

VLIII150 Fuel Cell System

User Instructions

Disclaimer

This manual contains safety guidelines and operational recommendations. However, this does not mean that this manual can cover all circumstances. The customer is responsible for meeting all local safety requirements to ensure the safety of the fuel cell system during operation, maintenance and storage.

Horizon reserves the right to modify the User Instructions from time to time and at its sole discretion. It is the responsibility of the User to verify the accuracy of the information in the User Instructions with Horizon to ensure optimal performance of the fuel cell for the User's installation and operational circumstances

The following actions will invalidate the fuel cell system warranty:

- Disassemble or improperly tamper with the fuel cell system under any circumstances.
- Operate the fuel cell system in a manner not specified in the system settings or in the user manual for a specific product.
- Damage to a fuel cell system by accident, mis-operation, man-made damage or negligence.
- Hydrogen is supplied to the fuel cell system from a hydrogen source that does not meet the requirements from User Instructions.
- Hydrogen is supplied to the fuel cell system at a hydrogen source pressure not in conformity with the requirements from User Instructions.

Under no circumstances should the user dismantle or tamper with the system. In case of disassembly or tampering, the warranty will be void. If you have any questions or need help with the system or its technology, please contact Horizon.

Revision history

Revision history			
Revision#	Description	Author	Date
1.0	The first edition	Kevin Ren	2023/3/1

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1. Product Uses and Functions

1.1. Product Uses

The VLIII150 fuel cell system of Horizon Fuel Cell Technologies (Horizon) is one of the best fuel cell systems in the hydrogen fuel cell industry. It is mainly applied in the following fields:

1. It can be used as a direct source of power or range extender for vehicles such as trucks, buses, coaches, tractors, rail transit and other electric transportation vehicles.
2. It can be used as a standalone or backup power supply for industrial and commercial users including hospitals, schools and other businesses. It can also be used as an energy storage system to balance power connected to an electricity grid.

1.2. Product Function

A hydrogen fuel cell is a generator that converts the chemical energy of hydrogen and oxygen directly into electrical energy. The basic principle is that hydrogen releases electrons at the anode by a catalyst, and the electrons are conducted to the cathode through an external circuit. Protons are transferred to the cathode through a proton exchange membrane (PEM) and interact with oxygen under the action of the catalyst to generate water, electricity and heat. The fuel cell system has the following advantages:

1. High efficiency: the fuel cell directly converts chemical energy into electric energy without intermediate conversion between heat energy and mechanical energy (generator).
2. Zero emissions: the fuel cell is fueled by hydrogen and oxygen, and the only emission is clean water. It works without carbon monoxide or carbon dioxide, also does not emit sulfur or any particulates. Therefore, hydrogen fuel cell

vehicles are truly zero-emission, zero-pollution vehicles, hydrogen fuel is the ideal vehicle fuel.

3. Short refilling time: hydrogen fuel cell vehicles use hydrogen storage tanks to store fuel. Hydrogen refilling time is about 5-10 minutes, providing continuous operation of a vehicle with typical range of 300-500 kilometers.

2. Product Performance Description

2.1. Working Principle

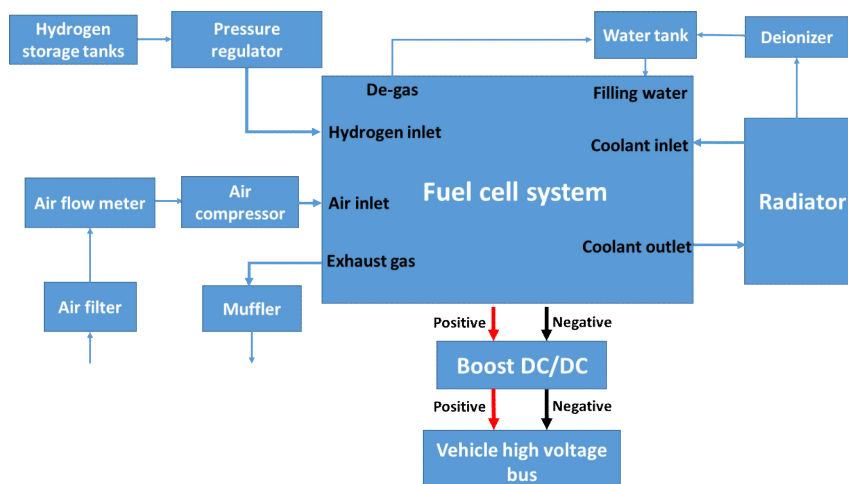
A fuel cell system is a power generation device that converts the chemical energy of hydrogen and oxygen directly into electric energy. Its core component is the fuel cell stack. For an operating fuel cell system, it also requires the matching oxygen supply system, hydrogen supply system, heat dissipation system and electrical control system. Ambient air passes through an air filter, is pressurized by an air compressor before an intercooler cools the compressed air down before it passes through a humidifier and finally enters the fuel cell stack.

Hydrogen, stored at 350 Bar in storage tanks, passes through a decompression device and enters a hydrogen heat exchanger that heats the hydrogen before it enters the fuel cell stack. Hydrogen and oxygen react to generate water, electricity and heat. The heat generated by the reaction is dissipated by a radiator.

The generated electricity is boosted by an inverter to match the vehicle voltage. It directly supplies the motor and electrical components of the vehicle, or power to the auxiliary batteries.

The water produced by the reaction is discharged into the atmosphere along with the air remaining in the reaction and a trace amount of hydrogen that has not fully reacted. The working principle diagram of the fuel cell system is shown in Figure 2-1 below.

Figure 2-1 Working principle diagram of the gas power system



2.2. Product Operating Conditions

2.2.1. Requirements of Fuel and Coolant

To ensure the normal operation of the fuel cell system, there are strict requirements for hydrogen, air, and coolant. The detailed requirements are shown in Table 2-1 below.

Table 2-1 gas and liquid specifications

Type	Specifications
Hydrogen (>99.97%)	
Other ingredients	<300ppm
	<2ppm CO ₂
	<0.1ppm CO
	<5ppm H ₂ O
	<2ppm hydrocarbon
	<5ppm O ₂
	<300ppm He
	<100ppm N ₂ 、Ar
	< 0.004ppm H ₂ S, COS, CS ₂ , mercaptans
	< 0.01ppm of formaldehyde
	<0.2 ppm formic acid

	<0.1ppb NH ₃
	< 0.05 ppm halogenated compounds
Air	
Oxygen	>20.95%
Nitrogen	<78.08%
Other gas components	
	<0.1ppm CO
	<1% CO ₂
	<1ppm O ₃
	<0.01ppm SO ₂
	<0.04ppm Hydrogen sulfide
	<0.025ppm NO
	<0.05ppm NO ₂
	<0.008ppm Volatile organic compounds
	<0.01ppb NH ₃
Atmospheric particle composition	
	<90µg/m ³ PM10
	<15µg/m ³ PM2.5
Cooling fluid	
	50% deionized water + 50% glycol
	particle size<100µm
	Conductivity<5µs/cm

Note:

- Choose the coolant carefully. Ordinary coolant may not be applicable. The additives may cause the conductivity to be too high or the insulation resistance of the system to be too low. Therefore, please check with Horizon about the manufacturer and model of the coolant before using with the fuel cells.
- Ethylene glycol is a toxic reagent. Drink or inhaling steam, may cause physical health problems, the operation of ethylene glycol must follow the product instructions.

2.2.2. High and Low Voltage Power Distribution Requirements

Parts of the fuel cell system require high and low voltages for operation. The power requirements are as shown in Table 2-2:

Table 2-2 High and Low Voltage Power Supply Requirement table

No.	Distribution form	Demand voltage	Demand power	Note
1	High voltage distribution	500~720VDC (Lithium bus voltage)	20kW (starting heating for low temperature, PTC is 14kW)	≤15min
2	Low voltage power distribution	24VDC	600W	24 V normal power

2.2.3. Introduction of Matching Air Compressor

The VLIII150 system needs an external oxygen supply system. After physical matching and system verification, Horizon recommends air compressor, which has high pressure ratio, large flow and low noise.

The performance parameters of air compressor are shown in Table 2-3. The map of the air compressor is shown in Figure 2-2:

Table 2-3 Introduction of Air Compressor

Number	Project parameters	Unit	Minimum	Maximum	Note
1	Matching stack power	kW	/	?	
2	Power	kW	-	42	Rated 30kW
3	Speed range	Rpm	20000	95000	
4	Outlet flow	g/s	0	180	Pressure ratio is 3.0
5	inlet temperature	°C	-40	45	
6	Coolant pressure	kPa	-	300	absolute
7	Inlet ambient temperature	°C	-30	45	
8	Maximum heat dissipation power of air compressor	kW	-	2	

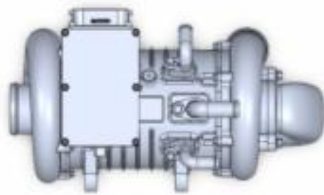
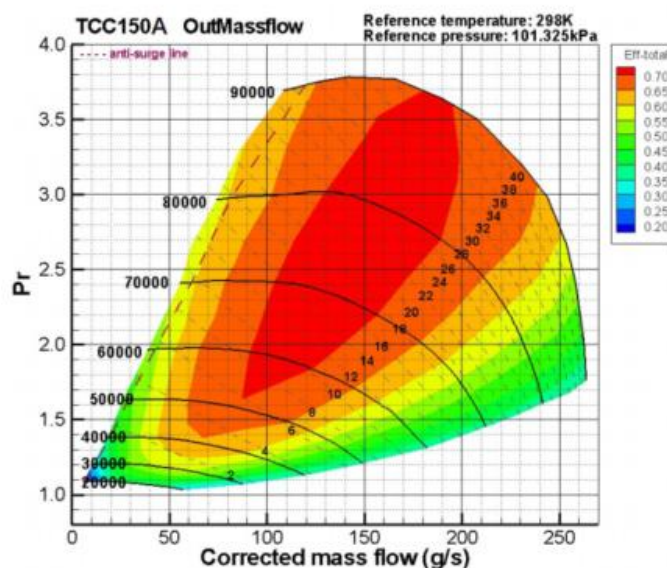
9	Protection grade	-	-	IP67	
10	Weight	Kg	Air compressor weight 17.3kg,		
11	Air compressor with controller graphics				

Figure 2-2: Air Compressor MAP Diagram



2.2.4. Introduction of Matching DCDC

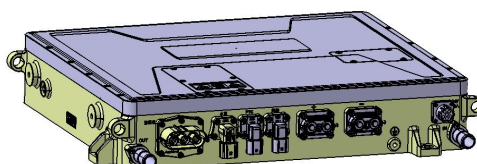
The VLIII150 system requires an external DCDC. After physical matching and system verification, Horizon recommends the model. The performance parameters of DCDC are shown in Table 2-4 below. The appearance of the DCDC is shown in Figure 2-3 below:

Table 2-4: DCDC Performance Parameters

No.	Item	Parameter	Note
1	Rated power (kW)	180	

2	Input voltage (DCV)	45-750	
3	Input current (A)	750A Max	
4	Output voltage (DCV)	400-750VDC	Rated 560V
5	Output current (A)	0-600A	
6	Low voltage platform (V)	24	From vehicle (18-32V)
7	maximum efficiency (%)	≥ 98	Input voltage $\geq 200V$, output voltage 560V
8	Protection grade	IP67	

Figure 2-3: DCDC Appearance Diagram



2.2.5. Introduction of Matching Pumps

The VLIII150 system needs a matching water pump. After physical matching and system verification, Horizon recommends the model The performance parameters of the water pump are shown in table 2-5, the appearance of the pump is shown in figure 2-4, and the characteristic curve of the pump is shown in figure 2-5:

Table 2-5 Parameters of the water pump

No.	Item	Parameter	Note
1	Liquid head pump flow head requirements	$\geq 475L/min@175Kpa$	
2	Rated power (W)	≤ 2900	
3	Voltage platform (V)	450-750V	
4	The motor type	Permanent magnet synchronous machine	
5	Motor rated speed/peak speed (RPM)	6600/6750	
6	Ambient temperature (°C)	-40~80	
7	Liquid temperature (°C)	-40~90	

Figure 2-4 Appearance Diagram of the Pump

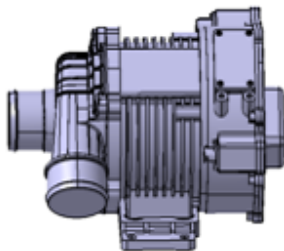
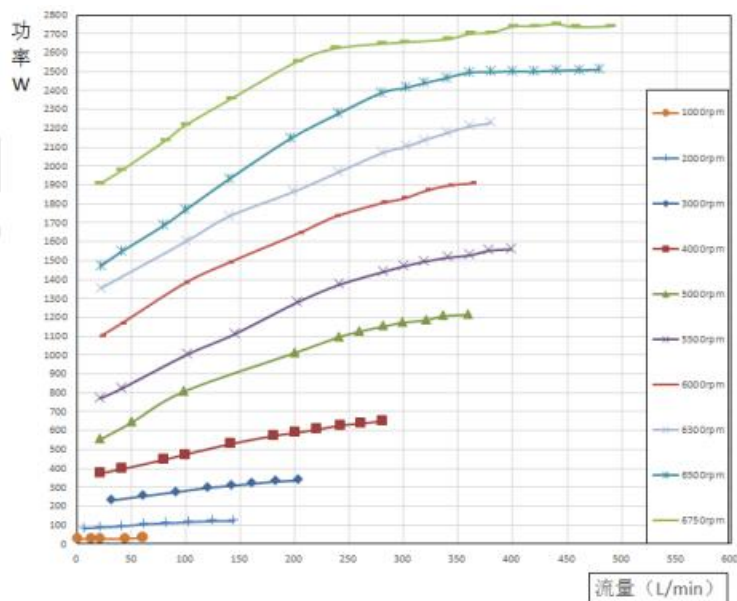


Figure 2-5 Characteristic Curve of the Pump



2.2.6. Auxiliary Cooling Requirements

The main DC/DC and air compressor and controller cooling cannot be integrated into the fuel cell cooling system. It needs to be integrated into the Auxiliary cooling system. The heat dissipation and flow requirements are shown in Table 2-6.

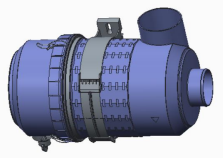
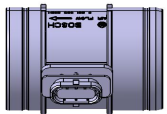
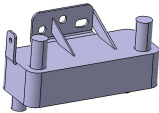
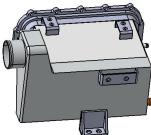
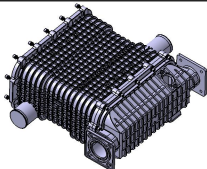
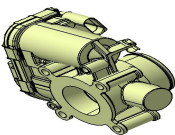
Table 2-6: Vehicle Cooling Demand Table

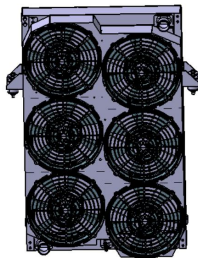
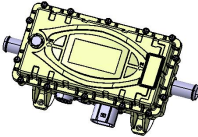
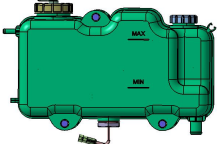
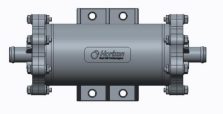
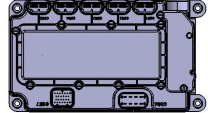
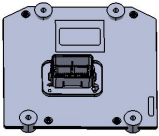
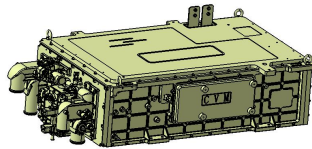
No.	Item	Power (kW)	Required flow rate (L/min)	Inlet and outlet water temperature (°C)	Flow water resistance (bar)	Heat loss (kW)	Pressure resistance of cooling line (bar)	The interface size
1	Main DC/DC (Including air	250	≥35	≤65	≤0.42	11.4	<2	φ25

	compressor control)							
2	Air compressor	40						

2.2.7 Introduction of Other Core Parts

Table 2-7: Summary of Core Components

No.	Item	Figure	Role
1	Air filter		Purifies air
2	Air flow meter		Monitor / feedback of air flow
3	Hydrogen heat exchanger		Increases the temperature of the hydrogen
4	Intercooler		Reduces the temperature of the air entering the stack
5	Humidifier		Adds moisture to the air entering the stack
6	Throttle		Adjusts the internal operating pressure of the stack

7	The radiator		Takes away the excess heat from the system
8	PTC heater		Heating for low temperature cold start
9	Water tank		Replenish water to the system
10	Deionizer		Absorbs the ions in the coolant, reducing the conductivity of the coolant
11	Low voltage distribution box		Provides low voltage distribution to the system
12	Controller		Control system that communicates between system and vehicle
13	Fuel cell stack		Oxygen and hydrogen react to generate an output voltage

2.3. Product Performance

The performance parameters of VLIII150 product is shown in Table 2-8:

Table 2-8 VLIII150 Fuel Cell System Parameters

150kW Fuel Cell System Technical Parameter (D20.0 Stack)			
No.	Item	Technical Parameter	Remark
1	System Rated/Peak Power(Kw)	150/151	Recommended output power is between 20-90%
2	Stack Power (Kw)	190	
3	Stack Current Range	0-825	
4	Stack Operating Voltage Range /Rated Voltage (V)	190-380/245.1	
5	DC Output Voltage Range	450-750VDC	Output power will decrease if voltage less than 500V
6	DC Output Current Range	0-300A	
7	Stack Number(pcs)	380	With CVM voltage detection
8	Ambient Temperature(°C)	-35-45	
9	System Operating Temperature(°C)	-35-85	

10	Response Time(s,start-up to idle)	≤ 25	Ambient temperature $> 5^{\circ}\text{C}$
11	Response Time(s,start-up to 90% rated power)	≤ 15	hot condition
12	Idle power to down time at room temperature (S)	≤ 120	$\geq 5^{\circ}\text{C}$
13	Idle power to down time at low temperature (S)	≤ 180	@-30°C
14	-35°C Low temperature starting time(min)	≤ 6	
15	Vehicle high voltage delay power off time (min)	≥ 5	Used for low temperature shutdown purging
16	Maximum response power of dynamic loading and unloading (kW/S)	10/12	
17	Idle Power (kW/S)	≤ 15	10% system rated power
18	Mass(kg, excluding booster DCDC)	230	Included DC/DC $\leq 300\text{kg}$
19	System Dimension L*W*H*(mm,with DCDC)	1015*660*690	Confirmed with 3D data

20	System mass power density (W/kg)	652	
21	Rated point efficiency(%)	≥ 43	Boost DC efficiency and radiator fan power are not included
22	Max efficiency (% at idle power)	$\geq 60\%$	
23	High voltage protection class	IP67	
24	Max Altitude (m)	≤ 3000	If the power exceeds 1000m, reduce the power usage
25	System noise (dB)	≤ 85	
26	Fuel (Hydrogen requirement)	Concentration $\geq 99.97\%$	Meet Standards GBT37244-2018
27	Hydrogen utilization(%)	$> 97/98\%$	
28	Inlet pressure of the hydrogen injection module (MPa)	1.2 ± 0.1	gauge pressure
29	Nominal pressure range for anode and cathode media(kPa)	170/150	gauge pressure

30	Hydrogen ports are reserved for the system	1/2 inch ferrule connector	
31	Hydrogen consumption (kg/h)	≤ 11	
32	Air consumption (g/s)	≤ 200	
33	Water flow rate (L/min)	≥ 360	@lift 15m
34	Rated point heat dissipation (kW)	≤ 220	BOL
35	Coolant	Deionized water or FC special coolant	Dynalene or Dick
36	System insulation resistance(M Ω , conductivity 2, 1000V)	≥ 1	Reserved ground hole, M8 bolt; The positive and negative levels of the fuel cell system are respectively tested for 500V insulation of the housing
37	Vehicle insulation alarm value (Ω/V)	level 3:100	level 1 and 2 fuel cell systems shut down normally, and the level 3 fuel cell system stopped abruptly
		level 2: 300	

		level 1: 500	
38	Vehicle pure electric insulation requirements (MΩ)	>3	
39	Communication methods	CAN 2.0B	Baud rate 250/500K optional
40	24V low voltage platform(V)	18-32	
41	24V low power supply requirements (W)	≤500	Vehicle provides system control power supply
42	Hydrogen pipe joint leakage(ppm)	≤5	
43	Installation	It is recommended under the vehicle cab	If installed in other positions, add protection against rain, sun, and collision

3. Product Installation Instructions

3.1. Product External Interface Description

VLIII150 has a total of 9 mechanical interfaces

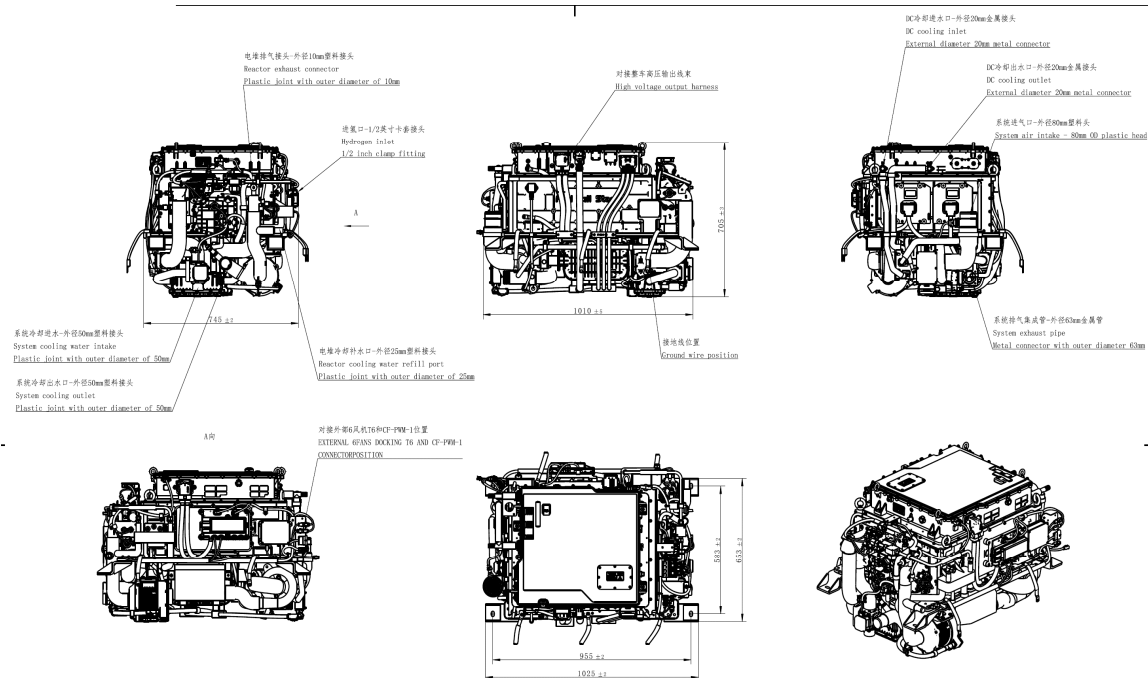
That is, hydrogen interface, system air inlet, system exhaust air outlet, system cooling water inlet, system cooling water outlet, system exhaust port, system replenishment port, Auxiliary heat dissipation cooling inlet, Auxiliary heat dissipation

cooling outlet. the specifications of each interface are shown in Table 3-1, and the detailed location of the interface is shown in Figure 3-1:

Table 3-1: VLIII150 Interface Specification Sheet

No.	Item	Reserved Interface specification	External description
1	Hydrogen inlet	3/4 inch (the tube inserting)	3/4 inch 316L steel pipe
2	System air inlet	φ95 Plastic joint (OD)	φ95 Silicone tube (inside diameter)
3	System exhaust gas out	φ63 metal joint (OD)	φ63 Silicone tube (inside diameter)
4	System cooling inlet	Φ50 Plastic joint (OD)	Φ50 Silicone tube (inside diameter)
5	System cooling outlet	φ950 Plastic joint (OD)	Φ50 Silicone tube (inside diameter)
6	System exhaust port	Φ10 Plastic joint (OD)	Φ10 Silicone tube (inside diameter)
7	System replenishment port	Φ25 Plastic joint (OD)	Φ25 Silicone tube (inside diameter)
8	Auxiliary heat dissipation cooling inlet	Φ25 Plastic joint (OD)	Φ25 Silicone tube (inside diameter)
9	Auxiliary heat dissipation cooling outlet	Φ25 Plastic joint (OD)	Φ25 Silicone tube (inside diameter)

Figure 3-1: Interface Location Map

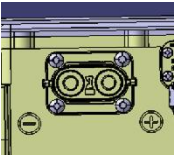






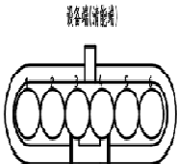
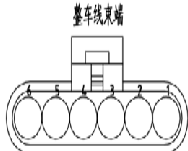
3.2. Electrical Interface Description

External connectors are needed to connect the fuel cell system with the vehicle.

External connectors are shown in table 3-2:

Table 3-2: External connector description

	NAME	Pin number	Definition of Pin	Fuel cell harness / device end plug model	Vehicle harness / equipment end connector model	wire size (mm ²)	Line length / outlet position	REMARKS
1	High voltage interface	1	DC output negative	HVMC2P12MV 103	HVMC2P12FV170 (Amphnol 90°bent)	70	According to the 3D model	High voltage wire and plug shall be solved by the whole vehicle
		2	DC output positive			70		

2	24V negative pole		24V-			25	According to the 3D model	Fuel electric frame to vehicle girder grounding	
3	24 V normal power		24V+	 V-CONN-B KET: 643800-5	 V-CONN-B KET: 613801-5	6	According to the 3D model	24V normal power, voltage range 19-28VDC, required power: rated 440W, peak 600W. It needs to be connected in parallel to the vehicle battery.	
4	Low voltage signal port	1	DC24V ON	 AMP: 282108-1 (公)	 AMP: 282090-1 (母)	0.75	According to the 3D model	DC24V power on, with delayed power-off function	
		2	/					spare port	
		3	/					spare port	
		4	CAN_H			0.5mm ² Twisted pair shield wire		Communicate with the whole vehicle, and the energy scavenging equipment has no can termresistance	
		5	CAN_L						
		6	CAN_GN D						

4. System Running

The fuel cell system is equipped with a set of electrical control system. This system can allow engineers to perform manual, automatic or monitoring operations on the fuel

cell system, and it is also equipped with an automatic alarm and protection devices. When the fuel cell system in operation fails, it will automatically send out an alarm signal or even shut down to ensure that the fuel cell system is in a normal working state at any time or notify the engineer for targeted maintenance.

4.1. Run the Operation Process

4.1.1. Routine Inspection Before Starting

Drivers are advised to check the fuel cell system before driving (Early stage of vehicle operation) :

1. Visual inspection of the stack module. Check the fuel cell stack module for damage, deformation, scratches on the surface, etc.
2. Hydrogen concentration detection. Use a hydrogen leak detector to detect the hydrogen concentration above the system. If there is a hydrogen leak, please shut down the hydrogen system and fuel cell in time, and then notify Horizon for after-sales repair.
3. Check at the interface. The cooling water valve of the fuel cell engine system is closed, and there is no leakage or looseness at the interface; there is no debris in the hydrogen pipeline connector, which is fixed and reliable; there is no looseness or leakage of the cooling water inlet and outlet pipeline interfaces; CAN line is firmly fixed; the external plug of the CAN line is connected correctly without looseness; the controller's 24V low-voltage wiring harness is connected correctly.
4. Tank water level check. The water level of the water tank needs to be within the normal level. If the water level is insufficient, the specified coolant must be added.
5. Radiator inspection. Inspect the radiator for damage or deformation and for leaks.

4.1.2. Boot Process

- Fuel cell system for stationary power stations

1. Turn on the power gate on 24V.

2. The system status changes from 7 (self-test) to 4 (standby).
3. Apply high voltage and check whether the fuel cell input high voltage is normal or fluctuating.
4. Start the fuel cell system. At this time, the system status changes to 2 (running). If the system fails to start normally, shut down the system (default startup fails if time exceeds 1.5 minutes). When the system status changes from 5 (shutdown) to 4 (standby), after the system is completely shut down, turn on the system again.

- Fuel cell system for vehicles

1. Turn on the power gate on 24V.
2. The vehicle is connected to 24V ON, and the system enters self-test.
3. After the self-test is over, connect the high voltage power, the SOC is normal, and the system starts to run.

4.1.3. Working Process

1. Real-time monitoring of the related parameters and status is required during system operation. The items to be monitored are: communication state (with or without interference, delay or acceleration), loading rate, output voltage and current.
2. During the system operation, it cannot be in the no-load state or the overload state for a long time. It is necessary to minimize the idle time and the number of start-stop times of the system, and to avoid the system's rapid load increase or decrease.

Notes on operation:

- Run at least 1 or 2 times at full power at least every month.
- Minimize the running time at less than 30% of the rated power.
- Try to avoid frequent power ON/OFF.
- If it is not running for a long time or running at low power for a long time, it needs to run at high power for 10-30 minutes at startup to reach full power output.

4.1.4. Shutdown Process

- Fuel cell system for stationary power stations

1. Stop the system and the system status changes from 5 (shutdown) to 4 (standby).

2. Turn off the high voltage power, disconnect the 24V power, and turn off the hydrogen supply.
3. Check whether the amount of water in the water tank is within the normal range and whether external water refilling is required.

- Fuel cell system for vehicles

1. The vehicle is disconnected from high voltage power and the power 24V ON
2. The whole vehicle purges the system through high-pressure delay
3. Disconnect the 24V power after the purge
4. Check whether the amount of water in the water tank is within the normal range and whether external water refilling is required.

4.2. Safety Protection in Usage

1. Using the time gap in operation, check the fuel cell system regularly for abnormalities such as water leaks, gas leaks, and hydrogen tail row openings or other abnormal sounds, identify and deal with them timely, and check whether the water tank level is normal in real time.
2. Collect system operation data in time, download and record system data on a regular basis.
3. Avoid operating the system in areas with severe air pollution (such as: black smoke, burning whip, heavy dust, etc.).
4. No open flames are allowed around the system.

4.3. System Communication Protocol

For more information, please refer to: Communication Protocol.

4.4. System Error

For more information, please refer to the Error Code Table.

5. Maintenance and Repair

5.1. Maintenance of Fuel Cell System

The daily maintenance of the fuel cell system is divided into: daily inspection and maintenance, weekly inspection and maintenance, monthly inspection and maintenance and long-term parking inspection and maintenance. The following is a brief description in the form of a table.

Table 5-1: Daily Inspection and Maintenance Record of Fuel Cell System

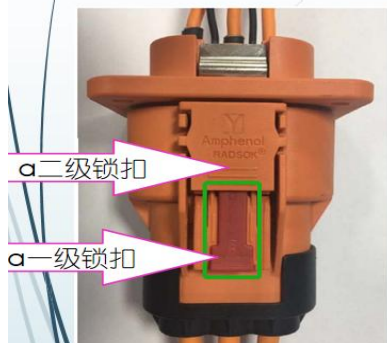
No.	Maintenance item	Specific operation method	Estimated time	Note
1	After starting, observe whether the parameters are normal	Start the vehicle after it is electrified, observe the parameters through the display screen as well as visual inspection.	5min	If there is a fuel cell system failure, please contact Horizon after-sales

Table 5-2 Weekly Inspection and Maintenance Record of Fuel Cell System

No.	Maintenance item	Specific operation method	Estimated time	Note
1	Check the level of coolant	Visually check tank level	3min	When it is below the MIN line of the minimum scale, timely fill the fuel cell special antifreeze to the level not higher than the MAX line of the maximum scale line
2	System hydrogen leak detection	The system is electrified, hydrogen is fed through system control, and leakage is detected by hand-held measuring instrument.	5min	If the hydrogen concentration meter shows a hydrogen leak of more than 25ppm, tighten the joint until it shows less than 5ppm. If a single connector is tightened for more than three

				times, replace it with a new one.
3	System clean	If the hydrogen concentration meter shows a hydrogen leak of more than 25ppm, tighten the joint until it shows less than 5ppm. If a single connector is tightened for more than three times, replace it with a new one.	5min	Clean with no foreign matter

Table 5-3 Monthly Inspection and Maintenance Record of Fuel Cell System

No.	Maintenance item	Specific operation method	Estimated time	Note
1	High and low voltage electrical components	Check whether the high and low voltage plug-in is loose, whether the wiring harness is firmly fixed, and whether there is wear	5min	<p>Each high voltage and low voltage plug-in of the system has a latch. Visually check whether the latch is in place. If the latch is not installed, the plug-in is loose.</p> <p>Example: The plug-in latch is in place</p> 
2	System component fixation inspection	Check components such as water filters, water tanks, air filters, silencers, deionizers, etc. for firmness, and check bolts for looseness	5min	If it is loose, tighten it according to torque requirements. For details, see Torque requirements.
3	Radiator inspection	Check the radiator surface for foreign objects	5min	If yes, clean it up in time

4	Air inlet, air filter inlet	Check the air inlet inlet, dust cap and air filter inlet for blockage, catkins, etc		If yes, clean it up in time
5	Fixture of system and pipe line	Check whether the bolts are loose or worn, and whether the clamps on the pipeline are loose.		If it is loose, tighten it according to torque requirements. For details, see Torque requirements.

Table 5-4 Fuel Cell System Long-term Parking (more than 30 days) Maintenance Record Sheet

No.	Maintenance project	Specific operation method	Estimated time	Note
1	Long downtime before storage	Ensure that the fuel cell is normally shut down and purged, and the 24V power main brake is closed. If the planned shutdown time is greater than 90 days, the fuel cell system and the coolant in the pipeline need to be emptied.	10min	(special antifreeze for fuel cell must be used when the lowest ambient temperature is below 5°C)
2	Fuel cell system operates regularly	Open the 24V handle switch, start the fuel cell to work for more than 20 minutes, and then shut down the vehicle normally	30min	The fuel cell starts and stops once a month

5.2. Maintenance of system Components

5.2.1. System component maintenance list

Regularly check of fuel cell system is required to make sure fuel cell and vehicle system running safely . Users need to maintenance and record based on period as shown in below tab 5-5.

Tab 5-5 Maintenance list

No.	Item	Maintenance category	Maintenance cycle	Remarks
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1	Coolant filter	1、Cleaning 2、Exchange	1、10,000km 2、50,000km or 2 year	If the coolant needs to be drained, simultaneous cleaning of the coolant filter is recommended
2	Air filter element	1、Cleaning and dusting 2、Exchange	1、5,000km 2、10,000km	Based on the actual operating environment, the final replacement mileage is subject to actual conditions
3	Deionizer	Exchange	5,000km (It is recommended the first replacement at 3000km)	The deionizer replacement depends on the alarm threshold of the vehicle insulation value, the vehicle and system insulation value, etc. The final replacement mileage is subject to the actual situation
4	Fuel cell specific coolant	Exchange	30,000km or 1 year	
5	H2 concentration sensor	Calibration	1time/year	
6	Fix point and connector	Check	10,000km/time	Check all fixed points and connectors of the fuel cell system once every 10,000 kilometers to check whether the connections of fixed points and connectors are loose For fixed points and connectors, see Section 6 of 1.2.2.
7	Radiator	Cleaning and dusting	5,000km	

8	Hydrogen leakage detection at each joint of the system hydrogen circuit	Power on the vehicle normally, let the fuel cell system start working for 5 minutes, turn off the vehicle key, and normally shut down the system, and detect the leakage points of each joint through the handheld hydrogen concentration measuring instrument.	10,000km	If the hydrogen concentration meter shows a hydrogen leak of more than 25ppm, tighten the joint until it shows less than 5ppm. If a single connector is tightened for more than three times, replace it with a new one.
9	Low voltage distribution box fuse	check	5,000km	Multimeter Check whether the fuse works

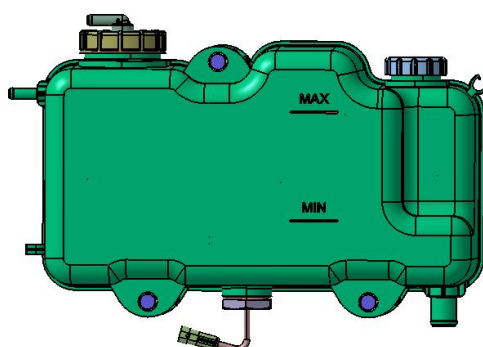
5.2.2 Maintenance operations of system components

1、 Regularly check of coolant is required for fuel cell system

1) If the minimum ambient temperature is below 5 ° C, all coolant needs to be replaced with fuel cell antifreeze. Select a fuel cell antifreeze whose freezing point is lower than the lowest ambient temperature based on the lowest ambient temperature.

2) Fill according to the liquid level every month, and the water level of the water tank should be between the minimum MIN and the maximum MAX water level, as shown in Figure 5.1 below.

Figure 5.1 Filling water tank

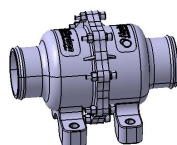


2、 Radiator maintenance

- 1) Make sure vehicle is in “P” status, fuel cell system is power off and vehicle is cut off from high and low voltage system
- 2) Use high-pressure air gun to clean up branches, leaves, and other foreign objects inside the protective net, and use high-pressure air to purge the electronic fan blades and motor grooves to clean up the deposited dust;
- 3) Use high-pressure water gun ($\leq 5\text{bar}$) to clean the surface of the radiator, and clean the dust, catkins, leaves and other foreign matters deposited on the fins of the radiator;
- 4) Dry radiator fan by using high pressure air.

3、regularly check coolant filter

- 1) Make sure vehicle is in “P” status, fuel cell system is power off and vehicle is cut off from high and low voltage system
- 2) drain and recycle coolant, remove coolant filter, using high pressure water to clean filter screen
- 3) Re-install coolant filter and refill the coolant to radiator

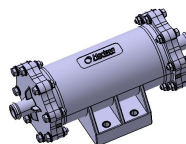


coolant filter

4、Deionizer change procedures

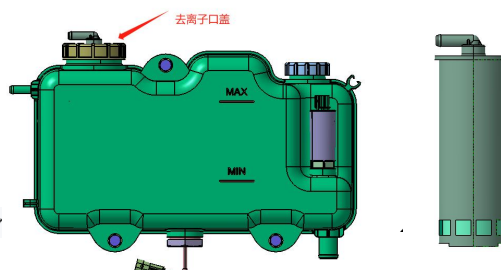
4.1 Replace the external deionizer

- 1) Lower the coolant in the system to the level below the deionizer
- 2) loosen bracket of two ends;
- 3) replace old deionizer with new one;
- 4) install brackets of two ends



4.2 Built-in deionizer replacement (integrated in expansion tank)

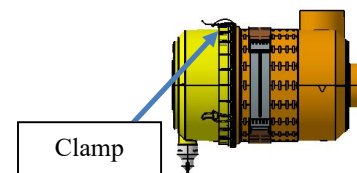
- 1) Unscrew the deion port cover on the expansion tank;



- 2) Remove the deionizer in the water tank;
- 3) Put in the new deionizer and retighten the lid;
- 4) Refill with coolant.

5、Air filter change procedures:

- 1) loosen five clamps of air filter ;
- 2) take out used filter screen and replace with new one ;
- 3) Combine the shell and fix five clamps.



6、Check fixed points and connector connection

- 1) Check whether bolts are loose at the mounting point, radiator, air compressor, intercooler humidifier integrated module, water pump, electric reactor, DC, ground points, and bonding points.
- 2) Check whether the DCL 24V negative terminal grounding point, DCL 24V positive power supply fuse box, high voltage component shell grounding point, 4, heat dissipation fan 24V negative power supply grounding point, fuel point system and vehicle grounding point, fixing bolts are loose.
- 3) The 24V positive fuse of the heat dissipation fan is a power supply plug. Check whether the plug latch is in place.

5.2.3. Torque requirements for standard parts and universal parts

Bolt	Corresponding torque	Clamp	Corresponding torque
M5	5±0.5N.M	Clamp 11-20	3±0.5N.M
M6	10±1.0N.M	Clamp 14-27	3±0.5N.M
M8	24±2.4N.M	American double clamp 17-32	5.4±0.8N.M
M10	45±4.5N.M	German double compensation clamp 25-40	5.4±0.8N.M
M12	75±7.5N.M	German double compensation clamp 30-50	5.4±0.8N.M

		German double compensation clamp 40-60	5.4±0.8N.M
		German double compensation clamp 60-80	5.4±0.8N.M
		American double clamp 22-32	5.4±0.8N.M
		Heavy clamp with pad 30-80	8±0.8N.M

5.3. After-sales

If the problem of maintenance of the fuel cell system cannot be solved, please contact Horizon technical support.

6. Transportation and Storage

6.1. System Transportation

- During transportation, the product should not be subjected to severe vibration, impact or placed upside down.
- The transportation temperature should be in the range of -20 °C ~ 40 °C.
- The product should be able to adapt to sea and air transportation conditions.
- When the product is transported by sea or air, it should be sealed and packed with other protective measures to avoid unnecessary damage.

6.2. System Storage

- The product is placed in a dry and ventilated environment, and the storage temperature is in the range of 5 °C ~ 35 °C.

Long term storage

- Long-term storage means that the system will not boot for more than 1 month
- The fuel cell system has a long-term storage of its recoverable attenuation, which requires that it be turned on once a month for at least 20 minutes each time.

7. Safety

Fuel cell stacks generate high voltage electricity, and high temperature, high pressure gas and liquid flow when the fuel cell system is running. Please strictly observe all warnings, cautions and safety instructions. Failure to follow these instructions may result in safety accidents such as burns, electric shocks, and electric shocks.

7.1. General Safety

1. The fuel of the fuel cell system is hydrogen and oxygen, so open flames are strictly prohibited.
2. In the non-operating state, there may be residual voltage in the fuel cell stack. Check the voltage before maintenance.
3. When the system is running, please make sure that all interfaces, screens and electrical enclosures are firmly connected.
4. Do not place or use the fuel cell stack in a humid environment.
5. When operating a fuel cell stack or system, remove jewelry, watches, rings, and metal objects to avoid short circuits.

7.2. Safety at High Temperature and High Pressure

1. When operating in an outdoor environment, the temperature of the fuel cell stack can reach 80 ° C and above. Do not touch the stack during the operation of the stack or within a short period of time after the stack comes to a stop.
2. When high-pressure gas is used in fuel cell stacks or auxiliary systems, there may be a risk of shock. Before opening each pipeline and fittings, the entire circuit needs to be depressurized.

3. The fuel cell stack is assembled under high pressure. Do not disassemble the stack at will.

7.3. Safety at High Voltage

1. Before operating the stack, connect the positive and negative voltages of the stack to a suitable load.
2. If the electrical equipment is not completely insulated somewhere, electric leakage of stack may occur. Leakage may occur inside or outside the stack module. Minimize the leakage, ensure that all electrical equipment and wires in the stack module are completely insulated, and ensure that electrical equipment are insulated.
3. Select the high-voltage wiring harness of the stack according to the required voltage, current and insulation temperature. According to the specific application and operating environment of the end customer, it meets the conditions of rated voltage, current load, rated insulation temperature, etc.
4. In the case of vehicle insulation failure, never touch conductive parts such as bus or connectors.
5. Ensure that all electrical interfaces and electrical connectors are properly installed and connected. It is not necessary to apply great force when installing electrical interfaces and electrical connectors to avoid damage to the stack.
6. Please avoid the following unsafe situations:
 - Incorrect grounding;
 - Foreign substances or debris appear between the components of the stack and the hardware, resulting in a reduction in insulation performance;
 - Operate electrical wires or electrical equipment with wet hands, or touch wet ground;
 - Use worn wires;
 - Each electrical interface is incorrectly connected or reconnected multiple times;
 - Short circuit occurred;

7.4. Safety of Hydrogen

1. Hydrogen is a colorless, odorless, highly flammable gas.

2. When operating hydrogen, strictly follow the specifications and the recommendations of the gas supplier.
3. Hydrogen is non-toxic, but will consume oxygen in the air and cause hypoxia. No alarm will occur before an accident occurs.

Hydrogen molecules are smaller than any other gas molecule, so hydrogen molecules are difficult to dissolve. Hydrogen can diffuse through a variety of air-tight materials. Fuel pipelines, non-welded connections, non-metallic materials, such as gaskets, O-rings, pipe threads, packaging, etc. may have potential leak points or penetration points. Moreover, because the molecular size of hydrogen is small, it will produce great buoyancy and diffusivity, so the leaked hydrogen will diffuse, and it will soon be diluted in the atmosphere. The hydrogen leak rate of the stack will gradually increase with the increase of the service life of the stack.

The responsibility for detecting and mitigating hydrogen leaks is up to the customer. Hydrogen leaks that originate from the stack, can be quickly detected by a hydrogen detector. It is important to have warning systems in place before the hydrogen / oxygen mixture reaches a flammable concentration.

7.5. Safety of Stack Ablation

When the stack is operating, it may cause internal stack ablation. The following conditions may cause stack ablation:

- When operating the stack, the stack is severely under-hydrogenated (insufficient exhaust, the stack is in a supercooled operating state for a long time);
- Operate the stack beyond its maximum operating temperature.

7.6. Safety of Hypoxia

When the stack is operating, it consumes oxygen. When the stack is poorly ventilated and the floor space is small, special attention needs to be paid to the oxygen concentration to not fall lower than health requirements.

7.7. Warning Sign Description

(1) Cautious of high temperature warning signs:



Warning hot surface

(2) Cautious of electric shock warning signs:



Warning electric shock

(3) Prohibition of stepping warning signs



禁止蹬踏

No stepping on surface

(4) Antifreeze warning sign

