# Fuel Cell and Electrolyzer Testing Solutions


Kewell


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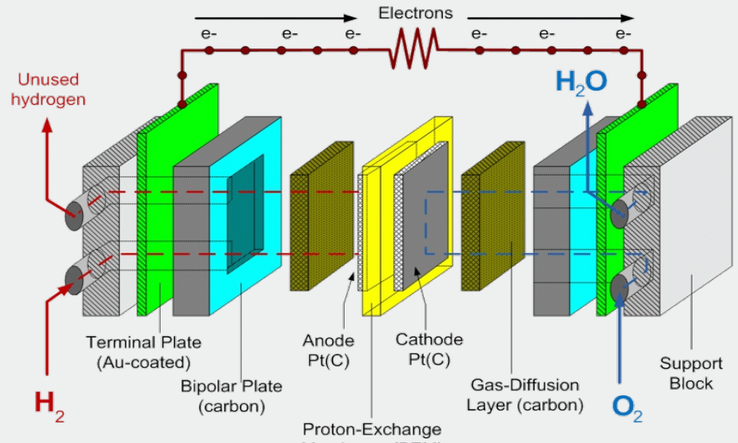
# Fuel Cell Stack Test System

## C100 PEM Fuel Cell Test System
for testing single cells

In the development and production processes of materials such as proton exchange membranes (PEM ), MEA, gas diffusion layers, catalysts, etc., it is necessary to conduct testing and evaluation of their performance, durability, and consistency. C100 PEM fuel cell test system support relevant testing requirements for US DOE and Japanese JIS C8832.

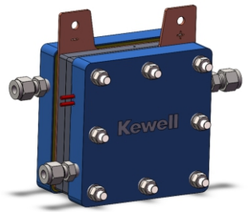
Single cell test system

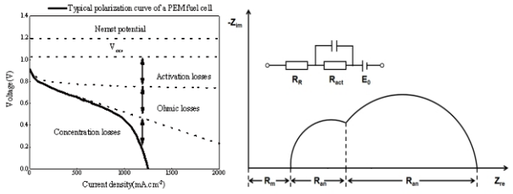



Typical PEM fuel cell MEA structure

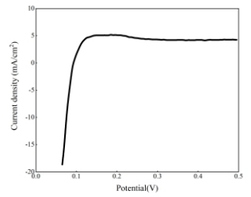
## ADVANTAGES

- High control accuracy: gas flow rate(0.8%Rdg+0.2%F.S.), temperature (RT+5~95℃，±1℃), dew point temperature(RT+5~90 ℃，±1℃), and backpressure(15kPa~300kPa.g，±2kPa).
- Multiple testing functions: sensitivity, performance curve (polarization curve & power curve), and durability test.
- Anti reversal potential: DC electronic load can support -2.5V@120A test.
- PC software functions: Simultaneous data storage across 8 channels, Multi-axis graphing and icons following, Customizable script programming functionality.
- Specialized fixtures: 5cm², 25cm², 50cm².
- Optional electrochemical testing: EIS/CV/LSV.

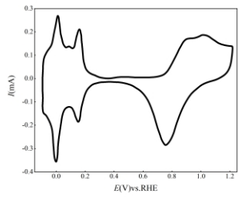



Fuel cell overpotential polarization curves and impedance spectra




Cyclic voltammetry measurement of fuel cell active area



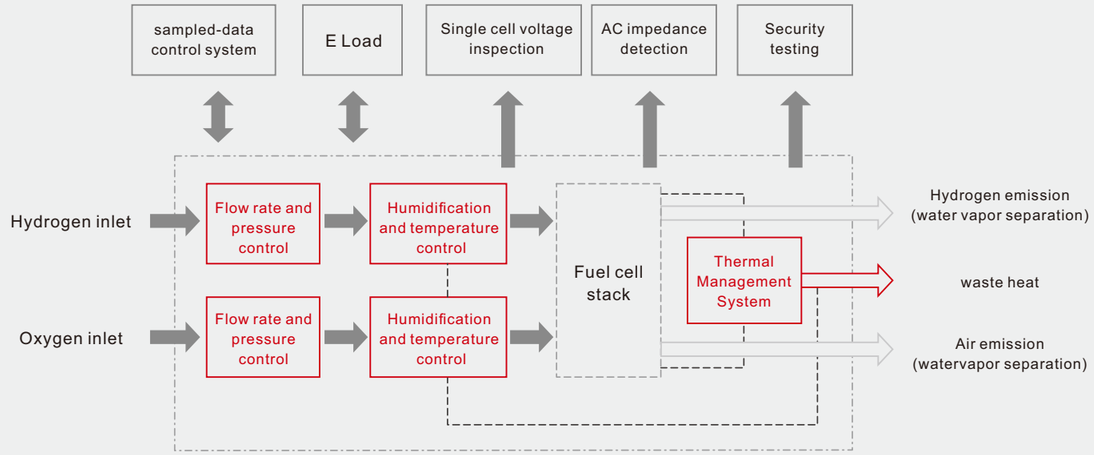

Linear sweep voltammetry for measuring hydrogen permeation current density

# Fuel Cell Stack Test System

## PEM Fuel Cell Short Stack Test System

The test system is compatible with the interfaces and protocols of mainstream international electrochemical workstations. It supports existing electrochemical devices of clients with plug-ins, to meet the requirements of electrochemical and AC impedance testing.

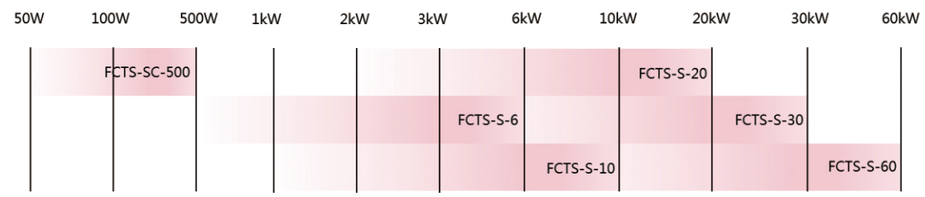
Fuel cell short stack test system




Principle block diagram of fuel cell test system

## ADVANTAGES

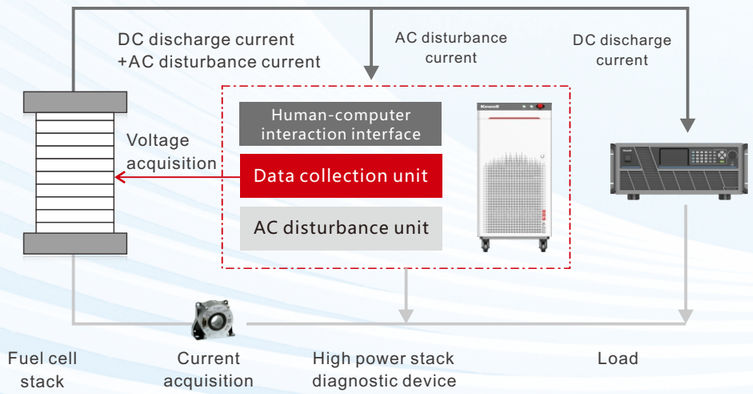
- Support relevant testing requirements for US DOE and Japanese JIS C8832.
- High accuracy control: gas inlet flow(±(0.8%Rdg+0.2%F.S.)), gas pressure(±1kPa), gas temperature(±1℃), dew point temperature(±1℃), coolant flow rate(1%F.S), and coolant temperature(±1℃).Compact design (W*D*H: 360*555*615, mm).
- Hardware protection functions: gas pressure monitoring, insulation monitoring, hydrogen leakage, temperature abnormality, manual emergency stop, emergency exhaust, independent safety unit.
- Software protection functions: Heartbeat monitoring, automatic processing of three-level security alarm, etc.
- Optional functions: gas mixing function, rapid dew point function, and hydrogen circulation function, etc.
- PC software platform: parameter tags, custom scripts, custom functions, and custom interfaces. Support 24/7 unattended operation.
- Support sub-zero cold start test.




Fuel cell short stack test system product portfolio

## High Current EIS Test

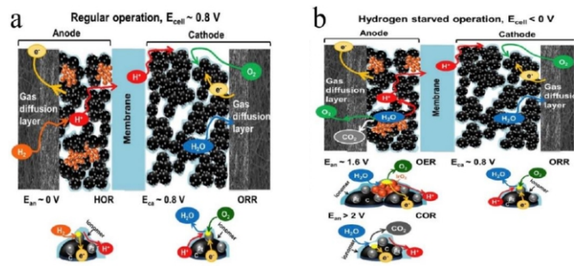
Adopting high-order and high-accuracy data acquisition units, it is possible to achieve the detection of single cell impedance and whole stack impedance.By integrating software, hardware, and data acquisition, the test system can ensure the safty in logic.




Block diagram for EIS testing of fuel cell stacks

## Anti Reversal Potential Test

Through operation of the electronic load in quadrants I and IV, and the powerful software script editing function, the test system monitors data throughout the testing process and provides protection in a timely manner.




Fuel cell electrode reaction (a)Normal fuel supply (b)Fuel starvation

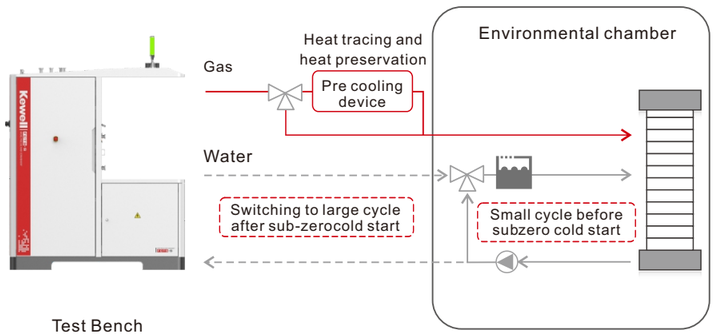
## Sub-Zero Cold Start Testing

Kewell has rich experience in developing and designing fuel cell test systems with integrated environmental chambers. The test system has many functions, such as:

·Safty protection logic.

·Configure and control all parameters on the upper computer.

·Seamless switching between different circulation.



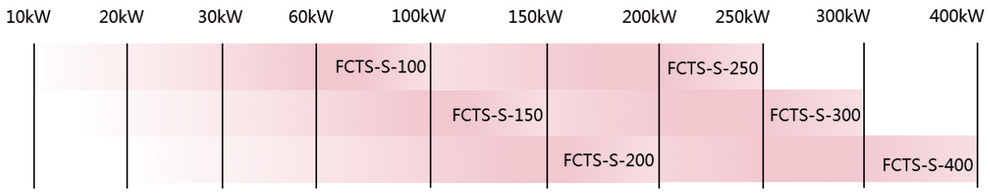

Block diagram of the coordination between fuel cell short stack test bench and environmental chamber

# Fuel Cell Stack Test System

## PEM Fuel Cell Stack Test System

In the development and production of fuel cell stacks, it is necessary to test and evaluate their performance, durability, and consistency. The Kewell FCTS-S series fuel cell stack test system can accurately complete a series of tests mentioned above, covering a power range of 60-400kW, and it supports the relevant testing standards of the US DOE and Japan JIS C8832.

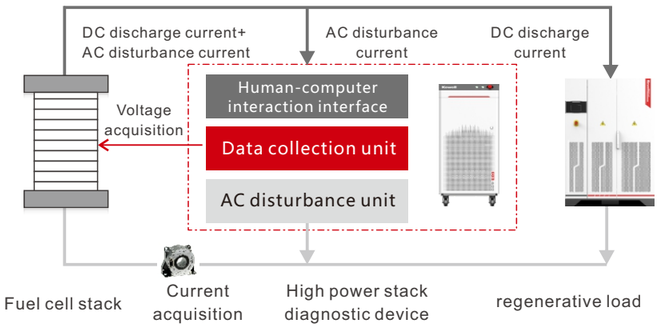

Fuel cell stack test system



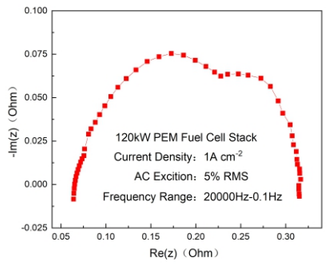

Fuel cell stack test system product portfolio

## High Current EIS Testing

Kewell analyzed the impact of regenerative DC electronic loads on impedance testing of fuel cell through a large amount of test data, and avoided the shunt effect of regenerative DC electronic load on impedance testing process by optimizing impedance algorithms and changing equipment wiring layout,thereby obtaining the true impedance spectrum of fuel cell.



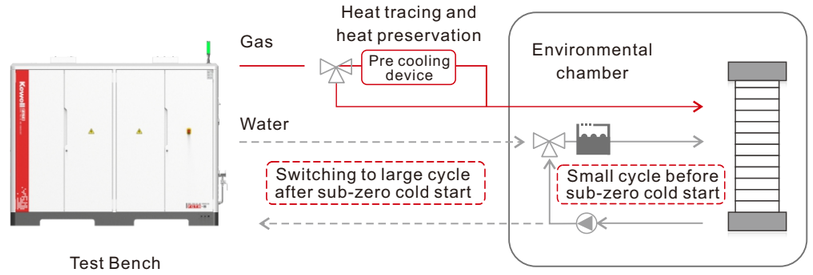

Block diagram for EIS testing of fuel cell stacks




Data from actual EIS test platform

## Sub-Zero Cold Start Testing

By combining the environmental chamber and test system, the performance of fuel cell can be examined during sub-zero cold start test. This covers the start-up strategy of the fuel cell stack, the minimum start-up temperature and start-up time. It is also compatible with performance test of fuel cells at room temperature.



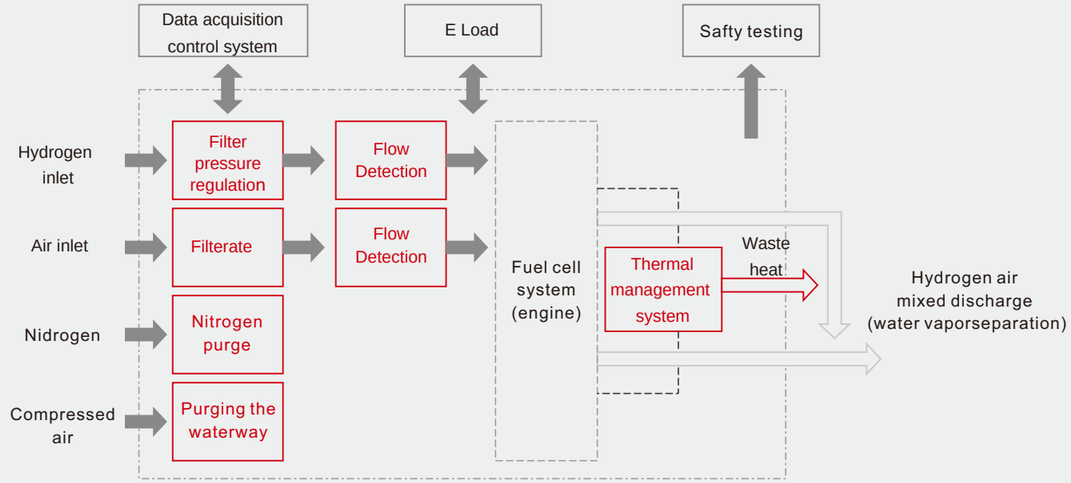

Schematic diagram of integrated environmental chamber in fuel cell stack testing platform

# Fuel Cell System(Engine) Test Syetem

## PEM Fuel Cell System(Engine) Test System

In the development and production process of fuel cell system (engine), it is necessary to test and evaluate the performance and durability. Kewell FCTS-M series fuel cell system(engine) test system can provide a relatively stable testing environment for fuel cell system.The rated power range of FCTS-M series fuel cell system test system is150kW-400kW.In addition,it supports the relevant testing requirements of Chinese GB/T24 554-2022 and Japanese JIS C62282 for fuel cell system test.

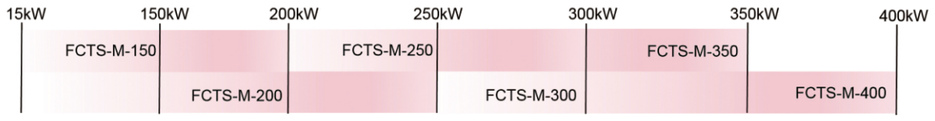

Fuel cell system(engine) test syetem




Principle block diagram of fuel cell system(engine) test system

## ADVANTAGES

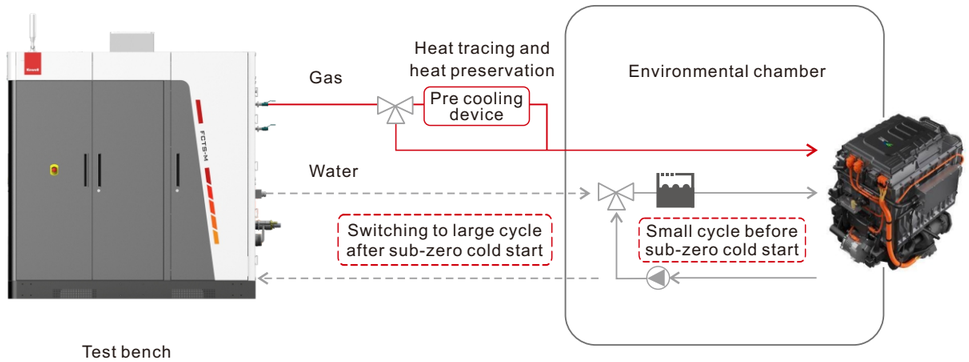
- Support relevant testing requirements for Chinese GB/T 24554-2022 and Japanese JIS C62282.
- Automatic control: gas intake and exhaust, primary and secondary coolant circulation thermal management, gas & water purging, low-voltage power supply, measurement and control unit, and safety protection.
- The minimum footprint is only 2.4m².
- Hardware protection function: gas pressure monitoring, insulation monitoring, hydrogen leakage, temperature abnormality, manual emergency stop, emergency exhaust, peripheral safety linkage I/O, independent safety unit.
- Software protection function: Heartbeat monitoring, automatic processing of three-level security alarm, etc.
- PC software platform: predefined testing steps, automatic process testing, DBC file import andparsing, data storage, graphic display, automatic report generation.
- Support 24/7 unattended operation.




Fuel cell system(engine) test system product portfolio

## Environmental Testing: Sub-Zero Cold Start and Altitude Simulation

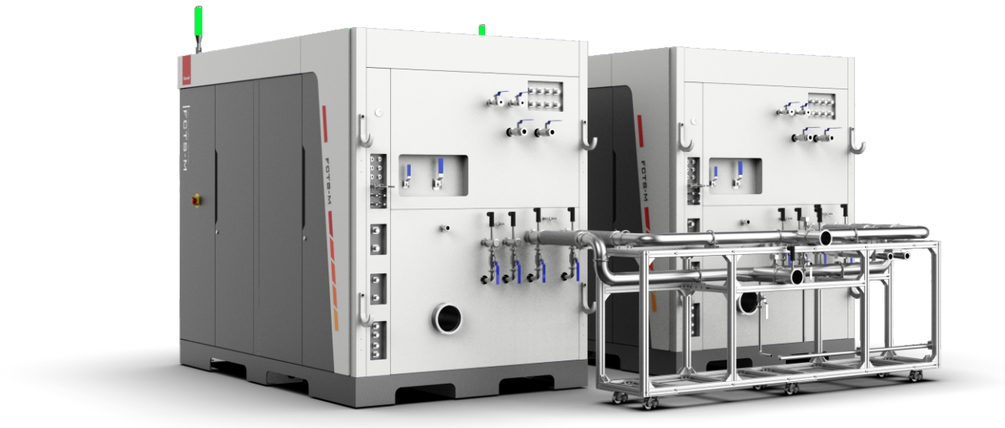
Kewell has mature and rich case experience in the integration of fuel cell system(engine) test system and environmental chambers, which can meet the testing requirements of clients for sub-zero cold start and altitude simulation.




Block diagram of fuel cell system(engine) test system and environmental chamber

## Dual-System Parallel Testing

Kewell introduces the dual-system parallel test solution, which, on the one hand, uses two test systems of the same model to test two independent fuel cell systems(engine). On the other hand, through pipeline switching, the hydrogen supply, gas exhaust, and cooling system can be paralleled to meet the requirement of higher power fuel cell system(engine) test.



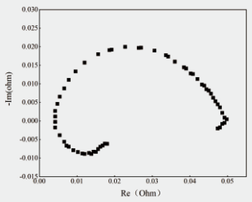
Dual-system parallel test system

# Electrolyzer Test System

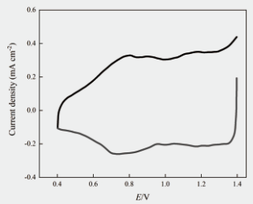
## Electrolyzer Test System
### for Single Cells

E500 series electrolyzer single cell test system is mainly aimed at material-level research, development, and validation testing for water electrolysis that includes boundary performance testing, stressor condition testing, electrochemical testing, and durability testing. The electrolyzer single cell test system has the characteristics of high-accuracy data acquisition and fast response, which can meet the testing requirements of PEM&ALK&AEM electrolyzer.

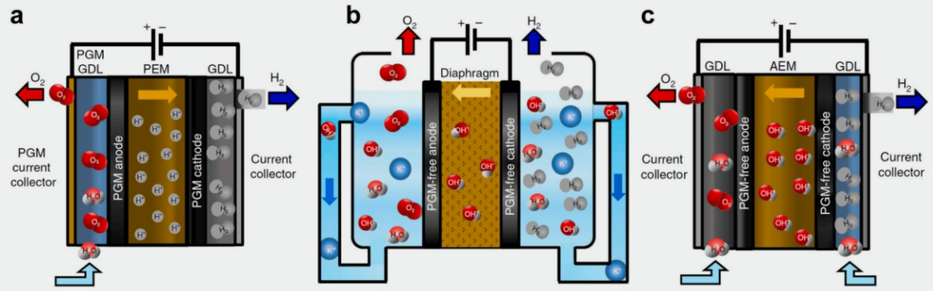

Electrolyzer test system for single




Single electrolyzer cell EIS plot

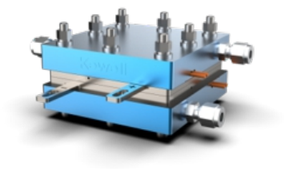



Electrolyzer CV test




## ADVANTAGES

- Support the testing requirements for electrolyzer proposed by EU JRC.
- Wide range and high accuracy: water flow(1% F.S.), water temperature(±1°C ), electrical conductivity(≤0.5μS/cm), gas flow rate (1% F.S.), and backpressure(max. 5MPa).
- Gas processing: cooling, drying, and filtering.
- High accuracy online measurement of gas flow rate(dew point temperature ≤ -40 ℃).
- Rapid sampling analysis of anode gas or cathode gas.
- Complete hardware protection functions: hydrogen leakage, abnormal temperature, manual emergency stop, emergency exhaust, oxygen in hydrogen, hydrogen in oxygen, independent safety unit.



- Support electrolyzer testing functions: stressor condition, performance curve (polarization curve, power curve), durability.
- PC software platform: 8 channels data storage and customizable script programming.
- Specialized fixtures: 5cm²、25cm²、50cm².
- Multiple electrochemical testing: EIS/CV.

Technical differences in PEM/ALK/AEM electrolyzer test systems

| | PEM | ALK | AEM |
|---|---|---|---|
| Anode reaction | $H_2O \rightarrow 2H^+ + \frac{1}{2}O_2 + 2e^-$ | $2OH^- \rightarrow H_2O + \frac{1}{2}O_2 + 2e^-$ | $2OH^- \rightarrow H_2O + \frac{1}{2}O_2 + 2e^-$ |
| Cathode reaction | $2H^+ + 2e^- \rightarrow + H_2$ | $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ | $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$ |
| Electrolyte | Pure water | KOH/NaOH(5M) | KOH/NaOH(1M) |
| Nominal current density | 1-2A/cm² | 0.2-0.8A/cm² | 0.2-2A/cm² |
| Voltage range | 1.4-2.5V | 1.4-3V | 1.4-2V |
| Cell pressure | ≤50bar | ≤40bar | ≤40bar |

# Electrolyzer Test System

Electrolyzer multi-channel test system for single cells

## Electrolyzer Multi-Channel Test System
### for Single Cells

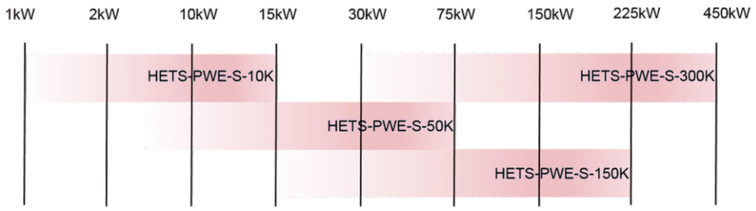
Addressing such problems as long development cycle of core materials of PEM electrolyzer, heavy workload of material channel single cell test system, which serves as a better solution. The test system supports material screening, activation test, screening and process development, and time-consuming durability assessment, Kewell develops the E500 series multiprocess test, performance comparison test, and durability test.The Kewell E500 series adopts a modularized design as a whole, with the expansion ability of 8 units/12 channels. It can conduct multiple sets of parallel comparative experiments, efficiently complete testing and development.The test system is divided into two versions: high pressure version and low pressure version. Each version can be freely combined with standard test channel units and professional test channel units. The test bench has high scalability and compatibility, which can meet the testing needs of different client.

Kewell E500 electrolytic multi-channel test system for single cells adopts modularized design. It is divided into standard and professional versions. For each version, there are matching modules to be freely equipped for different module number, independent/common backpressure, manual/auto testing, etc. This highly scalable and compatible test system can meet the test requirements of different customers.

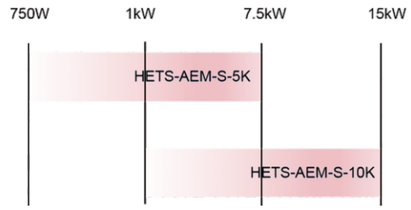
## Electrolyzer Short Stack Test System

The Kewell HETS series electrolyzer short stack test system is suitable for testing different types of electrolyzer short stacks, including proton exchange membrane (PEM), anion exchange membrane (AEM), alkaline (ALK). It supports tests for hydrogen production energy consumption, gas production quality, polarization curve, durability and stressor condition of the electrolyzer. It features high accuracy and fast response, and can meet various testing functions specified in the relevant standards of PEM/AEM/ALK electrolyzer short stack.

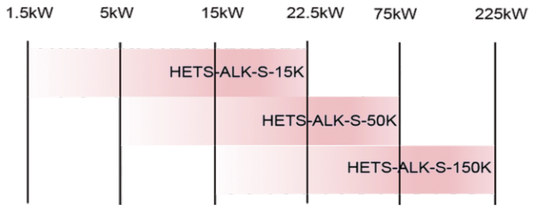

Electrolyzer short stack test system




PEM electrolyzer short stack test system product portfolio




PEM electrolyzer short stack
test system product portfolio




ALK electrolyzer short stack
test system product portfolio

## ADVANTAGES

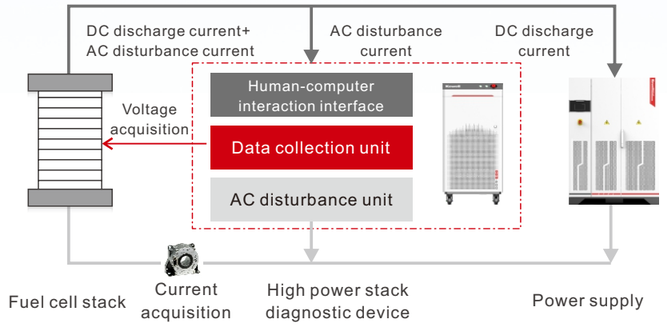
- Support the testing requirements for electrolyzer proposed by EU JRC.
- Meet 5%~150% wide power operating conditions.
- Meet a wide pressure range of 100kPag-4MPag gas production.
- High accuracy control: water flow(1% F.S.), water temperature(±1°C), electrical conductivity (≤0 .5μS/cm), hydrogen/oxygen automatic backpressure(≤20KPa), uniform pressure and differential pressure control (max. differential pressure 4MPa).
- Automatic control: water replenishment and replacement, nitrogen purging, integrated measurement and security protection.
- EIS testing function, supporting fixed frequency and sweep frequency modes.
- PC software platform: parameter tags, custom scripts, custom functions, custom curves, and custom interfaces.
- 24/7 hours unattended operation.
- Hardware protection function: gas pressure monitoring, insulation monitoring, hydrogen leakage, temperature abnormality, manual emergency stop, emergency exhaust, independent safety unit.
- Software protection function: Heartbeat monitoring, automatic processing of three-level security alarm, etc.
- Positive pressure type explosion-proof (≥50kW) PLC cabinet, electrical cabinet, CVM cabinet.
- Excellent equipment manufacturing process: The pipeline manufacturing adopts 316L stainless steel material and undergoesmultiple processes such as acid washing, passivation, electrolysis, and polishing etc.



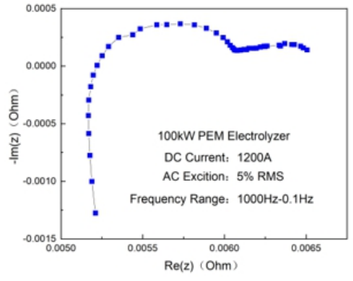


## High Current EIS Test

The DS-600 EIS test bench developed by Kewell can avoid the influence of power supply on impedance testing from both algorithm and structure aspects. The DS-600 can accurately obtain the results of the entire stack impedance and cell impedance of PEM electrolyzer, and it has 960A disturbance ability, which can meet the testing of low-power electrolyzer under low voltage and high current conditions.




Block diagram of electrolyzer short stack EIS testing




Data from actual EIS test platform

# Electrolyzer Test System


A. Indoor version

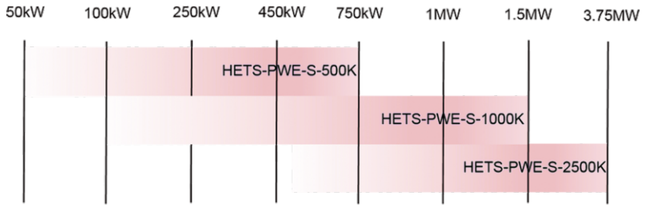

B. Outdoor container version

## Electrolyzer Stack Test System

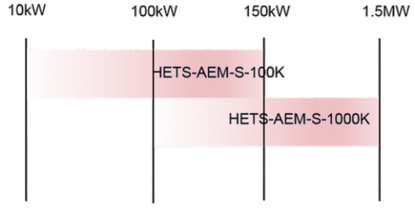
The Kewell electrolyzer stack test system is suitable for high-power electrolyzer testing of different types, including proton exchange membrane (PEM), anion exchange membrane (AEM), alkaline exchange membrane (ALK). It can test and verify the hydrogen production energy consumption, gas production quality, polarization curve, durability, and stressor condition of the electrolyzer.

## ADVANTAGES

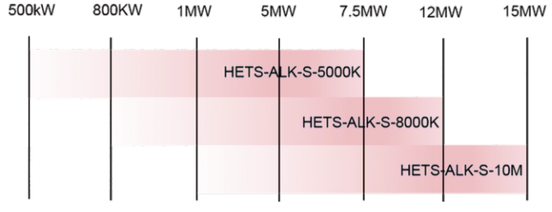
- Support the testing requirements for electrolyzer proposed by EU JRC
- Meet 5%~150% wide power operating conditions.
- Meet a wide pressure range of 100kPag-4MPag gas production.
- High accuracy control: water flow(1% F.S.), water temperature(±1°C), electrical conductivity (≤0 .5μS/cm), hydrogen/oxygen automatic backpressure(≤20KPa), uniform pressure and differential pressure control (max. differential pressure 4MPa).
- Gas processing: cooling, drying, and filtering.
- High accuracy online measurement of gas flow rate.
- Rapid sampling analysis of anode gas or cathode gas.
- Automatic control: water replenishment and replacement, nitrogen purging, integrated measurement and security protection.
- EIS testing function, supporting fixed frequency and sweep frequency modes.
- PC software platform: parameter tags, custom scripts, custom functions, custom curves, and custominterfaces.
- 24/7 hours unattended operation.
- Hardware protection function: gas pressure monitoring, insulation monitoring, hydrogen leakage, temperature abnormality, manual emergency stop, emergency exhaust, indepen -dent safety unit.
- Software protection function: Heartbeat monitoring, automatic processing of three-level security alarm, etc.
- Positive pressure type explosion-proof (≥50kW)  PLC cabinet, electrical cabinet, CVM cabinet.
- Excellent equipment manufacturing process: The pipeline manufacturing adopts 316L stainless steel material and undergoes multiple processes such as acid washing, passivation, electrolysis, and polishing etc.




PEM electrolyzer stack test system product portfolio




AEM electrolyzer stack test system product portfolio




ALK electrolyzer stack test system product portfolio

## Software Features

Kewell has developed a software platform specifically for supervisory control and data acquisition (SCADA) for testing systems. Users can manually control the operation or use a graphical user interface (GUI) for fully automatic operation of the operating system through this software. The operating system mainly consists of modules such as tags, script compiler and runner, custom interface, data graphics, real-time formulas, and security alarm module.