LUBRICATION SYSTEM
for CI engine

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NOTES

This document is applied for Kubota CI engines for OEM.
This document is intend to provide installation guide for the engine to the application.
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LUBRICATION SYSTEM

1. GENERAL

All moving parts of the engine must be lubricated to function properly. For this purpose, the lubricating oil circulating through the engine has a number of functions. In addition to reducing friction, the oil cools down the engine, controls expansion and dispersion of bearing areas, provides a sealing action, prevents rusting, seals out dust, and purifies products generated in the cylinders by incomplete combustion.

[1] LUBRICATION SYSTEM

A typical lubrication system is shown in figure 1. Lubricating oil in the oil pan is circulated by a pump throughout the system as indicated by the arrows. Oil pressure is controlled between 245 to 343 kPa (2.5 to 3.5 kg/cm^2, 35.6 to 49.8 psi) and it is delivered to each section of the engine before returning to the oil pan. There are two main oil passages. One is through the crankshaft to the crank pin metal and the other is in the wall of the crankcase to the rocker arm shaft of valve train. Should oil pressure fall for any reason, parts can become scored or other serious problems will arise. A warning lamp indicates oil pressure drop when it falls below 49 kPa (0.5 kg/cm^2, 7.1 psi) or 98 kPa (1.0 kg/cm^2, 14 psi) depending on engine type.

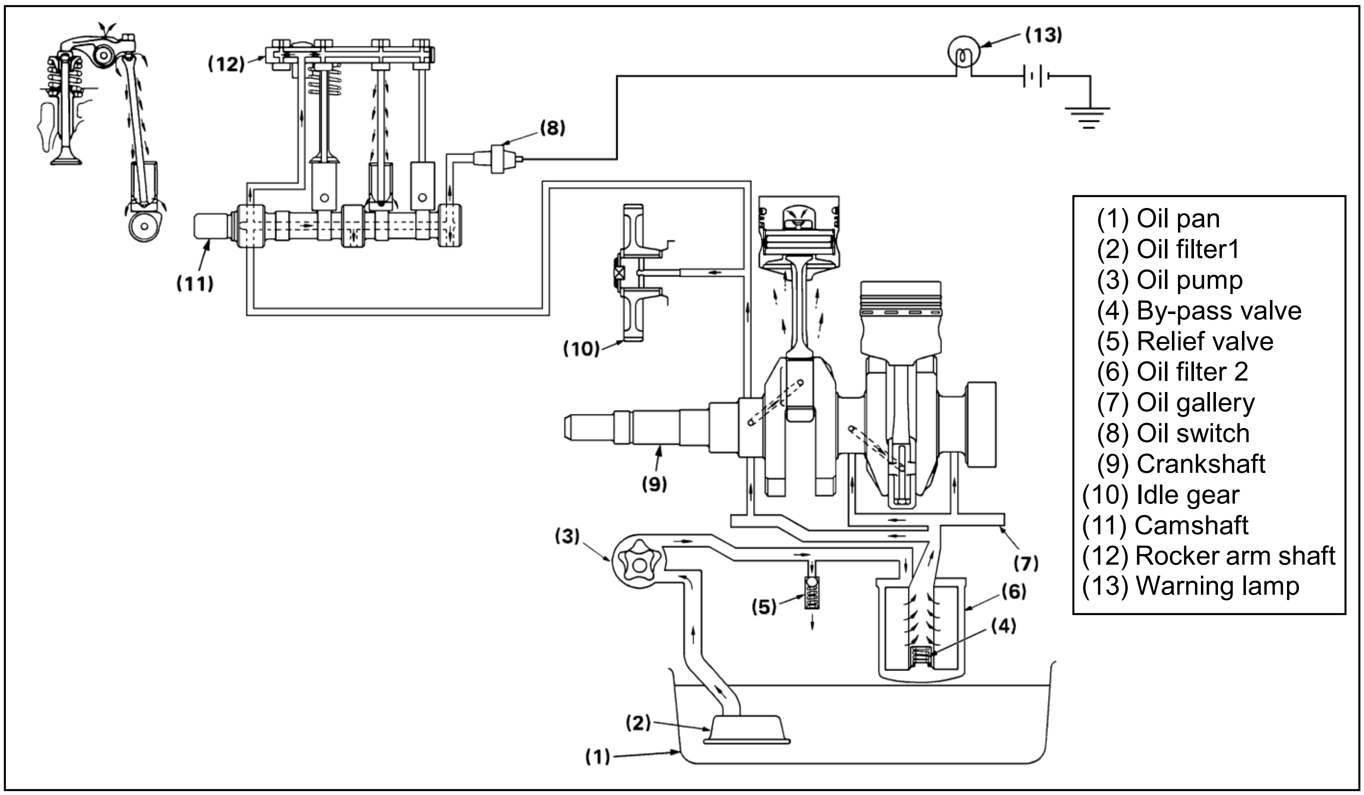


Figure 1 Lubrication system

The lubrication system of this diesel engine comprises the oil pan (1), oil filter 1 (2), oil pump (3), valve (5), oil filter 2 (6), and oil switch (8). Engine oil, after being cooled in the oil pan (1), passes through oil filter 1 (2) as it is drawn by the oil pump. Oil, pressurized by the trochoid type pump (3) is then filtered by oil filter 2 (6) to remove fine particles. Then it passed through oil gallery (7) (the oil passage in the crankcase) to be forcibly supplied to crankshaft (9), connecting rod, idle gear (10), camshaft (11) and rocker arm shaft (12) to lubricate them. Oil splashed by the crankshaft or oil dripping from the clearances between parts lubricates the pistons, cylinders connecting rod small ends, fuel camshaft, tappets, push rods, intake and exhaust valves and timing gear.

2. LUBRICATING OIL

Note:
- **The use of synthetic oil is not recommended.**
- **Poor quality oil will shorten engine life.**
- **Use only the specified lubricating oils.**

[1] FUNCTIONS OF ENGINE OIL

(1) Anti-wear action

The most important role of engine oil is prevention of seizures and to reduce frictional forces to minimize the wear between moving parts and contact surfaces depending on the reduction of friction force. (Such as cylinder walls and piston rings and both ends of connecting rods, crankshaft bearings, camshaft, tappets, etc.).

(2) Cooling action

The combustion chamber becomes extremely hot. Oil not only lubricates friction parts of piston but also cools the engine by acting as a heat exchange medium. This prevents seizures and high temperature oxidation of the oil itself. This cooling action is an extremely critical function. Extremely high viscosity or insufficient supply will result in seizures due to inadequate cooling.

(3) Sealing action

Cylinder walls and compression rings seal the combustion chamber to allow build-up of compression. Oil seals the clearance between the cylinder walls and rings to provide more complete sealing and prevent leakage of the compressed air to maintain the compression pressure. It also prevents combustion gas from blowing back into the crankcase.
The prevents reduction of engine output and contamination of oil by unburned fuel.

(4) Engine cleaning action

Oil removes deposits inside the engine to prevent wear due to build-up of deposits.

(5) Corrosion preventive action

Oil prevents acid corrosion of metal parts, such as bearing metals, etc.

(6) Rust prevention action

Engine oil prevents rusting caused by condensation of acidic gases.

[2] CLASSIFICATION OF ENGINE OIL

(1) Classification by viscosity

SAE (Society of Automotive Engineers) Standards are generally used to classify engine oil viscosities. Viscosity is a principal property of oil, the higher the viscosity, the thicker the oil film formed over the metal surface will be and the lower the viscosity, the thinner the film thickness becomes.
Viscosity varies with temperature. The higher the temperature, the lower the viscosity and vice versa. Engine oil should have the appropriate viscosity and have properties which are not affected by viscosity changes caused by temperature changes. In other words, engine oil must have a high viscosity index.*1
Multi-grade oils having relatively low viscosity (SAE 10W-30) can provide superior lubrication at both low temperature and high temperatures. Such oils are available commercially for all-season use.

*1: "High viscosity index" means less viscosity change by temperature fluctuation.

Table 1 SAE J-300

Vis-cosity No.	Max. Viscosity*2 at each temp. (CP)	Max. temp.*3 expressing tolerable pump discharge performance	Viscosity at 100 deg. C (212 deg. F)	
			Min.	Max.
0W	3250 at -30 deg. C (-22 deg. F)	-35 deg. C (-31 deg. F)	3.8	
5W	3500 at -25 deg. C (-13 deg. F)	-30 deg. C (-22 deg. F)	3.8	
10W	3500 at -20 deg. C (-4 deg. F)	-25 deg. C (-13 deg. F)	4.1	
15W	3500 at -15 deg. C (5 deg. F)	-20 deg. C (-4 deg. F)	5.6	
20W	4500 at -10 deg. C (14 deg. F)	-15 deg. C (5 deg. F)	5.6	
25W	6000 at -5 deg. C (23 deg. F)	-10 deg. C (14 deg. F)	9.3	
20	-	-	5.6	< 9.3
30	-	-	9.3	< 12.5
40	-	-	12.5	< 16.3
50	-	-	16.3	< 21.9

*2: Measured by CCS viscometer (ASTM D-2602).
*3: Measured by mini rotary viscometer (ASTM D-3829). When the viscosity is less than 30000 CP, the maximum temperature is measured.

(2) Recommended oil for mechanical engine

- **Refer to the following table for the suitable American Petroleum Institute (API) classification of engine oil according to the engine type (with internal EGR, external EGR or non-EGR) and the fuel type used: (Low sulfur, Ultra-low sulfur or High sulfur fuels).**

Table 2

Fuel type	**Engine oil classification (API classification)**	
	Engines with non-EGR **Engines with internal EGR**	**Engines with external EGR**
High sulfur fuel [0.05% (500 ppm) ≤ Sulfur content < 0.50% (5000 ppm)]	**CF** (If the "CF-4, CG-4, CH-4, or CI-4" engine oil is used with a high-sulfur fuel, change the engine oil at shorter intervals. (approximately half))	-
Low sulfur fuel [Sulfur content < 0.05% (500 ppm)] or Ultra-low sulfur fuel [Sulfur content < 0.0015% (15 ppm)]	**CF, CF-4, CG-4, CH-4** or **CI-4**	**CF** or **CI-4** (Class CF-4, CG-4 and CH-4 engine oils cannot be used on EGR type engines.)

EGR: Exhaust Gas Re-circulation

- **CJ-4, CK-4 classification oil is intended for use in engines equipped with aftertreatment system and is not recommended for use in Kubota mechanical engines.**
- **Oil used in the engine should have API classification and proper SAE engine oil viscosity according to the ambient temperatures where the engine is operated.**
- **With strict emission control regulations now in effect, the CF-4 and CG-4 engine oils have been developed for use with low sulfur fuels, for on-highway vehicle engines. When a non-road engine runs on high sulfur fuel, it is advisable to use a "CF or better" classification engine oil with a high Total Base Number (a minimum TBN of 10 is recommended).**

[3] DEGRADATION OF ENGINE OIL

Engine oil is subjected to extremely harsh conditions. Since it is used at high temperatures and in situations where combustible compounds and soot become mixed, then degradation inevitably occurs. Cause and effect of oil degradation are described below.

(1) Effect of oxidation due to temperature changes
Oxidation of engine oil accelerates when oil is exposed to oxygen in the air at high temperatures. The speed of oxidation is faster with increase of temperature.
Generally, the speed of oxidation is doubled at each increase of 10 deg. C (50 deg. F) and the speed of oxidation accelerated further after the temperature reaches 150 deg. C (302 deg. F). The speed of oxidation is also affected by the metal which contacts engine oil and is the fastest when exposed copper-based metals.
Oil oxidation differs in low temperature sections, in the bearing system and in high temperature sections such as the ring grooves.
Specific oxidation conditions are described briefly below.

Oil temperature & oxidation process

Table 3 Below 125 deg. C (257 deg. F)

Engine parts	Engine oil oxidation process
Main bearing, crank pin, oil pan, etc.	Gradual oil oxidation - peroxide generated - acid, (rich in extreme pressure property) hydroxyl acid-sludge generated polymerization, rate of wear

Table 4 125 to 200 deg. C (257 to 392 deg. F)

Engine parts	Engine oil oxidation process
Piston skirt, piston ring	Substantial oil oxidation - Gluey deposits generated polymerization, rate of wear

Table 5 Above 200 deg. C (392 deg. F)

Engine parts	Engine oil oxidation process
Piston ring, piston head	Thermal cracking of oil and sludge light substance - combustion heavy substance - soot and hard carbon

(2) Effect of oxidation due to combustion
Oxidation of oil is not only affected by the oxidation of the oil itself but by entrance of aldehyde, peroxide, etc. which is produced by combustion. Gas with these substances blow back and is mixed with engine oil. Thus oxidation of oil is accelerated. With diesel engines, which used diesel fuel with higher sulfur content than gasoline, sulfur dioxide produced by combustion goes through the ring belt area as blow-by gas, changes into SO_3 after contacting the metal oxide. The absorbs water and becomes sulfuric acid it oxidizes the oil and accelerates cylinder wear.

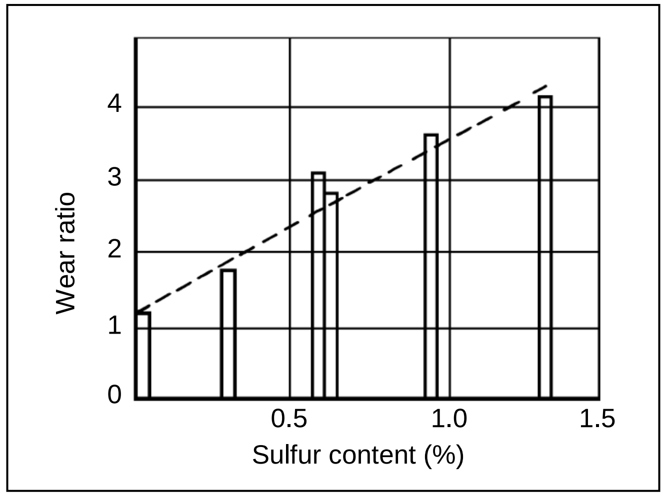


Figure 2 Effect of sulfur on wear

[4] ANALYSIS RESULTS AND ENGINE OIL CHANGE INTERVALS

To determine proper engine oil change intervals, it is necessary to study the results of engine oil analysis and internal smear characteristics and wear of engine parts. It is not practical to over-haul an engine every time an inspection is necessary. Generally, judgement of oil change is based on the result of oil analysis and experience.

1) Viscosity
Viscosity of oil increases as the oil oxidizes and as it mixes with incompletely burnt fuel by-products (soot etc.). Since pressure loss is greater as oil volume decreases improper or insufficient lubrication can result. High viscosity of oil causes greater frictional resistance which generates more heat. This can eventually cause seizure of major parts such as cylinders, bearings etc. and lead to serious problems.
Oil must be changed before viscosity increase is too great.

(2) Total acid value

Oils in which additives are used have a certain acid value even when new. The acid value increases as the oil itself becomes oxidized and contaminated by combustion byproducts.
The acid value must be controlled to a 2 mg/KOH/g increase from the value when new.
Oil must be changed before acid number becomes too high.

(3) Alkalinity

Detergent and dispersing agents contained in engine oil have a weak alkalinity to neutralize combustion byproducts (especially sulfuric acid in diesel engines) and oil oxides. This alkalinity decreases gradually with use term. By checking this decrease of alkalinity, you can check the remaining level of detergent and dispersing agents in the oil, which in turn is an accurate indication of when to replace oil.
Generally certain allowances are made for exact replacement intervals but minimum alkalinity is usually considered to be approximately 1.0 mg/KOH/g.

(4) Insoluble matter of solvent

The amount of sludge in engine oil is measured by the percent of insoluble matter of solvent (weight %).
As shown in figure 3, N-pentane insoluble matter includes oxidized compounds of fuel or oil, inorganic matter such as dust and metal powder and soot. Oxidized compounds of fuel or oil are considered the reminder of N-pentane insoluble matter without insoluble benzene content, which is called the resin matter.

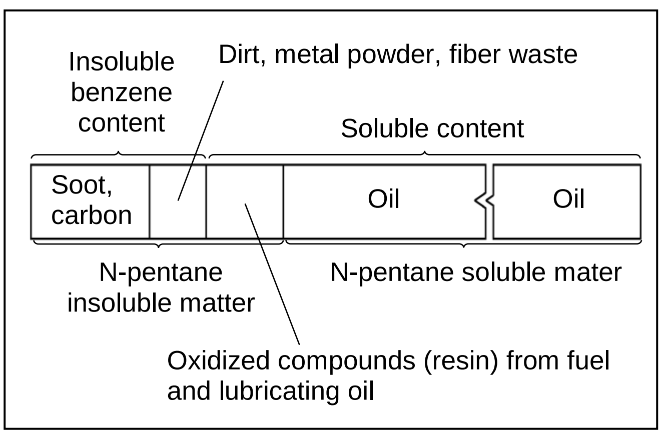


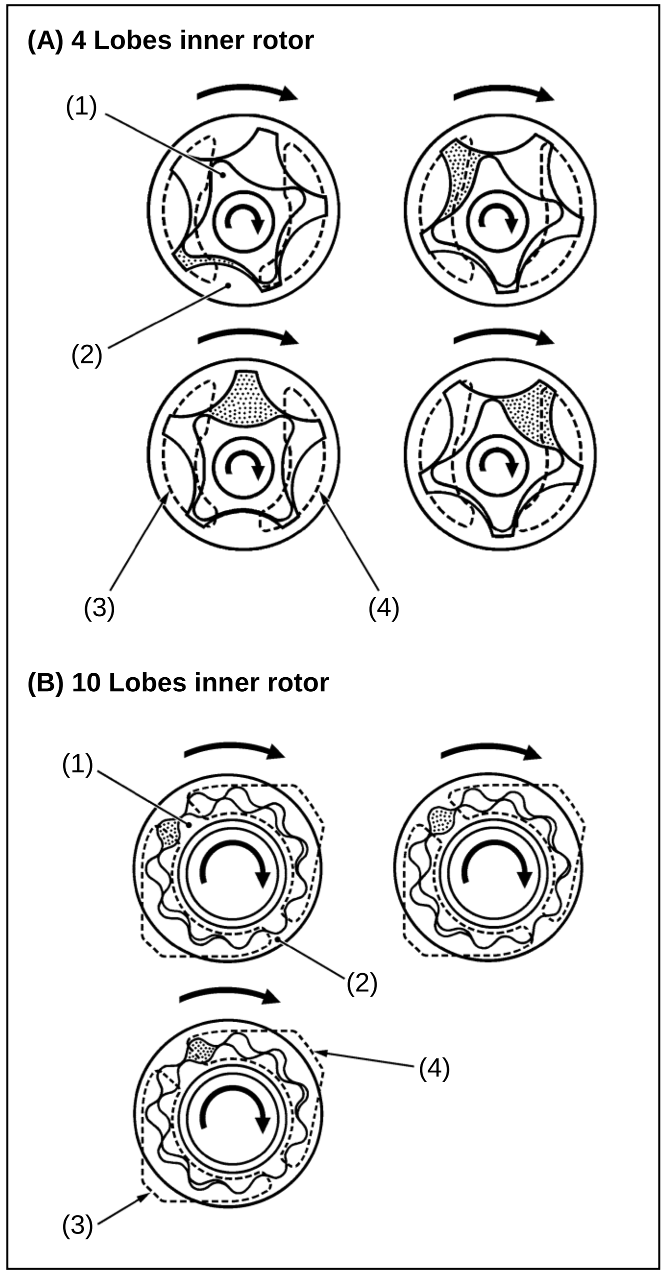
Figure 3

Generally, the limit of N-pentane insoluble matter should be within 2.0% and insoluble benzene content within 1.5%.
Oil must be changed before sludge amount is too great.
See “OPERATOR’S MANUAL” for oil change intervals.

3. LUBRICATING OIL PUMP

(1) Oil pump

A trochoid pump is used to pump oil. It is compact and driven by the crankshaft gear.
It also runs extremely smoothly and quietly.
The casing is made of an aluminum alloy and the rotor of a sintered steel alloy.



(1) Inner rotor (3) Inlet port
(2) Outer rotor (4) Outlet port

Figure 4 Oil pump

The rotor has a precise clearance of 0.1 mm (0.0039 in) which requires very careful attention. Make absolutely sure that no dirt or other foreign matter enters into oil pump through the oil filter.

Oil pump specifications

Table 6 For SM series

Type	Trochoid pump
Inner rotor delivery volume (at oil pump speed: 2000 rpm)	4 lobes 8.0 or 10 L/min 2.1 or 2.6 U.S. gal/min
Engine oil pressure (at engine rated speed)	197 to 441 kPa 2.00 to 4.50 kg/cm^2 28.5 to 64.0 psi

Table 7 For 05 series except V1505-CR-TE5

Type	Trochoid pump
Inner rotor delivery volume (at engine speed: 2000 rpm)	10 lobes 22.1 L/min 5.84 U.S gal/min
Engine oil pressure (at engine rated speed)	197 to 441 kPa 2.00 to 4.50 kg/cm^2 28.5 to 64.0 psi

Table 8 For V1505-CR-TE5 model

Type	Trochoid pump
Inner rotor delivery volume (at engine speed: 2000 rpm)	9 lobes 32.8 L/min 8.66 U.S gal/min
Engine oil pressure (at engine rated speed)	196 to 539 kPa 2.00 to 5.49 kg/cm^2 28.5 to 78.1 psi

Table 9 For 03 series

Type	Trochoid pump
Inner rotor delivery volume (at oil pump speed: 2000 rpm)	4 lobes 24.3 or 27.2 L/min 6.42 or 7.19 U.S. gal/min
Engine oil pressure (at engine rated speed)	294 to 441 kPa 3.00 to 4.50 kg/cm^2 42.7 to 64.0 psi

Table 10 For 07 series

Type	Trochoid pump	
	V2607	V3307
Inner rotor delivery volume (at engine speed: 2000 rpm)	10 lobes 36.5 L/min 9.64 U.S. gal/min	10 lobes 45.6 L/min 12.0 U.S. gal/min
Engine oil pressure (at engine rated speed)	245 to 441 kPa 2.50 to 4.50 kg/cm^2 35.6 to 64.0 psi	196 to 392 kPa 2.00 to 4.00 kg/cm^2 28.4 to 56.9 psi

Table 11 For V3 series

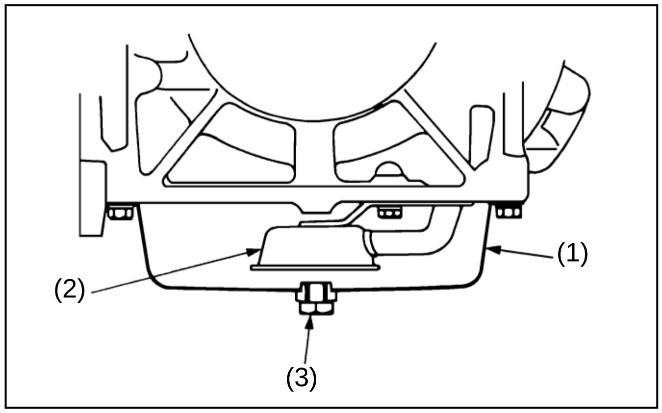
Type	Trochoid pump
Inner rotor delivery volume (at engine speed: 2000 rpm)	10 lobes 45.6 L/min 12.0 U.S. gal/min
Engine oil pressure (at engine rated speed)	196 to 392 kPa 2.00 to 4.00 kg/cm^2 28.4 to 56.9 psi

Table 12 For 09 series

Type	Trochoid pump
Inner rotor delivery volume (at engine speed: 2000 rpm)	10 lobes 52.2 L/min 13.8 U.S. gal/min
Engine oil pressure (at engine rated speed)	300 to 450 kPa 3.06 to 4.58 kg/cm^2 43.6 to 65.2 psi

4. LUBRICATING OIL FILTER

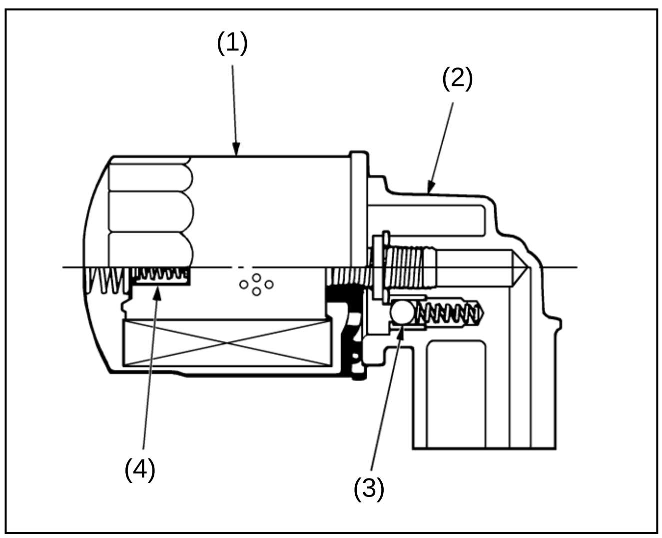
Oil in the oil pan first passes through filter 1 and is then suctioned by the oil pump. It then flows through filter 2 lubricating the various parts.
Oil filter 1 is installed near the bottom of the oil pan and removes dirt and foreign matter.



(1) Oil pan (3) Drain plug
(2) Oil filter 1

Figure 5 Oil filter 1

Oil filter 2 is installed under the gear case on the side of gear case and is a standard full-flow type cartridge which requires minimum maintenance.



(1) Oil filter 2 (Oil filter cartridge) (3) Relief valve
(2) Gear case (4) By-pass valve

Figure 6 Oil filter 2

● **Function of valves and switches**

Relief valve

Maintains lubricating oil pressure at constant value adjusted to maintain pressure of 200 to 440 kPa (2.0 to 4.5 kg/cm^2, 28 to 64 psi).

By-pass valve

By-pass valve is built into oil filter 2, if the filter becomes clogged, insufficient lubrication will result. To prevent this, the by-pass valve opens when the pressure difference before and after the filter exceeds 98 kPa (1.0 kg/cm^2, 14 psi) to provide oil to engine parts.

Oil switch

An oil switch is fitted at the camshaft bearing. If oil pressure drops below 49 to 98 kPa (0.5 to 1.0 kg/ cm^2, 7.1 to 14 psi)*4 a lamp connected to the switch lights up, advising the operator to stop engine and investigate the cause of the pressure drop.

*4: These will vary slightly according to model.

● **Remote oil filter**

When remote oil filter is used, the oil pressure at idling is as follows.
98 kPa (1.0 kg/cm^2, 14 psi) or more
[Oil temperature: 90 to 95 deg. C (194 to 203 deg. F)]

5. OIL PAN

The oil pan holds a specified volume of oil, which is drawn up by the pump during operation and returns along the inside walls of the crankcase.
This flow cycle is repeated continuously as the engine runs.
The oil drain is located according to how the engine is installed and positioned for easy access for special drain requirements.

Oil gauge (Dipstick)

The standard oil gauge is installed on the side of crankcase. The part which is inserted is made of rubber, which is grooved to release internal pressure during insertion. The oil gauge is stamped with lines indicating upper and lower limits. If oil is supplied far above the top limit, engine output will be reduced and oil temperature will be increased, so watch this point carefully.
Proper oil level is not indicated for a few minutes after the engine is stopped because of the time required for oil to return to the oil pan. Oil level must be measured in level position.

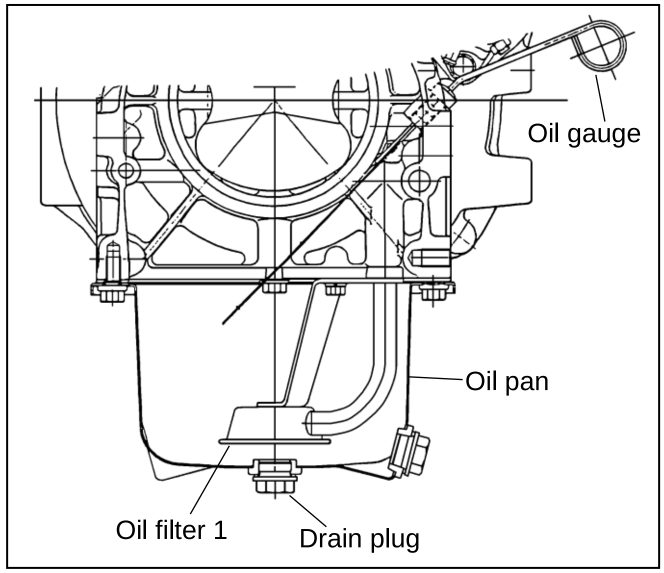


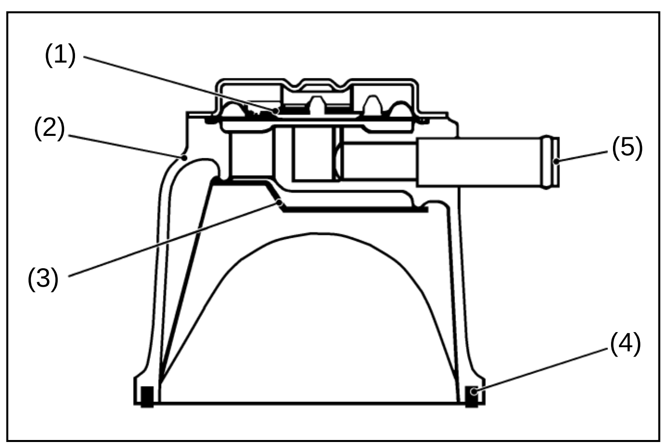
Figure 7 Oil gauge

6. OIL SUPPLY PORT

Oil is supplied to the engine through the oil supply port located on top of the cylinder head cover or on the gear case or crankcase.
Oil flows through cylinder head and crankcase or gear case to the oil pan. This oil supply port should be easily accessible for servicing, even after the engine has been installed.
Care must be taken to decide the position of oil supply port so that the oil can be easily supplied to the piping installed on the machine.

7. CLOSED BREATHER

Closed breather system has been adopted to prevent the release of blow-by gas into the atmosphere.
After its oil content is filtered by oil shield (3), the blow-by gas is fed back to the intake manifold through breather valve (1) to be used for re-combustion.



(1) Breather valve (4) Rubber packing
(2) Cylinder head cover (5) Breather hose
(3) Oil shield

Figure 8 Closed breather system

REVISION HISTORY

File Name	Remarks	Date
KORD3_16-055_5_lubrication_system.pdf	New release	Jun. 8, 2016
KORD3_21-045_ Lubrication_system_for_CI_engine.pdf	Add V1505-CR-TE5 model	Apr. 16, 2021
KORD3_22-206_ Lubrication_system_for_CI_engine.pdf	Add 09 series specification	Jun. 29, 2022