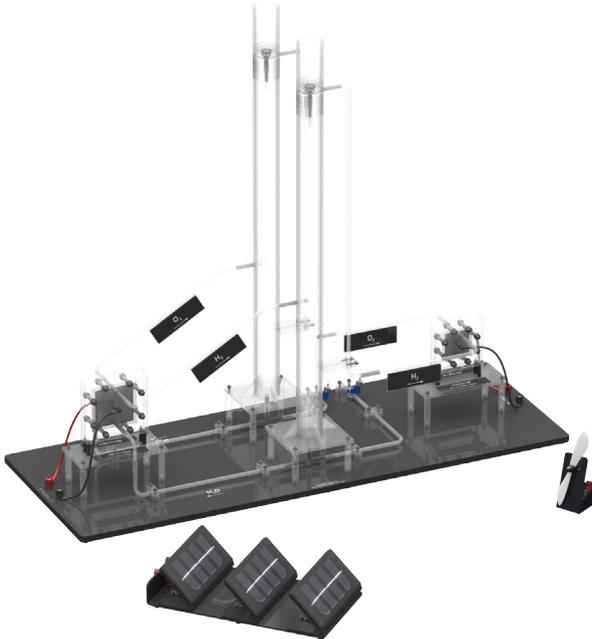


Operating Instructions



D201 - Exhibition Kit

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The Exhibition Set

The Exhibition Set offers the option of easily visualizing the functionality of hydrogen technology. The model demonstrates that electrical energy (e.g. from renewable energy sources) can be stored temporarily in the form of hydrogen, using electrolysis. This chemical energy can then be made available again in an environmentally friendly way, using the fuel cell, should the demand for electrical energy increase or should the primary energy source fail (e.g. wind, solar). All that is needed for generating electricity are hydrogen and oxygen. Water is a by-product of this process.

These operating instructions document all process steps required for starting up and operating the Exhibition Set.

We hope you enjoy many instructive hours with the Exhibition Set.

The team at,

H-TEC EDUCATION

About these instructions

- These operating instructions are intended for the supervisor in charge.
- These operating instructions have to be read and observed before use.
- These operating instructions have to be available for reference and have to be stored in a safe place.
- All safety instructions must be observed.
- This product may only be put into operation and operated under the directions of the responsible supervisor.

Safety information

Read and observe the general safety instructions included separately with this product before using the product!

Product-specific safety information

The product may only be used:

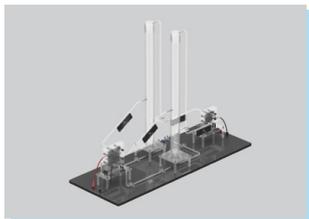
- according to the intended use
- in compliance with all safety information

The components of this product feature freely accessible, live electric contact surfaces. Connecting to an impermissible operating voltage may result in a fire hazard, a risk of electric shock and damage to the components.

The product may only be operated under the constant supervision of an adult trained in the handling of this product.

The product should only be operated in a display cabinet or similar if adequate ventilation with an air velocity of 0.5m/s at the product is ensured. The operator should ensure this by taking appropriate measurements.

Contents



1x Demonstration model



2x Overflow tanks



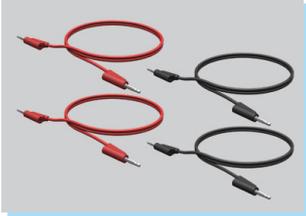
1x Fuel cell gas flow indicator / Water trap



1x Solar module



1x Fan module



2x Cable Set

Connection cables, 4mm, 50cm length, red
Connection cables, 4mm, 50cm length, black



1x Companion text book

Additional tools required: 2.5mm hex key

Overview

The “Exhibition” demonstration model at a glance

The “Exhibition” demonstration model consists of an electrolyser, two water reservoirs and a fuel cell, all mounted to a black base plate. When the electrolyser is supplied with electrical energy, it produces hydrogen and oxygen from distilled water. The gases enter the fuel cell via the water reservoir and a system of tubes where, provided a load (consumer) is connected, they are converted back to water while electrical energy and heat are being generated. The demonstration model is equipped with two 4 mm female connectors for connecting multilam (banana) plugs. The individual components are shown in the following graphic.

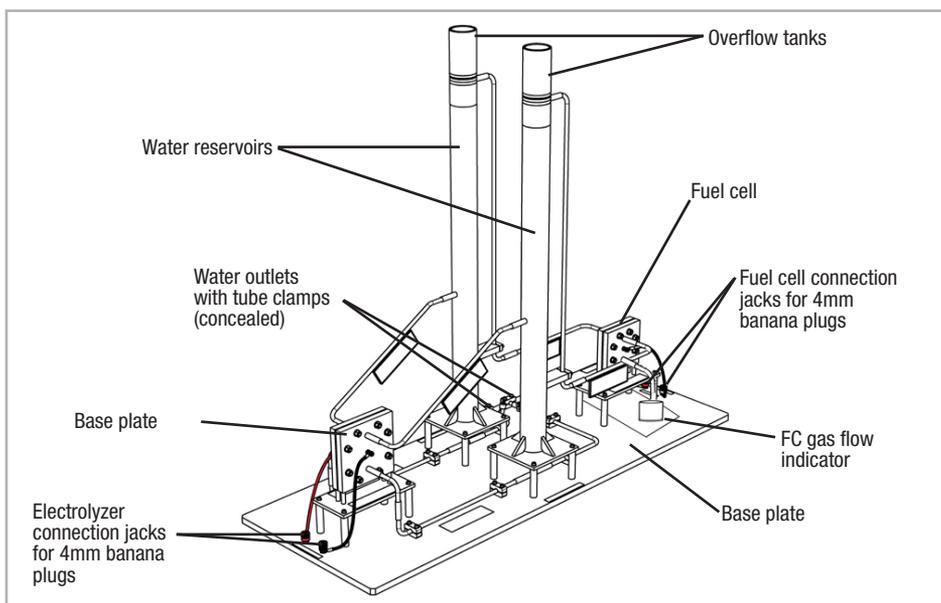


Fig. 1: The demonstration model at a glance

Starting up

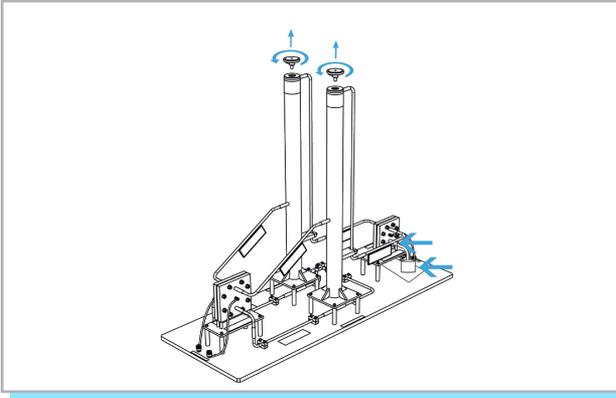


Fig. 2: Assembly

Assemble the demonstration model as shown in Figure 2.

- Remove both locking screws by turning them counter-clockwise.
- Place Gas Flow indicator below fuel cell, and attach tubes from fuel cell.

The preparation for storage and transportation is carried out in reverse order to assembly.

Do not yet connect the power supply to the electrolyzer.

Filling

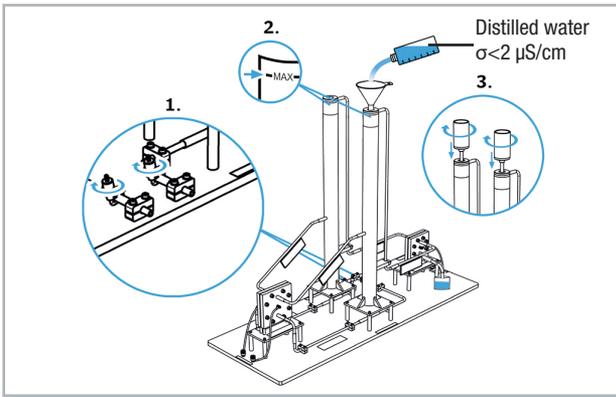


Fig. 3: Filling

- Close both tube clamps on the water outlets.
- Fill the water reservoir with distilled water, up to the -MAX- mark, and add water to Gas flow indicator bowl. **Note: Use only distilled water ($\sigma < 2 \mu\text{S}/\text{cm}$) as shown in Figure 3.**
- Attach both overflow tanks to the water reservoir using a clockwise motion.

Operation

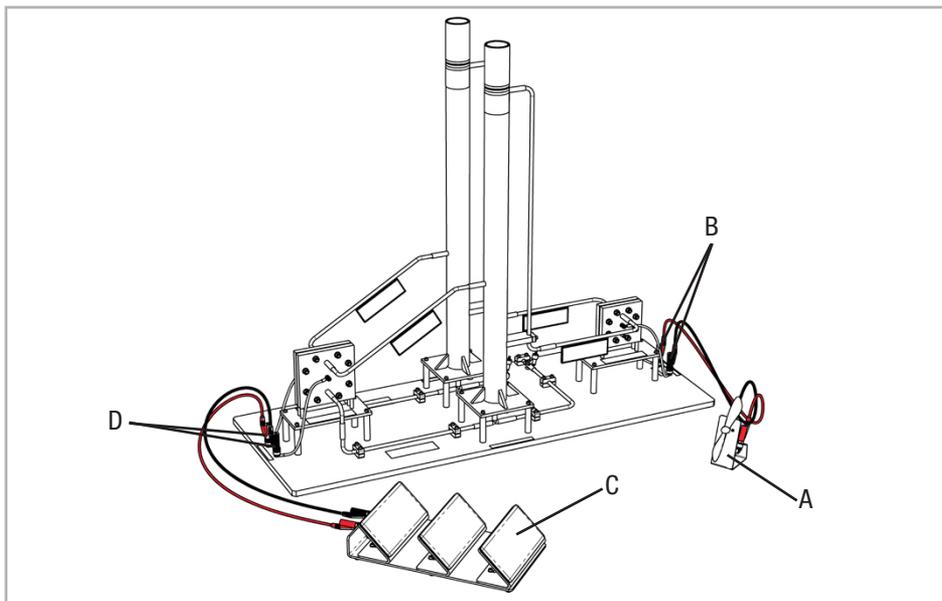


Fig. 4: Exhibition Set operation

- Read and observe the general safety instructions.
- Using the connecting cables, connect the propeller (A) with the respective connections (B) on the fuel cell, while ensuring correct polarity (red = “+”, black = “-”).
- Using the connecting cables, connect the solar module (C) with the respective connections (D) on the electrolyzer, while ensuring correct polarity (red = “+”, black = “-”). If using an alternative power source, make sure to comply with the electrical specifications as defined in the technical data.
- Provide the solar module with adequate direct sunlight or with light from a powerful, concentrated electrical light source. The shadow of an individual module created by the light must not be projected onto another module. The water is split into hydrogen and oxygen at a ratio of 2:1. Gas production can be recognized by gas bubbles rising inside the water reservoirs.
- The Exhibition Set is now in operation. The propeller vane will start to rotate as soon as the hydrogen and the oxygen reach the fuel cell. Warm-up takes approximately 5-10 minutes. If the model is operated by solar module, and if lighting conditions are extremely poor, warm-up may take longer.

- During operation, small amounts of water pass through the electrolyzer's polymer electrolyte membrane (PEM) from the oxygen side. This may cause the water level to rise on the hydrogen side and fall on the oxygen side. In addition, distilled water is being consumed during operation.
- Always maintain the water levels in the water reservoirs between the -MAX- and the -MIN- mark. For this reason, check and, if necessary, adjust the water level during operation.
- If the water level needs to be adjusted, gas production must be stopped. For this purpose, remove the connecting cables on the power supply from the respective connections on the electrolyser. To remove water, briefly open the tube clamp on the respective water outlet (see Chapter "Shutting down").
- Distilled water may be added ($\sigma < 2 \mu\text{S}/\text{cm}$) to the respective water reservoir with the overflow tank in place.

⚠ CAUTION**Risk of injury from hydrogen ignition!**

Damaged tubes or leaking connections may cause hydrogen to escape. Hydrogen and hydrogen-air mixtures may ignite when in proximity to an ignition source.
Check tubes and connections for damage before each setup and before each use.

⚠ CAUTION**Risk of injury from hot surfaces!**

A diode on the underside of the base plate protects the electrolyzer against reverse polarity. The protection diode becomes very hot in case of incorrect polarity. Touching the protection diode may cause injuries.
When connecting the power supply, ensure the correct polarity of the electric connections (red = "+", black = "-"). Do not touch the protection diode.

⚠ CAUTION**Risk of injury from hot surfaces!**

The surface of solar modules may become very hot during operation. Touching the surface of the solar modules may cause injuries.
Do not touch the surface of the solar modules during operation. Let the surface of the solar modules cool to at least 60 °C before disassembly or removal.

⚠ CAUTION**Risk of injury from hydrogen ignition!**

During operation, small amounts of hydrogen are continuously released into the atmosphere. Escaping hydrogen may ignite when in proximity to an ignition source. Keep product away from ignition sources. Ensure ventilation in accordance with the general safety instructions.

⚠ CAUTION**Risk of fire due to electrical overload.**

Any operation beyond the electrical specifications will lead to excessive overheating of the electrolyzer. This may cause a fire.
Never operate the electrolyzer beyond the electrical specifications stated in the technical data.



CAUTION

Risk of damage due to electrical overload

Any operation beyond the electrical specifications will lead to irreparable damage to the electrolyzer.

Never operate the electrolyzer beyond the electrical specifications stated in the technical data.

CAUTION

Risk of damage due to voltage

Applying voltage to a fuel cell or a solar module leads to irreparable damage to the components.

Do not apply voltage to fuel cells and solar modules.

CAUTION

Risk of damage due to insufficient distance to lamps

The solar module may become excessively hot or sustain irreparable damage if it is too close to the lamp.

Observe the minimum distance defined by the manufacturer when operating solar modules with lamps.

CAUTION

Risk of damage due to improper handling

Operating the electrolyzer using water with an electrical conductivity of $\sigma \geq 2 \mu\text{S/cm}$ will cause irreparable damage to the electrolyzer. Only fill the electrolyzer using distilled water with an electrical conductivity of $\sigma < 2 \mu\text{S/cm}$.

NOTE

Water in the fuel cell

Ensure that no water enters the fuel cell. A water film on the electrode surface may suppress the reaction of hydrogen and oxygen in the fuel cell. In such cases, the output of the fuel cell will be inadequate.

Technical data

Exhibition model:

H x W x D:.....	700 x 300 x 1300 mm
Weight:.....	4.8 kg

Electrolyzer:

H ₂ Production:.....	35 mL/min
O ₂ Production:.....	17.5 mL/min
Permissible current:.....	0 - 5 A
Permissible operating voltage:.....	0 - 2.0 VDC
Electrode area:.....	36 cm ²
Guide value for distilled water:.....	<2 µS/cm
Permitted operating pressure:.....	0 - 20 mbar
H x W x D:.....	100 x 100 x 40 mm

Fuel Cell:

Short circuit current:.....	3.3 A
Open circuit voltage:.....	1 VDC
Power output:.....	1.2 W
Electrode area:.....	16 cm ²
Permitted operating pressure:.....	0 - 20 mbar
H x W x D:.....	80 x 80 x 40 mm

Accessories:

Water reservoir:.....	approx. 500 mL / reservoir
Solar module:.....	2.0V / 1.0 A
Load (fan):.....	10 mW

Troubleshooting

Despite hydrogen and oxygen being produced, the load connected to the fuel cell is not working.

Possible Cause:

- The overflow tanks are not secured firmly in place.

Solution:

- Turn the overflow tanks clockwise, until they are secured firmly in place.

Possible Cause:

- The load has not been connected correctly, or is not receiving any voltage.

Solution:

- Check the connecting cables, and power supply.

Solution:

- Carefully nudge the propeller by hand to bypass the starting current.

Possible Cause:

- The product requires a brief warm-up period before the gases produced by the electrolyzer reach the fuel cell, where they are converted to water while electrical energy and heat are being generated. Warm-up can take longer if lighting conditions are extremely poor.

Solution:

- Wait the 5-10 minutes for the warm-up process to complete.

The fuel cell has low output.

Possible Cause:

- The fuel cell was stored too dry, or for too long. A fuel cell with a dry Polymer Electrolyte Membrane will lose power.

Solution:

- Continue operation. The fuel cell automatically moistens itself during operation, which will slowly let it reach its full capacity again.

Possible Cause:

- Water has entered the fuel cell during operation. This can cause a rapid decline in performance.

Solution:

- Continue operation. Excess water will be expelled from the fuel cell during operation. The fuel cell will slowly return to full capacity.

With the solar module connected, no gas production takes place in the electrolyzer.

Possible Cause:

- The light intensity is insufficient.

Solution:

- Operate the solar module using either adequate direct sunlight or concentrated light from a powerful electrical light source. Energy-saving light bulbs, fluorescent tubes etc. are unsuitable for the operation of solar modules.

The fan does not work despite a supply voltage being present and the connecting cables being connected correctly.

Possible Cause:

- The fan is broken.

Solution:

- Contact H-TEC Education

The output of the solar module is insufficient, despite adequate light intensity and the connecting cables being connected correctly.

Possible Cause:

- The solar module is defective.

Solution:

- Contact H-TEC Education

Despite correct setup, the electrolyzer or the fuel cell is not working.

Possible Cause:

- No distilled water was used. The electrolyzer and/or the fuel cell has/have sustained irreparable damage.

If the above-mentioned solutions do not eliminate the cause of the error, please contact H-TEC EDUCATION.

Shutting down

After disconnecting the power supply from the electrolyser, continue operating the fuel cell until the connected load stops by itself. This allows some water to remain in the fuel cell, moistening the PEM. In addition, this procedure also prevents that hydrogen is released unnecessarily.

CAUTION

Risk of injury from hydrogen ignition!

Escaping hydrogen may ignite when in proximity to an ignition source. Prevent hydrogen from being released into the atmosphere. Completely use up all hydrogen before dismantling.

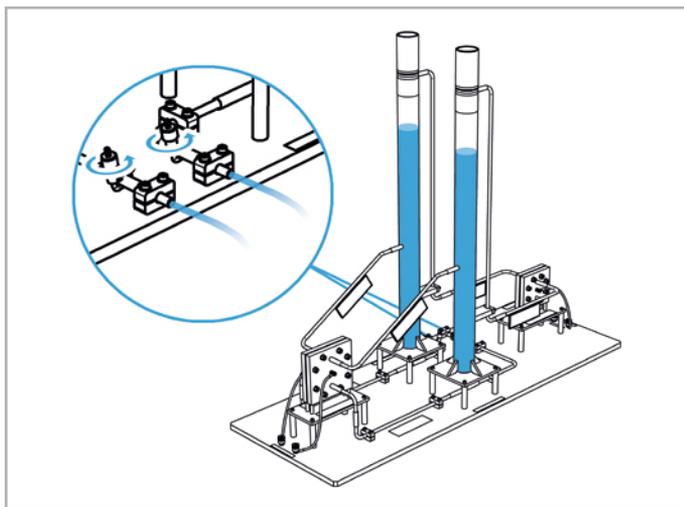


Fig. 5: Emptying the water reservoir

- Disconnect the power supply from the connections on the electrolyser.
- Any hydrogen present has to be consumed before draining the storage tanks.
- To extend the water outlets, the tubes may be fitted to the water outlets.
- Open both tube clamps on the water outlets.
- Drain the water reservoir, as shown in Figure 5. The water must be disposed of correctly.
- Close both tube clamps on the water outlets again.

Before putting the product into storage, observe the following points:

- You must ensure that the power supply is disconnected from the connections on the electrolyzer.
- Carefully remove any water drops from the product with a soft, lint-free cloth. This prevents the formation of water stains. Do NOT use chemicals to clean.

Maintenance

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

- Use fresh, distilled water ($\sigma < 2 \mu\text{S}/\text{cm}$) for each new start-up.
- After operation, remove the water from the water reservoir.

Transportation and storage

With regard to transport and storage of the product, the following points should be observed to ensure a long service life. Transport and storage only:

- With the transport safety device in place (see Chapter “Assembly”)
- In the original packaging
- Dry and dust-free
- At temperatures from 4 °C to 50 °C
- Protected from shock and vibrations

Disposal

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

WARNING

Fire hazard from catalytic substances

The catalysts for the electrodes of fuel cells and electrolyzers promote burning when they come into contact with flammable substances. Avoid contact with hydrogen, alcohol fumes or other organic fumes. Ensure correct disposal.

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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