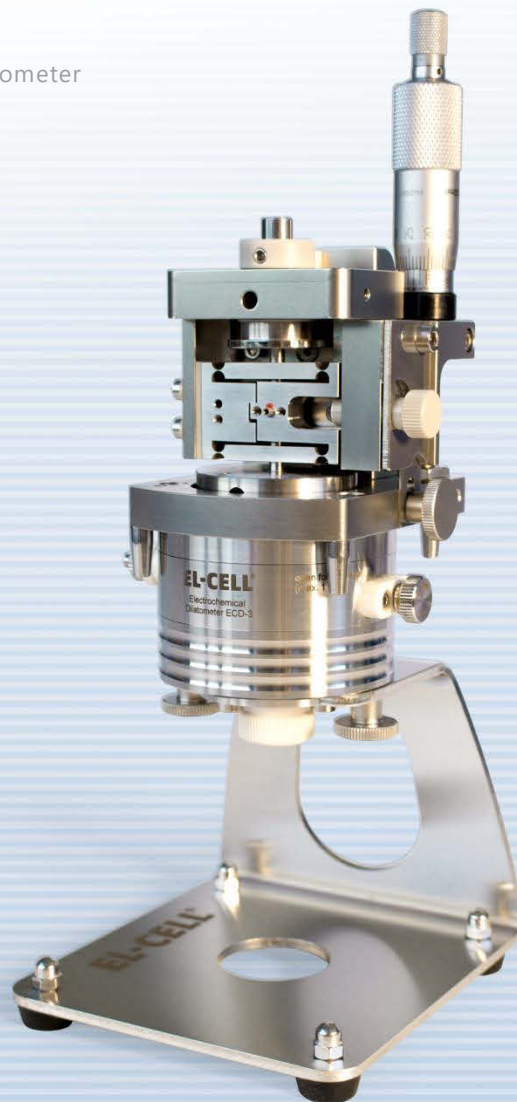


User Manual

Release 1.51

ECD-3-nano

Electrochemical dilatometer



The information in this manual has been carefully checked and believed to be accurate; however, no responsibility is assumed for inaccuracies.

EL-Cell GmbH maintains the right to make changes without further notice to products described in this manual to improve reliability, function, or design. EL-Cell GmbH does not assume any liability arising from the use or application of this product.

EL-Cell GmbH

Tempowerkring 8

21079 Hamburg - Germany

phone: +49 40 79012-737

fax: +49 40 79012-736

e-mail: info@el-cell.com

web: www.el-cell.com

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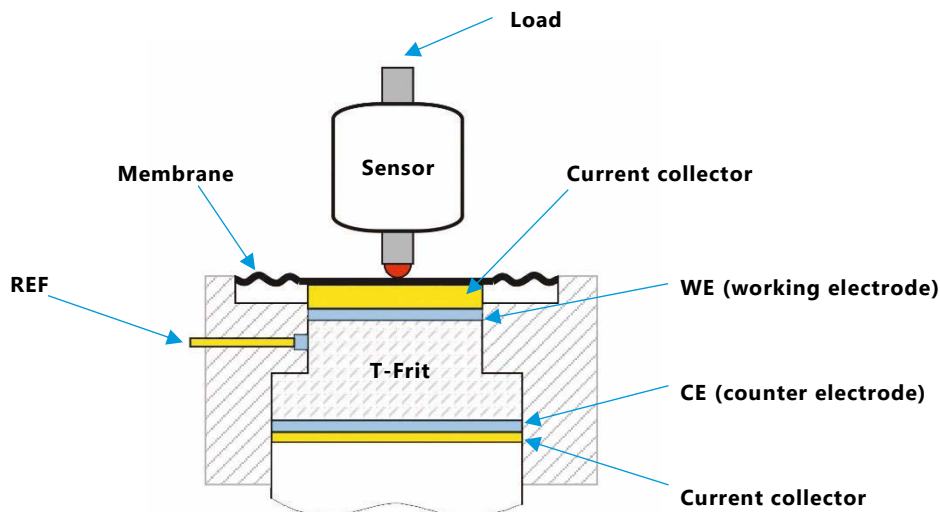
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1 Product description

The ECD-3-nano electrochemical dilatometer is dedicated to the measurement of charge-induced strain (expansion and shrinkage) of electrodes down to the nanometer range. The ECD-3-nano has been particularly developed for the investigation of Li-ion battery and other insertion-type electrodes. It may, however, also be used for many other electrochemical systems utilizing aprotic organic electrolyte solutions.

The electrode materials used can either be bound film or single crystals/grains (e.g. graphite flakes). The maximum sample size is 10 mm x 1 mm (diameter x thickness).

The heart of the ECD-3-nano is an electrochemical cell, hermetically sealed against ambient atmosphere. The two electrodes inside are separated by a stiff glass frit which is fixed in position. The upper working electrode (**WE**) is sealed by means of a thin metal foil, through which any charge-induced thickness change is transmitted towards the sensor/load unit above. This working principle allows determining the height change of the working electrode without any interference from that of the counter electrode (**CE**).

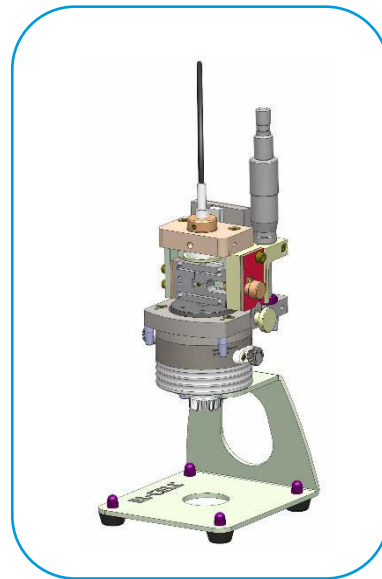
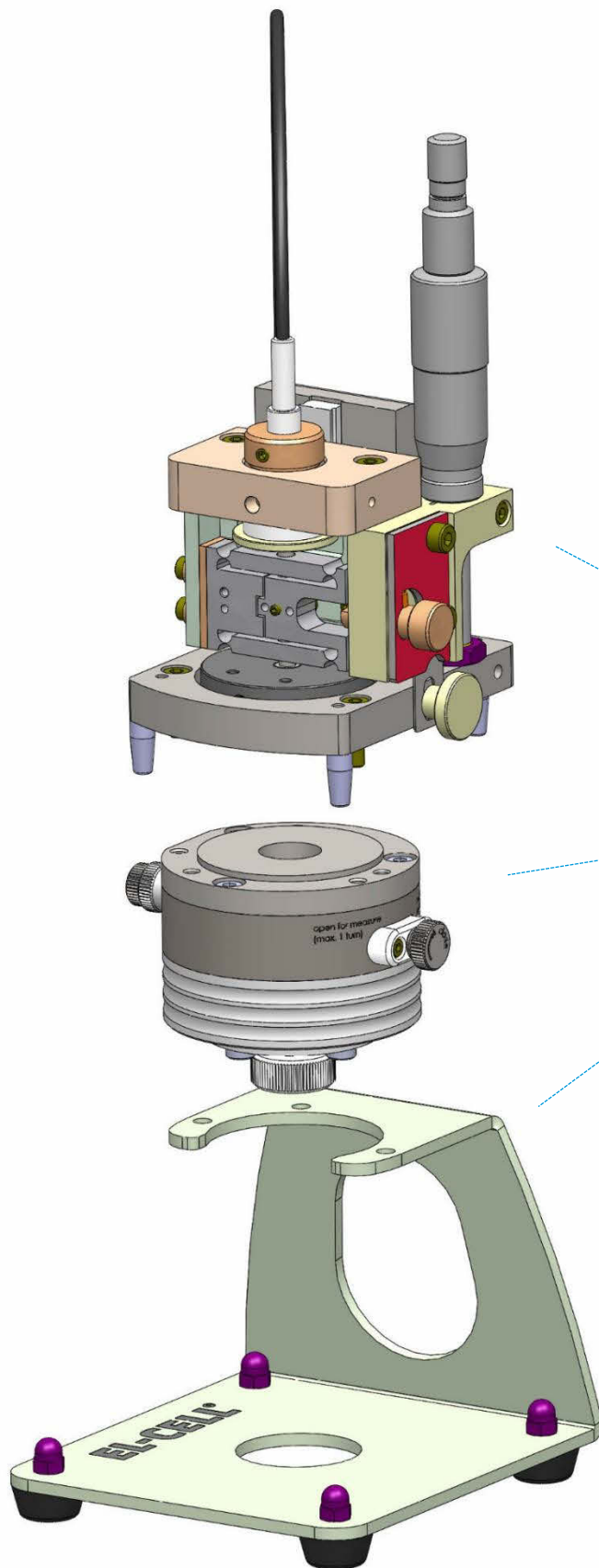


A high-resolution capacitive displacement transducer detects dimensional changes of the WE ranging from a few nanometers up to 250 micrometers during one and the same experiment that may last between a few minutes to many days.

The ECD-3-nano features an integrated USB data logger for recording the electrode displacement, temperature, cell potentials and current. Analog outputs of displacement and temperature are provided for integration with external instruments.

For best accuracy and drift stability, the dilatometer is to be operated inside a temperature controlled chamber.

Basic structure of the ECD-3-nano:

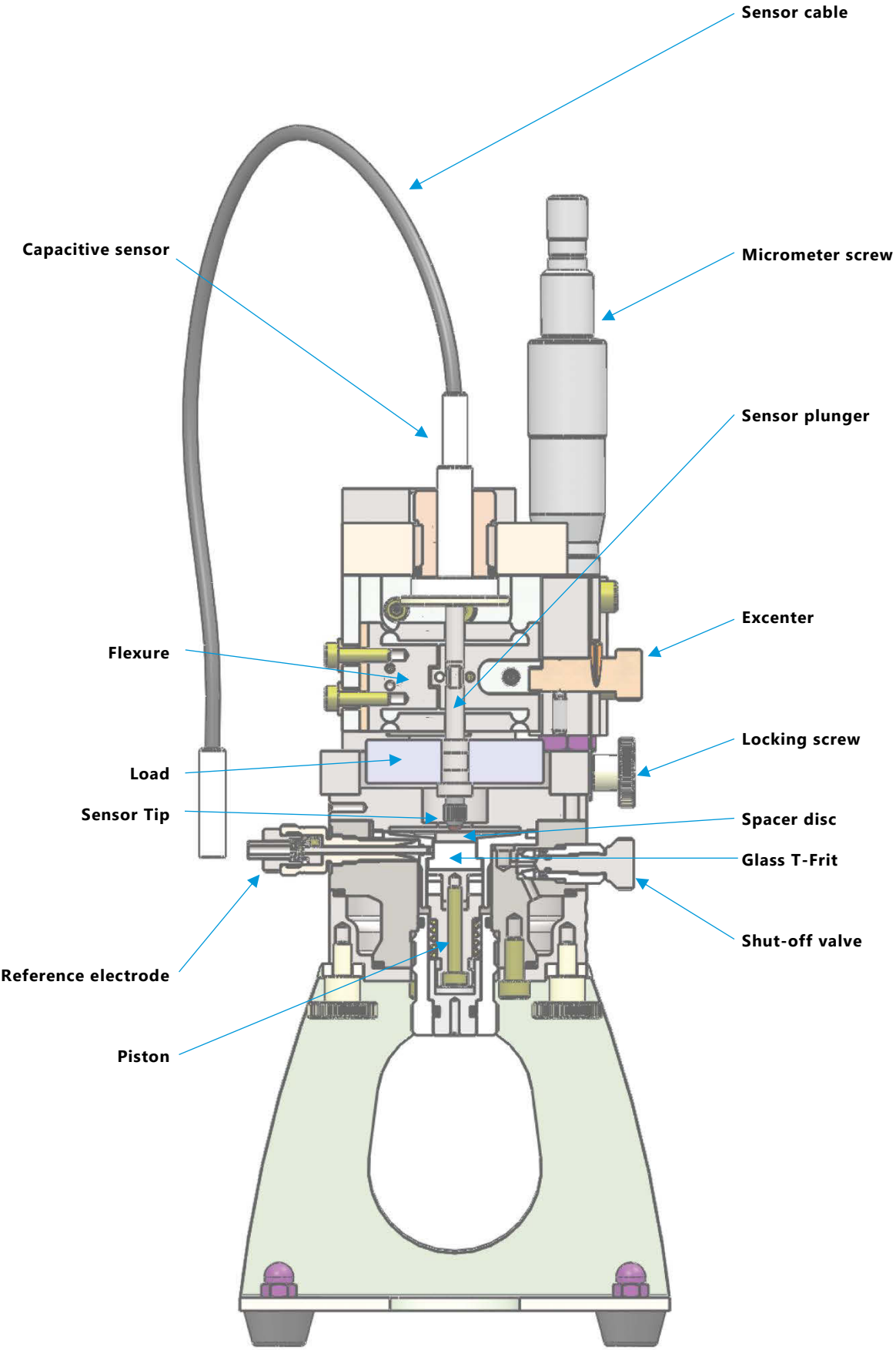


Sensor unit
Details shown on the following page

Cell body

Bracket

Cut drawing of the ECD-3-nano:



2 Features

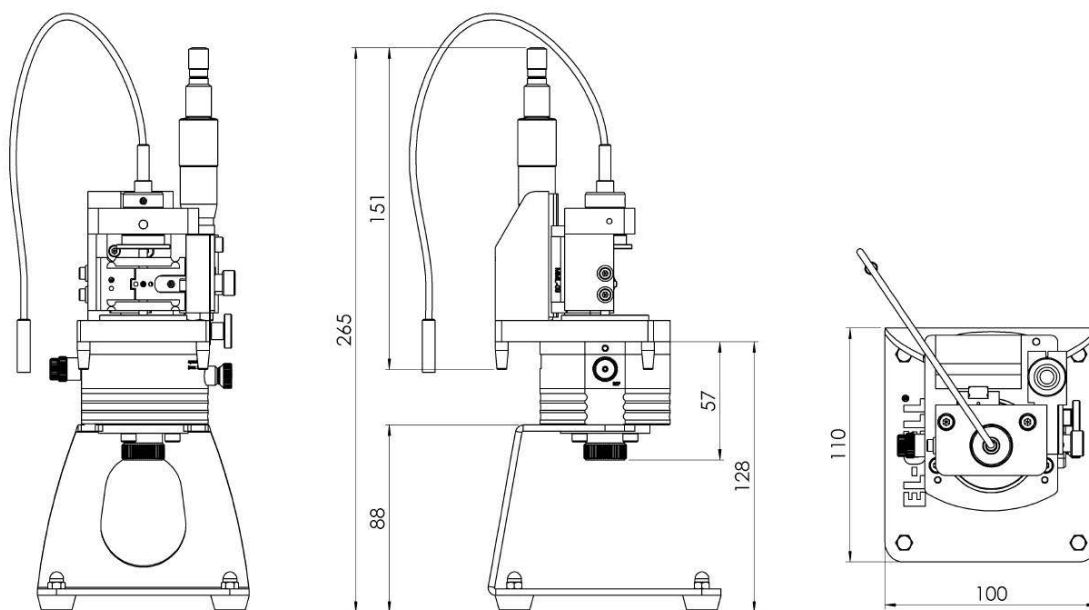
The ECD-3-nano is an electrochemical dilatometer for measuring changes of thickness of the working electrode of a battery test cell. The main features of the ECD-3-nano are briefly described in the following:

- High resolution capacitive sensor system with <math><5\text{ nm}</math> resolution, drift stability of <math><20\text{ nm/hour}</math> (sample-free instrument at constant temperature), and $250\text{ }\mu\text{m}$ full range.
- Conditioning electronics with analog output signals (-10 to 10 V) for displacement and temperature.
- Integrated USB data logger for the recording of displacement, temperature, cell potentials and current.
- 3-electrode electrochemical cell

3 Technical Data

- Working (upper) electrode: bound electrode film or single crystal/grain; max. sample size 10 mm x 1 mm (diameter x thickness)
- Counter (lower) electrode: 12 mm diameter
- Load on working electrode: 1 N
- Electrolyte volume: approx. 0.5 ml
- Materials in contact with electrolyte: PEEK, borosilicate glass, stainless steel 316L for aproti, gold for aqueous electrolytes

Operating temperature range: Cell and sensor: -20 to +70 °C;
Conditioning electronics and data logger: 0 to +40 °C



All measurements in mm

4 Safety Precautions

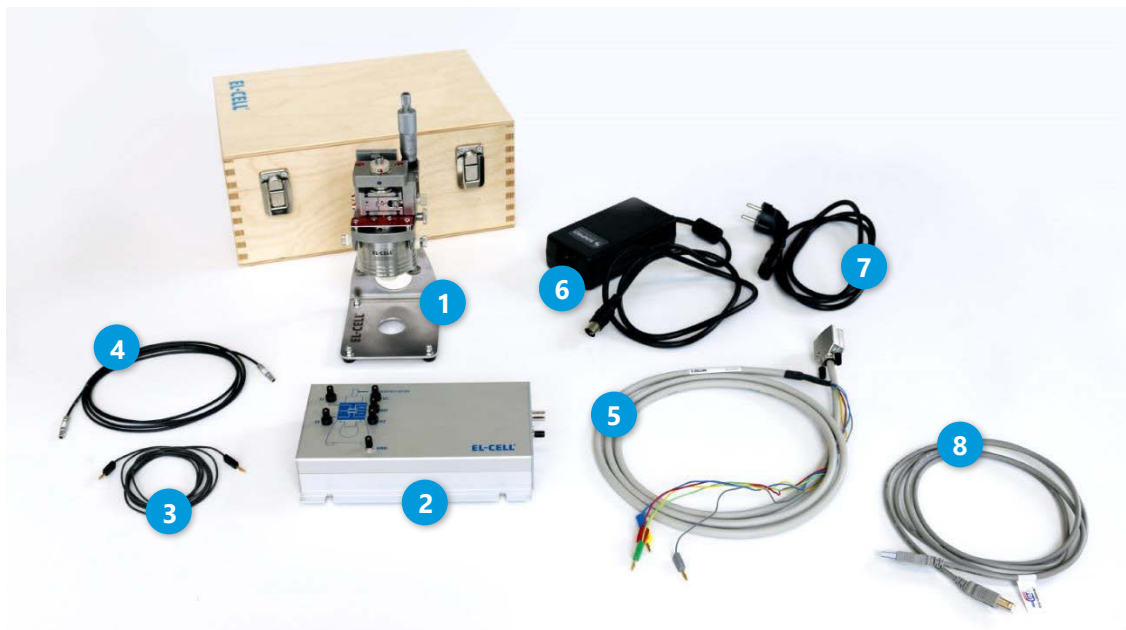
Use proper safety precautions when using hazardous electrolytes. Wear protective glasses and gloves to protect you against electrolyte that may accidentally spill out of the instrument during filling, operation, and disassembly.

5 Unpacking

Check the contents of the packages against the list given below to verify that you have received all of the required components. Contact EL-CELL, if anything is missing or damaged.

NOTE: Damaged shipments must remain within the original packaging for freight company inspection.

List of Components:



1. ECD-3-nano dilatometer [ECD3-00-0001-A](#), assembled
2. Box ECD-3-nano [ECE1-00-0006-F](#), assembled
3. Sensor-GND cable [ECE1-00-0041-A](#)
4. Sensor cable (PISeca) [SEN9023](#)
5. ECD cell cable [ECE1-00-0033-F](#)
6. Power supply SPU 45E-303 [ELT9207](#)
7. Power cord IEC 60320 C14 EURO L sw 1.5 m [ELT9222](#)
8. USB cable typ A/B (2.0 m) [ELT9167](#)



- 9. USB stick containing EC-Link data logger software [ECE1-00-0052-B](#)
- 10. Allen wrench 2.5 mm [WZG9059](#)
- 11. Allen wrench 3 mm [WZG9058](#)
- 12. 3 x PE Seal II ECD-3 piston [ECC1-01-0044-D](#)
- 13. 3 x PTFE Seal ECD-3 piston [ECC1-00-0044-C](#)
- 14. 1 x PTFE Seal ECD 33.3 x 1.8 mm (3 pcs.) [ECC1-01-0043-D/3](#)
- 15. 3 x O-Ring 33 mm x 1.78 mm [DIC9034](#)
- 16. 3 x O-Ring 50.5 mm x 1.78 mm [DIC9038](#)
- 17. T-Frit 10/12.5 [ECC1-00-0041-B](#)
- 18. Stiff plate [ECD1-00-0041-A](#)
- 19. 3 x Ferrule 1.5 mm (short top part) [ECC1-00-0029-H](#)
- 20. 3 x Ferrule 1.0 mm [ECC1-00-0029-B](#)
- 21. Membrane (aprotic) 1.4404 [ECC1-00-0019-D](#)
- 22. Spacer disc Set 2.1 – 2.3 mm (3 pcs) [ECC1-01-0012-F](#)

- 23.** Separator (GF/A) 12 mm x 0.26 mm (10 pcs) [ECC1-01-0012-Q/X](#)
- 24.** Demonstration kit for ECD [ECD1-00-0900-A](#)
- 25.** Allen wrench set (0.9 / 1.3 / 1.5 / 2) (4 pcs) [ECC1-01-0028-A](#)
- 26.** Open end wrench AF7 [ECC1-09-2037-A](#)
- 27.** Filling tube for ECD-3 [ECD3-01-0001-A](#)
- 28.** Removing tool for ECD-3 piston [ECC1-09-2005-A](#)
- 29.** Allen screw driver 2.5 mm [WZG9003](#)
- 30.** Spherical allen screw driver 3 mm [WZG9002](#)
- 31.** Tweezer antiacid / stainless [WZG9001](#)

6 Start-up and disassembly

Follow the same procedure beginning at step 3 when disassembling the instrument after an experiment has been completed.

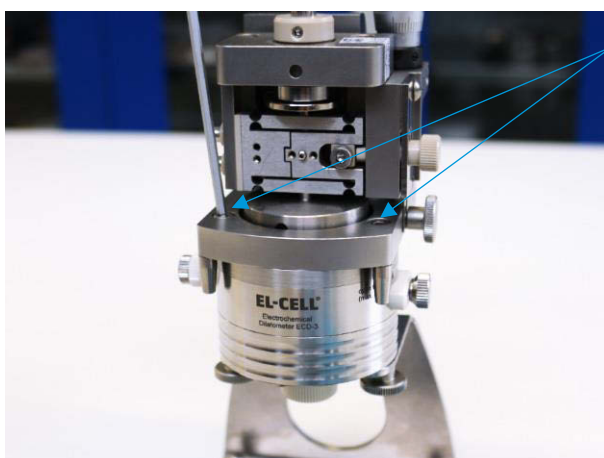
General advise: Practice the assembly procedure outside the glove box with dummy components before going for the real experiment. Make sure you have understood the how and why of each single step. Ask us otherwise.



1. After unpacking the ECD-3, remove the transport lock from the sensor unit.



2. Unscrew the two inner screws first, only then the two outer screws.



3. Unscrew and detach the sensor unit.



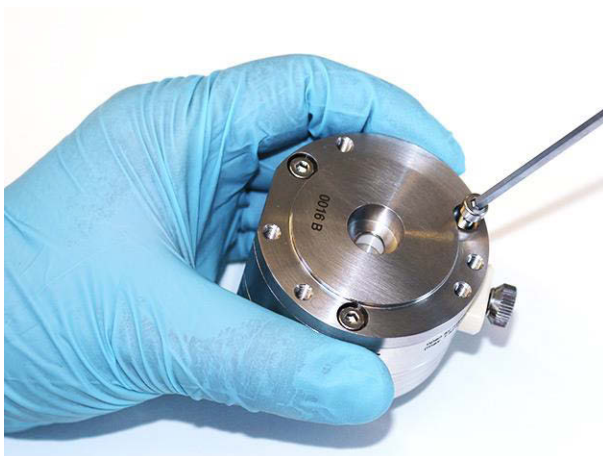
4. Screw off the cell body from the bracket.



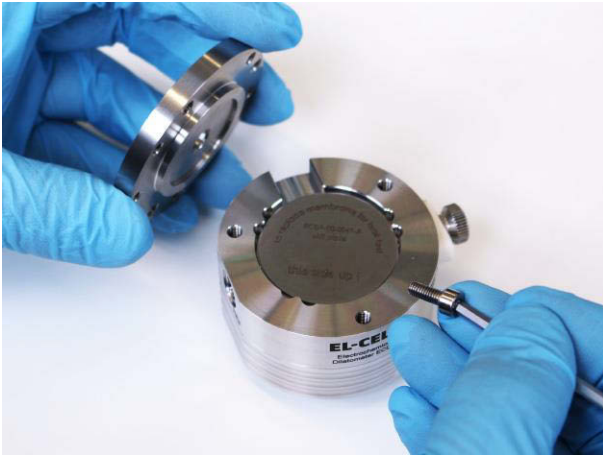
5. Unscrew the spring load from the cell body.



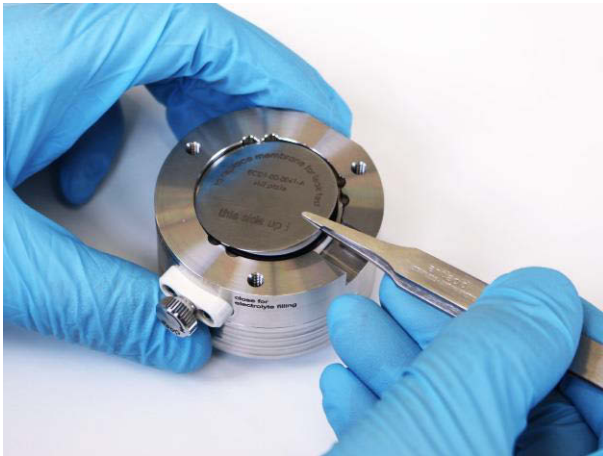
6. Unscrew the reference electrode.



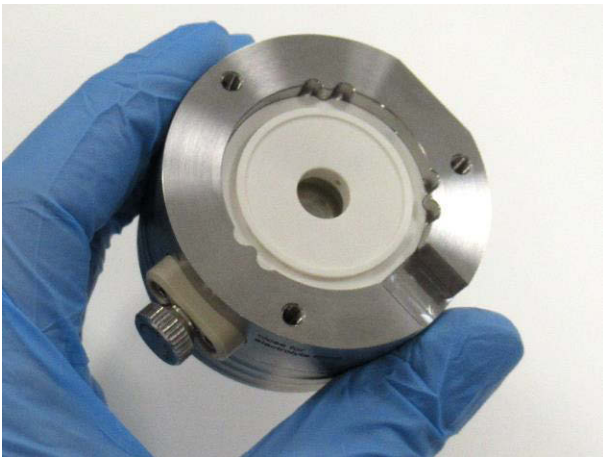
7. Remove the cover flange



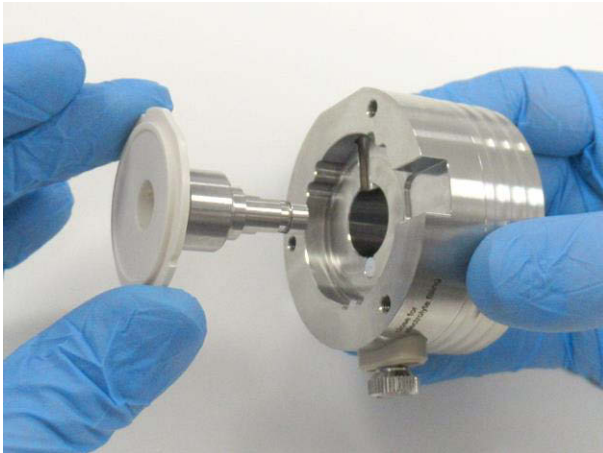
8. When disassembling the dilatometer for the first time, remove the stiff plate below the cover flange. This plate is for transport only. For the actual experiment, replace the plate by the provided metal membrane.



9. Remove the stiff plate or membrane from the cell body



10. Now the frit flange with the PTFE-Seal and the piston in the middle are visible.



11. Pull the frit flange out of the cell body.



12. Make sure to renew the little PTFE ferrule.



13. Loosen the socket screw at the end of the piston a little with the Allen wrench (half turn). This releases the disk springs inside piston and allows it to be pulled out.



14. Pull the piston out of the frit flange by using the dedicated removal tool.

We advise you to hold the removal tool between your thumb and index finger as shown in the picture. This allows the piston to be pulled out safely.

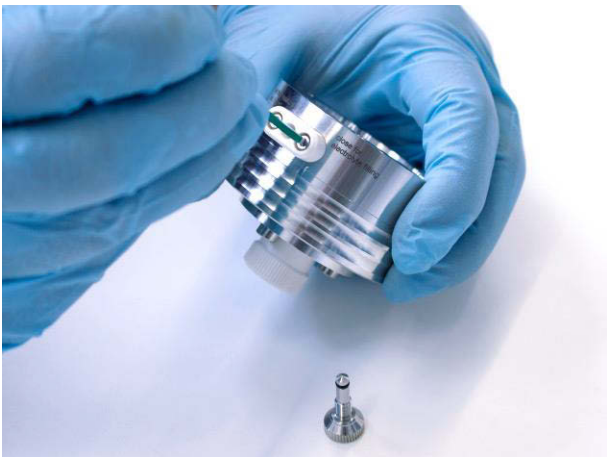
Remove the T-Frit afterwards.



15. Remove the three screws that fix the dead volume cover.



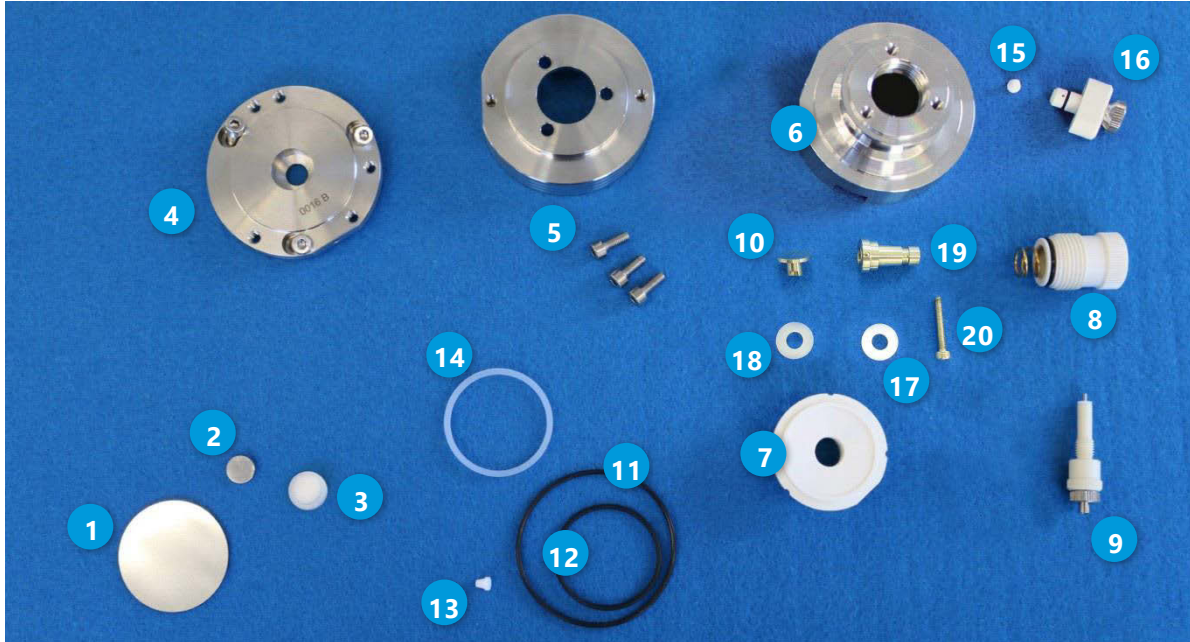
16. Remove the dead volume cover and both O-Rings.



17. Unscrew the valve stem and the valve body.

All the below shown parts need to be dried before they can be moved into the glove box for assembly. Recommended drying conditions: 80°C, <0.01 mbar, 12 hours.

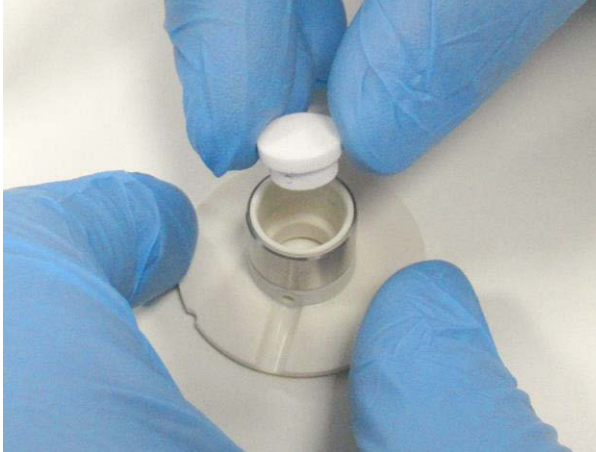
NOTE: For highly moisture sensitive systems, we recommend drying the glass frit separately at higher temperature: 180°C, <0.01 mbar, 12 hours.



- | | |
|--|---|
| 1. Membrane (aprotic) 1.4404 | 11. O-Ring 50.5 x 1.78 mm, EPDM |
| 2. Spacer disc (proper thickness depends on working electrode thickness) | 12. 2 x O-Ring 33.05 x 1.78 mm, EPDM |
| 3. T-frit | 13. Ferrule 1.0 mm, PTFE |
| 4. Cover flange with three screws | 14. PE-Seal for ECD-3 (33 mm x 1.6 mm) |
| 5. Dead volume cover with three screws | 15. Ferrule 1.5 mm, PTFE |
| 6. ECD-3 base body | 16. Shut-off valve (Note: This part needs to be disassembled before drying, see chapter 13) |
| 7. Frit flange | 17. PTFE Seal ECD-3 piston |
| 8. Spring load | 18. PE Seal II ECD-3 piston |
| 9. Reference electrode | 19. Thrust screw VII (ECD-3) |
| 10. Piston PTFE-sealing, internal thread (ECD-3) | 20. Socket screw |

7 Assembling the cell inside the glove box

After moving the different parts of the disassembled cell body into the glove box, follow the steps below. Protect yourself and handle the chemicals with care.



1. Inside the glove box: Insert the T-frit with the smaller side pointing downwards into the frit flange.

Note: Make sure that the inside of the frit flange does not get damaged/ scratched when inserting the T-frit. Replace the frit flange as necessary.



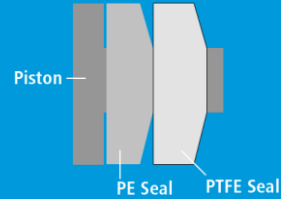
2. Inside the glove box: Put a glass fiber separator (12 mm diameter) on top of the frit



3. Inside the glove box: Insert the lithium metal counter electrode.



4. Inside the glove box: First place the PE sealing (PE Seal II ECD-3 piston) followed by the PTFE sealing (17.PTFE Seal ECD-3 piston) on the piston. The outward curved side of the sealing rings must face away from the piston (see sketch below)



5. Inside the glove box: Add the thrust screw.

Align it so that the mark on the thrust screw is centered on the recess in the piston.



6. Inside the glove box: Tighten the socket screw firmly with the provided allen wrench.



7. Inside the glove box: Attach the counter piston from below. Use the removal tool to push it. Make sure that the stack is firmly held together.



8. Inside the glove box: Tighten the socket screw at the end of the pistol using the tools provided.

Important note:

Only use a frit flange with an attached metal support ring as shown in the picture. Otherwise the frit flange may be damaged when trying to tighten the screw!



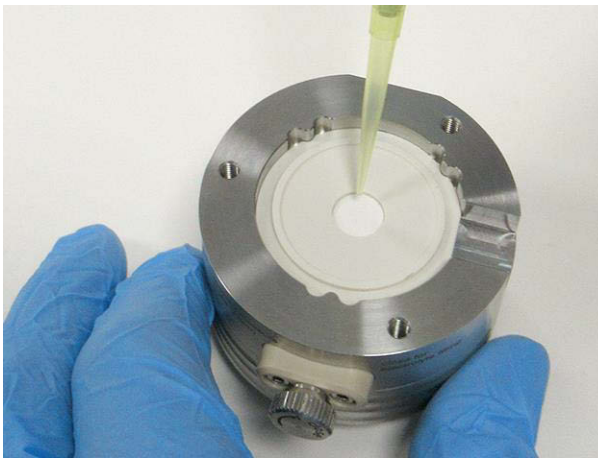
9. Inside the glove box: Insert the two big O-rings and attach the dead volume cover to the base body.



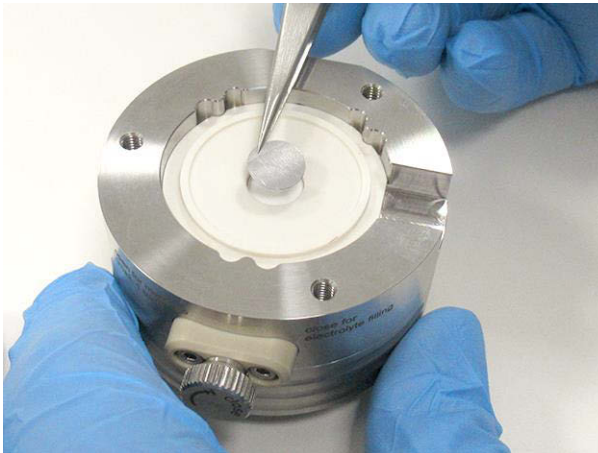
10. Inside the glove box: : Put this assembly into the cell base body. Make sure that the two grooves at the frit flange and the cell base body are properly aligned.

Don't forget to insert the little PTFE ferrule!

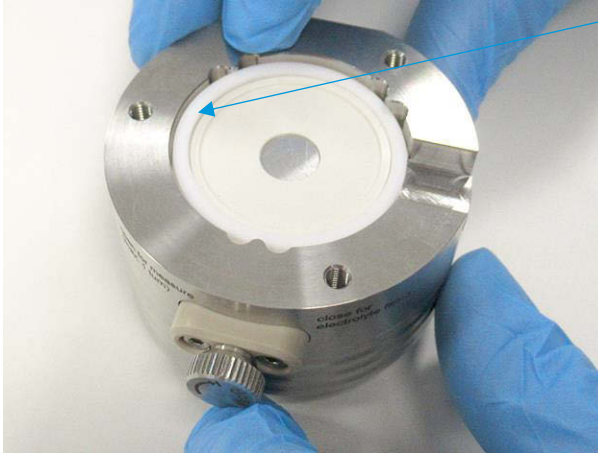
Note: Make sure that the frit flange is fully inserted. You may otherwise damage the cell.



11. Inside the glove box: : Add 320-420 μ l of electrolyte using a pipette.



12. Inside the glove box: : Add 320-420 μ l of electrolyte using a pipette.



13. Inside the glove box: : Insert the PTFE seal, make sure it is inserted correctly.



14. Inside the glove box: : Put the spacer disc on top of the electrode, make sure that it is placed in the center of the electrode. The proper spacer disc thickness depends on the working electrode thickness, see chapter 14.



15. Inside the glove box: Then put the membrane on top.



16. Inside the glove box: Attach the cover flange.



17. Inside the glove box: Now close the cell body with the three cover screws. In the first step, tighten the screws slightly with the enclosed screwdriver.



18. Inside the glove box: After that, we recommend using the allen key to tighten the screws in small increments on all three sides until they reach the stop.



19. Inside the glove box: Then check that the cell cover is firmly seated on the housing and that no gap is visible.



20. Inside the glove box: Now screw in the spring load into the cell base.



21. Inside the glove box: Pick up some lithium with the reference pin. Make sure that the hole of the reference pin is completely filled with lithium metal. Incomplete filling may result in scatter/noise of the WE potential.

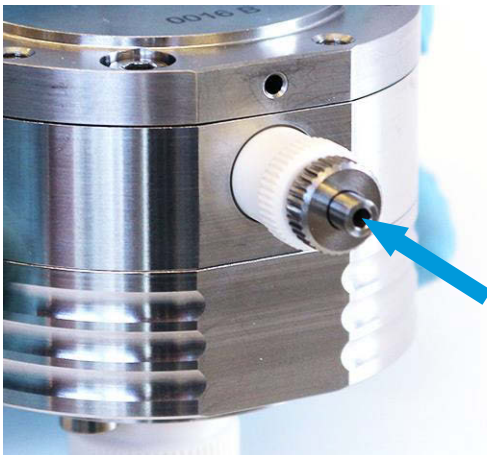
Make sure that the reference pin and the PTFE ferrule are not corroded or damaged. The PTFE ferrule must be white and must not show any black coloration. Replace if necessary.



22. Inside the glove box: Lithium must not come into contact with the PTFE ferrule (see arrow)!



23. Inside the glove box: Attach the reference pin firmly to the cell body.



24. Inside the glove box: Push onto the back of the reference pin while screwing it in.

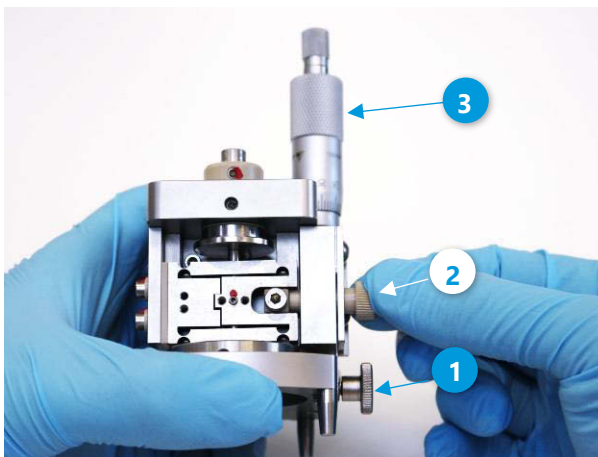


25. Inside the glove box: The cell is now assembled and hermetically sealed, and can be removed from the glove box.

8 Further assembly outside the glove box

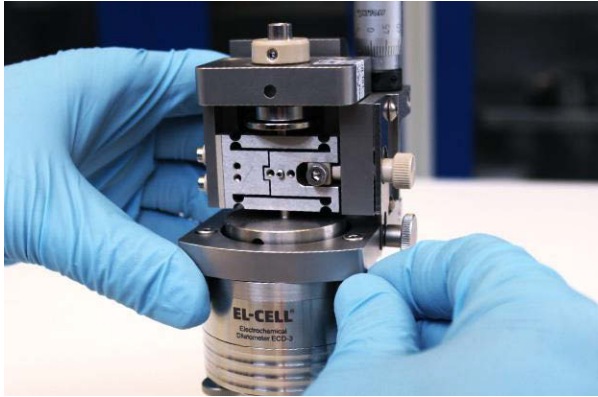


26. Hook the assembly into the bracket and fasten it with the two knurled screws.

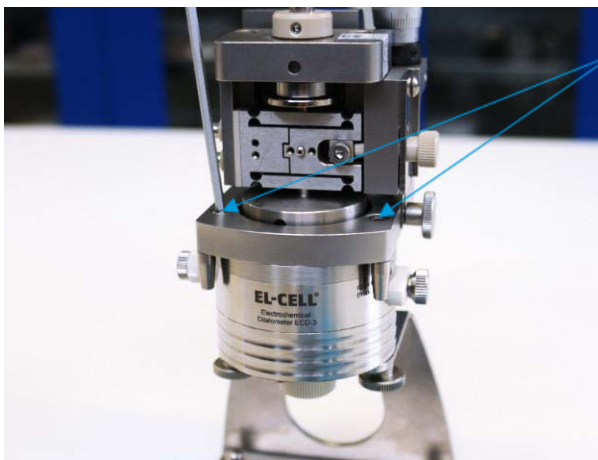


27. Unlock the locking screw (1) and the excenter (2). Then turn the micrometer screw (3) clockwise until the sensor tip is in the upmost position.

Note: Not following the above instruction may result in damage of the membrane, the glass frit, or even the sensor unit, when attaching the sensor unit onto the dilatometer cell.



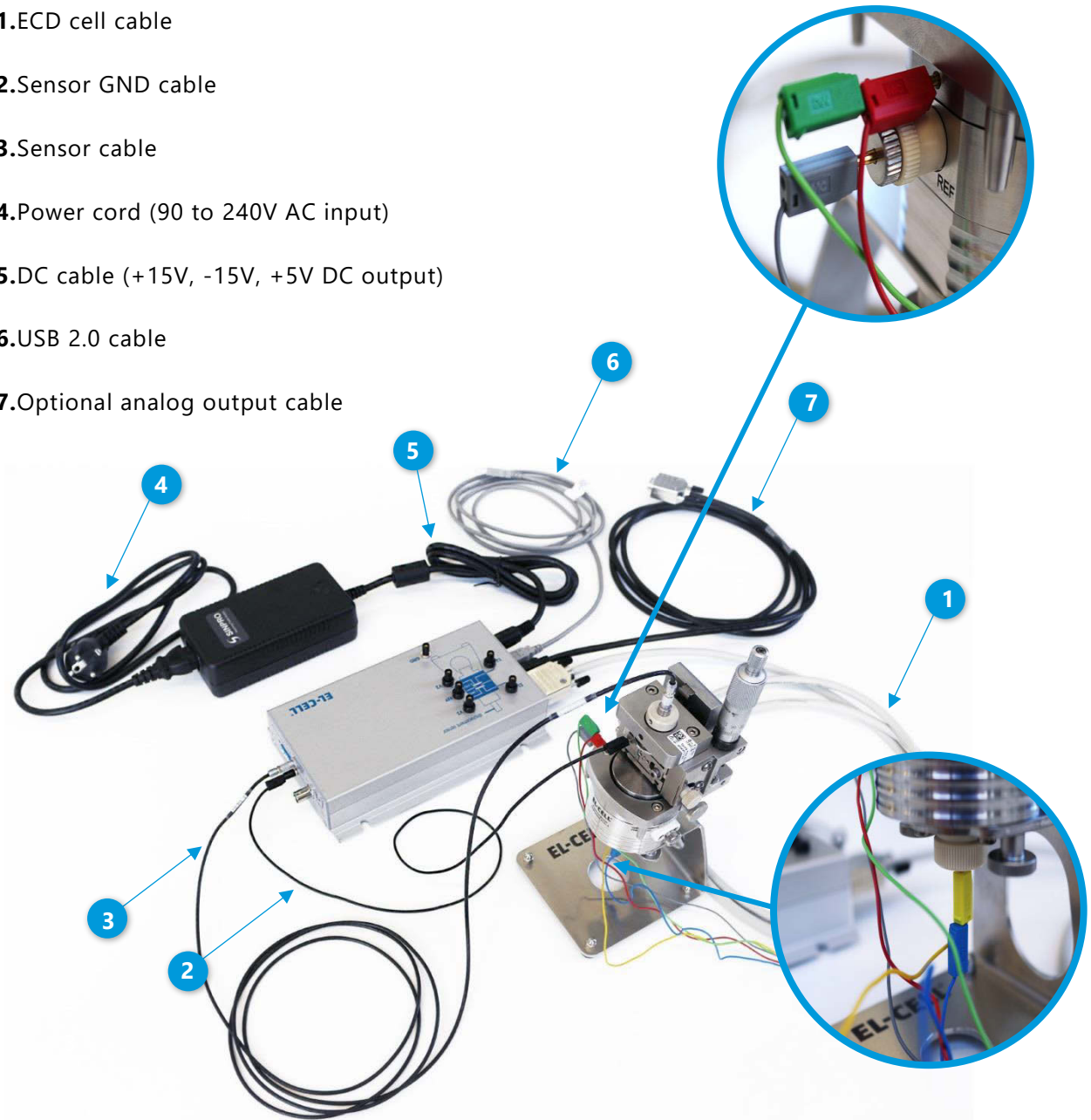
28. Attach the sensor unit onto the dilatometer cell.



29. Fasten the screws to fix the sensor unit.

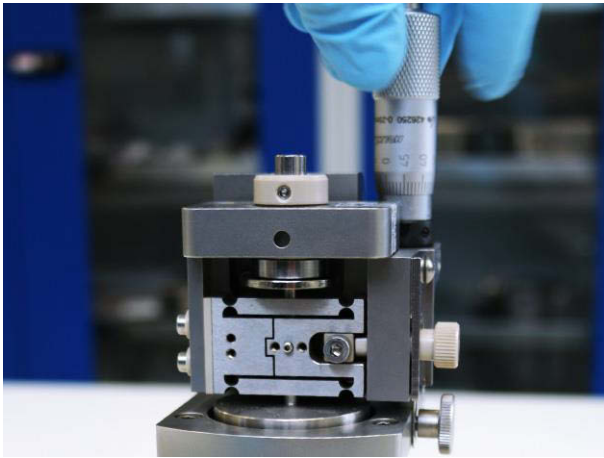
Then connect all cables as shown in the photo below. We highly recommend operating the dilatometer in a temperature controlled environment.

1. ECD cell cable
2. Sensor GND cable
3. Sensor cable
4. Power cord (90 to 240V AC input)
5. DC cable (+15V, -15V, +5V DC output)
6. USB 2.0 cable
7. Optional analog output cable

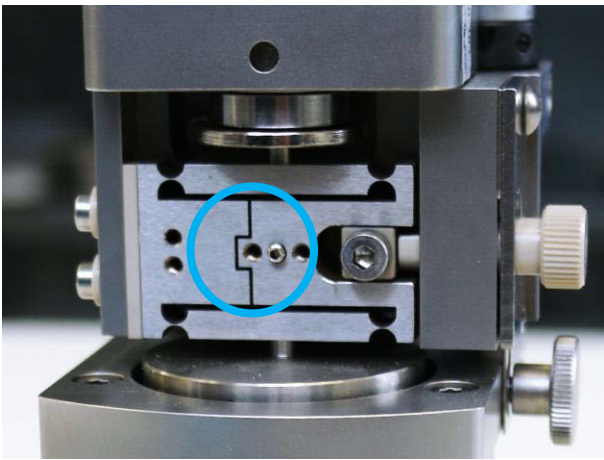




30. Unlock the locking screw (1) and the excenter (2), if not already done.



31. Lower the sensor tip by turning the micrometer screw counter-clockwise.



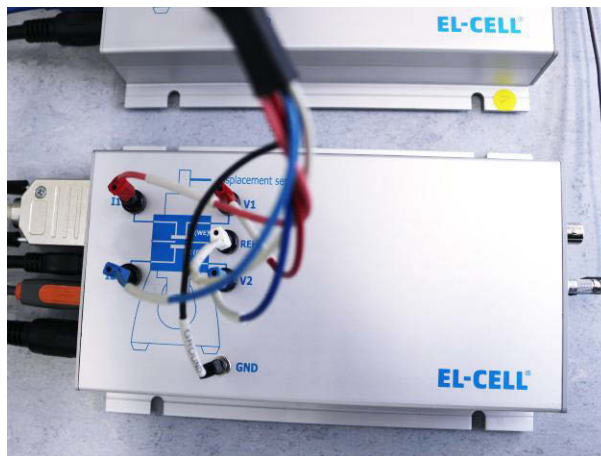
32. The sensor position is indicated by the LED bar graph indicator at the controller box of the ECD-3-nano. Any yellow LED indicates a valid position.



33. For best accuracy and resolution, adjust the sensor approximately in central position.



34. Open the shut-off valve in order to connect the dead volume with the cell volume. This prevents that the measured displacement is affected by possible gas evolution.



35. Example: Connecting a Biologic data logger cable (available on request). View the whole wiring on page 22.

Finally, connect your potentiostat or battery tester to the 4 mm jacks on the front panel of the controller box. Make sure that both instruments share a common ground (GND) potential. Almost any potentiostat or battery tester can be used. The rightmost column in the table below refers to the example of using a Biologic potentiostat (MPG-2, SP, VSP and VMP series).

| Contoller Box | Potentiostat | Biologic Potentiostat, VSP, VMP3, etc. |
|---------------|-------------------------|--|
| I1 | WE Current | WE |
| V1 | WE Sense | Ref1 |
| REF | Reference | Ref2 |
| V2 | CE Sense (if available) | Ref3 |
| I2 | CE | CE |
| GND | GND (if available) | GND |

Before starting the electrochemical cycle we recommend holding the cell at constant potential (or open-circuit) for several hours to allow for baseline stabilization. The initial rest period helps to discern charging induced dimensional changes from the initial creeping.

NOTE: All materials display a more or less pronounced creeping. They tend to shrink when applying a load, and to swell when removing this load. A major contribution to the initial creeping seen right after cell assembly is to be assigned to the construction materials of the

dilatometer. Creeping of the working electrode is induced each time the mechanical properties of the working electrode are altered by charging. Therefore, each charge induced height change is followed by some creeping. The charge induced creeping effects are real and not artefacts of the measurement.

9 EC-Link Software Installation

In order to record the displacement signal together with the cell voltage, cell current, electrode potential and temperature, the software of the integrated data logger needs to be installed on a Microsoft Windows® PC.

- You must be logged into an account with administrator privileges.
- Save your work and close down all active programs.
- On the installation media, run **CDM*_Setup**. This will install the FTDI driver required to establish the USB connection with the data logger.
- On the installation media, run **Setup**. This will install the EC-Link data logger software. Follow any instructions that may appear on your screen.
- Once installation is finished plug in the provided USB cable into both the host PC and the ECD-3-nano controller box.
- Launch the EC-Link data logger software if not already done.
- After a few seconds, EC-Link should report a valid connection and you are ready to start the measurement.

Additional information on the EC-Link software can be found in a separate manual (<https://el-cell.com/support/manuals>).

10 Calibration and Settings

Calibration of the instrument has been carried out at the factory. The corresponding settings of the EC-Link software are stored in the file **Settings ECD-3-nano [Device-ID].V2** in the installation directory on the local hard drive and on the installation media. If the default settings have been changed for any reason, the original settings can be restored by copying **Settings ECD-3-nano[Device-ID].V2** from the installation media into the directory C:\ProgramData\EC-LINK. The settings affect only the data logger readings.

The DIP switches at the controller box affect both the displacement readings of the USB data logger and the analog output signal. Leave the switches in their default position as shown in the screenshot on the next page.



11 Recording the Displacement Signal with an External Potentiostat

Many of today's battery testers and potentiostats provide additional analog inputs that may be used to record sensor signals along with cell current and potential.

In the following, the combination of the ECD-3-nano with a Biologic potentiostat (MPG-2, SP, VSP and VMP series) is described as an example. The Biologic potentiostats feature two analog inputs that are used here to record both displacement and temperature.

1. Connect the 9-pin Sub-D connector of the optional analog output cable to the analog input of the respective VMP3 channel.
2. In the Biologic EC-Lab software, load the experiment settings [ECD-3-nano.mps](#) provided on the EC-Link installation media. The settings are shown in the External Devices dialog (see screenshot below; actual settings may differ). Adapt the [Parameter Settings](#) of the charge/ discharge protocol to your particular experiment, if necessary.

Analog IN 1

Convert E/V to Displacement/ μ m

with 10 V = -125 μ m (max)

-10 V = 125 μ m (min)

Analog IN 2

Convert E/V to T/ $^{\circ}$ C

with 0 V = 0 $^{\circ}$ C (max)

10 V = 80 $^{\circ}$ C (min)

12 Using the Reference Electrode

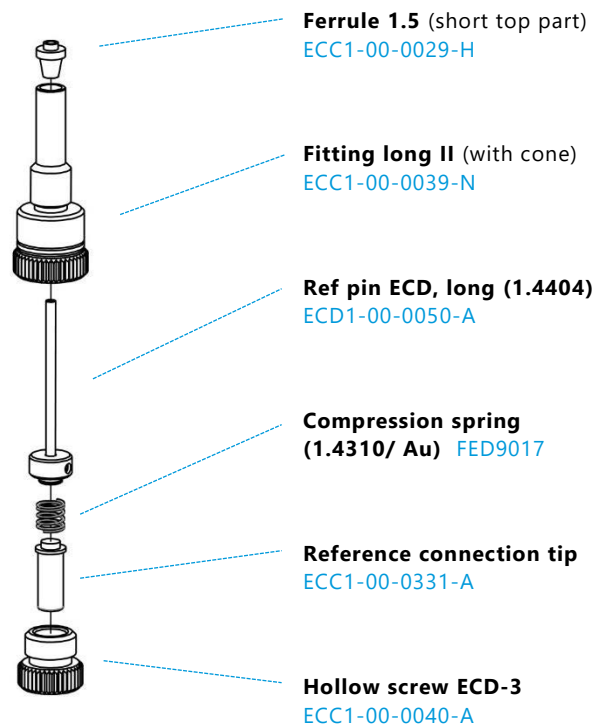
The reference electrode assembly is basically comprised of a metal pin with a blind bore at the end pointing to the glass frit. The user needs to fill the blind bore with the reference material before attaching the reference assembly to the cell body. For most aprotic lithium chemistries, lithium metal is a proper reference material. For aprotic supercap electrolytes, PTFE bound activated carbon may serve as a (pseudo) reference material.

To make sure that, in the assembled state, the reference material is actually pressed against the glass frit of the cell stack, it is advised to push onto the back of the reference pin while screwing in the pin.

NOTES:

- Avoid any direct contact of the PTFE ferrule with lithium metal. PTFE is being reduced to (black and porous) carbon when getting in contact with lithium.
- The standard dilatometer comes with a stainless steel reference pin, which is good for use with lithium metal. In contrast, the gold reference pin, which is part of the optional aqueous kit, must not be used with lithium metal. Gold and lithium spontaneously alloy when getting into contact with each other.

Components of the reference electrode:



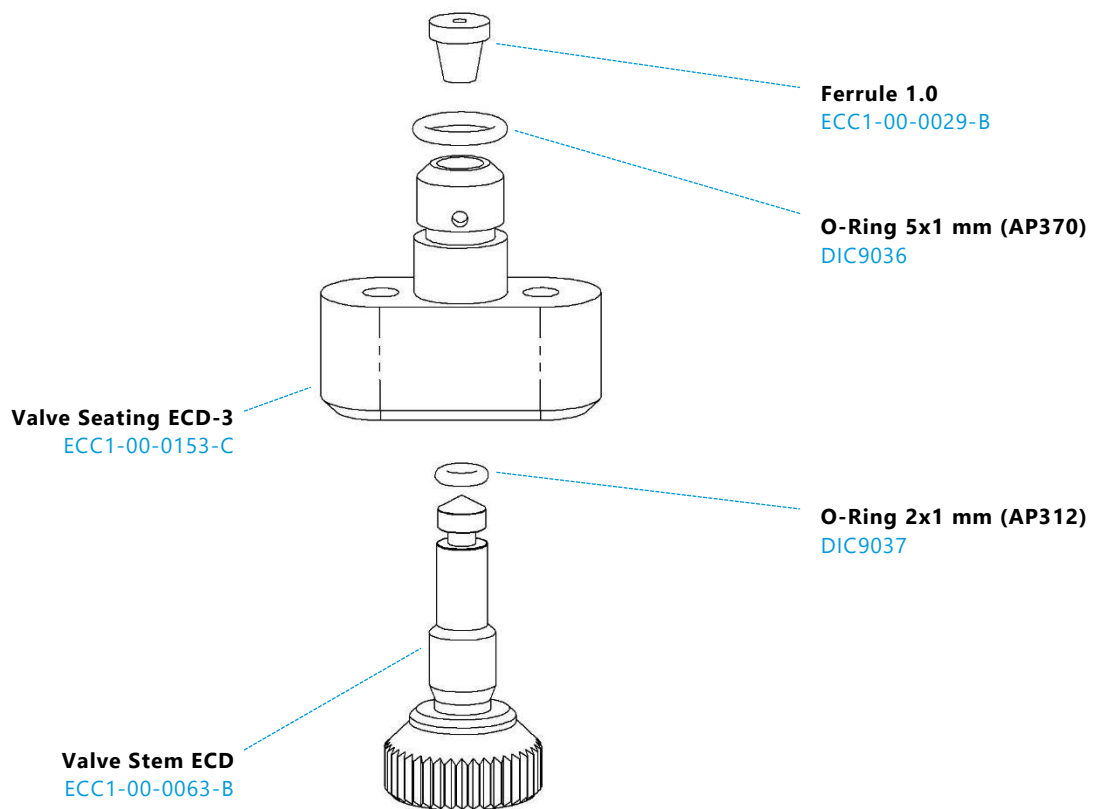
13 Using the valve

The shut-off valve serves to make or break the connection between the cell volume and the dead volume of the dilatometer. During the filling procedure, the valve needs to be closed. This way, the cell volume can be effectively evacuated and then filled with electrolyte. Afterwards, when running the experiment, the valve should be open. This way, unwanted pressure build-up via gas evolution is effectively mitigated.

NOTES:

- Close the valve gently by hand. Excessive torque may damage the valve.
- Some valve parts may get into electrolyte contact. It is therefore advised to unscrew the valve seating and the valve stem after use. The two O-ring seals and the PTFE ferrule may stay in place. Wash with plenty of water or other appropriate solvent.
- Dry the valve parts in the disassembled state (80°C, vacuum, overnight) before reassembly inside the glove box.

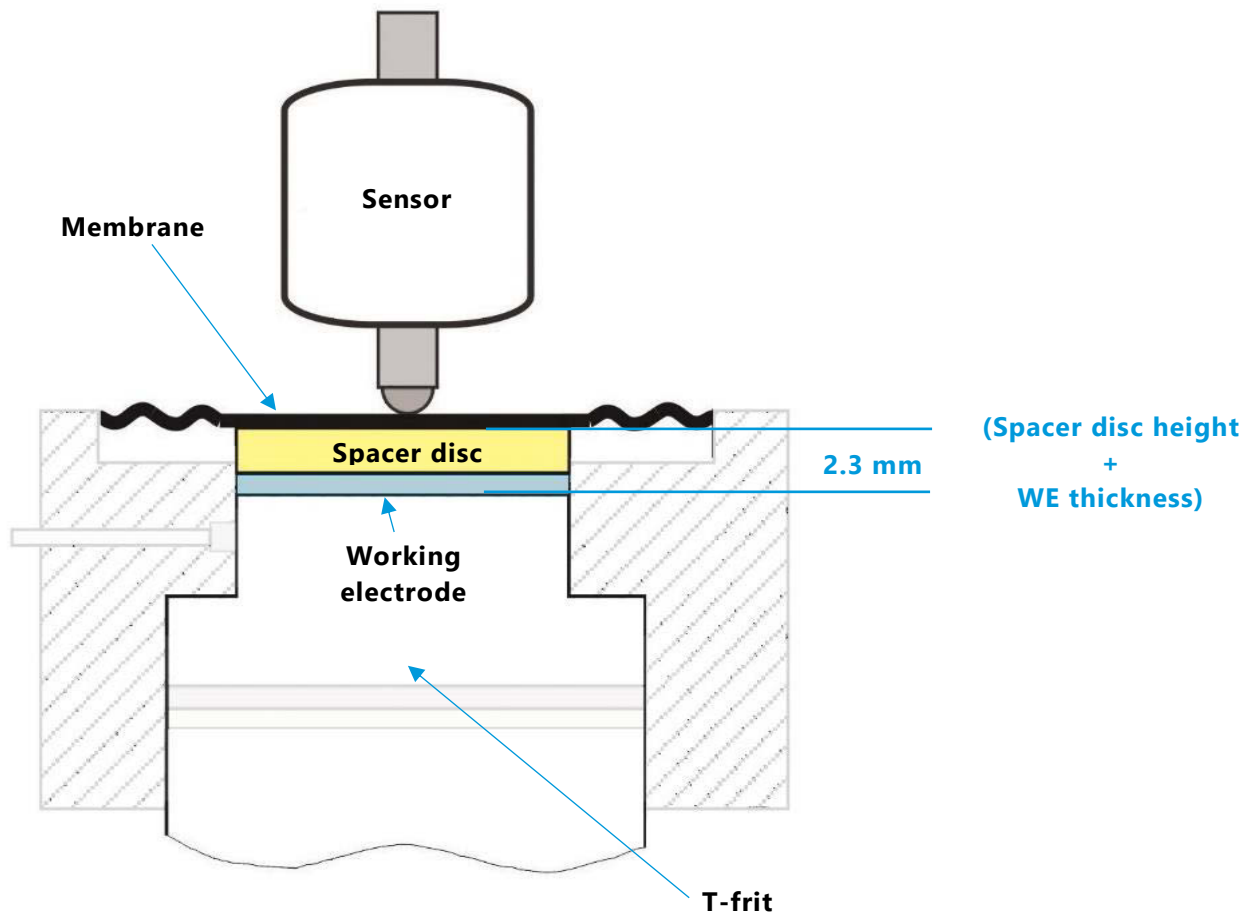
Components of the valve:



14 Choosing the appropriate spacer disc

In order to achieve electrical contact between the electrode and the membrane, it is important to fill the 2.3 mm gap between the T-Frit and the Membrane. This is achieved by the stack comprised of the spacer disc (current collector) and the working electrode.

Choose a proper spacer disc height depending on the thickness of your electrode. Spacer discs are available in different heights ranging from 0.9 mm to 2.3 mm in 0.1 mm steps. If in doubt choose the next higher spacer disc. We recommend using the 2.3 mm spacer disc for all electrodes in the thickness range 0 to 150 μm .



15 Dilatometer Disassembly and Cleaning

When disassembling the dilatometer cell, wear protective gloves and glasses.

Collect parts that have been in contact with electrolyte on a separate tray for subsequent cleaning.

1. Disconnect all cables from the dilatometer cell and the sensor unit.
2. Remove the dilatometer cell from the temperature chamber.

Then follow the instructions as described in chapter 6, starting at step 3.



Clean all wetted parts right after disassembly. Ultrasonic cleaning with water and/or detergent wash is recommended. Valves and tubing may clog if not properly purged with water or other solvent.

After cleaning, dry all parts in vacuum at 80°C in vacuum (<0.1 mbar) overnight. See page 15 for a list of all parts that need to be dried.

16 Care Instructions

Upon assembly make sure that the reference pin and the PTFE ferrule are not corroded or damaged. The PTFE ferrule must be white and must not show any black coloration.

We strongly recommend to replace all O-rings, sealings and ferrules before each test.

17 Consumables

Cell Body:

- T-Frit 10/12.5 (5 pcs.) [ECC1-00-0041-B/V](#)
- Membrane (aprotic) 1.4404 (3 pcs.) [ECC1-00-0019-D/3](#)
- O-Ring 33.05 x 1.78 mm (10 pcs.) [DIC9034/X](#)
- Ferrule 1.0 (10 pcs.) [ECC1-00-0029-B/X](#)
- Ferrule 1.5 (10 pcs.) [ECC1-00-0029-H/X](#)
- O-Ring 50.5 x 1.78 mm (10 pcs.) [DIC9038/X](#)
- PTFE-Seal for ECD (33 x 1.6) (3 pcs.) [ECC1-01-0043-D/3](#)
- PTFE-seal for ECD-3 piston (3 pcs.) [ECC1-01-0044-C/3](#)
- O-Ring 9.75 mm x 1.78 mm (AP370) (10 pcs.) [DIC9006/X](#)
- Spacer disc (set) 2.1-2.3 [ECC1-01-0012-F](#)
- Spacer disc (set) 1.8-2.0 [ECC1-01-0012-G](#)
- Spacer disc (set) 1.5-1.7 [ECC1-01-0012-H](#)
- Spacer disc (set) 1.2-1.4 [ECC1-01-0012-K](#)
- Spacer disc (set) 0.9-1.1 [ECC1-01-0012-L](#)
- Separator (GF/A) 12 x 0.26 mm, (10 pcs) [ECC1-01-0012-Q/X](#)
- PE Seal II ECD-3 piston (3 pcs) [ECC1-01-0044-D/3](#)
- O-Ring 2.0 mm x1.0 mm (AP312) (10 pcs) [DIC9037/X](#)

Sensor Unit:

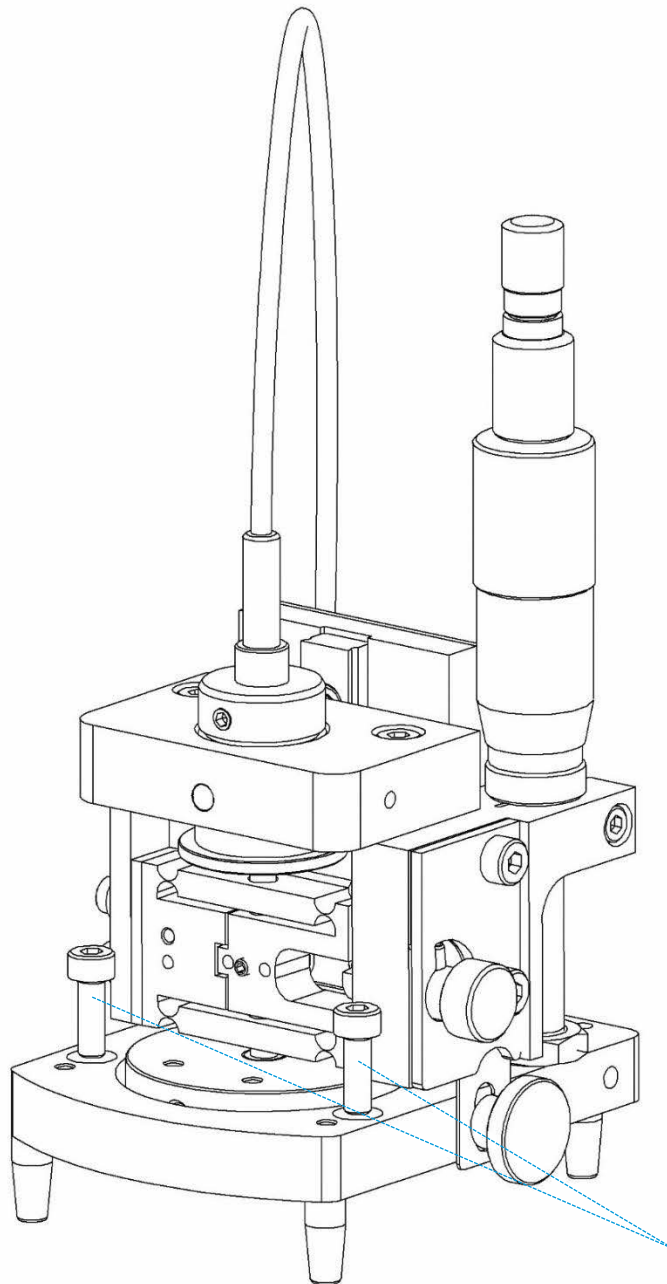
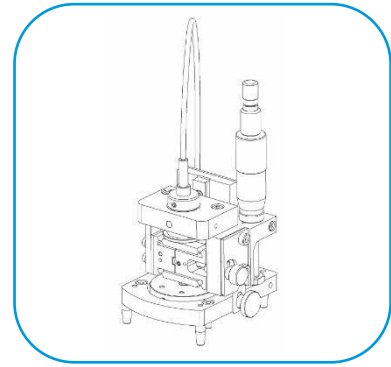
- Socket screw [DIN-912 M4 x 12](#)

18 Spare Parts

Components Sensor Unit

ECD1-00-0030-A

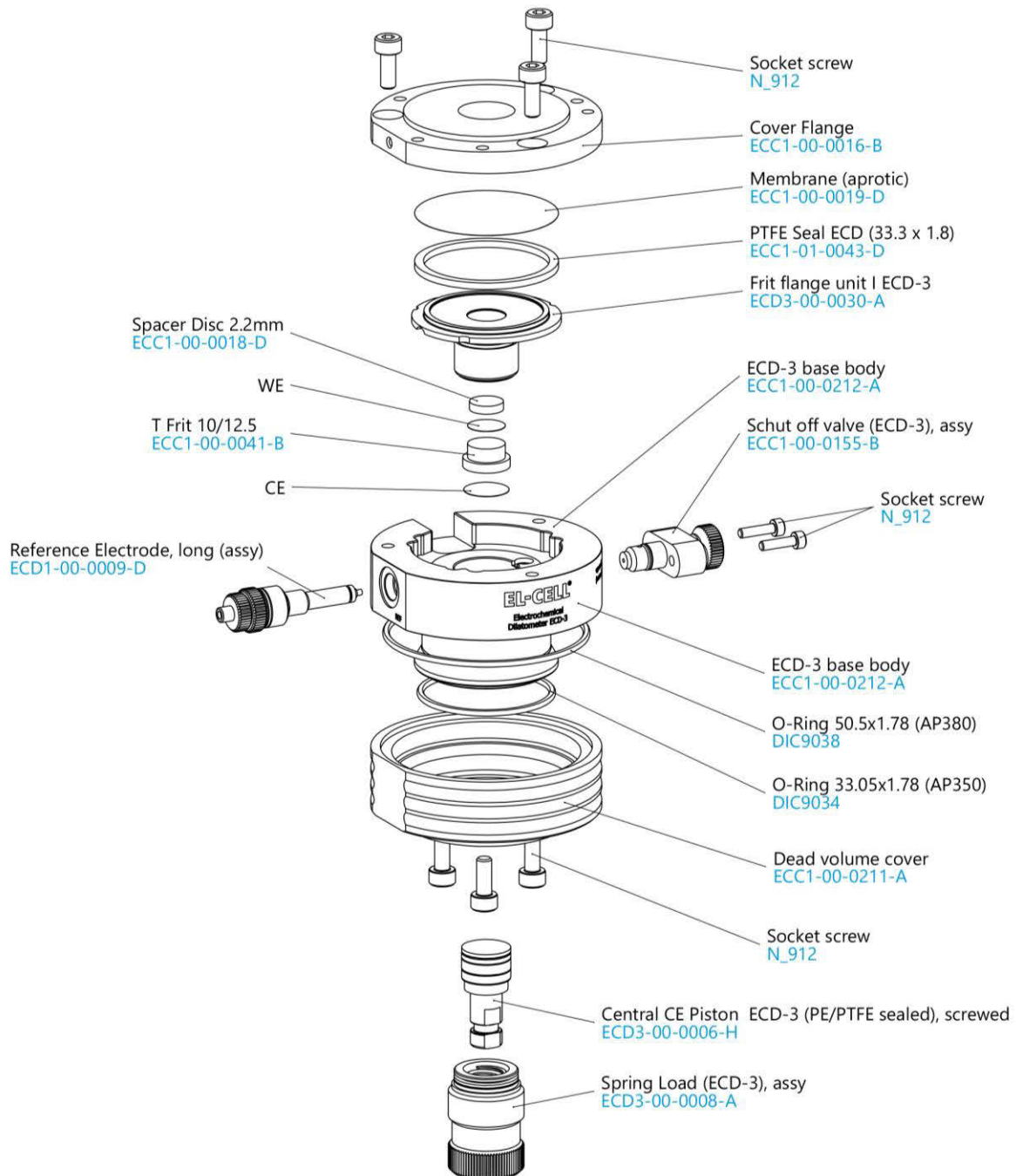
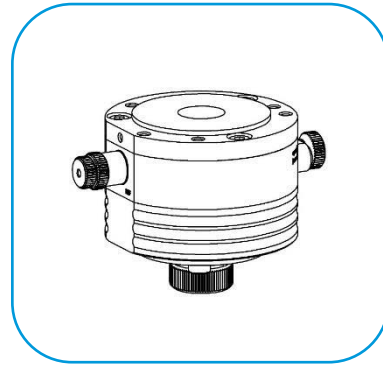
There are no further spare parts available for the sensor unit. For repair, please contact EL-CELL.



Socket screw
DIN-912 M4x12

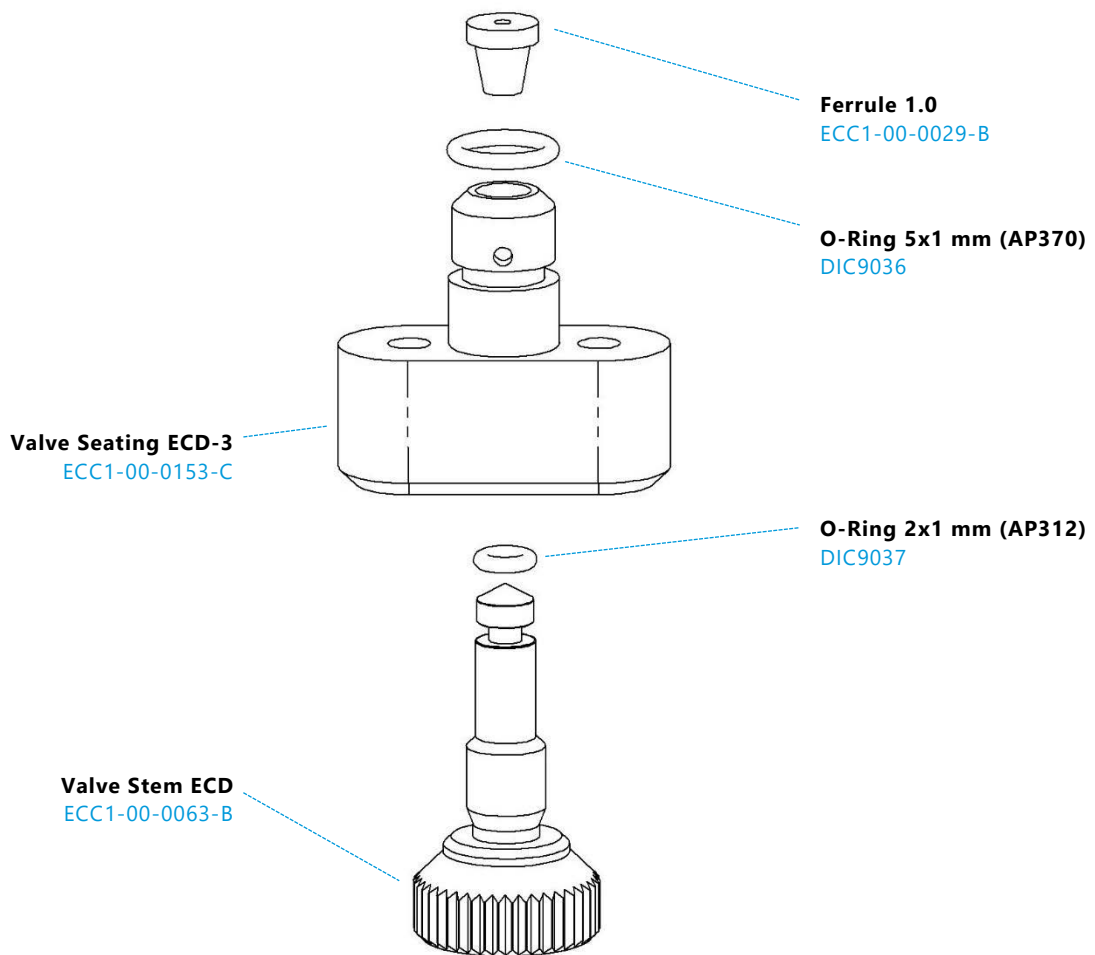
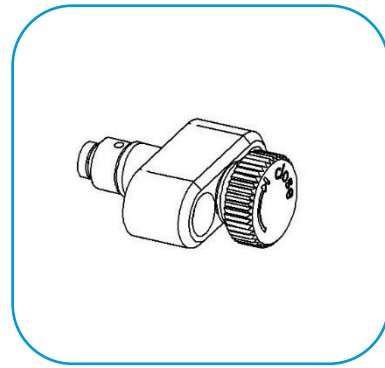
Components Cell Body

ECD3-00-0002-A



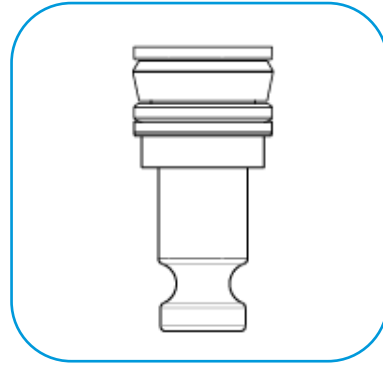
Shut-off valve (ECD-3), assy

ECC1-00-0155-B



Central CE piston ECD-3 (PE-sealed), screwed

ECD3-00-0006-D



Piston PTFE-sealing, internal thread (ECD-3)
ECC1-00-0126-O

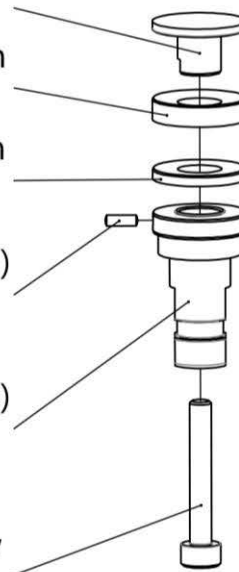
PTFE Seal ECD-3 piston
ECC1-01-0044-C

PE Seal II ECD-3 piston
ECC1-01-0044-D

DIN 7 A 1,5 m6x4 Cylindrical pin (A4)
NRM0013

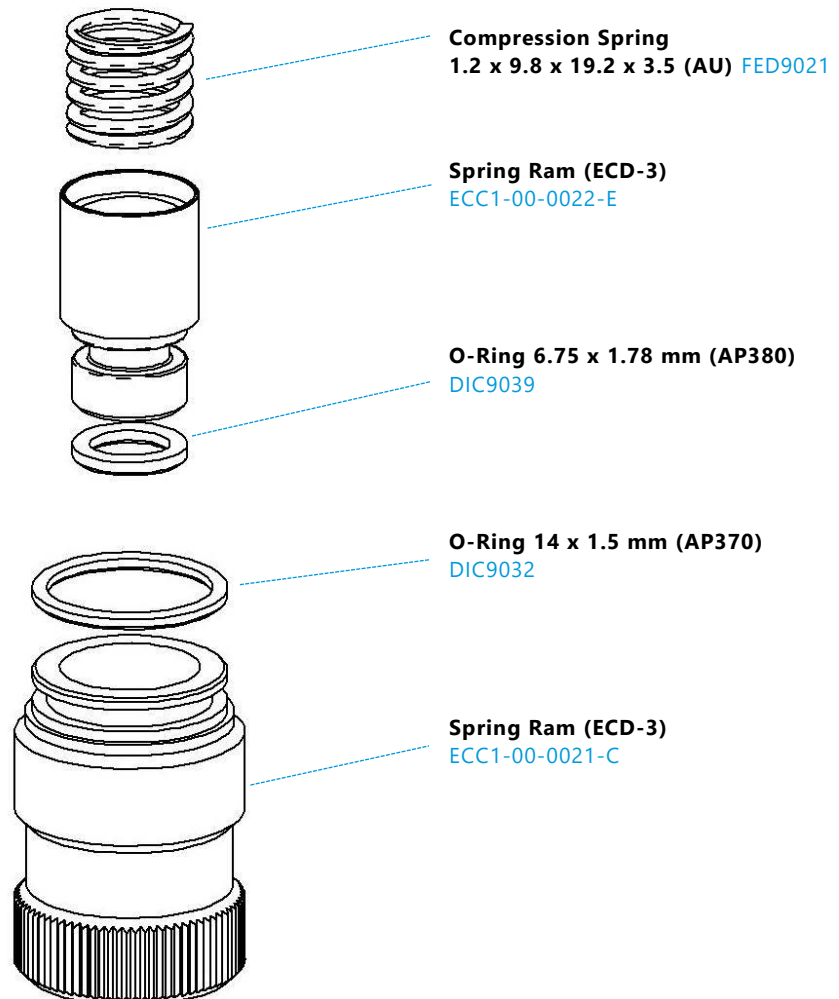
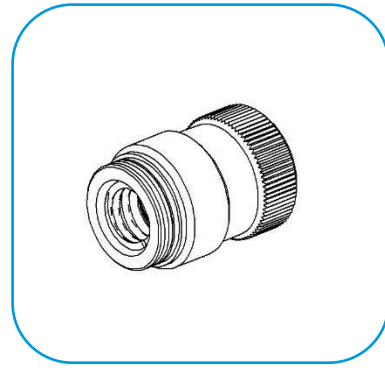
Thrust Screw VII (ECD-3)
ECC1-00-0066-G

Socket screw
N_912



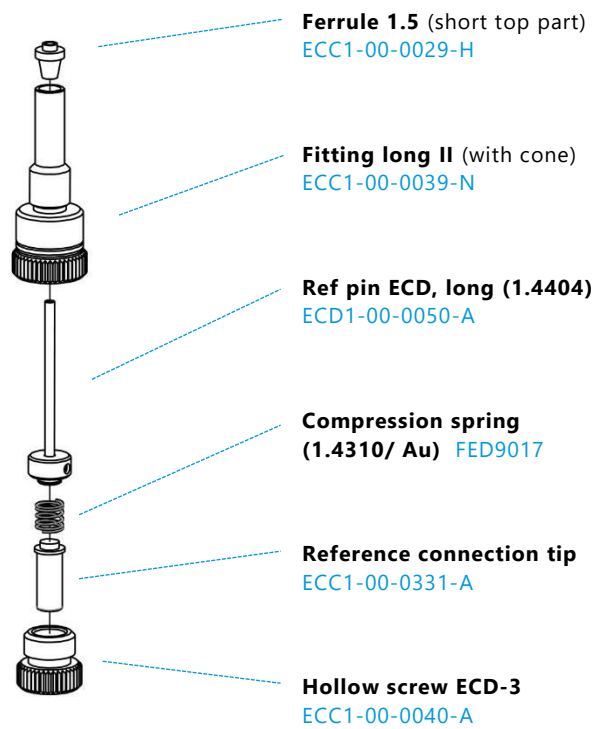
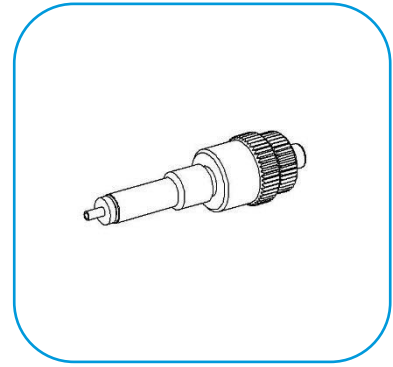
Spring load (ECD-3), assy

ECD3-00-0008-A



REF electrode ECD, long, assy (1.4404)

ECD1-00-0009-D



19 Connector and Cable Pin-out

Cell Cable (4 x 2 x 0.25 mm², TP, shielded):

ECE1-00-0033-F

One end of the cable is terminated by a Sub-D HD M15 connector (to box); the other end is terminated by 2 mm banana connectors. A Pt100 sensor is located beneath the black shrink tube at the end of the cable pointing to the dilatometer. The cable shield is tied to the Sub-D connector housing.

| Pin # | Signal | Cable Color | Color of 2 mm connector |
|-------|----------|-------------|-------------------------|
| 1 | V1 | Red | Red |
| 2 | V2 | Blue | Blue |
| 3 | - | - | - |
| 4 | REF | Grey | Grey |
| 5 | I2 | Yellow | Yellow |
| 6 | - | - | - |
| 7 | - | - | - |
| 8 | - | - | - |
| 9 | - | - | - |
| 10 | I2 | Green | Green |
| 11 | Pt100(1) | Brown | - |
| 12 | Pt100(2) | White | - |
| 13 | - | - | - |
| 14 | - | - | - |
| 15 | - | - | - |

Biologic Auxiliary Cable (2 x 2 x 0.14 mm², TP, shielded): ECE1-00-0039-B

Both connector housings are tied to the cable shield. The cable shield is connected to GND.

| IEEE 1394 to Box | | | Sub-D M9 to Biologic AUX Input | |
|------------------|--------------|-------------|--------------------------------|------------|
| Pin # | Signal | Cable Color | Pin # | Signal |
| 1 | | | | |
| 2 | GND | Black | 7 | GND |
| 3 | | | | |
| 4 | Temperature | Blue | 6 | Analog IN2 |
| 5 | | | | |
| 6 | Displacement | Green | 1 | Analog IN1 |

20 Technical support

Technical support for this product is exclusively provided by EL-Cell GmbH.

EL-Cell GmbH

Tempowerkring 8
21079 Hamburg - Germany

phone: +49 40 79012-737

fax: +49 40 79012-736

e-mail: info@el-cell.com

web: www.el-cell.com

21 Warranty

For a period of one year from the date of shipment, EL-Cell GmbH (hereinafter Seller) warrants the goods to be free from defect in material and workmanship to the original purchaser. During the warranty period, Seller agrees to repair or replace defective and/or nonconforming goods or parts without charge for material or labor, or, at the Seller's option, demand return of the goods and tender repayment of the price. Buyer's exclusive remedy is repair or replacement of defective and nonconforming goods, or, at Seller's option, the repayment of the price.

Seller excludes and disclaims any liability for lost profits, personal injury, interruption of service, or for consequential incidental or special damages arising out of, resulting from, or relating in any manner to these goods.

This Limited Warranty does not cover defects, damage, or nonconformity resulting from abuse, misuse, neglect, lack of reasonable care, modification, or the attachment of improper devices to the goods. This Limited Warranty does not cover expendable items. This warranty is void when repairs are performed by a non-authorized person or service center. At Seller's option, repairs or replacements will be made on site or at the factory. If repairs or replacements are to be made at the factory, Buyer shall return the goods prepaid and bear all the risks of loss until delivered to the factory. If Seller returns the goods, they will be delivered prepaid and Seller will bear all risks of loss until delivery to Buyer. Buyer and Seller agree that this Limited Warranty shall be governed by and construed in accordance with the laws of Germany.

The warranties contained in this agreement are in lieu of all other warranties expressed or implied, including the warranties of merchantability and fitness for a particular purpose.

This Limited Warranty supersedes all prior proposals or representations oral or written and constitutes the entire understanding regarding the warranties made by Seller to Buyer. This Limited Warranty may not be expanded or modified except in writing signed by the parties hereto.