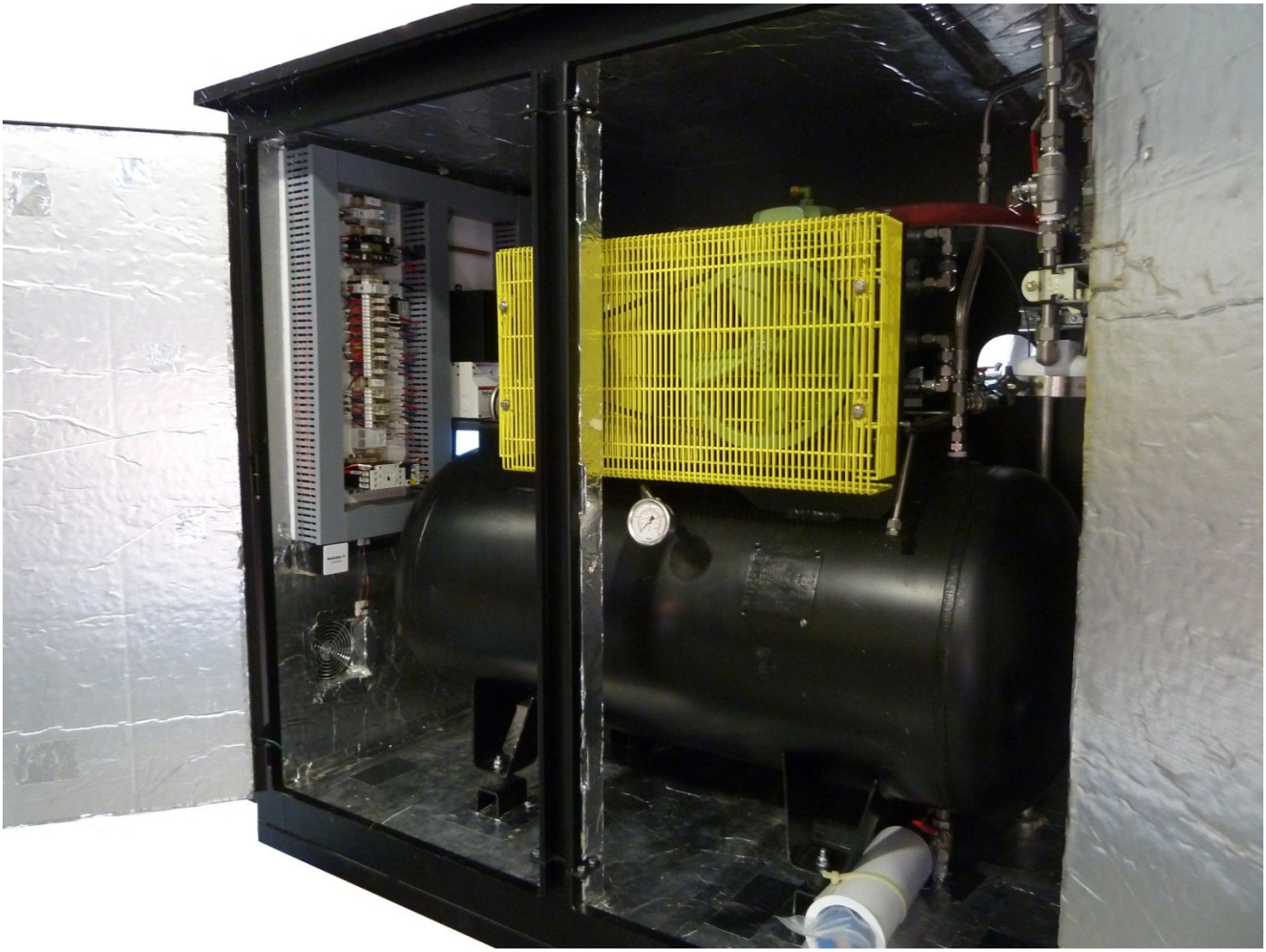
M-HACS-1112

Hybrid Air Compressor Manual



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Forward

Thank you for purchasing Ensol System's Hybrid Air Compressor Package.

Please read through this manual before operating the unit as it contains particular start up, shut down and disconnection procedures.

If you have any questions or concerns, contact Ensol at:

Ensol Systems Inc.

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Section 1 – Quick Start-Up & Critical Maintenance

1.1 Quick Start-Up Procedure

The following are steps for a quick start procedure. For a more detailed description of the package, PLC and Fuel Cell operation and start up, please read through Section 4 of this manual.

1. Ensure the EFOY Pro Fuel Cells are in Automatic Standby or Charging mode.
2. Ensure all fuses are closed and breakers are set to 'On'.
3. Ensure all manual ball valves internal to the compressor package are in the closed position.
4. Screw the puck style filter into the compressor inlet. Ensure that the desiccant air dryer is filled with the desiccant beads and is properly closed.
5. Go to the Output Jogging page by pressing the 'F3' button on the PLC. Test each device individually for operation by pressing their corresponding control buttons on the screen. If one device does not seem to be working, check the fuses and wiring. If all three are functioning, proceed to step 6.
6. The next step will be to start the system. Before this is done, ensure that all tools and hardware are removed from inside the package for safety reasons. Proceed to the Pressure Set page by pressing the 'F4' button on the PLC. Set the pressure set point and the +/- set point value as required by the system. Next go to the System Control page by pressing the 'F2' button on the PLC. Press the 'Start' button and the system will now be in operation.
7. Once the receiver is full, slowly open the two manual ball valves located on either side of the desiccant dryer. This will allow the air to flow out to any externally connected instrumentation.
8. To shut down the system, simply go to the System Control page by pressing the 'F2' button on the PLC, and press the 'Stop' button.

1.2 Critical Maintenance Schedule

The following are critical maintenance activities for the Hybrid Air Compressor Package:

1. The Swan Air Compressor recommends that the oil be changed after the first 50 hours of operation and every 1000 hours thereafter. It is our recommendation that Mobil SHC 524 be used for this application. SHC 524 is high quality, synthetic, shear stable hydraulic oil with a wide temperature range and maximized anti-wear protection properties.

2. The desiccant filter is a Van Air Model ID15/SW in-line desiccant dryer designed to dry compressed air. The SG-23 filter cartridge has a part number of 26-0888 and needs to be replaced once the desiccant beads have changed from a blue to a pink color (as seen through the site glass).

3. The exhaust water collection tanks should be emptied or replaced on the same schedule/requirement as the fuel cartridges. Empty fuel cartridges can be used for water collection.

4. Do not let the fuel cells run out of fuel. This could lead to the unit shutting down and failure of the air compressor. In winter operating conditions, allowing the fuel cell to run out of methanol may cause the unit to freeze, which may damage the device. Once frozen the fuel cell needs 24 hours in a warm, dry environment before it can be restarted.

Section 2 – General Information

2.1 Product Introduction

The Ensol Systems Hybrid Air Compressor package provides clean, dry and reliable air to instruments requiring pneumatic power (i.e. shutdown valves, control valves, pneumatic switches, pneumatic pumps etc.).

Powered by a hybrid system of photovoltaic cells and DMFC's (Direct Methanol Fuel Cell), these packages are reliable even in the most remote and harsh environments.

The design philosophy is to use solar energy when you have it, with a methanol fuel cell as a back-up when you don't. This will provide you with 100% reliable power even in the darker months of winter.

2.2 Product Specifications

AIR COMPRESSOR SKID (ACS) SPECIFICATION SHEET

Model:	*ACS-2224*
No. compressors	1
Max. volume output @ 0 psi @ 100 psi	221 Litres/min 166 Litres/min
Standard pressure range	0 to 125 psig
Estimated due point	-40°C
Volume of tank	60 gallon
Outlet line size	1/2" tube connection
Nominal compressor motor power	3/4 HP
Power sources	Methanol fuel cells & Photovoltaic solar panels
Fuel cell model	EFOY Pro 2200
Fuel cartridge	M28 (28 L container)
No. fuel cells	2
No. fuel cartridges	2
No. batteries	8
No. solar panels	6
Max. power output per solar panel	235 W
Charging power per day[(1)]	4320 - 7050 Wh/day
Nominal DC voltage	24 V
Battery bank capacity[(2)]	300 Ah
Environmental design temperature	-40°C to +45°C (-40°F to +113°F)
Recommended storage temperature	+5°C to +60°C (+41°F to +140°F)
Dimensions L x W x H	1524 x 1219 x 1325 mm (5 x 4 x 4.3 ft)
Weight (dry)	<2500lbs depending upon configuration.
Warranty	12 months

[(1)] Values depend on # of solar panels and installation area's solar insolation.
[(2)] Depends on battery type and application.

Section 3 System Installation

3.1 Installation Overview

The skid has been designed to be field mounted onto a supporting structure. The solar panels are included with the skid but are to be mounted to user supplied structures on site, unless otherwise agreed upon with Ensol Systems.

3.2 Skid Installation Recommendation

The drawing HACS-4400 -500, details a recommended approach. Actual supporting structures must take the site conditions into consideration.

3.3 Power and Grounding Installation Requirements

The Ensol Air Compressor enclosure must be grounded at the site after installation. An exterior ground lug is provided for a 2/0 ground cable connection.

In the case where the air compressor package is also being used to power other instruments on site, please use the extra power connection terminals provided (these are terminals 5 and 6 on terminal strip 2). Please see drawing HACS-4400-601, 602 & 603 for details.

3.4 Solar Panel Installation

Since each site location will have varied methods of mounting Solar Panels, Ensol Systems does not include panel mounting poles, unless otherwise agreed upon.

Solar Panels should be installed facing south if installed in the northern hemisphere and should face north if installed in the southern hemisphere. For locations that may experience days of snow throughout the year, ensure the panels are mounted with 0 degrees of tilt.

Please see drawing HACS-4400-601, 602 & 603 for Solar Panel Array wiring details.

The NEC requires that wires carrying the system current never exceed 80% of the conductor's current rating. Ensol Systems is not responsible for any incorrect solar panel wire sizing in the case where Ensol does not install the panels on site.

3.5 Batteries

Sealed Lead-Acid batteries are provided to store the solar and fuel cell energy, and will supply the large current draw for the intermittent operation of the compressor. Battery cables provide the link between the batteries, equipment and charging system. Faulty connections can lead to poor performance and terminal damage, meltdown or fire.

Batteries Inspection

- Examine the outside appearance of the battery. The tops of the batteries and terminal connections should be clean, free of dirt and corrosion, and dry.
- If fluid is on the top of a gel or AGM battery this means that the battery is being overcharged and the performance and life will be reduced
- Check battery cables and connections. Replace any damaged cables with a min. #6 AWG. Tighten any loose connections.

Changing or Disconnecting Batteries

- Use extreme caution while working on the batteries and ensure appropriate PPE is utilized.
- First disconnect the solar panel array from the solar charge controller. Failure to do so may cause damage to the solar charge controller.
- Next isolate the batteries from the electrical system by disconnecting all fuses and breakers.
- Disconnect the system wiring from the batteries first, beginning with the positive leads, then continue to disconnect the remaining batteries from one another
- When reconnecting the batteries, please follow the wiring diagram HACS-4400-601. Connect two batteries in series to provide the 24VDC. Do this for all sets of two, and then connect each set in parallel. Lastly connect the electrical system to the bank of batteries. This includes power wiring, and the fuel cell wiring.
- Once the battery bank is connected, check that the voltage going to the system is within the range of 23-29VDC. If this is not the case, do not close any fuses or breakers and check that the wiring matches drawing HACS-4400-601. If the wiring matches and the voltage still is not within the correct range, test each battery individually to see if any are defective or damaged.
- If the voltage is within the range of 23-29VDC, reconnect all the loads via the fuses and circuit breakers.
- Lastly reconnect the solar panel array to the charge controller.

3.6 Methanol Fuel Cell

The EFOY Pro Fuel Cells will already be mounted, but all their accessories still may need to be connected.

Connect all accessories in the following order:

- First, connect the methanol fuel cartridge. Screw the M28 cartridge adapter to the cartridge if not already done so, then bring the fuel line from the fuel cell through the wall to the cartridge and screw the fuel line from the fuel cell to the top of the M28 adapter.

- Second, connect the exhaust tubing line to the EFOY Pro fuel cell's exhaust port. This is a small tube stub protruding just next to the fuel line. Connect the exhaust tube to the water collection container.
- Third, connect the wiring harness and remote to their respective ports. Ensure that the remote is plugged into the 'Remote' RJ45 port and not the 'Data' port.

3.7 Air Filter & Dryer

The air compressors inlet filter is a puck shaped filter with a 3/4" Male NPT connector on the bottom. This should be installed on the underside of the skid, screwed into the inlet port.

The desiccant air dryer may not have the desiccant filter preinstalled. Undo the dryer retainer, remove the housing and replace the filter cartridge.

Section 4 System Operation

4.1 General System Operation

The Air Compressor System's basic operation is quite simple. A hybrid system consisting of an array of solar panels and of a methanol fuel cell (illustrated in Figure 1), will charge a bank of sealed lead-acid batteries. This stored electrical power is then used to run the air compressor, PLC and whatever other loads may be involved. A pressure transducer sends the pressure signal to the PLC, which will in turn start the air compressor if the pressure falls below the pre-set pressure set point. The PLC will also control anything else required for a safe, optimized operation.

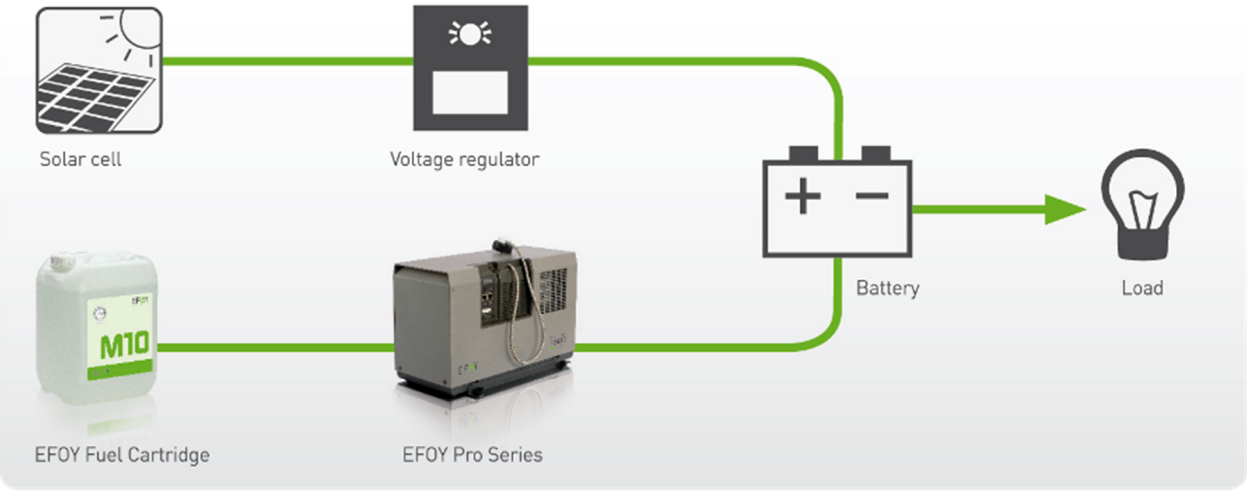


Figure 1 – Hybrid System

The layout is set up for ease of operation and maintenance, but is also crucial for proper operation of the equipment. The fuel cell is located in a separate compartment because it needs to stay above 5°C. While operating, the unit will give off heat and will keep itself warm in the insulated compartment. If the unit is not operating and the temperature surrounding it drops below 5°C, the unit will go into anti-freezing mode which runs the unit sufficiently to keep itself warm.

If the surrounding area gets too hot, the thermostat will activate an input in the PLC to turn the exhaust fan on. This fan will pull the warm air from the fuel cell compartment into the rest of the enclosure, while pulling cool air from outside into the fuel cell compartment. This will maintain the fuel cell at an optimal temperature, regardless of the outside temperature. It will also keep the rest of the equipment reasonably warm during normal operation.

4.2 PLC Program Operation

For an in depth look into how the air compressor system works, you will need to understand how the PLC program operates. This section will go through each page of the program, step by step, hopefully giving a better understanding of its operation.

The Home Screen for the program, as seen in Figure 2, will allow you to jump to any of the stated screens in the program. To return to the home screen at any time, press the 'F1' key on the bottom of the PLC.

Figure 2 - Home Screen

The System Control screen is illustrated in Figure 3. This screen will allow the user to start the program's operation, and will also allow the user to completely shut down the system. In shut down mode, nothing will run automatically, but the user will still be able to jog any of the outputs as seen in Figure 4. To jump to this screen at any point in time, press the 'F2' button.

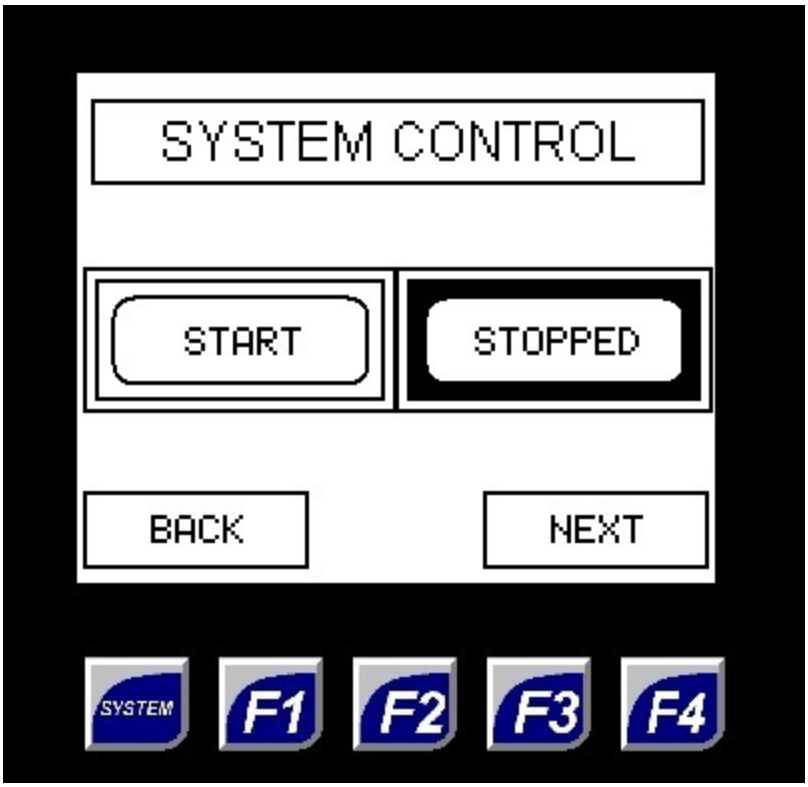


Figure 3 - System Control

Figure 4 displays the Output Jogging page. This page allows the user to test any of the outputs for their operation, without having the system running. Note that it will not hold the output active, and will return to a non-powered state once the user de-presses the button. To jump to this screen at any point in time, press the ‘F3’ button.

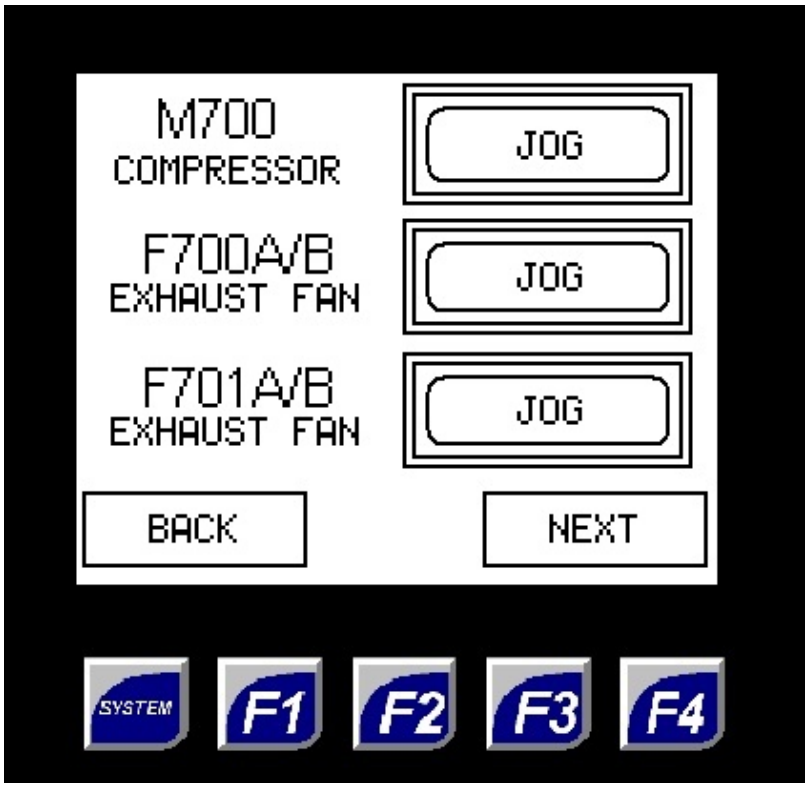


Figure 4 - Output Jogging

Figure 5 displays the Pressure Set page. This page is used to display the current tank pressure and is used to set when the compressor will turn on and off. The pressure PV value displays the current tank pressure. The pressure set-point is the pressure at which the compressor will pump the tank up to, while the on/off pressure is used to give the compressor some hysteresis. The on/off value is subtracted or added to the set-point to give you your on and off pressure respectively.

For example, if the pressure set-point is set to 110 psi and the on/off pressure to 5 psi, the compressor will turn on when the pressure drops below 105psi and will turn off when the pressure rises above 115psi. To jump to this screen at any point in time, press the 'F3' button.

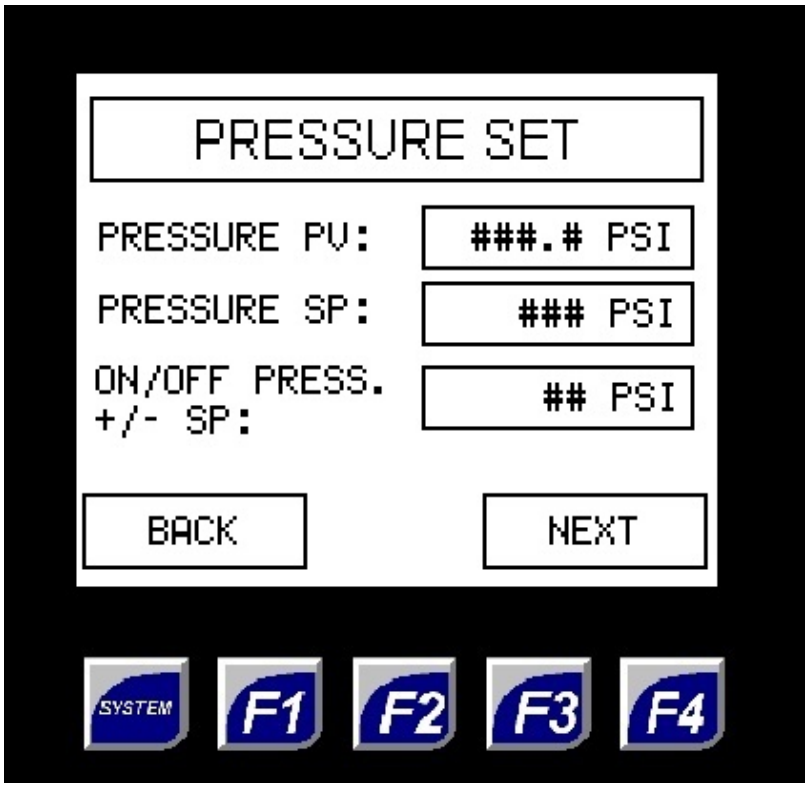


Figure 5 – Pressure Set

The Pressure Alarms page is shown in Figure 6. This page is used to set high and low pressure alarms for the tank. Each value can be configured to send alarms to an external control system if desired. By default PAHH-700 is set to 150 psi and will shut down the system if the pressure rises to this level. The remaining alarms by default are only warnings locally.

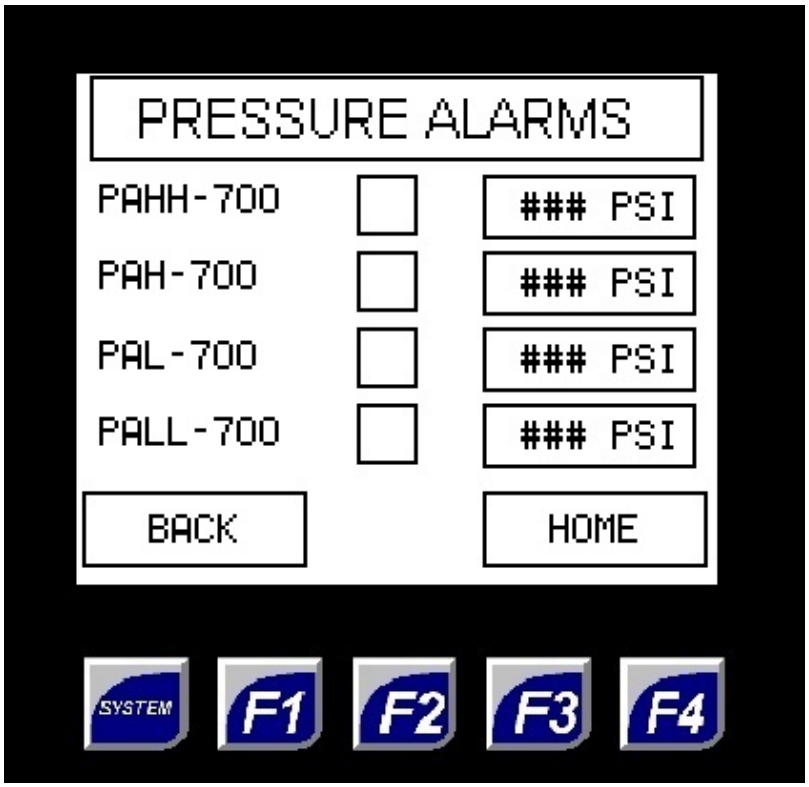


Figure 6 – Pressure Alarms

The Run Time page is shown in Figure 7. This page provides the compressors total run time, the run time system the compressor was last service and the hours until the next service is required. The compressor needs to be service every 1000 hours, which includes an oil change, belt check etc. Once the run time has gone past the 1000 hours, a warning will come up telling the user that the compressor needs to be serviced and a reset button will appear. Once the compressor has been serviced, the reset button should be pressed. This will restart the service hours and remove the warning.

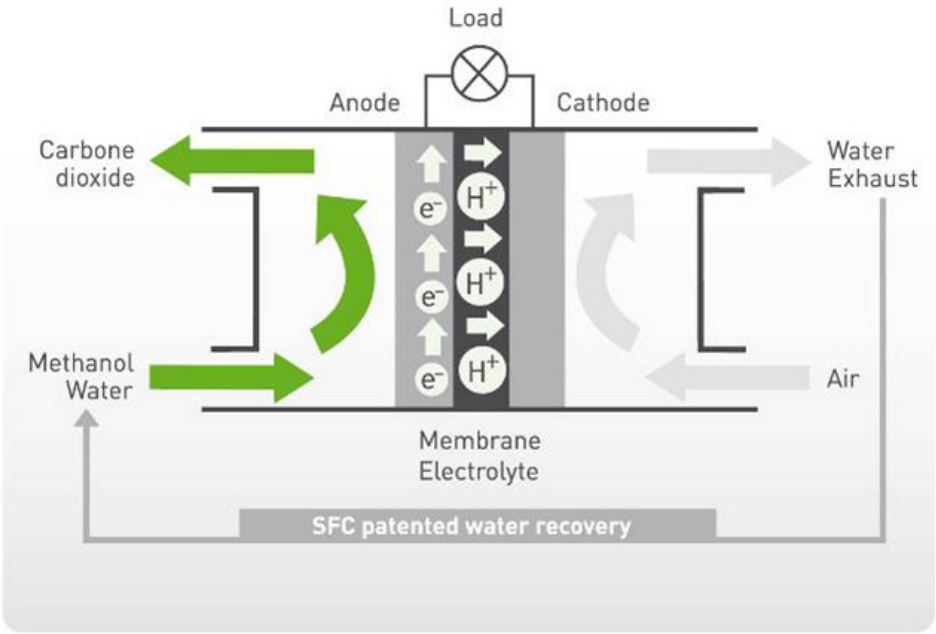
Figure 7 – Run Time

4.3 Solar System Operation

The solar system is comprised of two 130Watt solar panels. If possible, try to face the panels south towards the sun. Since the panels are on the mast, the lighting system may need to be located on the south side of the area desired to be lit, in order to have the panels face south.

4.4 Fuel Cell Operation

The SFC EFOY Pro fuel cell uses a catalytic process to directly convert methanol into electricity (see Figure 8). The byproduct of this reaction is water, small amounts of CO_2 and heat. To eliminate freezing, the water must be collected internally. The collected water should be changed out at the point in time that the fuel cartridge is replaced.



Methanol + Oxygen → Carbon dioxide + Water vapor

$2\ CH_3OH + 3\ O_2 \rightarrow 2\ CO_2 + 4\ H_2O$

Figure 8

Since the EFOY Pro fuel cell is a 'smart' fuel cell, charging and monitoring to the batteries is handled automatically (example in Figure 9). With the remote which is included, the user can view the charging mode, battery voltage, charging current, system operating hours and firmware version, and can also change the charging mode. By pressing the power button on the remote, the user can turn the system off, put it in automatic or turn the system on for one charge cycle.

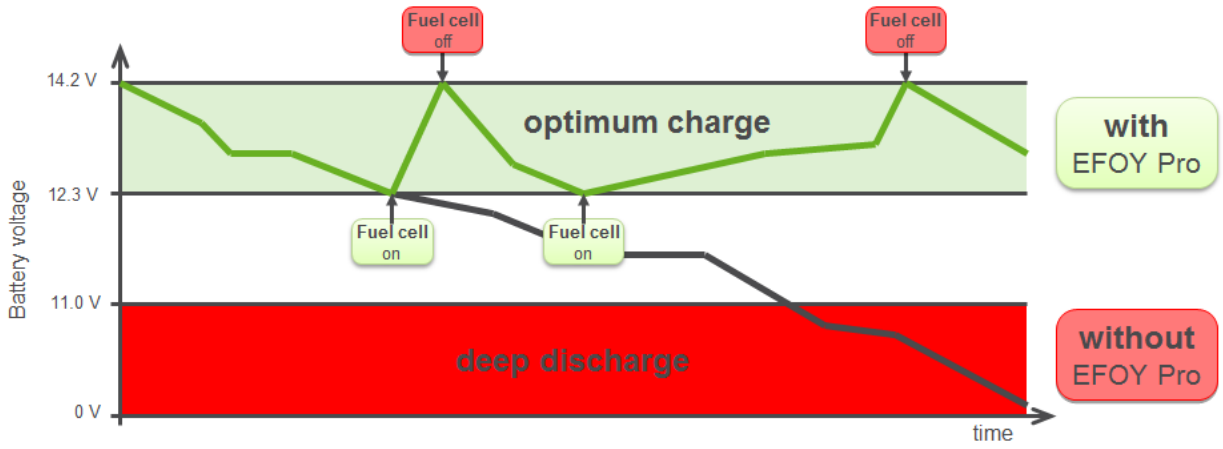


Figure 9

Ensol Systems has pre-programmed the fuel cell's parameters for the installation location. If charging voltage set points need to be altered, please contact Ensol Systems.

For a full description of the EFOY Pro fuel cell's operation, please see the manual provided by SFC's document 101123_UM_EFOY_Pro_GB_v02.

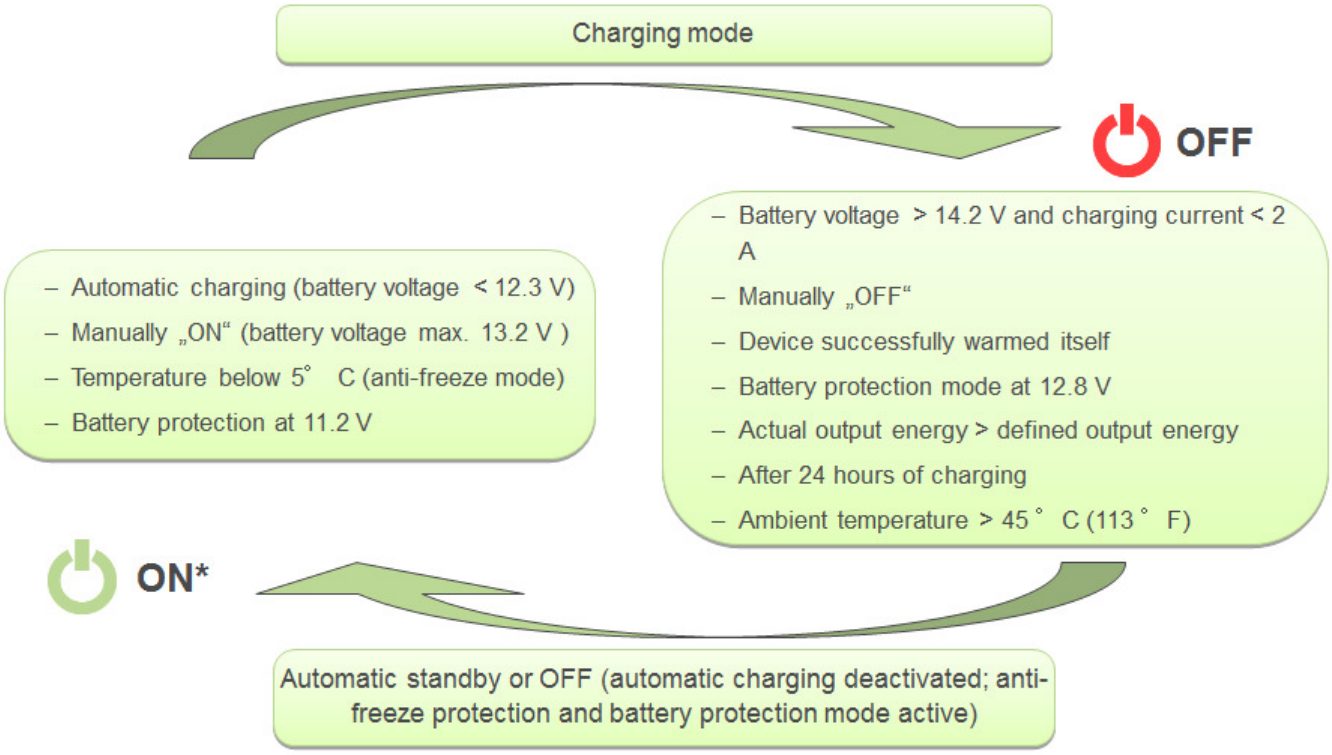
4.5 UN Certified Methanol Fuel Cartridges

The EFOY Pro uses special plastic fuel cartridges to facilitate ease of use and transport:

- The methanol fuel cartridges are UN certified containers certified for transport on cargo planes.
- The containers are spill resistant and designed to withstand significant impact force.
- Empty cartridges should be recycled.
- 28L cartridges are the largest available size and a cartridge adapter is required to use this cartridge with the EFOY Pro fuel cell. DO NOT THROW AWAY THE CARTRIDGE ADAPTER!

- The fuel cell methanol is ultrapure. Do not puncture the cartridge. To avoid contamination, do not transfer residual methanol from an old cartridge to a new cartridge. DO NOT USE ANY OTHER METHANOL SOURCE TO FUEL THE EFOY PRO! Impure/contaminated methanol will severely degrade the performance and life of the EFOY and will **VOID WARRANTY**.

4.6 Operational States

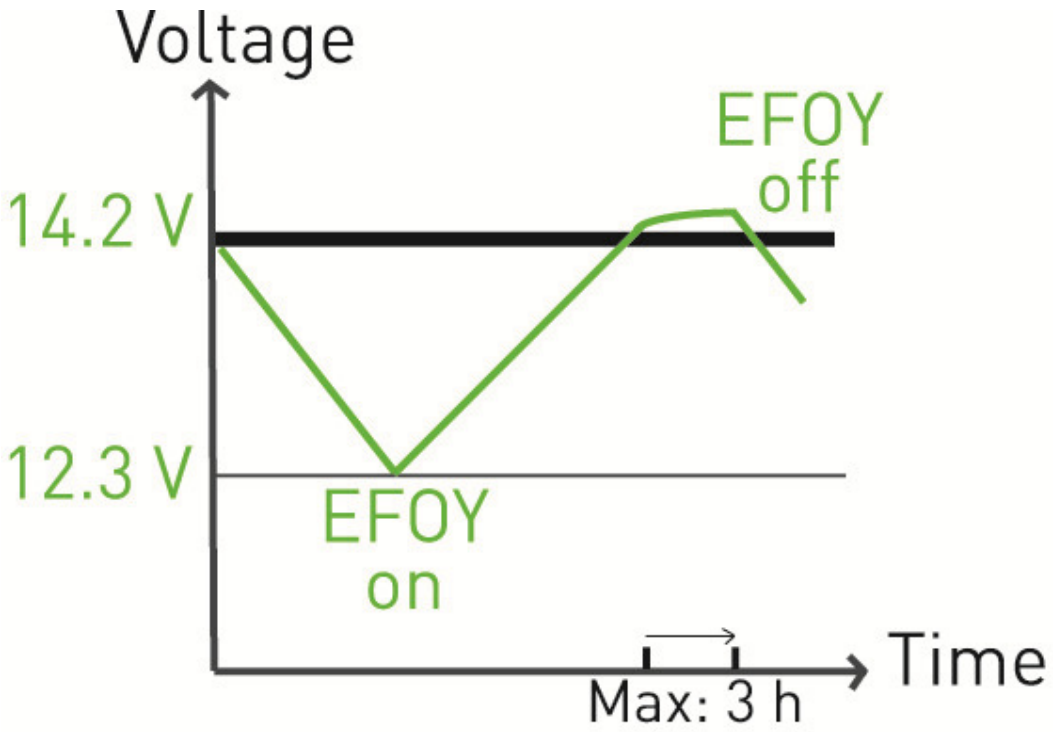


- Note that a minimal battery voltage of 9.0V or 18.5 V is required for the EFOY Pro to start.

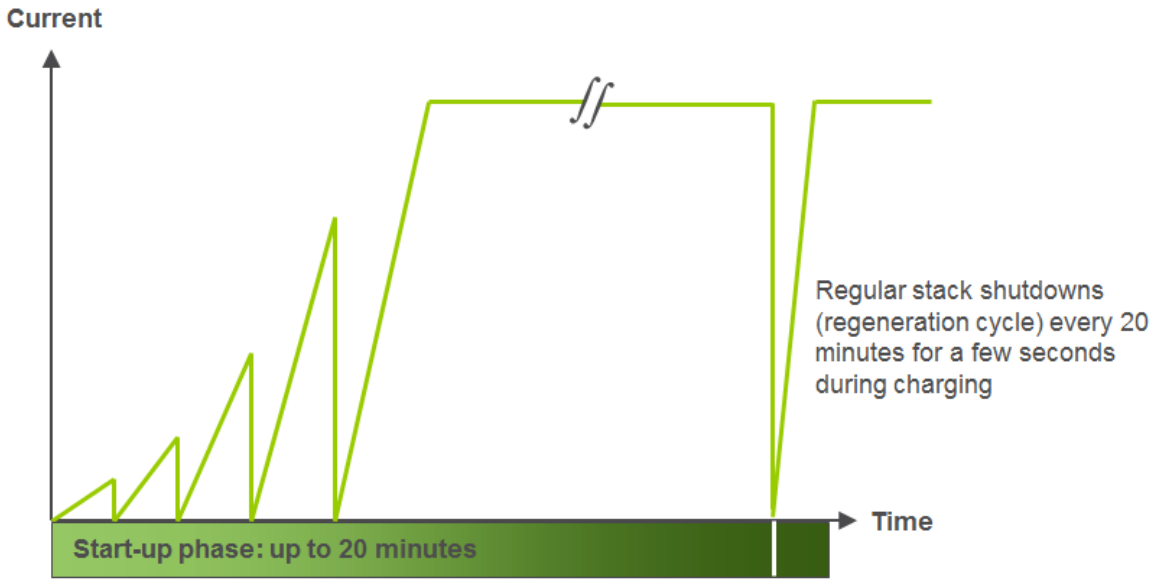
4.7 Default Parameters of cutoff threshold

New charging strategy (firmware 9.20 since mid of August 2010):

- Switch on voltage: 12.3 V (11.0 - 13.0 V)
- Switch off voltage: 14.2 V (13.5 - 14.7)
- Switch off current: 2 A / 4 A @ EFOY Pro 2200 (0.5 - 10 A)
- Switch off time: 3 hours (0 - 5 hours)
- This ensures full battery charging and maximizes battery life

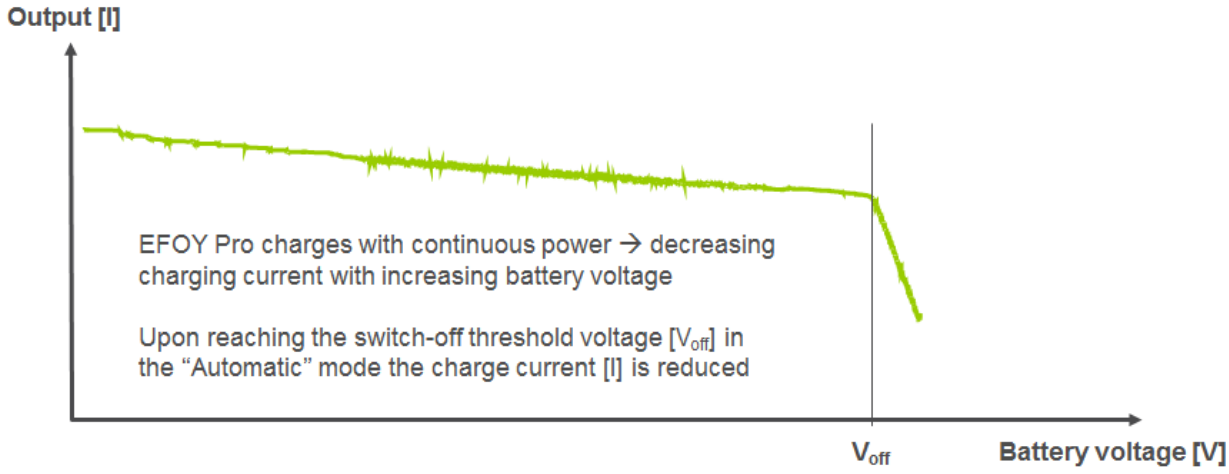


4.8 Startup and Shutdown Phases



Note:

- Device needs a start-up phase of 10 -20 min to achieve full power
- During start-up phase several starts until full power is achieved



End of charging

- The switch-off process allows a controlled disconnection of the EFOY Pro Fuel Cell
- The switch-off process may take up to 30 minutes
- Avoid interrupting the switch-off process!

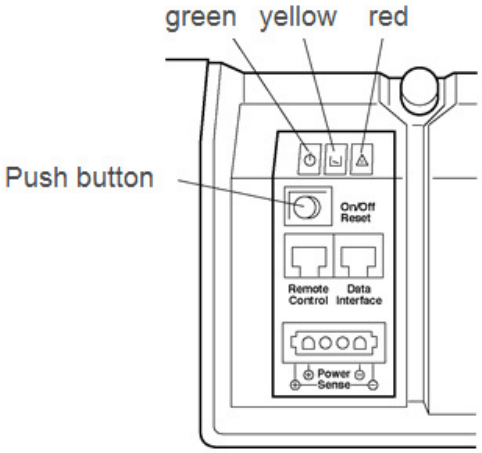
4.9 Anti–Freeze Protection Mode

- Note that the Hybrid Light Tower is heavily insulated to ensure that the system works in cold temperatures.
- THE ANTI-FREEZE PROTECTION MODE WILL NOT WORK WITHOUT FUEL! Please ensure that the fuel cell does not run out of methanol in freezing temperatures. If the fuel cell freezes, 24 hours will be required for the fuel cell to warm back up and be returned to service.
- The Anti-Freeze Mode will keep the EFOY Pro warm while the temperature is below 5^{o}C (This will work even when the unit is “OFF”).
- Anti-Freeze Mode requires the connection to a faultless, adequately charged battery and fuel cartridge.
- Fuel consumption will be dependent upon external temperature differential. Weather, insufficient insulation, ambient temperature and operating mode can have an impact on fuel consumption.
- The EFOY Pro does not give the produced energy to a fully charged battery in Anti-Freeze Mode. Rather, the stack “burns” methanol and supplies the peripheries (pumps, etc…) to heat up the system. The batteries will not be overcharged.
- Startup temperature (when the Anti-Freeze Mode has not been activated) is 5 ^{o}C.

4.10 Operation at the Device

Push button

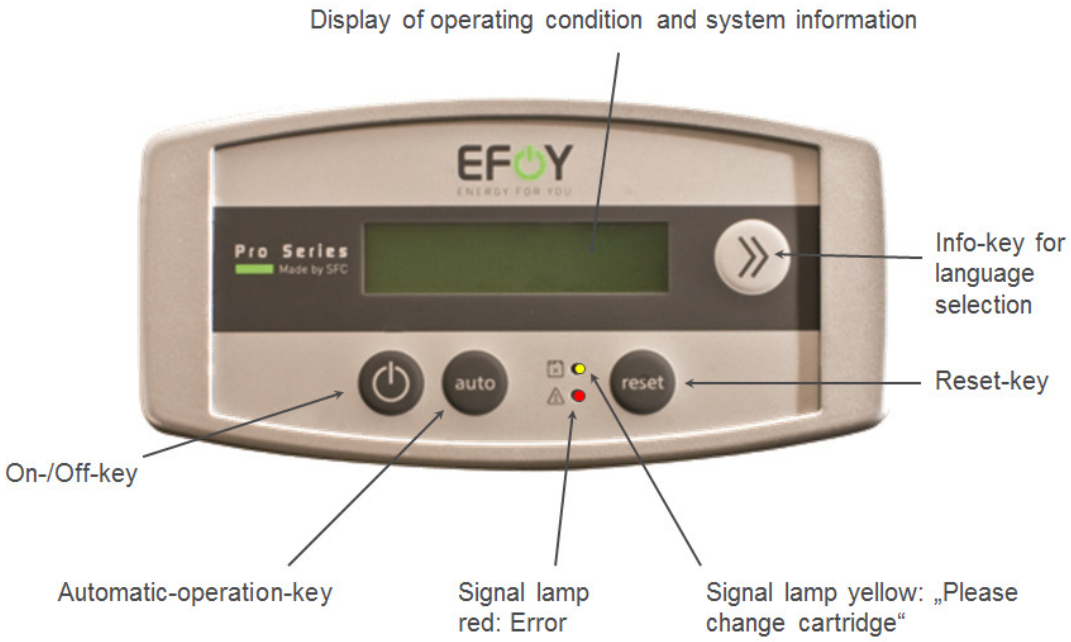
	Result
Push shortly (< 0.5 s)	Reset
Push longer (> 3 s)	On/Off



LED state

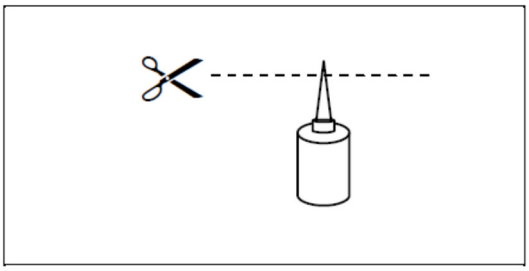
	Green	Yellow	Red
On	Ready	Add service fluid	Error
Blinking	Shutting down	Cartridge empty	Interruption
Off	Off or error	No error	

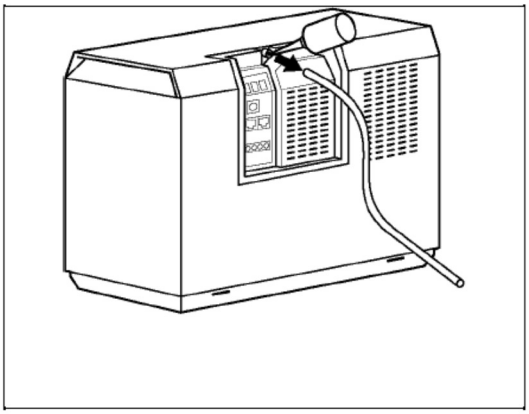
Remote Control:



4.11 Service Fluid

- If service fluid is low the yellow light will turn on at the EFOY Pro and the message “Please refill service fluid” will appear at the control panel display.
- Normally, there is no need to add service fluid prior to the initial start-up.
- Note that the fuel cell produces its own service fluid during operation. This is critical to the function of the device. If the EFOY Pro is operated continuously at temperatures above the acceptable operating range (45 °C), the service fluid will be expelled faster than it can be regenerated and cause a failure. For this reason, it is critical that the thermostat and fan provided with the Fuel Cell Power Package are maintained in working order and set at an appropriate temperature.
- Service fluid can be added by removing the exhaust line as pictured below.





Section 5 Error Messages

5.1 Error Classifications Ranges

- 10 Internal hardware or firmware issue - Contact Ensol Systems.
- 20 Fuel - Change the cartridge and reset.
- 30 Service Fluid - Add service fluid and reset. Check thermostat and fan function.
- 40 Environmental Issue – Temperature too high or too low to maintain function.
- 50 Battery - Battery voltage too high or low. Check connections. Check solar charge controller.
- 70 Reservoir - Internal fuel problem. Check fuel connections and reset.
- 80 System - Internal voltage or system error. Reset.

5.2 Error Types

- A = Automatic reset (after error cause is remedied)
- M = Manual user intervention required
- F = Anti-freeze protection is possible from this error, if the error cause currently no longer exists
- P = Permanent error (not resettable)
- R = Reset required to restart system
- W = Warning

5.3 Most Common Error Messages

- 12, 13, 14 - Failure due to blocking of exhaust or circulation pump defect.
- 32, 31, 30, 41 - Failure due to high surrounding temperature. Check installation and ensure air circulation is adequate.
- 52-54 - Check battery (voltage too low) and/or battery connection problem
- 72, 76 - Failure in Methanol dosing or internal sensors. Possible issues in Methanol cartridge because of fuel line.

Display message	Error code	error type	Error description	Remedial measure	Potential error causes	Notes
Please contact service	1	P	System configuration incomplete	Repair by SFC required	Firmware update failed	
	10	P	Serious system error	Repair by SFC required	Stack damaged	
	15	P				
Please contact service	13	A (1x / 30s) R F	Stack power output too low	Press RESET (max. 3 attempts), repair required if error reoccurs	Hardware defect	
	14	A (1x / 30s) R F	Fluid level sensor defect			
	17	R F	Abnormal power difference between stack and output			
Please check exhaust hose	11	A (1x /30s) R F	Stack voltage too low (error 11: during operation, error 18: during start-up)	Solve potential error cause, then press RESET (max. 3 attempts)	Exhaust hose blocked, not sufficient fresh air	Test: disconnect exhaust hose and press "Reset", if fuel cell is now running the exhaust hose is blocked
	18	A (3x / 300s) R F				
Please change fuel cartridge	20	M R F	Empty fuel cartridge detected (internal fuel sensor)	Change fuel cartridge (solve error cause) then press RESET	Error causes if fuel cartridge not empty: - Bad connection of fuel cartridge connector (air leak) - Dirty fuel cartridge connector	
	22	M R F				
Please refill service fluid	30	M R F	Low service fluid level (error 30: <20%, error 31: <5%)	Add service fluid (solve potential error causes) then press RESET	- Operation at high ambient temperatures or insufficient cooling air	
	31	M R F			- Fluid level measurement defect	
Interruption: Surroundings too warm	32	A F	Service fluid level below 40%	Wait (until temperature has dropped)	-Ambient temperature to high (avoid direct sunlight) - Poor air ventilation in installation space	
	41	A F	Temparature to high (internal sensor)			
Interruption: Please defrost device slowly	40	A M	Temperature too low (stack temperature sensor < 3 °C)	Defrost unit (ca. 24 h at room temperature)	- Anti-freeze protection did not work (due to an error)	
Please check battery voltage	50	A F T	Battery voltage too low (sense line)	Solve error cause (check battery and connections)	Battery voltage < 10,5 / 21 V -> charge with battery charger	
	51	A	Battery voltage too high (sense line)		Battery voltage > 16,5 / 33 V -> check external battery charger and disconnect if necessary	
	52	A	Batttery voltage too low (power line)		Check connection to battery: - Check battery cables - Check battery fuses	
	53	A	Battery voltage too high (power line)			
Please contact service	54	A	Battery voltage measurement defect	If the error persists a repair is required	Circuit Board defect	
	70	R	Error fuel reservoir sensors	Press RESET (max. 3 attempts), repair required if error reoccurs		
	73	R	Internal fuel sensor defect			
	75	R	Reservoir error (emptying time too long)			
	80	R	Internal voltage reference out of tolerance			
	83	R	DC/DC-Transformer defect			
	84	R A	Self test equipment			
	76	P	Serious reservoir error	Permanent error - repair required	- Error 70 or error 72 reoccurred 3 times	

Please check fuel cartridge connector	72	A M F R	**Reservoir error (refilling time too long)**	**Solve potential error cause,** then press RESET (max. 3 attempts)	**- Firmware problem (FW <9.11)** - Bad connection of fuel cartridge connector (pumps air) - Dirty fuel cartridge connector	Firmware update recommended (fixed with FW 9.11 or higher)
Please install Filter XT	38	W	**Filter EFOY XT is removed**	**install Filter**		only EFOY 2200 XT
Please contact service	85	R	**Filter-Circuit-Board EFOY XT not detected**	**Press RESET (max. 3 attempts), repair required if error reoccurs**		only EFOY 2200 XT
no display information	137	A	**Filter change confirmed**	**no action required**		only EFOY 2200 XT
Please change Filter XT	139	M	**Filter change is displayed**	**change Filter EFOY XT**		only EFOY 2200 XT
no display information	90	A	**Antifreezemode successfully**	**no action required**		
Update: DO NOT UNPLUG BATTERY	99	A	**Firmware update is performed**	**not interrupt firmware update**		
no display information	140	A	**Antifreezemode not possible**	**fix other error**	**another error is blocking the antifreezemode**	
no display information	172	A	**Error 72 was once ignored**	**no action required**		
no display information	184	A	**Self test equipment successfully**	**no action required**		
Firmware corrupt update required	without	A	**transfer defective firmware**	**repeate firmware-update**		
No connect or Check battery	without		**Remote control has no connection to fuel cell**	**Check connection, load battery if necessary**	- Remote control is connected to wrong port (Data Interface) - Batter voltage < 8,5 V - No communication (defect)	

Appendix A Drawings

Drawing Number	Description
HACS-4400-201	Piping & Instrumentation Diagram
HACS-4400-500	Recommended Installation Details
HACS-4400-501	Enclosure Layout Details
HACS-4400-601	Electrical System Wiring Schematic
HACS-4400-602	PLC Wiring Schematic
HACS-4400-603	Control Panel Backpan Details

Appendix B Vendor Manuals

Manufacturer	Description	Title
ASCO	PRESSURE TRANSDUCER	Instruction Manual
HORNER	PROGRAMMABLE LOGIC CONTROLLER	Instruction Manual
SWAN	AIR COMPRESSOR	Instruction Manual
TRISTAR	SOLAR CHARGE CONTROLLER	Instruction Manual
VAN AIR SYSTEMS	DESICCANT AIR DRYER	Instruction Manual