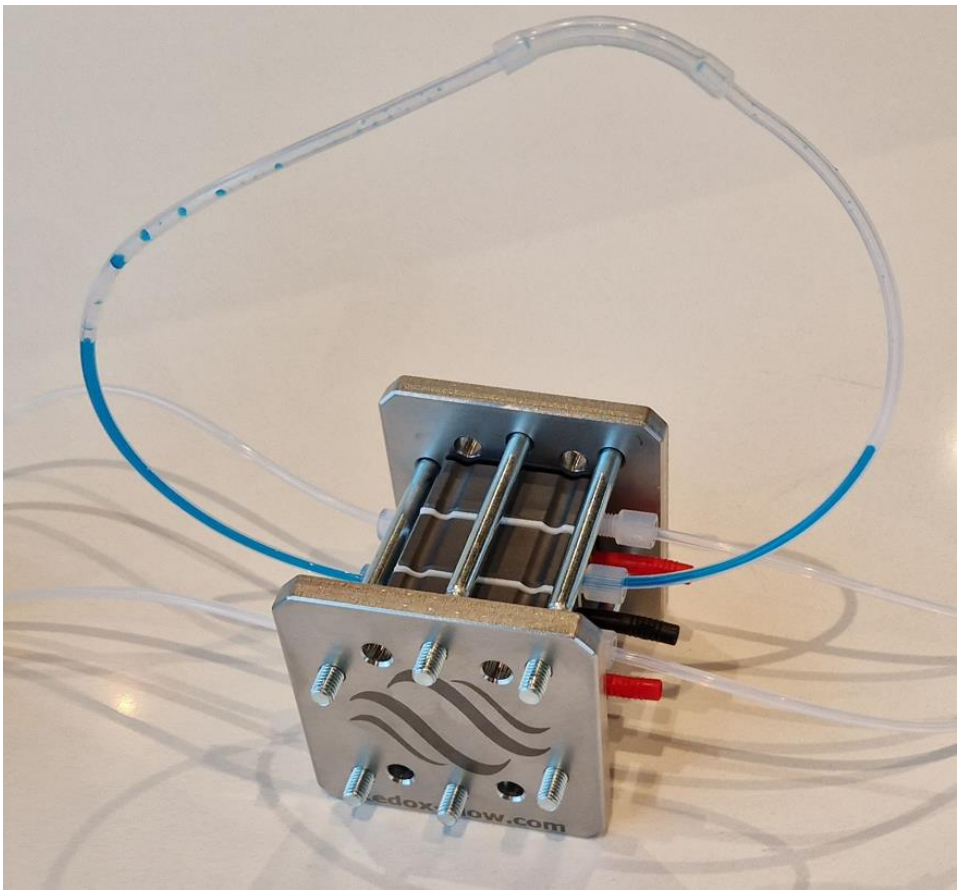
OCV Cell

Overview & assembly manual

Redox Flow
www.redox-flow.com



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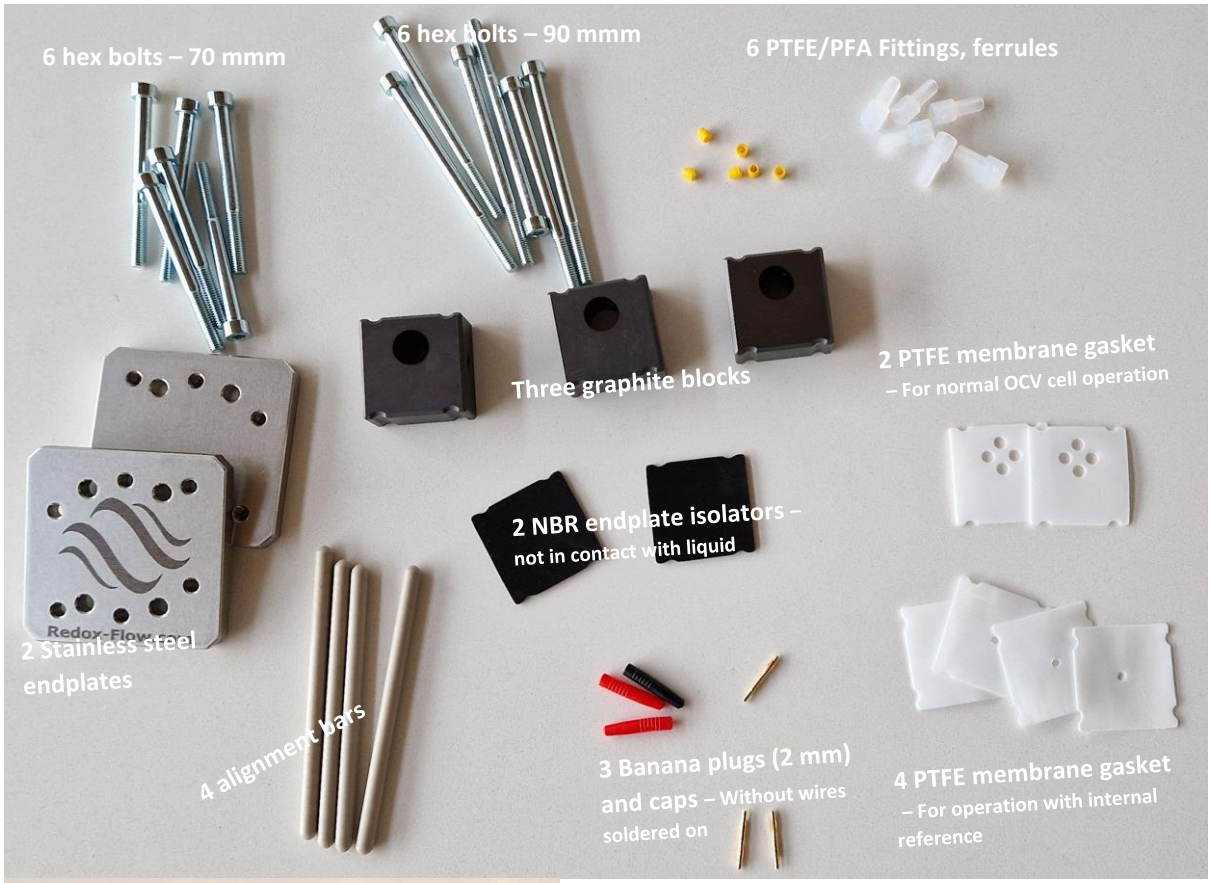
Notes

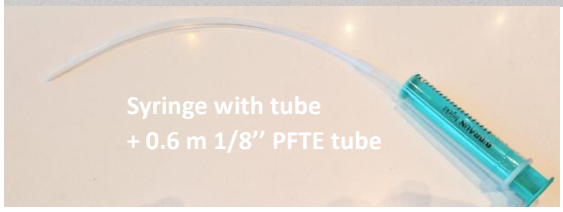
This OCV cell is intended for research purposes only and can be assembled in several ways. The main two ones show below (*Normal OCV cell (no internal reference)* and *OCV cell with internal reference*).

There is no warranty on performance, corrosion, or lifetime on the items. It is purely for research purposes.

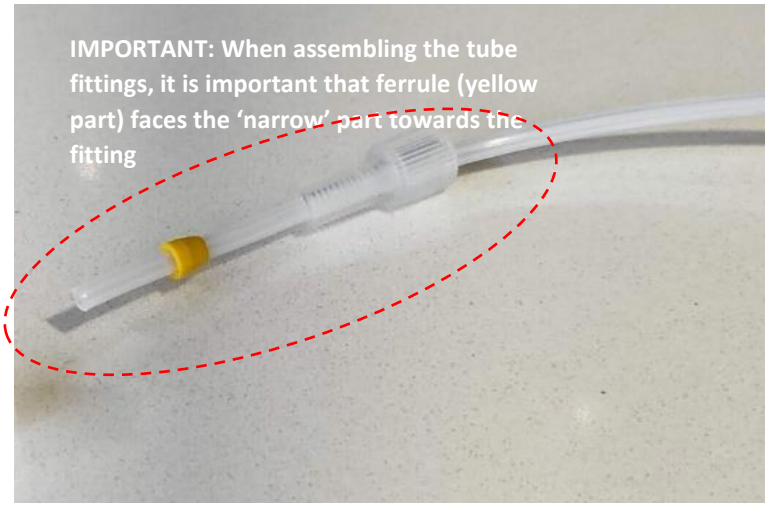
Version 1.0 – November 20, 2023

Overview of included components



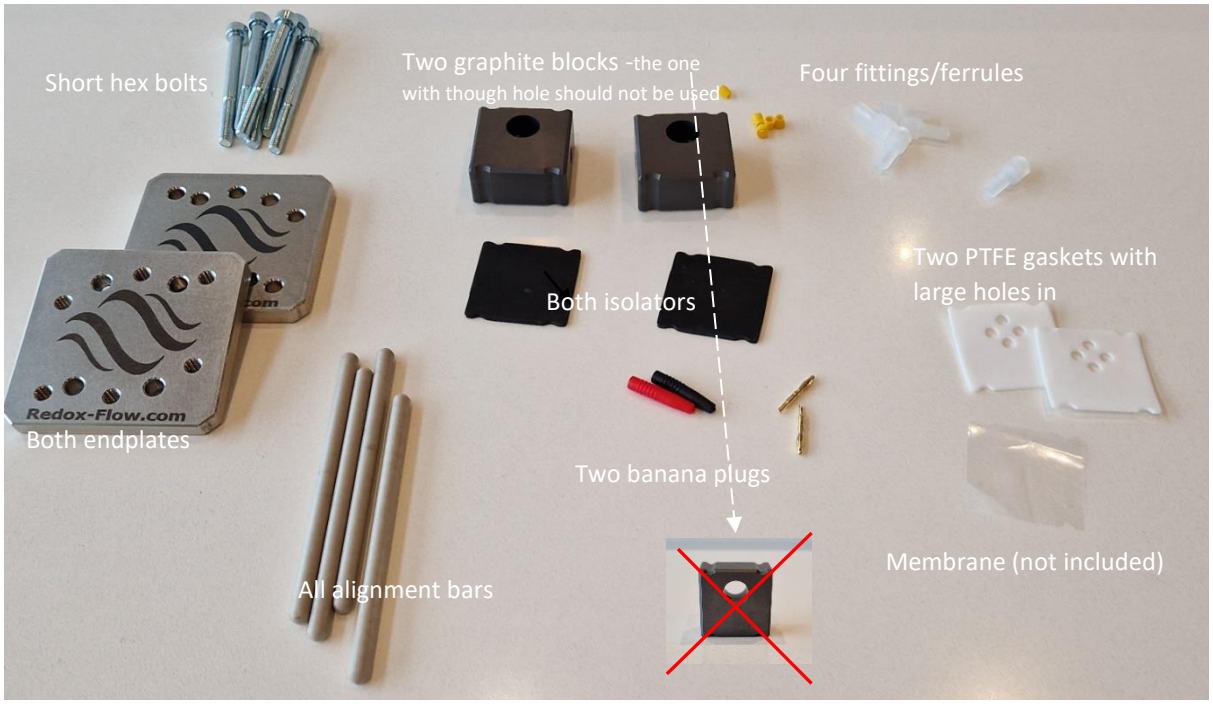


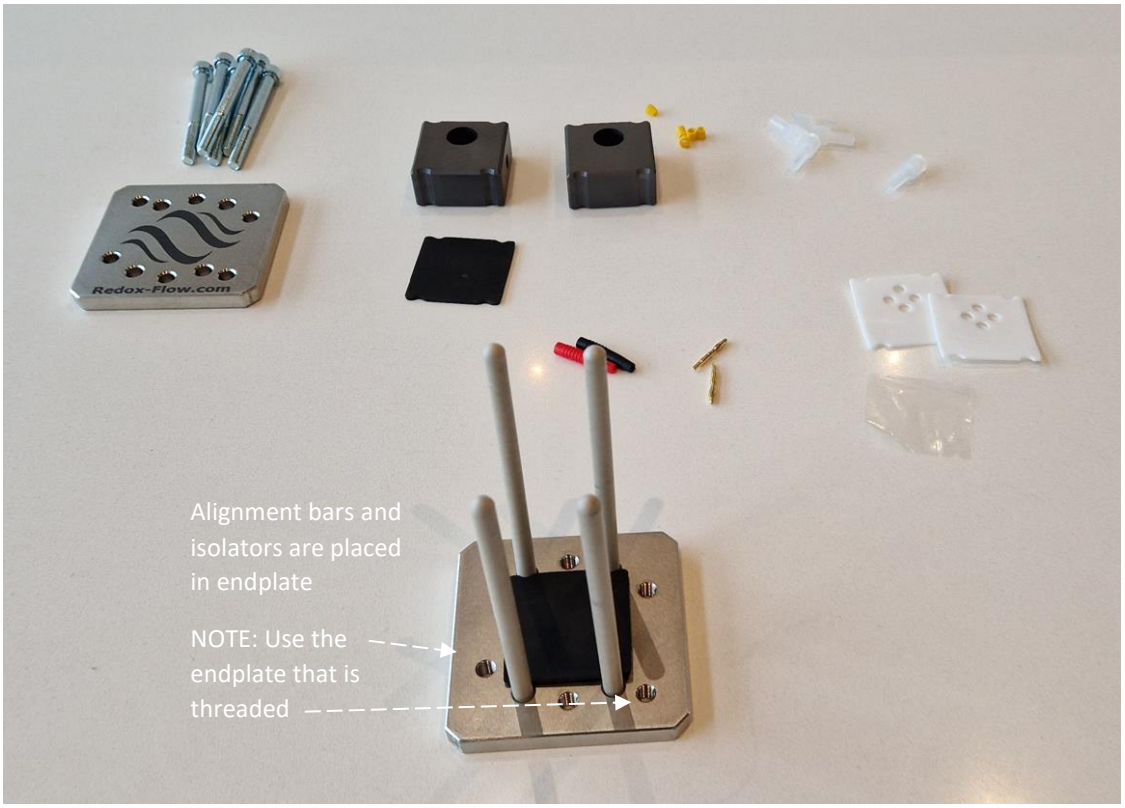
The cell comes unassembled

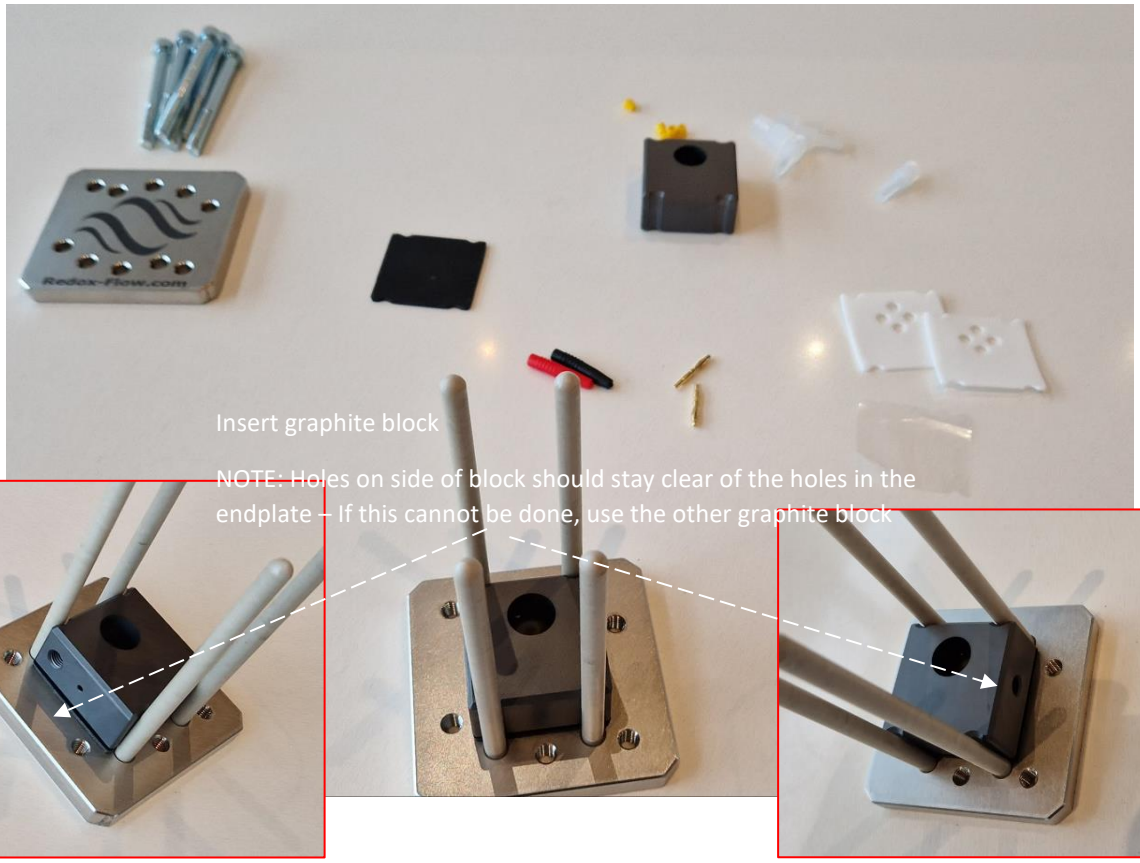


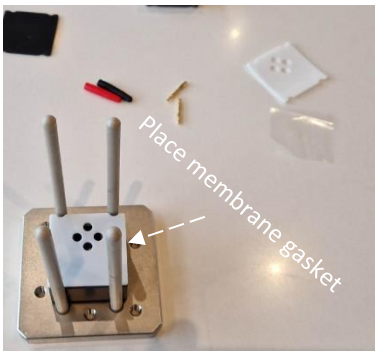
Standard OCV cell (no internal reference)

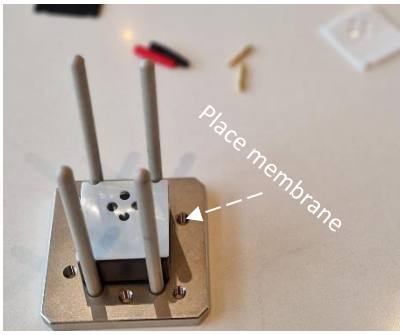
Overview of the components needed for this assembly

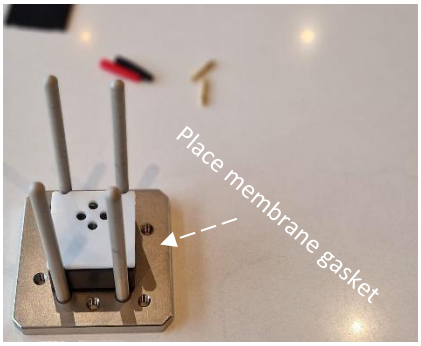


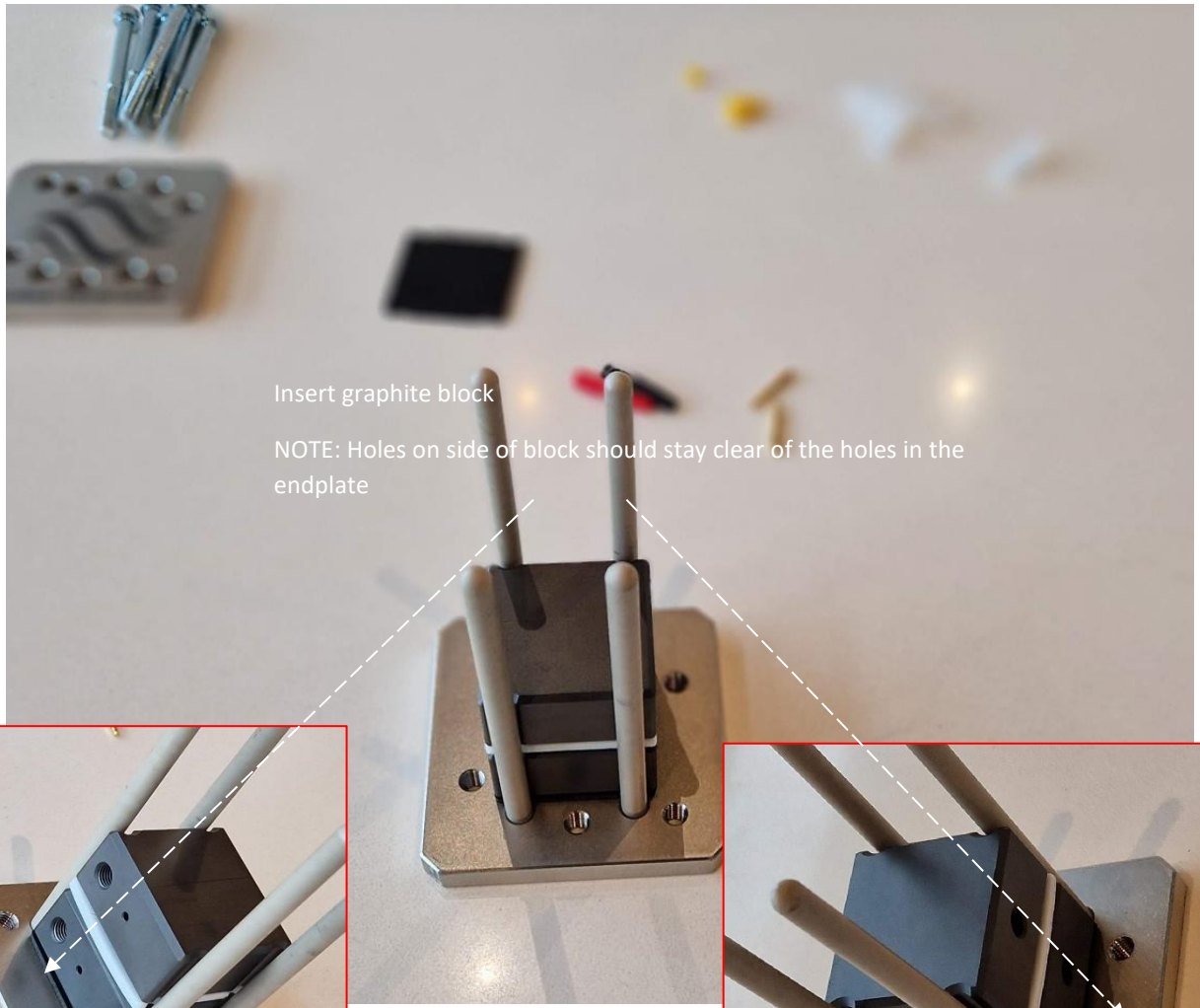

Redox-Flow.com
Alignment bars and isolators are placed in endplate
NOTE: Use the endplate that is threaded

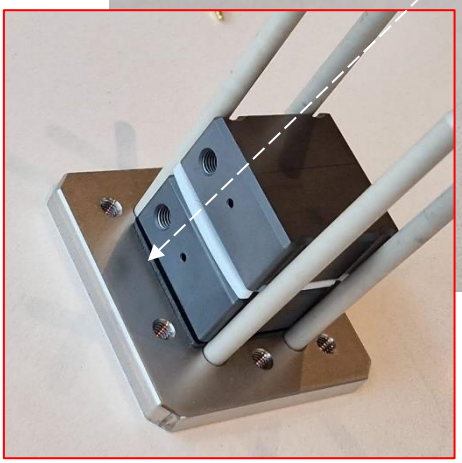

Redox-Flow.com
Insert graphite block
NOTE: Holes on side of block should stay clear of the holes in the endplate – If this cannot be done, use the other graphite block

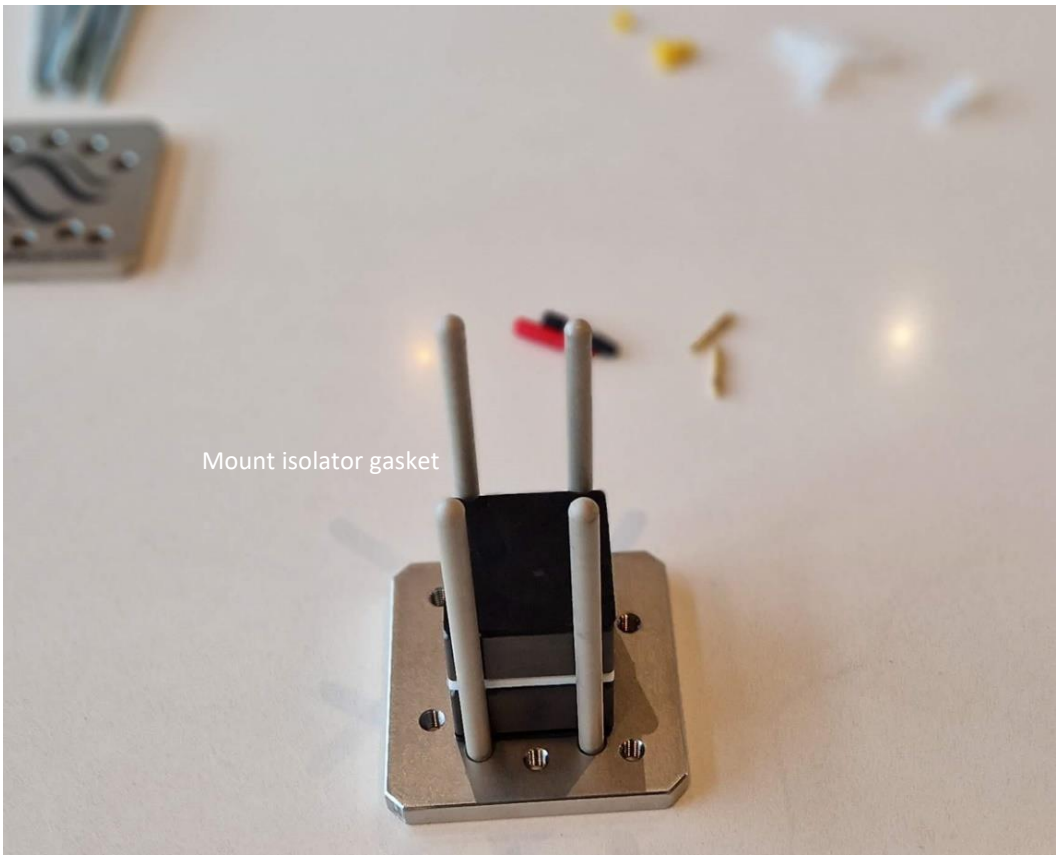

Place membrane gasket


Place membrane

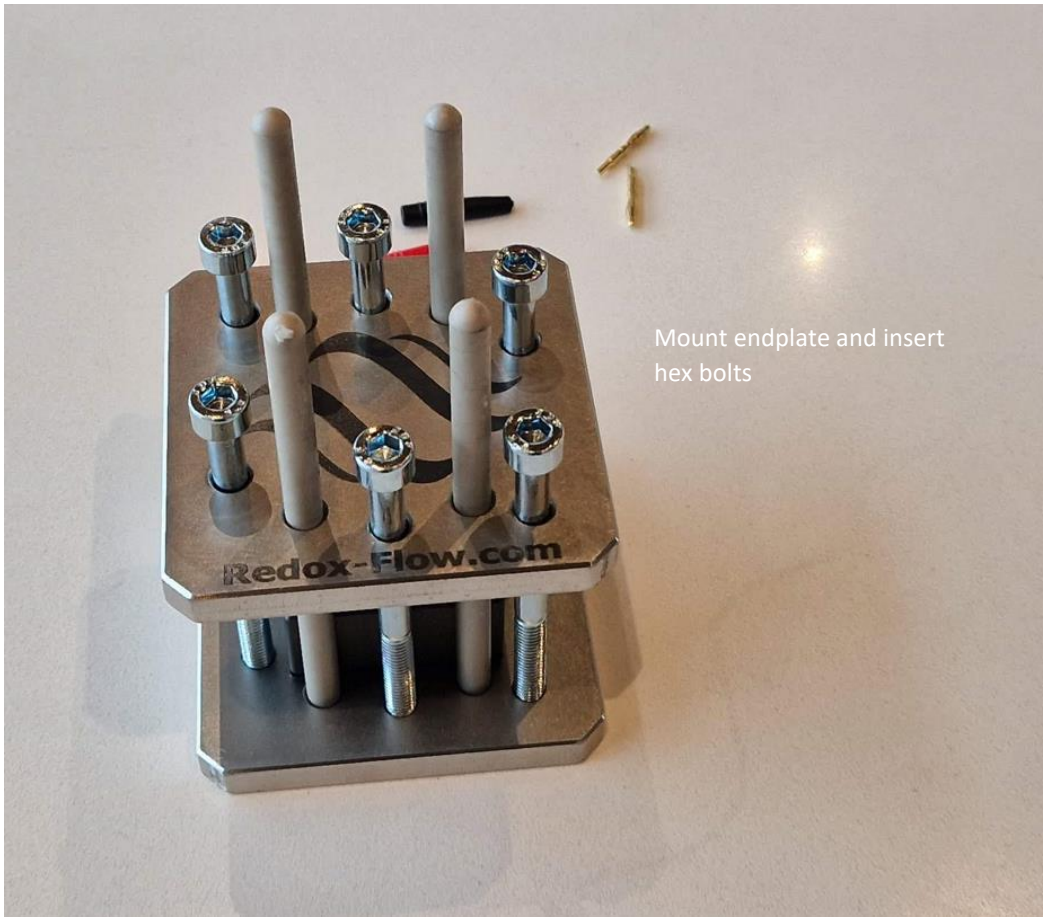

Place membrane gasket


Insert graphite block
NOTE: Holes on side of block should stay clear of the holes in the endplate

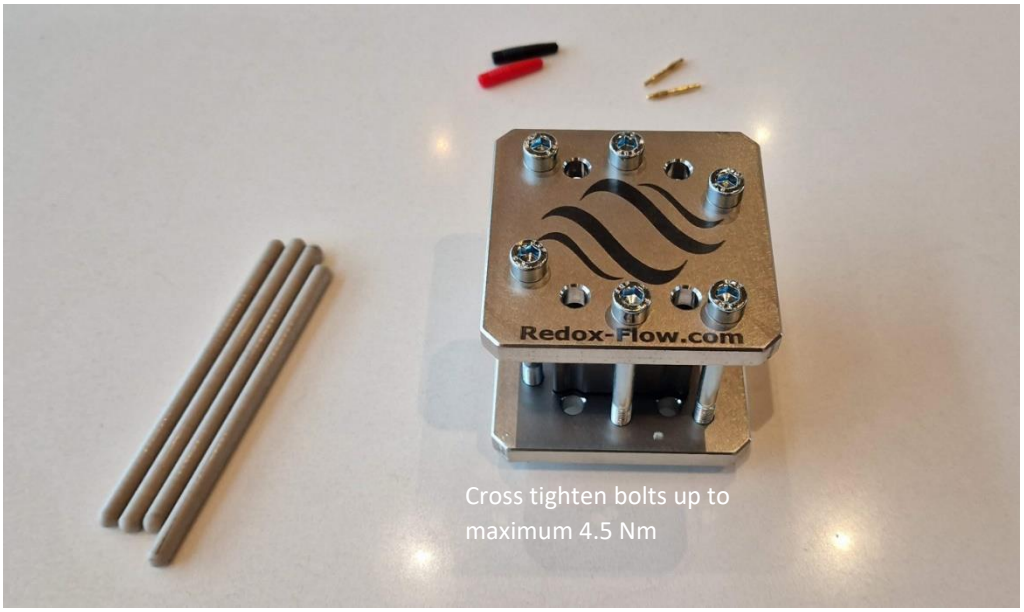




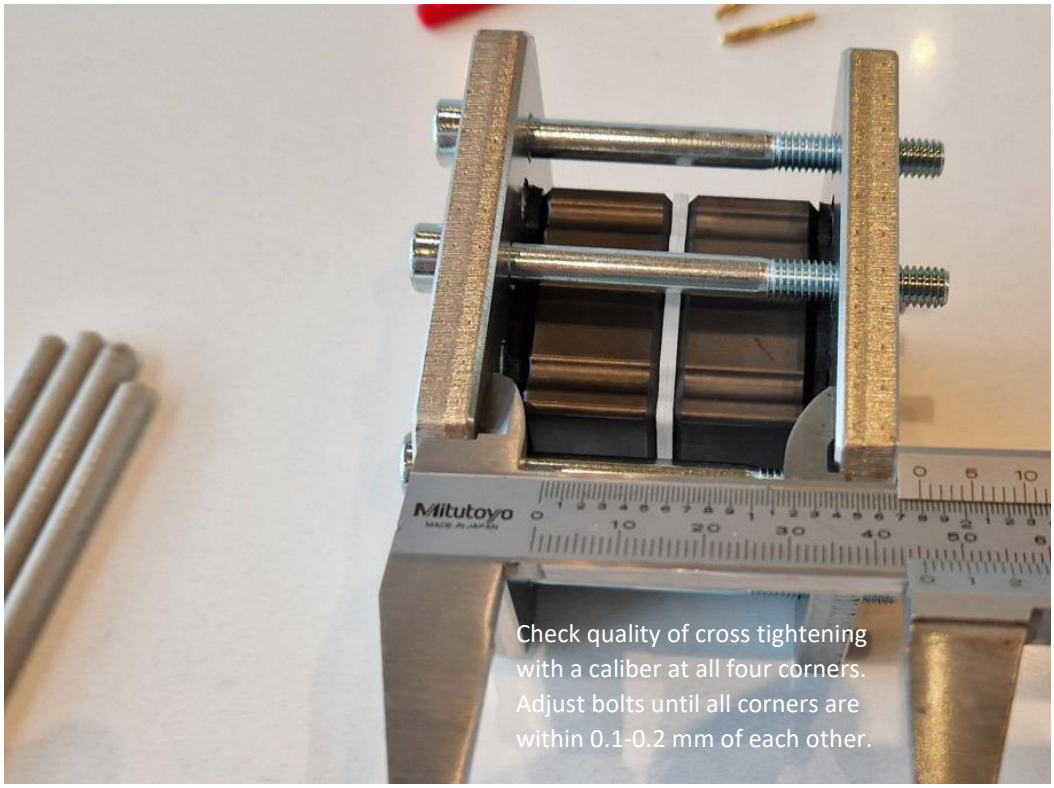
Mount isolator gasket



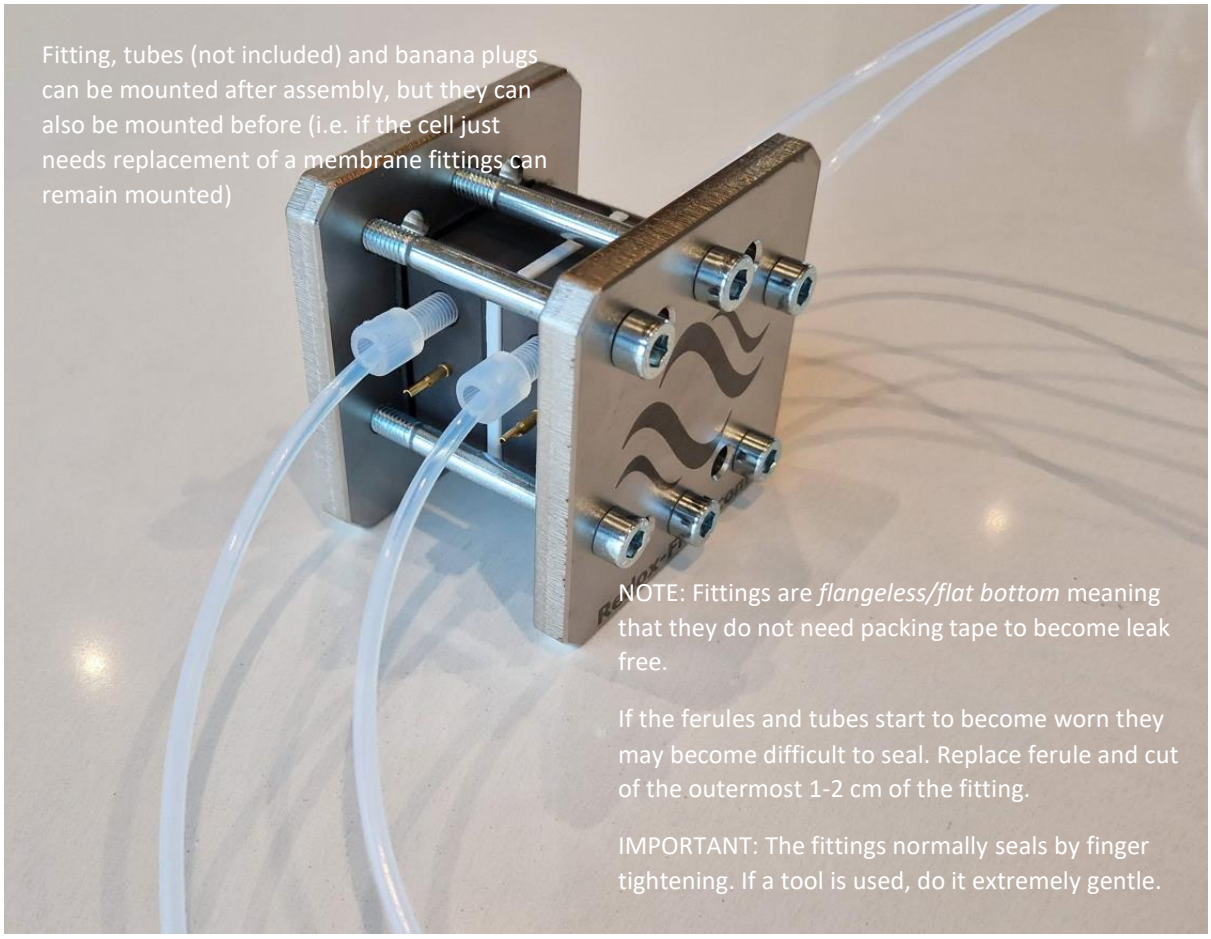
Mount endplate and insert hex bolts

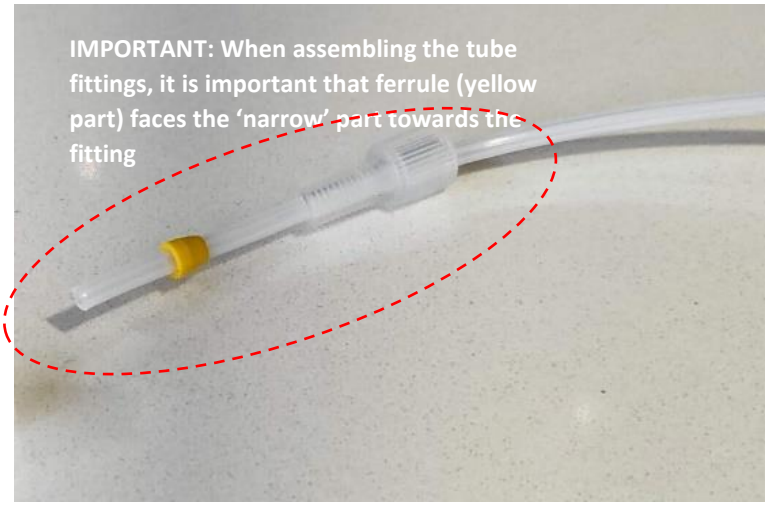


Cross tighten bolts up to maximum 4.5 Nm

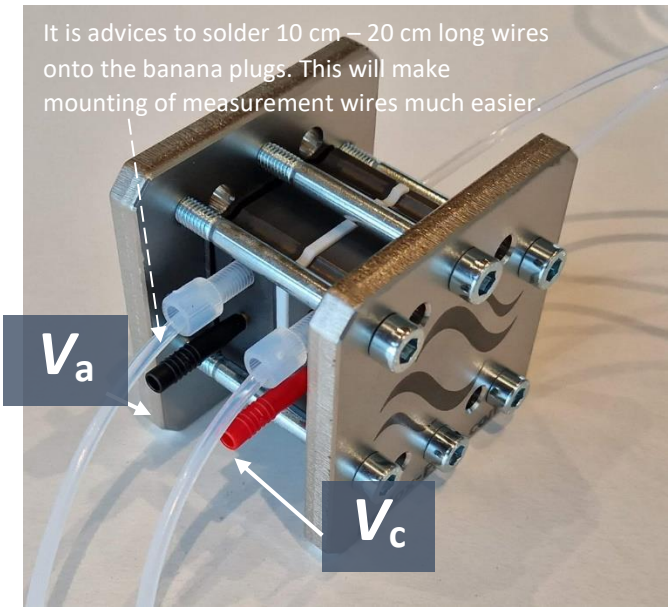


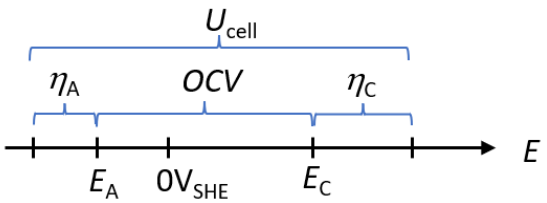
Check quality of cross tightening with a caliber at all four corners. Adjust bolts until all corners are within 0.1-0.2 mm of each other.

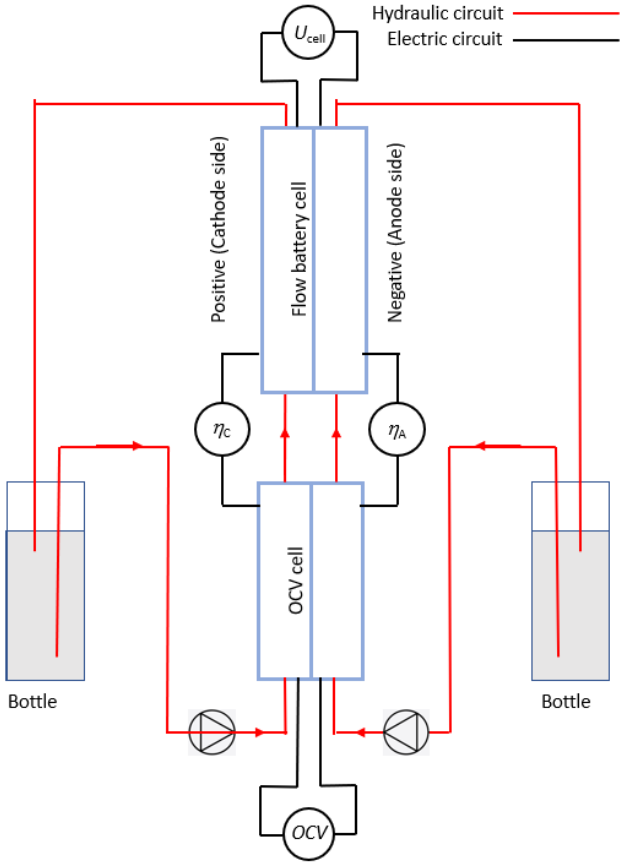

Fitting, tubes (not included) and banana plugs can be mounted after assembly, but they can also be mounted before (i.e. if the cell just needs replacement of a membrane fittings can remain mounted)
NOTE: Fittings are *flangeless/flat bottom* meaning that they do not need packing tape to become leak free.
If the ferules and tubes start to become worn they may become difficult to seal. Replace ferule and cut of the outermost 1-2 cm of the fitting.
IMPORTANT: The fittings normally seals by finger tightening. If a tool is used, do it extremely gentle.


IMPORTANT: When assembling the tube fittings, it is important that ferrule (yellow part) faces the 'narrow' part towards the fitting

Electrical connections







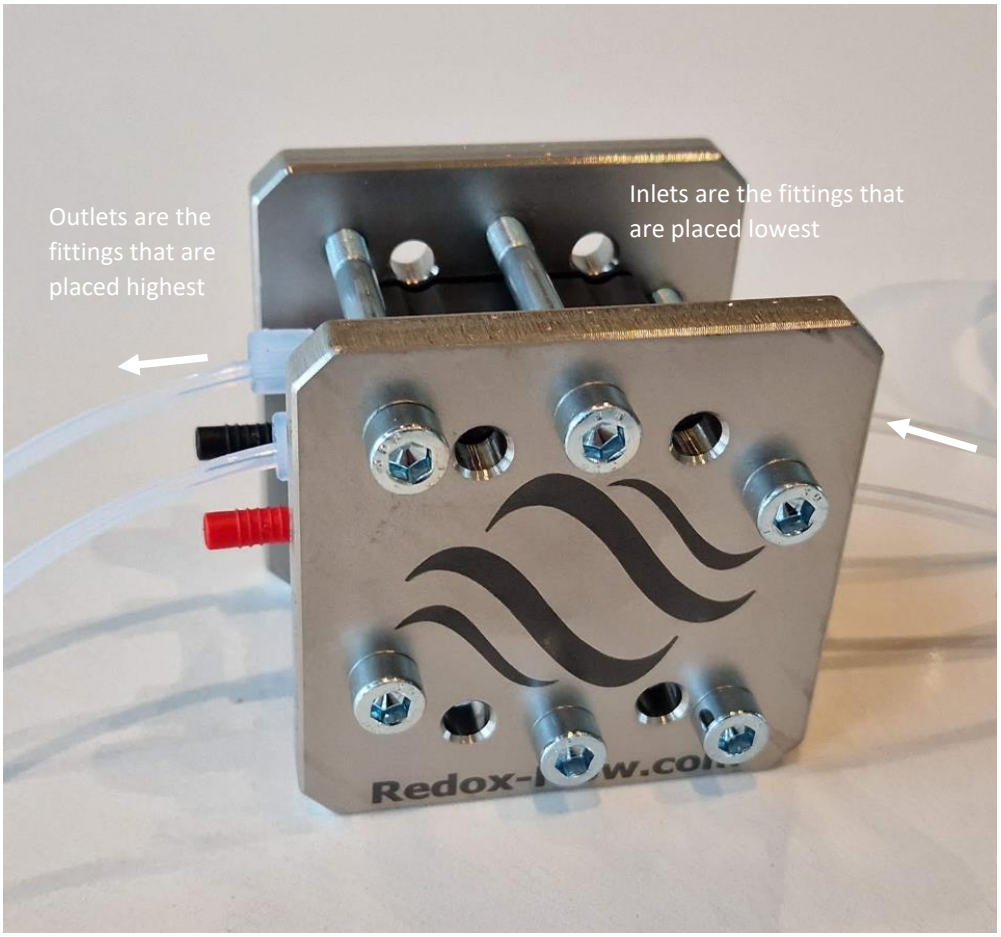
OCV cell - In its most basic configuration only the voltage difference in the OCV cell is measured. In this case a voltage measurement is done between V_a and V_c.

Anode & cathode overpotential measurements – This includes two additional voltage measurements (besides the one of the OCV measurement). Here the voltage between V_a and the current collector of the negative side of the flow battery cell is measured (η_A), as well as the difference between V_c and the current collector of the positive side of the flow battery cell (η_C). See figure above.

IMPORTANT: Measurement of η_A and η_C must be done with the highest consideration as the circuits have high impedance and are prone to errors if not done correctly. Ensure

- All the electrical equipment involved in the measurement on the set-up must be connected to the same electrical ground
- Use high impedance voltage measurement equipment – possibly in conjunction with galvanic isolation circuits
- Minimise mechanical vibration from pumps e.g. fixation of tubes so they do not vibrate
- All air bubbles inside cells (both OCV and flow battery) must thoroughly pumped out

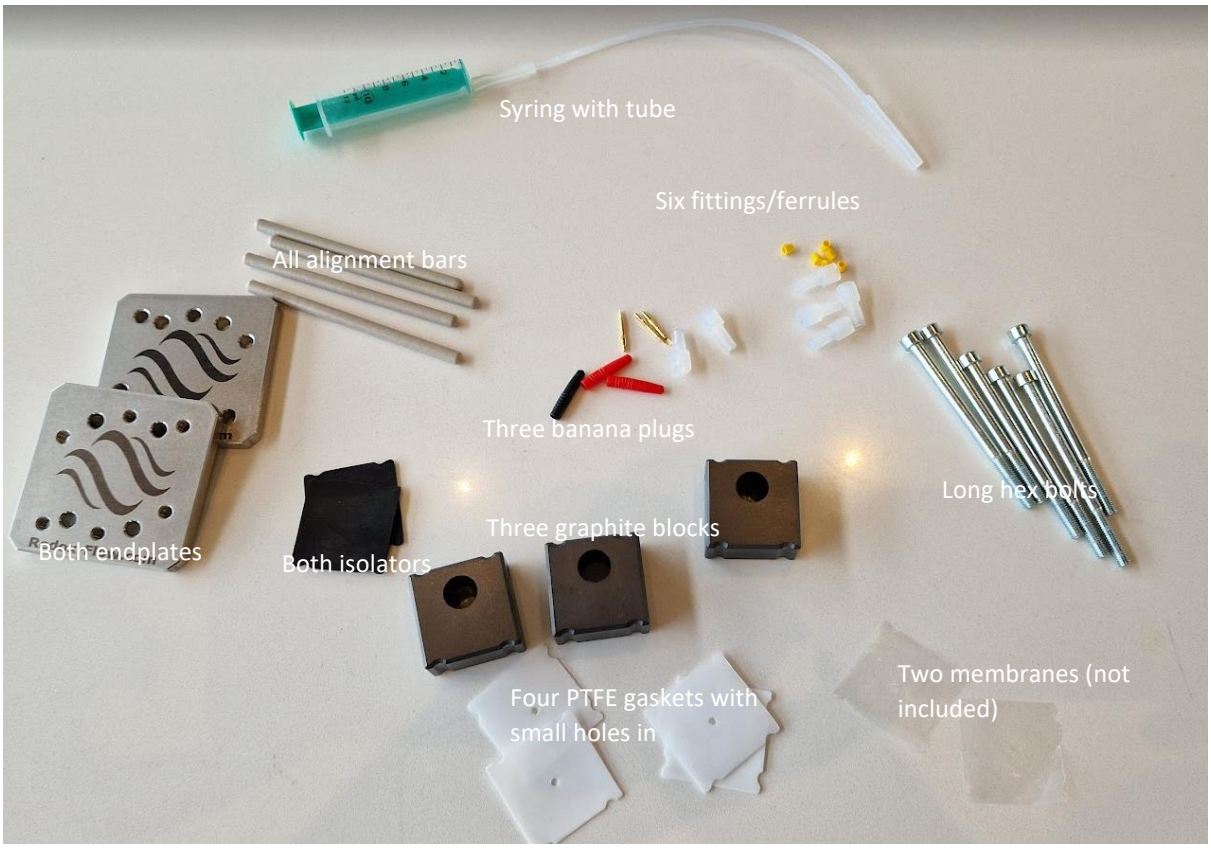
Hydraulic circuit - In most cases the OCV has to be placed hydraulically in front of the flow battery cell. To ensure that bubbles inside the chamber is flushed out have the flow direction as shown in picture below



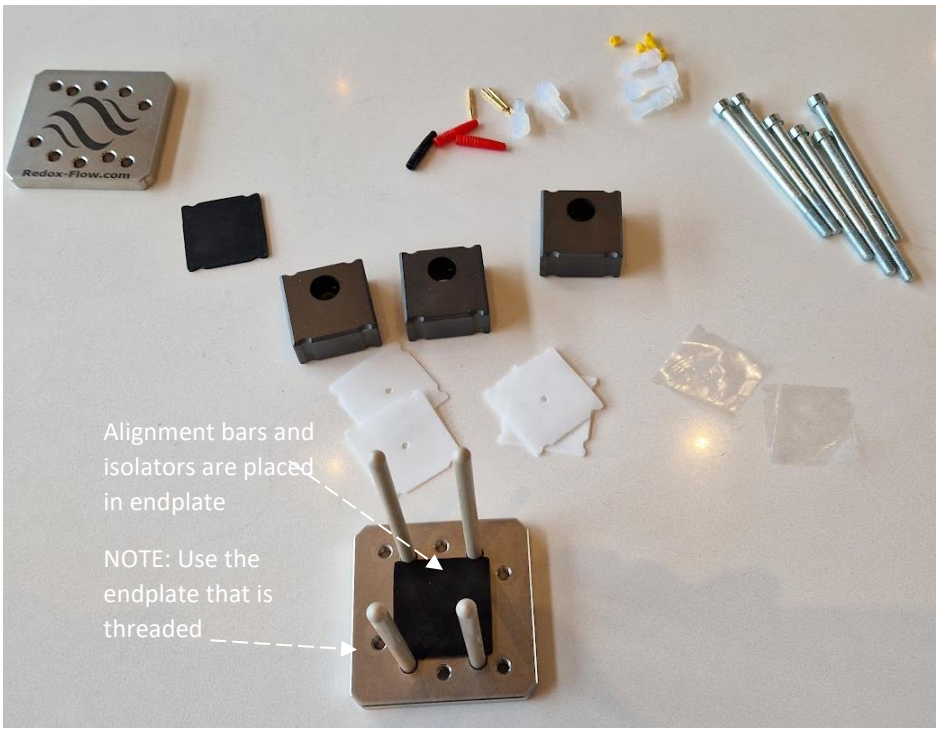
OCV cell with internal reference

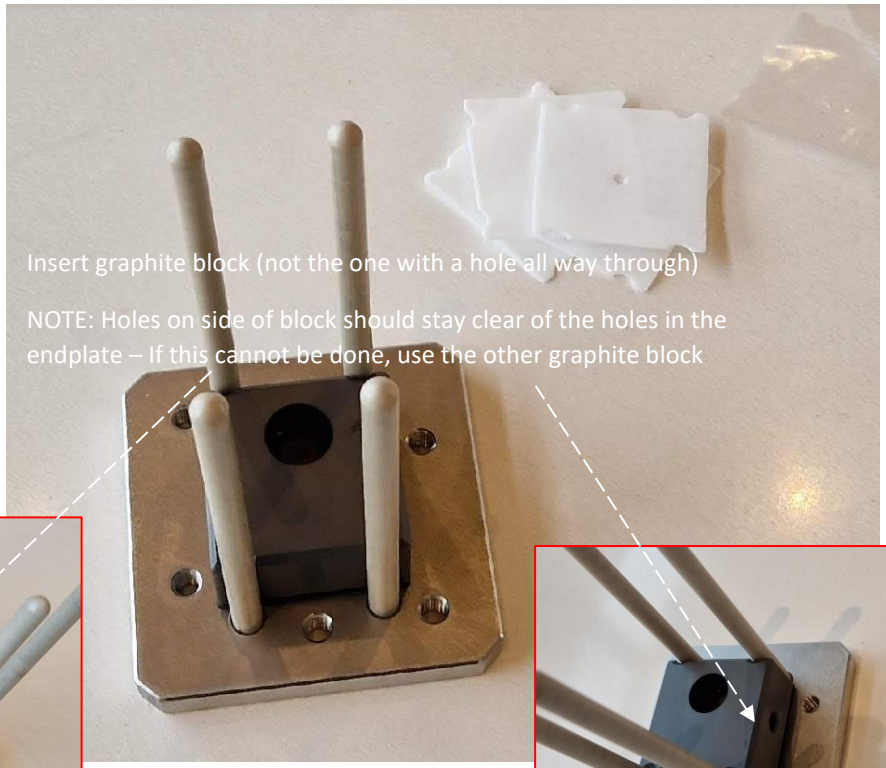
NOTE – Using the OCV cell with internal reference, requires that the user is highly skilled in electrochemistry and measurement of voltage signals from high impedance sources.

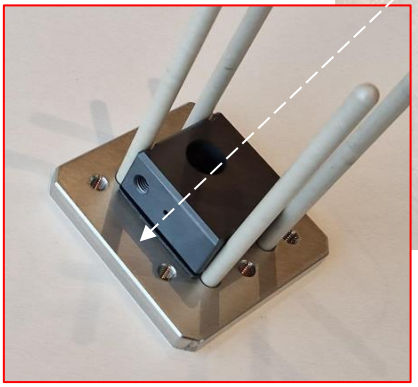
Overview of the components needed for this assembly

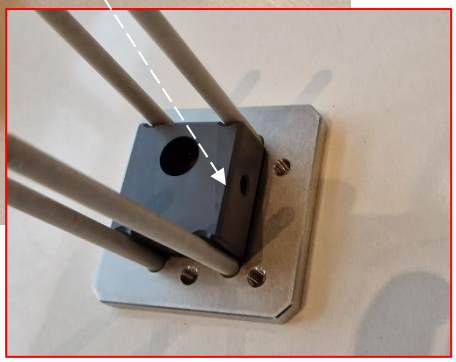


Assembly of OCV cell with internal reference









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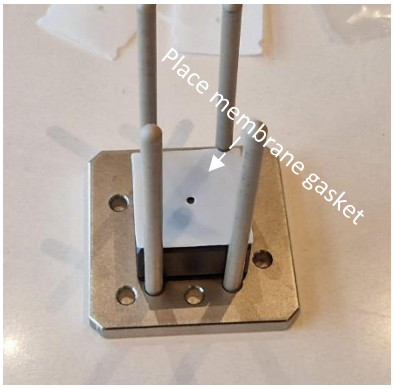
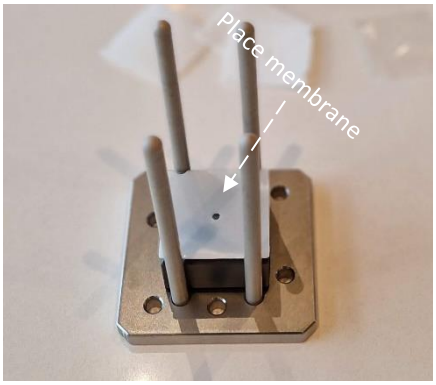
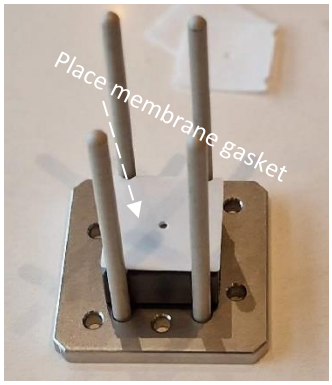
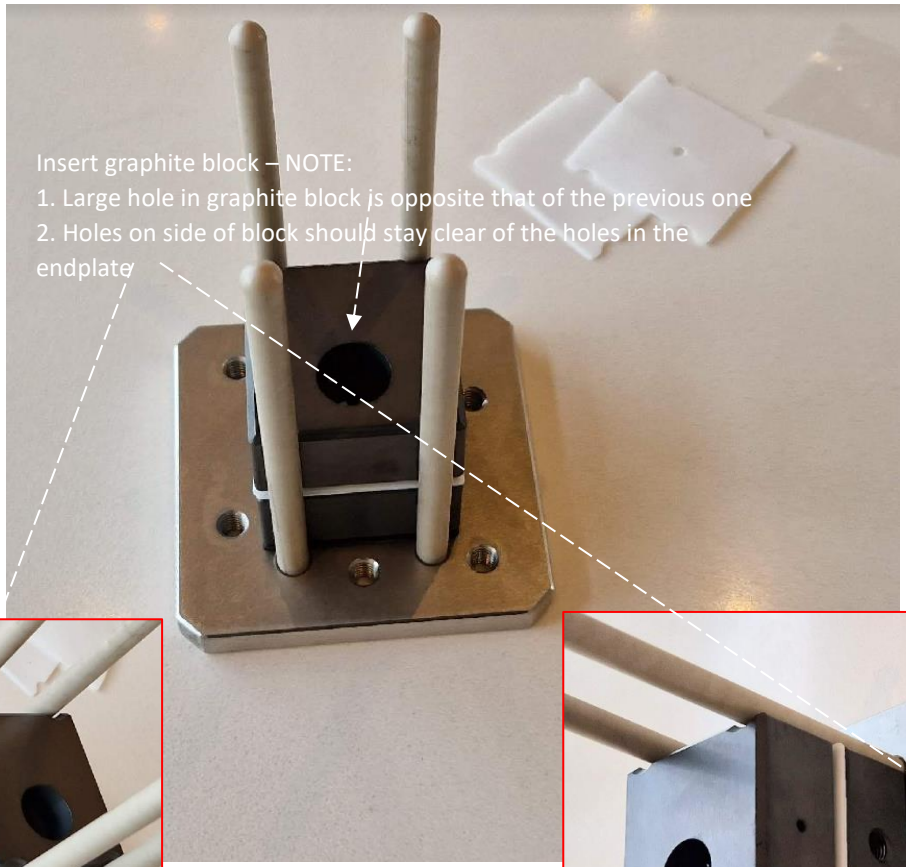
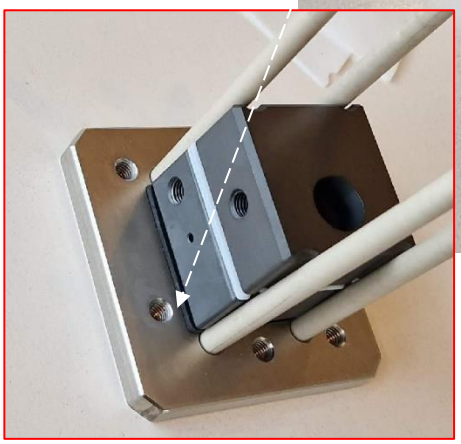
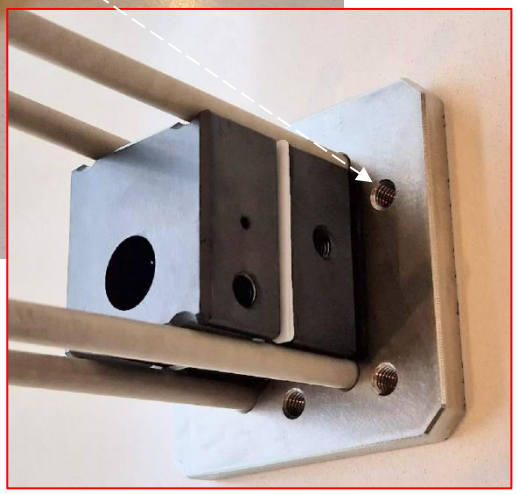

Place membrane gasket

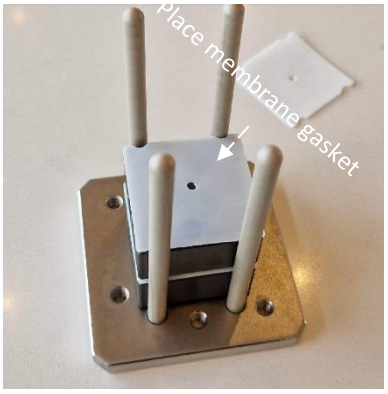

Place membrane

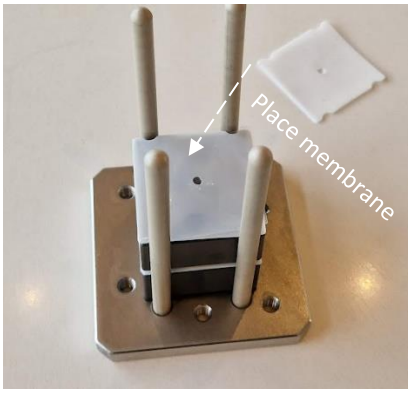

Place membrane gasket

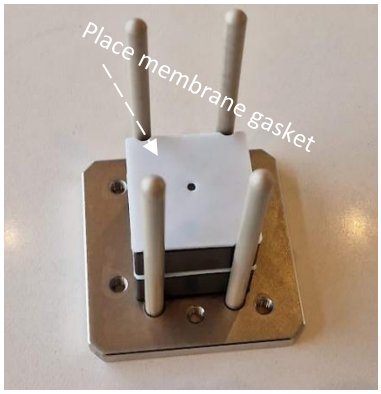

Insert graphite block – NOTE:
1. Large hole in graphite block is opposite that of the previous one
2. Holes on side of block should stay clear of the holes in the endplate

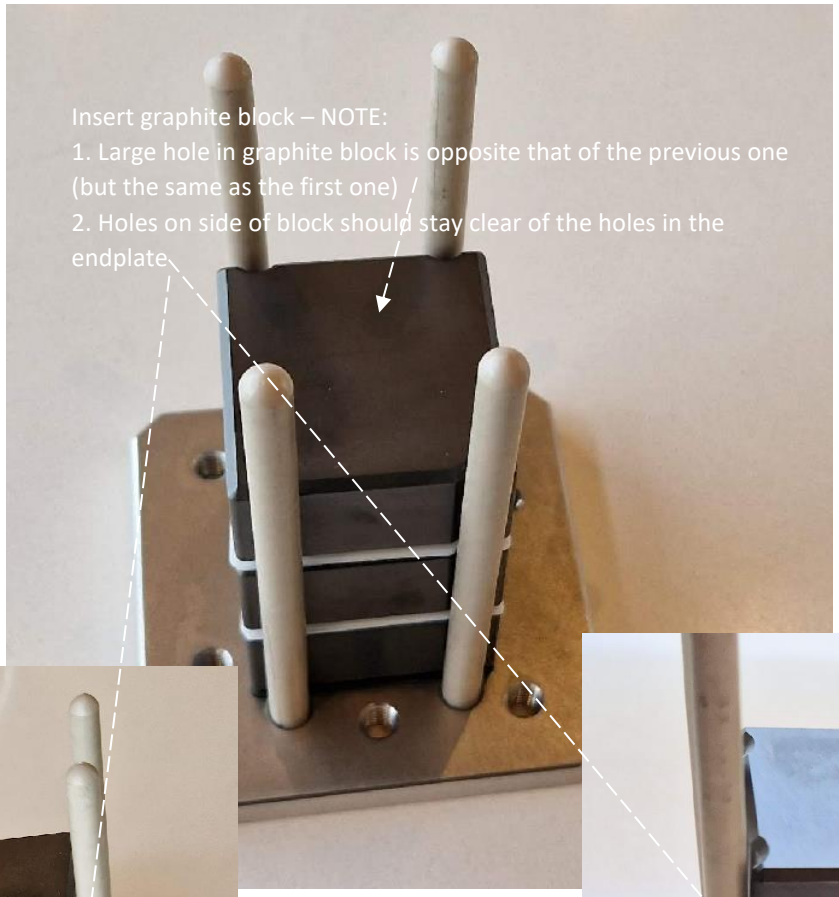


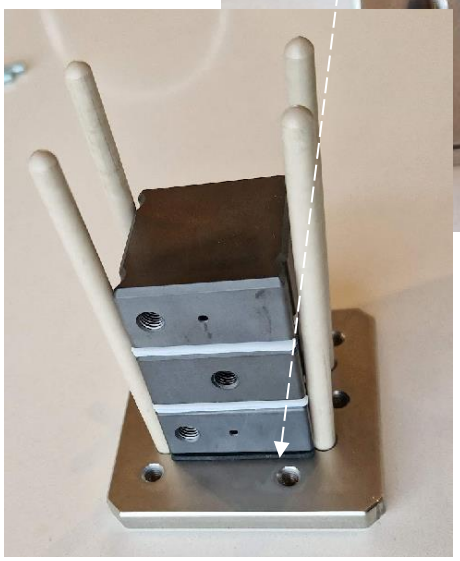












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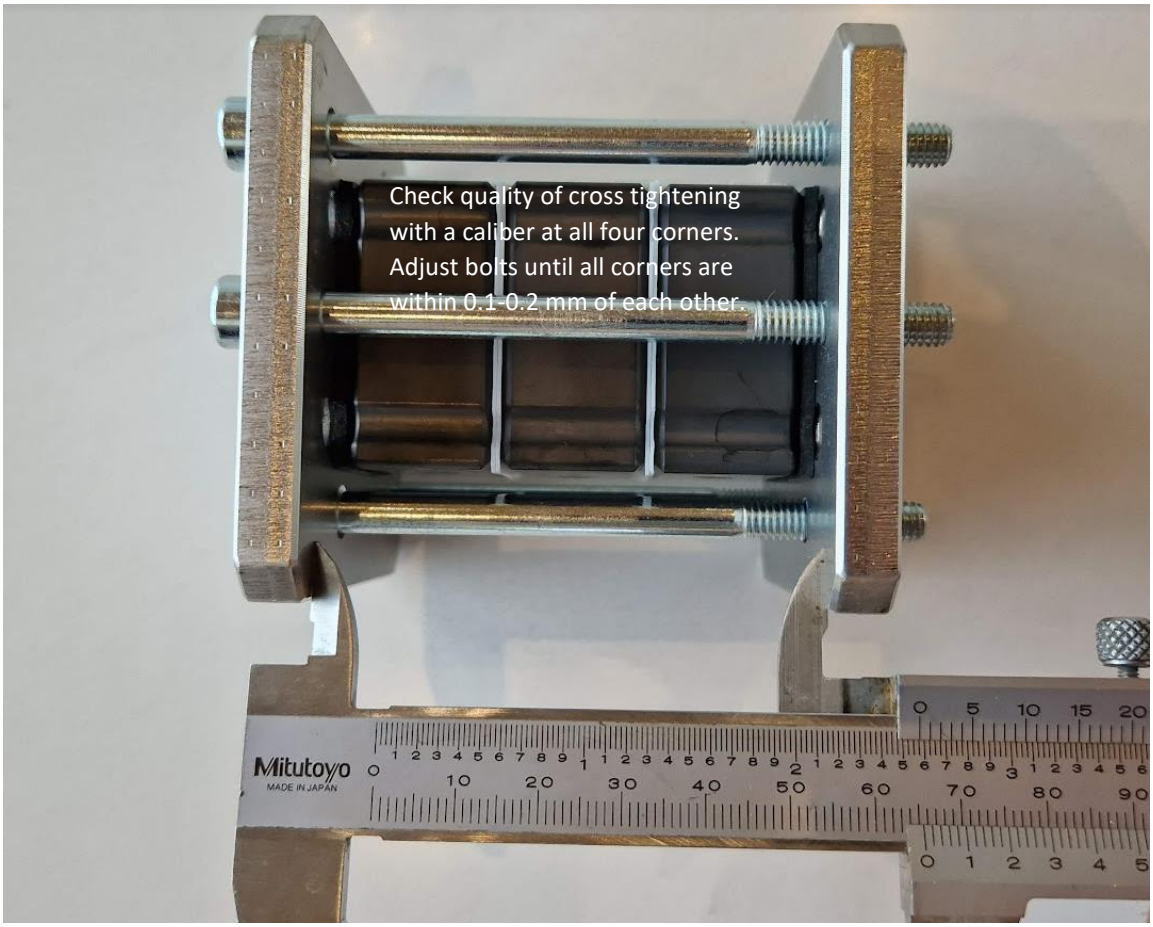
Place isolator


Mount endplate and insert
hex bolts
Redox-Flow.com


Cross tighten bolts up to
maximum 4.5 Nm
Redox-Flow.com


Check quality of cross tightening
with a caliber at all four corners.
Adjust bolts until all corners are
within 0.1-0.2 mm of each other.
Mitutoyo
MADE IN JAPAN

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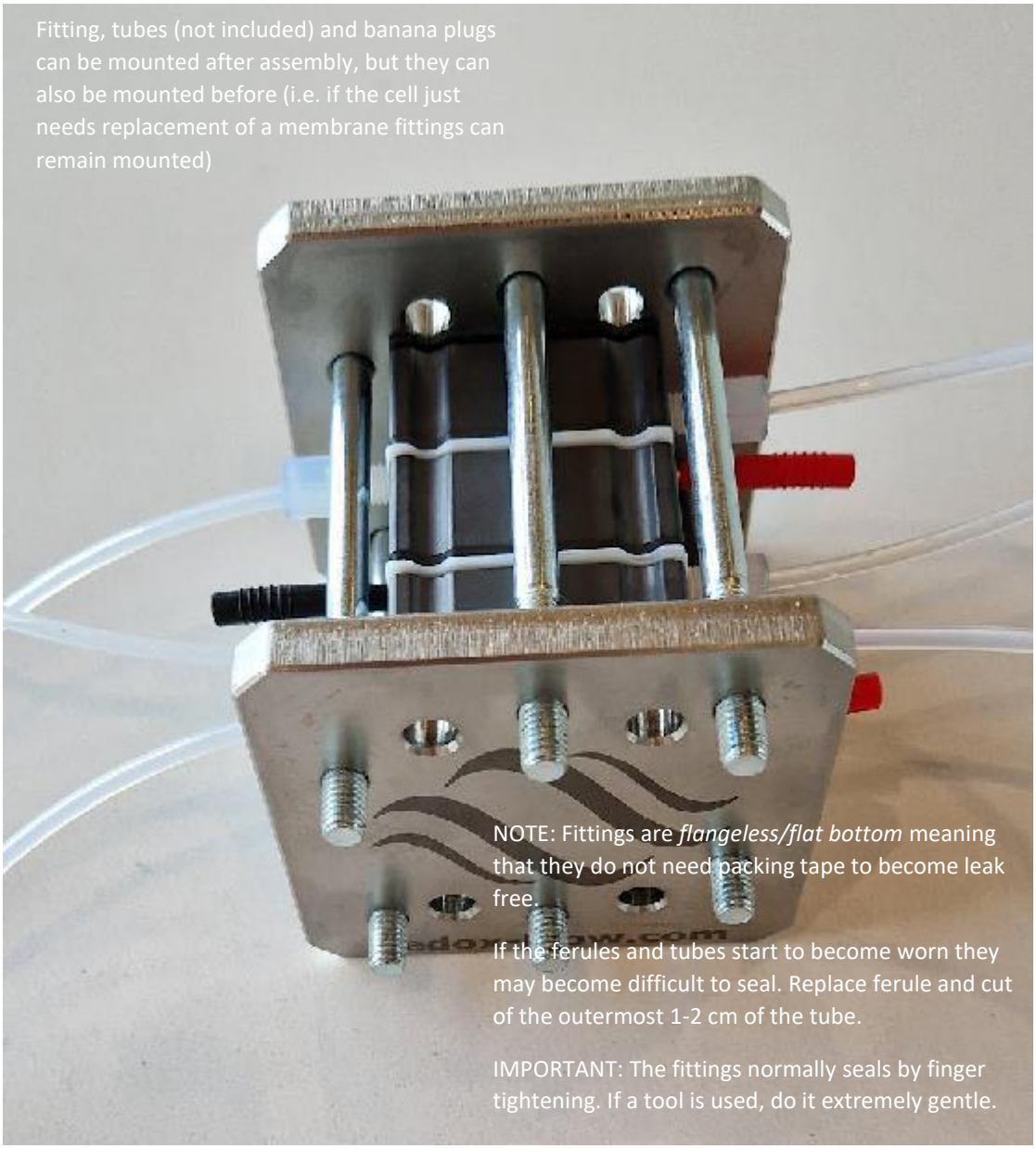

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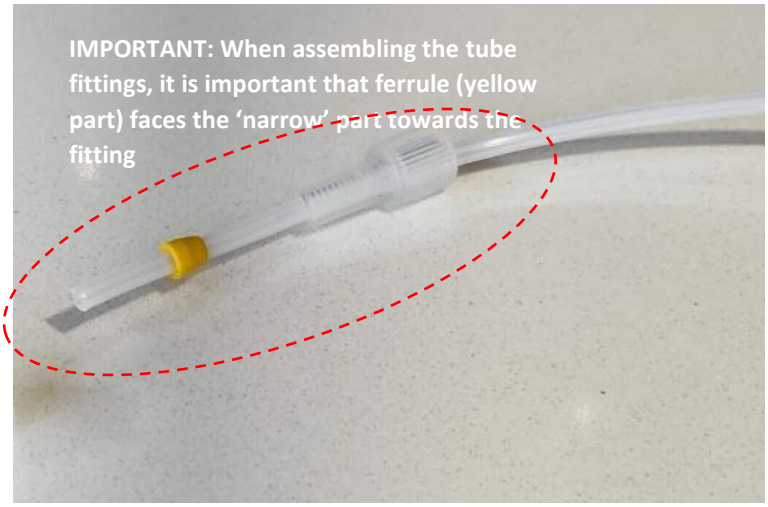
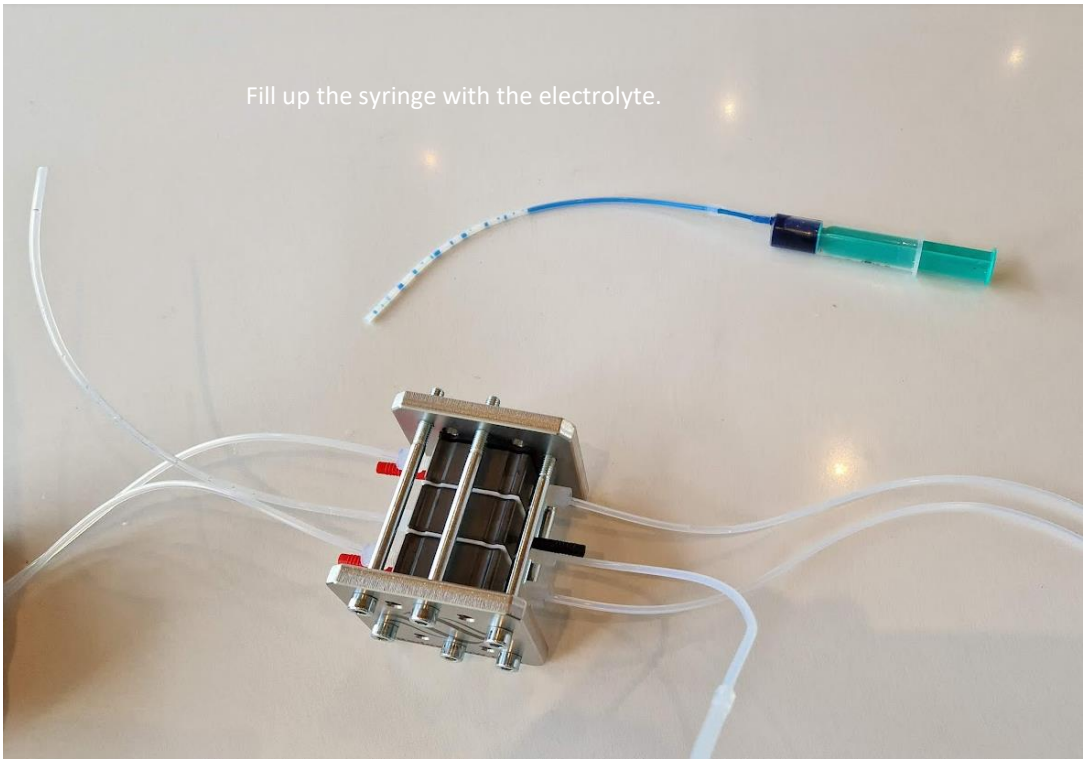
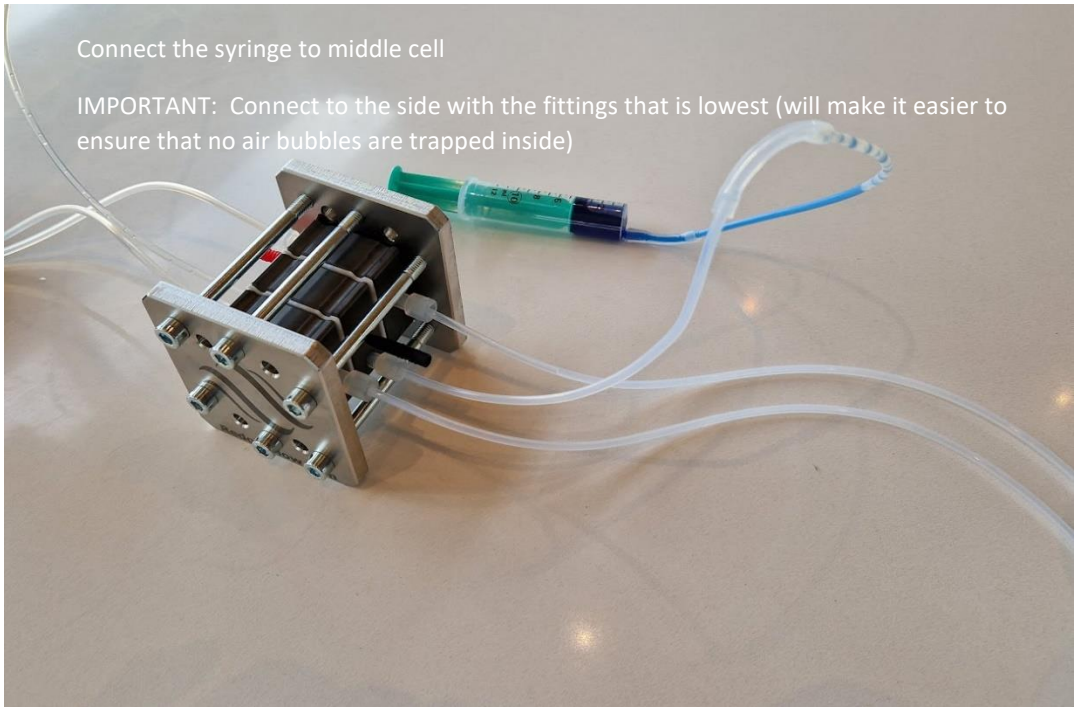
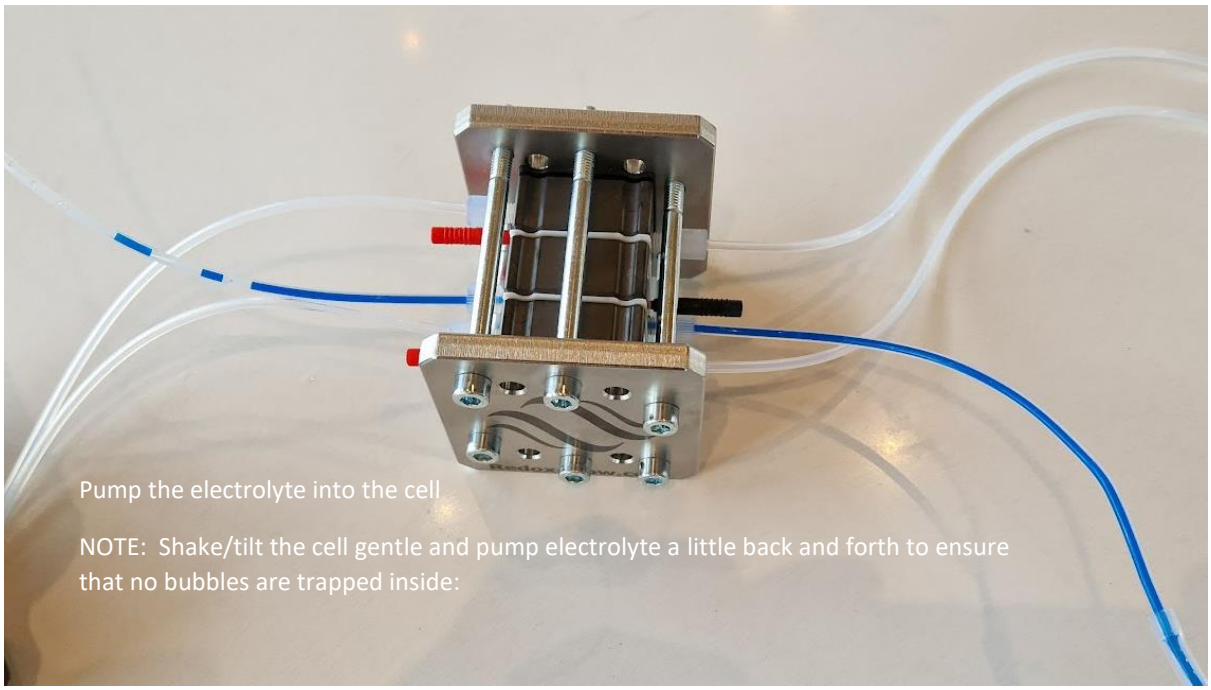
IMPORTANT: The fittings normally seals by finger tightening. If a tool is used, do it extremely gentle.



Filling the reference chamber with electrolyte

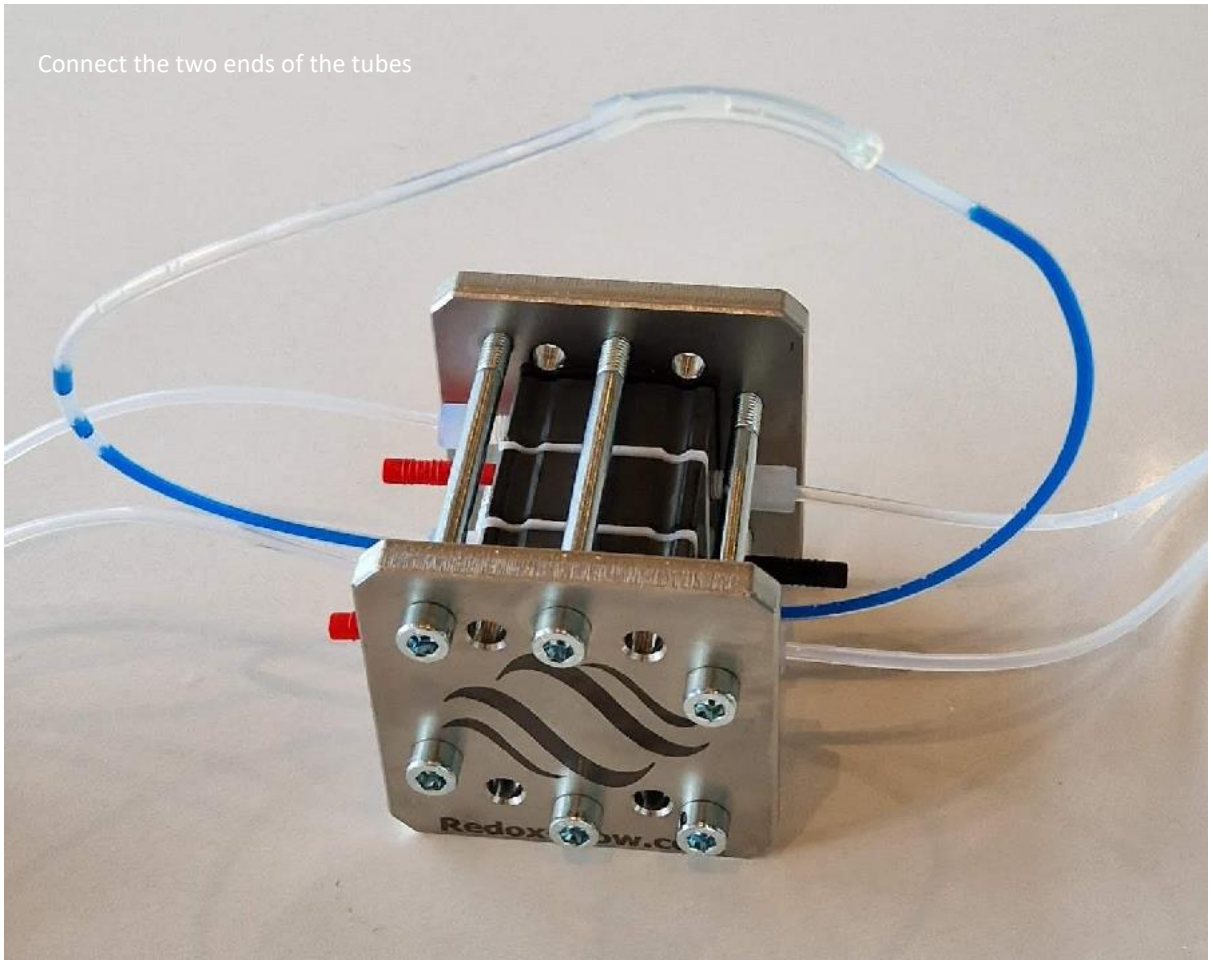






Pump the electrolyte into the cell

NOTE: Shake/tilt the cell gentle and pump electrolyte a little back and forth to ensure that no bubbles are trapped inside:



Connect the two ends of the tubes

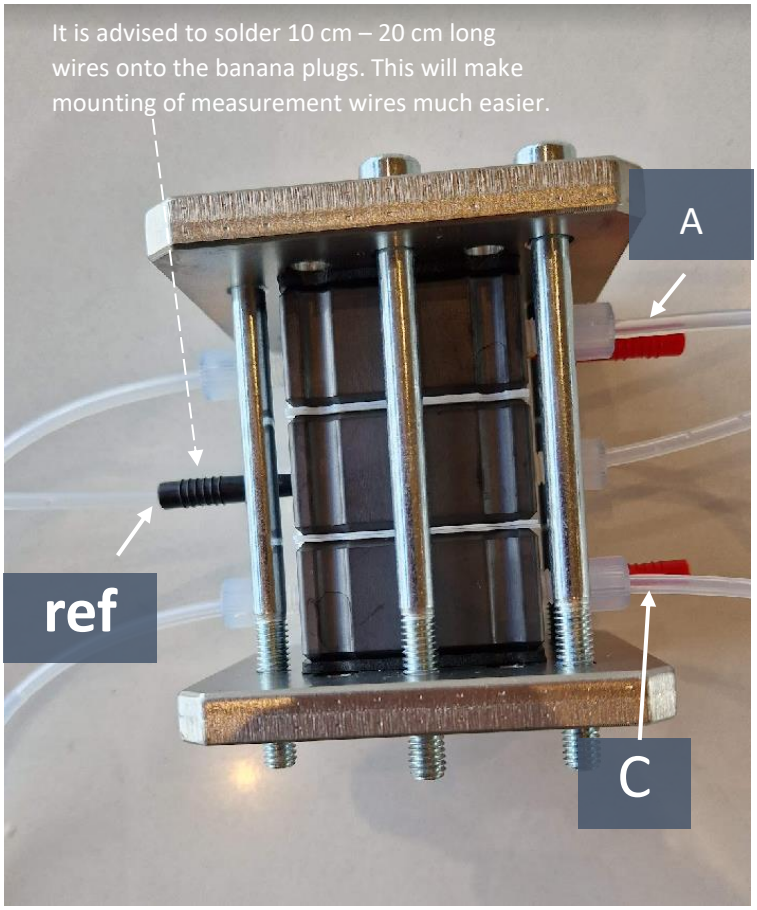
Electrical/hydraulic connections

NOTE – Using the OCV cell with internal reference, requires that the user is highly skilled in electrochemistry and measurement of voltage signals from high impedance sources.

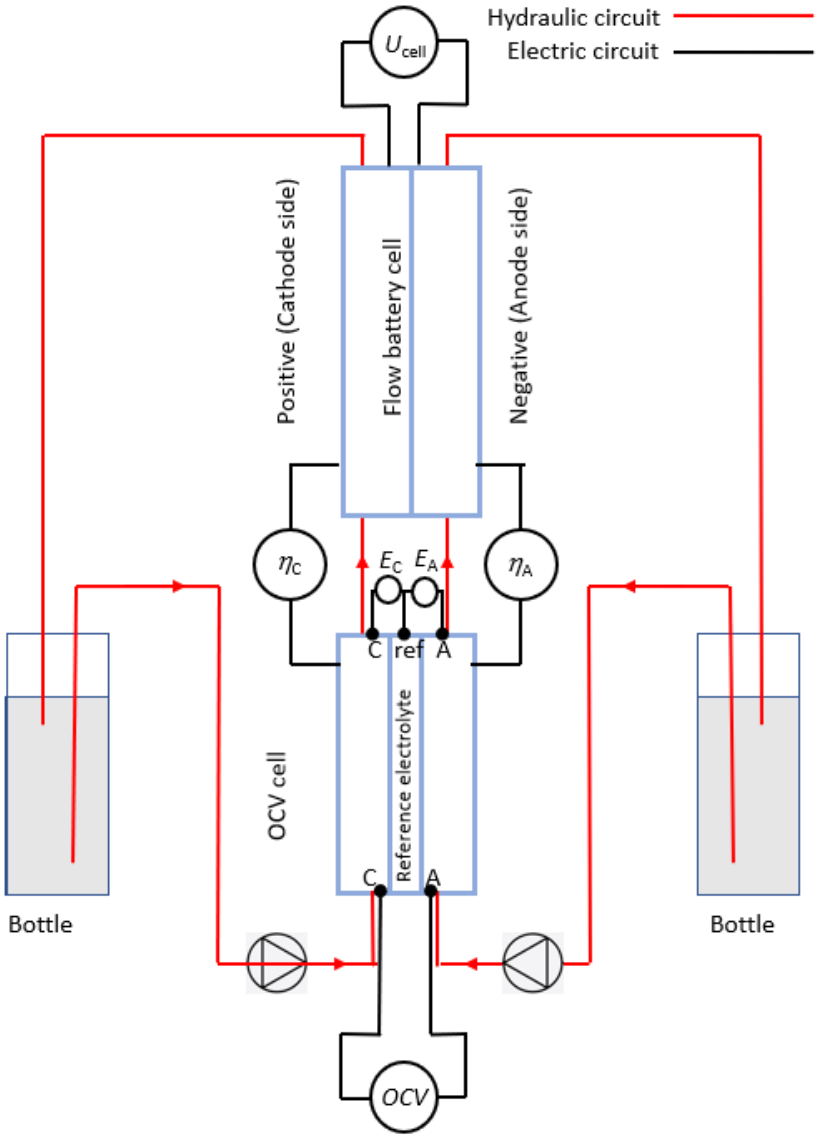
Compared to the standard OCV cell with two chambers, this configuration adds a third chamber (half cell) that is filled with a *standard* electrolyte (e.g. V3+/V4+) that will make the chamber work as a reference electrode. In this configuration, the cell has the same capabilities as the standard OCV cell (OCV and overpotentials), with the exception that all potentials are measured relative to the reference electrolyte.

The electrical connections on the cell are shown on the photo below. While the *hydraulic/electrical diagram* and the *Energy/voltage diagram* is shown on next pages. Here *ref*, *A* and *C*, refers to the electrical contacts in all figures.

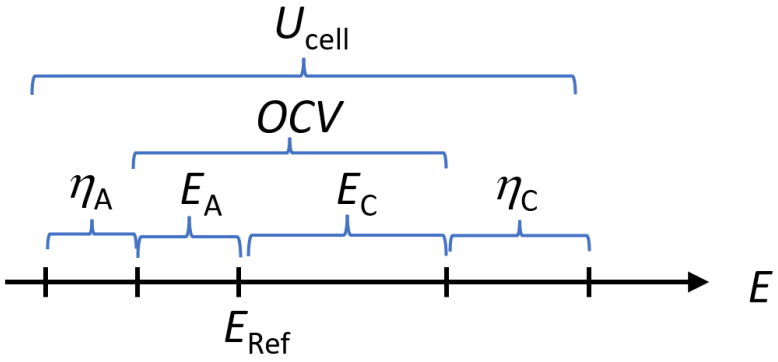
Electrical connections



Electrical/Hydraulic diagram



Energy/voltage diagram



Compared to the standard OCV measurement, it is from the electrical and energy/voltage diagrams seen that the OCV measurement is replaced by two voltage measurements. They measure the negative side (E_A) and positive side (E_C) relative to the reference electrolyte. I.e. the sum of the two potentials is the OCV (i.e. $OCV=E_A+E_C$).

From the energy/voltage diagram it can also be seen that $U_{cell} = OCV+E_A+E_C+\eta_A+\eta_C$ and that all potentials can be related to an absolute value (E_{Ref}).

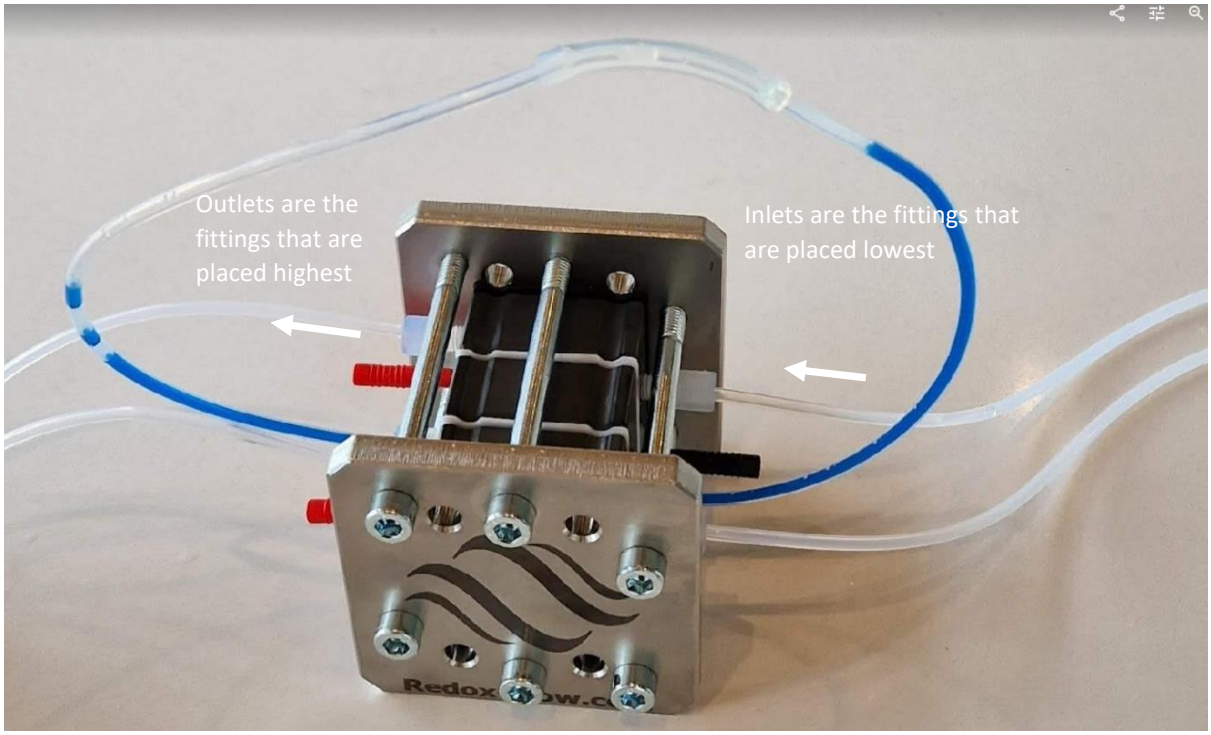
The OCV cell with internal reference can be connected in several ways and also independent of each other.

- E_A and E_C are measured from the voltage difference between *A - ref* and *C – ref*, respectively, as shown in the electrical diagram
- η_A and η_C are measured from the voltage difference between *A-anode current collector* and *C-current collector* on the flow battery cell, respectively. This is also shown in the electrical diagram.

IMPORTANT: Measurement of E_A, E_C, η_A and η_C must be done with the highest consideration as the circuits have high impedance and are prone to errors if not done correctly. Ensure

- All the electrical equipment involved in the measurement on the set-up must be connected to the same electrical ground
- Use high impedance voltage measurement equipment – possibly in conjunction with galvanic isolation circuits
- Minimise mechanical vibration from pumps e.g. fixation of tubes so they do not vibrate
- All air bubbles inside cells (both OCV and flow battery) must thoroughly pumped out

Hydraulic circuit - In most cases the OCV cell is placed hydraulically in front of the flow battery cell. To ensure that bubbles inside the chamber is flushed out have the flow direction as shown in picture below



NOTES:

1. In the present setup the reference chamber is with a static/non-replaced electrolyte solution. However, it can also be pumped through continuously from a bottle (like the anolyte/catholyte). But his has not been tested by redox-flow.com

2. A choice as reference electrolyte for vanadium flow batteries is the pristine vanadium solution (50/50 of V3+ and V4+).

3. For other battery types redox-flow.com has not tested references. But for neutral/alkaline Zobell solution (50/50 solution of ferro and ferricyanide) will most likely work. However, as ferro/ferri cyanide forms insoluble salts with almost all divalent and trivalent metal ions, it is important to use a highly selective membrane like the E600 series from Fumatech.