



Operating Instructions

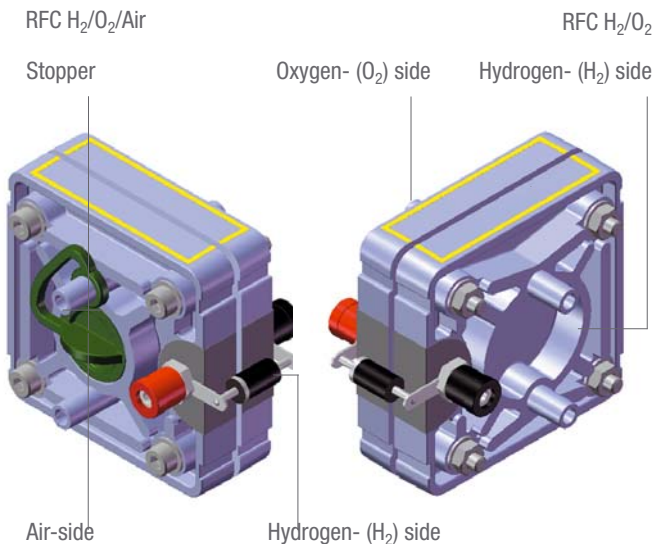
R101 RFC H₂/O₂

R102 Double RFC H₂/O₂

R103 RFC H₂/O₂/Air

R104 Double RFC H₂/O₂/Air

Overview



RFC = Reversible Fuel Cell

General Safety Precautions

- The units may only be set up and operated by a responsible supervisor.
 - **WARNING!** Not suitable for children under 12 years!
 - Read the Operating Instructions before setting up the fuel cell. Follow them during use and keep them readily available for reference.
 - Wear protective goggles.
 - Equipment and gases must be used and stored out of the reach of small children.
 - The equipment may only be used with h-tec solar modules (h-tec Solar Module Basic, Art.-Nr. 2086; Solar Module Tutorial, Art.-Nr. A113; Solar Module Tutorial Double, Art.-Nr. A118), h-tec batterybox (BatteryBox, Art.-Nr. A115) or h-tec plug-in power supply (h-tec PowerSupply, Item No. 2033).
 - Plug-in power supplies can be dangerous - they are not toys!
 - Disconnect the unit from the plug-in power supply and the solar module before cleaning with liquids.
 - Unless instructed to the contrary by the manual, do not reverse or short-circuit the connecting terminals.
 - The units must not be operated when empty. Always ensure that they contain sufficient water. Pay attention to the water level marks.
 - Remove flammable gases, vapours or liquids from the area surrounding fuel cells and electrolyzers. The catalytic materials involved may cause spontaneous ignition.
 - Hydrogen and oxygen may escape from the units. Operate the units in well-ventilated rooms to ensure that the gases do not accumulate and form explosive mixtures.
 - The units may only be operated in display cases if adequate ventilation is guaranteed under all circumstances. The operator is responsible for ensuring this.
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General Safety Precautions

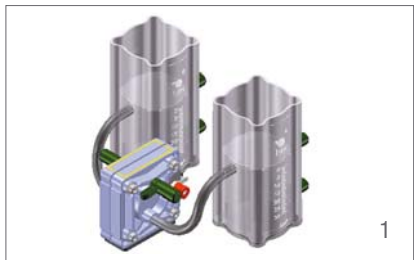
- Remove from the vicinity of the units anything that could ignite the hydrogen (e.g. open flame, materials that can become charged with static electricity, substances with a catalytic action).
 - Remove from the vicinity of the units all substances that could spontaneously ignite in increased oxygen concentration.
 - Do not smoke.
 - Hoses, plugs and gas tanks are used for pressure compensation. They must not be fixed or secured with clamps, adhesive, etc.
 - Only use the gas storage tanks associated with or supplied with the units. Never connect alternative gas storage tanks.
 - The units may only be operated at room temperature and ambient pressure.
 - Minimum separation distances must be observed when using solar modules and artificial lights. These are: 30 cm between h-tec solar modules and the h-tec Videolight, and 50 cm in the case of the h-tec Spotlight. When using lights from other manufacturers, observe the minimum distance specified by them.
 - **WARNING!** The surface of solar modules can get very hot during extended operation.
 - Tell your students about any potential dangers and carefully supervise experimentation.
 - h-tec accepts no responsibility for injuries or damage sustained in the event that these Safety Precautions are not followed.
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Introduction

This PEM fuel cell (PEM = Proton Exchange Membrane) is reversible, meaning it can work in either electrolysis or fuel cell mode. As an electrolyser, it uses an external voltage to break down water into hydrogen and oxygen. As a fuel cell, it produces electricity by using hydrogen and oxygen gas (or atmospheric oxygen).

H₂/O₂ Setting up

Read the Operating Instructions and the General Safety Precautions before using any of the equipment.



Note:

Setup is described using the h-tec gas storage tank (Storage 30 Item No. A103).

1. Use hoses to connect the bottom connectors of the RFC to the connectors on the fuel cell side of the gas storage tanks (**Fig. 1**).

2. Fit caps to the connectors on the electrolysis side of the gas storage tanks and to the top gas connectors of the RFC.

Note:

When using R103 or R104, make sure that the stopper is fitted to the air inlet.

3. Fill both storage tanks with distilled water up to the top mark of the compensation tank.
4. Open the upper caps on both sides of the cell one after the



other. Air will escape from the gas storage tanks and from the cell and the cell will be flooded. The process is complete when water comes out of the top gas connectors (Fig. 2).

5. Re-cap the gas connectors.

H₂/Air Setting up

1. Use a hose to connect the bottom connector on the hydrogen side of the RFC to the connector on the fuel cell side of the gas storage tank (Fig. 3).

2. Fit caps to the connectors on the electrolyser side of the gas storage tank and to the top gas connector on the hydrogen side of the RFC.
3. Fill the storage tank with distilled water up to the top mark of the compensation tank.
4. Open the top cap on the hydrogen side of the cell. Air will escape from the gas storage tank and from the cell and



the hydrogen side of the cell will be flooded. The process is finished when water comes out of the top gas connector.

5. Re-close the gas connector on the hydrogen side.

Note:



To flood the O₂ side, fit the stopper(s) so that the water can be well distributed in the cell.

6. Now moisten the cell by introducing distilled water through the bottom O₂ connector until it escapes from the top O₂ connector (Fig. 4).

7. Remove the stopper(s) from the oxygen side of the RFC. The cell is now ready for use in electrolysis mode.

Gas production/storage

1. Connect a DC voltage source (e.g. h-tec solar module, PowerSupply or BatteryBox). When doing so, make sure that the polarity is correct (red = „+“, black = „-“) and observe the maximum permissible voltage.

Important:

The maximum permissible voltage for the RFCs R101 and R103 is 2 V, and for the RFCs R102 and R104 is 4 V.

2. The current breaks down the water into hydrogen and oxygen in a ratio of 2:1. The gases collect in the gas storage tank(s) and displace the water there into the compensation tank(s). In air mode, the oxygen produced escapes into the environment.
3. When the gas storage tanks are full, excess gas will escape in the form of bubbles.

Fuel cell mode

1. Remove the voltage source and connect a load (e.g. Ventilator Fan Tutorial).
2. The cell will use the stored gas (or the stored hydrogen and the atmospheric oxygen in air mode) to generate electricity, along with water and a small amount of heat.

Emptying the storage tanks

1. Open the caps on the fuel cell.
2. Hold the storage tanks over a collecting tray and remove the bottom caps from the tanks. The water will run out.

Accessories (not included)

- TubeSet Basic Item No. A120
 - Water bottle 100 ml with filler tip Item No. A125
 - Gas storage tank Storage 30 Item No. A103
 - Plug-in PowerSupply Item No. 2033
 - BatteryBox Item No. A115
 - Ventilator Fan Tutorial Item No. A105
 - Solar module Tutorial Item No. A113
 - Solar module Tutorial Double
(for RFC R102 or RFC R104) Item No. A118
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Maintenance

The fuel cells we provide in our sets are maintenance-free. However, always remember:

- Use fresh, distilled water each time.

Before putting the cell away:

- Continue operating the cell until the electric load (e.g. the motor) stops by itself. This will ensure that a little water remains in the cell and keeps the membrane moist.
- Close the caps and the stopper so that the water in the cell does not evaporate quickly.

Troubleshooting

The RFC only produces low power in fuel cell mode

Cause:

- There is still too much water in the cell.

Solution:

- Extend the electrolysis mode until gas production noticeably slows. The remaining water in the cell will now have been used up and the cell will be dry enough for the fuel cell mode.

The RFC does not work in electrolysis mode in spite of being set up correctly

- You have not used distilled water. The cell is permanently damaged.
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RFC H₂/O₂ (R101)Single-cell RFC for H₂/O₂ operationElectrolyser mode: 5 cm³/min H₂; 2,5 cm³/min O₂
Power: 1,16 W

Fuel cell mode: Power: 300 mW

H x W x D: 50 x 40 x 57 mm

Weight: 54 g

Double RFC H₂/O₂ (R102)Double-cell RFC for H₂/O₂ operationElectrolyser mode: 10 cm³/min H₂; 5 cm³/min O₂
Power: 2,33 W

Fuel cell mode: Power: 600 mW

H x W x D: 56 x 42 x 57 mm

Weight: 63 g

RFC H₂/O₂/Air (R103)Single-cell RFC for H₂/O₂ or H₂/Air operationElectrolyser mode: 5 cm³/min H₂; 2,5 cm³/min O₂
Power: 1,16 WFuel cell mode: Power H₂/O₂: 300 mW
Power H₂/Air: 100 mW

H x W x D: 50 x 40 x 57 mm

Weight: 52 g

Double RFC H₂/O₂/Air (R104)Double-cell RFC for H₂/O₂ or H₂/Air operationElectrolyser mode: 10 cm³/min H₂; 5 cm³/min O₂
Power: 2,33 WFuel cell mode: Power H₂/O₂: 600 mW
Power H₂/Air: 200 mW

H x W x D: 56 x 42 x 57 mm

Weight: 60 g