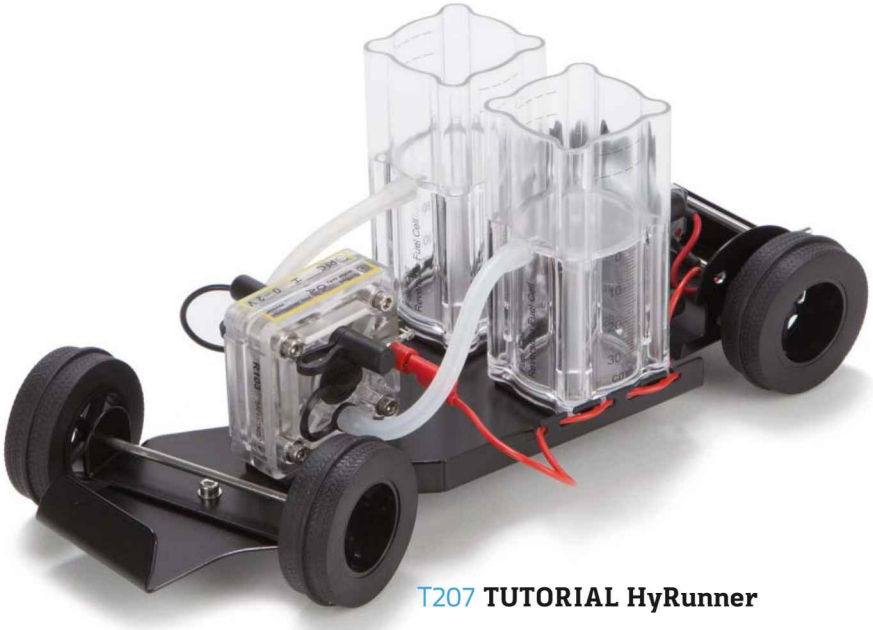
H-TEC EDUCATION
a GP JOULE company

Operating Instructions



T207 **TUTORIAL HyRunner**

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Your Duties as a Supervisor

These Operating Instructions are intended for the responsible supervisor.

- Read the Operating Instructions before using the equipment. Observe the instructions and keep them on hand.
- Pay particular attention to the general safety instuctions (see Page 5).
- This product may be set up and operated only under the supervision of the person responsible.

Objective / Introduction

The development of new energy sources will be one of the main tasks of the 21st century, as energy requirements increase, resources of coal, oil and gas decline, and climate change accelerates. Hydrogen technology is particularly important in this regard. Fuel cells allow electricity to be produced directly from hydrogen and oxygen. Their only waste product is water.

In turn, the fuel for these fuel cells can be produced by a process called electrolysis, which uses electricity (e.g. from solar cells) to split water into hydrogen and oxygen. Together, these two technologies form the solar hydrogen cycle.

The cells contained in our sets can do both: generate electricity and produce hydrogen. They allow all stages of the solar hydrogen cycle to be clearly explained through simple experiments. They outline a simple principle, which works on small and large scales, and in doing so conserves resources and helps the environment. No wonder then that all experts in fuel cell technology predict excellent prospects for the future.

These operating instructions explains the design, setup and operation of the TUTORIAL HyRunner. You will also find suggestions for using it in the classroom.

Our team wishes you exciting experiments and interesting insights into the future of energy supply.

H-TEC EDUCATION GmbH

Intended Use

The equipment described in this operating instructions allows the principles of PEM fuel cells (PEM = proton exchange membrane) and PEM electrolysers to be demonstrated, and appropriate measurements to be taken. The equipment has been developed for teaching and demonstration purposes only.

Any other use is prohibited.

WARNING!

The hydrogen (H_2) and oxygen (O_2) used in fuel cells can be dangerous if handled improperly. In order to avoid any risks you must follow the recommended safety instructions when using the equipment.

All steps for the H_2/O_2 and H_2/Air modes of operation are explained as an example.

H-TEC cells are clearly color-coded according to their function.

yellow: reversible fuel cell (RFC), which can also be used as an electrolyser

blue: electrolyser

red: fuel cell

General safety instructions

CAUTION:

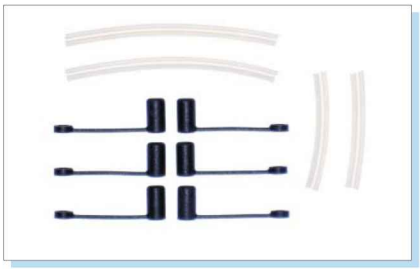
The **general safety instructions** attached separately to the product must be read before using the product and must be observed!

Content

Solar Module Tutorial

Chassis Vehicle Plate

Water Bottle 100 ml (with filler tip)

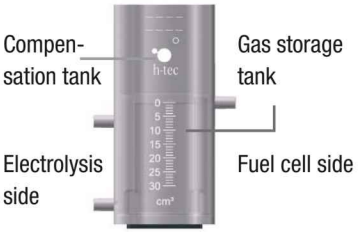


TubeSet

Cap (for gas connector)
Stopper (for sealing air inlet)

Cable (2 mm)

Gas storage tank Storage 30



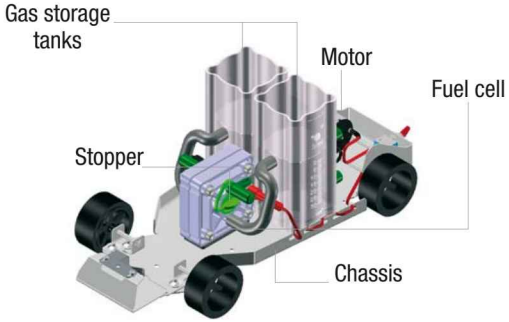
Reversible Fuel Cell (RFC)
RFC H_2/O_2/Air

TUTORIAL HyRunner (T207)

The TUTORIAL HyRunner is a working model of a hydrogen fuel cell car with a reversible fuel cell RFC H_2/O_2/Air and two gas storage tanks. Hydrogen can be manufactured and stored with the cell via the application of electrical current from an external power supply.

The charging time with Solar Module Tutorial and sunlight is approximately nine minutes.

The running time is approximately eight minutes. The reversible fuel cell can be operated in either oxygen-breathing or air-breathing mode **(H_2/O_2 mode see page 9, H_2/Air mode see Page 12).**

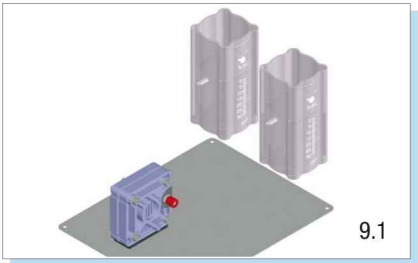


TUTORIAL HyRunner (T207)

Contents of the set:

- 1x RFC cell H_2/O_2/Air
- 2x Gas storage tank Storage 30
- 1x Solar Module Tutorial
- 2x Cable 2 mm
- 1x Chassis
- 2x Tubes
- 6x Caps
- 1x Water Bottle 100 ml
- 1x Protective goggles
- 1x Textbook
- 1x general safety instructions

H_2/O_2 mode - Setup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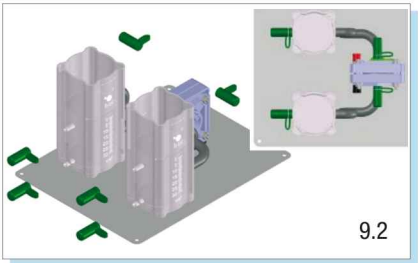
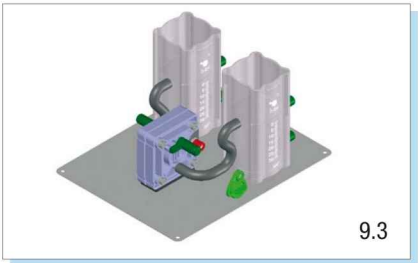
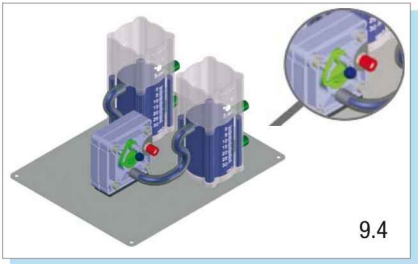

9.2


9.3


9.4

For better clarity, the following figures are pictured without the chassis of the TUTORIAL HyRunner.

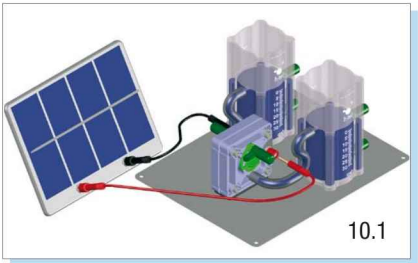
1. Place the two gas storage tanks and the reversible fuel cell on the chassis **(Fig. 9.1).**
2. Using a hose, connect the bottom connectors of the reversible fuel cell to the connectors on the fuel cell side of the storage tanks **(Fig. 9.2).**
3. Fit caps to the connectors on the electrolysis side of the gas storage tanks **(Fig. 9.2).**
4. Fit caps to the top gas connectors of the fuel cell **(Fig. 9.2).**
5. Make sure that the stopper for sealing the air inlet on the cell is fitted **(Fig. 9.3).**
6. Fill both storage tanks with distilled water up to the top mark of the compensation tank.
7. Open the upper caps on both sides of the cell. Air will escape from the gas storage tanks and from the cell and the cell will be flooded. The process is complete when water comes out of the top gas connectors **(Fig. 9.4).**

Note

The rising water level can easily be seen in the labyrinth inside the cell. If air bubbles form, they may interfere with the system. Allow the process to run until you see no more air bubbles.

8. Re-cap the gas connectors.

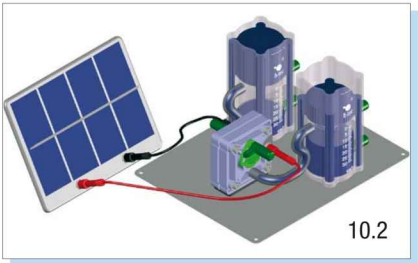
H_2/O_2 mode - Gas production


10.1

1. Use the cables to connect the solar module to the appropriate terminals on the fuel cell. When doing so, make sure that the polarity is correct (red = „+“, black = „-“). The cell will begin to produce hydrogen and oxygen in a 2:1 ratio **(Fig. 10.1).**

Note

If the lighting is not sufficient, you can use a powerful halogen spotlight.

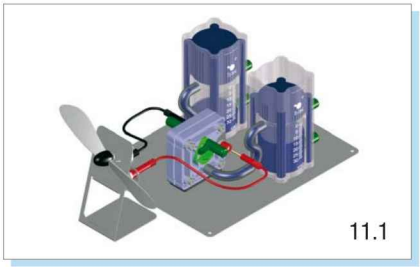

10.2

2. Oxygen is produced on the positive side of the cell, and hydrogen on the negative side. The gases collect in the gas storage tanks and displace the water there into the compensation tanks **(Fig. 10.2).**

H_2/O_2 mode - Gas storage

When the gas storage tanks are full, excess gas will escape in the form of bubbles.

H_2/O_2 mode - Gas consumption

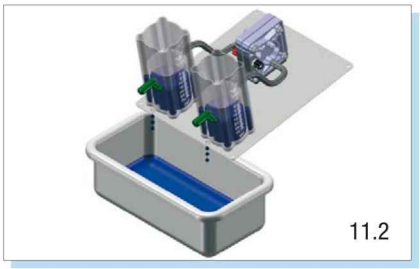


11.1

1. Remove the solar module and connect the motor of the TUTORIAL HyRunner. The cell will use the gas to generate current, along with water and small amounts of heat **(Fig. 11.1, Page 11).**
2. The gas level drops. If the gases are used up, the cell will draw water and the motor will stop.
3. Reconnect the solar module. Gas production will start again.

Note

Make sure that the oxygen side of the cell is sufficiently moist. Re-flood the cell if necessary.



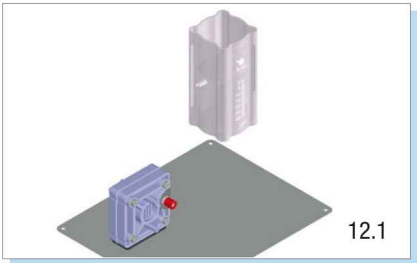
11.2

Emptying the storage tanks

(at the end of operation)

1. Remove the storage tanks and the fuel cell from the chassis.
2. Remove the caps from the fuel cell.
3. Hold the gas storage tanks over a collecting tray and remove the bottom caps from the tanks. The water will run out **(Fig. 11.2).**

H_2/Air mode - Setup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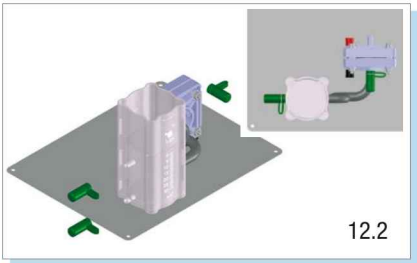
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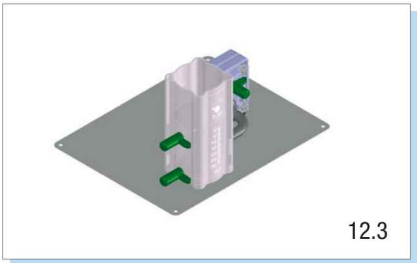
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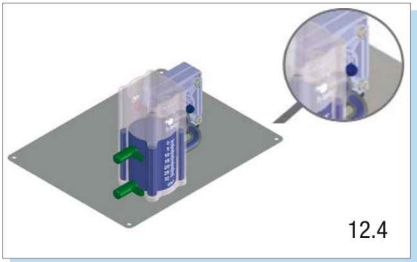
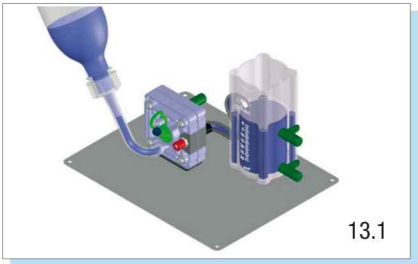

12.4

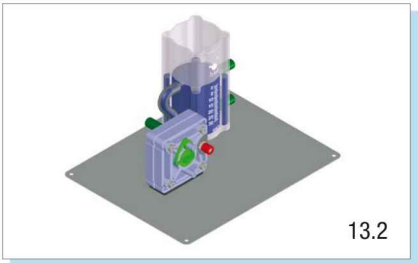
1. Place a gas storage tank and the cell on the chassis **(Fig. 12.1).**
2. Using a hose, connect the bottom connector of the fuel cell on the hydrogen side to the connector on the fuel cell side of the gas storage tank **(Fig. 12.2).**
3. Fit caps to the connectors on the electrolysis side of the gas storage tank **(Fig. 12.2).**
4. Fit a cap to the top gas connector on the hydrogen side of the fuel cell **(Fig. 12.2, 12.3).**
5. Fill the gas storage tank with distilled water up to the top mark of the compensation tank.
6. Open the top cap on the hydrogen side of the cell. Air will escape from the gas storage tank and from the cell and this side of the cell will be flooded. The cell is flooded when water comes out of the top gas connector **(Fig. 12.4).**
7. Re-cap the gas connector on the hydrogen side.

Note

The rising water level can easily be seen in the labyrinth inside the cell. If air bubbles form, they may interfere with the system. Allow the process to run until you see no more air bubbles.



13.1



13.2

8. Fit the included filler tip on the water bottle.

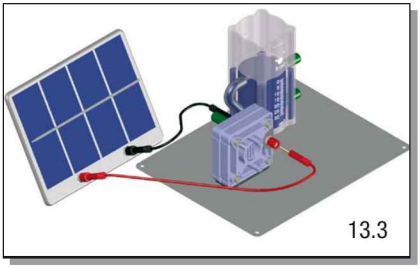
Note

Before flooding the cell, fit the stopper so that the water will be well distributed in the cell.

9. Connect the water bottle to the bottom connector on the oxygen side of the cell and flood this side as well **(Fig. 13.1).**

10. Disconnect the water bottle. The cell is now ready for use **(Fig. 13.2).**

H_2/Air mode - Gas production

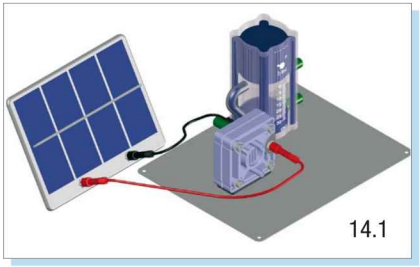


13.3

1. Remove the stopper.

2. Use the cables to connect the solar module to the terminals on the fuel cell.

When doing so, make sure that the polarity is correct (red = „+“, black = „-“). The cell will begin to produce hydrogen and oxygen in a 2:1 ratio **(Fig. 13.3).**


14.1

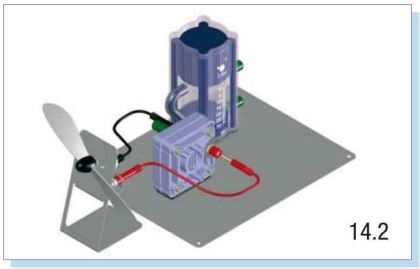
Note
If the lighting is not sufficient, you can use a powerful halogen spotlight.

3. Oxygen is produced on the positive side of the cell, and hydrogen on the negative side. As the cell is operated in fuel cell mode with atmospheric oxygen, only the hydrogen will be collected in the gas storage tank. It displaces the water there into the compensation tank **(Fig. 14.1).** The process runs until the water on the oxygen side of the cell is used up.

H_2/Air mode - Gas storage

When the gas storage tank is full, excess gas will escape in the form of bubbles.

H_2/Air mode - Gas consumption


14.2

1. Remove the solar module and connect the motor of the TUTORIAL HyRunner. The cell will use the produced gas together with the atmospheric oxygen to generate current, along with water and small amounts of heat **(Fig. 14.2).**

   When operating with atmospheric oxygen, the power of the cell is somewhat lower than when operating with pure oxygen.

2. The gas level drops. If the hydrogen is used up, the cell will draw water and the motor will stop.

3. Re-connect the solar cell. Gas production will start again.

Note

Make sure that the oxygen side of the cell is sufficiently moist. Re-flood the cell if necessary.


15.1

Emptying the storage tank
(at the end of operation)

1. Remove the storage tank and the fuel cell from the chassis.
2. Remove the caps from the fuel cell.
3. Hold the gas storage tank over a collecting tray and remove the bottom cap from the tank. The water will run out **(Fig. 15.1).**

Experimental Guidelines

The H-TEC textbook contains detailed experimental instructions for calculating characteristics and efficiencies of the cells, as well as extensive background information on hydrogen technology. Below, you can find some brief suggestions for how you can use the equipment in the classroom to clearly demonstrate the basic principles of hydrogen technology.

TUTORIAL HyRunner

- Use the equipment as an electrolyser to produce H_2 and O_2 in a ratio of 2:1.
- Compare the performance of the electrolyser (gas volume per unit time) when using the solar module with sunlight versus artificial light.
- Run the TUTORIAL HyRunner as a solar car without a fuel cell by connecting the solar module directly to the motor.
- Run the TUTORIAL HyRunner as a fuel cell car using self-generated hydrogen in H_2/O_2 or H_2/Air modes.
- Compare the car's performance in different modes by measuring its speed or range.
- If you have two cars available, have a race based on time or distance to compare the operating modes (H_2/O_2, H_2/Air, solar car).

Maintenance

The fuel cells we provide in our sets are maintenance-free. However, always remember:

- Use fresh, distilled water each time.
- Drain the water from the storage tanks after use.

Before putting the cell away:

- Continue operating the cell until the motor stops by itself. This will ensure that a little water remains in the cell and keeps the membrane moist.
- Close the caps and the stopper so that the water in the cell does not evaporate.
- Wipe the chassis dry in order to prevent water marks.

Technical Data

TUTORIAL HyRunner (T207)

Electrolysis mode:	5 cm^3/min H_2 2.5 cm^3/min O_2 1.16 W	Gas storage tank:	30 cm^3 H_2 / 30 cm^3 O_2
		Solar module:	2.0 V / 600 mA
		H x W x D:	100 x 115 x 260 mm
Fuel cell mode:	H_2/O_2: 300 mW H_2/Air: 100 mW	Weight:	600 g

Fault Diagnostics

The cell only produces low power.

Cause:

- The cell has been stored for a very long time or is too dry. A cell with a dry membrane will lose power.

Solution:

- Continue operating the cell. The cell will moisten itself during operation and gradually return to full power.

The electric load (e.g. motor) connected to the cell does not work, despite hydrogen being present.

Cause:

- There is too much water in the cell. Water in the fuel cell leads to a rapid reduction in power. This condition can occur if the electrolyser runs in permanent operation for too long and pumps water to the hydrogen side of the fuel cell. With reversible cells, it is possible that the cell has not been operated for long enough in electrolysis mode, so that too much water still remains in the cell.

Solution:

- Dry the cell by opening the connectors and blowing through the cell. In the case of reversible cells, change back to electrolysis mode.

No hydrogen is produced when the solar cell is connected.

Cause:

- The light intensity is insufficient.

Solution:

- Check the power specifications designed for the light source. You need sufficient sunlight or halogen lamps with focused light. Energy-saving lamps, fluorescent tubes, etc. are not suitable for the operation of solar modules.

The cell does not work despite being set up correctly.

Cause:

- You have not used distilled water. The cell is permanently damaged.

Disposal

Do not dispose of electrolysers as general household waste.

Warning: Risk of fire due to catalytic substances

The catalysts for the electrodes of fuel cells and electrolysers 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.

Notes

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