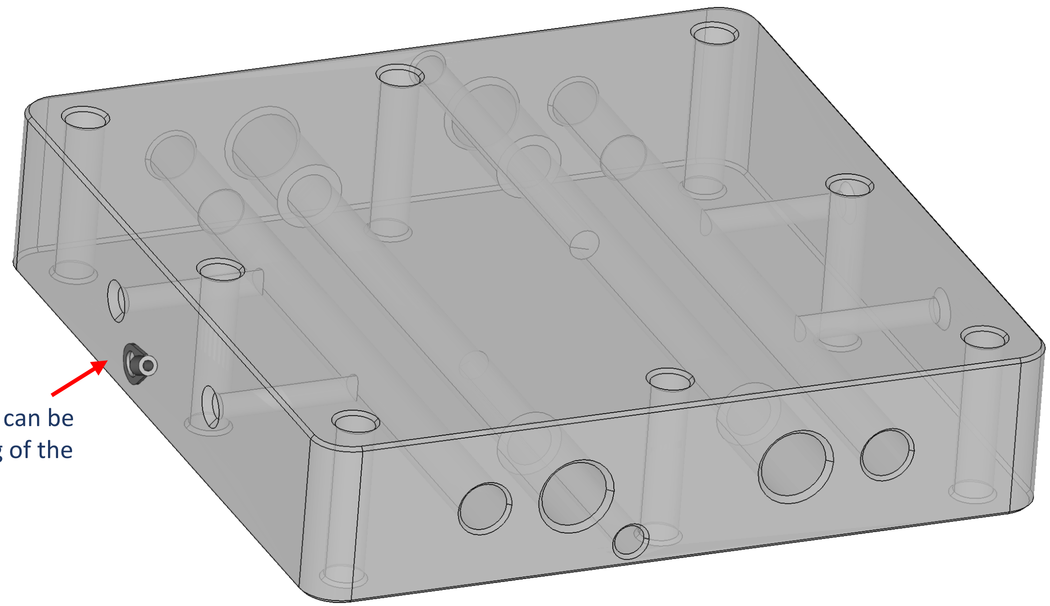
The stainless steel block comes with ø4 mm holes that explicitly have been made for temperature sensors. However, the other holes (heat cartridges or cooling/heating liquid) can also be used for thermometers (if unused)



Ø4 mm holes for temperature sensors

Grounding of stainless steel block

If the stainless steel block is fitted with heat cartridges, it is for safety recommended to electrically ground the stainless steel block. An example is shown below.



Cable lug with (Ø4 mm bolt) can be used for electrical grounding of the stainless steel block.

Replacement of PTFE layer on stainless steel block

The PTFE layer on the stainless steel block is anticipated to endure through-out the lifetime of the product. However, due to scratches or similar it may be necessary to change it. For this reason the unit comes with two replacement PTFE sheet (approximately 12 cm x 12 cm). When replacing follow the instructions:

1. Ensure that the old PTFE layer and adhesive is completely removed from the stainless steel block
2. Place the new PTFE layer on the block and use a tool (e.g. 'credit card' like tool) to scrabe on the surface to ensure that the PTFE sheet adheres well to the stainless steel block and that no air bubbles remain under the PTFE layer.
3. Place the stainless steel block on a flat surface with the PTFE facing downward and an 2-4 kg item on top for 24 hours to ensure that the PTFE layer adheres well to the stainless steel block