

Operating Instructions



F107 PEMFC KIT



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Introduction

Diminishing resources, more severe environmental impacts and the ever-increasing demand for energy force us to reevaluate the structure of our energy supply system. Automobile and oil companies increasingly invest in hydrogen technology because it offers solutions to some of these concerns. This fascinating technology combines a sound energy supply with minimal impact on our natural resources.

It is important to learn about this technology, especially for young people, who will most likely spend a large part of their lives with it.

The PEMFC Kit offers the possibility to become familiar with hydrogen technology in a step-by-step procedure, by way of simple experiments.

The PEMFC Kit represents a state-of-the-art technology. It can be used for practical demonstration of the operation of fuel cells by means of simple

experiments. The cell can also be completely dismantled and can therefore also be used for vivid demonstration of a fuel cell's simple design.

The PEMFC Kit is consistently environmentally conscious in all operating modes, requiring only hydrogen and oxygen or ambient air for the generation of electricity. Water is produced as a by-product.

All steps required for setup, operation and assembly/dismantling of the PEMFC Kit are described below.

Please read through the Operating Instructions carefully beforehand.

h-tec
Hydrogen Energy Systems

wishes you many enjoyable hours learning about this technology with the PEMFC Kit.

Intended Use

The PEMFC Kit allows the principle of proton exchange membrane (PEM) fuel cells and PEM electrolyzers to be demonstrated and measurements taken. The system has been developed for teaching and demonstration purposes only.



Hydrogen and oxygen are required for operation of the PEMFC Kit. Air can also be used as an alternative to oxygen. Should the equipment be used improperly, these gases present a hazard. To prevent accidents, observe the General Safety Precautions at all times when working with the PEMFC Kit.

Any other use is prohibited!

- The system is intended for teaching and demonstration purposes in schools, universities, institutions and companies only.
- It may only be set up and operated by a competent person.
- Read the Operating Instructions before setting up the PEMFC Kit. Follow them during use and keep them readily available for reference.
- Wear protective goggles.
- The system is not a toy. Operate the PEMFC Kit and keep it and the gases produced out of the reach of small children.
- Unless specified otherwise, do not short-circuit or reverse the polarity of the terminals.
- Do not operate the system dry. Always ensure that it contains sufficient water.
- Remove inflammable gases, vapours and fluids from the vicinity of fuel cells and electrolyzers. The catalysts contained in the system can trigger spontaneous combustion.
- Hydrogen and oxygen may escape from the system. To prevent the gases collecting and forming explosive mixtures only use the system in well-ventilated rooms.



General Safety Precautions

- The system may only be operated in a display case, which is sufficiently ventilated at all times. The operator is obliged to prove this by means of appropriate measurements.
- Remove from the vicinity of the system anything that could ignite the hydrogen (naked flame, materials that can become charged with static electricity, substances with a catalytic action). 
- Remove from the vicinity of the system all substances that could spontaneously ignite with increased oxygen concentration.
- Do not smoke. 
- Hoses, plugs and tanks are used for pressure compensation. They must not be fixed or secured with clamps, adhesive, etc.
- Only use the gas storage tanks belonging to or supplied with the system to store gas. Never connect other alternatives.
- Only operate the system at room temperature and ambient pressure.
- Do not position any solar modules and lights in use closer than the minimum permitted distance (30 cm)

General Safety Precautions

between h-tec solar modules and the h-tec Videolight, and 50 cm between them and the h-tec Spotlight, or see other manufacturers' stipulations).

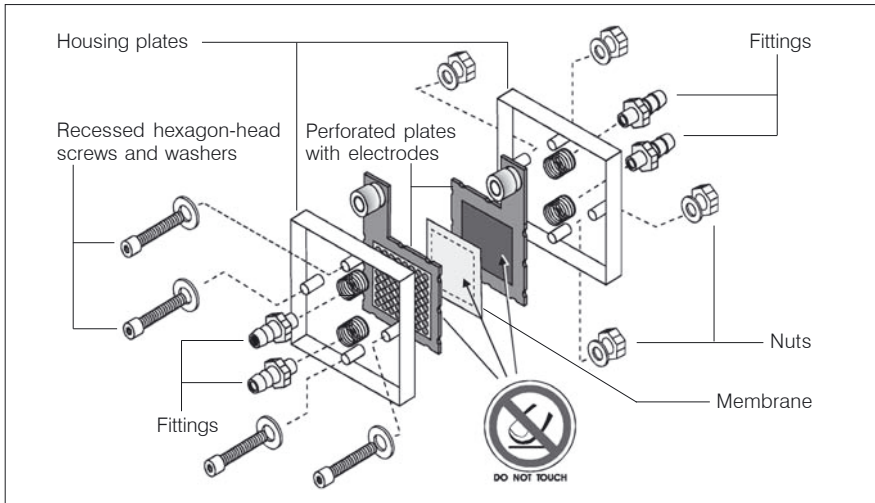
- The surface of solar modules can get very hot during extended operation.

- Tell your students about any potential dangers and carefully supervise experimentation.

h-tec will not accept any responsibility for injuries or damage sustained in the event of these Safety Precautions not being followed.

Equipment and Materials

View of PEMFC Kit



- PEM fuel cell, can be fully dismantled for tuition purposes

Item No. F107

Hydrogen sources

- Electrolyser 10
Item No. E102
- Electrolyser 5
Item No. E101

Additional equipment and materials required

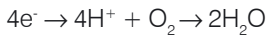
- Commercial distilled (deionised) water with a conductivity of $<2\mu\text{S}/\text{cm}$
- Absorbent cloths

Operation of a PEM fuel cell

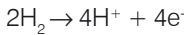
In a fuel cell, chemical energy is converted directly into electrical energy, i.e. without use of a combustion process. Hydrogen and oxygen supplied from outside the process react to form water, generating electrical current and heat in the process. The oxygen can be supplied in pure form, or in the form of air.

The membrane-electrode unit forms the heart of the PEM fuel cell. The following reactions take place within it:

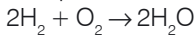
Cathode:



Anode:



Complete reaction:



The hydrogen gas supplied to the anode is oxidized. Under the catalytic action of the electrode (e.g. platinum), it is broken down into protons and electrons. The H^+ ions migrate through the proton-conductive membrane to the cathode side. If an external electric circuit is provided to the cathode, the electrons travel to the cathode, performing electrical work in the process. The oxygen supplied to the cathode is reduced, combining with the protons to form water.

“Open outlet” gas supply mode

The “open outlet” gas supply mode is employed with all hydrogen sources which supply a continual gas flow. These include pressurized gas cylinders with a fine control valve (preferably with pressure reducer), electrolyzers, and chemical hydrogen sources.

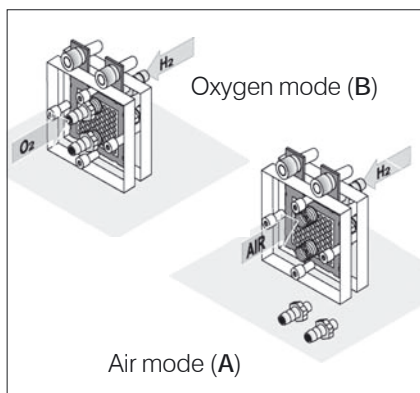
Supply from pressurized gas cylinders

1. Push connecting hoses (e.g. silicon) onto the valves of the pressurized gas cylinder and the fuel cell inlets.
2. Push two further hoses onto the outlets of the fuel cell, and place the free ends in a beaker of deionised water.
3. Open the valves on the pressurized gas cylinders sufficiently for a little gas to escape through the hoses into the water. Approximately one gas bubble should escape each minute.

Cylinders with spray head may also be employed as an economical alternative to pressurized gas cylinders with fine control valves. In this case, a little gas is always blown into the cells at a time. Continuous operation is however difficult by this method.

Electrolyzers can also be used to supply the h-tec fuel cells with hydrogen and oxygen. Any type of electrolyzer may be used, but those employing alkali, acid or membrane electrolytes are generally employed. For safety reasons, absorption bottles must always be connected between the cell and electrolyzers employing alkali or acid electrolyte.

To avoid any problems, use equipment from the h-tec range for gas production. **Should h-tec equipment not be employed, the quality of the gases generated must be monitored carefully. h-tec assumes no responsibility for damage or injury in such cases.**



Setup

Important!

An oxygen supply is not essential for use of the h-tec PEMFC Kit fuel cell. In the absence of an oxygen supply, the cell operates as an air-breathing fuel cell. It obtains sufficient oxygen from

the atmosphere by diffusion and convection. In this operating mode, however, full power is not reached. To increase the power, unscrew the **fittings** on the oxygen side (Figs. **A** and **B**).

“Closed outlet” gas supply mode

The “closed outlet” gas supply mode is employed with all hydrogen sources which deliver the gas at a slight pressure (e.g. by means of a water column) and with which the hydrogen would thus escape unused in the „open outlet“ operating mode. Such sources include the Hofmann apparatus and hydride or gas storage systems.

Only in this operating mode can efficiency measurements be performed.

1. Use a hose clamp to seal the ends of the fuel cell hoses on the outlet side, in order to prevent the hydrogen from flowing out unchecked. In order to prevent damage to the cell, avoid gas pressures over 0.6 bar when using hydride storage systems.
2. Should the voltage on the fuel cell drop, open the hose clamp briefly in order to allow inert gases to escape.

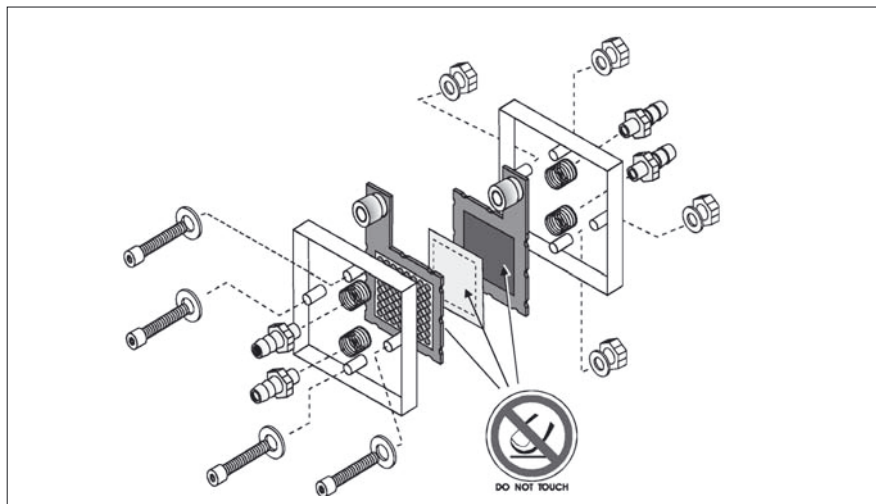
Note:

As excess gas is not allowed to escape continuously, concentrations may form of other gases which may be present in the hydrogen and which are not consumed in the fuel cell. In extreme cases, the fuel cell may become completely filled with inert gases. The reaction gas is then prevented from entering the cell.

Assembly/Dismantling

The PEMFC Kit fuel cell can be completely dismantled. Note that the polymer electrode membrane and the electrodes are extremely sensitive

components. They can be removed from the cell and shown to students; we strongly advise against passing these components around the class, however.



Dismantling

1. Untighten the four nuts and remove the four recessed hexagon-head screws holding the cell together.
2. Dismantle the cell. You are left with two housing plates to which the electrical terminals remain attached (perforated plates and electrodes), and the proton-conductive membrane.
3. **Carefully** remove the electrical terminals from the housing plates together with the membrane.

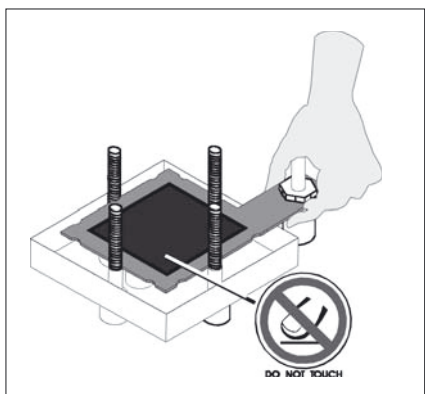
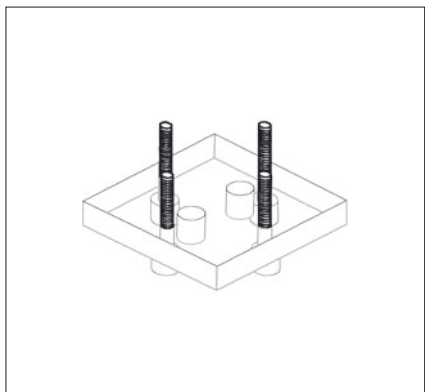
4. **Carefully** remove the membrane. The electrodes remain attached to the perforated plates.
5. Screw the fittings out of the housing plates.

Caution!

These components are easily damaged.

When removing and replacing the electrodes, observe the correct assembly orientation. The electrodes and the membrane are sensitive to contamination in any form, and in particular by metal ions. Avoid therefore touching them except at the edges.

Assembly/Dismantling



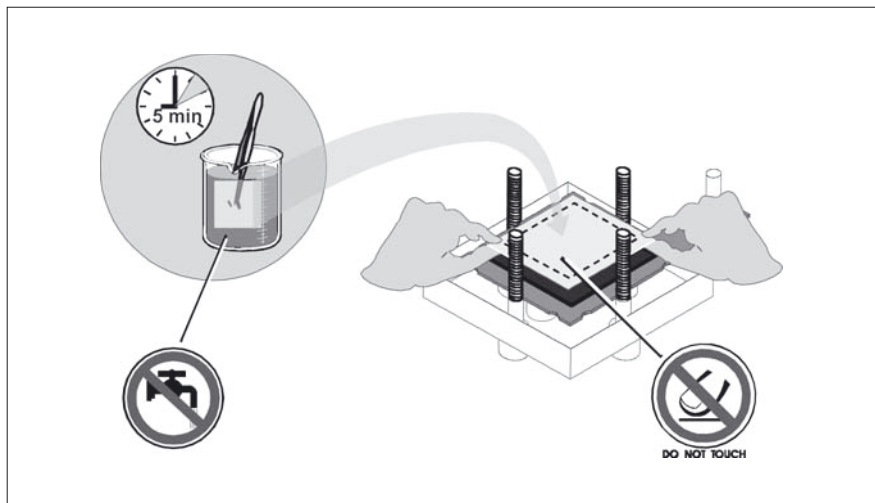
Assembly

Assembly of the cell is the reverse of the dismantling procedure.

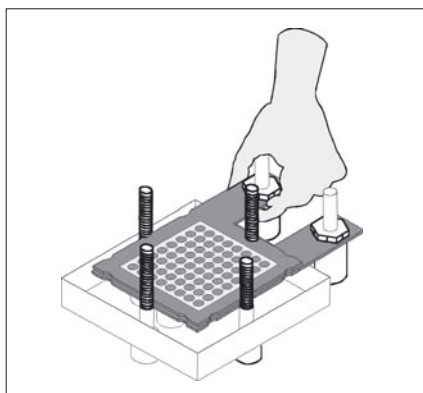
Before refitting the membrane, allow it to soak for at least 5 minutes in deionised water.

1. Place a washer over each of the four screws. Insert the screws into one of the housing plates and turn them such that the housing plate rests upon the screw heads (if the black fittings are removed from the housing plate, this operation can be performed on a flat bench top).
2. Place one of the perforated plates on the acrylic glass housing. The thicker side of the seal must face towards the acrylic glass. The electrode points upwards.
3. If the electrode has been removed from the perforated plate, proceed as follows: place the electrode on the perforated plate. Ensure that the orientation of the electrode is correct. The side showing the outline of the perforated plate must face the plate again. Ensure that the electrode is centred.

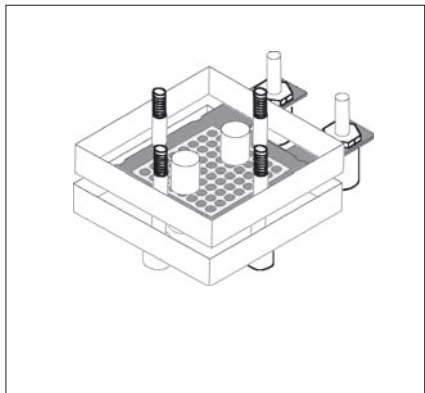
Assembly/Dismantling



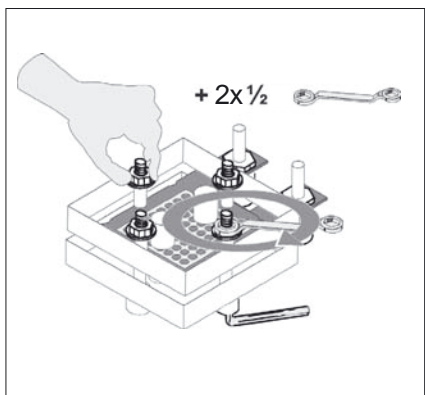
4. Remove the membrane from the deionised water, holding it at two opposite corners. Place it, still wet, upon one of the electrodes. The membrane and electrode are held in position by the moisture.
5. If the electrode has been removed from the perforated plate: place the second electrode in position. The pattern of the perforated plate on the electrode must be facing towards the perforated plate to be placed upon it. The orientation of the two electrodes must correspond. The second electrode must not project into the area of the seal when the plate is placed in position.
6. Place the second perforated plate in position. The thicker side of the seal must face towards the acrylic glass housing which is not yet in place.



Assembly/Dismantling



7. Place the acrylic glass housing on the screws.
8. Place the remaining washers and nuts on the screws, and screw the nuts finger-tight at first.



9. Tighten the nuts alternately a little at a time (max. one-half turn) until a gap of 4.0 mm is left between the acrylic glass plates.

Caution!

Overtightening may damage the electrodes. We recommend that the distance be checked by means of a calliper gauge. Should a calliper gauge or similar instrument not be available, tighten the nuts twice, approximately half a turn each time.

10. Screw the fittings into the four holes in the housing plates.
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Technical Data

<u>PEMFC Kit</u>		Electrode area	16 cm ²
Item No.	F107	Operating modes of the fuel cell	H ₂ / O ₂ or H ₂ / Air
Height	90 mm	Power (H ₂ / O ₂)	600 mW
Width	80 mm	Power (H ₂ / Air)	200 mW
Depth	78 mm		
Weight	225 g	Generated voltage short-circuit-proof	0.4-0.96 V DC

Maintenance

Fuel cells of the type employed are maintenance-free.

Fault Diagnostics

The most frequent causes of faults during operation of fuel cells are:

Insufficient gas supply

A fuel cell requires hydrogen and oxygen (or air). Only when both gases are present can electric power be generated.

Insufficient moistening

The membrane of the cell must be moist for operation. Should the relative atmospheric humidity drop below 70%, a risk exists of it drying out. In order to prevent the membrane from drying out too quickly, we recommend that the

fittings be closed during storage. This can be achieved by connecting a hose between the inlet and the outlet. Should the membrane dry out, it will not damage the cell; it will simply result in poorer initial performance. The quickest and simplest way to remoisten the membrane is to connect the two sides of the cell together by means of a hose, and to blow through them physically several times.

Damage to the catalyzer

Never connect an external voltage to the fuel cell, as this will instantly destroy the catalyzer.
