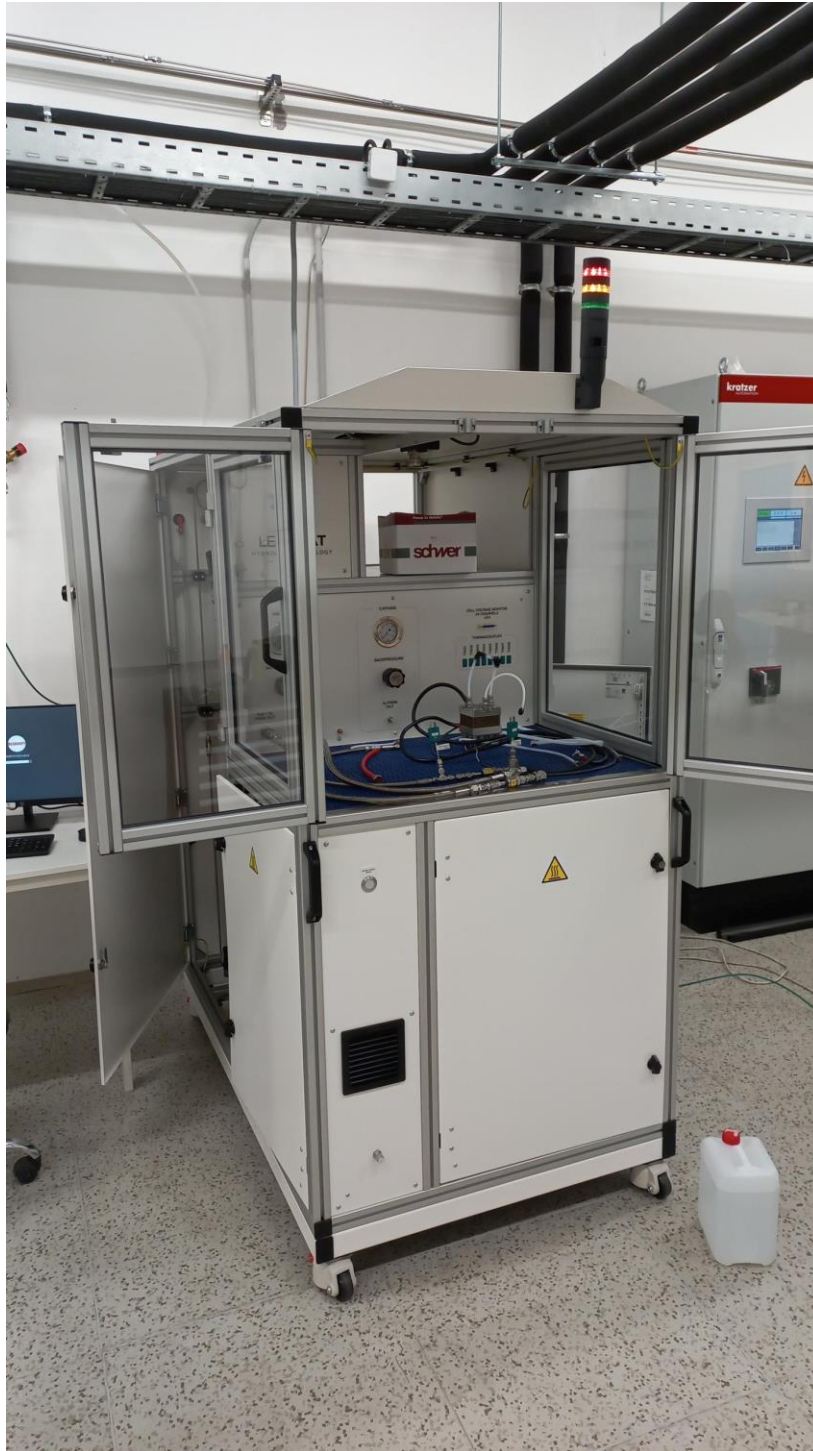


ETS-10 Technical Specifications



1. Cathode (hydrogen) line	Description	Accuracy
Pressurized vessel for collection of condensed water from produced hydrogen	Volume 2 l, max pressure 40 barg, automatic draining	
	Pressure relief valve, set to 45 barg, control mechanism is sealed to avoid manipulation	
	Level measurement by differential pressure sensor, span 100 mbar (~100 cm of water)	±0.15 mbar (±1.5 mm of water)
	The water level needs to be above the critical low level, otherwise the test station cannot be operated.	
Pressure control	Manual backpressure valve, range 0 .. 40 barg	
	Manometer 0 .. 60 barg	
	If the pressure exceeds 41 barg, a warning is triggered. If the pressure exceeds 43 barg, an emergency shutdown is triggered.	
	Pressure sensor 0 .. 60 barg	±0.5% FS (±300 mbarg)
Oxygen sensor in hydrogen exhaust	0.0 .. 5.0% vol. O ₂ in H ₂	±0.3 % vol. + 2% FS
	If the oxygen concentration exceeds 0.8% vol. O ₂ , an emergency shutdown is triggered. This rule applies to RUNNING mode only.	
Secondary vessel for collection of condensed water from exhaust	Volume 1.25 l, automatic draining	
Hydrogen production measurement	0.50 .. 50.00 Nl/min *	±0.3% FS + ±0.5% reading
2. Anode (oxygen) line	Description	Accuracy
Pressurized vessel for water refilling and collection of condensed water from produced oxygen	Volume 10 l (max. water volume 8.6 l), max. pressure 10 barg, automatic water refilling	
	Pressure relief valve, set to 15 barg, control mechanism is sealed to avoid manipulation	
	Level measurement by differential pressure sensor, span 100 mbar (~100 cm of water)	±0.15 mbar (±1.5 mm of water)
Pressure control	Manual backpressure valve, range 0 .. 10 barg	
	Manometer 0 .. 16 barg	
	Pressure sensor 0 .. 16 barg	±0.5 % FS (±80 mbarg)
Hydrogen sensor in oxygen exhaust	0.0 .. 5.0% vol. H ₂ in O ₂	±0.3 % vol. + 2% FS
	If the hydrogen concentration exceeds 0.4% vol. H ₂ , a warning is triggered. If the hydrogen concentration exceeds 0.8% vol. H ₂ , an emergency shutdown is triggered.	
Flow control	Gear pump controlled by servo motor (0 .. 1500 RPM)	
	Inline turbine flow sensor 0.6 .. 10.0 l/min	±1.0 % reading
	DUT differential pressure sensor 0.0 .. 1.2 bar	±0.06% FS (±0.6 mbar)
	DUT inlet pressure sensor 0 .. 16 barg	±0.5% FS (±80 mbar)
Water temperature control	-50 .. 200 °C, temperature sensor Pt1000	
	Heater in the water recirculation circuit, power 4.2 kW @ 400 V	
	Heat exchanger for cooling, 2.6 kW, 9 l/min coolant flow, inlet temperature of coolant 20 °C, outlet 25 °C	
Conductivity measurement 1	0.04 .. 1000 µS/cm	±0.03 µS/cm
pH measurement 2	0 .. 14 pH	±0.5 % FS
	It is crucial to ensure that this sensor is always immersed in a liquid. Failure to do so may result in the sensor drying out and becoming damaged.	
Secondary vessel for collection of condensed water from exhaust	Volume 1.25 l, automatic draining	
Oxygen production measurement	0.25 .. 25.00 Nl/min *	±0.3 % FS + ±0.5 % reading
3. General parameters		
Nitrogen inlet pressure	Recommended supply pressure 6.5 .. 8.5 barg	

	Pressure sensor 0 .. 16 barg	±0.5% FS (±80 mbarg)
DI water supply	Recommended supply pressure 1.0 .. 2.0 barg, recommended water conductivity <1 µS/cm	
	Integrated water tank 20.0 l, automated DI water refilling from the tank to the anode pressurized vessel, refill flow rate 0.26 l/min @ 10 barg, low water level alarm	
Wetted materials	Stainless steel 1.4404 (AISI 316L)	
4. DC source		
1000 A, 1000 V, 250 kW	Connected to a power supply from TLU that is not part of the test station. The power supply is located in test center in Jablonec.	±0.03% FS
5. DUT connectivity		
Cell voltage monitoring	24x ±5 V, 24 bit	±0.02% FS + 0.05% of reading (±3.5 mV)
Auxiliary temperature measurement	8x thermocouple type K, type K miniature sockets on the front panel 2 thermocouples for measurement of DUT oxygen and hydrogen exhausts are supplied with the test station.	±1.5 K
6. Electrical parameters		
Power supply	3 phases, 400 V, 50 Hz	
Power supply cable	5x10 mm ²	
Power socket	terminals	
Nominal current	40 A	
Circuit breaker	3x63 A, tripping characteristics B or C	
Short circuit rating	10 kA	
Control circuits voltage	24 VDC	
7. Safety		
Emergency stop	An emergency stop mushroom button is located on the front panel the test station and is marked clearly with yellow label "EMERGENCY STOP". Pressing the button triggers a safety error and a safe controlled shutdown of category 1 according to EN 60204-1, section 9.2.2.	
Safety controller	Safety PLC	
Inertization	Nitrogen flush with nitrogen stored in internal tanks in case of a power loss or triggering of a safety function	
Explosion protection	To be installed in a safe (non hazardous) area only	
Ventilation	Integrated ventilator inside the process technology cabinet, flow 44 m ³ /h The ventilator inside the process technology cabinet actively circulates and replaces the air within the cabinet, effectively removing any potentially dangerous gas mixtures. The test station must be operated in a well-ventilated room.	
Ambient hydrogen detector	It is mandatory to have a hydrogen monitoring system installed in the room where the station is operated. The monitoring system must be connected to the dry contacts interface of the test station. The connection between the monitoring system and the test station is made using two separate channels, ensuring redundancy and reliability. The supplied connector provided with the test station is designed specifically for this purpose and should be connected to the port labeled "REMOTE SAFETY DRY CONTACT" on the test station. When one of the channels is opened, an emergency shutdown (power supply is turned off and both lines are flushed with nitrogen) is triggered. The hydrogen monitoring system should include an acoustic and optical alarm signalization that notifies the user in case of a hydrogen alarm. Installation and maintenance of hydrogen detectors is responsibility of the customer. Hydrogen detectors are not supplied with the test station. Please ensure to adhere to all additional local requirements applicable to the installation and operation of hydrogen devices and gas detectors, while also following best practices, local codes of regulation (if applicable), and industry standards for the implementation of safety systems to effectively manage the risks associated with hydrogen.	
8. Control system		
PLC	Beckhoff CX5230, Intel Atom® x5-E3930, 1.3 GHz, 2 cores, 4 GB DDR4 RAM, 40 GB CFast card IP address: 192.168.8.20	
Industrial PC (IPC)	Intel® Celeron® J1900 - Quad Core 2.0 GHz (2.42 GHz Burst), 8 GB RAM, 240 GB SSD, Windows 10 IoT Enterprise LTSC 2019 64bit IP address: 192.168.8.21	
Database	PostgreSQL server running on the IPC, port: 5432	
Remote control	OPC UA server running on the IPC, port: 4840	
Ethernet ports	Remote safety shutdown (2-channel dry contact), M12, 5-pin socket, A-coded 2x RJ45 LAN programming interface (labeled LAN), connected to internal switch, local IP range: 192.168.8.0 WAN interface (labeled WAN), connected to IPC, set to DHCP by default	

DUT load communication	SCPI using LAN IP address: 192.168.8.30, port: 3000
Sampling frequency	1 Hz
9. Interfaces	
Nitrogen supply	Compression tube fitting, female port for 6 mm outer diameter pipe
Hydrogen exhaust	Compression tube fitting, female port for 6 mm outer diameter pipe
Oxygen exhaust	Compression tube fitting, female port for 6 mm outer diameter pipe
DI water supply	Compression tube fitting, female port for 6 mm outer diameter pipe
Water drain	Hose adapter
Chiller supply	Compression tube fitting, female port for 12 mm outer diameter pipe
Chiller exhaust	Compression tube fitting, female port for 12 mm outer diameter pipe
Conformity	
CE marking	Low voltage Directive 2014/35/EU Electromagnetic compatibility Directive 2014/30/EU Pressure Equipment Directive 2014/68/EU RoHS Directive 2011/65/EU

Test bench is compliant with technical specifications required by “EU harmonised polarisation curve test method for low-temperature water electrolysis”.

1 Conductivity measurement cannot be performed when the test station is used for testing of AEM electrolyzers.

2 pH measurement cannot be performed when the test station is used for testing of PEM electrolyzers.

* Normal liter per minute (NI/min) is a unit of measurement used to express the flow rate of a gas under standard conditions of temperature and pressure. Specifically, NI/min refers to the volume of a gas that flows per minute at a temperature of 0°C (32°F) and a pressure of 1 atmosphere (101.325 kPa or 14.7 psi).