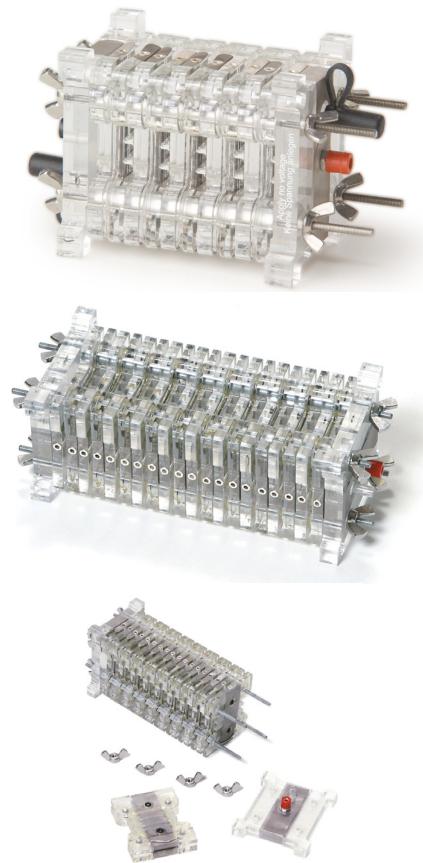


# Operating Instructions



**F108** - Fuel Cell Stack 3

**F109** - Fuel Cell Stack 5

**F110** - Fuel Cell Stack 10



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## Introduction

Hydrogen gas is oxidized within a fuel cell. In the process, the chemical energy stored in the hydrogen gas is converted directly, i.e. without combustion, to electrical energy. This process takes place in the heart of the fuel cell, the membrane electrode assembly (MEA).

The MEA comprises two electrodes (cathode: oxidizer side and anode: fuel side) and the proton exchange membrane (PEM). The PEM is a special plastic film which is permeable to protons but which presents a barrier to electrons.

Hydrogen gas is split by catalysis into electrons and protons in the fuel cell. Owing to the chemical imbalance, the protons (cations) diffuse through the PEM. The resulting potential difference can be tapped on the electrodes in the form of a no-load voltage. As soon as an electric circuit is connected to the fuel cell, the surplus electrons flow to the cathode, where they combine with the oxygen and the protons to form water ( $H_2O$ ).

With the fuel cell described, the water produced escapes via the air vent in the form of water vapour. The equipment has been developed for teaching and demonstration purposes only.

### **Any other use is prohibited.**

### **Danger!**

The hydrogen ( $H_2$ ) and oxygen ( $O_2$ ) reacting together in the fuel cell represent a source of danger if handled improperly. In order to avoid any risks you must follow the General Safety Precautions when working with the fuel cell. This Fuel Cell Stack is designed as a Hydrogen/Air stack. Therefore, Oxygen is not to be used with this design.

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wishes you many enjoyable hours learning about this technology with the Fuel Cell Stacks.

## Intended Use

The Fuel Cell Stacks allow the principle of proton exchange membrane (PEM) fuel cells to be demonstrated and measurements taken. The system has been developed for teaching and demonstration purposes only.

### **Any other use is prohibited!**

Hydrogen and atmospheric oxygen are required for operation of the Fuel Cell Stacks.

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 Fuel Cell Stacks.

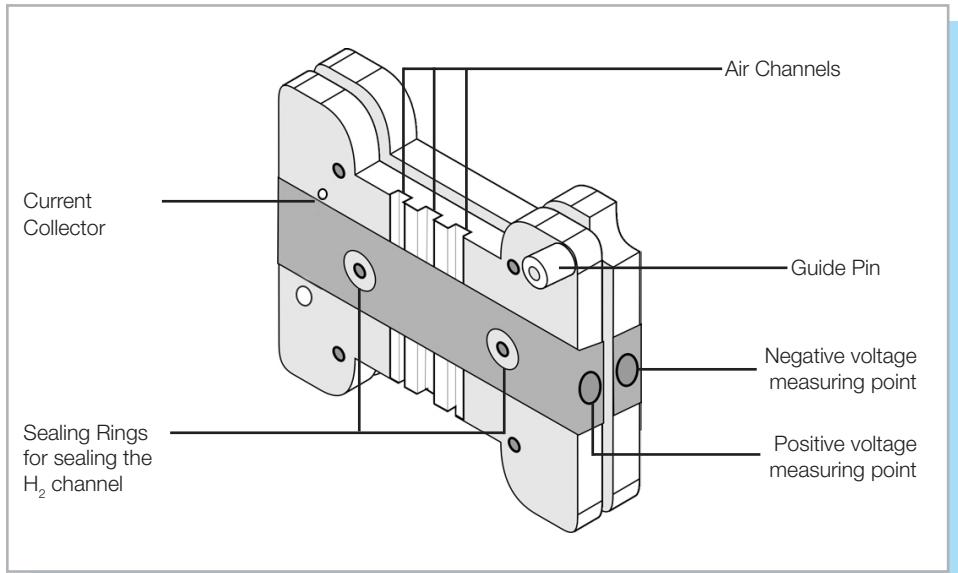


## General Safety Precautions

- 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.
- 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, vapors 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 wellventilated 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.
- 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.
- WARNING! The surface of solar modules can get very hot during extended operation.
- Make sure students know about any potential dangers and carefully supervise experimentation.
- Remove flammable gases, vapors or liquids from the area surrounding fuel cells and electrolyzers. The catalytic materials involved may cause spontaneous ignition.
- H-TEC Education accepts no responsibility for injuries or damage sustained in the event that these Safety Precautions are not followed.

## Equipment and Materials

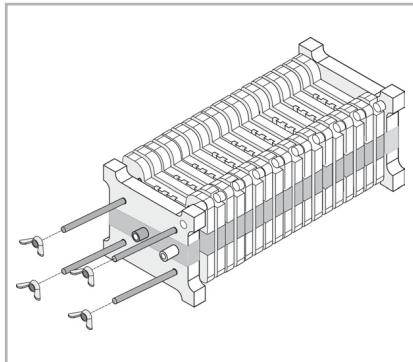
View of Fuel Cell Stack (single cell):



The individual cells of the Fuel Cell Stack are glued together and not screwed. The glued joints may loosen without the contact pressure existing in the stack. However, this can easily be rectified by applying slight pressure before assembling the stack.

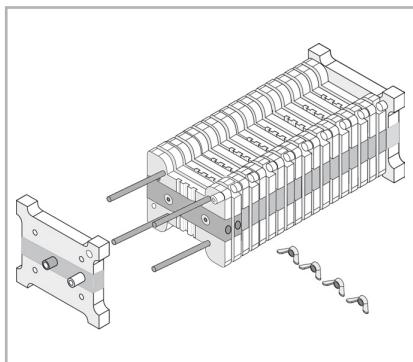
Before assembling the stack, it is essential to ensure that the O-rings are not damaged and are correctly seated in the grooves.

## Assembling the stack

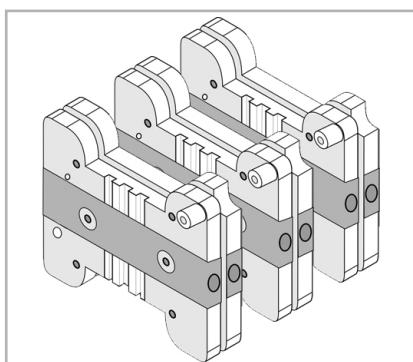


The Fuel Cell Stack is able to be dismantled and used with any number of cells up to a maximum of 10.

To disassemble the Fuel Cell Stack:

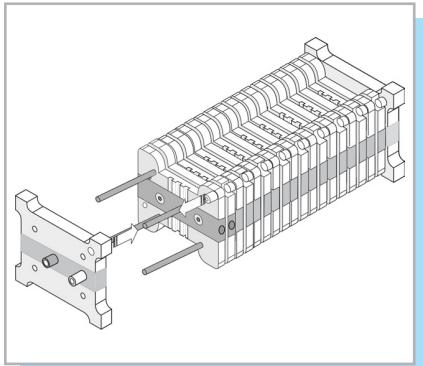


1. Remove the wing nuts on the positive "+" side (red socket) of the Fuel Cell Stack while holding the corresponding wing nut on the opposite side of the Stack.

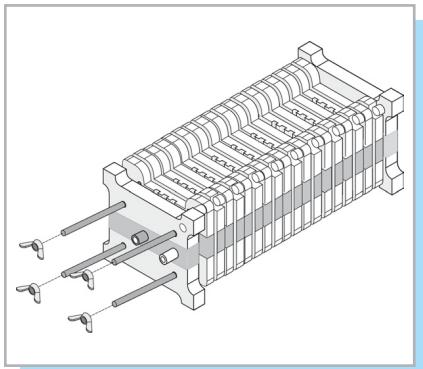


2. Remove the free end plate.
3. You are now able to remove the cells or add additional cells. The maximum number of cells is limited to 10.

- When fitting the cells, it is essential to ensure that:
- The side with the air channels is always facing upward.
- The O-rings are correctly seated in the grooves.
- The locating peg of the end plate, or the locating per of the previous individual cell, engages in the hole of the hydrogen side of the next cell.



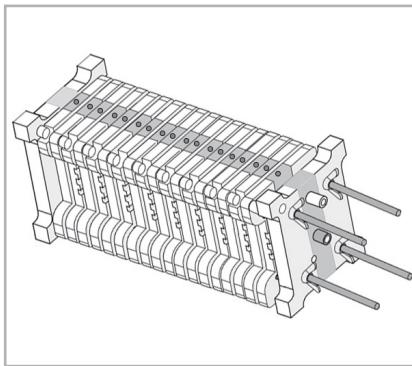
4. Replace the second end plate. Make sure that the locating peg of the last fuel cell engages in the hole in the end plate provided. The two gas connections of the Fuel Cell Stack must now lie on diagonally opposing sides.



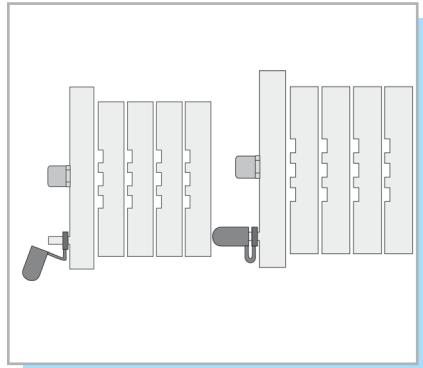
5. Replace the wing nuts and tighten them on opposing corners. Then, tighten the wing nuts by hand.

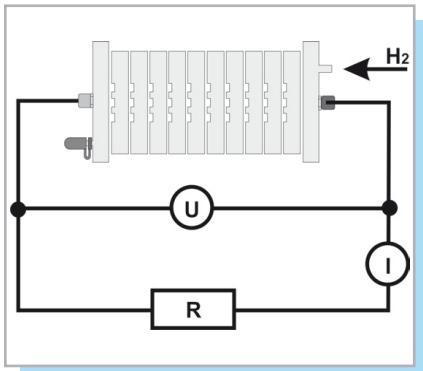
6. To verify a good seal, apply a slight vacuum and monitor for 1 minute. The Stack should maintain vacuum during the test if the seals are good.

## Operation



- 1.** Read the General Safety Precautions.
- 2.** Set up the Fuel Cell Stack so the air channels point horizontally.
- 3.** Close the hydrogen output with the rubber cap.
- 4.** Connect a hydrogen supply to one of the gas connections.
- 5.** Open the rubber cap briefly to allow hydrogen to flow completely through the Fuel Cell Stack. Then close the rubber stack again.
- 6.** Connect an electrical load to the positive ("+", red) and negative ("-", black) connections of the fuel cell.
- 7.** Connect Fan Tutorial to any single cell within the stack. If you do not have a Fan Tutorial to connect as a load, turn on a fan somewhere in the room. This will help transfer ambient oxygen through the stack and remove excess heat.





**8.** The system is now ready for operation and can be used for demonstration or experimentation purposes. Voltage measuring points are provided on each individual cell, so that individual voltage measurements can also be made.

- Any failure to achieve the required output will probably be due to air in the hydrogen hose, which can be eliminated by removing the cap for a short time to flush the stack with a fresh hydrogen supply.



## Technical Data

### Individual Cell:

H x W x D:.....	60 x 50 x 20 mm
H <sub>2</sub> / Air Power:.....	200 mW
Electrode Area:.....	3 cm <sup>2</sup>
Permitted operating pressure:.....	0 - 20 mbar

### 3 Cell Stack:

H x W x D:.....	90 x 70 x 60 mm
Weight:.....	0.15 kg
H <sub>2</sub> / Air Power:.....	600 mW
Electrode Area:.....	3 cm <sup>2</sup> per cell
Permitted operating pressure:.....	0 - 20 mbar

### 5 Cell Stack:

H x W x D:.....	130 x 70 x 60 mm
Weight:.....	0.3 kg
H <sub>2</sub> / Air Power:.....	1 W
Electrode Area:.....	3 cm <sup>2</sup> per cell
Permitted operating pressure:.....	0 - 20 mbar

### 10 Cell Stack:

H x W x D:.....	200 x 50 x 20 mm
Weight:.....	0.5 kg
H <sub>2</sub> / Air Power:.....	2 W
Electrode Area:.....	3 cm <sup>2</sup> per cell
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.

## Maintenance

The components of the product do not require maintenance. The following points should be observed, though:

- Use freshly distilled water for each operation.
- After operation, remove the water from the gas storage tanks.
- Stored in a sealed (zip-top style) bag.

## 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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