Overhaul Manual

model RD1

TK235 & TK353

THERMO KING

TK 7291-1 (1-85)

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TK235 DIESEL ENGINE SPECIFICATIONS

The following standard (production) and allowable service limit specifications are given for a standard engine. 0.25 mm undersize rod bearings are available.

GENERAL	Standard	Service Limit
No. of Cylinders	2	—
Bore	2.83 in. (72 mm)	—
Stroke	2.83 in. (72 mm)	—
Displacement	35.7 cu. in. (0.585 litre)	—
Horsepower	10.7 hp @ 2400 rpm	—
Fuel Injection Timing	21° BTC	—
Valve Clearance		
Intake (cold)	.0079 in. (0.2 mm)	—
Exhaust (cold)	.0079 in. (0.2 mm)	—
Firing Order	1,2	—
Compression Ratio	23:1	—
Compression Pressure	455 psi (3137 kPa) @ 320 rpm	—
High Speed	2350 ±20 rpm — KD-I	—
	2450 ±50 rpm — MD-I	—
Low Speed	1300 ±20 rpm	—
Oil Pressure	42.7-56.9 psi (294-392 kPa)	—
Nozzle Injection Pressure	2275 psi (15,690 kPa)	—
Oil Base Capacity	8 qts (7.57 litre)	—
VALVE SPRING AND GUIDE		
Valve Spring		
Free Length	1.44 in. (36.5 mm)	1.38 in. (35.0 mm)
Compressed Length/Pressure	1.15 in./20.7 lb (29.3 mm/9.4 kg)	1.15 in./16.5 lb (29.3 mm/7.5 kg)
Valve Guide I.D.		
Intake	.2760-.2766 in. (7.01-7.025 mm)	.2787 in. (7.08 mm)
Exhaust	.2762-.2768 in. (7.015-7.030 mm)	.2787 in. (7.08 mm)
Valve Stem Diameter		
Intake	.2740-.2744 in. (6.96-6.97 mm)	.2717 in. (6.9 mm)
Exhaust	.2740-.2744 in. (6.96-6.97 mm)	.2717 in. (6.9 mm)
Valve Stem Clearance		
Intake	.0016-.0026 in. (0.040-0.065 mm)	.005 in. (0.13 mm)
Exhaust	.0018-.0028 in. (0.045-0.070 mm)	.005 in. (0.13 mm)
Valve Depth		
Intake	.0374 in. (0.95 mm)	.0492 in. (1.25 mm)
Exhaust	.0374 in. (0.95 mm)	.0492 in. (1.25 mm)
Valve Seat Angle	45°	—
Valve Face Angle	45°	—
Valve Seat Width	.0697 in. (1.77 mm)	—
Valve Margin	.0295-.0453 in. (0.75-1.15 mm)	.0276 in. (0.70 mm)
VALVE TRAIN		
Tappet Diameter	.3929-.3935 in. (9.98-9.995 mm)	.3917 in. (9.95 mm)
Tappet Clearance to Block	.0002-.0014 in. (0.006-0.035 mm)	.0039 in. (0.10 mm)
Push Rod Length	5.354-5.362 in. (136.0-136.2 mm)	5.335 in. (135.5 mm)
Rocker Arm Bearing Inside Diameter	.5518-.5525 in. (14.016-14.034 mm)	.5551 in. (14.1 mm)
Rocker Shaft Diameter	.5505-.5512 in. (13.982-14.0 mm)	.5472 in. (13.9 mm)
Rocker Arm to Bearing Clearance	.0006-.0020 in. (0.016-0.052 mm)	.0059 in. (0.15 mm)

CAMSHAFT	Standard	Service Limit
Lobe Height		
Intake and Exhaust Valves	1.3780 in. (35.0 mm)	1.3543 in. (34.4 mm)
Fuel Pump	1.7717 in. (45.0 mm)	1.7520 in. (44.5 mm)
Camshaft Bushing Inside Dia. (flywheel end)	1.0626-1.0654 in. (26.99-27.06 mm)	—
Journal Diameter (flywheel end)	1.0606-1.0614 in. (26.94-26.96 mm)	—
Bushing to Journal Clearance (flywheel end)	.0012-.0048 in. (0.031-0.122 mm)	.0059 in. (0.15 mm)
Camshaft Bushing Outside Dia.	1.1831-1.1845 in. (30.05-30.085 mm)	—
Camshaft Bushing Bore in Block	1.1811-1.1819 in. (30.0-30.02 mm)	—
End Play	None	—
PISTON, PISTON RINGS		
Pistons, Type	Relief cast — full float pin	—
Piston Outside Diameter	2.8312-2.8324 in. (71.913-71.943 mm)	2.8287 in. (71.85 mm)
Clearance to Cylinder Liner Wall	.0022-.0046 in. (0.057-0.117 mm)	.0118 in. (0.3 mm)
Piston Rings		
Ring to Groove Clearance:		
No. 1 Compression — Barrel Face	.0026-.0039 in. (0.065-0.1 mm)	.0079 in. (0.2 mm)
No. 2 Compression — Tapered Face	.0014-.0028 in. (0.035-0.070 mm)	.0079 in. (0.2 mm)
No. 3 Oil Control with Expander	.0008-.0022 in. (0.02-0.055 mm)	.0059 in. (0.15 mm)
Ring End Gap		
No. 1	.008-.016 in. (0.2-0.4 mm)	.059 in. (1.5 mm)
No. 2	.008-.016 in. (0.2-0.4 mm)	.059 in. (1.5 mm)
No. 3	.008-.016 in. (0.2-0.4 mm)	.059 in. (1.5 mm)
PISTON PIN		
Outside Diameter	.7870-.7874 in. (19.991-20.0 mm)	.7866 in. (19.98 mm)
Piston Pin Bearing Inside Diameter	.7884-.7889 in. (20.025-20.038 mm)	.7913 in. (20.1 mm)
Clearance to Bushing	.001-.0019 in. (0.025-0.047 mm)	—
CYLINDER LINER		
Inside Diameter	2.8346-2.8358 in. (72.0-72.03 mm)	2.8398 in. (72.13 mm)
Projection above Block	.0002-.0030 in. (0.005-0.075 mm)	.000 in. (0.00 mm)
CONNECTING RODS		
Rod Large End Bore (torqued w/o insert)	1.6929-1.6935 in. (43.000-43.016 mm)	—
Rod Bearing Inside Diameter (torqued)	1.5745-1.5762 in. (39.992-40.036 mm)	1.5795 in. (40.12 mm)
Allowable twist per 4 in. (100 mm)	.0012 in. (0.03 mm)	.0031 in. (0.08 mm)
Allowable parallelism per 4 in. (100 mm)	.0012 in. (0.03 mm)	.0031 in. (0.08 mm)
Side Clearance to Journal	.0079-.0157 in. (0.2-0.4 mm)	.0197 in. (0.5 mm)
CRANKSHAFT		
Main Bearing Inside Diameter		
Flywheel end	2.3622-2.3639 in. (60.0-60.044 mm)	2.3669 in. (60.12 mm)
Intermediate Bearing (torqued)	1.7323-1.7340 in. (44.0-44.044 mm)	1.7370 in. (44.12 mm)
Gear End	1.7323-1.7340 in. (44.0-44.044 mm)	1.7370 in. (44.12 mm)
Main Bearing Journal Diameter		
Flywheel end	2.3602-2.3608 in. (59.950-59.964 mm)	2.358 in. (59.90 mm)
Intermediate	1.7303-1.7309 in. (43.950-43.964 mm)	1.7283 in. (43.90 mm)
Gear end	1.7303-1.7309 in. (43.950-43.964 mm)	1.7283 in. (43.90 mm)
Main Bearing Clearance		
Flywheel end	.0014-.0037 in. (0.036-0.094 mm)	.0059 in. (0.15 mm)
Intermediate	.0014-.0037 in. (0.036-0.094 mm)	.0059 in. (0.15 mm)
Gear end	.0014-.0037 in. (0.036-0.094 mm)	.0059 in. (0.15 mm)
Rod Bearing Journal Diameter	1.5728-1.5734 in. (39.95-39.964 mm)	1.5717 in. (39.92 mm)
Rod Bearing Clearance	.0011-.0034 in. (0.028-0.086 mm)	.0059 in. (0.15 mm)
Crankshaft end play	.003-.007 in. (0.085-0.175 mm)	.012 in. (0.3 mm)

CYLINDER BLOCK	Standard	Service Limit
Main Bearing Bore		
Main bearing housing (flywheel end)	2.5591-2.5598 in. (65.0-65.019 mm)	—
Intermediate bearing housing (torqued)	1.8898-1.8904 in. (48.0-48.016 mm)	—
Gear end (block)	1.9291-1.9298 in. (49.0-49.016 mm)	—
Push Rod Bore	0.2421-0.2539 in. (6.15-6.45 mm)	—
Camshaft ball bearing bore (gear end)	.9841-.9846 in. (24.996-25.009 mm)	—
TIMING GEARS		
Timing Gear Backlash		
Crank Gear to Pump Gear	.0034-.0051 in. (0.086-0.13 mm)	.0118 in. (0.3 mm)
Crank Gear to Cam Gear	.0034-.0051 in. (0.086-0.13 mm)	.0118 in. (0.3 mm)
LUBRICATION SYSTEM		
Oil Pump		
Oil Pump Type	Trochoid	—
Relief Valve Set at	42.7-56.9 psi (294-392 kPa)	—
Vane & Rotor to Cover Clearance	.0024-.0040 in. (0.06-0.1 mm)	.006 in. (0.15 mm)
Rotor Tip to Vane Clearance	.0020-.0040 in. (0.05-0.1 mm)	.006 in. (0.15 mm)
Vane to Body Clearance	.0004-.0020 in. (0.01-0.05 mm)	.003 in. (0.08 mm)
FUEL SYSTEM		
Nozzle Type	YDN-OSDYD1	—
Injection Pressure	2276 psi (15,960 kPa)	—
Tightening Torque	18-20 ft/lb (24.4- 27.1 N·m)	—
Injection Lines, O.D.	.236 in. (6 mm)	—
Injection Lines, I.D.	.059 in. (1.5 mm)	—
Injection Timed at	21° BTC	—
ELECTRICAL SYSTEM		
Starter Motor (Nippondenso)		
Voltage	12V dc	—
Rotation — viewed from pinion end	clockwise	—
Clutch	Over-running clutch	—
Method of engagement	Magnetically engaged sliding pinion	—
Performance — NO LOAD*		
Voltage	11V	
Current	180 amps @11V	—
RPM	Over 3500 rpm @11V	—
Clearance		
Commutator Original Diameter	1.181 in. (30.0 mm)	
Commutator Minimum Diameter	1.142 in. (29.0 mm)	

*NOTE: Do not supply more than 11 volts to the starter during unloaded testing to prevent overspeed damage.

TK353 DIESEL ENGINE SPECIFICATIONS

The following standard (production) and allowable service limit specifications are given for a standard engine. 0.25 mm undersize rod bearings are available.

GENERAL	Standard	Service Limit
No. of Cylinders	3	—
Bore	2.83 in. (72 mm)	—
Stroke	2.83 in. (72 mm)	—
Displacement	53.6 cu. in. (0.878 litre)	—
Horsepower	16.1 hp @ 2400 rpm	—
Fuel Injection Timing	21° BTC	—
Valve Clearance		
Intake (cold)	.0079 in. (0.2 mm)	—
Exhaust (cold)	.0079 in. (0.2 mm)	—
Firing Order	1,3,2	—
Compression Ratio	23:1	—
Compression Pressure	455 psi (3137 kPa) @ 320 rpm	—
High Speed	2350 ±20 rpm — RD-I	—
Low Speed	1300 ±20 rpm	—
Oil Pressure	42.7-56.9 psi (294-392 kPa)	—
Nozzle Injection Pressure	2275 psi (15,690 kPa)	—
Oil Base Capacity	10 qts (9.46 litre)	—
	15w – 40	
VALVE SPRING AND GUIDE		
Valve Spring		
Free Length	1.44 in. (36.5 mm)	1.38 in. (35.0 mm)
Compressed Length/Pressure	1.15 in./20.7 lb (29.3 mm/9.4 kg)	1.15 in./16.5 lb (29.3 mm/7.5 kg)
Valve Guide I.D.		
Intake	.2760-.2766 in. (7.01-7.025 mm)	.2787 in. (7.08 mm)
Exhaust	.2762-.2768 in. (7.015-7.030 mm)	.2787 in. (7.08 mm)
Valve Stem Diameter		
Intake	.2740-.2744 in. (6.96-6.97 mm)	.2717 in. (6.9 mm)
Exhaust	.2740-.2744 in. (6.96-6.97 mm)	.2717 in. (6.9 mm)
Valve Stem Clearance		
Intake	.0016-.0026 in. (0.040-0.065 mm)	.005 in. (0.13 mm)
Exhaust	.0018-.0028 in. (0.045-0.070 mm)	.005 in. (0.13 mm)
Valve Depth		
Intake	.0374 in. (0.95 mm)	.0492 in. (1.25 mm)
Exhaust	.0374 in. (0.95 mm)	.0492 in. (1.25 mm)
Valve Seat Angle	45°	—
Valve Face Angle	45°	—
Valve Seat Width	.0697 in. (1.77 mm)	—
Valve Margin	.0295-.0453 in. (0.75-1.15 mm)	.0276 in. (0.70 mm)
VALVE TRAIN		
Tappet Diameter	.3929-.3935 in. (9.98-9.995 mm)	.3917 in. (9.95 mm)
Tappet Clearance to Block	.0002-.0014 in. (0.006-0.035 mm)	.0039 in. (0.10 mm)
Push Rod Length	5.354-5.362 in. (136.0-136.2 mm)	5.335 in. (135.5 mm)
Rocker Arm Bearing Inside Diameter	.5518-.5525 in. (14.016-14.034 mm)	.5551 in. (14.1 mm)
Rocker Shaft Diameter	.5505-.5512 in. (13.982-14.0 mm)	.5472 in. (13.9 mm)
Rocker Arm to Bearing Clearance	.0006-.0020 in. (0.016-0.052 mm)	.0059 in. (0.15 mm)

CAMSHAFT	Standard	Service Limit
Lobe Height		
Intake and Exhaust Valves	1.3780 in. (35.0 mm)	1.3543 in. (34.4 mm)
Fuel Pump	1.7717 in. (45.0 mm)	1.7520 in. (44.5 mm)
Cam Journal Bore in Block (flywheel end)	1.1811-1.1819 in. (30.0-30.02 mm)	—
Camshaft Journal Outer Diameter (flywheel end)	1.1787-1.1795 in. (29.94-29.96 mm)	—
Bore to Journal Clearance (flywheel end)	.0016-.0032 in. (0.040-0.082 mm)	.0059 in. (0.15 mm)
End Play	None	—
PISTON, PISTON RINGS		
Pistons, Type	Relief cast — full float pin	—
Piston Outside Diameter	2.8312-2.8324 in. (71.913-71.943 mm)	2.8287 in. (71.85 mm)
Clearance to Cylinder Liner Wall	.0022-.0046 in. (0.057-0.117 mm)	.0118 in. (0.3 mm)
Piston Rings		
Ring to Groove Clearance:		
No. 1 Compression — Barrel Face	.0026-.0039 in. (0.065-0.1 mm)	.0079 in. (0.2 mm)
No. 2 Compression — Tapered Face	.0014-.0028 in. (0.035-0.070 mm)	.0079 in. (0.2 mm)
No. 3 Oil Control with Expander	.0008-.0022 in. (0.02-0.055 mm)	.0059 in. (0.15 mm)
Ring End Gap		
No. 1	.008-.016 in. (0.2-0.4 mm)	.059 in. (1.5 mm)
No. 2	.008-.016 in. (0.2-0.4 mm)	.059 in. (1.5 mm)
No. 3	.008-.016 in. (0.2-0.4 mm)	.059 in. (1.5 mm)
PISTON PIN		
Outside Diameter	.7870-.7874 in. (19.991-20.0 mm)	.7866 in. (19.98 mm)
Piston Pin Bearing Inside Diameter	.7884-.7889 in. (20.025-20.038 mm)	.7913 in. (20.1 mm)
Clearance to Bushing	.001-.0019 in. (0.025-0.047 mm)	—
CYLINDER LINER		
Inside Diameter	2.8346-2.8358 in. (72.0-72.03 mm)	2.8398 in. (72.13 mm)
Projection above Block	.0002-.0030 in. (0.005-0.075 mm)	.000 in. (0.00 mm)
CONNECTING RODS		
Rod Large End Bore (torqued w/o insert)	1.6929-1.6935 in. (43.000-43.016 mm)	—
Rod Bearing Inside Diameter (torqued)	1.5745-1.5762 in. (39.992-40.036 mm)	1.5795 in. (40.12 mm)
Allowable twist per 4 in. (100 mm)	.0012 in. (0.03 mm)	.0031 in. (0.08 mm)
Allowable parallelism per 4 in. (100 mm)	.0012 in. (0.03 mm)	.0031 in. (0.08 mm)
Side Clearance to Journal	.0079-.0157 in. (0.2-0.4 mm)	.0197 in. (0.5 mm)
CRANKSHAFT		
Main Bearing Inside Diameter		
Flywheel end	2.3622-2.3639 in. (60.0-60.044 mm)	2.3669 in. (60.12 mm)
Intermediate Bearing (torqued)	1.7323-1.7340 in. (44.0-44.044 mm)	1.7370 in. (44.12 mm)
Gear End	1.7323-1.7340 in. (44.0-44.044 mm)	1.7370 in. (44.12 mm)
Main Bearing Journal Diameter		
Flywheel end	2.3602-2.3608 in. (59.950-59.964 mm)	2.3583 in. (59.90 mm)
Intermediate (flywheel & gear end)	1.7303-1.7309 in. (43.950-43.964 mm)	1.7283 in. (43.90 mm)
Gear end	1.7303-1.7309 in. (43.950-43.964 mm)	1.7283 in. (43.90 mm)
Main Bearing Clearance		
Flywheel end	.0014-.0037 in. (0.036-0.094 mm)	.0059 in. (0.15 mm)
Intermediate (fywheel & gear end)	.0014-.0037 in. (0.036-0.094 mm)	.0059 in. (0.15 mm)
Gear end	.0014-.0037 in. (0.036-0.094 mm)	.0059 in. (0.15 mm)
Rod Bearing Journal Diameter	1.5728-1.5734 in. (39.95-39.964 mm)	1.5717 in. (39.92 mm)
Rod Bearing Clearance	.0011-.0034 in. (0.028-0.086 mm)	.0059 in. (0.15 mm)
Crankshaft end play	.003-.007 in. (0.085-0.175 mm)	.012 in. (0.3 mm)

CYLINDER BLOCK	Standard	Service Limit
Main Bearing Bore		
Main bearing housing (flywheel end)	2.5591-2.5598 in. (65.0-65.019 mm)	—
Intermediate bearing housing (torqued)	1.8898-1.8904 in. (48.0-48.016 mm)	—
Gear end (block)	1.9291-1.9298 in. (49.0-49.016 mm)	—
Push Rod Bore	0.2421-0.2539 in. (6.15-6.45 mm)	—
Camshaft ball bearing bore (gear end)	.9841-.9846 in. (24.996-25.009 mm)	—
TIMING GEARS		
Timing Gear Backlash		
Crank Gear to Pump Gear	.0034-.0051 in. (0.086-0.13 mm)	.0118 in. (0.3 mm)
Crank Gear to Cam Gear	.0034-.0051 in. (0.086-0.13 mm)	.0118 in. (0.3 mm)
LUBRICATION SYSTEM		
Oil Pump		
Oil Pump Type	Trochoid	—
Relief Valve Set at	42.7-56.9 psi (294-392 kPa)	—
Vane & Rotor to Cover Clearance	.0024-.0040 in. (0.06-0.1 mm)	.006 in. (0.15 mm)
Rotor Tip to Vane Clearance	.0020-.0040 in. (0.05-0.1 mm)	.006 in. (0.15 mm)
Vane to Body Clearance	.0004-.0020 in. (0.01-0.05 mm)	.003 in. (0.08 mm)
FUEL SYSTEM		
Nozzle Type	YDN-OSDYD1	—
Injection Pressure	2276 psi (15,960 kPa)	—
Tightening Torque	18-20 ft/lb (24.4- 27.1 N·m)	—
Injection Lines, O.D.	.236 in. (6 mm)	—
Injection Lines, I.D.	.059 in. (1.5 mm)	—
Injection Timed at	21° BTC	—
ELECTRICAL SYSTEM		
Starter Motor (Nippondenso)		
Voltage	12V dc	—
Rotation — viewed from pinion end	clockwise	—
Clutch	Over-running clutch	—
Method of engagement	Magnetically engaged sliding pinion	—
Performance — NO LOAD*		
Voltage	11V	
Current	180 amps @11V	—
RPM	Over 3500 rpm @11V	—
Clearance		
Commutator Original Diameter	1.181 in. (30.0 mm)	
Commutator Minimum Diameter	1.142 in. (29.0 mm)	

***NOTE:** **Do not supply more than 11 volts to the starter during unloaded testing to prevent overspeed damage.**

TORQUE VALUES FOR TK235 & TK353 DIESEL ENGINE

	Part No.	Dia. (mm)	Length (mm)	N·m	ft/lbs
Camshaft Retaining Screw	55-4635	8	10	15-16	11-12
Clutch Mtg Bolt	55-4589	—	—	41	30
Connecting Rod Bolt	11-5042	7	—	22-27	16-20
Crankshaft Gear Nut	11-5034	28	—	69-74	51-54
Crankshaft Pulley Nut	11-5035	18	—	58-68	43-50
Cylinder Head Stud	55-4595	12	—	34-39	25-29
Cylinder Head Nut	55-4597	12	—	22-27	16-20
Cylinder Head Mtg Bolt	55-4594	12	—	98-109	72-80
Cylinder Head Mtg Bolt	55-4596	8	—	22-27	16-20
Flywheel Mtg Bolt	11-5038	10	—	64-68	47-50
Fuel Cam and Cam Gear Nut	11-5026	18	—	58-68	43-50
Gear Case Mtg Bolt	55-4648	8	85	24-27	18-20
Gear Case Mtg Bolt	55-1141	8	45	24-27	18-20
Gear Case Mtg Bolt	55-4649	8	120	24-27	18-20
Gear Case Mtg Bolt	55-4647	8	75	24-27	18-20
Injection Nozzle Mtg Stud	55-4626	8	65	24-27	18-20
Injection Pump Mtg Stud	55-4620	8	—	24-27	18-20
Mounting Flange Bolt	55-4604	10	18	43-49	32-36
Intermediate Main Bearing Hsg Set Bolt	55-4618	10	—	45-49	33-36
Intermediate Main Bearing Hsg Bolts	55-4617	8	—	30-34	22-25
Oil Sump Mtg Bolt	55-4606	6	25	8-10	6-7
Oil Sump Mtg Bolt	55-4655	6	32	8-10	6-7
Oil Pan Mtg Bolt	55-4611	8	28	8-10	6-7
Oil Pan Mtg Bolt	55-4612	8	40	8-10	6-7
Oil Pump Mtg Screw	55-4637	6	22	10-12	7-9
Oil Fill Tube Mtg Screw	55-4749	8	25	24-27	18-20
Rear Main Bearing Hsg Mtg Bolts	55-1140	8	—	24-26	18-19
Rocker Arm Support Mtg Nut	55-4624	10	—	36-39	27-29
Starter Mtg Bolt	55-4677	10	35	45-49	33-36
Starter Mtg Bolt	55-4680	10	25	45-49	33-36
Thermostat Housing Mtg Bolt	55-4611	8	28	24-27	18-20
Thermostat Housing Mtg Bolt	55-4612	8	40	24-27	18-20
Water Pump Mtg Bolt	55-4648	8	85	24-27	18-20
Water Pump Mtg Bolt	55-4655	6	35	24-27	18-20
Water Pump Mtg Bolt	55-4654	8	90	24-27	18-20
Hollow Bolts (not specified)	—	8	—	12-16	9-12
	—	10	—	19-30	14-22
	—	12	—	24-34	18-25
Other Bolts (not specified)	—	4	—	3	2-2.5
	—	6	—	8-10	6-7
	—	8	—	24-27	18-20
	—	10	—	43-49	32-36
	—	12	—	68-73	50-54

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Disassembly

Contents

Engine Disassembly

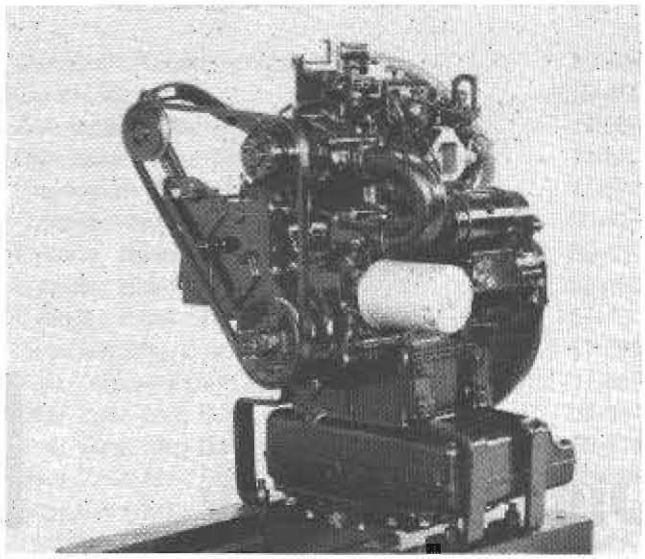


Fig. 2-1 Assembled Engine

1. Remove clutch retaining bolt and, with a standard puller, remove clutch. Use care to prevent damage to clutch assembly.
2. Remove fuel and throttle solenoids and solenoid brackets.
3. Remove starter.
4. Remove alternator and belt.
5. Remove water pump assembly including thermostat housing, bypass coolant hose, idler pulley and adjustment assembly and alternator mounting bracket.
6. Disconnect injection lines. Cover all injection lines and fuel lines with plastic covers or tape. Even the smallest amount of dirt may damage the fuel system.

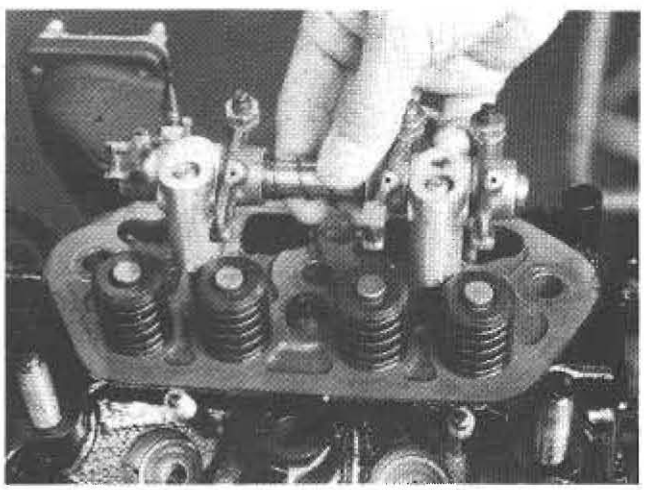


Fig. 2-2 Removing Rocker Arm Shaft Assembly

7. Disconnect the fuel return pipe from the injector nozzles.
8. Remove the injector nozzles.
9. Remove the valve cover.
10. Remove rocker arm shaft assembly (Fig. 2-2). Loosen the bolts in progression.
11. Withdraw push rods and keep them in order if they are to be reused.
12. Remove rocker arm oil tube.
13. Remove cylinder head bolts and remove cylinder head.

    When removing or replacing the cylinder head, gradually loosen or tighten the nuts in accordance with the specified order to prevent head distortion.

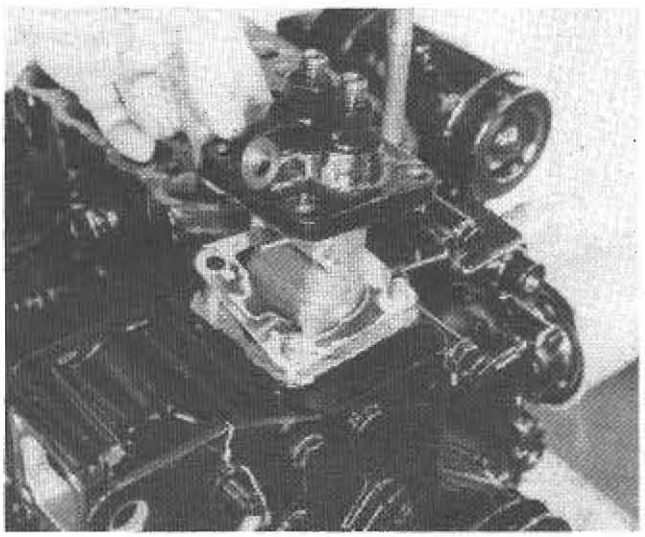


Fig. 2-3 Removing Injection Pump Assembly

14. Remove the cover from the timing bearing housing. Remove the fuel injection pump assembly (Fig. 2-3).

    NOTE: Slowly withdraw the fuel pump from the gear case, being careful not to damage the rack. Check the rack position through the viewing window in the gear housing.

15. Remove the crankshaft pulley and key. A puller may be used if needed.

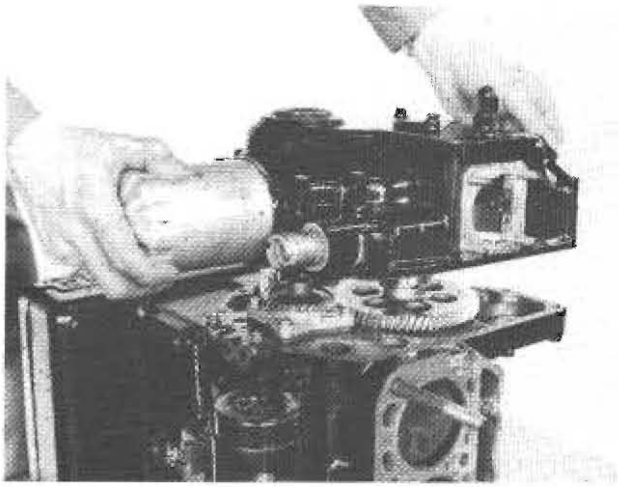


Fig. 2-4 Remove Gear Housing Assembly

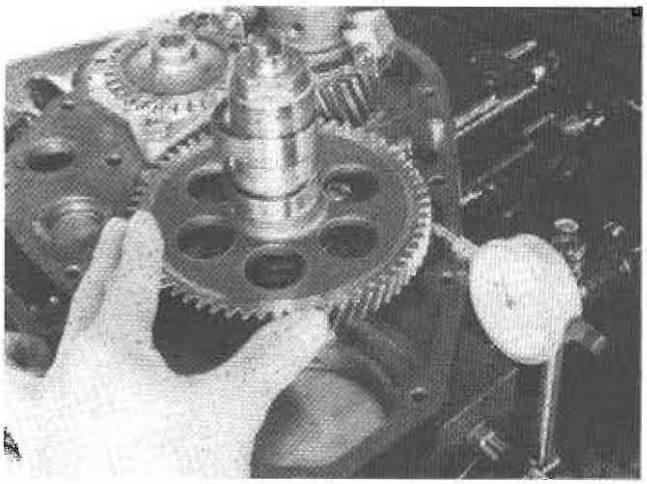


Fig 2-5 Checking Gear Lash

16. Remove gear housing assembly (Fig. 2-4).

17. Check the timing gear lash at this point (Fig. 2-5). If the lash is within specifications, there is a good possibility the gears are reuseable.

    Standard crankshaft gear to camshaft gear backlash is .0034 to .0051 in. (0.086 to 0.13 mm).

    Standard oil pump to crankshaft gear lash is .0034 to .0051 in. (0.086 to 0.13 mm).

    If the lash is excessive, discard the gears.

18. Remove governor from crankshaft gear. Remove governor sleeve. Remove gear nut and governor.

19. Remove oil pump assembly.

20. Remove oil pan dipstick and oil pan.

21. Remove connecting rod bearing caps. Withdraw the piston and connecting rod up through the cylinder bore after checking for a ring ridge.

    CAUTION: DO NOT use an air wrench on the rod cap bolts. Due to their close fit, the rapid speed will seize them in the cap.

    Arrange the connecting rods, bearing caps and pistons in correct order if they are to be reused. The connecting rods and caps are numbered by the manufacturer. Marking will not normally be needed.

22. Remove the flywheel. It is doweled and needs no marking.

23. Remove rear main bearing housing bolts and intermediate main bearing housing set bolt.

24. Using a plastic or soft hammer as a drift (Fig. 2-6), drive the crankshaft free of the crank gear and front and rear main bearings. Remove crankgear. Carefully withdraw crankshaft through flywheel end with intermediate and rear main bearing housings attached.

25. Remove intermediate and rear main bearing housings from crankshaft.

26. Remove camshaft retainer screw (Fig. 2-7). Remove the camshaft.

    CAUTION: Be careful to avoid damaging the camshaft bearings.

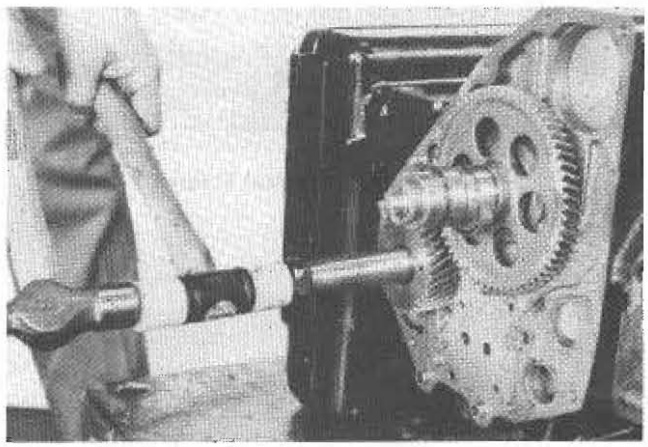


Fig. 2-6 Crankshaft Removal

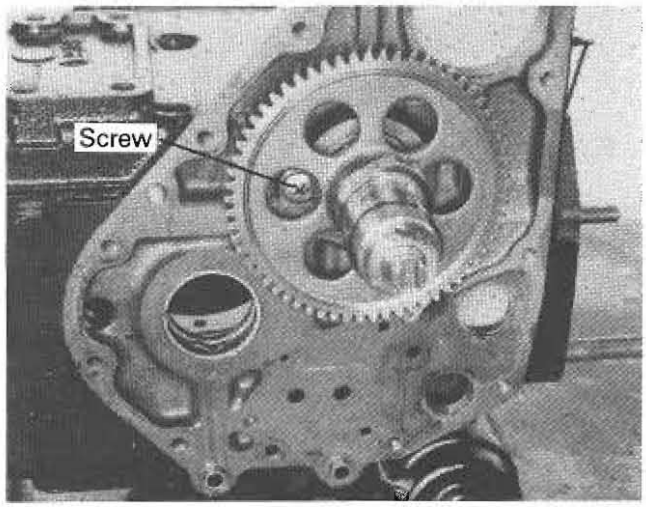


Fig. 2-7 Camshaft Retainer Screw

27. Remove the tappets. Keep tappets with their respective cylinders.

28. Thoroughly clean and inspect cylinder liner. Run deglazer in and out of cylinder liner quickly to remove varnish to improve heat transfer.

29. Check cylinder liners for wear, out-of-round, pocketing, or any other problems that would require replacement. The inside diameter of the liner should not be greater than 2.8398 in. (72.13 mm) or .0024 in. (0.06 mm) out-of-round (Fig. 2-9).

30. Remove cylinder liner with a suitable puller.

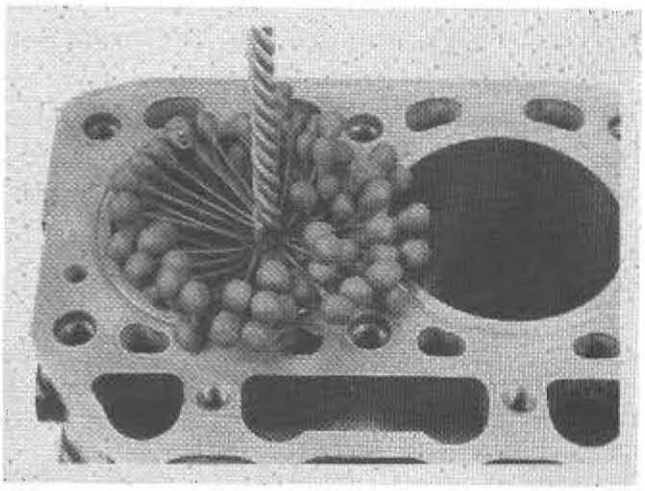


Fig. 2-8 Breaking Glaze on Cylinder Liner

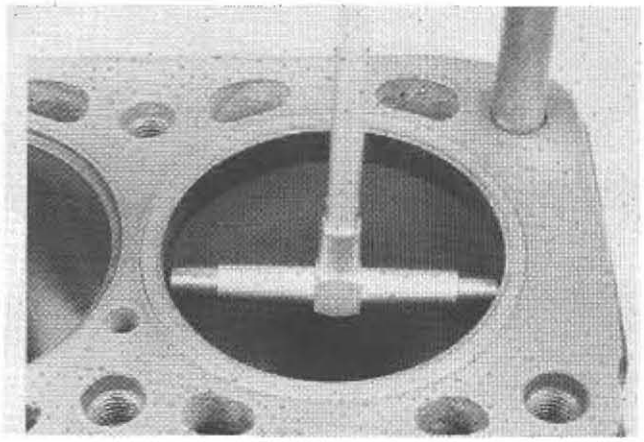


Fig. 2-9 Cylinder Liner Measurement

3

Inspection and Reconditioning

Contents

Inspection and Reconditioning

Now that the engine is disassembled, this section will cover the cleaning, inspection, overhaul and reassembly of individual engine components. The following section of this manual describes the reassembly of the engine.

After disassembling the engine, check the component parts and discard unuseable parts such as gaskets, burned valves, broken rings, etc. Items that may require machine shop work should be checked first so that this work can be completed by the time the engine is ready for reassembly.

CYLINDER BLOCK

1. Thoroughly clean the cylinder bore and liners. Inspect the block and the outer surface of the cylinder liner for evidence of pitting or corrosion. If the liner or cylinder bore ledge is eroded to the extent that sealing is affected, the cylinder liner or block must be replaced.

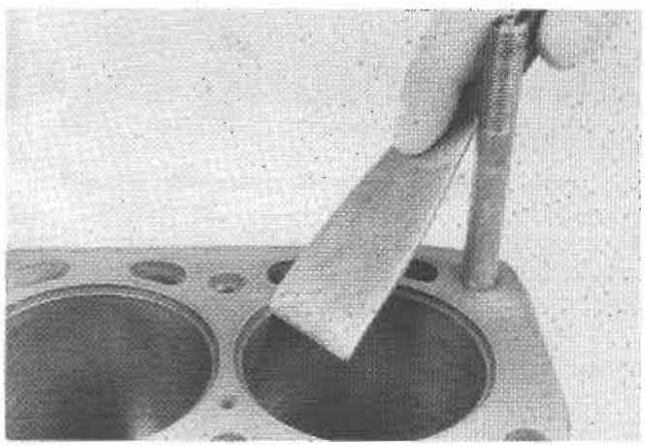


Fig. 3-1 Inspect and Clean Cylinder Bore and Ledge

2. Inspect the cylinder block for cracks, damage and distortion. Using a straight edge and feeler gauge, check the block to head mating surface. If there is more than .0028 in. (0.070 mm) distortion on the two-cylinder engine block or .0039 in. (0.1 mm) distortion on the three-cylinder block, resurface the block.

3. Inspect the tappet bores in the block and check tappet to bore clearance with a small hole gauge and micrometer. Tappet clearance should be .0002 to .0014 in. (0.006 to 0.035 mm). There is very little, if any, wear associated with these bores.

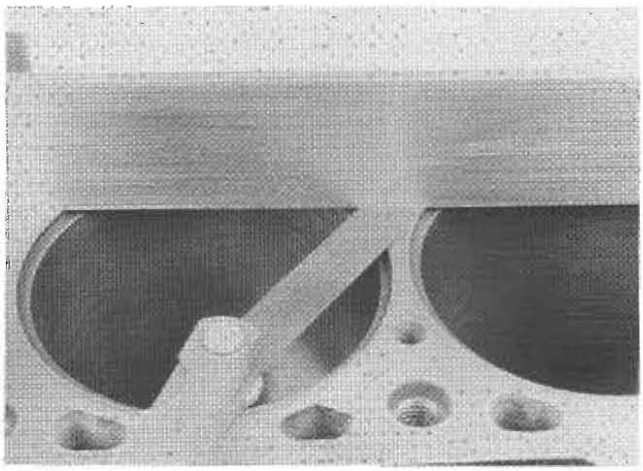


Fig. 3-2 Measuring Block Distortion

4. Coat the exterior outer surface of the cylinder liner with engine oil. Insert the coated liner into the cylinder block by hand. If the cylinder liners are replaced, check the diameter and roundness of the new cylinder liner. Standard cylinder liner diameter is 2.83 in. (72.0 mm) and out-of-roundness should be .001 in. (0.025 mm).

5. Check the projection of the cylinder liner above the block head (Fig. 3-3). If the top edge of the cylinder liner is below deck, the liner will not seal properly to the cylinder head. Excessive projection will increase the top clearance and damage the gasket. Cylinder liner projection should be flush to .0030 in. (flush to 0.075 mm). If the cylinder liner projection is below deck or excessive, try another liner or file it down.

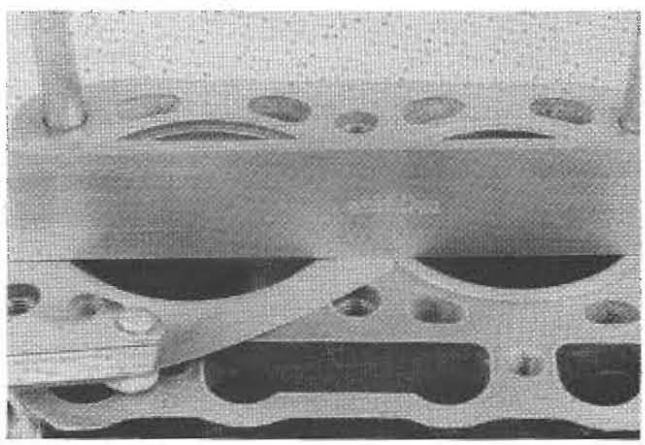


Fig. 3-3 Measuring Sleeve Projection

PISTONS

1. Remove and discard the old piston rings.
2. Measure the piston diameter (Fig. 3-4). The measurement should be taken .3543 in. (9.0 mm) up from the bottom of the skirt and at a right angle to the piston pin. Piston diameter should not be less than 2.8287 in. (71.85 mm).

   NOTE: When working with a piston and rod assembly, do not clamp it in a steel jaw vise. Use a soft jaw vise or use soft covers over the steel jaws. Clamping the rod in a steel vise will put small nicks in the rod. These become stress raisers and can cause premature rod failure.

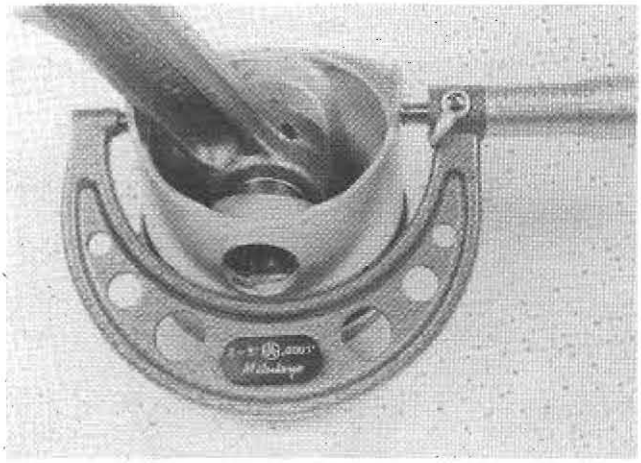


Fig. 3-4 Piston Measurement

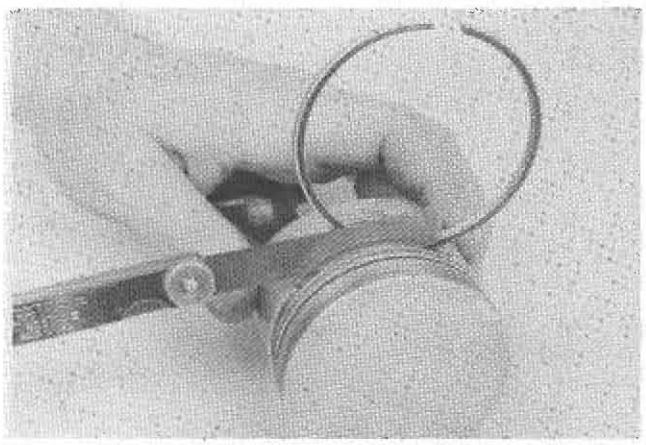


Fig. 3-5 Checking Ring Groove Clearance

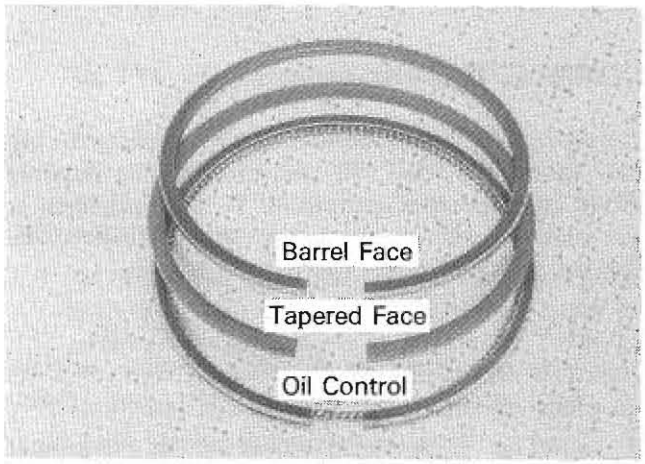


Fig. 3-6 Piston Ring Identification

3. Clean the ring grooves with a ring groove cleaner, being careful not to scrape any metal from the piston. If it is not possible to obtain a ring groove cleaner, a used ring can be broken and sharpened to do the job.
4. Using a new set of piston rings, check the ring to groove clearance by inserting a feeler gauge along with the ring and roll it all the way around the piston ring groove. Excessive side clearance requires piston replacement. Do not install rings yet; ring end gap will need to be checked.
5. Use a long .0010 in. (0.025 mm) feeler gauge, and check the clearance between the cylinder liner and piston. Lay it against the piston vertically at a position 90° from the wrist pin holes. This is the widest part of the piston. Now carefully try to insert the piston along with the feeler gauge into the proper cylinder bore. The piston and gauge should be able to be pulled out using a 1 to 3 lb. (0.043 to 1.3 kg) pull. The clearance should not exceed .0118 in. (0.3 mm). Check top and bottom of cylinder bore to make sure there is no taper.

PISTON PINS

The wrist pin and bushing carries a great deal of load concentrated in a small area, and the fit is very critical. It is recommended that a qualified machine shop do the pin fitting when the engine is overhauled.

1. Because of the very close tolerances (.0010 to .0019 in. [0.025 to 0.047 mm]) involved between the wrist pin, piston bore and rod bushing, measuring wear becomes very difficult using standard micrometers and small hole or telescopic gauges.

   If precision gauging equipment is not available, the wrist pin to bushing fit can be checked by oiling the wrist pin and inserting it in the bore. It should be snug and require at least a hand push fit.
2. Measure the piston pins and replace any piston pins that exceed .0010 in. (0.025 mm) wear (outside diameter less than .7866 in. [19.98 mm]).

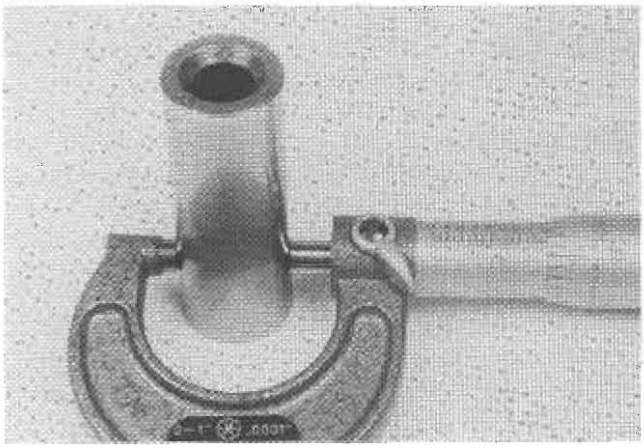


Fig. 3-7 Wrist Pin Measurement

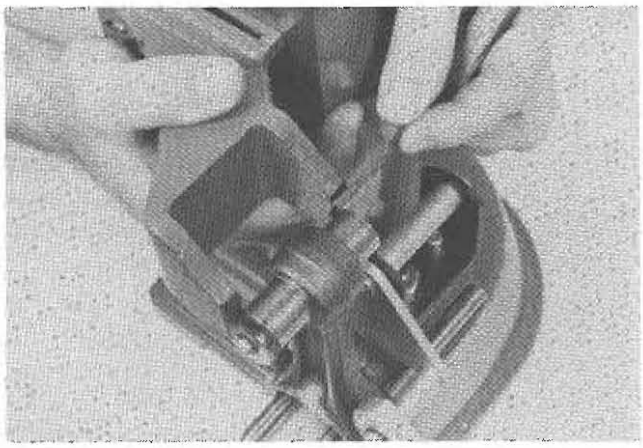


Fig. 3-8 Checking Rod Twist

CONNECTING RODS

The procedures for reconditioning a rod, honing the big end, fitting the wrist pin and straightening requires varied and expensive equipment. If this equipment is not available, most machine shops are able to recondition the rods to like-new specifications.

1. The connecting rods should, if possible, be glass bead cleaned, which in turn, stress relieves them.

   NOTE: A glass bead cleaner does an exceptional job of cleaning a rod and is highly recommended. Most machine shops offer this service and the price is usually quite reasonable.

2. Use a rod alignment fixture to check for connecting rod twist or parallelism (Fig. 3-8 & 3.9). The service limit is .0031 in. (0.08 mm) per 4 in. (100 mm). If the rod is twisted or bent beyond the service limit, the rod will have to be straightened or replaced.

3. Press out the piston pin bushing using a suitable tool. Reinstall the new bushing, and if a bushing expanding tool is available, expand the bushing in the bore. Ream or hone the new bushing to the finished size. Each bushing is usually fitted to its own individual pin.

   The inside diameter of the piston pin bearing should be no greater than .7913 in. (20.1 mm).

4. The connecting rod and cap should be assembled and torqued to 16-20 ft/lb (22 to 27 N·m) without the bearing. Measure the big end bore, and if there is more than .0010 in. (0.025 mm) out-of-round, the big end should be reconditioned. Standard big end bore inside diameter is 1.6929 to 1.6935 in. (43.000 to 43.016 mm).

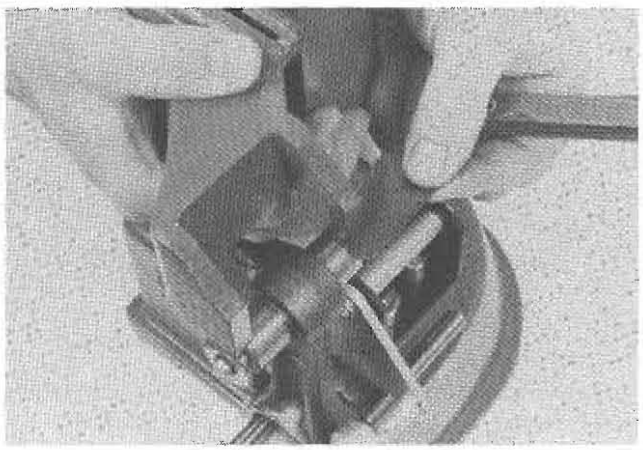


Fig. 3-9 Checking Rod Parallelism

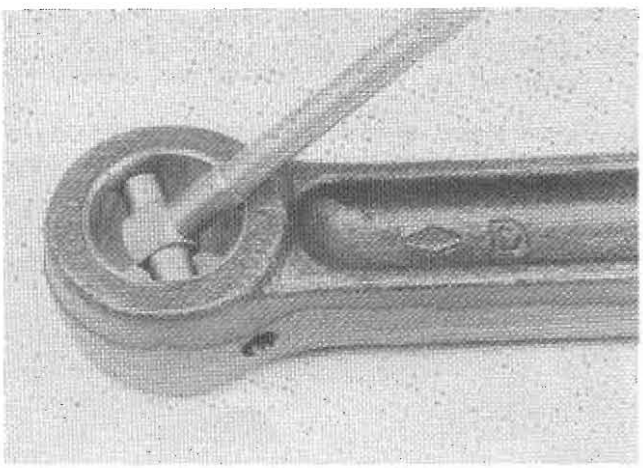


Fig. 3-10 Checking Piston Pin Rod Bearing Bore

5. The connecting rod and cap should be assembled with the bearing and torqued to 16 to 20 ft/lb (22 to 27 N·m). If the inside diameter exceeds 1.5795 in. (40.12 mm), replace the bearing.

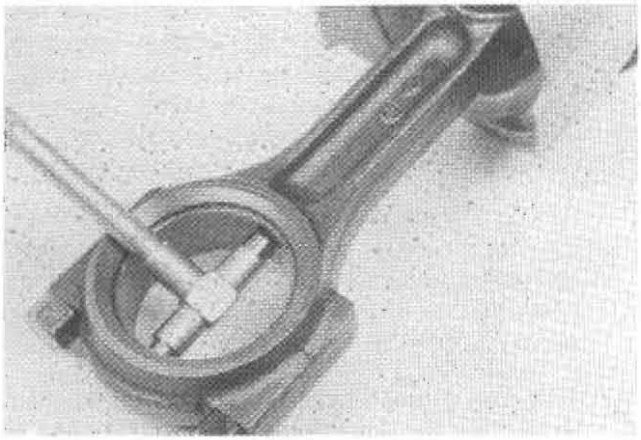


Fig. 3-11 Measuring Rod Bearing Inside Diameter (torqued)

CRANKSHAFT

1. Remove the rear and intermediate main bearing housings from the crankshaft.

2. Check the crankshaft journals, crankpins and oil seal surface for evidence of wear, damage or clogging of oil ports. Inspect the front (gear end) shaft, seal surface and crankshaft gear for damage or wear. Check the rear (flywheel end) seal surface for a groove left by the lip seal. If there are grooves in the surface, the crankshaft should be replaced or repaired.

3. Measure the crankshaft main journals. The diameter of the main journal should be 2.3583 to 2.3608 in. (59.90 to 59.964 mm) on the flywheel end journal. The diameter should be 1.7283 to 1.7309 in. (43.90 to 43.964 mm) on the intermediate and gear end journals.

   If there is more than .0010 in. (0.025 mm) out-of-round or taper wear on any of the main journals, replace the crankshaft.

4. Measure the rod journals. The diameter should be 1.5717 to 1.5732 in. (39.92 to 39.96 mm). If there is more than .0010 in. (0.025 mm) out-of-round or taper wear on any of the rod journals, replace the crankshaft.

5. Inspect the main bearings and main bearing housings. Measure the inside diameter of the flywheel and gear end crankshaft main bearings. The inside diameter of the flywheel end bearing should be 2.3622 to 2.3669 in. (60.0 to 60.12 mm). The inside diameter of the gear end main bearing should be 1.7323 to 1.7370 in. (44.0 to 44.12 mm). The main bearing inside diameter should be measured twice, 90° to each other. If the wear exceeds the service limit or the bearing is out-of-round, replace the bearing.

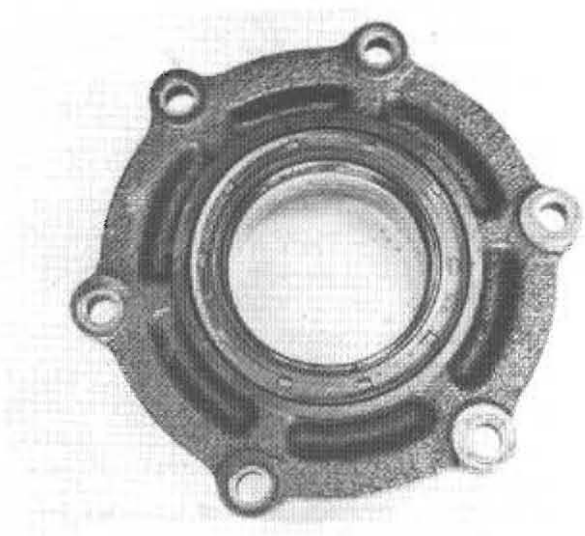


Fig. 3-12 Main Bearing Cover Assembly

6. Use the special insertion and extraction tool to remove the main bearings from the flywheel end main bearing housing and the gear end of the engine block.

   NOTE: The main bearing housing must be installed on the cylinder block to replace either the gear end or flywheel end main bearing. The insertion and extraction tool is designed to utilize one end main bearing as a guide while the other end main bearing is removed or installed.

7. To remove the gear end (front) main bearing from cylinder block, assemble special insertion/extraction tool in the cylinder block as shown in Fig. 3-13. Refer to Fig. 3-14 to see clearly the position and relationship of the pieces assembled in the block in Fig. 3-13.

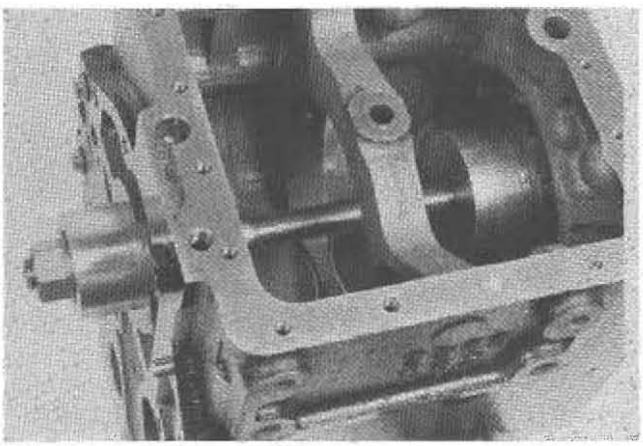


Fig. 3-13 Insertion and Extraction Tool Assembled in Block for Gear end Main Bearing Removal

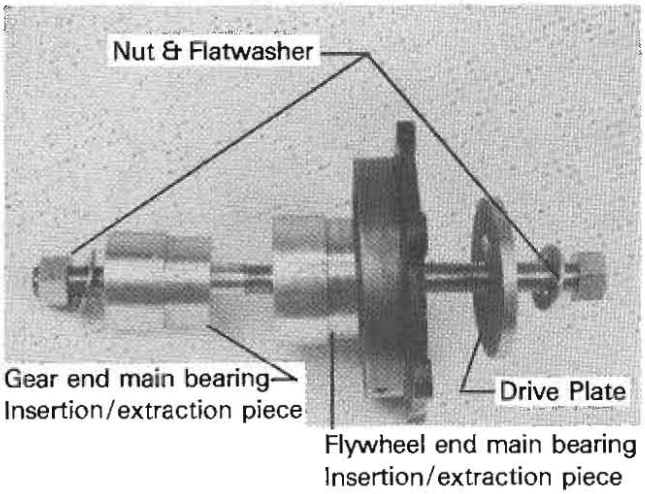


Fig. 3-14 Proper Arrangement of Insertion & Extraction Tool Pieces for Gear End Main Bearing Removal

First position the gear end (small) main bearing insertion/extraction piece in the gear end main bearing from the outside of the block. Then install the flywheel end insertion/extraction piece in the flywheel end main bearing from the inside of the block. Insert the 5/8 inch diameter bolt through both insertion/extraction pieces and install drive plate on flywheel end against main bearing housing. Install flatwasher and nuts and tighten in place. Pull gear end bearing into engine block cavity by tightening nut on flywheel end of block.

8. To install the gear end (front) main bearing in the cylinder block, assemble the special insertion/extraction tool in the cylinder block as shown in Fig. 3-15.

   First install the flywheel end insertion/extraction piece in the flywheel end main bearing from the inside of the block.

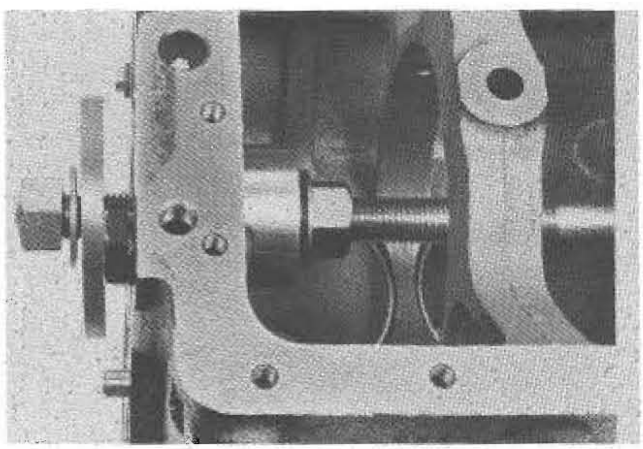


Fig. 3-15 Insertion & Extraction Tool Assembled in Block for Gear End Main Bearing Insertion

Next insert the long thread end of the 5/8 inch bolt through the flywheel end insertion/extraction piece and part way into the engine block cavity. Install a nut and flatwasher on the bolt. Place the bearing on the gear end insertion/extraction piece and position in gear end bore inside the block.

CAUTION: Make sure the oil hole in the bearing and block are aligned. Also be sure the chamfered lip of the bearing faces into the bore. Lubricate the outer surface of the bearing for easier installation.

Slide bolt through gear end insertion/extraction piece. Place the drive plate, washer and nut on the bolt. Tighten nut and washer against gear end insertion/extraction piece inside the block. Tighten the nut and washer against the drive plate on the outside of the block to pull the bearing into bore. The bearing should slide in smoothly without binding or pinching. Tighten nut until the bearing contacts the drive plate. Remove tool.

9. To remove flywheel end main bearing from main bearing housing, assemble special insertion/extraction tool in the cylinder block as shown in Fig. 3-16. Refer to Fig. 3-17 to see clearly the position and relationship of the pieces assembled in the block in Fig. 3-16.

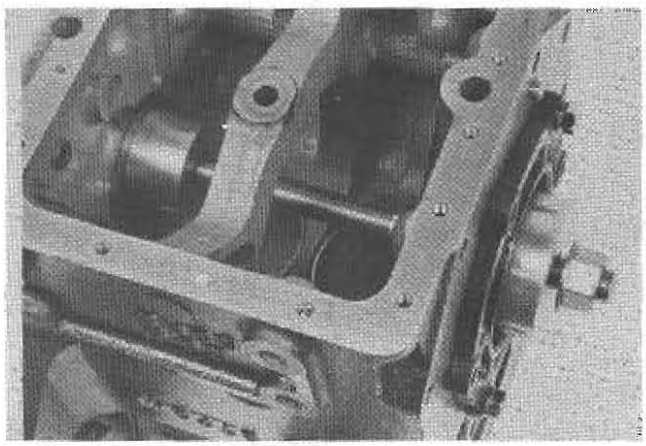


Fig. 3-16 Insertion & Extraction Tool Assembled in Block for Flywheel End Main Bearing Removal

First position the flywheel end insertion/extraction piece in the flywheel end main bearing from the outside of the block. Next install the gear end insertion/extraction piece in the gear end bearing from inside the block. Insert the 5/8 inch diameter bolt through both insertion/extraction pieces and install drive plate on gear end against block surface. Install flatwashers and nuts and tighten in place. Pull flywheel end bearing into engine block cavity by tightening nut on gear end of block.

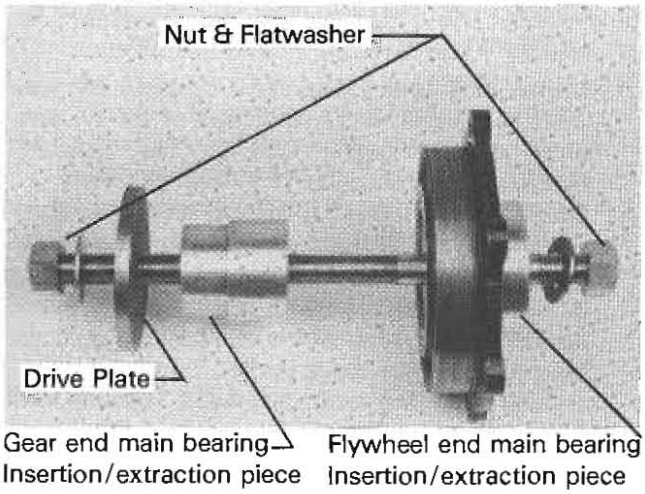


Fig. 3-17 Proper Arrangment of Insertion & Extraction Tool Pieces for Flywheel End Main Bearing Removal

10. To install the flywheel end main bearing in the main bearing housing, assemble the special insertion/extraction tool in the cylinder block as shown in Fig. 3-18.

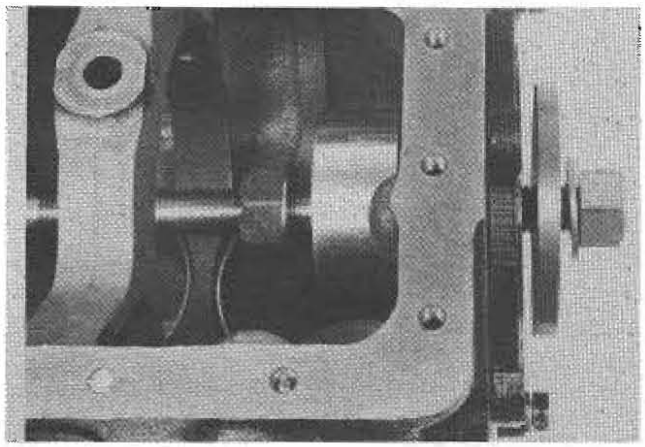


Fig. 3-18 Insertion & Extraction Tool Assembled in Block for Flywheel End Main Bearing Insertion

First install the gear end insertion/extraction piece in the gear end main bearing from the inside of the block.

Next insert the long thread end of the 5/8 inch bolt through the gear end insertion/extraction piece and part way into the engine block cavity. Install a nut and flatwasher on the bolt. Place the bearing on the flywheel end insertion and extraction piece and position the piece inside the block in the flywheel end bore in the main bearing housing.

CAUTION: Make sure the oil hole in the bearing and housing are aligned. Also be sure the chamfered lip of the bearing faces into the bore. Lubricate the outer surface of the bearing for easier installation.

Slide bolt through flywheel end insertion/extraction piece. Place the drive plate, washer and nut on the bolt. Tighten the nut and washer against the flywheel end insertion/extraction piece inside the block. Tighten the nut and washer against the drive plate on the outside of the main housing to pull the bearing into the bore. The bearing should slide in smoothly without binding or pinching. Tighten nut until the bearing contacts the drive plate. Remove tool.

11. Assemble the intermediate bearing housings together with the new bearing inserts and torque the housing bolts to 33 to 36 ft/lb. (45 to 49 N·m). The inside diameter of the bearing insert should be 1.7323 to 1.7370 (44.0 to 44.12 mm).

Measure the bearing inside diameter twice, 90° to each other.

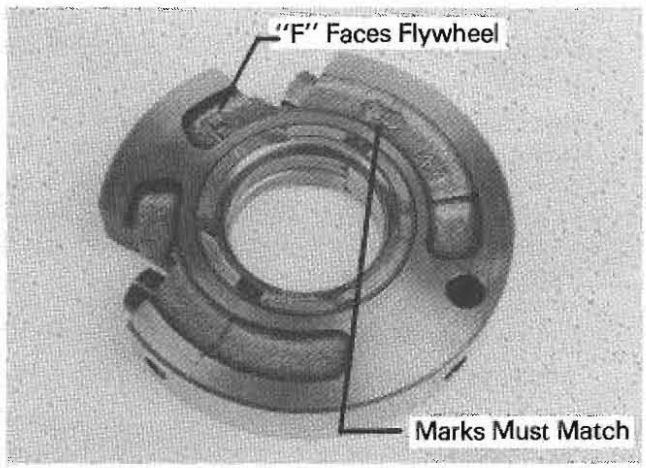


Fig. 3-19 Intermediate Main Bearing

12. Place a piece of plastic gauge on each intermediate main crankshaft journal. Disassemble intermediate main bearings and install bearings and housing on crankshaft. The "F" on the body of the main bearing must face the flywheel end of the crankshaft. Make sure the marks on the top and bottom of the bearings also match (Fig. 3-19). Tighten the housing bolts to 33 to 36 ft/lb (45 to 49 N·m). Remove caps and check the bearing clearance.

CAUTION: Intermediate bearing inserts can be installed upside down. Check oil hole alignment.

13. Reassemble bearings on crankshaft and torque housing bolts to 33 to 36 ft/lb (45 to 49 N·m).

CAUTION: The "F" on the body of the bearing housing must face the flywheel end of the crankshaft.

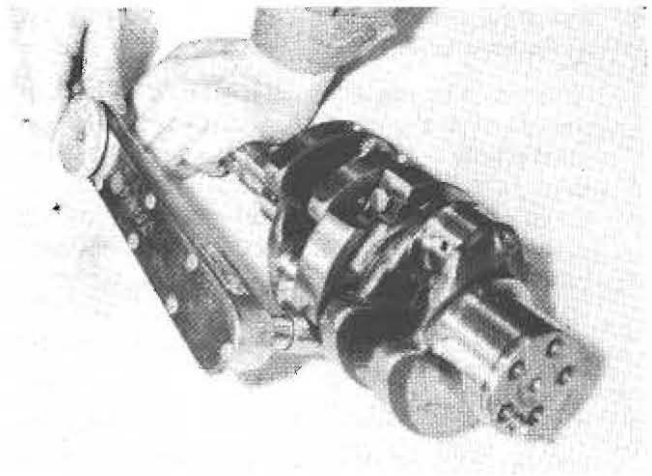


Fig. 3-20 Torque Housing Bolts on Crankshaft

CAMSHAFT

1. Check the journals and cam lobes for wear or damage.
2. Measure the cam lobe height (Fig. 3-21). The height of the intake or exhaust valve cams should be 1.3543 to 1.3780 in. (34.4 to 35.0 mm). The height of the injection pump cam should be 1.7520 to 1.7717 in. (44.5 to 45.0 mm).

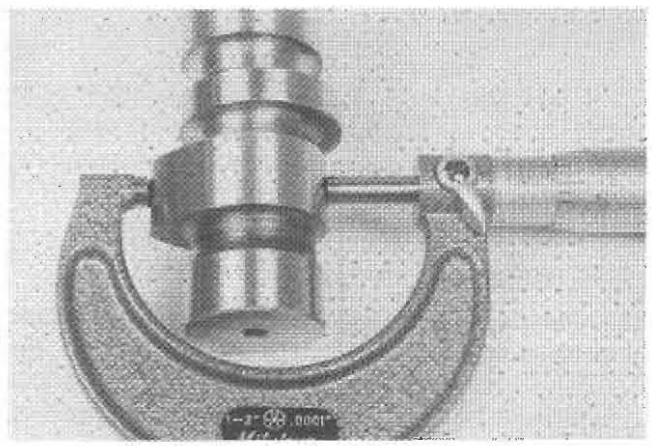


Fig. 3-21 Camshaft Lobe Measurement

Check the lobe faces for damage. Clean up slight imperfections.

If the valve cam lobe wear exceeds the limit, the camshaft should be replaced. If injection pump cam wear exceeds the limit, press off the camshaft gear and injection pump cam. Reinstall camshaft gear and new injection pump cam.

3. Measure the flywheel end camshaft journal diameters. The flywheel end journal diameter for the 2-cylinder engine should be 1.0606 to 1.0614 in. (26.94 to 26.96 mm). The flywheel end journal diameter for the 3-cylinder engine should be 1.1787 to 1.1795 in. (29.94 to 29.96 mm).
4. Inspect and measure the inside diameter of camshaft bushing in the flywheel end of the cylinder block (TK235 engine ONLY). The standard bushing inside diameter is 1.0626 to 1.0654 in. (26.99 to 27.06 mm). Replace the bushing or camshaft when the bushing to journal clearance exceeds .0059 in. (0.15 mm).

   Remove worn bushings with special bushing insertion/extraction tool. Drive old bushing through bore into cylinder block cavity. Using special insertion/extraction tool, insert new bushing with bushing notch on top, facing in (Fig. 3-22). Drive bushing in until the rear face of tool's collar is flush with the block surface (Fig. 3-23).

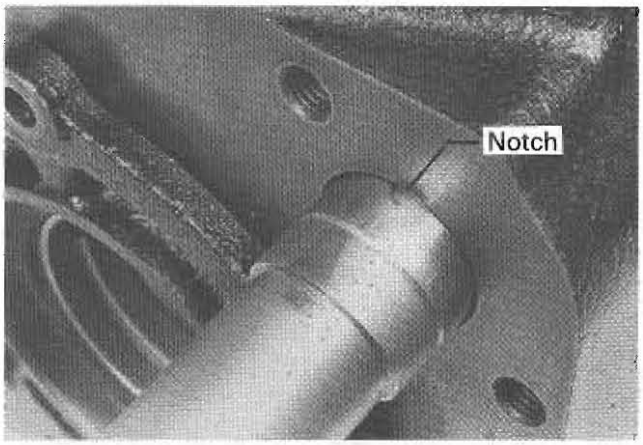


Fig. 3-22 Camshaft Busing Installation (TK235 only)

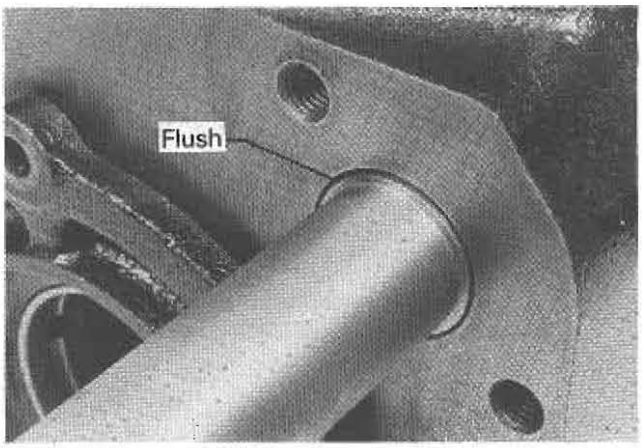


Fig. 3-23 Proper Installation Depth — Back of Tool Collar Flush with Block Surface

5. Inspect camshaft ball bearing for excessive play and free rotation. Inspect camshaft gear for wear and damage. Press off camshaft gear and injection pump cam to replace camshaft gear or ball bearing.

6. Measure camshaft deflection (TK353 engine only) with a dial indicator and a set of "V" blocks. Set the dial indicator on the gear end intermediate journal and zero the dial indicator. Rotate the camshaft one full turn and note the highest reading. The camshaft deflection is 50% of this figure. Replace the camshaft if there is more than .002 in. (0.051 mm) deflection.

7. Inspect oil passages and oil bleed holes for obstructions.

CYLINDER HEAD

Disassembly and Inspection

1. Drive out the front precombusion chamber assembly and packing very carefully with a soft punch.

2. With a valve spring compressor, remove the valve spring assembly and valves from the head (Fig. 3-24).

   NOTE: When you remove the valves from the cylinder head, be sure to MARK the cylinders and keep the parts of each intake and exhaust valve SEPARATE.

3. Remove valve stem seals and discard.

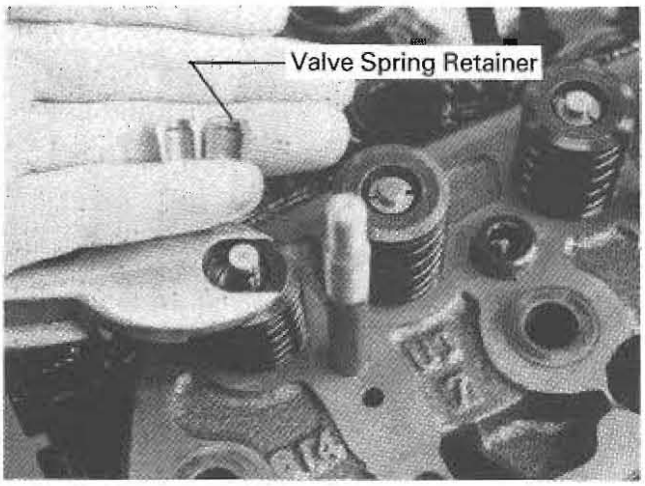


Fig. 3-24 Valve Removal

4. Inspect cylinder head for cracks, damage and distortion (Fig. 3-25). Use a straight edge and feeler gauge to measure distortion. If there is more than .0028 in. (0.070 mm) distortion on the two-cylinder engine head or .0039 in. (0.10 mm) distortion on the three-cylinder head, resurface or replace the head.

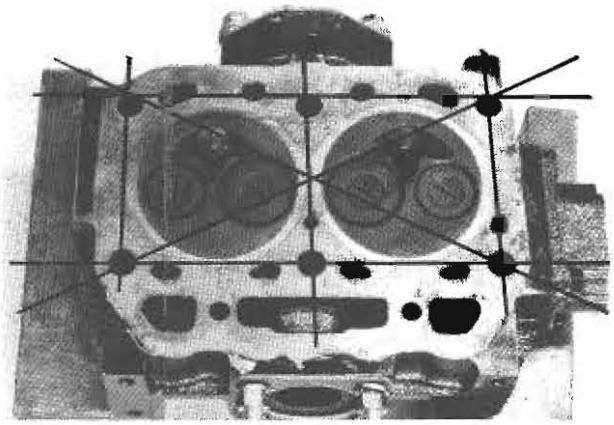


Fig. 3-25 Check Head Distortion

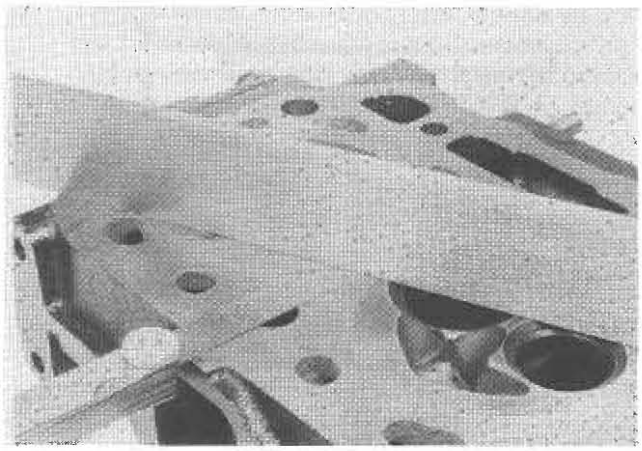


Fig. 3-26 Measuring Head Distortion

Valve Springs

Check valve spring for squareness, free length, compressed length and pressure, and tilt. If the spring exceeds the service limits for free length, compressed length and pressure, tilt or squareness, replace the spring.

Valves

1. Inspect and measure the valve stems. Standard size is .2740 to .2744 in. (6.96 to 6.97 mm). Replace valves that are worn to .2717 in. (6.9 mm).

2. Check the valve margin. If there is less than .0276 in. (0.70 mm) margin left, replace the valves.

3. Check for bent valves in the grinding machine. There should not be more than .0012 in. (0.03 mm) deflection.

4. Regrind the valve face angle to 45°.

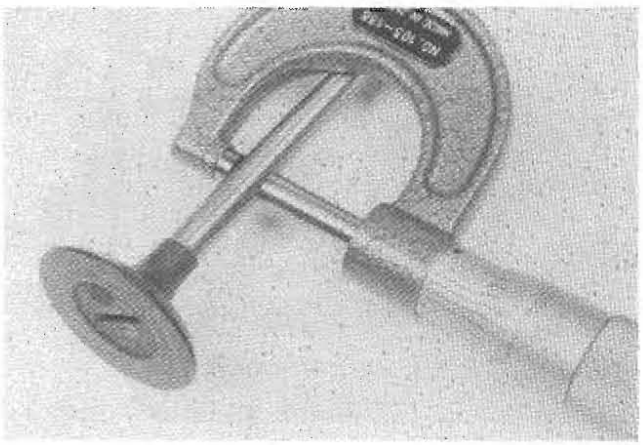


Fig. 3-27 Measuring Valve Shaft Diameter

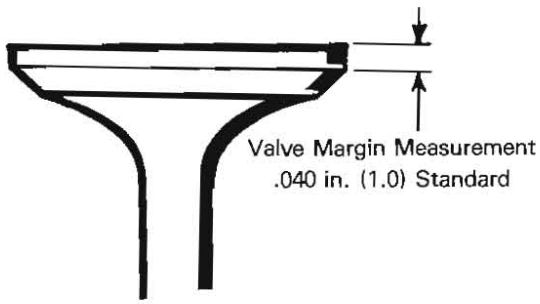


Fig. 3-28 Valve Margin

Valve Guides

1. Use a valve guide carbon cleaner to remove carbon from the guides. Check the valve stem to valve guide clearance. Replace valves in their respective seats and raise the valve 3/8 in. (9.53 mm). Check lateral deflection in four directions. Lateral deflection should not exceed .0250 in. (0.635 mm). If the valve guide wear (lateral deflection) is excessive, replace the guides.

   If the engine has accrued a great many hours of running time, it is a good idea to replace the guides as they are usually worn. Because the valve seat grinding procedure is piloted off of the guides, a new straight guide will ensure an accurate valve seat.

2. Remove the valve guides with a press or tool, driving the valve guides out from the top of the cylinder head down.

3. Reinstall the new valve guides using a press. Press the guides in from the top of the cylinder head. Insert the guides until the outer groove reaches the cylinder head surface (Fig. 3-29).

CAUTION: Be sure not to mix intake and exhaust valve guides. The exhaust valves guides have a special gas groove on their inside surface.

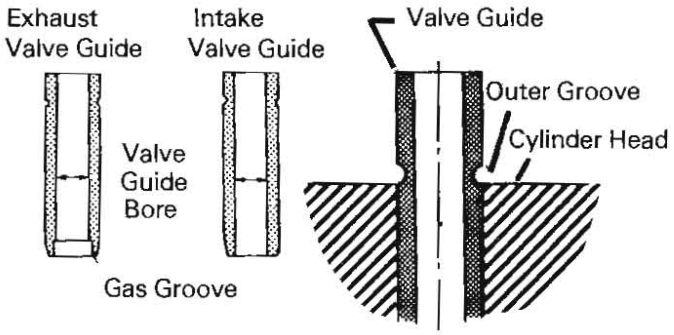


Fig. 3-29 Valve Guide Insert Position

Valve Depth

A very critical dimension for most diesel engines is the depth that the valves are set down into the head (valve depth). If they are set too deep (the result of valve grinding), the combusion chamber volume enlarges and the compression ratio drops. This, in turn, results in hard starting. It is very important to check valve depth before any valve or seat grinding is attempted. If this dimension is already at the limit, the cylinder head may have to be replaced.

1. To check valve seat depth, reinstall the valves in their respective seats and check the depth (Fig. 3-30). Valve seat depth should be .0374 to .0492 in. (0.95 to 1.25 mm).

2. If the depth has not exceeded the specified limit, grind the valves and recheck the depth.

3. If the limit still has not been exceeded, go ahead and grind the seats.

4. If the depth figure is now beyond specifications, the valve will have to be replaced.

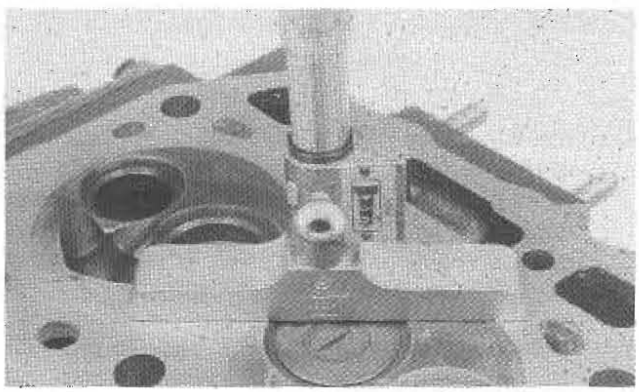


Fig. 3-30 Checking Valve Depth

Valve Seat Grinding

1. If the valve depth is not excessive, grind the seats to a 45° angle. The valve guide bore is .2760 in. (7 mm) in diameter.

   If the seat width becomes excessive (more than .0697 in. [1.77 mm]), 15° and 70° stones may be used to narrow and also raise or lower the seat.

   As the seat is being ground, periodically check the seating of the valve with Prussian Blue or a similar type of dye, making sure the seat is contacting as close to the middle of the valve face as possible.

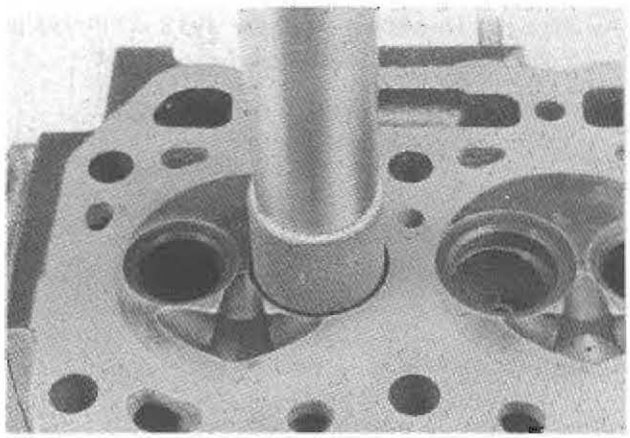


Fig. 3-31 Using Valve Seat Grinding Equipment

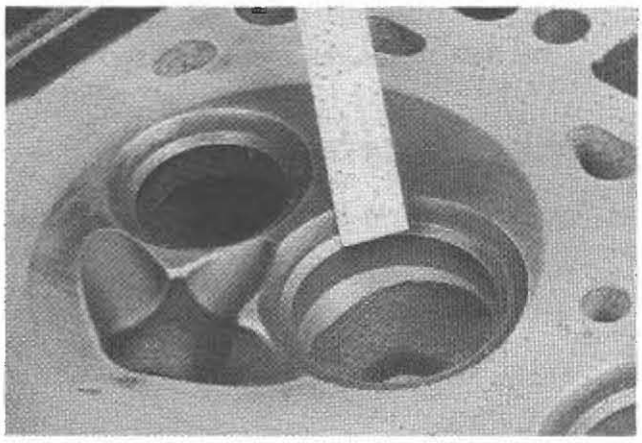


Fig. 3-32 Seat Width Measurement

2. After all valve seats have been ground, the valves may be lapped. Put a small amount of a medium grit compound on each valve face and, using a valve lapping tool, spin the valve against the seat for a short period. Then lift the valve and rotate it about a quarter of a turn. Drop the valve back into the seat and continue lapping. Repeat this procedure until the compound is used up. Remove all traces of grind compound with a thorough cleaning.

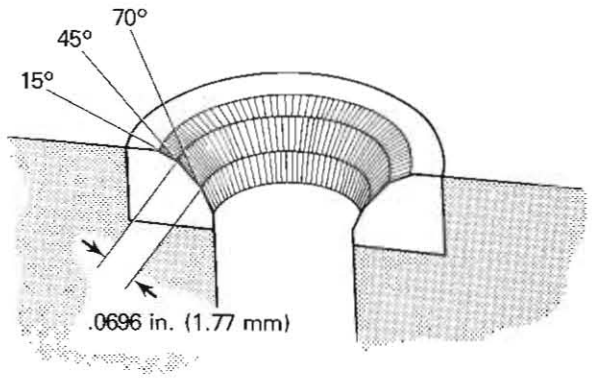


Fig. 3-33 Valve Seat Angle

Rocker Arm Shaft Assembly

1. To disassemble, remove the clips at both ends of the rocker arm shaft. Then remove the springs, rocker arms and brackets. Arrange the rocker arms in the sequence of disassembly to ensure ready reassembly into correct position.

   NOTE: The intake and exhaust valve rocker arms differ in shape and size. When disassembling and reassembling, be sure to carefully identify them.

2. Measure and inspect the rocker arm shaft and bushings. The outside diameter of the shaft should be .5472 to .5512 in. (13.9 to 14.0 mm). The inside diameter of the bushing should be .5518 to .5551 in. (14.016 to 14.108 mm). Replace worn or damaged parts. Remove the bushing with a press. Press the new bushing in and hone to size (.5518 to .5525 in. [14.016 to 14.034 mm]).

3. Check wear on rocker face. Recondition or replace.

4. Reassemble the rocker shaft, stands, rocker arms, springs, etc. Be sure to loosen all the valve lash adjustment screws.

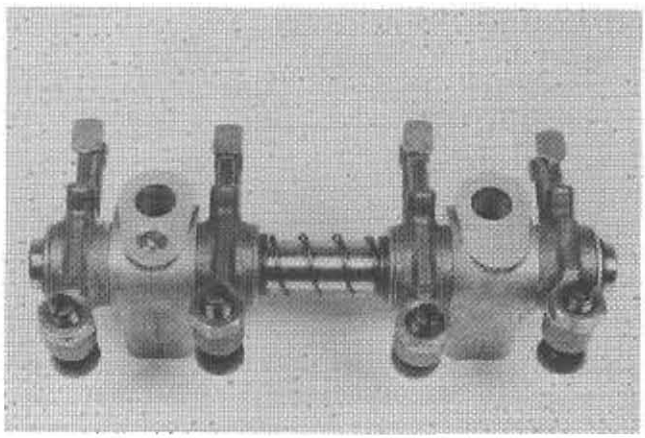


Fig. 3-34 Rocker Arm Shaft Assembly

Cylinder Head Reassembly

1. After all cylinder head components have been reconditioned, reground or replaced, the head is ready for reassembly.
2. Install new valve stem seals.

   NOTE: New seals should always be used.

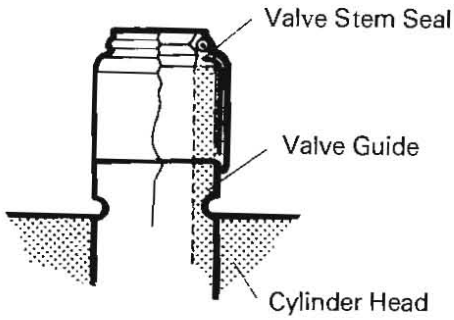


Fig. 3-35 Valve Stem Seal

3. Coat valve stem with oil and install valves in cylinder head. Oil coating prevents stem from seizing in new valve stem oil seal.
4. Install valve springs and retainers.
5. After the valves are installed, place the head on its side and fill up the exhaust ports with diesel fuel. Check the exhaust valves for leakage. Repeat the procedure for the intake valves. Only a slight seepage should be noticed coming from the valves.

   NOTE: If the leakage seems excessive, the leaking valve will have to be removed and lapped again.

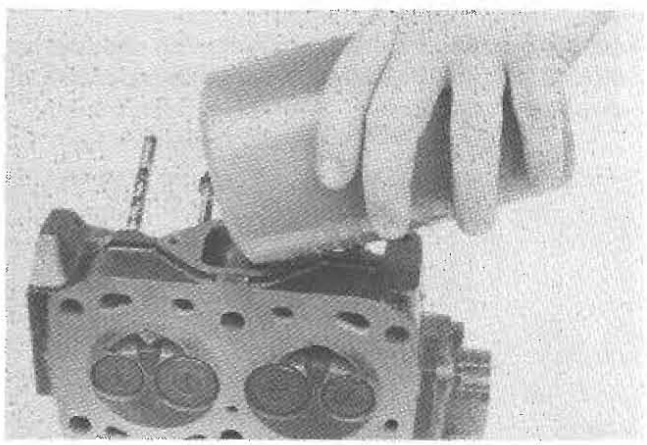


Fig. 3-36 Testing Sealing Ability of Valves

6. Install hard caps on valves and grease top of caps. Install valve rocker arm supports and rocker arm assemblies on cylinder head.

PUSH RODS

1. Check the push rods for bending and wear at the ends. Roll the push rod on a flat surace. Replace the rods that do not roll smoothly.

LIFTERS

1. Inspect the face of the tappets for wear or damage. Place a straight edge on the tappet face and hold in front of a light. Tappet face should have a slight crown (convex surface) or be flat. Replace worn tappets. Measure the outside diameter of the lifter with a micrometer, and replace those that exceed the wear limit. Lifter diameter should be .3917 to .3935 in. (9.950 to 9.995 mm).

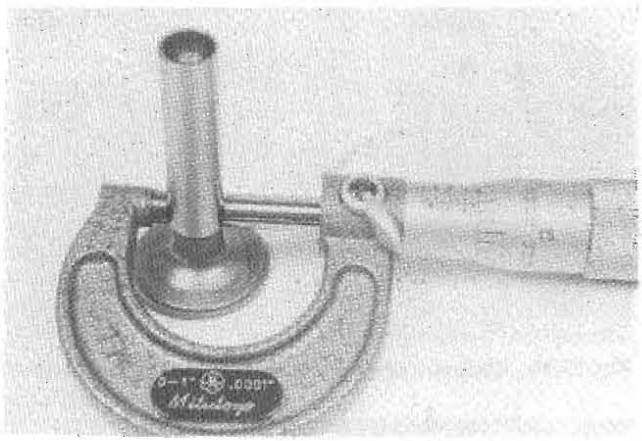


Fig. 3-37 Measuring Valve Tappets

ENGINE LUBRICATION SYSTEM

The TK235 and TK353 diesel engines have a pressure lubrication system. Oil is circulated by a trochoid gear type oil pump driven off a gear on the crankshaft and has several times the capacity required by the engine, the excess being returned to the crankcase. Oil is supplied by a suction tube with a screened inlet which picks up clean oil without any residue which may have settled in the bottom of the pan.

From the oil pump, the oil is forced through a pressure regulator to a full-flow filter, then to the oil gallery. Oil from the gallery flows to camshaft journals.

Connecting rod bearings are supplied through drilled passages in the crankshaft. Tappets and cylinder walls are lubricated by oil thrown from connecting rod bearings as the crankshaft revolves. From the rear camshaft bearing passageway, oil is piped outside the engine to the rocker arm shaft where the surplus drains back into the crankcase. Oil pressure is automatically regulated to 43 to 57 psi (294 to 392 kPa) by a spring-loaded relief

valve. Oil pressure may exceed this setting when the oil is cold.

Oil pressure is affected by oil temperature, viscosity and engine speed. Subnormal pressures usually may be traced to lack of oil, faulty pressure control valve, loose oil connections or worn bearings.

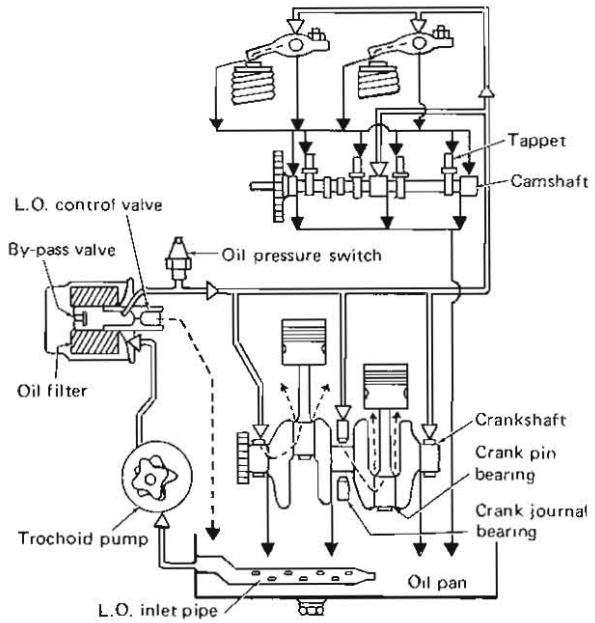


Fig. 3-38 TK235 Engine Lubrication System

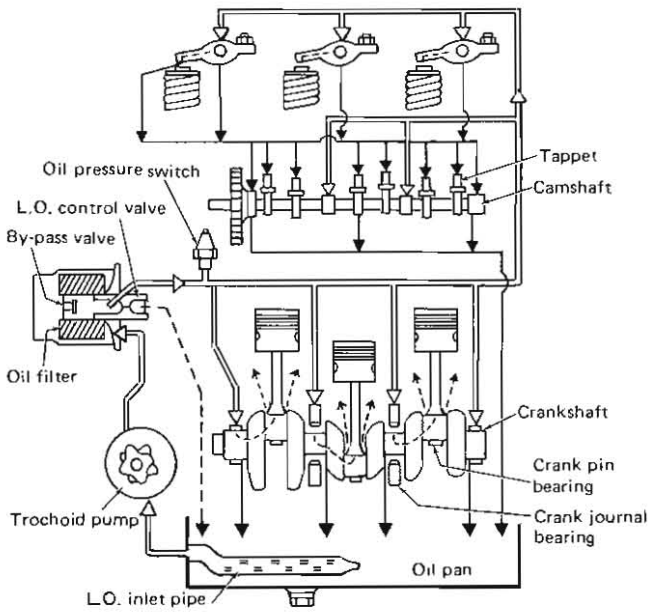


Fig. 3-39 TK353 Engine Lubrication System

Oil Pump

1. Visually inspect the vane, rotor and pump body for scratches or other damage. Reassemble the vane in the pump body.
2. Check for excessive clearance between the vane (outer rotor) and pump body.
3. The vane to pump body clearance should be .0004 to .002 in. (0.01 to 0.05 mm). If clearance exceeds .003 in. (0.08 mm), replace the oil pump.

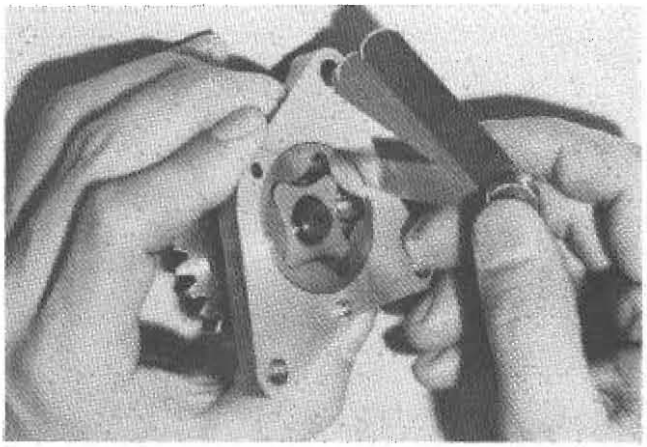


Fig. 3-40 Oil Pump Vane to Body Clearance

4. Check for excessive clearance between the rotor and vane with a feeler gauge. The vane to rotor clearance should be .0020 to .0040 in. (0.05 to 0.1 mm). If the clearance exceeds 0.006 in. (0.15 mm), replace the oil pump.

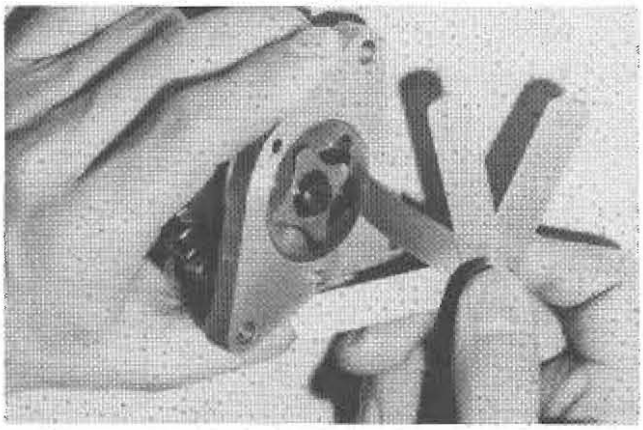


Fig. 3-41 Oil Pump Vane to Rotor Clearance

5. Check for excessive clearance between the pump cover and the vane rotor with a straight edge and feeler gauge. If the clearance exceeds .006 in. (0.15 mm), replace the oil pump.

WATER PUMP

Inspection

1. Make sure the pump shaft rotates smoothly.
2. Check to make sure there is no play on the pump shaft. If there is any play, replace the pump.
3. Inspect the impeller for damage or corrosion.
4. Check the seal hole for signs of leakage. If coolant leaks from the hole, disassemble the pump and replace the mechanical seal.

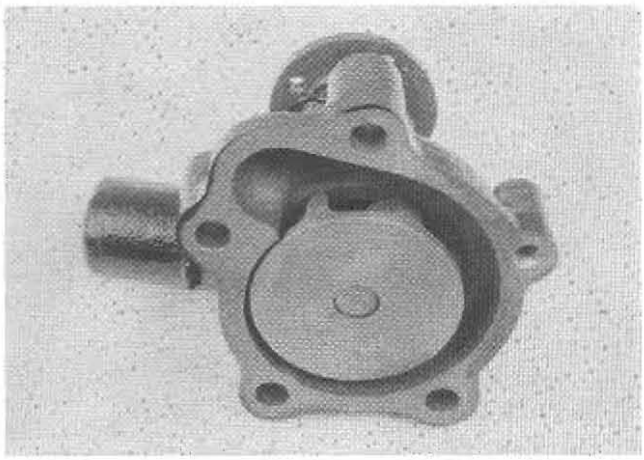


Fig. 3-42 Water Pump

Disassembly

1. Remove the impeller using a gear puller.
2. Remove mechanical seal.
3. Remove pulley flange from shaft with a gear puller.
4. Remove snap ring.
5. Press pump shaft and bearing assembly out the pulley side of the housing.
6. Check housing for cracks, wear or external damage. Clean thoroughly.
7. Discard the impeller, bearing unit and seal assembly because these parts are contained in a new repair kit.

Reassembly

1. Press new shaft and bearing into pump housing from pulley side of pump until the snap ring can be inserted.
2. Insert snap ring in housing.
3. Press pulley flange on shaft.

CAUTION: Shaft must be supported or snap ring or bearing may be damaged when pressing impeller or pulley mounting flange onto shaft.

4. Install mechanical seal on shaft.
5. Press impeller on shaft.

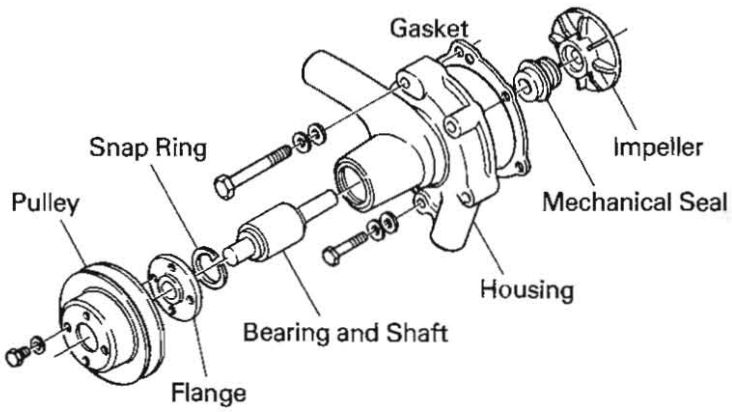


Fig. 3-43 Water Pump Assembly

4

Reassembly

Contents

Engine Reassembly

After the major components of the engine have been disassembled, repaired and reassembled, you are ready to reassemble the engine. During reassembly, it is very important to keep the engine as clean as possible. Dirt is one of the major factors in the failure of rebuilt engines. Do not reassemble the engine in an area where any type of grinding is done. Keep your workbench, tools and your hands clean. Keep sub-assemblies covered until they are needed. If you have to leave the engine for more than a short period of time, cover the engine until you return.

Make sure you carefully follow the reassembly order that is given because certain parts, if not installed in the correct order, will require the engine to be disassembled again so they can be installed.

Check all assembly tolerances such as end play, gearlash, etc., carefully. Neglecting these tolerances can cause serious problems later in the engine's life.

1. Install the starter mounting flange and alignment pins on the flywheel end of the cylinder block. Tighten the mounting bolt to 32 to 36 ft/lb (43 to 49 N·m).
2. Coat tappet barrels and faces with engine assembly compound or engine oil and install tappets.

   NOTE: This MUST BE DONE before camshaft is installed.
3. Apply oil to the camshaft ball bearing and gently install and tap shaft into place in cylinder block (Fig. 4-1). Install and tighten camshaft screw.

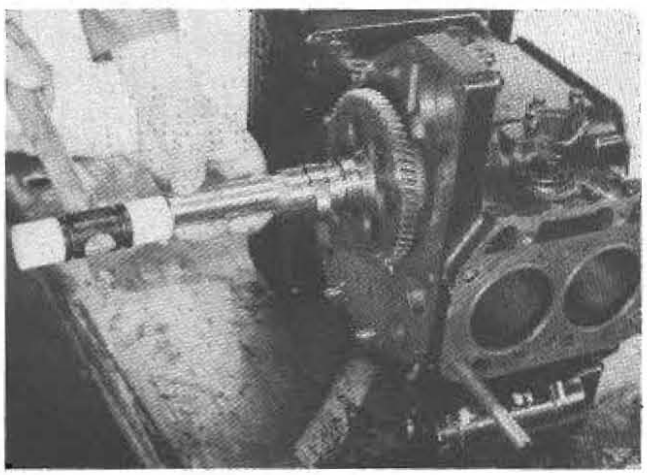


Fig. 4-1 Camshaft Installation

4. Use plastigauge to check crank pin to rod bearing oil clearance. Clean the inside surface of the crank pin bearing. Fit the connection on the crank pin of the crankshaft. Place a piece of plastigauge on the crank pin along the full length of the bearing surface. Coat bolts with oil. Install rod end cap and tighten bolts in steps to 16 to 20 ft/lb (22 to 27 N·m).

   CAUTION: Do not rotate the crankshaft when tightening the end cap rod bolts.

   Loosen bolts and measure clearance. Standard clearance should be .0011 to .0059 in. (0.028 to 0.15 mm).

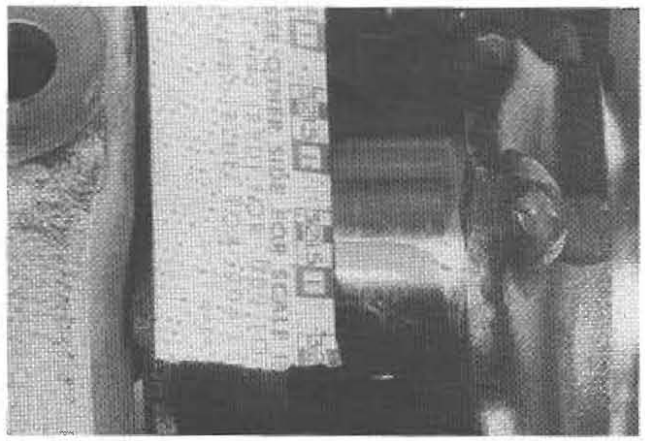


Fig. 4-2 Checking Rod Bearing Clearance

5. Replace connecting rod on crank pin. Using a feeler gauge, check rod side clearance. If the clearance is less than .0079 to .0197 in. (0.2 to 0.5 mm), the rod side faces can be lapped on a lapping board. Remove rod from crankshaft.

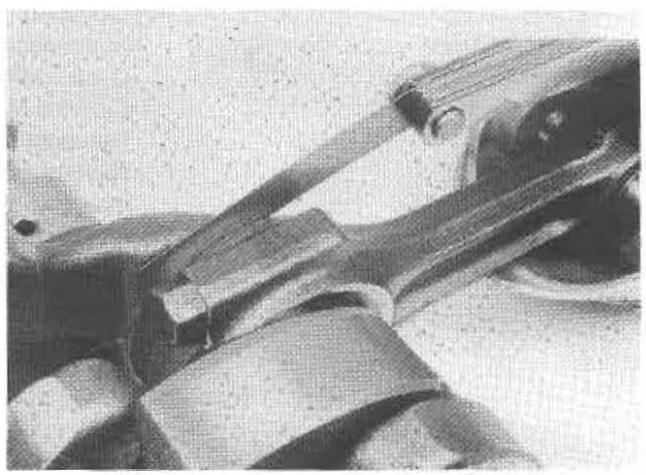


Fig. 4-3 Checking Connecting Rod Side Clearance

6. Place the engine on its side on a wooden base. Insert crankshaft. Align the intermediate main bearing set bolt holes (Fig. 4-4). Install and tighten intermediate bearing set bolt(s) to 22 to 25 ft/lb (30 to 34 N·m).

CAUTION: Make sure center main bearing alignment is correct. Refer to page 19.

7. Install new oil seal in main bearing housing. Coat the inside of the seal with light grease. RTV compound may be used on outer diameter only.

   Install main bearing housing on crankshaft and tighten mounting bolts to 18 to 19 ft/lb (24 to 26 N·m).

8. Using a dial indicator, check the crankshaft end play. It should be .0030 to .0120 in. (0.085 to 0.30 mm). If the clearance is excessive, the crankshaft, the intermediate main bearing (flywheel end intermediate bearing on TK353 engine) or both may have to be replaced.

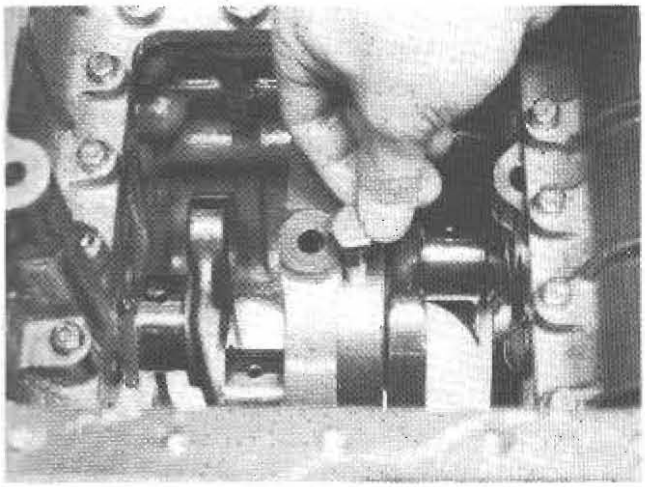


Fig. 4-4 Aligning Set Bolt Holes

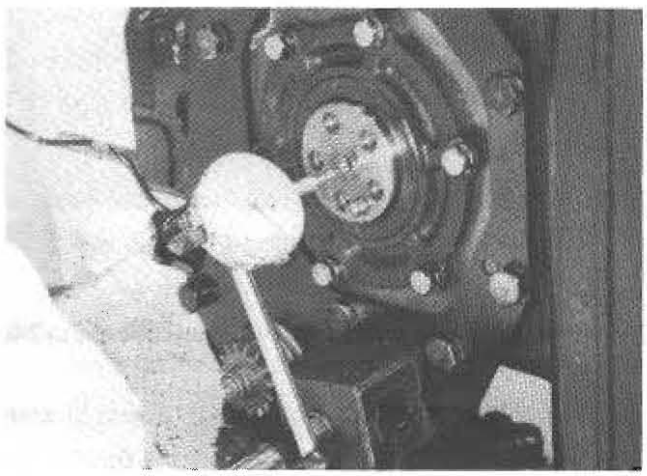


Fig. 4-5 Checking Crankshaft Endplay

9. Install the flywheel and torque mounting bolts to 47 to 50 ft/lb (64 to 68 N·m). Measure flywheel end runout. Should be within .0039 in. (0.1 mm).

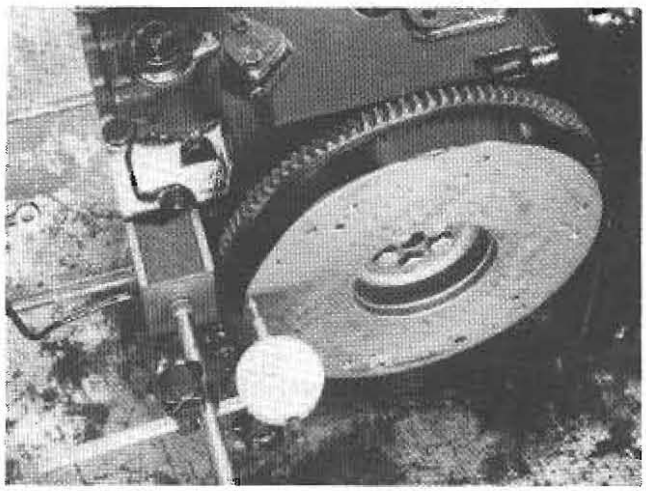


Fig. 4-6 Checking Flywheel Runout

10. Check ring end gaps by placing ring in respective cylinder bore. Slide ring to bottom of cylinder and square up with piston. Measure gap with feeler gauge. File to adjust as necessary.

No. 1	top	.008 to .016 in. (0.2 to 0.4 mm)
No. 2		.008 to .016 in. (0.2 to 0.4 mm)
No. 3	bottom	.008 to .016 in. (0.2 to 0.4 mm)

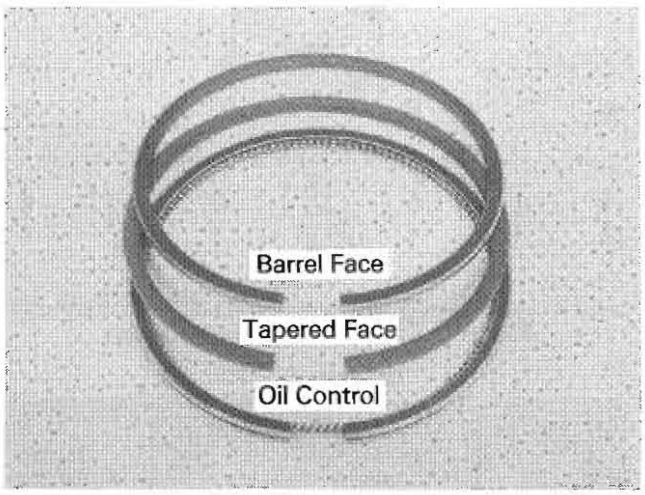


Fig. 4-7 Piston Ring Identification

11. Heat the pistons in hot water (150 to 200 F [65 to 93 C]). Coat piston pin with oil and install pins into pistons and rods and install lock ring.

12. Install piston rings on piston with align "mark" facing top of piston (Fig. 4-8). Alternate ring end gaps 120° to be sure no ring end gaps are in line

with piston pin hole (Fig. 4-9). When these things have been checked, coat the cylinder liner and the piston and rings with engine oil. Using a ring compressor, install the piston assemblies.

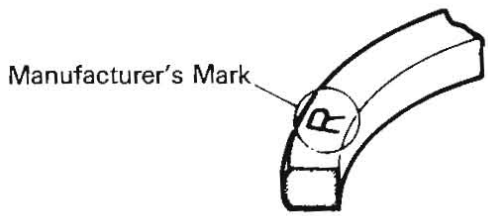


Fig. 4-8 Manufacturer's Ring Mark

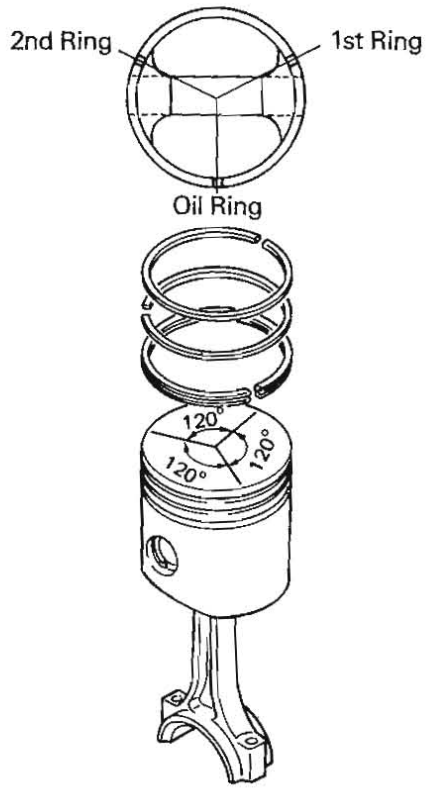


Fig. 4-9 Piston Ring Gap Location

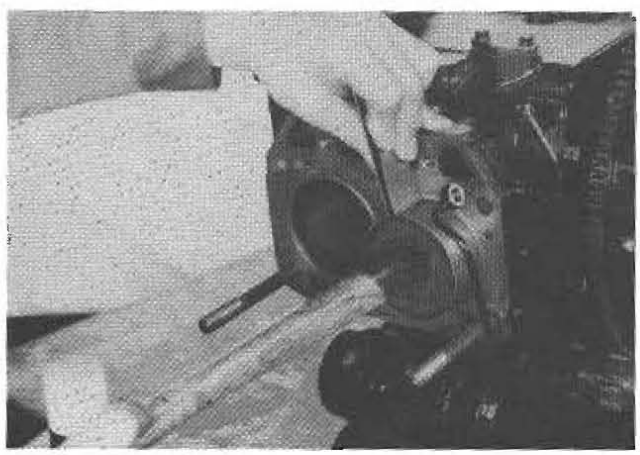


Fig. 4-10 Installing Piston and Ring Assembly

13. Fit the rod bearing on the crankpin and install rod end cap. Torque bolts in steps to 16 to 20 ft/lb (22 to 27 N·m).
14. Install cover on oil pan. Tighten oil pan bolts to 6 to 7 ft/lb (8 to 10 N·m).

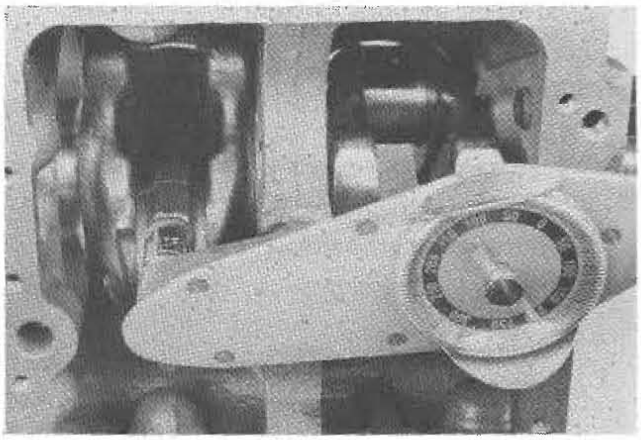


Fig. 4-11 Torquing Connecting Rod End Cap

15. Install crankshaft gear on crankshaft and align crankshaft and camshaft gear timing marks. Install governor weight support and weights. Install crankshaft gear mounting nut and tighten to 51 to 54 ft/lb (69 to 74 N·m).

    Install governor sleeve.

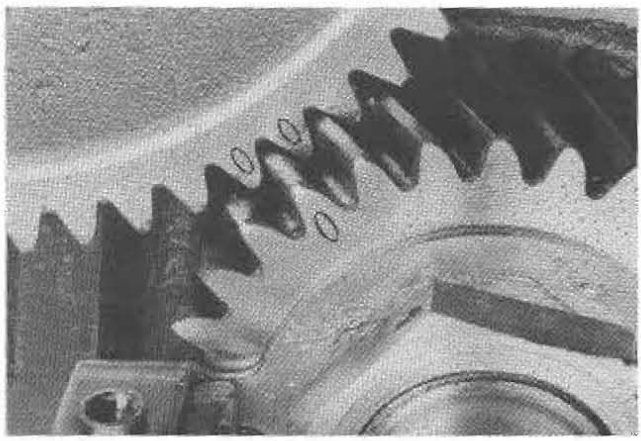


Fig. 4-12 Align Timing Marks

16. Install oil pump and tighten mounting bolts to 7 to 9 ft/lb (10 to 12 N·m).
17. Install gear cover gasket. Install oil seal in gear-case cover.

    Coat the inside of the seal with light grease. RTV compound may be used on outer diameter only. Install gear cover on engine and torque to 18 to 20 ft/lb (24 to 27 N·m).

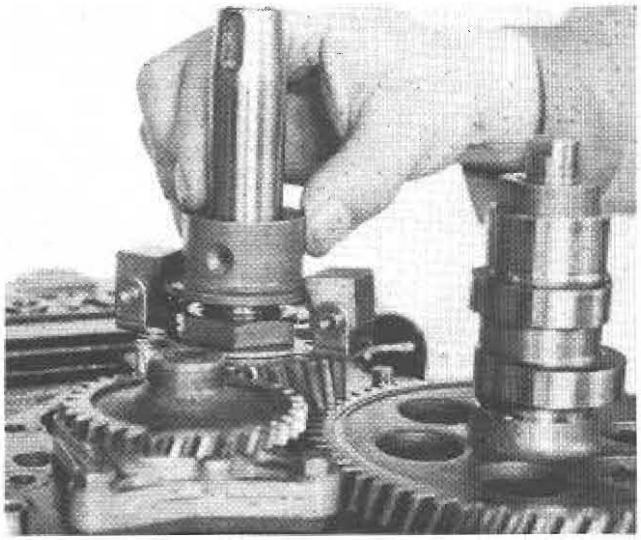


Fig. 4-13 Governor Sleeve Installation

18. Install V pulley assembly and lock nut. Torque nut to 43 to 50 ft/lb (58 to 68 N·m)

19. Clean injection pump timing shims in suitable solvent. Reinstall on cylinder body. Looking through the timing gear window, align the governor lever with the rack pin of the pump and install pump. Tighten mounting nuts to 18 to 20 ft/lb (24 to 27 N·m). See Section 5 for injection pump timing or repair.

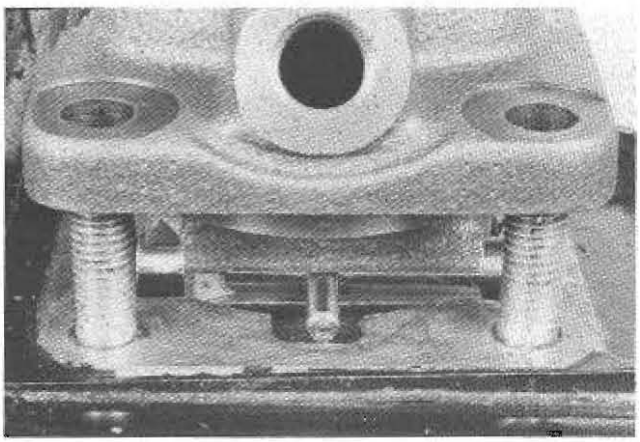


Fig. 4-14 Injection Pump Installation

20. Install cylinder head gasket and place cylinder head on block. Torque 12 mm diameter head bolts to 72 to 80 ft/lb (98 to 109 N·m) and 8 mm diameter head bolts to 16 to 20 ft/lb (22 to 27 N·m) in steps per torque sequence shown.

21. Connect lube oil line to cylinder head.

22. Install gasket and water pump assembly on cylinder head. Tighten to 18 to 20 ft/lb (24 to 27 N·m). Install water hose from water pump to engine block.

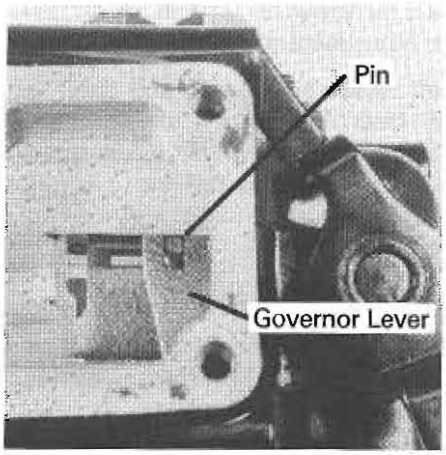


Fig. 4-15 Governor Lever and Rack Pin Alignment

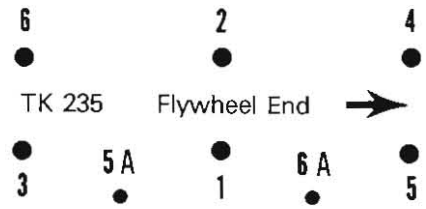


Fig. 4-16 TK235 Cylinder Head Torque Sequence: 1-2-3-4-5-5A-6-6A

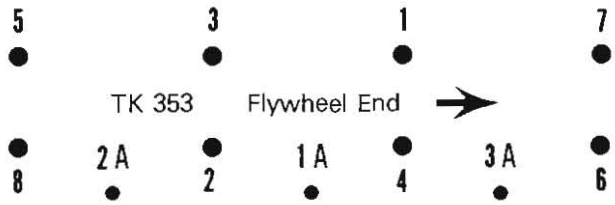


Fig. 4-17 TK353 Cylinder Head Torque Sequence: 1-1A-2-2A-3-3A-4-5-6-7-8

23. Insert push rods in cylinder body.

24. Install rocker arm assembly on cylinder head. Make sure that the valve adjusting screws have been loosened and backed out before tightening the rocker stand locking nuts.

CAUTION: Tightening down the rocker shaft with the valve lash adjustments in the original position may bend the push rods.

Tighten locking nuts in sequence to 27 to 29 ft/lb (36 to 39 N·m) to keep the assembly as level as possible.

CAUTION: Do not use an air wrench to install rocker stand bolts. The tilting of the rocker shaft

assembly along with the speed of the air wrench will gall the bolts to the aluminum rocker stands.

25. Adjust the valves to .0079 in. (0.20 mm). Refer to valve adjustment procedure, Section 5.

26. Install rocker arm gasket and cover on cylinder head. Insert combustion chambers and gaskets. Install nozzle insulator and injection nozzle. Connect the high pressure fall line to injection nozzles and tighten nozzle holder assembly to 18 to 20 ft/lb (24 to 27 N·m).

27. Connect fuel return pipe.

28. Check and adjust the governor linkage. Refer to governor adjustment procedure, Section 5. Install timing gear cover on gearcase.

29. Fill crankcase with engine oil.

30. Check injection pump timing. Refer to injection pump timing procedure, Section 5.

Fuel System

5

Contents

Fuel System

The fuel injection system used on the Thermo King TK235 and TK353 diesel engines is manufactured by Yanmar. It is a high pressure system used in conjunction with a prechamber or swirl chamber.

The components of the fuel system are:

1. Fuel tank (may be the truck fuel tank).
2. Prefilter.
3. Electric fuel pump.
4. Fuel filter assembly.
5. Injection pump.
6. Injection nozzles.

Two 7 psi (48.3 kPa) electric fuel pumps (connected in series) pull fuel from the fuel tank through a prefilter and push it through the fuel filters to the injection pump. The injection pump requires a positive inlet pressure of about 1 psi (7 kPa).

The injection pump plungers are activated by a fuel pump cam extension on the engine camshaft. The governor sleeve and weight assembly is mounted on the end of the crankshaft, relaying the governor's speed requirements to the injection pump through a linkage arrangement located in the front timing cover. The injection pump raises the pressure of the fuel and feeds the correct amount of fuel to the nozzle at the correct time. The increased fuel pressure lifts the spring loaded valve in the nozzle admitting fuel into the combustion chamber.

The most common cause of fuel system problems is contamination. It cannot be stressed enough that the fuel must be clean, and fuel tanks must be free from contaminants.

Fuel filters must be changed regularly, and whenever the fuel system is opened up. All possible precautions should be taken to keep dirt from entering the system. This means all fuel lines should be capped when open. The work should be done in a relatively clean area, if possible, and the work should be completed in the shortest time possible.

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

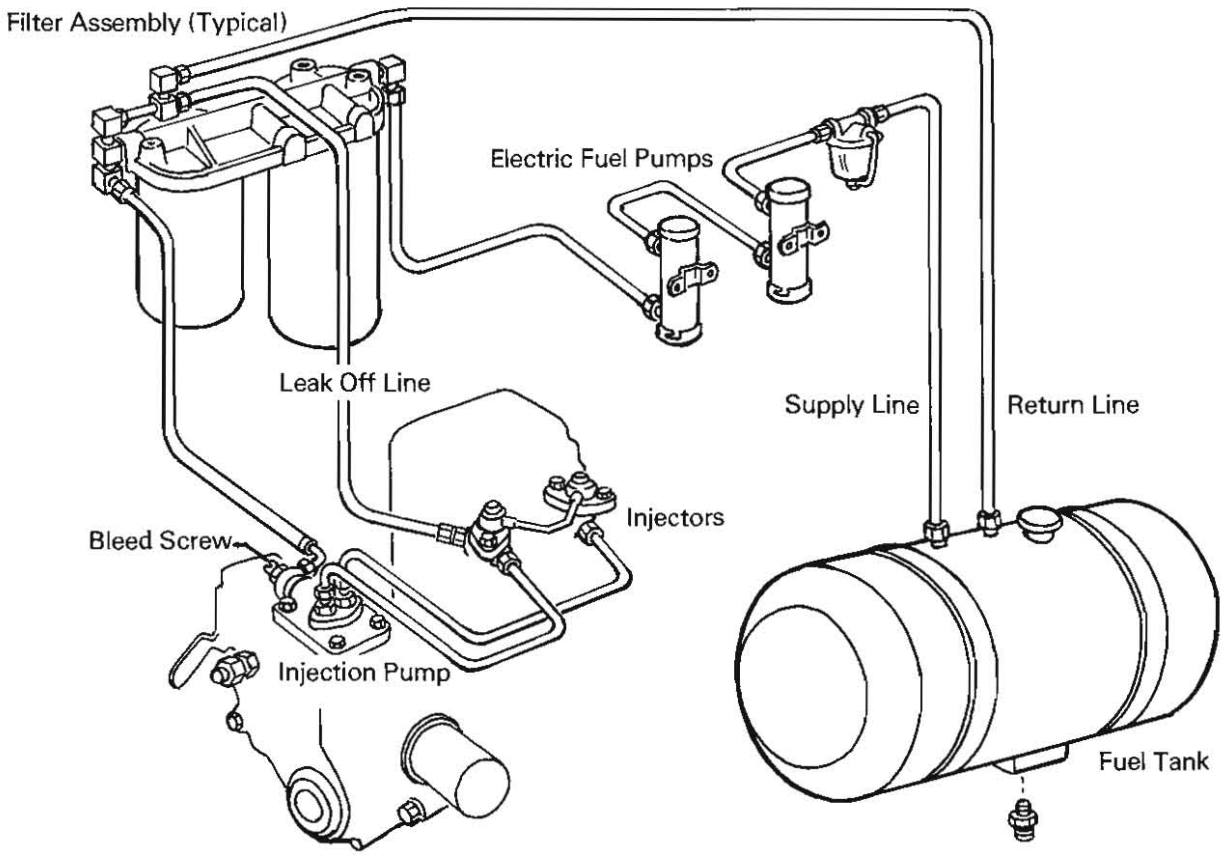


Fig. 5-1 Typical Fuel System

The following procedures can be done under field conditions:

1. Bleeding fuel system free of air.
2. Maintenance involving the fuel tank and filter system.
3. Speed and governor adjustments.
4. Electric transfer pump replacement or repair.
5. Injection line replacement.
6. Pump timing.
7. Nozzle spray pattern testing and adjustment.
8. Minor rebuilding of nozzles.

BLEEDING THE FUEL SYSTEM

If the engine runs out of fuel or repairs are made to the fuel system, or air gets into the system for any other reason, the fuel system will have to have the air bled out.

NOTE: BE SURE to keep the fuel tank vent opeu. If the vent becomes clogged, a partial vacuum develops in the tank, and this increases the tendency for air to enter the system.

Proceed as follows:

1. Loosen the air bleed screw on the injection pump banjo bolt.
2. The electric fuel pumps do not energize when the on-off switch is turned on. They receive current from the 8D circuit after the unit is running and has built enough oil pressure to engage the low oil pressure relay. The pumps can however be energized by holding the Preheat-Start switch in the Preheat position. The pumps are connected to the Preheat-Start switch to ensure fuel is being pumped to the engine before and during start up. This circuit can be utilized to turn on the pumps to bleed the fuel system. Run the pumps until a clear flow of fuel is noted at the air bleed screw. Tighten the screw.
3. Loosen the injection nozzle box nuts at the injection nozzles.
4. Crank the engine until fuel appears at the nozzles. Tighten the injection nozzle box nuts and start the engine.

   NOTE: Fuel will not appear at the nozzles by merely energizing the electric fuel pumps. The engine mnst be cranked.

INJECTION PUMP REPLACEMENT

NOTE: The procedure ontlined will assume the pump is being removed and replaced on the engine. If the pump is not removed, only the last portion of the procedure is used.

Pump Removal

1. Remove the fuel supply line and the four nuts holding pump to timing cover.
2. Remove inspection plate on the side of the timing cover.
3. Center the rack in the pump body, then remove injection pump from timing cover. The timing shim will usually stay attached to the pump.

   CAUTION:If the rack is not positioned correctly, the pump will not come out of the timing cover.

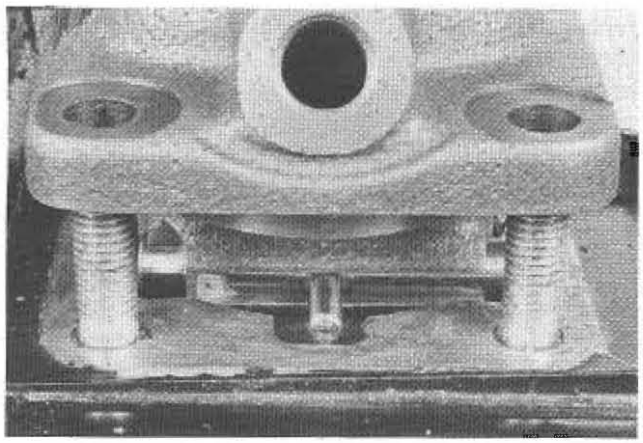


Fig. 5-2 Injection Pump Removal

Pump Installation

1. Remove small inspection plate on front timing cover. Replace the shim gasket on the injection pump if it has been damaged during pump removal. New shims are supplied in sets. Select the same thickness shim that was removed from the pump.

   NOTE: Do not put gasket sealer on the shim or pump until the injection timing of the pump has been checked. The shim may have to be replaced with one of a different thickness.
2. Center the rack in the pump body and insert the pump in the timing gear cover. The rack pin must be indexed with the governor arm as the pump is being inserted.
3. Install the washers and nuts. Torque the nuts to 18 to 20 ft/lb (24 to 27 N·m).
4. Install the fuel line on the pump.

INJECTION PUMP TIMING

Timing the Injection Pump to the Engine

There are two different types of timing procedures used on the TK235 and TK353 engines. One procedure in-

volves checking to make sure that both cylinders are timed correctly to each other, and the second procedure times the injection pump correctly to the engine. If the cylinders are not timed correctly to each other, it is of no value to time the injection pump to the engine because one of the two cylinders would be out of time. The individual plungers in the injection pump are timed to each other by the use of spacers in the pump plunger base. It is rare that an injection pump would change individual cylinder timing unless it had been through some type of repair process, but if all other possible problems with a rough running engine have been checked, and especially if the engine's injection pump has been replaced or repaired recently, it may be beneficial to check individual cylinder timing. Because the possibility of incorrect individual cylinder timing is so minimal, the procedure for timing the pump to the engine will be covered first. The procedure for individual cylinder timing is very similar to timing the injection pump so it will be covered last.

NOTE: The cylinders on the engine are numbered from the flywheel end to the water pump end. The number 1 cylinder is next to the flywheel. The number 2 (or 3) cylinder is next to the water pump. The timing marks on the flywheel are matched to this system.

1. Rotate the engine in the direction of rotation (clockwise as viewed from the water pump end) until the number 1 cylinder (closest to flywheel) is at approximately dead center of the compression stroke. The valve cover should be removed to identify the compression stroke. Both valves of the number 1 cylinder will be loose. Check the position of the timing marks in relation to the illustration.

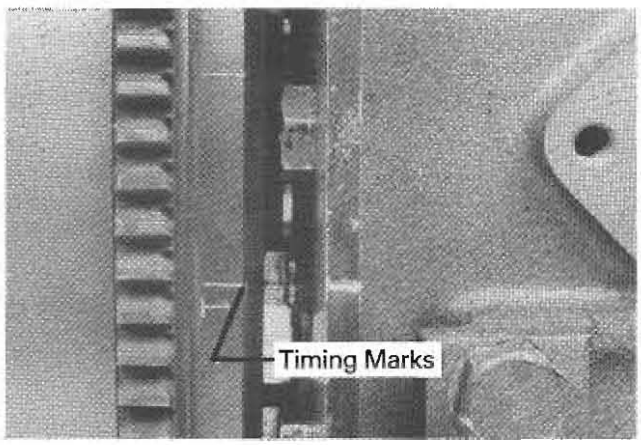


Fig. 5-3 Flywheel Timing Marks

CAUTION: The cylinders have timing marks stamped on the flywheel (180° or 120°) apart. Top dead center marks are identified by the number of the cylinder stamped next to them. Injection timing marks are unmarked. The timing marks are most easily viewed through the curbside door.

2. Remove the high pressure line from the number 1 injector on the injection pump. Remove the delivery valve holder, delivery valve and spring. Care must be taken to prevent dirt from entering the fuel injection system. Replace the delivery valve holder.
3. Install a drip tube on the nozzle holder.
4. Activate the run solenoid by turning the unit switch on. Make sure the Diesel-Electric switch is in the Diesel position. Use a jumper wire to activate the electric fuel pump. Jumper number 2 wire to 8F wire at the roadside control panel.

   CAUTION: Loosen the box nut on the high pressure line of the number 2 cylinder to prevent any possibility of the engine firing.

5. The engine should be close to the top dead center position with the plunger port in the pump closed. No fuel should flow from the drip tube.
6. Turn the engine backwards past the injection timing mark until fuel flows from the drip tube.
7. Slowly rotate the engine in the direction of rotation while watching the drip tube. When the fuel flow slows to approximately one drip every 10 to 15 seconds, check the timing marks. They should be lined up.

   NOTE: A diesel injection timing light is available and may also be used to time the engine.

8. If the timing marks did not line up, a shim or shims will have to be added or subtracted from the injection pump. Adding shims will retard the injection timing, subtracting shims will advance the timing. Increasing or decreasing shim thickness by .004 in. (0.1 mm) will change the timing by 1°.
9. After shims have been added or subtracted, recheck the timing.
10. When the injection pump has been correctly timed to the engine, remove the pump and put a light coat of silicone gasket sealer on the shim pack and pump.
11. Reinstall the pump and torque the nuts to 18-20 ft/lb (24-22 N·m).
12. Reinstall delivery valve and spring. Torque delivery valve holder to 30 ft/lb (40.7 N·m).
13. Reinstall high pressure lines, bleed air from nozzles and test run engine.

Timing Individual Cylinder Injection

This procedure should be used when a poor running engine has had all possible problems checked but continues to run badly. If the injection pump has been repaired or replaced, the chance of individual cylinder timing problems occurring is greater.

To check individual cylinder timing, follow the pump timing procedure but instead of changing shims to adjust pump timing if it is incorrect, check the timing of number 2 (and 3) injector to the engine after checking number 1. All cylinders should time on their respective flywheel timing marks.

If the injection pump plungers are not correctly timed to each other, the pump must be removed and sent to a diesel injection equipment shop for calibration.

If the cylinder injection timing of all cylinders is not uniform, make them uniform by adding a plunger stroke adjusting shim to the "timing delayed" part or extracting the shim from the "timing advanced" part.

Fuel Injection Pump Check

If the fuel control rack has excessive sliding resistance, undesirable engine conditions such as irregular running or hunting (bursts) of engine speed occurs. To check the fuel control rack for freedom of movement, lay the fuel control rack upright. If the rack smoothly moves down by its own weight along the full length of the pump side, its free movement is good. Turn it upside down to test its downward movement.

When the control rack has high sliding resistance, possible causes are:

1. The rotary sliding section of the plunger assembly offers high resistance.
2. The delivery valve holder has excessively been tightened (as a result the plunger barrel is distorted).
3. The fuel control rack, gear segment of the fuel control brush or the outside of the fuel control rack has been scratched; or dirt has stuck to these parts. As a result, the fuel control rack cannot move smoothly.
4. The fuel control rack hole of the fuel injection pump body has been scratched.
5. The plunger barrel packing is improperly fitted, and as a result the plunger barrel is distorted. (In this case, the fuel oil will leak into the crankcase and dilute the lubricating oil. This demands careful attention.)

   In the above case, disassemble the fuel injection pump and rinse or recondition it.

If the rack sticks, the injection pump will have to be disassembled and inspected.

FUEL INJECTION PUMP DISASSEMBLY

In the event that complete disassembly of the fuel pump is necessary, prepare containers to keep the various parts of each cylinder in order to ensure correct reassembly. Do not mix the parts from one cylinder with another.

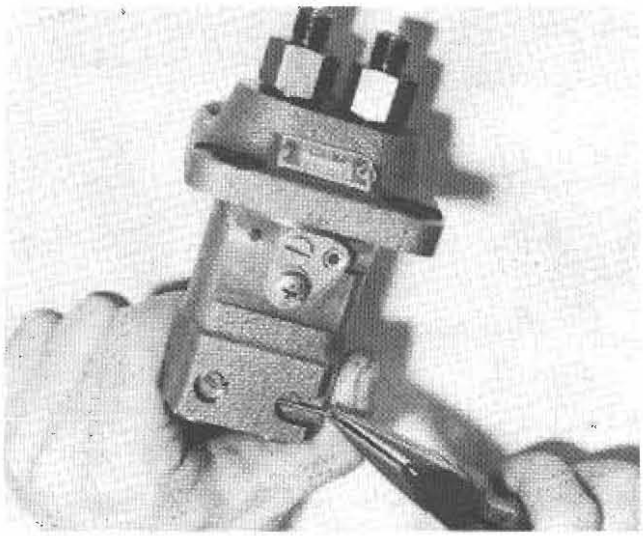


Fig. 5-4 Remove Plunger Guide Stopper Pin

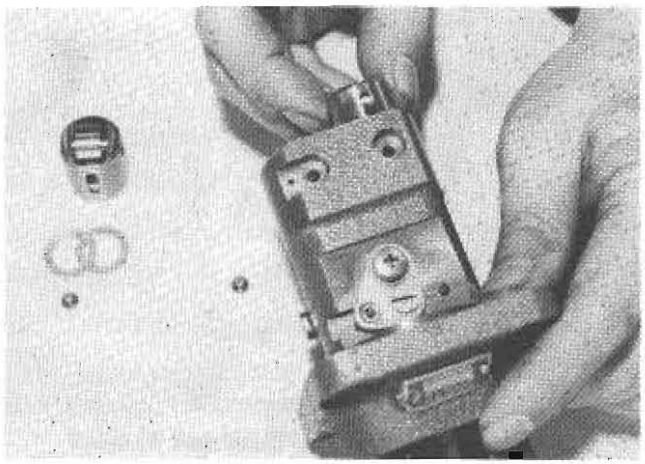


Fig. 5-5 Remove Plunger Guide

1. Remove the plunger guide stopper pin.
2. Remove the plunger guide.

   CAUTION: When removing the plunger guides, keep the plunger stroke adjusting shims with the proper guide.
3. Remove the plunger, plunger spring lower seat, plunger spring and plunger prestroke adjusting shim.

4. Remove the upper seat and pinion.
5. Remove the control rack.
6. Remove the delivery valve holder and spring, delivery valve packing and delivery valve assembly.
7. Remove the plunger barrel.

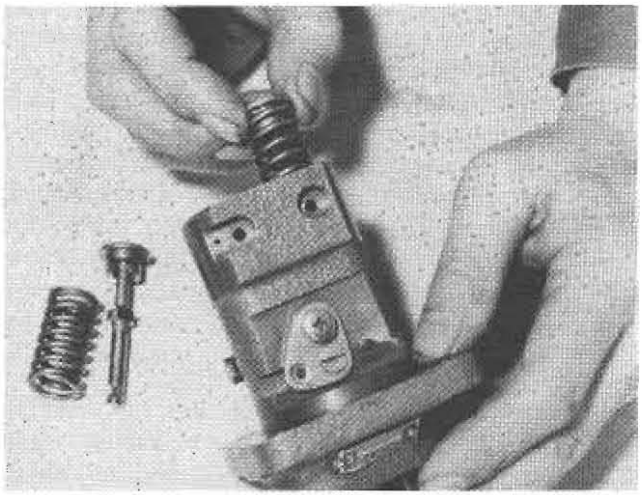


Fig. 5-6 Remove Plunger Assembly

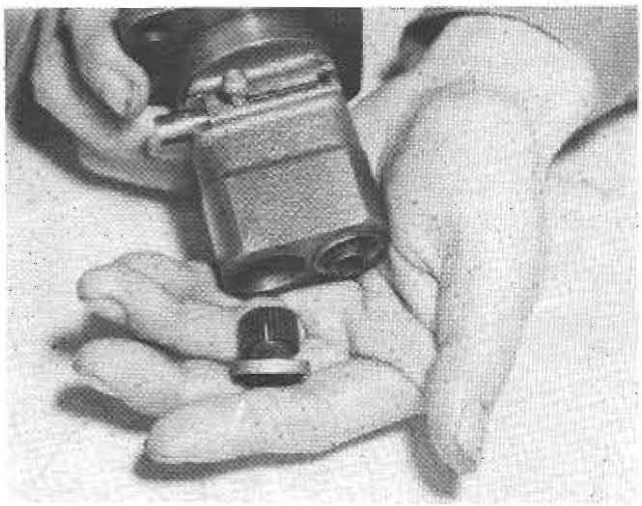


Fig. 5-7 Remove Upper Seat and Pinion

Inspection of Major Components

1. Inspection of the Plunger and Barrel

   Due to the close tolerance (.0004 in. [0.001 mm]) of the plunger and barrel assembly, make sure it is free from excessive scratches, wear, chips and foreign material. Also, the free fall of the plunger should be smooth.

   The plunger should be checked visually, under a magnifying glass, for excessive wear or possible chips on the helix.

   If there is any chipped area on the lead helix, it will not be indicated in any of the tests.

   a. Inspect the plunger. If the plunger is chipped, replace the plunger and barrel assembly.

   b. Inspect the outside diameter of the plunger. Examine the surface with a magnifying glass. Even the slightest imperfection will prevent the plunger from operating properly. Check for burrs, nicks, erosion, cracks, chipping and excessive wear. If necessary, replace the plunger and barrel assembly.

   c. Free fall of the plunger and barrel.
   After thoroughly cleaning the plunger and barrel, tilt them about 60°. Plunger should slide down slowly (Fig. 5-10)

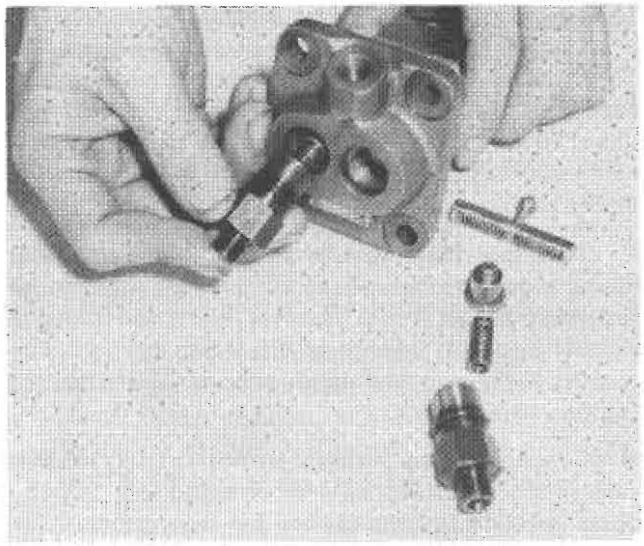


Fig. 5-8 Remove Delivery Valve Assembly

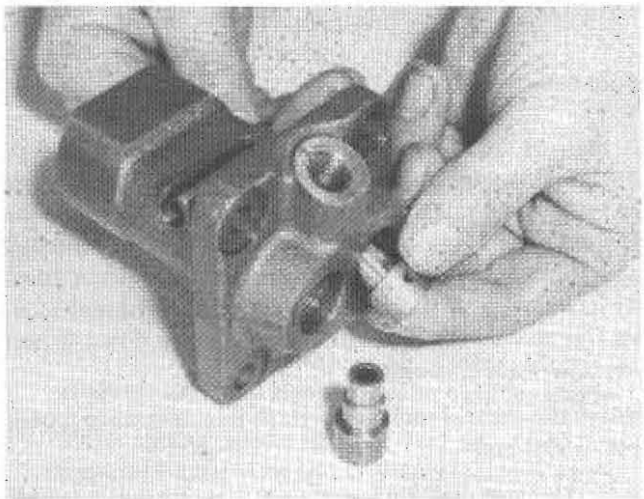


Fig. 5-9 Remove Plunger Barrel

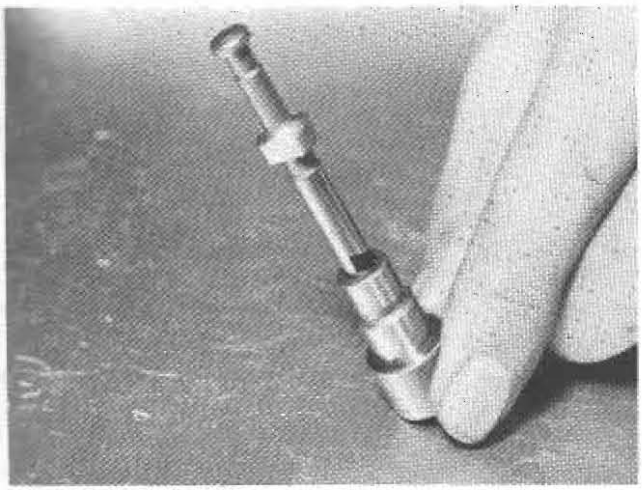


Fig. 5-10 Plunger and Barrel Free-Fall Test

Repeat this test several times while rotating the plunger. If it slides down too fast or if it sticks halfway, correct (lap or clean) or replace it.

2. Delivery Valve Inspection

   a. Inspect the delivery valve, and replace it if the suction collar or seat is scratched, dented or shows signs of wear.

   b. Thoroughly clean the delivery valve. After cleaning, press the lower end down with your finger to close it. Remove your finger, and it should spring back. If it does not spring back, it should be replaced because the suction collar section is probably badly worn.

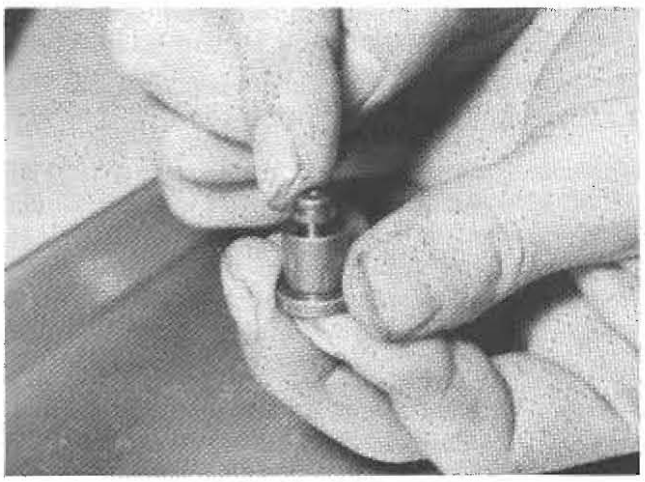


Fig. 5-11 Delivery Valve Spring Back Test

3. Inspection of the Control Sleeve and Control Rack

   Check that the control sleeve and control rack do not have any abnormal gear contact, scratches or foreign matter on them. Any abnormal gear engagement will increase the friction resistance of the control rack and may cause engine trouble.

4. Inspection of the Delivery Spring and Plunger Spring

   Check for any abnormal contact/damage on the springs and deformation of the springs.

5. Plunger Guide Inspection

   There should not be any "play" between the pin and the inside/outside roller pin. Also be sure there is no "pitching" on the surface of the outside wheel of the roller.

Fuel Injection Pump Assembly

Do not mix the various parts of each valve. If one valve part is defective, replace all the valves. During assembly, keep the parts in clean fuel oil and match the "matching marks".

1. Place the left plunger barrel gasket in position.
2. Install the left plunger barrel.
3. Install the left delivery valve assembly and gasket together.
4. Install the left delivery valve spring. Tighten the left delivery valve holder with a torque wrench. Torque should be 29-32 ft. lb. (39.3 to 43.4 N·m).
5. Install the fuel control rack.
6. Install the left fuel control sleeve.
7. Install the upper seat of the left plunger spring.
8. Install the left plunger spring.
9. Install the left plunger.
10. Install the lower seat of the left plunger spring.
11. Install the plunger location adjusting shim.
12. Install the left plunger guide.
13. Install the left plunger guide stop. Set the stop by pressing the plunger by hand. (Press the plunger guide by moving the rack so that the plunger collar can be fixed into the groove of the regulating gear tooth.)
14. Place only the right fuel control gear tooth in the pump body.
15. Apply the procedures given in steps 1 to 4 to the right unit.
16. Insert the right fuel control sleeve in the pump body. Check that the "matching lines" of both the regulating ring and regulating gear tooth match.
17. Repeat steps 7 to 13 on the right unit.

18. Repeat steps 15 through 17 on the right unit for the injection pump on the TK353 engine.
19. Set the plunger guide checking pin.
20. Repeat fuel coutrol rack free movement test.

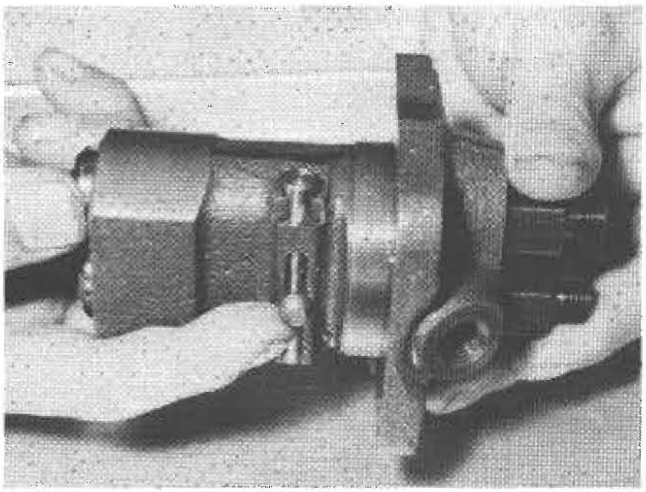


Fig. 5-12 Fuel Rack Free Movement Test

INJECTION NOZZLES

The nozzles are Yanmar throttle type with 1 mm injection orifice. Injection angle is 0 degrees. Injection pressure is 2,200 psi (15,168 kPa).

Fuel, under high pressure from the injection pump enters the annular groove in the top of the nozzle body, flows through the fuel ducts into the pressure chamber above the valve seat and acts on the differential area of the nozzle valve. When the hydraulic pressure exceeds the force exerted by the pressure adjusting spring, the valve is lifted off its seat and fuel is forced from the orifice into the spray hole chamber and combustion chamber. Any fuel that leaks past the needle and pintle returns to the tank past the stem, spring and through the hollow adjustment to the return line.

The valve returns to its "normally closed" position on the valve seat when the hydraulic pressure in the pressure chamber drops below the force exerted on the valve by the pressure adjusting spring.

Testing Injection Nozzle

Install nozzle in nozzle tester Part No. 204-290.

NOTE: Tube 204-451 is available separately. This tube should be bent to fit the nozzle. Only clean, filtered, diesel fuel must be used in the nozzle tester.

CAUTION: Keep hands away from spraying nozzles. The pressure of the fnel spraying from the nozzle can penetrate into the flesh destroying tissues and may cause blood poisoning.

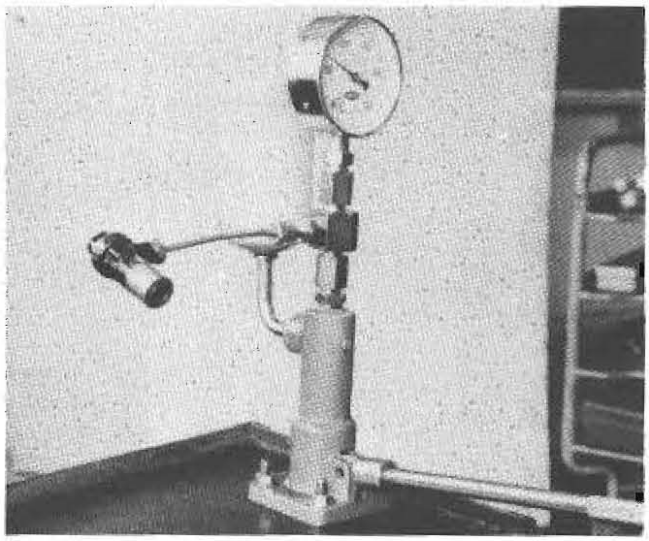


Fig. 5-13 Nozzle Tester

Buzzing

Close the hand valve and operate the handle several times rapidly and with a full stroke. If the nozzle is operating properly, there will be a buzz and a high whistle.

NOTE: If the pumping speed is increased, the buzzing stops and the oil then leaves the nozzle with a hissing noise.

Opening Pressure

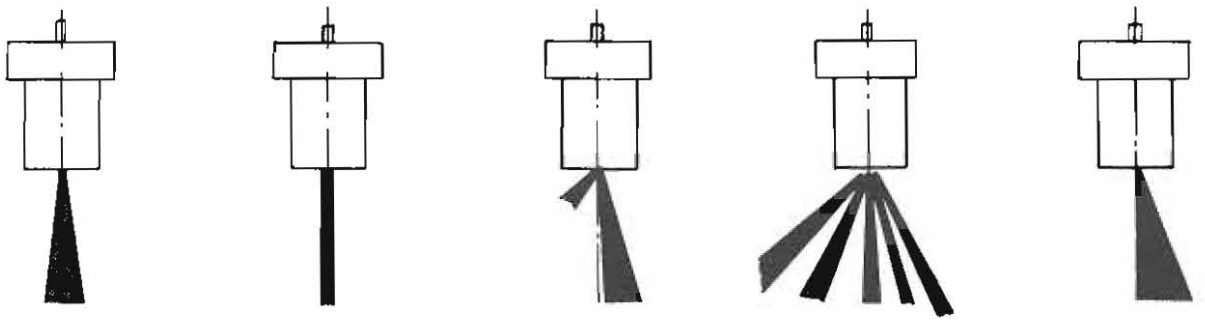
Test opening pressure. Open the hand valve so the gauge will register. Slowly force the handle down and determine the opening pressure. The nozzle should buzz distinctly during spraying.

Opening pressure for nozzles in new condition should be 2,275 to 2,350 psi (15,684 to 16,201 kPa).

Minimum opening pressure for used nozzles is 2200 psi (15,167 kPa). All nozzles in the engine should be within 70 lb (483 kPa). Adjust as necessary to bring nozzle to correct opening pressure. Adjustment is accomplished by removing the nozzle spring retainer and adding a nozzle spring adjusting shim. An adjusting shim of .004 in. (0.1 mm) increases injection pressure by approximately 142 psi (981 kPa).

Pattern

Check the spray pattern. Close the hand valve and operate the pump. Operate pump at about 4 to 6 strokes per second and observe spray. The spray pattern should be almost symmetrical around the axis of the nozzle and without side jets.



A	B	C	D	E
Good	Incorrect 1. Low injection pressure 2. Valve sticking 3. Nozzle spring bent	Incorrect 1. Scratch or dirt in the nozzle hole 2. Carbon deposit in the hole	Incorrect 1. Injection hole worn 2. Carbon deposit in the hole	Incorrect 1. Improperly sealed injection valve 2. Damaged or worn injection hole 3. Carbon deposit in the hole

Fig. 5-14 Nozzle Spray Pattern

Dripping

Open hand valve and operate pump slowly to build pressure up to within 300 psi (2,068 kPa) of opening pressure.

NOTE: There should be no dripping until the pressure gets within 300 psi (2,068 kPa) of opening pressure or less.

Leakage

During the testing procedure, there should be very little if any fuel flowing from the return fuel port. If enough fuel is leaking past the nozzle valve and body to cause flow down the side of the nozzle during testing, the nozzle should be repaired or replaced.

Nozzle Repair

1. Secure the nozzle in a vise and remove the spring nut.
2. Remove spring nut packing and adjusting shims, spring, spring retainer and spindle.
3. Secure holder in vise with nozzle up. Loosen nozzle nut and then remove carefully to avoid dropping nozzle. When removing the nozzle, use care to keep needle valve from falling out. Nozzle body and pintle valve can be reconditioned with special care, skill and equipment. Body and valve can be purchased separately and installed in holder but should be tested and set for opening pressure.
4. Submerge nozzle needle and nozzle head separately in filtered diesel fuel. Put the needle into the head while holding head vertical. The nozzle needle, when pulled out approximately 1/3 of its length must slide to its seat by its own weight. Turn the needle and repeat the procedure in several different positions.

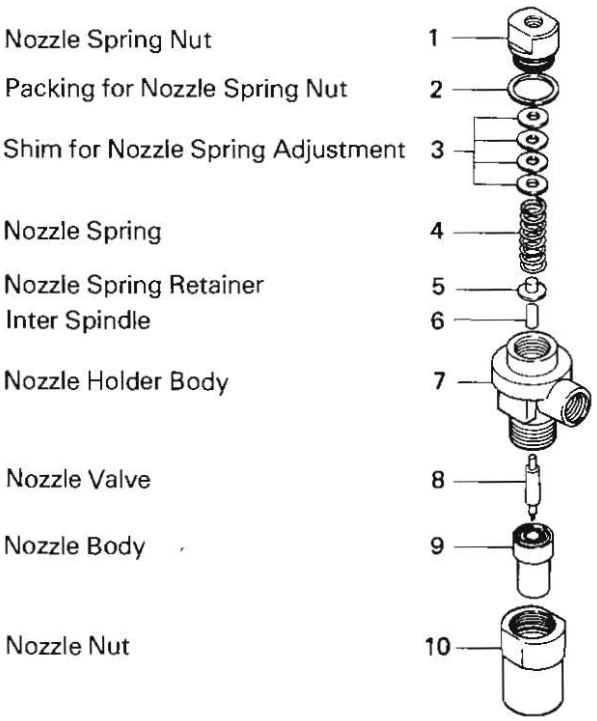


Fig. 5-15 Exploded View of Injection Nozzle

NOTE: If the needle does not seat in all positions, replace nozzle and needle.

5. Thoroughly rinse all parts and assemble the nozzle holder.

   NOTE: If new nozzle and needle are installed, they must first be thoroughly cleaned in solvent to remove the anti-rust compound.

6. Clean all components. Reinstall spindle, spring retainer and spring. Replace adjusting shims and spring nut packing. Install nozzle spring nut, but do not tighten. Leave the nut loose a turn or two.

7. Install nozzle assembly and tighten. Then tighten nozzle spring nut.

8. Test and adjust nozzle to proper pressure by adding or removing adjustment shims. Add shims to increase pressure or remove shims to decrease pressure.

   NOTE: If further work is needed, it is recommended that the nozzle be sent to a diesel injection service shop. For reconditioning in an emergency situation, the pintle valve and holder can be cleaned with Part No. 204-283 nozzle cleaning kit. Refer to Service Bulletin TK 4190.

   NOTE: All replacement springs should be visually checked before installation.

INJECTION PUMP AND GOVERNOR ADJUSTMENTS

To determine the correct speed settings for a particular Thermo King unit model, see "Specifications" section or consult the maintenance manual for that model.

When the diesel engine fails to maintain the correct engine speeds, check the following before adjusting the speed:

1. Check the prefilter screen. Recheck the speed.
2. Bleed air out of the fuel system. Recheck the speed.
3. Bleed air out of the nozzles. Recheck the speed.

Make the engine speed adjustments with the engine fully warmed up.

The engine has two solenoids mounted on one bracket attached to the exhaust manifold side of the engine. The upper solenoid controls high speed. The lower solenoid is a combination on-off and low speed solenoid. The speed of the engine should be checked with a hand tachometer, TK Part 204-220, on the crankshaft pulley bolt or by the use of a stroboscope tachometer, TK Part 204-436.

CAUTION: DO NOT try to adjust the fuel limit screw on the front of the timing cover. The fuel limit screw is a FACTORY SET smoke and power controller. It does not control any phase of the engine speed, and it is not a sensitivity screw. The fuel limit screw should not be adjusted or tampered with in the field.

IDLE STOP AND THROTTLE SOLENOID ADJUSTMENTS

NOTE: Refer to appropriate unit maintenance manual for high and low speed throttle solenoid adjustment procedure.

Fuel Limiting Screw

The fuel limiting screw is located on the front of the timing gear cover. This screw is preset at the factory and SHOULD NEVER need adjustment. The engine has enough reserve horsepower and torque to preclude the governor lever from coming up against the fuel limiting screw and its internal torque spring. There is the possibility however that an inexperienced mechanic might try to adjust the screw to cure some unrelated engine problem making it necessary to readjust the fuel limiting screw. Indications that the fuel limiting screw has been moved are excessive black smoke when the engine changes speeds or the engine having difficulty in picking up speed.

CAUTION: Be sure the fuel limiting screw HAS been tampered with before attempting to readjust it. If the engine is simply having difficulty in picking up speed, the engine has a fuel supply problem (weak or defective electric fuel pump, air leak in fuel line, clogged lines, filters or nozzle, or injection pump problems). Misadjustment of the fuel limiting screw can seriously damage the engine.

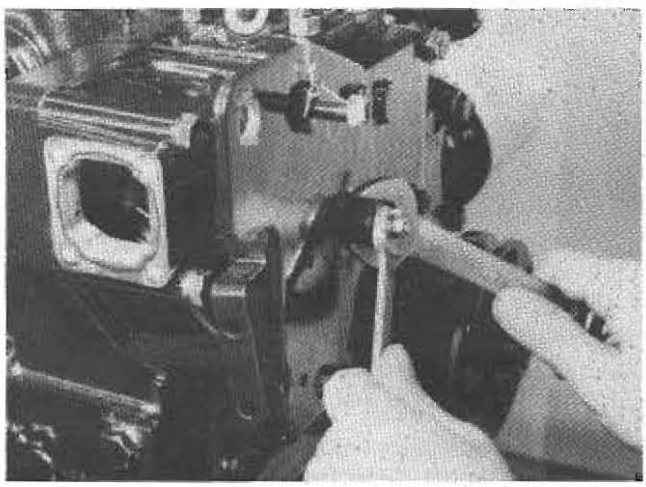


Fig. 5-16 Fuel Limiting Screw Adjustment

1. Remove all solenoid linkages.
2. Remove the side inspection from the timing cover.
3. Remove the fuel limiting screw cover and loosen the jam nut.

   NOTE: The two small 8 mm nuts fixiug the torque spring adjustment cannot be accurately field adjusted. If they have been tampered with, they can be reset by unlocking them and then setting the outer nut approximately 2-1/2 to 3 threads in from the end of the shaft.

4. Lightly move the control lever forward, but do not compress the fuel limit screw torque spring. Watch the two nuts that project from the fuel limit screw. If the nuts start to move, the torque spring is being compressed and the control lever has been pulled too far back.
5. Use a pencil or similar item to gently push the rack control lever back towards the engine while still holding the control lever up against the fuel limit screw torque spring without compressing it. As the rack control lever is being pushed back, it will encounter a resistance at a certain point. From that point on, any further movement to the left will put tension on the governor spring and will cause the control lever to begin to move. Repeat this procedure two or three times until the rack control lever can be moved too and stopped at the resistance point without causing a movement of the control lever.

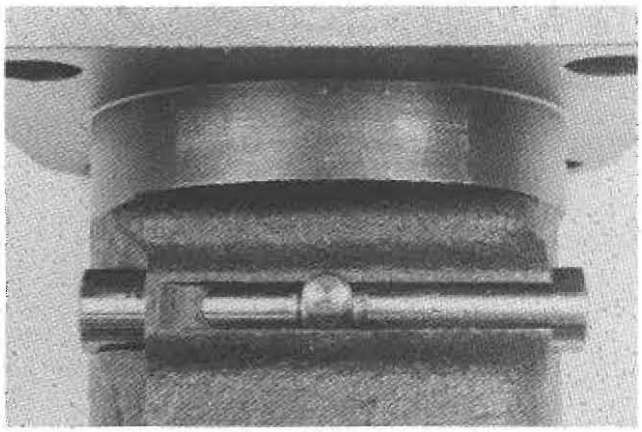


Fig. 5-17 Fuel Limiting Screw Rack Alignment

6. There is a punch mark on the rack shaft which should now align with the edge of the machined area of the injection pump. If the pump mark is out of alignment, adjust the fuel limiting screw in or out until the punch mark is aligned. Move the rack control lever back and forth a few times to recheck the punch mark alignment. A strong light source may be needed because of the difficulty in seeing the punch mark.
7. Tighten the fuel limit screw jam nut and reinstall the cover nut.

ADJUST ENGINE VALVE CLEARANCE

1. Remove valve cover. Torque 12 mm diameter head bolts prior to adjusting valves: 80 ft/lb (108.5 N·m). Valve clearance should be checked after the first 500 hours of engine operation and after 2000 hours maximum of operation. It is very important that valves be adjusted to the correct specifications for satisfactory engine operation. Insufficient valve clearance will result in compression loss and misfiring of cylinders resulting in burned valves and seats. Excessive valve clearance will result in noisy valve operation and abnormal wear of the valves and rocker arms. The intake and exhaust valves are adjusted with the valve in the closed position.

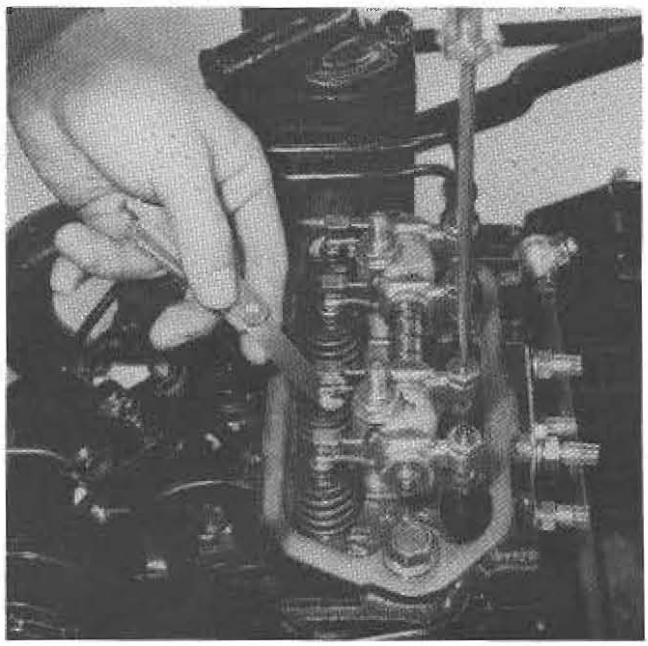


Fig. 5-18 Intake and Exhaust Valve Clearance

2. The intake valve and exhaust valve are adjusted to .0079 in. (0.2 mm) with the temperature at 70 F (21 C).

   Turn the engine by using the belt on the crankshaft pulley. Rotate the engine in the direction of rotation (clockwise as viewed next to flywheel) from the water pump end.

   CAUTION: Make sure fnel rack is off to prevent engine from starting.

   a. Turn engine so No. 1 cylinder is on compression with piston at TDC. Both push rods should turn freely. Adjust both valves on No. 1 cylinder.

b. On the TK235 engine, revolve crankshaft 180° to TDC mark of No. 2 cylinder. Adjust both valves. On the TK353 engine, revolve the crankshaft 240° to TDC mark of No. 3 cylinder, and adjust both valves.

c. On TK353 engine, turn the crankshaft 240° to align TDC mark of No. 2 cylinder and adjust both valves.

d. BE SURE to tighten locking nut while holding the ball head screw in position.

e. Install valve cover making sure that gasket is in position.

Electrical

6

Contents

Electrical

STARTER

Construction and Operating Principles

The starter consists of the motor that develops starting torque, a magnetic switch that engages the motor, and a pinion that engages the flywheel gear to transfer the starting torque.

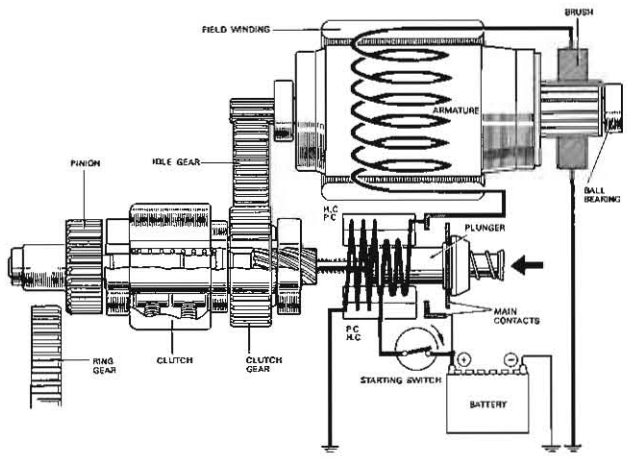


Fig. 6-1 Starter Motor Pull-in Pictorial

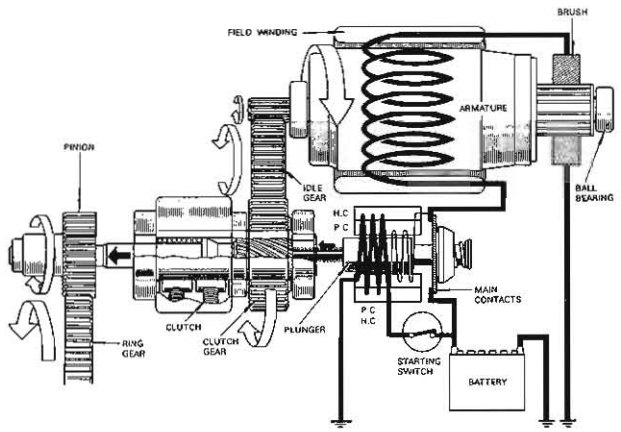


Fig. 6-2 Starter Motor Operating Pictorial

Motor

The starting motor is a high output series wound motor in which the armature coil and field are connected in series.

Magnetic Switch

The magnetic switch actuates the shift lever that forces the pinion into engagement with the ring gear and holds it in that position while cranking. It also serves to release the pinion after the engine starts, simultaneously bringing the motor to a stop.

Pinion

The pinion shaft is driven by an over-running clutch assembly. When the engine is started and the flywheel gear turns faster than the pinion, the pinion turns freely to prevent damage to the other components.

Starter Disassembly

1. Disconnect the lead wire from the terminal of the magnetic switch.
2. Remove two through bolts from drive end housing. Then separate the starting motor from magnetic switch.
3. Remove screws from drive housing, and separate the drive housing from magnetic switch housing.
4. Pull out the overrunning clutch, and remove the steel ball and return spring.

   NOTE: Be careful not to lose the steel ball and spring located between magnetic switch and overrunning clutch.
5. Remove the idle gear, roller and retainer from magnetic switch.
6. Remove the brushes from brush holder, then pull out the armature from yoke.

   NOTE: The clutch gear assembly and magnetic switch are not repairable, and the mechanic must use his judgement as to reuse or replace these parts.

Starter Inspection and Reassembly

1. The following magnetic switch tests should be performed with the specified voltage applied. The starter must be assembled without the motor.

   NOTE:
   a. Do not attempt to disassemble the magnetic switch. It cannot be repaired and must be replaced if defective.
   b. Perform each test as quickly as possible (3-5 seconds) to prevent the coils from burning.

   a. Pull-in Test

   When the negative battery (-) terminal is connected to magnetic switch body and "C" terminal, and the positive (+) terminal to the "50" terminal, the pinion should extend out.

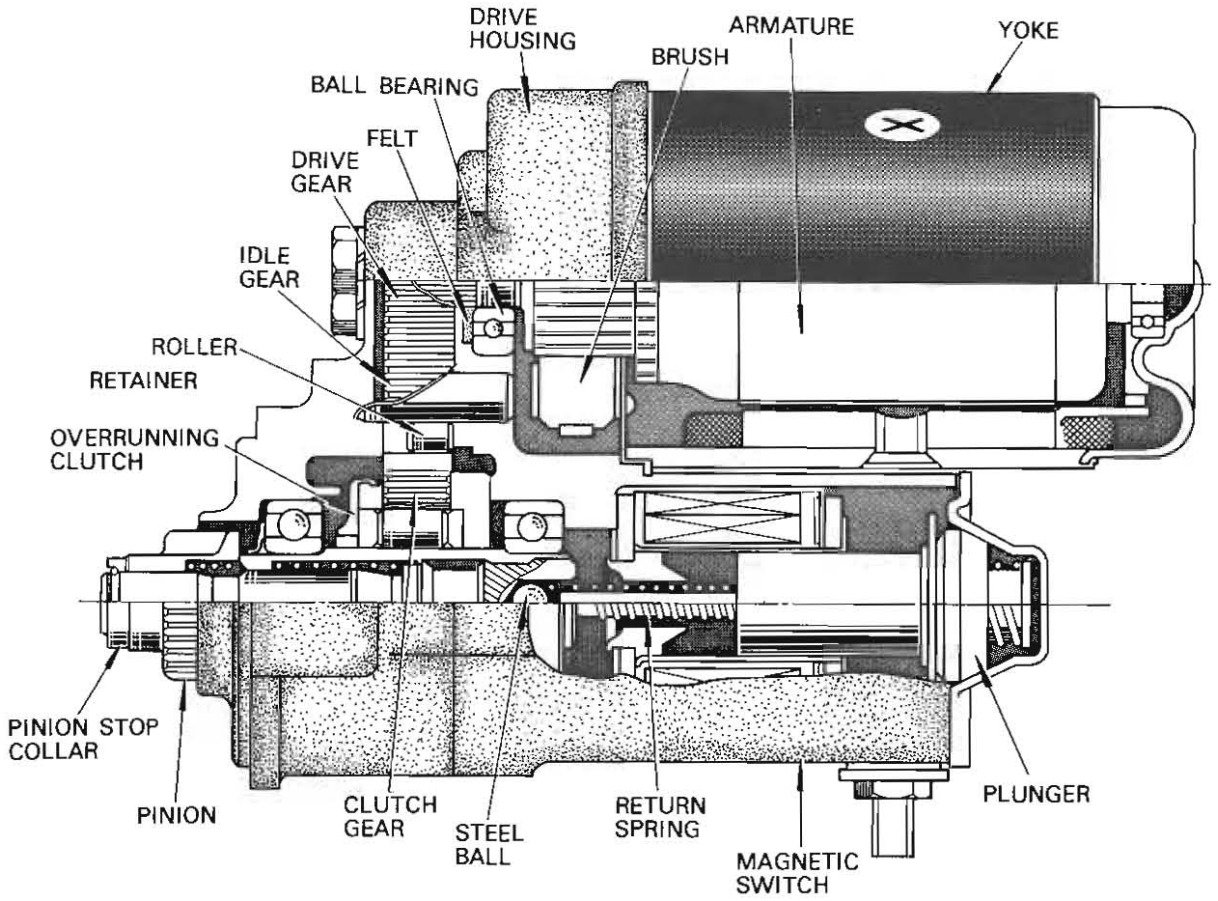


Fig. 6-3 Cutaway View of Starter

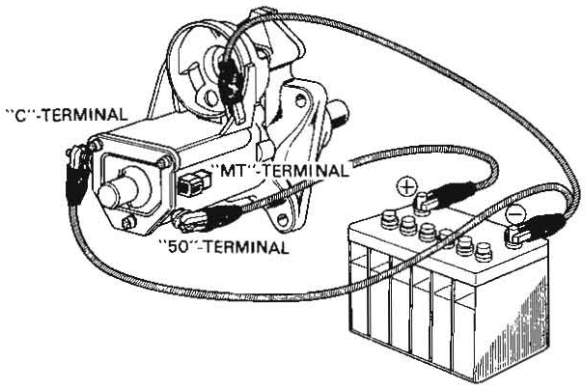


Fig. 6-4 Pull-in Test

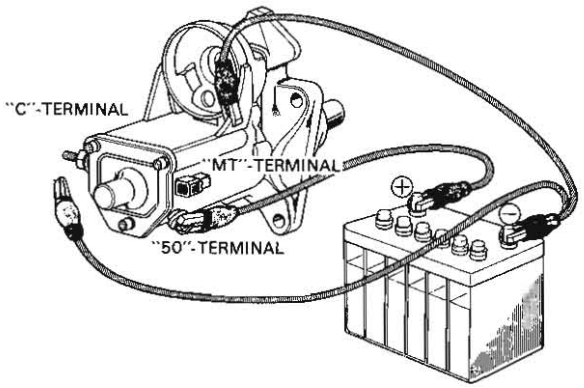


Fig 6-5 Hold-in Test

b. Hold-in Test

With the same connection as in the pull-in test, disconnect the "C" terminal. The pinion should remain extended.

c. Return Test

With the same connection as in the hold-in test, connect positive (+) jumper wire from battery to "C" terminal. At this time, disconnect "50" terminal jumper wire. The pinion should return quickly (Fig. 6-6).

d. Remove plunger cover and plunger from starter. Inspect switch contactor points. If the points are roughened or corroded, dress them as necessary.

2. Make a good visual inspection of armature commutator for thrown solder, deformed windings, signs of overheating, and shaft damage on bushing ends or center carrier.

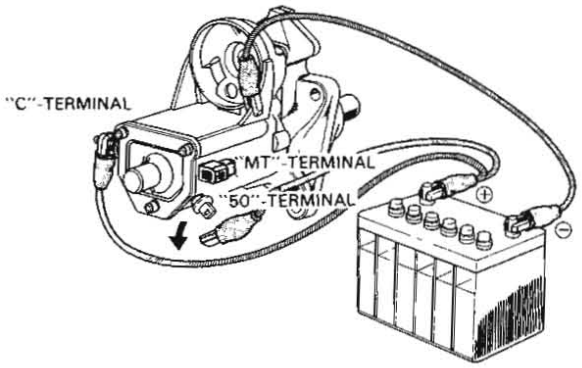


Fig 6-6 Return Test

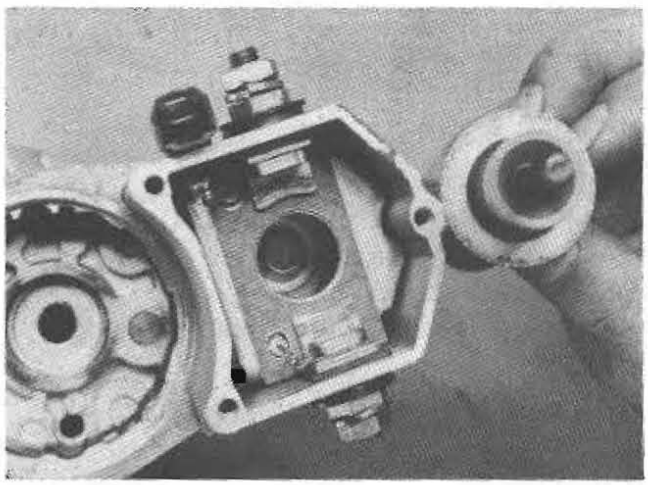


Fig 6-7 Inspect Switch Contactor

3. Check the commutator for roughness, corrosion and out of round. Commutator should not be out of round by more than .0157 in. (0.4 mm).
   a. If necessary, dress with a fine sandpaper.
   b. Turn the commutator in a lathe if damage is excessive. Outside diameter of commutator should be 1.1417 to 1.1811 in. (29.0 to 30.0 mm). Replace armature if commutator exceeds service limit.
   c. After commutator is turned, check and recut mica if necessary.
   d. Test the armature coil for a short. Position the armature on a growler tester and slowly turn the armature with a piece of iron attached to the core. If the iron piece is attracted by the magnetic force or it vibrates, it indicates that the armature coil is shorted. If such is the case, repair or replace the coil.
   e. Armature coil continuity test. With the ohmmeter, check continuity between the segments on the commutator. If there is no continuity, it indicates the coil circuit is open and necessary repair or replacement of the coil should be made.

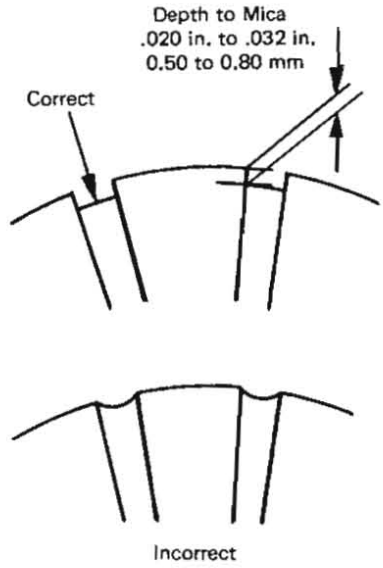


Fig. 6-8 Undercutting of Mica

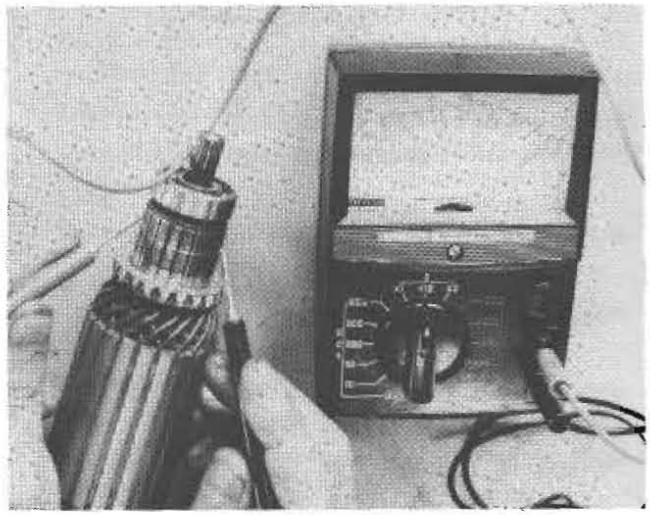


Fig. 6-9 Armature Continuity Test

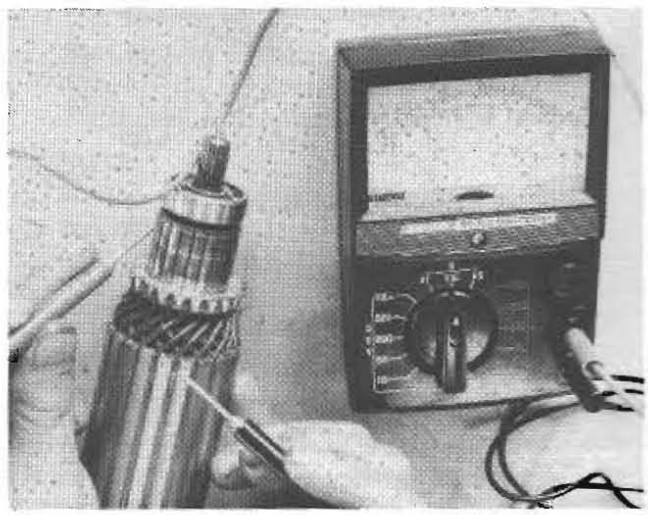


Fig. 6-10 Armature Ground Test

f. Armature coil insulation test. With the ohmmeter, check the insulation between the commutator (coil) and core. If there is continuity, it indicates that the coil insulation is defective and the coil should be repaired or replaced.

4. Inspect field winding for wear or damage. All connections should be clean and tight.

   a. Using an ohmmeter, check for continuity between the field coil brush lead and power feed wire ("C" terminal).

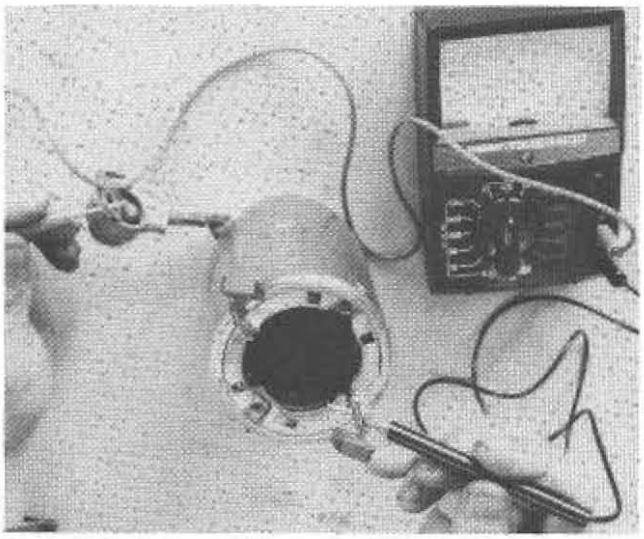


Fig. 6-11 Field Winding Continuity Test

   b. Check for a ground between the field coil and the case. Make necessary repairs if grounded. If there is still continuity, the field winding should be replaced.

5. a. Brush holders can also be tested with an ohmmeter. Touch one probe to holder plate and the other probe positive brush holder. There should be no continuity. If there is continuity, repair or replace the brush holder.

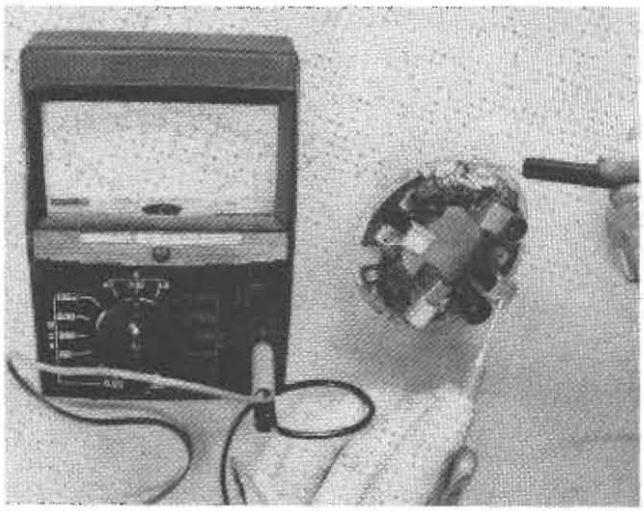


Fig. 6-12 Brush Holder Insulation Test

   b. Measure the brush length and replace if the brush is reduced to .397 in. (10 mm).

   NOTE: If the negative side brushes mounted on the brush holder are worn, replace the entire brush holder. If the positive side brushes connected to field winding are worn, replace the entire field yoke assembly.

   c. Check brush spring tension. Inspect brush springs for overheating or deformation and replace if necessary.

6. Inspect bearings for wear and damage. Check pinion teeth for wear. The pinion should turn freely in direction of rotation and be locked in opposite direction of rotation.

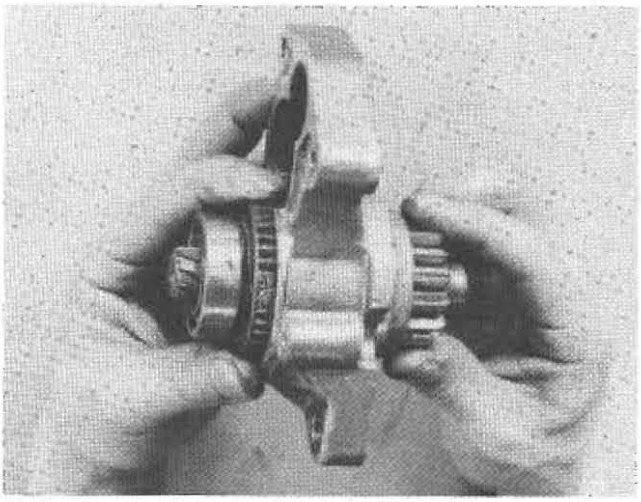


Fig. 6-13 Inspect Bearings, Pinion Teeth and Clutch

7. Starter can now be reassembled using light grease for lubrication of spline, pinion gear, idle gear, roller retainer, coil spring and ball, and clutch gear. Do not forget to assemble the steel ball and spring.

   NOTE: Points to be noted when assembling the starter motor to the engine.

   a. Use care not to damage and get oil on the brushes when assembling them.

   b. Securely tighten the starting motor to the engine as a great load is imposed on the starting motor when cranking the engine.

   c. Check to make sure all the connections are tight. Otherwise the increase in contact resistance will lead to starting failure.

8. Perform No Load Performance Test. Clamp starter firmly in vice. Apply 11 volt to starter. The starter should show smooth steady operation with current draw of 180A maximum and speed of 3,500 rpm.