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# **Power Solutions International, Inc.**

## **8.8L LP Engine Operation and Maintenance Manual**

201 Mittel Dr.  
Wood Dale, IL 60191

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## **IMPORTANT**

The information, specifications, and illustrations contained in this manual are based on data that was current at the time of publication. Power Solutions International, Inc. reserves the right to make changes and/or improvements at any time without notification, liability, or without applying those changes or improvements to vehicles previously manufactured and/or sold.

### **NOTICE**

Be advised that this motor vehicle may be equipped with computer / recording devices. Their function is to allow an authorized individual to download data or information relating to the operation or performance of this vehicle.

The stored data or information may be neither downloaded nor retrieved except by the vehicle's registered owner, or, in the alternative, by another individual or entity authorized by the registered owner, (e.g., Certified Service Dealer) who may need this data or information to properly service or diagnose this vehicle for repair or following an accident.

Any access to this information without the owner's consent may be in violation of law and may subject that person or entity to criminal penalties.

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## FOREWORD

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# FOREWORD

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## Foreword

Power Solutions International, Inc. is committed to continuous research and development to improve products and introduce technological advances. Procedures, specifications, and parts defined in published technical service literature may be altered.

**NOTE: Photo illustrations identify specific parts or assemblies that support text and procedures; other areas in a photo illustration may not be exact.**

This manual includes necessary information and specifications for operators to operate and maintain the PSI 8.8L LP engine. Contact your dealer for more information.

**Refer to the applicable technical service literature**

*Engine Service & Diagnostic Manual  
Warranty Policy and Procedures Manual*

Technical Service Literature is revised periodically. Use only up-to-date service information.

To order technical service literature, contact your dealer.

All marks are trademarks of their respective owners.

## About the Manual

This manual contains information needed to correctly operate and maintain your engine as recommended by PSI. Numerous illustrations, symbols and feature descriptions are used to aid in understanding the meaning of the text. The illustrations, symbols or feature descriptions may not be available for all applications, please contact your dealer for complete information. Both metric and U.S. customary values are listed in this manual. The U.S. Customary value is listed first, followed by the metric value in brackets. For additional service literature refer to Service Literature noted in this manual. This manual does not cover vehicle or equipment maintenance procedures.

When referring to the left-hand or right-hand side of the engine, this will be as viewed from the rear. (Looking at the flywheel)

Consult the original vehicle or equipment manufacturer for specific maintenance recommendations.

## SAFETY INFORMATION

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# SAFETY INFORMATION

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## Safety Information

This manual provides general and specific maintenance procedures essential for reliable engine operation and your safety. Since many variations in procedures, tools, and service parts exist, advice for all possible safety conditions and hazards cannot be stated.

Read safety instructions before doing any service and test procedures for the engine. See related manuals for more information.

Obey Safety Instructions, Warnings, Cautions, and Notes in this manual. Not following Warnings, Cautions, and Notes can lead to injury, death, or damage to the engine or vehicle.

### Safety Terminology

Three terms are used to stress your safety and safe operation of the engine: Warning, Caution, and Note.

**Warning:** A warning describes actions necessary to prevent or eliminate conditions, hazards, and unsafe practices that can cause personal injury or death.

**Caution:** A caution describes actions necessary to prevent or eliminate conditions that can cause damage to the engine or vehicle.

**Note:** A note describes actions necessary for correct, efficient engine operation.

## Safety Instructions

### Work Area

- Keep work area clean, dry, and organized.
- Keep tools and parts off the floor.
- Make sure the work area is ventilated and well lit.
- Make sure a First Aid Kit is available.

### Safety Equipment

- Use correct lifting devices.
- Use safety blocks and stands.

### Protective Measures

- Wear protective safety glasses and shoes.
- Wear correct hearing protection.
- Wear cotton work clothing.
- Wear sleeved heat protective gloves.
- Do not wear rings, watches or other jewelry.
- Restrain long hair.

## SAFETY INFORMATION

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### Vehicle

- Shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.
- Clear the area before starting the engine.

### Engine

- The engine should be operated or serviced only by qualified individuals.
- Provide necessary ventilation when operating engine in a closed area.
- Keep combustible material away from engine exhaust system and exhaust manifolds.
- Install all shields, guards, and access covers before operating engine.
- Do not run engine with unprotected air inlets or exhaust openings. If unavoidable for service reasons, put protective screens over all openings before servicing engine.
- If an engine is not safe to operate, tag the engine and ignition key.

### Fire Prevention

- Make sure charged fire extinguishers are in the work area.

**NOTE: Check the classification of each fire extinguisher to ensure the following fire types can be extinguished.**

1. Type A — Wood, paper, textiles, and rubbish

2. Type B — Flammable liquids
3. Type C — Electrical equipment

### Batteries

- Always disconnect the main negative battery cable first.
- Always connect the main negative battery cable last.
- Avoid leaning over batteries.
- Protect your eyes.
- Do not expose batteries to flame or sparks.
- Do not smoke in workplace.

### Compressed Air

- Use an OSHA approved blow gun. Limit blow gun air pressure to 30 psi (207 kPa).
- Wear safety glasses or goggles.
- Wear hearing protection.
- Use shielding to protect others in the work area.
- Do not direct compressed air at body or clothing.

## SAFETY INFORMATION

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### Tools

- Make sure all tools are in good condition.
- Make sure all standard electrical tools are grounded.
- Check for frayed power cords before using power tools.

### Fluids Under Pressure

- Use extreme caution when working on systems under pressure. Pay close attention when working with the fuel system.
- Follow approved procedures only.

### Fuel

- Do not smoke in the work area.
- Do not refuel the tank when the engine is running.

### Removal of Tools, Parts, and Equipment

- Reinstall all safety guards, shields, and covers after servicing the engine.
- Make sure all tools, parts, and service equipment are removed from the engine and vehicle after all work is done.

### Propane Safety Instructions

#### Warnings:

- Never loosen fittings or vent any propane. Escaping propane can cause frostbite and severe freeze burns. Wear insulated PVC rubber gloves resistant to propane, goggles for protection against accidental release of pressurized products, and thermal protective clothing when handling refrigerated liquids.
- Do not remove any valves, bulkheads, or fittings from a tank unless the tank has been drained completely. The pressure inside a propane tank can push a loosened bulkhead or valve out with enough force to cause injury or death.
- Keep all sources of ignition away from propane vehicles while the fuel system is being serviced. Even if the tank and fuel lines are empty, there may still be flammable vapors near the vehicle.
- Do not disconnect any propane hoses unless they have been completely drained using the proper procedure.
- Do not vent or release propane indoors or near sewers, pits or low lying areas. Propane can accumulate in low spots, creating a fire hazard. Propane can also displace oxygen, creating a suffocation hazard.
- Always unplug the fuel control box or disconnect the battery before you work on any part of the fuel system.

**NOTE: It is recommended that you obtain and read the NFPA (National Fire Protection Association) #58, Standard for the Storage and Handling of Liquefied Petroleum Gases.**

## SAFETY INFORMATION

### First Respondent and Operator Warning

Material ID Number: 1075  
Guide Number: 115

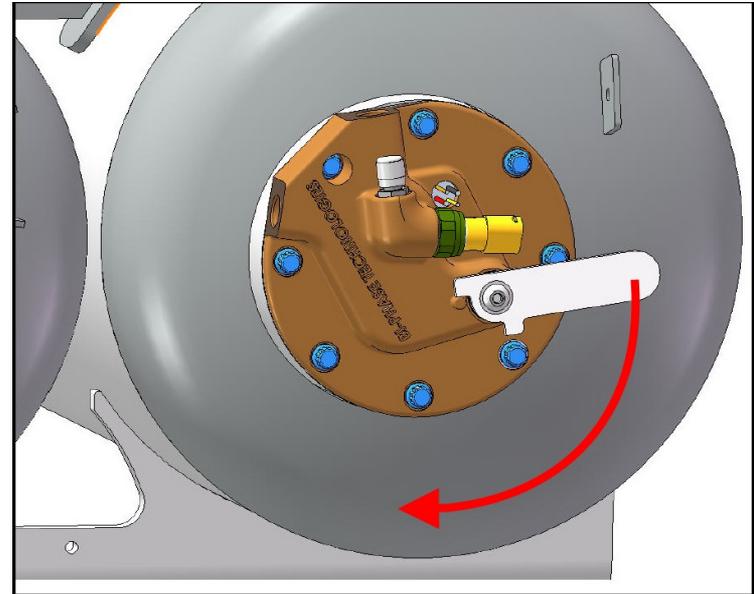
**NOTE: Please refer to Cautions and Warnings in the PHMSA Emergency Response Guidebook. (Pipeline and Hazardous Material Safety Administration)**

### 1/4 Turn Safety Shut-Off Valve

The fuel system utilizes a manual shut-off valve to be used in the case of an emergency.

The valve is located on the front of the left-hand side fuel tank (driver's side). To operate the valve, grab firmly and pull the valve down a 1/4 of a full turn (90°) until the tab on the lever bottoms out on the dowel. This will manually stop fuel flow from the tanks.

Refer to figure 1 to the right.



**Figure 1 - 1/4 Turn Safety Shut-Off Valve**

## SAFETY INFORMATION

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### Propane Safety Specifications

Specification	Item	Unit
Initial Boiling Point @ 14.7 psi	-44° (-42.2°)	°F (°C)
Weight per 1gal of liquid @ 60°F.	4.24 (7.28)	lbs/gal (kg/L)
Ignition Temperature in Air	920°-1,120° (493.3°-604.4°)	°F (°C)
Air/Fuel Ratio by Volume	15.6:1	
Air/Fuel Ratio by Weight	24:1	

Chemical Formula: C<sub>3</sub>H<sub>8</sub>

## WARRANTY

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# WARRANTY

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## Warranty

### EPA and CARB Emission System Warranty

#### WARRANTY PERIOD

Government agencies including the United States Environmental Protection Agency (EPA) and the California Air Resources Board (CARB) require Power Solutions International, Inc. to provide emissions warranty to end users. PSI must warrant the engine is designed, built and equipped so as to conform at the time of sale with applicable regulations and be free from defects in materials and workmanship for a defined period of years or miles, whichever occurs first (Emissions Warranty). PSI will provide emissions warranty coverage as required by the EPA and CARB regulatory agencies. Emissions Warranty does not cover, remanufactured, dealer rebuilt or dealer exchange engines.

- 5 years
- 50,000 miles (80,467 km)
- Or if covered by any basic or extended warranty (if greater than above)

Your 8.8L LP engine conforms to U.S. Environmental Protection Agency (EPA) regulations for emission systems.

The California Air Resources Board, United States Environmental Protection Agency and Power Solutions International, Inc. are pleased to explain the emission control system warranty on your PSI 8.8L LP engine. In California, new motor vehicles must be designated, built and equipped to meet the State's stringent anti-smog standards. Power Solutions International, Inc. warrants the emission control system on your engine for the periods of time listed, provided there has been no abuse, neglect or improper maintenance of your vehicle.

Your emission control system includes parts such as the LPG fuel-injection system, the ignition system, catalytic converter, and engine computer. Also included may be hoses, belts, connectors and other emission-related assemblies.

Where a warrantable condition exists, Power Solutions International, Inc. will repair your truck at no cost to you including diagnosis, parts and labor.

#### Manufacturer's Warranty Coverage

5 years or 50,000 miles (whichever first occurs):

1) If your truck fails a Smog Check inspection, all necessary repairs and adjustments will be made by Power Solutions International, Inc. to ensure that your emission control system is working properly. This is your Emission Control System PERFORMANCE WARRANTY.

2) If any emission-related part on your truck is defective, the part will be repaired or replaced by Power Solutions International, Inc. This is your short-term emission control system DEFECTS WARRANTY.

## WARRANTY

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### **Federal Emission System Warranty (cont.)**

#### **Owner's Warranty Responsibilities**

As the truck owner, you are responsible for the performance of the required maintenance listed in your Operation and Maintenance manual. Power Solutions International, Inc. recommends that you retain all receipts covering maintenance on your truck, but Power Solutions International, Inc. cannot deny warranty solely for the lack of receipts or for your failure to ensure the performance of all scheduled maintenance.

You are responsible for presenting your truck to a certified dealer as soon as a problem exists. The warranty repairs should be completed in a reasonable amount of time, not to exceed 30 days.

As the truck owner, you should also be aware that Power Solutions International, Inc. may deny you warranty coverage if your truck or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

In the case of emergency when a warranted part or warranty station is not reasonably available to you, repairs may be performed at any available service establishment, or by you, using any replacement part. Power Solutions International, Inc. will reimburse you for your expenses including diagnostic charges for such an emergency repair or replacement, which cannot exceed Power Solutions International, Inc's suggested retail price for all warranted parts replaced and labor charges based on Power Solutions International, Inc's recommended time allowance for the warranty repair and the geographically appropriate hourly labor rate.

All receipts and failed parts must be kept in order to receive compensation for warranted repairs reimbursable due to an emergency.

If you have any questions regarding your warranty rights and responsibilities, you should contact Power Solutions International, Inc. at 888-331-5764 or the California Air Resource Board at 9528 Telstar Avenue, El Monte, CA 91731.

## WARRANTY

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### Federal Emission System Warranty (cont.)

#### WARRANTY EXCLUSIONS

The following items are not reimbursable under the PSI warranty terms.

- Any repair on an engine that has exceeded the hour or time limitation of the stated warranty.
- PSI may deny any claims that in their sole discretion are the result of misapplication of the engine or part.
- Units that are under development (i.e. prototype projects, engineering projects).
- Any repair on an engine where the hours of operation or in-service date has been misrepresented.
- Any repair on an engine if the hour meter has been altered so that the true hours on the engine cannot be determined.
- Any repair on an engine where the date of service has been misrepresented to place an out-of-warranty engine inside the warranty period.
- Engines damaged by an Act of God or force majeure.
- Routine maintenance repairs.
- Repairs required due to improper storage precautions.
- Adjustments made to improve performance beyond PSI estimated normal standards.
- Use of other than genuine OEM parts, unless in an emergency situation.
- Any failure that is a result of the application and not a defect in the materials or workmanship from PSI as deemed by PSI.
- Repairs to parts that, upon analysis, are found not to be defective.
- Repairs to engines used for re-powering on-road vehicles.
- All consequential expenses, including, but not limited to, those resulting from equipment failure such as lodging, food, downtime or replacement equipment rental.
- Any misapplication or misuse of the product as deemed by PSI.
- Towing or transportation expense for moving an engine or engine-powered equipment from the customer location to the repair location.
- Repairs caused by damage due to poor workmanship.

For additional warranty information please refer to the "Power Solutions International Warranty Policy and Procedures Manual".

## SECTION 1 – ENGINE SYSTEMS

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## SECTION 1 – ENGINE SYSTEMS

### Engine Serial Number

The engine serial number can be found in two locations.

The serial number label will be located on the right-hand side valve cover as shown in figure 3.

The number will also be stamped on the left-hand side of the engine, near the flywheel as shown in figure 4.

### Engine Serial Number Examples

8.8L12345

### Engine Serial Number Codes

8.8L - Engine Displacement

12345 - Engine Serial Number



Figure 3 - Serial Number Label Location



Figure 2 - Serial Number Label Example

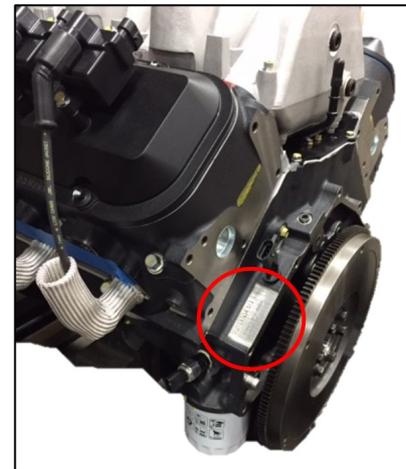


Figure 4 - Stamped Location of Serial Number

## SECTION 1 – ENGINE SYSTEMS

### Engine Emission Label

The U.S. Environmental Protection Agency (EPA) exhaust emission label is attached to the plate on top of the intake manifold as shown in figure 6. The EPA label typically includes the following:

- Model year
- Engine family and displacement
- Advertised horsepower rating
- Emission family and control systems



Figure 5 - Emission Label Example

### Engine Spec Label

There will also be an Engine Spec Label that contains the spec description, spec number, and an engine spec barcode. This will be located on the plate mounted to the top of the intake manifold as shown in figure 6.

### Engine Accessories

The following engine parts may have manufacturer's labels or identification plates:

- Alternator
- Compressor
- Engine Control Module

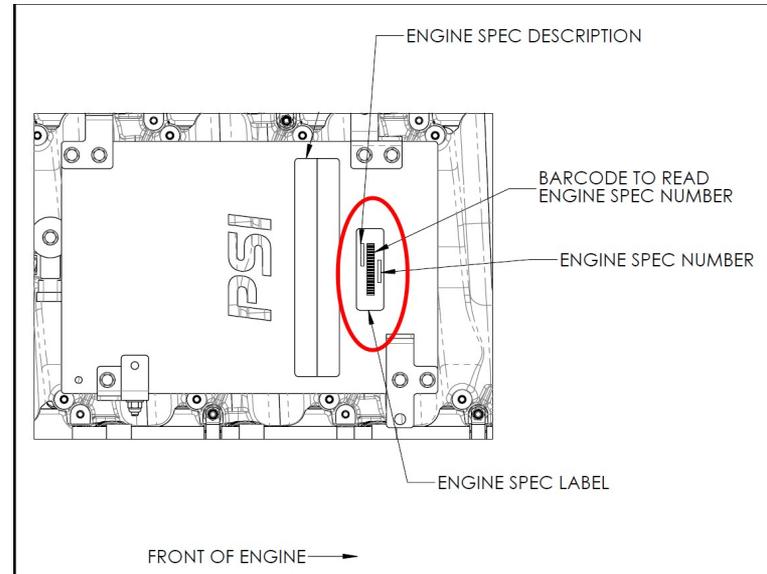


Figure 6 - Engine Spec Label

## SECTION 1 – ENGINE SYSTEMS

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### Engine Specification

#### Engine Description

The PSI 8.8L LP engine has been designed to produce greener emissions while providing reliability and power through the use of a liquid propane fuel injection system.

For additional information on engine specifications please refer to the Appendix section of the manual.

#### Air Management System

The PSI 8.8L LP engine uses a naturally aspirated air intake system that utilizes an electronically controlled throttle body to control air flow.

#### Crankcase Assembly

The crankcase is designed to withstand high-pressure loads during operation. It is a single piece crankcase with parent bore cylinders and forged pistons. The oil pump is a shaft driven gear pump, driven by the camshaft drive adapter. The crankcase also utilizes an internally integrated wire mesh breather system to vent pressure to the engine intake.

#### Crankshaft

The crankshaft has five main bearing sets with fore and aft thrust controlled by the main thrust bearing. Forged connecting rods are used with a full floating piston pin, the pin is secured in the piston head by circlips. The rear oil seal carrier is located between the crankshaft and the oil pan.

### Cylinder Head

The cylinder head has two valves per cylinder for controlled air flow. The push rod driven valve train uses hydraulic roller lifters and individual rocker arms. There is a port in the cylinder head where the fuel injectors are located and the cam gear is driven by the timing chain.

#### Electronic Control System

An Engine Control Module (ECM) will monitor and control engine performance in order to ensure maximum performance and compliance with EPA emissions requirements.

The ECM monitors the engine and exhaust systems to verify that operation remains within emissions limits. If emissions parameters are not met an emissions fault will be logged, the Malfunction Indicator Lamp (MIL) will illuminate, and one or more fault codes will be present. This may result in a derate in engine performance.

## SECTION 1 – ENGINE SYSTEMS

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### Engine Description (cont.)

#### Fuel System

The PSI 8.8L LP engine is equipped with a BiPhase LPEFI® (Liquid Propane Electronic Fuel Injection) fuel system. This system utilizes liquid fuel injection to improve power, efficiency and operating characteristics.

Fuel will be drawn from an LP fuel tank via a supply pump. The fuel will then pass through a supply lock-off valve, excess flow valve, and past the fuel pressure and fuel temperature sensors. The pressurized fuel is then fed to the two fuel rails mounted on each side of the engine. The liquid fuel is vaporized as it is being injected into the cylinders and ignited. Excess pressurized fuel is returned from the fuel rail via a fuel return line, the fuel will pass through an excess flow valve and a return lock-off before being returned to the tank.

#### Fuel System Overview

The LPEFI® system works the same as a gasoline fuel injected system, with the only difference being that it injects liquid propane into each intake port. The fuel system will operate just as a gasoline fuel system, with a slight modification in the fuel enrichment strategy during engine startup. A typical gasoline fuel system requires a rich mixture that is very dense and dependent on ambient temperature. With the liquid propane injection, the engine is capable of normal startup with a fuel mixture that is much leaner, thus allowing a reduction in startup emissions.

The LPEFI® system utilizes three main components: a fuel tank, the fuel lines, and the fuel injectors. The tank is located near the back of the vehicle and the lines run from the tank to the fuel rails that are mounted on each side of the PSI 8.8L LP engine.

#### Fuel System - Fuel Lines

Fuel lines in the LPEFI® system are composed of two different hoses, one inside of the other. The inner nylon hose supplies LP to the fuel injector while the space between the outside of the inner hose and the inside of the larger outer hose is utilized as the fuel return passage. There will be two fuel lines coming out of the fuel tank. One is used as the supply and return line for the left side fuel rail while the other line is used for the supply and return to the right side fuel rail.

## SECTION 1 – ENGINE SYSTEMS

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### Engine Description (cont.)

#### Fuel System - Tanks

The tank is the most complex portion of the LPEFI® system. The primary tank includes the following components:

- Internal Electric Fuel Pump
- Fuel Filter
- Fuel Supply Valve
- Fuel Return Valve
- Fuel Pump Baffle (used to keep pump submerged in LP)
- Fuel Level Float
- Pressure Relief Valve
- Overfill Prevention Device
- Liquid Service Valves
- Vapor Service Valves
- Fuel Supply Lock-Off Valve
- Fuel Return Lock-Off Valve

A secondary tank can be used to increase fuel capacity in the system. The secondary fuel tank will simply supply additional fuel to the primary tank once the fuel level begins to deplete. The tank levels are monitored and controlled by the Engine Control Module.

The propane will remain a liquid throughout the liquid supply portion of the system due to the fuel pump maintaining a 35 to 50 psi boost in tank pressure. The pressure will remain in the fuel line all the way up to the injectors. If the injectors are closed the fuel will pass through an internal cooling bushing within the injector before being forced into the return lines and back to the tank. In some cases, the liquid propane fuel can become vaporized and cause a loss in power or hard starting due to excessive heat.

In order to counter this, the LPEFI® system will go through a 5-30 second system purge at every startup attempt to rid the system of any vapor.

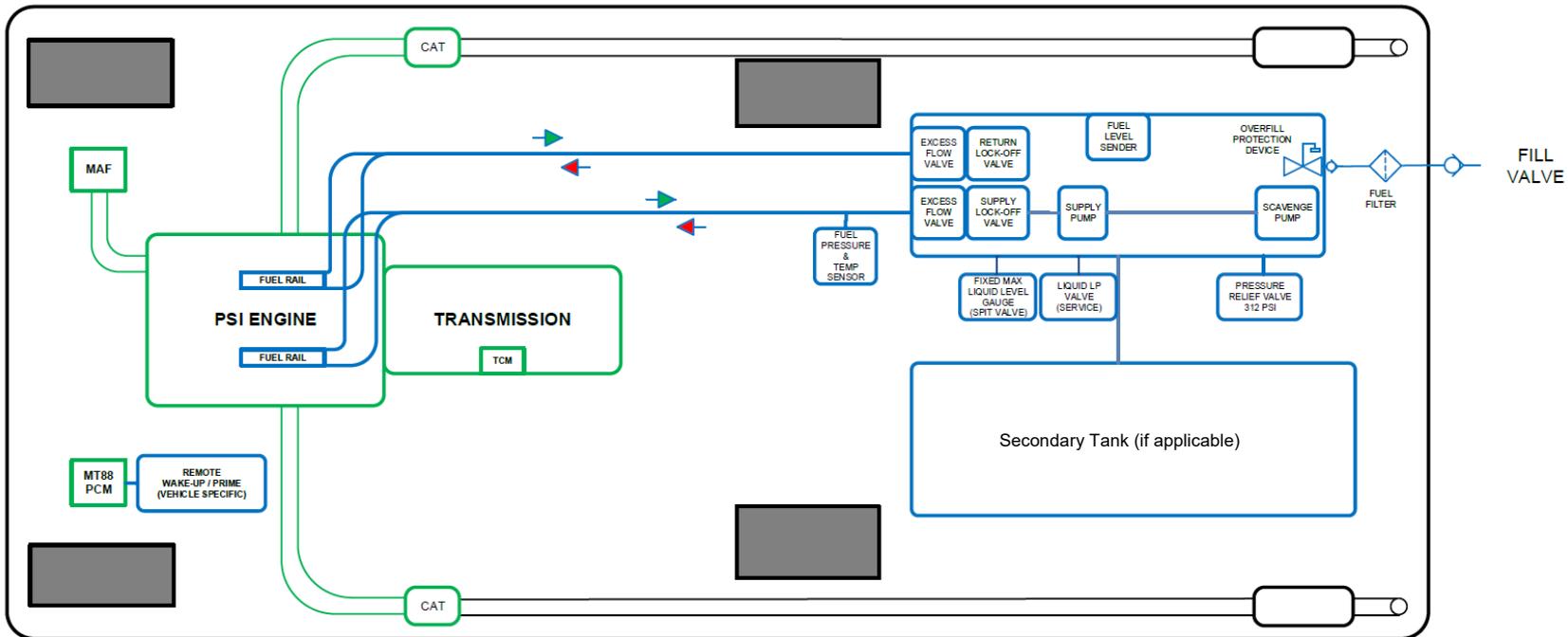
#### Fuel System - Injectors and Fuel Rails

The fuel injectors in the LPEFI® system are specifically designed for use with liquid propane. Electronically the function will be similar to a gasoline fuel injector, holding a resistance value between 13 and 15 ohms.

The fuel rails use the same concentric design as the fuel lines and each injector has a supply and return passage. These passages in the injectors are separated by the cooling bushing, which is used to cause a pressure reduction resulting in the fuel being vaporized. The vaporization of the fuel will help keep the supply side of the system cool, which in turn helps the fuel remain in a liquid state while in the supply side of the fuel lines. The fuel is immediately turned to a vapor when it exits the injector into the intake port. This can cool the intake air allowing for additional power and reduced emissions.

# SECTION 1 – ENGINE SYSTEMS

## Engine Description (cont.)



**Figure 7 - Fuel System Layout**  
(For Reference Only)

## SECTION 1 – ENGINE SYSTEMS

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### Engine Features

#### Coolant Temperature Control

The ECM will begin to derate the engine if the coolant temperature surpasses the allowable range. Prior to activation of the standard warning system, the ECM will derate the engine once temperatures exceed above a certain limit. Derates will occur according to vehicle manufacturer specifications. For thermostat temperature limits please refer to the Appendix section.

#### Electronic Speedometer and Tachometer

The PSI 8.8L LP engine system will calculate vehicle speed. The calculated speed will be a function of transmission speed, final drive ratio, and tire size revolutions per minute. The PSI PowerLink tool can be used to modify any changes that occur to these systems. The in-dash tachometer uses a signal generated from the engines crank sensor.

#### Engine Starter Engagement Limitations

The ECM will prevent starter engagement when the transmission is in gear.

#### Air Compressor

An air compressor is standard for all applications with air brakes or air suspension.

### Engine Electronic Governor Control

The engine governor controls will limit engine rpm to ensure that it remains within a safe operating range.

The low speed governor prevents engine rpm from dropping below a certain limit when hot or cold. This is done to avoid any chance of engine stall when various loads are demanded on the engine. For low speed governor limits refer to the Appendix section.

The high speed governor is designed to limit the engine rpm when in neutral, and while in-gear. This is done to avoid any possibility of engine damage due to excessively high rpm. For high speed governor limits refer to the Appendix Section

#### Engine Component Protection System

The PSI 8.8L is designed to protect all systems from damage by monitoring data such as engine temperature, oil temperature, oil pressure, coolant level, and engine speed. If critical engine parameters are exceeded this system will alert the driver by using a series of warning lamps and derating the engine if necessary.

To make any modification to the Engine Protection System you must contact the vehicle Manufacturer or a certified service dealer.

## SECTION 1 – ENGINE SYSTEMS

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### **Engine Features (cont.)**

#### **ECM Logging System**

The ECM will log any DTC's that occur during engine operation.

#### **Cold Idle Kick**

If the ECM senses the engine temperature is below a certain limit the Cold Idle Kick (CIK) will begin to increase (kick) engine idle rpm. Once the engine temperature is at or above operating temperature the ECM will allow the engine to idle at the normal idle speed. For idle speeds and temperatures refer to the Appendix section.

#### **PSI Power Link Password Protection**

This feature will prevent unauthorized users from changing any parameters when using the PSI PowerLink tool. There will be a specific set of passwords that allow a user certain rights and capabilities when using the tool. In order to make any adjustments to ECM parameters you will need to contact the vehicle manufacturer.

#### **Service Diagnostics**

The PSI PowerLink provides diagnostic information using the J1939 datalink.

#### **Engine Related Optional Features**

##### **Cruise Control**

The ECM is capable of controlling a cruise control feature. The system will function similarly for all electronic engines. The minimum and maximum cruise control speeds will be dependent upon the application.

#### **VEPS (Vehicle Equipment Programming System)**

The PSI 8.8L LP engine will use the Vehicle Equipment Programming System (VEPS) in order to allow specific ECM parameters to be modified when necessary. These modifications can be made with the PSI PowerLink tool or by a certified service center.

#### **Engine Crank Inhibit (ECI)**

ECI prevents starter engagement once the vehicle has been started and the engine is running.

## SECTION 1 – ENGINE SYSTEMS

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### Engine Related Optional Features (cont.)

#### Power Take Off (PTO) — In Cab

The in cab engine speed control feature, commonly referred to as PTO, allows the operator to set and maintain a constant engine speed without using the accelerator pedal. It is commonly used for powering auxiliary devices.

The in-cab engine speed control feature provides 3 conditions in which the operator may select PTO speeds:

- Stationary Preset - Permits the operator to select up to four preset speeds while the vehicle is stationary.
- Stationary Variable Speed - Permits the operator to select any engine speed within the PTO boundaries.
- Mobile Variable Speed - Permits the operator to select a desired variable speed for moving or stationary PTO operations.

Customer programmable parameters within the ECM provide in-cab engine speed control related options that can be adjusted to suit the customer's needs. The accelerator pedal is disabled for all mobile variable speed modes. Choosing the rpm set points or presets is one example.

#### Power Take Off (PTO) — Remote

When control over engine speed is required from outside the vehicle's cab, remote mounted switches must be used to turn on PTO engine speed control and select the desired engine speed. This functionality is referred to as Remote Engine Speed Control (RESC). The system provides for two preset rpm positions. Customer programmable parameters within the ECM provide RESC related options that can be adjusted to suit the customer's needs. Choosing the rpm set point or presets is one example.

#### Cold Start Assist

The PSI 8.8L LP engine will have an optional cold start assist system. This system can be supplied as a plug-in block heater, a plug-in oil heater, or a combination of both. The heating option is required if the vehicle routinely operates in temperatures below the normal operating range. For other temperature requirements refer to the Appendix section or Cold Weather Operation section.

A block coolant heater and oil heater is required at temperatures below -20°F (-28.9°C).

## SECTION 1 – ENGINE SYSTEMS

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### **Engine Related Optional Features (cont.)**

#### **Road Speed Governor (RSG)**

RSG is a feature with customer programmable parameters designed to regulate the maximum vehicle speed as controlled by the accelerator pedal. A separate setting is possible when the vehicle is in Reverse.

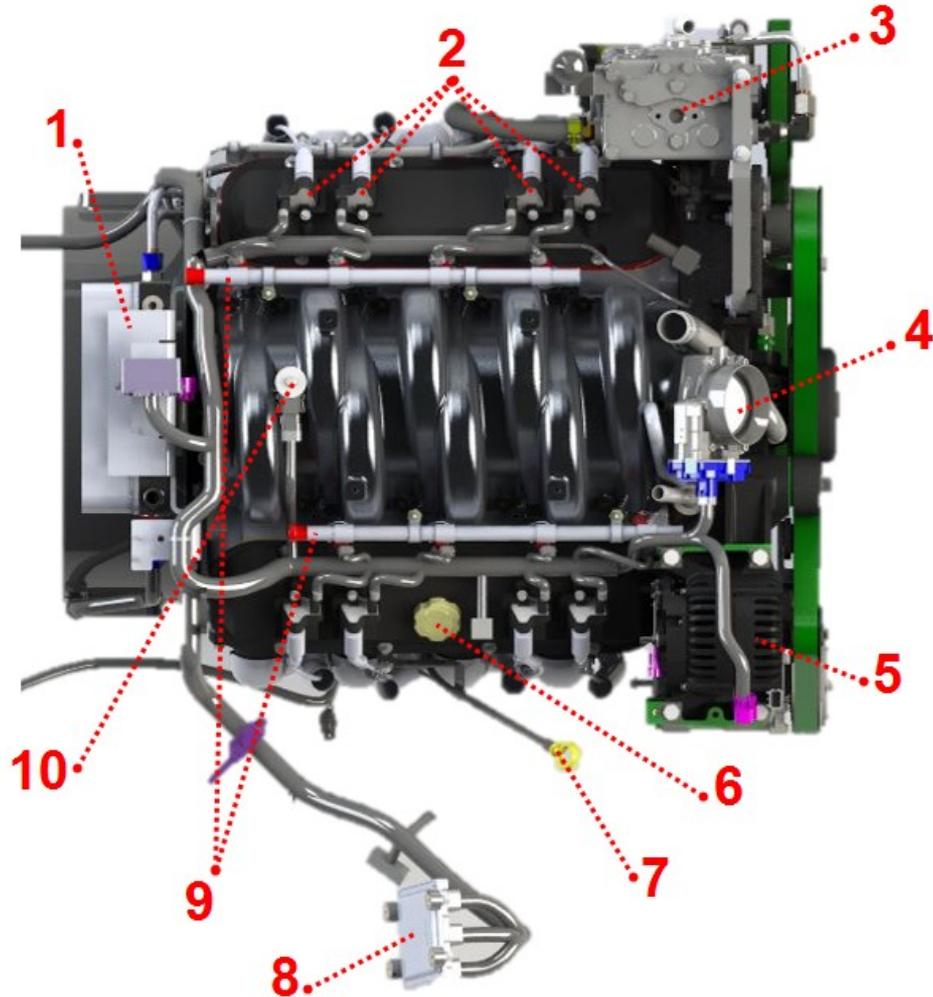
These options can be enabled by programmable parameters within the Engine Control Module (ECM).

## SECTION 1 – ENGINE SYSTEMS

### Component Location – Top

Figure 8 - Typical Top View

1. Oil Cooler
2. Ignition Coils
3. Compressor
4. Throttle Body
5. Alternator
6. Oil Fill Cap
7. Dipstick and Tube
8. Engine Control Module (ECM - Chassis Mounted)
9. Fuel Rails
10. MAP Sensor



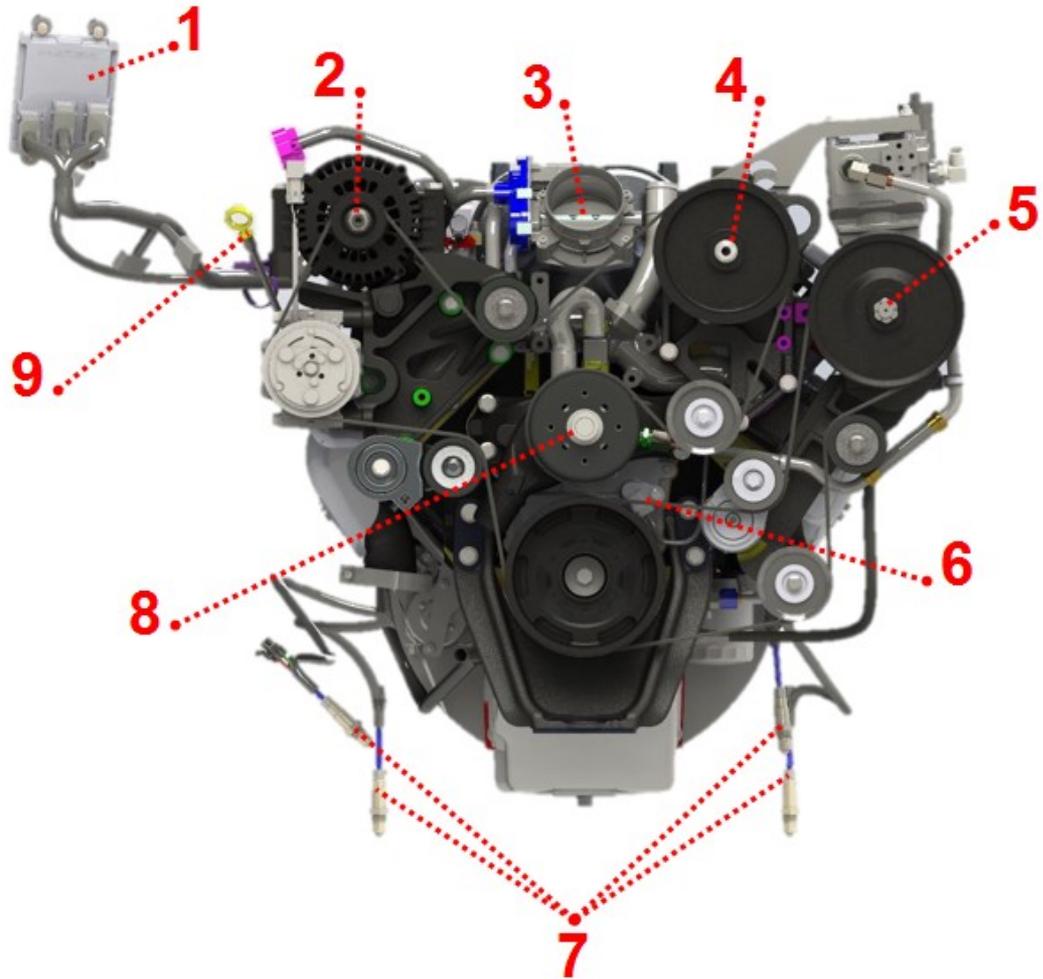
Front →

## SECTION 1 – ENGINE SYSTEMS

### Component Location – Front

Figure 9 - Typical Front View

1. Engine Control Module (ECM - Chassis Mounted)
2. Alternator
3. Throttle Body
4. Power Steering Pump and Pulley
5. Compressor
6. Cam Position Sensor
7. O2 Sensors (Located in Exhaust)
8. Water Pump
9. Dipstick and Tube

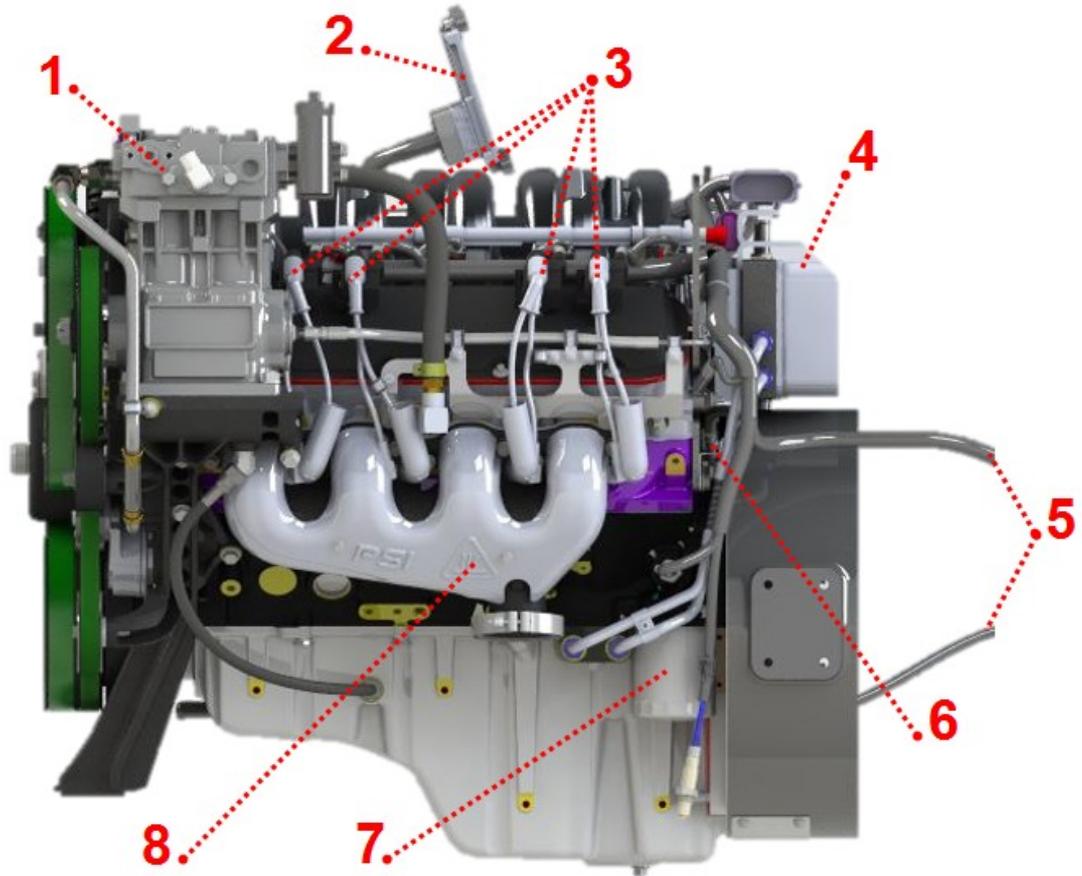


## SECTION 1 – ENGINE SYSTEMS

### Component Location – Left

Figure 10 - Typical Left View

1. Compressor
2. Engine Control Module (ECM - Chassis Mounted)
3. Ignition Coils
4. Oil Cooler
5. Leads to Post-Cat O2 Sensors
6. Crank Position Sensor
7. Oil Filter
8. Exhaust Manifold



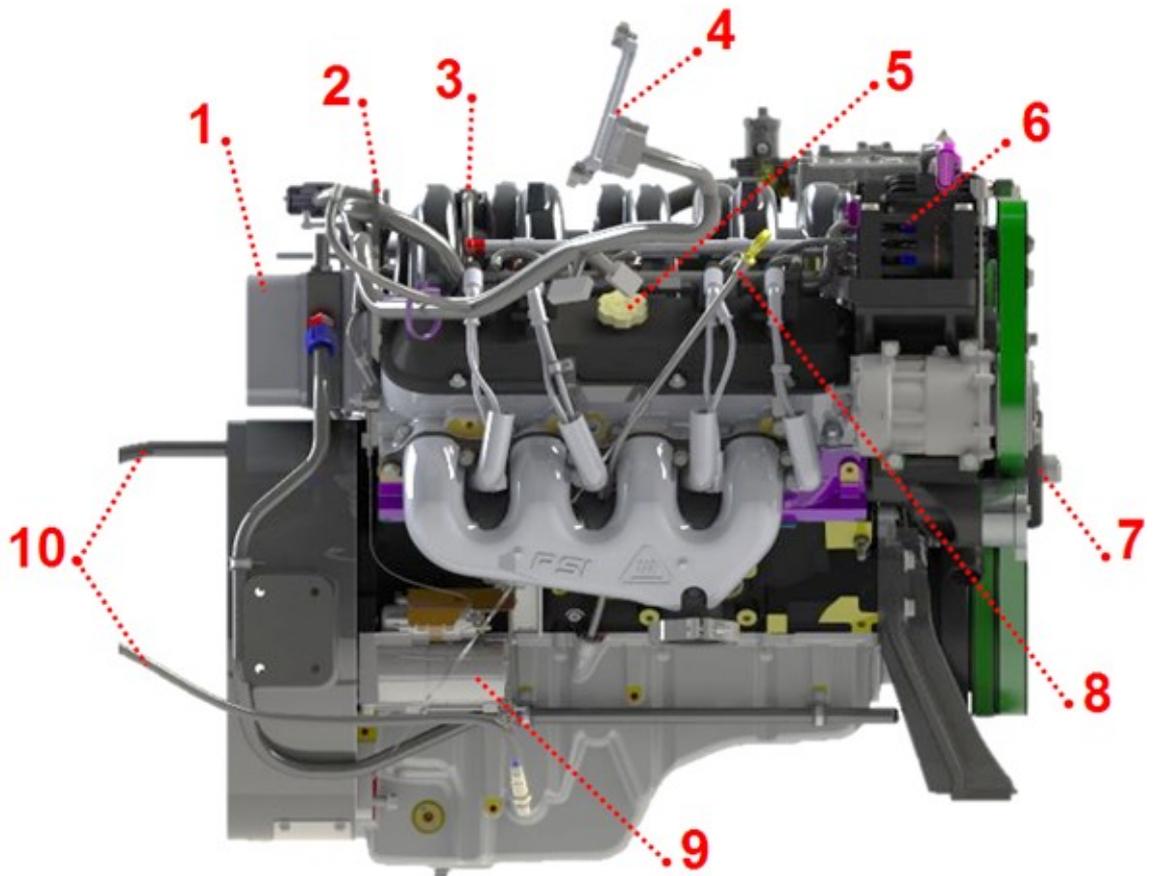
← Front

## SECTION 1 – ENGINE SYSTEMS

### Component Location – Right

Figure 11 - Typical Right View

1. Oil Cooler
2. Right Rear Lifting Eye
3. MAP Sensor
4. Engine Control Module  
(ECM - Chassis Mounted)
5. Oil Fill Cap
6. Alternator
7. Water Pump Pulley
8. Dipstick and Dipstick Tube
9. Starter Motor
10. Leads to Post-Cat O2 Sensors



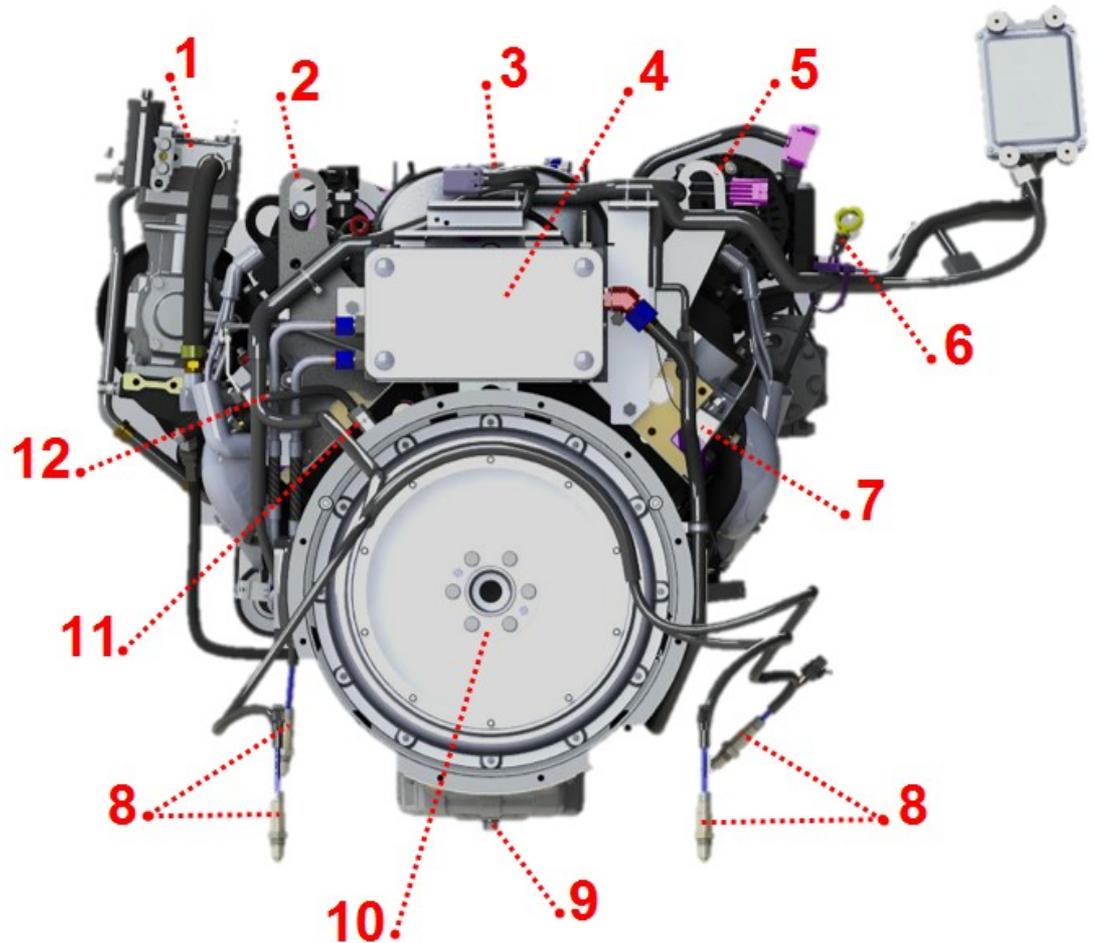
Front →

## SECTION 1 – ENGINE SYSTEMS

### Component Location – Rear

Figure 12 - Typical Rear View

1. Compressor
2. Left Rear Lifting Eye
3. MAP Sensor
4. Oil Cooler
5. Right Rear Lifting Eye
6. Dipstick and Dipstick Tube
7. Right Side Knock Sensor
8. O2 Sensors (in Exhaust)
9. Oil Drain Plug
10. Flywheel / Flex Plate
11. Crank Position Sensor
12. Left Side Knock Sensor



## SECTION 2 – REQUIREMENTS FOR FUEL, ENGINE OIL, AND COOLANT

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## SECTION 2 – REQUIREMENTS FOR FUEL, ENGINE OIL, AND COOLANT

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### Fuel

HD-5 Consumer Grade Propane is required for the PSI 8.8L LP engine. The gas should meet all requirements of the ASTM D1835 standard (current year version), and should also be odorized.

#### ACCEPTABLE FUEL AND BLENDS

- HD-5 Commercial Propane
- More than 90% Propane
- Less than 5% Propylene
- Odorized Propane

#### UNACCEPTABLE FUEL AND BLENDS

- HD-10 Commercial Propane
- Standard Commercial Propane
- Contaminated Propane
- Less than 90% Propane
- More than 5% Propylene
- Odorless Propane

#### UNSAFE PRACTICES

 **WARNING: Keep propane gas and containers away from heat, sparks, and open flames. Avoid contact with eyes, skin, and clothing.**

**Caution:** To prevent engine damage, do not mix any other fuel forms with propane. This can cause an unexpected reaction that may damage the engine and those around it.



Figure 13 - NFPA 704 Hazard Class

## SECTION 2 – REQUIREMENTS FOR FUEL, ENGINE OIL, AND COOLANT

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### Engine Oil

#### ENGINE OIL QUALITY AND SERVICE CATEGORIES

The PSI 8.8L LP engine requires the use of synthetic blend oil that meets Dexos1® standards. This requirement will provide a reduction in volatility and oil consumption, significant wear protection, and improved piston cleanliness. Meeting the Dexos1® standard can also enhanced aeration control for improved fuel efficiency while providing better oxidation properties.

All oil used in the PSI 8.8L LP engine must meet the Dexos1® specification and display the green Dexos1® logo. (Shown Below)



#### Oil Recommendation

#### SAE Oil Viscosity Grades

It is required that the Dexos1® oil meet SAE 5W-30 viscosity standards. This oil weight will be used regardless of ambient temperature.

**NOTE: A plug in oil heater is an option if the engine is being operated in conditions that may need a cold start assist.**

### Coolant

#### Coolant Mixtures

It is required that the PSI 8.8L LP engine uses DEX-COOL® Coolant in the cooling system, or any PSI approved alternative coolant. DEX-COOL® is a nitrite-, nitrate-, phosphate-, silicate-, borate and amine-free formulation that uses a patented carboxylate technology to provide maximum protection. DEX-COOL® meets ASTM D 3306 standards and is recommended for use in automotive applications.

The PSI 8.8L LP engine requires the use of a 50/50 mixture of DEX-COOL® and distilled water. This mixture will not vary depending on ambient temperature, the mixture will always remain 50% DEX-COOL® and 50% distilled water.

#### Contamination of Coolant

Coolant color can help indicate the condition of the coolant.

- Coolant color should be orange (clear - not cloudy).
- Coolant must not have floating debris or visible oil.
- At times, DEX-COOL® may begin to change to a pink color tone. This is normal and should not be a concern as long as it has remained clear.

### Instrument Panel Gauge Cluster

During engine starts and engine operation, gauges and indicator lamps should be checked periodically.

Gauges may vary with vehicle applications. Warning and indicator lamps show conditions not indicated by the gauges.

See the *Vehicle Operator Manual* for description of indicator lamps for the drivetrain, chassis components, and cabin.

### WARNING LAMPS

Warning lights signal when a reading is outside preset limits.

- Warning lamps indicate situations that must be inspected before operating the vehicle.

**NOTE: Please reference the vehicle operation manual for visual representations of the Instrument Panel Gauge Cluster.**

### Wait to Start Lamp

The Wait to Start lamp will illuminate during the fuel system purge. This will take 5-40 seconds before the engine should be started (see Fuel System section for details). When the Wait to Start lamp is extinguished, start the engine. See Starting the Engine section for further information.

If the operator does not wait for the lamp to extinguish, the result may be a hard start or no start condition.

### Maintenance Lamp

The Maintenance lamp will illuminate in conjunction with other warning lights or general text and warning messages. It may be accompanied by an audible alarm to indicate an alert condition to the operator.

### Amber Warning Lamp (AWL)

The Amber Warning Lamp (AWL) may illuminate by itself, or in conjunction with other warning lights or general text and warning messages, to indicate an alert condition to the operator. It is normal for this lamp to illuminate under certain high load and/or high ambient temperature conditions. It is safe to drive the vehicle. However, if the lamp continues to light or remains on, contact an authorized service provider to have the problem corrected at the first opportunity.

## SECTION 3 – INSTRUMENTS, INDICATORS, AND SWITCHES

---

### **RED Stop Lamp (RSL)**

**CAUTION:** To prevent engine damage, shut down engine immediately, if the RED Stop Lamp flashes

The RED Stop Lamp indicates that a severe fault condition exists and the engine should be shut down as soon as it is safe to do so. Damage to the engine and/or catalytic converter may already be occurring or have occurred when this lamp illuminates. When the STOP ENGINE LAMP illuminates the engine will go into a reduced power mode.

If the engine is shut down while the vehicle is in service, a single restart attempt may be performed after waiting a minimum of 30 seconds. If, upon restarting, the fault condition still exists the lamp will come on and the engine should be shut down. At this point the vehicle is unsafe to drive and should be transported to an OEM authorized repair facility.

### **Malfunction Indicator Lamp (MIL)**

The Malfunction Indicator Lamp (MIL) illuminates when the Engine Manufacturer Diagnostic (EMD) system detects a malfunction related to the emissions control system. The illuminated MIL indicates the vehicle needs to be serviced at the first convenient opportunity. Lamp may remain active after repair until system operation confirms repair.

## SECTION 3 – INSTRUMENTS, INDICATORS, AND SWITCHES

---

### GAUGES

#### Typical Water Temperature Gauge

The water temperature gauge indicates the temperature of coolant in the cooling system. The gauge operates only when the ignition switch is turned to ON. For normal operating temperatures refer to the Appendix section.

**CAUTION:** To prevent engine damage, do not operate engine above the maximum allowable temperature; this may cause internal damage. If the engine reaches maximum temperature, a derate will occur.

The indicator lamp will be activated as engine coolant temperatures increase above the allowable threshold. If engine temperature suddenly rises, shut down engine and determine the cause of overheating. If necessary, contact an authorized service provider. Operating the engine above these temperatures may result in derate or engine damage. For temperature limit details refer to the Appendix section.

#### Oil Temperature Gauge

The engine oil temperature gauge indicates the oil temperature of the engine.

#### Oil Pressure Gauge

The engine oil pressure gauge indicates operating oil pressure. The engine oil pressure indicator lamp and alarm will be activated at critical low oil pressures during various engine speeds. Shut down the engine immediately if the lamp and alarm are activated. For detailed oil pressure parameters please see the Appendix section.

**CAUTION:** To prevent engine damage, shut down engine immediately if the oil pressure indicator lamp and alarm are act

**SECTION 4 – ENGINE OPERATION**

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## SECTION 4 – ENGINE OPERATION

### Preoperation Checklist



**GOVERNMENT REGULATION:** Engine fluid (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluid and other contaminated materials (e.g. filters, rags, etc.) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

**! WARNING:** To prevent personal injury or death, provide ventilation when operating an engine in a closed area. Inhalation of exhaust gas can be fatal.

This engine has been given pre-delivery and delivery service by your dealer and is ready for operation. The operator should fully understand the use and function of all controls and instruments.

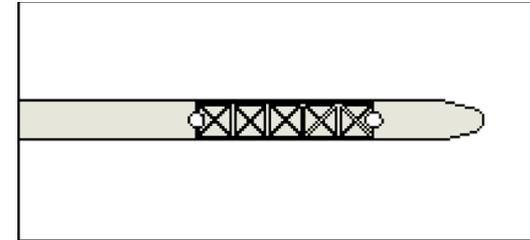


Figure 14 - Oil Level Gauge (typical)

**CAUTION:** To prevent engine damage, do not overfill with oil.

1. Check cooling system level.
2. Within 10 minutes of shutting down the engine, check for correct oil level.
3. Inspect for coolant, fuel or oil leaks.
4. Inspect air cleaner and piping for tightness and correct installation of filter element.
5. Check for loose or hanging electrical connections.
6. Check belt condition and alignment.
7. Fill the fuel tank with recommended fuel. See Acceptable Fuel Blends section.
8. Inspect exhaust system for obstruction or damage.

## SECTION 4 – ENGINE OPERATION

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### Preparing the Fuel System



**GOVERNMENT REGULATION:** Engine fluid (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluid and other contaminated materials (e.g. filters, rags, etc.) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

**! WARNING:** To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

**! WARNING:** To prevent personal injury or death, do not smoke while in or around the vehicle. Keep fuel away from flames and sparks.

### Purging the Fuel System

1. Roll the key on as you would to start the vehicle normally.
2. The Wait to Start lamp will illuminate while the fuel system performs the purging procedure. (this will take 5-30 seconds depending on engine heat and engine off time)
3. Once the fuel system purge is complete, the Wait to Start lamp will extinguish. The engine is ready to be started at this time.

See Starting the Engine section for further detail.

**NOTE:** If the engine runs out of fuel or the fuel filter has been drained and the engine will not start, contact your local dealer.

**CAUTION:** To prevent engine damage, if engine fails to start after 20 seconds of cranking, stop cranking engine and wait 2 minutes to allow the starter motor to cool.

## SECTION 4 – ENGINE OPERATION

---

### Starting the Engine

**! WARNING:** To prevent personal injury or death, do not use ether, gasoline, gasohol, or other starting aids.

**! WARNING:** To prevent personal injury or death, do not install ether start equipment, if an engine has a cold starting device or other cold climate starting aid.

**! WARNING:** To prevent personal injury or death, do not use ether starting fluid to start the engine.

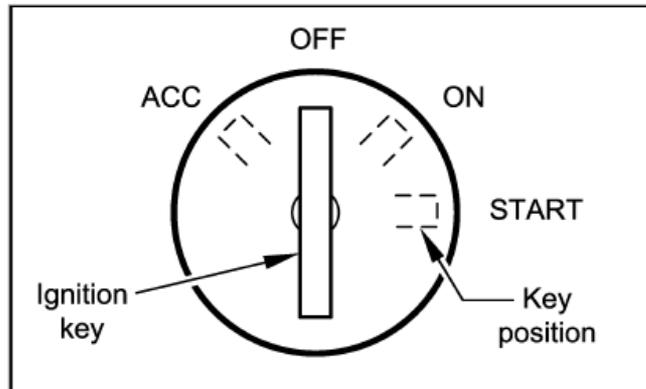


Figure 15 - Ignition switch positions

1. Set parking brake and shift transmission to park or neutral.

**CAUTION:** To prevent damage to the engine, do not depress the accelerator pedal.

2. Depress clutch pedal if equipped.
3. Turn ignition switch to ON. The Wait to Start lamp will illuminate continuously. Do not crank engine while lamp is on continuously.
4. When the Wait to Start lamp is extinguished turn ignition switch to START. If the vehicle has pushbutton starting, press and hold starter button.
5. When the engine starts, release the ignition switch or starter button. The ignition switch returns to ON and the engine continues to run.
6. With the transmission in neutral, release clutch pedal if equipped.

## SECTION 4 – ENGINE OPERATION

---

### Starting the Engine (cont.)

**CAUTION:** To prevent damage to the engine, if the engine fails to start after 20 seconds of cranking, do the following:

- Turn ignition switch to OFF and wait 2 minutes.
  - Repeat steps 1 through 5.
  - If after three attempts the engine does not start, determine the cause.
  - If starting attempts are continued, the starter motor can be damaged.
7. Verify engine reaches the low idle range. Check all gauges during warm-up. For idle speeds refer to the Appendix section
  8. For minimum oil pressure at idle speed refer to the Appendix section. If oil pressure is too low the low oil pressure warning may illuminate along with an amber lamp. A DTC may also become present.

**CAUTION:** To prevent engine damage – do not increase engine speed until oil pressure gauge indicates normal. If oil pressure does not reach the minimum limit after startup, shutdown the engine as soon as it can be safely turned off.

9. During normal engine operation the low oil pressure lamp will illuminate if minimum oil pressures are not met. If the lamp remains illuminated for an extended period of time a derate may occur.

**NOTE:** If engine starts and then stops, repeat engine starting procedure. If more than three attempts are required, determine the cause of the no-start and correct.

## SECTION 4 – ENGINE OPERATION

---

### Emergency Starting

 **WARNING:** To prevent personal injury or death, do not use ether starting fluid to start the engine.

 **WARNING:** To prevent personal injury or death, do the following when jump starting an engine:

- Wear eye protection.
- Do not smoke.
- Keep flame and sparks away from battery.
- The starting system may require a 12V or 24V system. The engine system is a 12V system. Please contact your dealer for this information before jump starting the engine.

**CAUTION:** To prevent engine damage, do not allow metal tools to contact positive terminal of battery.

1. Set parking brake and shift transmission to park or neutral.
2. Shut off lights, heater, air conditioner, and other electrical loads in both vehicles.
3. Make sure vehicles are not touching.
4. Connect one end of the first jumper cable to the positive (+) terminal of the dead battery or to the positive (+) terminal of the jump start stud. Connect the other end to the positive (+) terminal of the charged battery.

 **WARNING:** To prevent personal injury or death, always connect jumper cable for positive battery terminals first.

 **WARNING:** To prevent personal injury or death, do not attach jumper cable to a negative (-) dead battery terminal. This can cause sparks and an explosion.

5. Connect one end of the second jumper cable to the negative (-) terminal of the charged battery and the other end to chassis frame of the vehicle with the dead battery.
6. Start the engine in the vehicle that has the charged battery.
7. Start the engine in the vehicle that has the dead battery.

 **WARNING:** To prevent personal injury or death, always disconnect jumper cable from negative contacts first.

8. Disconnect the jumper cable from negative terminal and chassis frame.
9. Disconnect the jumper cable from positive battery terminals or one terminal and jump start stud.

## SECTION 4 – ENGINE OPERATION

---

### Operation

#### IDLE SPEED

**⚠ WARNING:** To prevent personal injury or death, provide ventilation when operating an engine in a closed area. Inhalation of exhaust gas can be fatal.

Idle speed will vary depending on engine temperature. The engine will utilize the Cold Idle Kick when engine temperature is below a certain degree. This will allow rpm to be increased, providing a quicker engine warmup. During this time, engine rpm may fluctuate. For normal idle speed please refer to the Appendix section.

#### COLD WEATHER OPERATION

**⚠ WARNING:** To prevent personal injury or death, do not use ether, propane, gasoline or gasohol as starting aids.

**NOTE:** If operating in temperatures below -20°F (-28.9°C), contact an authorized service provider or dealer for information about special cold weather equipment and precautions.

A block coolant heater and oil heater is required at temperatures below -20°F (-28.9°C).

**NOTE:** Do not use a Winter Front under any conditions. Use of a Winter Front can lead to overheating and possible engine damage.

1. Before operating the engine at 32°F (0°C) or lower, follow preoperation checks and check or service the following:
  - Correct battery size
  - Full battery charge and charging system operation
  - Condition of other electrical equipment
  - Cooling system leaks
  - Correct coolant and cooling system level
2. At the end of each day of operation, perform the following:
  - Fill the fuel tank with the correct fuel.
  - Check oil level.
  - Clean external surfaces of the engine and accessories to prevent dirt or snow buildup.
  - Clean the outside of the radiator to prevent dirt or snow build up.

## SECTION 4 – ENGINE OPERATION

---

### Operation (cont.)

#### HOT WEATHER OPERATION

1. Before operating the engine above 90°F (32°C), follow preoperation checks and check or service the following:
  - Full battery charge and charging system operation
  - Condition of other electrical equipment
  - Cooling system leaks
  - Correct coolant and cooling system level
2. At the end of each day of operation, perform the following:
  - Check oil level.
  - Clean external surfaces of the engine and accessories to prevent dirt buildup.
  - Clean outside and in between radiators to prevent dirt buildup.

#### ENGINE SHUTDOWN

Simply turn the key to the OFF position for proper engine shutdown.

## SECTION 4 – ENGINE OPERATION

---

### Operation (cont.)

#### ENGINE WARNING PROTECTION SYSTEM (EWPS)

EWPS warns the operator of engine conditions that can damage the engine. Optional engine shutdown is available, contact your dealer for information.

The EWPS is the base system in which all engines are equipped. If one or more faults are detected, the ECM will illuminate the RED Stop Lamp, and set a corresponding Diagnostic Trouble Code (DTC).

Coolant temperature, coolant level, oil temperature, and oil pressure will be monitored using this system. If a threshold is exceeded at any time, a series of lamps may illuminate and the engine may need to be shutdown as soon as it is safe to be turned off. A derate may also occur.

If a Warning Threshold is exceeded, the amber warning lamp will illuminate. If a Critical Threshold is exceeded, the red STOP lamp will illuminate.

Depending on vehicle configuration options and emissions certification level, the MIL may also be illuminated when a derate condition is achieved.

- |   |   |                                   |
|---|---|-----------------------------------|
|  |  | • Coolant Temp Warning Threshold  |
|  |  | • Coolant Temp Critical Threshold |
|  |  | • Oil Temp Warning Threshold      |
|  |  | • Oil Temp Critical Threshold     |
|  |  | • Oil Pressure Warning Threshold  |
|  |  | • Oil Pressure Derate Threshold   |
|   |  | • Low Coolant Warning Threshold   |

**NOTE: These images are for reference only. Refer to the vehicle operation manual for visual representation of the warning lamps.**

## SECTION 4 – ENGINE OPERATION

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### Operation (cont.)

#### ENGINE MANUFACTURER DIAGNOSTICS (EMD) OVERVIEW

The EMD system uses many individual pre-programmed “monitors” to ensure the vehicle is meeting emissions standards. An EMD monitor is a strategy to evaluate the performance of an emissions related system or component. All monitors are designed for execution in a prescribed frequency; the monitors run automatically during every run cycle.

The operator will be alerted to emissions system problems when the Malfunction Indicator Lamp (MIL) illuminates. Non-emissions faults will illuminate the Amber Warning lamp. When the MIL illuminates, bring the vehicle in for service at the next available opportunity. The EMD system does not change the way the vehicle should be driven, the recommended driving style, or the way you use the vehicle.

The EMD is capable of causing an engine derate, in this case the engine STOP lamp will illuminate to notify the driver. The EMD system will not cause an automatic engine shutdown, it is up to the driver to turn off the engine as soon as it is safe to do so. Once the engine is off the driver may attempt to cycle the key back on to restart the engine. If the engine is restarted and the STOP lamp remains illuminated, the engine should be shut off and the driver should seek a tow truck to get the vehicle to a service center.

#### ROAD SPEED GOVERNOR (RSG)

RSG is the top vehicle speed the ECM allows. RSG can be set from factory or with the PSI Powerlink using VEPS. A Reverse Speed Governor will also accompany the RSG settings, this will allow a limit to be set for vehicle speed while in reverse. The RSG will have two setting in VEPS:

- OFF
- Vehicle speed determined by customer

To have an RSG set, changed or turned off, call an authorized service provider.

#### ROAD OPERATION

Correct road operation of your vehicle provides the following:

- Satisfactory engine performance
- Maximum fuel economy
- Long service life

General guidelines for correct road operation:

1. Accelerate smoothly and evenly to engine's rated speed. Rapid acceleration causes high fuel consumption.
2. When approaching a hill, press accelerator smoothly to start the upgrade at full power. Downshift to maintain maximum vehicle speed.

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

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## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

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### Maintenance Schedule

 **WARNING:** The fuel system is under pressure. Do not service the fuel system until it has been relieved of pressure. Servicing the fuel system, or a component of the fuel system, while it is under pressure may result in injury or death.

### Replacement Parts

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Key Replacement Parts	Industry Standard	PSI Part Number
Engine Oil (7.5 quarts)	DEXOS 5W-30	DEXOS 5W-30
Engine Oil Filter		PSI - 80000983
Engine Coolant	DEX-COOL 50/50	DEX-COOL 50/50
LP Fill Filter	*or any PSI approved coolant.	PSI - 32502612
Spark Plug		PSI - 80000808
Spark Plug Wire		PSI - 80000064

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

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### Maintenance Schedule

### Power Solutions International, Inc. - 8.8L LP Engine

Service Procedure	Miles (Kilometers)	Hours	Months
Change Oil and Filter	5,000 (8,000)	200	6
Perform Coolant Quality Check (including Freeze Point)		<i>Perform Annual Inspection</i>	
Inspect Fuel System (including 80% level gauge)(1)		<i>Perform Annual Inspection</i>	
Inspect/Replace Belts, Tensioners, Air Intake Piping, Clamps	15,000 (24,000)	600	18
Replace internal and external Fuel Filters (more often if poor fuel quality)	70,000 (112,000)	1,400	42
Inspect Electrical System	35,000 (56,000)	1,400	42
Flush Coolant System / Replace Coolant (2)	60,000 (97,000)	2,400	72
Inspect/Replace Spark Plugs and Plug Wires (3)	60,000 (97,000)	2,400	72
Replace Air Filter		<i>Contact your Dealer</i>	

1 - Follow the recommended inspection instructions in the NFPA 58 Standard.

2 - Test coolant quality for proper chemical balance and replace if outside manufacturers specification.

3 - For heavier duty service, inspect/replace spark plugs at 45,000 miles (72,000 Km).

**NOTE: When performing these service procedures, the interval should be decided by whichever increment comes first.**

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES



**GOVERNMENT REGULATION:** Engine fluid (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluid and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

**! WARNING:** To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

**! WARNING:** To prevent personal injury or death, do not let engine fluid stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

### OIL LEVEL

Recommended to check before engine operation.

1. Park vehicle on level ground.

**NOTE:** Do not check oil level if engine is running or immediately after engine shutdown. Oil level should be checked within 10 minutes of engine shutdown.

2. Shut down the engine and check oil level within 10 minutes.
3. Remove the dipstick from the dipstick tube.

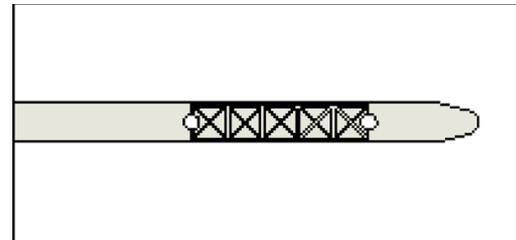


Figure 16 - Oil Level Gauge (typical)

**CAUTION:** To prevent engine damage, do the following:

- Make sure oil level readings are within the crosshatched operating range on the oil level gauge.
  - Do not overfill the engine with oil.
  - Do not operate engine if oil level is above or below the operating range.
4. If oil level is below operating range, fill with recommended oil until the level is correct.
  5. If oil level is above operating range, drain oil until the level is correct.

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

### Service Procedures (cont.)

#### COOLANT LEVEL

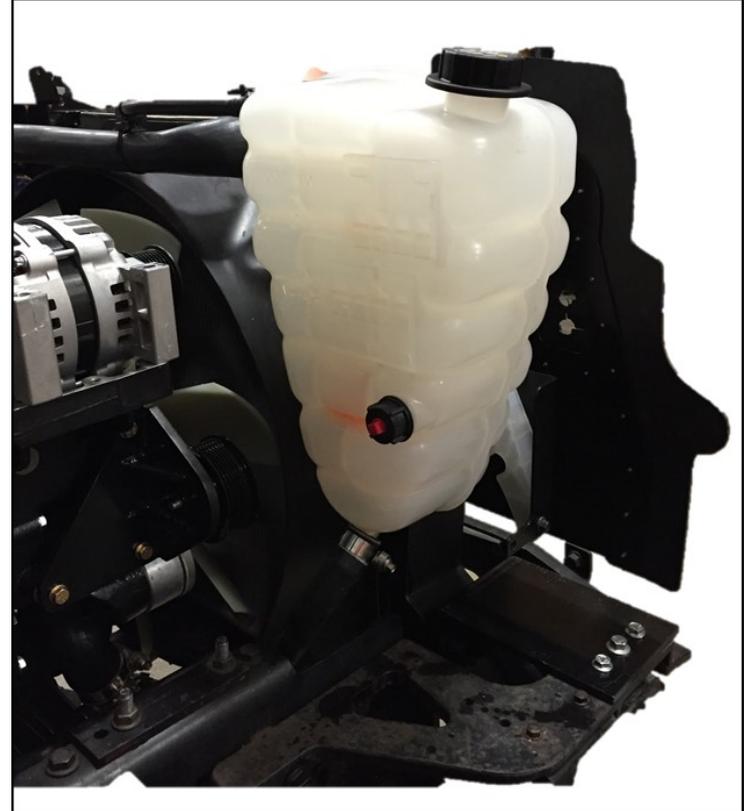
Recommended to check before engine operation.

**NOTE:** Be sure to use a 50/50 blend of DEX-COOL and distilled water.

**⚠ WARNING:** To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

**⚠ WARNING:** To prevent personal injury or death, do not let engine fluid stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids

1. Park vehicle on level ground, set the parking brake, and shut down the engine.
2. Check coolant level in the coolant tank.
  - For cold engine check, coolant level should be between the COLD MIN and COLD MAX marks.
  - For hot engine check, coolant level should be at the COLD MAX mark (top of coolant tank).
  - If coolant level is below the COLD MIN mark on a cold engine or below the COLD MAX mark on a hot engine, continue with steps 3 and 4.



**Figure 17 - Typical Coolant Tank (for reference only)**

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

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### Service Procedures (cont.)

#### COOLANT LEVEL (cont.)

 **WARNING:** To prevent personal injury or death, do the following when removing the radiator cap or coolant tank cap:

- Allow the engine to cool for 15 minutes or more.
  - Wrap a thick cloth around the radiator cap or coolant tank cap.
  - Loosen cap slowly a quarter to half turn to vent pressure.
  - Pause for a moment until all pressure has escaped to avoid being scalded by steam.
  - Continue to turn cap counter clockwise to remove.
3. Remove coolant tank cap.
    - If engine is cold, add coolant up to the COLD MAX mark.
    - If engine is hot, add coolant up to the bottom of the coolant tank fill neck.
  4. Install and tighten coolant tank cap.

### EXTERNAL LEAKAGE

Service Interval: Before Engine Operation

 **WARNING:** To prevent personal injury or death, shut down engine, set parking brake, and block wheels before inspecting for external leakage.

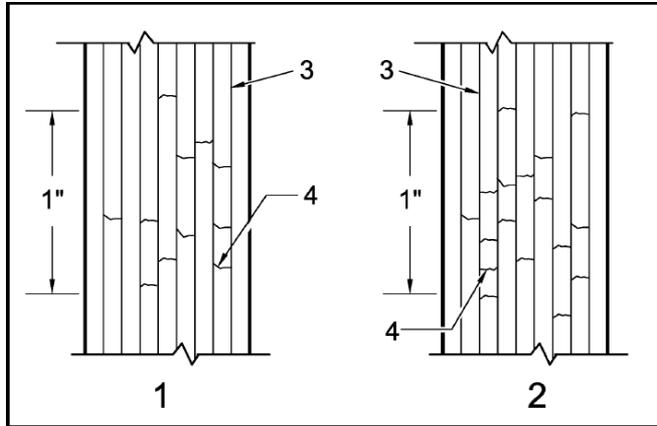
1. Check for the following conditions:
  - Cracked hoses
  - Loose hose connections
  - Coolant stains
  - Oil stains
  - Fuel stains
  - Leakage at water pump
2. Correct problems.

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

### Service Procedures (cont.)

#### BELT, AIR INTAKE PIPING AND CLAMPS

Service Interval: Check every 15,000 miles (24,000 km), 18 months, or 600 hours. Whichever comes first.



**Figure 18 - Belt Condition**

1. Belt in good condition
2. Belt ready for replacement
3. Belt ribs
4. Cracks in belt

Inspect condition of all drive belts (Figure 18). Install a new belt if any of the following conditions exist:

- Excessive wear
- Missing material
- Grease or oil contamination
- Over three cracks per inch in a belt rib

#### Removing the Belt

##### Main Drive Belt

1. Insert a 3/8-inch drive ratchet into the machined hole on the belt tensioner.
2. Rotate the auto tensioner in the clockwise direction to relieve tension from the belt and remove the belt from the auto tensioner pulley and other pulleys as required.
3. Slowly release the ratchet; the auto tensioner automatically adjusts.
4. Remove the ratchet from the tensioner.

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

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### Service Procedures (cont.)

#### BELT, AIR INTAKE PIPING AND CLAMPS (cont.)

##### Removing the Belt

###### Air Compressor Belt

1. Attach a 3/8–inch drive ratchet and a 15mm socket to the tensioner.
2. Rotate the auto tensioner in the counter clockwise direction to relieve tension from the belt and remove the belt from the auto tensioner pulley and other pulleys as required.
3. Slowly release the ratchet; the auto tensioner automatically adjusts.
4. Remove the ratchet from the tensioner.

##### Installing the Belt

###### Main Drive Belt

1. Insert a 3/8–inch drive ratchet into the machined hole on the belt tensioner.
2. Rotate the auto tensioner in the clockwise direction to relieve tension from the pulley and install the belt on the auto tensioner pulley and other pulleys as required.
3. Slowly release the ratchet; the auto tensioner automatically adjusts. Ensure the belt is routed properly.
4. Remove the ratchet and socket.

##### Installing the Belt

###### Air Compressor Belt

1. Attach a 3/8–inch drive ratchet and a 15mm socket to the tensioner.
2. Rotate the auto tensioner in the counter clockwise direction to relieve tension from the pulley and install the belt on the auto tensioner pulley and other pulleys as required.
3. Slowly release the ratchet; the auto tensioner automatically adjusts. Ensure the belt is routed properly.
4. Remove the ratchet and socket.

**NOTE: See Figures 19 and 20 for proper belt routing.**

##### AIR INTAKE PIPING AND CLAMPS

Inspect hoses, pipes, and clamps for any of the following conditions, install new parts when needed:

- Loose hoses or clamps, tighten or replace as required
- Ruptured hoses
- Cracked air cleaner housing

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

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### Service Procedures (cont.)

#### BELT, AIR INTAKE PIPING AND CLAMPS (cont.)

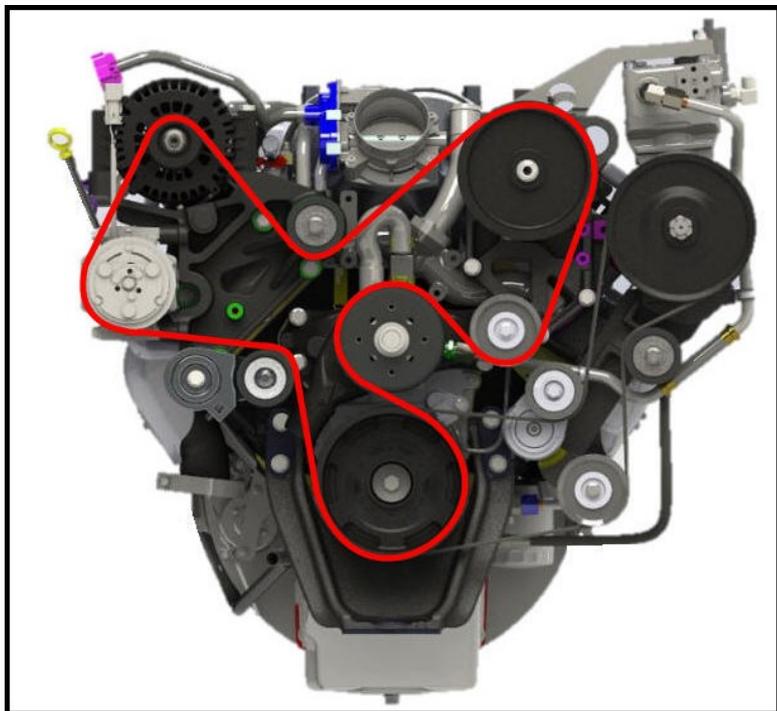


Figure 19 - Typical Main Drive Belt Routing

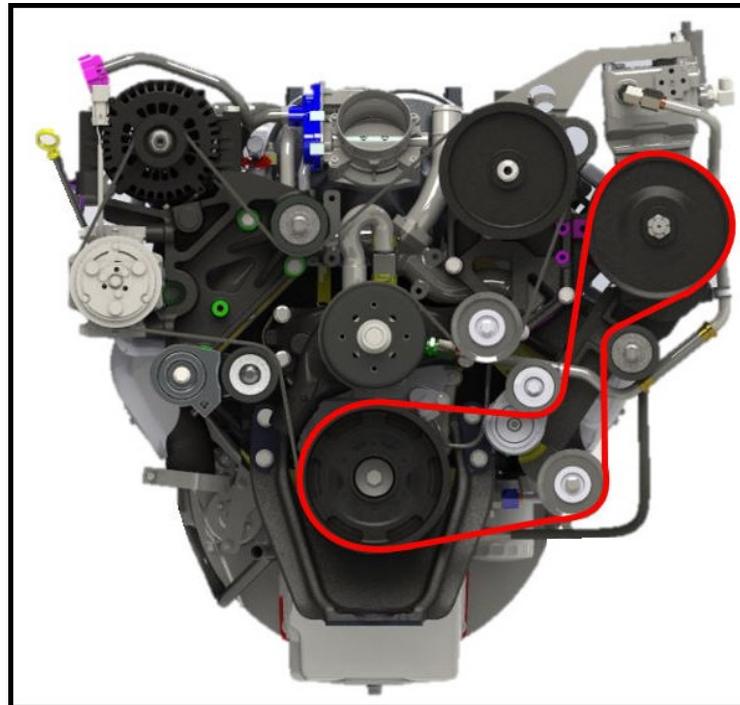


Figure 20 - Typical Air Compressor Belt Routing

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

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### Service Procedures (cont.)

#### COOLANT FREEZE POINT

Check freeze point with a refractometer.

1. Put drop of coolant on refractometer window.
2. Look through eyepiece and focus.
3. Record freeze point.
4. Adjust coolant concentration as necessary to achieve desired freeze point protection.

Service Interval: Check annually.

**NOTE: Be sure that the antifreeze mix is 50% distilled water and 50% DEX-COOL.**

50/50 Mixture Freeze Point: -34°F (-37°C).

#### ENGINE OIL AND FILTER

 **WARNING:** To prevent personal injury or death, wear safety glasses and avoid moving components such as fans, pulleys, and belts when taking an engine oil sample.



**GOVERNMENT REGULATION:** Engine fluid (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluid and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.

 **WARNING:** To prevent personal injury or death, wear protective clothing when draining hot oil.

 **WARNING:** To prevent personal injury or death, do not let engine fluid stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

### Service Procedures (cont.)

#### ENGINE OIL AND FILTER (cont.)

1. Park the vehicle on level ground. Set the parking brake and shift the transmission to park or neutral.
  2. Run the engine until operating temperature is reached, then shut down the engine.
  3. Remove the oil filter. (Make sure the filter seal is still on the filter.)
  4. Dispose of the oil filter according to local regulations.
  5. Using clean engine oil, lubricate the circumference of the new oil filter O-ring.
  6. Install new oil filter into oil filter housing and tighten to 25 ft·lb (34 N·m).
  7. Put a drain pan under the oil pan drain plug, remove the oil pan drain plug, and drain the oil.
  8. Inspect the oil pan drain plug O-ring. If it is free of defects, it can be reused. Replace if required.
  9. Lubricate the oil pan drain plug O-ring with clean engine oil and put the O-ring onto the drain plug.
  10. Install the oil pan drain plug and tighten to 21 ft·lb (28 N·m).
  11. Dispose of oil according to applicable local regulations.
- CAUTION:** To prevent engine damage, do not overfill with oil.
12. Add engine oil with the correct oil viscosity and formulation. DEXOS 5W-30 must be used.

13. Check the oil level gauge. Oil level must be within the crosshatched operating range.
14. Start the engine and run at low idle.
15. Run the engine at various speeds for 2 minutes to fill the oil passages. Shut off the engine. Check for leaks, especially around the oil filter and the oil pan drain plug.
16. Shut down the engine for 5 minutes to allow the oil to return to the oil pan.

**CAUTION:** To prevent engine damage, do not overfill with oil.

17. Recheck oil level and add oil as needed.

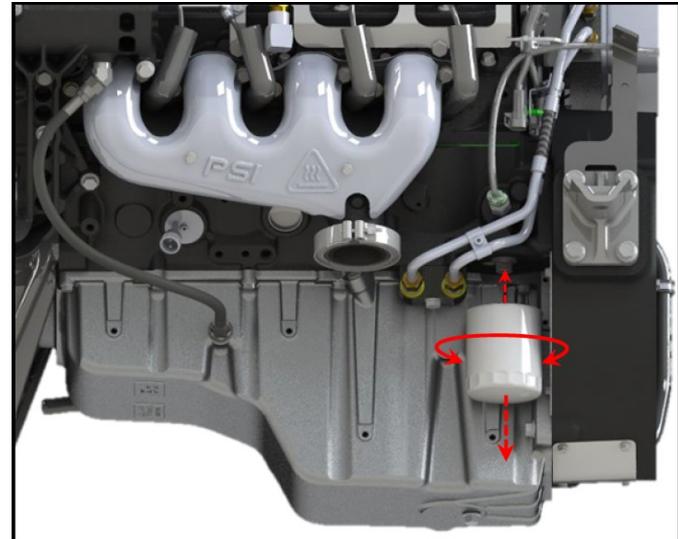


Figure 21 - Oil Filter Replacement

## SECTION 5 – MAINTENANCE SCHEDULE AND SERVICE PROCEDURES

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### Service Procedures (cont.)

#### ELECTRICAL SYSTEM

Service Interval: Annually

1. Check wiring harness for cracks, rubbing, and loose connections.
2. Check sensors for loose connections, corrosion, or cracks.
3. Check battery cables for the following conditions:
  - Broken insulation
  - Rubbing or chaffin
  - Corroded or loose connections
4. Repair items identified

## SECTION 6 – LONG TERM STORAGE

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## SECTION 6 – LONG TERM STORAGE

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### General Information

If the engine or machine is to be placed in storage for a period of one to six months, it is recommended that the following steps be followed:

- Store indoors with consistent temperature and low humidity if possible.
- Protect the air cleaner inlet from water entry.
- Protect the exhaust outlet or muffler outlet from water entry.
- Check the coolant freeze point and top off radiator.
- Use a weather proof storage bag, with desiccant bag inside, for extra protection.

At the end of each and every three-month storage period:

- Carefully check all drive belts, paying particular attention to the point where the straight run of the belt starts to bend around the pulley. Check grooves in the pulley for corrosion.
- Check the level of coolant.
- Check the level of oil in the sump on the dipstick.
- Rotate crankshaft by hand to re-distribute load on the valve train and to keep seals from becoming stuck. Be sure engine rests in a different position (~180 degrees).
- If battery is still installed in unit, slowly recharge battery. This can be done every month to extend the service life of the battery.

Storing an engine over six months:

(Follow all previous procedures in addition to the following.)

- Drain the engine crankcase and refill with recommended oil.
- Change the oil filter.
- Disconnect and remove the battery.
- Clean exterior surface of the engine.
- If the engine is equipped with an automotive type clutch or PTO clutch, make sure that the clutch is disengaged.

At the end of each and every six-month storage period:

- Check that existing preservation of all external surfaces is sound and complete, paying particular attention to crankshaft lip seal surfaces, re-preserve as necessary.
- Ensure that all aperture covers (air intake, exhaust manifolds, etc.) are securely positioned.
- Perform all 3 month inspections listed.

**NOTE: The lubricating oil and fully primed filter must be replaced with oil to the listed specification every twelve months, even though the oil has not been used. Oil left standing in an engine will oxidize and can be contaminated by condensation within the crankcase.**

## SECTION 6 – LONG TERM STORAGE

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### General Information (cont.)

#### Removing an Engine from Storage

When removing an engine or machine from storage, the following steps should be taken to be sure the engine is in proper operating condition:

- Remove all protective storage coverings from engine / machine.
  - Check engine oil level. If engine has been dormant for over 12 months change engine oil and filter.
  - Check coolant level and strength, add and adjust as necessary.
  - Inspect drive belt system. Check for cracks in belt and corrosion on pulleys. Replace and clean as needed. If applicable grease pulley bearings.
  - Install a new or fully charged battery. If installing a used battery check electrolyte levels.
  - Inspect all engine systems thoroughly for leaks, tears, broken wires, etc.
  - Rotate engine by hand at least 360 degrees before attempting to start to be sure engine rotates smoothly.
  - When starting engine watch all gauges closely. Be sure engine oil pressure rises within 10 seconds of engine run time. If no oil pressure shut down engine.
- Allow engine to run at idle for approximately 5 minutes, then raise engine to a 'high idle', 1000-1500 rpm and bring to full operating temperature. Watch all gauges closely, if any system is out of specification shut down engine immediately and find cause.
  - After engine has successfully reached operating temperature shut down and re-check all fluid levels and systems.

## SECTION 7 – SERVICE RECORDS

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## SECTION 7 – SERVICE RECORDS

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### Maintenance Service Record

 **WARNING:** To prevent personal injury or death, read all safety instructions in the “Safety Information” section of this manual.

 **WARNING:** To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

Save scheduled maintenance work orders and receipts for proof of correct maintenance. Failure to maintain work orders and receipts may affect your warranty coverage.







## SECTION 7 – SERVICE RECORDS

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### Daily Care and Report

 **WARNING:** To prevent personal injury or death, read all safety instructions in the “Safety Information” section of this manual.

 **WARNING:** To prevent personal injury or death, put transmission in neutral or park, set parking brake, and block wheels before doing diagnostic or service procedures.

Check the following before engine operation to prevent engine failure. Report all problems for immediate service.

- Oil level
- Oil, air, fuel or coolant leaks
- Coolant system level
- Excessive consumption of crankcase lubricating oil, coolant or fuel
- Unusual engine noise

Do the following before engine operation to prevent engine failure.

- Add coolant if necessary. Make sure fill cap seal is in good condition and the cap is installed tightly.
- Fill the fuel tank with correct fuel.
- Inspect external surfaces of the engine, around and on the radiators, and accessories. Clean as necessary.





## Appendix

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## Appendix

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### Engine Specifications

### Power Solutions International, Inc. - 8.8L LP Engine

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<b>General Specifications</b>	<b>Item</b>	<b>Unit</b>
Engine Type	Big Block V-8	
Displacement	535 (8.767)	In <sup>3</sup> (L)
Compression Ratio	10.1:1	
Stroke	4.500 (114.3)	In (mm)
Bore	4.350 (110.5)	In (mm)
Firing Order	1-8-7-2-6-5-4-3	
Aspiration	Natural	
RPM Range (Min & Max)	700 / 2,800	min / max
Low Speed Governor		
Cold	850	rpm
Hot	750	rpm
High Speed Governor		
Throttle (neutral)	2,600	rpm
Throttle (in-gear)	2,700	rpm

## Appendix

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### Engine Specifications

### Power Solutions International, Inc. - 8.8L LP Engine

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<b>Lubrication Specifications</b>	<b>Item</b>	<b>Unit</b>
Minimum Pressure @ Idle	8 (55.1)	psi (kPa)
Engine Oil Capacity		
Minimum	7.0 (6.62)	qts (L)
Maximum	7.5 (7.10)	qts (L)

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<b>Cooling System Specifications</b>	<b>Item</b>	<b>Unit</b>
Standard Thermostat Range		
Full Open	214 (101.1)	F° (C°)
Closed	190 (87.2)	F° (C°)

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## Appendix

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