Horizon
Fuel Cell Technologies

VL50 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**
Draft	Draft	**Wei**	2021/6/18

Contents

1. Product Uses and Functions

1.1 Product Uses

The VL50 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 500-500 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.

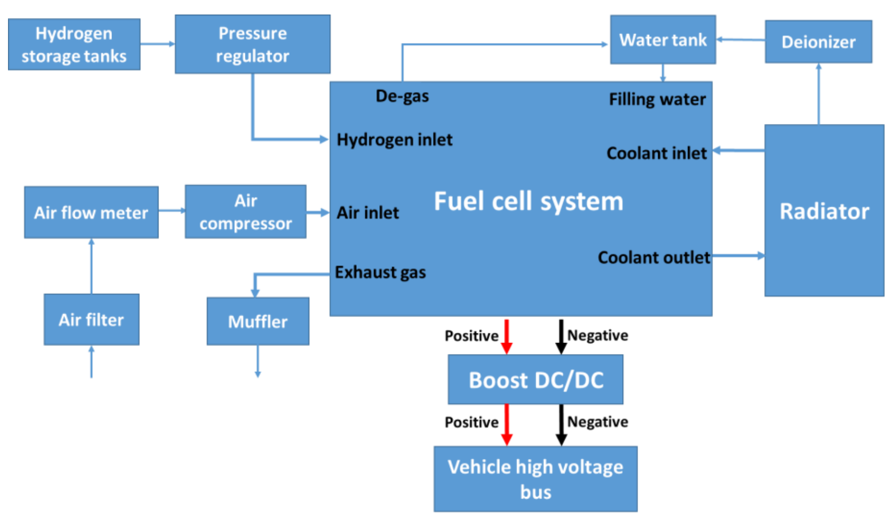
Hydrogen, stored at 350 Bar in storage tanks, passes through a decompression device and enters a hydrogen heat exchanger that heats the hydrogen before it enters the fuel cell stack. Hydrogen and oxygen react to generate water, electricity, and heat. The heat generated by the reaction is dissipated by 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 principal diagram of the fuel cell system is shown in Figure 2-1 below.

Figure 2-1 Working principal diagram of the fuel cell 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 purity >99.97%	
Other ingredients	＜500ppm
	＜2ppm CO_2
	＜0.2ppm CO
	＜5ppm H_2O
	＜2ppm hydrocarbon
	＜5ppm O_2
	＜500ppm He
	＜100ppm N_2
	＜ 0.004ppm H_2S, COS, CS_2, mercaptans)
	＜ 0.01ppm of formaldehyde
	＜0.2 ppm formic acid
	＜0.1ppm NH3
	＜ 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
	＜0.01ppm 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 System Working Condition Requirements

The operating conditions allowed by the system are shown in Table 2-2.

Table 2-2 List of System Operating Conditions

No.	Environment requires	Specific parameters
1	Stack start temperature	≥ -50℃（< 5℃ External heating aid is required）
2	Ambient temperature range	-50~45℃ (at >45℃, for every 1℃ increase, the performance decreases by 1.25%)
3	Storage temperature	-40~65℃
4	Elevation range	0~2000m (power derated over 1000m)
5	Humidity range	0%~100%RH (non-condensing state)
6	Air pressure	0.8~1.3bar (gauge pressure)

7	Hydrogen pressure	10±1bar (gauge pressure)
8	Acceptable difference between hydrogen and oxygen pressures	20kPa

2.2.3 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 2-3:

Table 2-3 High and Low Voltage Power Supply Requirement table

No.	Distribution form	Demand voltage	Demand power	Note
1	High voltage	300~400VDC	10kW (startup heating power for subzero temperatures)	≤15min
2	Low voltage	24VDC	3kW (cooling fans and other 24vdc hotel loads)	

2.2.4 **Air Compressor**

The VL50 system needs an external oxygen supply system. After physical matching and system verification, Horizon recommends an air compressor which has high pressure ratio, large air flow rate and low noise.

The air compressor specification is shown in Table 2-4. The performance map of the air compressor is shown in Figure 2-2:

Table 2-4 Air Compressor Specification

Number	Parameters	Unit	Minimum	Maximum	Note
1	Matching fuel cell system power	kW	30	50	
2	Power	kW	-	10	Rated 8kW
3	Speed	rpm	50000	100000	
4	Mass flow rate	g/s	0	70	
5	Outlet pressure	kPa	150	250	Continuous operation
6	Inlet pressure	kPa	70	100	

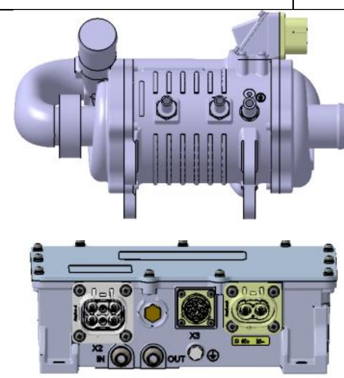
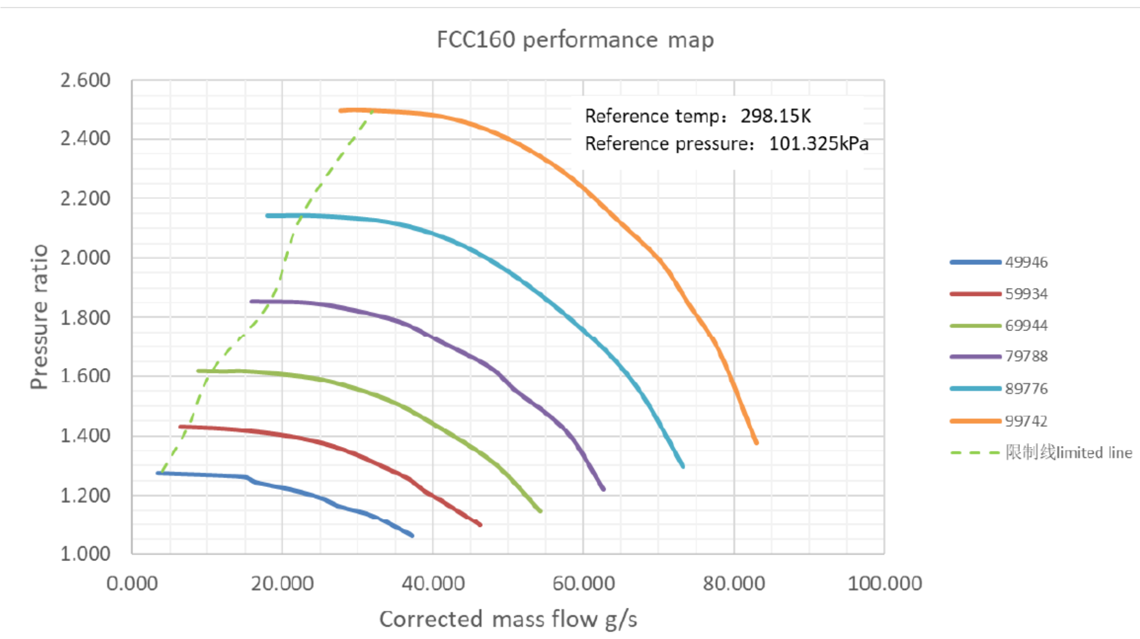
7	Inlet ambient air temperature	℃	-40	45	
8	System transient response time	sec.	-	1.9	From minimum to maximum speed
9	Ingress Protection Rating	-	-	IP67	
10	Weight	Kg	Air compressor weight 8.6kg, control weight 7.5kg		
11	An iso-view of the air compressor with controller				

Figure 2-2: Air Compressor Performance Map



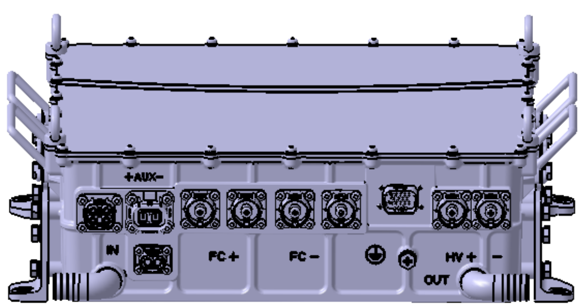
2.2.5 **DCDC Converter**

The VL50 system requires an external DCDC converter. After physical matching and system verification, Horizon recommends the DCDC converter with the specification shown in Table 2-5 below. A view of the DCDC is shown in Figure 2-3 below:

Table 2-5：DCDC Performance Parameters

No.	Parameter (unit)	Value	Note
1	Rated power (kW)	60	
2	Input voltage（Vdc）	90-420	Rated97.5V
3	Input current（A）	500	
4	output voltage（Vdc）	450-700V/260-400	
5	Output current（A）	180	
6	Low voltage (Vdc)	18-32	
7	maximum efficiency（%）	≥96	Load above 30%, boost ratio ≤5
8	Ingress Protection Rating	IP67	

Figure 2-3：DCDC Converter



2.2.6 **Water Pump**

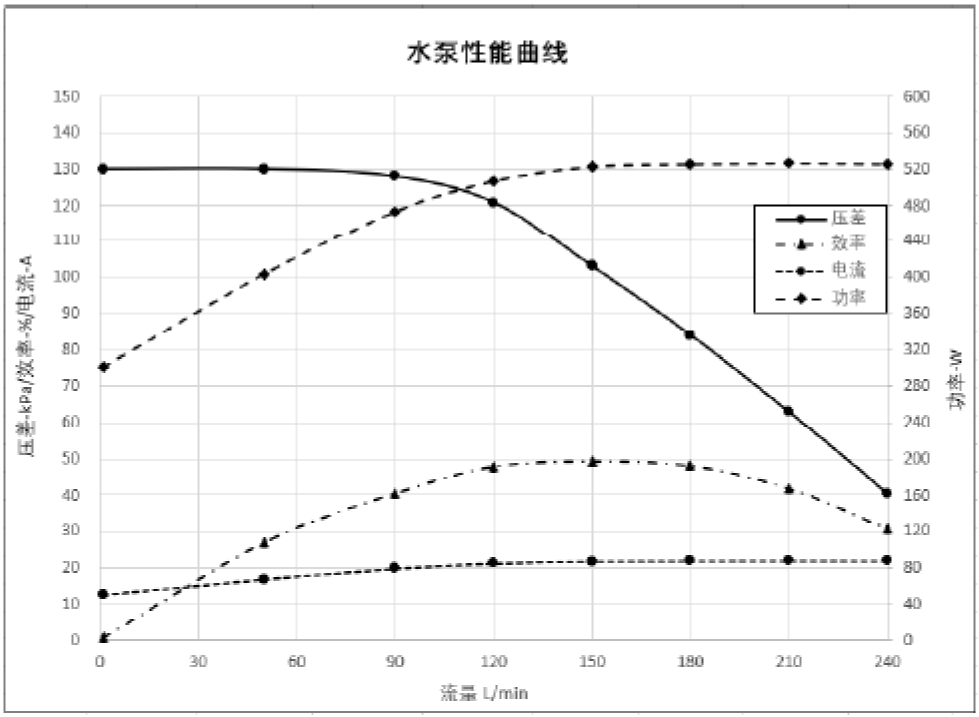
The VL50 system needs a matching water pump. After physical matching and system verification, Horizon recommends a water pump with the specification shown in table 2-6, and the characteristic curve of the pump is shown in figure 2-5:

Table 2-6 Parameters of the water pump

No.	Parameter	Value	Note
1	Flow rate at a given pump head	⩾150L/min@10m	
2	Rated power (W)	⩽600	
3	Power supply voltage (Vdc)	24V	

4	Motor type	Permanent magnet synchronous machine	
5	Motor rated speed/peak speed (RPM)	2000-5650rpm	
6	Ambient temperature (℃)	-40-80	
7	Coolant temperature (℃)	-40-80	
8	Water pump efficiency	≥97%	

Figure 2-5 Characteristic Curve of the Pump



Vehicle 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 vehicle cooling system. The heat dissipation and flow requirements are shown in Table 2-7.

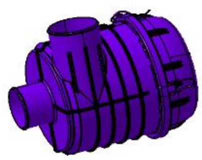
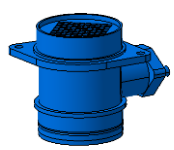
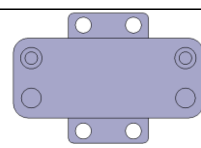
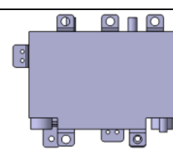
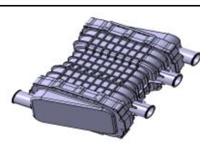
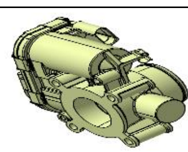
Table 2-7：Vehicle Cooling Demand Table

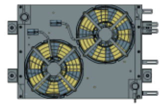
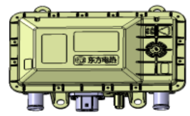
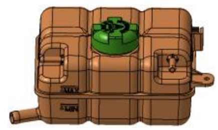
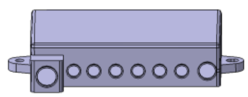
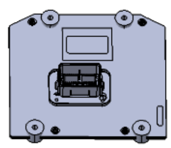
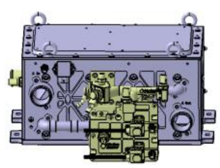
No.	Item	Power (kW)	Required Flow Rate (L/min)	Inlet Coolant Temperature (℃)	Pressure Drop (kPa)	Heat Rejection (W)	Fitting size

1	Main DC/DC	60	≥20	≤65	≤28 （20L/min）	1900	φ25
2	Air compressor + controller	8	4-6	≤65	≤35kPa （4L/min）	1200	φ10

2.2.7 Other Balance-of-Plant (BOP) Components

Table 2-8：Other BOP Components

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

7	Radiator		Rejects heat from the system
8	PTC heater		Heats coolant for freeze startup
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		Generates electric power

2.3 System Performance

The performance parameters of VL50 system is shown in Table 2-9:

Table 2-9 VL50 Fuel Cell System Parameters

No.	Parameter	Value	Note
1	Rated power (kW)	50	
2	Rated current (A)	0-480	Boost DC input

3	Maximum working current (A)	500	Boost DC input
4	Operating voltage (Vdc)	110-220	Boost DC input
5	Boost DC output voltage（V）	450-700V/260-400	Rated at 560V
6	Boost DC output current（A）	0-170	
7	Ambient temperature (℃)	-30-45	
8	Storage temperature (℃)	-40-60	
9	Idle power（kW）	⩽8	
10	Response time (s) Boot to idle	≤30	Ambient temperature > 5℃
11	Response time (s) Idle to 90% rated power	≤20	After the system goes through the first engine
12	Mass (kg)	≤165kg	Without DC/DC、 Radiator、Pipe lines and other accessories, etc
13	Size L*W*H (mm)	940*793*710	Subject to reality
14	Rated point efficiency (%)	≥40	cooling fan power excluded
15	Ingress Protection Rating	IP67	
16	Operation Altitude (m)	2000	Power derating over 500m
17	Hydrogen Purity	≥ 99.97%	
18	Hydrogen inlet pressure (MPa)	1.1±0.1	Gauge pressure
19	Hydrogen consumption (kg/h)	≤4.3	Rated power
20	Coolant	Deionized water or FC special coolant;	Dynalene, Dike
21	Insulation resistance (Ω/V)	≥500	1、 Reserved ground hole, M8 bolt; 500V insulation test of the

			positive and negative electrodes of the fuel cell system； **2**、Insulation resistance of the vehicle ≥2MΩ
22	Communication mode	CAN 2.0B	
23	Installation	Suggested to install in the cabin	If installed to other locations, need to increase then protection from rain, sun, collision

3. Product Installation

3.1 Interface Description

VL50 has a total of 3 mechanical interfaces, which are

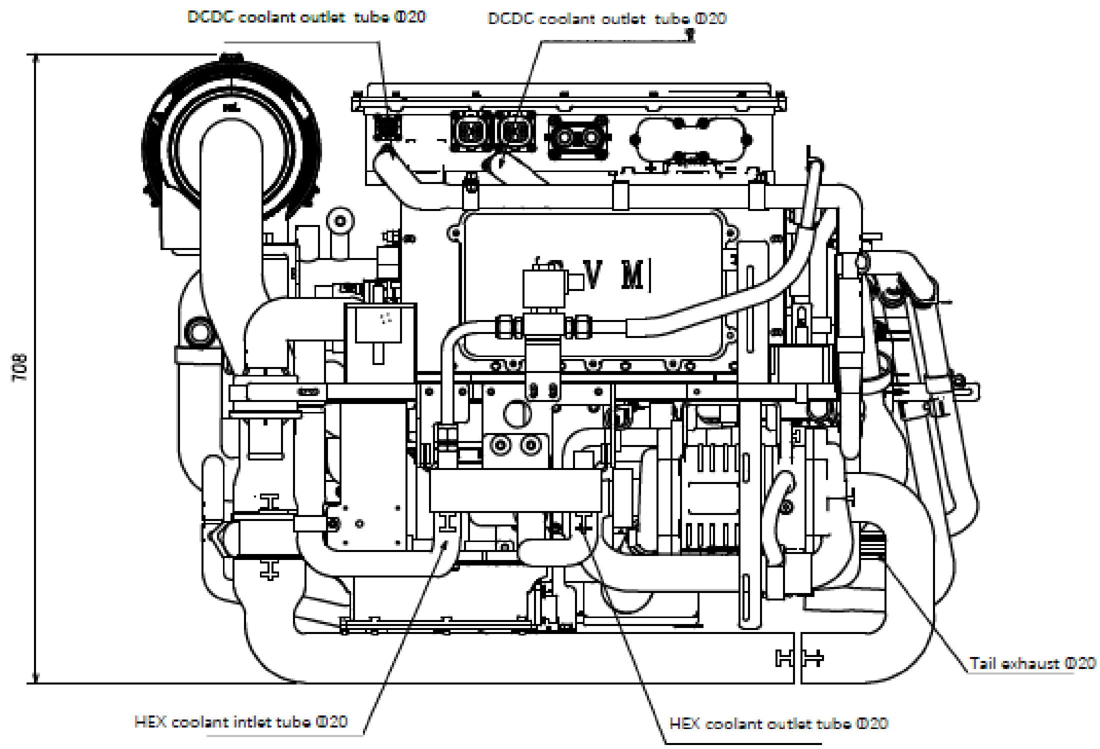
- Hydrogen inlet
- Coolant inlet
- Coolant outlet

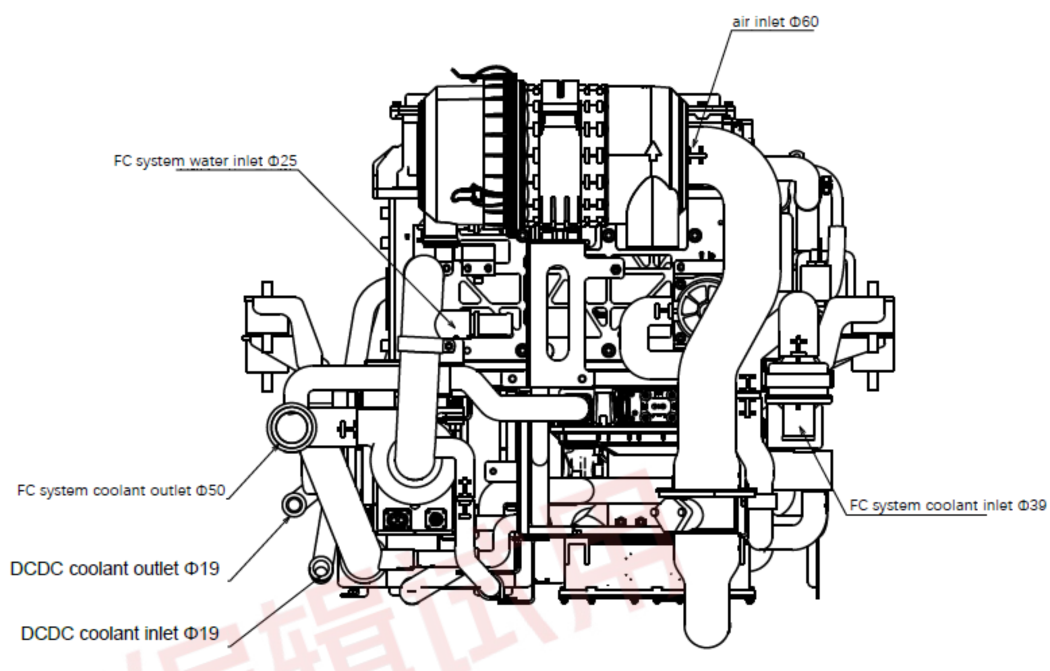
There are three electrical interfaces, which are high voltage output+, High voltage output- and vehicle communication interface, the specification of each interface is shown in Table 3-1, and the detailed location of the interface is shown in Figure 3-1:

Table 3-1：VL50 Interface Specification Sheet

No.	Item	Interface – VL50 Side	Interface – Vehicle Side
1	Hydrogen inlet	1/2nut cutting sleeve	1/2stainless steel
2	Coolant inlet	Φ 10 pagoda	Φ 10 silicone hose
3	Coolant outlet	Φ 11 pagoda	Φ 11 silicone hose
4	High voltage output +	High voltage connector	High voltage connector
5	High voltage output -	High voltage connector	High voltage connector
6	Vehicle communication interface	Low voltage connector	Low voltage connector

Figure 3-1：Interface Locations


DCDC coolant outlet tube Φ20
DCDC coolant outlet tube Φ20
708
Tail exhaust Φ20
HEX coolant intlet tube Φ20
HEX coolant outlet tube Φ20


air inlet Φ60
FC system water inlet Φ25
FC system coolant outlet Φ50
DCDC coolant outlet Φ19
DCDC coolant inlet Φ19
FC system coolant inlet Φ39

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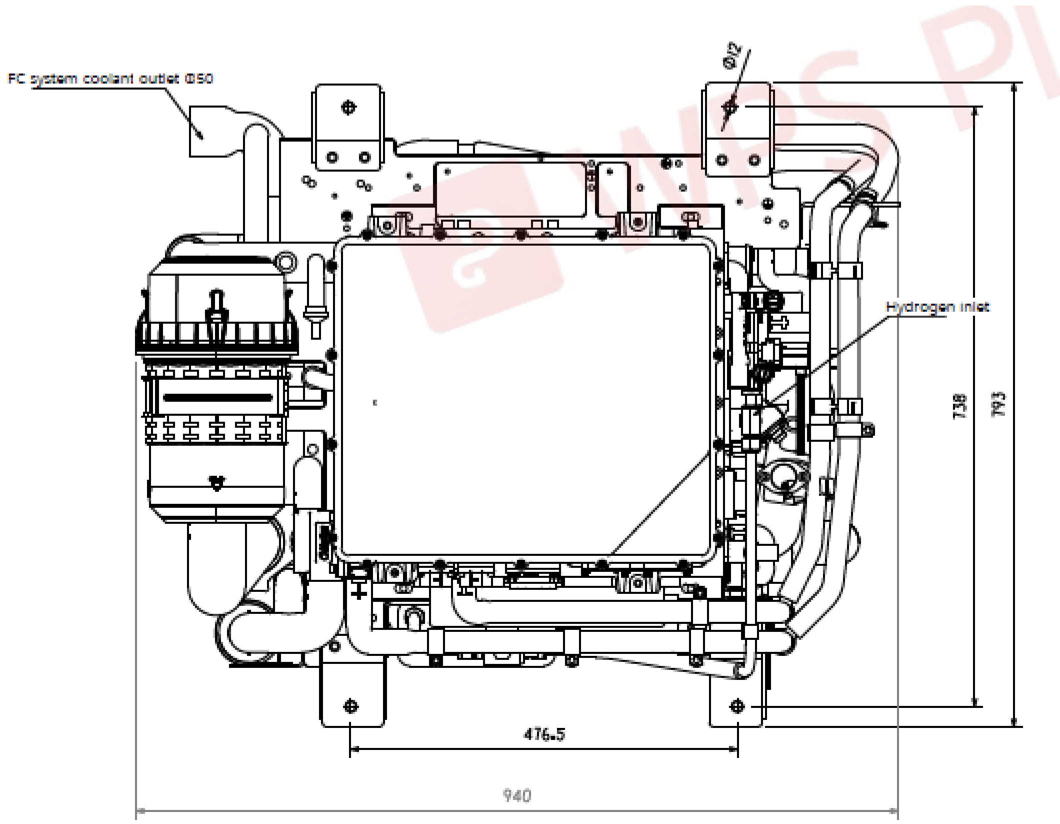
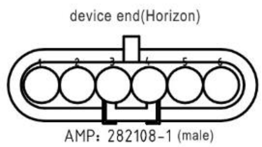
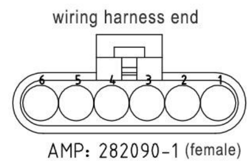


3.2 Electrical Interface

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

No.	Item	Pin no.	Pin definition	Connector – VL50 System Side	Mating Connector – Vehicle Side	Wire Size (mm2)	Note
1	High voltage interface	1(A)	DC positive	HVMC2P12MV403	HVMC2P12FS470	70	Amphenol connectors. DCDC power output
		2(B)	DC negative			70	

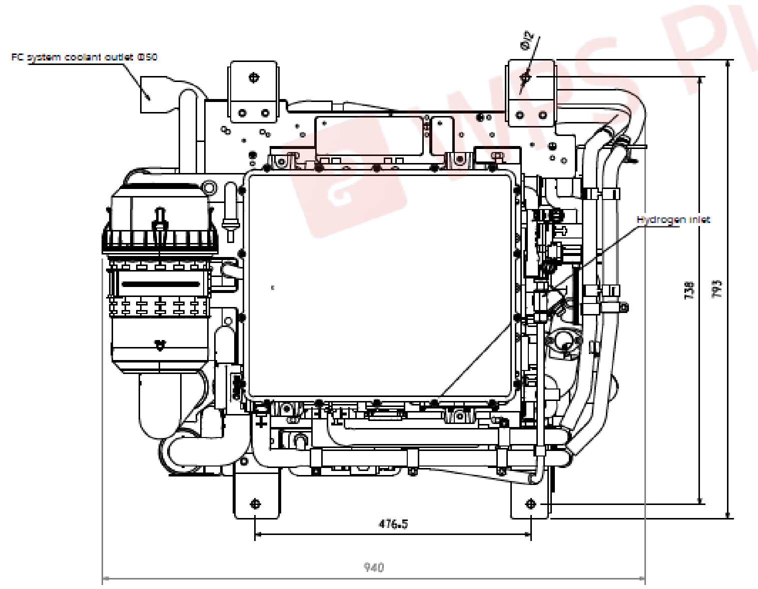
<table>
<tr><td>2</td><td>24V System power supply</td><td></td><td>24V power</td><td>M8 terminal stud</td><td>Y8-50</td><td>50</td><td>maximum power demand of 3000W</td></tr>
<tr><td rowspan="6">3</td><td rowspan="6">Low voltage interface</td><td>1</td><td>DC12V ON power</td><td rowspan="6">
</td><td rowspan="6">
</td><td>0.75</td><td>12Vdc to turn fuel cell on</td></tr>
<tr><td>2</td><td>Reserved</td><td></td><td>Spare</td></tr>
<tr><td>3</td><td>Reserved</td><td rowspan="4">0.5 double twisted shield wire</td><td>Spare</td></tr>
<tr><td>4</td><td>CAN_H</td><td rowspan="3">FCU has no CAN termination resistor</td></tr>
<tr><td>5</td><td>CAN_L</td></tr>
<tr><td>6</td><td>CAN block</td></tr>
</table>

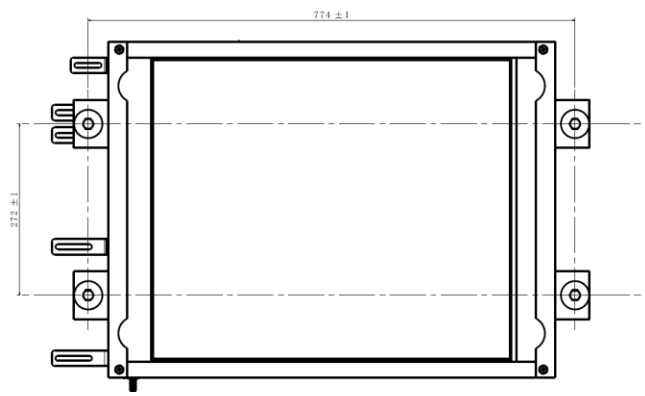
3.3 Detailed Installation

The system can be mounted on the vehicle longitudinal beam by 4 shock mounts. For mounting bolts, it is recommended to use M10 carbon steel grade 8.8 colored zinc-coated hexagon flange bolts with a torque of 45±4.5 N*m.

The radiator can be mounted on the vehicle longitudinal beam. For mounting bolts, it is recommended to use M10 carbon steel grade 8.8 colored zinc-coated hexagon flange bolts with a torque of 45±4.5N*m. The number of bolts is 4. The system assembly point is shown in Figure 3-2:

Figure 3-2：System and radiator assembly point





Installation steps are as follows:

1. Lift the radiator assembly to the installation position and fasten the mounting bolts and nuts;

2. Install the fuel cell system into the installation position, and fasten the mounting bolts and nuts;

3. Connect the relevant water pipes of the radiator and fasten the high and low voltage docking plug-ins of the fuel cell system into place;

4. The shell and other accessories of the vehicle have been installed, and the entire fuel cell system has been installed.

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 immediately, and then notify Horizon for serive.
3. Check at the interfaces. 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 secured 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 24V power.
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 24V power.
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 50% of the rated power.
- Try to avoid frequent power ON/OFF.
- If it does not run for a long time or run at low power for a long time, it needs to run at high power for 10-50 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 Service

5.1 Maintenance of Fuel Cell System

The daily maintenance of the fuel cell system includes: daily inspection and maintenance, weekly inspection and maintenance, monthly inspection and maintenance and long-term parking inspection and maintenance. The following tables shows the details.

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	Follow the system instructions

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 level, fill the antifreeze timely to the level no higher than the line
2	System hydrogen leak detection	The system is electrified, hydrogen is fed through system control, and leakage is detected by a hand-held detector	5min	The leak detector does not show a hydrogen leak

3	System clean	Remove foreign objects with an air gun or vacuum cleaner	5min	Clean with no foreign objects

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 connectors are loose, whether the wiring harness is secured, and whether there is wear	5min	Immediately report any abnormality
2	System component fixation inspection	Check all parts for fastness and bolts for looseness	5min	
3	Radiator inspection	Check the radiator for any blockage	5min	

Table 5-4 Fuel Cell System Long-term Parking (more than 50 days) Maintenance Record Sheet

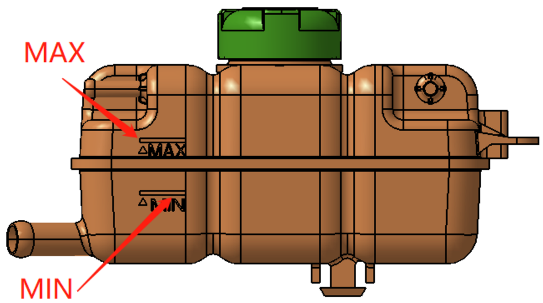
No.	Maintenance project	Specific operation method	Estimated time	Note
1	Long downtime before storage	Make sure the fuel cell is normally shut down and purged, and the 24V power supply is closed. If deionized water or purified water is added, please drain the coolant in the pipeline	10min	(special antifreeze for fuel cell must be used when the lowest ambient temperature is below 5℃)
2	Check fuel regularly	Open the 24V handle switch, start the fuel cell to work for more than 20 minutes, and then shut down the vehicle normally	50min	The fuel cell starts and stops once a month

5.2 Coolant Maintenance

Both DCDC and fuel cell systems require periodic inspections of the coolant.

- If the minimum ambient temperature is below 5°C, all coolants need to be replaced with special antifreeze for fuel cells. The mixing ratio of ethylene glycol and deionized water is 1:1.

- Use a handheld conductivity tester regularly to check the conductivity of the coolant in the fuel cell system. If the conductivity is> 5 μs / cm², the deionizer needs to be replaced in time.
- Fill every 2000 hours according to the liquid level. When the system is cold and the air bubbles in the system's cooling line are empty (the cooling water circuit can be exhausted by frequently turning on 24V electricity every 50s), the water level needs to be in between of the lowest and the highest levels, as shown in the figure below.



5.3 Aftersales

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 ℃ ~ 40 ℃.
- 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 ℃ ~ 35 ℃.

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:

（2）Cautious of electric shock warning signs:

（3）Prohibition of stepping warning signs

（4）Antifreeze warning sign