FUEL SYSTEM

CONTENTS

1. GENERAL

[1] GASOLINE

- Unleaded regular gasoline.
- E10 (10 % ethanol is added to gasoline)

[2] LPG

- Commercial liquid propane gas only.
- Equivalent to propane HD–5 of GPA * standards.
- KUBOTA RECOMMENDED LPG FUEL SPECIFICATIONS

C_3H_8	C_3H_6	C_4H_{10}	Others
≥ 90 %	≤ 5 %	≤ 2.5 %	–

(vol %)

■ **NOTE**

- *** GPA means Gas Processors Association (U.S.A)**

[3] NATURAL GAS

- Natural gas is equivalent to city gas.
- Filters that remove 99% of solids such as abrasive silicates-dirt, rust-scale, metallic shavings or welding debris from piping and fittings must be used to remove particulates larger than 1 micron from fuel before it enters the engine fuel system.
- Coalescing filters must be used whenever liquids i.e. water, hydrocarbons or sulfur-Hydrogen Sulfide (H2S) are present in fuel. Removal of these liquids is essential to prevent poor engine performance and detonation.
  Excessive levels of Total Sulfur and H2S will result in damage to internal parts and components of the engine by creating sulfuric acid when mixing with moisture inside the engine. Drain valves for trapped liquids on coalescing filters are to be automatic and have recovery vessel to prevent trapped liquids from being spilled on the ground or ingested back into the engine. Filters must be maintained according the filter manufacturer's recommendation in order to achieve rated filtration levels.
- DO NOT USE fuels that have total sulfur content greater than 11.4 mg/m^3 (0.5/100 $grain/ft^3$ *1) or Hydrogen Sulfide (H2S) content greater than 6 ppmv *2.
- This manual describes the performance with Japanese standard natural gas.
- The lower heating value: 40.6 MJ/m^3 (1090 BTU/ft^3 *3 or 9699 $kcal/m^3$)
- Contact Kubota for further information of fuel used.
  *1: 1 grain = 64.80 mg (= 1/7000 lb)
  *2: ppmv = mL/m^3
  *3: 1 BTU/ft^3 = 3.730×10^{-3} MJ/m^3 = 9.406 $kcal/m^3$

2. CAUTIONS

[1] FOR SAFETY (WG1605-L / N / GL / LN / GLN, WG2503-L / N / GL, WG3800-L / N / GL)

- All fuel connections added to this engine must be installed by qualified personnel utilizing recognized procedures and standards.
- The non-KUBOTA installed parts, such as hoses, fittings, piping should be approved for LPG and natural gas use and conform to UL, CSA, NFPA, MSHA and all other applicable standards.
- The following standards must be followed prior to installation: UL, CSA, NFPA and MSHA standards.

(1) Tightening Torque And Leak Check For Vaporizer

Each fitting must be sealed with approved joint sealant compound, and be tightened to the specified torque using a wrench and leak check must be performed as shown in the below table.

TIGHTENING TORQUE AND LEAK CHECK PRESSURE

<table>
<tr><th rowspan="2">Fitting</th><th rowspan="2">Qty.</th><th rowspan="2">Size</th><th colspan="3">Tightening torque</th><th colspan="3">Leak check pressure</th></tr>
<tr><th>Nm</th><th>kgfm</th><th>ft-lb</th><th>kPa</th><th>kgf/cm²</th><th>psi</th></tr>
<tr><td>LPG / NATURAL GAS OUT (VAPOR)</td><td>1</td><td>ϕ19 mm (3/4 in.) Hose Fitting</td><td>–</td><td>–</td><td>–</td><td rowspan="2">1730 to 1760</td><td rowspan="2">17.65 to 17.95</td><td rowspan="2">250.9 to 255.1</td></tr>
<tr><td>LPG / NATURAL GAS IN (LIQUID) *</td><td>1</td><td>1/4-18 NPTF</td><td>19.6 to 39.2</td><td>2.0 to 4.0</td><td>14.5 to 28.9</td></tr>
<tr><td>WATER IN/OUT</td><td>2</td><td>ϕ16 mm (5/8 in.) Hose Fitting</td><td>–</td><td>–</td><td>–</td><td>200 to 220</td><td>2.0 to 2.2</td><td>28.5 to 31.3</td></tr>
</table>

* NOT KUBOTA supplied

(2) Setting And Vibration Limits

Mount the vaporizer and lockoff valve according to the Installation Instructions.

[2] FOR EMISSION REGULATIONS (WG1605-L / N / GL / LN / GLN, WG2503-L / N / GL, WG3800-L / N / GL)

(1) Vaporizer

In order to conform to applicable EPA and CARB Emissions regulations when operating WG1605-L / N / GL / LN / GLN, WG2503-L / N / GL and WG3800-L / N / GL engine, only a KUBOTA GENUINE vaporizer can be used.

Vaporizer can only be installed by an authorized KUBOTA DISTRIBUTOR or the Final Engine Assembler (FEA) in which this engine is used.

(2) Length Of The Gas Hose

The hose length between the vaporizer and the D-EPR (Electronic Pressure Regulator) must not exceed 700mm (27.6 in).

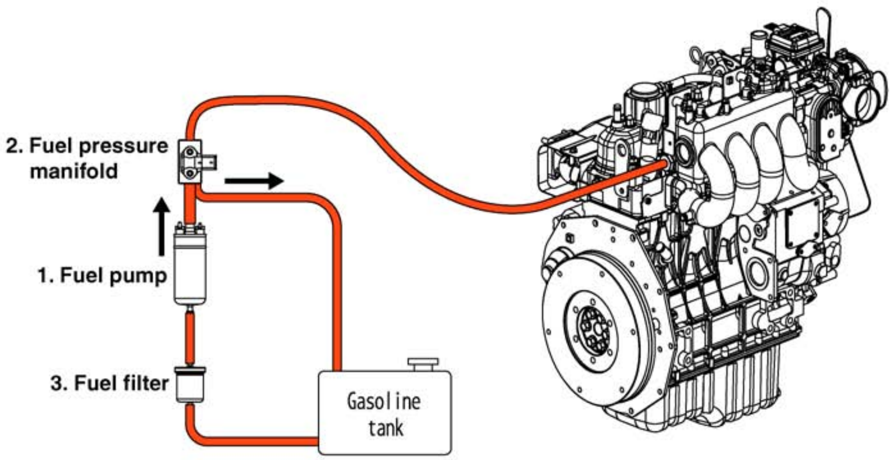
3. EVAPORATIVE EMISSION CONTROLS “GASOLINE FUEL SYSTEM”

1. Fuel pressure manifold must be mounted away from engine compartment heat.
   Must be in cool location, preferably close to the machine fuel tank.
2. FEA supplied non-metallic fuel line must conform to permeation Category 1 of SAE J2260. (40 CFR 1048.105 (a))
3. The gasoline fuel tank must have a self-tethered fuel cap sealed up to a positive pressure of 24.5 kPa (3.5 psig). (40 CFR 1048.245 (e) (1) (i))
   Cap must comply with CARB and EPA regulations.
4. Liquid fuel in the fuel tank may not reach boiling during continuous engine operation in the final installation at an ambient temperature of 30 °C. (40 CFR 1048.105 (d))
5. Note that gasoline with a Reid vapor pressure of 62 kPa (9 psi) begins to boil at about 53 °C at atmospheric pressure, and at about 60 °C for fuel tanks that hold pressure as described in §1048.245 (e) (1) (i). (40 CFR 1048.105 (d))
   FEA must confirm that bulk gasoline in fuel tank will not boil under continuous normal engine operating condition when tested at 30 °C ambient at application review.
6. Nonmetal fuel tanks must also use one of the qualifying designs for controlling permeation emissions specified in 40 CFR 1060.240. (40 CFR 1048.245 (e) (1) (i))
7. FEA must consult Kubota when changes are made to the fuel system after application review.

4. FUEL DIAGRAM

WG1605-G / GL / GLN, WG2503-G / GL, WG3800-G / GL

- Mark 1, 2 and 3 are supplied by KUBOTA.
  The other parts including hose should be procured by OEM.
- Each pipes should be surely connected by clamp.
- Refer to next page.



FUE001A

Figure 4-1

WG1605-L / GL / N / LN / GLN, WG2503-L / GL / N, WG3800-L / GL / N

- Mark 1 and 2 are supplied by KUBOTA.
  The other parts including hose should be procured by OEM.
- Each pipes should be surely connected by clamp.

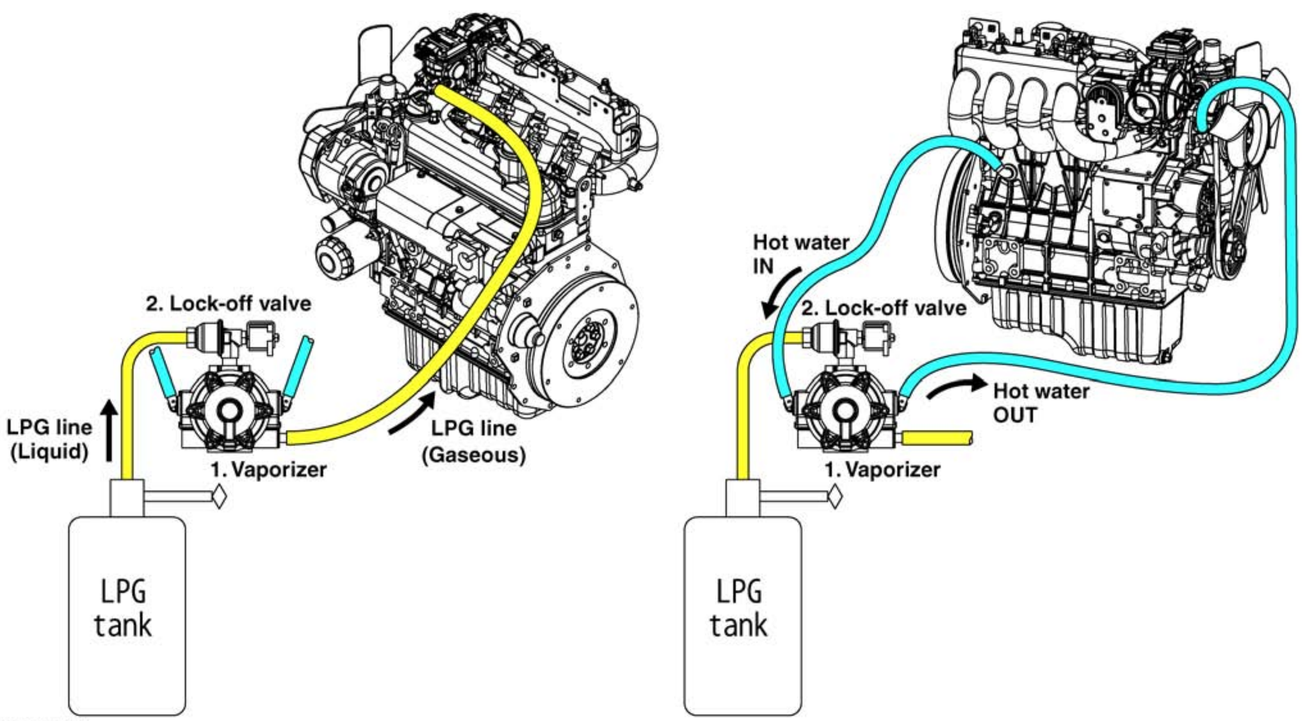


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Figure 4-2

5. ELECTRIC GASOLINE FUEL PUMP

The gasoline system will utilize an external electric gasoline fuel pump. The pump will be mounted in the chassis of the vehicle, or equipment near the fuel tank. Gasoline rated fuel hose and securing devices supplied by the OEM, will be used to transfer the pumped fuel to the Gasoline Fuel Pressure Manifold assembly. Most industrial equipment will be exposed to dusty and dirty environments, therefore use caution when opening the gasoline tank, to prevent dirt and debris from falling in the tank.

The electric gasoline fuel pump, utilized on USA emission certified engines are a critical part of the certified emissions system, and do not require any periodic adjustment.

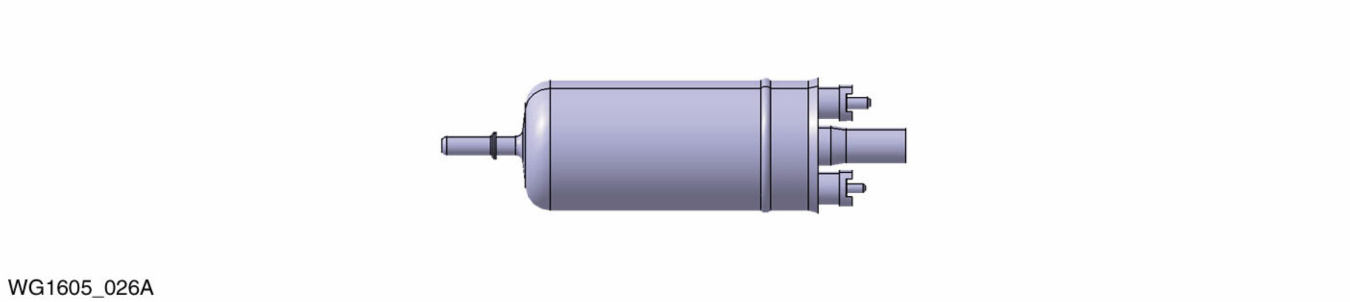


Figure 4-3

Fuel Filter

The fuel filter is installed in the fuel line between the fuel tank and the feed pump.

As the fuel flows from the inlet through the filter element, the dirt and impurities in the fuel are filtered,allowing only clean fuel to penetrate the inside of the filter element. The cleaned fuel flows out from the outlet.

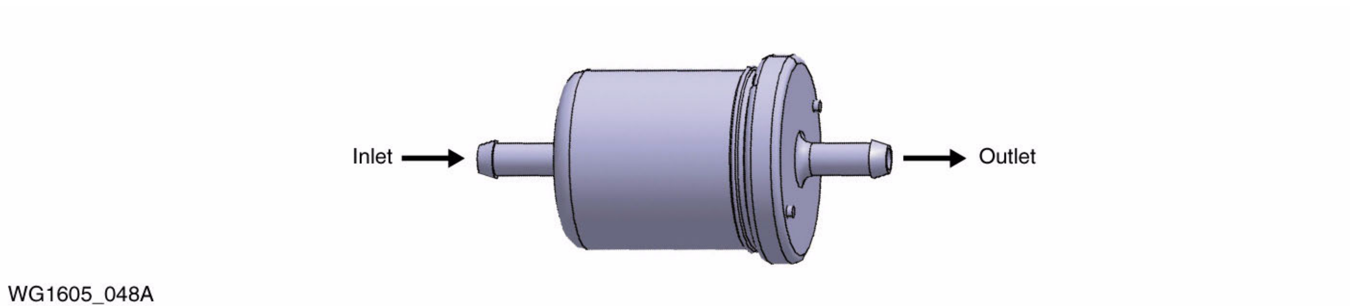
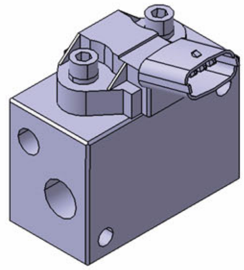


Figure 4-4

6. GASOLINE FUEL PRESSURE MANIFOLD

The gasoline fuel system, utilizes a Fuel Pressure Manifold assembly, to control the delivery pressure to the gasoline injector rail. The manifold is mounted to the chassis, between the electric fuel pump and the gasoline injector rail. The manifold is equipped with a sensor, which provides the ECU with the gasoline fuel temperature, and pressure being regulated to the gasoline injector rail. The ECU uses the fuel temperature and pressure, to calculate the precise amount of gasoline, to be injected to the engine during operation. The manifold is designed into the system, to control pressure, as well as the amount of gasoline, to be returned to the fuel tank. In normal gasoline delivery systems, the electric fuel pump, delivers a constant pressure to the injector rails, and allows a significant amount of fuel to be recycled to the tank, thus causing the gas to heat and vaporize, and requiring the use of a vapor recovery system to control the excess vapor. The system manages the fuel pressure at the manifold and minimizes the amount of returned fuel, thus reducing the vapor fuel in the tank.



WG1605_027A

Figure 4-5

7. DIRECT ELECTRONIC PRESSURE REGULATOR (D-EPR)

The Direct Electronic Pressure Regulator (D-EPR) is the primary fuel control device, used to maintain both performance and emissions control. The D-EPR contains an internal computer, which communicates to the KUBOTA Engine Control Unit (ECU), via a Communications Area Network (CAN), high speed connection.

The D-EPR precisely controls the fuel flow required to insure Stoichiometric (correct air/fuel mixture for complete burn) fuel delivery to the engine combustion chambers. The D-EPR also contains internally mounted fuel pressure and temperature sensors, which provide input across the CAN link, to the ECU, for fuel calculation. The ECU will process this information and command changes back across the CAN link, to the D-EPR, to adjust fueling.

The D-EPR internal computer also maintains certain levels of diagnostics within the system, to ensure emissions control is always maintained. If the D-EPR detects a fault within the regulator or fuel delivery system, the D-EPR will send that fault information across the CAN link to the ECU. The ECU will then activate the Malfunction Indicator Light (MIL), in the operator control panel. Depending on the type of fault, and its effect on fuel control, or engine performance, the ECU may command the D-EPR to change fueling, limit fuel delivery, or in some cases shut down the engine.

The D-EPR is connected directly to the mixer on all certified engines.

The D-EPR utilized on USA emission certified engines is a critical part of the certified emissions system, and do not require any periodic adjustment.

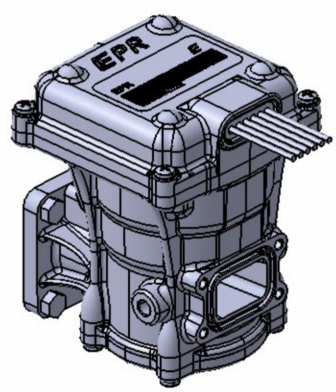


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Figure 4-6

8. MIXER ASSEMBLY

The air valve mixer, is an air-fuel metering device, and is completely self-contained. The mixer is an air valve design, utilizing a relatively constant pressure drop, to draw fuel into the mixer, from cranking, to full load. The mixer is mounted in the air stream, ahead of the throttle control device.

When the engine begins to crank, it draws in air, and with the air valve covering the inlet, negative pressure begins to build. This negative pressure signal, is communicated to the top of the air valve chamber, through 4 vacuum ports, in the air valve assembly. A pressure/force imbalance begins to build, across the air valve diaphragm, between the air valve vacuum chamber, and the atmospheric pressure below the diaphragm. The air valve vacuum spring is calibrated, to generate from 101.6 mm (4.0 in.) of water column at start, to as high as 355.60 mm (14.0 in.) of water column, at full throttle. The vacuum being created is referred to as Air Valve Vacuum (AVV). As the air valve vacuum reaches 101.6 mm (4.0 in.) of water column, the air valve begins to lift against the air valve spring. The amount of AVV generated, is a direct result of the throttle position. At low engine speed, the air valve vacuum is low, and the air valve position is low, thus creating a small venturi for the fuel to flow. As the engine speed increases the AVV increases and the air valve is lifted higher, thus creating a much larger venturi.

The mixer is attached to the Electronic Throttle Body (ETB), via an adapter. The adapter is fitted with specific spacers, and o-rings, to insure a seal tight fit with the ETB.

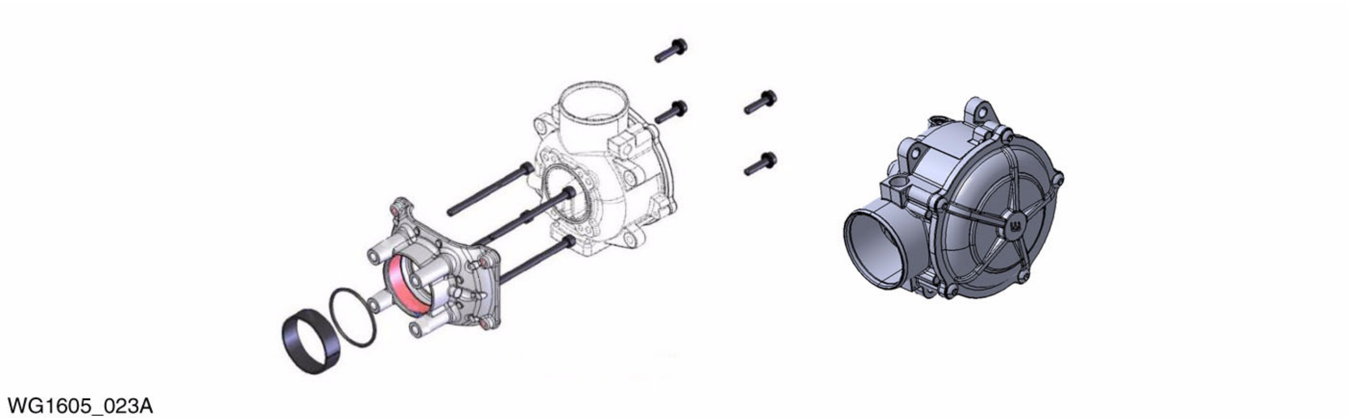

Figure 4-7

	KBT Part No.
WG1605	EG523-4401Δ
WG2503	EG543-4402Δ
WG3800	EG505-4401Δ

9. LPG FUEL LOCK-OFF VALVE

Fuel Lock-off Valve is used to isolate the D-EPR and all downstream components from upstream fuel pressure when the engine is shut-off.

The LPG fuel lock-off device is an integrated assembly. The electric lock-off assembly is a 12.0 V, normally closed valve. The solenoid is mounted to the valve body. When energized the solenoid opens the pilot valve, within the lock-off, which uses the tank pressure, to assist in opening the valve. By using the pilot valve, to help open the valve, the service life of the valve is extended, and requires less electrical energy, to open the valve. The valve opens during cranking, and remains open, during the run cycles of the engine. The lock-off supply voltage is controlled by the Engine Control Unit (ECU), or may be energized by a relay, which supplies battery voltage, when energized.

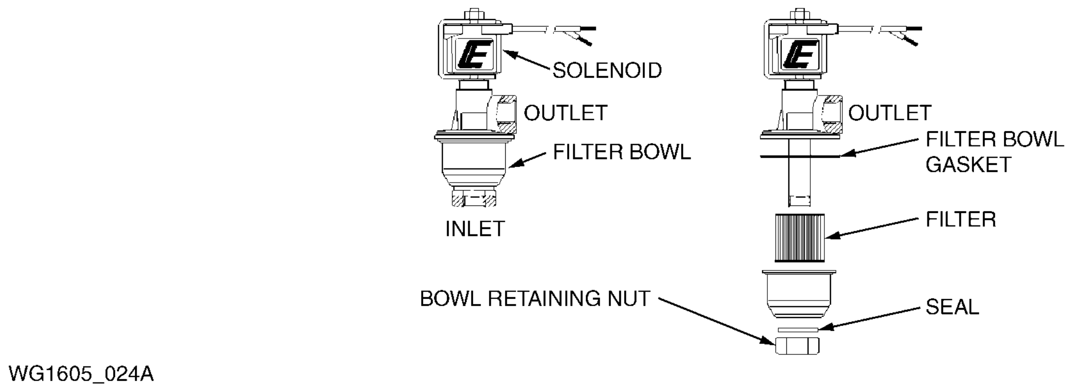

Figure 4-8

10. VAPORIZER (DUAL STAGE REGULATOR (DSR))

The DSR is a combination vaporizer, pressure regulating device. The DSR is a two stage regulator that is a positive pressure regulator that is normally open in the secondary chamber, when the engine is cranking or running, pressure from the secondary chamber passes from the regulator to Direct Electronic Pressure Regulator (DEPR), and mixer.

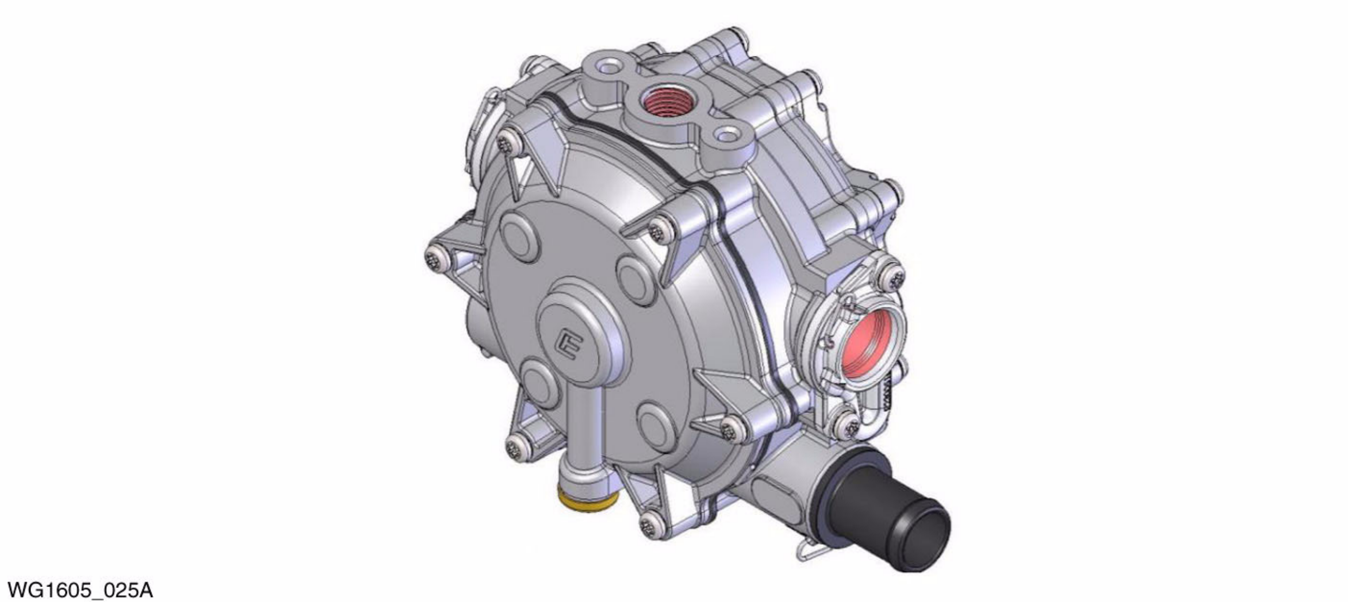

Figure 4-9

11. INJECTOR

In the injector, electric currents are applied to a solenoid coil to move the valve with an attached magnetic body up and down. While the valve opens, the fuel is injected from the edge hole of the valve in proportion to the pressure difference before and after the injector.

The fuel injection quantity can be adjusted by the electric current applying time, which is controlled by ECU.

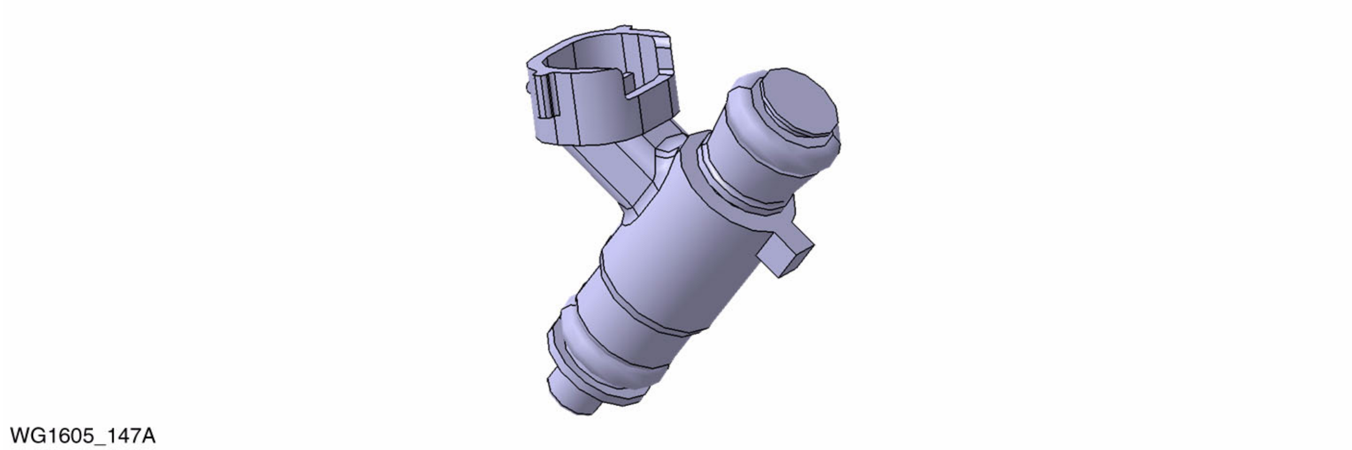

Figure 4-10

12. REVISION HISTORY

File Name	Remarks	Date
KORD3_18-022_FUEL_SYSTEM.pdf	Revision of Natural Gas description	May 23, 2018