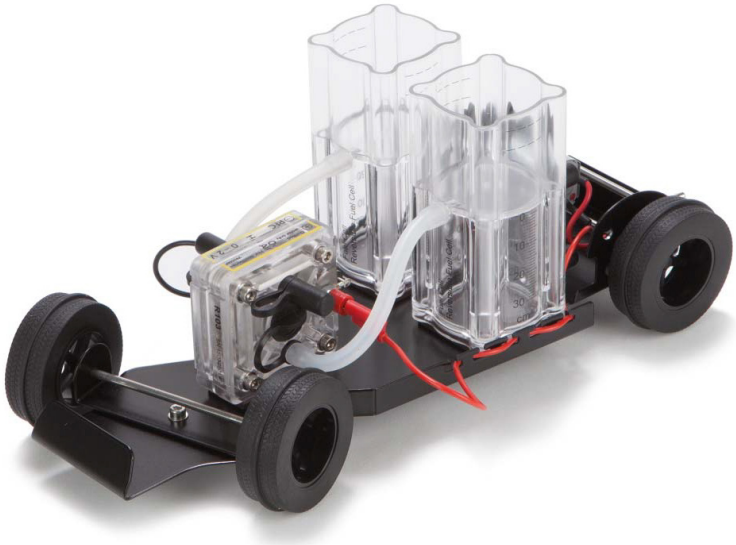
H-TEC EDUCATION

Operating Instructions



T207 - TUTORIAL HyRunner

H-TEC EDUCATION

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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!
The product may only be used:

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

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 Precautions
- This product should 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.

H-TEC Education

Intended Use

The equipment described in this manual allows the principles of PEM fuel cells (PEM = proton exchange membrane), PEM electrolyzers and solar modules 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!

Distilled water is required to operate the Tutorial HyRunner. The electrolyser splits this water into hydrogen and oxygen. In the fuel cell, hydrogen (H2) and oxygen (O2) react again. These gases can be dangerous if handled improperly. In order to avoid any risks you must follow the recommended safety precautions when using the equipment.

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

yellow: Reversible Fuel Cell (RFC)
Can be used as FC or EZ

blue: Electrolyzer (EZ)

red: Fuel Cell (FC)

General Safety Precautions

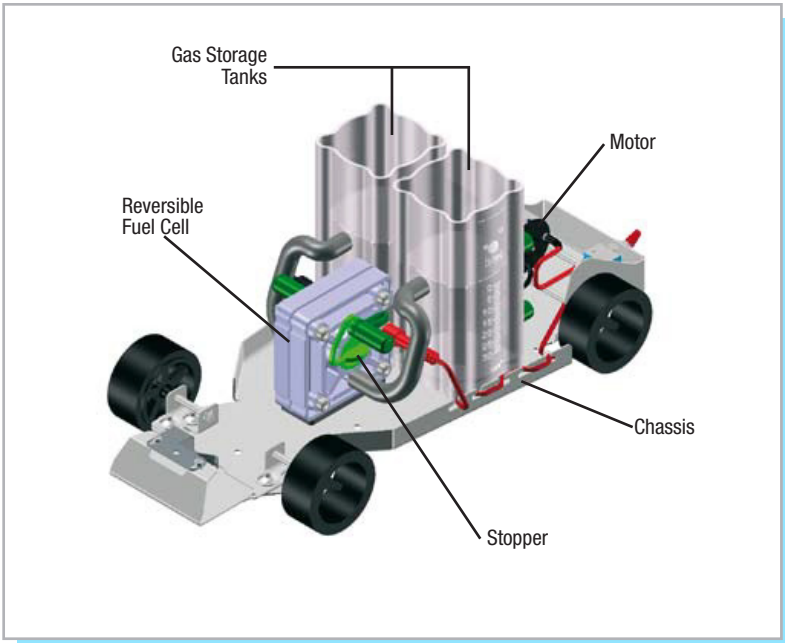
The General Safety Precautions attached separately to the product must be read before using the product and must be observed!

Additional note

Make sure the polarity is always correct (red = “+” , black = “-”)!

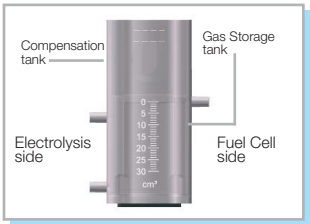
Overview of TUTORIAL HyRunner (T207)

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.



Contents

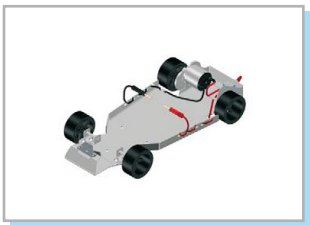
1x Tutorial Solar Module



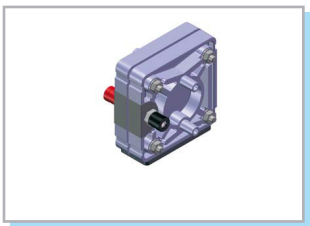
2x Gas Storage Tank - Storage 30

Note: When filling the tanks do this in strict accordance with the assembly instructions of each experiment.

The tanks are provided with a measurement scale on the gas storage tank itself and two fill level marks on the compensation tank.



1x Vehicle Chassis Plate



1x Reversible Fuel Cell (H_2/O_2/Air)

1x Water Bottle

1x Tube Set

1x Cable Set - 25cm length - 2mm

Detail view:

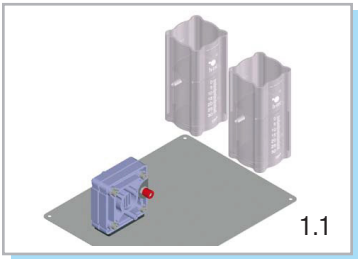
6x Caps for gas connector

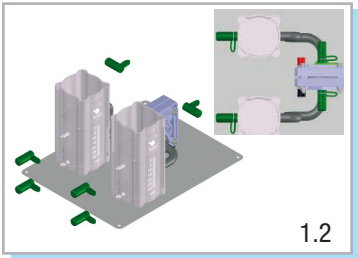
1x Stopper for sealing air inlet

1x Textbook

H_2/O_2 Mode - Set Up & Operation

Set Up


1.1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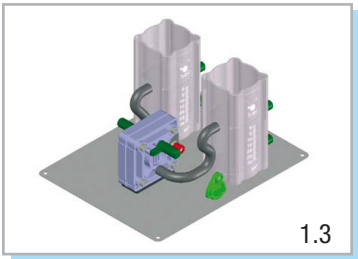
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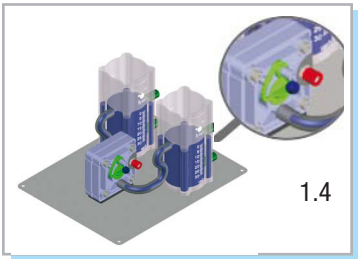
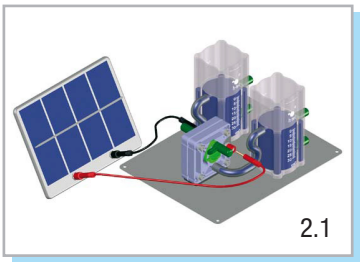

1.4

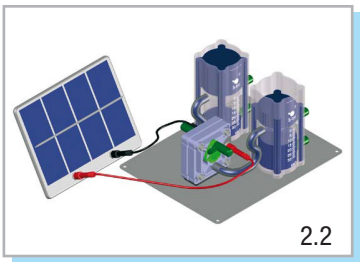
For better clarity the photos are shown without the chassis of the Tutorial HyRunner.

1. Place the two gas storage tanks and the Reversible Fuel Cell on the chassis (Fig. 1.1).
2. Using a hose, connect the bottom connectors of the RFC to the connectors on the fuel cell side of the storage tanks (Fig. 1.2).
3. Fit caps to the connectors on the electrolysis side of the gas storage tanks (Fig. 1.2).
4. Fit caps to the top gas connectors of the fuel cell (Fig. 1.2).
5. Make sure that the stopper for sealing the air inlet on the RFC is snugly in the inlet (Fig. 1.3).
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 RFC. Air will escape from the gas storage tanks and the RFC. The cell will be flooded with water. The process is complete when water comes out of the top gas connectors (Fig. 1.4).

   NOTE: The rising water level can easily be seen 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.

Electrolysis Mode (Gas Production)


2.1


2.2

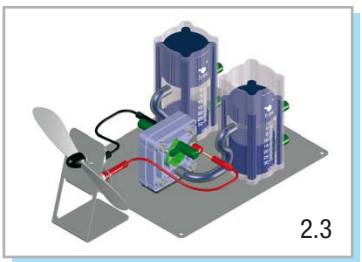
1. Use the cables to connect the solar module to the appropriate terminals on the RFC. When doing so, make sure that the polarity is correct (red = "+", black = "-"). The cell will begin to produce hydrogen and oxygen in a 2:1 ratio (Fig. 2.1).

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

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. 2.2).

   NOTE: When the gas storage tanks are full, excess gas will escape in the form of bubbles. When this happens, unplug the solar module from the RFC.

Fuel Cell Mode (Gas Consumption)


2.3

NOTE: TUTORIAL HyRunner does not have a fan, instead connect the RFC to the wires connected to the motor.

1. When the solar module is unplugged, ensure the motor is switched off, then plug the wires from the chassis into the RFC taking care to use correct polarity (red = "+", black = "-"). When switched on, the cell will use the stored gas to generate current, along with water and small amounts of heat (Fig. 2.3).

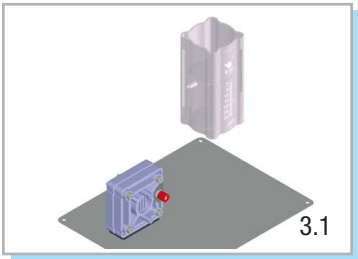
2. When the gas is used up, the RFC will draw in water. This will cause the motor to stop.

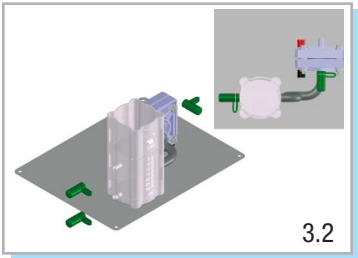
3. When the motor stops, unplug the chassis and reconnect the solar module. This will resume gas production.

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

H_2/Air Mode - Set Up & Operation

Set Up


3.1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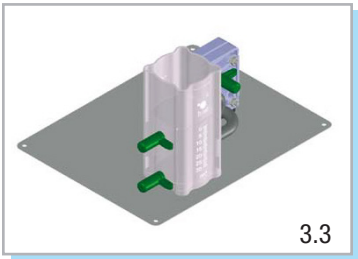
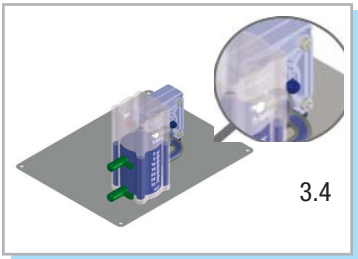
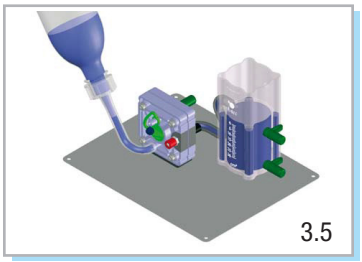

3.3

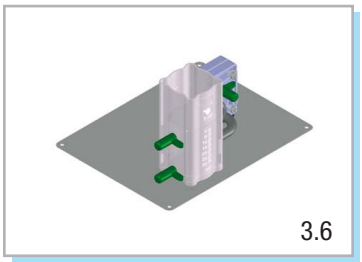

3.4

For better clarity the photos are shown without the chassis of the Tutorial HyRunner.

1. Place a gas storage tank and the cell on the chassis (Fig. 3.1).
2. Using a hose, connect the bottom connectors of the RFC to the connectors on the fuel cell side of the storage tanks (Fig. 3.2).
3. Fit caps to the connectors on the electrolysis side of the gas storage tanks (Fig. 3.2).
4. Fit a cap to the top gas connector on the hydrogen side of the fuel cell (Fig. 3.3).
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 RFC. Air will escape from the gas storage tanks and the RFC. The cell will be flooded with water. The process is complete when water comes out of the top gas connectors (Fig. 3.4).
7. Re-cap the gas connector on the hydrogen side.

NOTE: The rising water level can easily be seen 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.


3.5

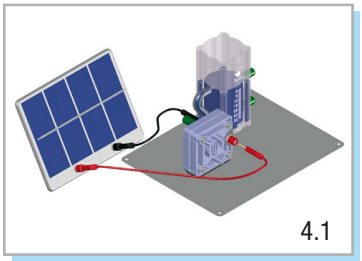

3.6

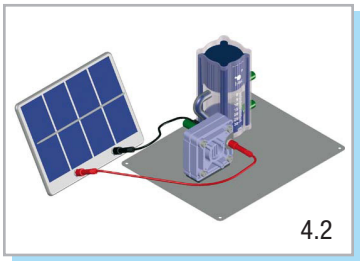
8. Attach the water bottle to the bottom connector on the oxygen side of the RFC with the included tubing (Fig. 3.5).

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

9. Squeeze the bottle to flood the oxygen side of the cell. When the oxygen side is flooded and the bottle is disconnected, the RFC is ready for use (Fig. 3.6).

Electrolysis (Gas Production)


4.1


4.2

1. Remove the stopper.

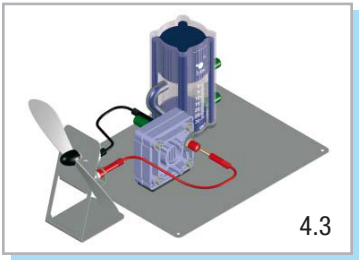
2. Use the cables to connect the solar modules to the terminals on the RFC. When doing so, make sure the polarity is correct (red = “+”, black = “-”). The cell will begin to produce hydrogen and oxygen in a 2:1 ratio (Fig. 4.1).

   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. The gas will collect in the gas storage tank and displace the water there into the compensation tank (Fig. 4.2).

   NOTE: When the gas storage tanks are full, excess gas will escape in the form of bubbles. When this happens, unplug the solar module from the RFC.

Fuel Cell Mode (Gas Consumption)


4.3

NOTE: TUTORIAL HyRunner does not have a fan, instead connect the RFC to the wires connected to the motor.

1. When the solar module is unplugged, ensure the motor is switched off, then plug the wires from the chassis into the RFC taking care to use correct polarity (red = "+", black = "-"). When switched on, the cell will use the stored gas, along with atmospheric oxygen to generate current, along with water and small amounts of heat (Fig. 4.3).
2. When the gas is used up, the RFC will draw in water. This will cause the motor to stop.
3. When the motor stops, unplug the chassis and reconnect the solar module. This will resume gas production.

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

Emptying the storage tank


5.1

1. Remove the RFC and the storage tanks from the chassis.
2. Remove the caps from the RFC.
3. Hold the gas storage tank over a collecting tray and remove the bottom cap from the tank. The water will drain out from tank and the RFC (Fig. 5.1).

Experimental guidelines

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

- Use the equipment as an electrolyzer to produce H_2 and O_2 in a ratio of 2:1.
- Compare the performance of the electrolyzer (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).

Technical Data

Box:

H x W x D:	380 x 215 x 125 mm
Weight:	1.15 kg

Electrolyzer:

H_2 Production:	7.0 mL/min
O_2 Production:	3.5 mL/min
Permissible Power:	1.7 W @1A
Electrode Area:	3 cm^3
Guide value for distilled water:	<2 µS/cm
Permitted operating pressure:	0 - 20 mbar

Fuel Cell:

H_2 / O_2 Operation:	500 mW @ 750 mA
H_2 / Air Operation:	200 mW @ 300 mA
Electrode Area:	3 cm^3
Permitted operating pressure:	0 - 20 mbar

Accessories:

Gas storage tank:	30 mL H_2 & 30 mL O_2
Solar module:	2.0V / 600 mA

Troubleshooting

The fuel cell has very little power.

Possible Cause:

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

Solution:

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

No hydrogen is produced when the solar cell is connected.

Possible Cause:

- The light intensity is insufficient.

Solution:

- In order to operate solar modules, either adequate direct sunlight or concentrated light from a powerful electrical light source is required. Energy-saving light bulbs, fluorescent tubes etc. are unsuitable for the operation of solar modules.

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

Possible 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 fuel cell by opening and blowing out the connections, or change back to electrolysis mode by connecting the solar module to the cell.

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

Possible Cause:

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

Should the above-mentioned solutions not remedy the cause of error, please contact H-TEC EDUCATION.

Shutting down

- Continue operating the fuel cells until the consumer (e.g. the motor) stops independently. This allows some water to remain in the fuel cell, moistening the PEM. This procedure also prevents unnecessary discharge of hydrogen.
- Draining the gas storage tanks:

1 . All gas has to be consumed before draining the storage tanks.

⚠ CAUTION

Risk of injury from hydrogen ignition
Escaping hydrogen can ignite in proximity to an ignition source. Prevent hydrogen from escaping. Completely use up all hydrogen at the end of experiments, before dismantling.

2 . Remove the components from the experimentation plate or vehicle plate as one unit.

3 . Pour water into a collecting vessel.

- Disassembly is carried out in reverse order to assembly.

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

- Close the connections of fuel cells and electrolysers with caps. This prevents the PEM from drying out. The same applies to stoppers on fuel cells.
- Remove any water droplets from the experimentation plate or vehicle plate with a soft, lint-free cloth. This prevents the formation of water stains.

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.

Disposal

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

⚠ WARNING

Fire hazard from 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.

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