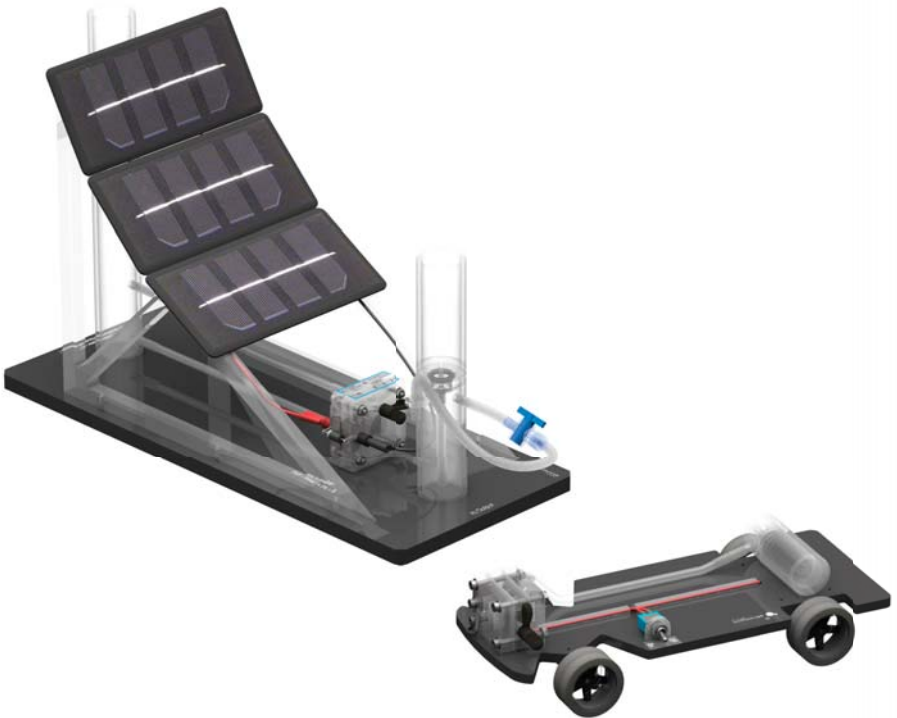


Operating instructions



D203 Fuel Cell Concept Car & Gas Station



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Introduction

Dwindling resources, increasing environmental pollution and an ever-growing energy demand lead companies in the energy sector to rethink their business models. Both the automotive industry and mineral oil companies are increasingly investing in hydrogen technology, because it can offer a way out: The use of hydrogen technology allows for a more efficient energy supply while conserving natural resources as much as possible.

The hydrogen filling station “Gas Station” is used to generate and store hydrogen. The car named the “Fuel Cell Concept Car” is filled with hydrogen, showcasing the technology of future fuel cell vehicles under realistic conditions.

These devices allow for the function of PEM fuel cells (PEM = proton exchange membrane) and PEM electrolyzers to be demonstrated.

We hope you enjoy many instructive hours with the Gas Station and Fuel Cell Concept Car.
Sincerely yours,

H-TEC EDUCATION

About these instructions

These operating instructions are intended for the supervisor in charge.

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

Safety instructions

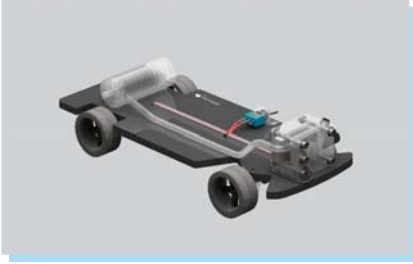
Product-specific safety instructions

The product may only be used:

- According to its intended use
- In compliance with all safety instructions
- In perfect working order

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.

Content



car



filling station



overflow



tube
with shut-off valve



water bottle



transport box with insert
(optional)



companion book



operating instructions

general safety instructions

Overview

The "Gas Station" filling station at a glance

The "Gas Station" filling station consists of an electrolyzer, a hydrogen storage tank, a water reservoir and three solar modules, mounted to a base plate. When the solar modules are provided with adequate light, the electrolyzer produces hydrogen which is stored in the hydrogen storage tank. Hydrogen is removed via the tube. The electrolyzer is connected to the solar modules via banana plugs using two 2 mm female connectors. The individual components are shown in the following graphic.

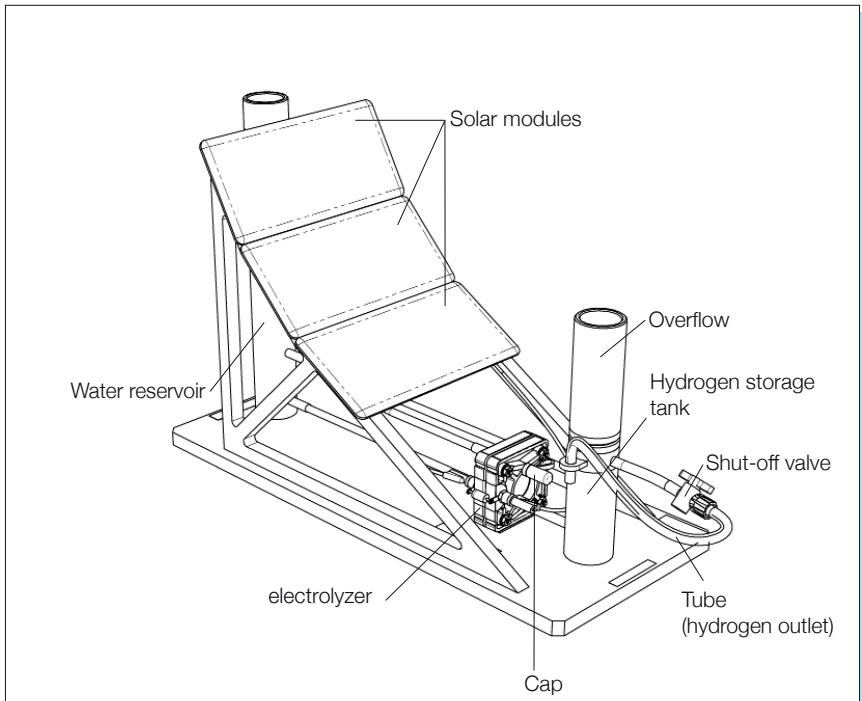


Fig. 1: The filling station at a glance

The “Fuel Cell Concept Car” at a glance

The “Fuel Cell Concept Car” consists of a two-cell, air-breathing fuel cell stack and a hydrogen storage tank, mounted to a vehicle base plate. The car can be operated when it is supplied with hydrogen via the hydrogen storage tank. The individual components are shown in the following graphic.

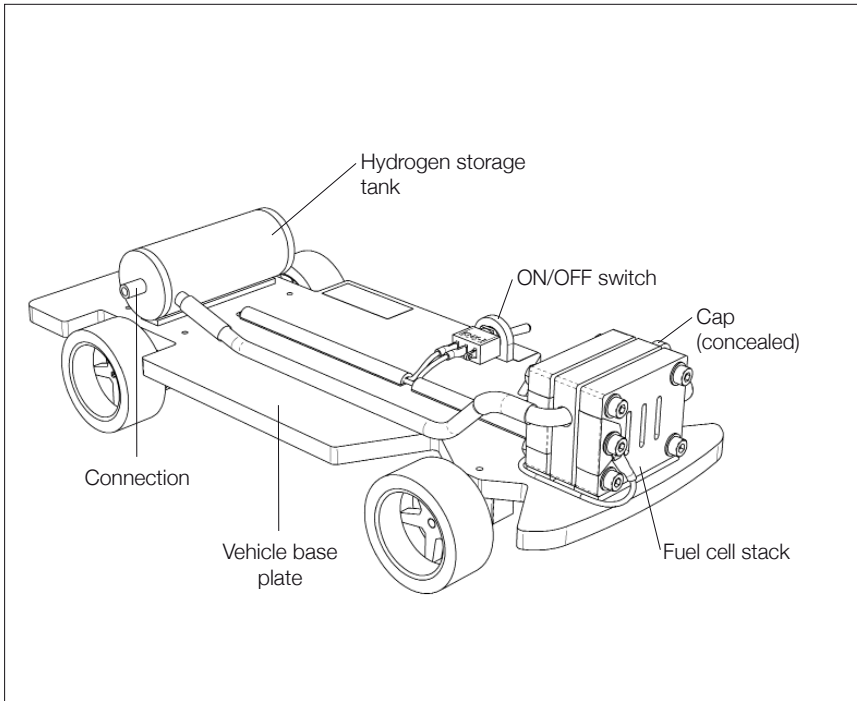


Fig. 2: The car at a glance

Starting up

Assembly

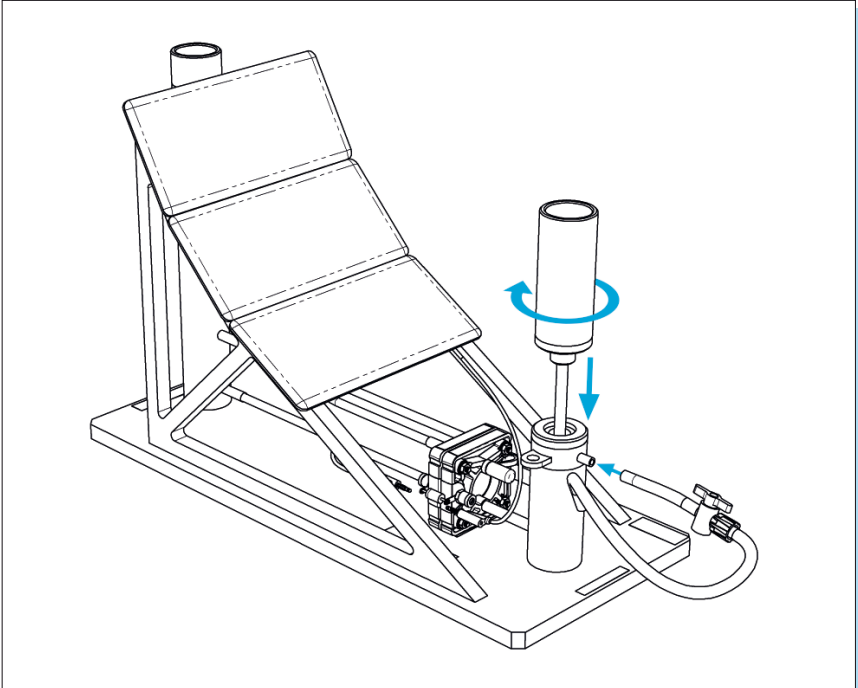


Fig. 3: Assembly

Assemble the filling station as shown in figure 3.

- Attach the overflow to the hydrogen storage tank using a clockwise motion.
- Attach the tube to the connection on the hydrogen storage tank.

Do not yet connect the cables to the electrolyzer.

Filling

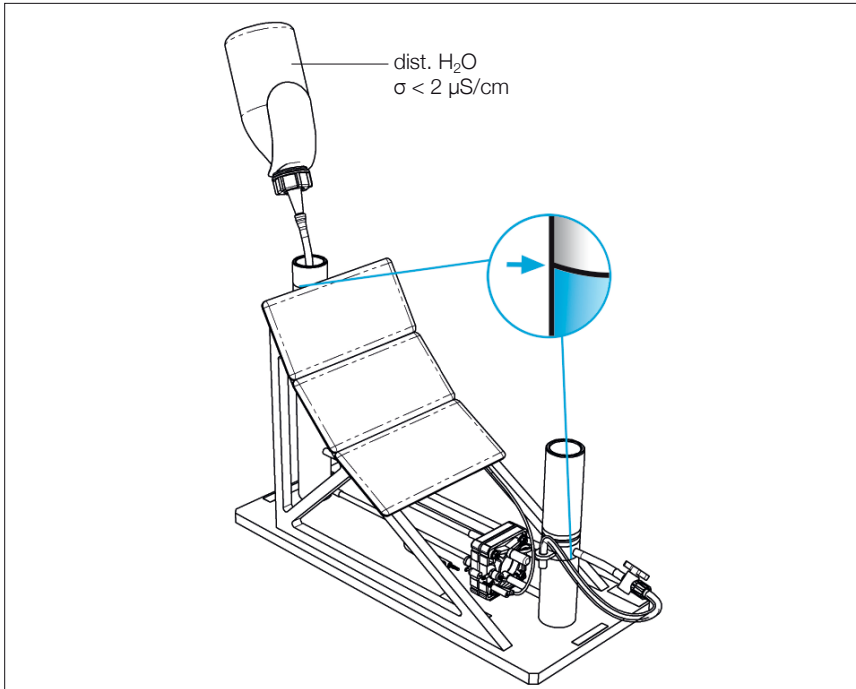


Fig. 4: Filling

- Open the shut-off valve on the tube.
- Fill the water reservoir up to the mark with distilled water ($\sigma < 2 \mu\text{S}/\text{cm}$) as shown in figure 4.
- Fill the hydrogen storage tank up to the mark with distilled water ($\sigma < 2 \mu\text{S}/\text{cm}$) as shown in figure 4.
- Briefly open the cap on the electrolyzer until a small amount of water comes out of the opening. Close the cap again.
- Fill the hydrogen storage tank again up to the mark with distilled water ($\sigma < 2 \mu\text{S}/\text{cm}$).

Operation

 CAUTION

Risk of injury from hydrogen ignition

Damaged tubes or leaking connections may cause hydrogen to leak. 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

The protection diode on the electrolyzer becomes very hot in case of incorrect polarity.

Touching the diode on the electrolyzer may cause injuries.

Before starting up, ensure correct polarity of the connecting cables and the electrical connections (red = “+”, black = “-”).

Do not touch the diode.

 CAUTION

Risk of injury from hot surfaces

The surface of solar modules may become very hot during operation.

Touching the surface of solar modules may cause injuries.

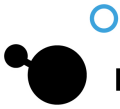
Do not touch the surface of solar modules during operation. Let the surface of the solar modules cool to 40 °C before removing.

 CAUTION

Risk of injury from hydrogen ignition

Escaping hydrogen may ignite when in proximity to an ignition source.

Prevent hydrogen from escaping. Completely use up all hydrogen at the end of experiments and before dismantling.



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

NOTE

Water in the fuel cell

Ensure that there is no water in the tube of the filling station. Remove any water in the tube by briefly opening the tube clamp or the shut-off valve, if and as needed.

If water enters the fuel cell by way of the tube, a film of water on the electrode surface may suppress the reaction of hydrogen and oxygen within the fuel cell. In such cases, the output of the fuel cell will be inadequate.

Operating the filling station

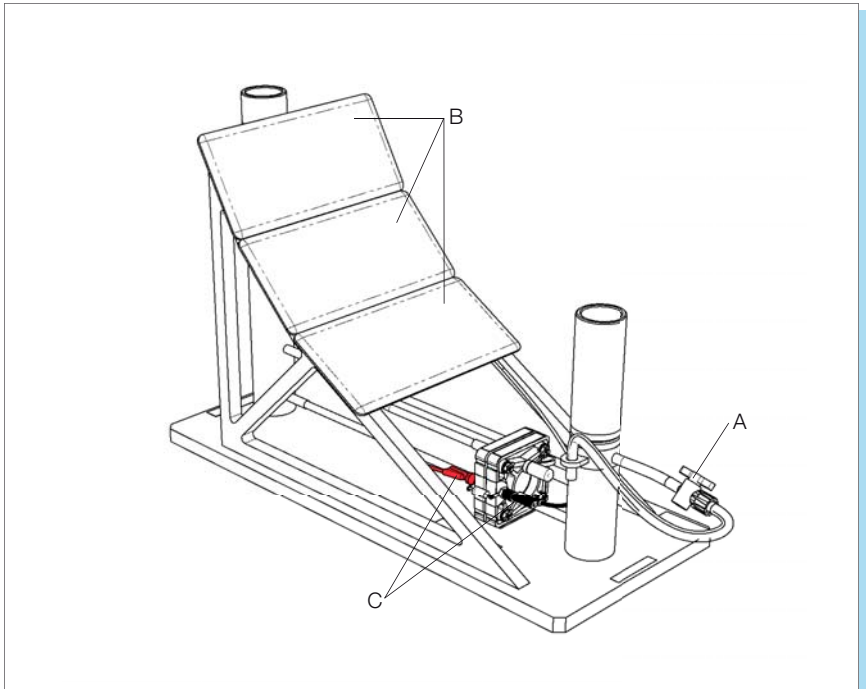


Fig. 5: Operating the filling station

- Close the shut-off valve (A).
- Connect the cables of the solar modules (B) with the connections (C) on the electrolyzer while ensuring correct polarity (red = "+", black = "-").
- Provide solar modules with adequate direct sunlight or with light from a power, concentrated electrical light source.
The water is split into hydrogen and oxygen at a ratio of 2:1. Oxygen escapes into the room via the water reservoir.

- After each refill with distilled water, the residual air must be purged from the system. To do this, produce approximately half a tank of hydrogen and release the gas by briefly opening the shut-off valve, and venting most of the gas. Repeat 2-3 times to ensure pure hydrogen.
- When the hydrogen storage tank is filled, excess hydrogen escapes as bubbles. Gas production must then be stopped by removing the cables of the solar modules from the connections of the electrolyzers
- The filling station is now ready for use.
- During operation, small amounts of water pass through the PEM from the oxygen side to the hydrogen side. This may cause the water level to rise on the hydrogen side and fall on the oxygen side. check, and if necessary, adjust the water level regularly during operation, To this end, the water on the hydrogen side mus be removed and supplied to the oxygen side. If the water level needs to be adjusted, hydrogen production must be stopped by removing the cables of the solar modules from the connections of the electrolyzers.
- The distilled water is consumed during operation. Pay attention to the water levels and regularly top off with a little distilled water($\sigma < 2\mu\text{S/cm}$). The water levels in the water reservoir and in the hydrogen storage tank should be kept approximately at the fill level marking at all times. (For the hydrogen storage tank, this is only possible if no hydrogen is being stored.

Operating the car

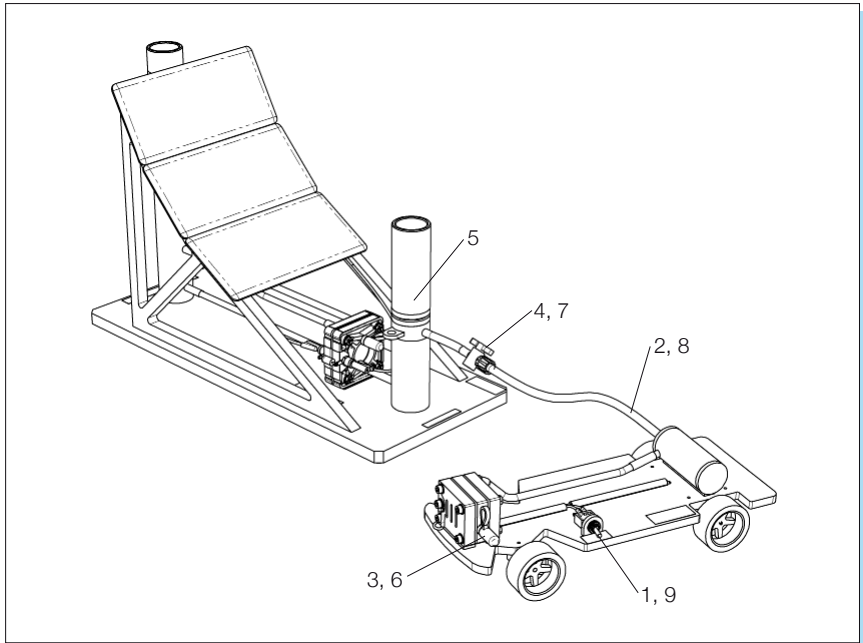


Fig. 6: Operating the car

- 1. Set the switch to “OFF”.
- 2. Attach the tube to the connection on the hydrogen storage tank of the car.
- 3. Open the cap on the fuel cell stack.
- 4. Open the shut-off valve.
- 5. Wait until the column of water inside the overflow of the filling station’s hydrogen storage tank has completely dropped. The hydrogen is now inside the hydrogen storage tank of the car.
- 6. Close the cap on the fuel cell stack.
- 7. Close the shut-off valve.
- 8. Remove the tube from the connection on the hydrogen storage tank of the car.
- 9. To start operation of the car, set the switch to “ON”. The driving range on one full tank is approximately seven minutes.

Technical data

Item name: Fuel Cell Concept Car & Gas Station
 Item no: D203

Filling station “Gas Station”

H x W x D: 245 mm x 360 mm x 150 mm
 Weight: 1250 g
 Permissible operating pressure: 0 - 20 mbar

Solar module:

Active solar area: approx. 180 cm²
 Open-circuit voltage: approx. 2000 mV DC
 Operating current: approx. 1050 mA*

Electrolyzer:

Number of cells: 1
 Active surface per cell: 17 mm x 17 mm
 Operating medium: distilled water ($\sigma < 2 \mu\text{S/cm}$)
 Permissible operating voltage: 0 - 2 V DC
 Permissible operating current: 0 - 1.5 A
 Rated power consumption: 1.5 W
 H₂ gas production at rated power output approx. 5 mL/min
 O₂ gas production at rated power output approx. 2.5 mL/min

Gas storage tank and water reserve:

Fill volume H₂O, H₂-side: approx. 30 mL
 Fill volume H₂O, O₂-side: approx. 95 mL
 Gas storage volume H₂: approx. 25 mL
 Gas storage volume O₂: –

* Under standard test conditions (STC)

Car “Fuel Cell Concept Car”

H x W x D: 70 mm x 105 mm x 245 mm

Weight: 320 g

Permissible operating pressure: 0 - 20 mbar

Gas storage tank:

Gas storage volume H₂: approx. 10 mL

Gas storage volume O₂: –

Fuel cell:

Number of cells: 2

Active surface per cell: 20 mm x 20 mm

Operating media: hydrogen and atmospheric oxygen from air

Open-circuit voltage: Max 2V DC

Short circuit current: Max 650 mA

Rated power output: approx. 300 mW

H₂ gas consumption at rated power output: .. approx. 6 mL/min

O₂ gas consumption at rated power output: .. approx. 3 mL/min**

Drive/propulsion:

Type: electric motor

Number of motors: 2

Rated power consumption (total): approx. 150 mW

** from ambient air

Troubleshooting

The fuel cell only has a low output.

Possible cause:

- The fuel cell was stored too dry or for too long. A fuel cell with a dry polymer electrolyte membrane (PEM) will lose power.

Solution:

- Continue operation. The fuel cell moistens itself during operation, which slowly allows it to reach its full capacity again.

Despite hydrogen being present, the load connected to the fuel cell (e.g. the motor) is not working.

Possible cause:

- Water has entered the fuel cell during operation (e.g. through the gas storage tanks). This may cause a rapid decline in performance.

Solution:

- Dry the fuel cell by opening and blowing out the connections.

CAUTION

Risk of damage due to compressed air

The use of compressed air for drying the fuel cell may cause irreparable damage to the fuel cell.

When drying it, only blow out the fuel cell without using any high pressure air.

With the solar module connected, no hydrogen is produced in the electrolyzer

Possible cause:

- The light intensity is insufficient.

Solution:

- Operate the solar module(s) 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 power supply is connected and there is gas production, but no gas is stored in the hydrogen storage tank.

Possible cause 1:

- The shut-off valve is not closed.

Solution:

- Close the shut-off valve.

Possible cause 2:

- The overflow tank is not secured firmly in place.

Solution:

- Secure the overflow tank firmly in place.

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

Continue operating the fuel cell until the motor 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 escaping. Completely use up all hydrogen at the end of experiments and before dismantling.

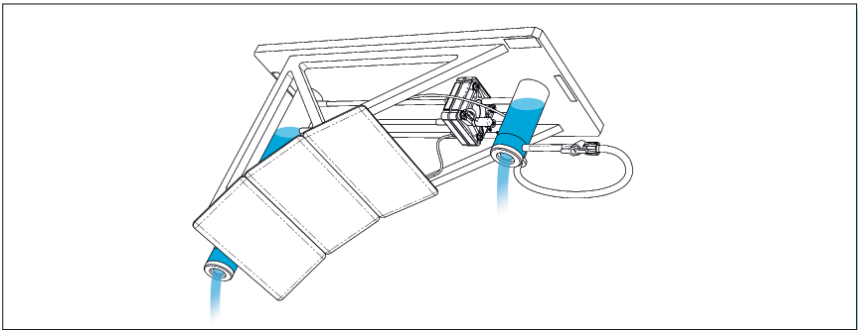


Fig. 7: Draining the hydrogen storage tank and the water reservoir

- Remove the cables of the solar modules from the connections of the electrolyzer.
- Stored hydrogen has to be consumed before draining the storage tanks.
- Close the shut-off valve.
- Remove the overflow.
- Drain the hydrogen storage tank and the water reservoir, as shown in figure 7. The water must be disposed of correctly (e.g. drain).

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

- You must ensure that the cables of the solar modules are removed from the connections of the electrolyzer. The electrolyzer may sustain irreparable damage if left connected.
- Carefully remove any water drops from the product with a soft, lint-free cloth. This prevents the formation of water stains.

Maintenance

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

- Use fresh, distilled water for each new start-up.
- After operation, remove the water from the hydrogen storage tank and from the water reservoir.

Transport 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:

- 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

Risk of fire due to 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 not be disposed of as unsorted household waste. The symbol of the crossed-out wheellie bin indicates the requirement for separate disposal.

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

