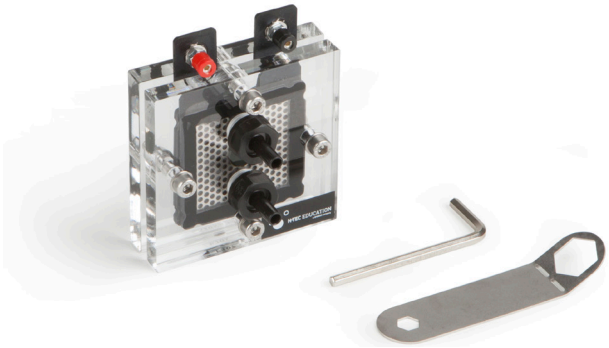
H-TEC EDUCATION

Operating Instructions



F107 - PEMFC Kit

H-TEC EDUCATION

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Introduction

Diminishing resources, more severe environmental impacts and the ever-increasing demand for energy forces us to re-evaluate 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 Education
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.

Any other use is prohibited!

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.

General Safety Precautions

- 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.
- Remove inflammable gases, vapors 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.

- Hoses, plugs and tanks are used for pressure compensation. They must not be fixed or secured with clamps, adhesive, etc.
- 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.
- 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.
- Do not smoke.

- 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.

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General Safety Precautions

- Do not operate the system dry. Always ensure that it contains sufficient water.
- 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.
- Tell you students about any potential dangers and carefully supervise experimentation.
- Hoses, plugs and tanks are used for pressure compensation. They must not be fixed or secured with clamps, adhesive, etc.
- Do not position any solar modules and lights in use closer than the minimum permitted distance (50 cm between H-TEC Education solar modules and the H-TEC Education Spotlight, or see other manufacturers' stipulations).
- The surface of solar modules can get very hot during extended operation.

H-TEC Education does not accept responsibility for injuries or damage sustained in the event of these Safety Precautions not being followed.

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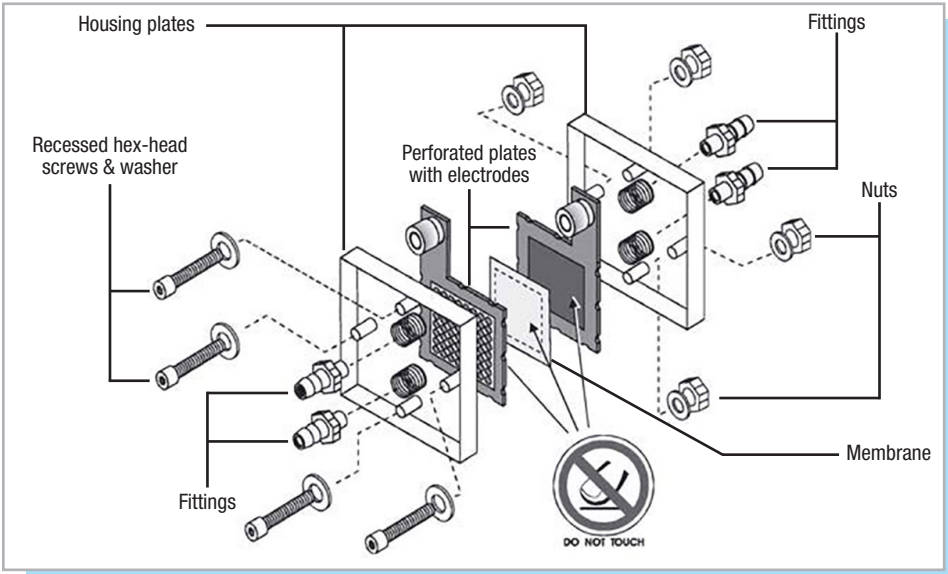


This PEM fuel cell can be fully dismantled for educational purposes. - **Item No. F107**

Hydrogen Sources:

- Electrolyzer 65
  Item No. E206
- Electrolyzer 230
  Item No. E207

Additional Equipment:

- Commercially distilled (deionized) water with a conductivity of < 2 µS/cm
- Connecting hoses

Operation of PEM fuel cell

In a fuel cell, chemical energy is converted directly into electrical energy (i.e. without use of 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:

$4e^- \longrightarrow 4H^+ + O_2 \longrightarrow 2H_2O$

Anode:

$2H_2 \longrightarrow 4H^+ + 4e^-$

Complete reaction:

$2H_2 + O_2 \longrightarrow 2H_2O$

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.

Setup

"Open outlet" gas supply mode

The "open outlet" gas supply mode is employed with all hydrogen sources that can supply 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

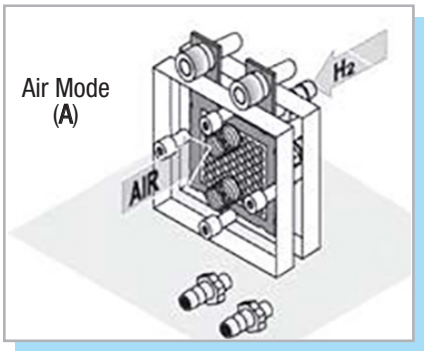
1. Connect silicone hoses to the valves of the pressurized gas cylinder and the fuel cell inlets.
2. Connect two additional hoses to the outlets of the fuel cell, and place the free ends in a beaker of deionized water.
3. Open the valves on the pressurized gas cylinders sufficiently for a small amount of gas to escape through the hoses into the water. Approximately one gas bubble should escape each minute.

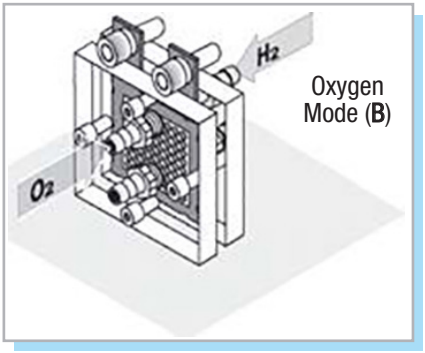
Electrolyzers can also be used to supply the PEM fuel cells with hydrogen and oxygen. Any type of electrolyzer may be used, but those employing alkali, acid or membrane electrolytes are generally employed. For safety reasons, absorption bottles should always be connected between the cell and electrolyzers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

To avoid any problems, use equipment from the H-TEC Education product catalog for gas production. Should H-TEC Education equipment not be employed, the quality of the gases generated must be monitored carefully. H-TEC Education assumes no responsibility for damage or injury in such cases.

Important!

An oxygen supply is not essential for use of the H-TEC Education PEMFC Kit. 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 (Figures A & 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:

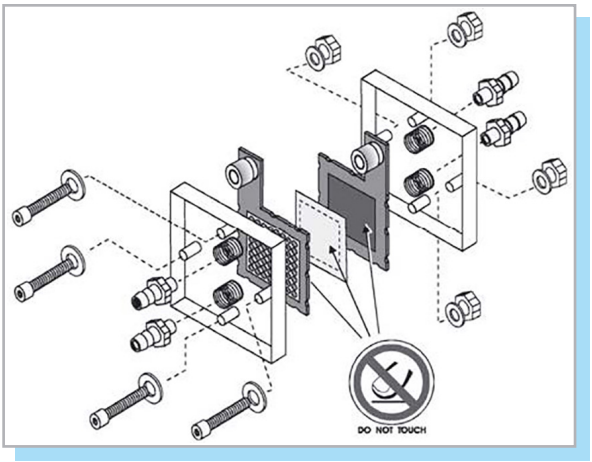
As excess gas is not allowed to escape continuously, concentrations may form of other gases which may be present in the hydrogen and which are not consumed in the fuel cell. In extreme cases, the fuel cell may become completely filled with inert gases. The reaction gas is then prevented from entering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

Using the Air Plate

Assemble the fuel cell as described in the “Assembly” section. Using the fuel cell in this configuration will allow heat to dissipate. Heat dissipation will keep the fuel cell from drying out as fast. This allows you to apply more current to the cell, and in return, get more power.

Assembly

The PEMFC Kit can be completely dismantled. Note that the proton exchange membrane and the electrodes are extremely sensitive components. They can be removed from the cell and shown to students. However, we strongly advise against passing these components around the class.



Disassembly

1. Loosen the four nuts and remove the four recessed hex-head screws holding the cell together.

2. Dismantle the cell. There are two housing plates to which the electrical terminals remain attached (Perforated plates and electrodes), and the proton exchange membrane.

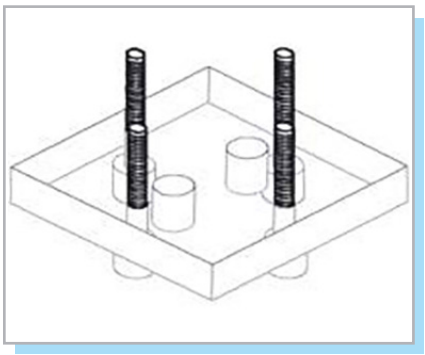
3. Carefully remove the electrical terminals from the housing plates together with the membrane.

4.Carefully remove the membrane. The electrodes should remain attached to the perforated plates.

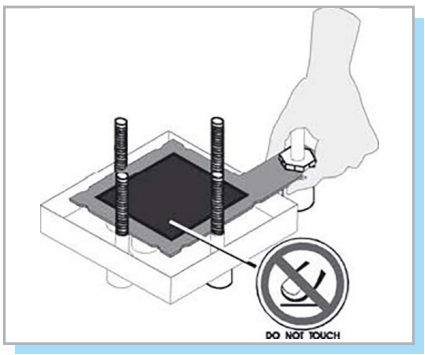
5. Unscrew the fitting from the housing plates.

Assembly

Assembly of the cell is the reverse of the dismantling. If reassembling with the air plate, Step 1 should be done with air plate instead of hydrogen plate. Always wear gloves when handling the membrane.

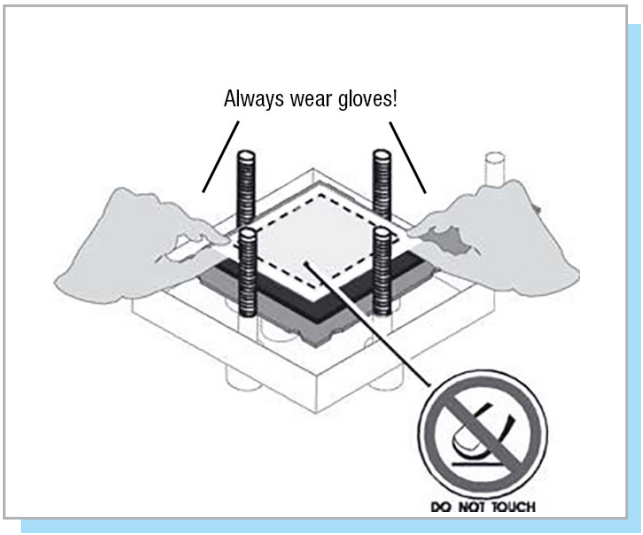


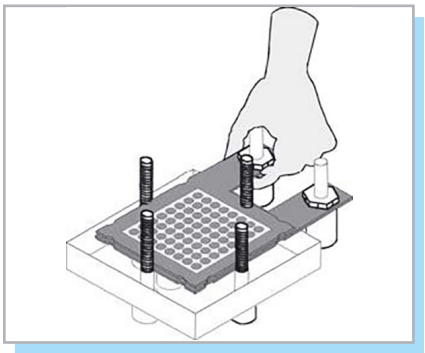
1. Place a washer over each of the four bolts. Insert the bolts into one of the housing plate and turn it upside down so it is resting on the head of the bolts.



2. Place the positive (red) perforated plate on the acrylic housing. The thicker side of the seal, with the front of the banana jack, should face the acrylic. The electrode should point upward.

Assembly

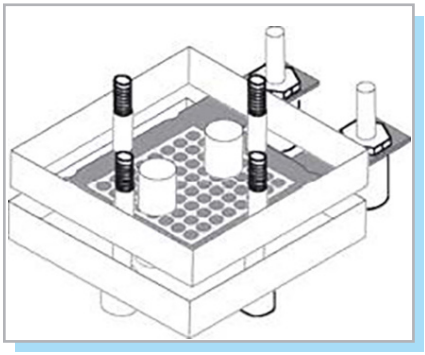




3. Holding the membrane electrode assembly (MEA) at two opposite corners, place it upon the perforated plate.

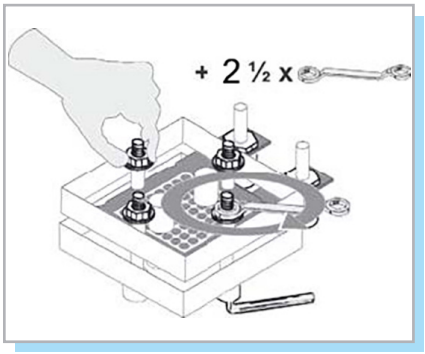
4. Place the second (negative) perforated plate in position. The thicker side of the seal must face towards the acrylic housing which is not yet in place. The two banana jacks should be facing the same direction.

Assembly



5. Place the acrylic housing on the screws.

6. Place the remaining washers and nuts on the screws, and screw the nuts finger-tight at first.



7. Tighten the nuts alternately a little at a time (max. two and one-half turns) until a gap of 4mm is left between the acrylic plates.

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

8. Screw the fittings into the four holes in the housing plates.

Technical Data

H x W x D:	100 x 80 x 90 mm
Weight:	0.2 kg
H_2 / O_2 Power:	1 W @ 1.5 A
H_2 / Air Power (with O_2 Plate):	880 mW @ 1.5 A
H_2 / Air Power (with Air Plate):	1.2 W @ 2A
Permissible Voltage:	0.4 - 1 VDC
Electrode Area:	16 cm^2
Permitted operating pressure:	0 - 20 mbar

Troubleshooting

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 re-moisten 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.

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

Maintenance

The H-TEC Education PEMFC Kit is maintenance-free.

Disposal

Do not dispose of fuel cells and electrolyzers as general household waste.

According to European regulations, used electric and electronic devices may no longer be disposed of as unsorted household waste. The symbol of the crossed-out wheelie bin indicates the requirement for separate disposal.

Your local waste management company can provide you with additional information about disposal options.

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