Overhaul Manual

TK 2.44, 2.49, 3.66, 3.74, 3.88 and 3.95

TK 8312-2 (Rev. 1/97)

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TK 2.44 & TK 3.66 Diesel Engine Specifications

The TK 2.44 is a two cylinder engine. The TK 3.66 is a three cylinder engine. Unless it is otherwise noted, the specifications for both of these engines are the same.

General	**TK 2.44**	**TK 3.66**
Model	2TN66	3TN66
Type	Four Stroke Cycle Water Cooled	Four Stroke Cycle Water Cooled
Number of Cylinders	2	3
Bore	2.60 in. (66.0 mm)	2.60 in. (66.0 mm)
Stroke	2.53 in. (64.2 mm)	2.53 in. (64.2 mm)
Displacement	26.8 cu. in. (439 cc)	40.2 cu. in. (658 cc)
Power Rating	8.2 hp (6.0 kW)	11.2 hp (8.2 kW)
Compression Ratio	23 to 1	23 to 1
Direction of Rotation	Counterclockwise (Viewed from Flywheel)	Counterclockwise (Viewed from Flywheel)
Firing Order	1, 2	1, 3, 2
Fuel Injection Timing	14 Degrees BTDC	14 Degrees BTDC
Nozzle Injection Pressure	1707 psi (11768 kPa)	1707 psi (11768 kPa)
Oil Pressure	18.5 psi (127 kPa) Minimum @ 230 F (110 C) & 1600 rpm	18.5 psi (127 kPa) Minimum @ 230 F (110 C) & 1600 rpm

Valve Train	**Standard Dimensions**	**Wear Limit**
Valve Spring		
Free Length	1.10 in. (28.0 mm)	0.99 in. (25.2 mm)
Inclination		.03 in. (0.8 mm)
Valve Guide Inside Diameter		
Intake	.2165-.2171 in. (5.500-5.515 mm)	.2197 in. (5.580 mm)
Exhaust	.2165-.2171 in. (5.500-5.515 mm)	.2197 in. (5.580 mm)
Valve Stem Outside Diameter		
Intake	.2150-.2156 in. (5.460-5.475 mm)	.2126 in. (5.400 mm)
Exhaust	.2144-.2150 in. (5.445-5.460 mm)	.2126 in. (5.400 mm)
Valve Depth		
Intake	.016 in. (0.40 mm)	.039 in. (1.00 mm)
Exhaust	.033 in. (0.85 mm)	.039 in. (1.00 mm)
Valve Guide Projection		
Intake	.276 in. (7.00 mm)	
Exhaust	.276 in. (7.00 mm)	
Valve Stem to Rocker Arm Clearance		
Intake	.008 in. (0.20 mm)	
Exhaust	.008 in. (0.20 mm)	
Valve Seat Angle		
Intake	30 Degrees	
Exhaust	45 Degrees	

Valve Train (continued)	**Standard Dimensions**	**Wear Limit**
Valve Seat Width		
Intake	.045 in. (1.15 mm)	.065 in. (1.65 mm)
Exhaust	.056 in. (1.41 mm)	.075 in. (1.91 mm)
Push Rod Length	4.488-4.528 in. (114.00-115.00 mm)	
Rocker Arm Bushing Inside Diameter	.3937-.3945 in. (10.000-10.020 mm)	.3972 in. (10.090 mm)
Rocker Arm Shaft Outside Diameter	.3925-.3933 in. (9.970-9.990 mm)	.3919 in. (9.955 mm)
Rocker Arm Bushing to Rocker Arm		
Shaft Clearance	.0004-.0020 in. (0.010-0.050 mm)	.0053 in. (0.135 mm)
Tappet Outside Diameter	.7067-.7074 in. (17.950-17.968 mm)	.7059 in. (17.930 mm)
Tappet Bore Inside Diameter	.7087-.7094 in. (18.000-18.018 mm)	.7106 in. (18.050 mm)
Tappet To Tappet Bore Clearance	.0013-.0027 in. (0.032-0.068 mm)	
Camshaft		
Cam Lobe	1.1799-1.1823 in. (29.970-30.030 mm)	1.1713 in. (29.750 mm)
Camshaft Journal		
Timing Gear End	1.4150-1.4157 in. (35.940-35.960 mm)	1.4114 in. (35.850 mm)
Middle	1.4138-1.4148 in. (35.910-35.935 mm)	1.4114 in. (35.850 mm)
Flywheel End	1.4150-1.4157 in. (35.940-35.960 mm)	1.4114 in. (35.850 mm)
Camshaft Bearing Inside Diameter		
Timing Gear End Bearing Insert	1.4173-1.4199 in .(36.000-36.065 mm)	1.4213 in. (36.100 mm)
Middle Bearing	1.4173-1.4183 in. (36.000-36.025 mm)	1.4213 in. (36.100 mm)
Flywheel End Bearing	1.4173-1.4183 in. (36.000-36.025 mm)	1.4213 in. (36.100 mm)
Camshaft Journal to		
Camshaft Bearing Clearance		
Timing Gear End	.0016-.0049 in. (0.040-0.125 mm)	
Middle	.0026-.0045 in. (0.065-0.115 mm)	
Flywheel End	.0016-.0033 in. (0.040-0.085 mm)	
Camshaft Deflection	.001 in. (0.02 mm)	
Camshaft End Play	.002-.006 in. (0.05-0.15 mm)	.016 in. (0.40 mm)
Piston, Piston Rings, and Wrist Pin		
Piston Outside Diameter Measuring		
Point (From Bottom of Piston)	.20 in. (5.0 mm)	
Piston Outside Diameter		
Standard	2.5956-2.5967 in .(65.927-65.957 mm)	2.5925 in .(65.850 mm)
1st Oversize	2.6054-2.6066 in .(66.177-66.207 mm)	2.6024 in. (66.100 mm)
2nd Oversize	2.6152-2.6164 in .(66.427-66.457 mm)	2.6122 in. (66.350 mm)
Piston to Cylinder Wall Clearance	.0017-.0041 in .(0.043-0.103 mm)	

Piston, Piston Rings, and Wrist Pin (continued)

Piston Ring Groove Width		
Top Ring Groove	.0612-.0618 in .(1.555-1.570 mm)	
Middle Ring Groove	.0598-.0604 in. (1.520-1.535 mm)	
Bottom Ring Groove	.1382-.1388 in. (3.510-3.525 mm)	
Piston Ring Width		
Top Ring	.0579-.0587 in. (1.470-1.490 mm)	
Middle Ring	.0579-.0587 in. (1.470-1.490 mm)	
Bottom Ring	.1366-.1374 in. (3.470-3.490 mm)	
Piston Ring to Ring Groove Clearance		
Top	.0026-.0039 in. (0.065-0.100 mm)	.0079 in. (0.200 mm)
Middle	.0012-.0026 in. (0.030-0.065 mm)	.0079 in. (0.200 mm)
Bottom	.0008-.0022 in. (0.020-0.055 mm)	.0079 in. (0.200 mm)
Piston Ring End Gap		
Top Ring	.006-.014 in. (0.15-0.35 mm)	.059 in. (1.50 mm)
Middle Ring	.010-.016 in. (.025-.040 mm)	.059 in. (1.50 mm)
Bottom Ring	.006-.014 in. (0.15-0.35 mm)	.059 in. (1.50 mm)
Wrist Pin Bore Inside Diameter	.7874-.7877 in .(20.000-20.008 mm)	.7882 in. (20.020 mm)
Wrist Pin Outside Diameter	.7870-.7874 in .(19.991-20.000 mm)	.7864 in. (19.975 mm)
Wrist Pin to Wrist Pin Bore Clearance	0-.0007 in. (0-.017 mm)	.0018 in. (0.045 mm)

Connecting Rod

Wrist Pin Bushing Inside Diameter	.7884-.7889 in .(20.025-20.038 mm)	.7913 in. (20.100 mm)
Wrist Pin to Wrist Pin Bushing Clearance	.0010-.0019 in .(0.025-0.047 mm)	.0043 in (0.110 mm)
Side Clearance (Crank to Rod)	.008-.016 in .(0.20-0.40 mm)	.022 in. (0.55 mm)
Twist per 4 in. (100 mm)	.002 in. (0.05 mm)	.003 in. (0.08 mm)
Parallelism per 4 in. (100 mm)	.002 in. (0.05 mm)	.003 in. (0.08 mm)

Crankshaft and Crankshaft Bearings

Main Journal Outside Diameter		
Standard	1.5736-1.5740 in. (39.970-39.980 mm)	1.5717 in. (39.920 mm)
Undersize	1.5638-1.5642 in. (39.720-39.730 mm)	1.5618 in. (39.670 mm)
Main Bearing Inside Diameter		
Standard	1.5748-1.5765 in. (40.000-40.042 mm)	1.5776 in. (40.070 mm)
Undersize	1.5650-1.5666 in. (39.750-39.792 mm)	1.5677 in. (39.820 mm)
Main Bearing Clearance	.0008-.0028 in .(0.020-0.072 mm)	.0059 in. (0.150 mm)
Rod Journal Outside Diameter		
Standard	1.4161-1.4165 in. (35.970-35.980 mm)	1.4142 in. (35.920 mm)
Undersize	1.4063-1.4067 in. (35.720-35.730 mm)	1.4043 in. (35.670 mm)

Crankshaft and Crankshaft Bearings (continued)

Rod Bearing Inside Diameter		
Standard	1.4173-1.4190 in. (36.000-36.042 mm)	1.4201 in. (36.070 mm)
Undersize	1.4075-1.4091 in. (35.750-35.792 mm)	1.4102 in. (35.820 mm)
Rod Bearing Clearance	.0008-.0028 in. (0.020-0.072 mm)	.0059 in .(0.150 mm)
End Play	.0037-.0105 in. (0.095-0.266 mm)	.0130 in .(0.330 mm)
Deflection		.0008 in. (0.020 mm)

Cylinder Block

Cylinder Inside Diameter		
Standard	2.5984-2.5996 in. (66.000-66.030 mm)	2.6063 in. (66.200 mm)
1st Oversize	2.6083-2.6094 in. (66.250-66.280 mm)	2.6161 in. (66.450 mm)
2nd Oversize	2.6181-2.6193 in. (66.500-66.530 mm)	2.6260 in. (66,700 mm)
Cylinder Roundness	0-.0004 in. (0-0.010 mm)	.0008 in. (0.020 mm)
Deck Distortion		.002 in. (0.05 mm)

Cylinder Head

Distortion	0-.002 in. (0-0.05 mm)	.006 in. (0.15 mm)

Timing Gears

Timing Gear Lash		
Crankshaft Gear to Idler Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Crankshaft Gear to Oil Pump Gear	.0043-.0075 in. (0.110-0.190 mm)	.0079 in. (0.200 mm)
Idler Gear to Camshaft Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Idler Gear to Fuel Injection Pump Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Idler Gear Bushing Inside Diameter	.7874-.7882 in. (20.000-20.021 mm)	.7906 in .(20.080 mm)
Idler Gear Shaft Outside Diameter	.7858-.7866 in. (19.959-19.980 mm)	.7846 in. (19.930 mm)
Idler Gear Shaft to Idler Gear Bushing Clearance	.0008-.0024 in. (0.020-0.062 mm)	.0059 in. (0.150 mm)

Oil Pump

Type	Trocoid	
Outer Rotor to Pump Body Clearance	.0039-.0063 in. (0.100-0.160 mm)	.0098 in. (0.250 mm)
Inner Rotor Tip to Outer Rotor Lobe Clearance		.0059 in. (0.150 mm)
Rotor Plate to Rotor Clearance	.0012-.0035 in. (0.030-0.090 mm)	.0051 in. (0.130 mm)
Rotor Shaft to Rotor Shaft Bore Clearance	.0006-.0019 in. (0.015-0.048 mm)	.0079 in. (0.200 mm)
Pressure Control Valve Setting	42.7-56.9 psi (294-392 kPa)	

Starter

No Load Test		
Voltage	11 volts	
Current	180 amps @ 11 volts	
Speed	More than 3500 rpm @ 11 volts	
Commutator Outside Diameter	1.18 in. (30.0 mm)	1.14 in. (29.0 mm)

TK 2.49 & TK 3.74 Diesel Engine Specifications

The TK 2.49 is a two cylinder engine. The TK 3.74 is a three cylinder engine. Unless it is otherwise noted, the specifications for both of these engines are the same.

General	**TK 2.49**	**TK 3.74**
Model	2TNE66KC	3TNE66KC
Type	Four Stroke Cycle Water Cooled	Four Stroke Cycle Water Cooled
Number of Cylinders	2	3
Bore	2.60 in. (66.0 mm)	2.60 in. (66.0 mm)
Stroke	2.83 in. (72.0 mm)	2.83 in. (72.0 mm)
Displacement	30.1 cu. in. (493 cc)	45.1 cu. in. (739 cc)
Power Rating	9.1 hp (6.8 kW)	12.5 hp (9.3 kW)
Compression Ratio	23.1 to 1	23.1 to 1
Direction of Rotation	Counterclockwise (Viewed from Flywheel)	Counterclockwise (Viewed from Flywheel)
Firing Order	1, 2	1, 3, 2
Fuel Injection Timing	14 Degrees BTDC	14 Degrees BTDC
Nozzle Injection Pressure	1707 psi (11768 kPa)	1707 psi (11768 kPa)
Oil Pressure	18.5 psi (127 kPa) Minimum @ 230 F (110 C) & 1600 rpm	18.5 psi (127 kPa) Minimum @ 230 F (110 C) & 1600 rpm

Valve Train	**Standard Dimensions**	**Wear Limit**
Valve Spring		
Free Length	1.10 in. (28.0 mm)	0.99 in. (25.2 mm)
Inclination		
Valve Guide Inside Diameter		
Intake	.2165-.2171 in. (5.500-5.515 mm)	.2197 in. (5.580 mm)
Exhaust	.2165-.2171 in. (5.500-5.515 mm)	.2197 in. (5.580 mm)
Valve Stem Outside Diameter		
Intake	.2150-.2156 in. (5.460-5.475 mm)	.2126 in. (5.400 mm)
Exhaust	.2144-.2150 in. (5.445-5.460 mm)	.2126 in. (5.400 mm)
Valve Depth		
Intake	.012-.020 in. (0.30-0.50 mm)	.039 in. (1.00 mm)
Exhaust	.030-.037 in. (0.75-0.95 mm)	.039 in. (1.00 mm)
Valve Guide Projection		
Intake	.276 in. (7.00 mm)	
Exhaust	.276 in. (7.00 mm)	
Valve Stem to Rocker Arm Clearance		
Intake	.006-.010 in. (0.15-0.25 mm)	
Exhaust	.006-.010 in. (0.15-0.25 mm)	
Valve Seat Angle		
Intake	30 Degrees	
Exhaust	45 Degrees	

Valve Train (continued)	**Standard Dimensions**	**Wear Limit**
Valve Seat Width		
Intake	.045 in. (1.15 mm)	.065 in. (1.65 mm)
Exhaust	.056 in. (1.41 mm)	.075 in. (1.91 mm)
Push Rod Length	4.488-4.528 in. (114.00-115.00 mm)	
Rocker Arm Bushing Inside Diameter	.3937-.3945 in. (10.000-10.020 mm)	.3972 in. (10.090 mm)
Rocker Arm Shaft Outside Diameter	.3926-.3932 in. (9.972-9.987 mm)	.3917 in. (9.950 mm)
Rocker Arm Bushing to Rocker Arm		
Shaft Clearance	.0005-.0019 in. (0.013-0.048 mm)	.0055 in. (0.140 mm)
Tappet Outside Diameter	.7067-.7074 in. (17.950-17.968 mm)	.7059 in. (17.930 mm)
Tappet Bore Inside Diameter	.7087-.7094 in. (18.000-18.018 mm)	.7106 in. (18.050 mm)
Tappet To Tappet Bore Clearance	.0013-.0027 in. (0.032-0.068 mm)	.0047 in. (0.120 mm)
Camshaft		
Cam Lobe	1.1799-1.1823 in. (29.970-30.030 mm)	1.1713 in. (29.750 mm)
Camshaft Journal		
Timing Gear End	1.4150-1.4157 in. (35.940-35.960 mm)	1.4114 in. (35.850 mm)
Middle	1.4138-1.4148 in. (35.910-35.935 mm)	1.4114 in. (35.850 mm)
Flywheel End	1.4150-1.4157 in. (35.940-35.960 mm)	1.4114 in. (35.850 mm)
Camshaft Bearing Inside Diameter		
Timing Gear End Bearing Insert	1.4173-1.4199 in .(36.000-36.065 mm)	1.4213 in. (36.100 mm)
Middle Bearing	1.4173-1.4183 in. (36.000-36.025 mm)	1.4213 in. (36.100 mm)
Flywheel End Bearing	1.4173-1.4183 in. (36.000-36.025 mm)	1.4213 in. (36.100 mm)
Camshaft Journal to		
Camshaft Bearing Clearance		
Timing Gear End	.0016-.0033 in. (0.040-0.085 mm)	
Middle	.0026-.0045 in. (0.065-0.115 mm)	
Flywheel End	.0016-.0049 in. (0.040-0.125 mm)	
Camshaft Deflection	.001 in. (0.02 mm)	.002 in. (0.05 mm)
Camshaft End Play	.002-.010 in. (0.05-0.25 mm)	.016 in. (0.40 mm)
Piston, Piston Rings, and Wrist Pin		
Piston Outside Diameter Measuring		
Point (From Bottom of Piston)	.39 in. (10.0 mm)	
Piston Outside Diameter		
Standard	2.5969-2.5980 in .(65.960-65.990 mm)	2.5945 in .(65.900 mm)
1st Oversize	2.6067-2.6079 in .(66.210-66.240 mm)	2.6043 in. (66.150 mm)
2nd Oversize	2.6165-2.6177 in .(66.460-66.490 mm)	2.6142 in. (66.400 mm)
Piston to Cylinder Wall Clearance	.0010-.0022 in .(0.025-0.055 mm)	

Piston, Piston Rings, and Wrist Pin (continued)

Piston Ring Groove Width		
Top Ring Groove	.0610-.0618 in .(1.550-1.570 mm)	
Middle Ring Groove	.0622-.0628 in. (1.580-1.595 mm)	
Bottom Ring Groove	.1185-.1191 in. (3.010-3.025 mm)	
Piston Ring Width		
Top Ring	.0579-.0587 in. (1.470-1.490 mm)	
Middle Ring	.0579-.0587 in. (1.470-1.490 mm)	
Bottom Ring	.1169-.1177 in. (2.970-2.990 mm)	
Piston Ring to Ring Groove Clearance		
Middle	.0035-.0049 in. (0.090-0.125 mm)	
Bottom	.0008-.0022 in. (0.020-0.055 mm)	
Piston Ring End Gap		
Top Ring	.006-.014 in. (0.15-0.35 mm)	.059 in. (1.50 mm)
Middle Ring	.006-.014 in. (.015-.035 mm)	.059 in. (1.50 mm)
Bottom Ring	.006-.014 in. (0.15-0.35 mm)	.059 in. (1.50 mm)
Wrist Pin Bore Inside Diameter	.7874-.7877 in .(20.000-20.008 mm)	.7882 in. (20.020 mm)
Wrist Pin Outside Diameter	.7870-.7874 in .(19.991-20.000 mm)	.7835 in. (19.900 mm)
Wrist Pin to Wrist Pin Bore Clearance	0-.0007 in. (0-.017 mm)	.0047 in. (0.120 mm)

Connecting Rod

Wrist Pin Bushing Inside Diameter	.7884-.7889 in .(20.025-20.038 mm)	.7913 in. (20.100 mm)
Wrist Pin to Wrist Pin Bushing Clearance	.0010-.0019 in .(0.025-0.047 mm)	.0079 in (0.200 mm)
Side Clearance (Crank to Rod)	.008-.016 in .(0.20-0.40 mm)	.022 in. (0.55 mm)
Twist per 4 in. (100 mm)	.001 in. (0.03 mm)	.003 in. (0.08 mm)
Parallelism per 4 in. (100 mm)	.001 in. (0.03 mm)	.003 in. (0.08 mm)

Crankshaft and Crankshaft Bearings

Main Journal Outside Diameter		
Standard	1.5736-1.5740 in. (39.970-39.980 mm)	1.5709 in. (39.900 mm)
Undersize	1.5638-1.5642 in. (39.720-39.730 mm)	1.5610 in. (39.650 mm)
Main Bearing Inside Diameter		
Standard	1.5753-1.5759 in. (40.013-40.029 mm)	1.5768 in. (40.050 mm)
Undersize	1.5655-1.5661 in. (39.763-39.779 mm)	1.5669 in. (39.800 mm)
Main Bearing Clearance	.0013-.0023 in .(0.033-0.059 mm)	.0059 in. (0.150 mm)
Rod Journal Outside Diameter		
Standard	1.4161-1.4165 in. (35.970-35.980 mm)	1.4138 in. (35.910 mm)
Undersize	1.4063-1.4067 in. (35.720-35.730 mm)	1.4039 in. (35.660 mm)

Crankshaft and Crankshaft Bearings (continued)		
Rod Bearing Inside Diameter		
Standard	1.4178-1.4185 in. (36.013-36.029 mm)	1.4197 in. (36.060 mm)
Undersize	1.4080-1.4086 in. (35.763-35.779 mm)	1.4098 in. (35.810 mm)
Rod Bearing Clearance	.0013-.0023 in. (0.033-0.059 mm)	.0059 in .(0.150 mm)
End Play	.0035-.0107 in. (0.090-0.271 mm)	.0130 in .(0.330 mm)
Deflection		.0008 in. (0.020 mm)
Cylinder Block		
Cylinder Inside Diameter		
Standard	2.5984-2.5996 in. (66.000-66.030 mm)	2.6063 in. (66.200 mm)
1st Oversize	2.6083-2.6094 in. (66.250-66.280 mm)	2.6161 in. (66.450 mm)
2nd Oversize	2.6181-2.6193 in. (66.500-66.530 mm)	2.6260 in. (66,700 mm)
Cylinder Roundness	0-.0004 in. (0-0.010 mm)	.0012 in. (0.030 mm)
Deck Distortion		.002 in. (0.05 mm)
Cylinder Head		
Distortion	0-.002 in. (0-0.05 mm)	.006 in. (0.15 mm)
Timing Gears		
Timing Gear Lash		
Crankshaft Gear to Idler Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Crankshaft Gear to Oil Pump Gear	.0043-.0075 in. (0.110-0.190 mm)	.0079 in. (0.200 mm)
Idler Gear to Camshaft Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Idler Gear to Fuel Injection Pump Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Idler Gear Bushing Inside Diameter	.7874-.7882 in. (20.000-20.021 mm)	.7906 in .(20.080 mm)
Idler Gear Shaft Outside Diameter	.7858-.7866 in. (19.959-19.980 mm)	.7846 in. (19.930 mm)
Idler Gear Shaft to Idler Gear Bushing Clearance	.0008-.0024 in. (0.020-0.062 mm)	.0059 in. (0.150 mm)
Oil Pump		
Type	Trocoid	
Outer Rotor to Pump Body Clearance	.0039-.0063 in. (0.100-0.160 mm)	.0098 in. (0.250 mm)
Inner Rotor Tip to Outer Rotor Lobe Clearance		.0059 in. (0.150 mm)
Rotor Plate to Rotor Clearance	.0012-.0035 in. (0.030-0.090 mm)	.0051 in. (0.130 mm)
Rotor Shaft to Rotor Shaft Bore Clearance	.0005-.0017 in. (0.013-0.043 mm)	.0079 in. (0.200 mm)
Pressure Control Valve Setting	42.7-56.9 psi (294-392 kPa)	

Starter

No Load Test		
Voltage	11 volts	
Current	180 amps @ 11 volts	
Speed	More than 3500 rpm @ 11 volts	
Commutator Outside Diameter	1.18 in. (30.0 mm)	1.14 in. (29.0 mm)

TK 3.88 Diesel Engine Specifications

General	**TK 3.88**
Model	3TNA72
Type	Four Stroke Cycle Water Cooled
Number of Cylinders	3
Bore	2.83 in. (72.0 mm)
Stroke	2.83 in. (70.2 mm)
Displacement	53.6 cu. in. (879 cc)
Power Rating	15.2 hp (11.2 kW)
Compression Ratio	22.3 to 1
Direction of Rotation	Counterclockwise (Viewed from Flywheel)
Firing Order	1, 3, 2
Fuel Injection Timing	16 Degrees BTDC
Nozzle Injection Pressure	1707 psi (11768 kPa)
Oil Pressure	18.5 psi (127 kPa) Minimum @ 230 F (110 C) and 1600 rpm

Valve Train	**Standard Dimensions**	**Wear Limit**
Valve Spring		
Free Length	1.47 in. (37.4 mm)	1.33 in. (33.7 mm)
Inclination		.04 in. (1.0 mm)
Valve Guide Inside Diameter		
Intake	.2758-.2764 in. (7.005-7.020 mm)	.2787 in. (7.080 mm)
Exhaust	.2758-.2764 in. (7.005-7.020 mm)	.2787 in. (7.080 mm)
Valve Stem Outside Diameter		
Intake	.2734-.2740 in. (6.945-6.960 mm)	.2717 in. (6.900 mm)
Exhaust	.2734-.2740 in. (6.945-6.960 mm)	.2717 in. (6.900 mm)
Valve Depth		
Intake	.020 in. (0.50 mm)	.039 in. (1.00 mm)
Exhaust	.033 in. (0.85 mm)	.039 in. (1.00 mm)
Valve Guide Projection		
Intake	.354 in. (9.00 mm)	
Exhaust	.354 in. (9.00 mm)	
Valve Stem to Rocker Arm Clearance		
Intake	.008 in. (0.20 mm)	
Exhaust	.008 in. (0.20 mm)	
Valve Seat Angle		
Intake	30 Degrees	
Exhaust	45 Degrees	

Valve Train (continued)	Standard Dimensions	Wear Limit
Valve Seat Width		
Intake	0.57 in. (1.44 mm)	.078 in. (1.98 mm)
Exhaust	.070 in. (1.77 mm)	.089 in. (2.27 mm)
Push Rod Length	5.551-5.591 in. (141.00-142.00 mm)	
Rocker Arm Bushing Inside Diameter	.4724-.4732 in. (12.000-12.020 mm)	.4760 in. (12.090 mm)
Rocker Arm Shaft Outside Diameter	.4711-.4718 in. (11.966-11.984 mm)	.4707 in. (11.955 mm)
Rocker Arm Bushing to Rocker Arm		
Shaft Clearance	.0006-.0021 in. (0.016-0.054 mm)	.0053 in. (0.135 mm)
Tappet Outside Diameter	.8239-.8252 in. (20.927-20.960 mm)	.8240 in. (20.930 mm)
Tappet Bore Inside Diameter	.8268-.8276 in. (21.000-21.021 mm)	.8287 in. (21.050 mm)
Tappet To Tappet Bore Clearance	.0016-.0037 in. (0.040-0.094 mm)	
Camshaft		
Cam Lobe	1.3366-1.3406 in. (33.950-34.050 mm)	1.3287 in. (33.750 mm)
Camshaft Journal		
Timing Gear End	1.5724-1.5732 in. (39.940-39.960 mm)	1.5689 in. (39.850 mm)
Middle	1.5713-1.5722 in. (39.910-39.935 mm)	1.5689 in. (39.850 mm)
Flywheel End	1.5724-1.5732 in. (39.940-39.960 mm)	1.5689 in. (39.850 mm)
Camshaft Bearing Inside Diameter		
Timing Gear End Bearing Insert	1.5748-1.5774 in. (40.000-40.065 mm)	1.5787 in. (40.100 mm)
Middle Bearing	1.5748-1.5758 in. (40.000-40.025 mm)	1.5787 in. (40.100 mm)
Flywheel End Bearing	1.5748-1.5758 in. (40.000-40.025 mm)	1.5787 in .(40.100 mm)
Camshaft Journal to		
Camshaft Bearing Clearance		
Timing Gear End	.0016-.0049 in. (0.040-0.125 mm)	
Middle	.0026-.0045 in. (0.065-0.115 mm)	
Flywheel End	.0016-.0033 in. (0.040-0.085 mm)	
Camshaft Deflection	.001 in. (0.02 mm)	
Camshaft End Play	.002-.006 in. (0.05-0.15 mm)	.016 in. (0.40 mm)
Piston, Piston Rings, and Wrist Pin		
Piston Outside Diameter Measuring		
Point (From Bottom of Piston)	.31 in .(8.0 mm)	
Piston Outside Diameter		
Standard	2.8316-2.8328 in. (71.922-71.952 mm)	2.8272 in. (71.810 mm)
1st Oversize	2.8414-2.8426 in. (72.172-72.202 mm)	2.8370 in. (72.060 mm)
2nd Oversize	2.8513-2.8524 in. (72.422-72.452 mm)	2.6469 in. (72.310 mm)
Piston to Cylinder Wall Clearance	.0019-.0043 in. (0.048-0.108 mm)	

Piston, Piston Rings, and Wrist Pin (continued)

Piston Ring Groove Width		
Top Ring Groove	.0616-.0622 in .(1.565-1.580 mm)	
Middle Ring Groove	.0598-.0604 in. (1.520-1.535 mm)	
Bottom Ring Groove	.1382-.1388 in. (3.510-3.525 mm)	
Piston Ring Width		
Top Ring	.0579-.0587 in. (1.470-1.490 mm)	
Middle Ring	.0579-.0587 in. (1.470-1.490 mm)	
Bottom Ring	.1366-.1374 in. (3.470-3.490 mm)	
Piston Ring to Ring Groove Clearance		
Top	.0030-.0043 in. (0.075-0.110 mm)	.0079 in. (0.200 mm)
Middle	.0012-.0026 in. (0.030-0.065 mm)	.0079 in. (0.200 mm)
Bottom	.0008-.0022 in. (0.020-0.055 mm)	.0079 in. (0.200 mm)
Piston Ring End Gap		
Top Ring	.004-.010 in. (0.10-0.25 mm)	.059 in. (1.50 mm)
Middle Ring	.010-.016 in. (.025-.040 mm)	.059 in. (1.50 mm)
Bottom Ring	.006-.014 in. (0.15-0.35 mm)	.059 in. (1.50 mm)
Wrist Pin Bore Inside Diameter	.8268-.8271 in .(21.000-21.009 mm)	.8276 in. (21.020 mm)
Wrist Pin Outside Diameter	.8264-.8268 in .(20.991-21.000 mm)	.8258 in. (20.975 mm)
Wrist Pin to Wrist Pin Bore Clearance	0-.0007 in. (0-.018 mm)	.0018 in. (0.045 mm)

Connecting Rod

Wrist Pin Bushing Inside Diameter	.8278-.8283 in .(21.025-21.038 mm)	.8307 in. (21.100 mm)
Wrist Pin to Wrist Pin Bushing Clearance	.0010-.0019 in .(0.025-0.047 mm)	.0043 in (0.110 mm)
Side Clearance (Crank to Rod)	.008-.016 in .(0.20-0.40 mm)	.022 in. (0.55 mm)
Twist per 4 in. (100 mm)	.002 in. (0.05 mm)	.003 in. (0.08 mm)
Parallelism per 4 in. (100 mm)	.002 in. (0.05 mm)	.003 in. (0.08 mm)

Crankshaft and Crankshaft Bearings

Main Journal Outside Diameter		
Standard	1.7311-1.7315 in. (43.970-43.980 mm)	1.7291 in. (43.920 mm)
Undersize	1.7213-1.7217 in. (43.720-43.730 mm)	1.7193 in. (43.670 mm)
Main Bearing Inside Diameter		
Standard	1.7323-1.7339 in. (44.000-44.042 mm)	1.7350 in. (44.070 mm)
Undersize	1.7224-1.7241 in. (43.750-43.792 mm)	1.7252 in. (43.820 mm)
Main Bearing Clearance	.0008-.0028 in .(0.020-0.072 mm)	.0059 in. (0.150 mm)
Rod Journal Outside Diameter		
Standard	1.5736-1.5740 in. (39.970-39.980 mm)	1.5717 in. (39.920 mm)
Undersize	1.5638-1.5642 in. (39.720-39.730 mm)	1.5618 in. (39.670 mm)

Crankshaft and Crankshaft Bearings (continued)

Rod Bearing Inside Diameter		
Standard	1.5748-1.5765 in. (40.000-40.042 mm)	1.5776 in. (40.070 mm)
Undersize	1.5650-1.5666 in. (39.750-39.792 mm)	1.5677 in. (39.820 mm)
Rod Bearing Clearance	.0008-.0028 in. (0.020-0.072 mm)	.0059 in .(0.150 mm)
End Play	.0035-.0107 in. (0.090-0.271 mm)	.0130 in .(0.330 mm)
Deflection		.0008 in. (0.020 mm)

Cylinder Block

Cylinder Inside Diameter		
Standard	2.8346-2.8358 in. (72.000-72.030 mm)	2.8425 in. (72.200 mm)
1st Oversize	2.8445-2.8457 in. (72.250-72.280 mm)	2.8524 in. (72.450 mm)
2nd Oversize	2.8543-2.8555 in. (72.500-72.530 mm)	2.8622 in. (72,700 mm)
Cylinder Roundness	0-.0004 in. (0-0.010 mm)	.0008 in. (0.020 mm)
Deck Distortion		.002 in. (0.05 mm)

Cylinder Head

Distortion	0-.002 in. (0-0.05 mm)	.006 in. (0.15 mm)

Timing Gears

Timing Gear Lash		
Crankshaft Gear to Idler Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Crankshaft Gear to Oil Pump Gear	.0043-.0075 in. (0.110-0.190 mm)	.0079 in. (0.200 mm)
Idler Gear to Camshaft Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Idler Gear to Fuel Injection Pump Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Idler Gear Bushing Inside Diameter	.7874-.7882 in. (20.000-20.021 mm)	.7906 in .(20.080 mm)
Idler Gear Shaft Outside Diameter	.7858-.7866 in. (19.959-19.980 mm)	.7846 in. (19.930 mm)
Idler Gear Shaft to Idler Gear Bushing Clearance	.0008-.0024 in. (0.020-0.062 mm)	.0059 in. (0.150 mm)

Oil Pump

Type	Trocoid	
Outer Rotor to Pump Body Clearance	.0039-.0063 in. (0.100-0.160 mm)	.0098 in. (0.250 mm)
Inner Rotor Tip to Outer Rotor Lobe Clearance		.0059 in. (0.150 mm)
Rotor Plate to Rotor Clearance	.0012-.0035 in. (0.030-0.090 mm)	.0051 in. (0.130 mm)
Rotor Shaft to Rotor Shaft Bore Clearance	.0006-.0019 in. (0.015-0.048 mm)	.0079 in. (0.200 mm)
Pressure Control Valve Setting	42.7-56.9 psi (294-392 kPa)	

Starter

No Load Test		
Voltage	11 volts	
Current	180 amps @ 11 volts	
Speed	More than 3500 rpm @ 11 volts	
Commutator Outside Diameter	1.18 in. (30.0 mm)	1.14 in. (29.0 mm)

TK 3.95 Diesel Engine Specifications

General	**TK 3.95**
Model	3TNE72KC
Type	Four Stroke Cycle Water Cooled
Number of Cylinders	3
Bore	2.83 in. (72.0 mm)
Stroke	3.07 in. (78.0 mm)
Displacement	58.2 cu. in. (953 cc)
Power Rating	16.8 hp (12.5 kW)
Compression Ratio	22.9 to 1
Direction of Rotation	Counterclockwise (Viewed from Flywheel)
Firing Order	1, 3, 2
Fuel Injection Timing	14 Degrees BTDC
Nozzle Injection Pressure	1707 psi (11768 kPa)
Oil Pressure	18.5 psi (127 kPa) Minimum @ 230 F (110 C) and 1600 rpm

Valve Train	**Standard Dimensions**	**Wear Limit**
Valve Spring		
Free Length	1.47 in. (37.4 mm)	1.33 in. (33.7 mm)
Inclination		.04 in. (1.0 mm)
Valve Guide Inside Diameter		
Intake	.2758-.2764 in. (7.005-7.020 mm)	.2787 in. (7.080 mm)
Exhaust	.2758-.2764 in. (7.005-7.020 mm)	.2787 in. (7.080 mm)
Valve Stem Outside Diameter		
Intake	.2740-.2746 in. (6.960-6.975 mm)	.2717 in. (6.900 mm)
Exhaust	.2734-.2740 in. (6.945-6.960 mm)	.2717 in. (6.900 mm)
Valve Depth		
Intake	.016-.024 in. (0.40-0.60 mm)	.039 in. (1.00 mm)
Exhaust	.030-.037 in. (0.75-0.95 mm)	.039 in. (1.00 mm)
Valve Guide Projection		
Intake	.354 in. (9.00 mm)	
Exhaust	.354 in. (9.00 mm)	
Valve Stem to Rocker Arm Clearance		
Intake	.006-.010 in. (0.15-0.25 mm)	
Exhaust	.006-.010 in. (0.15-0.25 mm)	
Valve Seat Angle		
Intake	30 Degrees	
Exhaust	45 Degrees	

Valve Train (continued)	**Standard Dimensions**	**Wear Limit**
Valve Seat Width		
Intake	0.57 in. (1.44 mm)	.078 in. (1.98 mm)
Exhaust	.070 in. (1.77 mm)	.089 in. (2.27 mm)
Push Rod Length	5.551-5.591 in. (141.00-142.00 mm)	
Rocker Arm Bushing Inside Diameter	.4724-.4732 in. (12.000-12.020 mm)	.4760 in. (12.090 mm)
Rocker Arm Shaft Outside Diameter	.4711-.4718 in. (11.966-11.984 mm)	.4705 in. (11.950 mm)
Rocker Arm Bushing to Rocker Arm		
Shaft Clearance	.0006-.0021 in. (0.016-0.054 mm)	.0055 in. (0.140 mm)
Tappet Outside Diameter	.8239-.8252 in. (20.927-20.960 mm)	.8228 in. (20.900 mm)
Tappet Bore Inside Diameter	.8268-.8276 in. (21.000-21.021 mm)	.8287 in. (21.050 mm)
Tappet To Tappet Bore Clearance	.0016-.0037 in. (0.040-0.094 mm)	.0059 in. (0.150 mm)
Camshaft		
Cam Lobe	1.3366-1.3406 in. (33.950-34.050 mm)	1.3287 in. (33.750 mm)
Camshaft Journal		
Timing Gear End	1.5724-1.5732 in. (39.940-39.960 mm)	1.5689 in. (39.850 mm)
Middle	1.5713-1.5722 in. (39.910-39.935 mm)	1.5689 in. (39.850 mm)
Flywheel End	1.5724-1.5732 in. (39.940-39.960 mm)	1.5689 in. (39.850 mm)
Camshaft Bearing Inside Diameter		
Timing Gear End Bearing Insert	1.5748-1.5774 in. (40.000-40.065 mm)	1.5787 in. (40.100 mm)
Middle Bearing	1.5748-1.5758 in. (40.000-40.025 mm)	1.5787 in. (40.100 mm)
Flywheel End Bearing	1.5748-1.5758 in. (40.000-40.025 mm)	1.5787 in .(40.100 mm)
Camshaft Journal to		
Camshaft Bearing Clearance		
Timing Gear End	.0016-.0049 in. (0.040-0.125 mm)	
Middle	.0026-.0045 in. (0.065-0.115 mm)	
Flywheel End	.0016-.0033 in. (0.040-0.085 mm)	
Camshaft Deflection	.001 in. (0.02 mm)	.002 in. (0.05 mm)
Camshaft End Play	.002-.010 in. (0.05-0.25 mm)	.016 in. (0.40 mm)
Piston, Piston Rings, and Wrist Pin		
Piston Outside Diameter Measuring		
Point (From Bottom of Piston)	.49 in .(12.4 mm)	
Piston Outside Diameter		
Standard	2.8323-2.8335 in. (71.940-71.970 mm)	2.8307 in. (71.900 mm)
1st Oversize	2.8421-2.8433 in. (72.190-72.220 mm)	2.8406 in. (72.150 mm)
2nd Oversize	2.8520-2.8531 in. (72.440-72.470 mm)	2.8504 in. (72.400 mm)
Piston to Cylinder Wall Clearance	.0018-.0030 in. (0.045-0.075 mm)	

Piston, Piston Rings, and Wrist Pin (continued)

Piston Ring Groove Width		
Top Ring Groove	.0610-.0618 in .(1.550-1.570 mm)	
Middle Ring Groove	.0622-.0628 in. (1.580-1.595 mm)	
Bottom Ring Groove	.1185-.1191 in. (3.010-3.025 mm)	
Piston Ring Width		
Top Ring	.0579-.0587 in. (1.470-1.490 mm)	
Middle Ring	.0579-.0587 in. (1.470-1.490 mm)	
Bottom Ring	.1196-.1177 in. (2.970-2.990 mm)	
Piston Ring to Ring Groove Clearance		
Middle	.0035-.0049 in. (0.090-0.125 mm)	.0079 in. (0.200 mm)
Bottom	.0008-.0018 in. (0.020-0.045 mm)	.0079 in. (0.200 mm)
Piston Ring End Gap		
Top Ring	.004-.010 in. (0.10-0.25 mm)	.059 in. (1.50 mm)
Middle Ring	.010-.016 in. (.025-.040 mm)	.059 in. (1.50 mm)
Bottom Ring	.008-.018 in. (0.20-0.45 mm)	.059 in. (1.50 mm)
Wrist Pin Bore Inside Diameter	.8268-.8271 in .(21.000-21.009 mm)	.8276 in. (21.020 mm)
Wrist Pin Outside Diameter	.8264-.8268 in .(20.991-21.000 mm)	.8228 in. (20.900 mm)
Wrist Pin to Wrist Pin Bore Clearance	0-.0007 in. (0-.017 mm)	.0047 in. (0.120 mm)

Connecting Rod

Wrist Pin Bushing Inside Diameter	.8278-.8283 in .(21.025-21.038 mm)	.8307 in. (21.100 mm)
Wrist Pin to Wrist Pin Bushing Clearance	.0010-.0019 in .(0.025-0.047 mm)	.0079 in (0.200 mm)
Side Clearance (Crank to Rod)	.008-.016 in .(0.20-0.40 mm)	.022 in. (0.55 mm)
Twist per 4 in. (100 mm)	.001 in. (0.03 mm)	.003 in. (0.08 mm)
Parallelism per 4 in. (100 mm)	.001 in. (0.03 mm)	.003 in. (0.08 mm)

Crankshaft and Crankshaft Bearings

Main Journal Outside Diameter		
Standard	1.7311-1.7315 in. (43.970-43.980 mm)	1.7283 in. (43.900 mm)
Undersize	1.7213-1.7217 in. (43.720-43.730 mm)	1.7185 in. (43.650 mm)
Main Bearing Inside Diameter		
Standard	1.7328-1.7334 in. (44.013-44.029 mm)	1.7343 in. (44.050 mm)
Undersize	1.7230-1.7236 in. (43.763-43.779 mm)	1.7244 in. (43.800 mm)
Main Bearing Clearance	.0013-.0023 in .(0.033-0.059 mm)	.0059 in. (0.150 mm)
Rod Journal Outside Diameter		
Standard	1.5736-1.5740 in. (39.970-39.980 mm)	1.5713 in. (39.910 mm)
Undersize	1.5638-1.5642 in. (39.720-39.730 mm)	1.5614 in. (39.660 mm)

Crankshaft and Crankshaft Bearings (continued)		
Rod Bearing Inside Diameter		
Standard	1.5753-1.5759 in. (40.013-40.029 mm)	1.5772 in. (40.060 mm)
Undersize	1.5655-1.5661 in. (39.763-39.779 mm)	1.5673 in. (39.810 mm)
Rod Bearing Clearance	.0013-.0023 in. (0.033-0.059 mm)	.0059 in .(0.150 mm)
End Play	.0035-.0107 in. (0.090-0.271 mm)	.0130 in .(0.330 mm)
Deflection		.0008 in. (0.020 mm)
Cylinder Block		
Cylinder Inside Diameter		
Standard	2.8346-2.8358 in. (72.000-72.030 mm)	2.8425 in. (72.200 mm)
1st Oversize	2.8445-2.8457 in. (72.250-72.280 mm)	2.8524 in. (72.450 mm)
2nd Oversize	2.8543-2.8555 in. (72.500-72.530 mm)	2.8622 in. (72,700 mm)
Cylinder Roundness	0-.0004 in. (0-0.010 mm)	.0012 in. (0.030 mm)
Deck Distortion		.002 in. (0.05 mm)
Cylinder Head		
Distortion	0-.002 in. (0-0.05 mm)	.006 in. (0.15 mm)
Timing Gears		
Timing Gear Lash		
Crankshaft Gear to Idler Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Crankshaft Gear to Oil Pump Gear	.0043-.0075 in. (0.110-0.190 mm)	.0079 in. (0.200 mm)
Idler Gear to Camshaft Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Idler Gear to Fuel Injection Pump Gear	.0016-.0047 in. (0.040-0.120 mm)	.0079 in. (0.200 mm)
Idler Gear Bushing Inside Diameter	.7874-.7882 in. (20.000-20.021 mm)	.7906 in .(20.080 mm)
Idler Gear Shaft Outside Diameter	.7858-.7866 in. (19.959-19.980 mm)	.7846 in. (19.930 mm)
Idler Gear Shaft to Idler Gear Bushing Clearance	.0008-.0024 in. (0.020-0.062 mm)	.0059 in. (0.150 mm)
Oil Pump		
Type	Trocoid	
Outer Rotor to Pump Body Clearance	.0039-.0063 in. (0.100-0.160 mm)	.0098 in. (0.250 mm)
Inner Rotor Tip to Outer Rotor Lobe Clearance		.0059 in. (0.150 mm)
Rotor Plate to Rotor Clearance	.0012-.0035 in. (0.030-0.090 mm)	.0051 in. (0.130 mm)
Rotor Shaft to Rotor Shaft Bore Clearance	.0005-.0017 in. (0.013-0.043 mm)	.0079 in. (0.200 mm)
Pressure Control Valve Setting	42.7-56.9 psi (294-392 kPa)	

Starter

No Load Test		
Voltage	11 volts	
Current	180 amps @ 11 volts	
Speed	More than 3500 rpm @ 11 volts	
Commutator Outside Diameter	1.18 in. (30.0 mm)	1.14 in. (29.0 mm)

Torque Values for TK 2.44 & TK 3.66 Engines

Description	Dia. x Pitch (mm)	N•m	ft-lb	kgm
Camshaft Thrust Plate Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Connecting Rod Bolt	7x1	22.6-27.5	16.6-20.3	2.3-2.8
Crankshaft Pulley Bolt	12x1.25	83.4-93.2	61.5-68.7	8.5-9.5
Cylinder Head Mtg. Bolt	8x1.25	32.4-36.3	23.9-26.8	3.3-3.7
Engine Lift Bracket Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Exhaust Manifold Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Exhaust Manifold Mtg. Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Exhaust Manifold Mtg. Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Flywheel Mtg. Bolt	10x1.25	80.4-86.3	59.3-63.7	8.2-8.8
Fuel Injection Nozzle Assy.	20x1.5	49.0-53.0	36.2-39.1	5.0-5.4
Fuel Injection Nozzle Nut		39.2-44.1	28.9-32.5	4.0-4.5
Fuel Injection Pump Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Fuel Injection Pump Mtg. Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Fuel Injection Pump Inspection Plate Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Inspection Plate Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Gear Case Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Air Bleed Screw Assy.	12	24.5-34.3	18.1-25.3	2.5-3.5
Glow Plug	10x1.25	14.7-19.6	10.8-14.5	1.5-2.0
Idler Gear Shaft Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Intake Manifold Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Main Bearing Bolt	9x1.25	52.0-55.9	38.3-41.2	5.3-5.7
Oil Intake Pipe Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pan Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pan Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pump Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Rear Seal Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Rocker Arm Support Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Rocker Arm Support Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Rocker Arm Support Mtg. Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Starter Mtg. Bolt	12x1.75	78.5-98.1	57.9-72.3	8.0-10.0
Starter Mounting Flange Mtg. Bolt	10x1.5	44.1-53.9	32.5-39.8	4.5-5.5
Thermostat Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Housing Inspection Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Cover Inspection Cover Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Valve Cover Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Water Pump Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Water Pump Pulley Mtg. Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Water Pump Pulley Mtg. Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2

Torque Values for TK 2.49 & TK 3.74 Engines

Description	Dia. x Pitch (mm)	N•m	ft-lb	kgm
Camshaft Thrust Plate Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Connecting Rod Bolt	7x1	22.6-27.5	16.6-20.3	2.3-2.8
Crankshaft Pulley Bolt	12x1.25	83.4-93.2	61.5-68.7	8.5-9.5
Cylinder Head Mtg. Bolt	8x1.25	37.3-41.2	27.5-30.4	3.8-4.2
Engine Lift Bracket Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Exhaust Manifold Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Exhaust Manifold Mtg. Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Exhaust Manifold Mtg. Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Flywheel Mtg. Bolt	10x1.25	80.4-86.3	59.3-63.7	8.2-8.8
Fuel Injection Nozzle Assy.	20x1.5	49.0-53.0	36.2-39.1	5.0-5.4
Fuel Injection Nozzle Nut		49.0-53.0	36.2-39.1	5.0-5.4
Fuel Injection Pump Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Fuel Injection Pump Mtg. Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Fuel Injection Pump Inspection Plate Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Inspection Plate Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Gear Case Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Air Bleed Screw Assy.	12	24.5-34.3	18.1-25.3	2.5-3.5
Glow Plug	10x1.25	14.7-19.6	10.8-14.5	1.5-2.0
Idler Gear Shaft Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Intake Manifold Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Main Bearing Bolt	9x1.25	52.0-55.9	38.3-41.2	5.3-5.7
Oil Intake Pipe Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pan Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pan Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pump Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Rear Seal Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Rocker Arm Support Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Rocker Arm Support Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Rocker Arm Support Mtg. Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Starter Mtg. Bolt	12x1.75	78.5-98.1	57.9-72.3	8.0-10.0
Starter Mounting Flange Mtg. Bolt	10x1.5	44.1-53.9	32.5-39.8	4.5-5.5
Thermostat Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Housing Inspection Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Cover Inspection Cover Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Valve Cover Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Water Pump Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Water Pump Pulley Mtg. Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Water Pump Pulley Mtg. Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2

Torque Values for TK 3.88 Engine

Description	Dia. x Pitch (mm)	N•m	ft-lb	kgm
Camshaft Thrust Plate Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Connecting Rod Bolt	7x1	22.6-27.5	16.6-20.3	2.3-2.8
Crankshaft Pulley Bolt	12x1.25	83.4-93.2	61.5-68.7	8.5-9.5
Cylinder Head Mtg. Bolt	9x1.25	58.8-63.7	43.4-47.0	6.0-6.5
Engine Lift Bracket Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Exhaust Manifold Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Exhaust Manifold Mtg. Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Exhaust Manifold Mtg. Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Flywheel Mtg. Bolt	10x1.25	80.4-86.3	59.3-63.7	8.2-8.8
Fuel Injection Nozzle Assy.	20x1.5	49.0-53.0	36.2-39.1	5.0-5.4
Fuel Injection Nozzle Nut		39.2-44.1	28.9-32.5	4.0-4.5
Fuel Injection Pump Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Fuel Injection Pump Mtg. Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Fuel Injection Pump Inspection Plate Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Inspection Plate Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Gear Case Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Air Bleed Screw Assy.	12	24.5-34.3	18.1-25.3	2.5-3.5
Glow Plug	10x1.25	14.7-19.6	10.8-14.5	1.5-2.0
Idler Gear Shaft Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Intake Manifold Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Main Bearing Bolt	10x1.25	73.5-83.4	54.2-61.5	7.5-8.5
Oil Intake Pipe Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pan Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pan Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pump Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Rear Seal Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Rocker Arm Support Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Rocker Arm Support Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Rocker Arm Support Mtg. Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Starter Mtg. Bolt	12x1.75	78.5-98.1	57.9-72.3	8.0-10.0
Starter Mounting Flange Mtg. Bolt	10x1.5	44.1-53.9	32.5-39.8	4.5-5.5
Thermostat Housing Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Timing Gear Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Housing Inspection Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Cover Inspection Cover Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Valve Cover Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Water Pump Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Water Pump Pulley Mtg. Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Water Pump Pulley Mtg. Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2

Torque Values for TK 3.95 Engine

Description	Dia. x Pitch (mm)	N•m	ft-lb	kgm
Camshaft Thrust Plate Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Connecting Rod Bolt	7x1	22.6-27.5	16.6-20.3	2.3-2.8
Crankshaft Pulley Bolt	12x1.25	83.4-93.2	61.5-68.7	8.5-9.5
Cylinder Head Mtg. Bolt	9x1.25	58.8-63.7	43.4-47.0	6.0-6.5
Engine Lift Bracket Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Exhaust Manifold Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Exhaust Manifold Mtg. Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Exhaust Manifold Mtg. Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Flywheel Mtg. Bolt	10x1.25	78.5-88.3	57.9-65.1	8.0-9.0
Fuel Injection Nozzle Assy.	20x1.5	49.0-53.0	36.2-39.1	5.0-5.4
Fuel Injection Nozzle Nut		49.0-53.0	36.2-39.1	5.0-5.4
Fuel Injection Pump Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Fuel Injection Pump Mtg. Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Fuel Injection Pump Inspection Plate Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Inspection Plate Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Gear Case Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Fuel Injection Pump Air Bleed Screw Assy.	12	24.5-34.3	18.1-25.3	2.5-3.5
Glow Plug	10x1.25	14.7-19.6	10.8-14.5	1.5-2.0
Idler Gear Shaft Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Intake Manifold Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Main Bearing Bolt	10x1.25	78.5-83.4	57.9-61.5	8.0-8.5
Oil Intake Pipe Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pan Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pan Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Oil Pump Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Rear Seal Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Rocker Arm Support Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Rocker Arm Support Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Rocker Arm Support Mtg. Stud	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Starter Mtg. Bolt	12x1.75	78.5-98.1	57.9-72.3	8.0-10.0
Starter Mounting Flange Mtg. Bolt	10x1.5	44.1-53.9	32.5-39.8	4.5-5.5
Thermostat Housing Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Timing Gear Housing Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Housing Inspection Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Cover Mtg. Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Timing Gear Cover Inspection Cover Bolt	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Valve Cover Mtg. Nut	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Water Pump Mtg. Bolt	8x1.25	22.6-28.4	16.6-21.0	2.3-2.9
Water Pump Pulley Mtg. Nut	6x1	9.8-11.8	7.2-8.7	1.0-1.2
Water Pump Pulley Mtg. Stud	6x1	9.8-11.8	7.2-8.7	1.0-1.2

Engine Disassembly 2

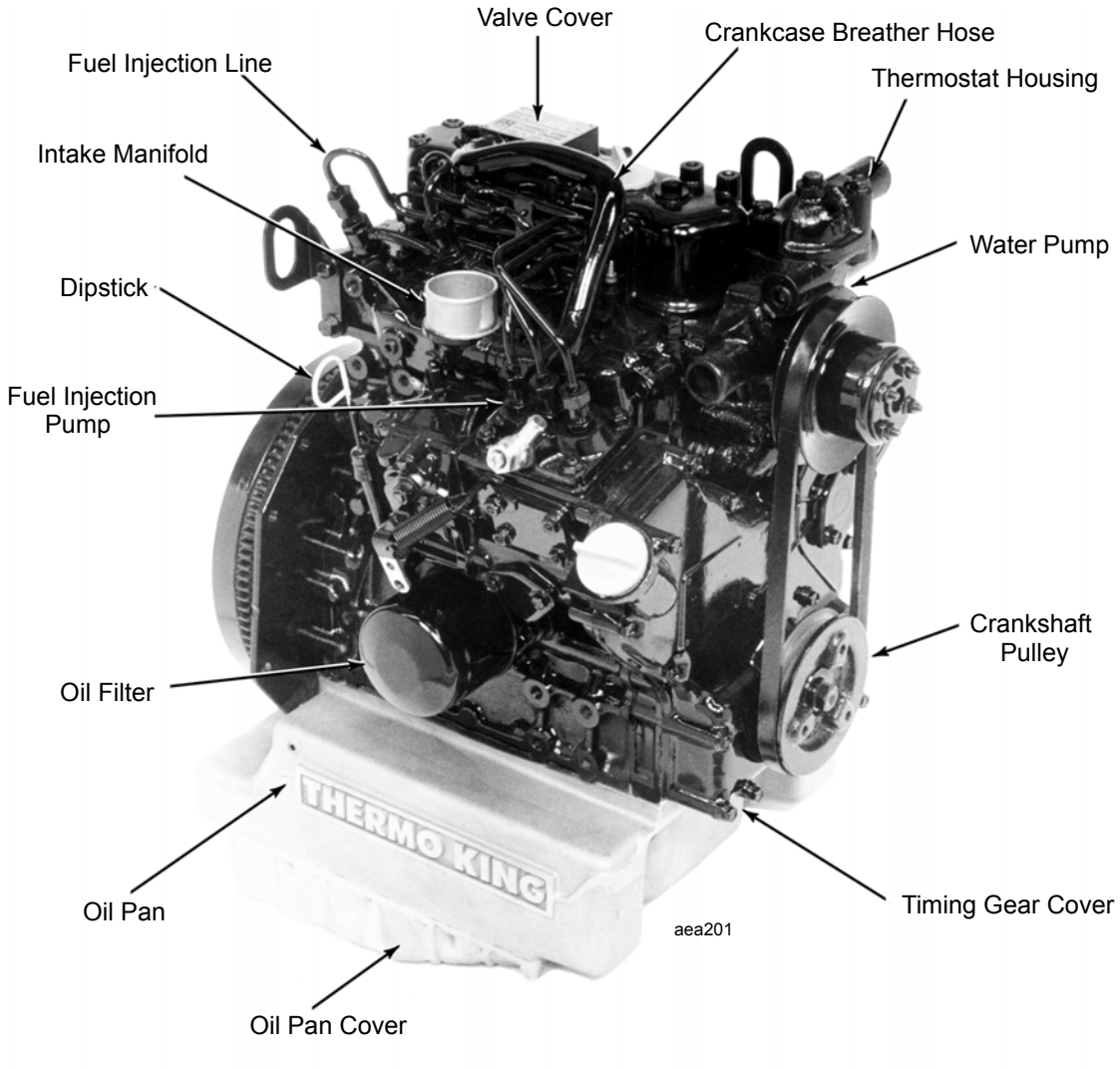
Engine Disassembly

Before disassembling the engine, drain the engine oil and coolant, remove the following parts from the engine, and remove the engine from the unit:

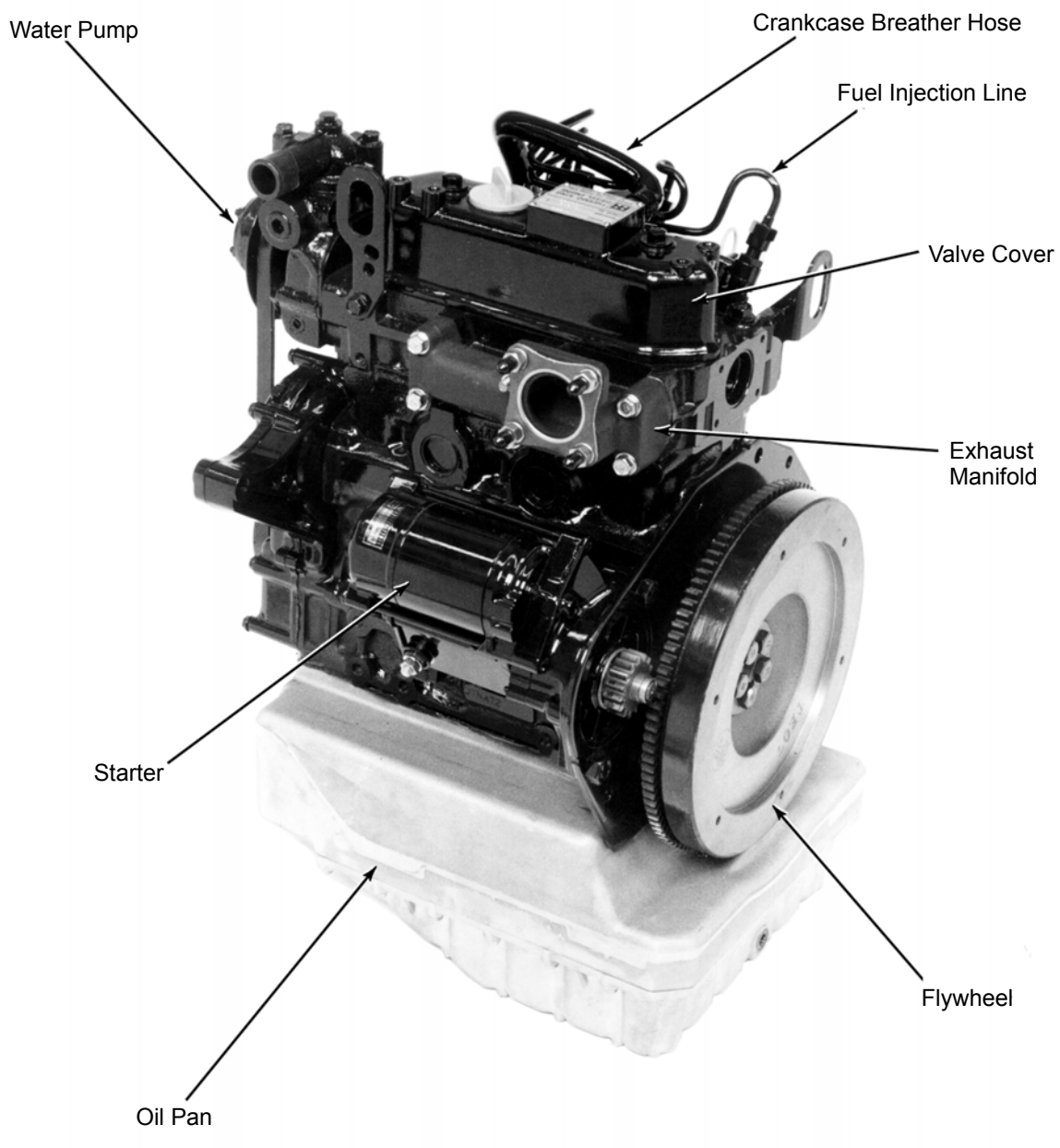
Battery Cables
Fuel Lines
Electrical Wiring
Fuel/Throttle Solenoid
Coolant Hoses
Air Cleaner and Intake Hose
Exhaust Pipe and Muffler

While disassembling the engine, note things such as the position of dowel pins and O-rings, and the existing timing marks and bearing cap marks. Identical components in the valve train and the crankshaft assembly should be kept in order or marked. This prevents mixing up these components and allows the components to be placed in their original positions when the engine is assembled.

1. Remove the starter.

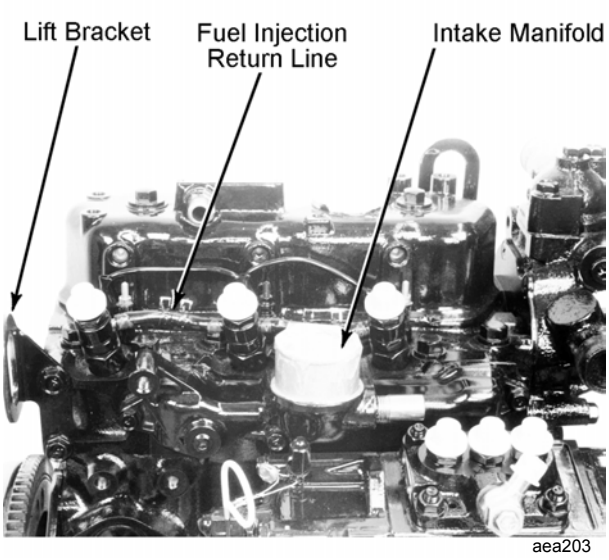


TK 3.88 Front View



TK 3.88 Rear View

2. Remove the exhaust manifold.
3. Remove the fuel injection lines. Cover all the injection lines, fuel lines, and fittings with plastic covers or tape. The smallest amount of dirt can damage the fuel system.
4. Remove the crankcase breather hose.
5. Remove the fuel injection return lines.
6. Remove the intake manifold.

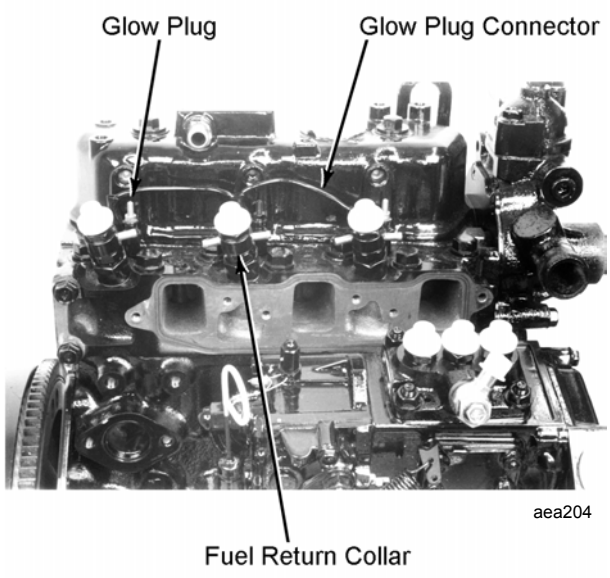


Intake Manifold

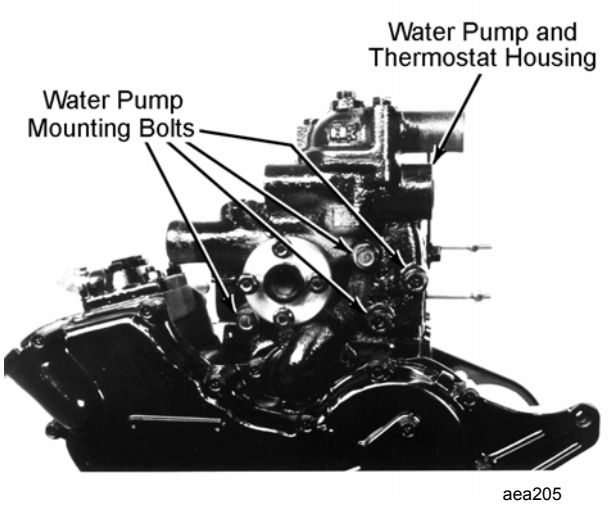
7. Remove the fuel injection nozzles.

   NOTE: Removing the lift bracket from the cylinder head and the fuel return collars from the fuel injection nozzles makes it easier to remove the injection nozzles.

8. Remove the glow plug connector.
9. Remove the glow plugs.



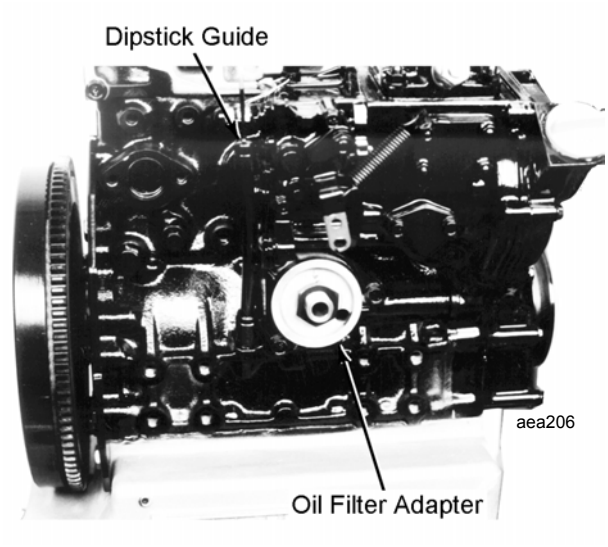
Fuel Injection Nozzles



Water Pump

10. Remove the water pump.

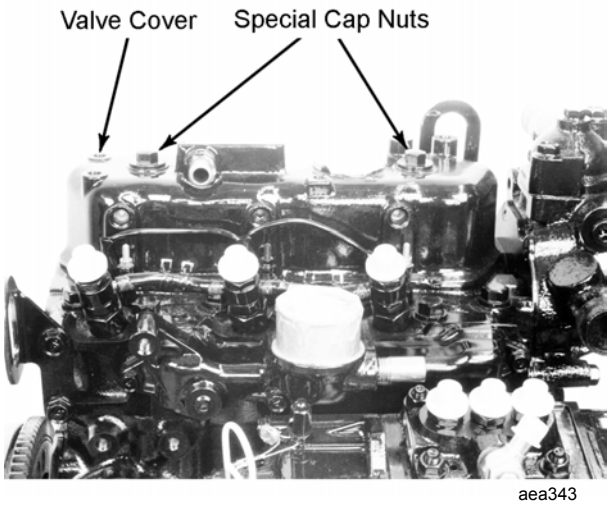
11. Remove the oil filter and the oil pressure control valve. On the TK 3.88 and TK 3.95 the oil pressure control valve is attached to the oil filter adapter.



Oil Filter Adapter

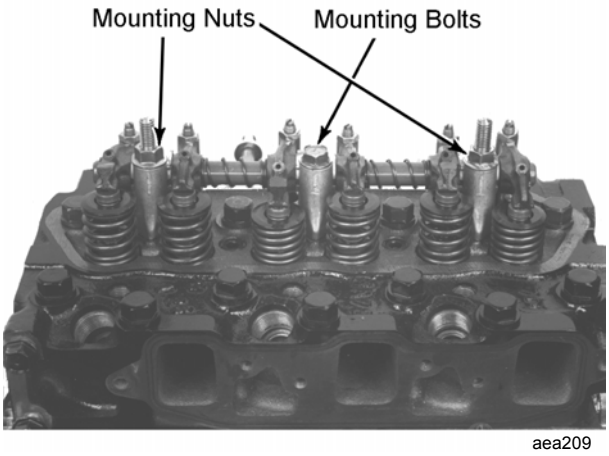
12. Remove the dipstick and the dipstick guide.

13. Remove the valve cover by removing the two special cap nuts. Inspect the O-rings under these cap nuts and replace the O-rings, if necessary, during assembly.



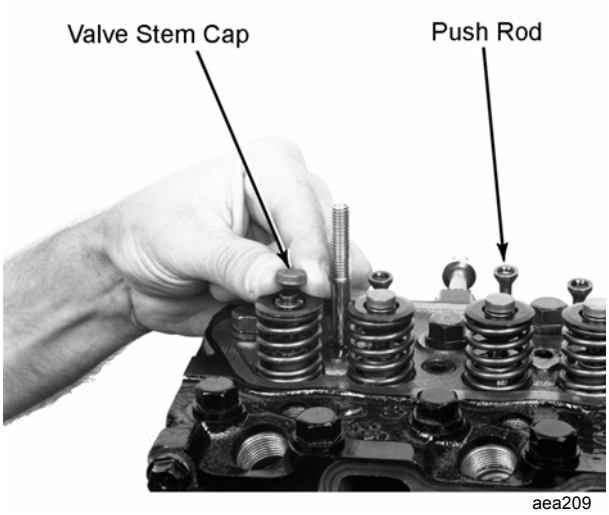
Valve Cover

14. Remove the rocker arm assembly by removing the nuts and (and bolt on three cylinder engines) that mount the rocker arm supports. Alternately loosen each nut and bolt one turn at a time to evenly release the spring pressure on the rocker arm assembly.



Rocker Arm Assembly

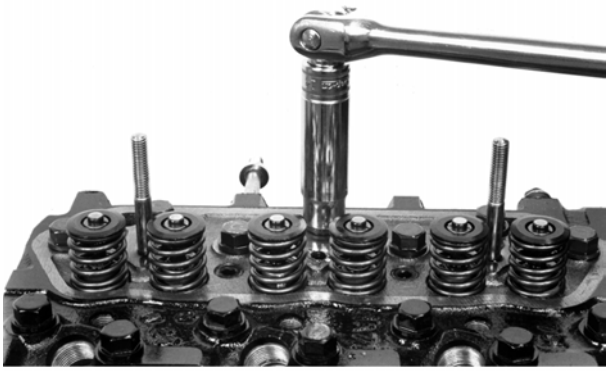
15. Remove the valve stem caps and keep them in order.



Valve Stem Caps

16. Remove the push rods and keep them in order if they will be reused.

17. Break each cylinder head bolt loose 1/4 to 1/2 turn in a crisscross pattern starting at the ends. Then remove the cylinder head bolts.

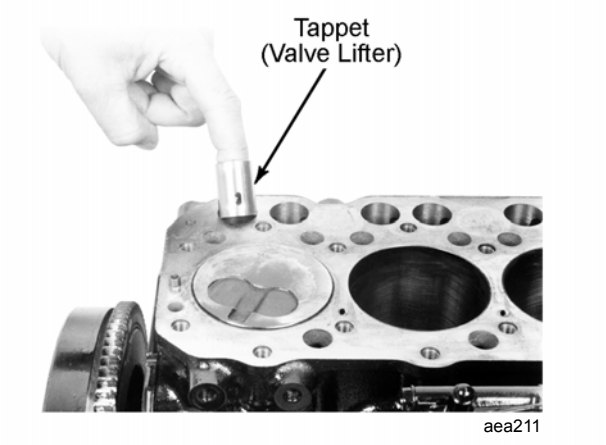


Cylinder Head Bolts

18. Remove the cylinder head from the cylinder block.

19. Remove the tappets (valve lifters) and keep them in order so they will be placed in the same position when assembled.

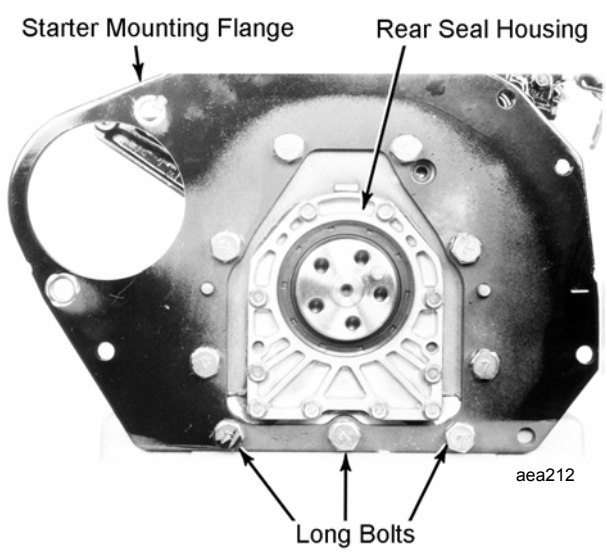
NOTE: The tappets can be removed from either the top or the bottom of the block. If the engine is turned upside down with the cylinder head off, the lifters may fall out.



Removing Tappet

20. Remove the starter mounting flange.

NOTE: The bolts at the bottom of the starter mounting flange, which screw into the oil pan, are longer than the other bolts that fasten the starter mounting flange to the engine.

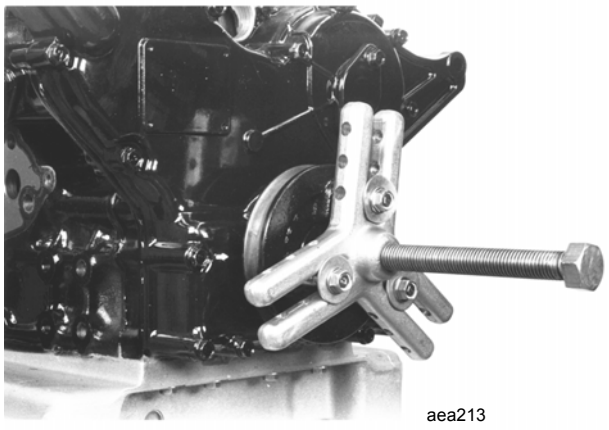


Starter Mounting Flange

21. Remove the rear seal housing.

22. Remove the front crankshaft bolt.

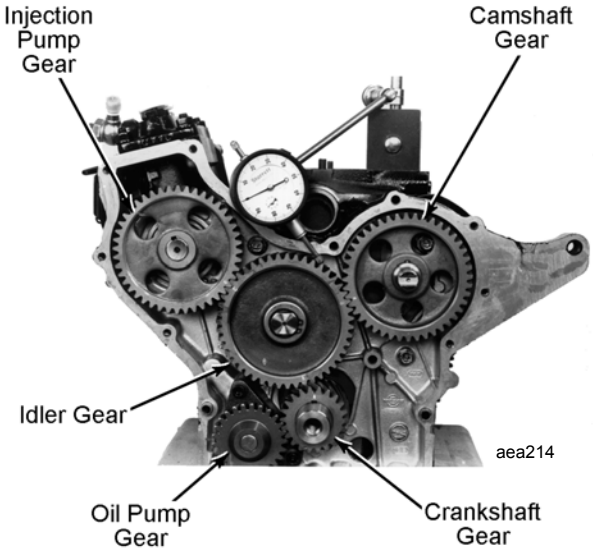
23. Remove the crankshaft pulley by using a suitable puller.



Removing Crankshaft Pulley

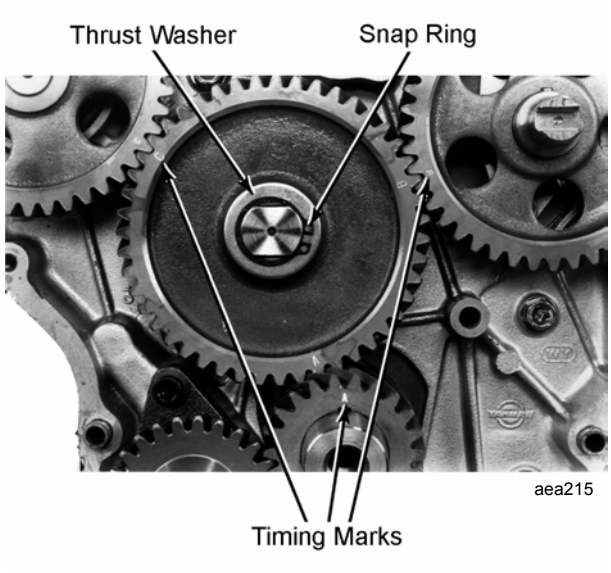
24. Remove the timing gear cover.

25. Check the timing gear lash. If the gear lash is within specifications (refer to Specifications), the gears can probably be reused. If the gear lash is excessive, some or all of the gears must be replaced to meet the specifications.



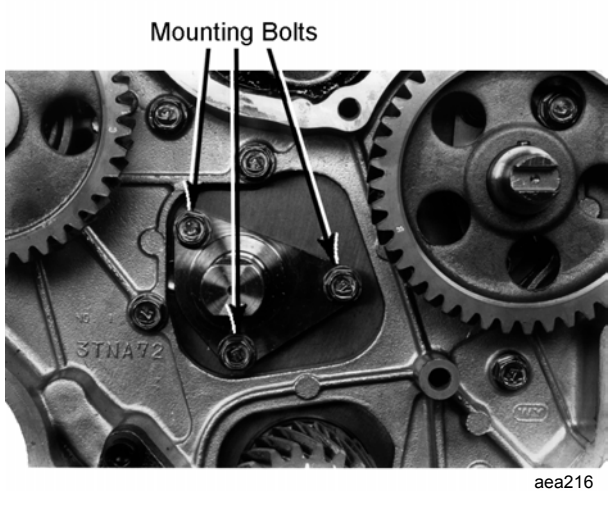
Check Timing Gear Lash

26. Remove the snap ring from the idler shaft and remove the thrust washer and the idler gear. Note the timing marks on the timing gears. The timing marks must be aligned when the engine is assembled. The A mark on the crankshaft gear is straight up when the piston in the cylinder next to the water pump is at top dead center.



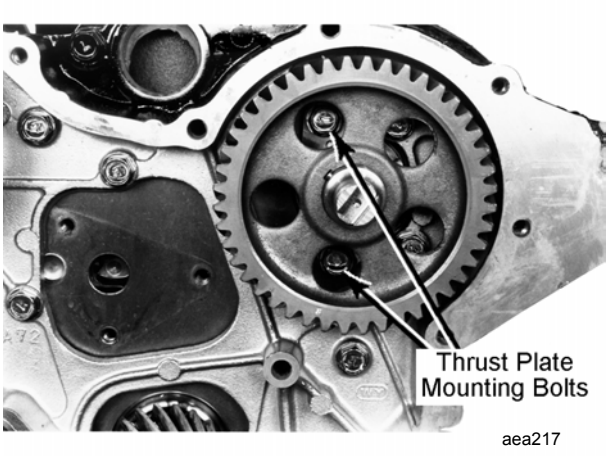
Idler Gear and Timing Marks

27. Remove the idler gear shaft from the cylinder block.



Idler Gear Shaft

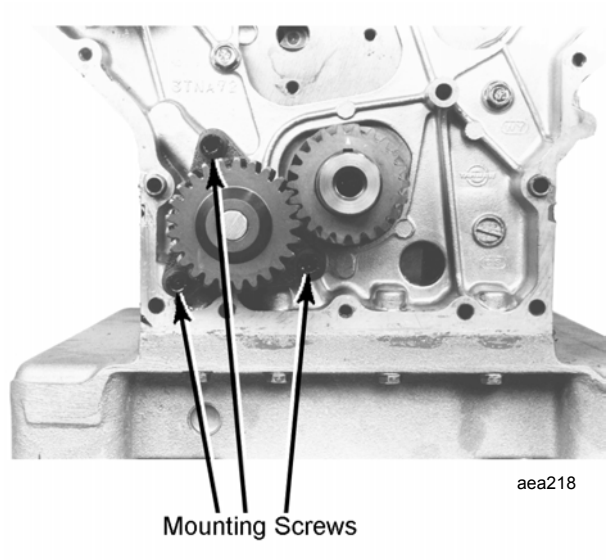
28. Remove the mounting bolts from the camshaft thrust plate by turning the camshaft gear to access the bolts through the holes in the gear.



Camshaft Gear

29. Carefully remove the camshaft to avoid scratching or marring the camshaft bearings.

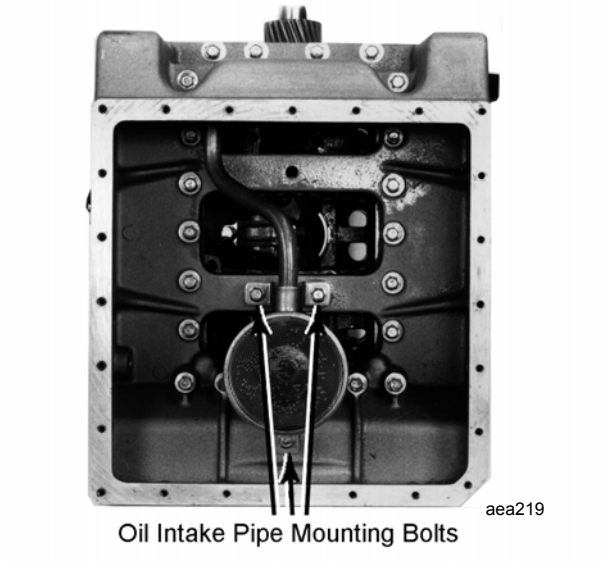
30. Remove the oil pump.



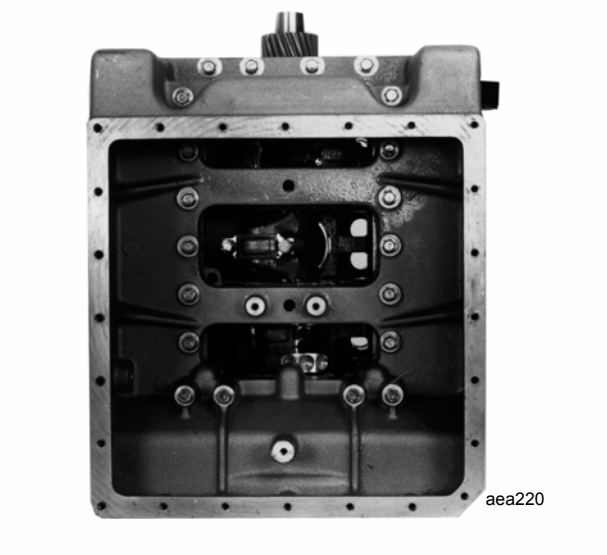
Oil Pump

31. Make sure the oil has been drained and remove the oil pan and the oil intake pipe.

NOTE: Some engines have two piece oil pans. The oil pan cover must be removed to access some of the mounting bolts that fasten the top half of the oil pan to the block.

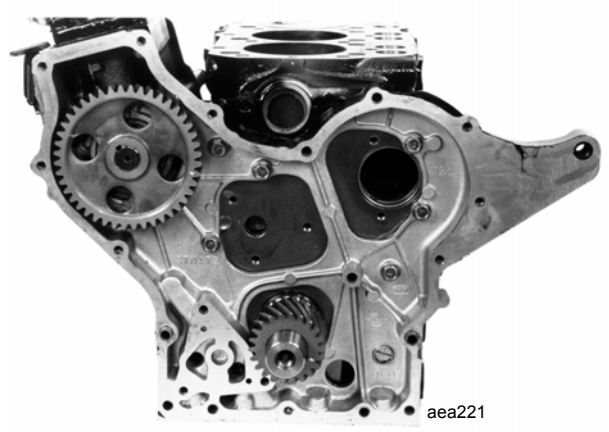


Remove Oil Pan Cover



Oil Pan Mounting Bolts

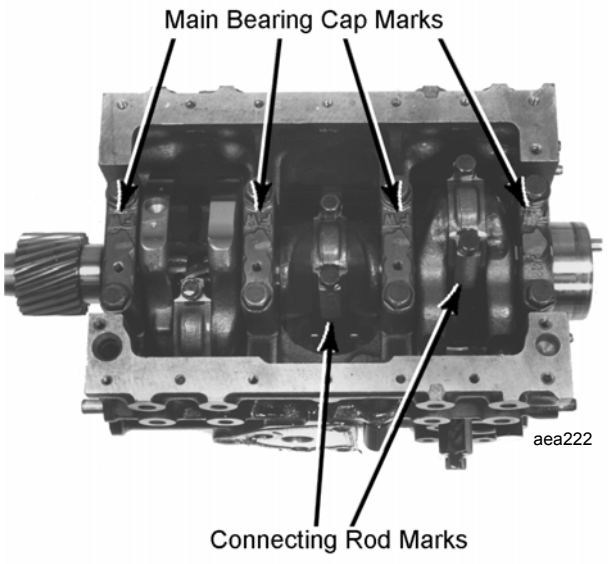
32. Remove the timing gear housing and injection pump.



Timing Gear Housing and Injection Pump

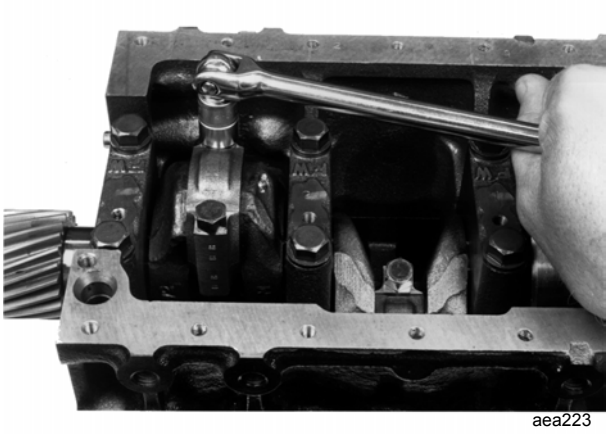
33. Remove the ring ridge from the top of each cylinder, if necessary.

34. Mark, or note the existing marks on, the connecting rod caps, connecting rods, pistons, and main bearing caps so they can be placed in the same position when assembled.



Identification Marks

35. Remove the connecting rod caps.

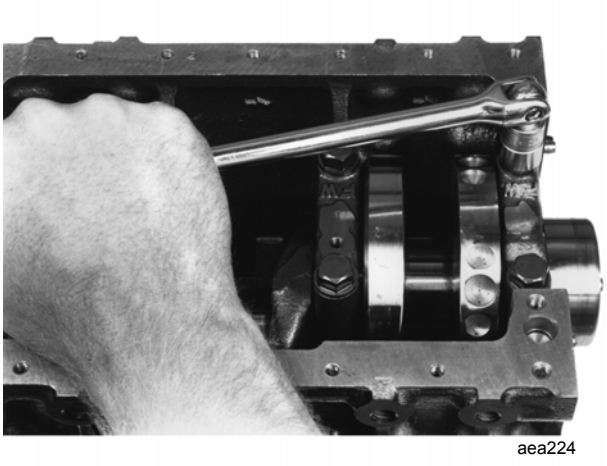


Removing Connecting Rod Caps

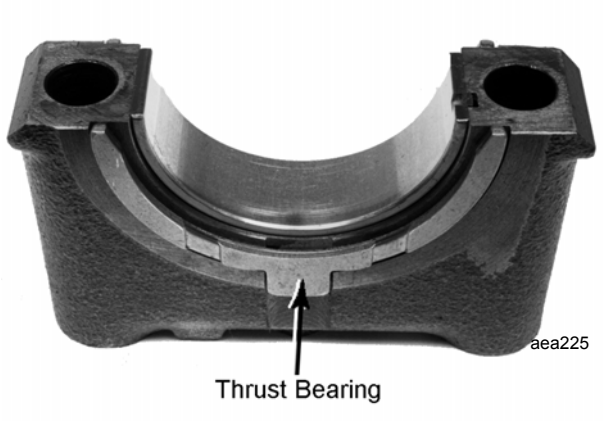
36. Carefully remove the piston and connecting rod assemblies through the top of the cylinders to avoid scratching or marring the cylinder walls.

37. Remove the main bearing caps.

NOTE: The rear main bearing cap (flywheel end) has a thrust bearing on each side. Make sure to remove these two thrust bearings.



Removing Connecting Main Bearing Caps



Rear Main Bearing Cap

38. Carefully remove the crankshaft from the block.

NOTE: The upper rear main bearing (flywheel end) has a thrust bearing on each side. Make sure to remove these two thrust bearings.

Upper Rear Main Bearing

Inspection and Reconditioning 3

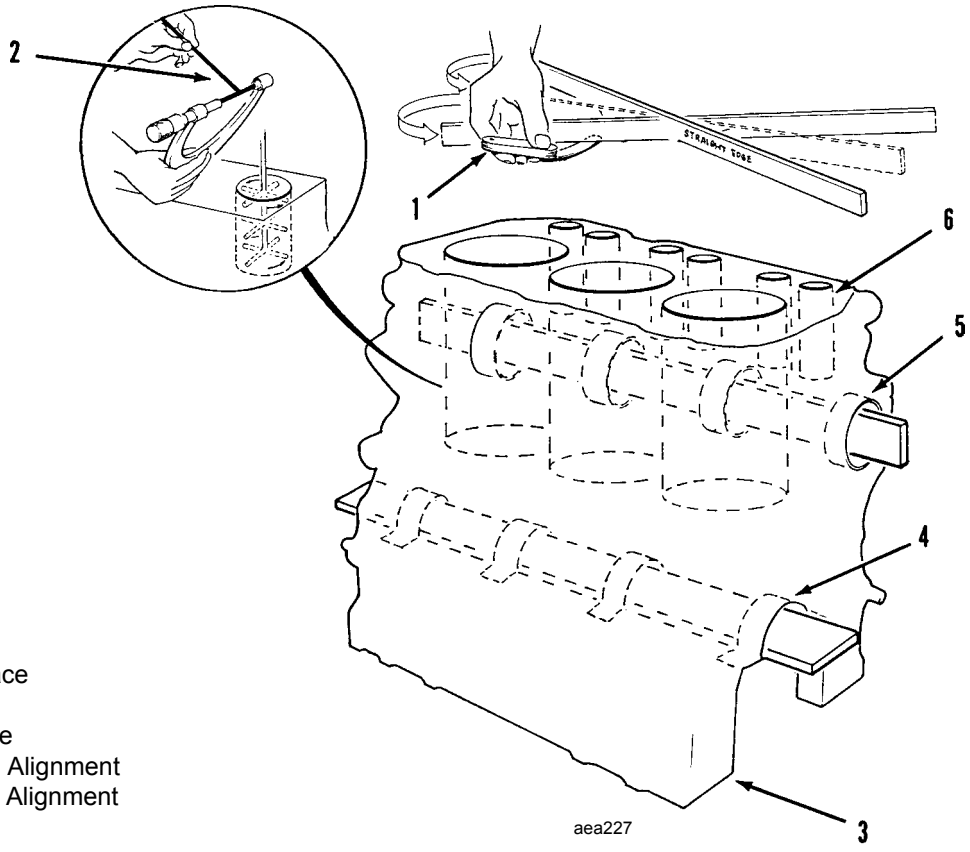
Inspection and Reconditioning

NOTE: Refer to the Specifications Section for specific dimensions that are not given in this section.

This section covers the cleaning, inspection, overhaul, and assembly of individual engine components. After disassembling the engine, check the components and discard unusable parts such as gaskets, O-rings, burned valves, and broken rings. Check the items that may need machine shop work first so this work can be completed by the time the rest of the engine is ready to assemble.

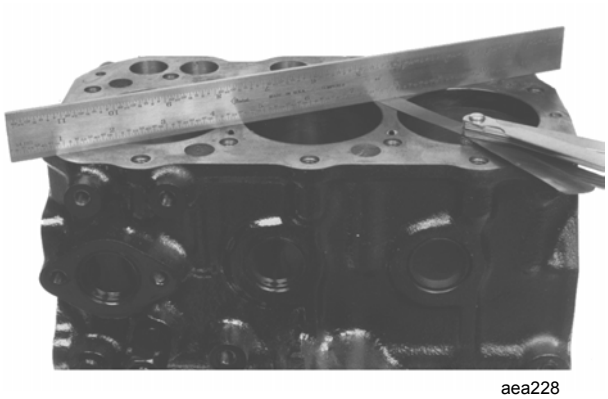
Cylinder Block

1. Inspect the cylinder block for cracks, damage, and distortion. Use a straight edge and a feeler gauge to check the cylinder block deck for distortion. Check all four sides, both diagonals, and the center lines of the cylinder block deck. If there is more than .002 in. (0.05 mm) distortion, resurface the cylinder block. Do not remove more than .002 in. (0.05 mm) from the surface of the cylinder block.



1 Head Mating Surface
2. Cylinder Bore
3. Pan Mating Surface
4. Main Bearing Bore Alignment
5. Cam Bearing Bore Alignment
6. Lifter Bore

Block Measurements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Checking Block Distortion

2. Check each cylinder for out of round, taper, pocketing, or any other damage that would require boring the cylinders. Measure each cylinder both parallel and perpendicular to the crankshaft, at the top, the middle, and the bottom of the cylinder bore. The cylinder out of roundness should not exceed the wear limit (refer to Specifications), and should not be tapered more than .0030 in. (0.076 mm). If the cylinders are in good condition, deglaze the cylinders with a glaze breaker.


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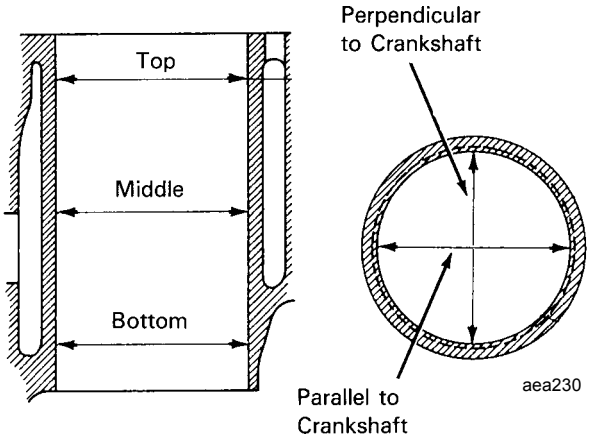
Measuring Cylinder Diameter



Cylinder Measuring Positions

3. If the cylinders must be bored, determine which oversize pistons should be used. Pistons are available in .010 and .020 in. (0.25 and 0.50 mm) oversizes.

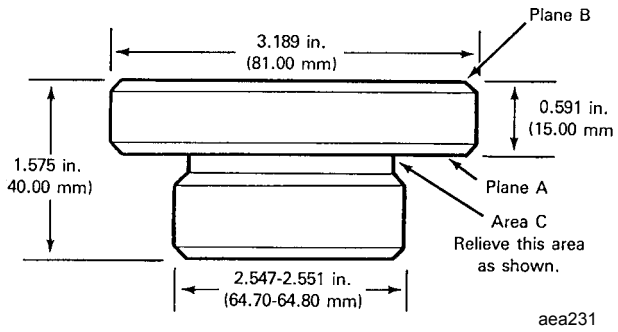
   NOTE: If the .020 in. (0.50 mm) oversize is not large enough to clean up the cylinders, cylinder sleeves and standard pistons must be installed. Use the following procedure to install cylinder sleeves:

   a. Bore and hone the cylinder block to accept the cylinder sleeves. The recommended interference fit for the cylinder sleeves is .0029-.0041 in. (0.075-0.105 mm).

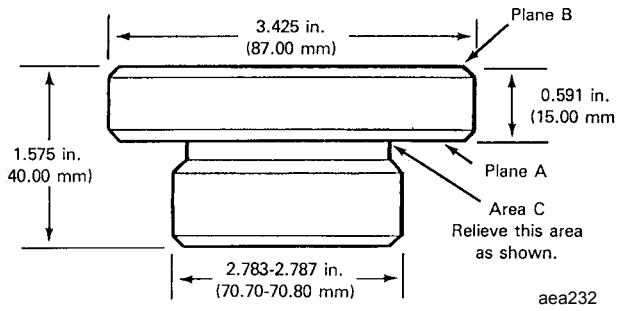
      Measure each cylinder sleeve and subtract .0035 in. (0.090 mm). Bore and hone each cylinder to match this dimension. The roughness average of the final surface finish should be less than 248 micro inches (6.3 microns).

   b. Press the cylinder sleeves into the cylinder block using a hydraulic press and a pressing tool.

The pressing tool can be fabricated using the dimensions in the illustrations below.



TK 2.44, TK 2.49, TK 3.66, and TK 3.74 Pressing Tool



TK 3.88 and TK 3.95 Pressing Tool

Planes A and B must be parallel.

Planes A and B must be perpendicular to the center line of the tool.

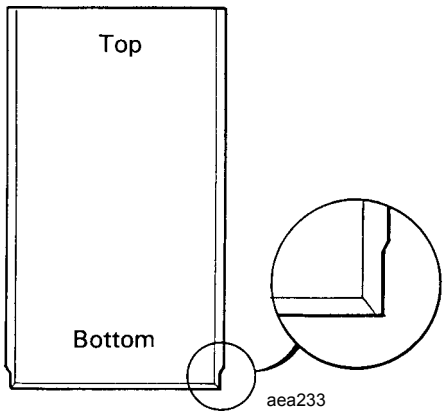
Relieve area C slightly as shown to prevent interference with the sleeve.

Bevel all the edges slightly.

c. Use a hydraulic press to press the cylinder sleeves into the block.

Place the pressing tool in the top end of the cylinder sleeve.

The bottom end of a cylinder sleeve has a slightly smaller outside diameter than the rest of the sleeve.

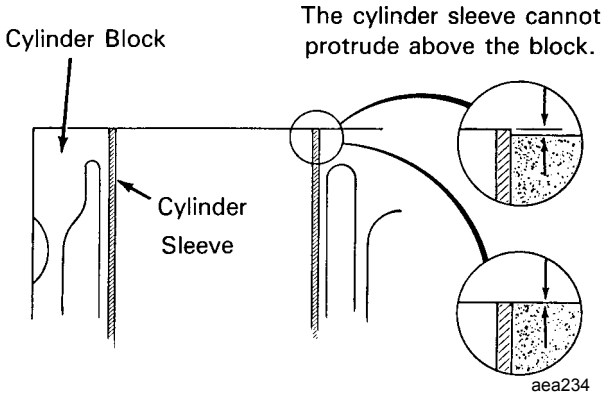


Cylinder Sleeve

Spray oil on the outside of the cylinder sleeve or on the inside of the cylinder bore in the block.

Place the cylinder sleeve in the block and press the sleeve into place. The pressing load should be 2200-4400 lb. (1000-2000 kg)

The top of the cylinder sleeve must be flush with the top of the block. The cylinder sleeve cannot protrude above the top of the block at all.



Cylinder Sleeve Installation

d. Bore and hone each cylinder sleeve to obtain the correct piston clearance.

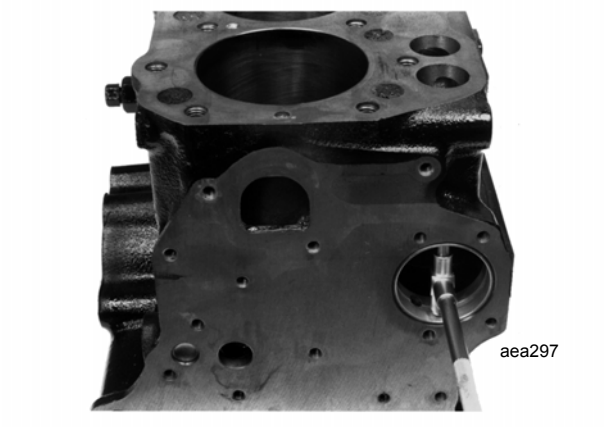
4. Measure each piston. Bore and hone each cylinder to obtain the correct piston to cylinder clearance (refer to Specifications).

   CAUTION: The pistons will vary slightly in diameter. Therefore, each piston must be measured and each cylinder must be bored and honed to match each piston.

   The roughness average of the final surface finish in the cylinders should be 59 to 118 micro inches (1.5 to 3.0 microns).

5. Measure the front camshaft bearing insert. If the front camshaft bearing insert is larger than the wear limit (refer to Specifications) or has a damaged surface, remove the bearing insert with a bearing driver. If the block will be boiled out, remove the bearing insert and all the core plugs.

   NOTE: The middle and rear camshaft bearings do not have bearing inserts.

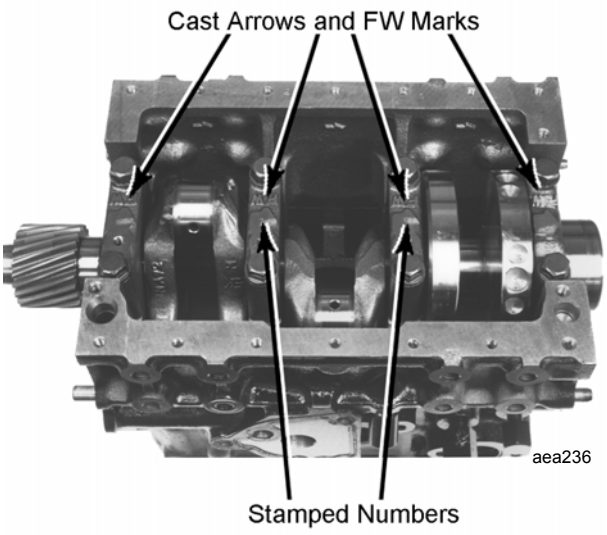


Measuring Front Camshaft Bearing Insert

6. Measure the middle and rear camshaft bearings. If the middle or rear camshaft bearings are larger than the wear limits (refer to Specifications), or if the surfaces have been damaged significantly, replace the block.

   Minor damage to the camshaft bearings can be cleaned up with a brake cylinder hone. The camshaft bearings should also be lightly honed after the block has been boiled out.

7. Install the main bearing caps in their proper positions. The cast arrows are labeled FW and should point to the rear (flywheel end) of the engine. The main bearing cap that is machined for the thrust bearing goes to the rear end of the engine. The main bearing caps with numbers stamped on them go to the middle of the engine with the main bearing cap marked number one closest to the rear of the engine. The main bearing cap with no number goes to the front end of the engine. Torque the main bearing cap bolts (refer to Specifications).

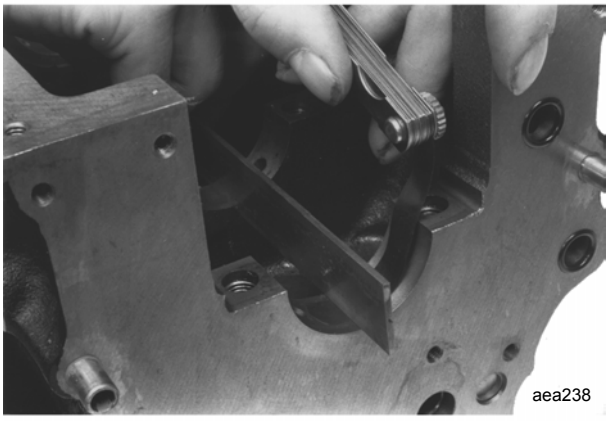


Main Bearing Cap Marks

8. Measure the main bearing bores both vertically and horizontally. If the main bearing bores are more than .001 in. (0.25 mm) out of round, the block must be align bored.

Measuring Main Bearing Bore

9. Check the main bearing bore alignment with a straight edge and a .0015 in. (0.381 mm) feeler gauge. Lay the straight edge in main bearing bores of the block and place the feeler gauge between the straight edge and each main bearing bore. There should be some drag on the feeler gauge at each main bearing bore. If there is no drag on the feeler gauge at any main bearing bore, the block must be align bored.



Checking Main Bearing Bore Alignment

10. Measure each tappet bore in the block. If any of the tappet bores are larger than the wear limit (refer to Specifications) the block must be replaced. Normally very little, if any, wear occurs in the tappet bores. Small scratches or nicks should be cleaned up with a brake cylinder hone. The tappet bores should also be lightly honed after the block has been boiled out.

Measuring Tappet Bore

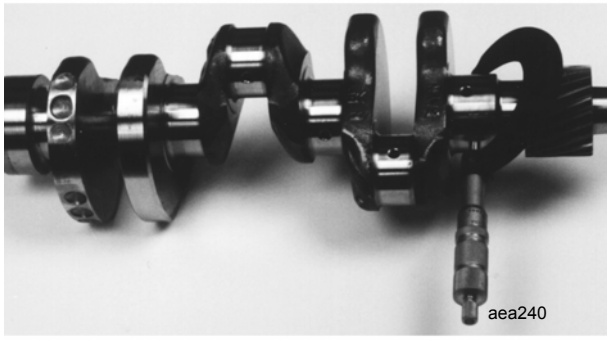
11. Check or replace all of the core plugs.

Crankshaft

1. Check the crankshaft for cracks and check the main journals, rod journals, and the oil seal surface for excessive wear or damage. Check to see that the oil passages are not clogged or dirty.

2. Measure the main journals. If any of the main journals are smaller than the wear limits (refer to Specifications), or tapered or out of round more than .0010 in. (0.025 mm), the main journals must be ground undersize.

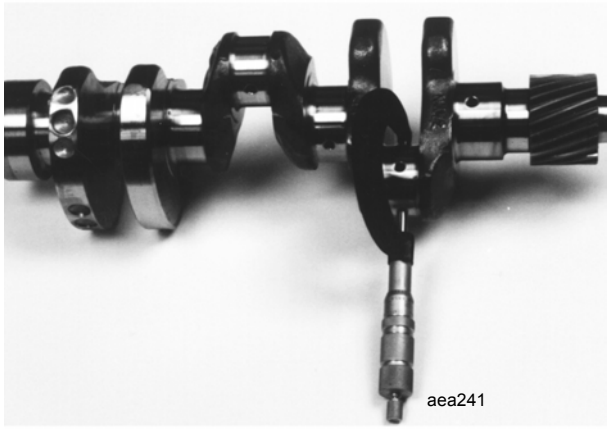
   Only the .010 in. (0.25 mm) undersize main bearings are available. Refer to Specifications for the suggested outside diameter of undersized main journals.



Measuring Main Journal

NOTE: The most accurate method of determining the outside diameter of the undersized main journals is to install the main bearing caps with the undersized bearing inserts in place. Properly torque the main bearing caps to the block and measure the inside diameter of the main bearings. Subtracting the suggested oil clearance (refer to Specifications) from the inside diameter of the main bearings results in the correct outside diameter for the undersized main journals.

3. Measure the rod journals. If any of the rod journals are smaller than the wear limits, (refer to Specifications) or tapered or out of round more than .0010 in. (0.025 mm), the rod journals must be ground undersize.

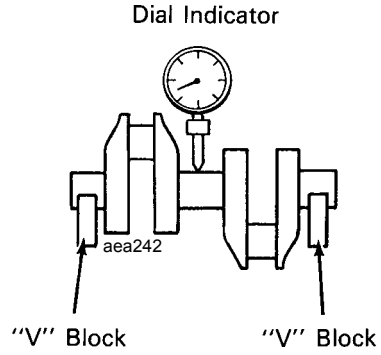


Measuring Rod Journal

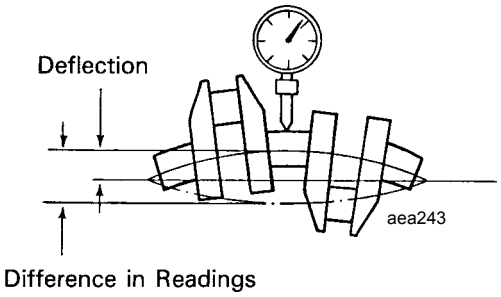
Only the .010 in. (0.25 mm) undersize rod bearings are available. Refer to Specifications for the suggested outside diameter of undersized rod journals.

NOTE: The most accurate method of determining the outside diameter of the undersized rod journals is to install the rod caps with the undersized bearing inserts in place. Properly torque the rod caps to the rods and measure the inside diameter of the rod bearings. Subtracting the suggested oil clearance (refer to Specifications) from the inside diameter of the rod bearings results in the correct outside diameter for the undersized rod journals.

4. Measure the crankshaft deflection by placing the front and rear main journals in a set of "V" blocks, or place the crankshaft in the block resting on only the old front and rear upper main bearing inserts. Set a dial indicator on a middle main journal and rotate the crankshaft one full turn. The crankshaft deflection equals one half of the largest difference in readings on the dial indicator. If the crankshaft deflection is greater than .0008 in. (0.020 mm) the crankshaft must be replaced.



Measuring Crankshaft Deflection



Crankshaft Deflection

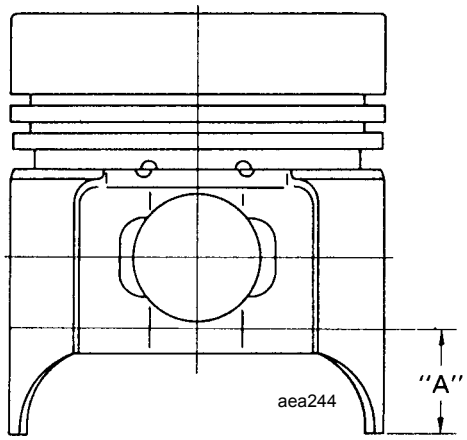
5. Inspect the crankshaft timing gear for chipped or worn teeth and for any cracks on or between the teeth. To remove the gear use a standard gear puller. Install the gear by pressing it onto the crankshaft. Apply a sealant to the inside of the gear and to the outside of the crankshaft when installing the gear to prevent oil leaks.

Pistons

1. Remove and discard the old piston rings.
2. Remove the wrist pin circlips and push the wrist pin out of the piston. If it is difficult to push the wrist pin out of the piston, heat the piston in hot water that is at 120 to 140 F (49 to 60 C).

   NOTE: Do not clamp a connecting rod in a vise with steel jaws. Instead, use a vise that has soft jaws, or use soft jaw covers. Clamping a connecting rod in the steel jaws of a vise will put small nicks in the connecting rod. These nicks raise the stress on the connecting rod and can cause the connecting rod to break while the engine is running.

3. Remove the carbon from the top of the piston but do not scratch the piston. Clean the piston and inspect it for damage. Replace the piston if it has any cracks, or if the top of the piston is significantly burned or damaged.
4. Measure the outside diameter of each piston. This measurement should be taken perpendicular to the wrist pin at a specific distance, called “A”, above the bottom of the piston skirt. Refer to Specifications for the suggested values for distance “A”. If the piston is smaller than the wear limit (refer to Specifications), replace the piston.



Distance “A”

Measuring Piston

5. Clean the ring groves with a ring groove cleaner. Be careful to avoid scraping any metal off the piston. If a ring groove cleaner is not available, break a used ring and sharpen the end. This can be used to clean the ring grooves.

6. Use a new set of piston rings and a feeler gauge to check the clearance between the rings and the ring grooves. If the clearance between a new ring and its respective ring groove is greater than the wear limit (refer to Specifications), the piston must be replaced.

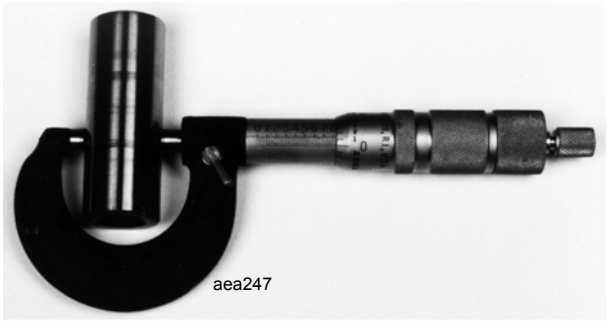
Checking Ring Clearance

7. Measure the inside diameter of the wrist pin bore. If the inside diameter of the wrist pin bore is larger than the wear limit (refer to Specifications), replace the piston.

Wrist Pins

The wrist pin and the connecting rod bushing carry a large load concentrated in a small area. Therefore a precise fit is critical. If possible, a qualified machine shop should fit new wrist pins to new connecting rod bushings when an engine is overhauled.

1. Measure the outside diameter of the wrist pins with a micrometer. If a wrist pin is smaller than the wear limit (refer to Specifications), replace the wrist pin.
2. If a micrometer with this degree of accuracy is not available, the fit between the wrist pin and the connecting rod bushing can be checked by oiling the wrist pin and inserting it into the connecting rod bushing. The fit should be snug and it should take a slight push to move the wrist pin through the connecting rod bushing, but the wrist pin should rotate freely.



Measuring Wrist Pin

Connecting Rods

The procedures used to recondition a connecting rod, which include honing the connecting rod bearing bore, straightening the connecting rod, and replacing the connecting rod bushing, require various pieces of expensive equipment. If this equipment is not available, most machine shops can recondition serviceable connecting rods to meet standard specifications.

1. If possible, bead blast the connecting rods with glass beads. Bead blasting does an exceptional job of cleaning the rods, and it also relieves stress by removing minor surface damage that tends to increase stress.

   NOTE: Bead blasting the connecting rods is highly recommended. Most machine shops offer this service and the price is usually quite reasonable.

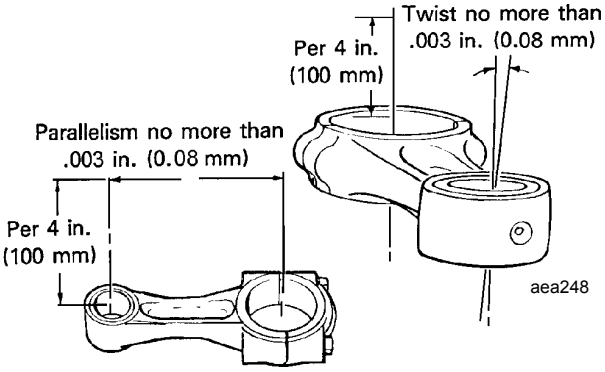
2. Check each connecting rod bearing by installing the connecting rod cap with the bearing inserts in place and properly torquing the rod cap bolts (refer to Specifications).

3. Measure the inside diameter of the connecting rod bearings. If any of the connecting rod bearings are larger than the wear limits (refer to Specifications) or show significant damage, replace the entire set of connecting rod bearing inserts.

4. Check each connecting rod bearing bore by installing the rod caps with the rod bearing inserts removed and properly torquing the rod cap bolts (refer to Specifications).

5. Measure each connecting rod bearing bore both parallel and perpendicular to the rod. If the rod bearing bore is more than .001 in. (0.25 mm) out of round the rod must be reconditioned or replaced.

Measuring Rod Bearing Bore



Measuring Connecting Rod Twist and Parallelism

6. Use a connecting rod alignment fixture to check each rod for twist and parallelism. The service limit for both twist and parallelism is .003 in. per 4 in. (0.08 mm per 100 mm). If the twist or parallelism exceeds the wear limit, straighten or replace the rod.

7. Measure the inside diameter of the connecting rod bushings. If the connecting rod bushings are larger than the wear limits (refer to Specifications) or show significant damage, replace the connecting rod bushings.

Measuring Rod Bushing

8. To replace a connecting rod bushing, press the old bushing out of the connecting rod. Press the new bushing into the rod and make sure to align the oil hole in the bushing with the oil hole in the top of the rod.

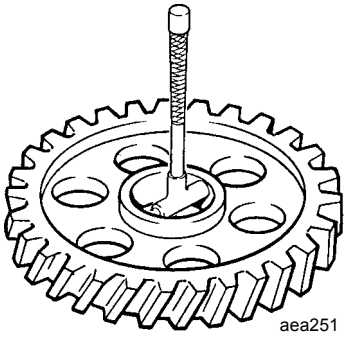
9. Finish the new bushing by reaming or honing it to size. Each connecting rod bushing must be sized to its individual wrist pin. Measure the outside diameter of the wrist pin. Adding the suggested oil clearance of .0010-.0019 in. (0.025-0.047 mm) to the outside diameter of the wrist pin results in the correct inside diameter for the finished connecting rod bushing.

Timing Gears

1. Inspect the timing gears for chipped or excessively worn teeth, and for any cracks on or between the teeth. The gear lash should have been checked during the disassembly of the engine. If not, check the gear lash during the assembly of the engine.

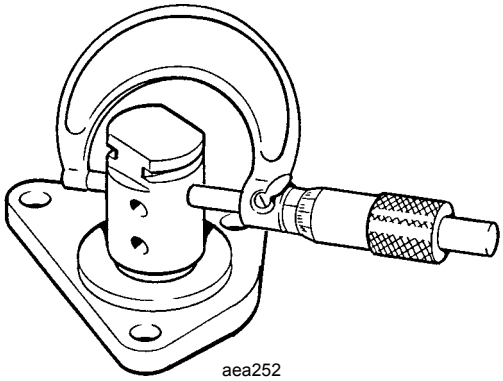
   NOTE: The camshaft, crankshaft, and injection pump gears use a press fit. To remove these gears use a standard gear puller or a hydraulic press. Install these gears with a hydraulic press.

2. Measure the inside diameter of the idler gear bushing. The standard dimensions are .7874-.7882 in. (20.000-20.021 mm). The wear limit is .7906 in. (20.080 mm). If the idler gear bushing is larger than the wear limit or is significantly damaged, replace the idler gear bushing. To replace the bushing, press the old bushing out of the idler gear and press the new bushing into the idler gear.



Measuring Idler Gear Bushing

3. Measure the outside diameter of the idler gear shaft. The standard dimensions are .7858-.7866 in. (19.959-19.980 mm). The wear limit is .7846 in. (19.930 mm). If the idler gear shaft is smaller than the wear limit or is significantly damaged, replace the idler gear shaft.



Measuring Idler Gear Shaft

Camshaft

1. Check the camshaft journals, the cam lobes, the thrust plate, and the camshaft gear for wear or damage.

2. Measure the camshaft journals. If any of the camshaft journals are smaller than the wear limit (refer to Specifications) or significantly damaged, replace the camshaft.

Measuring Camshaft Journals

3. Measure the cam lobes. If any of the cam lobes are smaller than the wear limit (refer to Specifications) or significantly damaged, replace the camshaft.

Measuring Cam Lobes

4. Measure the camshaft deflection by placing the front and rear camshaft journals in a set of "V" blocks. Set a dial indicator on a middle camshaft journal and rotate the camshaft one full turn. The camshaft deflection equals one half of the largest difference in readings on the dial indicator. If the camshaft deflection is greater than the wear limit (refer to Specifications), the camshaft must be replaced.

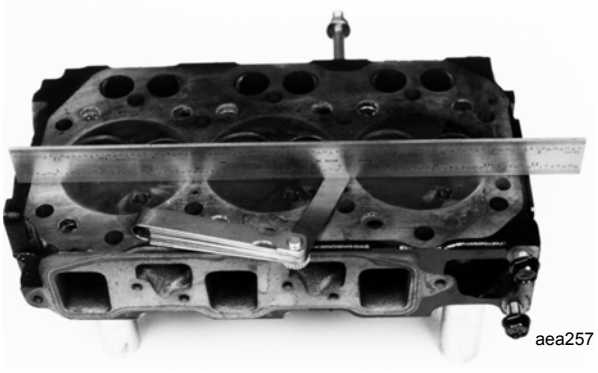
Measuring Camshaft Deflection

5. Check the thrust plate clearance (end play) by placing a feeler gauge between the thrust plate and the camshaft gear. If the clearance exceeds the wear limit (refer to Specifications), replace the thrust plate and check the clearance again. If the clearance still exceeds the wear limit after replacing the thrust plate, replace the camshaft gear also. To remove the camshaft gear use a standard gear puller or a hydraulic press. Install the camshaft gear with a hydraulic press.

Checking Thrust Plate Clearance

Cylinder Head

1. Clean all the carbon and any other deposits from the cylinder head with a gasket scraper or a wire brush. Visually inspect the cylinder head for cracks and the sealing surfaces for damage.



Checking Cylinder Head Distortion

2. Use a straight edge and a feeler gauge to check the cylinder head deck for distortion. Check all four sides, both diagonals, and the center lines of the cylinder head

deck. The standard distortion is .002 in. (0.05 mm). The wear limit is .006 in. (0.15 mm). Resurface or replace the head if the distortion exceeds the wear limit.

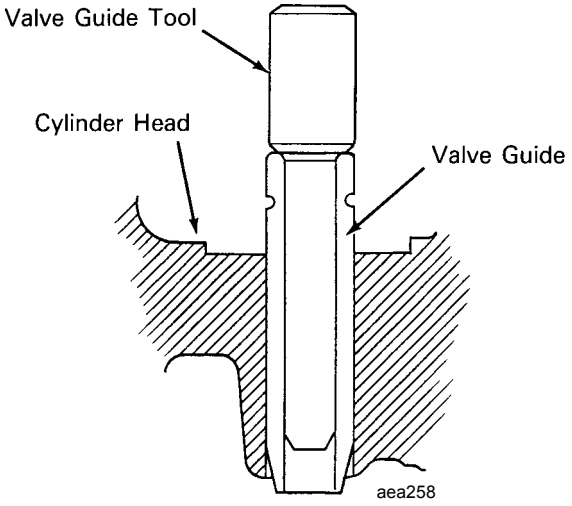
Disassembly

1. Use a valve spring compressor to remove the valve keepers.
2. Remove the valve spring retainers, the valve springs, and the valves. Mark each valve or keep them in order so they can be returned to their original positions when assembled.
3. Remove the valve stem seals and boil out the head if possible.

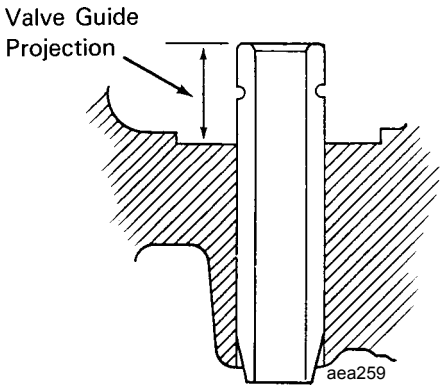
Valve Guides

1. Remove the carbon from the valve guides with a valve guide carbon beater.
2. Measure the inside diameter of the valve guides with a small hole gauge or a graduated set of tapered pilots. If the valve guides are larger than the wear limits (refer to Specifications), replace the valve guides.

   NOTE: If the engine has been in use for some time and has accumulated many hours of running time, it is advisable to replace the valve guides because they usually show significant wear after numerous hours of service. Because the valve seat grinding procedure is centered by a pilot placed in the valve guide, new straight valve guides allow the valve seats to be ground accurately.
3. Remove the valve guides by using a valve guide tool and a press or a hammer to drive the valve guides out through the bottom of the cylinder head.
4. Install the new valve guides using the valve guide tool and a press or a hammer. Drive the valve guide into the top of the cylinder head until the valve guide projection (the distance between the top of the valve guide and the top of the valve spring seat) is correct. Refer to Specifications for the recommended valve guide projections.



Removing or Installing Valve Guides

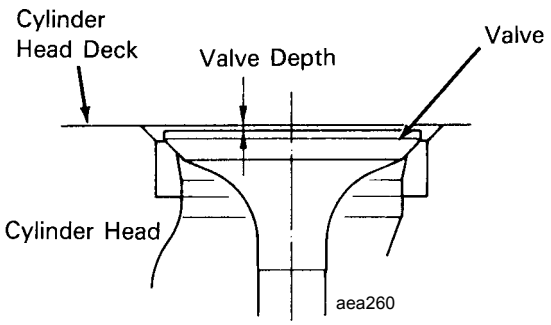


Valve Guide Projection

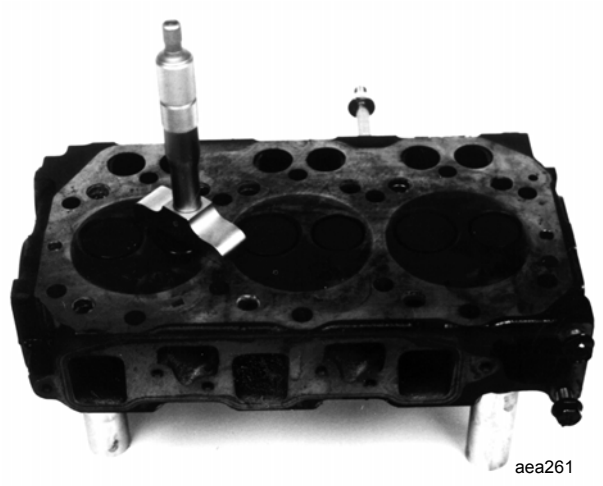
5. After installation, ream the new valve guides. Use a ream that matches the smallest standard dimension for the inside diameter of the valve guides (refer to Specifications).

Valve Depth

The valve depth is the distance between the cylinder head deck and the valve.



Valve Depth



Measuring Valve Depth

The valve depth is a critical dimension for most diesel engines. Grinding the valve or the valve seat increases the valve depth. As the valve depth increases, the volume of the combustion chamber also increases and the compression ratio decreases. Decreasing the compression ratio can cause hard starting or poor performance. Therefore it is very important to check the valve depth of each valve before and after grinding the valve, and before and after grinding the valve seat. If the valve depth is near the wear limit before grinding the valve or valve seat, the valve, the valve seat or both may need replacement. If the valve depth is over the wear limit after grinding the valve or the valve seat, the valve, the valve seat or both must be replaced.

To check the valve depth, install the valves in their respective valve seats and measure the valve depth of each with a depth gauge or a caliper. The wear limit for both the intake and exhaust valves in all of these engines is .039 in. (1.00 mm).

Valves

1. Clean and inspect the valves. Replace valves that are cracked, bent, or have valve faces that are significantly damaged.
2. Measure the outside diameter of the valve stems. If the valve stem is smaller than the wear limit (refer to Specifications), replace the valve.

Measuring Valve Stem

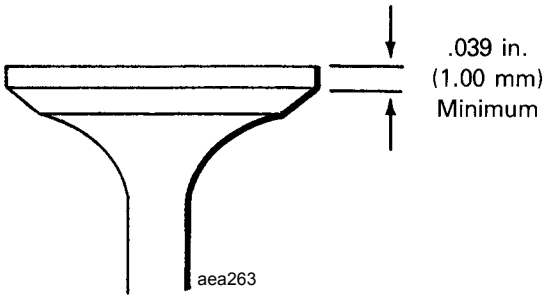
3. The valves can be ground to clean up any wear or minor damage on the valve faces. Grind the valves until all signs of wear or damage are removed. Grind the valve faces to the following angles:

   Intake 30 degrees

   Exhaust 45 degrees

4. After grinding the valves, check the valve margin. Replace any valve with a valve margin that is less than .039 in. (1.00 mm).

   NOTE: Valves with a valve margin that is not even after being ground are slightly bent. These valves should be replaced if the valve margin is less than .039 in. (1.00 mm) at the narrowest point.



Valve Margin

5. After grinding the valves, install the valves in their respective valve seats and check the valve depth of each. Replace any valve that has a valve depth over the wear limit.

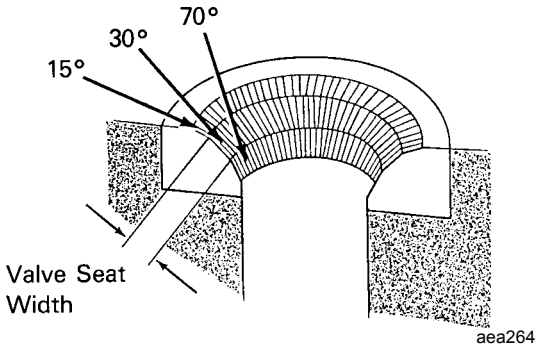
Valve Seats

1. Inspect the valve seats for any major damage that would require valve seat replacement.

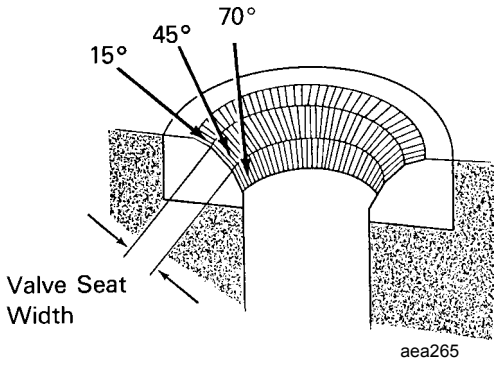
2. Grind each valve seat to remove any sign of wear or minor damage. Valve seats that show no wear or damage should also be ground lightly to clean up any slight imperfections. Grind the valve seats to the following angles:

   Intake 30 degrees

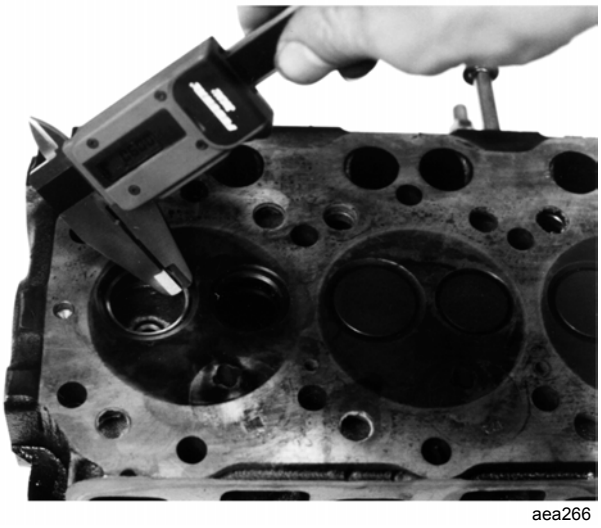
   Exhaust 45 degrees



Intake Valve Seat Angles



Exhaust Valve Seat Angles



Measuring Valve Seat Width

3. After grinding the valve seats, install the valves in their respective valve seats and check the valve depth of each. Replace any valve that has been ground and now has a valve depth over the wear limit. Replace any valve seat that has a new valve installed and still has a valve depth over the wear limit.
4. Check the width of the valve seats with a caliper.
5. Use Prussian Blue or a similar dye to check the alignment of the each valve seat and valve face. The valve seat should contact the middle of the valve face.
6. Use 15 and 70 degree grinding stones to size and align the valve seats to meet the width specifications (refer to Specifications), and alignment recommendation above.

Valve Seat Replacement

1. Use a standard valve seat removal tool to remove a valve seat from the cylinder head.

   NOTE: If a valve seat removal tool is not available, use a welding torch to heat the valve seat insert red hot at two spots directly across from each other.

   Allow the valve seat insert to cool and contract for 3 to 5 minutes.

   Pry the valve seat insert out of the cylinder head with a small pry bar.

2. Clean any carbon or other foreign material out of the valve seat insert bore in the cylinder head.
3. Measure the outside diameter of the new valve seat insert and the inside diameter of the valve seat insert bore. The valve seat insert should be .002 to .004 in. (0.05 to 0.10 mm) larger than the valve seat insert bore for a proper interference fit.
4. Chill the valve seat insert and install it with a valve seat installation tool.
5. Grind the new valve seats after installation.

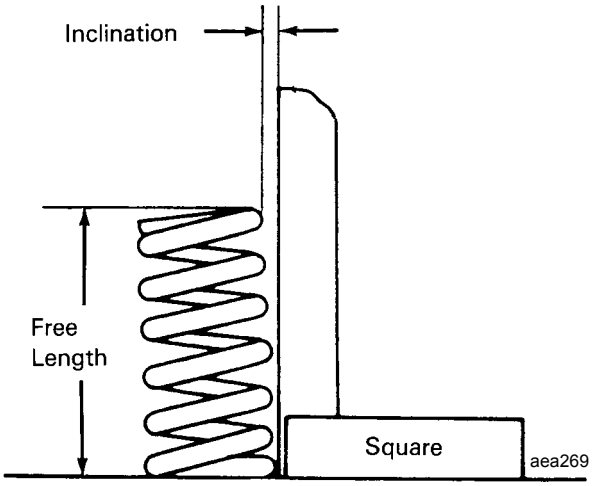
Valve Springs

1. Clean and inspect the valve springs. Replace valve springs that are cracked, or significantly scratched or damaged.
2. Measure the free length of the valve springs with a caliper. Replace any valve springs that are shorter than the wear limits (refer to Specifications).

Measuring Valve Spring Free Length

3. Check the inclination of the valve springs with a square. Replace any valve springs with inclinations larger than the maximum limits (refer to Specifications).

Checking Valve Spring Inclination

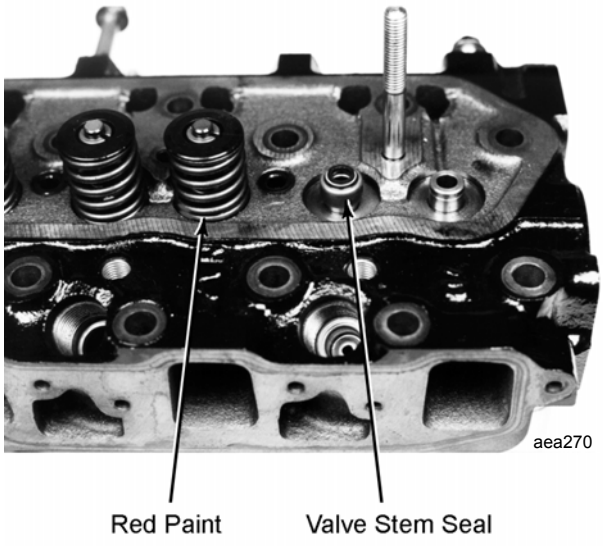


Valve Spring Measurements

4. Inspect the valve stem caps, the valve spring retainers, and the valve keepers. Replace any of these components that show significant wear or damage.

Cylinder Head Assembly

Assemble the cylinder head after all the components have been reconditioned or replaced. Thoroughly clean the cylinder head and all the components before assembly.



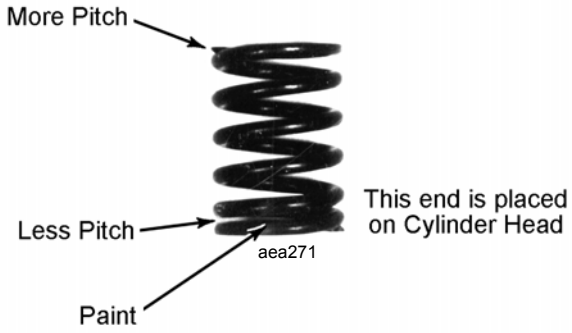
Installing Valve Stem Seals

1. Lightly oil the valve stem seals and place them on the valve guides.

   NOTE: New valve stem seals should always be used when assembling the cylinder head.

2. Oil the valve stem and place the valves in their respective valve seats. Oiling the valve stems prevents them from seizing to the new valve stem seals.

3. Install the valve springs. The end of a valve spring that has less pitch (this end is wound tighter and may have some paint on it) should be placed on the cylinder head.



Valve Spring

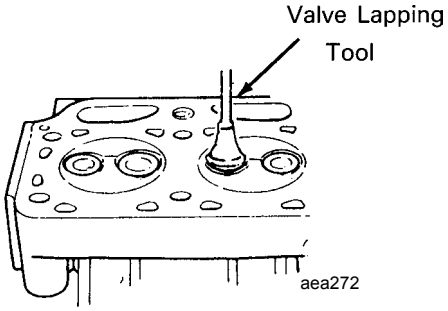
4. Place the valve spring retainers in the valve springs and compress the valve springs with a valve spring compressor.

5. Install the valve keepers and remove the valve spring compressor.

6. After installing the valves, place the cylinder head on the intake side and fill the exhaust ports with diesel fuel. Check to see if any diesel fuel is leaking past the exhaust valves. Turn the cylinder head over and check the intake valves in the same way. Minor seeping is acceptable, but any valves that leak significantly must be removed and lapped.

   a. To lap a valve place a small amount of medium grit valve lapping compound on the valve face.

b. Place the valve in the valve seat and use a valve lapping tool to spin the valve against the valve seat for a short time.



Lapping Valves

c. Lift the valve off the valve seat, rotate the valve about a quarter of a turn, and drop the valve back onto the valve seat. Spin the valve against the valve seat again for a short time. Repeat this several times.

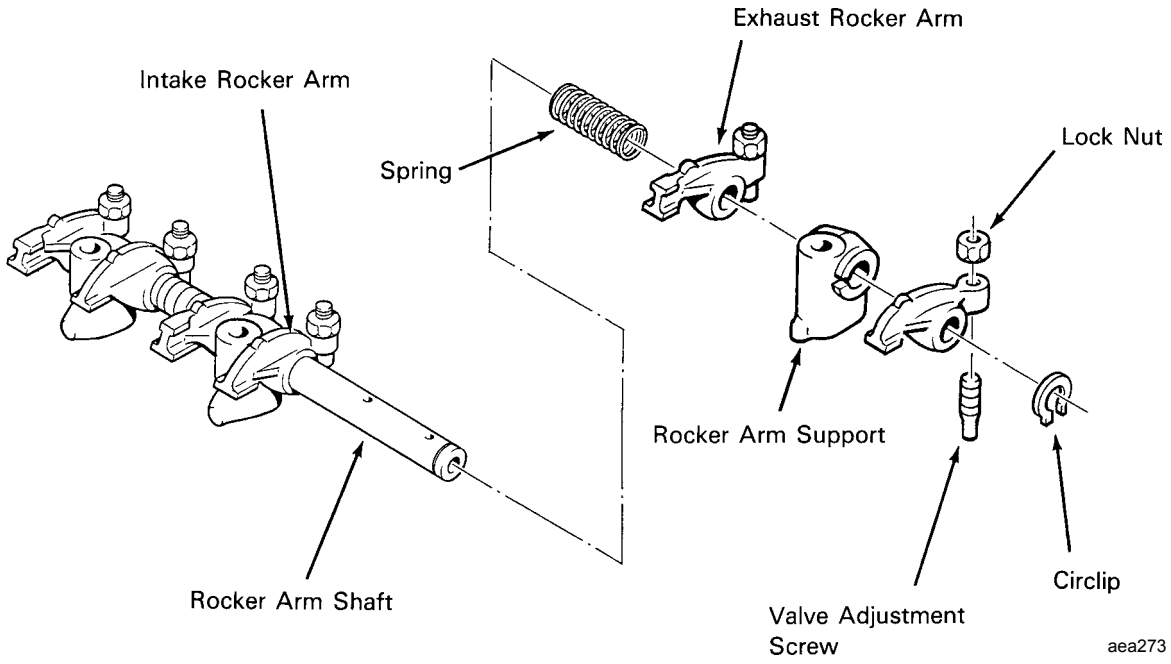
d. Remove the valve and wipe the lapping compound off the valve seat and the valve face. The valve seat should appear smooth and be an even gray color. The valve face should show a smooth, even gray ring where it contacts the valve seat. Repeat the lapping procedure if either the valve seat or the valve face does not appear smooth and even.

7. Recheck the valves for leaks after they have been lapped.

Rocker Arm Assembly

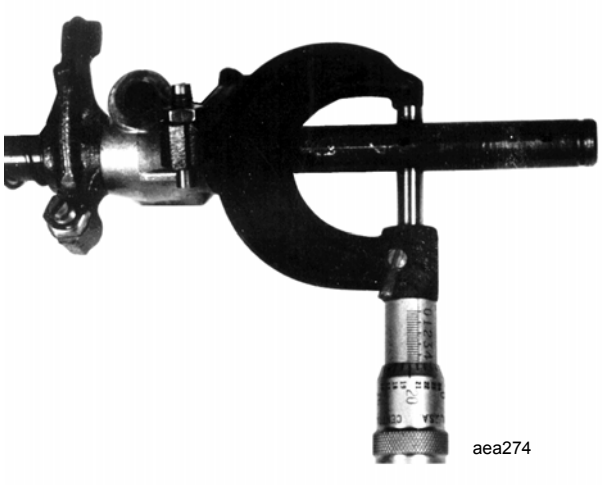
NOTE: The intake and exhaust rocker arms are different. Note the differences, mark them, or keep them in order during disassembly to make sure they are reassembled in the correct order.

1. Remove the circlips from both ends of the rocker arm shaft.



Three Cylinder Rocker Arm Assembly

2. Remove the rocker arms, the rocker arm supports, and the springs from the rocker arm shaft. Keep these parts in order, to make sure they will be assembled correctly.
3. Clean and inspect all the components of the rocker arm assembly. Replace any parts that show significant wear or damage.
4. Measure the outside diameter of the rocker arm shaft at the pivot point of each rocker arm. Replace the rocker arm shaft if it is smaller than the wear limit (refer to Specifications) at any of the rocker arm pivot points.



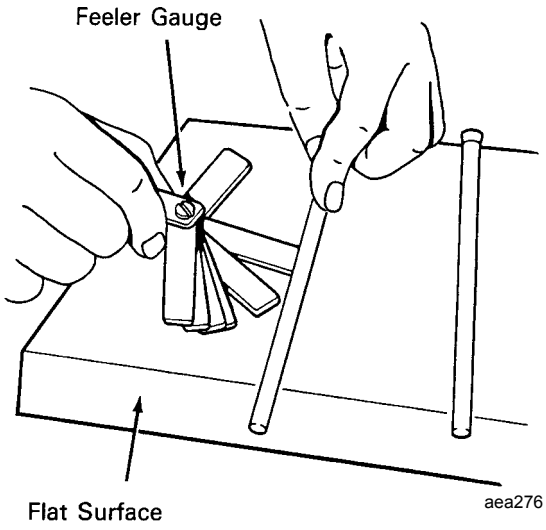
Measuring Rocker Arm Shaft

Measuring Rocker Arm Bushing

5. Measure the inside diameter of each rocker arm bushing. If a rocker arm bushing is larger than the wear limit (refer to Specifications) or shows significant damage, replace the bushing or the rocker arm.
6. Replace the rocker arm bushing by pressing the old bushing out of the rocker arm and pressing the new bushing into the rocker arm. Use a hone or a ream to size the bushing to the standard dimension (refer to Specifications).
7. Loosen the lock nut and remove the valve adjustment screw from each rocker arm. Inspect each valve adjustment screw and replace any that show significant wear or damage. Place the valve adjustment screws back in the rocker arms but do not tighten the lock nuts.
8. Reassemble the rocker arm assembly and make sure the parts are in the correct order.

Push Rods

1. Clean and inspect the push rods. Replace any Push Rods that show significant wear or damage.

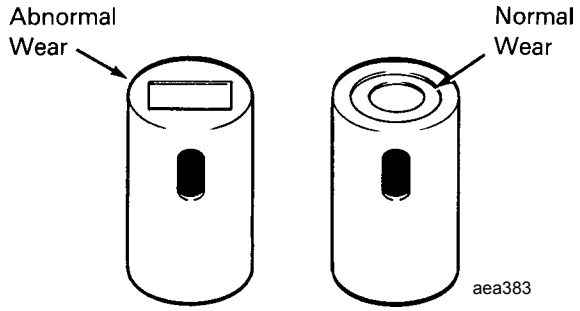


Checking Bend in Push Rods

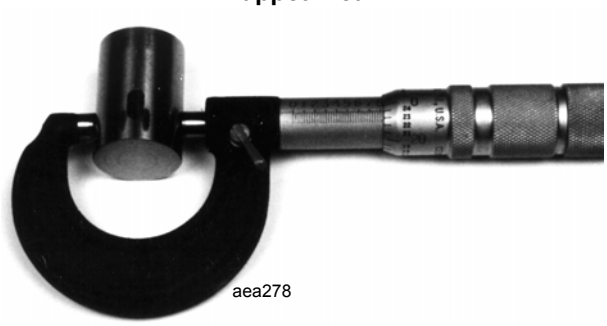
2. Place each push rod on a completely flat surface and use a feeler gauge to check the how much the push rod is bent. Replace any push rod that is bent more than .003 in. (0.075 mm).
3. Measure the length of each push rod. Replace any Push Rods that are shorter than the minimum standard dimension (refer to Specifications).

Tappets

1. Clean and inspect the tappets. Normally the tappets rotate while the engine is running. This causes normal wear to appear as concentric rings on the surface of the tappet that contacts the cam lobe. A tappet that does not rotate shows an abnormal wear pattern straight across its contact surface. Replace any tappet that shows an abnormal wear pattern, significant wear, or significant damage.



Tappet Wear

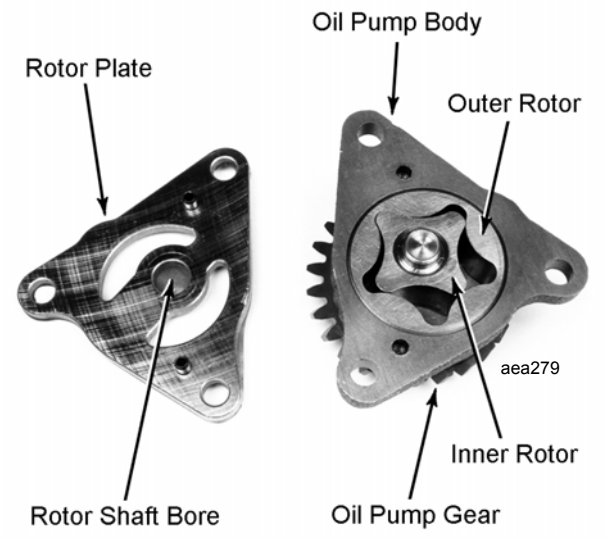


Measuring Tappet

2. Measure the outside diameter of each tappet. Replace any tappets that are smaller than the wear limit (refer to Specifications).

Oil Pump

1. Remove the rotor plate and inspect the oil pump. If the rotor plate, the inner rotor, the outer rotor, or the oil pump body show significant wear, scratches, or damage, replace the oil pump.



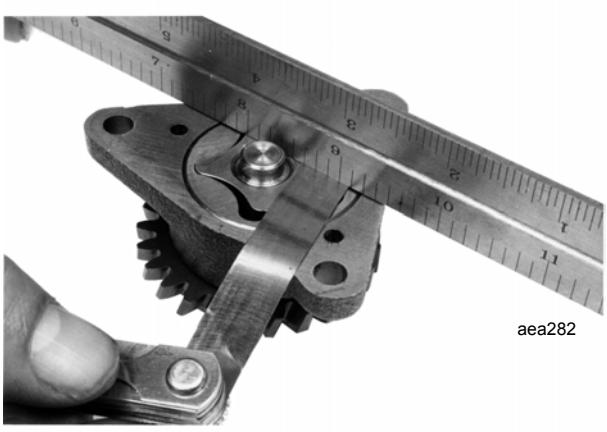
Oil Pump Assembly

2. Use a feeler gauge to check the clearance between the oil pump body and the outer rotor. The standard dimension is .0039 to .0063 in. (0.100 to 0.160 mm). The wear limit is .0098 in. (0.250 mm). If the clearance between the oil pump body and the outer rotor is larger than the wear limit, replace the oil pump.
3. Use a feeler gauge to check the clearance between the inner rotor and the outer rotor. Place the feeler gauge between the tip of a vane on the inner rotor and the high point of a lobe on the outer rotor. If the clearance between the inner rotor and the outer rotor is more than .0059 in. (0.150 mm), replace the oil pump.

Checking Clearance Between Oil Pump Body and Outer Rotor

Checking Clearance Between Inner Rotor and Outer Rotor

4. Check the clearance between the rotor plate and both rotors. Place a straight edge across the oil pump body and insert a feeler gauge between the straight edge and the rotors. The standard dimension is .0012 to .0035 in. (0.030 to 0.090 mm). The wear limit is .0051 in. (0.130 mm). If the clearance between the rotor plate and either rotor exceeds the wear limit, replace the oil pump.



Checking Clearance Between Rotor Plate and Rotors

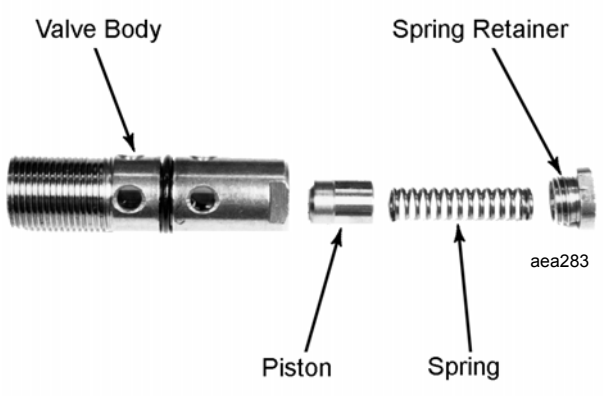
5. Measure the outside diameter of the rotor shaft and the inside diameter of the rotor shaft bore in the rotor plate. Subtract the diameter of rotor shaft from the diameter of the rotor shaft bore to obtain the rotor shaft clearance. Refer to Specifications for the standard dimension. The wear limit is .0079 in. (0.200 mm). If the rotor shaft clearance exceeds the wear limit, replace the oil pump.

6. Hold the oil pump body in one hand and the oil pump gear in the other hand. Move the rotor shaft around to check the fit between the rotor shaft and the oil pump body. If it is loose or wobbly, replace the oil pump.

Oil Pressure Control Valve

The oil pressure control valve is adjusted and assembled at the factory. Do not disassemble the control valve unless there is reason to believe it is defective. To disassemble the valve, remove the spring retainer from the valve body and remove the spring and the piston.

Replace the oil pressure control valve if any of the components show significant wear or damage, or if the piston does not move freely in the valve body.

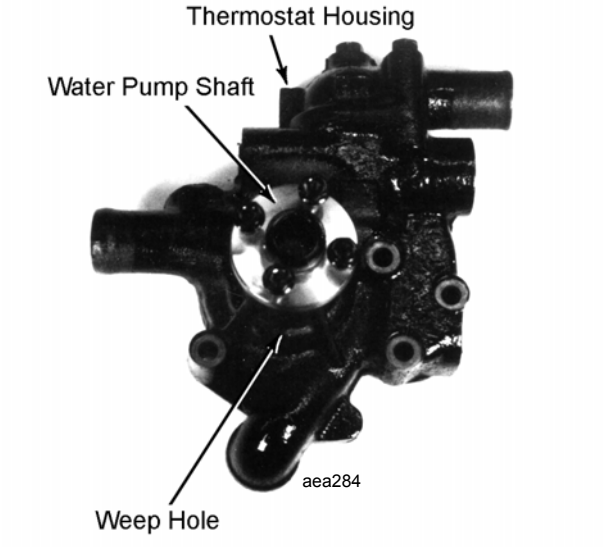


TK 3.88 Oil Pressure Control Valve

The oil pressure can be adjusted by adding or removing shims located between the spring and the spring retainer. The standard oil pressure is 43-57 psi (294-392 kPa).

Water Pump

1. Check the weep hole on the bottom of the water pump for any signs of leaking coolant. If coolant is leaking out of the weep hole, the mechanical seal is leaking and the water pump must be replaced.



Water Pump and Thermostat Assembly

2. Check the water pump bearing. If the water pump shaft does not rotate smoothly, or if it is loose or wobbly, replace the water pump.

Manifolds

1. Inspect the manifolds for cracks, damage, or a build up of carbon.
2. Use a straight edge and a feeler gauge to check the manifolds for distortion. Resurface or replace the manifold if it is distorted more than .006 in. (0.15 mm).

Checking Manifold Distortion

Engine Assembly 4

Engine Assembly

Assembly Precautions

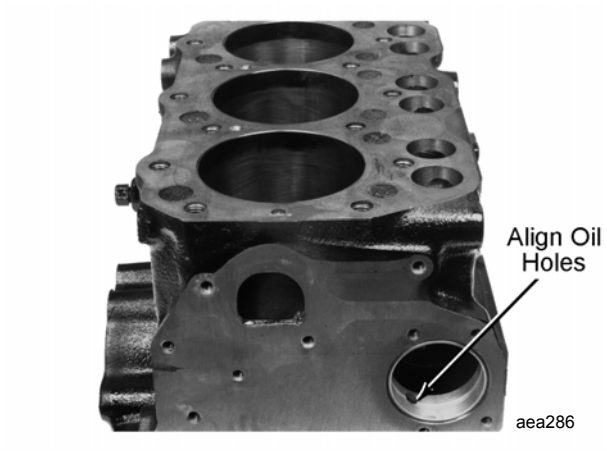
NOTE: Refer to the Specifications section for specifications not given in this section.

After the components of the engine have been repaired, reconditioned, or replaced, the engine can bee assembled. It is very important to keep the engine as clean as possible while it is being assembled, because dirt is one of the major factors that contributes to the failure of rebuilt engines. To avoid problems, take these precautions:

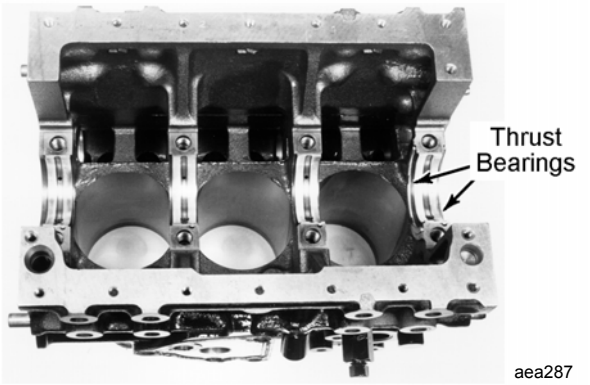
1. Do not assemble the engine in an area where any type of grinding is done.
2. Keep your workbench, tools, and hands clean.
3. Keep sub-assemblies covered until they are needed.
4. If the engine must be left, even for a short period of time, cover the engine until you return.
5. Make sure to follow the sequence of assembly exactly. If certain parts are not installed in the correct order, the engine may require some disassembly to install these parts properly.
6. Check all the assembly tolerances such as bearing clearance, end play, and gear lash carefully. Neglecting these tolerances can cause serious reliability problems in a rebuilt engine.

Assembly Procedure

1. Install the front camshaft bearing insert using a bearing driver. Make sure the oil holes in the bearing insert line up with the oil holes in the front camshaft bearing bore.
2. Install or check all of the oil gallery and core plugs.
3. Place the new upper main bearing inserts in the cylinder block. The upper main bearing inserts are identical and have oil holes and oil groves in them. Make sure the holes in the bearing inserts line up with the holes in the main bearing bores.

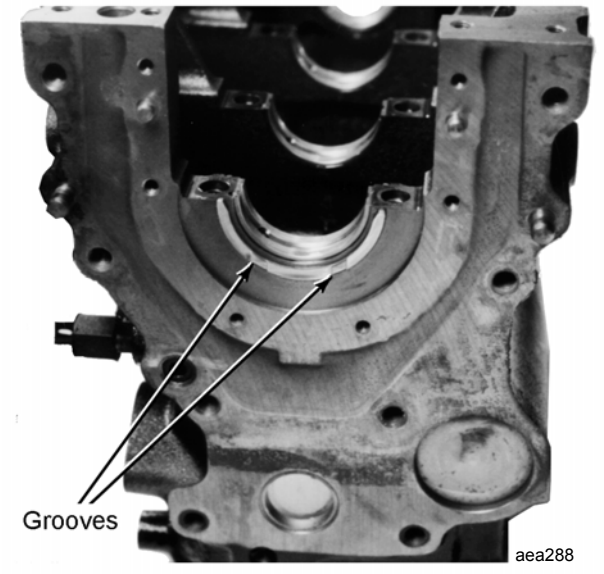


Install Camshaft Bearing



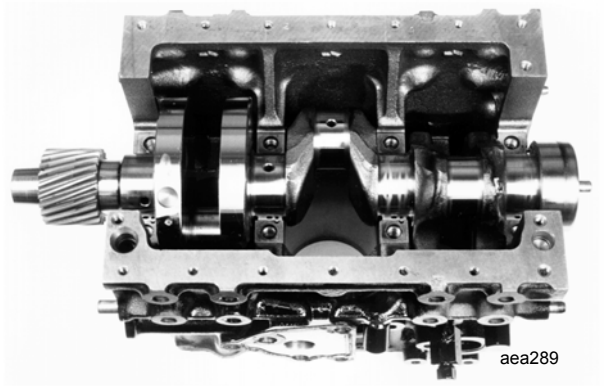
Install Upper Main Bearings

4. Place the upper thrust bearings in position on each side of the upper rear main bearing. The grooves on the thrust bearings should face away from the upper rear main bearing.



Install Upper Thrust Bearings

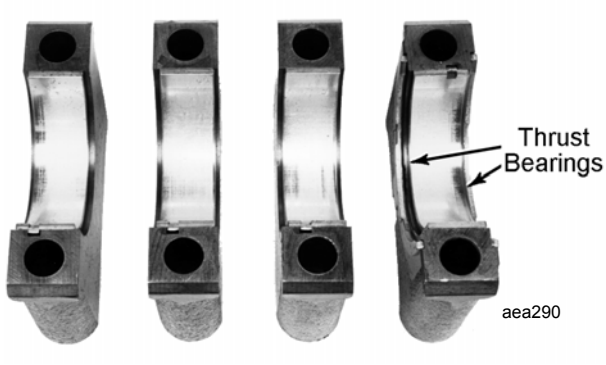
5. Carefully lay the crankshaft in the upper main bearing inserts.



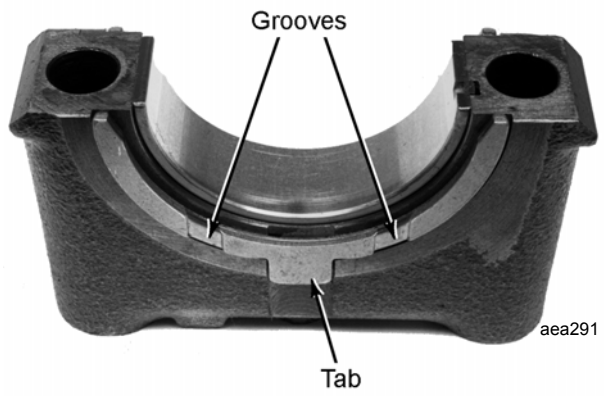
Install Crankshaft

6. Place the new lower main bearing inserts in the main bearing caps. The lower main bearing inserts are plain and identical.

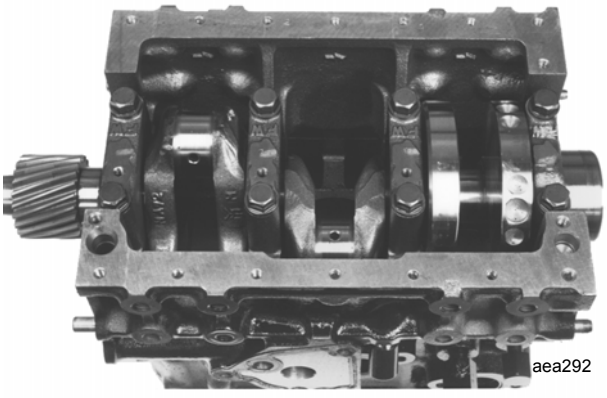
7. Place the lower thrust bearings in position on each side of the rear main bearing cap. The lower thrust bearings each have a tab on the bottom. The grooves on the thrust bearings should face away from the rear main bearing cap.



Install Lower Main Bearings

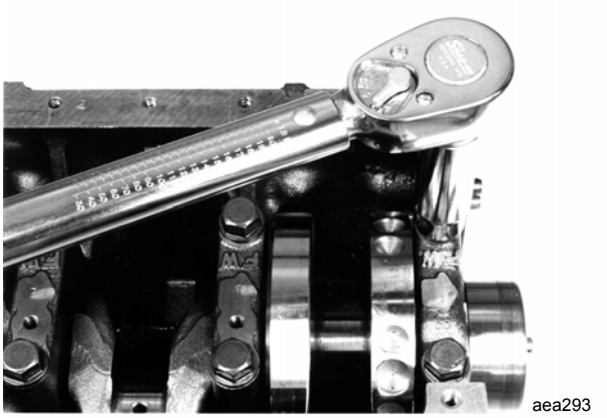


Install Lower Thrust Bearings



Main Bearing Cap Placement

8. Place a piece of plastigauge on each main bearing journal and install the main bearing caps in their proper positions. The cast arrows on the main bearing caps are labeled FW and should point to the rear (flywheel end) of the engine. The main bearing cap with the thrust bearings goes to the rear end of the engine. The main bearing caps with numbers stamped on them go to the middle of the engine with the main bearing cap marked number one closest to the rear main bearing. The main bearing cap with no number goes to the front end of the engine.
9. Install and properly torque the main bearing cap bolts (refer to Specifications).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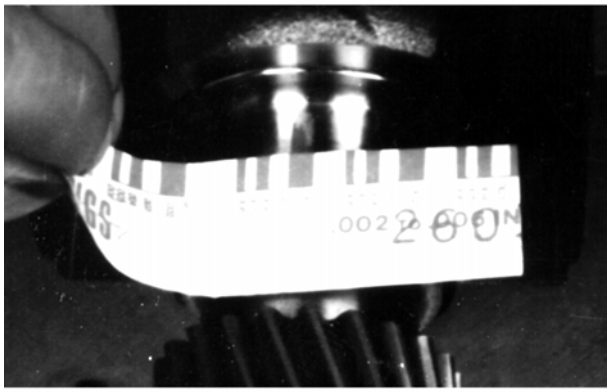
Torque Main Bearing Cap Bolts

10. Remove the main bearing caps and check the plastigauge to determine the clearance of each main bearing. Refer to Specifications for the recommended main bearing clearance.
11. Lubricate the main bearings, the main journals, and the thrust bearings with engine assembly compound or engine oil. Replace and torque the main bearing caps.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Check Plastigauge

12. Use a dial indicator to check the crankshaft end play. The wear limit is .0130 in. (0.330 mm). If the end play is larger than the wear limit, the thrust bearings must be replaced.


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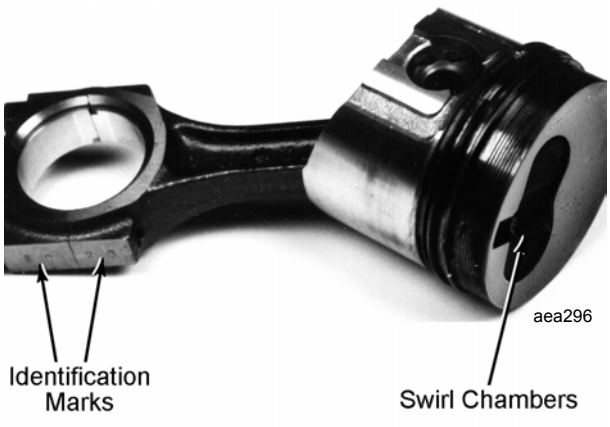
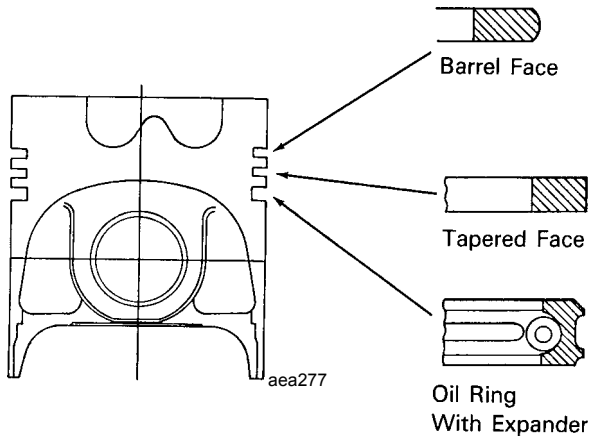
Check End Play

13. Install each piston on its respective connecting rod by heating the piston in hot water and then pressing the wrist pin into the piston and through the rod bushing. Install the circlips. The swirl chamber on the top of the piston must point toward the identification marks on the connecting rod.



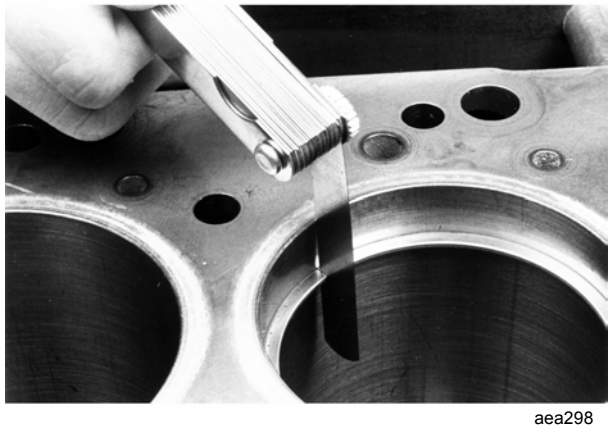
Assemble Piston and Rod

14. Each piston has three piston rings.
    a. The top ring is a barrel faced compression ring.
    b. The middle ring is compression ring with a tapered face.
    c. The bottom ring is an oil ring with a separate internal expander.



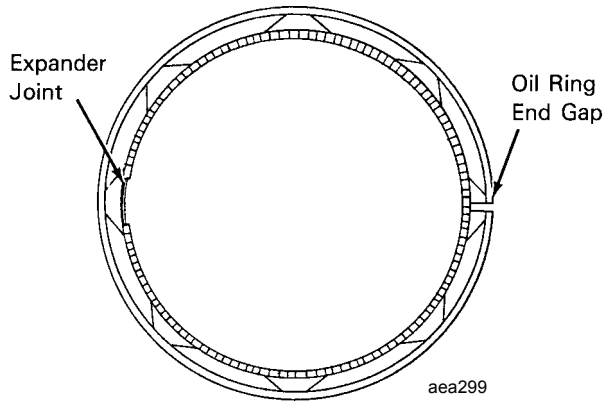
Ring Placement

15. Before installing the piston rings, check the end gap of each ring. Place a ring in its respective cylinder. Level the ring in the cylinder with a piston and check the end gap with a feeler gauge. If the end gap is not correct (refer to Specifications), check to make sure that the cylinder bore is the correct size and that the ring is the correct size.



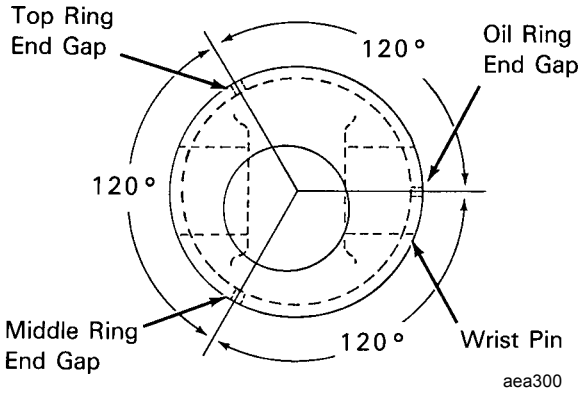
Check End Gap

16. Place the piston rings on their respective pistons in the proper order. Use a ring spreader to install the rings, but do not spread the rings more than necessary. The manufacturer's mark near the end gap of each ring should always face the top of the piston.



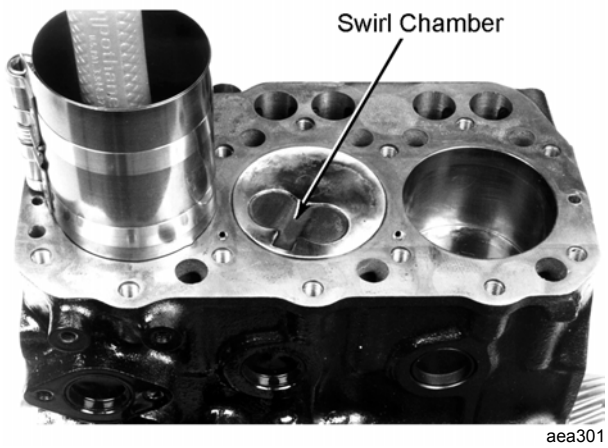
Oil Ring Installation

17. Place the oil ring expander in the bottom ring groove.
18. Place the oil ring in the bottom ring groove over the expander with the end gap of the oil ring positioned 180 degrees from the joint in the expander.
19. Place the compression ring with the tapered face in the middle ring groove.
20. Place the barrel faced compression ring in the top ring groove.
21. Place the connecting rod bearing inserts in the connecting rods and the rod caps.
22. Stagger the end gaps of the piston rings on each piston so the end gaps are at 120 degree intervals and no end gaps line up with the wrist pin.



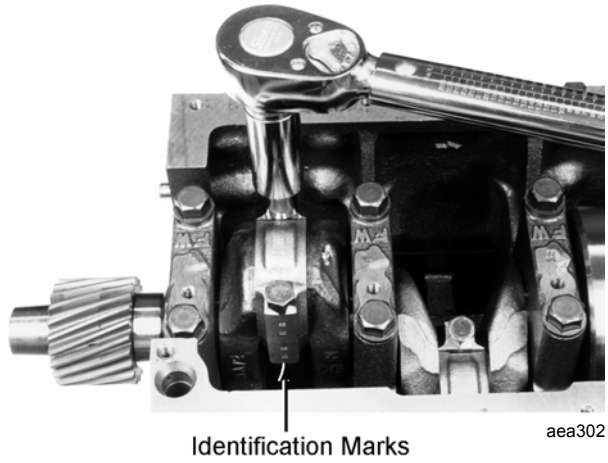
Ring Alignment

23. Oil each cylinder, piston, piston ring, wrist pin, and rod bushing, with engine oil.
24. Use a ring compressor to install each piston assembly. The swirl chamber on top of the piston and the identification marks on the connecting rod should face toward the intake side of the engine, away from the camshaft.



Install Piston

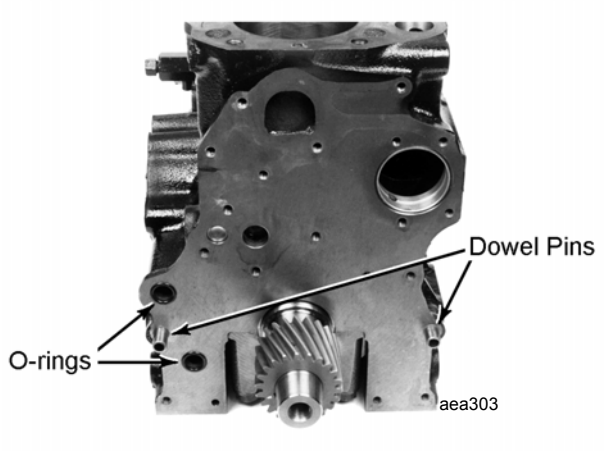
25. Place a piece of plastigauge on each rod journal. Install each rod cap correctly by matching the identification marks with those on the connecting rod.
26. Install and properly torque the rod cap bolts (refer to Specifications).



Torque Rod Cap Bolts

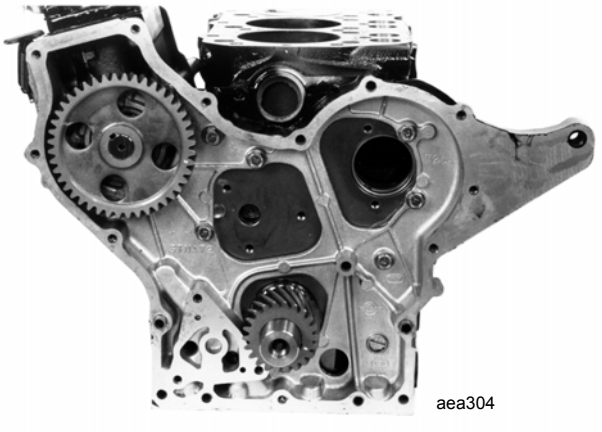
27. Remove the rod cap and check the plastigauge to determine the clearance of each connecting rod bearing. Refer to Specifications for the recommended rod bearing clearance.

28. Lubricate the rod journal and the rod bearings of each connecting rod with engine assembly compound or engine oil. Install and torque the rod caps.
29. After installing each piston assembly, turn the crankshaft over several times. Check to see that the bearings move freely and that the pistons and rings slide through the cylinders easily and do not scratch the cylinder walls.
30. Use a feeler gauge to check the side clearance between the crankshaft and each connecting rod. The standard dimension is .008 to .016 in. (0.20 to 0.40 mm).
31. Place new O-rings on the front of the engine block and make sure the dowel pins are in place.

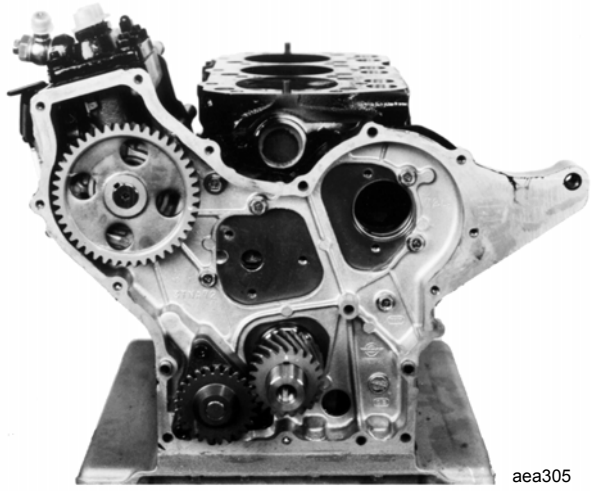


Front of Engine Block

32. Place a thin layer of silicone sealant on the back sealing surface of the timing gear housing.
33. Install the timing gear housing. Make sure to align the dowel pins and tighten the mounting bolts.
34. Install the oil pump with a new gasket and tighten the mounting bolts.



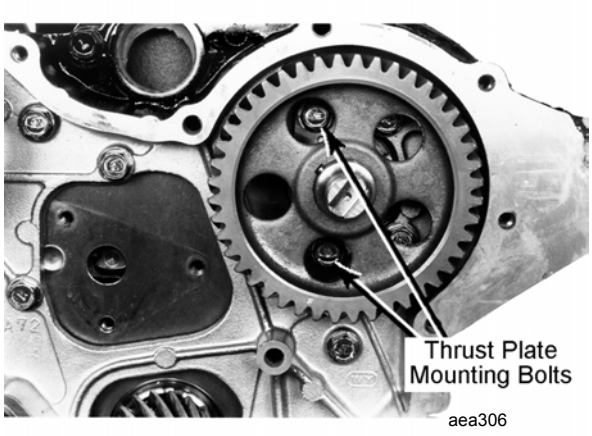
Install Timing Gear Housing



Install Oil Pump

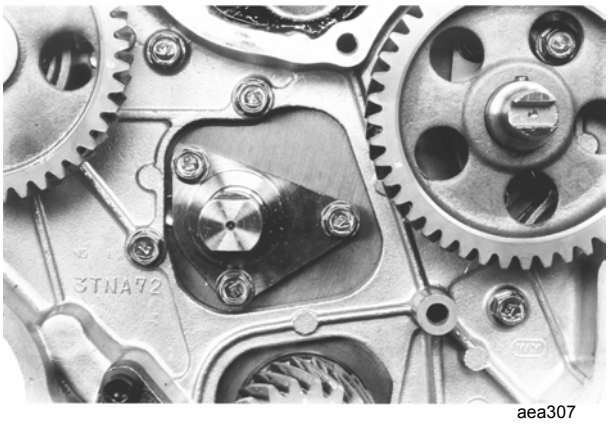
35. Lubricate the camshaft bearings, journals, and lobes with engine assembly compound or engine oil.
36. Carefully install the camshaft to avoid damaging the camshaft bearings.

37. Install and tighten the camshaft thrust plate mounting bolts.



Install Camshaft

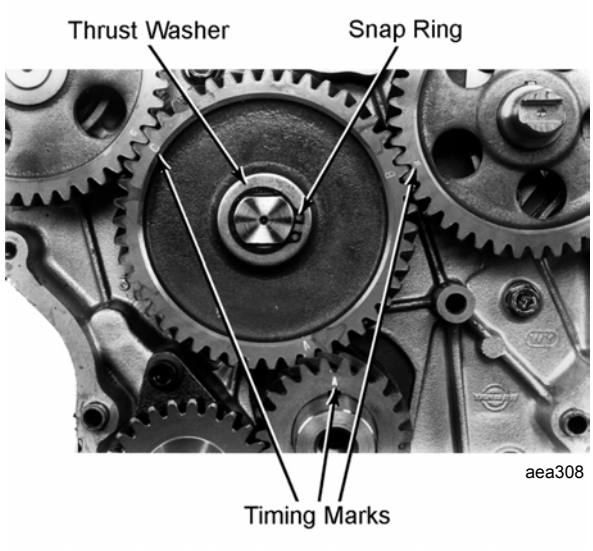
38. Install the idler shaft and tighten the mounting bolts.



Install Idler Shaft

39. Install the idler gear and align the timing marks. The idler gear tooth marked with an A should line up with the A between the teeth on the crankshaft gear. The idler gear tooth marked with a B should line up with the B between the teeth on the camshaft gear. The injection pump gear tooth marked with a C should line up with the C between the teeth on the idler gear.

40. Place the thrust washer and the snap ring on the idler gear shaft. The sharp edge of the thrust washer and the snap ring should face away from the idler gear.



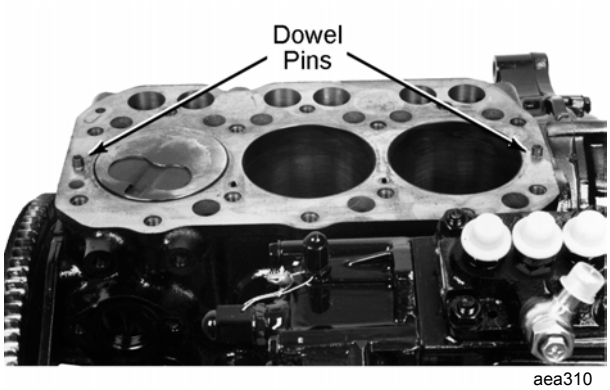
Install Idler Gear

41. Use a dial indicator to check the gear lash between the timing gears, if it has not been checked already.

42. Lubricate the tappets with engine assembly compound or engine oil. Insert each tappet into its respective tappet bore.

Install Tappets

43. Make sure the dowel pins are in place in the top of the block.



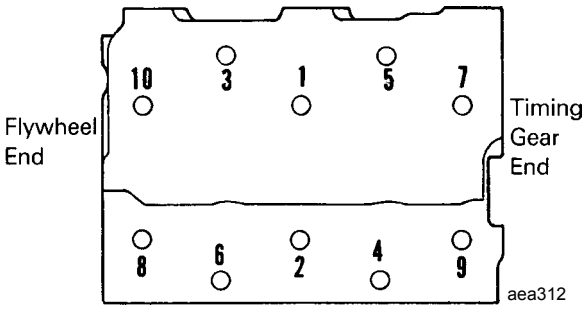
Check Dowel Pins

44. Place a new head gasket on the block. Align the head gasket with the dowel pins and make sure the engine model inscription is facing up.

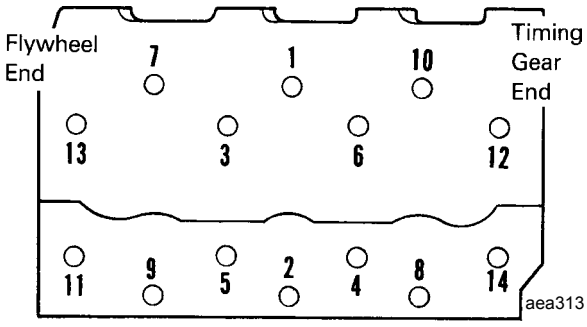
Install Head Gasket

45. Place the cylinder head on top of the block and the head gasket. Make sure to align the head with the dowel pins.

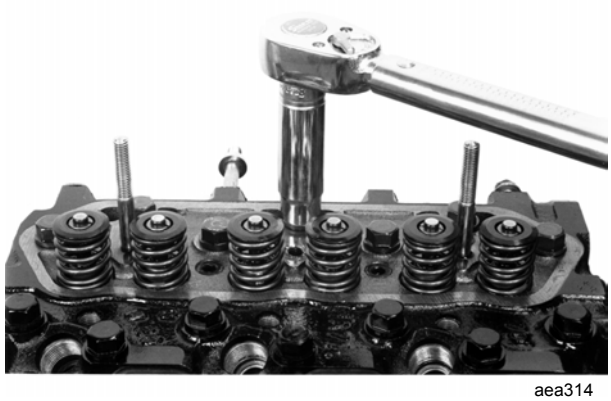
46. Install the cylinder head bolts. Torque the cylinder head bolts in two or three equal increments using the sequence shown in the illustrations. Refer to Specifications for the recommended torque.



Two Cylinder Head Bolt Torque Sequence



Three Cylinder Head Bolt Torque Sequence



Torque Cylinder Head Bolt Sequence

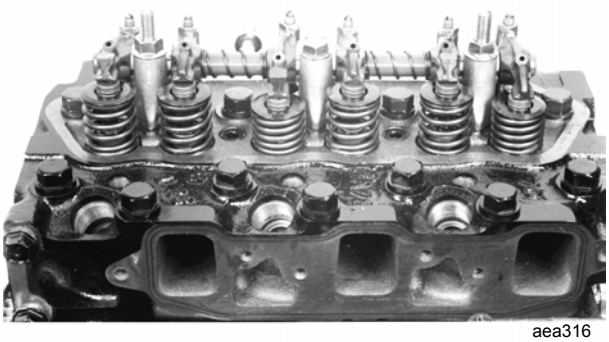
47. Install the push rods in their respective openings. Make sure the push rods are seated properly in the tappets. Lubricate the socket in the top end of each push rod with engine oil.

48. Place the valve stem caps on the valve stems.

Install Valve Stem Caps

49. Place the rocker arm assembly in position on the mounting studs. Make sure all of the valve adjustment screws are loose and have been backed out a few turns.

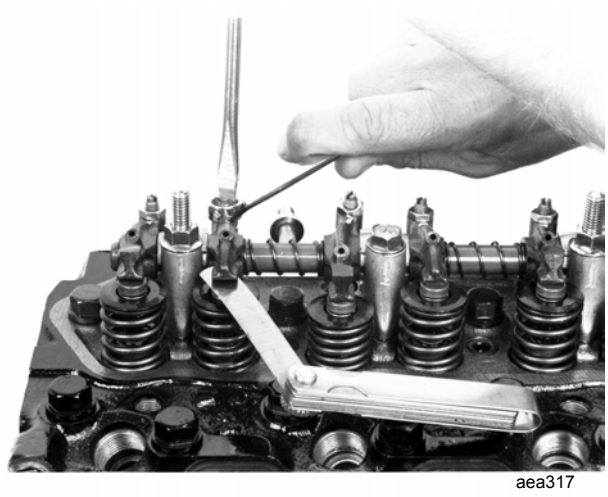
50. Install the rocker arm mounting nuts (and bolt on the three cylinder engines). Alternately turn each nut (and bolt) one turn at a time to evenly apply the valve spring pressure to the rocker arm assembly. Make sure the valve adjustment screws all seat properly in the sockets on the ends of the push rods while the rocker arm assembly is being tightened.



Install Rocker Arm Assembly

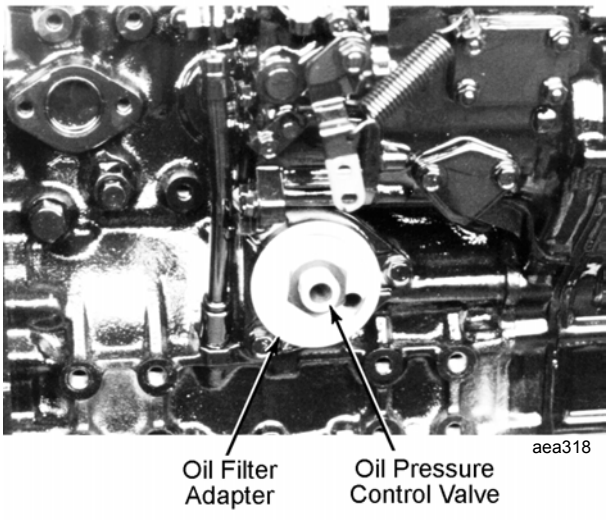
51. Torque the rocker arm mounting nuts (and bolt). Refer to Specifications for the recommended torque.

52. Adjust both the intake and the exhaust valves. Refer to the valve adjustment procedure at the end of the Run In Procedure section.



Adjust Valves

53. Install the oil pressure control valve and the oil filter. On the TK 3.88 and the TK 3.95 the oil pressure control valve is attached to the oil filter adapter.



Install Oil Pressure Control Valve

54. Pressure check the engine's lubrication system, if possible. A pressure check can point out problem areas in the lubrication system, and it eliminates the possibility that any of the engine components are dry when the engine is first started.

    a. Fill the tank with engine oil and attach the outlet line to the engine at the fitting for an oil pressure gauge or oil pressure switch.

    b. Cap off any other open oil system fittings such as the feed line for the bypass filter.

    c. Pressurize the tank to 60 psi (413 kPa) and open the outlet line to the engine.

    d. The tank will fill the oil filter first and will then pressurize the whole lubrication system. The oil pressure control valve may release some oil into the bottom end.

    e. Check each main bearing and rod bearing. Oil should drip from each bearing at a fairly good rate, but there should be no large streams of oil from any of the bearings.

    f. Check the idler gear shaft and the front camshaft bearing. Oil should drip from each at a fairly good rate, but there should be no large streams of oil from either.

    g. Check the rocker arm assembly. Oil should drip from each rocker arm bushing and from the hole in each rocker arm at a fairly good rate, but there should be no large streams of oil from any of the rocker arms or bushings.

    h. Turn the engine over several times and check the components again.

    i. Lack of oil or a low flow rate at any of these components indicates there is a restriction in an oil gallery or passage leading to the component. Excessive oil flow at any of the components indicates that the oil clearance is too large, the wrong part has been used, or a component is damaged or missing.

55. Install the valve cover with a new gasket and put new O-rings on the special cap nuts.

56. Install the oil pan.

    a. **One Piece Oil Pan**

        (1) Check to make sure the dowel pin and O-ring are in place in the bottom of the block.

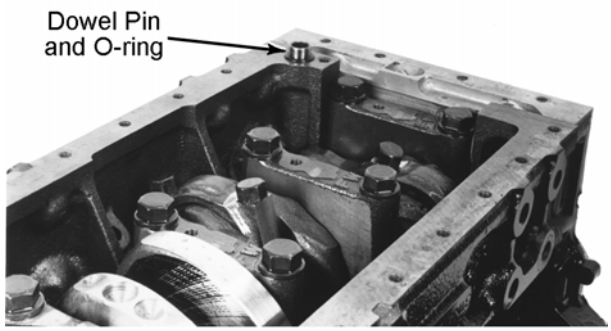
        (2) Install the oil intake pipe.

        (3) Place a thin layer of sealant on the sealing surface of the oil pan and place the oil pan in position on the bottom of the block.

        (4) Install the oil pan mounting bolts. Make sure the rear end of the block and the oil pan are flush before tightening the mounting bolts.

    b. **Two Piece Oil Pan**

        (1) Check to make sure the dowel pin and O-ring are in place in the bottom of the block.



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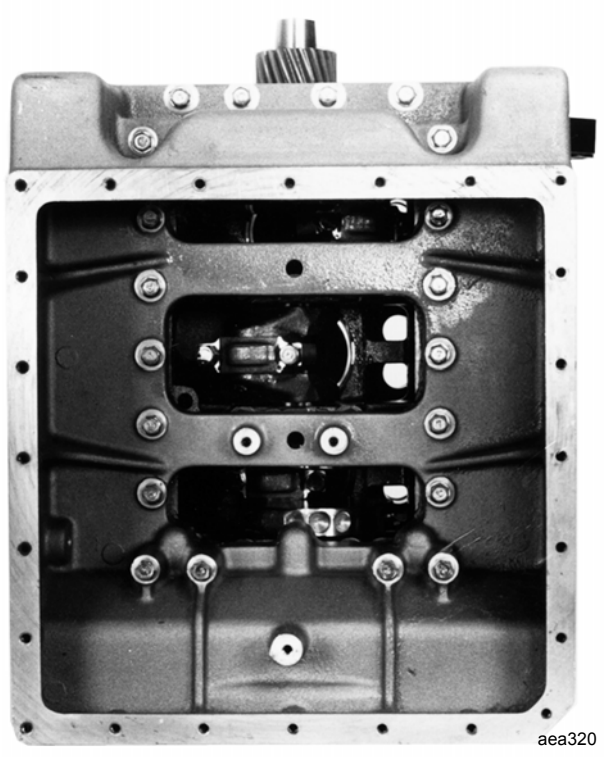
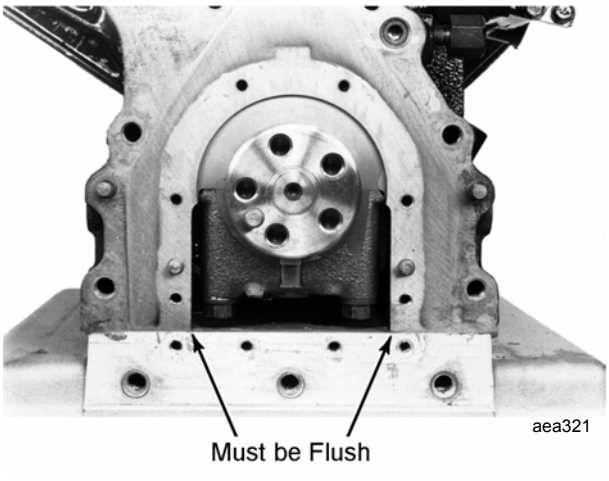
Check Dowel Pin and O-ring

        (2) Place a thin layer of sealant on the top sealing surface of the oil pan and place the oil pan in position on the bottom of the block.

(3) Install the oil pan mounting bolts. Make sure the rear end of the block and the oil pan are flush before tightening the mounting bolts.

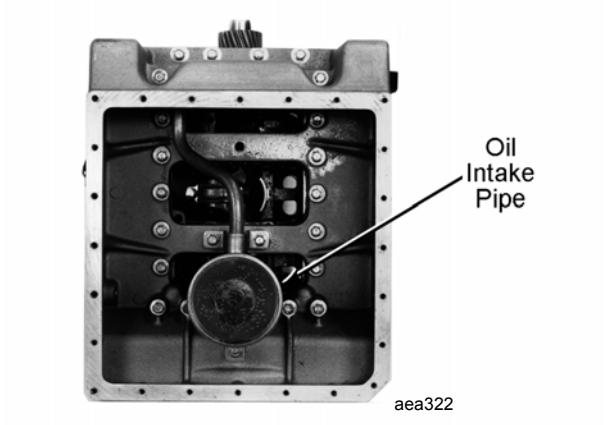


Install Oil Pan Mounting Bolts



Check Block and Oil Pan

(4) Install the oil intake pipe.



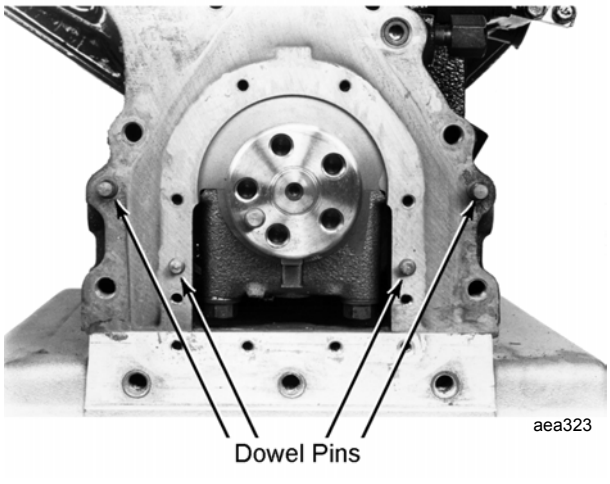
Install Oil Intake Pipe

(5) Place a thin layer of sealant on the sealing surface of the oil pan cover and place the oil pan cover in position on the oil pan.

(6) Install and tighten the oil pan cover mounting bolts.

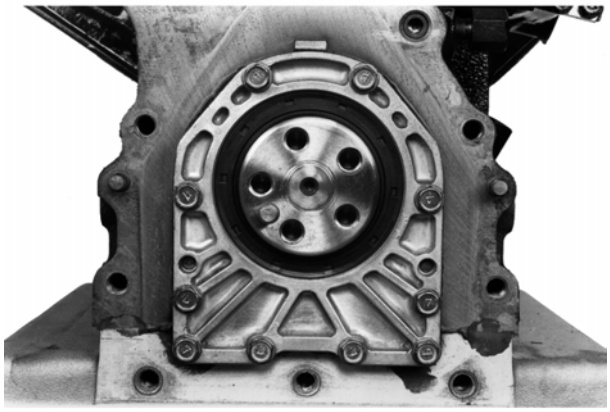
57. Install the dipstick guide and insert the dipstick.

58. Check to make sure the dowel pins are in position in the rear of the block.

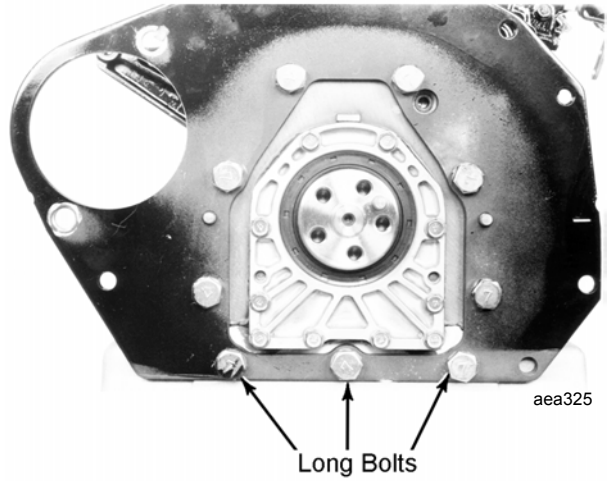


Check Dowel Pins

59. Replace the rear seal by pressing the old seal out of the rear seal housing and pressing a new seal in.
60. Coat the lip of the rear seal with engine oil.
61. Place a thin layer of sealant on the sealing surface of the rear seal housing.
62. Place the rear seal housing in position and make sure to align the dowel pins.
63. Install and tighten the mounting bolts for the rear seal housing.



Install Rear Seal Housing

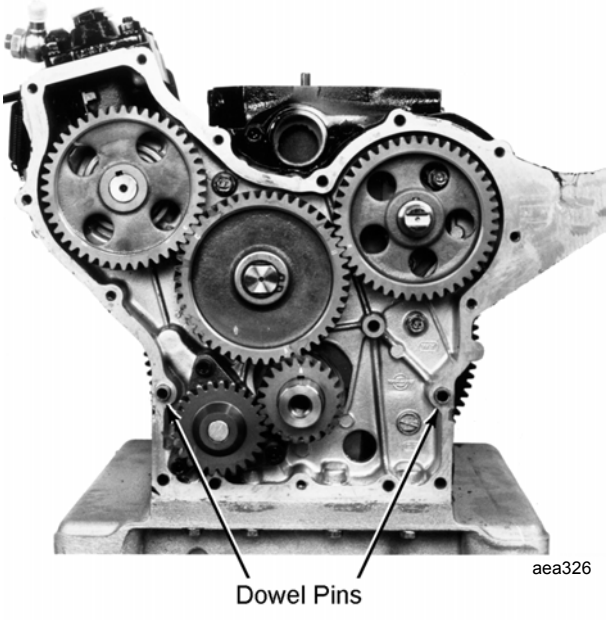


Install Starter Mounting Flange

64. Place the starter mounting flange in position on the rear of the block and make sure to align the dowel pins.
65. Install and tighten the mounting bolts for the starter mounting flange.

    NOTE: The bolts at the bottom of the starter mounting flange, which screw into the oil pan, are longer than the other bolts that fasten the starter mounting flange to the engine.

66. Install the flywheel and torque the flywheel mounting bolts. Refer to Specifications for the recommended torque.
67. Check to make sure the dowel pins are in position in the timing gear housing.



Check Dowel Pins

68. Replace the front seal by pressing the old seal out of the timing gear cover and pressing a new seal in.
69. Coat the lip of the front seal with engine oil.

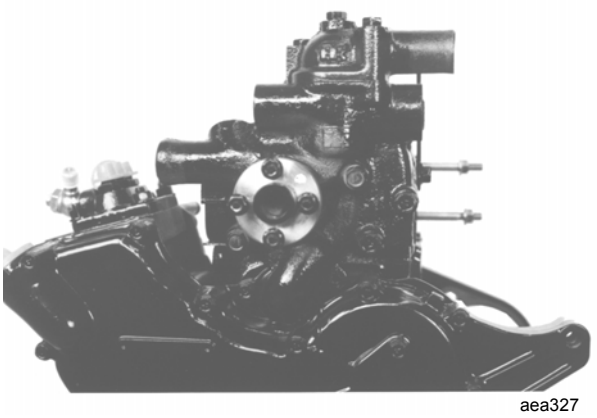
70. Place a thin layer of sealant on the sealing surface of the timing gear cover.

71. Place the timing gear housing in position and make sure to align the dowel pins.

72. Install and tighten the mounting bolts for the timing gear cover.

73. Install the crankshaft pulley and torque the mounting bolt to 61.5 to 68.7 ft-lb (83.4 to 93.2 N•m).

74. Install the water pump with a new O-ring, a new thermostat, and new gaskets.

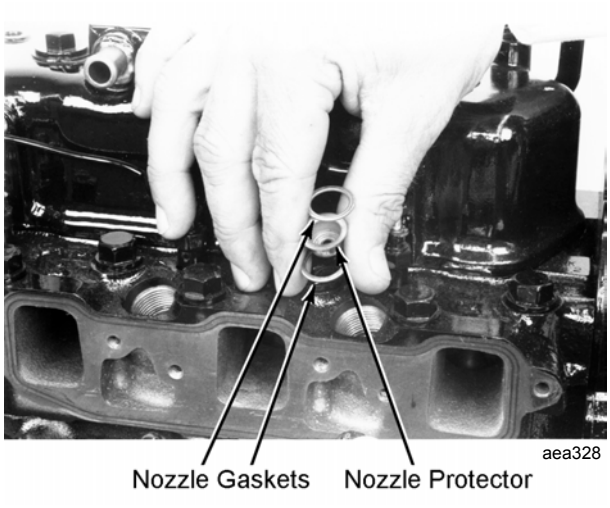


Install Water Pump

75. Install the glow plugs and torque them to 10.8 to 14.5 ft-lb (14.7 to 19.6 N•m).

76. Install the glow plug connector.

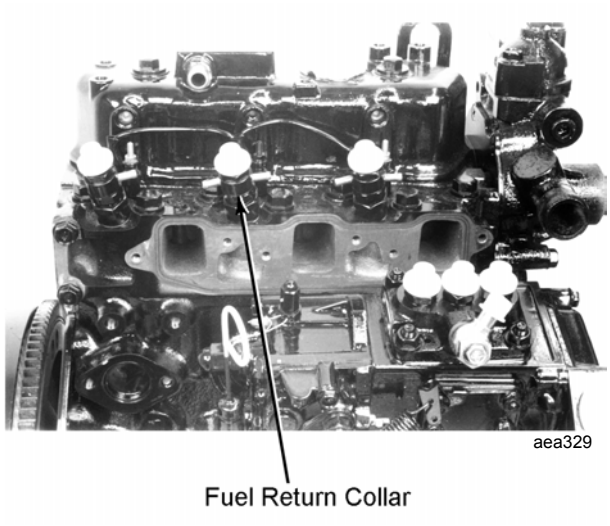
77. Place a nozzle gasket, a nozzle protector, and another nozzle gasket in each opening for the fuel injection nozzles. The nozzle gaskets are made of copper and one goes on each end of the nozzle protector. The nozzle protector is shaped like a cup and the bottom of the cup should face down.



Install Nozzle Gaskets and Protectors

78. Install the fuel injection nozzles and torque them to 36.2 to 39.1 ft-lb (49.0 to 53.0 N•m).

NOTE: Replace the fuel return collars and the lift bracket if they were removed to install the fuel injection nozzles.



Install Fuel Injection Nozzles

79. Install the intake manifold with a new gasket.
80. Install the fuel return lines.
81. Install the crankcase breather hose.
82. Install the fuel injection lines.
83. Install the exhaust manifold with a new gasket.
84. Install the starter.

Lubrication System 5

Lubrication System

These engines all use a pressure lubrication system. A trochoid type oil pump circulates the oil through the system to lubricate the engine components. The oil pump is driven by the crankshaft gear, and is attached to the lower part of the timing gear housing.

The oil is picked up by a screened inlet near the bottom of the oil pan. The inlet is positioned far enough from the bottom of the pan to avoid picking up any of the residue that tends to settle on the bottom of the pan. The oil then passes through the intake pipe to the oil pump.

The oil pump forces a large volume of high pressure oil through an oil gallery to the oil filter. Dirt and other particles are trapped in the filter element as the oil passes through the oil filter. If the filter element becomes clogged, a bypass valve built into the oil filter allows the oil to bypass the filter element. This keeps the engine components from being starved for oil if the filter element is clogged.

After passing through the oil filter, the oil is still at high pressure when reaches the oil pressure control valve and the main oil gallery. The oil pressure control valve limits the oil pressure in the main oil gallery to approximately 43 psi (294 kPa) by diverting the excess oil back into the oil pan. Oil passages connected to the main oil gallery supply oil to the idler gear shaft, the fuel injection pump, and to each main bearing.

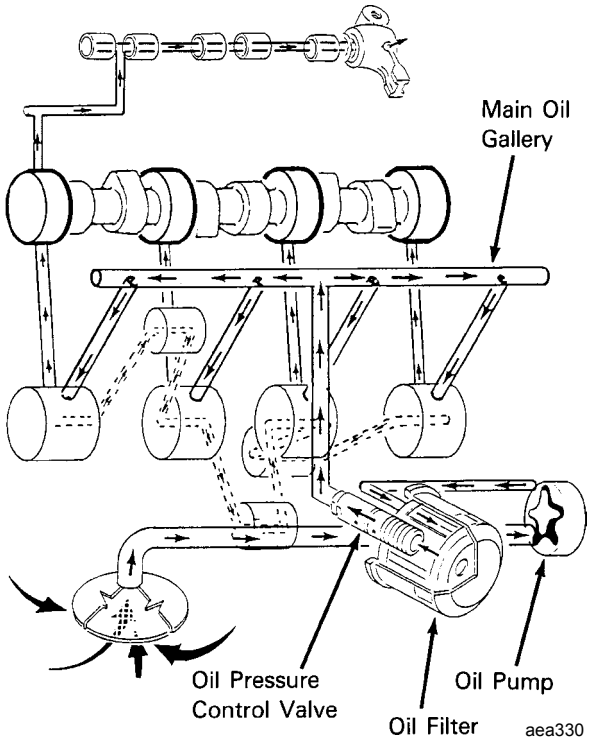
Oil from the idler gear shaft lubricates the idler gear bushing, the idler gear, and the other timing gears before returning to the oil pan.

The oil that flows to the fuel injection pump returns to the oil pan after lubricating the injection pump components.

Some of the oil supplied to the main bearings flows through passages in the crankshaft to the connecting rod bearings. This oil is thrown around the bottom end of the engine as is flows out of the bearings while the crankshaft rotates. Some of this oil lubricates the cylinder walls. Some of this oil lands in the holes on the top of the connecting rods and lubricates the wrist pins and the connecting rod bushings. The oil eventually returns to the oil pan.

Some of the oil supplied to the main bearings flows through passages in the cylinder block to the camshaft bearings. From here some of the oil flows through passages in the cylinder block, the cylinder head, and the rocker arm supports to the rocker arm shaft. The rocker arm shaft supplies oil to the rocker arm bushings and the rocker arms. Some oil squirts out of holes in the rocker arms to lubricate the valve stem caps and the valve stems. The oil that is pumped up to the rocker arm assembly flows back down through the push rod openings and lubricates the tappets and the cam lobes as it returns to the oil pan.

Oil pressure is affected by oil temperature, oil viscosity, and engine speed. Low oil pressure can usually be traced to the lack of oil, a faulty oil pressure control valve, loose connections in the lubrication system, or worn bearings. Low oil pressure is not normally caused by a faulty oil pump.



Lubrication System

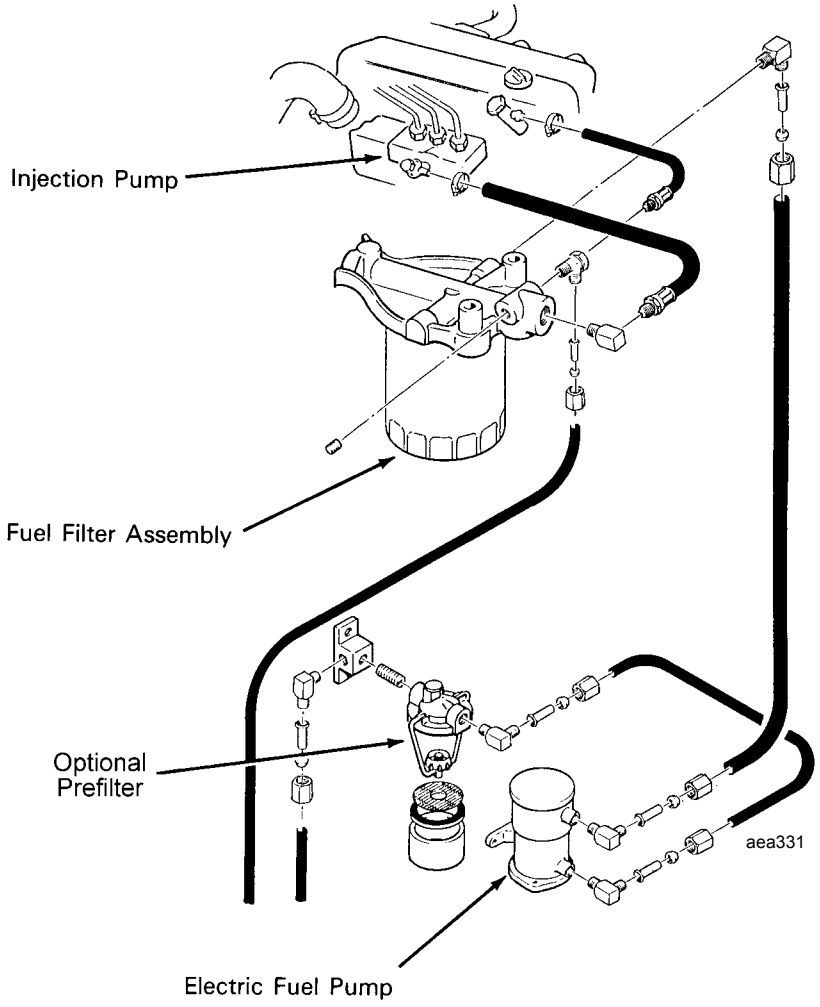
Fuel System 6

Fuel System

The fuel systems for these engines are basically the same. The major components of the fuel system are:

1. Fuel Tank
2. Prefilter (Optional)
3. Electric Fuel Pump
4. Fuel Filter
5. Injection Pump
6. Injection Nozzles

The fuel is drawn from the fuel tank, through the prefilter (if used), to the electric fuel pump. A prefilter specially designed for diesel fuel is the only type of prefilter that should be used.



Fuel System

The electric fuel pump pressurizes the fuel to approximately 10 psi (69 kPa) and forces the fuel through the fuel filter to the injection pump. The injection pump forces the fuel, at a very high pressure, through the injection nozzles. The injection nozzles atomize the fuel as it is injected indirectly into the combustion chambers through the prechambers.

The system uses a Bosch in-line injection pump. The injection pump camshaft is driven at one end by the engine's timing gears. The cam lobes actuate the plungers, which force fuel through the injection nozzles. A governor assembly is connected to the other end of the injection pump camshaft. The governor meters the amount of fuel delivered to the injection nozzles by controlling the position of the plungers.

The fuel system is relatively trouble free and, if properly maintained, does not usually require major service or repair between engine overhauls.

The most common cause of problems in the fuel system is contamination. The fuel must be clean, the fuel tanks must be free of contaminants, and the fuel filters must be changed regularly. Any time the fuel system is opened, all possible precautions must be taken to keep dirt from entering the system. All fuel lines must be capped when disconnected. The work should be done in a relatively clean area and the work should be completed in the shortest time possible.

Thermo King recommends that any major injection pump or nozzle repairs be done by a qualified diesel injection service shop. The investment in equipment and facilities to service these components is quite high. Therefore, this equipment is not found in most repair shops.

The following procedures can be done under field conditions:

1. Bleeding air from the fuel system.
2. Maintenance of the fuel tank and fuel filter system.
3. Speed adjustments.
4. Electric fuel pump repair or replacement.
5. Injection line replacement.
6. Injection pump timing and minor repair.
7. Injection nozzle testing, adjustment, and minor repair.

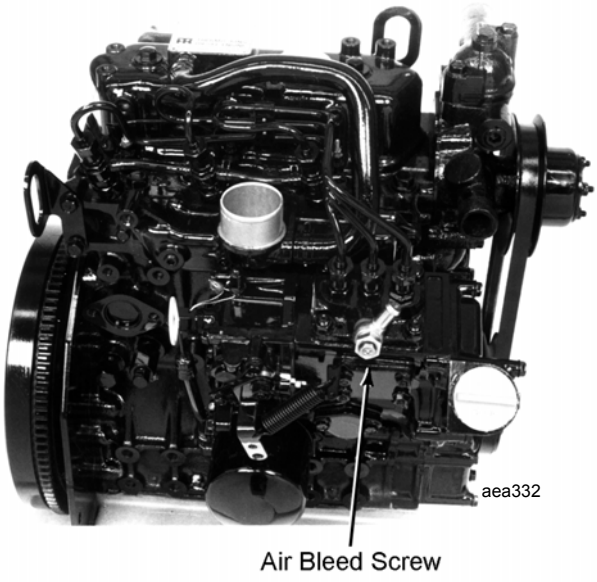
Bleeding Air From The Fuel System

Air usually gets into the fuel system when the engine runs out of fuel or if repairs are made to the fuel system.

NOTE: Be sure to keep the vent in the fuel tank open. If the vent becomes clogged, a partial vacuum develops in the fuel tank. This increases the chance that air will enter the fuel system.

Use the following procedure to bleed air out of the fuel system.

1. Loosen the air bleed screw or the inlet fitting on the injection pump.



Air Bleed Screw Location

2. Energize the electric fuel pump by turning the unit on.
3. Tighten the air bleed screw when air bubbles are no longer present in the fuel flowing out of the air bleed screw.
4. Loosen the injection lines at the injection nozzles.
5. Crank the engine over with the starter until fuel appears at all of the injection nozzles.

   NOTE: Fuel will not appear at the injection nozzles by merely running the electric fuel pump. The engine must be turned over with the starter.

6. Tighten the injection lines and start the engine.

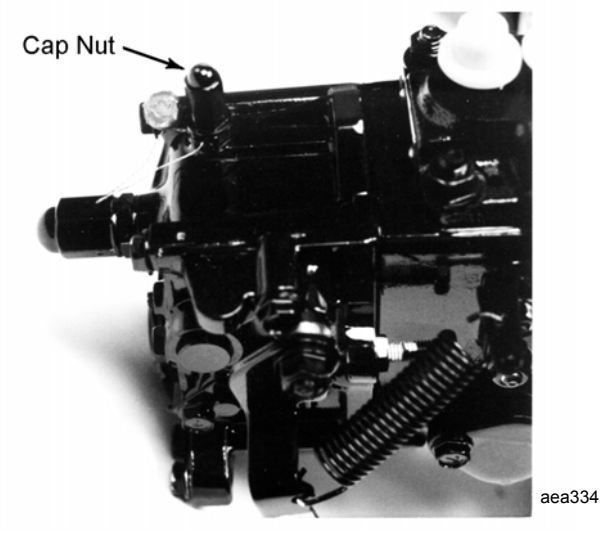
Maximum Speed Stop Screw Adjustment

NOTE: The maximum speed stop screw is covered with an anti-tamper cap and is not adjustable on later model engines.

1. Start the engine and run it on high speed.

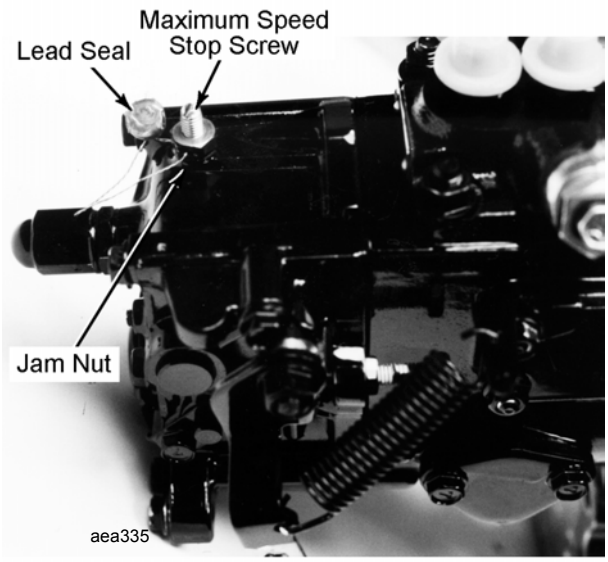
Maximum Speed Stop Screw Location

2. Remove the cap nut from the maximum speed stop screw.



Remove Cap Nut

3. Remove the lead seal from the jam nut on the maximum speed stop screw. Loosen the jam nut, and back the maximum speed stop screw out (turn counterclockwise) two to three turns.



Remove Lead Seal

4. With the engine running in high speed, check the engine speed and adjust as necessary for that particular unit.
5. With the engine running in high speed, turn the maximum speed stop screw in (clockwise) until it touches the governor linkage. The engine speed will decrease and you will feel resistance when the maximum speed stop screw begins to contact the governor linkage. Back the maximum speed stop screw out one turn from the point where it first touches the governor linkage.
6. Lock the maximum speed stop screw in this position with the jam nut, replace the cap nut, and install a new lead seal.

Fuel Limit Screw Adjustment

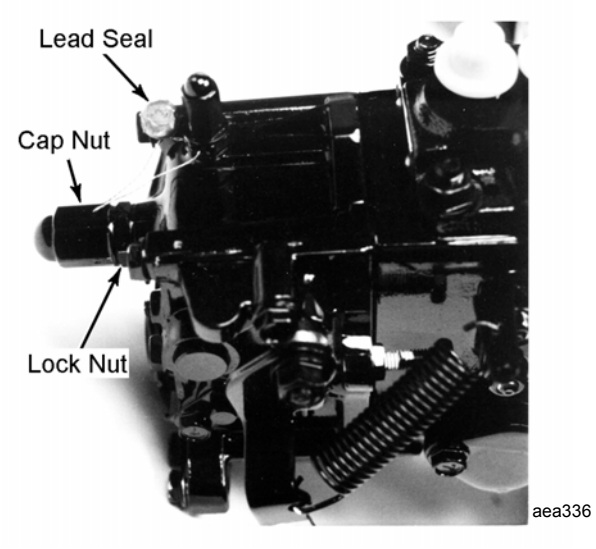
NOTE: The fuel limit screw is covered with an anti-tamper cap and is not adjustable on later model engines.

The fuel limit screw is located on the end of the injection pump governor housing, which faces toward the flywheel. The fuel limit screw is set when the injection pump is calibrated at the factory and SHOULD NOT be adjusted unless there is reason to believe someone has tampered with it. Evidence that the fuel adjustment screw has been moved includes a damaged or missing lead seal, an engine that has difficulty picking up speed, or an engine that emits excessive amounts of black smoke when the engine changes speed. Use the following procedure to adjust the fuel limit screw.

NOTE: Two adjustments are required to adjust the fuel limit screw properly. First the fuel limit screw assembly must be removed from the governor housing to adjust the plunger clearance. The fuel limit screw assembly can then be replaced and adjusted correctly.

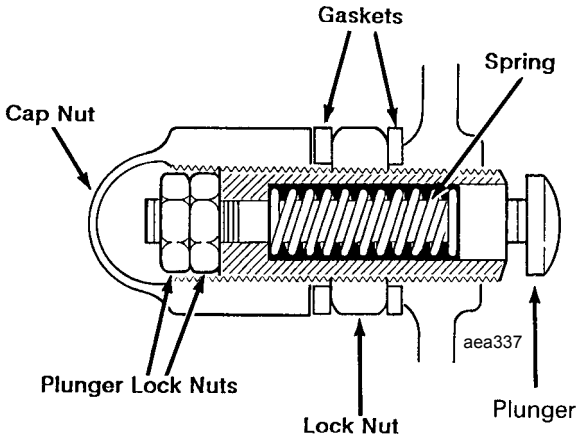
Adjust Plunger Clearance

1. Remove the lead seal and the cap nut from the fuel adjustment screw.



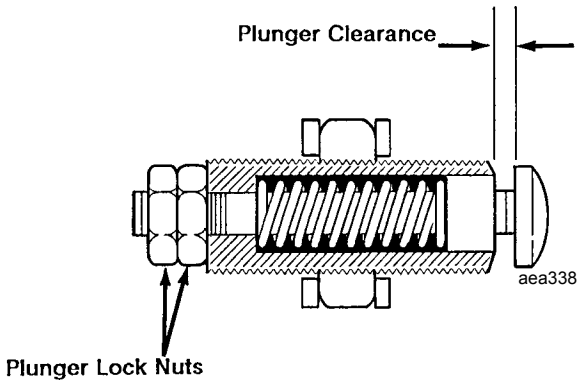
Fuel Limit Screw Location

2. Loosen the lock nut and remove the fuel limit screw assembly from the governor housing.



Fuel Limit Screw Assembly

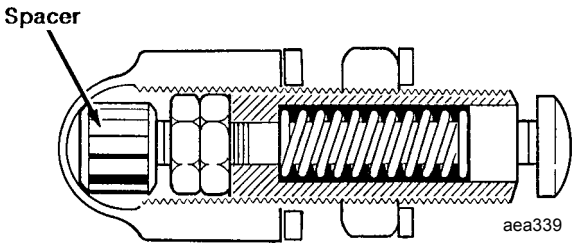
3. Check the plunger clearance with a feeler gauge. The plunger clearance should be .016 in. (0.40 mm). Use the two plunger lock screws to adjust the plunger clearance if necessary.



Check Plunger Clearance

Adjust Fuel Limit Screw

1. The plunger must be locked in place so it will not move while the fuel limit screw is being adjusted.



Lock Plunger

a. Make a spacer 3/8 in. (9.5 mm) in diameter and 5/16 in. (7.9 mm) long from a rod or a bolt.

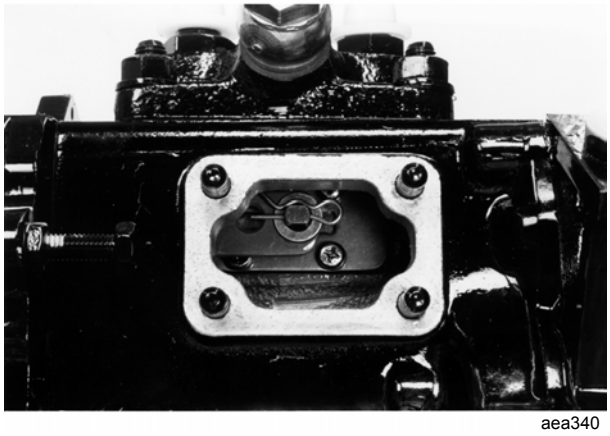
b. Place the spacer in the cap nut.

c. Screw the cap nut onto the fuel limit screw assembly until it is finger tight.

d. Check the plunger and make sure it cannot move.

2. Place the fuel limit screw assembly in the governor housing. Make sure the lock nut is turned out toward the cap nut enough to allow adjustment.

3. Remove the inspection plate from the side of the injection pump housing.



Remove Inspection Plate

4. Remove the 20 wire from the reset switch so the reset switch will not trip.

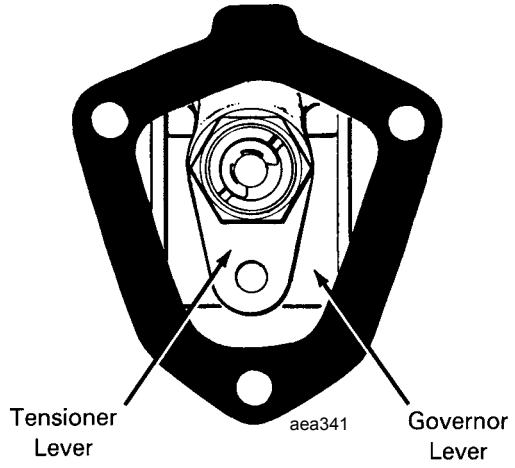
5. Disconnect the 8S circuit to the starter solenoid at the jumper plug near the starter.

6. Turn the unit on, but do not start it.

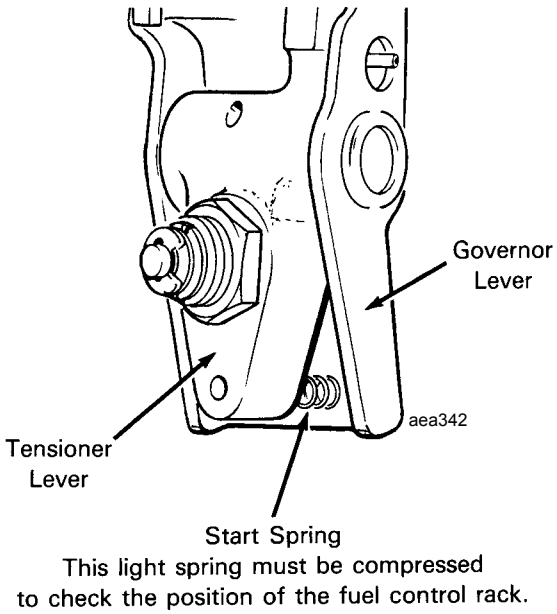
7. Set the thermostat well below the box temperature so it calls for high speed, and make sure that the throttle lever is in the high speed position.

8. Use a screwdriver to push the fuel control rack toward the front of the engine, approximately .25 in. (6 mm), until the start spring is fully compressed. The start spring is fully compressed when the governor lever contacts the tensioner lever; you will feel a definite stop when this happens. The start spring is a light spring that is located between the tension lever and the governor lever.

CAUTION: Do not push on the fuel control rack too hard or the governor spring will stretch and the tensioner lever will move away from the fuel limit screw. This will throw the adjustment off.

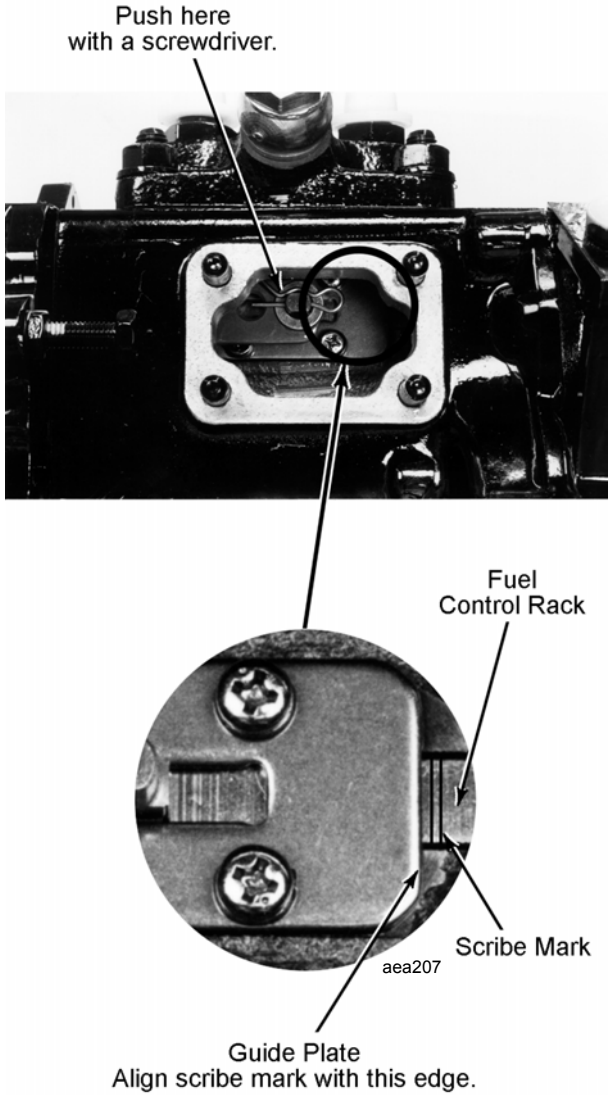


Tensioner Lever and Governor Lever



Tensioner Lever, Start Spring, and Governor Lever

9. Turn the fuel limit screw in or out to align the scribe mark on the fuel control rack with the edge of the guide plate.



Align Scribe Mark with Guide Plate

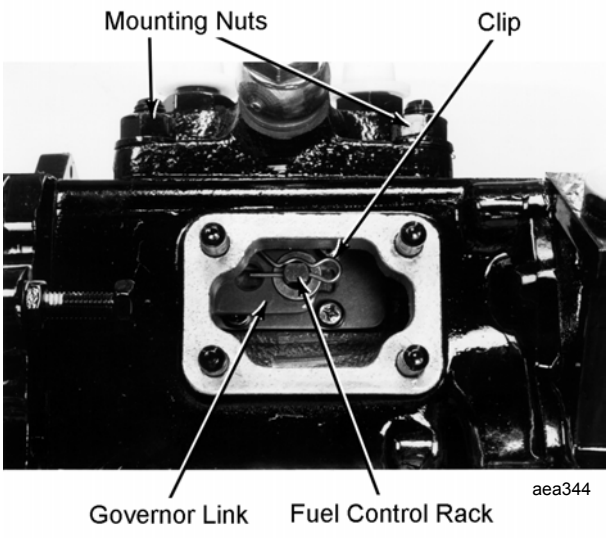
10. Fasten the fuel limit screw assembly in this position with the lock nut.

11. Recheck the alignment of the scribe mark and the edge of the guide plate.
12. Turn the unit off and connect 20 wire to the reset switch.
13. Reconnect the 8S circuit to the starter solenoid at the jumper plug near the starter.
14. Remove the cap nut and spacer from the fuel limit screw.
15. Install the cap nut without the spacer.
16. Install a new lead seal.
17. Install the inspection plate.

Fuel Injection Pump

Removal

1. Remove the inspection plate from the side of the injection pump housing.



Remove Inspection Plate

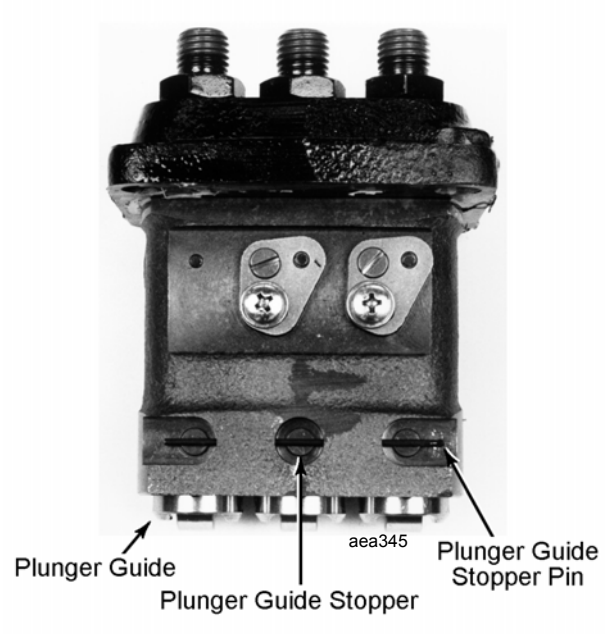
2. Remove the clip and disconnect the governor link from the fuel control rack.
3. Remove the nuts from the four studs on top of injection pump.
4. Center the fuel control rack and remove the injection pump from the housing.

   NOTE: The timing shims will usually stay attached to the injection pump.

Disassembly

NOTE: Prepare containers to keep the various parts for each cylinder separate. DO NOT mix the parts for one cylinder with parts for another. The steps in this procedure that describe the components for an individual cylinder must be performed on the components of each cylinder.

1. Remove the plunger guide stopper pin.

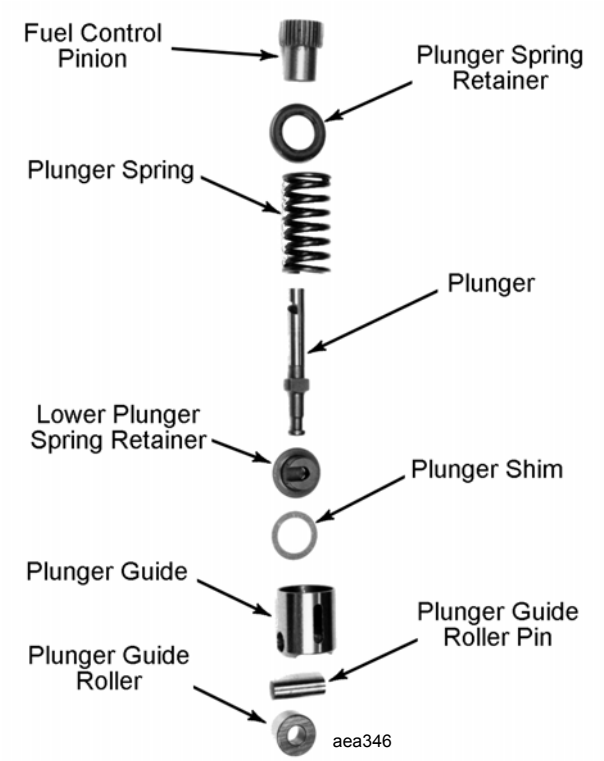


Fuel Injection Pump Assembly

2. Push in on the plunger guide and remove the plunger guide stopper.

3. Remove the plunger guide, the plunger shims, the plunger spring, the plunger spring retainers, the fuel control pinion, and the plunger.

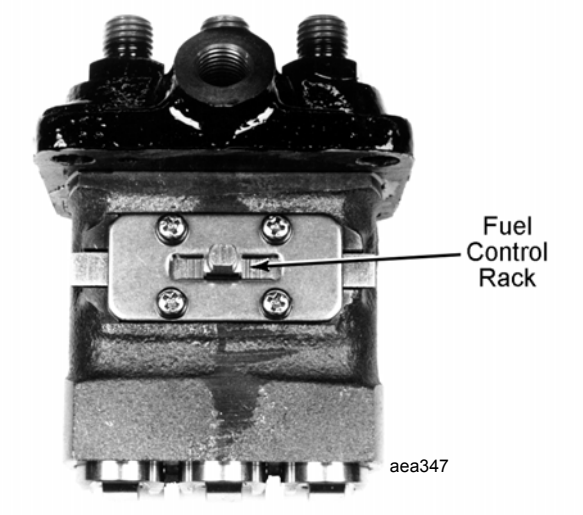
   NOTE: Make sure to keep the plunger shims with their respective plunger guides.



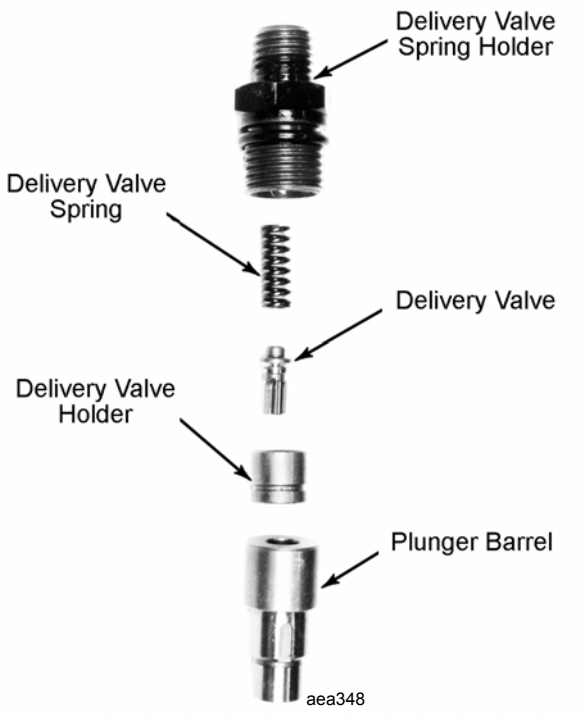
Plunger and Associated Components

4. Remove the fuel control rack.

5. Remove the delivery valve spring holder, the delivery valve spring, the delivery valve, the delivery valve holder, the plunger barrel, and the plunger barrel seal.



Fuel Injection Pump Assembly



Delivery Valve and Associated Components

Major Component Inspection

NOTE: If a plunger assembly or a plunger guide assembly is replaced the injection pump must be recalibrated by a qualified diesel injection service shop.

Plunger and Plunger Barrel

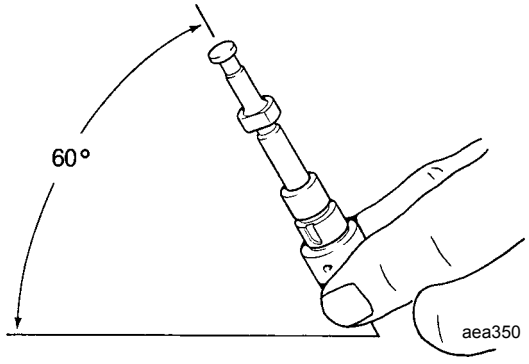
NOTE: Because the clearance between the plunger and the plunger barrel is only .0004 in. (0.010 mm), these components must be replaced if they show any sign of wear or damage. The plunger and plunger barrel are replaced as a set.

1. Clean the plungers and carefully inspect them with a magnifying glass. Replace any plunger that is scratched, worn, discolored, or has any chips on the edges of the lead groove.

Plunger

2. Test the plunger and the plunger barrel using the following procedure:

   a. Insert a plunger about half way into its respective plunger barrel while holding them horizontally.



Plunger Test

   b. Slowly tilt them up to an angle of approximately 60 degrees. The plunger should slide smoothly into the plunger barrel.

   c. Repeat this test several times and turn the plunger about a quarter of a turn each time.

   d. Replace the plunger if it slides into the plunger barrel too easily or if it stops part way in.

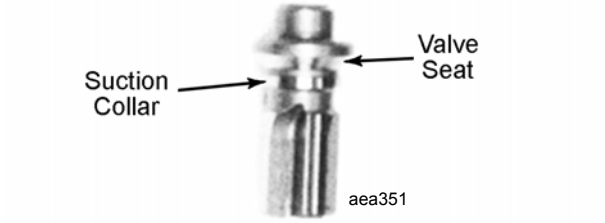
Plunger Barrel Seal

The plunger barrel seal keeps the diesel fuel from diluting the engine oil. Therefore, the plunger barrel seal must be replaced if it shows any signs of wear or damage.

Delivery Valve

The delivery valve and the delivery valve holder are a set and must be replaced together.

1. Clean and inspect the delivery valve. Replace the delivery valve if the suction collar or the seat is scratched, damaged, or shows any signs of wear.

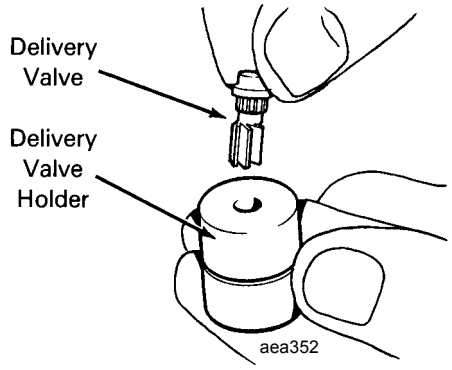


Delivery Valve

2. Test the suction collar using the following procedure:

   a. Hold the delivery holder upright and cover the hole in the bottom with your finger.

   b. Place the delivery valve in the delivery valve holder and press it into the delivery valve holder. The delivery valve should spring back a little when it is released.



Delivery Valve Test

c. Remove your finger from the hole on the bottom of the delivery valve holder. The delivery valve should drop until the valve seat rests on the delivery valve holder.

d. Replace the delivery valve if it does not pass this test.

Springs

Replace the delivery springs or the plunger springs if they show any signs of wear or damage.

Plunger Guide Assembly

Clean and inspect the plunger guide. Replace the plunger guide as an assembly if it shows any of the following:

1. Excessive play between the plunger guide and the roller pin.
2. Excessive play between the roller and the roller pin.
3. Wear or damage evident on the roller, the roller pin, or on the sides of the plunger guide.

Fuel Control Rack And Pinions

Replace the fuel control rack if it is bent or damaged, or if the gear teeth show excessive wear.

Replace the fuel control pinions if the gear teeth show excessive wear or damage.

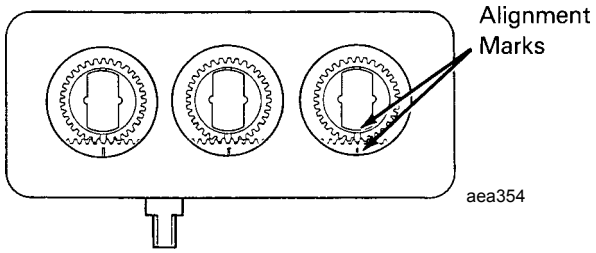
Assembly

NOTE: The steps in this procedure that describe the components for an individual cylinder must be performed on the components of each cylinder.

1. Place the plunger barrel seal in the injection pump body.
2. Install the plunger barrel. Make sure to align the groove in the side of the plunger barrel with the pin in injection pump body.

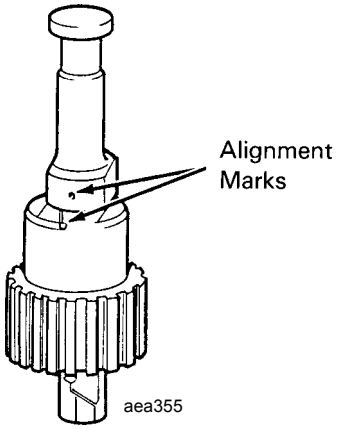
Plunger Barrel

3. Place the delivery valve assembly and the delivery valve spring in the injection pump body.
4. Install the delivery valve spring retainer, but tighten it only hand tight.
5. Install the fuel control rack and position it so the alignment marks are visible through the bottom of the injection pump body.
6. Install the fuel control pinion and make sure the alignment mark lines up with the alignment mark on the fuel control rack.



Align Marks

7. Install the plunger spring and the plunger spring retainer.
8. Place the lower plunger spring retainer on the plunger.
9. Place the plunger in the fuel control pinion. Make sure to align the alignment mark on the plunger with the alignment mark on the fuel control pinion.



Align Marks

10. Place the plunger shims in the plunger guide.
11. Place the plunger guide over the lower plunger spring retainer.
12. Press the plunger guide into the injection pump body and compress the plunger spring. If you cannot press the plunger guide into the injection pump body, move the fuel control rack back and forth a bit to align the plunger and the fuel control pinion.
13. Install the plunger guide stopper by inserting it into the injection pump body and the slot in the side of the plunger guide.
14. Release the plunger guide. The plunger spring and the plunger guide stopper should now hold the plunger guide in place.
15. After installing the components for each cylinder, install the plunger guide stopper pin.
16. Torque the delivery valve spring retainers to 29 to 32 ft-lb (39 to 43 mm).

Installation

1. Center the fuel control rack and place the fuel injection pump in the injection pump housing.

   NOTE: Make sure the timing shims are in place.

2. Install and torque the mounting nuts to 18 to 20 ft-lb (24 to 27 mm).
3. Connect the governor link to the fuel control rack and install the clip.
4. Install the inspection cover.

Injection Pump Timing

Two different timing procedures are used on these engines. One procedure times the injection pump to the engine. The other procedure checks the timing of each individual cylinder.

If the individual cylinders are not timed correctly to each other, timing the injection pump to the engine has little value because some of the cylinders would be out of time. The individual cylinders are timed to each other by using shims between the plunger guides and the lower plunger spring retainers. Because shims are used, it is unusual for the timing of the individual cylinders to change unless the injection pump has been repaired. If an engine is running roughly and all other possible causes have been checked, it may be worth while to check the individual cylinder timing,

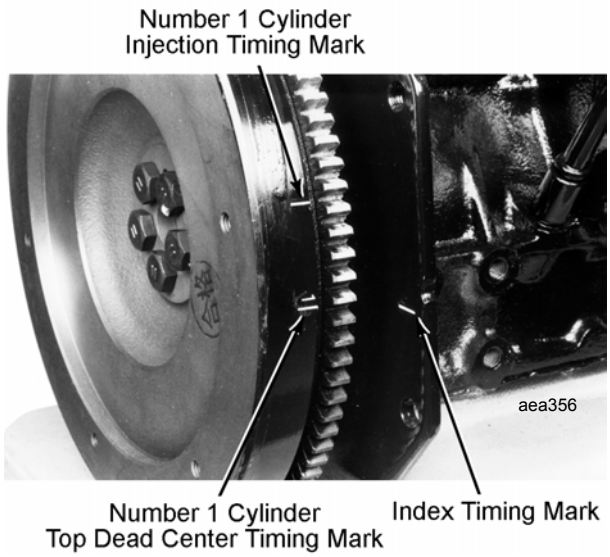
especially if the injection pump has been repaired or replaced recently.

Timing Injection Pump To Engine

NOTE: The cylinders on these engines are numbered from the flywheel end to the water pump end. The number 1 cylinder is next to the flywheel. On the two cylinder engines the number 2 cylinder is next to the water pump. On the three cylinder engines the number 2 cylinder is in the middle and the number 3 cylinder is next to the water pump. The timing marks on the flywheel are also numbered this way.

The timing marks on the flywheel of the two cylinder engines are stamped 180 degrees apart. The timing marks on the flywheel of the three cylinder engines are stamped 120 degrees apart. The top dead center marks have the cylinder number stamped next to them. The injection timing marks have no identification marks.

The index timing mark is stamped on the side of the starter mounting plate that faces the flywheel. This timing mark is on the intake side of the engine.



Timing Marks

CAUTION: Before turning the engine by hand, loosen all the injection lines at the injection nozzles to prevent the any possibility that the engine might fire.

1. Rotate the engine in the normal direction of rotation (counterclockwise from the flywheel end) until the number 1 cylinder is at top dead center of the compression stroke.
   a. Remove the valve cover and check the rocker arms and push rods on the number 1 cylinder.
   b. If the rocker arms and push rods are loose, the number 1 cylinder is at top dead center of the compression stroke.
   c. If the rocker arms and push rods are tight, the number 1 cylinder is at top dead center of the exhaust stroke. Rotate the engine 360 degrees to place the number 1 cylinder at top dead center of the compression stroke.
2. Remove the injection line for cylinder number 1 from the delivery valve spring holder.
3. Remove the delivery valve spring holder, the delivery valve spring, and the delivery valve for the number one cylinder.
4. Replace the delivery valve spring holder and connect it to a drip tube.
5. Turn on the electric fuel pump. If the engine is near top dead center on the number one cylinder no fuel should be flowing from the drip tube.
6. Rotate the engine backwards past the injection timing mark for the number 1 cylinder until fuel flows from the drip tube.
7. Slowly rotate the engine in the correct direction of rotation while watching the drip tube. When the fuel flow has slowed to one drip in every 10 to 15 seconds, check the timing marks. The injection timing mark for the

number 1 cylinder should be lined up with the index timing mark on the starter mounting plate.

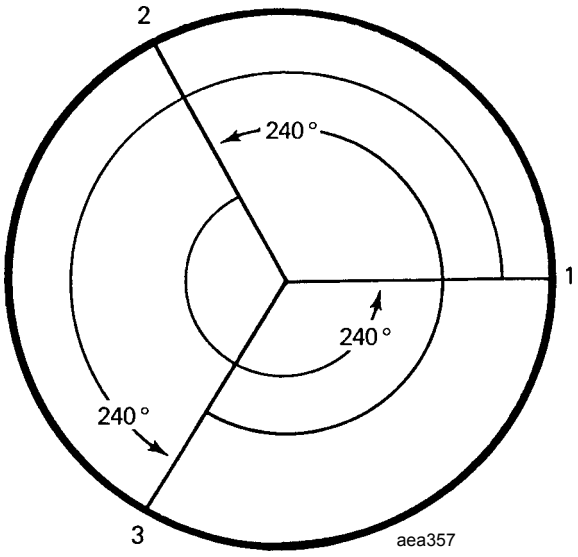
8. If the timing marks do not line up, timing shims must be added or subtracted from the group to timing shims between the injection pump and the injection pump housing. Adding shims retards the timing. Subtracting shims advances the timing. Changing the total thickness of shims by .004 in. (0.01 mm) will change the timing by approximately 1 degree.
9. After changing shims, check the timing again.
10. When the timing is correct, place a light coat of sealant on the shims, the injection pump, and the injection pump. New shims can be dipped in lacquer thinner to activate the sealant.
11. Install the injection pump. Torque the mounting nuts to 18 to 20 ft-lb (24 to 27 mm).
12. Install the delivery valve and spring. Torque the delivery valve spring retainer to 29 to 32 ft-lb (39 to 43 mm).
13. Replace and tighten the injection lines, bleed the air from the fuel system, and test run the engine.

Individual Cylinder Timing

To check the individual cylinder timing, follow the procedure for timing the injection pump to the engine, but do not adjust the timing. Check the timing of the other cylinders after checking the number 1 cylinder. The injection timing mark for each cylinder should line up in the same position as the timing mark for the number 1 cylinder, if the individual cylinders are correctly timed to each other.

If the individual cylinders are not in time, The injection pump must be removed and sent to a qualified diesel injection service shop for calibration.

NOTE: On the three cylinder engines the order for the flywheel timing marks is 1, 2, 3, but the firing order is 1,3,2. The reason for this is that the engine fires every 240 degrees of crankshaft rotation. Therefore, when checking the individual cylinder timing, check the number 1 cylinder first. Then rotate the engine past the number 2 cylinder timing marks to the number 3 cylinder timing marks and check the number 3 cylinder. Finally, rotate the engine past the number 1 cylinder timing marks to the number 2 cylinder timing marks and check the number 2 cylinder.



Three Cylinder Firing Order

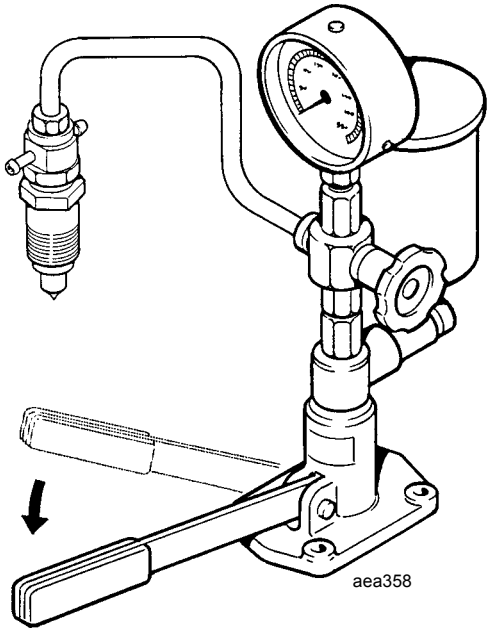
Injection Nozzles

Testing

1. Attach the injection nozzle to a nozzle tester (Part No. 204-290).

   NOTE: Use only testing fluid or clean filtered diesel fuel to test injection nozzles.

CAUTION: Keep your hands away from the nozzle spray. The nozzle spray is at such high pressure that it can break the skin and penetrate into the underlying tissue. Such an injury is very painful and can lead to serious complications such as blood poisoning.



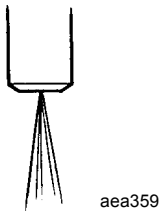
Testing Injection Nozzles

2. Close the pressure gauge valve and push the hand lever completely down several times.

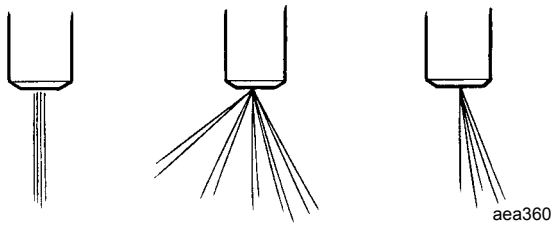
   a. The injection nozzle should make a shrill whistling noise.

   b. A straight conical spray pattern should form along the center line of the injection nozzle, with a cone angle of 5 to 10 degrees.

   c. The spray pattern should make a perfect circle on a piece of paper placed 12 in. (300 mm) below the injection nozzle.



Acceptable Spray Pattern



Unacceptable Spray Patterns

3. Open the pressure gauge valve and check the opening pressure by pushing the hand lever completely down several times.

   a. The injection nozzle should make a buzzing sound.

   b. The opening pressure should be 1707 ± 73 psi (11768 ± 500 kPa).

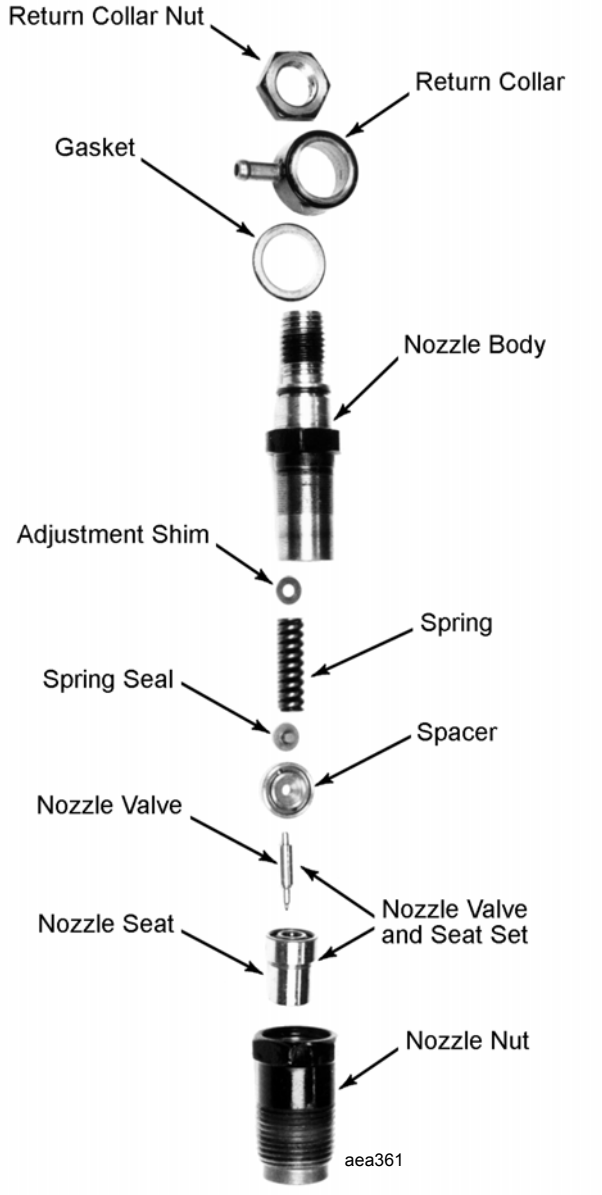
   c. Adjust the opening pressure by changing the number of adjustment shims above the spring. Refer to the injection nozzle repair section.

4. Leave the pressure gauge valve open and check to see if the injection nozzle drips by slowly pressing on the hand lever to bring the pressure up to 300 psi (2068 kPa) below the opening pressure of the injection nozzle. Maintain this pressure for at least 5 seconds. Fuel should not drip from injection nozzle in less than 5 seconds.

5. Repair the injection nozzle if it fails any of these tests or if fuel leaks out of the return collar ports during the tests.

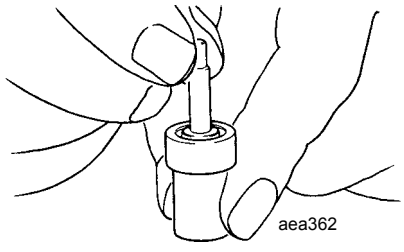
Repair

1. Place the nozzle body in a vise that has aluminum jaws or jaw covers.
2. Loosen and remove the nozzle nut.



Injection Nozzle Assembly

3. Remove the nozzle valve and seat set from the nozzle nut and submerge them in diesel fuel. Make sure to keep them together as a set.
4. Remove the nozzle body from the vise.
5. Remove the spacer, spring seat, spring, and adjustment shim from the nozzle holder.
6. Inspect the spacer. Replace the spacer if any wear or damage is evident.
7. Inspect the spring. Replace the spring if it is bent, scratched, or rusted.
8. Use a nozzle cleaning tool kit to clean the nozzle valve and seat set.
   a. Clean the carbon off the outside of the nozzle seat with a brass brush.
   b. Clean the inside of the nozzle with the cleaning tools and solvent.
   c. Thoroughly rinse the nozzle seat and valve with cleaning spray and submerge them separately in diesel fuel.
9. Test the nozzle valve and seat set.
   a. Place the nozzle valve in the nozzle seat while holding the nozzle seat in a vertical position.
   b. Pull the nozzle valve about half way out of the nozzle seat.



Testing Nozzle Valve and Seat Set

c. Release the nozzle valve. The nozzle valve should slide into the nozzle seat by itself.

d. Rotate the nozzle valve in the nozzle seat about 90 degrees at a time, and repeat this test four or five times.

e. Replace the nozzle valve and seat set if the nozzle valve does not slide smoothly into the nozzle seat.

NOTE: A new nozzle valve and seat set should be thoroughly cleaned and tested before being installed.

10. Assemble the injection nozzle and torque the nozzle nut to 29 to 33 ft-lb (39 to 44 N•m).

11. Test the injection nozzle and adjust the opening pressure as necessary. Add shims or replace the present shim with a larger one to increase the opening pressure. Remove shims or replace the present shim with a smaller one to decrease the opening pressure.

Electrical 7

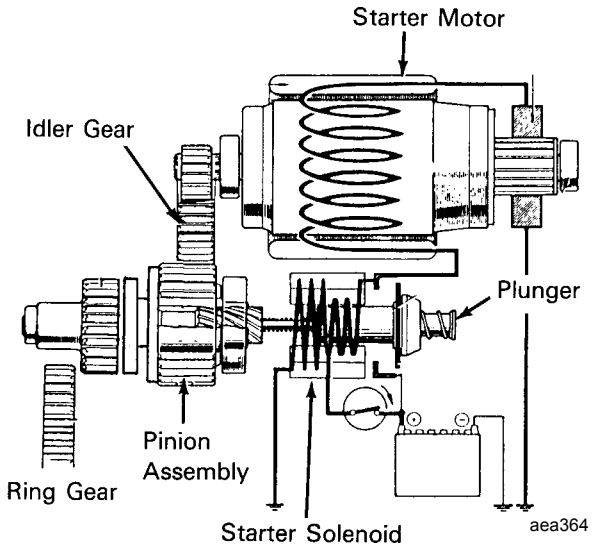
Glow Plugs

The glow plugs heat the prechambers in the cylinder head. This helps the engine start easier in cold weather. The glow plugs can be tested with an ohmmeter. Each glow plug should have a resistance of 0.7 to 1.0 ohms. Replace glow plugs with a resistance that is out of this range.

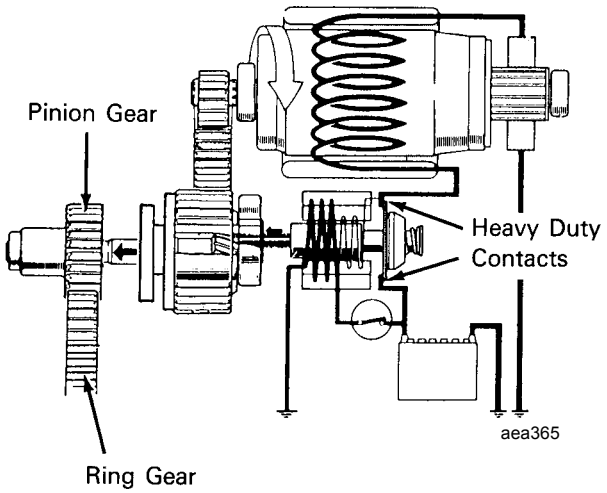
Glow Plug

Starter

The major components of the starter are the starter motor, the starter solenoid, and the pinion assembly. The starter motor turns the pinion assembly through an idler gear. When the starter solenoid is energized, it energizes the starter motor through a set of heavy duty contacts, and it extends the pinion gear to engage the ring gear on the engine's flywheel. The pinion assembly includes an over-running clutch that allows the pinion gear to turn freely if the engine is turning faster than the starter while the starter is energized.



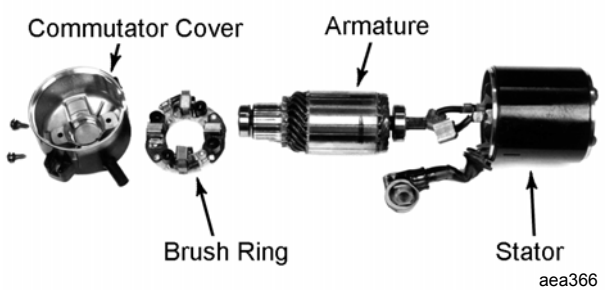
De-energized Starter



Energized Starter

Disassembly

1. Disconnect the stator lead from the C terminal on the side of the starter solenoid.
2. Remove the two through bolts from the commutator cover and remove the starter motor from the starter solenoid and pinion housing.
3. Disassemble the starter motor.



Starter Motor

a. Remove the two screws, which fasten the brush ring to the commutator, from the back of the commutator cover and remove the commutator cover from the starter motor.

b. Place the brush springs on the sides or the brush holders.

c. Remove the positive brushes (the brushes connected to the stator) from the brush holders.

d. Pull the negative brushes (the brushes connected to the brush holder assembly) part way out of the brush holders and place the brush springs on top of the brush holders against the sides of brushes. This is called the locked position and it holds the brushes in place off the commutator.

e. Remove the brush holder assembly from the commutator.

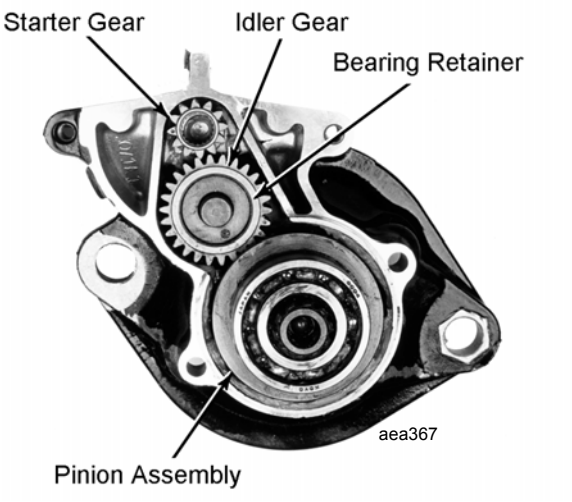
f. Remove the armature from the stator.

4. Remove the two screws from the pinion housing and separate the pinion housing from the starter solenoid. Make sure to keep track of the solenoid spring and the steel ball that are located between the solenoid plunger and the pinion shaft.

5. Remove the components from the pinion housing.

   a. Remove the starter motor gear.

   b. Remove the bearing retainer, bearings, and idler gear.



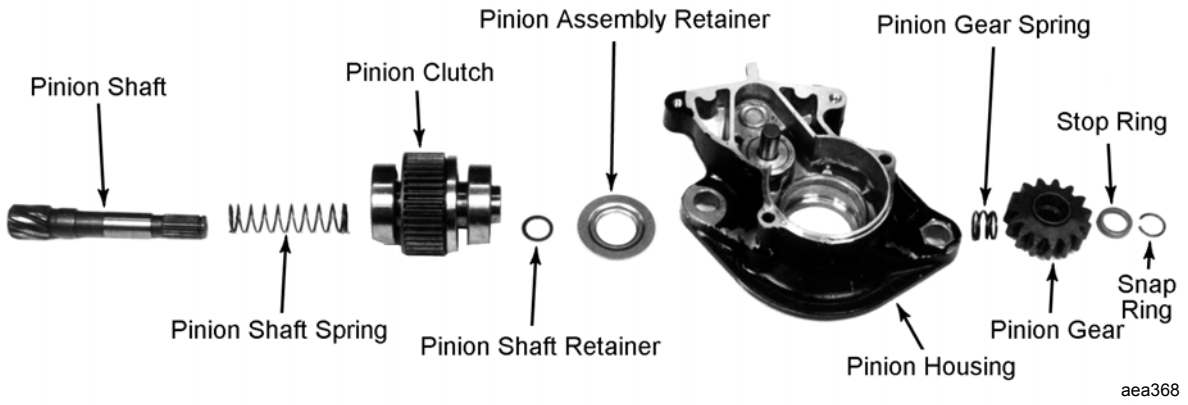
Pinion Housing

c. Support the end of the pinion shaft that faces the starter solenoid.

d. Push the pinion gear away from the stop ring and hold the pinion gear in that position.

e. Push the stop ring off the snap ring and remove the snap ring from the end of the pinion shaft.

f. Remove the stop ring, pinion gear, and pinion gear spring from the pinion gear shaft.



Pinion Assembly

g. Remove what remains of the pinion assembly from the pinion housing.

h. Remove the pinion assembly retainer, pinion shaft retainer, pinion clutch, and pinion shaft spring from the pinion shaft.

6. Disassemble the starter solenoid.

a. Remove the three screws from the cover and remove the cover from the starter solenoid.

b. Remove the plunger from the starter solenoid.

Starter Solenoid Assembly

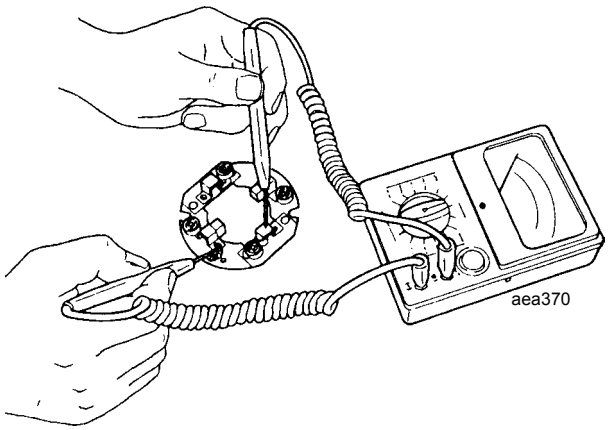
Major Component Inspection

Starter Motor

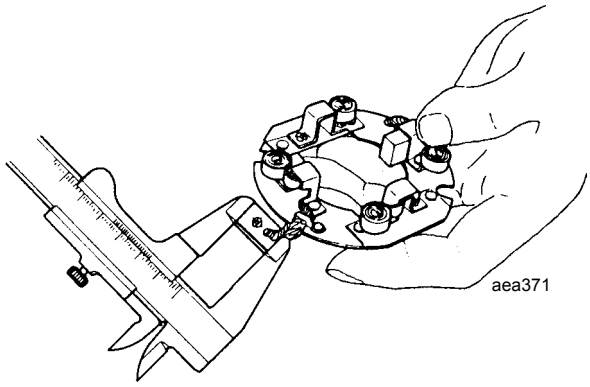
1. Check the brush ring assembly.

a. Check the brush holders with an ohmmeter. The positive brush holders should have infinite resistance to the brush ring plate. The negative brush holders should have continuity to the brush ring plate.

b. Check the brushes. Replace the brushes if they are chipped or cracked, or measure less than 0.4 in. (10 mm) on the short side. Replace the brushes as a set, or replace the brush ring assembly.



Check Brush Holders

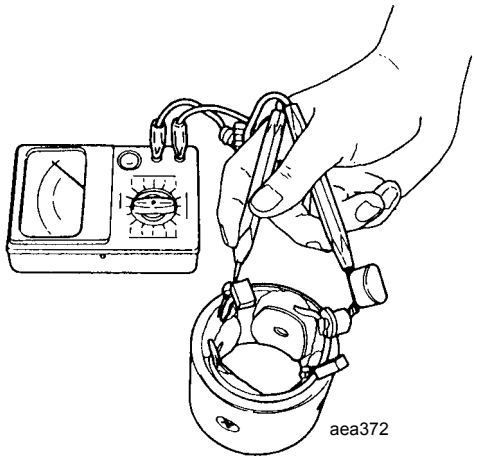


Measure Brushes

c. Check the brush springs. Replace the brush springs if they are discolored, deformed, or if the spring tension is low.

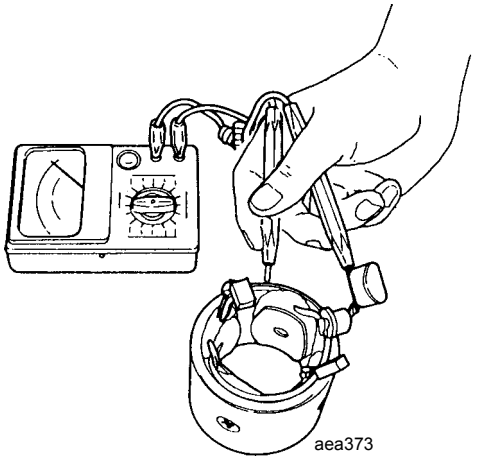
2. Check the Stator.

a. Check the field coil with an ohmmeter. There should be continuity between the stator lead and both positive brushes. Replace the stator if there is no continuity or high resistance in the field coil.



Check Field Coil

b. Check the stator insulation with an ohmmeter set on the RX1000 scale. There should be infinite resistance between the stator lead and the stator frame. Replace the stator if there is any continuity between the stator lead and the stator frame.



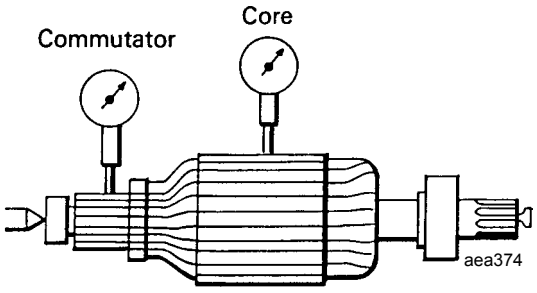
Check Stator Insulation

3. Check the armature.

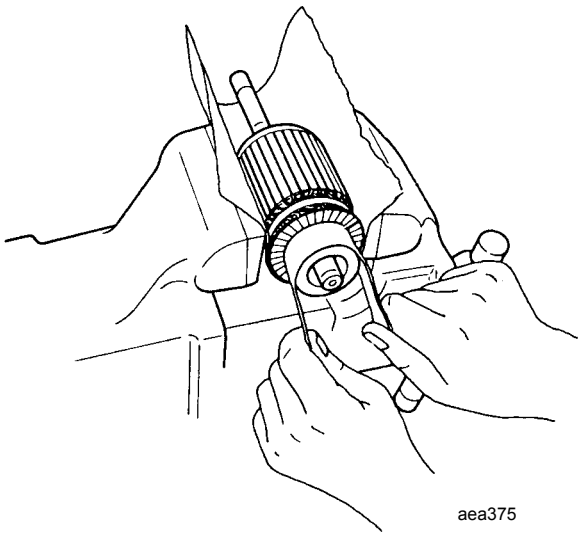
   a. To check the bearings, turn them by hand. Replace the bearings if they are rough or seem loose.

   b. Visually check the armature. Replace the armature if there is any sign of thrown solder, discolored windings, bubbled insulation, burned or damaged commutator bars, or damaged shafts.

   c. Place the armature in a lath and check the commutator and the core with a dial indicator. The distortion, run out, or out of round should not exceed .015 in. (0.40 mm).



Check Armature Distortion



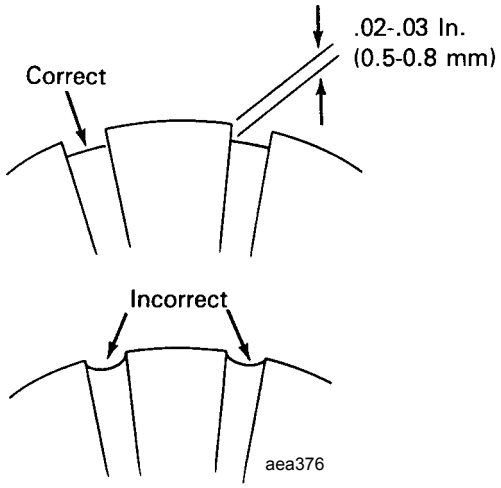
Clean Up Commutator

d. Turn the commutator or the core down if they exceed this limit. Also turn the commutator down to remove any wear grooves made by the brushes.

e. Replace the armature if the commutator has an outside diameter that is less than 1.142 in. (29.00 mm) after being turned down.

f. If the commutator is only dirty, clean it up with 500-600 grit sandpaper.

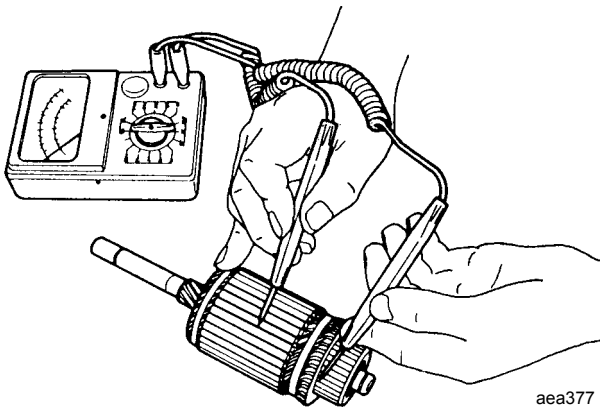
g. After turning down the commutator, check the undercut of the mica. The standard undercut is .02-.03 in. (0.5-0.8 mm). Cut the undercut down to the proper depth if it is less than .02 in. (0.5 mm).



Check Undercut

h. Check the armature coils with a growler and an ammeter. Place the ammeter leads on each pair of commutator bars that are directly opposite each other. The ammeter will show no current in an open coil and lower than normal current in a shorted coil. Replace the armature if any of the coils are defective.

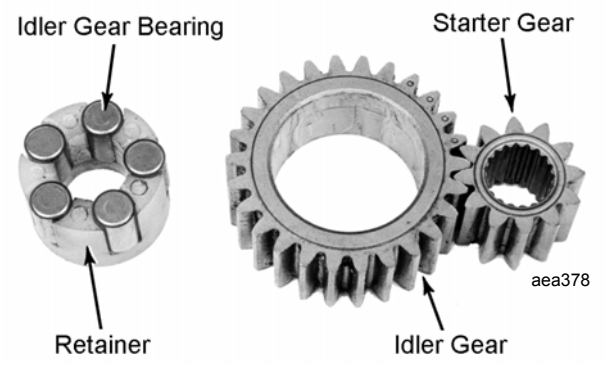
i. Check the armature insulation with an ohmmeter set on the RX1000 scale. There should be infinite resistance between each commutator bar and the armature core or shafts. Replace the armature if there is any continuity between the armature coils and the core.



Check Armature Insulation

Gears and Bearings

Inspect the starter gear, idler gear, idler gear bearings, and bearing retainer. Replace any of these parts that show significant wear or damage.



Inspect Gears and Bearings

Pinion Assembly

1. Inspect each part of the pinion assembly and replace any part that shows significant wear or damage.

2. Check the overrunning clutch.

   a. Hold the pinion clutch.

   b. Place the pinion shaft in the pinion clutch and try to rotate the pinion shaft in both directions.

   c. The pinion shaft should rotate freely in one direction and should not rotate in the other direction.

   d. Replace the pinion clutch if the pinion shaft does not rotate smoothly in the proper direction, or if it rotates in both directions.

Starter Solenoid

1. Check the heavy duty contacts on the plunger and inside the starter solenoid. Clean these contacts if they are dirty or burnt.

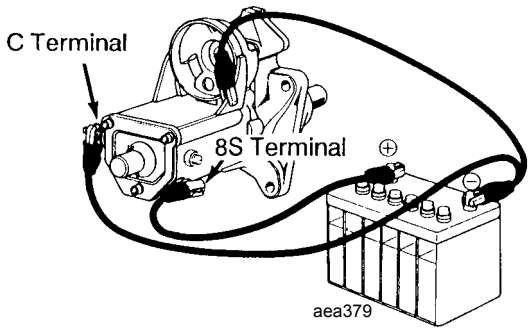
2. Use the assembly procedure to assemble the starter solenoid, place the pinion assembly in the pinion housing, and attach the starter solenoid to the pinion housing. Test this assembly as follows:

   a. Use jumper wires to connect the negative (-) terminal of a 12 volt battery to the starter solenoid chassis and to the C terminal on the starter solenoid.

   b. Use a jumper wire to connect the positive terminal of the battery to the 8S terminal on the starter solenoid. The starter solenoid should energize and the pinion gear should extend. If the starter solenoid does not energize, replace it.

   c. Disconnect the jumper wire from the C terminal on the starter solenoid. The starter solenoid should remain energized. If the start solenoid does not remain energized, replace it.

   d. Disconnect the jumper wire from the 8S terminal on the starter solenoid. The starter solenoid should de-energize and the pinion gear should retract. If the start solenoid does not de-energize, replace it.



Energize Starter Solenoid

Assembly

1. Place the plunger back inside the starter solenoid and install the cover.

2. Install the components of the pinion housing. Use a light grease to lubricate the components in the pinion housing.

   a. Place the pinion shaft spring, pinion clutch, pinion shaft retainer, and pinion assembly retainer on the pinion shaft.

   b. Place this part of the pinion assembly in the pinion housing.

   c. Support the end of the pinion shaft that faces the starter solenoid.

   d. Place the pinion gear spring and the pinion gear on the pinion shaft.

   e. Push the pinion gear onto the pinion shaft as far as possible and hold it in that position.

   f. Place the stop ring on the pinion shaft and push the stop ring to the pinion gear. Make sure the groove in the stop ring faces away from the pinion gear.

   g. Place the snap ring in the groove on the end of the pinion shaft.

h. Release the pinion gear and let it push the stop ring over the snap ring. Make sure the snap ring is seated in the groove in the stop ring.

3. Place the steel ball in the end of the pinion shaft that faces the starter solenoid.

4. Place the spring on the starter solenoid plunger.

5. Attach the starter solenoid to the pinion housing.

   NOTE: Check the operation of this assembly using the procedure in the starter solenoid inspection section.

6. Place the idler gear around the shaft in the pinion housing.

7. Place the bearings in the bearing retainer and use some light grease to lubricate the bearings and to hold them in place.

8. Place the bearings and bearing retainer inside the idler gear with the closed end of the bearing retainer covering the bearings.

9. Place the starter gear in the pinion housing.

10. Assemble the starter motor.

    a. Place the armature in the stator.

    b. Make sure the negative brushes are in the locked position and place the brush ring on the commutator.

    c. Place the positive brushes in the brush holders.

    d. Move the brushes and the brush holders to their normal positions. Make sure that the brushes move freely in the brush holders and that the brush springs hold the brushes against the commutator.

    e. Place the commutator cover in position on the starter motor. Make sure the armature bearing is seated in the commutator.

    f. Install the two screws that fasten the brush ring assembly to the commutator cover.

11. Place the starter motor in position on the starter solenoid and pinion housing. Make sure that the armature shaft engages the starter gear and that the armature bearing is seated in the starter solenoid and pinion housing.

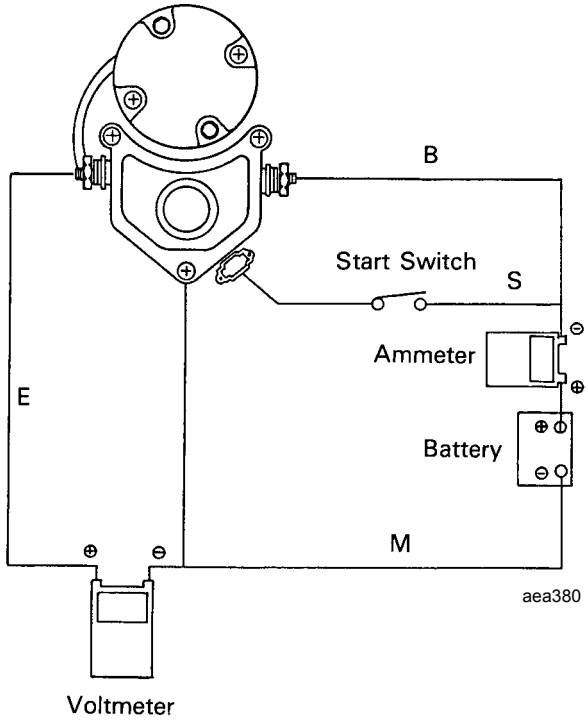
12. Install the two through bolts.

13. Connect the stator lead to the C terminal on the starter solenoid.

No Load Test

CAUTION: Do not run the starter with no load for more than 30 seconds.

1. Clamp the starter in a vise.



No Load Test

2. Connect the starter to a 12 volt battery as shown in the illustration.
3. When the switch is turned on, check the current, voltage, and starter speed. The standard values are: 180 amps, 11 volts, 3,500 rpm.

Fuel Solenoid

Some of these engines are equipped with a fuel solenoid. When the fuel solenoid is energized, it places the fuel rack in the on position. This allows fuel to flow in the fuel injection pump. The fuel solenoid has two coils, the pull-in coil and the hold-in coil. The pull-in coil must be momentarily energized to place the fuel rack in the on position. The energized hold-in coil can then hold the fuel rack in the on position. Use the following procedure to test the fuel solenoid:

1. Place a jumper wire between the black wire CH pin in the fuel solenoid connector and a good chassis ground.
2. Test the pull-in coil by momentarily placing a jumper between the 8DP pin in the fuel solenoid connector and the 2 terminal at the fuse link. The fuel solenoid should make a definite click when the pull-in coil is energized and should click again when the pull-in coil is de-energized.

   NOTE: The pull-in coil will draw 35-45 amps so do not leave the jumper connected to the 8DP pin for more than a few seconds.

   a. If the pull-in coil does energize, go to step 3.

   b. If the pull-in coil does not energize, check the resistance of the pull-in coil by placing an ohmmeter between the 8DP and the CH pin in the fuel solenoid connector. The resistance of the pull-in coil should be 0.2 to 0.3 ohms. If the resistance of the pull-in coil is not in this range, replace the fuel solenoid.

3. Test the hold-in coil.

   a. Energize the hold-in coil by placing a jumper between the 8D pin in the fuel solenoid connector and the 2 terminal at the fuse link.

   b. Momentarily energize the pull-in coil by placing a jumper between the 8DP pin in the fuel solenoid connector and the 2 terminal at the fuse link. The fuel solenoid should make a definite click when the pull-in coil is energized, but should not click when the pull-in coil is de-energized.

   c. De-energize the hold-in coil by removing the jumper from the 8DP pin and the 2 terminal. The fuel solenoid should make a definite click when the hold-in coil is de-energized.

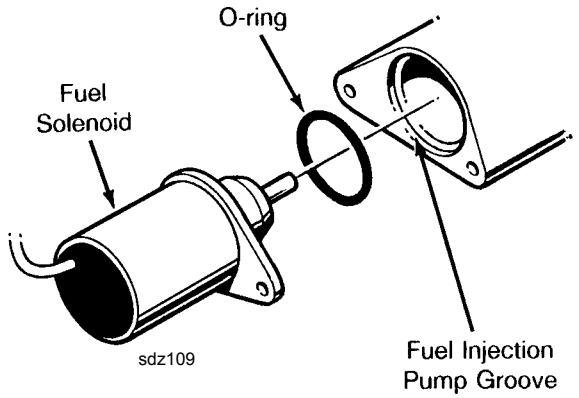
   d. If the hold-in coil does not function properly, check the resistance of the hold-in coil by placing an ohmmeter between the 8D pin and the CH pin in the fuel solenoid connector. The resistance of the hold-in coil should be 24 to 29 ohms. If the resistance of the hold-in coil is not in this range, replace the fuel solenoid.

Fuel Solenoid Replacement

1. Disconnect the 20 wire from the reset switch to prevent the reset from tripping.
2. Disconnect the fuel solenoid wire connector and remove the old fuel solenoid.
3. Connect the fuel solenoid wire connector to the new fuel solenoid.
4. Turn the unit on to energize the fuel solenoid.

   NOTE: The fuel solenoid must be energized when it is being installed. If not, the plunger and the linkage may not line up correctly and the fuel solenoid will not function properly.

5. Place the O-ring in the groove in the end of the fuel injection pump. Make sure the O-ring is positioned correctly during installation to avoid damage and leaks.
6. Install the new fuel solenoid.
7. Turn the unit off and make sure to connect the 20 wire to the reset switch.



Fuel Solenoid Components

Run In Procedure 8

Run In

The run in of a rebuilt engine will often determine the oil consumption, power output, and other variables during the service life of the engine. It is important to run in a rebuilt engine properly. How an engine will be run in is determined by the type of equipment and the time that is available. Thermo King recommends an engine be run in on a dynamometer if possible.

Dynamometer Run In Procedure

1. Pressurize the lubrication system of the engine with an oil pressure tank if the engine has been stored for any length of time. This prevents a dry start.
2. Start the engine and run it at 1400 rpm with a load that is 6 to 8% of the engine's rated output for a short time.
3. Run the engine at 1400 rpm with a load that is 15% of the engine's rated output for 15 minutes.
4. Run the engine at 2400 rpm with a load that is 22 to 25% of the engine's rated output for 30 minutes.
5. Run the engine at 1400 rpm with a load that is 15% of the engine's rated output for 30 minutes.
6. Run the engine at 2400 rpm with a load that is 30 to 35% of the engine's rated output for 10 minutes.
7. If time permits, additional run in time is desirable. Vary the speed and load in ranges between 1400 to 2400 rpm and 10 to 25% of the engine's rated output.

Run In Procedure Without Dynamometer

1. Run the engine on a test stand with no load for approximately 15 minutes in both low speed (1400 rpm) and high speed (2400 rpm). Check the engine for abnormal noises, coolant, fuel, or oil leaks.

   CAUTION: DO NOT run a newly rebuilt engine without a load for a long period of time. This can cause the engine's oil consumption to be higher than normal.

2. Mount the engine in a unit and run the unit on high speed heat for 2 hours. Occasionally place the unit in low speed heat to vary the compression pressures and engine temperatures.
3. Mount the unit on a truck and run the unit in high speed heat with truck doors open for 2-10 hours.

Valve Clearance Adjustment

The valve clearance should be checked after the first 500 hours of engine operation and every 2000 hours after that. It is very important to have the valves adjusted properly. If the valve clearance is too small, that cylinder may lose compression, misfire, and burn the valve and valve seat. If the valve clearance is too large, the valve will be noisy and the valve and rocker arm may wear abnormally. Adjust the valves at room temperature with the valves closed.

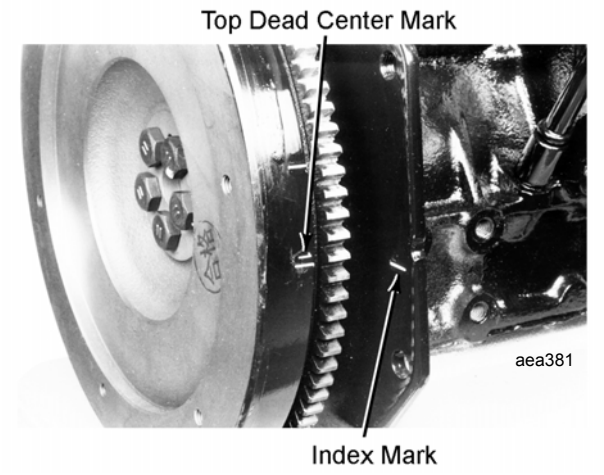
Two Cylinder Procedure

1. Remove the valve cover.
2. Torque the cylinder head bolts to the proper torque.

   NOTE: The cylinders on these engines are numbered from the flywheel end to the water pump end. The number 1 cylinder is next to the flywheel. The number 2 cylinder is next to the water pump. The timing marks on the flywheel are also numbered this way.

   The timing marks on the flywheel of the two cylinder engines are stamped 180 degrees apart. The top dead center marks have the cylinder number stamped next to them. The injection timing marks have no identification marks.

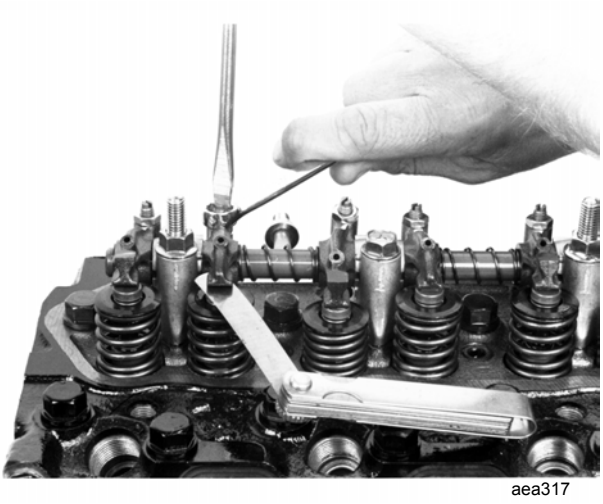
   The index timing mark is stamped on the side of the starter mounting plate that faces the flywheel. This timing mark is on the intake side of the engine.



Timing Marks

CAUTION: Before turning the engine by hand, loosen all the injection lines at the injection nozzles to prevent the any possibility that the engine might fire.

3. Rotate the engine in the normal direction of rotation (counterclockwise from the flywheel end) until the number 1 cylinder is at top dead center of the compression stroke.
   a. Check the rocker arms and push rods on the number 1 cylinder.
   b. If the rocker arms and push rods are loose, the number 1 cylinder is at top dead center of the compression stroke.
   c. If the rocker arms and push rods are tight, the number 1 cylinder is at top dead center of the exhaust stroke. Rotate the engine 360 degrees to place the number 1 cylinder at top dead center of the compression stroke.
4. Check the valve clearance of both valves for the number 1 cylinder with a feeler gauge. Refer to Specifications for the recommended valve clearance.
5. Adjust the valves if necessary by loosening the lock nut and turning the adjustment screw until the valve clearance is correct.



Adjusting Valve Clearance

6. Hold the adjustment screw in place and tighten the lock nut.
7. Recheck the valve clearance.
8. Rotate the engine in the normal direction of rotation (counterclockwise from the flywheel end) until the number 2 cylinder is at top dead center of the compression stroke.
   a. Check the rocker arms and push rods on the number 2 cylinder.
   b. If the rocker arms and push rods are loose, the number 2 cylinder is at top dead center of the compression stroke.
   c. If the rocker arms and push rods are tight, the number 2 cylinder is at top dead center of the exhaust stroke. Rotate the engine 360 degrees to place the number 2 cylinder at top dead center of the compression stroke.
9. Check and adjust both valves for the number 2 cylinder.
10. Install the valve cover.

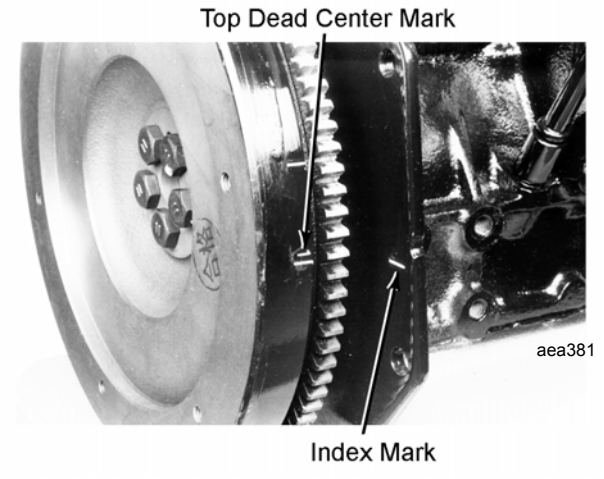
Three Cylinder Procedure

1. Remove the valve cover.
2. Torque the cylinder head bolts to the proper torque.

NOTE: The cylinders on these engines are numbered from the flywheel end to the water pump end. The number 1 cylinder is next to the flywheel. The number 2 cylinder is in the middle and the number 3 cylinder is next to the water pump. The timing marks on the flywheel are also numbered this way.

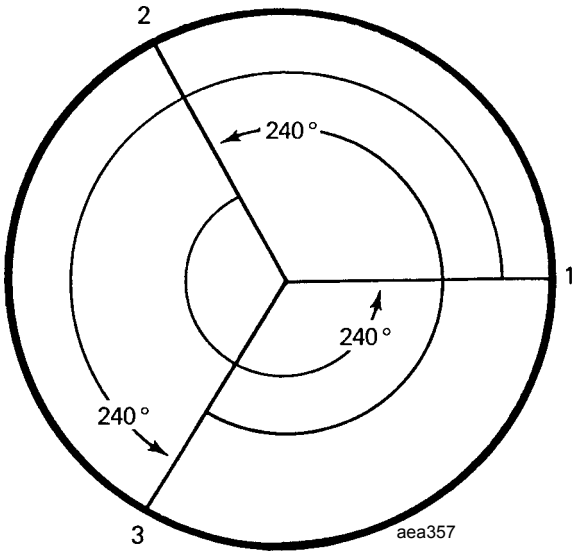
The timing marks on the flywheel of the three cylinder engines are stamped 120 degrees apart. The top dead center marks have the cylinder number stamped next to them. The injection timing marks have no identification marks.

The index timing mark is stamped on the side of the starter mounting plate that faces the flywheel. This timing mark is on the intake side of the engine.



Timing Marks

On the three cylinder engines the order for the flywheel timing marks is 1, 2, 3, but the firing order is 1,3,2. The reason for this is that the engine fires every 240 degrees of crankshaft rotation. Therefore, when adjusting the valves, check the number 1 cylinder first. Then rotate the engine past the number 2 cylinder timing marks to the number 3 cylinder timing marks and check the number 3 cylinder. Finally, rotate the engine past the number 1 cylinder timing marks to the number 2 cylinder timing marks and check the number 2 cylinder.



Valve Adjustment and Firing Order

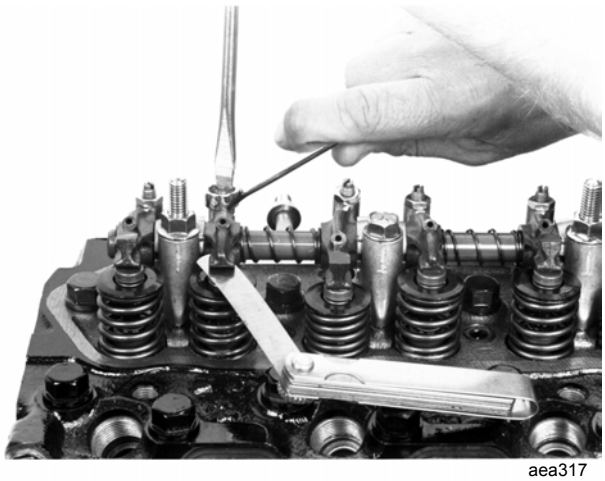
CAUTION: Before turning the engine by hand, loosen all the injection lines at the injection nozzles to prevent the any possibility that the engine might fire.

3. Rotate the engine in the normal direction of rotation (counterclockwise from the flywheel end) until the number 1 cylinder is at top dead center of the compression stroke.
   a. Check the rocker arms and push rods on the number 1 cylinder.
   b. If the rocker arms and push rods are loose, the number 1 cylinder is at top dead center of the compression stroke.

c. If the rocker arms and push rods are tight, the number 1 cylinder is at top dead center of the exhaust stroke. Rotate the engine 360 degrees to place the number 1 cylinder at top dead center of the compression stroke.

4. Check the valve clearance of both valves for the number 1 cylinder with a feeler gauge. Refer to Specifications for the recommended valve clearance.

5. Adjust the valves if necessary by loosening the lock nut and turning the adjustment screw until the valve clearance is correct.



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Adjusting Valve Clearance

6. Hold the adjustment screw in place and tighten the lock nut.

7. Recheck the valve clearance.

8. Rotate the engine in the normal direction of rotation (counterclockwise from the flywheel end) until the number 3 cylinder is at top dead center of the compression stroke.

   a. Check the rocker arms and push rods on the number 3 cylinder.

   b. If the rocker arms and push rods are loose, the number 3 cylinder is at top dead center of the compression stroke.

   c. If the rocker arms and push rods are tight, the number 3 cylinder is at top dead center of the exhaust stroke. Rotate the engine 360 degrees to place the number 3 cylinder at top dead center of the compression stroke.

9. Check and adjust both valves for the number 3 cylinder.

10. Rotate the engine in the normal direction of rotation (counterclockwise from the flywheel end) until the number 2 cylinder is at top dead center of the compression stroke.

    a. Check the rocker arms and push rods on the number 2 cylinder.

    b. If the rocker arms and push rods are loose, the number 2 cylinder is at top dead center of the compression stroke.

    c. If the rocker arms and push rods are tight, the number 2 cylinder is at top dead center of the exhaust stroke. Rotate the engine 360 degrees to place the number 2 cylinder at top dead center of the compression stroke.

11. Check and adjust both valves for the number 2 cylinder.

12. Install the valve cover.

Compression Test

Compression tester adapters are available for these engines. Use Adapter P/N 204-672 and Glow Plug Adapter P/N 204-675, if possible. Combustion chambers in diesel engines are relatively small, and the compression ratios are relatively high. Therefore, to obtain accurate and consistent compression readings:

- The adapter used to connect a compression tester to an engine must closely approximate the size and shape of the part being replaced.

- A Schrader valve must be installed in the end of the adapter that is facing the combustion chamber.
- The compression tester and connecting hose must have a small internal volume.

An adapter can be fabricated, but it must meet those guidelines. If not, the compression readings will not be accurate. Refer to Service Bulletin No. T&T 068 for more information.

1. Run the engine until it reaches the normal operating temperature and then stop the engine.

   NOTE: The compression should be tested when the engine is near the normal operating temperature. If it is not possible to run the engine, follow the rest of this procedure. The compression pressures will be approximately 10% lower than those on a warm engine.

2. Remove the wire from the fuel solenoid and loosen the injection lines at the injection nozzles.

   CAUTION: The fuel solenoid must be disconnected and the injection lines must be loosened to prevent the injection of fuel into the cylinders during the test. If a cylinder fires during the test, the resulting pressure will destroy the test equipment. The manufacturer of the test equipment disclaims all responsibility for damage or injury resulting from a cylinder firing during the test.

3. Remove all of the glow plugs.
4. Disconnect the air cleaner.
5. Connect the compression tester (P/N 204-542) to a cylinder with an acceptable adapter.
6. Turn the engine over with the starter and observe the pressure gauge. Stop cranking the engine when the pressure stabilizes.
7. Note the final reading, release the pressure, and disconnect the tester.
8. Repeat this procedure on each cylinder.
9. Compare the final readings of all the cylinders.
10. An engine in good condition will have a minimum compression pressure of approximately 400 psi (2758 kPa) at cranking speed (250 rpm) using the Thermo King compression tester (Part No. 204-542) and an acceptable adapter.
11. Because the compression pressures will vary depending on what kind of equipment is used, the most important factor is the variation between cylinders. The variation between cylinders should not exceed 10%.