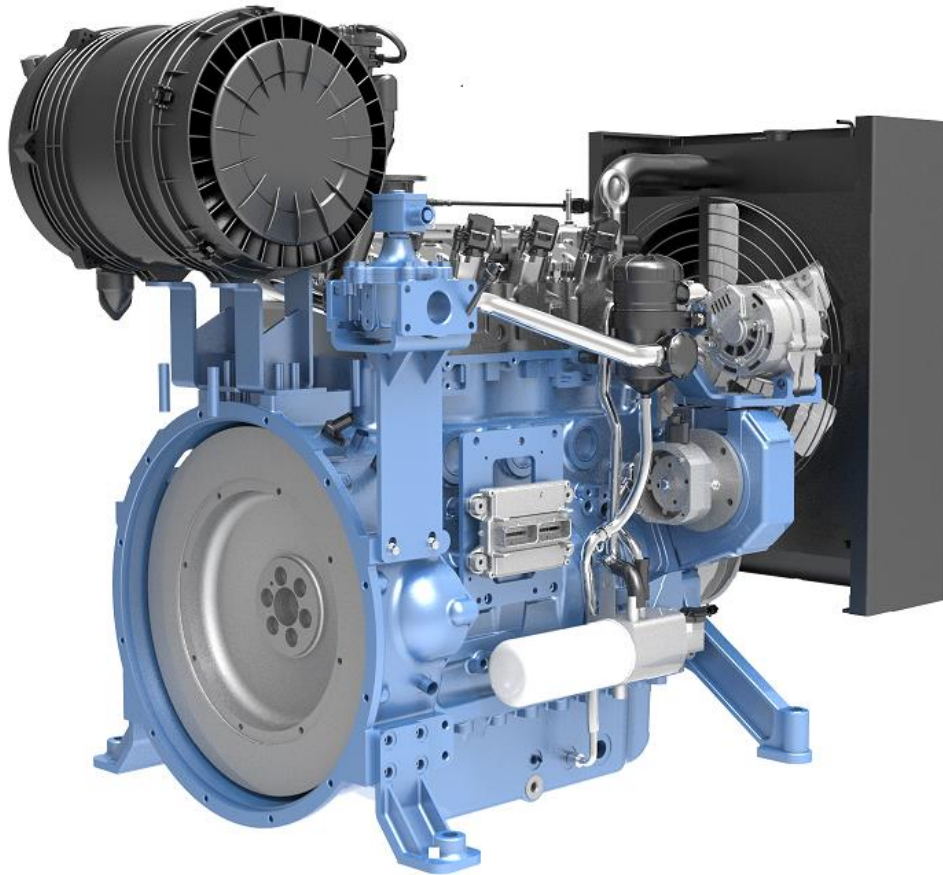




# WP04GNA INSTALLATION AND APPLICATION MANUAL

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EMISSION-RELATED INSTALLATION INSTRUCTIONS  
FOR WP04GNA ENGINE  
NON-COMMERCIAL FUELS, NG, LPG & VPG Non-Emergency



3100 GOLF ROAD, ROLLING MEADOWS, IL

WEICHAI EMISSION-RELATED INSTALLATION INSTRUCTIONS

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## INSTALLATION OF CERTIFIED ENGINES

Thank you for your recent purchase of an EPA certified WEICHAI Nonroad and Stationary Industrial Engine.

These instructions are intended to provide the installer of the engine all the information that is necessary to properly install the engine and related components into the equipment chassis. The United States Environmental Protection Agency (EPA) requires that the manufacturer of the engine provide installation instructions to the equipment manufacturers as defined in the Code of Federal Regulations (40CFR 1048.130).

**Failing to follow these instructions when installing a certified engine in a piece of nonroad equipment violates federal law (40 CFR 1068.105(b)), subject to fines or other penalties as described in the Clean Air Act.**

**This engine is certified to be used in nonroad and stationary constant speed only equipment applications. Do not install this engine for use in any variable speed applications!**

This industrial engine comes fully equipped and certified with a complete emissions control system which includes the fuel system, sensors and actuators, a fully integrated engine management system, and an exhaust after treatment system including a three-way catalyst. When this industrial engine is correctly installed by an Original Equipment Manufacturer (OEM), it will meet or exceed the Emission Standards for Large Spark Ignited (LSI) engines established by the US Environmental Protection Agency (EPA). This engine has been certified to exhaust emission standards in 40 CFR Part 1048 and 40 CFR Part 60 JJJ including appropriate deterioration factors, over the regulated useful lifetime of seven years or 5000 hours, whichever occurs first.

Emissions compliance throughout the useful lifetime requires proper engine maintenance. Please refer to the maintenance schedule in the service manual for details.



## NOTICE OF IMPORTANT REQUIREMENTS OF CERTIFIED ENGINES

**Important Notice-** The required Emissions Control Information label has been placed on this certified engine during the WEICHAI assembly process. If you install the engine in a way that makes the engine's emission control information label hard to read during normal engine maintenance, you must place a duplicate label on the equipment, as described in 40 CFR 1068.105. Contact Weichai to request a duplicate label (Dial 1-855-922-9001).

**Important Notice-** This engine uses a crankcase recirculation system that routes all crankcase gasses back to the engine intake air system. The EPA requires every certified industrial engine to have a closed crankcase and no crankcase emissions may be vented to the atmosphere as described in the Code of Federal Regulations (40 CFR 1048.115). Please refer to the Intake Air System section included in these instructions for details.

**Important Notice-** To meet EPA exhaust emissions field testing requirements it is important that the OEM design the exhaust system so that a 20-centimeter extension can be temporarily installed on the equipment's exhaust outlet. The extension is required in order to prevent dilution of the exhaust sample with ambient air during the exhaust emissions test.

**Important Notice-** EPA requires that WEICHAI warranty all emission-related components as defined in 40 CFR Part 1048.120. Please refer to the Emission Related Warranty Statement included with the sale of all new engines for further details. Warranty for non-critical emissions components will be as defined in the individual purchase agreement.



## SYSTEM OVERVIEW

### STOICHIOMETRIC, RICH BURN CONTROL

The 4G engine control module is the backbone of the EControls control system. Proven in a multitude of applications around the world, the 4G based engine control system delivers reliable operation and optimal engine operation no matter the environment. The 4G engine control system for highly regulated emission countries enables operation at the stoichiometric air / fuel ratio with Rich Burn and a three-way catalyst (TWC). Stoichiometric engine operation ensures that there is precise amount of air delivered to completely burn all the fuel. The stoichiometric Air Fuel Ratio (AFR) for natural gas is 17.7:1 and for propane is 15.5:1. Figure 1 shows the required 4G engine control system configurations for Propane (VPG), Natural Gas (NG) and Bi-Fuel (VPG and NG) with the TWC.

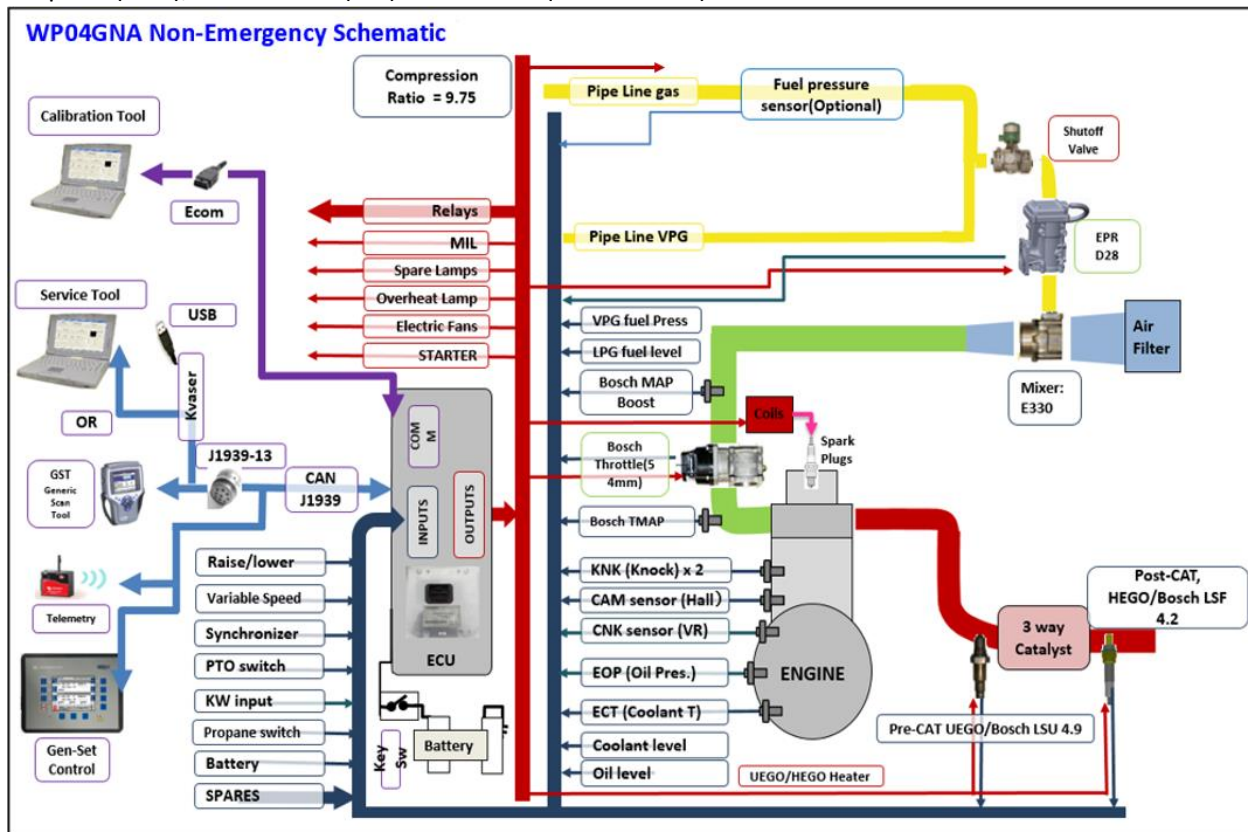


Figure 1 WP4GNA Non-Emergency Schematic

### Bi-FUEL

The 4G Engine Controls System has full engine software control authority, therefore switching from Natural Gas (NG) to Propane (LPG/VPG) fuel is a software command from the operator console or a switch input into the 4G ECM. The Weichai WP04GNA engine is capable of operating in bi-fuel mode starting from VPG/LPG and switching to NG after the NG pressure develops from operation. With the proper valve and sensor arrangement the fuel supply transition can be made while in operation, under full load, and automatically.

NG/VPG is WP04GNA standard configuration. With an add-on option, WP04GNA can also support LPG, manual or automatic switching.

WEICHAI EMISSION-RELATED INSTALLATION INSTRUCTIONS



## **TELEMATICS SUPPORT**

Hardware and software capability exist in the full authority 4G control system to send and receive CAN communication files in a structured message format. The input and output file structure and variable content need to be defined by the customer and implemented by WEICHAI. There will be an engineering change associated with setting up the file structures and debugging the communications with the telematics module. Equipment and technical support is available from Weichai.

### **Diagnostic Messages**

The 4G engine control system contains a highly configurable diagnostic list that can be tailored to each application's specific needs using the calibration spreadsheet. With each available P-code listed along with the short-name description. Note that not all DTCs necessarily apply to every application.

### **ECM: Engine Control Module: 4G 90 pin**

The ECM is full authority, by this we mean it includes the ignition and air/fuel ratio control, contains all the I/O to interface the engine with the application and has a complete set of diagnostics. By implementing all functions in one box the overall system complexity is reduced as is the total system cost.

Some of features included in the ECMs are, lean burn or stoichiometric combustion control, continuous fuel injection control or standard digital injectors, ignition control electronic boost control for turbochargers – VGT or wastegate, drive-by-wire throttle control, oxygen sensor based closed-loop air/fuel ratio control (wide band (UEGOs) or switching (HEGOs)), adaptive spark and fuel control, EGR control, transmission / engine coordination, speed control/governing (idle, max speed, all-speed, cruise control) and vehicle network interface systems (CAN, J1708, J1850, Ford SCP).

### **DEPR: Direct Acting Electronic Pressure Regulator**

Our fuel control device is referred to as a Direct Acting Electronic Pressure Regulator or D-EPR shown as in Figure 2. Its benefits to our customers and the end customer are:



Figure 2 Direct Acting Electronic Pressure Regulator

- It is a continuous fuel flow device. This allows the most homogeneous mixture of air and fuel to the engine yielding optimum combustion with minimum emissions and maximum fuel economy.
- It operates on low pressure fuel from 6 to 20 inches of water of inlet pressure, no pressure intensification system required.
- It does not wear in the case of dry fuels (NG) and it does not stick or clog due to heavy hydrocarbons or waxes found in LPG.
- It is fast and accurate, providing precise air/flow ratio control during transients (or load acceptance).

The DEPR is a single-stage microprocessor based electromechanical fuel pressure regulator that incorporates a high speed actuator. It communicates with the Engine Control Module (ECM) over a Controller Area Network (CAN) link, receiving fuel pressure commands and broadcasting DEPR operating parameters back to the ECM. The DEPR can regulate fuel pressure between +/- 17 inches of water column above the Mixer air inlet pressure, providing sufficient control authority to stall an engine either rich or lean. When the DEPR receives an output pressure command from the ECM, the valve is internally driven to attain targeted fuel pressure, the DEPR then closes the loop internally using a built in fuel pressure sensor to maintain target fuel pressure/fuel flow rate, until another external command from the ECM is received.



Figure 3 E330 Mixer

**MIXER: E330**

A relatively constant pressure drop mixer is used to draw fuel when coupled with EPR. The basic principle of the product is to introduce air and fuel into engine. It also aids in introducing turbulence into the air and fuel assisting in making it a homogeneous mixture. The mixer also acts to increase or decrease the fuel entering the engine proportional to the amount of air flowing in the engine on a volumetric basis.

E330 MIXER provide the following benefits to the market:

- Superior fuel/air ( $\phi$ ) ratio accuracy
- Reduced part to part fuel/air ratio repeatability
- Extended diaphragm life through material selection and design
- Performance over the -40C to +125C temperature range
- Eliminate LPG fuel contamination issues
- Superior low flow resolution and repeatability, eliminates idle adjustment





**HEAVY-DUTY DUAL STAGE REGULATOR:**

The heavy-duty dual stage regulator vaporizes liquid propane to gaseous form and also regulates the fuel pressure to meet the fuel pressure requirement as is shown in Figure 4.



Figure 4 Heavy-Duty Dual Stage Regulator

The HD DSR is a two stage fully mechanical regulator that is available in LPG configurations. The DSR is normally open with a positive outlet pressure and must be used with fuel lock-off upstream to prevent fuel flow when the engine is not cranking or running. The HD DSR is connected to the DEPR, by a low pressure flexible hose. It also has a reference port that is connected to the fuel / air mixer for turbo-charged applications.

Key features of the HD Dual Stage Regulator are:

- Full mechanical pressure regulation
- Can be engine or chassis mounted (vibration requirements are defined on the installation drawing).
- Flows 250 kW at the rate inlet pressure.
- 1725 kPa inlet regulated down to a 3.5 kPa outlet pressure



## ENGINE MOUNTING SUSPENSION

### Maximum inclination angles

Maximum inclination angles at which the engine will operate satisfactorily:

- Transverse inclination, intake 10 deg
- Transverse inclination, exhaust 10 deg
- Longitudinal inclination, front 5 deg
- Longitudinal inclination, back 5 deg

### Engine General Dimension

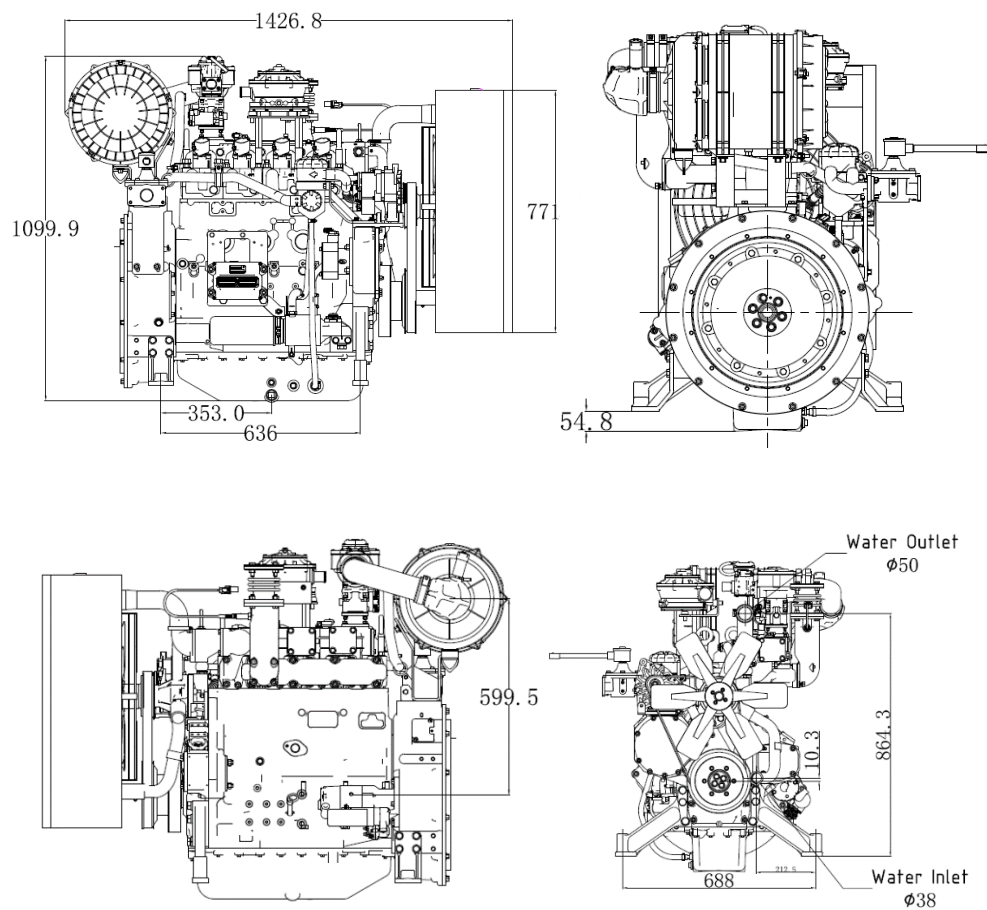


Figure 5 Engine General Dimensions and Layout



**ELECTRICAL SYSTEM**  
**WIRE HARNESS DIAGRAM**

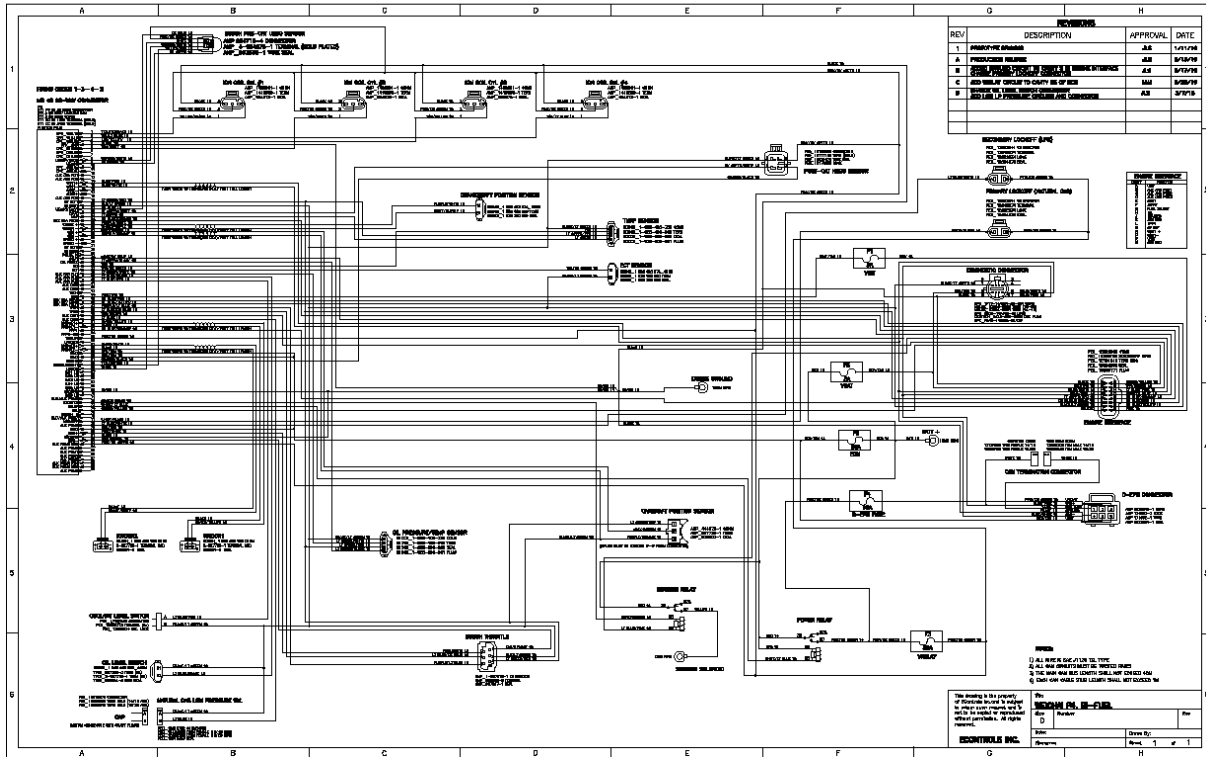


Figure 6 Wire Harness Diagram

**CONTROL PANEL:**

Optional: PV380 AND RELATED HARNESS, Murphy MPC10, MPC20, and additional panel options are available. Contact Weichai for details.

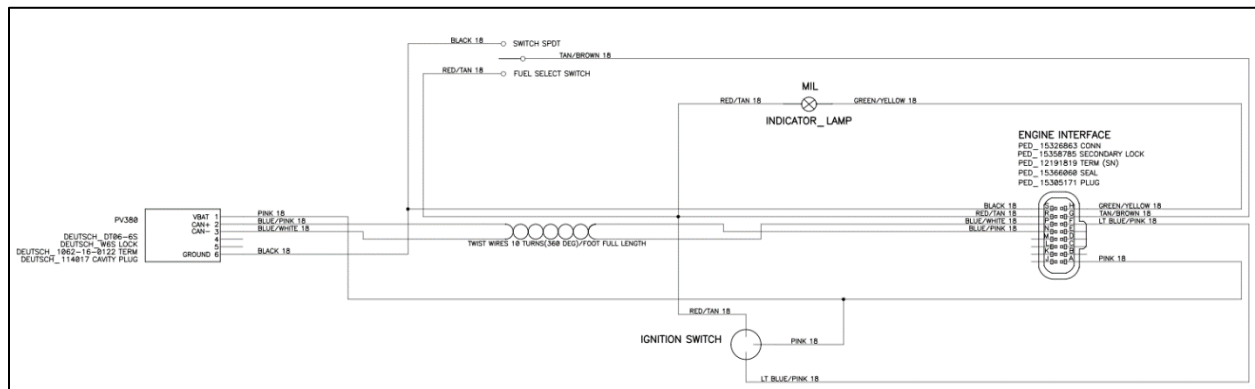


Figure 7 PV380 & Related Harness

**BATTERY SETUP**

WEICHAI EMISSION-RELATED INSTALLATION INSTRUCTIONS



One 12V battery is used to provide 12V to the control system. The battery needs to be setup according to the steps below:

- Engine Electrical System is 12-volt DC Negative Ground
- The Engine Battery should be 650CCA or Greater. Never disconnect the battery when running. The batteries should be attached to the engine at all times.
- Connect positive (+) red wire to positive (+) terminal on battery.
- Connect negative (-) black wire to negative (-) terminal on battery.

**CANBUS J1939 INTERFACE CONNECTING WITH ZTR TELEMATICS**

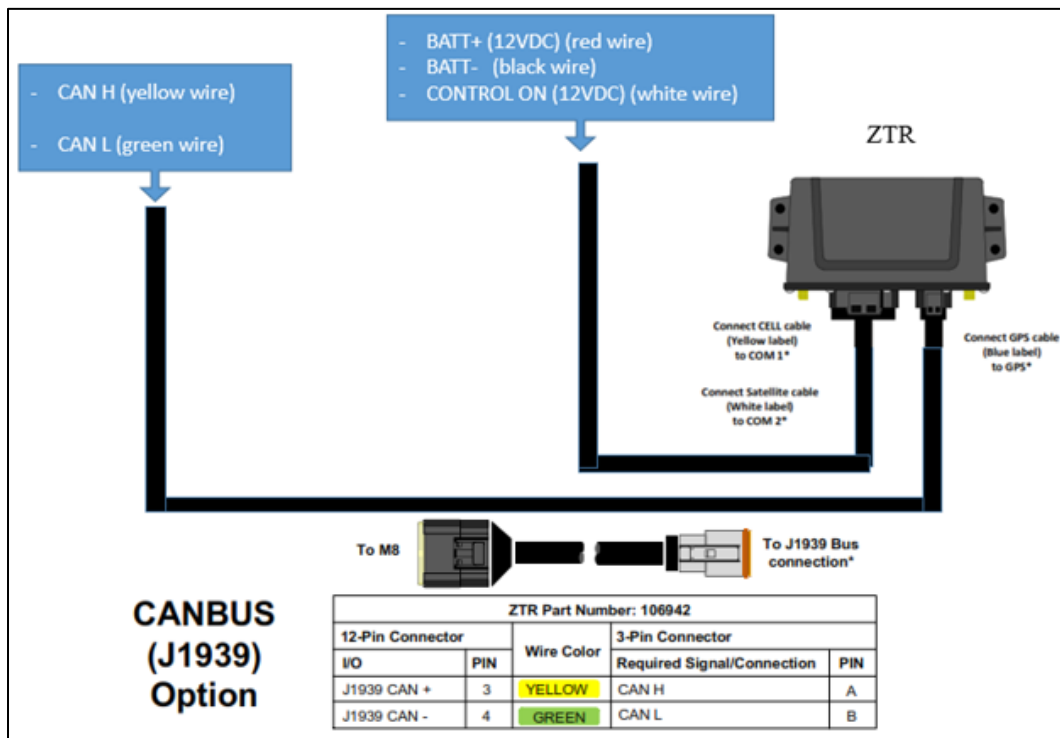


Figure 8 CANBUS J1939 Interface Connection with ZTR Telematics

**INTAKE AIR SYSTEM**

The intake system should be sealed between the mixer inlet and the filter. Proper clamps should be used to ensure unfiltered air is not drawn into the system. Use piping with minimum diameter equal to mixer inlet. When in an enclosure it can sometimes be necessary to use an externally mounted filter. It can be beneficial to engine life and performance to draw in air from the coolest location possible

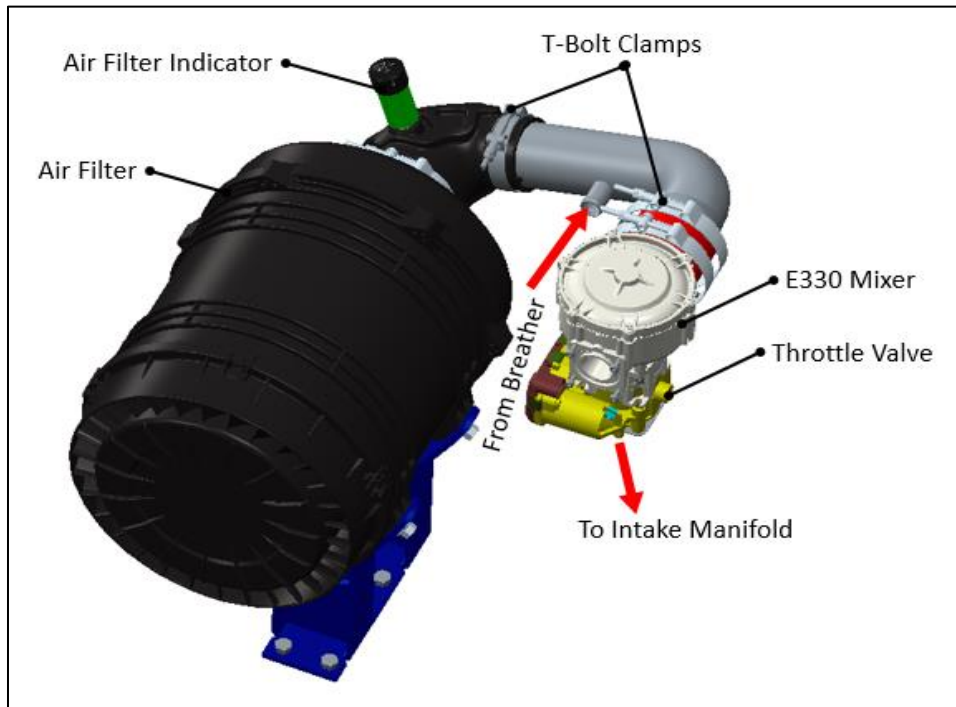


Figure 9 Intake Air System

**CLOSED CRANKCASE VENTILATION**

Weichai engine uses a closed crankcase system as shown in Figure 10. The breather separates the crankcase oil/gas mixture and lets the oil return to the sump and sends the gas into the intake system.

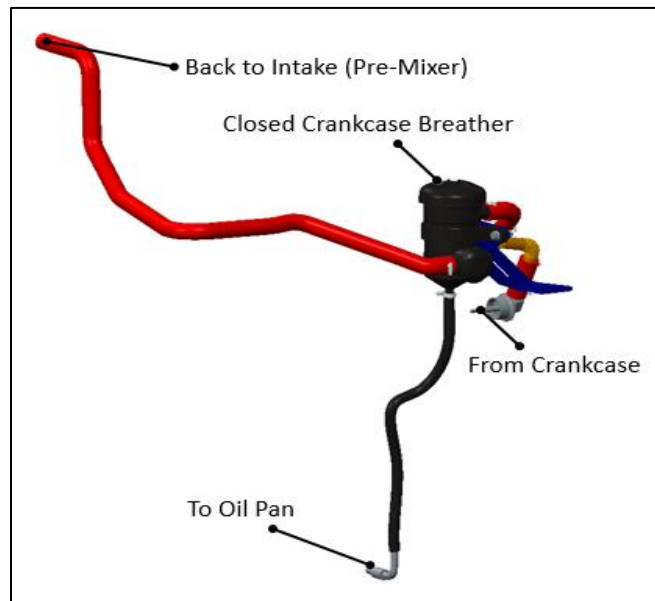


Figure 10 Closed Crankcase Ventilation System



## NATURAL GAS/WELLHEAD GAS FUEL SYSTEM

The fuel first passes the fuel shut-off valve when the engine starts cranking. Then it goes through the DEPR and comes into the mixer to be mixed with the air from the air filter as shown in Figure 11.

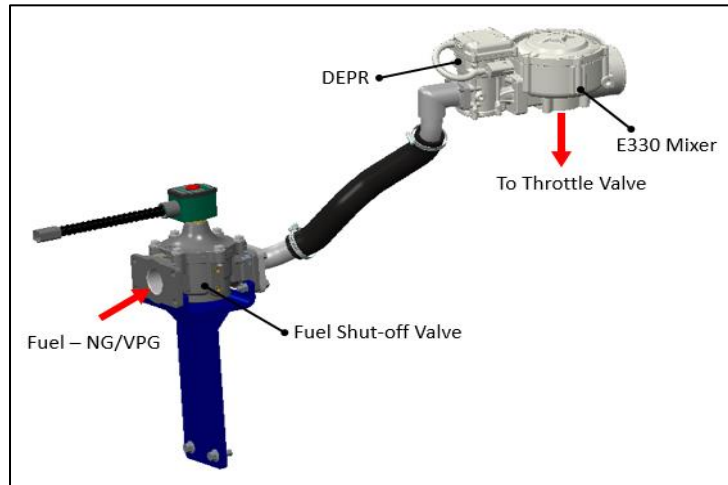


Figure 11 Natural Gas/Wellhead Gas Fuel System

## LPG & NG DUAL FUEL SYSTEM

When the engine operates with LPG, the NG shutoff valve will be closed. The LPG first enters the LPG shutoff valve and then goes to LPG evaporator to turn the LPG to vapor and later enters the DEPR and further mixes with the air in the mixer as shown in Figure 12.

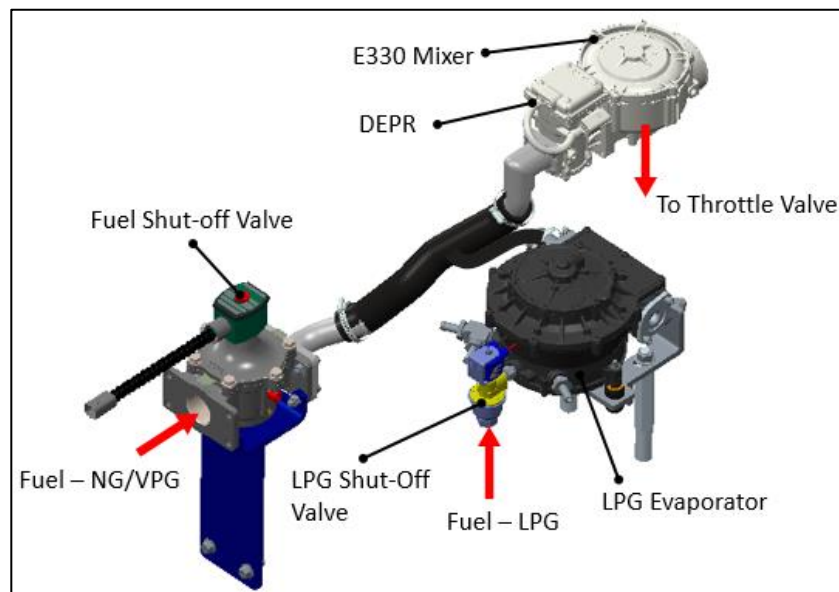


Figure 12: LPG & NG Dual fuel system



### VPG SINGLE FUEL SYSTEM

For single VPG fuel application, the same shut-off valve as NG is used to turn on or off the fuel, but the shut-off valve needs to be connected with the secondary fuel connector from the harness as Secondary Lock-off (LPG) only.

### COOLING SYSTEM

Figure 13 shows the configuration of the cooling system.

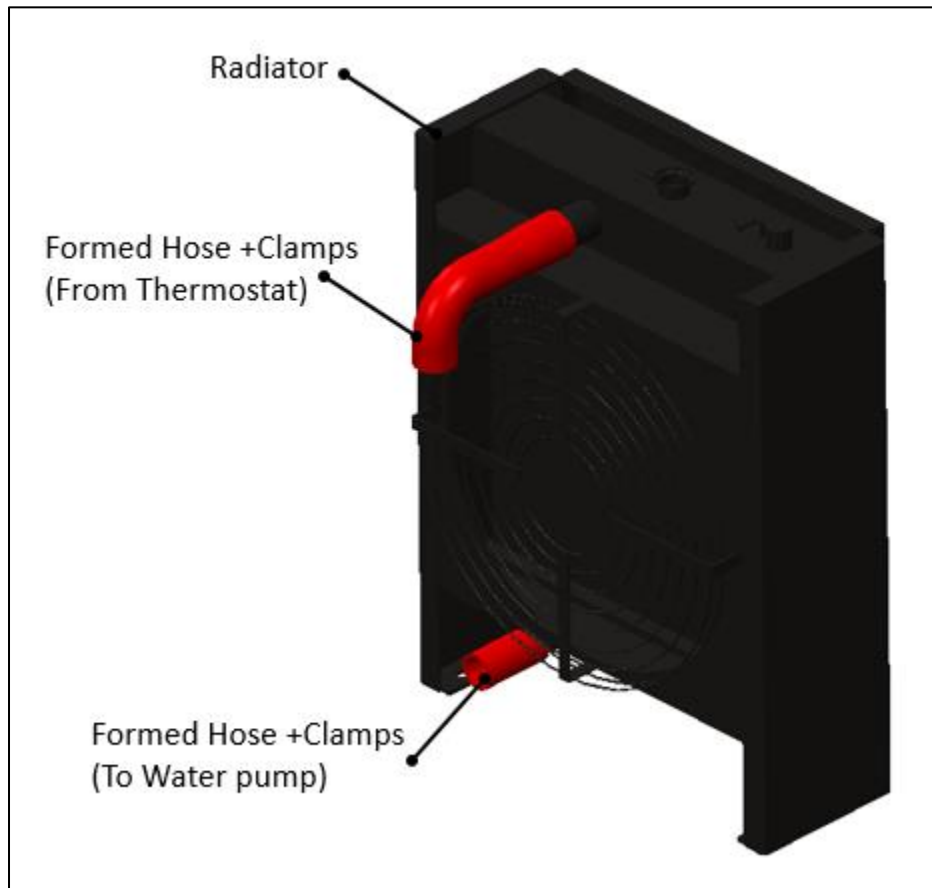


Figure 13 Cooling System



## PRE-CATALYST OXYGEN SENSOR

Apply an adequate amount of anti-seize compound to the threads of the oxygen sensor and install the sensor in the O2 sensor port located on the exhaust manifold elbow pipe. Tighten the sensor to the specified torque 29.5ft-lb ~44ft-lb (40Nm~60Nm). Anti-seize on thread only, don't put on the sensor.

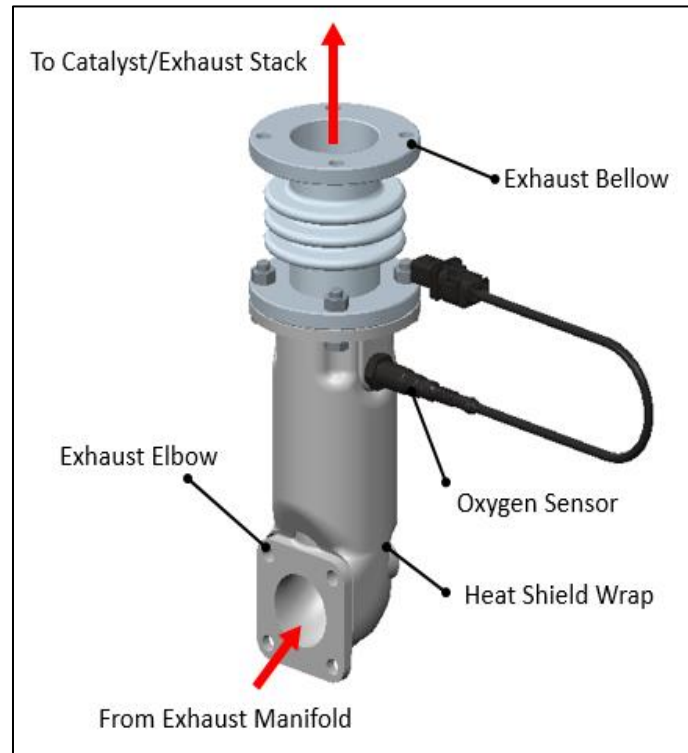


Figure 14 UEGO sensor installation

## POST-CATALYST OXYGEN SENSOR

In general, the sensor installation point must be tested sufficiently by the customer for function and durability. There shall be no possibility of exhaust leaks upstream of the sensor as exhaust pulsations can draw in ambient air, leading to erroneous measurements.

Installation in the exhaust line must be at a point guaranteeing representative exhaust gas composition whilst also satisfying the specified temperature limits. The active sensor ceramic element is heated up quickly. This means that the sensor installation location must be selected to minimize exhaust-side stressing with condensation water in order to prevent ceramic element crack. This is helped by locating the sensor on the outlet of the catalyst assembly.

### Design measures:

- Locate sensor as close to the catalytic converter outlet as possible, without exceeding maximum allowed temperature range





- Attempt to achieve rapid heating-up of the exhaust pipes in the area in front of the sensor. The exhaust pipe in front of the sensor should not contain any pockets, projections, protruding or edges etc. to avoid accumulation of condensation water. A downside slope of the pipe is recommended.
- The use of a sensor type with double protection tube can give a better protection of the sensor ceramic against condensation water drops. In this case make sure, that the front hole of the double protection tube does not point against exhaust gas stream.

#### System measures:

- Never switch on sensor heating before engine starting.
- Delayed switch-on or power control of the sensor heater (e.g. as a function of engine and ambient temperature), so that the maximum allowed ceramic temperature is not exceeded when there is condensation water present.

Installation angle should be inclined at least 10° towards horizontal (electrical connection upwards), thus preventing the collection of liquids between sensor housing and sensor element during the cold start phase. Other installation angles must be inspected and tested individually.

Avoid inadmissible heating up of the sensor cable grommet, particularly when the engine has been switched off after running under max load conditions. The use of cleaning/greasing fluids or evaporating solids at the sensor plug connection is not permitted. Assemble with high temperature resistant grease on the screw-in thread. Tightening torque: 29.5ft-lb ~44ft-lb (40Nm~60Nm), material characteristics and strength of the thread must be appropriate. Recommended material for the thread boss in the exhaust pipe is temperature resistant stainless ferritic steel, e.g. X 5 CrNi 18 9, DIN 17440 1.4301 or 1.4303 or SAE 30304 or SAE 30305 (US standard)

The sensor's protection tube must protrude completely into the exhaust-gas flow.

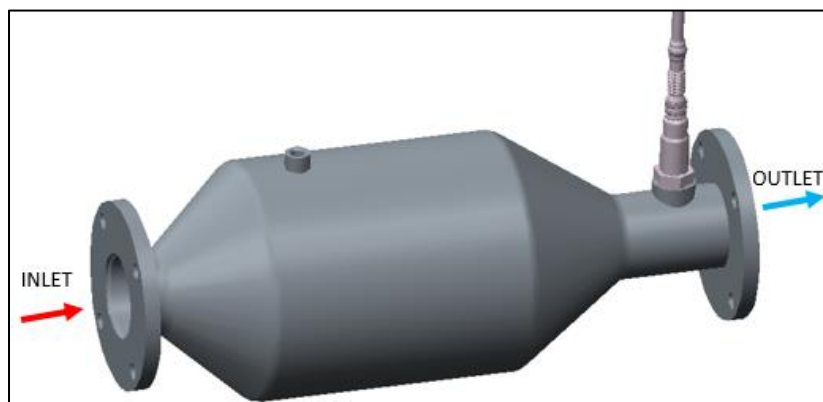


Figure 15 TWC and Post HEGO Sensor Installation

There is to be no possibility of the sensor protection tube contacting the opposite side of the exhaust pipe. A waterproof electrical connector's version is required.



The sensor must not be exposed to strong mechanical shocks (e.g. while the sensor is installed). Otherwise the sensor element may crack without visible damage at the sensor housing.

For physical reasons the sensor needs ambient air at its reference gas side. Replacement of the air volume inside the sensor must be guaranteed by a sufficient air permeability of the wires and the connectors between sensor and ECU. The breathability should be higher than 1 ml/minute at a test pressure of 100mbar.

Underfloor installation of the sensor remote from the engine requires an additional check of the following points:

- Positioning of the sensor with respect to stone impact hazard.
- Positioning and fixing of cable and connector with respect to mechanical damage, cable bending stress and thermal stress.

The sensor cable must be routed so that it is free of bends, mechanical tension, and chafing points considering the movement of the exhaust system in relation to the vehicle body. The cable and connector should not be subjected to excessive temperatures that could cause damage.

#### **Additional instructions for the installation downstream the catalytic converter**

- Between catalyst and sensor location absolute gas tightness of the exhaust system must be ensured.
- When the sensor is installed in the exhaust pipe there should be no detachable connections between catalytic converter and sensor (e.g. flange, clamp-screw joint).
- In order to protect the active sensor ceramic against condensation water from the exhaust gas side the sensor heater voltage must be power controlled after cold start of the engine. During the condensation water phase, the ceramic temperature should be kept at approx. 302degF ~572degF (150°C-300°C). The corresponding control parameter must be determined according to application.
- The sensor should be mounted as close to the outlet of the catalytic converter as possible without exceeding sensor maximum temperatures.
- The sensor should be mounted as far from the exhaust pipe outlet as possible to avoid dilution from ambient air. Minimum distance between sensor and exhaust outlet should be 15.7 inches (400 mm).

#### **CATALYTIC CONVERTER**

A very important component in a low emission engine is the catalytic converter. Weichai Engines use a TWC converter. For this type of catalytic converter to work properly, the following two criteria must be met:

- The air-to-fuel ratio must oscillate between rich and lean.
- The catalyst substrate (also known as a "brick," located inside the converter shell) must be kept hot.

Strict compliance with these provisions, conditions, and operating limits for catalytic converters must be maintained. If these parameters cannot be met or are not known, additional engineering and validation are required.



### Operation

- The continuous operating exhaust gas temperature must be between 1112 deg F (600°C) and 1562 deg F (850°C).
- The Product installer shall take necessary precautions to accommodate shell skin temperatures up to 1202 deg F (650°C).
- System backpressure must remain with +/- 5% of nominal conditions.
- Engine misfires and exhaust stream containments are not permissible.

### Vibration

- Vibration isolation must be provided between the engine and the TWC.
- Vibration isolation must be provided between the Product and the chassis.
- Vibration acceleration loads shall not exceed 10g.

### Installation

- Product shall not support mounting loads from adjacent components.
- Product must be mounted within +/- 10° of horizontal. Any other orientation must be approved by the manufacturer.
- Product must be supported at a minimum of two mounting locations.
- Installer shall ensure mounting hardware, such as fasteners, is sufficient for the application.
- Manufacturer recommends use of graphite gaskets for flanged joints.
- Heat shields must be reviewed by the manufacturer.
- Product cannot be used in corrosive environments (i.e. salt water).

Mounting the catalytic converter in the proper location will control the substrate temperature. To quickly heat up the catalyst and to ensure an effective operating temperature, the center of the substrate must be located a minimum of 30 inches (762mm) downstream of the exhaust manifold flange. This measurement is made along the length of the exhaust pipe and must take all bends and curves into consideration. The Max distance allowed downstream of the exhaust manifold flange is 36 inches (914mm). Figure 16 depicts an example catalytic converter setup.

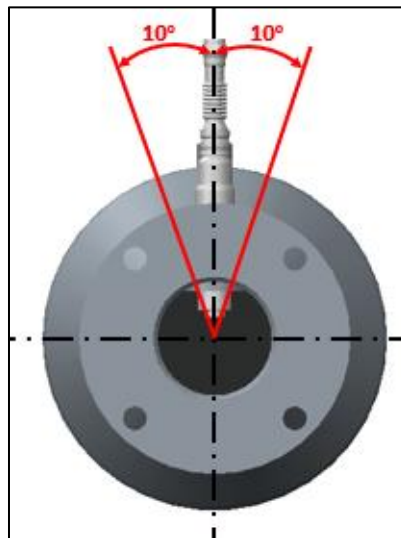


Figure 16 CATALYTIC CONVERTER ORIENTATION



Figure 17 depicts an example of catalytic mounting options.

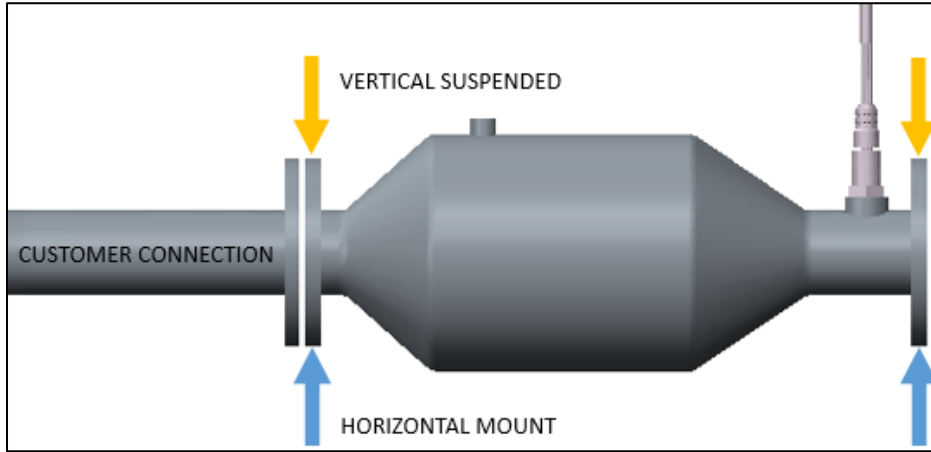


Figure 17 CATALYTIC CONVERTER MOUNTING OPTIONS

### FLYWHEEL

All the Weichai engines come with SAE 1 standard flywheel with SAE 3 adapters. The adapter will be used depending on the customer requirement and the adapters are as shown in below picture. Contract Weichai representative for assistance of the connector/adaptor installation.

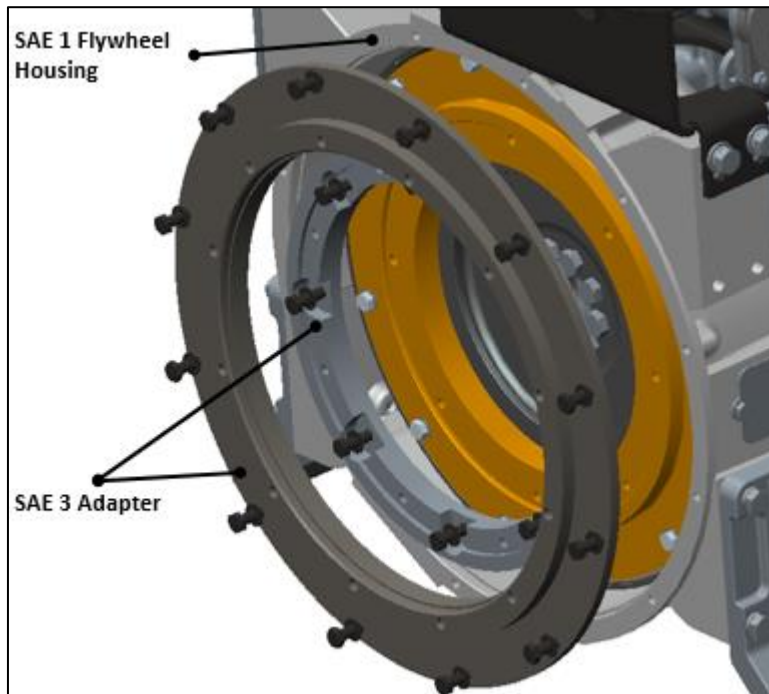


Figure 18 Flywheel and Flywheel housing



## ADJUSTABLE PARAMETERS

This engine has been certified by the US EPA to operate on pipeline quality commercial Natural Gas fuel as well as commercial LPG/propane.

The Fuel System is non-adjustable and it can compensate for changes within commercial fuels at different locations in the US. Customers can use a fuel switch (PG Switch in Figure 19) to switch between NG and LPG operation. The default setting is for NG, the other position "PG" is for fuels with LPG/VPG (short Engine Interface Pin G & R).

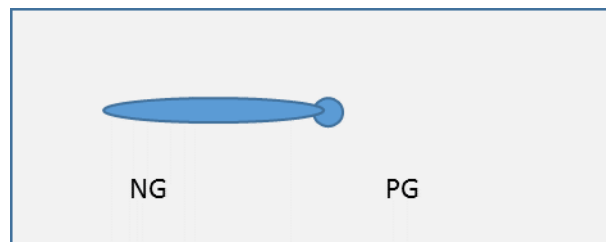


Figure 19 Fuel Switch for Different Fuel BTU Ranges

**WARNING: ADJUSTMENTS MADE TO THE FUEL DELIVERY SYSTEM WILL INFLUENCE THE TAILPIPE EXHAUST EMISSIONS. IT IS THE OWNER/OPERATOR'S RESPONSIBILITY TO TEST THE SPECIFIC FUEL TYPE AT EACH SITE OF INSTALLATION AND DETERMINE THE CORRECT FUEL SYSTEM SETTINGS.**

### Fuel Pressure

Fuel Pressure need to be checked for the first start as in the Table 1

Table 1 EPR inlet pressure specification

Maximum EPR Pressure	kPa	6.9
Minimum EPR Pressure	kPa	1.5

## FUEL SYSTEM DIAGNOSTIC

### FUEL SYSTEM DESCRIPTION

The Engine Control Module (ECM) receives information from various engine sensors in order to control the operation of the Integrated Electronic Pressure Regulator (EPR) and Shut-Off Valve. The Shut-Off Valve solenoid prevents fuel flow unless the engine is cranking or running.

At Key ON, the DEPR valve receives a two (2) second prime pulse from the ECM, allowing time for the fuel to flow through the fuel filter and fuel lines to the IEPR.

The fuel is then to the Mixer. Engine cranking generates vacuum which provided lift for the mixer air valve and is commonly referred to as air valve vacuum. Once in the mixer, the fuel is combined with air and is drawn into the engine for combustion.



## OIL LEVEL GAUGE INSTALLATION

The WP04GNA Weichai engine comes equipped with the capability of using an oil level gauge. If a gauge was purchased through Weichai America Corporation, the connector on the wiring harness and the connector on the gauge should be a match. If the gauge was not supplied by Weichai America Corporation, please contact our service department and the right connector can be purchased.

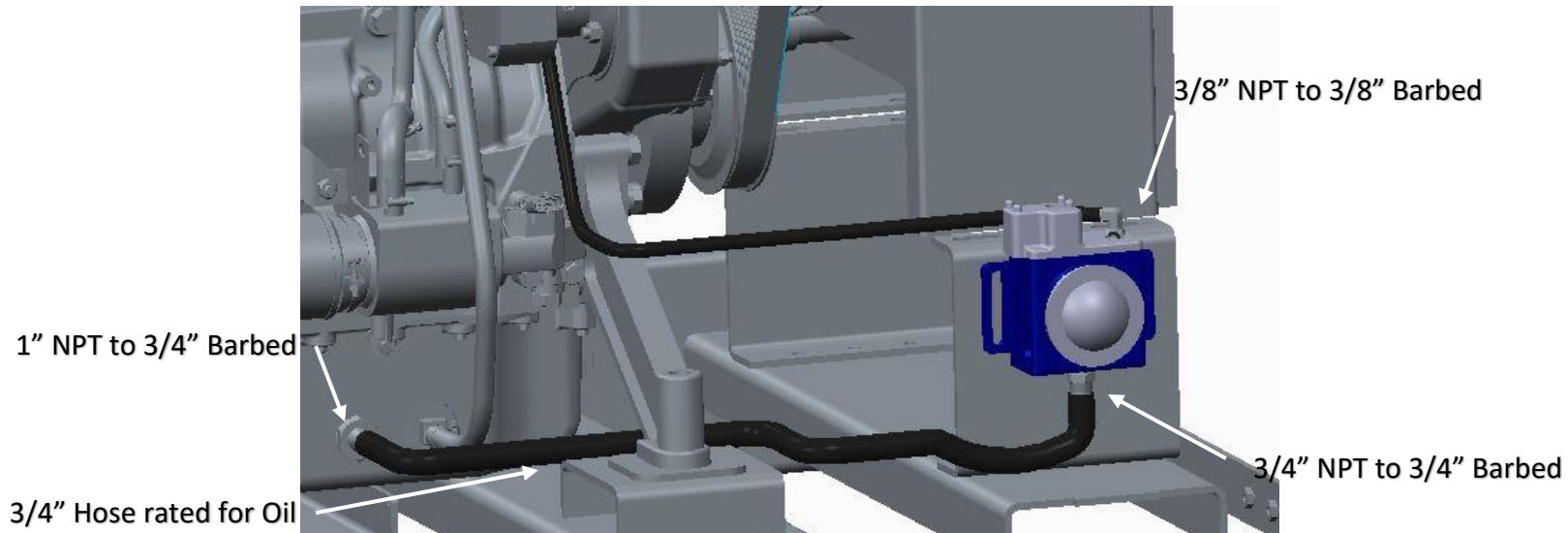


Figure 20: Oil Feed to Oil Level Gauge

To install the gauge, remove the 1" NPT plug from the oil pan shown in **Error! Reference source not found.**, and install a 1" NPT to 3/4" barbed hose fitting. Use 3/4" hose rated for oil to connect the gauge to the fitting. If the gauge must be balanced according to the owner's manual, an Oil Balance Line Kit can be purchased from our service department. The kit includes one Oil Balance Line Block, four M6x1.0x35 bolts, two gaskets, one 1/8" NPT to 3/8" barbed fitting, one oil fill neck assembly and 3/8" hose at the desired length. Remove the oil cap, sandwich the Oil Balance Line Block with provided gaskets, place the oil fill neck assembly on top of the gasket and thread provided bolts into the four holes. Ensure the fill neck is pointing at the 3 o'clock position so that it does not hit the exhaust manifold, and oil poured into the filler neck will drain into the engine and not on the ground. Torque bolts to 9 Nm. See **Error! Reference source not found.** for reference.

When running the balance line from the oil level gauge to the Oil Balance Line Block, ensure there are no peaks or valleys. The line must gradually increase from the gauge to the block.

Set the center of the gauge 1.75" from the bottom of the engine feet for the correct level during operation.

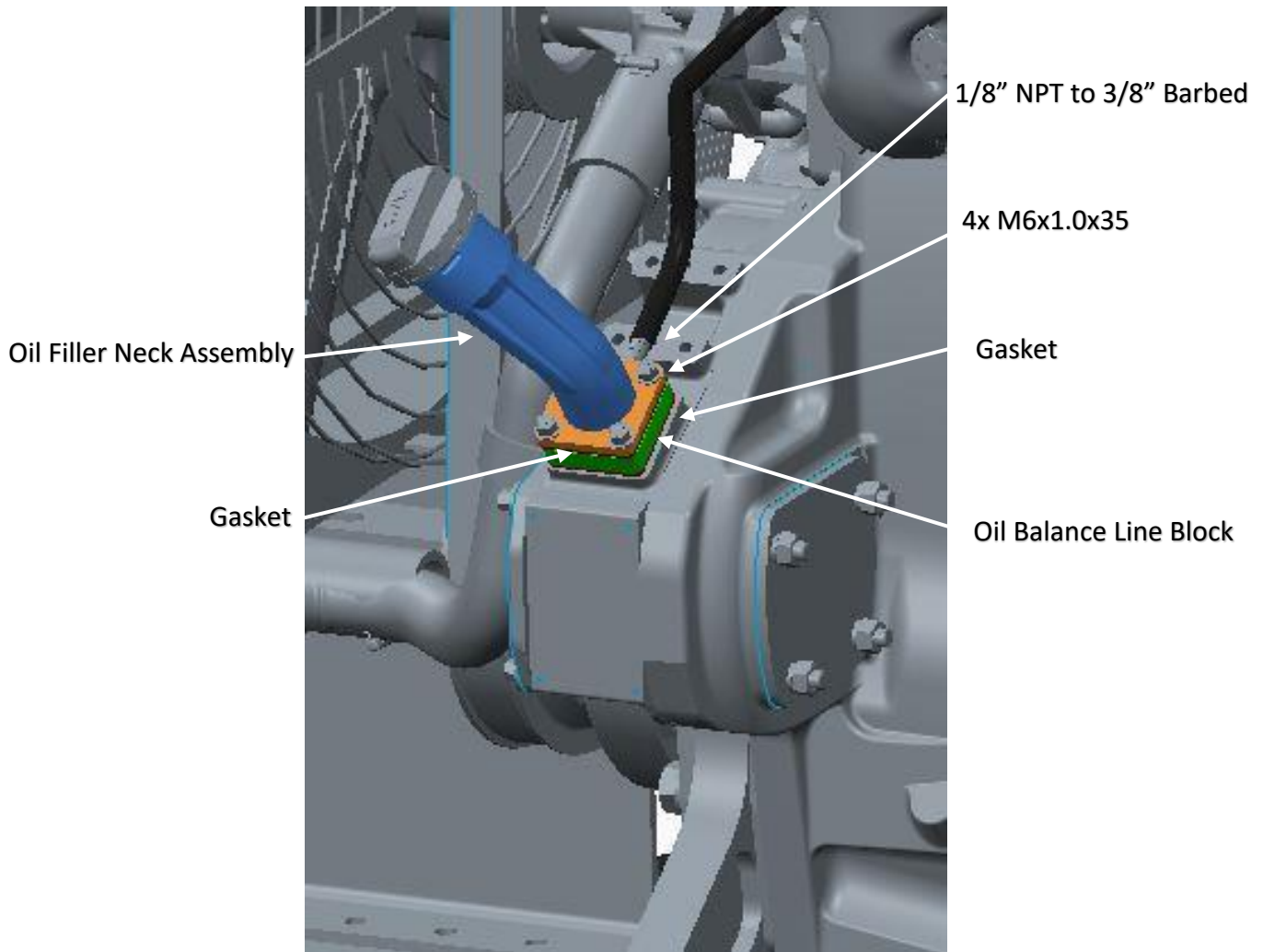


Figure 11: Balance Line

**ABBREVIATION DEFINITION**

ABBREVIATION	DEFINITION
DEPR	Direct acting Electronic Pressure Regulator
DSR	Dual Stage Regulator
DST	Diagnostic Service Tool
ECM	Engine Control Module
LPG	Liquid Propane Gas
NG	Natural Gas
TWC	Three Way Catalyst
VPG	Vapor Propane Gas