

# EDUSTAK PRO

Build Yourself Fuel Cell Stack Kit – FCSU-33



User Manual

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# 1. Introduction

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## 1.1 Foreword

Thank you for choosing Horizon Fuel Cell Technologies' EDUSTAK PRO. We hope you will enjoy to use it! Please read all these instructions before operating the EDUSTAK PRO for the first time, and shall keep all manuals for future reference.

If you still have any questions about operating or using your EDUSTAK PRO, please contact Horizon.

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## 1.2 Production disclaimer

Any unauthorized service, modification may adversely affect the safety, durability, and performance of the system and shall immediately void any warranty on the system. Misuse, neglect, or improper servicing of this equipment may result in the kit damage. Do not operate this kit if it is damaged. Failure to observe instructions contained in this manual will void any limited warranties and could result in suspension or denial of service, legal action, or both.

The EDUSTAK PRO has not been tested at environmental temperature extremes. Therefore, no guarantee of performance is made for operation at ambient temperatures less than 5° C and greater than 40° C .

## 1.3 Contact details

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## 2. General Information

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### General Safety Instructions

- Read the user manual before operating the EDUSTAK PRO, and keep it close to the device at all times.
- As the graphite plate is exposed outside, the EDUSTAK PRO that customers got should be kept away from any metal parts which may cause a short circuit and incur the damage of cells.
- EDUSTAK PRO must not be stored at temperatures over 40°C (313 K) and must not be operated at temperatures over 40 °C (313 K). Protect from heat and direct sunlight.
- Operate the EDUSTAK PRO in a well-ventilated space.
- When the EDUSTAK PRO is not used for a long time, ensure to store it in a cool, dry storage.
- Do not smoke in the vicinity of the EDUSTAK PRO or its fuel cartridge. Protect from heat and ignition sources. Hydrogen is highly flammable!
- Keep all EDUSTAK PRO and its fuel cartridges out of reach of children, even when cartridge is empty or only partly full.
- The area surrounding the fuel cartridge shall be kept clear and free of combustible materials, gasoline and other flammable vapors and liquids;
  - This appliance is not tested for use with medical devices.
  - Save these instructions and review frequently during use.

## 2. General Information

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### **HYDROSTIK PRO safety information:**

- Remove the HYDROSTIK PRO from the pressure regulator immediately after use.
- DO NOT try to disassemble, open or repair the cartridges when broken or worn out!
- DO NOT store cartridges under direct sunlight.
- Keep it away from fire. Fire Hazard!
- Keep it in a safe, dry and cool place.
- Keep it away from temperatures above 50°C while filling, storage and using.
- Provide adequate ventilation and refrain from placing items on or around the appliance during operation. Refrain from placing the appliance in enclosures or causing the appliance to not vent freely.
- Keep away from alkaline and acidic environment.
- This is not toy – keep away from children.
- The HYDROSTIK PRO cartridge must be placed horizontally when it is being charged otherwise the cartridge can crack!
- HYDROSTIK PRO contents are flammable. Do not disassemble.
- Avoid contact with HYDROSTIK PRO contents.
- Remove the HYDROSTIK PRO from the pressure regulator immediately after use.
- When using the appliance, basic safety precautions should always be followed to reduce risk of fire, or personal injury.
- Hydrogen shall be stored, handled and used with caution so life and health are not jeopardized and the risk of property damage is minimized.
- After an accident or in the event of damage to the fuel cartridge potentially poses a fire hazard. Keep away from ignition sources and ensure good ventilation.

### 3. Part List

- a. EDUSTAK PRO\*
- b. HYDROSTIK PRO\*\*
- c. Manometer
- d. EDUSATK PRO blower
- e. Wires
- f. Air pressure bulb
- g. HYDROATIK PRO base
- h. Purging valve with tube
- i. Screws
- j. Three port connector
- k. 3 Silicon tubes
- l. Clamp with tube
- m. Pressure regulator
- n. HYDROSTIK PRO support



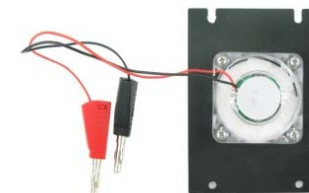
a



b



c



d



e



f



g



h



i



j



k



l



m



n

\* The EDUSTAK PRO is already assembled when you receive it for the first time.

\*\*The HYDROSTIK PRO contains no hydrogen when you get it for the first time, you have to fully charge it with the refilling station HYDROFILL PRO (sold separately) or hydrogen charging tube (sold separately).

## 4. EDUSTAK PRO Specifications

Type of fuel cell	PEM
Number of cells	10
Rated Power	20W
Performance	6V @ 3.4A
Reactants	Hydrogen and Air
External temperature	5 to 40°C
Max stack temperature	60°C
H2 Pressure	0.45-0.55bar
Hydrogen purity	$\geq 99.995\%$ dry H2
Humidification	self-humidified
Cooling	Air (integrated cooling fan)
Dimension	105mm*90mm*130mm
Weight	1000 g
Flow rate at max output*	0.25 L/min
Start up time	$\leq 30S$ at ambient temperature
Efficiency of stack	40% @ at full power
Low voltage shut down	5V
Over current shut down	10A
Over temperature shut down	60°C

\* The flow rate may change with the power output.

\*\* The specification is subject to change without notice.

## 5. Operating Guide

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### Using advices

In order to reach the best performances from your EDUSTAK PRO, and to guarantee his life span; we strongly recommend to respect the following advises:

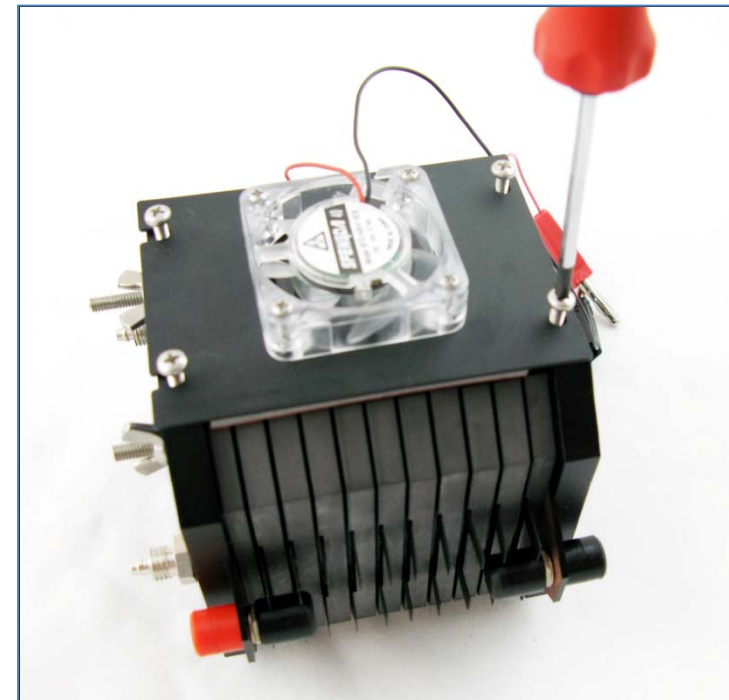
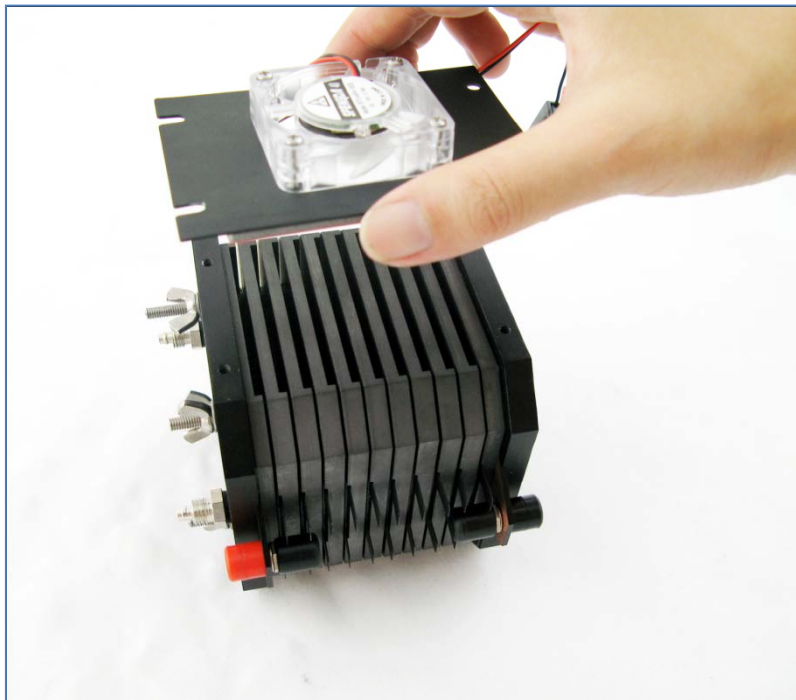
- Strictly follow the user's manual.
- Graphite plates must never be short circuited. Ensure that the place where you will operate is well electrically insulated.
  - Make sure the EDUSTAK PRO has passed the leakage testing before operation.
  - Operate it in a well-ventilated, dry area.
  - HYDROSTIK PRO should be connected to the pressure regulator tightly when operation.
  - Make sure to respect the polarity when you connect the EDUSTAK PRO to a load.
  - When EDUSTAK PRO connects an electrical load for testing, ensure the output voltage keeps constant at approx. 6V, not less than 5V.
  - When the EDUSTAK PRO is operated at the Max. output power, the stack surface temperature will be reach 55° C. Avoid any direct contacts with your skin.
  - The EDUSTAK PRO is not equipped with the controller. Do not connect it to the home appliance.
  - When you have finished using the system, disconnect the HYDROSTIK PRO from the pressure regulator immediately. Put the EDUSTAK PRO back to the zip lock bag for storage.
  - If leakage happens after several assemblies, place the EDUSTAK PRO into the purified water. Use the air pressure bulb to inject air into the stack. Observe where the bubbles come from and then adjust the stack assembly. But the stack must not be tested and operated with the water vapor inside. The stack must be dry.
  - Avoid strong collision.



## 5. Operating Guide

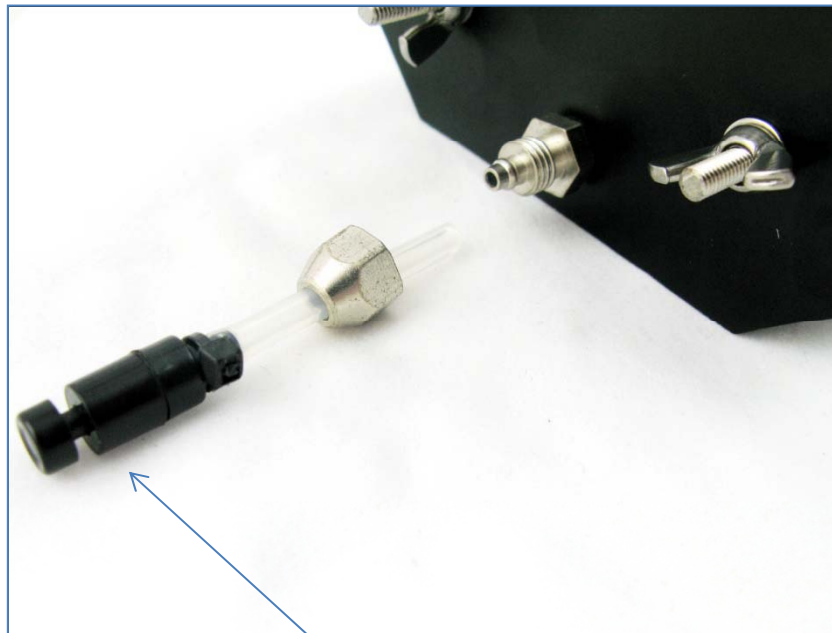
**Note:** The EDUSTAK PRO has been delivered fully mounted and tighten to ensure the required performances. It could be directly tested and operated.

**Step 1:** Using the screwdriver to screw the EDUSTAK PRO blower on the EDUSTAK PRO side where you can see the holes. Ensure you put it in the correct position as shown below .



## 5. Operating Guide

**Step 2:** Unscrew the bolt as shown in the picture below, opposite to the red socket side. Put the bolt on the purging valve tube and connect the free end of its to the EDUSTAK PRO nozzle. Ensure the connection is tight and then, firmly screw the bolt on the nozzle.

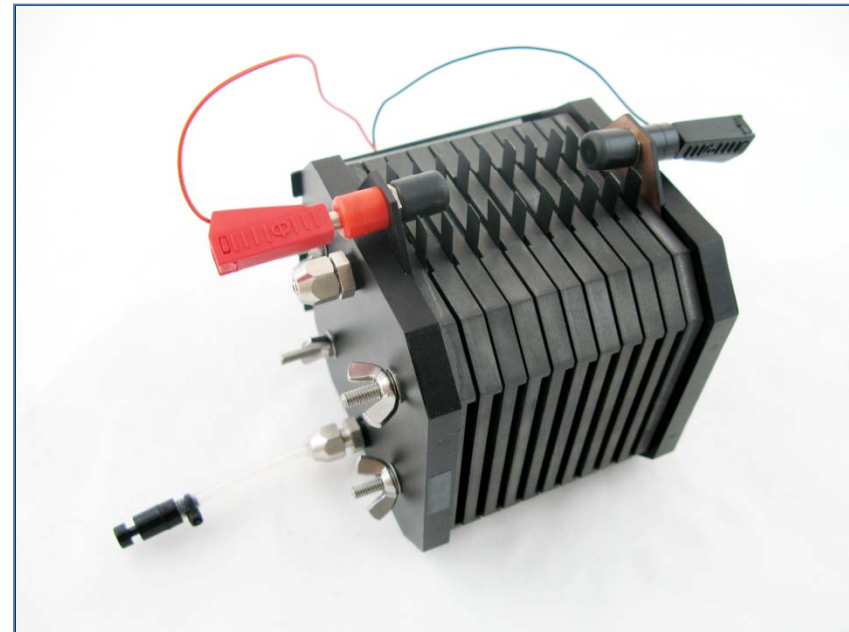
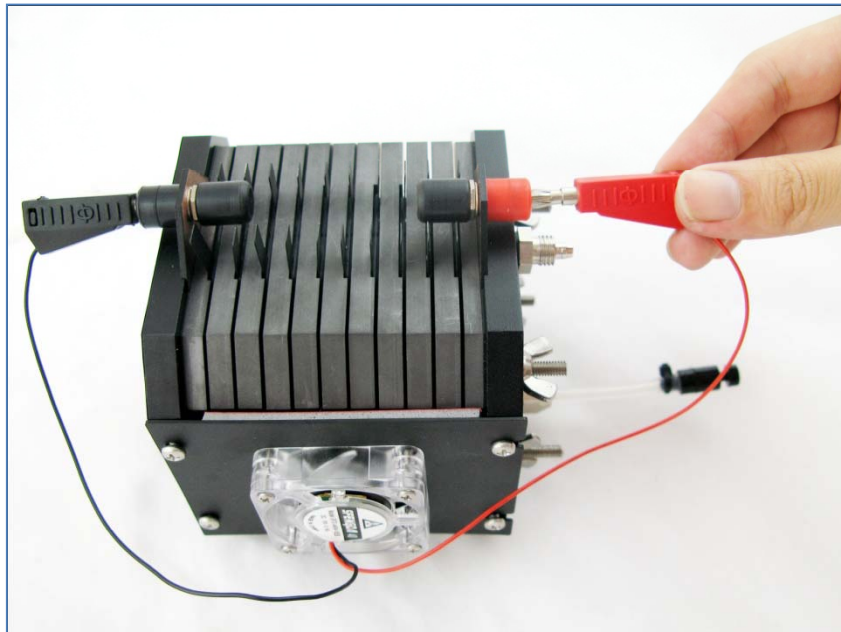


Purging valve



## 5. Operating Guide

**Step 3:** Plug the blower wires into the EDUSTAK PRO sockets. Ensure to respect the polarity shown by the color code.



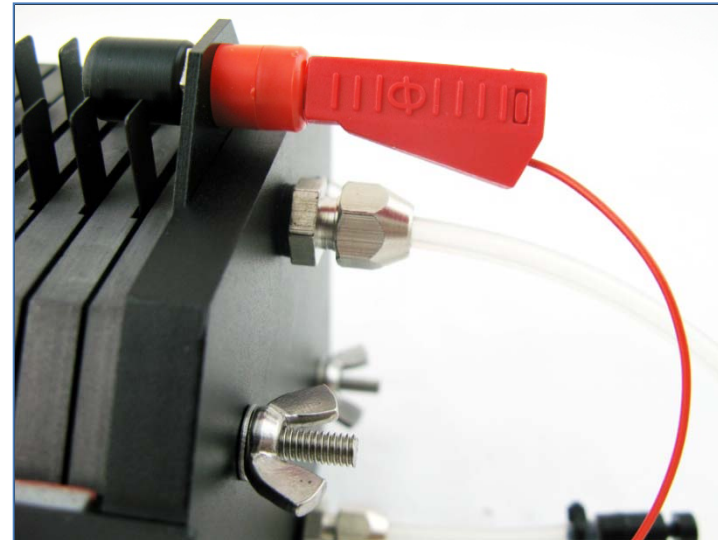
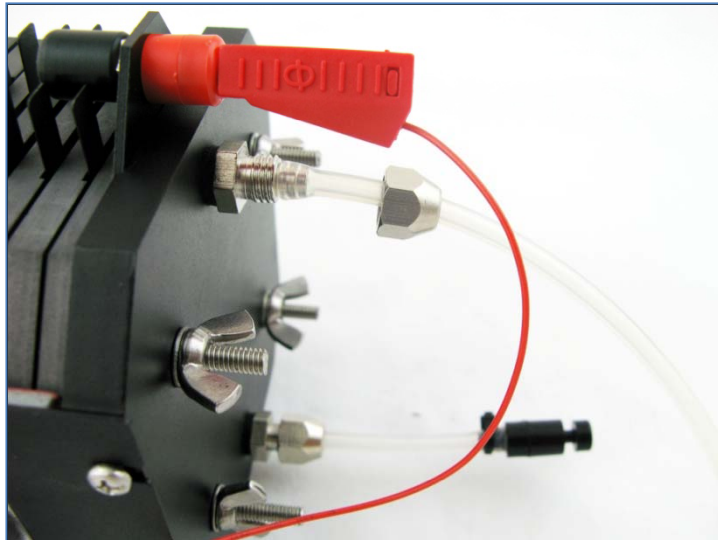
## 5. Operating Guide

**Step 4:** Unscrew the pressure regulator bolt, and pass it around the 20 cm long tube. Connect on tube end to the main part of the pressure regulator. Ensure the connection is tight and then, screw the bolt on the pressure regulator.



## 5. Operating Guide

**Step 5:** Unscrew the bolt located on the top side nozzle of the EDUSTAK PRO, close to the red socket side. Insert the bolt around the tube and connect its remaining end to the EDUSTAK PRO nozzle. Make sure the connection is tight and then screw the bolt firmly.





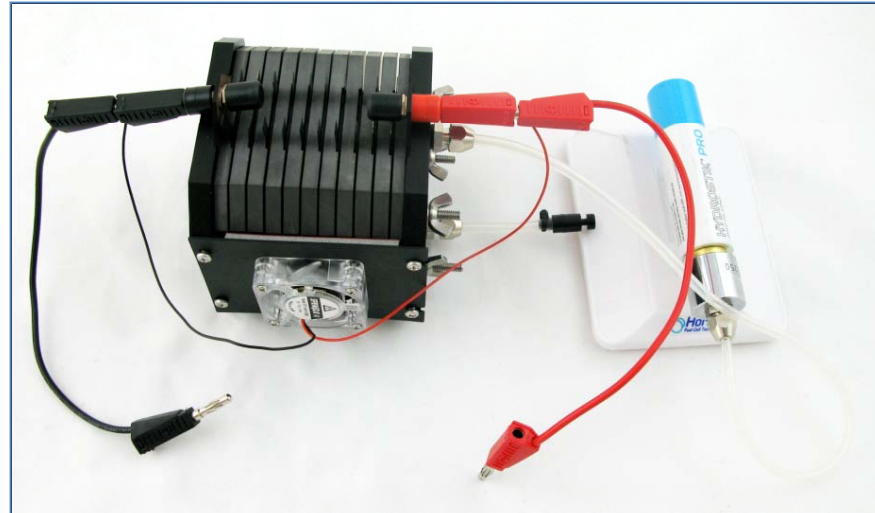
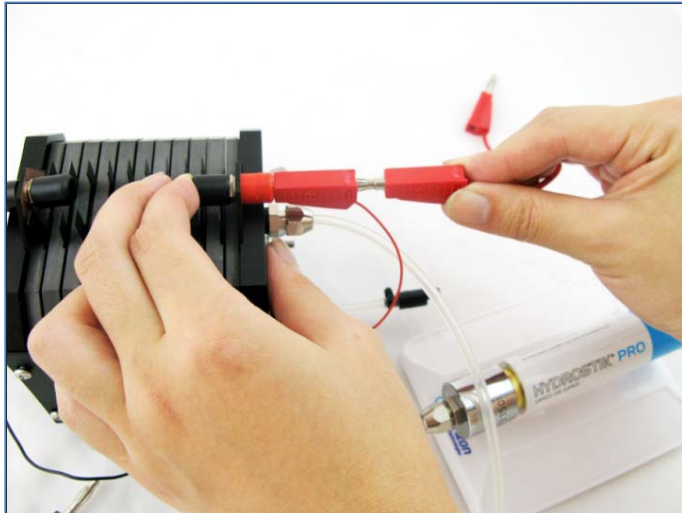
## 5. Operating Guide

**Step 6:** Put the HYDROSTIK PRO support on its base. Ensure both part meet perfectly. Place the HYDROSTIK PRO onto its support and lightly screw the pressure regulator onto the HYDROSTIK PRO nozzle. Stop to screw it as soon as both part meet together. No hydrogen is released at this moment.



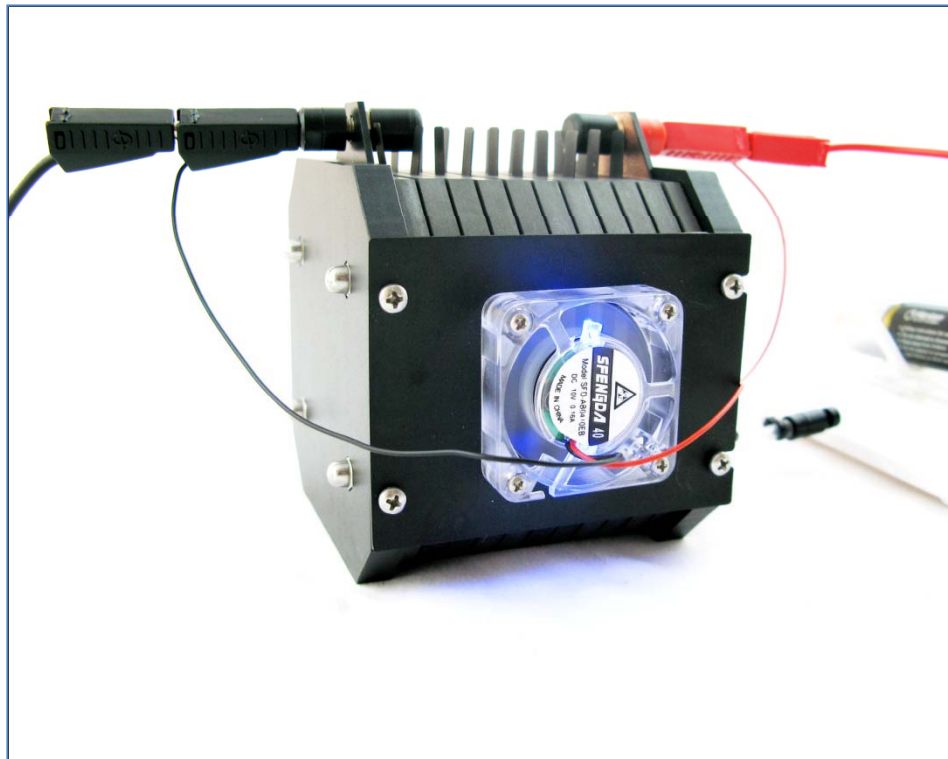
## 5. Operating Guide

**Step 7:** As shown below, plug one end of the small red wire into the first one, already plugged into the EDUSTAK PRO.



## 5. Operating Guide

**Step 8:** Plug the remaining end of the wires into a load. Then, you can finish to tightly screw the HYDROSTIK PRO to pressure regulator. As soon as it is done, the LED located on the EDUSTAK blower will light on. It means that the system is working and the energy contained in the hydrogen is turned into an electrical current.

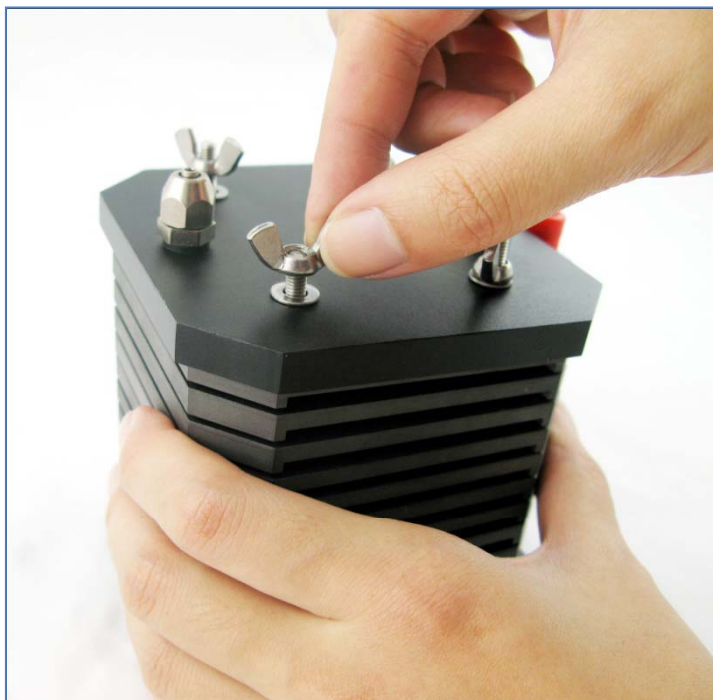


Press the purging valve and release to purge the EDUSTAK PRO every two minutes for its good performances. As soon as you have finished to use the EDUSTAK PRO, unscrew the HYDROSTIK PRO from the pressure regulator IMMEDIATELY in order to keep the Hydrogen inside and prevent the air flows into the cartridge to damage the metal hydride in it. The EDUSTAK PRO LED will not light off directly, don't panic it is absolutely normal. This fact is due to a remaining quantity of hydrogen inside the Fuel cell.



## 6. Disassembly Guide

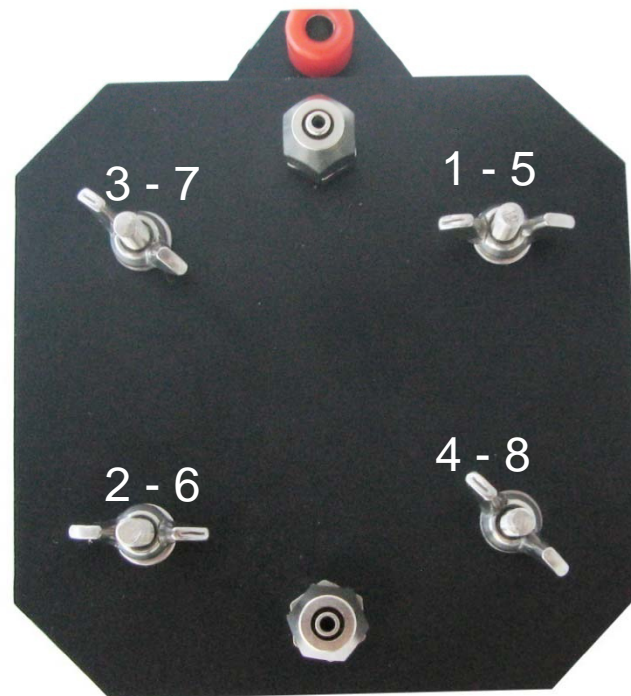
**Note:** If you wish to disassemble the stack by yourselves, we advise you to proceed according to the following instructions. Before disassembling the EDUSTACK PRO, wear gloves and operate in a clear and clean area in order to not pollute the fuel cell.



**Step 1:** Unscrew the 4 wing nuts and the 4 washers anti clockwise. Accord a special attention to the way you unscrew the wind nuts (refer to the following page). Only after, you can remove the upper end plate.

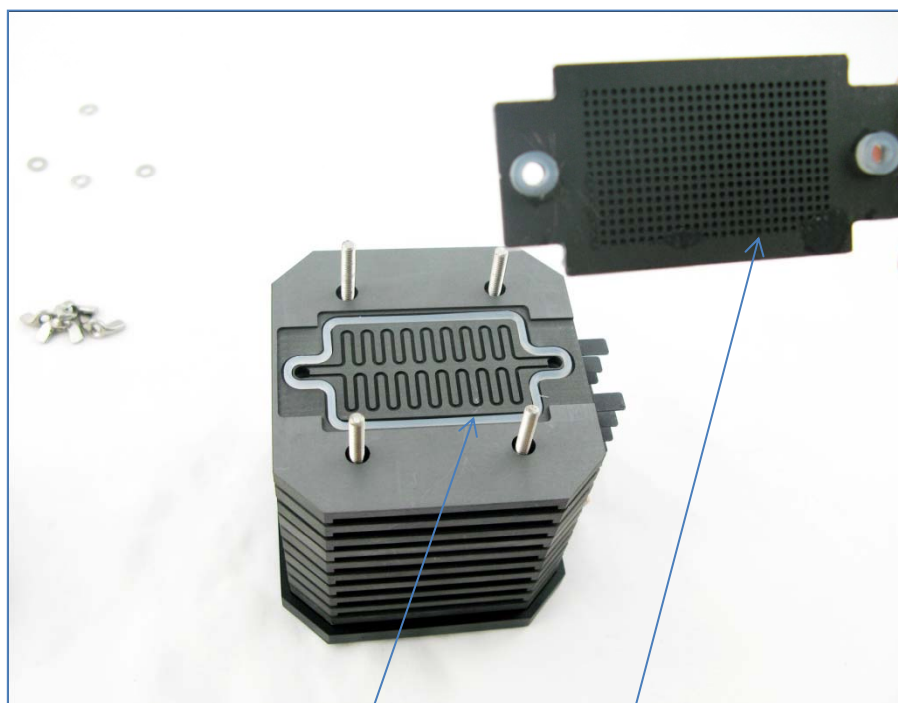
## 6. Disassembly Guide

**Important note:** Start by unscrew the right top corner wing nut only on the half of the available length. Do the same with the left bottom corner wing nut, then with the top left one and finish by the bottom right corner. After that, restart the operation in the same order and fully unscrew the wing nut.



## 6. Disassembly Guide

**Step 2:** Slowly, remove the first cell. You will notice that the EDUSTAK PRO is made with single fuel cell separated by graphite plates. In each graphite plate there is a groove which is designed to put seals inside.



Sealing

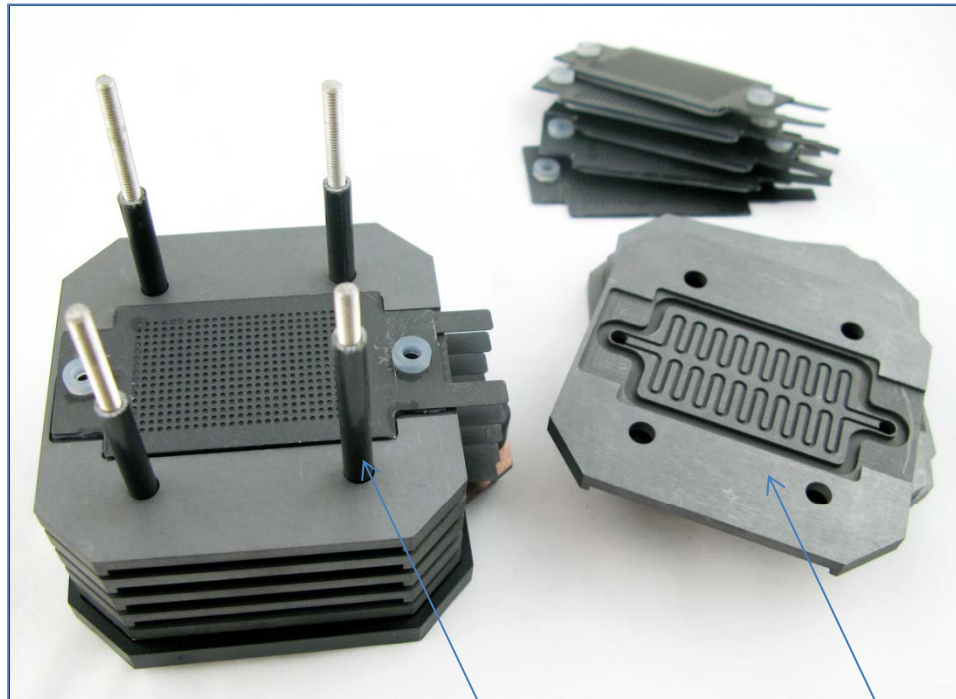
Single cell



Upper end plate

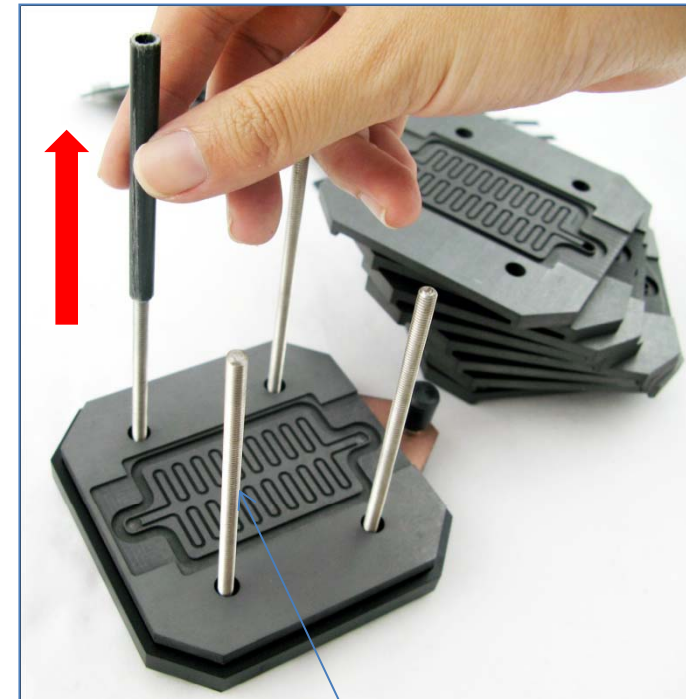
## 6. Disassembly Guide

**Step 3:** Make one pile with each kind of component to be sure you will reassemble it in the good order after. Remove the insulation tubes.



Insulation tube

Graphite plate



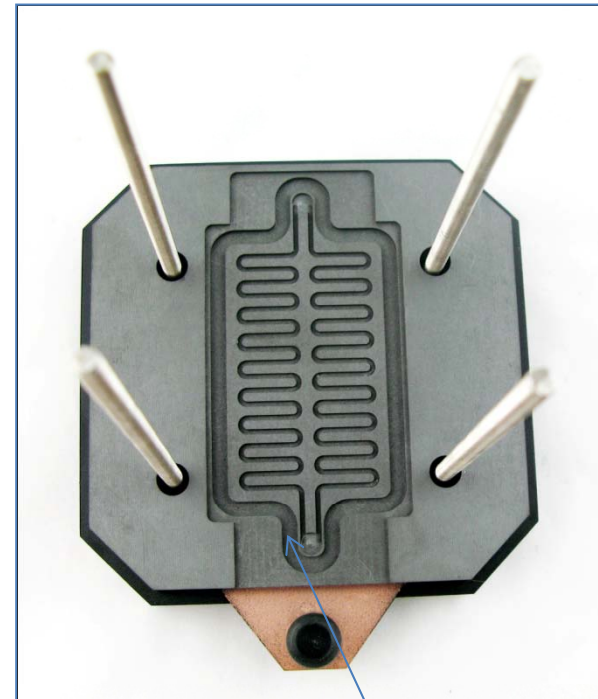
Screw rod

## 6. Disassembly Guide

**Step 4:** Now the EDUSTAK PRO is fully disassembled. Take care to not loose any components.



Low end plate with the  
screw rod



Sealing groove



## 6. Disassembly Guide

Now you have disassembled the EDUSTAK PRO, you get the following parts from the EDUSTAK PRO.

- a. Low end plate with 4 screw rods
- b. Upper end plate
- c. Single cell (10pcs)
- d. Graphite plate (9pcs)
- e. Sealing (10pcs)
- f. Insulation tube
- g. Wing nuts and washers



a



b



c



d



e



f



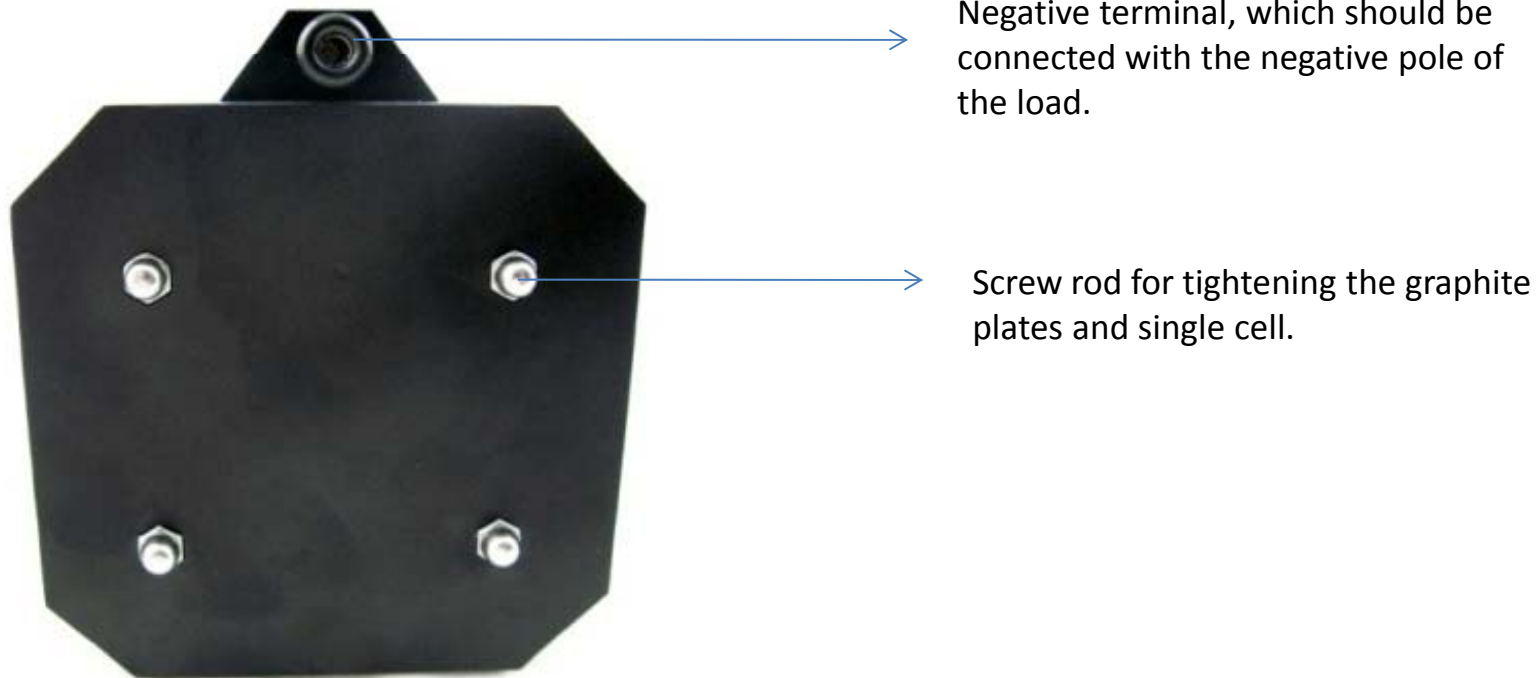
g

Note: For any manipulation of dismounted elements, be sure not to insert elements which could disturb the system sealing, damage MEAs and/or create short-circuit.

## 6. Disassembly Guide

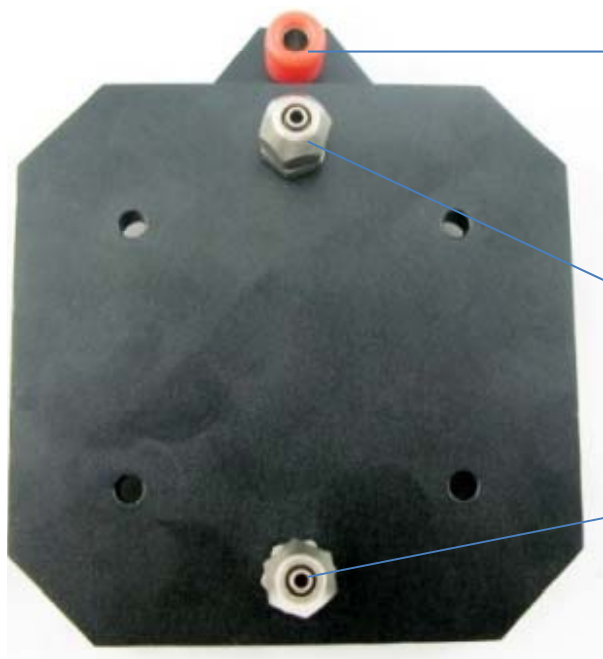
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### 5 Main Parts Description



#### 1. Lower end plate

## 6. Disassembly Guide



Positive terminal of the stack, which should be connected with the positive pole of the load.

Hydrogen nozzle. Due to the stack has front and back, normally hydrogen will flow into the stack via upper gas nozzle and release through bottom nozzle. Make sure the silicon tubes are tightly connected to the hydrogen nozzles , otherwise the hydrogen will leak.

### 2. Upper end plate





They are important components of the stack, which are the critical parts for power generation.

### 3. Single cells

## 6. Disassembly Guide

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They are made of graphite.  
There should be 9 pieces of mid-plates for 10 piece single cell stack.

### 4. Graphite mid-plates



They are the important components in the stack, which prevents the stack from the hydrogen leakage. It can never be ignored when you are assembling the stack.

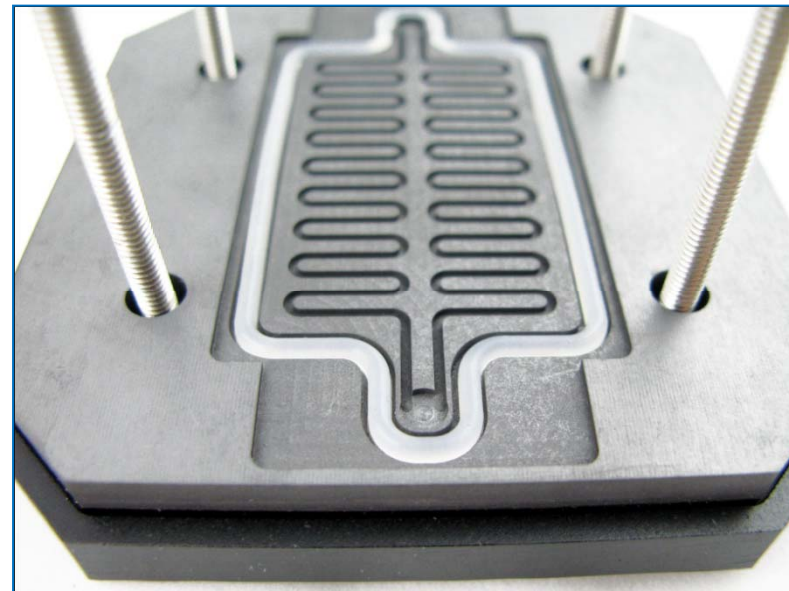
### 5. Rubber sealing

## 7. Assembly Guide

**Note:** Now you may assemble the EDUSTAK PRO, please do the following guide.

**Tools** maybe needed during the assembly.

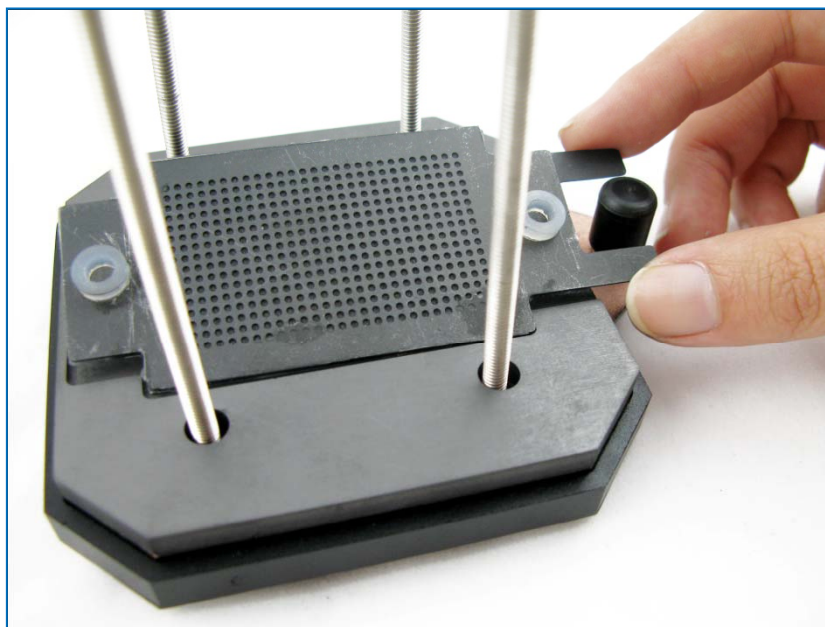
**Step 1:** Take the lower end plate and insert the first rubber sealing into its groove, as it is shown below.



**Note:** Pay close attention to the direction of the rubber sealing. The round side of the rubber sealing should be facing upwards.

## 7. Assembly Guide

**Step 2:** Put a single cell on the sealing. Ensure the single cell meet perfectly with the groove and the white nozzles are on the upper side. Ensure to put the two ends of the cell in the same side than the black socket located on the lower end plate. And then put the a graphite plate on it and ensure it is well oriented.



**Note:** Pay close attention to the direction of the graphite plate. This side without the raised edge marked in the above picture should face the black socket located on the lower end plate.

## 7. Assembly Guide

**Step 3:** Repeat the operation with the 9 remaining cells and with the 8 plates. After that you just have to pass the insulation tube around the screw as it is shown below.





## 7. Assembly Guide

**Step 4:** Ensure it is stable and put upper end plate on it. Ensure the red socket is in the same side as the black one.



## 7. Assembly Guide

**Step 5:** Put the washers around the screw and put the wing on it. Screw the wind nuts starting by the diagonals in order not to damage the stack.



**Note:** After assembly, measure the length between the upper end plate and the lower end plate (including the end plates). The length should be  $86\text{mm} \pm 0.2\text{mm}$ . If the length is not within the range. You have to reassemble the stack. Otherwise leakage will occur.



## 8. Leakage testing

### 8.1. Part lists for leakage testing

- a. EDUSTAK PRO
- b. Manometer
- c. Air pressure bulb
- d. Purging Valve with tube
- e. Three-port connector
- f. 2 silicon tubes
- g. Clamp with tube



a



b



c



d



e



f



g

**Note:** After assembling the product, you have to do the leakage testing before any use. THIS STEP IS VERY IMPORTANT because it permits to avoid any risks of damaging the EDUSTAK PRO.

## 8. Leakage testing

### 8.2. Leakage testing process

**Step 1:** First connect the lateral ends of the three port connector to the two short silicon tubes. Then link the tube where there is the clamp (bigger diameter) to the three port connector.

**Step 2:** Connect the other side of the clamp tube with the air pressure bulb. Ensure all the connections are tight.

**Step 3:** Connect a free ends of one of the lateral tubes to the manometer after having unscrewed the small bolt on its base and having passed it around the tube. After that screw the bolt on the pressure gauge basis.



## 8. Leakage testing

**Step 4 :** Unscrew the bolts on the upper part of the EDUSTAK PRO. Connect the EDUSTAK PRO to the last free end of silicon tubes after having passed one bolt around. Notice that you have to link the tube with the nozzle located on the red socket side of the EDUSTAK. Do the same with the purging valve tube and the remaining nozzle.

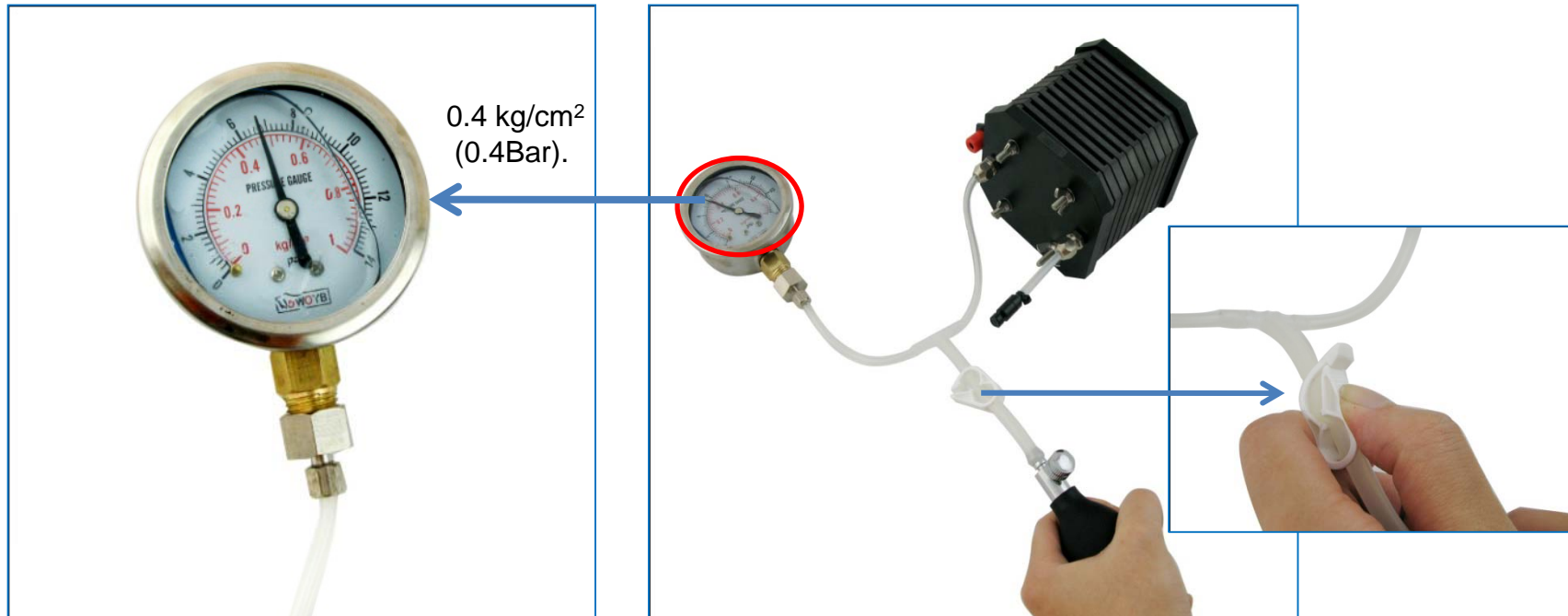
**Step 5:** Turn the switch slowly on the air pressure bulb in clockwise until it can't be turned anymore.



**Step 6:** Squeeze the air pressure bulb in order to reach an internal pressure of  $0.4 \text{ kg/cm}^2$  (0.4Bar). You can read the pressure directly on the manometer.

## 8. Leakage testing

**Step 7:** Close the clamp and release the air pressure bulb . Then observe the pressure gage, if the pressure stays between  $0.4 \text{ kg/cm}^2$  (0.4Bar) to  $0.3 \text{ kg/cm}^2$  (0.3Bar) in 30s, then there is not serious leakage on the whole EDUSTAK PRO. The EDUSTAK PRO could be used without problems.



**Step 8:** If the pressure goes down lower than  $0.3 \text{ kg/cm}^2$  (0.3Bar) quickly, please re-assemble the EDUSTAK PRO and check the following things carefully:

1. If the single cells have been installed in the right direction.
2. If the sealing has been installed in the right direction.
3. If the graphite plates and single cells have been screwed tightly.

## 9. FAQ

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**Q: What is EDUSTAK PRO?**

**A:** EDUSTAK PRO is designed by Horizon Fuel Cell Technologies for the stringent demand of fuel cell scientists and professionals.

Built for long life performance and scalability, they fit the needs for those who want to:

- do advanced research on MEAs
- investigate thermal effects in stacks
- perform professional training
- integrate fuel cell systems
- quick start a fuel cell lab

EDUSTAK PRO is fully modular from one to ten cells or more as required. Scale down or up can be achieved in lab environment by the user with simple tools.

Made of thick (6mm) graphite bipolar separators, the stack can be heavily equipped with sensors to investigate MEAs behavior.

**Q: How does EDUSTAK PRO work?**

**A:** After the stack has been assembled, and leakage checking has been done, connect the hydrogen supply, purging valve and load, etc. Make everything is ready for operation.

Supply hydrogen to the stack. The fuel cell starts heating and produce electricity.

Purging should be done manually every 2 minutes during operation.

**Q: What are the key features?**

**A:** The key feature are listed below:

- Stack can be taken apart and rebuilt to change single cell or insert sensors.
- Stack power can easily be scaled by adding/removing cells.
- Optimal thermal management with air cooling circulation in each plate.
- Stack is delivered with complete instruction guide.

## 9. FAQ

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**Q: What is the EDUSTAK PRO composed of?**

**A:** It is composed of end plates, single cell, sealing ring, flow channel plate, lead screw, insulation tube and fastening screws.

**Q: What is the power output of the EDUSTAK PRO?**

**A:** The rated output power for EDUSTAK PRO with 10pcs of single cell is 20W.

**Q: What are the requirements for the hydrogen supply to the EDUSTAK PRO?**

**A:** The hydrogen pressure during stack operating should be maintained between 0.45-0.55Bar and the purity should be more than 99.995%. The stack should be purged timely during the running time to ensure the hydrogen purity inside the cell.

**Q: How is EDUSTAK PRO different from other fuel cell education kits?**

**A:** The key feature of the EDUSTAK PRO is its ability to be personally assembled and dismantled by the user. We believe it's the best way to understand how a fuel cell really works.

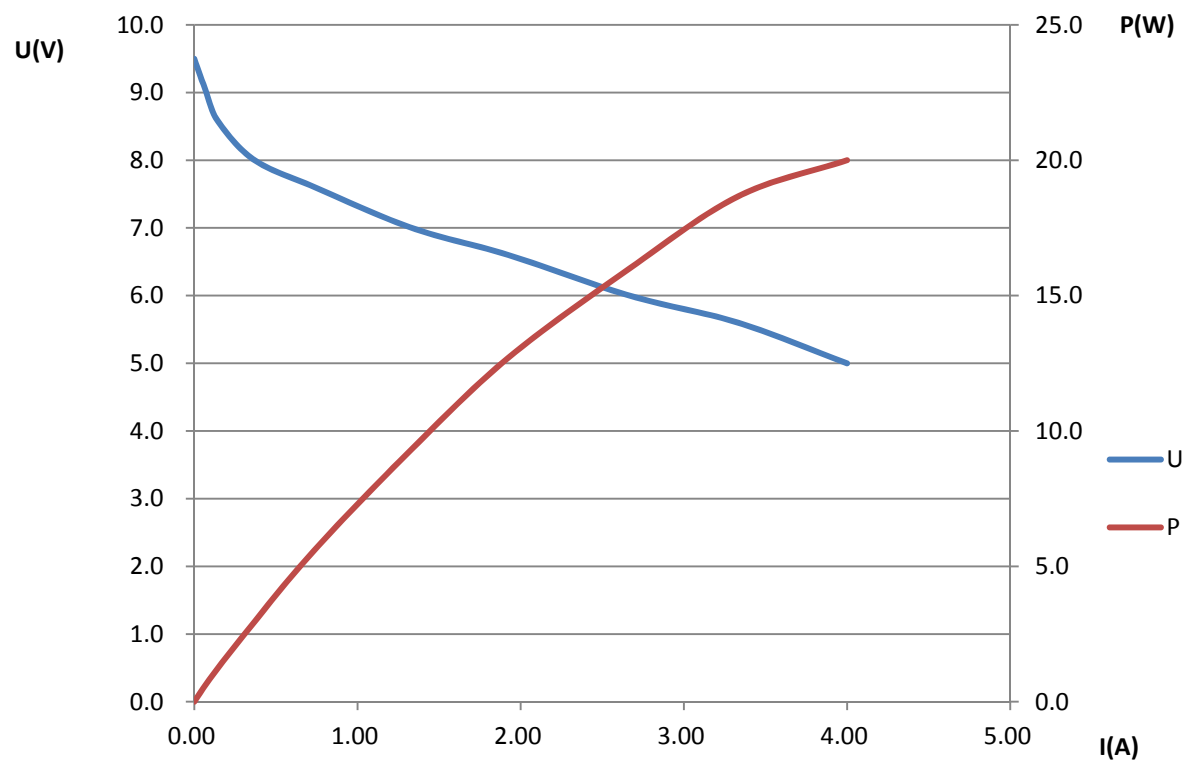
**Q: What is a HYDROSTIK PRO and what is it used for?**

**A:** HYDROSTIK cartridges store energy (up to 15 Watt hours) as hydrogen, which is stored in a solid metal hydride form inside the cartridge. The HYDROSTIK PRO does not store any power. Power is delivered by a fuel cell that converts the chemical energy of hydrogen stored in HYDROSTIK into usable electricity. When HYDROSTIK PRO cartridges are connected to Horizon's fuel cell devices, hydrogen from the HYDROSTIK PRO cartridge joins oxygen from the air through the fuel cell to generate electrical power. The HYDROSTIK PRO storage method makes it possible to use specially designed fuel cell devices with a practical, refillable and safe hydrogen supply. The HYDROSTIK PRO also offers the feature of being refillable many times.

## 9. FAQ

**Q: What is the EDUSTAK PRO performance curve?**

**A:** The performance curve with blower is listed below:



**Note:** User can increase or decrease the temperature to observe the stack performance. When the environment temperature is high, reduce the stack running temperature appropriately. When the environment temperature is low, please increase the stack running temperature appropriately. But the stack running temperature should not exceed 50 °C.

## 9. FAQ

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**Q: What is the hydrogen consumption rate?**

**A:** The hydrogen consumption rate is related to the load current and number of cell. The ideal value is  $I \times \text{number of cell} \times 7 \text{ ml/min} \cdot A$ . But during the running process, the value will be changed because of short circuit loss, purging loss, blower running loss and controller operation loss, etc. The loss is about 10%. Take 10pcs of cell as an example, the hydrogen consumption rate at max. output is 265ml/min or more.

**Q: The blower can be removed from the stack?**

**A:** No. The blower can supply fresh air to the stack and release heat. It is used for controlling the stack temperature under different power.

**Q: Wouldn't repeated assembly and dismantling damage the fuel cell?**

**A:** In conventional fuel cell stacks, yes, due to change in compression, gas sealing issue and mechanical disintegration. Not for EDUSTAK PRO. The secret is in our technology, a sealing border which allows the separation of Membrane Electrode Assemblies (MEAs or the fuel cells) from the bipolar conductive plates.

**Q: How can I replace the single cells?**

**A:** If a single fuel cell in the stack is damaged due to mishandling or loses power after extended usage, you can simply replace it with a new one. This is not possible in a conventional fuel cell stack as you cannot dismantle it. You can purchase a cell replenishment kit from us (a pack of 5 MEAs).

**Q: How can I obtain the required hydrogen supply?**

**A:** We strongly recommend metal hydride canisters as they are safe and simple to use. You can purchase from us or from your local market.

**Q: Do students need to be trained on any specific technical skills prior to building the EDUSTAK PRO?**

**A:** No. All they need is enthusiasm, creativity, and exploratory minds.



## 9. FAQ

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**Q: Can students share the EDUSTAK PRO?**

**A:** Yes, we designed it to be an interactive and fun learning educational kit. From building the stack, running simple experiments to full system integration projects, there are so many activities that students can do with the EDUSTAK PRO. We believe the ideal group size would be 3-4 students per stack.

**Q: How to keep EDUSTAK PRO always in a good condition?**

**A:** It should be kept in an air tight container. You should test it 2-3 times once a week and control it based on the temperature curve. After the EDUSTAK PRO has been stored for a long time, activate it and run it with high power.

**Q: How to activate the EDUSTAK PRO?**

**A:** Connect the positive side to the negative side for 0.1-1 second to make short circuit to the fuel cell stack. It is not allowed to be more than 1 second. Short circuit is the most effective way to quickly active the fuel cell stack. Make sure the stack has been assembled successfully and has no leakage problem.

**Q: What are the refill options for HYDROSTIK PRO cartridges?**

1. HYDROSTIKs can be recharged using Horizon's HYDROFILL PRO cartridge refilling solution.
2. You may contact your local Horizon service provider for HYDROSTIK PRO refill support at [sales@horizonfuelcell.com](mailto:sales@horizonfuelcell.com)
3. If needed HYDROSTIK PRO can be disposed after use, they are fully recyclable and do not contain any harmful materials.

**Q: Where do I recycle a spent or damaged HYDROSTIK PRO ?**

Contact your local consumer waste recycling center or return the HYDROSTIK PRO to a Horizon Fuel Cell Technologies vendor. Typically, HYDROSTIKs can be recycled where rechargeable batteries are recycled.

## 10. Troubleshooting

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### 1. The EDUSTAK PRO generates no voltage.

**Solution:** If the electrical connection to the EDUSTAK PRO is correct, check whether :

- a. The HYDROSTIK PRO has been fully charged with hydrogen.
- b. The hydrogen cartridge HYDROSTIK PRO is tightly connected to the pressure regulator.
- c. The EDUSTAK PRO has passed the leakage testing.

If, in spite of correct setup, the no-load voltage on the EDUSTAK PRO is too low , the cause probably lies in a dried out MEA in the EDUSTAK PRO. The MEA is moistened automatically during operation. This may take up to 5 minutes.

### 2. The EDUSTAK PRO leakages after assembly.

**Solution:** Check the following parts:

- a. The rubber sealing direction.
- b. The single cell direction.
- c. The graphite plate direction

All these parts should be placed in the correct direction and connected tightly. Please refer to the Assembly Guide for detailed information.

### 3. I squeeze the air pressure bulb, but the Manometer shows no pressure at all and the connection s are tight.

**Solution:** Turn the switch slowly on the air pressure bulb in clockwise until it can't be turned anymore.

## 10. Troubleshooting

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### 4. The pressure goes down quickly when I squeeze the air pressure bulb.

**Solution:** Close the clamp on the air pressure bulb tube . If the pressure still goes down quickly after the clamp has been closed, please re-assemble the EDUSTAK PRO and check the following things carefully:

1. If the single cells have been installed in the right direction.
2. If the sealing has been installed in the right direction.
3. If the graphite plates and single cells have been screwed tightly.