VL30 Fuel Cell System

User Instructions

Disclaimer

This manual incorporates safety guidelines and recommendations. However, it is not intended to requirements and to ensure safety during operation, maintenance and storage of the stack.

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.

Actions that will void the fuel cell stack warranty:

- Attempt, under any circumstance, to disassemble the fuel cell stack.
- Operate fuel cell stack in a specified manner not in system settings or in specific product user manuals.
- Failure of fuel cell system caused by accidents, misuse, human injury or negligence.
- Use impure or incorrect fuel.
- Operate the fuel cell stack with a controller not designed and built by Horizon for the specific fuel cell.
- Operate the fuel cell with no controller, or the controller used is not produced by Horizon Company.
- Supply hydrogen to fuel cell system using hydrogen source which does not meet the requirements of Horizon Company.
- Supply hydrogen to fuel cell system with hydrogen pressure which does not meet the requirements of Horizon Company.

Do not attempt, under any circumstance, to disassemble or inappropriately tamper with the fuel cell. There will be no returns, refunds or exchanges should disassembly or tampering occur. If you have questions or need help with regards to the fuel cell and its technology contact: support@horizonfuelcell.com

Revision history

Revision history			
Revision#	**Description**	**Author**	**Date**
Draft	Draft	Kevin Ren	2023/07/30

Contents

1. Product Uses and Functions

1.1 Product Uses

The VL 30 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.

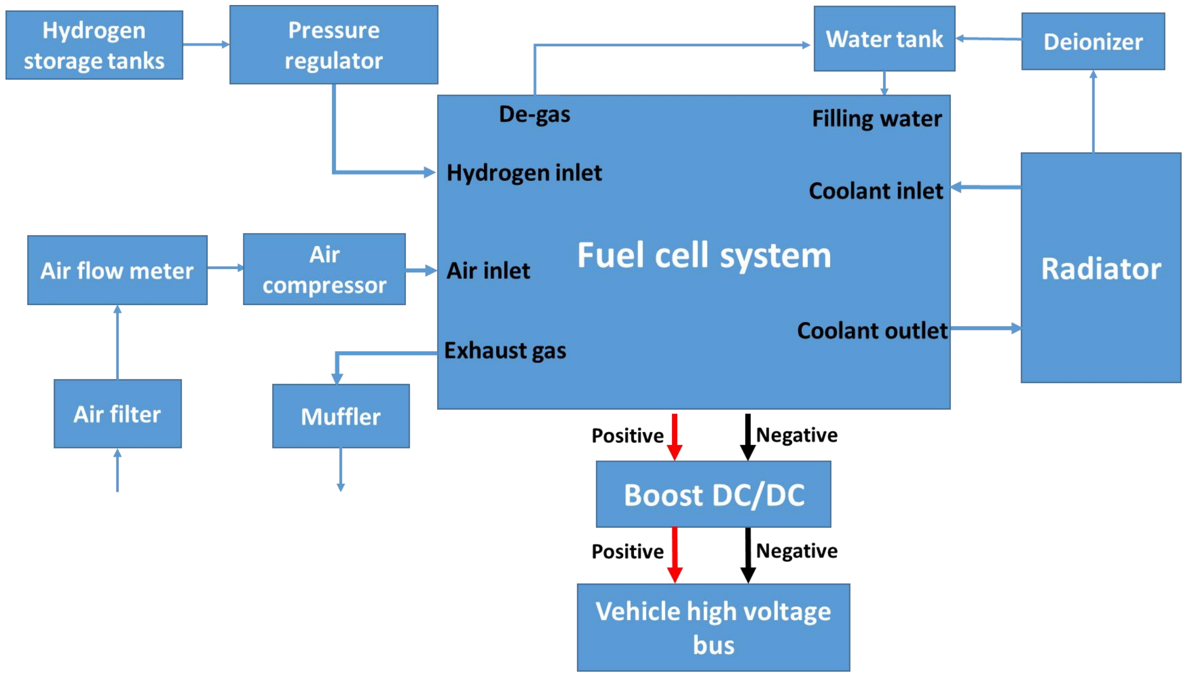
Hydrogen, stored at 350 Bar in storage tanks, passes through a decompression device and enters a hydrogen heat exchanger that heats the hydrogen before it enters the fuel cell stack. Hydrogen and oxygen react to generate water, electricity, and heat. The heat generated by the reaction is dissipated by 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 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	<300ppm
	<2ppm CO_2
	<0.2ppm CO
	<5ppm H_2O
	<2ppm hydrocarbon
	<5ppm O_2
	<300ppm 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	≥ -30℃ （< 5℃ External heating aid is required）
2	Ambient temperature range	-30~45℃ (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	11±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	500~600VDC	9kW (startup heating power for subzero temperatures)	≤15min
2	Low voltage	24VDC	4kW (cooling fans and other 24vdc hotel loads)	

2.2.4 Air Compressor

The VL30 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

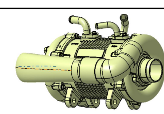
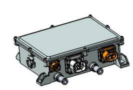
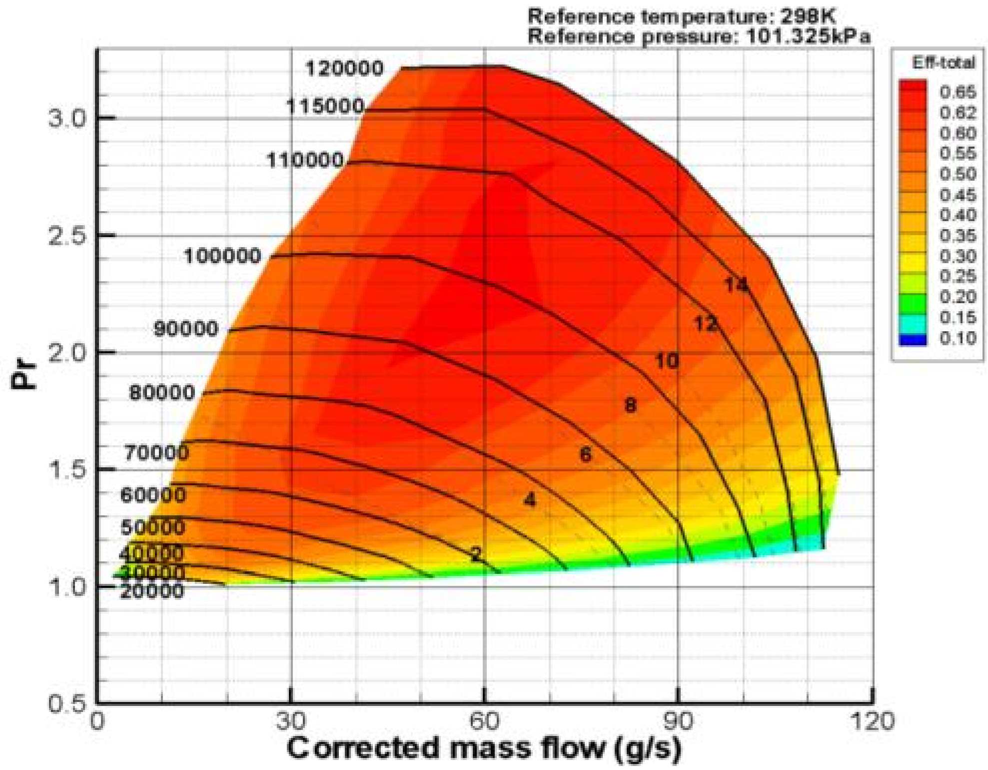
Number	Parameters	Unit	Minimum	Maximum	Note
1	Matching fuel cell stack power	kW	20	75	
2	Power	kW	-	15	
3	Speed	rpm	-	12000	
4	Mass flow rate	g/s	0	105	
5	Outlet pressure	kPa	95	220	Continuous operation
6	Inlet pressure	kPa	80	101	
7	Inlet ambient air temperature	℃	-40	45	
8	System transient response time	sec.	-	5	From minimum to maximum speed
9	Ingress Protection Rating	-	-	IP67	
10	Weight	Kg	Air compressor weight 10kg, control weight 5.8kg		
11	An iso-view of the air compressor with controller	 			

Figure 2-2：Air Compressor Performance Map



2.2.5 **DCDC Converter**

The VL30 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)	80	
2	Input voltage（Vdc）	100-350	
3	Input current（A）	500A±5A Max	
4	output voltage（Vdc）	400-750	
5	Output current（A）	0-170	
6	Low voltage (Vdc)	24	From 24V power supply
7	maximum efficiency（%）	97	Load above 30%
8	Ingress Protection Rating	IP67	

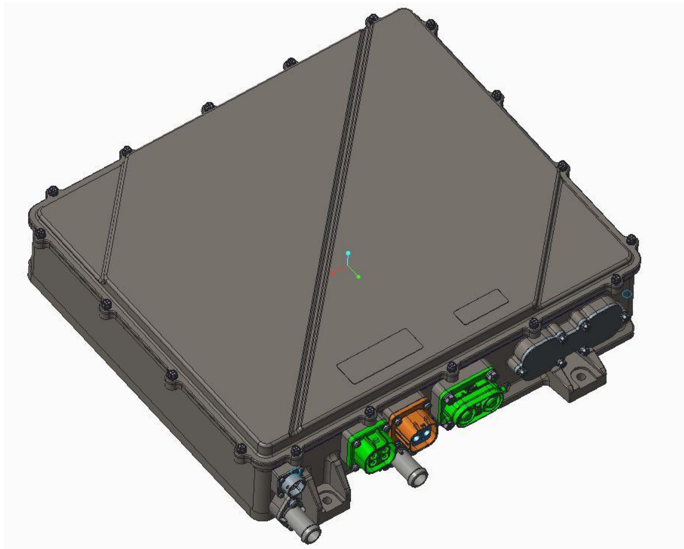


Figure 2-3：DCDC Converter

2.2.6 **Water Pump**

The VL30 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, a view of the pump is shown in figure 2-4, 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	≥180L/min	
2	Rated power (W)	≤930	
3	Operation voltage (V)	16-32	
4	Operation current (A)	⩽40	
5	Pressure difference	⩾150kPa	
6	Ambient temperature (℃)	-40~100	
7	Coolant temperature (℃)	-40~100	
8	Water pump efficiency	≥55%	

Figure 2-4 Water Pump

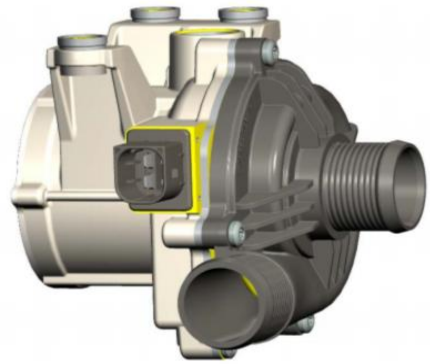
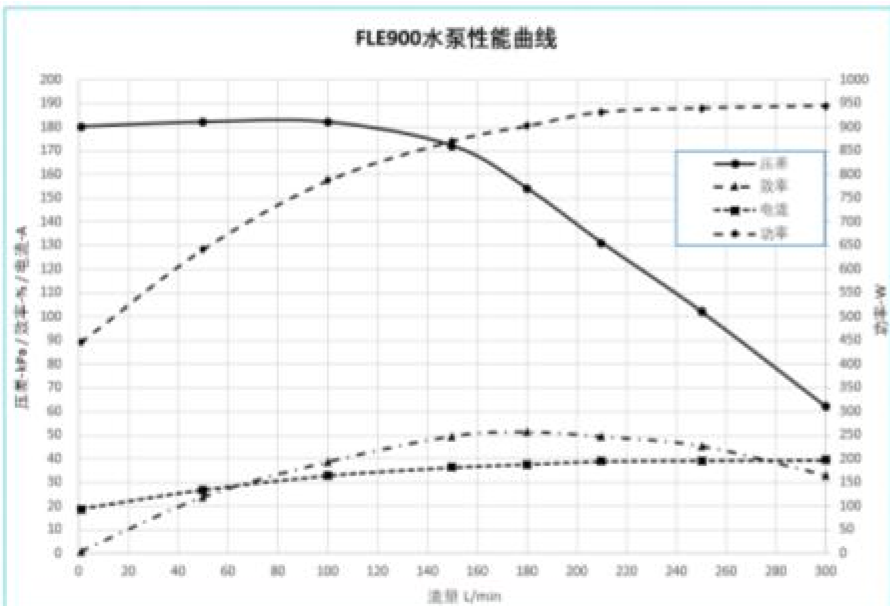
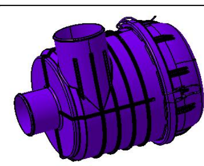


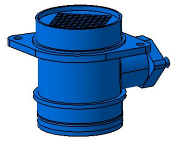
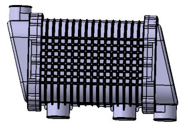
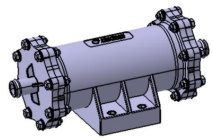
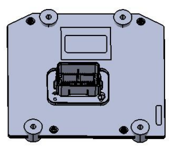
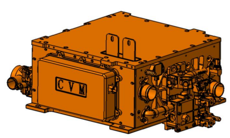
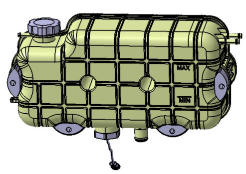
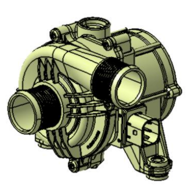
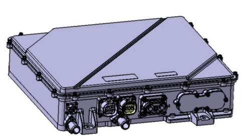
Figure 2-5 Characteristic Curve of the Pump

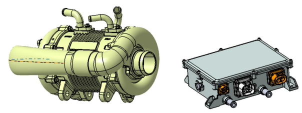
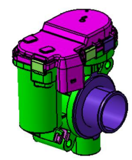
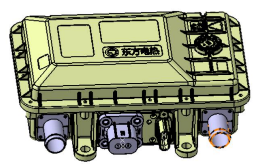


2.2.7 Other Balance-of-Plant (BOP) Components

Table 2-8：Other BOP Components

No.	Item	Drawing	Function
1	Air filter		Prevents damaging size particles from entering fuel cell

2	Air flow meter		Monitoring feedback of air flow
3	Humidifier		Adds humidity to the air entering the stack
4	Radiator		Removes excess heat from the system
5	Ion Exchange		Absorbs ions in the coolant and reduce the conductivity of the coolant
6	Controller		Control system, system and load communication
7	Fuel cell stack		Oxygen and hydrogen react to produce power
8	Fill water tank		Filling water and purge air for the fuel cell system
9	Fuel cell high voltage water pump		Powers the cooling cycle of the fuel cell
10	Constant voltage DC		Fuel cell system power management module

11	Air compressor and controller		Provide air for the system
12	Throttle		Adjusts the internal operating pressure of the stack
13	PTC heater		Heats coolant for freeze startup

2.3 System Performance

The performance parameters of VL30 system is shown in Table 2-9:

Table 2-9 VL30 Fuel Cell System Parameters

No.	Parameter	Value	Note
1	Rated power (kW)	30	
2	Rated current (A)	54.5	
3	Maximum working current (A)	110	
4	Operating voltage (Vdc)	500-600	
5	Ambient temperature (℃)	-30-45	
6	Storage temperature (℃)	-40-60	
7	Response time (s) Boot to idle	30	Ambient temperature > 5℃
8	Response time (s)	90	

	Idle to rated power		
9	Mass (kg)	≤250	
10	Size L*W*H (mm)	2076*1060*1597	
11	Rated point efficiency (%)	≥40	cooling fan power excluded
12	Ingress Protection Rating	IP67	
13	Operation Altitude (m)	2000	Power derating over 1000m
14	Hydrogen Purity	≥ 99.99%	
15	Hydrogen inlet pressure (MPa)	1.1±0.1	Gauge pressure
16	Hydrogen consumption (L/min)	≤450	Rated power
17	Coolant	Deionized water or FC special coolant;	Dynalene, Dike
18	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
19	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

3.2 System connection instructions

- Need to connect the tailpipe of the system, the hydrogen inlet (connected to the hydrogen source), and the high-pressure end of the DCDC (need to be connected to the load). After all the pipelines are connected, manually add a certain amount of deionized water to the system tank.Coolant inlet

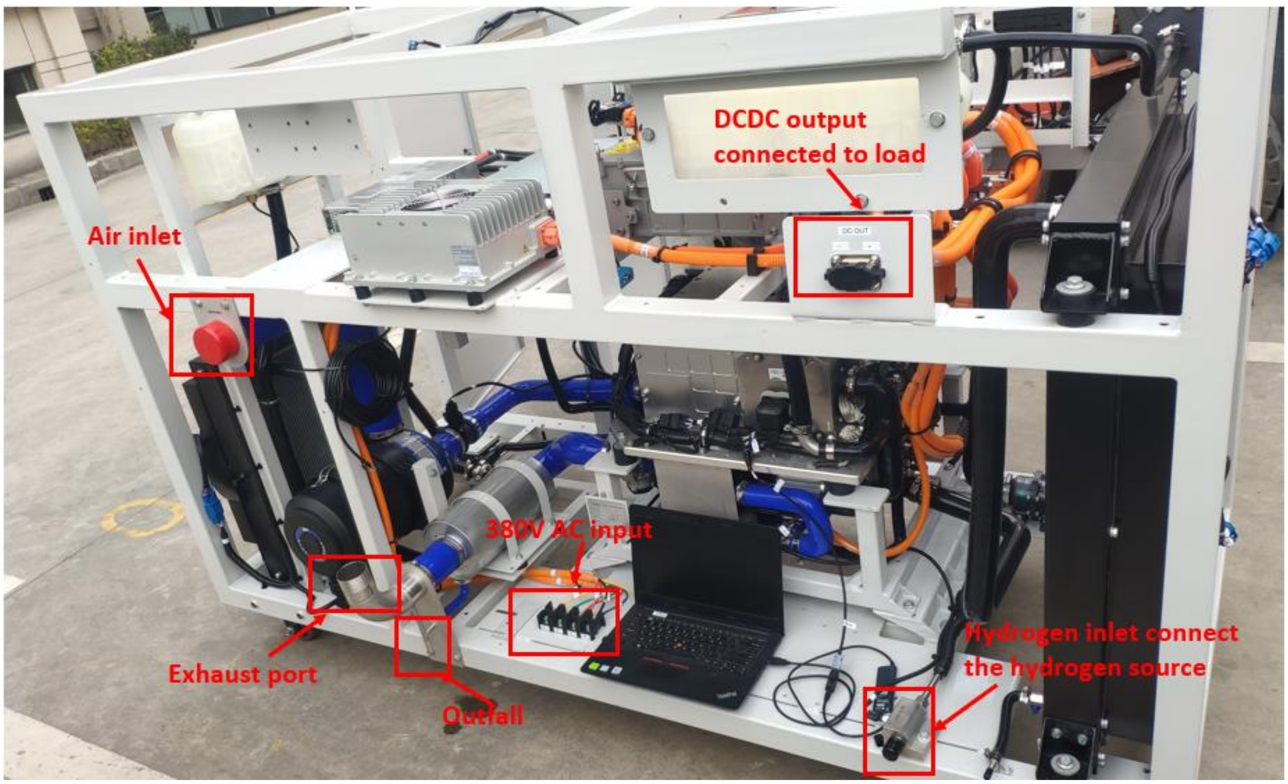


Figure 3-1-1 System connection diagram

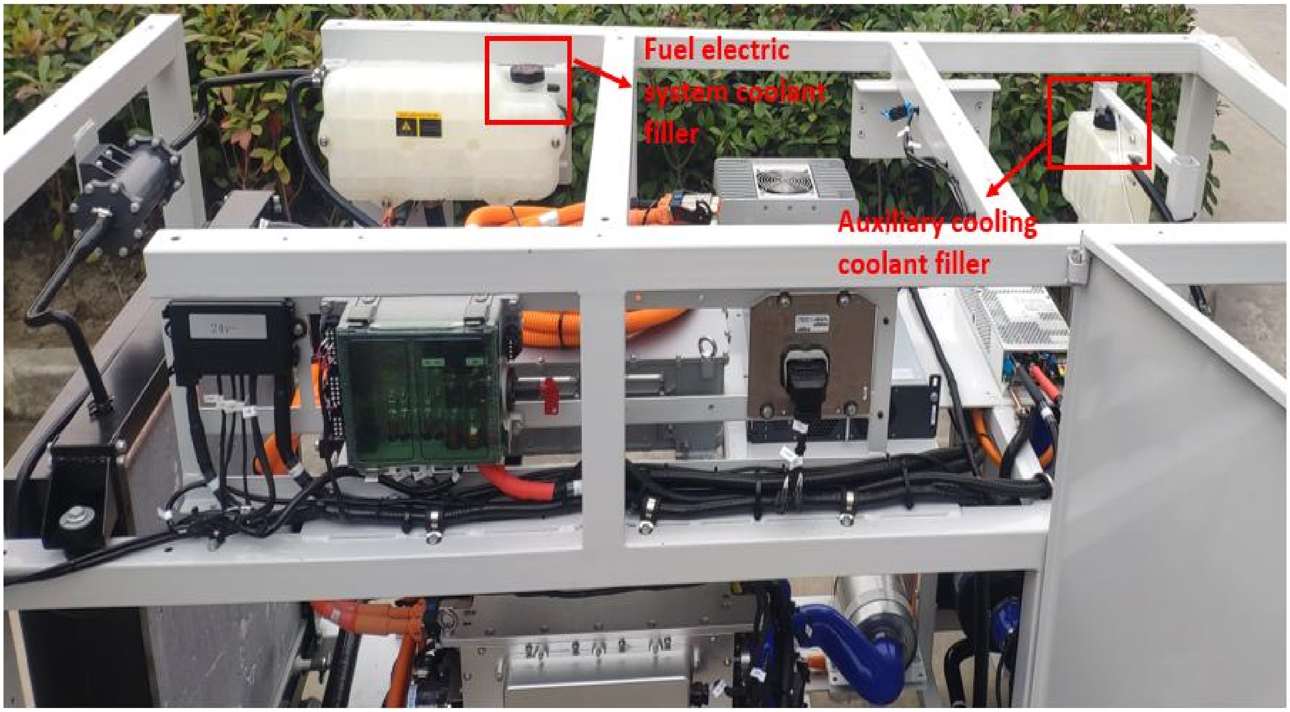


Figure 3-1-2Coolant filling instructions

3.3 Electrical Interface

External connectors are needed to connect the fuel cell system with the vehicle. External connectors are shown in table 3-2:

As shown in Figure 3-2, it is the connection method of the communication line between the system and the computer. Connect the communication line we configured with KVASER, one end of the communication line is connected to the CAN2 interface of the system ECU1, and the other end of the KVASER is connected to the computer. In addition, the system reserves a network cable interface, which can control the system through the Internet.

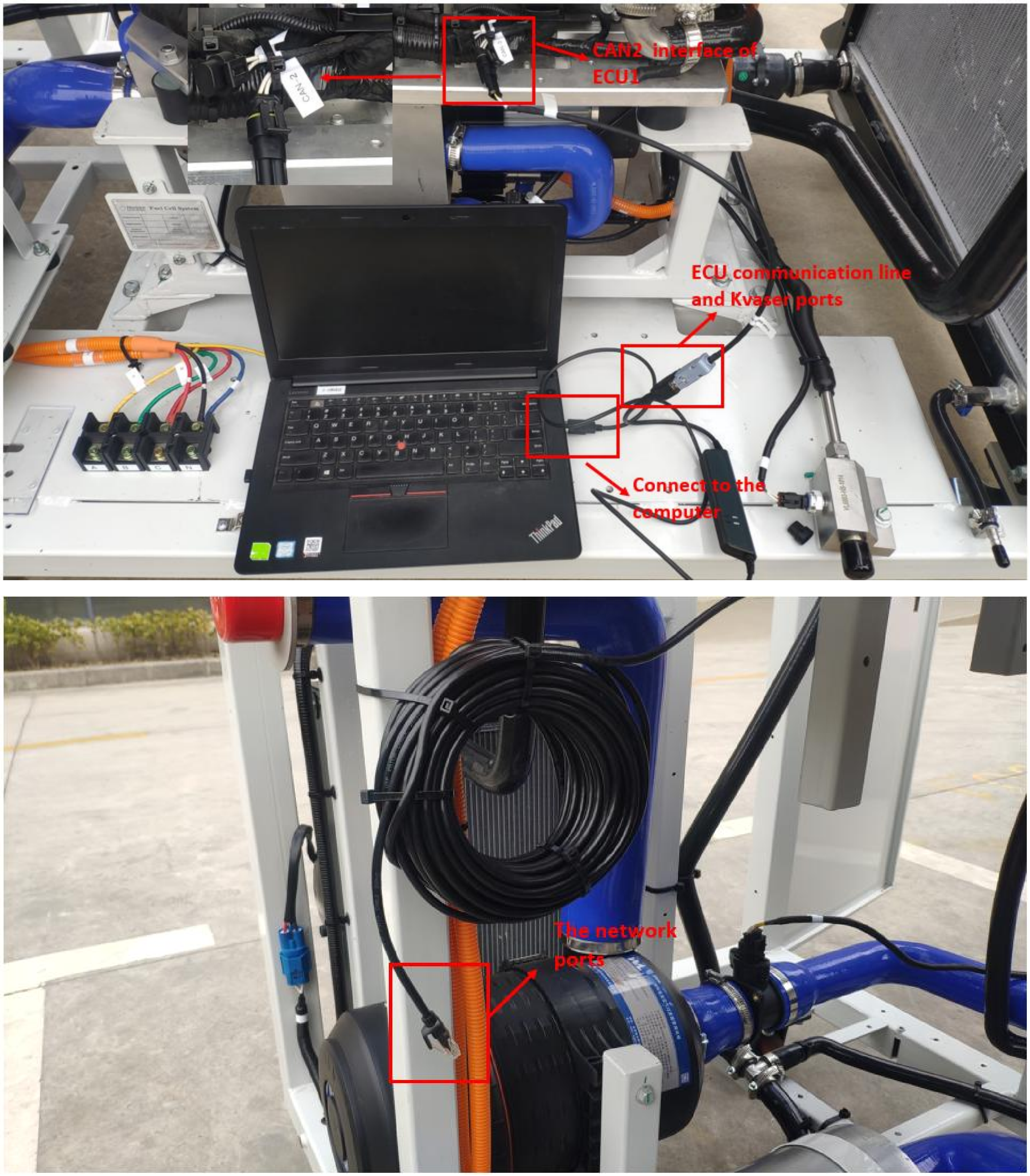


Figure 3-2 Communication line connection

3.3 Screen display control instructions

As shown in Figure 3-3, it is the control interface of our system, which can start and shut down the system and modify the power through the control of the screen.

Operation 1： When you click this button , it will become Set Remote Control , At this time, it can be operated on the display screen, Otherwise, Ethernet operation will be performed.

Operation 2： This button is the lock key of the screen, Clicking this button will Set Control Lock , before power setting and other operations can be performed . Otherwise, the screen will not operate.

Operation 3： This is the system emergency stop button. When the button becomes Reset Normal Mode , the system will be in emergency stop state.

Operation 4： After the power setting is completed, click this button to change to STOP to start the system. Clicking again will stop the system.

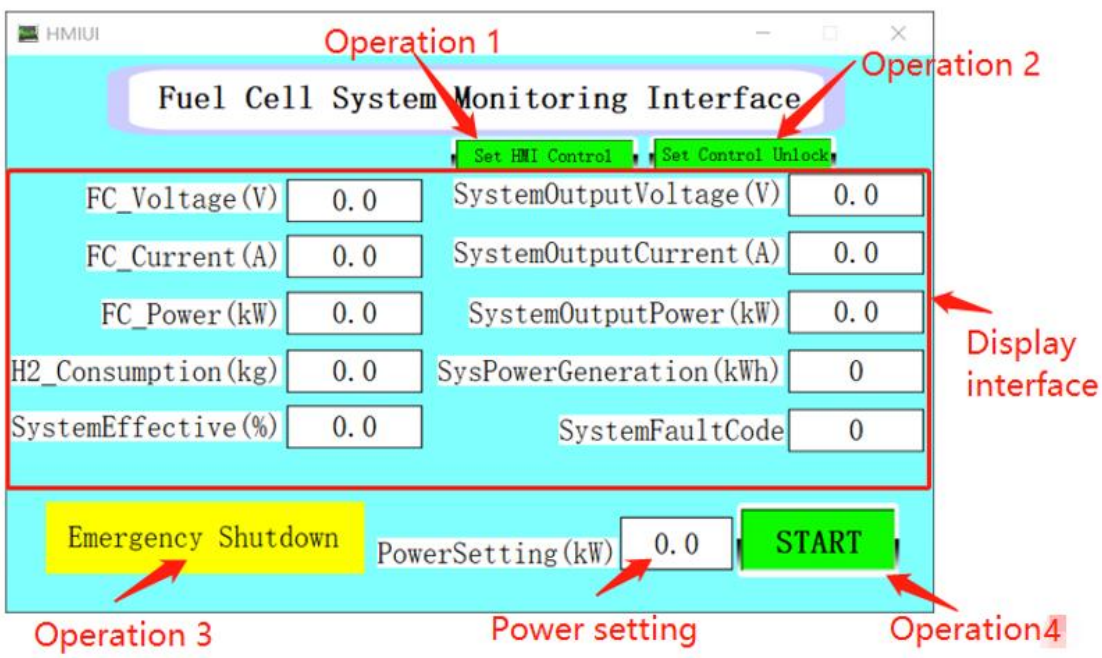


Figure 3-3 Screen control interface

4. Software operation instructions

4.1 Open the Software

Unzip the application package, run Horizon VL series monitor.exe. Note: if the package decompressed to the C drive, please right click the computer mouse to allow Horizon VL series monitor.exe operation in administrator mode. Otherwise, the software can't write to Excel and blf file, thus failed to recording.

4.2 Getting Started

First, make sure the fuel cell system is properly wired. Second, supply the 24V power. Third, click the Run button, as long as the CAN connection indicator shows ONLINE, it means the system communication is run correctly. Forth, Click the "control signal" button to connect the CAN communication module.Fifth,wait the system to complete self-check, then it runs into standby status, after that the fuel cell system is ready to operate.

Note: It is necessary to add enough deionized water and expelling all the air in the coolant circuit to start the fuel cell system for the first time.

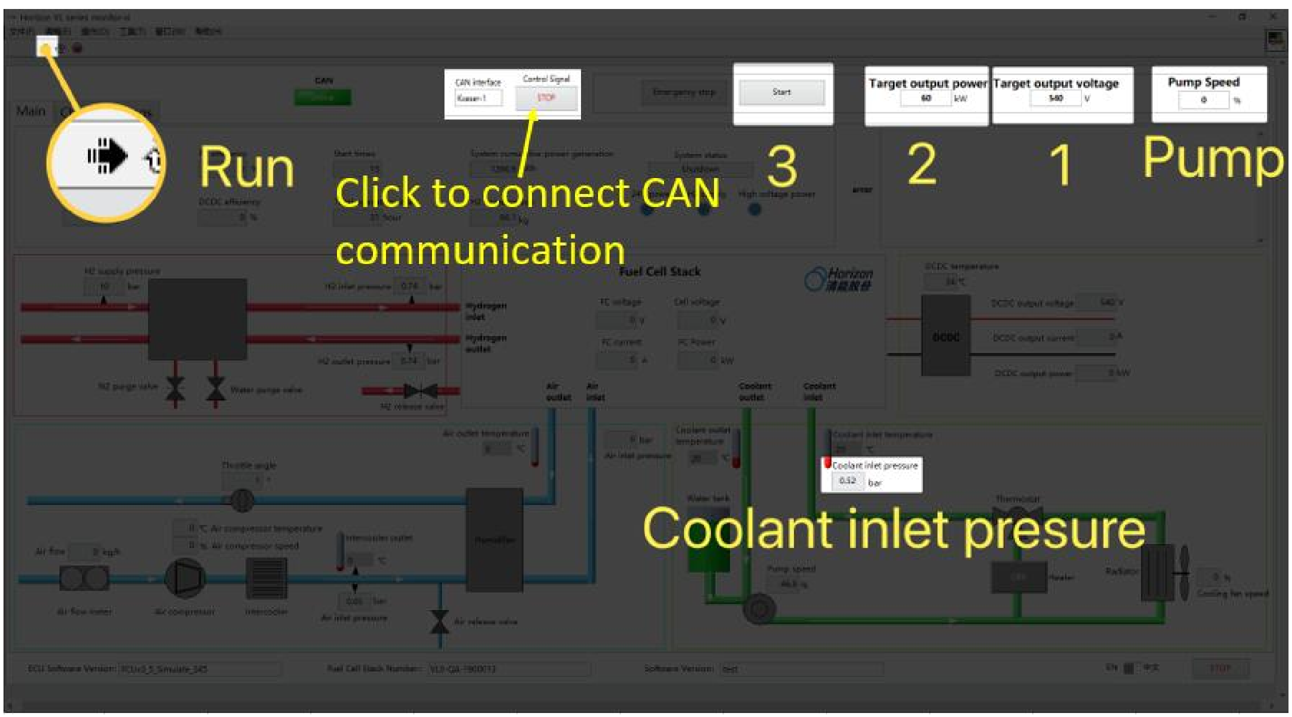


Fig4-1 Software operation interface

Start steps

(1) . Set the output voltage which is marked in 1；

(2) . Set the target power which is marked in 2；

(3) . Click the button which is marked in 3 to start the fuel cell system. If the system need to be stop, please click the button marked in 3 again.

Before run the fuel cell system, the water pump need to be turn on to expelling the air in the coolant line. When the coolant inlet pressure stabilizes between ± 0.01 bar, it can be considered that the air in the coolant circuit has been emptied. The specific steps to set the pump speed and waiting time can refer to the following table. Make sure that the pump speed is 0 before start the Fuel Cell System.

Pump speed	10%	20%	30%	40%	50%	40%	30%	20%	10%	0%	50%
Waiting Time	2min	2min	2min	2min	2min	2min	2min	2min	2min	2min	2min

4.3 Monitoring system status

4.3.1 Main

On the main page, you can see various real-time observation values from the fuel cell system.

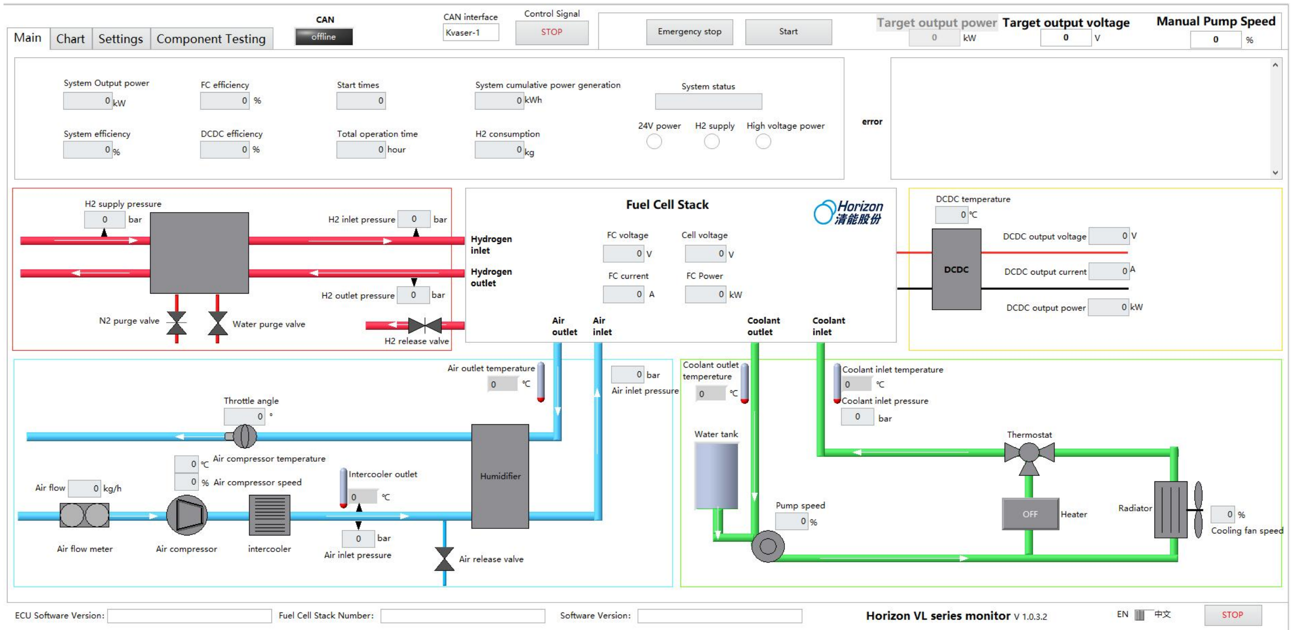


Fig4-2 Main interface

4.3.2 Chart

On the chart page, you can see the Historical data curve of some observed values. Both X axis and Y axis can change the axis range by modifying the numbers on both sides of the axis, Y axis supports mouse operation. When the mouse moves into the corresponding Y-axis range, the Y-axis can be zoomed in and out by the mouse wheel.

4: The option on the left side of the chart can be checked to show/hide the curve.

5: The box on the right is the curve setting option, you can change setting items such as curve color

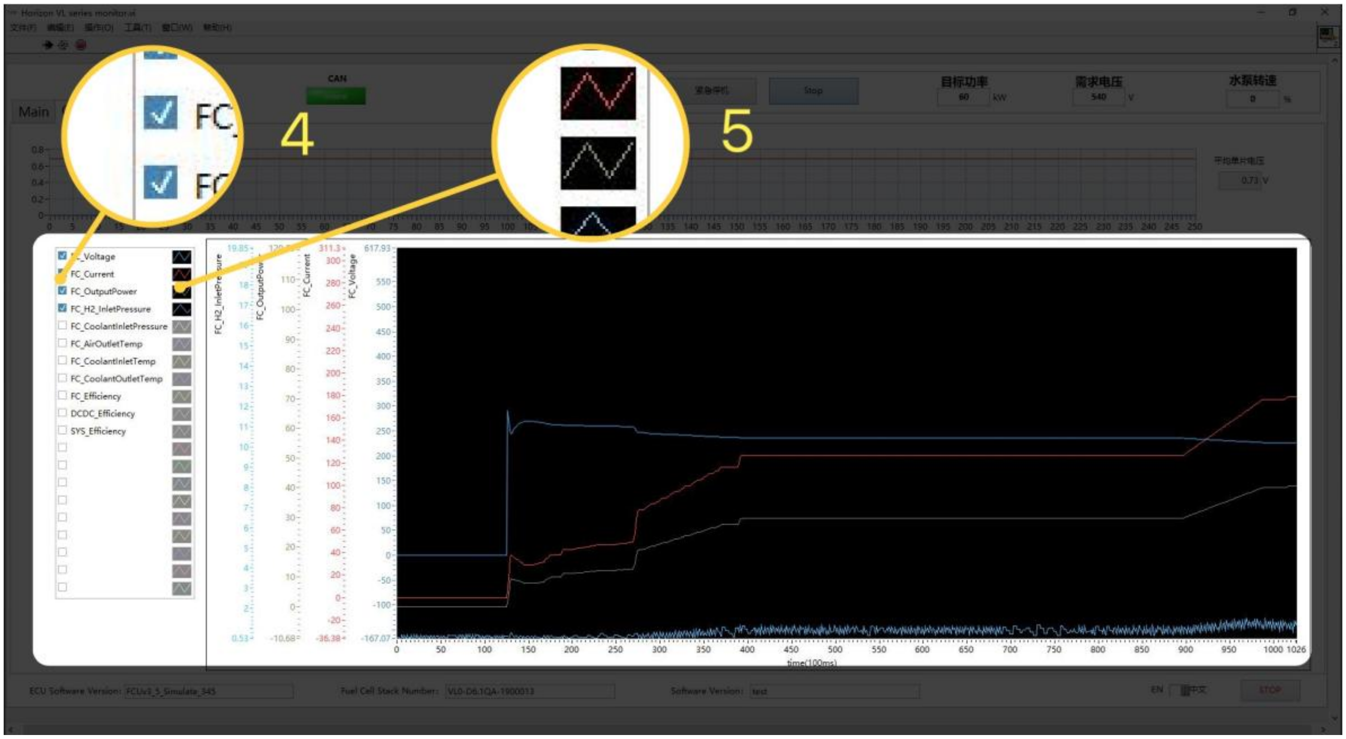


Fig4-3 Chart interface

4.4 Calibration parameters

This operation has a high risk and must be carried out under the guidance of Horizon Fuel Cell Technologies.

(I): Click the path selection icon to select the file. The calibration interface will appear when the correct file is selected.

(II): Click to select the parameter you want to modify, The selected row will be highlighted. Click the value again, and the value can be modified when it becomes the input state.

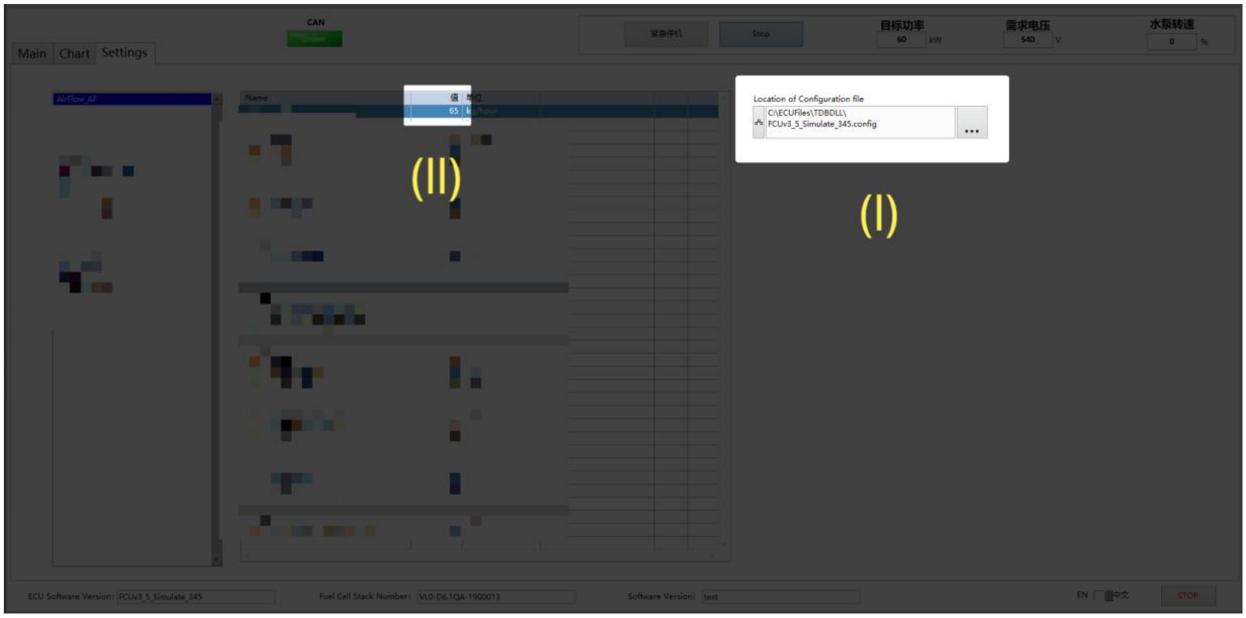
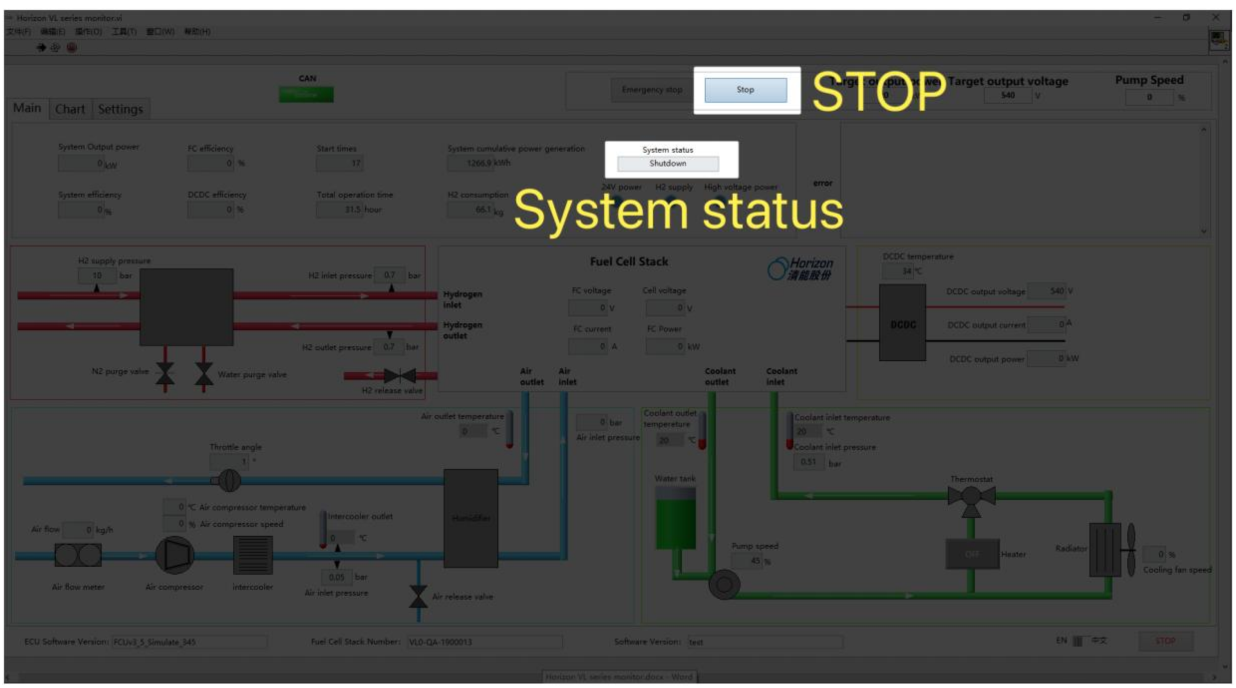


Fig4-4 Calibration parameters interface

4.5 System shutdown

Click the Stop button and wait for the system to execute the shutdown command. When the system status turn into standby, it means the shutdown command is over.



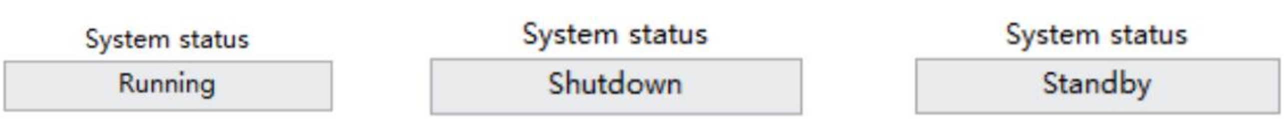


Fig4-5 Shutdown steps

4.6 Firmware update

When the stack is in self-check, standby and fault state, you can click the update ECU firmare button to update the program. Select the .srz file required by the update program and click start to start the update. After the program is updated, click update ECU firmare again to shrink the window before starting the operation.

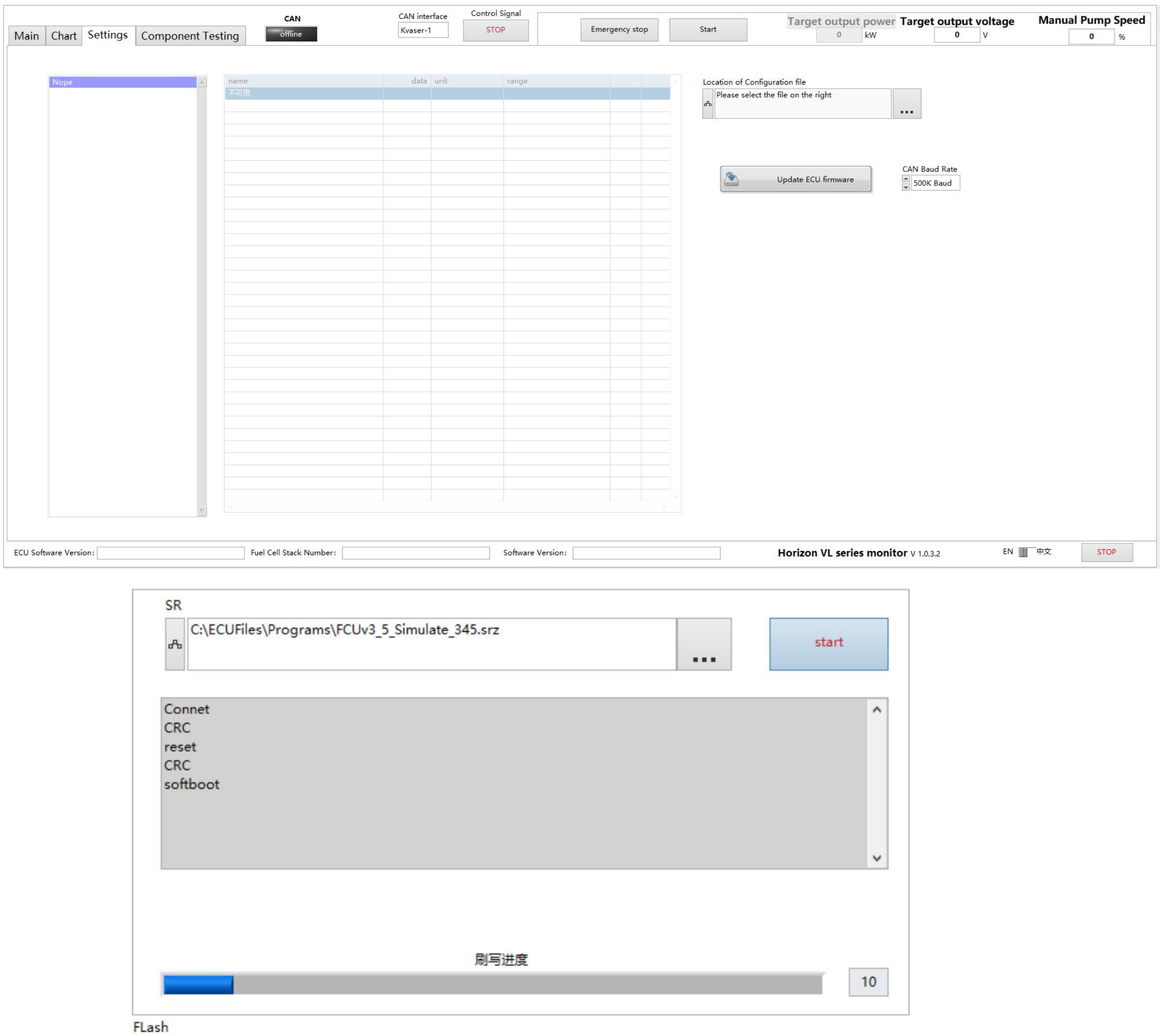
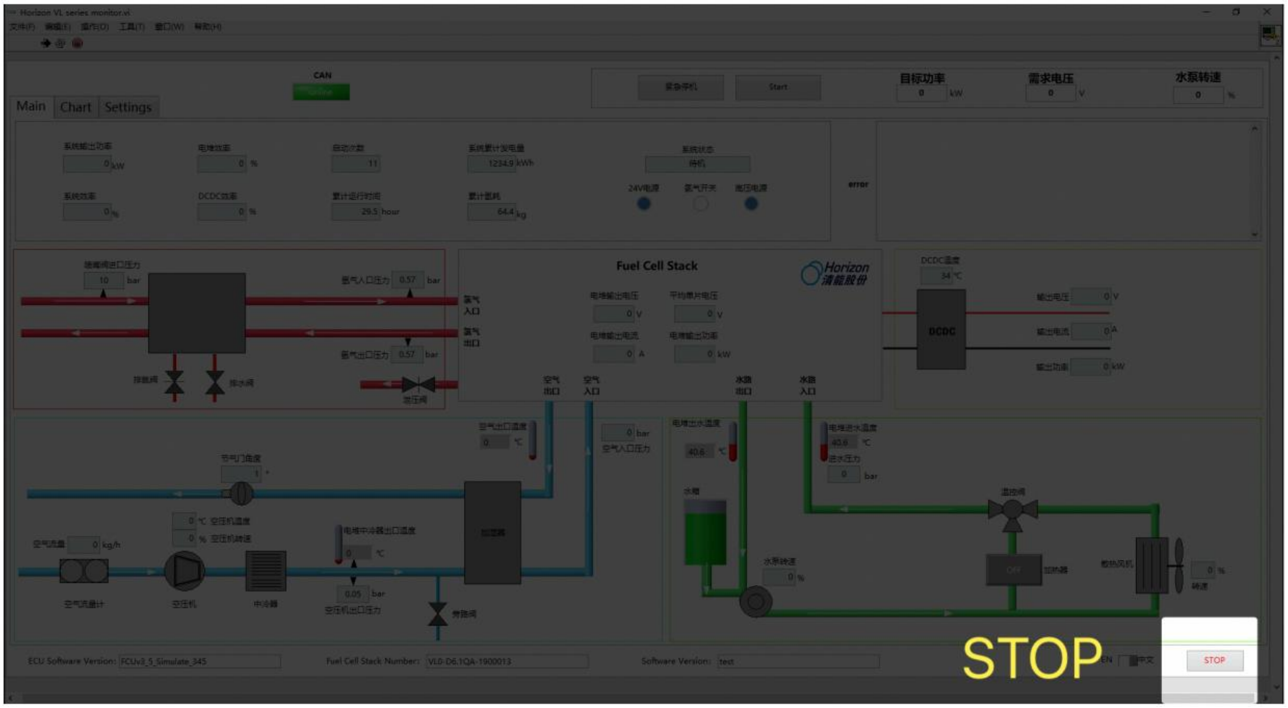


Fig4-6 Firmware update

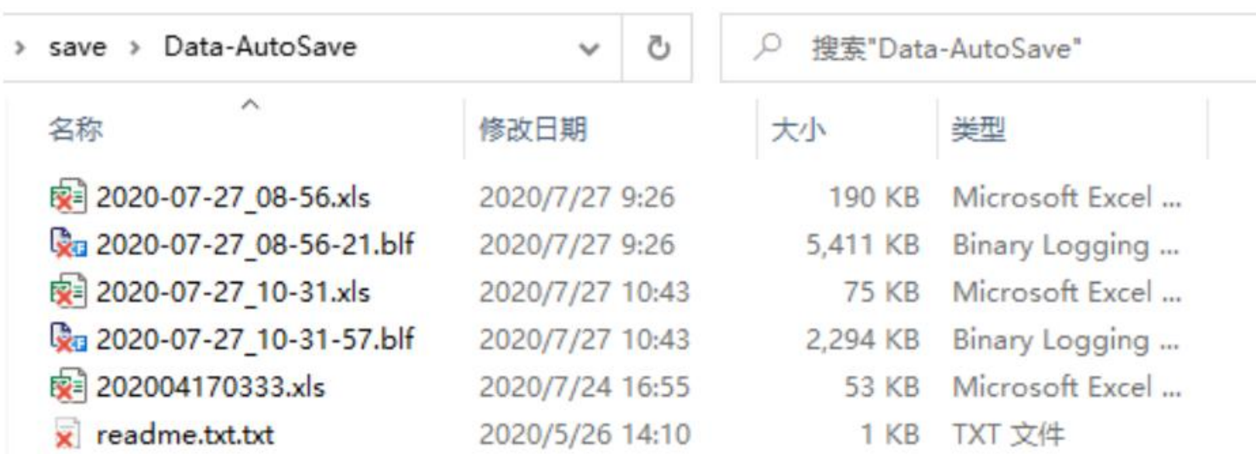
4.7 Stop Horizon VL series monitor

Click the STOP button to stop the Horizon VL series monitor software running.



4.8 Data record

After the program runs correctly, Labview will automatically save the datas to the folder named Save which belongs to the same foder where the application programmes located.


save › Data-AutoSave

搜索"Data-AutoSave"

名称	修改日期	大小	类型
2020-07-27_08-56.xls	2020/7/27 9:26	190 KB	Microsoft Excel ...
2020-07-27_08-56-21.blf	2020/7/27 9:26	5,411 KB	Binary Logging ...
2020-07-27_10-31.xls	2020/7/27 10:43	75 KB	Microsoft Excel ...
2020-07-27_10-31-57.blf	2020/7/27 10:43	2,294 KB	Binary Logging ...
202004170333.xls	2020/7/24 16:55	53 KB	Microsoft Excel ...
readme.txt.txt	2020/5/26 14:10	1 KB	TXT 文件

5. Precautions for system operation

5.1.1 Routine inspection before startup

The fuel cell engine system needs to be checked as follows before starting, but it is not limited to the following points:

1. Visual inspection of the stack module. Check whether the fuel cell stack module is damaged, deformed, etc., and whether there are scratches on the surface.
2. Check at the interface. There is no water leakage or looseness at the interface of the fuel cell system; the hydrogen pipeline joints are free of debris, and the fixing is firm and reliable; the stack cooling water inlet and outlet pipe interfaces are not loose or leaking; the air pipeline clamps are not loose, and the fixing is firm; the can line The external plug-in connection is normal and there is no looseness; the controller 24V low-voltage wiring harness is connected normally; the weak current connection line has no empty plug hanging in the air, and it is firmly fixed.
3. Check the water level of the water tank. The water level of the water tank needs to be within the normal water level. If it is not enough, add the specified coolant. Radiator check. Check whether the radiator is damaged or deformed, and whether there is leakage.

5.1.2 System operation process

During system operation, real-time monitoring of relevant parameters and status is required. The items that need to be monitored are: whether the communication is normal (with or without interference, delay or acceleration), output voltage and current, water inlet pressure, etc. You can view the real-time status of relevant data during system operation on the chart interface.

During the test, use the operating gap to check regularly whether the fuel cell system has any abnormal phenomena such as water leakage, gas leakage, hydrogen tail discharge or other abnormal noises, and report and deal with it in time, and check whether the water tank water level is normal every day; the user collects timely system operation data, download and record system data regularly; avoid running the system in areas with serious air pollution (such as black smoke, burning whip, heavy dust, etc.); no open flames are allowed around the system.

5.1.3 System fault reset operation

If the system reports related fault information during operation, to restore the system state to the standby state, you can do as follows:

1. Turn off the 24V power supply;
2. Turn on the computer according to the normal startup process again, and the system status on the display screen will be displayed as standby.

6. Maintenance and Service

6.1 Maintenance of Fuel Cell System

The daily maintenance of the fuel cell system is divided into: daily 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 6-1： 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 system after it is electrified, observe the parameters through the display screen as well as visual inspection	5min	Follow the system instructions

Table 6-2 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	Timely feedback if any abnormality is found
2	System component fixation inspection	Check all parts for fastness and bolts for looseness	5min	
3	Radiator and air filter inspection	Check the radiator and air filter for any blockage	5min	
4	Check the level of coolant	Visually check tank level	1min	When it is below the level, fill the antifreeze timely to the level no higher than the line

Table 6-3 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	Make sure the fuel cell is normally shut down and purged, and the 24V power supply is closed. If deionized water or	10min	(special antifreeze for fuel cell must be used when

		purified water is added, please drain the coolant in the pipeline		the lowest ambient temperature is below 5°C)
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 system normally	30min	The fuel cell starts and stops once a month

6.2 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 30s), the water level needs to be in between of the lowest and the highest levels, as shown in the figure below.

6.3 Aftersales

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

7. Transportation and Storage

7.1 System transport

➢ Products in the transport process should not be violent vibration, impact and inverted.

➢ The transport temperature is within the -40℃ to 65℃ range.

➢ Products should be able to adapt to sea and air transport conditions.

➢ Products should be sealed packaging and other protective measures to avoid unnecessary damage while it is in sea and air transport conditions.

7.2 System storage

➢ Safe and reliable storage sites or warehouses should be provided to prevent damage. The product should have proper method of receiving and distributing the goods in the storehouse.

➢ Products placed in a ventilated and dry environment, storage temperature in the -40°C to 65°C range. In the case of normal storage, since the factory date within six months, if it is rust or damaged, the factory should be responsible for the products.

7.2.1 Short time Storage

➢ When the store environment temperature is < 30°C, the performance attenuation is slow, we recommend to operate the stack with 80% load for 1 hour to maintain performance monthly.

➢ When the store environment temperature is > 30°C, it should be sealed storage and we recommend to operate the stack with 80% load for 1 to 2 hours to maintain performance every two weeks.

7.2.2 Long time Storage

For the long time storage, the performance degradation is inevitable but it can be recoverable and the recovery time is longer than the normally used stacks. There are two ways to recovery for the stacks stored for a long time.

- First, make sure the hydrogen supply is enough. Second, connect load to let the system output 20% total power for 3 minutes. Then shut down the system and restart after few minutes. Operating at 40% total power for 3 minutes. Shut down again and repeat the steps until the power is up to 80% total power, operate the system for 1 to 2 hours.
- Make sure the hydrogen supply is enough and let the stack in the process of gradual load to restore its performance slowly by exhaust and short-circuit control.

8. 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.

8.1 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.

8.2 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.

8.3 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;

8.4 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.

8.5 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.

8.6 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.

8.7 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

（4）Antifreeze warning sign