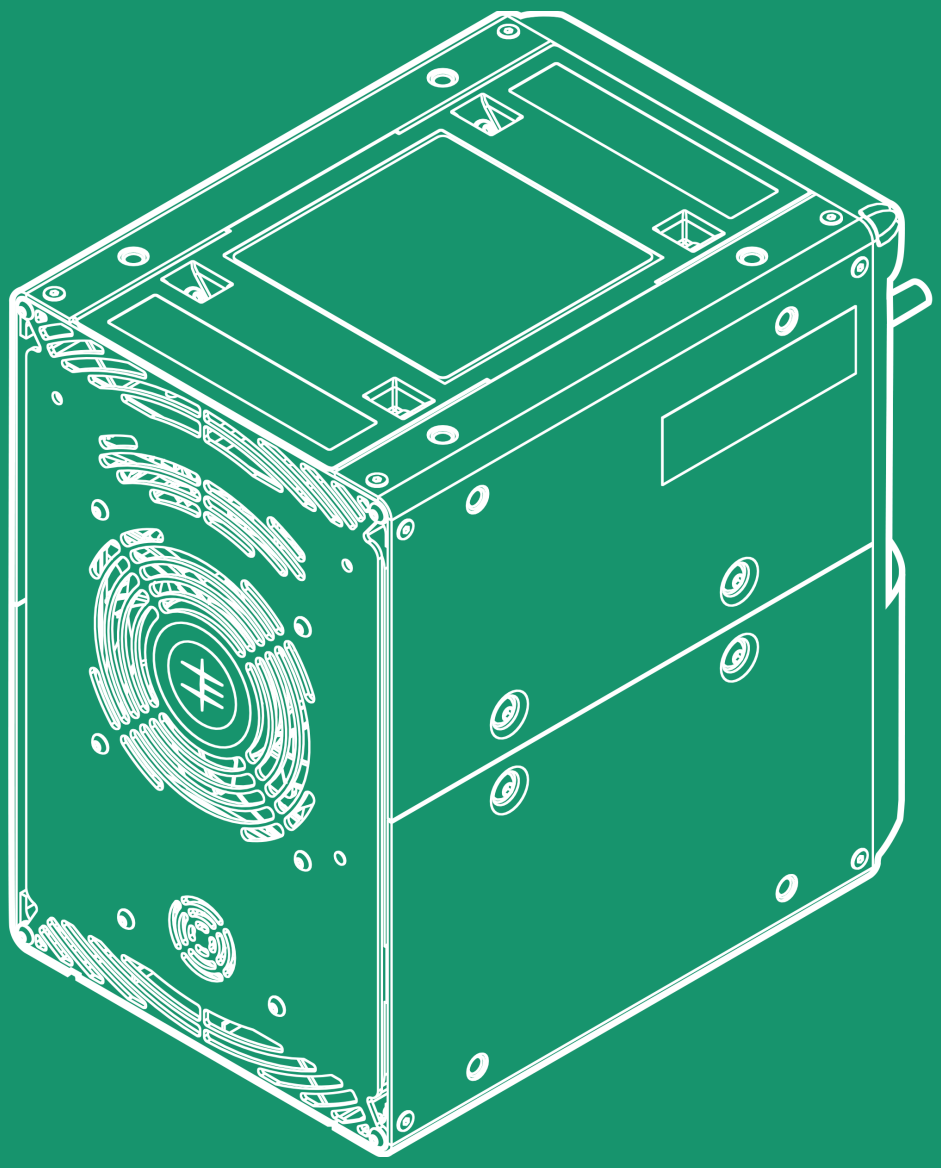
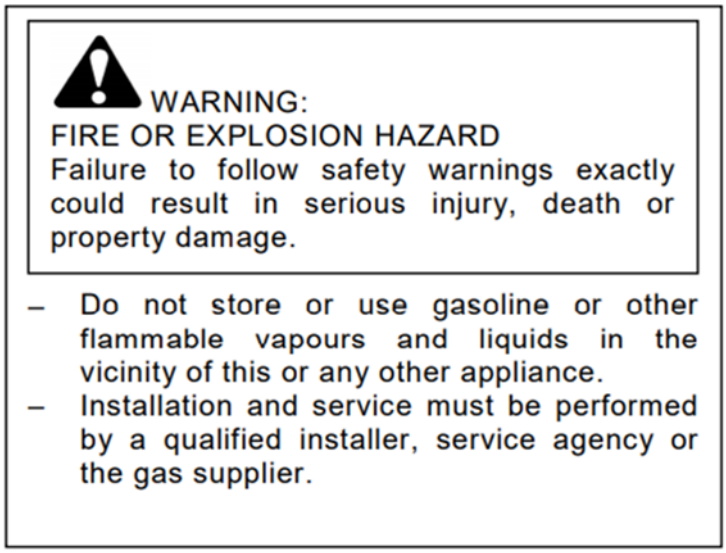
IE-POWER™

User Manual

IE-POWER 1T/U Fuel Cell Module

Users must read all instructions provided and retain the manual for future reference.
Original Instructions. Version 1.





This User Manual is intended as a general guidance only and does not purport to address the specific situations that could potentially arise from the use of fuel cell module systems and their usage in connection with all stationary power, portable power, and Industrial Truck (MHE) applications. The recipient is responsible for ensuring that all personnel have read and understood this User Manual before being allowed to handle, operate, install, and store any equipment supplied by Intelligent Energy.

The recipient must ensure that any personnel responsible for operating the fuel cell module for stationary power, portable power, and Industrial Truck (MHE) applications are suitably trained and certified in compliance with any applicable local, state, and federal laws and regulations and good industry practice. The recipient is responsible for complying with any relevant health and safety policies and procedures that may apply to the operation of stationary power, portable power, and Industrial Truck (MHE) applications and use and storage of hydrogen on any sites. Intelligent Energy has a limited product warranty to the recipient that it will repair and replace any defective equipment resulting from the authorised use of the equipment provided, full terms and conditions available on request. Notwithstanding the above, Intelligent Energy, to the fullest extent permitted by law, accepts no liability (including liability in respect of any error or defects in the fuel cell module system) for any damage caused as a result of recipient's unauthorised use of the equipment provided. The recipient acknowledges that the manner in which the equipment is stored, used, or operated is not under the control of Intelligent Energy Limited. Intelligent Energy has made every effort to ensure that this User Manual is accurate and disclaims liability for any inaccuracies or omissions that may have occurred.

Glossary of terms:

- IE - Intelligent Energy Ltd
- FCM – Fuel cell module
- MHE – Material handling equipment
- APU – Auxiliary power unit
- POC – Performance optimisation cycle (see section 8.3)
- CAN – Controller area network
- BMS – Battery management system
- PE – Protective earth
- EMC – Electromagnetic compatibility
- ESD – Electrostatic discharge
- EMI – Electromagnetic interference
- VOCs – Volatile organic compounds
- LEL – Lower explosive limit
- LED –Light emitting diode
- DVM – Digital volt meter
- DMM – Digital multimeter
- PPE – Personal protective equipment
- ROHS – Restriction of hazardous substances
- CE – European conformity
- FCC – Federal Communications Commission

Contents:

1 Safety and warnings

1.1 IN CASE OF AN EMERGENCY

- Stop power generation from the fuel cell modules by disconnecting the Fuel cell module (FCM) enable signal (see section 8.1)
- Isolate the DC supply (see section 6.1.4)
- Isolate the fuel supply (see section 7.3)

1.2 WARNING: FIRE OR EXPLOSION HAZARD

- Failure to follow safety warnings exactly could result in serious injury, death, or property damage
- The Fuel Cell Module shall be kept clear and free of combustible materials, gasoline and other flammable vapours and liquids (see section 7.3)
- Installation and service must be performed by a qualified installer, service agency or gas supplier

IE-POWER 1T/1U forms part of the IE-POWER^{TM} series of hydrogen fuelled, air-cooled (AC) Fuel Cell Modules (FCM), individually ranging from 1kW to 4kW. The IE-POWER 1T/1U compact design 1kW fuel cell modules match the needs of the stationary, portable, and Industrial Truck (MHE) market. Ease of use and installation is aided with horizontal and vertical installation flexibility together with variants that allow cooling air to flow either through-the-unit (through flow) or in-and-out-on-a-single-face (U-flow).

The IE-POWER 1T/1U is designed for Industrial Truck (MHE), Portable and Stationary Power applications. The IE-POWER 1T/U is a 1kW fuel cell module incorporating a unique coaxial airflow system to enable both through-flow and U-flow air management. Power is delivered via an electrochemical reaction between hydrogen (H_2) and oxygen (O_2) resulting in quiet operation with the only emission being water vapour (H_2O).

It is CE & FCC marked for use for three applicable applications:

- Industrial Truck (MHE)
- Stationary Power
- Portable Power

This is an important distinction and particularly in the system's response to failure, in this case the response to failure is to shut down the output, normally by isolating the hydrogen supply. This course of action would not be appropriate where it is intended as the single source of supply or in the provision of critical supplies to, for example medical equipment, emergency lighting, interlocking, etc.

• The FCM should only be installed, operated, and maintained in accordance with this user manual

• The safety assessment applied to this product limits use to non-essential / non-critical applications or where it is the back-up to another form of power supply rather than being the primary source. Where the intended use is outside that assessed by Intelligent Energy, the customer must assess and design their system appropriately with regard to this limitation

1.3 Warnings

1.3.1 General warnings specific to the fuel cell module

- On receipt of your fuel cell module, if any signs of damage to the packaging or fuel cell module casing are present, photograph all signs of damage and contact Intelligent Energy Ltd immediately
- Prior to the installation inspect the FCM and do not install if there is visible damage to the unit
- The FCM should only be installed, operated, and maintained in accordance with this user manual
- All IE-POWER 1T/1U inspections must be performed by a competent technician during periods of non-operation, unless otherwise stated in Inspection details
- The safety assessment applied to this product limits use to non-essential / non-critical applications or where it is the back-up to another form of power supply rather than being the primary source. Where the intended use is outside that assessed by Intelligent Energy, the customer must assess and design their system appropriately with regard to this limitation
- Do not operate the fuel cell module if signs of obstruction or damage are witnessed on the air inlets / outlets (see section 13.1)
- Do not operate the fuel cell module when there are obvious signs of damage and deterioration to the outer casing, hydrogen coupling, electrical power connections or communication ports (see section 13.1)
- Do not use this fuel cell module if any part has been under water. Immediately call qualified service personnel to inspect the fuel cell module and to replace any function part which has been under water.
- IE-POWER 1T/1U is not designed for indoor use for Portable Power.
- Do not remove hydrogen supply hose, or mains DC cables during operation
- The IE-POWER 1T/1U must be provided with free venting air in the range of +5 to +35°C, it must not be operated outside this range
- Do not remove the air inlet case and the internal filter while operating the FCM (see section 13.2)
- Do not operate indoors: for outdoor use only during portable applications as risk of asphyxiation; (see section 11.7.1)
- Do not remove the external casing
- The FCM enclosure must be designed such that the exhaust gas cannot be recirculated into the air inlet
- The name plate and warning labels should be visible in use, or in the case of integration into a product or application, be duplicated/incorporated in overall integrated product's outer case labelling
- Failure to install the IE-POWER 1T/1U in the correct orientation can result in loss of performance, unexpected shutdown and potentially system failure (see section 11.5)
- Do not install upside down (see section 11.5.1)
- Vertical airflow NOT permitted (see section 11.5.1)
- The IE-POWER 1T/1U consumes oxygen as it operates, therefore the minimum air ventilation requirement must be observed at all times to ensure safety of personnel in the room (see section 11.7)
- Do not electrically overload the IE-POWER 1T/1U (see section 6.1.10)
- The unit contains live electrical components which could be hazardous, even when not operating
- Fault diagnosis must be carried out by trained and competent personnel only
- The safety case of the overall installation must consider the fault condition of the fuel cell module as part of its analysis of the full function of the system
- Failure to perform routine maintenance may reduce overall efficiency of your fuel cell module (see section 13.1)
- Failure to perform monthly filter inspections may reduce the overall efficiency of the fuel cell module (see section 13.2)
- Whilst replacing the filter DO NOT touch the internals of the fuel cell module. Potentially live components present
- Whilst replacing the filter DO NOT touch the fuel cell module stack during this procedure
- Do not use solvents or aerosol cleaning chemicals to clean your fuel cell module. Solvents and airborne chemical cleaners have the potential to permanently damage the fuel cell module (see section 13.1)
- Cleaning of the IE-POWER 1T/1U should only be performed with the use of a clean and dry microfibre cloth

1.3.2 Hydrogen warnings

- Pressurised hydrogen present, highly flammable!
- All ancillary hydrogen supply equipment must use hydrogen approved fixtures and fittings
- The hazards of gas release from installation failure / over pressure / pressure relief operation must be assessed, additional hydrogen monitoring equipment must be installed in all areas where hydrogen build-up could occur
- The installer shall implement routine maintenance and inspection schedules in relation to hydrogen production and storage in the vicinity of the fuel cell module installation
- The operational area must be kept free of combustible materials, a minimum distance of 6 metres from any potential combustible materials, including gasoline and other flammable vapours and liquids must be implemented
- No sources of ignition including naked flames in the vicinity of hydrogen operation area
- At installation, the external hydrogen pipework must be bled of air or inert gas before operation
- The Hydrogen pipe/hose that connects to the unit should always be fastened down to avoid applying stress and force to the unit
- The integration needs to include additional safety measures, when required, to account for monitoring a high pressure H2 supply (see section 11.7)
- The integrator must perform monthly checks of the hydrogen pipework for leaks, particularly when connectors have been disconnected and re-connected, such as cylinder exchange or installation modifications
- The hydrogen pressure must be provided in a regulated state to the module inlet
- Do not connect or disconnect the H_2 supply connector from the FCM, or interfere with the H_2 supply installation if the hydrogen is not isolated locally at the supply or cylinder
- When installing and operating hydrogen systems, hydrogen general safety guidance must be considered: ISO 14687-3:2014 grade E category 3 & ISO/TR 15916 basic considerations for the safety of hydrogen systems
- The hazards of gas release from over pressure / pressure relief operation must be assessed, additional hydrogen monitoring equipment must be installed in all areas where hydrogen build-up could occur
- The FCM must be set up in a well-ventilated environment with consideration given to the precautions of hydrogen safety
- Ensure hydrogen supply can be isolated in case of an emergency
- Hydrogen gas should be provided at a regulated pressure to the module inlet (see section 7.2)
- Self-fill Hydrogen supply cylinders must be correctly purged of non-reactive and reactive gas
- In relation to local hydrogen production and storage in the vicinity of the installation, the installer must follow BS EN IEC 62282-5-100:2018 4.4: Operating and Storage instructions: Use of Hydrogen
- The LEL (lower explosive level) of Hydrogen is considered to be 4% by volume (4% v/v). The stored hydrogen installation atmosphere should be monitored and maintained at below 25% of the lower explosion limit LEL (4% v/v)

1.3.3 Environmental warnings

- For use in a well-ventilated environment with consideration of hydrogen safety precautions (see section 6)
- Environmental protection required from snow, excessive dust, and vegetation
- Not rated for use below 5ºC, above 35ºC, above 1500m and outside shock & vibration specification
- A minimum distance of 2 meters must be observed from the entire FCM installation to areas of vegetation (plus expected growth), public ways and vehicles. The inclusion of signage and barriers should be considered to prevent a breach of the 2-meter clearance
- If the FCM installation is to be located in an area prone to seismic activity, a suitable seismic hazard zone risk assessment must be performed prior to delivery
- Additional installation protections must be considered in regard to weather related phenomena including protection against wind, rain, lightening, snow, ice, and freezing temperatures (see section 1.6)
- The FCM must be protected from potential airborne particles, additional filtration may be necessary to protect the FCM from airborne particles which may include but are not limited to dust, dirt, sand, pollen, soot, and liquid droplets present in the air
- The performance of the FCM will be adversely affected by air airborne contaminates which may include but are not limited to sulphur dioxide SO2, nitrogen oxides NOx, carbon monoxide CO, ammonia NH3, hydrocarbons CxHy, and Toluene C7H8. The integrator must ensure that the location of the FCM is not in an area prone to the listed airborne contaminates
- Necessary precautions and risk evaluations must be observed when installing the system in areas that are prone to flooding or seismic activity
- Do not use IE-POWER 1T/1U if there is water visible on it
- Do not use this [portable[1]] fuel cell module if any part has been under water. A flood-damaged [portable[1]] fuel cell module is [extremely[1]] [potentially[1]] dangerous. Attempts to use the [portable[1]] fuel cell module can result in fire or explosion. A qualified service agency should be contacted to inspect the [portable[1]] fuel cell module and to replace all gas[1] controls, control system parts, electrical parts that have been wet

1) *See full warning in section 1.6*

1.3.4 Electrical warnings

- DC Voltage electrical hazard is present
- Do not remove electrical casing covers, risk of electric shock and consequential injury
- The electrical installation must be performed by a trained and competent person, making use of the appropriate personal protective equipment (PPE), suitable handheld tools and a calibrated digital voltmeter/ multimeter (DVM / DMM) or voltage indicator & proving device
- When the IE-POWER 1T/1U is running it will stay live if the power cables are disconnected
- Battery connection and over current protection need to comply to IEC 62485-2:2018
- Do not use the chassis / earth / ground terminal as a reference for the communications and vice versa
- Do NOT electrically overload the FCM. Overloading will lead to excessive load being drawn from the battery. Drawing excessive load may cause damage to the equipment (see section 6.1.10)
- Do NOT allow external devices connected to the FCM to increase the voltage beyond the maximum system rated 58V. Overvoltage will damage the FCM
- Ensure DC power cables are not more that 10m long
- Ensure communication cables are not more than 10m long
- Series connection NOT permitted
- NEVER connect a red/+ve wire or connector to a black/-ve wire or connector
- NEVER connect a black/-ve wire or connector to a red/+ve wire or connector
- When installed in a building, the chassis of the IE-POWER 1T/1U must be connected to a suitable earth/ground point – usually the electrical Protective Earth (PE) is used
- An Earth or chassis connection must always be made to the case/chassis of the FCM using the M6 stud
- When used on an Industrial Truck (MHE) the FCM case/chassis must be connected to the chassis of the truck.
- When installed in a building, the FCM chassis must always be connected to a suitable earth/ ground point. In many cases this will be common with the AC mains supply's electrical Protective Earth (PE).
- When used in Industrial Truck (MHE), the chassis of IE-POWER 1T/1U must be connected to the vehicle chassis or battery box chassis
- When used in portable applications the chassis of the IE-POWER 1T/1U must be connected to a designated earth/ground point
- Chassis to vehicle chassis or installation earth/ground connection MUST always be made
- FCM must be setup for the earthing arrangement of the application. Power output is isolated from earth/chassis as standard
- Either + or – (but never both) may be connected to earth externally (see section 6.1.8)
- Either + or – (but never both) may be connected to earth internally (see section 6.1.8)
- Ensure hybridised battery bank is identified for use with the fuel cell module, the fuel cell module will be configured to operate with the specified battery requirements including size, capacity, type etc. Damage may occur if an incorrect specified battery bank is installed (see sections 6.1.3, 6.1.4 & 14.2)
- Trained and competent personnel to install enable/run interface to activate the FCM (see section 8.3)
- At start-up there will be an in-rush current to the FCM to charge the capacitors within the FCM
- The battery pack must provide power during Performance Optimisation Cycles (POC) (see section 9.3)
- In extreme cases Voltage Ripple has the potential to cause damage to the components of DC circuits within the FCM.
- The integrator should also be aware of Electromagnetic Interference (EMI) and utilise the correct earthing techniques (see section 6.1.10)
- The integrator must incorporate adequate protection devices to shield / isolate the fuel cell module from the lead acid battery bank circuit during the periods of equalisation charging.
- When the fuel cell module installation is deactivated, confirm isolation via a calibrated digital voltmeter/ multimeter (DVM / DMM) or voltage indicator & proving device prior to removal as there is a risk of residual voltage on live components after shutdown (see section 6.1.10)
- The plugs that connect to the FCM can also be used to provide isolation but MUST NOT be withdrawn if there is current flowing.
- Even when the IE-POWER 1T/1U is NOT running the cables may still be powered from the load side battery or external power source (see section 6.1.10)
- During installation and maintenance, the IE-POWER 1T/1U must be off, and the load, battery or external power supply must be isolated and made safe (see section 6.1.10)

1.3.5 Mechanical / Installation warnings

- In the instance of the fuel cell module being remotely controlled, the installation must incorporate a process to shut down the fuel cell module in the event of an emergency
- A suitable safety assessment will need to be undertaken for the entire FCM installation
- The user shall perform routine inspections that align with all FCM installation ancillary equipment's manufactures terms and conditions of use
- Failure to install the IE-POWER 1T/1U in the correct plane of orientation can result in system failure (see section 11.5)
- The inlet air must be free of the following contaminates: Sulphur compounds, Hydrocarbons, Carbon Monoxide, Ammonia
- Avoid exposure to volatile organics (VoCs), poisonous/corrosive gasses and anything with a prominent scent. This includes but is not limited to cleaning products, air-fresheners, glues/adhesives/epoxies, chemical solvents, ammonia, and salt spray. Particular care should be taken to avoid storing or transporting the fuel cell in an enclosed space (e.g., drawer, bag, or box) with potential contaminants as this may accelerate the contamination process (see section 7.1).
- Incorrect mounting may reduce shock and vibration specification (see section 11.5.2)
- Do not obstruct air flow to inlet or exhaust (see section 7.1.4)
- All inlets and outlets must be kept free of obstruction (see section 7.1.1)
- Ensure that the air inlet(s) and exhaust outlet(s) including bypass inlets cannot be blocked
- This fuel cell module power system uses oxygen from the area in which it is being used. It should not be used in a confined space or unusually tight construction unless provisions are provided for adequate process and ventilation air (see section 11.7)
- Do not block or obstruct air openings communicating with the area that the fuel cell module is being operated (see section 11.7.1)
- A minimum distance of 300mm must be observed from the ventilation face and connector face of the FCM to any solid structure, ensuring sufficient airflow to enter and exit the FCM (see section 11.7)
- The FCM installation must not allow blockages of the ventilation and connector faces
- If additional filtration is proven necessary particular attention must be observed so that the filter does not restrict the required airflow of the FCM (see section 11.7)
- The electronics cooling air vent must never be blocked, a blocked air vent will result with the fuel cell module shutting down.
- The design of the installation must allow exhaust heat to dissipate
- The IE-POWER 1T/1U must be set up in a well-ventilated environment with consideration given to the precautions of hydrogen safety. These precautions relate to good general practice when using hydrogen and especially to the storage, supply, or generation of the hydrogen used to supply the FCM (see section 7.1.4)
- A minimum distance of 300mm must be observed from the ventilation face and connector face of the FCM to any solid structure, ensuring sufficient airflow to enter and exit the FCM (see section 11.2)
- Air must not be recirculated between the exhaust and inlet (see section 7)
- Hot air that that is generated by other equipment within 0.6m of the inlet of the IE-POWER is of concern if it raises the inlet temperature to above the system specification
- Do not install equipment above IE-POWER 1T/1U that could release flammable/corrosive material onto the product e.g., batteries
- Any surface in contact with the IE-POWER 1T/1U must be less than +50°C
- The IE-POWER 1T/1U should not be located in an area where sleeping may occur
- The IE-POWER 1T/1U consumes oxygen as it operates therefore the minimum air ventilation requirement must be observed at all times to ensure safety of personnel in the room (see section 11.7)
- If the IE-POWER 1T/1U has been stressed due to excessive vibration or shock, return to Intelligent Energy for investigation
- DO NOT use the IE-POWER 1T/1U for Portable Power indoor applications as it may be easily moved to a location with inadequate ventilation[1]
- DO NOT use the IE-POWER 1T/1U for Stationary Power indoor applications where the overall installed power exceeds 10kW as inadequate ventilation cannot be guaranteed[1]
-

1) *These applications are possible with the addition of hydrogen leak detection, and oxygen depletion detection, but separate additional certification is needed - outside the certification of this product.*

1.4 Stationary, Portable, and Industrial Truck (MHE): Certification standards, and installation regulations

Application	EN IEC standard	Location	Safety measures
Stationary Power Defined as: Application 'bolted down' and 'fixed' in an installation. Application is a small part of the installation. Whole installation can be moved but takes some effort. Application is off when moved. Can be a vehicle APU, that provides power when vehicle is stationary. E.g., H_2 powered 'Cell Site/Base Transceiver Station (BTS)', data centre, welfare cabin, vehicle movable lighting tower.	EN IEC 62282-3-100:2020/2019 Fuel cell module technologies - Part 3-100: Stationary fuel cell module power systems - Safety	Indoor >10kW	Use FORBIDDEN unless additional depleted oxygen detection and hydrogen detection is added with ADDITIONAL overall use certification.
		Outdoor >10kW	Evaluate additional outdoor environmental requirements including wind, rain, dust, and ingress protection incorporate as part of system integration.[1]
		Indoor ≤10kW	Ensure safety ventilation advice is followed, see 10.6.1.
		Outdoor ≤10kW	Evaluate additional outdoor environmental requirements including wind, rain, dust, and ingress protection incorporate as part of system integration.[1]
Portable Power Defined as: Application NOT fastened or secured to a specific location. Typically has a handle or wheels. Easily moveable (short distance) without use of vehicle or crane. Is off when moved. FCM is a major part of the application. Overall application will include hydrogen storage or equivalent. Hydrogen storage may be integrated or separate. E.g., H_2 powered small portable generator replacement. Small hand moveable lighting tower.	EN IEC 62282-5-100:2018 Fuel cell module technologies - Part 5-100: Portable fuel cell module power systems - Safety	Indoor	Use FORBIDDEN unless additional depleted oxygen detection and hydrogen detection is added with ADDITIONAL overall use certification.
		Outdoor	Evaluate additional outdoor environmental requirements including wind, rain, dust, and ingress protection incorporate as part of system integration.[1]
Industrial Truck (MHE) Defined as: Application integrated onto a truck. Integrated directly or as part of a removable 'battery tank'. Integrated with H_2 storage and electrical energy storage etc. Provides propulsion power. Not part of a road legal vehicle. E.g., H_2 powered MHE/ forklift	EN/IEC 62282-4-101:2014 Fuel cell module technologies - Part 4-101: Fuel cell module power systems for propulsion other than road vehicles and auxiliary power units (APU) - Safety of electrically powered Industrial Truck (MHE)	Indoor	Ensure safety ventilation advice is followed, see 11.7
		Outdoor	Evaluate additional outdoor environmental requirements including wind, rain, dust, and ingress protection incorporate as part of system integration.[1]

1) *Outdoor application should normally have sufficient ventilation. If a particular outdoor application has any restrictions to ventilation, then ensure safety ventilation advice is followed (see section 11.7).*

1.5 Additional certification information

The design of this product is to meet the requirements of the applicable International and European fuel cell module safety standards for Stationary, Portable and Industrial Truck (MHE) fuel cell module power systems as shown in the certification table in section 1.4.

The product is CE marked for the 3 applications above. For more details on the IE-POWER 1T/1U CE marking achieved (see section 17).

The part numbers of the certified product are displayed in section 5.

The standards above include some requirements that will need to be considered and met where appropriate by the system integrator. These are highlighted in section 16. These requirements include components such as batteries and hydrogen storage which are not included in the FCM itself but used with it as part of an overall integration.

The stationary power installation standard includes useful additional guidance:

- EN / IEC 62282-3-300:2012 Fuel cell module technologies – Part 3-300: Stationary fuel cell module power systems – Installation

This document may also be of use for Portable Power and Industrial Truck (MHE) applications as there is no similar installation standard for those applications.

For advice on applications that go beyond the scope above, including automotive, please consult Product Support of Intelligent Energy Ltd.

In all cases the FCM must only be used in non-hazardous (unclassified) areas.

1.6 Installation protection ratings

The IE-POWER 1T/1U has a IP20 ingress protection rating.

For outdoor use additional ingress protection, according to IEC 60529, must be added as part of the overall integration or installation.

- IP23 or greater is required for Stationary Power applications
- IPX4 or greater s required for Industrial Truck (MHE) / Materials Handling Equipment applications
- IPX4D or greater is required for Portable Power applications

Any surfaces in contact with the unit must not be above +50°C.

Where required by the application, the outer enclosure must protect the IE-POWER 1T/1U against vegetation, animal (including vermin) and insect intrusion and damage. Distances from public ways should be considered and assessed prior to the installation or deployment for all applications.

The potential for impact, and vehicular impact should be considered and assessed especially in Industrial Truck (MHE) applications. The connector face should be protected against impact by the installation or integration as it is made of thermoplastic. For Industrial Truck (MHE) applications, please refer to the enclosure and impact clauses detailed in section 16. Possible impact and damage to connections should also be considered and mitigated. Additional air filtration to protect the fuel cell module must be considered if the external installation is in a location prone to high levels of airborne contaminants.

The unit contains live electrical components which could be hazardous, even when not operating.

- Do not remove the casing covers
- Do not remove hydrogen supply hose, or mains DC cables during operation
- Necessary precautions and risk evaluations must be observed when installing the system in areas that are prone to flooding or seismic activity
- Do not use this [portable[1]] fuel cell module if any part has been under water. A flood-damaged [portable[1]] fuel cell module is [extremely[1]] [potentially[2]] dangerous. Attempts to use the [portable[1]] fuel cell module can result in fire or explosion. A qualified service agency should be contacted to inspect the [portable[1]] fuel cell module and to replace all gas[3] controls, control system parts, electrical parts that have been wet

1) *Wording in square brackets applies to portable power applications CE marked to appropriate portable safety standard. The mobility of portable applications increases the possibility of the unit being under water*

2) *Wording in square brackets applies to stationary power applications CE marked to appropriate portable safety standard. The lack of mobility of stationary power applications decreases the possibility of the unit being under water*

3) *Exact wording given in portable power safety standard is 'fuel' but this product only uses gaseous fuel so 'gas' used for clarity and consistency with other fuel cell module safety standards*

2 Product Specification for IE-POWER 1T/1U

Performance	Rated net power	1.0kW [1,2] 1.2kW max >24V
	Output voltage and regulation	16V to 58V via factory configuration parameters [3] Typically for use with 24, 36 or 48V battery User configurable for -ve, +ve or floating earth Voltage regulation to ETSI 300-132-2 @ 48V
	Rated current	50A max ≤ 24V; 25A @48V
	Emissions	Water vapour in warm air exhaust [4]
Fuel	Fuel type	Hydrogen gas
	Fuel pressure	0.5 – 0.7 bar gauge [5]
	Fuel consumption	Less than 70g per kWh[6]
	Fuel supply and storage	Designed for use with external fuel storage or production, (not included). Use of reformer and electrolyser gas subject to suitable pressure and purification.
	Fuel composition	99.9% gaseous hydrogen or better [7]
Operations and maintenance	Manual start/stop	Customer interface connections provided for 'enable/reset' and 'run' switch or signal Accessory switches available [8]
	Automatic start/stop	Operation governed by factory configurable time, voltage, and current levels in 'run' state. Level set to suit application battery and load [2, 8]
	Status display	7 state LED status indication Status info (CAN/Serial) on Customer Port Accessory Port allows use of accessory display [8]
	Start-up time	Less than 20 seconds [9]
Safety & certification	Certification	CE & FCC for Indoor Industrial Truck (MHE), Outdoor Portable Power and Stationary use
	Health monitoring	Options available [8, 10]
Physical	Mass	~10.4kg
	Max dimensions	196mm (W) × 294mm (H) × 294mm (D) [11]
	Connection, gas	5/16" SAE J2044 male spigot [12]
	Connections, electrical power	Amphenol SurLok Plus 5.7mm (120A) receptacles Positive red with SR2 key Negative black with SB0 key
	Connection, chassis/earth	M6 stud
	Connections, Customer Comms/Signal	26-way high density female D-sub connector Enable/Reset; Run; Status; CAN/Serial; Index
	Connections, Accessory Comms/Signal	15-way high density female D-sub connector Proprietary connections for accessories Interlock loop
	Vibration (to IEC/EN 60068-2-6)	5 to 30Hz, 10mm peak 5G 30 to 200Hz, 2.5G 10 minutes per sweep, 4 hours for each of 3 axes
	Non-repetitive shock (to IEC/EN 60068-2-27	50G, 10 times, for each of 2 directions, 3 axes
	Audible Noise	A-weighted emission sound pressure level does not exceed 70 dB(A) [16]
Normal Operating conditions	Altitude	0 – 1500m [8, 13]
	Operating temperature range	+5°C to +35°C [14, 15, 17]
	Operating humidity range	10% to 90% [8, 17]
	Storage temperature	-40°C to +70°C

• Not rated for use below 5ºC, above 35ºC, above 1500m and outside shock & vibration specification

1) *>95% duty cycle.*

2) *Typically hybridised with external battery allowing higher combined peak power. Available load power reduced during battery charge. Multiple units may be operated in parallel to increase power.*

3) *Rated power available when above 24V.*

4) *No production of CO, CO2, or NOx. Contains safety permitted trace levels of hydrogen.*

5) *+/- 100mbar pressure transients on purge permitted.*

6) *Achieved at 25ºC, beginning of life.*

7) *According to quality characteristics of Type 1, Grade E and Category 3 hydrogen fuel specified in BS ISO 14687-3:2014(E).*

8) *Please contact us to discuss your requirements.*

9) *Start up time may increase at stated environmental extremes.*

10) *Options available for continuous health monitoring and predictive maintenance scheduling for high system availability.*

11) *Dimensions excludes protruding fasteners, mating connectors and accessories. Unit designed to be used with either the H-axis vertical or rotated so the W-axis is vertical. Any single axis may be +/-15° (see section 11).*

12) 13) 14) 15) *Future capability improvement planned.*

16) *Conditions: Distance 1m; Height of 1.6m; Power 1.2kW; Temperature 20ºC; Humidity 50% RH; Sea level elevation.*

17) *De-rated power when RH is less than 30%.*

3 Parts of the IE-POWER 1T/1U

An annotated overview of the key components of the IE-POWER 1T/1U can be seen in the diagrams below. There are four mounting points on each of the four side faces. Additional information can be found in subsequent sections of this document. This includes information on installation, mounting and key dimensions in section 10 and information concerning connections to the unit can be found in section 6.

Ventilation face (metal grille)

1. **Status LED**
2. **Main air inlets 2 off for IE-POWER 1U and bypass air inlets for IE-POWER 1T**
3. **Main air outlet**
4. **Electronics air inlet**
5. **Electronics air outlet**
6. **Power earth arrangement hatch**

• On receipt of your fuel cell module if any signs of damage to the packaging or fuel cell module casing are present, photograph all signs of damage and contact Intelligent Energy Ltd immediately

Connector face (electrical, hydrogen and communications)

1. Status LED
2. Hydrogen connection
3. Customer communications signal connection
4. Accessory communications signal connection
5. Main air inlet for IE-POWER 1T
6. Chassis/earth connection stud
7. Positive power connector
8. Negative power connector
9. Serial number plate

• On receipt of your fuel cell module if any signs of damage to the packaging or fuel cell module casing are present, photograph all signs of damage and contact Intelligent Energy Ltd immediately

4 Product Interface

4.1 Interface specifications

Performance	Function	Connection Specification
Hydrogen Inlet **0.5 -0.7 bar gauge** **Average flow rate 56slpm** **(Peak flow 80 slpm for <1 sec during purge)**	Fuel supply.	5/16" SAE J2044 male spigot **See section: 7.3**
Air Inlets **0 – 6,500slpm** **+5 - +40°C**	Ambient air for FCM electrochemical reaction, cooling, and safety dilution.	**See section: 7**
Exhaust air **0 – 6,500slpm** **+5 - +60°C**	Air exhaust to ambient.	Can be ducted, contact Intelligent Energy Ltd. **See section: 7**
Power connection **21.0 - 58.0V** **Delivered current 0 – 50Amps** **Max cable length 10m**	Power for connected DC load. Start-up and shutdown power prior to and after operation.	Amphenol Surlok Plus 5.7mm (120A) receptacles. Positive RED with SR2 key. Negative BLACK with SB0 key. Used with mating plugs for 16mm² OR 25mm² cable. **See section: 6.1.2**
Chassis / earth connection	Connection to Industrial Truck (MHE) chassis or installation earth / ground for EMC and ESD countermeasures.	M6 stud. **See section: 6.1.1**
Customer communications / signal connection **Maximum cable length 10m**	Enable / Reset, Run, Status, CAN/Serial, Index.	26-way high density female D-sub connector. **See section: 7.4.1**
Accessory communications / signal connection **Maximum cable length 10m**	Proprietary connections for accessories. Interlock loop.	15-way high density female D-sub connector. **See section: 7.4.2**
Status LED	7 state status indication.	Ventilation face, connector face. **See section: 7.4.3**

5 IE-POWER 1T/1U overview

The IE-POWER 1T/1U provides regulated DC power at nominal 24V, 36V or 48V output and is designed for use with external electrical energy storage such as a battery or super capacitor.

The unit contains an Intelligent Energy air cooled fuel cell stack and the required balance of plant and control to allow it to operate in the form of a self-contained FCM (Fuel Cell Module) which is then integrated with external electrical energy storage and gas storage, generation, or supply.

The unit is available in two main physical configurations.

- The IE-POWER 1T configuration has the main airflow entering and exiting on opposite faces and this is referred to as '**T**hrough-flow'
    - Part number **10017642** is detailed in this manual
- The IE-POWER 1U has the main airflow entering and exiting on the same face and this is referred to as '**U**-flow'
    - Part number **10017641** is detailed in this manual

These different configurations allow for easier installation and integration. Through-flow or U-flow air ventilation are factory configured at time of dispatch.

IE-POWER 1T/1U refers to all the information that is common to both configurations.

• Hydrogen gas should be provided at a regulated pressure to the module inlet

The module then consumes the hydrogen it requires to support the electrical load and its own internal needs. The IE-POWER 1T/1U power connection acts as both an input and an output for electrical power to and from the external battery and to the external load. The IE-POWER 1T/1U will generate power when it is given both Enable and Run signals (see section 8).

During normal operation the FCM will use its own power to support its own internal needs such as operating fans, valves, and controllers. Periodically the IE-POWER 1T/1U will conduct a performance optimisation cycle (POC) to maintain performance, where power delivery is briefly interrupted. In this period the module will hybridise with the external battery and the load will be briefly supplied from it (see section 9.3).

The IE-POWER 1T/1U will hold the DC output at the configured nominal voltage while connected to an external battery or power supply so that the system will act as a hybrid system. In the hybrid system, the battery is used to provide power whilst the fuel cell module starts, supports the load during the fuel cell module performance optimisation cycle process (POC), in the standby state and during shutdown. The nominal operating voltage and related parameters are factory configured at time of dispatch. Configuration settings allow the unit to charge the external battery and/or supply load power when parameters cross lower thresholds and to cease charging when parameters cross upper thresholds (see section 14).

When first connected, the unit will assume that the battery will need to be charged, unless the voltage indicates that the battery is already fully charged. If, during normal operation the load drops to a low level (a pre-set level from the configuration used) the fuel cell module will enter a standby state (see section 9.4). This is designed to optimise fuel consumption. If the DC installation voltage, then dips below a pre-set voltage, the fuel cell module will restart.

This document is to help the users for operation, user maintenance and installation of the IE-POWER 1T/1U. However, more information can be found in EN/IEC 62282-3-300:2012 Fuel cell module technologies – Part 3-300: Stationary fuel cell module power systems – Installation. This document is guidance for Stationary Power applications. There is no equivalent document for Portable or Industrial Truck (MHE) Power applications but the more general guidance in this document may be of use for these applications.

Intelligent Energy is responsible for the safety of the IE-POWER 1T/1U including its connection points if used in accordance with this manual. The installer / integrator is responsible for the safety of the whole installation including hydrogen storage, generation, supply, batteries and any other equipment or infrastructure. A suitable safety assessment will need to be undertaken for the entire installation.

6 Connections

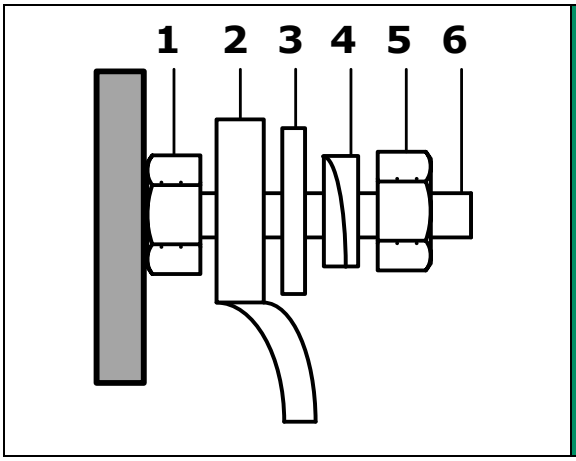
This section details the electrical, air, hydrogen, and communications / signal connections together with the related topic of status indication.

- The FCM must be set up in a well-ventilated environment with consideration given to the precautions of hydrogen safety (see section 11.7)
- The electrical installation must be performed by a trained and competent person, making use of the appropriate personal protective equipment (PPE), suitable handheld tools and a calibrated digital voltmeter/ multimeter (DVM / DMM) or voltage indicator & proving device (see section 6.1.4)

6.1 Electrical Connections

6.1.1 Chassis Connection IE-POWER 1T/1U

A 10mm^2 earth conductor should be used as a minimum, terminated with a suitable 10mm^2 M6 crimp. The cable should be kept as short as practicable. The earth cable **must** be connected with the following arrangement



1. M6 chassis back nut.
2. Earth lug.
3. M6 flat washer.
4. M6 spring washer.
5. M6 nut.
6. M6 chassis earth stud

The M6 outer nut (5) torque setting is: **4.5 -5 N.m**

As the system operates at a voltage of less than 60V, this is not a 'Protective Earth (PE)' and is not required to provide protection against shock hazards. This essential connection is a return for Electromagnetic Compatibility (EMC) and Electrostatic Discharge (ESD) countermeasures within the FCM. In some applications the FCM will firstly connect to the metal chassis of a battery box or battery tank that is used to house the FCM, and this tank or box will then in turn connect to the chassis of the truck itself. When forming part of a larger system, the FCM will firstly be installed to connect to the chassis of the system which will then in turn connect to a suitable earth/ground point. For stationary power applications this second connection will also be a permanent installation. For portable power applications this may part of a plug and socket arrangement.

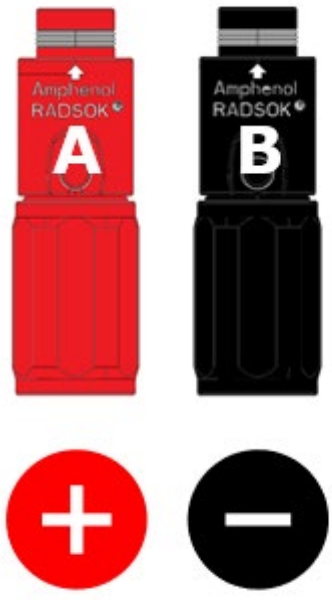
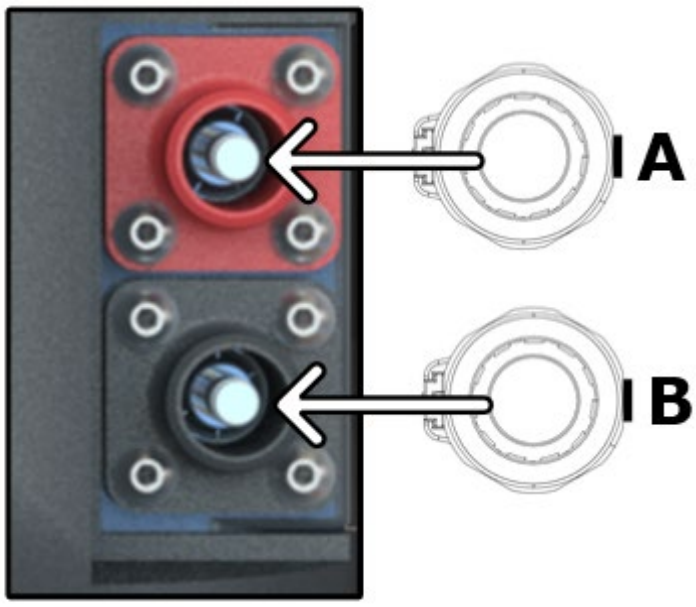
- An Earth or chassis connection must always be made to the case/chassis of the FCM using the M6 stud provided and illustrated above
- When used on an Industrial Truck (MHE) the FCM case/chassis must be connected to the chassis of the truck
- When installed in a building, the FCM chassis must always be connected to a suitable earth/ ground point. In many cases this will be common with the AC mains supply's electrical Protective Earth (PE)

6.1.2 Power Connections to IE-POWER 1T/1U

The FCM is fitted with separate single pole red +ve and a black -ve Amphenol SurLok Plus 5.7mm (120A) receptacles as shown below.

1. M6 Stud for connection to chassis / earth / ground.
2. Power connection RED+VE.
3. Power connection BLACK-VE.

These connectors incorporate a keyway lock to avoid misconnection and are finger touch proof on both sides. Details of use and selection are given in the tables below.

FCM Termination face Keyed connector	Amphenol connectors engage with an affirming "click"	Positive (+) release switch (A) is located to the right of the connector once mated
		
A) Positive quick release switch B) Negative quick release switch	No twisting / turning of the connector is required	Negative (-) release switch (B) is located to the right of the connector once mated

Power cable type	Power cable length	Connector	When used
25mm² red	10m max	SLPIPA25BSR2 	This is the default **preferred choice** where an assessment has not been made based on acceptable voltage drop. Suitable for higher current, longer cable, lower voltage applications.
25mm² black	10m max	SLPIPA25BSB0 	
16mm² red	10m max	SLPIPA16BSR2 	May be used if assessment shows that voltage drop is acceptably low. Suitable for lower current, shorter cable, higher voltage applications.
16mm² black	10m max	SLPIPA25BSB0 	

Instructions relating to the correct crimping method of the Amphenol SurLok Plus connectors can be found via the manufacture's website. Please use the link below and refer to page 7.

https://www.amphenol-industrial.com/images/catalogs/IA-9%20Surlok%20Plus%20Assembly%20Instructions.pdf

Other connector variants are available but the 'SR2' colour and key pattern must be used for +ve connections and the 'SB0' colour and key pattern must be used for -ve connections. Cable lengths should be 10m or less. This means both the red +ve wire can be up to 10m long and the black -ve wire can be up to 10m long. Use of 25mm^2 cable is recommended as it is a better choice for applications that use higher currents.

Transitioning to an even larger cable may be desirable for longer runs (within the 10m limit) at high currents when operating at lower voltages in some cases. Cable sizing needs to consider the maximum output current of the unit, acceptable cable voltage drop, cable length, cable grouping and thermal loading etc. The cable runs should be as short and direct as practicable. The positive and negative cable should be routed together along the same path.

In all cases, suitable cables should be selected for the application taking consideration of environmental factors etc. Tri-rated cable is often used for this type of application.

For use and integration into Industrial Truck (MHE) see additional information in section 4.13.3 1 of MHE standard BS EN 62282-4-101:2014

- Series connection NOT permitted
- NEVER connect a red/+ve wire or connector to a black/-ve wire or connector
- NEVER connect a black/-ve wire or connector to a red/+ve wire or connector

6.1.3 Cable length and Voltage Drop

This table below shows the % voltage drop at different currents, battery supply voltage and distance.

A distance of approximately 10m means there is a 10m red and a 10m black cable.

The table shows % volt drop for the preferred 25mm^2 cable and minimum acceptable 16mm^2 cable.

Current	10A			20A			50A
Battery Voltage	24V	36V	48V	24V	36V	48V	24V
Distance	Voltage Drop as a percentage of supply voltage for 16mm^2 and 25mm^2 cable						
1m 16mm^2	0.09 %	0.06 %	0.04 %	0.18 %	0.12 %	0.09 %	0.44 %
1m 25mm^2	0.06 %	0.04 %	0.03 %	0.11 %	0.08 %	0.06 %	0.28 %
2m 16mm^2	0.18 %	0.12 %	0.09 %	0.35 %	0.24 %	0.18 %	0.89 %
2m 25mm^2	0.11 %	0.08 %	0.06 %	0.23 %	0.15 %	0.11 %	0.57 %
3m 16mm^2	0.27 %	0.18 %	0.13 %	0.53 %	0.35 %	0.27 %	1.33 %
3m 25mm^2	0.17 %	0.11 %	0.09 %	0.34 %	0.23 %	0.17 %	0.85 %
5m 16mm^2	0.44 %	0.3 %	0.22 %	0.89 %	0.59 %	0.44 %	2.21 %
5m 25mm^2	0.28 %	0.19 %	0.14 %	0.57 %	0.38 %	0.28 %	1.42 %
10m 16mm^2	0.89 %	0.59 %	0.44 %	1.77 %	1.18 %	0.89 %	4.43 %
10m 25mm^2	0.57 %	0.38 %	0.28 %	1.13 %	0.76 %	0.57 %	2.83 %

These values are for guidance and so their suitability should be checked for the proposed application.

Voltage drops in cables are progressively more pronounced on 48V, 36V and 24V supplies than on 230V ac mains supplies, so a larger cable size may typically be used to minimise voltage drop than is common practice for 230V ac work.

These cables must be connected to the battery to load circuit as shown below in 6.1.4.

6.1.4 Description of Battery to Load Circuit and FCM connection, protection, and isolation

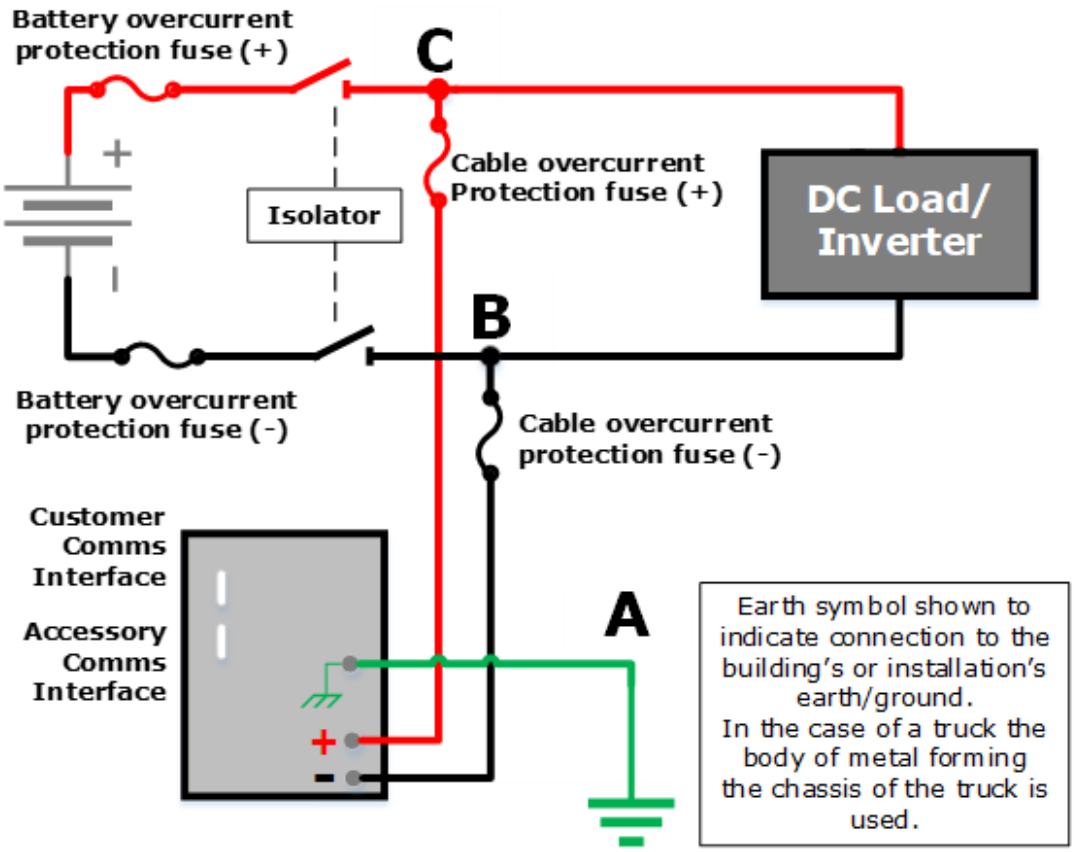
Fuel cell modules and batteries may be hybridised in different ways. In all cases, general electrical good practice for sizing and protection of cables should be followed.

In some cases, the battery and FCM are required to provide the similar maximum power and current and the FCM takes over providing power when the battery becomes depleted. In these cases, the same cable size may be used throughout. The battery overcurrent protection fuse(s) in the diagram below are always needed but the cable overcurrent protection fuse(s) in the diagram is not needed in this case.

For example, if the load is 1kW at 48V then current will be 21A. Use of 25A fusing and a 25A maximum current in the FCM configuration together with a minimum of 16mm^2 cable is a likely solution, but 25mm^2 cable may be a better choice if the length of cable is long.

In other cases, the FCM is incapable of providing the peak power of the load, and this is always provided by the battery, but somewhat more than the average power of the load, which is much lower, is provided by FCM. The FCM actually needs to be rated for the average power of the load plus the power to recharge the battery between peaks of usage.

For example, if the load is 0.8kW average at 24V and 8kW peak, then the battery needs to supply 333A and the FCM needs to supply 42A (with 200W allowance for battery re-charge). In this case the battery overcurrent fuse would be chosen to be 400A, and the battery to load cables would be chosen to be at least 150mm^2. The cable to the fuel cell module would be 25mm^2 and the fuel cell module's configuration would be set for a maximum current of 50A. In addition, 50A cable overcurrent protection fuse (s) would need to be fitted as the 400A battery fuse is incapable of protecting a 25mm^2 conductor.



IE-LIFT 1T/U electrical connections (viewed from connector face)

Means of isolation is shown next to the battery fuse above. Whilst this may be an isolator switch as is common practice for 230V ac mains work, in many cases, codes and standards may not mandate this and removal of a fuse etc may be an acceptable but less convenient option.

⚠ • The plugs that connect to the FCM can also be used to provide isolation but MUST NOT be withdrawn if there is current flowing

Fuses are shown in the image above, use of circuit breakers is acceptable too, but fuses are more common for DC battery work. Guidance on electrical practice for battery system may be found in the standard: EN IEC 62485-2:2018. Safety requirements for secondary batteries and battery installations. Stationary batteries.

Note:	The IE-POWER 1T/1U will need up to 120W for 20 seconds during start up, to initialise the valves and fans needed for operation, prior to generating its own power. This time will be extended during cold start-up which is a future feature.
Note:	The battery pack must provide power at the desired voltage. The battery pack must be capable of powering the load during module performance optimisation cycle (see section 9.3). For description of the communications and signal connections see section 7.4

As previously stated, the chassis of the FCM must be connected to the installation's earth/ground or chassis. This will also be connected to the chassis of the load or inverter etc, and metal structures used to support the batteries etc.

6.1.5 Earth/ground or chassis referencing of DC power output: Isolated supplies

In the diagram on the previous page the +ve and -ve outputs of the fuel cell module and battery are isolated (i.e., have no connection to the chassis of the unit and the earth/ground of the installation or chassis of the truck). This practice is used in Industrial Truck (MHE). This is because high-capacity batteries are used in metal boxes or tanks. This approach is a countermeasure against a metal tool causing a connection between a battery box and battery terminal during installation and maintenance. Fusing and isolation should be used on positive lines as a minimum and will protect against overcurrent. Fusing and isolation may also be applied to the negative lines as this gives additional protection for faults to earth/ground or chassis, where required. As supplied, the +ve and -ve power outputs of IE-POWER 1T/1U are not connected to chassis internally within the unit.

6.1.6 Earth/ground or chassis referencing of DC power output: Supplies with negative connected to earth

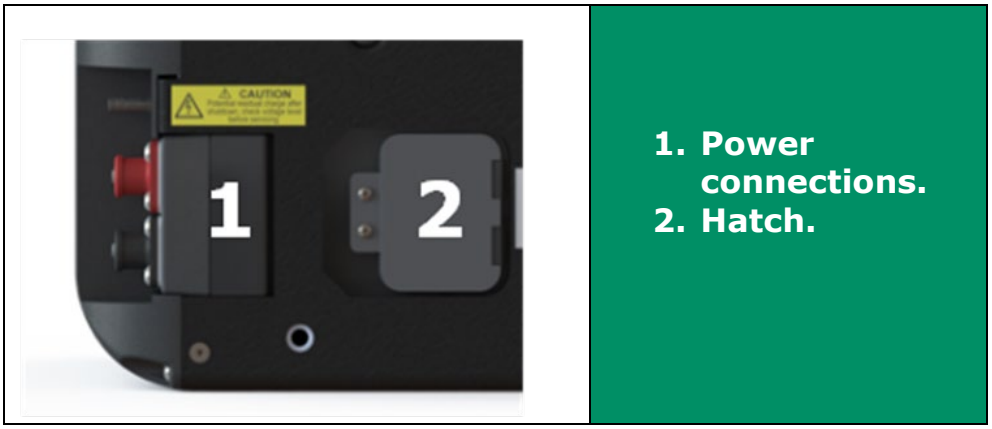
Connecting the negative of a supply to the earth/ground is a common practice, in general and for **datacomms** installations. Usually, the connection will be made at the source of the highest power. If this is the battery, a connection would be made between points **'A'** and **'B'** in previous diagram. If the FCM was the source of highest power, the connection would be made at the FCM. The FCM has a configurable internal link to make it easy to make this connection. Fuses and isolation should only be used on +ve lines on such a system, and those shown in the -ve lines are replaced by a direct connection.

6.1.7 Earth/ground or chassis referencing of DC power output: Supplies with positive connected to earth

Connecting the positive of a supply to the earth/ground is practice used in **telecom** installations. This technique protects buried cables against corrosion. Usually, the connection will be made at the source the highest power. If this is the battery, a connection would be made between points **'A'** and **'C'** in the previous diagram. If the FCM was the source of highest power, the connection would be made at the FCM. The FCM has a configurable internal link to make it easy to make this connection. Fuses and isolation should only be used on - ve lines on such a system, and those shown in the +ve lines are replaced by a direct connection.

6.1.8 Positive / Negative earth configuration hatch

Access to make a +ve line or -ve line connection to chassis in the FCM is available via a removable hatch. The +/- power output is isolated from earth/chassis/earth/ground as standard. The location is shown below, please contact Intelligent Energy Ltd to discuss positive / negative configurations.



- Either + or – (but never both) may be connected to earth externally
- Either + or – (but never both) may be connected to earth internally

6.1.9 Parallel connection of multiple fuel cell modules.

The IE-POWER 1T/1U is capable of being parallel connected via the positive and negative terminals to increase power capability. A maximum of 8 systems can be connected together via a central termination junction box. It is possible to connect a greater number of systems together in a hierarchal arrangement, consult Intelligent Energy for further information.

Parallel connection of units is permitted to increase power. In this case, use of additional overcurrent protection and increased wire gauge will need to be considered and calculated. Each unit will need to have a chassis connection, see 6.1.1.

• The earth/ground link feature under the hatch (see section 6.1.8) must not be used when connecting units in parallel. If required it should be made external to the FCM

Where the system has multiple fuel cell modules operating in parallel the number of modules providing power will vary depending on the load required. When the first fuel cell module receives the Run command (digital input) it will start immediately. If the load power is reduced it will switch into "idle", ready to restart based on a voltage trigger.

Subsequent fuel cell modules will start when required. Power exceeding 64% of the rated output power from the module will then trigger the next module in the sequence to start up. The load is then shared across the modules until the required power again exceeds 64% of the combined rated power output triggering the next module, and so on until all modules are operational and full rated output is achieved. There is a fixed 20 second qualification time for checking power is above threshold, therefore there is at least 20 second delay between the switch on of each additional system.

If the load drops, then a reverse sequence will happen per the operation described above based on the load being <20% of the combined rated output of the operational modules. The subsequent fuel cell modules are only started if their Run switch is enabled. If additional control is required, the Run switch can be used to determine how many fuel cell modules could be running and even provide wear levelling. Load is shared equally across the modules and across the stacks in the modules, for example. 8kW load across 8 modules equals 1kW per module and 1kW per stack.

6.1.10 Over voltage / Ripple voltage protection.

The integrator must be mindful of potential electrical interference when the fuel cell module installation features an electrical convertor such as a DC to AC power inverter, if unregulated will have a detrimental effect on the FCM performance and health.

An example of electrical convertor interference is Voltage Ripple, an undesired by-product caused by the conversion of AC to DC electrical power.

• In extreme cases Voltage Ripple has the potential to cause damage to the components of DC circuits within the FCM

Voltage ripple can be surpressed with smoothing capacitors that the integrator should consider when designing their overall fuel cell installation.

• The integrator should also be aware of Electromagnetic Interference (EMI) and utilise the correct earthing techniques (see section 6.1.1)

The FCM installation incorporates a hybridised battery bank which may feature a Battery Management System (BMS). Lithium-Ion battery banks require a BMS in all instances, whereas Lead Acid battery banks do not require a BMS. The integrator may decide a BMS is necessary to maintain the performance and health of the Lead Acid battery bank. However, the integrator must be aware of lead acid battery equalisation charges.

An equalisation charge is a periodically purposeful overcharge of the lead acid batteries with its purpose to remove detrimental sulfate-crystals that build up on the internal plates overtime. During the equalisation charges.

• The integrator must incorporate adequate protection devices to shield / isolate the fuel cell module from the lead acid battery bank circuit during the periods of equalisation charging

- Chassis to vehicle chassis or installation earth/ground connection MUST always be made
- FCM must be setup for the earthing arrangement of the application. Power output is isolated from earth/chassis as standard
- The electrical installation must be performed by a trained and competent person, making use of the appropriate personal protective equipment (PPE), suitable handheld tools and a calibrated digital voltmeter/ multimeter (DVM / DMM) or voltage indicator & proving device.
- Ensure hybridised battery bank is identified for use with your fuel cell module, the fuel cell module will be configured to operate to the specified battery requirements including size, capacity, type etc. Damage may occur if an unspecified battery bank is installed
- Do **NOT** electrically overload the FCM. Overloading will lead to excessive load being drawn from the battery. Drawing excessive load may cause damage to the equipment
- Do **NOT** allow external devices connected to the FCM to increase the voltage beyond the maximum system rated 58V. Overvoltage will damage the FCM
- When the fuel cell module installation is deactivated, confirm isolation via a calibrated digital voltmeter/ multimeter (DVM / DMM) or voltage indicator & proving device to ensure all cabling is fully discharged prior to removal as there is a risk of residual voltage on live components after shutdown
- When the IE-POWER 1T/1U is running it may stay live if the power cables are disconnected
- During installation and maintenance, the IE-POWER 1T/1U must be off, and the load, battery or external power supply must be isolated and made safe
- EVEN when the IE-POWER 1T/1U is NOT running the cables may still be powered from the load side battery or external power source
- At start-up there will be an in-rush current to the FCM to charge the capacitors within the FCM

7 Air Supply

To produce electrical power, the IE-POWER 1T/1U requires an unobstructed air inlet supply and air outlet/ exhaust.

⚠ • Air must not be recirculated between the exhaust and inlet. See section 11.7 Air supply and ventilation

7.1.1 Through-flow configuration air interfaces

The **main air** path provides air for:

- Fuel cell module stack electrochemistry, cathode cooling and cathode ventilation
- Purge dilution ventilation

The Through-flow variant IE-POWER 1T/1U main airflow inlet is via the grille on the connector face (rear face on diagram) and exit via the main air outlet face (front face on diagram) as depicted by the above image.

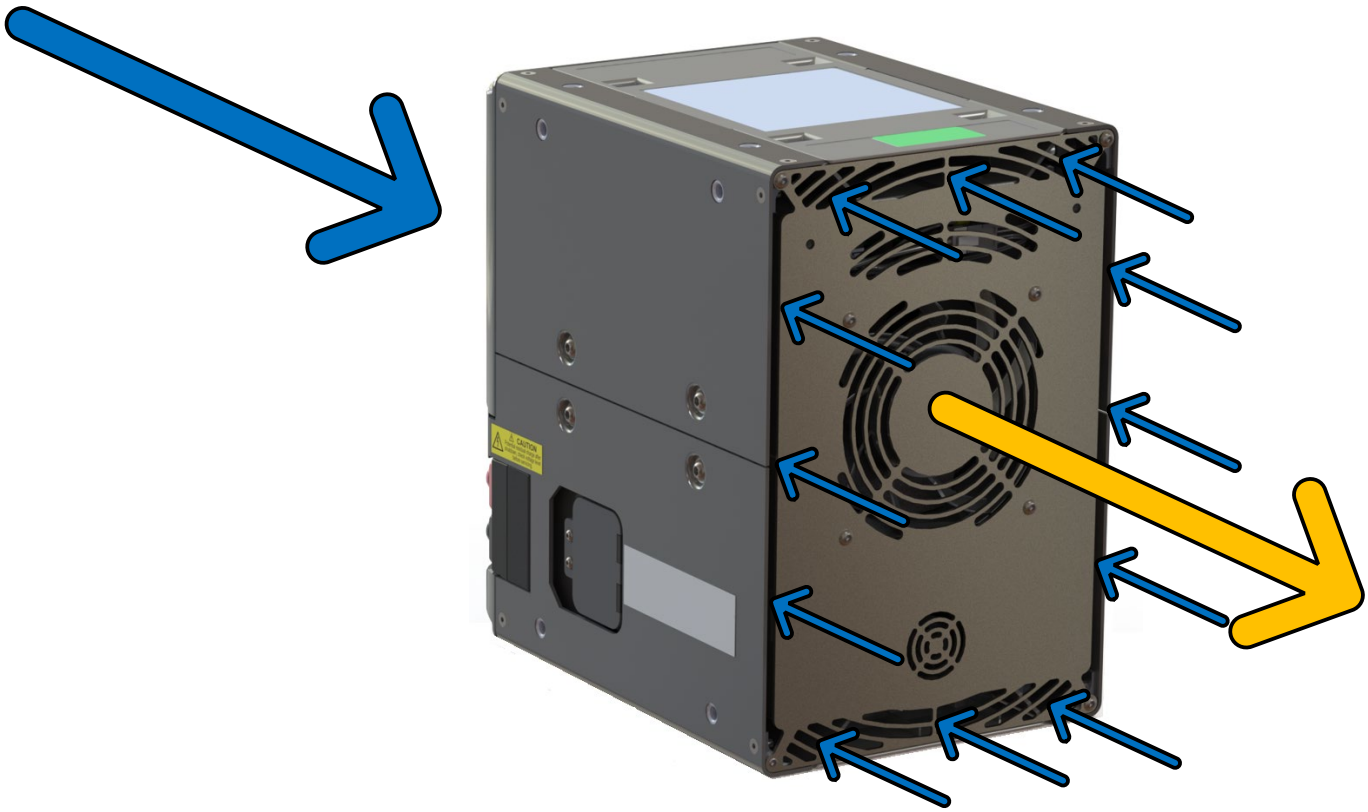
In addition, the unit will draw bypass air from peripheral areas at both ends of the FCM and this modifies the flow of air in the main of path, reducing airflow in the fuel cell module stack whilst maintaining or increasing airflow in the main fan. This is used during:

- Start-up and shutdown
- Cold operations
- Low power operation
- Performance Optimisation Cycles (POC)

⚠ • All inlets and outlets must be kept free of obstruction

Bypass air will be drawn from the top and bottom inlet grilles and peripheral inlet gaps of the main air outlet face, as illustrated by small arrows on the diagram below.

Bypass air will also be drawn from the periphery of the main inlet grille on the connector face as depicted below.



- All inlets and outlets must be kept free of obstruction

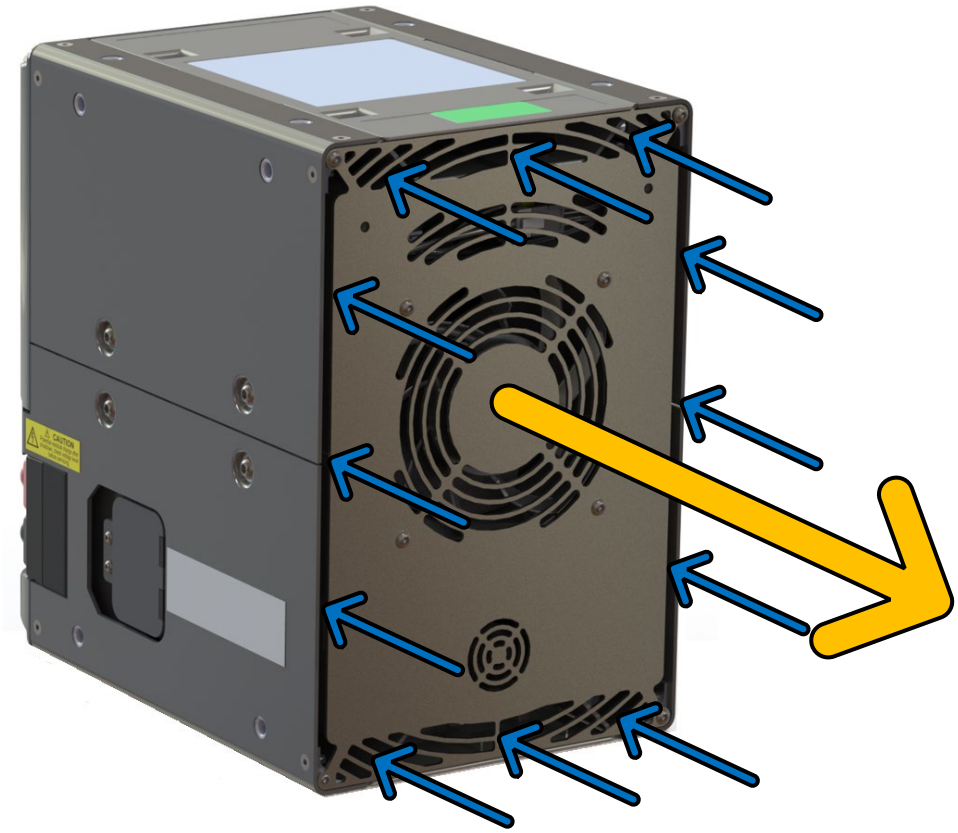
7.1.2 U-flow configuration air interfaces

The **main air** path provides air for:

- Fuel cell module stack electrochemistry, cathode cooling and cathode ventilation
- Purge dilution ventilation

All air enters and leaves on the same face on the U-flow variant IE-POWER 1U.

There is no air flow on the connector face of the unit.



The main airflow enters on the periphery of the main outlet face via the top and bottom inlet grilles and peripheral inlet gaps of the main air outlet face, as illustrated by small arrows on the diagram.

The main airflow exhausts are via the large circular exit as depicted by the large exhaust airstream image.

In addition, the unit will draw bypass air using the same inlets as for the main air path in the diagram above.

Bypass air modifies the flow of air in the main air path, reducing airflow in in the fuel cell module stack whilst maintaining or increasing airflow in the main fan. This is used during:

- Start-up and shutdown
- Cold operations
- Low power operation
- Performance Optimisation Cycles (POC)

- All inlets and outlets must be kept free of obstruction

7.1.3 Through-flow and U-flow electronics air interfaces

The **electronics cooling air** path provides air for:

- Cooling of electronics and motors
- Ventilation for fuel cell module stack end plates and bodies of valves

The electronics cooling air enters and exists on the same face of the unit and follows a completely different and path within the FCM to the main air path.

The electronics cooling air enters via the round fan inlet shown by an arrow and exits across the rectangular opening as shown below by arrows.

⚠ • The electronics cooling air vent must never be blocked, a blocked air vent will result with the fuel cell module shutting down

⚠ • All inlets and outlets must be kept free of obstruction

7.1.4 Through-flow and U-flow additional air flow interfaces

In addition, there are two side seams on the largest faces of the unit and to a lesser degree some top seams. Together with unused mounting holes, all of these can be additional entry points for bypass and main path air. They are not required for airflow and may be blocked, especially if managing separated air volumes.

Seams and mounting holes that may be blocked are highlighted below with dashed (seams) and arrows (unused mounting holes). Also present on non-visible sides.

- Do not obstruct air flow to inlet or exhaust, ensuring that they cannot be blocked
Ensure there is no significant obstruction within 300mm of the air inlets including bypasses and air outlets

- Avoid exposure to volatile organics (VoCs), poisonous/corrosive gasses and anything with a prominent scent. This includes but is not limited to cleaning products, air-fresheners, glues/adhesives/epoxies, chemical solvents, ammonia, and salt spray. Particular care should be taken to avoid storing or transporting the fuel cell in an enclosed space (e.g., drawer, bag, or box) with potential contaminants as this may accelerate the contamination process

- The IE-POWER 1T/1U must be set up in a well-ventilated environment with consideration given to the precautions of hydrogen safety. These precautions relate to good general practice when using hydrogen and especially to the storage, supply, or generation of the hydrogen used to supply the FCM (see section 7.3)

7.2 Hydrogen fuel

• When installing and operating hydrogen systems, hydrogen general safety guidance must be considered: ISO 14687-3:2014 grade E category 3 & ISO/TR 15916 basic considerations for the safety of hydrogen systems

The hydrogen must be at least **99.9%** pure.

Summary Hydrogen fuel requirements:	**Quantity**
Hydrogen Fuel	99.9%
Total Non-Hydrogen gases	0.1%
Water	Non-condensing at ambient conditions
Limit for individual contaminants:	
Total Hydrocarbons	0.2ppm
Nitrogen, Argon, Helium	0.1%
Carbon dioxide	0.2ppm
Sulphur compounds	4ppb
Max particulates concentration	1mg/kg
Max particle diameter	75micron

The hydrogen supply to the fuel cell module needs to be regulated to **0.5 to 0.7 bar gauge**, maintaining the pressure during rapid changes of flow rate.

If the system experiences a supply pressure exceeding its maximum rating, the system will either not start or shutdown if operating.

A supply pressure in excess of 3 bar gauge could potentially damage the unit and result in a leak.

Where the above is possible, appropriate pressure relief devices or methods (e.g., pressure relief device or burst disk) with an upper tolerance limit of no more than 3 bar gauge shall be used in the FCM hydrogen supply installation, to protect internal components from damage due to overpressure.

• The hazards of gas release from over pressure / pressure relief operation must be assessed, additional hydrogen monitoring equipment must be installed in all areas where hydrogen build-up could occur

It is recommended that the inlet hydrogen shall be filtered via a gauze filter with a maximum pore size of 40microns, to remove any particulates / solid debris that may enter upstream pipework through assembly / disassembly of any interfaces. Pressure drop across the filter should be considered, to ensure the inlet pressure to the system is maintained within specification at all times during operation.

• The installer shall implement routine maintenance and inspection schedules in relation to hydrogen production and storage in the vicinity of the fuel cell module installation

• Hydrogen gas should be provided at a regulated pressure to the module inlet

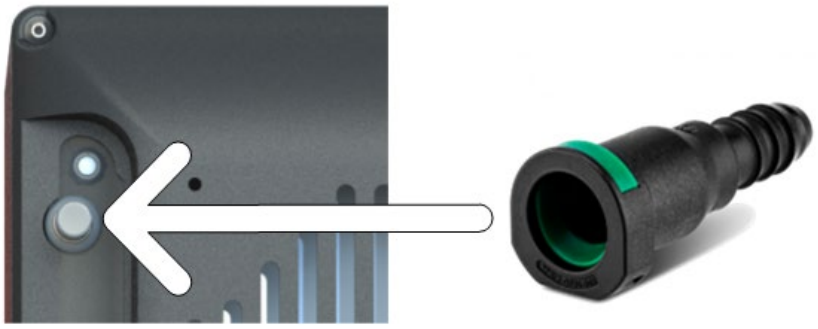
• The hazards of gas release from over pressure / pressure relief operation must be assessed, additional hydrogen monitoring equipment must be installed in all areas where hydrogen build-up could occur

• In relation to local hydrogen production and storage in the vicinity of the installation, the installer must follow BS EN IEC 62282-5-100:2018 4.4: Operating and Storage instructions: Use of Hydrogen

• The LEL (lower explosive level) of Hydrogen is considered to be 4% by volume (4% v/v). The stored hydrogen installation atmosphere should be monitored and maintained at below 25% of the lower explosion limit LEL (4% v/v)

7.3 Hydrogen connection

The hydrogen connection to the system is on the connector face of the system located above the communication ports. The connection on the unit for the hydrogen supply is a male 5/16” SAE J2044 spigot.



The push fit mating female connection is available from NORMA. Contact Intelligent Energy for further information.

A)5/16” SAE J2044 spigot connector	B)Quick release push button	C)Supply hose mating face
		
Push the fitting onto the port and engage the lock with a distinctive "click" that secures the connection	Confirm H_2 supply is isolated prior to engaging the green quick release button and removing the fitting	Ensure the choice of hose and sealing clamp are compatible with the fitting

The IE-POWER 1T/1U will consume less than 70g/kWh at rated power. This is equivalent to 16.8slpm at rated power. It must be noted that the flow will spike high during hydrogen purges, which if incorrectly regulated can lead to a low-pressure fault of the system.

The FCM provides required dilution for potential internal leaks and purge releases, and checks for leaks during start-up, shutdown and running. Any leaks and releases from the unit are designed to be diluted to a safe level, meaning that hydrogen cannot build up to an unsafe level external to the unit.

The FCM is not able to detect leaks/ hydrogen releases that occur externally to it. This includes those on the supply to it. The FCM is not able to isolate the external supply during such an event.

The FCM operates at a relatively low pressure, a high-pressure storage cylinder and ancillary installation equipment has a much higher capacity to leak than the FCM itself.

The overall installation shall be assessed for risk and will include additional safety measures including but not limited to:

- Documented routine inspection
- Suitable installation location
- Safety for hydrogen supply, storage / generation

The assessment will determine the need for use of ventilation and/ or leak detection and atmospheric hydrogen monitoring equipment.

Note: When preparing a cylinder for use with a hydrogen fuel cell, it must first be purged of air using pure Nitrogen or other inert gas (after a regulator or valve has been fitted to its opening). This is necessary because air contains Oxygen, which is highly reactive with Hydrogen, so adding Hydrogen to a cylinder containing air will create a flammable stoichiometric mixture of hydrogen and oxygen at some point during the fill process. Pre-purging using Nitrogen avoids this.

After air has been removed from the cylinder – having been replaced by Nitrogen – the Nitrogen must in turn be replaced by Hydrogen. Since nitrogen is unreactive with hydrogen, purging in this order avoids potentially reactive mixtures.

• It is required that the external system has an automatic shut-off valve as part of the hydrogen feed line. This allows the hydrogen to be isolated at source if required

• All ancillary hydrogen supply equipment must be hydrogen approved fixtures and fittings

• Do not connect or disconnect the H2 supply connector from the FCM, or interfere with the H2 supply installation if the hydrogen is not isolated locally and at the supply or at the cylinder

• The integrator must perform monthly checks of the hydrogen pipework for leaks, particularly when connectors have been disconnected and re-connected, such as cylinder exchange or installation modifications

• At installation, the external hydrogen pipework must be bled of air or inert gas before operation

• Self-fill Hydrogen supply cylinders must be correctly purged of non-reactive and reactive gas
The Hydrogen pipe/hose that connects to the unit should always be fastened down to avoid applying stress and force to the unit

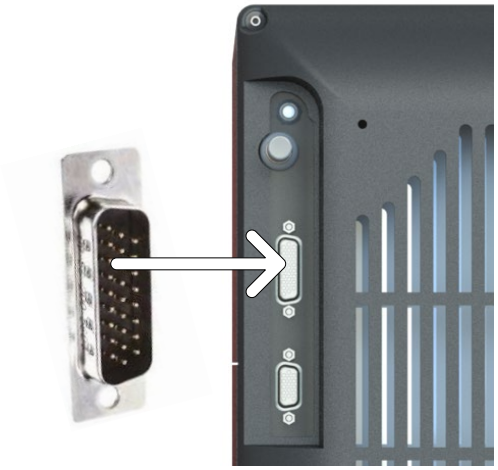
• The systems installation must be kept at a minimum distance of 6 metres from any potential combustible material, including gasoline and other flammable vapours and liquids

• The IE-POWER 1T/1U must be set up in a well-ventilated environment with consideration given to the precautions of hydrogen safety

7.4 Communication connections

7.4.1 Customer Port

26-way high density 3 row sealed female D -sub connector. Mating connector is male. Pinout and details given below.



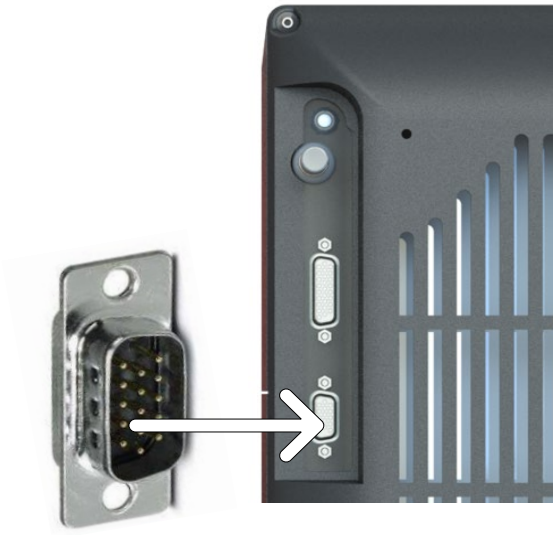
Name	Pin	Notes
Customer CAN A HI	11	As CAN standard. Duplicate terminals to allow easy connection, Speed set to 500kbits/s as standard, see section 14.2 for CAN speed options. Not internally terminated, 120Ω required at two extremities of CAN bus
Customer CAN A LO	10	
Customer CAN B HI	20	
Customer CAN B LO	19	
Customer Ground / Zero Volts	21	Isolated from both chassis earth/ground and electrical power output +/-
	24	
	26	
Customer Serial Rx	23	5V signal level, contact Intelligent Energy for further details.
Customer Serial Tx	25	
Chassis/Shield	22	Connected to chassis, available for screens and shields. Isolated from electrical power output +/- and Customer Earth/ Ground / Zero volts
	SHELL	
Customer 5V	14	Current Limited Isolated 5V for RUN and ENABLE signals
Customer 5V	12	
Run Signal +ve	15	Short to Customer 5V to give RUN Command
System Enable Signal +ve	13	Short to Customer 5V to give ENABLE Command
Status - Normally Open	9	Provides a "System Running" signal to Customer (Potential/volt free contact)
Status - Common	8	
Status - Normally Closed	7	
Unit Index Value 1	2	Used to provide location identification when multiple units used. Link to GND_REF to use. Contact Intelligent Energy for further details.
Unit Index Value 2	3	
Unit Index Value 4	4	
Unit Index Value 8	5	
Unit Index Value 16	6	
GND_REF	1	
Not Used	16,17,18	

The CAN connection can be used to communicate with the IE-POWER 1T/1U using Intelligent Energy's proprietary CAN protocol. CAN to J1939 configuration can be provided, please contact Intelligent Energy for further details.

7.4.2 Intelligent Energy accessory port

15-way high density 3 row sealed female D-sub connector. Mating connector is male.

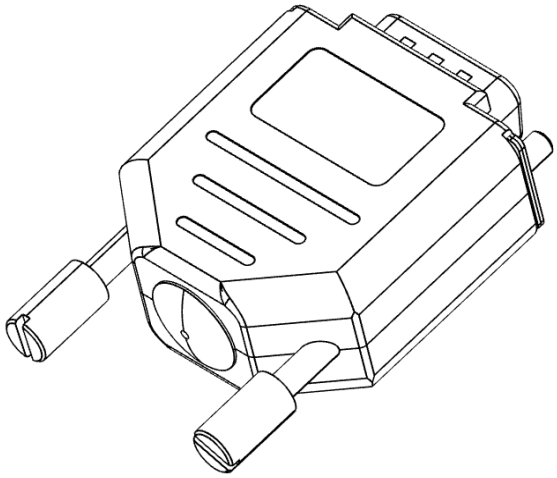
This is a proprietary Accessory interface. It is to be used when connecting multiple units and accessories.



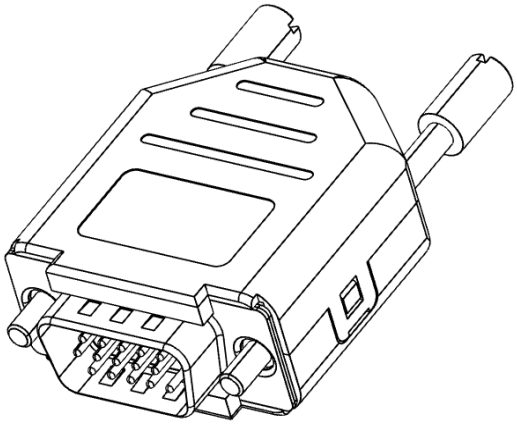
This interface includes a loop interlock connection and pins 4 and 15 need to be joined to allow the FCM to operate.

A plug is provided depicted in the image below which enables an interlock connection by connecting pin 4 to pin 15.

Rear view



Front view



- Do not use the power earth/ground as a reference for the communications and vice versa
- Ensure communication cables are not more than 10m long

7.4.3 Status LED

FCM status is given by the LEDs located on the connector face and the main air outlet face of the unit.

LEDs are provided on both front and rear faces, so status remains visible for different installation and integration scenarios. Details of the LED status signals are displayed below. Other states exist during programming etc.

Ventilation LED

Connector LED

LED MODE	System State	Description
OFF	**OFF**	No external power and / or no enable signal
BLUE CONSTANT	Start-up Running Shut down	Power produced, or power production imminent*
BLUE FLASH SLOW >2.5s ON>2.5s OFF>	Standby Shut down	Will produce power once battery discharges or power demand increases*
BLUE FLASH STANDARD >1s ON>1s OFF>	Running with de-rate shut down	System producing less power than expected*
BLUE FLASH FAST >0.25s ON>2.5s OFF>	Inactive awaiting run signal	Run signal not present
AMBER FLASH FAST >0.25s ON>0.25s OFF>	Fault – external issue	Fault – usually an external issue, may be resolved by integrator
AMBER CONSTANT	Fault – internal issue	Fault – usually an internal issue Contact IE Product Support
*No power output during shutdown		
Other LED states exist associated with programming etc.		

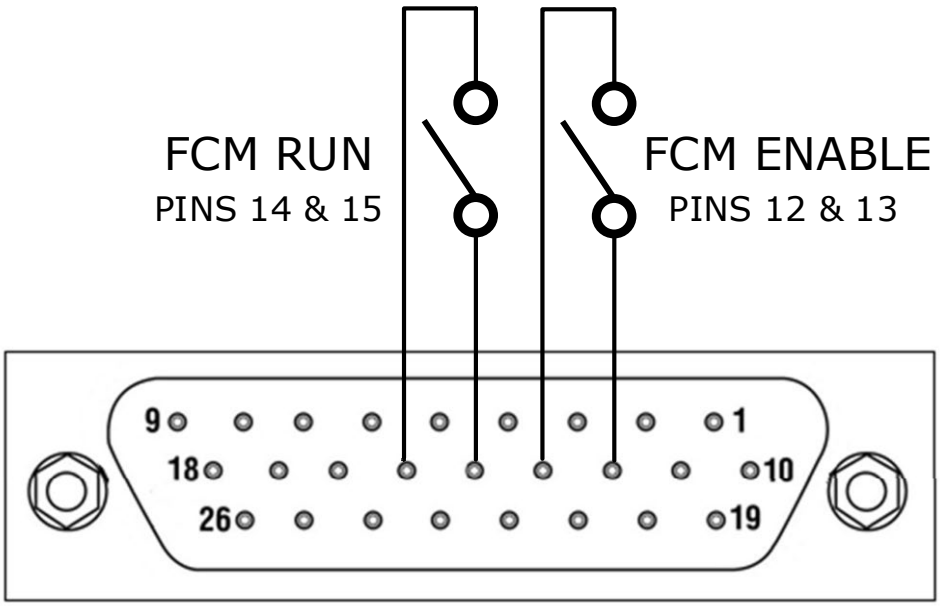
8 IE-POWER 1T/1U Commands and states

8.1 Module Enable/Reset

To enable the IE-POWER 1T/1U, the Enable Negative needs to be connected to the Positive Enable pin and held. This can be done by making a connection between the Enable Positive and Negative pins (12 & 13) of the 26-way customer connector. In the event of a fault the Enable connection needs to be cycled to reset the fault status, please see illustration below.

8.2 Module Run

To produce power the Enable signal must be present prior to the Run signal. The Run Negative pin needs to be connected to the Positive Run pin and held. This can be done by connecting the Run Positive and Negative pins (14 & 15) of the 26-way customer connector, please see illustration below. When the signal is received and a load demand is present, in optimum installation and environmental conditions the FCM will start and deliver power within 20 seconds, provide power, and maintain the battery voltage.



Amphenol HD male 26-way D-sub connector or equivalent to be connected to the female 26-way D-sub connector located on the rear of the fuel cell module. Manufacture Part No: L717HDA26P.

Note:	The FCM will need 120W for 20 seconds during start up, to initialise the active devices including cooling fans, valves, and power electronics.

8.3 IE-POWER 1T/1U status signal

A continuous IE-POWER 1T/1U System Running Status signal will be present whilst the FCM is running with no fault present, and the unit has not moved to Standby. The System Running Status signal is accessible via a potential/volt free contact, located on pins 7 (Normally open), 8 (Common) and 9 (Normally closed) of the 26-way customer connector (see section 7.4.1).

If the Enable is off there is no System Running Status signal. If the Enable is on but there is no Run signal, then there will be no System Running Status signal present after the system has completed any required shutdown actions. If the Enable and Run signals are present and there is no System Running Status signal, then the FCM is in Standby or Fault.

When the Enable and Run signals are present the status signal should be used as a process indicator to the Installation Controller, the Enable signal should be deactivated when the System Running Status signal is no longer present, except under emergency stop conditions. The FCM will stop producing power once the thresholds of the configuration are achieved (see section 13) and transitioned to a Standby state.

Once in Standby state the FCM will remove the System Running Status signal. In optimum running conditions the shutdown process will take approximately 30 seconds, please be aware upper and lower temperature limits will increase the time of the shutdown process, so it is recommended in all cases to use the status signal to confirm the shutdown process has completed. For more information, please contact Intelligent Energy Ltd.

The correct process to stop the fuel cell system at any time is:

- Remove Run signal
- Waiting until the System Running Status provides no signal
- Remove the Enable signal

Be aware that the Enable signal is required to allow the FCM to correctly shutdown. Non-emergency shutdowns as defined by the removal of the Enable and hydrogen supply are not recommended, except in emergency conditions, this stops the FCM performing its shutdown process correctly, this is detrimental to the performance of FCM.

Note:	In the event of a critical shutdown, emergency stop shutdown, or an incorrect shutdown (where the enable and run signals are removed too quickly) the FCMs internal air controls and actuators may not have had the opportunity to revert to their start-up positions. The louvres and actuators will return to the correct state once the system is set to run. If the system is enabled without then going into run then internal louvre could be in an open position exposing the FCMs internal air sensor to external air movement, and this may cause additional FCM trips if high winds are present in the vicinity of the installation. It is recommended that if a shutdown as described above occurs, the operator enables the system then runs briefly and then stops the FCM (run signal removed, enable signal remaining). This will allow the FCM to perform its shutdown process, allowing the internal louvres and actuators to revert to their starting position

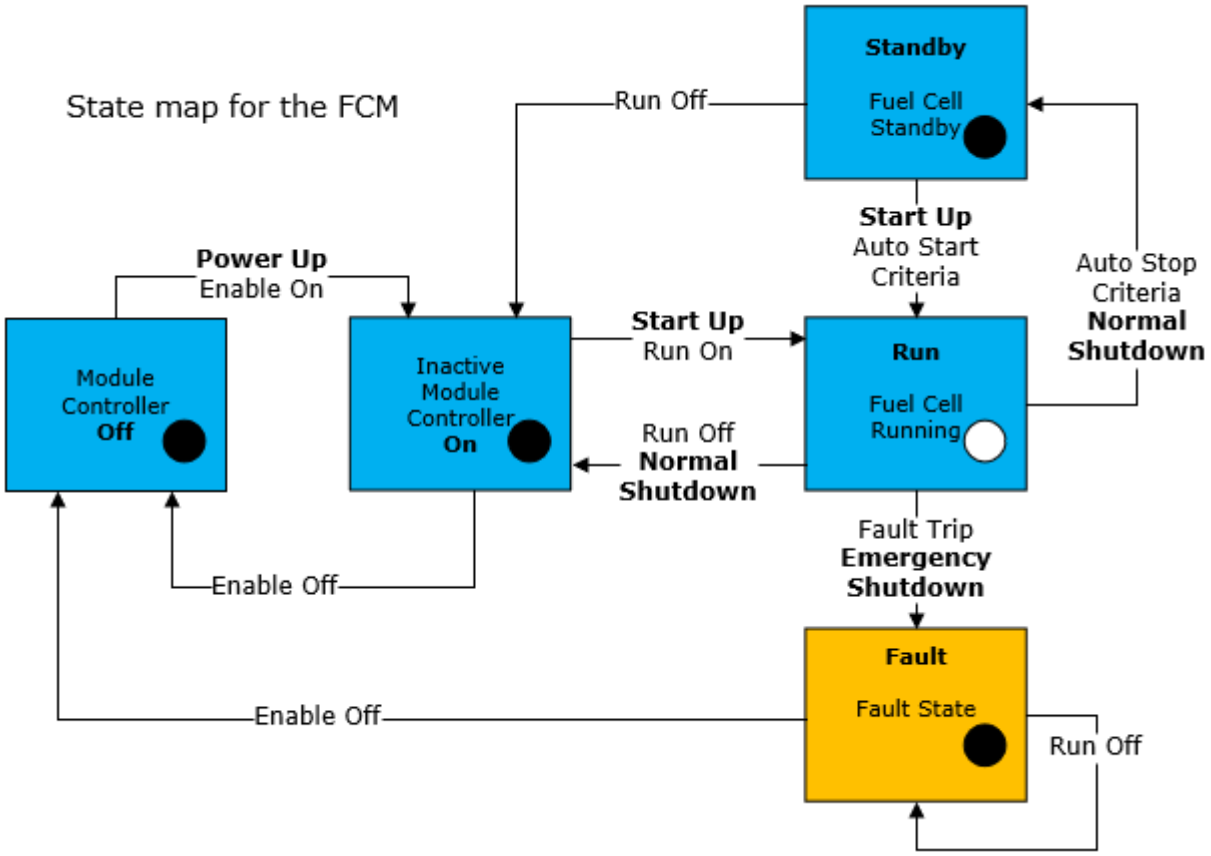
- In the instance of the fuel cell module being remotely controlled, the installation must incorporate a process to shut down the fuel cell module in the event of an emergency
- Trained and competent personnel to install enable / run interface to activate the FCM

8.4 IE-POWER 1T/1U software states

The IE-POWER 1T/1U has five possible states:

- Module Controller Off
- Inactive Module Controller On, (No Run signal)
- Fuel cell module Standby
- Fuel cell module Run
- Fault

The diagram below represents the interaction of the five possible software states of operation.



Please note the following points:

1. The small circle in each state box indicates the condition of the IE-POWER 1T/1U status pins. This is inactive (Black circle: ●) in all states apart from fuel cell module running where it is active (White circle: ○).

2. In all states, removing the Enable signal returns the IE-POWER 1T/1U to the Module Controller Off state.

3. If the IE-POWER 1T/1U enters a fault condition the fault becomes latched. The Enable line must be cycled to clear the fault.

4. For start and stop criteria see section 14. Control parameters and standard factory setting.

9 Operation of IE-POWER 1T/1U

9.1 Operation summary IE-POWER 1T/1U

The IE-POWER 1T/1U outputs DC power at a regulated voltage of 24V, 36V or 48V to a battery bank and load (see section 6.1.4). The DC supply will be held at nominal voltage by a battery or external supply to act as a hybrid system. In the hybrid system, the battery is used to provide power whilst the fuel cell module starts. It supports the load during the fuel cell module performance optimisation cycle (POC) and while the system is in the standby mode. The nominal operating voltage is factory settable upon request.

- The hydrogen pressure must be provided in a regulated state to the module inlet

The IE-POWER 1T/1U will generate power when it is given both 'Enable' and 'Run' signals (see sections 8.2) and detects DC voltage and fuel pressure are present via the onboard electronics.

9.2 Anode purge

As the fuel cell module operates, it is necessary to remove water and any impurities from the anode (the negative electrode that receives the fuel). This is done by exhausting a small amount of hydrogen to the coolant air stream. The hydrogen is mixed with the air stream so that, as the mixture exhausts the module, the concentration is low enough to be safe (will not sustain flammability and explosivity). There is normally no impact on power production during anode purge. The presence of sufficient air to sustain this safety dilution is monitored and interlocked.

9.3 Performance Optimisation Cycle (POC)

During normal operation, the IE-POWER 1T/1U will periodically conduct an optimisation cycle which improves the performance of the fuel cell module. Multiple cycles are triggered in rapid succession at start-up. Cycles occur less than 15 times an hour during running. Power production is reduced or suspended for up to 12 seconds during the cycle so an external power source may be needed to briefly provide power to the load.

9.4 Standby state

It is undesirable for fuel cell module durability and efficiency to operate at very low power (below 50%) for extended periods (see section 9.6). The system can enter standby state based on the configuration parameters (see section 14). If there is more than one power source connected to the DC installation (such as a mains grid or photovoltaic array) with a higher output voltage than the FCM 'Delayed stop over voltage' parameter can switch the unit to Standby. Similarly, if there is no load present the 'Delay stop under current parameter' can switch over to Standby, the intention of this feature is to boost the system fuel efficiency.

Once in standby mode, the FCM will restart and provide power if the battery voltage dips to 'Delay (or immediate) Start under voltage' parameters.

Note: It is important that the configuration is correct for the target installation. Particularly with regard to type of battery to be used (see section 14.1).

9.5 Fault state

If the parameters of the IE-POWER 1T/1U leave the normal operational range the controller will adjust the operation of the fuel cell module to try to compensate; if this is not possible then a fault is triggered. When a fault has been triggered the controller will latch. To clear the fault, the controller needs to be reset by cycling the Enable / Reset signal. Any faults that are triggered before start will prevent the unit starting. For reset instructions see section 10.

9.6 Optimising the Fuel Consumption of IE-POWER 1T/1U

The fuel cell module uses the hydrogen to produce electrical current (plus water and heat).

The cell efficiency can be improved with the following steps:

- FCMs will be most efficient if used often. The IE-POWER 1T/1U should be run at more than 80% power for 30 minutes, at least once every 3 months
- FCMs will be most efficient, and have longer life, if operated at between 50% and 100% power
- If the FCM is ran for prolonged periods of time at less than 50% power, the overall lifespan may be reduced
- FCMs will be most efficient if operated between 10°C – 20°C

10 Faults

10.1 Procedure to reset a fault

If the IE-POWER 1T/1U has a fault it will:

- Immediately disconnect the internal DC-DC converter to stop providing power to the load
- Perform a shutdown
- Close inlet valves to remove the hydrogen supply from the fuel cell module

In the case of a critical fault, it will:

- Immediately disconnect the internal DC-DC converter to stop providing power to the load
- Immediately close inlet valves to remove the hydrogen supply from the fuel cell module

To reset a fault, follow the procedure below:

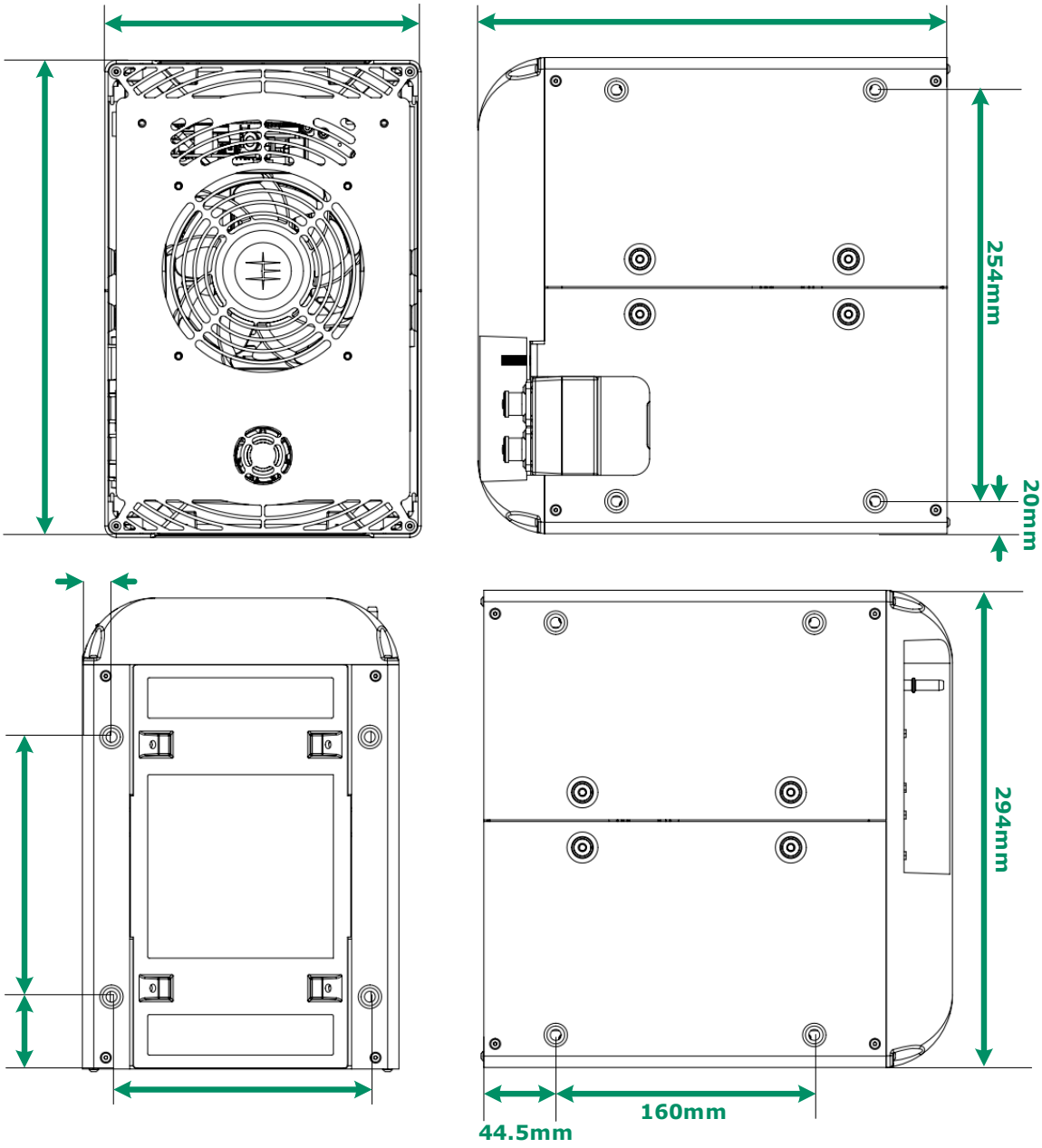
1) Check that the load is disconnected
2) Switch the Run signal to 'Off'
3) Switch the Enable signal to 'Off'
4) Wait for five seconds
5) Return the Enable signal to 'On'
6) Set the Run signal to 'On'
7) Return the load to required setting

• The safety case of the overall installation must consider the fault condition of the fuel cell module as part of its analysis of the full function of the system

11 Installation and set up

11.1 Overall dimensions and mounts

The diagrams below give overall size for IE-POWER 1T/1U and fixing centres for mounting. Dimensions are in mm and exclude protruding fasteners, connectors, and mated connectors.



Mounting centres:

- Four off M8 threaded holes are provided on each of four side faces
- Centres are 254mm x 160mm on two largest side faces
- Centres are 160mm x 160mm on two smallest side faces

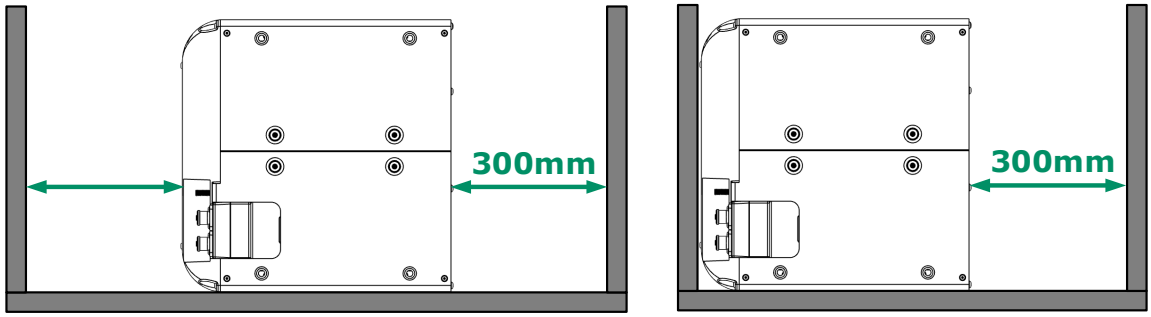
Fasteners and torque:

- Use A2 stainless steel fasteners recommended
- Avoidance of countersunk fasteners recommended
- Thread depth is 10mm
- Required torque is 18Nm

11.2 FCM clearance and environmental tolerances

The following clearance tolerances and environmental concerns must be acknowledged when determining the location of the FCM installation.

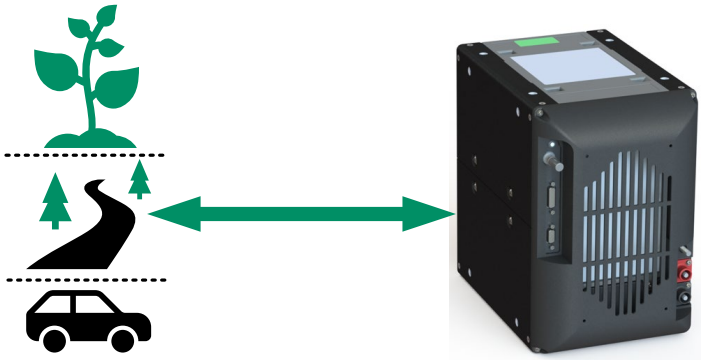
• A minimum distance of 300mm must be observed from the ventilation face and connector face of the FCM to any solid structure, ensuring sufficient airflow to enter and exit the FCM (see section 11.7)



• The FCM installation must not allow blockages of the ventilation and connector faces

• The area surrounding the FCM installation must be kept free of gasoline and other flammable liquids and vapours

• A minimum distance of 2 meters must be observed from the entire FCM installation to areas of vegetation (plus expected growth), public ways and vehicles. The inclusion of signage and barriers should be considered to prevent a breach of the 2-meter clearance



The FCM integrator must consider potential environmental impacts on the installation.

• If the FCM installation is to be located in an area prone to seismic activity, a suitable seismic hazard zone risk assessment must be performed prior to delivery

The region of the FCM installation must be classified to determine which category of seismic zone it belongs to, zone 1 being the most dangerous, zone 4 being the least dangerous.

• Additional installation protections must be considered in regard to weather related phenomena including protection against wind, rain, lightening, snow, ice, and freezing temperatures (see section 1.6)

• The FCM must be protected from potential airborne particles, additional filtration may be necessary to protect the FCM from airborne particles which may include but are not limited to dust, dirt, sand, pollen, soot, and liquid droplets present in the air

• If additional filtration is proven necessary particular attention must be observed so that the filter does not restrict the required airflow of the FCM (see section 11.7)

• The performance of the FCM will be adversely affected by air airborne contaminates which may include but are not limited to sulphur dioxide SO_2, nitrogen oxides NO_x, carbon monoxide CO, ammonia NH_3, hydrocarbons C_xH_y, and Toluene C_7H_8. The integrator must ensure that the location of the FCM is not in an area prone to the listed airborne contaminates

11.3 Mass and handling.

Mass is ~10.4kg

For ease of handling, positioning & installation, mounting holes (see 11.1) can be fitted with:

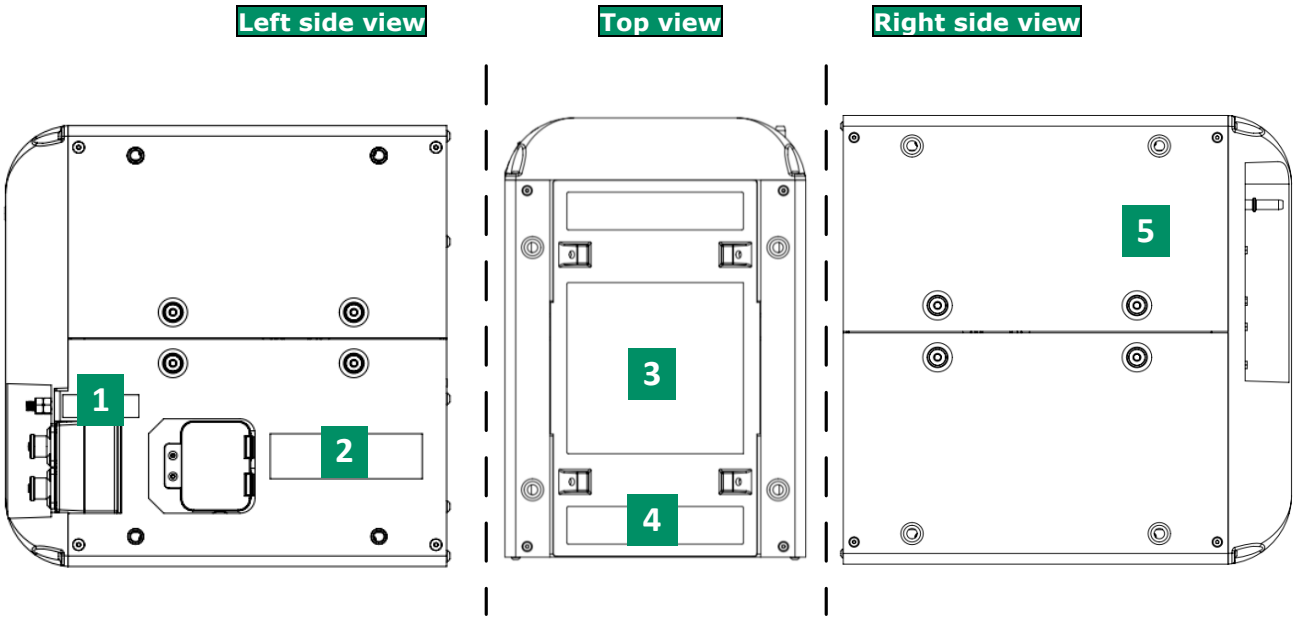
- Paired handles (M8 hole 160mm pitch)
- Feet (M8)
- Lifting eyes (M8 use diagonally opposite holes). These should be removed before use unless intended as part of the integration
- Accessory handles and feet are available from Intelligent Energy (see section 16.3)

11.4 Label information

The locations of the IE-POWER 1T/1U name plate and warning labels are as shown below.

• The name plate and warning labels should be visible in use, or in the case of integration into a product or application, be duplicated/incorporated in overall integrated product's outer case labelling

In addition, labels and warnings, duplicated labels and warnings and incorporated labels and warnings should be translated into the relevant local language as necessary.



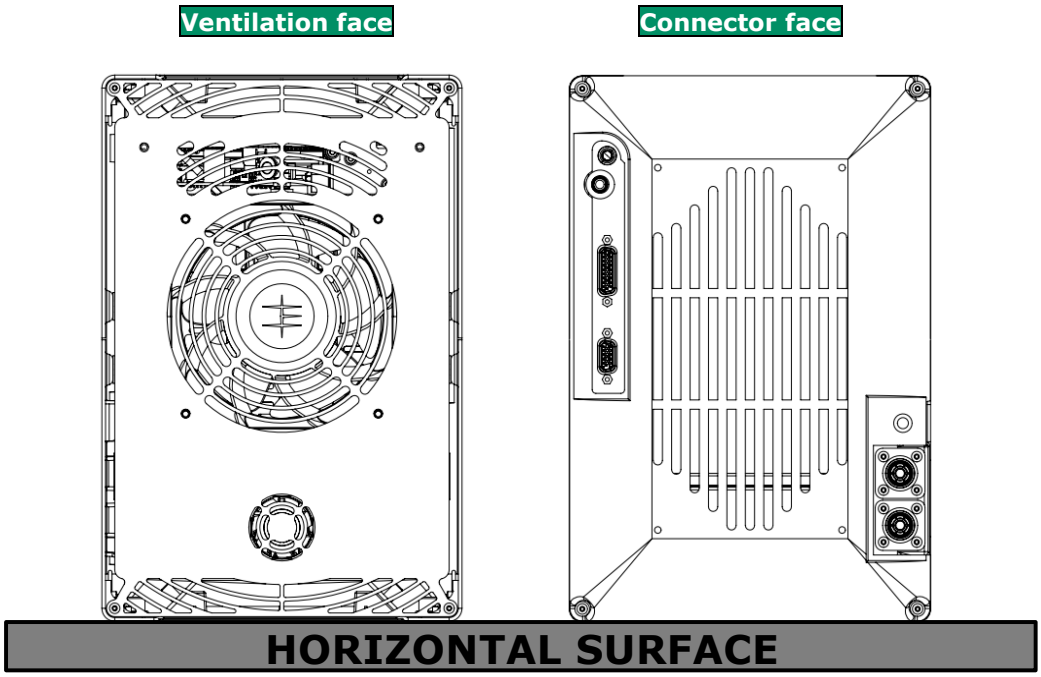
1. Electrical warning.
2. Electrical warning.
3. Name plate.
4. Serial number.
5. Hydrogen warning.

11.5 Mounting and orientation

11.5.1 Permissible orientations

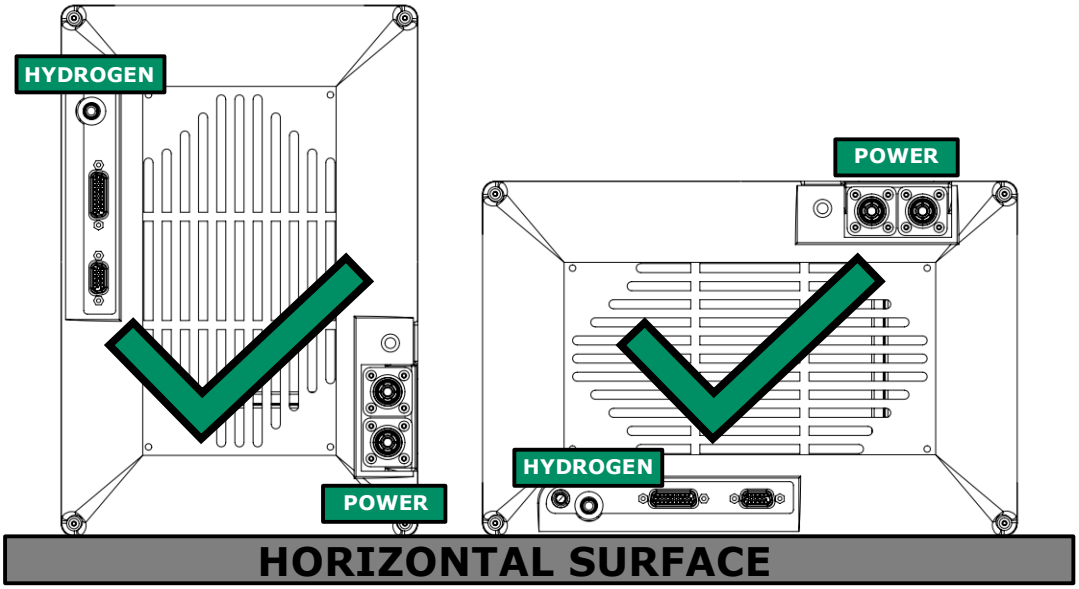
The IE-POWER 1T/1U must always be installed with horizontal airflow.

The Ventilation face (metal grille) and Connector face (electrical, hydrogen and comms) are associated with airflow:



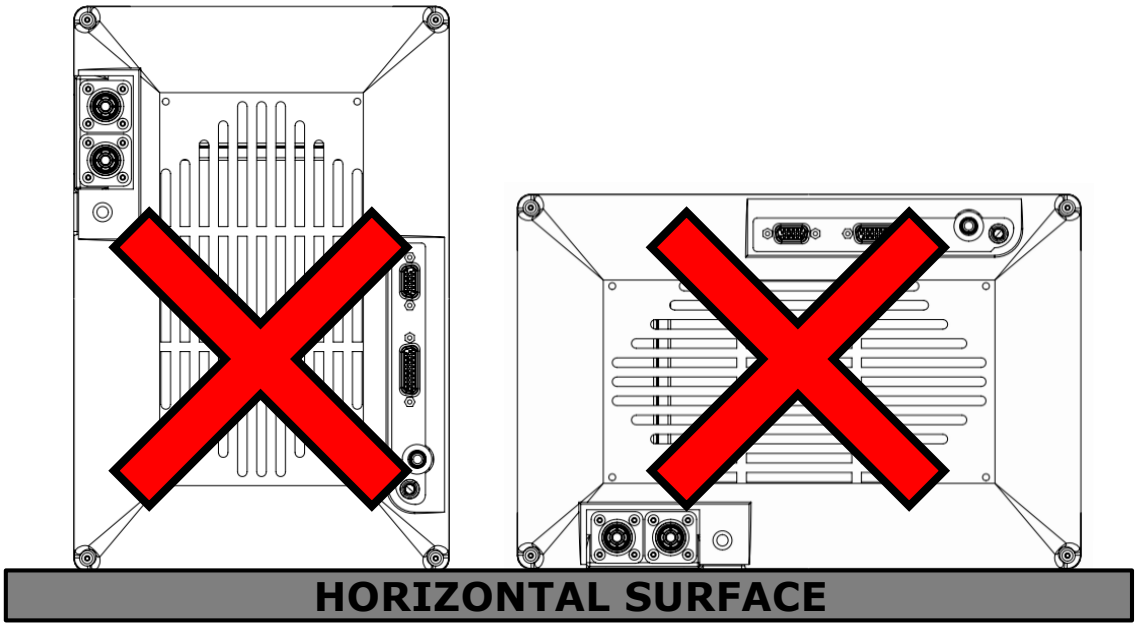
There are two permissible mounting orientations as shown below:

- When facing at the connector face hydrogen connection always on the left
- When facing the connector case, power connection always on right
- 15º of angular tilt permitted in one direction

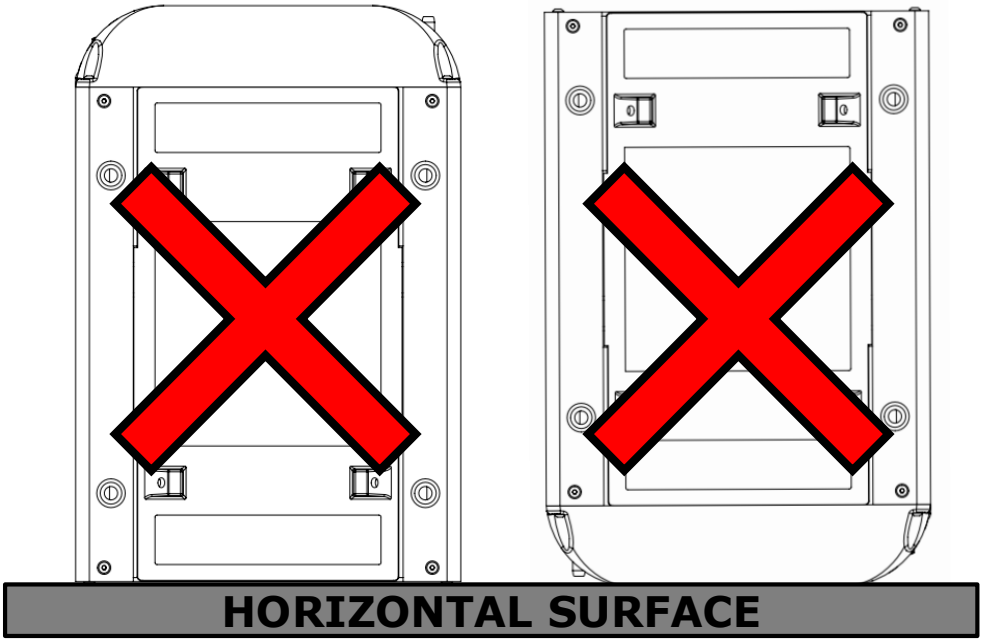


• Failure to install the IE-POWER 1T/1U in the correct orientation can result in loss of performance, unexpected shutdown and potentially system failure

There are four forbidden orientations that must not be used.



• Do not install upside down



• Vertical airflow NOT permitted

11.5.2 Mounting faces

The unit must be mounted using a minimum of eight M8 fasteners. When correctly orientated (see 11.5.1) either of the two possible bottom faces are designated as the MAIN mounting faces and must have four M8 mounting fasteners fitted correctly with 18Nm torque (see 11.1). Four Additional M8 fasteners also fitted correctly with 18Nm torque are required to be fitted to any other face or most distant corner points on two faces.

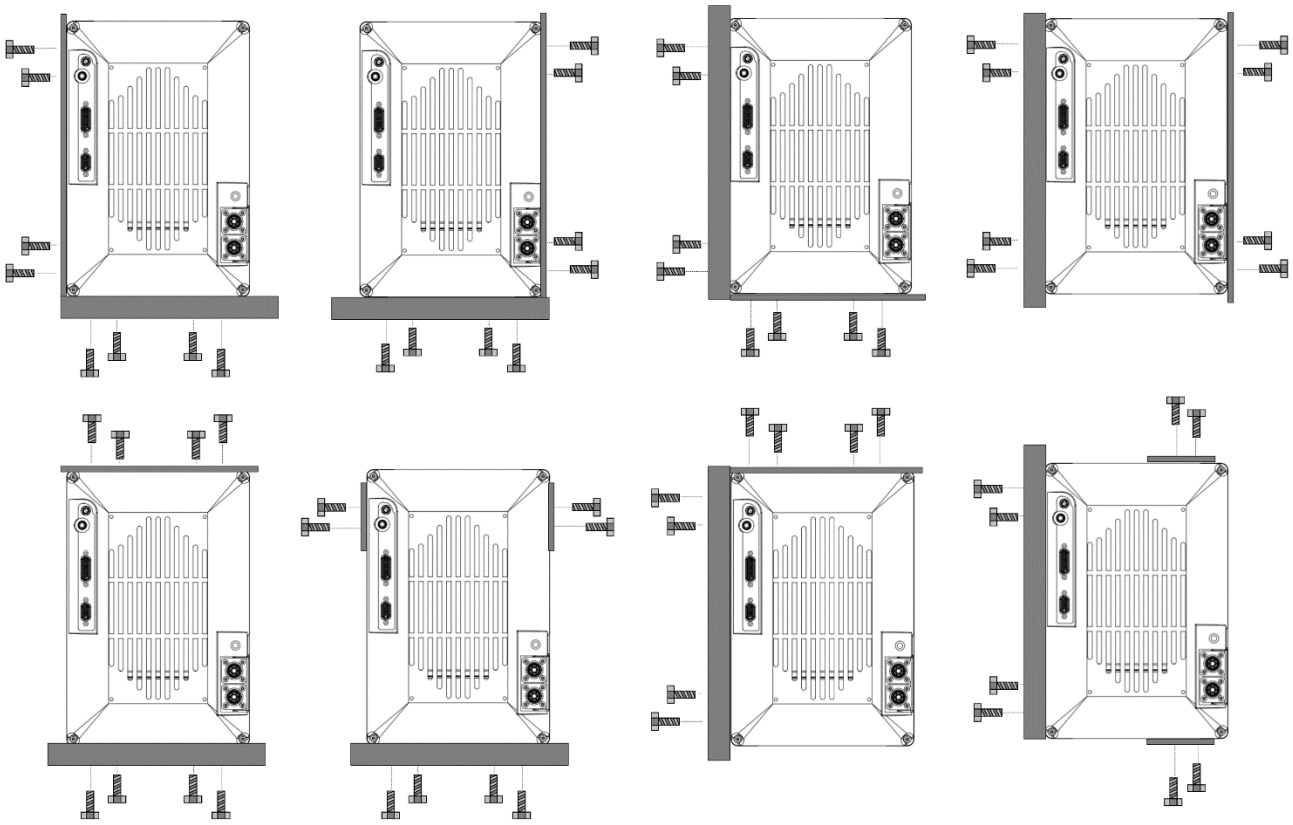
Short face closest to 'power connection' or long face closest to 'hydrogen connection' used as **MAIN PRIMARY** structural mount face.

- Always fit 4 fasteners to a **MAIN PRIMARY** mount face as depicted in the 16 images below
- Always fit 4 or more Additional fasteners to another **SECONDARY** face, or most distant corner points on two faces as depicted in the 16 images below

Main Primary Mounting Surface

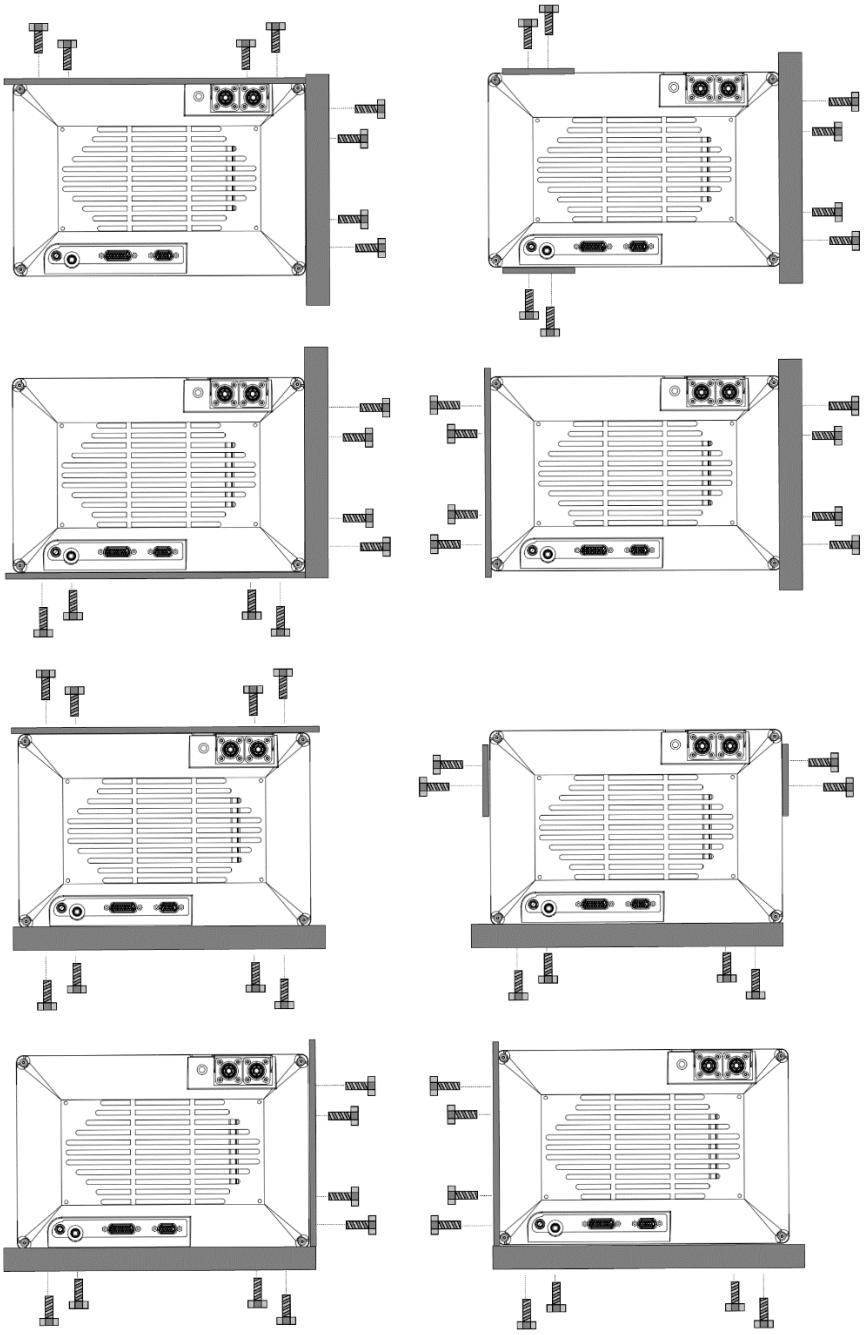
Secondary Mounting Surface

Vertical Mounting



• Incorrect mounting may reduce shock and vibration specification

Horizontal Mounting



• Incorrect mounting may reduce shock and vibration specification

11.5.3 Other mounting considerations

Unused mounting points may be used for secondary mounting to clip wires, pipes, and hoses.

• Prior to the installation inspect the FCM and do not install if there is visible damage to the unit

The unit is 294mm deep, allow a sufficient gap to the connector face (electrical, hydrogen and comms) of the IE-POWER 1T/1U for cables and pipes to have ease of access.

The installation must consider access for maintenance purposes including filter change. It is recommended to mount the unit on a shelf with front and rear access for maintenance activity.

11.6 Vibration and shock loads

The vibration and shock ratings are given in Section 2.

These should be checked against the requirements of the application.

Note: This FCM does not have an endurance shock rating. This means it may not be suitable for some applications including Industrial Truck (MHE) use where floors are not smooth. Contact Intelligent Energy for additional information.

• If the IE-POWER 1T/1U has been stressed due to excessive vibration or shock, return to Intelligent Energy for investigation

11.7 Air supply and ventilation

11.7.1 General requirements

For safe operation the air supplied to the unit must be:

Sufficient to provide safety dilution for hydrogen releases and leaks and to have sufficient air intake to avoid oxygen depletion The unit will shut down in the presence of inlet and our outlet blockages that substantially diminish airflow, typically within 25mm of the unit.

• The IE-POWER 1T/1U consumes oxygen as it operates, therefore the minimum air ventilation requirement must be observed at all times to ensure safety of personnel in the room

As a minimum for safety for a single IE-POWER 1T/1U measure the room:

- Rooms of less than 5m^3 must have a permanent vent area of 100cm^2
- Rooms greater than 5m^3 must have a permanent vent area of 50cm^2
- If multiple FCMs are being used additional ventilation may be required, especially if the load is more than 10kW. Contact Intelligent Energy Product Support for further advice

The above is applicable only if openable windows (or equivalents such as grilles or louvre panels) are also present. In cases where free ventilation is insufficient, such as internal rooms without windows, extraction must be provided. If the extraction is adjacent to the fuel cell module system, the rate must be at least 30l/s. If the extraction is elsewhere in the room the rate must be at least 60l/s. The above ventilation requirements are what is needed for the IE-POWER 1T/1U; the hydrogen storage and supply may impose additional requirements. The Installer may also need to consider the effect of the fuel cell module operation on oxygen depletion, additional mitigation should be considered for this. This is the responsibility of the integrator to manage safely and in accordance with local laws and regulations.

See additional FCM application details in sections 11.7.2, 11.7.3 and 11.7.4

For efficient operation the air supplied to the unit should:

Have sufficient overall rate of air exchange to reject the heat generated by the unit which is a similar amount to the electrical power generated. In conditions where the ambient temperature increases, there will be a need for an increased volume of air exchanged. Inlet and outlet blockages and restrictions will reduce efficiency, this is due to an increased demand on the internal fans and hydrogen fuel consumption. Recirculation of outlet air to the inlet will reduce efficiency and increase fuel use, this can be caused by air restrictions and open airpaths between the inlet and the outlet. During operation the FCM will elevate the local ambient temperature.

• The design of the installation must allow exhaust heat to dissipate

Failure to prevent temperature build will result in an increased demand on the FCM internal fans eventually resulting in a system shutdown due to the maximum operating temperature threshold being breached. All potential external airflow obstacles / restrictions to the inlets and outlets of the FCM must observe a distances of 300mm. When implemented the stated distance of 300mm will generally avoid the issues stated above, however it may be possible to operate efficiently with some level of restriction at closer distances with good design. Use of external inlet and outlet filters, fans, ducting, fixed louvres, adjustable louvres, dampers, and extractors will introduce additional pressure drop. This will impact fuel efficiency and may reduce the ability to operate at hot ambient temperatures without the use of additional cooling devices.

10Pa external pressure drop at an airflow of 5m^3/minute will have negligible impact on the system. (This approximates to 1.5m of 120mm circular duct or 4.5m of 150mm duct or 20m of 200mm duct but this does not account for transitions.) The system will still operate with 100Pa external pressure drop at an airflow of 5m^3/minute, but this will have a have significant impact on operation and efficiency at high ambient temperatures.

The FCM provides required dilution for potential internal leaks and purge releases, and checks for leaks during start-up, shutdown and running. Any leaks and releases from the unit are designed to be diluted to a safe level, meaning that hydrogen cannot build up to an unsafe level external to the unit. The FCM is not able to detect leaks, hydrogen releases, operation of pressure relief etc that occur externally to the FCM, including those on the supply to it, and is not able to isolate the external supply during such an event. The FCM operates at a relatively low pressure. A high-pressure supply or storage cylinder has a much higher capacity to leak than the FCM itself.

• The integration needs to include additional safety measures, when required, to account for monitoring a high pressure H_2 supply

The IE-POWER 1T/1U should be setup in a well-ventilated environment with consideration given to the precautions of hydrogen control. The IE-POWER 1T/1U requires a free supply of clean air to deliver power output. The unit will require up to **6,500 slpm** of unrestricted air flow and air exchange when operated at rated power. The operator must consider the air flow required for the environmental conditions expected. At hotter ambient temperature and higher load, more air flow will be required. The enclosure must not unduly restrict the air flow.

• The FCM enclosure must be designed such that the exhaust gas cannot be recirculated into the air inlet

As part of the design, air flow is also used to manage the risk of a hydrogen build-up. The hydrogen purge gas is routed into the main air flow such that it is diluted to below the low flammability limit at the point of exit from the unit; therefore, the installer must take care not to restrict the exhaust stream. Also, this gas stream will contain hydrogen, this is at a concentration where it is not flammable. Intelligent Energy are responsible for the safety of the IE-POWER 1T/1U including its connection points if used in accordance with this manual. The integrator is responsible for the safety of the whole installation including hydrogen storage, supply, generation, batteries and any other equipment or infrastructure.

• A suitable safety assessment will need to be undertaken for the entire FCM installation

• The IE-POWER 1T/1U must be provided with free venting air in the range of +5 to +35°C, it must not be operated outside this range

The installation of the IE-POWER 1T/1U must consider other equipment near the IE-POWER 1T/1U which may elevate the local ambient temperature during operation. A local increase of ambient temperature may affect the performance of the fuel cell module.

Note: Unusually tight construction is considered as obstructive where:

1) Walls and ceiling exposed to the outside atmosphere have a continuous water vapour retarder with a rating of 6 × 10-11 kg/ (m2 × Pa × s) (1 perm) or less with openings gasketed or sealed.

2) Weather stripping has been added on windows and doors that are able to be opened; and

3) Caulking or sealants are applied to areas such as joints around window and door frames, between sole plates and floors, between wall-ceiling joints, between wall panels, at penetrations for plumbing, electrical and gas lines, and at other openings.

- This fuel cell module power system uses oxygen from the area in which it is being used. It should not be used in a confined space or unusually tight construction unless provisions are provided for adequate process and ventilation air

- The hazards of gas release from installation failure / over pressure / pressure relief operation must be assessed, additional hydrogen monitoring equipment must be installed in all areas where hydrogen build-up could occur

- Hot air that that is generated by other equipment within 0.6m of the inlet of the IE-POWER 1T/1U is of concern. Heating of the ambient air should be limited to 5% of expected operating power of the IE-POWER 1T/1U in order to limit the ingestion of hot air

- The FCM must be set up in a well-ventilated environment with consideration given to the precautions of hydrogen safety

- Do not operate indoors: for outdoor use only during portable applications as risk of asphyxiation,

- The IE-POWER 1T/1U should not be located in an area where sleeping may occur

11.7.2 Stationary Power considerations

A stationary power installation is a fixed installation and risks must be assessed for ventilation safety as part of installation and integration (see section 11.7).

Indoor use is permitted for powers up to 10kW. Above 10kW the risks associated with hydrogen release (which may also be from the supply rather than the FCM) and oxygen depletion are considered to be greater and use of hydrogen detection and low oxygen concentration detection and becomes necessary. Of course, these may be necessary at lower power levels as determined by the risk assessment for the installation and integration. Outdoor use normally is considered to have free and available air. If this is not the case, then further assessment is needed.

11.7.3 Industrial Truck (MHE) considerations

An Industrial Truck (MHE) integration and deployment must be assessed for ventilation safety as part of the integration into the truck and fleet deployment (see section 11.7).

Indoor use is permitted. There is no power limit given, and generally Industrial Trucks (MHE) are used in voluminous warehouses and factories, so this is reasonable. Additional consideration may be needed if operating in restricted spaces such as cold storage etc. Outdoor use normally is considered to have free and available air. If this is not the case, then further assessment is needed.

11.7.4 Portable Power considerations

A Portable Power product, by its very nature can potentially be used anywhere. This means there is a high risk of use in a small poorly ventilated area. Indoor use is only practically possible and permitted

if hydrogen detection and low oxygen concentration detection is included in the product (see section 11.7).

- IE-POWER 1T/1U is not designed for indoor use for Portable Power

A future accessory pack will add the hydrogen detection and low oxygen concentration detection and interfacing to external hydrogen storage cut-off to allow indoor use. Outdoor use normally is considered to have free and available air. If this is not the case, then further assessment is needed.

12 Efficiency and Troubleshooting Guide

At all times, our stated efficiency is based on system testing completed in Intelligent Energy's laboratories.

Efficiency is stated based on the module being:

- Positioned and operated in free flowing (i.e., unobstructed) air
- Operated at all times with the integrated air filter clean, and free of particulate detritus
- Operated in environment with ambient air pressure equivalent to that found at sea level
- Operated in environment with ambient air temperature of between 20-25°C and relativehumidity of ~50%RH
- Operated with H_2 inlet pressure maintained in the correct range and when run at rated power (1kW output in respect of IE-POWER 1T/1U)

System fuel consumption is likely to increase when:

- Module is run at less than rated power for extended periods
- Inlet and/or exhaust airflow is obstructed or partially obstructed (including the integrated air filter becoming clogged / blocked)
- There are changes in air pressure (e.g., via increase in altitude)
- The relative Humidity level changes (more so in extremes given in data sheet)
- Operating air temperature significantly increases (Over 25°C will have an effect, with this much more pronounced at or above 35°C)

External air-flow changes during normal operation will add a level of complexity to the above.

Note:

a) In all the above conditions (or combination thereof), IE-POWER products will continue deliver power, albeit with increased fuel consumption.

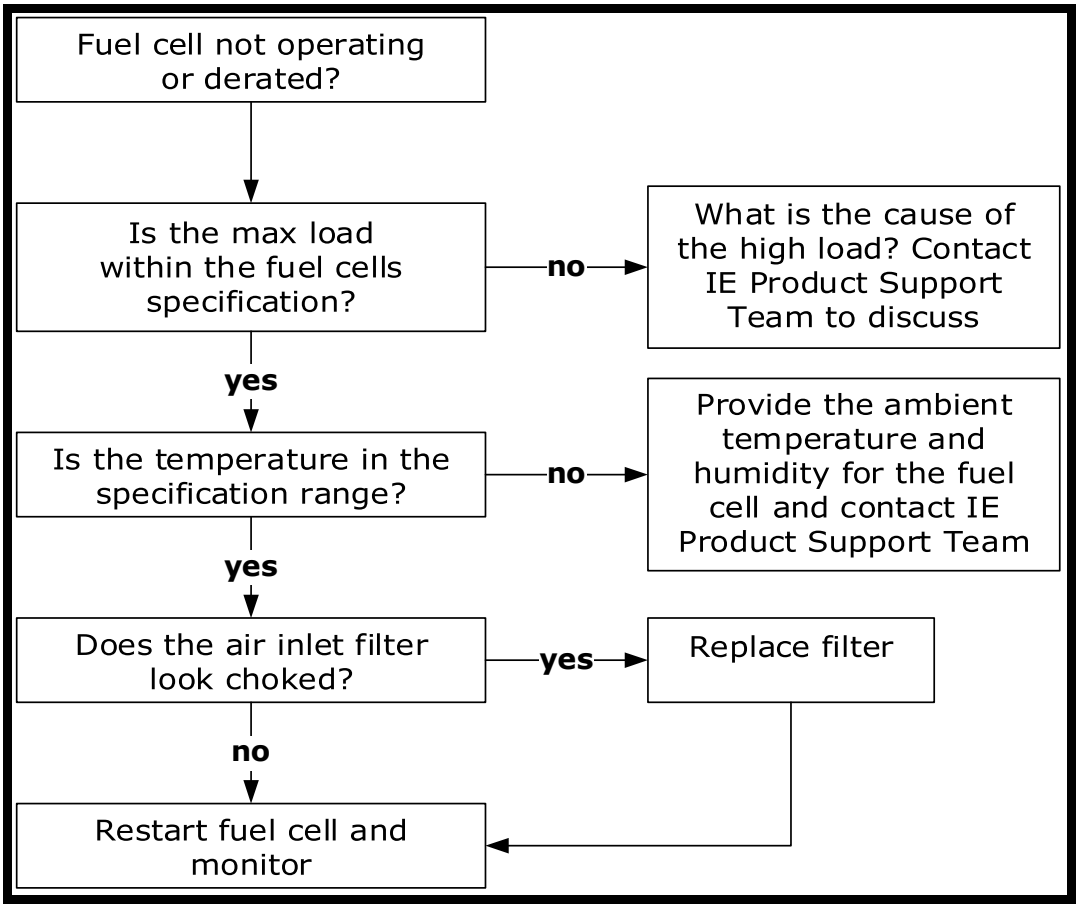
b) In environmental extremes, (very high temperature or very low temperature or very low or very high humidity, or a combination thereof) de-rating of power output is expected. This will further affect system fuel consumption / efficiency.

c) Air filters are considered consumable and should be checked regularly for signs of discoloration that may indicate partial blockage of filter. Replacement frequency will be dependent on the end user's site conditions.

Fault	Cause	Action
No Power from the FCM	No command to Start	Verify that the module is in Enable and Run modes (see section 8.2)
	Fuel cell module over temperature	See 12.1 Stack temperature check procedure
	Incorrect Hydrogen pressure	See 12.3 Fuel check procedure
	No Power provided	See 12.4 Electrical system check procedure
	Hydrogen Leak	See 12.2 Check for fuel leak

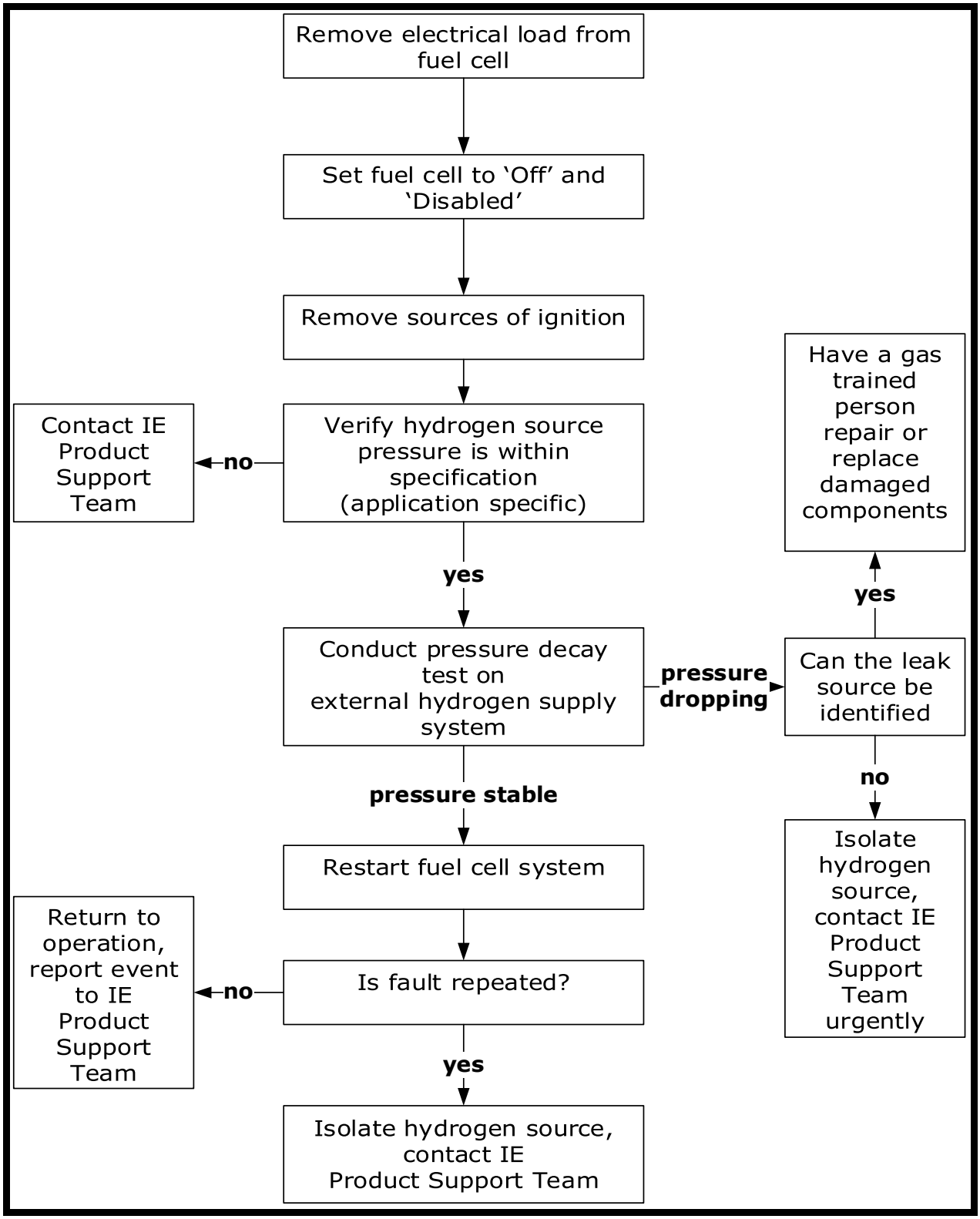
• Fault diagnosis must be carried out by trained and competent personnel only

12.1 Stack temperature check procedure



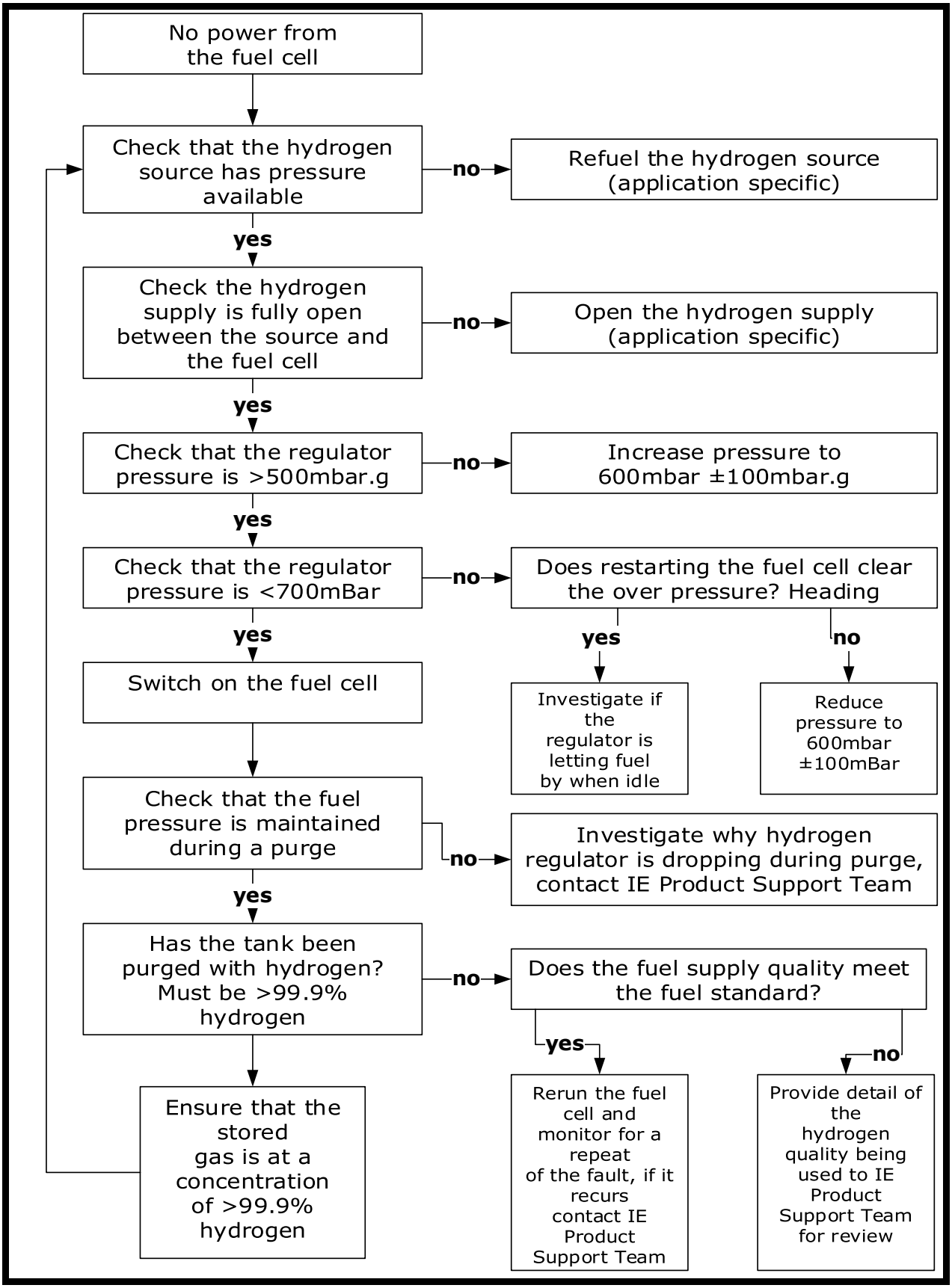
• Fault diagnosis must be carried out by trained and competent personnel only

12.2 Check for fuel leak



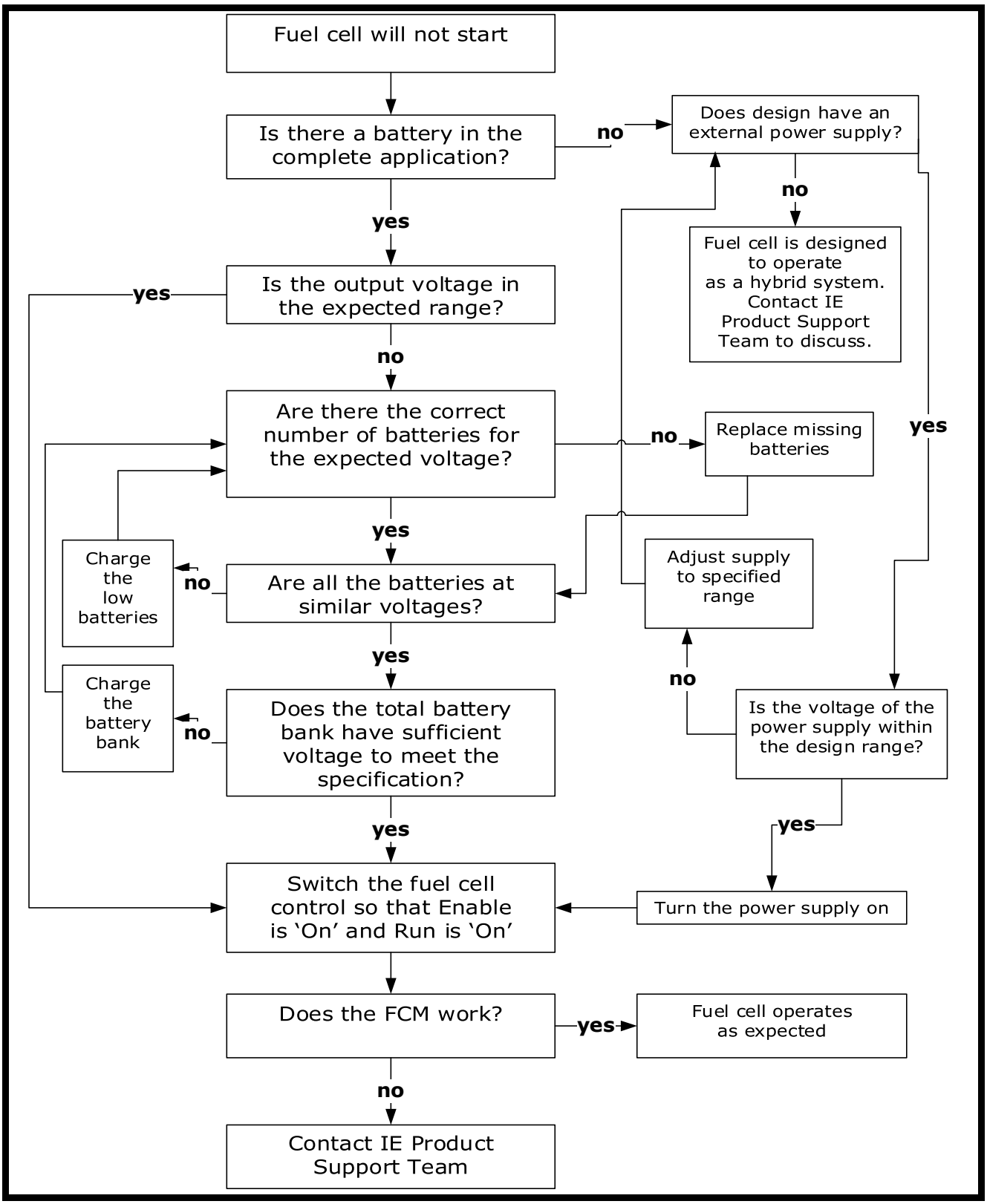
• Fault diagnosis must be carried out by trained and competent personnel only

12.3 Fuel check procedure



• Fault diagnosis must be carried out by trained and competent personnel only

12.4 Electrical system check procedure



- Fault diagnosis must be carried out by trained and competent personnel only

13 Maintenance Procedures

13.1 User maintenance

The user shall perform monthly maintenance inspections on the IE-POWER 1T/1U and associated installation ancillary equipment, including but not limited to the H_2 storage facility, H_2 supply equipment, H_2 regulators, H_2 monitoring equipment, and hybridised battery bank.

• The user shall perform routine inspections that align with all FCM installation ancillary equipment's manufactures terms and conditions of use

The monthly inspections shall be conducted to ensure that the IE-POWER 1T/1U casing, connectors and surrounding installation supports have not been compromised or damaged, particularly during operations of where the FCM is removed, or the surrounding installation is modified.

• Cleaning of the IE-POWER 1T/1U should only be performed with the use of a clean and dry microfibre cloth

• All IE-POWER 1T/1U inspections must be performed by a competent technician during periods of non-operation, unless otherwise stated in Inspection details

Please refer to the table below that details components that require inspection.

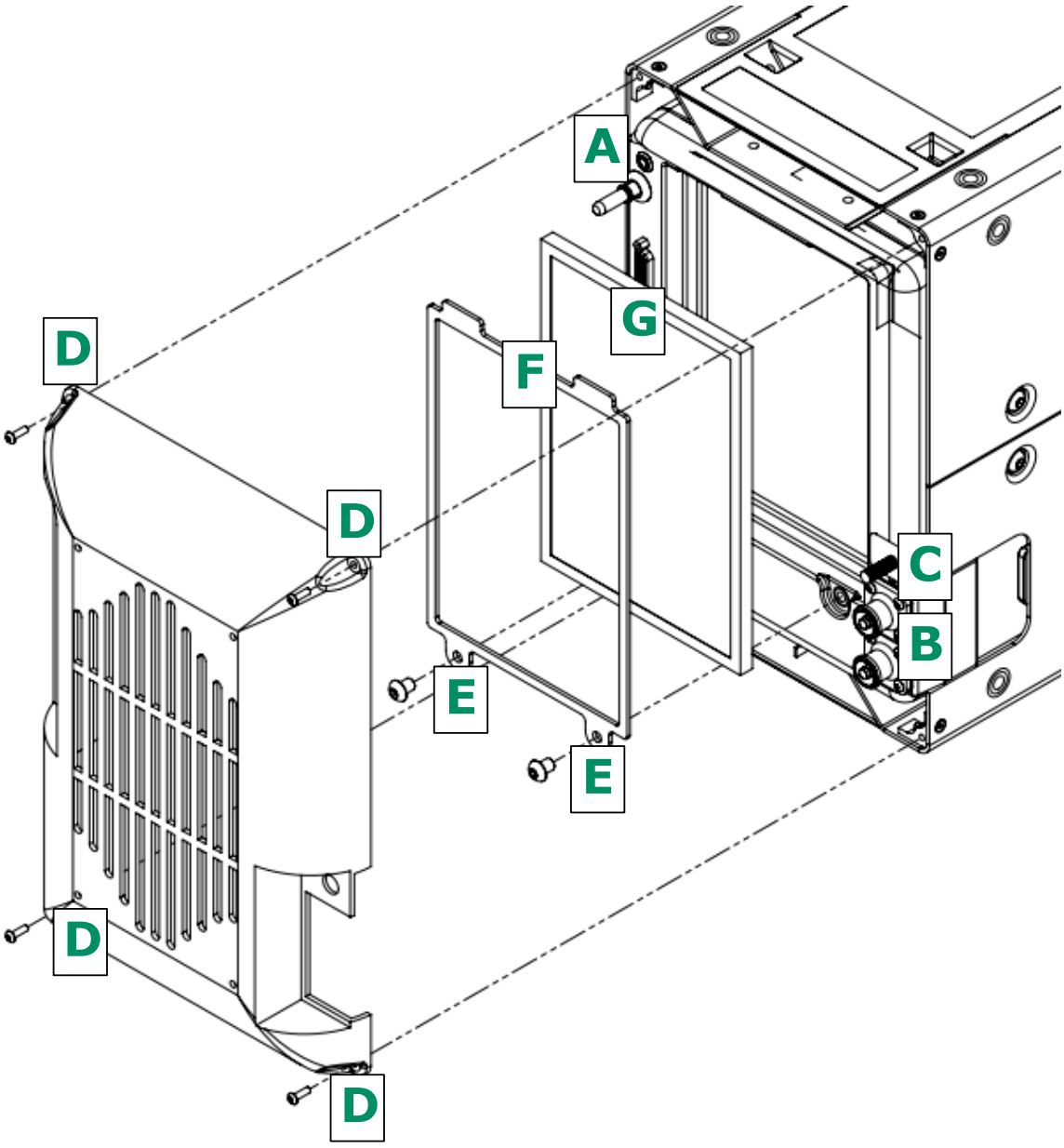
	Component	Location	Inspection details
1.	IE-POWER 1T/1U Positive and negative DC terminals	Connector face	Check for chips, nicks, and burrs, do not operate if damage is present
2.	IE-POWER 1T/1U Positive and negative DC cabling	Vicinity of DC terminals	Check for chips, nicks, and burrs, do not operate if damage is present
3.	IE-POWER 1T/1U Customer communication signal connector	Connector face	Check for scarring and corrosion to the terminals, do not operate if damage is present
4.	Customer communication cabling	Vicinity of customer connector	Check for chips, nicks, and burrs, do not operate if damage is present
5.	IE-POWER 1T/1U Accessory communication signal connector	Connector face	Check for scarring and corrosion to the terminals, do not operate if damage is present
6.	Accessory communication cabling / bypass	Vicinity of accessory connector	Check for chips, nicks, and burrs, do not operate if damage is present
7.	IE-POWER 1T/1U Hydrogen connector	Connector face	Check for chips, nicks, and burrs, do not operate if damage is present
8.	Hydrogen supply hose	Vicinity of hydrogen connector	Check for chips, nicks, and burrs, do not operate if damage is present
9.	IE-POWER 1T/1U casing	Outer body of FCM	Check for discolouration, cracks, and dents, do not operate if damage is present
10.	IE-POWER 1T/1U fixing mounts and fixings	Outer body of FCM	Check for chips, nicks, and burrs, replace when necessary
11.	IE-POWER 1T/1U external foundation	Primary / secondary mounting of FCM	Check for cracks and deformation, do not operate if damage is present
12.	IE-POWER 1T/1U metal grille	Ventilation face	Check for dents, discolouration, and corrosion, do not operate if damage is present
13.	IE-POWER 1T/1U plastic air inlet	Connector face	Check for cracks and discoloration, do not operate if damage is present
14.	IE-POWER 1T/1U status LED x 2	Ventilation / connector faces	Confirm operation whilst the FCM is operational
15.	IE-POWER 1T/1U air inlets	Ventilation / connector faces	Ensure no blockages are present, do not operate if air inlets are obstructed
16.	IE-POWER 1T/1U air outlets	Ventilation face	Ensure no blockages are present, do not operate if air outlets are obstructed
17.	IE-POWER 1T/1U filter inspection	Internal	See section 13.2

Maintenance inspections should be documented on a suitable template and added to a library of permanent records. Not performing these basic checks will reduce unit efficiency. During the periods of routine maintenance, if obvious signs of damage and deterioration are discovered contact Intelligent Energy Ltd.

- Failure to perform routine maintenance may reduce overall efficiency of your fuel cell module
- Do not use solvents or aerosol cleaning chemicals to clean your fuel cell module. Solvents and airborne chemical cleaners have the potential to permanently damage the fuel cell module
- Do not operate the fuel cell module when there are obvious signs of damage and deterioration to the outer casing, hydrogen coupling, electrical power connections or communication ports
- Do not operate the fuel cell module if signs of obstruction or damage are witnessed on the air inlets / outlets
- Do not use this fuel cell module power system if any part has been under water. Immediately call qualified service personnel to inspect the fuel cell module power system and to replace any function part which has been under water

13.2 Filter Change Procedure

Refer to the diagram below and follow the step-by-step procedure



1. **Switch off the Run and Enable signal.**
2. **Isolate hydrogen supply and disconnect from the IE-POWER 1T/1U (A).**
3. **Isolate the DC power cabling and disconnect from the IE-POWER 1T/1U(see 6.1.2).**
4. **Wait 15 mins (B).**
5. **Disconnect the chassis earth bond (C).**
6. **Remove x 4 front cover retaining screws (D).**
7. **Remove x 2 filter retaining screws (E).**
8. **Displace the filter retaining plate (F).**
9. **The dirty filter can be lifted out (G).**
10. **Dispose of the dirty filter appropriately.**
11. **Place clean filter in front of IE-POWER 1T/1U and refit frame and screws.**
12. **Refit front cover and screws.**
13. **Refit chassis earth bond (see 6.1.1).**
14. **Confirm chassis earth bonds is reconnected.**
15. **Reconnect the DC power cabling (see 6.1.2) and isolation devices.**

- Do not remove the air inlet case and the internal filter while operating the FCM
- Failure to perform monthly filter inspections may reduce the over efficiency of the fuel cell module
- Whilst replacing the filter DO NOT touch the internals of the fuel cell module. Potentially live components present
- Whilst replacing the filter DO NOT touch the fuel cell module stack during this procedure

13.3 Contact Intelligent Energy Product Support Team

In the event of a fault with the IE-POWER 1T/1U, please contact the Intelligent Energy Product Support Team. Either contact your local representative or email:

product.support@intelligent-energy.com

Please state the model of your product and the serial number (by the name plate). If you have a fault, please provide as much detail as possible.

14 Control parameters and standard factory settings

The IE-POWER 1T/1U configuration is factory settable. The IE-POWER 1T/1U will be provided with 48V Factory Configuration unless custom configuration is requested when ordered. If there is a need to adjust the configuration after installation, contact Intelligent Energy Product Support.

14.1 IE-POWER 1T/1U Factory Configurations

This table is the default settings… These are put forward with the intention that they will not compromise equipment or batteries attached to the system. Different settings would/should be proposed based on customer requirements. For example, if connected to a battery management system, then the "Hard Set Output Voltage" should be used.

Parameter		Unit	Range	Factory Setting (48V)	Factory setting (24V)
Voltage limits					
1.	**Target Output Voltage**	**V**	15.0 to 58.0	52	26
2.	**Delayed Start Under-Voltage**	**V**	0.0 to 60.0	48	24
3.	**Immediate Start Under-Voltage**	**V**	0.0 to 60.0	46	22
4.	**Deny Start Under-Voltage**	**V**	0.0 to 50.0	40	20
5.	**Delayed Stop Over-Voltage**	**V**	0.0 to 60.0	54	27
6.	**Minimum Output Voltage**	**V**	0.0 to 56.0	48	24
7.	**Hard Set Output Voltage**	**-**	0 or 1	0	0
Current limits					
1.	**Delayed Stop Under-Current**	**A**	0.0 to 120.0	2	2
2.	**Output Current Limit**	**A**	0.0 to 40.0 (50.0)	40	40
Power limits					
1.	**Output Power Limit**	**W**	0 to 1200	1200	1200
Timing limits					
1.	**Output Voltage Rise Rate**	**V/s**	0.017V/s to 2000.000V/s	0.017V/s	0.017V/s
2.	**Delayed Stop OV Qualification Time**	**s**	0 to 3600	60	60
3.	**Delayed Stop UC Qualification Time**	**s**	0 to 3600	20	20
4.	**Restart Delay**	**s**	0 to 3600	20	20
5.	**Delayed Start Qualification Time**	**s**	0 to 14400	60	60
CAN BUS settings					
1.	**System Index**	**-**	1 to 8	1	1
2.	**CAN Speed**	**-**	1 to 4	3	3
3.	**CAN Mode**	**-**	1 to 4	3	3
4.	**J1939 Send Address**	**-**	1 to 255	1	1
5.	**Serial Speed**	**-**	1 to 6	4	4

14.2 FCM Configuration parameter

Voltage limits		
1.	**Target Output Voltage (V)**	The voltage that the FCM will try to maintain in normal operation. This is normally approximately the battery float voltage.
2.	**Delayed Start Under-Voltage (V)**	This trigger is to stop the FCM starting if the batteries have been deeply discharged, e.g., batteries left for several weeks.
3.	**Immediate Start Under-Voltage (V)**	Emergency start for low battery condition after Standby mode.
4.	**Deny Start Under-Voltage (V)**	This parameter is to protect the hybrid battery from being charged when it is too low.
5.	**Delayed Stop Over-Voltage (V)**	Voltage to put the FCM into standby if an auxiliary power source is started e.g., Photovoltaic array, requires a time delay to be triggered see **Delayed Stop OV Qualification Time**.
6.	**Minimum Output Voltage (V)**	Minimum voltage that the FCM will deliver.
7.	**Hard Set Output Voltage (-)**	This removes the Output voltage rate of rise if set to 1. The module will start-up at the Target voltage.
Current limits		
1.	**Delayed Stop Under-Current (A)**	Trigger to prevent the FCM running if there is a low load, designed to prevent poor overall system efficiency. Requires a time delay to be triggered see **Delayed Stop UC Qualification Time**.
2.	**Output Current limit (A)**	The available current for each FCM. *****
Power limits		
1.	**Output Power limit (W)**	The available power that can be delivered by the FCM, for different target voltages. *
Timing limits		
1.	**Output Voltage Rise Rate (V/s)**	Rate of rise for the output voltage from BUS voltage to Target after start-up.
2.	**Delayed Stop OV Qualification Time (s)**	The time for the auxiliary power present trip to be completed to leave running mode see **Delayed Stop Over Voltage**.
3.	**Delayed Stop UC Qualification Time (s)**	

		The time for the low load trigger to trip to move to standby mode see **Delayed Stop Under Current**.
4.	**Restart Delay (s)**	Minimum time that the FCM will remain in Standby mode before it checks for low voltage.
5.	**Delayed Start Qualification Time (s)**	The time for the initial trigger to be completed to leave standby mode see **Delayed Start Under Voltage**.
CAN BUS settings		
1.	**System Index**	This is to allow multiple systems to be connected together via CAN (maximum 8).
2.	**CAN rate Setup**	This is to allow the user to select the CAN BUS speed.
3.	**CAN Mode**	Sets the Data format of the CAN data stream 1 = J1939lite, 3 = Standard 11CAN IDs
4.	**CAN J1939 Send Address**	The fixed J1939 Send Address is only used if CAN Mode is set to 1 and provides a fixed Send Address.
5.	**CAN Speed**	Sets the baud rate of the CAN data stream. 1 = 125kBps, 2 = 250kBps, 3 = 500kBps, 4 = 1000kBps

Note: ***** That the maximum power (P) that can be delivered is determined by multiplying the target voltage (V) and the maximum current (I). (P=V x I).

15 CAN flag and fault messages

The messages on the CAN bus contain details of faults and indicators that can be useful to the user. The fault flags are separated into 4 category levels: 1) Indicator, 2) Controlled, 3) Shutdown, 4) Critical. Raw CAN data and fault message decoders are available on request. For more details, please contact Intelligent Energy Ltd.

16 Storage, Spare parts, and disposal

16.1 Storage

The IE-POWER 1T/1U must be stored as follows:

- Level, resting on the base
- Do not place desiccant inside the packaging
- At temperatures between -40°C and +70°C
- Ideal temperature for storage is between +10°C and +25°C
- Must be protected from moisture and dust during storage
- The Hydrogen inlet port must be protected during storage

16.2 Transportation

For transport, follow the instructions for storage taking care that:

- The IE-POWER 1T/1U must be transported in a level orientation
- The IE-POWER 1T/1U must not be subjected to mechanical shocks where possible
- The IE-POWER 1T/1U must be protected from moisture and dust during transport
- The IE-POWER 1T/1U original packaging must be retained for transportation and returns processes

16.3 Spare parts and accessories

For spare parts contact IE Product Support Team at: product.support@intelligent-energy.com

Spare parts list:

- Filter: 10014248
- Filter retaining plate: 10014901
- Filter retaining screws: 009487
- Front cover grille: 10015660
- Front cover grille retaining screws: 001134 / 001558
- Rear U-flow adaptor: 10013644
- Rear U-flow adaptor retaining screws: 007180

Accessories list:

- Carry handle: 10015587
- Rubber feet: 10015589
- Hydrogen supply hose and NORMA quick release fitting: 10015690
- Positive RED Amphenol SurLok 25mm: 10015312
- Negative BLACK Amphenol SurLok 25mm: 10015313
- Male D-sub 15way e-stop bypass connector:10017169

Only use Intelligent Energy Ltd approved parts.

16.4 Disposal

When the IE-POWER 1T/1U reaches end of life, please contact Intelligent Energy Product Support or your local representative for assistance with reconditioning or recycling and disposal.

17 Applicable Standards for integration and installation

17.1 Industrial Truck (MHE) Standard

When the IE-POWER 1T/1U is used as part of an Industrial Truck (MHE) installation, the integrator/ installer should comply with the requirements specified in EN / IEC 62282-4-101:2014 and the clauses listed below.

The following clauses must be observed and applied to the integration and installation:

4.2.2 - Piping, hoses, tubing, and fittings
4.2.4 – Hydrogen pressure vessels
4.3 – Over-pressure and thermal protection
4.4 - Regulators
4.10.6 - Electrostatic discharge (ESD)
4.12.3 - Enclosures
4.13.2 - Internal wiring
4.13.3 - External wiring
4.13.4 - Emergency switching off requirements (disconnection) for connections for fuel cell power system
4.13.9.1 - Batteries
5.6.2 – Ultimate strength – Hazardous gas and pressurized parts
5.18.1 – Enclosure loading test
5.18.2 - Test for thermoplastic enclosures
8 – Instructions

The stationary power installation standard EN / IEC 62282-3-300:2012 includes useful additional guidance. This document may also be of use for Industrial Truck (MHE) applications as there is no similar installation standard for this application.

17.2 Stationary Power Standards

When the IE-POWER 1T/1U is used for a Stationary Power application, the integrator/ installer should comply with the requirements specified in EN / IEC 62282-3-100:2020 and in particular the clauses listed below, which are related to installation and integration.

4.2.6 - Mounting (shock, vibration, and bump)
4.4.14 – Maximum temperature the unit can operate at
4.9.3.2 a) – Maximum operating pressure
4.13 – System enclosures
7.3 – Marking and installation on rating plate

The stationary power installation standard EN / IEC 62282-3-300:2012 includes useful additional guidance.

17.3 Portable Power Standards

When the IE-POWER 1T/1U is used for a Portable Power application, the integrator/ installer should comply with the requirements specified in EN / IEC 62282-5-100:2018 and in particular the clauses listed below, which are related to installation and integration

4.2.1 – Material compatibility, pressure relief and over pressure protection

4.4 – Hydrogen storage

4.17.2 – Enclosure requirements

The stationary power installation standard EN / IEC 62282-3-300:2012 includes useful additional guidance. This document may also be of use for Portable Power applications as there is no similar installation standard for this application

18 EU Declaration of Conformity

The Declaration of Conformity is available on request from product.support@intelligent-energy.com, it declares that the product is in conformity with the relevant provisions of the Machinery Directive, EMC Directive and the ROHS Directive as well as applicable standards documents.

EU authorised representative:
Certification Company
Veluwezoom 42, 1327 AH, Almere
The Netherlands

T +441509 271 271 **E** product.support@intelligent-energy.com
Intelligent Energy Charnwood Building, Ashby Road, Loughborough, LE11 3GB, UK
www.intelligent-energy.com

 Printed URM-27057 version 1.0

Published by: Intelligent Energy Ltd, Charnwood Building, Holywell Park, Ashby Road, Loughborough LE11 3GB. Tel: +44 (0)1509 271271 (Registered in England with company number: 03958217).