

# Fuel Enhancement System<sup>®</sup> Installation & Operation Manual with Safety Instructions



For 12V or 24V Engines

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**Attention`**

Installation of the **Fuel Enhancement System** must be carried out exclusively by mechanics trained and certified by Empire Hydrogen. All installation work must be performed by licensed professionals who have received specific training from Empire Hydrogen on proper procedures and hydrogen safety protocols. Installation by untrained or unauthorized individuals may result in engine or vehicle damage and poses significant safety risks, including the potential for hydrogen-related explosions that could lead to serious injury or death.

**COLD WEATHER CONDITIONS**

If the temperature drops below -30°C, completely drain the system of water or store the equipment in a heated area to prevent damage.

# Fuel Enhancement System<sup>®</sup>

## Installation & Operation Manual

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## Installation Overview:

1. Order a 12V or 24V Empire Hydrogen Fuel Enhancement System (FES) according to the engine operating voltage.
2. Take proper safety precautions.
3. Choose a position on the equipment for the FES installation (pg. 8)
4. Build an L bracket or frame to hold the FES securely in place on the equipment. (pg. 10)
5. Mount the frame and FES using bolts, rubber engine mounts or cable springs as necessary.
6. Run 6 gauge wire from the engine battery to the FES. Install a 80 Amp breaker on the positive wire. Cover with wire loom and secure with cable ties. (pg. 11)
7. Detach the air intake manifold and drill a hole behind the air filter, at a distance of 12 to 16 inches from the turbocharger. Insert the provided threaded bent pipe from the Fuel Enhancement System (FES), ensuring the bend is directed toward the turbocharger. (See page 14 for reference)
8. Run a 3/8" rubber fuel line from the FES to the air intake manifold. Use hose clamps to secure the fuel line to the FES and threaded bent pipe. Secure it with cable ties.
9. Wearing rubber gloves and eye protection, mix the supplied KOH chemical with distilled water (4 litres of water for a single tank FES and 8 litres of water for a dual tank FES. Pour the solution into each reservoir using a funnel .Fill to the upper line on the tank. until to the upper blue line. Close the lids tight. (pg. 15)
10. Start the engine. The FES should start to bubble within 30 seconds.

## Operator's Responsibilities and Information

1. A **Steady Green Light** on the outside of the cabinet indicates that the Fuel Enhancement System is operating properly. This green light must turn off when the engine is shut off.
2. A **Flashing Green Light** indicates that the water level is low and must be replenished. Flashing may also indicate system not ready.
2. Fill tanks to a maximum of the upper limit line with **DISTILLED WATER** only. **An LED** will illuminate when upper limit line is reached – Do Not Over Fill. If over filling occurs drain the solution until at the upper limit line.
3. The Fuel Enhancement System internal dryer/blowback unit has an automatic drain valve that will open when the FES is not operating. This will drain a small amount of water onto the ground.
4. Ensure Winter Switch is ON when temperature goes below 0°C.
5. Drain the system completely below -30°C or park the truck in a heated area.
6. To turn the unit off completely, press the **red (Off)** button on the circuit breaker connected close to the engine battery. Rotate the yellow lever out of sight to turn the system back on. Do Not Turn Off Below 0°C without draining the system.

\*\*\*\*\***WARNING**\*\*\*\*\*

 NO SMOKING  NO SPARKS  NO OPEN FLAMES

**Keep Away from The System Cabinet At All Times.**

## **Hydrogen Safety Guidelines**

**Please read these important Hydrogen (H<sub>2</sub>) and Oxygen (O<sub>2</sub>) safety facts**

1. Hydrogen burns hotter and faster than any other gas, about 10 times faster than gasoline.
2. A hydrogen flame is nearly invisible, and slightly blue.
3. Hydrogen is an odorless and colorless gas and is non-toxic.
4. Hydrogen burns / explodes very fast at concentrations as little as 4% hydrogen in air, and as high as 95% concentration.
5. Do not allow any ignition source such as a cigarette, electrical or grinding spark, or flame near the Fuel Enhancement System.
6. Platinum (such as platinum jewelry or a platinum sparkplug) is a powerful catalyst for hydrogen and will ignite hydrogen on contact, as if platinum was a flame. No spark or flame is required for platinum to ignite hydrogen instantly.
7. When as little as a cup of hydrogen is ignited, it creates a very loud bang or concussion that can permanently damage hearing of nearby people.
8. Burning hydrogen creates H<sub>2</sub>O (pure water) in the form of ultra-hot steam and plasma (flame).
9. Refer to a Hydrogen Material Safety Data Sheet (MSDS) for more safety information.



## Step by Step Installation Procedures

### **IMPORTANT:**

The Empire Hydrogen Fuel Enhancement System (“FES”) is a vital component, integrated into the normal operation of a diesel engine. As such, the FES **MUST** be installed or removed by a fully qualified and licensed mechanic with expertise on the engine in question, and who has been trained by Empire Hydrogen on the installation and removal procedures. The use of unqualified or untrained technicians for the installation or removal of the FES could lead to damage to the engine and will void the Empire Hydrogen or engine warranty.

### **Introduction**

The FES converts distilled water into hydrogen and oxygen gases that flow to a diesel engines air intake and into the cylinders. Hydrogen burns ten times faster than diesel. The result is a faster and more efficient ignition of the diesel fuel with reduced fuel consumption, harmful emissions and greenhouse gases.

Note that catalytic convertors and Diesel Particulate Filters (DPF) burn or collect exhausted fuel after it leaves the engine cylinder, where no automotive benefit is gained. Empire’s Fuel Enhancement System burns fuel more efficiently during the power stroke, so there is less unburned fuel going out the exhaust pipe. Empire’s Fuel Enhancement System target market is large diesel trucks with engines in the range of 12 to 16 litres. The FES cost can typically be amortized usually in less than a year.

## Planning The Mounting Location



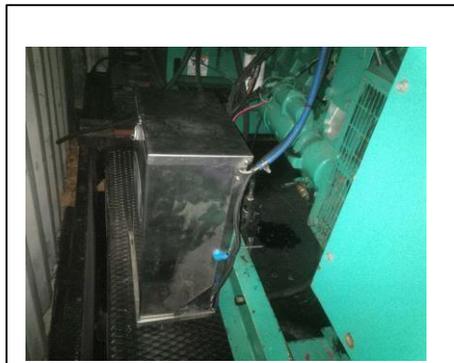
**Figure 1, Cab-mounted Fuel Enhancement System®**

The FES requires a sturdy mounting to the truck. It must be out of the way of moving parts, hot exhaust components, and not exposed to colliding with objects passing near the truck. Provide adequate ground clearance. Provide room above the FES for refilling distilled water and system servicing. Also, leave room to open the front panel of the system.

Plan the following:

- Route the 12V or 24V electrical power cables (using #6 gauge wire) from the engine battery to the Fuel Enhancement System (FES).
- Route the hydrogen rubber fuel line from the FES to the engine air intake.
- Install the system in an easily accessible location to allow for routine servicing.
- Ensure installation is positioned away from any potential water spray from the vehicle's wheels.

Sample Installation Photos



## Mounting Bracket Installation

The FES requires a mounting bracket, suitable for the position and type of installation. Typically, an L shaped bracket is used to support the back and bottom of the FES. It should allow for convenient access and removal of the FES for servicing.

Trucks experience significant vibration and the FES is heavy. It may be necessary to protect the FES from vibration by use of rubber engine mount cushions or cable springs. It is imperative that lock washers are used with all mounting nuts.

In all cases, it is important to be able to access the Fuel Enhancement System for servicing. The top must be accessible for adding water. The front must be accessible for cover removal and servicing.



## Warning

**Do Not drill or weld to a tempered-steel truck chassis,**  
as this may void the truck warranty and cause the truck  
chassis to structurally fail.

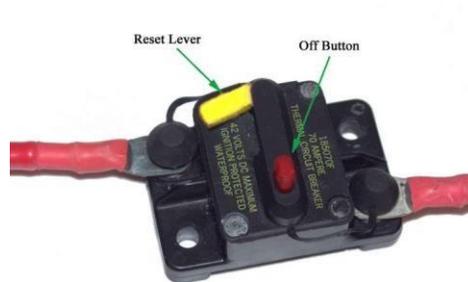
## Electrical Wiring & Circuit Breaker Set Up

The Fuel Enhancement System requires up to 40 Amps of electrical current from the engine alternator. There must be enough current capacity from the alternator to handle normal electrical loads plus the FES load, plus a reserve margin so the alternator does not overheat.

Ensure correct wire gauge for the wire-run between the battery and the Fuel Enhancement System<sup>®</sup>:

### **#6 AWG (Used for Typical Installations)**

If too small of a wire gauge is used, the wire will overheat and may create a fire risk. Use only red-coloured wire for the +12 Volt circuit, and black-coloured wire for the negative 12 Volt (also called vehicle ground) circuit. Do not use the truck's chassis as a ground conductor for the FES, as the current is too high. Insert the wires into plastic split loom as shown below.



### **Circuit Breaker**

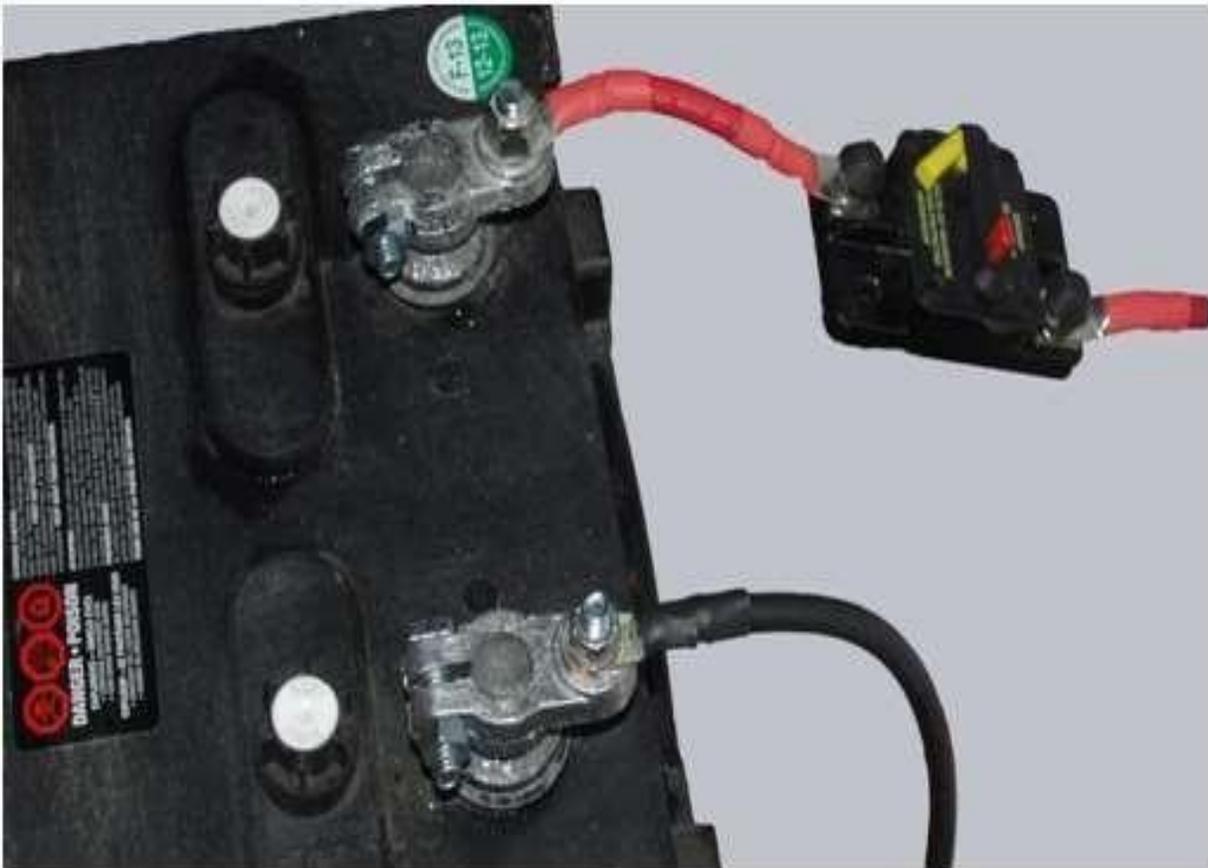
An 80 Amp circuit breaker (above) is required to protect the wiring from being overloaded. The circuit breaker is installed at the battery end of the positive wire. In the event of a short circuit event, the circuit breaker will shut off and protect the wiring and prevent a fire.

### **Important**

Protect all wires from chafing, moving surfaces, and hot exhaust surfaces. Also, keep wires from interfering with vehicle mechanisms such as brakes, drive shaft, and engine controls. Wires must also be protected from road gravel and tire-tread debris.

## Battery Connections

Check that each battery connection is attached to the proper battery post. Polarity is critically important to prevent destruction of the FES electronics. The black #6 AWG wire always connects to the negative post of the battery. See picture below. Verify this every time by looking at the battery markings.



### **Vehicle battery external charging procedure**

If charging the vehicle battery with an external charger, make sure to shut off the FES circuit breaker by pressing the circuit breaker's **'Off'** button. Following this above procedure guarantees that the hydrogen system will not inadvertently produce hydrogen when the engine is not running.

### **Hydrogen gas dissipation procedure**

If a non-running engine was accidentally injected with hydrogen for more than a minute, it must be purged before the engine is started, otherwise an internal hydrogen explosion could damage the engine and possibly cause engine damage or injury.

To purge the engine of hydrogen gas, first shut off the FES. Make sure that the vehicle is in a well ventilated area where hydrogen gas cannot accumulate above. Remove the vehicle's engine air intake filter. Blow compressed clean air into one side of the air intake system for about one minute. Keep all dirt and small objects away from the air intake.

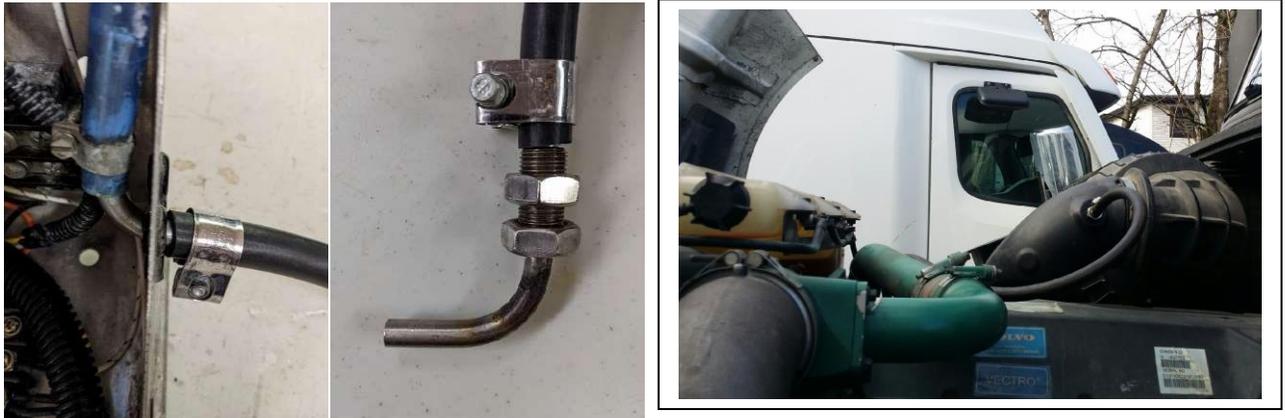
**Double Check** all mechanical/electrical/electronic mountings and connections for reliability. Make sure there are no chafing surfaces to wear through wire insulation.

- a. Clean the truck's battery posts if required.
  - i. Remove the battery cable clamps
  - ii. Clean the posts and clamps with baking soda and water.
  - iii. Wire-brush the posts and cable clamps before re-assembly. This eliminates oxidised lead from causing a poor electrical connection.
- b. Run and dress the power cables to the Fuel Enhancement System.
- c. Trim the ends of the red and black cables to the correct length. This is the very last stage of dressing the heavy red and black power cables.
- d. Strip off ½ inch of insulation from each cable end, being careful not to damage the wire strands.
- e. Crimp on the proper lugs. The lug wire size must match the wire gauge. Also, the lug hole size must be suitable for the machine screws securing them to the battery clamps.

While tightening the machine screws that secure the lugs, use a second wrench to hold the battery clamp so the torque does not strain a battery post.

### **Hydrogen / Oxygen Gas Hose Installation**

- As a gas hose, we recommend the use of a standard 3/8" rubber fuel line hose. If necessary, Empire Hydrogen can provide a heated hose that will allow for system use in cold climates.
- Connect one end of the gas hose to the Fuel Enhancement System exit pipe and secure with a hose clamp.



- The opposite end of the gas hose should be securely connected to the engine's air intake manifold, pipe positioned downstream of the air filter and approximately 12 to 16 inches from the turbocharger.
- Route the hydrogen gas hose from the Fuel Enhancement System to the engine air intake manifold and secure it. Keep the hose away from hot or moving surfaces. Ensure the hose is long enough to be properly secured with tie straps.
- The install kit includes a threaded bent steel pipe. Remove the air intake manifold and drill an appropriate size hole for the threaded portion of the pipe. Do not allow any drilling debris or parts to be sucked into the engine.
- From inside the manifold, install the bent pipe with the L facing towards the turbocharger. Use a sealant to create an airtight seal around the threads. Use the outer nut to secure the bent pipe in place. Install the rubber fuel line hose and secure with a hose clamp.
- If removing the FES from any engine, make sure to plug the hole in the air intake manifold to prevent dust and dirt from being sucked into the cylinders.

## Electrolyte

Electrolyte is a liquid that conducts electricity. Empire's FES uses 6% (by weight) potassium hydroxide (KOH) in distilled water. The distilled water is consumed and should be replenished with every fuel fill. KOH is depleted slowly over a few months of FES operation.

## Electrolyte Disposal

Empire's electrolyte is **CAUSTIC**. Electrolyte that is to be disposed should be neutralized first. This can be done by mixing the electrolyte one-to-one with standard vinegar. Protective clothing and eye protection must be worn.

## System Testing

After Empire's Fuel Enhancement System installation is complete, perform the following steps:

- a. Remove all installation tools and supplies from the vehicle
- b. Close the FES circuit breaker near the battery by rotating the yellow handle on the circuit breaker until it clicks.
- c. Inspect the entire installation
- d. Start truck engine

You should see bubbles rising in the water reservoirs within a minute. If not, make sure the engine voltage is above 13.5 Volts, measured at the FES's electrical input terminals. If the FES is still not working, check your work for a wiring error. Call Empire Hydrogen for technical assistance if needed.

Shut off the truck's engine and note that the green light on the front of the FES shuts off and bubbles stop forming inside the FES.

**It is crucial that hydrogen and oxygen stop flowing when the engine is shut off, otherwise an explosion hazard will exist.**

## KOH (Electrolyte) Mixing Instructions

The purpose of KOH is to make distilled water conduct electricity. The following instructions must be followed in the exact order listed below, for safety reasons.

**Danger** –Always add **KOH to water**, never the reverse. Begin by filling the bucket with water, then slowly add the KOH while stirring continuously. The mixing process is **exothermic**, meaning it will generate heat. It is normal for the water to become warm during this reaction.

**Warning** – do not use tap water or any water except distilled water to make up the electrolyte. Distilled water contains no minerals. Minerals will damage the electrolytic cell plates.

**Warning** – Avoid contact between KOH or the electrolyte and aluminum. KOH reacts with aluminum to produce hydrogen gas, which can be hazardous. If contact occurs, immediately neutralize the area with vinegar to help reduce the reaction.

Mixing a new batch of electrolyte is only required for a new FES or every 3-6 months thereafter. The Empire Hydrogen FES is normally shipped with a package of KOH powder, sufficient for 4 L of water or a normal double cell FES unit.

1. Set out
  - a. Safety full face mask
  - b. Rubber apron
  - c. Rubber gloves
  - d. An empty plastic bucket,
  - e. 4 Liters of **Distilled Water**
  - f. Plastic stir stick
  - g. 6” funnel
2. Wear the safety gear. KOH is caustic.
3. Measure 4 L of distilled water into the bucket
4. Slowly pour one pack of KOH powder into the distilled water while stirring. The KOH will dissolve quickly. The mixture will become very warm.
5. Using a funnel, carefully pour the prepared electrolyte solution into the FES tank until it reaches the upper fill limit. Stop filling immediately when the LED indicator on the FES unit turns ON.



## **Installing a Hydrogen Sensor Alarm**

When a Fuel Enhancement System is installed in an enclosed area such as a generator shed, it is important to protect the premises with a hydrogen sensor. Hydrogen is explosive in concentrations as low as 4.0 %. Install the hydrogen sensor at a location where the light hydrogen gas will accumulate. The sensor should be connected with an alarm ,if the alarm sounds use the breaker switch to stop the gas production immediately.



## **Cold Weather Operation**

The FES is fitted with internal heating elements to prevent the distilled water from freezing down to -30°C. The Winter Switch must be flipped to ON any time the temperature is expected to fall below 0°C. **BELOW -30°C, THE FES MUST BE DRAINED.** Allowing the FES to freeze will damage the electrolysis cells. Refer to the FES wiring diagram or troubleshooting guide for instructions on activating the heater switch (located inside the power control box). When the engine is running and the FES is operating, it generates sufficient heat to operate down to -30°C. Below this temperature the FES must be drained.

When the engine is not running and the FES is not operating, the internal heating elements are powered by the vehicle batteries. In normal situation, they will operate for 24 hours without significantly draining the batteries. If required for longer periods, the FES is supplied with an AC to DC transformer and connections to plug into a normal 110V – 220V AC power source.

## **Recommended Tools and Parts List**

### **Safety Equipment:**

1. Goggles or full-face shield
2. Rubber gloves
3. Rubber apron
4. Steel toe boots

### **Parts:**

5. Empire Hydrogen Fuel Enhancement System
6. 6-8 gauge black and red wires with lug connectors, wire loom and ties
7. 80 amp breaker
8. 3/8 inch rubber fuel line hose, hose clamps and ties
9. L bracket for mounting FES
10. Plan for mounting to vehicle
11. Mounting bolts, rubber engine mounts
12. Distilled water
13. Package of KOH

### **Tools:**

14. Plastic bucket, stir stick and funnel
15. Wrenches to match mounting bolts
16. Phillips screwdriver
17. Wire crimpers
18. Voltmeter, clamp meter
19. Drill and bits (for air intake manifold)
20. Sealant (for air intake manifold)