F2CFA614B*E019
F2CFA614C*E019
Tier 2
Engine

SERVICE MANUAL

Part number 47441651
1st edition English
October 2012

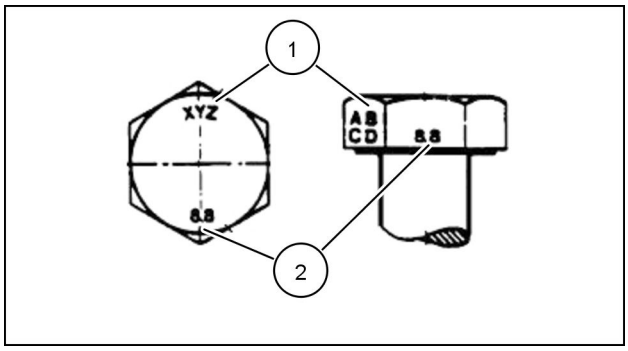
CASE

METRIC FLANGED HARDWARE

NOM. SIZE	CLASS 8.8 BOLT and CLASS 8 NUT		CLASS 10.9 BOLT and CLASS 10 NUT		LOCKNUT CL.8 W/CL8.8 BOLT	LOCKNUT CL.10 W/CL10.9 BOLT
	UNPLATED	PLATED W/ZnCr	UNPLATED	PLATED W/ZnCr		
M4	2.4 N·m (21 lb in)	3.2 N·m (28 lb in)	3.5 N·m (31 lb in)	4.6 N·m (41 lb in)	2.2 N·m (19 lb in)	3.1 N·m (27 lb in)
M5	4.9 N·m (43 lb in)	6.5 N·m (58 lb in)	7.0 N·m (62 lb in)	9.4 N·m (83 lb in)	4.4 N·m (39 lb in)	6.4 N·m (57 lb in)
M6	8.3 N·m (73 lb in)	11 N·m (96 lb in)	12 N·m (105 lb in)	16 N·m (141 lb in)	7.5 N·m (66 lb in)	11 N·m (96 lb in)
M8	20 N·m (179 lb in)	27 N·m (240 lb in)	29 N·m (257 lb in)	39 N·m (343 lb in)	18 N·m (163 lb in)	27 N·m (240 lb in)
M10	40 N·m (30 lb ft)	54 N·m (40 lb ft)	57 N·m (42 lb ft)	77 N·m (56 lb ft)	37 N·m (27 lb ft)	53 N·m (39 lb ft)
M12	70 N·m (52 lb ft)	93 N·m (69 lb ft)	100 N·m (74 lb ft)	134 N·m (98 lb ft)	63 N·m (47 lb ft)	91 N·m (67 lb ft)
M16	174 N·m (128 lb ft)	231 N·m (171 lb ft)	248 N·m (183 lb ft)	331 N·m (244 lb ft)	158 N·m (116 lb ft)	226 N·m (167 lb ft)
M20	350 N·m (259 lb ft)	467 N·m (345 lb ft)	484 N·m (357 lb ft)	645 N·m (476 lb ft)	318 N·m (235 lb ft)	440 N·m (325 lb ft)
M24	607 N·m (447 lb ft)	809 N·m (597 lb ft)	838 N·m (618 lb ft)	1118 N·m (824 lb ft)	552 N·m (407 lb ft)	

IDENTIFICATION

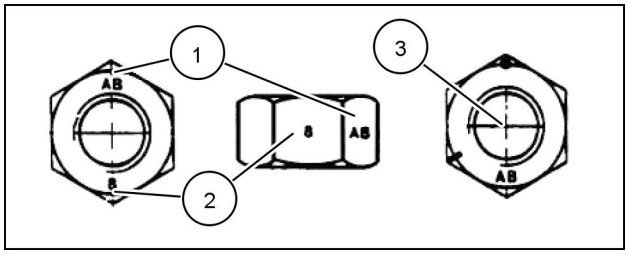
Metric Hex head and carriage bolts, classes 5.6 and up



20083680 1

1. Manufacturer's Identification
2. Property Class

Metric Hex nuts and locknuts, classes 05 and up



20083681 2

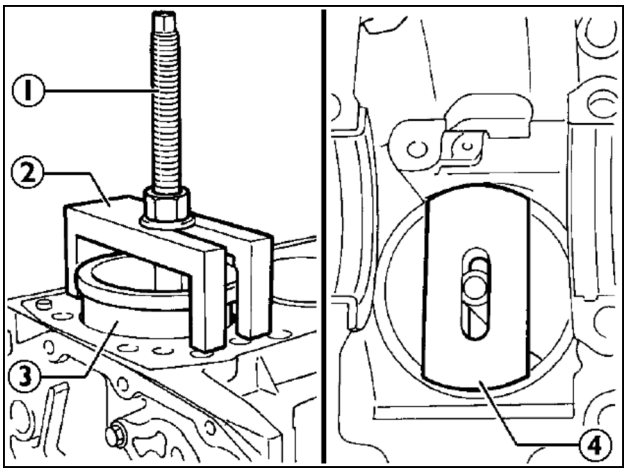
Engine - Service limits

Engine specifications	
Compression ratio	15.9:1
Bore	**117 mm** (**4.6 in**)
Stroke	**135 mm** (**5.3 in**)
Displacement	**8710 cm³**
Turbocharging	Inter-cooled, Direct injection
Lubrication	Forced by gear pump, relief valve single action oil filter
Oil pressure (Warm engine) - Idling - Peak RPM	 **4 bar** (**58 psi**) **5 bar** (**73 psi**)
Cooling	Liquid cooled
Water pump control	Belt driven
Thermostat (Start of opening)	**83.5 - 86.5 °C** (**182.3 - 187.7 °F**)
Intake valve timing - Opens before TDC - Closes after BDC Exhaust valve timing - Opens before BDC - Closes after TDC	 **17 °** **31 °** **48 °** **9 °**
Valve lash setting (when engine is cold) - Intake - Exhaust	 **0.35 - 0.45 mm** (**0.014 - 0.018 in**) **0.55 - 0.65 mm** (**0.022 - 0.026 in**)
Firing Order	1 - 4 - 2 - 6 - 3 - 5
Injection pressure	**1800 bar** (**26100 psi**)
Injector calibration	**290 - 302 bar** (**4205 - 4379 psi**)
Cylinder block and piston	
Cylinder liner bore - Upper - Lower	 **130.500 - 130.525 mm** (**5.138 - 5.139 in**) **129.510 - 129.535 mm** (**5.099 - 5.100 in**)
Cylinder liner external diameter - Upper - Lower	 **130.461 - 130.486 mm** (**5.136 - 5.137 in**) **129.475 - 129.500 mm** (**5.097 - 5.098 in**)
Clearance between the OD of liners and ID of bores - Upper - Lower	 **0.014 - 0.064 mm** (**0.001 - 0.003 in**) **0.010 - 0.060 mm** (**0.0004 - 0.0024 in**)
Cylinder liner - ID A* - ID B* * Selection class - Protrusion	 **117.000 - 117.012 mm** (**4.606 - 4.607 in**) **117.010 - 117.022 mm** (**4.607 - 4.607 in**) **0.035 - 0.065 mm** (**0.001 - 0.003 in**)
Pistons - Measuring dimension - External diameter (supplied as spares) - External diameter (production only) - Pin bore	 **15 mm** (**0.591 in**) **116.894 - 116.906 mm** (**4.602 - 4.603 in**) **116.904 - 116.916 mm** (**4.603 - 4.603 in**) **52.016 - 52.022 mm** (**2.048 - 2.048 in**)
OD of piston - ID of cylinder liner	**0.094 - 0.118 mm** (**0.004 - 0.005 in**)
Piston protrusion	**0.873 - 1.117 mm** (**0.034 - 0.044 in**)
Piston pin diameter	**51.994 - 52.000 mm** (**2.047 - 2.047 in**)
Piston pin OD - pin bore	**0.016 - 0.028 mm** (**0.0006 - 0.0011 in**)
Piston ring grooves - Top	 **3.120 - 3.140 mm** (**0.123 - 0.124 in**)

Crankcase Liner - Remove

Prior operation:
Connecting rod and piston - Remove (10.105)

1. Use tool **380000366 (2)** in conjunction with tool **380000152 (4)** as shown in the figure.
2. Check to make sure the plate **(4)** rests on the cylinder liner correctly.
3. Screw down the nut of the screw **(1)** and extract the cylinder liner **(3)** from the crankcase.



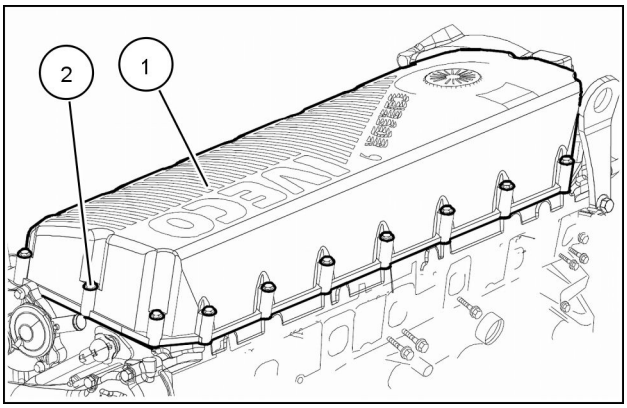
LINERPULLER 1

Next operation:
Crankcase Liner - Measure (10.001)

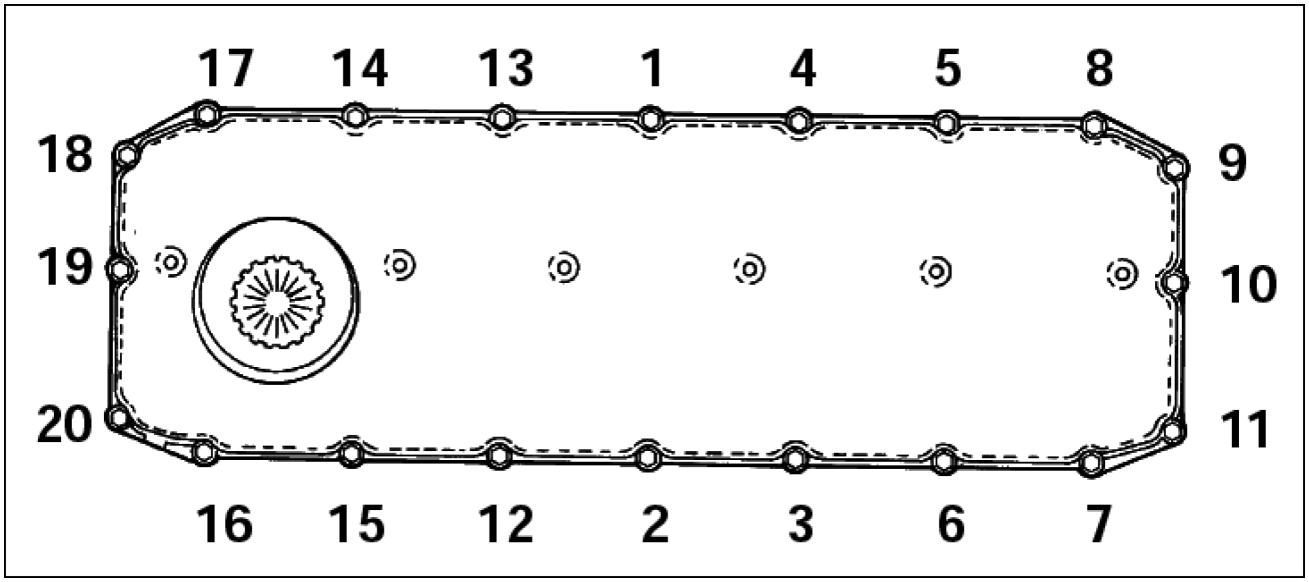
Valve cover - Install

Prior operation:
Valve cover - Remove (10.101)

1. Install the valve cover **(1)** and tighten the screws **(2)** to the required torque using the sequence illustrated below.



VALVECOVER4 1

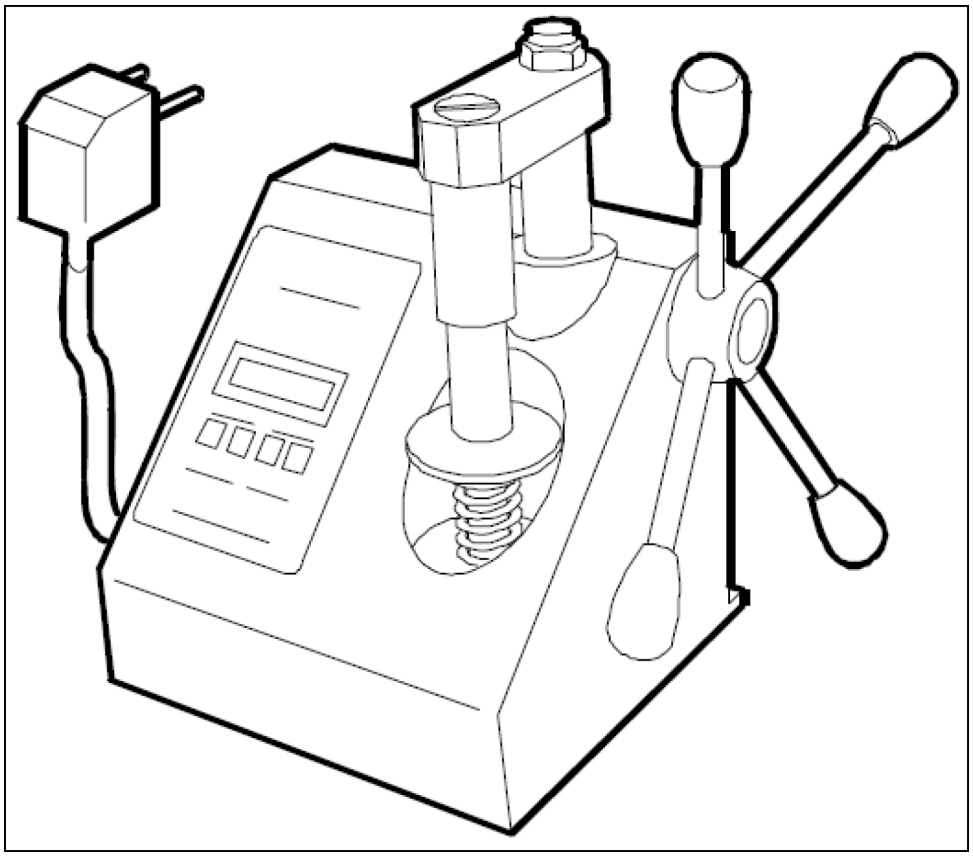


VALVECOVER 2

Valve cover torque sequence

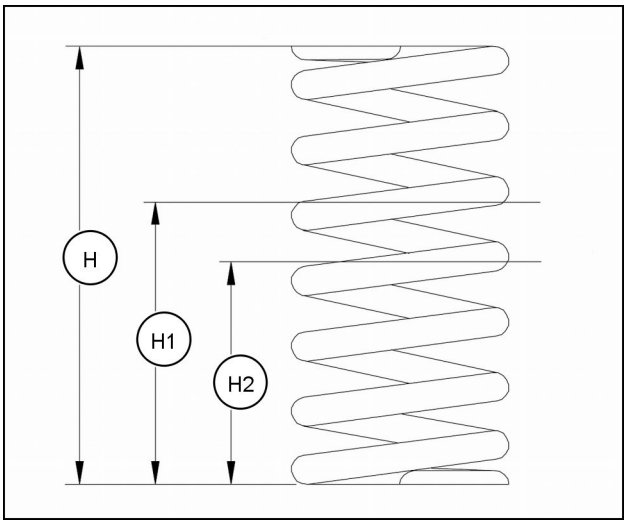
Valves Spring - Check

Prior operation:
Cylinder head - Disassemble (10.101)



VALVESPRING2 1

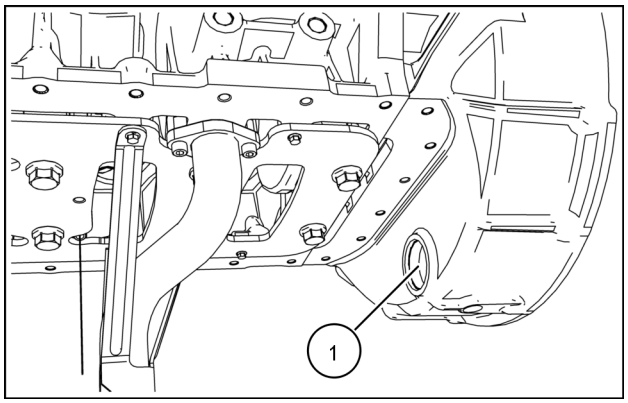
1. Before assembly, the flexibility of the valve springs must be checked.
2. Compare the load and elastic deformation data with those of the new springs given below.
   - **(H) = 70.77 mm** (**2.786 in**) at no load.
   - **(H1) = 51 mm** (**2.008 in**) at a load of **437 - 483 N** (**98 - 109 lb**).
   - **(H2) = 39 mm** (**1.535 in**) at a load of **707 - 773 N** (**159 - 174 lb**).



VALVESPRING 2

Next operation:
Cylinder head - Assemble (10.101)

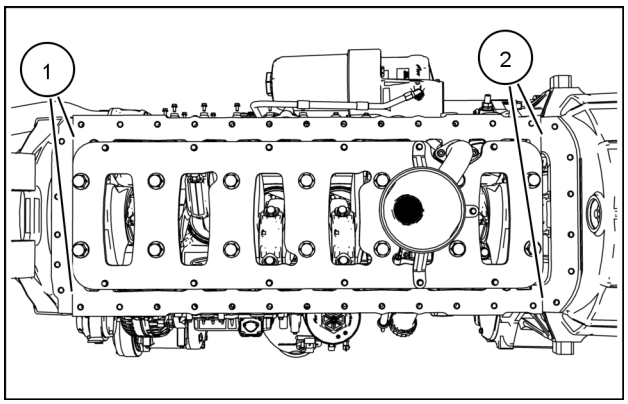
5. Remove the plug **(1)** from the flywheel housing.



23119838 5

6. Apply a bead of **LOCTITE® 5970** to the engine block approximately **1.5 mm** (**0.059 in**) thick at the joints of the front cover **(1)** and flywheel housing **(2)**.

NOTE: *Installation of the oil pan is recommended within* ***5 min*** *of sealant application.*



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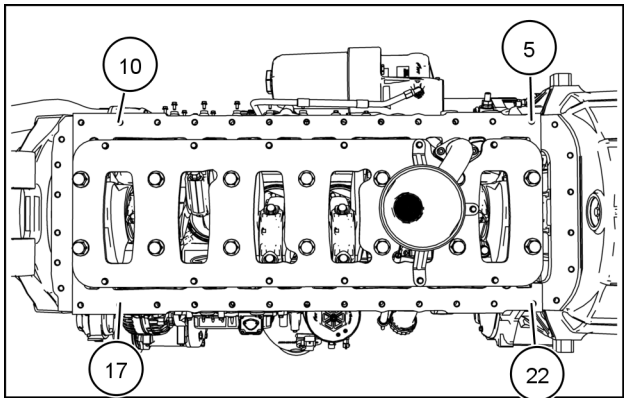
7. Install **M10x1.5** guide pins that are approximately **120 mm** long into locations **(5)**, **(10)**, **(17)** and **(22)** to ensure proper alignment of the oil pan during assembly.

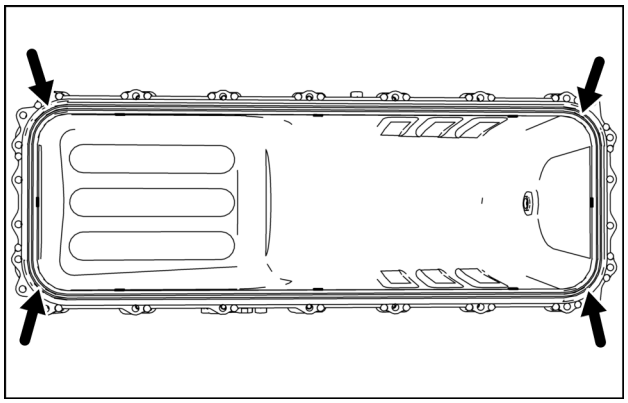


23119839 7

8. Apply **LOCTITE® 5970** to all four corners of the oil pan gasket.

NOTE: 60 - 80 ° *coverage is recommended.*

NOTE: *Installation of the oil pan is recommended within* ***5 min*** *of sealant application.*



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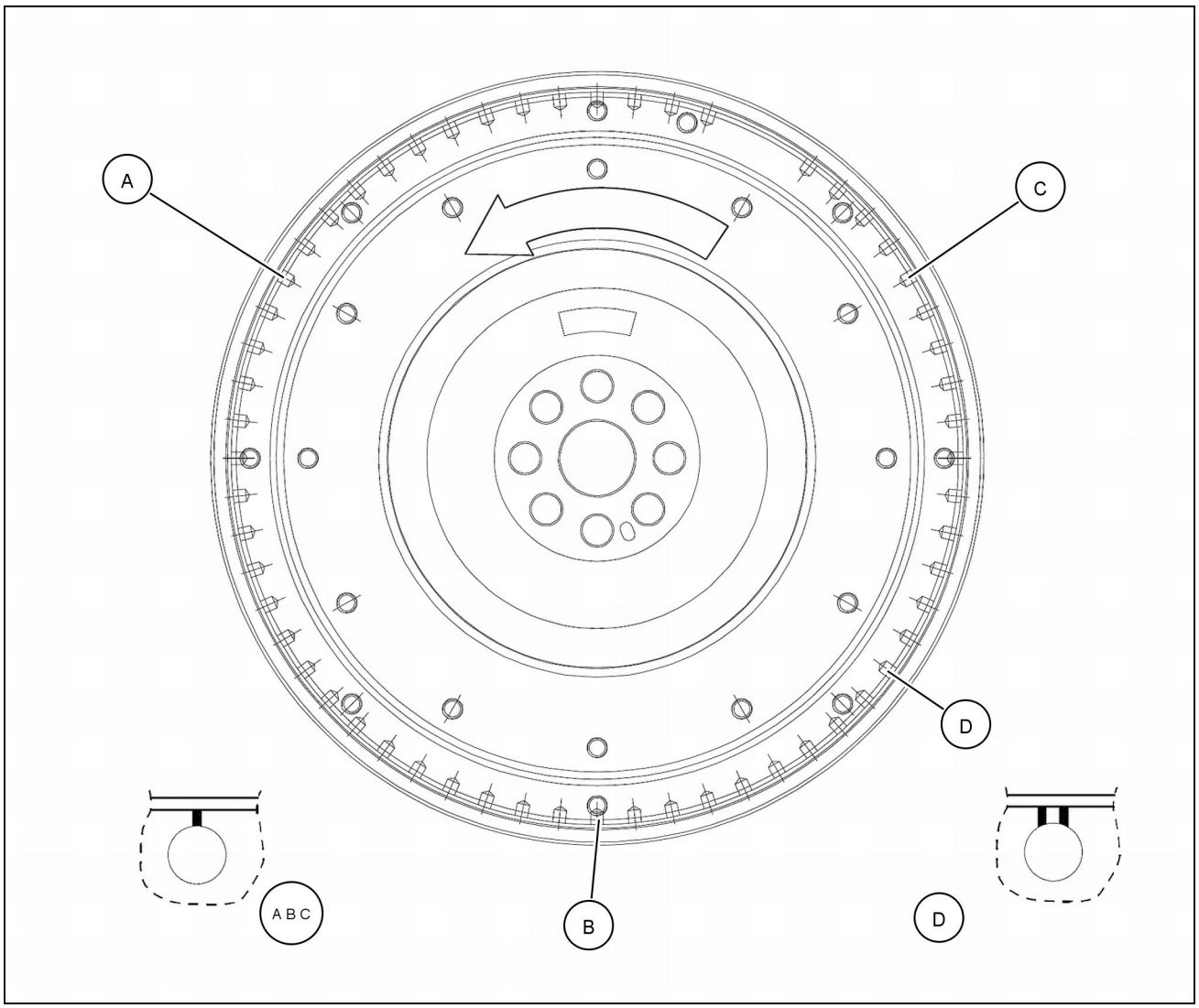
Engine flywheel - Detailed view



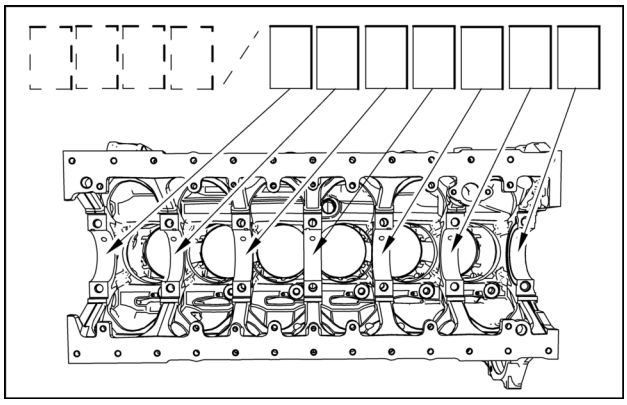
FLYWHEEL2 1

Engine Flywheel

This illustration shows the reference marks on the flywheel indicating the position of the cylinders.

- **(A)** - Hole with one reference mark corresponding to the TDC of pistons 3 and 4.
- **(B)** - Hole with one reference mark corresponding to the TDC of pistons 1 and 6.
- **(C)** - Hole with one reference mark corresponding to the TDC of pistons 2 and 5.
- **(D)** - Hole with two reference marks that indicates **54 °** before TDC of pistons 1 and 6.

Determine the block bearing bore class. The class numbers are stamped on the inside of the block at the number seven main journal.



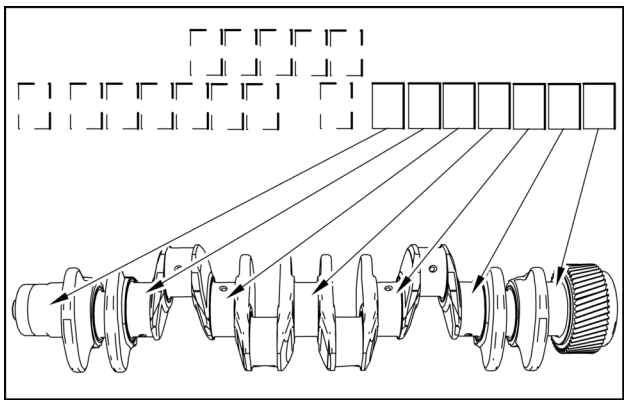
NHVM12ENG0010AA 3

5. Determine the diameter class of the main journals. The class numbers are stamped on the last throw of the crankshaft at the time of manufacture.

NOTE: *If the crankshaft has been ground or you cannot find the stamping, each journal must be measured and classed individually.*

6. Use the tables below to determine the correct bearing halves to be used for each block bore and main journal combination.

NOTE: *The upper* ***(U)*** *and lower* ***(L)*** *bearing halves can be different thicknesses.*



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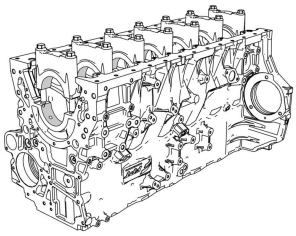
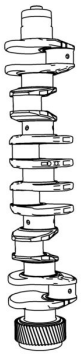
Bearing selection for a standard crankshaft

Standard



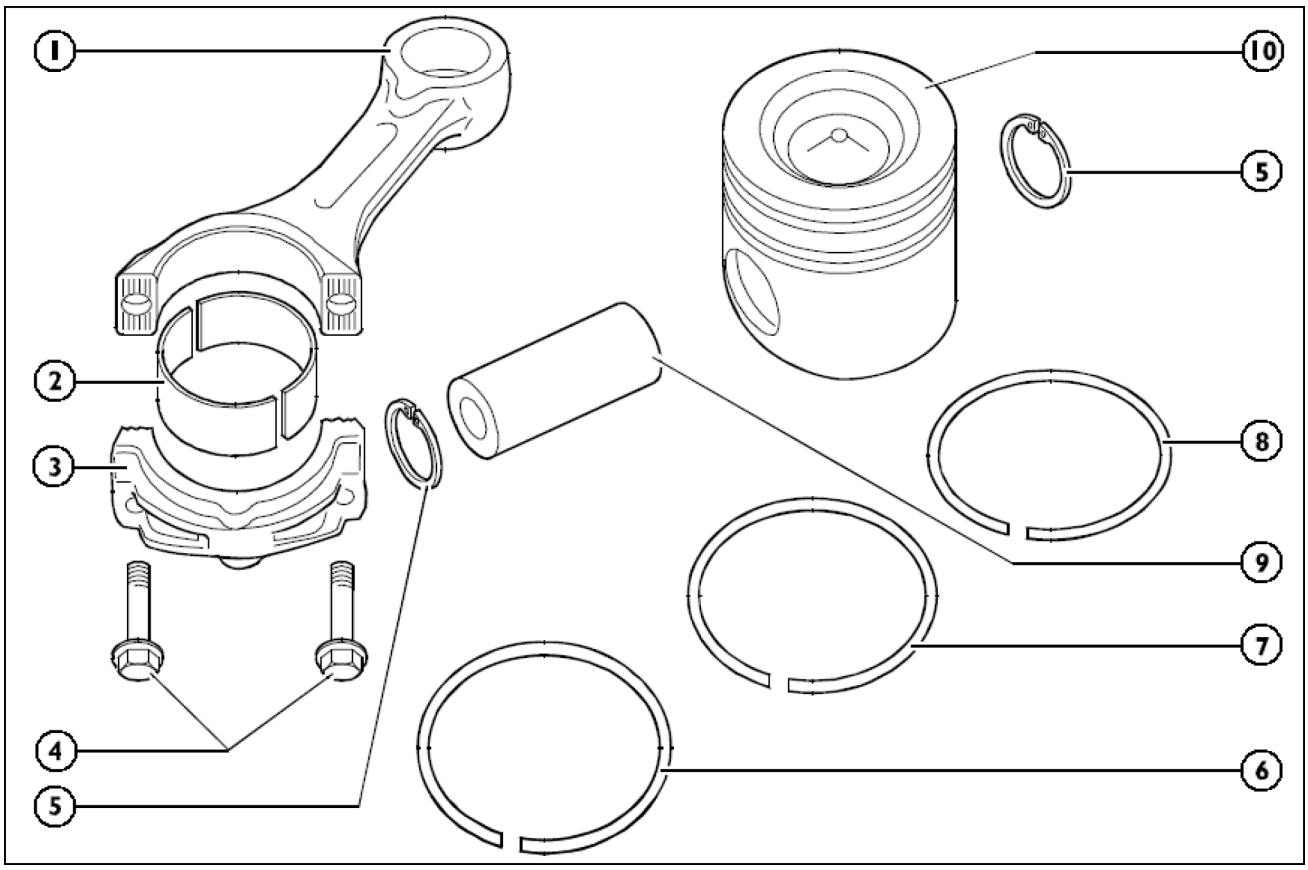


Main journal diameter	Class		1	2	3
92.970 - 92.980 mm (**3.6602 - 3.6606 in**)	1	**(U)**	Green	Green	Yellow*
		(L)	Green	Yellow*	Yellow*
92.980 - 92.990 mm (**3.6606 - 3.6610 in**)	2	**(U)**	Red	Green	Green
		(L)	Green	Green	Yellow*
92.990 - 93.000 mm (**3.6610 - 3.6614 in**)	3	**(U)**	Red	Red	Green
		(L)	Red	Green	Green

Red = **2.968 - 2.978 mm** (**0.1169 - 0.1172 in**)
Green = **2.978 - 2.988 mm** (**0.1172 - 0.1176 in**)
Yellow* = **2.988 - 2.998 mm** (**0.1176 - 0.1180 in**)

* Production only. Substitute with Green bearings if needed.

Connecting rod and piston - Exploded view



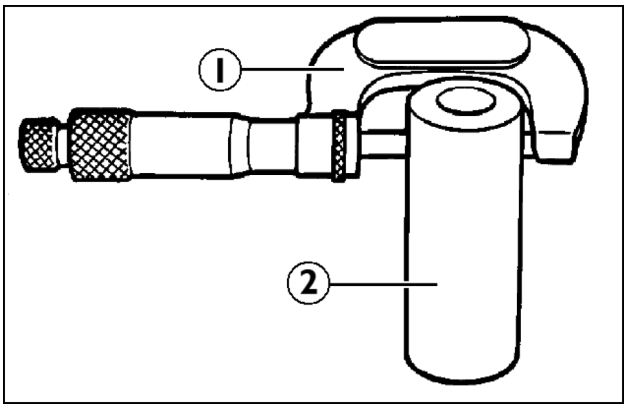
CONRODPISTON 1

(1) Connecting rod
(2) Half bearings
(3) Connecting rod cap
(4) Cap bolts
(5) Snap ring
(6) Oil control ring
(7) Bevel cut intermediate ring
(8) Trapazoidal combustion ring
(9) Piston pin
(10) Piston

Piston Pin - Measure

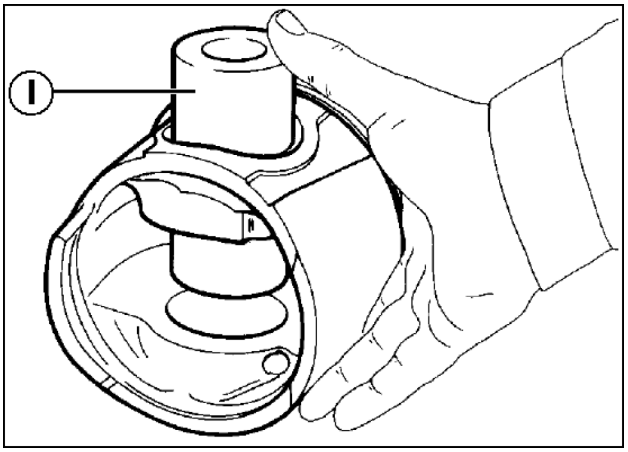
Prior operation:
Connecting rod and piston - Disassemble (10.105)

1. Measure the diameter of the piston pin **(2)** with a micrometer **(1)**.



PISTONPIN3 1

2. Lubricate the pin **(1)** and the pin housing in the piston with engine oil.
3. Insert the pin into the piston. It must be inserted with slight finger pressure and it should not come out by gravity.



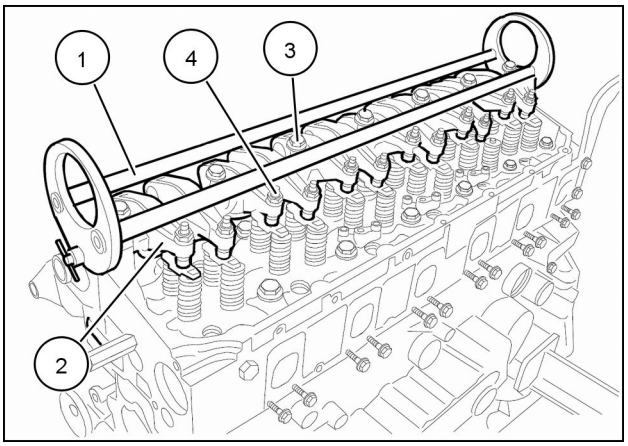
PISTONPIN4 2

Next operation:
Connecting rod and piston - Assemble (10.105)

Rocker arm - Install

Prior operation:
Rocker arm - Remove (10.106)

1. Make sure the adjusting screws **(4)** on the rocker arms **(2)** are fully backed off. Failure to do so may cause binding during the installation process.
2. Apply tool **380000149 (1)** to the rocker shaft.
3. Torque the bolts **(3)** to **94 - 115 N·m** (**69 - 85 lb ft**).

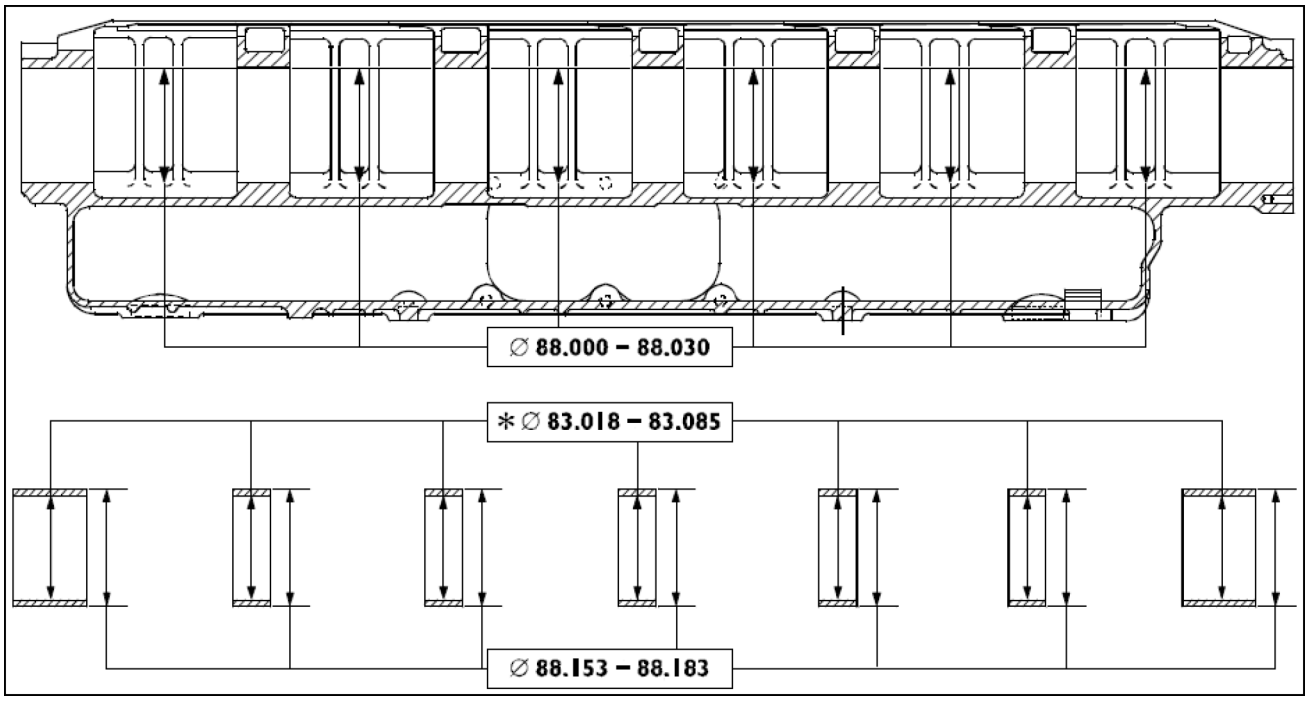


ROCKERASSEMBLY 1

Next operation:
Rocker arm - Clearance (10.106)

Camshaft bushings - Replace

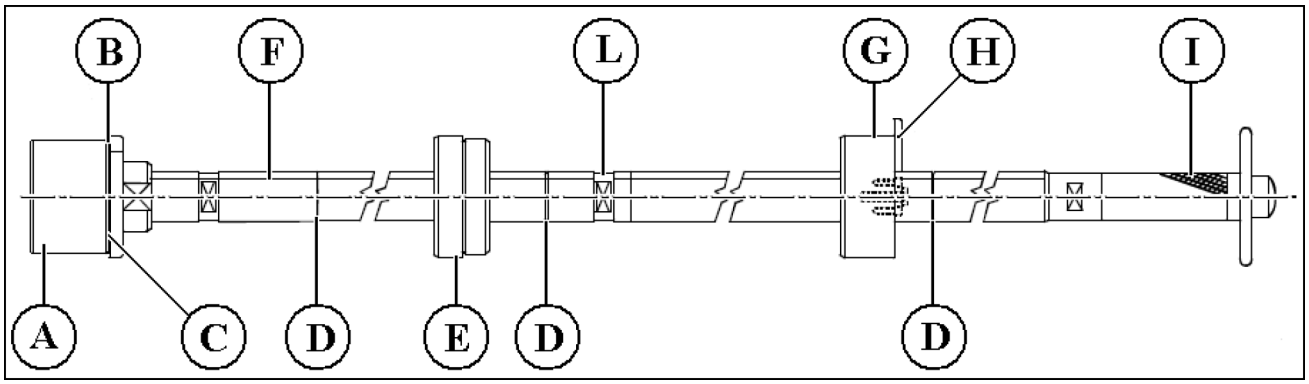
Prior operation:
Camshaft - Remove (10.106)



CAMBUSHING 1

*** Measurement to be taken after installation.**

1. The surface of the bushing must show no sign of seizing or scoring. Replace them if they do.
2. Measure the inside diameter of the bushings with a bore gauge. If you find a higher tolerance than specified, replace them.
3. To remove and install the bushings, use the appropriate drift **380000146**.



CAMBUSHING4 2

(A) Drift with seat for removal and installation of bushings
(B) Grub screw for positioning bushings
(C) Reference mark to insert bushing 7 correctly
(D) Reference marks (red) to insert bushings 1 - 6
(E) Guide bushing
(F) Guide line
(G) Guide bushing to secure the seventh bushing mount
(H) Plate securing the yellow bushing to the cylinder head
(I) Grip
(L) Extension coupling

Index

Engine - 10

Balancer and damper - 110

Index

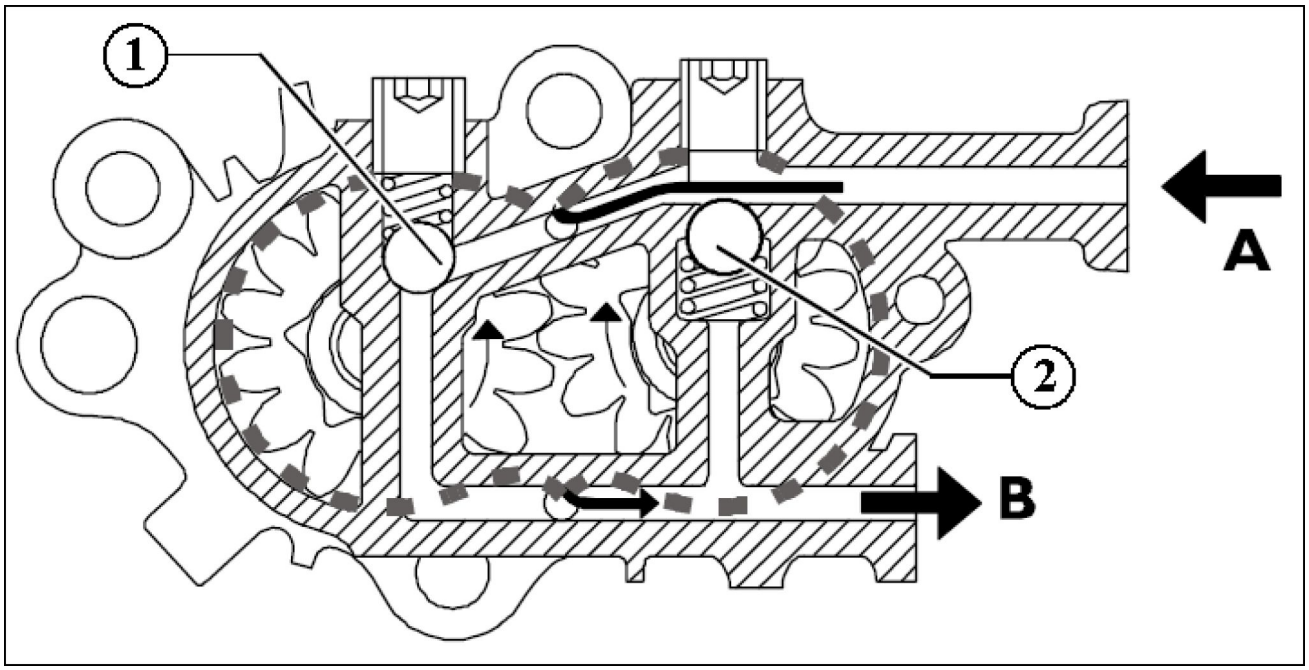
Engine - 10

Pump drives - 114

Fuel lift pump Gear pump - Overview

Installed on the rear side of the high pressure pump and used to supply it. It is controlled by the high pressure pump shaft.

Normal operating conditions



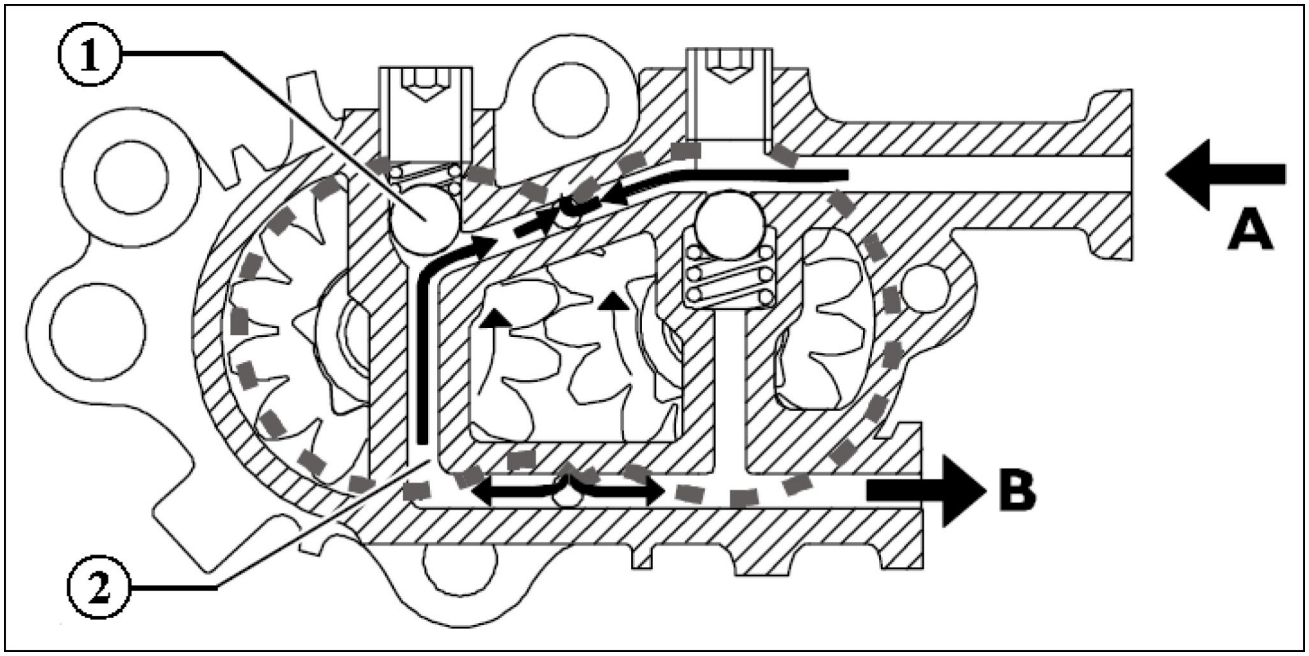
TRANSFERPUMP 1

(A) Fuel inlet from tank

(B) Fuel outlet to filter

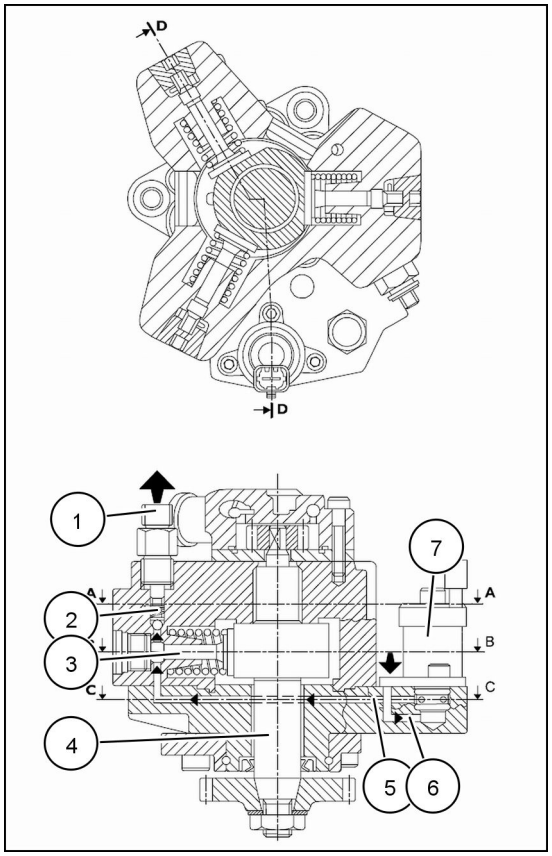
(1) and **(2)** By-pass valves in closed position

Overpressure conditions at outlet



TRANSFERPUMP2 2

The by-pass valve **(1)** cuts in when overpressure is generated at outlet **(B)**. The existing pressure, overcoming the valve spring **(1)**, makes inlet and outlet fuel use the passage **(2)**.



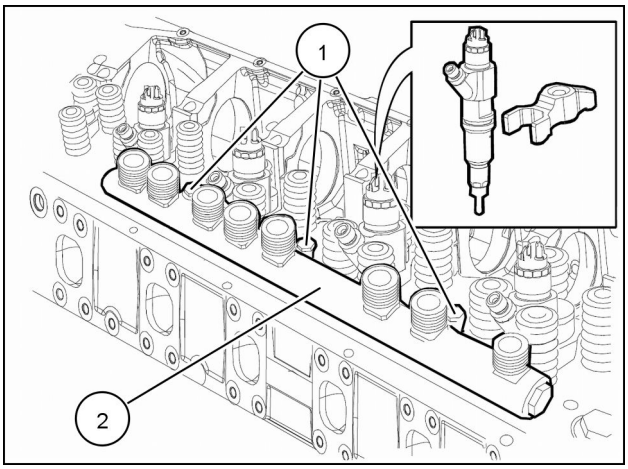
HPFUELPUMP3 3

(1) Fuel outlet fitting to the rail
(2) Delivery valve to the rail
(3) Pumping element
(4) Pump shaft
(5) Pumping element supply duct
(6) Pressure regulator supply duct
(7) Pressure regulator

Pumping element **(3)** is oriented to pump shaft **(4)** cam. During intake, the pumping element is supplied through supply duct **(5)**. The fuel amount to be sent to the pumping element is set by the pressure regulator **(7)**. The pressure regulator meters fuel flow to pumping element according to the Pulse Width Modulated (PWM) signal received from the EDC. During the pumping element compression stage, fuel reaches the pressure required to open the delivery valve to the common rail **(2)** and to feed it through the outlet **(1)**.

Common rail - Remove

1. Remove the retaining screws **(1)** and remove the rail **(2)**.

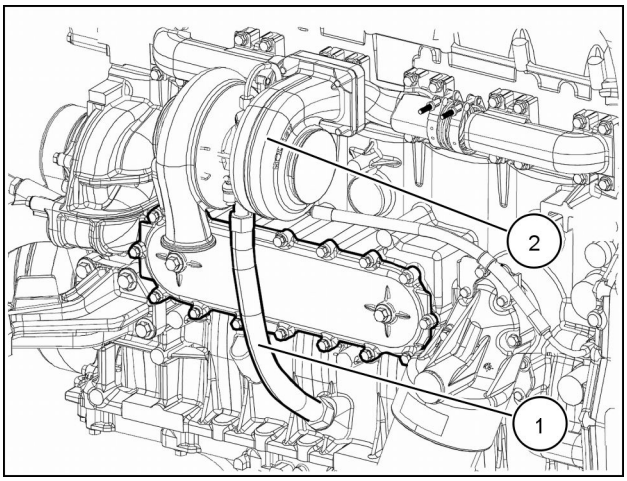


INJECTOR 1

Next operation:
Common rail - Install (10.218)

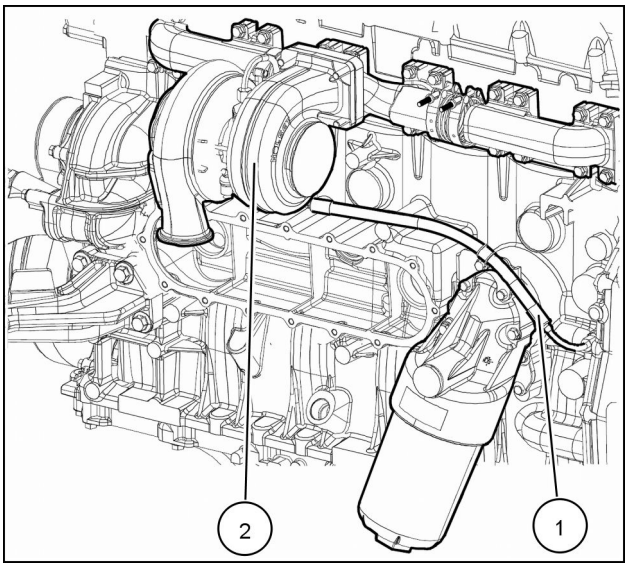
Turbocharger - Remove - Oil line

1. Remove the oil drain line **(1)** from the turbocharger **(2)**.



OILCOOLER5 1

2. Remove the oil supply line **(1)** from the turbocharger **(2)**.

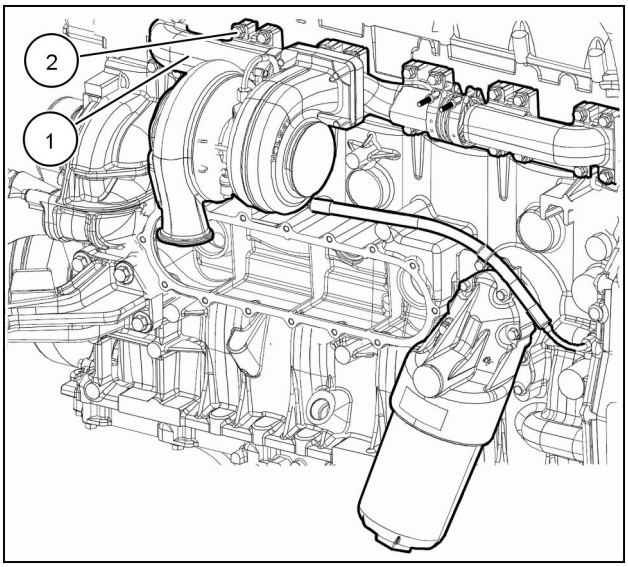


RIGHTSIDEVIEW 2

Exhaust manifold - Install

Prior operation:
Exhaust manifold - Remove (10.254)

1. Install the exhaust manifold **(1)** and tighten the screws **(2)** to the required torque.

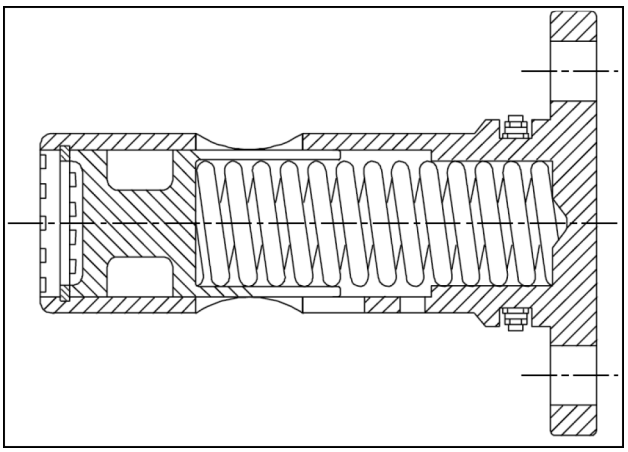


RIGHTSIDEVIEW 1

Next operation:
Turbocharger - Install (10.250)

Oil pressure valve - Overview

The oil pressure control valve is located on the left-hand side of the crankcase. Start of opening pressure is **5 bar** (**72.5 psi**).



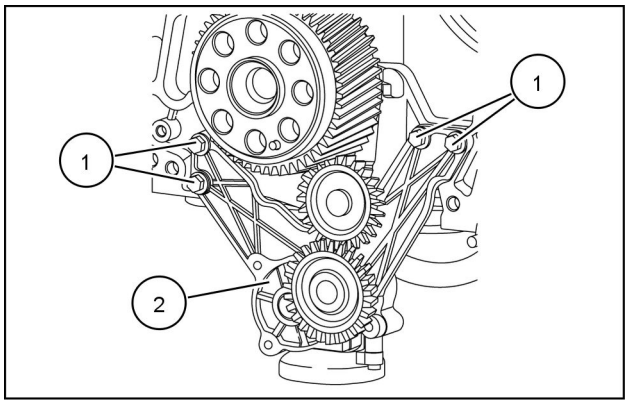
PSICONTROLF3C 1

Engine oil pump - Install - Recovery oil pump

1. Install the recovery oil pump **(2)** onto the engine block.

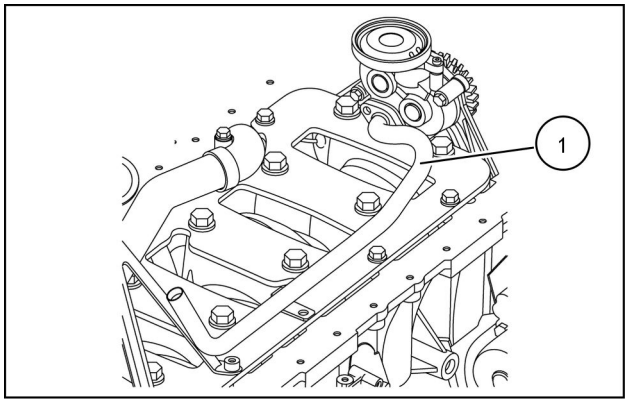
NOTICE: *Be sure the intermediate gear shaft is properly seated in the main bearing cab prior to torquing the bolts.*

2. Torque the bolts **(1)** to **25 N·m** (**18 lb ft**).



NHIL12ENG0030AA 1

3. Install the drain tube **(1)**.



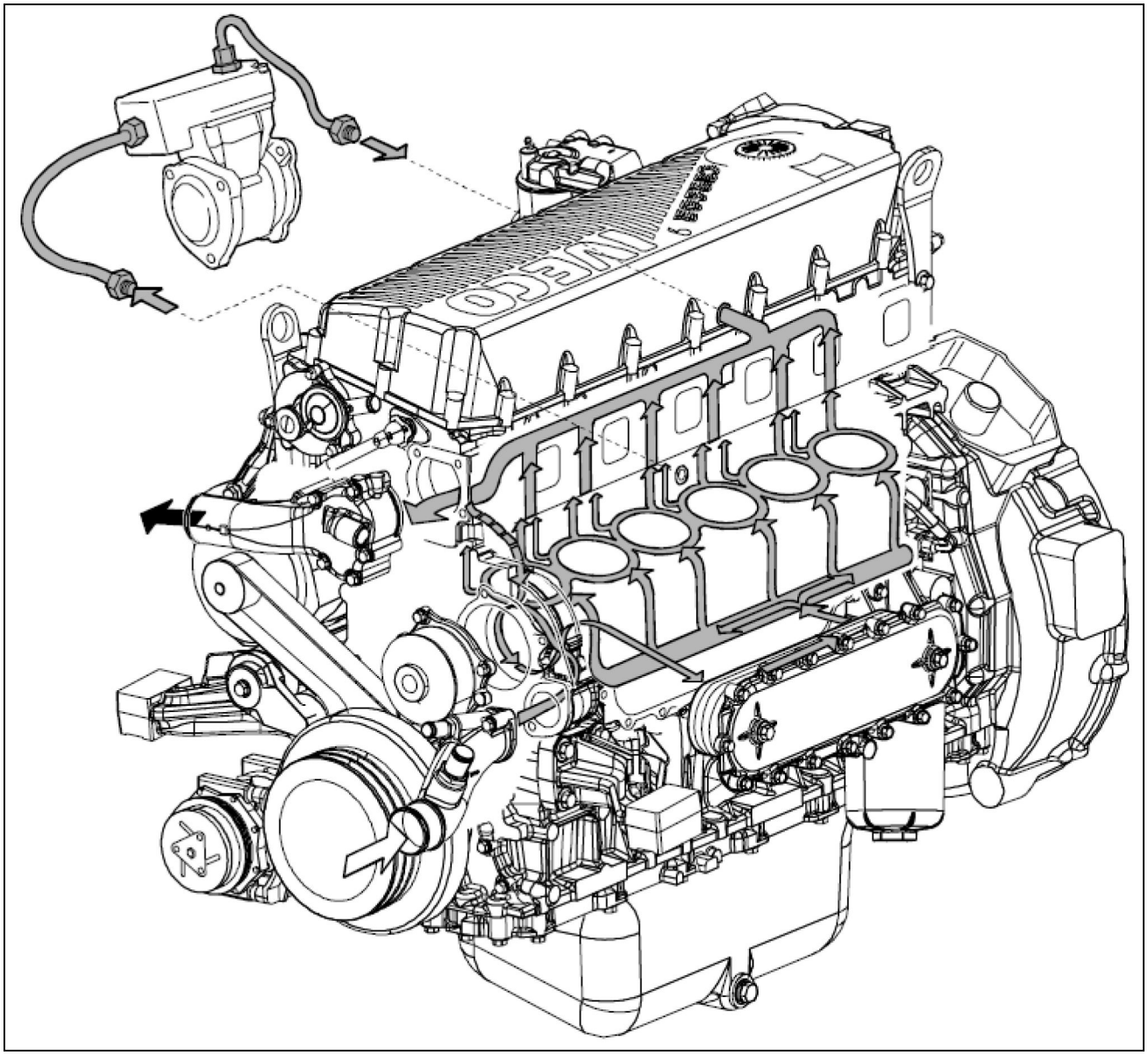
NHIL12ENG0031AA 2

Engine cooling system - Overview

The engine cooling system is a closed circuit, forced circulation system. It consists mainly of the following components.

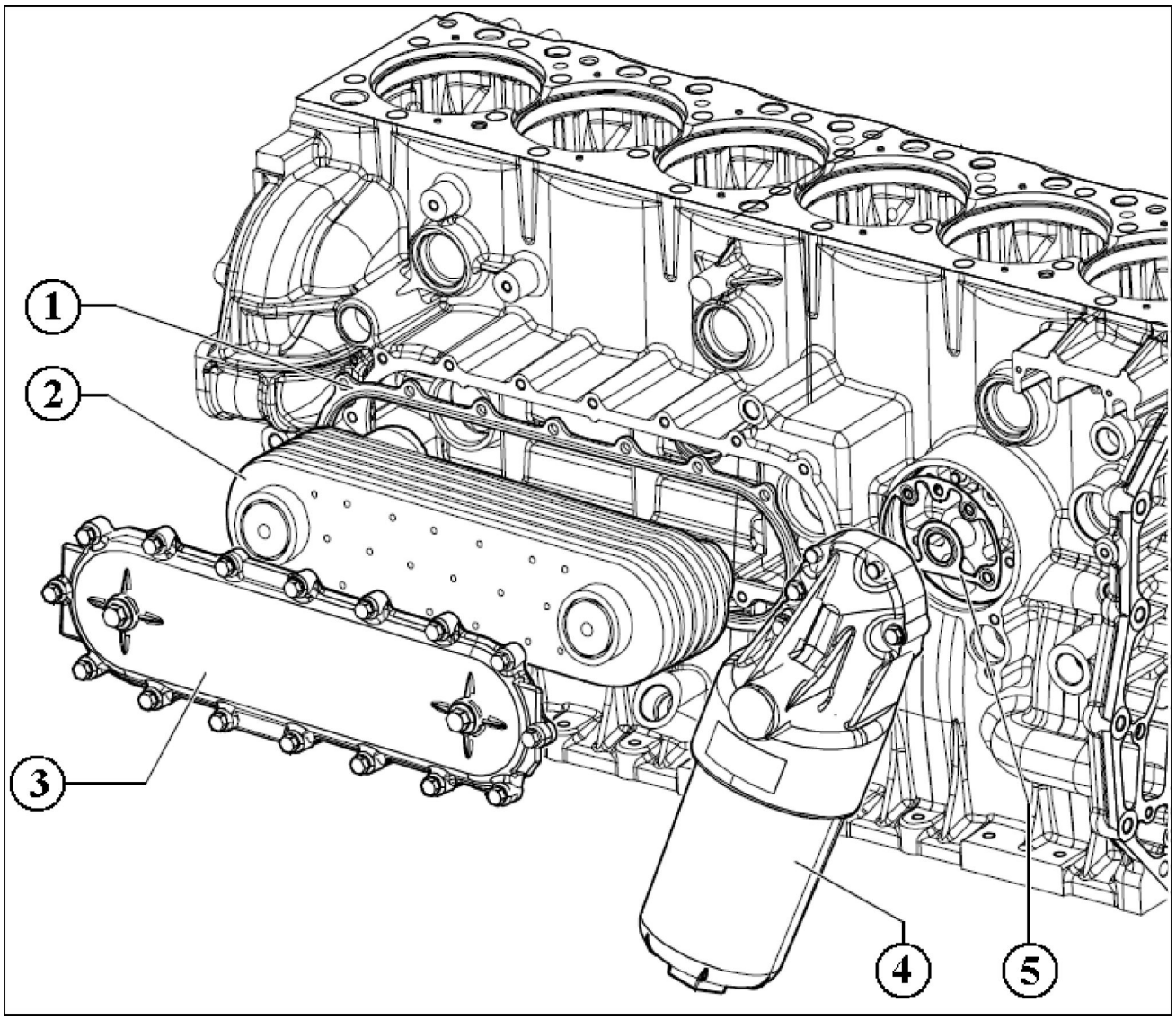
- Expansion tank (not supplied)
- A heat exchanger to cool down lubrication oil
- A water pump with centrifugal system incorporated in the cylinder block
- Fan (not supplied)
- A 2-way thermostat controlling the coolant circulation.

The water pump is driven by the crankshaft by a poli-V belt and sends coolant to the cylinder, especially to the cylinder head, (bugger quantity). When the coolant temperature reaches and overcomes the operating temperature, the thermostat is opened and form here the coolant flows into the radiator and is cooled down by the fan. The pressure inside the system, due to the temperature change, is adequately controlled through the expansion vessel.



COOLINGSYSTEM2 1

Engine oil cooler - Overview



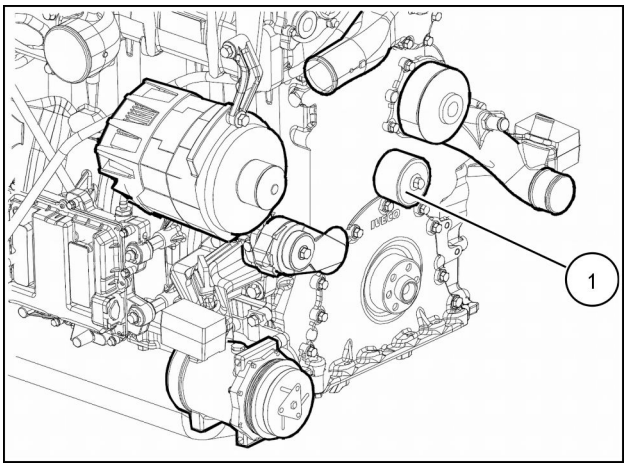
OILCOOLER 1

(1) Oil cooler gasket
(2) Internal heat exchanger element
(3) Cover
(4) Oil filter
(5) Oil filter seal

Idler pulley - Remove

Prior operation:
Belt - Remove (10.414)

1. Remove the idler pulley **(1)**.



FRONTVIEW6 1

Next operation:
Idler pulley - Install (10.414)

Index

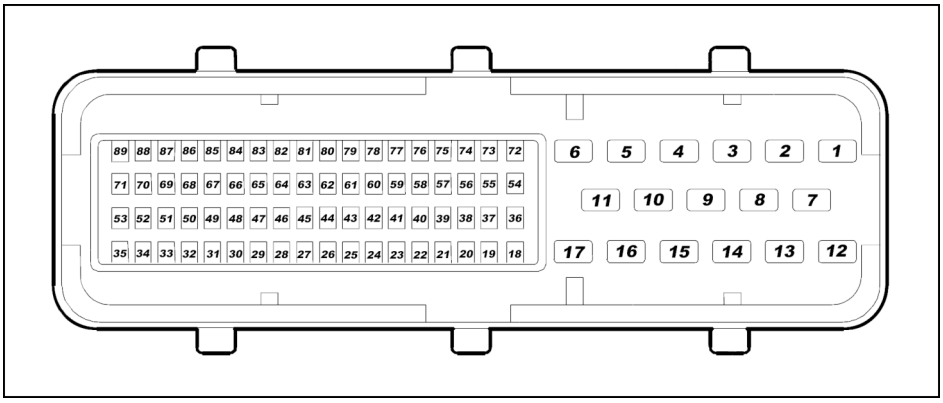
Electrical systems - 55

Fuel injection system - 010

Electrical systems - 55

Engine intake and exhaust system - 014

F2CFA614B*E019
F2CFA614C*E019



CONNECTORB 4

Chassis connector B

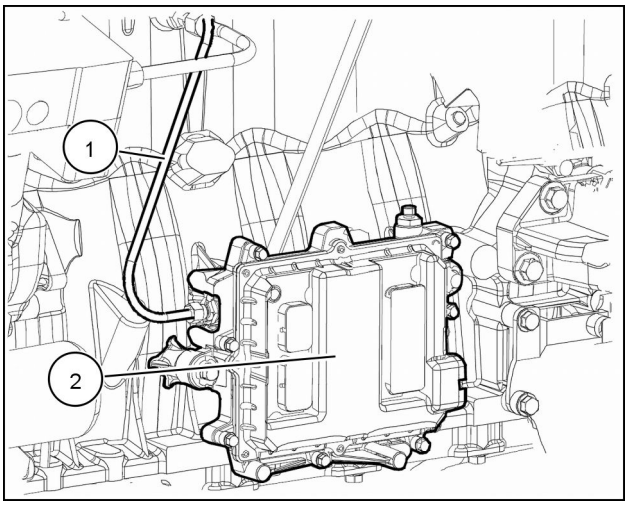
ECU pin out for connector B

ECU pin	Wire number	Function
(1)	-	Free
(2)	7151	+30 positive
(3)	7153	+30 positive
(4)	-	Free
(5)	0151	Ground
(6)	0151	Ground
(7)	-	Free
(8)	7151	+30 positive
(9)	7151	+30 positive
(10)	0151	Ground
(11)	0151	Ground
(12)	0094	Preheat enable relay - (ground)
(13)	-	Free
(14)	-	Free
(15)	-	Free
(16)	-	Free
(17)	-	Free
(18)	-	Free
(19)	-	Free
(20)	-	Free
(21)	-	Free
(22)	-	Free
(23)	-	Free
(24)	-	Free
(25)	-	Free
(26)	-	Free
(27)	-	Free
(28)	-	Free
(29)	5163	EDC system diagnosis inducing - (power supply)
(30)	-	Free
(31)	-	Free
(32)	-	Free
(33)	-	Free
(34)	Green	CAN - L line (ECB)
(35)	White	CAN - H line (ECB)
(36)	-	Free
(37)	-	Free
(38)	-	Free
(39)	-	Free

Engine control unit - Install

Prior operation:
Engine control unit - Remove (55.015)

1. Install the ECU **(2)** and cooling plate onto the engine block as one unit.
2. Install the fuel line **(1)** onto the cooling plate.



ELECCONTROL 1

Electrical systems - 55

Alternator - 301

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F2CFA614C*E019