



ECO MARATHON PRESSURE REGULATOR

EMPR

USER GUIDE



SAFETY, HANDLING & SUPPORT

WARNING: *Failure to follow these safety instructions could result in gas leakage, injuries, damage to the Eco Marathon Pressure Regulator (EMPR) or other property. Read all the safety information below before using EMPR.*

Handling Handle EMPR with care. EMPR is not designed for extreme conditions, rough handling, vibration, shock or drop. Keep EMPR away from heat, flame, strong sunlight, water, dust, soil or mud. Do not use a damaged EMPR.

Repairing Do not troubleshoot, disassemble or tamper with EMPR. Do not attempt to repair or replace any component by yourself.

Hydrogen Follow all local rules and regulations for safe handling, storage and usage of Hydrogen gas. Do not smoke when operating EMPR. It is recommended to operate in a well ventilated environment.

Pressure Never operate beyond EMPR's rated inlet pressure of 350bar.

Connectors and ports Never force a connector into a port or apply excessive pressure. If the connector and port do not join with reasonable ease, they probably do not match. Check for obstructions and ensure that the connector matches the correct port.

High-consequence activities EMPR is a customized system with pending safety tests and certifications. It is not intended for use where the failure of the system could lead to death, personal injury or severe environmental damage.

Disclaimer Every effort has been made to ensure that the information in this manual is accurate. This manual serves to adequately recommend safe operating procedures, but shall not be treated as comprehensive. Do not use EMPR in any other way than the one recommended in this manual. Spectronik reserves the right to change system specifications, appearance or discontinue the product at any time.

Warranty Spectronik warrants the included hardware product and accessories against defects in materials and workmanship for 1 year after delivery. Spectronik does not warrant against normal wear and tear, nor damage caused by accident or abuse.

To obtain service, contact support@spectronik.com

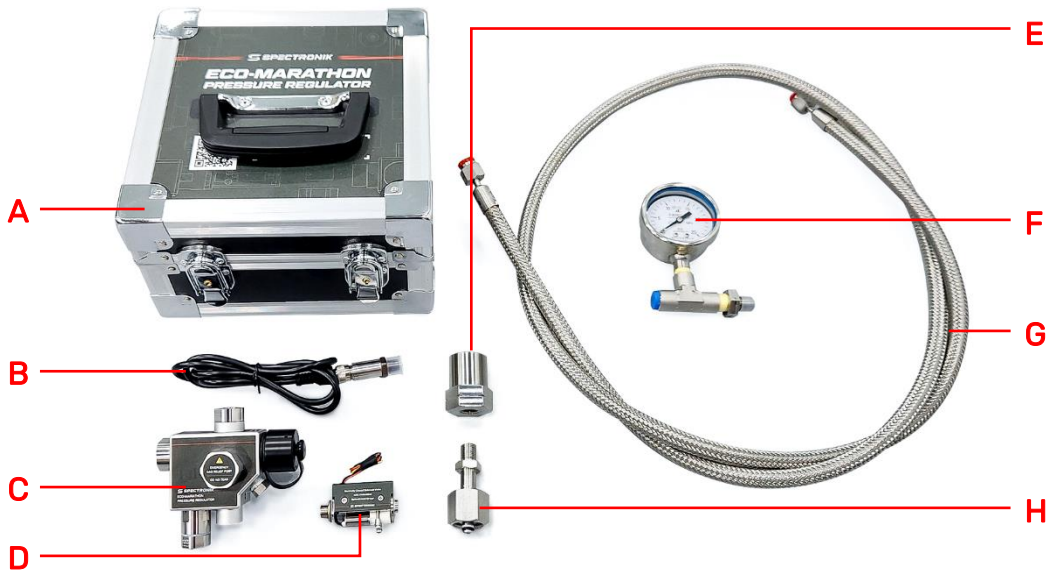
1 OVERVIEW

1.1 Eco Marathon Pressure Regulator

Eco Marathon Pressure Regulator (EMPR) is specially designed for teams taking part in the Hydrogen prototype and urban category Shell Eco Marathon competitions, with in-built smart and safety features including:

- **Two-stage pressure regulation with factory preset outlet:** Inlet up to 350bar and outlet of 0.5bar (factory adjustable). Inherently safe for fuel cell operation without the need for manual adjustment.
- **High flow-rate:** 36NLPM Hydrogen flow-rate capable of powering up to 3kW fuel cell.
- **Pressure relief devices:** thermal pressure relief device (TPRD), emergency relief valve and safety relief valve at the low pressure outlet ensure safe operation.
- **Ultra low-power high-flow solenoid valve:** Normally Closed (NC) solenoid valve for added safety, with a low operating continuous power consumption of 0.35W for fuel efficiency.
- **Gas pressure transducer:** live status monitoring of the remaining fuel pressure in the gas cylinder.

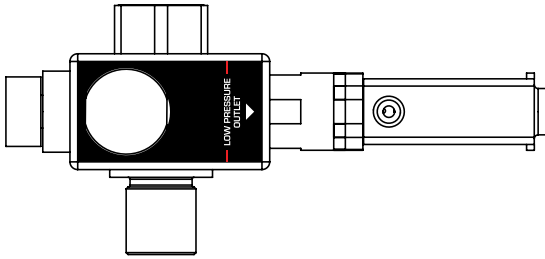
1.2 What's In The Box:



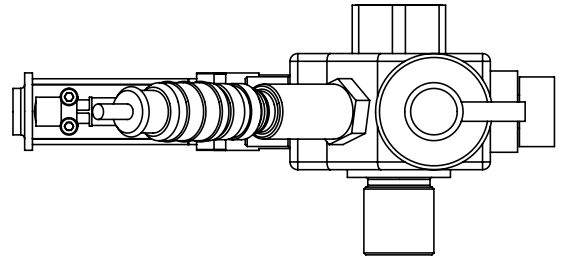
Item Description

A	Flight/storage case	E	Cylinder adapter
B	Gas pressure transducer	F	Refueling pressure gauge
C	EMPR	G	Stainless steel refueling hose
D	NC solenoid valve	H	Refueling adapter

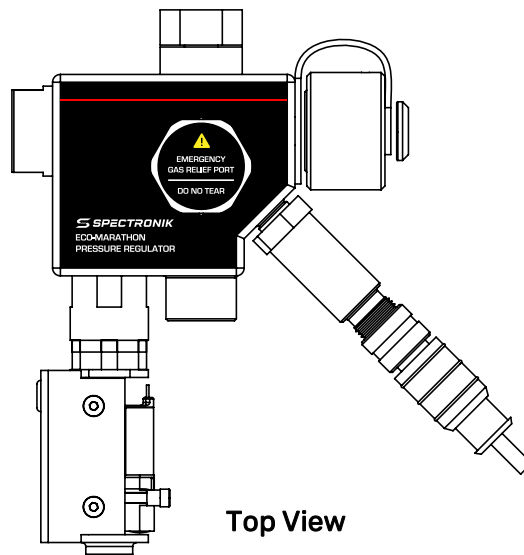
1.3 EMPR Overview



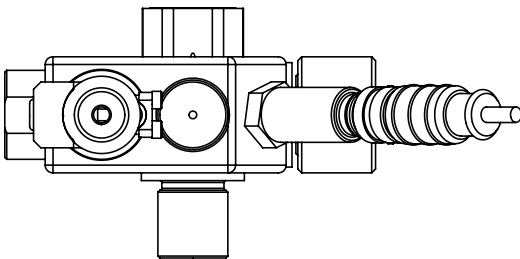
Left View



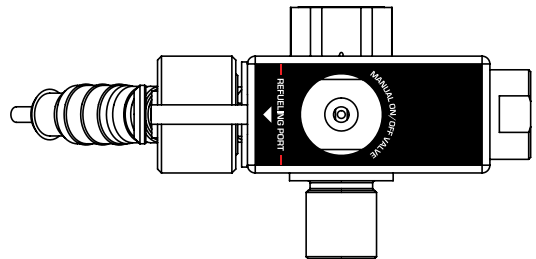
Right View



Top View

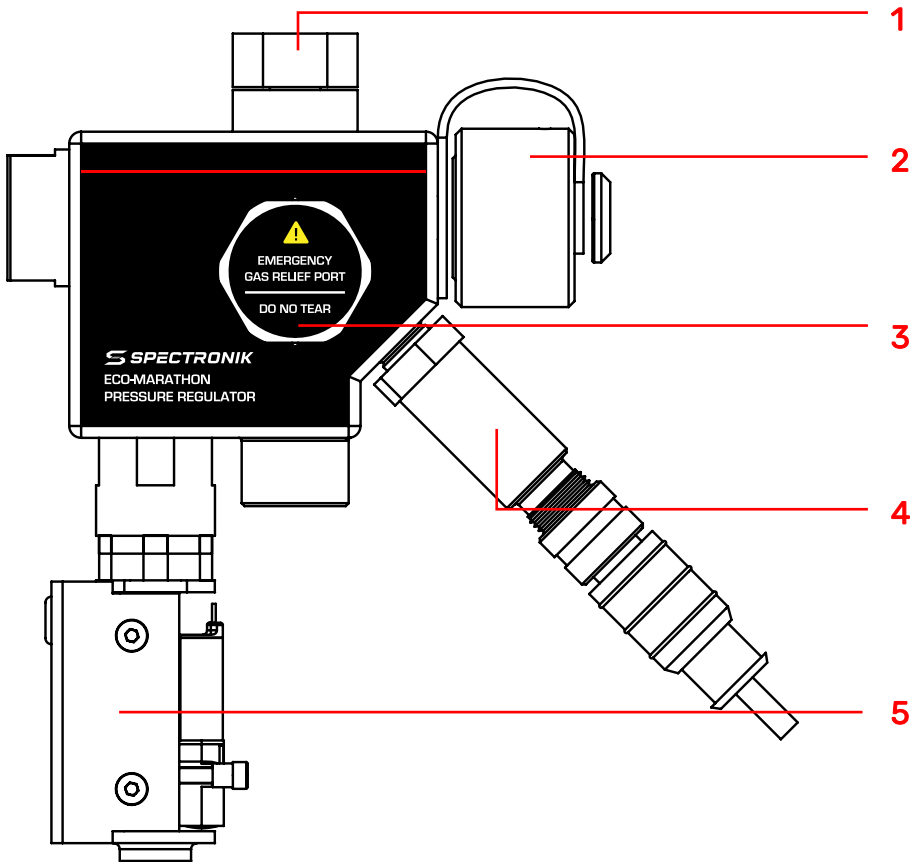


Front View



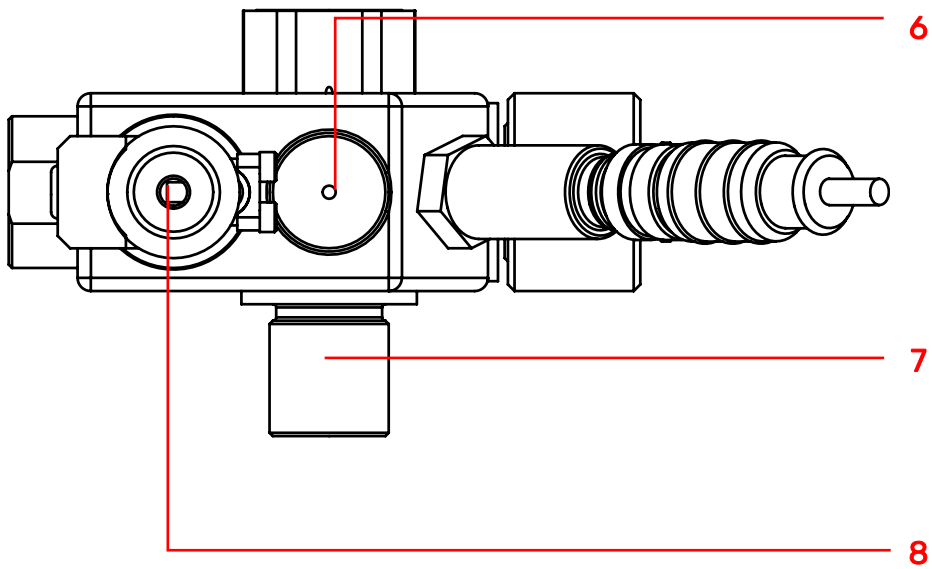
Back View

1.4 Features And Function



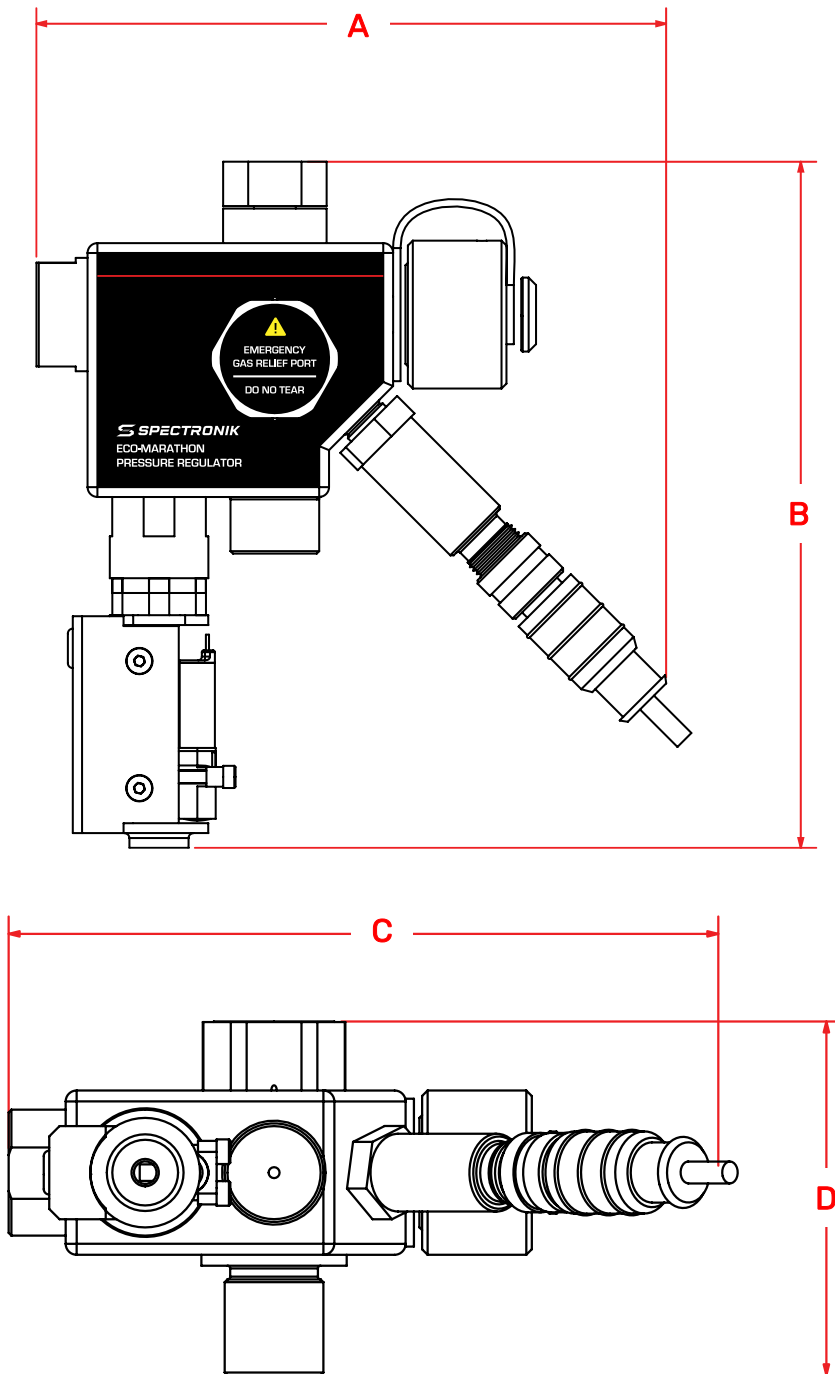
Feature	Function
1 Manual On/Off Valve	<ul style="list-style-type: none">Open/close the regulator using 5mm Allen Hex key
2 Refueling Port	<ul style="list-style-type: none">To connect to refueling hose for gas refillingIn-built one-directional safety valve
3 Emergency Relief Port	<ul style="list-style-type: none">For venting of gas in the event of mechanical failure
4 Gas Pressure Transducer	<ul style="list-style-type: none">Live status monitoring of remaining gas pressure in the cylinder
5 NC Solenoid Valve	<ul style="list-style-type: none">Open/close the low pressure outletCan be connected to a Hydrogen gas detector

1.4 Features And Function



Feature	Function
6 Thermal Pressure Relief Device (TPRD)	<ul style="list-style-type: none">▪ To vent gas pressure in the cylinder in the event of fire▪ Activated at 110°C
7 Connection to gas cylinder	<ul style="list-style-type: none">▪ To connect EMPR to gas cylinder thread M18 x 1.5▪ Cylinder adapter (NPT1/4) can also be used
8 Low pressure gas outlet connector	<ul style="list-style-type: none">▪ To supply low pressure gas to fuel cell▪ M5 female

1.5 Dimensions



Dimensions in mm

A 127.80

C 129.41

B 139.20

D 64.60

2 SPECIFICATIONS

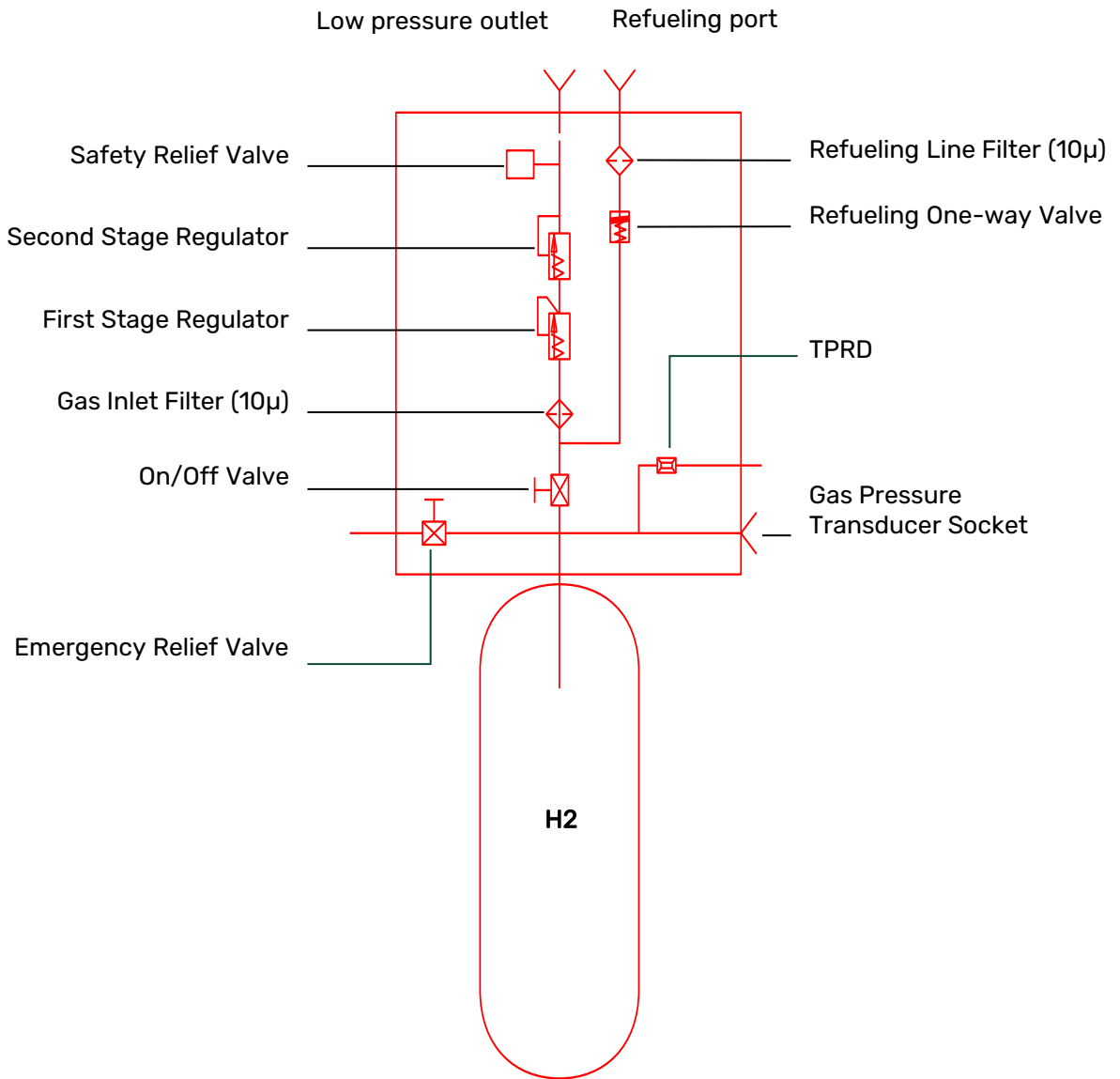
2.1 Eco Marathon Pressure Regulator

Gas media	Hydrogen, Nitrogen
Rated inlet pressure	350bar (35MPa)
Gas outlet pressure (@ rated flow)	0.45-0.75bar (factory set during order)
Max outlet pressure (@ zero flow)	Gas outlet pressure + 0.3bar
Low pressure safety relief valve	3bar (factory set during order)
Rated operating flow rate	36NLPM
Operating temperature	[-20,45]°C
Dimension	132 x 128 x 65 mm
Weight	590g

2.2 Connection Sizes

Connection to gas cylinder	M18 x 1.5
Cylinder adapter	M18 x 1.5 to NPT ¼ female
Refueling port	M22 x 2
Refueling adapter	M22 x 2 (to EMPR) M12 x 1.25 (to stainless steel refueling hose)
Stainless steel refueling hose	M12 x 1.25
Refueling pressure gauge	M12 x 1.25 (to stainless steel refueling hose) NPT ¼ female (to user's Hydrogen source)
NC Solenoid Valve	G1/8 (to EMPR) M5 female (low pressure gas outlet)
Gas pressure transducer	NPT 1/8 (to EMPR) M12 x 1 (to data transmission cable)

2.3 Schematic Diagram

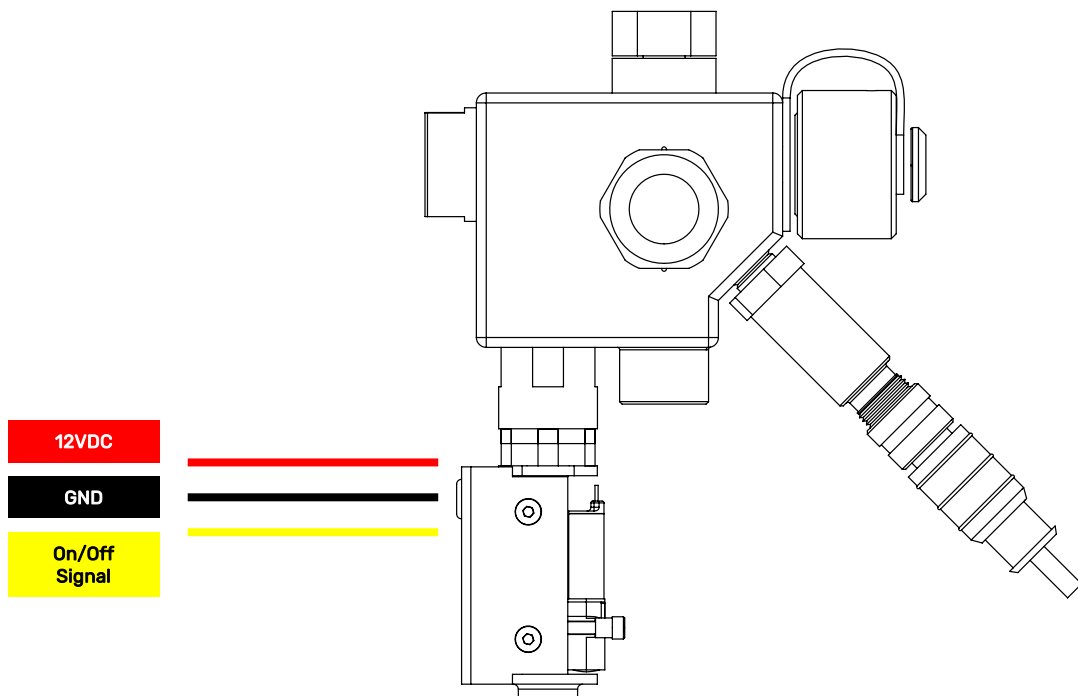


3 NORMALLY-CLOSED (NC) SOLENOID VALVE

3.1 Notes on the NC Solenoid Valve

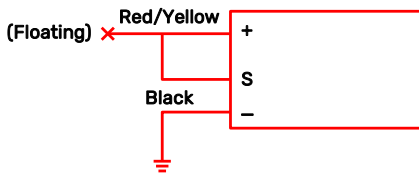
- NC Solenoid Valve is useful as it blocks the low pressure outlet gas supply to the fuel cell unless intentionally instructed to open via the On/Off signal.
- Shell Eco Marathon competition rules also mandate that the NC Solenoid Valve's On/Off signal shall be connected to a Hydrogen gas detector, to turn off the gas supply in the event of Hydrogen gas leakage.
- While it is highly recommended, the usage of NC Solenoid Valve for other applications is optional, and it can be detached from the EMPR should the user wishes to do so.
- Please note that while the EMPR is capable of delivering up to 36NLPM flowrate, it will ultimately be limited by the NC Solenoid Valve – which in this case will be 15NLPM, sufficient for most Eco Marathon use cases where the fuel cell power is below 1kW.
- The NC Solenoid Valve has an embedded Spike-&-Hold driver to reduce the holding voltage to 3.3VDC after the initial 12VDC to turn on the valve. This allows minimum power consumption of 350mW.
- User can change to other solenoid valves, such as Spectronik's Highflow Miniature Valve Module, for other applications which require higher flowrate.

3.2 Setting up the NC Solenoid Valve

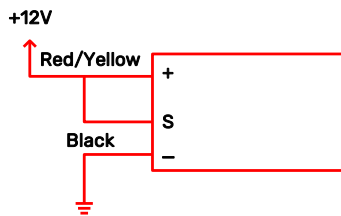


3.3 2-Wire Operation

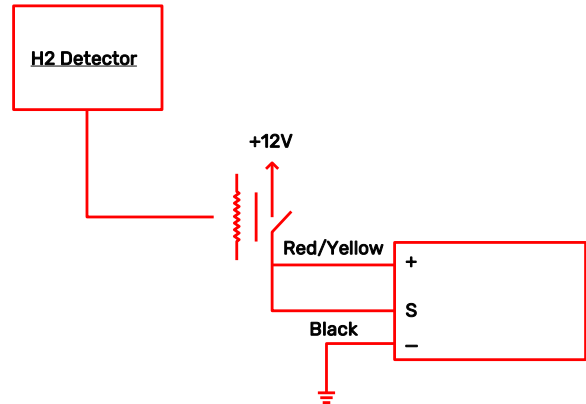
OFF:



ON:

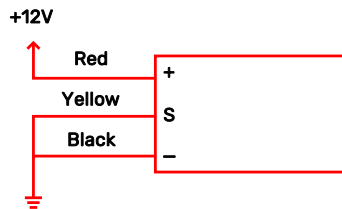


H2 Detector:

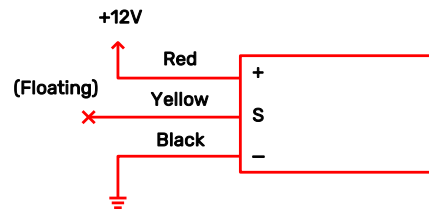


3.4 3-Wire Operation

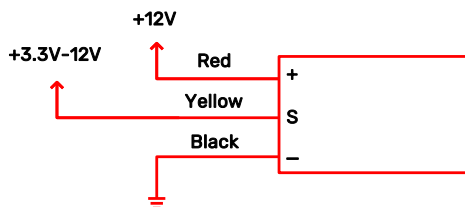
OFF:



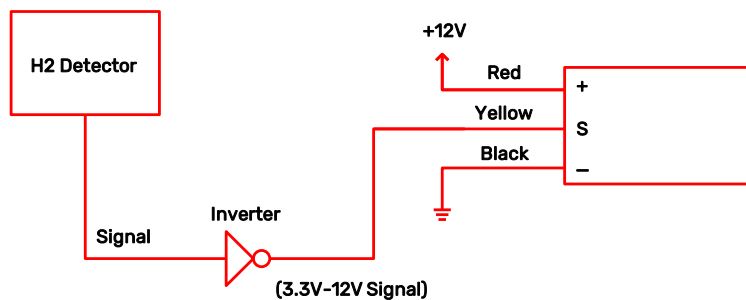
OR



ON:



H2 Detector:



4 GAS PRESSURE TRANSDUCER

4.1 Features and Applications

- Stainless steel 316 body
- Welded configuration without sealing o-rings
- 10-90% proportional voltage output
- Voltage reversal protection
- Hydrogen gas pressure measurement
- Hydraulic system pressure measurement

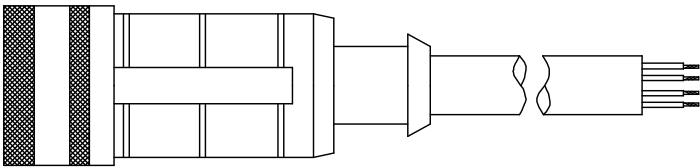
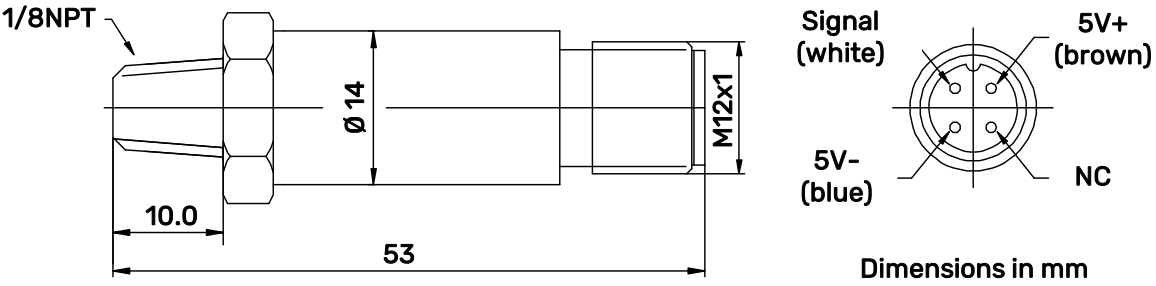
4.2 Technical Specifications

• Pressure range:	0-50 MPaG
• Output voltage (I _o):	0.5-4.5VDC
• Precision (including non-linearity, hysteresis, repeatability and calibration error, 25°C and V _{cc} 24VDC):	+/- 0.5% F.S.
• Long term stability:	+/- 0.25% F.S. per year
• Pressure cycling:	>= 5 x 10 ⁶
• Operating temperature:	-40 to 120°C
• Storage temperature:	-40 to 105°C
• Over pressure:	1.5X
• Burst pressure:	2X
• Response time:	10ms
• Supply voltage (V _{cc}):	4.75-5.25VDC
• Output load resistance:	>= 10k.ohm
• Over voltage:	16VDC
• Reverse over voltage:	-16VDC
• Insulation resistance:	>= 20M.ohm @ 100VDC
• Ingress protection:	IP65
• Vibration:	X/Y/Z, 20g, sine 11ms
• Shock:	10g, 5-2000Hz

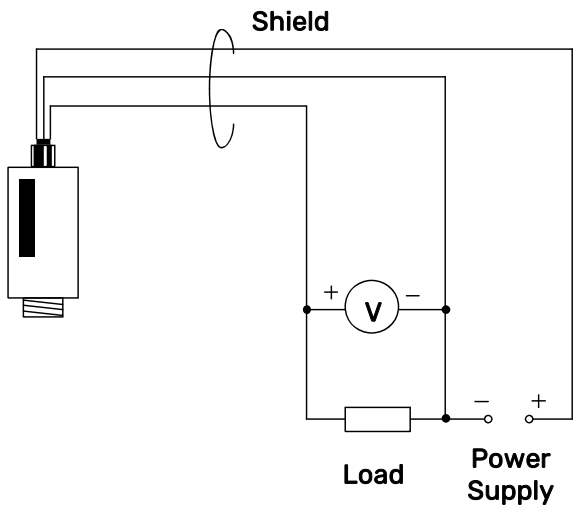
4.3	Notes
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- Ensure that all system connections are secure and leak free. Hydrogen leakage may cause fire or explosion in extreme cases.
- If the pressure port of the transducer is blocked by a foreign object, do not use a sharp tool to clear the passage. It is recommended to dissolve the foreign object in a solvent instead.
- Do not tamper with the device. Contact us for re-calibration purposes.

4.4 Pin Definition



4.5 Pin Definition



5 OPERATING PROCEDURES

5.1 Setting Up EMPR

1. Visually check EMPR for obvious cracks or other physical damage.

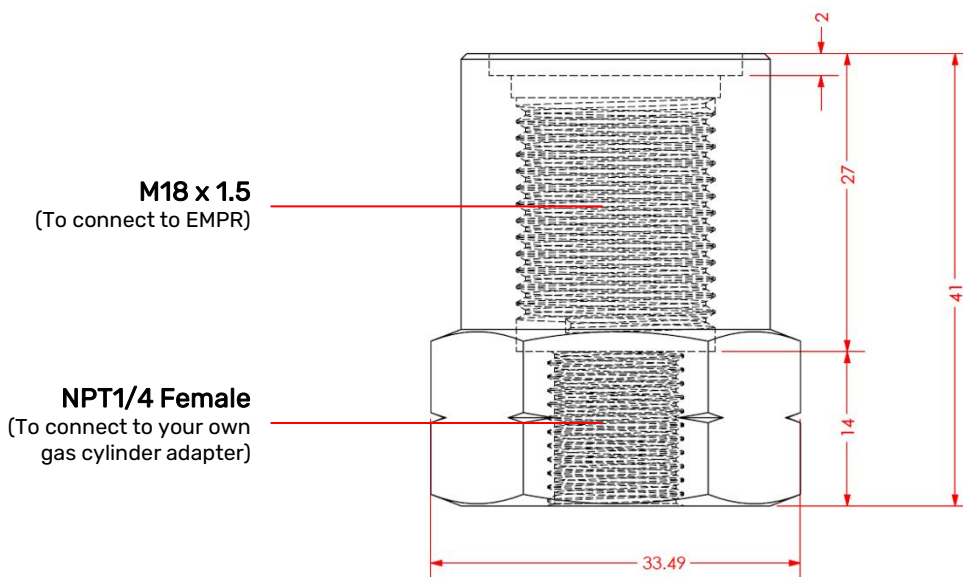
Warning: never use a faulty regulator.

2. Prepare the necessary wiring of the Gas pressure transducer (B) by following the wiring diagram in Section 4. Keep the pressure transducer port sealing plug in the flight/storage case to prevent losing it.
3. Connect the NC Solenoid Valve (D) securely to the EMPR. Prepare the necessary wiring by following the 2-wire or 3-wire operation diagram in Section 3. Connect your desired gas output connector to the Low pressure gas outlet connector (8).

Warning: the Manual On/Off Valve (1) is opened by factory default because it is assumed that you will use the NC Solenoid Valve. If you do not use the NC Solenoid Valve, please block the G1/8 port on the EMPR that is linked to the NC Solenoid Valve. Otherwise, the low pressure gas will flow out all the time.

4. Finally, screw the EMPR into your empty gas cylinder by manually turning the M18 x 1.5 threaded Connection to gas cylinder (7) into its corresponding female socket at the cylinder neck. There is no need to apply excessive force at the end of the turns. Your gas cylinder is now ready for gas filling. **Note:** an ID16 CS3 Viton O-ring (provided) may or may not be needed depending on your gas cylinder thread design.

Tip: If your empty gas cylinder has a different connection type, you may use the Cylinder adapter (E) which has a NPT1/4 female socket for you to connect your own adapter that matches your gas cylinder.



Cylinder adapter (E), dimension in mm

5.2 Filling the Gas Cylinder

1. Connect the Refueling Adapter (H) to the Refueling Pressure Gauge (F) via the Stainless Steel Refueling Hose (G). Then, connect the Refueling Adapter to the EMPR's Refueling Port (2).
2. The Refueling Pressure Gauge has a NPT ¼ female port to receive your incoming Hydrogen source. Prepare the necessary adapter to link your Hydrogen source to this port. This adapter is not provided due to the different connector standards of Hydrogen source cylinders worldwide.

Warning: the pressure gauge provided has a maximum pressure of 25MPa. It is assumed that the Hydrogen source will be standard industrial steel cylinder with pressure of less than 20MPa and that filling the empty gas cylinder will be by means of pressure cascade. If you are connecting directly to a gas booster pump or higher source pressures, change the pressure gauge or bypass it completely. **At any time, do not operate higher than 35MPa.**

3. When the entire connection from your Hydrogen source to the EMPR's Refueling Port has been established, turn on your Hydrogen source. Hissing sound can be heard as gas rushes in from the source into the empty gas cylinder. Leave it for some time for the pressure in the source and cylinder to reach equilibrium.
4. If you are using a gas booster pump, it can now be turned on.
5. EMPR has an in-built one-directional safety valve to prevent gas from flowing back into the source. At the end of refueling, turn off your Hydrogen source and vent the remaining gas in the Stainless Steel Refueling Hose. Then, disconnect the Refueling adapter from EMPR and close the Refueling Port using its cap.
6. The filled gas cylinder is now ready for usage.

5.3 Using The Filled Gas Cylinder

1. Connect your gas tubing to the Low pressure gas outlet connector (8) of the NC Solenoid Valve.
2. Activate the NC Solenoid Valve by giving it an ON signal. Gas will now flow out of the low pressure outlet.
3. To turn off the gas, send an OFF signal to the NC Solenoid Valve.

Tip: keep a 5mm Allen Hex key accessible at all times. If the NC Solenoid Valve fails, gas may leak out of the low pressure outlet. Close the Manual On/Off Valve (1) by using the Allen key to turn it clockwise.

Reminder

- Wear safety goggles and gloves at all times.
- Ensure connections are firm and secure, but do not use excessive force to over-tighten.
- Never operate EMPR at inlet pressure beyond 350bar.
- Gas cylinder may become warm when filled with Hydrogen gas. Never fill a gas cylinder too quickly. If you are using a booster pump, it is advisable to pause the filling process every 30-50bar to prevent over temperature.

5.4 Storage

When not in use, keep EMPR in its original Flight/storage case and store it in a cool, dry place.