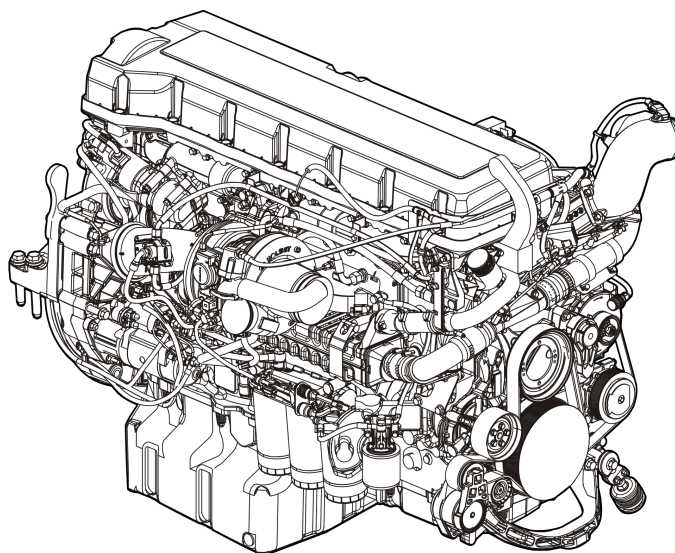


Specifications
D16F**Specifications**

W2005633

Contents:

- "General" page 2
- "Engine" page 2
- "Valve Mechanism" page 4
- "Engine Timing Gear" page 7
- "Crank Mechanism" page 9
- "Lubricating and Oil System" page 12
- "Fuel System" page 13
- "Inlet and Exhaust System" page 14
- "Cooling System" page 15
- "Engine Control System" page 17
- "Tightening Torques and Patterns" page 18

Note: Information is subject to change without notice.
Illustrations are used for reference only and can differ slightly from the actual vehicle being serviced. However, key components addressed in this information are represented as accurately as possible.

Specifications

General

Type Designation	Rated Power	@RPM	Maximum Torque	@RPM
D16F600	447 kW (600 HP)	1825	2779 Nm (2050 ft-lb)	1000–1500
D16F550	410 kW (550 HP)	1950	2508 Nm (1850 ft-lb)	1000–1500
D16F535	399 kW (535 HP)	1950	2508 Nm (1850 ft-lb)	1000–1500
D16F500	373 kW (500 HP)	1950	2508 Nm (1850 ft-lb)	1000–1400
D16F500	373 kW (500 HP)	1950	2237–2373 Nm (1650–1750 ft-lb)	1000–1400
D16F450	336 kW (450 hp)	1950	2237 Nm (1650 ft-lb)	1000–1400
D16F475	354 kW (475 hp)	1950	2237–2373 Nm (1650–1750 ft-lb)	1000–1600

Number of cylinders	6
Cylinder bore	144 mm (5.66 inches)
Stroke	165 mm (6.49 inches)
Swept volume	16.1 dm ³
Firing sequence	1-5-3-6-2-4
Compression ratio	16.0:1
Low idling	10 rps (600 rpm)
Fast idling	33 rps (2000 rpm)
Maximum full load revolutions	30 rps (1800 rpm)
Weight of engine with flywheel, flywheel housing without starter motor (dry)	1,270 kg (2800 lbs)
Total length	1450 mm (57.08 inches)
Total width	877 mm (34.52 inches)
Total height	1280.5 mm (50.41 inches)

Engine

Cylinder Block

Length	1156 mm (45.51 inches)
Height, upper block face — crankshaft center	453 mm (17.8 inches)
Height, lower block face — crankshaft center	120 mm (4.72 inches)

Cylinder Head

Type	6 cylinder
Length	1194 mm (47.00 inches)
Width	438 mm (17.24 inches)
Height	135 mm (5.31 inches)
Maximum unevenness (base plane)	0.02 mm on 100 mm measurement length

Cylinder Head Bolt

Quantity	38
Thread size	M18
Length	188 mm (7.40 inches)

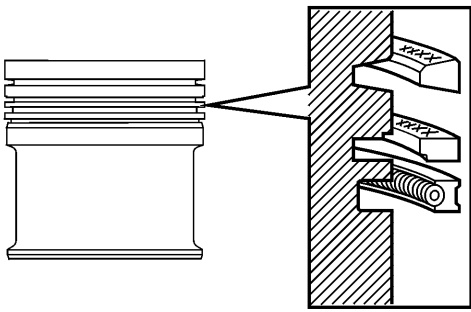
Cylinder Liner

Type	Wet, replaceable
Total height	288 mm (11.33 inches)
Height of sealing surface above block face	0.15–0.21 mm (0.0059–0.0082 inch)
Number of sealing rings	3
Cylinder liner protrusion	0.15–0.21 mm (0.0059–0.0082 inch)

Piston

Type	Pendulum rod
Number of ring grooves	3
Front marking	"FRONT" or arrow pointing forward
Wrist pin diameter	63 mm (2.48 inches)
Piston above deck	0.35 +0.1 to –0.3 mm (0.0137 +0.0039 to –0.0118 inch)

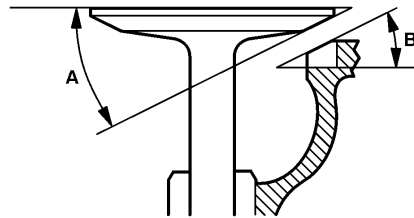
Piston Rings

 T2010058	
Compression Rings	
Quantity	2
Specifications	Wear Tolerance
Piston ring clearance in grooves:	
Upper compression ring (trapezoidal form)	0.1 mm (0.0039 inch)
Lower compression ring	0.07 mm (0.0027 inch)
Piston ring gap measured in ring opening:	
Upper compression ring	0.62 mm (0.0244 inch)
Lower compression ring	1.1 mm (0.0433 inch)
Oil Ring	
Quantity	1

Width including spring	4.55 mm (0.1791 inch)	
Specifications		Wear Tolerance
Piston ring clearance in grooves	0.04 mm (0.0015 inch)	0.1 mm (0.0039 inch)
Piston ring gap measured in ring opening	0.55 mm (0.0216 inch)	0.9 mm (0.0354 inch)

Valve Mechanism

Valves



T2019432

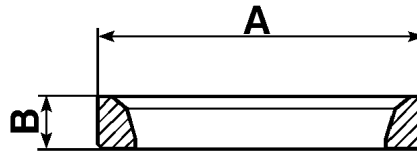
Valve disc, diameter:	
Inlet	49 mm (1.92 inches)
Exhaust	46 mm (1.81 inches)
Valve stem, diameter:	
Inlet/Exhaust	10 mm (0.39 inch)
Valve seat angle (A):	
Inlet	19.5 degrees
Exhaust	44.5 degrees
Seat angle in cylinder head (B):	
Inlet	20 degrees
Exhaust	45 degrees

Specifications	Wear Tolerance
Measurement between valve disc and cylinder head face:	
Inlet 1.15 ± 0.25 mm (0.0452 ± 0.0098 inch)	1.5 mm (0.0590 inch) maximum
Exhaust 1.65 ± 0.25 mm (0.0649 ± 0.0098 inch)	2.0 mm (0.0787 inch) maximum
Note: The valves also must be replaced when replacing the valve seats.	

Valve clearance cold engine, adjustment value:	
Inlet	0.3 mm (0.0118 inch)
Exhaust	0.6 mm (0.0236 inch)
Exhaust, VEB	4.2 mm (0.1654 inch)
Valve clearance cold engine, check value:	
Inlet	0.25-0.35 mm (0.0022-0.0139 inch)
Exhaust	0.55-0.65 mm (0.0221-0.0259 inch)
Exhaust, VEB	4.1-4.3 mm (0.1614-0.1693 inch)

Valve recession:	
Inlet	0.9-1.4 mm (0.0354-0.0550 inch)
Exhaust	1.3-1.8 mm (0.0512-0.0708 inch)

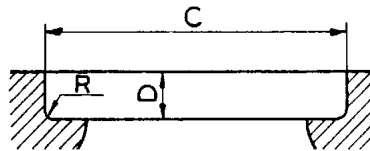
Valve Seats



T2014128

Standard		Oversize
Outer diameter (A)		
Inlet	52 mm (2.04 inches)	52.2 mm (2.055 inches)
Exhaust	49 mm (1.92 inches)	49.2 mm (1.937 inches)
Height (B)		
Inlet	7.75 mm (0.305 inch)	NA
Exhaust	7.9 mm (0.311 inch)	

Valve Seat Location



T2012872

Standard		Oversize
Diameter (C)		
Inlet	52.0 mm (2.04 inches)	52.2 mm (2.055 inches)
Exhaust	49.0 mm (1.92 inches)	49.2 mm (1.937 inches)
Depth (D)		
Inlet/Exhaust	11.7 mm (0.4606 inch)	NA
Bottom radius position (R)		
Inlet/Exhaust	0.8 mm (0.0314 inch) maximum	NA

Valve Guides

Length	
Inlet/Exhaust	83.5 mm (3.287 inches)
Inner diameter	
Inlet/Exhaust	10 mm (0.393 inch)
Height above cylinder head spring surface	
Inlet/Exhaust	24.4 ± 1.0 mm (0.9606 ± 0.0393 inch)

Clearance valve stem-to-guide:

Inlet	0.4 mm (0.0157 inch) maximum
Exhaust	0.4 mm (0.0157 inch) maximum

The measurements are calculated by the measurement method described in the Service Literature, see group 214.

Rocker Arms

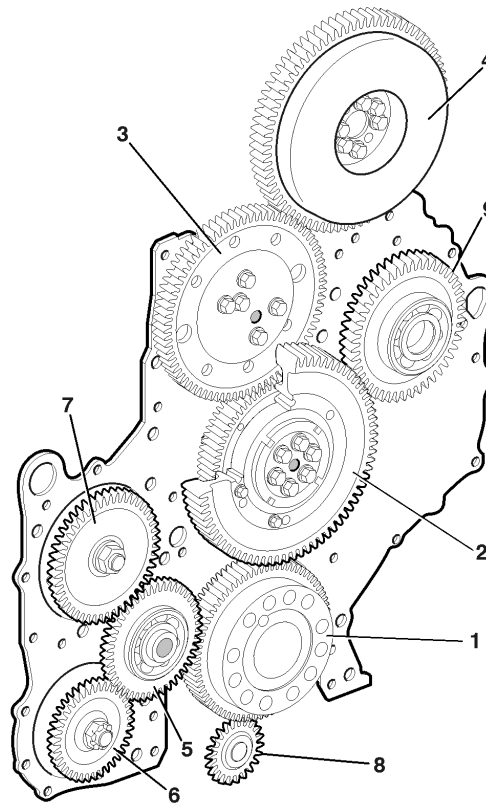
Bearing clearance	0.1 mm (0.0039 inch) maximum
Rocker arm roller clearance	0.1 mm (0.0039 inch) maximum

Valve Springs

Inlet	
Length unloaded	67.5 mm (2.65 inches)
522 N load	57.0 mm (2.24 inches)
1205 N load	43.3 mm (1.70 inches)
Rigid length	40.3 mm (1.58 inches) maximum
Exhaust	
Outer valve spring:	
Length unloaded	69.3 mm (2.72 inches)
930 N load	54.0 mm (2.12 inches)
1813 N load	39.5 mm (1.55 inches)
Rigid length	37.0 mm (1.45 inches) maximum
Inner valve spring:	
Length unloaded	67.0 mm (2.63 inches)
465 N load	51.0 mm (2.00 inches)
887 N load	36.5 mm (1.43 inches)
Rigid length	34.0 mm (1.33 inches) maximum

Engine Timing Gear

Timing Gears



T2019433

Number of teeth:

1. Drive gear, crankshaft	63
2. Idler gear	
Outer drive	84
Inner drive	56
3. Idler gear, adjustable	85
4. Drive gear, camshaft	84
5. Idler gear, power steering pump	29
6. Drive gear, power steering pump	36
7. Drive gear, air compressor	48
8. Drive gear, lubricating oil pump	37
9. Engine power take-off (if equipped)	55
Backlash	0.05–0.17 mm (0.0019–0.0066 inch)
Idler gear axle diameter	99.97–99.99 mm (3.9358–3.9366 inches)
Idler gear bushing diameter	100.036–100.05 mm (3.9384–3.9389 inches)
Diametrical clearance for idler gear	0.05 mm (0.0019 inch) maximum

Camshaft

Checking camshaft setting is done with a cold engine and valve clearance equals zero	
The inlet valves for cylinder number one at flywheel position 6 degrees after TDC should be open 1.0–1.8 mm (0.0394–0.0708 inch).	
When checking, the timing gears must be rotated in the correct direction (clockwise seen from the front) in order to take up all tooth gear lash.	
Drive type	Gear
Number of bearings	7
Note: These are check values only and are not for machining purposes.	
Diameter bearing journals, standard	69.97–70.00 mm (2.7547–2.7558 inches)
Undersize:	
0.25 mm	69.72–69.78 mm (2.7448–2.7472 inches)
0.50 mm	69.47–69.53 mm (2.7350–2.7373 inches)
0.75 mm	69.22–69.28 mm (2.7251–2.7275 inches)
Valve lift	
Inlet	13.7 mm (0.539 inch)
Exhaust (non-VCB)	14.5 mm (0.570 inch)
Exhaust (VCB)	15.0 mm (0.590 inch)
Permitted wear, entire camshaft profile	0.1 mm (0.0039 inch) maximum
Unit injector, stroke	18 mm (0.7086 inch)
End float	0.35 mm (0.0137 inch) maximum
Permitted out-of-round (with new bearing)	0.05 mm (0.001 inch) maximum
Bearing, permitted diametrical wear	0.05 mm (0.001 inch)

Camshaft Bearings

Camshaft bearing thickness, standard	1.92 mm (0.0755 inch)
Oversize:	
0.25 mm	2.05 mm (0.0807 inch)
0.50 mm	2.17 mm (0.0854 inch)
0.75 mm	2.30 mm (0.0905 inch)
Camshaft:	
Camshaft end clearance	0.04–0.24 mm (0.0015–0.0094 inch)
Adjustable idler gear clearance	0.05–0.15 mm (0.0020–0.0058 inch)
Geartrain backlash	0.05–0.17 mm (0.0020–0.0066 inch)

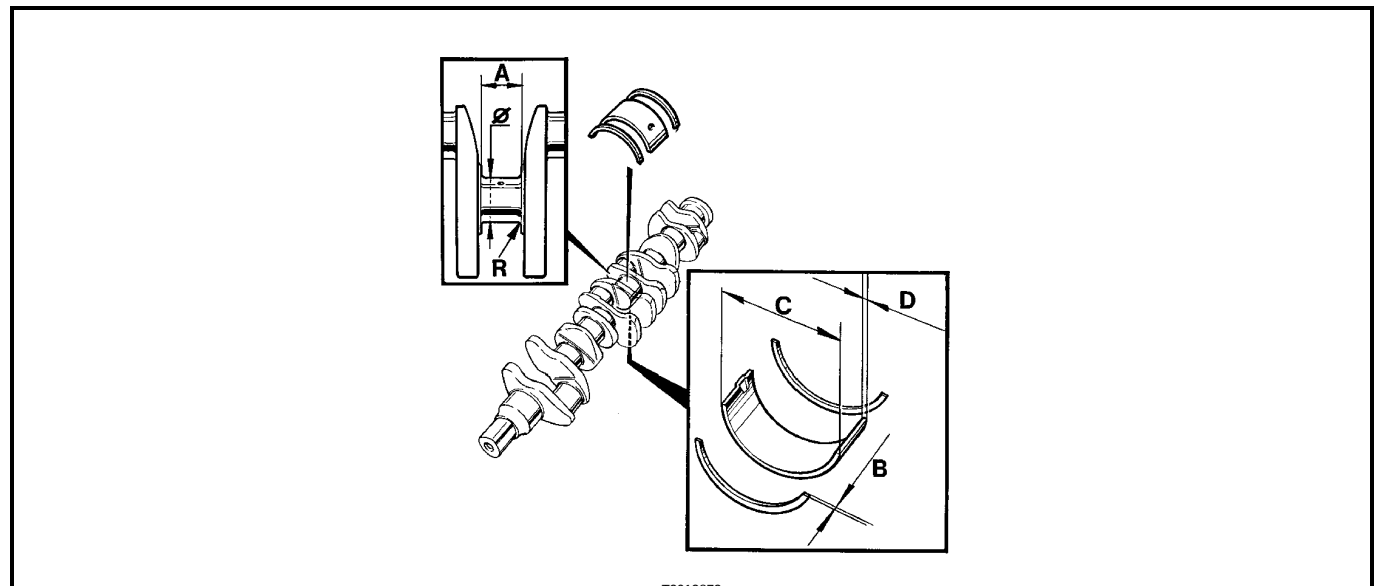
Crank Mechanism

Crankshaft

Length	1256 mm (49.44 inches)
Crankshaft axial clearance	0.15 mm (0.0059 inch)
Main bearing and camshaft bearing journal out-of-round	0.01 mm (0.00039 inch) maximum
Main bearing and camshaft bearing journal taper	0.02 (0.00078 inch) maximum
Middle bearing runout	0.15 mm (0.0059 inch)
Note: These measurements refer to lubricated components.	

Crankshaft:	
Crankshaft end clearance	0.04–0.24 mm (0.0015–0.0094 inch)
Crankshaft rear seal depth	7.5–8.5 mm (0.3130–0.3168 inch)

Main Bearing Journals



Diameter standard	118 mm (4.645 inches)
Undersize:	
0.25 mm (0.0098 inch)	117.75 mm (4.635 inches)
0.50 mm (0.0196 inch)	117.50 mm (4.625 inches)
0.75 mm (0.0295 inch)	117.25 mm (4.616 inches)
1.00 mm (0.0393 inch)	117.00 mm (4.606 inches)
1.25 mm (0.0492 inch)	116.75 mm (4.596 inches)
Surface finish, main bearing journal	Ra 0.25
Surface finish, radius	Ra 0.4
Width, axial bearing pin (A) standard	49.0 mm (1.929 inches)
Oversize:	
0.2 mm (0.0078 inch) (axial bearing 0.1)	49.2 mm (1.937 inches)
0.4 mm (0.0157 inch) (axial bearing 0.2)	49.4 mm (1.944 inches)
0.6 mm (0.0236 inch) (axial bearing 0.3)	49.6 mm (1.952 inches)
Recess radius (R)	4.5 mm (0.177 inch)

Note: These are check values only and are not for machining purposes.

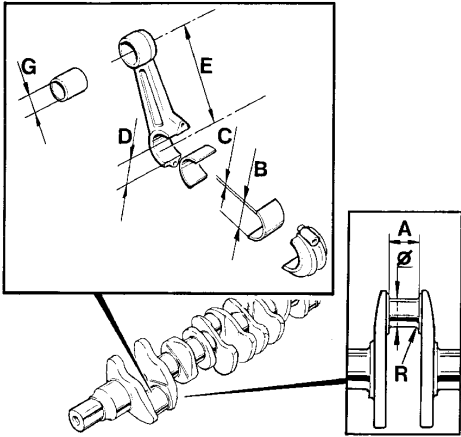
Thrust Washers (Axial Bearing)

Width (B) standard	3.18 mm (0.125 inch)
Oversize:	
0.1 mm (0.0039 inch)	3.28 mm (0.125 inch)
0.2 mm (0.0078 inch)	3.38 mm (0.125 inch)
0.3 mm (0.0118 inch)	3.48 mm (0.125 inch)
0.4 mm (0.0157 inch)	3.58 mm (0.125 inch)

Main Bearings

Outer diameter (C)	123.12 mm (4.847 inches)
Thickness (D) standard	2.51 mm (0.098 inch)
Oversize:	
0.25 mm (0.0098 inch)	2.64 mm (0.103 inch)
0.50 mm (0.0196 inch)	2.76 mm (0.108 inch)
0.75 mm (0.0295 inch)	2.89 mm (0.113 inch)
1.00 mm (0.0393 inch)	3.01 mm (0.118 inch)
1.25 mm (0.0492 inch)	3.14 mm (0.123 inch)
Diametrical clearance, main bearing	0.07–0.14 mm (0.002–0.005 inch)

Connecting Rod Bearing Journal



T2012874

Diameter	112 mm (4.4094 inches)
Undersize:	
0.25 mm (0.0098 inch)	111.75 mm (4.3995 inches)
0.50 mm (0.0196 inch)	111.50 mm (4.3897 inches)
0.75 mm (0.0295 inch)	111.25 mm (4.3799 inches)
1.00 mm (0.0393 inch)	111.00 mm (4.3700 inches)
1.25 mm (0.0492 inch)	110.75 mm (4.3602 inches)
Surface finish, connecting rod bearing journal	Ra 0.25
Surface finish, radius	Ra 0.4
Width (A)	60 mm (2.3621 inches)
Recess radius (R)	4.5 mm (0.1771 inch)

Note: These are check values only and are not for machining purposes.

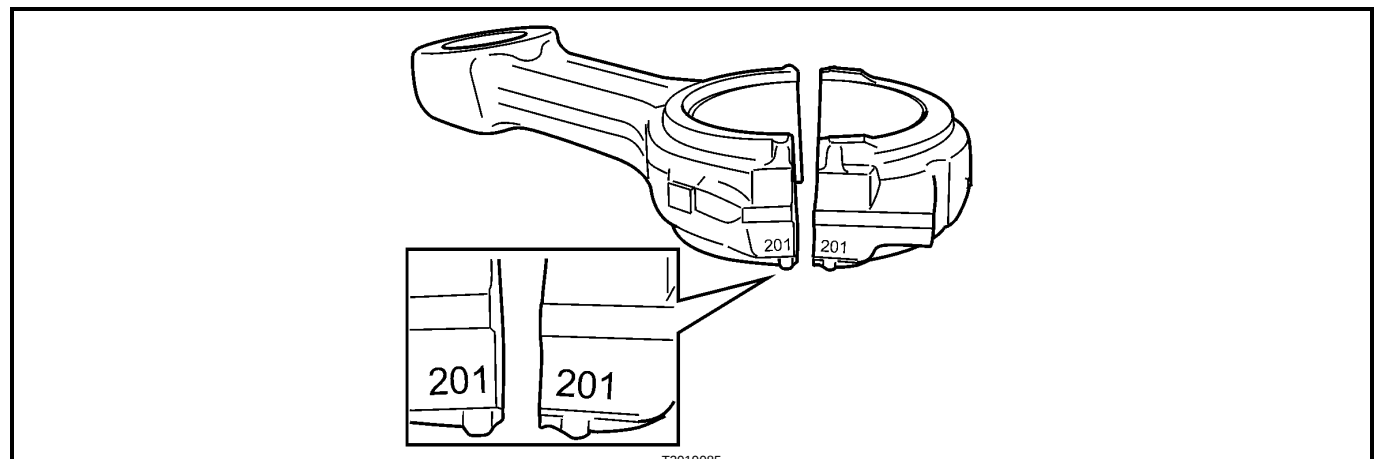
Connecting Rod Bearings

Outer diameter (B)	116.8 mm (4.5984 inches)
Thickness (C) standard	2.35 mm (0.0925 inch)
Oversize:	
0.25 mm (0.0098 inch)	2.48 mm (0.0976 inch)
0.50 mm (0.0196 inch)	2.60 mm (0.1023 inch)
0.75 mm (0.0295 inch)	2.73 mm (0.1074 inch)
1.00 mm (0.0393 inch)	2.85 mm (0.1122 inch)
1.25 mm (0.0492 inch)	2.98 mm (0.1173 inch)
Diameter, connecting rod big-end bearing bore (D)	116.8 mm (4.5984 inches)

Connecting Rod

Length, center-to-center (E)	280 mm (11.0235 inches)
Wrist pin bushing internal diameter (G)	63 mm (2.4803 inches)
End float, connecting rod-to-crankshaft	0.35 mm (0.0137 inch) maximum
Big-end bearing, diametrical play	0.10 mm (0.0039 inch) maximum
Straightness, maximum deviation per 100 mm (3.936 inches) of measured length	0.06 mm (0.0023 inch)
Torsion, maximum deviation per 100 mm (3.936 inches) of measured length	0.15 mm (0.0059 inch)

Note: The measurements refer to lubricated components.



The marking "FRONT" on the rod faces forward.

The connecting rod and cap are marked as a pair with a three-digit serial number.

Flywheel, Installed

Axial runout (manual gearbox), measurement radius 150 mm (5.9054 inches)	0.1 mm (0.0039 inch) maximum
Number of teeth, starter motor ring gear	153
Sensor groove, flywheel	54

Flywheel, Housing Installed

Axial runout of contact surface that mates with the clutch housing	0.1 mm (0.0039 inch) maximum
Radial runout of contact surface that mates with the clutch housing	0.05 mm (0.0019 inch) maximum

Lubricating and Oil System

Oil

Oil change volume, see Service Information, group 175.
--

Oil Pressure

Operating speed (over 1100 rpm)	300–650 kPa (43.51–94.27 psi)
Low idling	270 kPa (39.16 psi) minimum

Oil Pressure, Rocker Arm Shaft

VCB not activated (less than 900 rpm)	90–110 kPa (13.05–15.95 psi)
VCB activated (greater than 950 rpm)	200 kPa (29.0 psi) minimum

Oil Temperature

Warm running engine with coolant temperature between 75–95°C (167–203°F)	85–105°C (185–221°F) up to 120°C (248°F) at high engine loads
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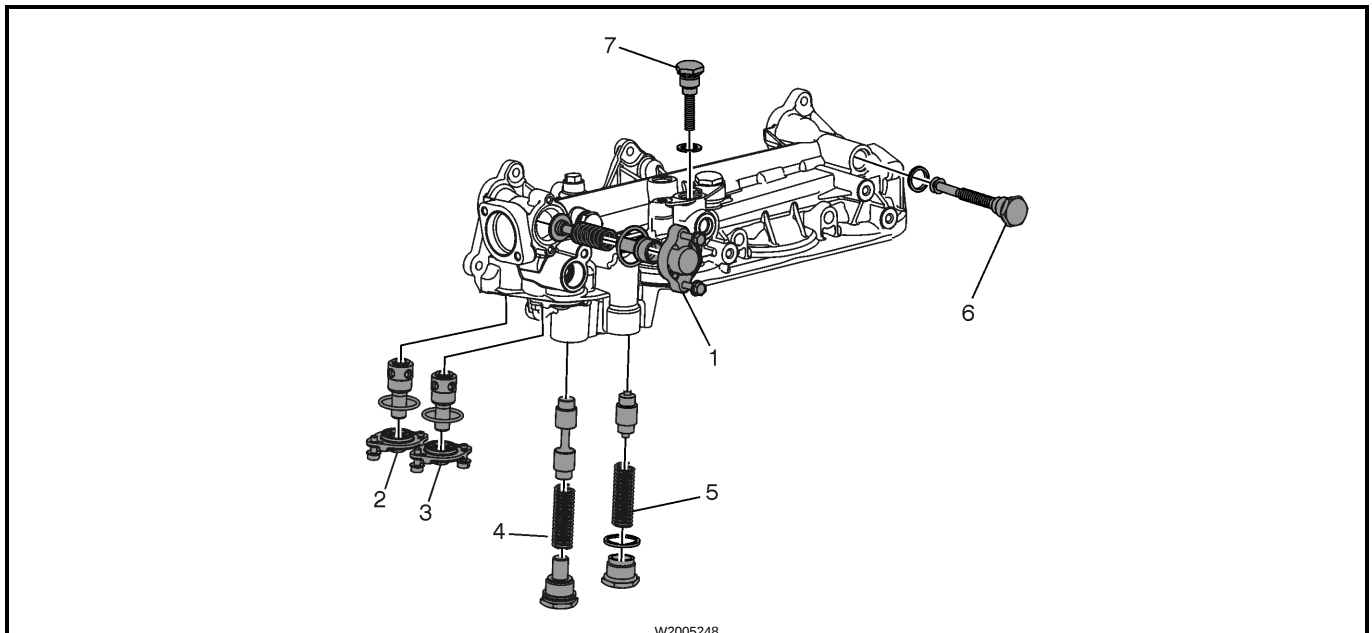
Lubricating Oil Pump

Drive type	Gear
Number of teeth, drive gear	37
Backlash	0.05–0.40 mm (0.0019–0.0157 inch)

Oil Filter

Full flow filter	2
Bypass filter	1

Oil Valves



1. Control valve, oil cooler (bypass)		
Spring, free length	69 mm (2.7165 inches)	
Spring, under load of 13–15 N (1.3–1.5 kgf)	40 mm (1.5747 inches)	
2. Safety valve, lubrication oil pump		
Marking		Violet
3. Reduction valve		
Marking		Blue
4. Control valve, piston cooling (balancing)		
Spring, free length	122 mm (4.8031 inches)	
Spring, under load of 95 N (9.7 kgf)	63 mm (2.4803 inches)	
5. Opening valve, piston cooling		
Spring, free length	122 mm (4.8031 inches)	
Spring, under load of 95 N (9.5 kgf)	63 mm (2.4803 inches)	
6. Overflow valve, full flow filter		
Spring, free length	69 mm (2.7165 inches)	
Spring, under load of 13–15 N (1.3–1.5 kgf)	40 mm (1.5747 inches)	
7. Overflow valve, bypass filter		
Spring, free length	69 mm (2.7165 inches)	
Spring, under load of 13–15 N (1.3–1.5 kgf)	40 mm (1.5747 inches)	

Fuel System

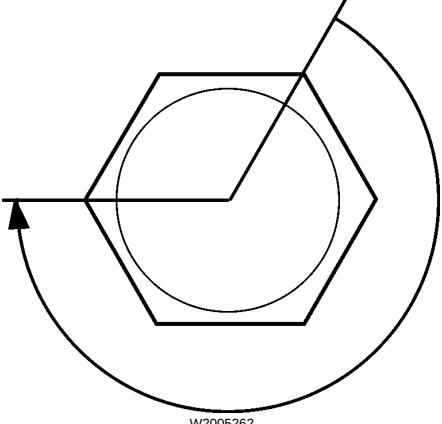
Fuel Pump

Fuel pump pressure:		
600 rpm	100 kPa (14.5 psi) minimum	
1200 rpm	300 kPa (43.5 psi) minimum	
Full load	300 kPa (43.5 psi) minimum	

Overflow Valve

Opening pressure	300–550 kPa (43.5–80 psi)
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Unit Injectors



W2005262

Unit injector preload:
Tighten the adjustment screw to zero clearance and then turn an additional 4 flats (0.75 ± 0.1 mm) clockwise.

Inlet and Exhaust System

Variable Geometry Turbocharger

Turbine rotor shaft axial clearance	0.051–0.052 mm (0.002–0.006 inch) maximum
Turbine rotor shaft radial clearance	0.381–0.533 mm (0.015–0.021 inch) maximum

Intake Manifold Air Temperature Sensor

Cold engine, engine off	Ambient temperature
Engine warm and running with coolant temperature at 75–95°C (167–203°F)	40°C (104°F) above ambient temperature

Heat Retention Function

Heat retention activated:
Coolant temperature (engine load greater than 40%)Less than 70–80°C (158–176°F)
Note: This value can be programmed from 70°C (158°F) to 80°C (176°F). Parameter AZN, MID 128.

Heat retention deactivation:
Coolant temperature (engine load greater than 40%)Greater than 70–80°C (158–176°F)
Note: This value can be programmed from 70°C (158°F) to 80°C (176°F). Parameter AZN, MID 128.

Engine Brake

3-way switch can be at OFF, at 50% or at 100% braking power.
--

VCB

Activated:	
Engine speed	Greater than 950 rpm
Vehicle speed	Greater than 5 km/h (3.1 mph)
Engine oil temperature	Greater than 55°C (131°F)
Intake manifold pressure	Less than 173.7 kPa (25.19 psi)
Deactivated:	
Engine speed	Less than 900 rpm
Vehicle speed	Less than 5 km/h (3.1 mph)
Engine oil temperature	Less than 55°C (131°F)
Intake manifold pressure	Greater than 198.7 kPa (28.82 psi)

VCB

Braking Force (%)	VCB (On/Off)
50%	On
100%	On
Cruise mode	Auto on/off

VCB Cruise Mode

Activated:	
Engine speed: The value must be increased by 300 rpm for the first five activations. Applies at engine oil temperatures between 55–70°C.	
Engine speed	Greater than 1000 rpm
Vehicle speed	Greater than 5 km/h (3.2 mph)
Engine oil temperature	Greater than 55°C (131°F)
Intake manifold pressure	Less than 173.7 kPa (25.19 psi)
Deactivated:	
Engine speed	Less than 900 rpm
Vehicle speed	Less than 5 km/h (3.2 mph)
Engine oil temperature	Less than 55°C (131°F)
Intake manifold pressure	Greater than 198.7 kPa (28.82 psi)

Exhaust Back Pressure

Exhaust back pressure	15 kPa (2.175 psi) maximum
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Cooling System

General

Pressure valve opens at	90 kPa (13 psi)
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Thermostat

Quantity	1
Opening temperature	82°C (179°F)

Coolant

For cooling system volumes and coolant requirements, refer to Service Information, group 18: "Coolant requirements, Volvo Engines."

Fan On/Off

Activated System	Conditions	Fan Engagement
Coolant temperature	100°C (212°F)	Activated
Coolant temperature	96°C (205°F)	Deactivated
Intake manifold temperature	85°C (185°F)	Activated
Intake manifold temperature	80°C (176°F)	Deactivated
Engine ECU temperature	Greater than 100°C (212°F)	Activated
Engine ECU temperature	Less than 95°C (203°F)	Deactivated
AC system	Greater than 20 bar (290 psi)	Activated

E-Viscous Fan

Activated System	Conditions	Fan Engagement
Coolant temperature	96°C (205°F)	Variable fan speed activation
Engine ECU temperature	Greater than 100°C (212°F) Less than 95°C (203°F)	1200 rpm Deactivated
Intake manifold air temperature	Greater than 70°C (150°F) Engine torque greater than half of maximum Nm	1200 rpm 7 second delay after engine brake activated
AC system, AC compressor clutch activated	Engine speed greater than 1500 rpm Ambient temperature greater than 40°C (104°F) Vehicle speed less than 45 km/h (28 mph)	1200 rpm
AC system, AC compressor clutch activated	Engine speed greater than 1200 rpm Ambient temperature greater than 30°C (86°F) Vehicle speed less than 45 km/h (28 mph)	1000 rpm
AC system, AC compressor clutch activated	Ambient temperature greater than 35°C (95°F) Vehicle speed less than 10 km/h (6 mph)	1200 rpm
AC system, AC compressor clutch activated	Ambient temperature greater than 20°C (68°F) Vehicle speed less than 20 km/h (12 mph)	600 rpm
AC system, AC compressor clutch activated	Refrigerant pressure greater than 20 bar (300 psi)	Full engagement

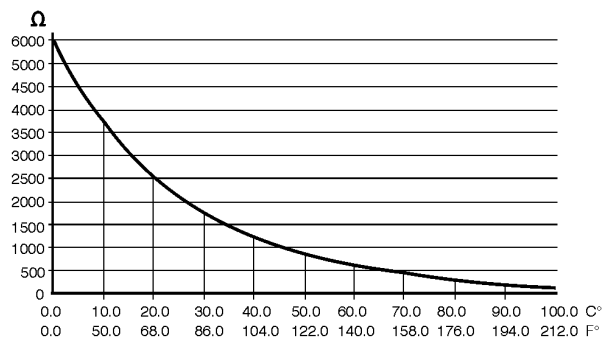
Engine Control System

Engine ECU

Number of pins	2 x 62
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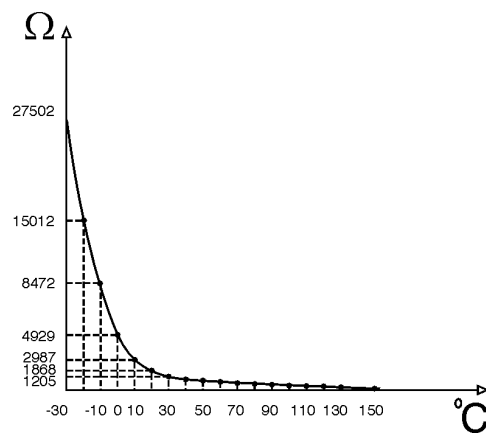
Sensors

Coolant Temperature Sensor



W2005110

Engine Oil Temperature Sensor



T2019011

Intake Manifold Pressure Sensor

Check values	1.05–1.30 volts at 100 kPa (14.5 psi)
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Camshaft Sensor

Distance to camshaft	0.3–1.0 mm (0.118–0.0393 inch)
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Flywheel Sensor

Distance to flywheel	0.3–1.0 mm (0.118–0.0393 inch)
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Crankcase Pressure Sensor

Sensor alarm limit	Greater than 5 kPa (0.7 psi or 1.5 inches of mercury)
Crankcase pressure, normal value	Less than 1.0 kPa (0.145 psi)

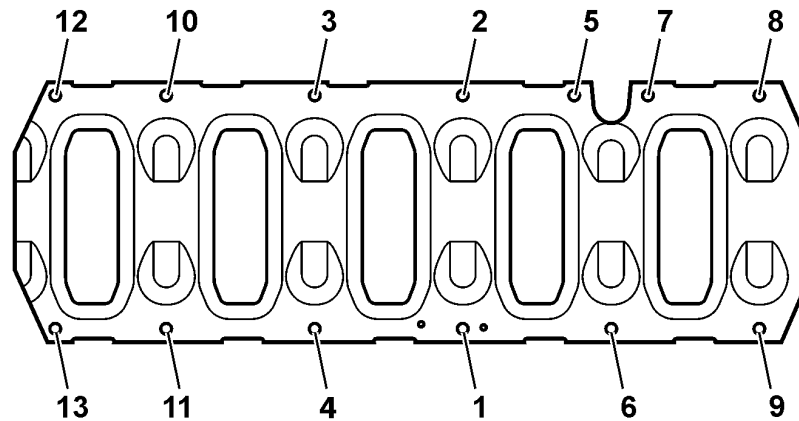
Tightening Torques and Patterns

Tightening Torques Group 20

General Tightening Torques	
M6 standard bolt 8.8	10 ± 1.5 Nm (7 ± 1 ft-lb)
M8 standard bolt 8.8	24 ± 4 Nm (18 ± 3 ft-lb)
M10 standard bolt 8.8	48 ± 8 Nm (35 ± 6 ft-lb)
M12 standard bolt 8.8	85 ± 15 Nm (63 ± 11 ft-lb)
M14 standard bolt 8.8	140 ± 25 Nm (103 ± 18 ft-lb)
M16 standard bolt 8.8	190 ± 35 Nm (140 ± 26 ft-lb)
Only torque-tightened bolts can be reused.	
Torque and angle tightened (yield limit) bolts:	
8.8	One time use only, cannot be reused
10.9	Reusable
12.9	Reusable
Note: Check bolts before reusing. Bolts showing damage, such as cut marks on the underside, should be discarded.	

Tightening Torques Group 21

Front engine mounting, cylinder block	275 ± 45 Nm (203 ± 33 ft-lb)
Front engine mounting, cushion to bracket	140 ± 25 Nm (103 ± 18 ft-lb)
Front engine mounting, cushion to crossmember	85 ± 15 Nm (63 ± 11 ft-lb)
Rear engine mounting, flywheel housing	300 ± 45 Nm (221 ± 33 ft-lb)
Rear engine mounting, rear engine pad (M20 bolts)	540 ± 90 Nm (398 ± 66 ft-lb)
Rear engine pad, frame	200 ± 30 Nm (148 ± 22 lb-ft)
Main bearing cap:	
Step 1	300 ± 20 Nm (221 ± 15 ft-lb)
Step 2	120 ± 5 degrees angle of tightening
Connecting rod cap:	
Step 1	20 ± 3 Nm (15 ± 2 ft-lb)
Step 2	60 ± 3 Nm (44 ± 2 ft-lb)
Step 3	90 ± 5 degrees angle of tightening
Note: Use cross pattern.	
Piston cooling nozzle	24 ± 3 Nm (18 ± 2 ft-lb)

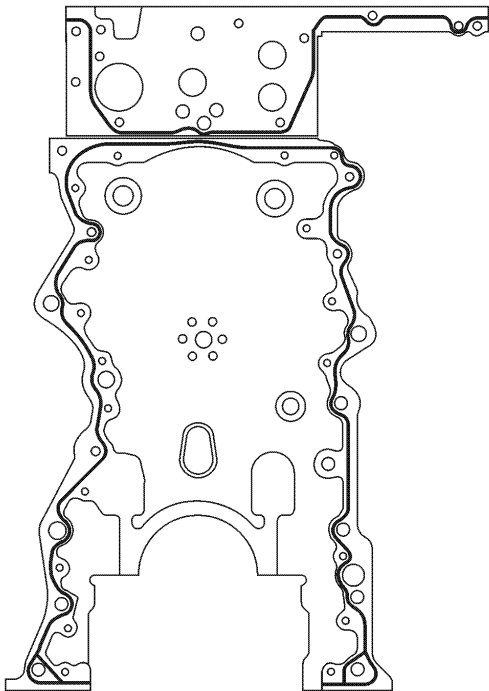


T2020549

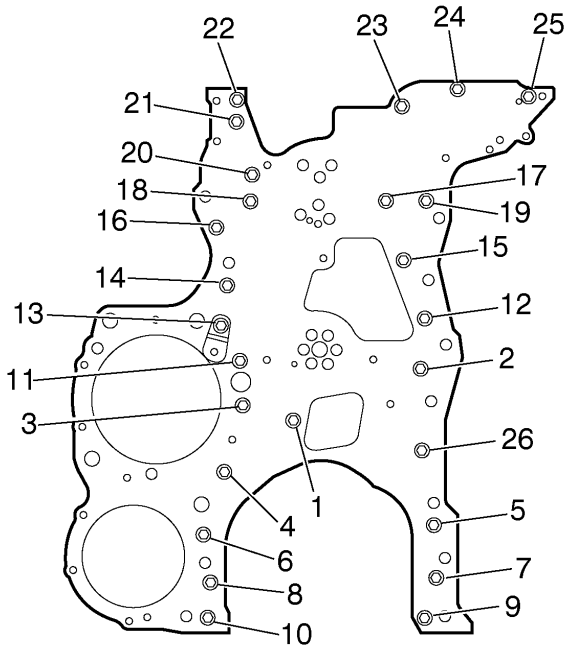
Engine stiffening frame:

Step 1		65 ± 5 Nm (48 ± 4 ft-lb)
Step 2		90 ± 5 degrees angle of tightening

Note: Tighten the bolts in the order shown.



T2021199

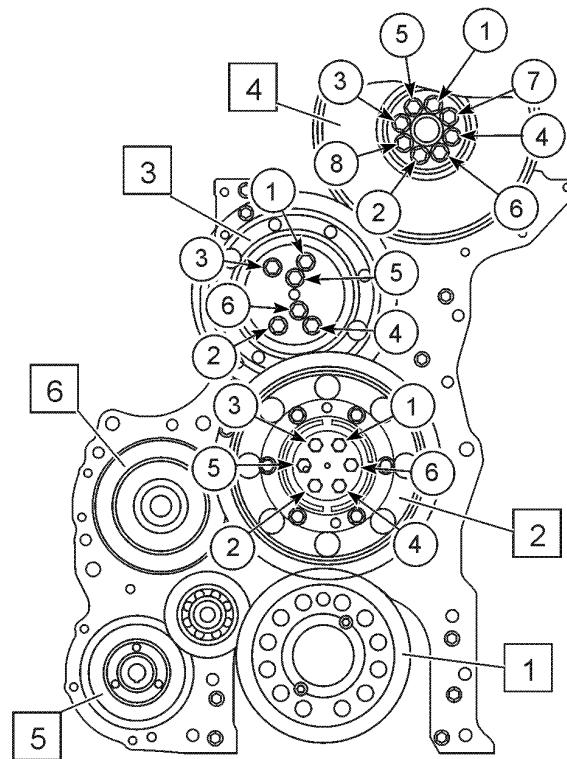


W2005981

Timing gear plate:		
Step 1. Tighten bolts 1–25		28 ± 4 Nm (21 ± 3 ft-lb)
Step 2. Tighten bolt 26		60 ± 8 Nm (44 ± 6 ft-lb)
Step 3. Tighten bolts 1–26		28 ± 4 Nm (21 ± 3 ft-lb)

Note: Apply sealant and tighten bolts in the order shown.

Note: Do not reuse fasteners, one time use only.



T2021214

1. Drive gear, crankshaft See Flywheel

2. Idler gear, outer gear:

Step 1 25 ± 3 Nm (18 ± 2 ft-lb)

Step 2 110 ± 5 degrees angle of tightening

Note: Tighten bolts in the order shown.

3. Idler gear, adjustable:

Step 1 35 ± 4 Nm (26 ± 3 ft-lb)

Step 2 120 ± 5 degrees angle of tightening

Note: Tighten bolts in the order shown.

4. Drive gear, camshaft:

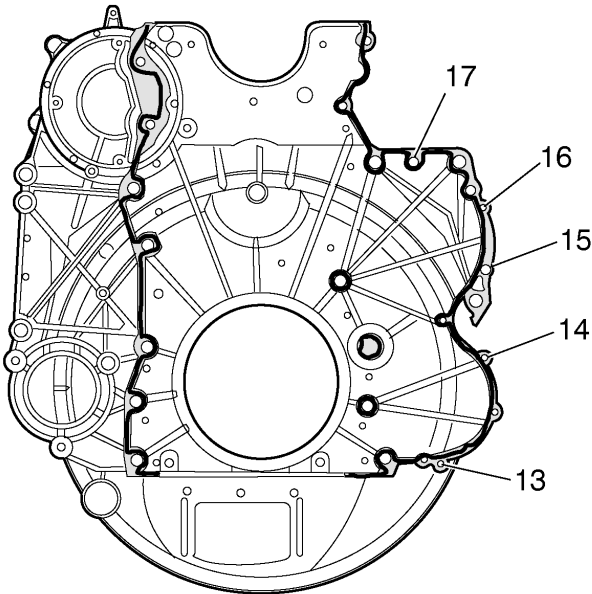
Step 1 45 ± 5 Nm (33 ± 4 ft-lb)

Step 2 90 ± 5 degrees angle of tightening

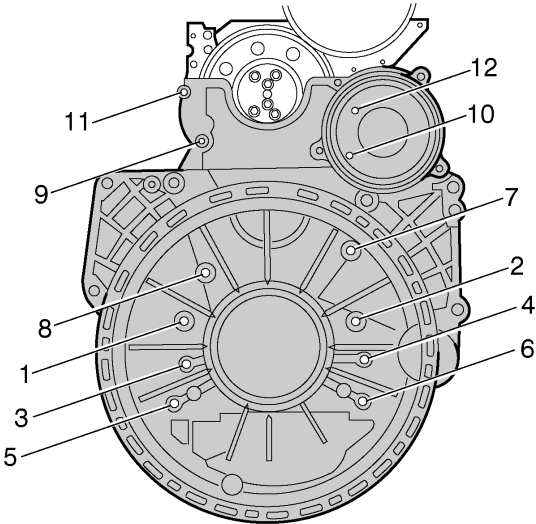
Note: Tighten bolts in the order shown.

5. Drive gear, power steering pump 100 ± 10 Nm (74 ± 7 ft-lb)

6. Drive gear, air compressor 200 ± 50 Nm (148 ± 37 ft-lb)



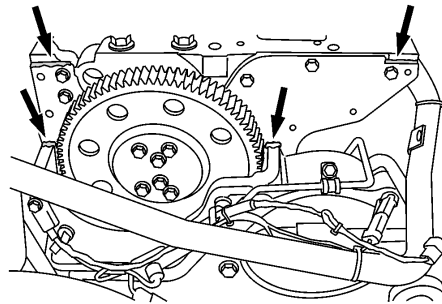
W2005982



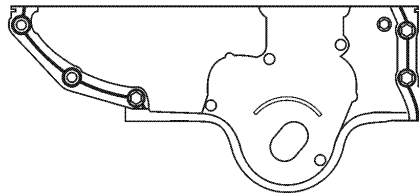
W2005983

Flywheel housing:	
Tighten M14 bolts	160 ± 20 Nm (118 ± 15 ft-lb)
Tighten M10 bolts	48 ± 8 Nm (36 ± 6 ft-lb)
Tighten M8 bolts	24 ± 4 Nm (18 ± 3 ft-lb)

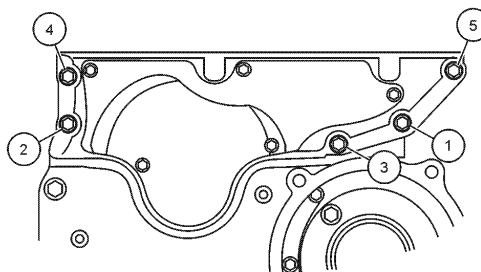
Note: Apply sealant as shown in the upper illustration. Tighten bolts in the order shown in the illustrations.



W2005102



T2021198

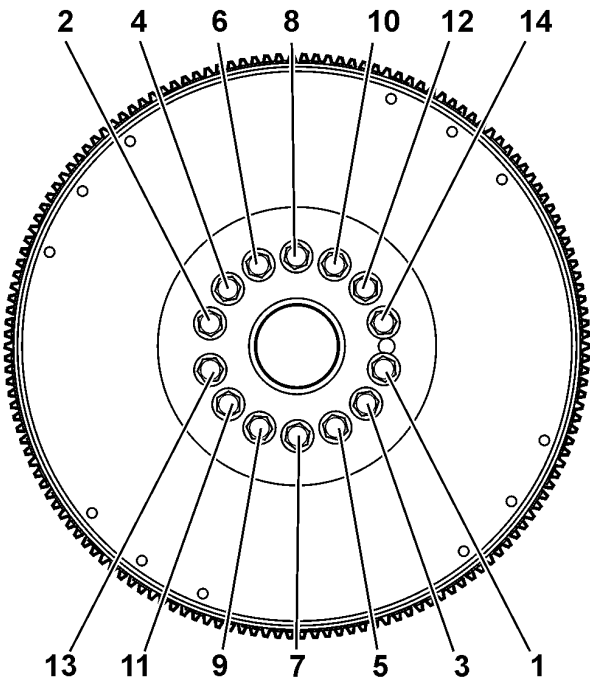


T2021197

Timing gear cover 24 ± 4 Nm (18 ± 3 ft-lb)

Note: Apply sealant and tighten bolts as shown.

Note: Alignment tool required.

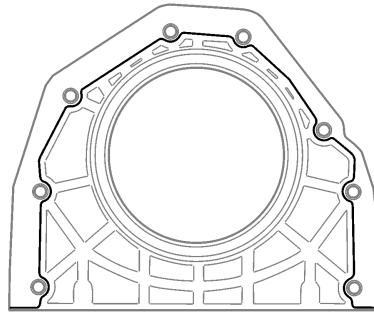


T2020550

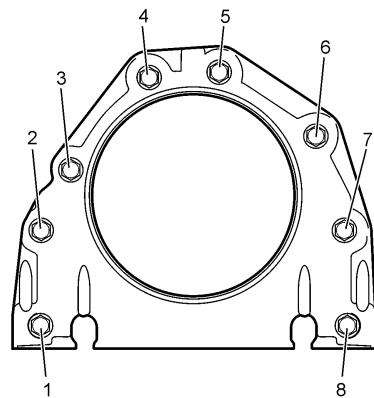
- Flywheel:
- | | | |
|--------|-------|--------------------------------------|
| Step 1 | | 60 ± 5 Nm (44 ± 4 ft-lb) |
| Step 2 | | 120 ± 10 degrees angle of tightening |

Note: Make sure the flange is clean and dry before installation.

Note: Tighten the bolts in the order shown.



T2019437

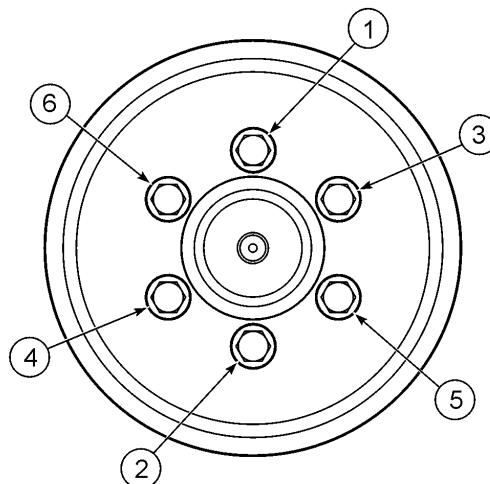


T2020547

Cover, front crankshaft seal:

- | | |
|--|-----------------------------------|
| Step 1. Tighten all bolts | Hand tight |
| Step 2. Tighten bolts (2) and (7) | 24 ± 4 Nm (18 ± 3 ft-lb) |
| Step 3. Tighten all bolts in the order shown | 24 ± 4 Nm (18 ± 3 ft-lb) |

Note: Apply sealant as shown in the upper illustration.

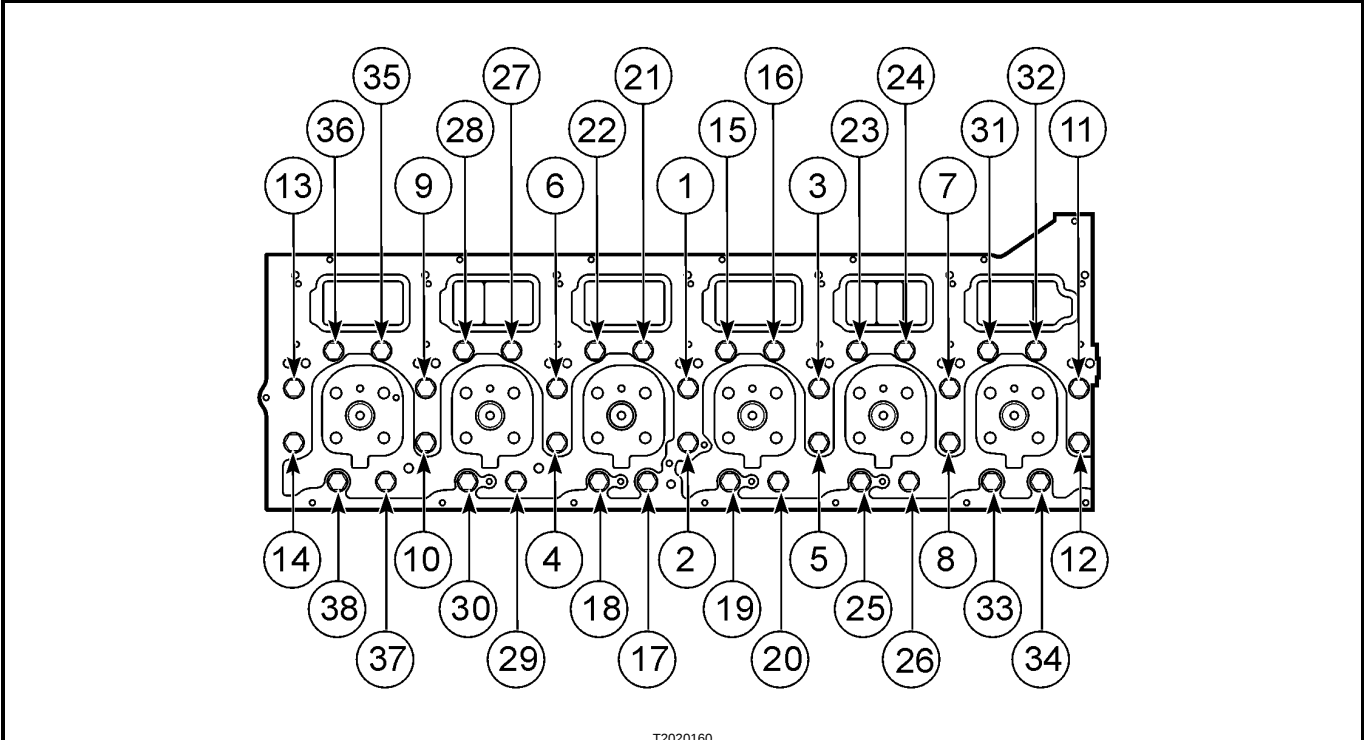


T2019436

Vibration damper:

- | | |
|--------|------------------------------------|
| Step 1 | 35 ± 5 Nm (26 ± 4 ft-lb) |
| Step 2 | 90 ± 10 Nm (66 ± 7 ft-lb) |

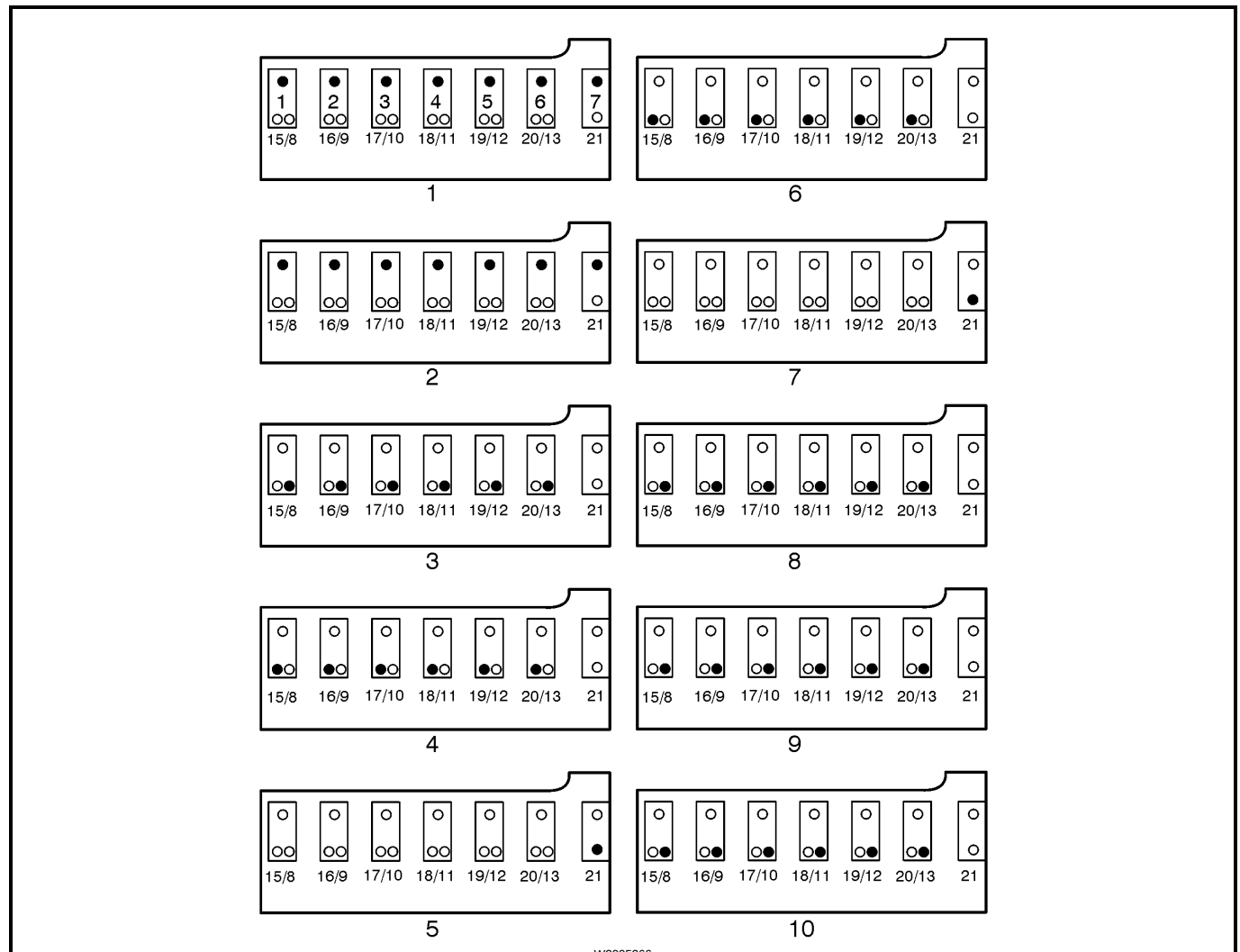
Note: The vibration damper 8.8 bolts are one-time use only and should not be reused. Tighten the bolts 1, 2, 3, 4, 5, 6, 1 in the order shown.



T2020160

- Cylinder head:
- | | |
|--------|---|
| Step 1 | 100 ± 10 Nm (74 ± 7 ft-lb) |
| Step 2 | 90 ± 5 degrees angle of tightening |
| Step 3 | Additional 90 ± 5 degrees angle of tightening |

Note: The cylinder head must be installed according to instructions, see 21124-1 Cylinder Head Installation, group 21.



W2005266

Note: Tighten the bolts in the numbered steps to make sure that the rocker arm shaft is installed without bending or distortion.

Step 1. Tighten bolts 1–7	15 ± 3 Nm (11 ± 2 ft-lb)
Step 2. Angle tighten bolts 1–7	90 ± 5 degrees
Step 3. Tighten bolts 11, 10, 12, 9, 13, 8 in gradual steps to contact, then	100 ± 10 Nm (74 ± 7 ft-lb)
Step 4. Tighten bolts 15–20	50 ± 5 Nm (37 ± 4 ft-lb)
Step 5. Tighten bolt 21	60 ± 5 Nm (44 ± 4 ft-lb)
Step 6. Angle tighten bolts 15–20	120 ± 5 degrees
Step 7. Angle tighten bolt 21	100 ± 5 degrees
Step 8. Loosen bolts 8–13	
Step 9. Tighten bolts 8–13	50 ± 5 Nm (37 ± 4 ft-lb)
Step 10. Angle tighten bolts 8–13	120 ± 5 degrees

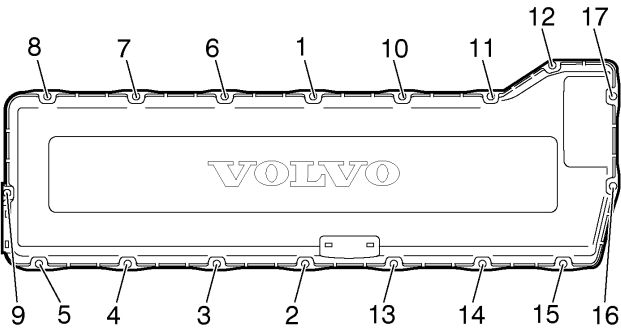
Locknut, inlet valve adjustment screw	38 ± 4 Nm (28 ± 3 ft-lb)
or, angle tighten after contact	60 ± 5 degrees

Locknut, exhaust valve bridge adjustment screw	38 ± 4 Nm (28 ± 3 ft-lb)
or, angle tighten after contact	60 ± 5 degrees

Locknut, exhaust valve, VEB, adjustment screw	38 ± 4 Nm (28 ± 3 ft-lb)
or, angle tighten after contact	45 +0/-10 degrees

Locknut, VEB rocker arm	52 ± 4 Nm (38 ± 3 ft-lb)
or, angle tighten after contact	45 ± 5 degrees

VEB control valve or rocker shaft oil supply (non-VEB)	20 ± 3 Nm (15 ± 2 ft-lb)
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W2005984

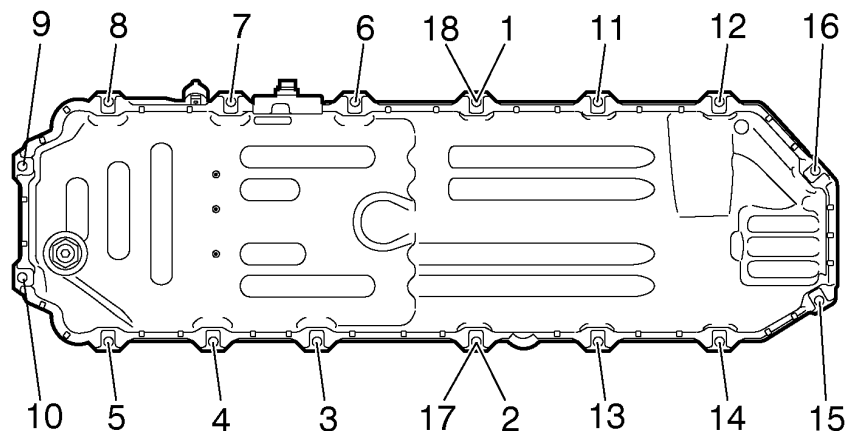
Valve cover 24 ± 3 Nm (18 ± 2 ft-lb)

Note: Tighten bolts in the order shown.

Note: If the valve cover is replaced, a new Engine Certification Label must be printed using VCADS Pro “Engine Label Print” group 2841 and affixed to the cover.

Tightening Torques Group 22

Oil pump:	
Step 1	35 ± 3 Nm (26 ± 2 ft-lb)
Step 2	90 ± 5 degrees angle of tightening
Oil pressure pipe (coupling nut)	201 ± 20 Nm (148 ± 15 ft-lb)
Oil suction pipe	24 ± 3 Nm (18 ± 2 ft-lb)
Oil plug, longitudinal oil channel	136 ± 13 Nm (100 ± 10 ft-lb)
Oil cooler retaining bolts	27 ± 4 Nm (20 ± 3 ft-lb)
Step 1	10 ± 4 Nm (7.5 ± 3 ft-lb)
Step 2	27 ± 4 Nm (20 ± 3 ft-lb)
Note: Tighten diagonally in order 1, 2, 3, 4, 1.	
Oil cooler cover	24 ± 3 Nm (18 ± 2 ft-lb)
Oil filter housing	24 ± 3 Nm (18 ± 2 ft-lb)
Oil filter	22 ± 3 Nm (16 ± 2 ft-lb)
Oil pressure sensor	30 ± 5 Nm (22 ± 4 ft-lb)



W2005085

Oil pan 24 ± 4 Nm (18 ± 3 ft-lb)

Note: Tighten bolts in the order shown.

Drain plug, oil pan 60 ± 10 Nm (44 ± 7 ft-lb)

Note: The hex-head plug must not be installed with a copper washer. Use only the steel washer.

Tightening Torques Group 23

Retainer, unit injector (*new copper sleeve*) The tightening procedure applies only when a new copper sleeve is installed, where the first tightening "seats" the copper sleeve.

First tightening:

Step 1 20 ± 5 Nm (15 ± 4 ft-lb)

Step 2 180 ± 5 degrees angle of tightening

Loosen the retainer screw before the second tightening.

Second tightening:

Step 1 20 ± 5 Nm (15 ± 4 ft-lb)

Step 2 60 ± 5 degrees angle of tightening

Retainer, unit injector (*reused copper sleeve*)

Step 1 20 ± 5 Nm (15 ± 4 ft-lb)

Step 2 60 ± 5 degrees angle of tightening

Locknut for adjusting bolt, unit injector 52 ± 4 Nm (38 ± 3 ft-lb)
 or, angle tighten after contact 45 ± 5 degrees

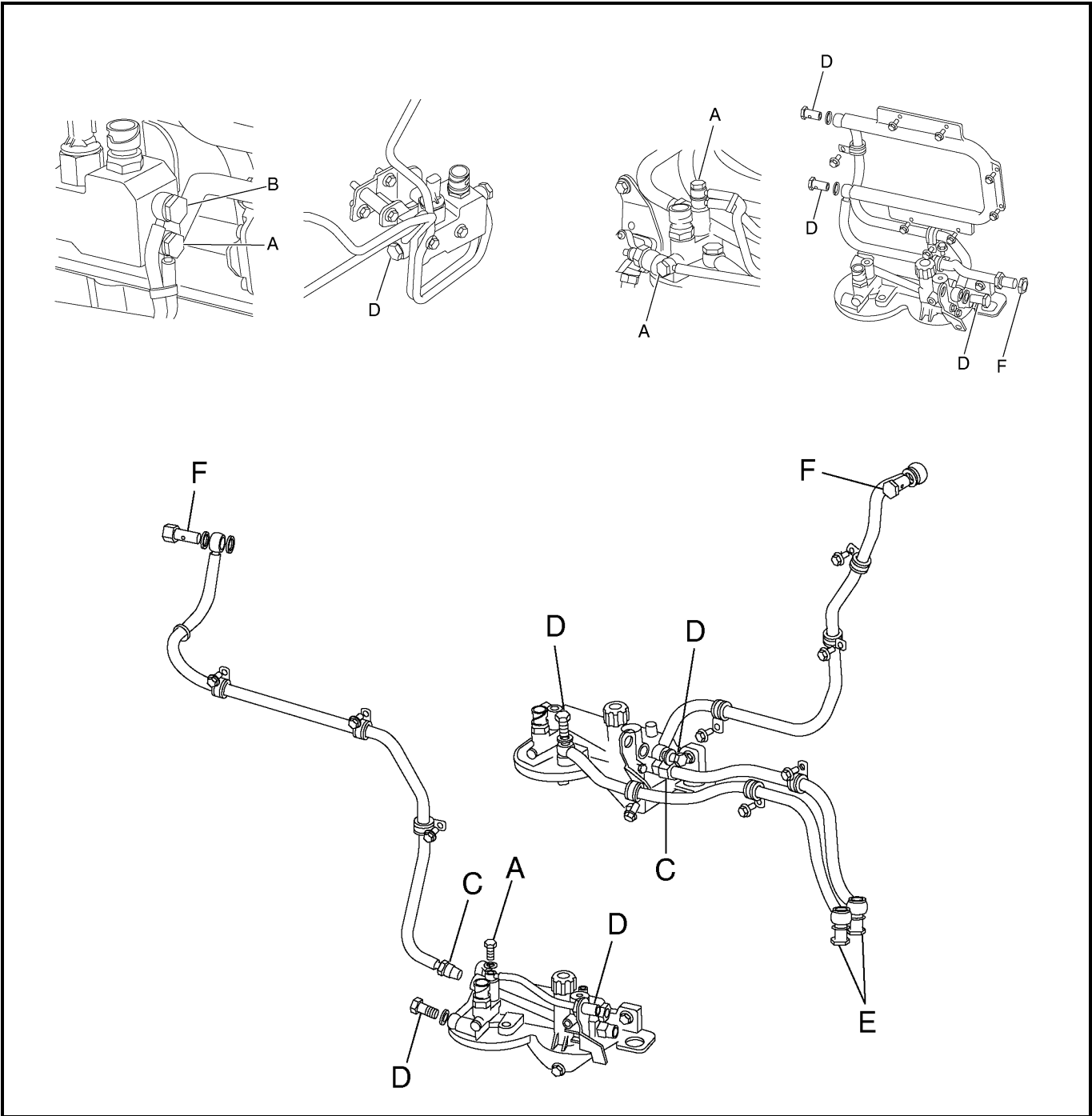
Fuel gallery plug 30 ± 3 Nm (22 ± 2 ft-lb)

Tandem pump mounting bolts 24 ± 4 Nm (18 ± 3 ft-lb)

Fuel pump (mounted on power steering pump) $8 +2/-0$ Nm ($6 +1/-0$ ft-lb)

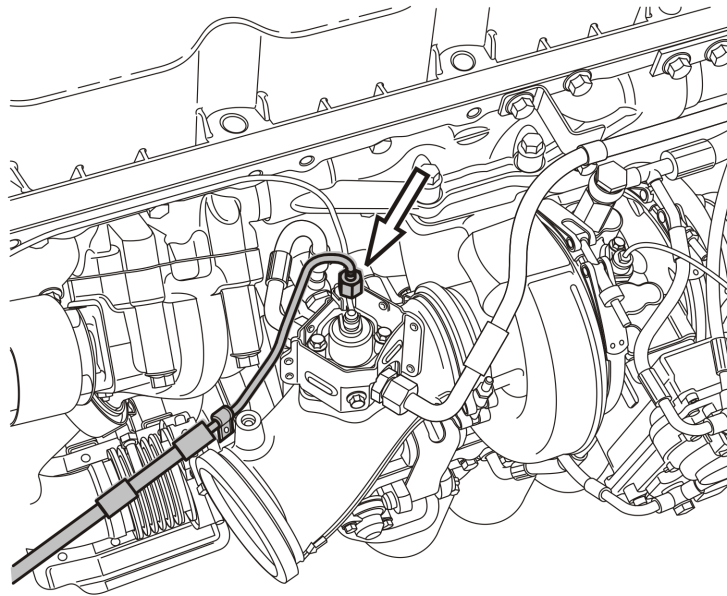
Fuel filter housing 24 ± 4 Nm (18 ± 3 ft-lb)

Fuel filter (pre, main) 18 ± 3 Nm (13 ± 2 ft-lb)



Fuel line fittings:

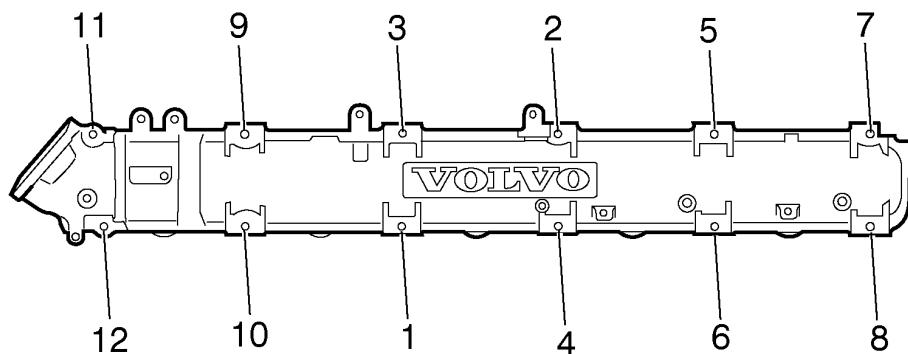
A	18 ± 3 Nm (13 ± 2 ft-lb)
B	28 ± 4 Nm (20.5 ± 3 ft-lb)
C	30 ± 4 Nm (22 ± 3 ft-lb)
D	35 ± 5 Nm (26 ± 4 ft-lb)
E	40 ± 5 Nm (29.5 ± 4 ft-lb)
F	48 ± 5 Nm (35 ± 4 ft-lb)



W2005826

Hydrocarbon injector, fuel supply line $15 \pm 0.5 \text{ Nm}$ ($135 \pm 5 \text{ in-lb}$)

Tightening Torques Group 25



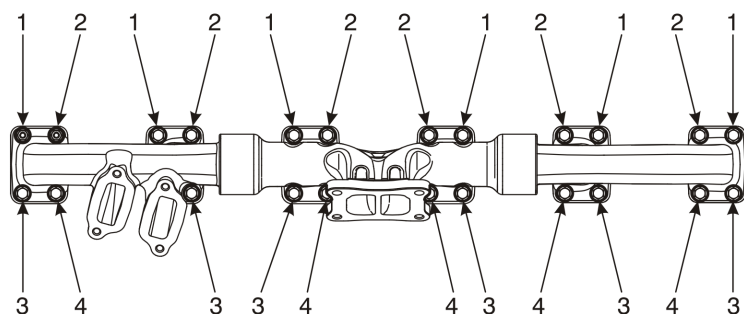
W2005980

Intake manifold (10.9 grade fasteners used):

Step 1 $10 \pm 4 \text{ Nm}$ ($7.5 \pm 3 \text{ ft-lb}$)
Step 2 $26 \pm 2 \text{ Nm}$ ($19 \pm 1.5 \text{ ft-lb}$)

Note: Install the intake manifold with a new seal ring.

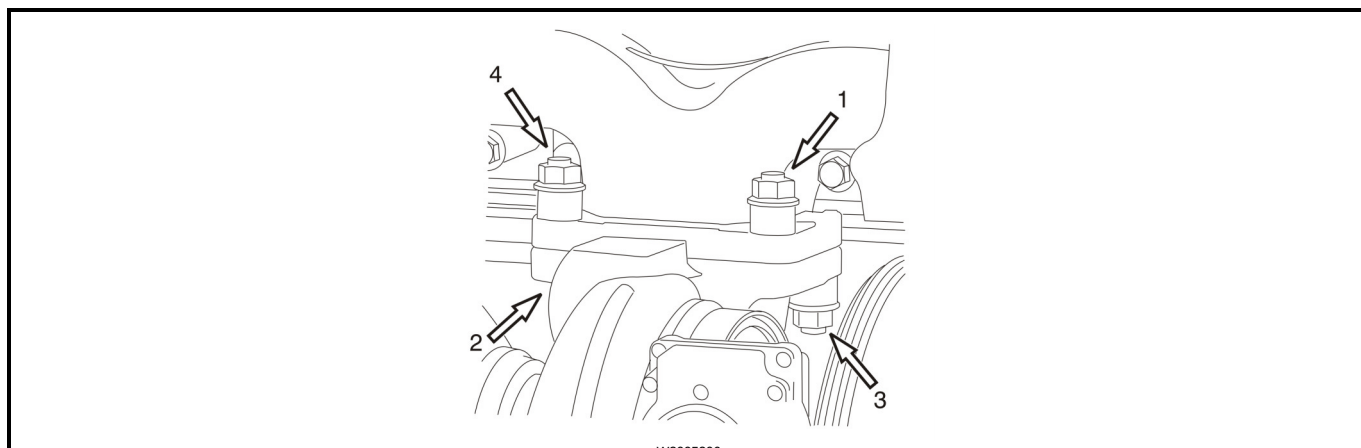
Intake manifold plug	20 ± 3 Nm (15 ± 2 ft-lb)
Housing, preheater:	
Step 1	10 ± 2 Nm (8 ± 1 ft-lb)
Step 2	24 ± 3 Nm (18 ± 2 ft-lb)
Note: Tighten using a cross pattern.	
Preheater terminal connections	10 ± 1.5 Nm (8 ± 1 ft-lb)



W2005710

Exhaust manifold:	
Step 1. Tighten bolts (1) to contact	10 Nm (7 ft-lb) maximum
Step 2. Tighten bolts (2) to contact	10 Nm (7 ft-lb) maximum
Step 3. Tighten bolts (3)	52 ± 4 Nm (38 ± 3 ft-lb)
Step 4. Tighten bolts (2)	52 ± 4 Nm (38 ± 3 ft-lb)
Step 5. Tighten bolts (4)	52 ± 4 Nm (38 ± 3 ft-lb)
Step 6. Tighten bolts (1)	52 ± 4 Nm (38 ± 3 ft-lb)

EGR cooler:	
Lower mounting studs, nuts	24 ± 4 Nm (18.5 ± 3 ft-lb)
Upper mounting bolts (do not reuse)	12 ± 1 Nm (9 ± 1 ft-lb)
Drain cock mounting	15 ± 3 Nm (11 ± 2 ft-lb)
Drain nipple	3 ± 0.5 Nm (26.5 ± 4.5 in-lb)
EGR valve mounting	62 ± 5 Nm (46 ± 3.5 ft-lb)
EGR hot pipe clamps	20 ± 4 Nm (15 ± 3 ft-lb)
EGR valve oil line fittings	30 ± 5 Nm (22 ± 3 ft-lb)
EGR cold pipe V-clamps	10 ± 2 Nm (7 ± 1 ft-lb)
EGR cold pipe hose clamps	12 ± 2 Nm (9 ± 1.5 ft-lb)
Mixing chamber inlet pipe	24 ± 4 Nm (18.5 ± 3 ft-lb)



Turbocharger 135 ± 8 Nm (100 ± 6 ft-lb)

Note: Tighten the turbocharger nuts in the sequence shown.

Charge air pipe connection	7 ± 1 Nm (62 ± 9 in-lb)
Diffuser V-clamp	12 ± 2 Nm (9 ± 1.5 ft-lb)
Turbocharger oil supply line	28 ± 5 Nm (35.5 ± 4 ft-lb)
Turbocharger oil return	24 ± 4 Nm (18 ± 3 ft-lb)
Turbocharger coolant supply	48 ± 5 Nm (35 ± 4 ft-lb)
Turbocharger coolant lines	60 ± 6 Nm (44 ± 4.5 ft-lb)
SRA coolant lines	12 ± 2.5 Nm (12 ± 2 ft-lb)

Diesel Particulate Filter (DPF):

Compact (right under cab):

Lower mounting bracket	48 ± 8 Nm (35 ± 6 ft-lb)
Mounting strap fastener	27 ± 4 Nm (20 ± 3 ft-lb)
Exhaust V-band clamp	7 ± 2 Nm (62 ± 18 in-lb)
DPF V-band clamp	20 ± 3 Nm (15 ± 2 ft-lb)

Vertical (back of cab):

Mounting bracket	85 ± 15 Nm (63 ± 11 ft-lb)
Mounting strap fastener	23 ± 1 Nm (17 ± 1 ft-lb)
Exhaust V-band clamp	7 ± 2 Nm (62 ± 18 in-lb)
DPF V-band clamp	20 ± 3 Nm (15 ± 2 ft-lb)

After-Treatment Fuel (AF):

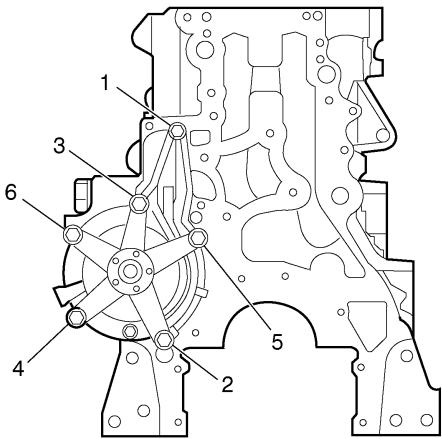
Injector:

Mounting bolts	14 ± 0.5 Nm (125 ± 4.5 in-lb)
Fuel line fitting	15 ± 0.5 Nm (135 ± 5 in-lb)
Cooling lines	48 ± 5 Nm (35 ± 4 ft-lb)

Shut-off Valve:

Mounting	13.5 ± 3 Nm (120 ± 24 in-lb)
Fuel line fittings	see Group 23

Tightening Torques Group 26



W2005979

Coolant pump	24 ± 4 Nm (18.5 ± 3 ft-lb)
Note: Tighten in sequence twice.	
Front and side cover, thermostat housing	24 ± 4 Nm (18.5 ± 3 ft-lb)
Fan belt tensioner	48 ± 8 Nm (35 ± 6 ft-lb)
Belt idler	70 ± 12 Nm (52 ± 9 ft-lb)
Fan hub	48 ± 8 Nm (35 ± 6 ft-lb)

Tightening Torques Group 28

Sensor and Location	Specification
Flywheel position/speed, top of flywheel housing	8 ± 2 Nm (6 ± 1 ft-lb)
Camshaft position, timing gear cover	8 ± 2 Nm (6 ± 1 ft-lb)
Turbocharger speed, top middle of turbocharger	8.5 ± 2 Nm (75 ± 18 in-lb)
Oil level/temperature, inside sump	10 ± 1 Nm (89 ± 9 in-lb)
Oil pressure, block, front of air compressor	30 ± 5 Nm (22 ± 4 ft-lb)
Coolant level, surge tank	Plug-in
Coolant temperature, front right side cylinder head	22 ± 3 Nm (16 ± 2 ft-lb)
Fuel pressure, fuel filter housing	25 ± 3 Nm (18.5 ± 2 ft-lb)
AF fuel pressure, behind fuel filter housing	25 ± 3 Nm (18.5 ± 2 ft-lb)
Crankcase pressure, alternator mounting bracket	25 ± 3 Nm (18.5 ± 2 ft-lb)
Charge air pressure, mixing chamber	10 ± 1 Nm (89 ± 9 in-lb)
Humidity, fresh air pipe	27 ± 3 Nm (20 ± 2 ft-lb)
Charge air temperature, intake manifold	10 ± 1 Nm (89 ± 9 in-lb)
EGR temperature, EGR venturi	45 ± 4.5 Nm (33 ± 3 ft-lb)
EGR differential pressure, EGR venturi	20 ± 3 Nm (15 ± 2 ft-lb)
DPF temperature, DPF inlet, catalyst, outlet modules	45 ± 4.5 Nm (33 ± 3 ft-lb)
DPF differential pressure, DPF inlet, catalyst, outlet modules:	
Box	6 ± 1 Nm (53 ± 9 in-lb)
Fitting nuts	16.3 ± 2.7 Nm (12 ± 2 ft-lb)
NOx sensor, exhaust pipe after DPF	50 ± 10 Nm (37 ± 7 ft-lb)
NOx module, frame bracket	24 ± 4 Nm (18 ± 3 ft-lb)

Tightening Torques Group 3

Starter motor mounting nuts:	
Delco	85 ± 15 Nm (63 ± 11 ft-lb)
Melco	60 ± 6 Nm (44 ± 5 ft-lb)
Starter cables (Bat+, E-):	
Delco	26 ± 1.5 Nm (19 ± 1 ft-lb)
Melco	25 ± 5 Nm (18.5 ± 3.5 ft-lb)
Starter control wire:	
Delco	2.2 ± 0.2 Nm (19.5 ± 2 in-lb)
Melco	4 ± 1 Nm (35 ± 9 in-lb)
Alternator:	
Mounting bracket	48 ± 8 Nm (35 ± 6 ft-lb)
Pad mounts	65.5 ± 7.5 Nm (48 ± 5.5 ft-lb)
Pulley nut	101.5 ± 6.5 Nm (75 ± 5 ft-lb)
Battery terminal	6.5 ± 0.25 Nm (57.5 ± 2.5 in-lb)
Ground terminal	6.2 ± 0.5 Nm (55 ± 5 in-lb)
I, R terminals	2.3 ± 0.5 Nm (20 ± 5 in-lb)
AC refrigerant compressor mounting bolts	24 ± 4 Nm (18 ± 3 ft-lb)
Wiring harness conduit to block	24 ± 3 Nm (18 ± 2 ft-lb)
Wiring harness conduit cover	3.5 ± 0.5 Nm (31 ± 4 in-lb)
Cable channel cover	3.5 ± 0.5 Nm (31 ± 4 in-lb)

Tightening Torques Group 5

Air compressor nut	85 ± 15 Nm (63 ± 11 ft-lb)
Air compressor out connection	130 ± 20 Nm (96 ± 15 ft-lb)
Air compressor gear	270 ± 20 Nm (200 ± 15 ft-lb)