User's Manual and Operating Instructions

HydroStik Metal Hydride Cartridges

Version 9.1

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HYDROSTIK METAL HYDRIDE CARTRIDGES

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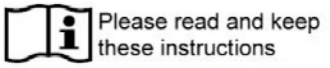
	Keep these instructions with this appliance
	Halten Sie diese Anweisungen mit diesem Gerät
	Gardez ces intructions avec cet appareil
	Conservare il presente manuale nei pressi dell'apparecchio
	Bewaar deze handleiding bij het apparaat

Further copies can be obtained from Horizon Fuel Cell Technologies or by emailing support@horizonfuelcell.com

Please refer to the Horizon website for latest information www.horizonfuelcell.com

Specifications and descriptions in this document were in effect at the time of publication. Horizon Fuel Cell Technologies reserves the right to change specifications, product appearance or to discontinue products at any time.

• Regarding This Manual

1. This Manual should be passed on to the end user.
2. Read this manual carefully and fully understand how to operate this product before you start operation.
3. Horizon Fuel Cell Technologies makes no warranty of any kind with regard to this material, but not limited to, implied warranties of merchantability for particular purpose.
4. All rights reserved. No part of this manual may be reproduced in any form without Horizon Fuel Cell Technologies' written permission.
5. Great effort has been expended to ensure that the descriptions in this manual are correct. Should you, however, come across a questionable area or note an inconsistency, a telephone call or email to Horizon Fuel Cell Technologies noting the questionable area would be highly appreciated.
6. The contents of this manual are subject to change without prior notice.

• Regarding Protection, Safety, and Prohibition Against Unauthorized Modification.

1. For the protection and safe use of the product and the system controlled by it, be sure to follow the instructions on safety described in this manual when handling the product. In addition, if you handle the product in contradiction to these instructions, our company does not guarantee safety.
2. The following safety symbol marks are used on the product concerned or in this Manual:

WARNING

A WARNING sign denotes a hazard. It calls attention to procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in injury or death of personnel.

CAUTION

A CAUTION sign denotes a hazard. It calls attention to a procedure, practice, condition or the like, which, if not correctly performed or adhered to, could result in damage to or destruction of part or all of the product.

IMPORTANT:

Indicates that operating the hardware or software in this manner may damage it or lead to system failure.

NOTE:

Draws attention to information essential for understanding the operation and features.

TIP:

Gives information that complements the present topic.

• Disclaimer

1. This manual incorporates safety guideline and recommendations. However, it is not intended to cover all situations. It is responsibility of customer to meet all local safety requirements and to ensure safety during operation, maintenance and storage of the HydroStik canister.
2. Horizon Fuel Cell Technologies assumes no liability to any party for any loss or damage, direct or indirect, caused by the use or any unpredictable defect of the product.
3. Although all efforts have been made to ensure the accuracy and completeness of the information contained in this document, Horizon reserves the right to change the information at any time and assumes no liability for its accuracy.

II. Introduction

Thank you for purchasing the HydroStik Metal Hydride Cartridges.
Please lead the following respective documents before preparing and using the HydroStik Metal Hydride Cartridges.

● General Precautions

IMPORTANT:

READ ALL INSTRUCTIONS

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.

DO NOT use an attachment not recommended, as it may result in a risk of electric shock or fire.

DO NOT disassemble or tamper with appliance.

WARNING

! WARNING: Fire Hazard!

Do not tamper with device. Read and understand Operation instructions.

! WARNING: This is not toy – keep away from children.

Contents are flammable. Do not disassemble.

Avoid contact with contents.

Do not expose to temperature above 50°C or open flames.

Follow usage instructions.

Remove from fuel cell device immediately after use.

WARNING

! WARNING: Under no circumstance is the cartridge to be disassembled. Exposure to air will render the hydride material useless and require replacement. Materials within the hydride are potentially dangerous.

The cartridge must be placed horizontally when it is being charged otherwise the cartridge can crack!

CAUTION

! CAUTION: When using the appliance, basic safety precautions should always be followed to reduce risk of fire, electric shock or personal injury.

IMPORTANT:

IMPORTANT SAFETY WARNING AND INSTRUCTIONS TO REDUCE RISK OF INJURY:

Keep away from children.

Keep away from alkaline and acidic environment.

Before using the appliance, be sure everyone using reads and understands all safety instructions and other information contained in the operation instructions!

NOTE:

Hydrogen shall be stored, handled, and used so life and health are not jeopardized and the risk of property damage is minimized.

THIS APPLIANCE is not tested for use with medical devices.

TIP:

Save these instructions and review frequently during use.

- **Product Specification**

Metal Hydride Cartridge for Hydrogen Storage

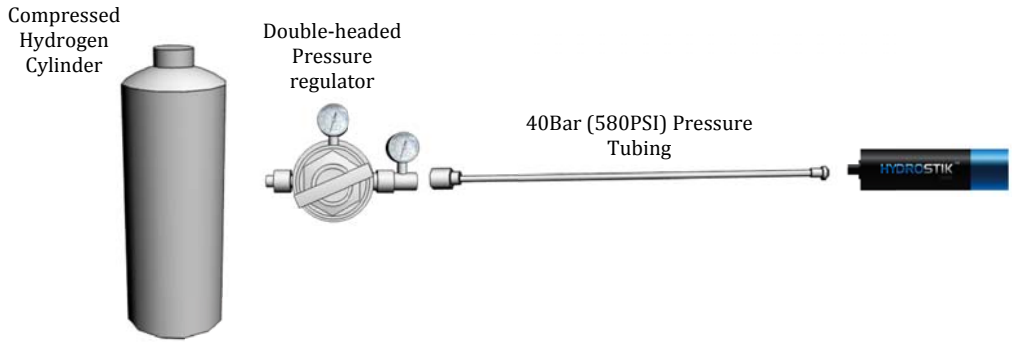
General	Model	HydroStik				
	Hydrogen Storage Capacity	10NL	Dimensions(mm)	Ø22 x 87mm	Weight	90g
	Cylinder Material	Aluminum 6061				
	Cylinder Color	Sliver				
	Operating Temperature	0～35 °C				
Hydrogen Charging	Gas Purity	>99.99% (CO <1ppm, CO_2<10ppm, O_2<4ppm)				
	Gas Dew Point	< -50°C				
	Charging Pressure	1.5MPaG @ 20°C				
	Charging Temperature	0～30°C				
Hydrogen Discharging	Typical Discharging Performance	20-40ml/m (based on MiniPak)				
		Discharging Condition/outlet pressure: 0MPaG; Ambient:15°C Discharging flow rate is maintained up to 95% of the whole storage capacity.				
	Discharging	0～1.5MPaG @ 25°C (Depends on the remaining H2 amount.)				
	Discharging Temperature	5～50°C (When the temperature is below 5°C, the discharging hydrogen capacity will be less than this specification.)				
Features	Safety	Hydrogen gas is stored in solid metal powder under low pressure. It is safer than conventional methods for storing liquid and compressed hydrogen.				
	Compact size	10NL of hydrogen can fit in your hand. 350NL can easily be assembled on the Hydrobike.				
	Scalable	The storage devices can supply fuel for any size hydrogen-based application - small or large, vehicular, portable, on-board or stationary.				
	Reversible	The storage devices can be discharged and recharged with speed, efficiency and control.				
	Long life	The canisters are robust and are designed to have a long service life.				
	Easy handling	Our storage devices hold more hydrogen than compressed hydrogen cylinders, readily accept hydrogen from reformers, electrolyzers and other sources, and can be used safely in more applications than liquid hydrogen.				
	No extra heat needed	Fully operable at an ambient temperature,with a moderate pressure difference for absorbing and discharging hydrogen gas.				

III. Principles of Hydrogen / HydroStik Metal Hydride Cartridges

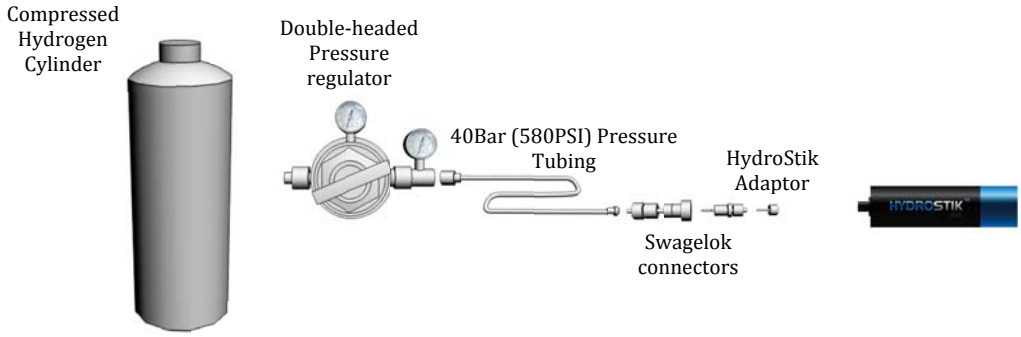
Metal hydride hydrogen storage Cartridges developed and manufactured by Horizon Fuel Cell Technologies are designed with an aluminum alloy materials enclosure and a 6AB2 alloy for hydrogen absorption. After activation, the AB2 alloy is capable of absorbing hydrogen, expanding and releasing heat until saturation. The internal pressure of the fully charged cartridge remains at 30 Bar (435PSI) at ambient temperatures of 20˚C - 25˚C and the weight is 0.9 gram higher. Once the cartridge valve is opened and pressure is reduced, hydrogen will be continuously released from the alloy that will absorb heat. If the heat absorption rate decreases, so will the hydrogen release rate. The cartridge enclosure materials are made of an aluminum alloy that has excellent heat conductivity properties that can facilitate heat conduction of the alloy during gas absorption and release processes. Gas absorption efficiency of the alloy can be significantly impacted by oxidization due to humidity, therefore dry hydrogen gas with a purity of no less than 99.99% is required for use.

● Mechanism Sampling

Option 1



Option 2



IV. Safety Instructions

The safe and successful use of the HydroStiks and hydrogen in general starts with knowing of and adhering to appropriate standards and guidelines for the design of the hydrogen facilities.

CAUTION

× Safety shall be considered in all phases of a hydrogen facility life cycle, beginning with its initial design and continuing through its fabrication, construction, operation, maintenance, and ending with its decommissioning.

× Regardless of quantity, all hydrogen systems and operations must be devoid of hazards by providing adequate ventilation, designing and operating to prevent leakage, and eliminating potential ignition sources.

× Safety systems should be installed to detect and counteract or control the possible effects of such hazards as cartridge failures, leaks and spills, collisions during transportation, vaporization system failures, ignitions, fires and explosions, cloud dispersions, and the exposure of personnel to cryogenic or flame temperatures. Undetected hydrogen leaks can lead to fires and explosions.

× Cartridges (filled with hydrogen) shall be kept away from fire, and temperatures above 50˚C while filling, storage and using.

× The maximum outlet pressure of the regulator should not exceed 40 Bar (580PSI) to avoid any complications or failures with the cartridges.

× When using a cylinder to refill or activate the cartridge, the inlet pressure from the compressed cylinder should be at least 1.5 times that of the outlet pressure.

WARNING

The cartridge must be placed horizontally when it is being charged otherwise the cartridge can crack!

• Hydrogen Operating Procedures

Operating procedures along with instrumentation and control systems shall be evaluated for their capacity to provide the required safety. Analysis or certification testing shall verify equipment performance.

•Personnel

- Personnel handling hydrogen or handling equipment for hydrogen systems must become

familiar with the physical, chemical, and specific hazardous properties of hydrogen gas.
- Training should include detailed safety programs that recognize human capabilities and limitations.

- Storage
  - Store the cartridges in a safe and secure place.
  - Store the cartridges in a dry and cool place.
  - DO NOT store the cartridges in sunlight.

● Training

Operator training shall be reviewed and demonstrated to be adequate before operations commence. Operator training should be evaluated continuously.

● Emergency Procedures

The safety of personnel at and near the hydrogen lab shall be carefully reviewed and emergency procedures developed at the earliest planning and design stages. Advance planning for a variety of emergencies such as fires and explosions shall be undertaken so the first priority is the reduction of risk to life.

IMPORTANT:

Analyses of accidents have shown that the response, through design or operating procedures, to a failure should be such that a single failure does not lead to a series of failures or a chain reaction of failures; such as, any failure must be restricted to a local event; otherwise, the hazard and potential for damage is greatly enhanced.

V. Requirements HydroStik Metal Hydride Cartridge

- **Provided by Horizon**

  (1) HydroStik metal hydride cartridge

  (2) Refilling tubing connects the cartridge to the regulator

  (3) A Horizon-designed adaptor that connects the SWAGELOK connector to the HydroStik

- **Other Items Required**

  (1) A compressed hydrogen cylinder with pressure of 150 - 200 Bar (1276 – 2900PSI).

  (2) A H_2 pressure regulator that can handle an input pressure of at least 200 Bar (2900PSI) and deliver output pressures that can be adjusted from 10 Bar (145PSI) to 40 Bar (580PSI). This regulator should include 2 pressure gauges that can display the input pressure and the output pressure.

  (3) Male & Female SWAGELOK 1/8” quick connectors type QC4-B-200 and QC4-D-200.

  (4) A 40Bar (580PSI) resistant hose assembly connecting the output of the regulator to the SWAGELOK quick connector.

  (5) A water basin that is big enough to hold the cartridge underwater in a horizontal position.

  (6) Two adjustable wrenches.

VI. Before Operation

Before starting the operation process, regardless of quantity, it is crucial to check all hydrogen systems on the safety and operational aspects in order to rule out and exclude any possible hazards, failures or setbacks during the process. Therefore, it is highly recommended that the whole operation will be carried out adequate and will follow all instructions provided here. Doing so will also maintain the cycle and lifetime of the HydroStik.

● Checklist before operation

(1) Do the lab and operation environment *comply* and *consist* with all the safety standards regarding the usage of hydrogen and HydroStiks?

(2) Is the *training of the operator sufficient*, and is the operator *aware* and does he/she *understand* all the safety aspects regarding the operation of the HydroStiks and hydrogen in general?

(3) Is the safety of the personnel at and near the hydrogen lab taken into account, and are all emergency procedures *clear* and *intelligible*?

(4) Are the HydroStik cartridges checked for any traces of *damage*, *deformation*, *leakage*, or *impact of any kind*?

(5) Are all the tube *connections and nuts* checked regularly, so no contamination of any kind will interfere in the process?

● Checklist during operation

(1) Operations against rules stated in this user manual are strictly prohibited.

(2) Strictly comply with the safety operation regulations. Keep close attention to the changing of the working pressure, temperature and working media, etc.

(3) Disassembling any parts of the HydroStik cartridge under pressure is strongly prohibited.

(4) It is strongly prohibited to use the pressure cartridges beyond the operation conditions.

VII. (Re)Filling the HydroStik Metal Hydride Cartridge

There are two options for (re)filling the HydroStik Metal Hydride Cartridge. How these operations are carried out, is stated in this paragraph.

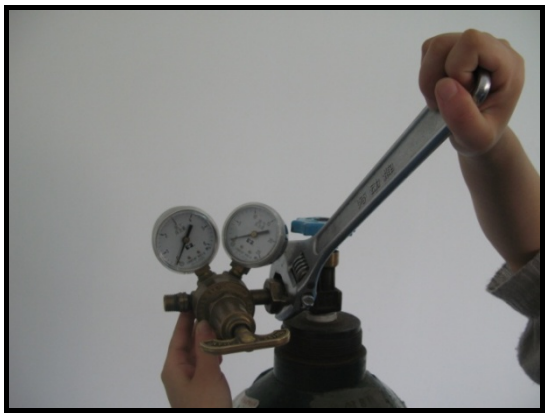
IMPORTANT:

Note that all directions are based on the equipment used as standard by Horizon Fuel Cell Technologies. We cannot feasibly cover all international variations of equipment, threads, dimensions and therefore omit these details to reduce confusion. Therefore we highly recommend that you read through the instructions without putting the equipment together to familiarize yourself with the process and make sure you have all the correct components. It is very important that the connections equipment match, as any leakage is very dangerous.

- **Option I.**

Direct Cartridge (Re)Filling: one cartridge at a time

(1) Use a wrench to (anti-clockwise) screw securely the dual headed pressure regulator to the pressurized hydrogen cylinder that can be obtained from a local gas company. (See pictures below)



(2) Again using a wrench, screw the nut on the hydrogen cable provided to the dual headed pressure regulator provided. The nut needs to be tightened by turning the wrench anticlockwise. (See pictures below)

(3) Turn the duel headed pressure regulator handle anti-clockwise until it is tight. Make sure it is in the closed condition, so that the dual pressure regulator shows a zero reading on both dials.

CAUTION

Inspect the connections for leaks by applying some soap water on all connections. If you notice bubbles appearing please close the cylinder valve, stop the procedure and contact your professional suppliers for technical support.

IMPORTANT:

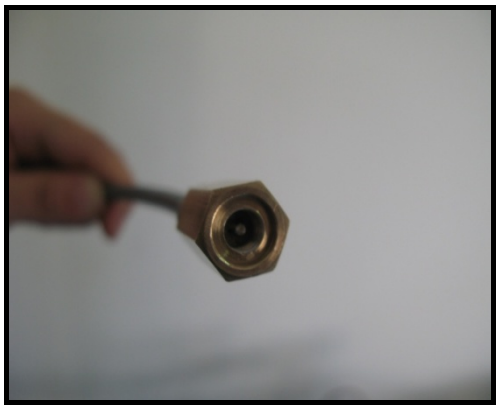
Also if the cylinder's pressure is lower than 30Bar (435PSI), stop using this cylinder because the pressure is too low to charge the cartridge.

NOTE:

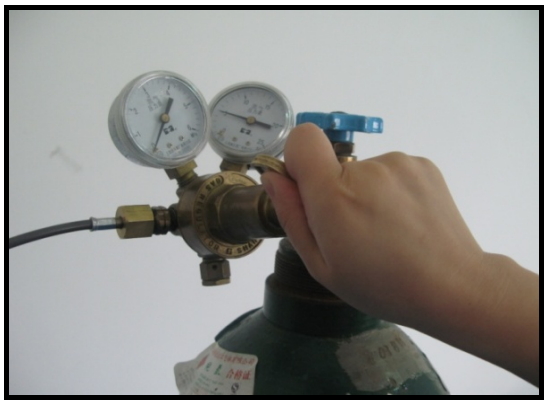
Before connecting the HydroStik, turn on the dual headed pressure regulator valve clockwise to 1Bar (14.5PSI) to release the impure gases

out of the tube. Repeat this 2-3 times for pure gases used in the next hydrogen charging process.

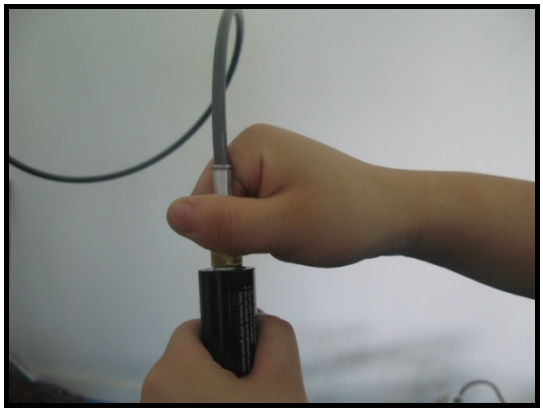
(4) Prepare a plastic tub that the metal hydride cartridge can lie in horizontally, with enough water (ambient temperature) to cover the metal hydride cartridge. Holding the other end of the Hydrogen cable, connect the HydroStik Metal Hydride cartridge to the cable by turning the cartridge clockwise until it is securely fastened to the cable. (See pictures below)



(5) Place the HydroStik into the tub full of water so that it lies horizontally under the water. Slowly turn the dual headed pressure regulator valve clockwise, making sure you watch the left-handed pressure reading. When it reaches 30 Bar (435PSI) allow the Metal Hydride cartridge to fill for about 30 minutes. And then turn the dual headed pressure regulator valve anti-clockwise until it is tight to check if the dial moves slowly towards zero. If the dial does not move that means the cartridge is fully filled. If the dial moves down continuously, please turn the headed pressure regulator to 30 Bar (435PSI) for continuous charging.



(6) Turn off the dual headed pressure regulator anti-clockwise until it is closed. At this time the lower pressure meter still indicates the pressure you charged the cartridge. Disconnect the HydroStik from the hydrogen cable. The meter will be back to 0.



(7) Use the wrench to disconnect the hydrogen cable from the pressure regulator and turn the hydrogen supply off if not use them anymore.

- **Option II.**

SWAGELOK Refilling: one cartridge at a time

(1) Separate the SWAGELOK quick connector system into male (QC4-D-200) and female (QC4-B-200) parts (fig 1).

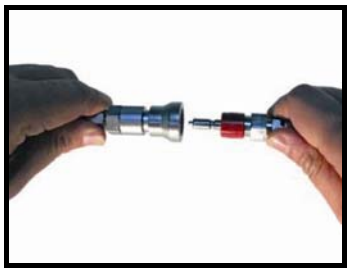


Fig 1

Fig 2

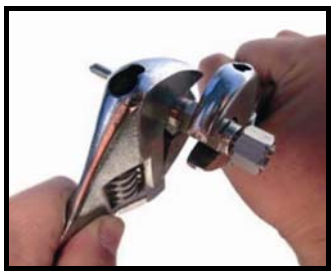


Fig 3

Insert the fine point of the special Horizon-designed adaptor (figure 2) into the male (QC4-D-200) part of the SWAGELOK connector. Once the adaptor component is positioned inside the SWAGELOK unit, use the wrench to tightly fasten the SWAGELOK nut onto the adaptor (figure 3). This will create a permanent connection between the adaptor and the male part of the SWAGELOK unit. Once the nut is fastened, do not attempt to disassemble it.

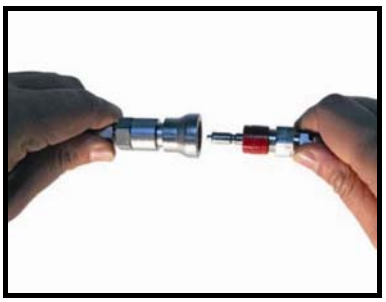


Fig 4

Fig 5

Reassemble the female and male parts of the SWAGELOK unit (figures 4&5), and connect it to your regulator's hose.

IMPORTANT: This hose must be resistant to 40 Bar (580PSI) of pressure.

(2) If your regulator is already connected to your pressurized hydrogen cylinder and tested for leaks, go directly to step 6.

Make sure the hydrogen pressure cylinder valve on top of the cylinder is tightly closed.

To connect your regulator/hose assembly to the pressurized hydrogen cylinder, use the adjustable wrench to tighten the

regulator inlet connector nut onto the compressed cylinder in a counter clockwise direction (figure 6&7).

Fig 6

Fig 7

(3) Make sure the regulator inlet valve is closed. To close the regulator's valve, turn the regulator's adjusting knob in the counter clockwise direction (figure 8&9).

Fig 8

Fig 9

(4) Slowly open the compressed cylinder valve to observe the reading in the high pressure gauge (figure 10). This will indicate the internal pressure of the compressed cylinder, which should not be more than 200 Bar (2900PSI) (figure 11), but above 30 Bar (435 PSI).

Fig 10

Fig 11

(5) Inspect the connections for leaks by applying some soap water on all connections (figures 12&13). If you notice bubbles appearing please close the cylinder valve, stop the procedure and contact your professional suppliers of the pressure regulator and/or compressed cylinder for technical support.

Fig 12

Fig 13

(6) Before connecting the HydroStik for filling, we must get rid of any non-Hydrogen gases from the system. Open (clockwise) the regulator's valve to 1 Bar (14.5PSI) for 5 secs and then close (counter-clockwise) it again (figure 14).

Fig 14

(7) Screw (clockwise) the HydroStik cartridge onto the SWAGELOK / Horizon adaptor assembly (figure 15&16).

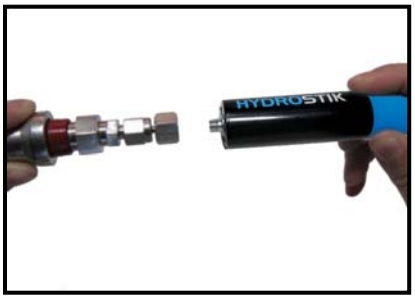


Fig 15

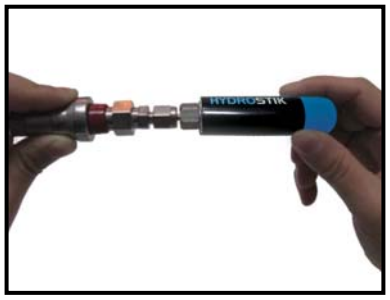


Fig 16

(8) Fill the water basin with cold water. This helps the refueling process in two ways:

NOTE:

1. To help the absorption of Hydrogen into the metal hydride by keeping the cartridge cool.

2. To be able to check for any leakages coming from the cartridge, cable or connection points.

Place the HydroStik connected to the SWAGELOK/hose assembly horizontally into the water basin (figure 17).

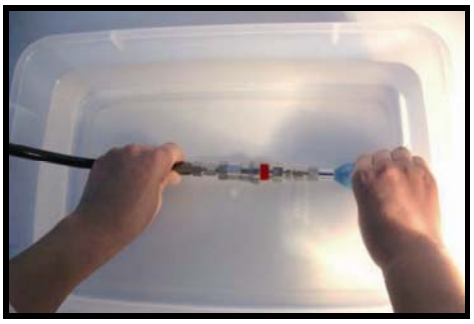


Fig 17

(9) Turn the regulator adjustment knob slowly in the clockwise direction until the low pressure gauge indicates a reading of no more than 1 Bar (14.5PSI). Look at the cartridge and connections in the water to ensure no bubbles are appearing under water. If you see bubbles close the cylinder valve, stop this procedure, and go back to step 1. If problems persist, please contact your professional suppliers for technical support.

(10) After completing steps 1-10, turn the regulator knob slowly until the outlet low pressure gauge indicates the reading 30 Bar (435PSI). Wait for 30 minutes. Please ensure no bubbles are released inside the water basin during this process. If you see bubbles, close the pressure cylinder valve, stop the process and contact technical support.

(11) After 30 minutes, check if the pressure is below 30 Bar (435PSI). If it is, continue the refilling process until it reaches a constant pressure of 30 Bar (435PSI), otherwise unscrew the regulator knob (counter clockwise) until you feel it loosens. The low pressure gauge reading should remain at 30 Bar (435PSI).

(12) Close the compressed cylinder valve.

Remove the cartridge and all connections from the water basin. Unscrew the cartridge from the SWAGELOK connector assembly quickly. This will ensure the cartridge will not release much hydrogen into the air.

VIII. Maintenance

Sustainability, Storage

In order to keep the HydroStik Metal Hydride Cartridges in the optimal condition, please follow the subsequent instructions.

WARNING

DO NOT try to dissemble, open or repair the cartridges when broken or worn out!

IMPORTANT:

1. Empty HydroStik Metal Hydride Cartridges:

- DO NOT try to open the cartridges.
- DO NOT try to repair the cartridges when worn out or broken.
- DO NOT store cartridges in direct sunlight.
- Keep it away from fire.
- Keep in a safe place.
- Keep in a dry, cool place.
- Keep away from children.

2. Filled HydroStik Metal Hydride Cartridges:

- DO NOT try to open the cartridges.
- DO NOT try to repair the cartridges when worn out or broken.
- DO NOT store cartridges in direct sunlight.
- Keep away from fire.
- Keep in a safe place.
- Keep in a dry, cool place.
- Keep away from children.
- Keep away from temperatures above 50˚C while filling, storage and using.
- The maximum outlet pressure of the regulator should not exceed 40 Bar (580PSI).

IX. FAQ

This FAQ section of our HydroStik Metal Hydride Cartridges will help you find the answers to numerous queries.

» Where can I get my HydroStik Metal Hydride Cartridge refilled?

To refill or order, visit our online Horizon Hydrogen Shop or contact info@horizonfuelcell.com and you will be diverted to your local Horizon HydroStik Metal Hydride Cartridge outlet.

» Can a refill shop also supply a new HydroStik Metal Hydride Cartridge?

Yes, our Horizon Hydrogen retail outlets can supply and exchange HydroStik Metal Hydride Cartridges contact info@horizonfuelcell.com for your nearest Horizon Hydrogen outlet.

» What is the cost of the initial charge on a cylinder?

This varies between place and time, please ask at your nearest Horizon Hydrogen outlet or contact us directly info@horizonfuelcell.com or via our Horizon Online Store.

» I have inherited unwanted empty or broken HydroStik Metal Hydride Cartridges how do I dispose of them?

To locate your nearest HydroStik Metal Hydride Cartridge outlet please call Horizon Fuel Cell Technologies or use our website.

» I have purchased a HydroStik Metal Hydride Cartridge, should I have received a (gas pressure) regulator of any kind with it?

No, regulators are not included as standard you will need to order those as well. Items that are supplied are:

(1) A HydroStik metal hydride cartridge

(2) A Horizon-designed adaptor that connects the SWAGELOK connector to the HydroStik.

Alternatively you can purchase one online visiting the Horizon Online Store or contact info@horizonfuelcell.

» Do HydroStik Metal Hydride Cartridges come delivered to you sealed? How are they sealed?

There is a gas tight valve in the cartridge head that doesn't allow for gas to release. This will not be an issue though as the canisters will not contain any gases during delivery.

» I would like to exchange my Cartridge for a different size, can we do this at any Horizon related outlet?

No, for now we only distribute a single size HydroStik Metal Hydride Cartridge.

» Taking Cartridges abroad/availability of HydroStik Metal Hydride Cartridge abroad?

Hydrostiks can be carried in hand luggage and put into check-in luggage. If in carry-on it would best to check with the airline how many cartridges you are allowed to carry onboard, understanding is that US airlines it would be best o check with the airline how many you are allow onboard.

» How many hours of electricity are provided by a HydroStik Metal Hydride Cartridge?

The HydroStik Metal Hydride Cartridges contain up to 11 Wh of electricity. So if drawing 1W from the fuel cell, it will run for 11hours.

» How can I monitor how much gas is left in a cylinder?

This can be measured by weight, measuring the empty weight gives you the benchmark level and then you can work out the total amount of hydrogen by understanding that 11Liters of Hydrogen =1gram so make sure your scales can work in $1/10^{th}$ of $1/100^{th}$ of a gram to get accurate readings. Pressure cannot be used as a measurement of the amount of Hydrogen in the canister as the pressure is almost the same between 10%-90% full.

» What are the dimensions of cylinders?

Canister name: HydroStik Metal Hydride Cartridge

Weight: 90g

Height: 85mm

Diameter: 22mm