

VANGUARD

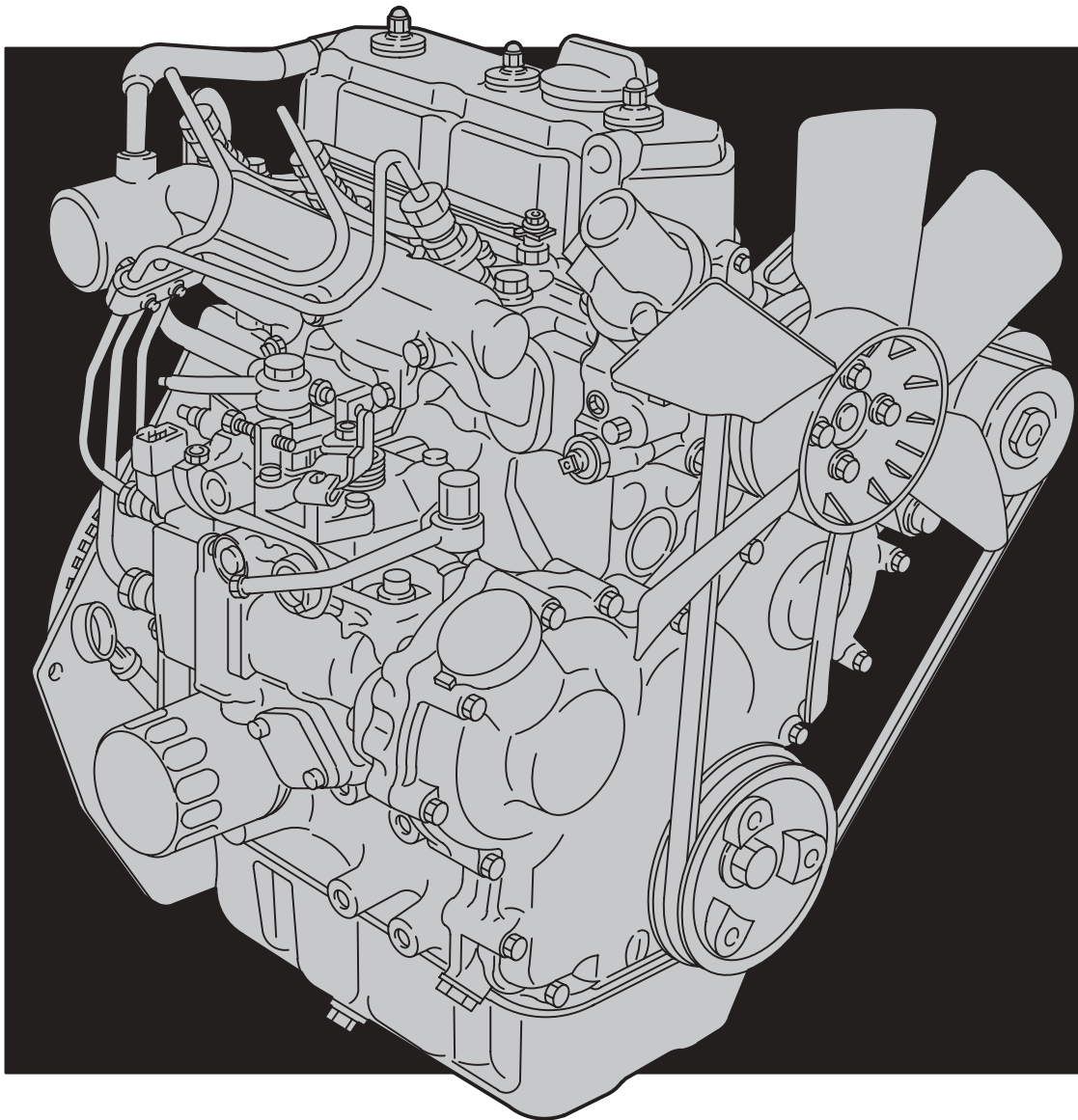
3/LC

cylinder liquid cooled



REPAIR MANUAL

For 3 Cylinder Liquid-Cooled Diesel Engines



FOREWORD

The information, procedures and specifications provided in this repair manual are current as of the date of publication and subject to change without notice. Appropriate changes will be included in the next revision of this manual.

Note: Manufacturing standards may vary from service specifications. Always refer to the service procedures and specifications in this manual when engine service is required.

GENERAL REPAIR INSTRUCTIONS

Before attempting a B&SD engine overhaul or a tune-up, it is necessary that your shop be equipped with proper tools, equipment and mechanics who are thoroughly familiar with Briggs & Stratton engine design and construction. With your shop thus equipped, this book will serve as a guide in performing the various steps necessary to do a complete and satisfactory job. Use only genuine replacement parts. Always use recommended service tools.

This engine is designed and manufactured using metric dimensions. The English equivalents provided may have been rounded up or down to the closest numerical interpretation of the metric dimension.

The terms Inspect, Check, Test and Replace are used as follows:

INSPECT – Visual inspection – look for signs of wear, scoring, cracks, stripped threads, etc.

CHECK – Measure by means of plug gauges, micrometer, feeler gauges, scale, etc.

TEST – Analyze with proper test equipment.

REPLACE – This usually means to take off the old part and reassemble it or replace it with a new one.

Disassembly

As engine is being disassembled, mark parts which are part of an assembly, to prevent interchanging. Arrange parts in an orderly manner, keeping parts which are an assembly together.

Visually inspect each part as it is removed – look for signs of wear, scoring, cracks, stripped threads, etc.

Inspection and Measurement

Carefully check parts that can be reconditioned and/or reused.

Replace any parts that are not within specification.

Clean parts to be reused

Clean or wash disassembled parts.

Assemble

Use a torque wrench to torque bolts and nuts to required specifications.

Replace all gaskets, cotter pins, oil seals and O-rings.

ABBREVIATIONS

Abbreviation	Meaning
ASSY	Assembly
BDC	Bottom Dead Center
DT	Diesel Turbocharger
EX	Exhaust
ID	Inside Diameter
IN	Intake
LH	Left Hand
MP	Multi-purpose

Abbreviation	Meaning
OD	Outside Diameter
OPT	Optional
O/S	Oversize
RH	Right Hand
SAE	Society of Automotive Engineers
T/C	Turbocharger
TDC	Top Dead Center
U/S	Undersize

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ENGINE IDENTIFICATION NUMBERS

The engine model and type number are located on the valve cover, Fig. 1. The serial number is stamped into the right side of the cylinder block, behind the intake manifold, Fig. 2.

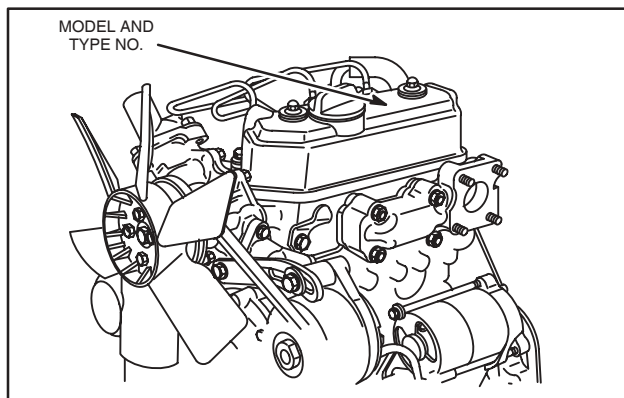


Fig. 1 – Engine Model And Type Number

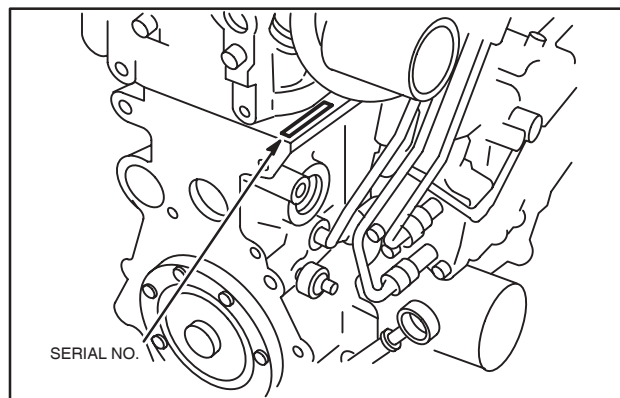


Fig. 2 – Engine Serial Number

GENERAL INFORMATION

1

IN THE INTEREST OF SAFETY



This safety alert symbol indicates that this message involves personal safety. Signal words danger, warning and caution indicate hazard degree. Death, personal injury and/OR property damage may occur unless instructions are followed carefully.



WARNING: DO NOT

1. DO NOT run engine in an enclosed area. Exhaust gases contain carbon monoxide, an odorless and deadly poison.
2. DO NOT place hands or feet near moving or rotating parts. Keep all guards in place.
3. DO NOT place hands or feet near electric cooling fan (if equipped). Fan may start suddenly, depending on coolant temperature.
4. DO NOT store, spill, or use diesel fuel near an open flame, or devices such as a stove, furnace, or water heater which use a pilot light or devices which can create a spark.
5. DO NOT refuel indoors where area is not well ventilated. Outdoor refueling is preferred.
6. DO NOT fill fuel tank while engine is running. Allow engine to cool for 2 minutes before refueling. Store fuel in approved, correct color safety containers.
7. DO NOT remove fuel tank cap while engine is running.
8. DO NOT operate engine when smell of fuel is present or other explosive conditions exist.
9. DO NOT operate engine if diesel fuel is spilled. Move machine away from the spill and avoid creating any ignition until the spill has been wiped up.
10. DO NOT smoke when filling fuel tank.
11. DO NOT tamper with maximum speed set screw or full load set screw of the injector pump which may increase the governed engine speed.
12. DO NOT tamper with the engine speed selected by the original equipment manufacturer.
13. DO NOT operate engine with a damaged muffler or without muffler. Inspect periodically and replace, if necessary. If engine is equipped with muffler deflector(s), inspect periodically and replace, if necessary, with correct deflector(s).
14. DO NOT operate engine with an accumulation of grass, leaves, dirt or other combustible material in the muffler area.
15. DO NOT use this engine on any forest covered, brush covered, or grass covered unimproved land unless a spark arrester is installed on the muffler. The arrester must be maintained in effective working order by the operator. In the State of California the above is required by law (Section 4442 of the California Public Resources Code). Other states may have similar laws. Federal laws apply on federal lands.

16. DO NOT touch hot muffler(s) or cylinder(s) because contact may cause burns.
17. DO NOT remove the radiator cap while the engine is hot. To avoid scalding from hot coolant or steam blowing out of the radiator, use extreme care when removing the radiator cap. If possible, wait for engine to cool. If not possible, wrap a thick rag around cap while removing. To release pressure, slowly turn cap counter clockwise to the first stop. When all pressure has been released, press down on cap and continue turning.
18. DO NOT start or run engine with air cleaner or air cleaner cover removed.



WARNING: DO

1. ALWAYS DO disconnect the negative wire from the battery terminal when servicing the engine or equipment, TO PREVENT ACCIDENTAL STARTING.
2. ALWAYS DO disconnect fuel shut off solenoid wire from injection pump before checking compression, TO PREVENT ACCIDENTAL STARTING.
3. DO wear eye protection when operating or repairing equipment.
4. DO keep governor parts free of grass and other debris which can affect engine speed.
5. DO examine muffler(s) periodically to be sure it is functioning effectively. A worn or leaking muffler(s) should be repaired or replaced as necessary.
6. DO check fuel lines and fittings frequently for cracks or leaks. Replace if necessary.



CAUTION:

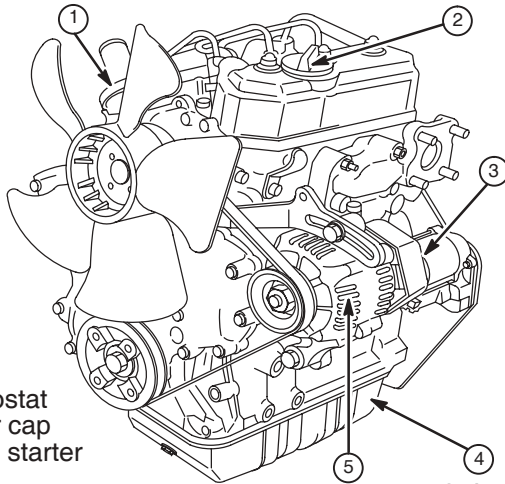
DO use clean fresh diesel fuel with a minimum of 40 cetane.

DO NOT use kerosene. The injection pump requires diesel fuel for lubrication. Damage to the injection pump and/or engine may result if kerosene is used.

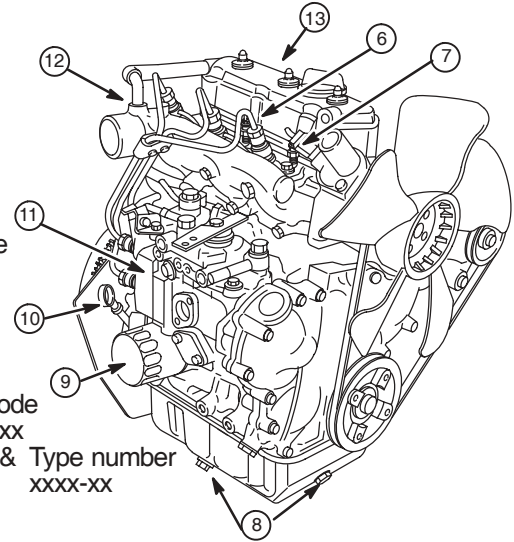
NOTE: Use Original Briggs & Stratton-Daihatsu Service Replacement Parts when servicing your engine. Authorized Briggs & Stratton-Daihatsu Service Centers carry a stock of such parts. The use of Briggs & Stratton-Daihatsu parts preserves the original design of your engine. Imitation replacement parts may not fit or function as original Briggs & Stratton-Daihatsu parts and can expose the operator to potential personal injury. Contact any Authorized Briggs & Stratton-Daihatsu Service Center for Original Briggs & Stratton-Daihatsu Replacement Parts.

ENGINE VIEWS

Diesel

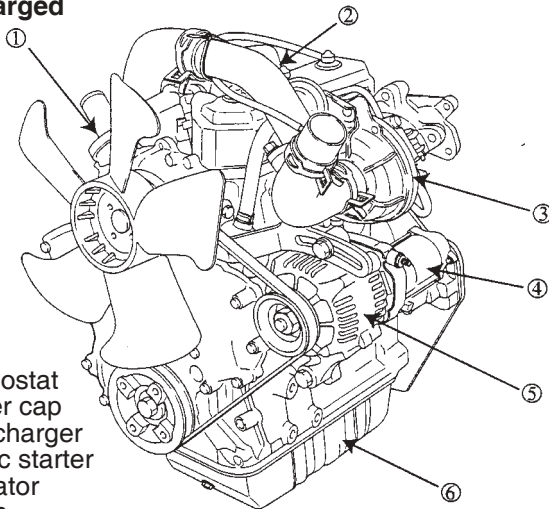


- 1. Thermostat
- 2. Oil filler cap
- 3. Electric starter
- 4. Oil pan
- 5. Alternator

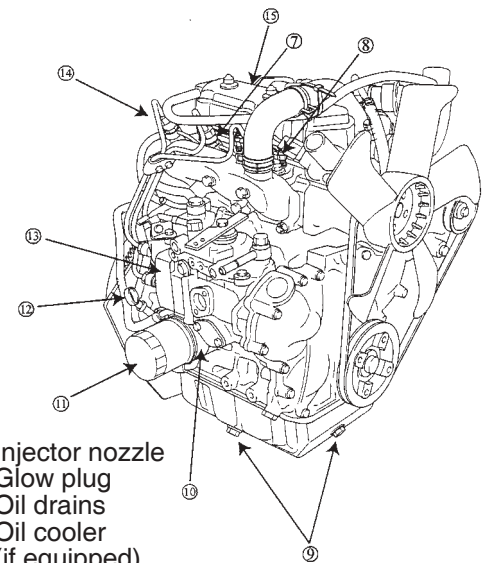


- 6. Injector nozzle
- 7. Glow plug
- 8. Oil drains
- 9. Oil filter
- 10. Dipstick
- 11. Injector pump
- 12. Engine Date code
xxxxxxx
- 13. Engine Model & Type number
xxxxx xxxx-xx

Turbo-charged Diesel



- 1. Thermostat
- 2. Oil filler cap
- 3. Turbocharger
- 4. Electric starter
- 5. Alternator
- 6. Oil pan



- 7. Injector nozzle
- 8. Glow plug
- 9. Oil drains
- 10. Oil cooler
(if equipped)
- 11. Oil filter
- 12. Dipstick
- 13. Injector pump
- 14. Engine Date code
xxxxxxx
- 15. Engine Model & Type number
xxxxx xxxx-xx

GENERAL INFORMATION

1

ENGINE SPECIFICATIONS

Model	432447	522447	582447 @58A447 @588447
Type	Diesel, 4-cycle, 3 cylinder, in-line, liquid cooled		
Valve mechanism	OHV, gear driven		
Bore x stroke mm (in)	68 x 64 (2.680 x 2.520)	68 x 78 (2.680 x 3.070)	72 x 78 (2.834 x 3.070)
Piston displacement cc (cu in)	697 (42.5)	850 (52.0)	952 (58.1)
Firing order	1-2-3 (front, center, back)		
Compression ratio	25.0:1	24.4:1	24.0:1 @ 24.8:1
Compression pressure (normal) @ 300 RPM Engine at operating temperature – glow plugs removed	Bar (psi) 33.0 (469)	32.0 (455)	34.0 (498) @ 37 (526)
Compression pressure (minimum) @ 300 RPM Engine at operating temperature – glow plugs removed	Bar (psi) 30.0 (425)	29.0 (412)	30.5 (433) @ 27 (384)
Gross HP @ 3600 RPM	19.5	23.6	26.5 @ 28.0
Gross Torque @ 2400 RPM	32.5	40.0	44.1 @ 49.2
Dimensions (L x W x H) mm (in)	441.8 x 440.4 x 523.9 (17.4 x 17.34 x 20.6)	434.4 x 442.9 x 548.4 (17.1 x 17.44 x 21.59)	434.4 x 442.9 x 548.4 (17.1 x 17.44 x 21.59) @ 434.4 x 447.5 x 559.0 (17.1 x 17.62 x 22.01)
Dry weight kg (lbs)	76 (168)	78 (172)	89 (196)

Cylinder Head	Type		Single piece casting		
	Material		Cast Iron		
Valve Specifications	Combustion Chamber		Swirl Type		
	Valve seat angle	Intake	45°		
		Exhaust	45°		
	Valve timing	Intake	Opens	10° BTDC	235°
			Closes	45° ABDC	
		Exhaust	Opens	45° BBDC	235°
			Closes	10° ATDC	
Valve clearance (cold)		Intake mm (in)	0.20 (.008 in)		
		Exhaust mm (in)	0.20 (.008 in)		
Cylinder Block & Camshaft	Cylinder block		Mono-block, three cylinder, cast iron		
	Camshaft		Carbon steel		
Connecting Rod & Piston	Connecting rod		Carbon steel		
	Piston Pin Bearing		Machined – Piston pin, slip fit		
	Crankpin Bearing	Material aluminum alloy – replaceable insert			
	Piston		Heat resistant aluminum alloy		
	Piston ring	Compression ring		Two, chrome plated	
		Oil ring		One, combination type, chrome plated	
Crankshaft & Crankshaft Bearing	Crankshaft		One piece cast iron		
	Crankshaft main bearing	Material	Replaceable insert – aluminum alloy		

GENERAL INFORMATION

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LUBRICATING SYSTEM

Lubricating Method		Pressure lube
Oil Pump	Type	Trochoid
	Drive	Gear drive
Oil Filter	Type	Full flow, paper
Oil Capacity		3.3 ltr (3.5 qt)
Oil Pump Relief Valve Opening Pressure		4.6 Bar (65 psi)
Lubrication Oil		API SE/CD class or higher

COOLING SYSTEM

Cooling Method		Liquid cooled, forced circulation
Coolant Capacity (engine only)		Approximately 1.8 ltr (1.9 qt)
Cooling System Pressure		1.0-0.75 Bar (15-11 psi)
Pressure Cap Capacity		0.9 Bar (13 psi)
Water Pump	Type	Centrifugal
	Drive	V-belt
Thermostat	Type	Wax pellet with bypass
	Specification	82° C (180° F)
Cooling Fan	Drive	V-belt

FUEL SYSTEM

Fuel Requirements		Diesel fuel (Cetane number 40 or higher)
Injector Pump	Type	Bosch VE (distributor type)
	Injector Timing (Plunger stroke) #1 Cyl. TDC	See Tables 1 & 2, Page 6
Injector Nozzle	Nozzle Type	Throttle type
	Injector pressure Bar (psi)	140 (1,991)
Idle Speed RPM		See Table 3, Page 7

ELECTRICAL SYSTEM

Battery	Voltage	12V (negative ground)
	Capacity	24 AH (28 AH cold)
Charging System	Alternator	28 Volt AC output – Minimum
	Regulator/rectifier	14 Amp DC output with charge indicator circuit
	Alternator {Optional}	40 Amp DC output – Internally regulated
Glow Plug	Voltage/Current V/A	11 Volts / 9.5 Amps
Starter	Voltage/Kilowatt V/K	Reduction gear type – 12 Volts / 1.0 kw {12 Volts / 1.2 kw, optional}

TABLE 1
Injection Pump Timing
Engine Date Code Before 99010100

Model/Type No.	Timing Specification
432447-0150-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0105-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0106-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0107-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0108-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0109-E2	0.93 ± .03 mm (.0365" ± .001")
582447-0105-E2	0.93 ± .03 mm (.0365" ± .001")
582447-0125-E2	0.81 ± .03 mm (.032" ± .001")
582447-0130-E2	0.93 ± .03 mm (.0365" ± .001")
582447-0131-E2	0.81 ± .03 mm (.032" ± .001")

TABLE 2
Injection Pump Timing
Engine Date Code After 98123100

Model Series	Timing Specification
432447 – All	0.90 ± .03 mm (.035" ± .001")
522447 – All	0.90 ± .03 mm (.035" ± .001")
582447 – All	0.81 ± .03 mm (.032" ± .001")
58A447 – All	0.90 ± .03 mm (.035" ± .001")
588447	

INJECTOR PUMP IDENTIFICATION

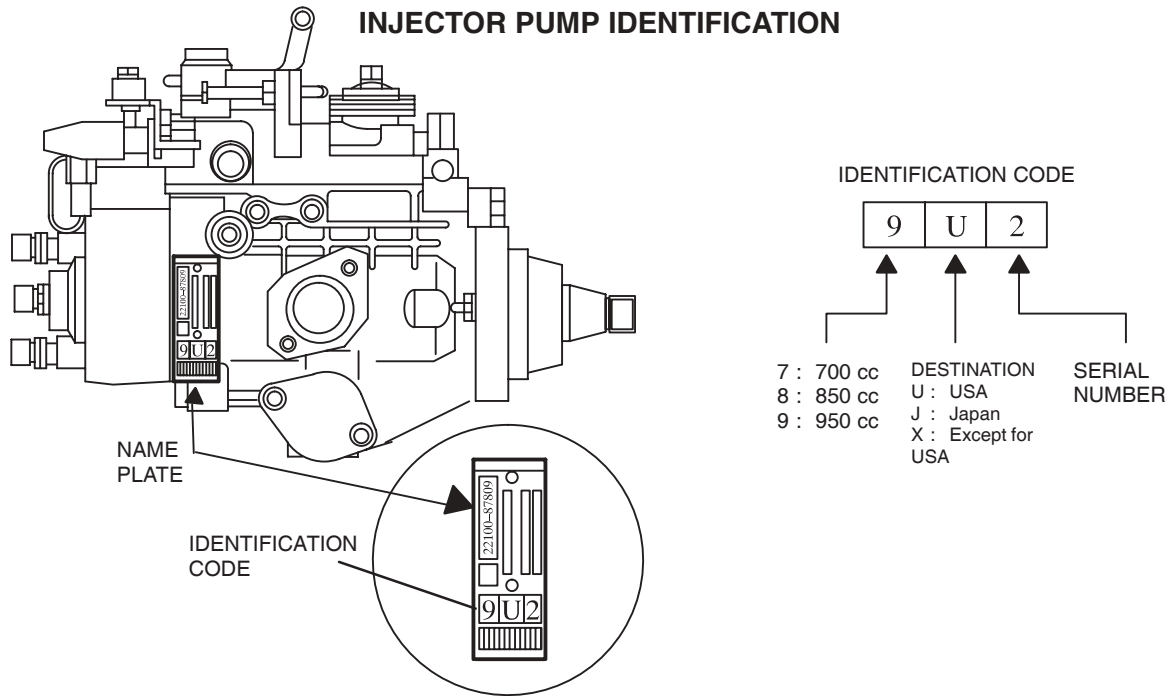


TABLE 3
Engine Speed Specification Chart

Pump Mfg. Part No.	ID Code	Model & Type No.	Idle Speed (rpm)	Top No Load (rpm)
22100-87801	7U1	432447-0105-E2	1200±50	3850±50
22100-8713	7U2	432447-0205-E2	1200±50	3850±50
22100-87802	9U1	582447-0105-E2	1200±50	3850±50
		582447-0205-E2	1200±50	3850±50
		582447-0130-E2	1200±50	3300±50
		582447-0230-E2	1200±50	3300±50
		582447-0219-E2	1600±50	3600±50
		582447-0222-E2	1600±50	3600±50
		582447-0221-E2	1750±50	3600±50
22100-87806	9U2	582447-0225-E2	1050±50	3850±50
		582447-0232-E2	1200±50	3400±50
		582447-0125-E2	1850±50	3420±50
22100-87807	8U1	582447-0131-E2	1700±50	3600±50
		582447-0231-E2	1700±50	3600±50
22100-87809	8U2	522447-0105-E2	1200±50	3850±50
		522447-0108-E2	1600±50	3350±50
22100-87810	8U3	522447-0106-E2	1850±50	3420±50
		522447-0109-E2	1850±50	3420±50
22100-87815	8U4	522447-0107-E2	1525±50	2775±50
22100-87817	8U5	522447-0107-E2	1540±50	2790±50
22100-87811	9U4	588447-0205-E2	1540±50	2790±50
22100-87818	9U5	588447-0205-E2	1200±50	3850±50
		588447-0216-E2	1200±50	3850±50
		588447-0230-E2	1800±50	3600±50
		588447-0225-E2	1600±50	3600±50
		588447-0225-E2	1050±50	3850±50

Description	Wrench/Socket Size	Torque
Alternator Adjust. Bracket	12 mm	19.0 Nm (170 in. lbs.)
Alternator – 14 Amp (to bracket)	12 mm	19.0 Nm (170 in. lbs.)
Alternator – 40 Amp (to bracket)	12 mm	61.0 Nm (45 ft. lbs.)
Alternator Bracket (to block)	12 mm	19.0 Nm (170 in. lbs.)
Camshaft Gear	17 mm	41.0 Nm (30 ft. lbs.)
Camshaft Retainer	10 mm	8.0 Nm (70 in. lbs.)
Conn. Rod Nuts	12 mm	36.0 Nm (320 in. lbs.)
Crankshaft Pulley	19 mm	88.0 Nm (65 ft. lbs.)
Cyl. Head Bolts (8 mm dia.)	12 mm	34.0 Nm (25 ft. lbs.)
Cyl. Head Bolts (9 mm dia.)	13 mm	43.0 Nm (32 ft. lbs.)
Cyl. Head Bolts (10 mm dia.)	14 mm	68.0 Nm (50 ft. lbs.)
Exhaust Manifold	12 mm	19.0 Nm (170 in. lbs.)
Fan Pulley	10 mm	7.0 Nm (60 in. lbs.)
Flywheel	14 mm	47.0 Nm (35 ft. lbs.)
Fuel Delivery Lines	17 mm	25.0 Nm (220 in. lbs.)
Fuel Return Line	17 mm	27.0 Nm (20 ft. lbs.)
Glow Plug	12 mm Deep	17.0 Nm (150 in. lbs.)
Idler Gear	12 mm	25.0 Nm (220 in. lbs.)
Injector Pump (mounting)	12 mm	19.0 Nm (170 in. lbs.)
Injector Pump Drive Gear	19 mm	61.0 Nm (45 ft. lbs.)
Injector Pump Bracket	12 mm	19.0 Nm (170 in. lbs.)
Injector Nozzle	21 mm Deep	61.0 Nm (45 ft. lbs.)
Injector Pump Distributor Bolt	14 mm	17.0 Nm (150 in. lbs.)
Intake Manifold	10 mm	8.0 Nm (70 in. lbs.)
Main Bearing Screws	14 mm	58.0 Nm (43 ft. lbs.)
Oil Drain Plug	14 mm	25.0 Nm (220 in. lbs.)
Oil Pan	10 mm	8.0 Nm (70 in. lbs.)
Oil Pressure Relief Valve	19 mm	34.0 Nm (25 ft. lbs.)
Oil Pump Gear	12 mm	19.0 Nm (170 in. lbs.)
Oil Pump Pickup	10 mm	8.0 Nm (70 in. lbs.)
Rear Seal Support	10 mm	6.0 Nm (50 in. lbs.)
Rocker Arm Assy.	12 mm Deep	19.0 Nm (170 in. lbs.)
Rocker Arm Adjustment	10 mm	11.0 Nm (95 in. lbs.)
Starter	14 mm	40.0 Nm (30 ft. lbs.)
Starter Bracket	14 mm	34.0 Nm (25 ft. lbs.)
Starter Solenoid	Phillips	9.0 Nm (80 in. lbs.)
Starter Motor Thru Bolts	10 mm	9.0 Nm (80 in. lbs.)
Timing Gear Case	10 mm	8.0 Nm (70 in. lbs.)
Timing Gear Cover (3 different lengths)	10 mm	8.0 Nm (70 in. lbs.)
Valve Cover	10 mm	6.0 Nm (50 in. lbs.)
Water Pump	12 mm	19.0 Nm (170 in. lbs.)

GENERAL INFORMATION

1

BRIGGS & STRATTON DAIHATSU NUMERICAL NUMBER SYSTEM

All Briggs & Stratton Daihatsu engines have a unique numerical designation system. Each engine is identified by a Model, Type and Code/Serial number. Example: Model Type Code/Serial

432447 0125 01 020521145

This chart explains the numerical model designation system. It is possible to determine most of the important mechanical features of the engine by merely knowing the model number. Here is how it works.

CUBIC INCH DISPLACEMENT	FIRST DIGIT AFTER DISPLACEMENT	SECOND DIGIT AFTER DISPLACEMENT	THIRD DIGIT AFTER DISPLACEMENT	FOURTH DIGIT AFTER DISPLACEMENT
	BASIC DESIGN SERIES	CRANKSHAFT, CARBURETOR, GOVERNOR	PTO BEARING, REDUCTION GEAR, AUXILIARY DRIVE, LUBRICATION	TYPE OF STARTER
6	0 - Gas-Mechanical	0 - Horizontal Shaft	0 - Plain Bearing/DU Non-Flange Mount	0 - Without Starter
8	1 - Natural Gas-Mechanical	Diesel Electronic or Mechanical Governor		1 - Rope Starter
9	2 - Diesel-Mechanical		1 - Plain Bearing Flange Mounting	2 - Rewind Starter
10	3 - Gas-Electronic	1 - Horizontal Shaft		3 - Electric Starter Only 120 Volt Gear Drive
11	4 - Natural Gas-Electronic	Vacu-Jet Carburetor Pneumatic Governor	2 - Sleeve Bearing Flange Mounting Splash Lube	4 - Electric Starter/Generator 12 Volt Belt Drive
12	5 - Diesel-Electronic			
13	6	2 - Horizontal Shaft	3 - Ball Bearing Flange Mounting Splash Lube	5 - Electric Starter Only 12 Volt Gear Drive
16	7	Pulsa-Jet Carburetor Pneumatic or Mechanical Governor		6 - Alternator Only
17	8 - Diesel - Turbo		4 - Flange Mounting Pressure Lubrication on Horizontal Shaft	7 - Electric Starter 12 Volt Gear Drive With Alternator
18	9			
19	A - Diesel Turbo	3 - Horizontal Shaft	5 - Plain Bearing Gear Reduction (6 to 1) CW Rotation Flange Mounting	8 - Vertical Pull Starter or Side Pull Starter
22	B to Z	Flo-Jet Carburetor Pneumatic Governor		
23		4 - Horizontal Shaft	6 - Plain Bearing Gear Reduction (6 to 1) CCW Rotation	
24				
25		5 - Vertical Shaft	7 - Plain Bearing Pressure Lubrication on Vertical Shaft	
26		Vacu-Jet Carburetor Pneumatic or Mechanical Governor		
28		6 - Vertical Shaft	8 - Plain Bearing Auxiliary Drive (PTO) Perpendicular to Crankshaft	
29		7 - Vertical Shaft		
30		Flo-Jet Carburetor Pneumatic or Mechanical Governor		
32		8 - Vertical Shaft	9 - Plain Bearing Auxiliary Drive Parallel to Crankshaft	
35				
38		9 - Vertical Shaft		
40		Pulsa-Jet Carburetor Pneumatic or Mechanical Governor		
42				
43				
44				
46				
52				
58				

The type number identifies certain unique features such as the crankshaft or governor spring used on an engine.

The code/serial number identifies the assembly date of the engine and serial number. In some instances it is necessary to know the code/serial number as well as the model and type number when performing adjustments, repairs or ordering replacement parts for an engine. Here is how it works.

Example: 990521150

- | | |
|--|--|
| <p>A. The first two digits, 02, indicate the calendar year, 2002.</p> <p>B. The second two digits, 05, indicate the calendar month, May.</p> | <p>C. The third two digits, 21, indicate the calendar month day.</p> <p>D. The last three digits, 145, indicate the serial number.</p> |
|--|--|

MAINTENANCE SCHEDULE

More frequent service is required when operating in adverse conditions (note 4 below).

1

System	Maintenance Operation	Daily	Every 50 hours	Every 100 hours	Every 200 hours	Every 600 hours	Every 800 hours	Yearly
Lubrication system	Check oil level	•						
	Check for oil leaks	•						
	Change oil		•1	•2				•5
	Change oil filter		•1		•2			
Cooling system	Check coolant	•						
	Change coolant							•
	Check fan belt			•				
Engine	Service air cleaner		•1	•2, 4		•3, 4		
	Check cylinder head bolt torque					•		
	Check valve clearance					•		
Electrical system	Check battery electrolyte				•			
Fuel system	Change fuel filter element						•6	

1 Perform first maintenance operation after 50 hours.

2 Then perform maintenance operation at this interval.

3 Replace after ever 600 hours of operation.

4 Service more often when operating under heavy load or in high temperatures.

5 Perform maintenance annually if operated less than 100 hours.

6 Follow manufacturer's maintenance schedule if non-B&SD approved part is used.

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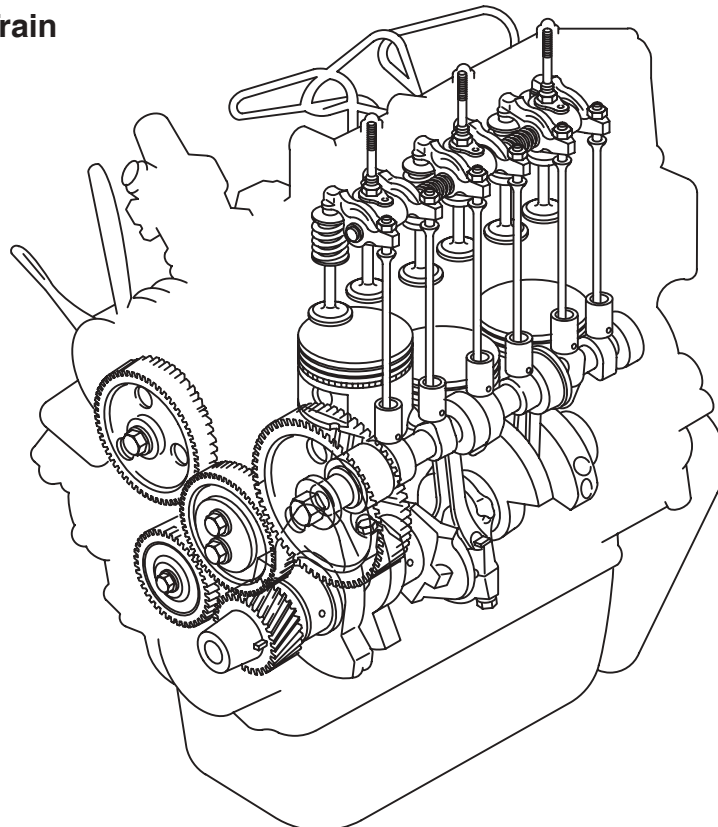
Section 2

Cylinder Head and Valves

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ADJUST VALVES	14

Overhead Valve Train



CYLINDER HEAD AND VALVES

REMOVE CYLINDER HEAD



ALWAYS disconnect fuel shut off solenoid wire from injection pump before checking compression, to prevent accidental starting.

Drain cooling system and disconnect radiator hoses.

1. Remove the following parts from engine, Fig. 1-Fig. 5:
 - a. Alternator adjusting bracket screw
 - b. V-belt
 - c. Fan (if equipped)

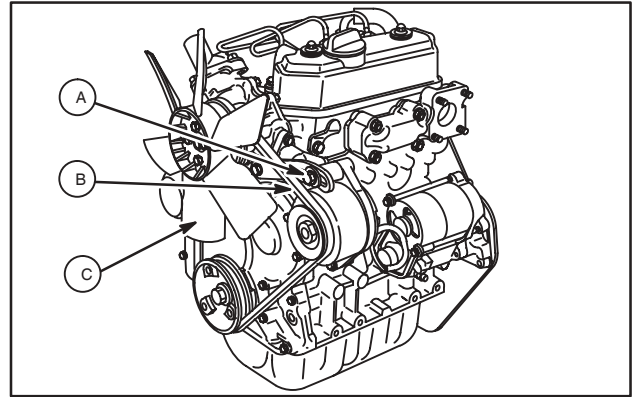


Fig. 1 – Remove V-belt And Fan

Fig. 2:

- d. Water pump
- e. Exhaust manifold

NOTE: Remove exhaust system before removing exhaust manifold.

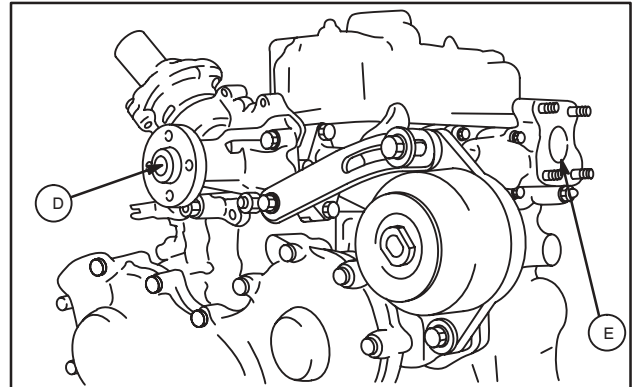


Fig. 2 – Remove Water Pump And Exhaust Manifold

Fig. 3:

- f. Valve cover

Discard rubber seal.

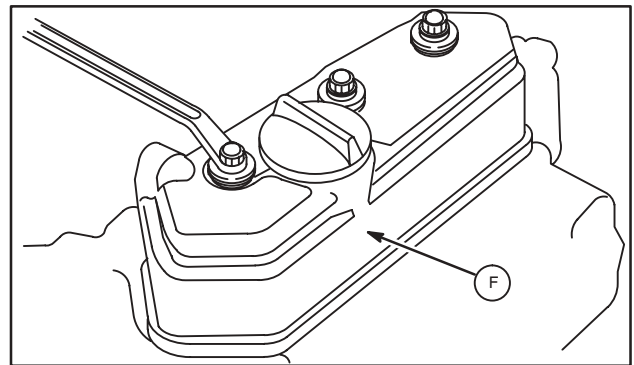


Fig. 3 – Remove Valve Cover

NOTE: Clean areas around fuel lines and injectors to prevent dirt entry.

Fig. 4:

- g. Fuel delivery lines
- h. Fuel return line
- i. Glow plug wiring
- j. Breather tube and intake manifold

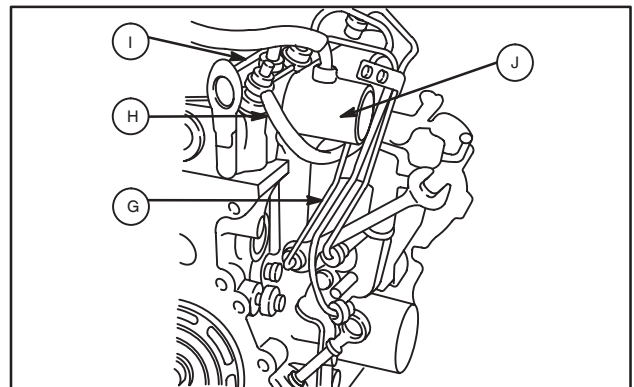


Fig. 4 – Remove Fuel Lines

Fig. 5:

- k. Fuel injector nozzles
- l. Glow plugs

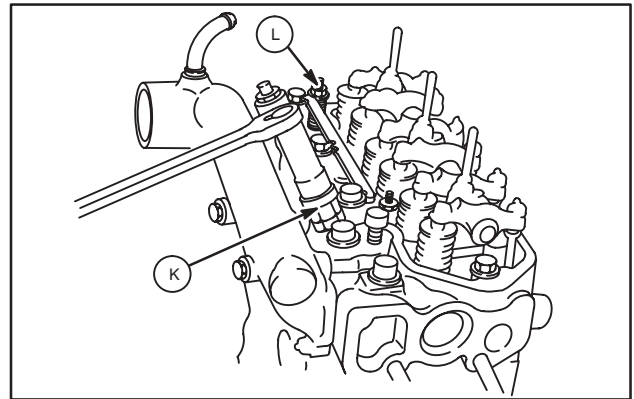


Fig. 5 – Remove Glow Plugs And Injectors

2. Set No. 1 piston at TDC, Fig. 6:

- a. Rotate crankshaft pulley until timing mark on pulley is aligned with reference point on timing cover.
- b. If intake and exhaust valves have clearance, No. 1 piston is at TDC – compression stroke.
- c. If intake and exhaust valves do not have clearance, turn crankshaft pulley one complete revolution. Valves will then have clearance.

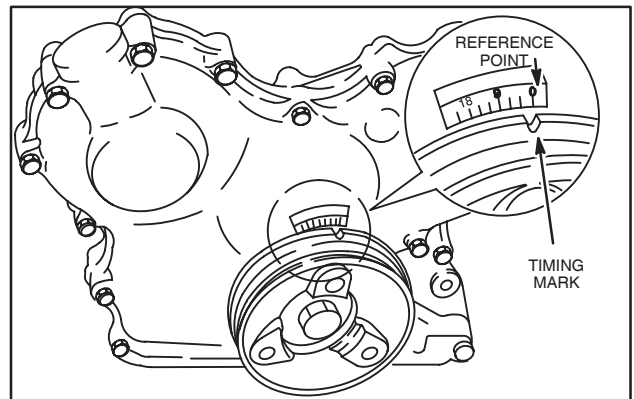


Fig. 6 – Set Cylinder No. 1 At TDC

3. Remove rocker arm assembly and push rods, Fig. 7.

- a. Remove valve stem caps.

NOTE: Mark push rods so that they may be reassembled in their original position.

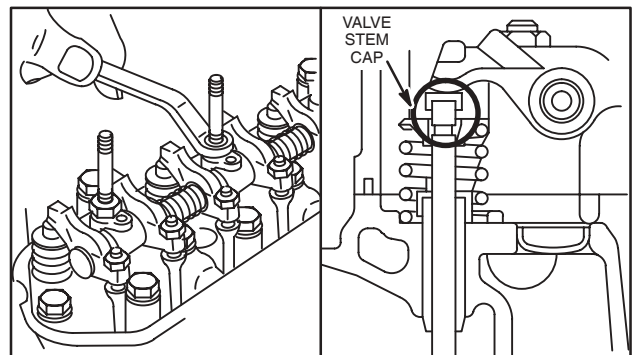


Fig. 7 – Remove Rocker Arm Assembly And Push Rods

4. Remove cylinder head assembly, Fig. 8.

- a. Loosen cylinder head bolts in the order shown.

NOTE: Current style head bolts are 9 mm diameter. Early style head bolts are 8 mm diameter. Torque specifications are different.

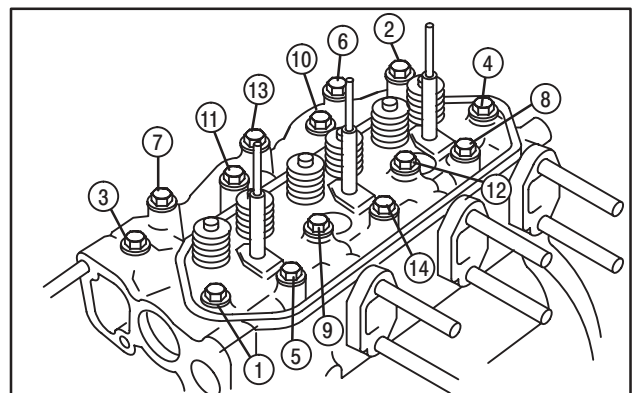


Fig. 8 – Loosen Cylinder Head Bolts

CYLINDER HEAD AND VALVES

2

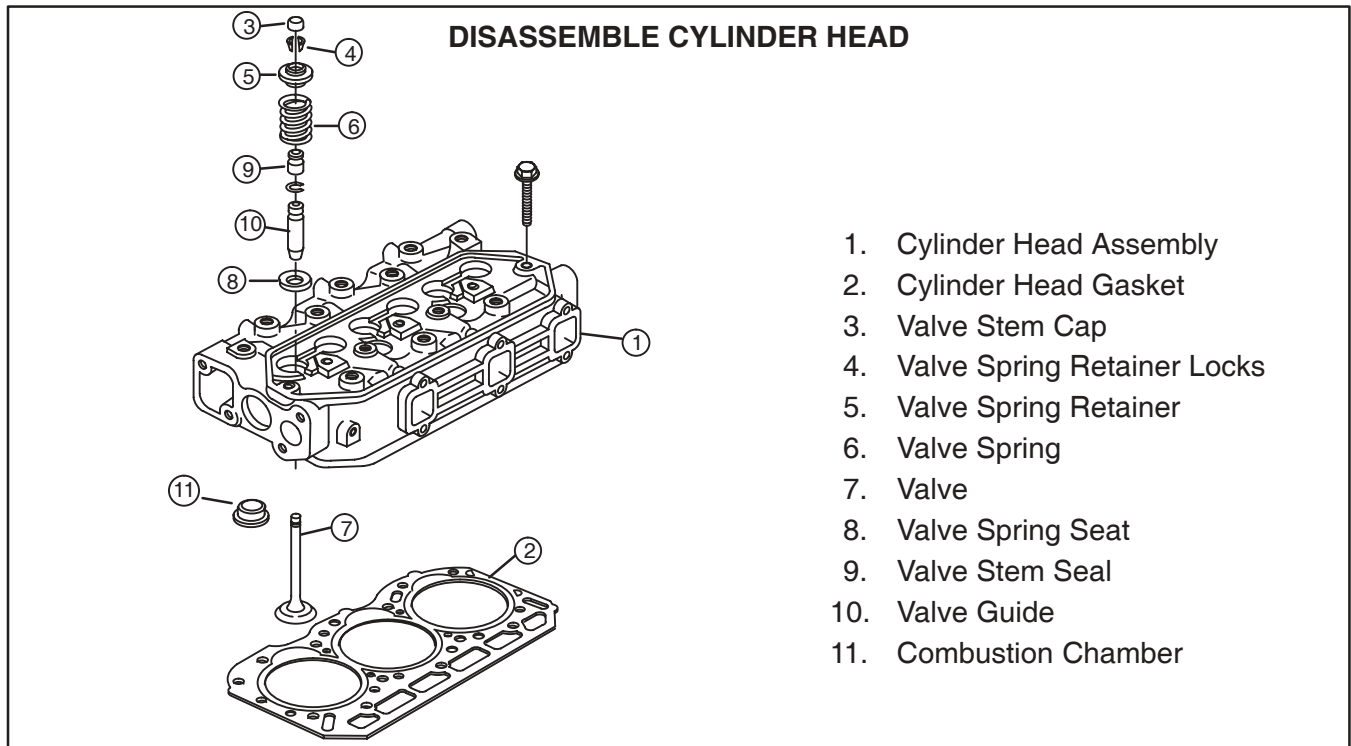


Fig. 9 – Cylinder Head Components

Remove valves, Fig. 10.

1. Use valve spring compressor, Tool #19417, to compress valve springs. Remove the following parts, Fig. 9:
 - a. Valve spring retainer locks – 4
 - b. Valve spring retainer – 5
 - c. Valve spring – 6
 - d. IN and EX valve – 7
 - e. Valve spring seats – 8

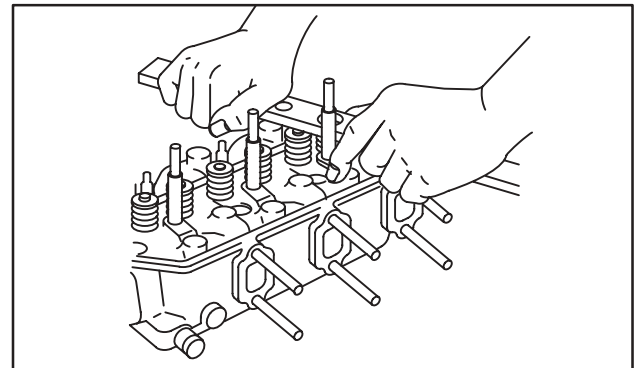


Fig. 10 – Remove Valves

2. Remove and discard valve stem seals, Fig. 11.

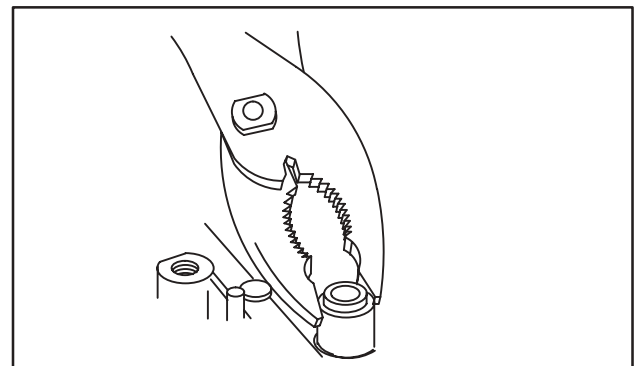


Fig. 11 – Remove Valve Stem Seal

INSPECT AND REPAIR

1. Check cylinder head mounting surfaces, Fig. 12 and Fig. 13.

Be sure all gasket material is removed from surfaces before checking. Use a gasket scraper if necessary.

- a. Inspect cylinder head for cracks or damage.
- b. Use a straight edge and check cylinder head lower surface for distortion.

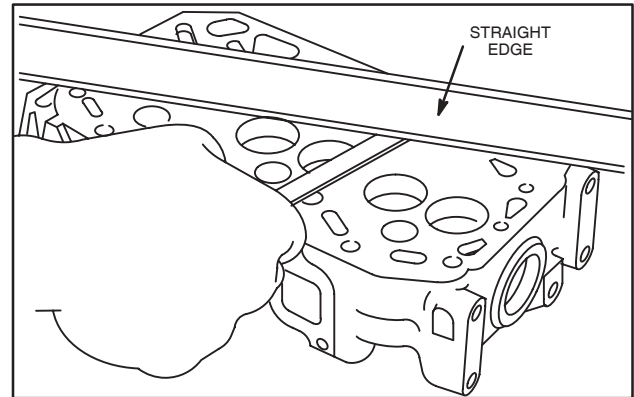


Fig. 12 – Check Cylinder Head For Distortion

Fig. 13:

- c. Check intake and exhaust manifold mounting surfaces.

If mounting surfaces are distorted more than 0.1 mm (0.004 in.), the cylinder head must be replaced.

It is not recommended that cylinder head mounting surfaces be resurfaced.

NOTE: Intake manifold and exhaust manifold may be checked in the same manner. Use same specifications as cylinder head.

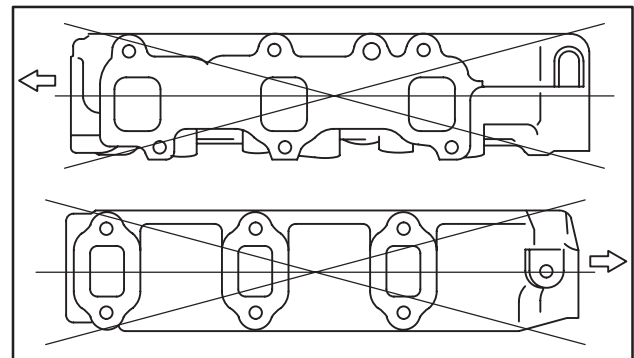


Fig. 13 – Check Cylinder Head For Distortion

CHECK COMBUSTION CHAMBER

Engine Model 522000: combustion chambers are not replaceable.

Engine Models 432000 and 582000 with date code after 990111007: combustion chambers are not replaceable.

NOTE: Only Engine Models 432000 and 582000 with date code before 981225006 have replaceable combustion chambers.

1. Check combustion chamber, Fig. 14.
 - a. Use a straight edge and feeler gauge.

If combustion chamber protrudes more than 0.05 mm (.002 in.) above surface of cylinder head, it must be replaced.

2. Remove combustion chamber, Fig. 15.

Insert a 10 mm brass rod through injector nozzle hole and drive out combustion chamber.

NOTE: Do not damage threads in injector hole.

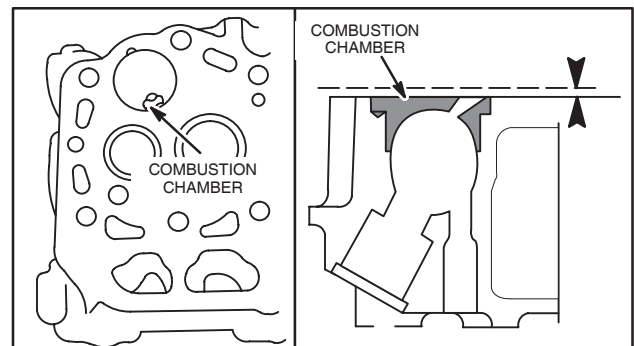


Fig. 14 – Check Combustion Chamber

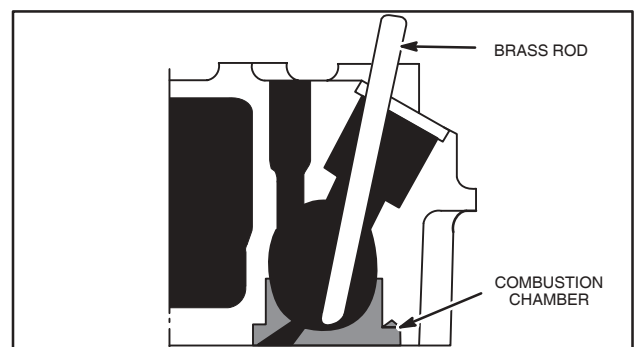


Fig. 15 – Remove Combustion Chamber

CYLINDER HEAD AND VALVES

3. Install combustion chamber, Fig. 16.

Align locating projection on combustion chamber with groove in cylinder head. Use a soft hammer and drive in new combustion chamber until it bottoms.

2

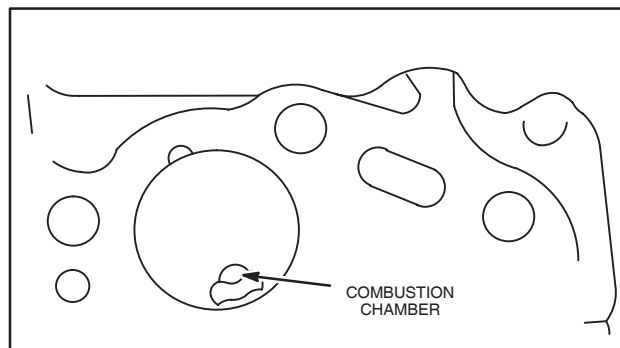


Fig. 16 – Install Combustion Chamber

CHECK AND REPAIR VALVE GUIDES

1. Check valve guide bushings for wear using reject gauge, Tool #19382, Fig. 17.

Remove if damaged or if reject gauge enters valve guide.

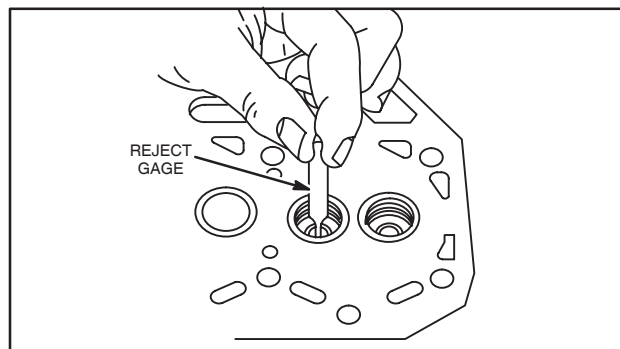


Fig. 17 – Check Valve Guide Bushing

2. Remove valve guide bushing if required, Fig. 18.
 - a. Use bushing driver, Tool #19367, and press out valve guide bushing from combustion chamber side.
 - b. Check valve guide bushing OD. Then see specifications below.

Std. Bushing OD: – 11.05 mm (.435 in.)

Replacement Bushing OD: – 11.08 mm (.4362 in.)

- c. If bushing OD measurement indicates that a replacement bushing has already been installed, the cylinder head must be replaced.

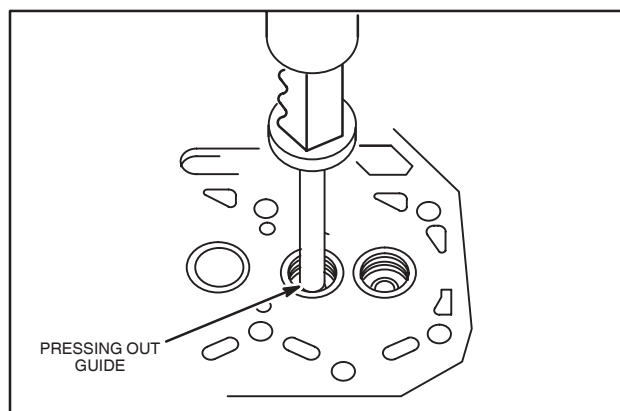


Fig. 18 – Remove Valve Guide Bushing

- Using bushing driver, Tool #19416, press in new valve guide bushing until tool bottoms on cylinder head, Fig. 19.

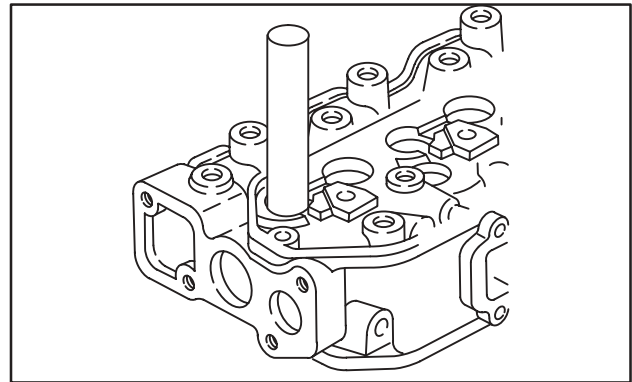


Fig. 19 – Installing Valve Guide Bushing

VALVES AND SEATS

- Valve faces may be resurfaced to 45°. See Fig. 20 for dimensions for valves. Lap valves and seats with valve lapping Tool, #19258 and valve lapping compound, Tool #94150.

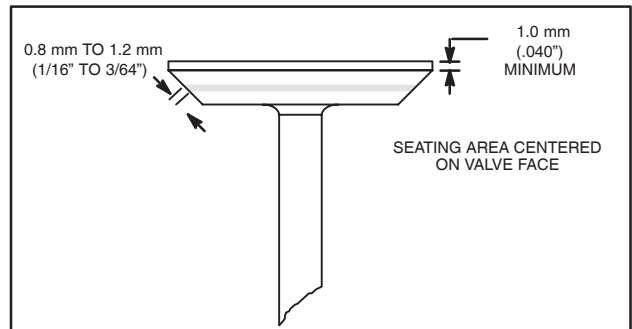


Fig. 20 – Valve Dimensions

- Valve seats may be reconditioned using valve seat cutter, Tool #19446.

NOTE: Check valve guide bushings first. If valve guides are worn, they must be replaced before refacing valve seats

If valve seat is wider than dimension shown in Fig. 21, a narrowing cutter should be used to ensure that contact area of valve seat is centered on face of valve, Fig. 20.

- Use a 60° cutter to narrow seat from bottom and a 30° cutter to narrow seat from top, Fig. 21.

NOTE: If valve seat is loose or cracked, replace cylinder head.

- Measure valve stem diameter at specified distance from end of valve, as shown in Fig. 22.

Replace IN if less than 5.927 mm (0.2333 in.).

Replace EX if less than 5.923 mm (0.2332 in.).

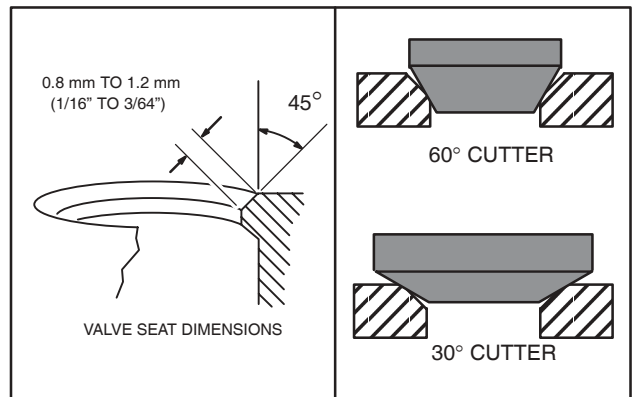


Fig. 21 – Valve Seat Dimensions

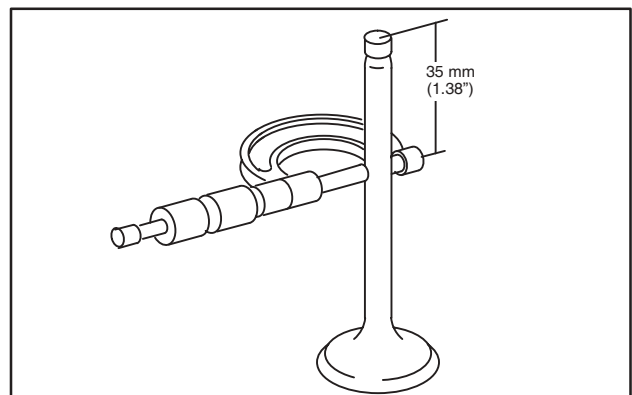


Fig. 22 – Measure Valve Stem Diameter

CYLINDER HEAD AND VALVES

4. Inspect valve stem cap for wear, Fig. 23.

Replace if cap is worn recessed.

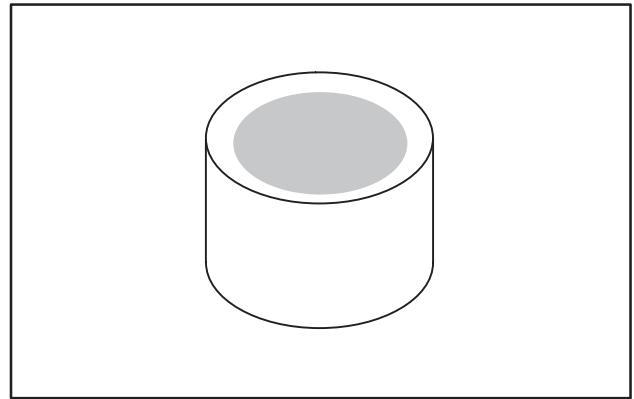


Fig. 23 – Check Valve Stem Cap

5. Check valve springs for squareness and free length, Fig. 24.

Replace if out of square more than 1.0 mm (.040 in.).

Replace if free length is less than 30.7 mm (1.209 in.).

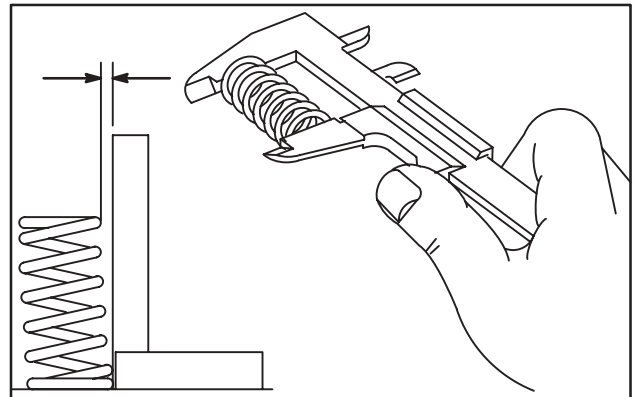


Fig. 24 – Check Valve Springs

DISASSEMBLE ROCKER ARM SHAFT

1. Remove snap rings from ends of rocker arm shaft. Remove set screw from center rocker arm support. Disassemble rocker arm assembly. Note position of all components, Fig. 25.

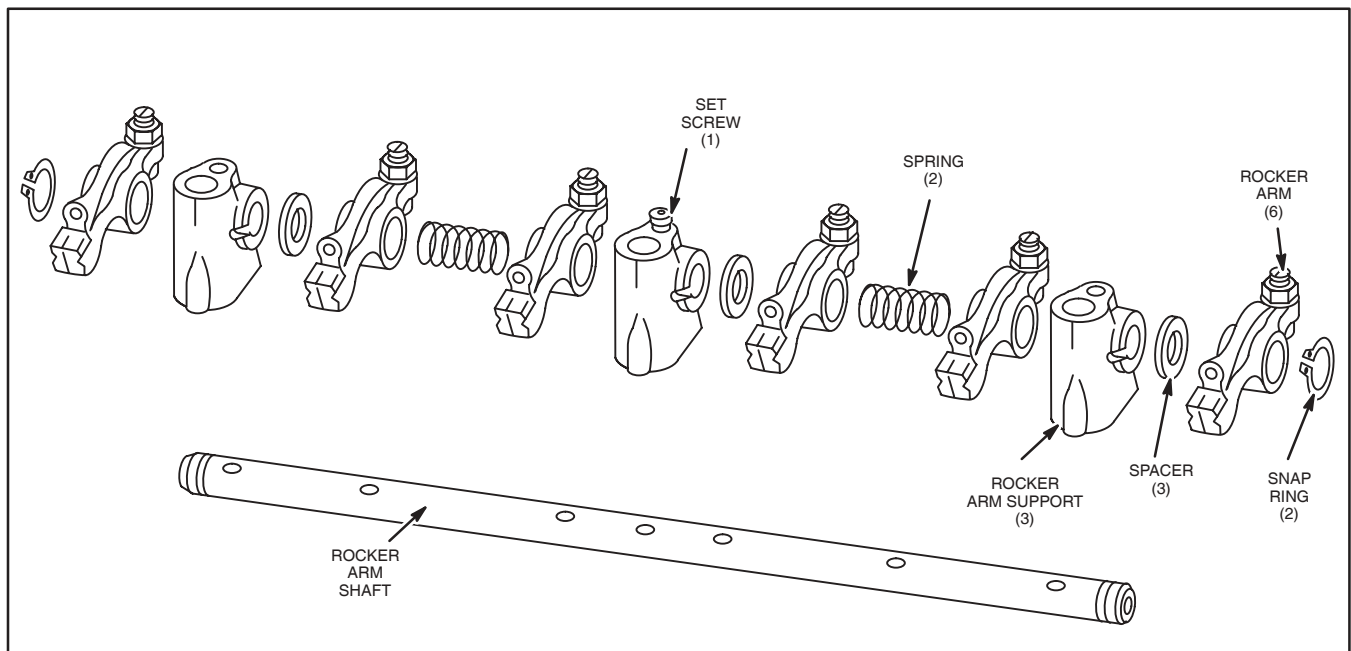


Fig. 25 – Rocker Arm Components

- 2. Check rocker arms and shaft, Fig. 26.
 - a. Check rocker arm-bearing surface.

Replace if greater than 10.03 mm (0.395 in.).

- b. Check rocker arm shaft

Replace if less than 9.96 mm (0.392 in.).

- c. Check rocker arm studs for stripped threads and replace if required.

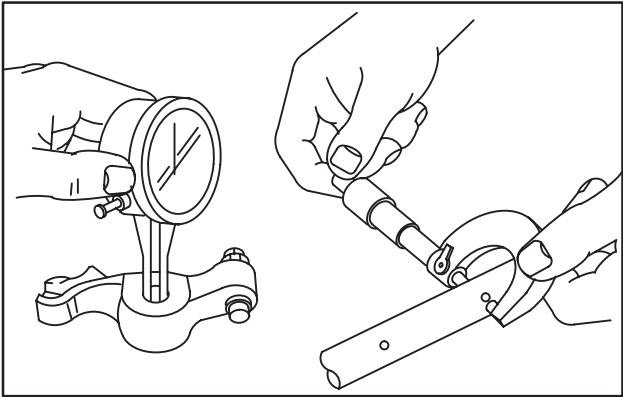


Fig. 26 – Checking Rocker Arm And Shaft

ASSEMBLE ROCKER ARM SHAFT

- 1. Oil all components before assembling. Small grooves in rocker shaft next to oil holes must face down. Assemble rocker arm components, noting order of assembly as shown in Fig. 27. Note position of three thrust washers. Install set screw in center rocker arm shaft support.

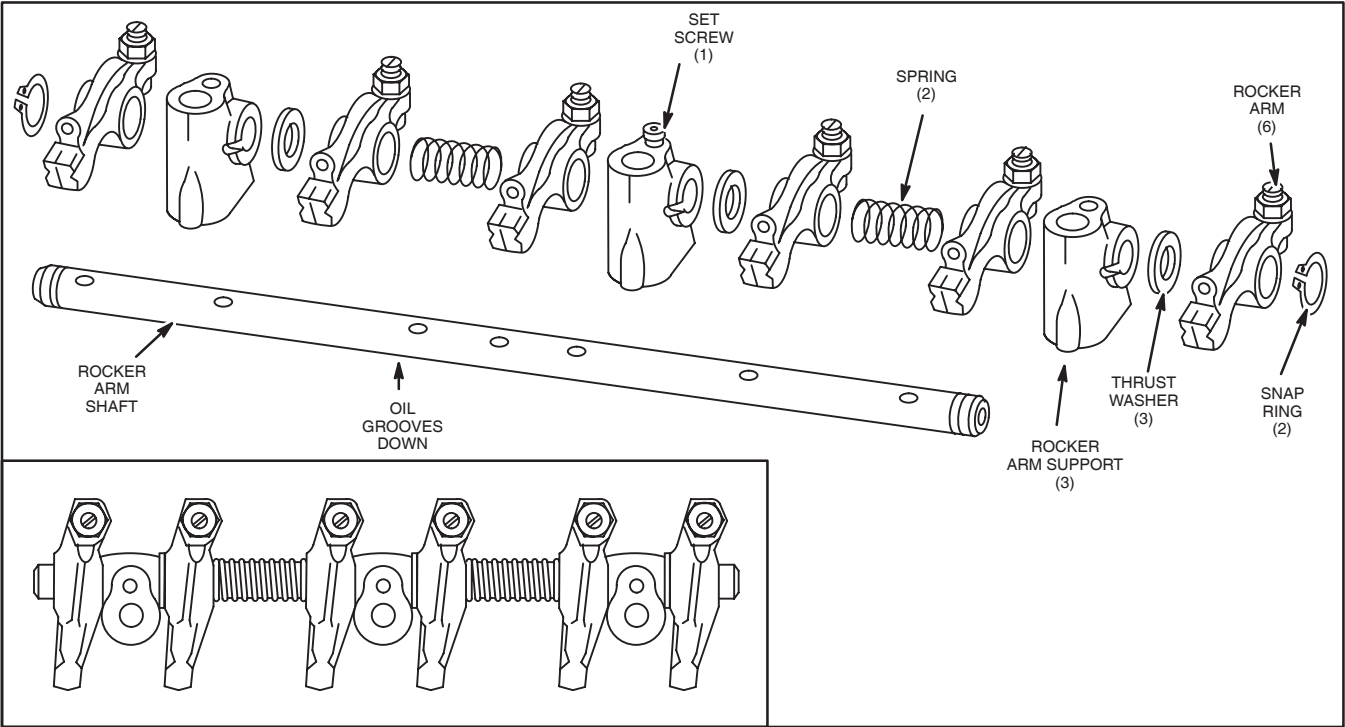


Fig. 27 – Rocker Arm Components

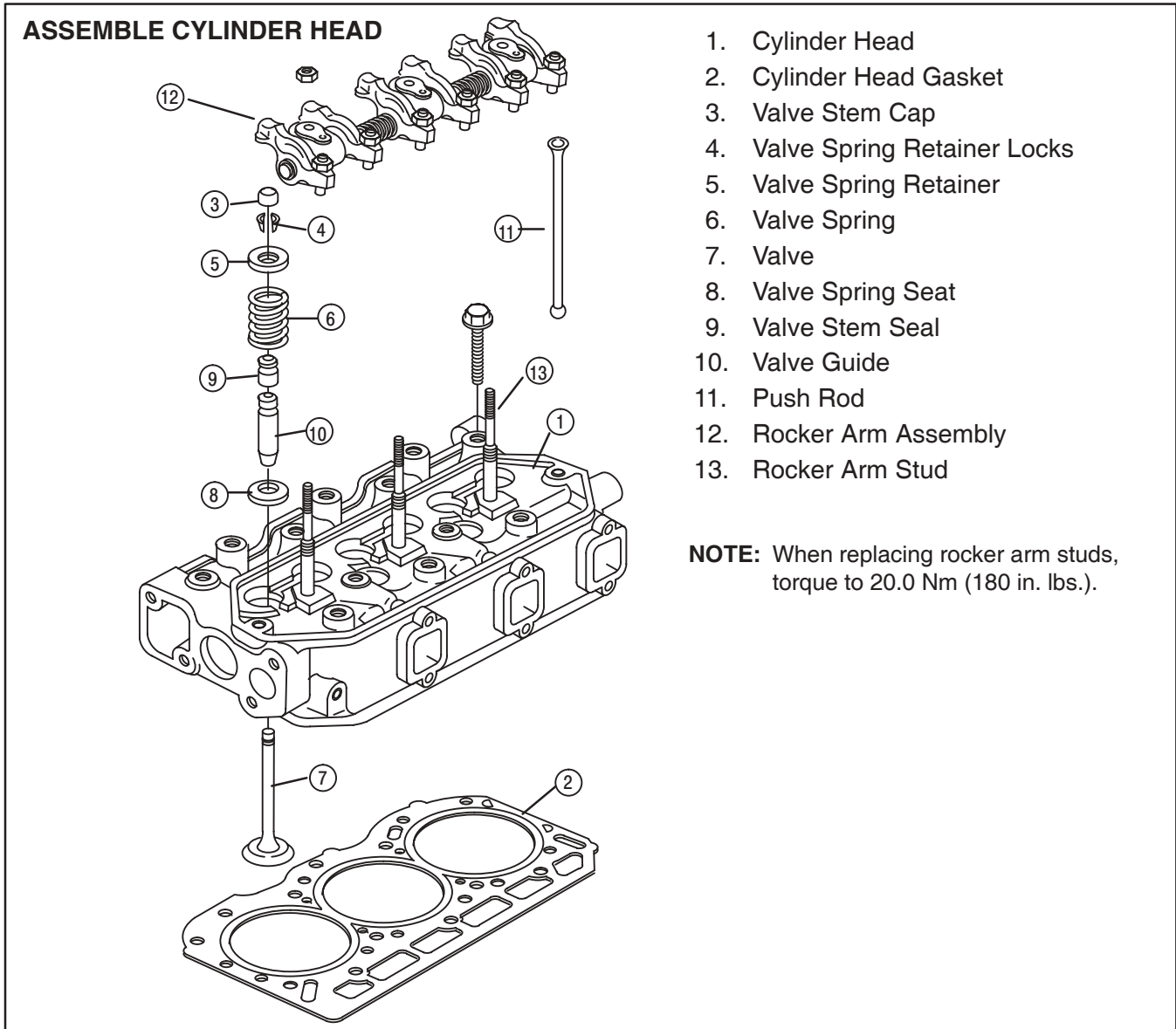


Fig. 28 – Cylinder Head Components

1. Install new valve stem seals, Fig. 29. Oil inner surface and lip of seal before installing. Press seal on to valve guide bushing until it bottoms.

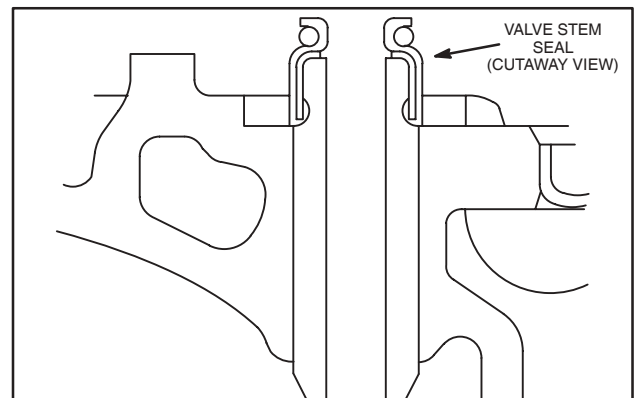


Fig. 29 – Install Valve Stem Seals

2. Install valve spring seats, Fig. 30.

NOTE: Lightly coat valve stems with Valve Guide Lubricant #93963 before installing valves.

3. Install valves.

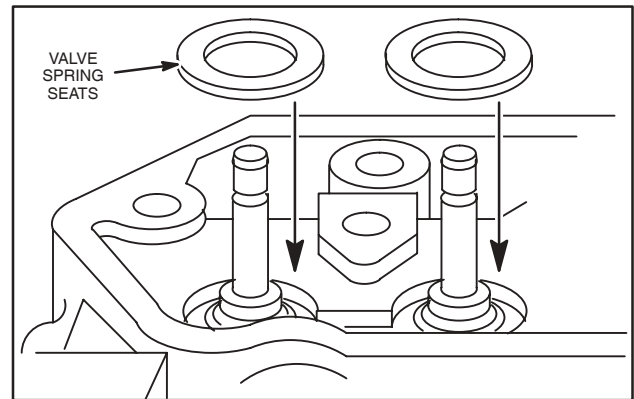


Fig. 30 – Install Valve Spring Seats And Valves

4. Install valve springs with valve spring compressor, Tool #19417, Fig. 31.

NOTE: After installing valve spring retainer locks, tap valve spring retainer lightly with a soft hammer to ensure locks are seated.

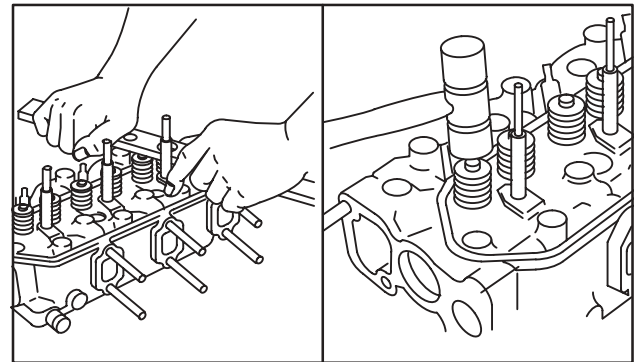


Fig. 31 – Install Valve Springs

INSTALL CYLINDER HEAD

1. Place cylinder head gasket over alignment dowels on cylinder block, Fig. 32.

NOTE: Make sure coolant, oil passages and head bolt holes are aligned.

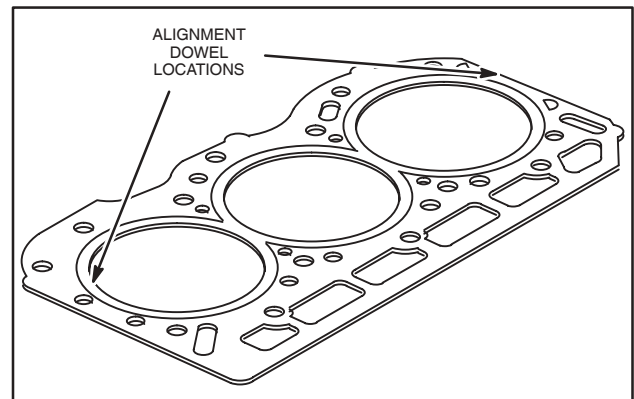


Fig. 32 – Install Cylinder Head Gasket

2. Install cylinder head assembly, Fig. 33. Lubricate threads of cylinder head bolts with engine oil. Torque head bolts in 14.0 Nm (10 ft. lbs.) increments in sequence shown.

NOTE: Current style head bolts are 9 mm diameter. Early style head bolts are 8 mm diameter.

- a. Torque 9 mm head bolts to 43.0 Nm (32 ft. lbs.).
- b. Torque 8 mm head bolts to 34.0 Nm (25 ft. lbs.).

NOTE: Engine Models 58A447 588447 have 10 mm diameter head bolts. Torque head bolts to 68 Nm (60 ft. lbs.).

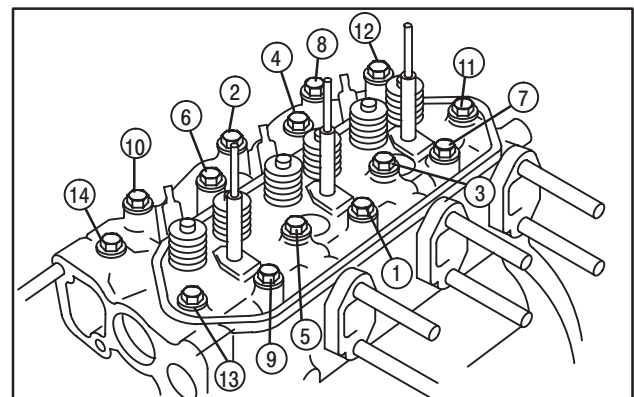


Fig. 33 – Install Cylinder Head Assembly

CYLINDER HEAD AND VALVES

- Lubricate push rods with engine oil then install with recessed end up, Fig. 34.

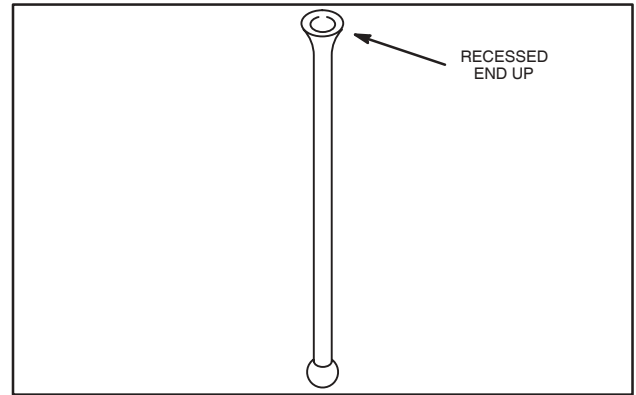


Fig. 34 – Install Push Rods

- Install valve stem caps on valve stems. Install rocker arm assembly, Fig. 35. Install washers and torque nuts to 19.0 Nm (170 in. lbs.).

NOTE: Make sure rocker adjustment studs are seated in recessed end of push rods.

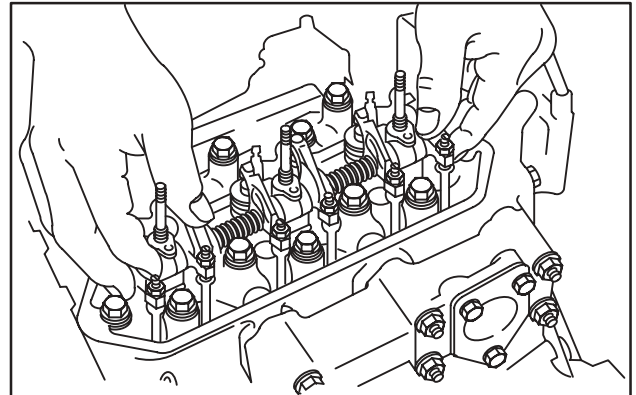


Fig. 35 – Install Rocker Arm Assembly

- Install intake manifold with new gasket, Fig. 36.
 - Torque screws to 8.0 Nm (70 in. lbs.).

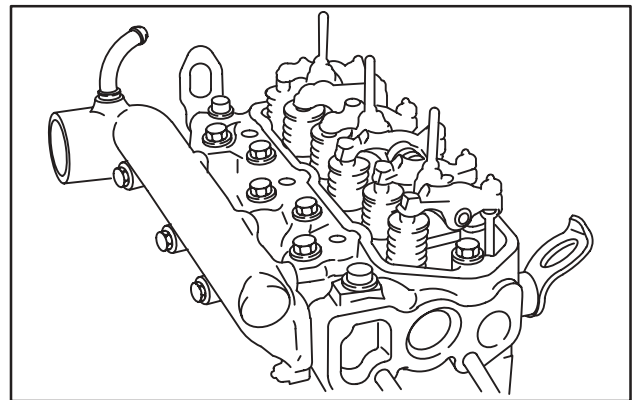


Fig. 36 – Install Intake Manifold

- Install Injectors, fuel lines and glow plugs, Fig. 37.
 - Torque injectors to 61.0 Nm (45 ft. lbs.).
 - Torque fuel return line to 27.0 Nm (20 ft. lbs.).
 - Torque fuel delivery lines to 25.0 Nm (220 in. lbs.).
 - Torque glow plugs to 17.0 Nm (150 in. lbs.).

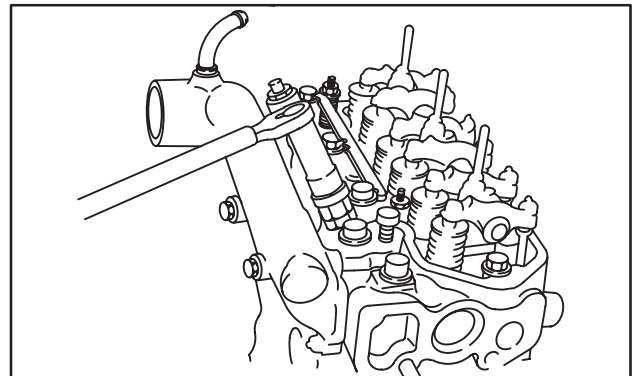


Fig. 37 – Install Glow Plugs And Injectors

7. Install exhaust manifold with new gasket, Fig. 38.
 - a. Torque screws to 19.0 Nm (170 in. lbs.).

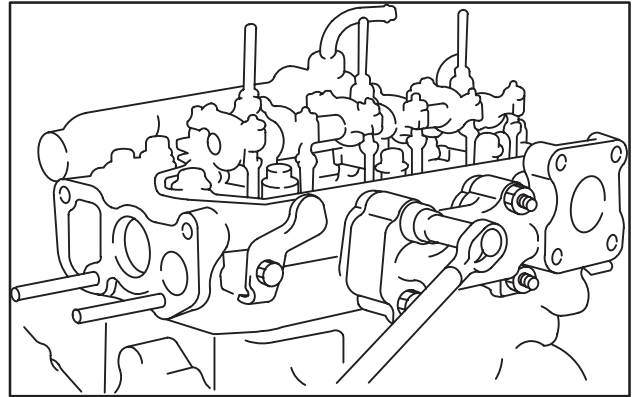


Fig. 38 – Install Exhaust Manifold

GENERAL ASSEMBLY

1. Install water pump with new gasket, Fig. 39.
 - a. Torque screws and nuts to 19.0 Nm (170 in. lbs.).

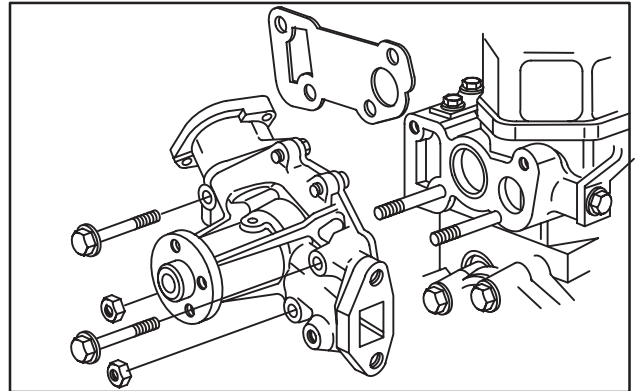


Fig. 39 – Install Water Pump

2. Install water pump pulley, Fig. 40.
3. Install fan (if equipped).
 - a. Torque screws to 7.0 Nm (60 in. lbs.).

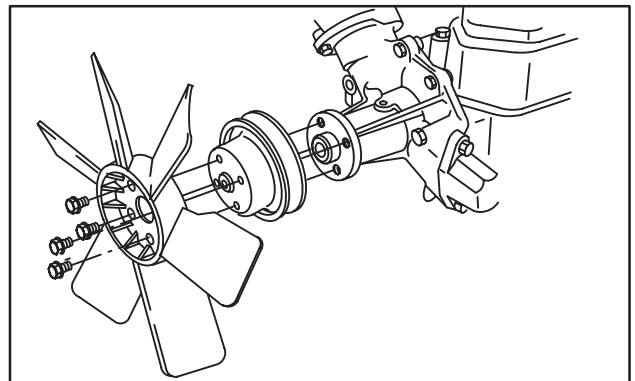


Fig. 40 – Install Water Pump Pulley And Fan

4. Install V-belt, Fig. 41.
5. Install alternator bolts (A) and (B).

Belt deflection limit is 10–12 mm/10 kg (3/8–1/2 in/22 lbs.).

- a. Torque bolt (A) to 19.0 Nm (170 in. lbs.).
- b. Torque bolt (B) to 61.0 Nm (45 ft. lbs.).

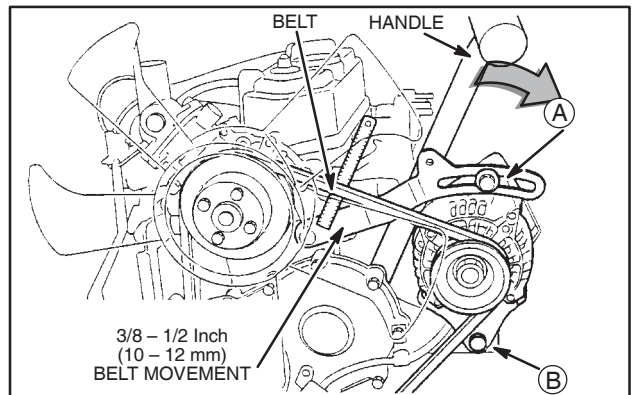


Fig. 41 – Adjusting V-belt

CYLINDER HEAD AND VALVES

ADJUST VALVES

1. Before adjusting valves, make sure that No. 1 cylinder is at TDC – compression stroke, Fig. 42.

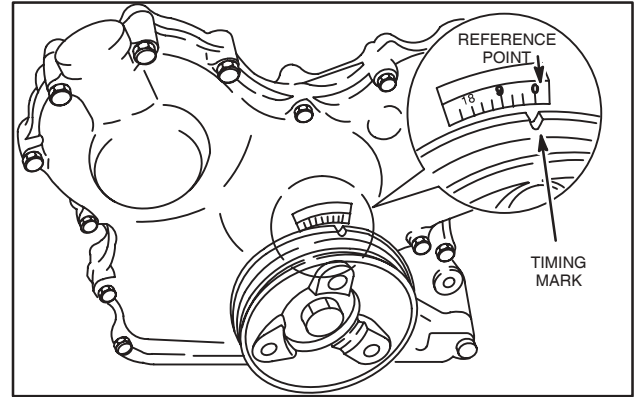


Fig. 42 – Set Cylinder No. 1 at TDC

- a. Adjust valves and check, Fig. 43.

Valve Clearance (cold) IN and EX 0.20 mm (0.008 in.)

- b. Torque adjusting screws and jam nuts to 11.0 Nm (95 in. lbs.).

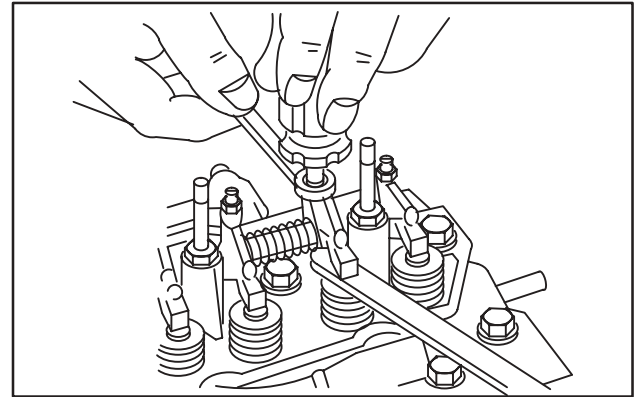


Fig. 43 – Adjust Valve Clearances

With No. 1 piston at TDC of compression stroke, check and adjust valve clearances for cylinders shown in chart at right.

Rotate crankshaft one complete turn (360°) clockwise to check and adjust remaining valves.

Piston Position Cylinder		1	2	3
No. 1 piston at TDC, of compression stroke	IN	●		●
	EX	●	●	
Rotate Crankshaft 360° clockwise	IN		●	
	EX			●

2. Install valve cover with new rubber seal, Fig. 44.

- a. Torque cover nuts to 7.0 Nm (50 in. lbs.).

NOTE: Make sure rubber seal is in groove in valve cover.

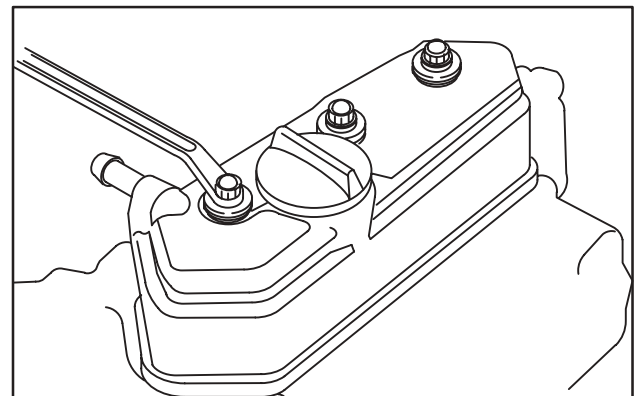


Fig. 44 – Install Valve Cover

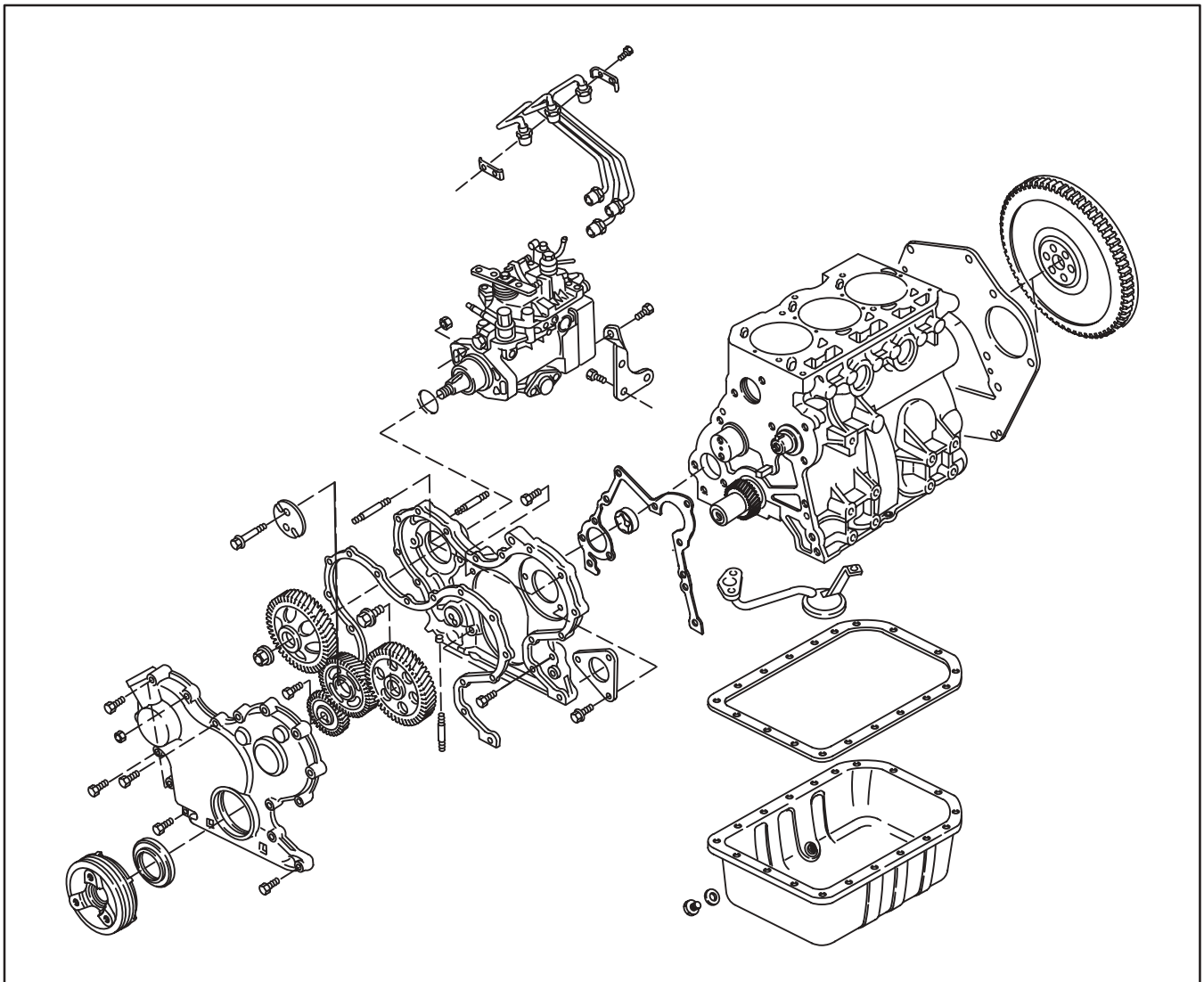
Section 3

Timing Gears and Gear Case

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REMOVE GEAR CASE	4
REPLACE TIMING GEAR COVER OIL SEAL	5
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TIMING GEARS AND GEAR CASE

REMOVING TIMING GEAR COVER AND GEARS

Make sure that #1 cylinder is at TDC, compression stroke. See Section 2, Fig. 6.

Remove V-belt and fan (if equipped). Drain oil from engine.

NOTE: Clean areas around fuel lines and injectors to prevent dirt entry.

1. Remove the following parts, Fig. 1.
 - a. Glow plug wiring.
 - b. Glow plugs.
 - c. Injector pump bracket.
 - d. Remove fuel delivery lines.

2. Remove the following parts, Fig. 2.
 - a. Remove oil pan and discard gasket.
 - b. Remove oil pick-up tube and strainer. Discard gasket.

3. Remove bell housing adapter screw if equipped and install flywheel holder, Tool #19418.
4. LEAVE TOOL INSTALLED.
 - a. Remove crankshaft pulley using Tool # 19420, Fig. 3.

5. Remove timing gear cover, Fig. 4.
 - a. Discard timing gear cover gasket.

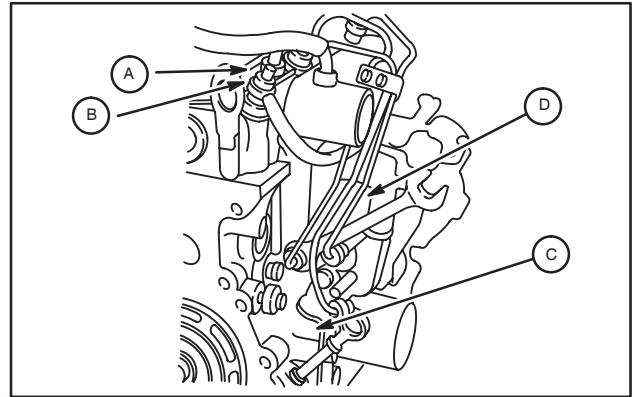


Fig. 1 – Remove Fuel Delivery Lines

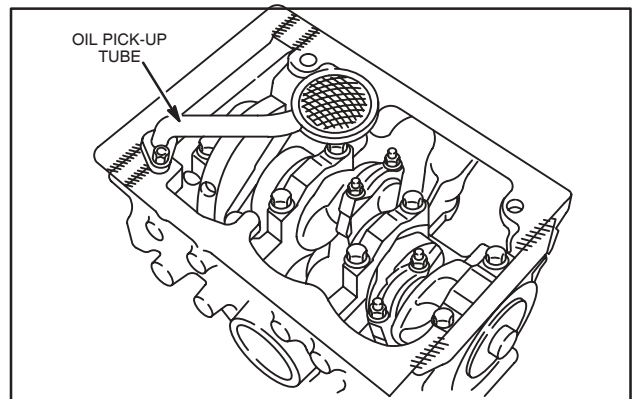


Fig. 2 – Removing Oil Pan

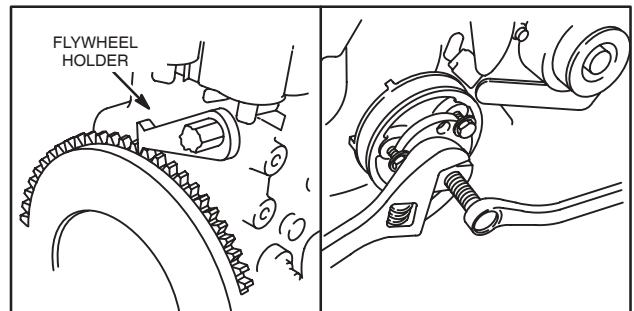


Fig. 3 – Removing Crankshaft Pulley

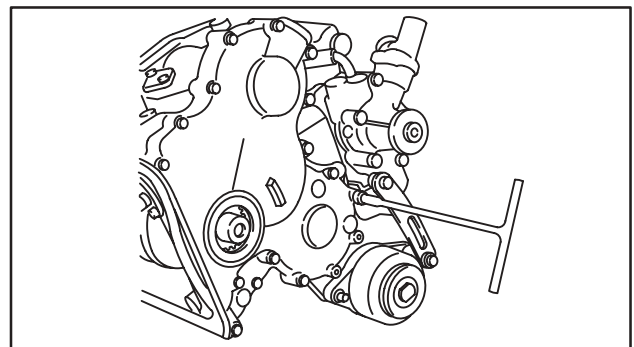


Fig. 4 – Removing Timing Gear Cover

6. Remove oil pump drive gear, Fig. 5.
 - a. Check oil pump drive gear for damaged teeth.

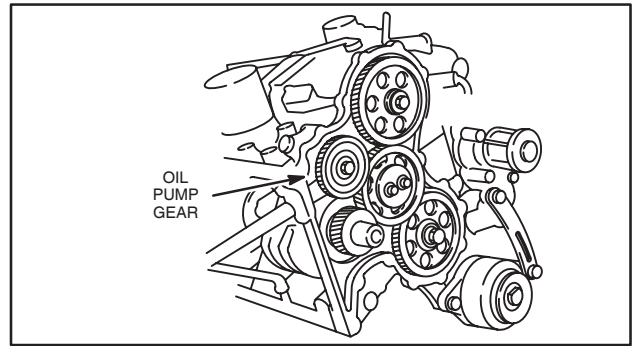


Fig. 5 – Removing Oil Pump Gear

CHECKING GEARS

Inspect gear teeth for wear or damage.
CHECK GEARS IN SEQUENCE SHOWN.

1. Check gear backlash between idler gear and crankshaft gear using dial indicator as shown in Fig. 6.
 - a. Set tip of indicator on gear tooth, then rock idler gear back and forth noting indicator reading.

NOTE: Crankshaft must not turn while checking.

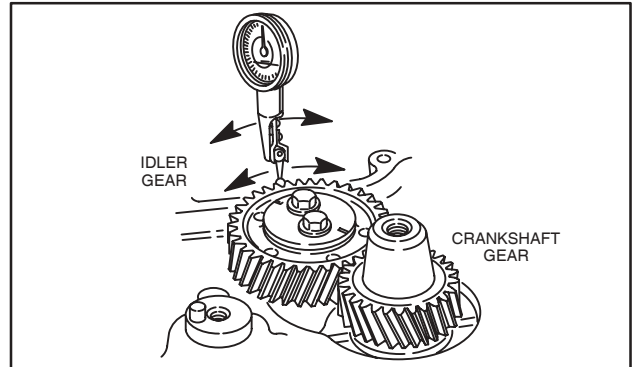


Fig. 6 – Checking Idler Gear Backlash

2. If backlash exceeds 0.2 mm (.008”) check idler gear bearing and shaft for wear, Fig. 7.

Reject Dimension: Idler Gear ID –
34.17 mm (1.345”)

Idler Gear Shaft OD –
33.91 mm (1.335”)

- a. If idler gear bearing and shaft are within specification, replace with new idler gear and recheck.
- b. If backlash exceeds 0.2 mm (.008”) with NEW idler gear, crankshaft gear is worn.

NOTE: If crankshaft gear is worn the crankshaft must be replaced.

3. Hold idler gear as shown and check gear backlash between camshaft timing gear and idler gear using dial indicator, Fig. 8.

Camshaft timing gear backlash must not exceed 0.2 mm (.008”).

NOTE: Idler gear must not turn while checking.

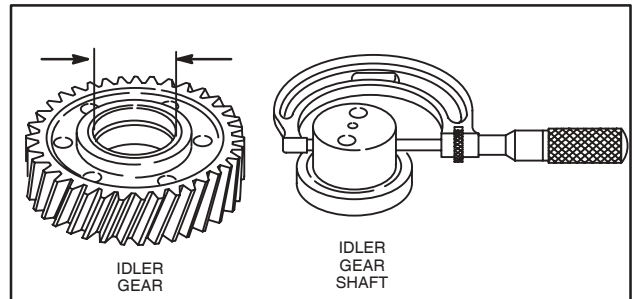


Fig. 7 – Checking Idler Gear And Shaft

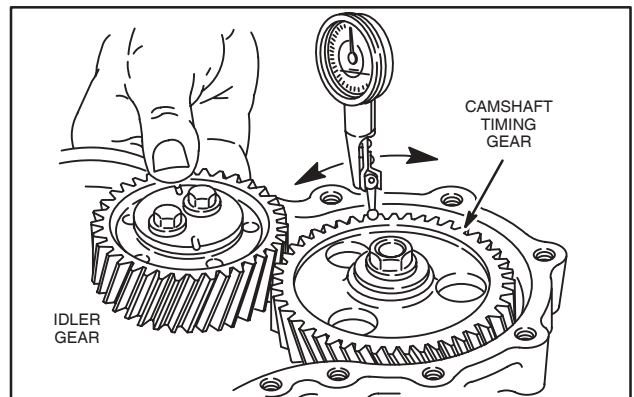


Fig. 8 – Checking Camshaft Timing Gear Backlash

TIMING GEARS AND GEAR CASE

4. Hold idler gear as shown and check gear backlash between injector pump timing gear and idler gear using dial indicator, Fig. 9.

Injector pump timing gear backlash must not exceed 0.2 mm (.008").

NOTE: Idler gear must not turn while checking.

If gears are worn it is recommended that they be replaced as a set.

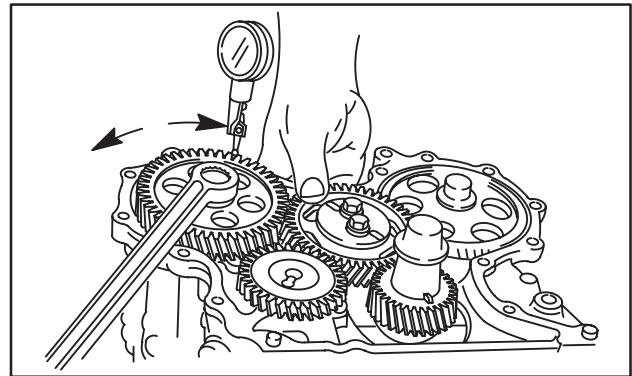


Fig. 9 – Checking Injector Pump Timing Gear Backlash

REMOVE GEAR CASE

1. Remove injector pump timing gear with a three jaw puller, Fig. 10.
 - a. Remove 2 nuts and injector pump. Discard O-ring.

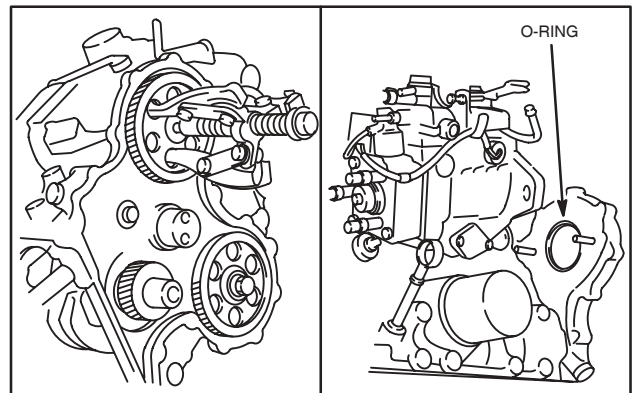


Fig. 10 – Removing Injector Pump

2. Remove parts in sequence shown, Fig. 11.
 - a. Remove 3 screws and camshaft retainer.
 - b. Remove remaining 5 screws.

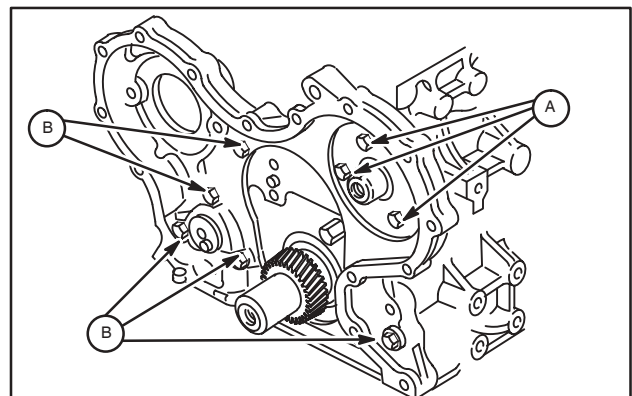


Fig. 11 – Removing Timing Gear Case

3. Remove timing gear case and discard gasket, Fig. 12.
 - a. Remove oil pump rotor from cylinder block.

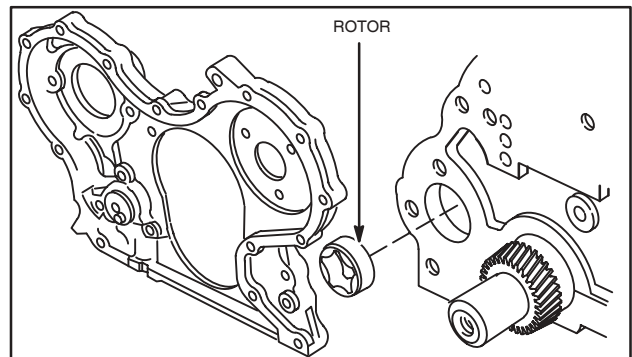


Fig. 12 – Remove Timing Gear Case

REPLACE TIMING GEAR COVER OIL SEAL

1. Drive out oil seal.
2. Use seal driver, Tool #19423, to install new oil seal, Fig. 13.

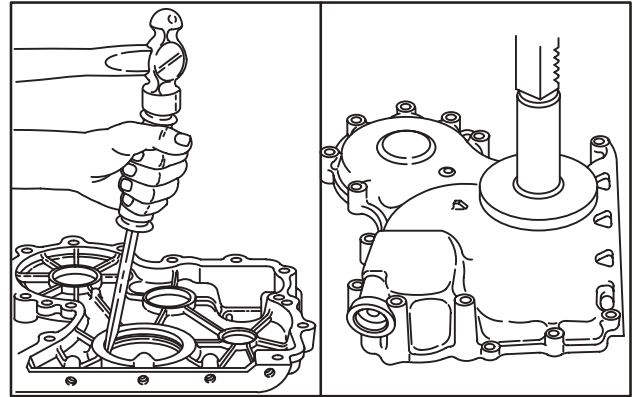


Fig. 13 – Replacing Oil Seal

ASSEMBLE TIMING GEAR CASE AND GEARS

1. Clean and lubricate oil pump rotor with engine oil and install in cylinder block, Fig. 14.
 - a. ID mark on rotor must face cylinder block.

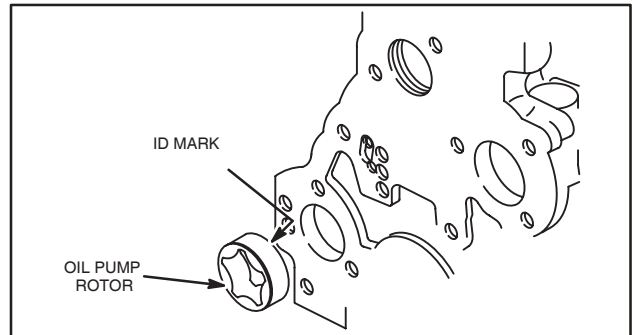


Fig. 14 – Installing Oil Pump Rotor

2. Install timing gear case with new gasket. Install camshaft retainer, Fig. 15.

NOTE: It may be necessary to rotate oil pump drive to engage oil pump rotors.

NOTE: Position camshaft retainer so that center hole does not interfere with camshaft.

Note position, length and number of screws as shown.

- a. M6 x 28 mm (M6 x 1.1"): 4
- b. M6 x 18 mm (M6 x 0.7"): 3
- c. M6 x 16 mm (M6 x 0.6"): 1

Torque screws to 8.0 Nm (70 in. lbs.).

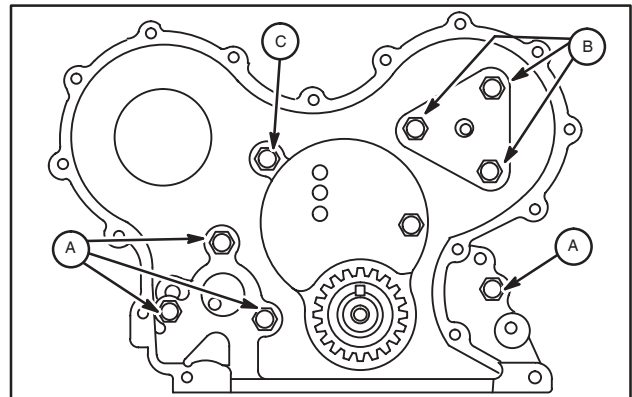


Fig. 15 – Installing Timing Gear Case

3. Assemble injector pump to gear case with new O-ring and install nuts and support bracket screw finger tight, Fig. 16.

NOTE: Pump must be able to rotate.

- a. Align timing mark on injector pump with timing mark on gear case.

NOTE: See Section 10 for injector pump timing procedure.

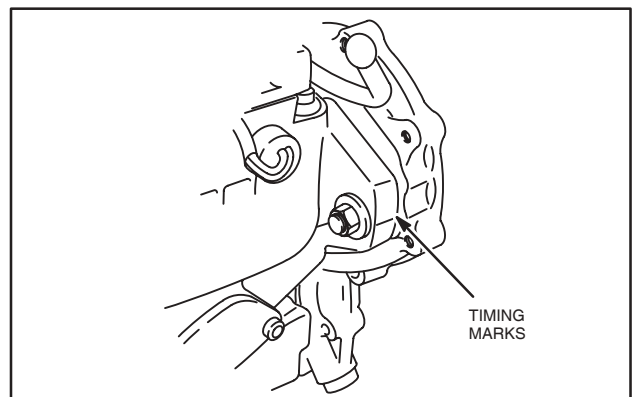


Fig. 16 – Install Injector Pump

TIMING GEARS AND GEAR CASE

4. Assemble idler gear shaft with arrow up, as shown in Fig. 17.

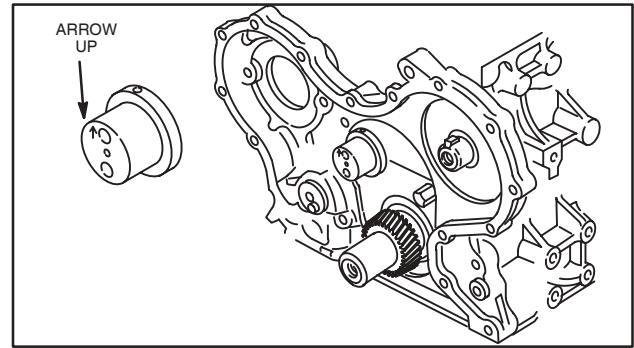


Fig. 17 – Installing Idler Gear Shaft

Engine models 432000 and 582000 after date code 990111007, and all engine models 522000 are equipped with right angle helical timing gears. Timing marks are identified by letters (A, AA, B, BB, etc.), instead of numbers. The timing procedure is the same.

5. With crankshaft key at 12 o'clock position, assemble idler gear so that timing mark 11 (AA) is aligned with timing mark 1 (A) on crankshaft gear, timing mark 22 (BB) is aligned with timing mark 2 (B) on camshaft gear, and timing mark 33 (CC) is aligned with timing mark 3 (C) on injector pump gear, as shown in Fig. 18.
 - a. Install oil pump gear.

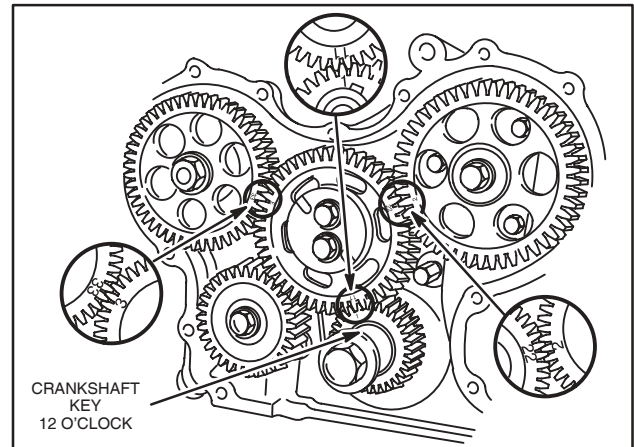


Fig. 18 – Aligning Timing Marks – Typical

6. Torque screws as shown, Fig. 19.
 - a. Camshaft Gear: 41.0 Nm (30 ft. lbs.)
 - b. Idler Gear: 25.0 Nm (220 in. lbs.)
 - c. Injector Pump Gear: 61.0 Nm (45 ft. lbs.)
 - d. Oil Pump Gear: 19.0 Nm (170 in. lbs.)

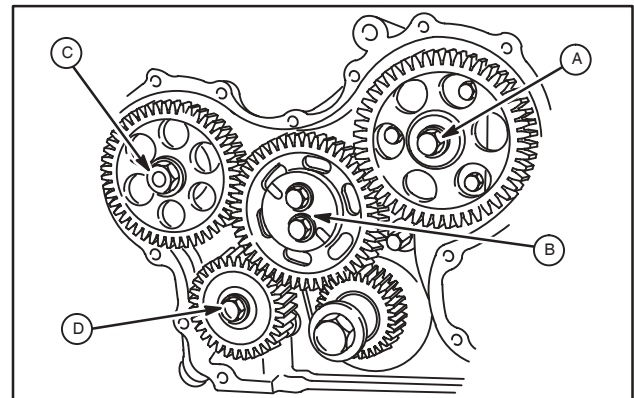


Fig. 19 – Torque Screws

7. Install timing gear cover with new gasket. Note position, length and number of screws as shown, Fig. 20.
 - a. M6 x 55 mm (M6 x 2.5"): 3
 - b. M6 x 45 mm (M6 x 2.1"): 2
 - c. M6 x 30 mm (M6 x 1.1"): 9
 - d. M6 nut: 2

Torque screws and nuts to 8.0 Nm (70 in. lbs.).

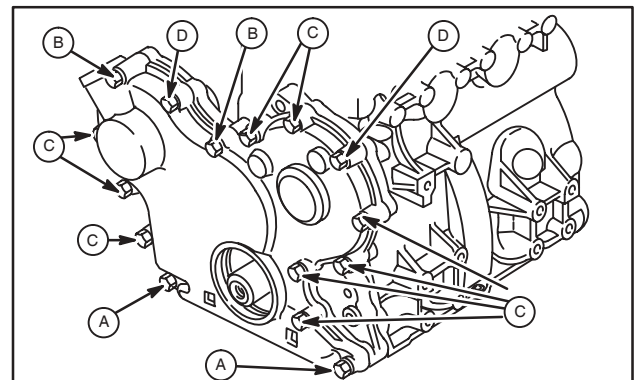


Fig. 20 – Installing Timing Gear Cover

8. Install crankshaft pulley with timing mark at 12 o'clock position (#1 cylinder), Fig. 21.

NOTE: Be sure alignment pin in crankshaft gear is seated in hole in pulley.

- a. Torque screw to 88.0 Nm (65 ft. lbs.).
- b. Remove flywheel holder.

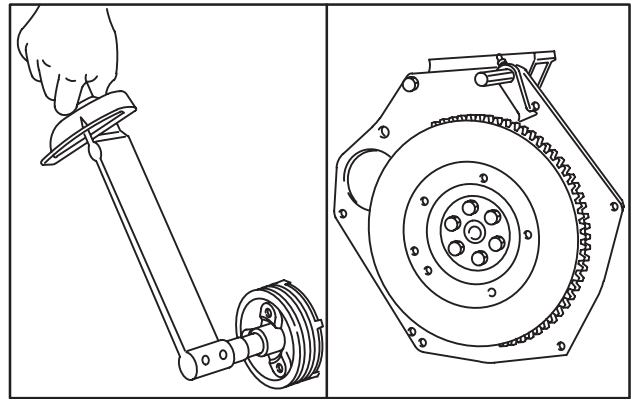


Fig. 21 – Installing Crankshaft Pulley

9. Install oil pick-up tube and strainer with new gasket. Torque to 8.0 Nm (70 in. lbs.).

- a. Apply a small bead of Permatex® No. 2 or similar sealant to crankcase areas shown, Fig. 22.
- b. Install oil pan with new gasket.
- c. Torque screws and nuts to 8.0 Nm (70 in. lbs.).

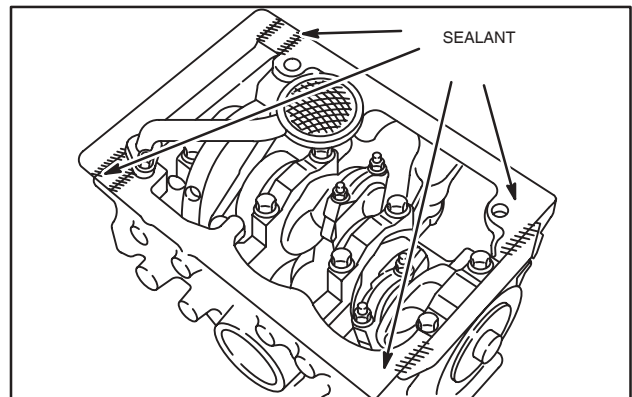


Fig. 22 – Installing Oil Pan

10. Install glow plugs, wiring and fuel delivery lines.

- a. Torque glow plugs to 17.0 Nm (150 in. lbs.).
- b. Torque fuel delivery lines to 25.0 Nm (220 in. lbs.), Fig. 23.

11. Install V-belt and fan (if equipped).

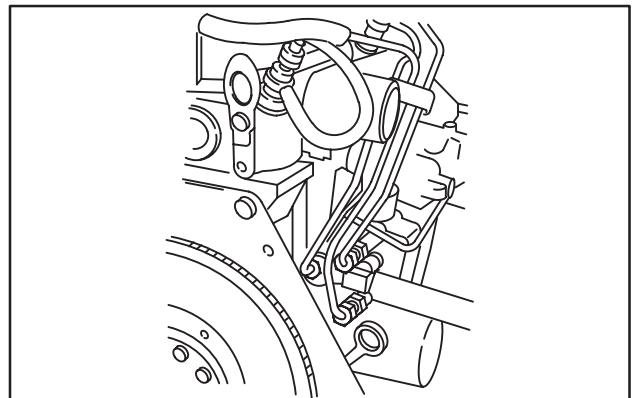


Fig. 23 – Installing Fuel Delivery Lines

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Section 4

Flywheel and Rear Seal Retainer

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REPLACING OIL SEAL	2
INSTALLING REAR SEAL RETAINER AND FLYWHEEL	2
INSTALL OIL PAN	3

REMOVING PAN AND FLYWHEEL

Drain oil from engine.

1. Remove oil pan screws and nuts. Remove oil pan and discard gasket Fig. 1.

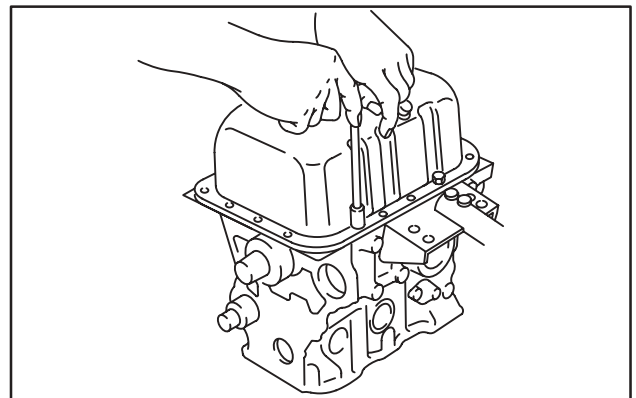


Fig. 1 – Removing Oil Pan

2. Install flywheel holder, Tool #19418
 - a. Remove flywheel screws and flywheel, Fig. 2.Inspect flywheel for cracks or damage. Inspect flywheel ring gear for worn, chipped or cracked teeth. If ring gear is worn or damaged the flywheel must be replaced.

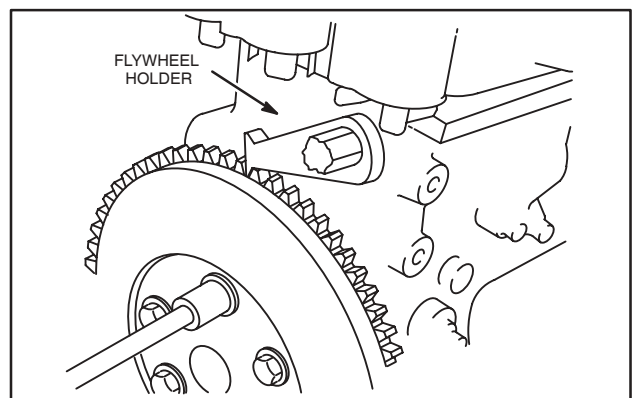


Fig. 2 – Removing Flywheel

FLYWHEEL AND REAR SEAL RETAINER

REMOVE REAR SEAL RETAINER

Remove rear seal retainer and discard gasket, Fig. 3.

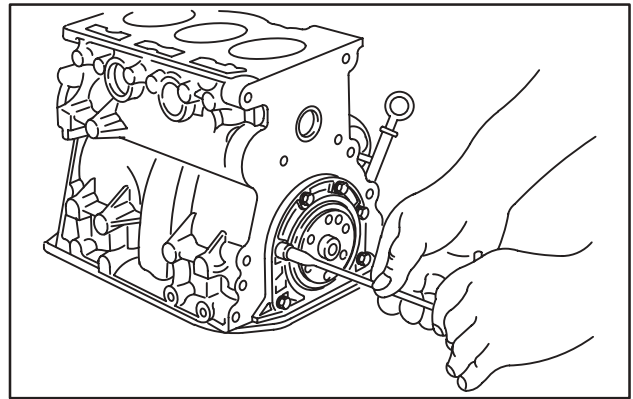


Fig. 3 – Removing Seal Retainer

REPLACING OIL SEAL

1. Remove oil seal, Fig. 4.

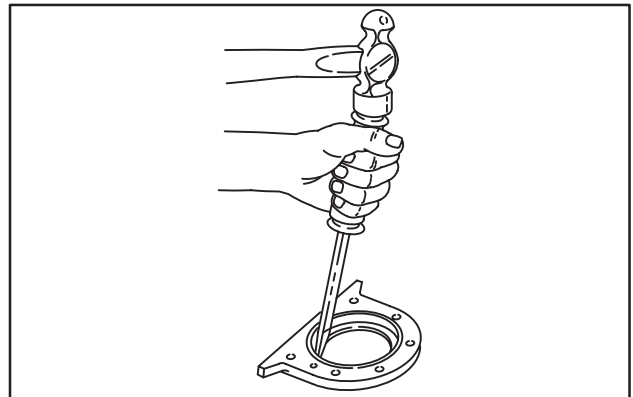


Fig. 4 – Removing Oil Seal

2. Lubricate outside diameter of oil seal.

- a. Using seal driver, Tool #19424 install new oil seal, Fig. 5.

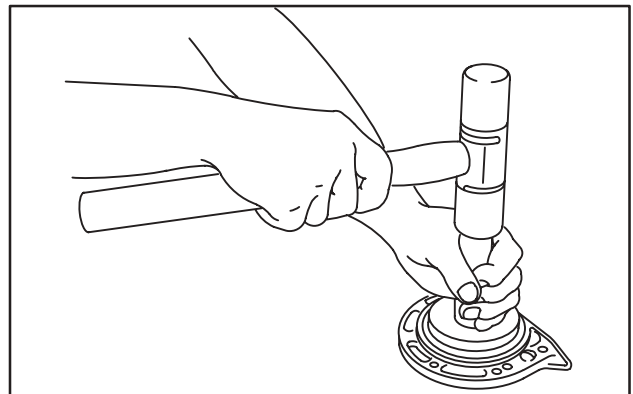


Fig. 5 – Installing Oil Seal

INSTALLING REAR SEAL RETAINER AND FLYWHEEL

1. Install rear seal retainer with new gasket, Fig. 6.

- a. Torque screws to 6.0 Nm (50 in. lbs.).

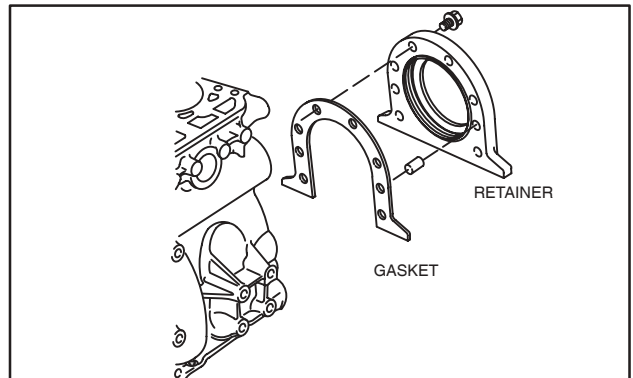


Fig. 6 – Installing Seal Retainer

2. Install flywheel, Fig. 7.

NOTE: Apply Permatex® No. 2 or similar sealant to flywheel screws.

- a. Torque flywheel screws to 47.0 Nm (35 ft. lbs.).

Remove flywheel holder.

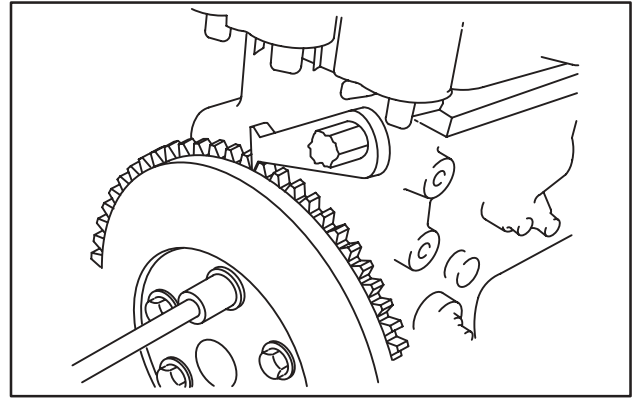


Fig. 7 – Installing Flywheel

INSTALL OIL PAN

1. Install oil pan with new gasket, Fig. 8.
 - a. Apply a small bead of Permatex® No. 2 or similar sealant to crankcase areas shown.
 - b. Torque screws and nuts to 8.0 Nm (70 in. lbs.).

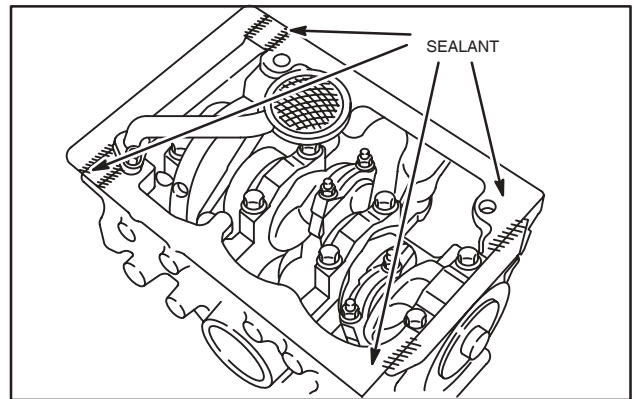


Fig. 8 – Installing Oil Pan

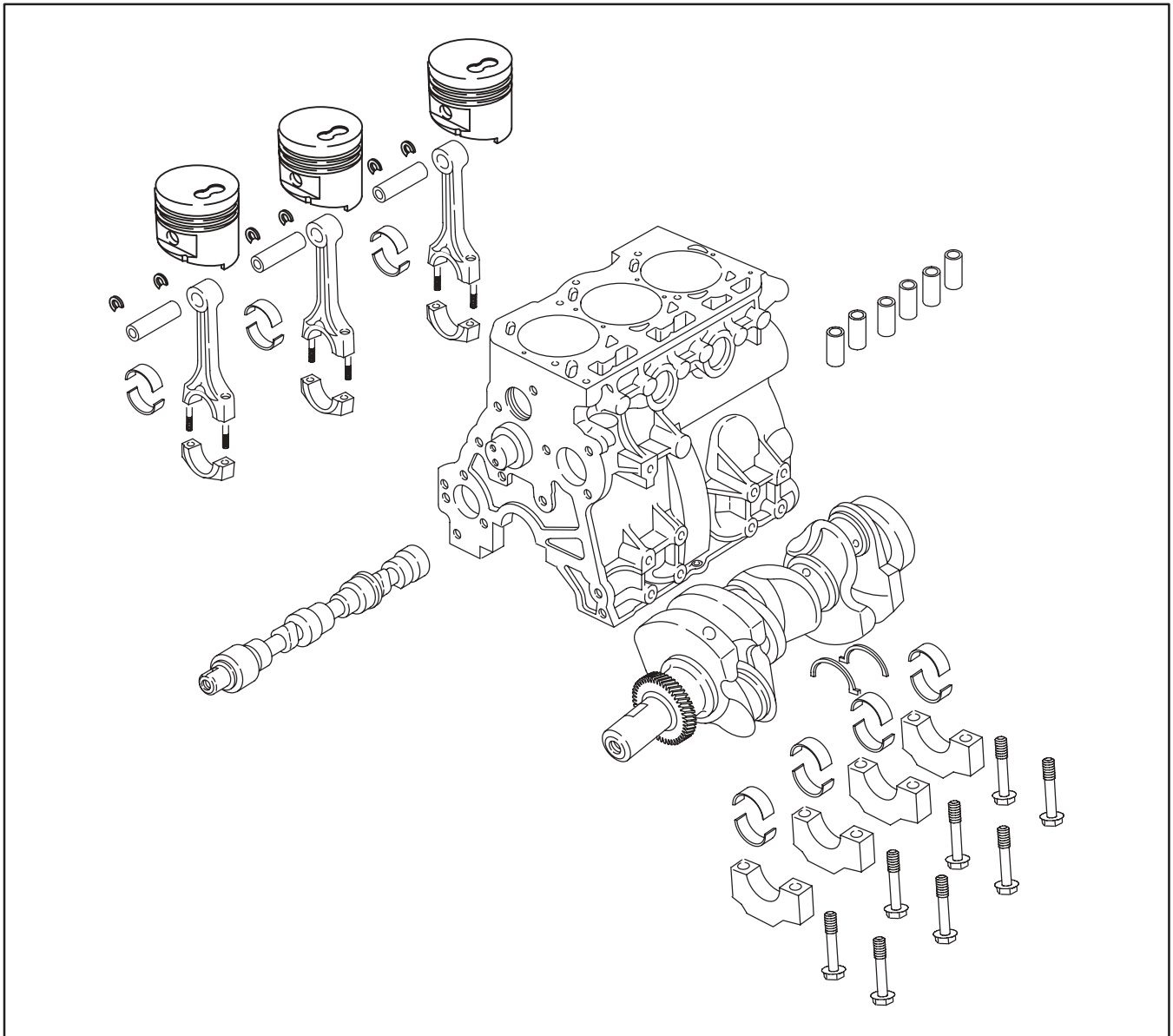
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Section 5

Cylinder Block Disassembly

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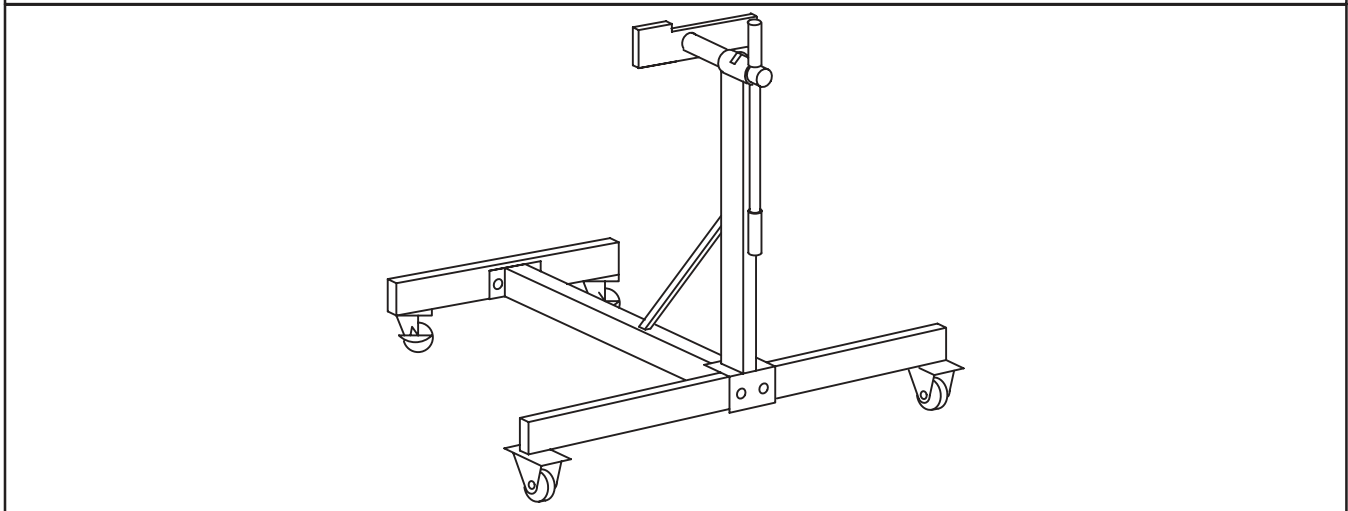
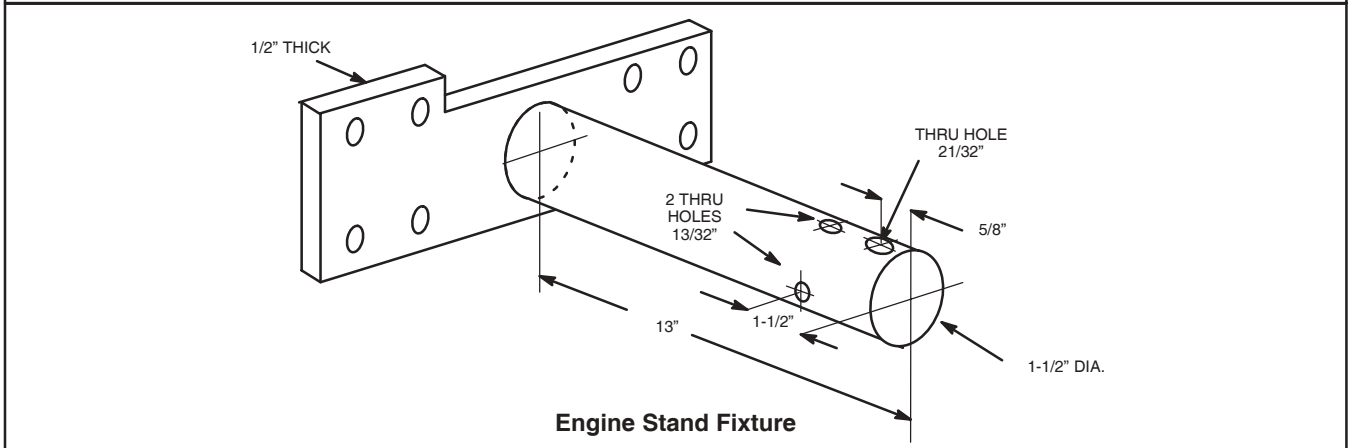
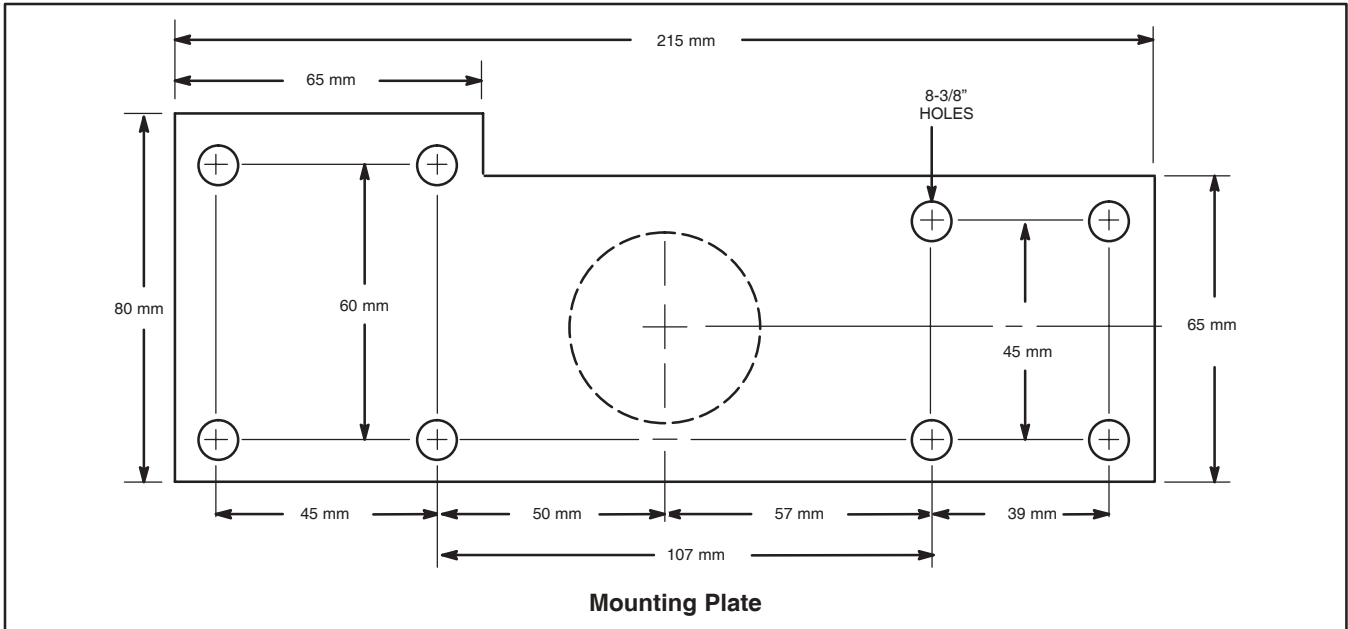


CYLINDER BLOCK DISASSEMBLY

ENGINE STAND

An automotive type engine stand is recommended when complete engine disassembly is required. See drawings below for dimensions to make an engine stand mounting fixture. The engine stand shown below is manufactured by Snap-On®.

5



CYLINDER BLOCK DISASSEMBLY

- 1. Remove cylinder head. See Sec. 2.
- 2. Remove oil pan, oil pick up tube, timing cover, gears and gear case. See Sec. 3.
- 3. Remove flywheel and rear seal retainer. See Sec. 4.
- 4. Remove starter motor, Fig. 1.

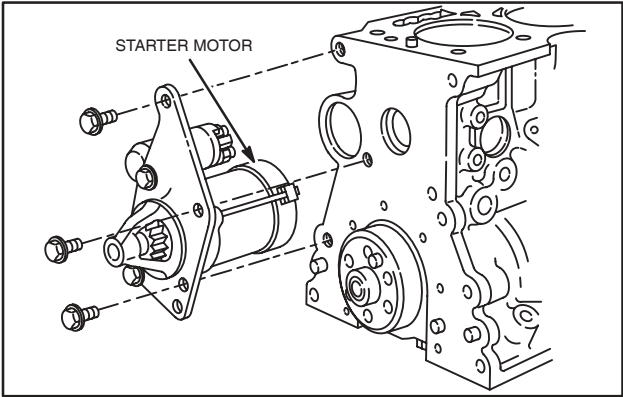


Fig. 1 – Removing Starter And Bracket

- 5. Remove alternator bracket and alternator, Fig. 2.

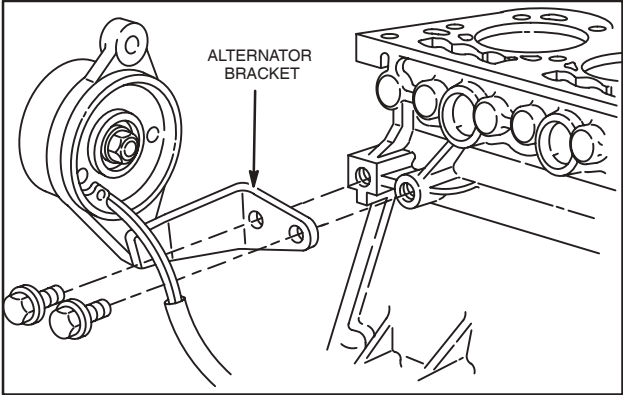


Fig. 2 – Removing Alternator

- 6. Remove valve lifters, Fig. 3.
 - a. Number lifters so that they may be re-installed in the same position.

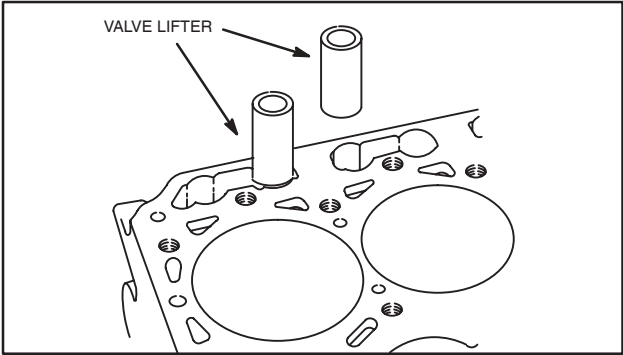


Fig. 3 – Removing Valve Lifters

- 7. Remove camshaft, Fig. 4.

NOTE: Use care when removing camshaft to prevent damaging cam bearing, journals and lobes.

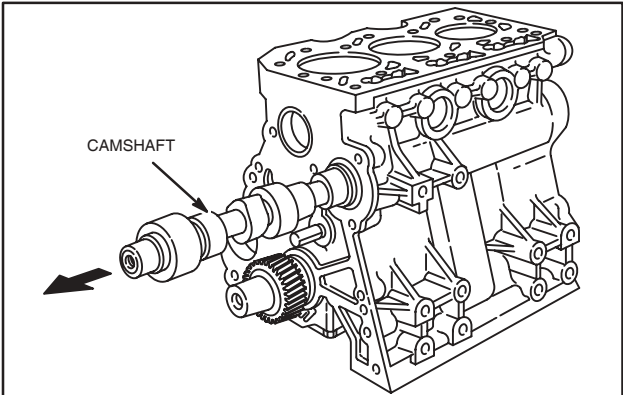


Fig. 4 – Removing Camshaft

CYLINDER BLOCK DISASSEMBLY

8. Remove connecting rod and piston assemblies, Fig. 5.

NOTE: Remove carbon or ridge from cylinder and number connecting rod/piston assemblies before removing from cylinders.

- a. Remove connecting rod cap with lower bearing.
- b. Push connecting rod and piston out through top of cylinder.
- c. Reassemble connecting rod cap to connecting rod to prevent interchanging components.

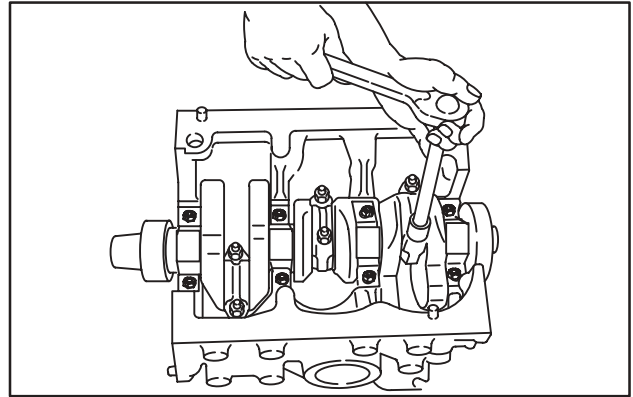


Fig. 5 – Removing Connecting Rod Assembly

9. Remove crankshaft main bearing caps, keeping main bearings with their respective caps, Fig. 6.

NOTE: Main bearing caps are numbered 1 through 4.

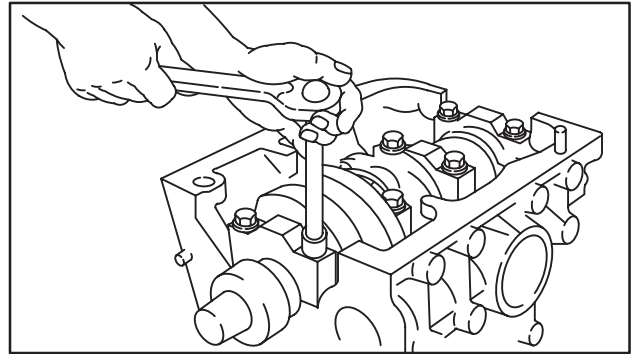


Fig. 6 – Removing Main Bearing Caps

10. Remove crankshaft, Fig. 7.

- a. Remove crankshaft thrust washers (#3 main bearing).
- b. Remove upper main bearings from saddles and place with respective bearing caps.

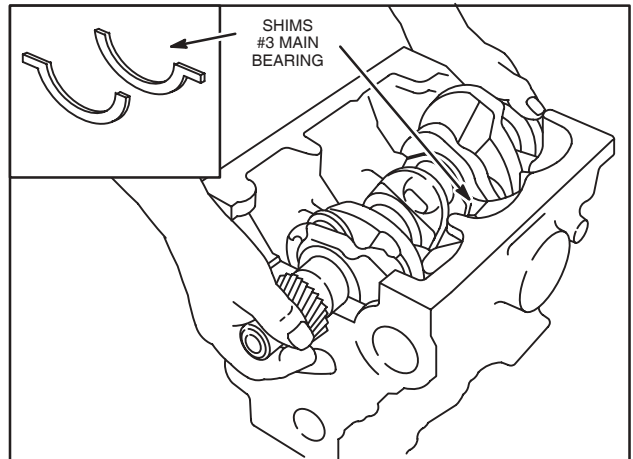


Fig. 7 – Removing Crankshaft

Section 6

Cylinder Block Inspection and Repair

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REPLACING CAMSHAFT PLUG	3

CHECKING CYLINDER BLOCK

Remove all traces of sealant and gasket material from mounting surfaces. Inspect cylinder block for damage, cracks and stripped threads. Inspect cylinder bores for damage or scores.

1. Check cylinder block deck for distortion, Fig. 1.

Distortion Limit: 0.08 mm (.003")

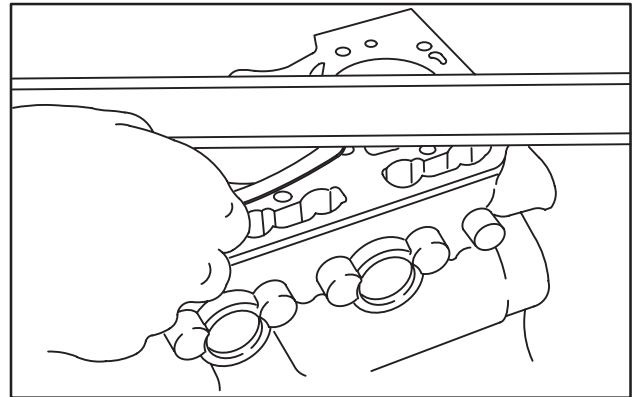


Fig. 1 – Checking Cylinder Block

2. If cylinder block exceeds limit shown, it may be resurfaced, Fig. 2.

Cylinder Block Height

Model Series 430000

Std: 229.20-229.80 mm (9.023-9.047")

Minimum Dimension:

229.10 mm (9.019") (After Resurfacing)

Model Series 520000 & 580000 Std:

238.70-239.30 mm (9.397-9.421")

Minimum Dimension:

238.60 mm (9.3937") (After Resurfacing)

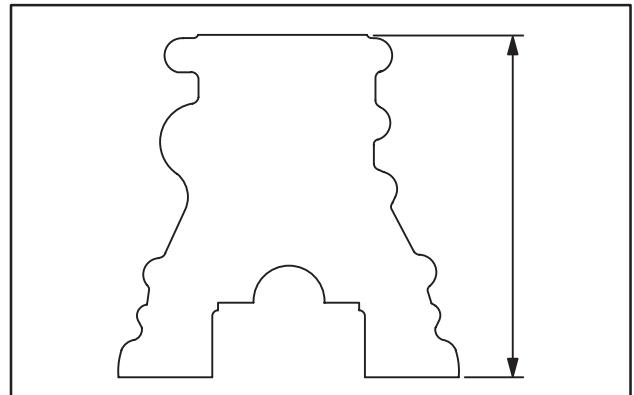


Fig. 2 – Cylinder Block Height

CYLINDER BLOCK INSPECTION AND REPAIR

3. Check cylinder bores for wear, Fig. 3.

Standard Bore Size:

Model Series 430000 & 520000:

68.00-68.030 mm (2.6770-2.6783")

Model Series 580000:

72.00-72.030 mm (2.8346-2.8358")

- a. Measure cylinder bore in 6 points at right angles as shown, Fig. 3.
- b. If cylinder bore is worn more than 0.075 mm (.003") or more than 0.035 mm (.0015") out of round, it must be resized.

Always resize to exactly .25 mm (.010") over standard bore size. If this is done accurately, the service oversize rings and pistons will fit perfectly and proper clearances will be maintained.

4. Check valve lifter bore, Fig. 4.

Std. Dimension: 18.018 mm (.7094")

Reject: 18.05 mm (.711")

5. Check valve lifter, Fig. 4.

Std. Dimension: 17.98 mm (.708")

Reject: 17.91 mm (.7051")

6. Check camshaft bearing, Fig. 5.

Replace if greater than 36.06 mm (1.420").

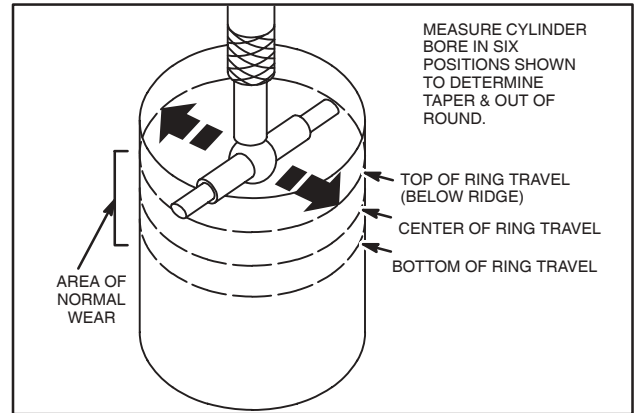


Fig. 3 – Checking Cylinder Bore

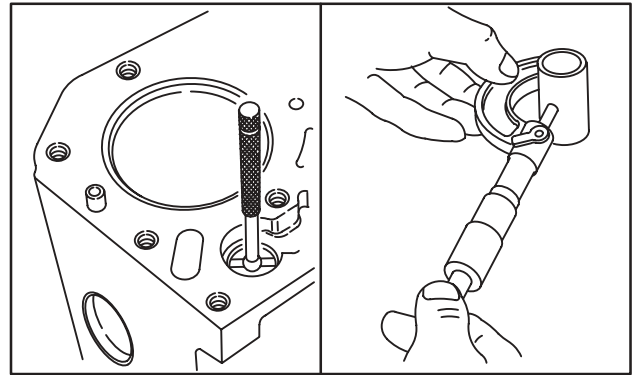


Fig. 4 – Checking Valve Lifter And Bore

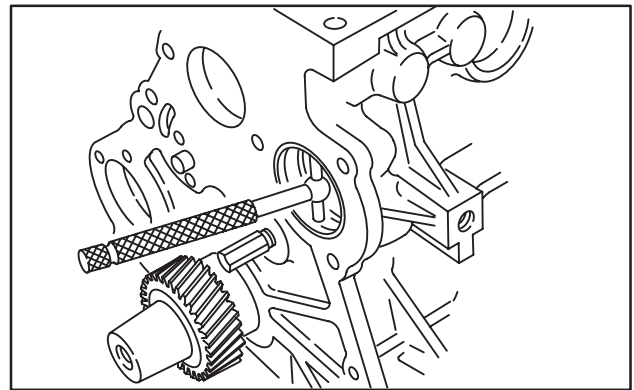


Fig. 5 – Checking Cam Bearing

REPLACING CAMSHAFT BEARING

1. Remove camshaft bearing, Fig. 6.

- a. Use camshaft bearing puller, Tool #19421.

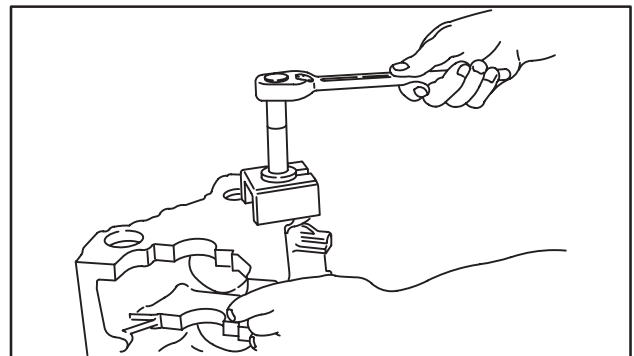


Fig. 6 – Removing Cam Bearing

2. Install camshaft bearing, Fig. 7.
 - a. Use camshaft bearing driver, Tool #19422.

NOTE: Notch on camshaft bearing must face out. Be sure oil hole in bearing is aligned with oil hole in cylinder block.

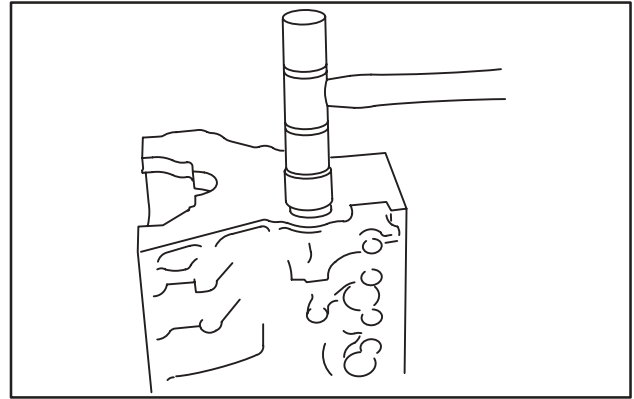


Fig. 7 – Installing Cam Bearing

REPLACING CAMSHAFT PLUG

1. Remove rear camshaft plug, Fig. 8.
 - a. Use a wood dowel or brass rod to prevent damage to camshaft bearing.

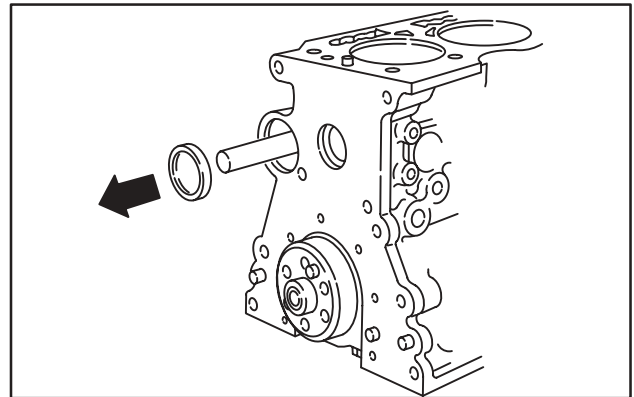


Fig. 8 – Removing Camshaft Plug

2. Install new camshaft plug using camshaft bearing driver, Tool #19422.
 - a. Install camshaft plug flush with cylinder block, Fig. 9.

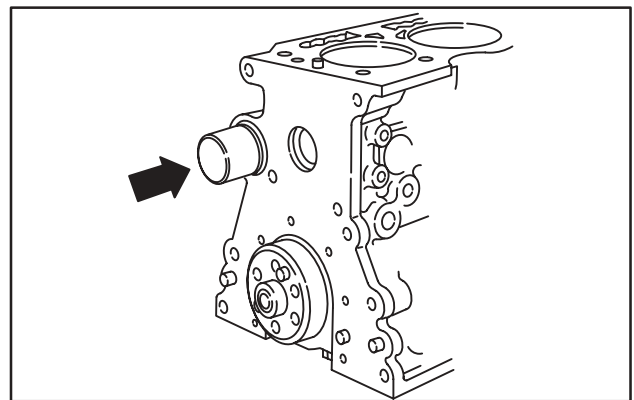


Fig. 9 – Installing Camshaft Plug

If cylinder block is being resized, the following parts should be removed so that cylinder block may be thoroughly cleaned.

1. Remove oil pressure switch, water gallery plug and oil filter adapter, Fig. 10.

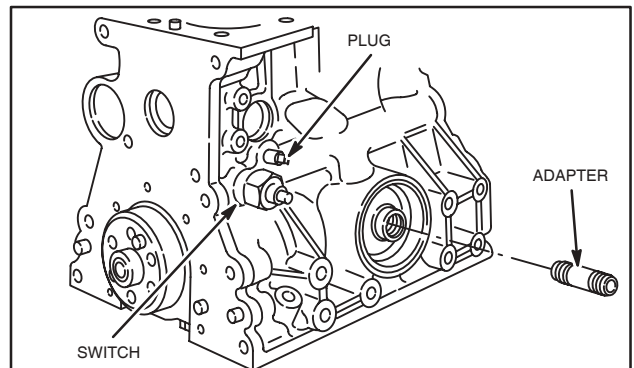


Fig. 10 – Removing Oil Pressure Switch

CYLINDER BLOCK INSPECTION AND REPAIR

2. Remove timing gear oil nozzle, Fig. 11.

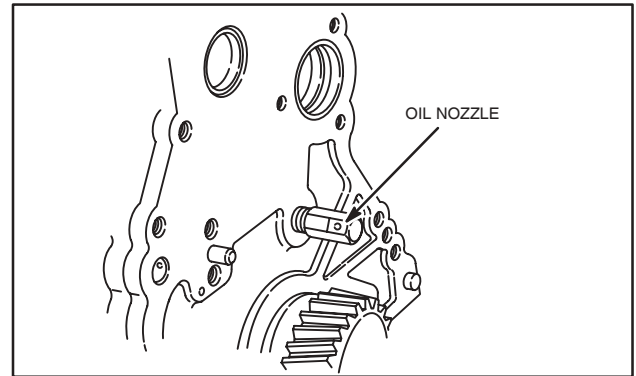


Fig. 11 – Removing Oil Nozzle

3. When re-installing oil nozzle, oil hole must be positioned at 45° angle, pointing towards idler gear, Fig. 12.

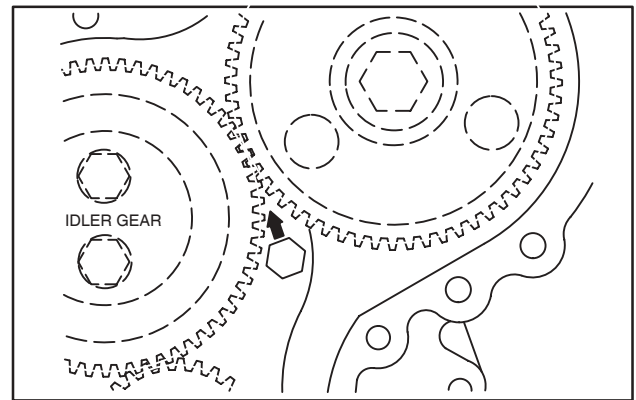


Fig. 12 – Installing Oil Nozzle

Section 7

Crankshaft, Camshaft and Bearings

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	Page
CHECKING CRANKSHAFT	1
CHECKING MAIN BEARING CLEARANCES	2
CHECKING CONNECTING ROD BEARING CLEARANCES	3
CHECKING CRANKSHAFT END PLAY	3
CHECKING CAMSHAFT	4

CHECKING CRANKSHAFT

Inspect crankshaft journals for grooves or signs of scoring. If found, crankshaft must be re-ground or replaced.

1. Check the main bearing and crankpin journals for wear and taper, Fig. 1.

Standard size:

Main – 41.976-42.000 mm (1.6526-1.6535”)

Crankpin – 36.976-37.000 mm (1.4557-1.4567”)

Maximum out of round and taper: 0.02 mm (0.0008”).

If crankshaft journals are not within specification, the crankshaft may be re-ground and .25 mm (.010”) undersize bearings installed. See illustrated parts list for part numbers.

2. Check the crankshaft for run-out at #3 main bearing journal, Fig. 2.

Maximum Run-out: 0.06 mm (0.0024”)

- a. If run-out exceeds specification shown, the crankshaft must be replaced.

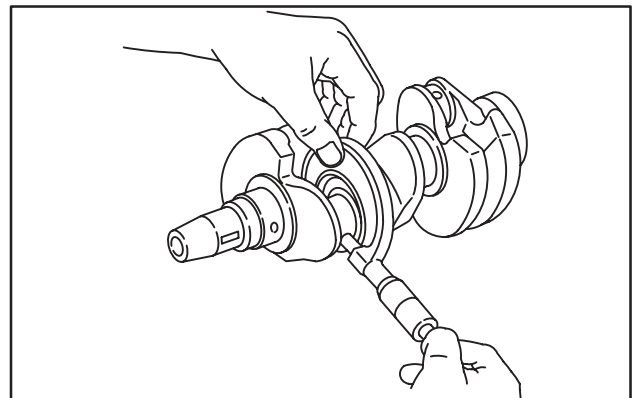


Fig. 1 – Checking Journals

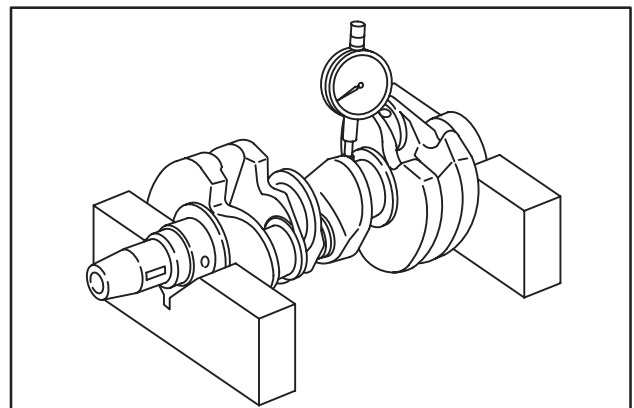


Fig. 2 – Checking Run-out

CRANKSHAFT, CAMSHAFT AND BEARINGS

3. Check crankshaft timing gear teeth for damaged teeth, Fig. 3.

NOTE: See Section 3 for procedure to check crankshaft timing gear for wear.

If crankshaft timing gear teeth are damaged or worn, the crankshaft must be replaced.

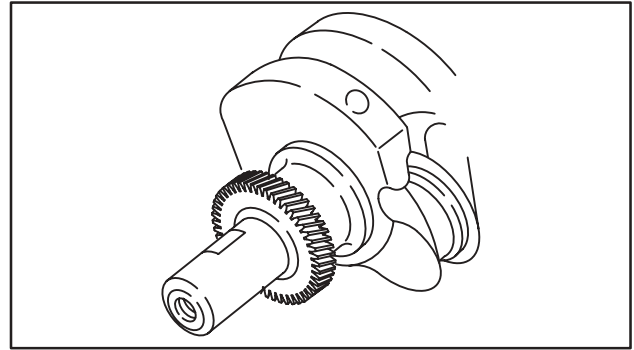


Fig. 3 – Checking Timing Gear

CHECKING MAIN BEARING CLEARANCES

If main bearings show signs of flaking or scoring, bearings must be replaced.

Main bearing saddles in cylinder block, main bearing caps, main bearings and crankshaft journals must be clean and free of oil.

1. With upper main bearings installed, install crankshaft.
 - a. Lay a strip of plastigage lengthwise on journal, Fig. 4.
Do not lay plastigage across oil hole in crankshaft journal.

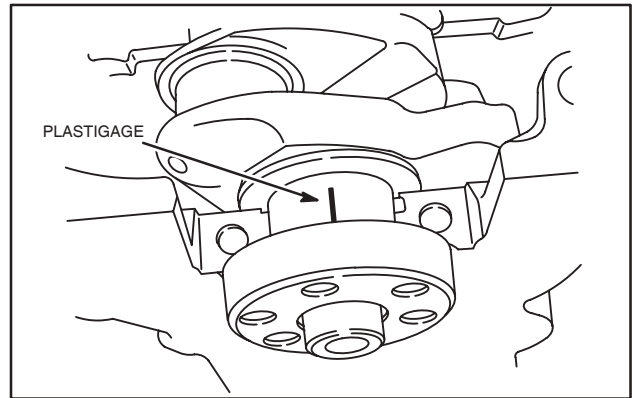


Fig. 4 – Install Plastigage

2. Assemble main bearing cap with bearing and torque to 58.3 Nm (43 ft. lbs.), Fig. 5.

DO NOT ALLOW CRANKSHAFT TO ROTATE.

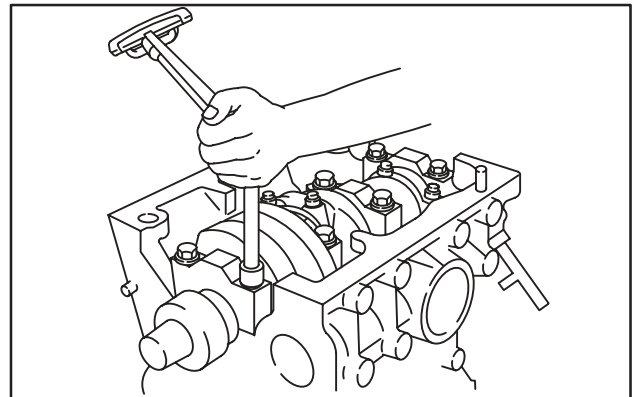


Fig. 5 – Torque Bearing Cap

3. Remove the bearing cap. Measure the plastigage at its widest point, Fig. 6. If the clearance is not within specification, replace the bearings.

Crankshaft Main Bearing Clearance:
STD: 0.020-0.044 mm (0.0008-0.0017")
Reject: 0.07 mm (0.0028")

Repeat procedure for each main bearing.

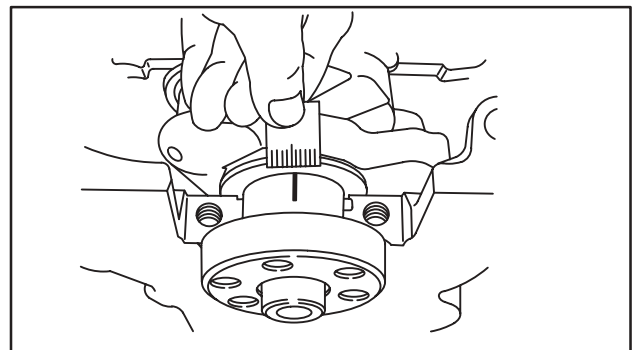


Fig. 6 – Measure Clearance

CHECKING CONNECTING ROD BEARING CLEARANCES

If connecting rod bearings show signs of flaking or scoring, bearings must be replaced.

Connecting rod bearings and crankpin journals must be clean and free of oil.

1. With upper bearing assembled to connecting rod, install connecting rod.
 - a. Lay a strip of plastigage lengthwise on journal, Fig. 7.

Do not lay plastigage across oil hole in crankpin journal.

2. Assemble connecting rod cap with bearing and torque to 36.0 Nm (320 in. lbs.), Fig. 8.
DO NOT ALLOW CRANKSHAFT TO ROTATE.

3. Remove the connecting rod cap. Measure the plastigage at its widest point, Fig. 9. If the clearance is not within specification, replace the bearings.

Connecting Rod Bearing Clearance:
STD: 0.020-0.044 mm (0.0008-0.0017")
Reject: 0.07 mm (0.0028")

Repeat procedure for each connecting rod.

CHECKING CRANKSHAFT END PLAY

With thrust washers installed, check crankshaft end play at #3 main bearing as shown, Fig. 10.

Crankshaft End Play:
STD: 0.020-0.24 mm (0.0008-0.0094")
Limit: 0.30 mm (0.012")

If end play exceeds limit, .125 mm (.005") over size thrust washers are available. See illustrated parts list.

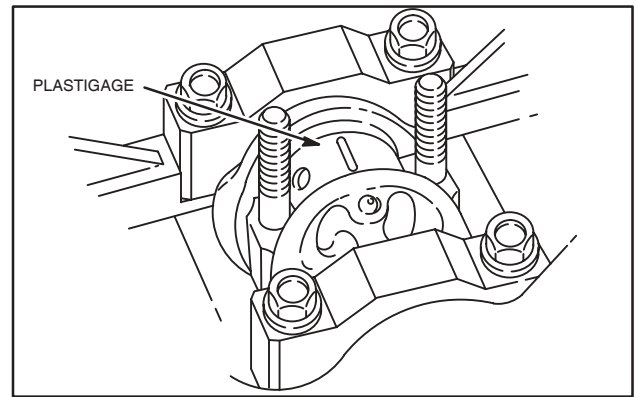


Fig. 7 – Install Plastigage

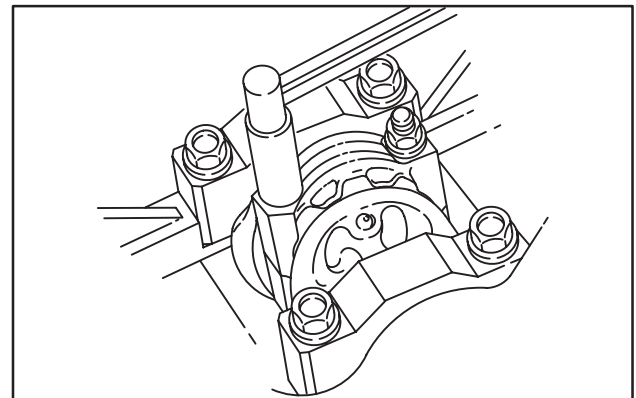


Fig. 8 – Torque Rod Cap

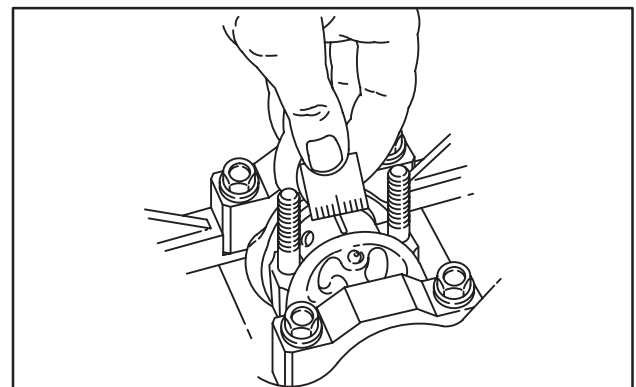


Fig. 9 – Measure Clearance

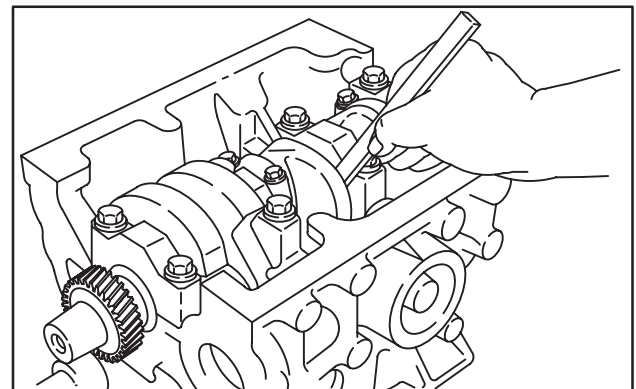


Fig. 10 – Checking Crankshaft End Play

CRANKSHAFT, CAMSHAFT AND BEARINGS

CHECKING CAMSHAFT

1. Measure camshaft lobe height, Fig. 11. If lobes are not to specification, replace the camshaft.

Intake and Exhaust:

STD: 30.065-30.135 mm (1.184-1.186")

Reject: 29.965 mm (1.18")

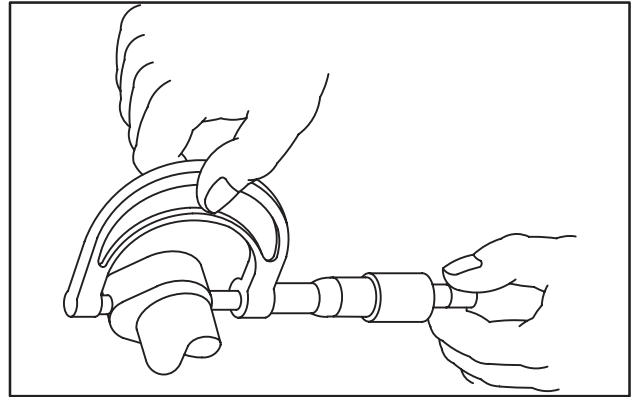


Fig. 11 – Checking Camshaft Lobes

2. Measure camshaft journals, Fig. 12.

**STD: Front – 35.959-35.975 mm
(1.4157-1.4163")**

Reject: 35.890 mm (1.413")

**STD: Center – 35.910-35.955 mm
(1.4138-1.4155")**

Reject: 35.84 mm (1.411")

**STD: Rear – 35.910-35.955 mm
(1.4138-1.4155")**

Reject: 35.84 mm (1.411")

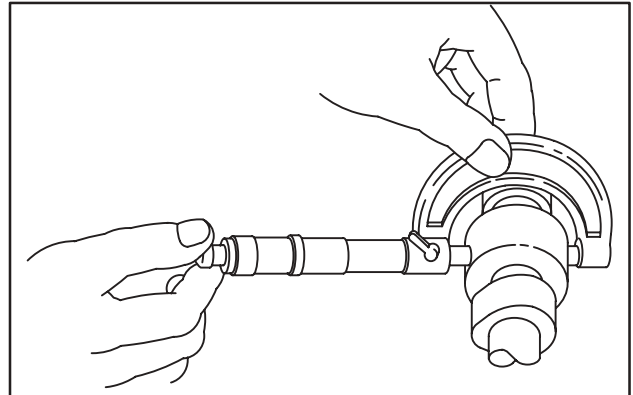


Fig. 12 – Checking Camshaft Journals

3. Measure camshaft run-out, Fig. 13.

Maximum Run-out: 0.03 mm (0.0012").

- a. If run-out exceeds specification shown, the camshaft must be replaced.

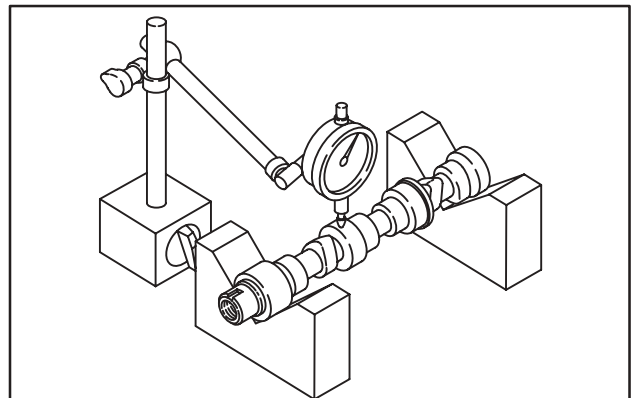


Fig. 13 – Checking Run-out

Section 8

Piston, Rings and Connecting Rod Inspection and Assembly

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CHECKING PISTON PIN AND CONNECTING ROD	2
ASSEMBLE PISTON AND CONNECTING ROD	3
ASSEMBLE PISTON RINGS TO PISTON	4

DISASSEMBLE PISTON AND CONNECTING ROD

1. Remove compression rings and oil ring using ring expander, Tool #19340, Fig. 1.
 - a. Then remove coil expander.

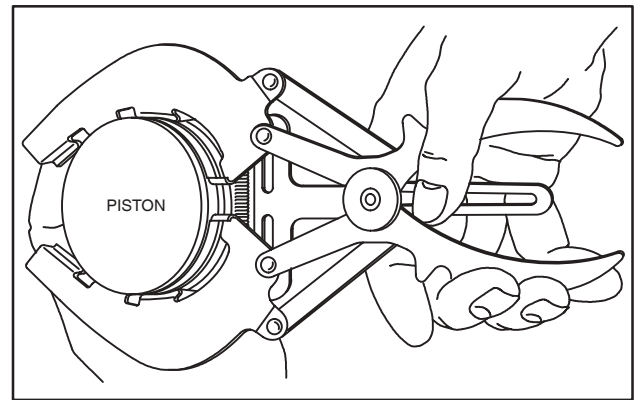


Fig. 1 – Removing Piston Rings

2. Disassemble piston from connecting rod, Fig. 2.
 - a. Remove piston pin retainers.
 - b. Piston pin is a slip fit.

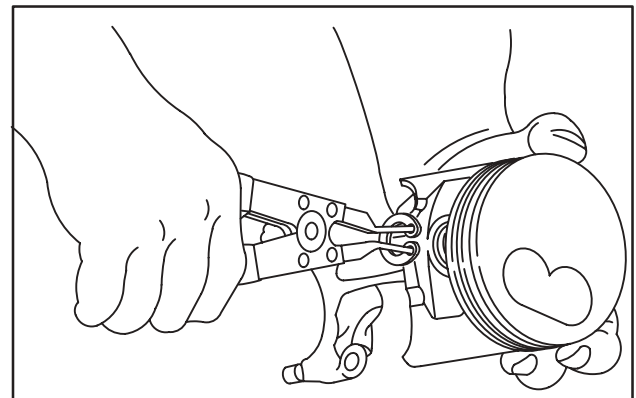


Fig. 2 – Disassembling Piston/Connecting Rod

PISTON, RINGS AND CONNECTING ROD INSPECTION AND ASSEMBLY

CHECKING PISTON AND RINGS

If the cylinder bore is to be resized there is no reason to check the piston as a new oversized piston will be used.

If the cylinder is not going to be resized and the piston shows no signs of scoring, the piston should be checked.

1. Check side clearance of ring grooves using NEW rings, Fig. 3. If a 0.12 mm (0.005") feeler gauge can be inserted, the ring groove is worn. The piston must be replaced.

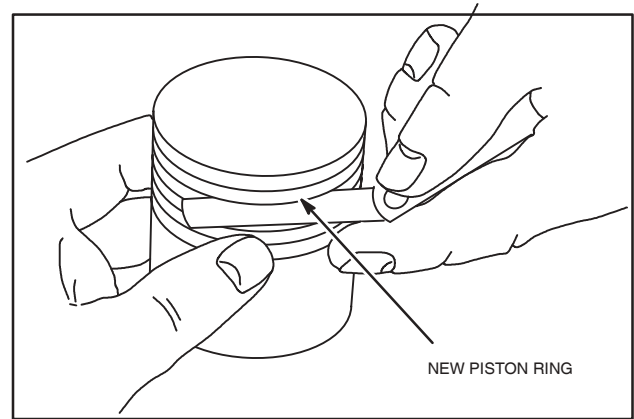


Fig. 3 – Checking Ring Grooves

2. Check ring end gap, Fig. 4.
 - a. Clean carbon from end of rings and using the piston, insert approximately 100 mm (3.9") into cylinder (below ring travel).

Ring End Gap Reject Size	
Compression Rings	Oil Ring
0.70 mm (0.028")	0.70 mm (0.028")

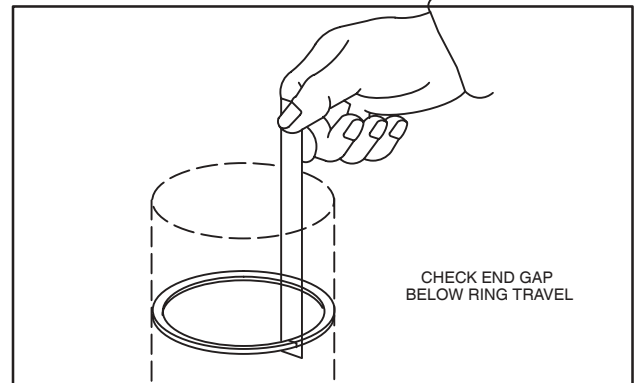


Fig. 4 – Checking End Gap

3. Check piston pin bore, Fig. 5.

Engine Models: 432447, 522447, 582447

 - a. **Replace** if greater than 18.03 mm (0.710") or .01 mm (.0004") out of round.

Engine Models: 58A447, 588447

 - b. **Replace** if greater than 21.03 mm (0.828") or .01 mm (.0004") out of round.

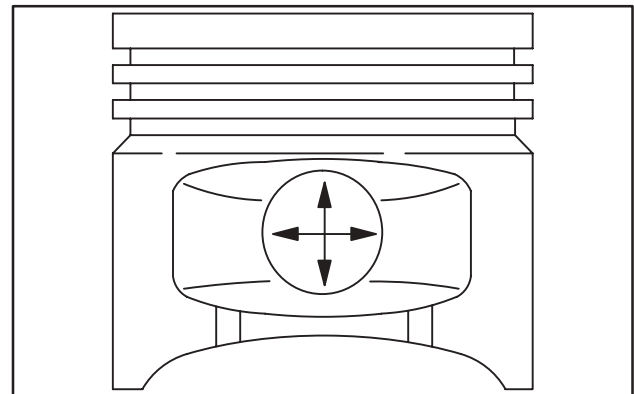


Fig. 5 – Checking Piston Pin Bore

CHECKING PISTON PIN AND CONNECTING ROD

1. Check piston pin, Fig. 6.

Engine Models: 432447, 522447, 582447

 - a. **Replace** if less than 17.98 mm (0.708") or .01 mm (.0004") out of round.

Engine Models: 58A447, 588447

 - b. **Replace** if less than 20.98 mm (0.826") or .01 mm (.0004") out of round.

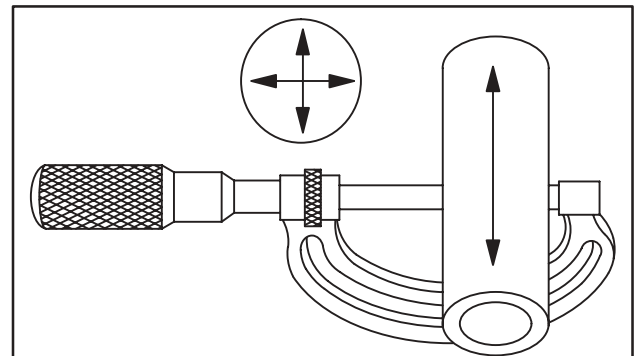


Fig. 6 – Checking Piston Pin

PISTON, RINGS AND CONNECTING ROD INSPECTION AND ASSEMBLY

2. Check piston pin bearing, Fig. 7.

Engine Models: 432447, 522447, 582447

- a. **Replace** if greater than **18.03 mm (0.710")** or **.01 mm (.0004")** out of round.

Engine Models: 58A447, 588447

- b. **Replace** if greater than **21.03 mm (0.828")** or **.01 mm (.0004")** out of round.

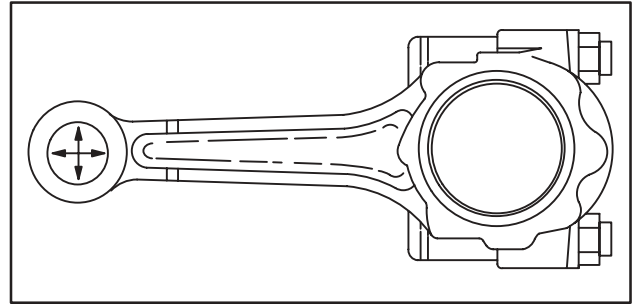


Fig. 7 – Checking Piston Pin Bearing

3. Check crankpin bearing end of connecting rod for out of round, Fig. 8.

- a. With bearing inserts removed, assemble connecting rod cap and torque to 36.0 Nm (320 in. lbs.).

Maximum out of round: 0.02 mm (0.0008")

- b. If out of round exceeds specification shown, the connecting rod must be replaced.

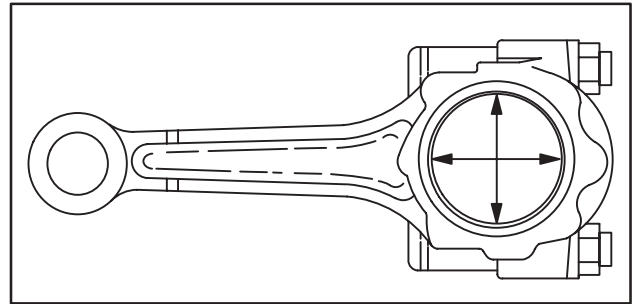


Fig. 8 – Checking Crankpin Bearing End

4. Check for bent or twisted connecting rod, Fig. 9.

NOTE: Thrust faces must be free of any burrs or nicks or connecting rod will not lay flat on surface plate.

- a. With connecting rod on a surface plate, any distortion will be evident by a rocking motion.
- b. If a 0.05 mm (0.002") feeler gauge can be inserted at piston pin end of connecting rod the rod must be replaced.

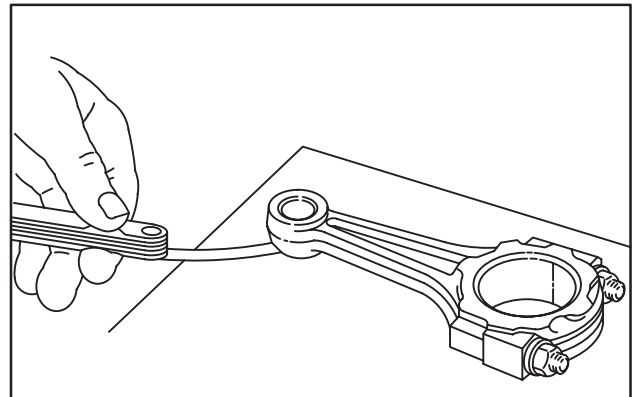


Fig. 9 –Checking Connecting Rod

ASSEMBLE PISTON AND CONNECTING ROD

Assemble piston to connecting rod, Fig. 10.

NOTE: Arrow on piston and ID mark on rod must face same side.

1. Lubricate piston pin with engine oil before assembly.
 - a. Be sure retainers are seated properly in piston.

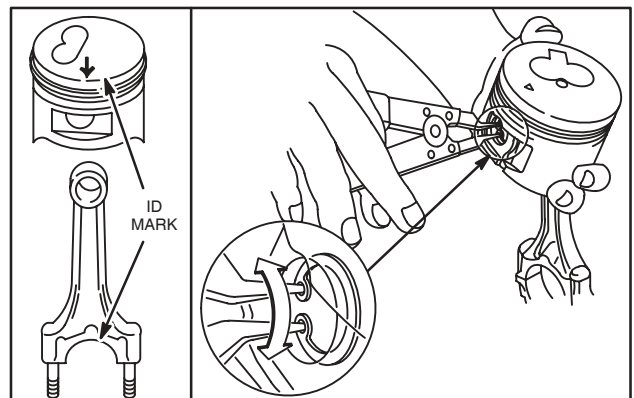


Fig. 10 – Assembling Piston And Rod

PISTON, RINGS AND CONNECTING ROD INSPECTION AND ASSEMBLY

ASSEMBLE PISTON RINGS TO PISTON

1. Install piston rings using ring expander, Tool #19340, Fig. 11.
 - a. Install oil ring coil expander making sure wire is inserted fully into coil.
 - b. Install oil ring.
 - c. Install center compression ring then, top compression ring with ID marks up.

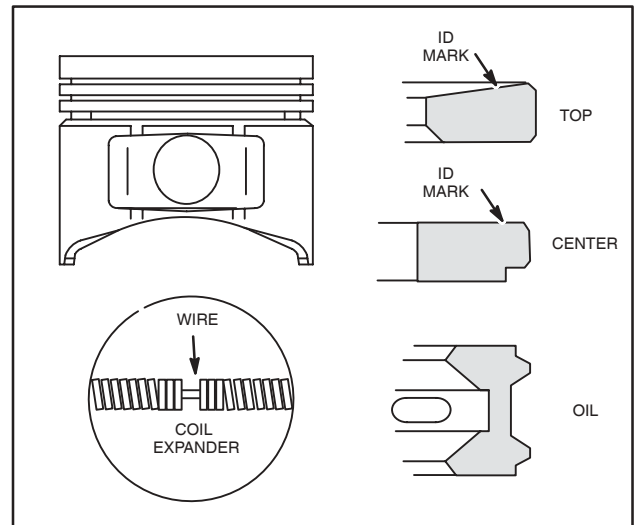


Fig. 11 – Installing Piston Rings

2. Stagger ring end gaps as shown, Fig. 12.

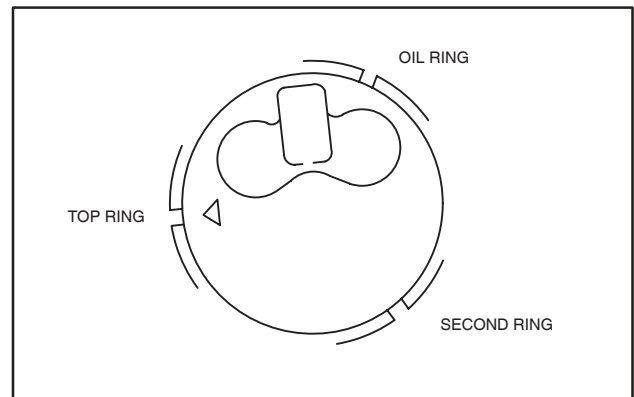


Fig. 12 – Stagger Ring End Gaps

Section 9

Cylinder Block Assembly

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Rear Seal Retainer and Starter Motor	3
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INSTALL TIMING GEAR CASE, CAMSHAFT AND GEARS	4
INSTALL ALTERNATOR	6

INSTALL CRANKSHAFT

Install main bearings in cylinder block, Fig. 1.

NOTE: Upper bearing has an oil groove and oil holes.

1. Install upper main bearings in their respective saddles.
 - a. Be sure bearing is seated in saddle and tang in bearing is aligned with notch in saddle.
 - b. Lubricate bearings with engine oil.

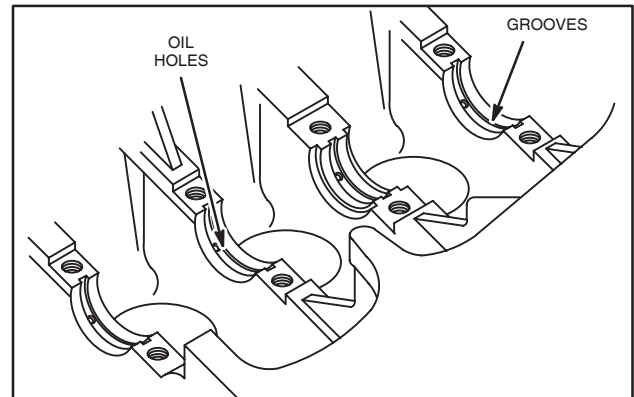


Fig. 1 – Installing Upper Main Bearings

2. Install lower main bearings in bearing caps, Fig. 2.
 - a. Be sure bearing is seated in bearing cap and tang in bearing is aligned with notch in bearing cap.
 - b. Lubricate bearings with engine oil.

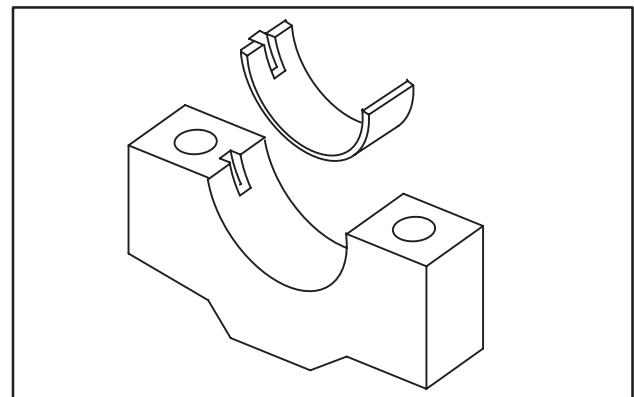


Fig. 2 – Installing Lower Main Bearings

CYLINDER BLOCK ASSEMBLY

3. Install crankshaft with gear facing front of cylinder block, Fig. 3. Take care not to damage journals or bearings.
 - a. Install crankshaft shims on #3 main bearing web with grooves facing out.
 - b. Lubricate journals with engine oil.

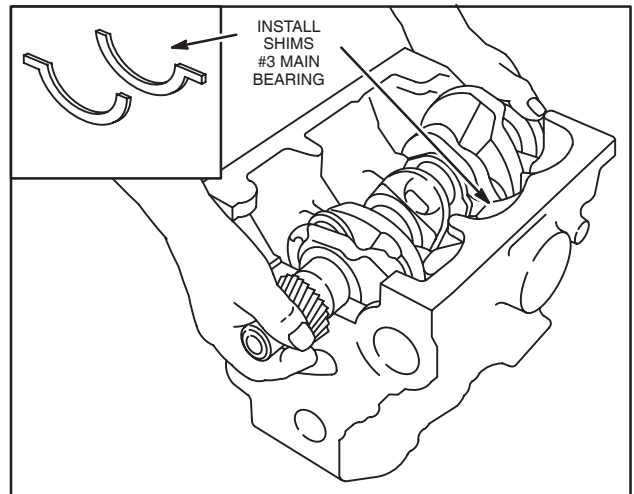


Fig. 3 – Installing Crankshaft

4. Install main bearing caps, Fig. 4. Lubricate threads of screws with engine oil.
 - a. Install bearing caps in their respective positions with arrows facing front.
 - b. Starting with #3 bearing cap, torque bearing caps one at a time in sequence shown to 58.0 Nm (43 ft. lbs.).
 - c. Recheck crankshaft end play.

Crankshaft End Play: 0.025-0.24 mm (0.0008-0.0094")

NOTE: After torquing bearing cap, make sure crankshaft rotates freely before proceeding to next bearing cap.

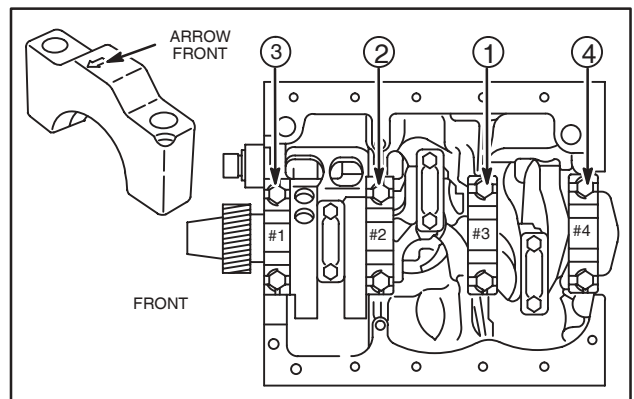


Fig. 4 – Installing Main Bearing Caps

INSTALL PISTONS AND CONNECTING RODS

1. Install connecting rod bearings, Fig. 5. Be sure tang on bearing is seated in notch in connecting rod and cap.
 - a. Install a piece of vinyl tubing over each connecting rod screw to prevent damage to screw threads or crankpin when installing piston and connecting rod.

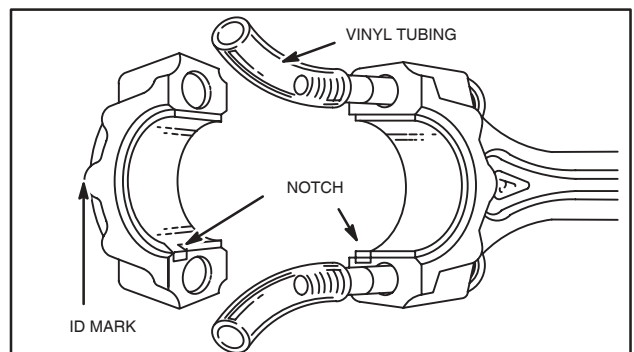


Fig. 5 – Installing Connecting Rod Bearings

Rotate crankshaft so that crankpin is at bottom of stroke. Then, lubricate cylinder walls, piston and rings, bearings and crankpins.

2. Using ring compressor, Tool #19070, install piston and connecting rod assemblies with arrow on piston facing front, Fig. 6.
 - a. Install connecting rod cap with ID mark facing front. Lubricate threads and torque nuts to 34.0 Nm (320 in. lbs.).

NOTE: After torquing rod cap, make sure crankshaft rotates freely before proceeding to next cylinder.

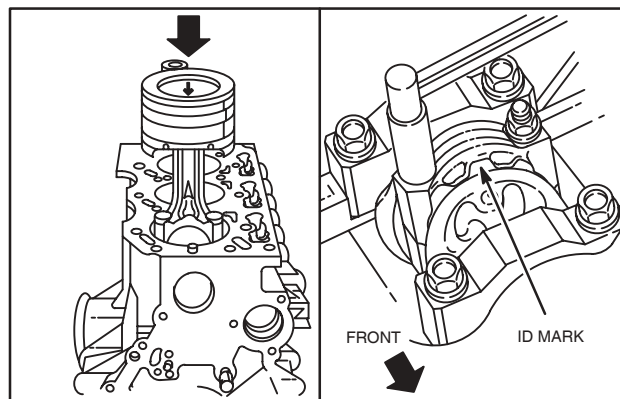


Fig. 6 – Installing Piston And Connecting Rod

GENERAL ASSEMBLY

1. Install gasket, oil pick-up tube and strainer, Fig. 7.
 - a. Torque screws to 8.0 Nm (70 in. lbs.).

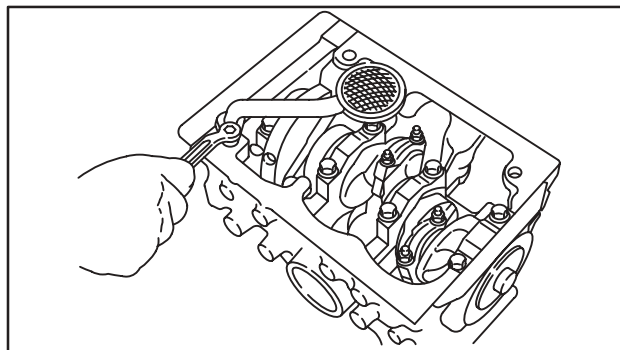


Fig. 7 – Installing Oil Pick-Up

2. Install gasket and rear seal retainer, Fig. 8.
 - a. Torque screws to 6.0 Nm (50 in. lbs.).
3. Install starter motor.
 - a. Torque screws to 34.0 Nm (25 ft. lbs.).

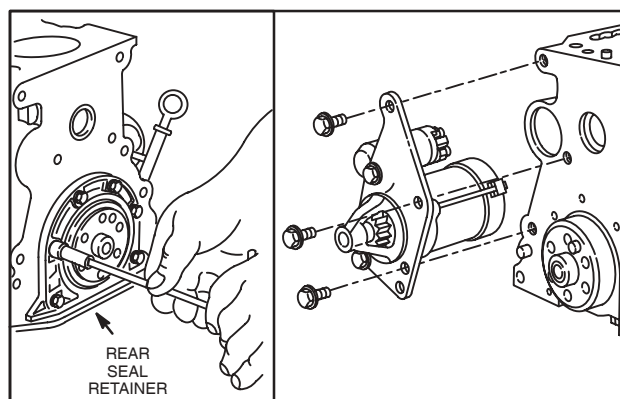


Fig. 8 – Installing Rear Seal Retainer

4. Install flywheel, Fig. 9.
 - a. Install flywheel holder, Tool #19418.
 - b. Apply Permatex® No. 2 or similar sealant to flywheel screws and torque to 47.0 Nm (35 ft. lbs.).

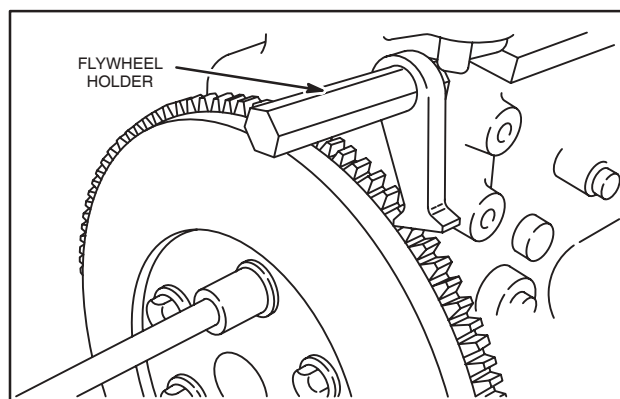


Fig. 9 – Installing Flywheel

CYLINDER BLOCK ASSEMBLY

INSTALL TIMING GEAR CASE, CAMSHAFT AND GEARS

1. Lubricate oil pump rotor with engine oil and install in cylinder block, Fig. 10.
 - a. ID mark on rotor must face cylinder block.

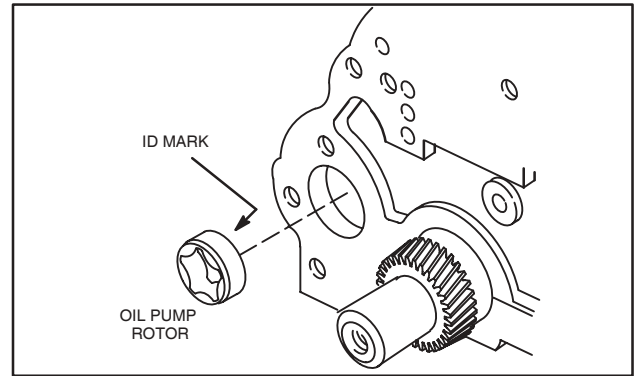


Fig. 10 – Installing Oil Pump Rotor

2. Install timing gear case with new gasket.
NOTE: It may be necessary to rotate oil pump drive to engage oil pump rotors.

Note position, length and number of screws as shown, Fig. 11.

- a. M6 x 28 mm (M6 x 1.1"): 4
- b. M6 x 16 mm (M6 x .6"): 1

Torque screws to 8.0 Nm (70 in. lbs.).

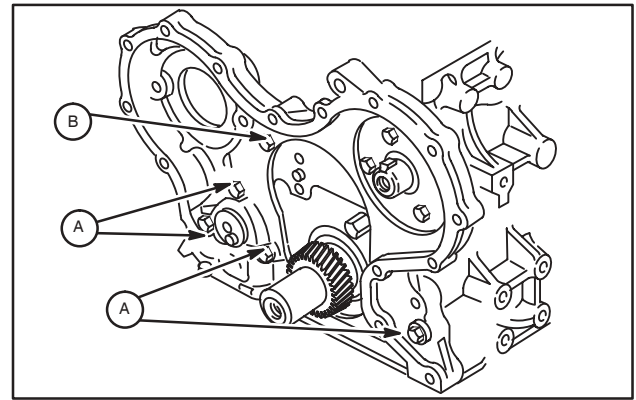


Fig. 11 – Installing Gear Case

3. Lubricate, then install camshaft in cylinder block, Fig. 12. Take care not to damage lobes or cam bearing.

- a. Install camshaft retainer.
- b. M6 x 18 mm (M6 x 0.7"): 3

Torque screws to 8.0 Nm (70 in. lbs.).

NOTE: Position camshaft retainer so that center hole does not interfere with camshaft.

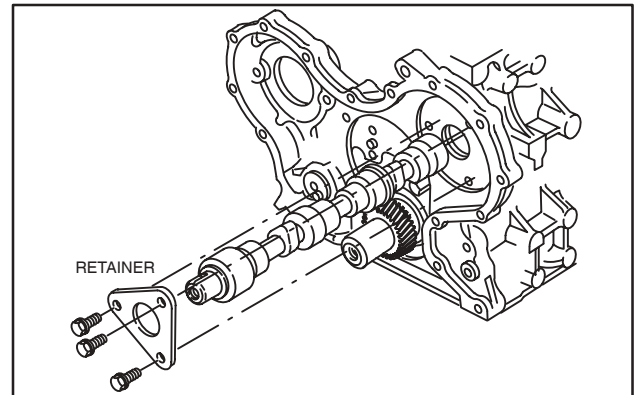


Fig. 12 – Installing Camshaft

4. Rotate crankshaft so that crankshaft key is at 12 o'clock position as shown in Fig. 13.

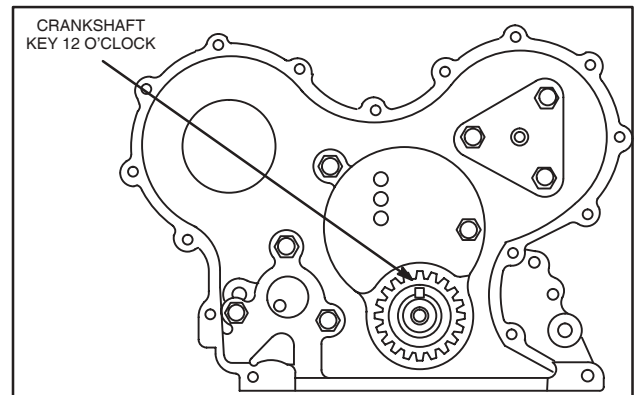


Fig. 13 – Rotate Crankshaft

5. Assemble injector pump to gear case with new O-ring and install nuts and support bracket screw finger tight, Fig. 14.

NOTE: Pump must be able to rotate

- a. Align timing mark on injection pump with timing mark on gear case.

NOTE: See Section 10 for injector pump timing procedure.

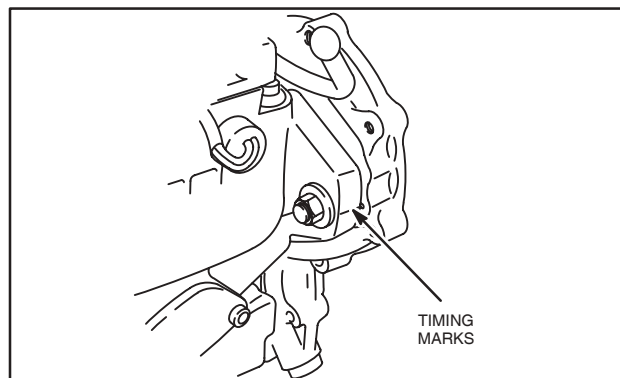


Fig. 14 – Install Injector Pump

6. Assemble idler gear shaft with ID mark up, as shown in Fig. 15.

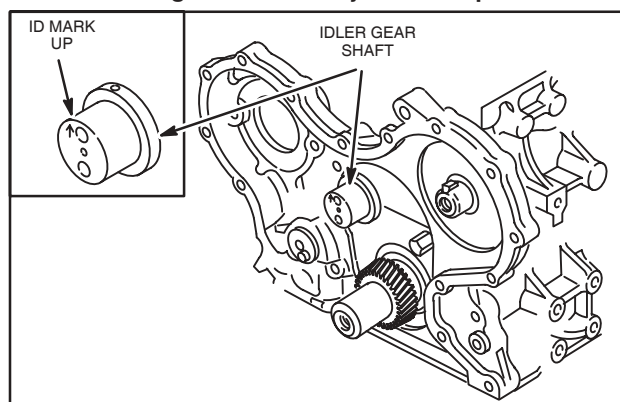


Fig. 15 – Assemble Idler Gear Shaft

Engine models 432000 and 582000 after date code 990111007, and all engine models 522000 are equipped with right angle helical timing gears. Timing marks are identified by letters (A, AA, B, BB, etc.), instead of numbers. The timing procedure is the same.

7. With crankshaft key at 12 o'clock position, assemble idler gear so that timing mark 11 (AA) is aligned with timing mark 1 (A) on crankshaft gear, timing mark 22 (BB) is aligned with timing mark 2 (B) on camshaft gear, and timing mark 33 (CC) is aligned with timing mark 3 (C) on injector pump gear, as shown in Fig. 16.
 - a. Install oil pump gear.

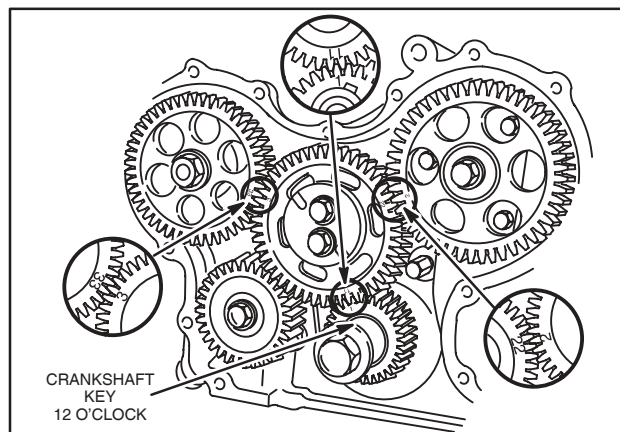


Fig. 16 – Aligning Timing Marks

8. Torque screws as shown, Fig. 17.
 - a. Camshaft Gear: 41.0 Nm (30 ft. lbs.)
 - b. Idler Gear: 25.0 Nm (220 in. lbs.)
 - c. Injector Pump Gear: 61.0 Nm (45 ft. lbs.)
 - d. Oil pump Gear: 19.0 Nm (170 in. lbs.)

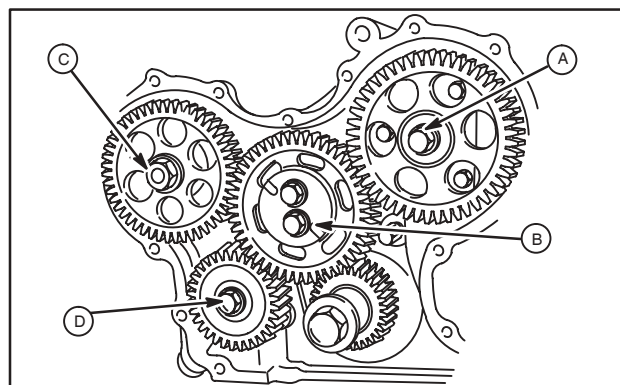


Fig. 17 – Torque Screws

CYLINDER BLOCK ASSEMBLY

9. Install timing gear cover with new gasket. Note position, length and number of screws as shown, Fig. 18.

- a. M6 x 55 mm (M6 x 2.5"): 3
- b. M6 x 45 mm (M6 x 2.1"): 2
- c. M6 x 30 mm (M6 x 1.1"): 9
- d. M6 nut: 2

Torque screws and nuts to 8.0 Nm (70 in. lbs.).

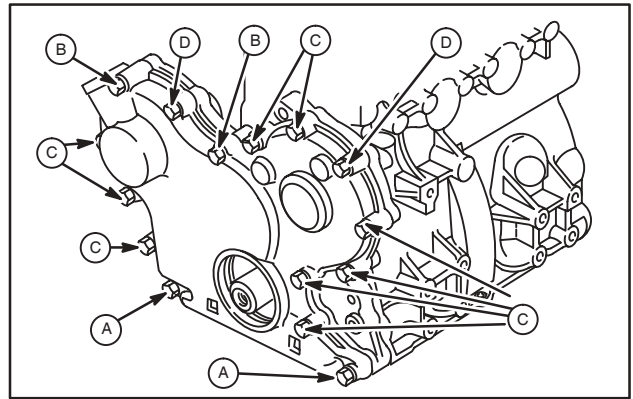


Fig. 18 – Installing Timing Cover

10. Install crankshaft pulley with timing mark at 12 o'clock position (#1 cylinder), Fig. 19.

NOTE: Be sure alignment pin in crankshaft gear is seated in hole in pulley.

- a. Torque screw to 88.0 Nm (65 ft. lbs.).
- b. Remove flywheel holder.

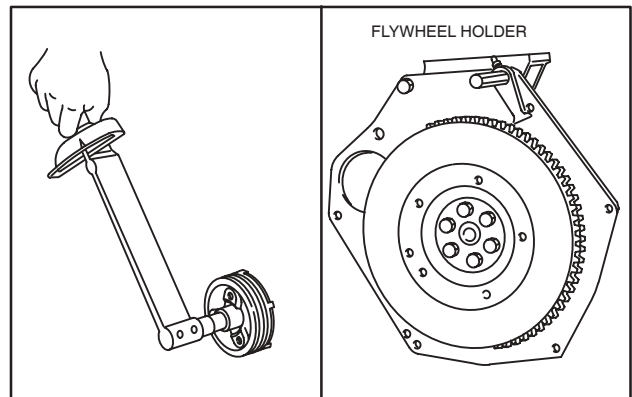


Fig. 19 – Installing Pulley

INSTALL ALTERNATOR

1. Install alternator bracket and alternator, Fig. 20.

- a. Torque screws to 19.0 Nm (170 in. lbs.).

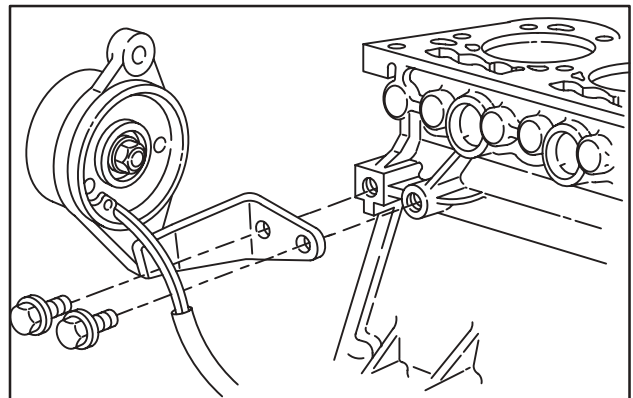


Fig. 20 – Install Alternator

GENERAL ASSEMBLY

1. Lubricate tappets with engine oil and install in cylinder block.
2. See Section 2 for installation of cylinder head and related components.

Section 10

Fuel System and Related Components

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The fuel system consists of a gear driven injector pump with fuel delivery and return lines and injector nozzles for each cylinder. Diesel fuel is drawn from the fuel tank through the fuel filter by the feed pump which is incorporated in the injection pump and delivers fuel to the injectors at a constant volume regardless of pump RPM. The feed pump also circulates fuel through the pump for lubrication purposes.

A single pump plunger meters and distributes fuel in the correct firing order through an injector nozzle in each combustion chamber. Excess fuel from the injector nozzles and pump is returned to the fuel tank by way of the overflow valve and return line. This system of fuel circulation lubricates and cools the injection pump and also warms the fuel in the fuel tank to help prevent fuel waxing in cold weather.

CAUTION: Always use clean fresh diesel fuel with a minimum of 40 cetane. DO NOT use kerosene. The injection pump requires diesel fuel for lubrication. Damage to the injection pump and/or engine may result if kerosene is used. Servicing the fuel injection system requires highly specialized equipment and procedures. Consult the Yellow Pages™ under Engines-Diesel-Fuel Injection Service & Parts for the nearest diesel fuel injection specialist if the injector pump or injector nozzles require servicing.

See Section 3 for procedure for removing and installing injector pump.

FUEL SYSTEM COMPONENTS

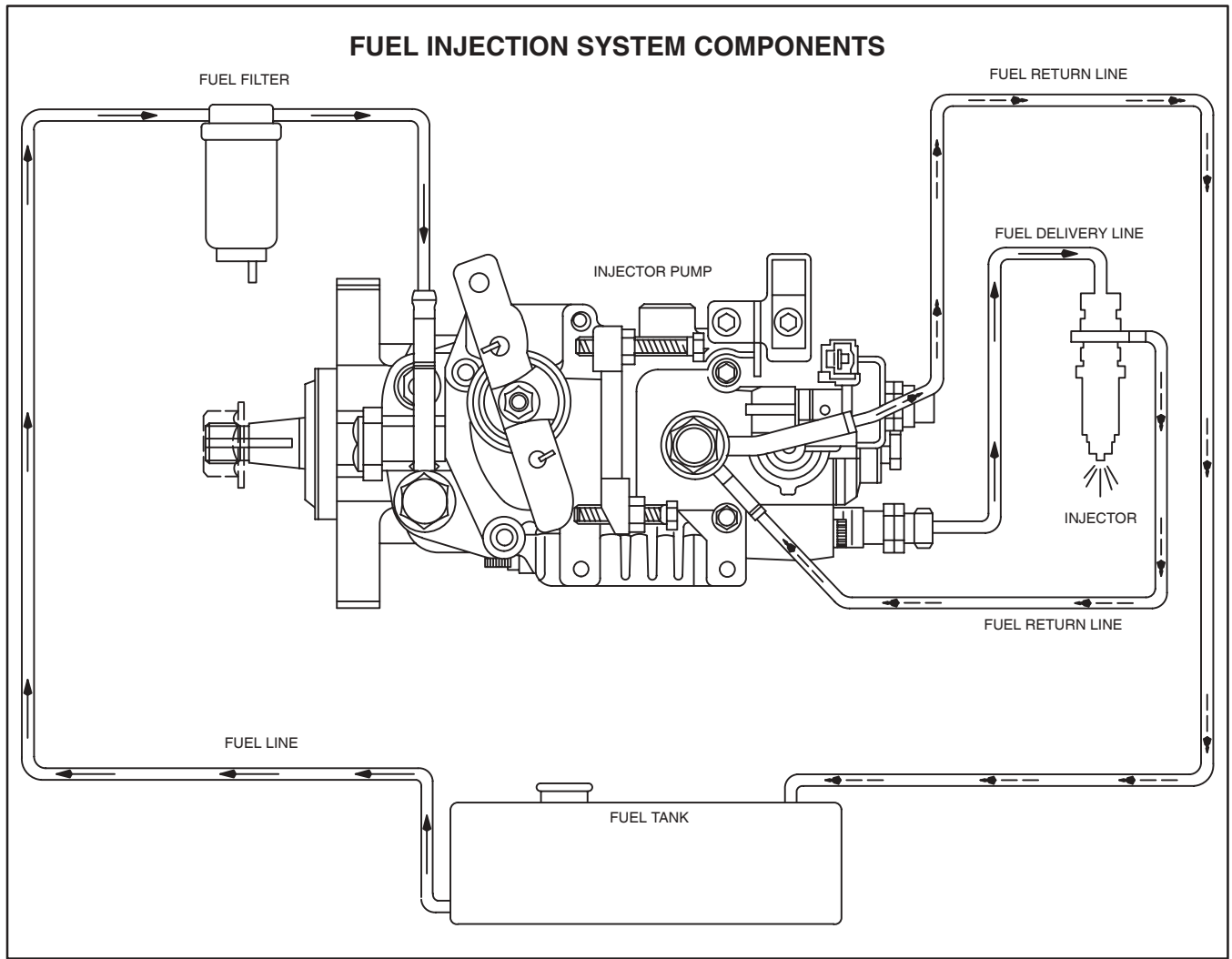


TABLE 1
Injection Pump Timing
Engine Date Code Before 99010100

Model/Type No.	Timing Specification
432447-0150-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0105-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0106-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0107-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0108-E2	0.93 ± .03 mm (.0365" ± .001")
522447-0109-E2	0.93 ± .03 mm (.0365" ± .001")
582447-0105-E2	0.93 ± .03 mm (.0365" ± .001")
582447-0125-E2	0.81 ± .03 mm (.032" ± .001")
582447-0130-E2	0.93 ± .03 mm (.0365" ± .001")
582447-0131-E2	0.81 ± .03 mm (.032" ± .001")

TABLE 2
Injection Pump Timing
Engine Date Code After 98123100

Model Series	Timing Specification
432447 – All	0.90 ± .03 mm (.035" ± .001")
522447 – All	0.90 ± .03 mm (.035" ± .001")
582447 – All	0.81 ± .03 mm (.032" ± .001")
58A447 – All	0.90 ± .03 mm (.035" ± .001")
588447	

INJECTOR PUMP

Checking Injector Pump Timing

NOTE: Clean areas around fuel lines and injectors to prevent any dirt from entering injector nozzles or delivery valve ports when fuel delivery lines are removed.

1. Remove fuel delivery lines from injector pump and injector nozzles, Fig. 1.

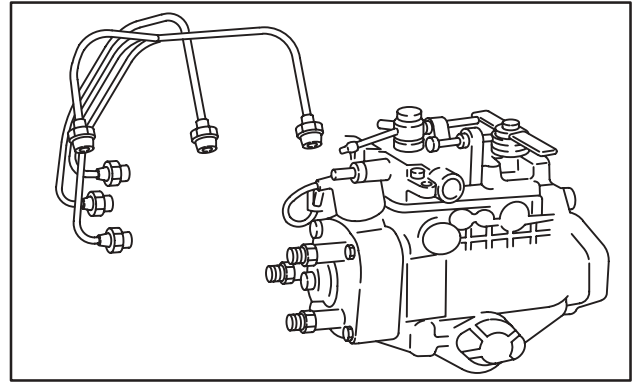


Fig. 1 – Removing Fuel Lines

2. Set No. 1 piston at TDC:
 - a. Rotate crankshaft until timing mark on pulley is aligned with reference point on timing cover, Fig. 2.
 - b. If intake and exhaust valves have clearance, No. 1 piston is at TDC – compression stroke.
 - c. If intake and exhaust valves do not have clearance, turn crankshaft pulley one complete revolution. Valves will then have clearance.

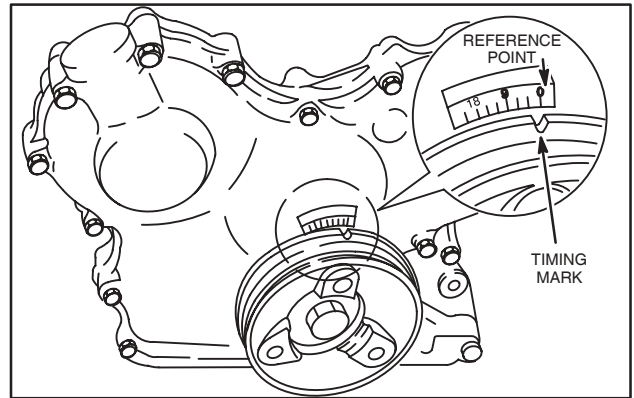


Fig. 2 – Align Timing Marks

3. Remove distributor head screw with washer and install injector pump timing gage, dial indicator Tool # 19441, Fig. 3.

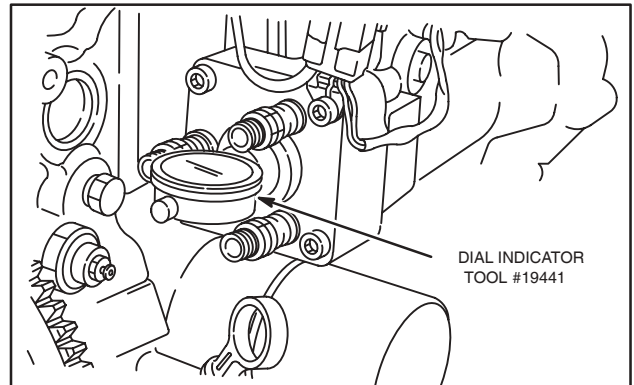


Fig. 3 – Install Timing Tool

4. Slowly rotate crankshaft counter-clockwise until dial indicator needle just stops moving. Set dial indicator at "0," Fig. 4.

NOTE: When indicator needle just stops moving, carefully rock crankshaft clockwise slightly, then counter-clockwise slightly to verify absolute "0."

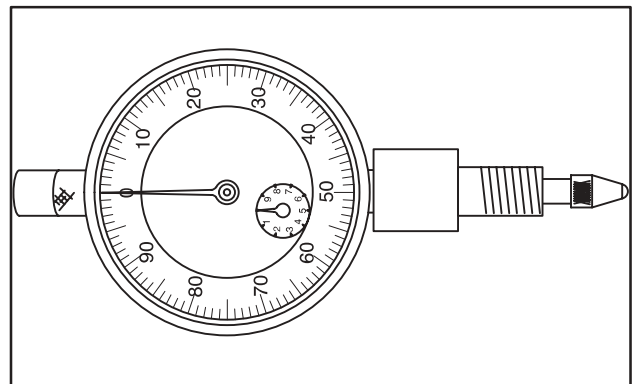


Fig. 4 – Setting Indicator

- Slowly rotate crankshaft clockwise until timing mark on pulley aligns with reference point on gear case cover (TDC), Fig. 5. Note dial indicator reading.

NOTE: Do not rotate crankshaft past TDC. If crankshaft is rotated past TDC rotate crankshaft back to “0” and repeat procedure.

- Refer to timing specification tables on page 3 for correct specification by engine model and type or code number.

If indicator reading is within specification, injector pump is properly timed. Proceed to step 6.

If indicator reading is not within specification, see procedure for **adjusting injector pump timing**.

- Remove timing gage and install distributor screw with new washer, Fig. 6.
 - Torque screw to 17.0 Nm (150 in. lbs.).
- Install fuel delivery lines.
 - Torque to 25.0 Nm (220 in. lbs.).

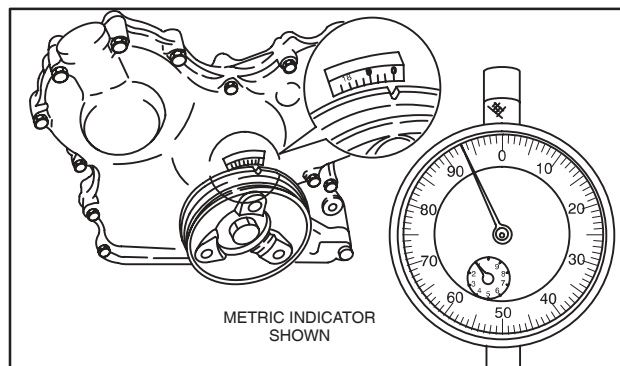


Fig. 5 – Checking Timing

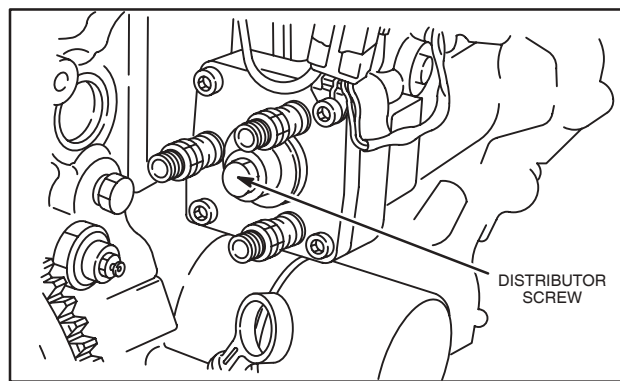


Fig. 6 – Install Distributor Screw

Adjusting Injector Pump Timing

Refer to timing specification tables on page 3 for correct specification by engine model and type or code number.

- Loosen injector pump mounting nuts and pump support bracket screw, Fig. 7. Rotate pump toward cylinder head as far as it will go.

NOTE: Loosen nuts and screw only enough to allow pump to be rotated with some resistance.

Perform Steps 2 through 4 as described in “Checking Injector Pump Timing”.

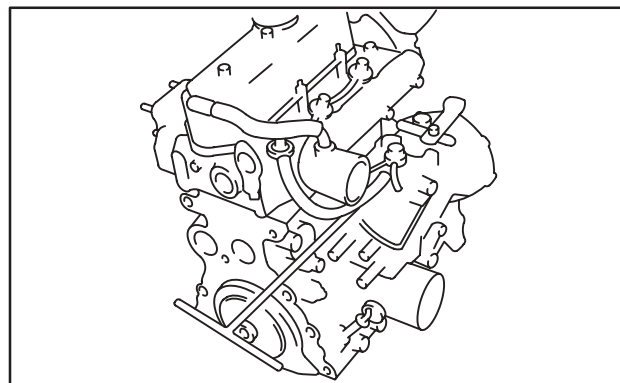


Fig. 7 – Loosen Pump

- Slowly rotate crankshaft clockwise until timing mark on pulley aligns with reference point on gear case cover (TDC), Fig. 8.

NOTE: Do not rotate crankshaft past TDC. If crankshaft is rotated past TDC rotate crankshaft back to “0” and repeat procedure.

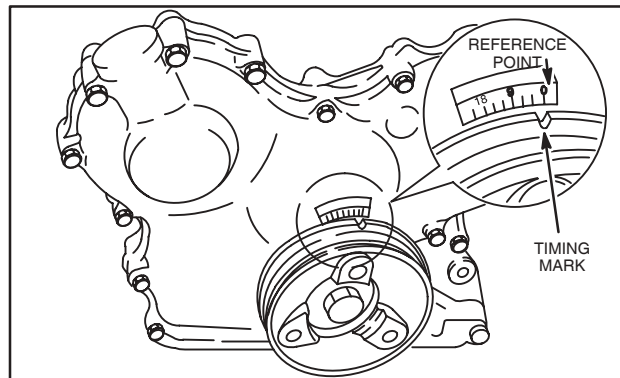


Fig. 8 – Align Timing Marks

INJECTOR PUMP

3. While observing dial indicator, slowly rotate injector pump away from cylinder head until indicator shows correct specification. Hold injector pump in this position and tighten outside pump mounting nut, Fig. 9.

NOTE: Do not rotate pump past specification. If pump is rotated past specification, rotate pump back toward cylinder head and repeat procedure.

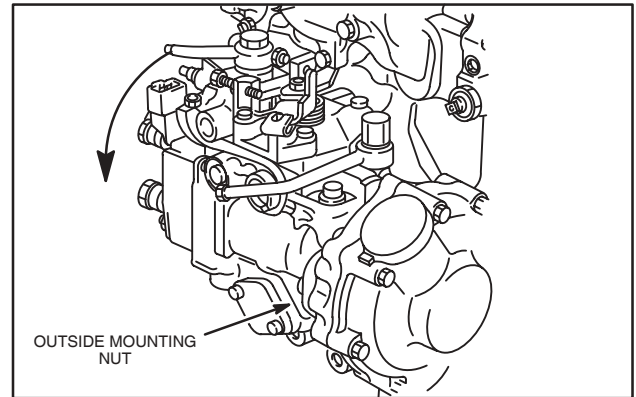


Fig. 9 – Adjusting Timing

4. To verify that timing is correct, rotate crankshaft counter-clockwise until dial indicator reads “0.” Then rotate crankshaft clockwise until timing mark on pulley aligns with reference point on gear case cover (TDC). Indicator should be within specification, Fig. 10.
5. Torque injector pump mounting nuts and pump support bracket screw to 19.0 Nm (170 in. lbs.).

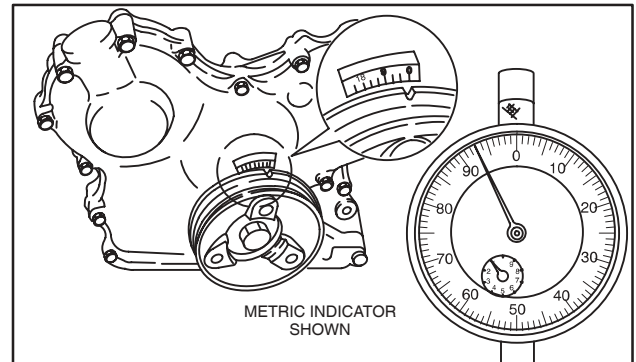


Fig. 10 – Verify Timing

6. Remove timing gage and install distributor screw with new washer, Fig. 11.
 - a. Torque screw to 17.0 Nm (150 in. lbs.).
7. Install fuel delivery lines.
 - a. Torque to 25.0 Nm (220 in. lbs.).

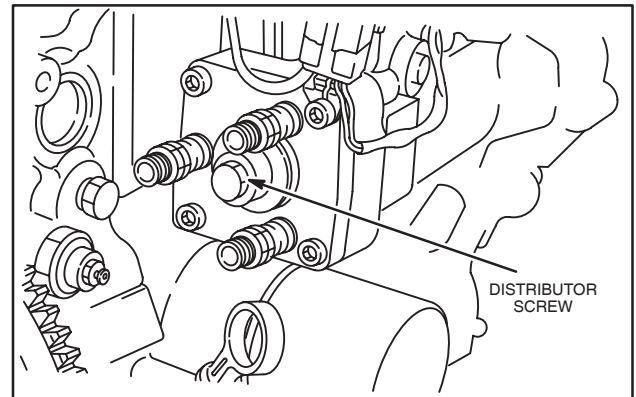


Fig. 11 – Installing Distributor Screw

INJECTORS

Remove Injectors

NOTE: Use care to prevent any dirt from entering injector holes or delivery valve ports when fuel delivery lines are removed.

1. Remove fuel delivery lines, Fig. 12.
2. Disconnect fuel return line hose.
3. Remove nuts and fuel return line.
 - a. Discard fuel return line gaskets.

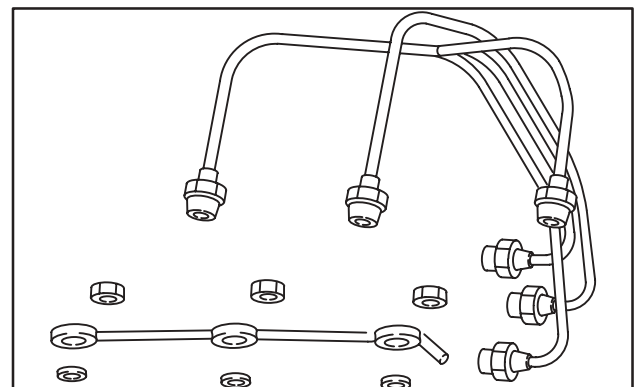


Fig. 12 – Removing Fuel Lines

4. Remove injector nozzles, Fig. 13.

- a. Discard injector gaskets.

NOTE: Handle injectors with extreme care. Do not drop!

Always use new fuel return line and injector nozzle gaskets when servicing fuel system.

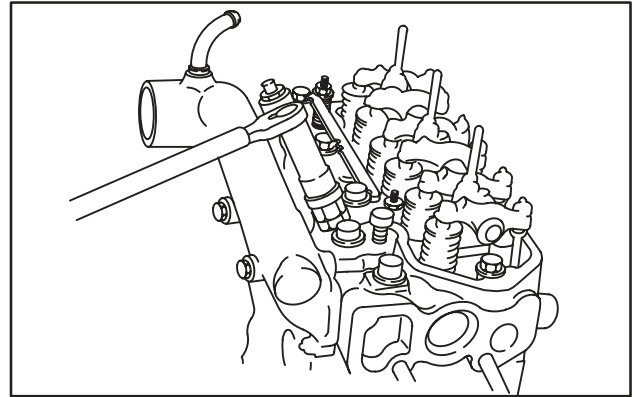


Fig. 13 – Removing Injectors

Checking Injectors

Fuel injector nozzle testing requires highly specialized equipment and procedures. Consult the Yellow Pages™ under Engines-Diesel-Fuel Injection Service & Parts for the nearest diesel fuel injection specialist.

The procedures and specifications listed are provided as an aid to the fuel injection specialist when testing injector nozzles.

1. With injector installed on a nozzle tester, operate the handle rapidly several times to clean off any carbon deposits on the injector port, Fig. 14.
2. Check “pop off” pressure of injector.

**Specification: 135 – 145 Bar
(1955 – 2100 psi)**

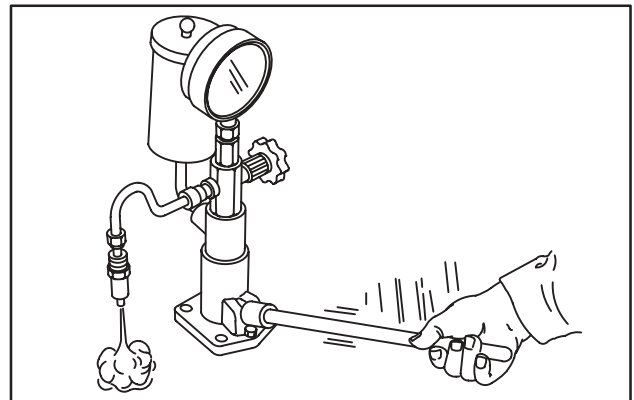


Fig. 14 – Checking Injector

If injector is not within specification, the injector shim may be changed, Fig. 15.

Replacement shims are available in .025 mm increments from .7 to 1.95 mm.

NOTE: As the shim thickness increases or decreases by .025 mm, injection pressure will vary about 5 Bar (71 psi).

Torque nozzle holder and injector body to 47.0 Nm (35 ft. lbs.).

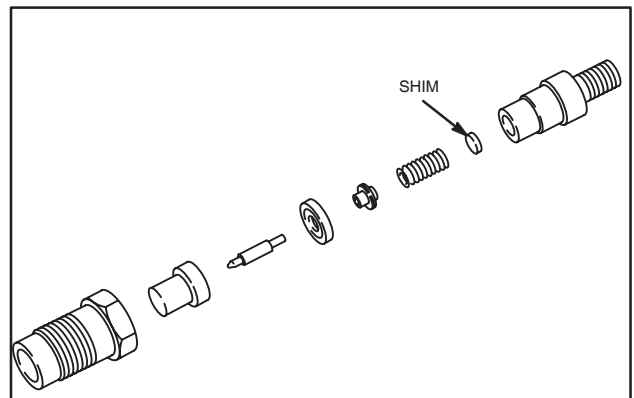


Fig. 15 – Injector Shim

INJECTORS

3. Check injector for leakage, Fig. 16.

Maintain injector pressure at approximately 120 Bar (1707 psi), for about 10 seconds. Make sure there is no leakage from nozzle or retaining nut area.

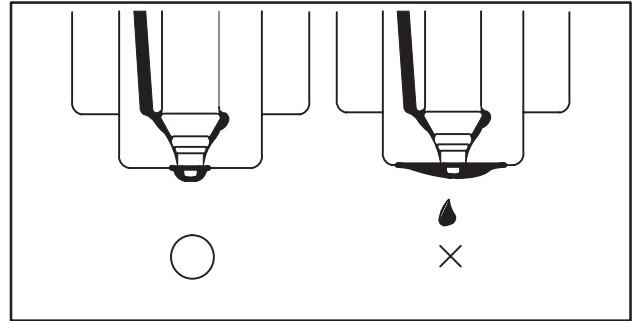


Fig. 16 – Checking Leakage

4. Check spray pattern of nozzle, Fig. 17.

Operate tester handle rapidly while observing pattern. Spray pattern should be uniform and centered under nozzle.

NOTE: A buzzing or chattering sound should also occur while operating handle. Nozzle should not drip between pump strokes.

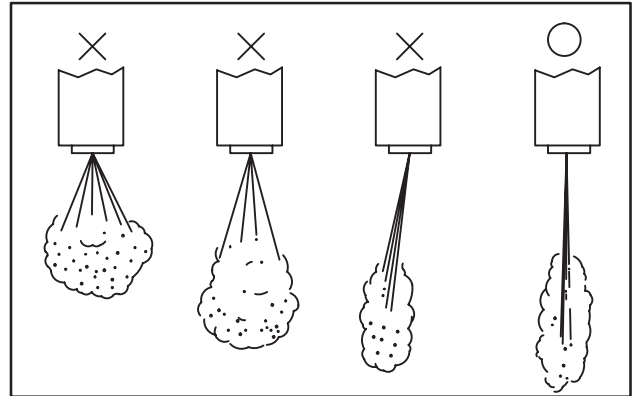


Fig. 17 – Checking Spray Pattern

Install Injectors

Install injectors and fuel return line with new gaskets, Fig. 18. Install fuel delivery lines.

- Torque injectors to 61.0 Nm (45 ft. lbs.).
- Torque fuel return line to 27.0 Nm (20 ft. lbs.).
- Torque fuel delivery lines to 25.0 Nm (220 in. lbs.).

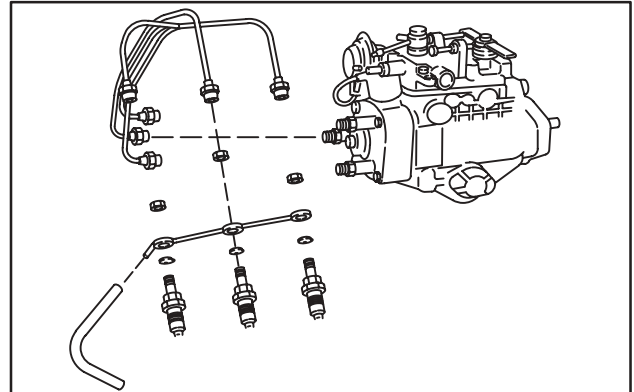


Fig. 18 – Installing Injectors

FUEL FILTER – GENERAL

The fuel filter consists of a replaceable cartridge type filter with a water level sensor and priming pump, Fig. 19.

Replace fuel filter cartridge every 800 hours of engine operation.

The water collector contains a float type sensor that activates a warning lamp when it collects a minimum of 80 cc's (2.5 fl. oz.) of water.

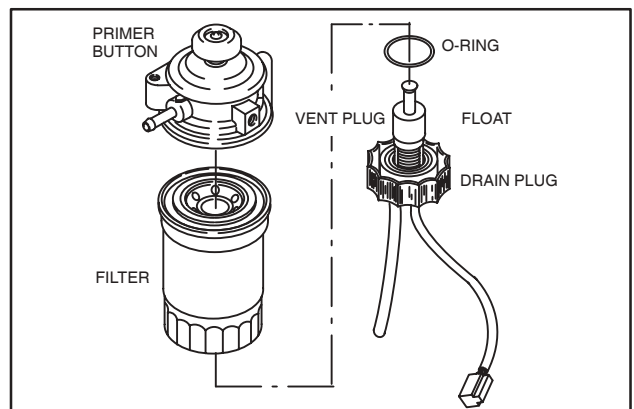


Fig. 19 – Fuel Filter

Draining Water Collector

When warning lamp comes on, drain water collector as follows:

1. Stop engine.
2. Place a drain pan under filter and loosen vent plug.
3. Loosen drain plug approximately 1 turn and drain water from filter until only fuel flows from filter.
4. Tighten drain plug and vent plug and wipe up any spills.
5. Start engine, making sure warning lamp goes out. Check for leaks.

Checking Float Sensor

The following test will be made with the meter in the “Diode Test Position” $\rightarrow + \text{|||||}$.

Disconnect sensor wire from equipment harness and remove float sensor from fuel filter.

1. Attach a meter test lead to each terminal in connector.
2. While holding drain plug in vertical position, raise float to end of travel, Fig. 20.
 - a. Meter should make a continuous tone.
3. Now lower float
 - a. Meter should display OL.

Replace drain plug and float sensor if not to specification.

FUEL SHUT-OFF SOLENOID

When the ignition switch is turned to the “On” and “Start” position the fuel shut off solenoid valve opens allowing fuel to enter the fill port and pressure chamber. When the keyswitch is turned “Off” the solenoid closes shutting off the the fuel supply and the engine, Fig. 21.

Solenoid is operating if a click is heard when keyswitch is turned “On” and “Off.”

If solenoid does not click, problem may be in equipment wiring to solenoid.

Checking Fuel Shut-Off Solenoid Wiring

The following test will be made with the meter in the $V \text{ ---}$ (DC Volts position).

Turn keyswitch to “Off” position and disconnect equipment solenoid wire.

1. Attach BLACK meter test lead to a good ground.
2. Attach RED meter test lead to connector in equipment solenoid wire and turn keyswitch to “On” position.
3. Meter should display battery voltage, Fig. 22.
 - a. If meter does not display battery voltage, check for broken solenoid wire, blown fuse (if equipped) or defective keyswitch.

Change Fuel Filter

1. Disconnect sensor wire and remove drain plug. Discard O-ring.
2. Remove fuel filter with a filter wrench.
3. Screw new filter on by hand until gasket contacts housing. Then tighten 1/3 turn more.
4. Install drain plug with new O-ring and connect sensor wire.
5. Activate primer button until resistance is felt.
6. Start engine and check for leaks.

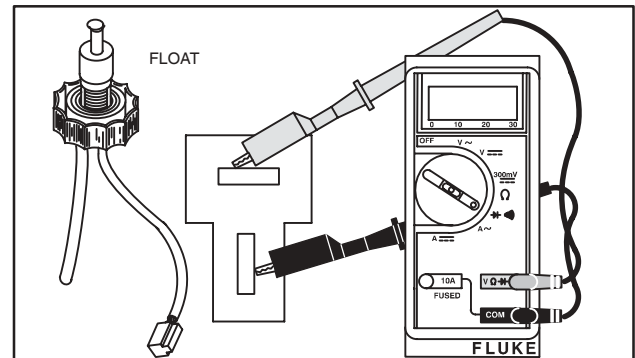


Fig. 20 – Checking Sensor

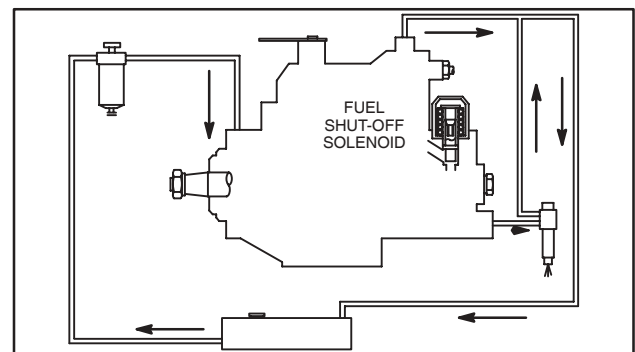


Fig. 21 – Fuel Shut-Off Solenoid

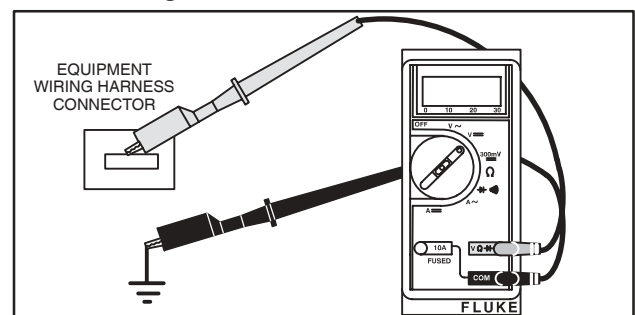


Fig. 22 – Testing Solenoid Wiring

INJECTOR PUMP IDENTIFICATION

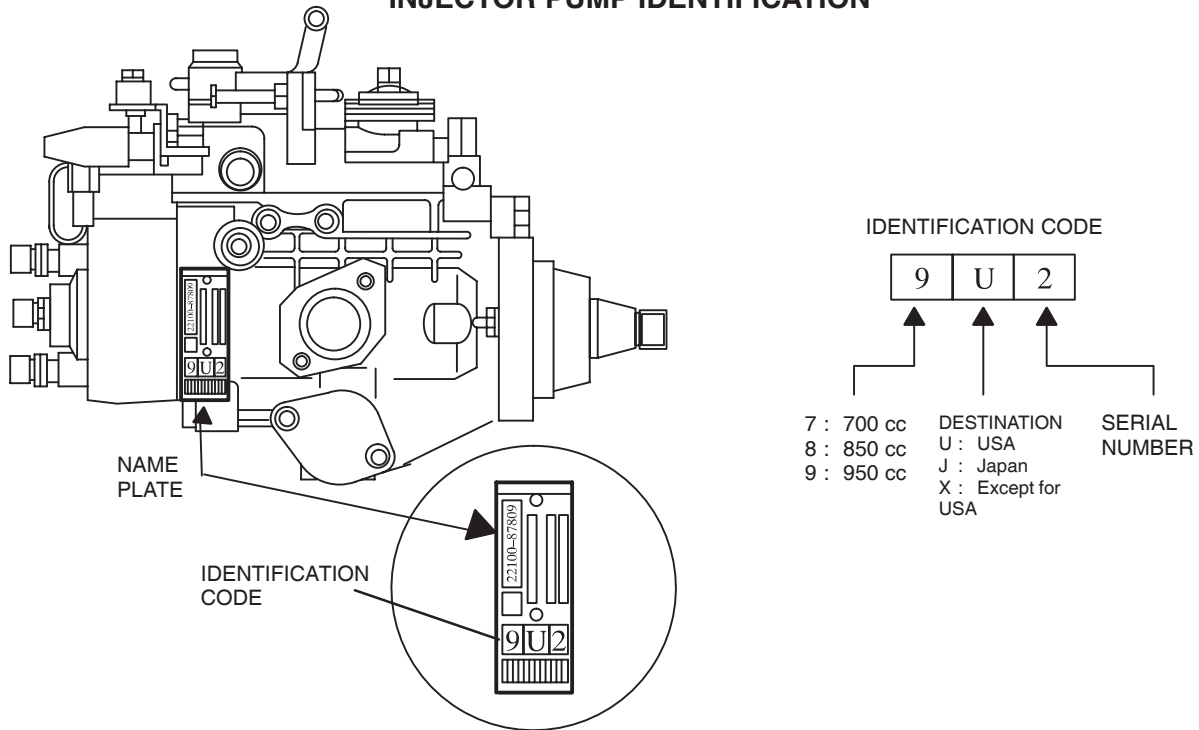


TABLE 3
Engine Speed Specification Chart

Pump Mfg. Part No.	ID Code	Model & Type No.	Idle Speed (rpm)	Top No Load (rpm)
22100-87801	7U1	432447-0105-E2	1200±50	3850±50
22100-8713	7U2	432447-0205-E2	1200±50	3850±50
22100-87802	9U1	582447-0105-E2	1200±50	3850±50
		582447-0205-E2		
		582447-0130-E2	1200±50	3300±50
		582447-0230-E2		
		582447-0219-E2	1600±50	3600±50
		582447-0222-E2		
22100-87806	9U2	582447-0221-E2	1750±50	3600±50
		582447-0225-E2	1050±50	3850±50
		582447-0232-E2	1200±50	3400±50
22100-87807	8U1	582447-0125-E2	1850±50	3420±50
		582447-0131-E2	1700±50	3600±50
22100-87809	8U2	522447-0105-E2	1200±50	3850±50
		522447-0108-E2	1600±50	3350±50
22100-87810	8U3	522447-0106-E2	1850±50	3420±50
		522447-0109-E2	1850±50	3420±50
22100-87810	8U3	522447-0107-E2	1525±50	2775±50
22100-87815	8U4	522447-0107-E2	1540±50	2790±50
22100-87817	8U5	522447-0107-E2	1540±50	2790±50
22100-87811	9U4	58A447-0205-E2	1200±50	3850±50
22100-87818	9U5	588447-0205-E2	1200±50	3850±50
		588447-0216-E2	1800±50	3600±50
		588447-0230-E2	1600±50	3600±50
		588447-0225-E2	1050±50	3850±50

ADJUST IDLE SPEED

Engine should be at operating temperature before adjusting idle speed.

Make sure speed control lever contacts idle speed screw with engine at idle.

1. Loosen idle speed screw lock nut and adjust idle speed screw to obtain RPM specified by model and type number shown in chart, Fig. 23.

NOTE: Do exceed RPM shown for specific model and type number.

- a. Torque lock nut to 6.0 Nm (50 in. lbs.).

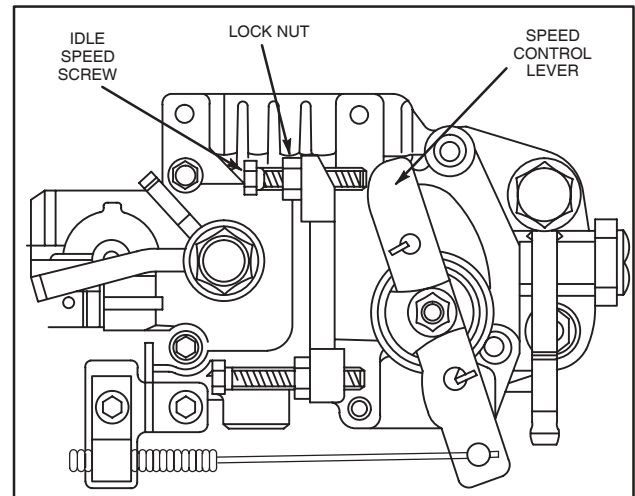


Fig. 23 – Adjusting Idle Speed

ADJUST TOP NO LOAD SPEED

Engine should be at operating temperature before adjusting idle speed.

Temporarily disconnect speed control wire at control bracket on pump.

1. Remove and discard top no load wire and seal.
2. Loosen top no load speed screw lock nut.
3. Move speed control lever to FAST position and adjust top no load speed screw to RPM specified by model and type number shown in chart, Fig. 24.

NOTE: Do exceed RPM shown for specific model and type number.

4. Stop engine and torque lock nut to 6.0 Nm (50 in. lbs.).
5. Reassemble speed control wire at bracket.
 - a. Tighten screws securely.
 - b. Make sure speed control lever contacts top no load screw when throttle lever is in FAST position.

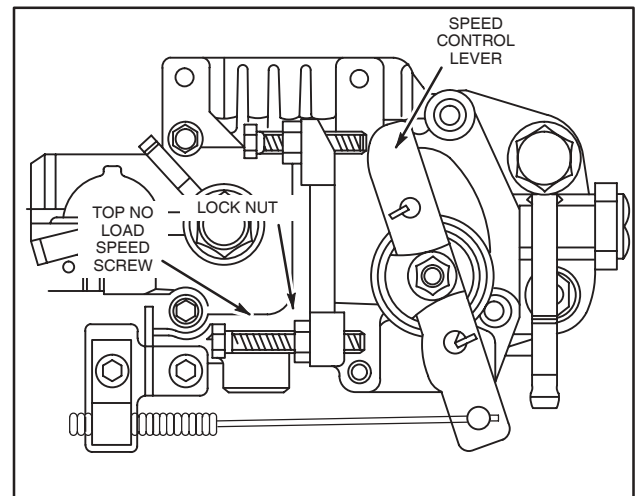


Fig. 24 – Adjusting Top No Load Speed

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Section 11

Electrical System

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Electrical System Components (Typical 40 Amp Alternator Shown)

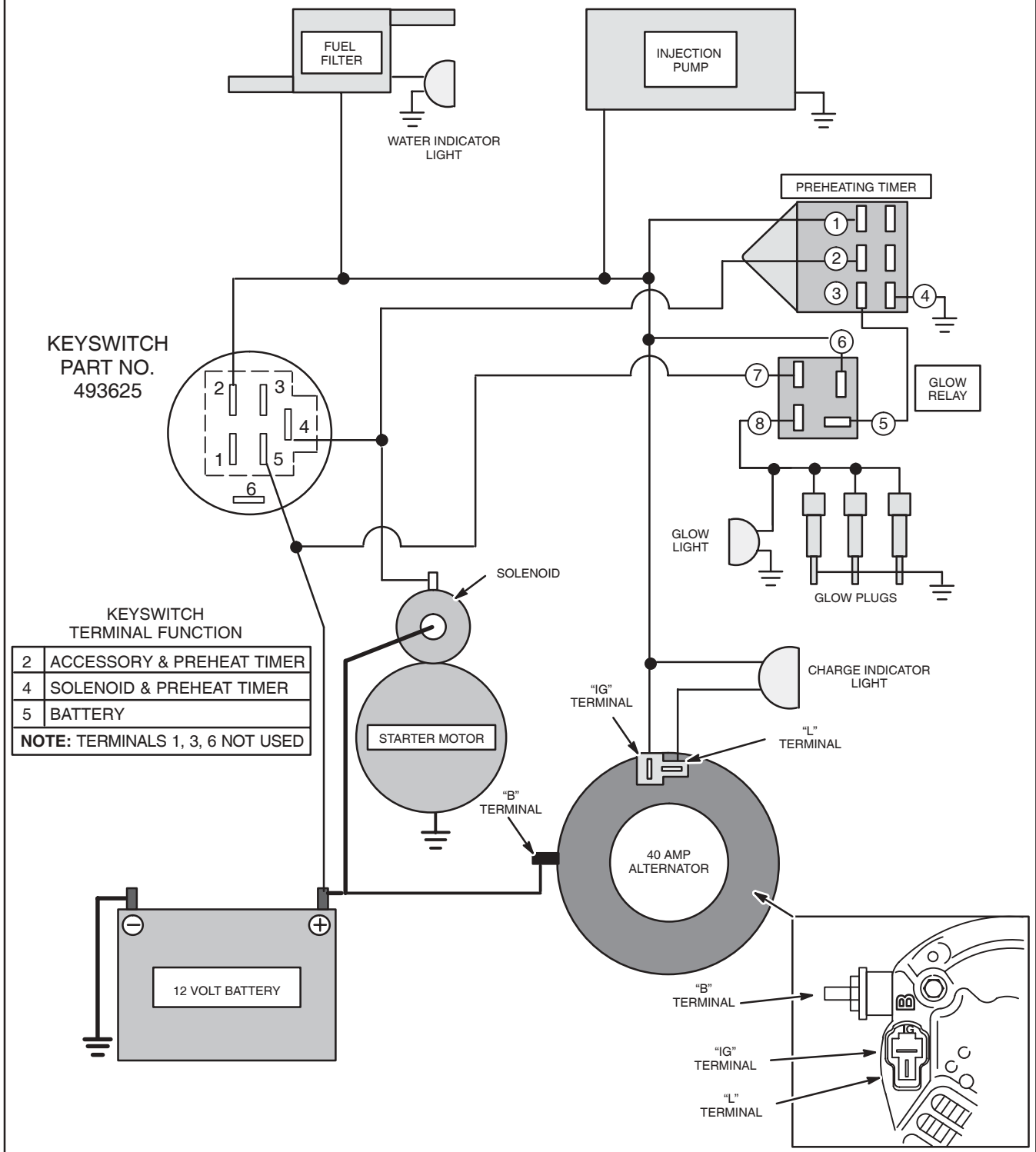


Fig. 1

GLOW PLUG SYSTEM

Glow Plug

The glow plug is a self regulating type, consisting of two metal heating element coils; a rush coil and a brake coil, Fig. 2. The rush coil provides rapid heating of the tip of the glow plug. The brake coil decreases current to the glow plug by increasing resistance as the temperature rises, regulating the temperature of the glow plug.

Glow Plug Specifications

Rated Voltage	11V
Rated Current	9.5A
Normal Resistance	1.0 Ω

Remove Glow Plug

Disconnect glow plug wiring from connector.

1. Remove glow plug connector nuts and connector.
2. Remove glow plugs, Fig. 3.

Handle glow plugs with care. Do not drop. Do not scratch heater section.

Test Equipment

The digital multimeter, Tool #19390 is required to test the glow plug.

Testing Glow Plug

With meter selector switch in $\rightarrow + \text{)))$ position, a continuous tone indicates continuity (complete circuit). No tone indicates no continuity (incomplete circuit). An incomplete circuit will be displayed as "OL."

1. Check glow plug for continuity as shown, Fig. 4.
 - a. If meter indicates NO continuity, replace glow plug.

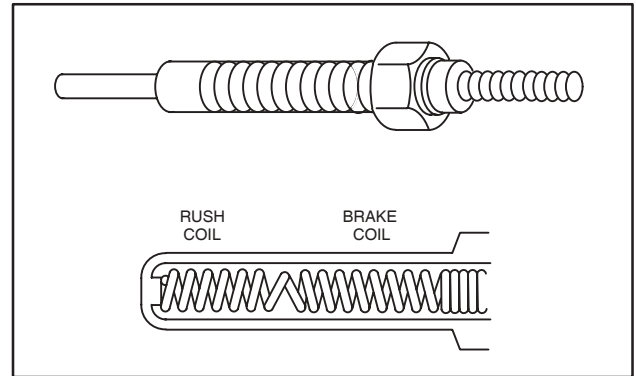


Fig. 2 – Glow Plug

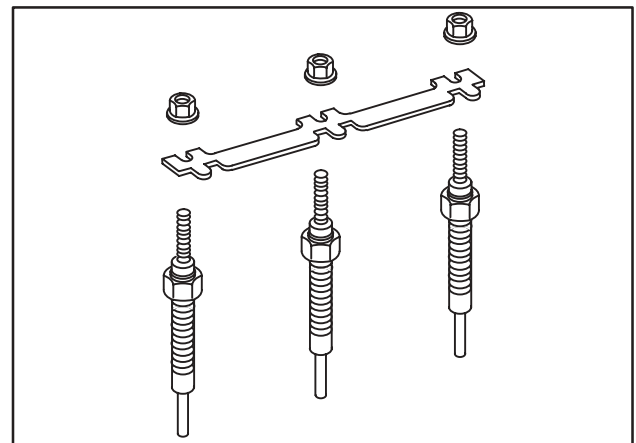


Fig. 3 – Removing Glow Plugs

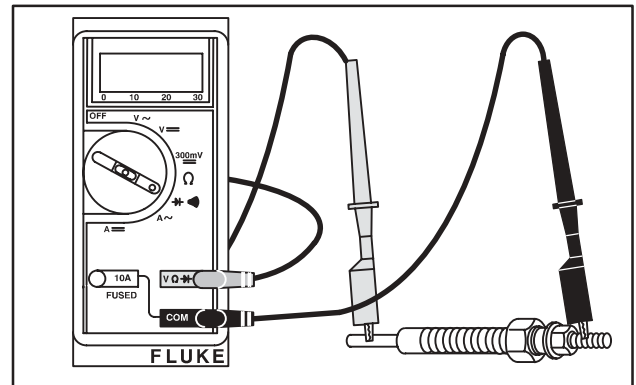


Fig. 4 – Testing Glow Plugs

PREHEAT TIMER AND GLOW RELAY

The preheat timer and glow relay regulate current to the glow plugs for preheating and starting. When the keyswitch is turned to the “On” position, with the engine cold, the preheat timer activates the glow plugs. An indicator light lights and remains on while the glow plugs are preheating the combustion chamber. When the indicator light goes out, the engine may be started. When the keyswitch is in the “Start” position, the glow plugs and light are activated again as the engine is cranking.

See Fig. 5 for terminal positions of the preheat timer and glow relay.

Testing Preheat Timer

The following test will be made with the meter in the **V** $\overline{\text{---}}$ (DC Volts position), Fig. 6.

Turn keyswitch to “Off” position.

1. Insert BLACK meter test lead probe into terminal #4.
2. Insert RED meter test lead probe into terminal #3.
3. Turn keyswitch to “On” position.
 - a. Glow light should light. Meter should display 1.5 volts maximum.
 - b. After 5 seconds (approximately), glow light should go out. Meter should display approximately battery voltage.
4. Replace preheat timer if not to specification.

NOTE: If glow light does not light, replace bulb.

Testing Glow Relay

The following test will be made with the meter in the **V** $\overline{\text{---}}$ (DC Volts position), Fig. 7.

Turn keyswitch to “Off” position.

1. Insert BLACK meter test lead probe into terminal #8.
2. Insert RED meter test lead probe into terminal #7.
3. Turn keyswitch to “On” position.
 - a. Meter should display battery voltage.
 - b. Turn keyswitch to “On” position.
 - a. Glow light should light. Meter should display 0.5 volts maximum.
 - b. After 5 seconds (approximately), glow light should go out. Meter should display approximate battery voltage.
4. Replace glow relay if not to specification.

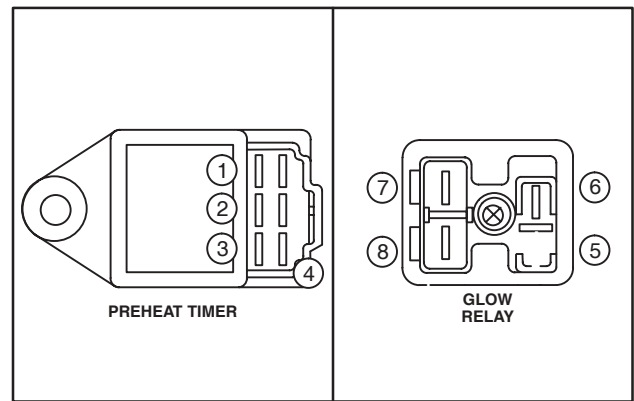


Fig. 5 – Terminal Positions

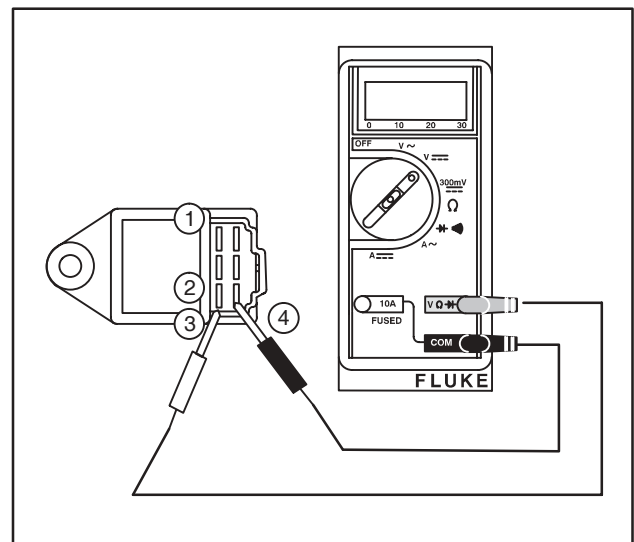


Fig. 6 – Testing Preheat Timer

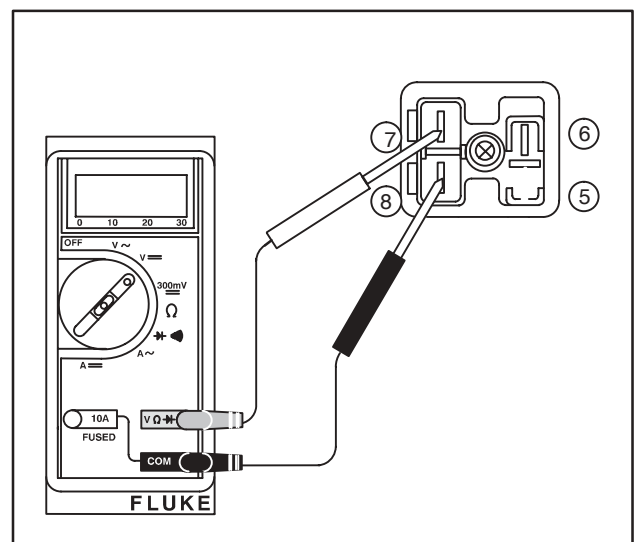


Fig. 7 – Testing Glow Relay

GLOW PLUG SYSTEM

KEYSWITCHES

Two types of keyswitches may be used on Briggs & Stratton Daihatsu diesel engines.

Fixed Timer Preheat Keyswitch – Part No. 493625

Keyswitch, Part No. 493625, is used with a preheat timer and glow relay, Fig. 8. With the keyswitch in the “On” and “Start” position, battery current is supplied to the preheat timer and glow relay. See keyswitch terminal positions and functions, Fig. 8.

See Fig. 78 and Fig. 79 at end of section, for wiring diagrams for keyswitch No. 493625.

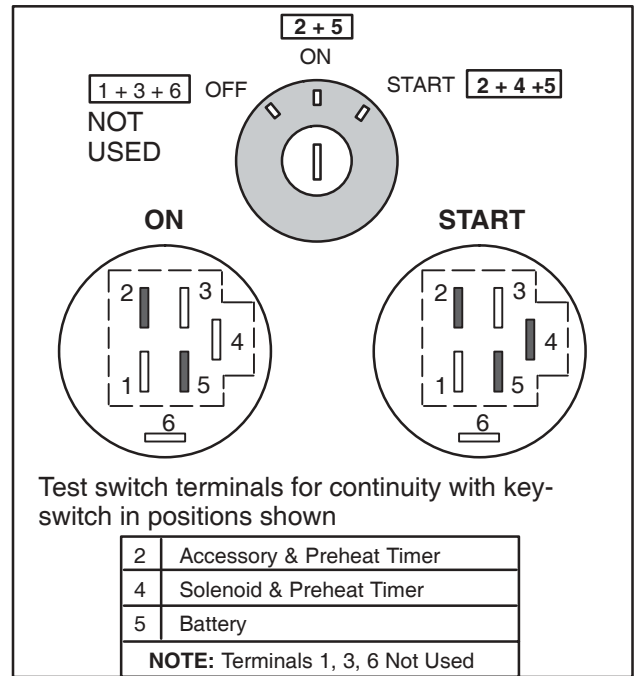


Fig. 8 – Keyswitch – Fixed Timer Preheat

Manual Preheat Keyswitch – Part No. 825129

The manual preheat keyswitch, Part No. 825129, is equipped with four positions and six terminals, Fig. 9. The “G1” terminal provides current to the glow plugs only when the switch is in the “Heat” position. When the keyswitch is turned to the “Start” position the “G2” terminal provides current to the glow plugs while the engine is cranking. See keyswitch terminal positions and functions, Fig. 10.

Symbols are shown as they appear on rear of keyswitch. Note that “B” terminal is connected to terminal below it, Fig. 10. Keyswitch will not function without connector.

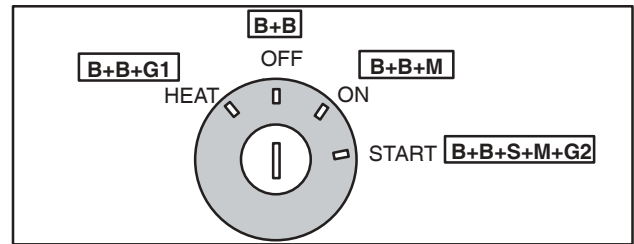


Fig. 9 – Keyswitch – Manual Preheat

See Fig. 80 and Fig. 81 for wiring diagrams for keyswitch No. 825129.

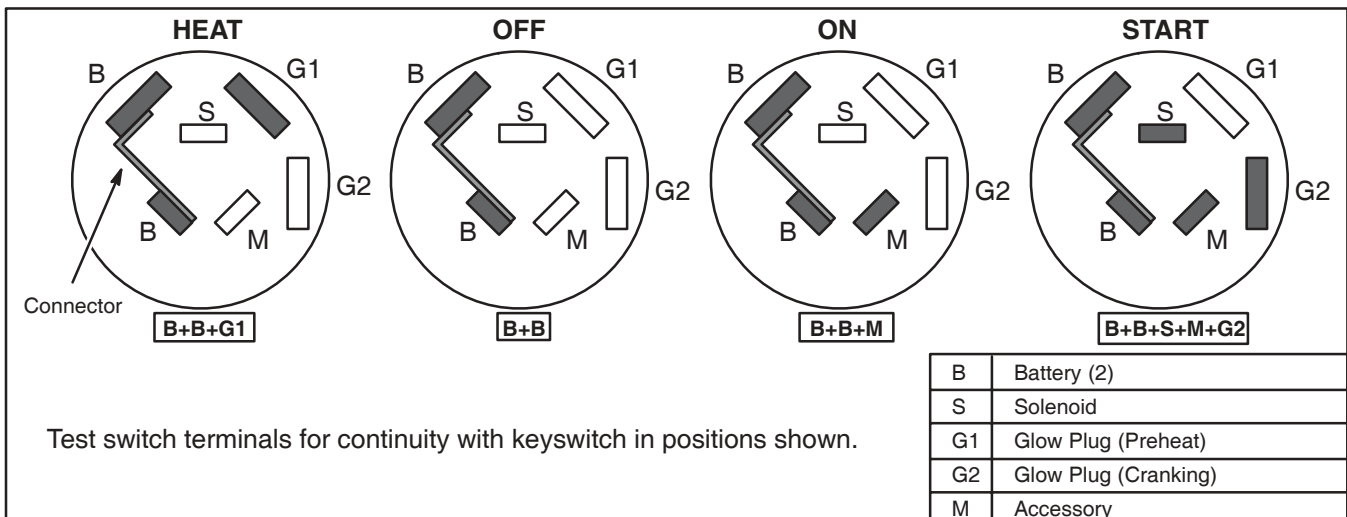


Fig. 10 – Terminal Positions And Functions

14 AMP CHARGING SYSTEM

The 14 amp charging system consists of two components:

1. The belt driven permanent magnet alternator produces AC voltage, Fig. 11. AC output will vary with engine RPM, from approximately 7 volts AC at 1000 RPM to 32 volts AC at 3000 RPM.

NOTE: A loose V-belt will cause low AC output.

Belt deflection limit is 9.5-11.5 mm/10 kg.
(3/8-7/16 in./22 lb.).

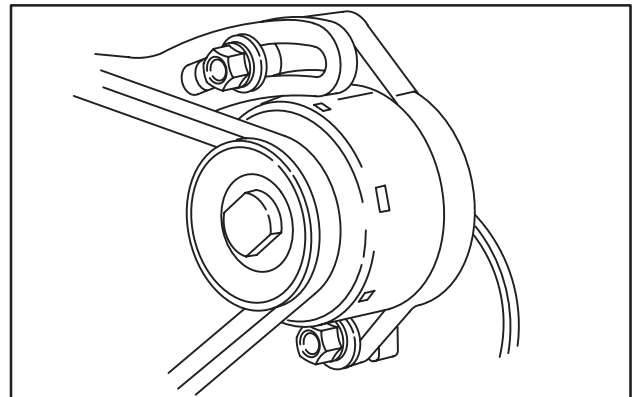


Fig. 11 – 14 Amp Alternator

2. The regulator-rectifier converts the AC current to DC and regulates current to the battery, Fig. 12. The charging rate will vary with engine RPM. The regulator-rectifier is equipped with a charging indicator light circuit.

NOTE: The regulator-rectifier requires a minimum battery voltage of 6 volts to function.

There will be no charging output if battery voltage is below 6 volts.

Fig. 78 and Fig. 80 at end of section, show wiring diagrams for typical 14 amp charging system.

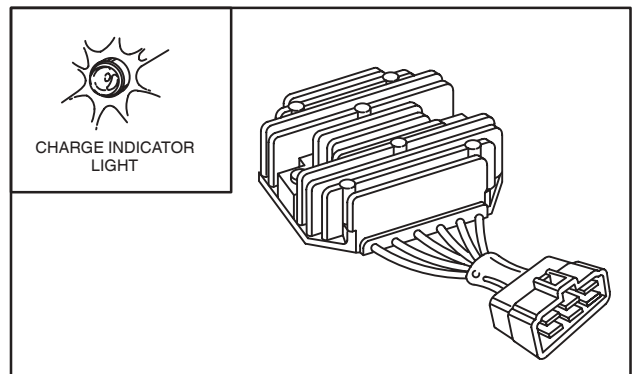


Fig. 12 – Regulator-rectifier

Test Equipment

The digital multimeter, Tool #19464 and the DC shunt, Tool #19468, Fig. 13, are required to test the charging system.

NOTE: The digital multimeter will withstand DC input of 10-20 amps for up to 30 seconds. To avoid blowing fuse in meter, the DC shunt is required.

Replacement fuse is available from your Briggs & Stratton source of supply. Order Part No. 19449.

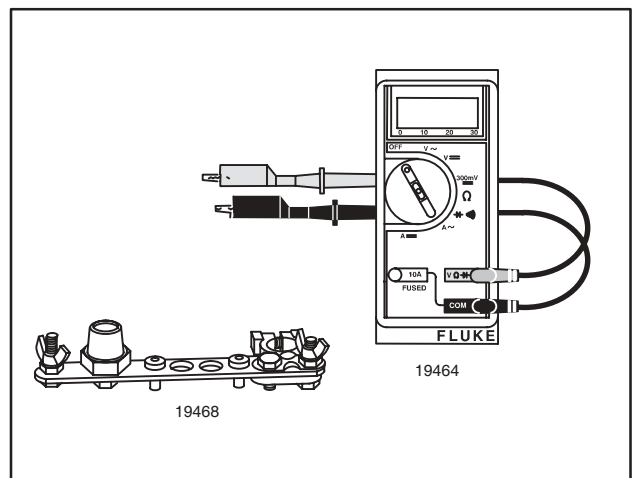


Fig. 13 – Test Equipment

CHARGING SYSTEMS

Testing Alternator – AC Output

The alternator output test will be performed with the meter in the V~ (AC volts) position, Fig. 14.

Disconnect alternator wires at connector.

Attach meter test leads to alternator output connectors BEFORE starting engine, Fig. 14.

1. With the engine running at 3300 RPM the output should be no less than 28 volts AC.
 - a. If no output or low output is found, replace alternator.
 - b. If alternator output is within specification, re-connect alternator wires and test regulator rectifier.

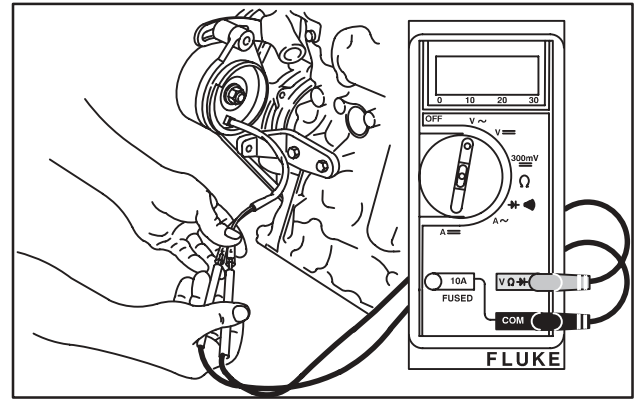


Fig. 14 – Testing Alternator Output

Testing Regulator-Rectifier – DC Output

The DC Shunt **must** be installed on the **negative** (-) terminal of the battery, Fig. 15. All connections must be clean and tight for correct amperage readings.

Attach meter test leads BEFORE starting engine.

The regulator-rectifier test will be performed with the meter in the **300mV==** position.

1. Attach RED meter test lead to RED post terminal on shunt.
2. Attach BLACK meter test lead to BLACK post terminal on shunt.

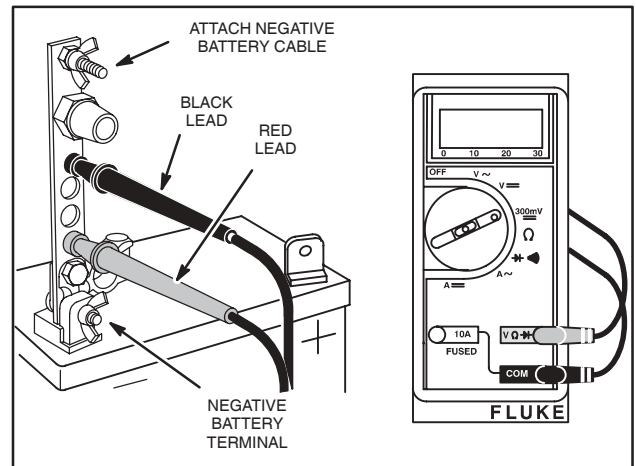


Fig. 15 – DC Shunt Installation

3. With the engine running at 3300 RPM, the output should be:

*** 4 – 14 Amps**

* Depending upon battery voltage and/or current draw on system.

4. If no or low output is found, be sure that regulator-rectifier is grounded properly and all connections are clean and secure. If there is still no or low output, replace the regulator-rectifier.

Charging Indicator Circuit

The green wire from the regulator-rectifier is used to activate the charging indicator light. With the keyswitch in the "ON" position and the engine not running the charge indicator light should light, Fig. 16. With the engine running the light should go out, indicating that the battery is being charged.

If the charge indicator light does not light when the keyswitch is in the "ON" position (engine not running), check the bulb and wiring.

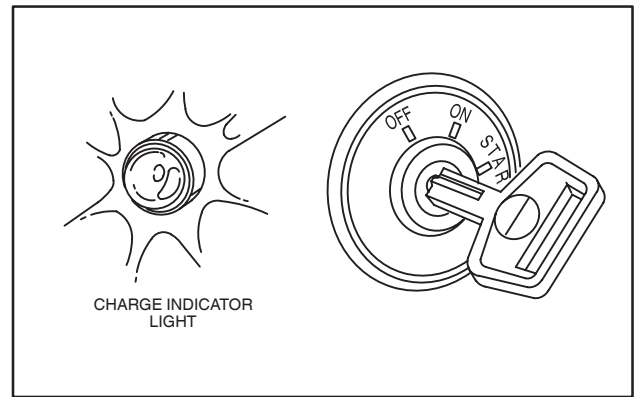


Fig. 16 – Charge Indicator Light

Testing Charging Indicator Bulb And Wiring

The following test will be made with the meter in the "Diode Test Position" $\rightarrow \text{+} \text{|||}$, Fig. 17.

With meter selector switch in $\rightarrow \text{+} \text{|||}$ position, a continuous tone indicates continuity (complete circuit). No tone indicates no continuity (incomplete circuit). An incomplete circuit will be displayed as "OL."

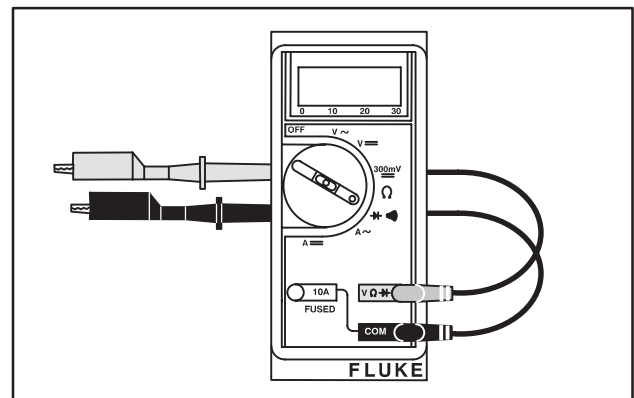


Fig. 17 – Meter Setting

Keyswitch must be in OFF position.

1. Disconnect output harness at regulator-rectifier.
2. Check continuity between charging indicator wire (green) and ground, Fig. 18.
 - a. If meter indicates continuity, bulb and wiring are OK. Replace regulator-rectifier.
 - b. If meter indicates NO continuity, replace bulb and re-test.
 - c. If meter indicates NO continuity with new bulb, the problem must be a broken wire (open circuit) in the charging indicator circuit.

If the charge indicator light remains on with the engine running, test the regulator-rectifier DC output. If output is within specification and charge indicator light remains on, replace the regulator-rectifier.

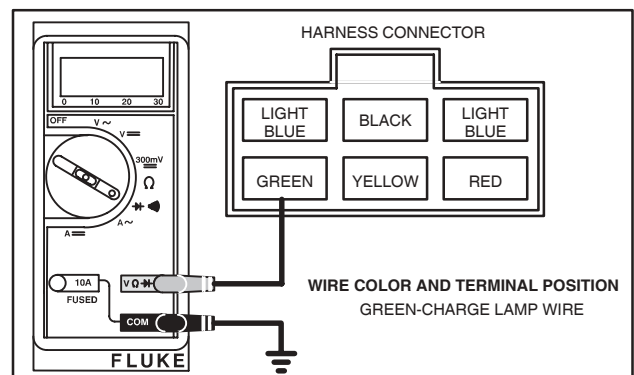


Fig. 18 – Testing Bulb And Wiring

CHARGING SYSTEMS

40 AMP CHARGING SYSTEM

Fig. 1 shows wiring diagram for 40 amp charging system.

The 40 amp charging system consists of a belt driven, internally regulated alternator, Fig. 19.

The alternator contains a charge light circuit ("L" terminal). With the keyswitch in the ON position and the engine not running the charge indicator light should light. With the engine running the light should go out, indicating that the battery is being charged.

If the charge indicator light does not light when the keyswitch is in the ON position (engine not running), check the bulb and wiring.

Note: A loose V-belt will cause low DC output.

Belt deflection limit is 9.5-11.5 mm/10 kg (3/8-7/16 in./22 lbs.).

TEST EQUIPMENT

The digital multimeter, Tool #19464 and the DC shunt, Tool #19468, Fig. 20, are required to test the charging system.

Note: The digital multimeter will withstand DC input of 10-20 amps for up to 30 seconds. To avoid blowing fuse in meter, the DC shunt is required.

Replacement fuse is available from your Briggs & Stratton source of supply. Order Part No. 19449.

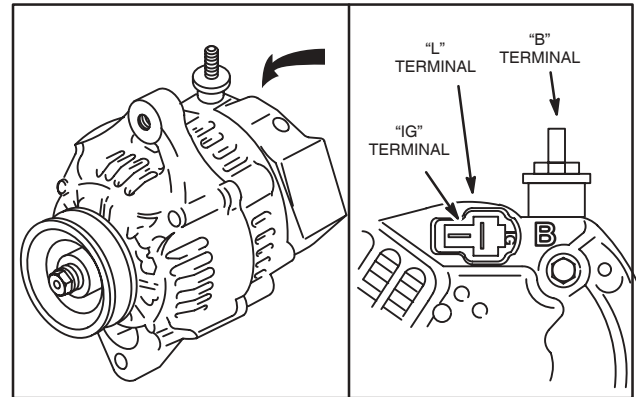


Fig. 19 – 40 Amp Alternator

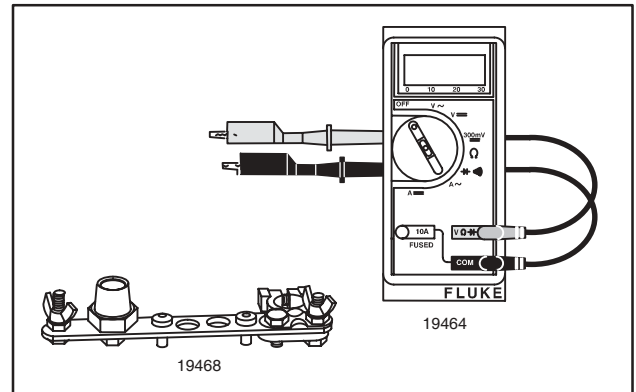


Fig. 20 – Test Equipment

TESTING ALTERNATOR – DC OUTPUT

The DC Shunt **must** be installed on the **negative** (-) terminal of the battery, Fig. 21. All connections must be clean and tight for correct amperage readings.

Attach meter test leads **BEFORE** starting engine.

The regulator-rectifier test will be performed with the meter in the **300mV** position.

1. Attach RED meter test lead to RED post terminal on shunt.
2. Attach BLACK meter test lead to BLACK post terminal on shunt.
3. With the engine running at 2000 RPM, the output should be:

* **4 – 20 Amps**

* Depending upon battery voltage and/or current draw on system.

4. If no or low output is found, be sure that all connections are clean and secure.
5. If all connections are OK, replace or repair the alternator.

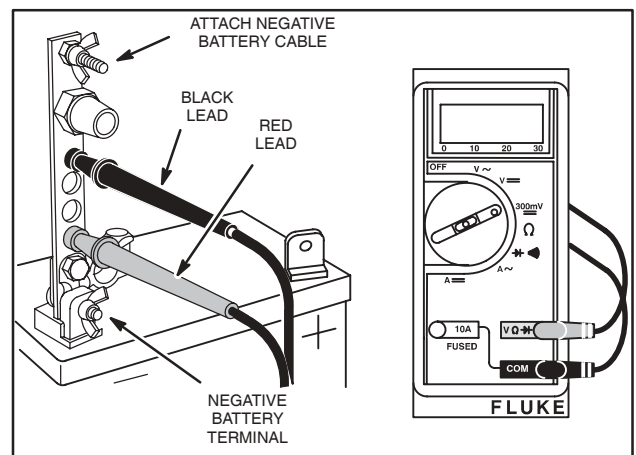


Fig. 21 – DC Shunt Installation

DISASSEMBLE ALTERNATOR

1. Remove pulley nut using tool #19491 and 10 mm deep socket as shown in Fig. 22.
 - a. Remove pulley and spacer.
 Replace pulley if damaged or worn.

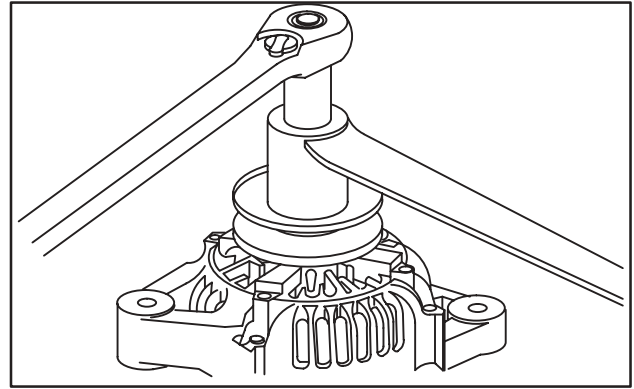


Fig. 22 – Remove Pulley

2. Remove nut and insulator at “B” terminal.
3. Remove three screws and brush cover, Fig. 23.

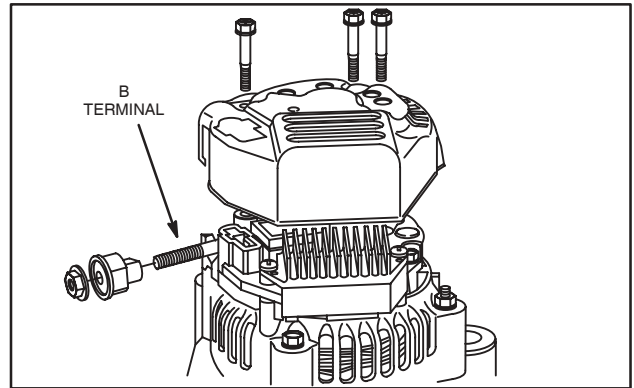


Fig. 23 – Remove Rear Cover

4. Remove two screws, then brush retainer assembly, Fig. 24.

Important: Length of brush retainer screws are different. Do not mix.
 Screw “A”: 11.5 mm
 Screw “B”: 9.0 mm

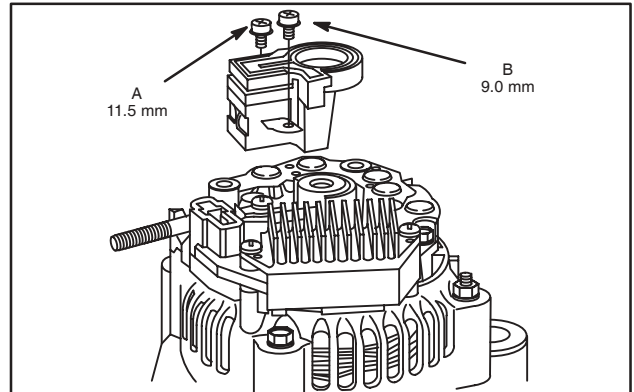


Fig. 24 – Remove Brush Retainer

5. Remove three screws and regulator, Fig. 25.

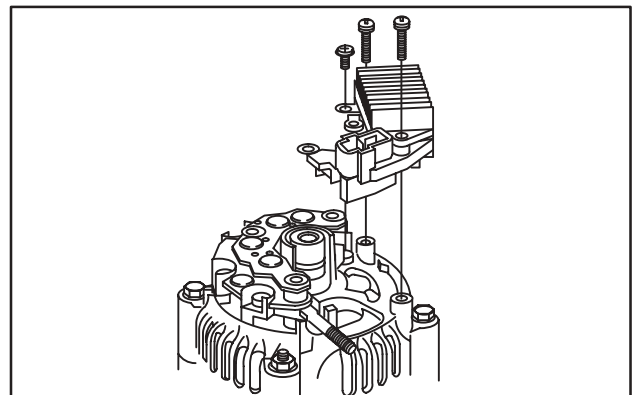


Fig. 25 – Remove Regulator

CHARGING SYSTEMS

6. Remove four stator lead screws from rectifier, Fig. 26.
 - a. Carefully straighten stator leads.
 - b. Remove rectifier.

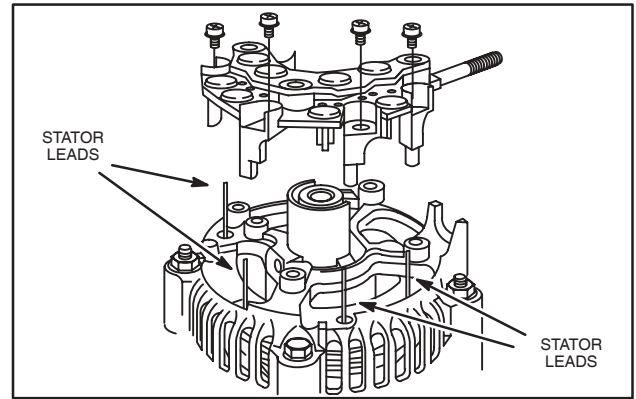


Fig. 26 – Remove Rectifier

7. Scribe or place a reference mark on drive end and brush end housing so that they may be re-assembled in original position.
8. Remove two nuts and two thru bolts.
9. Remove brush end housing being careful not to damage stator leads, Fig. 27.

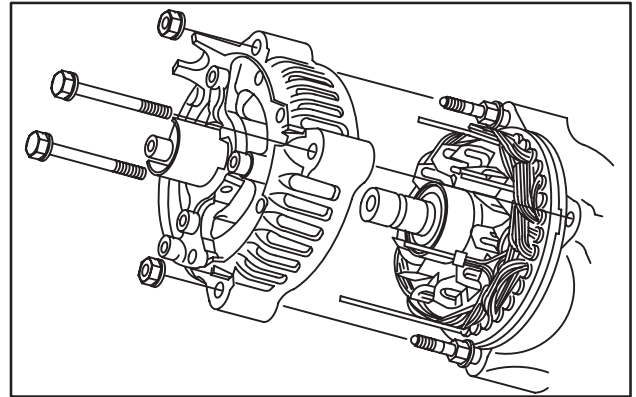


Fig. 27 – Remove Brush End Housing

10. Remove rotor from drive end housing, Fig. 28.
Note: Stator is NOT removable.

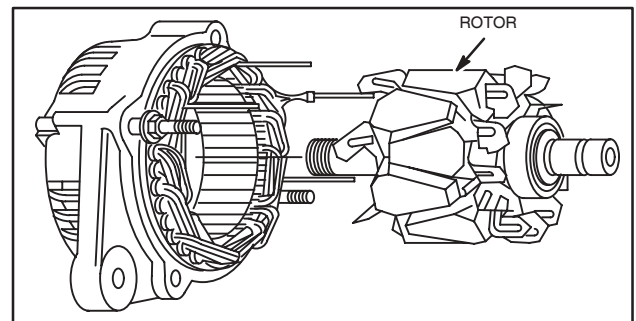


Fig. 28 – Remove Rotor

11

CHECKING BEARINGS

Ball bearings must rotate freely. If any rough spots are felt the ball bearing must be replaced.

Note: Rotor and ball bearing are an assembly. If bearing is worn, replace rotor assembly.

Remove Ball Bearing

1. Remove four screws and bearing retainer, Fig. 29.
2. Support drive housing on blocks.
3. Press out bearing from pulley side of drive end housing using driver #19416.

DO NOT re-use ball bearings that have been removed from drive end housing. The bearing races are usually damaged during removal.

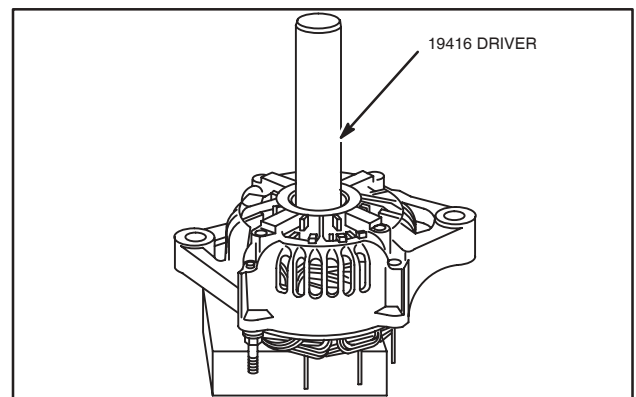


Fig. 29 – Remove Bearing Retainer

INSTALL BALL BEARING

1. Lightly lubricate bearing O.D. with engine oil.
2. Press in new bearing using bearing driver #19226, Fig. 30.
3. Install retainer and four screws.

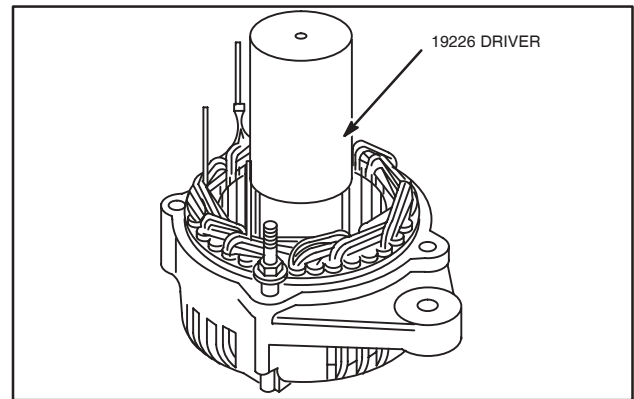



Fig. 30 – Install Ball Bearing

CHECKING ROTOR

The following test will be made with the meter in the “Diode Test Position” \rightarrow .

1. Use digital multimeter and check for continuity between slip rings as shown, Fig. 31.
 - a. Meter should make continuous tone (continuity).
 - b. If meter displays “OL”, (no continuity) replace rotor.
2. Check for continuity between slip ring and rotor shaft.
 - a. Meter should display “OL”, (no continuity).
3. Measure slip ring diameter, Fig. 32.

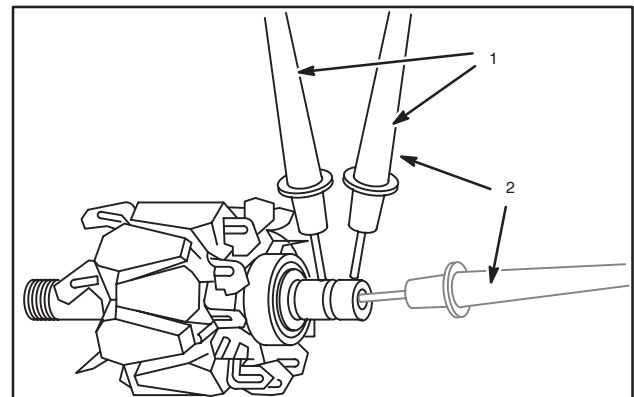


Fig. 31 – Check Rotor

STD: 14.4 mm (.567”)
Reject: 14.0 mm (.551”)

Slip rings may be cleaned with fine sandpaper (#300 – 500 grit).

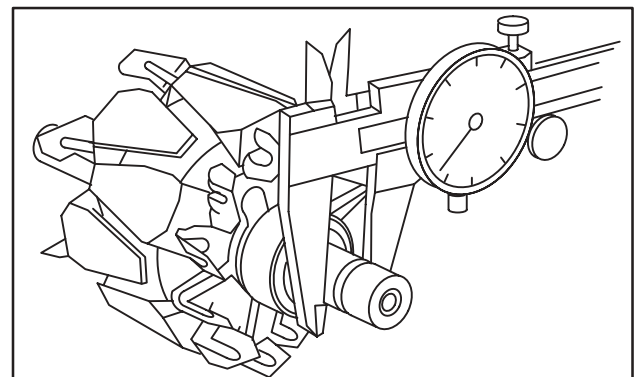


Fig. 32 – Check Slip Ring

CHECK BRUSHES

Measure length of brushes protruding from brush holder, Fig. 33.

STD: 10.5 mm (.413”)
Reject: 8.0 mm (.315”)

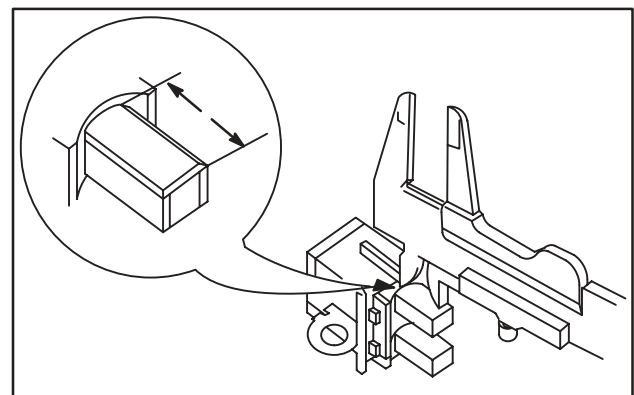


Fig. 33 – Check Brushes

CHARGING SYSTEMS

CHECK REGULATOR

The following test will be made with the meter in the “Diode Test Position” $\rightarrow + \text{|||||}$.

1. Attach BLACK meter test lead to terminal “A” as shown, Fig. 34.
2. Contact terminal “B” with RED meter test lead, Fig. 34.
 - a. Meter should “beep” once.
 - b. If meter displays “OL” or makes a continuous tone, regulator is defective. Replace regulator.

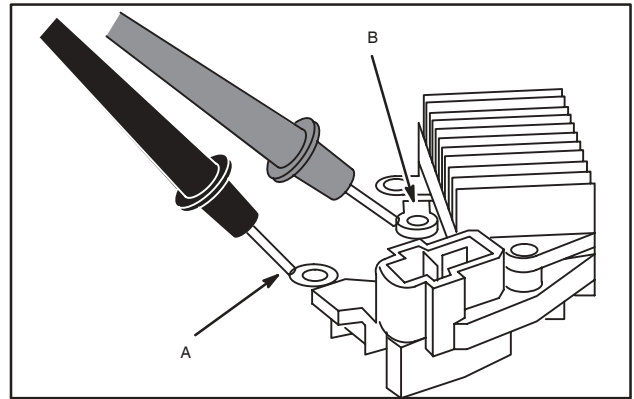


Fig. 34 – Check Regulator

CHECK RECTIFIER

The following test will be made with the meter in the “Diode Test Position” $\rightarrow + \text{|||||}$.

1. Attach BLACK meter test lead to “B” terminal, Fig. 35. Leave attached through Step 3.
2. Contact #1 terminal with RED meter test lead, Fig. 35.
 - a. Meter should “beep” once.
 - b. If meter displays “OL” or makes a continuous tone, diode is defective. Replace rectifier.
3. Repeat test at #2, #3 and #4 terminals.
 - a. Results must be the same.
4. Attach RED test lead to one of the three rectifier mounting holes, Fig. 36. Leave attached through Step 6.
5. Contact #1 terminal with BLACK meter test lead, Fig. 36.
 - a. Meter should “beep” once.
 - b. If meter displays “OL” or makes a continuous tone, diode is defective. Replace rectifier.
6. Repeat test at #2, #3 and #4 terminals.
 - a. Results must be the same.

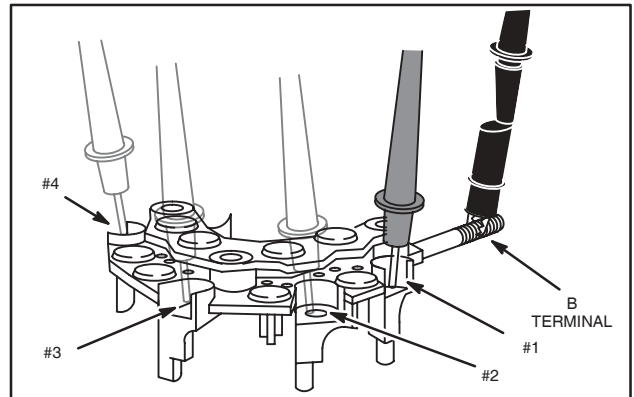


Fig. 35 – Check Rectifier

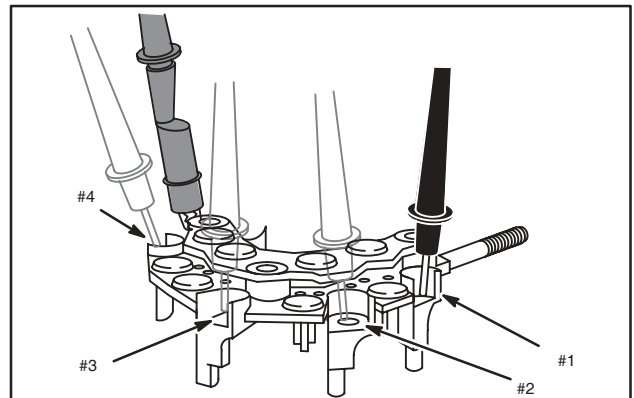


Fig. 36 – Check Rectifier

ASSEMBLE ALTERNATOR

1. Assemble rotor to drive end housing, Fig. 37.
2. Assemble spacer, pulley and nut to rotor shaft.
 - a. Do not tighten nut at this time.
 - b. Place pulley side down on work surface.

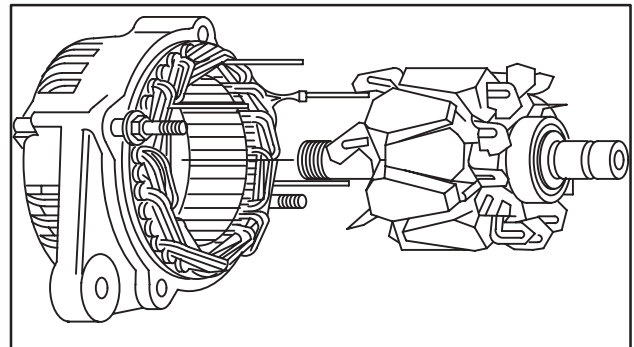


Fig. 37 – Installing Rotor

3. Assemble brush end housing to drive end housing with reference marks aligned, Fig. 38.

Note: Do not damage stator leads.

4. Install thru bolts and nuts.
 - a. Torque to 5.0 Nm (45 in. lbs.).

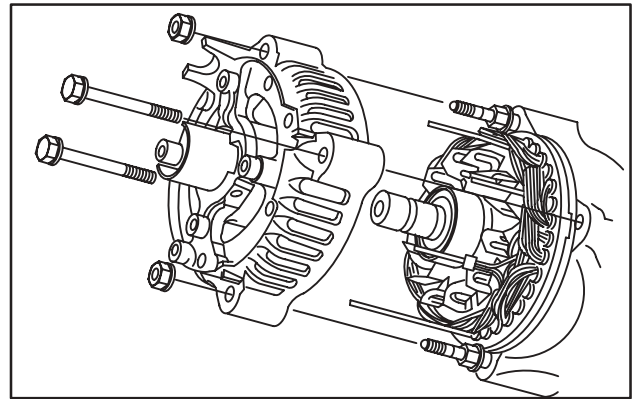


Fig. 38 – Assemble Housings

5. Align stator wires with holes in rectifier and assemble rectifier to brush end housing, Fig. 39.
6. Carefully form a “U” bend in stator wires.
 - a. Install screws and tighten securely.

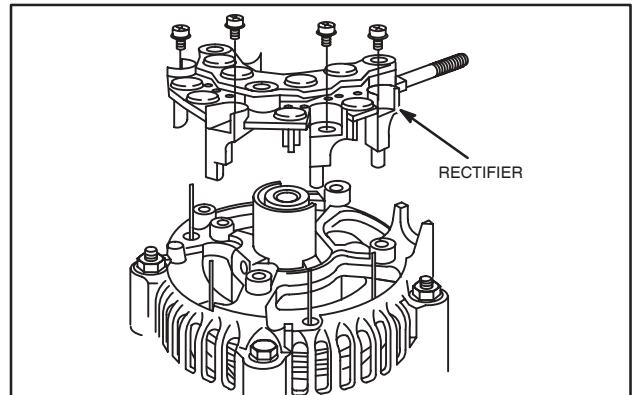


Fig. 39 – Install Rectifier

7. Install regulator with three screws shown, Fig. 40.

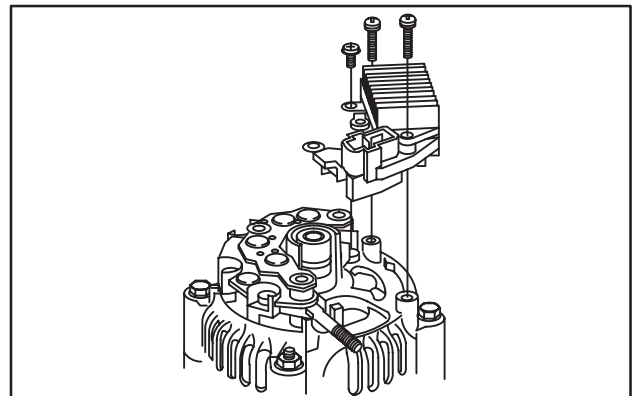


Fig. 40 – Install Regulator

8. Assemble cover to brush holder, Fig. 41.

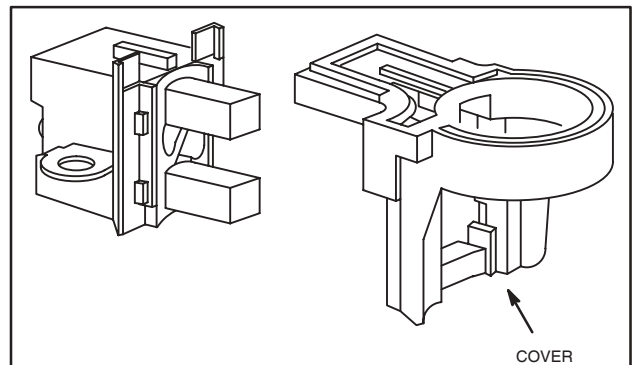


Fig. 41 – Install Brush Cover

CHARGING SYSTEMS

9. Install brush holder.

Important: Length of brush retainer screws are different. Install as shown, Fig. 42.

Screw "A": 11.5 mm

Screw "B": 9.0 mm

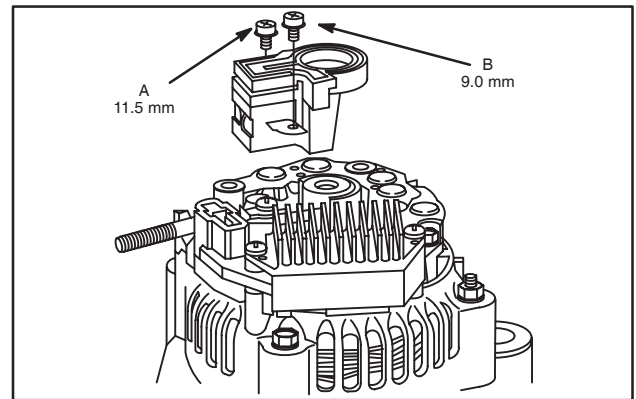


Fig. 42 – Install Brush Holder

10. Install rear cover and three screws, Fig. 43.

a. Torque screws to 3.0 Nm (25 in. lbs.).

11. Install insulator and nut.

a. Torque nut to 4.0 Nm (35 in. lbs.).

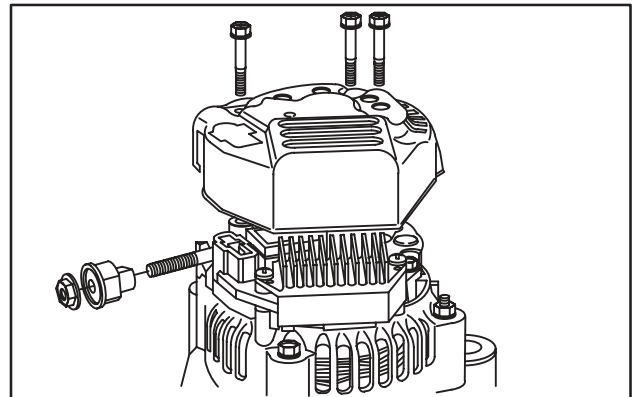


Fig. 43 – Install Cover

Torque drive pulley using the following procedure, Fig. 44.

1. Hold nut with tool #19491.

2. With torque wrench, turn 10 mm deep socket COUNTERCLOCKWISE.

a. Torque to 70.0 Nm (50 ft. lbs.).

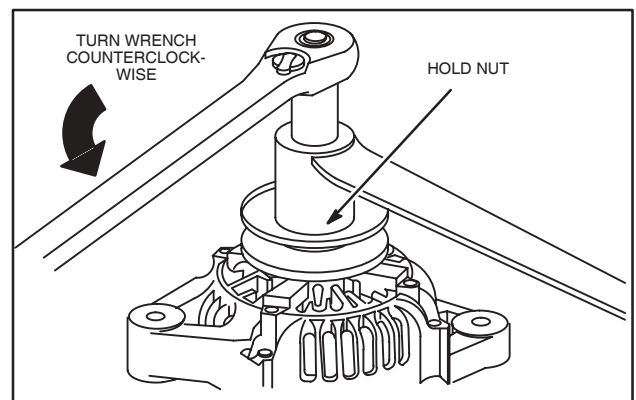


Fig. 44 – Torque Pulley

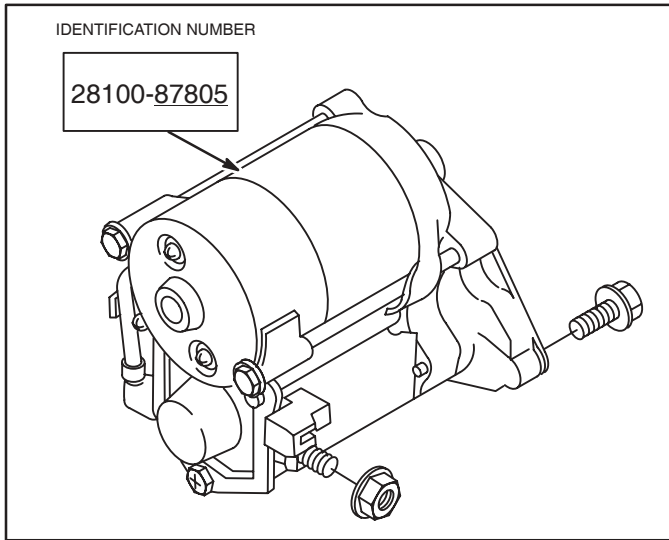


Fig. 45 – 1.0 Kw (Standard)

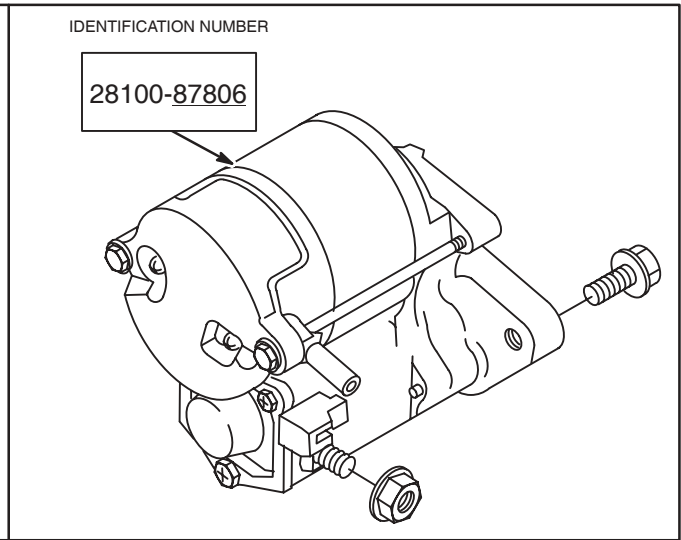


Fig. 46 – 1.2 Kw (Optional)

STARTER SYSTEM – GENERAL INFORMATION

Two different starter motors are used on Briggs & Stratton Daihatsu diesel engines. The standard motor is rated at 1.0 Kw., Fig. 45. The optional starter is rated at 1.2 Kw., Fig. 46. The starters are identified by their identification numbers. The starters are similar enough that service procedures and specifications are the same. Where differences occur, they will be shown.

STARTER CURRENT DRAW TEST – ALL (Starter Installed)

Important: When making the starter current draw test make sure that all parasitic load is removed from the engine and that engine has the correct viscosity oil.

Test Equipment

The following equipment is required to test current draw of starter, Fig. 47.

1. Digital multimeter, Tool #19464.
2. DC shunt, Tool #19468.
3. Two battery cables with alligator clips.
4. One jumper wire with alligator clips.
5. A fully charged 12 volt battery.

Engine temperature should be at least 21° C (70° F). Make sure battery and solenoid connections are clean and tight.

NOTE: Battery voltage must not be below 11.7 volts.

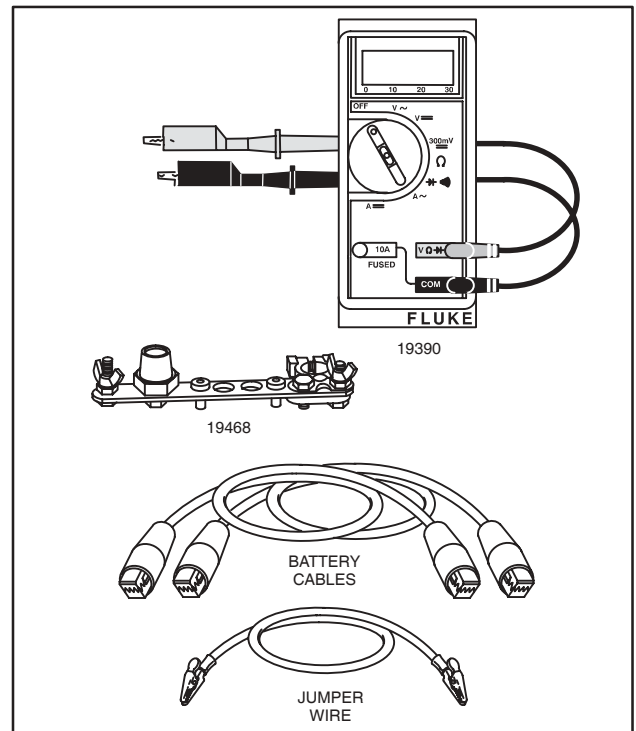


Fig. 47 – Test Equipment

STARTER SYSTEM

Testing Starter – All

NOTE: To prevent engine from starting, remove fuel shut off solenoid wire from injector pump.

The starter current draw test will be performed with the meter in the **300mV** DC position.

The DC Shunt **must** be installed on the **negative** (-) terminal of the battery, Fig. 48.

1. Attach RED meter test lead to RED post terminal on shunt.
2. Attach BLACK meter test lead to BLACK post terminal on shunt.
3. Activate starter.
 - a. Allow 3 seconds for meter reading to stabilize.
4. **Current draw should not exceed 140 amps DC.**

If amperage draw exceeds specification, remove starter from engine and perform No Load starter current draw test.

STARTER CURRENT DRAW TEST – NO LOAD

Remove starter motor.

To hold starter securely while testing, clamp starter mounting bracket in a vise. DO NOT clamp starter housing in a vise or field windings or magnets may be damaged.

Testing Starter (No Load)

The No Load starter current draw test will be performed with the meter in the **300mV** DC position.

The DC Shunt **must** be installed on the **negative** (-) terminal of the battery, Fig. 49.

1. Attach RED meter test lead to RED post terminal on shunt.
2. Attach BLACK meter test lead to BLACK post terminal on shunt.
3. Attach negative battery cable to a good ground such as drive housing.
4. Attach positive battery cable to battery terminal on solenoid.
5. Attach one end of jumper wire to solenoid tab terminal, Fig. 49.
6. Activate starter by contacting positive battery terminal with other end of jumper wire, Fig. 49.
 - a. Allow 3 seconds for meter reading to stabilize.
7. **Current draw should not exceed 90 amps DC.**

If amperage draw exceeds specification, replace starter.

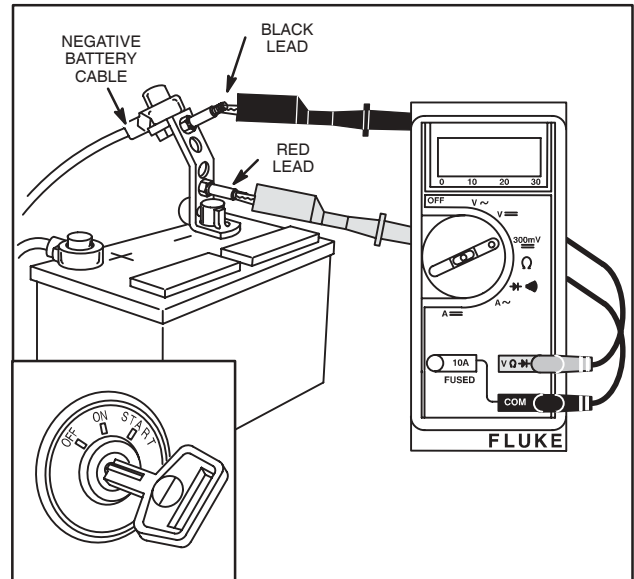


Fig. 48 – Starter Current Draw Test

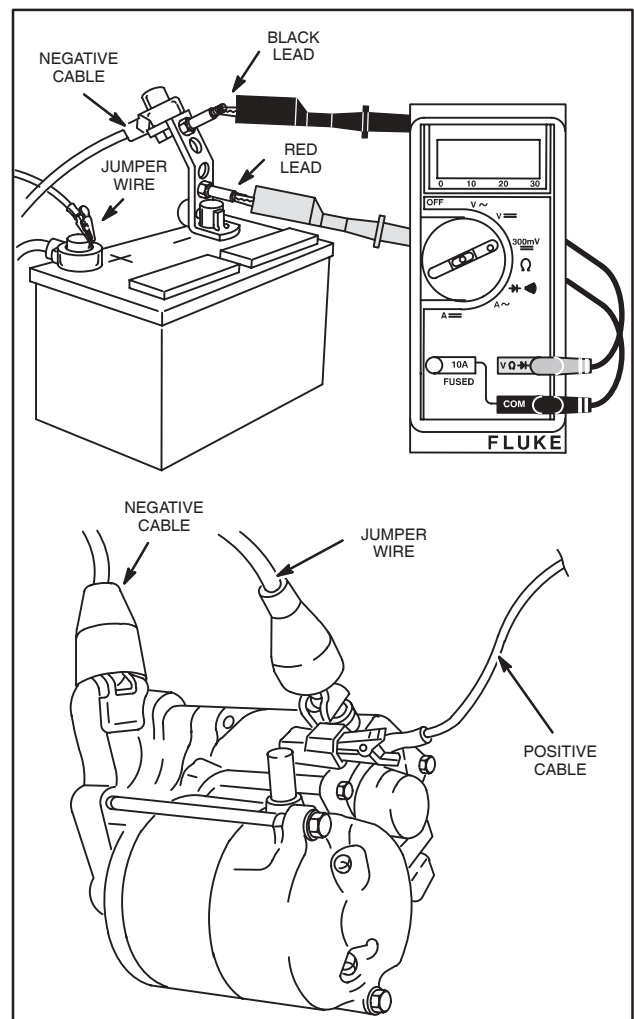


Fig. 49 – No Load Starter Current Draw Test

STARTER SOLENOID

Test Equipment

The starter solenoid test is performed with the starter removed from the engine.

The following equipment is recommended to test the solenoid.

1. One battery cable with alligator clips. Fig. 50.
2. A jumper wire.
3. A fully charged 12 volt battery.

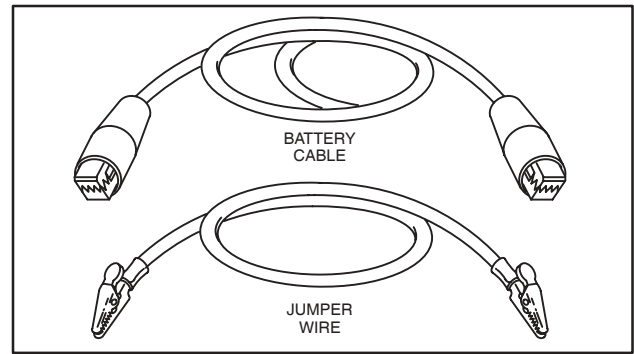


Fig. 50 – Test Equipment

Testing Starter Solenoid

1. Attach one end of battery cable to negative battery terminal and other end of cable to a good ground such as drive housing. Fig. 51.
2. Attach jumper wire to tab terminal on solenoid.
3. Activate solenoid by contacting positive battery terminal with other end of jumper wire.
 - a. Pinion must move outward quickly (engage).
4. Remove jumper wire from positive battery terminal.
 - a. Pinion must return quickly (disengage).

If pinion does not move, replace the solenoid.

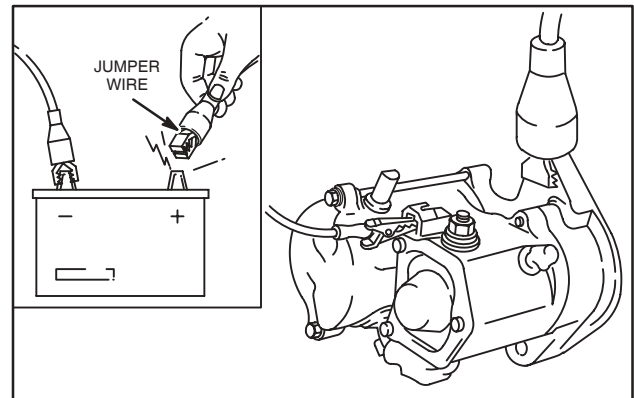
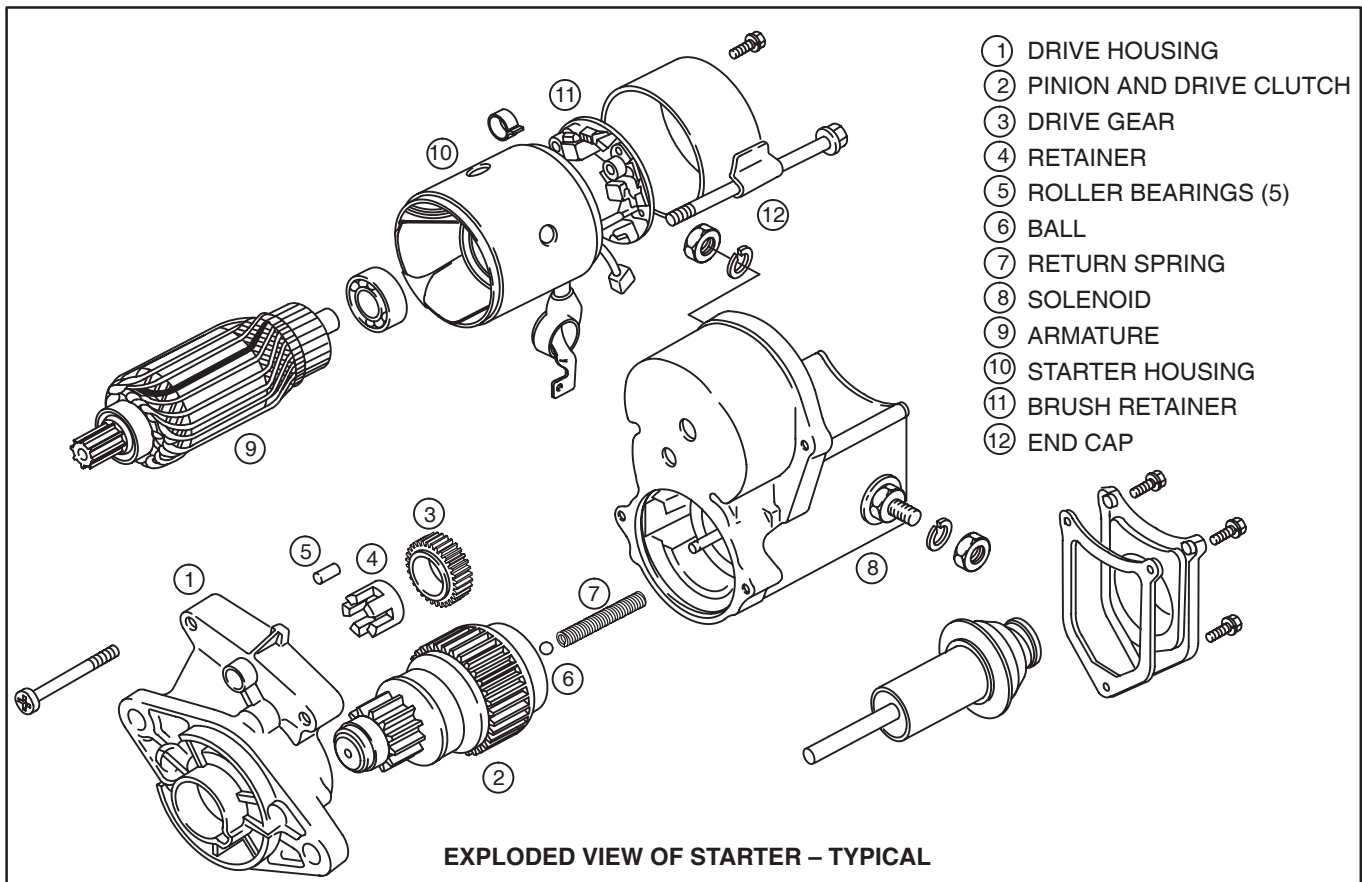


Fig. 51 – Testing Solenoid



EXPLODED VIEW OF STARTER – TYPICAL

STARTER SYSTEM

Remove Solenoid

1. Remove nut and field coil wire from stud terminal on solenoid, Fig. 52.

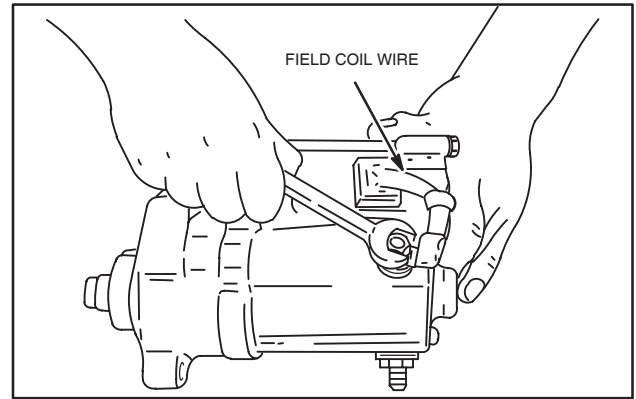


Fig. 52 – Removing Field Coil Wire

2. Remove through bolts and starter motor, Fig. 53.
DO NOT remove armature from starter housing or it will be necessary to re-assemble brushes to armature.

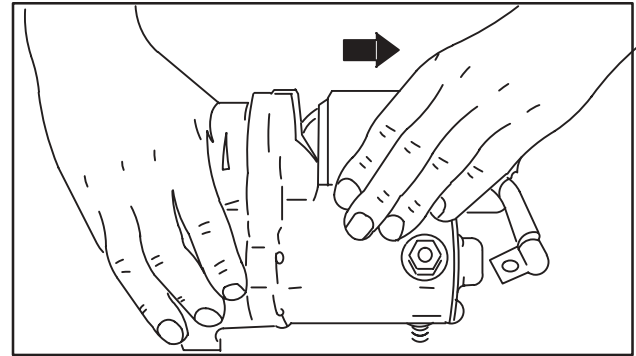


Fig. 53 – Removing Starter Motor

3. Remove two drive end cap screws. Hold starter in vertical position with drive housing down and separate solenoid housing from drive housing, Fig. 54. Note position of solenoid return spring and ball.

NOTE: The solenoid must be replaced as an assembly.

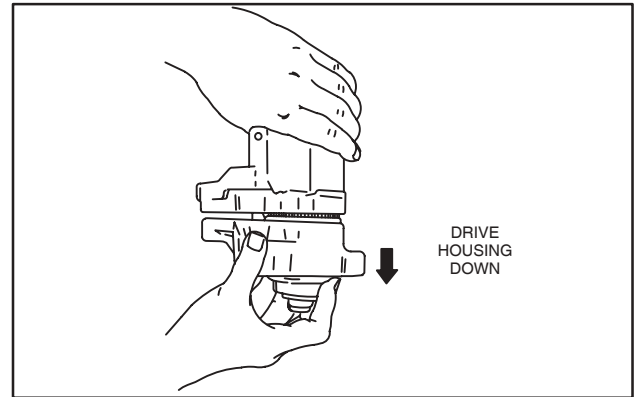


Fig. 54 – Removing Solenoid

Remove Pinion And Clutch Assembly

1. Remove drive gear from bearing. Remove bearing retainer and five roller bearings, Fig. 55.
2. Remove pinion and clutch assembly from drive housing.

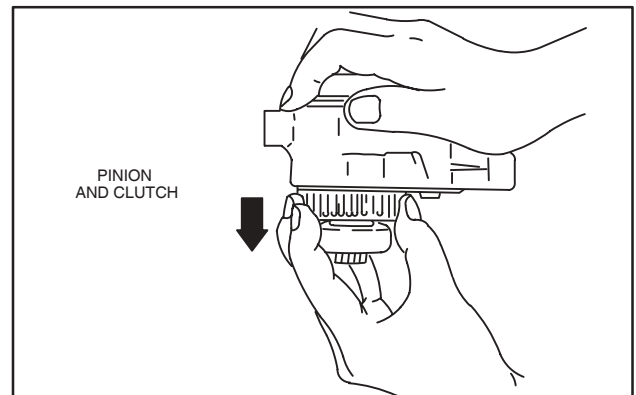


Fig. 55 – Removing Pinion And Clutch

Check Pinion And Clutch Assembly

Check pinion and gear for damage, Fig. 56. Pinion and shaft must rotate in clutch in clockwise direction only. Bearings must turn freely.

NOTE: The pinion and clutch must be replaced as an assembly.

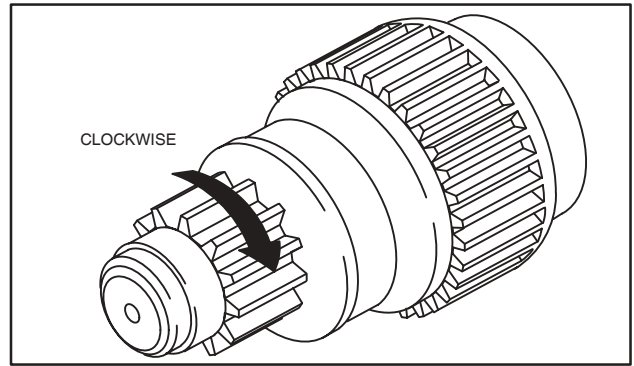


Fig. 56 – Checking Pinion And Clutch

Assemble Pinion And Clutch Assembly

1. Lubricate the following components with silicone grease before assembly, Fig. 57.

NOTE: See insert for correct assembly for type starter.

- a. Clutch gear.
- b. Bearing retainer and roller bearings.
- c. Drive gear.
- d. Pinion shaft bearings.
- e. Return spring ball.
- f. Return spring.

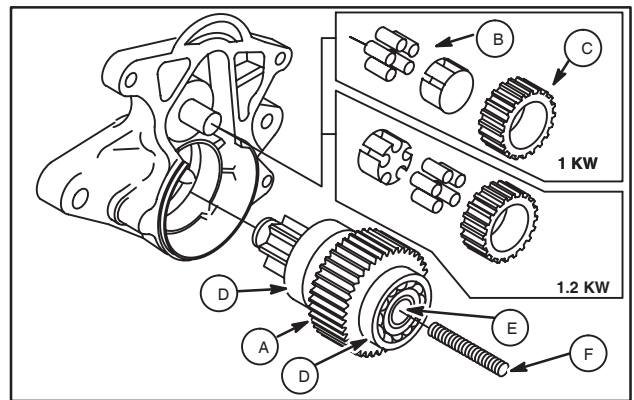


Fig. 57 – Assembling Pinion And Clutch

2. Assemble roller bearings and retainer to drive gear shaft, Fig. 58.

NOTE: Roller bearings must face drive housing. Retainer must face solenoid housing.

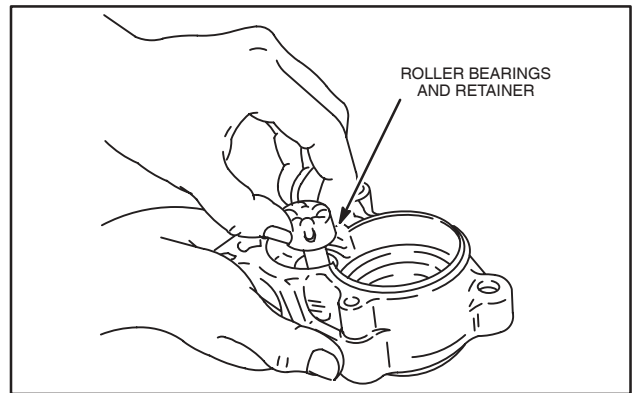


Fig. 58 – Assembling Roller Bearings

3. Mesh drive gear with clutch gear. Install pinion and clutch assembly and drive gear into drive housing together, Fig. 59. Install return spring ball in clutch.

Make sure roller bearings remain in position.

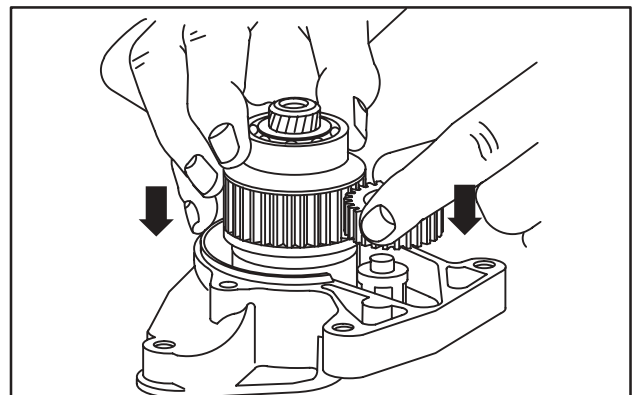


Fig. 59 – Assembling Drive Housing

STARTER SYSTEM

Install Solenoid

1. Insert return spring into solenoid plunger.
2. Align pilot hole in solenoid with drive gear shaft and assemble solenoid to drive housing, Fig. 60.
 - a. Torque screws to 9.0 Nm (80 in. lbs.).

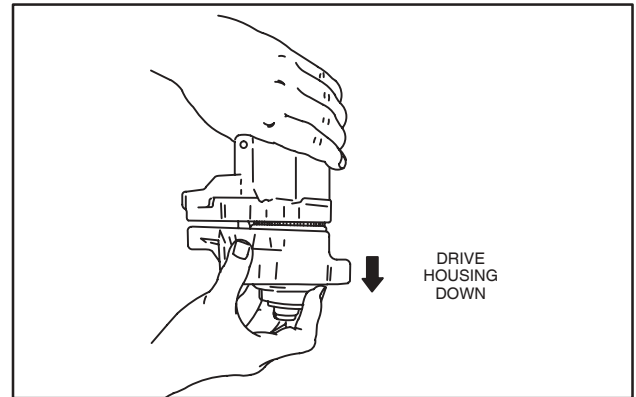


Fig. 60 – Installing Solenoid

3. Assemble starter motor to drive housing. Align tab on starter with notch in drive housing, Fig. 61.
 - a. Torque screws to 9.0 Nm (80 in. lbs.).
4. Install field coil wire.
 - a. Torque nut to 8 Nm (70 in. lbs.).

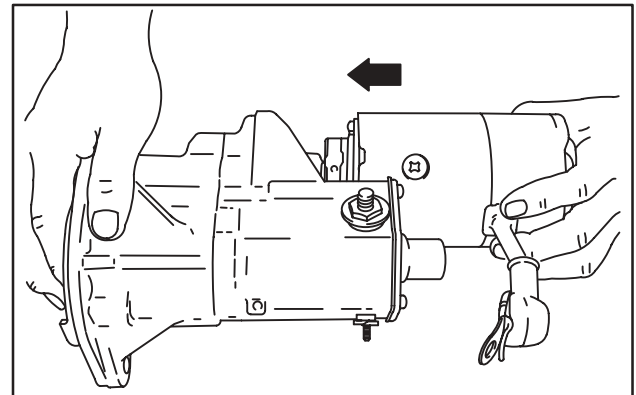


Fig. 61 – Installing Starter Motor

Replace Solenoid Plunger And Contacts

Place starter in a vise with cover plate up.

1. Remove three screws and cover plate.
 - a. Discard gasket.
2. Remove plunger and spring.

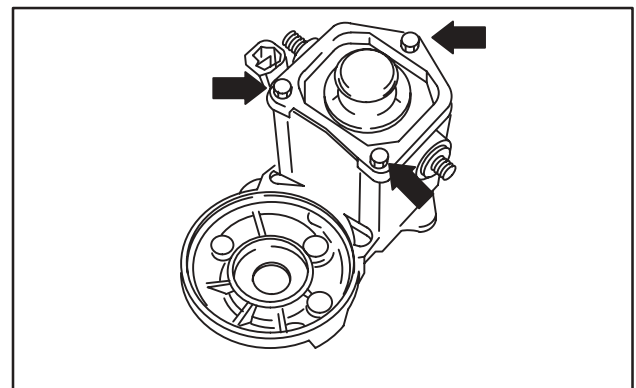


Fig. 62 – Remove Plunger

3. Replace contacts if burned or worn.
Note: Contacts and plunger must be replaced as an assembly.
4. Measure thickness of contact plates with calipers.

Reject Dimension: 0.9 mm (0.035").

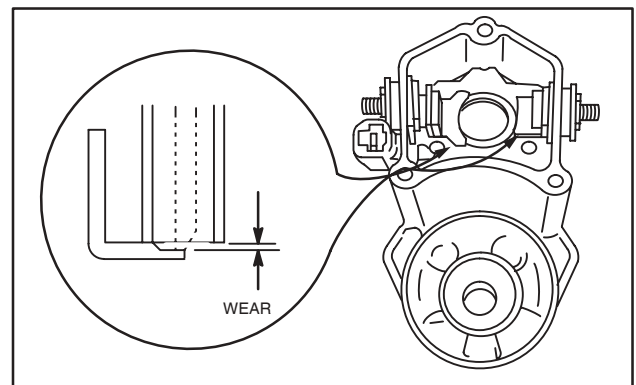


Fig. 63 – Checking Contacts

5. Remove two nuts with 14 mm wrench, Fig. 64.
6. Remove components in sequence shown, Fig. 65.

Field Wire Terminal Side:

- (1) G
- (2) F
- (3) E
- (4) D
- (5) C
- (6) B
- (7) A

Battery Wire Terminal Side:

Before 99010100: 1.0 KW / After 98123100: 1.0 KW
 Before 98083100: 1.2 KW / After 98090100: 1.2 KW

- | | |
|-------|-------|
| (1) N | (1) N |
| (2) M | (2) M |
| (3) L | (3) P |
| (4) K | (4) O |
| (5) J | (5) K |
| (6) I | (6) J |
| (7) H | (7) I |
| | (8) H |

7. Install components in sequence shown, Fig. 65.

Field Wire Terminal Side:

- (1) A
- (2) B
- (3) C
- (4) D
- (5) E
- (6) F
- (7) G

Battery Wire Terminal Side:

Before 99010100: 1.0 KW / After 98123100: 1.0 KW
 Before 98083100: 1.2 KW / After 98090100: 1.2 KW

- | | |
|-------|-------|
| (1) H | (1) H |
| (2) I | (2) I |
| (3) J | (3) J |
| (4) K | (4) K |
| (5) L | (5) O |
| (6) M | (6) P |
| (7) N | (7) M |
| | (8) N |

8. Do not tighten terminal nuts at this time.

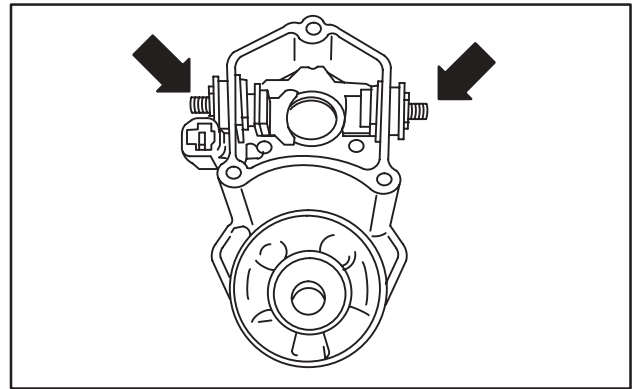


Fig. 64 – Loosen Nuts

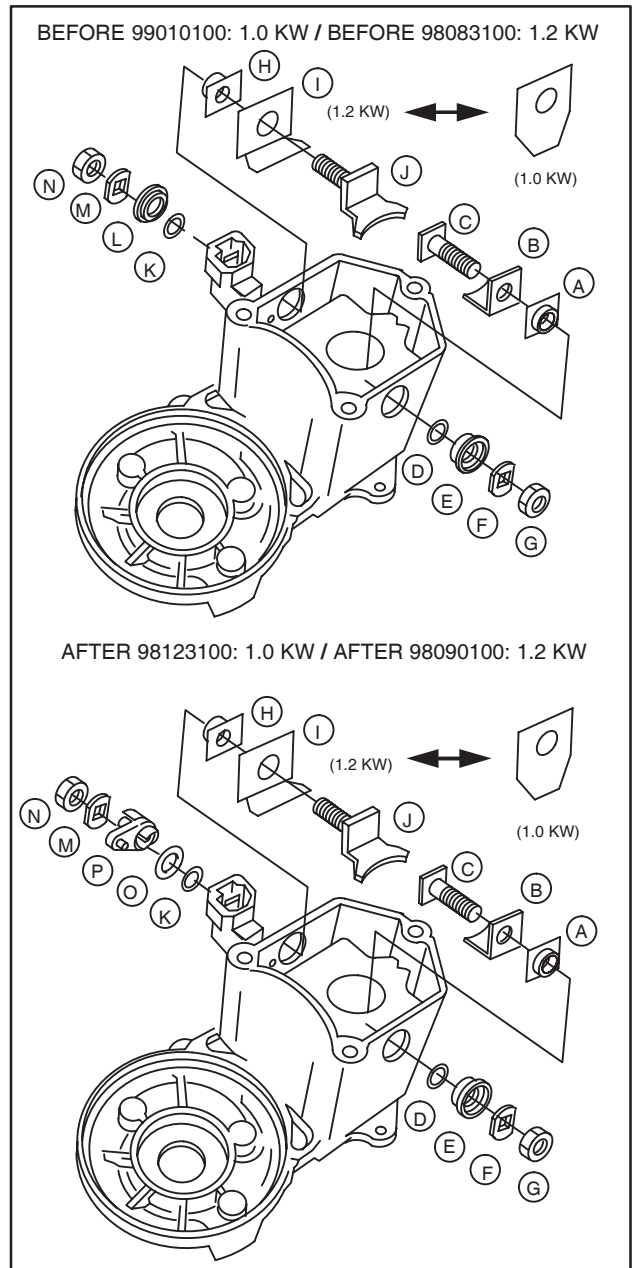


Fig. 65 – Contact Assemblies

STARTER SYSTEM

9. Install new plunger and spring.
10. Place bearing driver, Tool #19422 on plunger and compress plunger to end of travel. Maintain pressure.
 - a. Torque nuts to 17 Nm (150 in. lbs.).**Note:** This provides proper contact alignment with plunger and contact plates.
11. Clean contact plates and plunger contacts.
12. Install cover plate with new gasket.
 - a. Torque screws to 4 Nm (35 in. lbs.).

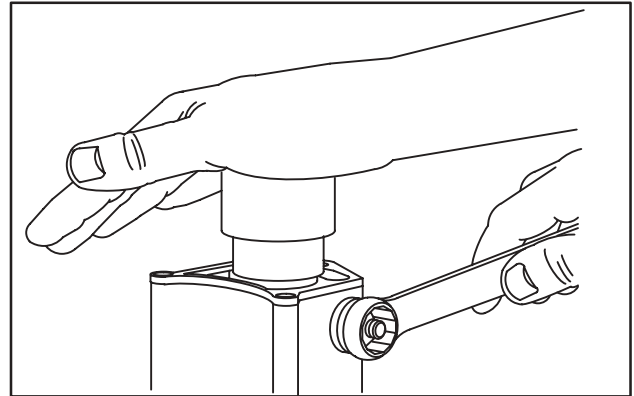


Fig. 66 – Aligning Contact Plates

DISASSEMBLE STARTER MOTOR

1. Remove starter motor from drive housing.
2. Remove screws and end cap.
3. Remove armature from motor housing, Fig. 67.

If armature drive splines or armature bearings are damaged or worn, replace armature.

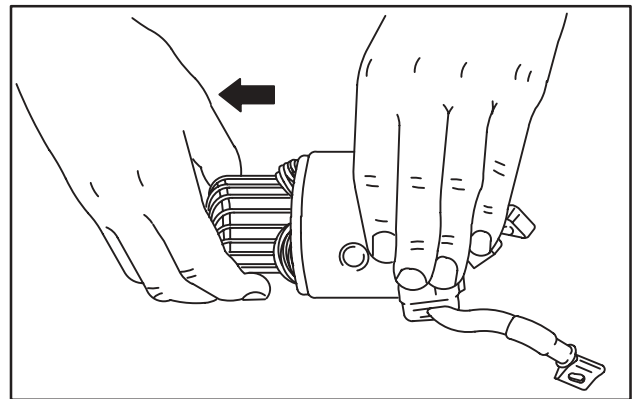


Fig. 67 – Disassemble Starter Motor

Inspect Armature Commutator

The armature commutator may be cleaned with fine sandpaper. DO NOT use emery cloth. Commutator may be machined to no less than 29.0 mm (1.142”), Fig. 68.

NOTE: Minimum depth of slots between commutator bars after machining is 0.2 mm (.008”).

The armature should be checked for shorts with a growler.

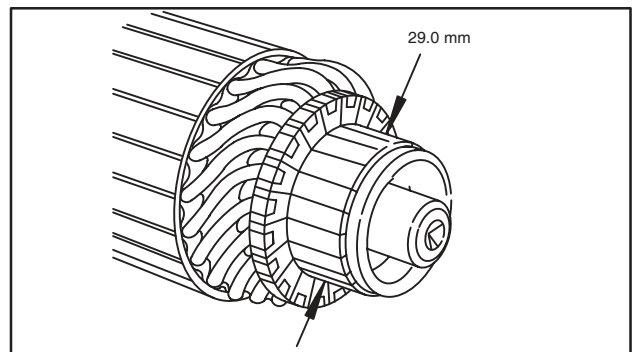


Fig. 68 – Commutator Specifications

Inspect Brushes

Minimum brush dimension is shown below Fig. 69.

1.0 KW Starter: 9 mm (.350”).

1.2 KW Starter: 10 mm (.400”).

If brushes are worn less than specification, replace as follows.

1.0 KW Starter: Replace brush retainer and brushes on starter housing.

1.2 KW Starter: Starter housing and brush retainer must be replaced as an assembly.

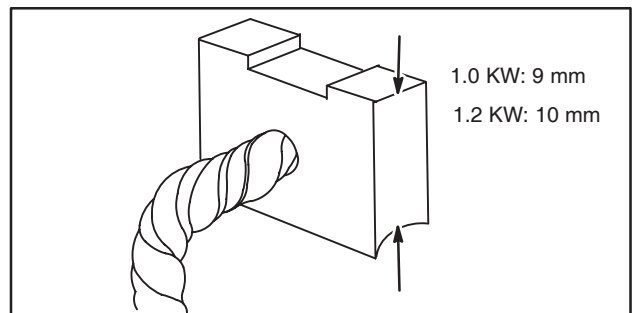


Fig. 69 – Minimum Brush Dimension

Use digital multimeter and check for continuity between field coil wire and brushes shown, Fig. 70.

The following test will be made with the meter in the "Diode Test Position" $\rightarrow + \text{ (diode symbol)}$.

1. Attach either meter test lead to field coil wire.
2. Contact first one positive brush, then opposite brush with other test lead as shown.
 - a. Meter should make continuous tone (continuity).
 - b. If meter does not make a tone, (no continuity) replace starter housing.

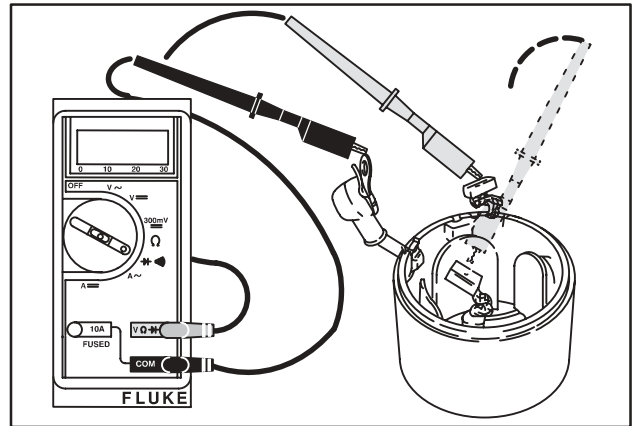


Fig. 70 – Checking Brushes

3. Attach either test lead to brush retainer, Fig. 71.
4. Contact first one negative brush, then opposite brush with other test lead as shown.
 - a. Meter should make continuous tone (continuity).
 - b. If meter does not make a tone, (no continuity) replace brush retainer.

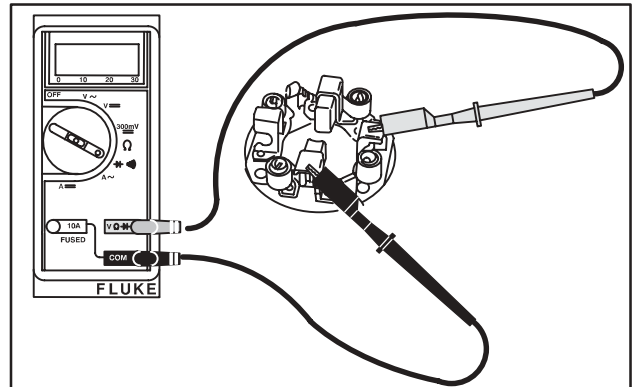


Fig. 71 – Checking Brushes

Replace Brushes – 1.0 KW Starter

1. Cut off brush lead wires at terminals as shown.
2. Use a fine file and carefully remove remaining lead wire from terminals.

L: 2.3 – 2.7 mm (0.090 – 0.106")

W: 6.5 – 7.5 mm (0.255 – 0.295")

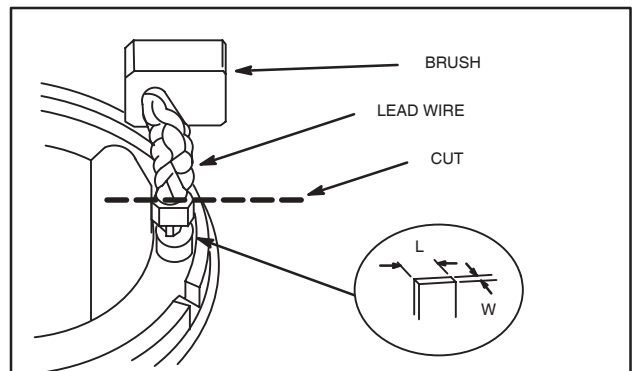


Fig. 72 – Clean Terminals

3. Crimp replacement brushes over terminals so that wires face in counterclockwise direction.
4. Solder brush lead wires to terminals.
5. Insert brushes into brush retainer.

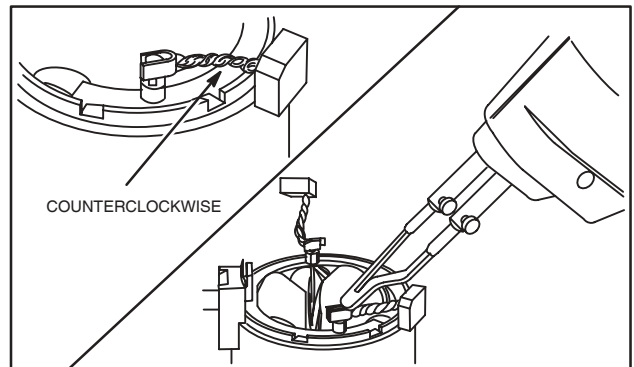


Fig. 73 – Install Brushes

STARTER SYSTEM

ASSEMBLE STARTER MOTOR

For ease of assembly, clamp splined end of armature in a vise as shown. Use soft jaws to prevent damage to spline, Fig. 74.

1. Place green seal protector from Kit #19356 over commutator.

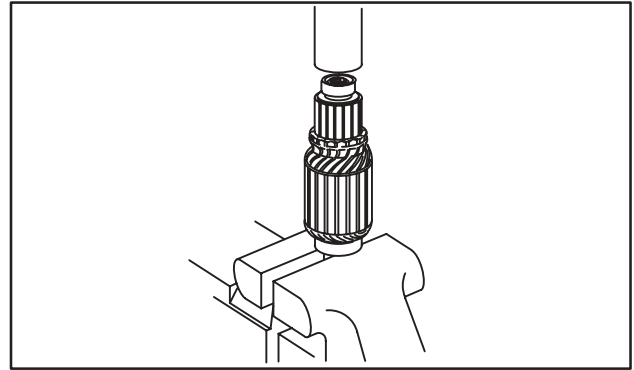


Fig. 74 – Assemble Starter Motor

2. Using seal protector as a guide, slide motor housing with brush retainer into position, Fig. 75. Remove seal protector.
 - a. Make sure brush wires are not grounding on brush retainer.

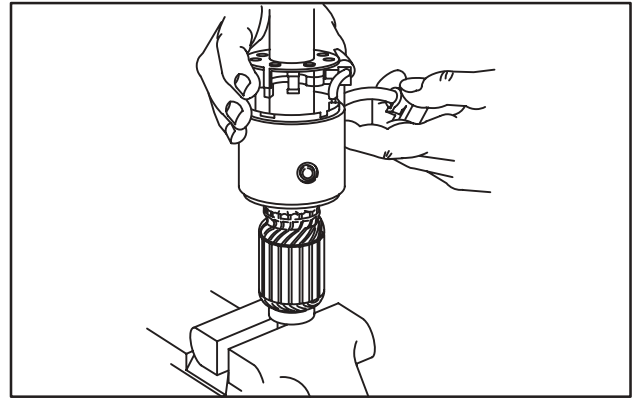


Fig. 75 – Assembling Motor Housing And Brushes

3. Align notch in end cap with rubber seal and install end cap, Fig. 76.
 - a. Make sure brush wires are not grounding on end cap.

Tighten screws securely.

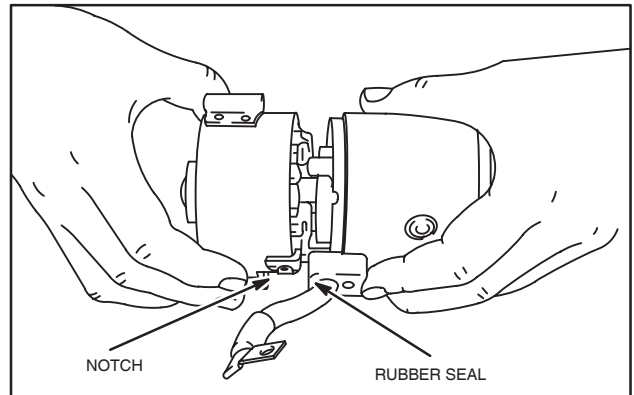


Fig. 76 – Installing End Cap

4. Assemble starter motor to drive housing. Align tab on starter with notch in drive housing, Fig. 77.
 - a. Torque screws to 9.0 Nm (80 in. lbs.).
5. Install field coil wire.
 - a. Torque nut to 9.0 Nm (80 in. lbs.).
6. Install starter
 - a. Torque screws to 34.0 Nm (25 ft. lbs.).

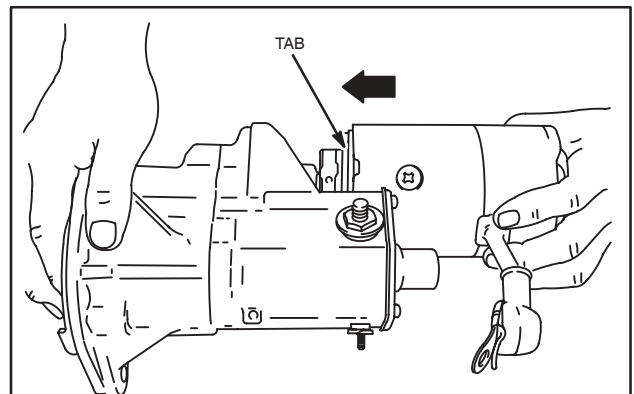


Fig. 77 – Installing Starter Motor

**Wiring Diagram – 14 Amp Alternator (Typical)
493625 Keyswitch With Fixed Preheat Timer and Glow Relay**

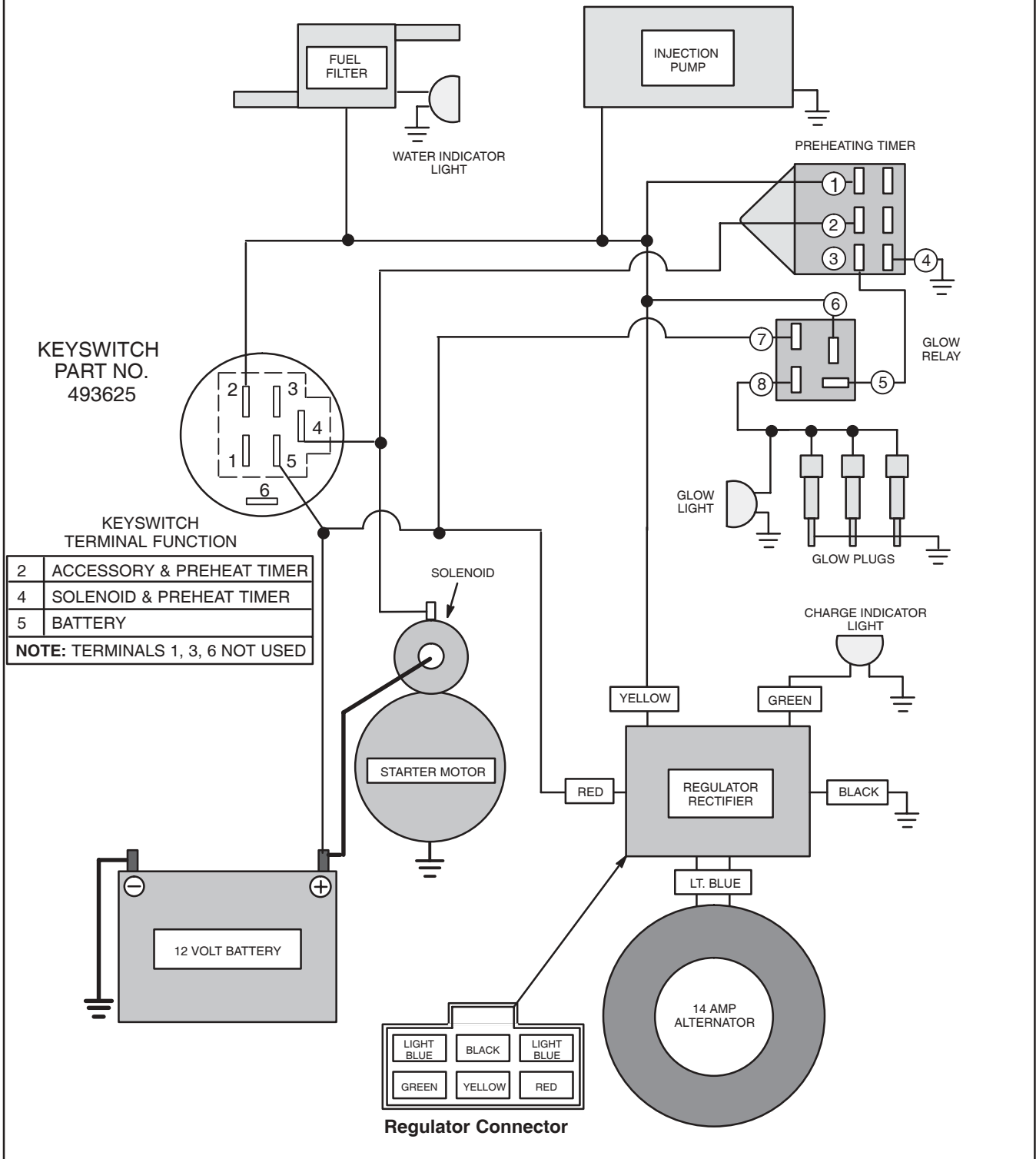


Fig. 78

**Wiring Diagram – 40 Amp Alternator (Typical)
493625 Keyswitch With Fixed Preheat Timer and Glow Relay**

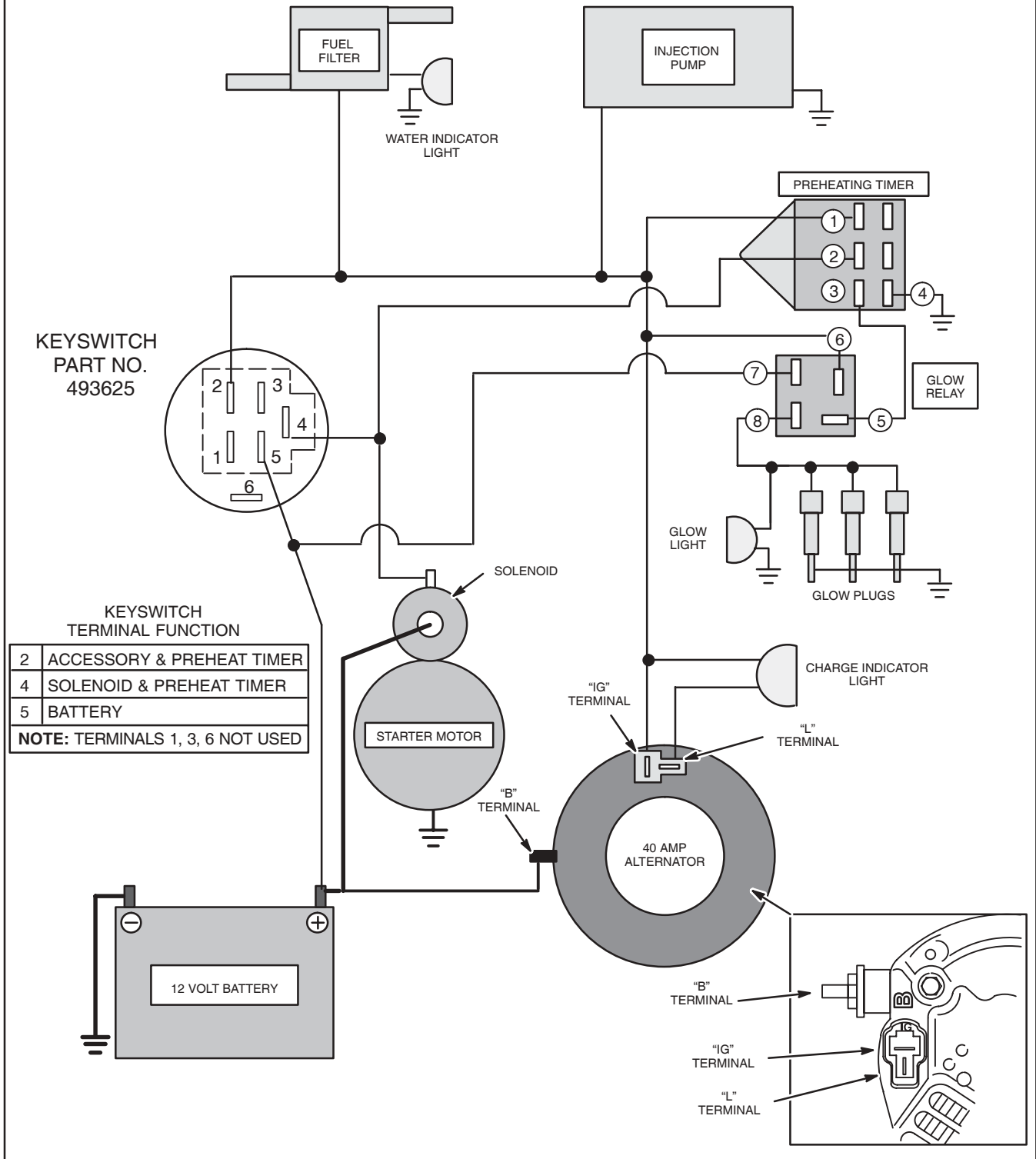


Fig. 79

**Wiring Diagram – 14 Amp Alternator (Typical)
825129 Keyswitch – Manual Preheat**

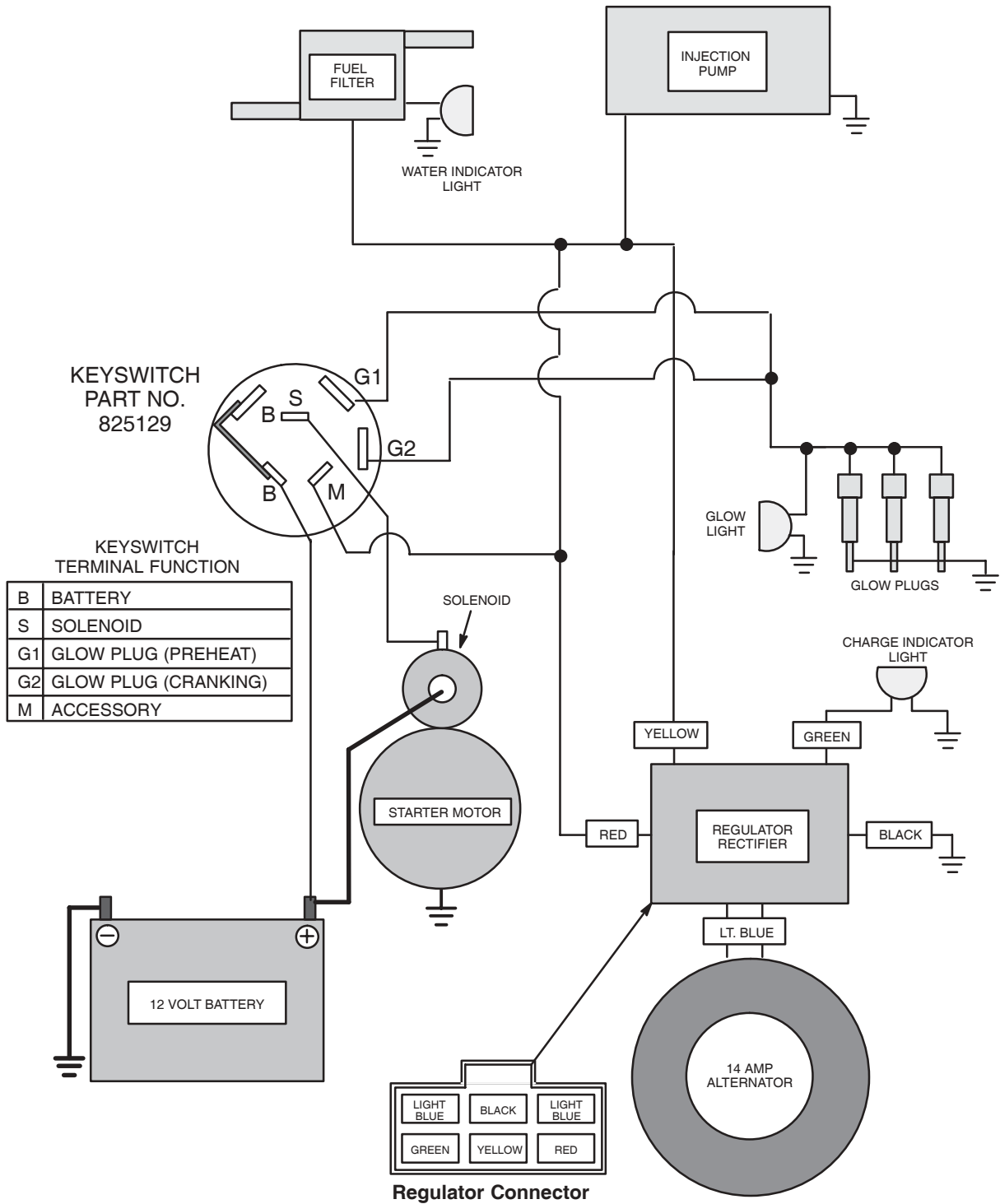


Fig. 80

**Wiring Diagram – 40 Amp Alternator (Typical)
825129 Keyswitch – Manual Preheat**

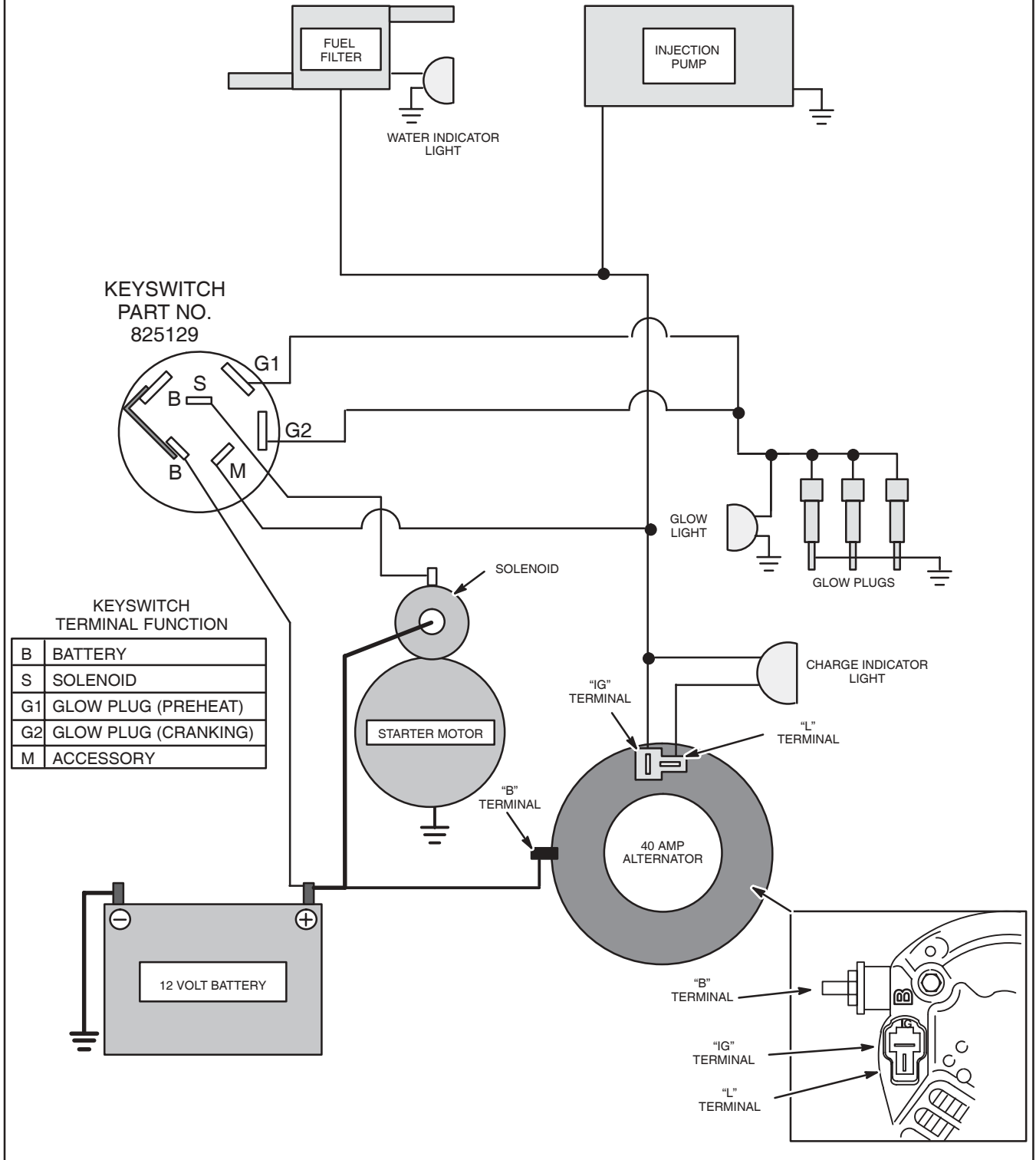
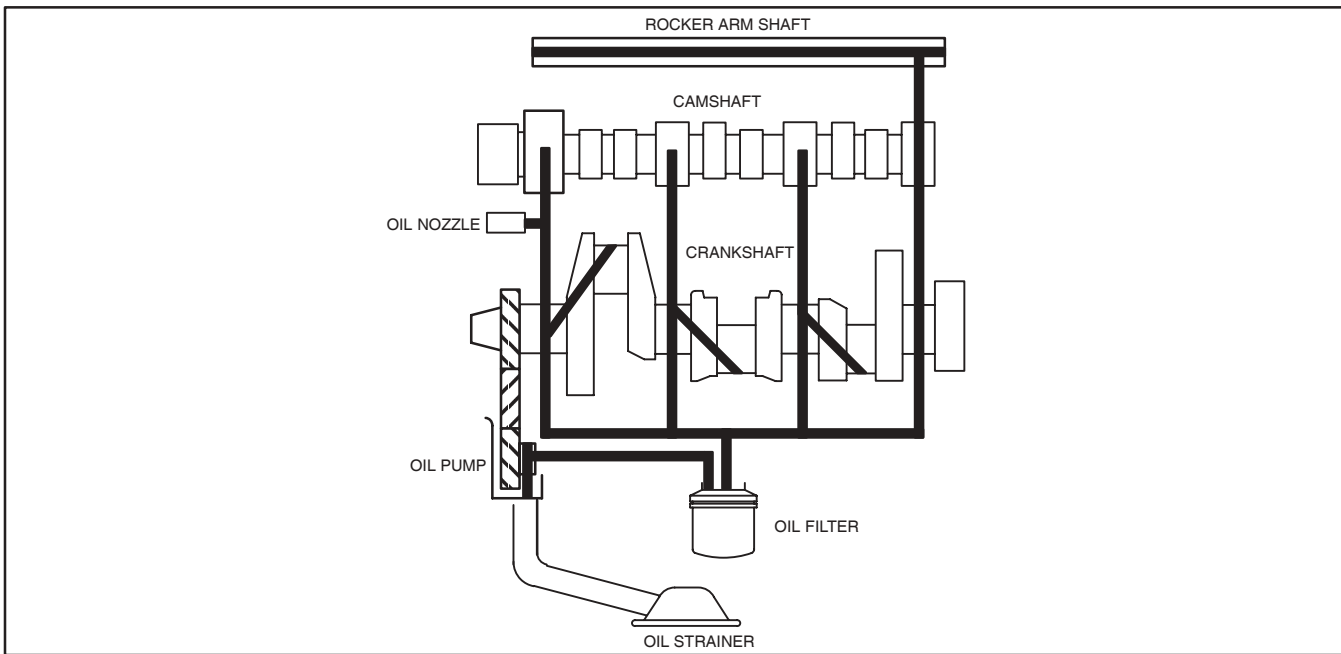


Fig. 81

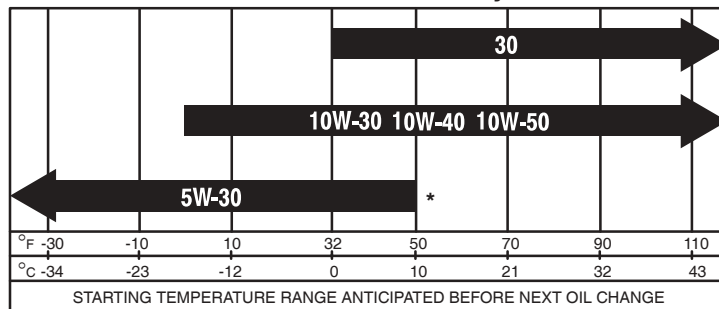
Section 12

Lubrication System

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ASSEMBLE GEAR CASE	
Install Oil Pump	7



Recommended SAE Viscosity Grades



* A synthetic 5W-30 oil may be used.

Use a high quality detergent oil classified "For Service SE/CD" or higher. Use no special additives with recommended oils.

LUBRICATION SYSTEM

DESCRIPTION

Briggs & Stratton Daihatsu gasoline and diesel engines use a full pressure lubrication system with an oil filter. The gear driven oil pump draws oil from a screened oil pickup in the oil pan and pumps the oil through the oil filter. The filtered oil flows through oil galleries in the cylinder block and is distributed to the main bearings, connecting rod bearings, camshaft bearings and rocker arm shaft.

A pressure relief valve limits the maximum oil pressure in the system.

CHANGE OIL

Change oil and filter after first 50 hours of operation. Thereafter, change oil every 100 hours of operation. Change oil filter every 200 hours of operation. Change oil and filter more often if engine is operated in dusty or dirty conditions or if engine is operated under heavy loads or high ambient air temperatures.

Remove oil drain plug and drain oil while engine is still warm, Fig. 1. Check oil drain plug gasket and replace if necessary. Install and torque drain plug to 24.8 Nm (220 in. lbs.).

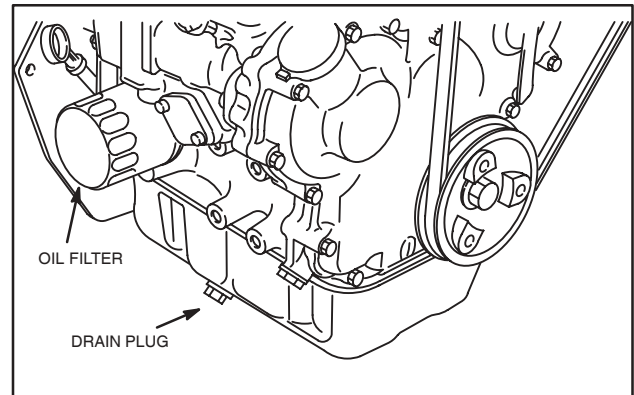


Fig. 1 – Oil Drain Plug

Remove oil fill cap and refill with oil of recommended grade and viscosity. See Page 1.

Oil Capacity: 3.3 liters (3.5 quarts)

Fill to FULL mark on dipstick.

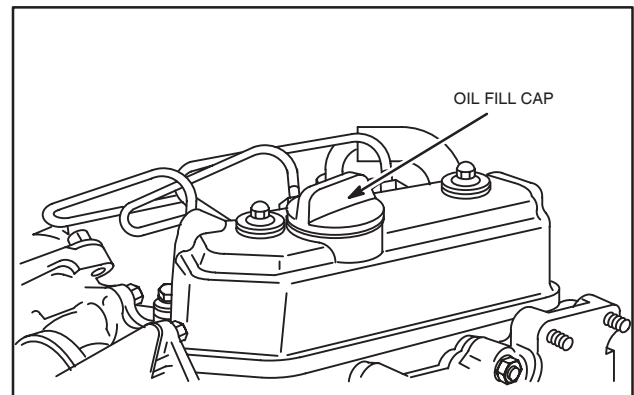


Fig. 2 – Oil Fill Cap

CHANGE OIL FILTER

Change oil filter every 200 hours of operation.

Before installing new filter, lightly oil filter gasket with fresh clean engine oil.

NOTE: Hand tighten 1/2 turn after gasket contacts mounting surface.

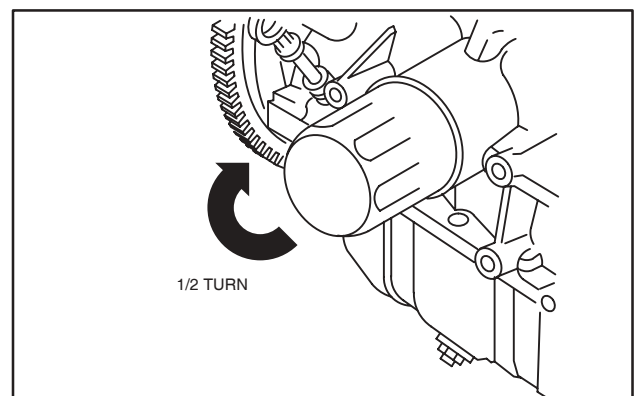


Fig. 3 – Replacing Oil Filter

CHECK OIL PRESSURE

1. Oil level should be between the LOW and FULL marks on dipstick. If oil level is low, check for leaks and add to FULL mark.

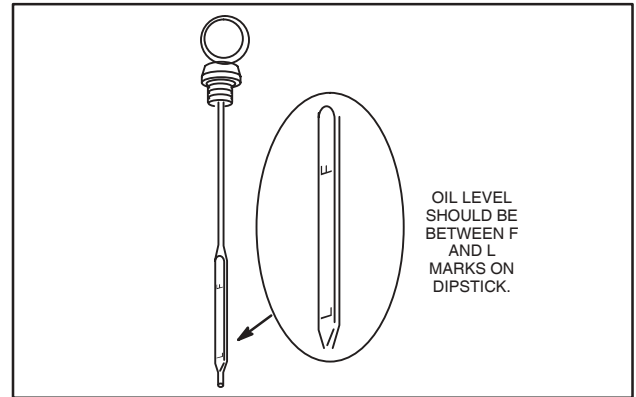


Fig. 4 – Oil Level

2. Remove oil pressure switch.
3. Install oil pressure gauge.
4. Start the engine and allow it to reach normal operating temperature.
5. Check oil pressure at 3000 RPM.

Oil Pressure: 2.0 ~ 5.0 Bar (28 ~ 70 psi)

See charts below for troubleshooting guide.

Low Oil Pressure
Engine RPM Too Low
Wrong Viscosity or Diluted Oil
Low Oil Level
Broken Pressure Relief Spring
Missing Pressure Relief Plunger
Worn Bearings
Damaged Or Defective Oil Pump
High Oil Pressure
Wrong Viscosity Oil
Plugged Oil Galleries

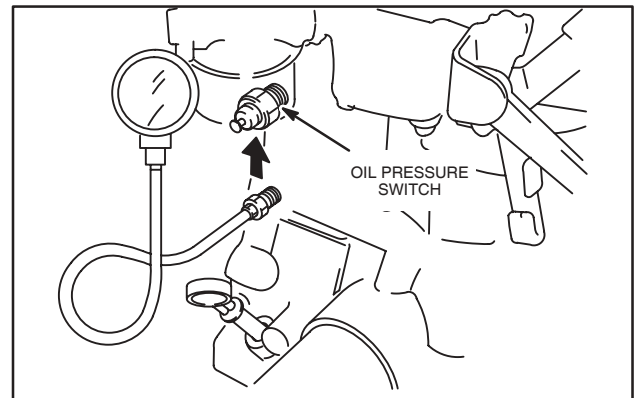
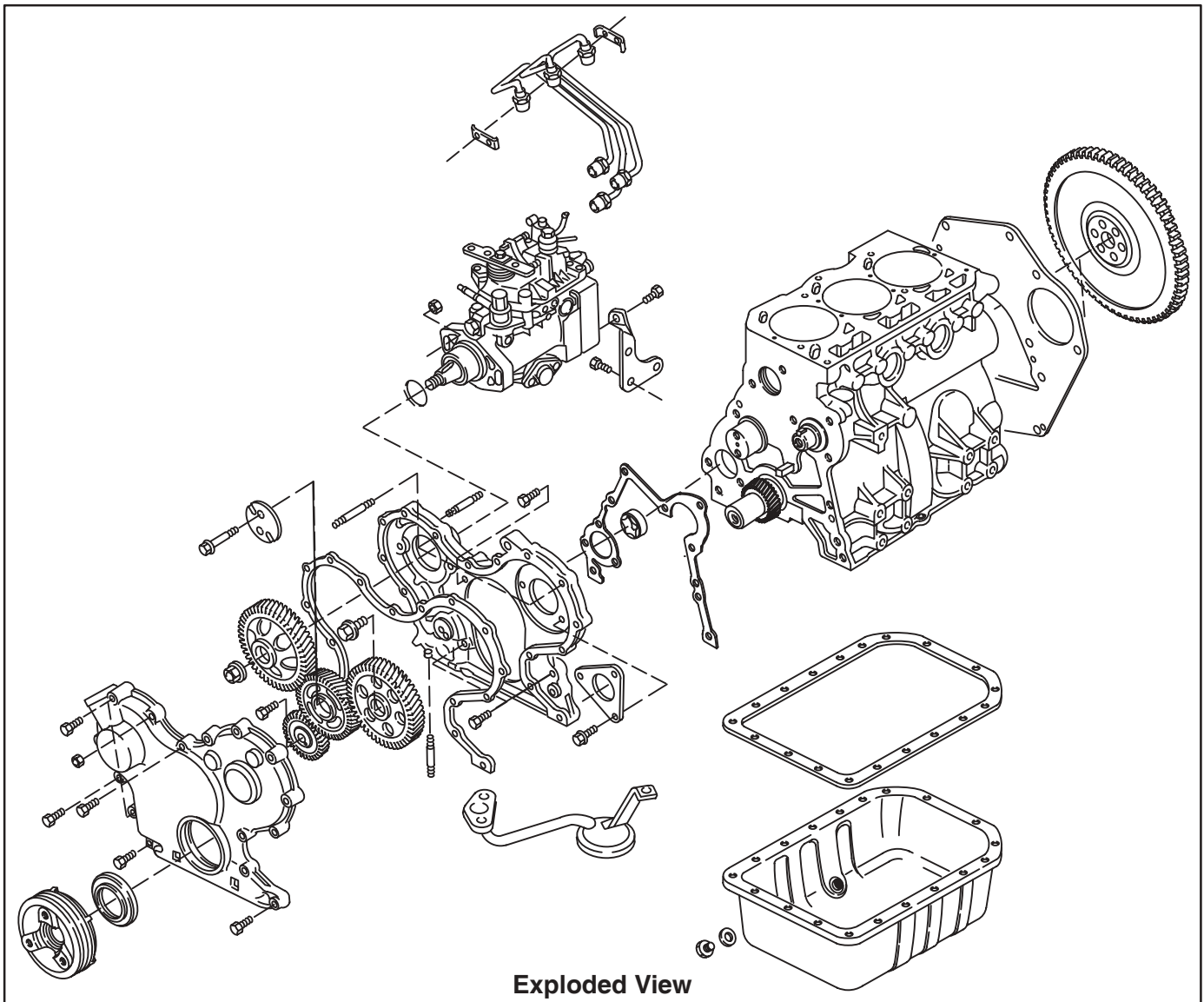


Fig. 5 – Checking Oil Pressure



DISASSEMBLE GEAR CASE

Remove Oil Pump

Make sure that #1 cylinder is at TDC, compression stroke. See Section 2.

Remove V-belt and fan (if equipped). Drain oil from engine.

NOTE: Clean areas around fuel lines and injectors to prevent dirt entry.

1. Remove the following parts, Fig. 6.
 - a. Glow plug wiring.
 - b. Glow plugs.
 - c. Injector pump bracket.
 - d. Remove fuel delivery lines.

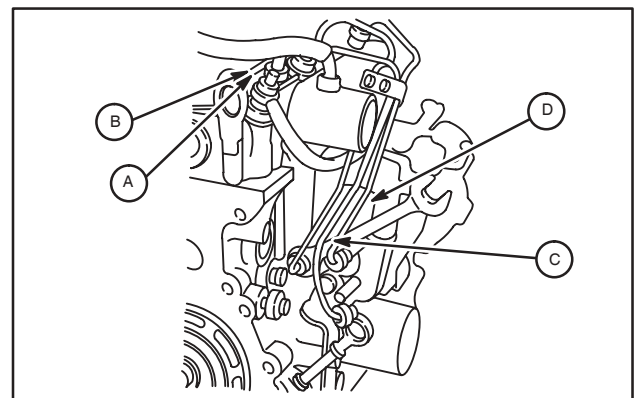


Fig. 6 – Remove Fuel Delivery Lines

2. Remove oil pan screws and nuts.
 - a. Remove oil pan and discard gasket.
 - b. Remove oil pick-up tube and strainer. Discard gasket, Fig. 7.

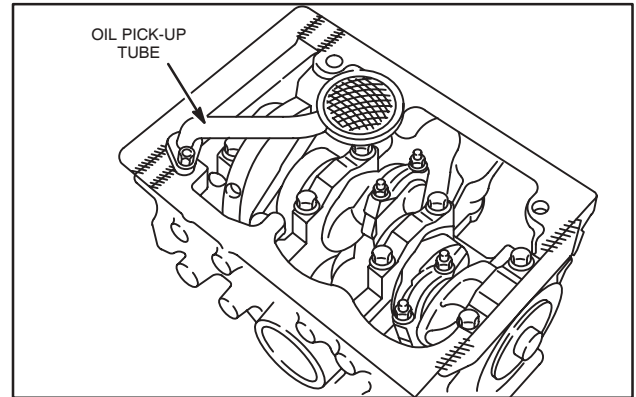


Fig. 7 – Removing Oil Pan

3. Remove bell housing adapter screw if equipped and install flywheel holder, Tool #19418.
LEAVE TOOL INSTALLED.
 - a. Remove crankshaft pulley using Tool # 19420, Fig. 8.

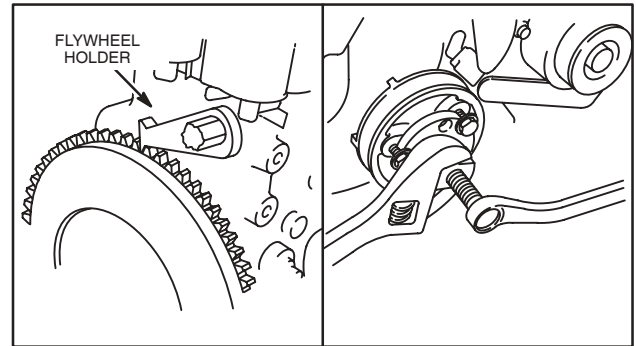


Fig. 8 – Removing Crankshaft Pulley

4. Remove timing gear cover, Fig. 9.
 - a. Discard timing gear cover gasket.

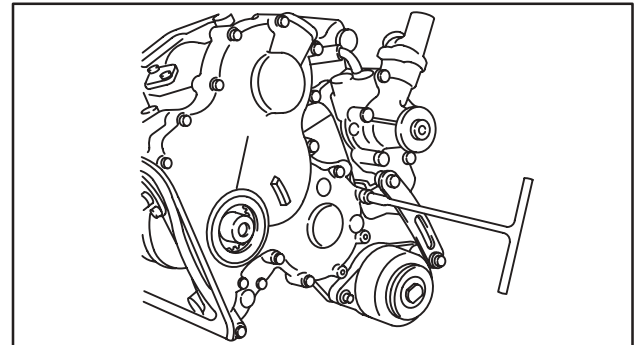


Fig. 9 – Removing Timing Gear Cover

5. Remove the following parts, Fig. 10.
 - a. Camshaft timing gear.
 - b. Oil pump gear.
 - c. Injector pump nut.
 - d. Idler gear.

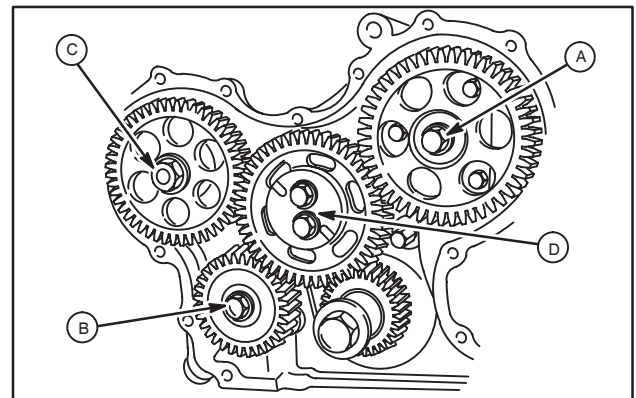


Fig. 10 – Removing Gears

LUBRICATION SYSTEM

6. Remove injector pump timing gear with a three jaw puller, Fig. 11.
 - a. Remove 2 nuts and injector pump. Discard O-ring.

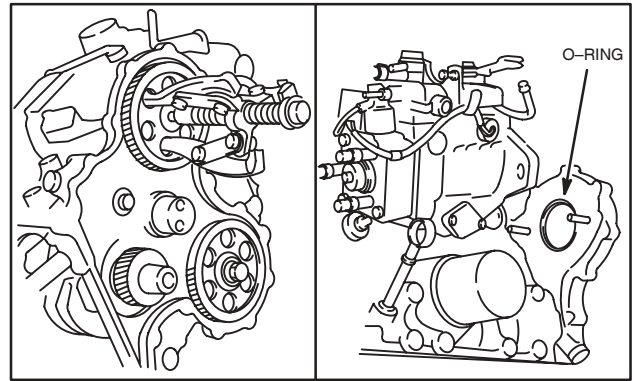


Fig. 11 – Removing Injector Pump

7. Remove parts in sequence shown, Fig. 12.
 - a. Remove 3 screws and camshaft retainer.
 - b. Remove remaining 5 screws.
 - c. Remove timing gear case and discard gasket.

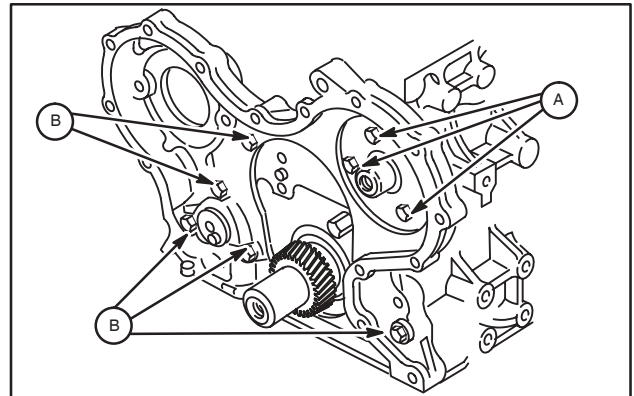


Fig. 12 – Removing Timing Gear Case

8. Inspect rotors for wear or damage, Fig. 13.

NOTE: If pump rotors are worn or damaged, replace the gear case.

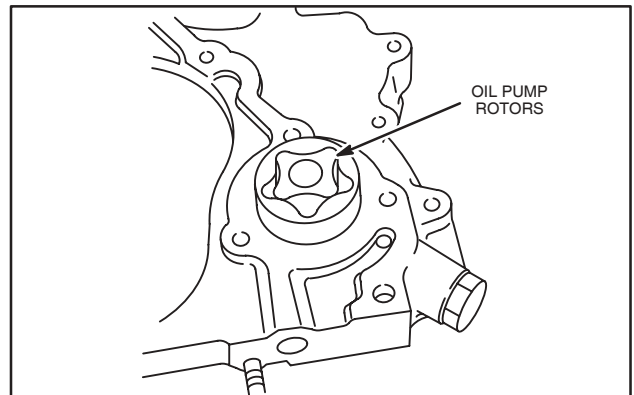


Fig. 13 – Inspect Rotors

9. Remove and check pressure relief valve assembly, Fig. 14.
 - a. Make sure plunger has no nicks or burrs.
 - b. Check pressure relief valve spring free length.
10. **Spring free length: 35.5 mm ± (1.400" ± .040")**

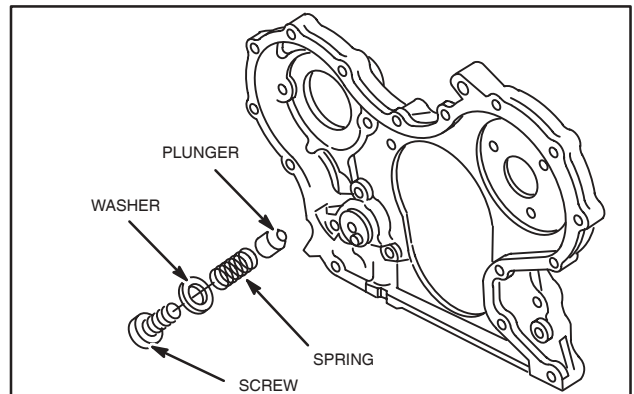


Fig. 14 – Checking Pressure Relief Valve

ASSEMBLE GEAR CASE

Install Oil Pump

1. Lubricate oil pump rotor with engine oil and install in cylinder block, Fig. 15.
 - a. ID mark on rotor must face cylinder block.

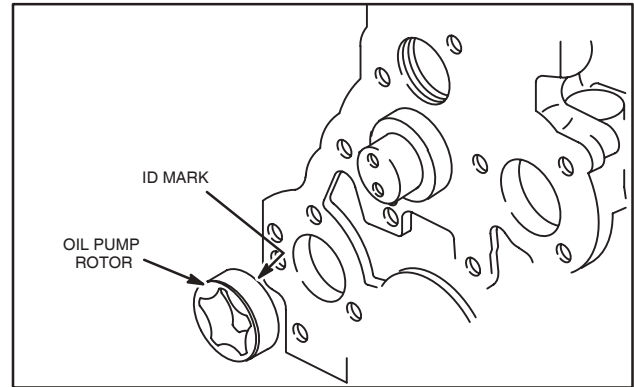


Fig. 15 – Installing Oil Pump Rotor

2. Install timing gear case with new gasket. Install camshaft retainer, Fig. 16.

NOTE: It may be necessary to rotate oil pump drive to engage oil pump rotors.

NOTE: Position camshaft retainer so that center hole does not interfere with camshaft.

Note position, length and number of screws as shown.

- a. M6 x 28 mm (M6 x 1.1"): 4
 - b. M6 x 18 mm (M6 x 0.7"): 3
 - c. M6 x 16 mm (M6 x 0.6"): 1
3. Torque screws to 8.0 Nm (70 in. lbs.).

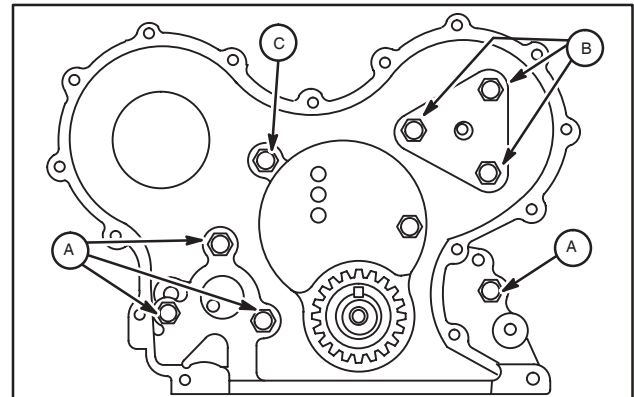


Fig. 16 – Installing Timing Gear Case

4. Assemble injector pump to gear case with new O-ring and install nuts and support bracket screw finger tight, Fig. 17.

NOTE: Pump must be able to rotate.

- a. Align timing mark on injector pump with timing mark on gear case.

NOTE: See Section 10 for injector pump timing procedure.

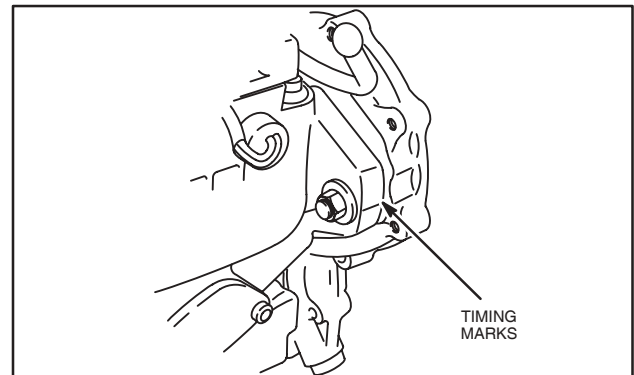


Fig. 17 – Install Injector Pump

Engine models 432000 and 582000 after date code 990111007, and all engine models 522000 are equipped with right angle helical timing gears. Timing marks are identified by letters (A, AA, B, BB, etc.), instead of numbers. The timing procedure is the same.

5. With crankshaft key at 12 o'clock position, assemble idler gear so that timing mark 11 (AA) is aligned with timing mark 1 (A) on crankshaft gear, timing mark 22 (BB) is aligned with timing mark 2 (B) on camshaft gear, and timing mark 33 (CC) is aligned with timing mark 3 (C) on injector pump gear, as shown in Fig. 18.
 - a. Install oil pump gear.

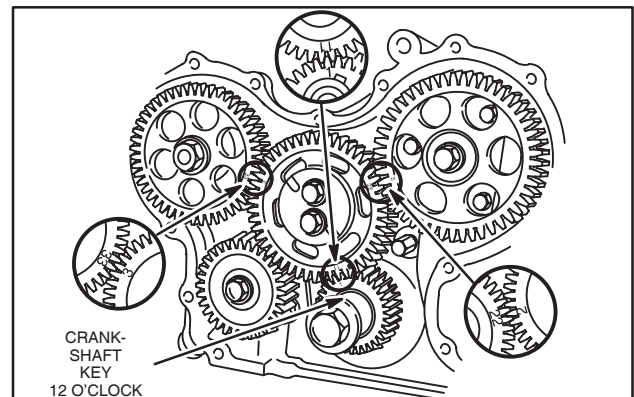


Fig. 18 – Aligning Timing Marks

LUBRICATION SYSTEM

6. Torque screws as shown, Fig. 19.
 - a. Camshaft gear:
41.0 Nm (30 ft. lbs.)
 - b. Idler gear:
25.0 Nm (220 in. lbs.)
 - c. Injector pump gear:
61.0 Nm (45 ft. lbs.)
 - d. Oil pump gear:
19.0 Nm (170 in. lbs.)

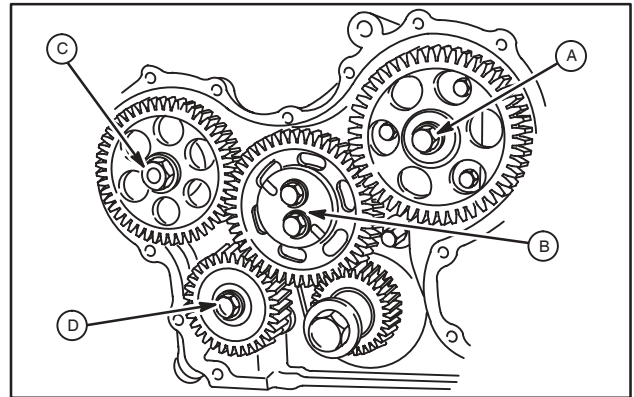


Fig. 19 – Torque Screws

7. Install timing gear cover with new gasket. Note position, length and number of screws as shown, Fig. 20.
 - a. M6 x 55 mm (M6 x 2.5"): 3
 - b. M6 x 45 mm (M6 x 2.1"): 2
 - c. M6 x 30 mm (M6 x 1.1"): 9
 - d. M6 nut: 2
8. Torque screws and nuts to 8.0 Nm (70 in. lbs.).

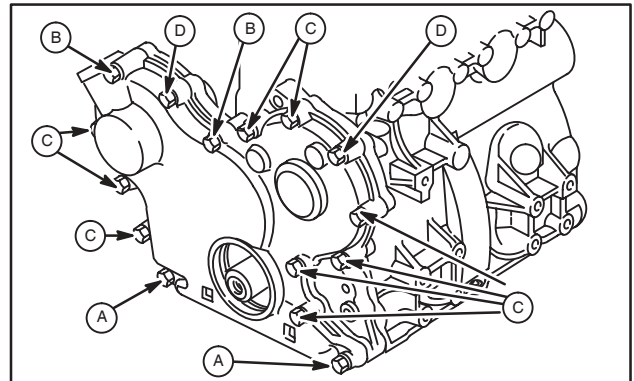


Fig. 20 – Installing Timing Gear Cover

9. Install crankshaft pulley with timing mark at 12 o'clock position (#1 cylinder), Fig. 21.

NOTE: Be sure alignment pin in crankshaft gear is seated in hole in pulley.

 - a. Torque screw to 88.0 Nm (65 ft. lbs.).
 - b. Remove flywheel holder.

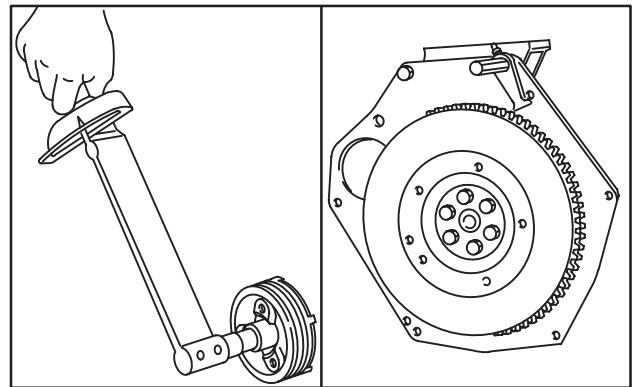


Fig. 21 – Installing Crankshaft Pulley

10. Install oil pick-up tube and strainer with new gasket. Torque to 8.0 Nm (70 in. lbs.).
 - a. Apply a small bead of Permatex® No. 2 or similar sealant to crankcase areas shown, Fig. 22.
 - b. Install oil pan with new gasket.
 - c. Torque screws and nuts to 8.0 Nm (70 in. lbs.).

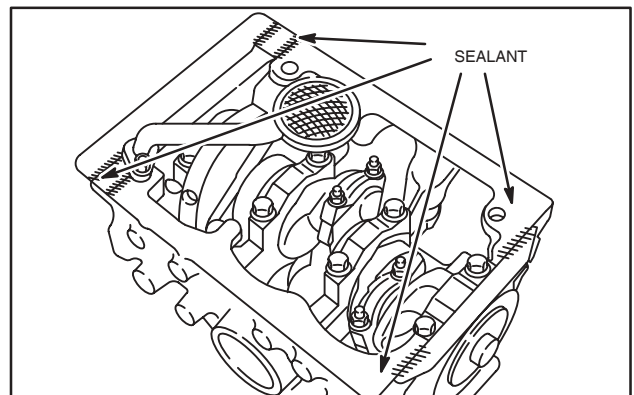


Fig. 22 – Installing Oil Pan

11. Install Glow plugs, wiring and fuel delivery lines.
 - a. Torque glow plugs to 17.0 Nm (150 in. lbs.).
 - b. Torque fuel delivery lines to 25.0 Nm (220 in. lbs.), Fig. 23.

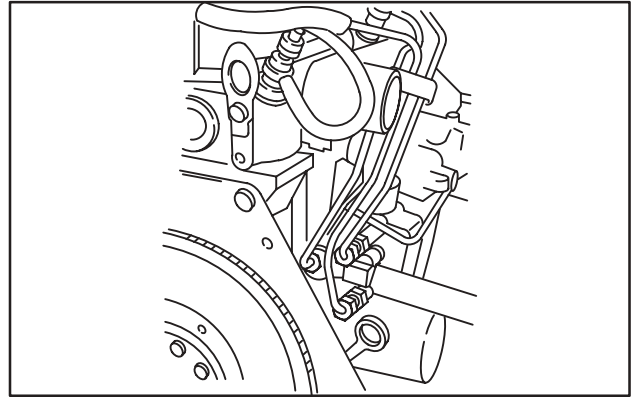


Fig. 23 – Installing Fuel Delivery Lines

12. Install V-belt, Fig. 24.
 13. Install alternator bolts (A) and (B).
- Belt deflection** limit is 10–12 mm/10 kg (3/8–1/2 in/22 lbs.).
- a. Torque bolt (A) to 19.0 Nm (170 in. lbs.).
 - b. Torque bolt (B) to 61.0 Nm (45 ft. lbs.).

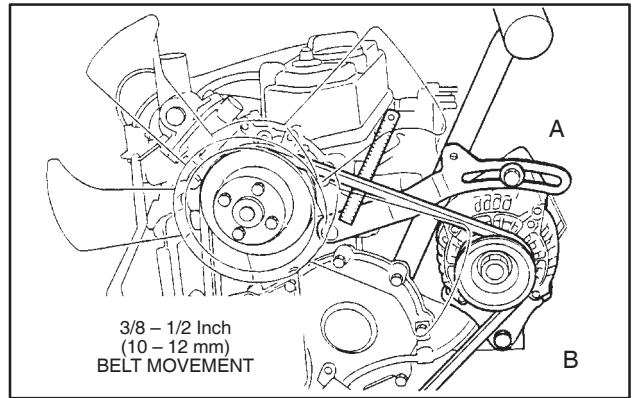


Fig. 24 – Adjusting V-belt

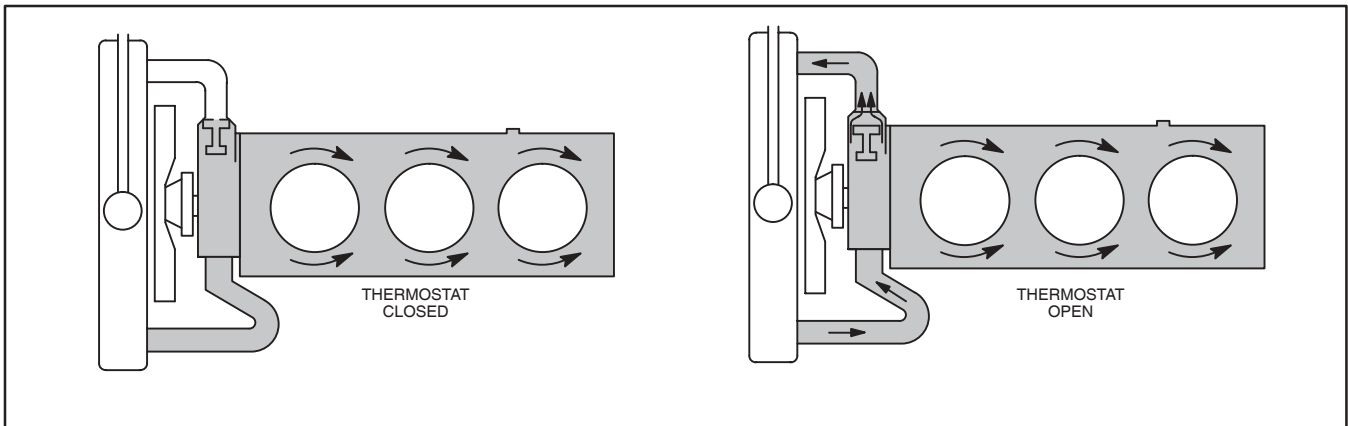
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Section 13

Cooling System

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Briggs & Stratton Daihatsu gasoline and diesel engines use a pressurized, forced circulation cooling system. The water pump circulates coolant through the cylinder block, cylinder head and radiator. The thermostat maintains optimum engine temperature.

The thermostat is equipped with a by-pass valve which permits coolant to re-circulate through the cylinder block and cylinder head.

As the engine warms, the by-pass valve closes as the thermostat opens, permitting complete circulation through the radiator.

Always maintain a 50% solution of phosphate free antifreeze at all times for adequate heat dissipation, lubrication and protection from freezing.

COOLING SYSTEM

CHECKING COOLING SYSTEM



WARNING: The cooling system is pressurized. Do not remove the radiator cap while the engine is hot. To avoid scalding hot coolant or steam blowing out of the radiator, use extreme care when removing the radiator cap. If possible, wait for engine to cool. Wrap a thick rag around cap while removing. To release pressure, slowly turn cap counter clockwise to the first stop. When all pressure has been released, press down on cap and continue turning.

Pressure Testing Cooling System

1. Remove radiator cap and make sure coolant is at correct level.
 - a. Coolant level must be no more than 25 mm (1") below bottom of filler neck.
2. Install cooling system pressure tester on radiator and pressurize system to 0.75 Bar (11 psi).
3. Check the following for any signs of leaking.

NOTE: System must maintain pressure during test.

- a. Hoses and connections (also check hoses for excessive bulging).
- b. Radiator.
- c. Water pump.
- d. Freeze plugs (cylinder block and cylinder head).

If system does not maintain pressure and no leaks are evident externally, check for an internal leak such as a blown head gasket, warped cylinder head or cylinder block.

Testing Radiator Cap

Make sure that rubber seal on radiator cap is not damaged or distorted. Rubber seals must be clean and free of debris to seal properly.

1. Install radiator cap on pressure tester and pressurize the cap.

Specification: 1.03 ~ 0.76 Bar (15 ~ 11 psi)

Replace cap if not within specification shown.

NOTE: Recommended pressure cap capacity is 0.9 Bar (13 psi).

CHANGING COOLANT

Coolant should be changed once a year. Change coolant with engine cold.

1. Remove radiator cap. Remove radiator drain plug and drain the system, Fig. 1.

2. Tighten drain plug.

NOTE: Follow state or federal laws regarding the proper procedure for disposing of anti-freeze.

3. Fill radiator with 50% solution of phosphate free antifreeze.
4. Start and run engine until thermostat opens (when coolant level drops, thermostat is open).
5. Check coolant level in radiator and add coolant as required, Fig. 2.

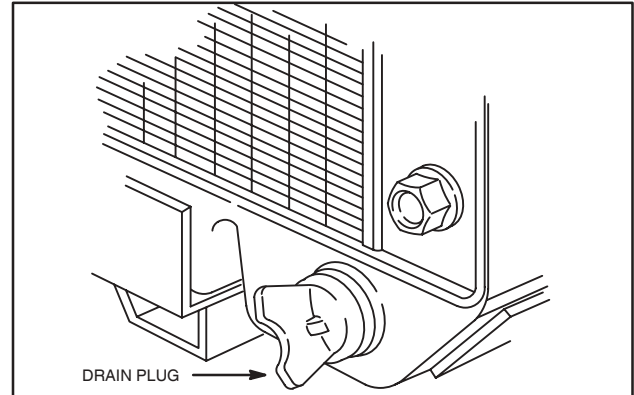


Fig. 1 – Draining Coolant

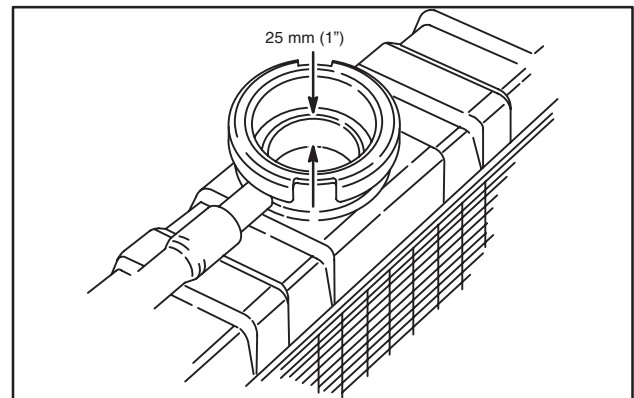


Fig. 2 – Adding Coolant

THERMOSTAT

Removing Thermostat – Engine Cold

1. Drain engine coolant.
2. Remove screws and coolant outlet housing.
3. Remove locating screw and thermostat, Fig. 3.
4. Remove all traces of gasket material.

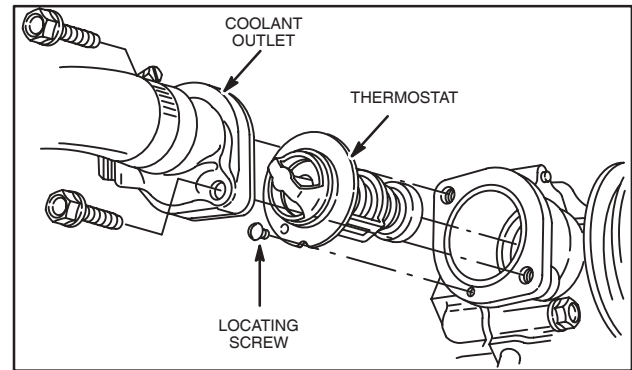


Fig. 3 – Removing Thermostat

Checking Thermostat

A thermometer capable of reading 100° C (210° F) or more is required.

1. Check to make sure thermostat valve is fully closed.
2. Immerse thermostat in water and heat water gradually, Fig. 4.
3. Note temperature when thermostat starts to open.
 - a. **81 ~ 84° C (178 ~ 183° F)**
4. Note temperature when thermostat is fully open.
 - a. **95° C (203° F)**
5. Remove thermostat from water and allow to cool.
 - a. Thermostat should close fully.

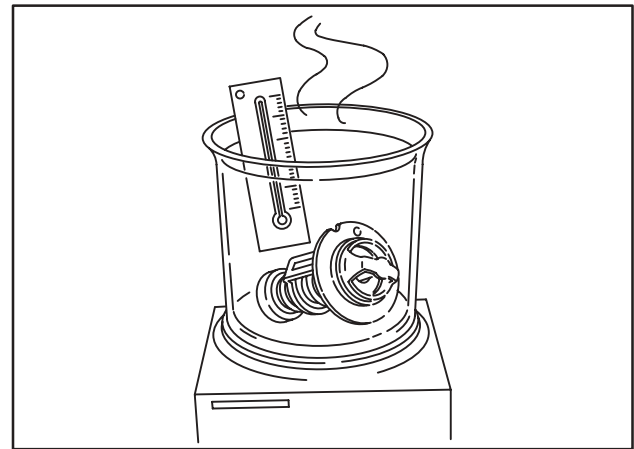


Fig. 4 – Checking Thermostat

Installing Thermostat

1. Insert thermostat in housing and install locating screw, Fig. 5.
2. Install coolant outlet housing with new gasket.
3. Torque screws to 8.0 Nm (70 in. lbs.).

Refill with coolant.

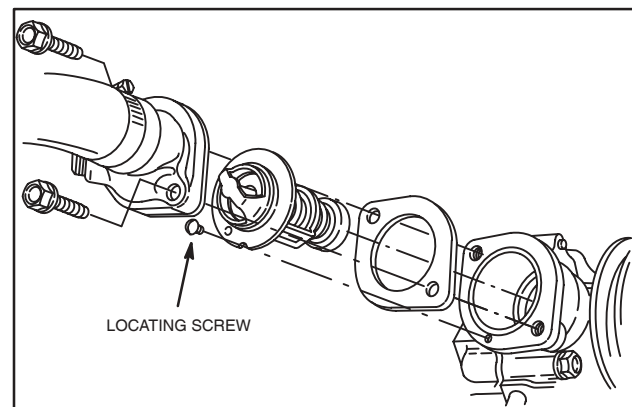


Fig. 5 – Installing Thermostat

COOLING SYSTEM

WATER PUMP

Inspecting Water Pump

Inspect water pump for signs of leaking at vent holes, mounting surfaces and water pump pulley shaft, Fig. 6.

1. Remove V-belt, alternator adjustment bracket, fan (if equipped) and water pump pulley.
 - a. Replace pulley if bent or damaged.

2. Check water pump bearings by rotating pulley flange by hand, Fig. 7.
 - a. Make sure pulley rotates smoothly.

If water pump shows evidence of leaking or bearings are rough, replace the water pump.

NOTE: Most water pump and cooling system failures result from using straight water as a coolant. Without water pump lubricant and corrosion inhibitors, the water pump will fail prematurely.

Removing Water Pump

Drain engine coolant.

1. Disconnect radiator hoses, Fig. 8.

Remove the following parts, Fig. 9.

2. Temperature gauge wire (if equipped).
3. Coolant outlet.
4. Coolant inlet.
5. Water pump.

Clean all traces of gasket material from mounting surfaces and inspect mounting surfaces for damage.

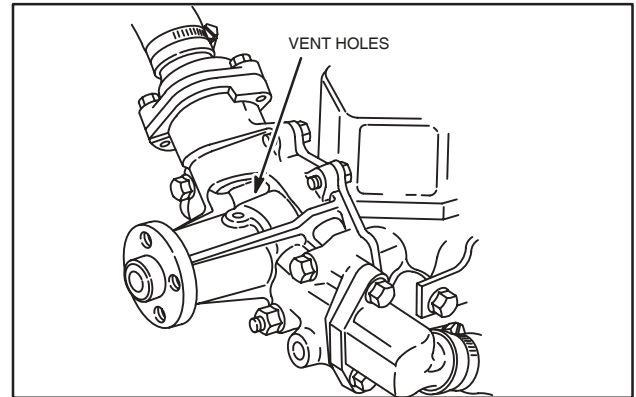


Fig. 6 – Inspecting Water Pump

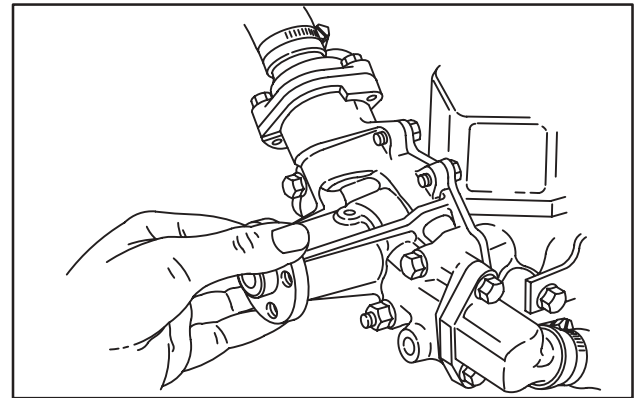


Fig. 7 – Checking Bearings

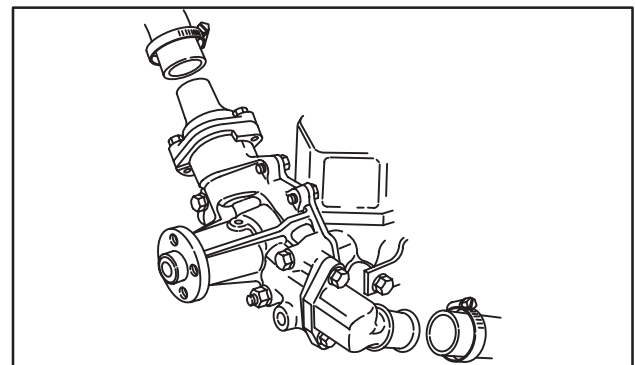


Fig. 8 – Remove Hoses

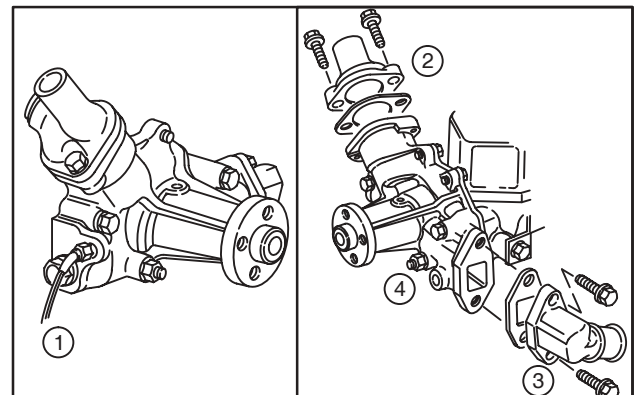


Fig. 9 – Removing Water Pump

Installing Water Pump

1. Install water pump with new gasket, Fig. 10.
 - a. Torque screws and nuts to 19.0 Nm (170 in. lbs.).

After installing water pump make sure pump rotates smoothly.

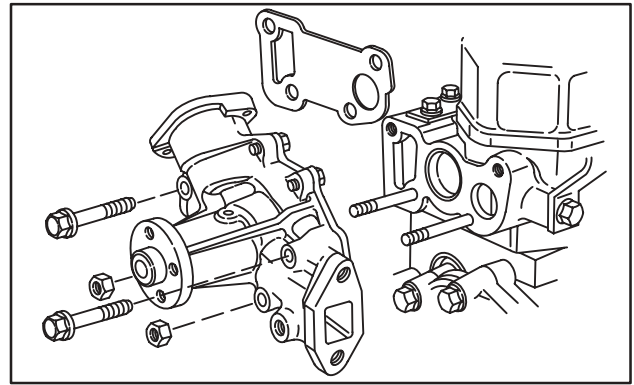


Fig. 10 – Installing Water Pump

2. Install coolant inlet with new gasket, Fig. 11.
 - a. Torque screws to 8.0 Nm (70 in. lbs.).
3. Install thermostat and coolant outlet with new gasket, Fig. 11.
 - a. Torque screws to 8.0 Nm (70 in. lbs.).
4. Install temperature gauge wire (if equipped).
5. Install radiator hoses.

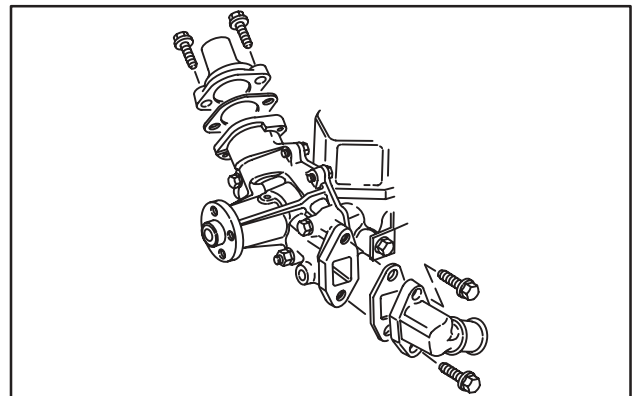


Fig. 11 – Installing Coolant Inlet And Outlet

6. Install fan (if equipped) and water pump pulley, Fig. 12.
 - a. Torque screws to 8.0 Nm (70 in. lbs.).

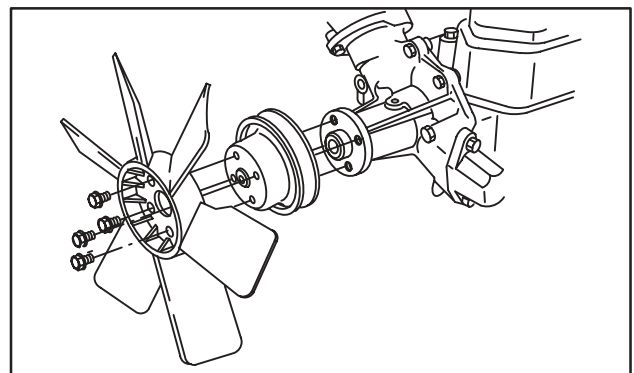


Fig. 12 – Installing Fan And Pulley

7. Install V-belt, Fig. 13.
 - a. **Belt tension adjustment:** 10-12 mm/10 kg (3/8-1/2 in./22 lbs.).
8. Refill cooling system.

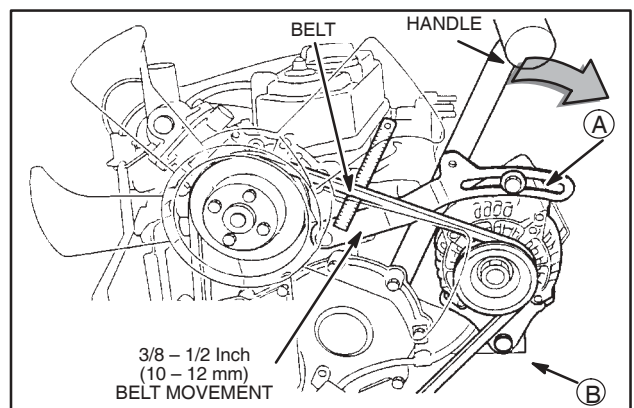


Fig. 13 – Install V-Belt

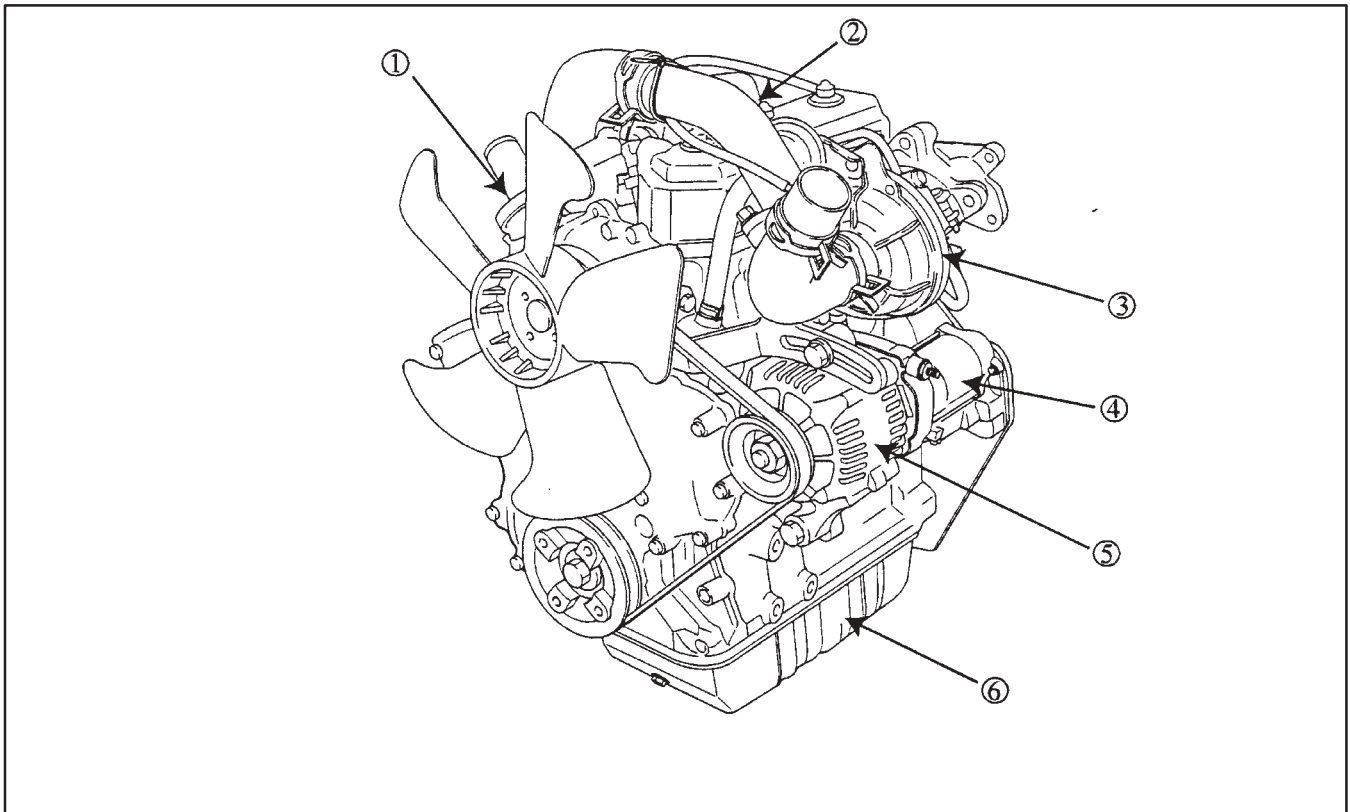
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Section 14

Turbocharger

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950 CC DIESEL TURBOCHARGED ENGINE

General Information

Models 588447 and 58A447 are turbocharged equipped diesel engines.

Turbocharger Lubrication System

Lubricating oil for the turbocharger is supplied from the rear of the cylinder head to the turbocharger via the oil inlet line. The oil supply is regulated by the inlet port diameter of the oil inlet line. The oil inlet line is installed with union screws at the cylinder head and the turbocharger.

Oil returns to the cylinder block via the oil outlet line.

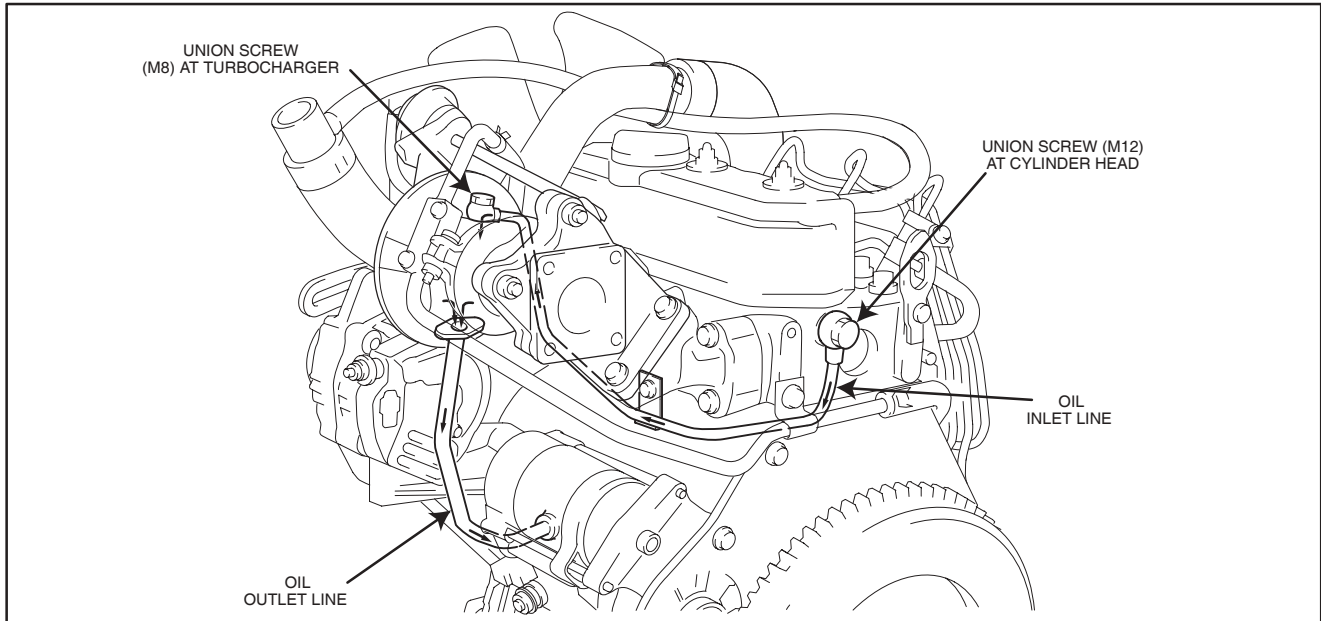


Fig. 1 – Lubricating System of Turbocharger

Full Floating Bearing

The turbine shaft for the turbocharger is equipped with a full floating bearing lubricated by engine oil.

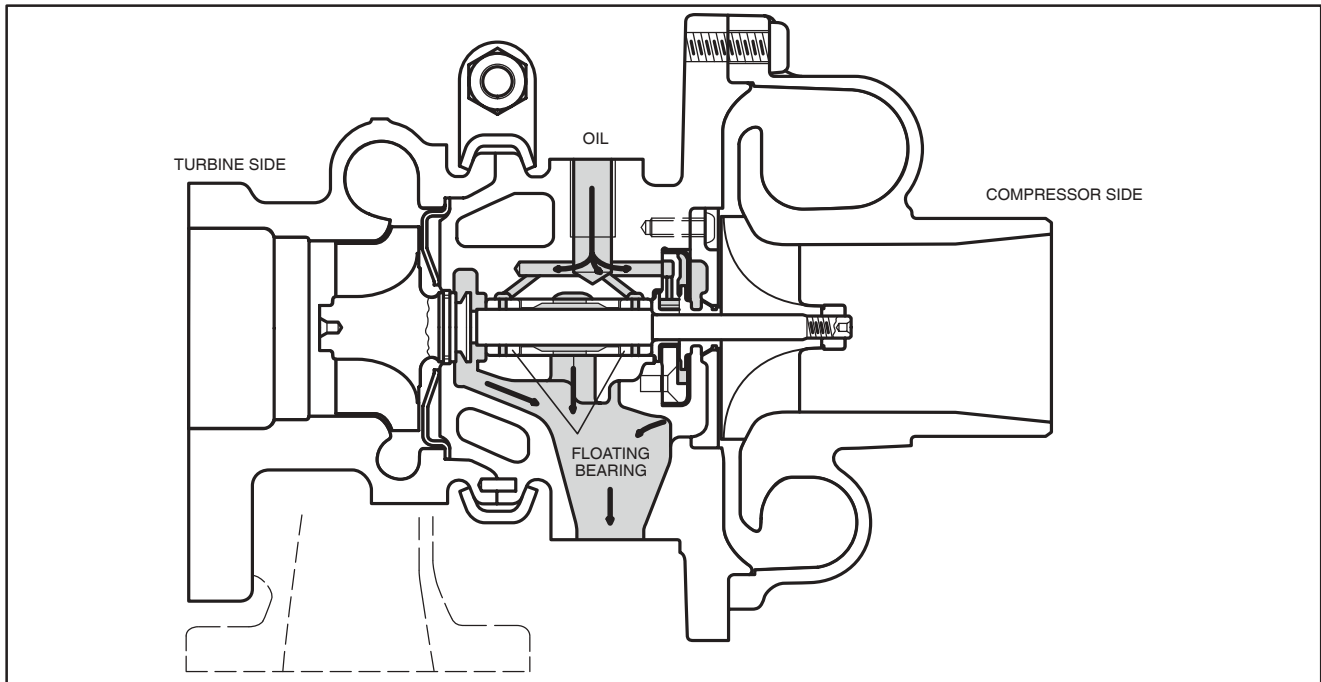


Fig. 2 – Full Floating Bearing

Turbocharger Cooling System

Coolant for the turbocharger is supplied from the rear right of cylinder block and returns to the water pump inlet.

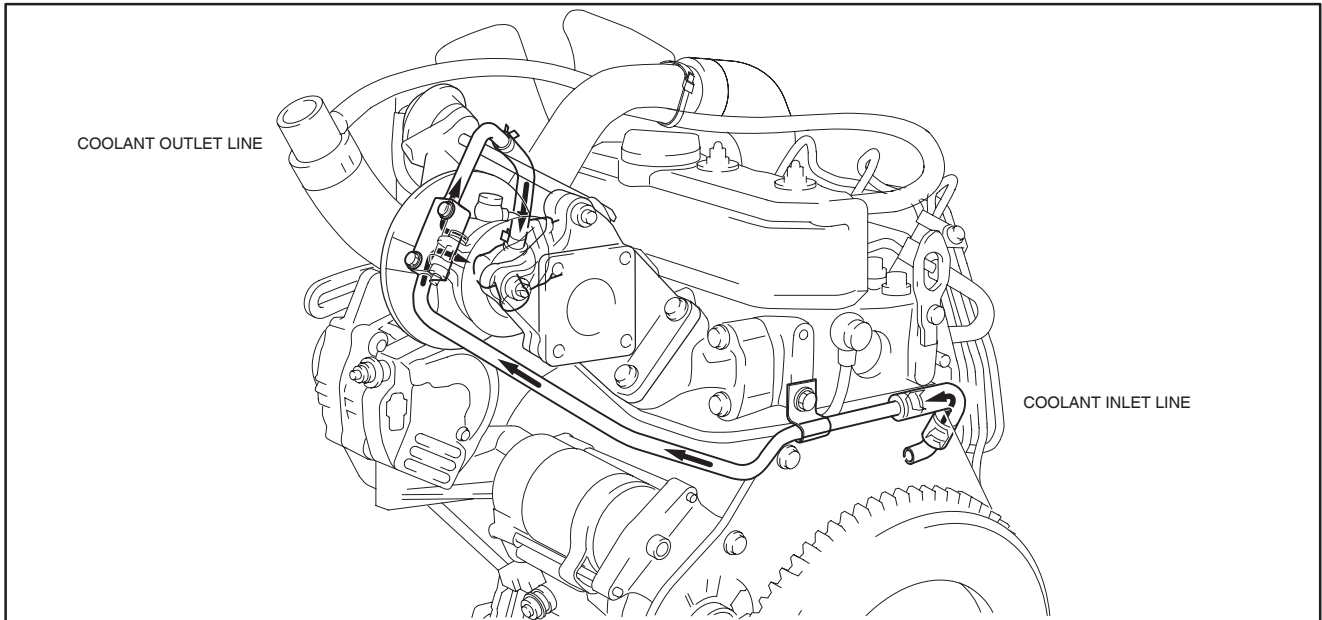


Fig. 3 – Cooling System of Turbocharger (1)

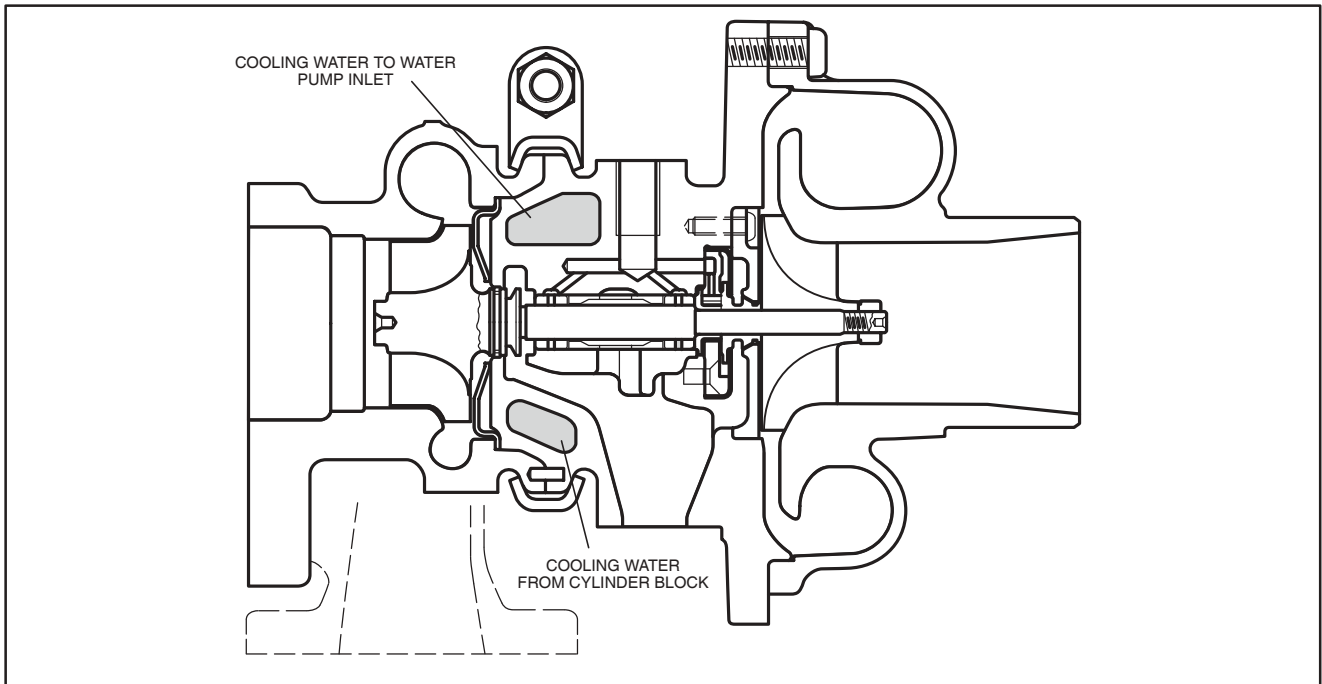


Fig. 4 – Cooling System of Turbocharger (2)

TURBOCHARGER

Turbocharger Waste Gate

The turbocharger is equipped with a waste gate to control turbocharger pressure.

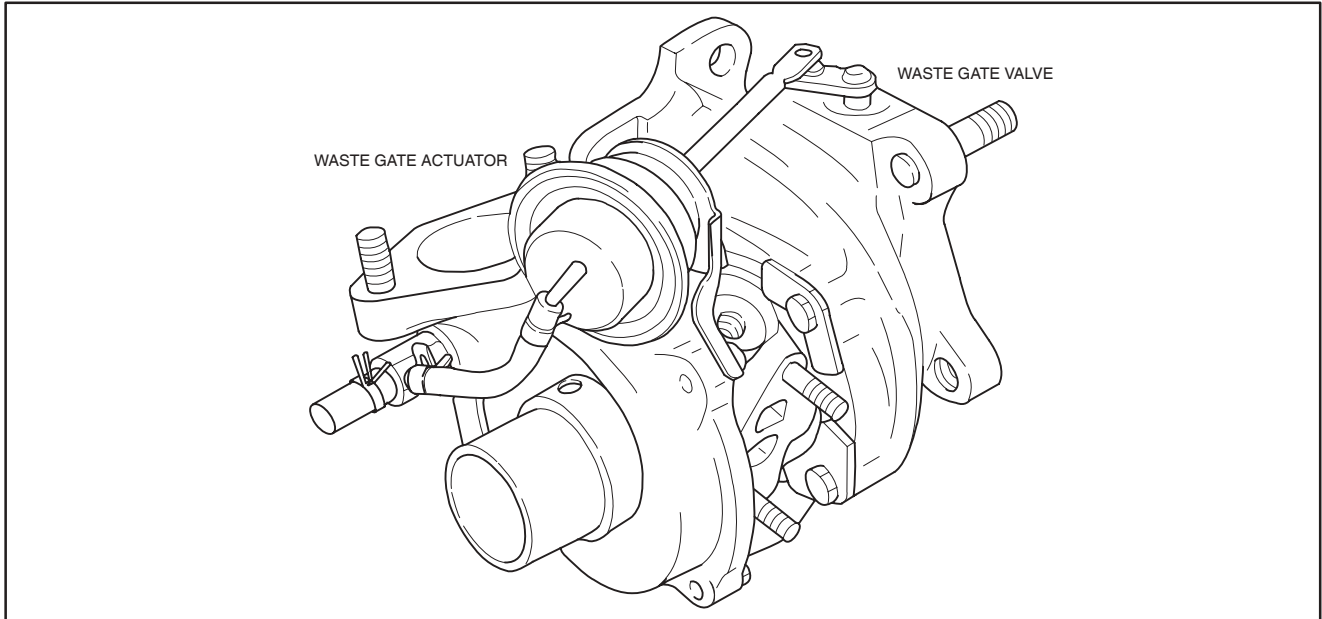


Fig. 5 – Turbocharger

Turbocharger Pressure Control System

As pressure in the turbocharger rises, the actuator for the waste gate valve opens allowing some of the exhaust gases to bypass the turbocharger.

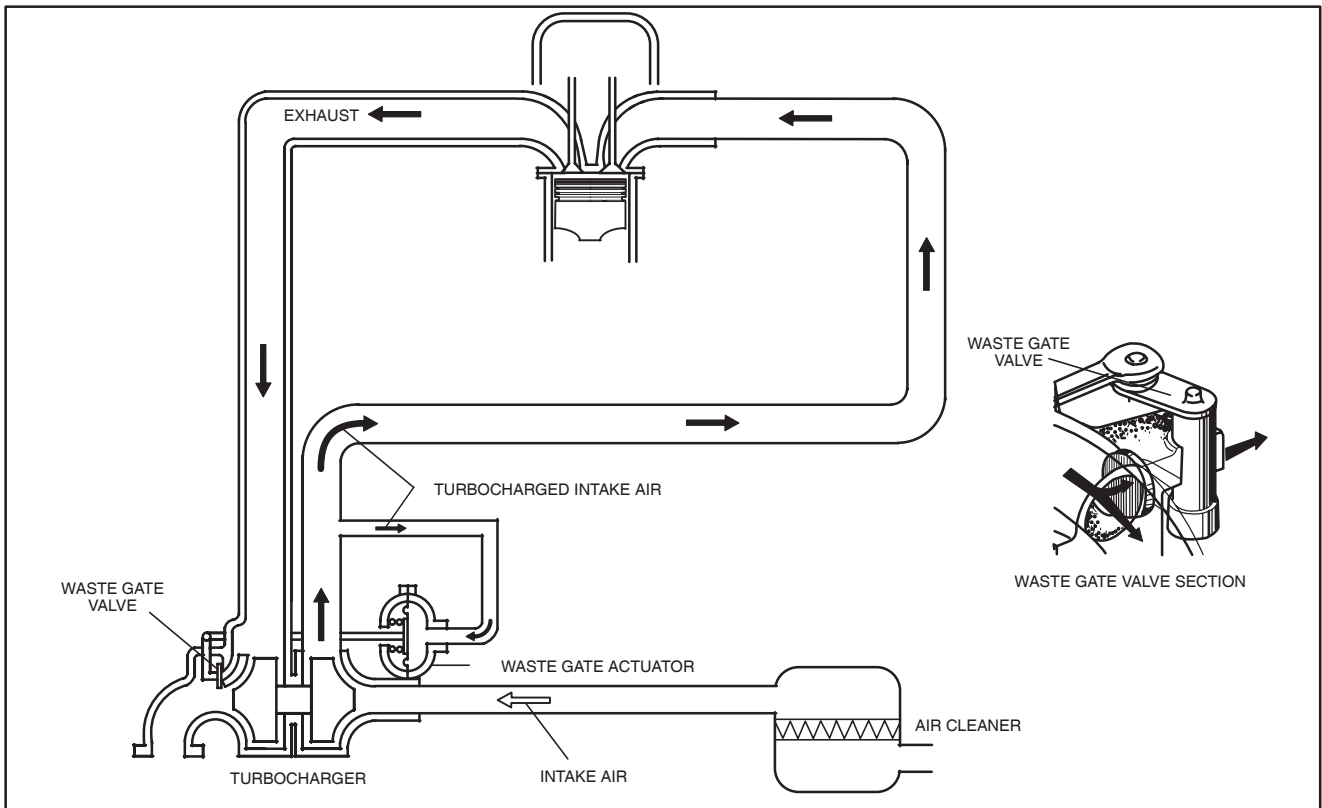


Fig. 6 – Turbocharger Pressure Control System

Crankcase Blow-by Recirculating System

Crankcase blow-by is recirculated as shown in Fig. 7

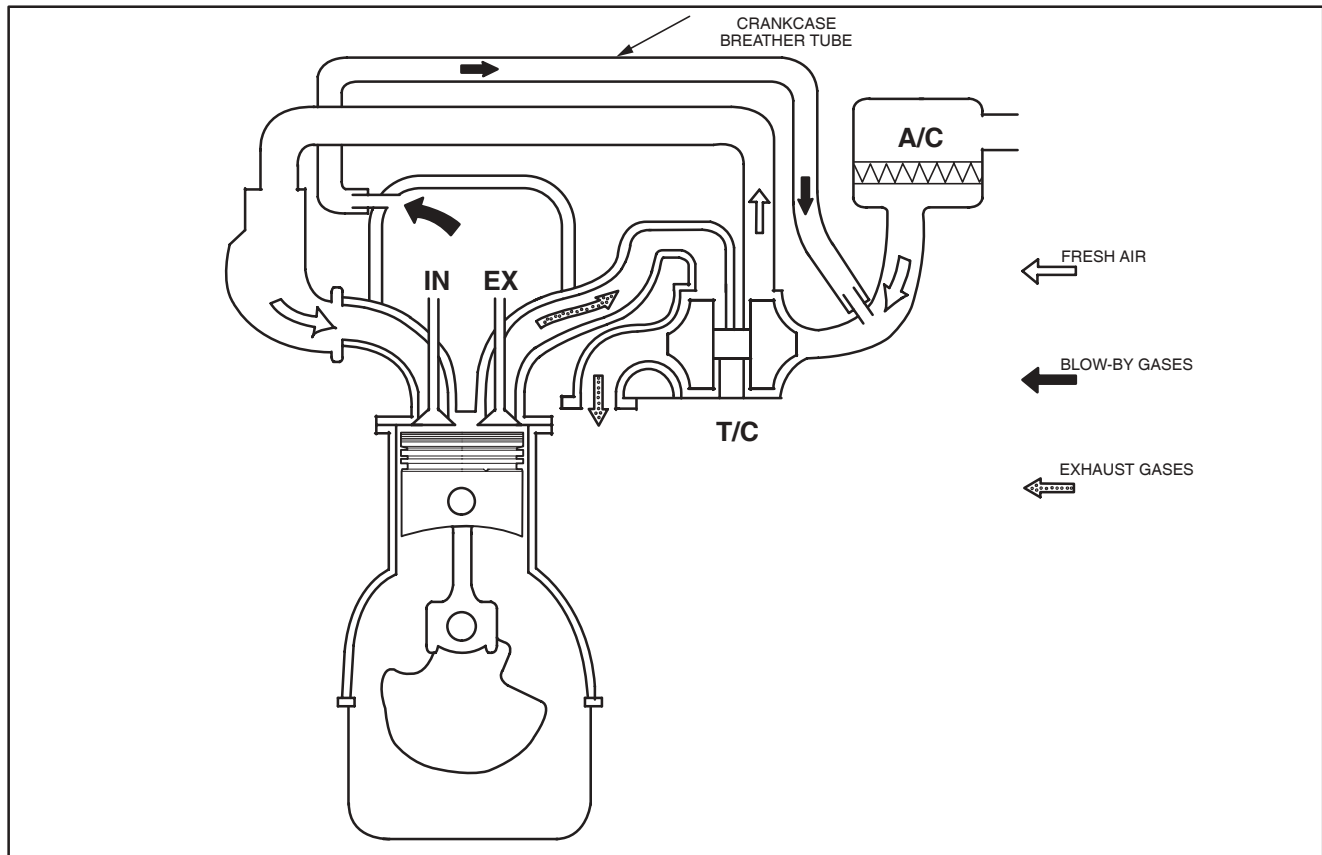


Fig. 7 – Crankcase Blow-by Recirculating System

CHECKING WASTE GATE ACTUATOR

1. Disconnect the waste gate actuator hose at the actuator.
2. Connect pressure/vacuum pump, Tool #19493.
3. Apply pressure of **14.2 psi (0.9 bar)** and ensure that the rod and link operate.
4. When pressure is released rod and link must return to original position.

NOTE: DO NOT apply pressure more than 21.3 psi (1.5 bar) to the waste gate actuator or the diaphragm will be damaged.

5. If the actuator hose is damaged or cracked it must be replaced.

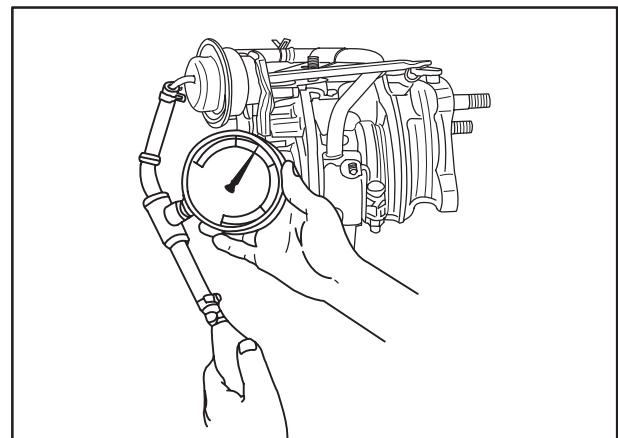


Fig. 8 – Checking Waste Gate Valve

TURBOCHARGER

SERVICING AND OPERATION INFORMATION

1. DO NOT disassemble the turbocharger.
2. When removing and installing turbocharger:
 - a. Handle the turbocharger carefully. DO NOT drop.
 - b. When removing the air intake system or lubrication system, be careful not to get dust or foreign matter into the turbocharger.
 - c. Use tape to cover the oil inlet and outlet ports, coolant ports, air intake and exhaust port to prevent the turbocharger from getting dust or debris into it.
 - d. After the turbocharger has been replaced, run the engine a minimum of 15 seconds at idle. If the engine speed is raised rapidly, it may cause damage to the turbocharger bearing.
 - e. Check oil and coolant lines for leaks.
 - f. Special heat treated mounting fasteners are used on the turbocharger. Do not substitute.

3. DO NOT lift or carry turbocharger by the waste gate actuator rod.

4. DO NOT remove residual oil from turbocharger.
5. DO NOT touch the turbocharger when the engine is running.
6. DO NOT run the engine with the intake pipe removed.
7. DO NOT place the turbocharger in a vertical position.

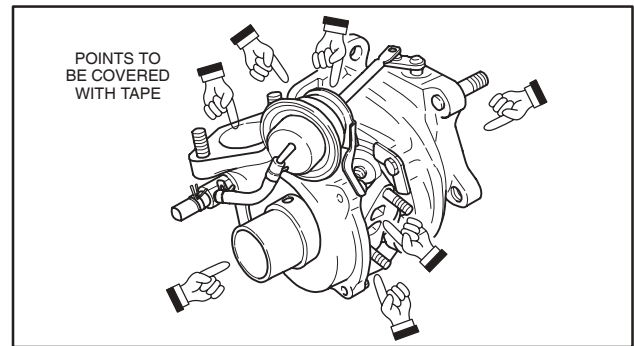


Fig. 9 – Cautions on Handling Turbocharger (1)

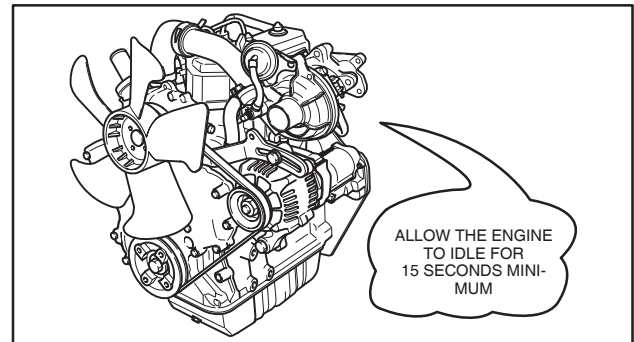


Fig. 10 – Cautions on Handling Turbocharger (2)

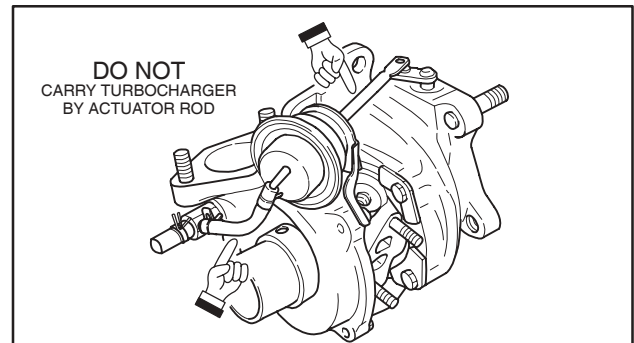


Fig. 11 – Cautions on Handling Turbocharger (3)

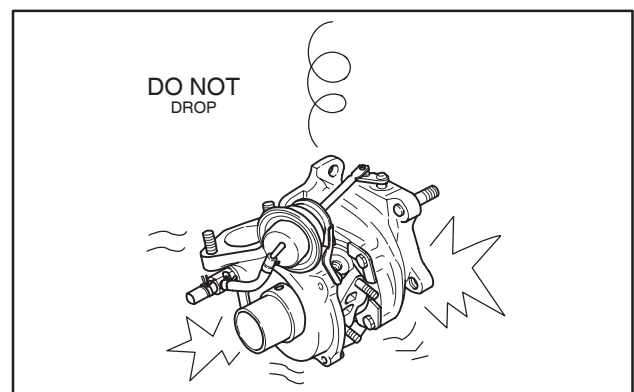


Fig. 12 – Cautions on Handling Turbocharger (4)

REMOVE TURBOCHARGER

1. Remove the muffler or exhaust pipe from the turbocharger.
2. Lift tab on tie strap and remove tie strap. Then remove crankcase breather tube at air intake tube.

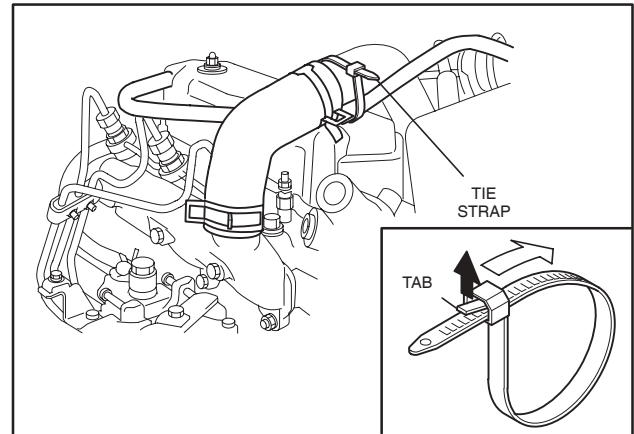


Fig. 13 – Remove Clamp

3. Disconnect the air intake tube at the turbocharger.
4. Disconnect the air intake tube from the air intake pipe.

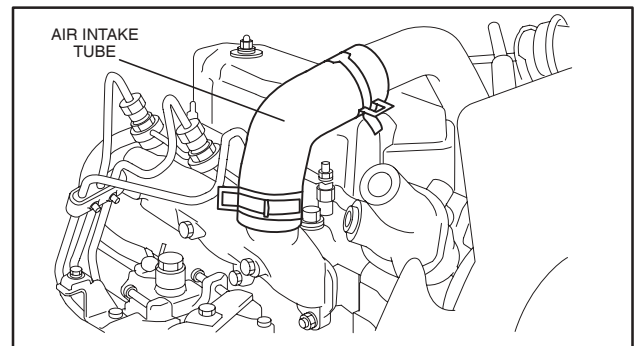


Fig. 14 – Disconnecting Air Intake Tube

5. Remove the two nuts, and remove the air intake pipe from turbocharger.

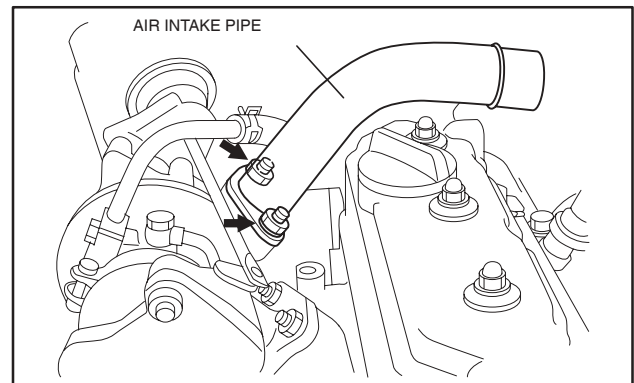


Fig. 15 – Removing Air Intake Pipe

6. Remove the coolant inlet hose from coolant inlet line.

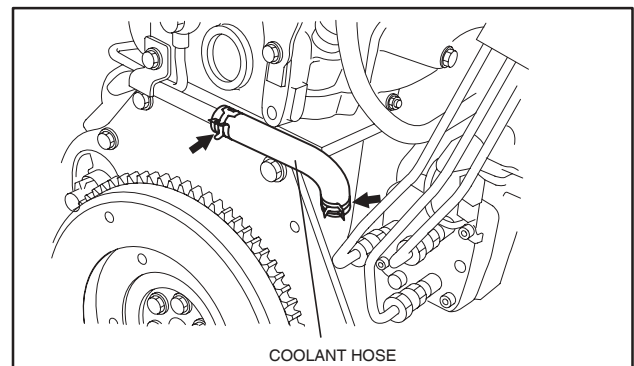


Fig. 16 – Removing Coolant Hose

TURBOCHARGER

7. Remove coolant outlet hose.

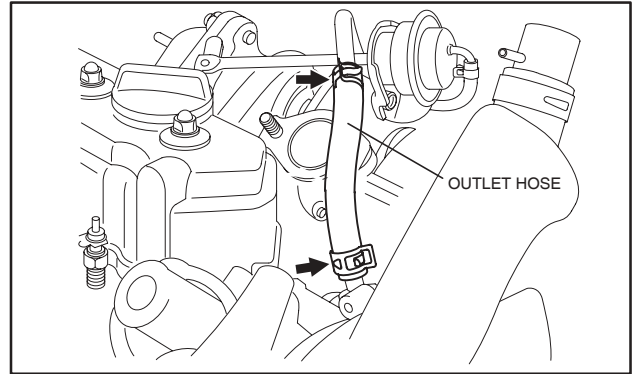


Fig. 17 – Disconnect Coolant Hose

8. Remove coolant inlet line bracket screw.

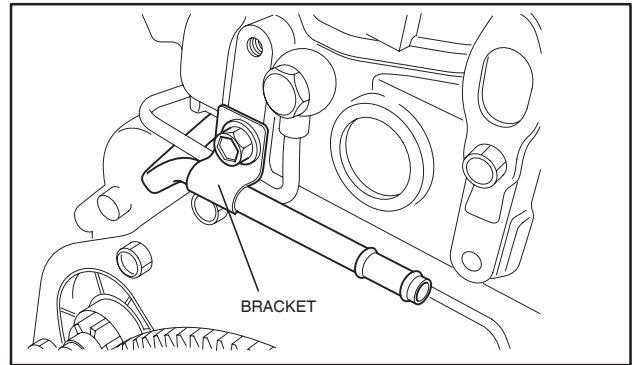


Fig. 18 – Remove Clamp

9. Remove two nuts, then remove coolant line assembly from turbocharger .

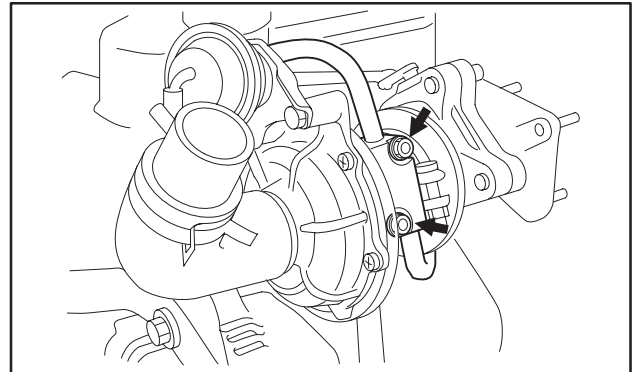


Fig. 19 – Removing Coolant Line

10. Remove oil inlet line union screw at turbo-charger. Discard the washer.

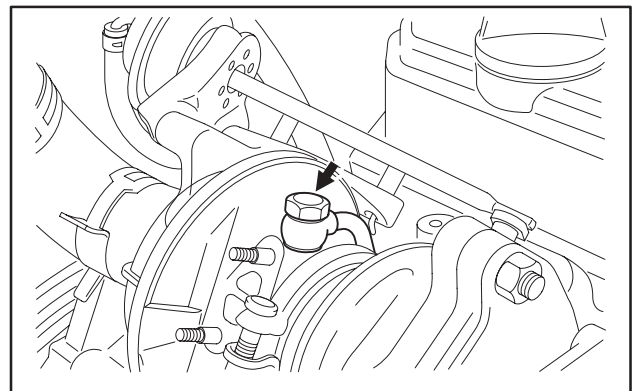


Fig. 20 – Removing Union Screw

11. Remove oil inlet line union screw at rear of cylinder head. Discard washers.

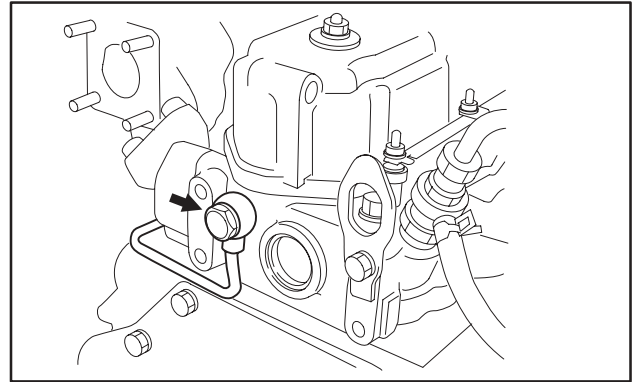


Fig. 21 – Removing Union Screw

12. Remove oil inlet line bracket screw at the exhaust manifold.

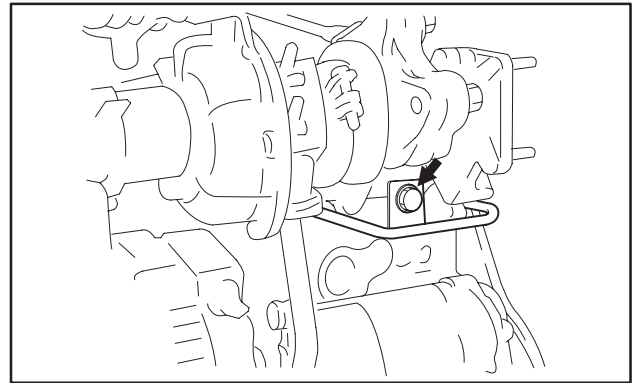


Fig. 22 – Removing Bracket Bolt

13. Remove two screws from turbocharger and pull out the oil outlet tube from the cylinder block. Discard “O” ring and gasket.

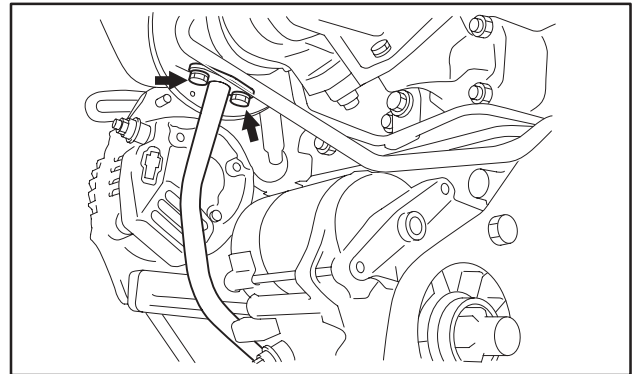


Fig. 23 – Removing Oil Outlet Tube

14. Remove screws (2) and nuts (3) and remove turbocharger mounting bracket. Discard gasket.

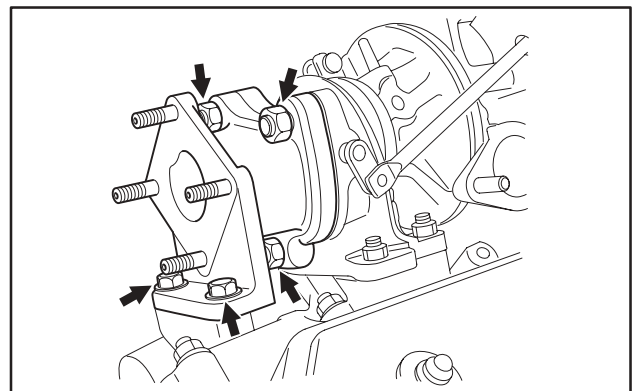


Fig. 24 – Removing Turbo Charger Bracket

TURBOCHARGER

15. Remove nuts (3), and remove the turbocharger assembly from the exhaust manifold.

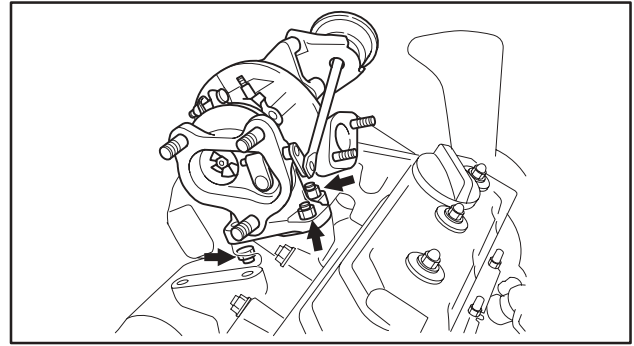


Fig. 25 – Removing Turbocharger Assembly

NOTE: When removing the turbocharger assembly, DO NOT lift or carry turbocharger by the waste gate actuator rod. Use tape to cover the oil inlet and outlet ports, coolant ports, air intake and exhaust port.

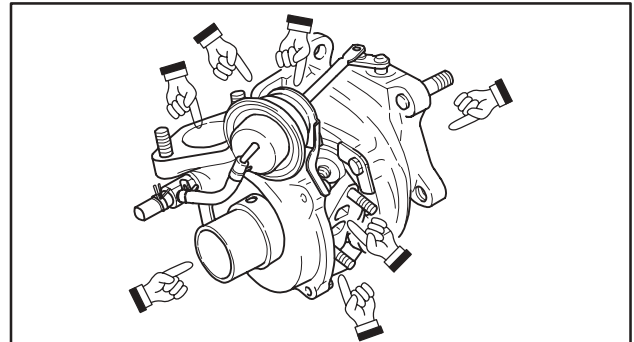


Fig. 26 – Removing Turbocharger Assembly

CHECKING TURBOCHARGER

1. Check blades of turbine and compressor for damage.
2. Rotate the blades by hand, and ensure that they turn freely without contacting the housing.
3. Check that oil is not leaking at the turbine side.
4. Check oil inlet union screws for dirt or debris. If the union screw is clogged, clean it using compressed air as shown below.

NOTE: If union screws are clogged, clean or replace the oil inlet line.

5. Check each part for damage or cracks. Replace defective parts.

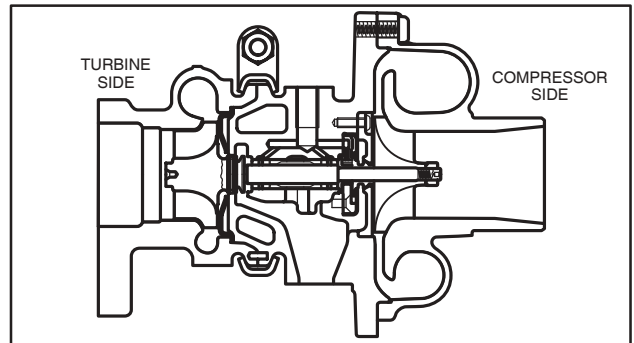


Fig. 27 – Checking Turbocharger Assembly

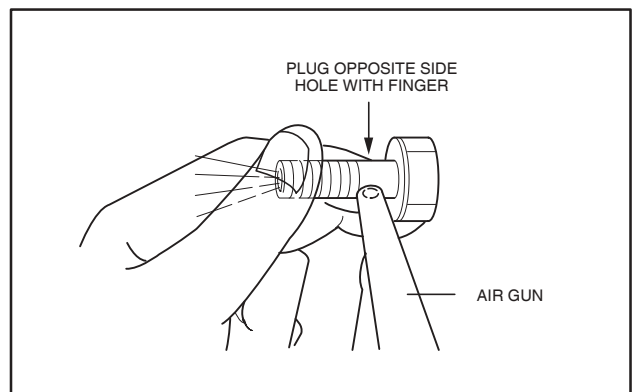


Fig. 28 – Cleaning Union Screw

INSTALL TURBOCHARGER

1. Install the turbocharger assembly with new gasket.
 - a. Torque nuts (3) to 25 Nm (18.0 ft.-lb).

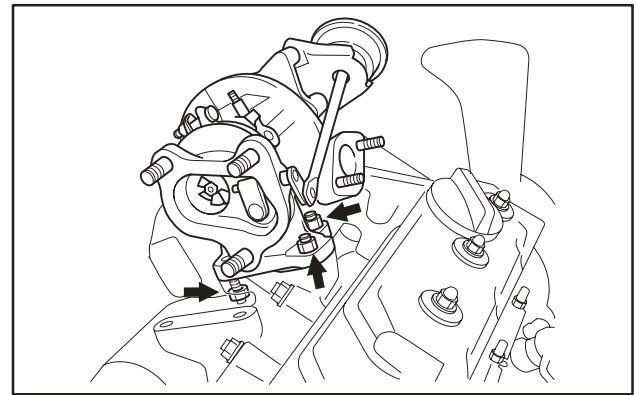


Fig. 29 – Installing Turbocharger Assembly

2. Install the turbocharger bracket with new gasket.
 - a. Temporarily tighten the nuts 1 and bolts 2 until the flange surfaces of the turbocharger, exhaust manifold and turbocharger stay in contact each other.
 - b. First torque nuts 1 to 34.0 Nm (25.0 ft.-lb)
 - c. Then torque screws 2 to 29.0 Nm (20.0 ft.-lb)

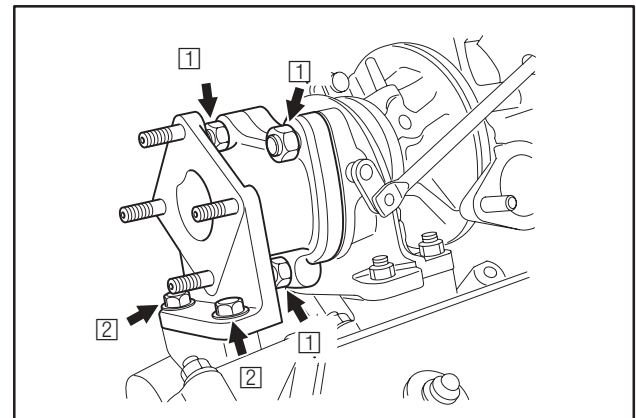


Fig. 30 – Installing Turbocharger Bracket

3. Install oil outlet line.
 - a. Insert the oil outlet tube into the cylinder block with new "O" ring.
 - b. Assemble to turbocharger with new gasket.
 - c. Torque screws to 8.0 Nm (70.0 in.-lb).

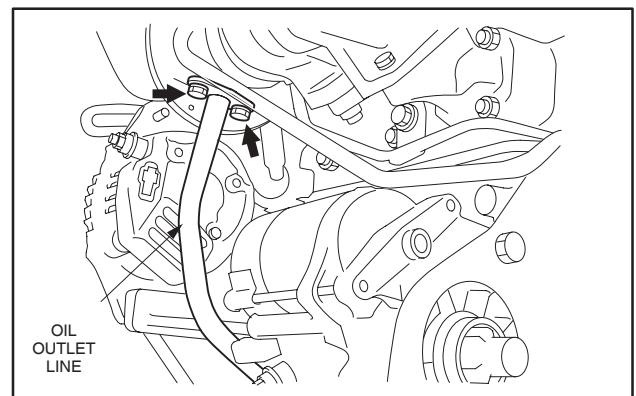


Fig. 31 – Installing Oil Outlet Tube

TURBOCHARGER

4. Install oil inlet line.
 - a. Temporarily install the union screw with washers at the cylinder head.
 - b. Temporarily install the union screw with washer at the turbocharger.
 - c. Temporarily install the inlet line bracket screw.
 - d. Then torque union screws and bracket screw.

Union screws:

Cylinder head side –	Turbocharger side –
44.0 Nm	18.0 Nm (170 in-lb)
(32.0 ft.-lb)	

Bracket screw:

19.0 Nm (170. in-lb)

5. Install Coolant Line at turbocharger with new gasket.
 - a. Torque nuts to 8.0 Nm (70 in. lbs.).

6. Install bracket screw.
 - a. Torque screw to 19.0 Nm (170 in. lbs.).

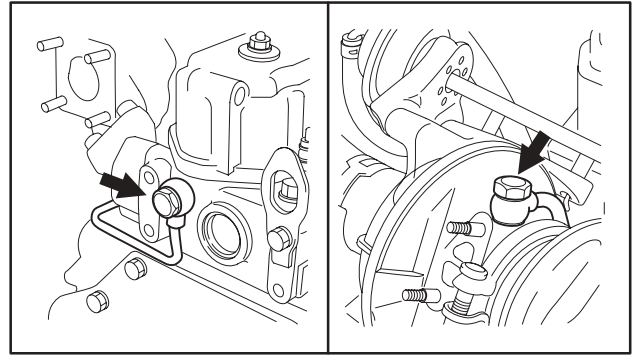


Fig. 32 – Installing Oil Inlet Line

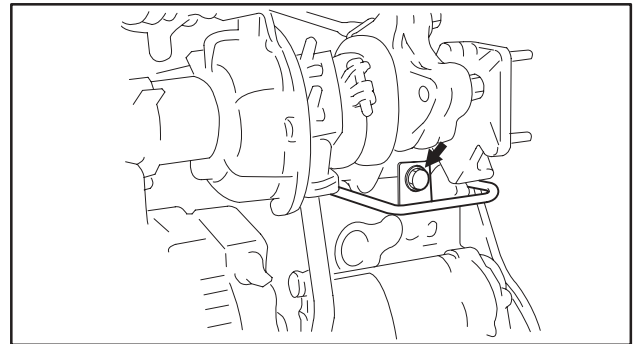


Fig. 33 – Installing Bracket Screw

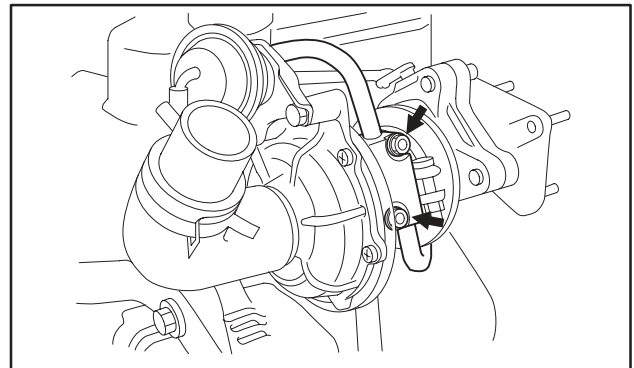


Fig. 34 – Installing Coolant Line

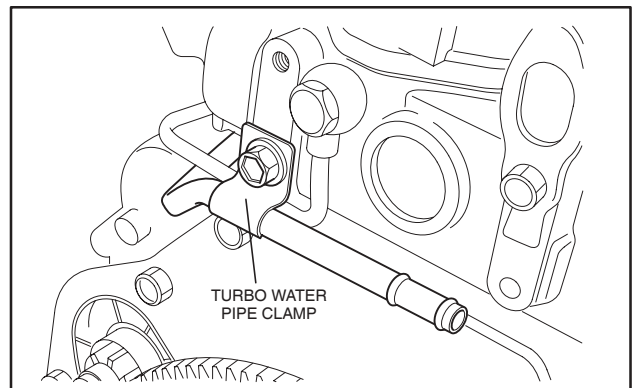


Fig. 35 – Install Bracket Screw

7. Install coolant outlet hose from turbocharger to coolant inlet housing as shown, Fig. 36. Install clamps with tabs as shown.

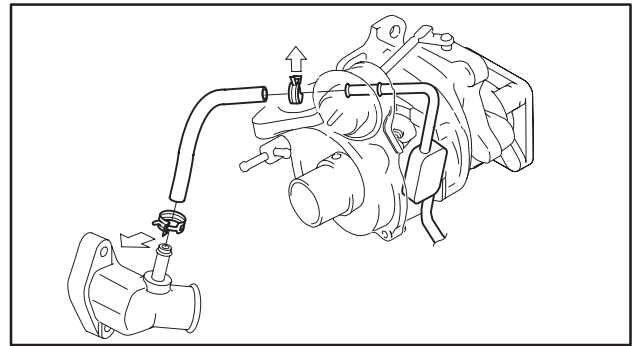


Fig. 36 – Install Coolant Outlet Hose

8. Install coolant inlet hose over inlet tube up to yellow mark on tube. Install clamps with tabs as shown.

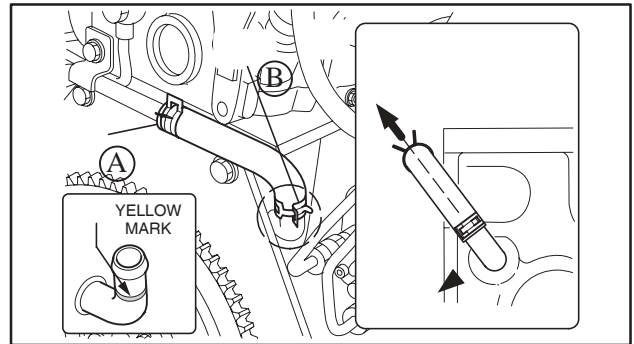


Fig. 37 – Install Coolant Inlet Hose

9. Install air intake pipe.
 - a. Torque nuts to 13.0 Nm (115 in. lbs.).

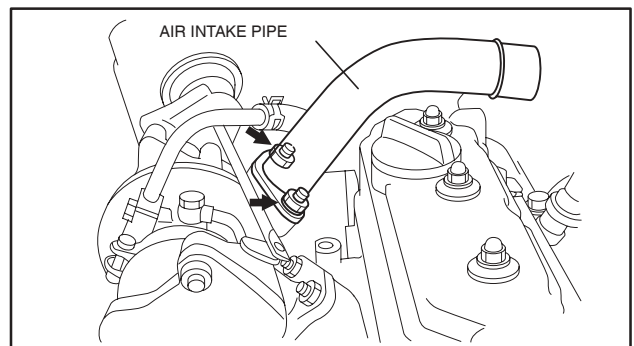


Fig. 38 – Installing Air Intake Pipe

10. Align the match marks (white paint), and install the air intake hose onto the air intake pipe.

Installation direction of clamps:

- Ⓐ Install the clamp so that tabs face rear of engine.
- Ⓑ Install the clamp so that tabs face out.

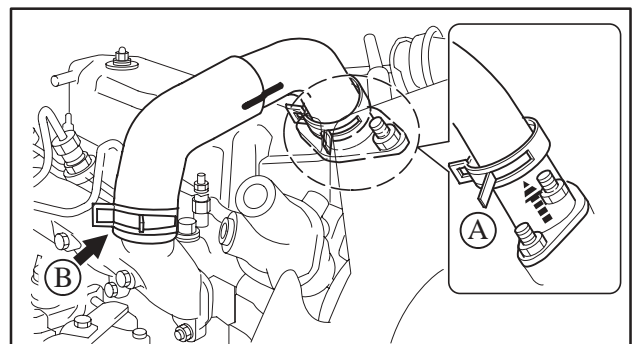


Fig. 39 – Installing Air Intake Hose

TURBOCHARGER

11. Install breather tube as shown.
12. Install muffler or exhaust pipe.
13. Connect the air hose connecting the air cleaner to the turbocharger.

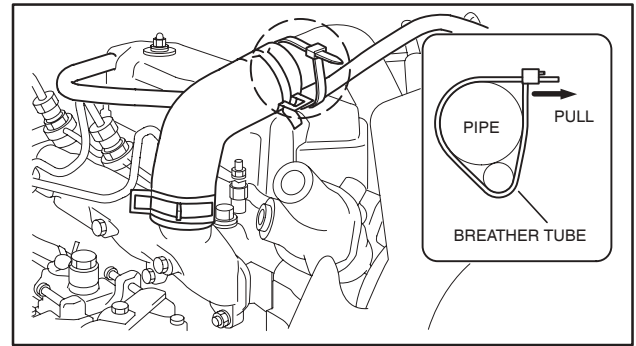


Fig. 40 – Installing Clamp

INSTALLATION OF COOLANT INLET TUBE

1. Apply sealer to the portion of tube that is to be installed in cylinder block.
2. Align the center of tube with the center of M10 thread at the rear end of the cylinder block.
3. Press-in tube until flange contacts the cylinder block.

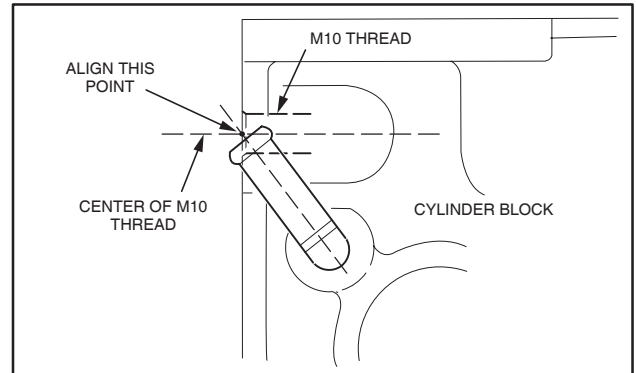


Fig. 41 – Installing Tube

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