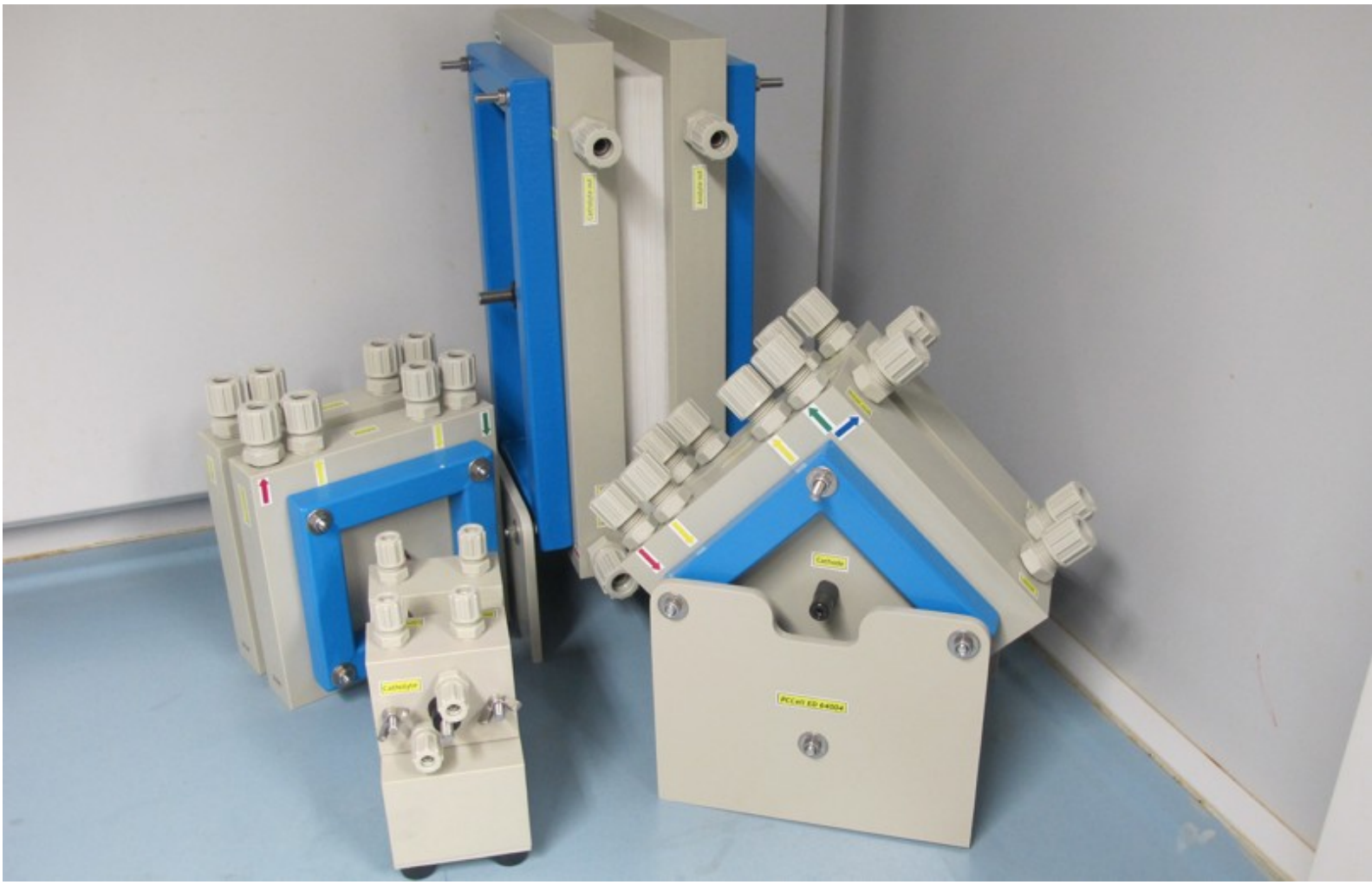
Electrodialysis Cell Unit

# PC*Cell* Micro ED, ED 64002,

# ED 64004 and ED 200

*Operation & Maintenance Instruction*



*Read these operation & maintenance instructions before start up!*
*To be held for future reference.*

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Version: Mar 2017

# Table of Contents

# 1. Safety Instructions

This Operation & Maintenance Manual contains basic information to be noted during installation, operation and maintenance of this product. It has to remain accessible at the device for reference at all times.

In addition to the general safety instructions under this main heading “Safety Instructions”, special safety precautions outlined in other sections must also be observed.

## *1.1. Identification of safety instructions in this operation manual*

The following information may endanger people, the environment and the device if they are disregarded. They are identified by the following symbols:

DANGER!
Indicates an immediate danger. Failure to follow this instruction may lead to death or extremely serious injuries.

WARNING!
Indicates a potentially hazardous situation. Failure to follow this instruction may lead to death or severe injury.

CAUTION!
Indicates a potentially hazardous situation. Failure to follow this instruction may lead to minor injury or damage to property.

ATTENTION!
Failure to follow these safety instructions may endanger the machine and its functions.

IMPORTANT!
This refers to additional information to facilitate operation and ensure the smooth running of the equipment.

Appropriate references attached directly on the products or any of its other parts like labels or markings e.g. for electrical connections or process fluid connections must be respected and held in completely readable condition for future reference.

## 1.2. Hazards due to non-compliance with the safety instructions

Failure to follow the safety instructions may endanger not only persons, but also the environment and the device. Failure to follow the safety instructions will invalidate any damage claims.

Non-compliance with the safety instructions may give rise to the following hazards:

- Failure of major functions of the device.
- Failure of important methods for maintenance and repair.
- Danger to persons due to electrical, mechanical and chemical effects.
- Danger to the environment due to leakage of hazardous substances.

## 1.3. Qualification and training of personnel

The personnel employed for installation, operation, inspection and maintenance must be qualified for this work. The areas of responsibility, competence and supervision of the personnel must be precisely defined by the owner. Personnel who do not have the required knowledge must be duly trained and instructed. If necessary, this training can also be provided by PCCell on behalf of the ED system's owner.

In addition, the owner of the system must ensure that the relevant personnel are fully familiar with and have understood the contents of this Operation & Maintenance Manual.

## 1.4. Electrical hazards

Basic safety precautions should always be followed when installing and using this electrical equipment. These include the following:

WARNING!
Risk of electric shock. The device has to be connected to an earthed socket outlet protected by a ground fault circuit interrupter (GFCI).

WARNING!

Replace any damaged cables immediately to reduce the risk of electric shock.

WARNING!

The control box and any electrical components may only be opened and serviced by qualified personnel.

For further details concerning electrical security, refer to the German VDE standards as well as local rules and regulations.

## *1.5. Chemical hazards*

When working on systems with chemicals, the accident prevention regulations applicable on site must be observed and the specified personal protective equipment worn. The following protective equipment is recommended at least:

Always wear protective glasses or a face protection shield.

Wear protective gloves suited for your process solutions.

Wear protective working clothes.

All people responsible for installation, operation and maintenance are advised to wear this protective equipment at least. Depending on the chemical nature of the process solutions, additional protective equipment may be necessary. It is in the responsibility of the owner to conduct a complete risk assessment before starting any work with the ED system.

Before doing any maintenance on the device, disconnect it from the mains supply and protect it against unintended restart.

CAUTION!

Any chemical still present in the hydraulic system may spray or flow out when the voltage supply is reconnected. This may lead to chemical burns or severe injuries.

System parts and lines may be pressurized. Working on the device requires special safety precautions and may only be carried out by instructed technical personnel.

CAUTION!

Always relieve the pressure before starting work on the device. Chemicals may spray out. This may lead to chemical burns or severe injuries.

The unit must be rinsed thoroughly with water when work is carried out in order to prevent any unintentional contact with the dosing medium. Never look into the open end of a blocked line. Chemicals may emerge unexpectedly.

Before start up, all hydraulic connections must be inspected for correct tightness and, if necessary, must be tightened up using appropriate tools.

CAUTION!

If connections are loosened for venting or other reasons, leaking chemical must be removed professionally. This is the only way to avoid the danger of physical injury and corrosion of the components

The supplier of chemicals used in this product provides Material Safety Data Sheets (MSDS). They must be followed and must be accessible to anyone who uses the unit. These Safety Instructions do not replace the supplier's MSDS.

WARNING

The electrodialytic process can produce new chemicals or chemicals with higher concentrations than originally used, especially concentrated acids and bases. Adequate protective measures have to be taken.

CAUTION

At the electrodes, explosive and/or toxic gases and aerosol may be produced. Also in this case, appropriate protection has to be ensured.

The cell has to be run in a tank large enough to collect any liquids passing out of the system. Leakage of hazardous substances (e.g. toxic, corrosive or abrasive) must be discharged in such a way as to exclude all danger to people and the environment. Statutory regulations must be observed.

## *1.6. Safety instructions for installation, inspection and maintenance*

The owner must ensure that all installation, inspection and maintenance work is undertaken by authorized and duly qualified skilled personnel who have also studied this Operation & Maintenance Manual.

The ED stack must always come to a complete stop before starting any work on it. Assembly and maintenance work on the control system must only be carried out after disconnecting the device from the power supply. The procedure specified in the operating manual for shutting down the installation must be observed without fail. Whilst the work is in progress, the unit must be safeguarded from being reactivated! Cables must only be connected in this condition. Non-compliance can lead to defects in the unit and will invalidate the warranty.

Pumps or units in contact with potentially harmful media must be decontaminated. Leakages of dangerous substances (e.g. aggressive, toxic), for example due to a broken diaphragm, must be suitably drained away so that they do not cause danger to persons or the environment. A safe and ecologically beneficial disposal of process materials as well as replacement parts must be ensured.

All safety mechanisms and guards must be refitted and reactivated as soon as the work is completed. The instructions outlined in chapter “Installation location” and “Start up” must be observed before starting the system again.

All safety instructions contained in this operating manual must be observed. The operating company is responsible for ensuring compliance with local safety regulations. Any faults that could affect safety must be rectified immediately.

Legal requirements must be observed.

Risks from electric power must be excluded (for further details, refer to the german VDE regulations and the requirements of the local public utilities).

IMPORTANT!

The device may only be modified or converted in consultation with the manufacturer by qualified technical personnel. The manufacturer declines any liability for any damage or injuries caused by wrong configuration or assembly of the device.

Genuine spare parts and accessories authorized by the manufacturer ensure greater safety. Liability for damage or loss may be voided if non PCCell parts are used.

# 2. General

The electrodialysis cell units Micro-ED, ED 64002, ED 64004 and ED 200 are used in laboratory electrodialysis processes to remove ions from one solution (diluate). The ions are collected in another solution (concentrate). The electrodialysis cell units allow to carry out different types of experiments for a variety of applications, to examine the characteristics of ion exchange membranes in use. It is designed as an easy-to-manage laboratory cell.

The PCCell Micro-ED unit is especially suited for small amounts of solution. It can be used with an open middle chamber for two or four milliliters of diluate solution or as a standard ED with up to 25 cell pairs. In the first case, only the concentrate solution is circulated, while the diluate can be stirred in the open chamber. In the standard operation mode diluate and concentrate are circulated.

The ED64002 and ED 64004 has an active membrane area of 64 $cm^2$ per membrane and an effective size of 110x 110 mm. The typical batch sizes of 500- 2000 ml can be performed (depending on the salt content, matrix material etc). Depending on the requirements those batch sizes are scale-able to lower and higher volumes.

The ED200 has an active membrane area of 200 $cm^2$ per membrane and an effective size of 125x 260 mm. The typical batch sizes of 2000- 20000 ml can be performed (depending on the salt content, matrix material etc). Depending on the requirements those batch sizes are scale-able to lower and higher volumes.

This cell with a process length of 20 cm can also be used in a multistep mode for single pass desalination. For such application, different types of spacers are available.

A standard electrodialysis cell unit consists of an anode chamber, a cathode chamber and a membrane stack between them. This configuration allows the setup of a variety of processes.

## 2.1. Standard electrodialysis

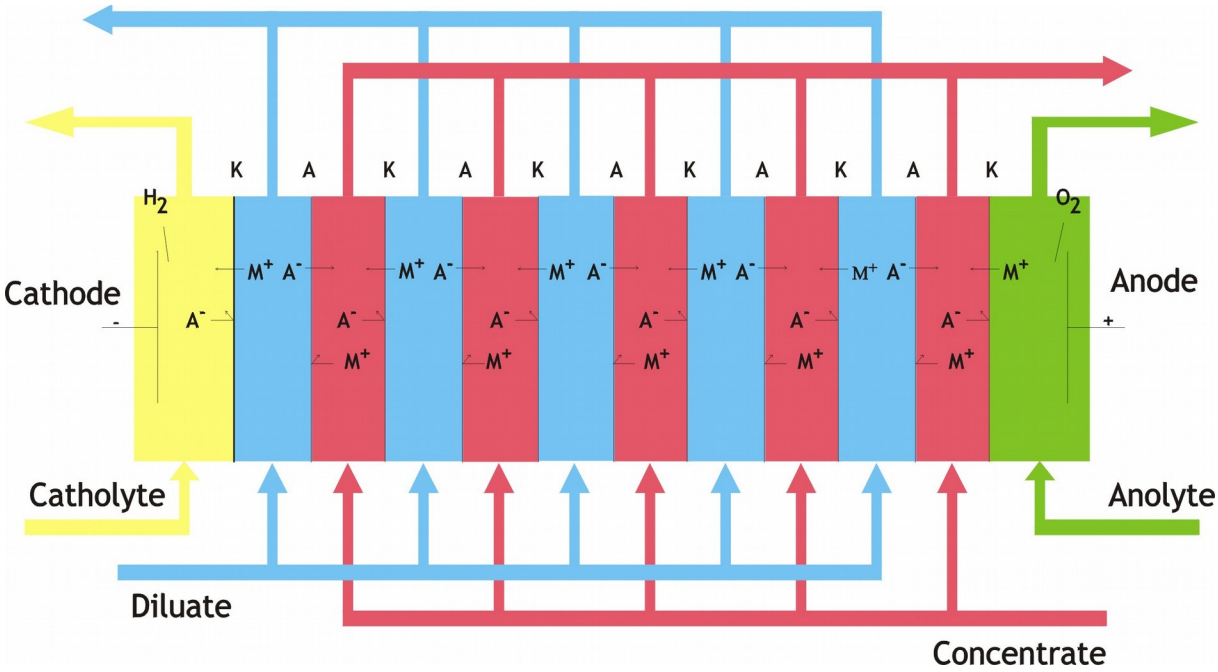



*Fig. 1: Functional setup of an ED stack. Salts are removed in cells called "Diluate" and are* collected in the Concentrate. Beside this, the electrodes need a solution, the Catholyte and the Anolyte.

A membrane stack for a standard ED consists of n (typically 5, 10, 50 or even 100) cell pairs, which are formed by n+1 cation exchange membranes, n anion exchange membranes and 2 n spacers.

At the shown polarity (Fig. 1), one of the cell systems is the diluate (where the ions are removed) and the other one is the concentrate in which the ions are collected. If the polarity is changed, the function of the cell system changes accordingly.

A complete ED System is set up by this ED Cell in combination with an ED pump unit, e.g. PCCell B-ED 1 and the external solvent tanks build (Fig. 2). Please note in this context, that the ED cell is only one part of the complete system and will work properly only in combination with the other parts.

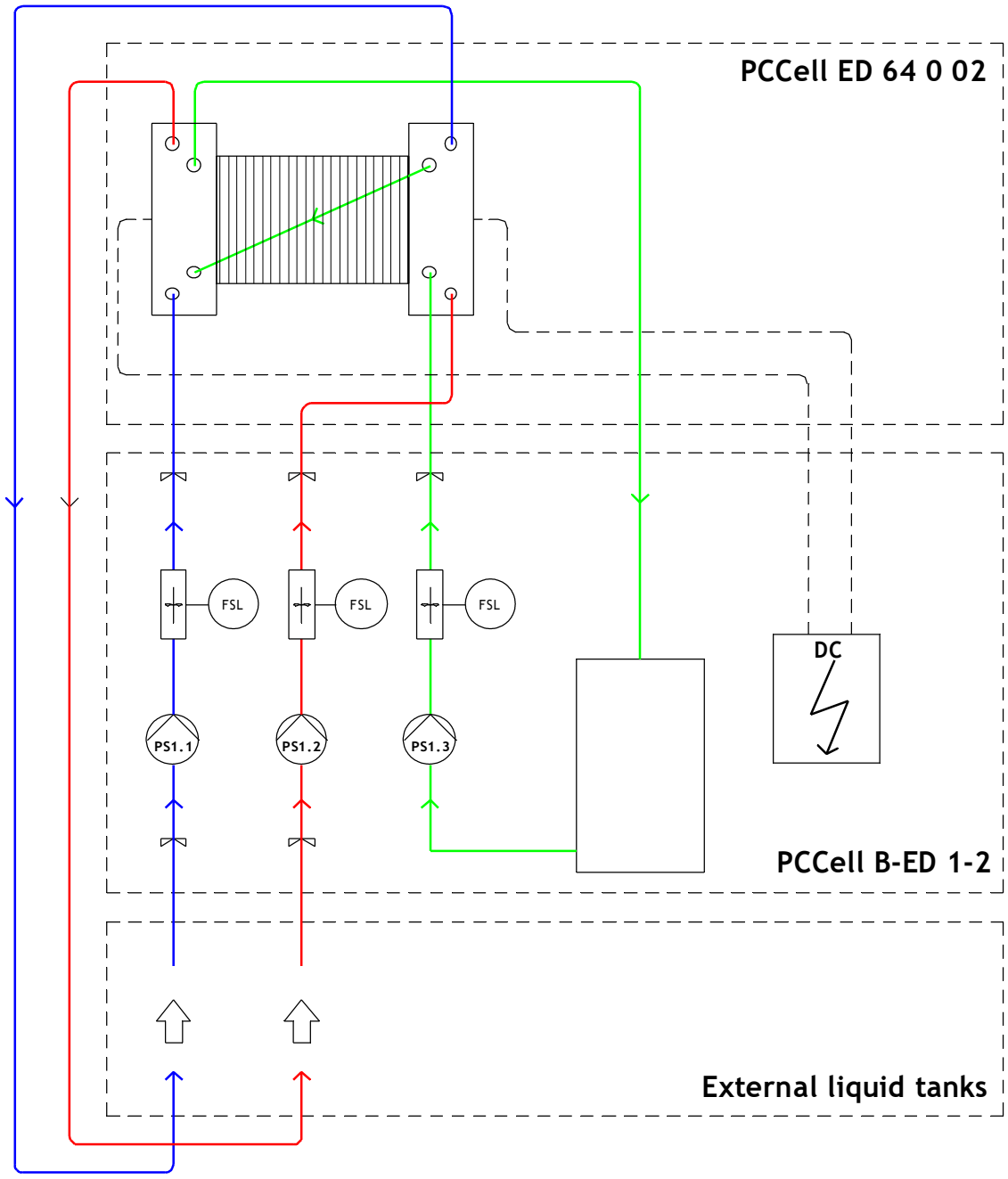



Fig. 2: Example of a complete ED setup, consisting of the stack (upper dotted rectangle), the ED pump unit (middle) and the external electrolyte containers (below).

## 2.2. Electrodialysis Reversal (EDR)

By changing the polarity of cathode and anode, the function of the diluate circuits and concentrate circuits are changed, too because the direction of the ions is reversed.

Thus, at places where oversaturation took place, now diluting processes take place and vice versa.

This can result in a (more) stable ED process.

Beside the electrical change, also a change of the inlet and outlets of the cell need to be performed and can be done by a PCCell T-Valve set.

Note!

To operate the electrodialysis in EDR mode, you require:

a) an EDR option in the ED cell (both electrodes need to be able to be used as anode)

b) a manual change of current direction as well as concentrate/diluate inlet or an EDR upgrade of the pump unit.

# 3. Technical Data

## *3.1. Electrodialysis cell components*

The PCCell electrodialysis cells consists of the components shown in the following:

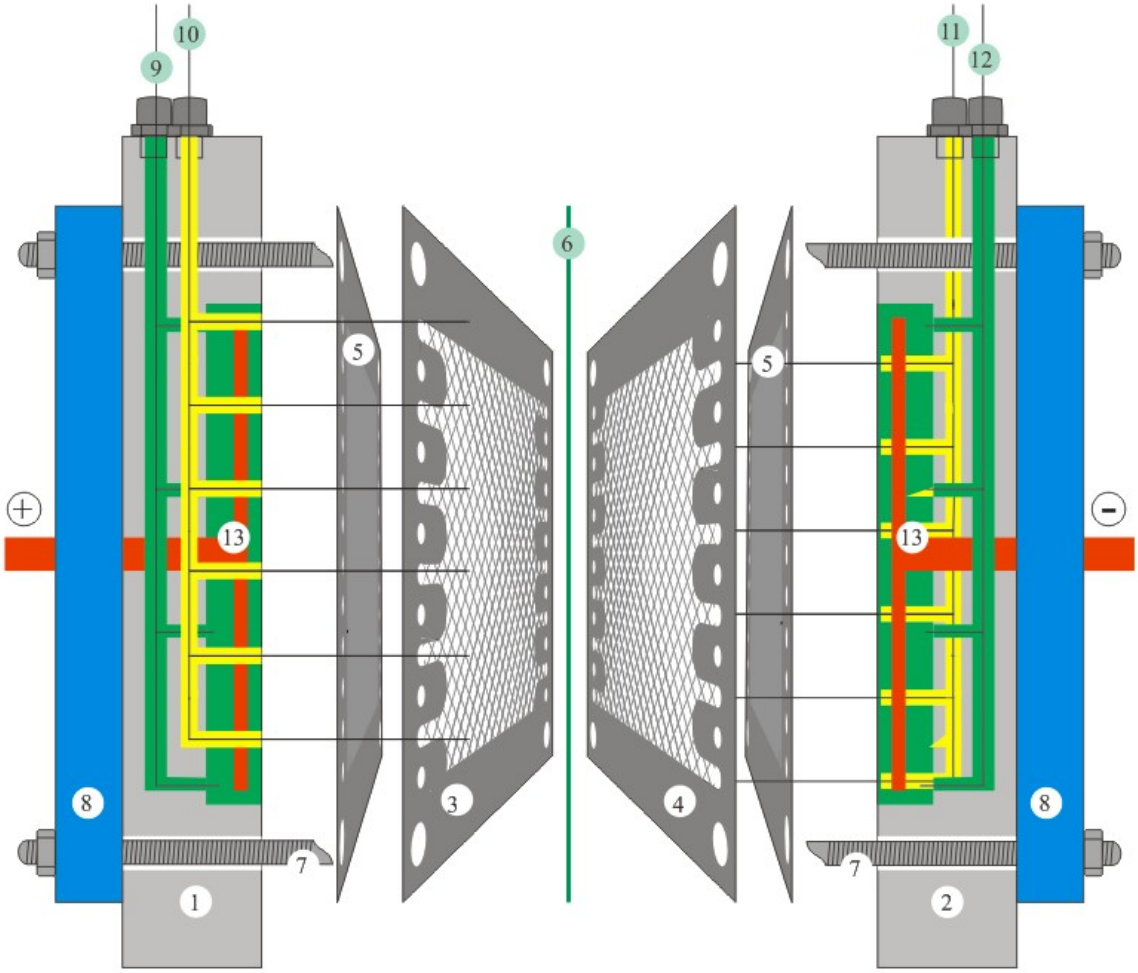



Fig. 3: Schematic view of a PCCell electrodialysis cell with its functional parts

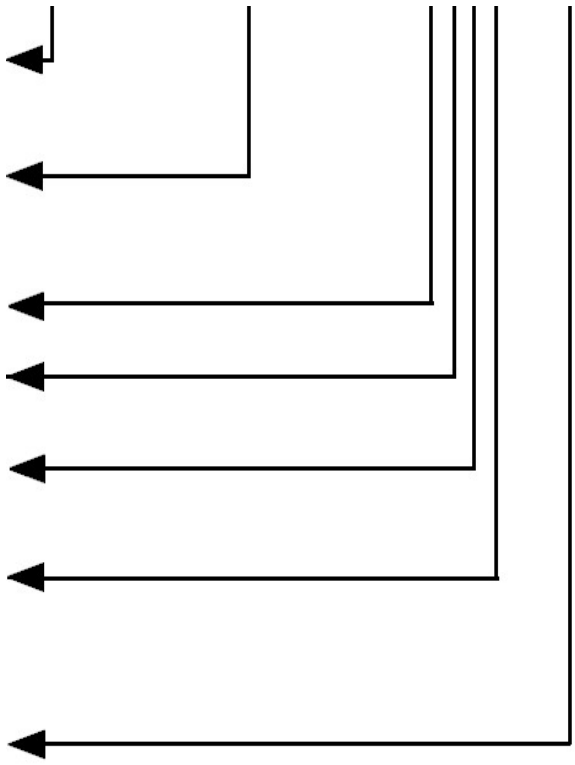
| # | Description | Art No. |
|---|---|---|
| 1,2 | Electrode end plates | |
| 3, 4, 5, 6 | Membrane stack | |
| 7, 8 | Screw set | |
| 9, 12 | Electrolyte inlet | |
| 10, 11 | Concentrate and diluate inlets | |
| 13 | Electrodes | |

## *3.2. Nomenclature of the cells*

the description of the cells is according the following scheme:

| Cell type | number of cell pairs | membranes | Type |
|---|---|---|---|
| ED 64 002- | 010- | 2201- | ED1 |
| ED Q380- | T10- | 1131- | ED1 |

| | |
|---|---|
| Cell type | ED 64 002/004, ED 200, ED Q380... |
| Number and type of cell pairs | 005 = 5 cell pairs (cp),<br>010 =10 cell pairs<br>T10 = 10 cell triplets (tp)<br>Q20 = 20 quad-pairs (qp) |
| Cation membrane | code according datasheet |
| Anion membrane | code according datasheet |
| Bipolar membrane | 0 = no bipolar<br>1 = standard bipolar |
| Spacer type | 1 = Polypropylene 0,45 mm<br>2 = Polyester 0,35 mm<br>3 = PP food grade |
| ED type | ED1 = conventional ED<br>EDR = electrodialysis reversal<br>ED3 = three cell stages with one center electrode |



## 3.3. Cell sizes

| *Stack Type* | | *Micro-ED* | *ED 64* | *ED 200* | *ED 1000 A* | *ED 1000 H* |
|---|---|---|---|---|---|---|
| *Characteristic* | | *ED* | *ED/EDBM* | *ED* | *cont-ED* | *ED* |
| Effective Membrane Area | $cm^2$ | 8 | 64 | 207 | 950 | 1050 |
| Membrane Size | cm | 6x4 | 11 x 11 | 12,5 x 26 | 30 x 50 | 30 x 50 |
| Spacer Type | mm | 0,45 | 0,45 | 0,35/0,45 | 0,35/0,45 | 0,35/0,45 |
| Processing Length | cm | 2,8 | 8 | 20 | 70 | 38 |
| Nominal Flowthrough / Cell | l/h | 0,5 | 8 | 8 | 10 | 30 |
| Membranes per Unit | max pcs | 25 | 60 | 100 | 200 | 200 |
| Eff. Membrane Area / Unit | max $m^2$ | 0,02 | 0,38 | 2,0 | 20 | 20 |

| *Stack Type* | | *ED Q380* | *ED 1600* | *ED Q1600* | *ED 2500* | *ED 4000 H* |
|---|---|---|---|---|---|---|
| *Characteristic* | | *ED/EDBM* | *ED* | *ED/EDBM* | *ED* | *ED* |
| Effective Membrane Area | $cm^2$ | 380 | 1840 | 1600 | 2530 | 4000 |
| Membrane Size | cm | 25 x 25 | 40 x 46 | 50 x 50 | 46 x 55 | 50 x 100 |
| Spacer Type | mm | 0,45 | 0,45 | 0,45 | 0,45 | 0,45 |
| Processing Length | cm | 20 | 40 | 40 | 55 | 85 |
| Nominal Flowthrough / Cell | l/h | 10 | - | 25 | - | 50 |
| Membranes per Unit | max pcs | 60 | 200 | 240 | 200 | 400 |
| Eff. Membrane Area / Unit | max $m^2$ | 2,28 | 36 | 38,4 | 50 | 160 |

## 3.4. Spacer types

| *Spacer Type* | | *0,35 mm* | *0,45 mm* | *0,5 mm* |
|---|---|---|---|---|
| *Characteristic* | | *low process length* | *high chemical stability* | *low pressure drop* |
| thickness | µm | 350 | 450 | 500 |
| material | cm | Silicone / Polyester | Silicone / Polypropylene | Silicone / Polypropylene |
| mesh type | | 45° | 45° | 45° |

## *3.5. Technical Data*

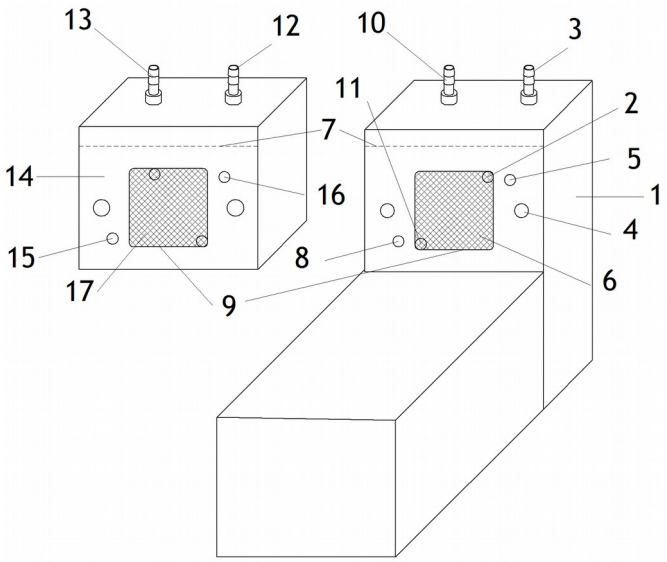



Fig. 4: PCCell Micro-ED Electrode End Plates.

| # | Description |
|---|---|
| 1 | Anode Block (PP) |
| 2 | Anolyte liquid outlet |
| 3 | Concentrate (Diluate) outlet |
| 4 | Clamping Bolt hole |
| 5 | Concentrate (Diluate) connector hole outlet to spacer |
| 6 | Anode |
| 7 | Membrane and Spacer size and position |
| 8 | Concentrate (Diluate) connector hole to intlet |
| 9 | Electrode compartment |
| 10 | Concentrate (Diluate) intlet |
| 11 | Anolyte liquid intlet |
| 12 | Diluate (Concentrate) outlet |
| 13 | Diluate (Concentrate) inlet |
| 14 | Cathode Block (pp) |
| 15 | Diluate (Concentrate) connector hole to intlet |
| 16 | Diluate (Concentrate) connector hole to outtlet |
| 17 | Cathode |

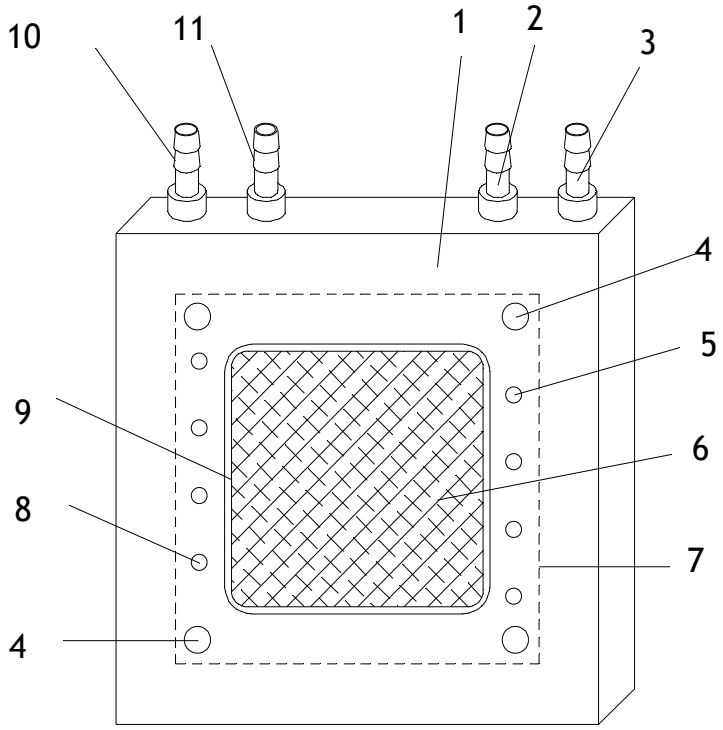



Fig. 5: PCCell ED 64002 Electrode End Plates.

| # | Description |
|---|---|
| 1 | Electrode Block (PP) |
| 2 | Electrolyte liquid inlet |
| 3 | Concentrate (Diluate) inlet |
| 4 | Clamping Bolt hole |
| 5 | Concentrate (Diluate) connector hole to spacer |
| 6 | Electrode |
| 7 | Membrane and Spacer size and position |
| 8 | Diluate (Concentrate) connector hole to outlet |
| 9 | Electrode compartment |
| 10 | Diluate (Concentrate) outlet |
| 11 | Electrolyte liquid outlet |

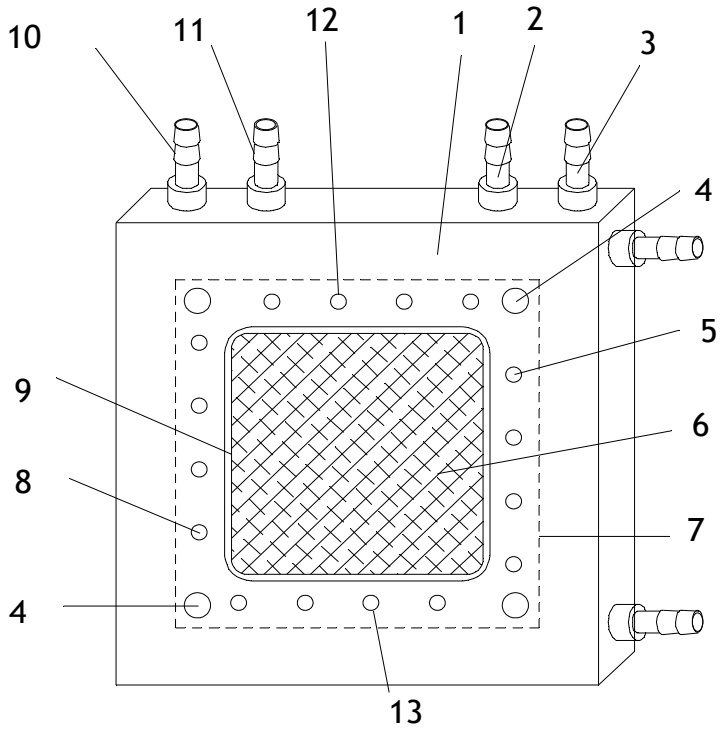



Fig. 6: PCCell ED 64 004 Anode End Plate.

| # | Description |
|---|---|
| 1 | Electrode block (PP) |
| 2 | Electrolyte liquid inlet |
| 3 | Concentrate (Diluate) inlet |
| 4 | Clamping bolt hole |
| 5 | Concentrate (Diluate) connector hole to spacer |
| 6 | Electrode |
| 7 | Membrane and Spacer size and position |
| 8 | Diluate (Concentrate) connector hole to outlet |
| 9 | Electrode compartment |
| 10 | Diluate (Concentrate) outlet |
| 11 | Electrolyte liquid outlet |
| 12 | Concentrate (Diluate) connector hole to spacer |
| 13 | Diluate (Concentrate) connector hole to spacer |
| Not shown | Rack set to mount the stack |

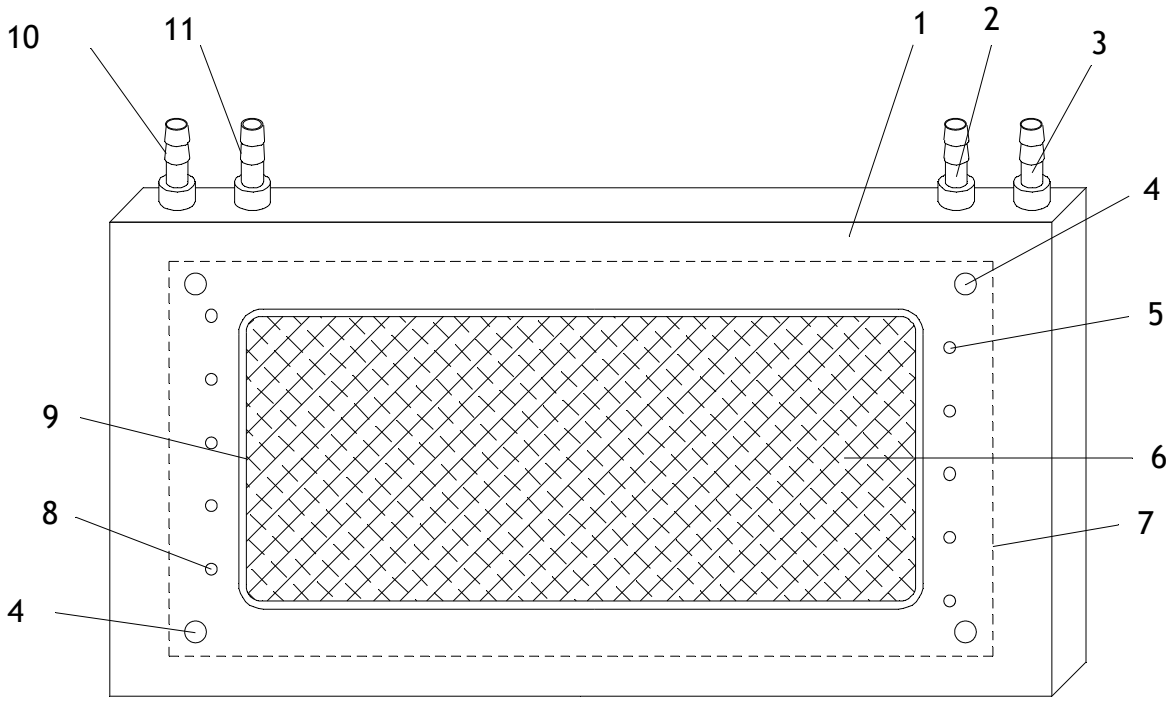



Fig. 7: PCCell ED 200 Electrode End Plate.

| # | Description |
|---|---|
| 1 | Electrode Block (PP) |
| 2 | Electrolyte liquid inlet |
| 3 | Concentrate (Diluate) inlet |
| 4 | Clamping Bolt hole |
| 5 | Concentrate (Diluate) connector hole to spacer |
| 6 | Electrode |
| 7 | Membrane and Spacer size and position |
| 8 | Diluate (Concentrate) connector hole to outlet |
| 9 | Electrode compartment |
| 10 | Diluate (Concentrate) outlet |
| 11 | Electrolyte liquid outlet |

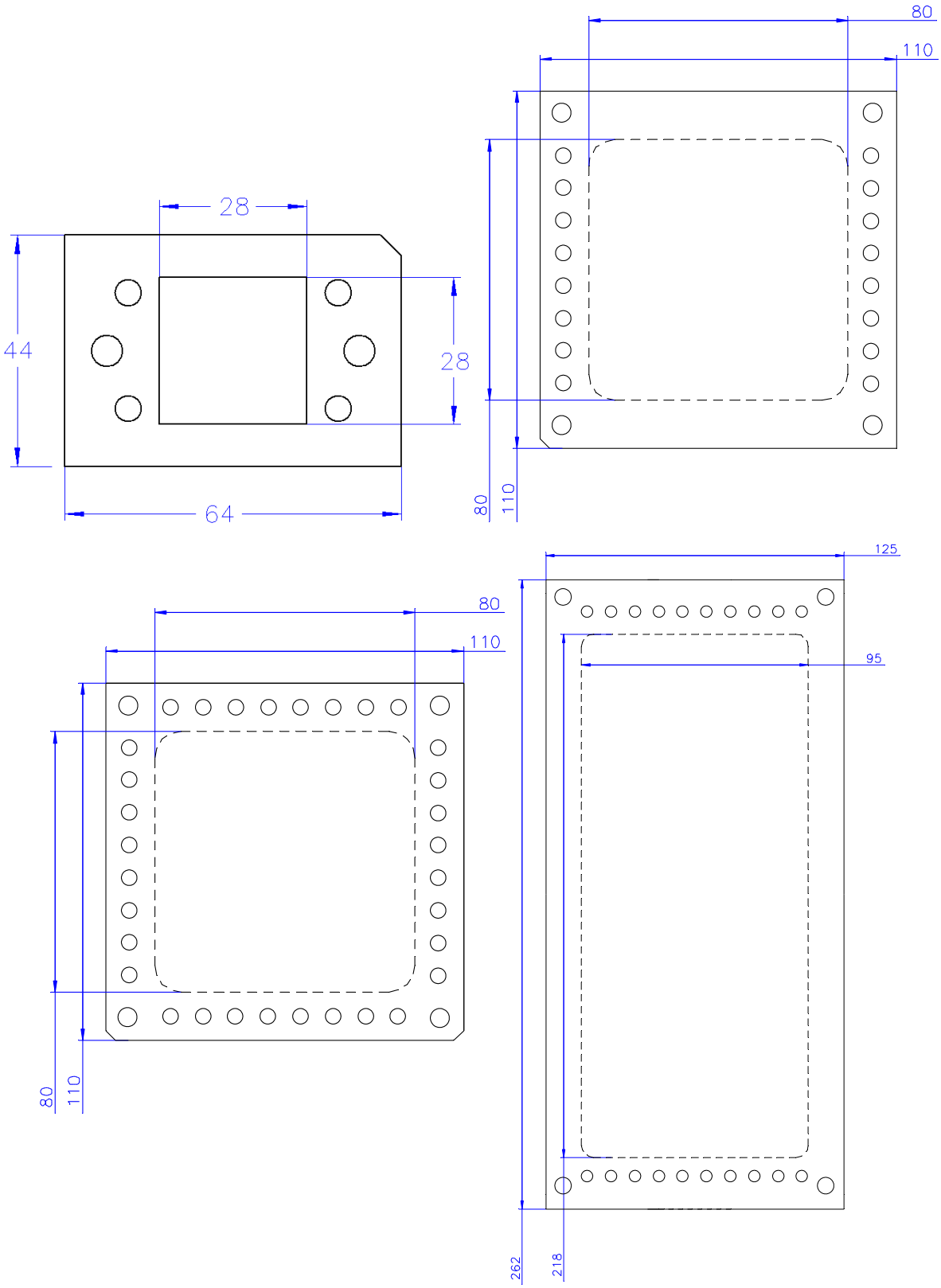



Fig. 8: PCCell Micro-ED, ED 64002, ED 64004 and ED 200 Membrane size. Size given is in mm. Dotted square area in the middle of the membrane is the active membrane area of the cell.

**Tab 1: Dimensions and Weight** (ca)

| | Micro-ED | ED 64002 | ED 64004 | ED 200 |
|---|---|---|---|---|
| width | 150 mm | 165 mm | 190 mm | 165 mm |
| depth | 70 mm | 150 mm | 150 mm | 150 mm |
| height | 140 mm | 190 mm | 190 mm | 300 mm |
| weight | 0.75 kg | 2.5 kg | 3 kg | 4 kg |

**Tab 2: Stack**

| | Micro-ED | ED 64002 | ED 64004 | ED 200 |
|---|---|---|---|---|
| Membrane size | 60 x 40 mm | 110 x 110 mm | 110 x 110 mm | 125 x 262 |
| Active membrane area | 7.8 $cm^2$ | 64 $cm^2$ | 64 $cm^2$ | 207 $cm^2$ |
| Number of membranes | Max. 25 cp | Max. 60 cp | Max. 60 cp | Max. 100 cp |
| Processing length | 28 mm | 80 mm | 80 mm | 200 mm |
| Membrane spacing | electrode - membrane: ca. 1 mm<br>over cells: 0.5 mm | | | |
| Current Connectors | 4 mm banana plugs | | | |

**Tab. 3: Medium Contacting Materials / End plate materials**

| | |
|---|---|
| Cell frame | polypropylene |
| Tubes | polyethylene |
| Electrodes | Titanium with Pt/Ir coating, stainless steel |
| Sealings | EPDM |
| End spacer | Silicone / polypropylene |
| Spacer ED 200oem | Silicone / polypropylene |

**Tab 4: Spacer Specification**

| | Silicone / PP | food Sil. / PP | Silicone / PES |
|---|---|---|---|
| thickness | 0.45 | 0.45 | 0.35 |
| orientation mesh to flow rate | 45° | 45° | 45° |

**Tab. 5:Spacer options**

| | PVC | Silicone | Viton | EPDM | Food approved silicone / polyetheylene | Silicone / Polyester | Silicone /PVDF | Silicone / Polyetheylene |
|---|---|---|---|---|---|---|---|---|
| End spacer | 1 | 1 | 1 | 1 | | 1 | 1 | |
| Spacer Micro-ED | 1 | 1 | | | 1 | 1 | 1 | 1 |
| Spacer ED 64 0 02 | | | | | 1 | 1 | | 1 |
| Spacer ED 64 0 04 | | | | | 1 | 1 | | 1 |
| Spacer ED 200 | | | | | 1 | 1 | 1 | 1 |

1 available

**Tab 6:Electrical connecting data**

| | Cell connection | | | |
|---|---|---|---|---|
| Type | 4 mm banana plugs (standard) or via firmly mounteable connector cable (optional).<br>DANGER!<br>only connect the cell with a galvanically isolated DC current circuit. | | | |
| Maximum Ratings | Micro-ED | ED 64002 | ED 64004 | ED 200 |
| Current: | ca. 5A* | ca. 5A* | ca. 5A* | ca. 16 A* |
| | ATTENTION<br>More than 12.8 A should be avoided as overheating of contacts can hardly be managed. | | | |
| | Micro-ED | ED 64002 | ED 64004 | ED 200 |
| Voltage: | Max. 2 V / cp<br>Max. 30 V per cell | Max. 2 V / cp<br>Max. 30 V per cell | Max. 2 V / cp<br>Max. 30 V per cell | Max. 2 V / cp<br>Max. 30 V per cell |

* (the application, temperature etc. might reduce the rating of the electrical connectors), over this value, a safe operation requires avoiding overheating of electrode studs and contacts.

**Tab 7: Hydraulic connecting data**

| | Micro-ED | ED 64002 | ED 64004 | ED 200 |
|---|---|---|---|---|
| Type (tube $d_i$ and $d_a$) | 4/ 6 mm | 8/ 10 mm | 8/ 10 mm | 8/ 10 (10/ 12) mm |
| Flow through electrode circuits: | nominal150 l/ h | nominal150 l/ h | nominal 150 l/ h | nominal 150 l/ h |
| Nominal flow through concentrate and diluate per single cell | 4-8 l / h (10 cell pairs result in 40-80 l / h) | 4-8 l / h (10 cell pairs result in 40-80 l / h) | 4-8 l / h (10 cell pairs result in 40-80 l / h) | 5 – 10 l/h (10 cell pairs result in 50-100 l / h) |
| Max. pressure | Trans-membrane pressure has to be kept zero: Never pump only one of the diluate / concentrate circuits! | | | |
| pressure drop over cell | Max. 0.5 bar | | | |

## *3.6. The hydraulic connectors of the cells*

The six functional liquid compartments (catholyte, anolyte, concentrate 1, diluate 1, concentrate 2 and diluate 2) require one inlet and outlet, each (see Tab. 8). Their direction can generally be changed, however flow-in and -out of diluate and concentrate should be at the same cell face (if 1 is chosen as the first inlet, 2 should be chosen as the corresponding inlet) to reduce trans-membrane pressure.

**Tab 8: The six hydraulic loops of an ED cell**

| *Liquid loop* | *Connector No.* | *Remarks* |
|---|---|---|
| Catholyte | 6 - 6' | Connectors on Cathode block. |
| Anolyte | 5 - 5' | Connectors on Anode block. |
| Concentrate | 2 - 2' | |
| Diluate | 1 - 1' | If 2 is the inlet of concentrate, 1 should used as inlet of the diluate |
| Concentrate 2 | 3 - 3' | |
| Diluate 2 | 4 - 4' | |

The connectors for diluate and concentrate are situated diagonally opposite of each other, those of the electrode chambers in the interior at the same sides respectively.

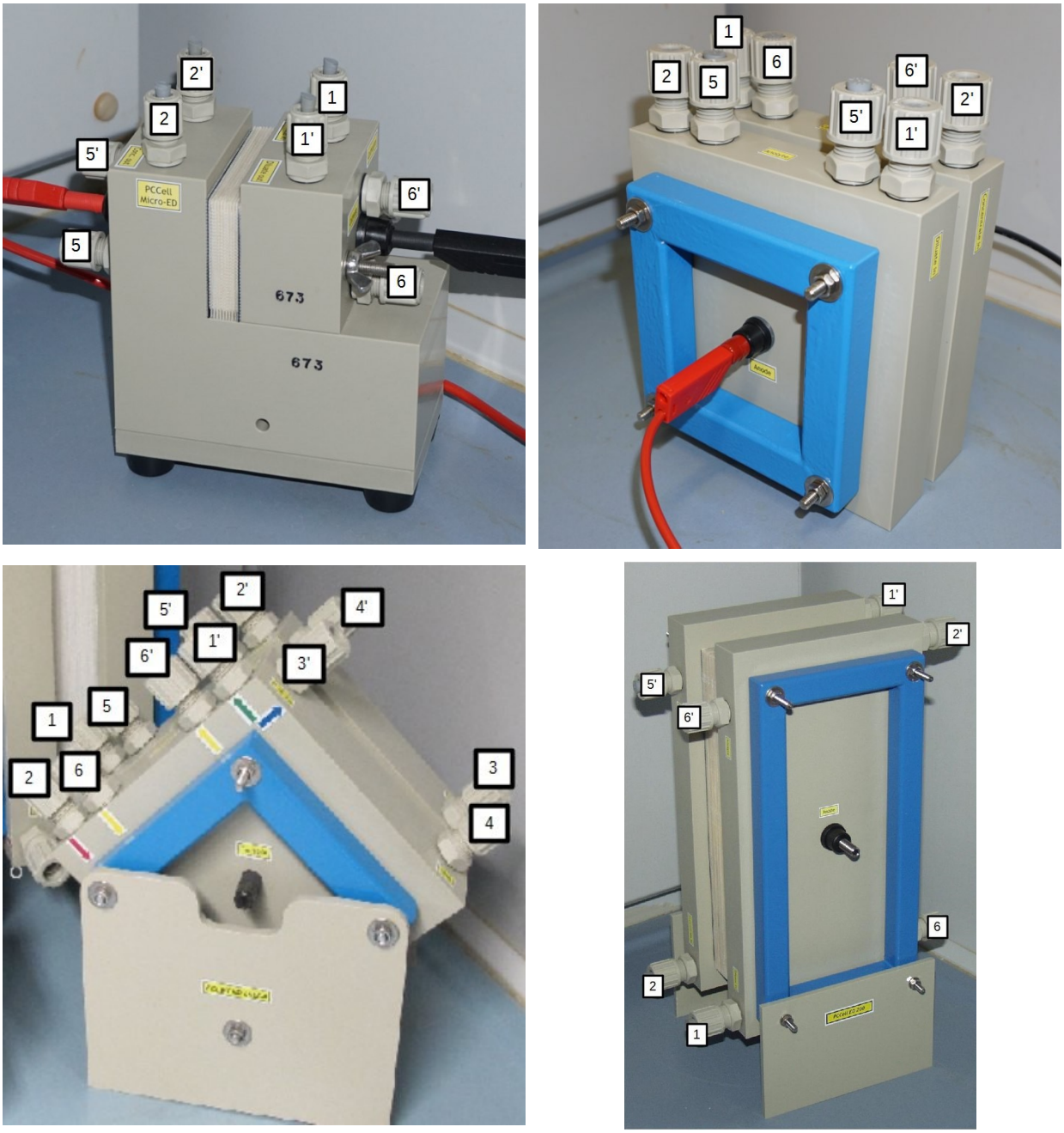



Fig. 9: The PC Cell ED cells with connectors (described in Tab 8). In the upper row on the left side is the Micro-ED. In the upper row on right side is the ED 64002 with the anode side in the front. In the lower row on the left side is the ED 64004 with cathode side in front. In the lower row on the right side is the ED 200 with the cathode side in the front.

## *3.7. Multiple stage operation with the ED200*

Multiple stage operation can be performed by special spacer sequences. With the model ED200, different configuration can be performed by combination of two, three or more stages in combination with one or more center electrodes. Depending on the number of stages, inversed outlet end-plates can be required.

| Stages | process length | end plate geometry | number of center electrodes | Code (example with 10 cell pairs per stage and standard membranes) |
|---|---|---|---|---|
| 1 | 20 cm | standard | 0 | ED 200-010-1101 -ED1 / EDR |
| 2 | 40 cm | inversed special cathode plate | 0 | ED 200-010-010-1101 -ED1 |
| 3 | 60 cm | standard | 0 | ED 200-010-010-010-1101 -ED1 |
| | | | 1 | ED 200-010-010-010-1101 -ED2 |
| 4 | 80 cm | inversed special cathode plate | 1 | ED 200-010-010-010-010-1101 -ED2 |

Tab. 9: Typical configurations of ED200 operated in multiple stages

Fig. 10: ED 200 with center electrode and two stages on the right side of center electrode and one stage on the left side of electrode. Flow from right to left.

## *3.8. Scope of Delivery*

IMPORTANT!

Please unpack the ED system and ordered accessories carefully in order not to miss small parts. Immediately compare the scope of delivery to the delivery note. If there are any discrepancies, contact your local distributor.

# 4. Installation

## *4.1. General Remarks*

For the selection of an ED stack, when designing a system as well as for the installation and operation, local rules and regulations must be obeyed. This equally refers to the selection of appropriate materials of construction, the handling of the chemicals and the electrical installation. At the same time the technical data of the ED cell must be taken into consideration. The system must be designed properly (e.g. pressure loss in lines depending on nominal diameter and length, current density and voltage).

The designer and the user are responsible to make sure that the whole system including the ED stack is constructed so that neither plant equipment nor buildings are damaged in the case of leakage or malfunction due to the failure of any parts (e.g. spacer rupture) or burst tube. If the chemical plant represents a potential danger, the installation must be carried out in a way that no unreasonably high consequential damages occur, even if the stack fails. Therefore we recommend the installation of leakage probes and containment tanks.

Always use appropriate tools for the installation of plastic connecting parts. To avoid damage, never apply excessive force.

WARNING!

By running an electrodialysis with this cell unit, concentrated acids and bases, which are corrosive, may be produced. Adequate protective measures have to be taken.

WARNING!

At the electrodes, explosive gases and aerosol may be produced. Also in this case, appropriate protection has to be ensured. The cell has to be run in a tank large enough to collect any liquids passing out of the system.

Please see also Chapter 1 for further instructions.

## 4.2. Installation Location

The installation location of the stack must be easily accessible for the operating and service staff.

The cell should be prevented from freezing conditions, direct sun should be avoided as well.

Treatment of freshly assembled stacks

ED stacks, which are fresh assembled will shrink and seal over a time period of some days. Upon delivery, they are assembled and tightened with a torque of 8 Nm and proved to be seal. However the settling process is not finished. This result in the necessity to tighten the stack over a time period of some days each day with a torque specially defined for each cell type.

| | maximum torques | Article No of tool set |
|---|---|---|
| Micro-ED | Carefully tightened with the hand | |
| ED 64002 / 64004 | 6 - 8 Nm | ED64-104-277 |
| ED 200 | 8 - 10 Nm | |
| ED Q380 | 15 - 20 Nm | |
| ED 1000A / ED 1000H | 12 - 15 Nm | |
| ED 1600 | 12 - 15 Nm | |
| ED 2500 | 12 - 15 Nm | |

Tab. 10: Maximum torques to be applied for cell closures

IMPORTANT:

Tighten the stack each day with a torque given in Tab. 10 until it becomes evident that the process of shrinkage and sealing has come to an end. This will usually take about one week for large stacks and can be finished within 1-2 days for smaller ones.

Never tighten with a torque of more than given in Tab. 10 !

Closing stack

- Close the stack by adding the upper electrode chamber and metal frame.
- Screw the stack by hand.
- Tighten the screws using a torque wrench with 6-8 Nm (12 Nm for the ED 200, ED 1000, ED 1600 and ED2500).
- Measure the distance of the end plates on all four sides.
- Tighten the screw with the highest distance with a standard wrench to the distance of the closest corner.
- Finally the distances of the end plate in the four corners should not differ by more than ± 0,3 mm.

## *4.3. Assembling And Disassembling Procedures*

### 4.3.1. Disassembling

- Flush the cell to remove all remains of toxic or aggressive substances.
- Disconnect all tubes and cables from the cell.
- Put the cell with one electrode chamber faced down on the desk and remove the 4 screws at the upper side.
- Remove the blue metal frame.
-

**Attention:**

The anodes (and cathodes, if the EDR option is used) are coated with iridium and must not be touched with hands or any other tools. Otherwise the coating might be damaged or destroyed.

-
- Remove sealing, membranes and spacers one after the other.
- Keep the membranes wet. Some membrane types have to be stored in saturated NaCl solution to prevent rolling. Please refer to the respective handling instruction.
- Spacers and sealings may be cleaned with water.

### 4.3.2. Assembling

To build-up the cell unit:

- Put the 4 bolts in the stainless steel frame and the anode chamber and put them on the table with the screws facing down as shown in Fig. 11.
- Put one end spacer onto the anode chamber.
- Prepare the membranes and spacers in four different staples in the following sequence as shown in Fig. 11:

  I cation exchange membrane,

  II spacer concentrate,

III anion exchange membrane and

IV spacer diluate.

To stack n cell pairs, you will need n spacer concentrate, n anion exchange membranes, n spacer diluate and n+1 cation exchange membranes.

- Check out the orientation of the spacers in staple II and IV. They need to be as indicated by the arrow in Fig. 11.
- Stack one membrane from staple I on the end block
- Stack a spacer from staple II on the membrane
- Stack one after the other from staple III, IV and again I, II ... on the stack until all membranes and spacers are stacked.
- You should have ended the stacking with the cation membrane of staple I.
- Finish the stack by adding a end sealing spacer.
- close the stack by adding the cathode chamber and metal frame.
- Finally, screw the stack with a torque wrench with 6Nm.

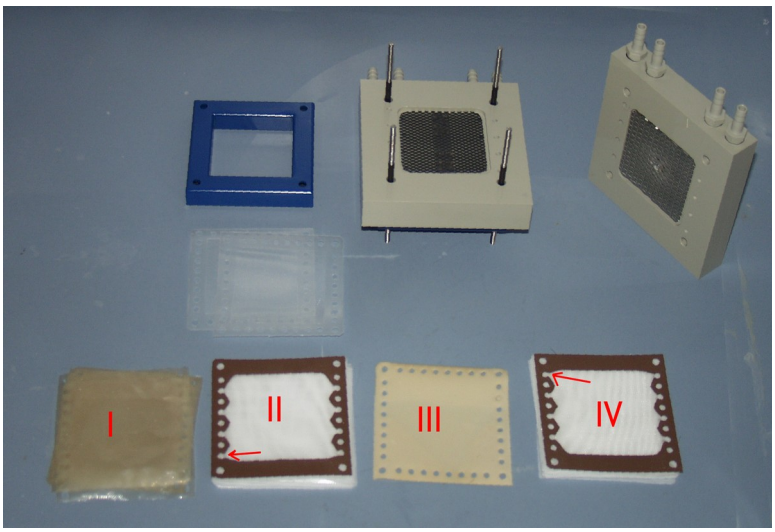



Fig. 11: Starting configuration to assemble a stack.

## *4.4. Assembling and Disassembling Procedures*

### 4.4.1. Disassembling

- Flush the cell to remove all remains of toxic or aggressive substances.
- Disconnect all tubes and cables from the cell.
- Put the cell with one electrode chamber faced down on the desk and remove the 4 screws at the upper side.
- Remove the blue metal frame.

**Attention:**

The anodes (and cathodes, if the EDR option is used) are coated with iridium and must not be touched with hands or any other tools. Otherwise the coating might be damaged or destroyed.

- Remove sealing, membranes and spacers one after the other.
- Keep the membranes wet. Some membrane types have to be stored in saturated NaCl solution to prevent rolling. Please refer to the respective handling instruction.
- Spacers and sealings may be cleaned with water.

### 4.4.2. Assembling

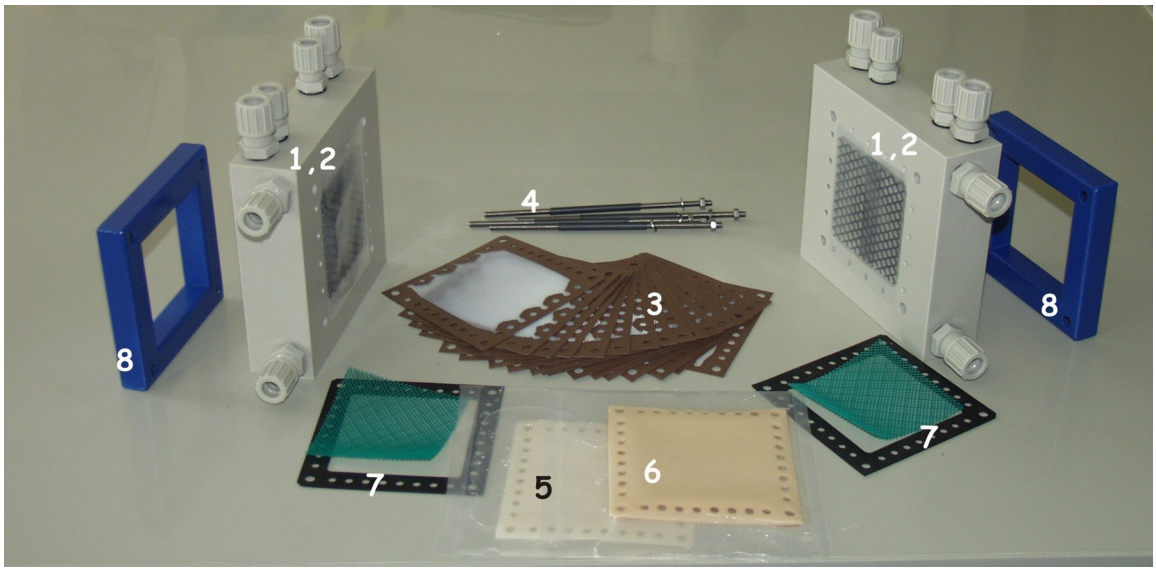



Fig. 12: PCCell ED 64004 parts. Anode end plate on the right side, Cathode on the left. Spacers (3) are shown in brown color, although they are colorless in reality. Sealing (7) may be replaced by end-spacers similar to (3).

To build-up the cell unit:

- Put the 4 screws (4) in the stainless steel frame (8) and the **anode chamber** (1, 2, right side of picture) and put them on the table with the screws facing down (as shown in fig. 12).
- Put the sealing (7) and the green spacer fabric onto the anode chamber (1, 2).
- Prepare the membranes and spacers in the sequence: cation exchange membrane, spacer diluate, anion exchange membrane and spacer concentrate. Respect the orientation of the spacers (see arrow) to diluate resp. concentrate inlets of the cell.
- Stack membranes and spacers one after the other in the prepared sequence from left to right.

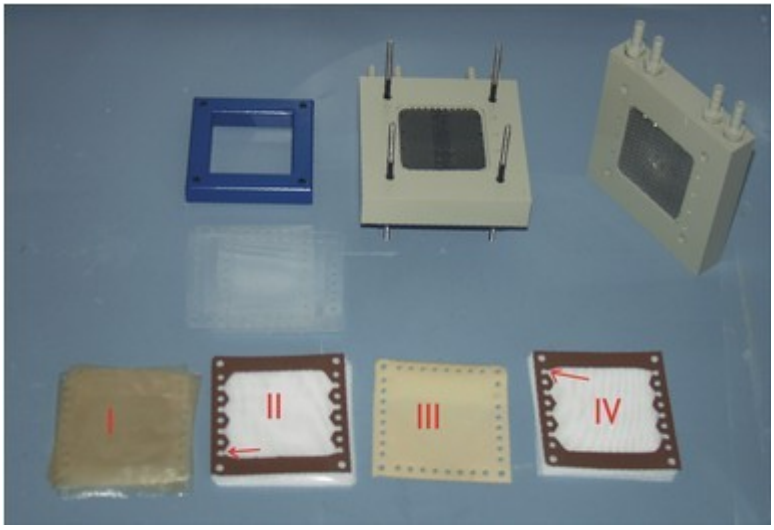



Fig. 13: Starting configuration to assemble a stack.

- Add a sealing (7) on the stacked membranes, put the spacer fabric on the membrane surface and close the stack by adding the cathode chamber and metal frame.
- Finally, screw the stack by hand weakly. Use a torque wrench to close the screws with 6-7 Nm. *Higher torques may damage the stack*. Control the distance of the end blocks on all sides.
- Proceed with a leakage test of all circuits.

### 4.4.3. Stacking of three- or four-chamber ED

The spacers of the PCCell ED 64004 can be arranged in four different ways as shown in figure 14 (The difference is in the positions of the inlet and outlet of the spacers as shown by an arrow). Each of the four spacers represent one of the four different independent cell circuits. A three chamber ED needs only three of the four possible orientations.

Fig. 14: The spacer of PCCell ED 64 0 04: The four spacers are identically, differing only in their orientation (see arrow).

### 4.4.4. Stacking of a four-chamber ED

- Prepare the anode end block in the orientation shown in 15.
- Prepare the membranes and spacers in the sequence you need in your setup.

  For a salt methathesis the configuration may look like :

  cation exchange membrane (CEM),

  spacer concentrate 1,

  anion exchange membrane (AEM),

  spacer diluate 1,

  cation exchange membrane (CEM),

  spacer concentrate 2

  anion exchange membrane (AEM) and

  spacer diluate 2
- Then, proceed as described under the chapter “Assembling”

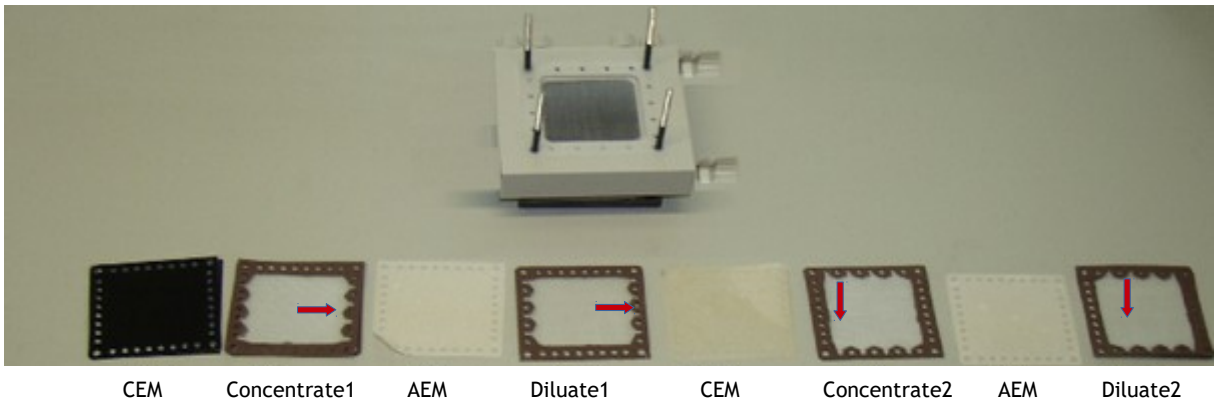



Fig. 15: Starting configuration to assemble a stack in a four chamber configuration.

### 4.4.5. Stacking of a three-chamber ED

The starting configuration for an ED with bipolar membranes has only three different membrane types and three spacer of different orientation. I is the end cation membrane towards the anode, II the acid spacers, III the anion membranes, IV the salt spacers, V the cation membranes, VI the base spacers, VII the bipolar membranes and VIII the end spacers.

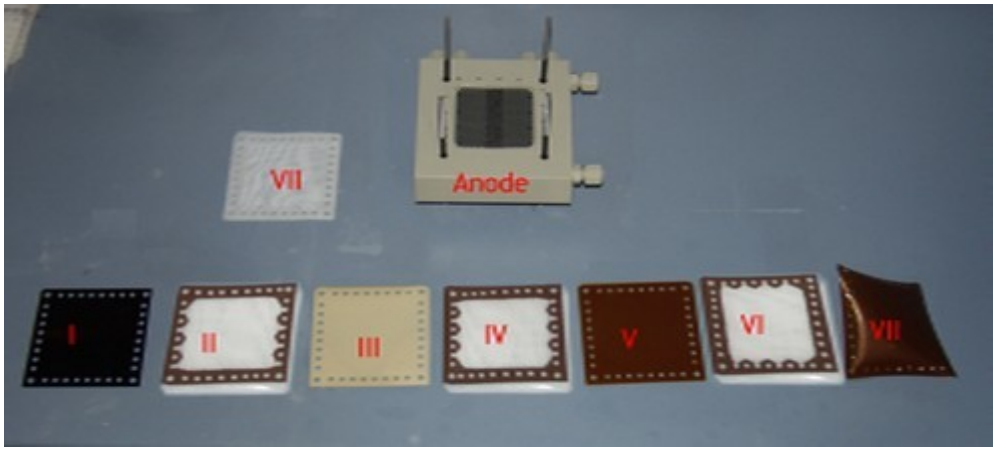



Fig. 16: Starting configuration for assembly of a three chamber configuration.

### 4.4.6. Mounting and use of the ED rack set

The PCCell ED 64004 is delivered with a rack set to be mounted on the cell as shown below. This rack set brings the cell into a diagonal position, wherein the inlet of each circuit shall be located at the lowest place and the outlet at the highest place. This prevents the formation of static air bubbles in the ED chambers.

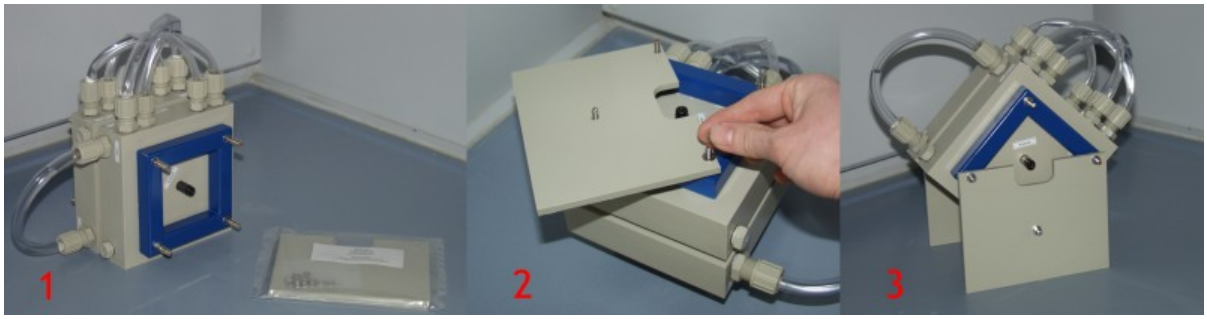



Fig. 17: Mounting the rack set.

### 4.4.7. Leakage Test

- Fill the electrolyte chambers with water.
- Complete fill the diluate and the concentrate chambers with water. Rinse out any remaining air bubbles.
- Close the diluate outlet and connect the diluate inlet with a hose under 2m water column pressure. The easiest way to achieve this is to place the stack on the floor and the water tank on a higher level (e.g. cupboard).

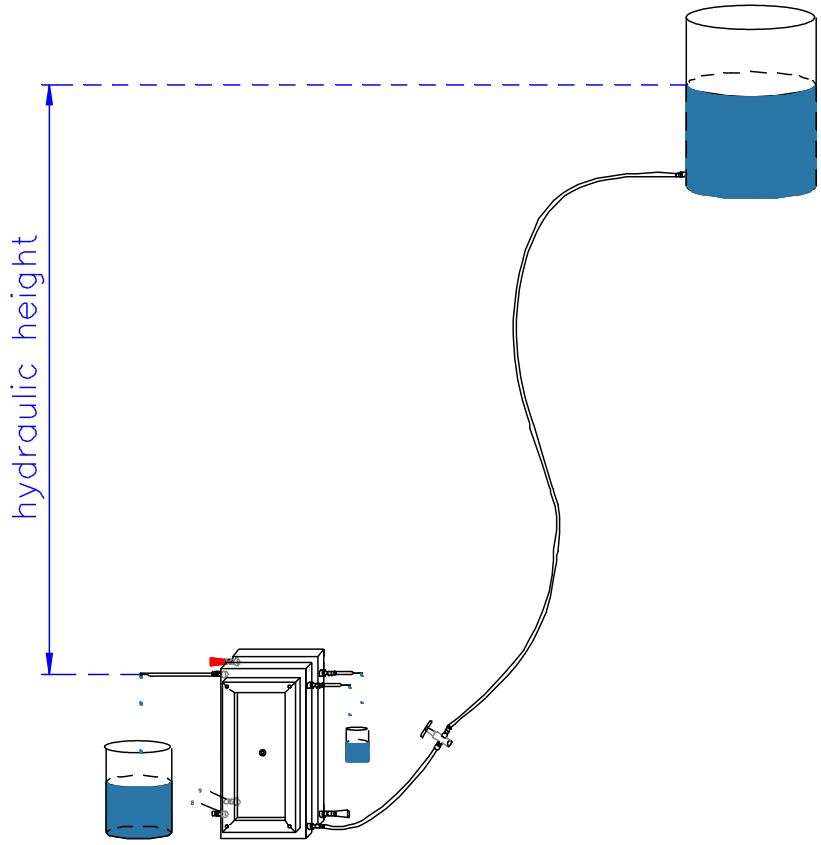



Fig. 18: Schematic setup of leakage test.

- Close the concentrate inlet.
- Collect the water coming out of the concentrate outlet.
- Determine the amount of water collected in time intervals of 5 min.
- Repeat this procedure with changed connections and check if the other chamber is tight.
- A leakage rate of less than 0.5 ml per minute and cell pair is acceptable. However, with a proper built-up, a leakage of less than 0.05 can be achieved.

- Check the electrode chambers. There should be no leakage.

Tip:
After the first assembling, leave the cell as it is for one night and repeat the leakage test. You may also flush the cell with warm (max 40 °C) water to warm it up. Then, let it cool down for several hours, fix the screws again and repeat the leakage test.

## *4.5. Electric Connection*

The ED cell has to be driven with a DC current which is galvanically sealed from all other electric circuits. The maximum ratings may never be exceeded (See “technical data”, ch. 5).

To connect the cell unit with the current supply, you have the possibilities shown in the picture below.

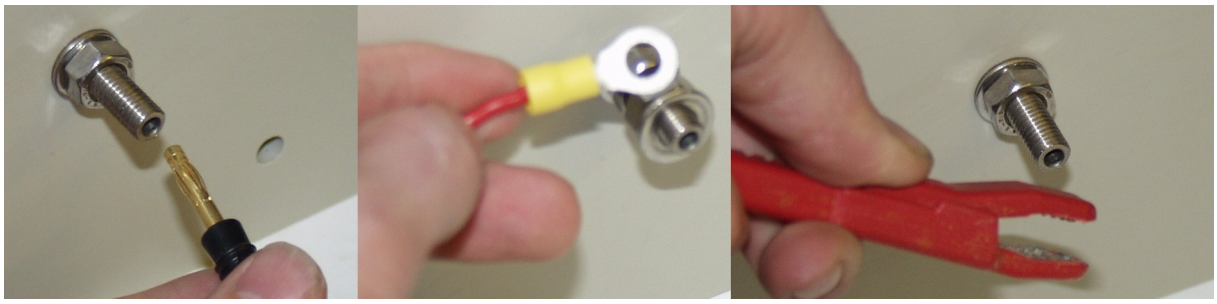


Fig. 19: Electrical connector options on an electrode stud. The shown stud has a 4 mm banana-plug hole and an M8 standard thread. Also other stud concepts may be used at PCCell ED 64.

Attention:
Never use the cathode as anode, because this will damage the electrode.

The connector cables for anode and cathode must have a sufficient cross section for the maximum current to be used. They need also a complete electrical isolation to ensure safe operations. Connect them directly on the shortest way to the DC power supply.

## *4.6. Connection of the ED Cell with solvent circuits*

Please note: This section describes the connection of the ED cell with other components, which are not part of the cell. The procedure given should serve as an example. Also other system components may be used and the procedure has to be adapted to the respective circumstances.

In the state of delivery, the connectors of the ED unit labelled according the meaning.

The following steps describe the assembly of a standard ED:

Setup of diluate circuit:

- Connect the diluate tank of your ED system (see Fig. 20) to the circulating pump inlet,
  the pump outlet to the inlet of the diluate loop (1 or 5) of the cell,
  connect the outlet of the diluate loop (4 or 8) to the diluate tank.
- Fill up the tank
- Make sure that all connections are firmly fixed and leak proof.
- Turn the pumps on to flush this circuit.

Caution:
Take care, that all tubes are seal and firmly fixed.

Setup the concentrate circuit:

- Please proceed in the same way as described for the diluate circuit.

Setup of the Anolyte and Catholyte circuit:

- Connect the electrolyte tank of your ED system (see Fig. 20) to the circulating pump inlet,
- the Electrolyte pump outlet is connected to the inlet of the anolyte chamber (6),

- the anolyte outlet (7) is connected to the catholyte inlet (2),
- the catholyte outlet (3) goes back to the tank.

According to this procedure, the anolyte chamber and the catholyte chamber are connected in one circuit, which implies that just one reservoir is required for both electrode circuits. If necessary, separate circuits for both electrodes can be established, as shown in Fig. 20.

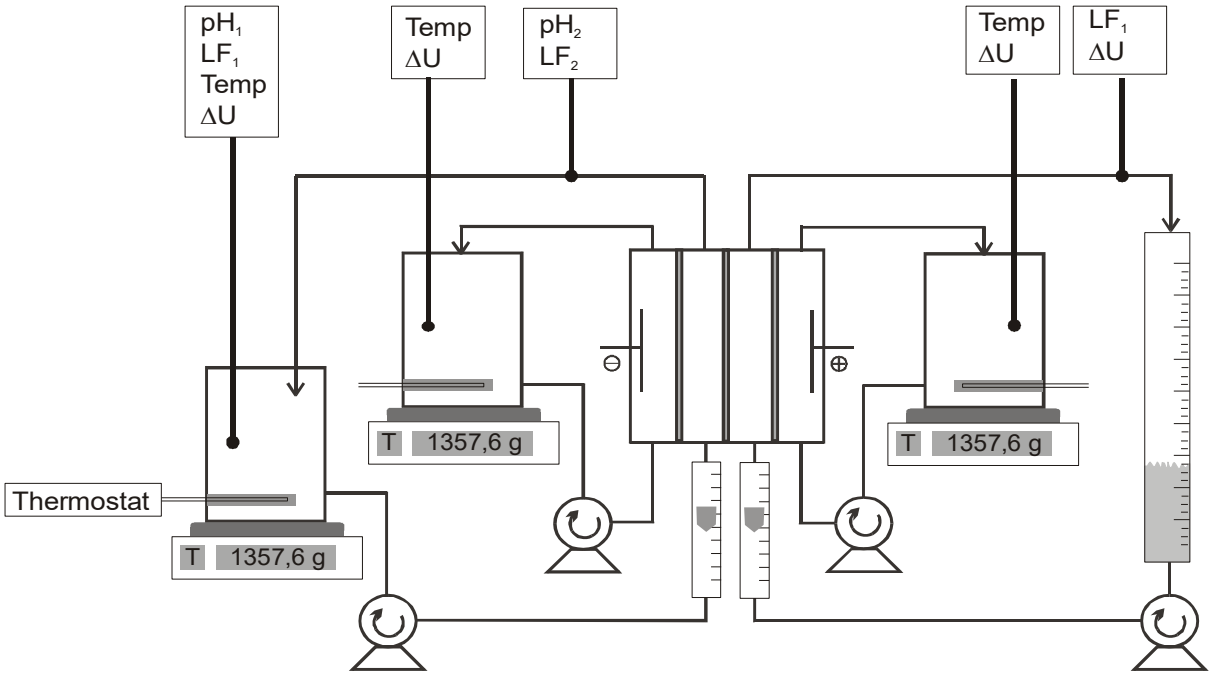



Fig. 20: An exemplary setup of an ED unit with four different pumps.

## 4.7. EDR: Changing the polarity of the electrodes

At EDR (Electrodialysis - reversal), the cathode is used as anode and the anode is used as the cathode.

Caution:

Please remark that a standard cathode can NOT be used as an anode. You need an optional EDR upgrade to change the polarity!

By this change of polarity, the functions of the different cell parts change. Please refer Tab. 11 to see what change in what way.

| *No.* | *Cell part used in nominal direction* | *... becomes the following function at inverse direction* |
|---|---|---|
| | Anode | Cathode |
| 6 | Anolyte inlet | Catholyte inlet |
| 7 | Anolyte outlet | Catholyte outlet |
| | Cathode | Anode |
| 2 | Catholyte inlet | Anolyte inlet |
| 3 | Catholyte outlet | Anolyte outlet |
| 1 | Diluate inlet | Concentrate inlet |
| 8 | Diluate outlet | Concentrate outlet |
| 5 | Concentrate inlet | Diluate inlet |
| 4 | Concentrate outlet | Diluate outlet |

Tab 11: Connectors at the ED cell and their change in meaning by changing the polarity of the electrodes (EDR).

## *4.8. Start-Up and Shut-Down*

At start-up, the flow of the fluids should be started first. A pressure difference over the membranes has to be avoided! A soft start of the pumps is recommended. When all electrolytes flow correctly, a leakage check should be performed (by watching the tank levels) to ensure that there is no hydraulic leakage.

Before applying a current, the maximum rating of amperage and voltage should be adjusted at the power supply outlet.

The current can be switched on after all air bubbles within pump, tubings and stack are removed and an air-free flow of liquid is to be observed. All fluxes should be between the minimum and maximum flow ratings (please see ch. 5).

To stop the ED process, stop the current first, then the pumps.

When the cell is not in use, it may stay filled with process solutions for some days, depending on the aggressiveness of the solutions. Alternatively, it can be rinsed with water.

The protocol for storage of the ED cell over longer time periods should be as follows:

- Rinse all circuits thoroughly with water
- Separate the ED cell of the hydraulic circuits, but do not remove the membranes from it
- Fill the cell (concentrate, diluate and electrolyte circuits) with salt water (15% NaCl)
- Close all in- and outlets with caps tightly
- Pack the stack in Polyethylene foil (e.g. a PE-stretch-foil package)
- Store it not in the sun nor in direct vicinity of a heater (to avoid formation of dry areas within the cell).
- Store it frost proof at temperatures less than 35°C
- When re-using the cell, both electrolyte chambers need to be rinsed thoroughly with water, otherwise toxic chlorine will be produced when the cell is operated again.

## 4.9. Frequently asked questions

**What electrode rinse solutions should be chosen?**

Generally, a 0,1 - 1 molar (preferably 0,25 m) solution can be used to provide a sufficient conductivity. The evolution of chlorine gas is not intended and may damage the electrodes.

Consequently, the choice of anions is restricted to the group of following ions: sulphate, amidosulphonate, nitrate (can be reduced on cathode), hydroxide and carbonate. Often used electrolytes are given in Tab. 12.

NOTE: This table lists examples of electrolyte substances. The applicability of each substance has to be tested for each application.

| *Diluate pH* | *acid* | *neutral* |
|---|---|---|
| no divalent cations present | sulfuric acid | sodium sulfate |
| divalent cations present | amidosulphonic acid | sodium amidosulphonate |

Tab. 12: Possible electrolyte substances for electrodialysis.

The choice of cation depends on the feed and concentrate. Fig. 21 shows the cation circuit from diluate through electrode rinse to concentrate: Cations from feed are entering on cathode side. On anode side, cations are leaving to concentrate.

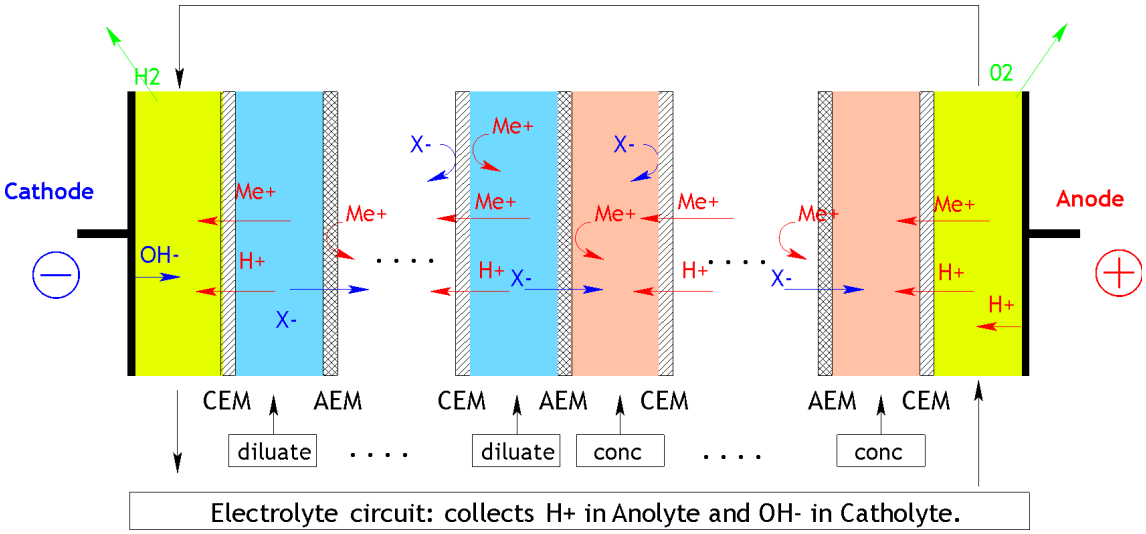



Fig. 21: Ionic scheme in Anolyte and Catholyte.

The electrolyte should be operated as a closed loop to recombine hydroxide ions and protons evolved in the electrode reactions. The cation composition in the electrolyte changes during operation until an equilibrium is formed which is determined by the ions entering from the feed. This is the reason, why sulphate is sometime a bad choice – because of the formation of sparely soluble salts.

**The flow rate through diluate drop down continuously. What can I do?**

Most often, this can be fixed by mechanical spacer cleaning:

To prepare the cleaning process see also chapter Assembling and Disassembling Procedures.

- Disconnect all tubes and cables from the cell.
- Put the cell with one electrode chamber faced down on the desk and remove the 4 screws at the upper side.
- Remove the blue metal frame.

Attention:
The anodes (and cathodes, if the EDR option is used) are coated with iridium and must not be touched with hands or any other tools. Otherwise the coating might be damaged or destroyed.

- Open the stack.
- Now grab the whole membrane package and remember the alignment for reassembling.
- Don't seperate the single layers from each other.
- Remove the package.

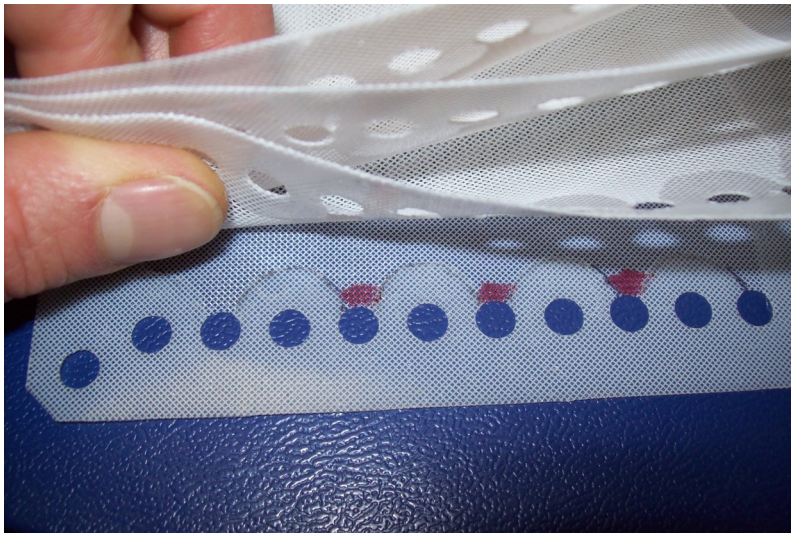


Fig. 22: Typical position of dirt/dust at the spacer-intakes.

Dust will typically collect at the red marked positions at the spacer-intakes (Fig. 1).

**Mechanical cleaning procedure:**

After removing the complete package, spread out the layers, like the pages of a book as shown in fig.1. Remove all dirt at the spacer intakes with a smooth brush and deionized water. Repeat this process for each spacer. When done, compress the package again. It's important that the wholes at the edge align with each other.

Now you can carefully move the package back into the stack. Consider the alignment when putting it back into place.

NOTE:

If the screws are worn (differently), you might consider to replace them by new ones.

Tipp: Use of prefilters:

PCCell provides small prefilter intended to provide particle free diluate and concentrate directly before entering the ED stack.

**Models:**

| *Order No.* | *Type* | *Pore size* |
|---|---|---|
| ED 64-104-156 | Filter F10 for ED 64 | 10 µm |
| ED 200-102-176 | Filter F20 for ED 200 | 10 µm |

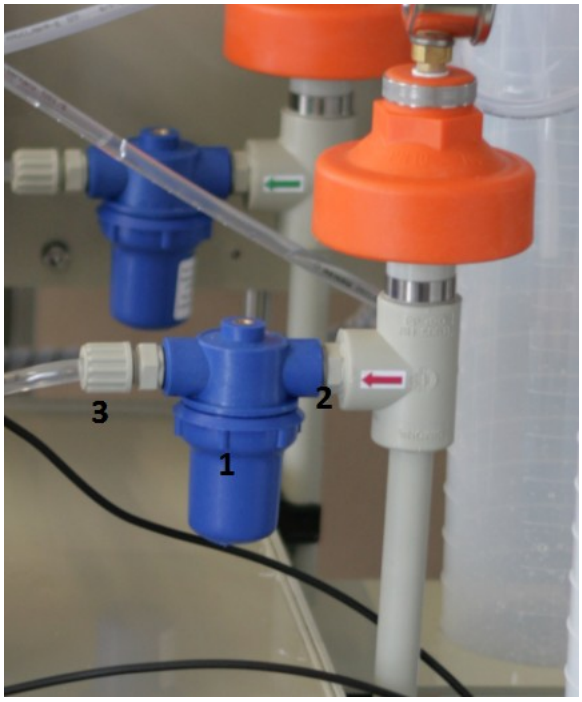



Fig. 23: Application example on a bench scale pump unit: The filter (1) is mounted with the screw connection (2) at the T-piece of the pressure measurement device. The hose connection (3) is screwed into the filter body and connects the hose in direction to the ED stack.

How can I calculate pump energy consumption for an industrial scale electrodialysis?

The pump energy consumption of an industrial scale ED is calculated by the following equation:

**P = v x t x p / z**

z = Current efficiency of pump

v = Flow rate of feed solutions through ED cell

p = Pressure drop of the ED cell at flow rate

t = batch time

**Example:**

One cubic meter sea water is desalinated to drinking water in a batch within 10 h with an ED 1000H with 10 $m^2$ active membrane area (50 cp) and a flow rate of 600 L / h and a pressure drop of 0,7 bar. Pump current efficiency is 45%.

Answer: 0,6 $m^3$ / h x 10 h x 800 mbar / 45% = 6 $m^3$ x 70000 kg/m $s^2$ / 0,45 = 0,2593 kWh

**What is the appropriate cleaning fluid for this type of cell?**

Membrane cleaning generally depends on the nature of material treated and the relevant questions are:

- What feed material is used?
- What type of dirt/adsorbants etc is expected?
- How can it be removed?

Life time of the membranes depends also on application:
Some acid concentration installations run for more than 7 years without any cleaning and replacement. A good starting point is to estimate a lifetime between 1 and 3 years.

Examples of cleaning considerations:
If Calciumcarbonate scaling occurs, cleaning with 5 or 10% HCl might be a good idea.
If Benzoic acid precipitated, cleaning with 4% NaOH can help.
In food treatment (e.g. whey demineralisation), you have to clean the stack each day. In process water cleanup, it depends on how much traces of humic acids are present. Usually, a cleaning period is 6 - 12 months. This also depend on a proper prefiltration. The cleaning liquid depends also on the kind of pollutants. Humic acids will be removed differently than a CIP-Cleaning, which is usually done with 2-4 % caustic and acid consequently.

# 5. Application Examples

The ED cell is intended to be driven in a batch process when the solution passes the cell at the respective flow-through multiple times until it is finished.

Application areas might be in the

- Desalination of salt water
- Stabilisation of wine
- Whey demineralisation
- Pharmaceutical application and
- Pickling bath recycling.

## *5.1. Batch desalination*

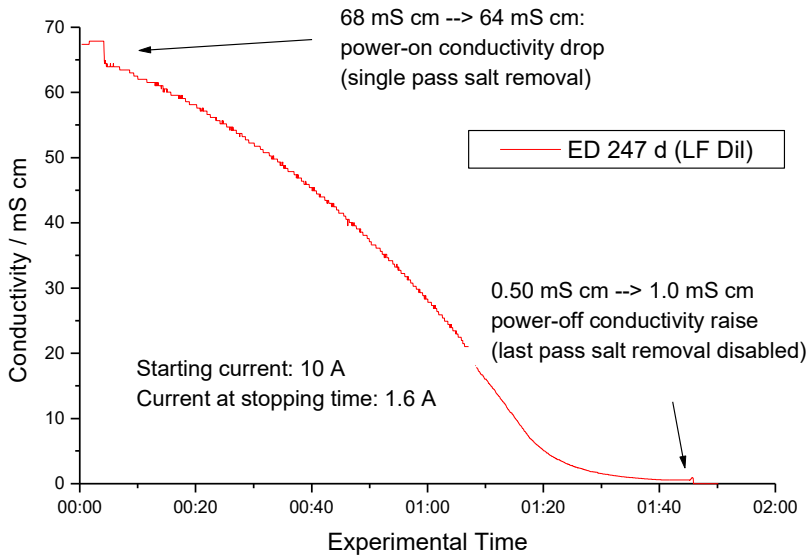



Fig. 24: A batch desalination of aqueous NaCl, about 14 l / m2.

Figure 24 shows an example of a batch desalination (conductivity of diluate against time). The effect of a single pass desalination at the start and stop time result in a conductivity jump. It depends on the current, flowing and other factors. The plot shows, that it is - more ore less - proportional to the current.

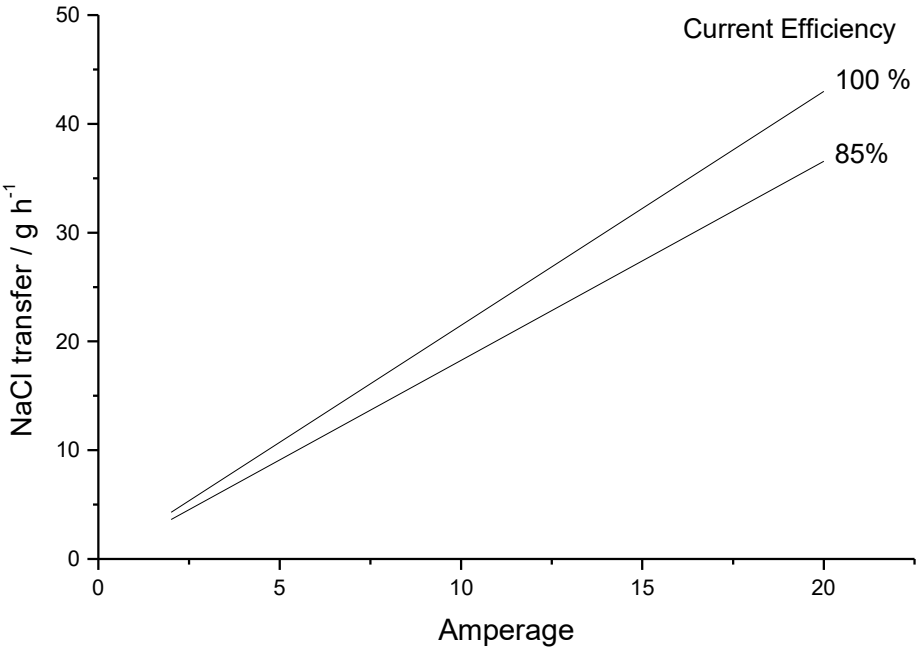



Fig. 25: Transport rate of one ED cell pair in dependence of the Amperage.

Figure 25 shows the salt (calculated as NaCl) removal in dependence of the current at theoretical current efficiency (ce) and at 85% ce. With the PCCell ED 200 you can expect for sodium chloride ce's in the range between 90 and 95 %. It depends on current density, concentration and other factors. The amount is given per cell pair. A 25 cell pair- unit will make 25 times of this.

## *5.2. Determining the process length of an ED process*

In a batch desalination, the conductivity of the diluate is decreasing over the time of desalination.

Within the desalination process, the ions are removed while the solution is in the cell.

Consequently, the solution enters the ED cell with a certain conductivity (red line) and as long as salt is removed, the conductivity at the outlet of the cell is different (black line). As soon as the desalination is stopped (the applied voltage is removed), the outlet conductivity will become the inlet conductivity (see black line jump at 1:30 h).

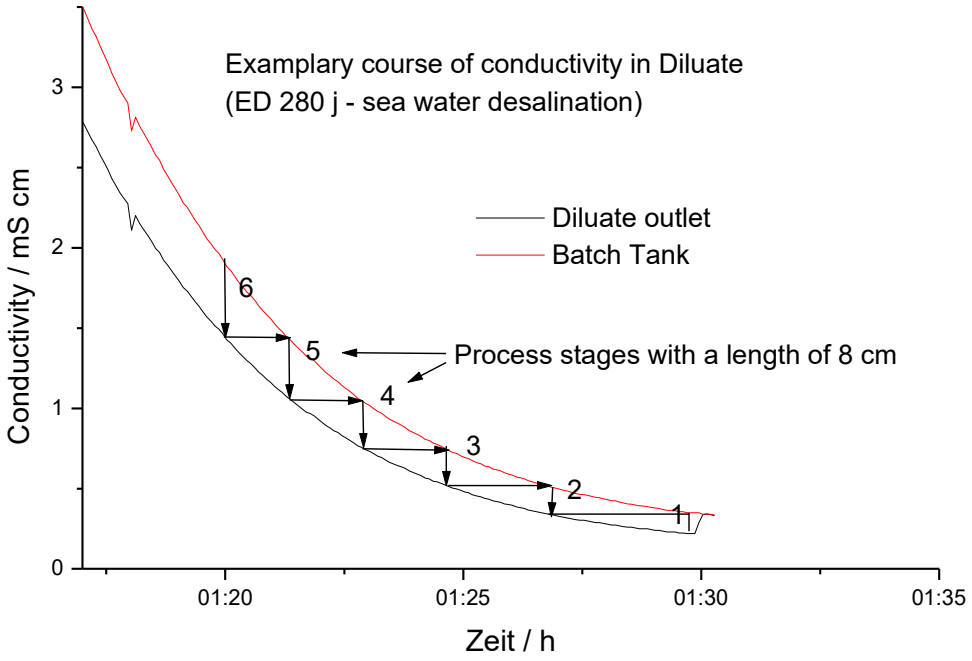



Fig. 26: Conductivity at inlet and outlet of an ED cell during desalination.

The vertical arrows no 6 to 1 shows what happens in a one way through: Each conductivity jump is performed by the current at this moment, which decreases from jump 6 to jump 1. A flow speed over the cell is constant and the current flowing at each moment within this experimental section is generated from a constant voltage,

it can concluded that the jump 1 – 5 can be done in one cell with 40 cm process length in one single flow-through.
Finally, by counting the jumps through the complete batch desalination course, the total process length can be calculated.
Typical process lengths for sea water desalinations to drinking water are about 2.5 m.

Of course the process length depends on the flow-through speed, voltage, the thickness of the cell, the cell geometry and finally on the amperage (which is also dependend of all the said factors).
However, the cell thicknes and basic geometry between laboratory and industrial cell is identically. And the flowthrough speed should also remain more or less constant between lab and industrial scale. As a rough estimate a target of about 10 cm / s at low concentrations is to be considered as a good value.

# 6. Application examples

## *6.1. Batch desalination of small sample volumes*

A sample solution is desalinated with the micro BED system.

| | |
|---|---|
| Cell: | Micro ED |
| No. of cell pairs: | 10 |
| Type of membranes: | PCSA<br>PCSK |
| Current: | |
| Voltage (max) | 22 V |
| Amperage (max) | 0,8 A |
| Feed Solutions: | |
| Diluate: | 180 mL |
| | NaCl 1.3 m |
| Concentrate: | 180 mL |
| | NaCl 1.3 m |

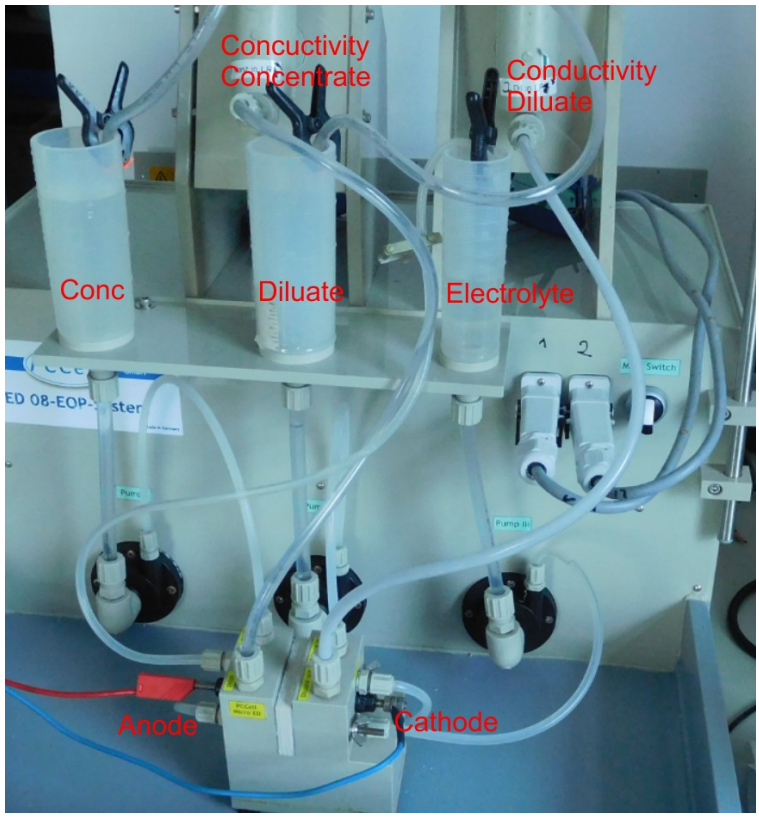



Fig. 27: Experimental test conditions.

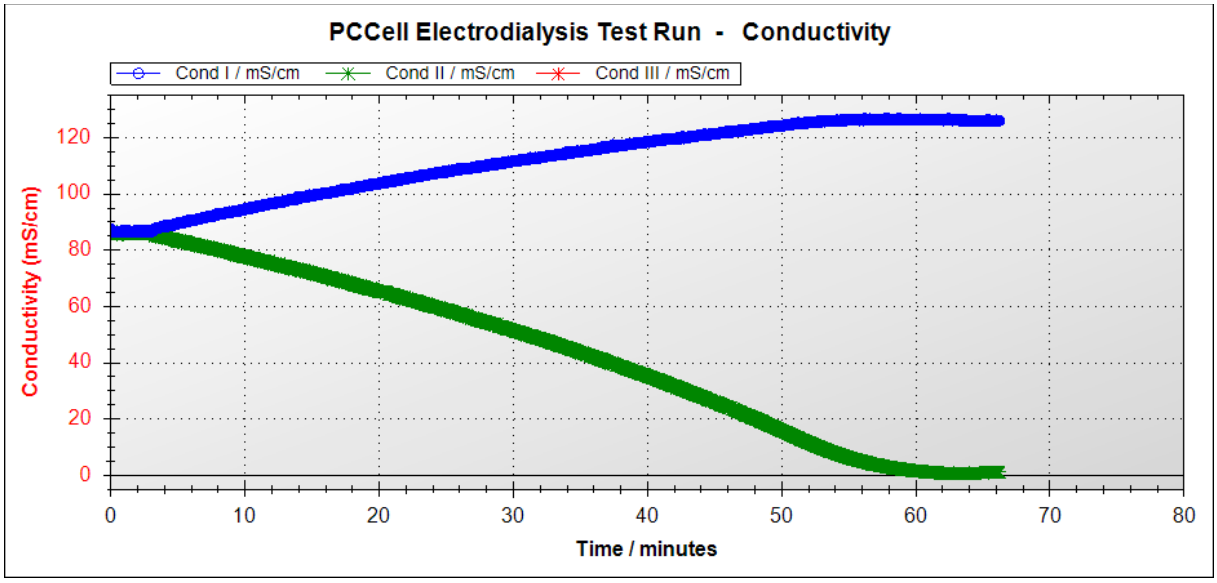



Fig. 28: conductivity changes against time

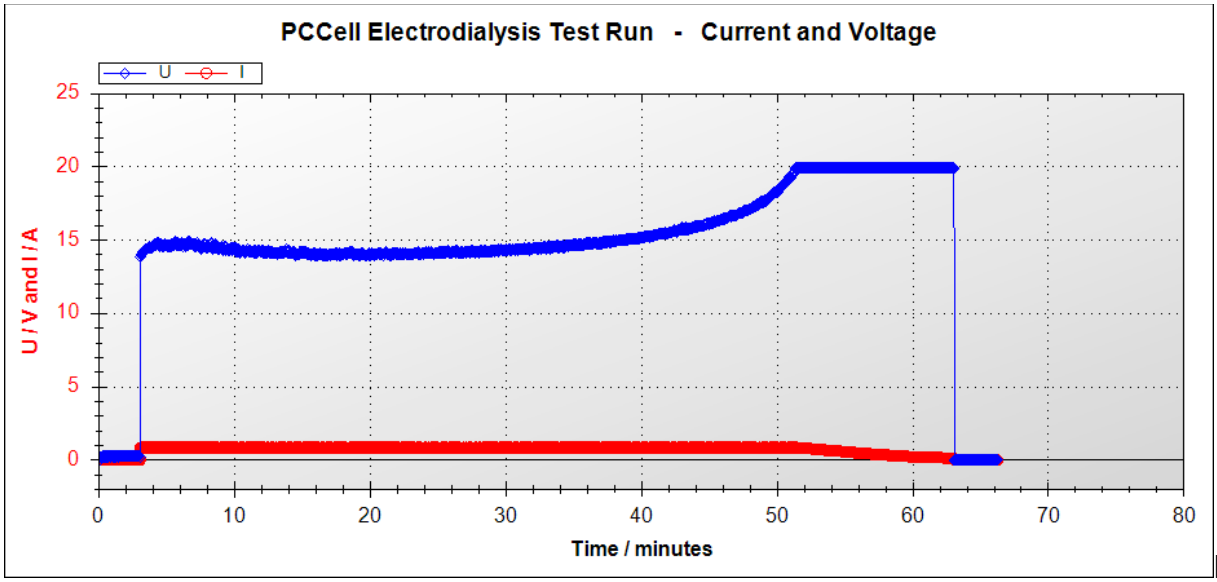



Fig. 29: current and voltage progress against time

Figure 28 shows the conductivities of concentrate/diluate as current is applied. Starting at a conductivity of about 86 mS/cm, values diverge as the process moves forward. In this example the salt of the diluate has been removed (<1 mS/cm) in about 60 min.

Figure 29 shows current and voltage progress. In the beginning, a constant current flow can be achieved at a relatively constant voltage. As the desalination moves forward, the overall conductivity through the cell diminishes and higher voltages are

necessary to keep up the current flow. When the voltage limit is reached, current flow (and with it desalination rate) decreases.

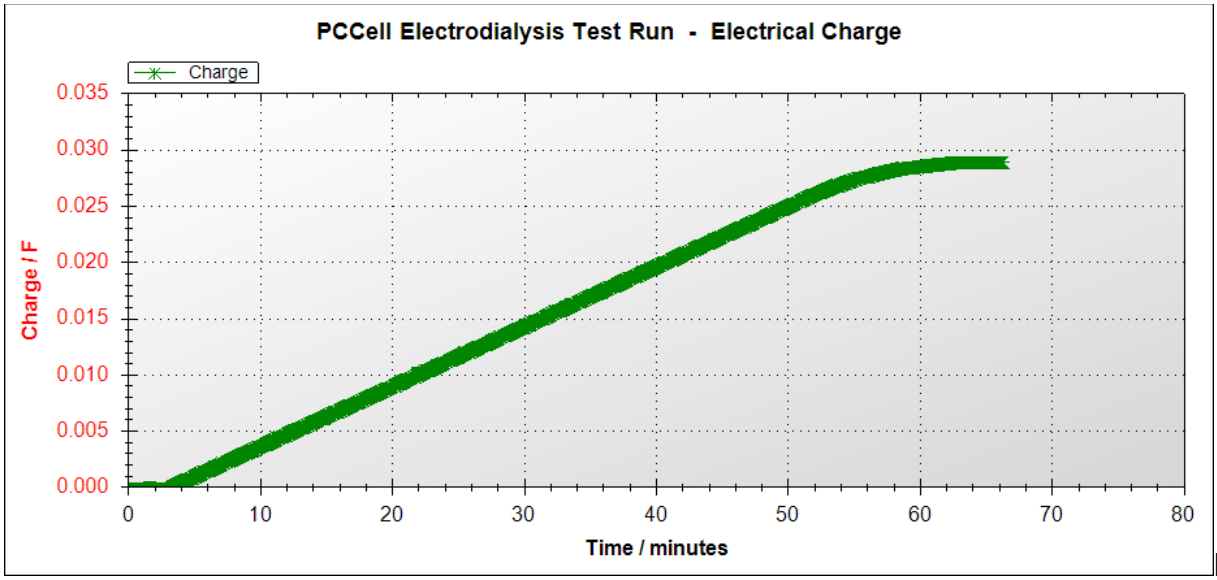



Fig. 30: The online view of the Coulomb counter in the PC Frontend.

The PC Frontend contains a coulomb counter, giving the charge for the batch.

## *6.2. Determination of water cotranfer (EOP measurement)*

This coulomb counting device is used to apply automatically a 120 As packet of charge to a given volume. The volume difference is determined volumetrically or gravimetrically.

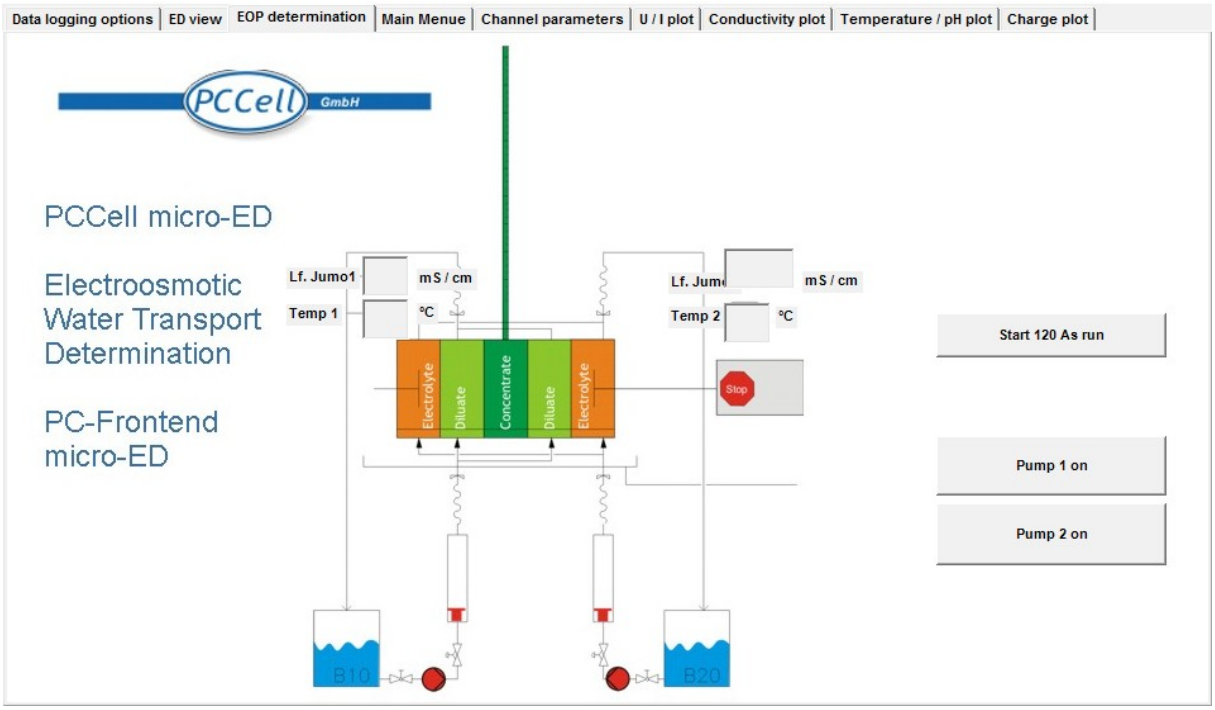



Fig. 31: Screenshot of the automatic water tranfer measurement device.

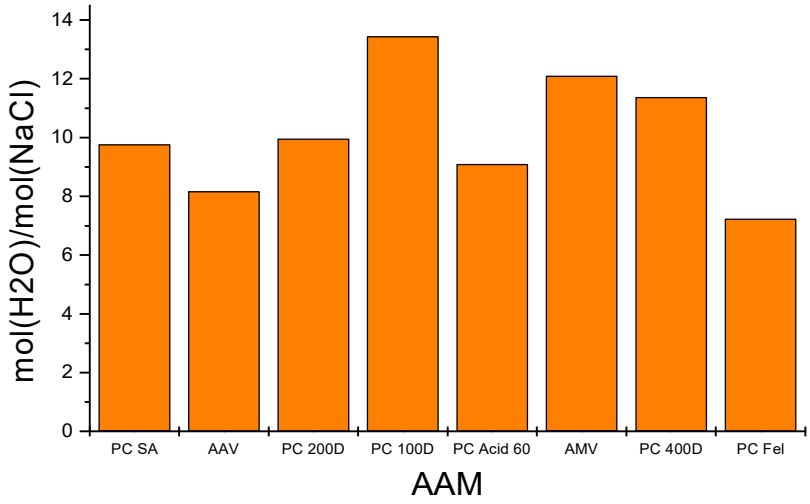



Fig. 32: Exemplary results for different anion exchange membranes in sodium 1 M NaCl.

# 7. Warranty, Liability Exemption and Proprietary Rights

ED Cells and Ion Exchange Membranes are offered for sale and warranted, as indicated below.

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In the event of a claim under the foregoing warranty, PCCell's sole obligation shall be to replace any product or part thereof that proves defective in material or workmanship provided the customer notifies us of any such defect within 30 days of delivery. The membrane in question must be returned to PCCell for review and testing only with prior authorization. PCCell shall not be liable for consequential, incidental or any other damages resulting from economic loss or property damages sustained by user from the use of its products.

**Warranty for membranes:**

If any faults occur or are detected during installation and commissioning or during operational tests, replacement and exchange is undertaken by PCCell free of charge; any mechanical damage which is not due to faults attributable to us is excluded under the guarantee.

**Liability exemption:**

PCCell accepts no liability for damage due to external influences or inappropriate handling or inappropriate use. PCCell is exempt from liability for any consequential damage or costs.

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The express written approval o f the manufacturer is required for permission to reproduce the operation instruction in full or in part through any photo-mechanical method (including photocopies, micro-copies, scans etc) or to distribute this information in newspapers, magazines or other media.

# 8. Declaration of Conformity

PCCell GmbH

## CE - DECLARATION OF CONFORMITY

**The undersigned manufacturer Headquarter:**

PCCELL GmbH
Lebacherstraße 60
66265 Heusweiler
Germany

**declares under its sole responsibility that the product series:**

Model: ED 64002, ED 64004 and ED 200

**is compliant to the essential safty rules (if applicable) stated in the directives:**

Low voltage directive 2006/95/CE

***We decline*** any responsibility for damages to person or things due to tampering on the maschine or lack or omission of maintenance and /or not authorized reparation.

**Heusweiler, 04.12.2013**

P. Altm

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PCCell GmbH
Geschäftsführer

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Note:

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