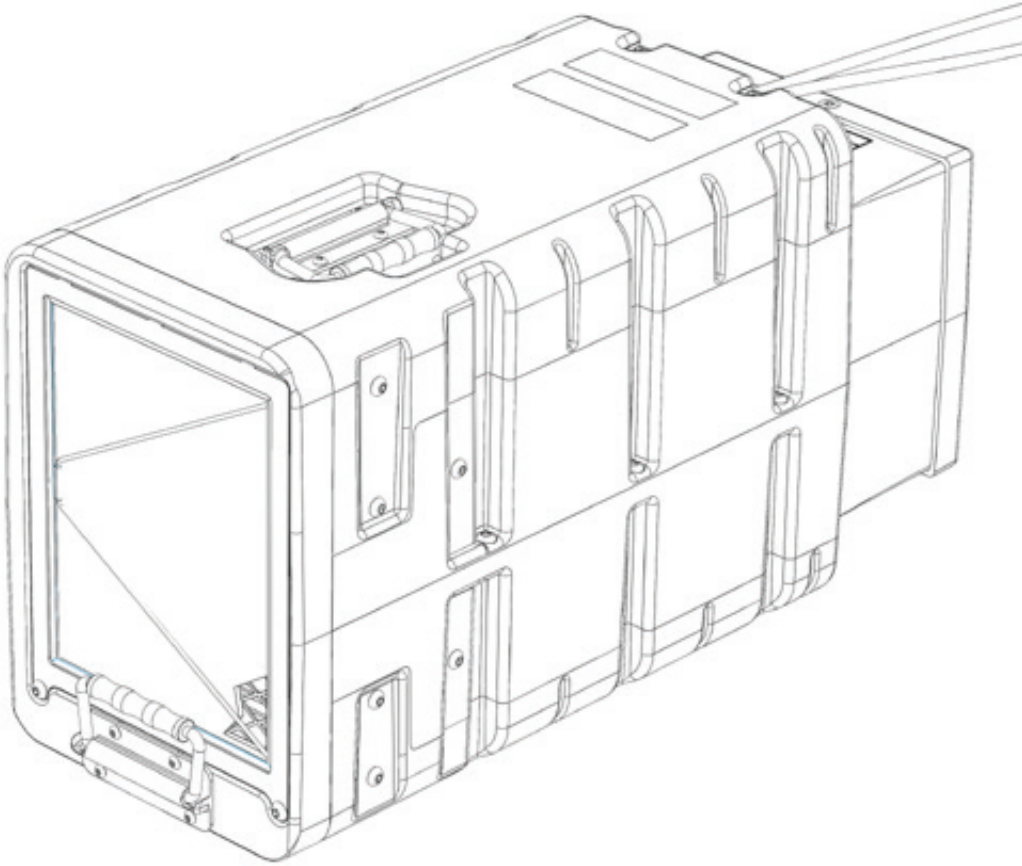




Intelligent
Energy



FCM-801 User Manual

1 Safety and warnings	3
1.1 In case of an emergency	
1.2 Warning	
2 Product specification and interface	4
2.1 Interface specification	
3 Connections	7
3.1 Electrical configuration	
3.2 Hydrogen fuel	
3.3 Air supply	
3.4 Hydrogen connection	
3.5 Communication connection	
3.6 CAN connection	
4 FCM-801 commands and status	10
4.1 Module enable	
4.2 Module run	
4.3 FCM-801 status	
4.4 FCM-801 software states	
5 Operation of FCM-801	12
5.1 Overview FCM-801	
5.2 Anode purge	
5.3 Fan pulse	
5.4 Standby state	
5.5 Fault state	
6 Faults	13
6.1 Procedure to reset the fault	
7 Installation and set up	14
7.1 Label information	
7.2 Mechanical mounting points	
7.3 Mechanical protection and covers	
7.4 Vibration and shock loads	
7.5 Air supply and ventilation	
7.6 Hydrogen connection	
7.7 Hydrogen fuel physical requirements	
8 Trouble-shooting guide	17
9 Maintenance procedures	18
9.1 User maintenance	
9.2 Contact Intelligent Energy product support	
9.3 Check for fuel leak	
9.4 Fuel check procedure	
9.5 Electrical system check procedure	
9.6 Stack temperature check procedure	
9.7 Louvre operation check	
9.8 Filter change procedure	
10 Control parameters and standard factory setting	23
11 End of life treatment and disposal	24
12 EU Declaration of Conformity	25
Disclaimer	26



The CE label shows that the product complies with the basic requirements of the applicable directives. For the declaration of conformity contact the manufacturer at servicing@intelligent-energy.com

The Fuel Cell Module 801 (FCM-801) uses hydrogen gas to provide electrical DC power. It should only be used by personnel who have been trained to use the product safely by Intelligent Energy. Do not remove the external covers or air filter.

- No naked flames in the vicinity of the FCM-801 or hydrogen operation areas
- Pressurised hydrogen present, highly flammable
- Ensure hydrogen supply can be isolated in the case of an emergency
- Direct current voltage is present
- Unit should be inspected for damage and checked for leaks prior to use
- Fault diagnosis should be carried out by trained and competent personnel only
- Do not remove the air filter while operating
- Do not remove the external covers
- Keep operational area free from combustibile materials
- Do not obstruct air flow to the inlet or exhaust
- For use in ventilated indoor environment
- For use in weather protected outdoor environment; must protect from wind and rain ingress
- Environmental protection required from snow, excessive dust and vegetation
- Do not use this fuel cell if any part has been under water. A flood damaged fuel cell is potentially dangerous. Attempts to use the fuel cell can result in fire or explosion.



1.1 In case of an emergency

- 1 Stop power production from the fuel cell by disconnecting the FCM-801 enable pin.
- 2 Isolate the DC supply (application specific).
- 3 Isolate the fuel supply (application specific).

1.2 WARNING: FIRE OR EXPLOSION HAZARD

Failure to follow safety warnings exactly could result in serious injury, death or property damage.

- Do not store or use gasoline or other flammable vapours and liquids in the vicinity of this or any other appliance.
- Installation and service must be performed by a qualified installer, service agency or the gas supplier.

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 systems and their usage in connection with all stationary and portable power applications. The recipient is responsible for ensuring that all personnel have read and understood this User Guide 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 fuel cell stationary and portable power 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 and portable power applications, and use and storage of hydrogen on any sites.

Intelligent Energy warrants to the recipient and it will repair and replace any defective equipment resulting from the authorised use of the equipment provided. 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 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.

2 Product specification and interface

Performance	Rated net power ¹	1.2kW @ 48V or 0.96kW @ 24V
	Output voltage regulation	to ETS 300-132-2
	Rated current	25A @ 48V or 40A @ 24V
	Emissions	Water vapour
Fuel	Fuel type	Hydrogen gas
	Fuel pressure	500mbar.g – 800mbar.g
	Fuel consumption	Less than 60g per kWh ²
	Fuel storage	External storage available separately Compatible with reformer technology or compressed hydrogen gas
	Fuel composition	99.9% gaseous hydrogen or better ³
Operations and maintenance	User interface	Options available ^{4,9}
	Start-up time	Less than 10s
	Automatic start/stop	Standard
	Manual start/stop	Available
	IP rating	IP20 ⁵
Certification	Health monitoring Certification	Options available ^{6,9} CE
	Physical	Mass
Max dimensions		225mm (W) × 300mm (H) × 550mm (D)
Connections, gas		G1/8 parallel BSP threaded port with face seal, female
Connections, electrical		Power leads 2 × 8AWG (8mm ²) 1 × CAN hi/low/gnd, 1 × LED driver, 1 × FCM run input, 1 × FCM enable input
Normal operating conditions	Altitude	0 – 4000m ^{7,9}
	Operating ambient temperature range	+5°C to +40°C ⁹
	Relative humidity	10% to 90% ^{8,9}
	Storage temperature	-40°C to +70°C

¹ >95% duty cycle

² Achieved at 25 °C, beginning of life

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

⁴ CAN interface can be provided

⁵ Options available for outdoor installation

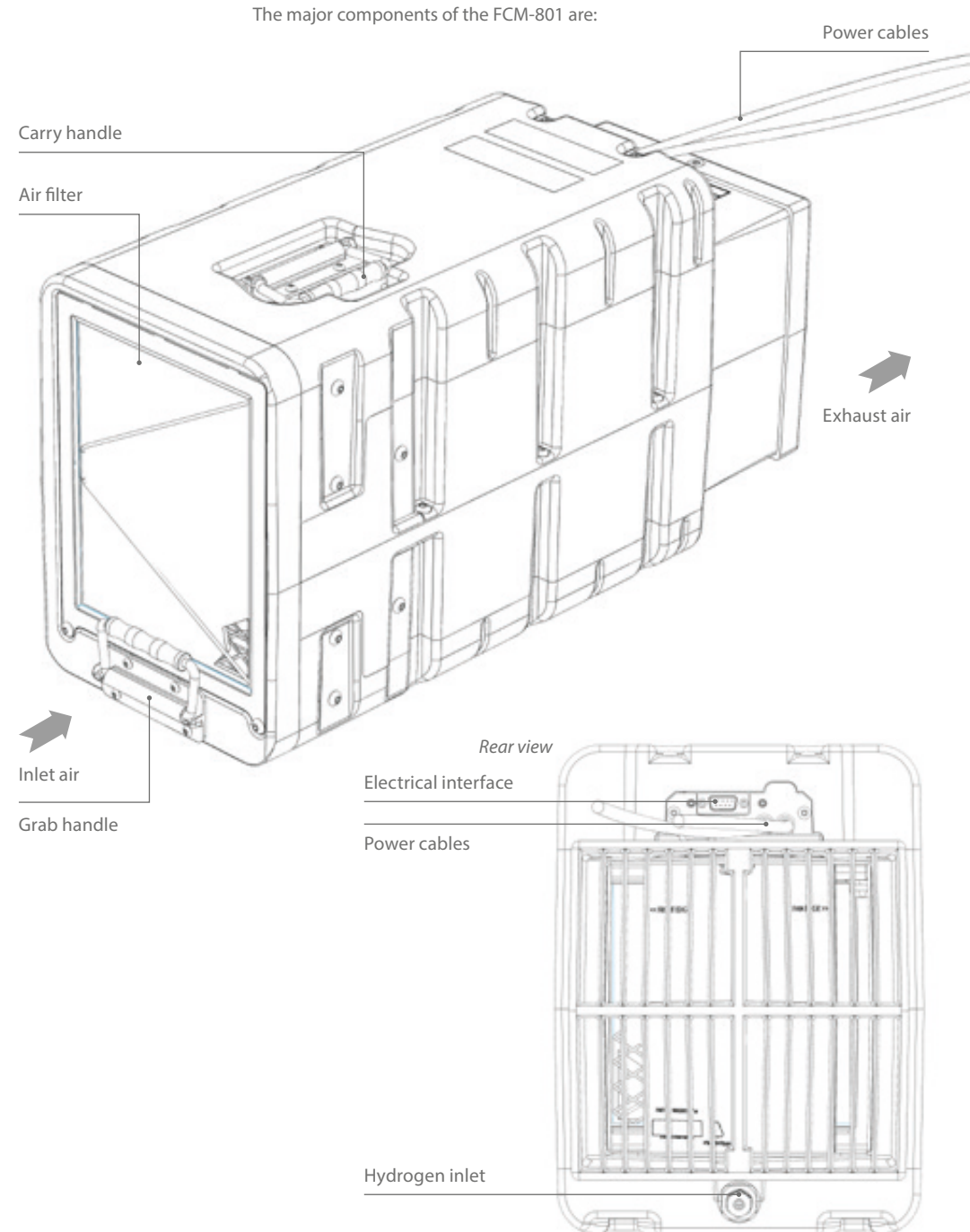
⁶ Options available for continuous health monitoring and predictive maintenance scheduling for high system availability

⁷ Rated power to 1500m. Power de-rate commences above 1500m

⁸ Rated power from 30%. Power de-rate commences below 30%

⁹ Please contact us to discuss your requirements

2 Product specification and interface



2.1 Interface specification

Performance	Function	Specification
Hydrogen inlet 500mbar.g – 800mbar.g	Fuel supply	G1/8 parallel thread, with face seal
Air inlet 0–8,800 SLPM 5–40°C	Ambient air filtration and supply	170×240mm duct
Exhaust air 0–8,800 SLPM 5–60°C	Air exhaust to ambient	150×150mm duct
Power connection 15.0–56.0V	Connection to DC bus	8AWG (8mm ²)
Communication port See section 3.4	Operational commands & diagnostics	D type 9 way

2.2 FCM-801 overview

The FCM-801 provides regulated DC at nominal 24V or 48V output. The FCM-801 will hold the DC output at the 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 starts, supports the load during the fuel cell fan pulse process and in the standby state. The nominal operating voltage is factory settable upon request.

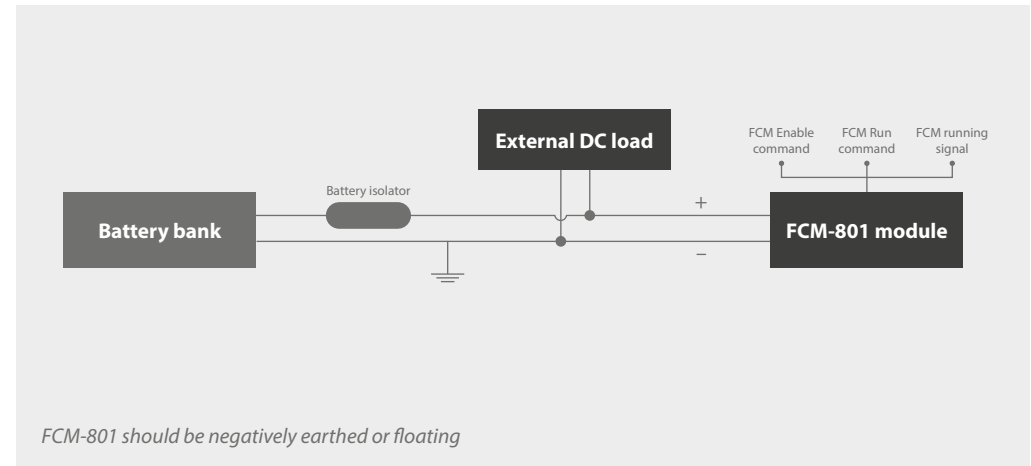
Hydrogen gas should be provided at a regulated pressure to the module inlet. The FCM-801 will generate power when it is given both Enable and Run signals (see Section 4). During normal operation, the FCM-801 will conduct a fan pulse where power delivery is briefly interrupted. In this period the fuel cell will hybridise with the external battery (see Section 5.3).

If, during normal operation the load drops to a low level (less than 2A) the fuel cell will enter a standby state (see Section 5.4). This is designed to optimise fuel consumption. If the DC Bus voltage then dips below a preset voltage, the fuel cell will restart.

The FCM-801 should be setup in a well ventilated environment with consideration given to the precautions of hydrogen control.

3.1 Electrical configuration

The FCM-801 is supplied with cables which are 8AWG (8mm²). These should be connected in a star configuration as shown in the figure below.



Warning: Do **NOT** electrically overload the FCM-801. Overloading will lead to excessive load being drawn from the battery. Drawing excessive load may cause damage to the equipment.

Note: Do **NOT** disconnect the main power leads with the enable signal present.

When the FCM-801 is running it will stay live if the power cables are disconnected.

The battery pack should provide power at the desired voltage. The battery pack should be capable of powering the load during module fan pulses (see section 5.3). For description of the command and signal connections see Section 4: Module Command and Status

3.2 Hydrogen fuel

The FCM-801 has a G1/8 parallel thread connection. The hydrogen supply needs to be regulated to 650mbar.g (± 150 mbar.g).

When installing and operating hydrogen systems, hydrogen general safety guidance should be considered:

- The hydrogen should be at least 99.9% pure and comply with the specification: ISO 14687-3:2014 grade E category 3.
- ISO/TR 15916 basic considerations for the safety of hydrogen systems.

3 Connections

3.3 Air supply

To produce electrical power the FCM-801 requires an unobstructed air supply which must not be recirculated between the exhaust and inlet.

- Do not obstruct the air inlet or exhaust.
- Do not recirculate the exhaust to the inlet.

The air should be free of the following contaminants:

- Sulphur
- Hydrocarbons

3.4 Hydrogen connection

The hydrogen connection to the system is below the air exhaust duct at the rear of the module, see Section 2 Product Interface. The hydrogen supply is connected via a G1/8 parallel BSP thread with a face seal. It is recommended that this is then connected via a Swagelok connector.

The hydrogen pipework should be checked periodically for leaks, particularly when connectors have been remade, such as cylinder exchange or installation.

3.5 Communication connection

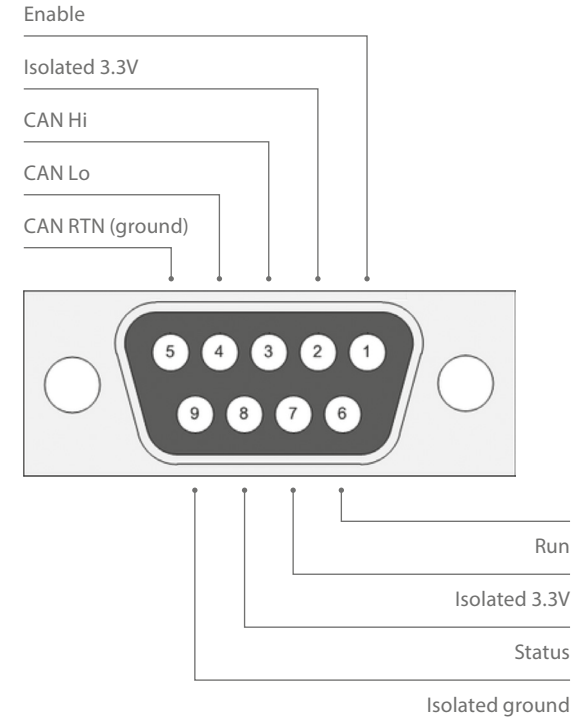
To operate the FCM-801, communications need to be provided through the D type connector. The pins of the connector have the following functions:

Pin No.	Description	Function
1	Enable	Provides power to the FCM-801
2	Isolated 3.3V	Power source for enable signal
3	CAN high	CAN pin
4	CAN low	CAN pin
5	CAN return (ground)	CAN reference
6	Run	Starts the fuel cell
7	Isolated 3.3V	Power for start command
8	Status	Status indicator
9	Isolated ground	Ground pin

3 Connections

3.6 CAN connection

The pins for the connector are as follows:



The CAN connection can be used to communicate with the FCM-801 using Intelligent Energy's proprietary CAN protocol. If multiple units are being connected to a common bus, then the CAN connections must also be connected, see Section 7 – Installation and set up.

4 FCM-801 commands and status

4.1 Module enable

To enable the FCM-801 the Enable pin needs a signal. To provide the signal, a connection must be made between pins 1 and 2.

4.2 Module run

To produce power, the Run pin needs a signal. To provide the signal, a connection must be made between pins 6 & 7 (N.B: Enable must also be present). When the signal is received, the FCM-801 will start and maintain the battery voltage. If the current draw is less than 2 Amps, the FCM-801 will go to standby state. The battery voltage will be monitored. If it drops below the nominal battery voltage, the fuel cell will then switch back to running mode.

4.3 FCM-801 status

A continuous FCM-801 status signal will be present whilst the fuel cell is running (with no fault present). If the run signal is present and there is no FCM-801 status signal present then the FCM-801 is in Standby or Fault.

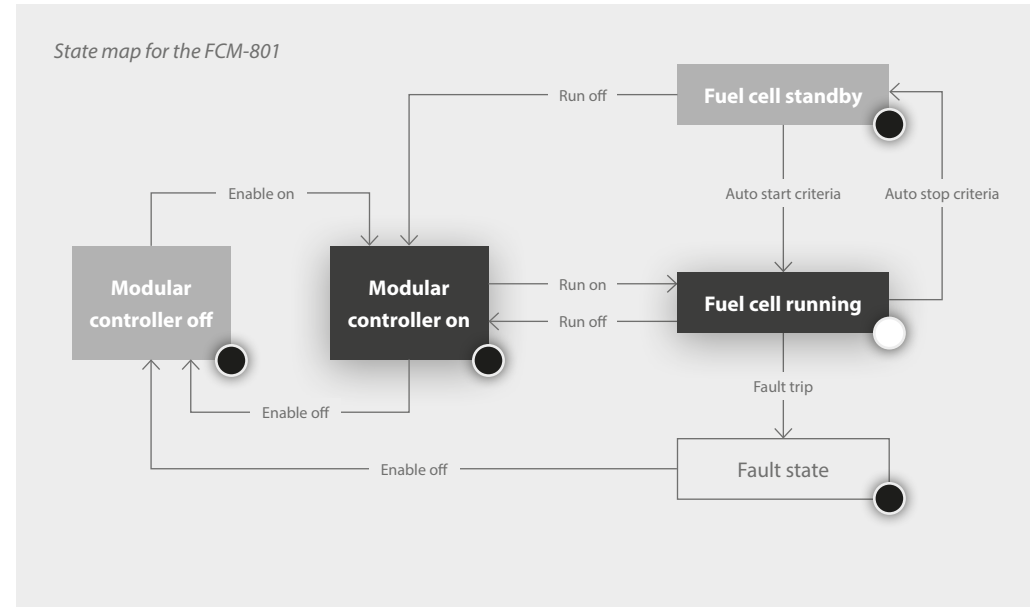
4.4 FCM-801 software states

The FCM-801 has 5 possible states:

- Controller off
- Controller on (run off)
- Fuel cell running
- Fuel cell standby
- Fault

4 FCM-801 commands and status

The states are transitioned as shown in the diagram below:



Please note the following points:

- 1 The small circle in each state box indicates the condition of the FCM-801 status pin. This is low (black: ●) in all states apart from fuel cell running where it is high (white: ○).
- 2 In all states, removing the enable signal returns the FCM-801 to the module controller off state.
- 3 If the FCM-801 enters a fault condition the fault is latched. The Enable line must be cycled to clear it.
- 4 For start and stop criteria see section 9 'Control Parameters and Standard Factory Setting'.

5 Operation of FCM-801

5.1 Overview FCM-801

The FCM-801 provides regulated DC at nominal 24V or 48V output to a battery bus. The DC bus 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 starts. It supports the load during the fuel cell fan pulse process and while the system is in the standby mode. The nominal operating voltage is factory settable upon request.

The hydrogen pressure should be provided in a regulated state to the module inlet. The FCM-801 will generate power when it is given both 'enable' and 'run' signals (see section 4.4) and detects DC bus and fuel pressure are present.

5.2 Anode purge

As the fuel cell operates, it is necessary to remove water and any impurities from the anode (the fuel side of the fuel cell). 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 that it will not sustain a flame. There is no impact on power production during anode purge.

5.3 Fan pulse

During normal operation, the FCM-801 will periodically conduct a fan pulse, which improves the performance of the fuel cell. Multiple fan pulses are triggered in rapid succession at start-up, then subsequently occur every 12 minutes. During a fan pulse, the coolant airflow is stopped and the fuel cell stack is disconnected from the load for 20 seconds. During this time, the external power source will provide power to the load.

5.4 Standby state

As a fuel saving measure the FCM-801 will stop producing power if the load drops below 2A for more than a minute; below this point, the ancillary equipment compromises the fuel cell efficiency. The load will then be provided by the battery.

The FCM-801 will continue to monitor the battery and, if its voltage drops below the nominal voltage, it will restart. When the fuel cell is running, it will power the load (if present) and float the battery voltage to the nominal set-point. This feature is designed to achieve the maximum useful energy from the fuel available.

5.5 Fault state

If the parameters of the FCM-801 leave the normal operational range then a fault is triggered. When a fault has been triggered the controller will latch. To clear the fault, the controller needs to be turned off via the Enable signal. For reset instructions see Section 6 Faults.

6 Faults

6.1 Procedure to reset the fault

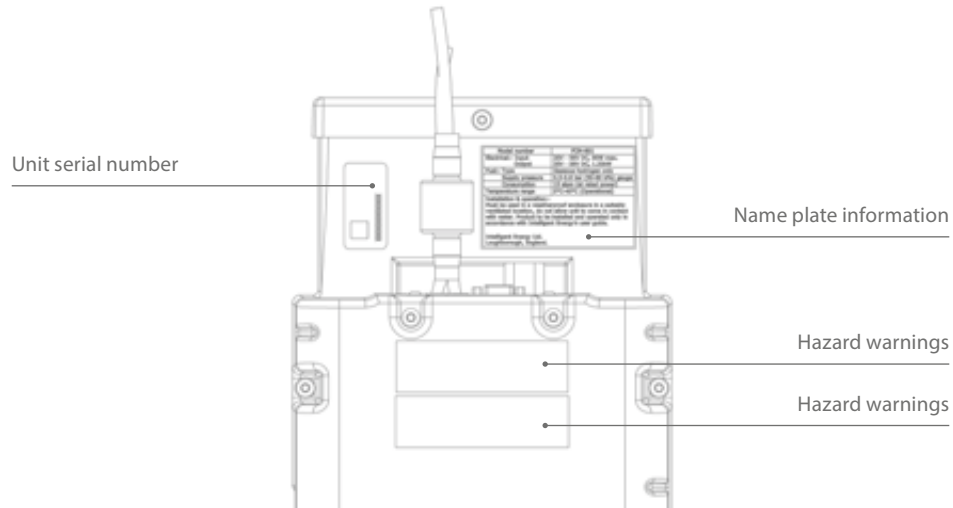
If the FCM-801 has a fault it will disconnect the internal DC-DC converter and stop providing power. To reset a fault follow the procedure below:

Process description	Procedure to reset the fault	
Detailed Instruction	Critical Point	Comments
Check that the load is disconnected		Installation specific
Switch the Enable signal to 'Off'		
Return the Enable signal to 'On'		
Set the Run signal to 'On'		
Return the load to required setting	If fault persists see trouble shooting	Installation specific

7 Installation and set up

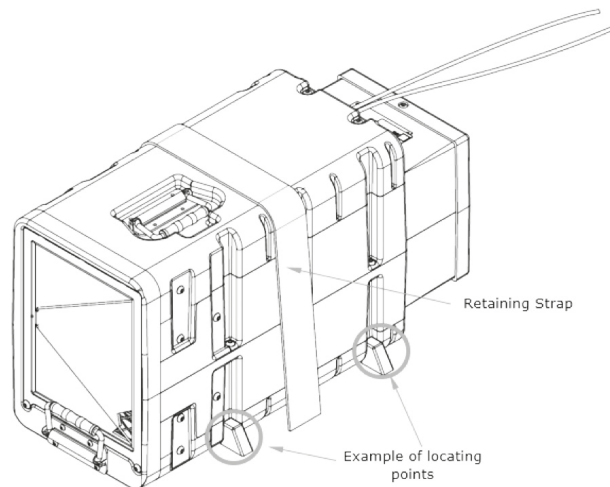
7.1 Label information

The FCM-801 is labelled as shown below. It should be visible or duplicated on the full installation outer case.



7.2 Mechanical mounting points

The FCM-801 should be installed in a similar manner to a heavy duty commercial vehicle or marine battery. Mount on a flat surface with retaining points, example below:



7 Installation and set up

It is recommended to mount on a rubber mat to reduce slippage, either use locating features as shown or locate in a formed channel to restrict lateral motion. In this case, use closed cell Neoprene foam padding around the sides to prevent free play and cushion the case from vibration.

Hold down with one or more battery/cargo straps, use cam buckles rather than ratchet fastenings due to the risk of over loading and distorting/breaking the casing. If using a bolt down metal strap arrangement, use thick closed cell Neoprene foam to spread the load and do not exceed 100N loading on the housing.

7.3 Mechanical protection and covers

The FCM-801 should be mounted with protection from weather and the elements. The FCM-801 has been designed to comply with IP20 rating and it must be mounted within an enclosure which is at least IP23 if used outside. If installed inside, the installer must ensure there is sufficient ventilation, see section 7.5 'Air supply and ventilation'. The covers and the installation must protect the FCM-801 from ingress of precipitation, flooding and vegetation or excessive dust. The covers should consider the need for maintenance access to the filter or for unit exchange.

The covers of the FCM-801 must not be removed by unauthorised personnel. The unit contains live electrical components which could be hazardous, even when not operating.

7.4 Vibration and shock loads

The mounting of the FCM-801 should ensure that it is not exposed to excessive shock or vibration loads.

Description	Maximum acceleration for the FCM-801	Frequency
Sinusoidal vibration	50m/s ²	5–30Hz
	25m/s ²	30–200Hz
Shock	300m/s ²	18ms

Ensure that the FCM-801 is stationary while it is operating.

7 Installation and set up

7.5 Air supply and ventilation

The FCM-801 requires a free supply of clean air to deliver power output. The unit will require up to 7000 slpm of unrestricted air flow. The application should consider the air flow required for the environmental conditions expected, the enclosure should not unduly restrict the air flow. The covers should be designed to enable the exhaust gas to leave the enclosure directly and so that it cannot be recirculated into the air inlet.

As part of the design, the main air flow is also used to manage the risk of a hydrogen build-up. The hydrogen purge gas is routed into the air flow so that it is diluted to below the low flammability limit at the point of exit from the unit; therefore, the installer should take care not to restrict the exhaust stream. This gas stream will contain hydrogen and so due fire prevention precautions should be observed. When dealing with hydrogen systems the installer must ensure that safe practices are observed, such as forced ventilation and/or hydrogen detection.

The FCM-801 should be provided with air in the temperature range of +5 to +40°C, it should not be operated outside this range. Do not use if the air has smoke or corrosive gas present.

7.6 Hydrogen connection

The FCM-801 requires hydrogen to fuel the electro-chemical reaction. Connection of the hydrogen fuel will be at the rear of the module. The connection type is a G1/8 parallel BSP thread with a face seal, it is recommended that this is then connected via a Swagelok connector.

The hydrogen pipework should be checked periodically for leaks. Particularly when connectors have been remade, such as cylinder exchange or installation.

7.7 Hydrogen fuel physical requirements

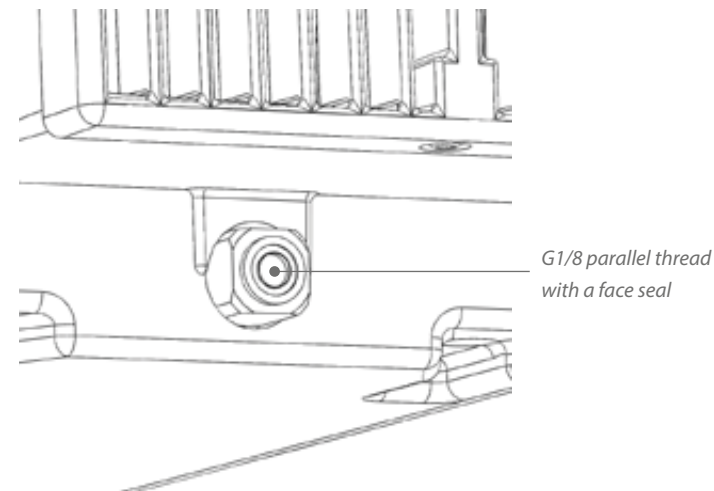
The fuel cell requires fuel pressure to feed hydrogen into the cell. The inlet pressure should be:

0.5 Bar.g to 0.8 Bar.g.

The FCM-801 will consume less than 16 slpm at rated power. It must be noted that the flow will spike high during hydrogen purges which, if poorly regulated, can lead to a pulse of low pressure.

It is required that the shut-off valve as part of the hydrogen feed line, to allow the hydrogen to be isolated at source, if required.

7 Installation and set up



8 Trouble-shooting guide

If you have any questions regarding your FCM-801 please email Intelligent Energy at servicing@intelligent-energy.com

Fault	Cause	Action
No power from the module	No command to start	Verify that the module is in Enable and Run modes
	No power provided	See 9.5 <i>Electrical system check procedure</i>
	Hydrogen leak	See 9.3 <i>Check for fuel leak</i>
	Incorrect hydrogen pressure	See 9.4 <i>Fuel check procedure</i>
	Fuel cell is over temperature	See 9.6 <i>Stack temperature</i>

9.1 User maintenance

The user can perform the following maintenance on the FCM-801:

- Electrical connections (by DC power trained staff)
- Hydrogen connections (by staff trained in use of compressed gas)
- Communication connection
- Monthly filter inspection
- Filter change
- Troubleshooting (see below)

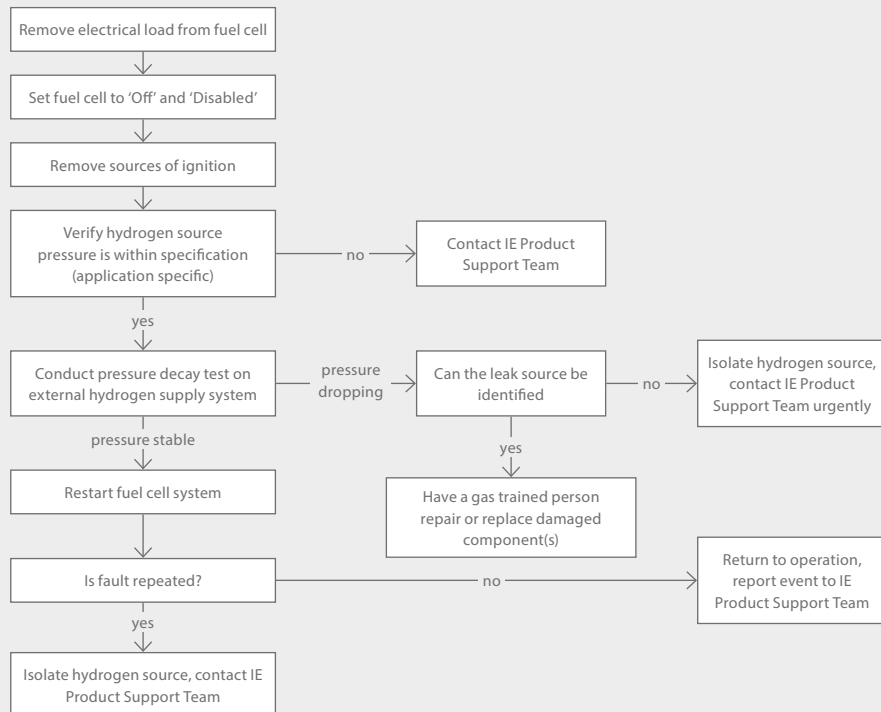
For all other maintenance tasks, please contact Intelligent Energy.

9.2 Contact Intelligent Energy Product Support

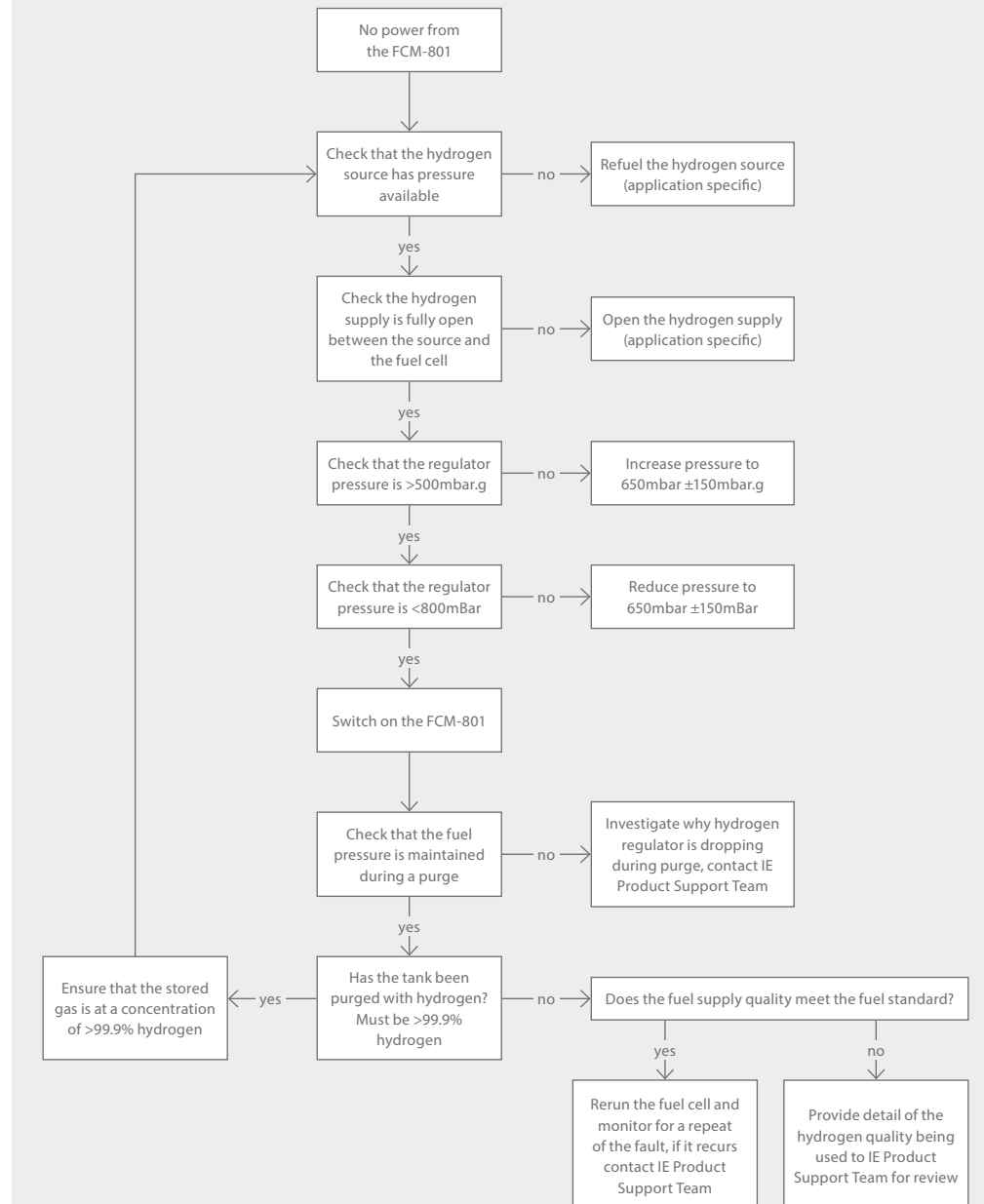
In the event of a fault with the FCM-801, please contact the Intelligent Energy Product Support Team. Either contact your local representative or email servicing@intelligent-energy.com

If you have a fault please provide as much detail as possible.

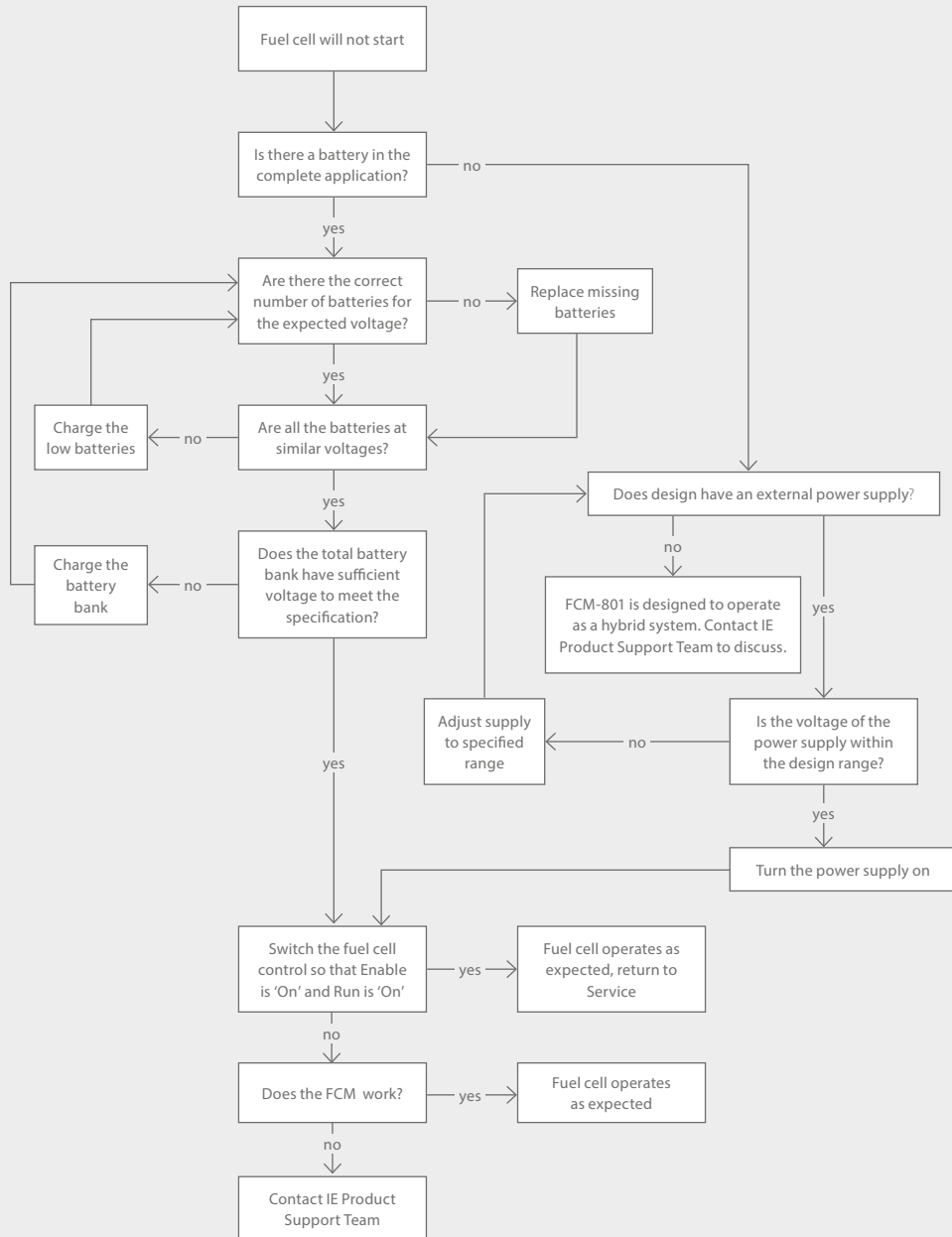
9.3 Check for fuel leak



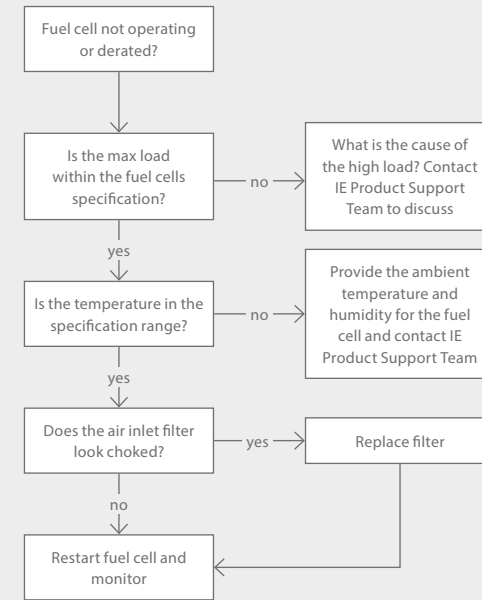
9.4 Fuel check procedure



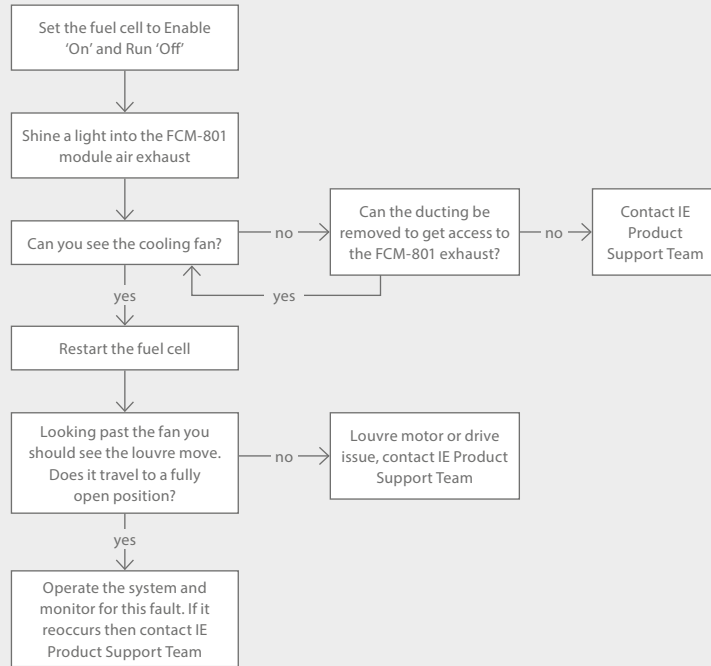
9.5 Electrical system check procedure



9.6 Stack temperature check procedure



9.7 Louvre operation check



9.8 Filter change procedure

- 1 Switch off the Enable and Run signals.
- 2 Isolate battery supply.
- 3 Isolate hydrogen supply.
- 4 Wait 15 minutes.
- 5 Use a 4mm allen key to remove two screws from the frame on the front of FCM- 801.
- 6 Pull bottom of frame forward and it will drop down.
- 7 The dirty filter can be pulled out.
- 8 Discard dirty filter.
- 9 Place clean filter in front of FCM-801 and refit frame and screws.

Warning do not touch the fuel cell stack during this procedure as it may be live.

Parameter	Unit	Range	Factory Setting (48V)	Factory Setting (24V)
Target Output Voltage	V	15.0 to 56.0	52	26
Delayed Start Under-Voltage	V	0.0 to 60.0	48	24
Delayed Start Qualification Time	s	0 to 14400	60	60
Immediate Start Under-Voltage	V	0.0 to 60.0	46	22
Delayed Stop Over-Voltage	V	0.0 to 60.0	54	27
Delayed Stop OV Qualification Time	s	0 to 3600	60	60
Delayed Stop Under-Current	A	0.0 to 120.0	2	2
Delayed Stop UC Qualification Time	s	0 to 3600	20	20
Deny Start Under-Voltage	V	0.0 to 50.0	40	20
System Index	-	1 to 8	1	1
Output Voltage Rise Rate	V/s	0.017 to 2000.00	0.017V/s	0.017V/s
Minimum Output Voltage	V	0.0 to 60.0	48	24
Output Current Limit	A	0.0 to 40.0	25	40
Hard Set Output Voltage	-	0 or 1	0	0
Output Power Limit	W	0 to 1250	1250	1250
Restart Delay	s	0 to 3600	20	20

11 End of life treatment and disposal

11.1 Storage

The FCM-801 should be stored as follows:

- The FCM-801 should be stored level, resting on the base.
- The FCM-801 should be stored in a sealed plastic bag.
- Do not place desiccant inside the plastic bag.
- The FCM-801 can be stored in temperatures between -40°C and +70°C. However, the ideal temperature for storage is between 10°C and 25°C.

11.2 Transportation

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

- The FCM-801 should be transported in a level orientation
- The FCM-801 should not be subjected to mechanical shocks where possible

11.3 Spare parts

For spare parts contact IE Product Support Team at servicing@intelligent-energy.com

Spare part list

- Filter intake air: 009016
- Filter retaining plate: 009015
- Filter retaining screws: 000969

11.4

When the FCM-801 reaches end of life, please contact Intelligent Energy for support with reconditioning or disposal at servicing@intelligent-energy.com

12 EU Declaration of Conformity In accordance with EN ISO 17050-1:2010

This declaration of conformity is issued under the sole responsibility of the manufacturer:

Intelligent Energy Limited

of

Charnwood Building, Holywell Park, Ashby Road, Loughborough, Leicestershire, United Kingdom, LE11 3GB

In accordance with the following Directive(s):

- | | |
|--------------|---|
| · 2006/42/EC | The Machinery Directive |
| · 2014/30/EU | The Electromagnetic Compatibility Directive |
| · 2014/34/EU | The ATEX Directive |

Intelligent Energy Limited hereby declares that:

- FCM 801 - 1.25kW Standalone Stationary Power Fuel Cell Module
- Part Number: 10004359

Is in conformity with the applicable requirements of the Directives set out above and the following standards documents:

- | | |
|-----------------------------|---|
| · EN 62282-3-100:2012 | Fuel cell technologies – Stationary fuel cell power systems – Safety |
| · EN 60204-1:2006+A1:2009 | Safety of machinery – Electrical equipment of machines – General requirements |
| · EN 13611:2007+A2:2011 | Safety and control devices for gas burners and gas burning appliances – General requirements |
| · EN 60079-10-1:2015 | Classification of areas – Explosive gas atmospheres |
| · EN 61000-6-2:2005 | Electromagnetic compatibility (EMC) – Generic standards – Immunity for industrial environments |
| · EN 61000-6-4:2007+A1:2011 | Electromagnetic compatibility (EMC) – Generic standards – Emission standard for industrial environments |

A copy of the official version of this certificate duly signed by an authorised signatory of the manufacturer is available upon request by emailing sales@intelligent-energy.com

Intelligent Energy Limited, Charnwood Building, Holywell Park, Ashby Road, Loughborough, Leicestershire, United Kingdom, LE11 3GB

23rd April 2018

Document Ref. No. 266-DOC-1736

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Published by: Intelligent Energy Ltd, Charnwood Building, Holywell Park, Ashby Road, Loughborough LE11 3GB. Tel: 01509 271271

(Registered in England with company number: 03958217).