Kewell

REXGEAR

Your Power Solution Expert

FCTS-S Series

Fuel Cell Stack Test System

Product Introduction

The development of FCTS-S system is designed to provide a stable testing platform for fuel cell stacks. The system contains KDLF series fuel cell specific energy recycling DC electronic load, gas flow and pressure control module, gas humidity and temperature adjustment control module, cooling module, stack cell voltage detection module and sampling control and protection module, etc., it adopts the Kewell's self-developed system test software to test the output characteristics of fuel cell stacks under different working conditions. Based on online data monitoring and processing by fuel cell stack test system platform, the polarization curve, power curve and other characteristic curves of the measured cell stack can be analyzed to find the optimal output condition of the cell stack, and the output voltage of individual cells in the cell stack can be monitored. The system is applicable to the R&D and performance testing of fuel cell stacks.

- Polarization curve test
- Sensitivity test
- Stable state test
- Dynamic operating condition test
- Activation test
- Durability test
- System insulation test
- Consistency of cell voltage

Product Features

- Online adjustable gas inlet pressure, temperature and dew point temperature for cathode and anode.
- Reserved anode connection for hydrogen circulation pump.
- Cathode and anode gas with wet/dry switching.
- Adjustable test step & each protection variable.
- Data recording and analysis capacities, automatic report generation and one-click export.
- Fuel cell specific electronic loads, multiple operating modes: CV, CC, CP, etc.
- Double safety protection: hardware & software, with customizable alarm values.
- Dual operation mode: Manual/Auto, supports long periods unattended work.
- Online hydrogen leak alarm and online insulation detection.
- Hydrogen safety discharge channel.

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Technical Parameters

Unit	Parameter	FCTS-S-60	FCTS-S-100	FCTS-S-150	FCTS-S-200	FCTS-S-250	FCTS-S-300	FCTS-S-400
Gas flow control	Power Range	15-60kW	25-100kW	37.5-150kW	50-200kW	62.5-250kW	75-300kW	100-400kW
	Anode flow range	15-1500 SLPM	25-2500 SLPM	40-4000 SLPM	50-5000 SLPM	60-6000 SLPM	80-8000 SLPM	100-10000 SLPM
	Flow control accuracy	±(0.8%Rdg+0.2%F.S)						
	Cathode flow range	45-4500 SLPM	80-8000 SLPM	120-12000 SLPM	150-15000 SLPM	180-18000 SLPM	200-20000 SLPM	250-25000 SLPM
	Flow control accuracy	± (0.8%Rdg+0.2%FS)						
	Nitrogen purging	It has nitrogen purging before and after testing, and nitrogen protection						
Gas pressure control	Back pressure control range	(Cell stack resistance + 15) kPa~300kPa.g						
	Back pressure control accuracy	±2kPa (stable state, hydrogen circulation, pulse discharge)						
Gas humidifi-cation control	Dew point temperature range	RT+5℃ ~90℃						
	Dew point temperature control accuracy	±1℃ (stable-state)						
Gas heating control	Temperature control range	RT+5℃ ~95℃						
	Temperature control accuracy	±1℃ (stable-state)						
Gas dry/wet bypass switch		Yes						
Cooling system temperature control range		RT+5℃ ~90℃						
DC electronic load		100~400 kW						
Cell voltage inspection	Detection channel	Expanded to 1024 (max)						
	Measuring range	(-5~5) VDC						
	Measurement accuracy	±1mV						

Optional Functions

- Gas mix function
- Quick dew point function
- Hydrogen circulation function
- Subzero startup performance test solution
- Customized pipeline interface
- Hydrogen concentration detection in exhaust gas
- Exhaust gas dehumidification
- Test cabinet
- Cooling circuit purging

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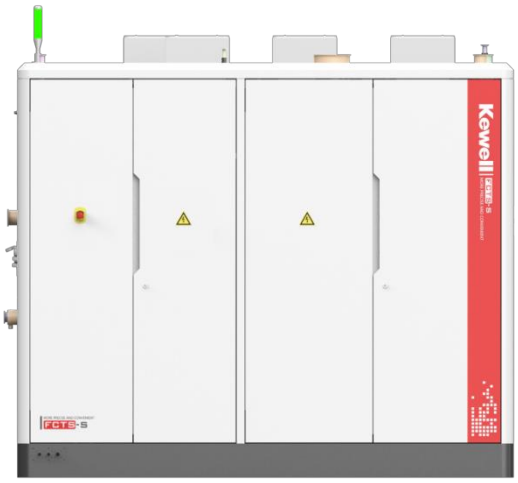
1 Product Overview

The FCTS-S system is designed to provide a stable testing platform for fuel cell stacks. The system contains the D2000 series fuel cell dedicated regenerative electronic load, gas flow and pressure control module, gas humidity and temperature adjustment module, cooling module, stack cell voltage detection module and sampling control and protection module, etc. It adopts Kewell's self-developed test software to test the output characteristics of fuel cell stacks under different working conditions. Based on online data monitoring and processing by fuel cell stack test system, the polarization curve, power curve and other characteristic curves of the measured stack can be analyzed to find the optimal output condition of the stack, and the output voltage of individual cells in the cell stack can be monitored. The system is applicable to the R&D and performance testing of fuel cell stacks.



Appearance (without test cabinet)

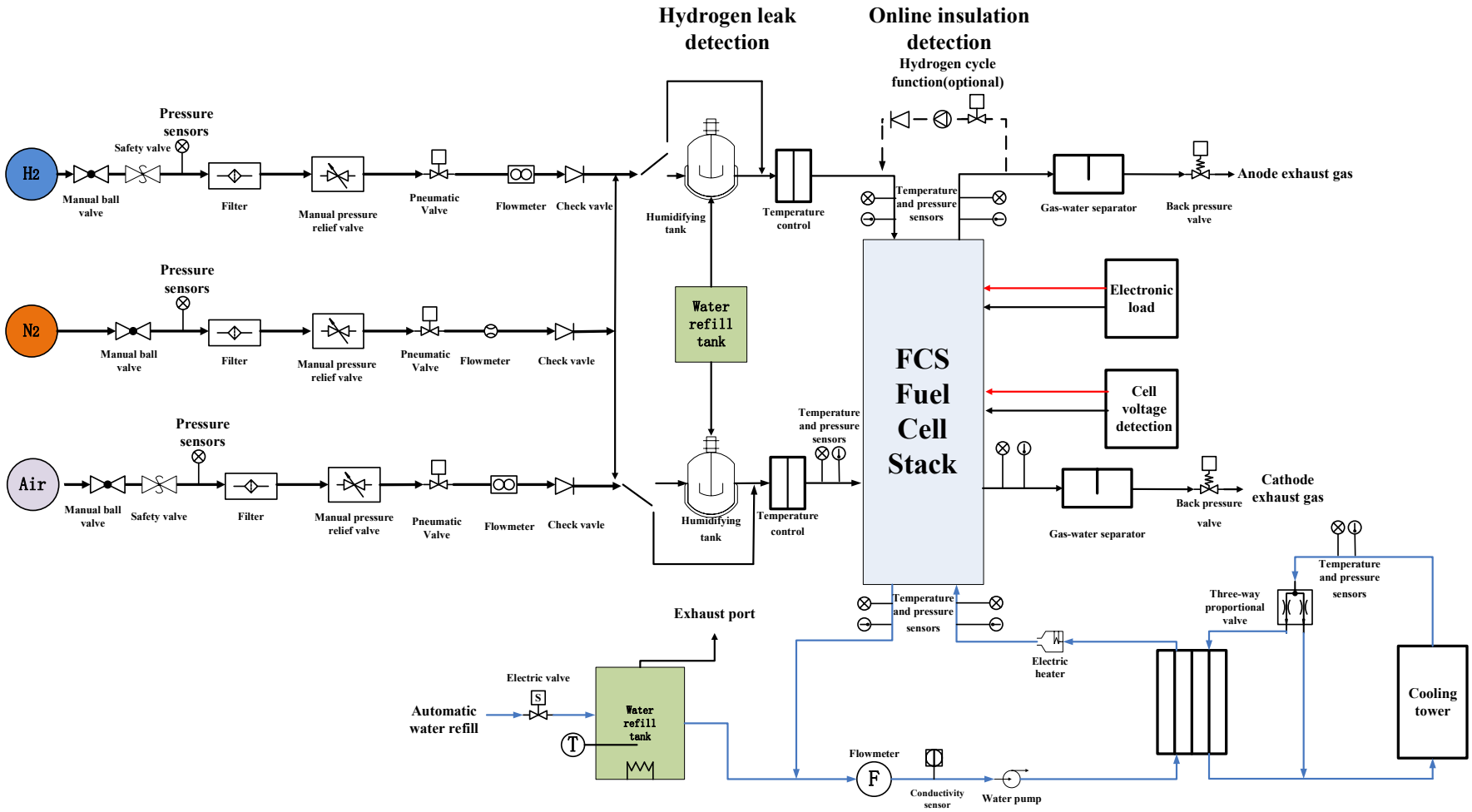
Appearance (with test cabinet)

2 Product Features

- Nitrogen purging, circulating water preheating, automatic water make-up and gas exhaust.
- Online adjustable gas inlet pressure, temperature and dew point temperature for cathode and anode.
- Automatic back pressure of the cathode/anode gas; cathode/anode gas and cooling water pressure tracking.
- Reserved anode connection for hydrogen circulation pump.
- Cathode and anode gas with wet/dry switching.
- Adjustable test step & each protection variable.
- Data logging and analysis, automatic report generation and one-click export.
- Electronic load with wide ranges of voltage and current, multiple operating modes: CV, CC, CP, etc.
- Safety protection at both hardware & software levels, with customizable alarm thresholds.
- Dual operation modes: Manual/Auto, support long periods of unattended work.
- Online hydrogen leak alarm and online insulation detection.

3 System Composition

The design drawing of the fuel cell stack test system is shown below:



The system contains anode gas supply unit, cathode gas supply unit, cooling system control unit, nitrogen purging unit, sampling and control processing unit, HMI, safety protection unit, regenerative electronic load, etc. The anode/cathode gas supply unit contains parts such as flow control, gas humidification, dry gas bypass, temperature control, back pressure control, exhaust gas treatment, and hydrogen circulation control (reserved interface). The test bench also contains hydrogen leakage detection, cell voltage detection, insulation resistance detection, AC internal resistance test (optional), etc.

3.1 Anode / Cathode Gas Supply Unit

Pursuant to the electrochemical reaction of the fuel cell stack, corresponding to parameters like flow, temperature, pressure, humidity required for the anode and cathode reaction gases, the gas supply unit can be divided into parts such as gas pretreatment, flow control, gas humidification, temperature control, back pressure control, and exhaust gas treatment. The cathode/anode gas and cooling water pressure tracking function is also available.

The hydrogen of the anode and the air of the cathode pass through the pipeline respectively, conveying the pressurized gas at the source end to the test bench. Through the gas pretreatment unit containing pressure detection, filter and other components, the mass and pressure of the gas are adjusted to the appropriate range. Here, the filter of the anode circuit will further filter the hydrogen to remove impurities, and the filter of the cathode circuit can filter the moisture content, solid particles, and oil content of the air.

The reactant gases are then sent into the tested stack through the mass flow control unit, humidification unit, and heating unit, and the humidification unit achieves fine humidity regulation by means of bubbling. The heating unit can effectively control the temperature of the reactant gas that enters the stack, and the humidification unit can precisely control gas temperature and dewpoint temperature.

The excess reactant gas passing through the stack is then discharged through the exhaust treating unit and the back pressure control unit. The back pressure control unit contains a back pressure regulating valve, and it can control the flow and pressure through the back pressure regulating valve and the mass flow controller (MFC).

The hydrogen and air are vented separately.

It reserves the interface of the hydrogen circulation pump on the hydrogen side, so that customers can check the operating conditions of the hydrogen circulation test.

A dry gas bypass is designed for the hydrogen and air supply circuits respectively, so as to meet the requirements of dry activation test of the stack.

3.2 Cooling System Control Unit

The cooling system control unit retains the temperature and exchanges heat energy before and during the operation of the stack. Therefore, the stack test system features the following functions of the stack cooling system: Water make-up and gas venting, flow control, preheating, precise temperature control, and conductivity reduction.

The cooling system circuits fall into two stages, namely the internal circulation circuit and the external circulation circuit, wherein the former is the circuit connected to the stack under test, and the medium is deionized water (DI water); the external circulation circuit is connected to the cooling tower, and the medium is ordinary water. The two circulation circuits exchange energy through plate heat exchangers.

The cooling system contains pressure/temperature/flow/conductivity sensors, water make-up tank, electric heating unit, circulating water pumps, plate heat exchangers, exhaust valves, proportional control valves, and other valves.

After transmitting the measured flow to the controller through the online flow meter of the cooling system, the control program can adjust the flow rate to a certain value as per the preset control model, so that the temperature difference between the inlet and outlet of the cell meets the user's requirements.

In case that the conductivity of the internal circulating water exceeds the required value, the system can reduce the conductivity of the circulating water gradually through water exchange.

3.3 Nitrogen Purging and Leak Detection Unit

The gas circuit purging unit consists of cathode and anode nitrogen purging, which allows the stack to be purged before and after the test.

The nitrogen purging module consists of the regulator, flow meter, check valve, etc.

3.4 Sampling and Control Processing Unit

It collects each monitoring value of the system and controls the functional operation of the system. The unit contains the controller module, digital/signal acquisition module, digital/signal output control module, communication data exchange module, etc.

3.5 Sensing and Transducing Unit

To guarantee the high-precision control, stability and reliability of the entire test system, all sensors used are from internationally renowned brands, and a signal conditioning unit is introduced for the sensors, transmitters and the acquisition system. The sampling sensors and key components adopt isolation transformers for power supply isolation. All sensors adopt two-wire current signal output, and the shielding layer is safely grounded at the signal source access point to protect the sensing signal from

interference of the external environment.

3.6 Stack Cell Voltage Acquisition Unit

To monitor the performance of the stack throughout the operation process, the test system is equipped with a cell voltage acquisition unit. It also supports expansion of the sampling channel by increasing the number of modules. The acquisition unit is integrated into the test platform.

3.7 HMI Unit

The system is equipped with Kewell's self-developed PC software with functions such as parameter display and setting, data storage, and graphical display. The system communication is realized through Ethernet and switch, allowing the test system to be operated remotely from the background. Moreover, the communication method of Ethernet has excellent anti-interference performance.

3.8 Safety Protection Unit

The stack test system has an all-around safety protection logic. The software implements three-level fault protection control logic: Level 1: alarm prompt; Level 2: load shed and shutdown; when a Level 3 fault occurs, it will stop immediately. Safety protection both ensures the safety of the test system and protects the safe operation of the stack under test.

At hardware level, the test system integrates the hydrogen concentration detection module, insulation resistance detection module, temperature switch, pressure switch, automatic pressure relief valve, etc., and there is a safety PLC to ensure safe operation even in the event of a system failure.

4 Functions & Parameters

4.1 Test Functions

The system supports the following tests:

- Fuel cell stack polarization curve test
- Fuel cell stack stressor test
- Monitoring and analyzing the operating characteristics and consistency of each cell in the stack
- Fuel cell stack start-up performance test
- Fuel cell stack steady-state condition test
- Fuel cell stack dynamic operation test
- Fuel cell stack activation test
- Fuel cell stack durability test
- Fuel cell stack system insulation test
- Real-time monitoring and alarm

4.2 Technical Parameters

Unit	Parameters	Specifications						
		FCTS-S-60-G	FCTS-S-100-G	FCTS-S-150-G	FCTS-S-200-G	FCTS-S-250-G	FCTS-S-300-G	FCTS-S-400-G
Power range		15-60kW	25-100kW	37.5-150kW	50-200kW	62.5-250kW	75-300kW	100-400kW
Gas flow control	Anode flow range	15-1500 SLPM	25-2500 SLPM	40-4000 SLPM	50-5000 SLPM	60-6000 SLPM	80-8000 SLPM	100-10000 SLPM
	Flow control accuracy	±(0.8%Rdg+0.2%F.S.)						
	Cathode flow range	45-4500 SLPM	80-8000 SLPM	120-12000 SLPM	150-15000 SLPM	180-18000 SLPM	200-20000SLPM	250-25000 SLPM
	Flow control accuracy	± (0.8%Rdg+0.2%F.S.)						
	Nitrogen purging	Support nitrogen purging before and after testing, and nitrogen protection						
Gas pressure control	Back pressure control range	(Cell stack resistance + 15) kPa~300kPa.g						
	Back pressure control accuracy	±2kPa (steady state, hydrogen circulation, pulse discharge)						
	Pressure detection	Hydrogen source end pressure detection, nitrogen source end pressure detection, air source end pressure detection, hydrogen/air pressure detection at the stack inlet; hydrogen/air pressure detection at stack outlet						
	Pressure detection accuracy	0.5%F.S.						
Gas humidification control	Humidification method	Bubbling + spraying						
	Dew point temperature range	RT+5~90℃						
	Dew point heating rate	≥4℃/min						
	Dew point temperature control accuracy	±1℃ (steady state)						
Gas heating control	Heating method	Plate heat exchanger						
	Temperature control range	RT+5-95℃						

	Temperature control accuracy	±1℃ (steady state)						
	Temperature detection accuracy	±0.5℃						
Stack cooling system	Coolant flow (under short-circuiting condition)	1.5-15m3/h	3-30m3/h	3.5-35m3/h	4-40m3/h	5.5-55m3/h	7-70m3/h	8-80m3/h
	Coolant	Deionized water						
	Cooling circuit detection	Stack entrance pressure/temperature detection, cooling circuit flow detection, conductivity detection						
	Flow measurement accuracy	±1% F.S.						
	Temperature control range	RT+5~90℃						
	Temperature control accuracy	±1℃ (steady state)						
	Temperature measurement accuracy	±0.5℃						
	Online conductivity test	Available, 0.01~20us/cm						
	Coolant supply	Coolant replenishment & gas exhaust						
Electronic load	Rated power	100kW	150kW	150kW	200kW	300kW	300kW	400kW
	Voltage range	12~1200V						
	Current range	0~300/600/900/1200A						
	Voltage & current accuracy	0.05%F.S.						
	Voltage & current customization	Available						
Cell voltage inspection	Detection channel	On demand						
	Measuring range	(-5~5) VDC						

	Measurement accuracy	±1mV		
	Protection/alarm	You can set the alarm limit, and battery voltage difference alarm and protection		
Protection function	Hydrogen leak detection	1000~40000ppm (Alarm limit can be set)		
	Insulation resistance detection	Impedance protection threshold can be set		
	Hardware protection	Pressure valve (controllable pressure relief protection); Temperature switch; Emergency stop button.		
	Software protection	Hydrogen leakage, insulation resistance over-limit, over-temperature protection, overvoltage protection, undervoltage protection, excessive low flow protection, electronic load fault protection, etc.		
	Upper computer	Standard I5 CPU, 8G RAM, 1T HDD, WIN10 system, dual screen display		
Dimensions (for reference) (mm, W*D*H)	Without test chamber*	2800*1600*2650(60-100KW)	3000*1800*2650(150-250kW)	3200*2000*2650(300-400kW)
Optional	Gas mixing function	Customizable		
	Exhaust gas dehumidification	With plate heat exchangers to reduce the moisture content in the exhaust gas		
	Test cabinet	Customizable, modular assembly, including hydrogen leak sensor, explosion-proof lamp		
	Quick dew point function	Dew point rise rate up to 10°C/min		
	Hydrogen circulation function	Standard machine with reserved interface, optional hydrogen circulation pump, gas-liquid separator, check valve, etc.		
	Hydrogen concentration detection in exhausts gas	Online measurement of hydrogen concentration in exhaust gas		
	Cooling circuit purging	Nitrogen or air purging of the stack cooling circuit		
	Subzero cold start performance test	Can be integrated with environmental chamber		
	Pipeline interface	Customizable		

*: Equipment dimensions are subject to actual equipment delivered.

4.3 Data Acquisition

- Test bench data record

During the test, the test bench mainly records the following parameters:

No.	Test point	No.	Test point
1	Time	14	Nitrogen source pressure
2	Hydrogen source end pressure	15	Coolant inlet temperature
3	Hydrogen inlet pressure	16	Coolant outlet temperature
4	Hydrogen outlet pressure	17	Coolant flow
5	Hydrogen flow	18	Coolant inlet pressure
6	Hydrogen inlet temperature	19	Coolant outlet pressure
7	Hydrogen outlet temperature	20	Coolant conductivity
8	temperature of hydrogen getting out of humidifying tank	21	Liquid level of water tank
9	Air source end pressure	22	Hydrogen leakage concentration detection
10	Air inlet temperature	23	Insulation resistance detection
11	Air outlet temperature	24	Cell voltage inspection
12	Air flow	25	Protection switch status
13	Air inlet pressure	26	Coolant heating condition

4.4 Design Accuracy

No.	Name	Accuracy
1	Gas flow controller	±(0.8%Rdg+0.2%F.S.)
2	Coolant flowmeter	≤1%F.S.
3	Temperature sensor	≤±0.5℃
4	Pressure sensor	≤±0.5%F.S.
5	Conductivity	≤±1.5%F.S.

4.5 Safety and Emergency Response

1) This involves the hydrogen leakage detector, temperature sensor, flow sensor, pressure sensor, etc. There is a hydrogen sensor in the test system to monitor hydrogen. In cases of hydrogen leak, the controller can respond according to leakage volume, and the system will shut down the load, cut off the gas source and enter emergency stop procedure once the set critical value is reached. Hydrogen safety

is extremely important, so we set an alarm lamp on the top of the test platform for warning the operators to enter the corresponding procedures in the event of hydrogen leak.

2) Parameters monitored may change later than the operator's perception upon some unexpected situations, such as gas leakage and abnormal fuel cell status. In such cases, the operator can push the emergency stop button, and the system will immediately act on key valves through the electric circuit, to disconnect the load, cut off gas source and open the exhaust valve for automatic pressure relief, etc. Meanwhile, the status signal of the emergency stop is sent to the controller, and the controller immediately executes the fault treatment procedure after receiving the signal to ensure the safety of fuel cell, equipment and personnel.

3) The system adopts backup PLC design, and it will take effect in extreme cases when the main control PLC fails. Then, the stop process will be executed to ensure the safety of the test bench and DUT.

4) The fuel cell stack test platform detects the operation status of the system and displays the fault code on the software interface.

The system can act in coordination with the laboratory safety protection system through communication or I/O port.

4.6 Key Components

Name	Description	Brands
Filters	Filter impurities from hydrogen and air	FITOK or equivalent brands
Solenoid / Pneumatic valves	Control the output of hydrogen, nitrogen and air	ASCO, CKD or equivalent brands
Check valves	Control the one-way output of hydrogen, nitrogen and air	FITOK or equivalent brands
Flow controllers	Detect and control the output flow of hydrogen and air	Alicat or equivalent brands
Pressure sensors	Detect the pressure of hydrogen, nitrogen, air and the water-cooling system	Wika, GEMS or equivalent brands
Temperature sensors	Detect the temperature of hydrogen, nitrogen, air and the water-cooling system	Wika, KOBOLD or equivalent brands
Hydrogen concentration detector	Detect hydrogen leaks in the space of the test platform	FIS or equivalent brands
Heating and humidifying modules	Control temperature and humidity of air and hydrogen by means of atomized humidification	Kewell
Back pressure control module	Control the pressure of hydrogen and air circuits	Equilibar, Link or equivalent brands
Cell voltage monitor module	Detect cell voltage in the fuel cell stack in real time	Kewell
Conductivity sensors	Test the conductivity of the coolant in cooling system to check if the requirements are met	Chemins or equivalent brands

Name	Description	Brands
Electronic load	Feed back the electricity from the fuel cell stack to the grid	Kewell
Note: If affected by uncontrollable factors, an equivalent brand may be selected upon the consent of the customer.		

5 Software

5.1 Software Introduction

1) Operating system

The PC software of this test system is compatible with platforms such as Microsoft Windows, which includes Windows7, Windows8, Windows10, etc. The standard configuration is I5 CPU, 8G RAM, 1T HDD, WIN10 system, dual screen display.

2) Registration

The first time of installation and use of this software requires registration, which will be completed before leaving the factory. Moreover, provided that the customer needs to install the software on another computer(s), the machine code of the computer(s) should be sent to Kewell, and Kewell will return a serial code.

3) User permissions

Three levels:

- **Admin**: It has all software operation permissions and can add or delete other users;

- **Tester**: It has battery test step editing in the software and other operation permissions, but cannot modify software parameter settings.

- **Guest**: it has the basic operation authority of the software, such as importing step files, but cannot modify the steps and other contents.

5.2 Test Bench Control Platform

- **Parameter setting:** The test bench supports customization of parameters like gas pressure, flow rate, temperature, dew point temperature, and cooling system temperature. The set values and measured values are saved automatically.

- **Control mode:** Direct control of variables (temperature, flow, pressure, dew point, water cooling flow, water cooling pressure, water cooling temperature difference, etc.).

- **Display information:** Real-time display of the data changes of each input and output conditions, and recording of the output voltage and current polarization characteristic curves of the fuel cell stack.

- **Alarm:** The test bench has real-time alarm and emergency processing functions, with which you

can read historical alarm information. It has protection delay setting and enabling functions.

- **Data saving**: The test bench can save the data in the above tables, and the available format is: .csv. Test reports can be generated automatically.

5.3 Software Functions

Class	Function/Mode	Description
System	Standard test modes	1. Manual testing. 2. Automatic testing.
	Basic functions	Support adding, editing, deleting, saving process etc., and predefined steps. Support the CVM CAN protocol through the DBC import function, to facilitate testing. Support saving test items and test processes, and one-click call. Support manual debugging mode in the debug interface. Support manual debugging mode of the electronic load. Load interface in manual mode with automatic current/power tracking. Support software control of each valve. Support bench alarm and threshold settings for global Level 1, 2, 3 alarm. Support curve display of real-time data. Support fault logging. Support viewing the CAN raw messages of the bench and stack connections in the software interface. Support manual operation of the "normal stop" and "emergency stop". Support automatic running of step tests as per national standards or custom step tests. Support step cycling, step skipping and pause. Support one-key remote reset of hardware faults (Mitsubishi PLC and electronic load). Support system configuration or range.ini file modification, software configuration or enabling, etc. Support one-click drainage, one-click dry nitrogen purging, one-click wet nitrogen purging and one-click heating.
	Other functions	Support Hioki internal resistance meter to read internal resistance and voltage. Support the combined use of Kewell load, Faith load, etc. Support integration of an electrochemical workstation. Support pressure retention with stack and bench. Support the calculation of H2 volume, air volume, dew point, humidity, etc. Support fault notification by email remotely. Logging, easy to analyze and find the cause of problems.

	System management	Support three levels of user rights assignment. Support for device management and editing.
	Data logging and analysis	Support data storage in csv format. Small database storage in specific formats. Support real-time curve display and query of historical project curves. Support automatic step report output.
Display	Login screen	Enter user name and password, or remember user information
	Status main screen	Display some status parameters for the anode, cathode and water-cooling chambers. The fault message display area shows fault messages clear at a glance.
	Manual control interface	Individual control of each valve
	Manual test interface	Set the status of three chambers (H2, air, and water) and loading current, support LUT functions. Individual load control.
	Process interface	Edit processes, import basic processes, edit, add, delete and save processes. Import operating conditions. Recall saved process files for subsequent test projects.
	System configuration interface	Users may switch/set some configurations of the system (see software interface for details)
	Real-time curve/ historical curve interface	A graphical representation of the current or historical test data for each test item

6 Operating Conditions

Operating conditions of the fuel cell stack test platform									
No.	Item	Specific requirements							Notes
		FCTS-S-60-G	FCTS-S-100-G	FCTS-S-150-G	FCTS-S-200-G	FCTS-S-250-G	FCTS-S-300-G	FCTS-S-400-G	
1	Hydrogen source	2-3MPa, up to 1500SLPM;	2-3MPa, up to 2500SLPM;	2-3MPa, up to 4000SLPM;	2-3MPa, up to 5000SLPM;	2-3MPa, up to 6000SLPM;	2-3MPa, up to 8000SLPM;	2-3MPa, up to 10000SLPM;	Complete the first stage of decompression at hydrogen source
2	Nitrogen source	1MPa~1.5Mpa, flow range 0~500 SLPM	1MPa~1.5Mpa, flow range 0~750 SLPM	1MPa~1.5Mpa, flow range 0~1000 SLPM	1MPa~1.5Mpa, flow range 0~1500 SLPM	1MPa~1.5Mpa, flow range 0~1500 SLPM	1MPa~1.5Mpa, flow range 0~2000 SLPM	1MPa~1.5Mpa, flow range 0~3000 SLPM	Complete the first stage of decompression at nitrogen source
3	Air source	5~8bar, max. flow up to 4500SLPM	5~8bar, max. flow up to 8000SLPM	5~8bar, max. flow up to 12000SLPM	5~8bar, max. flow up to 15000SLPM	5~8bar, max. flow up to 18000SLPM	5~8bar, max. flow up to 20000SLPM	5~8bar, max. flow up to 25000SLPM	Assigned by customer
4	Primary cooling circuit	The lab shall be provided with a water purifier for producing deionized water, for cooling liquid make-up in the internal cooling circuit before the test and real-time make-up of deionized water during the test. The conductivity of the effluent water is 0.3us/cm @25℃; pressure of outlet water 3~6bar; with peripheral water storage tank							
		Recommended water yield ≥200L/h	Recommended water yield 400L/h	Recommended water yield 500L/h	Recommended water yield 600L/h	Recommended water yield 600L/h	Recommended water yield 600L/h	Recommended water yield 800L/h	
		The system requires a one-time injection capacity of about 300L	The system requires a one-time injection capacity of about 800L	The system requires a one-time injection capacity of about 1000L	The system requires a one-time injection capacity of about 1500L	The system requires a one-time injection capacity of about 1500L	The system requires a one-time injection capacity of about 1500L	The system requires a one-time injection capacity of about 2000L	
5	Secondary cooling circuit	Flow rate ≥15m3/h; Supply water temperature <32℃; Water supply pressure 2~4bar	Flow rate ≥30m3/h; Supply water temperature <32℃; Water supply pressure 2~4bar	Flow rate ≥35m3/h; Supply water temperature <32℃; Water supply pressure 2~4bar	Flow rate ≥40m3/h; Supply water temperature <32℃; Water supply pressure 2~4bar	Flow rate ≥50m3/h; Supply water temperature <32℃; Water supply pressure 2~4bar	Flow rate ≥60m3/h; Supply water temperature <32℃; Water supply pressure 2~4bar	Flow rate ≥80m3/h; Supply water temperature <32℃; Water supply pressure 2~4bar	

6	Drainage circuit	Reserve a drainage passage or a ground drain to discharge water separated from the exhaust gas and cooling circuit						
7	Hydrogen exhaust	Reserve a hydrogen exhaust interface at the top of the lab, to discharge the unreacted hydrogen						
8	Air exhaust	Reserve an air exhaust interface at the top of the lab						
9	Power distribution	Mains power grid, three-phase five-wire system (including the heating system in cooling circulation unit, humidification unit, low voltage power supply)						
		Recommended to be ≥150KW	Recommended to be ≥250KW	Recommended to be ≥350KW	Recommended to be ≥500KW	Recommended to be ≥550KW	Recommended to be ≥600KW	Recommended to be ≥700KW	
10	Electronic load feedback power	150kW	150kW	150kW	200kW	300kW	400kW	500kW	Regenerative
11	Stack trolley	The test platform provides an enclosed test space for stack testing and the stack is moved on a trolley into the test platform to be in place						
12	Connecting pipes and cables	The connection between the test bench and the stack, including hydrogen interface, air interface, hydrogen/air exhaust, cooling circuit interface, ELV connector, communication interface, electronic load interface, voltage acquisition cables between the CVM and the stack, etc.						
13	Ambient temperature	When the external ambient temperature is below 0℃, the internal and external water must be drained when the equipment is out of use, and the antifreeze must be replaced when the equipmenomt is back in use						

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