SB2215E01
Oct.2001

Service Manual

G424 Gasoline/LP Engine
G424 LP Engine (Low Emission Version)

G20E-3, G25E-3, G30E-3
GC20E-3, GC25E-3, GC30E-3

Important Safety Information

Most accidents involving product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Read and understand all safety precautions and warnings before operating or performing lubrication, maintenance and repair on this product.

Basic safety precautions are listed in the “Safety” section of the Service or Technical Manual. Additional safety precautions are listed in the “Safety” section of the owner/operation/maintenance publication.
Specific safety warnings for all these publications are provided in the description of operations where hazards exist. WARNING labels have also been put on the product to provide instructions and to identify specific hazards. If these hazard warnings are not heeded, bodily injury or death could occur to you or other persons. Warnings in this publication and on the product labels are identified by the following symbol.

⚠ WARNING

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.
Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Operations that may cause product damage are identified by NOTICE labels on the product and in this publication.

DAEWOO cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are therefore not all inclusive. If a tool, procedure, work method or operating technique not specifically recommended by DAEWOO is used, you must satisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the operation, lubrication, maintenance or repair procedures you choose.

The information, specifications, and illustrations in this publication are on the basis of information available at the time it was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service given to the product. Obtain the complete and most current information before starting any job. DAEWOO dealers have the most current information available.

Index

GENERAL INFORMATION

How To Read This Manual

Scope of Explanation

This book describes the service procedures for the engine removed from the vehicle.
For procedures concerning removal of the engine from the vehicle and on-vehicle inspection and servicing, refer to the appropriate service manuals separately prepared for the individual models.

Maintenance and Servicing Procedures

(1) A diagram of the component parts is provided near the front each section in order to give the reader a better understanding of the installed condition of component parts.

(2) The numbers provided within the diagram indicate the sequence for maintenance and servicing procedures; the symbol [N] indicates a non-reusable part; the tightening torque is provided where applicable.

- Removal steps:
  The part designation number corresponds to the number in the illustration to indicate removal steps.
- Installation steps:
  Specified in case installation impossible in reverse order of removal steps. Omitted if installation is possible in reverse order of removal steps.
- Disassembly steps:
  The part designation number corresponds to the number in the illustration to indicates disassembly steps.
- Reassembly steps.
  Specified in case reassembly is impossible in reverse order of disassembly steps. Omitted if reassembly is possible in reverse order of disassembly steps.

Classification of Major Maintenance/Service points
When there are major points relative to maintenance and servicing procedures (such as essential maintenance and service points, maintenance and service standard values, information regarding the use of special tools, etc.), these are arranged together as major maintenance and service points and explained in detail.
⟵ A ⟶ : Indicates that there are essential points for removal or disassembly.
⟶ B ⟵ : Indicates that there are essential points for installation or reassembly.

Symbols for Lubrication, Sealants and Adhesives
Information concerning the locations for lubrication and for application of sealants and adhesives if provided, by using symbols, in the diagram of component parts, or on the page following the component parts page, and explained.

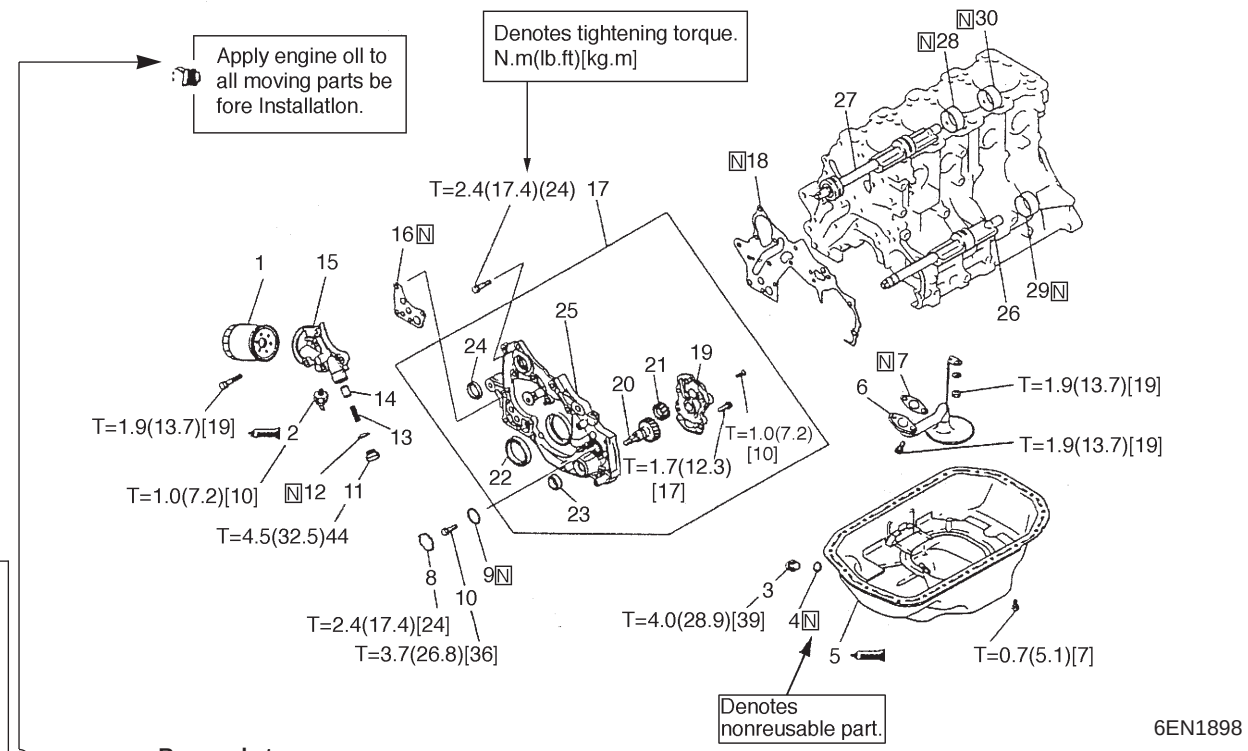
 .... Sealant or adhesive

 .... Engine oil or gear oil

Inspection
Only the inspections to be performed by using special tools or measuring instruments are covered. General service procedures not covered in this manual, such as visual inspections and cleaning of parts, however, should always be performed during actual service operations.

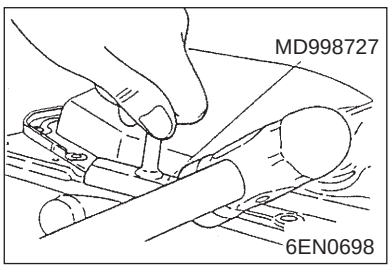
FRONT CASE AND OIL PAN
REMOVAL AND INSTALLATION

Indicates the section title.



Removal steps

- →N← 1. Oil filter
- →M← 2. Oil pressure switch
- 3. Drain plug
- →L← 4. Drain plug gasket
- ←A→ →K← 5. Oil pan
- 6. Oil screen
- 7. Oil screen gasket
- ←B→ →J← 8. Plug
- 9. O-ring
- ←C→ →I← 10. Flang bolt
- 11. Relief plug
- 12. Gasket
- 13. Relief spring
- 14. Relief plunger
- 15. Oil filter bracket
- 16. Oil filter bracket gasket
- →H← 17. Oil pump case assembly
- 18. Front case gasket
- G 19. Oil pump cover
- →G← 20. Oil pump drive gear
- →G← 21. Oil pump driven gear
- →F← 22. Crankshaft front oil seal
- →E← 23. Oil pump oil seal
- →D← 24. Counterbalance shaft oil seal
- 25. Front case
- 26. Counterbalance shaft, left
- 27. Counterbalance shaft, right
- ←D→ →C← 28. Counterbalance shaft, front bearing
- ←E→ →B← 29. Counterbalance shaft, rear bearing, left
- ←E→ →A← 30. Counterbalance shaft, rear bearing, right



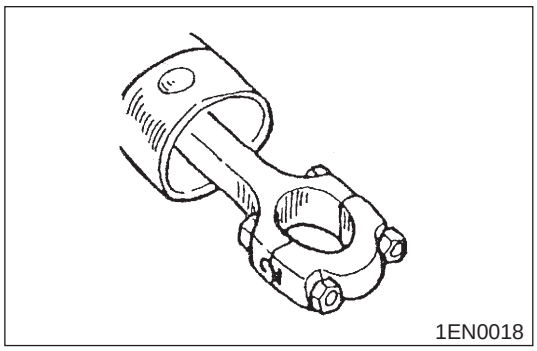
REMOVAL SERVICE POINTS

← A→ Oil pan removal

(1) Remove the all oil pan bolts.
(2) Drive in the special tool between the cylinder block and oil pan.
(3) Side the tool by striking the edge of the special tool to separate the oil pan from the cylinder block.

This alphabetical letter corresponds to the one assigned to a part in the removal, installation, disassembly or reassembly steps that are indicated in the drawing on the first page of each section.

Operating procedures, cautions, etc. on removal, installation, disassembly and reassembly are described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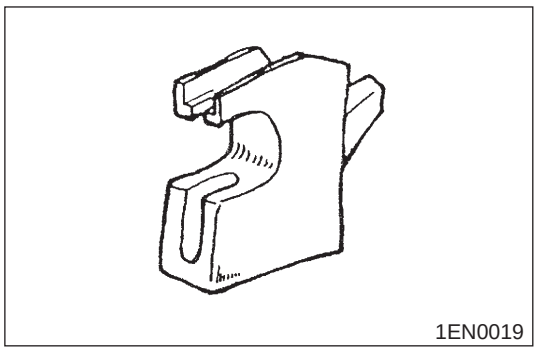
Precautions Before Servce

Removal and Disassembly

For prevention of wrong installation or reassembly and for ease of operation, put mating marks to the parts where no function is adversely affected.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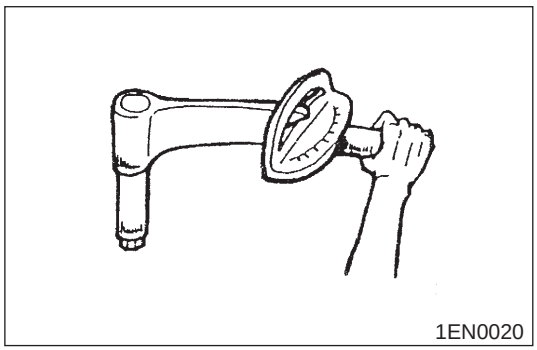
Special Tool

Be sure to use Special Tools when their use is specified for the operation.
Use of substitute tools will result in malfunction of the part or damage it.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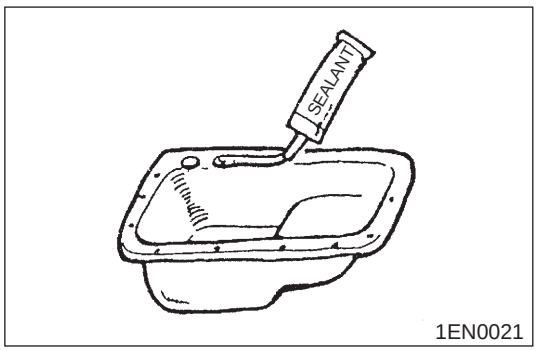
Tightening Torque

Tighten the part properly to specified torque.



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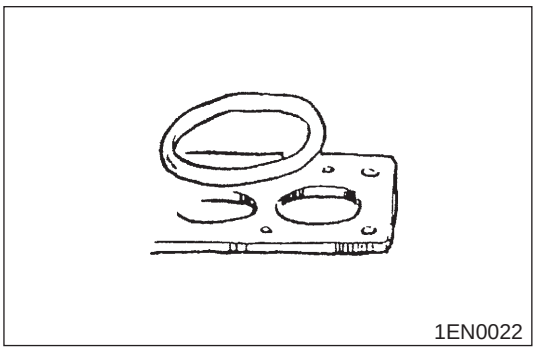
Sealant

Use specified brand of sealant.
Use of sealant other than specified sealant may cause water or oil leaks.



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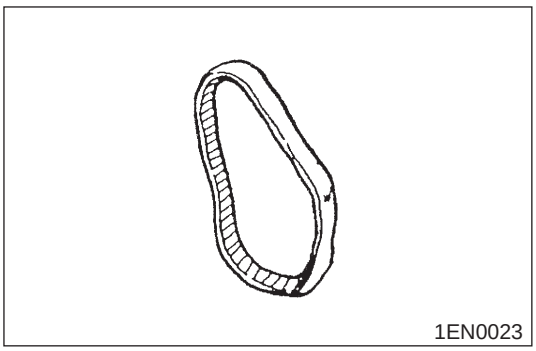
Replacement Part

When oil seal, O-ring, packing and gasket have been removed, be sure to replace them with new parts. However, rocker cover gasket may be reused if it is not damaged.



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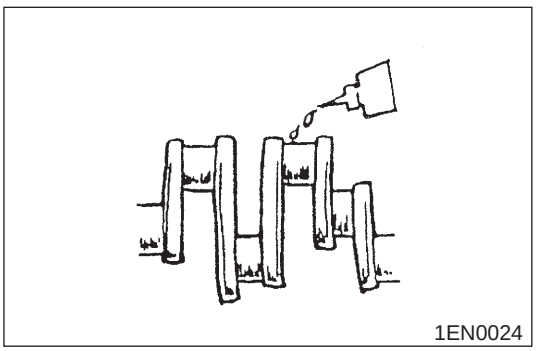
Rubber Parts

Do not stain timing belt and V-belt with oil or water. Therefore, do not clean the pulley and sprocket with detergent.



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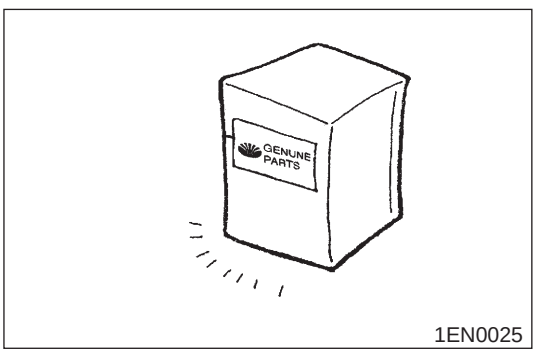
Oil and Grease

Before reassembly, apply specified oil to the rotating and sliding parts.



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Genuine Part

When the part is to be replaced, be sure to use genuine part.
For selection of appropriate parts, refer to the Parts Catalog.

General

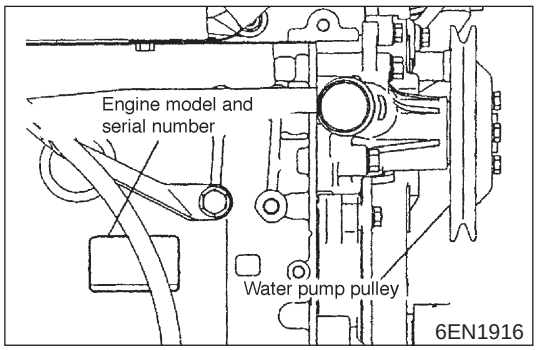
Engine models and numbers

Engine model	Fuel type
G424	Gasoline, LPG, LPG (Low Emission Version)

Indication of engine model and number

The engine model and serial number are stamped on the right side of cylinder block surface.

Engine model	Engine number
4G64	AA0001 to YY9999



Tightening Torque

Major Bolts and Nuts

Item			Torque			Remarks
			kg•m	lb•ft	N•m	
Ignition system	Water pump pulley bolt		0.9	6.5	9	
	Crankshaft pulley bolt		2.5	18.1	25	
	Spark plug		2.5	18.1	25	
	Distributor nut		1.2	8.7	12	
Tensioner belt	Timing belt cover bolt		1.1	8.0	11	
			0.9	6.5	9	
	Tensioner spring spacer		4.9	35.4	48	
	Tensioner bolt		4.9	35.4	48	
	Oil pump sprocket nut		5.5	39.8	54	
	Crankshaft bolt		12.0	86.8	118	
	Tensioner B bolt		1.9	13.7	19	
	Counterbalance shaft		4.6	33.3	45	
	Engine support bracket bolt		3.6	26.0	35	
	Camshaft sprocket bolt		9.0	65.1	88	
	Timing belt rear bolt		1.4	10.1	14	
Fuel system carburetor	Carburetor nut		1.2	8.7	12	
	Air horn nut		1.2	8.7	12	
	Stud		1.2	8.7	12	
	Fuel pump		1.1	8.0	11	
Fuel system LPG carburetor	LPG carburetor nut		1.2	8.7	12	
	Fuel pump cover		1.1	8.0	11	
Intake manifold	Water outlet bolt		1.4	10.1	14	
	Intake manifold bolt/nut		1.8	13.0	18	
Exhaust manifold	Oil level gauge guide bolt		1.4	10.1	14	
	Heat protector bolt		0.9	6.5	9	
	Exhaust manifold nut		3.5	25.3	34	
	Water inlet pipe bolt		1.4	10.1	14	
	Water pump bolt		1.4	10.1	14	
Rocker arm and camshaft	Rocker cover bolt		0.6	4.3	6	
	Bearing cap bolt	M8 × 25	2.4	17.4	24	
		M6 × 65	2.0	14.5	20	
Cylinder head, valve	Cylinder head bolt		8.0 kgf•m(57.9 lb•ft)[78 N•m]+ 0 + 2.0 kgf•m(14.5 lb•ft)[20 N•m]+ 1/4 turn + 1/4 turn			

Item		Torque			Remarks
		kg•m	lb•ft	N•m	
Front case, doil pan	Drain plug	4.0	28.9	39	
	Oil pan bolt	0.7	5.1	7	
	Oil screen bolt/nut	1.9	13.7	19	
	Oil pressure switch	1.0	7.2	10	
	Plug	2.4	17.4	24	
	Flange bolt	3.7	26.8	36	
	Relief plug	45	32.5	44	
	Oil filter bracket	1.9	13.7	19	
	Oil pump cover bolt	1.7	12.3	17	
	Oil pump cover screw	1.0	7.2	10	
	Front case bolt	2.4	17.4	24	
Piston, connecting rod.	Connecting rod bearing nut	2.0 kg•m(14.5 lb•ft) [20 N•m]+ 1/4 turn			
Crankshaft, cylinder block	Flywheel bolt	13.5	97.6	132	
	Rear plate bolt	0.9	6.5	9	
		6.0	43.4	59	
	Rear plate cover	1.1	8.0	11	
	Oil seal case bolt	1.1	8.0	11	
	Bearing cap bolt	2.0 kg•m(14.5 lb•ft) [20 N•m]+ 1/4 turn			
Starter motor	Starter motor bolt	2.7	19.5	26	

General Bolts and Nuts Tightening Torque

Standard Bolts and Nuts

Nominal diameter	Pitch	Torque, kg•m (lb•ft) [N•m]				
		Bolt, stud, nut (with spring washer)			Flange bolt, flange nut	
		Head mark 4	Head mark 7	Head mark 10	Head mark 4	Head mark 7
M5	M5	-	0.5 (0.5) [3.6]	-	-	0.6 (4.3) [5.9]
M6	M6	-	0.9 (6.5) [8.8]	1.2 (8.7) [12]	-	1.0 (7.2) [9.8]
M7	M7	1.2 (8.7) [12]	2.2 (15.9) [22]	3.0 (21.7) [29]	1.3 (9.4) [13]	2.4 (17.4) [24]
M8	M8	2.5 (18.1) [25]	4.5 (32.5) [44]	6.0 (43.4) [59]	2.6 (18.8) [25]	5.0 (36.2) [49]
M9	M9	4.2 (30.4) [41]	8.6 (60.0) [81]	10.7 (77.4) [105]	4.7 (34.0) [46]	9.5 (68.7) [93]
M10	M10	7.3 (52.8) [72]	14.0 (101.3) [137]	14.5 (104.9) [142]	-	-

Tapered Threads

Size	Torque, kg•m (lb•ft) [N•m]	
	Material of internal threads: Aluminum alloy	Material of internal threads: Cast iron or steel
NPTF 1/16	0.5 to 0.8 (3.6 to 5.8) [5 to 8]	0.8 to 1.2 (5.8 to 8.7) [8 to 11]
PT 1/8	0.8 to 1.2 (5.8 to 8.7) [8 to 11]	1.5 to 2.2 (10.8 to 15.9) [15 to 21]
PT 1/4	2.0 to 3.0 (14.5 to 21.7) [20 to 29]	3.5 to 4.5 (25.3 to 32.5) [34 to 44]
NPTF 1/4	2.0 to 3.0 (14.5 to 21.7) [20 to 29]	3.5 to 4.5 (25.3 to 32.5) [34 to 44]
PT 3/8	4.0 to 5.5 (28.9 to 39.8) [39 to 59]	5.5 to 7.5 (39.8 to 54.2) [54 to 73]
PT 1/2	7.0 to 10.0 (50.6 to 72.3) [69 to 98]	12.0 to 16.0 (86.8 to 115.7) [118 to 156]

New Tightening Method-By Use of Bolts to be Tightened in Plastic Area

A new type of bolts, to be tightened in plastic area, is currently used in some parts of the engine. The tightening method for the bolts is different from the conventional one. Be sure to observe the method described in the text when tightening the bolts.

Service limits are provided for the bolts. Make sure that the service limits described in the text are strictly observed.

- Area where the bolts are in use:
  (1) Cylinder head bolts
  (2) Main bearing cap bolts
  (3) Connecting rod cap bolts

- Tightening method
  After tightening the bolts to the specified torque, tighten them another 90° or 180° (twice 90°). The tightening method varies on different areas. Observe the tightening method described in the text.

Sealant

Part to be Applied	Brand
Semi circular packing	3M™ AAD Part No.8672 or equivalent
Rocker cover	3M™ AAD Part No.8672 or equivalent
Oil pressure switch	3M™ AAD Part No.8672 or equivalent
Oil pan	Silicone RTV sealant or eguivalent
Rear oil seal case	Silicone RTV sealant or eguivalent
Rear plate bolt	3M™ AAD Part No.8672 or equivalent
Oil seal case bolt	3M™ AAD Part No.8672 or equivalent

From in Place Gasket(FIPG)

The engine has several areas where the from-in-place gasket(FIPG) is in use. To ensure that gasket fully serves its purpose, it is necessary to observe some precautions when applying the gasket. Bead size, continuity and location are of paramount importance. Too thin a bead could cause leaks. Too thick a bead, on the other hand, could be squeezed out of location, causing blocking or narrowing of the fluid feed line. To eliminate the possibility of leaks from a joint, therefore, it is absolutely necessary to apply the gasket evenly without a break, while observing the correct bead size.

Since the FIPG used in the engine hardens as it reacts with the moisture in the atmospheric air, it is normally used in the metallic flange areas.

Disassembly

The parts assembled with the FIPG can be easily disassembled without use of a special method. In some cases, however, the sealant between the joined surfaces may have broken by lightly striking with a mallet or similar tool. A flat and thin gasket scraper may be lightly hammered in between the joined surfaces. In this case, however, care must be taken to prevent damage to the joined surfaces. For removal of the oil pan, the special tool “Oil Pan Remover” (MD998727) is available. Be sure to use the special tool to remove the oil pan.

Surface preparation

Thoroughly remove all substances deposited on the gasket application surfaces, using a gasket scraper or wire brush.
Check to ensure that the surfaces to which the FIPG is to be applied is flat. Make sure that there are no oils, greases and foreign substances deposited on the application surfaces. Do not forget to remove the old FIPG remaining in the bolt holes.

From-in-place gasket Application

Applied FIPG bead should be of the specified size and without breaks. Also be sure to encircle the bolt hole circumference with a completely continuous bead. The FIPG can be wiped away unless it is hardened. While the FIPG is still moist (in less than 15 minutes), mount the parts in position. When the parts are mounted, make sure that the gasket is applied to the required area only.

The FIPG application procedure may vary on different areas. Observe the procedure described in the text when applying the FIPG.

SPECIFICATIONS

General Specifications

Item \ Engine model			G424
Type			Water-cooled, 4-cycle, gasoline-powered and L.P.G.-powered
No. of cylinders and arrangement			4, in-line
Combustion chamber type			Semi-spherical
Valve mechanism			OHC
Total displacement, cm^3(cc) [cu in.]			2350 (2350) [143]
Bore x stroke, mm (in.)			86.5 × 100 (3.41 × 3.94)
Dry weight, kg (lb)			146 (322)
Compression ratio			8.6
Compression pressure, kPa (kgf/cm^2) [psi]			1128 (11.5) [163.5]
Valve timing	Intake valve	Open	12° BTDC
		Close	40° ABDC
	Exhaust valve	Open	54° BBDC
		Close	6° ATDC
Firing order			1 - 3 - 4 - 2
Ignition timing, BTDC/rpm			4°/740 (gasoline), 9°/740 (L.P.G.), 4°/740(dual fuel)
Fuel pump		Gasoline	Mechanical (diaphragm type)
Carburetor			Down-draft type
Governor			Air flow type
Lubrication system			Pressure feed, full-flow filtration type
Oil pump			Gear, driven by timing belt
Oil filter			Filter paper, cartridge type
Cooling system			Water-cooled, forced circulation
Water pump			Centrifugal, driven by V-belt
Thermostat			Wax type
Electrical system			12V DC, negative ground
Alternator, (12V-61A)			Alternator current, built-in fan and regulator
Starter motor, (12V-1.2kW)			Reduction drive
Distributor			Equipped with automatic timing controller, breaker less type
Spark plug (NGK)		Gasoline	BPR4ES
		L. P. G.	BPR5ES
Quantity of lubricating oil, cm^3 (liter) [U.S.gal]			4000(4.0) [1.06](including 300 cm^3(0.3 liter)[0.08 U.S.gal]in oil filter
Quantity of coolant, cm^3 (liter) [U.S.gal]			3100 (3.1) [0.82] (in engine proper)
IDLE RPM	LOW (RPM)		700 ± 25
	HIGH (RPM)		2700 ± 50

Service Specifications

Unit : mm(in.)

Item				Standard value	Limit	Remarks
Cylinder head	Flatness of gasket surface			0.03 (0.0012)		
	Grinding limit				0.2 (0.008)	Total resurfacing depth of both cylinder head and cylinder block
	Overall height			89.9 to 90.1 (3.539 to 3.547)		
	Oversize rework dimensions of valve guide hole		0.05 (0.0020)	13.05 to 13.07 (0.5138 to 0.5146)		
			0.25 (0.0098)	13.25 to 13.27 (0.5217 to 0.5224)		
			0.50 (0.0197)	13.50 to 13.57 (0.5315 to 0.5343)		
	Oversize rework dimensions of valve seat ring hole	Intake	0.30 (0.0118)	47.30 to 47.33 (1.8622 to 1.8634)		
			0.60 (0.0236)	47.60 to 47.63 (1.8740 to 1.8752)		
		Exhaust	0.30 (0.0118)	40.30 to 40.33 (1.5866 to 1.5878)		
			0.60 (0.0236)	40.60 to 40.63 (1.5984 to 1.5996)		
Camshaft	Cam height		Intake	41.62 (1.6386)	41.12 (1.6189)	
			Exhaust	41.62 (1.6386)	41.12 (1.6189)	
	Journal diameter			33.935 to 33.950 (1.33602 to 1.33661)		
	Oil clearance			0.05 to 0.09 (0.0020 to 0.0035)		
Valve	Overall length		Intake	106.6 (4.197)	106.1 (4.126)	
			Exhaust	105.2 (4.142)	104.7 (4.122)	
	Valve stem projection			42.05 (1.6555)	42.55 (1.6752)	
	Stem diameter		Intake	7.960 to 7.975 (0.31339 to 0.31398)		
			Exhaust	7.930 to 7.950 (0.31220 to 0.31299)		
	Face angle			45° to 45.5°		
	Thickness of valve head (margin)		Intake	1.2 (0.047)		
			Exhaust	2.0 (0.079)		
	Stem-to-guide clearance		Intake	0.025 to 0.058 (0.00098 to 0.00228)		
			Exhaust	0.050 to 0.088 (0.00197 to 0.00346)		
Valve spring	Free height			48.0 (1.89)	47.0 (1.85)	
	Load/installed height			176.5N (18kg) [39.7lbf]/40.4 (1.591)		
	Out-of-squareness			2° or less	4°	
Valve guide	Overall length		Intake	47 (1.85)		
			Exhaust	52 (2.05)		
	Inner diameter			8.000 to 8.018 (0.31496 to 0.31567)		
Valve seat	Valve contact width			0.9 to 1.3 (0.035 to 0.051)		
	Sinkage				0.2 (0.008)	
Piston	Outside diameter			86.47 to 86.50 (3.4043 to 3.4055)		
	Piston clearance			0.02 to 0.04 (0.0008 to 0.0016)		

Unit : mm(in.)

Item			Standard value	Limit	Remarks
Piston ring	End gap	No. 1 ring	0.25 to 0.40 (0.0098 to 0.0157)	0.8 (0.031)	
		No. 2 ring	0.45 to 0.60 (0.0177 to 0.0236)	0.8 (0.031)	
		Oil ring	0.20 to 0.60 (0.0079 to 0.0236)	1.0 (0.039)	
	Ring-to-ring groove clearance	No. 1	0.03 to 0.07 (0.0012 to 0.0028)		
		No. 2	0.03 to 0.07 (0.0012 to 0.0028)		
Piston pin	Outside diameter		22.002 to 22.005 (0.86622 to 0.86634)		
	Press-in load (at room temperature), N (kg) [lbf]		7350 to 17160 (750 to 1750) [1650 to 3860]		
Connecting rod	Big end center-to small end center length		149.9 to 150.0 (5.902 to 5.906)		
	Bend		0.05 (0.0020)		
	Twist		0.10 (0.0039)		
	Big end thrust clearance		0.10 to 0.25 (0.0039 to 0.0098)		
Crankshaft	End play		0.05 to 0.18 (0.0020 to 0.0071)		
	Journal outside diameter		56.982 to 57.000 (2.24338 to 2.24409)		
	Pin Outside diameter		44.985 to 45.000 (1.77106 to 1.77165)		
	Out-of-roundness and taper of journal and pin		0.005 (0.00020)		
	Concentricity journal and pin		0.03 (0.0012)		
	Oil clearance of journal		0.02 to 0.04 (0.0008 to 0.0016)		
	Oil clearance of pin		0.02 to 0.05 (0.0008 to 0.0020)		
Cylinder block	Cylinder inner diameter		86.50 to 86.53 (3.4055 to 3.4067)		
	Flatness of gasket surface		0.05 (0.0020)		
	Grinding limit			0.2 (0.008)	Total resurfacing depth of both cylinder head and cylinder block
	Overall height		289.9 to 290.1 (11.413 to 11.421)		
Oil pump	Side clearance	Drive gear	0.08 to 0.14 (0.031 to 0.0055)		
		Drive gear	0.06 to 0.12 (0.0024 to 0.0047)		
Drive belt	Deflection	New belt	7.0 to 10.0 (0.28 to 0.39)		
		Used belt	10 (0.39)		
Carburetor	Throttle bore diameter		32 (1.26)		
	Outer venturi diameter		24 (0.94)		
	Inner venturi diameter		9 to 12 (0.35 to 0.47)		
	Main jet (Symbol Size)		132.5		
	Main air jet diameter		0.9 (0.035)		
	Pilot jet diameter		0.55 (0.0217)		
	Pilot air jet diameter		1.6 (0.063)		
	Primary throtle valve to throtle bore clearance		1.1(0.043)		

Unit : mm(in.)

Item			Standard value	Limit	Remarks
Starter motor	Nominal output, kW		1.2		
	No-load characterstics	Voltage, V	11.0		
		Current, A	90 or less		
		Speed, rpm	3000		
	Commutator	Outer diameter	29.4 (1.16)	28.8 (1.13)	
		Runout	0.05 (0.0020)	0.1 (0.0039)	
		Undercut	0.5 (0.020)	0.2 (0.008)	
	Pinion gap		0.5 to 2.0 (0.020 to 0.079)		
	Brush length			Wear limit line	
Distributor	Centrifugal advance crank angle/engine speed, °/rpm	Start	0°/1000		
		End	20°/5000		
	Vacuum advance crank angle/vacuum, °/mmHg	End	0°/80		
		Start	23°/280		
Ignition coil	Primary coil resistance, Ω		1.08 to 1.32		
	Secondary coil resistance, Ω		22.1 to 29.9		
Spark plug	Plug gap		0.7 to 0.8 (0.028 to 0.031)		
Tahermostat	Valve opening temperature, °C (˚F)		82 (180)		
	Fully opening temperature, ˚C (˚F)		95 (203)		
	Valve lift		8 (0.31) or more		
Oil Pressure		Low Idle	50 kPa(7psi)		
		High Idle	450 kPa(65psi)		

MAINTENANCE

G424 engine requires a certain amount of maintenance. Suggested maintenance requirements are contained in this section. The owner should, however, develop his own maintenance schedule using the requirements listed in this section and any other necessary requirements resulting from optional additions to the engine system.

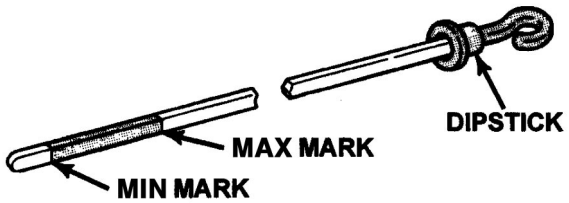
Test Fuel System for Leaks

- Obtain a pump spray bottle.
- Fill with an approved leak test solution or a mixture of water and dish soap.
- Spray a generous amount of the solution on the entire fuel system including the fuel storage container and fuel lines.
- Wait approximately 15-60 seconds then perform a visual inspection of entire fuel system.
- Leaks will cause the soapy solution to bubble.
- Repair any leaks before continuing.
- Crank the engine through several revolutions. This will energize the fuel lock and allow fuel to flow to the pressure regulator/vaporizer. Apply additional leak test solution to this portion of the fuel system and inspect as above.
- Repair any fuel leaks before continuing.

Check Engine Oil Level

IMPORTANT : Care must be taken when checking engine oil level. Oil level must be main-tained between the "MIN" mark and the "MAX" mark on the dipstick. To ensure that you are not getting a false reading, make sure the following steps are taken before checking the oil level.

1. Stop engine if in use.
2. Allow sufficient time (approximately 2 minutes) for the oil to drain back into the oil pan.
3. Remove dipstick. Wipe clean and reinstall. Push dipstick all the way into the dipstick tube.
4. Remove dipstick and note the oil level.
5. Oil level must be between the "MAX" and "MIN" marks.
6. If the oil level is below the "MIN" mark, proceed to Steps 7 and 8, and reinstall dipstick into the dipstick tube.
7. Remove oil filler cap from the valve rocker arm cover.
8. Add required amount of oil to bring level up to, but not over, the "MAX" mark on dipstick.



NOTE: When refill engine oil, refill same oil as that used before.

Inspect Engine for Fluid Leaks

- Start engine and bring up to operating temperature.
- Turn engine off.
- Inspect entire engine for oil and/or coolant leaks.
- Repair any/all leaks before continuing.

Change Engine Oil &Filter

- Start engine.
- Bring up to operating temperature.
- Shut down engine.
- Remove oil fill cap located in valve cover.
- Place drain pan under engine oil pan.
- Remove oil drain plug located at bottom of oil pan and allow engine oil to drain.

  CAUTION : OIL WILL BE HOT.
- Remove engine oil filter. Make sure the oil filter gasket does not stick to engine.

  CAUTION : OIL WILL BE HOT.
- Using a clean shop towel clean the engine oil filter gasket mating surface.
- Fill oil filter with engine oil.

- Lube oil filter gasket with engine oil.
- Install oil filter as per filter manufacturers instructions. DO NOT OVER TIGHTEN
- Fill crankcase with engine oil.
- Start engine & run approximately 60 seconds.
- Shut down engine, wait approximately 2 - 5 minutes and then check oil level.
- When oil level is satisfactory start engine and check for any possible leaks.
- Repair any/all leaks before returning unit to service.

NOTE

Engine Oil Specification : See, Lubrication System section

Inspect Accessory Drive Belts

See, "Testing & Adjusting" of Cooling System Section.

Inspect electrical system

- Clean battery outer surfaces with a mixture of baking soda and water.
- Inspect battery outer surfaces for damage. Replace as required.
- Remove battery cables and clean.
- Inspect battery cables for worn or missing insulation, frayed wire and/or corrosion. Replace as required.

Inspect Vacuum Lines and Fittings

- Visually inspect vacuum lines and fittings for physical damage such as brittleness, cracks, kinks and misrouting. Repair/replace as required.
- Solvent damage may cause vacuum lines to become soft. Vacuum lines damaged by oil and/or other solvents may collapse when the engine is running effectively closing the passage inside the line.

Check Coolant Level

- Engine must be off and cold.
- NEVER REMOVE THE PRESSURE CAP ON A HOT ENGINE.
- The coolant level should be equal to the "COLD" mark on the coolant recovery tank. Periodically remove the cooling system pressure cap and check coolant level inside system. The coolant level should be equal to the sealing surface of the pressure cap. If level is low replace pressure cap and repair any/all other leaks.
- On closed systems visually inspect the coolant recovery tank and hoses for physical damage
- On open systems carefully remove cooling system pressure cap. Coolant level will be approximately 30-40 mm below pressure cap sealing surface. If level is low replace pressure cap and repair any/all other leaks.

Inspect Coolant Hoses

- Visually inspect coolant hoses and clamps.
- Replace any hose that shows signs of swelling, cracking, abrasion hardening or any other damage/deterioration.
- Top-up cooling system with approved coolant.

Inspect Ignition System

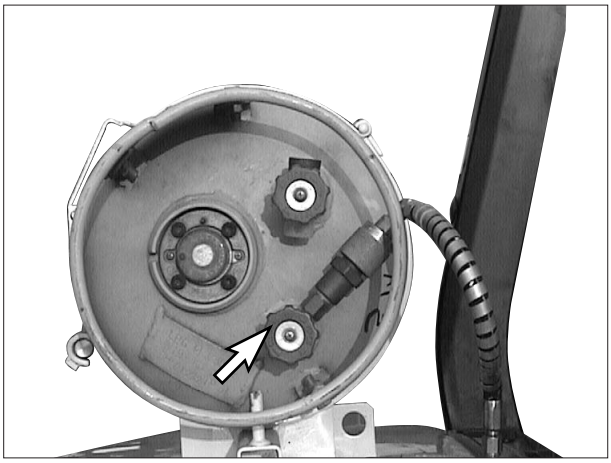
- Remove and inspect spark plugs. Replace as required.
- Test secondary wires with an Ohmmeter. Maximum resistance repair replace as required.
- Remove distributor cap and perform visual inspection of distributor cap and rotor. Replace cap & rotor if corrosion is found on contacts.
- Inspect distributor breaker unit and housing for signs of corrosion. Repair replace as required.

Replace Spark Plugs

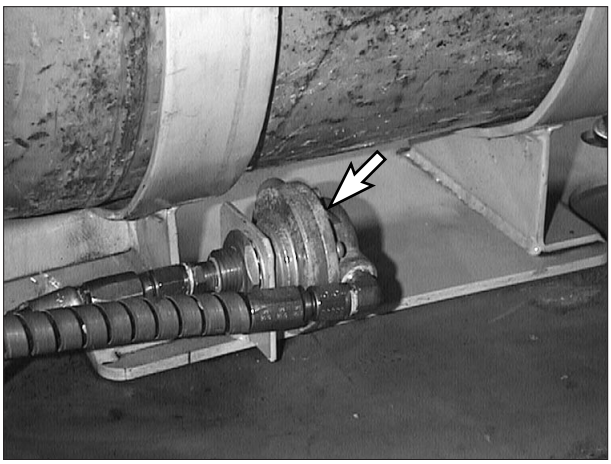
- Utilizing a gentle twisting motion remove the secondary high voltage leads from the spark plugs. Replace any damaged leads.
- Remove the spark plugs.
- Gap new spark plugs to proper specs.
- Apply anti-seize compound to spark plug threads.
- Install spark plugs.
- Do not over tighten.
- Install secondary high voltage leads.

Replace LP Fuel Filter Element

Park the lift truck in an authorized refueling area with the forks lowered, parking beake applled and the transmission in NEUTRAL.

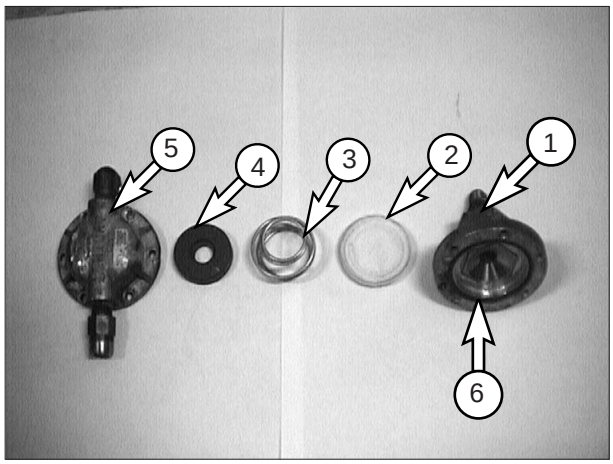


1. Close the fuel shutoff valve on the LP-Gas tank. Run the engine until fuel in the line runs out and the engine stops. Turn off the ignition switch and disconnect switch (if equipped).



2. Scribe a line across the filter housing covers.

3.Remove the cover retaining screws.



4. Remove cover (5), magnet (4), spring (3) and filter element (2) from bottom cover (1).
5. Replace the filter element (2).
6. Check bottom cover O-ring seal (6) for damage. Replace it if necessary.
7. Install the filter element (2), spring (3), magnet (4) and cover (5) on bottom cover (1). Align the scribe line on the covers.
8. Install the cover retaining screws. Tighten the screws in a sequence opposite each other.
9. Open the fuel valve by slowly turning the valve counterclockwise.
10. Crank the engine only enough to produce a vacuum at the fuelock. Turn the ignition key switch off.
11. Check the fuel lines and fittings for leaks with a soap solution. Make repairs if necessary.

Test Fuel Lock (Electric)

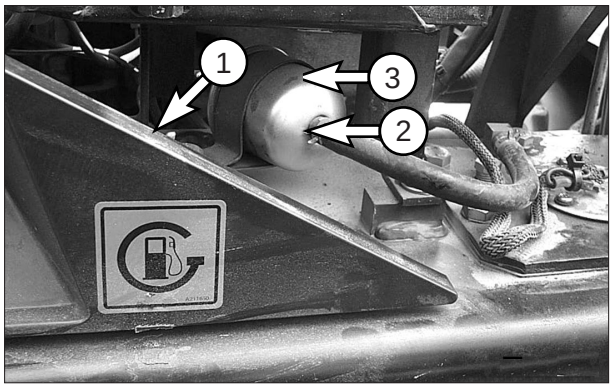
- Start engine.
- Locate electrical connector for fuel lock.
- Disconnect electrical connector.
- Engine will run out of fuel and stop in a short period of time. (The length of time increases with any increase in distance between the fuel lock and the pressure regulator).

Replace Gasoline Fuel Filter (Gasoline Truck and Dual Fuel Truck)

⚠ WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire.

Turn the disconnect switch OFF if fitted or disconnect the battery when changing fuel filters



1. Raise the hood and seat assembly.

2. Loosen Bolt(1) and clamps(2)(3).

3. Replace old fuel filter with new filter.

4. Fasten Bolt(1) and clamps(2)(3).

Inspect Gasoline Carburetor

See, gasoline carburetor in Gasoline fuel system section.

Inspect Pressure Regulator/Vaporizer

See, pressure regulator/vaporizer in LP fuel system section.

Inspect LP Mixer (Standard LP Truck)

See, LP mixer in LP fuel system section.

Inspect Variable Venturi Air/Fuel Mixer (Low Emission LP Truck)

See, Variable Venturi Air/Fuel Mixer in LP fuel system(Low emission version) section.

Inspect Complete Exhaust System for Leaks, Damage

- Perform visual inspection of exhaust system.
- Repair any/all leaks found.

Engine Control Unit(ECU) and others (Low Emission LP Truck)

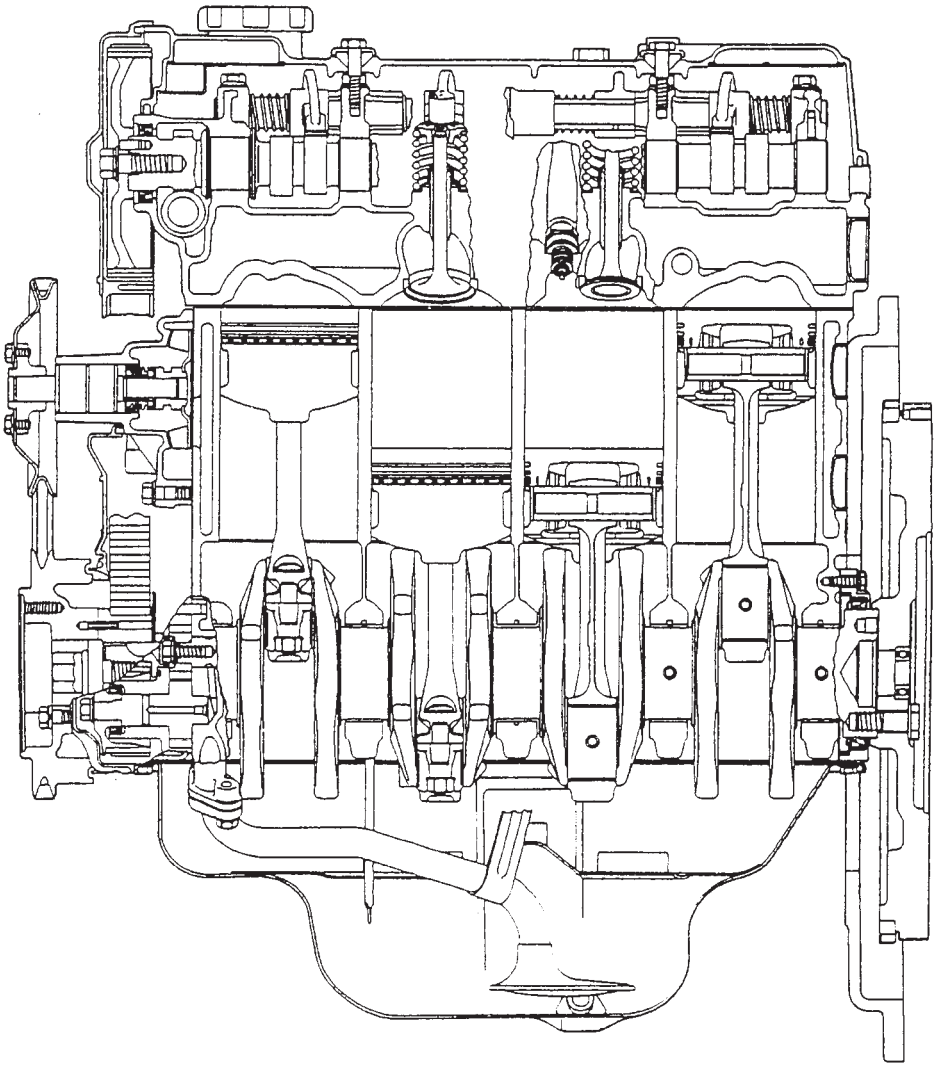
The commander, oxygen sensor and vacuum control solenoid are not serviceable. If faulty, they must be replaced. See Trouble Shooting Section

Maintenance Schedule

CHECK POINT	Interval Hours					
	Daily	Every 250hrs or a month	Every 500hrs or 3 months	Every 1000hrs or 6 months	Every 2000hrs or a year	Every 1000hrs or 18 months
General Maintenance Section						
Test fuel system for leaks	Prior to any service of maintenance activity					
Inspect engine for fluid leaks	O					
Check engine oil and filter	O					
Change engine oil and filter		O				
Inspect accessory drive belts				O		
Inspect electrical system					O	
Inspect all vacuum lines and fittings					O	
Inspect all fuel fittings and hoses					O	
Replace timing belt and counter balance shaft belt.						O
Check engine compression pressure						O
Engine Coolant Section						
Check coolant level	O					
Change coolant					O	
Inspect coolant hoses for leaks, cracks swelling, or deterioration				O		
Engine Ignition Section						
Inspect battery for case damage and corroded Cables					O	
Inspect ignition system				O		
Check ignition timing-adjust as necessary					O	
Replace spark plugs					O	
Fuel Lock-Off/Filter Section						
Replace LP fuel filter element				O		
Replce gasoline fuel filter					O	
Inspect lock-off and filter for fuel leaks					O	
Ensure lock-off stops fuel flow when engine is off					O	
Pressure Regulator Section						
Test regulator pressures					O	
Inspect pressure regulator for oil build-up					O	
Inspect pressure regulator assembly for fuel/coolant leaks					O	
Carburetor Section						
Check for air leaks in filter system					O	
Check for vacuum leaks on complete intake system					O	
Inspect air/gas valve assembly			O			
Inspect air/fuel mixture throat			O			
Inspect gasoline carburetor				O		
Check air cleaner indicator	O					
Inspect air cleaner		O				
Replace air filter element					O	
Engine Exhaust Section (Low Emission Version only)						
Inspect exhaust manifold for leaks					O	
Inspect manifold-to-catalyst exhaust piping and Connections for leaks					O	
Inspect catalyst inlet and outlet and leaks					O	

ENGINE SYSTEM

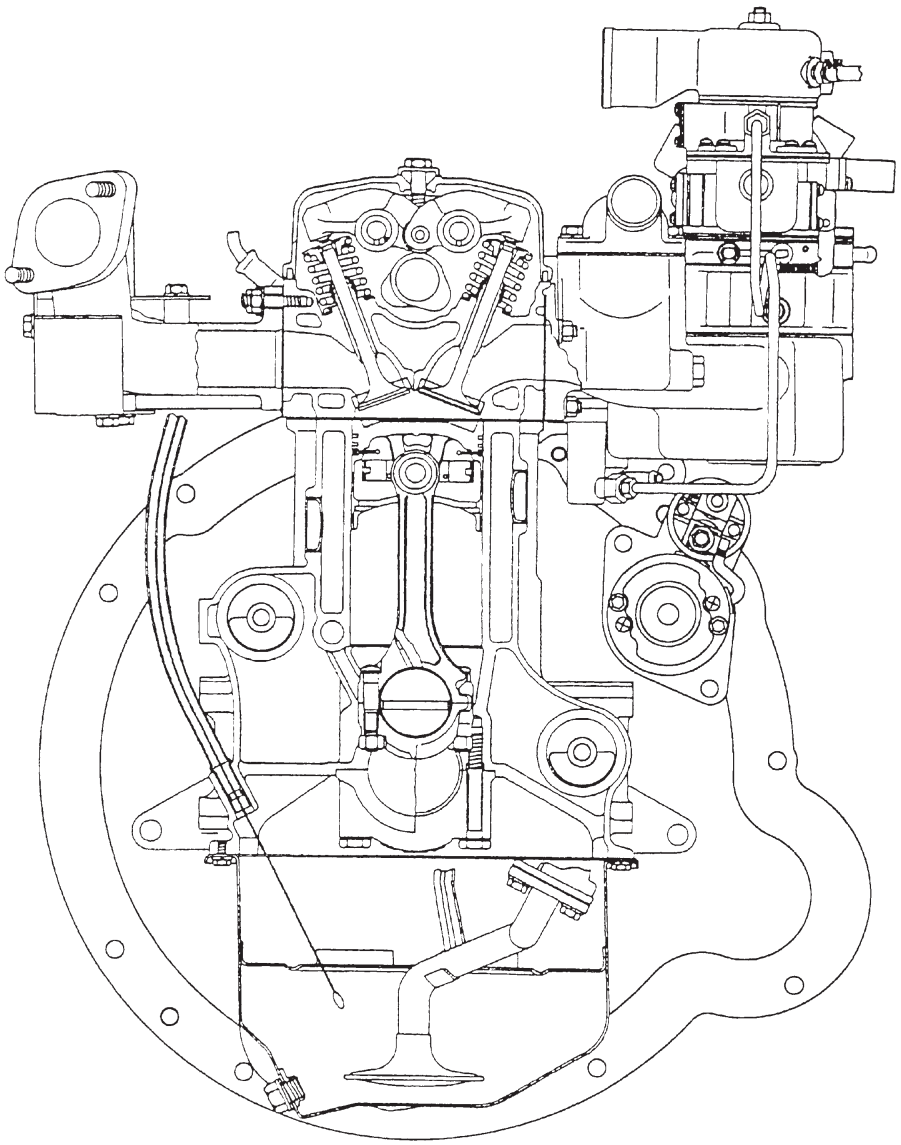
Engine Overview



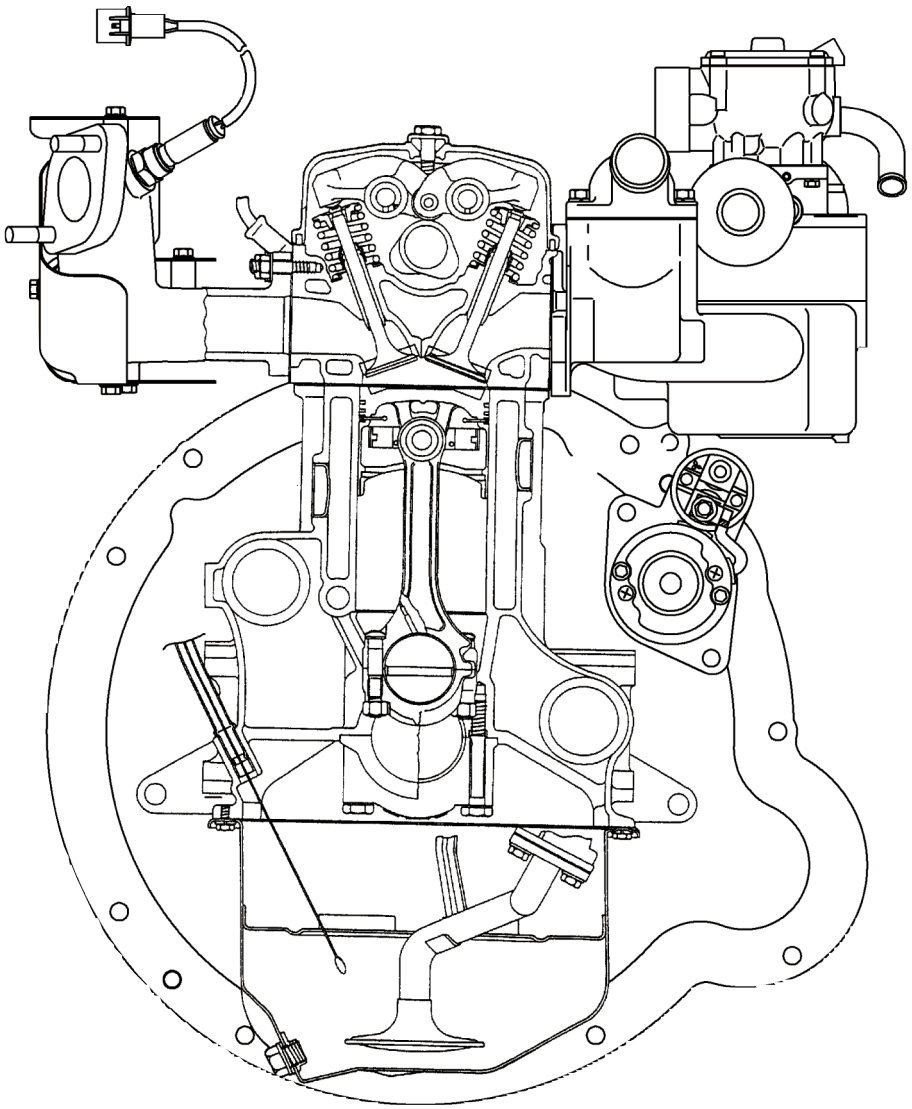
The cylinder blocks are made of the special cast iron and employ 5-bearing, deep skirt system.
The cylinder heads have hemisphere combustion chambers, are of cross flow type arranged with V-type valves and high efficient combustion is intended.

The camshaft is located on the top of the cylinder heads and driven by cog type timing belt.
Dual type exhaust manifold is employed in order to reduce output loss by exhaust interference.

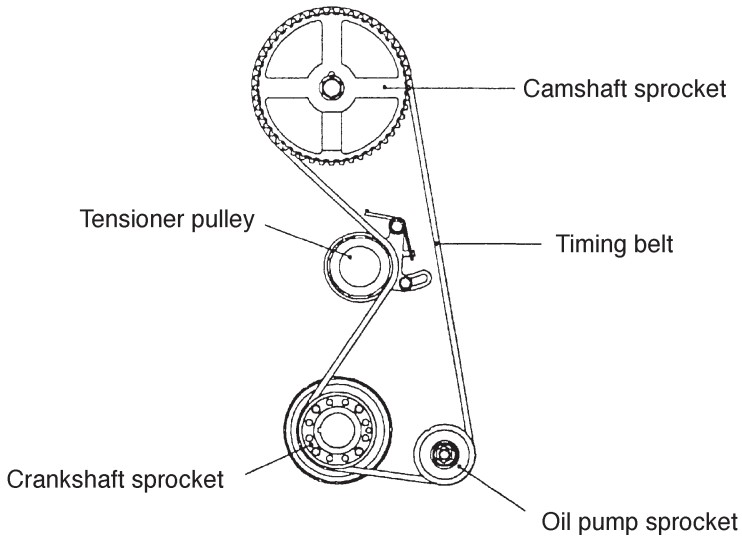
Gasoline Engine



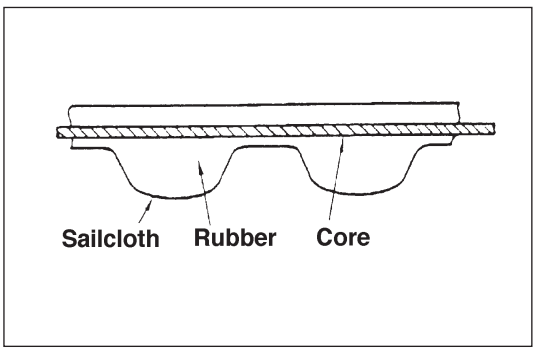
LPG Engine (Low Emission Version)



Timing System



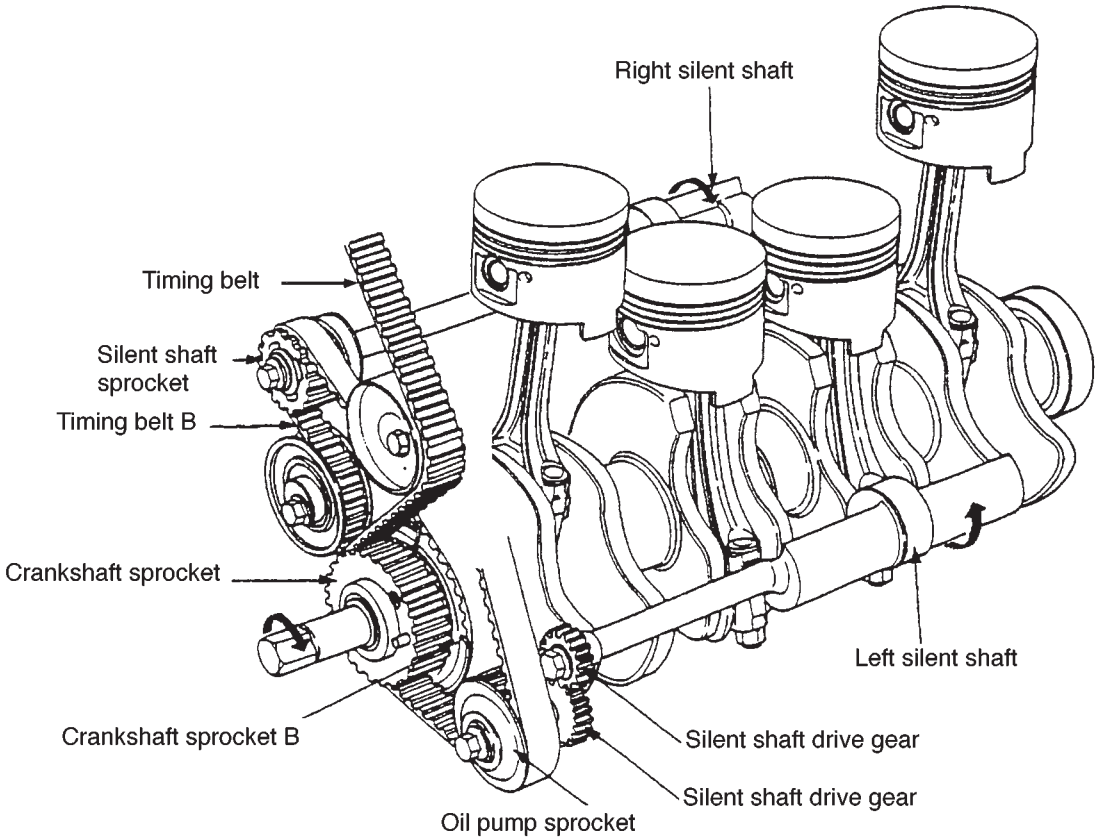
The timing belt is meshed with the sprockets, the crankshaft sprocket becomes the drive sprocket, and thus functions to drive the camshaft and oil pump.



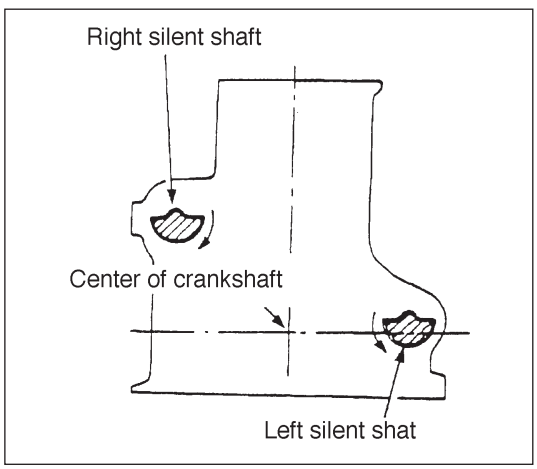
Timing belt

The timing belt is the cogged type, using rubber as its basic material, and it employs a high-strength glass fiber core which does not expand or contract.
The features of the cogged-type belt compared to a chin are no expansion/contraction, low noise level, no necessity for lubrication, light weight, etc.

Silent Shaft Mechanism

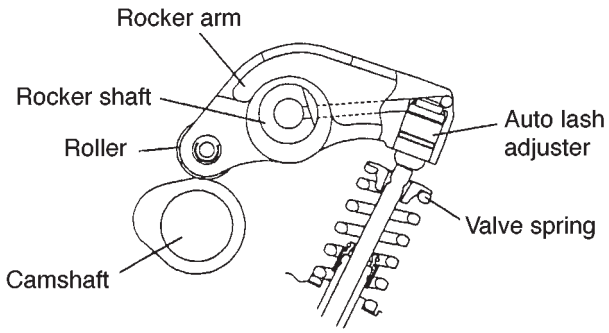


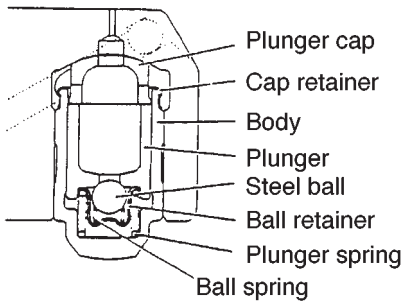
The silent shaft mechanism function mainly to eliminate, by the action of the silent shafts incorporated at both sides of the cylinder block, the vertical vibromotive force of the engine as well as the vibromotive moment in the rolling direction, thus making possible quieter operation of the vehicle.
The two silent shafts are arranged as shown in the figure below. The right silent shaft rotates in the same direction as the crankshaft, and the left silent shaft rotates in the opposites direction. Both of these silent shafts rotate at speed twice that of the crankshaft.
Right silent shaft is driven by timing belt B, and the left silent shaft is driven by drive gear.



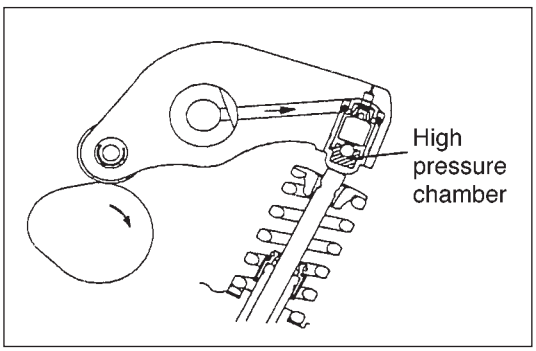
Auto Lash Adjuster

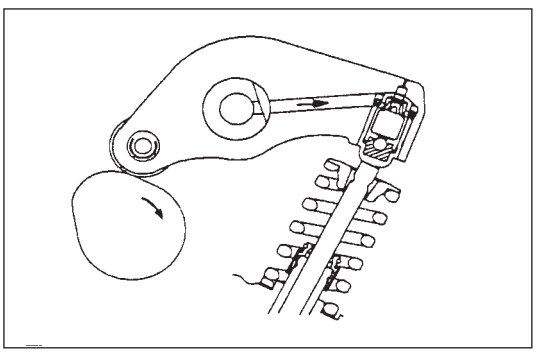
Construction

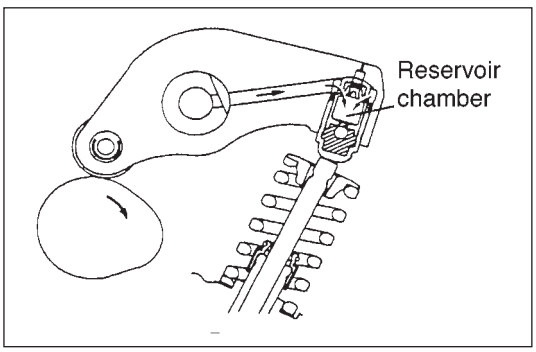




These engines have auto lash adjusters that eliminate the need for valve clearance adjustment and reduce noises of the valve system. The auto lash adjuster automatically absorbs change in the valve clearance caused by engine temperature change or wear of parts and adjusts the valve clearance always to zero.







Operation of Auto Lash Adjuster

(1) At Start of Valve Lift

When the cam lifts up the rocker arm, the hydraulic pressure immediately forces the ball in the high pressure chamber against the seat, closing the high pressure chamber.

(2) During Valve Lift

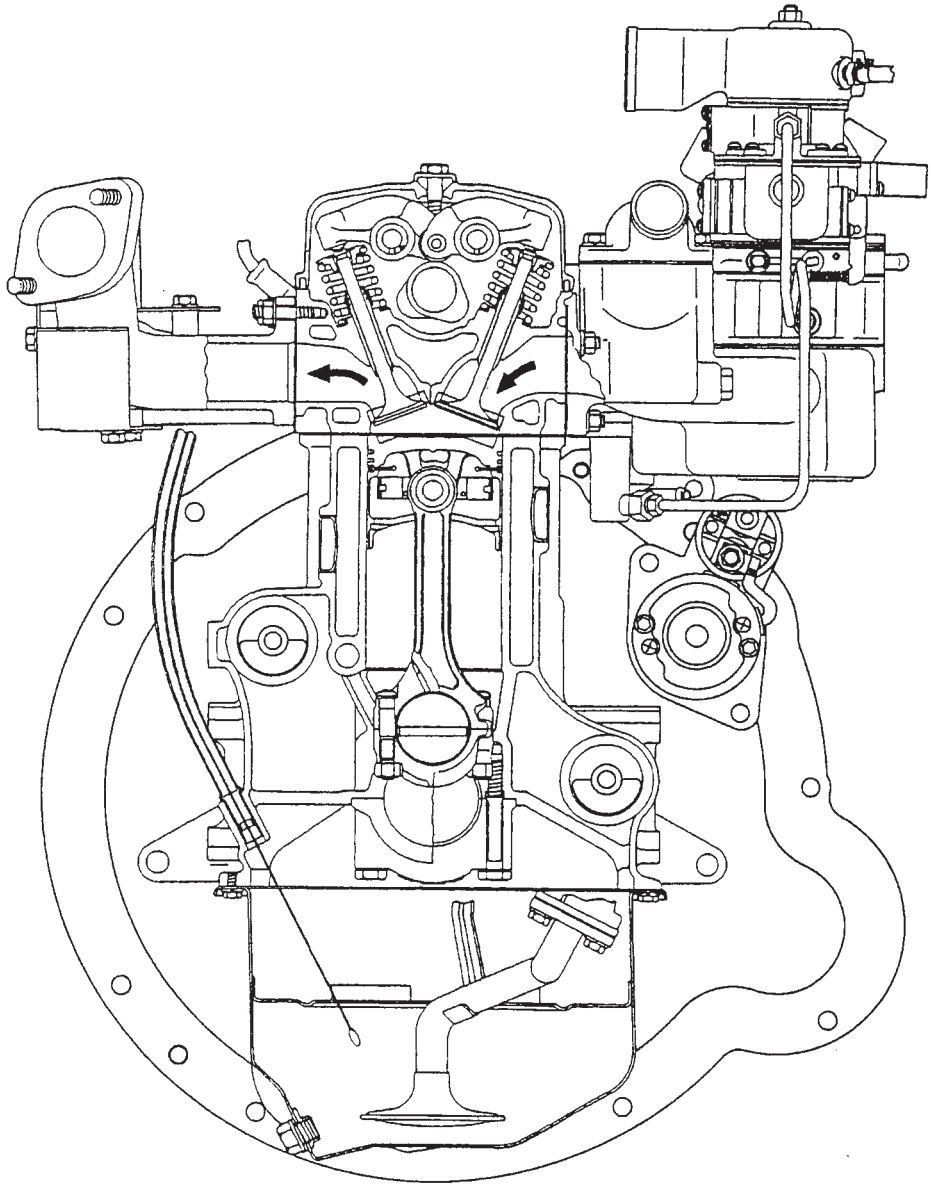
A small amount of oil leaks from the high pressure chamber through a clearance between the body inside and the plunger outside.

(3) At end of Valve Lift

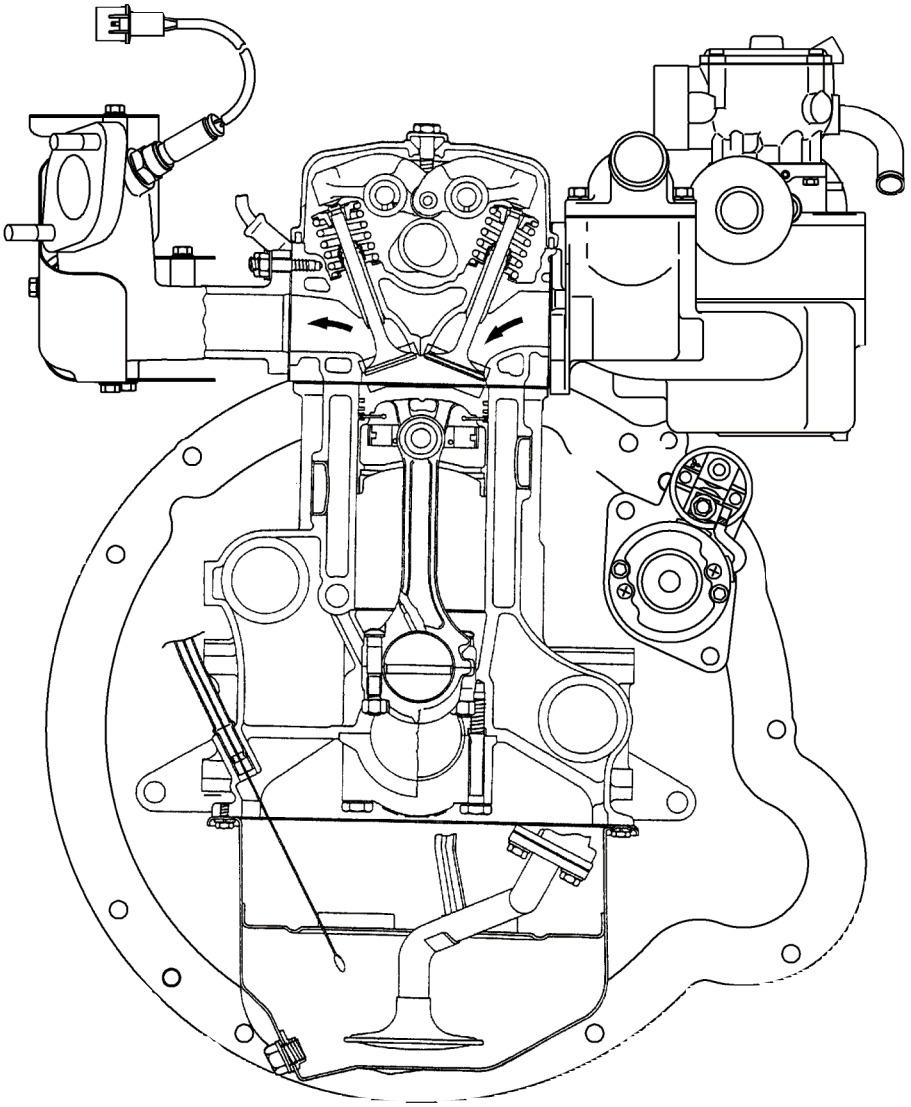
The plunger spring forces the body back to the initial position and oil is supplied to the high pressure chamber to make up for the leaked oil.

Intake and Exhaust System

Gasoline Engine

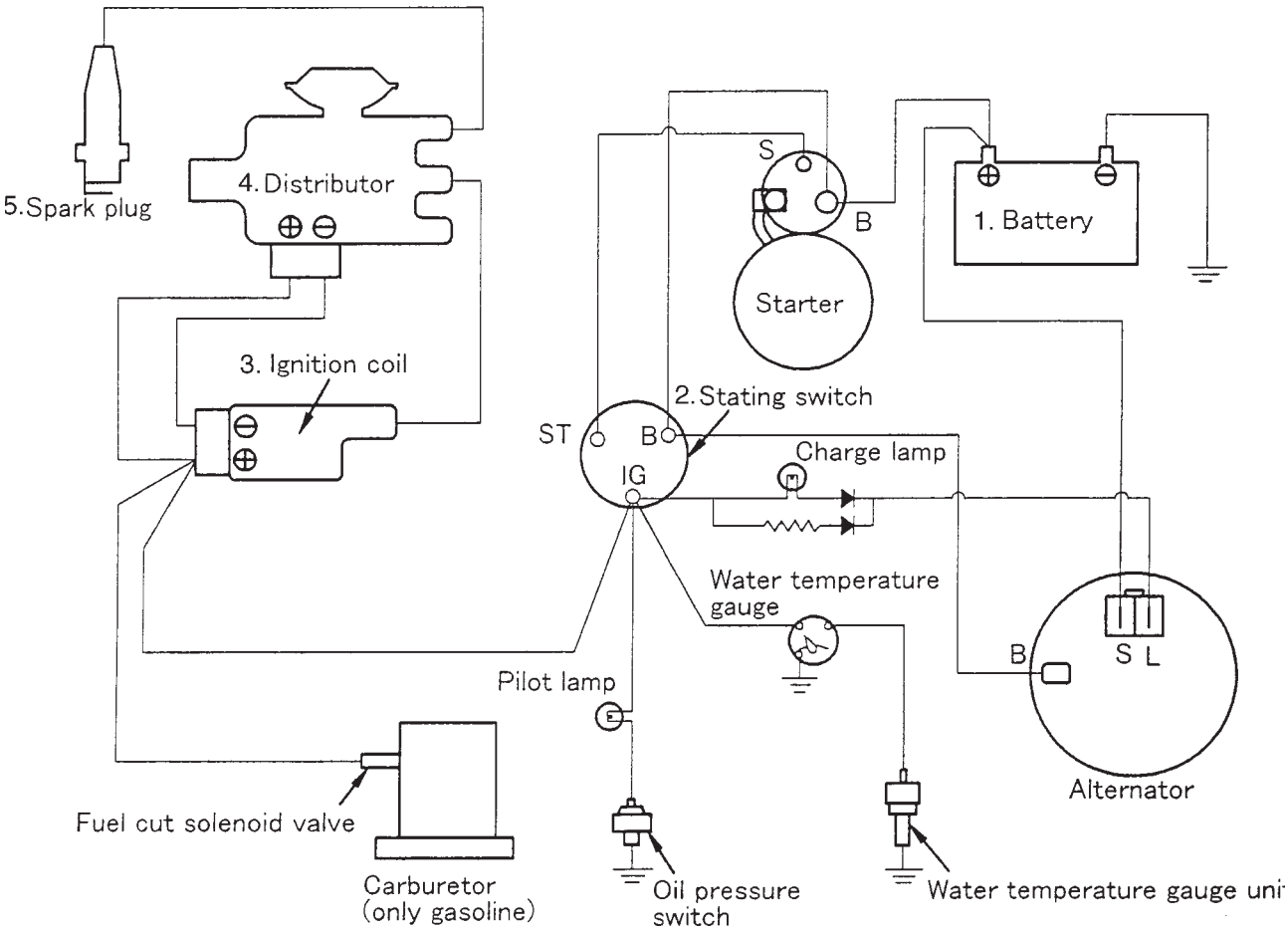


The intake manifold employs the shape having good intake performance.
The exhaust manifold employs a dual type and intend the reduction of output loss due to exhaust interference.



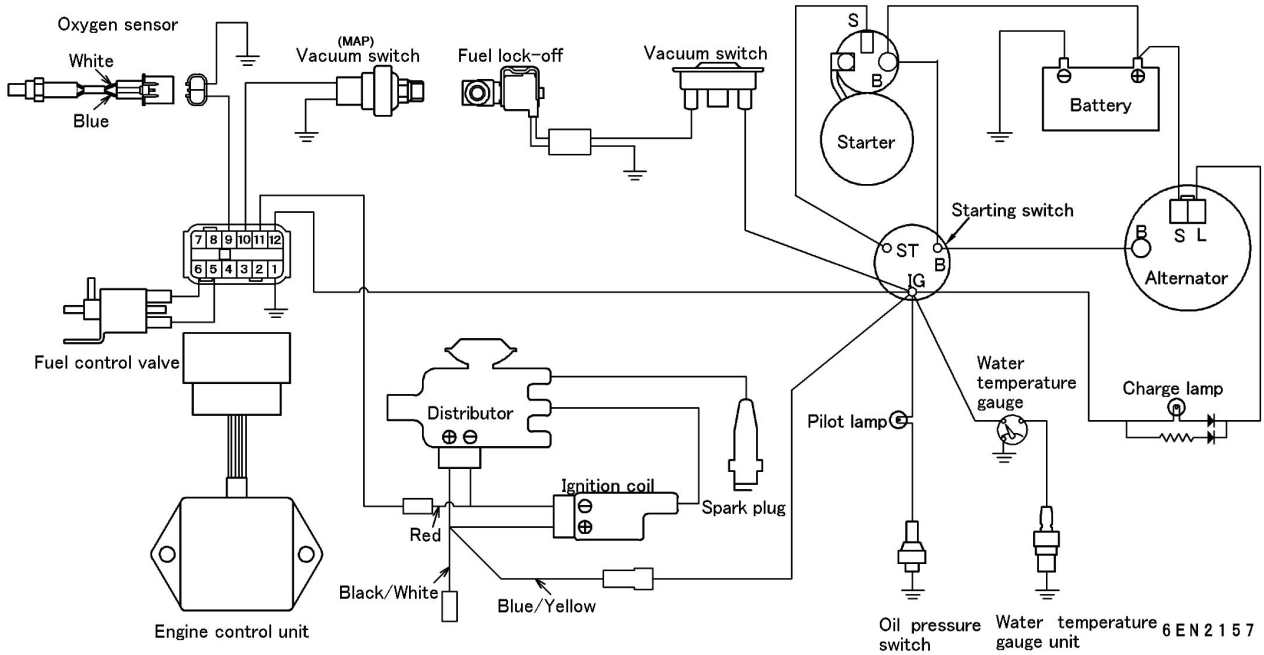
Electrical System

Wiring Diagram
(Gasoline Engine)



Stating motor is of the gear reduction type.
Distributor is of a breakerless type and employs the ignition advancer which uses jointly centrifugal type and vacuum type.

Wiring Diagram (LPG Engine, Low Emission Version)

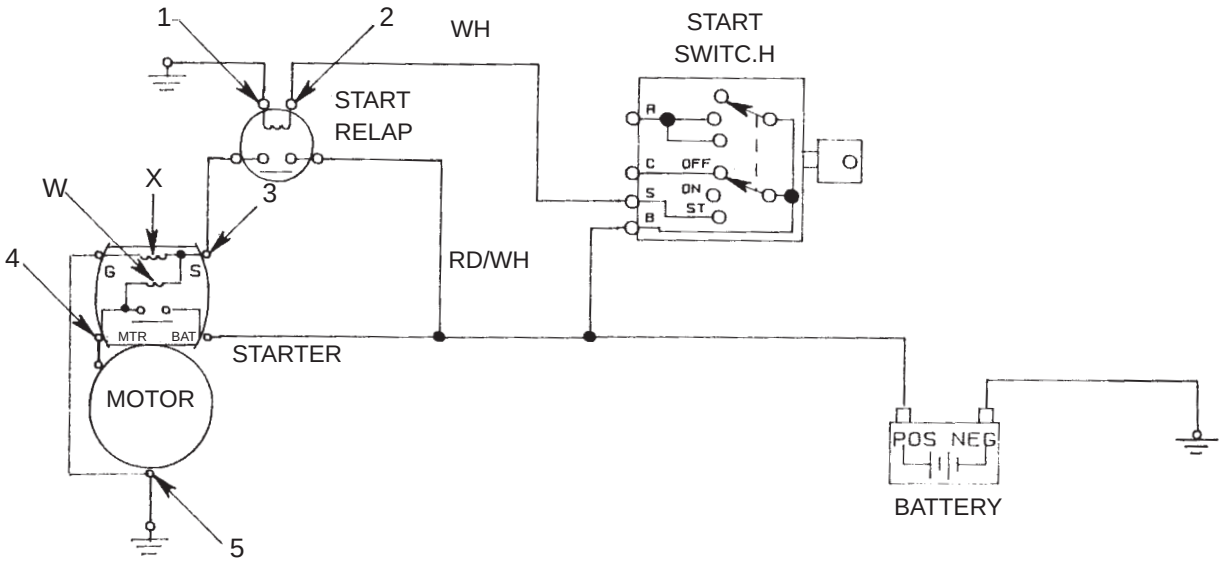


STARTING SYSTEM

General Description

The starting motor is used to turn the engine flywheel fast enough to make the engine run. The starting motor has a solenoid. When the ignition switch is activated, voltage from the electrical system will cause the solenoid to move the pinion toward the flywheel ring gear of the engine. The electrical contacts in the solenoid close the circuit between the battery and the starting motor just before the pinion engages the ring gear. This causes the starting motor to rotate. This type of motor "turn on" is a positive shift starting motor.

When the engine begins to run, the overrunning clutch portion of the pinion drive prevents damage to the armature caused by excessive speeds. The clutch does this by breaking the mechanical connection. The pinion will stay meshed with the ring gear until the ignition switch is released. A return spring in the overrunning clutch returns the clutch to its rest position.



Typical 12 Volt Starting Circuit
(1) Test point. (2) Test point. (3) Test Point. (4) Test Point. (5) Test Point. (X) Hold-in coil. (W) Pull-in coil.

Diagnosis Procedure

The following simplified procedure is intended to help the serviceman determine if a starting motor needs to be removed and replaced or repaired. It is not intended to cover all possible problems and conditions, but to serve only as a guide. The most common 12 volt circuit is shown and discussed.

General Information

All starting systems are made up of four elements. They are the ignition switch, start relay, the starting motor solenoid and starting motor.

Start switches are relatively low current devices. They are rated to switch approximately 5 to 20 amps. Because the coil of a start relay [between test point (1) and (2)] draws about 1 amp, the start switch can easily turn on the start relay and have long life.

The switch contacts of a typical start relay are rated to switch 30 amps. Because the solenoid requires 5 to 20 amps the start relay can easily switch this load.

The starting motor solenoid has two functions:
1. Engages the pinion with flywheel.
2. Is a high current switch rated about 1000 amps that actually turns on the starting motor.

The starting motor solenoid has two coils. Pull-in coil (W) draws about 40 amps and hold-in coil (X) requires about 5 amps. The instant the start relay closes, both coils (W) and (X) receive power. Battery voltage is applied to the high end of both coils, at test point (3) which is the start (S) terminal. The low end of hold-in coil (X) is permanently grounded to the ground post or motor housing of the starting motor. Grounding for the low end, test point (4), of pull-in coil (W) is momentary, and takes place through the DC resistance of the starting motor. As soon as magnetic force builds in both coils, the pinion moves toward the flywheel ring gear. The pinion will stop short of engagement of the flywheel ring gear. Only then will the solenoid contacts close to power the starting motor. This temporarily removes the ground from pull-in coil (W), and puts battery voltage on both ends of it while the starting motor cranks. During this period, the pull-in coil is out of the circuit. Cranking continues until power to the solenoid is broken by releasing the ignition switch.

The result of these switches and relays is to permit a 5 amp dash-mounted switch to turn on a 500 to 1000 amp motor used to crank an engine.

Battery voltage (power) available during cranking varies according to the temperature of the batteries. The following chart is a guide as to what to expect from a normal system.

TYPICAL SYSTEM VOLTAGE DURING CRANKING AT VARIOUS AMBIENT TEMPERATURES	
Temperature	12V System
-23 to -7 C (-10 to 20 F)	6 to 8 Volts
-7 to 10 C (20 to 50 F)	7 to 9 Volts
10 to 27 C (50 to 80 F)	8 to 10 Volts

Figure 1

The next chart shows maximum acceptable voltage loss in the high current battery circuit feeding the starting motor. These values are maximums for machines of approximately 2000 SMH and up. Newer machines would be less than those shown.

MAXIMUM ACCEPTABLE SYSTEM VOLTAGE DROPS DURING CRANKING	
Circuit	12V System
Battery(-) post to starting motor (-) terminal	0.7 Volts
Battery (+) post to solenoid (+) terminal	0.5 Volts
Solenoid Bat terminal to solenoid Mtr terminal	0.4 Volts

Figure 2

Voltages greater than those shown are most often caused by loose and/or corroded connections or defective switch contacts.

Diagnosis Procedure

TOOLS NEEDED	
Digital Multimeter or Equivalent	1
DC Clamp-On Ammeter or Equivalent	1

NOTICE

Do not operate the starting motor for more than 30 seconds at a time. After 30 seconds, the cranking must be stopped for two minutes to allow the starting motor to cool. This will prevent damage to the starting motor due to excessive heat buildup.

If the starting motor cranks real slow or does not crank at all, do the following procedure:

1. Measure battery voltage at the battery posts with the multimeter while cranking or attempting to crank the engine. Make sure to measure the battery posts. Do not measure the cable post clamps.

2. Is battery voltage equal to or greater than shown in Figure 1?

- If the battery voltage is correct, go to Step 3.
- If the battery voltage is too low, Charge or replace the battery.

NOTE: A low battery can be caused by battery condition or a shorted starting motor.

3. Measure current draw on the (+) battery cable between the battery and the starting motor solenoid with the clamp-on ammeter. The maximum current draw allowed is 350 Amp. At temperatures below 27°C (80°F), the voltage will be less and the current draw will be higer. If current draw is too much, the starting motor has a problem and must be removed for repair or replacement.

NOTE: If voltage at the battery post is within approximately 2 volts of the lowest value in the applicable temperature range of Figure1 and if the large starting motor cables get hot, then the starting motor has a problem and the Ammeter test is not needed.

4. Measure starting motor voltage from test point (4) to (5) with the multimeter while cranking or attempting to crank the engine.

5. Is voltage equal to or greater than shown in Figure 1?

- If the starting motor voltage is correct, the battery and starting motor cables down to the motor are within specifications. Go to Step 8.
- If the starting motor voltage is low, the voltage drop between the battery and the starting motor is too great. Go to Step 6.

6. Measure the voltage drops in the cranking circuits with the multimeter. Compare the results with maximum voltage drops allowed in Figure 2.

7. Are all the voltages within specifications ?

- If the voltage drops are correct, go to Step 8, to check the engine.

- If the voltage drops are too high, repair and/or replace the faulty electrical component.

8. Rotate the crankshaft by hand to make sure it is not locked up. Check oil viscosity and any external loads that would affect engine rotation.

9. Is the engine locked up or hard to turn ?

- If it is, repair the engine as required.

- If the engine is not hard to turn, go to Step 10.

10. Does the starting motor crank?

- If it does crank, remove the starting motor for repair and/or replacement.

- If it does not crank, check for blocked engagement of the pinion and flywheel ring gear.

NOTE: Blocked engagement and open solenoid contacts will give the same electrical symptoms.

Start Relay Tests

D167422 Relay

1. Put the multimeter on the 200 ohm scale.

2. Put the multimeter lead to the 85 and 86 terminals.

3. The indication on the meter must be 82 $\pm$ 5 ohms. If the indication is not correct, the start relay must be replaced.

4. Put the multimeter leads to the 30 and 87 terminals.

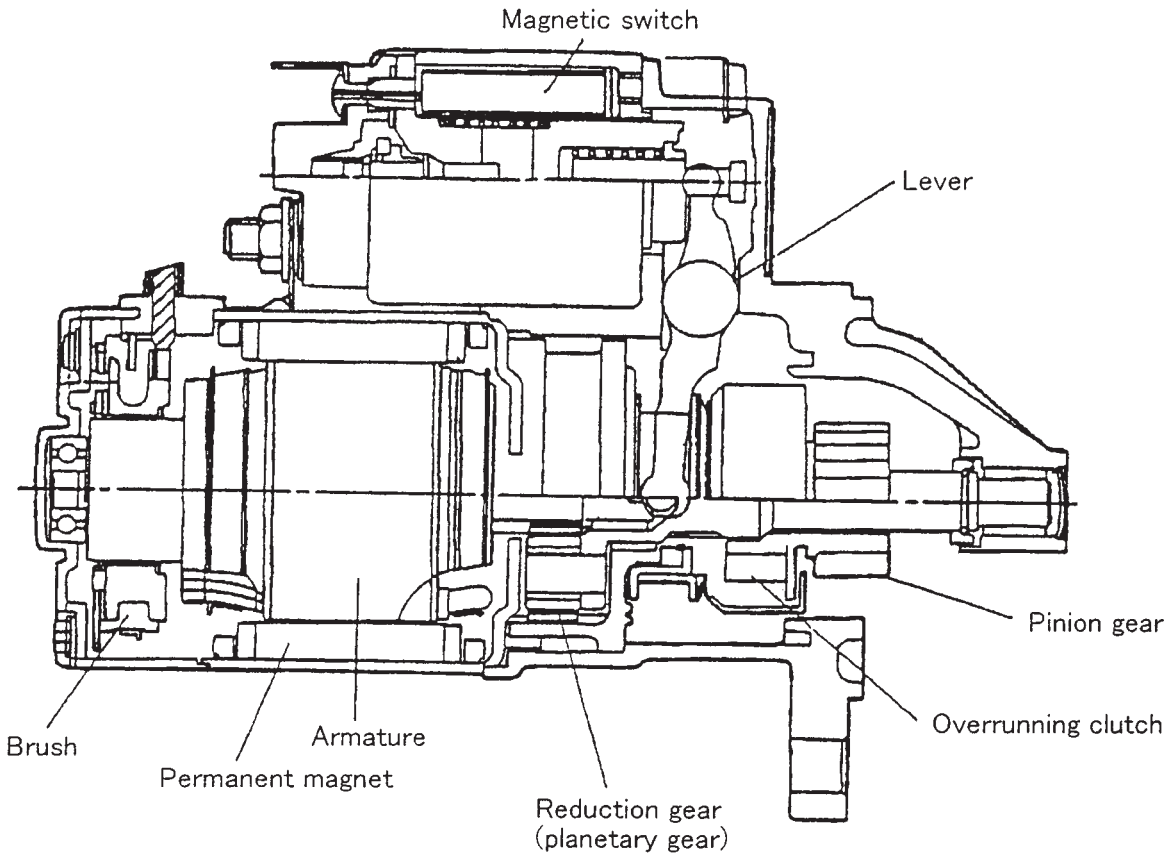
5. The indication must be "OL"(Over Load). If the indication is not correct, the start relay must be replaced.

6. Connect WH wire to 86 and BK wire to 85 terminal with the ignition switch to start position. Put the meter lead to 30 and 87 terminal.

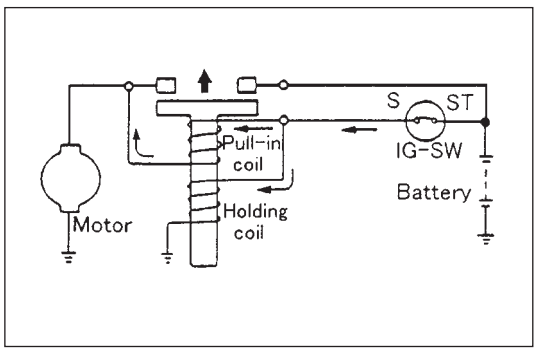
7. The indication must be Zero ohm. If the indication is not correct the start relay must be replaced.

Starter Motor

Planetary Gear Reduction Drive Type

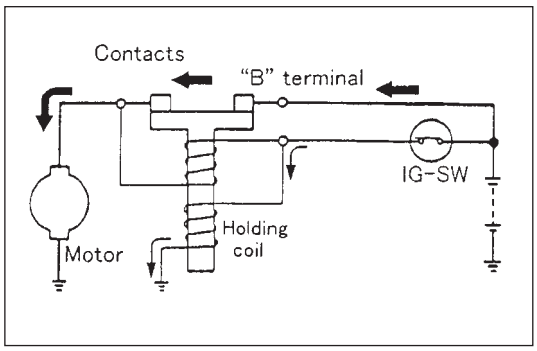


The starter motor is small in size light weight and high-output type.
Rotation of the motor are reduced by the reduction gear, and high torque is transmitted to the pinion gear.

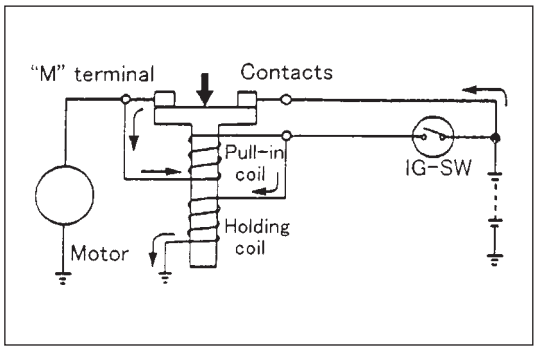


Operation

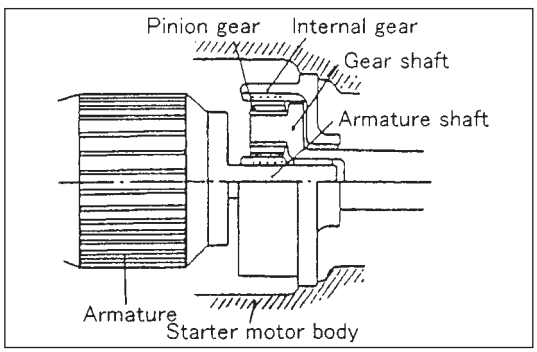
1. When the ignition key (IG-SW) is turned to the “ST” position, current flows from the S terminal of the magnetic switch to the pull-in coil and the holding coil. Current from the pull-in coil passes through the M terminal, flows to the starter’s brush, commutator, and armature, and then the armature begins to gently turn.



2. The plunger of the magnetic switch is then attracted, and the pinion is pushed out by the shift lever, meshing with the ring gear.
   As a result of the movement of the plunger, the contacts of the magnetic switch close, and, as a result, the starter is turned by the high current from the battery directly to the B terminal, and the engine is activated.
   When the contacts closes, the current flowing to the pull-in coil stops flowing, and the magnetic force decreases. At this time, what prevents the pinion from being returned by the return spring is the magnetic force of the holding coil.
   When the engine starts and the pinion is caused to rotate by the ring gear, there is a possibility of damage, and for that reason an over-running clutch is provided so that the rotation from the engine is not transmitted.

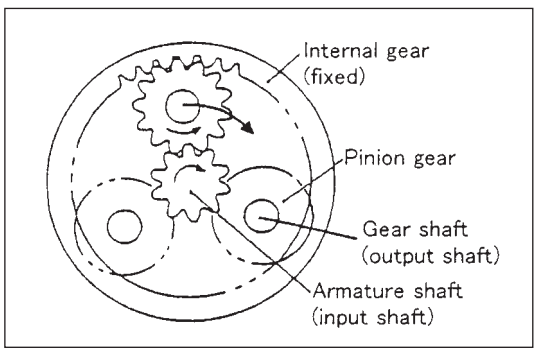


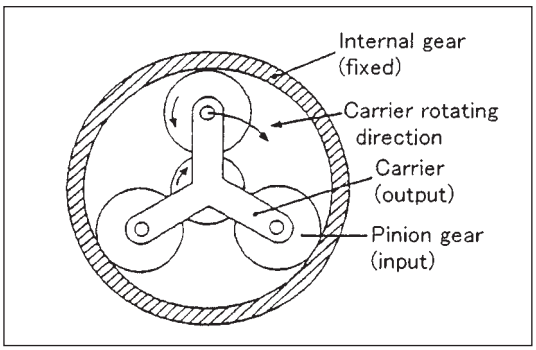
3. Because the contacts are still closed at the moment when the ignition key is turned to OFF, current from the battery flows in the reverse direction from the M terminal and through the pull-in coil, thus offsetting the magnetic force of the holding coil, with the result that the pinion is returned by the return spring, and the contacts are opened.



Construction of planetary gear type reduction drive

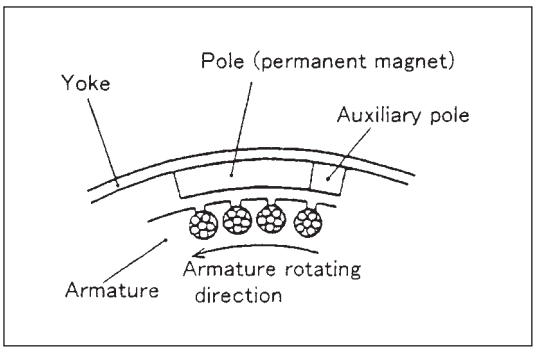
This reduction drive consists of a gear on the front end of the armature shaft, three pinion gears, a gear shaft that supports three pinion gears and work as the output shaft and the internal gear that is fixed to the starter motor body. The unit is called the simple planetary gear set.





When the internal gear is fixed as in the case of the starter motor, the carrier rotates in the same direction as the sun gear.

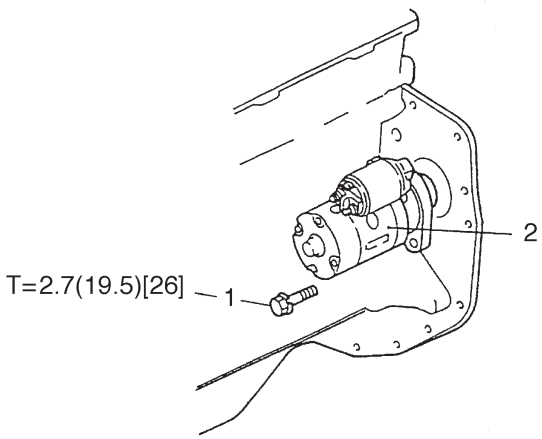
This may be used to determine the reduction ratio easily. Namely, the carrier reduction ratio = (43 + 11) / 11 ≒ 4.9



Permanent magnet pole

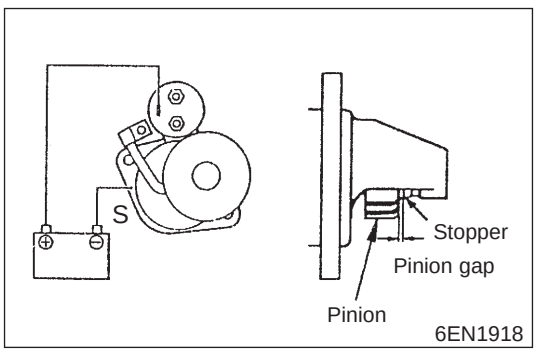
Conventionally, the field coil wound around the pole is energized to generate magnetic fluxes. This system uses a permanent magnet (ferrite magnet) for the pole, eliminating the field coil and reducing the size and weight.
The auxiliary pole helps generation of magnetic fluxes to ensure stable rotation and output characteristics.

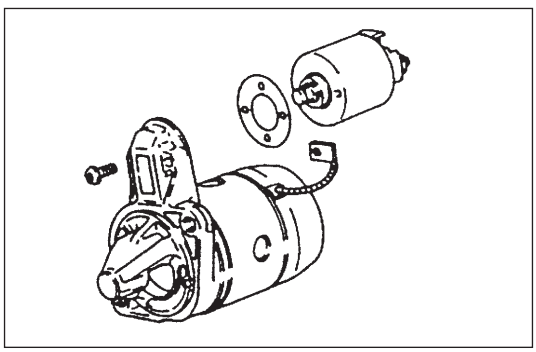
Removal and Installation



6EN0867

Removal steps
1. Bolt
2. Starter





Inspection

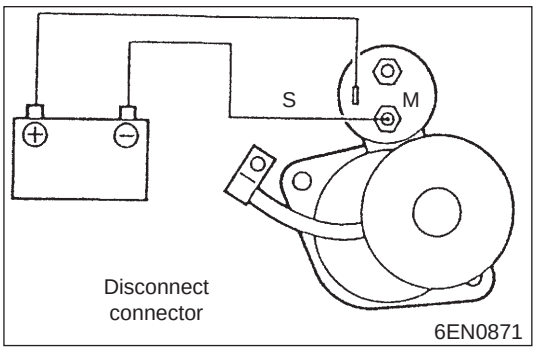
Pinion Gap Adjustment

(1) Disconnect the field coil wire from terminal M of the magnetic switch.
(2) Connect a 12 V battery between terminal S and starter motor body (positive terminal to terminal S).

Caution: This test must be performed quickly (in less than 10 seconds) to prevent the coil from burning out.

(3) Set switch to “ON”, and pinion will move out.
(4) Check pinion to stopper clearance (pinion gap) with a thickness gauge. Pinion gap: 0.5 to 2.0 mm (0.0197 to 0.0787 in.)

(5) If the pinion gap is out of specification, adjust by adding or removing gaskets between magnetic switch and front bracket.

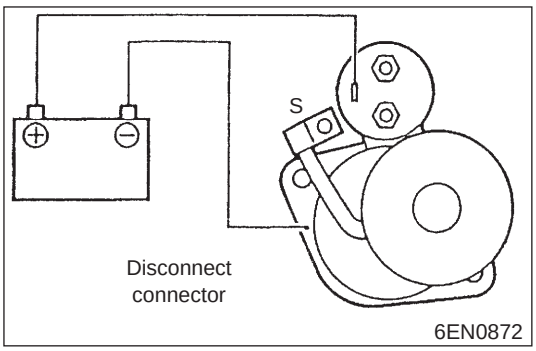


Pull-in Test of Magnetic Switch

(1) Disconnect field coil wire from terminal M of magnetic switch.
(2) Connect a 12V battery between terminal S and terminal M.

Caution: This test must be performed quickly (in less than 10 seconds) to prevent coil from burning.

(3) If pinion moves out, then pull-in coil is good. If it doesn't. replace magnetic switch.

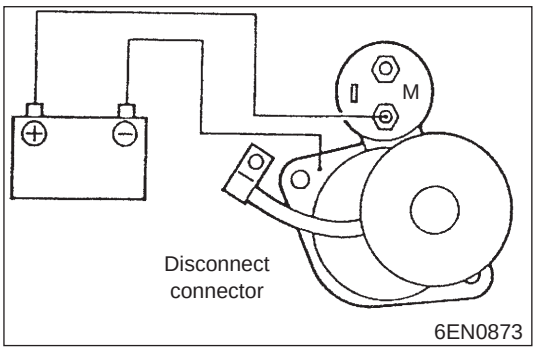


Hold-in Test of Magnetic Switch

(1) Disconnect field coil wire from terminal M of magnetic switch.
(2) Connect a 12V battery between terminal S and body.

Caution: This test must be performed quickly (in less than 10 seconds) to prevent coil from burning.

(3) Manually pull out the pinion as far as the pinion stopper position.
(4) If pinion remains out, everything is in order. If pinion moves in, hold-in circuit is open. Replace magnetic switch.



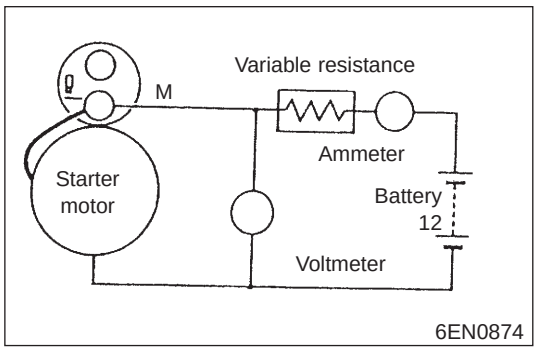
Return Test of Magnetic Switch

(1) Disconnect field coil wire from terminal M of magnetic switch.
(2) Connect a 12V battery between terminal S and body.

Caution: This test must be performed quickly (in less than 10 seconds) to prevent coil from burning.

(3) Pull pinion out and release. If pinion quickly returns to its original position, everything is in order. If it doesn't, replace magnetic switch.

Caution: Be careful not to get your fingers caught when pulling out the pinion.



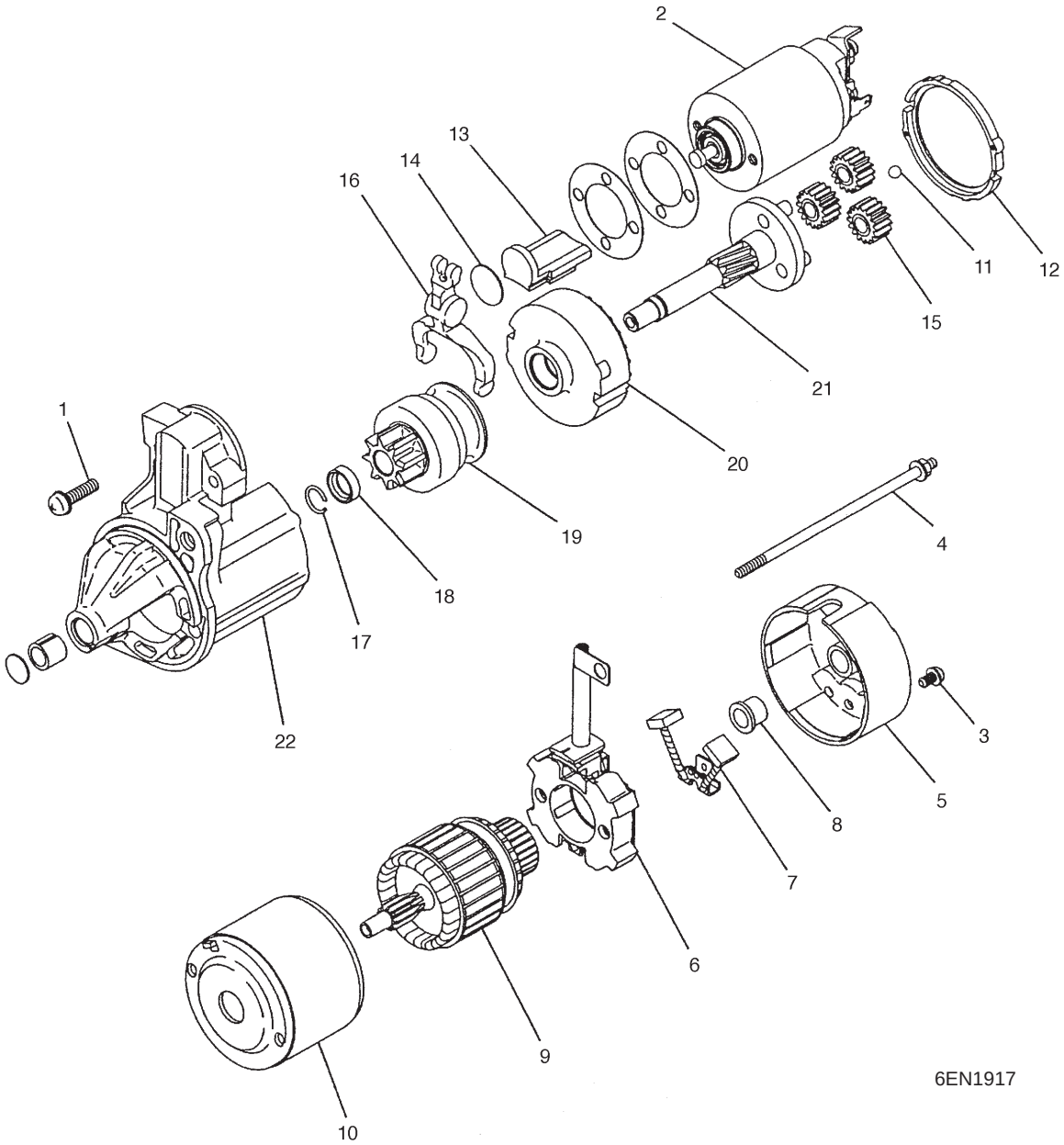
Free Running Test

(1) Place starter motor in a vise equipped with soft jaws and connect a fully-charged 12-volt battery to starter motor as follows:
(2) Connect a ammeter (100-ampere scale) and carbon pile rheostat in series with battery positive post and starter motor terminal.
(3) Connect a voltmeter (15-volt scale) across starter motor.
(4) Rotate carbon pile to full-resistance position.
(5) Connect battery cable from battery negative post to starter motor body.
(6) Adjust the rheostat until the battery voltage shown by the voltmeter is 11V.
(7) Confirm that the maximum amperage is within the specifications and that the starter motor turns smoothly and freely.

Current: max. 60 amps

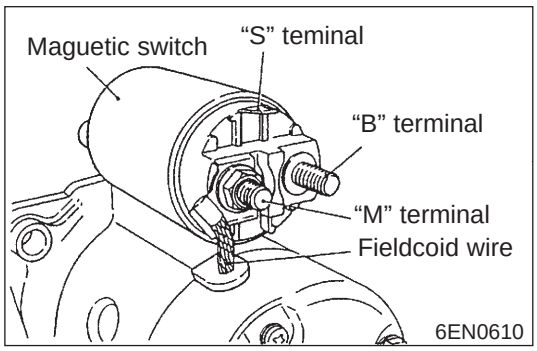
Symptom	Possible cause
Current is too large, and starter motor rotates at too low speeds. (Motor output torque is insufficient.)	•Contaminated or oil stained metal •Friction between armature core and pole piece •Armature coil and/or field coil not properly grounded •Armature coil short-circuited
Current is too large, and motor does not rotate at all.	•Electromagnetic switch not properly grounded •Armature coil and/or field coil not properly grounded •Seizure of metal
No current is available, and motor does not rotate.	•Armature coil and/or field coil open-circuited •Brush and/or pigtail open-circuited •Poor contact of brush and commutator due to contaminated commutator, high mica, etc.
Current is too small, and motor rotates at low speed. (Motor output torque is insufficient.)	Loose field coil connections (If the shunt coil alone is open-circuited or loosely connected, the motor will rotate at a high speed.)
Current is too large, and motor rotates at too high speeds. (Motor output torque is insufficient.)	Field coil short-circuited

Disassembly And Reassembly



Disassembly steps

1. Screw
←A→ 2. Magnetic switch
3. Screw
4. Screw
5. Rear bracket
6. Brush holder
7. Brush
8. Rear bearing
←B→ 9. Armature
10. Yoke assembly
←B→ 11. Ball
12. Packing A
13. Packing B
14. Plate
15. Planetary gear
16. Lever
←C→ →A← 17. Snap ring
←C→ →A← 18. Stop ring
19. Overrunning clutch
20. Internal gear
21. Planetary gear holder
22. Front bracket



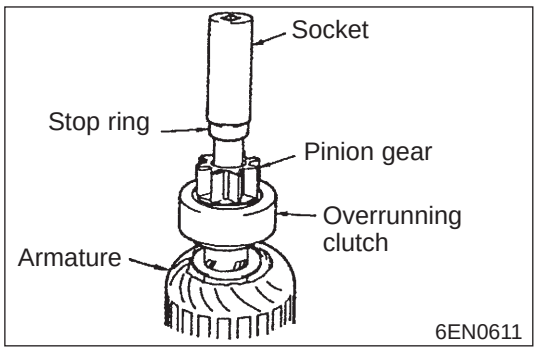
Disassembly Service Points

⟵ **A** ⟶ **Magnetic switch removal**

Disconnect the field coil wire from terminal M of the magnetic switch

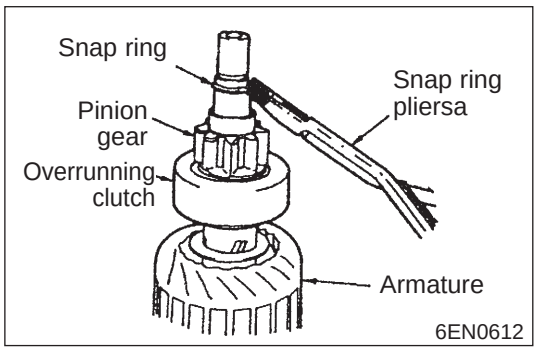
⟵ **B** ⟶ **Armature/ball removal**

Caution: When removing the armature, take care not to lose the ball (Which is used as a bearing) in the armature end.



⟵ **C** ⟶ **Snap ring/stop ring removal**

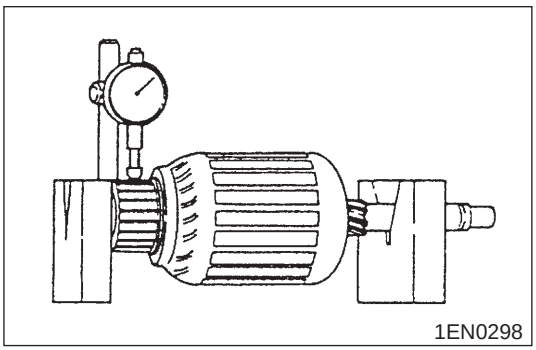
(1) Press stop ring off snap ring with a suitable socket.



(2) Remove snap ring with snap ring pliers and then remove stop ring and overrunning clutch.

Cleaning of Starter Motor Parts

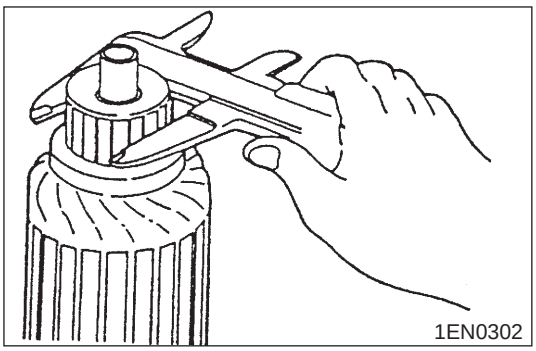
Do not immerse the parts in cleaning solvent. Immersion of the yoke, field coil assembly and/or armature will damage to insulation.
Do not immerse the drive unit cleaning solvent.
Overrunning clutch is pre-lubricated at the factory and solvent will wash lubricant form clutch.
The drive may be cleaned with a brush moistened with cleaning solvent and wiped dry with a cloth.



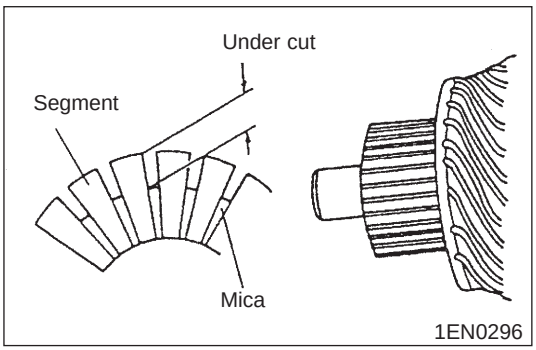
Inspection

1. Commutator

(1) Place the armature on a pair of V-blocks and check the runout using a dial gauge.
Standard value: 0.5 mm (0.020 in.)
Limit: 0.1 mm (0.004 in.)

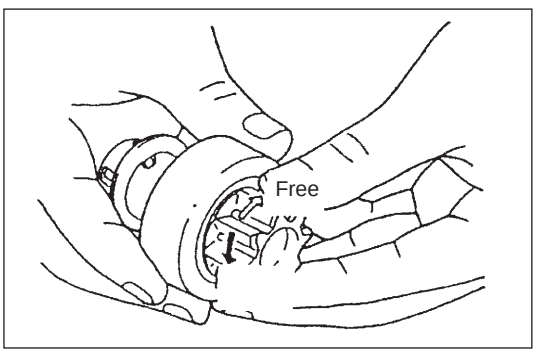


(2) Check the outer diameter of the commutator.
Standard value: 29.4 mm (1.16 in.)
Limited: 28.8 mm (1.13 in.)



(3) Check depth of the undercuts between the segments.
Standard value: 0.5 mm (0.020 in.)
Limited: 0.2 mm (0.008 in.)

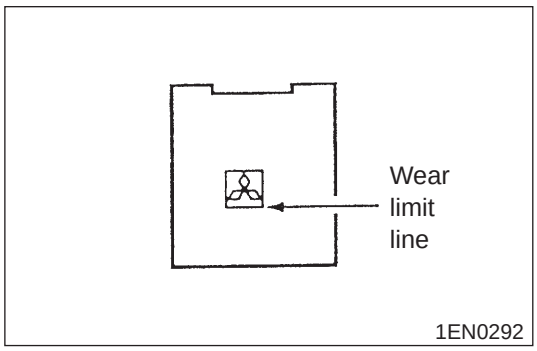
2. Overrunning Clutch Check



(1) While holing clutch housing, rotate the pinion. Drive pinion should rotate smoothly in one direction, but should not rotate in opposite direction. If clutch does not function properly, replace overrunning clutch assembly.
(2) Inspect pinion for wear or burrs. If pinion is worn or burred, replace overrunning clutch assembly. If pinion is damaged, also inspect ring gear for wear or burrs.

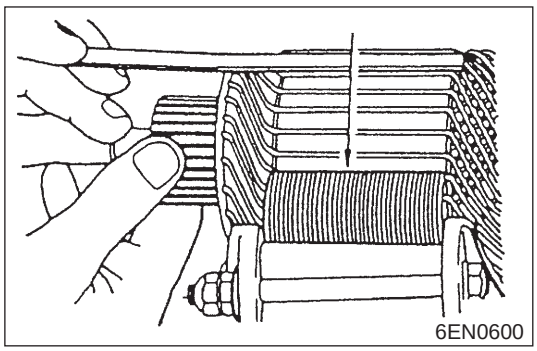
3. Front And Rear Bracket Bushing Check

Inspect bushing for wear or burrs. If bushing is worn or burred, replace front bracket assembly or rear bracket assembly.



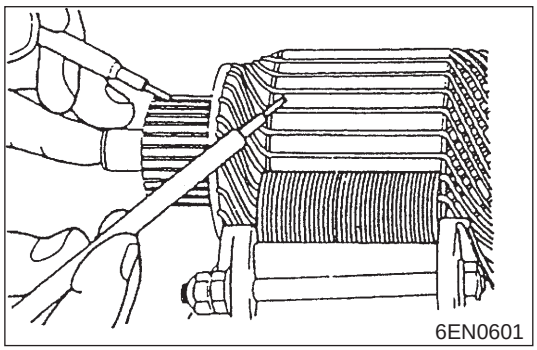
4. Brush

(1) Brushes that are worn beyond wear limit line, or oil soaked, should be replaced.
(2) When replacing ground brush, side the brush from brush holder by prying retainer spring back.



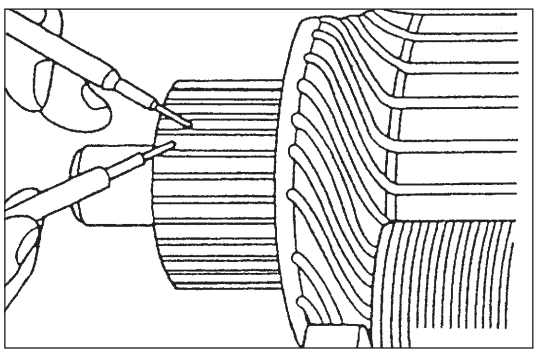
5. Armature Coil Short Circuit Test

(1) Place armature on a growler.
(2) Hold a thin steel blade parallel and just above while rotating armature slowly in growler. A shorted armature will cause blade to vibrate and be attracted to the core. Replace shorted armature.



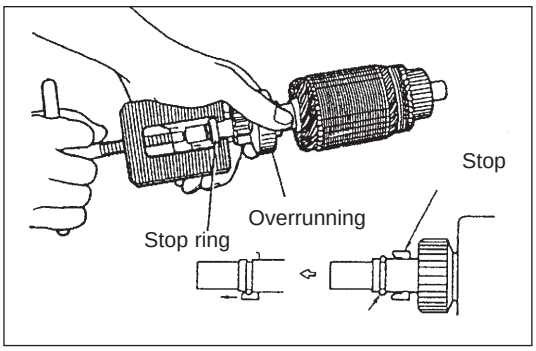
6. Armature Coil Ground Test

Check the insulation between ground commutator segment and the armature coil core. If there should be no continuity.



7. Armature Coil Open Circuit Check

Check the continuity between segments. If there should be continuity.



Reassembly Service Points

⟶ A ⟵ Stop ring/snap ring Installation

Using a suitable pulling tool, pull overrunning clutch stop ring over snap ring.

CHARGING SYSTEM

General Description

The alternator is an electrical and mechanical components driven by a belt from engine rotation. It is used to charge the storage battery during the engine operation. The alternator is cooled by an external fan mounted behind the pulley. The fan pulls air through the holes in the back of the alternator. The air exits the front of the alternator, cooling it in the process. The Daewoo CS-121 series also has an internal fan. This fan is mounted on the rotor. This fan pulls air through the holes in the back of the alternator to cool the rectifier bridge and regulator. The air exits the front of the alternator.

The alternator converts mechanical and magnetic energy to alternating current (AC) and voltage. This process is done by rotating a direct current (DC) electromagnetic field (rotor) inside a three phase stator. The alternating current and voltage (generated by the stator) are changed to direct current by a three phase, full wave rectifier system using six silicone rectifier diodes. Some alternators have three exciter diodes or a diode trio. They rectify the current needed to start the charging process. Direct current flows to the alternator output terminal.

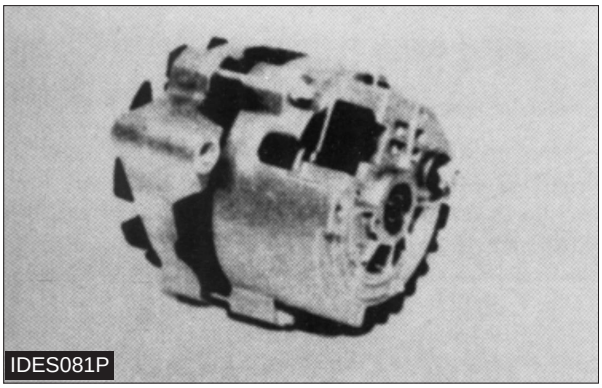
A solid state regulator is installed in or on the back of the alternator. Two brushes conduct current, through two slip rings, to the rotor field. Some alternators have a capacitor mounted on them. The capacitor protects the rectifier from high voltages. It also suppresses electrical noise through a radio, if equipped.

The alternator is connected to the battery through the ignition switch for alternator turn on . Therefore, alternator excitation occurs when the switch is turned on.

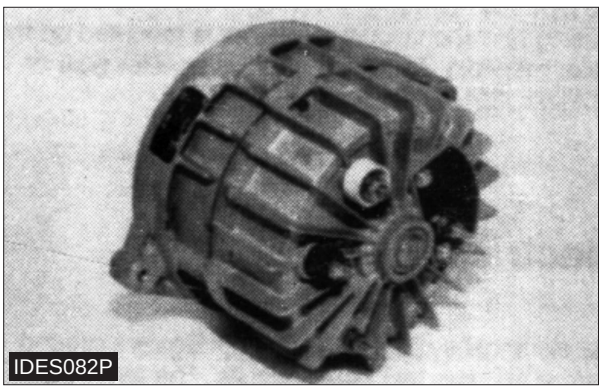
Alternators

The alternators used on these engines have three phase, full-wave, rectified output. They are the brush type. Refer to the Alternator Coverage chart for detailed systems operation information

ALTERNATOR COVERAGE	
Alternator Part Number	Manufacturer/ Series
D167411	Daewoo/CS-121
D187478	MICO/K1 Sealed

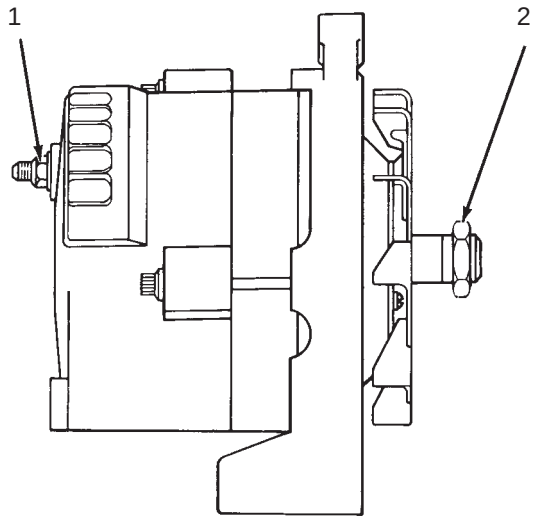


Daewoo CS-121 Alternator



Mico K1 Enclosed Alternator

Daewoo CS-121 Series



IDES043S

D167411

Rated voltage.....12 volts

Polarity is negative ground.

Rotation is clockwise.

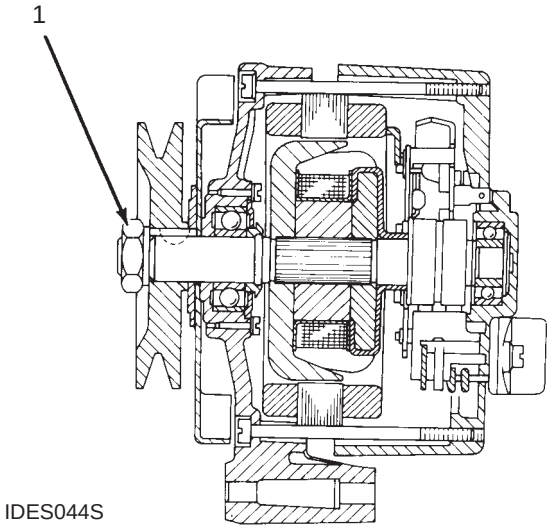
Output at 6500 rpm (cold) .....61 amps

Output voltage .....14.0 ± 0.5 volts

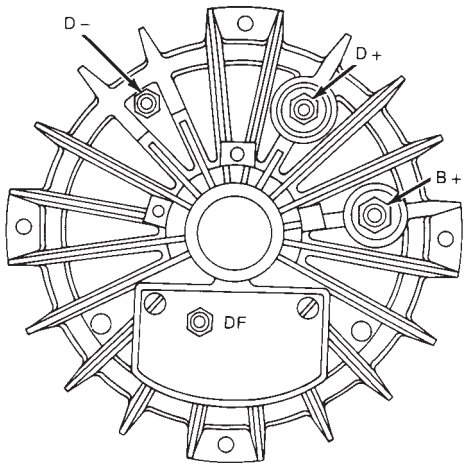
(1) Torque for battery terminal nut.....3.6 ± 0.8 N•m (32 ± 7 lb•in)

(2) Torque for pulley nut ...100 ± 7 N•m (75 ± 5 lb•ft)

D187478



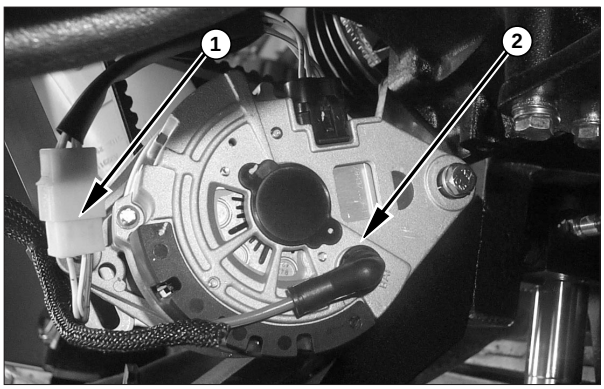
IDES044S



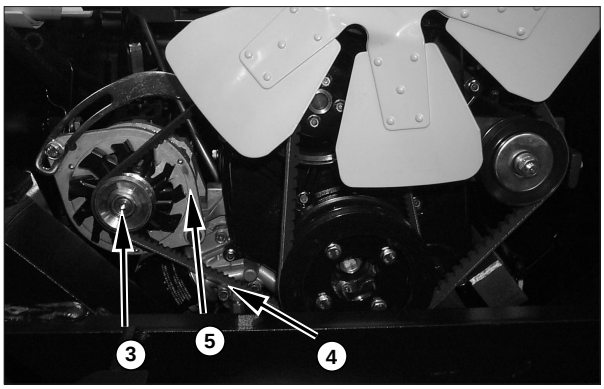
IDES045S

Remove & Install Alternator

NOTE : Hood, seat and dry air cleaner have been removed for photographic purposes.



1. Disconnect wire (1) and wire (2)



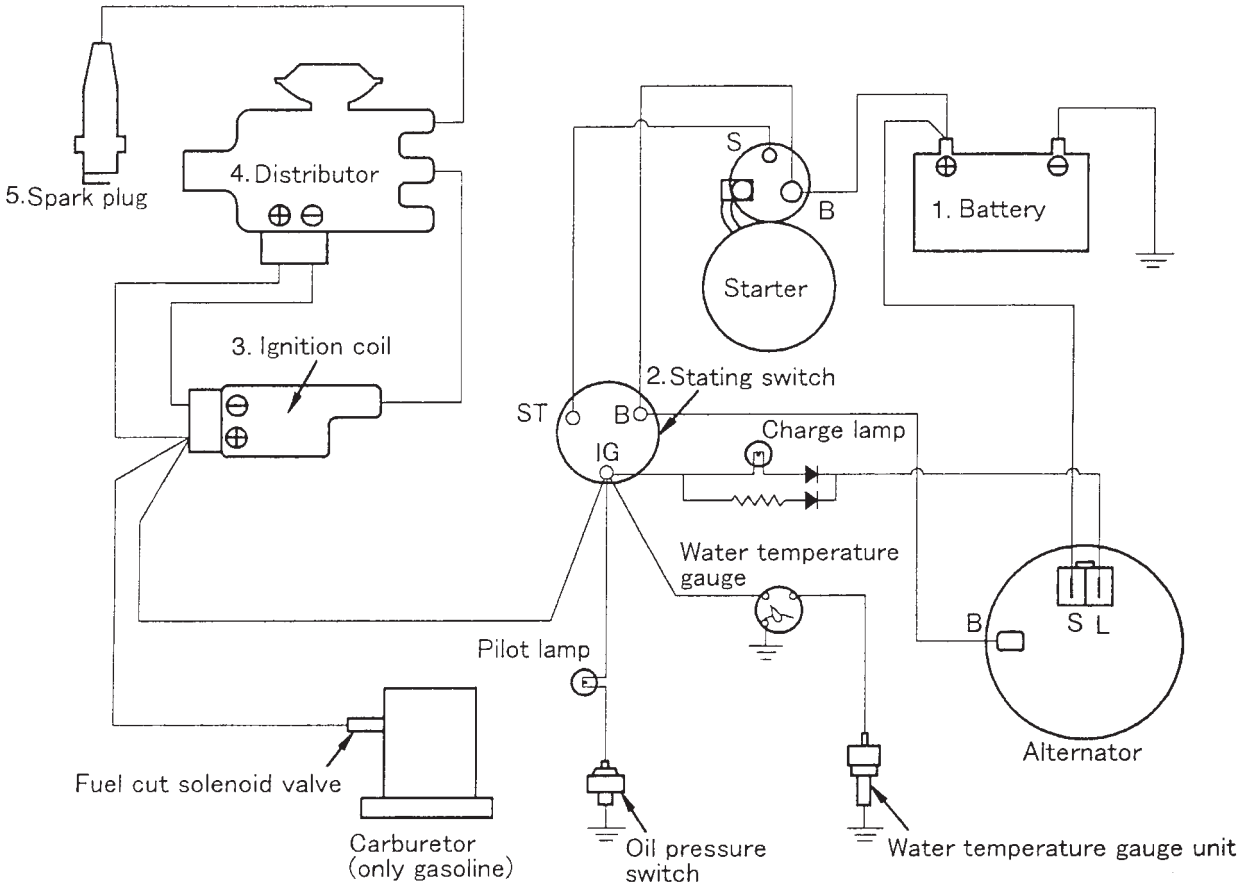
2. Remove bolt and washer (3), and remove belt (4).

3. Remove alternator (5).

NOTE : For the installation of the alternator, reverse the removal steps.

IGNITION SYSTEM

Breakerless Ignition System

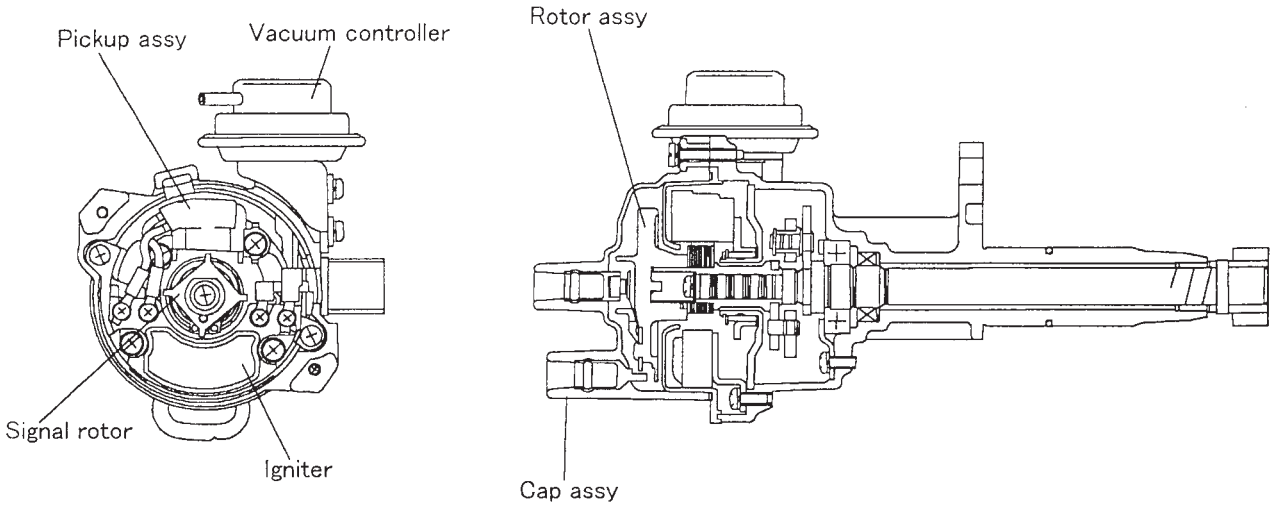


Ignition System Schematic
(1) Battery. (2) Ignition switch. (3) Coil. (4) Distributor. (5) Spark Plug.

The ignition system has battery (1), ignition switch (2), coil (3), distributor (4) with inner electronics circuits and spark plugs (5). The battery and ignition switch have terminals and closed contacts to permit battery current flow through the ignition system. These components must have closed current connections to complete the operation of the ignition circuit. Coil (3) and spark plugs (5) are of the standard type. The ignition coil changes the low voltage current into high voltage current to make a spark at the gap of the spark plug. The coil has two windings around a soft iron core. The primary has a small number of turns of heavy wire, and the secondary has many thousand turns of a very fine wire.

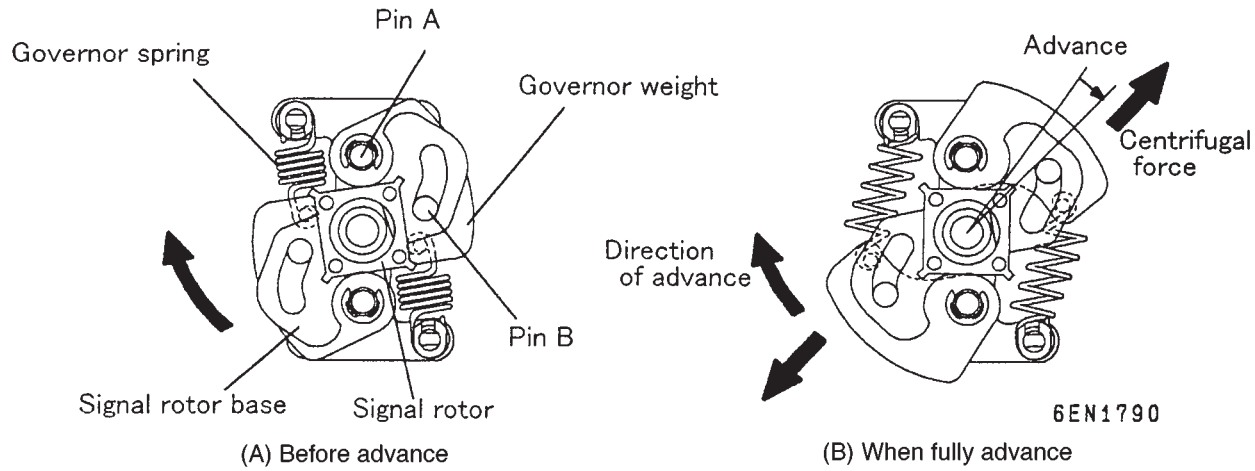
The primary winding is on the outside of the secondary windings.

Distributor



The distributor is the contactless type and is equipped with a centrifugal advancer and vacuum advancer.
The distributor is installed at the front side surface of the cylinder head, and is driven directly by the camshaft.

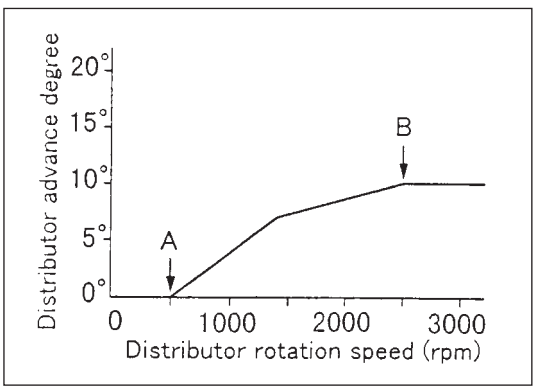
Governor advance mechanism



In the figure below, pin A rotates together with the shaft. A governor weight is installed to this pin A. There is a pin B on the governor weight which fits into the oblong hole in the cam base. The governor spring is attached to the spring hook of the governor weight, pulling the governor weight to the fully closed position. When the rotation speed increases, the governor weight is subjected to centrifugal force which causes it to open outward. When the centrifugal force becomes stronger than the tensile force of the spring, the weight opens, as shown by (b) in the figure below, thus maintaining a balance with the force of the spring. Because pin B of the weight is fit into the oblong hole in the cam base, the movement of pin B becomes rotation of the cam in the direction of rotation. In other words, the cam advances in relation to the shaft.

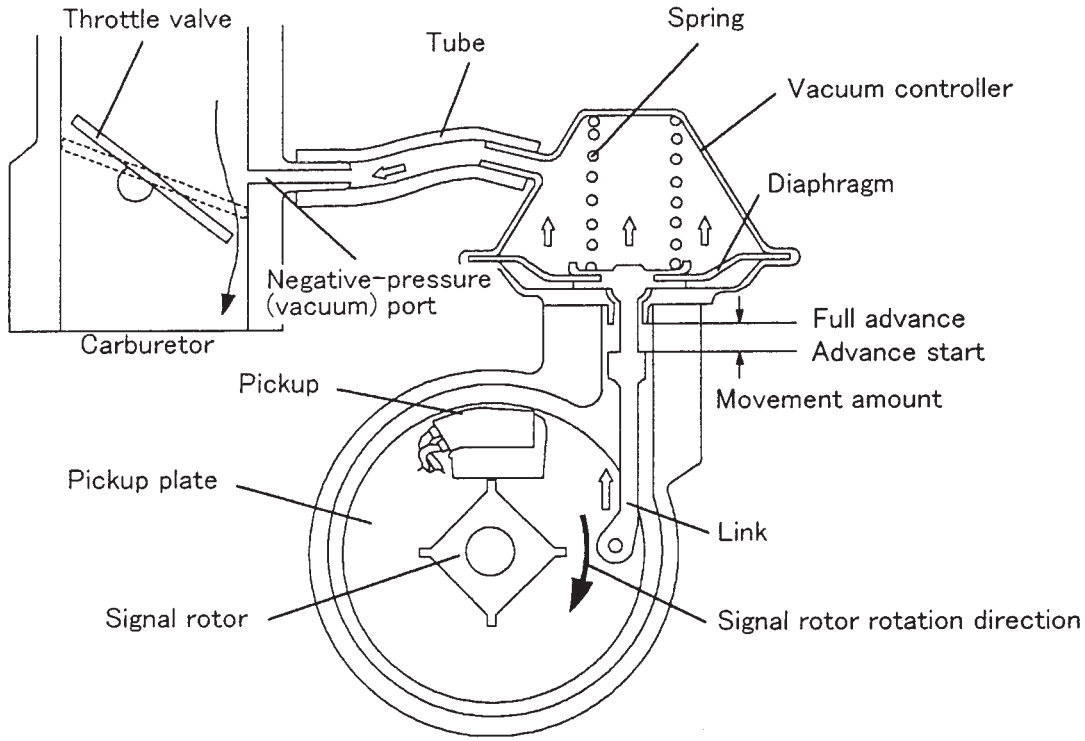
When the rotation speed becomes sufficiently high, pin B contacts the outer side of the oblong hole in the cam base, and the weight opens no further. This position is the fully advanced condition.

When the rotation speed decreases, the centrifugal force of the weight becomes weaker and the weight is closed by the force of the spring, thus returning to the original condition.



The advance characteristic of the centrifugal-advance device employed by the governor is as shown in the figure at the left. Point A is the beginning of advance, and point B shows the rotation speed at full advance.

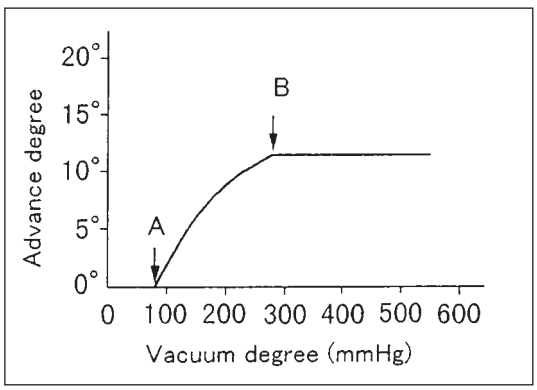
Vacuum advance mechanism



There is a diaphragm within the vacuum controller, with a spring at the negative-pressure (vacuum) side which pressure against the diaphragm. A link is attached to the diaphragm and is connected to the pickup plate. The pickup assy is installed on the pickup plate, and can rotate together with the pickup plate.

The negative pressure (vacuum) side of the vacuum controller is connected to the vacuum port of the carburetor by a tube.

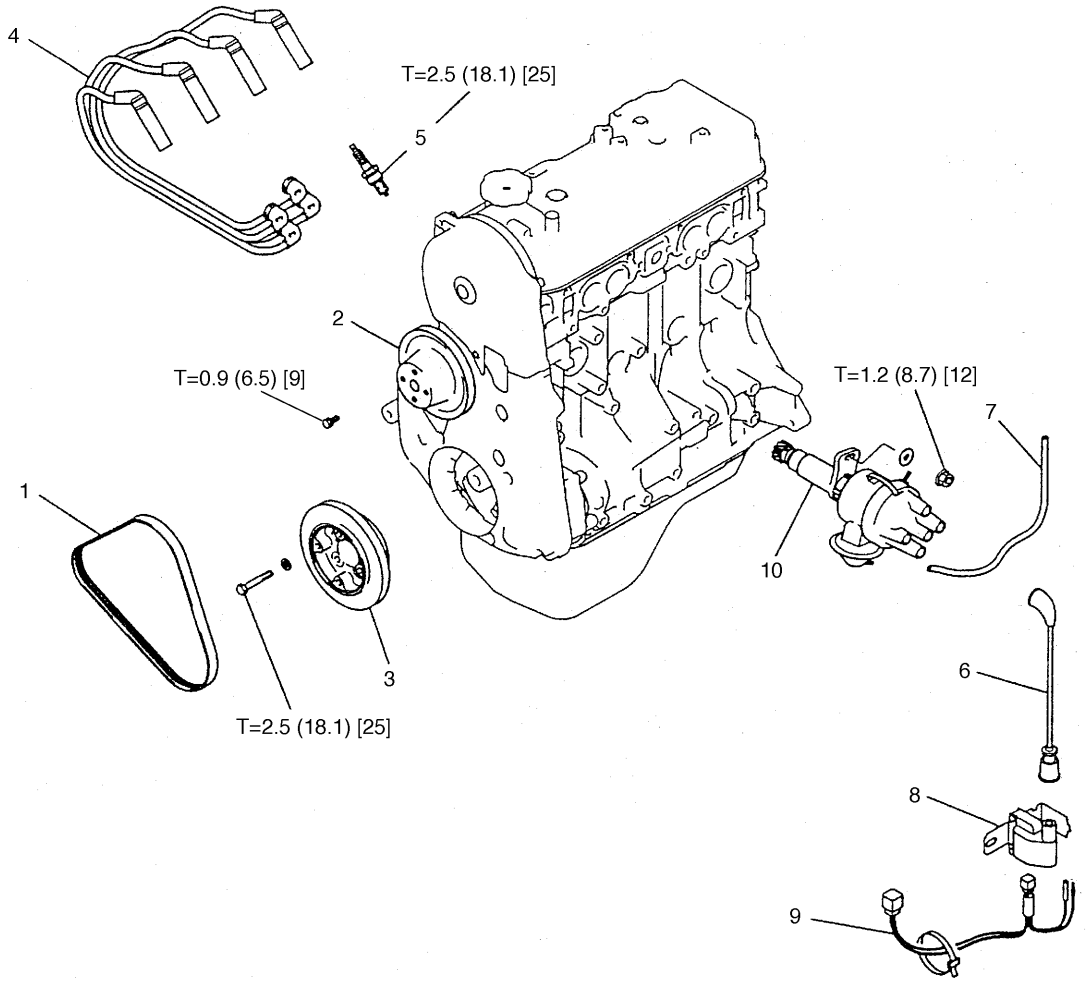
When the throttle valve of the carburetor is closed, the engine is in the idling condition, and there is no vacuum inside the tube at this time. When the throttle valve is partially open, the air within the tube is drawn out by the air/fuel mixture flowing near the vacuum port, thus resulting in a negative-pressure (vacuum) condition. Because the tube is connected to the negative-pressure (vacuum) port of the vacuum controller, the diaphragm pressure against the spring, and it moves in the direction of the arrow. Then the link rotates the pickup plate and, because the position of the pickup changes, the timing also changes. The direction is the direction opposite to the direction of signal rotor rotation, so that the projection of signal rotor will pass the pickup quickly. In this way, then, the ignition timing advances.



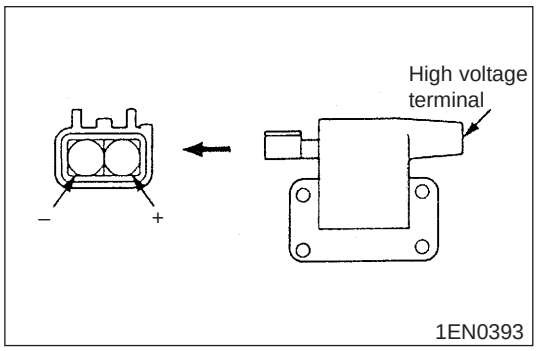
The figure at the left shows the advance characteristic curve of the vacuum-advance mechanism. Point A is the start of the advance, and point B is the end of the advance.

Because the magnitude of the degree of advance determined by balance of the strength of the vacuum and the pressure of the spring, if the spring is weak the degree of advance will be great at a small vacuum.

Removal and Installation



Removal steps
1. Drive belt
2. Water pump pulley
3. Crankshaft pulley
4. Spark plug cable
5. Spark plug
6. High tension cable
7. Vacuum
8. Ignition
9. Harness
→A← 10. Distributor



Inspection

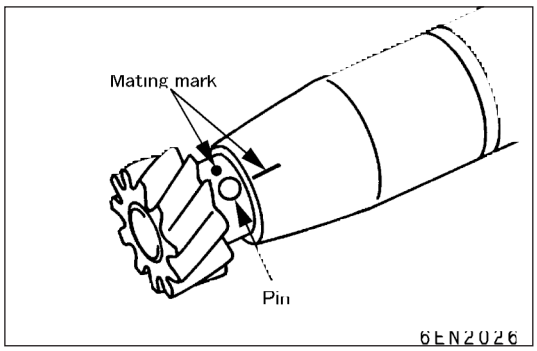
Ignition Coil

Perform the following measurements. Replace the ignition coil if the standard values are not met.

(1) Measure the resistance values of the primary and secondary coils and of the external resistor with a tester. If the readings are within the standard limits, it follows that there is no short or open circuit in the ignition coil.
Standard value:
Primary coil resistance value: 1.08 to 1.32 Ω
Secondary coil resistance value: 22.1 to 29.9Ω

Spark Plug Cable/High Tension Cable

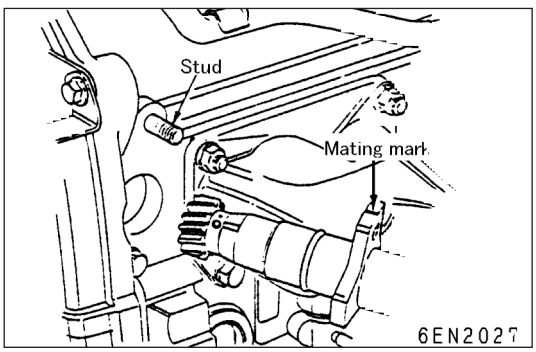
(1) Check the caps and covering for cracks.
(2) Measure the resistance values:
Standard value: 16 kΩ/m



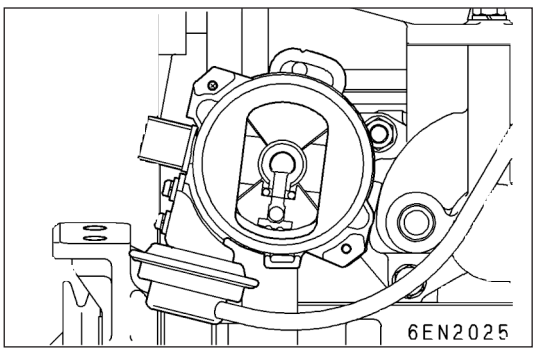
Installation Service Points

→A← **Distributor installation**

(1) Turn the crankshaft so that No. 1 cylinder is at top dead center.
(2) Aligh the distributor housing and gear mating marks.
(3) Shift 1 tooth of gear to meet the pin with the mating mark of distributor housing as shown in the illustration.

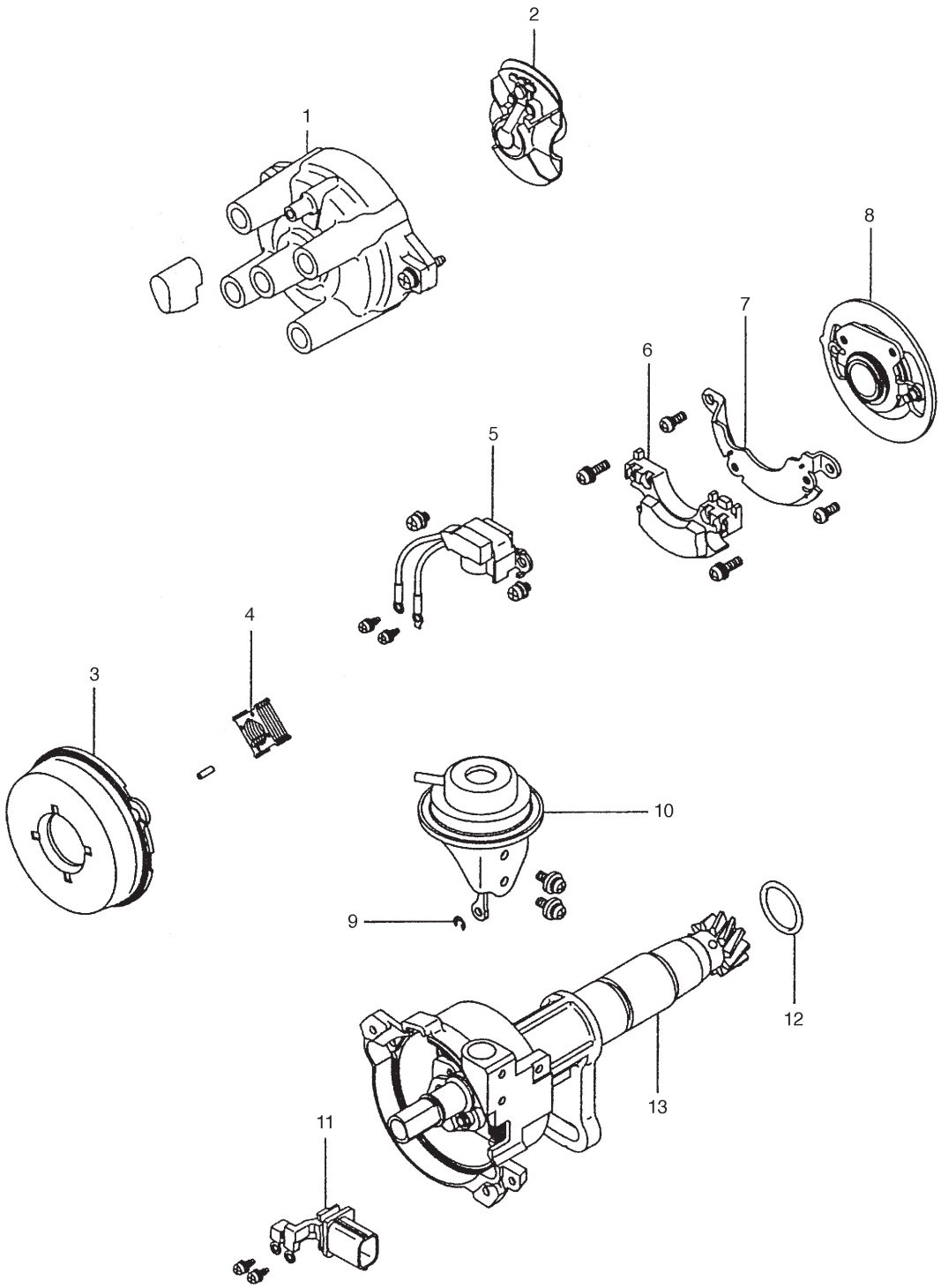


(4) Install the distributor to the engine while aligning mating of distributor housings (groove) of the distributor's installation flange with the center of the distributor installation stud.



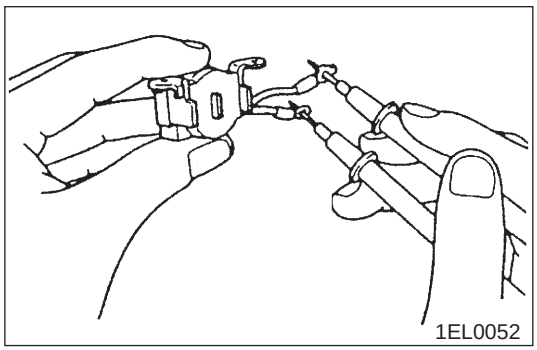
(5) Removes distributor cap and confirms that the rotor becomes as shown in the illustration.
(6) When the rotor is not in this position, redo from the operation in step (2).

Disassembly and Reassembly



Disassembly steps

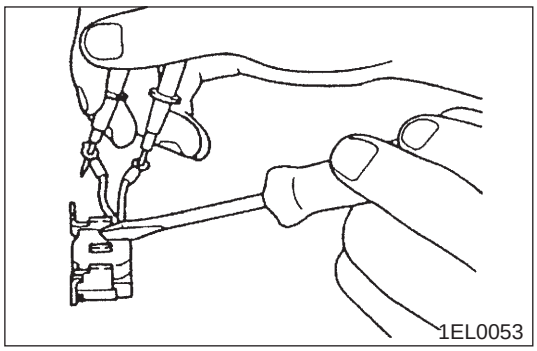
1. Distributor cap
2. Rotor
3. Cover
4. Signal rotor
→A← 5. Pickup coil assembly
6. Ignitor
7. Heat sink
8. Breaker assembly
9. Snap ring
10. Vacuum control
11. Connector assembly
12. O-ring
13. Distributor housing



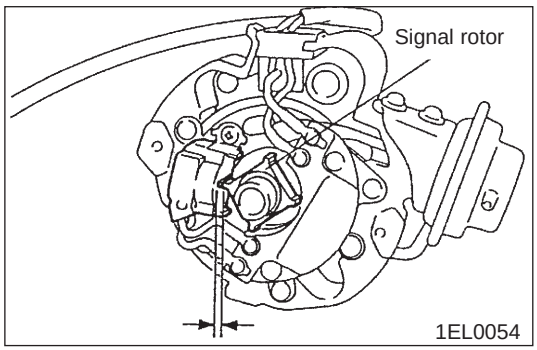
Inspection

Pickup Coil

(1) Using a tester, check the resistance of the pickup coil.
Standard value: 420 to 540Ω



(2) Check to make sure the pointer of the tester oscillates when the tip of a screwdriver is moved past by the core of the pickup col assembly.



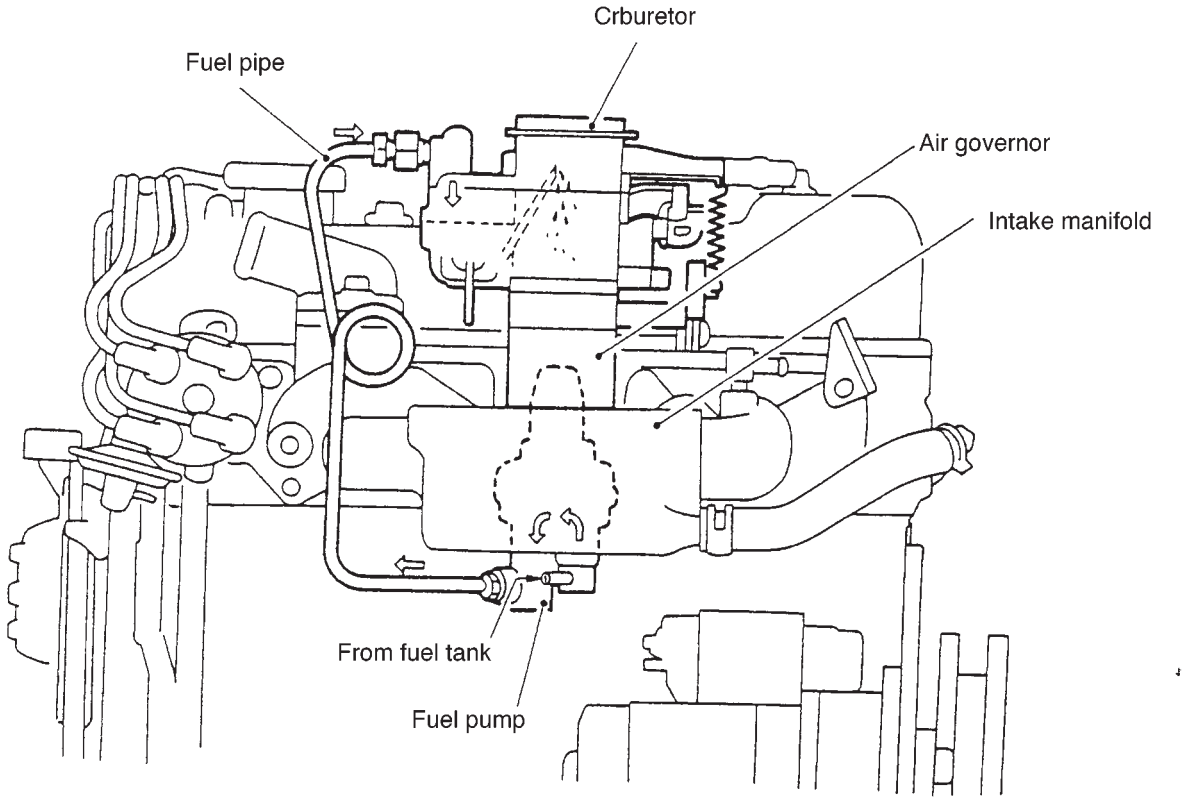
Reassembly Procedure

⟶ A ⟵ Pickup coil assembly installation

Check the air gap between the signal rotor and pickup assembly.
Standard value: 0.35 to 0.45 mm (0.0138 to 0.0177 in.)

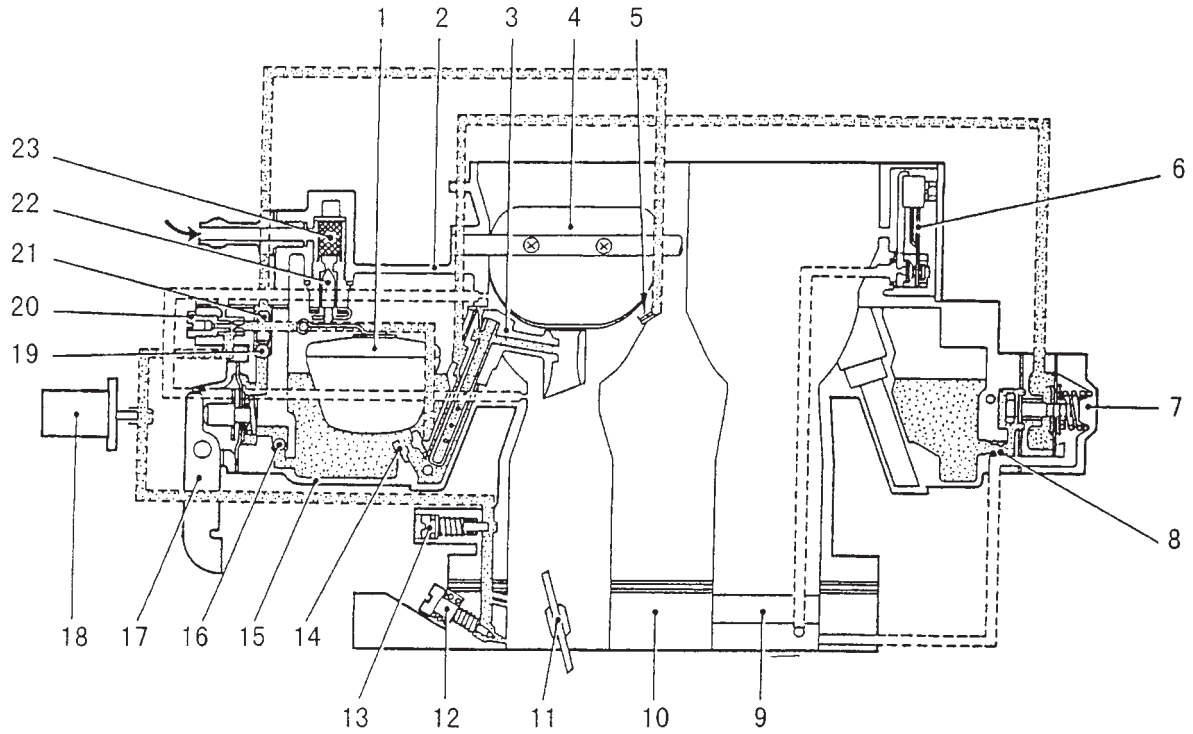
GASOLINE FUEL SYSTEM

General Description



The fuel pump pulls the fuel from fuel tank. The fuel flows through filter, which is installed on top of the fuel tank, to carburetor where the fuel is mixed with air at the correct ratio. This air and fuel mixture then goes to the inlet manifold. The air and fuel mixture takes in heat and is completely changed to vapor as it goes through the inlet manifold to the combustion chamber of each cylinder. The fuel pump keeps a supply of fuel to the carburetor at all conditions of operation and speeds of operation. The output of the fuel pump is controlled by the needs of the engine.

Gasoline Carburetor - Operation

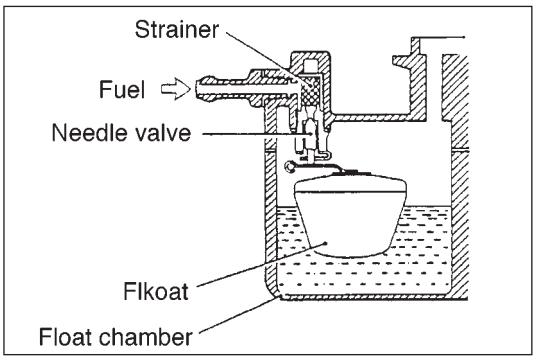


Construction of Carburetor
(1) Float. (2) Front chamber cover. (3) Primary inner venturi. (4) Choke valve. (5) Accelerator pump nozzle. (6) Idle compensator. (7) Membrane cover. (8) Enrichment jet. (9) Plug. (10) Throttle body. (11) Primary throttle valve. (12) Mixture adjusting screw. (13) Bypass screw. (14) Primary main jet. (15) Body. (16) Pump inlet ball. (17) Pump lever. (18) Fuel cutoff solenoid. (19) Pump outlet ball. (20) Primary pilot jet. (21) Valve weight. (22) Needle valve. (23) Fuel screen.

The carburetor is of the two-barrel, downdraft type which performs well in every engine operation ranging from slow idle to full speed.

1. Air system

Air passed through the air cleaner flows through the choke bore and venturi into the clearance of the throttle valve and supports idle running of the engine.
When engine speed increases to off-idle and more, intake air is metered by the venturi. Air flow to be fed to the cylinders is controlled by the throttle valve.

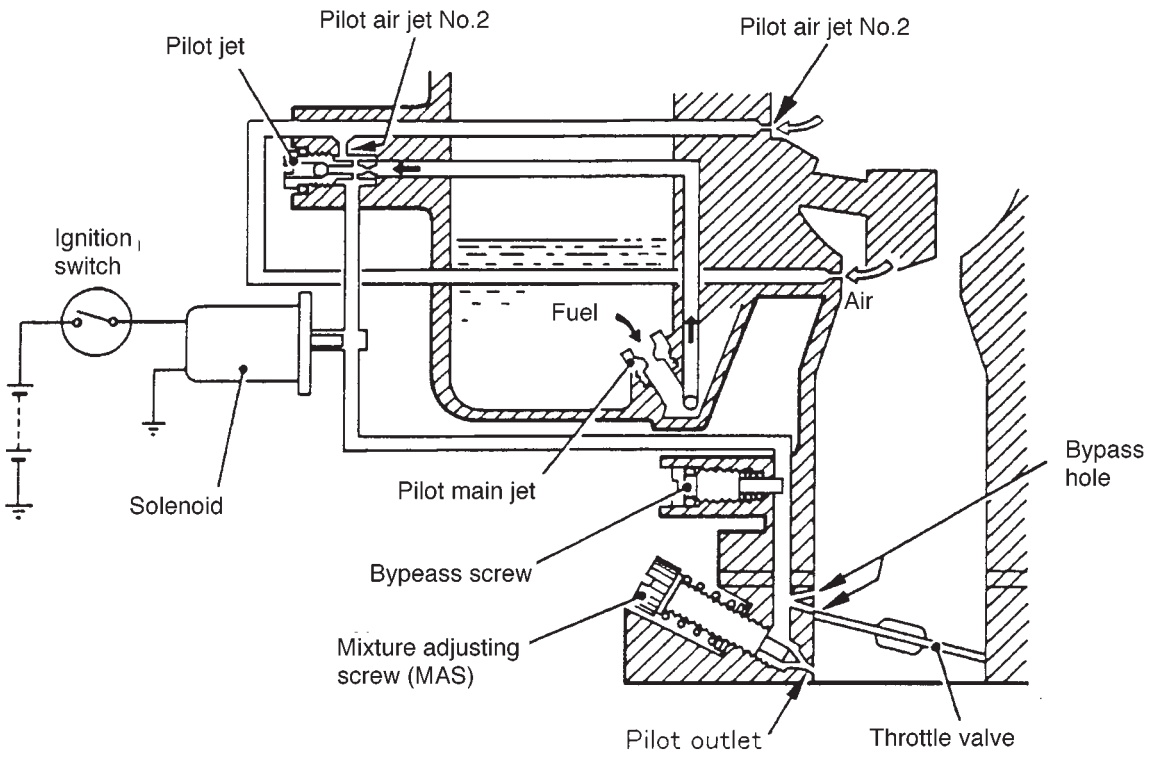


Float System

2. Float system

The float maintains a constant fuel level in the float chamber. Fuel from the fuel tank is pumped out by the fuel pump and filtered by the strainer. Then, fuel enters the float chamber through a needle valve.
With entrance of fuel in the float chamber, the float moves up gradually. At last, the float pushes the needle valve to shut off the fuel inlet.
When the fuel level lowers, the float moves down and releases the needle so that the fuel inlet is opened. With repetition of up-and-down movement of the float, fuel in the float chamber is kept at an almost constant level during engine operation.

3. Idle system



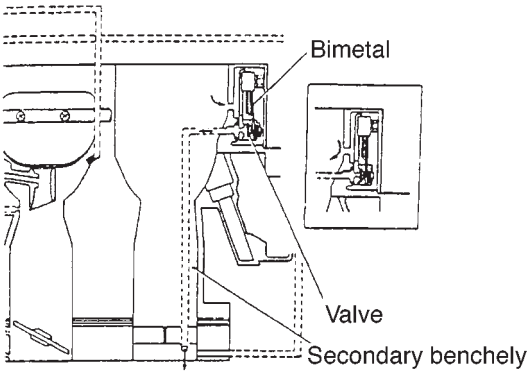
This system provides adequate air-fuel-mixture richness for smooth engine running ranging from slow-idle to light-load operation.

Fuel from the float chamber is sent through the main jet to the pilot jet where metering of fuel is made.

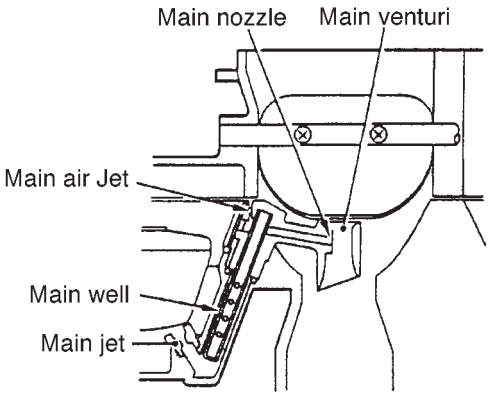
On the other hand, air entering the venturi air leak and that entering the pilot air jet No.2 join at the pilot air jet No.1 where metering of air is made. As a result of metering, fuel mixes with air and flows through the air-fuel-mixture passage to the pilot outlet. The flow of air-fuel-mixture is adjusted properly by the bypass screw and enters the air horn through the bypass hole or the pilot outlet. It mixes with the small amount of air that gets past the closed or slightly opened throttle valve. The final mixture flows into the engine cylinders.

The mixture adjusting screw is used for adjusting the richness of air-fuel-mixture necessary for good idling. The bypass screw is for the purpose of adjusting the flow of primary air-fuel-mixture to the bypass hole so as to provide sufficient mixture richness mainly for engine operation ranging from “off idling” to a part of medium-load operation.

The fuel cutoff solenoid in the idle system functions as follows : When the key switch is turned to ON, the solenoid attracts the needle valve to open the fuel feed line. When the key switch is turned to OFF, the needle valve protrudes to cut off the fuel feed line, thus preventing spontaneous running of the engine which is overheated.



Idle Compensator



Main Metering System

The idle compensator uses a bimetal. When the carbretor ambient temperature rises during idle or “off idle” running, the bimetal bends enough to open the compensator valve. Now additional air from the choke bore can flow through the auxiliary air passage to the intake manifold directly. It leans out the mixture enough to make up for the proper richness.

4. Main metering system

The wider the throttle valve opens, the faster the air flow in the venturi and the greater the vacuum in the inner venturi will be. As the vacuum becomes greater, additional fuel is discharged from the main nozzle.

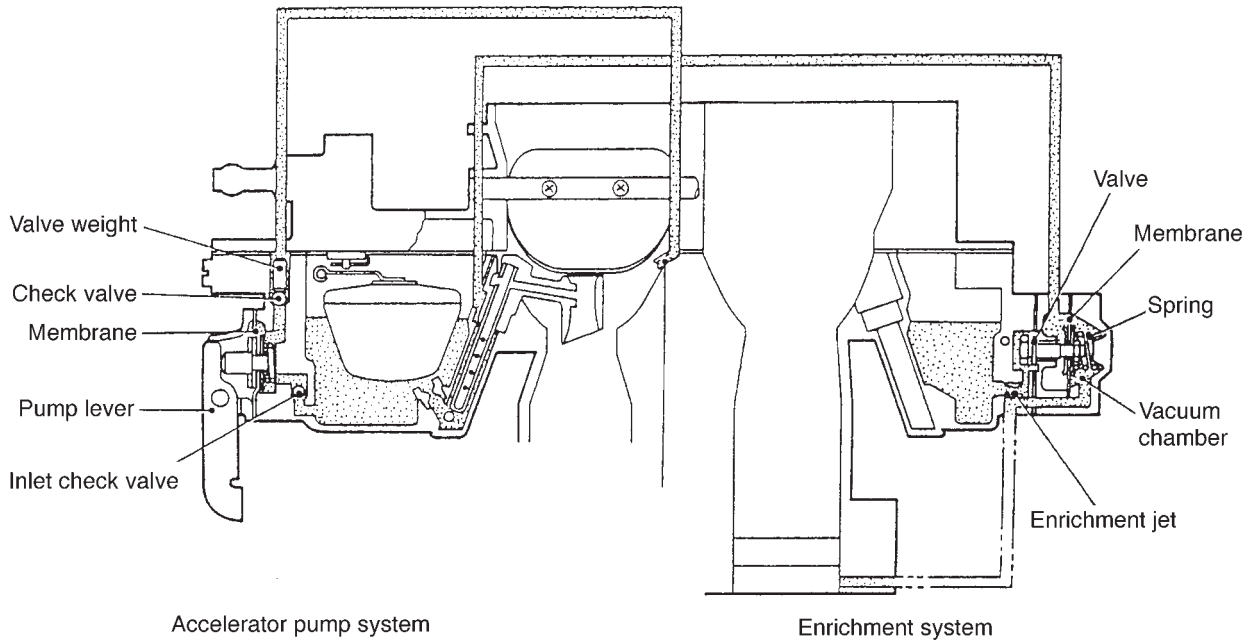
The main metering system is provided with the bleed valve press-fitted to the inner venturi and the main air jet.

Fuel metered by the main jet is bled by air from the main air jet and enters the bleed pipe through its holes. The fuel is discharged from the main nozzle and sucked by engine cylinders.

If percolation of fuel arises along the main well, gasoline vapor can escape from the main air jet through the relatively wide outside of the bleed pipe. This prevents liquid fuel from spurting from the main nozzle, thus assuring stable engine operation and easy restarting.

To prevent percolation due to conduction of heat from the engine, sufficient cooling of the float chamber periphery is taken into consideration in design of the carburetor.

5. Enrichment system



Enrichment and Accelerator-Pump systems

The enrichment system provides additional fuel feed to the main metering system during high-speed large-torque operation.

This system use the membrane (diaphragm) which is actuated by the intake manifold vacuum and membrane spring to open or close the fuel feed line.

During partial-throttle operation, a large manifold vacuum is applied to the vacuum chamber through the vacuum line and acts on the membrane to close the valve against the membrane spring force.

When the throttle is opened wide, manifold vacuum decreases.

This allows the membrane spring to open the valve. Now, more fuel from the float chamber is metered by the enrichment jet and can flow through the valve into the primary main line leading to the main metering system.

6. Accelerator-pump system

Rapid opening of the throttle for acceleration allows a sudden inrush of air. Thus there is a sudden demand for additional fuel. To provide this extra fuel, the accelerator-pump system can feed fuel immediately under pressure.

Fuel from the inlet check valve is sent to the pump nozzle through the outlet check valve by reciprocating movement of the membrane. The fuel is then injected into the main bore.

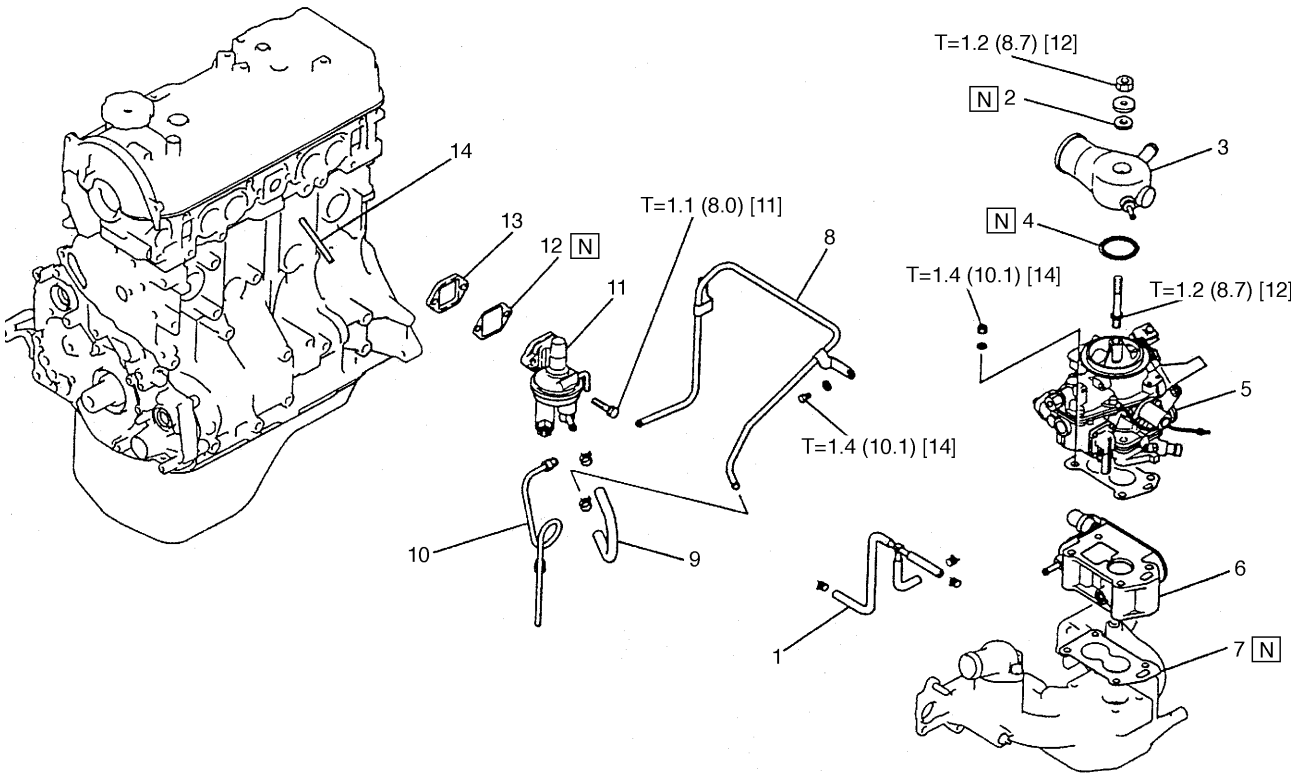
When the engine is accelerated quickly, the membrane is pushed by the pump lever linked to the throttle valve and forces fuel to flow under pressure. When the engine is decelerated, the membrane is pushed back by the spring and the pump chamber is refilled with fuel.

Pump delivery decreases with engine speed from which acceleration is starred. It does not deliver fuel at all when the angle of throttle valve from the idling position exceeds the preset angle.

7. Stating system

The starting system consists of the choke valve, lever assembly, choke connecting rod, and choke operating lever. This system is provided for feeding a very rich air-fuel mixture to the engine when the engine is started (until the engine warms up) or when a temporary increase of output is needed during engine operation. When the engine is cold, some throttle opening must be maintained so that the engine idles faster then it would when warm. This is done with “fast idle.” With the fast idle, the choke valve is closed while the throttle valve is held at a partially opened position most suitable to warming-up run.

Removal and Installation



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Removal steps

	1. Return set hose assembly	8. Fuel pipe
	2. Oil seal	9. Fuel hose
	3. Air horn	10. Fuel pipe
	4. Gasket	←B→ →A← 11. Fuel pump
←A→	5. Carburetor	12. Gasket
	6. Air governor	13. Insulator
	7. Gasket	14. Push rod

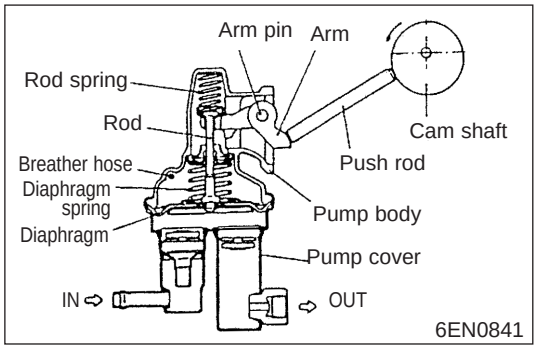
Removal Service Points

⟵ A ⟶ Carburetor removal

(1) Hold the carburetor in a level position while using care not to let fuel spill, remove it from the intake manifold.
(2) Turn the carburetor upside down on a pan to drain fuel.

⟵ B ⟶ Fuel pump removal

Placing the piston in No.1 cylinder at TDC on the compression stroke makes the fuel pump stroke lift the smallest, allowing easy removal of the pump.

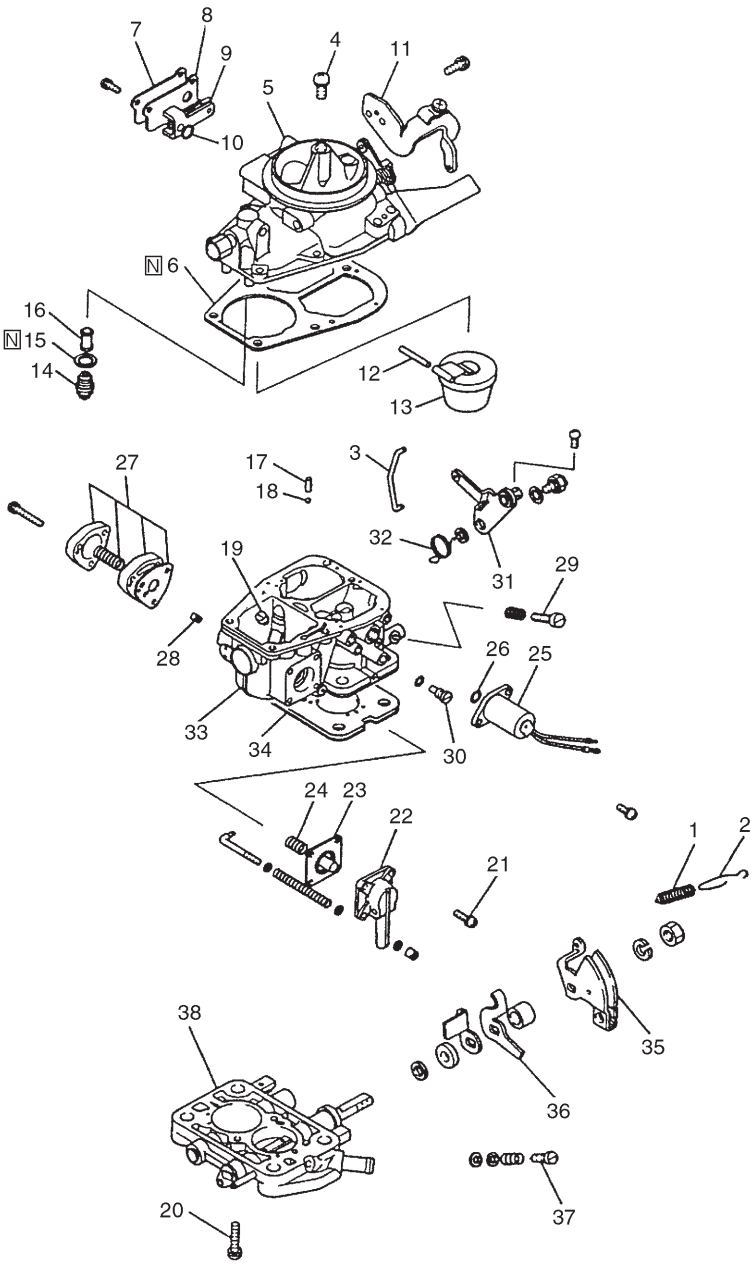


Installation Service Points

⟶ A ⟵ Fuel pump installation

(1) Bring the piston in No.1 cylinder to TDC on the compression stroke. This provides the smallest lift of the eccentric cam, allowing easy installation of the fuel pump.
(2) Apply engine oil to the surface of the push rod and insert it into the hole in the cylinder head. Make sure that the push rod sides smoothly.
(3) Install the fuel pump on the cylinder head with the insulator and a new gasket in between, and tighten the bolts completely.

Gasoline Carburetor
Disassembly and Reassembly



Disassembly steps

←A→	1. Throttle return spring
	2. Damper spring
←A→	3. Choke rod
	4. Screw
←B→	5. Float chamber cover
	6. Float chamber cover gasket
	7. Cover
	8. Packing
	9. Bimetal
	10. O-ring
	11. Accelerator wire bracket
→C←	12. Float pin
→C←	13. Float
	14. Needle valve assembly
	15. Packing
	16. Filter
←C→ →B←	17. Weight
←C→ →B←	18. Ball
←D→ →A←	19. Main jet
	20. Screw
	21. Screw
	22. Accelerator pump cover
	23. Diaphragm
	24. Spring
	25. Fuel cut solenoid
	26. O-ring
	27. Enrichment
	28. Enrichment jet
	29. Speed adjust screw
	30. Pilot jet
	31. Choke lever
	32. Spring
	33. Main body
	34. Insulator gasket
	35. Throttle lever
	36. Throttle control lever
	37. Mixture adjusting screw
	38. Throttle body

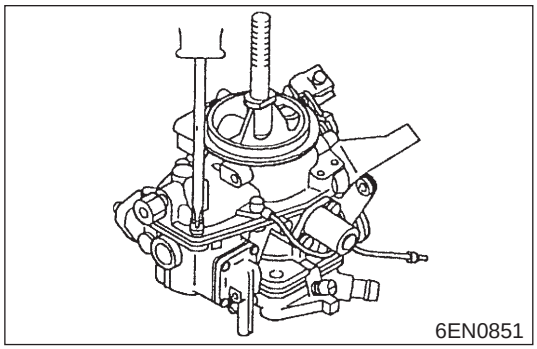
Service Points of Disassembly

The following parts must not be disassembled at the time of disassembly.

(1) Choke valve and choke shaft
(2) Inner venturi
(3) Throttle valve and throttle shaft

⟵ A ⟶ Return spring/choke rod removal

(1) When the spring is removed, avoid prying it with undue force or any other attempt that can cause damage to it.
(2) Press the end of the choke rod to force the rod out. Avoid applying a strong force to the plastic grommet of the rod fit-in hole.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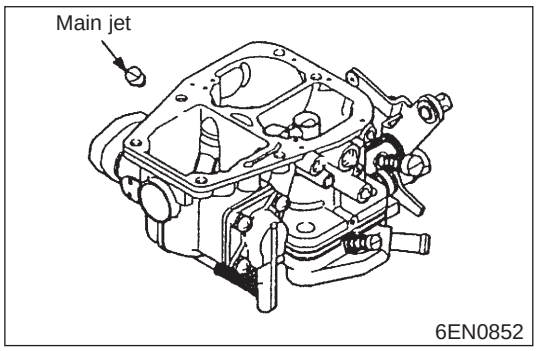
⟵ B ⟶ Float chamber cover removal

(1) Since the screws require great force to loosen, use a Phillips screwdriver that exactly fits in the cross recess in the screw heads.
(2) To remove the float chamber cover, slowly lift it, while using care not to give damage to the float. Don't tilt the main body, as the pump discharge weight and the related parts may come out and could be lost.

⟵ C ⟶ Pump weight/ball

Turn the main body upside down to remove the weight and ball.



6EN0852

⟵ D ⟶ Main jet removal

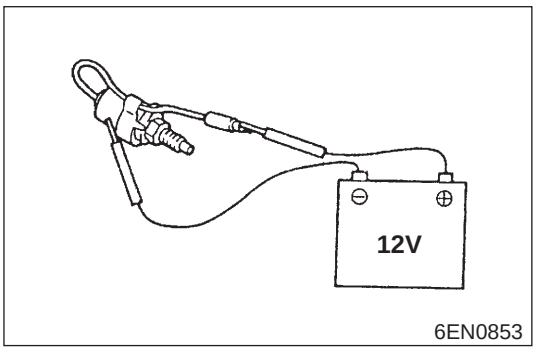
To remove the main jet, be sure to use a screwdriver whose tip exactly fits in the slot of the jet.

Inspection

1. General Inspection

Check the following and repair or replace parts if faulty.

(1) Check fuel passages (jets) and air passages (jets or orifices) for clogging. If clogged, wash thoroughly with cleaning solvent or detergent and remove dirt by compressed air. Do not use wire or other metal pieces.
(2) Check diaphragms, O-rings and springs for damage and cracks.
(3) Check that needle valve operates lightly. If the valve is hard to operate or is binding, repair or replace. If there is overflow, poor valve to seat contact is suspected. Check thoroughly.
(4) Check the fuel inlet filter (located above the needle valve) for clogging and damage.
(5) Check the float operation. Check float and lever for deformation and damage and replace if necessary.
(6) Check operation of the throttle valve, choke valve and link. If they do not operate lightly, wash well and apply engine oil sparelingly to their shaft.
(7) Check the float chamber cover and main body for damage and cracks.



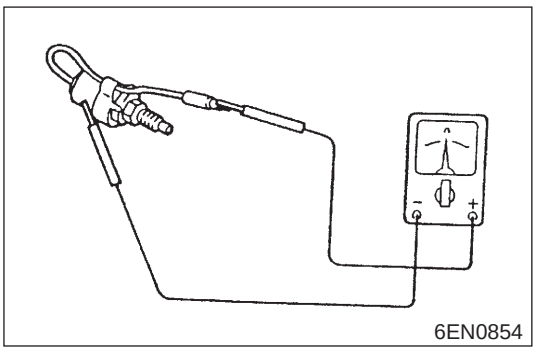
6EN0853

2. Fuel Cut Solenoid Valve Operation Check

(1) Connect the battery directly to the body and terminal of the fuel cut solenoid valve to apply the voltage.

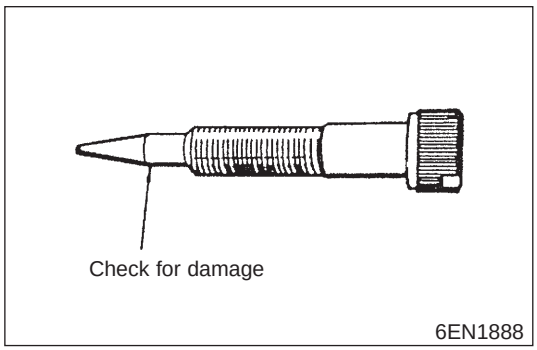
Caution: Use care not to short-circuit the battery.

(2) Listen to a click which should be heard when the valve operates normally at the moment the battery is connected.


6EN0854

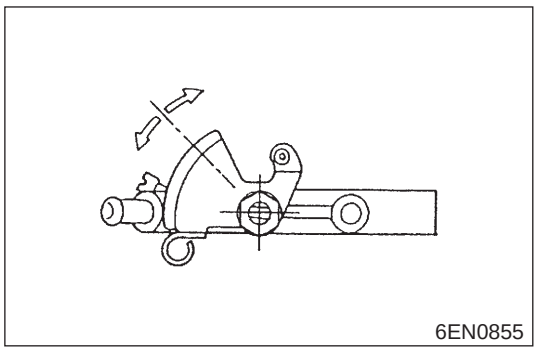
3. Fuel Cut Solenoid Valve Resistance Check

Measure the resistance between the body and the terminal of the fuel cut solenoid valve with a tester.
Standard value:
Approx. 90Ω [at 20°C (68°F)]



4. Inspection of Mixture Adjusting Screw (MAS)

Check tapered end of mixture adjusting screw (MAS) for damage from over tightening, etc.



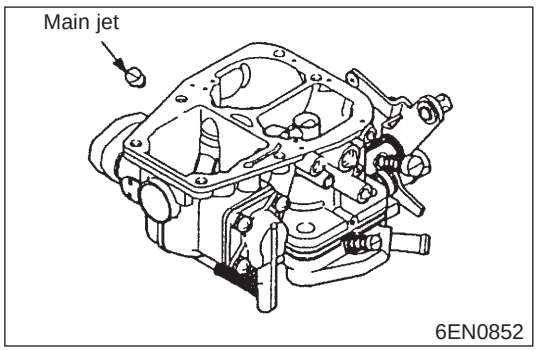
5. Throttle Body Check

Make sure that the throttle shaft moves smoothly. If any sticky movement is found, thoroughly clean the shaft, and then coat it with a small amount of engine oil. Do not disassemble the shaft unnecessarily.

Service Points of Reassembly

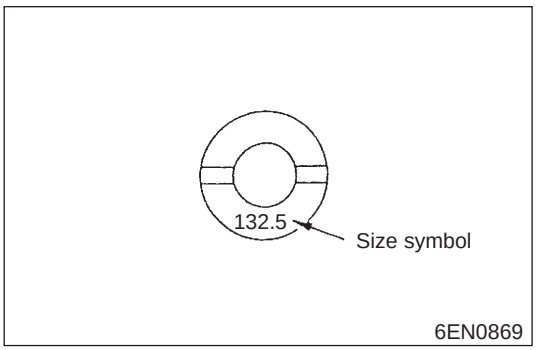
For reassembly, reverse the order of disassembly while paying much attention to the following:

(1) Clean every parts with clear cleaning oil before reassembly. Check all passages for clogging.
(2) Replace all the removed packings and gaskets.
(3) Make sure the throttle and choke linkage operates smoothly. If any sticky movement is found, clean or replace the linkage, and make sure that the carburetor operates without any problem.

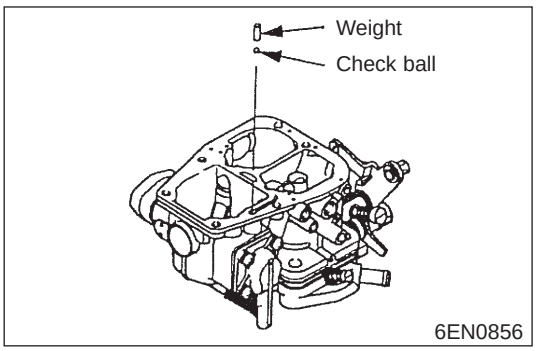


⟶ A ⟵ Installation of main jets

(1) When replacing a main jet, the oil jet and the new jet must be of the same size, because the jet is selected after exact flow measurement by factory. (A size symbol is stamped on each jet.)



(2) Main jets have size symbols stamped on their ends for identification.
Size symbols : 132.5

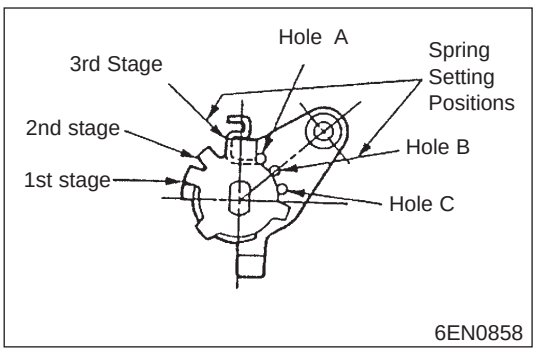


⟶ B ⟵ Check ball/weight installation

Install the acceleration check ball and weight.

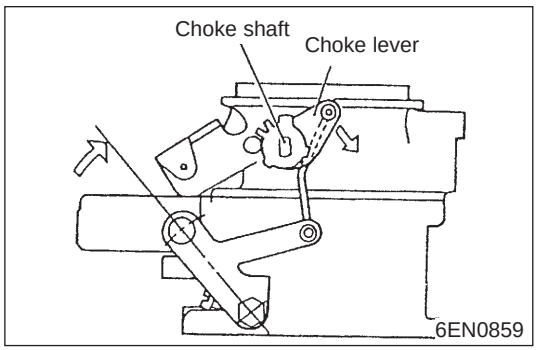
⟶ C ⟵ Float/float pin installation

After the float and float pin have been installed, make sure that the float is in a level position.



• Strangler spring setting positions

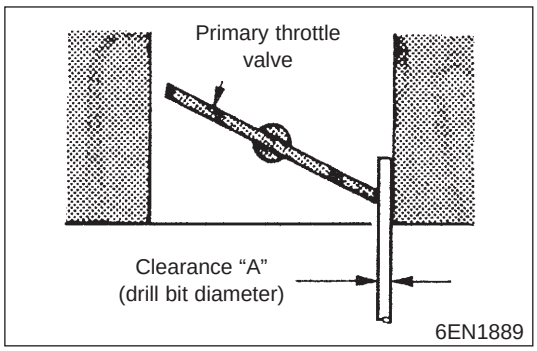
If the strangler spring of the choke valve shaft is out of position, set it correctly in the positions shown in the illustration.



Inspection and Adjustment After Reassembly

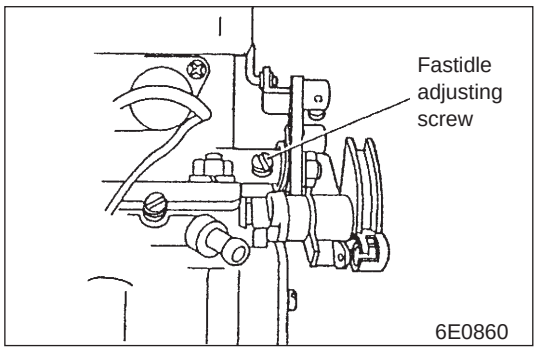
1. Fast Idle Opening

(1) Move the choke lever to place the choke valve in fully closed position.



(2) Measure the clearance "A" (primary throttle valve to throttle bore).

NOTE: Refer to the table in SERVICE SPECIFICATIONS for the clearance.

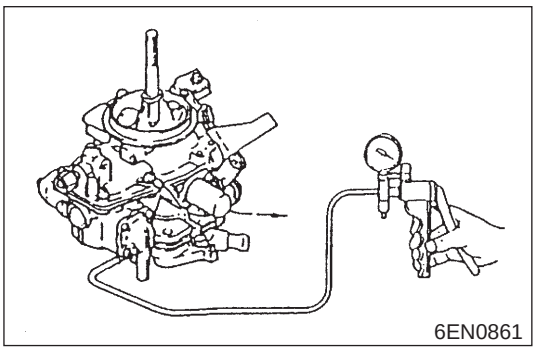


(3) If the clearance "A" is out of specifications, adjust to the standard value by the fast idle adjusting screw.

Screw direction of rotation	Clearance	Remarks
Clockwise	Increases	Fast idle speed increases
Counterclockwise	Decreases	Fast idle speed decreases

2. Choke valve Operation

(1) With the choke valve lever set to its full position, move the choke valve with a finger to make sure that the choke valve shaft has not an excessive play and the valve moves smoothly without sticking.
(2) If the choke valve can not be moved smoothly, clean the choke valve and the area around it.
(3) If the play of the choke valve shaft is excessive, replace the float chamber cover.

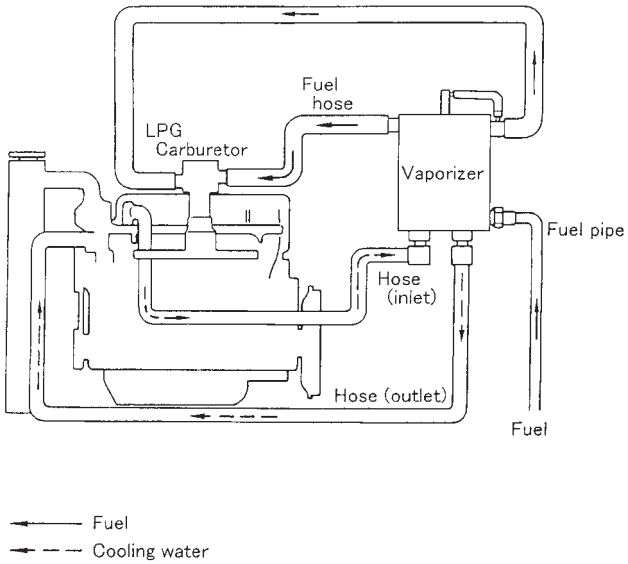


3. Ports

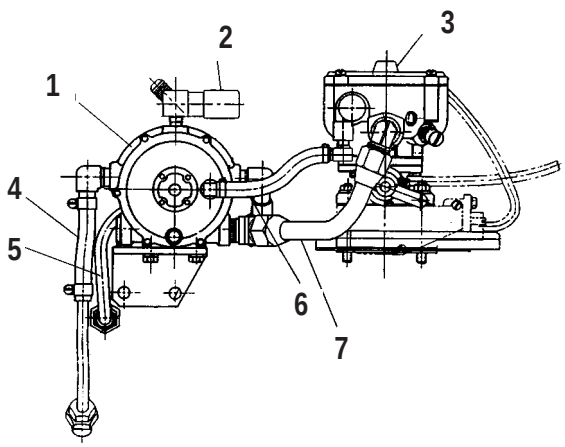
(1) Connect a hand vacuum pump and check each port for clogging.
(2) If clogged, clean the port and then blow air into it.

LP FUEL SYSTEM

General Description



Electric Fuelock Model

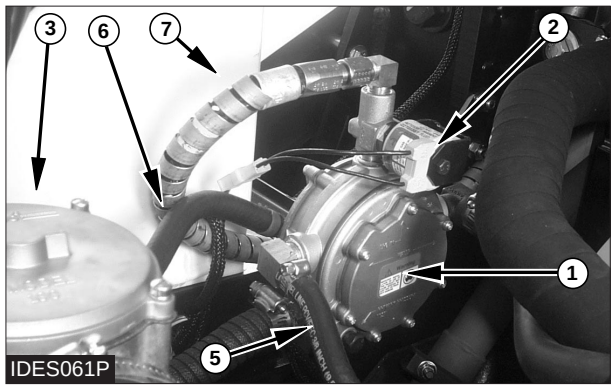


IDES062S

LP Fuel System Components

The basic components of this liquid petroleum (LP) fuel system are: the fuel tank, the fuel filter and relief valve, fuelock (2), converter (1) and carburetor (3).

Liquid fuel is sent to fuelock (2) by the pressure in the fuel tank, which is approximately 1030 kPa (150 psi). Fuelock (2) permits fuel flow to the converter when electrically activated by the oil pressure switch. LP fuel flows into converter (1), which changes the fuel to a vapor. The fuel receives heat in the converter from the engine coolant that flows in line (5) and out line (4). Carburetor vacuum activates the converters operation and the fuel flows to the carburetor through line (7). From carburetor (3), the vapor fuel goes through the inlet manifold to the combustion chamber of the engine. In the combustion chamber, the spark made by the spark plug will "ignite" (cause to burn) this vapor. Balance hose (6) keeps the correct air and fuel mixture in the carburetor when there is some restriction in the air cleaner.

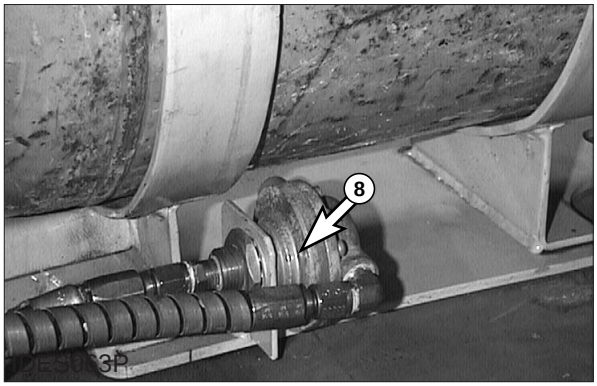


LP Fuel System Components
(1) Converter. (2) Fuelock. (3) Carburetor.
(4) Coolant ontlet line
(5) Coolant inlet line. (6) Balance hose.
(7) LP fuel line to carburetor

Electric Fuelock

Fuelock (2) is electrically activated by an oil pressure switch. When the engine is stopped, or if the engine oil pressure gets lower than the pressure for operation, the oil pressure switch will open. When the oil pressure switch opens, it will close the fuelock, which stops the supply of fuel to the converter.

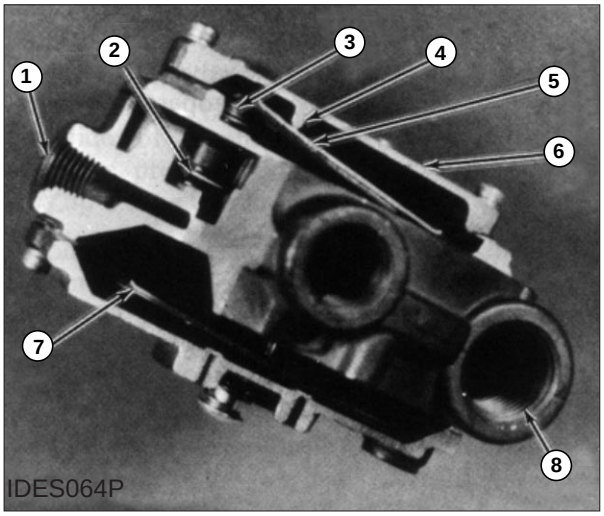
Fuel Filter



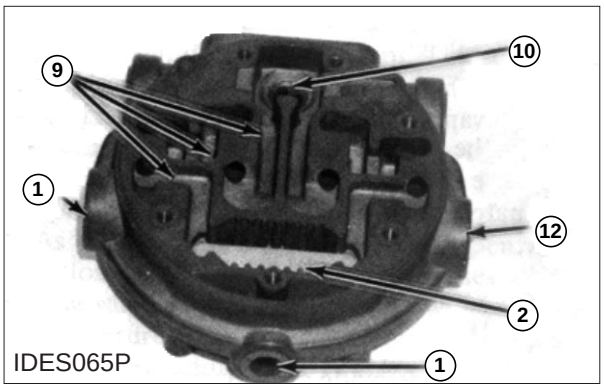
Fuel Filter
(8) Fuel filter.

On electric fuelock models, fuel filter (8) is mounted near the fuel tank. It cleans the fuel before it gets to the fuelock and converter.

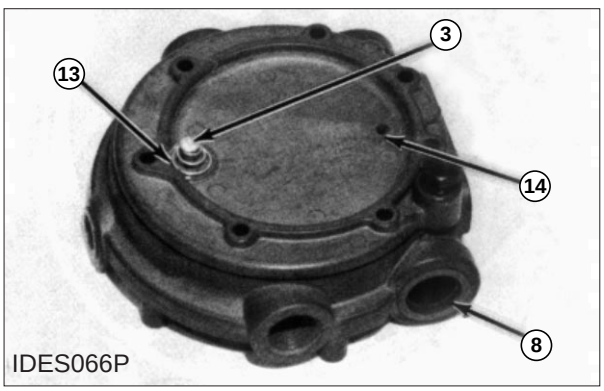
Converter



Converter Components
(1) LP fuel inlet opening. (2) Primary regulator valve.
(3) Primary valve pin. (4) Fulcrum.
(5) Primary diaphragm with lever. (6) Cover.
(7) Secondary diaphragm. (8) LP fuel outlet opening.

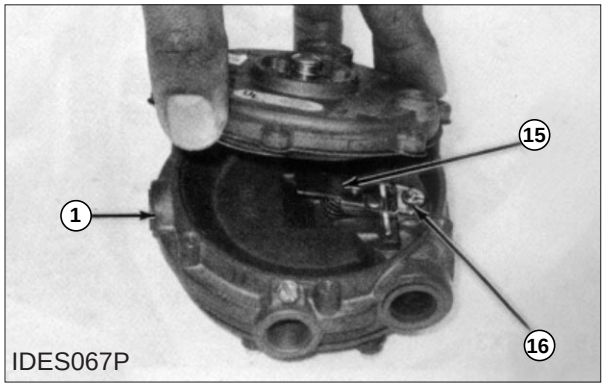


Converter Vaporized Chamber
(1) LP fuel inlet opening. (2) Primary regulator valve.
(9) Vaporizing chamber. (10) Vapor fuel outlet opening.
(11) Coolant outlet opening. (12) Coolant inlet opening.



Converter Primary Components
(3) Primary valve pin. (8) LP fuel outlet opening.
(13) Primary regulator spring. (14) Sensing opening.

The converter is a combination regulator and vaporizer. It receives liquid fuel through opening (1) at tank pressure from the fuelock. The fuel is available inside converter vaporizing chamber (9) when carburetor vacuum is felt in converter opening (8). When vacuum is not available at the fuelock or opening (8), primary valve pin (3) puts force on primary regulator valve (2) that makes a seat against an inner passage for the fuel inlet. The pin action is controlled by primary diaphragm with lever (5) and cover (6). Primary spring (13) is in compression when vacuum is not available.



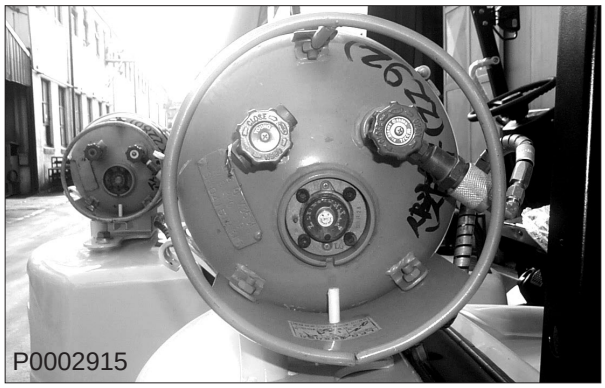
Converter Secondary Components
(1) LP fuel inlet opening. (15) Secondary lever assembly.
(16) Secondary regulator seat.

When the engine is running, the solenoid on the fuelock allows fuel to flow from the fuelock to converter opening (1). Vacuum is felt through converter opening (8) from the carburetor. This vacuum pulls in secondary diaphragm (7) with the diaphragm link, which moves secondary lever assembly (15). The secondary lever assembly moves secondary regulator seat (16) that opens fuel flow passage in chamber (9). At the same time, the vacuum flows through sensing opening (14) that causes primary diaphragm with lever (5) to pull in. This causes the diaphragm lever to make a pivot on cover (6) fulcrum (pivot point) (4). Primary valve pin (3) moves away from primary regulator valve (2) with the assistance of primary regulator spring (13).

When primary regulator valve (2) is off its seat, fuel is permitted to flow into vaporizing chambers (9). The fuel flows around and through the passages of the vaporizing chambers while the heat through the converter body is being taken in by the fuel which causes fuel to vaporize. The heat is a product of the engine coolant that goes in opening (12) and out opening (11). The flow of vapor fuel goes out opening (10) in the converter body, activated by open secondary regulator seat (16) to fuel outlet opening (8), through the fuel line to the carburetor.

The vaporizing chamber decreases LP fuel pressure from the tank to less than atmospheric pressure.
This expansion of the pressurized liquid fuel into vapor, can result in freezing. The heat from the engine coolant increases the temperature of the fuel in vaporizing chamber (9) from approximately -42°C (-44 °F) to +2 °C (+40 °F)

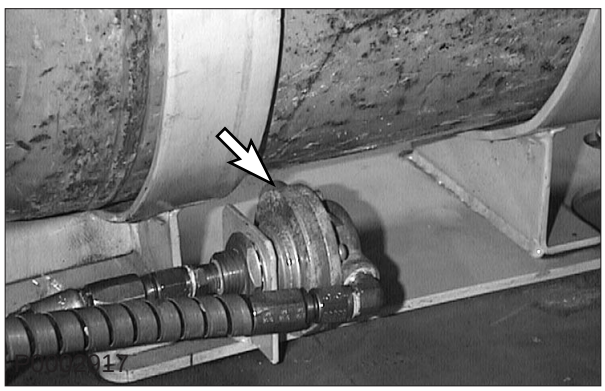
Fuel Tank



LP Fuel Tank

The fuel tank is made of heavy steel. The specific size of the tank is measured by the design of the lift truck, desired period of time the lift truck is to be operated before the tank has to be filled and how near an available supply of fuel is.

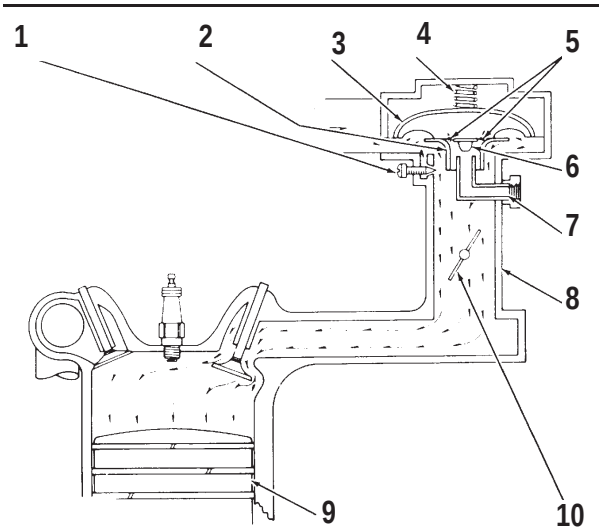
LP Relief Valve



Relief Valve

When the pressure in the LP fuel system gets too high, the relief valve releases the pressure to the atmosphere. The action of the relief valve prevents damage to the fuel lines and other components of the fuel system. The position of the valve is in a direction that the fuel will not get on the operator when the valve is activated.

Carburetor



IDES070S

LP Fuel Carburetor Schematic
(1) Idle air screw. (2) Air valve. (3) Diaphragm.
(4) Metering spring. (5) Passage. (6) LP gas metering valve.
(7) Power mixture adjustment. (8) Carburetor. (9) Piston.
(10) Throttle valve.

Lift trucks with LP (Liquid Petroleum) fuel system use an air valve type of carburetor (8). The operation of the carburetor controls the fuel mixture flow into the engine with the movement of throttle valve (10) and mixes the air flow with the LP fuel flow.

The air flow is measured by the operation of air valve (2) in the carburetor bowl. The stronger the air flow through the carburetor, the higher the air valve moves up. LP gas metering valve (6) is connected directly to air valve (2). As the air valve moves up, LP gas metering valve (6) also moves up. LP gas metering valve (6) is shaped to let in the correct amount of LP gas at any height related to air valve (2) upper movement. The air valve activates a pressure drop which gives a very high metering force (measured suction) to the fuel that flows in the carburetor at low engine speeds and it permits easy starting. At full engine speeds, the air valve is at the top of its upper movement. The valve then becomes an inverted (up side down) venturi and will let a large amount of air pass through.

When starting the engine, the intake stroke of piston (9) causes lower than atmosphere pressure (vacuum) in the carburetor. The vacuum is felt through passage (5) in air valve (2) and in the upper side of diaphragm (3). As a result, the atmospheric pressure flows in the carburetor and pushes up on the diaphragm.

Diaphragm (3) is lifted against the down pressure of metering spring (4). The vacuum that is felt on diaphragm (3) is variable according to engine speed and the position of throttle valve (10) opening. Air valve (2) measures the air flow that goes into the engine, respective to the demands of the engine and throttle valve (10) position.

The air pressure drop of 1.3 to 2.7 kPa (0.2 to 0.4 psi) is controlled by metering spring (4) which permits the force necessary to pull in the fuel into the air flow. LP gas metering valve (6) is connected to the air valve and lets in the correct amount of fuel from the LP converter to mix with the air at any opening of the air valve.

The carburetor is equipped with two limited mixture adjustments. Idle air screw (1) directs atmosphere (air) around the opening of air valve (2). As the idle air screw is adjusted open, the air valve loses a little more and causes the gas metering valve to close. The result will be less fuel in the mixture at idle. The second adjustment is power mixture adjustment (7). It controls the fuel mixture when gas metering valve (6) is fully in the up position. This adjustment is done only when the engine is at a load condition. A CO meter or exhaust analyzer is used for the power mixture adjustment. This adjustment has no effect at idle or in the light load range.

Tests or Adjustments

Adhere to the following warnings when performing any tests or adjustments while the engine is running.

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

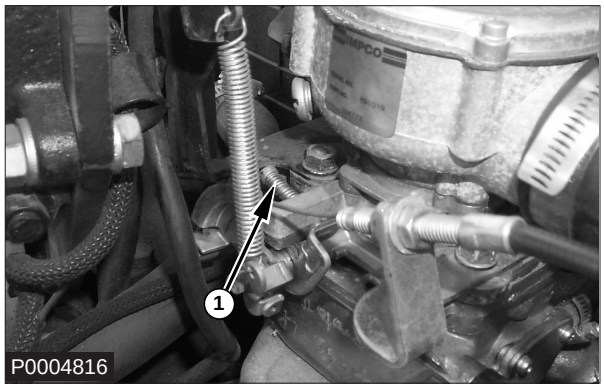
⚠ WARNING

Exhaust fumes contain carbon monoxide (CO) which can cause personal injury or death. Start and operate the engine in a well ventilated area only. In an enclosed area, vent the exhaust to the outside.

NOTE: The governor and accelerator linkage adjustments for the LP Fuel System are the same as those for the Gasoline Fuel System. For Governor and Accelerator Linkage Adjustments, see Gasoline Fuel System in the Testing And Adjusting.

Carburetor Adjustment

Low Idle Speed Adjustment



Low Idle Speed Adjustment
(1) Idle speed screw.

1. Make sure the setting for ignition timing is correct.

See Ignition Timing.

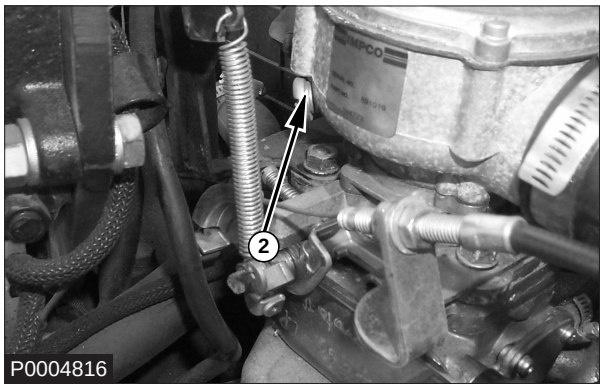
2. Connect the Electrical System Analyzer as shown in Engine RPM Check in the Testing And Adjusting.

3. Start and run the engine until the engine reaches normal operating temperature.

4. Adjust screw (1) to get the correct low idle speed.

5. Check low idle speed. The Correct low idle speed is: .....700 ± 25 rpm.

Idle Mixture Adjustment



Mixture Adjustment.
(2) Idle mixture Screw

1. Connect the Electrical System Analyzer to read engine rpm.

2. Check to be sure the ignition timing is set correctly.

3. Run the engine until normal operating temperature is reached.

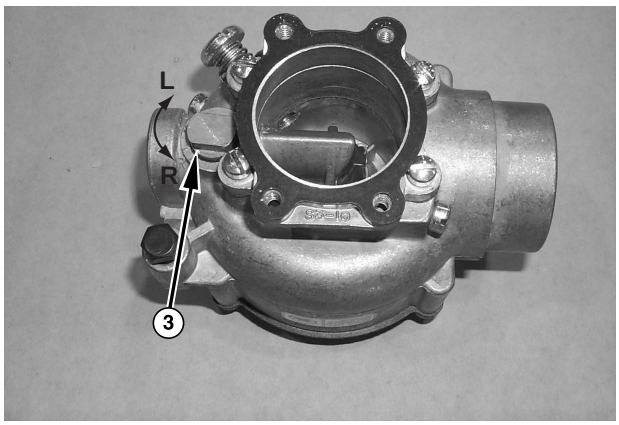
4. Check to be sure the low idle speed is set correctly.

5. Turn idle mixture screw (2) clockwise or counterclockwise to obtain the maximum smooth rpm.

6. Check and readjust (if required) the low idle speed again.

Power Mixture Adjustment

The method of adjustment depends upon the test equipment that is available. The power mixture can be adjusted using a CO meter, vacuum gauge or electrical system analyzer. The CO meter method is the preferred method for reduced emissions. The vacuum gauge method is the next most accurate method if CO measuring equipment is not available. The engine speed method is the easiest but least accurate method.



Power Mixture Adjustment
(3) Power mixture knob

Engine Speed Method

1. Connect the Electrical System Analyzer to read engine rpm.

2. Check to be sure the ignition timing is set correctly.

3. Run the engine until normal operating temperature is reached.

4. Turn the power mixture knob (3) midway between lean (L) and rich (R).

5. Accelerate the engine to high idle rpm. Put a load on engine by holding the tilt cylinder against relief.

6. Turn the power mixture knob toward lean (L) until engine rpm drops.

7. Turn the power mixture knob toward rich (R) until the rpm recover.

8. The correct mixture will be that setting just before the engine rpm drops.

CO Meter Method

The power mixture adjustment must be done with the engine in a load condition. A CO meter or exhaust analyzer testing equipment must be used to measure the CO content in the exhaust fumes. To adjust the power mixture, turn knob either toward the "L" (lean) or "R" (rich) fuel flow mixture for a 1.0 to 1.5 percent CO indication on the test equipment. Start the adjustment with knob in the middle position.

NOTE: A lift truck, that does not operate with a heavy load all the time, can operate efficiently with a leaner power mixture setting (less than 1.0 to 1.5 percent CO). This is because the truck will not be in operation constantly in a load condition for a long period of time. During heavy load and high speed conditions the lift truck requires a richer power mixture setting (1.0 to 1.5 percent CO).

Vacuum Gauge Method

1. Connect the vacuum gauge to the intake manifold. Start and run the engine until normal operating temperature is reached.

2. Run the engine at high idle. Turn power mixture knob to the middle position.

3. Put a load on the engine by operating the hydraulic system.

4. Monitor the vacuum gauge reading. Turn power mixture adjustment knob toward the "L" (lean) position, until the vacuum starts to drop. The correct mixture is the point at which the vacuum starts to drop.

Fuel System Leak Check

Outer Fuel System Leak Check

⚠ WARNING

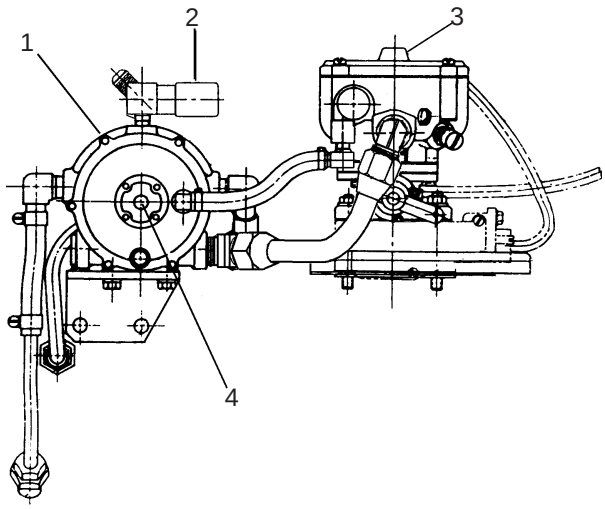
LP gas is highly flammable. To prevent personal injury, keep fire and flammable materials away from the lift truck when work is done on the fuel system.

Combustion gases from LP gas fuel system can be a danger. To find LP gas leaks, use soap and water solution or other foaming bubble solvent around fuel line connections and on other components that possibly cause LP gas leaks. The soap and water method is the best, use this method after repair completion on the fuel system or after the fuel system has been connected together again.

Fuel Filter Check

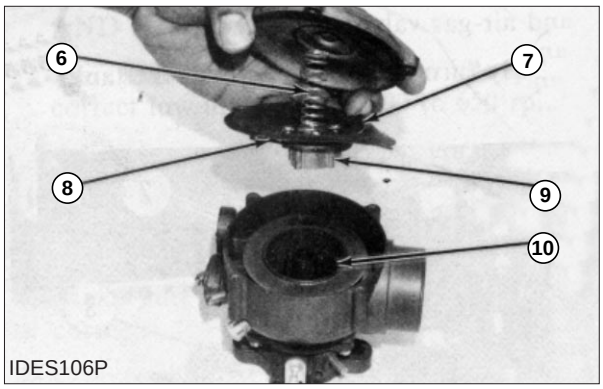
An indication of a dirty fuel filter that needs replacement is when frost (freezing vapor) is seen on the filter housing or the housing is very cold to touch. A dirty filter causes a fuel pressure drop across the filter, the fuel becomes a vapor and freezes. In this condition, engine power output decreases because of the lesser fuel flow. To replace the filter, see the Operation & Maintenance Manual for the respective model.

Inner Fuel System Leak Check



IDES105S

Inner Fuel System Leakage Check (Electric Fuelock).
(1) Converter. (2) Fuelock. (3) Carburetor cover.
(4) Primer button.



Carburetor Components (Carburetor Shown Removed For Better Illustration)
(6) Spring. (7) Backup plate and diaphragm. (8) Air valve ring. (9) Air-gas valve assembly. (10) Inner carburetor body.

1. Remove carburetor cover (3), spring (6), backup plate and diaphragm (7), air valve ring (8) and airgas valve assembly (9).

2. Slowly turn the LP fuel ON at the tank.

3. Check the inlet fuel jet for fuel flow (leakage) in carburetor body (10).

4. If the operation of fuelock (2) and converter (1) are correct, there will be no fuel flow.

5. If there is fuel flow, the leakage problem must be found either in the fuelock or the converter.

6. Push in primer button (4) on the converter to open the converter fuel regulator valve.

7. A small amount of fuel will flow through the carburetor inlet fuel jet as the fuel from fuelock (2) flows out of the hose.

8. If the operation of fuelock (2) is correct, the fuel flow will stop as soon as the system is empty.

Converter Leak Test

To check the converter for leakage after repair, do the procedure that follows:

1. Put a plug in the fuel outlet openings.

2. Put compressed air in the fuel inlet openings, up to a maximum of 725 kPa (120 psi).

3. Wait ten minutes and then check the converter or fuelock for air leaks. Listen for air to come out around gaskets or seals.

4. If there are no air leaks, then the converter is good.

5. If air does come out, then the converter will have to be disassembled to find the problem.

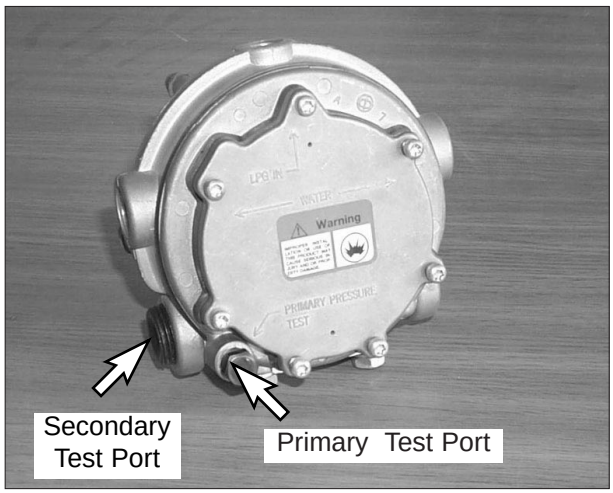
Recommendation For LP Fuel Systems

In freezing temperature conditions run the engine at fast idle until the engine coolant temperature is between 10 to 16˚C (50˚F to 60˚F). A low idle in cold temperature conditions can damage the engine because of poor circulation of the engine oil. Running the engine to move the lift truck short distances and then stopping the engine without the coolant being heated can cause the LP fuel to be trapped (cannot be released) in the converter. As this trapped fuel changes to a vapor with the engine stopped, this change causes too much pressure in the converter. The force from the pressure is put on the primary regulator valve against its seat. If this occurs often, the primary regulator valve in the vaporized area of the converter will be damaged.

LP Converter - Check, Clean

Test LP-Gas Converter

1. Obtain a test kit.
2. Start engine.
3. Close the liquid outlet valve in the fuel storage container.
4. Run engine out of fuel.
5. Install the 0-30kPa (0-5 psi) gauge in the primary test port.
6.. Install the 0-2.5kPa (0-10 in H_2O) gauge in the secondary test port.
7. Slowly open the liquid outiet valve in the fuel storage container.
8. Start the engine.
9. Operate the engine at idle, part throttle and full load.
10. Observe readings on both gauges.
11. The primary gauge reading should be approximately 10.3kPa (1.5 psi).
12. The secondary gauge should read approximately negative0.1kPa (0.5 in H_2O) to negative 2.5kPa (10 in H_2O).
13. If readings are out of specification, as required.



LP-Gas Converter

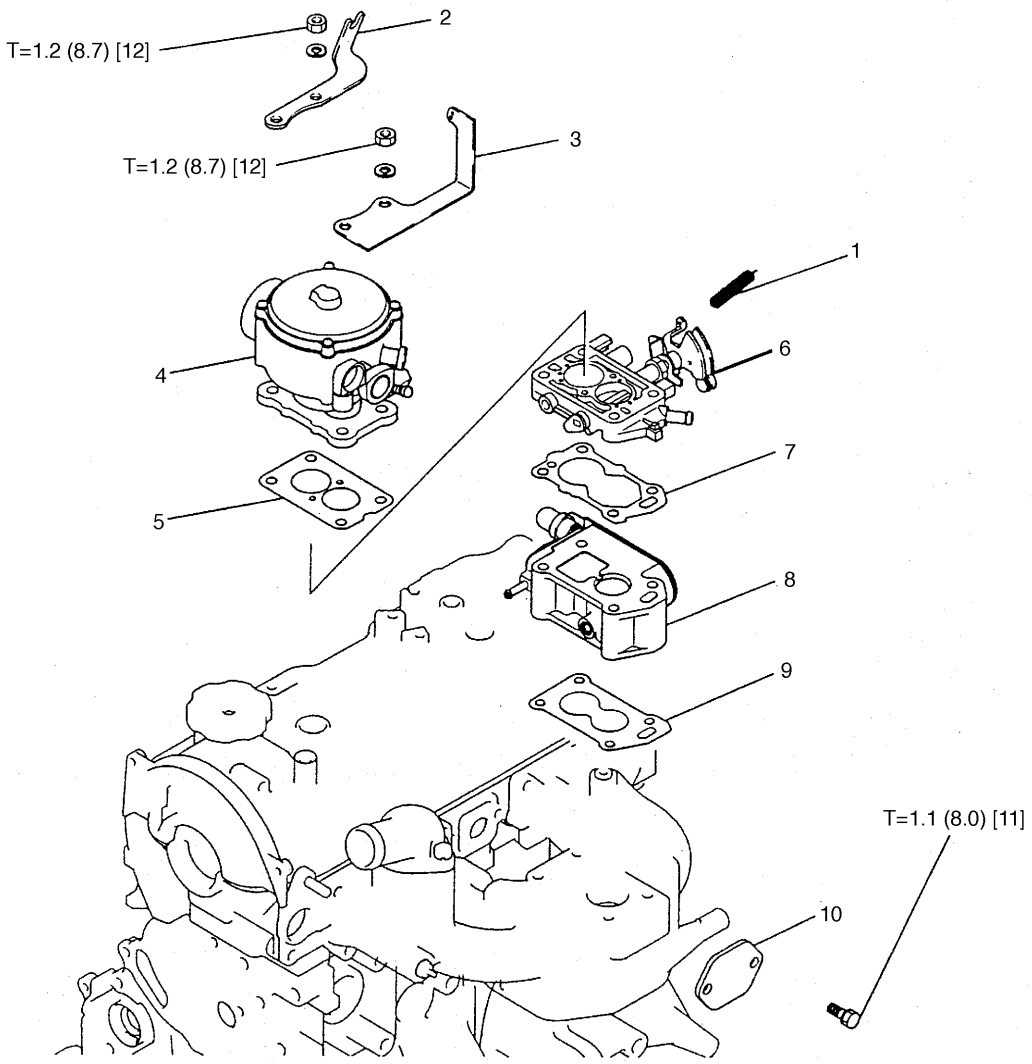
Inspect Converter for Oil Accumulation

1. Start engine.
2. Close the liquid outlet valve in the fuel storage container
3. Run engine out of fuel.
4. Remove the regulator secondary cover.
5. Remove secondary diaphragm.
6. Remove any concentrations of oil from the secondary chamber with soap and warm water.
7. If required, replace them with LP converter service kit.
8. Apply anti-seize compound to screw threads.
9. Re-assemble regulator in reverse order.
10. Slowly open the liquid outlet valve in the fuel storage container.
11. Start engine.
12. Perform leak test.

Disassembly & Assembly

LPG Carburetor

Remove & Install LP Gas Carburetor



6EN1890

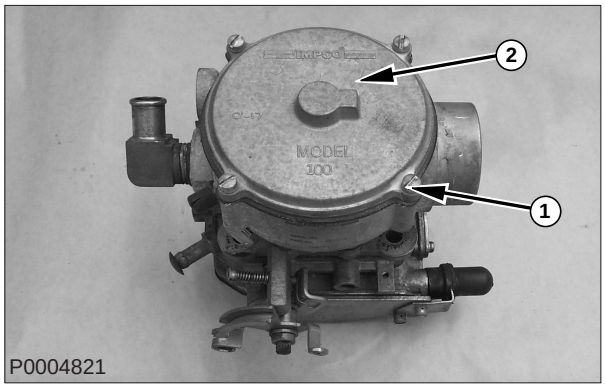
Removal steps

1. Throttle return spring
2. Accel wire assembly
3. Return spring support
4. LPG carburetor
5. Throttle chamber gasket
6. Throttle body
7. Carburetor gasket
8. Air governor
9. Air governor gasket
10. Fuel pump cover

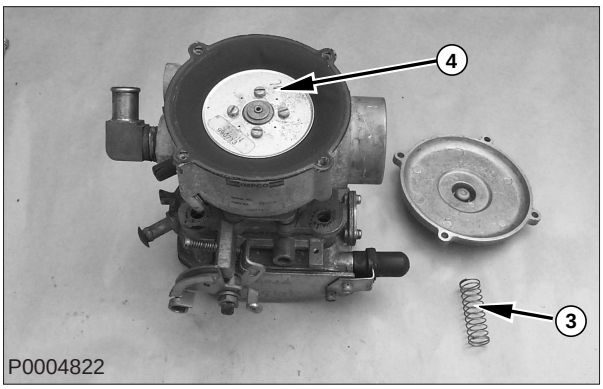
Disassemble LP Gas Carburetor

Start By:

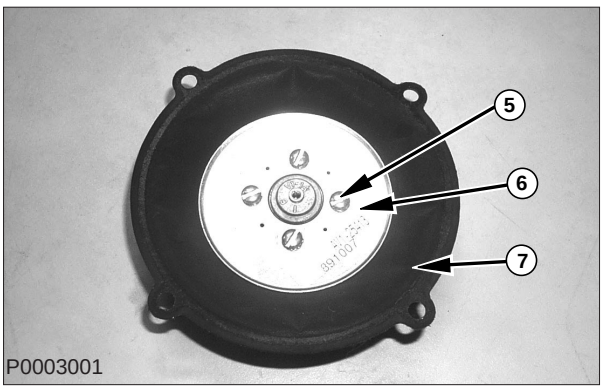
a. Remove LP Gas Carburetor.



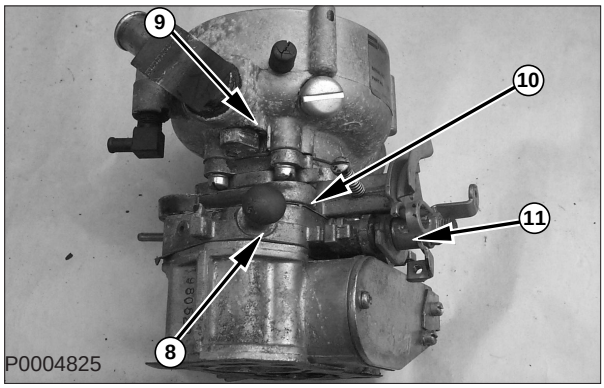
1. Remove four screws (1) and cover (2).



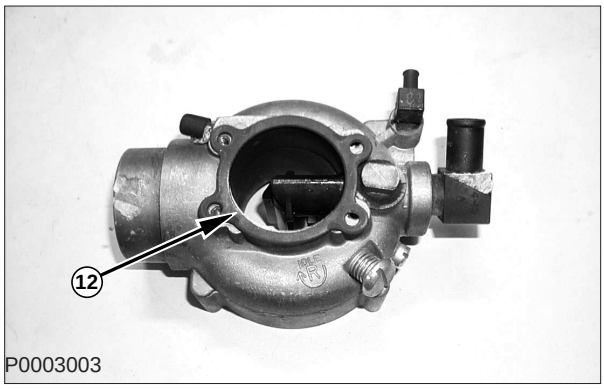
2. Remove spring (3). Remove diaphragm assembly (4).



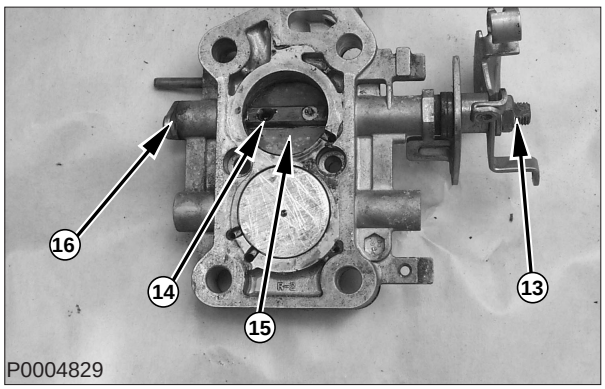
3. Remove four screws (5), backup plate (6), diaphragm (7) and the air valve ring from the inner carburetor body.



4. Remove power mixture screw (8), idle mixture screw (9) and the spring. Remove four screws (10).
Remove throttle body assembly (11) and the gasket.



5. Remove gasket (12).



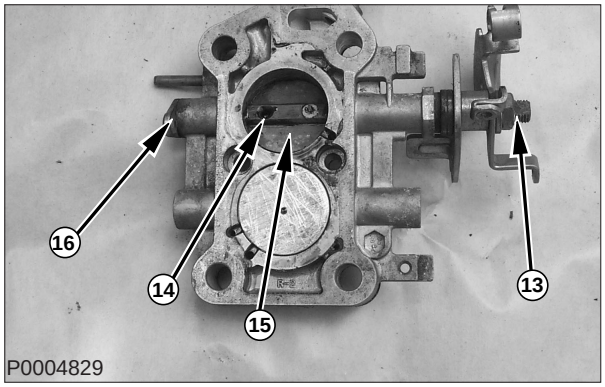
6. Remove nut (13).

7. Loosen the bolt and remove stop (16).

8. Remove two screws (14). Remove throttle plate (15).

9. Remove shaft assembly (17) from the throttle body.

Assemble LP Gas Carburetor



1. Check all parts for damage. Replace damaged parts with new as necessary.

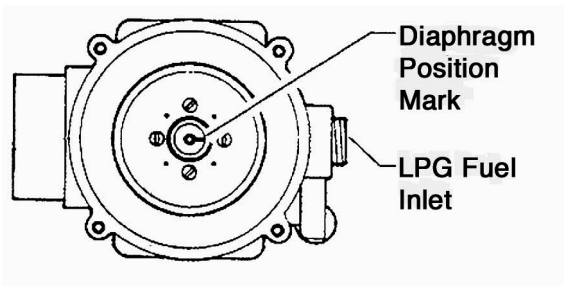
2. Make sure all parts are clean and free of dirt and foreign material.

3. Put throttle shaft (17) in position in the throttle body, and install stop lever (16).

4. Put throttle plate (15) in position and install the two screws.

5. Assemble in reverse order of disassembly.

NOTE : Air valve diaphragm must be oriented with position mark pointing toward LPG inlet.



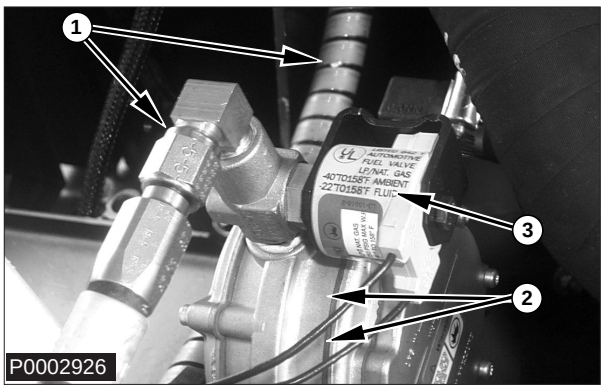
6. See Testing & Adjusting for proper test and adjust procedures.

End By:

a. Install LP Gas Carburetor.

LP Gas Fuelock

Remove & Install LP Gas Fuelock



1. Disconnect fuel lines (1).

2. Disconnect wire (2).

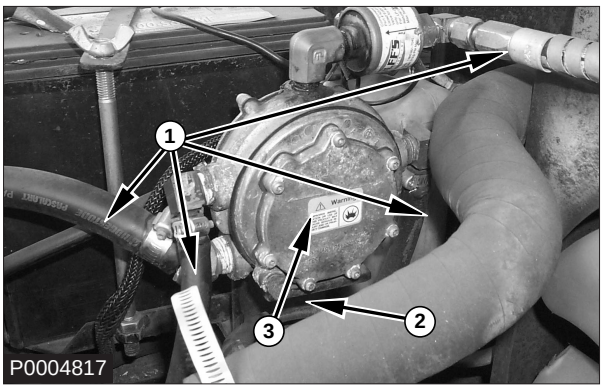
3. Remove fuelock (3).

NOTE: For the installation of the LP gas fuelock, reverse the removal steps.
Apply loctite PST or equivalent to fuelock pipe threads before installation.

LP Gas Converter

Remove & Install LP Gas Converter

Start by : Remove LP Gas Fuelock.



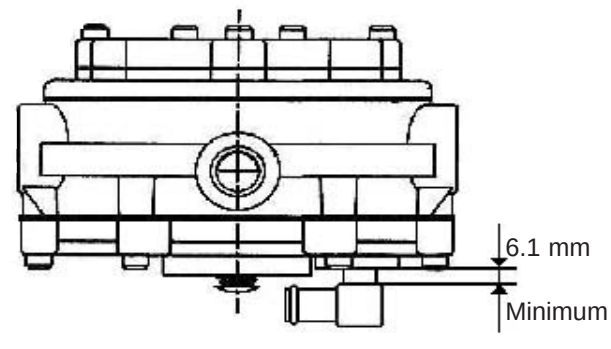
1. Remove lines (1).

2. Remove two bolts and nut (2).

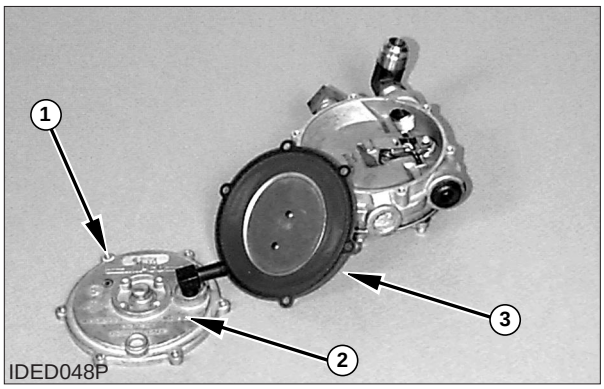
3. Remove LP gas converter (3).

NOTE : For the installation of the LP gas converter, reverse the removal steps.

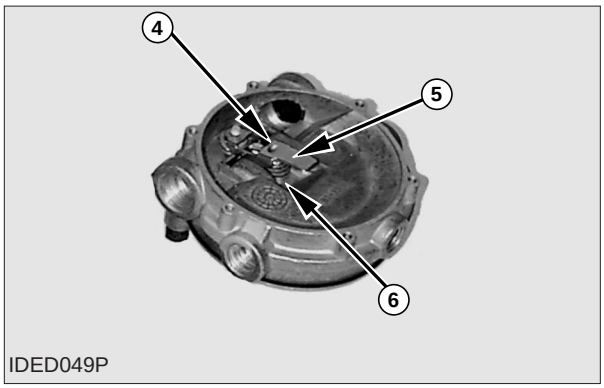
NOTE : When you assemble the elbow on LP converter, the elbow must be installed on the converter, keeping the minimum distance shown in the figure, to prevent contact with the secondary diaphragm.



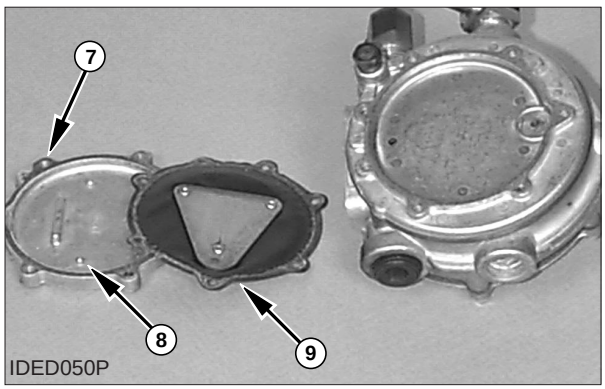
Disassembly of LP Gas Converter



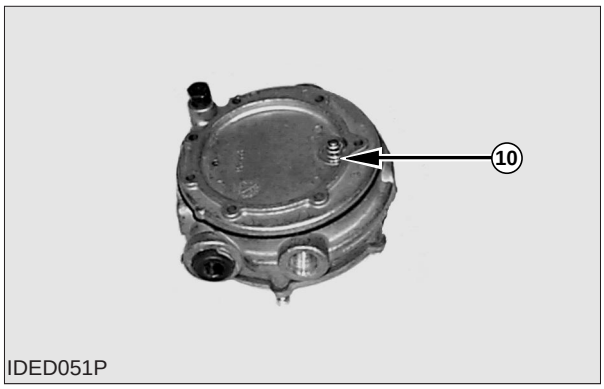
1. Remove six screws (1), cover (2), and diaphragm (3) from the converter.



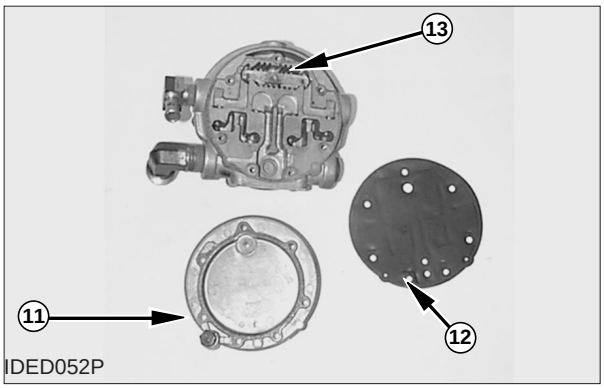
2. Remove screw (4), secondary lever (5), the seat, the pin and the spring (6).



3. Turn the converter body around, remove the seven screws (7), back cover (8), and the diaphragm (9).



4. Remove spring and plunger (10) from the intermediate cover.

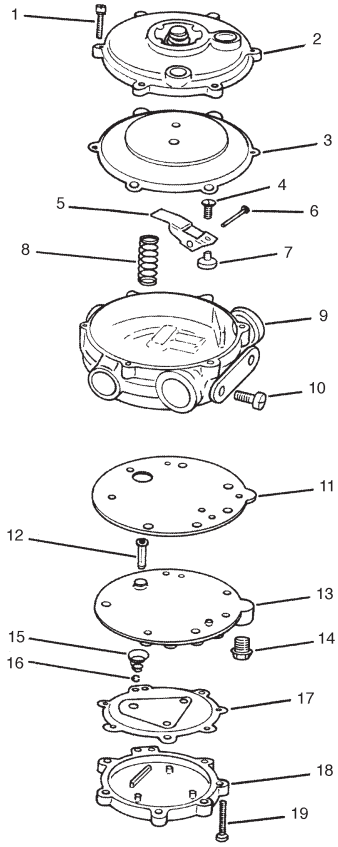


5. Remove intermediate cover (11), diaphragm (12) and the secondary regulator valve (13).

Inspection, Assembly of LP Gas Converter

1. Clean primary and secondary valves with soap and warm water and inspect for wear. Replace if required.
2. Clean primary and secondary diaphragms with soap and warm water and inspect for wear. Inspect primary diaphragm lever for straightness. Replace if required.
3. Alwasy replace the coolant chamber gasket.
4. Clean regulator castings with parts cleaning colvent and inspect. It is very rare for the castings to require replacement.
5. Reassemble regulator.
6. Use an anti-seize compound on screws.
7. Use an approved pipe sealant on fittings.

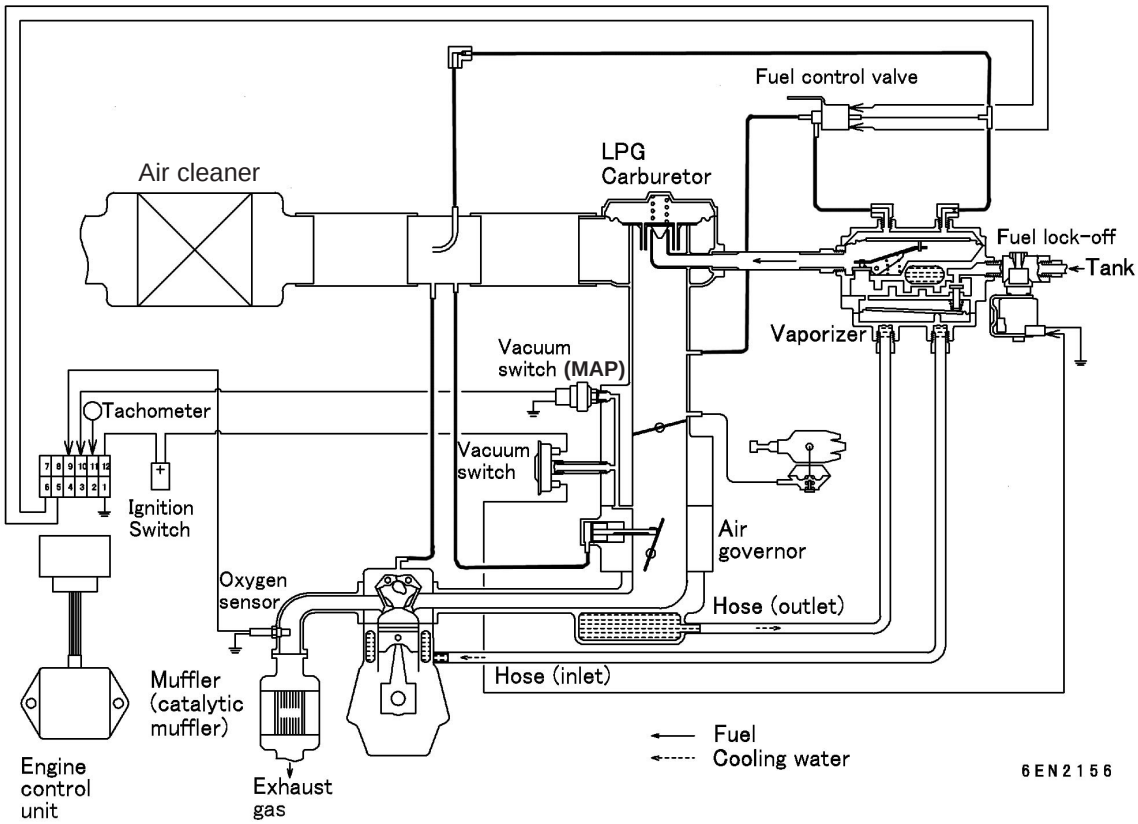
NOTE: For assembly of the LP gas converter reverse the disassembly steps.



1. Screw (6)
2. Cover Assembly, Secondary
3. Diaphragm Assembly, Secondary
4. Screw,
5. Lever, Secondary
6. Pin, Secondary Fulcrum
7. Seat, Secondary
8. Spring
9. Body Assembly With Jet
10. Screw (2)
11. Gasket, Body To Body Cover Plate
12. Pin, Valve Primary
13. Plate, Body Cover
14. Plug
15. Spring, Primary
16. E Ring, External
17. Diaphragm Assembly, Primary
18. Cover, Primary
19. Screw (7)

LPG FUEL SYSTEM (LOW EMISSION VERSION)

General Description

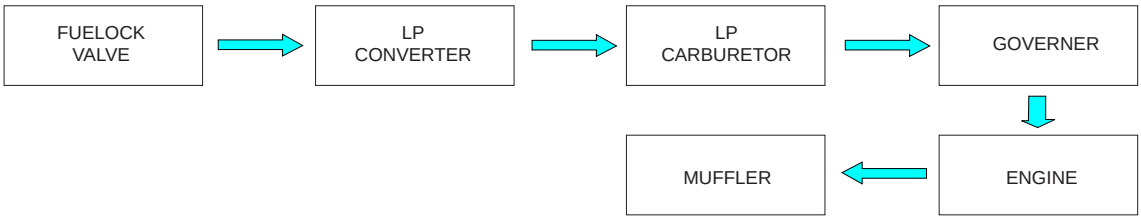


Schematic of G424 LP fuel system (low emission version)

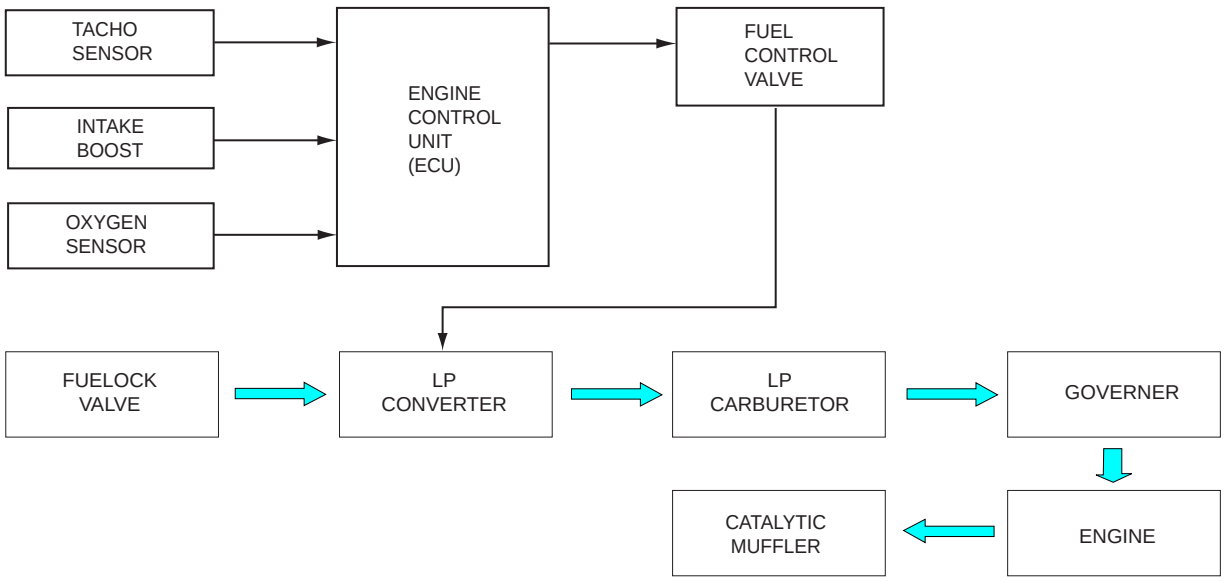
G242 LP engine (Low Emission Version) is different from standard G424 LP engine. To reduce emission of exhaust gas, closed loop carburetion system and catalytic muffler are applied to low emission version G424 LP engine.

Catalytic muffler reduces the emission level in the exhaust gas. In order to obtain maximum effect from the catalyst, an accurate control of the air fuel ratio is required. The engine controller uses an exhaust gas oxygen sensor (EGO) in the exhaust system to send information about exhaust gas conent to the controller. The controller then calculates any correction that may need to be made to the air fuel ratio. The controller makes these corrections to the air fuel ratio by manipulating the inlet fuel pressure to the carburetor through the fuel control valve (FCV). Reducing the fuel pressure leans the air/fuel mixfure. Increasing the fuel pressure richens the air/fuel mixture.

The controller uses engine exhaust gas oxygen sensors (EGO), engine speed (tachometer signal) and manifold absolute pressure sensors (MAP), to regulate the air/fuel mixtures, correcting for proper air/fuel. The fuel control valve (FCV) meters air valve vacuum (AVV) into the atmospheric reference side of the secondary regulator diaphragm. The atmospheric reference vent orifice allows for the controlled depletion of the vacuum over the diaphragm, this assists the dynamic response of the diaphragm.



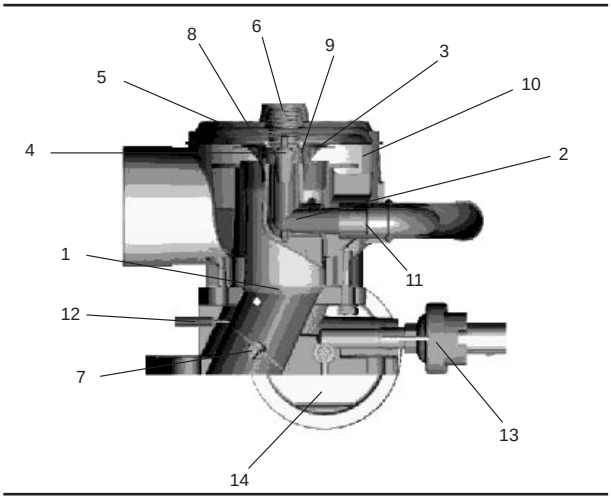
Open-loop LP Carburetion System : G424 LP engine



Closed-loop LP Carburetion System : G424 LP engine (low emission version)

LP Carburetor (Variable Venturi)

The variable venturi air/fuel mixer is mounted in the intake air stream between the air cleaner and the intake manifold. The design of the main section incorporates a cylindrical bore through the center (1) and a gas discharge jet (2). Incorporated into the inlet of the mixer bore is the air valve (3), tapered gas metering valve (4), air valve diaphragm (5) and calibrated air valve metering spring (6). The gas valve (4) is permanently attached to the air valve (3) with a face seal mounted in between the two parts (the air-gas valve assembly is mounted in the center of and supported by the diaphragm). When the engine is not running this face seal creates a gas tight seal against the gas discharge jet (2), with the downward force of the calibrated air valve spring (6). A throttle valve (7) is incorporated into the carburetor assembly.



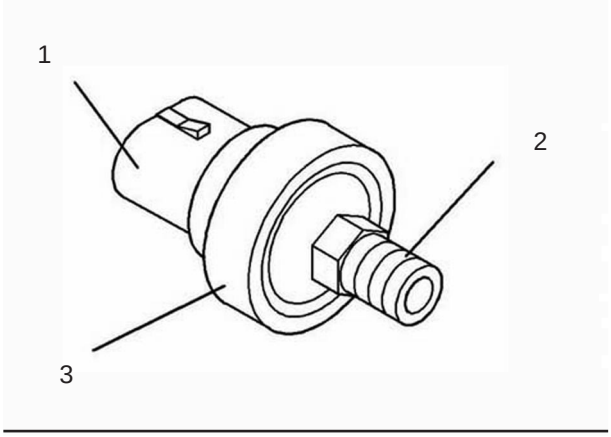
1. Mixer bore
2. Gas discharge jet
3. Air valve
4. Gas valve
5. Air valve diaphragm
6. Air valve spring
7. Throttle valve
8. Air valve vacuum chamber
9. Vacuum transfer ports
10. Atmospheric pressure
11. Fixed main mixture jet
12. Vacuum port
13. Vacuum switch (MAP)
14. Vacuum switch

As the engine is started it begins to draw in air. Since the air valve (3) is covering the inlet to the mixer bore a negative pressure begins to build. This negative pressure signal is communicated to the air valve vacuum chamber (8) through four vacuum transfer ports (9) in the air valve (3). A pressure / force imbalance begins to build across the air valve diaphragm (5) between the air valve vacuum chamber (8) and atmospheric pressure below the diaphragm (10).

As the negative pressure in the air valve vacuum chamber (8) reaches setting value of water column the air valve (3) begins to lift against the pressure of the calibrated air valve metering spring (6) .The amount of negative pressure generated is a direct result of throttle position and the amount of air flowing through the mixer into the engine. As the air valve (3) rises it lifts the tapered gas metering valve (4) off its seat and exposes the gas discharge jet (2) to the negative pressure signal generated within the mixer bore.
This allows the negative pressure signal to travel to the secondary vacuum chamber of the pressure regulator and operate the regulator. I he profile of the tapered gas valve (4), in conjunction with the regulator spring, meters out the desired A/F ratio.

A/F mixture at idle is adjusted with a tapered idle screw (not shown) which is capped at production and cannot be adjusted. A/F ratio at maximum load is limited by the fixed main mixture jet (11), which is sized for the application.
In addition the assembly includes two manifold sensors, one for switching the ECU control (13) depending on engine load, and the other for operating a lock-off solenoid (14). In addition the unit is fitted with a precisely controlled vacuum port (12) to allow control of ignition timing by vacuum load control.

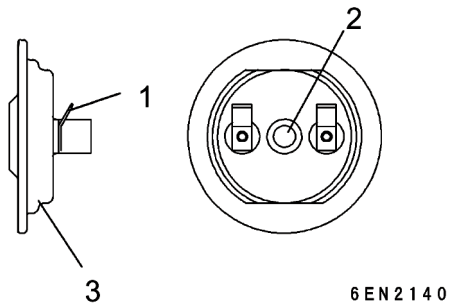
Vacuum Switch (MAP)



1. Electrical
2. Vacuum port
3. Main body

The vacuum switch is a simple direct acting contact pressure switch, consisting of a main body (3), an electrical connector with two pins (1) and a vacuum port connection (2).
The unit is normally open (i.e. the electrical connectors (1) are not common) when no vacuum is applied to the vacuum port (2).
When vacuum is applied to the port (2) unit respponds and closes the electriccal contacts (1) so that current may pass.

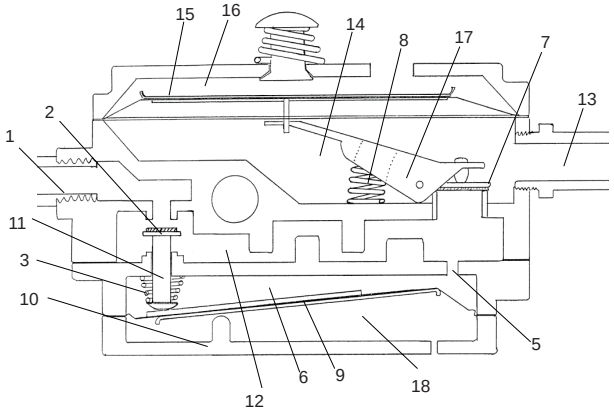
Vacuum Switch



1. Electrical
2. Vacuum port
3. Main body

The vacuum switch is a simple diaphragm unit, consisting of a main body (3) housing a diaphragm/spring, two electrical connectors (1) and a vacuum port connection (2).
The unit is normally open (i.e the electrical connectors (1) are not common) when no vacuum is applied to the vacuum port (2).
When vacuum is applied (see specification for limits) to the port (2) the diaphragm/spring in the body (3) responds and closes the electrical contacts (1) so that current may pass.

LP Converter



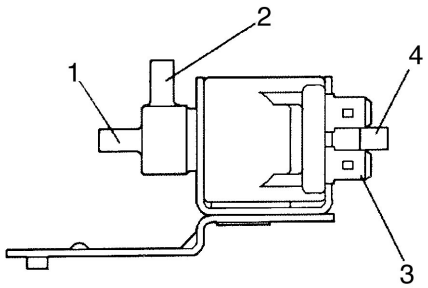
1. Fuel inlet
2. Primary valve
3. Primary spring
4. Primary heat exchanger chamber
5. Pressure transfer port
6. Primary diaphragm chamber
7. Secondary valve
8. Secondary spring
9. Primary diaphragm
10. Primary pivot
11. Primary pin
12. Coolant passage
13. Fuel outlet
14. Secondary vacuum chamber
15. Secondary diaphragm
16. Secondary atmospheric vent chamber
17. Secondary lever
18. Primary atmospheric chamber

Fuel (Propane Liquid), at tank pressure enters the regulator through the fuel inlet port (1). Propane liquid then flows through the primary valve (2), which is held normally open by the primary spring (3), and into the primary heat exchanger chamber of the regulator (4). A small transfer port (5) connects the primary heat exchanger chamber and the primary diaphragm chamber(6).

The secondary valve (7) at the outlet of the primary heat exchanger chamber (4) is held normally closed by the secondary spring (8). Therefore the pressure in the primary heat exchanger chamber (4) and the primary diaphragm chamber (6) begins to rise from atmospheric pressure. When the pressure in the primary heat exchanger chamber (4) and primary diaphragm chamber (6) reaches setting value it causes a pressure/force imbalance across the primary diaphragm (9) between the primary heat exchanger chamber and the primary atmospheric chamber (18) This causes the primary diaphragm and lever assembly (9) to pivot (10) against primary spring (3) pressure, raising primary valve pin (11), closing off the primary valve (2). Since fuel pressure falls from tank pressure, a liquid liquefied petroleum gas evaporates. As this phase change occurs the fuel takes on heat from the primary heat exchanger chamber of the regulator (4). This heat is replaced by engine coolant, which is piped through passage (12) in the heat exchanger section of the regulator. Fuel will not flow through the regulator to the carburetor until a negative pressure signal is received. When the engine is cranking or running, a negative pressure signal is generated by the carburetor. This negative pressure signal is communicated to the fuel outlet (13) and the regulator secondary vacuum chamber (14). The negative pressure signal acts upon the lower side of the secondary diaphragm (15) causing a pressure / force imbalance across the diaphragm between the secondary vacuum chamber (14) and the secondary atmospheric vent chamber (16). When the negative pressure signal reaches negative setting value the pressure force imbalance overcomes the secondary spring force (8) and the secondary diaphragm (9) moves downward. As the secondary diaphragm moves it causes the secondary lever (l7) to pivot and lift the secondary valve (7) off its seat allowing fuel to flow from the primary heat exchanger chamber (4) through the secondary chamber (14) and to the carburetor. Since fuel has now exited the primary heat exchanger chamber (4) the pressure in the chamber will drop, allowing the primary valve (2) to re-open. Whilst fuel is flowing, the calibrated secondary spring (8) will maintain a relatively constant pressure in the secondary vacuum chamber (14) and the amount of fuel flowing will vary depending on how far the secondary valve (7) opens in response to the negative pressure signal generated by the carburetor.

For closed loop control, the secondary atmospheric vent chamber (16) is connected to AVV via a fuel control valve, thus varying the secondary vacuum chamber pressure (14) in response to a pulse width modulated signal provided to the fuel control valve.

Fuel Control Valve

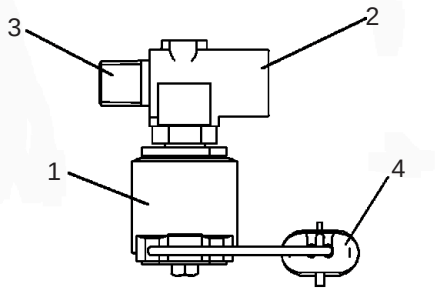


6EN2139

1. Carburetor AVV port connection
2. Vaporizer secondary vent chamber connection
3. Electrical connectors
4. Balance line connection

The fuel control valve is a three way valve, operated by a pulse width modulated electronic signal applied to the electrical connectors (3) by the fuel system ECU. With no voltage supplied, the vaporizer secondary vent chamber connection (2) port is connected to the balance line connection (4) port and in this state the pressure in the balance (4) pressure signal is transferred via (2) to the vaporizer and the carburetor AVV port (1) is blocked. When a signal is provided to the electrical connectors (3) the valve opens and connects the vaporizer secondary atmospheric vent chamber port (2) with the carburetor will provide a vacuum signal (AVV) which is therefore ‘pulsed’, into the vaporizer secondary chamber when port (1) and (2) are connected (i.e when the valve is energized).

Fuel Lock - Off

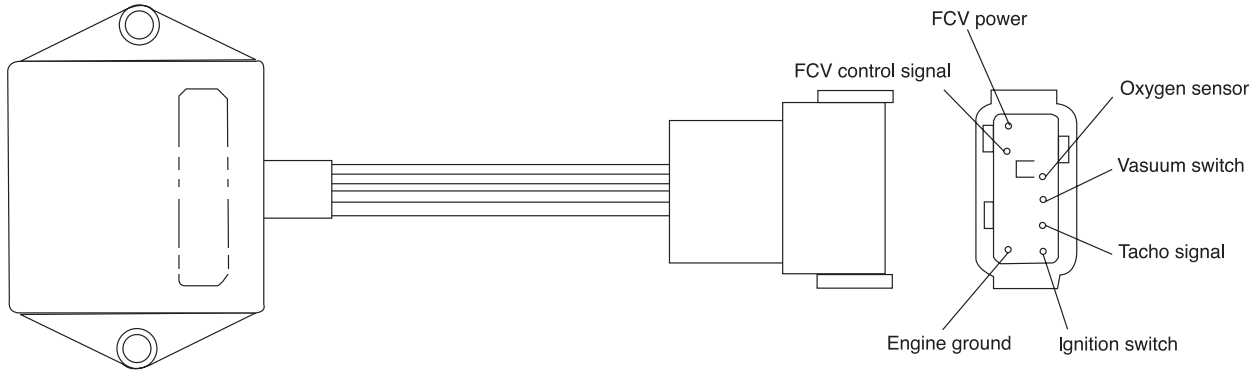


6EV2142

1. Solenoid coil
2. Fuel inlet connection
3. Fuel outlet connection
4. Electrical connector

The fuel lock-off unit is a direct acting plunger style unit. Fuel is provided to the fuel inlet connection (2) and passes into the fitter housing, and through the fitter. With no electrical signal applied to the electrical connector (4) the unit is normally closed via spring pressure inside the coil stem acting on the valve seat. When power is provided to the electrical connector (4), the coil (1) is energized and lifts the plunger inside the coil stem against spring pressure, and allows fuel to flow to the fuel outlet (3).

Engine Control Unit (ECU)



6EV2149

In order to obtain maximum emission reductions from the exhaust gas catalyst, accurate control of the engines operating air fuel ratio (AFR) is required. The engine control unit (ECU) uses input from three sources: excess oxygen information from the exhaust gas oxygen sensor (EGO), ignition pulses (engine RPM) and intake manifold pressure (high or low). This input is used to apply a duty cycle and a rate of change of that duty cycle to the fuel control valve (FCV). The duty cycle of the FCV has a direct effect on the AFR metered by the carburetor and burned by the engine. ECU algorithms are calibrated for a balance of optimal engine emissions, drive-ability, power and fuel consumption.

Within the ECU closed-loop algorithms there are two sets of calibration tables, one for high and one for low manifold pressure. The proper table is selected based on the input from the mechanical calibration of the manifold pressure switch used. Each of the two tables contains sixteen columns corresponding to sixteen engine RPM operating ranges. The proper column is selected based on engine rpm. These columns each have eight calibrations that affect the rate of duty cycle change and allow duty cycle stepping after EGO voltage crosses the .5 V threshold. The duty cycle stepping is used for AFR biasing and for rapid recovery during transient operation. EGO voltage and time since last EGO switch (across the .5 V threshold) determine the column calibration to apply to the rate of duty cycle change. There are additional calibrations for FCV duty cycle at cold EGO startup and for the number of ignition inputs per engine revolution.

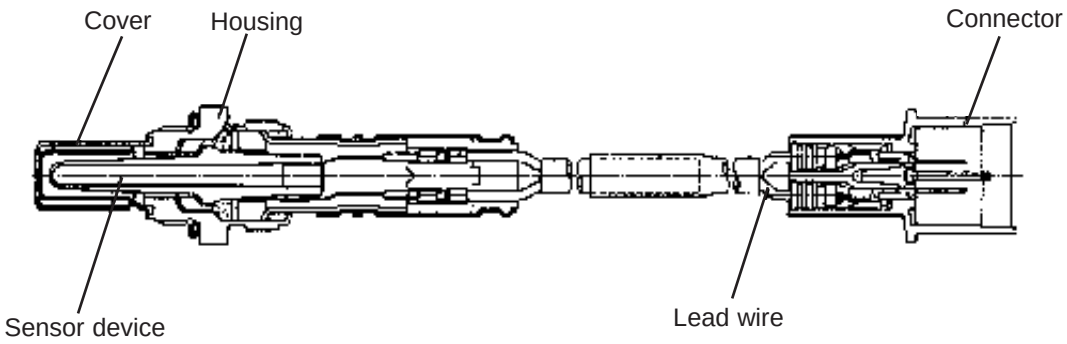
During operation a normal sequence of events is as follows:

If the EGO voltage is below .5 V, considered a lean condition, the controller steps FCV duty cycle to a lower value, then begins decreasing the FCV duty cycle at a constant rate. This decreases the flow of air valve vacuum (AVV) through the FCV to the secondary reference chamber of the fuel pressure regulator (sometimes referred to as a vaporizer). This vacuum is depleted at a relatively constant rate via a vent orifice referenced to atmospheric pressure, resulting in a pressure balance proportional to FCV duty cycle and vent orifice size. The lower flow through the FCV results in a higher overall chamber Pressure. Which results in a higher fuel pressure to the carburetor and a richer AFR. If the duty cycle continues to lower longer than a calibrated number of engine revolutions without an EGO switch, a different calibration is selected resulting in higher rate of duty cycle change until EGO switch.

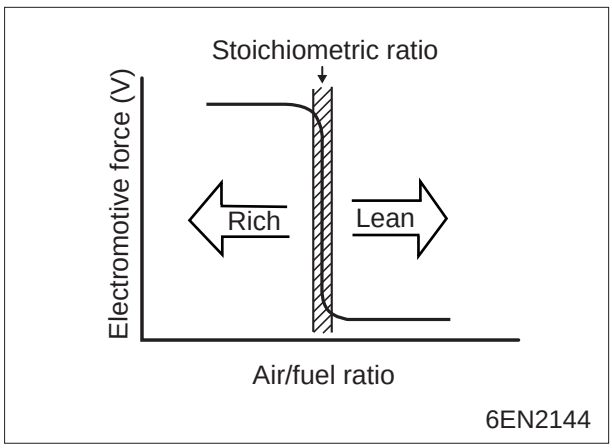
The calibration tables determine the step size, rate of duty cycle change and the number of engine revolutions without an EGO before going to higher rate.

If the EGO voltage is above .5 V, considered a rich condition, the controller steps FCV duty cycle to a higher value, then begins increasing the FCV duty cycle at a constant rate. This increases the flow of AVV through the FCV to the secondary reference chamber of the fuel pressure regulator. The higher flow through the FCV results in a lower overall chamber pressure, which results in a lower fuel pressure to the carburetor and a leaner AFR. If the duty cycle continues to lower longer than a calibrated number of engine revolutions without an EGO switch, a different calibration is selected resulting in higher rate of duty cycle change until EGO switch. The calibration tables determine the step size, rate of duty cycle change and the number of engine revolutions without an EGO before going to higher rate.

Oxygen Sensor

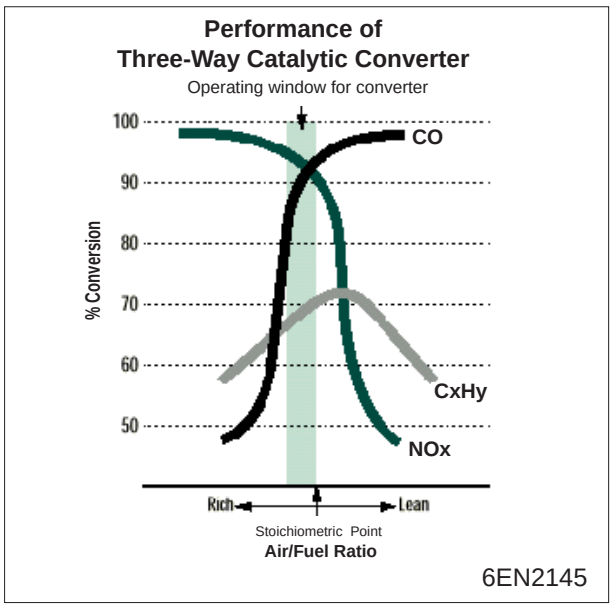


6EN2146



6EN2144

The oxygen sensor installed on the exhaust manifold makes use of the principles of a solid electrolyte oxygen concentration cell. The oxygen concentration cell is characterized by a sharp change of the output voltage in the vicinity of the stoichiometric air/fuel ratio.

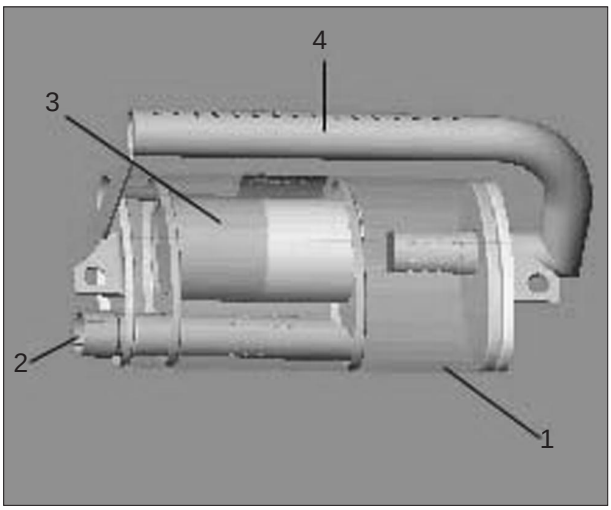


6EN2145

Using such characteristics, the oxygen sensor senses the oxygen concentration in the exhaust gas and feeds it to the engine control unit. The engine control unit then determines if the air/fuel ratio is richer or leaner as compared to the stoichiometric ratio and provides feedback control to adjust the air/fuel ratio to the stoichiometric ratio where the emission purification rate of the three-catalyst convector is optimum.

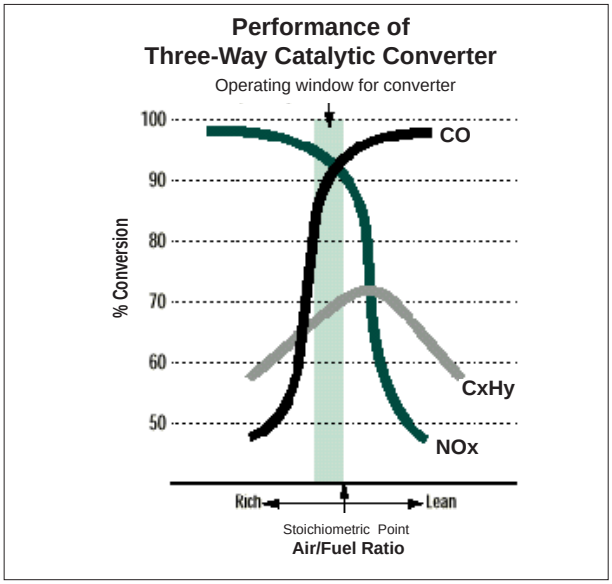
Catalytic Muffler

The catalytic muffler is mounted in the exhaust gas stream of G430 engine. The catalytic muffler facilitates oxidation and reduction reactions that reduce the amount of unwanted constituents in the exhaust gas stream. Catalytic mufflers have sound deadening and spark arresting features incorporated into the design.



After combustion the contents of the engine cylinder(s) are expelled into the exhaust system. These hot gases next travel to the catalytic muffler. The catalytic muffler is made up of a shell (1) incorporating an inlet (2) and an outlet (4). Inside, the catalytic muffler contains a three-way catalyst section (3) as well as sound dampening and spark arresting features. The three-way catalyst section (3) consists of a honeycomb coated with a mixture of platinum, palladium and rhodium. The hot exhaust gases enter the catalytic muffler through the inlet (1). Next the hot exhaust gases flow through the catalyst section (3) where an oxidation and reduction reactions take place. These chemical reactions reduce the amount of CO, HC and NOx in the engine exhaust. The exhaust gas then flows through the outlet (4).

Reaction	Stage
$CO + O_2 = CO_2$	Oxidation
$HC + O_2 = H_2O + CO_2$	Oxidation
$NO_x + CO = N_2 + CO_2$	Reduction
$NO_x + H_2 = N_2 + H_2O$	Reduction
$NO_x + HC = N_2 + H_2O = CO_2$	Reduction



Tests or Adjustments

Adhere to the following warnings when performing any tests or adjustments while the engine is running.

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

⚠ WARNING

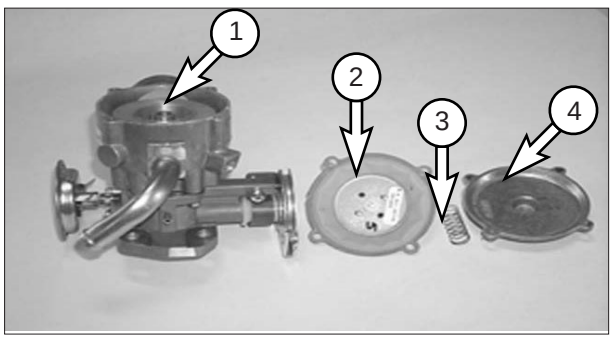
Exhaust fumes contain carbon monoxide (CO) which can cause personal injury or death. Start and operate the engine in a well ventilated area only. In an enclosed area, vent the exhaust to the outside.

LP Carburetor-Check, Clean

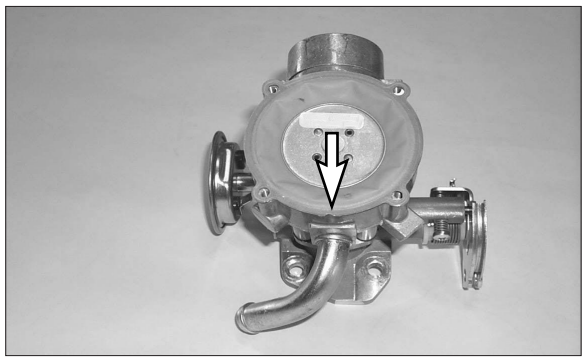
Check and Clean LP Carburetor.

The LP Carburetor requires periodic inspection, and cleaning. Inspection and cleaning are as follows :

1. Start engine.
2. Close the liquid outlet valve in the fuel storage container.
3. Run engine out of fuel.



4. Remove mixer lid (4).
5. Remove air valve (2) and spring (3).
6. Clean air valve with warm soapy water.
7. Clean mixer throat with approved carburetor cleaner.
8. Inspect air valve and mixer throat for wear, repair/replace as required.

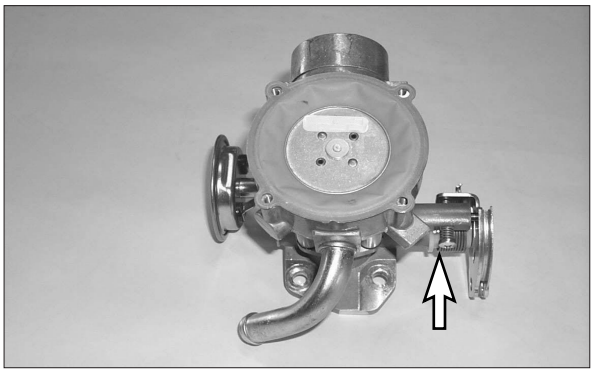


9. When reassembling mixer, locate the notch on air/gas valve diaphragm to point to fuel inlet.
10. Open the fule storage container liquid outlet valve solwly.
11. Check for leaks.
12. start engine and verify normal operation.

Check engine idle speed

Check engine low idle speed. If it does not meet specification, adjust idle speed adjustment screw.

Low idle speed specification : 700+/-25 rpm



NOTICE

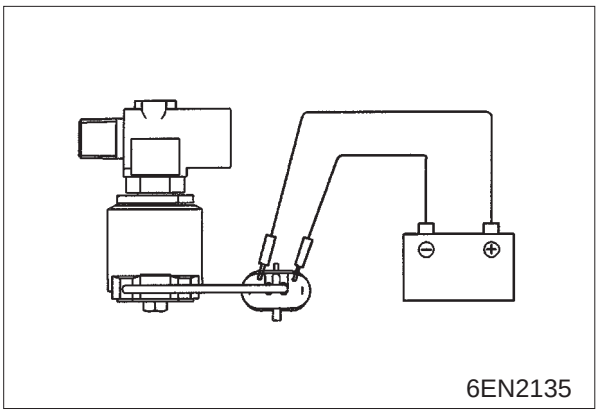
The idle air/fuel mixture is factory set, therefore, no further adjusstments are required. The part throttle air/fuel mixture is factory set, therefore, no further adjusstments are required. The full power air/fuel mixture is factory set, therefore no, further adjustments are required, either.

Inspect and lubricate throttle cable linkage every 500 service hours or 3 months.

LP Converter-Check, Clen

See, “LP Converter-Check, Clean” in LP Fuel System Section.

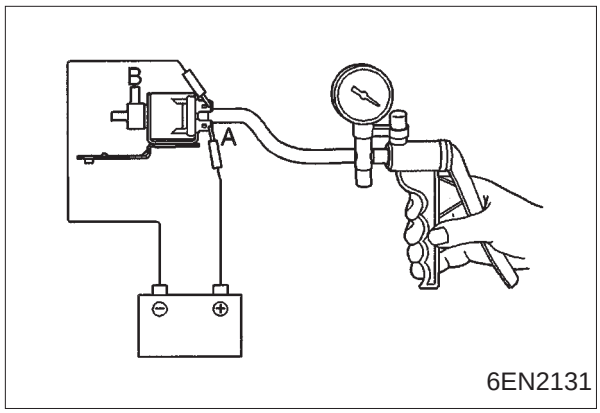
Inspection of Fuel Lock - Off



1. When voltage is impressed to the terminal of fuel lock-off, check whether there si operation sound.
2. If there is an abnormality, replace the fuel lock-off.

Inspection of Fuel Control Valve

1. Connect a hand vacuum pump to the nipple A of the vacuum switch.

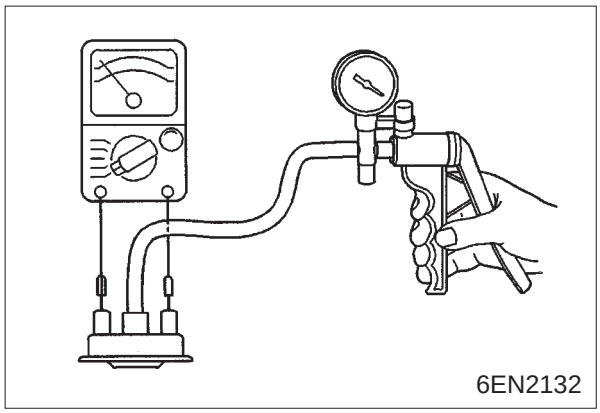


2. Battery voltage is impressed between the terminals of a fuel control valve, a hand vacuum pump is connecting in nipple A, and vacuum is applied.

Items	When B nipple is closed
When current is flowing	Vacuum is felt with a finger.
When Current is not flowing	Vacuum is not felt with a finger.

3. If there is an abnormality, replace the fuel control valve.

Inspection of Vacuum Switch

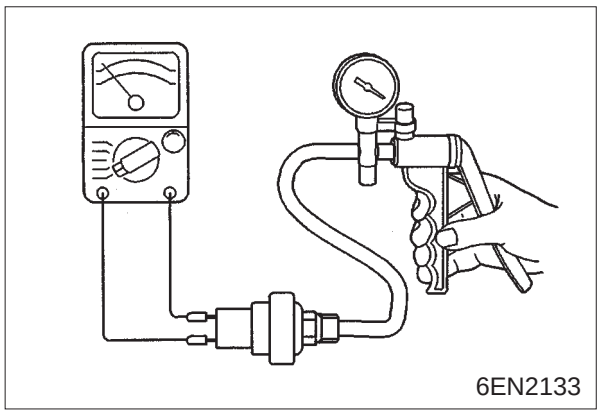


1. Connect a hand vacuum pump to the nipple of the vacuum switch.
2. Using a vacuum pump, vacuum (0.7 or more kPa) is applied to a vacuum sensor, and the existence of continuity between sensor terminals is checked.

Vacuum gauge	Continuity
Not applied	Non-conductive
0.7 kPa or more	Conductive

3. If there is an abnormality, replace the vacuum switch.

Inspection of Vacuum Switch (MAP)

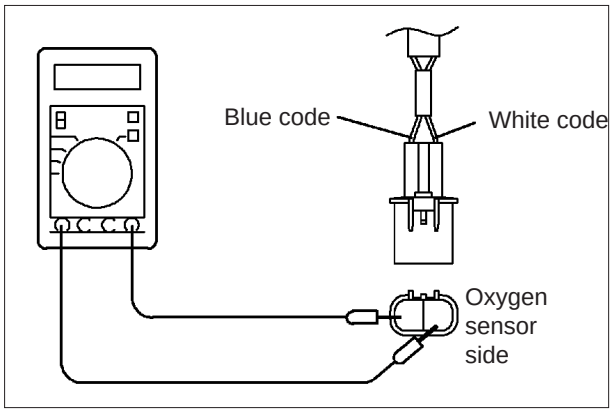


1. Connect a hand vacuum pump to the nipple of the vacuum switch.
2. Using a vacuum pump, vacuum (24 or more kPa) is applied to a vacuum sensor, and the existence of continuity between sensor terminals is checked.

Vacuum gauge	Continuity
Not applied	Non-conductive
24 kPa or more	Conductive

3. If there is an abnormality, replace the vacuum switch.

Inspection of Oxygen Sensor



(1) Before checking, warm up the engine until engine coolant temperature reaches 80 to 95°C

(2) In the state where engine is poerated disconnent the oxygen sensor connector and connect a voltmeter.

Caution

The right measurement cannot be pertormed if oxygen sensor connector is separated before engine starting

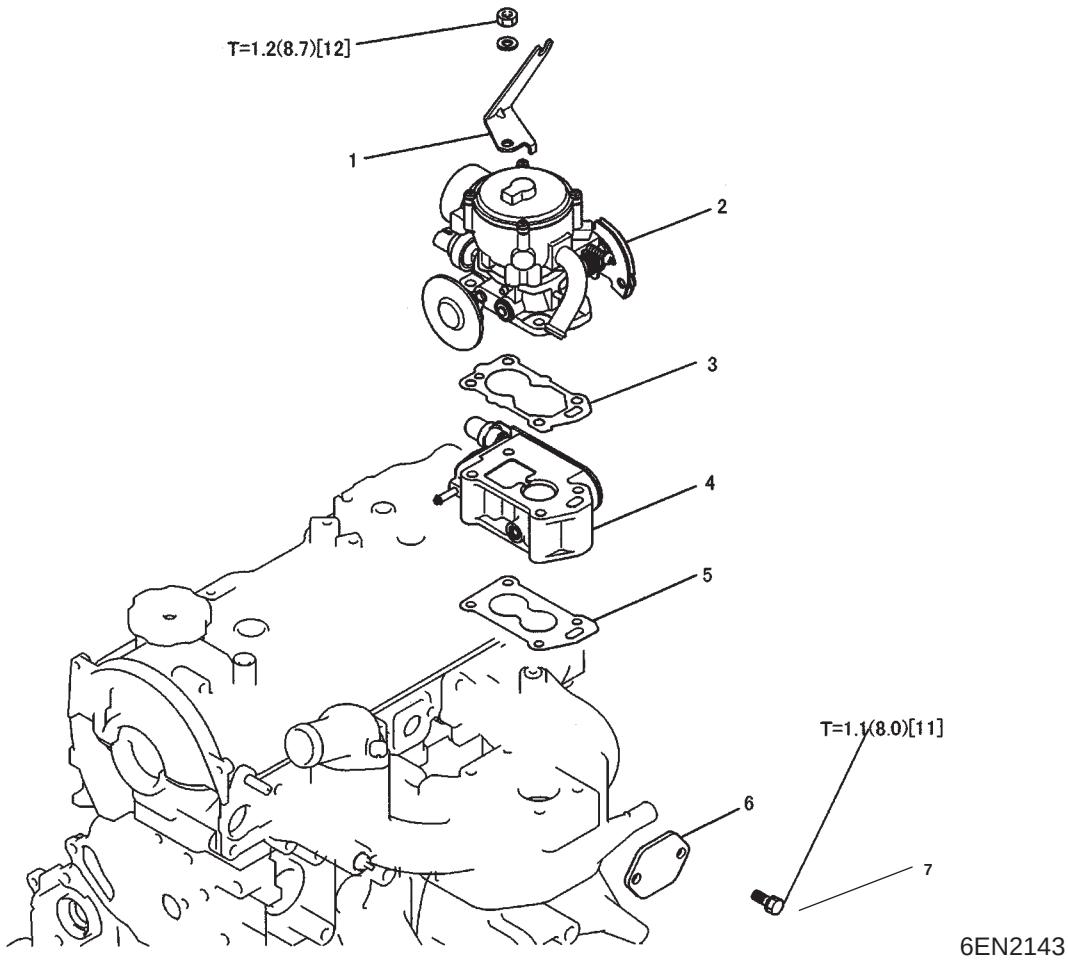
(3) Measure the oxygen sensor output voltage.
Standard value : 0.6 - 1.0V

(4) If there is a deviation from the standard value, replace the oxygen sensor.

Disassembly & Assembly

LPG Carburetor

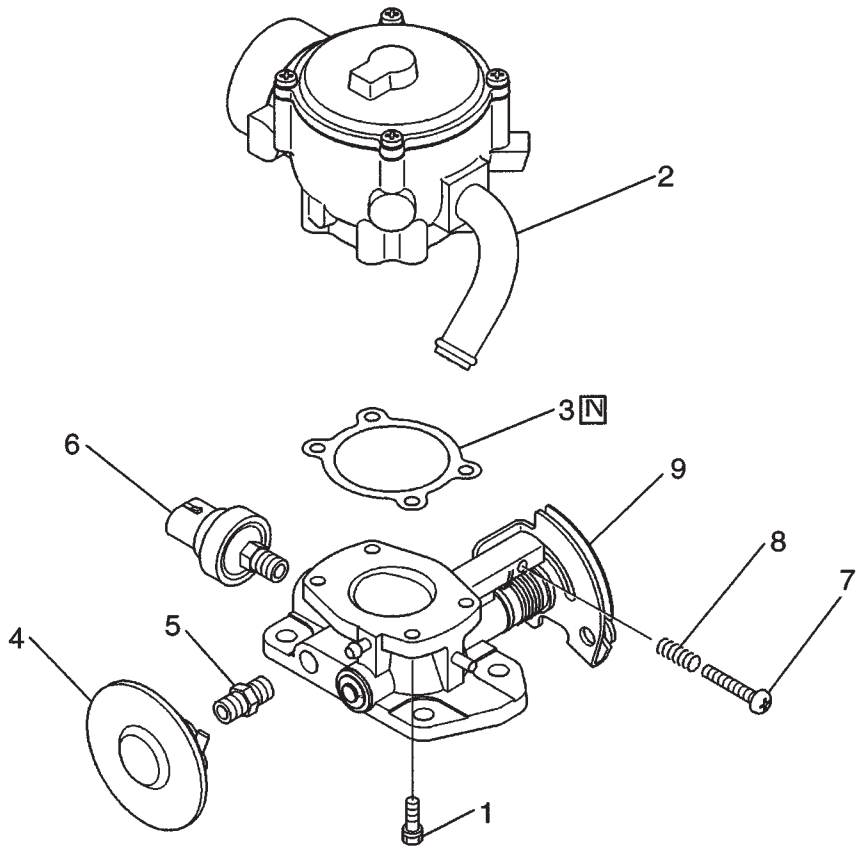
Removal and Installation of LP Gas Carburetor



Removal steps

1. Bracket - Accel Wire
2. LPG Carburetor
3. Carburetor Gasket
4. Air Governor
5. Governor Gasket
6. Fuel pump Cover
7. Bolt

Disassembly & Assembly of LP Gas Carburetor



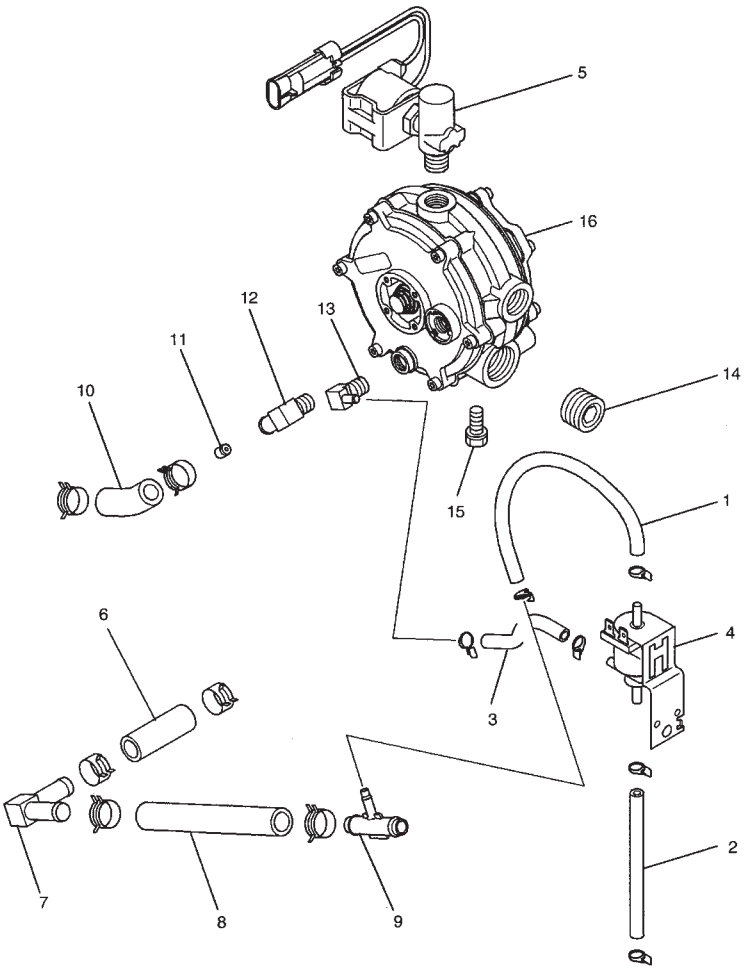
6EN2147

Removal steps

1. Bolt
2. LPG mixer
3. Gasket
4. Vacuum switch
5. Fitting
6. Vacuum switch (MAP)
7. Idle adjustment screw
8. Idle adjustment screw spring
9. Throttle body assembly

LP Gas Converter

Removal & Installation of LP Gas Converter



6EN2148

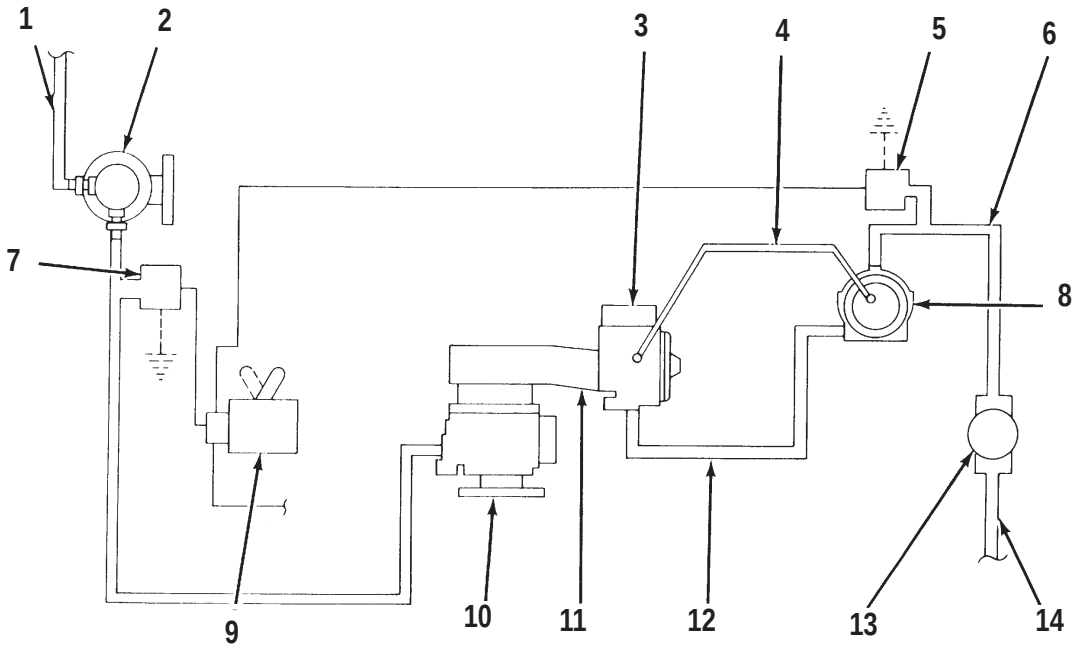
Removal steps

1. Vacuum hose
2. Vacuum hose
3. Vacuum hose
4. Fuel control valve
5. LPG shut off valve assembly
6. Balance hose
7. Check valve elbow fitting
8. Balance hose
9. Vacuum terminal
10. Balance hose
11. Jet
12. Elbow fitting
13. Elbow fitting
14. Fuel outlet plug
15. Bolt washer assembly
16. Converter

Disassemble & Assemble of LP Gas Converter

See, “Disassembly & Assembly” of LP Fuel System Section.

DUAL FUEL SYSTEM



IDES071S

Dual Fuel Basic Schematic
(1) Gasoline inlet line (from gasoline tank). (2) Mechanical fuel pump. (3) LP mixer. (4) Balance hose. (5) LP electric fuelock. (6) LP fuel line. (7) Gasoline electric fuelock. (8) Converter. (9) Selector switch. (10) Carburetor. (11) Elbow. (12) LP fuel line. (13) LP fuel filter. (14) LP fuel inlet line (from LP tank).

The dual fuel system is a combination of the gasoline and the liquid petroleum fuel systems. This system allows the operator to run the engine on gasoline or liquid petroleum fuel.

The basic components of the dual fuel system are the LP and gasoline fuel tanks, mechanical fuel pump (2), selector switch (9), gasoline carburetor (10), LP mixer (3), converter (8), LP fuelock (5), LP fuel filter (13), gasoline fuelock (7) and the connecting fuel lines.

When selector switch (9) is in the gasoline position, gasoline fuelock (7) is open. Gasoline is drawn through line (1), the fuel filter and fuel pump (2), fuelock (7) and into the carburetor, where the fuel is mixed with air at the correct ratio. The air and fuel mixture fuel then goes to the inlet manifold and is changed to a vapor. It then goes to the combustion chamber of each cylinder.

NOTE: Refer to the topics Gasoline Fuel System and Liquid Petroleum Fuel System for the operation of the components not explained here.

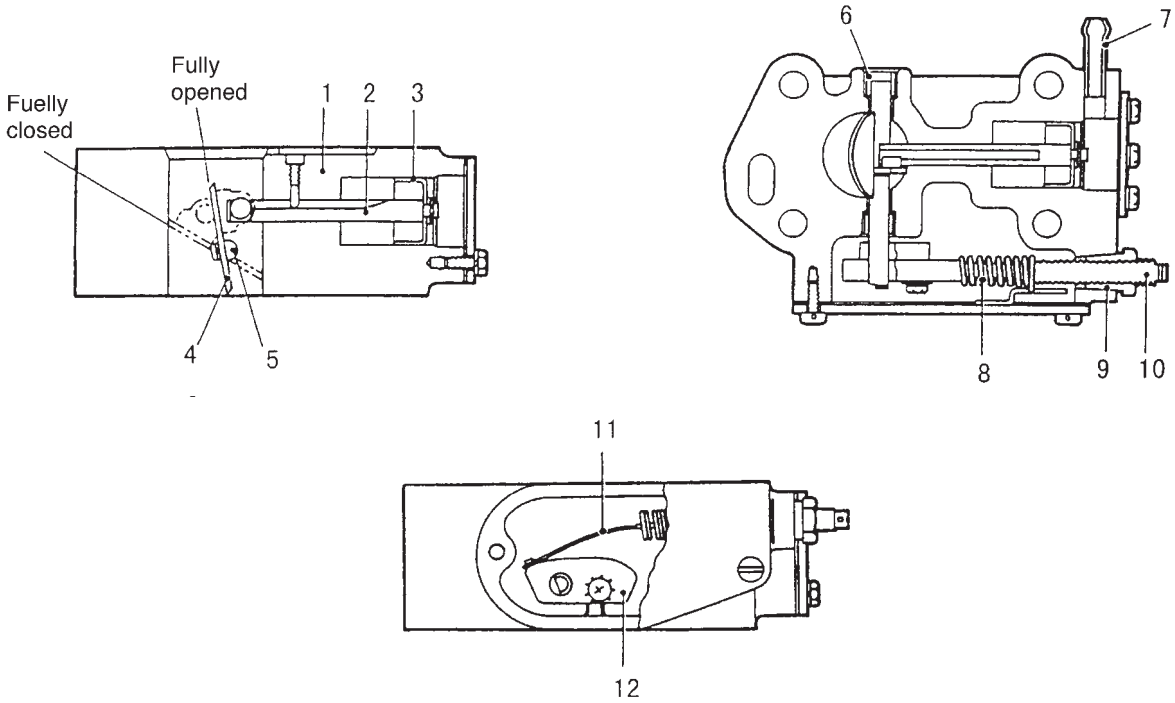
To change from gasoline to LP fuel, selector switch (9) should first be put in the OFF position. This is done to allow the gasoline in the line and the carburetor to be used before LP fuel is started. When selector switch (9) is turned OFF or to the LP position, power to gasoline fuelock (7) is stopped, which closes fuelock (7) and shuts off the gasoline supply to the carburetor.

When selector switch (9) is turned to the LP position, LP fuelock (5) opens and LP fuel flows through line (14), filter (13) and to converter (8). The converter changes the fuel to a vapor. This vapor flows through line (12) to mixer (3). The mixer sends the vapor through elbow (11) to the gasoline carburetor, which now acts as a throttle plate. From the carburetor, the vapor goes through the inlet manifold to the combustion chamber of each cylinder.

Balance hose (4) between the atmospheric opening in the converter and the mixer keeps the correct air and fuel mixture in the mixer when there is some restriction in the air cleaner.

GOVERNING SYSTEM

General Description



Sectional View of Air Governor
(1) Body. (2) Stabilizer rod. (3) Stabilizer piston. (4) Throttle plate. (5) Throttle plate shaft. (6) Bearing. (7) Nipple. (8) Spring. (9) Bush nut. (10) Adjusting screw. (11) Plate. (12) Cam

The air governor is located to the underside of the carburetor. It serves to protect the hydraulic pump, to limit the maximum traveling speed of the vehicle, and to prevent excessive increase of engine speed.

1. Governing operation

The throttle plate shaft is offset from the center of the governor bore. Also, the full-open position of the throttle plate does not coincide with the truly full-open position, but rather leans to the closing side. Therefore, the pressure of mixture flow acts on the throttle plate to rotate it in direction of closing, causing a torque to its shaft.

The torque stretches the return spring attached to the cam on the throttle plate shaft until the torque balances the tension of the spring, and the throttle plate is maintained at that open angle.

This is governing operation. That is, a balance between the pressure applied to the throttle plate, which depends on vacuum pressure, and the spring tension keeps the throttle plate at position between the full-open position and the full-close position to control the amount of mixture flowing into the engine.

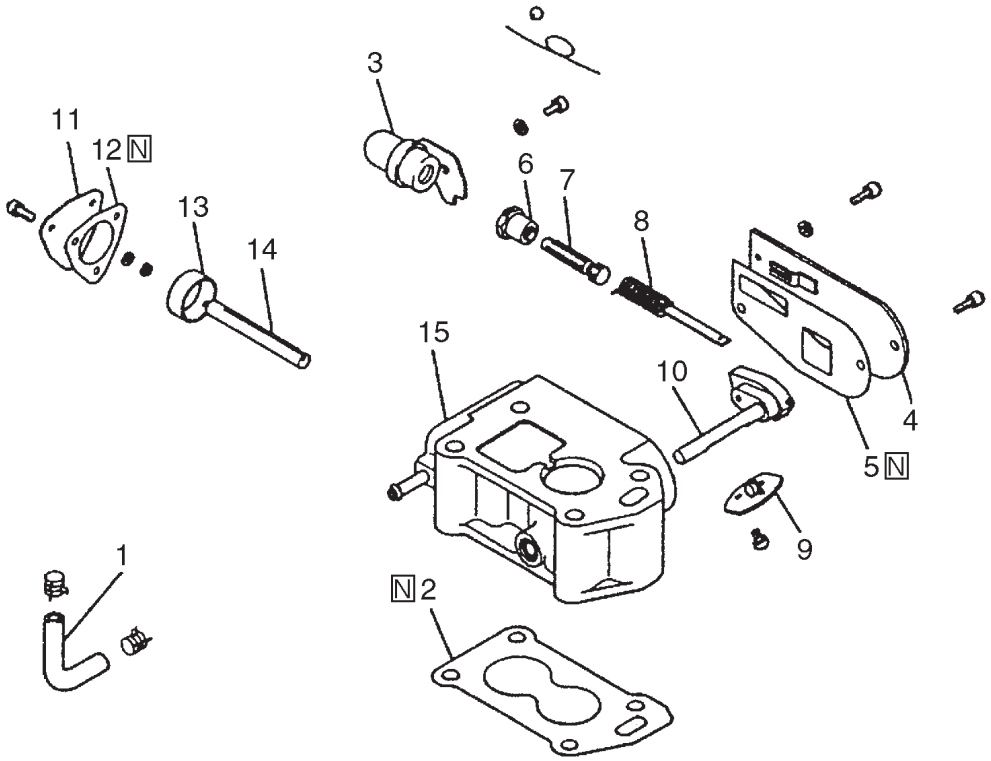
2. Auxiliary operation

The throttle plate opening angle of this governor is set under the full-open condition of the carburetor.

Accordingly, when the carburetor throttle valve is operated in the direction of closing, governor pressure applied to the throttle plate decreases and, therefore, the throttle plate is rotated by the spring in the direction of opening. As a result, engine speed increases. To prevent this, the governor is provided with a stabilizer piston.

The stabilizer piston acts to close the throttle plate when a large vacuum pressure is developed on the upper side of the throttle plate, so that proper opening of the throttle plate can be maintained in combination with the opening of the carburetor throttle valve. With the help of this auxiliary operation, the governing operation can follow up the variations of load quickly.

Air Governor
Disassembly and Reassembly



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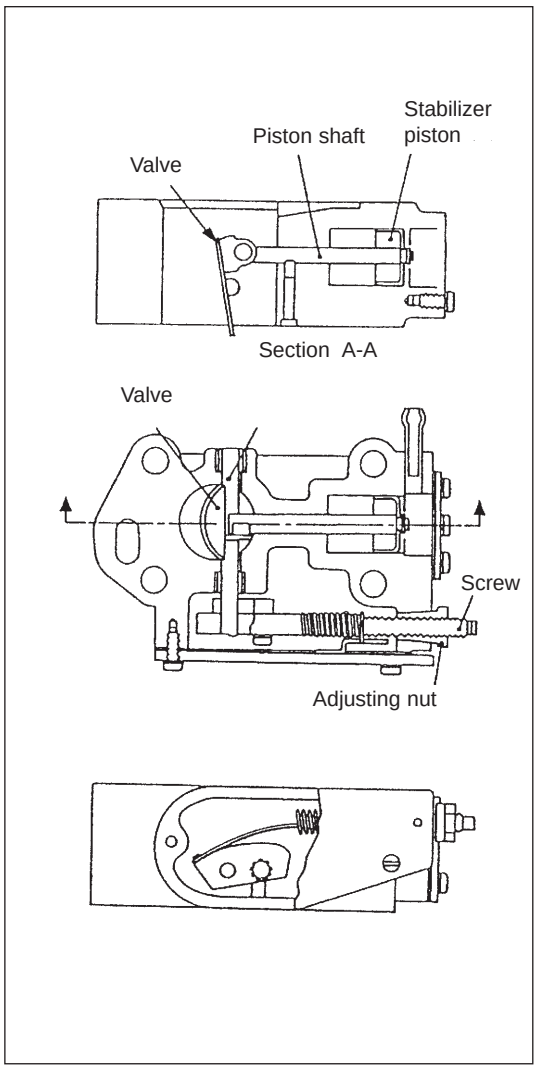
Disassembly steps
1. Ventilation hose
2. Gasket
3. Sealing cap
4. Cover plate assembly
5. Gasket
6. Adjusting nut
7. Adjusting screw
→A← 8. Plate assembly
→A← 9. Valve assembly
10. Valve shaft assembly
11. Piston cover
12. Gasket
13. Stabilizer piston
←A→ 14. Piston shaft
←B→ 15. Governor body

Disassembly Service Points

Caution: Since the air governor has been adjusted and sealed in the manufacturer's factory to conform to the specifications, it should not be disassembled in general cases. Like any other sealed components, the air governor should not be disassembled anywhere except the locations where a warranty claim decision is authorized. In addition, the cam on the throttle valve shaft should never be removed.



Inspection

1. Check the plate assembly (8) composed of a ribbon spring and coil spring for cracks and any other damage.
2. Check the valve shaft for wear, and also make sure that it rotates smoothly when mounted in the body.
3. Check the piston for damage. Check also the valve fit-in section of the shaft for damage.
4. Grease packed needle bearings are press-fitted at both ends of the valve shaft hole of the governor body. Avoid cleaning the body in gasoline or any other solvent.

Reassembly Service Points

Caution: Thoroughly clean all component parts before installation. Do not apply grease or oil anywhere in the body except the needle bearings (grease packed) in the throttle valve shaft hole.

⟶ A ⟵ Adjusting screw and nut setting

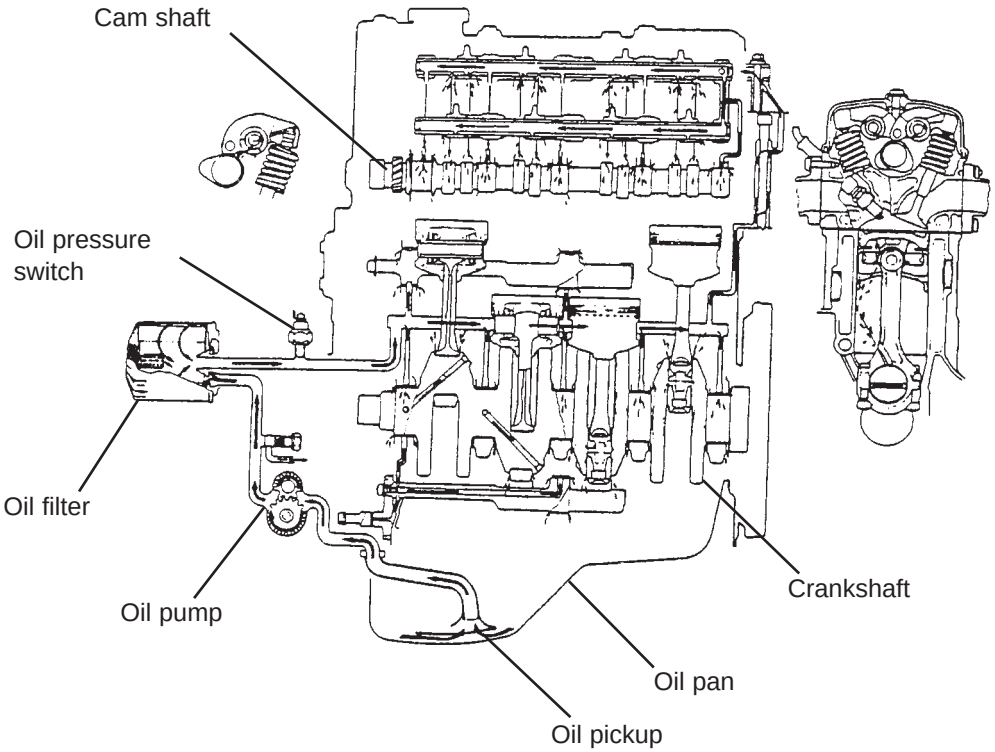
When assembling the air governor separately from the engine, temporarily assemble it so that the throttle valve will be in the fully opened position.

Governor Adjustment

See,Adjustment and Troubleshooting Section.

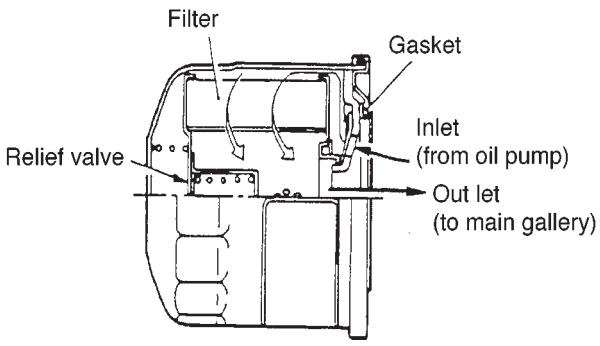
LUBRICATION SYSTEM

General Description



Lubricating system is the full-flow filtered pressure-feed oil system and the oil reserved in the oil pan is fed with pressure to each part of engine. After the oil pressure is adjusted through the relief valve, the oil is fed to the cylinder blocks and cylinder head.
In the cylinder head the oil is forcibly fed to the camshaft journals, rocker arm pivots and further cam surfaces.

OII Filter



Testing & Adjusting

Adhere to the following warnings when performing any tests or adjustments while the engine is running.

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

⚠ WARNING

Exhaust fumes contain carbon monoxide (CO) which can cause personal injury or death. Start and operate the engine in a well ventilated area only. In an enclosed area, vent the exhaust to the outside.

Engine Oil

Engine Oil Recommendation

The following oil specifications provide the guidelines for the selection of commercial products :

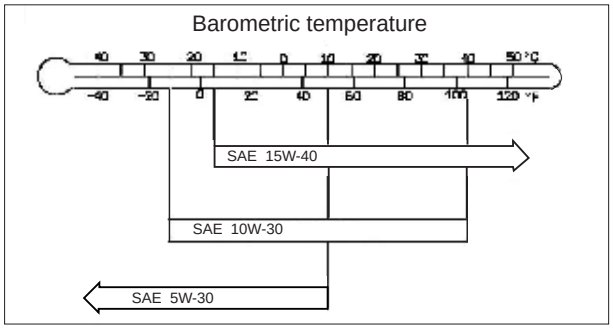
Use gasoline engine oil. Recommended API service classification is class SJ grade.

NOTICE

Failure to follow the oil recommendations can cause shortened engine life due to carbon deposits or excessive wear.

Prior to changing oil, select an oil based on the prevailing daytime temperature in the area in which the engine is operated. The chart in figure is a guide to selection the proper crankcase oil.

IMPORTANT : Oils containing “solid” additives, non-detergent oils, or low-quality oils are not recommended for use in G424 Engine.



Engine Oil Viscosity Recommendation

NOTE : In normal case, the recommended engine oil for G424 engine is SAE 10W - 30.

But, if the excessive valve noise occurs up to five minutes after a cold start and if the maximum ambient temperature is lower than 10°C (50°F), it is recommended to change engine oil to SAE 5W - 30 for that application.

Synthetic Oils

Synthetic engine oils are not recommended for use in G424 Engine. Synthetics may offer advantages in cold-temperature pumpability and high-temperature oxidation resistance.
However, synthetic oils have not proven to provide operational or economic benefits over conventional petroleum-based oils in G424 Engine. Their use does not permit the extension of oil change intervals.

Lubrication System Problems

One of the problems in the list that follows will generally be an indication of a problem in the lubrication system for the engine.

- Too much oil consumption.
- Low oil pressure.
- High oil pressure.
- Too much component wear.

Too Much Oil Consumption

- Engine outside oil leakage

Check for leakage at the seals at each end of the crankshaft. Look for leakage at the oil pan gasket and all lubrication system connections. Check to see if oil comes out of the crankcase breather. This can be caused by combustion gas leakage around the pistons. A dirty crankcase breather will cause high pressure in the crankcase, and this will cause gasket and seal leakage.

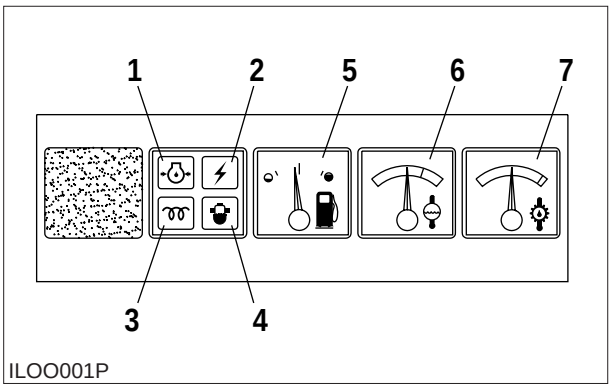
- Combustion area oil leakage

Oil leakage into the combustion area of the cylinders can be the cause of blue smoke. There are three possible ways for oil leakage into the combustion area of the stems.

1. Oil leakage between worn valve guides and valve stems.
2. Worn or damaged piston rings, or dirty oil return holes.
3. Compression ring and/or intermediate ring not installed correctly.

NOTE: Too much oil consumption can also be the result if oil with the wrong viscosity is used. Oil with a thin viscosity can be caused by fuel leakage into the crankcase, or by increased engine temperature.

Low Oil Pressure



ILOO001P

Instrument Panel
(1) Engine Oil Light

Before starting the engine, the engine oil light(1) on the instrument panel will turn on when the key switch is turned to the ON position. The light will turn off after the engine is started and while the engine is running, lidicating normal oil pressure. The light will turn on during operation only when there is insufficient engine oil pressure to properly lubricate the engine's internal paarts.

If the oil light comes on, indicating the pressure is low, check for the causes that follow:

1. Low oil level in the crankcase.

2. Defect in the oil pressure indicator light or oil pressure sensor unit.

3. Restriction to oil pump screen.

4. Leakage at the oil line connections.

5. Worn connecting rod or main bearings. Worn gears in the oil pump.

6. Oil pressure relief valve worn or stuck in the OPEN position.

7. Oil filter bypass valve stuck open. Oil filter is restricted. Replace oil filter.

High Oil Pressure

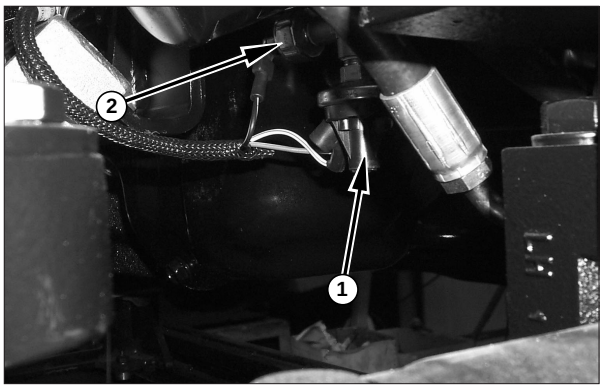
Oil pressure will be high if the oil pressure relief valve in the oil pump cannot move from the closed position.

Too Much Component Wear

When some components of the engine show bearing wear in a short time, the cause can be a restriction in an oil passage. A broken oil passage can also be the cause.

If an oil pressure check is done and the oil pressure is correct, but a component is worn because it does not get enough lubrication, look at the passage for oil supply to that component. A restriction in a supply passage will not let enough lubrication get to a component and this will cause early wear.

Oil Pressure Check



Oil Pressure Check
(1) LP pressure switch. (two-terminals) (2) Oil pressure switch. (one-terminal)

1. With the engine OFF, make sure the oil level is correct. Connect the analyzer to the engine as shown in Engine RPM Check in the Testing And Adjusting.

⚠ WARNING

Before the LP/oil pressure switch is removed, the engine must be stopped. Make sure oil pressure is released to prevent personal injury.

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2. Remove LP pressure switch (1) or oil pressure switch (2). Install the pressure gauge in adapter.

3. Start the engine and allow it to warm up to normal operating temperature.

4. Run the engine at 2000 rpm. Read the pressure gauge.

5. The oil pressure must be approximately 200 kPa (29 psi) at 2000 rpm. There is no adjustment to the oil pressure relief valve.

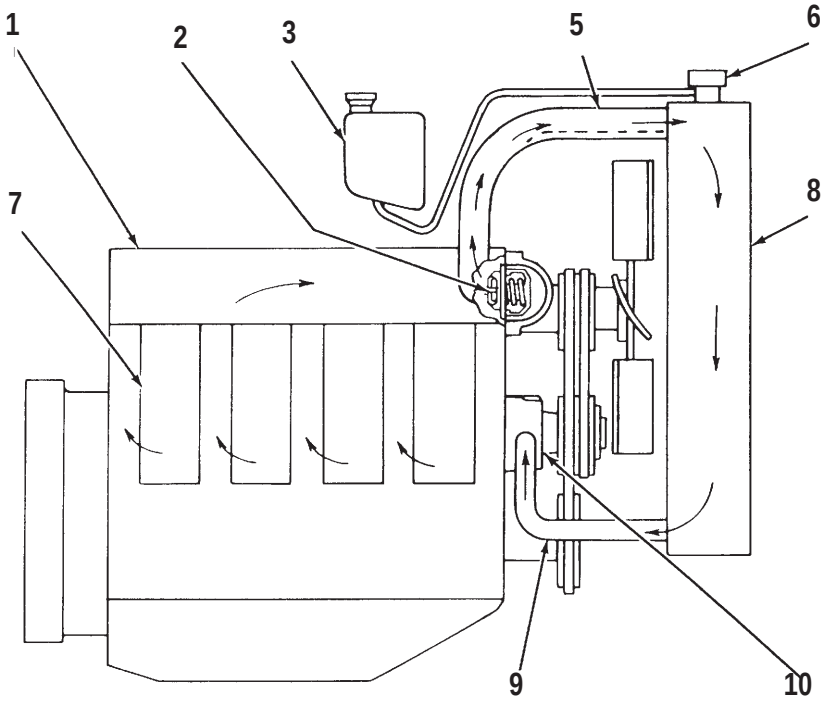
For the possible cause see Lubrication System Problems in Troubleshooting.

NOTE: A lower pressure indication, 50 kPa (7 psi), is normal at low idle speed.

For changing Engine Oil and Filter, See Maintenance Section

COOLING SYSTEM

General Description



Cooling System Schematic
(1) Cylinder head. (2) Thermostat. (3) Recovery tank. (5) Radiator top hose. (6) Radiator pressure cap.
(7) Cylinder walls. (8) Radiator. (9) Radiator lower hose. (10) Water pump.

Water pump (10) is installed on the front of the cylinder block. The water pump is driven by a single V belt from the crankshaft pulley. The inlet opening of the water pump is connected to the radiator lower hose (9). The outlet flow from the water pump goes through passages inside the cylinder block.

The coolant from the water pump through the cylinder block passages has primary coolant flow to and around the seats for the exhaust valves. This method gives the coolant with the coolest temperature flow to the hottest area during engine operation.

Cylinder walls (7) are cooled by the coolant flow through the block. After the coolant goes through the cylinder block it flows through cylinder head (1) to the thermostat housing, where the bypass type thermostat (2) is installed. The thermostat controls the opening to radiator (8) to control the temperature in the cooling system.

If the coolant is cold (cool), the thermostat will be closed. The coolant circulates (makes a complete circuit) from the water pump and through the cylinder block until the temperature of the coolant is warm enough to make the thermostat open. When thermostat (2) is open the coolant will go through radiator top hose (5) and into the top tank of radiator (8). Coolant then goes through the cores of the radiator. The air from the fan will make the coolant cool as the coolant flows to the bottom of the radiator and out hose (9) where the coolant returns to water pump (10).

The radiator is equipped with a shroud to increase the efficiency of the fan and cause the air to be pushed through the radiator and away from the lift truck.

If the coolant is hot and the cooling system pressure is too high, some coolant flows to the top of radiator (8) through the tube to recovery tank (3). The cooling system pressure is controlled by cap (6). When the cooling system pressure goes above its rated pressure, a valve opens in pressure cap (6) which releases the cooling system pressure to the atmosphere. After the engine is at normal temperature for operation, a development of vacuum is present in the cooling system. Pressure cap (6) permits air in the radiator to remove the vacuum at the same time coolant from recovery tank (3) is pulled back into the radiator.

Testing & Adjusting

Adhere to the following warnings when performing any tests or adjustments while the engine is running:

⚠ WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

⚠ WARNING

Exhaust fumes contain carbon monoxide (CO) which can cause personal injury or death. Start and operate the engine in a well ventilated area only. In an enclosed area, vent the exhaust to the outside.

This engine has a pressure type cooling system. A pressure type cooling system gives two advantages. The first advantage is that the cooling system can have safe operation at a temperature that is higher than the normal boiling (steam) point of water. The second advantage is that this type system prevents cavitation (the sudden making of low pressure bubbles in liquids by mechanical forces) in the water pump. With this type system, it is more difficult for an air or steam pocket to be made in the cooling system.

The cause for an engine getting too hot is generally because regular inspections of the cooling system were not made. Make a visual inspection of the cooling system before testing with testing equipment.

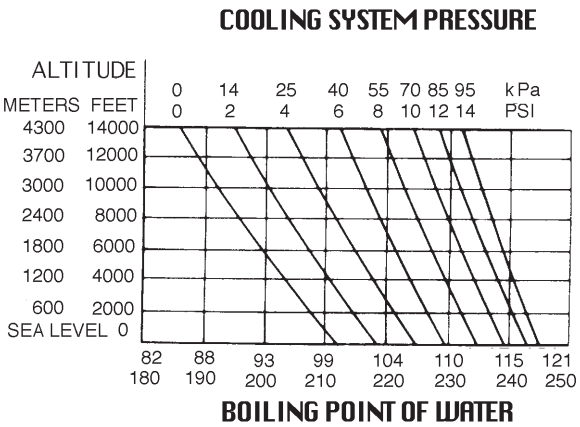
Cooling System Visual Inspection

⚠ WARNING

Do not loosen the filler cap or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

1. After the engine is cool, loosen the filler cap (on a radiator with a pressure cap, turn it to the first stop) to let pressure out of the cooling system. Then remove filler or pressure cap.
2. Check coolant level in the cooling system.
3. Look for leaks in the system.
4. Look for bent radiator fins. Be sure that air flow through the radiator does not have a restriction.
5. Inspect the drive belts for the fan.
6. Check for damage to the fan blades.
7. Look for air or combustion gas in the cooling system.
8. Inspect the filler cap and the surface that seals the cap. This surface must be clean.
9. Look for a large amount of dirt in the radiator core and on the engine.
10. Check for loose or missing fan shrouds that cause poor flow of cooling air.

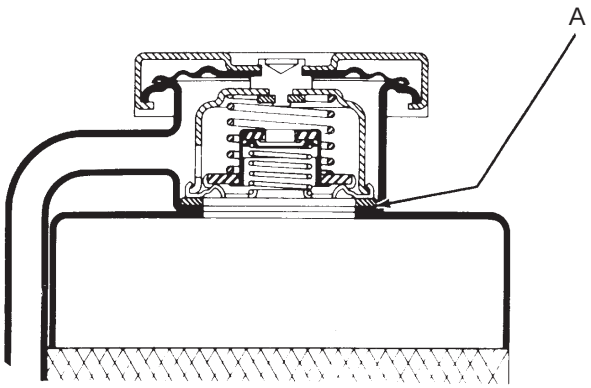
Cooling System Tests



IDES108S

Remember that temperature and pressure work together. When making a diagnosis of a cooling system problem, temperature and pressure must both be checked. Cooling system pressure will have an effect on cooling system temperatures. For an example, look at the chart to see the effect of pressure and height above sea level on the boiling (steam) point of water.

Pressure Cap Test



IDES109S

Pressure Cap Diagram
(A) Sealing surface of cap and radiator.

One cause for a pressure loss in the cooling system can be a bad seal on the pressure cap of the system. Inspect the pressure cap carefully. Look for damage to the seal or the sealing surface. Any foreign material or deposits on the cap, seal or seal or sealing surface must be removed.

To check the pressure cap opening pressure, do the following procedure.

⚠ WARNING

If the engine has been in operation and the coolant is hot, slowly loosen the pressure cap to the first stop and let the pressure out of the cooling system, then remove the pressure cap.

1. Remove pressure cap from the radiator.

2. Put the pressure cap on the Cooling

System Pressurizing Pump Tool.

3. Look at the gauge for the pressure that makes the pressure cap open. It must be as follows:
D460972 Cap .....85 to 110 kPa (12 to 16 psi)

4. If the pressure cap is bad, install a new pressure cap.

Cooling System Leak Check

To test the cooling system for leaks, use the following procedure:

⚠ WARNING

If the engine has been in operation and the coolant is hot, slowly loosen the pressure cap to the first stop and let the pressure out of the cooling system, then remove the pressure cap.

1. Remove pressure cap from the radiator.

2. Make sure the radiator is full (hot) or nearly full (cold) of coolant.

3. Attach the Cooling System Pressurizing Pump Tool to the radiator filler neck.

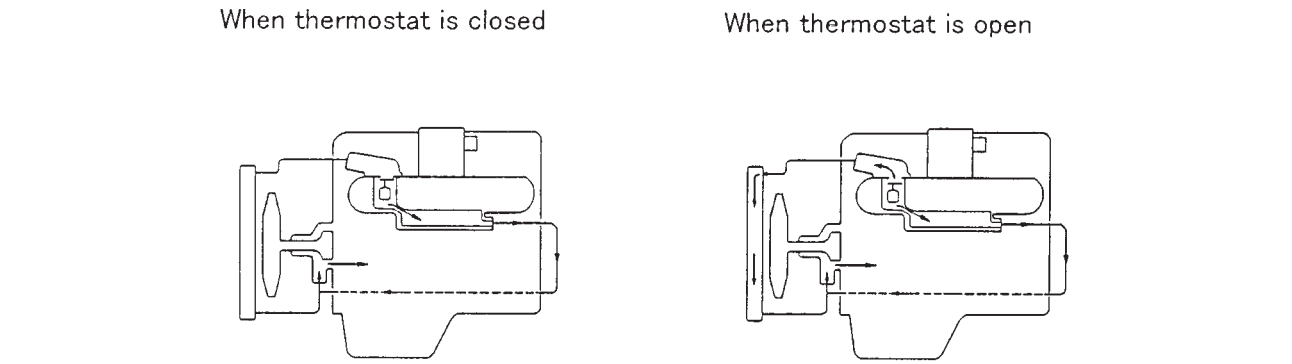
4. Pump the pressure to 20 kPa (3 psi) more than the rated pressure of the cap.

5. Check the radiator for outside leakage.

6. Check all connections and hoses of the cooling system for outside leakage.

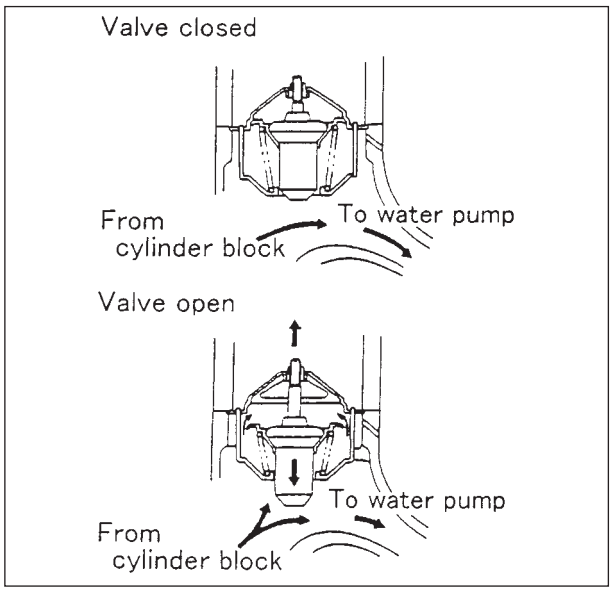
7. If there is no outside leakage and the pressure reading on the gauge is still the same after 5 minutes, the radiator and cooling system do not have leakage. If the reading on the gauge goes down and there is no outside leakage, there is leakage on the inside of the cooling system. Make repairs as necessary

Thermostat



The thermostat is the wax pellet type. A jiggle valve (which improves air bleeding during water supply) is provided on the flange part. When the thermostat is closed, the circulation of coolant is stopped, thereby making warm-up faster.

Operation



When the temperature of the coolant is low, the valve is closed by the spring, with the result that the coolant circulates within the engine, without passing through the radiator.
When the temperature of the coolant rises and reaches a certain specified temperature, the valve opens and the coolant also circulates through the radiator.

When the temperature increases further and reaches a certain specified temperature, the valve opens fully, allowing even more coolant to circulate through the radiator.
Thus, in this way the degree of valve opening is varied according to the temperature of the coolant, and the temperature of the coolant is adjusted by varying the amount of coolant caused to circulate through the radiator.

Thermostat Test

To test the thermostat opening temperature, use the following procedure:

⚠ WARNING

The pan, water and thermostat will be very hot and can cause burns. Do not touch the pan, water or thermostat. Handle the components with an insulated device for protection.

1. Remove the thermostat from the engine.
2. Hang the thermostat in a pan of water. Put a thermometer in the water. Put the thermostat completely under water. Do not let the thermostat make contact with the pan.
3. Put heat to the pan of water. Make the water in the pan move around. This keeps all of the water at the same temperature.
4. The thermostat must start to open when the temperature is 82°C (180°F). The thermostat must be fully open at 96°C(205°F).

Cooling System Heat Problems

To check if there is a good reason for heat problems do the checks that follow:

1. The indications of a heat problem are as follows:
- **a.** High coolant temperature indicator light is on or needle of coolant temperature gauge is in red range.
- **b.** Coolant boils out (comes out because of too much heat) of the cooling system during operations.
- **c.** Coolant boils out on the floor when the engine is stopped.
- **d.** Coolant must be added at the end of each shift but Steps b and c are not present.

2. If indication in Step 1 a is only present. It is possible the problem is only a damaged gauge, light or sender. Make a replacement of the defective part.

3. If indication in Step 1b is present, do the procedure that follows:
- **a.** Run the engine at medium idle (1200 rpm) for three minutes after high idle operation. This cools off the hottest parts of the engine before it is stopped.
- **b.** Install a coolant recovery system on the truck, if not already equipped.

4. If indications in Step 1b, 1c or 1d are present, but Step 1a is not and the high temperature indicator light does work, the problem can be a damaged radiator cap seal or there can be a leak in the cooling system. Complete the procedure that follows:
- **a.** Do the Pressure Cap Test, Cooling System Leak Check, Thermostat Test and Belt Adjustment in the Testing And Adjusting.
- **b.** Clean the radiator with hot water (steam clean) at low pressure and use detergent or air according to the different types of debris that caused the radiator to be dirty (plugged).
- **c.** Check the engine high idle setting.

NOTE: Another condition that can cause heat problems is the ignition timing. Retarded (late) timing causes the engine to send more heat to the cooling system. Advanced (early) timing causes the engine to send less heat to the cooling system.

Cooling System Recommendation

Coolant Information

NOTICE

DAEWOO recommends that the coolant mix contain 50% commercially available automotive antifreeze, and 50% water.

The coolant mixture of less than 30% concentration does not provide sufficient corrosion protection. Concentrations over 60% adversely affect freeze protection and heat transfer rates.

To prevent damage to your engine, never add coolant to an overheated engine. Allow the engine to cool first. If the lift truck is to be stored in, or shipped to, an area with freezing temperatures, the cooling system must be protected to the lowest expected outside (ambient) temperature.

The engine cooling system is protected with a commercially available automotive antifreeze, when shipped from the factory.

Check the specific gravity of the coolant solution frequently in cold weather to ensure adequate protection.

Clean the cooling system if it is contaminated, if the engine overheats or if foaming is observed in the radiator.

Old coolant should be drained, system cleaned and new coolant added as recommended with the commercially available automotive antifreeze.

Filling at over 20 liters per minute can cause air pockets in the cooling system.

After draining and refilling the cooling system, operate the engine with the radiator cap removed until the coolant reaches normal operating temperature and the coolant level stabilizes. Add coolant as necessary to fill the system to the proper level.

Operate with a thermostat in the cooling system all year-round. Cooling system problems can arise without a thermostat.

Coolant Water

Hard water, or water with high levels of calcium and magnesium ions, encourages the formation of insoluble chemical compounds by combining with cooling system additives such as silicates and phosphates.

The tendency of silicates and phosphates to precipitate out-of-solution increases with increasing water hardness. Hard water, or water with high levels of calcium and magnesium ions encourages the formation of insoluble chemicals, especially after a number of heating and cooling cycles.

DAEWOO prefers the use of distilled water or deionized water to reduce the potential and severity of chemical insolubility.

Acceptable Water	
Water Content	**Limits (ppm)**
Chlorides (Cl)	40 maximum
Sulfates (SO_4)	50 maximum
Total Hardness	80mg/ℓ maximum
Total Solids	250 maximum
pH	6.0~8.0

ppm = parts per million

Using water that meets the minimum acceptable water requirement may not prevent drop-out of these chemical compounds totally, but should minimize the rate to acceptable levels.

Antifreeze

NOTICE

DAEWOO recommends that the coolant mix contain 50% commercially available automotive antifreeze, or equivalent, and acceptable water to maintain an adequate water pump cavitation temperature for efficient water pump performance.

Premix coolant solution to provide protection to the lowest expected outside (ambient) temperature. Pure undiluted antifreeze will freeze at -23℃ (-10℉).

Only use a greater concentration (above 50%) of commercially available automotive antifreeze an needed for anticipated outside (ambient) temperatures. Do not exceed the recommendations, provided with the commercially available automotive antifreeze, regarding the coolant mixture of antifreeze to water.

DAEWOO recommends selecting automotive antifreeze suitable for gasoline engines using aluminum alloy parts. The antifreeze should meet ASTM-D3306 standard.

Make proper antifreeze additions.

Adding pure antifreeze as a makeup solution for cooling system top-up is an unacceptable practice. It increases the concentration of antifreeze in the cooling system which increases the concentration of dissolved solids and undissolved chemical inhibitors in the cooling system. Add antifreeze mixed with water to the same freeze protection as your cooling system.

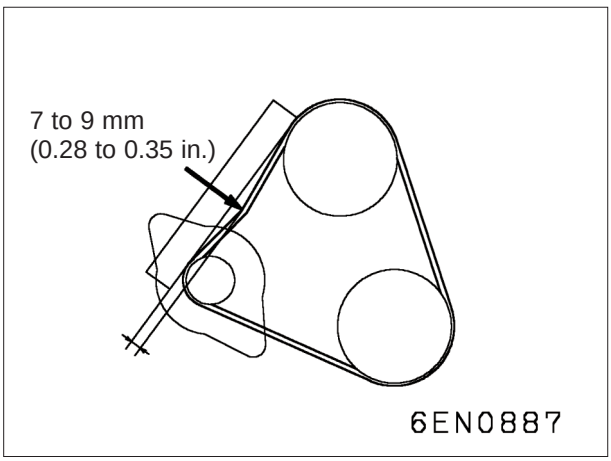
Belt Adjustment

Drive belts must grip the entire contact area of the pulley. When drive belts are too loose, the belts can slip, tear, burn, or grab and snap. More belts fail from being too loose than too tight.

Belts that are too tight can damage the engine by causing side loading of the crankshaft, crankshaft bearings, and accessories or accessory bearings. Too much belt tension will also stretch and weaken the belts.

After a belt has made one complete revolution it is considered used and should be adjusted to the used belt tension specification. When the drive belts are worn, they should be replaced. Tightening worn drive belts will not prevent slipping and can cause damage to the engine.

Do not use belt dressings to extend belt life. Most dressings contain chemicals that soften the belts. Check the belts at 1500 hour intervals. Also check all necessary mounting or adjusting bracket bolts.



The fan belt is properly tense if it deflects 7 to 9mm (0.28 to 0.35 in) as it is depressed with a finger between the pulley and pulley of the long distance side. Excessive tension can cause quick wear of the belt and bearings of the water pump and the alternator Excessive slackness ot presence of oil on the belt, on the other hand, can lead to engine overheating and insufficient charging due to slipping belt.

CATUTION : Never attempt to adjust tension of the fan belt while leaving the engine in operation.

V-Belt Diagnosis

Belts and pulleys wear evenly with use. Unusual signs of wear indicate some correction is needed. The correction of any of the listed conditions will help extend belt life.

Causes of Belt failure

- Misalignment of the pulleys.
- Wrong size belt.
- Wrong length belt.
- Wrong tension.
- Damaged pulley sheaves or bent pulley shafts.
- Damaged belt.
- Belt damaged during installation.
- Oil or grease on belts.

Base Cracking

A belt with excessive cross-checking that extends into the rubber on the base of a belt and shows little or no side wear indicates the belt is damaged. If the base of the belt shows cross-checking, the belt has been exposed to weather to the extent that the fabric is starting to rot.

Fabric Tear

A fabric tear can be the result of:
- Operating a belt on a worn pulley.
- Belt tension too light causing the belt to ride in the pulley groove.
- Dirty pulley grooves.
- Pulley misaligned.

Cover Tear

Cover tears result when the belts are too loose or too long and the belt rubs against other compo-nents. Adjust the belt tension and use the correct length of belt.

Slip Burn

Slip burns occur when the belts are too loose or slipping under load. Install a new belt and adjust properly. Check for a worn pulley.

Gouged Edge

A gouged edge in a belt can be caused by a damaged pulley, a misaligned pulley, or the belt being too loose or too long. Check the pulley and the belt for proper alignment and tension. Make sure other components are not misaligned and rubbing against the belt.

Worn Sides

Belts that are worn on the sides are probably too loose. The pulley may also be misaligned. Install a new belt and adjust properly. Check for a worn or misaligned pulley.

Excessive Stretch

A belt that is stretched beyond adjustment is usually the wrong size or is adjusted too tight.
Replace the belt and adjust the tension.

Flat Spots

Flat spots may result by not relieving the belt tension while storing the vehicle or engine. A temporary vibration will occur when the engine is first started. Flat spots are most noticeable with variable speed drives. Flat spots may disappear during normal engine operation. If the flat spots remain, replace the belts.

Internal Cord Damage

Cords may be broken by prying the belt onto the pulley or debris on the pulley. Internal cord damage will cause the belt to roll out of the pulley groove.
Replace the belt and adjust properly.

Service Procedures

Draining and Filling the Cooling System

Various methods and equipment can be used.

Draining

1. Place a drain pan under the radiator drain cock.

2. Install a tube on the drain cock.

3. Place the end of the tube in the pail or pan.

4. Make sure the cooling system is cool, then remove the radiator cap.

5. Open the drain cock completely.

6. Let the cooling system drain until the flow stops.

7. Place a drain pan under the engine.

8. Remove the drain plug in the engine block.

9. Let the engine block drain until the flow stops. There may be more drainage from the radiator at this time.

10. Replace the engine block drain plug.

11. Close the drain cock.

Filling

1. Check the radiator drain cock to be sure it is closed.

2. Check the engine drain plug to be sure it is tight.

3. Premix the antifreeze with clear water in 50/50 mixture.

IMPORTANT: If the old coolant is to be re-used, check it for glycol/water mix of 50/50.

4. Place a large top funnel in the radiator fill hole.

5. Slowly pour in the coolant. The filling may be slowed because of the thermostat being closed.

6. After the cooling system is filled to 1/2 inch below the fill hole, start the engine and let the cooling system warm up. When the thermostat opens, the coolant level may drop. If the level drops, add coolant until the level is up to the fill hole.

7. Replace the radiator cap.

8. Check the coolant level in the recovery tank. Add coolant if needed.

Flushing the Cooling System

Various methods and equipment can be used to flush the cooling system. If special equipment such as a back flusher is used, follow the equipment manufacturer's instructions.

NOTICE

If the engine is damaged Internally and a new engine assembly is installed in the vehicle, make sure all foreign material is completely flushed out of the cooling system. The oil cooler system should also be flushed out (if equipped). Failure to rid the oil or cooling system of debris can result in damage to the replacement engine.

IMPORTANT: Remove the thermostat before flushing the cooling system.

Radiator Service

Radiator Internal Deposits

A radiator with a dirty, obstructed, or leaking core will cause the engine to overheat. A scale deposit inside the radiator is a result of using hard, high mineral content water in the cooling system. The effect of heat on the minerals in the water causes the formation of scale, or hard coating, on metal surfaces within the radiator, thereby reducing the transfer of heat. Some hard water will produce a silt-like deposit which restricts the flow of water. Replace a radiator that is plugged or has a heavy scale on the core.

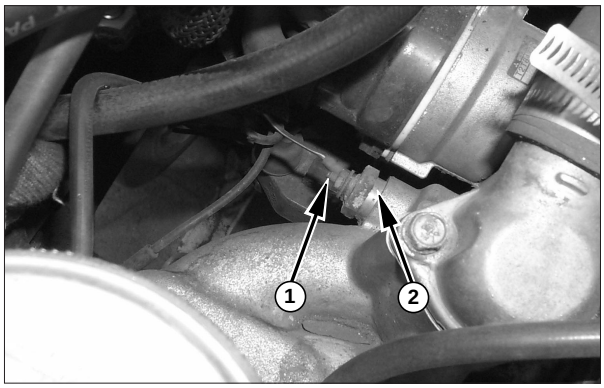
Scale Removal

To remove the hardened scale, a direct chemical action is necessary. A flushing compound at the specified rate of 30 grams per liter (4 oz. per gallon) of radiator capacity should be added to the coolant solution in the form of a dissolved solution while the engine is running. Operate the engine for 15 minutes or until it reaches normal operating temper-ature, then drain and flush the system with clean water.

There are various types of flushing compounds commercially available, but they should be obtained from a reliable source. Most compounds attack metals and should not remain in the engine for more than a few minutes. A neutralizer should be used in the cooling system immediately after a descaling solvent is used. For extremely hard, stubborn coatings, such as lime scale, use a stronger solution. The corrosive action of a stronger solution will affect the thin metals of the radiator, thereby reducing its operating life. A complete flushing and rinsing is mandatory and must be accomplished skillfully.

After the solvent and neutralizer have been used and the cooling system is flushed, drain the entire system and fill it with clean, soft water plus a high boiling type antifreeze that meets GM 6038-M spec-ifications. After filling the cooling system, check for radiator, hose, and engine coolant leaks.

Remove & Install Water Temperature Sender



1. Disconnect one wire connection (1).

2. Remove water temperature sender (2).

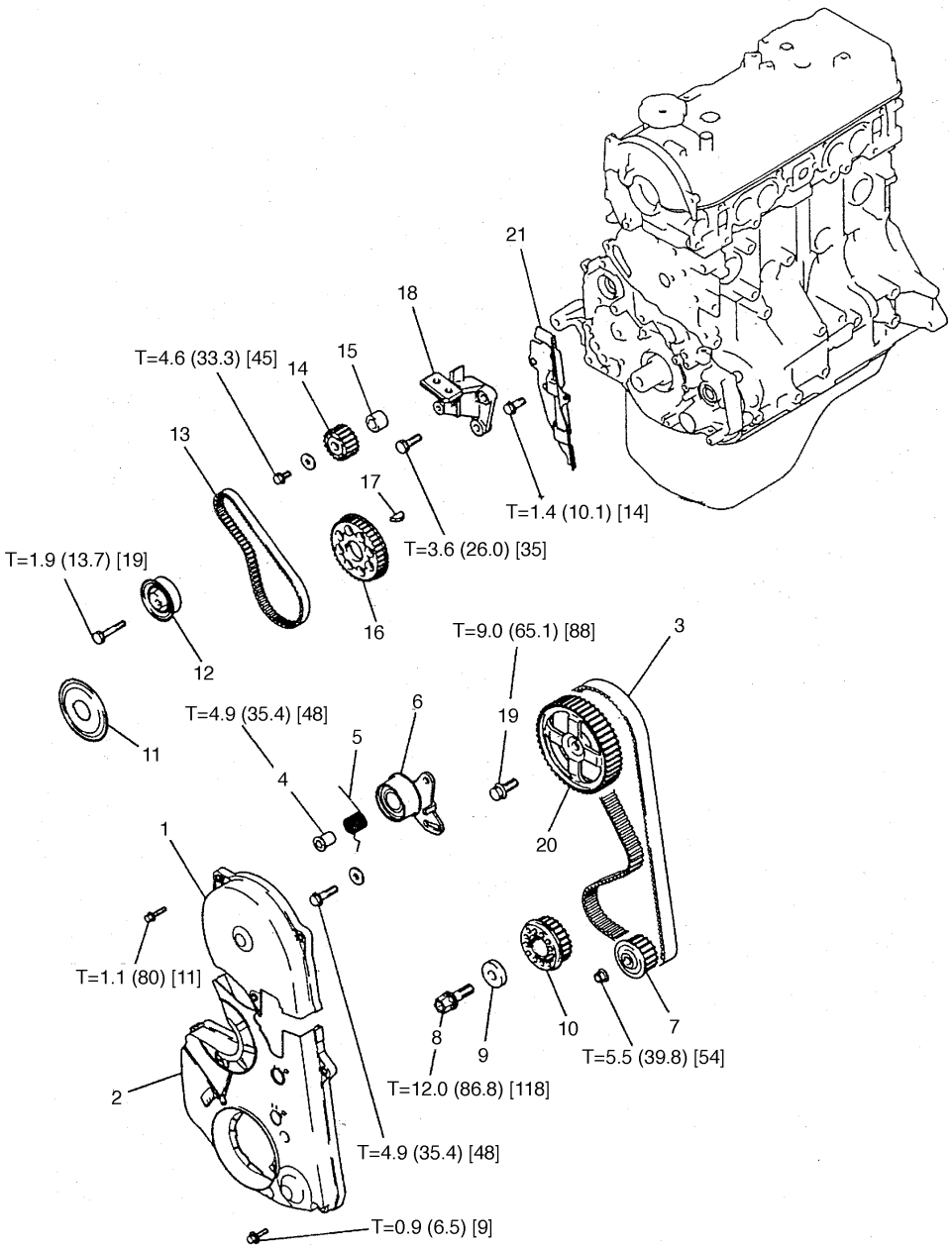
NOTE: For the installation of the water temperature sender, reverse the removal steps.

3. Use thread sealant on the water temperature sender threads.

BASE ENGINE SERVICE PROCEDURE

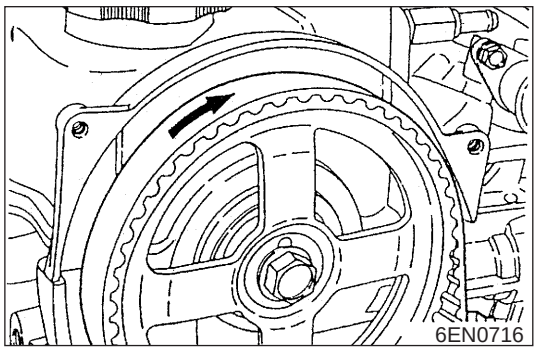
Timing Belt

Removal and Installation



Removal steps

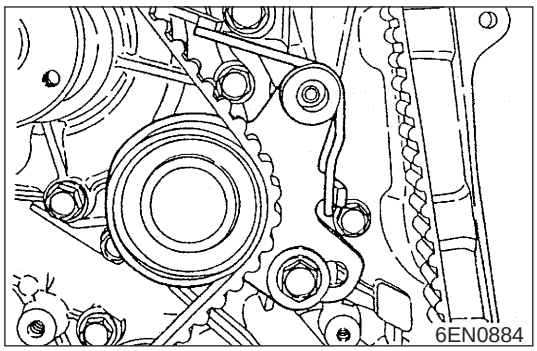
		1.	Timing belt front cover upper
		2.	Timing belt front cover lower
←A→	→H←	3.	Timing belt
	→G←	4.	Tensioner spacer
	→G←	5.	Tensioner spring
	→G←	6.	Tensioner pulley
←B→	→F←	7.	Oil pump sprocket
←C→	→E←	8.	Crankshaft bolt
		9.	Crankshaft washer
←D→		10.	Crankshaft sprocket
		11.	Flang
		12.	Tensioner B
←E→	→D←	13.	Timing belt B
←F→	→C←	14.	Counterbalance shaft sprocket
		15.	Spacer
←G→		16.	Crankshaft sprocket B
		17.	Crankshaft key
	→B←	18.	Engine support bracket
		19.	Camshaft sprocket bolt
←H→	→A←	20.	Camshaft sprocket
		21.	Timing belt rear cover

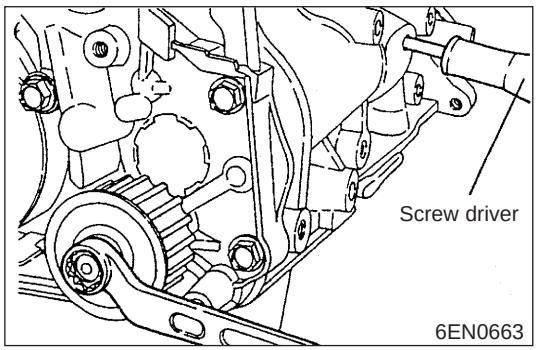


Removal Service Points

⟵ A ⟶ Timing belt removal

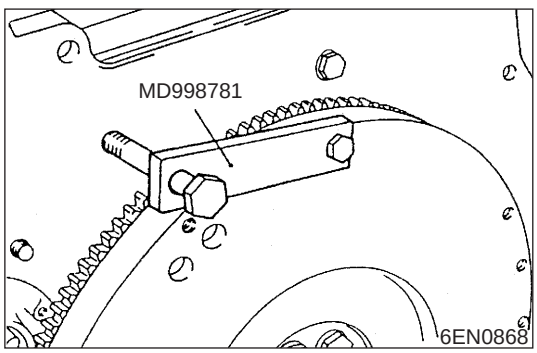
(1) When the timing belt is to be re-used, make an arrow mark on the back surface on the belt to indicate the rotating direction with a chalk or the like so that the belt can be installed in the same direction.
(2) Move the timing belt tensioner upward and temporarily tighten the tensioner lock bolt.
(3) Remove the timing belt.





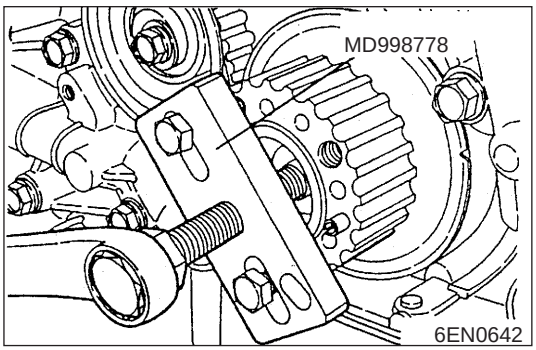
⟵ B ⟶ Oil pump sprocket removal

(1) Remove the plug on the left side of cylinder block.
(2) Insert a screwdriver (shank diameter 8 mm[0.31 in.]) to block the counterbalance shaft.
(3) Remove the nut.
(4) Remove the oil pump sprocket.



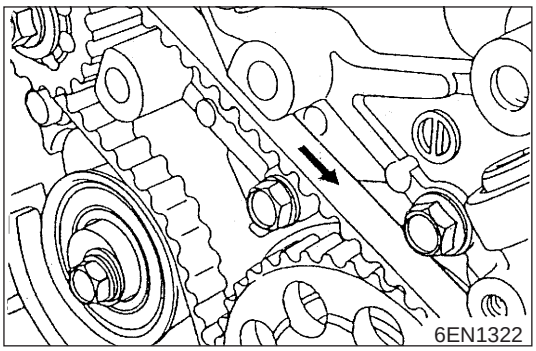
⟵ C ⟶ Crankshaft bolt removal

(1) Hold the flywheel with the special tool as shown.
(2) Remove the crankshaft bolt.



⟵ D ⟶ Crankshaft sprocket removal

(1) If it is difficult to remove the sprocket, use the special tool.

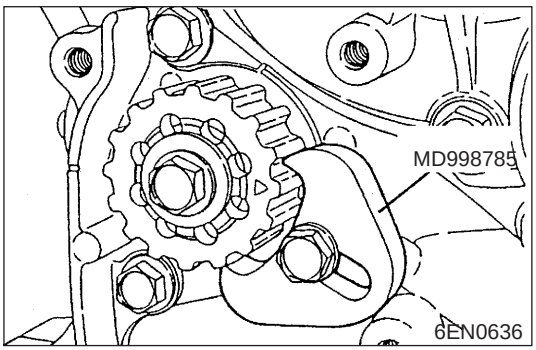


⟵ E ⟶ Timing belt "B" removal

(1) Make a mark on the back of the timing belt indicating the direction of rotation so it may be reassembled in the same direction if it is to be reused.

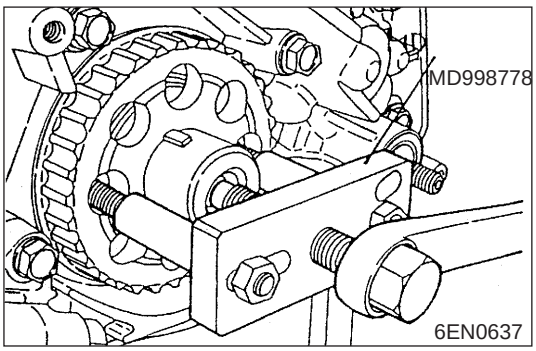
NOTE: Water or oil on the belt shortens its life drastically, so the removed timing belt, sprocket, and tensioner must be free from oil and water. These parts should not be washed. Replace part if seriously contaminated.

(2) If there is oil or water on each part check front case oil seals, camshaft oil seal and water pump for leaks.



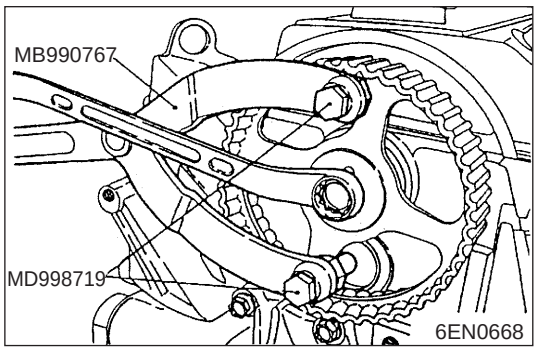
⟵ F ⟶ Counterbalance shaft sprocket removal

(1) Set the special tool as shown to prevent the counterbalance shaft sprocket from turning together.
(2) Loosen the bolt and remove the sprocket.



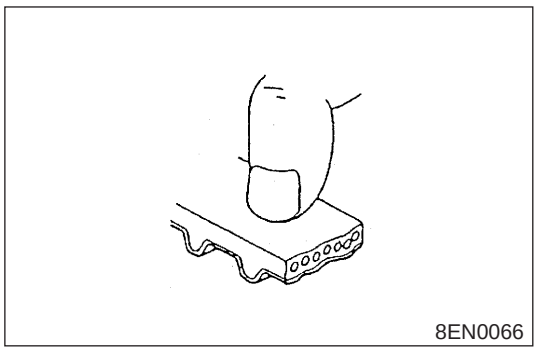
⟵ G ⟶ Crankshaft sprocket "B" removal

(1) If it is difficult to remove the sprocket, use the special tool.



⟵ H ⟶ Crankshaft sprocket removal

(1) Using the special tool show in the illustration, lock the camshaft sprocket in position.
(2) Loosen the camshaft sprocket bolt.



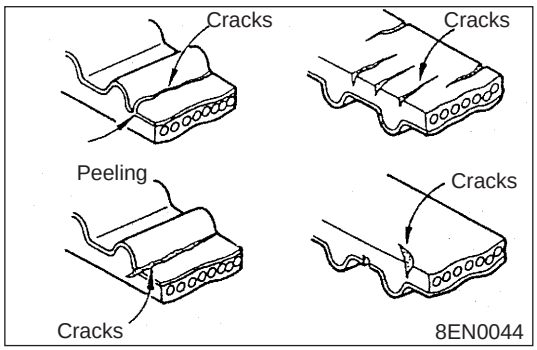
Inspection

1. Timing Belt

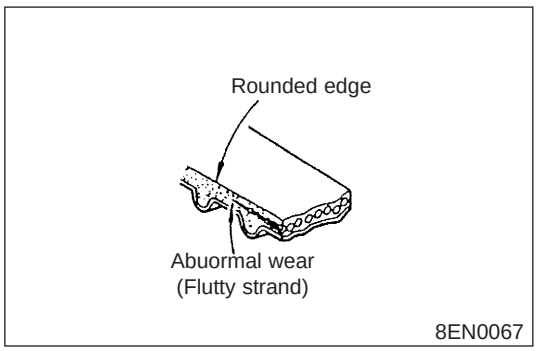
Replace belt if any of the following conditions exist.

(1) Hardening of back rubber.

Back side is glossy without resilience and leaves no indent when pressed with fingernail.

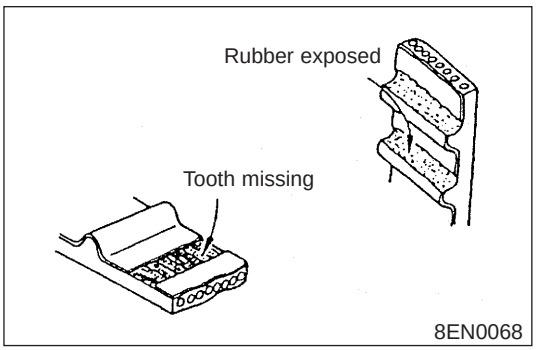


(2) Cracks on rubber back.
(3) Cracks or peeling of canvas.
(4) Cracks on tooth bottom.
(5) Cracks on belt sides.

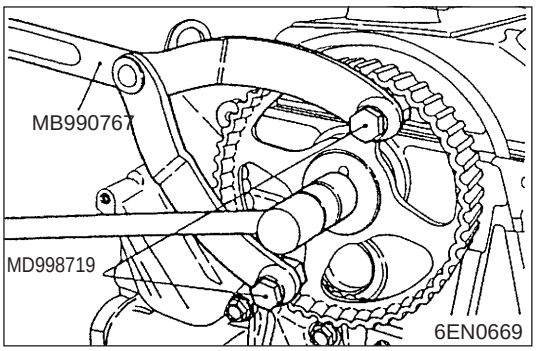


(6) Abnormal wear of belt sides.

NOTE: The sides are normal if they are sharp as if cut by a knife.



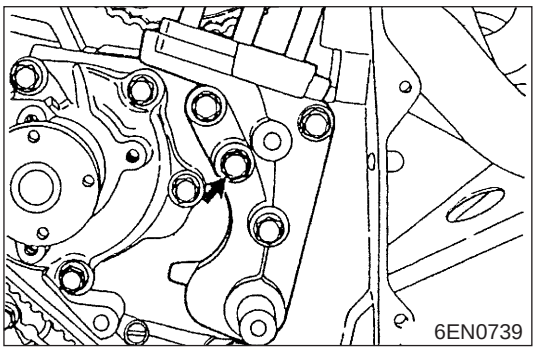
(7) Abnormal wear on teeth
  Earlier stage:
    Canvas worn (canvas fibers napped, rubber lost, discolored whitish, and unclear canvas texture)
  Latter stage:
    Canvas lost, rubber exposed (tooth width thinner)
(8) Missing tooth



Installation Service Points

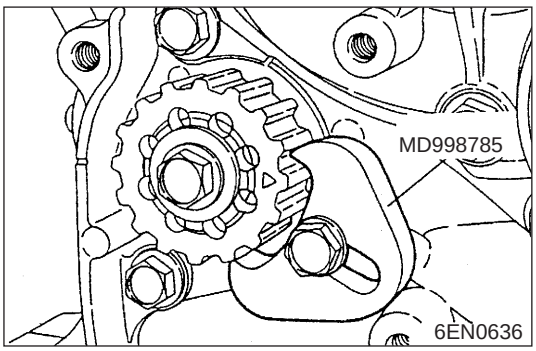
⟶ A ⟵ Camshaft sprocket installation

(1) Using the special tools show in the illustration, lock the camshaft sprocket in position.
(2) Tighten the camshaft sprocket bolt to the specified torque.



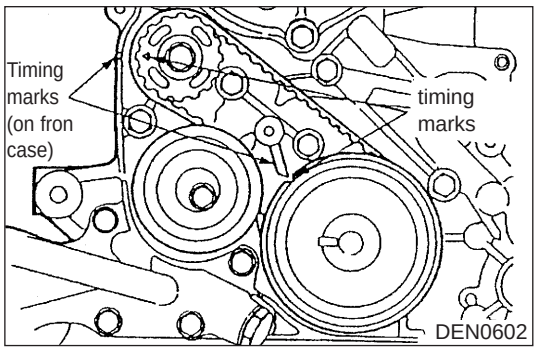
⟶ B ⟵ Engine support bracket installation

(1) Coat the bolts illustrated with sealant before tightening. Specified sealant: 3M™ AAD Part No. 8762 or equivalent



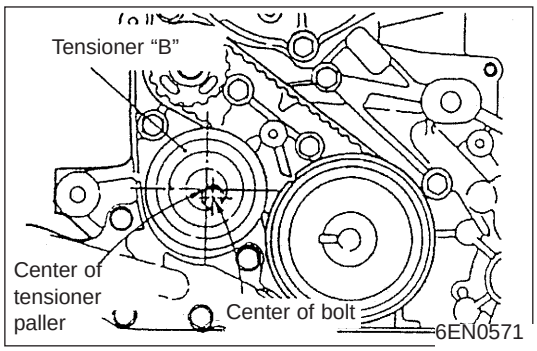
⟶ C ⟵ Counterbalance shaft sprocket installation

(1) Install the counterbalance shaft sprocket and screw the bolt.
(2) Install special tool as shown in the illustration to lock the counterbalance shaft.
(3) Tighten the bolt, and then remove the special tool.

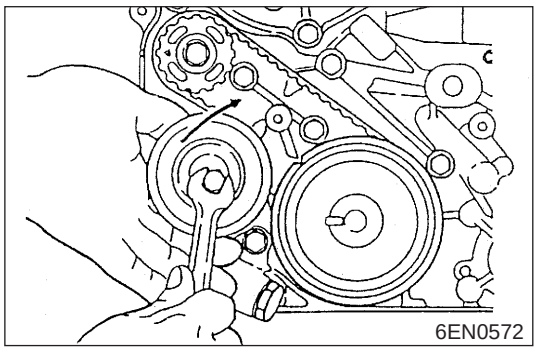


⟶ D ⟵ Timing belt “B” installation

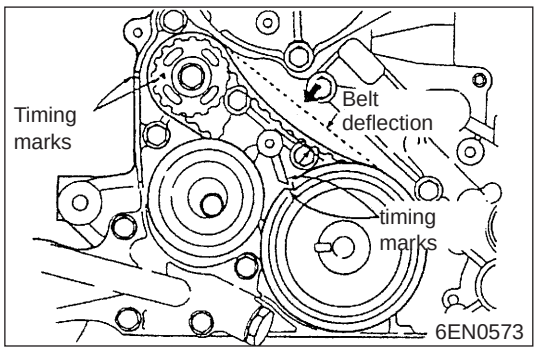
(1) Align timing mark on the crankshaft sprocket “B” and counterbalance shaft sprocket with the marks on the front case respectively.
(2) Install the timing belt “B” on the crankshaft sprocket “B” and counterbalance shaft sprocket. There should be no slack on the tension side.



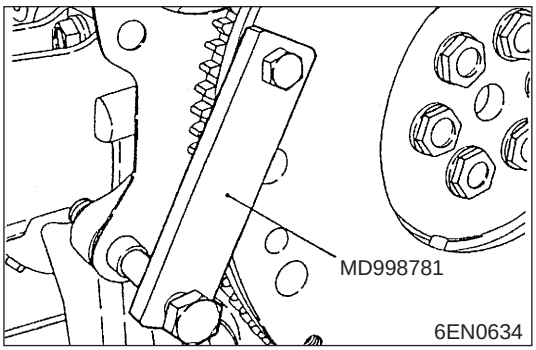
(3) Make sure that the relationship between the tensioner pulley center and the bolt center is as shown in the illustration.



(4) Move the tensioner “B” in the direction of arrow while lifting with a finger to give a sufficient tension to the tension side of timing belt. In this condition, tighten bolt to secure tensioner “B”. When the bolt is tightened, use care to prevent shaft from turning together. If shaft is turned together, belt will be over tensioned.

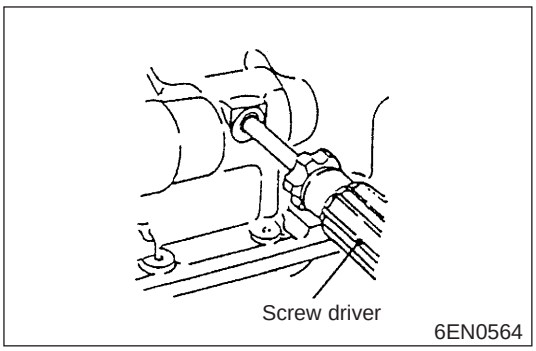


(5) Check to ensure that timing marks on sprockets and front case are in alignment.
(6) Press with index finger the center of span on the tension side of timing belt “B”. The belt must deflect 5 to 7 mm. [0.196 to 0.276 in].



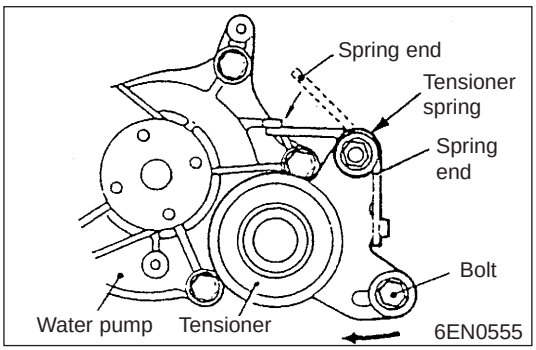
⟶ E ⟵ Crankshaft bolt installation

(1) Using the special tool, hold the flywheel.
(2) Install the crankshaft pulley in position.



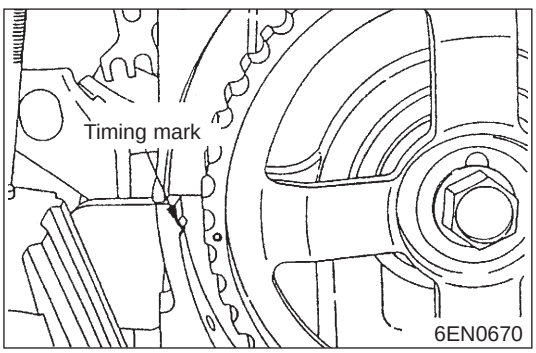
⟶ F ⟵ Oil pump sprocket installation

(1) Insert a phillips screwdriver (shank diameter 8 mm[0.31 in.] shaft) through the plug hole on the left side of the cylinder block to the left counterbalance shaft.
(2) Install the oil pump sprocket.
(3) Apply a proper amount of engine oil to the bearing surfaces of the nuts.
(4) Tighten the nuts to the specified torque.



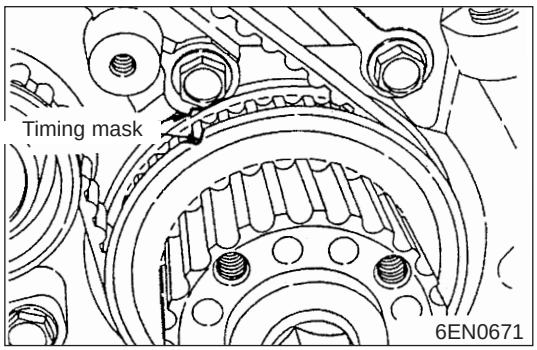
⟶ G ⟵ Crankshaft bolt installation

(1) Hook the tensioner spring end to the water pump body projection and tensioner bracket.
(2) Move the tensioner fully toward the water pump and tighten the bolt and tensioner spacer.

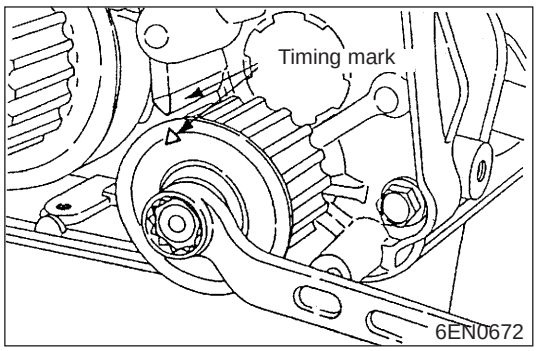


⟶ H ⟵ Timing belt installation

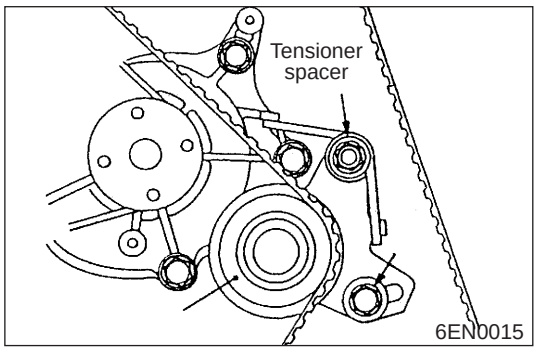
(1) Align the timing mark on the camshaft sprocket with that on the cylinder head.



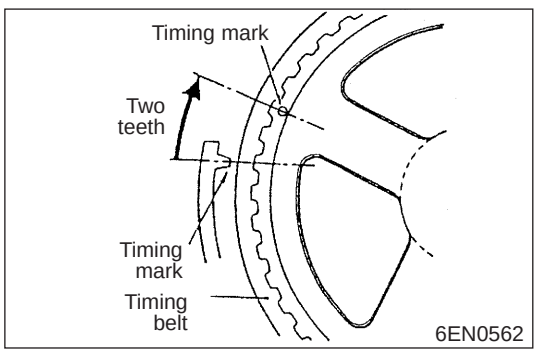
(2) Align the timing mark on the crankshaft sprocket with that on the front case.

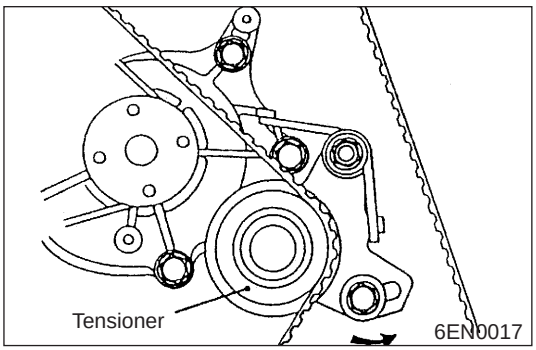


(3) Align the timing mark on the oil pump sprocket with its mating mark.

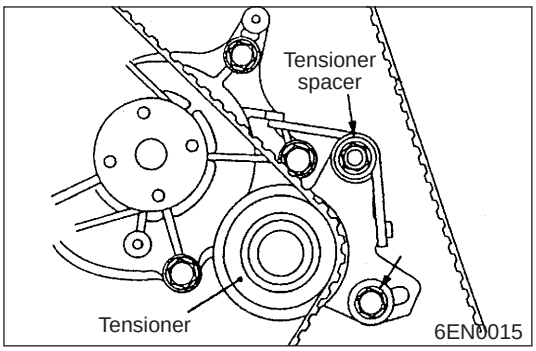


(4) Install the timing belt on the crankshaft sprocket, oil pump sprocket and camshaft sprocket in that order. There should be no slack on the tension side.
(5) Apply a reverse direction (counterclockwise) force to the camshaft sprocket to make the tension side of the belt “tight”. In that state, recheck that all the timing marks are in alignment.
(6) Loosen a turn or two the tensioner bolt and nut that were temporarily tightened to hold the tensioner on the water pump side. This gives tension to the belt by the action of the tensioner spring.
(7) Rotate the crankshaft by the amount equivalent to two camshaft sprocket teeth in the forward (clockwise) direction. Since this step is intended for giving the timing belt proper tension, do not attempt rotate the crankshaft in the reverse (counterclockwise) direction or press the belt to check the tension.



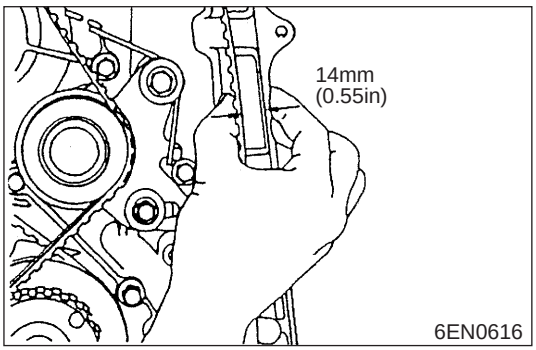


(8) Apply force to the tensioner in the direction shown by arrow to make the belt engage completely with each sprocket.



(9) Tighten the tensioner attaching bolt to the specified torque.
(10) Tighten the tensioner spacer to the specified torque.

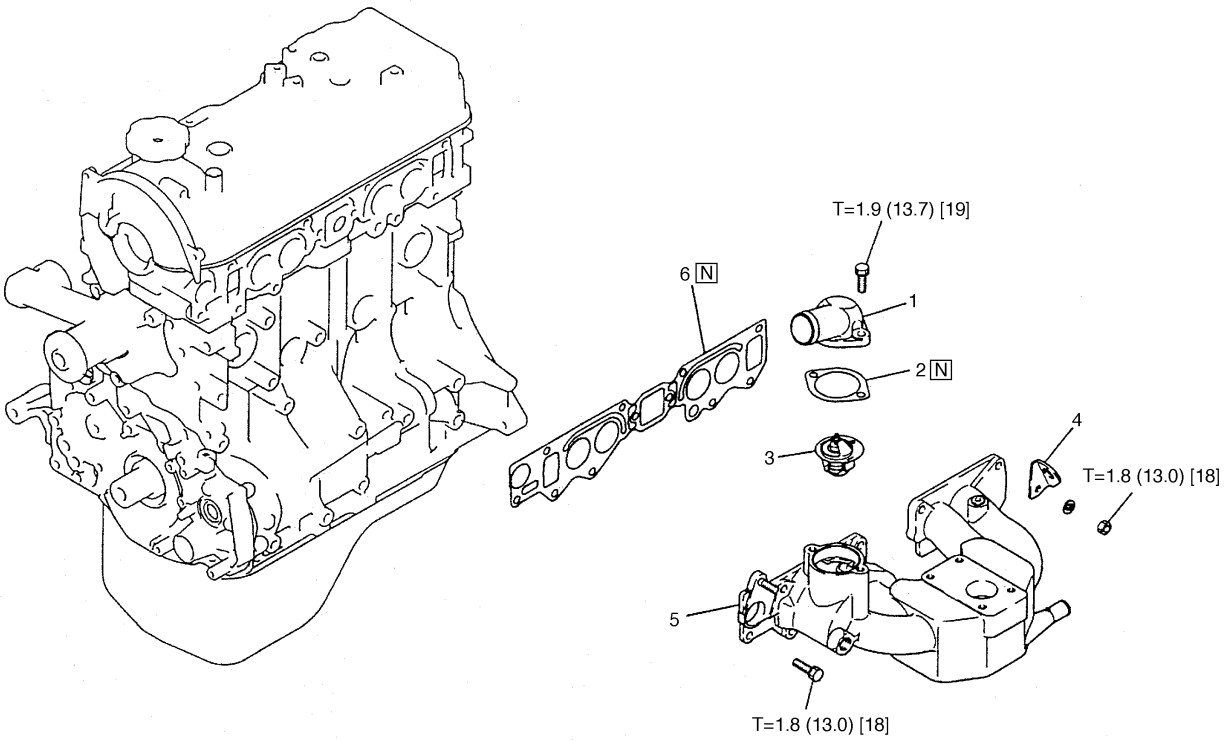
NOTE: If the nut is tightened first, the tensioner may also turn together with the nut and loose tension of the belt may result. Always tighten the bolt (at the bottom of the tensioner) first and then tighten the nut (at the top of the tensioner).



(11) Hold the center of the tension side span of the timing belt (between the camshaft and oil pump sprockets) between your thumb and index finger as shown. Then, make sure that the clearance between the belt back surface and cover meets the standard value.
Standard value: 14 mm (0.55 in.)

Intake Manifold

Removal and Installation



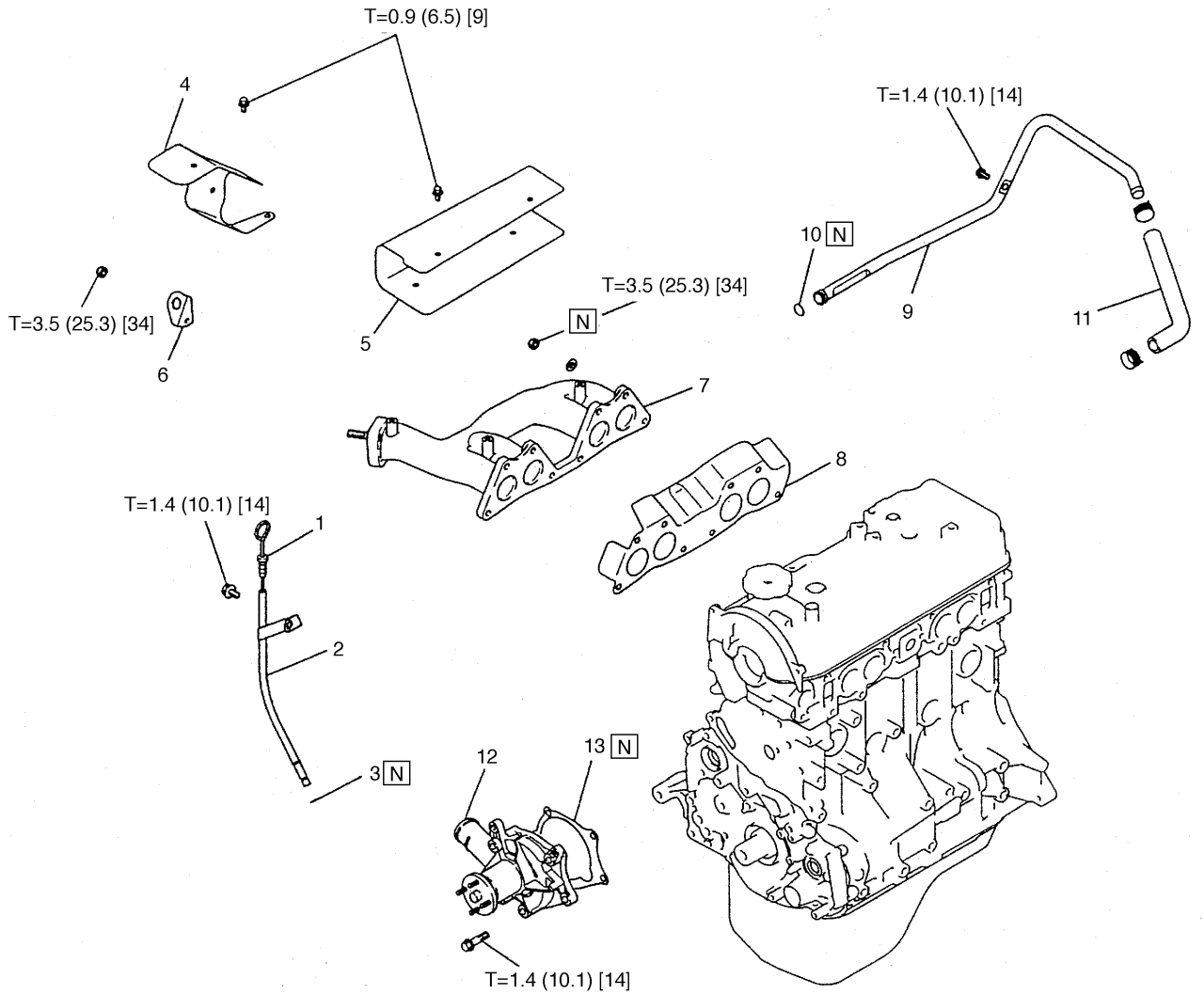
6EN1894

Removal steps
1. Water outlet
2. Gasket
3. Thermostat
4. Engine hanger
5. Intake manifold
6. Gasket

Exhaust Manifold and Water Pump

Gasoline/LPG Engine

Removal and Installation



6EN1895

Removal steps
1. Oil level gauge
2. Oil level gauge guide
3. O-ring
4. Heat protector A
5. Heat protector B
6. Engine hanger
7. Exhaust manifold
8. Gasket
→A← 9. Water inlet pipe
→A← 10.O-ring
11. Water hose
12. Water pump
13. Gasket

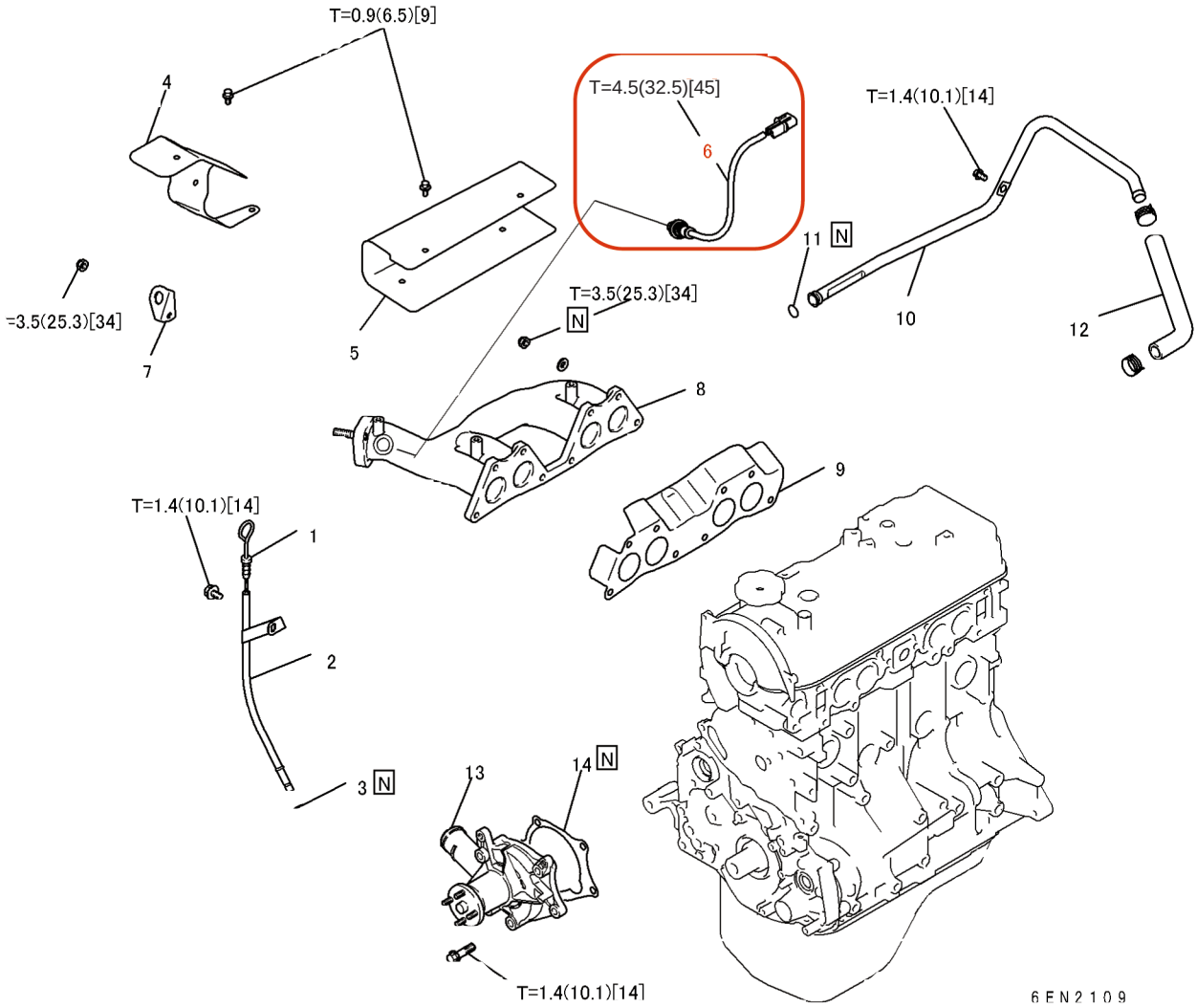
⟶ A ⟵ O-ring and water pipe installation

Replace the water inlet pipe O-ring with a new one.
Apply water to the outer circumference of the O-ring for easier insertion into the water pump and thermostat housing.

Caution:
1) Never apply engine oil or any other oil or grease to the O-ring.
2) Fasten the water pipe after the thermostat housing has been installed.

LPG Engine (Low Emission Version)

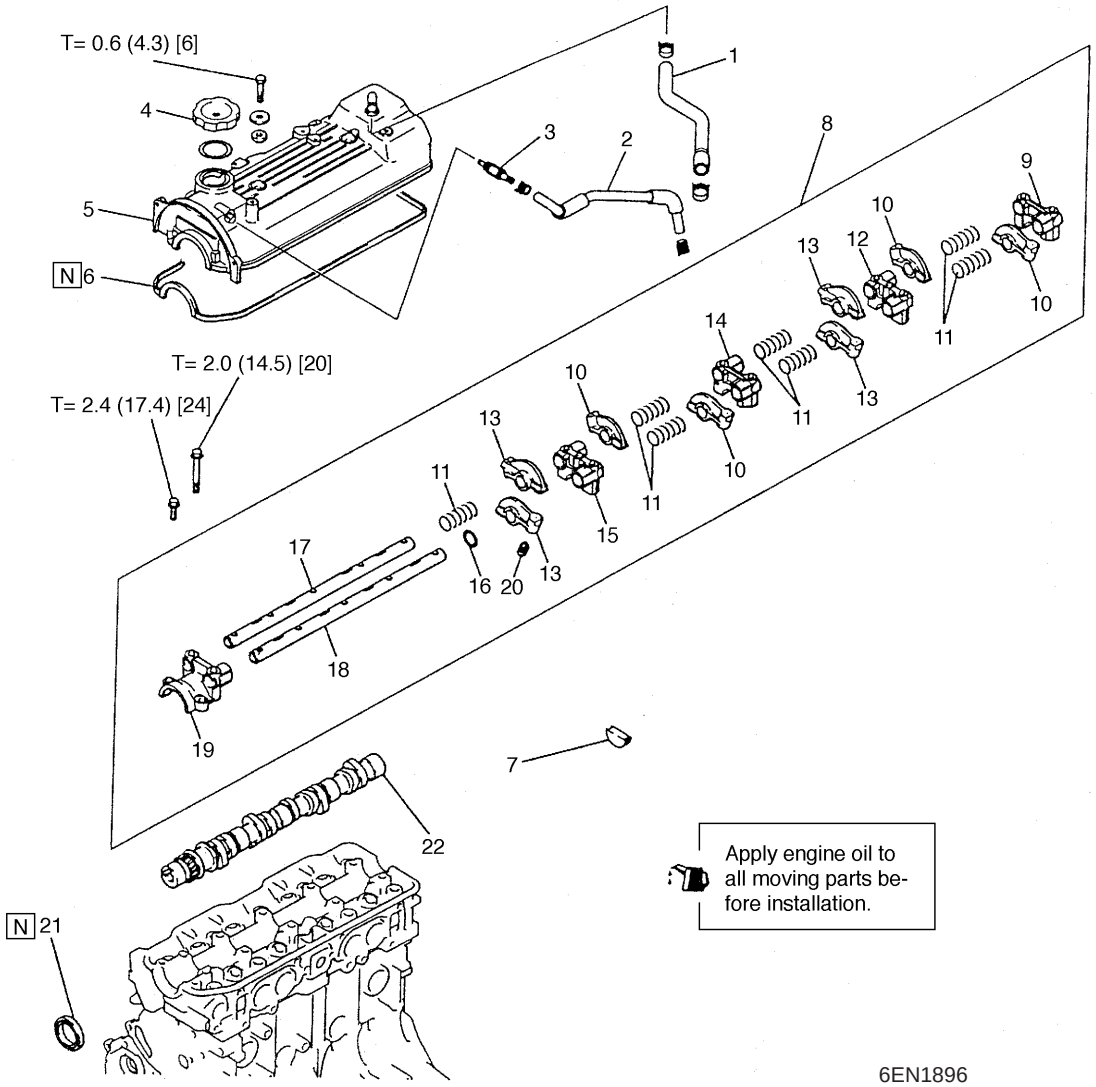
Removal and Installation



Removal steps
1. Oil level gauge
2. Oil level gauge guide
3. O-ring
4. Heat protector A
5. Heat protector B
6. Oxygen sensor
7. Engine hanger
8. Exhaust manifold
9. Gasket
→A← 10. Water inlet pipe
→A← 11.O-ring
12. Water hose
13. Water pump
14. Gasket

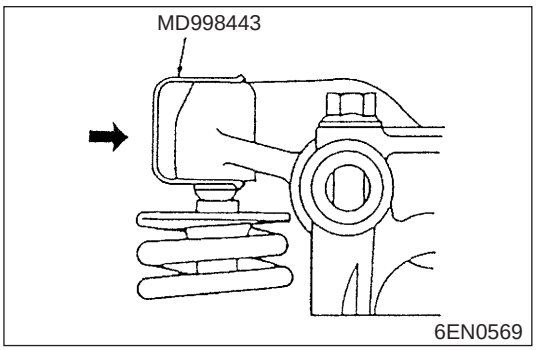
Rocker Arms And Camshaft

Removal and Installation



Removal steps

1. Breather hose
2. P.C.V. hose
3. P.C.V. valve
4. Oil filler cap
5. Rocker cover
6. Gasket
→G← 7. Semi-circular packing
←A→ 8. Rocker arms and rocker shafts
9. Rear bearing cap
10. Rear arm D
11. Spring
→D← 12. Bearing cap No. 4
13. Rocker arm C
→D← 14. Bearing cap No. 3
→D← 15. Bearing cap No. 2
→C← 16. Wave washer
→B← 17. Right rocker shaft
→B← 18. Left rocker shaft
19. Front bearing cap
→E← 20. Lash adjuster
→F← 21. Oil seal
→A← 22. Camshaft

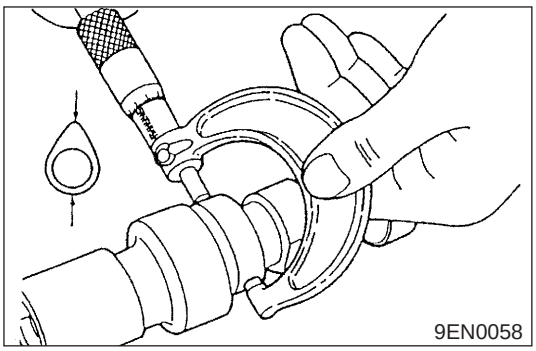


Removal Service Points

⟵ A ⟶ **Rocker arm and rocker shaft removal**

Caution:
If the lash adjuster is re-used, clean the lash adjuster.

(1) Fit the lash adjuster onto the rocker arm without allowing diesel fuel to spill out. Fit. Special tool MD998443 to prevent the lash adjuster coming free and falling to the floor.



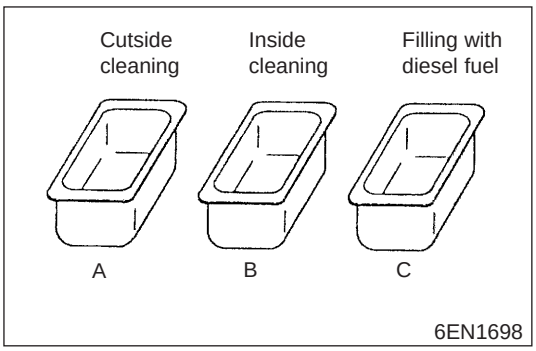
Inspection

1. Camshaft

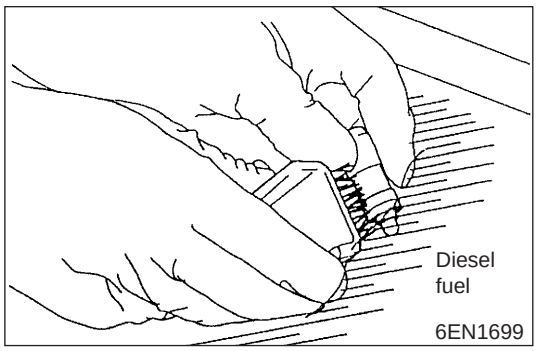
Measure the cam height and if the limit is exceeded, replace.
Standard value: 41.62 mm (1.6386 in.)
Limit: 41.12 mm (1.6189 in.)

2. Lash Adjuster

Caution:
•The lash adjusters are precision-engineered mechanisms. Do not allow them to become contaminated by dirt or other foreign substances.
•Do not attempt to disassemble the lash adjusters.
•Use only fresh diesel fuel to clean the lash adjusters

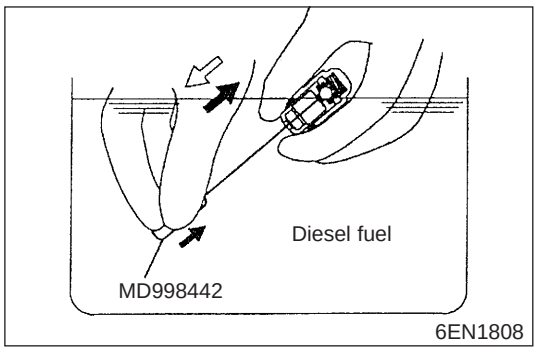


(1) Prepare three containers and approximately five liters of diesel fuel. Into each container, pour enough diesel fuel to completely cover a lash adjuster when it is standing upright. Then, perform the following steps with each lash adjuster.



(2) Place the lash adjuster in container A and clean its outside surface.

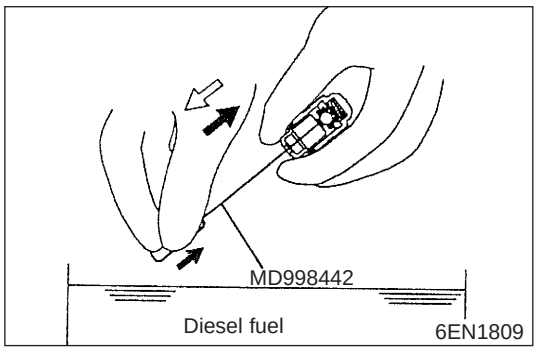
NOTE: Use a nylon brush if deposits are hard to remove.



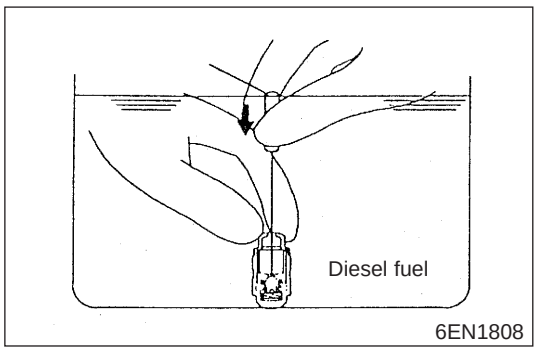
(3) While gently pushing down the internal steel ball using special tool MD998442, move the plunger through five to ten strokes until it slides smoothly. In addition to eliminating stiffness in the plunger, this operation will remove dirty oil.

Caution: The steel ball spring is extremely weak, so the lash adjuster's functionality may be lost if the air bleed wire is pushed in hard.

NOTE: If the plunger remains stiff or the mechanism appears otherwise abnormal, replace the lash adjuster.

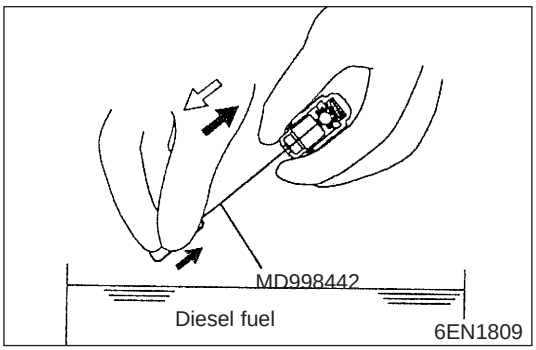


(4) Remove the lash adjuster from the container. Then, push down the steel ball gently and push the plunger to eliminate diesel fuel from the pressure chamber.

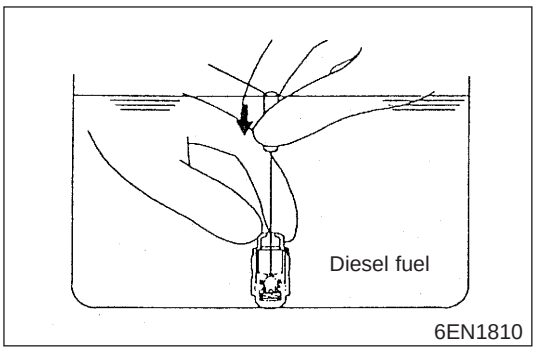


(5) Place the lash adjuster in container B. Then, gently push down the internal steel ball using special tool MD998442 and move the plunger through five to ten strokes until it slides smoothly. This operation will clean the lash adjuster's pressure chamber.

Caution: The steel ball spring is extremely weak, so the lash adjuster's functionality may be lost if the air bleed wire is pushed in hard.

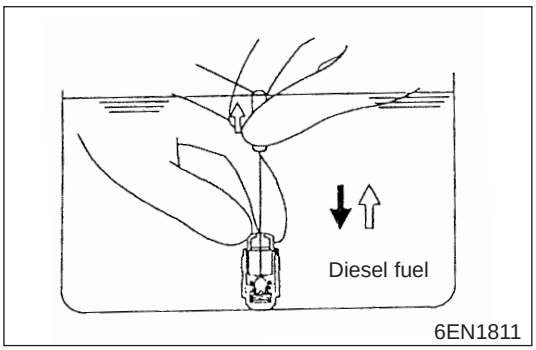


(6) Remove the lash adjuster from the container. Then, push down the steel ball gently and push the plunger to eliminate diesel fuel from the pressure chamber.

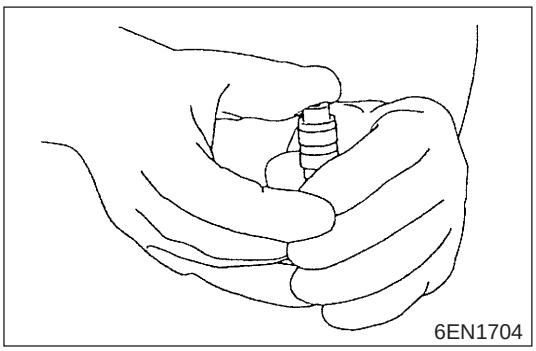


(7) Place the lash adjuster in container C. Then, gently push down the internal steel ball using special tool MD998442.

Caution: Do not use container C for cleaning. If cleaning is performed in container C, foreign matter could enter the pressure chamber when the chamber is filled with diesel fuel.



(8) Stand the lash adjuster with its plunger at the top, then push the plunger downward firmly until it moves through its greatest possible stroke. Return the plunger slowly, then release the steel ball and allow the pressure chamber to fill with diesel fuel.



(9) Remove the lash adjuster from the container, then stand the lash adjuster with its plunger at the top. Push the plunger firmly and check that it does not move.

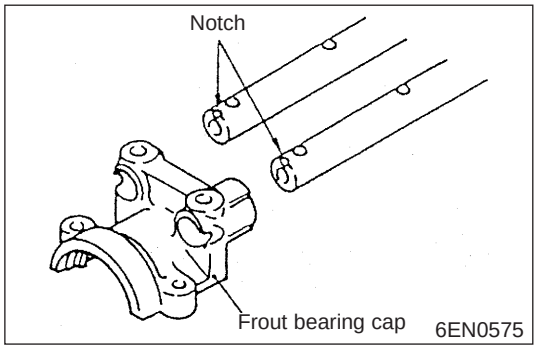
NOTE: If lash adjuster contracts, perform the operations (7) through (9) again to fill it with diesel fuel completely.
Replace the lash adjuster if it still contracts after performing these steps.

(10) Stand the lash adjuster upright to prevent diesel fuel spilling out. Do not allow the lash adjuster to become contaminated by dirt or other foreign matter. Fit the lash adjuster onto the engine as soon as possible.

Installation Service Points

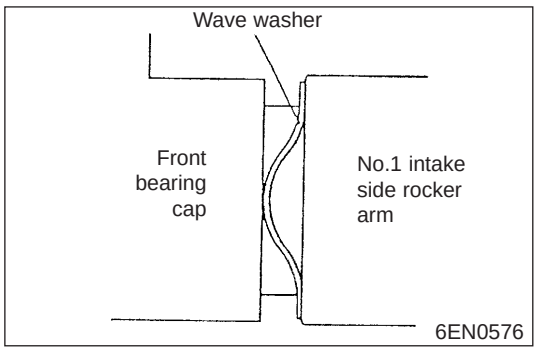
⟶ A ⟵ Camshaft installation

Apply engine oil to the journals and cams of the camshafts. Install the camshaft on the cylinder head.



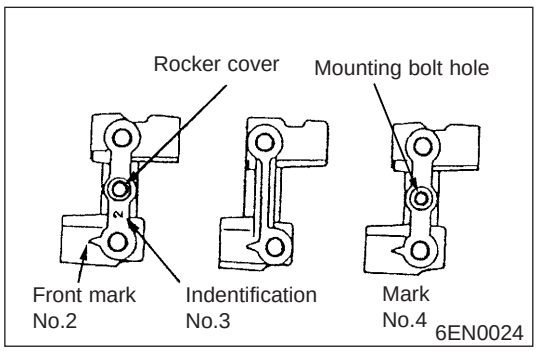
⟶ B ⟵ Rocker shaft installation

Insert the rocker shafts into the front bearing cap so that the notches on the shafts face up, and insert the installation bolts without tightening them.



⟶ C ⟵ Wave washer installation

Install the wave washer in correct direction as shown.

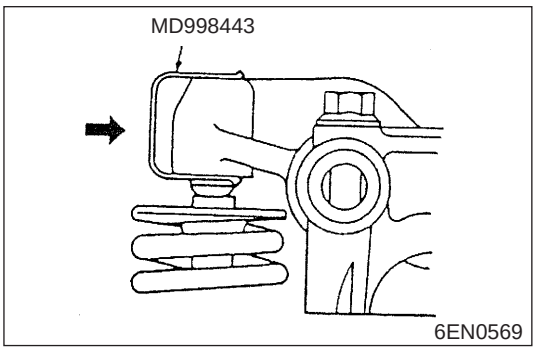


⟶ D ⟵ Bearing cap

(1) No.3 bearing cap looks very similar to No.2 and No.4 bearing caps.

NOTE: No.2 bearing cap is the same as No.4 bearing cap.

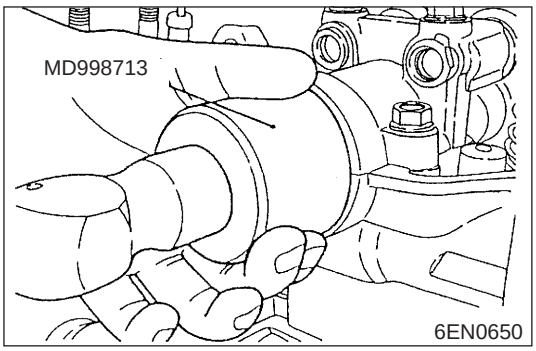
(2) Install the bearing caps with their front marks pointing to the camshaft sprocket side.



⟶ E ⟵ Lash adjuster installation

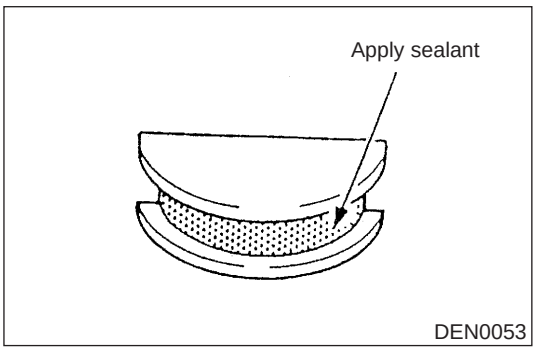
Caution: If the lash adjuster is re-used, clean the lash adjuster.

(1) Set special tool MD998443 to prevent the lash adjuster coming free and falling to the floor.



⟶ F ⟵ Camshaft oil seal installation

(1) Apply engine oil to the lip area of the oil seal and the camshaft front end outer diameter.
(2) Using special tool, install the camshaft oil seal.

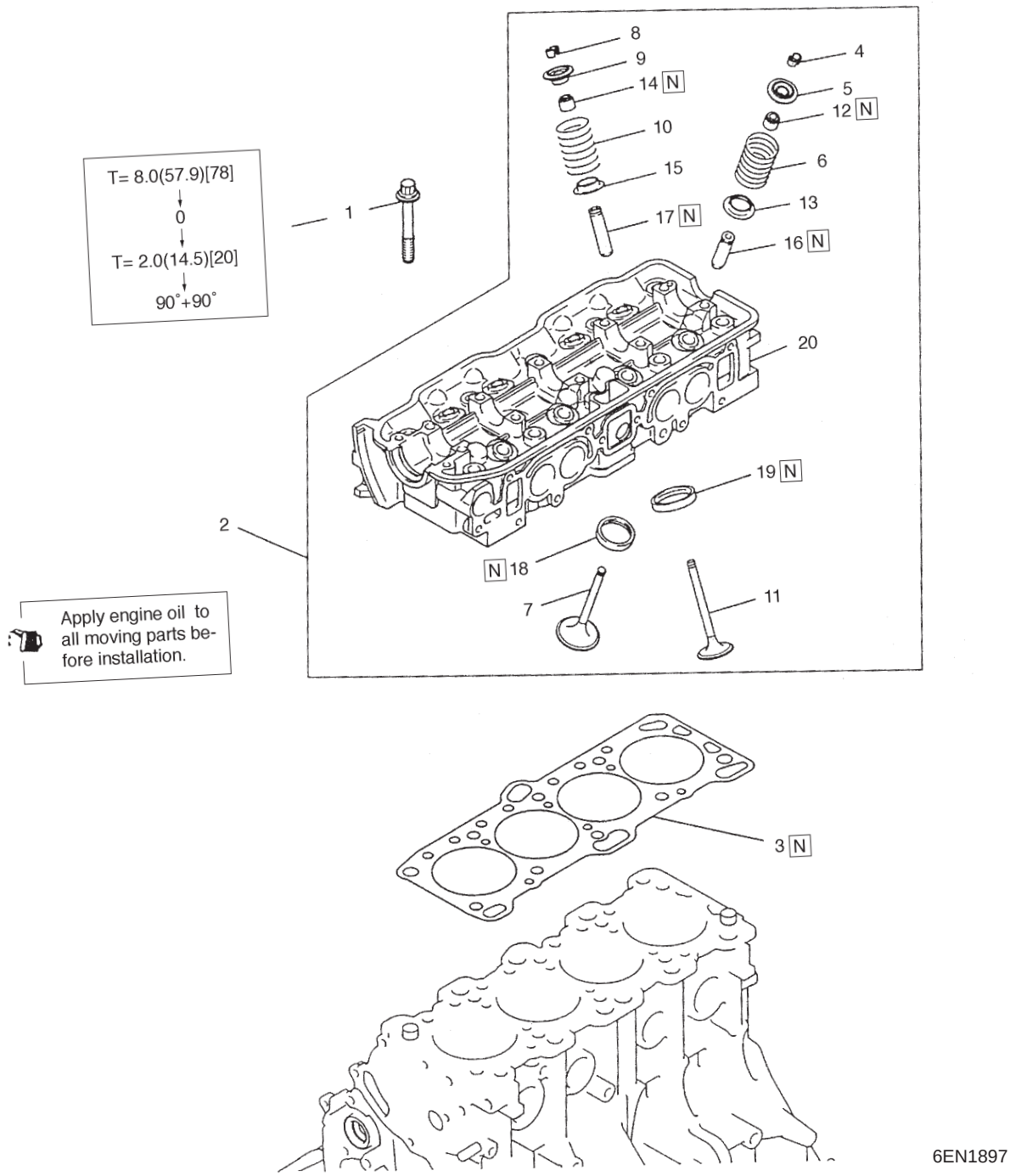


⟶ G ⟵ Semi-circular packing installation

(1) Apply sealant to the location shown in the illustration. Specified sealant: 3M™ AAD Part No. 8672 or equivalent.

Cylinder Head And Valves

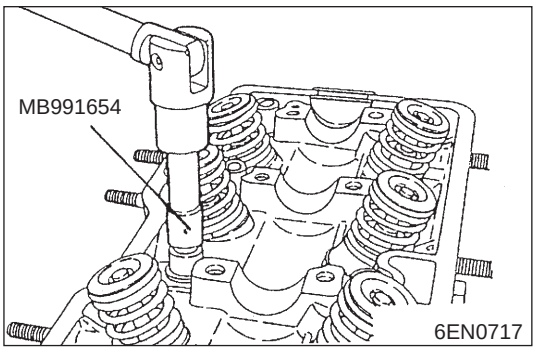
Removal and Installation



6EN1897

Removal steps

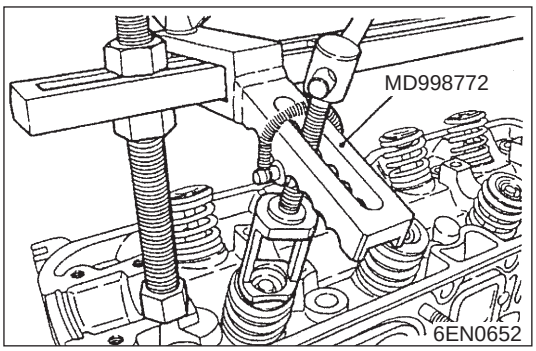
←A→	→D←	1. Cylinder head bolt
		2. Cylinder head assembly
		3. Cylinder head gasket
←B→	→C←	4. Retainer lock
		5. Valve spring retainer
	→B←	6. Valve spring
		7. Intake valve
←B→	→C←	8. Retainer lock
		9. Valve spring retainer
	→B←	10. Valve spring
		11. Exhaust valve
←C→	→A←	12. Valve stem seal
		13. Valve spring seat
←C→	→A←	14. Valve stem seal
		15. Valve spring seat
		16. Intake valve guide
		17. Exhaust valve guide
		18. Intake valve seat
		19. Exhaust valve seat
		20. Cylinder head



Removal Service Points

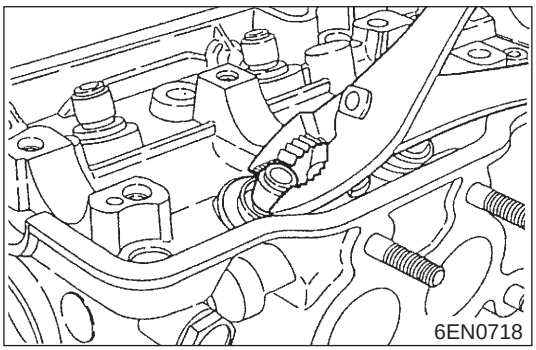
⟵ A ⟶ Cylinder head bolt removal

Using special tool, loosen the cylinder head bolts.
Loosen each bolt evenly, little by little, by two or three steps.



⟵ B ⟶ Retainer lock removal

Store removed valves, springs and other parts, tagged to indicate their cylinder No. and location for reassembly.



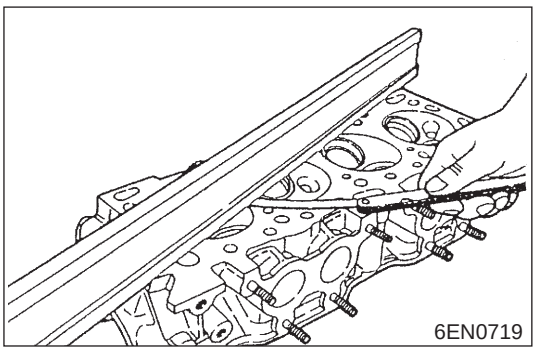
⟵ C ⟶ Valve stem seal removal

Caution: Do not reuse removed valve stem seal.

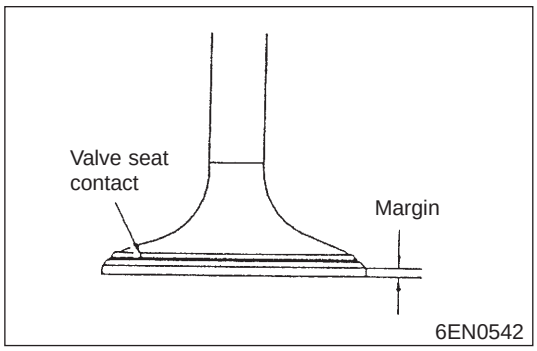
Inspection

1. Cylinder Head

(1) Check the cylinder head for water leaks, gas leaks, damage or cracks before cleaning.
(2) Thoroughly remove oil, water scale, sealant, carbon deposit, etc. After the oil passages have been cleaned, blow air to make sure that they are clean.
(3) Check the cylinder head gasket surface for flatness by using straightedge and thickness gauge.
If the service limit is exceeded, correct to meet the specification.
Standard valve: 0.03 mm (0.0012 in.) or less.
Limit: 0.2 mm (0.008 in.)
Grinding limit: 0.2 mm (0.008 in.)
Cylinder head height (when new): 89.9 to 90.1 mm (3.539 to 3.547 in.)



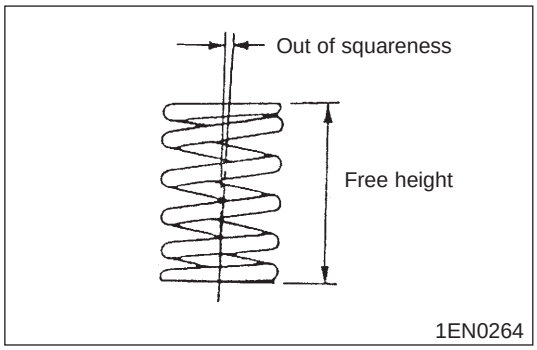
NOTE: Grinding the cylinder head is permitted as long as the total thickness of the metal removed from the cylinder head and the cylinder block does not exceed 0.2 mm (0.008 in.).



2. Valve

(1) Check the valve face for correct contact. If incorrect, reface. Valve seat contact should be maintained uniform at the center of valve face.
(2) If the margin exceeds the service limit, replace the valve:
Standard value:
Intake 1.2 mm (0.047 in.)
Exhaust 2.0 mm (0.079 in.)
Limit:
Intake 0.7 mm (0.028 in.)
Exhaust 1.5 mm (0.059 in.)
(3) Measure the valve's total length. If the measurement is less than specified, replace the valve.

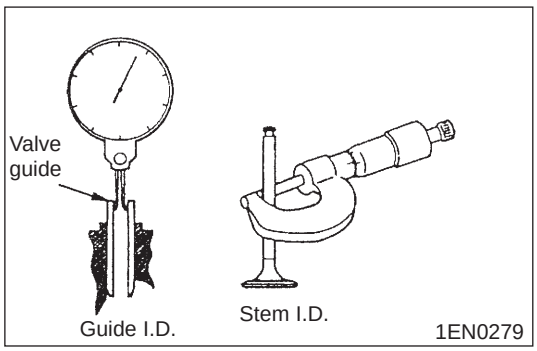
Standard value:
Intake 106.6 mm (4.197 in.)
Exhaust 105.2 mm (4.142 in.)
Limit:
Intake 106.1 mm (4.177 in.)
Exhaust 104.7 mm (4.122 in.)



3. Valve Spring

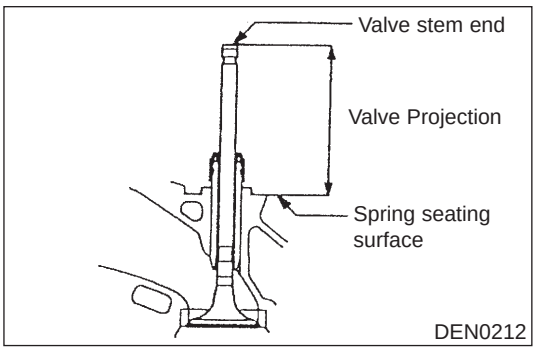
(1) Measure the free height of spring and, if it is smaller than the limit, replace.
Standard value: 48.0 mm (1.89 in.)
Limit: 47.0 mm (1.85 in.)

(2) Measure the squareness of the spring and, if the limit is exceeded, replace.
Standard value: 2 degrees or less
Limit: 4 degrees



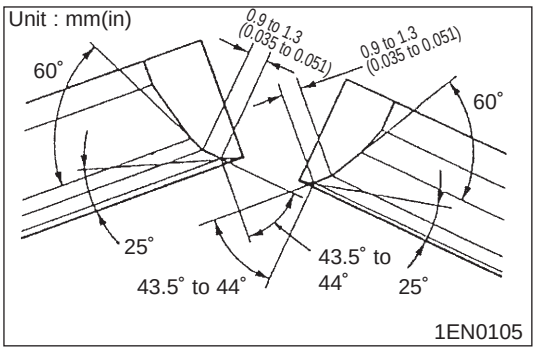
4. Valve Guide

Measure the clearance between the valve guide and valve stem. If the limit is exceeded, replace the valve guide or valve, or both.



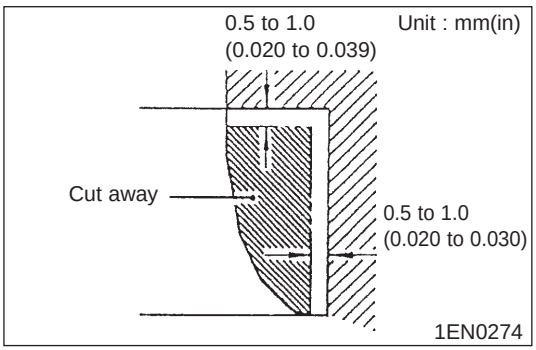
5. Valve Seats

(1) Assemble the valve, than measure the valve stem projection between the end of the valve stem and the spring seating surface. If the measurement exceeds the specified limit, replace the valve seat.
Standard value: 42.05 mm (1.6555 in.)
Limit: 42.55 mm (1.6752 in.)



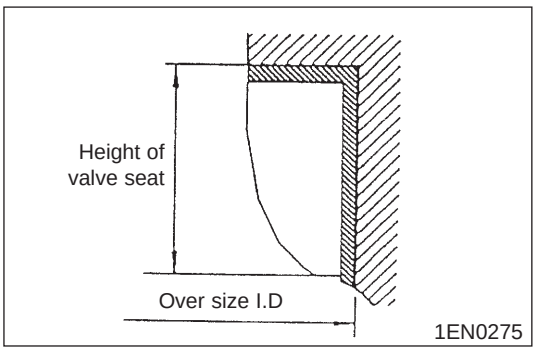
Valve Seat Reconditioning Procedure

(1) Before correcting the valve seat, check for clearance between the valve guide and valve and, if necessary, replace the valve guide.
(2) Correct to obtain the specified seat width and angle.
(3) After correction, valve and valve seat should be lapped with a lapping compound.



Valve Seat Replacement Procedure

(1) Cut the valve seat to be replaced from the inside to thin the wall thickness. Then, remove the valve seat.



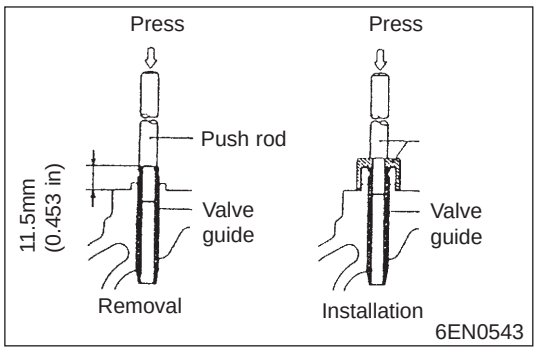
(2) Rebore the valve seat hole in the cylinder head to a selected oversize valve seat diameter.
(3) Before fitting the valve seat, cool the valve seat in liquid nitrogen, to prevent the cylinder head bore from galling.
(4) Using a valve seat cutter, correct the valve seat to the specified width and angle.
See “Valve Seat Reconditioning Procedure”.

Valve Guide Replacement Procedure

(1) Using a press, remove the valve guide toward the cylinder block side.
(2) Rebore the valve guide hole to the new oversize valve guide outside diameter.

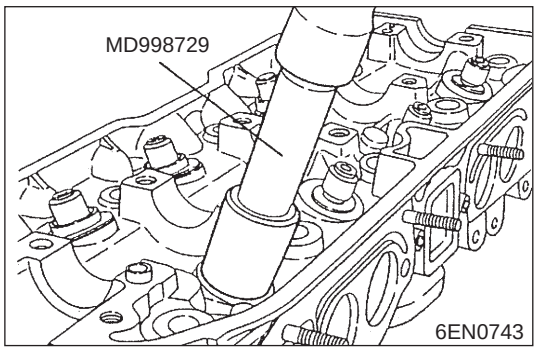
NOTE: Do not install a valve guide of the same size again.
Valve guide hole diameter.

0.05 O.S. 13.05 to 13.07 mm (0.5138 to 0.5146 in.)
0.25 O.S. 13.25 to 13.27 mm (0.5217 to 0.5224 in.)
0.50 O.S. 13.50 to 13.52 mm (0.5315 to 0.5323 in.)



(3) Press in the valve guide to the position shown in the illustration.
Standard value: 11.5 mm (0.453 in.)

NOTE:
1) Press-fit the valve guide, working from the cylinder head top surface.
2) Note that the intake and exhaust side valve guides are different in length.
3) After installing valve guides, insert new valves in them to check for sliding condition.

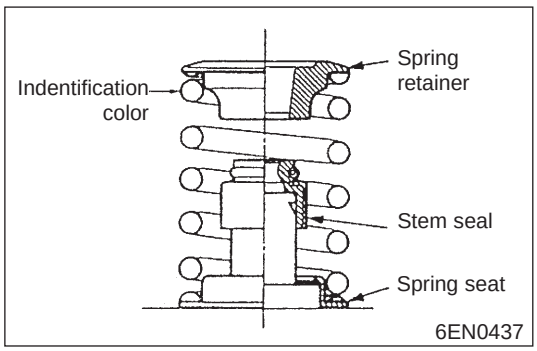


Installation Service Points

⟶ A ⟵ Valve stem seal installation

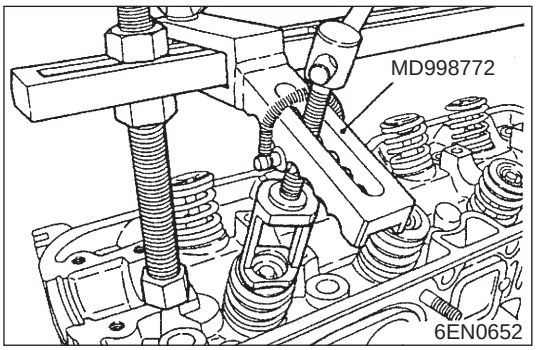
(1) Install the valve spring seat.
(2) Using special tool, install the new valve stem seat to the valve guide.

Caution:
1) Do not reuse removed valve stem seal.
2) The special tool must be used to install the valve stem seal. Improper installation could result in oil leaking past the valve guide.



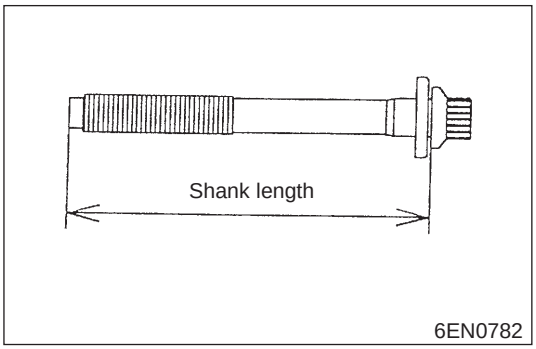
⟶ B ⟵ Valve spring installation

Direct the valve spring end with identification color toward the rocker arm.



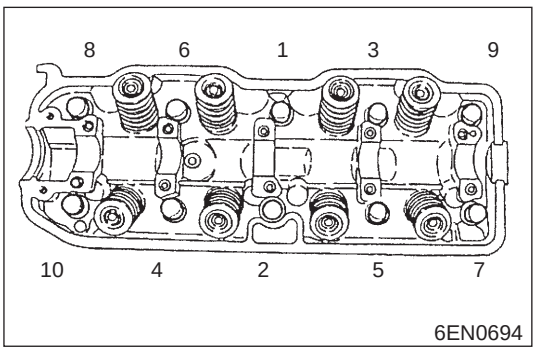
⟶ C ⟵ Retainer lock installation

The valve spring, if excessively compressed, causes the bottom end of the retainer to be in contact.



⟶ D ⟵ Cylinder head bolt installation

(1) When installing the cylinder head bolts, check that the shank length of each bolt meets the limit is exceeded, replace the bolt.
Standard value: 120.4 mm (4.740 in.)
(2) Apply engine oil to the bolt threads and washers.

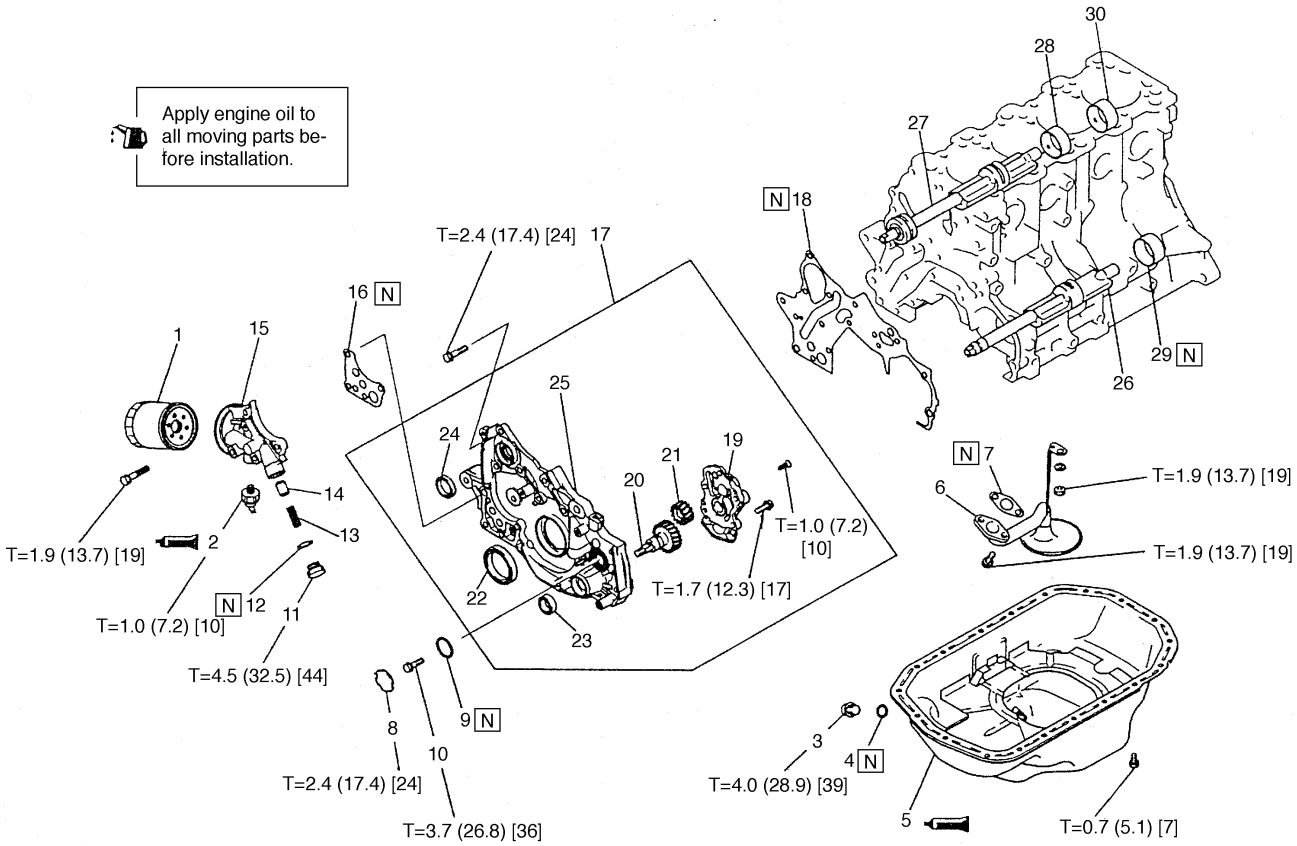


(3) According to the tightening sequence, tighten the bolts to 8.0 kg•m (57.9 lb•ft)[80 N•m].
(4) Loosen the bolts completely.
(5) Torque the bolts to 2.0 kg•m (14.5 lb•ft)[20 N•m].
(6) Tighten the bolts 1/4 turns (90°) more.
(7) Tighten the bolts 1/4 turns (90°) additionally.

Caution:
1) If the bolt is turned less than 90°, proper fastening performance may not be expected. When tightening the bolt, therefore, be careful to give a sufficient turn to it.
2) If the bolt is over tightened, loosen the bolt completely and then retighten it by repeating the tightening procedure from step (1).

Front Case And Oil Pan

Removal and Installation



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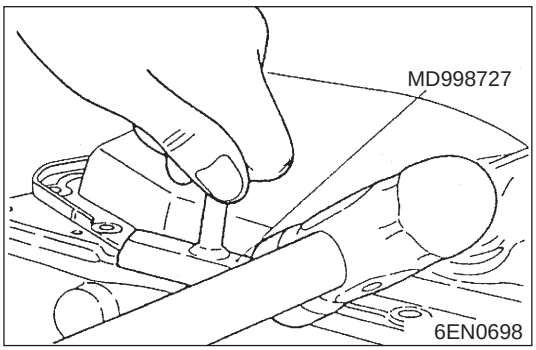
Removal steps

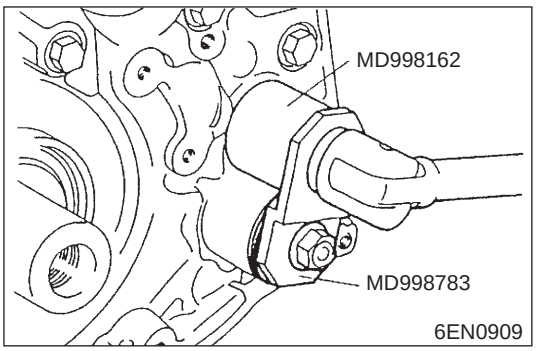
- →N← 1. Oil filter
- →M← 2. Oil pressure switch
- 3. Drain plug
- →L← 4. Drain plug gasket
- ←A→ →K← 5. Oil pan
- 6. Oil screen
- 7. Oil screen gasket
- ←B→ →J← 8. Plug
- 9. O-ring
- ←C→ →I← 10. Flange bolt
- 11. Relief plug
- 12. Gasket
- 13. Relief spring
- 14. Relief plunger
- 15. Oil filter bracket
- 16. Oil filter bracket gasket
- →H← 17. Oil pump case assembly
- 18. Front case gasket
- →G← 19. Oil pump cover
- →G← 20. Oil pump drive gear
- →G← 21. Oil pump driven gear
- →F← 22. Crankshaft front oil seal
- →E← 23. Oil pump oil seal
- →D← 24. Counterbalance shaft oil seal
- 25. Front case
- 26. Counterbalance shaft, left
- 27. Counterbalance shaft, right
- ←D→ →C← 28. Counterbalance shaft, front bearing
- ←E→ →B← 29. Counterbalance shaft, rear bearing,left
- ←E→ →A← 30. Counterbalance shaft, rear bearing, right



Removal Service Points

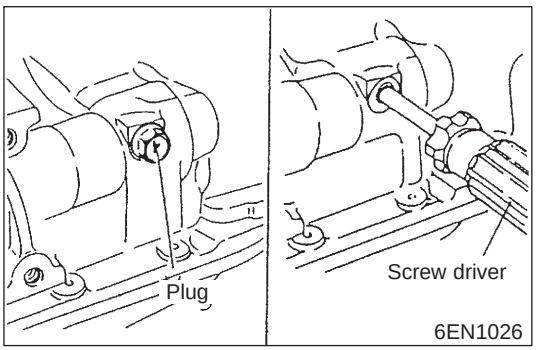
⟵ A ⟶ Oil pan removal

(1) Remove the all oil pan bolts.
(2) Drive in the special tool between the cylinder block and oil pan
(3) Side the tool by striking the edge of the special tool to separate the oil pan from the cylinder block.



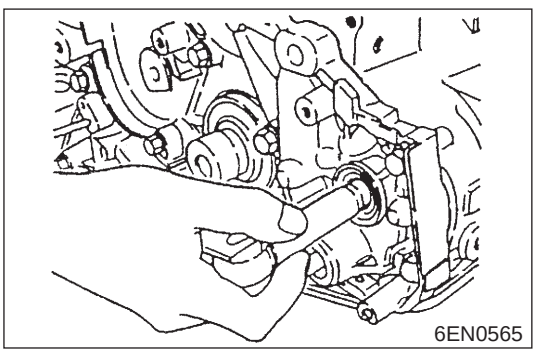
⟵ B ⟶ Plug removal

(1) Fit special tool MD998162 on the plug, then hold it in position with special tool MD998783.
(2) Loose the plug.

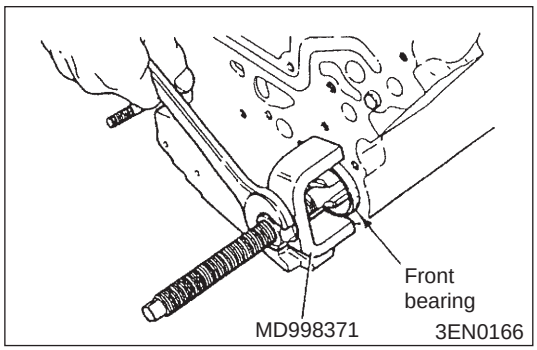


⟵ C ⟶ Oil pump oil seal installation

(1) Remove the plug on the side of cylinder block.
(2) Insert a phillips screwdriver(shank diameter 8mm[0.31 in.]) into the plug hole to lock the counterbalance shaft.



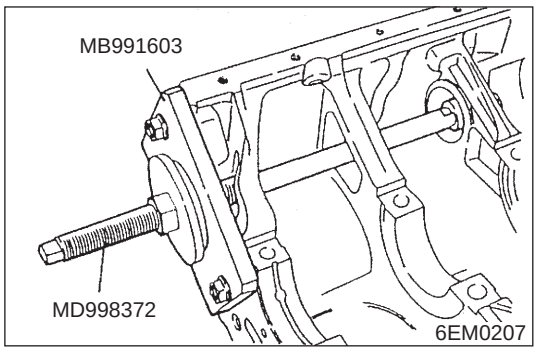
(3) Loosen the flange bolt.



⟵ D ⟶Counterbalance shaft front bearing removal

(1) Using the special tool, remove the counterbalance shaft front bearing from the cylinder block.

NOTE: Be sure to remove the front bearing first. If it has not been removed, the rear bearing puller cannot be used.



⟵ E ⟶Counterbalance shaft rear bearing removal

(1) Using the special tool, remove the counterbalance shaft rear bearing from the cylinder block.

NOTE: When removing the left counterbalance shaft bearing, install the special tool (MB991603) in front of the cylinder block.

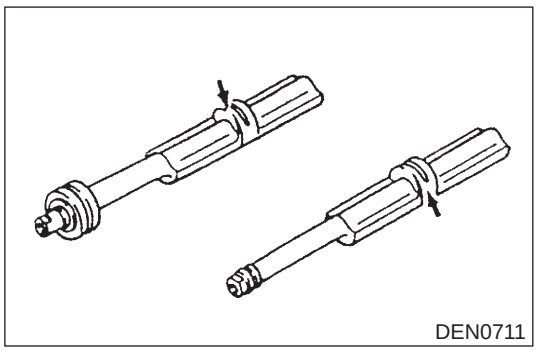
Inspection

1. Front Case

(1) Check oil holes for clogging and clean if necessary.
(2) Check the left counterbalance shaft front bearing section for wear, damage and seizure. If there is anything wrong with the section, replace the front case.
(3) Check the front case for cracks and other damage. Replace cracked or damaged front case.

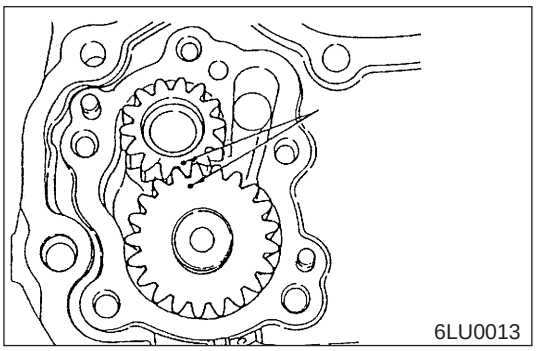
2. Oil Seal

(1) Check the oil seal lip for wear and Replace oil seal if necessary.
(2) Check the oil seal lip for deterioration. Replace oil seal if necessary.



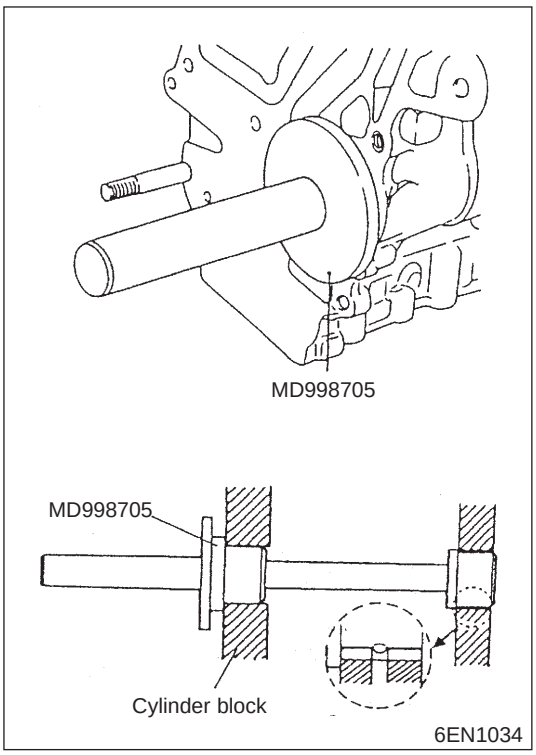
3. Counterbalance Shaft

(1) Check oil hole for clogging.
(2) Check journals for seizure, damaged and contact with bearing. If there is anything wrong with the journal assembly.



4. Oil Pump

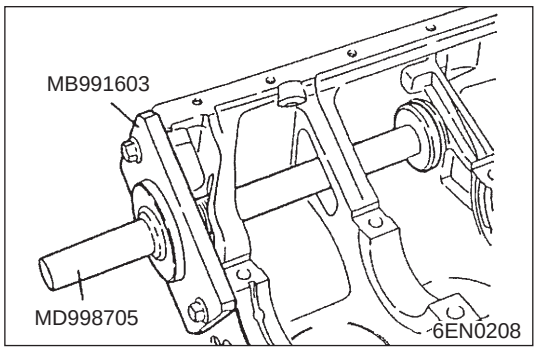
(1) Assemble the oil pump to the front case and rotate it to ensure smooth rotation with no looseness.
(2) Check the side clearance using a thickness gauge.
(3) Check the side clearance
Standard value:
0.08 to 0.14 mm (0.0031 to 0.0055 in.)
Drive gear
0.06 to 0.12 mm (0.0024 to 0.0047 in.)
Driven gear



Installation Service Points

⟶ A ⟵ Right counterbalance shaft rear bearing installation

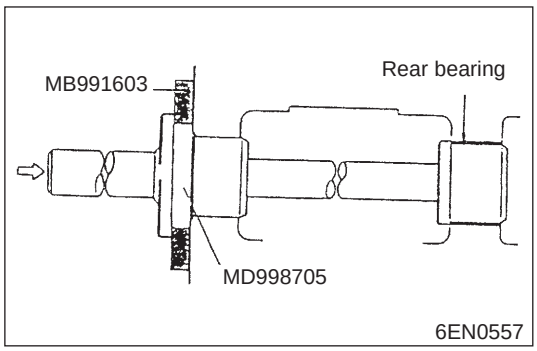
(1) Apply engine oil to the outer surface of bearing.
(2) Using special tools, install right rear bearing. Make sure that oil hole of bearing is aligned with oil hole of cylinder block.

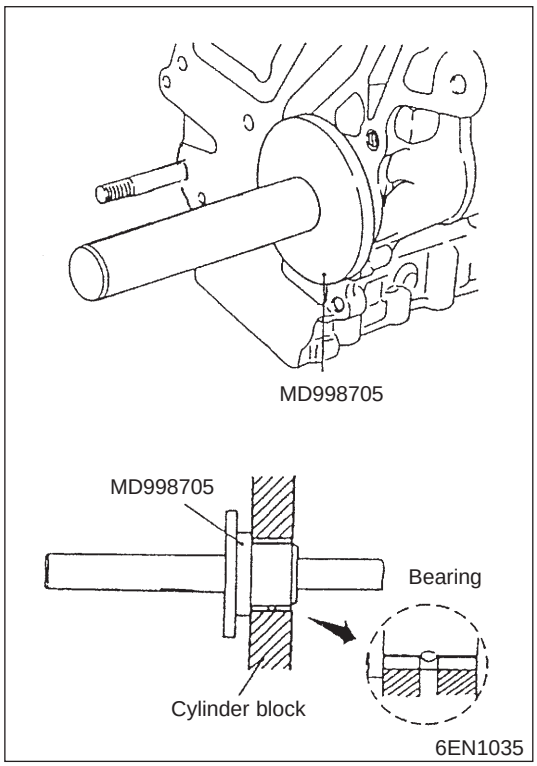


⟶ B ⟵ Left counterbalance shaft rear bearing installation

(1) Install the special tool (Guide Plate) to cylinder block.
(2) Apply engine oil to the rear bearing outer circumference and bearing hole in the cylinder block.
(3) Using the special tool, install the rear bearing.

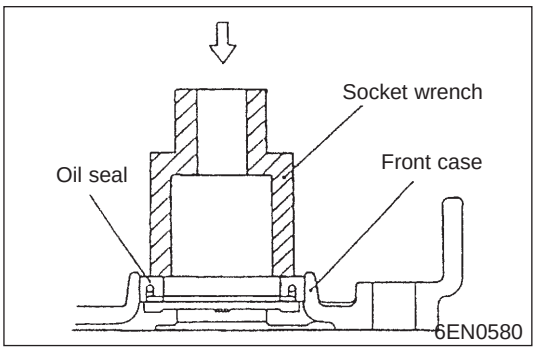
NOTE: The left rear bearing has no oil holes.





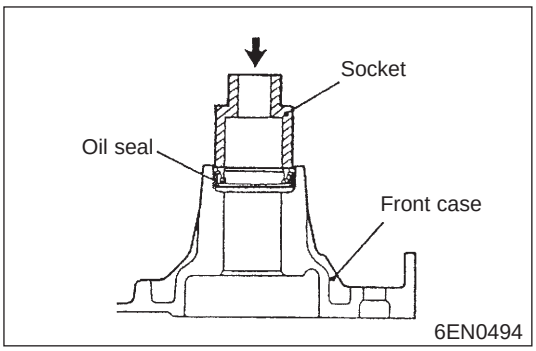
⟶ C ⟵ Counterbalance shaft front bearing installation

(1) Using the special tool, install the rear bearing.



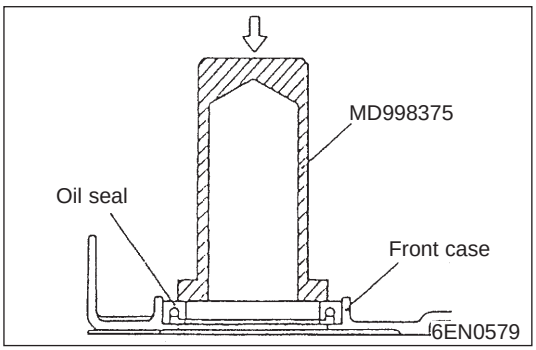
⟶ D ⟵ Counterbalance shaft oil seal installation

(1) Using a suitable socket wrench, install the counterbalance shaft oil into the front case.



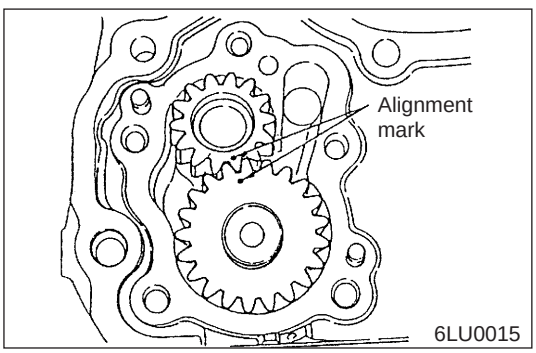
⟶ E ⟵ Oil pump oil seal installation

(1) Using a suitable socket wrench, install the oil pump oil seal into the front case.



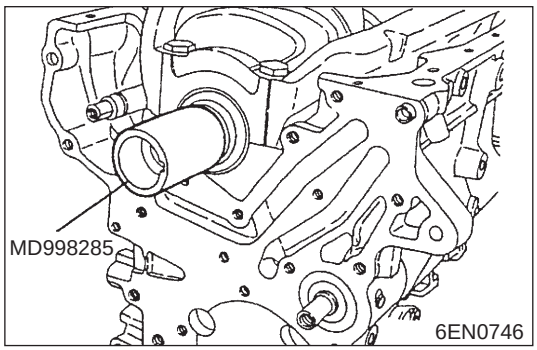
⟶ F ⟵ Crank shaft front oil seal installation

(1) Using the special tool, install the crankshaft front oil seal into the front case.



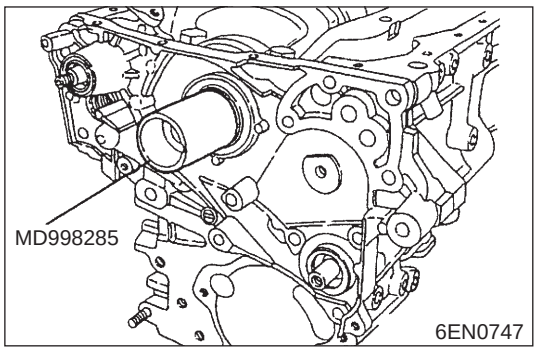
⟶ G ⟵ Oil pump driven gear/oil pump drive gear installation

(1) Apply engine oil amply to the gears and line up the alignment marks.

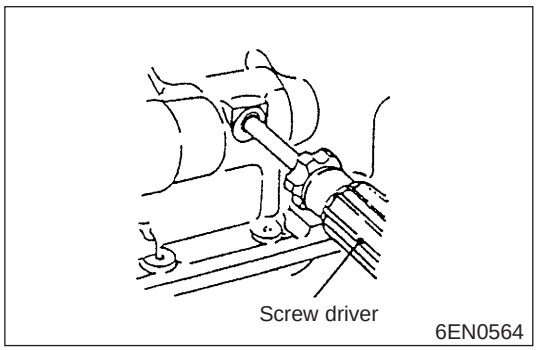


⟶ H ⟵ Front case installation

(1) Set the special tool on the front end of the crankshaft and apply a thin coat of engine oil to the outer circumference of the special tool to install the front case.

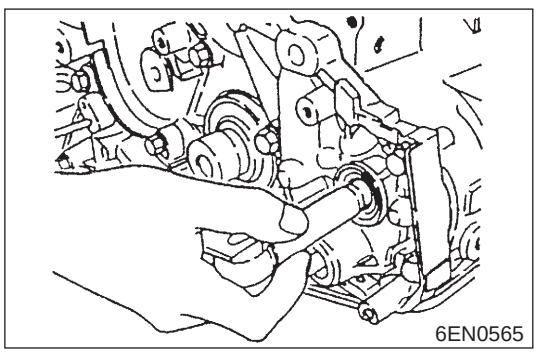


(2) Install the front case assembly through a new front case gasket and temporarily tighten the flange bolts(other than those for tightening the filter bracket).

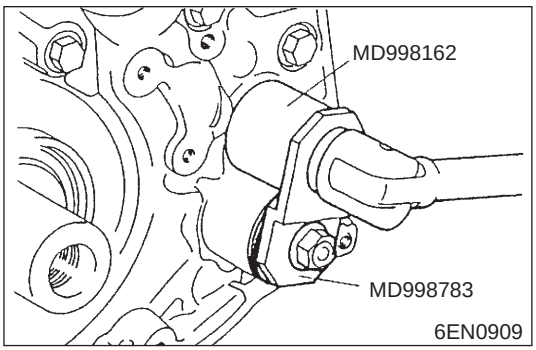


⟶ I ⟵ Flange bolt installation

(1) Insert a Phillips screwdriver into a hole in the left side of the cylinder block to lock the counterbalance shaft.

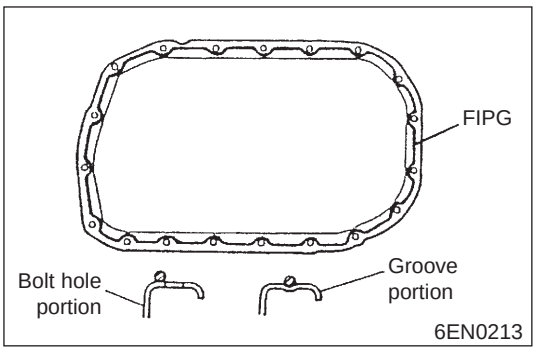


(2) Secure the oil pump driven gear onto the left counterbalance shaft by tightening the flange bolt to specified torque.



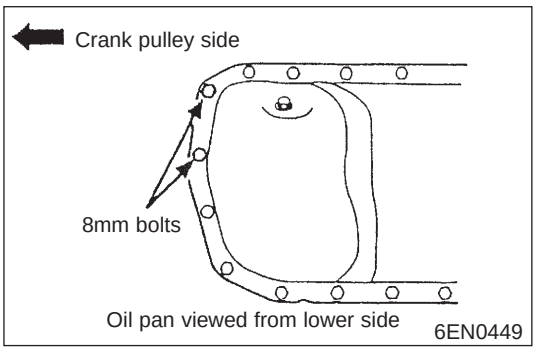
⟶ J ⟵ Plug installation

(1) Install a new o-ring to the groove of the front case.
(2) Install a plug to the front case.
(3) Fit the special tool MD998162 on the plug, and then hold in position with special tool MD998783.
(4) Tighten the plug to the special tool MD998783.
(5) Remove the special tools MD998783 and MD998162.

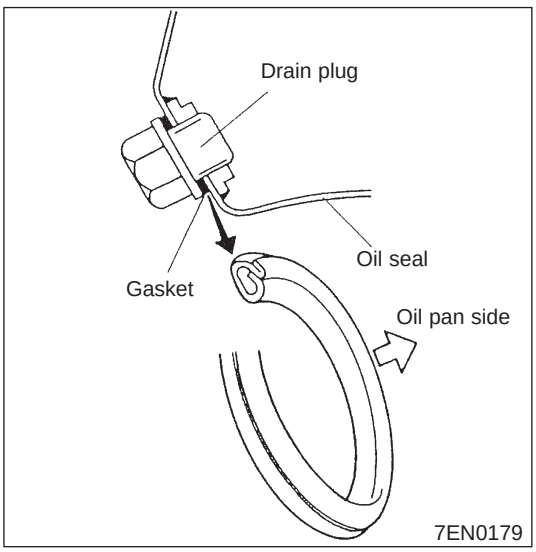


⟶ K ⟵ Oil pan installation

(1) Clean both mating surface of the oil pan and cylinder block.
(2) Apply a 4 mm (0.16 in.) wide bead of FIPG to the entire circumference of the oil pan flange. The oil pan should be installed in 15 minutes after the application of FIPG. Specified FIPG: 3M™ AAD Part No.8672 or equivalent



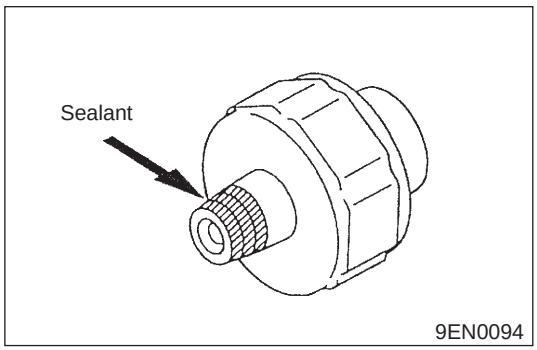
(3) Note the difference in bolt lengths at the location shown.



⟶ L ⟵ Drain plug gasket installation

(1) Install the drain plug gasket in the direction shown.

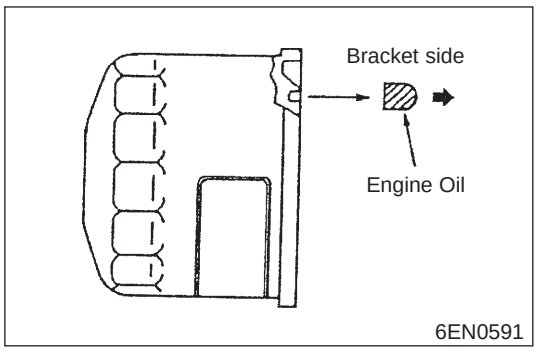
Caution: Fitting the gasket in a wrong way will result in oil leakage.



⟶ M ⟵ Oil pressure switch installation

Specified sealant: 3M™ AAD Part No. 8672 or equivalent

Caution:
1) Keep the end of threaded portion clear of sealant.
2) Avoid an over tightening.

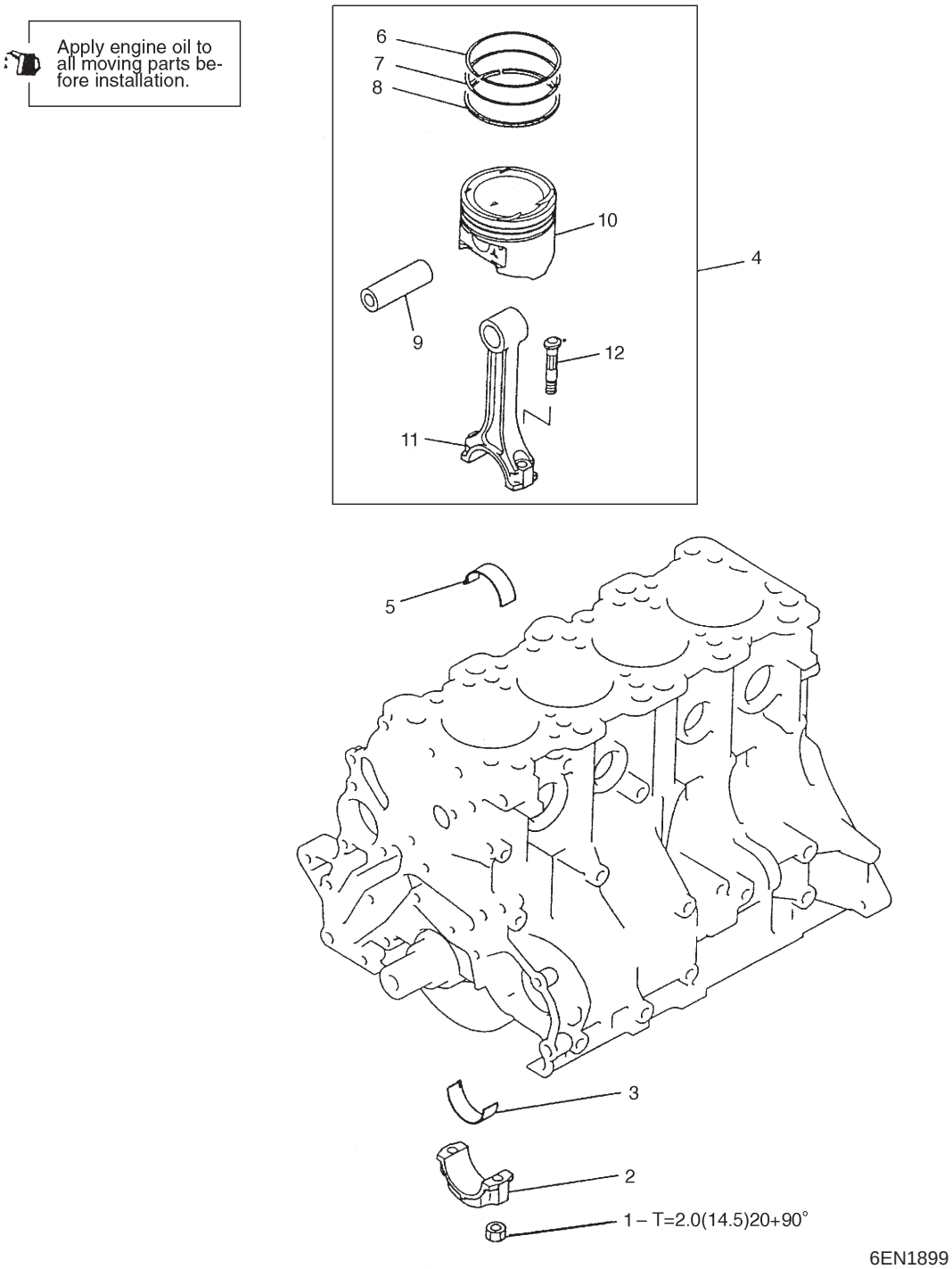


⟶ N ⟵ Oil filter installation

(1) Clean the installation surfaces of the filter bracket.
(2) Apply engine oil to the o-ring of oil filter.
(3) Screw the oil filter in until the o-ring contacts the bracket.

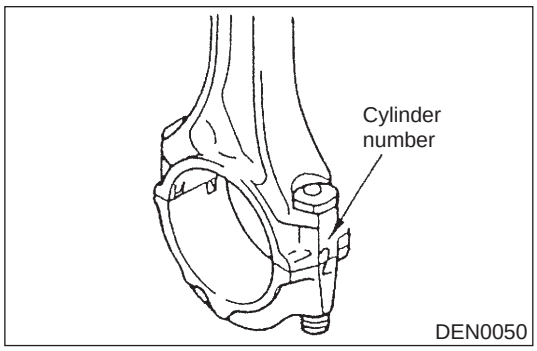
Piston And Connecting Rod

Removal and Installation



Removal steps

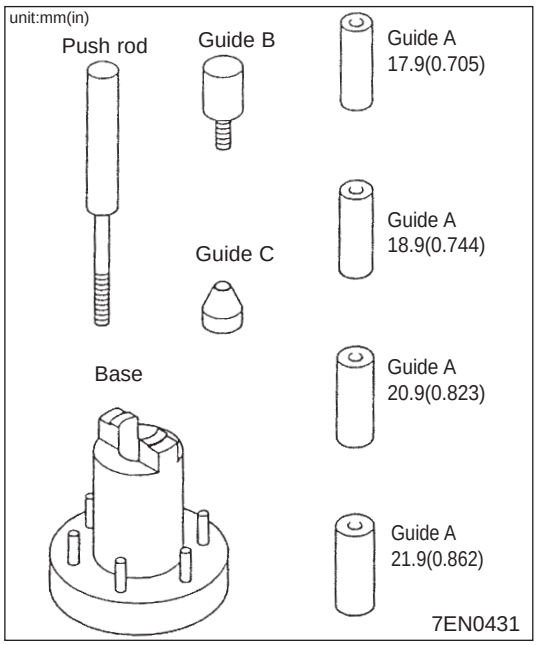
- →G← 1. Nut
- ←A→ →F← 2. Connecting rod cap
- →E← 3. Connecting rod bearing
- →D← 4. Piston and connecting rod assembly
- →E← 5. Connecting rod bearing
- →C← 6. Piston ring No. 1
- →C← 7. Piston ring No. 2
- →B← 8. Oil ring
- ←B→ →A← 9. Piston pin
- 10. Piston
- 11. Connecting rod
- 12. Bolt



Removal Service Points

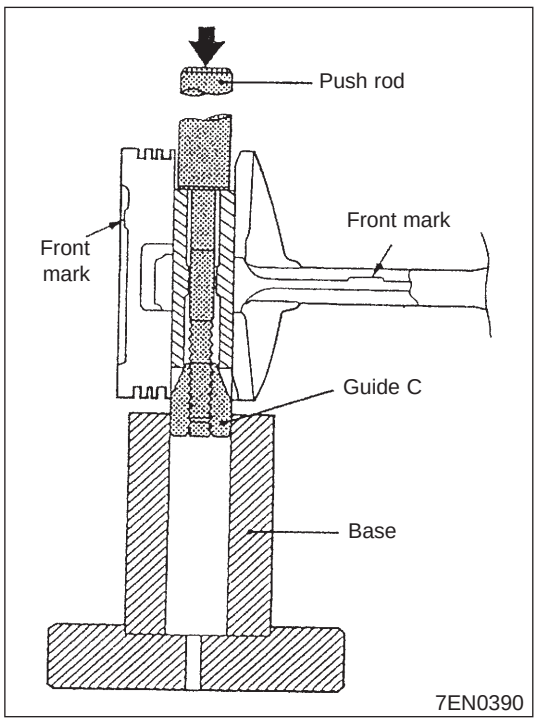
⟵ A ⟶ Connecting rod cap removal

Mark the cylinder number on the side of the connecting rod big end for correct reassembly.



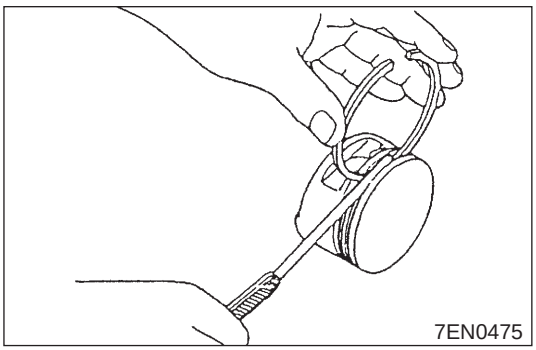
⟵ B ⟶ Piston pin removal

The special tool, Piston Pin Setting Tool (MD998780), consists of the parts shown in the illustration at the left.



(1) Insert the special tool, Push Rod, into the piston from the side on which the front mark is stamped in the piston head, and attach the guide C to the push rod end.
(2) Place the piston and connecting rod assembly on the special tool, Piston Pin Setting Base, with the front mark facing upward.
(3) Using a press, remove the piston pin.

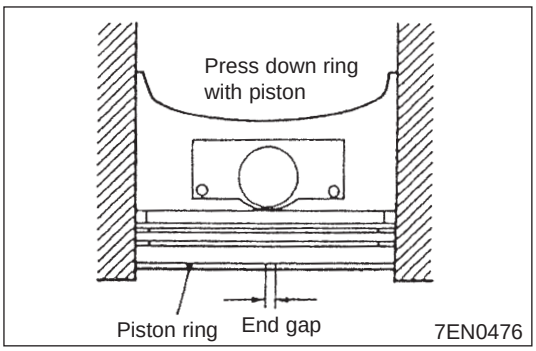
NOTE: Keep the disassembled piston, piston pins and connecting rods in order according to the cylinder number.

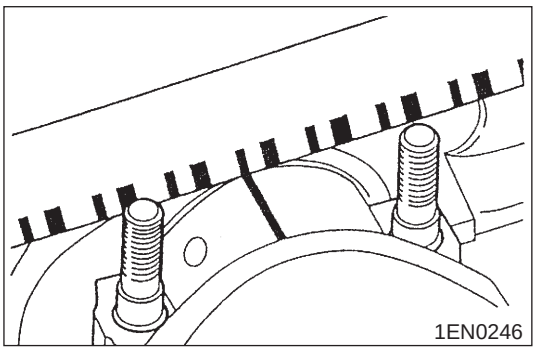


Inspection

1. Piston Ring

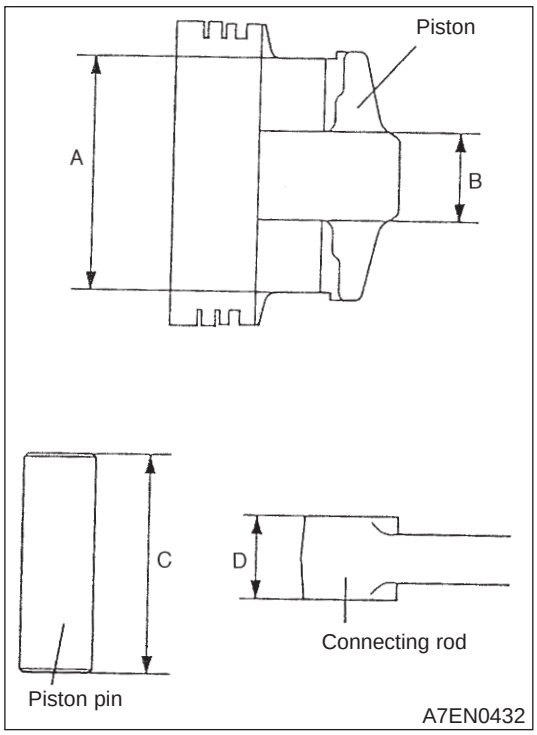
(1) Check for the clearance between the piston ring and ring groove. If the limit is exceeded, replace the ring or both piston and ring.
(2) Install the piston ring into the cylinder bore. Force it down with a piston, its crown being in contact with the ring, to correctly position it at right angles to the cylinder wall. Then, measure the end gap with a feeler gauge. If the ring gap is excessive, replace the piston ring.
Standard value:
No.1 0.25 to 0.40 mm (0.0098 to 0.0157 in.)
No.2 0.45 to 0.60 mm (0.0177 to 0.0236 in.)
Oil 0.20 to 0.60 mm (0.0079 to 0.0236 in.)
Limit:
No.1, No.2 0.8 mm(0.031 in.)
Oil 1.0 mm (0.039 in.)

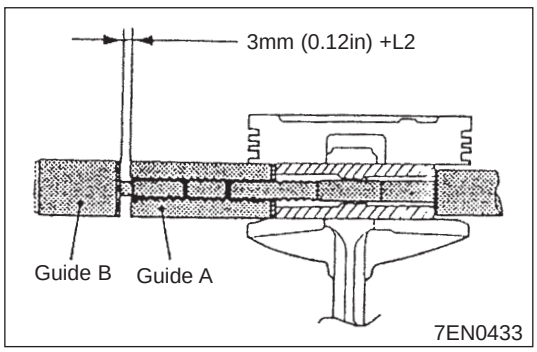


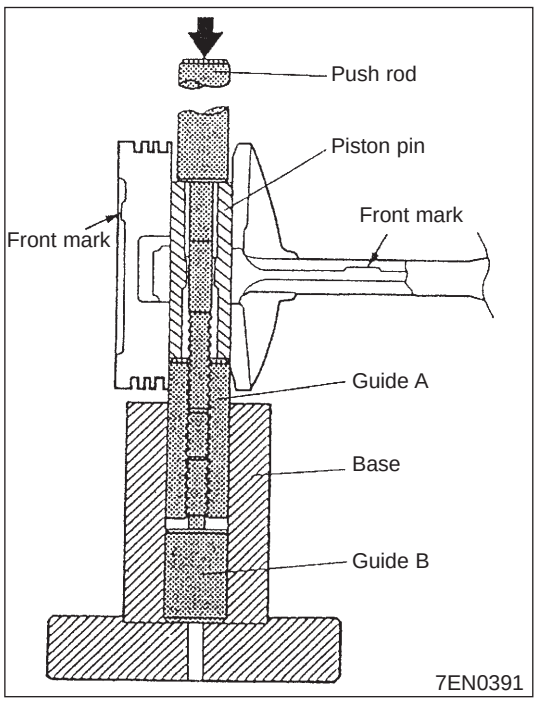


2. Crankshaft Pin Oil Clearance (Plastic Gauge Method)

(1) Remove oil from the crankshaft pin and the connecting rod bearing.
(2) Cut the plastic gauge to the same length as the width of the bearing and place it on the crankshaft pin in parallel with its axis.
(3) Install the connecting rod cap carefully and tighten the bolts to the specified torque.
(4) Remove the bolt and carefully remove the connecting rod cap.
(5) Measure the width of the plastic gauge at its widest part by using the scale printed on the plastic gauge package.
Standard value: 0.02 to 0.05 mm (0.0008 to 0.0020 in.)
Limit: 0.1 mm (0.004 in.)







Installation Service Points

⟶ A ⟵ Piston pin installation

(1) Measure the following dimensions of the piston, piston pin and connecting rod.
A: Piston pin insertion hole length
B: Distance between piston bosses
C: Piston pin length
D: Connecting rod

(2) Obtain dimension L (to be used later) from the above measurements by using by following formula.

$$L = \frac{(A - C) - (B - D)}{2}$$

(3) Insert the special tool, Push Rod, into the piston pin and attach the guide A to the push rod end.

(4) Assemble the connecting rod in the piston with their front marks facing the same direction.

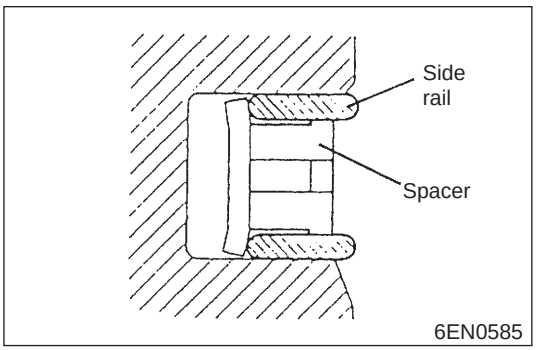
(5) Apply engine oil to the entire periphery of the piston pin.

(6) Insert the piston pin, push rod and guide A assembly having assembled in stop (3) from the guide A side into the piston pin hole on the front marked side.

(7) Screw the guide B into the guide A until the gap between both guides amounts to the value L obtained in step (2) plus 3 mm (0.12 in.)

(8) Place the piston onto the piston setting base with the front marks directed upward.

(9) Press-fit the piston pin using a press.
If the press-fitting force required is less than the standard value, replace the piston and piston pin set or/and the connecting rod.
Standard value: 750 to 1750 kgf
(1654 to 3859 lbf)
[7350 to 17160 N]

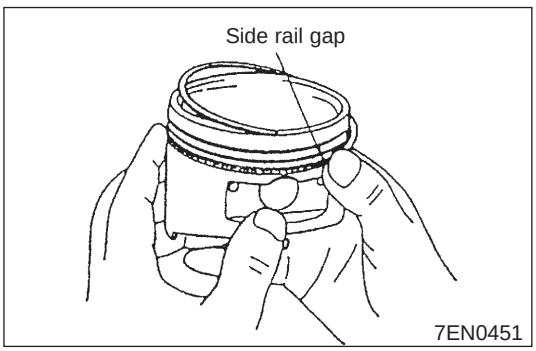


⟶ B ⟵ Oil ring installation

(1) Fit the oil ring spacer into the piston ring groove. First, install the upper side rail, and then install the lower side rail.

NOTE:
1) The side rails and spacer may be installed in either direction.
2) The new spacers and side rails are painted in the following colors to identify their sizes.

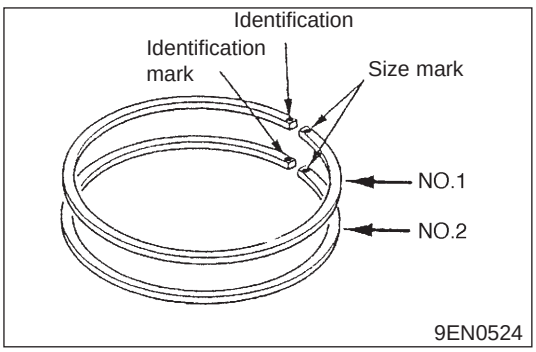
Size	Identification color
STD	No color
0.50 mm (0.020 in.) O.S.	Blue
1.00 mm (0.040 in.) O.S.	Yellow



(2) To install the side rail, first fit one end of the rail into the piston groove, then press the remaining portion into position by finger. See illustration.

Caution: The side rail could be broken if it is expanded with a piston ring expander in the same way as with a compression ring.

(3) Make sure that the side rails move smoothly in either direction.

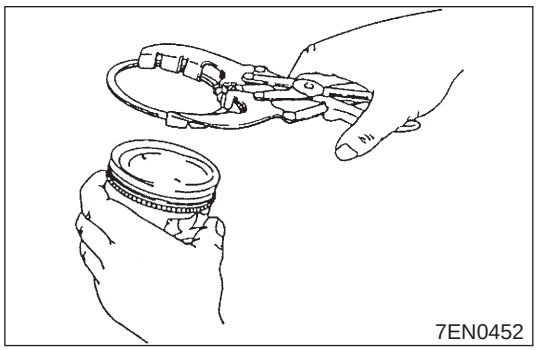


⟶ C ⟵ Piston ring No.2/piston ring No.1 installation

(1) To prevent wrong installation, check the identification mark of each piston ring. The installation mark is stamped near the ring gap.

NOTE: Size mark on piston ring are as follows.

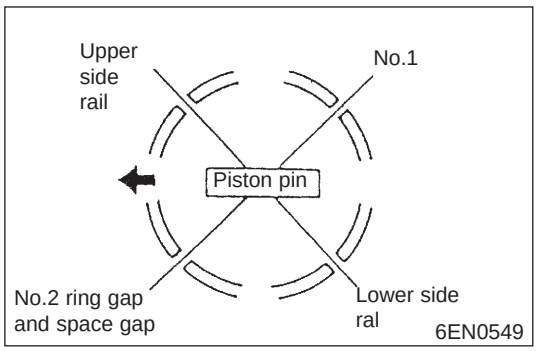
Size	Size mark
STD	Paint red
0.50 mm (0.020 in.) O.S.	50
1.00 mm (0.040 in.) O.S.	100



(2) Using piston ring expander, fit No.2 and then No.1 piston ring into position.

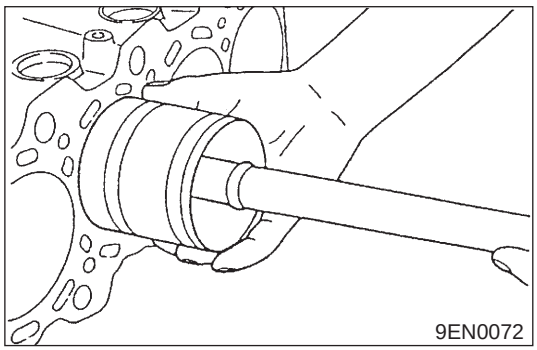
NOTE: Install piston ring with identification mark facing up, to the piston crown

(3) Install the No.1 piston ring in the same manner as step 2.

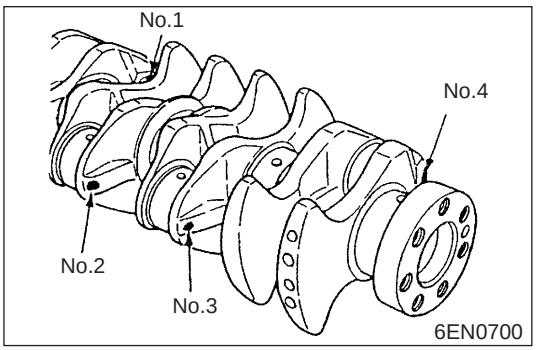


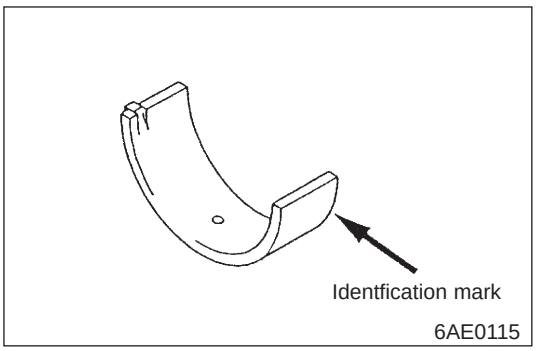
⟶ D ⟵ Piston and connecting rod installation

(1) Liberally coat engine oil on the circumference of the piston, piston ring, and oil ring.
(2) Arrange the piston ring and oil ring gaps (side rail and spacer) as shown in the illustration.
(3) Insert the piston and connecting rod assembly from above the cylinder in such a way that the front mark(arrow) on the top of the piston will be directed toward the camshaft sprocket.



(4) Insert the piston and connecting rod assembly with the piston rings held firmly with a ring band. Forcing it by pounding should be avoided because damage to the piston rings or crank pin could result.



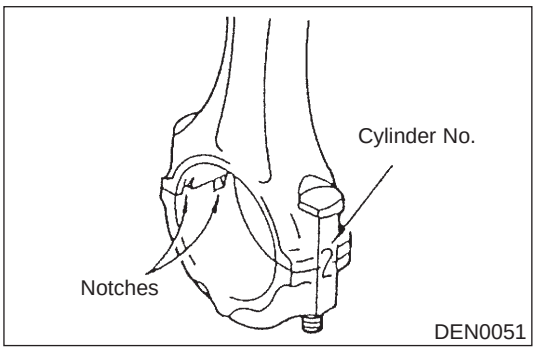


⟶ E ⟵ Connecting rod bearing installation

When the bearings are replaced, select and install them according to the identification colors on the crankshaft and identification marks stamped on the connecting rod bearing.

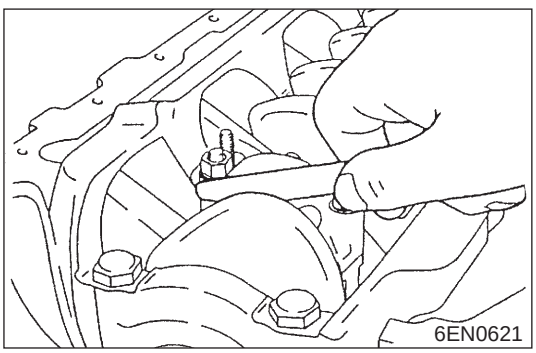
Crankshaft		Connecting rod bearing	
Pin identification color	Pin O.D. mm (in.)	Identification mark or color	Thickness, mm (in.)
Yellow	44.995 to 45.000 (1.77145 to 1.77165)	1 or Yellow	1.487 to 1.491 (0.05854 to 0.05870)
None	44.985 to 44.995 (1.77106 to 1.77145)	2 or None	1.491 to 1.495 (0.05870 to 0.05886)
White	44.980 to 44.985 (1.77086 to 1.77106)	3 or Blue	1.495 to 1.499 (0.05886 to 0.05902)

Connecting rod inside diameter:
48.000 to 48.015 mm (1.88976 to 1.89035 in.)



⟶ F ⟵ Connecting rod cap installation

(1) Verifying the mark made during disassembly, install the bearing cap to the connecting rod. If the connecting rod is new with no index mark, make sure that the bearing locking notches come on the same side as shown.



(2) Make sure that connecting rod big end side clearance meets the specification.
Standard value: 0.10 to 0.25 mm (0.0039 to 0.0098 in.)
Limit: 0.4 mm (0.016 in.)

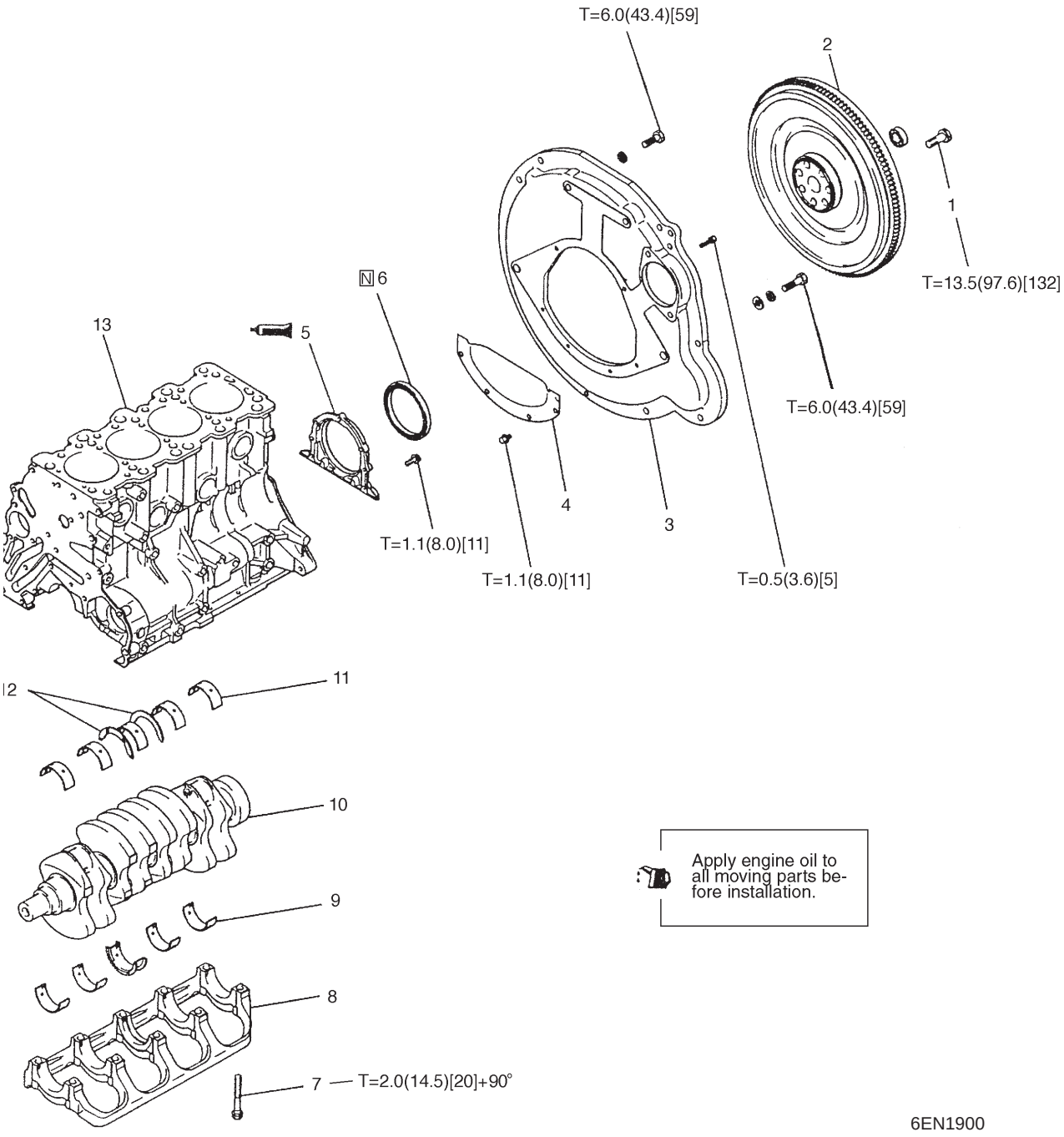
⟶ G ⟵ Connecting rod cap nut installation

(1) Since the connecting rod bolts and nuts are torque using a plastic area tightening method, they should be examined BEFORE reuse. If the bolt threads are “necked down”, the bolts should be replaced. Necking can be checked by running a nut with fingers to the full length of the bolt’s thread. If the nut does not run down smoothly, the bolt should replaced.
(2) Before installing the nuts, the threads should be oiled with engine oil.
(3) Install both nuts on the bolts finger tight, then alternately torque each nut to assemble the cap properly.
(4) Tighten the nuts to 2.0 kg•m (14.5 lb•ft) [20 N•m] and plus 1/4 (90°) turn.

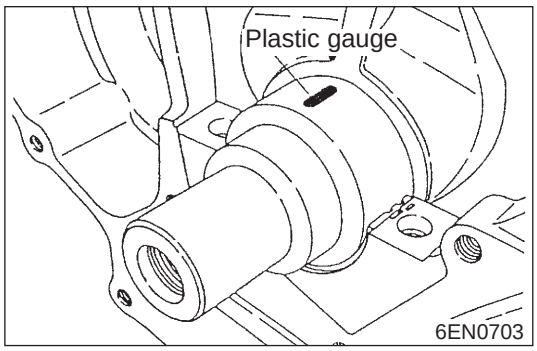
Caution:
1) If the nut is turned less than 90°, proper fastening performance may not be expected. When tightening the nut, therefore, be careful to give a sufficient turn to it.
2) If the nut is over tightened (exceeding 100°), loosen the nut completely and then retighten it by repeating the tightening procedure from step (1).

Crankshaft And Cylinder Block

Removal and Installation



Removal steps
1. Flywheel bolt
2. Flywheel
→F← 3. F/W Housing
4. Cover - F/W Housing
→E← 5. Oil seal case
→D← 6. Oil seal
→C← 7. Crankshaft bearing cap bolt
→C← 8. Crankshaft bearing cap
→B← 9. Crankshaft bearing lower
10. Crankshaft
→B← 11. Crankshaft bearing upper
→B← 12. Thrust bearing
13. Cylinder block



Inspection

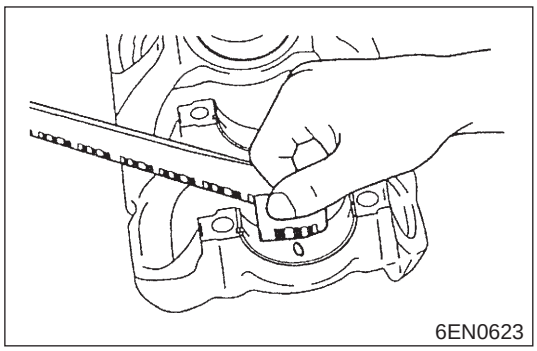
1. Crankshaft Oil Clearance (Plastic Gauge Method)

Use of the plastic gauge can facilitate the oil clearance measurement work.
To use the plastic gauge, proceed as follows:

(1) Remove oil from the crankshaft journal and crankshaft bearing.

(2) Install the crankshaft.

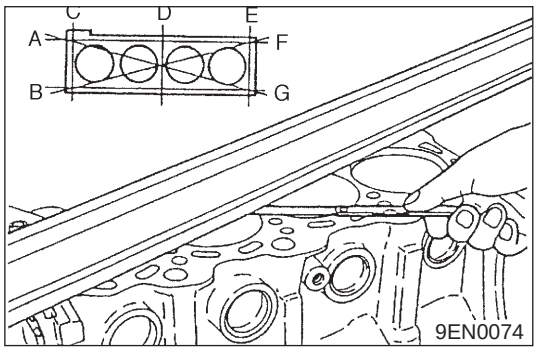
(3) Cut the plastic gauge to the same length as the width of the bearing and place it on the journal in parallel with its axis.



(4) Install the crankshaft bearing cap carefully and tighten the bolts to specified torque.

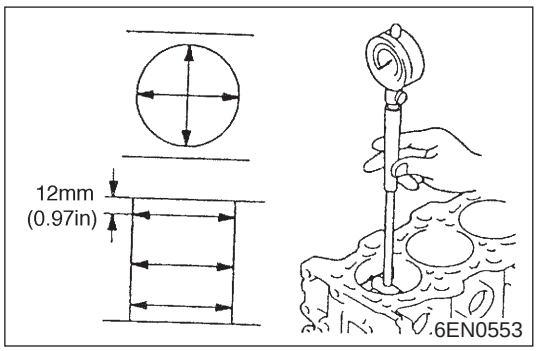
(5) Remove the bolt, and carefully remove the crankshaft bearing cap.

(6) Measure the width of the plastic gauge at its widest part by using a scale printed on the plastic gauge package.
Standard value: 0.02 to 0.04 mm (0.0008 to 0.0016 in.)
Limit: 0.1 mm (0.004 in.)

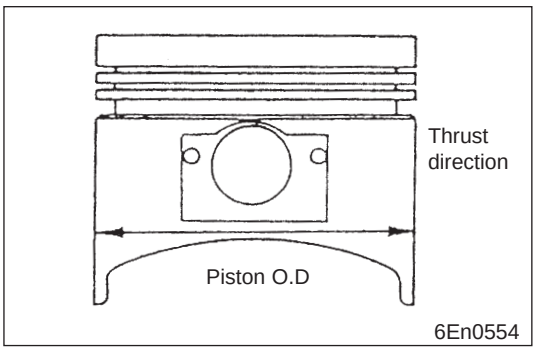


2. Cylinder Block

(1) Visually check for scratches, rust, and corrosion. Use also a flaw detecting agent for the check. If defects are evident, correct, or replace.
(2) Using a straightedge and feeler gauge, check the block top surface for warpage. Make sure that the surface is free from gasket chips and other foreign matter.
Standard value: 0.05 mm (0.0020 in.)
Limit: 0.1 mm (0.004 in.)



(3) Check the cylinder walls for scratches and seizure. If defects are evident, correct (bored to oversize) or replace.
(4) Using a cylinder gauge, measure the cylinder bore and cylindricity. If worn badly, rebore all cylinders to an oversize and replace piston rings. Measure at the points shown in the illustration.
Standard value:
Cylinder I.D.
86.50 to 86.53 mm (3.4055 to 3.4067 in.)
Cylindricity 0.1 mm (0.004 in.)

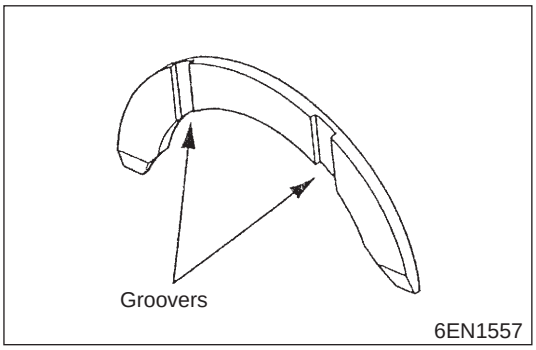


3. Cylinder Boring

(1) Oversize pistons to be used should be determined on the basis of largest bore cylinder.
(2) Oversize pistons are available in four size 0.50 mm (0.0197 in.), and 1.00 mm (0.0394 in.). Rebore the cylinder to a diameter that matches the selected piston outside diameter that matches the selected piston outside diameter with the specified clearance. The reference piston outside diameter measuring point is shown in the illustration.
(3) Based on the measured piston O.D. calculate the boring finish dimension.
Boring finish dimension = Piston O.D. + 0.02 to 0.04 mm (0.0008 to 0.0016 in.) (clearance between piston O.D. and cylinder) - 0.02 mm (0.0008 in.) (honing margin)
(4) Bore all cylinders to the calculated boring finish dimension.

Caution: To prevent distortion that may result from temperature rise during boring, bore cylinders, working from No.2 to No.4 to No.1 to No.3.

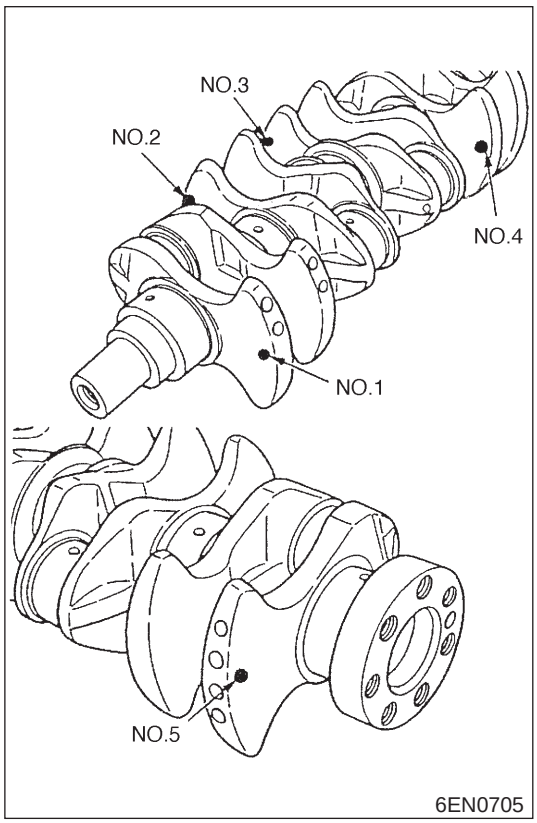
(5) Hone to the final finish dimension (piston O.D. + clearance between piston O.D. and cylinder).
(6) Check the clearance between the piston and cylinder.
Standard value:
Clearance between piston and cylinder
0.02 to 0.04 mm (0.0008 to 0.0016 in.)



Installation Service Points

⟶ A ⟵ Crankshaft thrust bearing installation

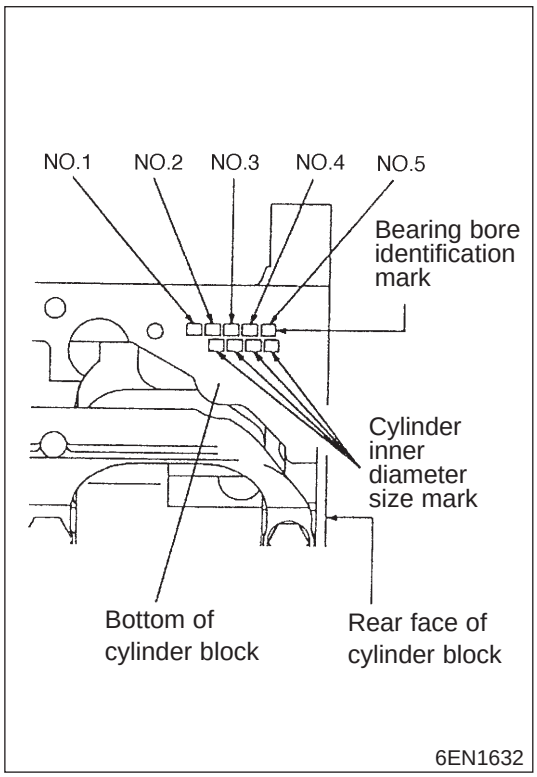
(1) Install the two thrust bearing in the No.3 bearing bore in the cylinder block. For easier installation, apply engine oil to the bearings, this will help fold them in position.
(2) The thrust bearings must be installed with their groove side toward the crankshaft web.



⟶ B ⟵Crankshaft bearing installation

(1) From the following table, select a bearing whose size is appropriate for the crankshaft journal outside diameter.

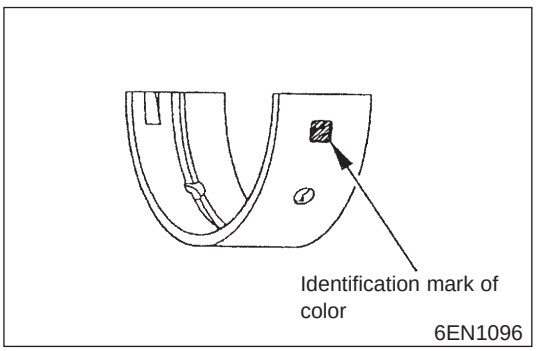
Crankshaft journal outside diameter		Cylinder block bearing bore	Crankshaft bearing for No.3	Identification mark or color
Identification color	Size mm (in.)	Identification mark	Identification mark or color	Identification mark or color
Yellow	56.994 to 57.000 (2.2439 to 2.2241)	0	1 or Green	0 or Black
		1	2 or Yellow	1 or Green
		2	3 or None	2 or Yellow
None	56.988 to 56.994 (2.2436 to 2.2439)	0	2 or Yellow	1 or Green
		1	3 or None	2 or Yellow
		2	4 or Blue	3 or None
White	56.982 to 56.988 (2.2434 to 2.2436)	0	3 or None	2 or Yellow
		1	4 or Blue	3 or None
		2	5 or Red	4 or Blue

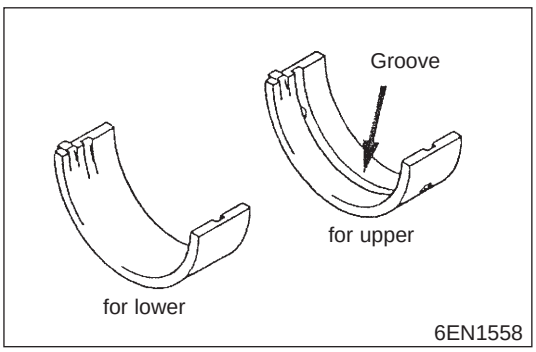


If the crankshaft journal outside diameter ID color is “yellow” and the cylinder block bearing bore ID mark is “1” for example, select a bearing whose ID mark is “2” or ID color is “yellow” for No. 1, 2, 4 and 5, and a bearing whose ID mark is “1” or ID color is “green” for No. 3.

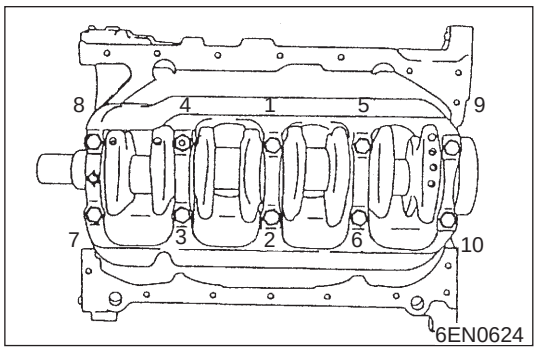
If there is no ID color paint on the crankshaft, measure the journal outside diameter and select a bearing appropriate for the measured value.

Crankshaft journal		Cylinder block bearing support section		Crankshaft bearing	
Identification color	O.D. mm (in.)	Identification mark	I.D. mm (in.)	Identification mark	Thickness mm(in.)
Yellow	56.994 to 57.000 (2.24385 to 2.24409)	0	61.000 to 61.006 (2.40157 to 2.40181)	1	1.988 to 1.991 (0.07827 to 0.07839)
		1	61.006 to 61.012 (2.40181 to 2.40204)	2	1.991 to 1.994 (0.07839 to 0.07850)
		2	61.012 to 61.018 (2.40204 to 2.40228)	3	1.994 to 1.997 (0.07850 to 0.07862)
None	56.988 to 56.944 (2.24362 to 2.24189)	0	61.000 to 61.006 (2.40157 to 2.40181)	2	1.991 to 1.994 (0.07839 to 0.07850)
		1	61.006 to 61.012 (2.40181 to 2.40204)	3	1.994 to 1.997 (0.07850 to 0.07862)
		2	61.012 to 61.018 (2.40204 to 2.40228)	4	1.997 to 2.000 (0.07862 to 0.07874)
White	56.982 to 56.988 (2.24338 to 2.24362)	0	61.000 to 61.006 (2.40157 to 2.40181)	3	1.994 to 1.997 (0.07850 to 0.07862)
		1	61.006 to 61.012 (2.40181 to 2.40204)	4	1.997 to 2.000 (0.07862 to 0.07874)
		2	61.012 to 61.018 (2.40204 to 2.40228)	5	2.000 to 2.003 (0.07874 to 0.07886)





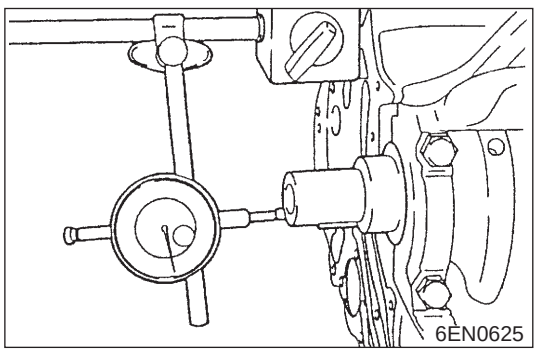
(2) Install the bearing having an oil groove to the cylinder block.
(3) Install the bearing having no oil groove to the bearing caps.



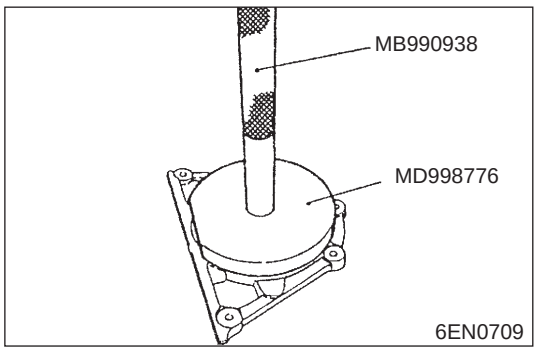
⟶ C ⟵ Bearing cap/bearing cap bolt installation

(1) Install the bearing caps so that their arrows are positioned on the timing belt side.
(2) When installing the bearing cap bolts, check that the shank length of each bolt meets the limit. If the limit is exceeded, replace the bolt.
Limit: Max. 71.1 mm (2.799 in.)
(3) Torque the bearing cap bolts to 2.5 kgf•m (18.1 lb•ft)[25 N•m] and, from that position, retighten them 1/4 (90°) turns more.

Caution:
1) If the bolt is turned less than 90°, proper fastening performance may not be expected. When tightening the bolt, therefore, be careful to give a sufficient turn to it.
2) If the bolt is over tightened (exceeding 100°), loosen the bolt completely and then retighten it by repeating the tightening procedure from step (1).

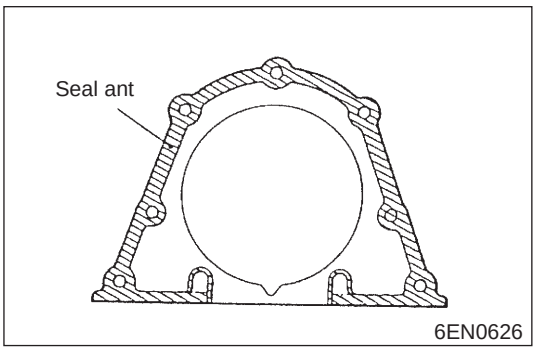


(4) After installing the bearing caps, make sure that the end play is correct. If the end play exceeds the limit, replace the crankshaft bearings.
Standard value: 0.05 to 0.25 mm (0.0020 to 0.0098 in.)
Limit: 0.4 mm (.016 in.)



⟶ D ⟵ Oil seal installation

(1) Using the special tool, knock, the oil seal into the oil seal case.

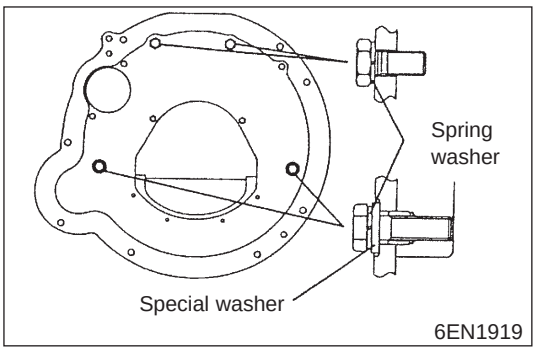


⟶ E ⟵ Sealant application to oil seal case.

Specified sealant: Silicone RTV sealant or equivalent.

NOTE:

1) Be sure to install the case quickly while the sealant is wet(within 15 minutes).
2) After installation, keep the sealant area away front the oil and coolant for approx. one hour.



⟶ F ⟵ Rear plate installation

(1) Be sure install the spring washers and special washers in correct position.

ADJUSTING AND TROUBLESHOOTING

Adjustment

The following is the method of adjustment of the carburetor and pneumatic governor on a reassembled engine.

Caution :

(1) The pneumatic governor hss been properly adjusted and sealed in the factory before shipping. Never break the seal unless it is necessary during engine overhaul.

(2) If the pneumatic governor is readjusted, seal it again and advise your user that he should not break the seal.

1. Valve Clearance Adjustment

Being adjusted automatically with a lash adjuster, the valve clearance needs no adjustment.

2. Ingition Timing Adjustment

(1) Let the engine warm up until the engine coolant temperature rises to 80 to 95°C (176 to 203°F).

(2) Remove the vacuum hose at throttle body side and plug open end of the nipple with something like rubber cap.

(3) Connect the timing light to the No.1 spark plug, and connect the power-supply leads of the light to 12V battery.

(4) Aim the timing light at the timing indicator at the crankshaft pulley.

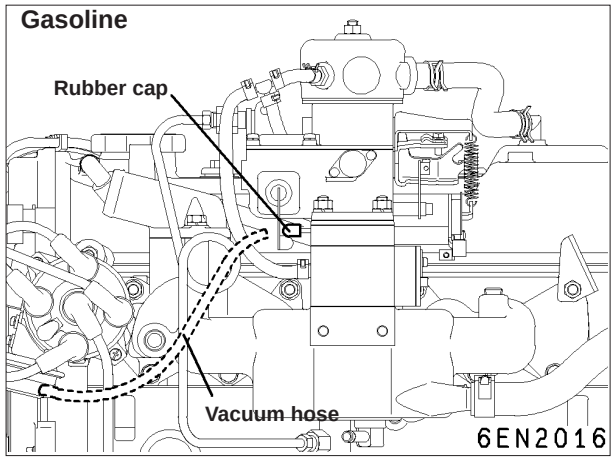
(5) Check that ignition timing is as indicated when the engine is running at idling speed.

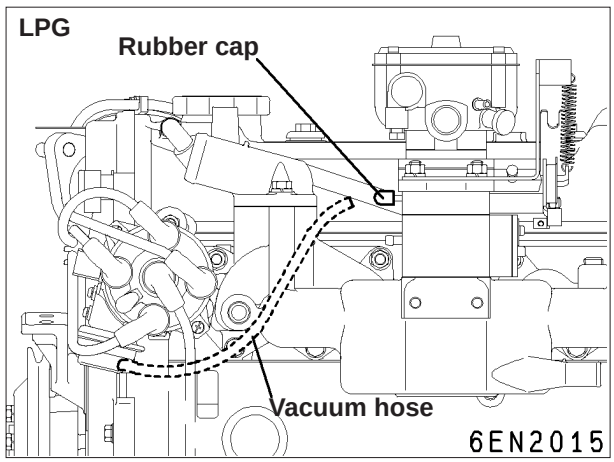
Standard value :
Gasoline 4°BTDC/740 rpm
LPG 9°BTDC/740 rpm

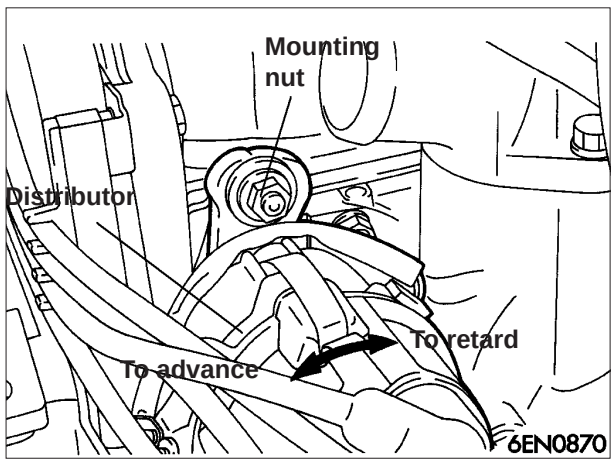
(6) If not within the standard value, loosen distributor fixing nuts and adjust by rotating distributor body.

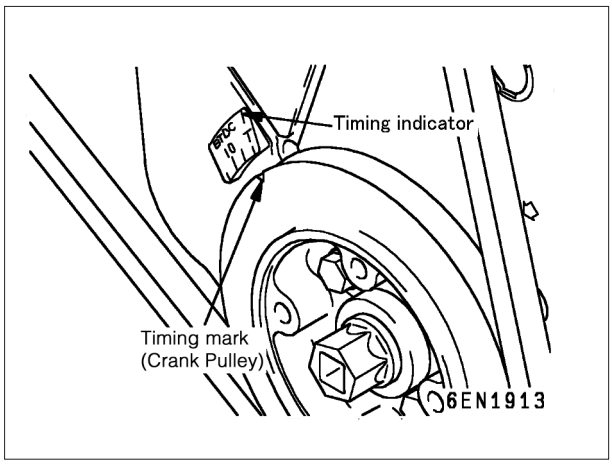
(7) Tighten the mounting nuts after adjusting.

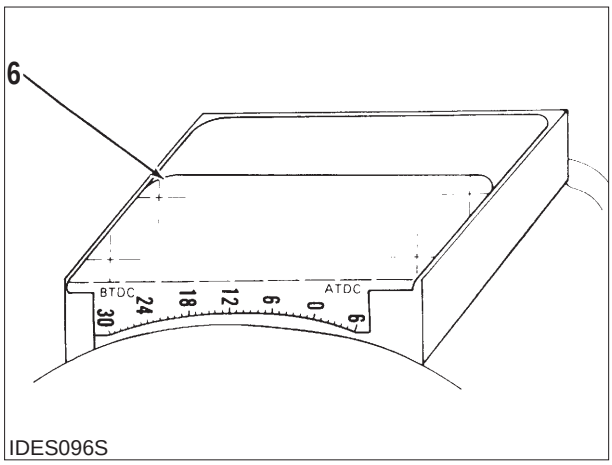
(8)Remove the rubber cap and connect the vacuum hose as it was.



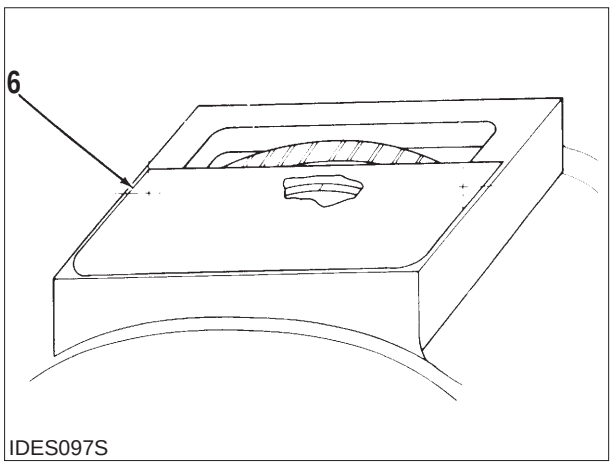








Timing Plate In Stored Position
(6) Timing Plate.



Timing Plate Rotated 180°
(6) Timing Plate.

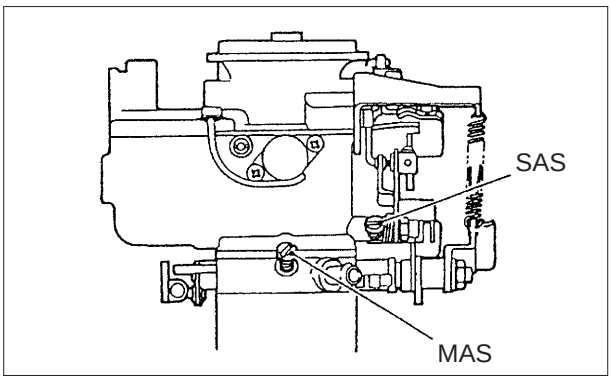
NOTE

Engine timing can be measured at not only engine crankshaft pulley but also flywheel assy. The measurement of engine timing at crankshaft pulley is exact but it is difficult and dangerous. The measurement of engine timing at flywheel side is safe, but it is need to adjust zero position of timing plate like the followings brfore measurement of engine timing.

1) Pull out key from key switch.
2) Remove timing plate(6) from the converter housing. The flywheel shoulder has a single timing mark on it. Put a white chalk mark on it, so it can be seen more easily.
3) Rotate timing plate (6) 180° and mount it on the converter housing again, using the other mounting holes on plate (6). When plate (6) is mounted, the timing marks should be close to the flywheel as shown.
4) Rotate engine and align the timing mark of engine crankshaft pulley to zero degree position of timing indicator near crankshaft balancer.
5) Note the timing mark on the flywheel indicates which position of timing plate(6). If timing mark does not indicate zero degree position of timing plate(6), the correct zero position should be marked on the timing plate.

3. Idling Speed Adjustment

Gasoline Carburetor



(1) Let engine warm up until the engine coolant temperature rises to 80 to 95°C (176 to 203°F)

(2) Back off the mixture adjussting screw (MAS) 3.5±0.5 turns.

(3) Adjust the engine speed to the specified low idling speed with the speed adjusting screw (SAS).
standard value : 700±25rpm

(4) Slowly turn down the mixture adjusting screw(MAS) to a point where the engine speed begins to decrease.

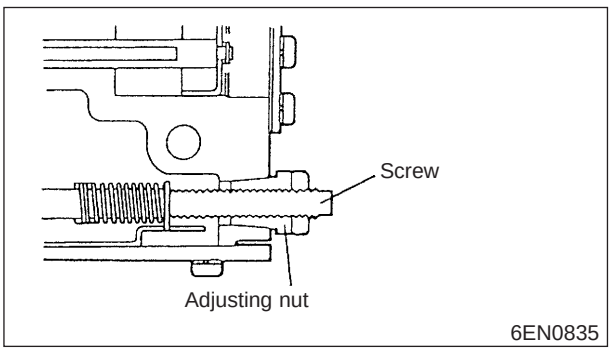
(5) After racing the engine two or three times (at approx .2500 rpm), re-adjust the speed adjusting screw to the point at which the engine rust at the specified idling speed.

LP Gas Carburetor

See “Tests & Adjustments” of LP Fuel System Section.

4. Air Governor Adjustment

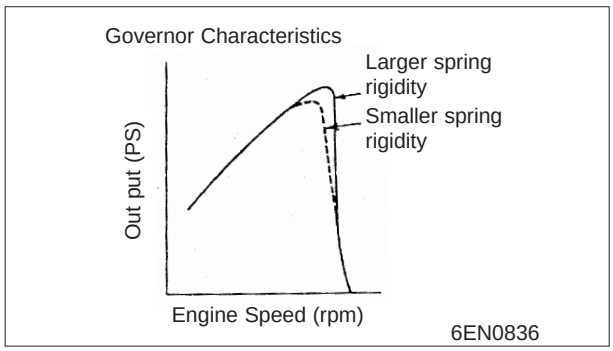
High speed adjustment



(1) Place all the hydraulic levers in the neutral position.
(2) Depress the accelerator pedal all the way. (The carburetor throttle valve will open fully.)
(3) While holding the adjust screw to prevent it from turning, rotate the adjusting nut either clockwise or counterclockwise to make the engine run at 2700 ± 50 rpm.

Adjusting nut:
Clockwise rotation
Increases the engine speed (increases the installed load of spring).
Counterclockwise rotation
Decreases the engine speed (decreases the engine installed load of spring).

5. Anti-Hunting Adjustment



(1) Place all the hydraulic levers or powertrain in the neutral position.
(2) Depress the accelerator pedal all the way. (The carburetor throttle valve will open fully.)
(3) Slowly rotate the adjusting screw clockwise until hunting disappears.

Adjusting screw:
Clockwise rotation
Increases spring tension (reduces the number of active turns of spring).
Counterclockwise rotation
Reduces spring tension (increases the number of active turns of spring).

Increasing the spring tension will eliminate hunting, but an excessively high tension will change the governor characteristics and produce some effects on the output characteristics of the engine. It is, therefore, imperative to limit the movement of the adjusting screw to less than two turns from the standard position.
(4) Clockwise rotation of the adjusting screw raises the engine maximum speed. Rotate the push nut counterclockwise to reduce the speed.
(5) Repeat anti-hunting adjustment two or three times by alternately adjusting the push nut and the adjusting screw until the best result is obtained.
(6) The number of active turns of spring should be around 13~15 when the adjustment is finished.

Troubleshooting

Engine Performance

Symptom	Cause
1. Poor engine idle.	A. Clogged air breather. B. Improper idle-fuel mixture adjustment. C. Cap or spark-plug wires arcing. D. Low grade fuel. E. Incorrect ignition timing. F. Spark plugs (fouled, burned, cracked porcelain). G. Spark plug wires broken or faulty insulation. H. Defective coil. I. Cracked or dirty distributor cap. J. Dirty carburetor. K. Leak at intake manifold or carburetor base. L. Low compression. (Check for blown head gasket). M. Loose or worn distributor. N. Head gasket, exhaust manifold, cracked head or valve seat.
2. Poor engine acceleration.	A. Idle mixture screw. B. Incorrect ignition timing. C. Incorrect distributor advance curve. D. Cracked or dirty distributor cap or rotor. E. Vacuum leak on the intake manifold or carburetor base. F. Spark plugs (fouled, burned, wrong heat range, cracked porcelain). G. Dirty carburetor. H. Low compression.

Engine Starting Problems

The following information will help to locate the starting problem:

1. Determine which engine system is causing the problem. To make an engine run, basic components - fuel, spark (ignition) and compression - are required. If all three components are present, the engine should run. If any one of the three is missing, weak or arriving at the wrong time, the engine will not run.

2. Determine if there is fuel present.

3. Check ignition system operation. Using appropriate spark tester, check for spark at coil and at each spark plug. If there is a spark at the spark plug wires, remove the spark plugs and make sure they are the correct type and heat range, and not fouled or burned.

4. Run a compression check on the engine to make sure it is mechanically sound.

Engine Starting Problems (Continued)

Symptom	Cause
1. No spark.	A. Distributor cap or spark plug leads arcing. B. Spark plugs fouled, burned or cracked porcelain. C. Spark plug wires are broken or have faulty insulation. D. Battery, electrical connections, damaged wiring. E. Ignition switch. F. Faulty ignition components. G. Cracked or dirty distributor cap. H. Shorted tachometer. (Disconnect tachometer and try again).
2. Engine will not crank over.	A. Battery charge low, damaged wiring or loose electrical connections. B. Circuit breaker tripped (if equipped). C. Bad ignition switch. D. Bad starter solenoid. E. Defective starter motor.

Charging System Problems

Symptom	Cause
1. Gauges indicate no battery charge.	A. Loose or broken drive belt. B. Loose or corroded electrical connections. C. Faulty ammeter or voltmeter. D. Battery will not accept charge. E. Faulty alternator or regulator.
2. Noisy alternator.	A. Loose mounting bolts. B. Worn, frayed or loose drive belt. C. Loose drive pulley. D. Worn or dirty bearings. E. Faulty diode trio or stator.

Instrument Problems

Symptom	Cause
1. Malfunctioning instruments or gauges.	A. Faulty wiring, loose or corroded terminals. B. Bad key switch. C. Faulty gauge. D. Faulty sender.

Engine Noise

No definite rule or test will positively determine the source of engine noise. Therefore, use the following information only as a general guide to engine noise diagnosis.

1. Use a timing light to determine if noise is timed with engine rpm or one-half engine rpm. Noises timed with engine rpm are related to crankshaft, rods, pistons, piston pins or flywheel. Noises timed to one-half engine rpm are valve-train related.

2. The use of a stethoscope can aid in locating a noise source. However, because noise will travel to other metal parts not involved in the problem, caution must be exercised.

3. If noise is believed to be confined to one particular cylinder, ground the spark plug leads one at a time. If noise lessens noticeably or disappears, it is isolated to that particular cylinder.

4. Try to isolate the noise to location in engine, front to back, top to bottom. This can help determine which components are at fault.

5. Sometimes noises can be caused by moving parts coming in contact with other components. Examples are: flywheel, crankshaft striking (pan and pan baffle), rocker arm striking valve cover or loose flywheel cover. In many cases, if this is found to be the problem, a complete engine teardown is not necessary.

6. When noise is isolated to a certain area and component, removal and inspection will be required. Refer to proper sections of service manual for pertinent information.

Symptom	Cause
1. Noise around the valve cover area.	A. Rocker arm striking valve cover. B. Rocker arm out of adjustment. C. Worn rocker arm. D. Bent push rod. E. Collapsed lifter.
2. Noise around the cylinder area.	A. Sticking valve. B. Carbon build-up. C. Connecting rod installed wrong. D. Bent connecting rod. E. Piston. F. Piston rings. G. Piston pin. H. Cylinder worn.
3. Noise around camshaft area (throughout engine).	A. Loss of oil pressure. B. Valve lifters. C. Cam bearings.
4. Noise in camshaft area area (front of engine).	A. Camshaft timing gear. B. Timing Belt. C. Valve lifter. D. Cam bearings.

Engine Noise (Continued)

Symptom	Cause
5. Noise in camshaft area (center of engine).	A. Valve lifter. B. Cam bearings.
6. Noise in camshaft area (rear of engine).	A. Valve lifter. B. Cam bearings.
7. Noise in crankshaft area (throughout engine).	A. Loss of oil pressure. B. Main bearings. C. Rod bearings.
8. Noise in crankshaft area (front of engine).	A. Crankshaft timing gear. B. Timing Belt. C. Main bearing. D. Rod bearing.
9. Noise in crankshaft area (center of engine).	A. Crankshaft striking pan or pan baffle. B. Main bearing. C. Rod bearing.
10. Noise in crankshaft area (rear of engine).	A. Loose flywheel. B. Drive plate. C. Main bearing. D. Rod bearing.
11. Engine spark knock.	A. Advanced timing. B. Low quality fuel. C. Engine running hot. D. Carbon deposits in engine.
12. Popping through carburetor.	A. Wrong ignition timing. B. Carburetor set too lean. C. Faulty accelerator pump (gasoline). D. Vacuum leak. E. Valve adjustment. F. Valve timing. G. Burned or stuck valve.
13. Hissing.	A. Vacuum leak. B. Leaking exhaust (manifolds or pipes). C. Loose cylinder heads. D. Blown head gasket.
14. Whistle.	A. Vacuum leak. B. Dry or tight bearing in an accessory.
15. Sparks jumping.	A. Defective high-tension cables. B. Cracked coil tower. C. Cracked distributor cap.
16. Squeaks or squeals.	A. Drive belt slipping. B. Dry or tight bearing in an accessory. C. Parts rubbing together.

Oil Pressure Diagnostics

The following table contains important information for the checking of oil pressure.

Condition	Information
1. Measuring oil pressure.	Use a good automotive oil pressure test gauge. Do not rely on the oil pressure gauge in the instrument panel.
2. Check engine oil level.	Oil level should be between the "MIN" and "MAX" marks.
3. Oil level in crankcase above "MAX" mark.	May cause loss of engine speed, oil pressure gauge fluctuation, drop in oil pressure and hydraulic valve lifter noise at high RPM.
4. Oil level in crankcase	Low oil pressure, oil pressure gauge fluctuation, internal below at or below "MIN" mark. engine noise and/or damage.
5. Change in oil pressure.	This may be a normal condition. Oil pressure may read high in the cooler times of the day and when engine is not up to operating temperature. As the air temperature warms up and the engine is running at normal operating temperature, it is normal for oil pressure to drop off slightly.
6. Low engine oil pressure	With modern engines and engine oils, low oil pressure readings at idle or high rpm do not necessarily mean there is a problem. If valve lifters do not "clatter" (at idle), there is a sufficient volume of oil to lubricate all internal moving parts properly. The reason for the drop in oil pressure is that engine heat causes an expansion of the internal tolerances in the engine and, the oil will thin out somewhat from heat.
7. Engine-to-engine variance.	It is not uncommon to see different oil pressure readings between like engines, as long as they fall within specifications. Differences in oil pressure can be attributed to differences in engine tolerances, gauges, wiring, senders, etc.

Oil Pressure Problems

Symptom	Cause
1. Low oil pressure.	A. Low oil level in crankcase. B. Defective oil-pressure gauge and/or sender. C. Oil broken down, contains water, wrong viscosity, engine running too hot or too cold, excessive idling with cold water (condensation). D. Relief valve stuck open, pickup tube restricted, worn parts in oil pump, air leak on suction side of oil pump or pickup tube. E. Oil passage plugs leaking, cracked or porous cylinder block. F. Excessive bearing clearance.
2. High oil pressure.	A. Wrong viscosity, oil full of sludge or tar. B. Defective oil pressure gauge and/or sender. C. Clogged or restricted oil passage. D. Oil pump relief valve stuck closed.

IMPORTANT: Oil pressure slightly higher than normal does not always indicate a problem.
Tolerance stack-up In the engine, oil viscosity or weather conditions could cause high oil pres-sure.

3. Excessive oil consumption.	A. Oil leaks. B. Oil diluted or of the wrong viscosity. C. Oil level too high. D. Drain holes in cylinder head plugged causing flooding of valve guides. E. Defective valve seals. F. Intake manifold gasket leaking, worn valve stem or valve guides. G. Defective oil cooler (if so equipped). H. Glazed, scuffed, worn, stuck, improperly installed; ring grooves worn; improper break-in; wrong end gap. I. Piston out-of-round, scored, tapered, glazed; excessive piston-to-cylinder clearance; cracked piston.

Water in Engine

Determine location of water in engine. This information is necessary to determine where the water came from and how it got into the engine. The most common problems are water on top of pistons and/or water in crankcase oil.

1. After locating the water, remove all the water from the engine by removing all spark plugs and pump cylinders by cranking engine over. Next change oil and filter. Start engine and see if problem can be duplicated. If so, there is more than likely a mechanical problem. If problem cannot be duplicated, it is either an operator error or a problem that exists only under certain environmental conditions.

2. If water is confined to cylinders, it is usually entering through the intake system, exhaust system or head gasket.

3. If the water is confined to crankcase, it is usually caused by a cracked or porous block or condensation.

4. If the water is located in both the cylinders and the crankcase, it is usually caused by water in the cylinders getting past the rings and valves.

5. Checking for rust in the intake manifold or exhaust manifolds is a good idea. Rust in these areas will give clues if the water entered through these areas.

Symptom	Cause
1. Water found on top of the pistons.	A. Cracked exhaust manifold (water cooled). B. Improper manifold-to-elbow gasket installation (water cooled). C. Loose cylinder head bolts. D. Blown cylinder head gasket. (Check for warped cylinder head or cylinder block). E. Cracked valve seat. F. Porous or cracked casting (check engine).
2. Water found in the crankcase oil.	A. Water seeping past piston rings or valves. B. Engine running cold (defective thermostat) causing condensation. C. Intake manifold leaking near a water passage. D. Cracked or porous casting.

Engine Overheating

Symptom	Cause
1. Mechanically related.	A. Engine rpm below specification for W.O.T. (engine laboring). B. Wrong ignition timing. C. Spark plug wires crossed (wrong firing order). D. Lean fuel mixture. E. Wrong heat range spark plugs. F Exhaust restriction. G. Valve timing off caused by a jumped or improperly installed timing chain and/or gears. H. Blown head gasket(s). I. Insufficient lubrication to moving parts of engine.
2. Cooling system related.	A. Loose or broken drive belt. B. Water shut-off valve partially or fully closed (if equipped). C. Clogged or improperly installed water strainer (if equipped). D. Water inlet hose kinked or collapsed. E. Water pickup clogged. F. Defective thermostat. G. Obstruction in cooling system such as casting flash, sand, or rust. H. Engine circulating pump defective. I. Low coolant level. J. Antifreeze not mixed properly. K. Heat exchanger cores plugged.

LP Fuel System (Standard and/or Low Emission Version)

Problem	Probable Cause	Probable Solution
Will Not Start/FCV Staying On	Fuel container empty	Fill fuel container • Do not exceed 80% of liquid capacity.
	Liquid valve closed	Open liquid valve slowly
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for click sound • Open valve slowly
	Plugged fuel line	Remove obstruction from fuel line • Close liquid fuel valve • Using caution, disconnect fuel line • Clear obstruction with compressed air • Re-connect fuel line • Leak test
	Clogged fuel filter	Repair/replace as required • Close liquid fuel valve • Using caution, disconnect fuel line • Remove/replace filter element • Clean fuel filter housing • Open liquid fuel valve • Leak test
	Faulty vapor connection between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight • Watch for kinked and/or pinched and/or collapsed hose
	Fuel lock malfunction	• Check circuit wiring • Check safety switch • Check fuelock • Repair/replace fuelock as required
	Pressure regulator malfunction	Test pressure regulator operation • Use test kit • Install primary pressure gauge • Install secondary pressure gauge • Crank engine and observe readings on pressure gauges • Compare readings to specifications • If readings are out of spec repair/replace pressure regulator
Will Not Start/FCV Staying On	Carburetor malfunction	Check carburetor •Remove air/gas valve assembly • Clean air/gas valve and carb throat • Check diaphragm for holes/damage • Check air/gas valve for wear/damage • Repair/replace as required
	Air filter plugged	Check air filter • Clean/replace as required
	No spark	Check for spark • See, lgnition system sectiom • Repair/replace as required
	Engine Mechanical	See Troubleshooting section

Problem	Probable Cause	Probable Solution
Difficult to Start	Fuel container almost empty	LPG vapor from liquid outlet • Fill fuel container • Do not exceed 80% of liquid capacity
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for click sound • Open valve slowly
	Clogged fuel filter	Repair/replace as required • Close liquid fuel valve • Using caution, disconnect fuel line • Remove/replace filter element • Clean fuel filter housing • Open liquid fuel valve • Leak test
	Plugged fuel line	Remove obstruction from fuel line • Close liquid fuel valve • Using caution, disconnect fuel line • Clear obstruction with compressed air • Re-connect fuel line • Leak test
	Faulty vapor connection between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight • Watch for kinked and/or pinched and/or collapsed hose
	Pressure regulator malfunction	Test pressure regulator operation • Use test kit • Install primary pressure gauge • Install secondary pressure gauge • Crank engine and observe readings on pressure gauges • Compare readings to specifications • If readings are out of specrepair/replace pressure regulator
	Air filter clogged	Check air filter • Clean/replace as required
	Engine Mechanical	See Troubleshooting section

Problem	Probable Cause	Probable Solution
Won't Run Continuously	Fuel container almost empty	LPG vapor from liquid outlet • Fill fuel container • Do not exceed 80% of liquid capacity
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for click sound • Open valve slowly
	Clogged fuel filter	Repair/replace as required • Close liquid fuel valve • Using caution, disconnect fuel line • Remove/replace filter element • Clean fuel filter housing • Open liquid fuel valve • Leak test
	Plugged fuel line	Remove obstruction from fuel line • Close liquid fuel valve • Using caution, disconnect fuel line • Clear obstruction with compressed air • Re-connect fuel line • Leak test
	Faulty vapor connection between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight • Watch for kinked and/or pinched and/or collapsed hose
	Pressure regulator freezes	Check level in cooling system • Must be full Check coolant strength • -35F minimum Check coolant hoses • Watch for kinks and/or pinched hoses • Verify one pressure hose and one return hose
	Incorrect idle speed	Check idle speed • Adjust idle speed to specification
	Engine Mechanical	See Troubleshooting section
Won't Accelerate/Hesitation During Acceleration	Fuel container almost empty	LPG vapor from liquid outlet • Fill fuel container • Do not exceed 80% of liquid capacity
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for click sound • Open valve slowly
	Clogged fuel filter	Repair/replace as required • Close liquid fuel valve • Using caution, disconnect fuel line • Remove/replace filter element • Clean fuel filter housing • Open liquid fuel valve • Leak test

Problem	Probable Cause	Probable Solution
Won't Run Continuously Accelerate/Hesitation During Acceleration	Faulty vapor connection between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight • Watch for kinked and/or pinched and/or collapsed hose
	Throttle butterfly not opening	Verify wide open throttle
	Incorrect full load air/fuel duty	Verify full load air/fuel duty cycle cycle
	Engine Mechanical	See Troubleshooting section
	Idle duty cycle too high (above 50%)	Correct/adjust hardware failure
Engine Stalls	Fuel container almost empty	LPG vapor from liquid outlet • Fill fuel container • Do not exceed 80% of liquid capacity
	Excess flow valve closed	Reset excess flow valve • Close liquid valve • Wait for click sound • Open valve slowly
	Clogged fuel filter	Repair/replace as required • Close liquid fuel valve • Using caution, disconnect fuel line • Remove/replace filter element • Clean fuel filter housing • Open liquid fuel valve • Leak test
	Plugged fuel line	Remove obstruction from fuel line • Close liquid fuel valve • Using caution, disconnect fuel line • Clear obstruction with compressed air • Re-connect fuel line • Leak test
	Faulty vapor connectionr between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight • Watch for kinked and/or pinched and/or collapsed hose
	Vacuum leak	Check for vacuum leaks • Between carburetor and intake manifold • Between intake manifold and cylinder head
	Fuel lock malfunction	• Check circuit wiring • Check safety switch • Check fuelock • Repair/replace fuelock as required

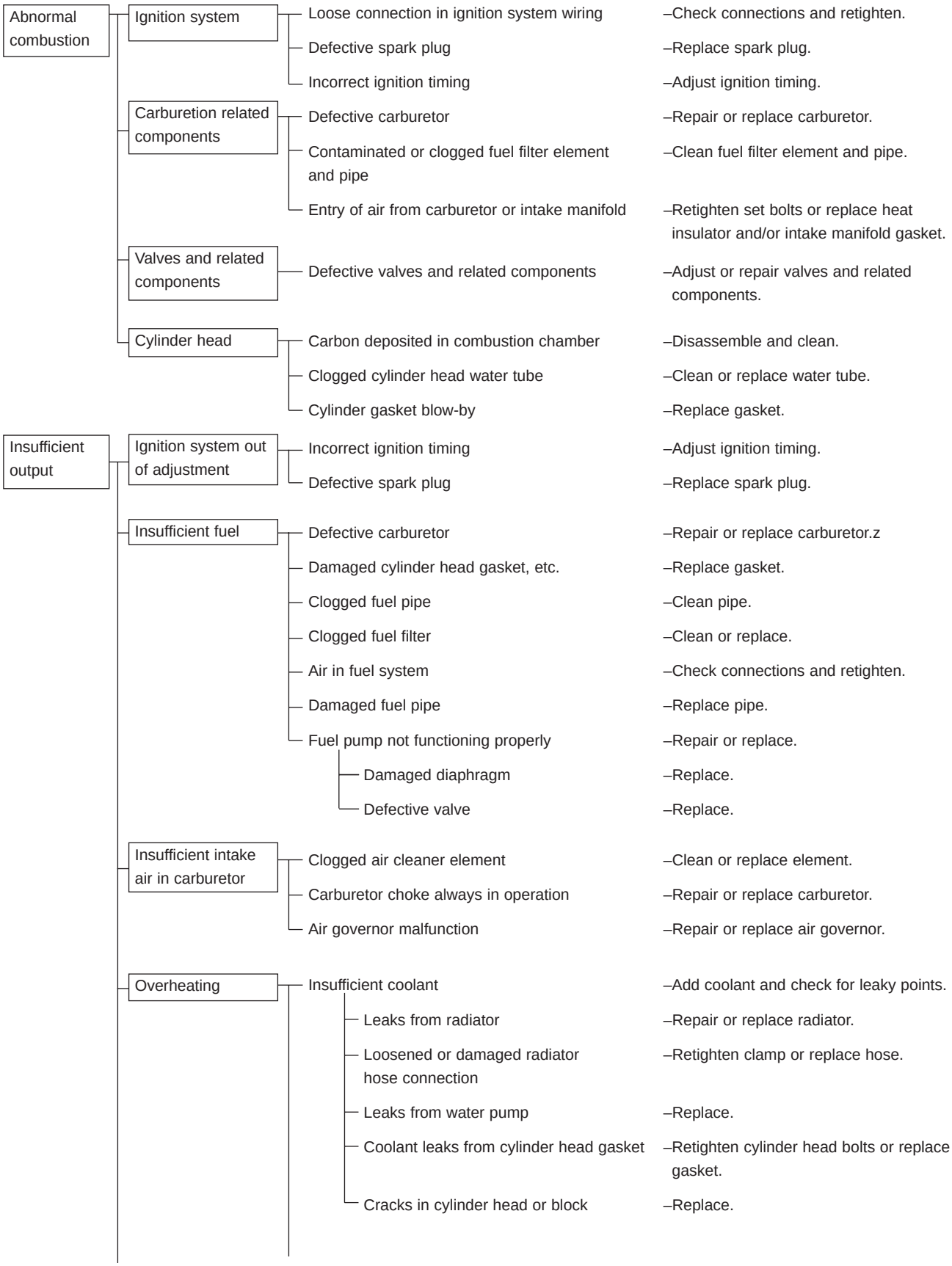
Problem	Probable Cause	Probable Solution
Engine Stalls	Pressure regulator malfunction	Test pressure regulator operation • Use test kit • Install primary pressure gauge • Install secondary pressure gauge • Crank engine and observe readings on pressure gauges • Compare readings to specifications • If readings are out of spec repair/replace pressure regulator
	Pressure regulator freezes	Check level in cooling system • Must be full Check coolant strength • -35F minimum Check regulator mounting position • Must be below top of radiator Check coolant hoses • Watch for kinks and/or pinched hoses • Verify one pressure hose and one return hose
	Faulty vapor connection between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight • Watch for kinked and/or pinched and/or collapsed hose
	Carburetor malfunction	Check carburetor • Remove air/gas valve assembly • Clean air/gas valve and carb throat • Check diaphragm for holes/damage • Check air/gas valve for wear/damage • Repair/replace as required
	Engine Mechanical	See Troubleshooting section
Rough Idle/Weak Ignition/Lean Condition	Incorrect idle speed setting	Check idle speed and adjust if necessaly
	Incorrect full load air/fuel duty cycle	Verify full load air/fuel duty cycle
	Faulty vapor connection between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight * Watch for kinked and/or pinched and/or collapsed hose
	Vacuum leaks	Check for vacuum leaks • Between carburetor and intake manifold • Between intake manifold and cylinder head
	Engine mechanical	See Troubleshooting section
High Idle Speed	Incorrect idle speed setting	Check idle speed • Adjust idle speed
	Sticking throttle	Check throttle • Repair replace as required
	Engine mechanical	See Troubleshooting section

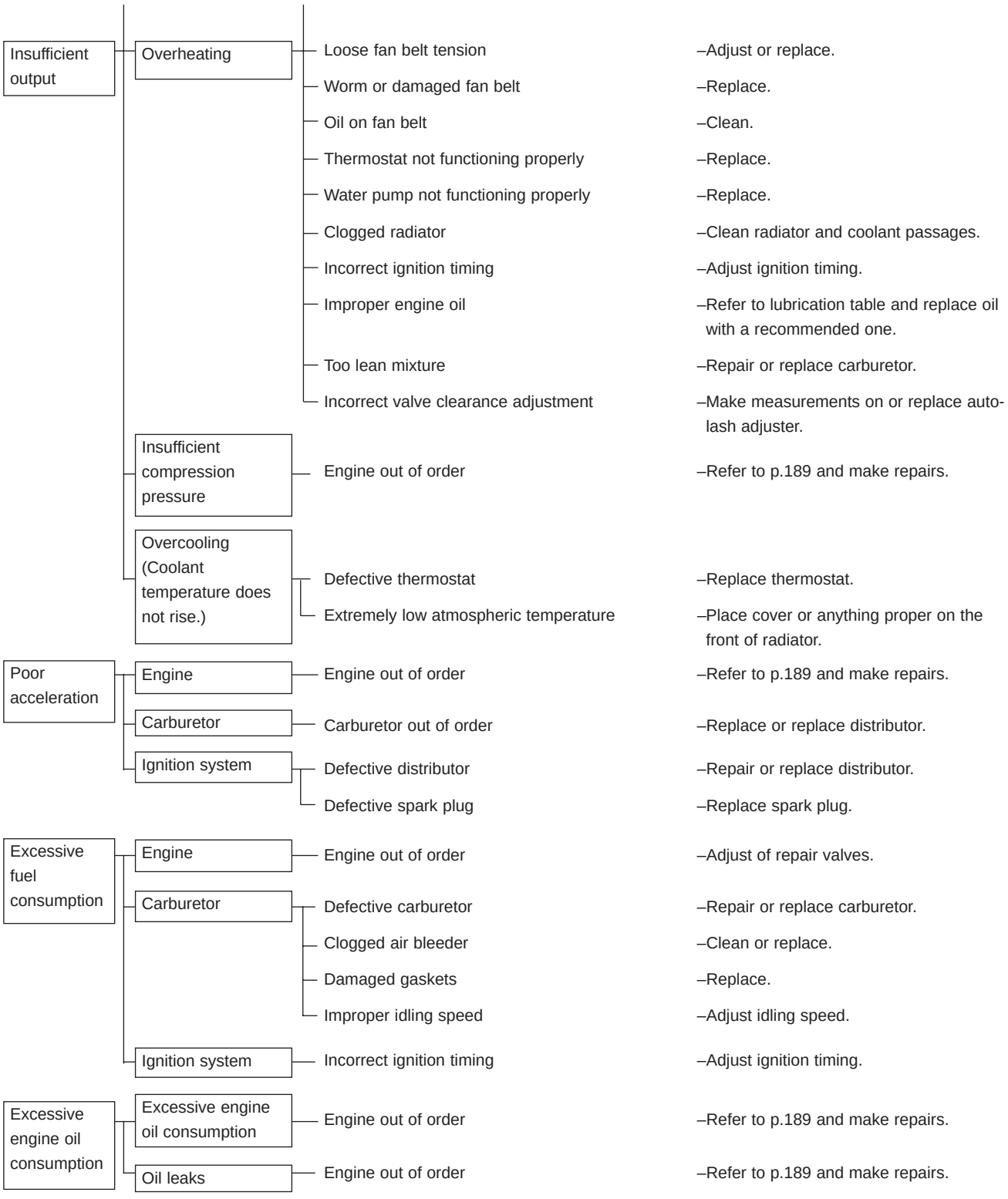
Problem	Probable Cause	Probable Solution
Carburetor Backfire	Incorrect full load air/fuel duty cycle	Verify full load air/fuel duty
	Faulty vapor connection between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight • Watch for kinked and/or pinched and/or collapsed hose
	Ignition malfunction	Check ignition system, repair/replace
	Incorrect ignition timing setting	Check ignition timing • Measure initial timing • Measure centrifugal timing advance
	Engine mechanical	See Troubleshooting section
Poor High Speed Performance/Lean Condition	Clogged fuel filter	Repair/replace as required • Close liquid fuel valve • Using caution, disconnect fuel line • Remove/replace filter element • Clean fuel filter housing • Open liquid fuel valve • Leak test
	Plugged fuel line	Remove obstruction from fuel line • Close liquid fuel valve • Using caution, disconnect fuel line • Clear obstruction with compressed air • Re-connect fuel line • Leak test
	Faulty vapor connection between pressure regulator and carburetor	Check connection • No holes in hose • Clamps must be tight • Watch for kinked and/or pinched and/or collapsed hose
	Throttle butterfly not opening	Verify wide open throttle
	Incorrect full load air/fuel duty cycle	Verify full load air/fuel duty cycle
	Carburetor malfunction	Check carburetor • Remove air/gas valve assembly • Clean air/gas valve and carb throat • Check diaphragm for holes/damage • Check air/gas valve for wear/damage • Repair/replace as required
	Pressure regulator malfunction	Test pressure regulator operation • Use test kit • Install primary pressure gauge • Install secondary pressure gauge • Crank engine and observe readings on pressure gauges • Compare readings to specifications • If readings are out of spec repair/replace pressure regulator
	Incorrect ignition timing setting	Check ignition timing • Measure initial timing • Measure centrifugal timing advance
	Air filter clogged	Check air filter • Clean/replace as required

Problem	Probable Cause	Probable Solution
Poor High Speed Performance/Lean Condition	Restricted exhaust system	Check exhaust system • Measure exhaust back-pressure • Compare to specs
	Engine mechanical	See Troubleshooting section
Excessive Fuel Consumption/LPG Exhaust Smell/Closed Loop System Not Working	Carburetor malfunction	Check carburetor • Remove air/gas valve assembly • Clean air/gas valve and carb throat • Check diaphragm for holes/damage • Check air/gas valve for wear/damage • Repair/replace as required
	Incorrect ignition timing setting	Check ignition timing • Measure timing @ low idle • Measure timing advance @ run
	Incorrect full load air/fuel duty cycle	Verify full load air/fuel duty cycle
	Engine mechanical	See Troubleshooting section
	Pressure regulator malfunction	Test pressure regulator operation • Use test kit • Install primary pressure gauge • Install secondary pressure gauge • Crank engine and observe readings on pressure gauges • Compare readings to specifications • If readings are out of spec repair/replace pressure regulator
	Air filter clogged	Check air filter • Clean/replace as required
	Weak ignition miss fire	See ignition system section
	Vacuum Leak	Replace fuel system vacuum hoses
	Fuel pressure too high	Replace/rebuild regulator.
	Exhaust system leaks	Repair exhaust system
	Oxygen sensor failure	Replace/reconnect oxygen sensor
	FCV failure	Replace/reconnect FCV
	Commander failure	Replace/reconnect commander

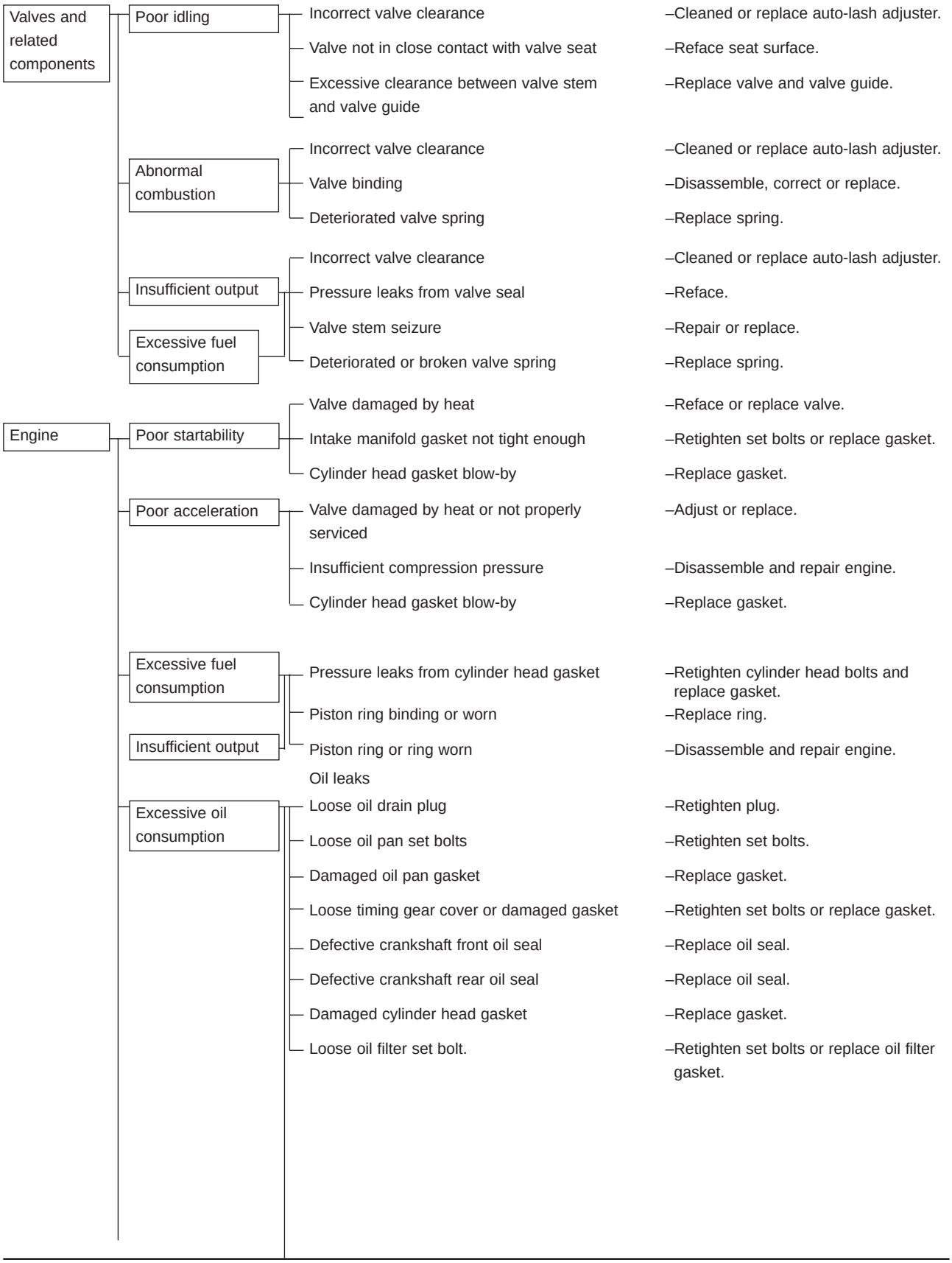
Troubleshooting Flow Chart

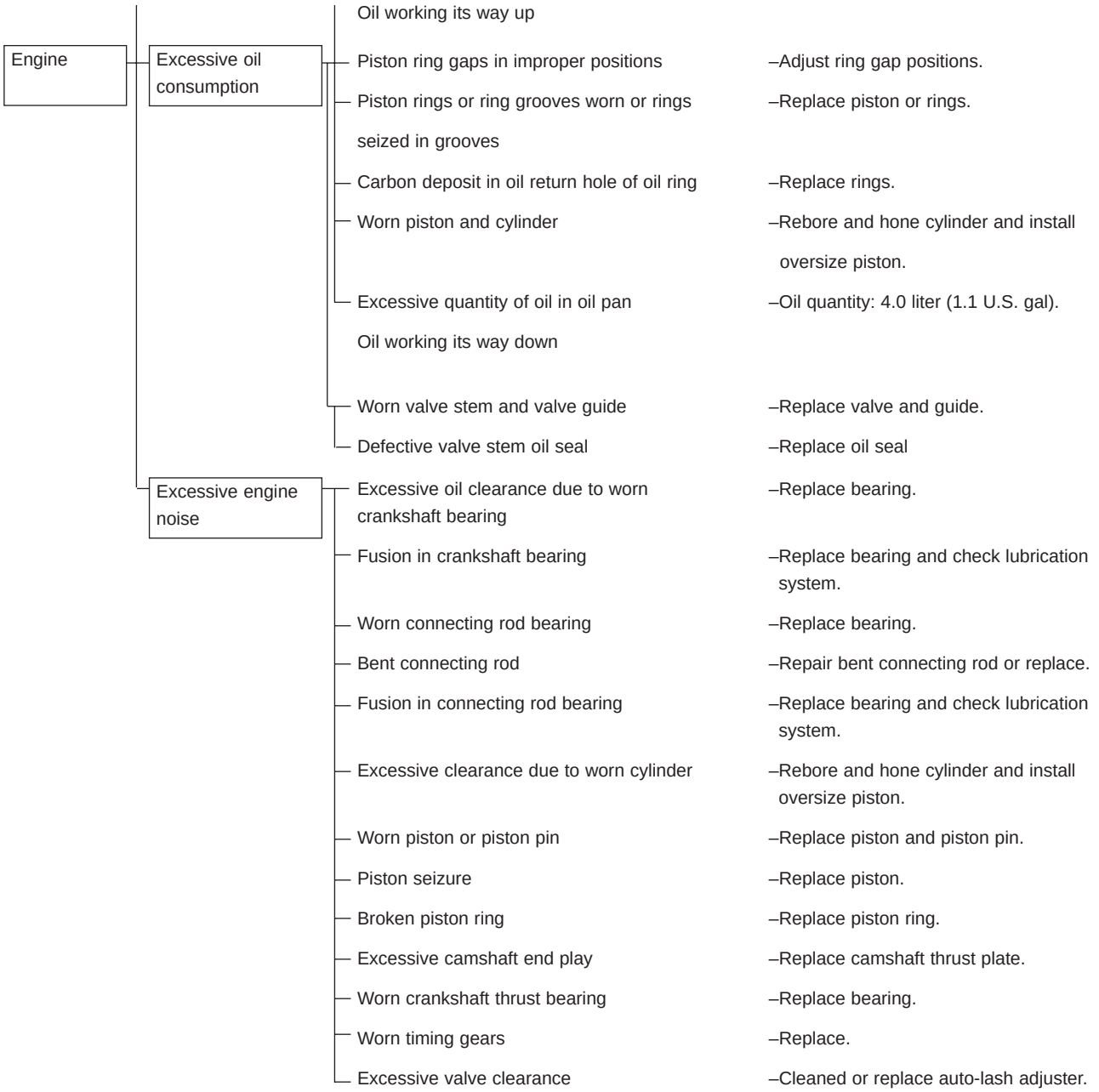
General



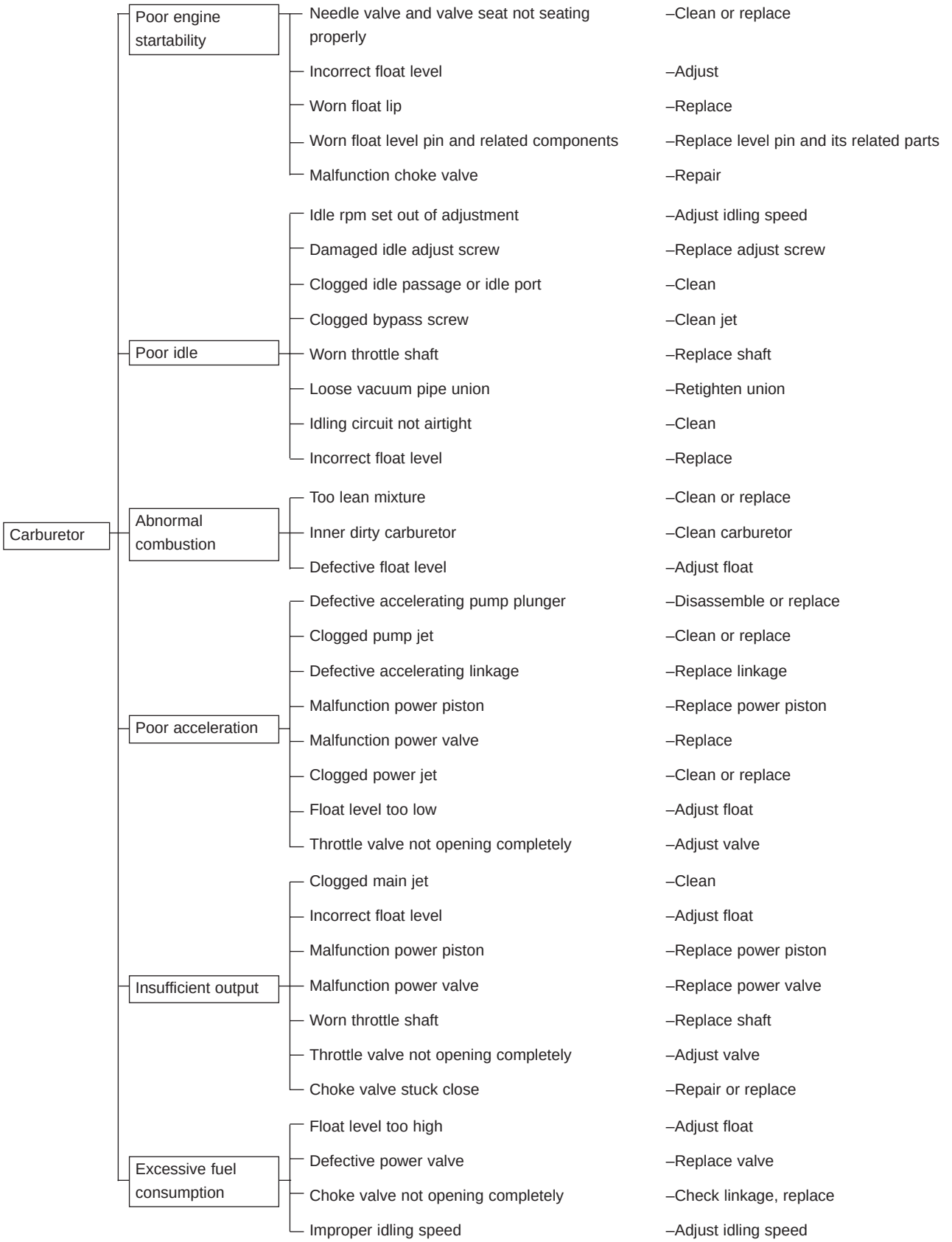

Insufficient output
Overheating
Loose fan belt tension
–Adjust or replace.
Worm or damaged fan belt
–Replace.
Oil on fan belt
–Clean.
Thermostat not functioning properly
–Replace.
Water pump not functioning properly
–Replace.
Clogged radiator
–Clean radiator and coolant passages.
Incorrect ignition timing
–Adjust ignition timing.
Improper engine oil
–Refer to lubrication table and replace oil with a recommended one.
Too lean mixture
–Repair or replace carburetor.
Incorrect valve clearance adjustment
–Make measurements on or replace auto-lash adjuster.
Insufficient compression pressure
Engine out of order
–Refer to p.189 and make repairs.
Overcooling (Coolant temperature does not rise.)
Defective thermostat
–Replace thermostat.
Extremely low atmospheric temperature
–Place cover or anything proper on the front of radiator.
Poor acceleration
Engine
Engine out of order
–Refer to p.189 and make repairs.
Carburetor
Carburetor out of order
–Replace or replace distributor.
Ignition system
Defective distributor
–Repair or replace distributor.
Defective spark plug
–Replace spark plug.
Excessive fuel consumption
Engine
Engine out of order
–Adjust of repair valves.
Carburetor
Defective carburetor
–Repair or replace carburetor.
Clogged air bleeder
–Clean or replace.
Damaged gaskets
–Replace.
Improper idling speed
–Adjust idling speed.
Ignition system
Incorrect ignition timing
–Adjust ignition timing.
Excessive engine oil consumption
Excessive engine oil consumption
Engine out of order
–Refer to p.189 and make repairs.
Oil leaks
Engine out of order
–Refer to p.189 and make repairs.

Base Engine

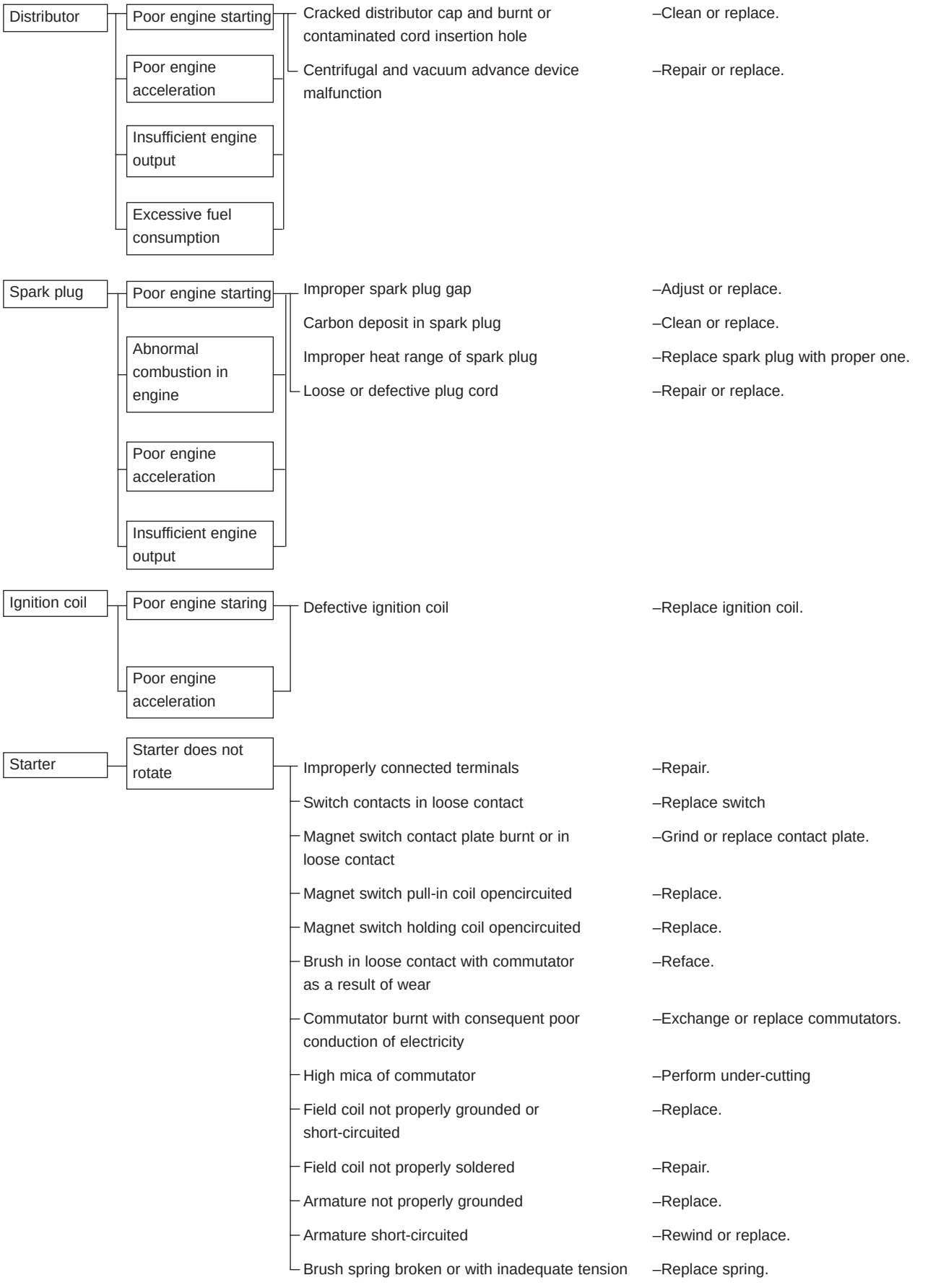

Valves and related components
Poor idling
Incorrect valve clearance
–Cleaned or replace auto-lash adjuster.
Valve not in close contact with valve seat
–Reface seat surface.
Excessive clearance between valve stem and valve guide
–Replace valve and valve guide.
Abnormal combustion
Incorrect valve clearance
–Cleaned or replace auto-lash adjuster.
Valve binding
–Disassemble, correct or replace.
Deteriorated valve spring
–Replace spring.
Insufficient output
Excessive fuel consumption
Incorrect valve clearance
–Cleaned or replace auto-lash adjuster.
Pressure leaks from valve seal
–Reface.
Valve stem seizure
–Repair or replace.
Deteriorated or broken valve spring
–Replace spring.
Engine
Poor startability
Valve damaged by heat
–Reface or replace valve.
Intake manifold gasket not tight enough
–Retighten set bolts or replace gasket.
Cylinder head gasket blow-by
–Replace gasket.
Poor acceleration
Valve damaged by heat or not properly serviced
–Adjust or replace.
Insufficient compression pressure
–Disassemble and repair engine.
Cylinder head gasket blow-by
–Replace gasket.
Excessive fuel consumption
Pressure leaks from cylinder head gasket
–Retighten cylinder head bolts and replace gasket.
Piston ring binding or worn
–Replace ring.
Insufficient output
Piston ring or ring worn
–Disassemble and repair engine.
Oil leaks
Excessive oil consumption
Loose oil drain plug
–Retighten plug.
Loose oil pan set bolts
–Retighten set bolts.
Damaged oil pan gasket
–Replace gasket.
Loose timing gear cover or damaged gasket
–Retighten set bolts or replace gasket.
Defective crankshaft front oil seal
–Replace oil seal.
Defective crankshaft rear oil seal
–Replace oil seal.
Damaged cylinder head gasket
–Replace gasket.
Loose oil filter set bolt.
–Retighten set bolts or replace oil filter gasket.

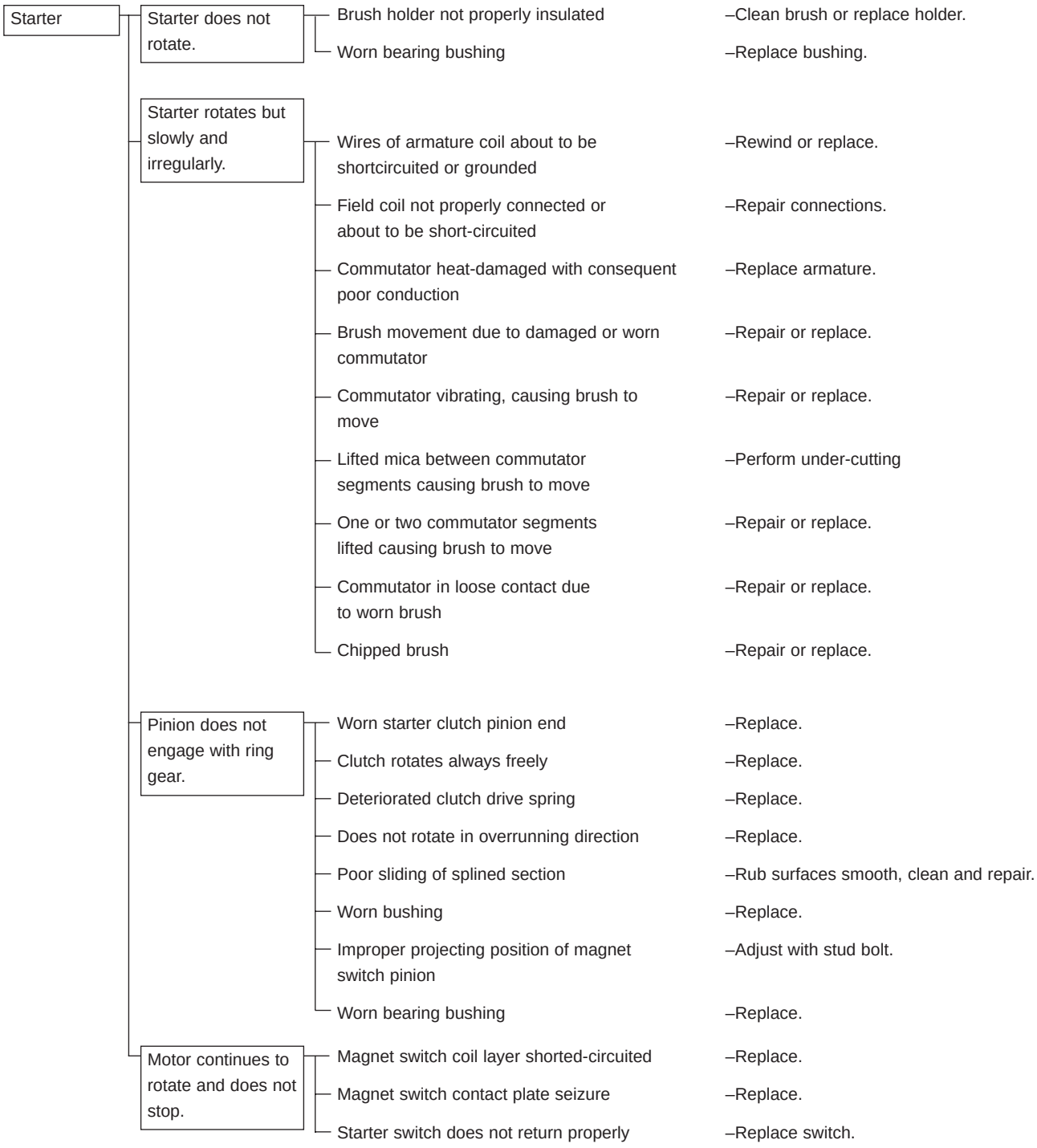

Engine
Excessive oil consumption
Oil working its way up
Piston ring gaps in improper positions
–Adjust ring gap positions.
Piston rings or ring grooves worn or rings seized in grooves
–Replace piston or rings.
Carbon deposit in oil return hole of oil ring
–Replace rings.
Worn piston and cylinder
–Rebore and hone cylinder and install oversize piston.
Excessive quantity of oil in oil pan
–Oil quantity: 4.0 liter (1.1 U.S. gal).
Oil working its way down
Worn valve stem and valve guide
–Replace valve and guide.
Defective valve stem oil seal
–Replace oil seal
Excessive engine noise
Excessive oil clearance due to worn crankshaft bearing
–Replace bearing.
Fusion in crankshaft bearing
–Replace bearing and check lubrication system.
Worn connecting rod bearing
–Replace bearing.
Bent connecting rod
–Repair bent connecting rod or replace.
Fusion in connecting rod bearing
–Replace bearing and check lubrication system.
Excessive clearance due to worn cylinder
–Rebore and hone cylinder and install oversize piston.
Worn piston or piston pin
–Replace piston and piston pin.
Piston seizure
–Replace piston.
Broken piston ring
–Replace piston ring.
Excessive camshaft end play
–Replace camshaft thrust plate.
Worn crankshaft thrust bearing
–Replace bearing.
Worn timing gears
–Replace.
Excessive valve clearance
–Cleaned or replace auto-lash adjuster.

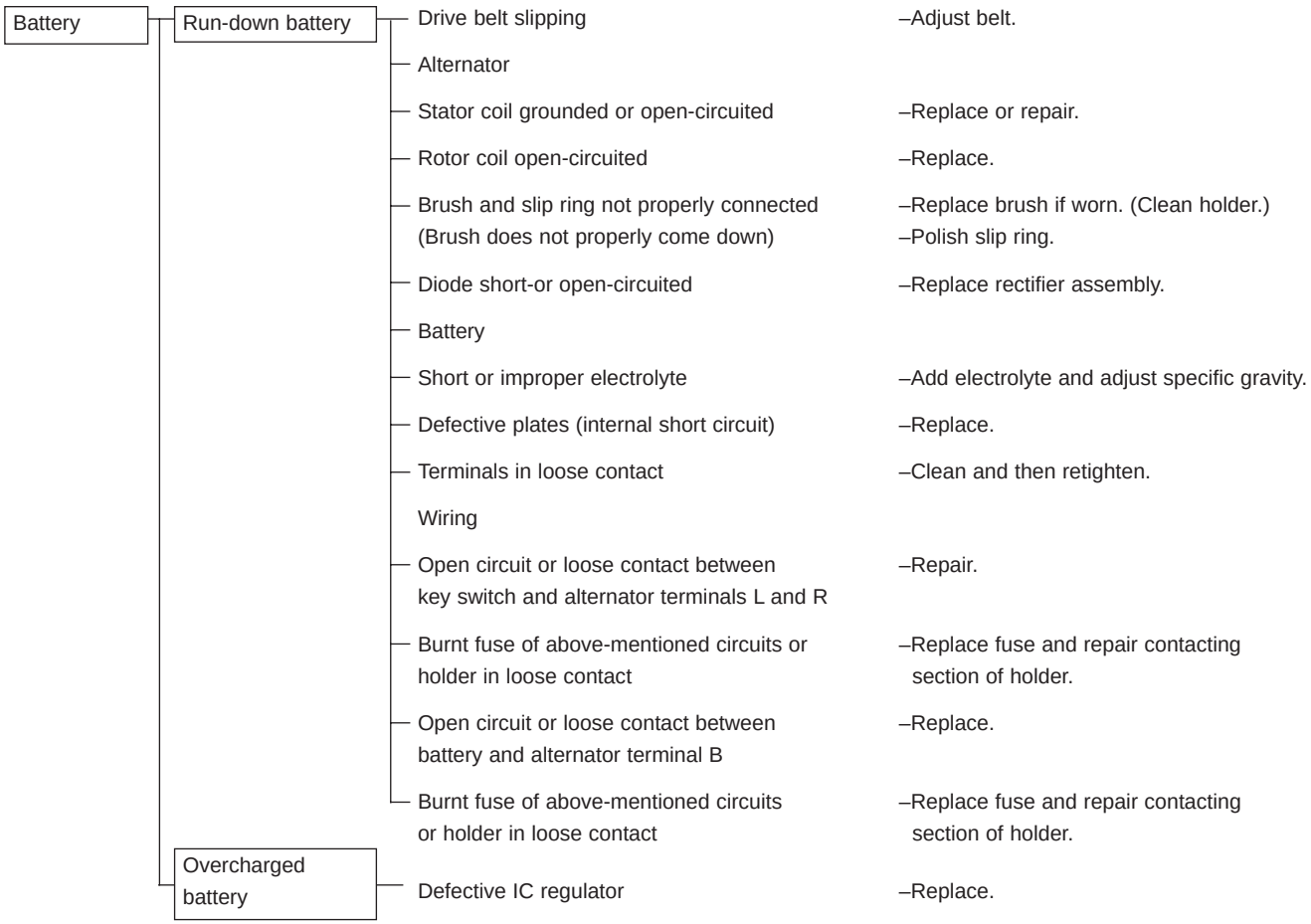
Carburetor


Carburetor
Poor engine startability
Needle valve and valve seat not seating properly
–Clean or replace
Incorrect float level
–Adjust
Worn float lip
–Replace
Worn float level pin and related components
–Replace level pin and its related parts
Malfunction choke valve
–Repair
Poor idle
Idle rpm set out of adjustment
–Adjust idling speed
Damaged idle adjust screw
–Replace adjust screw
Clogged idle passage or idle port
–Clean
Clogged bypass screw
–Clean jet
Worn throttle shaft
–Replace shaft
Loose vacuum pipe union
–Retighten union
Idling circuit not airtight
–Clean
Incorrect float level
–Replace
Abnormal combustion
Too lean mixture
–Clean or replace
Inner dirty carburetor
–Clean carburetor
Defective float level
–Adjust float
Poor acceleration
Defective accelerating pump plunger
–Disassemble or replace
Clogged pump jet
–Clean or replace
Defective accelerating linkage
–Replace linkage
Malfunction power piston
–Replace power piston
Malfunction power valve
–Replace
Clogged power jet
–Clean or replace
Float level too low
–Adjust float
Throttle valve not opening completely
–Adjust valve
Insufficient output
Clogged main jet
–Clean
Incorrect float level
–Adjust float
Malfunction power piston
–Replace power piston
Malfunction power valve
–Replace power valve
Worn throttle shaft
–Replace shaft
Throttle valve not opening completely
–Adjust valve
Choke valve stuck close
–Repair or replace
Excessive fuel consumption
Float level too high
–Adjust float
Defective power valve
–Replace valve
Choke valve not opening completely
–Check linkage, replace
Improper idling speed
–Adjust idling speed

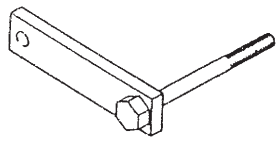
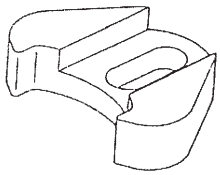
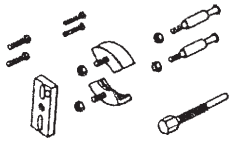
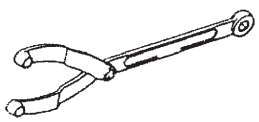
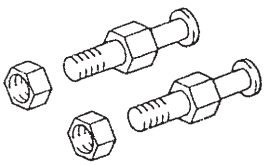
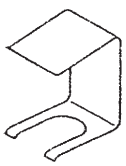
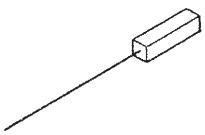
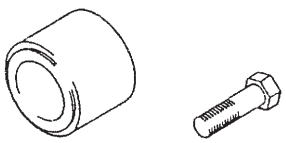
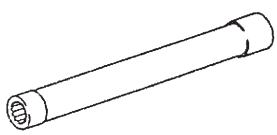
Electrical components

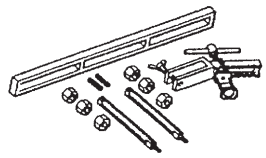
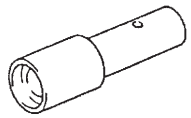
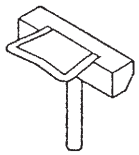
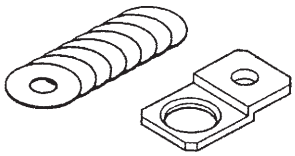
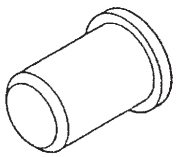
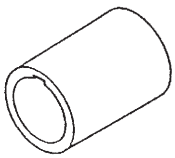
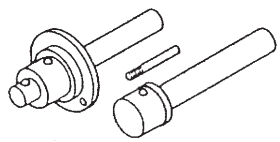
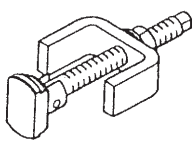


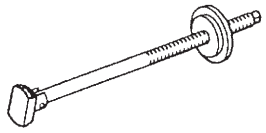
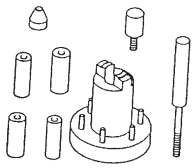
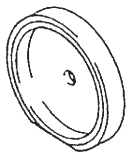
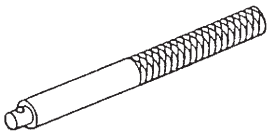

Starter
Starter does not rotate.
Brush holder not properly insulated
–Clean brush or replace holder.
Worn bearing bushing
–Replace bushing.
Starter rotates but slowly and irregularly.
Wires of armature coil about to be shortcircuited or grounded
–Rewind or replace.
Field coil not properly connected or about to be short-circuited
–Repair connections.
Commutator heat-damaged with consequent poor conduction
–Replace armature.
Brush movement due to damaged or worn commutator
–Repair or replace.
Commutator vibrating, causing brush to move
–Repair or replace.
Lifted mica between commutator segments causing brush to move
–Perform under-cutting
One or two commutator segments lifted causing brush to move
–Repair or replace.
Commutator in loose contact due to worn brush
–Repair or replace.
Chipped brush
–Repair or replace.
Pinion does not engage with ring gear.
Worn starter clutch pinion end
–Replace.
Clutch rotates always freely
–Replace.
Deteriorated clutch drive spring
–Replace.
Does not rotate in overrunning direction
–Replace.
Poor sliding of splined section
–Rub surfaces smooth, clean and repair.
Worn bushing
–Replace.
Improper projecting position of magnet switch pinion
–Adjust with stud bolt.
Worn bearing bushing
–Replace.
Motor continues to rotate and does not stop.
Magnet switch coil layer shorted-circuited
–Replace.
Magnet switch contact plate seizure
–Replace.
Starter switch does not return properly
–Replace switch.


Battery
Run-down battery
Drive belt slipping
–Adjust belt.
Alternator
Stator coil grounded or open-circuited
–Replace or repair.
Rotor coil open-circuited
–Replace.
Brush and slip ring not properly connected
–Replace brush if worn. (Clean holder.)
(Brush does not properly come down)
–Polish slip ring.
Diode short-or open-circuited
–Replace rectifier assembly.
Battery
Short or improper electrolyte
–Add electrolyte and adjust specific gravity.
Defective plates (internal short circuit)
–Replace.
Terminals in loose contact
–Clean and then retighten.
Wiring
Open circuit or loose contact between key switch and alternator terminals L and R
–Repair.
Burnt fuse of above-mentioned circuits or holder in loose contact
–Replace fuse and repair contacting section of holder.
Open circuit or loose contact between battery and alternator terminal B
–Replace.
Burnt fuse of above-mentioned circuits or holder in loose contact
–Replace fuse and repair contacting section of holder.
Overcharged battery
Defective IC regulator
–Replace.

SPECIAL TOOLS

Style	Tool No.	Tool name	Use
	MD998781	Flywheel stopper	Holding flywheel
	MD998785	Sprocket stopper	Holding counterbalance shaft sprocket
	MD998778	Crankshaft spocket puller	Removal of crankshaft sprocket
	MB990767	End yoke holder	Holding camshaft sprocket (Use with MD998719)
	MD998719	Pulley holding pins	Holding camshaft sprocket when loosening or torquing bolt (Use with MB990767)
	MD998443	Lash adjuster holder	Retainer for holding lash adjuster in rocker arm at timer of removal and installation of rocker arm and rocker shaft assembly
	MD998442	Air bleed wire	Air bleeding of lash adjuster
	MD998713	Camshaft oil seal installer	Installation of oil seal
	MB991654	Cylinder head bolt wrench(12)	Removal and installation of cylinder head bolt

Style	Tool No.	Tool name	Use
	MD998772	Valve spring compressor	Compression of valve spring
	MD998729	Valve stem seal installer	Installation of valve stem seal
	MD998727	Oil pan remover	Removal of the oil pan
	MD998162	Plug wrench	Removal and installation of front case cap plug
	MD998783	Plug wrench retainer	Removal and installation of front case cap plug (Use with MD998162)
	MD998375	Crankshaft front oil seal installer	Installation of crankshaft front oil seal
	MD998285	Crankshaft front oil seal guide	Guide for installation of crankshaft front oil seal
	MD998705	Silent shaft bearing installer	Installation of counterblance shaft front and rear bearing
	MD998371	Silent shaft bearing puller	Removal of counterblance shaft front bearing

Style	Tool No.	Tool name	Use
	MD998372	Silent shaft bearing puller	Removal of counterbalance shaft rear bearing
	MD998780	Piston pin setting tool	Removal and installation of piston pin
	MD998776	Crankshaft rear oil seal installer	Installation of crankshaft rear oil seal
	MB990938	Handle	Installation of crankshaft rear oil sear (Use with MD998776)

ITK-1 Pressure Gauge Kit

The IMPCO ITK-1 pressure gauge kit is designed for testing and troubleshooting IMPCO gaseous fuel systems. The kit contains the following:

- 0-160 psi gauge - For measuring fuel container pressure or on dual fuel systems it may be used to measure gasoline fuel system pressure.
- 0-5 psi gauge - For measuring IMPCO pressure regulator, primary pressure.
- 0-10” H2O gauge - For measuring IMPCO pressure regulator, secondary pressure.
- G2-2 lever gauge - For correct adjustment of the IMPCO pressure regulator, secondary lever.
- Assorted fittings
- Hose
- Instructions

FSA-1000 Fuel System Analyzer

See instructions for proper usage to check air/fuel mixture.