ENGINE

Section 3A- 1.7L Engine Mechanical - All Models

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Engine Specifications

NOTICE
Unit Of Measurement: mm (in.)

Piston Rings

Groove Width	1st Compression	2.080 - 2.100 (.0819 - .0827)
	2nd Compression	1.560 - 1.580 (.0614 - .0622)
	Oil Control	3.015 - 3.035 (.1187 - .1195)
Ring Thickness	1st Compression	1.978 - 1.990 (.0779 - .0783)
	2nd Compression	1.470 - 1.490 (.0579 - .0587)
	Oil Control	2.970 - 2.990 (.1169 - .1177)
End Gap	1st Compression	0.250 - 0.350 (.0098 - .0138)
	2nd Compression	0.200 - 0.300 (.0079 - .0118)
	Oil Control	0.200 - 0.400 (.0079 - .0157)
Ring to Groove Clearance	1st Compression	0.090 - 0.122 (.0035 - .0048)
	2nd Compression	0.070 - 0.110 (.0028 - .0043)
	Oil Control	0.025 - 0.065 (.0010 - .0026)
	Limit–All Rings	0.15 (0.006)

Piston

Piston Outside Diameter	Grade A	78.930 - 78.939 (3.1075 - 3.1078)
	Grade B	78.940 - 78.949 (3.1079 - 3.1082)
	Grade C	78.950 - 78.959 (3.1083 - 3.1086)
Piston To Cylinder Wall Clearance		0.061 - 0.079 (.0024 - .0031)
Pin Hole Inner Diameter	Production	27.004 - 27.009 (1.0631 - 1.0633)
Maximum Weight Difference Between Pistons in One Engine		22 gr. (.77 oz.)

Piston Pin

Piston Pin Outer Diameter	Production	26.995 - 27.000 (1.063)
	Limit	26.985 (1.0624)
Clearance	Production	.004 - .014 (0.0001 - 0.0005)
	Limit	0.04 (0.0016)

Engine Specifications (continued)

NOTICE
Unit Of Measurement: mm (in.)

Oil Pump

Oil pump shaft clearance in cylinder block	Production	0.040 - 0.125 (.0015 - .0049)
	Limit	0.200 (.0078)
Rotor end float	Production	0.035 - 0.100 (.0014 - .0039)
	Limit	0.150 (.0059)
Clearance between outer rotor and cylinder block	Production	0.24 - 0.36 (.0094 - .0141)
	Limit	0.40 (.0015)
Clearance between inner and outer rotors (mesh)	Production	0.13 - 0.15 (.0051 - .0059)
	Limit	0.20 (.0078)

Cylinder Block

Upper Surface Warp	Production	0.05 (0.0019) or Less
	Limit	0.1 (0.0039)
Crankshaft Journal Hole Diameter		55.976 - 56.000 (2.204 - 2.205)
Cylinder Bore Diameters	Nominal	79.000 (3.1102)
	Grade - A	79.001 - 79.010 (3.1102 - 3.1106)
	Grade - B	79.011 - 79.020 (3.1106 - 3.1110)
	Grade - C	79.021 - 79.030 (3.1110 - 3.1114)
Cylinder Block Height	Production	272 (10.71)

Cylinder Head

Warp and Flatness	Overall	0.075 (.0030)
	Per 125 mm (5 in.)	0.025 (.0010)
Valve Guide Inside Diameter		6.000 - 6.015 (.2362 - .2368)

Engine Specifications (continued)

NOTICE
Unit Of Measurement: mm (in.)

Camshaft Carrier

Camshaft Carrier Lower Face Warp	Production	Less Than 0.05 (.002)
	Limit	0.05 (.0019)
Journal Hole Diameter		27.000 - 27.021 (1.063 - 1.064)
Clearance between journal and bracket bearing surface	Production	0.040 - 0.082 (.0015 - .0032)
	Limit	0.110 (.0043)
Camshaft Carrier Height	Production	29.62 (1.166)

Camshafts

Journal Diameter	Production	26.939 - 26.960 (1.0605 - 1.0614)
	Limit	26.92 (1.0598)
Intake Lobe Lift (Camshaft Height)	Production	7.80 (.307)
	Limit	7.68 (.302)
Exhaust Lobe Lift (Camshaft Height)	Production	7.95 (.312)
	Limit	7.77 (.306)
Camshaft Runout	Production	0.03 (.0011)
	Limit	0.05 (.0019)

Engine Specifications (continued)

NOTICE
Unit Of Measurement: mm (in.)

Valve Adjustment

Valve Clearance	Intake	0.35 - 0.45 (.014 - .018)
	Exhaust	0.45 - 0.55 (.18 - .021)

Valve

Intake Valve Stem Diameter	Production	5.959 - 5.977 (.2346 - .2353)
	Limit	5.945 (.2341)
Exhaust Valve Stem Diameter	Production	5.954 - 5.972 (.2344 - .2351)
	Limit	5.940 (.2339)
Intake Valve Guide Inside Diameter	Production	6.000 - 6.015 mm (0.2362 - 0.2368)
Exhaust Valve Guide Inside Diameter	Production	6.000 - 6.015 mm (0.2362 - 0.2368)
Valve Stem Clearance	Intake	0.023 - 0.056 (.0009 - .0022)
	Exhaust	0.028 - 0.610 (.0011 - .0240)
Head Diameter	Intake	27.35 - 27.65 (1.077 - 1.088)
	Exhaust	26.35 - 26.65 (1.037 - 1.045)
Face Width	Intake	2.4 (.095)
	Exhaust	2.4 (.095)
Face Angle (New)	Intake	44° 40’
	Exhaust	44° 40’
Valve Margin (Production)	Intake	1.2 - 1.4 (0.047 - 0.055)
	Exhaust	
Margin (After Grinding)	Intake	1.0 (0.039)
	Exhaust	

Engine Specifications (continued)

NOTICE
Unit Of Measurement: mm (in.)

Valve Seat

Seat Angle	Intake	89° 30’
	Exhaust	89° 30’
Seat Width	Intake	1.7 (.067)
	Exhaust	1.5 (.059)
Seat Outer Diameter	Intake	28.6 (1.126)
	Exhaust	27.6 (1.086)
Seat Height	Intake	5 (.197)
	Exhaust	5 (.197)
Valve Recession (Max.)	Intake	1.05 (.041)
	Exhaust	0.6 (.024)

Valve Guide

Maximum Clearance	Intake	0.080 (.0031)
	Exhaust	0.095 (.0037)
Upper End Height	Intake	11.7 (.4606)
	Exhaust	

Valve Spring

Free Standing Height	Production	44.63 (1.76)
	Limit	44.13 (1.74)
Compressed Height at Pressure	Production	33.3 (1.31) at 160 N (36 lb)
	Limit	
Spring Inclination	Production	1.01 (0.040)
	Limit	
Valve Closed		33.3 (1.31)
Valve Open		25.3

Engine Specifications (continued)

NOTICE
Unit Of Measurement: mm (in.)

Crankshaft

Main Journal Outside Diameter-Grade 1, Size Mark:	Production	51.918 - 51.928 (2.0440 - 2.0444)
	Limit	51.912 (2.0438)
Main Journal Outside Diameter-Grade 2, Size Mark 	Production	51.928 - 51.938 (2.0444 - 2.0448)
	Limit	51.922 (2.0442)
Connecting Rod Journal Outside Diameter	Production	45.930 - 45.945 (1.8083 - 1.8089)
Main Bearing Clearance	Production	0.030 - 0.058 (.0011 - .0023)
	Limit	0.080 (.003)
Connecting Rod Journal Outside Diameter		45.930 - 45.945 (1.808 - 1.811)
Connecting Rod Bearing Clearance		0.025 - 0.058 (.0010 - .0023)
Crankshaft and Connecting Rod Journal Wear or Taper	Standard	0.05 (.0019) or Less
	Limit	0.08 (.003)
Crankshaft End Play (Thrust Clearance)	Production	0.05 - 0.15 (.0019 - .0059)
	Limit	0.20 (.0078)
Crankshaft Runout	Production	0.05 (.0019) or Less
	Limit	0.06 (.002)

Connecting Rod Crank Pin Bore

Inner Diameter	I (Blue Mark)	48.94 - 49.00 (1.927 - 1.929)
	II (Black Mark)	48.88 - 48.94 (1.924 - 1.927)
	III (Brown Mark)	48.82 - 48.88 (1.922 - 1.924)
Allowable Wear or Taper	Standard	0.05 (.0019) or Less
	Limit	0.08 (.003)

Connecting Rod Bushing

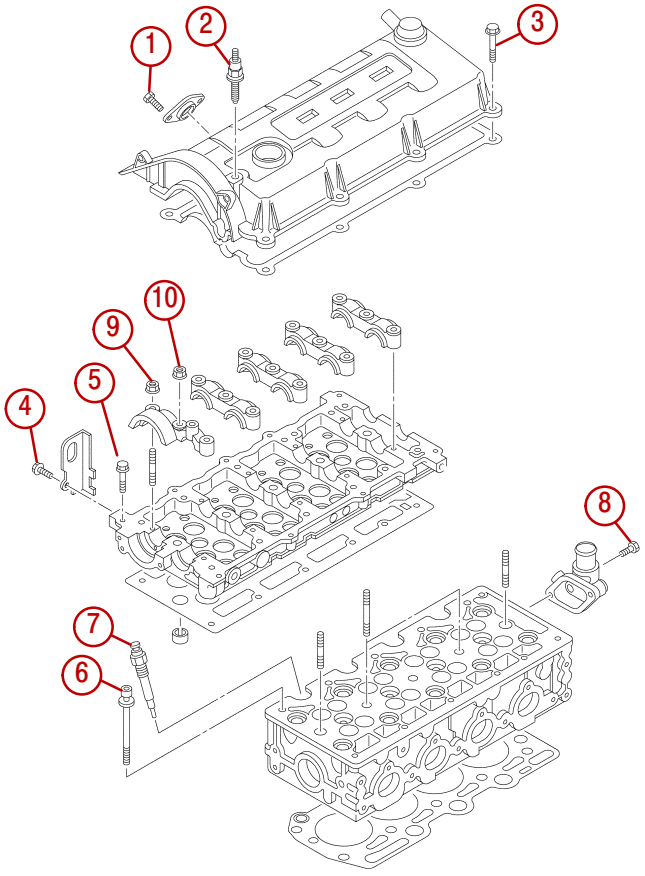
Connecting Rod Bushing Inner Diameter		27.008 - 27.015 (1.063 - 1.064)
Bushing To Piston Pin Clearance	Standard	0.008 - 0.020 (.0003 - .0008)
	Limit	0.05 (.002)

Torque Specifications

IMPORTANT: Tighten all fasteners not listed according to torque values shown in the Standard Torque Values table.

Specified Torque Values

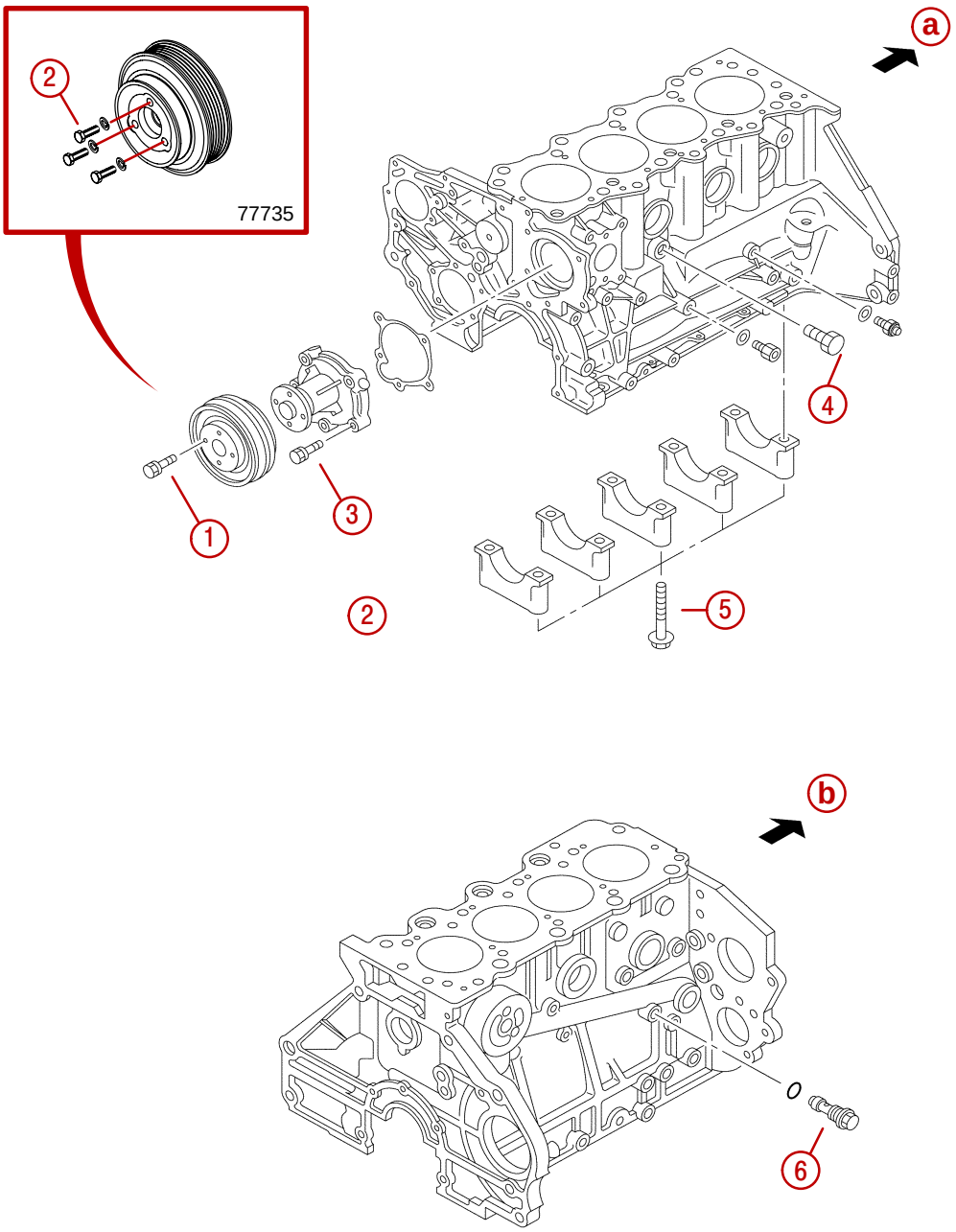
VALVE COVER, CAMSHAFT CARRIER AND CYLINDER HEAD



77081

Description			Nm	lb-in.	lb-ft
1	Bolt, Injector Cover	M6 x 1.0	9.8	86	
2	Bolt, Valve Cover	M6 x 1.0	9.8	86	
3	Bolt, Valve Cover	M6 x 1.0	9.8	86	
4	Bolt, Engine Lifting Eye	M8 x 1.25	25		18
5	Bolt, Carrier	M8 x 1.25	22		16
6	Bolt, Cylinder Head	M12 x 1.5			
	First Pass		39		29
	Second Pass		+ 60 degrees		
	Final Pass		+ 60 degrees		
7	Plug, Glow (If Equipped)	M10 x 1.25	17.5	155	
8	Bolt, Water Outlet	M8 x 1.25	24		18
9	Nut, Camshaft Bracket	M8 x 1.25	22		16
10	Nut, Camshaft Bracket	M10 x 1.25	43		32

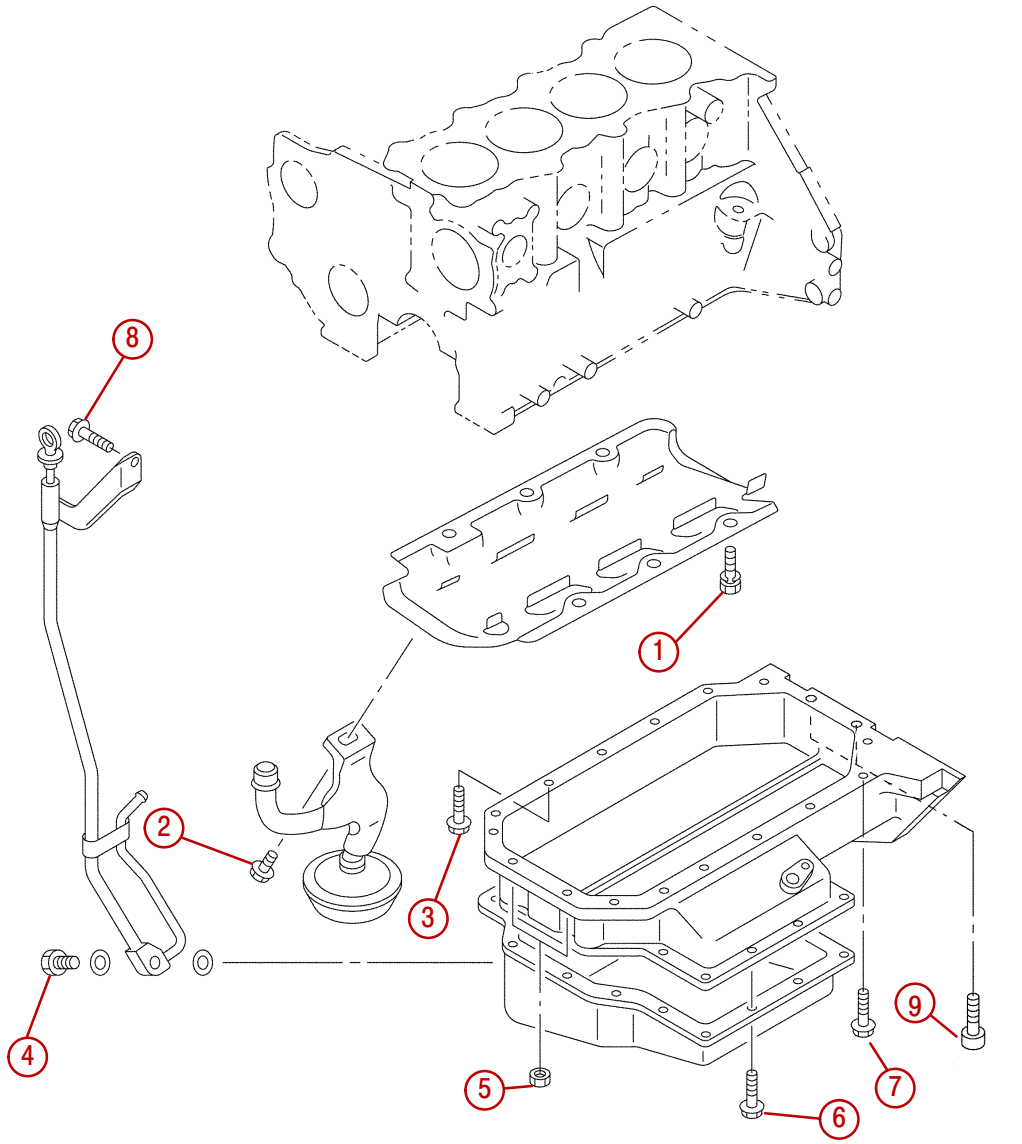
CYLINDER BLOCK AND WATER PUMP



a - Rear
b - Front

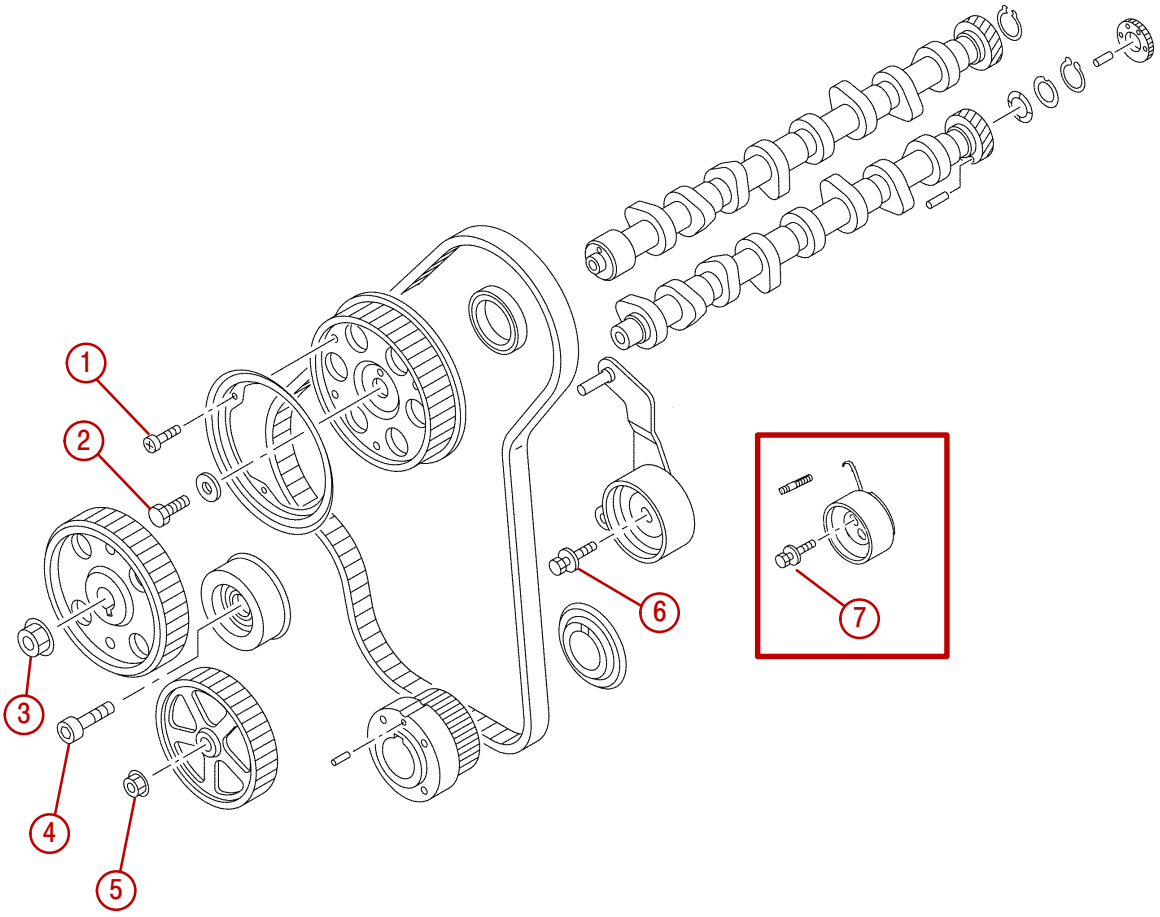
Description			Nm	lb-in.	lb-ft
1	Bolt, Water Pump Pulley	M6 x 1.0 x 30	9.8	86	
2	Bolt, Power Steering Pulley	M6 x 1.0 x 30	9.8	86	
3	Bolt, Water Pump	M8 x 1.25	24		18
4	Fitting, Water Pipe	PT 1/4	19	168	
5	Bolt, Bearing Cap	M11 x 1.5	88		65
6	Valve, Check	M18 x 1.5	29		21

OIL PAN AND RELATED PARTS



Description			Nm	lb-in.	lb-ft
1	Bolt, Baffle Plate	M8 x 1.25	19	168	
2	Bolt, Oil Pickup Assembly	M8 x 1.25	26		19
3	Bolt, Oil Pan Upper	M6 x 1.0	9.8	87	
4	Hollow Bolt, Oil Dipstick Assembly	M14 x 1.5	78		58
5	Nut, Oil Pan	M6 x 1.0	9.8	87	
6	Bolt, Oil Pan Lower	M6 x 1.0	9.8	87	
7	Bolt, Oil Pan Upper	M6 x 1.0	9.8	87	
8	Bolt, Guide Tube	M8 x 1.25	19	168	
9	Bolt, Oil Pan	M6 x 1.0	9.8	87	

TIMING PULLEYS AND RELATED PARTS



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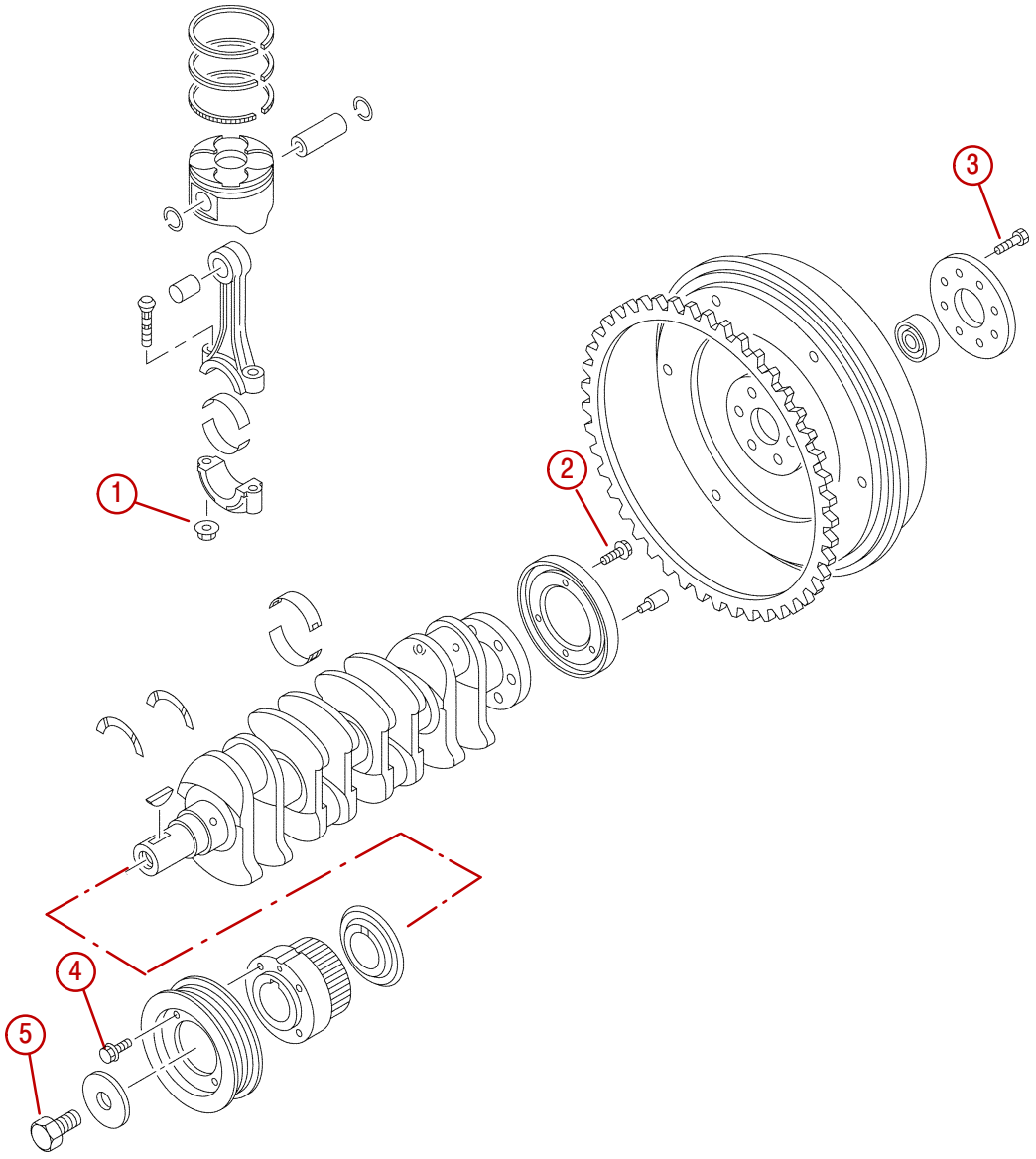
Description			Nm	lb-in.	lb-ft
1	Screw, Flange	M4 x 0.7	2.5	22	
2	Bolt, Camshaft Pulley	M12 x 1.5	64		47
3	Nut, Injection Pump Pulley	M14 x 1.5	69		51
4	Bolt, Idler	M12 x 1.25	80		59
5	Nut, Oil Pump Pulley	M10 x 1.25	44		32
6	Bolt, Design 1 (Plate Type Spring Tensioner)	M10 x 1.5	38		28
7	Bolt, Design 2 (Coil Type Spring Tensioner)	M10 x 1.5	49		36

CRANKSHAFT, CONNECTING ROD, FLYWHEEL AND CRANK PULLEY



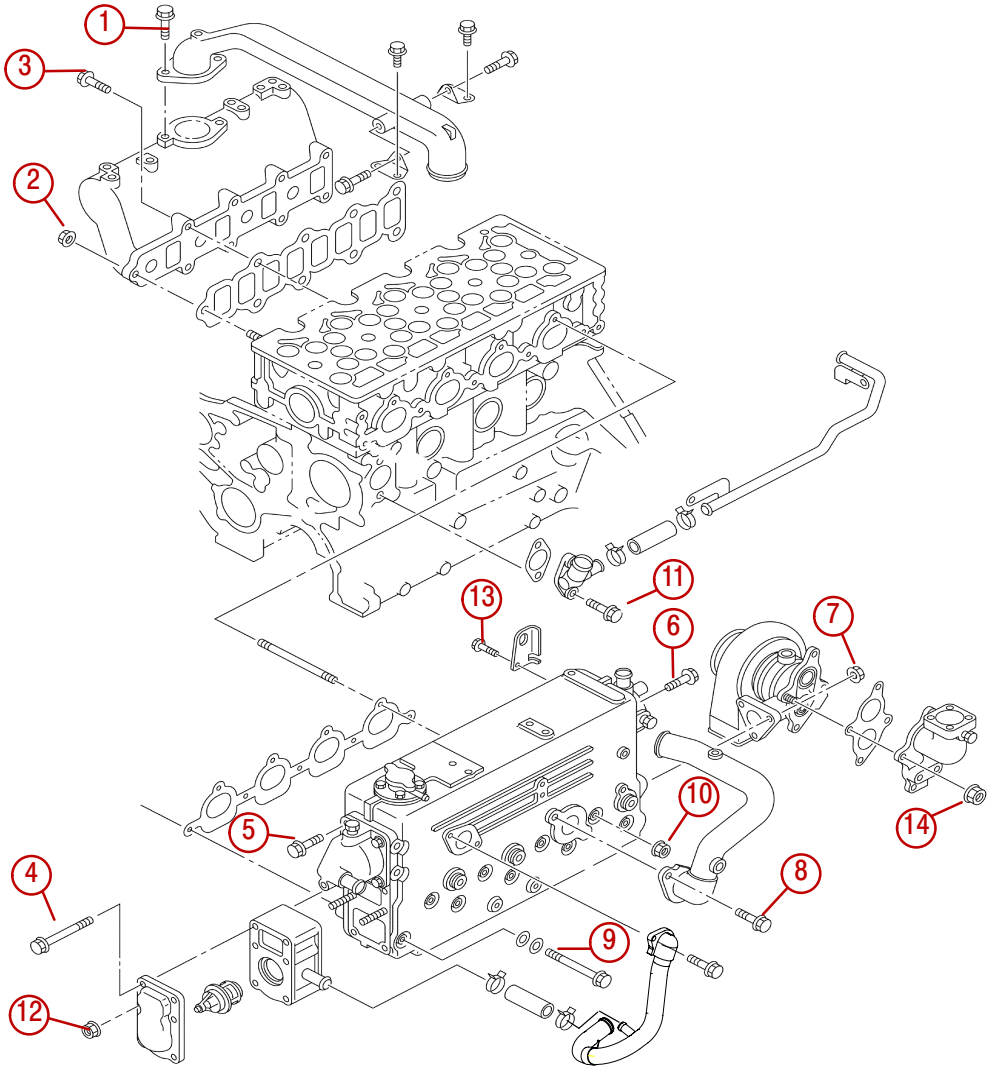
77085

	Description		Nm	lb-in.	lb-ft
1	Nut, Connecting Rod [1]	3/8 24UNF			
		First Pass	25		18
		Final Pass	100°		
2	Bolt, Rotor	M6 x 1.0	10.8 Nm		
3	Bolt, Flywheel [2]	M11 x 1.25	29 + 60°		21 + 60°
4	Bolt, Damper Pulley,	M8 x 1.25	20	177	
5	Bolt, Crank Pulley	M16 x 1.5	196		145

[1] Minimum torque–check after tightening: 54 - 88 Nm (40 - 64 lb-ft).

[2] DO NOT reuse flywheel bolts. Replace if removed once. Use locking compound on threads.

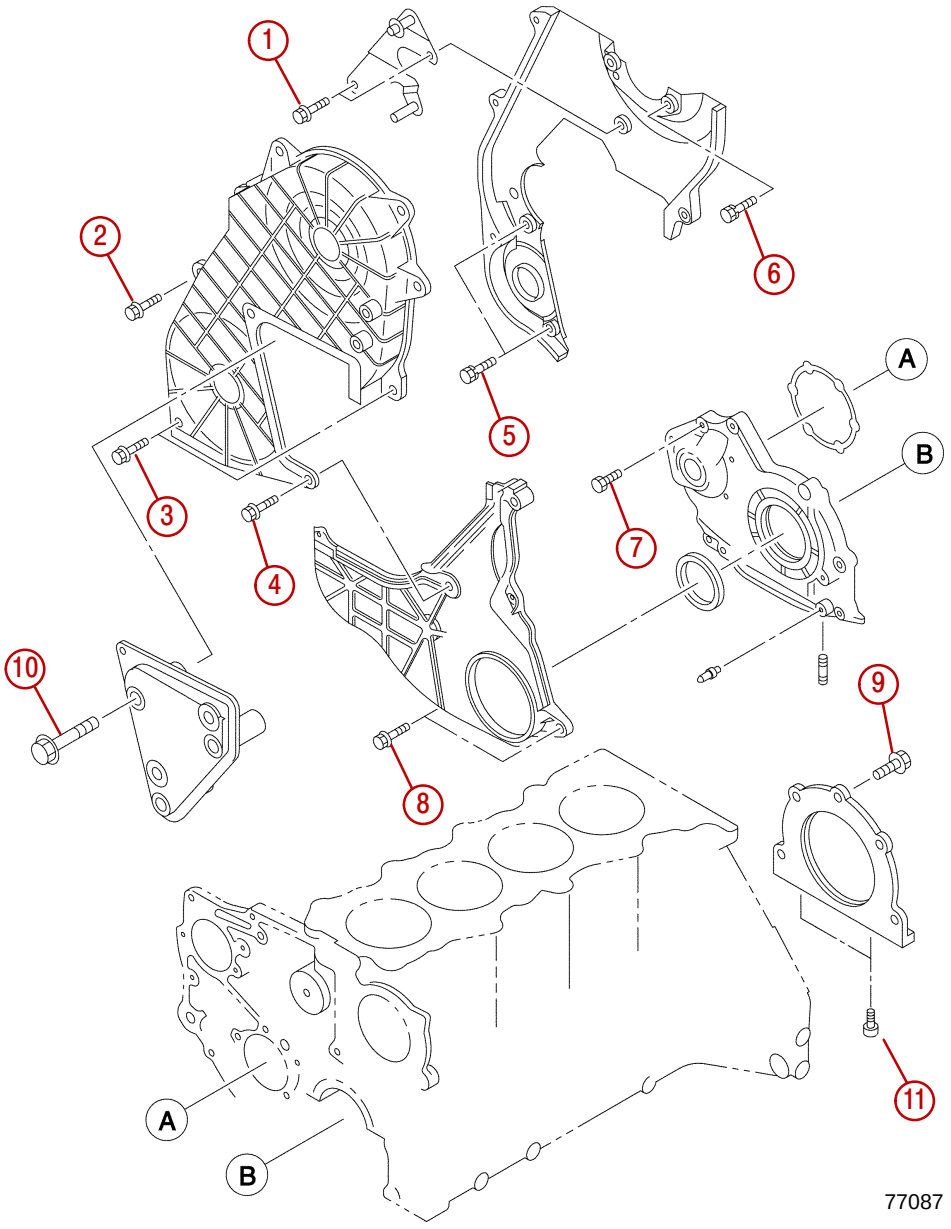
INTAKE MANIFOLD, TURBOCHARGER AND HEAT EXCHANGER



77086

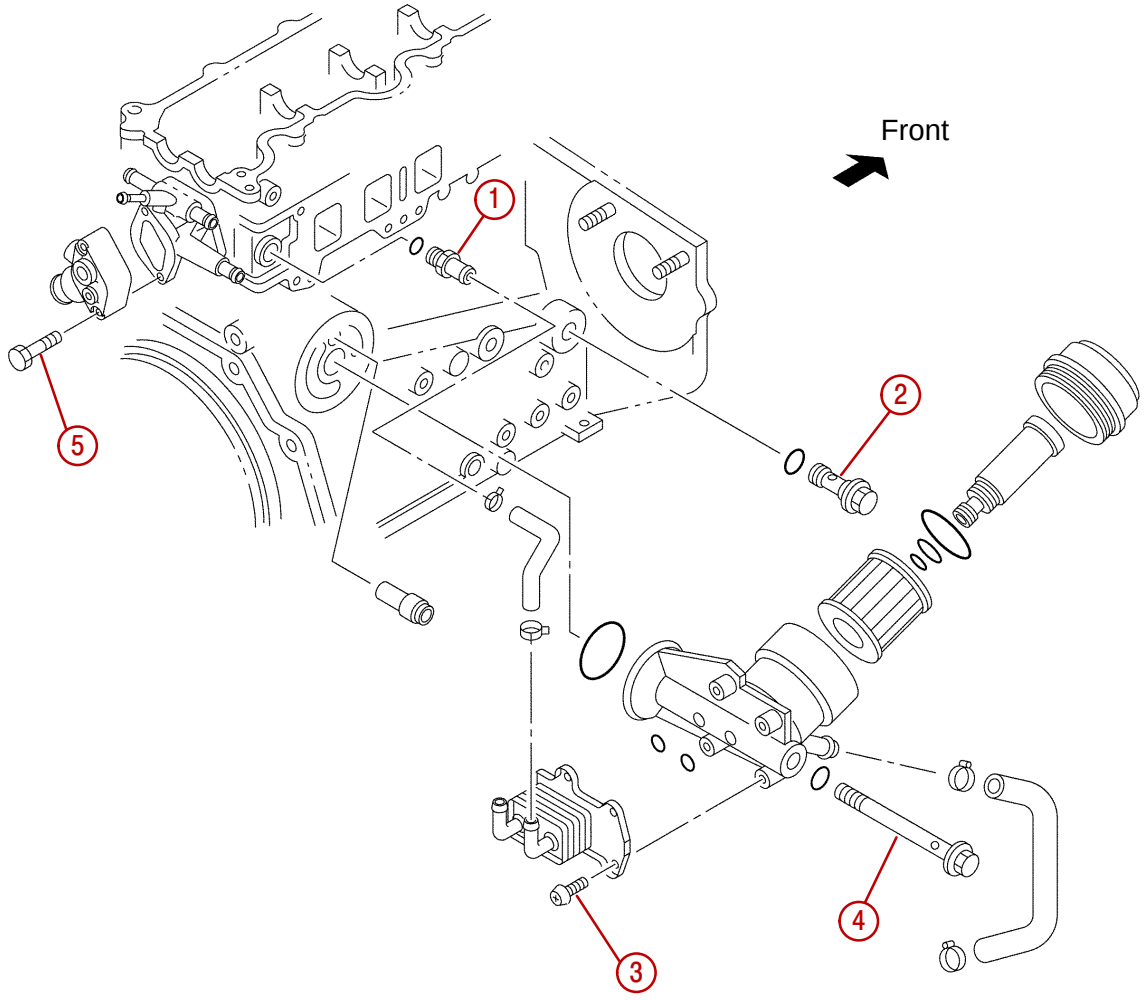
	Description		Nm	lb-in.	lb-ft
1	Bolt, Inlet Pipe	M8 x 1.25	19	168	
2	Nut, Inlet Manifold	M8 x 1.25	25		18
3	Bolt, Inlet Manifold	M8 x 1.25	25		18
4	Bolt, Thermostat Housing	M8 x 1.25	24		18
5	Bolt, Heat Exchanger Front Cover	M8 x 1.25	19	168	
6	Bolt, Heat Exchanger Rear Cover	M8 x 1.25	19	168	
7	Nut, Turbocharger	M10 x 1.5	44		32
8	Bolt, Water Pipe	M8 x 1.25	24		18
9	Bolt, Heat Exchanger	M8 x 1.25	19	168	
10	Nut, Heat Exchanger	M8 x 1.25	19	168	
11	Bolt, Suction Pipe	M8 x 1.25	24		18
12	Nut, Housing Cover	M8 x 1.25	24		18
13	Bolt, Engine Lifting Eye	M8 x 1.25	25		18
14	Nut, Exhaust Pipe	M10 x 1.25	44		32

TIMING COVERS, OIL PUMP RETAINER, FRONT AND REAR COVER



Description			Nm	lb-in.	lb-ft
1	Bolt, Bracket	M6 x 1.0	9.8	87	
2	Bolt, Timing Cover	M6 x 1.0	9.8	87	
3		M6 x 1.0	9.8	87	
4		M6 x 1.0	9.8	87	
5	Bolt, Dust Cover	M6 x 1.0	9.8	87	
6		M6 x 1.0	9.8	87	
7	Bolt, Oil Pump Retainer	M6 x 1.0	9.8	87	
8	Bolt, Timing Cover	M6 x 1.0	9.8	87	
9	Bolt, Rear Oil Seal Retainer	M6 x 1.0	9.8	87	
10	Bolt, Engine Plate	M10 x 1.5	40		30
11	Bolt, Rear Oil Seal Retainer	M6 x 1.0	9.8	87	

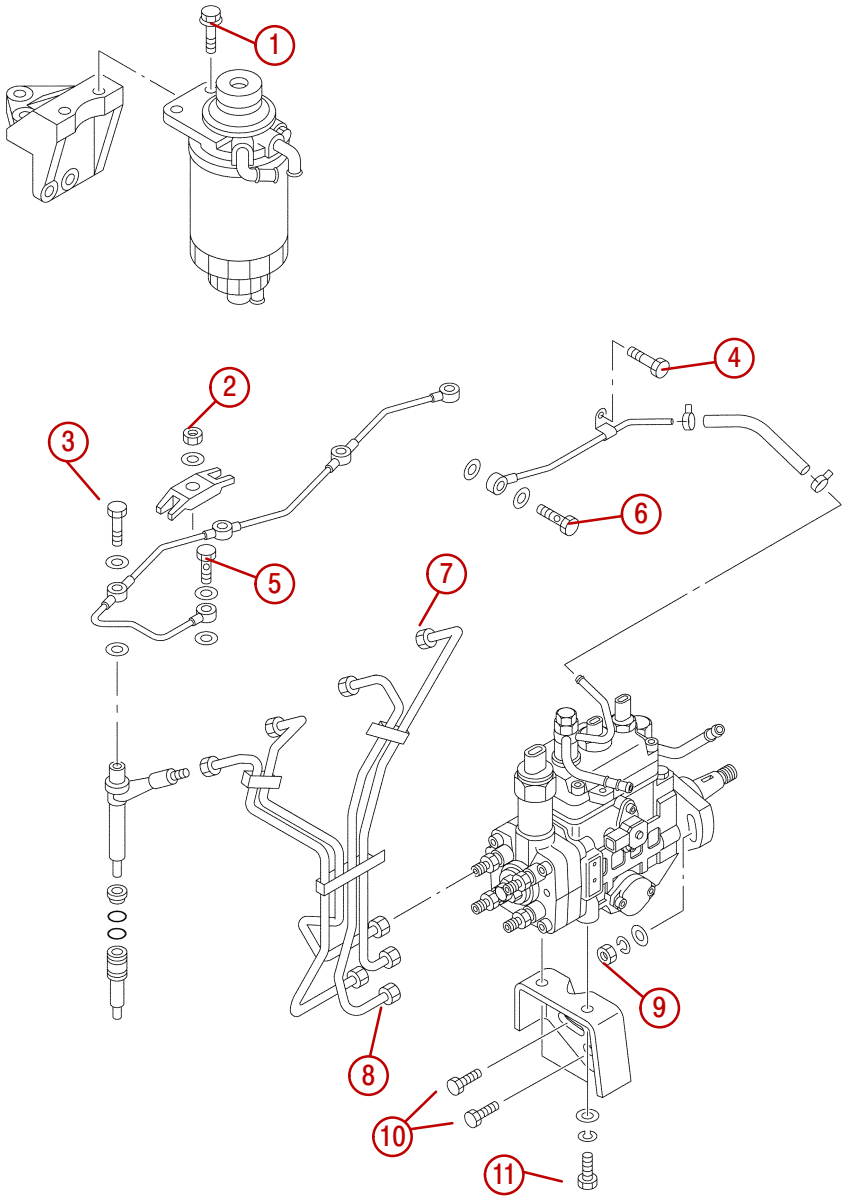
OIL FILTER AND ENGINE WATER OUTLET



77088

	Description		Nm	lb-in.	lb-ft
1	Fitting, Oil Cooler				
2	Valve, Relief	M24 x 1.5	39		29
3	Bolt, Oil Cooler		12	106	
4	Bolt, Oil Filter	M20 x 1.5	110		81
5	Bolt, Water Outlet	M8 x 1.25	24		18

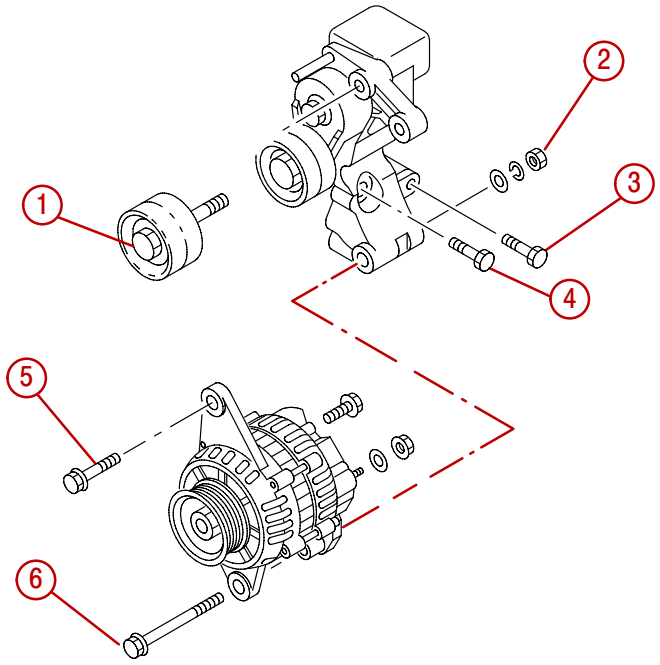
FUEL INJECTORS AND RELATED PARTS



77089

	Description		Nm	lb-in.	lb-ft
1	Bolt, Filter	M8 x 1.25	19	168	
2	Nut, Injector Bracket	M10 x 1.25	22		16
3	Bolt, Injector Hollow	M8 x 1.0	12.5	111	
4	Bolt, Fuel Return Pipe Clamp	M6 x 1.0	9.8	87	
5	Bolt, Fuel Return Hollow	M8 x 1.25	15	133	
6		M8 x 1.25	15	133	
7	Nut, Injection Pipe Sleeve	M12 x 1.5	20	177	
8		M12 x 1.5	20	177	
9	Nut, Injection Pump	M8 x 1.25	20	177	
10	Bolt, Bracket To Mount	M8 x 1.25	19	168	
11	Bolt, Bracket To Injection Pump	M10 x 1.5	38		28

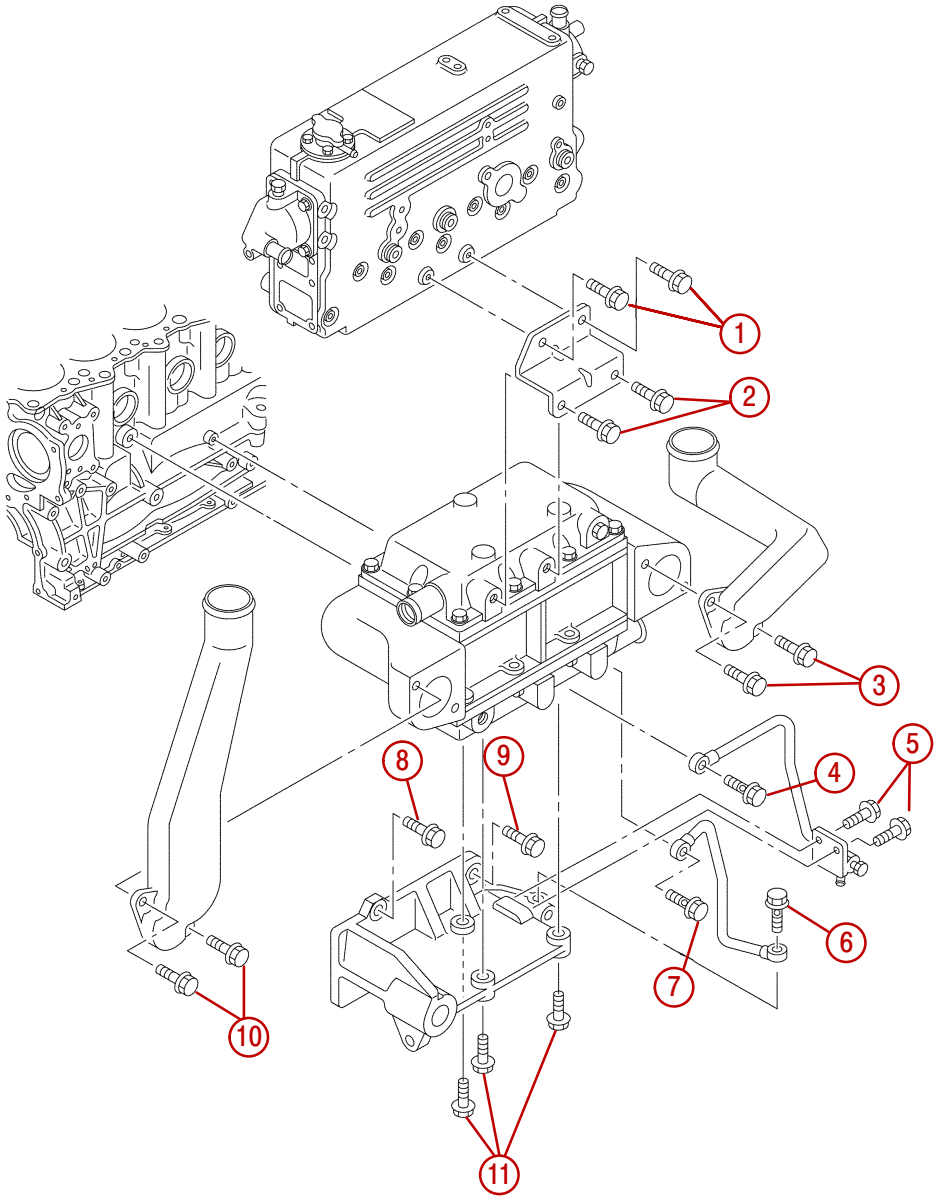
ALTERNATOR, TENSIONER AND BRACKET



77721

Description			Nm	lb-in.	lb-ft
1	Bolt, Automatic Tensioner		50		37
2	Nut, Alternator	M10 x 1.25	46		34
3	Bolt, Alternator Bracket	M10 x 1.5	48		35
4	Bolt, Alternator Bracket	M14 x 2.0	68		50
5	Bolt, Alternator-To-Bracket	M8 x 1.25	19	168	
6	Bolt, Alternator Lower Mounting	M10 x 1.25	46		34

AFTERCOOLER AND RELATED PARTS



77091

Description			Nm	lb-in.	lb-ft
1	Bolt, Bracket	M10 x 1.5	44		32
2		M10 x 1.5	44		32
3	Bolt, Air Duct	M8 x 1.25	19	168	
4	Bolt, Eye	M12 x 1.25	27		20
5	Bolt, Water Drain Bracket	M8 x 1.25	24		18
6	Bolt, Eye	M8 x 1.25	15	133	
7	Bolt, Eye	M12 x 1.25	27		20
8	Bolt, Port Mount Bracket	M10 x 1.5	51		38
9		M10 x 1.5	51		38
10	Bolt, Air Duct	M8 x 1.25	19	168	
11	Bolt, Aftercooler	M10 x 1.5	44		32

Standard Torque Values

HEX HEAD BOLT

IMPORTANT: The tightening torque values given in the table below are applicable to bolts and fasteners unless otherwise specified.

NOTICE
Unit Of Measurement: Nm (lb-ft)

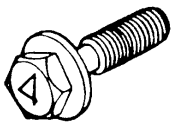
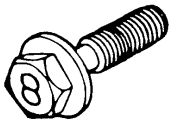
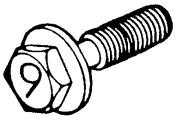
Identification			
			
Diameter x Thread Pitch (mm)			
M6 x 1.0	3.9 - 7.8 (3 - 6)	4.9 - 9.8 (4 - 7)	–
M8 x 1.25	7.8 - 17.7 (6 - 13)	11.8 - 22.6 (9 - 17)	16.7 - 30.4 (12 - 22)
M10 x 1.25	20.6 - 34.3 (15 - 25)	27.5 - 46.1 (20 - 34)	37.3 - 62.8 (28 - 46)
*** M10 x 1.5**	19.6 - 33.4 (14 - 25)	27.5 - 45.1 (20 - 33)	36.6 - 59.8 (17 - 44)
M12 x 1.25	49.1 - 73.6 (36 - 54)	60.8 - 91.2 (45 - 67)	75.5 - 114.0 (56 - 84)
***M12 x 1.75**	45.1 - 68.7 (33 - 51)	56.9 - 84.4 (42 - 62)	71.8 - 107.0 (53 - 79)
M14 x 1.5	76.5 - 115.0 (56 - 85)	93.2 - 139.0 (69 - 103)	114.0 - 171.0 (84 - 126)
***M14 x 2.0**	71.6 - 107.0 (53 - 79)	88.3 - 131.0 (65 - 97)	107.0 - 160.0 (79 - 118)
M16 x 1.5	104.0 - 157.0 (77 - 116)	135.0 - 204.0 (100 - 151)	160.0 - 240.0 (118 - 177)
***M16 x 2.0**	100.0 - 149.0 (74 - 110)	129.0 - 194.0 (95 - 143)	153.0 - 230.0 (113 - 170)
M18 x 1.5	151.0 - 226.0 (111 - 167)	195.0 - 293.0 (144 - 216)	230.0 - 345.0 (170 - 255)
***M18 x 2.5**	151.0 - 226.0 (111 - 167)	196.0 - 294.0 (145 - 217)	231.0 - 346.0 (170 - 255)
M20 x 1.5	206.0 - 310.0 (152 - 229)	270.0 - 405.0 (199 - 299)	317.0 - 476.0 (234 - 339)
***M20 x 2.5**	190.0 - 286.0 (140 - 211)	249.0 - 375.0 (184 - 277)	293.0 - 440.0 (176 - 325)
M22 x 1.5	251.0 - 414.0 (185 - 306)	363.0 - 544.0 (268 - 401)	425.0 - 637.0 (314 - 470)
***M22 x 2.5**	218.0 - 328.0 (161 - 242)	338.0 - 507.0 (249 - 374)	394.0 - 592.0 (291 - 437)
M24 x 2.0	359.0 - 540.0 (265 - 399)	431.0 - 711.0 (318 - 525)	554.0 - 831.0 (409 - 613)
***M24 x 3.0**	338.0 - 507.0 (249 - 374)	406.0 - 608.0 (300 - 449)	521.0 - 782.0 (385 - 577)

An asterisk (*) indicates that the bolts are used for female threaded parts that are made of soft materials such as casting.

FLANGED HEAD BOLT

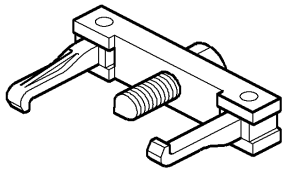
IMPORTANT: The tightening torque values given in the table below are applicable to bolts and fasteners unless otherwise specified.

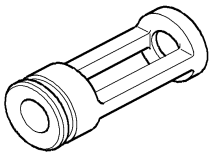
NOTICE
Unit Of Measurement: Nm (lb-ft)

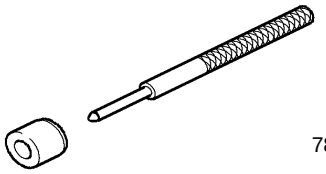
Identification			
Diameter x Thread Pitch (mm)			
M6 x 1.0		6.6 - 12.2 (5 - 9)	–
M8 x 1.25	10.5 - 19.6 (8 - 15)	15.3–28.4 (11 - 21)	18.1 - 33 (15 - 25)
M10 x 1.25	23.1 - 38.5 (17 - 28)	35.4 - 58.9 (26 - 43)	42.3 - 70.5 (31 - 52)
***M10 x 1.5**	22.3 - 37.2 (16 - 27)	34.5 - 57.5 (25 - 42)	40.1 - 66.9 (30 - 49)
M12 x 1.25	54.9 - 82.3 (41 - 61)	77.7 - 117.0 (57 - 86)	85.0 - 128.0 (63 - 94)
***M12 x 1.75**	51.0 - 76.5 (38 - 56)	71.4 - 107.0 (53 - 79)	79.5 - 119.0 (59 - 88)
M14 x 1.5	83.0 - 125.0 (61 - 92)	115.0 - 172.0 (85 - 127)	123.0 - 185.0 (91 - 137)
***M14 x 2.0**	77.2 - 116.0 (57 - 86)	108.0 - 162.0 (80 - 120)	116.0 - 173.0 (86 - 128)
M16 x 1.5	116.0 - 173.0 (86 - 128)	171.0 - 257.0 (126 - 190)	177.0 - 265.0 (131 - 196)
***M16 x 2.0**	109.0 - 164.0 (80 - 121)	163.0 - 244.0 (120 - 180)	169.0 - 253.0 (125 - 187)

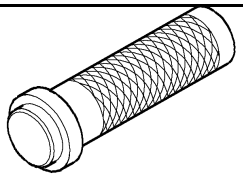
A bolt with an asterisk (*) is used for female screws of soft material such as cast iron.

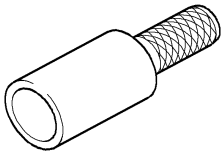
Special Tools

Remover	91-883844
Description: To remove injection pump drive pulley	 78038

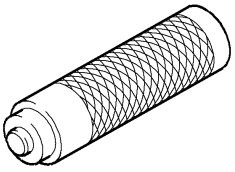
Adapter	91-883845
Description: Used in combination with typical valve spring compressor to compress valve spring	 78039

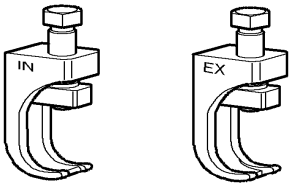
Installer / Remover	91-883846
Description: Install and remove valve guide	 78040

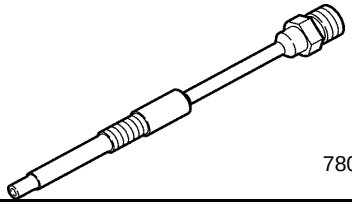
Installer	91-883847
Description: Install front crankshaft oil seal without crankshaft	 78041

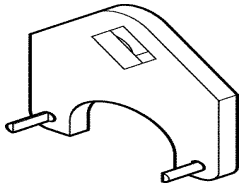
Installer	91-883848
Description: Install front crankshaft oil seal with crankshaft	 78042

Special Tools (continued)

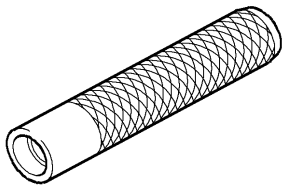
Installer	91-883849
Description: Install oil pump seal in oil pump cover	 78043

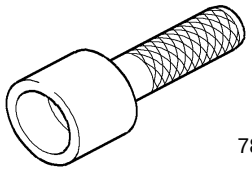
Compressor	91-883850
Description: Valve compressor to adjust valve clearance	 78044

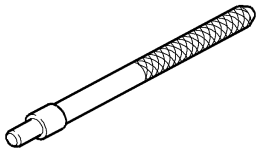
Adapter	91-883852
Description: Adapter to check engine compression pressure	 78046

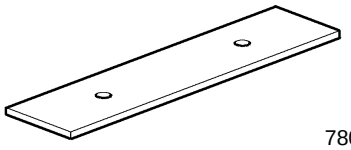
Locking Tool	91-883853
Description: To remove and install exhaust camshaft	 78047

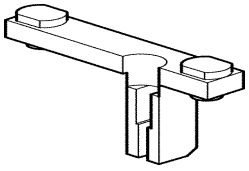
Special Tools (continued)

Installer	91-883854
Description: Install valve stem seal	 78048

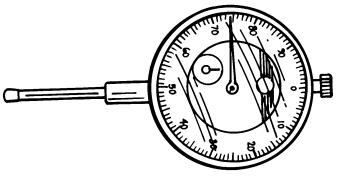
Installer	91-883855
Description: Install camshaft oil seal	 78049

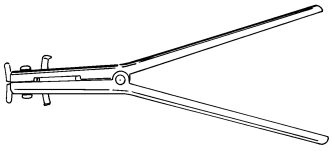
Remover	91-883856
Description: Removes injector sleeve	 78050

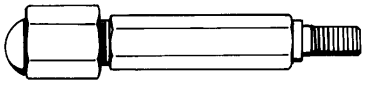
Aligner	91-883859
Description: Aligns cylinder block to oil pan upper	 78053

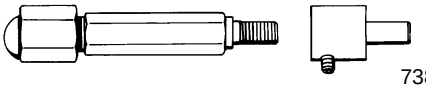
Oil Jet Pipe Installer	91-883860
Description: Positions and installs oil jet pipe to cylinder block	 78054

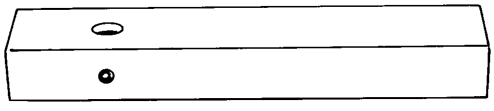
Special Tools (continued)

Dial Indicator	91-58222A1
Description: Measures various distances on engines	 73429

Piston Ring Expander	91-24697
Description: Installs and removes piston rings	 73700

Metric Dial Indicator Adaptor	91-801333510
Description: Used with metric dial indicator to set fuel injector pump timing	 73801

SAE Dial Indicator Adaptor	91-816997A1
Description: Used with SAE dial indicator to set fuel injector pump timing	 73802

Support Block	91-814812A1
Description: Used as a base for the Dial Indicator	 73803

Snap-On Special Tools

Description	Part Number
Compression Gauge	MT33B
Torque Angle Gauge (Degree Wheel Torquing)	TA360

Kent-Moore Special Tools

Can Be Ordered From:

Kent-Moore Tools, Inc.
29784 Little Mack
Roseville, MI 48066
Phone: (313) 574 - 2332

Description	Part Number
Valve Spring Compressor	J-8062
Piston Ring Compressor	J-8307

Lubricants / Sealants / Adhesives

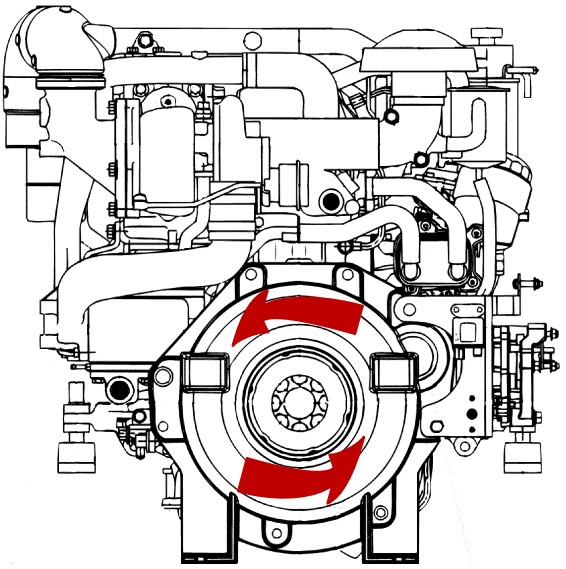
Description	Where Used	Method of Use	Part Number
Needle Bearing Assembly Lubricant [1]	Rod bearing and crankshaft journal	Coat surfaces	92 - 802868A1
Molybdenum Disulfide Grease	Piston skirt	Coat the two skirts on each piston.	Obtain Locally
Loctite 5699	Between front camshaft bracket and carrier	Apply to contact surfaces as indicated	Obtain Locally
	Half moon packing plugs in camshaft bracket	Apply to both sides of plug	
	Between camshaft carrier and valve cover	Apply to sealing surfaces as indicated	
	Between oil pump retainer and cylinder block	Apply a bead to sealing surfaces as specified	
	Water fitting for oil cooler coolant hose at block	Thread length	
Loctite 5999	Upper oil pan to block; lower oil pan to upper oil pan	Apply a bead to sealing surfaces as specified	Obtain Locally
Loctite 572 or Threebond© 1207C	Anode plug	Thread length	Obtain Locally
Loctite 262	Drain plugs	Thread length	
Loctite 262, Loctite 962T or Threebond© 1386	Oil spray nozzle	Around outside of nozzle	Obtain Locally
Engine Oil	As indicated throughout SECTION, in steps and tables	Coat surfaces	Obtain Locally
Silicone Grease	Oil seal	Coat lips	Obtain Locally

[1] Used in a mixture of 20% SAE30W engine oil and 80% Needle Bearing Lubricant.

Description

Engine Rotation

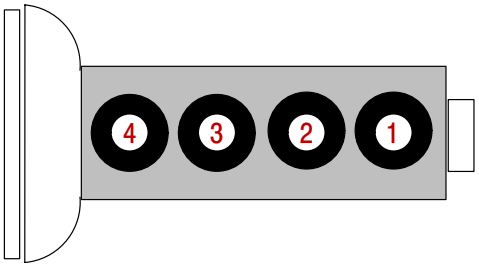
NOTE: *Engine rotation is described when observed from the rear of the engine (transom end) looking forward (water pump end).*



77122

Left-hand Rotation

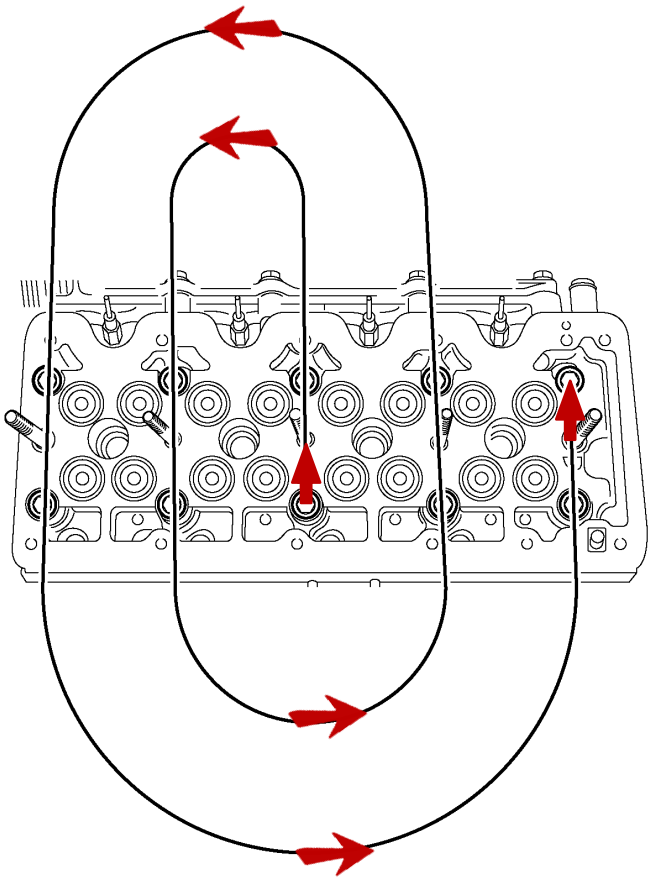
Engine Firing Order



Firing Order: 1 - 3 - 4 - 2

Cylinder Head Torque Sequence And Torque Specifications

IMPORTANT: Lubricate the underside of all bolt heads and threads with clean engine oil.

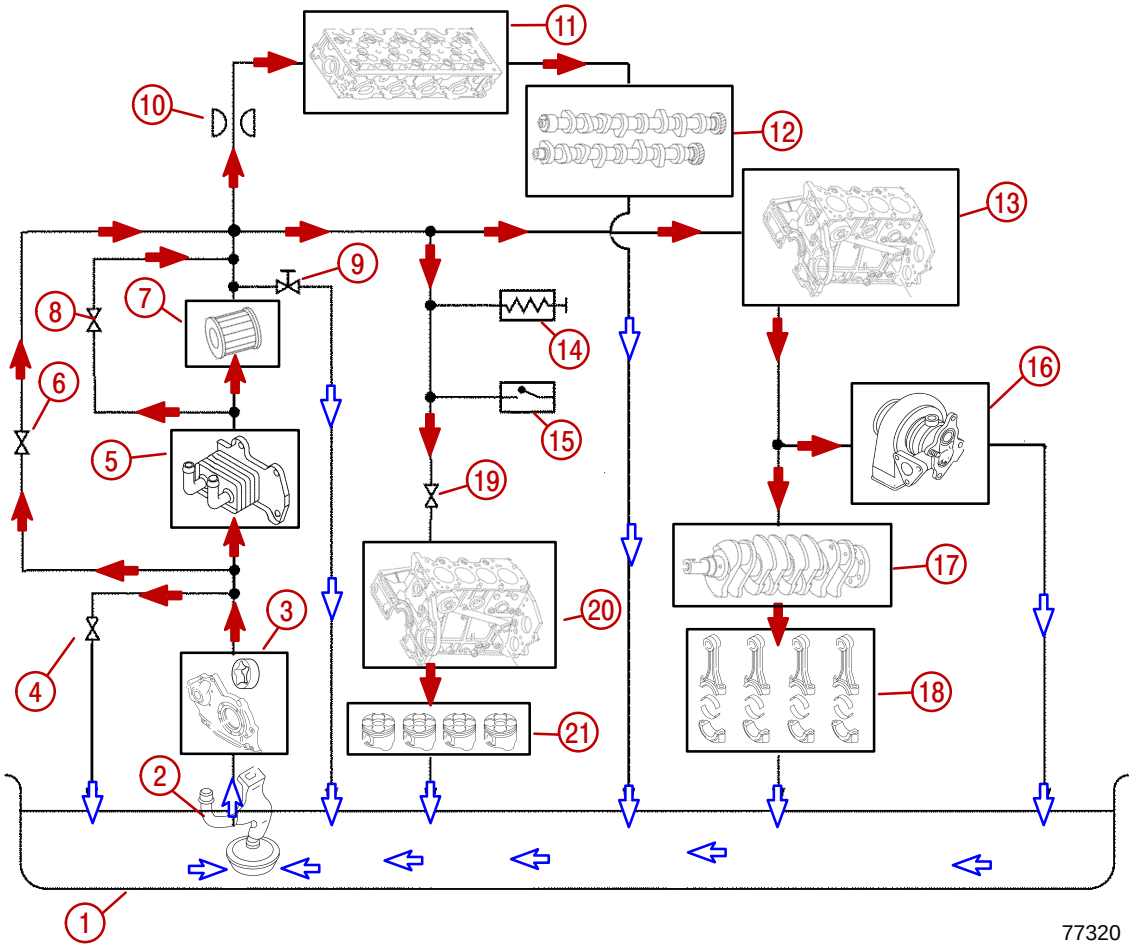


77120

1. **First Pass:** Torque bolts in sequence. Repeat sequence using same specification (to ensure better preload).
2. **Second Pass:** In sequence tighten each bolt through an angle of 60 degrees.
3. **Final Pass:** In sequence tighten each bolt through ANOTHER angle of 60 degrees.

Description		Nm	lb-in.	lb-ft
Bolt, Cylinder Head	M12 x 1.5			
First Pass		39		29
Second Pass		+60 degrees		
Final Pass		+ 60 degrees		

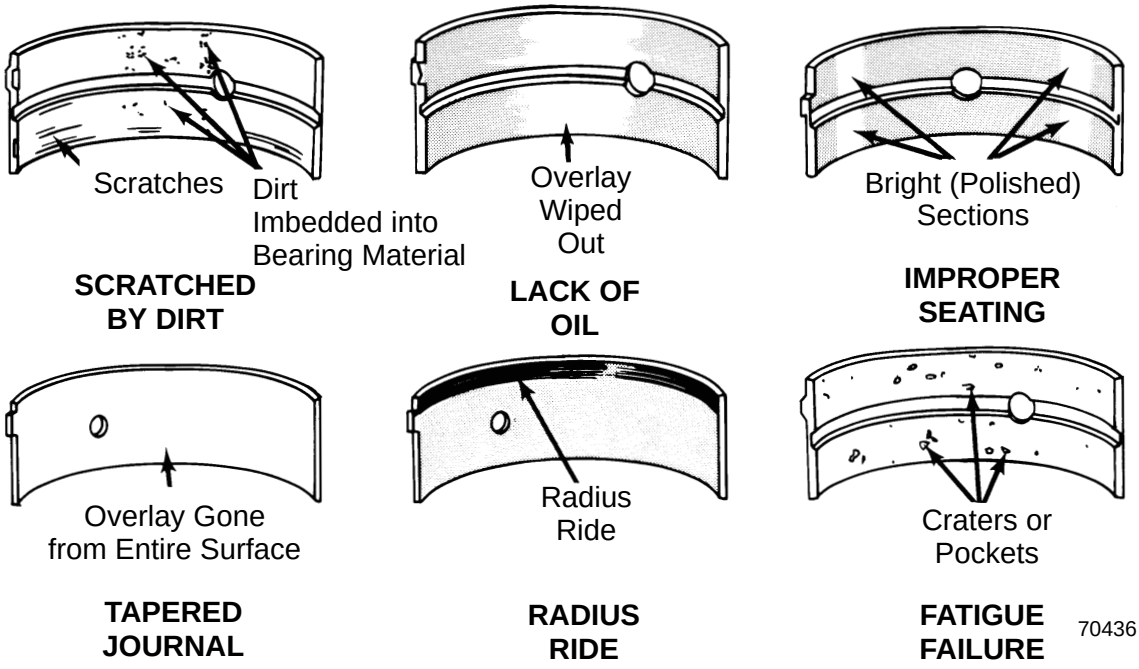
Lubrication Flow Diagram



Unpressured Oil **Pressurized Oil**

1 - Oil Pan
2 - Oil Pickup/Screen
3 - Oil Pump
4 - Relief Valve, 690 kPa (100 psi)
5 - Oil Cooler
6 - Relief Valve, 250 kPa (36 psi)
7 - Oil Filter
8 - Bypass Valve, 98 kPa (14.2 psi)
9 - Oil Drain
10 - Sized Orifice, 1.5 mm (.059 in.)
11 - Cylinder Head Oil Gallery
12 - Camshaft Bearings
13 - Main Oil Gallery
14 - Oil Pressure Sender
15 - Oil Pressure Switch, Opens at 31 - 52 kPa (4.5 - 7.5 psi)
16 - Turbocharger
17 - Crankshaft Bearings
18 - Connecting Rod Bearings
19 - Check Valve, 250 kPa (36 psi)
20 - Sub Oil Gallery
21 - Piston Oiling Jets

Examples of Bearing Failures



Compression Testing Procedure

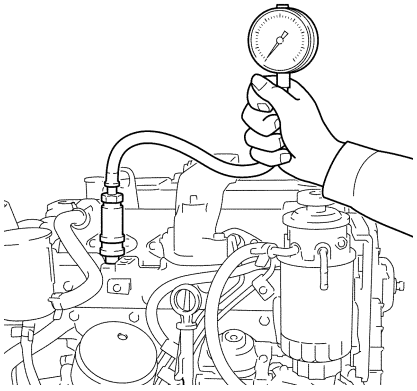
Periodically check engine compression pressure. Lowering of pressure causes loss of power, greater fuel consumption, smoke at the exhaust, low acceleration, unsteady slow idle, difficulty in starting and bearing seizure because of engine overheating.

1. Start engine and allow it to reach normal operating temperature.
2. Stop engine and shut off fuel supply.
3. Ensure that battery is fully charged.

IMPORTANT: To achieve the cranking rpm needed (250 rpm minimum) for a proper compression test it will be necessary to remove all of the glow plugs or hole plugs prior to testing.

4. Remove all glow plugs or plugs in glow plug holes.

5. Clean glow plug bore and install compression tester adapter in Cylinder number 1.



77123

6. Connect gauge to adapter and set gauge to zero reading.

Description	Part Number
Compression Gauge	MT33B

7. Operate starter (engine should be cranking at approximately 250 rpm) and check compression gauge reading.

Description		MPa	psi
Compression at 250 Minimum rpm	Standard	2.8	406
	Limit	2.5	363
Difference Between Cylinders		0.29	42

8. Readings lower than specified, or differences between cylinders greater than specified, indicate engine problems exist (such as faulty rings, valves, cylinders and pistons). Refer to appropriate sections and repair as needed.
9. Remove compression gauge and adapter.
10. Apply anti-seize compound to threads and install glow plugs, or hole plugs if equipped. Torque each glow plug or hole plug.

Description	Where Used	Method of Use	Part Number
Anti-seize Compound	Glow Plugs	Thread length	Obtain Locally

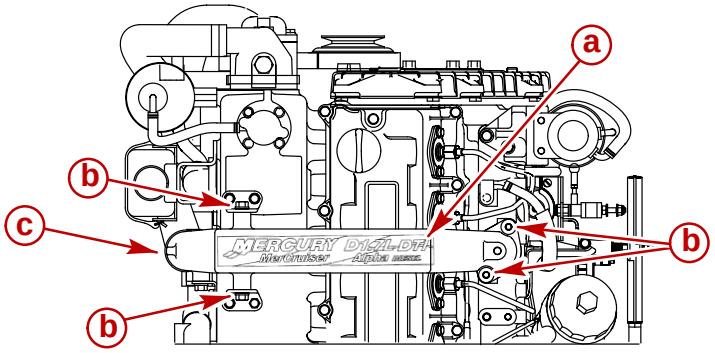
Description	Nm	lb-in.	lb-ft
Glow Plug / Hole Plug	20		15

11. Install electrical connectors on glow plug terminals, if equipped.

Valve Cover

Removal

1. Remove bolts retaining intake manifold air duct to intake manifold and valve cover.
2. Loosen clamps on port side of intake manifold air duct connection hose.
3. Remove intake manifold air duct.



77325

a - Air Duct
b - Bolts
c - Clamps

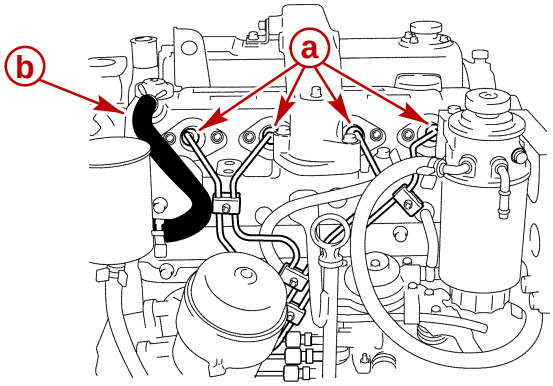
⚠ CAUTION

Safety glasses should be worn while working on fuel injection system. The fuel injection pump will generate pressures in excess of 13,790 - 27,580 kPa (2000 - 4000 psi). Use caution when removing injectors, injector lines or bleeding air from injection system.

⚠ CAUTION

Keep injector and injection pump fittings clean. Do not allow dirt to enter fittings when removing or installing pipes. Dirt will cause injectors or injection pump to malfunction.

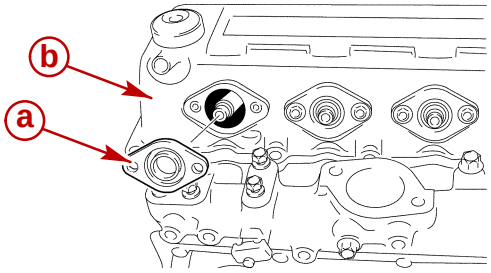
4. Remove fuel injector pipes.
5. Disconnect hose from PCV (Positive Crankcase Ventilation) oil separator.



77314

a - Injector Pipes
b - Hose

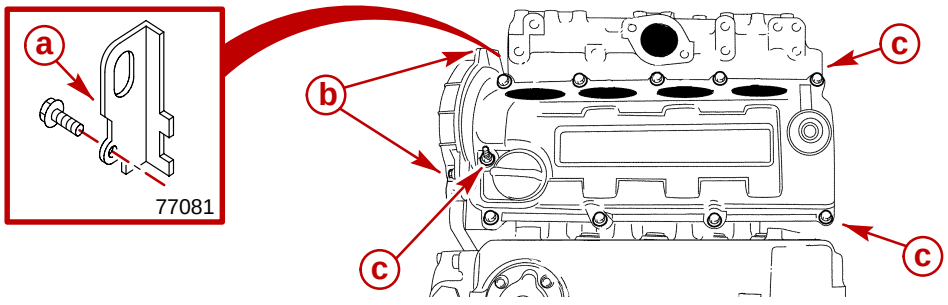
6. Remove injector covers.



77290

a - Injector Cover
b - Valve Cover

7. Remove front lifting eye.
8. Remove top two bolts in upper timing cover.
9. Remove valve cover bolts.
10. Remove valve cover.



77289

a - Lifting Eye
b - Timing Cover Bolts (2)
c - Valve Cover Bolts (9)

Cleaning

1. Clean gasket material and oil from cylinder head sealing surfaces.
2. Clean valve cover and remove gasket material from sealing surfaces.

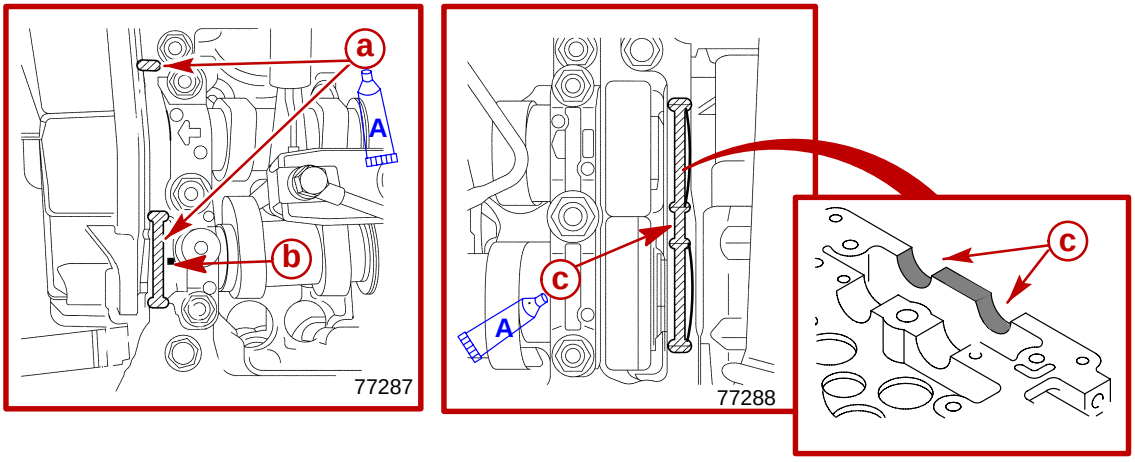
Inspection

1. Inspect sealing surfaces for deep nicks and scratches.
2. Replace or repair parts as needed.

Installation

1. Apply sealant, as shown, to surfaces of the camshaft carrier where indicated.

IMPORTANT: DO NOT cover oil return bore with sealant.



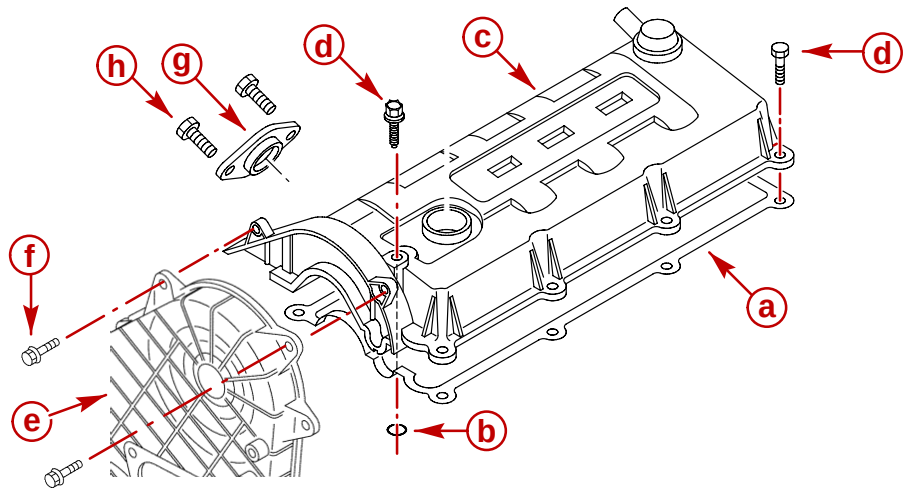
a - Sealant, Front Of Carrier
b - Oil Return Hole
c - Sealant, Half Moon Recess

	Description	Where Used	Method of Use	Part Number
A	Loctite 5699	Between camshaft carrier and valve cover, including half-moon recesses	Apply to sealing surfaces as specified	Obtain Locally

2. Place valve cover gasket on valve cover. Position O-ring seal inside recess in valve cover for valve cover bolt.

NOTE: *O-ring seal is inside cover on brass insert with recess.*

3. Install valve cover on camshaft carrier.
4. Install valve cover bolts. Temporarily hand tighten bolts.
5. Install the two timing cover bolts. Temporarily hand tighten bolts.
6. Install new injector covers on valve cover. Torque bolts.
7. Torque valve cover bolts.
8. Torque upper timing cover bolts.



77081 77372

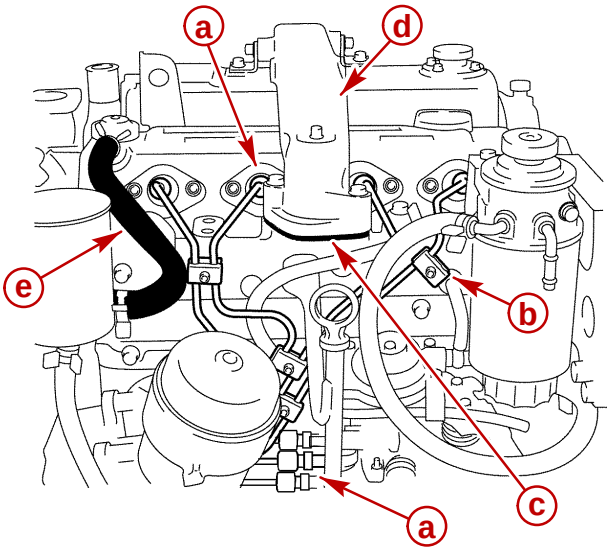
a - Gasket
b - O-ring Seal (Inside Cover)
c - Valve Cover
d - Valve Cover Bolt (9)
e - Timing Cover
f - Timing Cover Bolt (2)
g - Injector Cover
h - Injector Cover Bolt (8)

Description		Nm	lb-in.	lb-ft
Bolt, Valve Cover	M6 x 1.0	9.8	84	
Bolt, Injector Cover	M6 x 1.0	9.8	84	
Bolt, Timing Cover	M6 x 1.0	9.8	84	

⚠ CAUTION

Do not bend fuel injector pipes. Bending may cause metal to flake off inside pipes, causing injectors or injection pump to malfunction.

9. Install injector pipes and torque sleeve nuts.
10. Install injector pipe clamps and torque bolts.
11. Install intake manifold air duct using a new gasket. Torque bolts.
12. Tighten air duct hose clamps securely.
13. Install front engine lifting eye. Torque bolt.
14. Connect hose from PCV oil separator to valve cover.



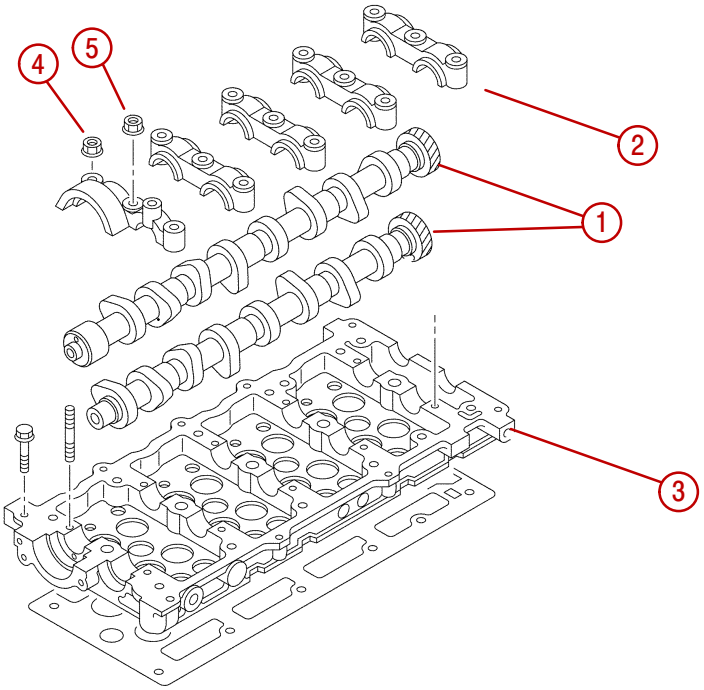
77314

a - Injector Pipes
b - Clamps
c - Gasket
d - Air Duct
e - Hose

Description		Nm	lb-in.	lb-ft
Nut, Injector Pipe Sleeve	M12 x 1.5	20		15
Clamp, Injector Pipe		9.8	84	
Bolt, Intake Manifold Air Duct	M8 x 1.25	19	168	
Bolt, Engine Lifting Eye	M8 x 1.25	25		18

Camshafts

Exploded View

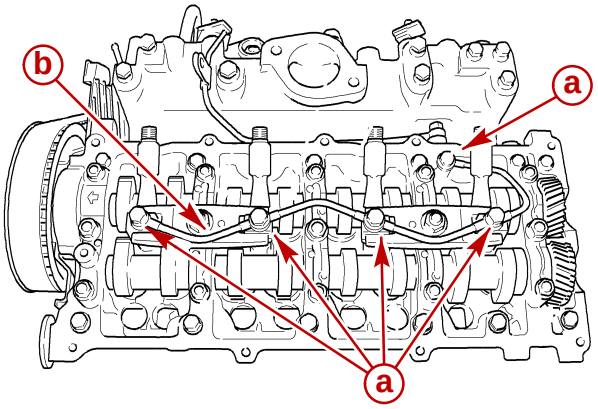


77308

1 - Camshafts
2 - Camshaft Brackets
3 - Camshaft Carrier
4 - Nut, M8
5 - Nut, M10

Removal

1. Remove valve cover.
2. Remove the 5 hollow bolts and seal washers. Remove fuel return inner pipe.



77160

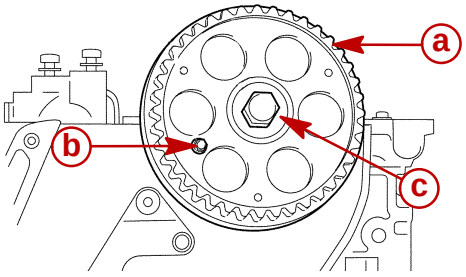
a - Hollow Bolts
b - Fuel Return Inner Pipe

3. Remove fuel injectors.
4. Remove timing belt covers.

⚠ CAUTION

Avoid engine damage. Ensure that engine is on TDC and timing marks are properly aligned.

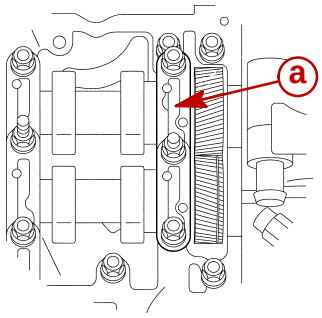
5. Remove timing belt.
6. Hold the camshaft pulley with TDC alignment bolt and remove camshaft pulley bolt.
7. Remove TDC alignment bolt and remove camshaft pulley.



77163

a - Camshaft Pulley
b - TDC Alignment Bolt, M6
c - Camshaft Pulley Bolt

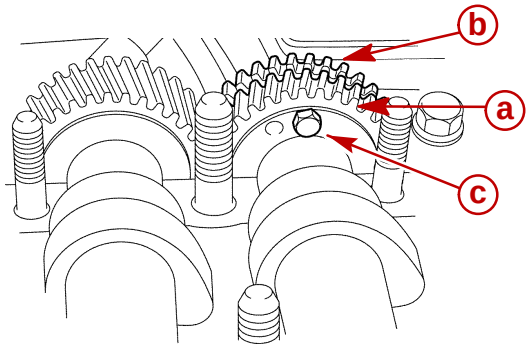
8. Remove the rear camshaft bracket.



77166

a - Rear Camshaft Bracket

9. Lock exhaust camshaft gear and sub gear together with the locking pin.

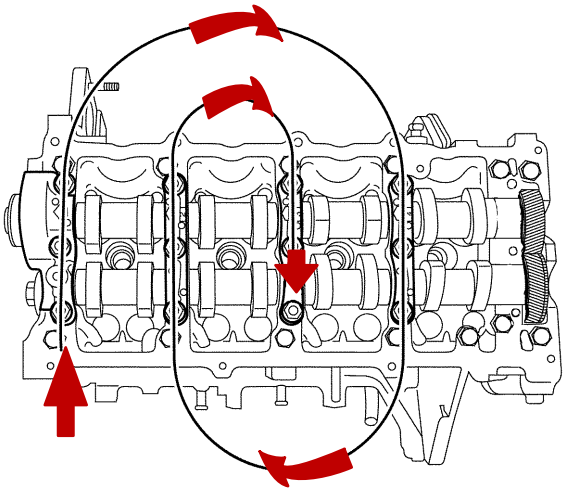


77166

a - Camshaft Gear
b - Sub Gear
c - Locking Pin (4 x 16 mm)

10. Loosen remaining camshaft bracket nuts in a spiral pattern, as shown, in stages of 1/2 to 1 turn at a time.

IMPORTANT: Camshaft brackets are numbered from one to five. Cast arrows in brackets point to front of engine. Note location and references before removing.



77167

Camshaft Bracket Loosening Pattern

Cleaning

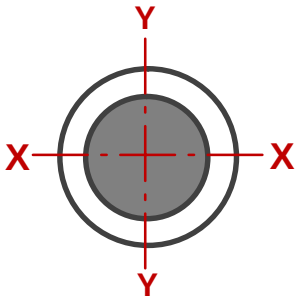
1. Clean camshafts with solvent and dry with compressed air.
2. Clean gasket surfaces and remove sealant residue.

Inspection

1. Check camshafts for wear and replace as necessary.
2. Check bearing brackets for wear and replace as necessary.

CAMSHAFT JOURNAL DIAMETER

1. Use a micrometer to measure each camshaft journal diameter in two directions (X-X) and (Y-Y). If the measured value is less than specified, the camshaft must be replaced.

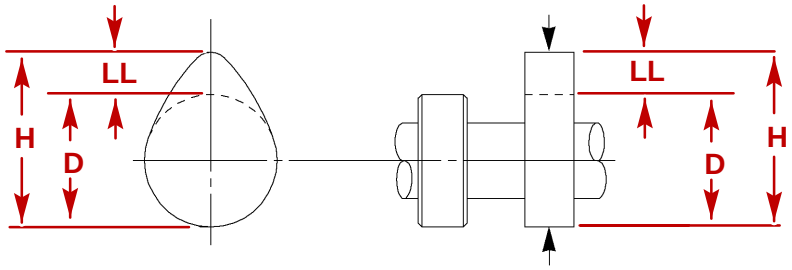


79687

Description		mm (in.)
Journal Diameter	Production	26.939 - 26.960 (1.0605 - 1.0614)
	Limit	26.92 (1.0598)

CAMSHAFT HEIGHT

1. Measure the total cam height (**H**) with a micrometer. Subtract the lobe diameter (**D**). The difference is lobe lift (LL). If the lobe lift is less than the specified limit, the camshaft must be replaced.

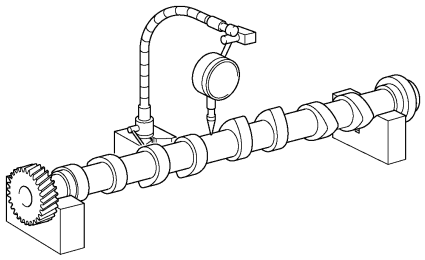


77207

Description		mm (in.)
Lobe Lift (**H** – **D** = **LL**)	Production-Intake	7.80 (0.307)
	Limit-Intake	7.68 (0.302)
	Production-Exhaust	7.95 (0.312)
	Limit-Exhaust	7.77 (0.306)

CAMSHAFT RUNOUT

1. Mount the camshaft on V-blocks.
2. Measure the runout with a dial indicator.
3. If the runout exceeds the specified limit, the camshaft must be replaced.



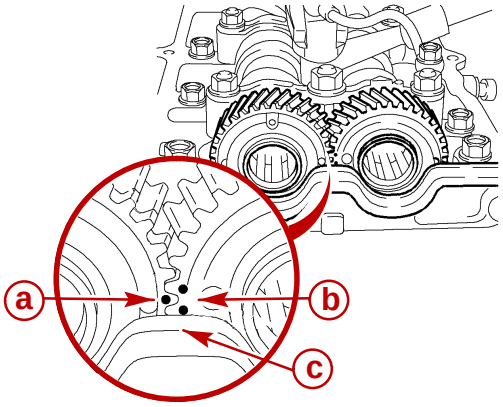
77208

Description		mm (in.)
Camshaft Runout	Production	0.03 (0.0011)
	Limit	0.05 (0.0019)

CLEARANCE BETWEEN JOURNAL AND CAMSHAFT BRACKET

1. Clean the camshaft journals and camshaft brackets.
2. Position camshafts in camshaft carrier. The mark on exhaust camshaft should be between the two marks on intake camshaft and approximately level with upper edge of camshaft carrier.

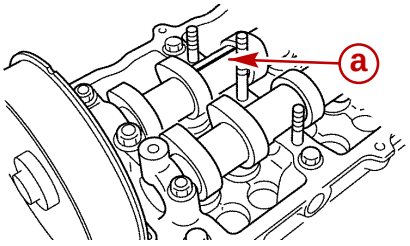
IMPORTANT: Ensure that engine is on TDC and timing marks are properly aligned.



77254

a - Exhaust Camshaft Mark
b - Intake Camshaft Marks
c - Upper Edge Of Carrier

3. Place Plastigage across the full width of the camshaft journals.

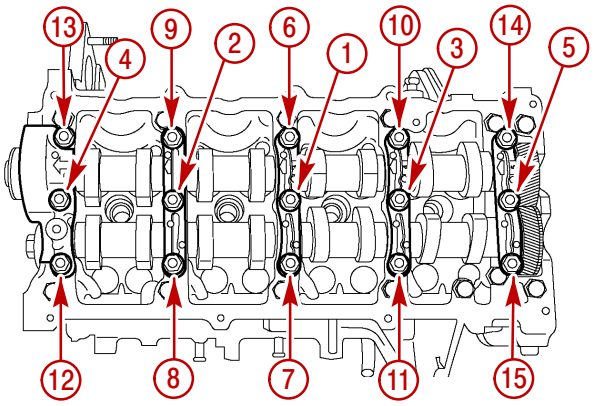


77209

a - Plastigage

4. Install the brackets. Tighten camshaft bracket nuts in sequence shown, in stages of 1/2 to 1 turn at a time. Torque nuts.

IMPORTANT: Do not allow the camshaft to turn during bracket installation and tightening.

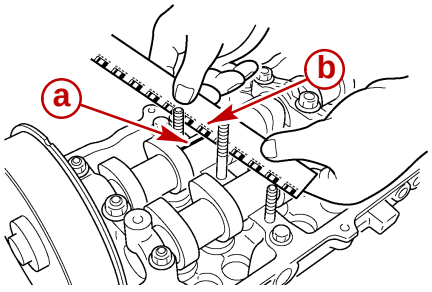


77284

Camshaft Torque Sequence

Description		Nm	lb-in.	lb-ft
Nut, Camshaft Bracket	M8x1.25	22		16
Nut, Camshaft Bracket	M10x1.25	43		32

5. Remove camshaft brackets and compare the width of the Plastigage against the scale printed on the Plastigage container.
6. If clearance between cam journal and bracket exceeds the limit, the camshaft and/or camshaft carrier assembly must be replaced.



77210

a - Plastigage
b - Scale

Description		mm (in.)
Clearance between journal and bracket bearing surface	Production	0.040 - 0.082 (.0015 - 0.0032)
	Limit	0.110 (.0043)

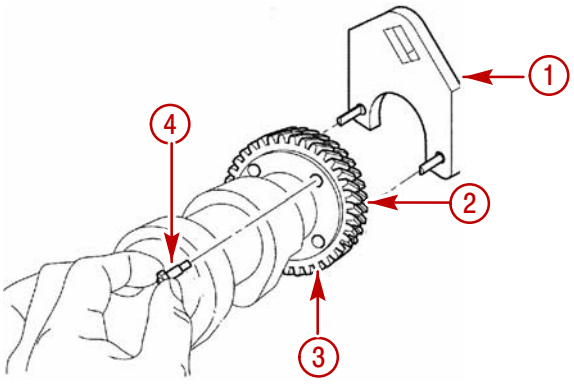
Installation

⚠ CAUTION

To avoid severe engine damage the engine MUST BE set on cylinder number 1 COMPRESSION STROKE at TDC before proceeding.

1. Ensure that engine is on TDC of cylinder number 1 compression stroke.
2. **When using existing exhaust camshaft:** Coat camshaft journals and lobes with clean engine oil.

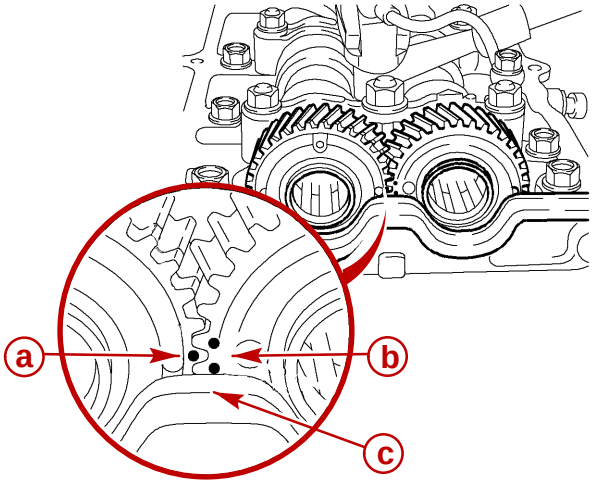
NOTE: When replacing the exhaust camshaft or if locking pin is removed prior to reassembly: *The exhaust camshaft sub gear must be pre–tensioned using special tool 91–883853 and connected to the exhaust camshaft gear using the adjusting pin.*



1 - Locking Tool 91–883853
2 - Exhaust Camshaft Sub Gear
3 - Exhaust Camshaft Gear
c - Adjusting Pin

3. Position camshafts in cam carrier. The mark on exhaust camshaft should be between the two marks on intake camshaft and approximately level with upper edge of camshaft carrier.

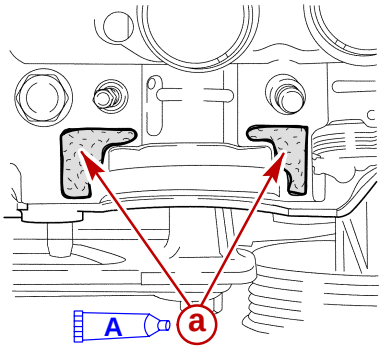
IMPORTANT: Ensure that engine is on TDC and timing marks are properly aligned.



77254

a - Exhaust Camshaft Mark
b - Intake Camshaft Marks
c - Upper Edge Of Carrier

4. Apply sealant to sealing surfaces between carrier and front camshaft bracket.



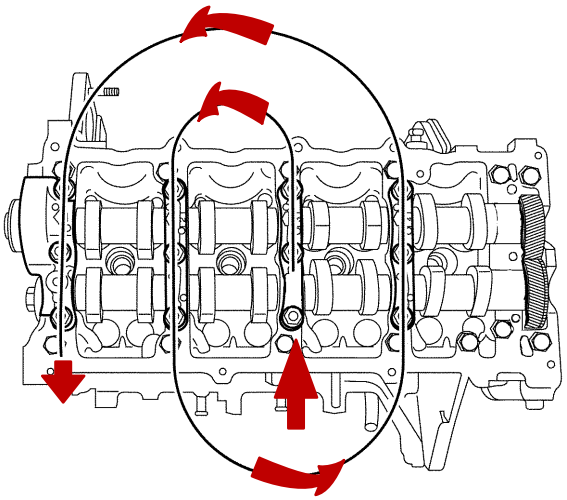
77255

a - Sealant

Description		Where Used	Method of Use	Part Number
A	Loctite 5699	Between carrier and front camshaft bracket	Apply to contact surfaces as indicated	Obtain Locally

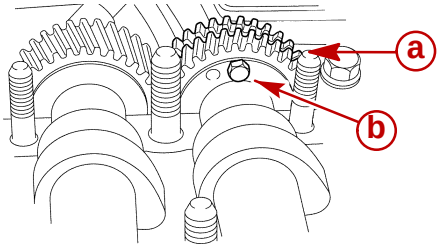
5. Install camshaft brackets 1 through 4. Tighten camshaft bracket nuts in a spiral pattern, as shown, in stages of 1/2 to 1 turn at a time, until hand tight.

NOTE: *Arrows on individual camshaft brackets point to front of engine.*



77167

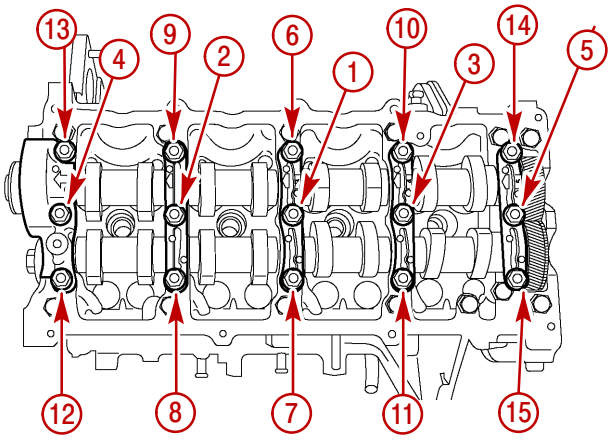
6. Remove locking pin from exhaust camshaft gear.



77166

a - Camshaft Gears
b - Locking Pin

7. Install camshaft bracket number 5.
8. Torque M8 nuts and M10 nuts in sequence.

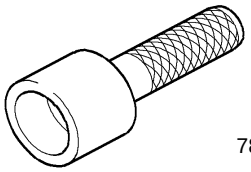


77284

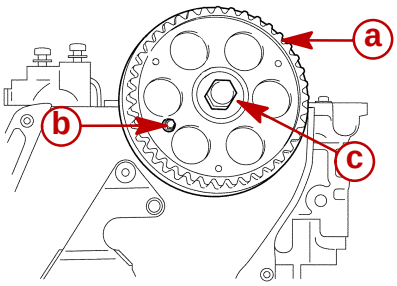
Camshaft Bracket Torque Sequence

Description		Nm	lb-in.	lb-ft
Nut, Camshaft Bracket	M8 x 1.25	22		16
Nut, Camshaft Bracket	M10 x 1.25	43		32

9. Install a new camshaft seal in camshaft carrier using special tool 91–883855.

Installer / Oil Seal	91-883855
Description: Installs the camshaft oil seal.	 78049

10. Install camshaft pulley and camshaft pulley bolt.
11. Install TDC alignment bolt. Torque camshaft pulley bolt.



77163

a - Camshaft Pulley
b - TDC Alignment Bolt (M6)
c - Camshaft Pulley Bolt

Description	Nm	lb-in.	lb-ft
Bolt, Camshaft Pulley	64		47

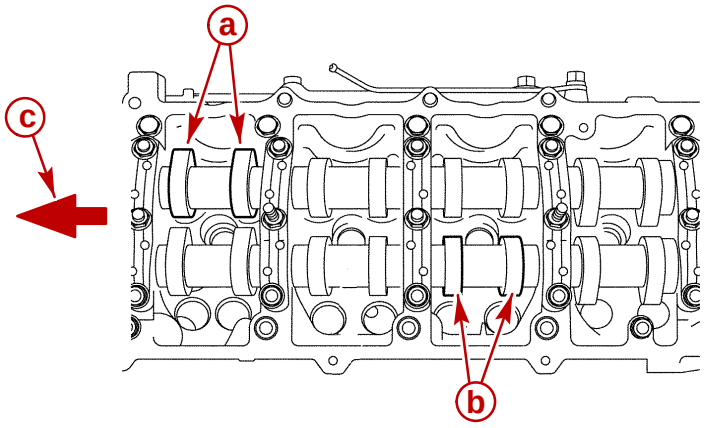
12. Inspect and adjust valve clearance.
13. Install fuel injectors with new O-rings and new gaskets.
14. Install fuel return inner pipe using hollow bolts with new seal washers.
15. Install valve cover.
16. Install injection pipes and related fuel components.
17. Install timing belt.
18. Install timing belt covers.

Valve Clearance

The valve clearances are checked on a cold engine.

INSPECTION

1. Remove intake air duct.
2. Remove valve cover.
3. Remove fuel injectors.
4. Turn engine in direction of engine rotation to cylinder number 1 TDC.
5. Continue to turn crankshaft in direction of engine rotation until camshaft pairs **"a"** and **"b"** point upwards. These valves are then closed and can be checked.



77124

a - Cylinder Number 1 Intake Camshaft Lobes
b - Cylinder Number 3 Exhaust Camshaft Lobes
c - Arrow Points To Front Of Engine

6. Check the valve clearance using a feeler gauge.

Description		mm (in.)
Valve Clearance	Intake	0.35 - 0.45 (0.014 - 0.018)
	Exhaust	0.45 - 0.55 (0.18 - 0.021)

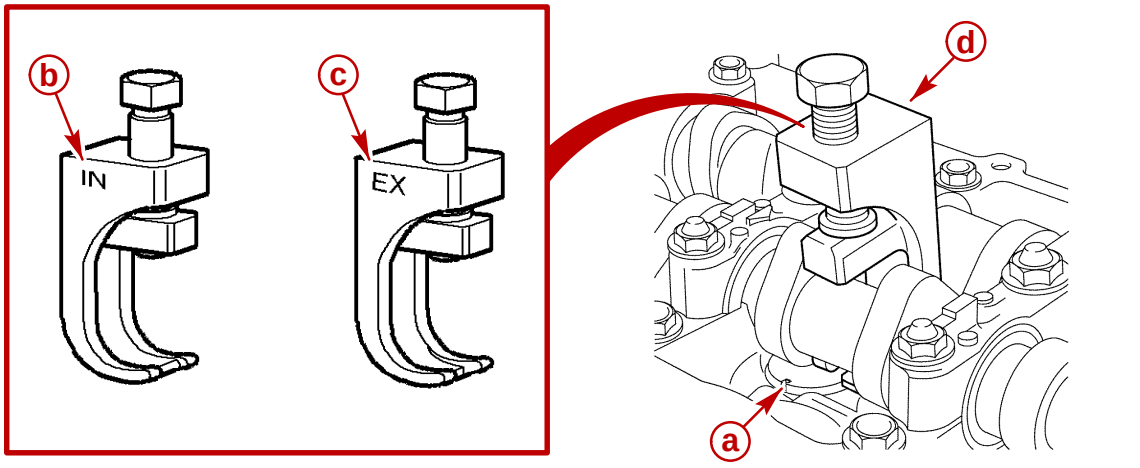
ADJUSTMENT

⚠ CAUTION

Avoid possible severe engine damage. Ensure that the valves are NOT adjusted when the pistons are at Top Dead Center (TDC). The valves can strike the pistons if adjusted with the pistons at TDC.

1. Turn camshaft follower (cup with shim) until follower groove points out.
2. Press down camshaft follower using appropriate special tool.

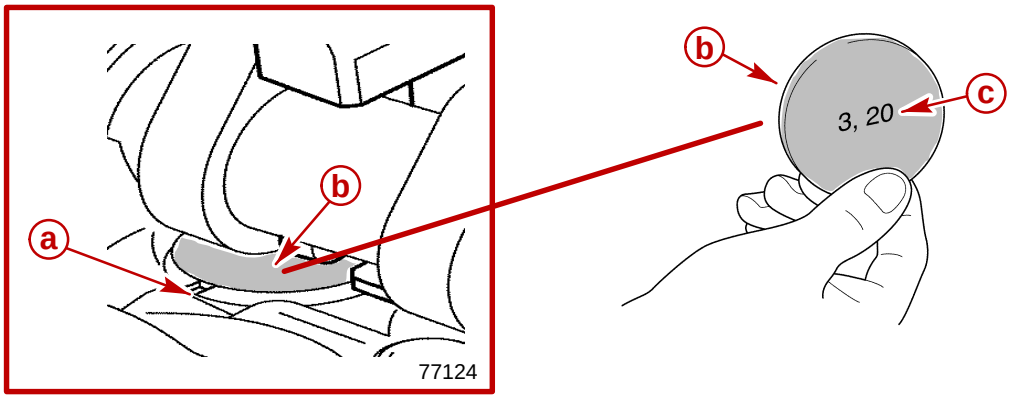
NOTE: *Different tool versions for exhaust and intake valves.*



77124

a - Follower Groove - Pointing To Outside
b - Intake Tool
c - Exhaust Tool
d - Special Tool Installed

3. Lever shim out from camshaft follower groove using a small screwdriver or similar.
4. Remove shim.



77125

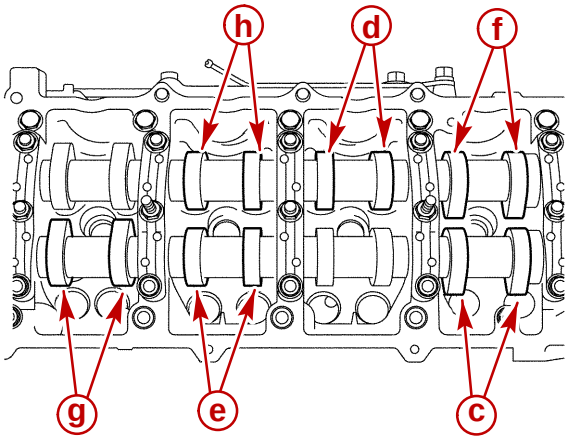
a - Follower Groove
b - Shim
c - Thickness Inscription In mm

5. Calculate the thickness of the shim necessary to obtain specified clearance. To do so, add the current measured clearance A to the thickness of the current shim B. Then, subtract from that sum C the desired clearance D. The difference between them is the thickness of shim needed E.

Example for determination of shim thickness:

Current measured clearance	**A**	0.45 mm (0.018 in.)
Thickness of installed shim	**+ B**	3.15 mm (0.124 in.)
Sum of **A** + **B**	**= C**	3.60 mm (0.142 in.)
Sum of **A** + **B**	**C**	3.60 mm (0.142 in.)
Valve clearance desired	**– D**	0.40 mm (0.016 in.)
Thickness of shim needed	**= E**	3.20 mm (0.126 in.)

6. Coat needed shim with clean engine oil and insert in camshaft follower with thickness inscription facing downwards.
7. Complete adjustments as follows:
   a. Turn the crankshaft 180° in direction of engine rotation - check and adjust valve pair **“c”** and **“d”**.
   b. Turn the crankshaft 180° in direction of engine rotation - check and adjust valve pair **“e”** and **“f”**.
   c. Turn the crankshaft 180° in direction of engine rotation - check and adjust valve pair **“g”** and **“h”**.



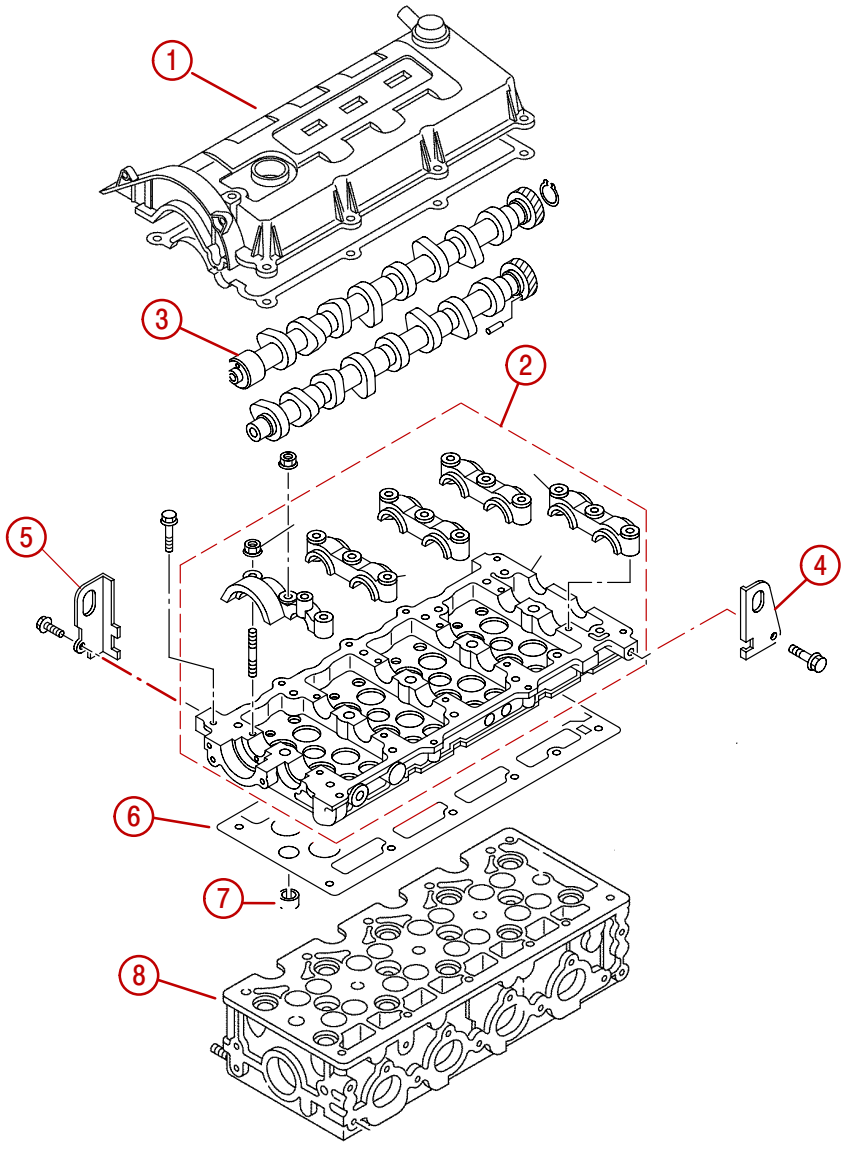
77126

Valve Pairs For Adjusting

8. Ensure proper valve clearance by re-checking all adjusted valves.
9. Install the fuel injectors.
10. Install the valve cover.
11. Install the injection pipes and related fuel components.
12. Install the intake air duct.

Camshaft Carrier

Exploded View

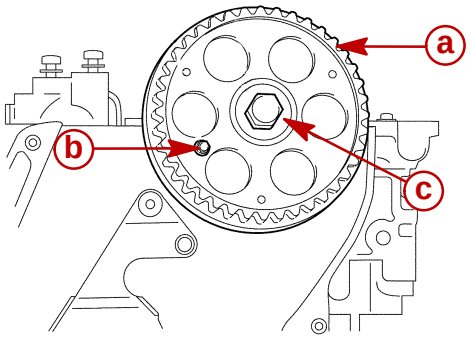


77311

1 - Valve Cover
2 - Camshaft Carrier And Brackets
3 - Camshafts
4 - Rear Lifting Eye
5 - Front Lifting Eye
6 - Carrier Gasket
7 - Dowel
8 - Cylinder Head

Removal

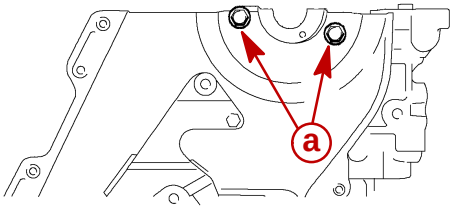
1. Remove valve cover.
2. Remove fuel return inner pipe.
3. Remove injectors.
4. Ensure that engine is on cylinder number 1 TDC and timing marks are properly aligned.
5. Remove timing covers and timing belt.
6. Hold the camshaft pulley with TDC alignment bolt and remove camshaft pulley bolt.
7. Remove TDC alignment bolt and remove camshaft pulley.



77163

a - Camshaft Pulley
b - TDC Alignment Bolt (M6)
c - Camshaft Pulley Bolt

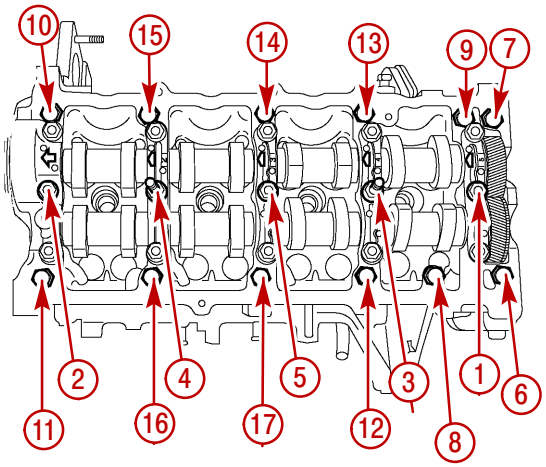
8. Remove upper dust cover bolts in front.



77164

a - Upper Dust Cover Bolts

9. Loosen all camshaft carrier bolts and nuts1/2 turn at a time in numbered sequence; then remove bolts and nuts.



77165

Camshaft Carrier Bolt Removal Sequence

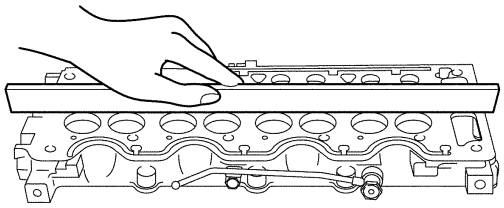
10. Remove camshaft carrier from cylinder head.
11. Discard old gasket.

Cleaning

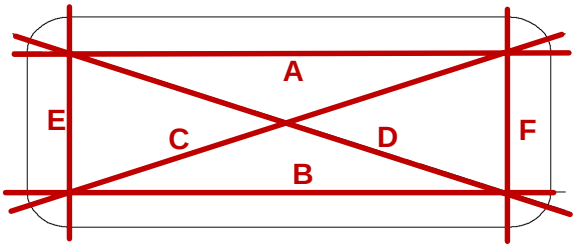
1. Clean all sealing surfaces.
2. Remove sealant residue.

Inspection

1. Using a straight edge and feeler gauge, check the bottom surface of camshaft carrier for straightness.
2. Measure the four sides (**A, B, E, F**) and the two diagonals (**C, D**).



77187



77188

Description		mm (in.)
Camshaft Carrier Lower Face Warp	Production	Less Than 0.05 (.002)
	Limit	0.05 (.0019)

3. Replace camshaft carrier if warp is greater than limit.
4. Measure height of camshaft carrier (sealing surface to sealing surface)

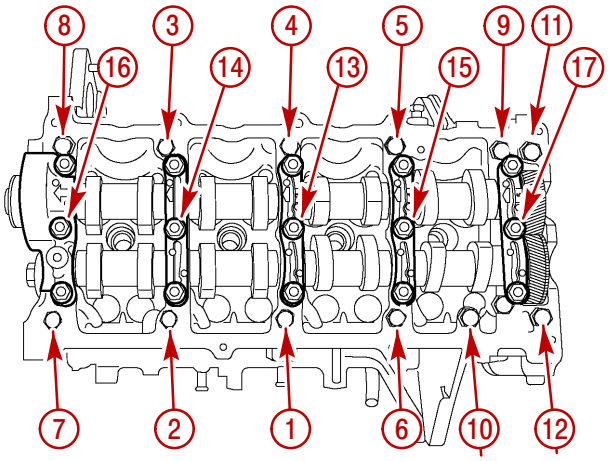
Description		mm (in.)
Camshaft Carrier Height	Production	29.62 (1.166)

5. Replace camshaft carrier if height is less than production specification.

Installation

IMPORTANT: Refer to Camshafts - Installation, in this Section, for proper sealing and installation of camshafts and brackets if removed previously.

1. Ensure that engine and camshafts are set on cylnder number 1 TDC and timing marks are properly aligned.
2. Install camshaft carrier on cylinder head using a new gasket.
3. Tighten all camshaft carrier bolts and nuts in steps of 1/2 to 1 turn in sequence. Torque bolts and nuts in sequence.

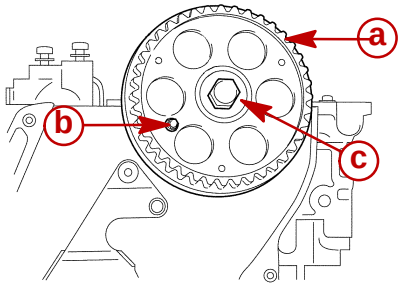


77284

Camshaft Carrier Torque Sequence

Description		Nm	lb-in.	lb-ft
Bolt, Camshaft Carrier	M8 x 1.25	22	–	16
Nut	M10 x 1.25	43		32

4. Install camshaft pulley.
5. Install TDC alignment bolt and torque camshaft pulley bolt.



77163

a - Camshaft Pulley
b - TDC Alignment Bolt
c - Camshaft Pulley Bolt

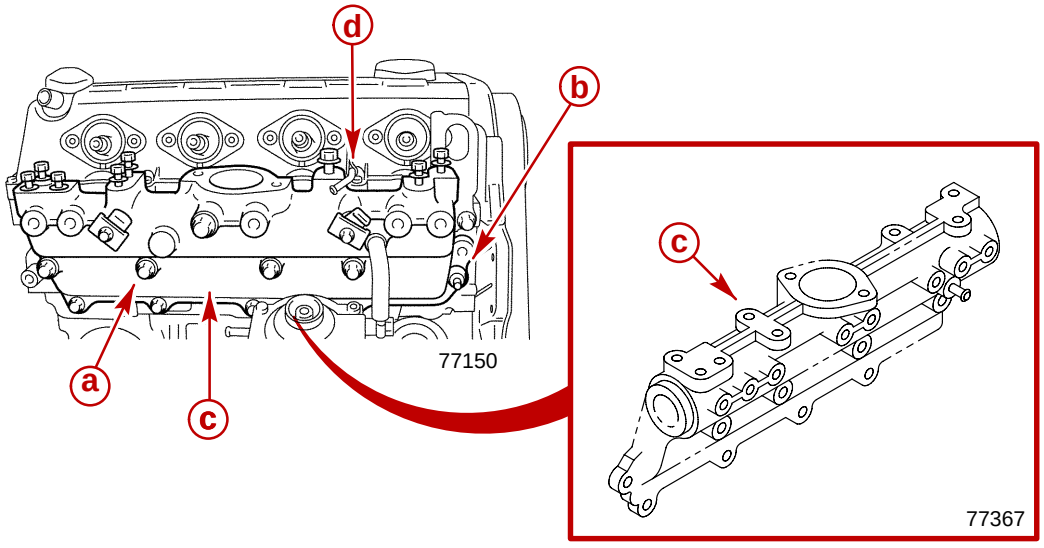
Description	Nm	lb-in.	lb-ft
Bolt, Camshaft Pulley	64		47

6. Install timing belt and timing covers.
7. Install injectors and fuel return inner pipe.
8. Install valve cover.

Intake Manifold

Removal

1. Remove the air duct from intercooler to intake manifold.
2. Disconnect fuel supply hose. Plug hose to prevent fuel from leaking into boat
3. Disconnect fuel return hose.
4. Remove fuel filter and bracket.
5. Remove fuel injector pipes.
6. Remove fuel injection pump.
7. Remove air cleaner and PCV oil separator bracket.
8. Disconnect oil dipstick tube from intake manifold.
9. Disconnect fuel return pipe clip.
10. Remove the intake manifold.



a - Bolt
b - Nut
c - Intake Manifold
d - Fuel Return Pipe Clip

11. Discard old gasket.

Clean

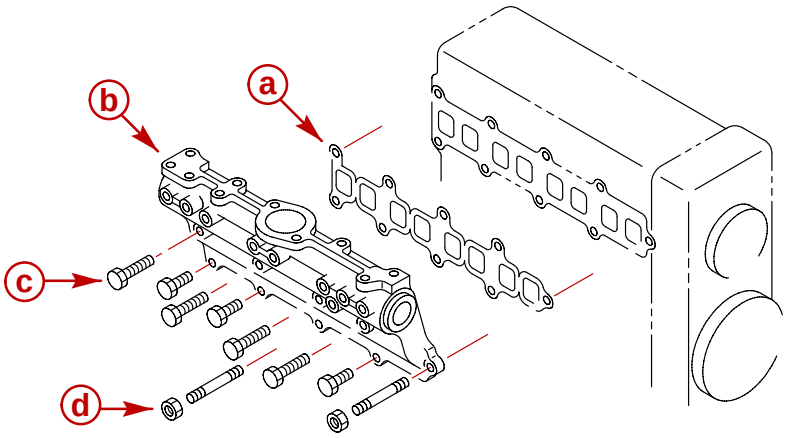
1. Clean with solvent and dry with compressed air.
2. Remove sealant residue and clean sealing surfaces.

Inspection

1. Inspect for cracks. Replace if cracked.
2. Ensure sealing surfaces are smooth and clean.

Installation

1. Install a new gasket and the intake manifold.
2. Tighten the fastening bolts and nuts in a cross pattern. Continuing the pattern, torque fasteners.



77291

a - Gasket
b - Intake Manifold
c - Bolts, M8 x 1.25
d - Nuts, M8 x 1.25

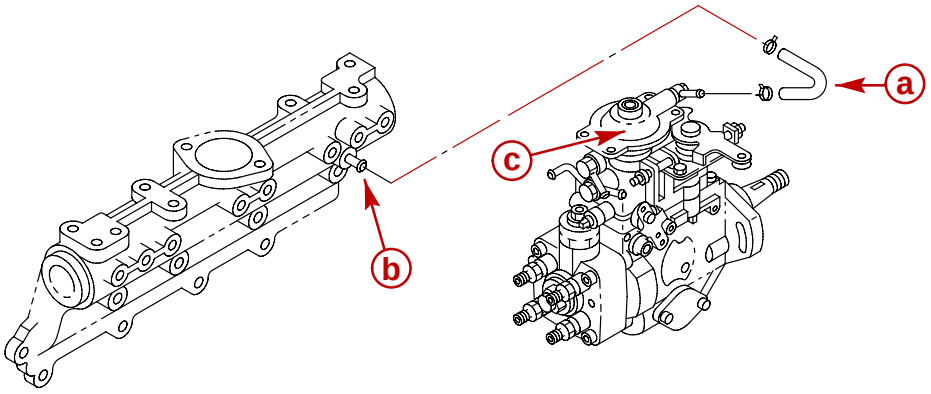
Description		Nm	lb-in.	lb-ft
Bolt / Nut, Intake Manifold	M8 x 1.25	25		18

3. Reconnect fuel return pipe clip to manifold. Torque bolt.

Description	Nm	lb-in.	lb-ft
Bolt, Fuel Return Pipe Clip	9.8	87	

4. Install fuel injection pump, fuel injector pipes and pressure hose. Refer to **Section 5**.

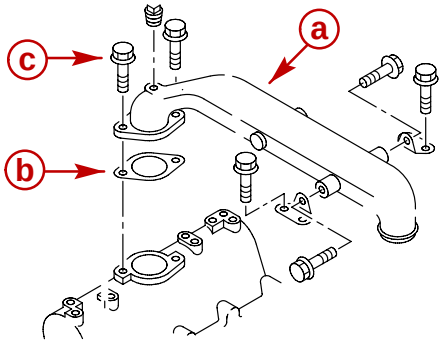
IMPORTANT: Ensure pressure hose from manifold fitting to boost compensator device on the injection pump is connected.



77367

a - Pressure Hose
b - Manifold Fitting
c - Boost Compensator

5. Install the intake manifold air duct with new gasket. Torque bolts.



77368

a - Air Duct
b - Gasket
c - Bolt

Description		Nm	lb-in.	lb-ft
Bolt, Air Duct	M8 x 1.25	19	168	

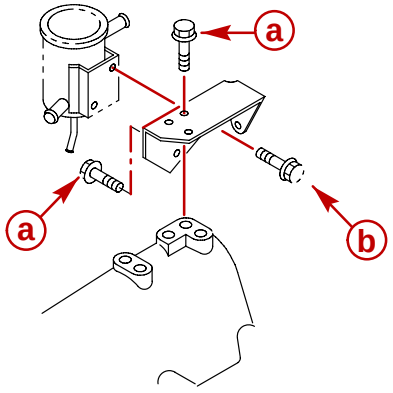
6. Install fuel filter and bracket. Torque bolts.

Description		Nm	lb-in.	lb-ft
Bolt, Filter Bracket	M8 x 1.25	19	168	

7. Unplug and connect fuel supply hose to filter inlet fitting.
8. Connect fuel return hose to filter.
9. Connect oil dipstick tube bracket to intake manifold. Torque bolt.

Description		Nm	lb-in.	lb-ft
Bolt, Dipstick Tube Bracket	M8 x 1.25	19	168	

10. Install bracket for air cleaner and oil separator.



77299

a - Bolt, Bracket (5)
b - Bolt, Oil Separator (2)

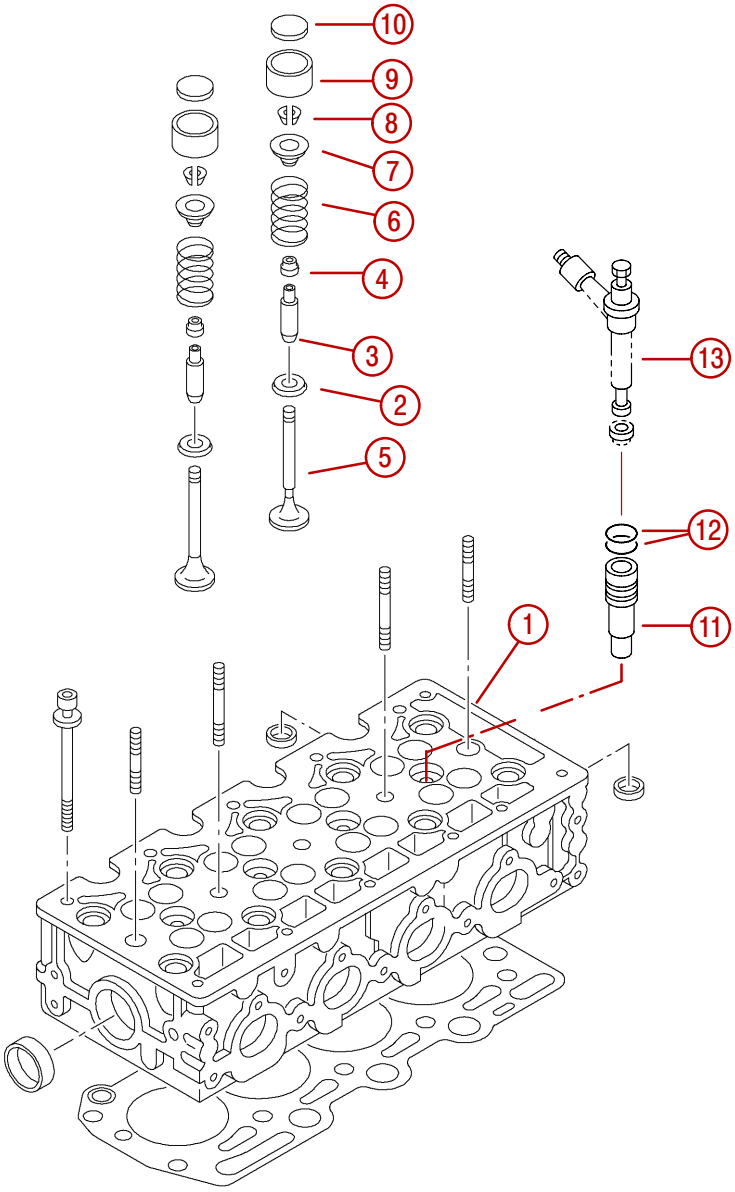
Description		Nm	lb-in.	lb-ft
Bolt, Bracket	M8 x 1.25	19	168	
Bolt, PCV	M8 x 1.25	19	168	

11. Connect hoses.

Cylinder Head

IMPORTANT: If a cylinder head is damaged, replacement cylinder heads are only available as assemblies complete with valve components. These complete cylinder head assemblies will fit all early model and later model engines.[1] Valve components from early model cylinder heads cannot be used on these later model complete cylinder head assemblies.

Exploded View



77236

1 - Cylinder Head
2 - Valve Spring Lower Seat
3 - Valve Guide
4 - Valve Stem Oil Seal
5 - Valve
6 - Valve Spring
7 - Valve Spring Retainer
8 - Split Collar
9 - Camshaft Follower
10 - Valve Shim
11 - Injector Sleeve
12 - Sleeve O-rings (2)
13 - Injector

Removal

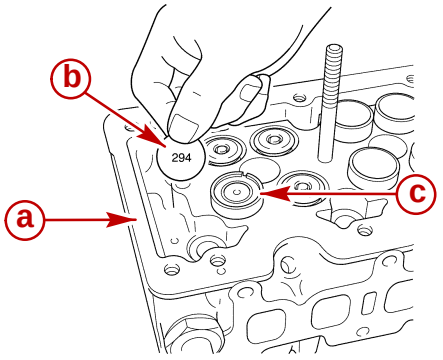
IMPORTANT: To avoid distorting cylinder head, remove head only when engine is cold.

1. Remove valve cover.

IMPORTANT: Ensure that engine is on cylinder number 1 TDC and timing marks are properly aligned before removing timing belt.

2. Remove timing covers and timing belt.
3. Remove camshaft carrier.
4. Remove valve shims and camshaft followers.

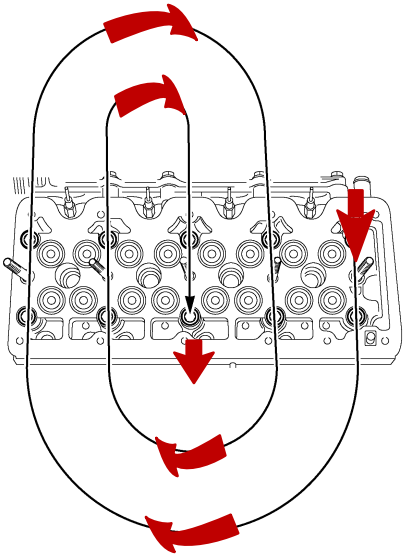
IMPORTANT: The valve shims are used to adjust valve clearance. Be sure to keep each valve shim and its corresponding camshaft follower together. Mark each camshaft follower location. They must be reinstalled in their original locations.



77241

a - Cylinder Head
b - Valve Shim
c - Camshaft Follower

5. Loosen cylinder head bolts in a spiral pattern, as shown, in stages of 1/2 to 1 turn until all are loose. Remove bolts.



77120

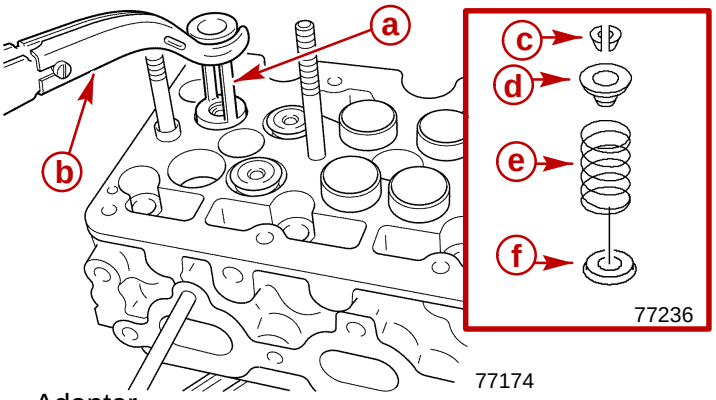
6. Remove cylinder head.

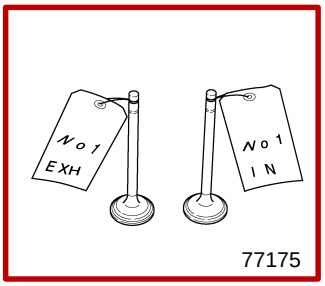
IMPORTANT: On engines equipped with glow plugs, remove glow plugs, lay cylinder head on its side or support on wooden blocks to avoid damage to glow plugs.

Disassembly

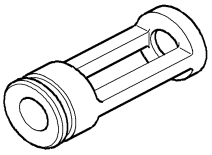
IMPORTANT: Mark location of all valve components; they must be reinstalled in their original locations.

1. Using valve spring compressor and Adapter, carefully remove split collars, retainer, spring and spring seat for each valve. Place valves in numbered rack according to their position in the engine or label the parts in order for reassembly to the original location.

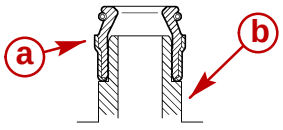




a - Adapter
b - Valve Spring Compressor
c - Split Collars
d - Retainer
e - Spring
f - Spring Seat

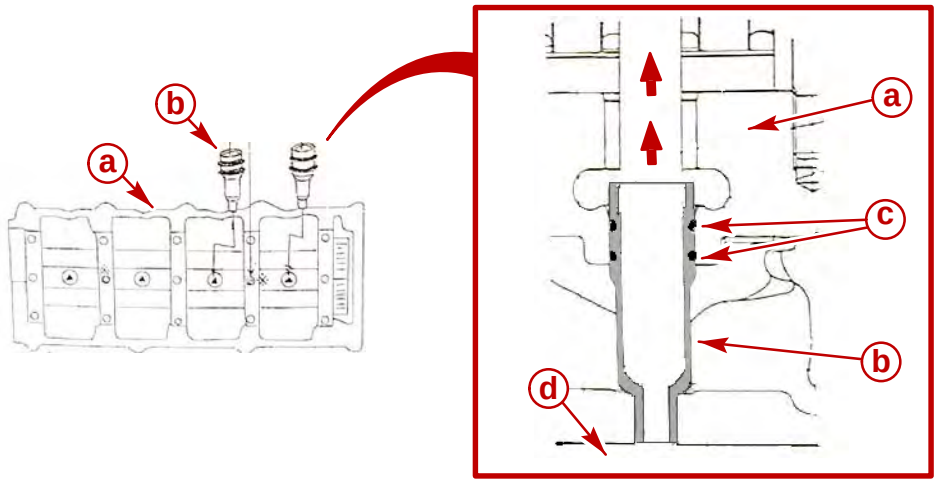
Adapter	**91-883845**
Description: Used in combination with typical valve spring compressor to compress valve spring	 78039

2. Remove valve seals from valve guides.



a - Valve Seal
b - Valve Guide

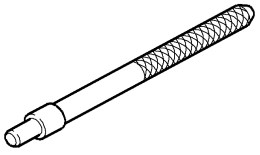
3. Using the special remover tool and a hammer, drive the injector sleeves out of the cylinder head from the combustion chamber side.
4. Remove and discard the 2 O-rings.



77800

Cross-Section Of Injector Sleeve In Cylinder Head

- **a** - Cylinder Head
- **b** - Injector Sleeve
- **c** - O-ring
- **d** - Combustion Chamber Side

Remover	**91-883856**
Description: Removes injector sleeve	 78050

Cleaning

1. Being careful not to damage the aluminum head, clean carbon deposits, residues and gasket material from combustion chambers and sealing surfaces.
2. Using wire wheel, remove carbon deposits from valves.
3. Wash head and components in cleaning solvent. Dry with compressed air.
4. Clean head bolt holes in engine block with a thread cleaning tool.

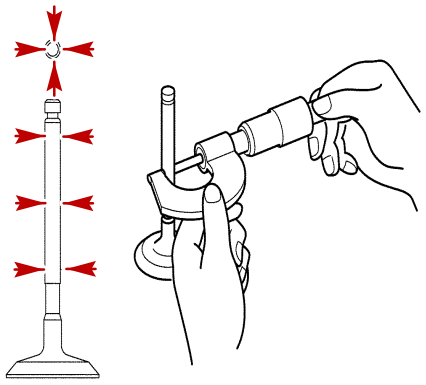
Inspection

GENERAL

1. Inspect glow plug seats for damage.
2. Inspect injector sleeves for leakage or damage.
3. Inspect injector sleeve bores in cylinder head for damage.
4. Inspect all gasket surfaces for deep grooves or pitting.
5. Inspect valve seats for cracks, excessive wear and looseness in counterbore.
6. Inspect valves for cracks, excessive wear and bent stems.
7. Inspect valve springs for discoloration due to excessive heat.
8. Inspect valve guides for cracks or chips. Inspect valve guide bores for seizure marks, carbon deposits or scoring. Inspect valve guide height.
9. Inspect valve spring keepers, retainers and spring seats for wear, distortion and cracks.
10. Inspect valve shims for pitting, cracking and discoloration due to excessive heat.
11. Inspect combustion chamber for melting of aluminum by faulty fuel injectors.

VALVES

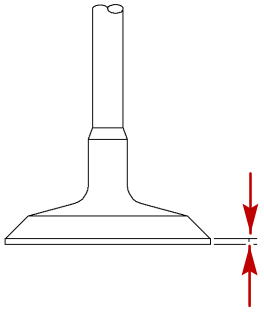
1. Measure valve stem diameter in three places.
2. If the measured value is less than specified limit, the valve and valve guide must be replaced as a set.



77196

Description		mm (in.)
Intake Valve Stem Diameter	Production	5.959 - 5.977 (.2346 - .2353)
	Limit	5.945 (.2341)
Exhaust Valve Stem Diameter	Production	5.954 - 5.972 (.2344 - .2351)
	Limit	5.940 (.2339)

3. Measure valve head margin.
4. If measured value is less than specified, the valve and the valve guide must be replaced as a set.

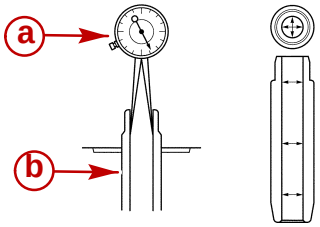


77197

Description		mm (in.)
Valve Margin (Production)	Intake	1.2 - 1.4 (0.047 - 0.055)
	Exhaust	
Margin (After Grinding)	Intake	1.0 (0.039)
	Exhaust	

MEASURE VALVE GUIDE WEAR

1. Using a caliper calibrator or a telescoping gauge, measure the valve guide inside diameter in three places.
2. If measured value is greater than specified, perform a valve stem clearance check.



77192

a - Caliper Calibrator
b - Valve Guide

Description		mm (in.)
Intake Valve Guide Inside Diameter	Production	6.000 - 6.015 mm (0.2362 - 0.2368)
	Limit	Not available
Exhaust Valve Guide Inside Diameter	Production	6.000 - 6.015 mm (0.2362 - 0.2368)
	Limit	Not available

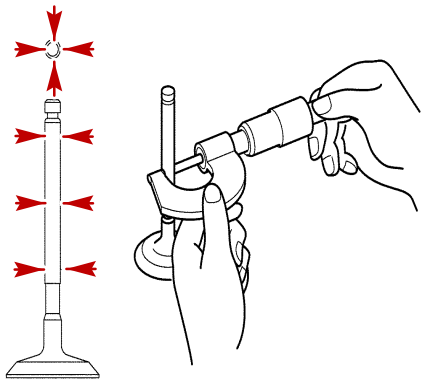
MEASURE VALVE STEM CLEARANCE

1. Using a valve with the specified stem diameter or a new valve, measure valve stem clearance.
   a. Attach a dial indicator to the cylinder head. Position it against the valve stem and close to the valve guide.
   b. While holding the valve head off the seat about 2 mm (1/16 in.), move the valve stem side to side in the guide. Compare sstem clearance with specifications.

Description		mm (in.)
Valve Stem Clearance	Intake	0.023 - 0.056 (0.0009 - 0.0022)
	Exhaust	0.028 - 0.610 (0.0011 - 0.0240)

VALVES

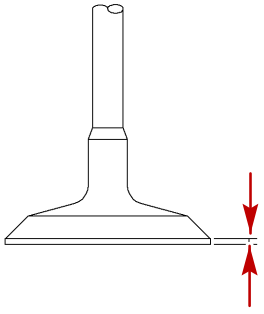
1. Measure valve stem diameter in three places.
2. If the measured value is less than specified limit, the valve and valve guide must be replaced as a set.



77196

Description		mm (in.)
Intake Valve Stem Diameter	Production	5.959 - 5.977 (.2346 - .2353)
	Limit	5.945 (.2341)
Exhaust Valve Stem Diameter	Production	5.954 - 5.972 (.2344 - .2351)
	Limit	5.940 (.2339)

3. Measure valve head margin.
4. If measured value is less than specified, the valve and the valve guide must be replaced as a set.

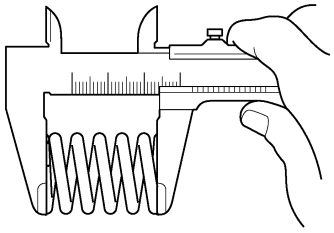


77197

Description		mm (in.)
Valve Margin (Production)	Intake	1.2 - 1.4 (0.047 - 0.055)
	Exhaust	
Margin (After Grinding)	Intake	1.0 (0.039)
	Exhaust	

VALVE SPRINGS

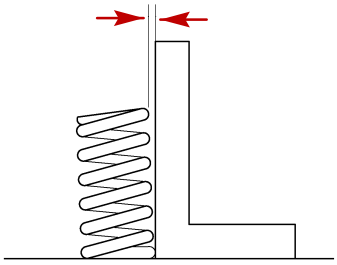
1. Use a vernier caliper to measure the valve spring free height. Replace spring if less than specified limit.



77198

Description		mm (in.)
Free Standing Height	Production	44.63 (1.76)
	Limit	44.13 (1.74)

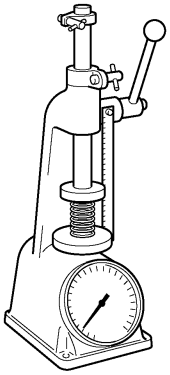
2. If the measured value exceeds the specified limit, the valve spring must be replaced.



77199

Description		mm (in.)
Spring Inclination	Production	1.01 (0.040)
	Limit	

3. Use a spring tester to measure the valve spring tension. Replace spring if less than specified limit.



77200

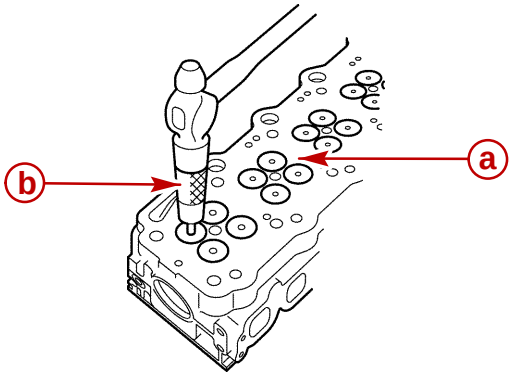
Description		mm (in.)
Compressed Height at Pressure	Production	33.3 (1.31) at 160 N (36 lb)
	Limit	

Repair

VALVE GUIDE REPLACEMENT

IMPORTANT: To avoid damage to the aluminium head, extreme care must be used when replacing the valve guides. Only a qualified machine shop should perform this operation. The guide inner diameter should be checked after installation and reamed to the specified production dimension.

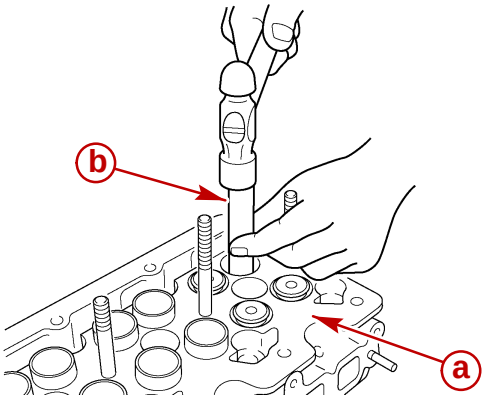
1. Using a hammer and valve guide driver, drive the valve guide out of cylinder head from the combustion chamber side of cylinder head.



77176

a - Cylinder Head
b - Valve Guide Driver

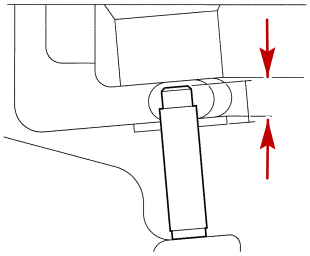
2. Apply engine oil to outside of new valve guide and install on valve guide driver.
3. Using a hammer drive valve guide into position from top of cylinder head.



77194

a - Top Of Cylinder Head
b - Valve Guide Driver

4. Measure the height of valve guide from upper face of cylinder head.



77195

Description		mm (in.)
Upper End Height	Intake	11.7 (.4606)
	Exhaust	

5. Check the guide inner diameter after installation and ream to the specified production dimension.

Description		mm (in.)
Intake Valve Guide Inside Diameter	Production	6.000 - 6.015 mm (0.2362 - 0.2368)
Exhaust Valve Guide Inside Diameter	Production	6.000 - 6.015 mm (0.2362 - 0.2368)

IMPORTANT: If the valve guide has been removed, both the valve and the valve guide must be replaced as a set.

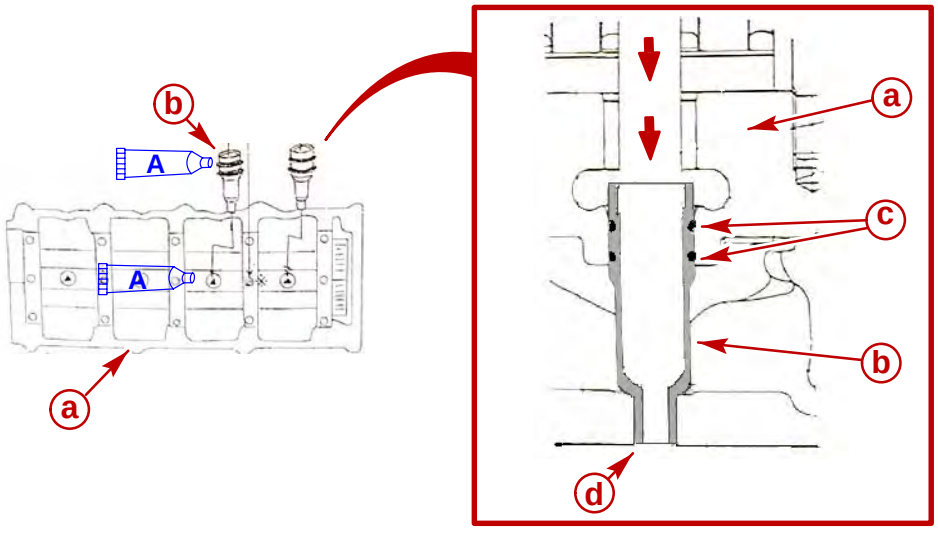
Reassembly

1. Install O-rings on injector sleeves. Apply a light coat of engine oil to O-rings and cylinder head injector sleeve bores.

⚠ CAUTION

Avoid severe engine damage. Injector sleeve O-rings form a seal between the combustion chamber, coolant passages and lubricating oil in the cylinder head. Severe engine damage could result if the O-rings are damaged during installation. Do not damage the O-rings during installation.

2. Using a clean fuel injector placed inside the injector sleeve, carefully insert the injector sleeve into bore in cylinder head. Do this for all injector sleeves.
3. Verify all injector sleeves are fully seated in cylinder head after installation.

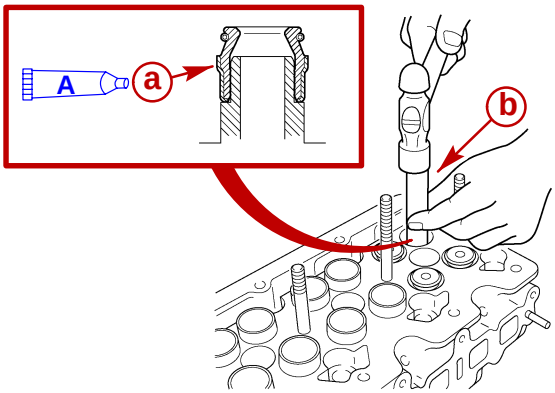


Cross-Section Of Injector Sleeve In Cylinder Head

a - Cylinder Head
b - Injector Sleeve
c - O-ring
d - Fully Seated

	Description	Where Used	Method of Use	Part Number
A	Engine Oil	Injector sleeve bore and O-rings	Coat surfaces	Obtain Locally

4. Install the valve spring lower seat.
5. Apply a coat of engine oil to valve seal inner surface. Install valve seal using valve seal installer.



77237

a - Valve Seal
b - Valve Seal Installer

Description		Where Used	Method of Use	Part Number
A	Engine Oil	Valve seal	Coat surfaces	Obtain Locally

IMPORTANT: Ensure that all valve components are installed in their original locations.

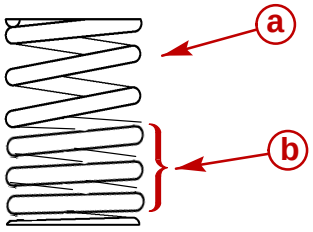
6. Apply a coat of engine oil to valve stem and install valve in cylinder head.

Description	Where Used	Method of Use	Part Number
Engine Oil	Valve stem	Coat surfaces	Obtain Locally

7. Turn the cylinder head up to install the valve springs.

IMPORTANT: Ensure that valves stay in cylinder head when turning the head.

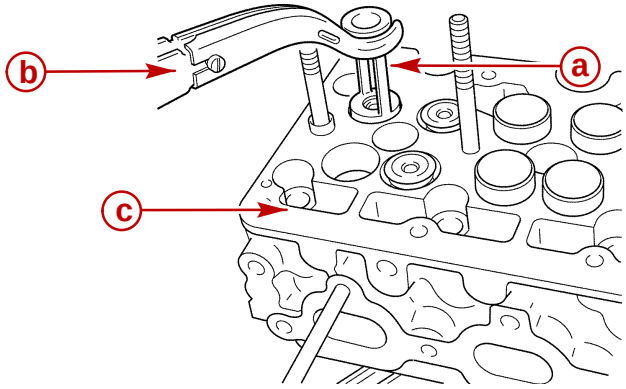
8. Install valve springs with the fine pitched end (the end with more windings) facing the cylinder head (down).



77238

a - Valve Spring
b - Fine Pitch

9. Install valve spring retainer and compress spring using valve spring compressor and adapter.
10. Install split collars on valve stem and release valve spring compressor. Ensure that collars seat properly in groove of valve stem.

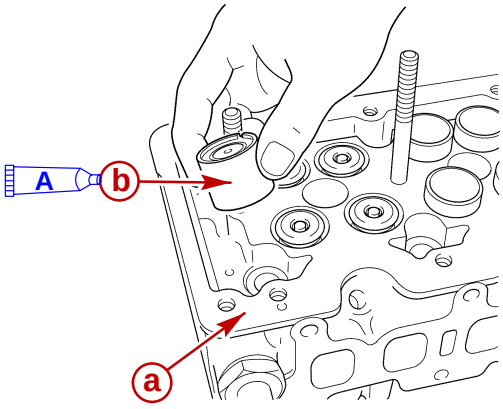


77174

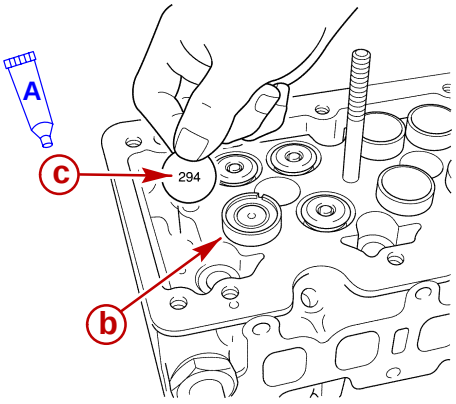
a - Adaptor
b - Valve Spring Compressor
c - Cylinder Head

11. Set split collars by tapping valve stem with a soft (plastic) hammer.
12. Apply engine oil to camshaft follower and valve shim.
13. Install camshaft follower and shim.

IMPORTANT: Ensure that cam followers and valve shims are installed in their original locations.



77172



77241

a - Cylinder Head
b - Camshaft Follower
c - Valve Shim

Description		Where Used	Method of Use	Part Number
A	Engine Oil	Camshaft follower and shim	Coat surfaces	Obtain Locally

Installation

⚠ CAUTION

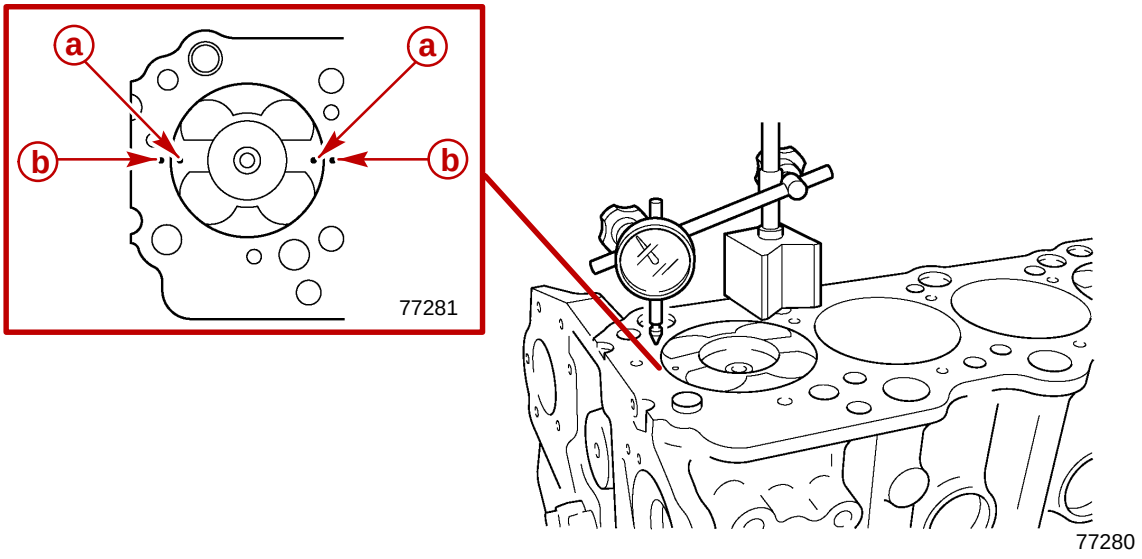
Head gasket thickness is very important on diesel engines. If head gaskets are too thin, the pistons will hit the valves or heads, causing severe damage. If head gaskets are too thick, cylinder compression may be low.

When cylinder heads are removed for service but pistons and cylinder liners are not disturbed, use the same thickness gaskets that were removed. Refer to Head Gasket Identification.

Refer to Determine Head Gasket Thickness during a complete engine rebuild or when pistons are being replaced.

DETERMINE HEAD GASKET THICKNESS

1. Carefully remove carbon deposits from piston top surface and gasket residue from cylinder block surface.
2. Using a dial indicator measure piston protrusion at 2 points.
3. Measure piston protrusion for each cylinder.
4. Note highest measured value. This will determine cylinder head gasket thickness.



a - Piston Surface
b - Cylinder Block Surface

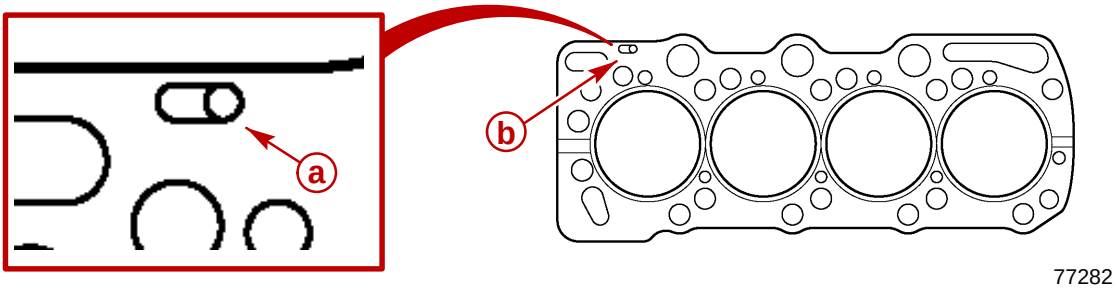
Description	mm (in.)
Piston Protrusion Range	0.58 - 0.78 (0.023 - 0.031)

5. Piston protrusion must be within the range shown.

NOTE: If piston protrusion is beyond the above range, engine should be inspected for worn or damaged components or improper assembly of components.

HEAD GASKET IDENTIFICATION

Select a cylinder head gasket of appropriate thickness (or grade) from chart below.



77282

a - Grade Mark (B is shown)
b - Grade Mark Location

Grade	Grade Mark	Highest Piston Projection mm (in.)	Thickness mm (in.)
A		0.58 - 0.64 (0.023 - 0.025)	1.45 (0.057)
B		0.65 - 0.71 (0.026 - 0.028)	1.50 (0.059)
C		0.72 - 0.78 (0.028 - 0.031)	1.55 (0.061)

CYLINDER HEAD

IMPORTANT: Head gaskets must be installed DRY. Do not use any sealer on gasket.

1. Install head gasket on cylinder block.
2. Align the cylinder block dowels and the cylinder head dowel holes.
3. Carefully set the cylinder head onto cylinder block.

⚠ CAUTION

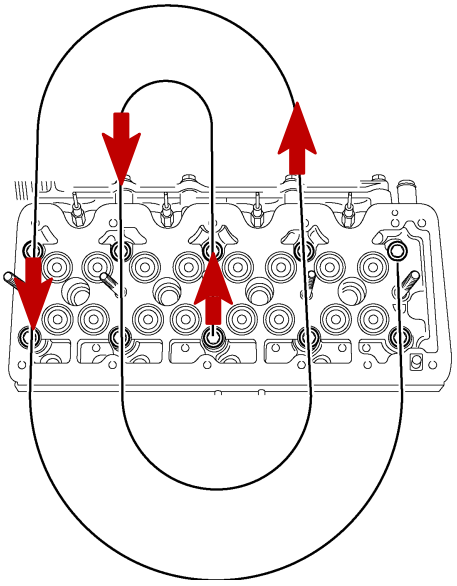
Avoid engine damage. Cylinder head bolts may be installed two times, and then must be replaced with new bolts. Replace the cylinder head bolts if uncertain of the number of times installed.

4. Apply engine oil to threads of cylinder head bolt and washer faces.

Description	Where Used	Method of Use	Part Number
Engine Oil	Cylinder head bolt and washer	Coat threads and surfaces	Obtain Locally

IMPORTANT: Follow torque sequence in each step.

5. Hand tighten the cylinder head bolts.
6. Torque the cylinder head bolts.



77120

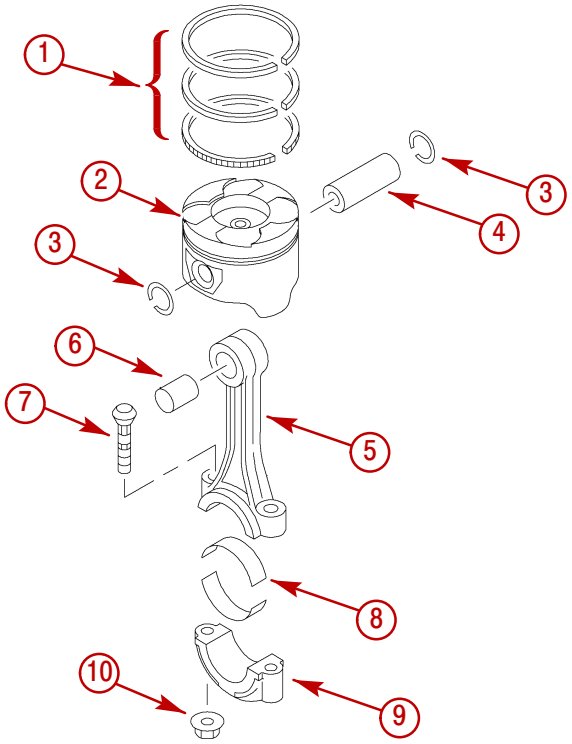
Torque Sequence Diagram

Description		Nm	lb-in.	lb-ft
Bolt, Cylinder Head	M8 x 1.25			
First Pass		39		29
Second Pass		+ 60 degrees		
Third Pass		+ 60 degrees		

7. Install camshaft tappets and valve shims.
8. Install camshaft carrier.
9. Install valve cover.
10. Install fuel injectors and fuel pipes.
11. Install timing belt and timing covers.

Connecting Rod / Piston Assembly

Exploded View

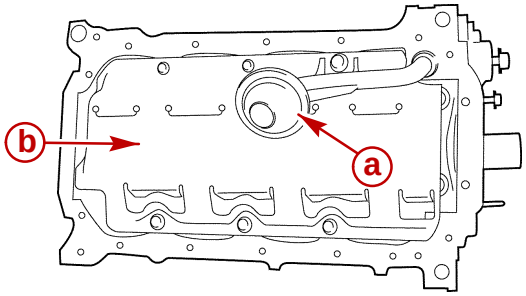


77177

1 - Piston Rings
2 - Piston
3 - Snap Ring
4 - Piston Pin
5 - Connecting Rod
6 - Connecting Rod Bushing
7 - Connecting Rod Bolt
8 - Connecting Rod Bearings
9 - Connecting Rod Cap
10 - Nut

Removal

1. Remove cylinder head.
2. Remove upper and lower oil pan.
3. Remove oil pickup assembly and oil baffle plate.



77145

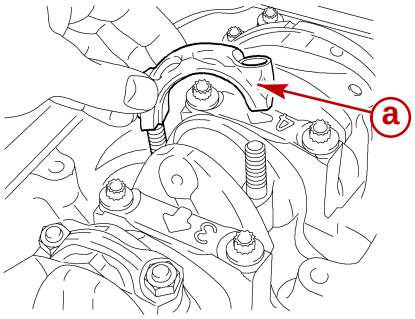
a - Pickup Assembly
b - Baffle Plate

4. Using a reamer remove any ridge or combustion deposits from top of cylinder bore.
5. Turn crankshaft to gain access to connecting rod bolts.

IMPORTANT: Mark the location of each connecting rod assembly to ensure that they are reassembled in the same location.

IMPORTANT: The mating surfaces of the connecting rods and the connecting rod bearing caps form an individual fit and as a result must not be interchanged or damaged under any circumstances. To avoid damage, do not lay connecting rods or connecting rod bearing caps on their mating surfaces.

6. Mark and remove connecting rod bearing cap.



77179

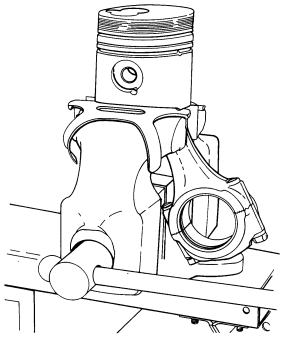
a - Bearing Cap

IMPORTANT: Connecting rod bolt threads can damage crankshaft journal and cylinder bore.

7. Cover connecting rod bolt threads with protective caps.
8. Push piston and connecting rod out of cylinder.

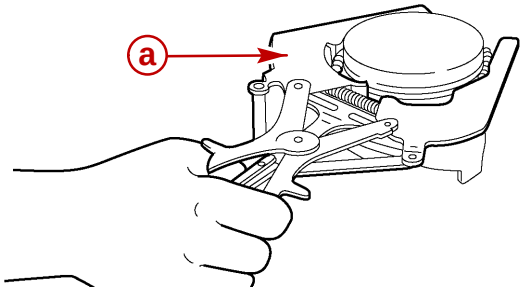
Disassembly

1. Clamp connecting rod in a soft jawed vise as shown.



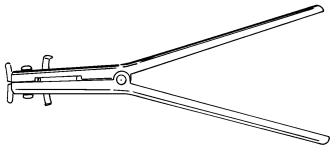
70290

2. Use Piston Ring Expander Tool to remove the two compression rings.

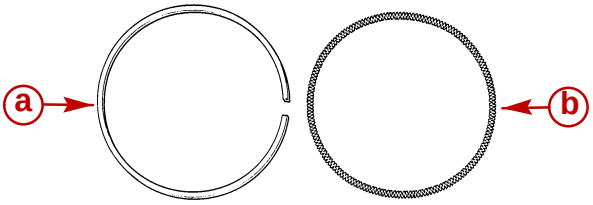


77182

a - Piston Ring Expander Tool

Piston Ring Expander	**91-24697**
Description: Installs and removes piston rings	 73700

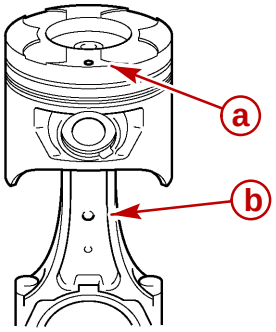
3. Using same tool, remove lower (oil control) rings and expanders.



70291

a - Oil Control Ring
b - Expander

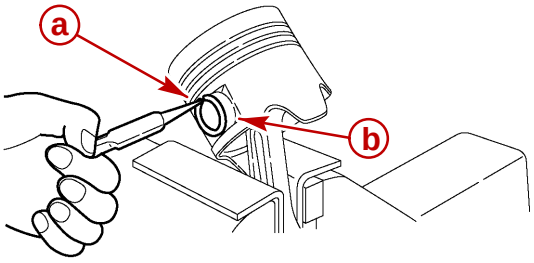
4. Note installation position of connecting rod relative to piston. Piston mark (raised dots) is on the same side as the mark on the connecting rod.



77183

a - Piston Mark
b - Connecting Rod Mark

5. Remove snap ring from piston using suitable tool. Push piston pin from piston and connecting rod by hand.



77184

a - Snap Ring
b - Piston Pin

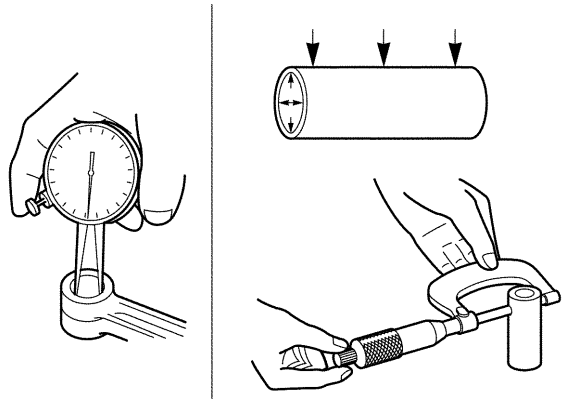
Cleaning

1. Clean all parts with solvent.
2. Clean oil passages.
3. Dry parts with compressed air.
4. Clean varnish from piston skirts and pins with a suitable cleaning solvent. DO NOT wire brush any part of piston.
5. Clean piston ring grooves. Ensure that oil ring holes are clean.

Inspection

CONNECTING ROD

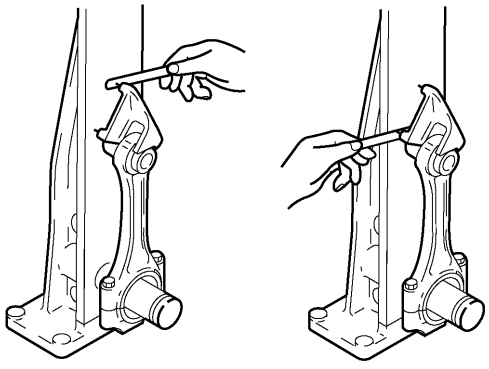
1. Check for twisted or bent rods and inspect for nicks or cracks. Replace damaged connecting rods.
2. Use a caliper calibrator and a micrometer to measure the piston pin and connecting rod bushing clearance. Replace the piston pin and/or the connecting rod bushing if clearance exceeds specified limits.



77231

Description		mm (in.)
Bushing To Piston Pin Clearance	Standard	0.008 - 0.020 (0.0003 - 0.0007)
	Limit	0.050 (0.0020)

3. Use a connecting rod aligner to measure distortion and parallelism between connecting rod crankshaft pin bore and bushing bore. Replace rod if either value exceeds specified limits.



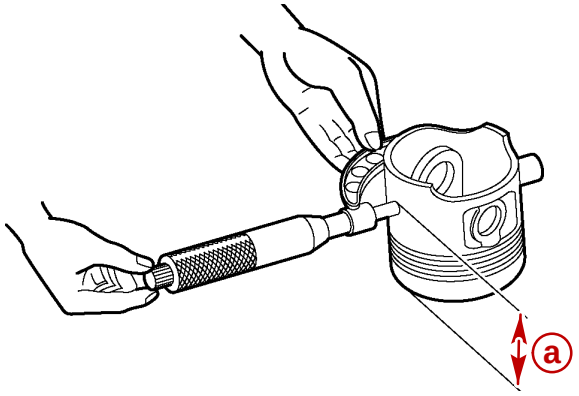
77234

Connecting Rod Alignment Per Length of 100 mm (4 in.)

Description		mm (in.)
Connecting Rod Distortion Per Length of 100 mm	Standard	0.05 - (0.002)
	Limit	0.10 (0.004)
Connecting Rod Parallelism Per Length of 100 mm	Standard	0.075 (0.003)
	Limit	0.15 (0.006)

PISTON

1. Inspect piston for cracked ring lands, skirts or pin bosses, wavy or worn ring lands, scuffed or damaged skirts and eroded areas at top of piston. Replace pistons that are damaged or show signs of excessive wear.
2. Inspect grooves for nicks or burrs that might cause rings to hang up.
3. Insert edge of rings into respective piston ring groove and roll ring entirely around the groove to make sure that ring is free. If binding occurs at any point, determine cause. If caused by ring groove, remove by dressing with a fine cut file. Do not remove excess material. (Verify with feeler gauge and compare to specifications.)
4. Measure piston outside diameter and determine piston service grade.



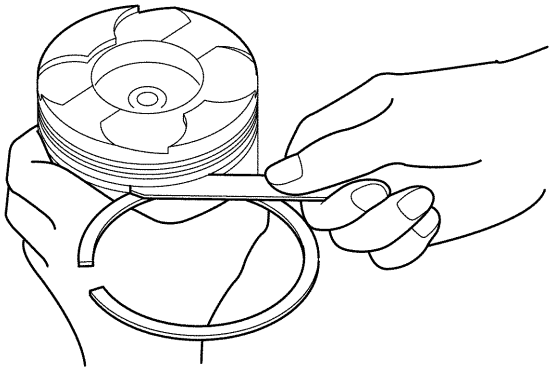
77205

Piston Outside Diameter

a - Piston Measuring Point - 57 mm (2 - 1/4 in.)

Description		mm (in.)
Piston Outside Diameter	Grade A	78.930 - 78.939 (3.1075 - 3.1078)
	Grade B	78.940 - 78.949 (3.1079 - 3.1082)
	Grade C	78.950 - 78.959 (3.1083 - 3.1086)

5. Using a feeler gauge, measure the clearance between the piston ring and the piston ring groove at several points around the piston. Replace piston if ring groove exceeds the specified limit.

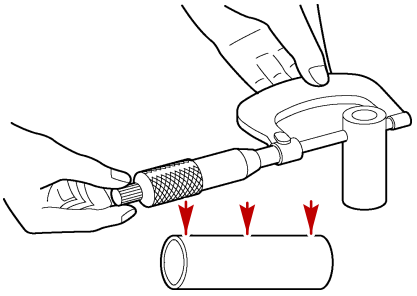


77228

Piston Ring and Piston Ring Groove Clearance

Description		mm (in.)
Ring to Groove Clearance	1st Compression	.090 - .122 (0.0035 - 0.0048)
	2nd Compression	.070 - .110 (0.0027 - 0.0043)
	Oil Control	.025 - .065 (0.0010 - 0.0026)
	Limit–All Rings	0.15 (0.006)

6. Use a micrometer to measure the piston pin outside diameter at several points. Replace pin if measured value is less than specified limit.



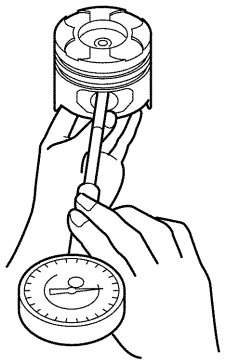
77229

Piston Pin Diameter

Description		mm (in.)
Piston Pin Outer Diameter	Standard	26.995 - 27.000 (1.0627 - 1.0629)
	Limit	26.985 (1.0624)

PISTON PIN AND CLEARANCE

1. Use an inside dial indicator to measure the diameter of piston pin hole.
2. Replace piston, if pin hole measurement is greater than specified.



77230

Piston Pin Hole

Description		mm (in.)
Pin Hole Inner Diameter	Production	27.004 - 27.009 (1.0631 - 1.0633)

3. Subtract piston pin outer diameter (measured previously) from piston pin hole diameter. Replace piston and pin if measured clearance is more than specified limit.

Description		mm (in.)
Clearance	Production	.004 - .014 (0.0001 - 0.0005)
	Limit	0.04 (0.0016)

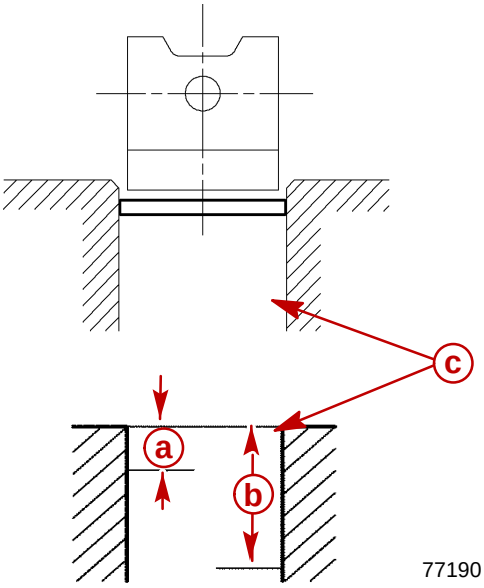
NOTE: *Calculate clearance using a new piston pin if measurement is greater than limit with existing piston pin. Replace as necessary.*

PISTON RING GAP

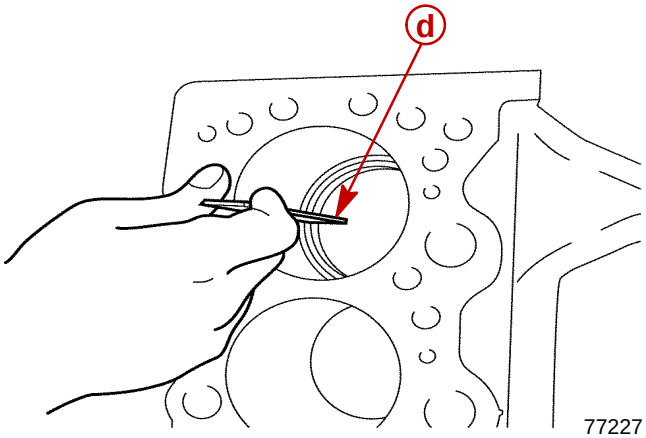
1. Insert the piston ring horizontally into the cylinder bore.
2. Using a piston inserted upside down, push the piston ring into the cylinder bore until it reaches measurement point "**a**" and measurement point "**b**". Cylinder bore diameter is smallest at these 2 points.

NOTE: Ensure that piston ring is not slanted to one side or the other. It must be perfectly horizontal.

3. Using a feeler gauge, measure the piston ring gap. Replace ring if gap exceeds specified limits.



77190



77227

Piston Ring Gap

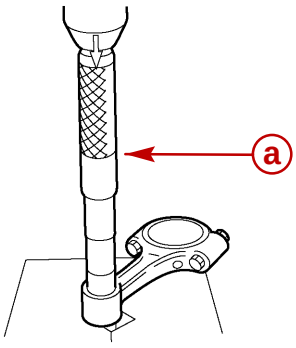
a - Measurement Point:
b - Measurement Point:
c - Cylinder Bore
d - Feeler Gauge

Description		mm (in.)
End Gap	1st Compression	.250 - .350 (0.010 - 0.014)
	2nd Compression	.200 - .300 (0.008 - 0.012)
	Oil Control	.200 - .400 (0.008 - 0.016)
	Limit - All Rings	0.8 (0.031)

Installation

CONNECTING ROD BUSHING

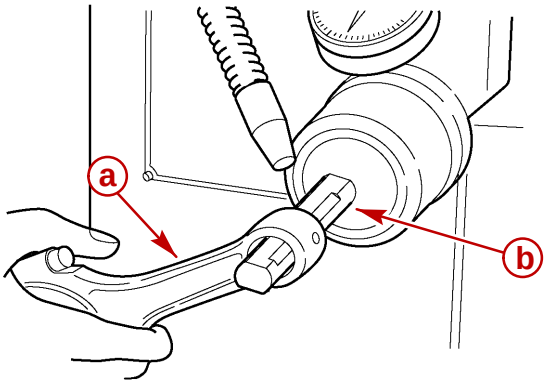
1. Using the connecting rod bushing tool, press a new connecting rod bushing into the connecting rod.



77232

a - Connecting Rod Bushing Tool

2. Ream new bushing to proper diameter.



77233

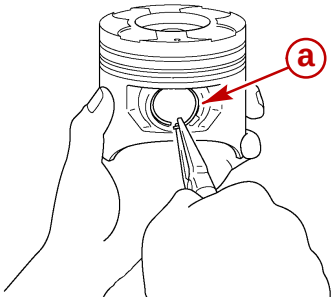
Connecting Rod Bushing Reaming

a - Connecting Rod
b - Reamer

Description	mm (in.)
Connecting Rod Bushing Inner Diameter	27.008 - 27.015 (1.0633 - 1.0635)

CONNECTING ROD AND PISTON ASSEMBLY

1. Clamp connecting rod in a soft jawed vise. Take care not to damage the connecting rod.
2. Install one piston pin snap ring to the piston.

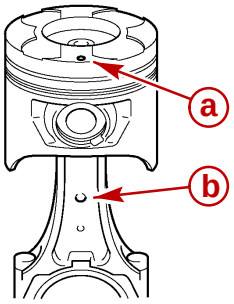


77243

a - Piston Pin Snap Ring

3. Install piston on connecting rod.

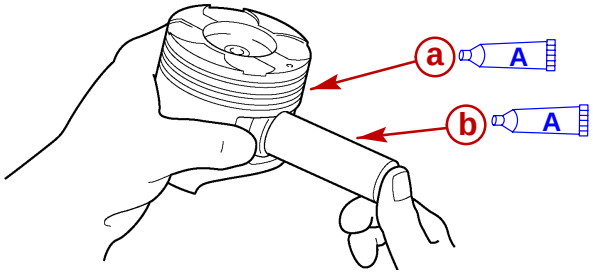
IMPORTANT: Ensure that the mark indicating piston front is on the same side as the mark (raised dots) on the connecting rod.



77183

a - Piston Mark
b - Connecting Rod Mark

4. Apply a coat of engine oil to piston pin and piston pin hole.
5. Install piston pin into piston and connecting rod until it makes slight contact with the first snap ring.

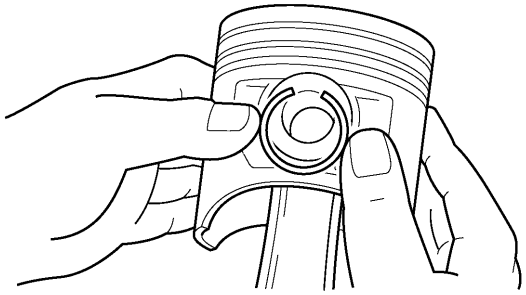


77245

a - Piston
b - Piston Pin

Description		Where Used	Method of Use	Part Number
A	Engine Oil	Piston and pin	Coat surfaces	Obtain Locally

6. Install second piston pin snap ring into piston snap ring groove.



77246

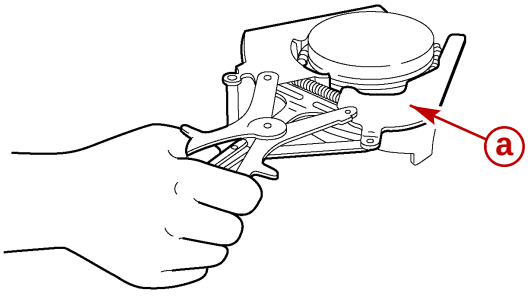
7. Check that connecting rod moves smoothly on piston pin.

PISTON RINGS

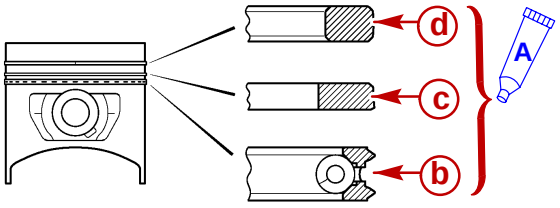
1. Apply engine oil to piston ring surfaces and piston.
2. Insert expander coil into oil ring groove so that there is no gap on either side of expander coil.

IMPORTANT: Use a piston ring expander to avoid damaging the piston rings.

3. Using the Piston Ring Expander Tool, install oil ring.



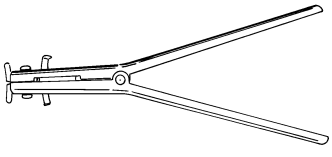
77182



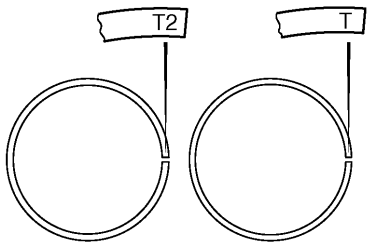
77248

a - Piston Ring Expander Tool
b - Oil Ring (Coil Expander Type)
c - Second Compression Ring
d - First Compression Ring

	Description	Where Used	Method of Use	Part Number
A	Engine Oil	Rings and piston	Coat surfaces	Obtain Locally

Piston Ring Expander	91-24697
Description: Installs and removes piston rings	 73700

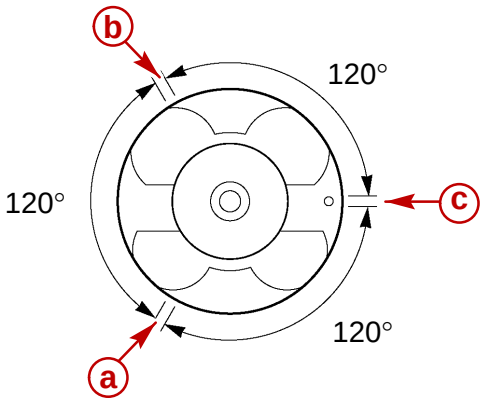
4. Install compression rings with stamped side facing up.



77249

5. Check that the piston rings rotate smoothly in the piston ring grooves.
6. Align piston ring gaps as shown.

NOTE: *The gap of each piston ring must be offset by 120 °.*

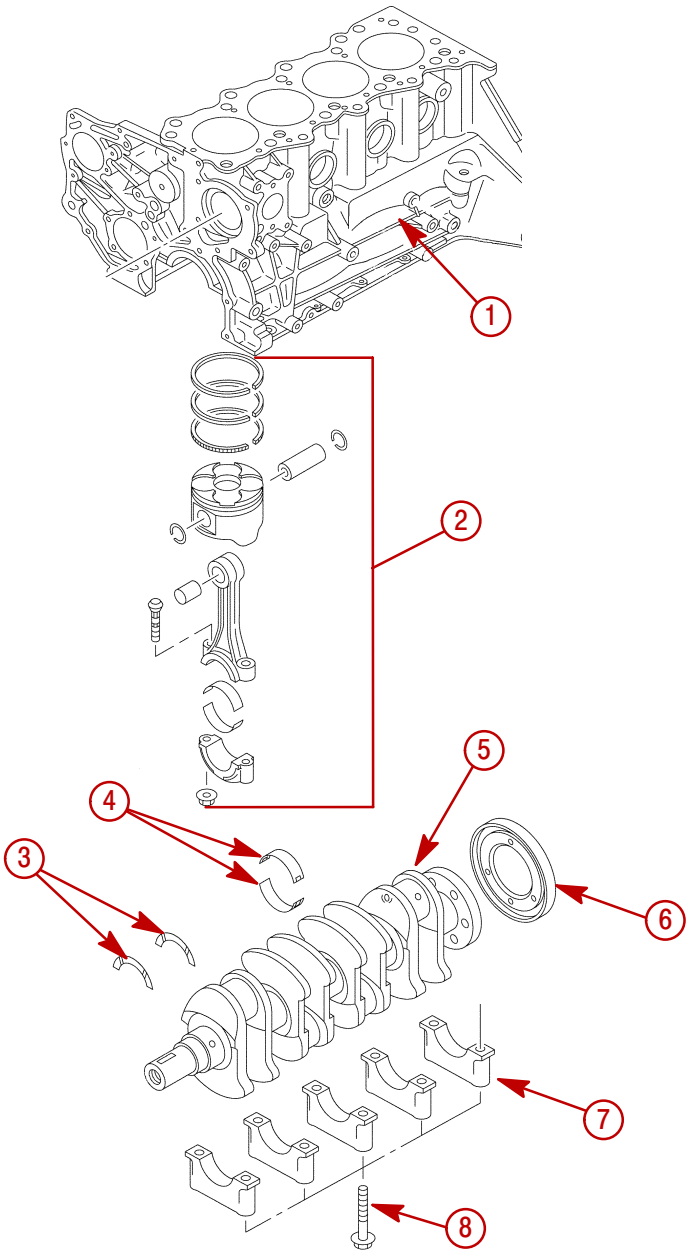


77250

a - Oil Ring Gap
b - Second Ring Gap
c - First Ring Gap

Crankshaft, Main Bearings And Cylinder Block

Exploded View

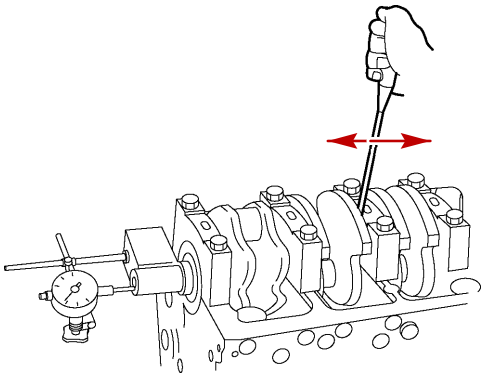


77304

1 - Cylinder Block
2 - Connecting Rod / Piston Assembly
3 - Thrust Bearing (Second Main Bearing)
4 - Main Bearing
5 - Crankshaft
6 - Rotor
7 - Main Bearing Caps
8 - Main Bearing Bolt

Removal

1. Remove cylinder head.
2. Remove oil pump assembly.
3. Remove oil pan, oil strainer and oil baffle plate.
4. Remove flywheel housing, coupler flywheel and rear main seal retainer.
5. Remove connecting rod / piston assemblies.
6. Measure crankshaft end play before removing. The thrust bearings will need to be replaced during reassembly if end play exceeds specified limit.



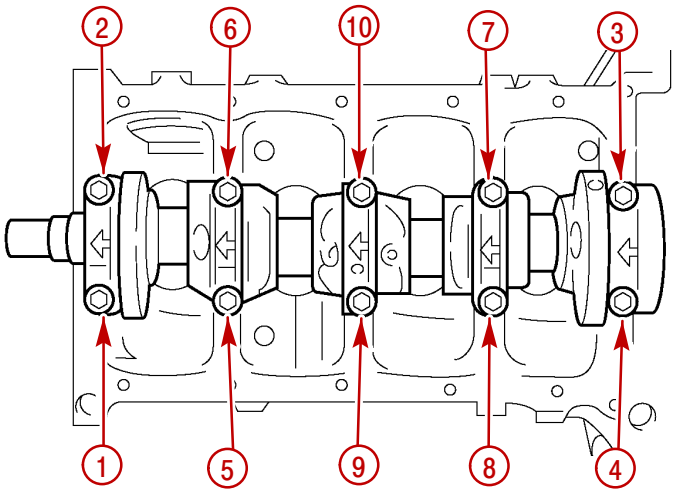
77212

Crankshaft End Play

Description		mm (in.)
Crankshaft End Play (Thrust Clearance)	Production	0.05 - 0.15 (0.002 - 0.006)
	Limit	0.20 (0.008)

7. Loosen main bearing bolts in sequence shown below and remove.

IMPORTANT: Main bearing caps have arrows pointing toward front of engine and are numbered 1 - 5 beginning at front. They must be reassembled in their original positions.



77186

Main Bearing Cap Removal Sequence

8. Remove crankshaft from cylinder block.

Cleaning

1. Clean crankshaft in solvent and dry with compressed air.
2. Clean oil passages.

Inspection

1. Inspect crankshaft for nicks, scratches and cracks.
2. Inspect crankshaft journals and oil seal surfaces for excessive wear.

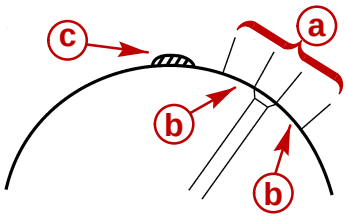
CRANKSHAFT NITRIDE TREATMENT INSPECTION

IMPORTANT: To increase crankshaft strength, Nitride Treatment has been applied. Because of this, it is not possible to regrind the crankshaft surfaces.

A 5 to 10% solution of ammonium cuprous chloride dissolved in distilled water can be used by trained technicians to test whether the crankshaft's nitride treatment is still effective.

⚠ CAUTION

Ammonium cuprous chloride in solution is highly corrosive. The solution can cause corrosion damage to parts of the crankshaft metal that have not had Nitride Treatment. The solution should not contact the oil ports and surrounding untreated areas of the crankshaft or damage to the crankshaft could occur.



77211

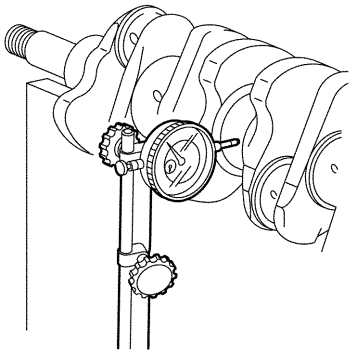
a - No Contact Area
b - 10 mm
c - Ammonium Cuprous Chloride

If there is no discoloration after 30 or 40 seconds, the crankshaft is considered usable.

Steam cleaning of the crankshaft surfaces immediately after such a test is required.

CRANKSHAFT RUNOUT

1. Place crankshaft in cylinder block or on V-blocks.
2. Set a dial indicator to the center of the crankshaft journal.
3. Gently turn the crankshaft in the normal direction of rotation. Read dial indicator as crankshaft is turned.
4. Replace crankshaft if runout exceeds the specified limit.



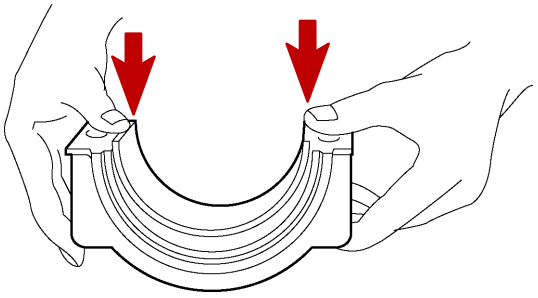
77213

Crankshaft RunOut

Description		mm (in.)
Crankshaft Runout	Production	0.05 (0.002) or less
	Limit	0.06 (0.002)

BEARING TENSION

1. Ensure that main bearing installs under tension. It should require firm pressure to fit the bearing into position.

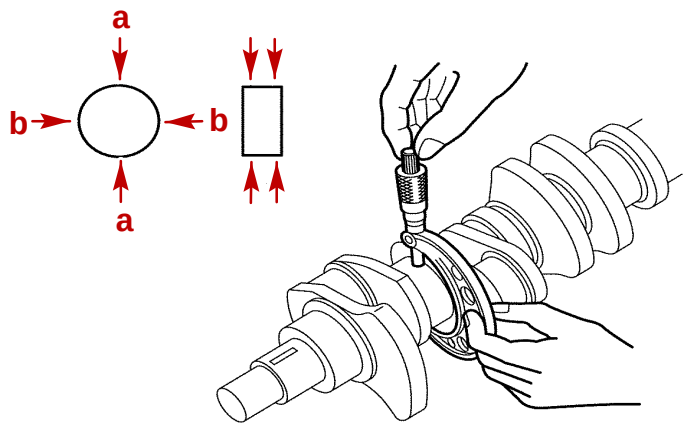


77214

Main Bearing Tension

MAIN BEARING JOURNAL AND ROD JOURNAL DIAMETER

1. Using a micrometer measure crankshaft journal diameters at points "**a**" and "**b**" on one side of journal then repeat measurements on opposite side of journal.



22215

Main Journal and Connecting Rod Journal Measurement

2. Measure connecting rod journal diameters using same procedure as for crankshaft journals.
3. Replace crankshaft if any measured values are less than limit.

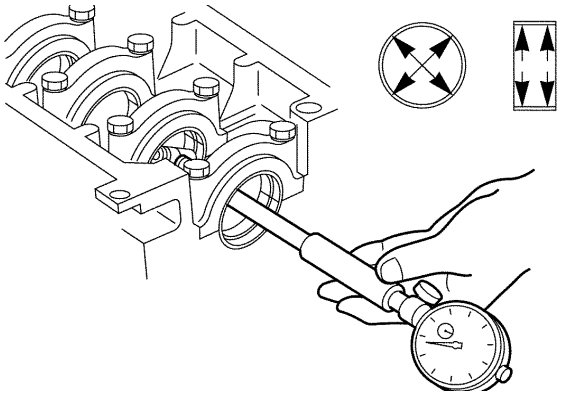
Description		mm (in.)
Main Journal Outside Diameter-Grade 1, Size Mark: 	Production	51.918 - 51.928 (2.0440 - 2.0444)
	Limit	51.912 (2.0438)
Main Journal Outside Diameter-Grade 2. Size Mark 	Production	51.928 - 51.938 (2.0444 - 2.0448)
	Limit	51.922 (2.0442)
Connecting Rod Journal Outside Diameter	Production	45.930 - 45.945 (1.8083 - 1.8089)
	Limit	45.926 (1.8081)
Crankshaft and Connecting Rod Journal Uneven Wear	Production	0.050 (0.002) or Less
	Limit	0.080 (0.003)

MAIN BEARING CLEARANCE

1. Install the main bearing caps with the bearings.
2. Torque the main bearing cap bolts.

Description	Nm	lb-in.	lb-ft
Bolt, Main Bearing Cap	88		65

3. Use a inside dial indicator to measure the main bearing inside diameter and taper.



77216

Description		mm (in.)
Crankshaft Journal and Bearing Clearance	Production	.030 - .058 (0.0012 - 0.0023)
	Limit	0.08 (0.0031)

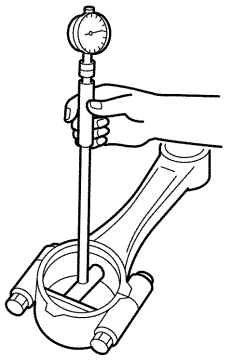
4. If the main bearing journal clearance exceeds the specified limit, the bearing and/or the crankshaft must be replaced.

ROD BEARING INSIDE DIAMETER

1. Install the bearing in the connecting rod.
2. Torque the bearing cap bolts.

Description	Nm	lb-in.	lb-ft
Bolt, Connecting Rod Bearing Cap	25 + 100°		18 + 100°

3. Use a inside dial indicator to measure the connecting rod bearing inside diameter.



77217

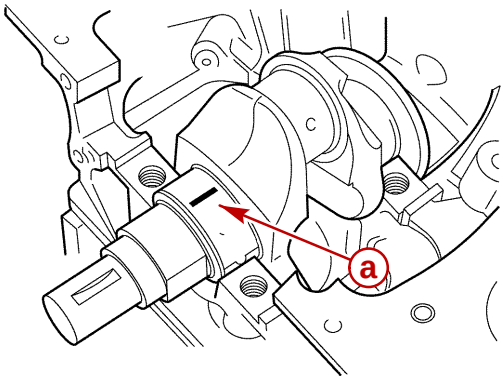
ROD BEARING CLEARANCE

1. If the clearance between the measured bearing inside diameter and the crankshaft rod journal exceeds the specified limit, the bearing and/or the crankshaft must be replaced.

Description		mm (in.)
Connecting Rod Journal and Bearing Clearance	Production	.025 - .058 (0.0009 - 0.0023)
	Limit	0.100 (0.0039)

MAIN BEARING CLEARANCE (WITH PLASTIGAGE)

1. Clean the cylinder block, the journal bearing fitting surface, the bearing caps and the bearings.
2. Install the bearings to the cylinder block.
3. Carefully place the crankshaft on the bearings.
4. Rotate the crankshaft approximately 30° to seat the bearing.
5. Place the Plastigage over the crankshaft journal across the full width of the bearing.

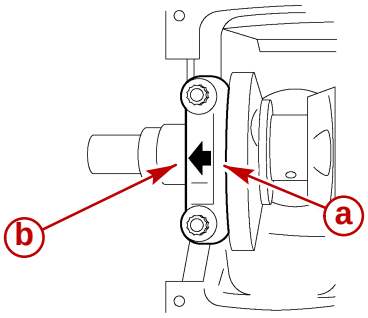


77218

a - Plastigage

6. Install the main bearing caps with the bearing.
7. Tighten the main bearing caps.

IMPORTANT: Do not allow the crankshaft to turn during bearing cap installation and tightening.

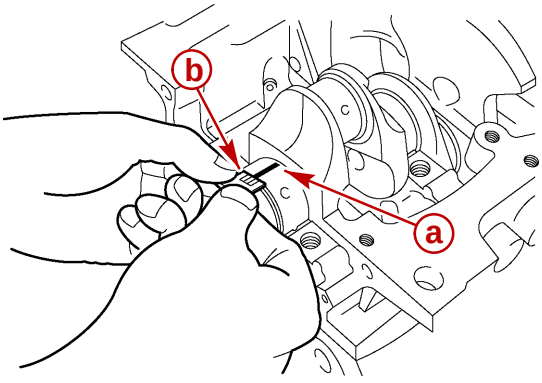


77219

a - Main Bearing Cap
b - Front

Description		Nm	lb-in.	lb-ft
Bolt, Main Bearing Cap	M11 x 1.5	88		65

8. Remove the bearing cap.
9. Compare the width of the Plastigage to the scale printed on the Plastigage container.
10. If the measured value exceeds the limit, perform the following additional steps.
    a. Use a micrometer to measure the crankpin outside diameter.
    b. Use an inside dial indicator to measure the bearing inside diameter.
    c. If the crankshaft journal and bearing clearance exceeds the specified limit, the crankshaft and/or the bearing must be replaced.



77220

a - Plastigage
b - Scale On Plastigage Container

Description	mm (in.)
Main Bearing Clearance	.030 - .058 (.0011 - .0023)

ROD JOURNAL AND BEARING CLEARANCE

1. Ensure the crankshaft, the connecting rod, the bearing cap and the bearings are clean.
2. Install the bearing to the connecting rod and the bearing cap.

IMPORTANT: Do not allow the crankshaft to move when installing the bearing cap.

3. Prevent the connecting rod from moving.
4. Attach the Plastigage to the connecting rod journal.
5. Apply engine oil to the Plastigage to keep it from falling.
6. Install the bearing cap and torque the nuts.

Description		Nm	lb-in.	lb-ft
Nut, Connecting Rod	3/8 in. 24UNF	25 + 100°		18 + 100°

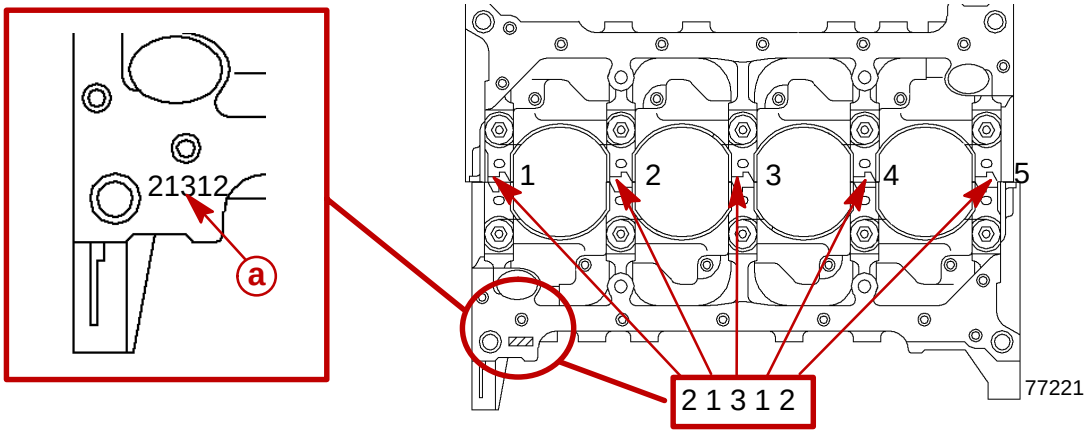
IMPORTANT: Do not allow the connecting rod to move when installing and tightening the bearing cap.

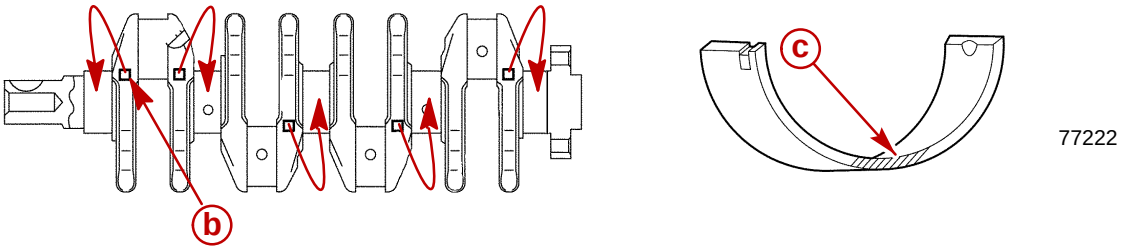
7. Remove the bearing cap.
8. Compare the width of the Plastigage attached to either the crankshaft or the bearing against the scale printed on the Plastigage container.
9. If the measured value exceeds the specified limit, perform the following additional steps.
   a. Use a micrometer to measure the connecting rod journal outside diameter.
   b. Use an inside dial indicator to measure the bearing inside diameter.
   c. If the connecting rod journal and bearing clearance exceeds the specified limit, the crankshaft and/or the bearing must be replaced.

Description		mm (in.)
Connecting Rod Journal and Bearing Clearance	Production	.025 - .058 (0.0009 - 0.0023)
	Limit	0.100 (0.0039)

MAIN BEARING SELECTION

When installing new main (crankshaft) bearings or inspecting old bearings, refer to the Main Bearing Selection Table.



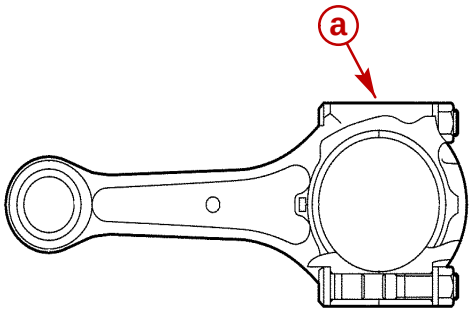


a - Cylinder Block Journal Size Marks
b - Crankshaft Journal Size Marks
c - Bearing Color Code

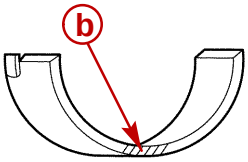
Main Bearing Selection Table					
Cylinder Block Journal mm (in.)		**Crankshaft Journal** mm (in.)		**Color Code**	**Oil Clearance** (Reference) mm (in.)
Size Mark	Diameter	Size Mark	Diameter		
1	55.992 - 56.000 (2.2044 - 2.2047)	▨▨	51.918 - 51.928 (2.0440 - 2.0444)	Blue	0.032–0.058 (.0013 - .0023)
		▨	51.928 - 51.938 (2.0444 - 2.0448)	Black	0.030–0.056 (.0012 - .0022)
2	55.984 - 55.992 (2.2041 - 2.2044)	▨▨	51.918 - 51.928 (2.0440 - 2.0444)		0.032–0.058 (.0013 - .0023)
		▨	51.928 - 51.938 (2.0444 - 2.0448)	Brown	0.030–0.056 (.0012 - .0022)
3	55.976 - 55.984 (2.2038 - 2.2041)	▨▨	51.918 - 51.928 (2.0440 - 2.0444)		0.032–0.058 (.0013 - .0023)
		▨	51.928 - 51.938 (2.0444 - 2.0448)	Green	0.030–0.056 (.0012 - .0022)

CONNECTING ROD BEARING SELECTION

When installing new connecting rod bearings or inspecting old bearings, refer to the Connecting Rod Bearing Selection Table.



77202



77223

d - Connecting Rod Size Mark
e - Connecting Rod Bearing Color Code

Connecting Rod Bearing Selection Table			
Connecting Rod Size Mark	**Bearing Color Code**	**Oil Clearance (Reference) mm (in.)**	**Limit mm (in.)**
I	Blue	0.025 - 0.054 (0.0009 - 0.0021)	0.10 (0.0039)
II	Black	0.027 - 0.056 (0.0010 - 0.0022)	
III	Brown	0.029 - 0.058 (0.0011 - 0.0023)	

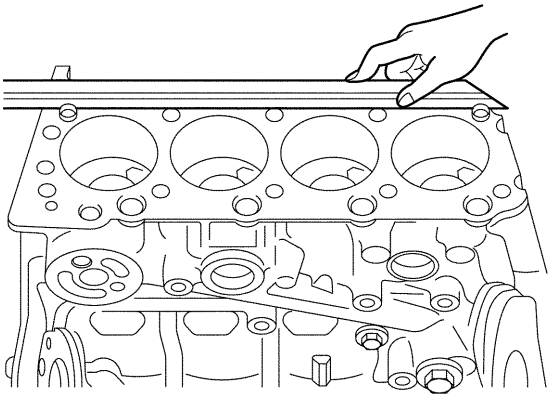
CYLINDER BLOCK SURFACE

Cleaning

1. Use compressed air to thoroughly clean the inside and outside surfaces of the cylinder block, the bolt and oil holes and the water jackets.

Measurement

1. Using a straight edge and a feeler gauge, measure the four sides (**A**, **B**, **E**, **F**) and the two diagonals (**C**, **D**) of the cylinder block upper face.
2. If the measured value is more than the limit, the cylinder block must be replaced.



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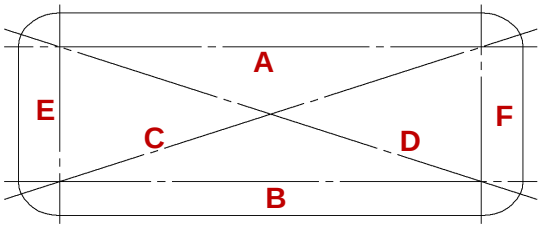
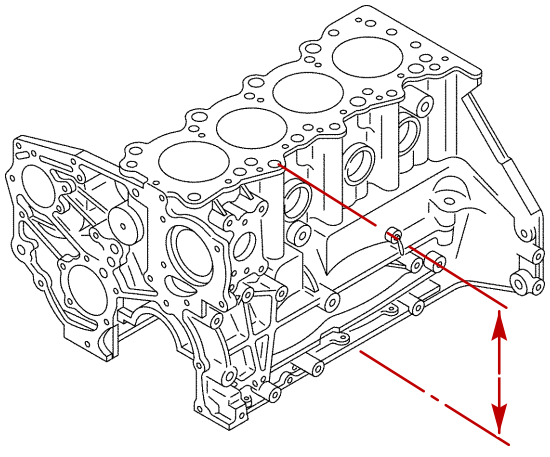


77188

Cylinder Block Upper Surface Warp

Description		mm (in.)
Upper Surface Warp	Production	0.05 (0.0019) or Less
	Limit	0.1 (0.0039)

3. Measure height of the cylinder block at the four edges to ensure block has not been machined.
4. If the measured value is less than indicated, the cylinder block must be replaced.



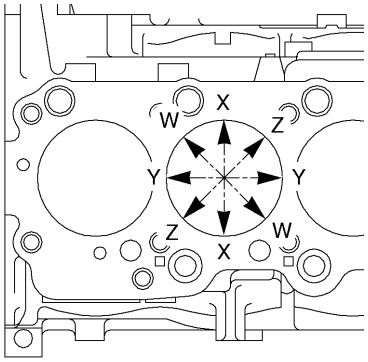
77258

Cylinder Block Height

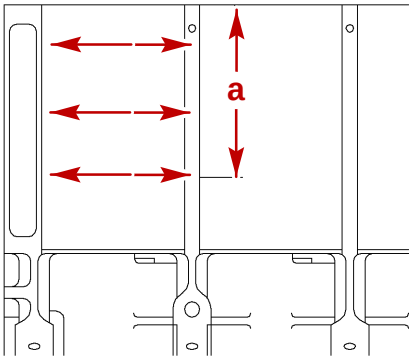
Description		mm (in.)
Cylinder Block Height	Production	272 (10.71)

CYLINDER BLOCK BORE MEASUREMENT

1. Take measurements at measuring point "**a**" across positions W-W, X-X, Y–Y and Z–Z at 12 mm, 55 mm and 95 mm (15/32 in., 2 - 5/32 in. and 3 - 3/4 in.) depths inside bore.
2. Calculate the average value of the four measurements, at indicated depths, to determine the correct cylinder grade.



77203



77204

Cylinder Bore Grade

Description	Bore/Piston Grade	mm (in.)
Cylinder Bore Diameters	Nominal	79.000 (3.1102)
	Grade - A	79.001 - 79.010 (3.1102 - 3.1106)
	Grade - B	79.011 - 79.020 (3.1106 - 3.1110)
	Grade - C	79.021 - 79.030 (3.1110 - 3.1114)

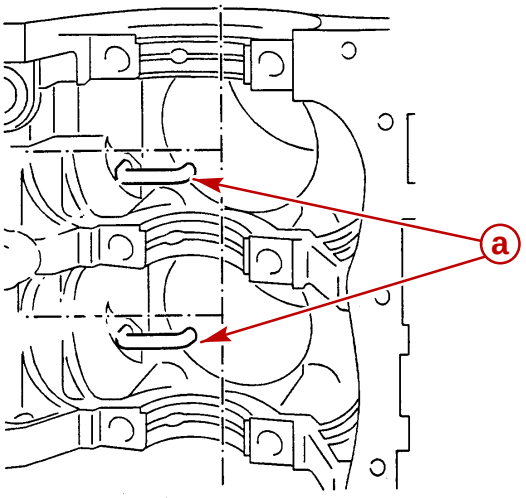
⚠ CAUTION

Avoid engine failure. Cylinder bores and pistons are in three standard sizes and correspond to the tolerance grades: Grade A, Grade B and Grade C. Select the correct piston grade designated for matching cylinder bore diameter.

CYLINDER BLOCK OIL SPRAY NOZZLES

Removal

1. With crankshaft removed, remove oil spray nozzles from near cylinder bores.



77715

a - Oil Spray Nozzles

Inspection

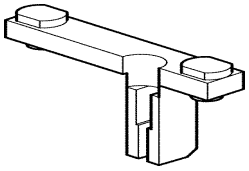
1. Clean passages of oil spray nozzles and cylinder block.
2. Check for damage on nozzles.
3. Replace if necessary.

Installation

1. Apply sealant around outside of oil spray nozzle.

Description	Where Used	Method of Use	Part Number
Loctite 262, Loctite 962T or Threebond 1386	Oil spray nozzle	Around outside of nozzle	Obtain Locally

2. Insert oil spray nozzles into cylinder block using the Oil Jet Installer tool.

Oil Jet Pipe Installer	**91-883860**
Description: Positions and installs oil jet pipe to cylinder block	 78054

3. Position nozzles perpendicular and at right angles to the crankshaft. Then complete installation.

⚠ CAUTION

Avoid engine damage. Oil spray from nozzles cools and lubricates engine components when properly distributed. Ensure oil spray nozzles are clean and correctly seated to allow proper oil spray distribution.

4. Ensure that nozzles are correctly seated.

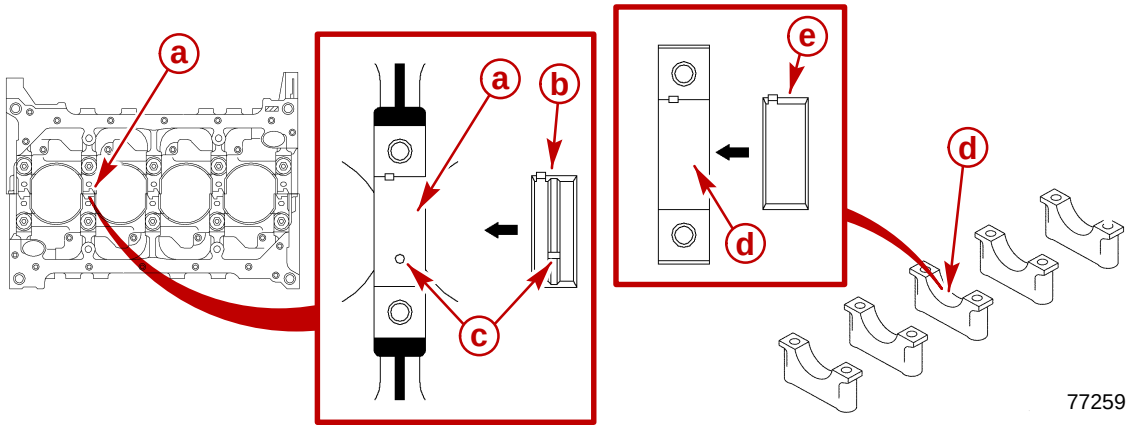
Installation

MAIN BEARINGS, CRANKSHAFT AND THRUST BEARINGS

IMPORTANT: The crankshaft upper main bearings have an oil hole and an oil groove. The lower bearings do not.

1. Carefully wipe any foreign material from the upper main bearing and the upper bearing fitting surfaces.
2. Install bearings as indicated.

NOTE: *Locate the position mark applied at disassembly if the removed upper main bearings are to be reused. Position accordingly.*

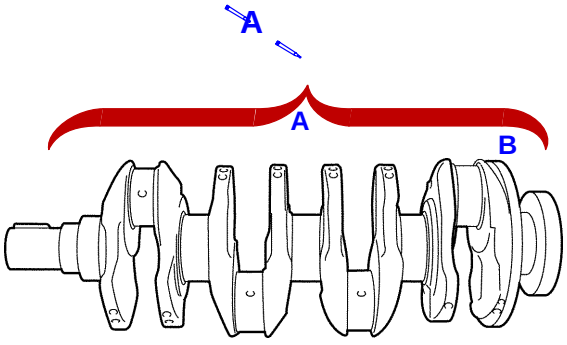


77259

a - Cylinder Block Fitting Surface
b - Upper Bearing Half With Oil Groove
c - Oil Hole
d - Bearing Cap Fitting Surface
e - Lower Bearing Half Without Oil Groove

NOTE: *Do not apply engine oil to the bearing back faces and the cylinder block bearing fitting surfaces.*

3. Apply an ample coat of engine oil to the crankshaft journals and the crankshaft bearing surfaces before installing the crankshaft.



77260

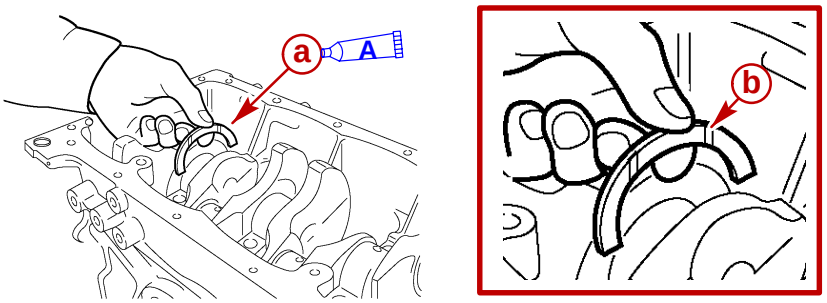
	Description	Where Used	Method of Use	Part Number
A	Engine Oil	Crankshaft	Coat surfaces	Obtain Locally

4. Install the crankshaft into the cylinder block and bearings.

5. Apply an ample coat of engine oil to the crankshaft thrust bearings.

IMPORTANT: The crankshaft thrust bearing oil grooves MUST face the crankshaft not the cylinder block.

6. Install the crankshaft thrust bearings with oil grooves facing cylinder number 2 crankshaft journal.



77261

a - Crankshaft Thrust Bearing
b - Oil Grooves

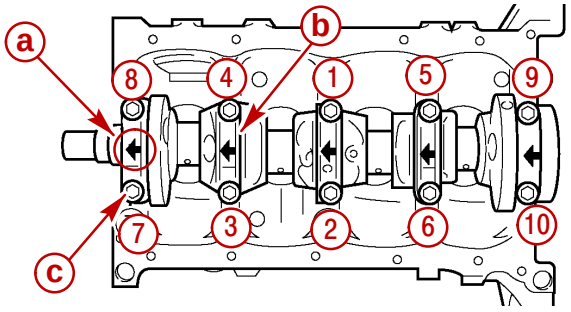
Description		Where Used	Method of Use	Part Number
A	Engine Oil	Crankshaft and thrust bearings	Coat surfaces	Obtain Locally

IMPORTANT: The bearing cap arrow marks MUST face the front of the engine and number must correspond to the bearing cap journal.

7. Apply a coat of engine oil to the threads and mating surfaces of bearing cap bolts.

Description	Where Used	Method of Use	Part Number
Engine Oil	Bearing cap bolt	Coat surfaces	Obtain Locally

8. Tighten the bearing cap bolts a little at a time in numbered sequence (1 - 10).
9. Torque all bearing cap bolts in numbered sequence (1 - 10).



77262

Main Bearing Cap Torque Sequence

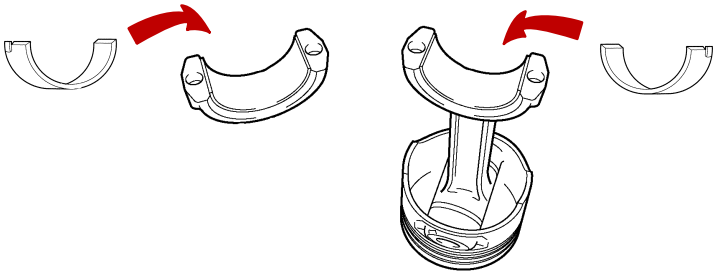
a - Arrow Mark (Points To Front)
b - Bearing Cap
c - Bolts

Description		Nm	lb-in.	lb-ft
Bolt, Main Bearing Cap	M11 x 1.5	88		65

10. Manually rotate the crankshaft to ensure that it turns smoothly.
11. At the same time, rotate the crankshaft until the crankpin is at BDC for cylinder that is ready for first piston to be installed.
12. Carefully wipe any foreign material from the connecting rod bearings and the connecting rod bearing fitting surfaces.

NOTE: *Do not apply engine oil to the bearing back faces and the connecting rod bearing fitting surfaces.*

13. Install the upper bearing to connecting rod.
14. Insert bearing shells into connecting rod and matching rod cap. Coat bearings and crankpin surfaces with a mixture of 20% SAE 30W engine oil and 80% Needle Bearing Lubricant.



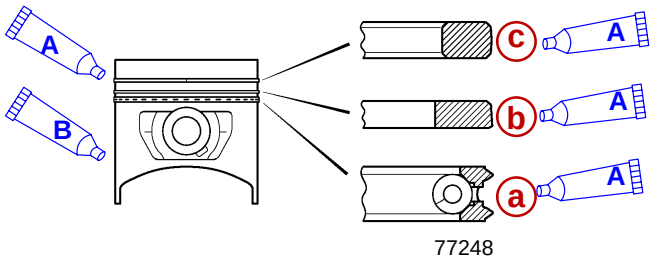
77251

NOTE: *Molybdenum disulfide grease will facilitate smooth break-in when the engine is first started after reassembly.*

Description	Where Used	Method of Use	Part Number
Needle Bearing Assembly Lubricant [1]	Rod bearing and crankshaft journal	Coat surfaces	92 - 802868A1

[1] Used in a mixture of 20% SAE30W engine oil and 80% Needle Bearing Lubricant.

15. Apply a coat of engine oil to the circumference of each piston ring and piston. Apply a coat of molybdenum disulfide grease to the two skirts on each piston.
16. Position the piston ring gaps as shown in the illustration.



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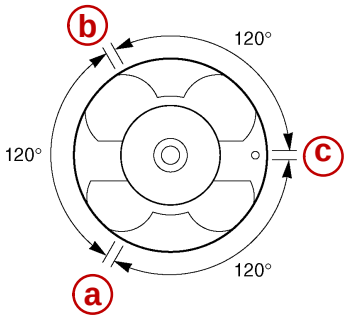


77250

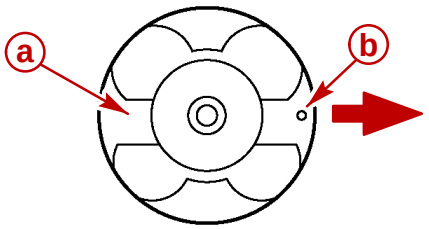
a - Oil Ring
b - Second Compression Ring
c - First Compression

	Description	Where Used	Method of Use	Part Number
A	Engine Oil	Piston and rings	Coat surfaces	Obtain Locally
B	Molybdenum Disulfide Grease	Piston skirt	Coat the two skirts on each piston.	Obtain Locally

17. Apply a coat of engine oil to the cylinder wall.

Description	Where Used	Method of Use	Part Number
Engine Oil	Cylinder Bores	Coat surfaces	Obtain Locally

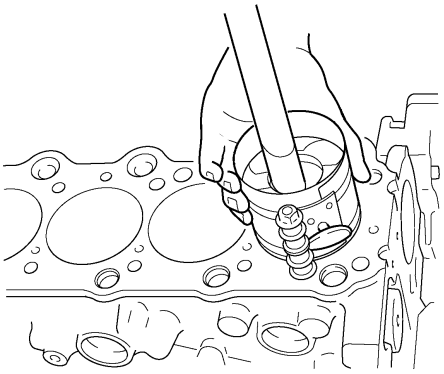
18. Use a piston ring compressor to compress the piston rings.
19. Position the front mark on the top of piston so that it is facing the front of the cylinder block.



77265

a - Top Of Piston
b - Front Mark

20. Install the piston by tapping on piston top with a suitable device. Align connecting rod with crankshaft pin and tap on piston top until the rod bearing contacts crankpin.



77265

NOTE: *Do not apply engine oil to the bearing back faces and the connecting rod bearing fitting surfaces.*

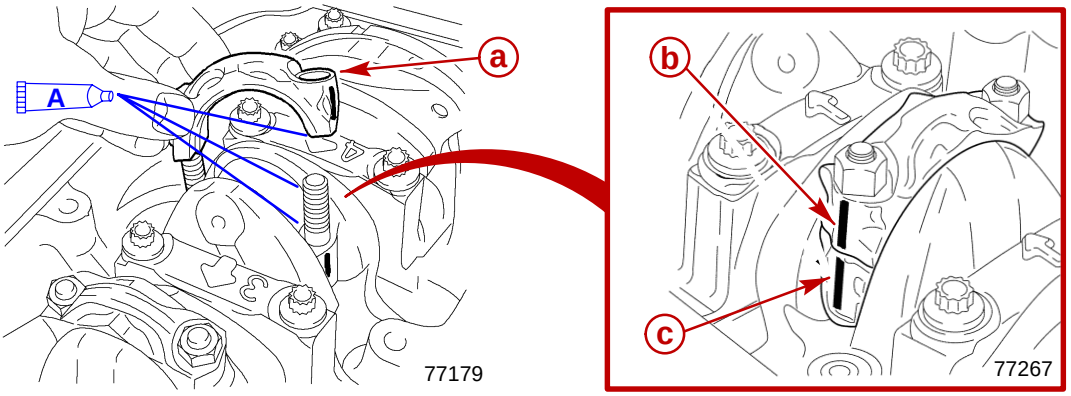
21. Install the connecting rod bearing cap. The bearing cap number (at the side of the bearing cap) and the connecting rod number must be the same and on the same side.

⚠ CAUTION

The bearing caps MUST be installed in the correct direction. Reversing the bearing cap direction will result in serious engine damage.

22. Apply a coat of engine oil to the threads and mating faces of each connecting rod cap, bolt and nut.

23. Torque the connecting rod cap nuts.



a - Rod Bearing Cap
b - Cap Number
c - Rod Number

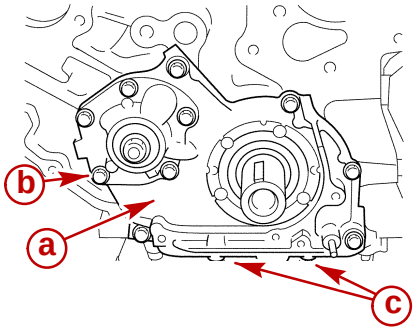
Description		Where Used	Method of Use	Part Number
A	Engine Oil	Bolts, nuts and connecting rod	Thread length and mating faces	Obtain Locally

Description		Nm	lb-in.	lb-ft
Nut, Connecting Rod Bearing Cap	3/8 in. 24UNF	25 + 100°		18 + 100°

Oil Pump

Removal

1. Remove belts.
2. Remove seawater pump (inboard models).
3. Remove timing belt covers.
4. Remove crankshaft pulley and oil pump pulley.
5. Remove oil pan.
6. Remove oil pump retainer.

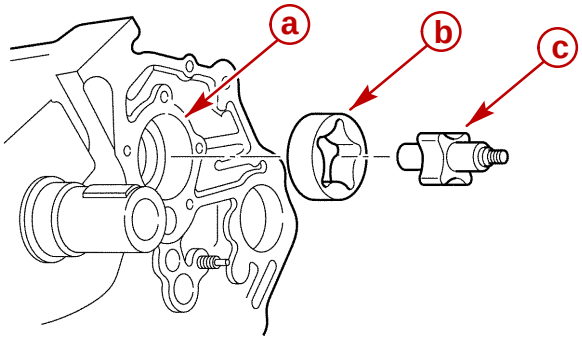


77270

a - Oil Pump Retainer
b - Bolt (10)
c - Front Oil Pan Studs And Nuts

Disassembly

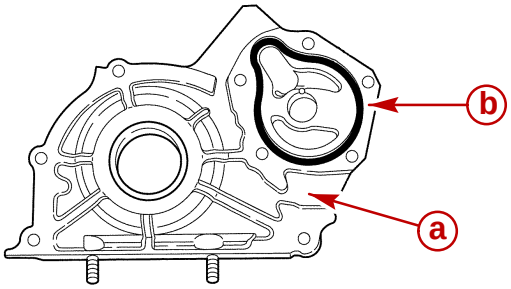
1. Remove inner and outer pump rotors from cylinder block.



77326

a - Cylinder Block
b - Outer Rotor
c - Inner Rotor

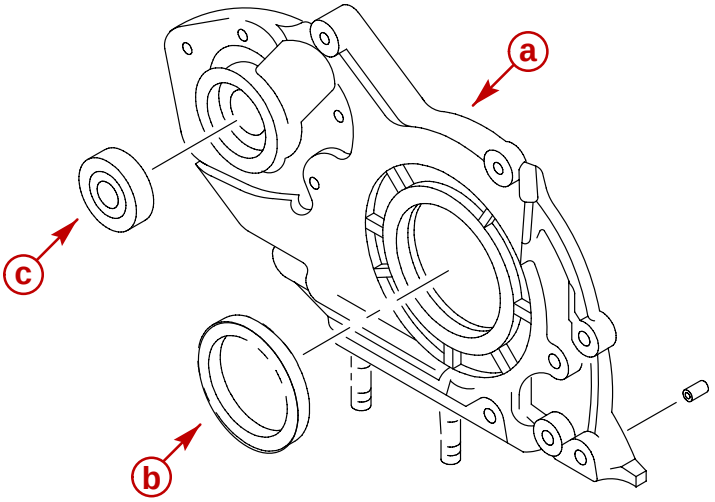
2. Remove oil pump O-ring from back side of oil pump retainer.



77324

a - Oil Pump Retainer
b - Oil Pump O-ring

3. Remove seals from retainer, using suitable tools.



77087

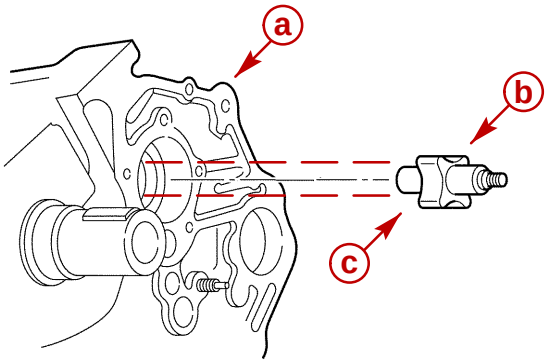
a - Oil Pump Retainer
b - Crankshaft Oil Seal
c - Oil Pump Seal

Cleaning

1. Clean all sealing surfaces.
2. Remove sealant residue.
3. Wash all parts in solvent and dry with compressed air.

Inspection

1. Inspect oil pump shaft, rotors and cylinder block for excessive wear or damage. Replace oil pump assembly if excessive wear or damage is found.
2. Check clearance of oil pump shaft in cylinder block.



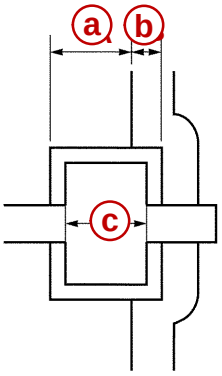
77326

a - Cylinder Block
b - Inner Rotor
c - Oil Pump Shaft

Description		mm (in.)
Oil pump shaft clearance in cylinder block	Production	0.040 - 0.125 (.0015 - .0049)
	Limit	0.200 (.0078)

3. Check oil pump rotor end float (end play).

NOTE: *Rotor end float is the difference between the combined cylinder block and retainer depths minus the thickness of the rotors.*

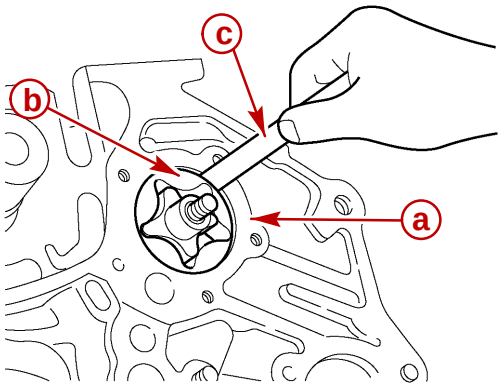


77327

a - Cylinder Block Depth
b - Retainer Depth
c - Inner and Outer Rotor Thickness

Description		mm (in.)
End Float [(**a** + **b**) – **c**]	Production	0.035 - 0.100 (.0014 - .0039)
	Limit	0.150 (.0059)

4. Check clearance between outer rotor and cylinder block.

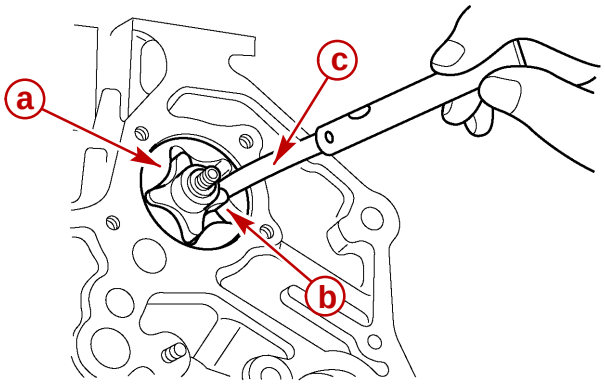


77328

a - Cylinder Block
b - Outer Rotor
c - Feeler Gauge

Description		mm (in.)
Clearance between outer rotor and cylinder block	Production	0.24 - 0.36 (0.0094 - .0141)
	Limit	0.40 (0.0157)

5. Check clearance between inner and outer oil pump rotors.



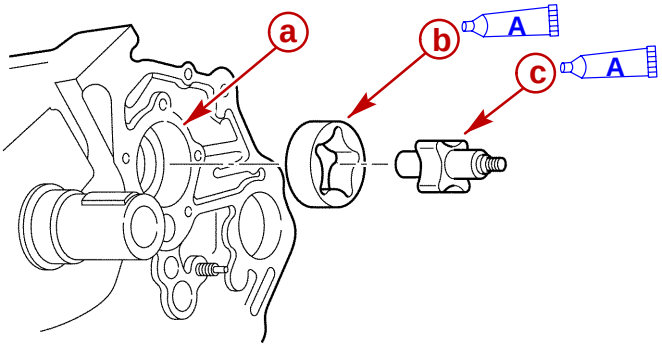
77329

a - Outer Rotor
b - Inner Rotor
c - Feeler Gauge

Description		mm (in.)
Clearance between inner and outer rotors (mesh)	Production	0.13 - 0.15 (0.0051 - .0059)
	Limit	0.20 (.0078)

Reassembly

1. Coat inner and outer oil pump rotor surfaces with engine oil.
2. Install inner and outer oil pump rotors in cylinder block.



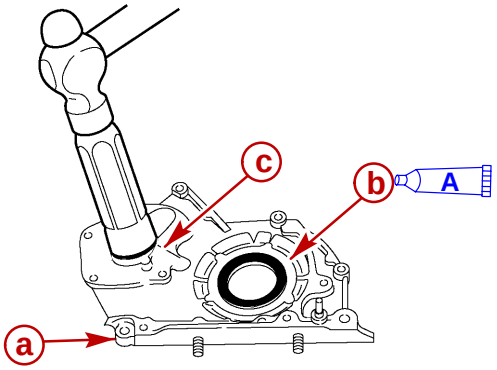
77323

a - Cylinder Block
b - Outer Pump Rotor
c - Inner Pump Rotor

	Description	Where Used	Method of Use	Part Number
A	Engine Oil	Inner and outer oil pump rotors	Coat surfaces	Obtain Locally

Installation

1. Coat sealing lips of oil seals with silicon grease. Install crankshaft seal and oil pump shaft seal in oil pump retainer.

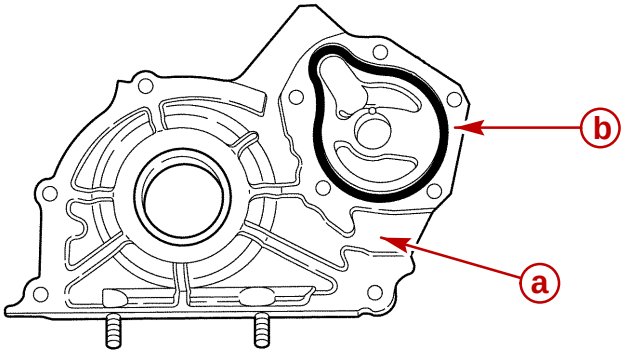


77271

a - Oil Pump Retainer
b - Crankshaft Oil Seal
c - Oil Pump Seal

	Description	Where Used	Method of Use	Part Number
A	Silicone Grease	Oil seal	Coat lips	Obtain Locally

2. Install a new oil pump O-ring in groove on rear side of oil pump retainer.

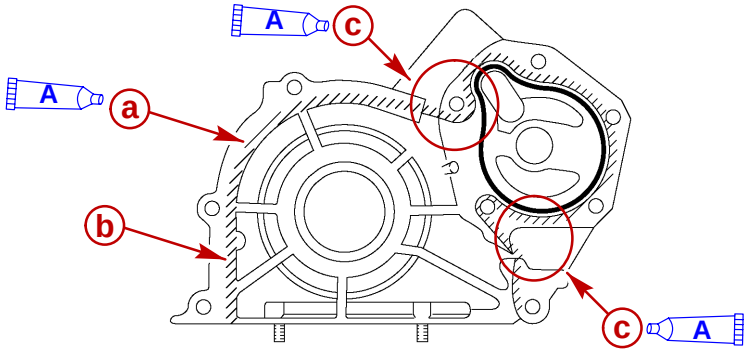


77324

a - Oil Pump Retainer
b - Oil Pump O-ring

3. Apply a bead of sealant to sealing surface of oil pump retainer where cross-hatch marks are shown in the following. A small amount of extra sealant must be added as indicated.

IMPORTANT: Ensure that a small amount of extra sealant is added where indicated.

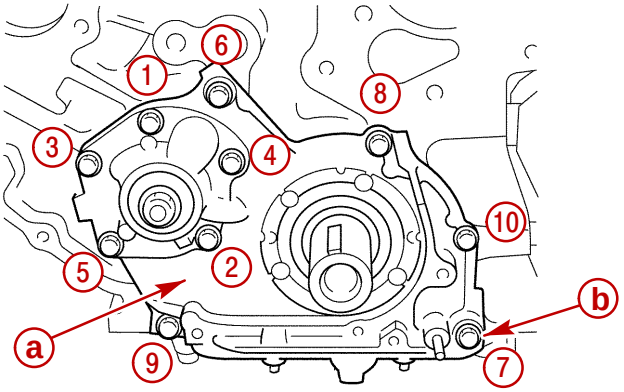


77269

a - Sealing Surface
b - Cross-Hatching Marks For Sealant Location
c - Extra Sealant Areas

Description		Where Used	Method of Use	Part Number
A	Loctite 5699	Between oil pump retainer and cylinder block	Apply a bead to sealing surfaces as indicated	Obtain Locally

4. Install oil pump retainer to cylinder block. Torque the five bolts around the oil pump in a circular pattern (1 - 5).
5. Torque remaining retainer bolts (6–10).



77270

Oil Pump Retainer Torque Sequence

a - Oil Pump Retainer
b - Bolts (10)

Description		Nm	lb-in.	lb-ft
Bolt, Oil Pump Retainer	M6 x 1.0	9.8	87	

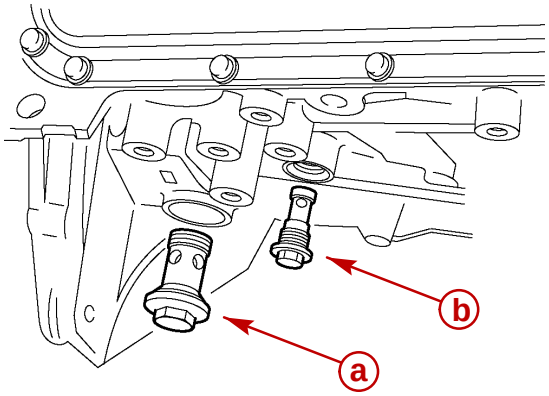
6. Install oil pan.
7. Install crankshaft pulley and oil pump pulley.
8. Install timing belt and covers.
9. On inboard models, install seawater pump and belt.

Oil Pressure Relief Valve And Check Valve

The oil pressure relief valve and check valve are installed in the lower, rear port side of the block.

Removal

1. Remove oil pressure relief valve and check valve from block.



77330

a - Oil Pressure Relief Valve
b - Check Valve

Cleaning

1. Clean all sealing surfaces.
2. Wash all parts in solvent and dry with compressed air.

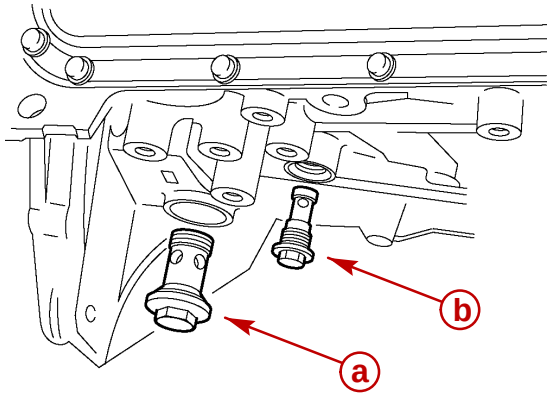
Inspection

NOTE: *The oil pressure relief valve has a built-in spring and does not require inspection.*

1. Check that valves slide freely in their bores when coated with oil.

Installation

1. Install oil pressure relief valve and check valve into block using new sealing rings.
2. Torque the oil pressure relief valve and check valve.



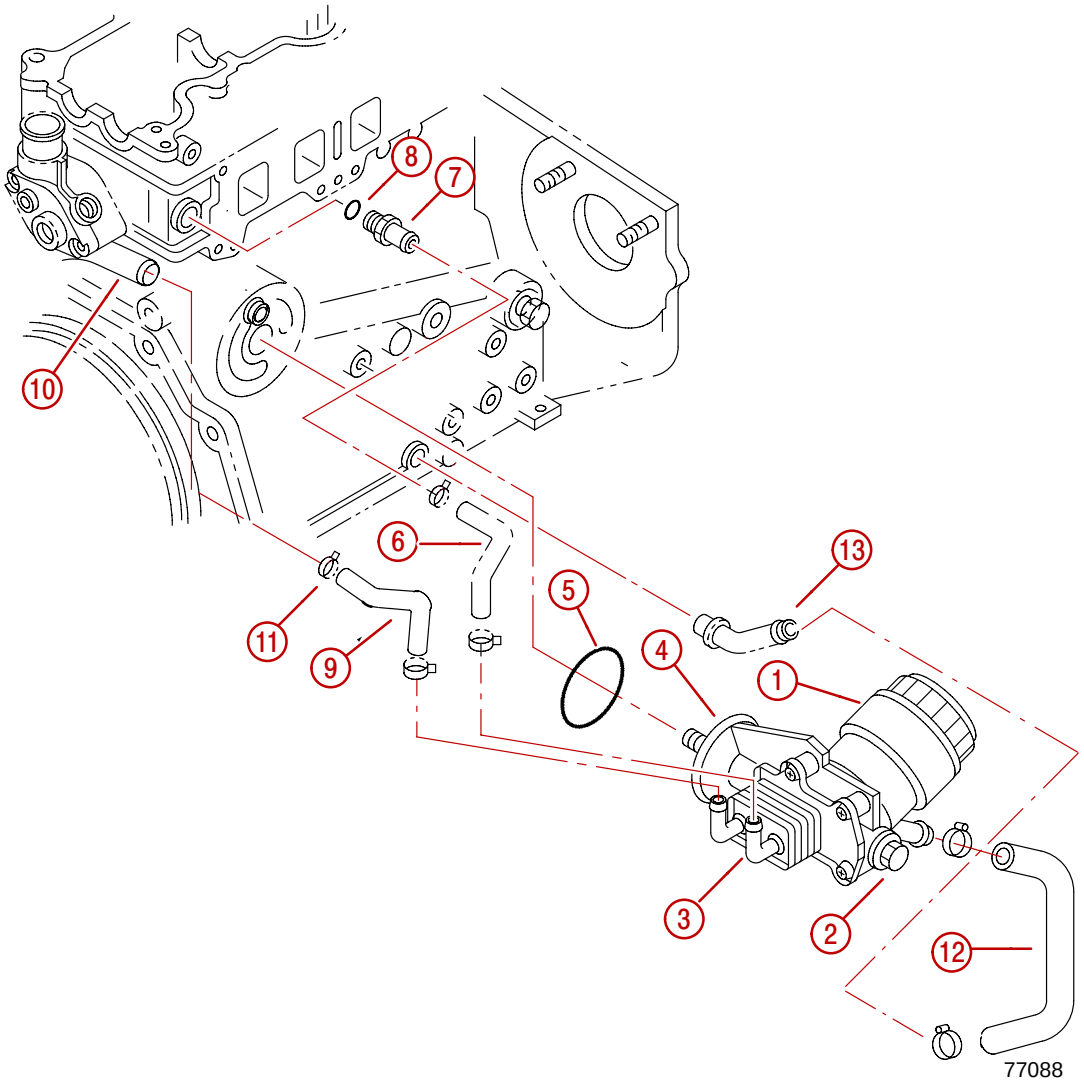
77330

a - Oil Pressure Relief Valve
b - Check Valve

Description		Nm	lb-in.	lb-ft
Valve, Oil Pressure Relief	–	39		28
Valve, Check	M18 x 1.5	29		21

Oil Filter and Oil Cooler Assembly

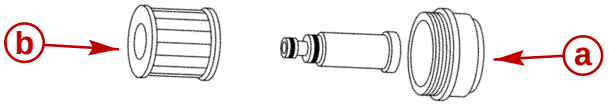
Exploded View



1 - Oil Filter Top Piece
2 - Hollow Retaining Bolt
3 - Oil Cooler
4 - Oil Filter Housing
5 - Housing-To-Cylinder Block O-ring
6 - Coolant Hose-To-Cylinder Head Water Fitting
7 - Cylinder Head Water Fitting
8 - Seal
9 - Coolant Hose-(To Water Pipe)
10 - Water Pipe
11 - Clamp
12 - Oil Drain Hose
13 - Oil Drain Pipe

Removal

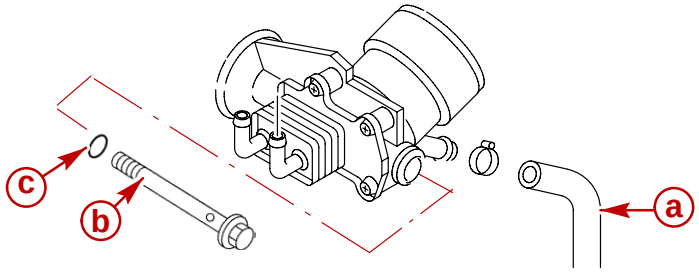
1. Drain coolant.
2. Disconnect coolant hoses from oil cooler.
3. Remove oil filter top piece and oil filter element.



77088

a - Oil Filter Top Piece
b - Oil Filter Element

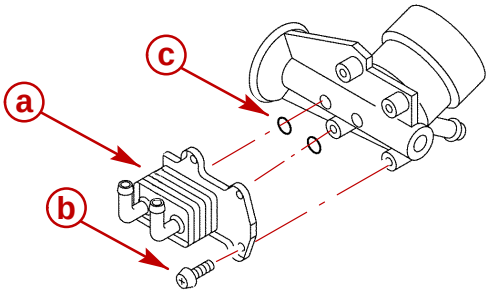
4. Disconnect oil drain hose from filter housing.
5. Remove oil filter housing hollow retaining bolt and O-ring.



77088

a - Oil Drain Hose
b - Hollow Retaining Bolt
c - O-ring

6. Remove oil filter housing and oil cooler assembly from cylinder block.
7. Remove bolts and separate oil cooler from oil filter housing. Note position of O-ring seals.



77088

a - Oil Cooler
b - Bolt
c - O-ring Seals

Cleaning

NOTE: *The oil filter element cannot be cleaned and reused. It must be replaced.*

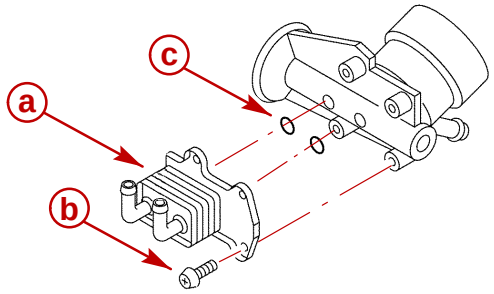
1. Clean all sealing surfaces.
2. Wash all parts in solvent and dry with compressed air.

Inspection

1. Inspect housing and cooler sealing surfaces for nicks and burrs.
2. Inspect oil cooler for cracks or deformation.
3. Inspect oil filter housing for cracks.
4. Inspect coolant hoses. Replace if damaged or worn.

Installation

1. Install new O-rings and bolt oil cooler to oil filter housing. Torque bolts.

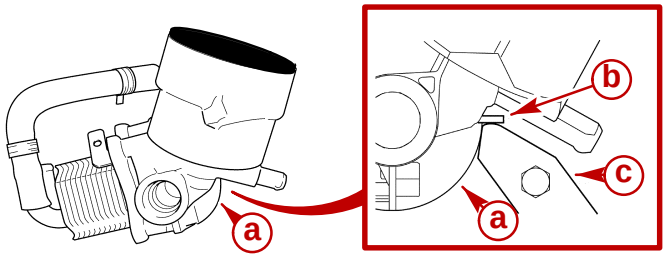


77088

a - Oil Cooler
b - Bolt
c - O-ring Seals

Description	Nm	lb-in.	lb-ft
Bolt, Oil Cooler	12	106	

2. Mount oil filter housing with oil cooler onto cylinder block. Engage the lug on the oil filter housing with locating stopper.



77316

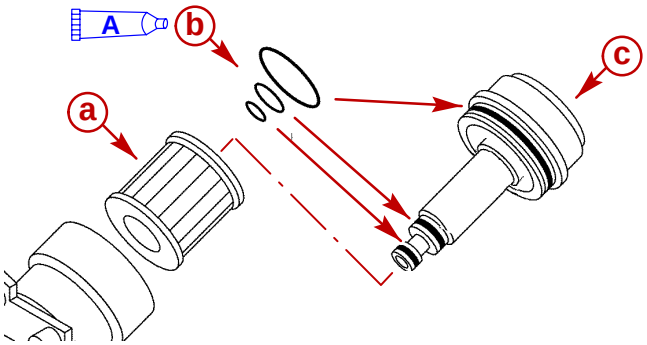
a - Oil Filter Housing
b - Lug
c - Locating Stopper

3. Apply engine oil to hollow retaining bolt threads and seat. Install hollow retaining bolt with new O-ring. Torque bolt.

Description	Where Used	Method of Use	Part Number
Engine Oil	Hollow bolt and O-ring	Coat threads and surfaces	Obtain Locally

Description		Nm	lb-in.	lb-ft
Hollow Bolt, Oil Filter Housing	M20 x 1.5	110		81

4. Connect oil drain hose to filter housing.
5. Install the three new O-rings.
6. Apply a coat of engine oil to the O-rings.
7. Install the oil filter element on the top piece.



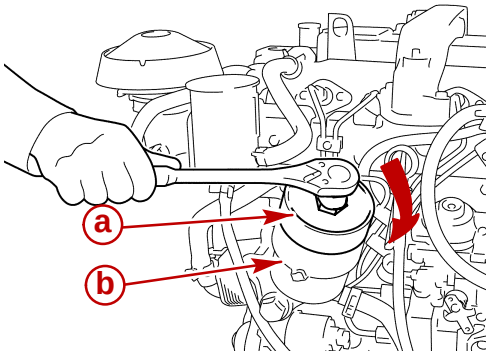
77242

a - Oil Filter Element
b - O-rings
c - Top Piece

Description		Where Used	Method of Use	Part Number
A	Engine Oil	O-rings	Coat surfaces	Obtain Locally

8. Install the top piece with the new oil filter element into the oil filter housing.
9. Turn the top piece until seated against the oil filter housing.
10. Using the filter wrench or socket, torque top piece.

IMPORTANT: Overtightening the top piece will cause deformation and oil leaks.

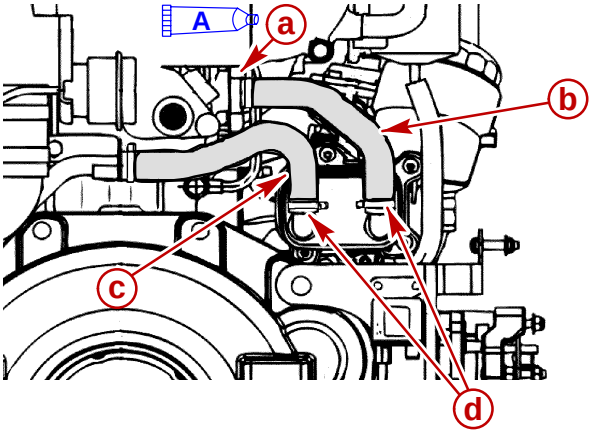


79740

a - Oil Filter Assembly
b - Filter Housing

Description	Nm	lb-in.	lb-ft
Oil Filter Top Piece	25		18

11. Ensure water fitting is not leaking. Apply specified sealant during installation if previously removed.
12. Connect and clamp coolant hoses.



77122

a - Water Fitting
b - Hose To Fitting
c - Hose To Water Pipe
d - Clamp

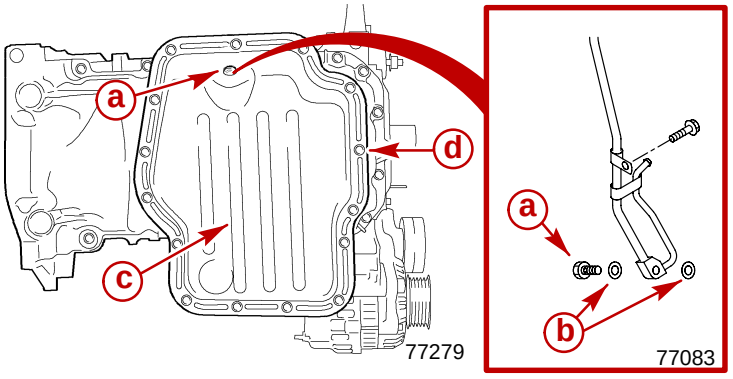
	Description	Where Used	Method of Use	Part Number
A	Loctite 5900 or 5699	Water fitting for oil cooler coolant hose at block	Thread length	Obtain Locally

13. Fill closed cooling system.
14. Ensure oil level is up to, but not over, MAX mark on dipstick.
15. Pre-lubricate turbocharger and engine.
16. Operate the engine for a few minutes. Stop the engine and wait for about ten minutes.
17. Check dipstick to ensure oil level is up to, but not over, MAX mark on dipstick.
18. Start engine and check for leaks.

Oil Pan And Oil Pickup Assembly

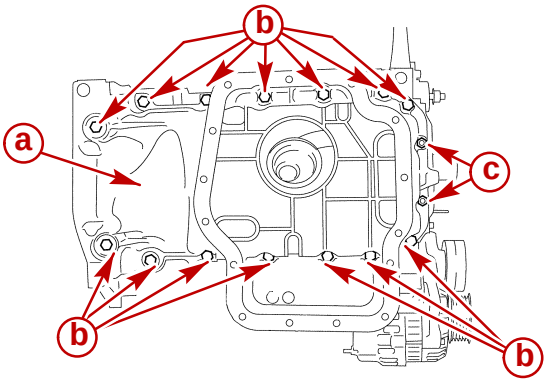
Removal

1. Remove oil dipstick tube hollow bolt and washers and drain oil into a suitable container.
2. Remove lower oil pan.



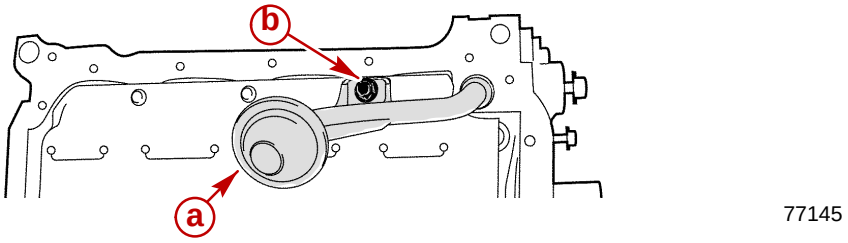
a - Hollow Bolt
b - Washer
c - Lower Oil Pan
d - Bolts (15)

3. Remove upper oil pan.



a - Upper Oil Pan
b - Bolts (14)
c - Nuts (2)

4. Remove oil pickup assembly and O-ring seal.



a - Oil pickup Assembly
b - Bolt

Cleaning

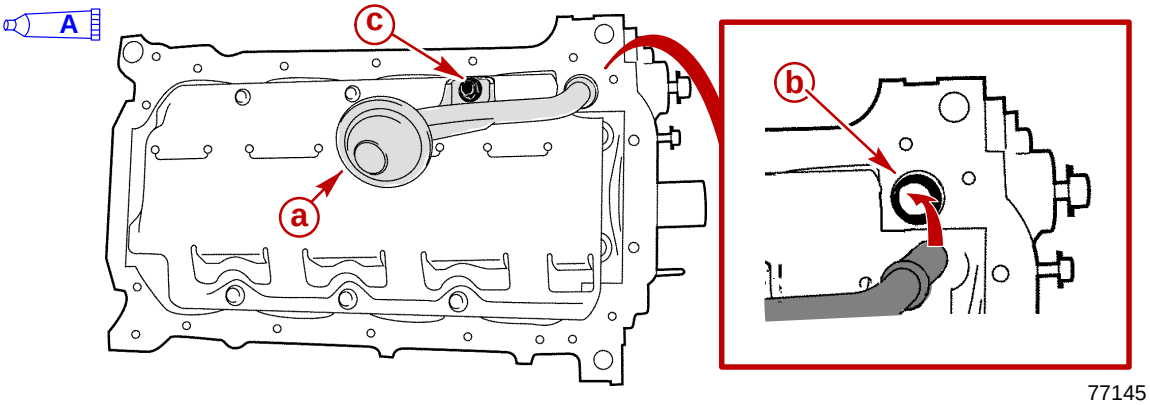
1. Wash parts in solvent and dry with compressed air.
2. Clean old gasket material and adhesive from all sealing surfaces.

Inspection

1. Inspect the oil pans and components for fatigue cracks.
2. Check all welds for leaks.
3. Inspect oil pick-up assembly for fatigue cracks or damage.

Installation

1. Install new O-ring seal on oil pickup assembly. Coat surfaces of O-ring with clean engine oil.
2. Install oil pickup assembly. Torque bolt.



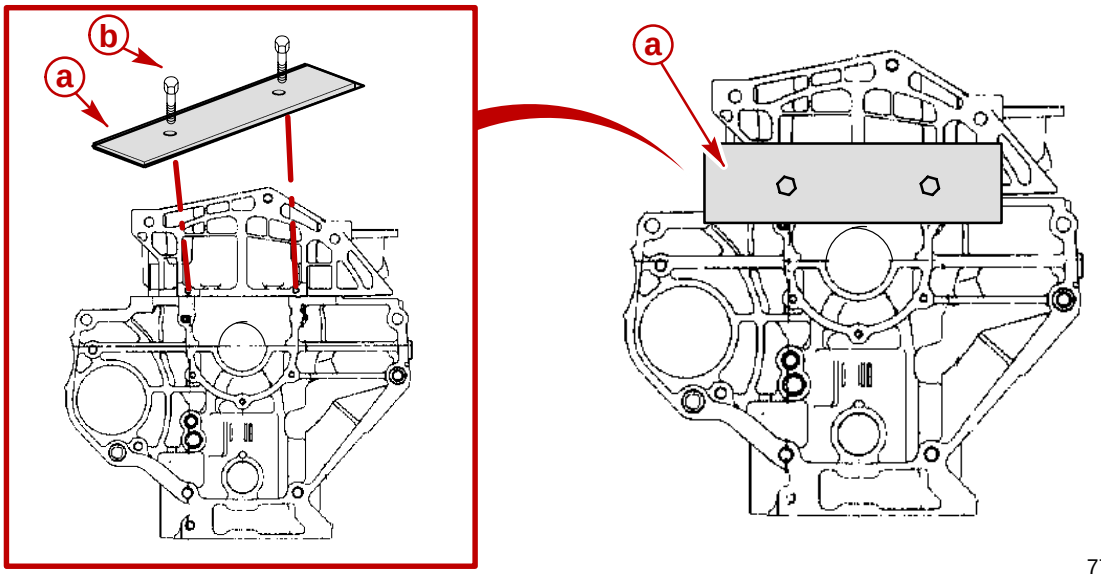
77145

a - Oil pickup Assembly
b - O-ring
c - Bolt

Description		Where Used	Method of Use	Part Number
A	Engine Oil	O-ring	Coat surfaces	Obtain Locally

Description		Nm	lb-in.	lb-ft
Bolt, Oil Pickup Assembly	M8 x 1.25	26		19

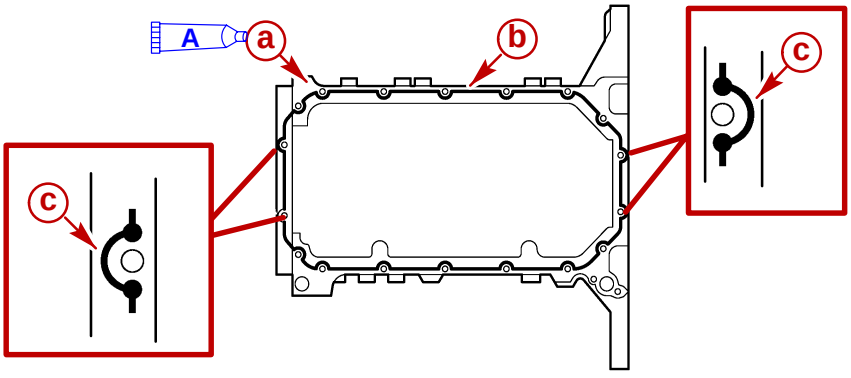
3. Mount the Aligner Tool (91-883859) as shown, to align cylinder block and upper oil pan. Use 2 M6 x 1.0 x 10mm–16mm long bolts obtained locally to hold in place temporarily.



77801

a - Aligner Tool
b - Bolts

4. Apply a 4 mm (5/32 in.) bead of specified sealant to sealing surface of cylinder block. Ensure that sealer application is around the outside of studs on front and rear.

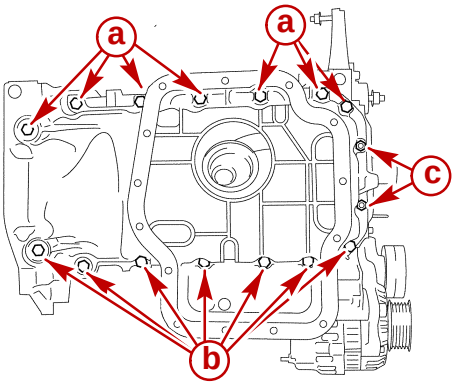


77277

a - Sealing Surface
b - Sealer
c - Sealer Application Around Studs

	Description	Where Used	Method of Use	Part Number
A	Loctite 5999	Upper oil pan to cylinder block	Apply a bead to sealing surfaces as specified	Obtain Locally

5. Install upper oil pan to cylinder block and position squarely against the Aligner Tool. Temporarily hand tighten bolts and nuts.
6. Ensure upper oil pan is aligned to cylinder block and torque bolts and nuts.

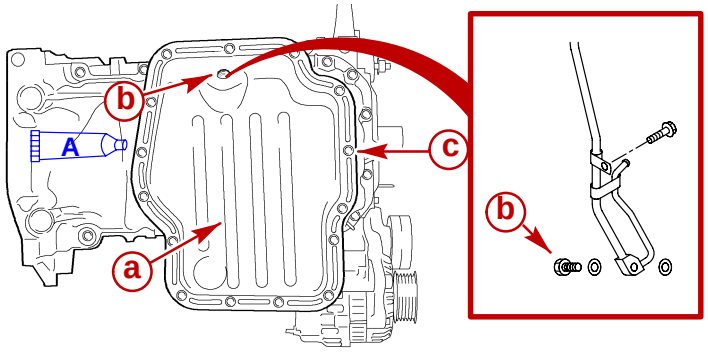


77278

a - Upper Oil Pan
b - Bolt (14)
c - Nuts (2)

Description		Nm	lb-in.	lb-ft
Nut / Bolt, Upper Oil Pan	M6 x 1.0	9.8	87	

7. Remove the two M6 bolts and the Aligner Tool.
8. Apply a 4 mm (5/32 in.) bead of specified sealant to sealing surface of upper oil pan.
9. Install lower oil pan. Torque bolts.
10. Install oil dipstick tube assembly with new sealing washers. Torque hollow bolt.



77279

a - Lower Oil Pan
b - Dipstick Tube Hollow Bolt And Washer
c - Bolts (15)

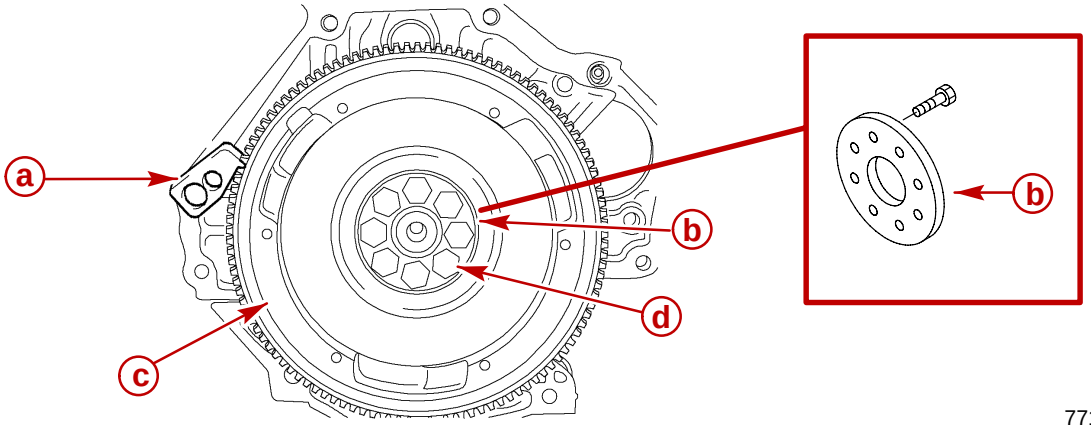
Description		Where Used	Method of Use	Part Number
A	Loctite 5699	Lower oil pan to upper oil pan	Apply a bead to sealing surfaces as specified	Obtain Locally

Description		Nm	lb-in.	lb-ft
Bolt, Lower Oil Pan	M6 x 1.0	9.8	87	
Hollow Bolt, Dipstick Tube	M14 x 1.5	39		29

Rear Oil Seal

Removal

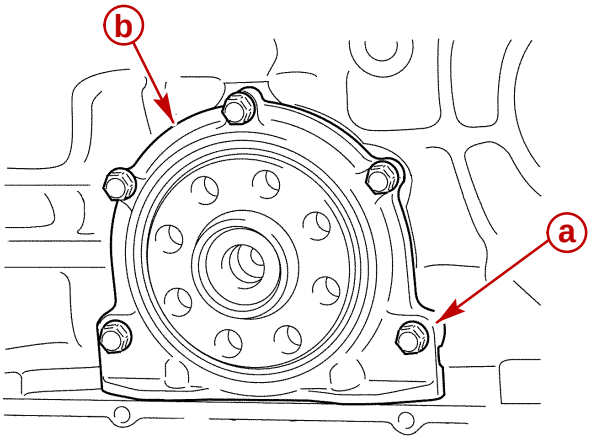
1. Remove the flywheel housing on sterndrive models. Remove the transmission and flywheel housing on inboard models.
2. Remove the flywheel coupler on sterndrive models, or the drive plate on inboard models.
3. Remove lower oil pan.
4. Remove upper oil pan.
5. Hold flywheel using appropriate lock device. Loosen and remove bolts.
6. Remove the flywheel washer and flywheel.



77137

a - Lock Device
b - Flywheel Washer
c - Flywheel
d - Bolts (8)

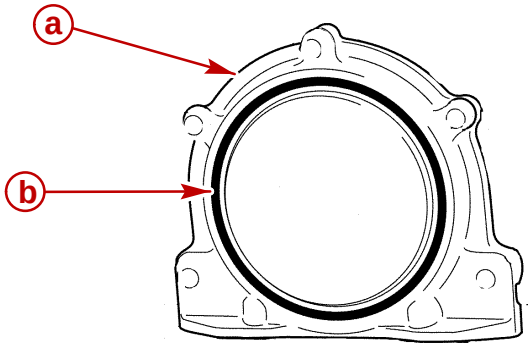
7. Remove the bolts from the rear oil seal retainer.
8. Remove the rear oil seal retainer from the cylinder block. Ensure that sealing surfaces are not damaged.



77138

a - Bolt
b - Rear Oil Seal Retainer

9. Carefully pry old rear oil seal out of the rear oil seal retainer using a suitable tool.



77138

a - Rear Oil Seal Retainer
b - Rear Oil Seal

Cleaning

1. Clean sealing surfaces.
2. Remove sealant residue.

Inspection

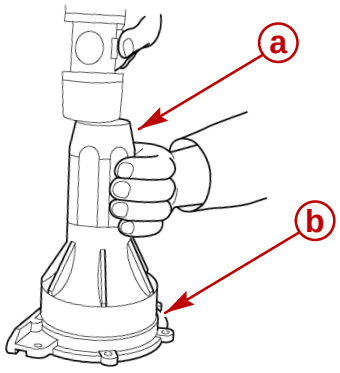
1. Inspect rear oil seal retainer sealing area for nicks and burrs.
2. Inspect rear oil seal retainer and crankshaft sealing area for nicks, burrs and scoring.

Installation

1. Coat inner lip of new rear oil seal with clean lubricant.

Description	Where Used	Method of Use	Part Number
Engine Oil	Inner lip of rear oil seal	Coat surfaces	Obtain Locally

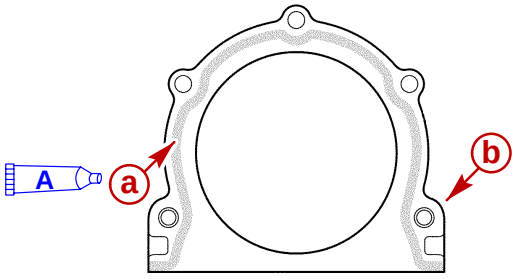
2. Install seal in rear oil seal retainer using a suitable seal driver.



77273

a - Seal Driver
b - Rear Oil Seal Retainer

3. Apply a bead of specified sealant to sealing surfaces of rear oil seal retainer.



77272

a - Sealant
b - Rear Oil Seal Retainer

Description		Where Used	Method of Use	Part Number
A	Loctite 5900	Between oil seal retainer and cylinder block	Apply a bead to sealing surfaces as specified	Obtain Locally

4. Install rear oil seal retainer. Torque bolts.

Description		Nm	lb-in.	lb-ft
Bolt, Rear Oil Seal Retainer	M6 x1.0	9.8	87	

5. Install upper and lower oil pans.
6. Suitably clean or chase the threads of flywheel bolt holes in crankshaft before proceeding.
7. Install flywheel and flywheel washer.

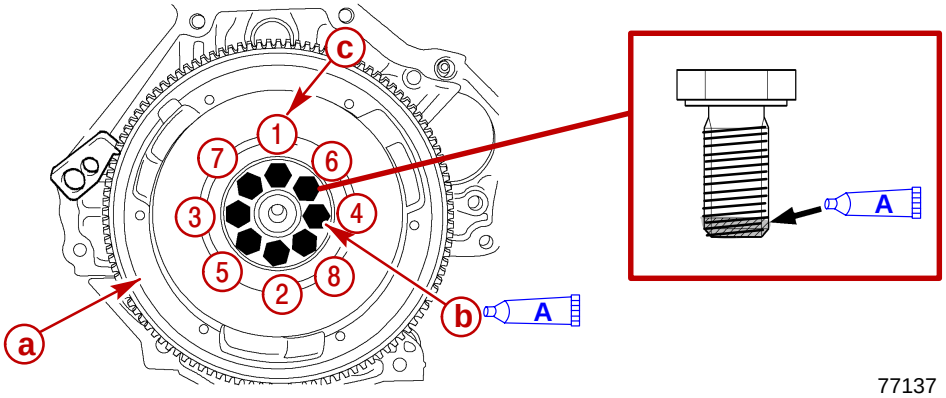
⚠ CAUTION

Avoid severe engine damage or injury. Flywheel mounting bolt are suitable for one time use only. They could fail if used more than once. Do not reuse flywheel mounting bolts.

8. Apply sealant to beginning threads of 8 NEW flywheel bolts and install the flywheel. Do not reuse flywheel mounting bolts.

IMPORTANT: The installation time using this sealant, including the torque check, is 10 minutes maximum.

9. Hold flywheel using an appropriate lock device. Tighten bolts in the numerical sequence shown. Torque bolts.

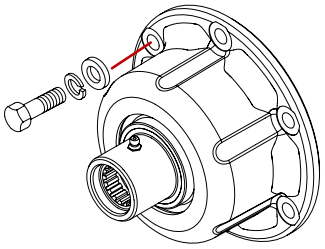


a - Flywheel
b - New Flywheel Bolts (8)
c - Sequence

Description		Where Used	Method of Use	Part Number
A	Loctite 262	New flywheel retaining bolts	Apply to beginning threads	Obtain Locally

Description		Nm	lb-in.	lb-ft
Bolt, Flywheel	M11 x 1.25	29 + 60°		21 + 60°

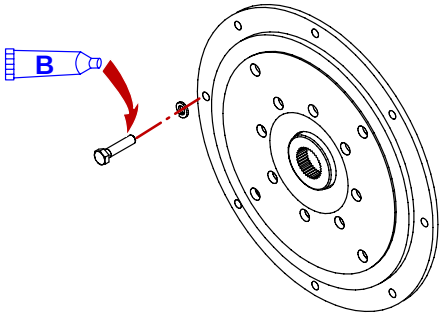
10. **On sterdrive models**: Install the flywheel coupler using the M10 bolts and lockwashers. Torque the bolts.



77770

Description		Nm	lb-in.	lb-ft
Bolt, Coupler	M10 x 1.5	44.1		33

11. **On inboard models**: Install the drive plate using the M7 bolts and lockwashers.Torque the bolts.



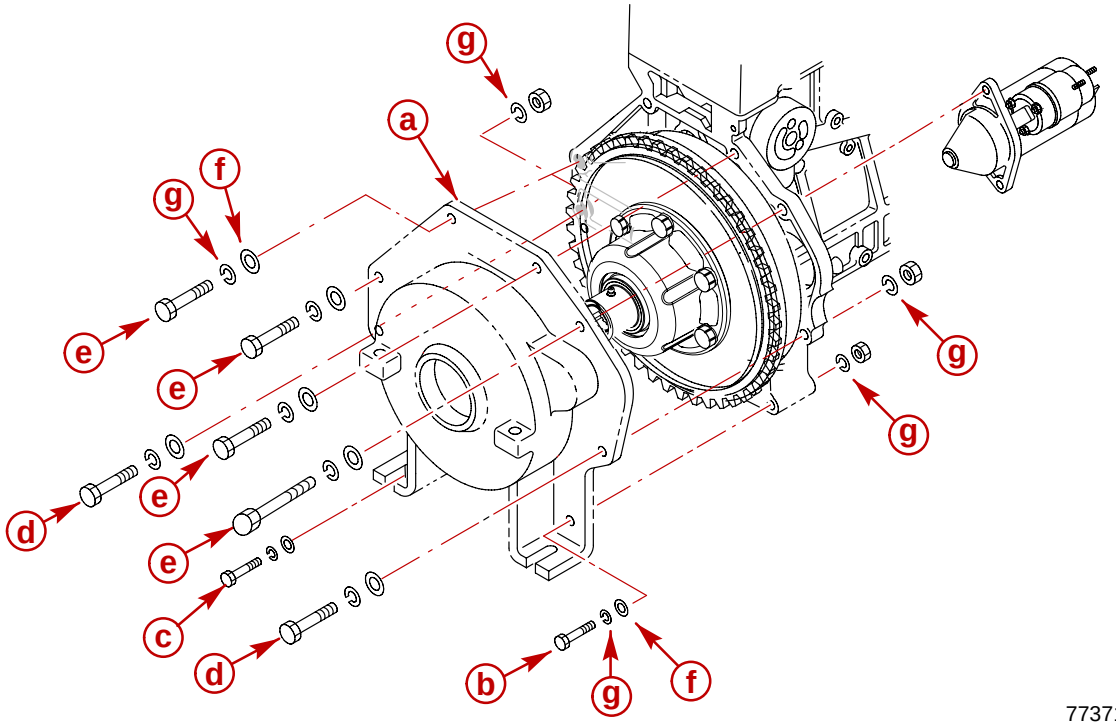
79705

Description		Nm	lb-in.	lb-ft
Bolt, Drive Plate	M7 x 1 x 30	14.9	132	

Description		Where Used	Method of Use	Part Number
B	Loctite 271	Drive Plate bolts	Apply to beginning threads	Obtain Locally

12. Install flywheel housing. Torque bolts and nuts.

NOTE: *There are different thread patterns and fastener combinations involved. Ensure the proper placement of each.*



Sterndrive Shown, Inboard Similar

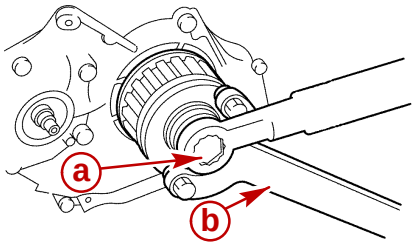
- **a** - Flywheel Housing
- **b** - Bolt, Washers and Nut - M10 x 1.5
- **c** - Bolt and Washers - M10 x 1.5
- **d** - Bolt, Washers and Nut - M12 x 1.25
- **e** - Bolt and Washers - M12 x 1.75
- **f** - Flat Washer
- **g** - Lock Washer

Description		Nm	lb-in.	lb-ft
Bolt and Nut	M12	86		64
Bolt and Nut	M10	44.1		33

13. **On inboard models:** Install the transmission. Refer to **Section 8A**.

Front Oil Seal Removal

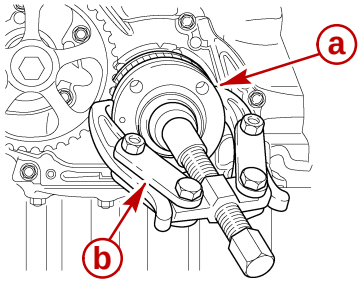
1. Remove engine drive belts.
2. Remove seawater pump (inboard models).
3. Remove timing belt covers and timing belt.
4. Remove crankshaft pulley.
5. Remove fastening bolt for timing belt drive pulley. Counterhold using special tool.



77140

a - Crankshaft Pulley Bolt
b - Special Tool

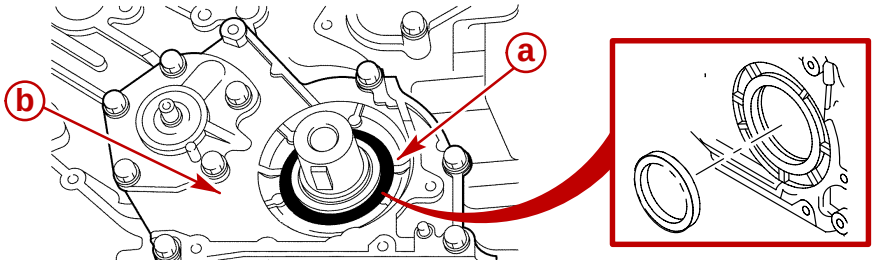
6. Remove timing belt drive pulley from crankshaft using puller.



77141

a - Crankshaft Pulley
b - Puller

7. Using a suitable tool, remove front oil seal from front oil seal retainer. Ensure that sealing surfaces and crankshaft are not damaged.



77142

a - Front Oil Seal
b - Retainer

Cleaning

1. Clean bore of seal retainer where seal resides.
2. Clean crankshaft sealing area.

Inspection

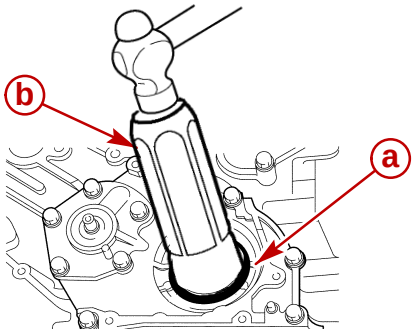
1. Inspect bore of seal retainer for nicks and burrs.
2. Inspect crankshaft seal area for nicks, burrs and scoring.

Installation

1. Coat inner lip of new seal with engine oil.

Description	Where Used	Method of Use	Part Number
Engine Oil	Front oil seal	Coat lips	Obtain Locally

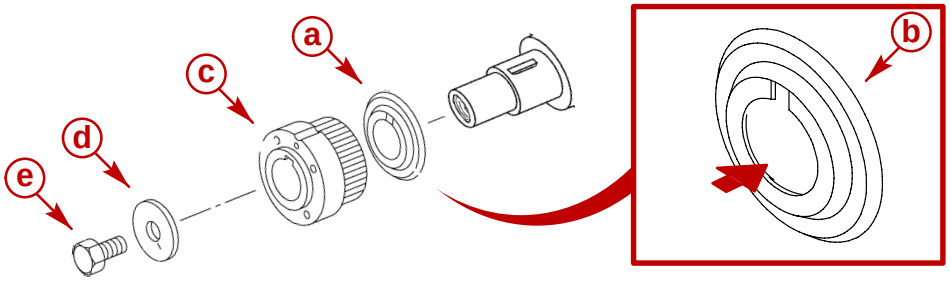
2. Install seal using seal driver part # 91–883848.



77370

a - Front Oil Seal
b - Seal Driver

3. Hold flywheel using suitable tool.
4. Install crankshaft timing belt pulley parts in order. Concave side of belt guide plate faces rear. Torque bolt.



77085

a - Belt Guide Plate
b - Concave Side
c - Crankshaft Timing Belt Pulley
d - Flat Washer
e - Bolt

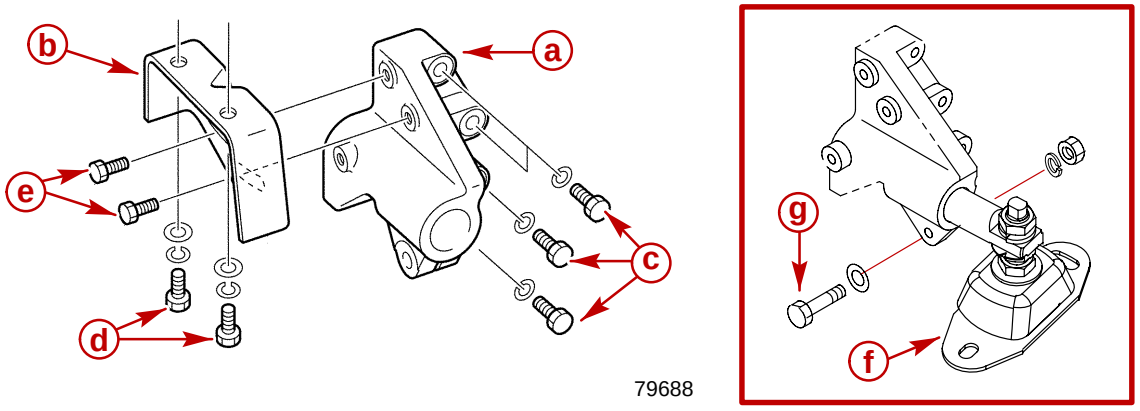
Description		Nm	lb-in.	lb-ft
Bolt, Crankshaft	M16 x 1.5	196		144

5. Install timing belt and timing belt covers.
6. Install serpentine belt and power steering belt, if equipped.
7. Install seawater pump (inboard models).

Front Engine Mounts

Starboard

1. **On models without power steering:** install the starboard engine mount bracket to the cylinder block.
2. **On models equipped with power steering:** install the power steering pump bracket and starboard engine mount bracket. Refer to Section 9A.
3. Torque mount bolts.
4. Install the rear bracket to the injection pump and mount bracket.
5. Torque rear bracket to mount bolts and rear bracket to injection pump bolts.
6. Install pedestal mount assembly to trunion.
7. After trunion and mount are adjusted, torque trunion clamping bolt.



Typical

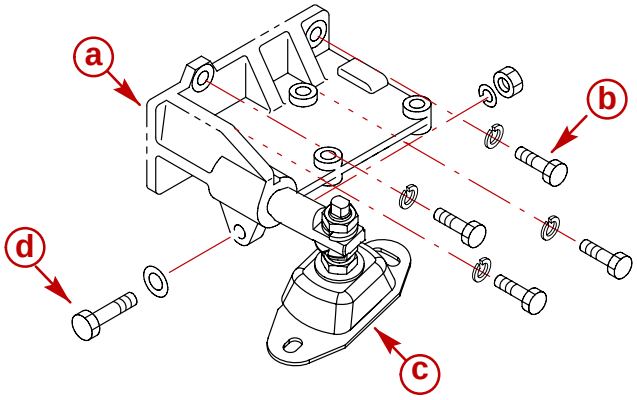
- **a** - Starboard Mount Bracket
- **b** - Rear Bracket
- **c** - Mount To Cylinder Block Bolt And Washer
- **d** - Rear Bracket To Injection Pump Bolt And Washers
- **e** - Rear Bracket To Mount Bolt
- **f** - Pedestal Mount Assembly
- **g** - Trunnion Clamping Bolt And Nut

Description		Nm	lb-in.	lb-ft
Bolt, Mount to Cylinder Block		51		37
Bolt, Bracket to Injection Pump		38		28
Bolt, Bracket to Mount		19		14
Bolt, Trunion Clamping		57		42

8. **On models equipped with power steering:** install the power steering pump. Refer to Section 9A.

Port

1. Install the port engine mount bracket to the cylinder block.
2. Torque mount bolts.
3. Install pedestal mount assembly to trunion.
4. After trunion and mount are adjusted, torque trunion clamping bolt.

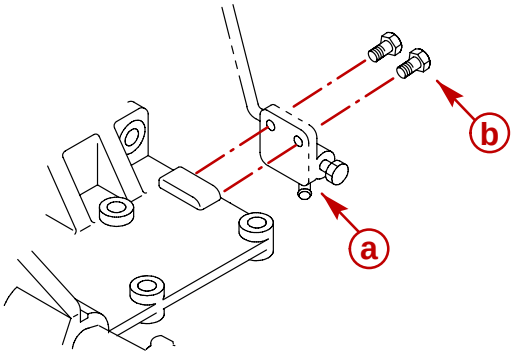


77775

a - Port Mount Bracket
b - Bolt And Lock Washer
c - Pedestal Mount Assembly
d - Trunion Clamping Bolt, Flat Washer, Lock Washer and Nut

Description		Nm	lb-in.	lb-ft
Bolt, Mount to Cylinder Block	M10 x 1.5	51		37
Bolt, Trunion Clamping		68		50

5. Attach coolant drain bracket to mount bracket. Torque bolts.



77774

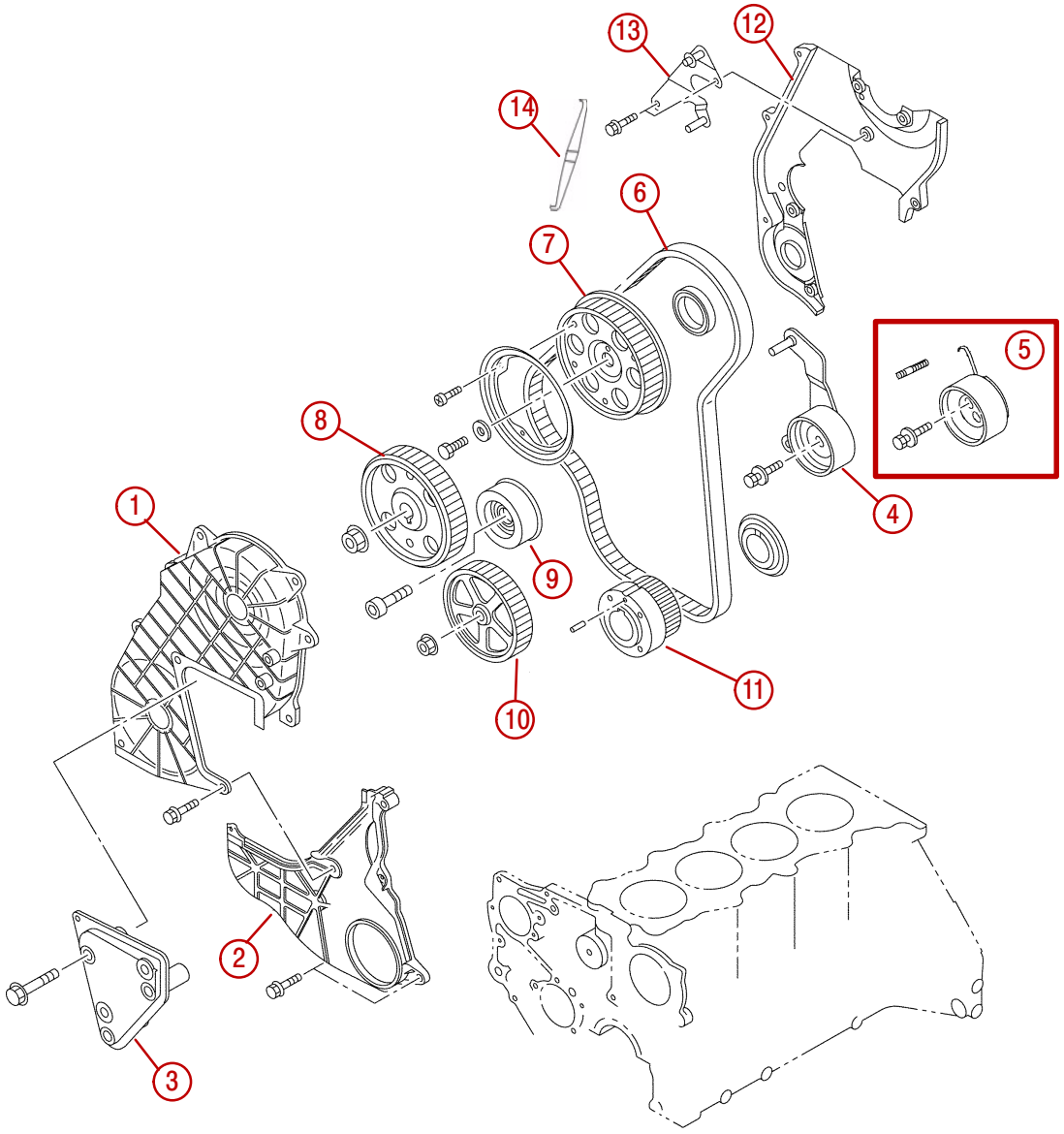
a - Drain Bracket
b - Bolt

Description		Nm	lb-in.	lb-ft
Bolt, Drain Bracket	M8 x 1.25	24		18

Oil Separator / Vent System

Refer to SECTION 7C - Turbocharger, for information.

Timing Belt And Related Components

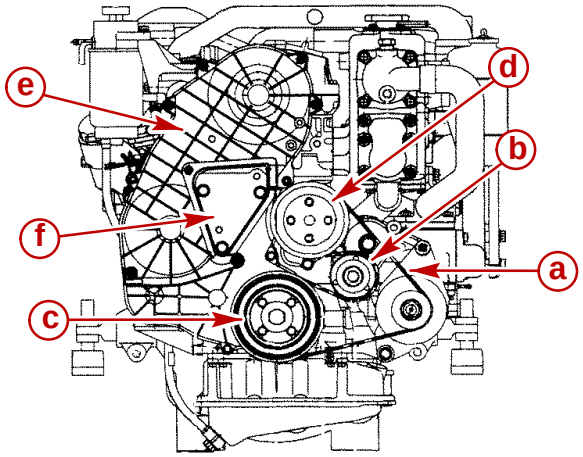


77151

1 - Upper Timing Cover
2 - Lower Timing Cover
3 - Engine Plate
4 - Tensioner Pulley Assembly -plate type
5 - Tensioner Pulley Assembly -coil type
6 - Timing Belt
7 - Camshaft Pulley
8 - Injection Pump Pulley
9 - Idle Pulley
10 - Oil Pump Pulley
11 - Crankshaft Pulley
12 - Dust Cover
13 - Tensioner spring retainer plate
14 - Plate Type Tension Spring

Removal

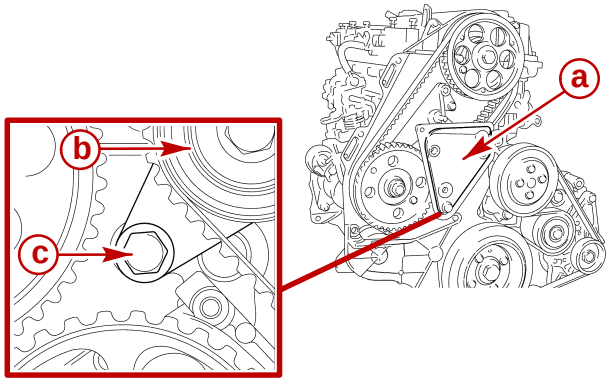
1. Remove engine drive belts.
2. Remove seawater pump (inboard models).
3. Remove crankshaft pulley.
4. Remove water pump pulley.
5. Remove engine plate.
6. Remove upper timing belt cover.



77121

a - Serpentine Belt
b - Belt Tensioner
c - Crankshaft Pulley
d - Water Pump Pulley
e - Upper Timing Belt Cover
f - Engine Plate

7. Reinstall bolt from engine plate for timing belt tensioner. Torque the bolt.

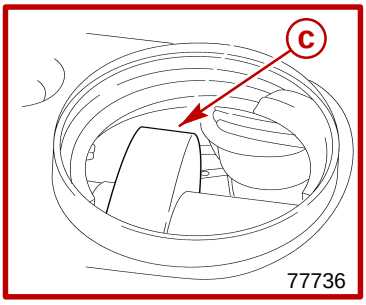


77127

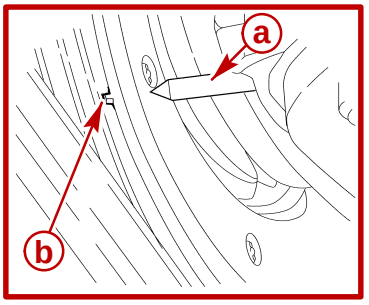
a - Engine Plate
b - Timing Belt Tensioner
c - Bolt

Description		Nm	lb-in.	lb-ft
Bolt, Tensioner	M10 x 1.5	38		28

8. Remove lower timing belt cover.
9. Turn the crankshaft in direction of engine rotation until cylinder number 1 is on TDC. The pointer on the oil pump must align with the mark on the crankshaft pulley and exhaust camshaft pair of lobes for cylinder number 1 points upwards.



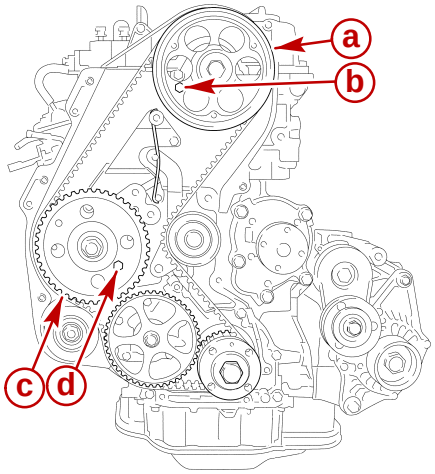
77736



77737

a - Pointer
b - Mark
c - Exhaust Camshaft Pair Of Lobes For Cylinder Number 1

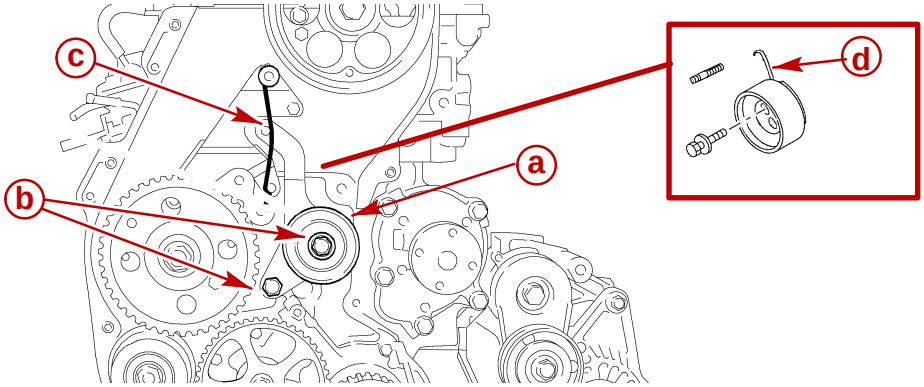
10. Install TDC alignment bolt in camshaft pulley
11. Install TDC alignment bolt in injection pump drive pulley.



77129

a - Camshaft Pulley
b - TDC Alignment Bolt, M6
c - Injection Pump Pulley
d - TDC Alignment Bolt, M8

12. Loosen the mounting bolts for timing belt tensioner pulley assembly.
13. Remove the plate type tensioner spring, or disconnect the coil type of tensioner spring if equipped.
14. Remove the tensioner pulley assembly.

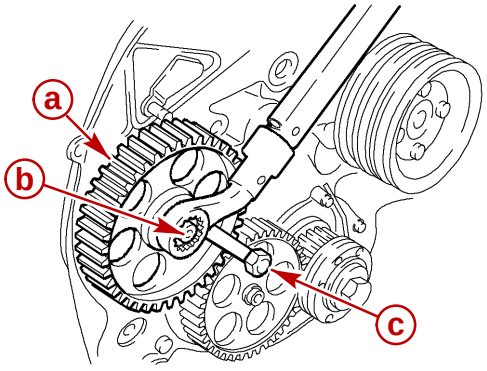


77152

Typical

a - Tensioner Pulley Assembly
b - Mounting Bolts
c - Plate Type Tensioner Spring
d - Coil Type Tensioner Spring

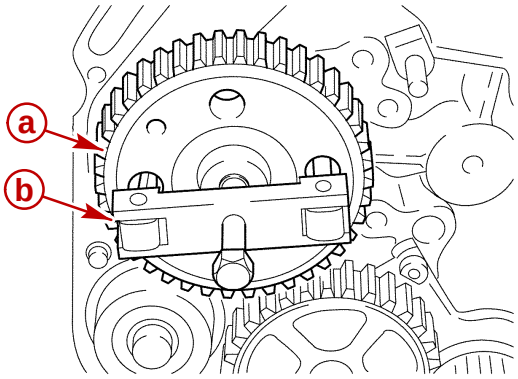
15. Mark direction of the timing belt and remove timing belt.
16. With TDC alignment bolt in place, remove injection pump drive pulley retaining nut.



77299

a - Injection Pump Pulley
b - TDC Adjustment Bolt (M8)
c - Pulley Nut

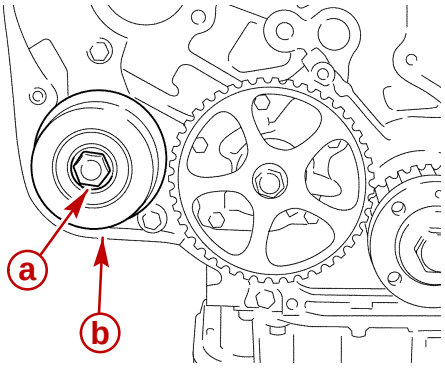
17. Remove TDC alignment bolt. Remove injection pump drive pulley using special tool. Note woodruff key in shaft (hidden).



77156

a - Injection Pump Pulley
b - Special Tool

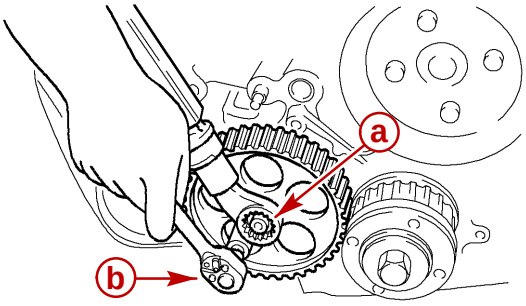
18. Remove pulley bolt and remove timing belt idler pulley.



77153

a - Pulley Bolt
b - Idler Pulley

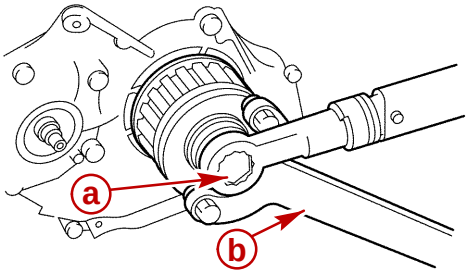
19. Remove the oil pump drive pulley. Counterhold using a separate wrench.



77159

a - Pulley Nut
b - Separate Wrench

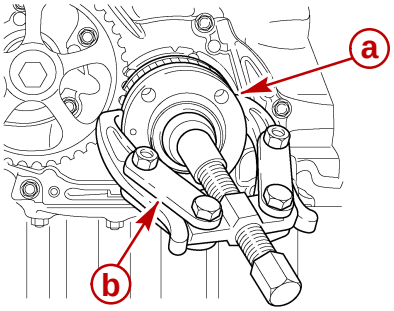
20. Remove fastening bolt for timing belt drive pulley, counterhold using special tool.



77140

a - Timing Belt Drive Pulley Bolt
b - Special Tool

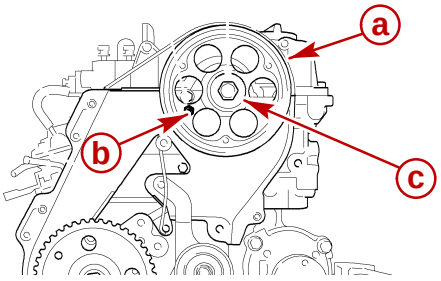
21. Remove timing belt drive pulley from crankshaft using puller.



77141

a - Timing Belt Drive Pulley
b - Puller

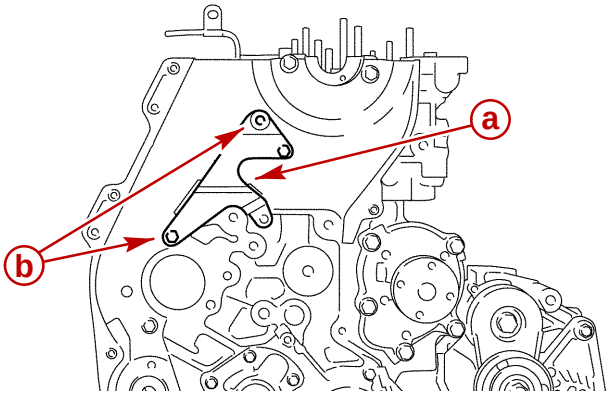
22. Lock the camshaft pulley with TDC alignment bolt.
23. Remove pulley bolt from camshaft pulley.
24. Remove TDC alignment bolt and remove camshaft pulley.



77152

a - Camshaft Pulley
b - TDC Alignment Bolt (M6)
c - Pulley Bolt

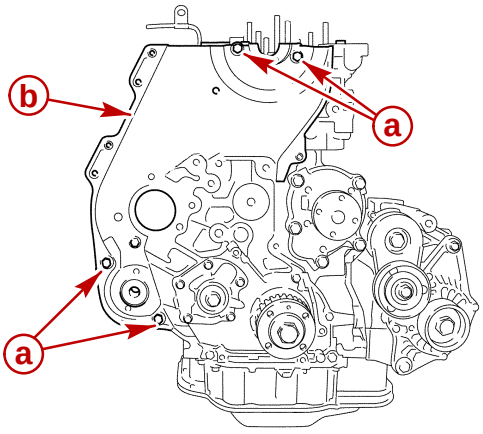
25. Loosen bolts and remove tensioner spring retainer plate, if equipped.



77157

a - Tensioner Spring Retainer Plate
b - Plate Bolts

26. Loosen bolts and remove dust cover.



77157

a - Bolts
b - Dust Cover

Cleaning

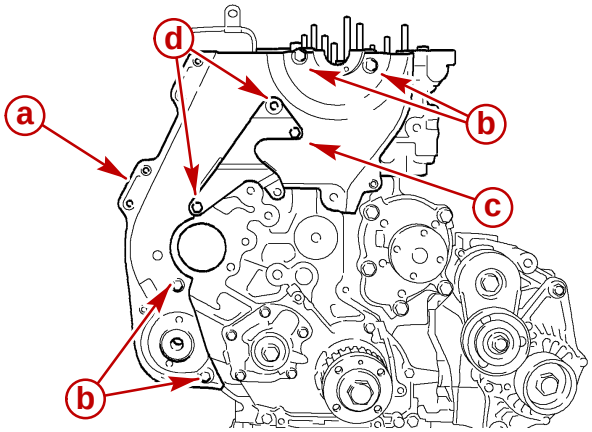
1. Clean all parts with solvent and dry with compressed air.

Inspection

1. Inspect timing covers for warp, cracks and wear from belts and pulleys. Replace covers if worn or damaged.
2. Inspect pulleys and belts for wear or damage. Replace as necessary.

Installation

1. Install the front dust cover and tensioner spring retainer plate, if equipped. Torque bolts.

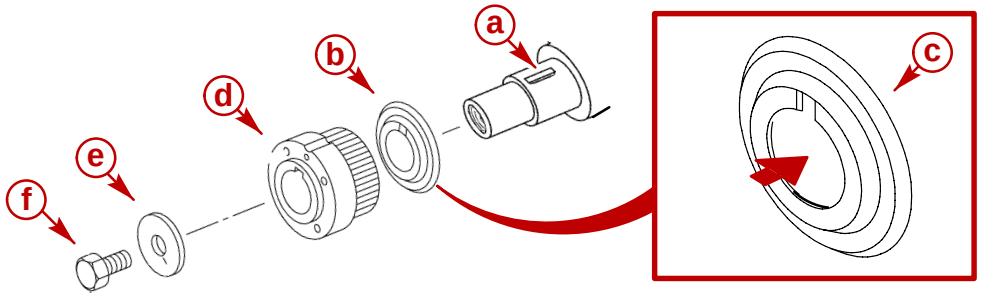


77294

a - Dust Cover
b - Cover Bolts
c - Tension Spring Retainer Plate
d - Plate Bolts

Description		Nm	lb-in.	lb-ft
Bolts, Front Dust Cover	M6 x 1.0	9.8	87	
Bolts, Tensioner Spring Retainer Plate	M6 x 1.0	9.8	87	

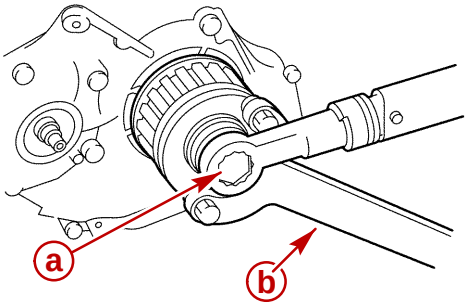
2. Install crankshaft timing belt pulley and parts in order. Concave side of belt guide flange MUST face the cylinder block.



77085

a - Woodruff Key
b - Belt Guide Flange
c - Concave Side
d - Crankshaft Timing Belt Pulley
e - Flat Washer
f - Bolt

3. Counterhold the crankshaft pulley using special tool and torque crankshaft pulley bolt.



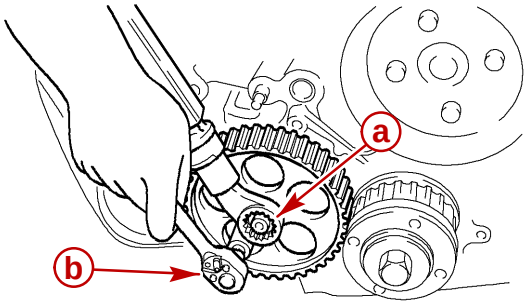
77296

a - Pulley Bolt
b - Special Tool

Description		Nm	lb-in.	lb-ft
Bolt, Crankshaft	M16 x 1.5	196		144

4. Install oil pump pulley to oil pump shaft.

5. Install oil pump pulley nut. Counterhold pulley using a separate wrench. Torque nut.

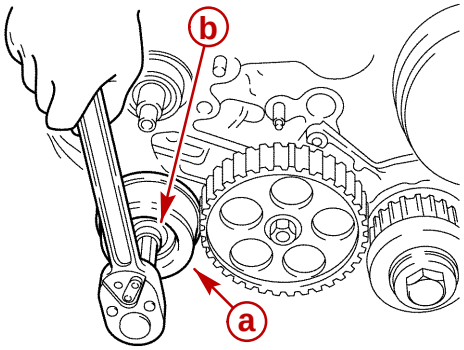


77159

a - Pulley Nut
b - Separate Wrench

Description		Nm	lb-in.	lb-ft
Nut, Oil Pump Pulley	M10 x 1.25	44		33

6. Install the idle pulley. Torque pulley bolt.

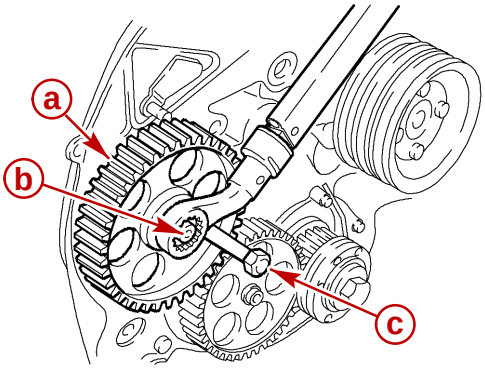


77298

a - Idle Pulley
b - Pulley Bolt

Description		Nm	lb-in.	lb-ft
Bolt, Idle Pulley	M12 x 1.25	80		59

7. Ensure that woodruff key is installed and install injection pump pulley.
8. Lock injection pump pulley using TDC alignment bolt.
9. Install and torque injection pump pulley nut.

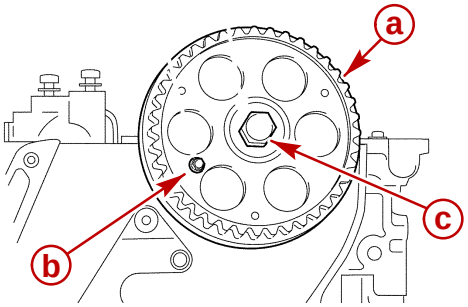


77299

a - Injection Pump Pulley
b - TDC Alignment Bolt (M8)
c - Injection Pump Pulley Bolt

Description		Nm	lb-in.	lb-ft
Nut, Injection Pump Pulley	M14 x 1.5	69		51

10. Ensure that woodruff key is installed and install camshaft pulley.
11. Install the camshaft pulley and lock the pulley with TDC alignment bolt.
12. Install and torque the camshaft pulley bolt.

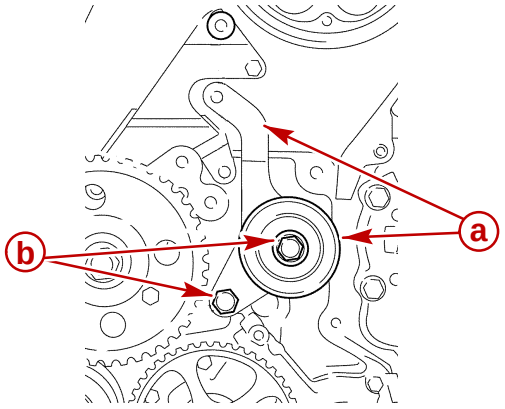


77300

a - Camshaft Pulley
b - TDC Alignment Bolt (M6)
c - Camshaft Pulley Bolt

Description		Nm	lb-in.	lb-ft
Bolt, Camshaft Pulley	M12 x 1.5	64		47

13. Install the tensioner pulley assembly. Temporarily hand-tighten mounting bolts.



77152

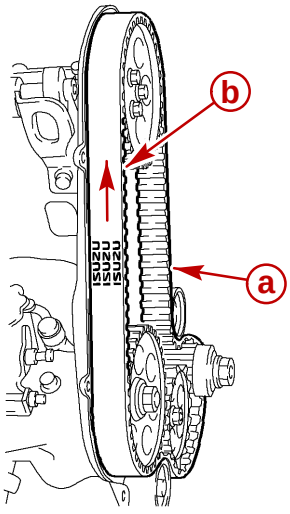
Typical Tensioner Asssembly

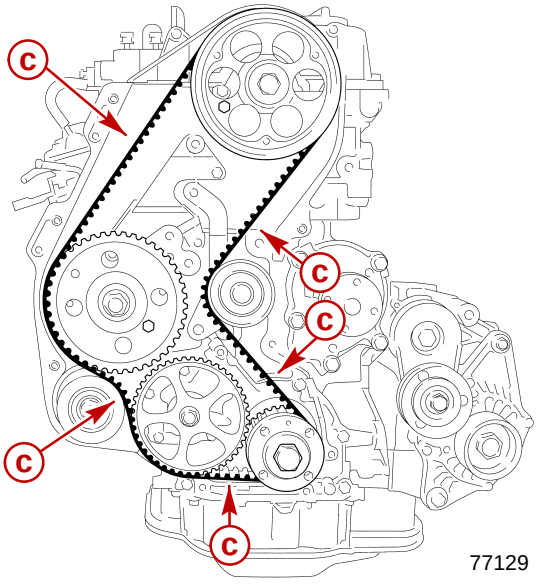
a - Tension Pulley Assembly
b - Mounting Bolt

14. Note the direction of timing belt operation and install accordingly. Ensure that belt is taut between adjacent pulleys.

⚠ CAUTION

To ensure proper operation of engine systems, the timing belt must be taut from the crankshaft drive pulley around all other drive pulleys including the tension pulley.





77129

a - Timing Belt
b - Direction Of Operation
c - Taut Belt Between Pulleys

15. Install the plate type tensioner spring, if equipped.

NOTE: *Slightly loosen tensioner pulley bolts if necessary.*

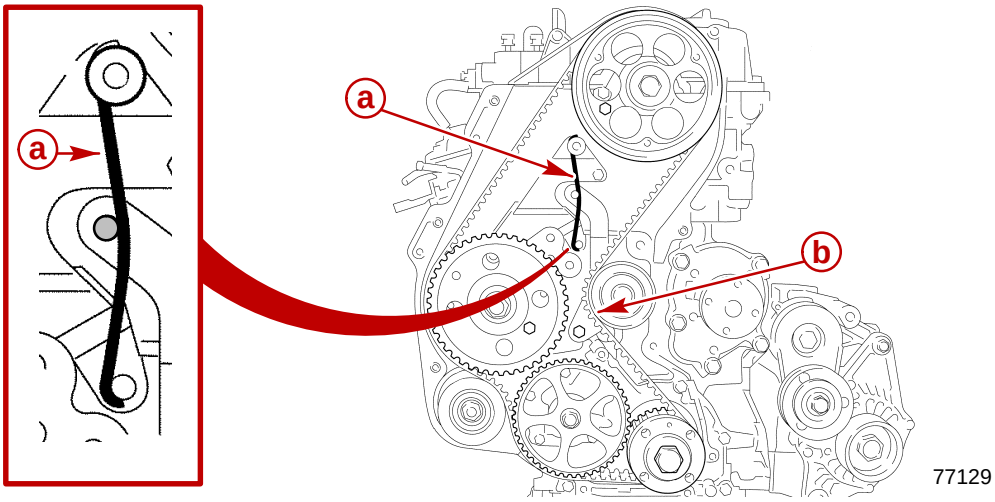
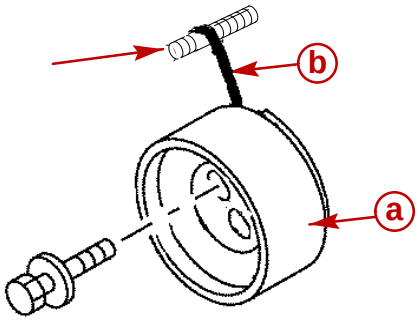


Plate Type Tensioner Spring Installation

a - Plate Type Tensioner Spring
b - Tension Pulley Load On Belt

16. Connect the coil type of tensioner spring onto the tensioner stud, if equipped.

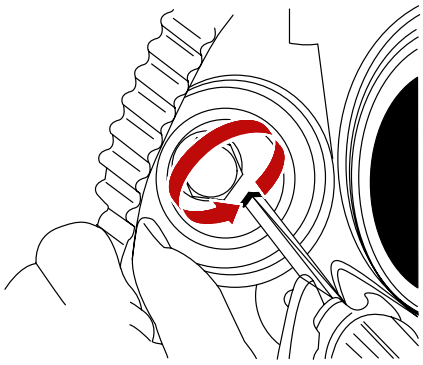
a. Position the end of the coil spring over the stud as shown and install the tensioner pulley assembly using the screw and washer provided.



Coil Type Tensioner Spring Installation

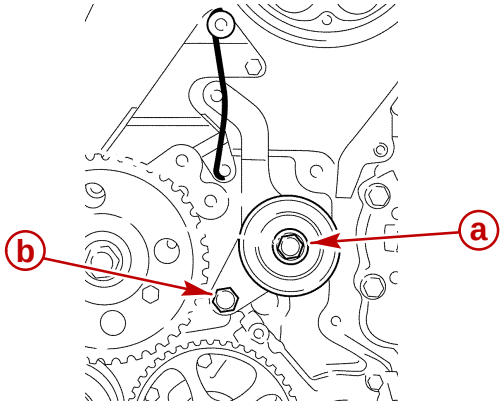
a - Coil Type Tensioner Spring
b - Tensioner Stud

b. Preload the tensioner spring by inserting an appropriate hex tool into the tensioner assembly and rotating the assembly counterclockwise around the center mounting bolt.



26380

17. Ensure that tensioner pulley rests against belt under spring load.
18. Remove camshaft and injection pump TDC alignment bolts.
19. Torque the tensioner pulley assembly upper mounting bolt. Temporarily hand-tighten lower bolt.



77152

Typical

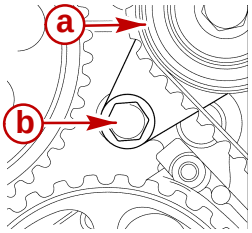
a - Upper Bolt
b - Lower Bolt

Description		Nm	lb-in.	lb-ft
Bolt, Tensioner Pulley Assembly (Plate Type Tensioner Spring)	M10 x 1.5	38		28
Bolt, Tensioner Pulley Assembly (Coil Type Tensioner Spring)	M10 x 1.5	49		36

20. Using the crankshaft drive pulley bolt, turn crankshaft approximately 780° in direction of engine rotation to cylinder number 1 TDC. Verify belt installation and timing.
21. Install the lower timing belt cover. Torque bolts.

Description		Nm	lb-in.	lb-ft
Bolt, Lower Timing Belt Cover	M6 x 1.0	9.8	87	

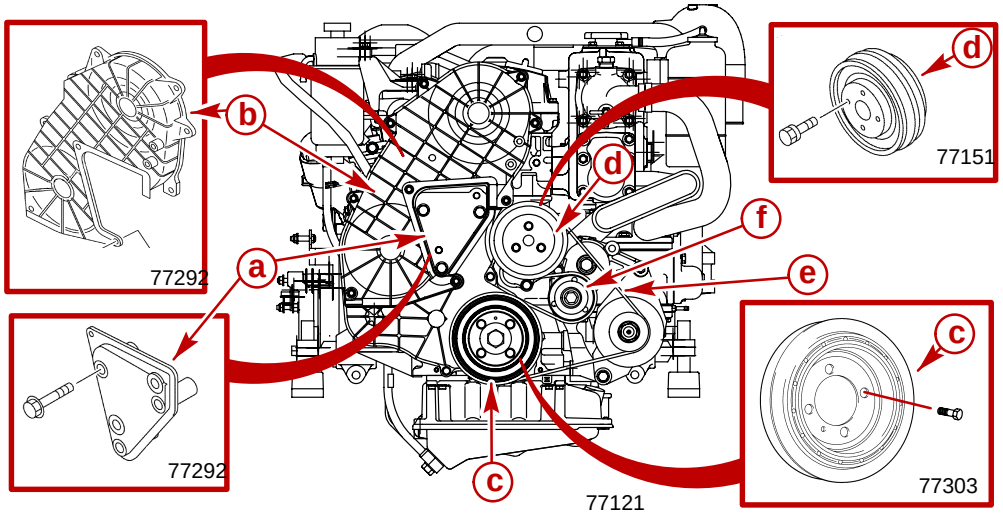
22. Remove and retain tensioner pulley assembly lower bolt.



77127

a - Tensioner Pulley
b - Lower Bolt

23. Install engine plate. Torque bolts, including tensioner pulley assembly lower bolt.
24. Install upper timing belt cover. Torque the bolts.
25. Install the crankshaft damper pulley to the crankshaft timing belt drive pulley. Torque bolts.
26. Install water pump pulley. Torque the bolts.
27. Install serpentine belt. Ensure that tensioner returns to initial position.
28. **On inboard models:** Install the seawater pump.



a - Engine Plate
b - Upper Timing Belt Cover
c - Crankshaft Damper Pulley
d - Water Pump Pulley
e - Serpentine Belt
f - Belt Tensioner

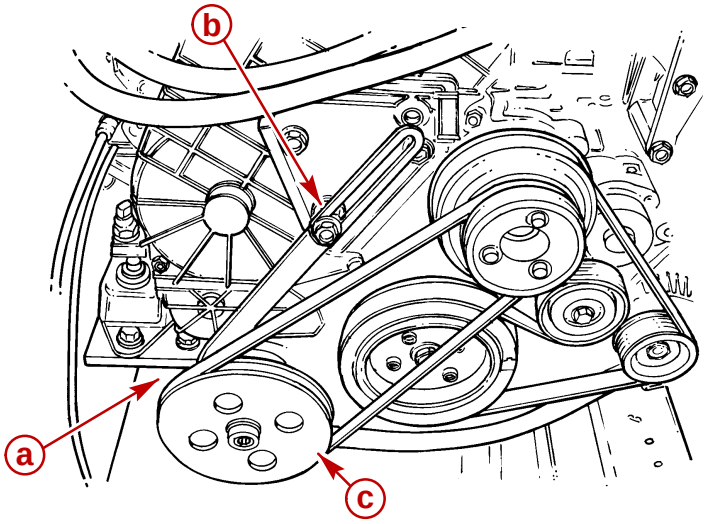
Description		Nm	lb-in.	lb-ft
Bolt, Engine Plate	M10 x 1.5	40		30
Bolt, Upper Timing Belt Cover	M6 x 1.0	9.8	87	
Bolt, Crankshaft Damper Pulley	M8 x 1.25	20		15
Bolt, Water Pump Pulley	M6 x1.0	9.8	87	

29. **On sterndrive models:**

a. install the power steering belt.

b. Pivot the power steering pump to adjust belt. Approximately 5 mm (3/16 in.) deflection should be measured at midpoint between the pulleys on the longest span.

c. Tighten mounting and tensioning bolts and nuts securely.



77321

a - Mounting Bolts (Hidden)
b - Tensioning Stud And Nut
c - Power Steering Pump And Pulley