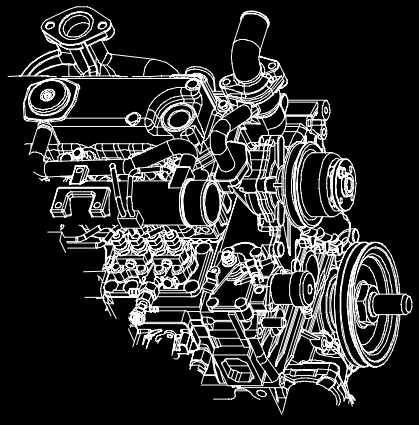
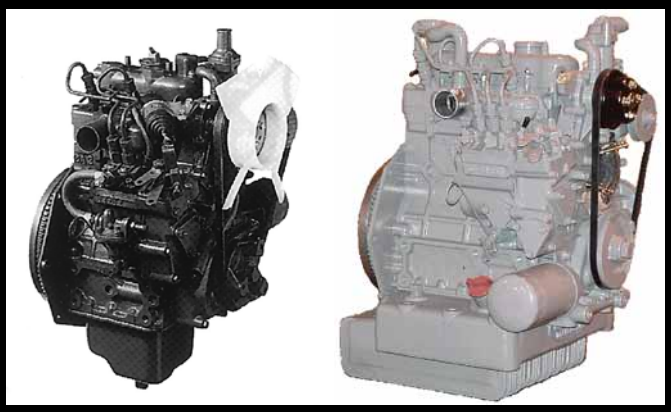
Carrier®

Diesel Engine





WORKSHOP MANUAL

for

CT2-29-TV (Z482-E2B)

Truck / ComfortPro

CT3-44-TV (D722-E2B)

Truck

Beginning With Serial Number 5A0001

62–11161 Rev A

Carrier TRANSICOLD

WORKSHOP MANUAL

DIESEL ENGINE

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SAFETY

SAFETY PRECAUTIONS

Your Carrier Transicold unit has been designed with the safety of the operator in mind. During normal operation, all moving parts are fully enclosed to help prevent injury. During all pretrip inspections, daily inspections, and problem troubleshooting, you may be exposed to moving parts. Please stay clear of all moving parts when the unit is in operation and when the unit main power switch is in the START/RUN position.

Engine Coolant

The engine is equipped with a pressurized cooling system. Under normal operating conditions, the coolant in the engine and radiator is under high pressure and is very hot. Contact with hot coolant can cause severe burns. Do not remove the cap from a hot radiator. If the cap must be removed, do so very slowly in order to release the pressure without spray.

Battery

This unit is equipped with a leadacid type battery. The battery normally vents small amounts of flammable hydrogen gas. Do not smoke when checking the battery. A battery explosion can cause serious physical harm and/or blindness.

SPECIFIC WARNING AND CAUTION STATEMENTS

To help identify the label hazards on the unit and explain the level of awareness each one carries, an explanation is given with the appropriate consequences:

⚠ DANGER

DANGER – warns against an immediate hazard which WILL result in severe personal injury or death.

⚠ WARNING

WARNING – warns against hazards or unsafe conditions which COULD result in severe personal injury or death.

⚠ CAUTION

CAUTION – warns against potential hazard or unsafe practice which could result in minor personal injury, or product or property damage.

NOTE

NOTE – gives helpful information that may help and avoid equipment and property damage.

The statements listed on the next page are specifically applicable to this unit and appear elsewhere in this manual. These recommended precautions must be understood and applied during operation and maintenance of the equipment covered herein.

⚠ WARNING

When removing the radiator cap, wait at least ten minutes after the engine has stopped and cooled down. Otherwise, hot water may discharge from the radiator, scalding anyone nearby.

⚠ WARNING

Check the injection nozzle only after confirming that nobody is near the spray. If the spray from the nozzle contacts the human body, cells may be destroyed and blood poisoning may result.

⚠ CAUTION

Stop the engine when attempting to check and change the fuel line.

⚠ CAUTION

Stop the engine when preparing to change the engine oil.

⚠ CAUTION

Stop the engine when preparing to change the engine oil filter.

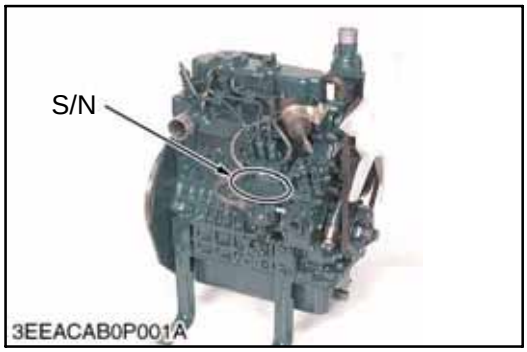
⚠ CAUTION

Secure the starter to prevent it from moving when power is applied to it.

SECTION 1

General

1.1 ENGINE IDENTIFICATION



When contacting Carrier Transicold, always specify your engine model number and serial number.

The engine model and its serial number need to be identified before the engine can be serviced or parts replaced.

Engine Serial Number (S/N)

The engine serial number is an identified number for the engine. It is marked after the engine model number.

It indicates basic model, month, year and sequence of manufacture as follows:

Serial Number

Z482- 7 K A 176

Last 3 Digits in Numerals (1 to 999 Units in Sequence)

7th Digit Sequential Numeral or Letter (Units Manufactured)

Alphabetical Numeral or Letter	0 to 9	A	B	C
Unit Number Sequence	to 19,998	19,999-20997	20,998-21,996	21,997-22,995

6th Digit Alpabetical Letter (Month of Manufacture - 1st Letter 1-9999 Units, 2nd Letter 10,000-19,998 Units)

Alphabetical letter	A,B	C,D	E,F	G,H	J,K	L,M	N,P	Q,R	S,T	U,V	W,X	Y,Z
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

5th Digit Alpabetical Letter or Numerals (Year of Manufacture)

Alphabetical letter or numerals	W	X	Y	1	2	3	4	5	6	7	8	9
Year	98	99	00	01	02	03	04	05	06	07	08	09

Basic model number

Table 1-1. Model Chart

KUBOTA MODEL NO.	CARRIER MODEL NO.	NEW ENGINE PART NO.	PRIMARY USE	REPLACES
Z482-E2B	CT2-29-TV	26-60001-03*	SOLARA Units	26-60001-01
Z482-E2B	CT2-29-TV	26-60001-04*	SUPRA Units	26-60001-02
Z482-E2B-ATC-1	CT2-29-TV	96-101-05K	ProHeat / ComfortPro PC5000 Units	NEW
Z482-E2B-TFX-1	CT2-29-TV	96-101-20K	ComfortPro PC6000 Units	NEW
D722-E2B	CT3-44-TV	26-60000-05*	GENESIS Units	26-60000-00
*** Beginning with Serial Number 5A0001**				

1.2 ENGINE SPECIFICATIONS

Table 1-2. Specification Chart

MODEL NUMBER (Carrier / Kubota)		CT2-29-TV / Z482-E2B	CT3-44-TV / D722-E2B
TYPE		Vertical, Water-cooled, 4 cycle IDI diesel engine	
NUMBER OF CYLINDERS		2	3
BORE X STROKE mm X mm (in. X in.)		67 X 68 (2.64 X 2.68)	
TOTAL DISPLACEMENT cm^3 (cu.in.)		479 (29.23)	719 (43.88)
BRAKE HORSEPOWER	SAE Intermittent H.P. kW (HP) / RPM	9.3 (12.5) / 3600	14.0 (18.0) / 3600
MAXIMUM BARE SPEED RPM		3800	
IDLING SPEED RPM		900 To 1000	
COMBUSTION CHAMBER		Spherical Type (E-TVCS)	
FUEL INJECTION PUMP		Bosch MD Type Mini Pump	
GOVERNOR		Centrifugal Ball Mechanical Governor	
INJECTION NOZZLE		Bosch Throttle-Type	
INJECTION TIMING (before T.D.C.)		19 to 21°	
FIRING ORDER		1-2	1-2-3
INJECTION PRESSURE (Valve Opening Pressure)		13.73 MPa (140 kgf/cm^2, 1991 psi.)	
COMPRESSION RATIO		23.5 : 1	
LUBRICATING SYSTEM		Forced Lubrication by Pump	
COOLING SYSTEM		Pressurized Radiator, Forced Circulation With Water Pump	
STARTING SYSTEM		Cell Starter (With Glow Plug)	
STARTING MOTOR		12V, 0.8 kW	
RECOMMENDED BATTERY CAPACITY (5 Hour Capacity)		12V, 28AH, equivalent	12V, 36AH, equivalent
CHARGING GENERATOR		12V, 150 W	12V, 150 W
FUEL		Diesel Fuel No.2-D (ASTM D975)	
LUBRICATING OIL		*Quality Better Than CF Class (API), SAE 10W-30 or 15W-40	
LUBRICATING OIL CAPACITY		2.5 L (2.64 U.S. Quarts)	3.8 L (4.02 U.S. Quarts)
		3.3 L (3.5 U.S. Quarts) (TFX-1 Only)	
Weight (DRY) kg (lbs.)		53.1 (117.1)	63.1 (139.1)

*See paragraph 1.7.2.

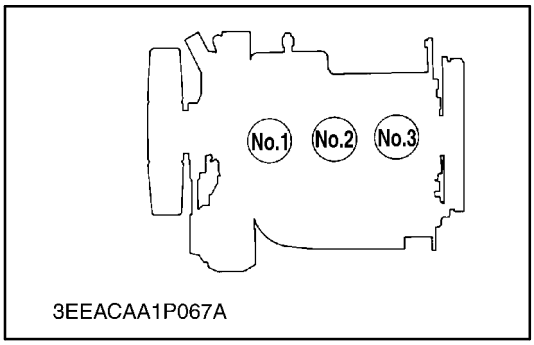
1.2.1 E2B ENGINE

Carrier/Kubota supply diesel engines conforming to federal emission regulations. The emission controls that have been put into effect have been stepped up to the second stage. Carrier/Kubota has executed the improvement in the engines to conform to this regulation.

In order to discriminate between engines conforming to Tier 1 / Phase 1 requirements and those conforming to Tier 2 / Phase 2 requirements, we have adapted E2B as a new model name for the engines conforming to Tier2 / Phase 2 regulations.

In the after-sale services for Tier 2 / Phase 2 engines, only use the dedicated parts for E2B models and carry out the maintenance services accordingly.

1.2.2 CYLINDER NUMBER



The cylinder numbers of diesel engines are designated as shown above. The sequence of cylinder numbers is given as No.1, No. 2, and No. 3 starting from the gear case end of the engine.

1.3 GENERAL PRECAUTIONS

During disassembly, carefully arrange removed parts in a clean area to prevent confusion latter. Screws, bolts and nuts should be replaced in their original position to prevent reassembly errors.

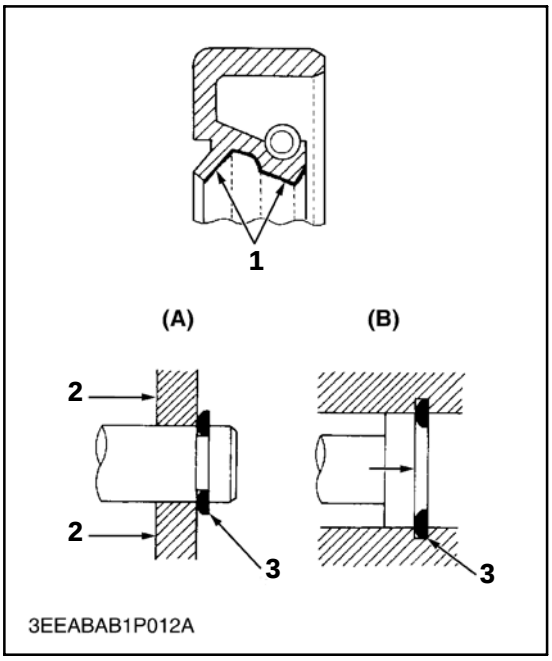
When special tools are required, use Carrier Transicold genuine special tools. Special tools which are not frequently used should be made according to the drawings provided.

Before disassembling or servicing electrical wires, make sure to always disconnect the grounding cable from the battery first.

Remove oil and dirt from parts before taking any measurements.

Use only Carrier Transicold genuine parts for parts replacements to maintain engine performance and to ensure safety.

Gaskets and o-rings must be replaced during reassembly. Apply grease to new o-rings or oil seals before assembling.



1. Grease
2. Force
3. Place the Sharp Edge against the Direction of Force

A External Snap Ring
B Internal Snap Ring

When reassembling external or internal snap rings, position them so that the sharp edge faces against the direction from which force is applied.

A newly serviced or reassembled engine should be run-in with no load for 15 minutes. Serious damage to the engine may result otherwise.

1.4 TORQUE SPECIFICATION

Screws, bolts and nuts must be tightened to the specified torque using a torque wrench. Several screws, bolts and nuts such as those used on the cylinder head must be tightened in the proper sequence and at the proper torque.

1.4.1 Torque Specifications For Special Use Screws, Bolts and Nuts

In removing and applying the screws, bolts and nuts marked with "*", a pneumatic wrench or similar tool, if employed, must be used with care. Failure to do so may result in stripped or seized screws, bolts and nuts.

When replacing "*" marked screws, bolt and nuts, apply engine oil to their threads and seats before reassembly.

The letter "M" in size and pitch means that the screw, bolt or nut dimension is metric. The size is the nominal outside diameter in mm of the threads. The pitch is the nominal distance in mm between two threads.

Item	Size x Pitch	N.m	kgf.m	ft-lbs
Cylinder Head Cover Bolt	M6 x 1.0	6.9 to 11.3	0.7 to 1.15	5.1 to 8.3
Injection Pipe Retaining Nut	M12 x 1.5	24.5 to 34.3	2.5 to 3.5	18.1 to 25.3
Overflow Pipe Retaining Bolt	M12 x 1.5	19.6 to 24.5	2.0 to 2.5	14.5 to 18.1
Nozzle Holder Assembly	M20 x 1.5	49.0 to 68.6	5.0 to 7.0	36.2 to 50.6
Glow Plug	M8 x 1	7.85 to 14.7	0.8 to 1.5	5.8 to 10.8
*Rocker Arm Bracket Bolt	M6 x 1	9.8 to 11.3	1.0 to 1.15	7.2 to 8.3
*Cylinder Head Bolt	M8 x 1.25	37.3 to 42.2	3.8 to 4.3	27.5 to 31.1
*Fan Drive Pulley Bolt	M12 x 1.5	117.7 to 127.5	12.0 to 13.0	86.8 to 94.0
*Idle Gear Shaft Mounting Bolt	M6 x 1	9.8 to 11.3	1.0 to 1.15	7.2 to 8.3
Oil Pump Mounting Bolt	M8 x 1.25	17.7 to 21.6	1.8 to 2.2	13.0 to 15.9
*Connecting Rod Bolt	M7 x 0.75	26.5 to 30.4	2.7 to 3.1	19.5 to 22.4
*Flywheel Bolt	M10 x 1.25	53.9 to 58.8	5.5 to 6.0	39.8 to 43.4
*Bearing Case Cover Mounting Bolt	M6 x 1	9.8 to 11.3	1.00 to 1.15	7.2 to 8.3
*Main Bearing Case Bolt 2	M7 x 1	26.5 to 30.4	2.7 to 3.1	19.5 to 22.4
*Main Bearing Case Bolt 1	M6 x 1	12.7 to 15.7	1.3 to 1.6	9.4 to 11.6
Nozzle Holder	–	34.3 to 39.2	3.5 to 4.0	25.3 to 28.9
Overflow Pipe	–	19.6 to 24.5	2.0 to 2.5	14.5 to 18.1
Nozzle Holder Assembly	–	49.0 to 68.6	5.0 to 7.0	36.2 to 50.6
Oil Pressure Switch	PT1/8	14.7 to 19.6	1.5 to 2.0	10.8 to 14.5
Starter (C Terminal Nut) (CT2-29-TV)	M8	7.8 to 9.8	0.8 to 1.0	5.8 to 7.2
Starter (B Terminal Nut) (CT3-44-TV)	M8	8.8 to 11.8	0.9 to 1.2	6.5 to 8.7
Starter (C Terminal Nut) (CT3-44-TV)	M8	5.9 to 11.8	0.6 to 1.2	4.3 to 8.7
Drain Plug W/ Copper Gasket	M12 x 1.25	32.4 to 37.3	3.3 to 3.8	23.9 to 27.5
Drain Plug W/ Copper Gasket	M22 x 1.5	63.7 to 73.5	6.5 to 7.5	47.0 to 54.2
Drain Plug W/ Rubber Coated Gasket	M12 x 1.25	44.1 to 53.9	4.5 to 5.5	32.5 to 39.8

1.4.2 Torque Specifications For General Use Screws, Bolts and Nuts

	Standard Screw and Bolt Grade 4			Special Screw and Bolt Grade 7		
	N.m	kgf.m	ft-lbs	N.m	kgf.m	ft-lbs
M6	7.9 to 9.3	0.80 to 0.95	5.8 to 6.9	9.8 to 11.3	1.00 to 1.15	7.23 to 8.32
M8	17.7 to 20.6	1.8 to 2.1	13.0 to 15.2	23.5 to 27.5	2.4 to 2.8	17.4 to 20.3
M10	39.2 to 45.1	4.0 to 4.6	28.9 to 33.3	48.1 to 55.9	4.9 to 5.7	35.4 to 41.2
M12	62.8 to 72.6	6.4 to 7.4	46.3 to 53.5	77.5 to 90.2	7.9 to 9.2	57.1 to 66.5

Screw and bolt material grades are shown by numbers punched on the screw and bolt heads. Prior to tightening, be sure to check out the numbers as shown below

Punched Number	Screw And Bolt Material Grade
None or 4	Standard Screw And Bolt SS41, S20C
7	Special Screw And Bolt S43C, S48C (Refined)

1.5 TROUBLESHOOTING

Symptom	Probable Cause	Solution	Reference
Engine Does Not Start	No fuel	Replenish fuel	
	Air in the fuel system	Vent Air	**1.7.5**
	Water in the fuel system	Change fuel and repair or replace fuel system	**1.7.5**
	Fuel pipe clogged	Clean	**1.7.5**
	Fuel filter clogged	Clean or change	**–**
	Excessively high viscosity of fuel or engine oil at low temperature	Use specified fuel or engine oil	**–**
	Fuel with low cetane number	Use specified fuel	**–**
	Fuel leak due to loose injection pipe retaining nut	Tighten retaining nut	**2.2.4.b**
	Incorrect injection timing	Adjust	**5.1.1**
	Fuel camshaft worn	Replace	**2.2.6.g**
	Injection nozzle clogged	Replace	**5.2.1/5.2.2**
	Injection pump malfunctioning	Replace	**–**
	Seizure of crankshaft, camshaft, piston, cylinder or bearing	Repair or Replace	**–**
	Compression leak from cylinder	Replace head gasket, tighten cylinder head screw, glow plug and nozzle holder	**–**
	Improper valve timing	Correct or replace timing gear	**2.2.6.e**
	Piston ring and cylinder worn	Replace	**2.3.3.d**
	Excessive valve clearance	Adjust	**1.7.6**
(Starter Does Not Run)	Battery discharged	Charge	
	Starter malfunctioning	Repair or replace	**6.2/6.3**
	Wiring disconnected	Connect	**–**
Engine Revolution Is Not Smooth	Fuel filter clogged or dirty	Clean or change	**1.7.5**
	Air cleaner clogged or dirty	Clean or change	**–**
	Fuel leak due to loose injection pipe retaining nut	Tighten retaining nut	**–**
	Injection pump malfunctioning	Replace	**2.2.6.a**
	Incorrect nozzle injection pressure	Replace	**5.2.2**
	Injection nozzle stuck or clogged	Replace	**5.2.2**
	Governor malfunctioning	Repair	**2.2.6.g**
Either White or Blue Exhaust Gas Is Observed	Excessive engine oil	Reduce to specified level	**1.7.1**
	Piston ring and liner worn or ring stuck	Repair or replace	**2.3.3.d**
	Incorrect Injection timing	Adjust	**5.1.1**
	Deficient compression	Check the cylinder compression pressure and top clearance	**2.1.1**

1.5 TROUBLESHOOTING (Continued)

Symptom	Probable Cause	Solution	Reference
Either Black or Dark Exhaust Gas Is Observed	Overload	Lesson load	**–**
	Low grade fuel used	Use specified fuel	**–**
	Fuel filter clogged	Clean or change	**–**
	Air cleaner clogged	Clean or change	**–**
	Deficient nozzle injection	Replace nozzle	**5.2.4**
Deficient Output	Incorrect injection timing	Adjust	**5.1.1**
	Engine's moving parts seem to be seizing	Repair or replace	**–**
	Uneven fuel injection	Replace injection pump	**2.2.6.a**
	Deficient nozzle injection	Repair or replace nozzle	**5.2.4**
	Compression leak	Check the compression pressure and repair	**2.1.1**
Excessive Lubricant Oil Consumption	Piston ring's gap facing the same direction	Shift ring gap direction	**2.2.7.b**
	Oil ring worn or stuck	Replace	**2.3.3.d**
	Piston ring groove worn	Replace worn piston	**2.3.3.e**
	Valve stem and valve guide worn	Replace	**2.3.1.d**
	Oil leaking due to defective seals or packing	Replace	**–**
Fuel Mixed into Lubricant Oil	Injection pump's plunger worn	Replace Injection pump	**5.1**
	Deficient nozzle injection	Replace nozzle	**5.2.4**
	Injection pump broken	Replace	**5.1**
Water Mixed into Lubricant Oil	Head gasket defective	Replace	**2.2.4.e**
	Cylinder block or cylinder head flawed	Replace	**–**
Low Oil Pressure	Engine oil level low	Replenish	**–**
	Oil filter cartridge clogged	Replace	**–**
	Relief valve stuck with dirt	Clean	**3.1.5**
	Relief valve spring weak or broken	Replace	**3.1.5**
	Excessive clearance of crankshaft bearing	Replace	**2.3.4.d**
	Excessive clearance of crankpin bearing	Replace	**2.3.4.c**
	Excessive clearance of rocker arm	Replace	**2.3.1.k**
	Oil passage clogged	Clean	**–**
	Incorrect oil type	Use specified type of oil	**–**
	Oil pump defective	Repair or replace	**2.2.6.h/3.2**
High Oil Pressure	Incorrect oil type	Use specified type of oil	**–**
	Relief valve defective	Replace	**3.1.5**

1.5 TROUBLESHOOTING (Continued)

Symptom	Probable Cause	Solution	Reference
Engine Overheated	Engine oil level low	Replenish	–
	Fan belt broken or improperly tensioned	Replace or adjust	–
	Coolant insufficient	Replenish	–
	Radiator net and radiator fin clogged with dust	Clean	–
	Inside of radiator corroded	Clean or replace	–
	Coolant flow route corroded	Clean or replace	–
	Radiator cap defective	Replace	–
	Radiator hose defective	Replace	–
	Running overloaded	Reduce load	–
	Head gasket defective	Replace	**2.2.4.e**
	Incorrect injection timing	Adjust	–
	Unsuitable fuel used	Use specified fuel	–
Low Battery Charge	Battery electrolyte level low	Replenish distilled water and charge	–
	Fan belt slips	Adjust belt tension or change belt	–
	Wiring disconnected	Connect	–
	Rectifier defective	Replace	–
	Alternator defective	Replace	–
	Battery defective	Change	–

1.6 SERVICING SPECIFICATIONS

1.6.1 Engine Body

Item		Factory Specification	Allowable Limit
Valve Clearance (Cold)		0.145 to 0.185 mm 0.00571 to 0.00728 in.	–
Compression Pressure		2.84 to 3.24 MPa 29.0 to 33 kgf/cm^2 412 to 469 psi	2.26 MPa 23.0kgf/cm^2 327 psi
Difference Between Cylinders		–	10% or less
Top Clearance		0.50 to 0.70 mm 0.0197 to 0.0276 in.	–
Cylinder Head Surface	Flatness		0.05 mm 0.0020 in.
Valve Recessing (Intake and Exhaust)		–0.10 to 0.10 mm –0.0039 to 0.0039 in.	0.30 mm 0.0118 in.
Valve Stem to Valve Guide	Clearance	0.030 to 0.057 mm 0.00118 to 0.00224 in.	0.10 mm 0.0039 in.
	Valve Stem O.D.	5.968 to 5.980 mm 0.23496 to 0.23543 in.	–
	Valve Guide I.D.	6.010 to 6.025 mm. 0.23661 to 0.23720 in.	–
Valve Face	Angle	0.785 rad. 45°	–
Valve Seat	Angle	0.785 rad. 45°	–
	Width	2.12 mm 0.0835 in.	–
Valve Spring	Free Length	31.3 to 31.8 mm 1.232 to 1.252 in.	28.4 mm 1.118 in.
	Tilt	–	1.2 mm 0.047 in.
	Setting Load/ Setting Length	64.7 N / 27.0 mm 6.6 kgf / 27.0 mm 14.6 lbs. / 1.063 in.	54.9N / 27.0 mm 5.6kgf / 27.0 mm 12.3lbs /1.063 in.
Rocker Arm Shaft to Rocker Arm	Clearance	0.016 to 0.045 mm 0.00063 to 0.00177 in.	0.15 mm 0.0059 in.
	Rocker Arm Shaft (O.D.)	10.473 to 10.484 mm 0.41232 to 0.41276 in.	–
	Rocker Arm (I.D.)	10.500 to 10.518 mm 0.41339 to 0.41410 in.	–
Push Rod	Alignment	–	0.25mm 0.0098 in.
Tappet to Tappet Guide	Clearance	0.016 to 0.052 mm 0.00063 to 0.00205 in.	0.10 mm 0.0039 in.
	Tappet (O.D.)	17.966 to 17.984 mm 0.70732 to 0.70803 in.	–
	Tappet Guide (I.D.)	18.000 to 18.018 mm 0.70866 to 0.70937 in.	–

1.6.1 Engine Body (Continued)

Item		Factory Specification	Allowable Limit
Timing Gear	Crank Gear to Idle Gear (Backlash)	0.043 to 0.124 mm 0.00169 to 0.00488 in.	0.15 mm 0.0059 in.
	Idle Gear to Cam Gear (Backlash)	0.047 to 0.123 mm 0.00185 to 0.00484 in.	0.15 mm 0.0059 in.
	Idle Gear to Injection Pump Gear (Backlash)	0.046 to 0.124 mm 0.00181 to 0.00488 in.	0.15 mm 0.0059 in.
	Crank Gear to Oil Pump Gear (Backlash)	0.041 to 0.123 mm 0.00161 to 0.00484 in.	0.15 mm 0.0059 in.
Idle Gear	Side Clearance	0.20 to 0.51 mm 0.0079 to 0.0201 in.	0.80 mm 0.0315 in.
Camshaft	Side Clearance	0.15 to 0.31 mm 0.0059 to 0.0122 in.	0.50 mm 0.0197 In.
	Alignment	–	0.01 mm 0.0004 In.
	Height (Intake / Exhaust)	26.88 mm 1.0583 in.	26.83 mm 1.0563 In.
Camshaft Journal to Cylinder Block Bore	Clearance	0.050 to 0.091 mm 0.00197 to 0.00358 in.	0.15 mm 0.00059 in.
	Camshaft Journal (O.D.)	32.934 to 32.950 mm 1.29661 to 1.29724 in	–
	Cylinder Block Bore (I.D.)	33.000 to 33.025 mm 1.29921 to 1.30020	–
Idle Gear Shaft to Idle Gear Bushing	Clearance	0.020 to 0.084 mm 0.00079 to 0.00331 in.	0.1 mm 0.0039 in.
	Idle Gear Shaft (O.D.)	19.967 to 19.980 mm 0.78610 to 0.78661 in.	–
	Idle Gear Bushing (I.D.)	20.000 to 20.051 mm 0.78740 to 0.78791 in.	–
Piston Pin Bore	I.D.	20.000 to 20.013 mm 0.78740 to 0.78941 in.	20.05 mm 0.7894 in.
Piston Pin to Small End Bushing	Clearance	0.014 to 0.038 mm 0.00055 to 0.00150 in.	0.10 mm 0.0039 in.
	Piston Pin (O.D.)	20.002 to 20.011 mm 0.78748 to 0.78783 in.	–
	Small End Bushing (I.D.)	20.025 to 20.040 mm 0.78839 to 0.78897 in.	–
Piston Pin to Small End Bushing (Spare Parts)	Clearance	0.015 to 0.075 mm 0.00059 to 0.00295 in.	0.15 mm 0.0059 in.
	Small End Bushing (I.D.)	20.026 to 20.077 mm 0.78845 to 0.79043 in.	–
Piston Ring Gap	Top Ring	0.15 to 0.30 mm 0.0059 to 0.0118 in.	1.20 mm 0.0472 in.
	Second Ring	0.30 to 0.45 mm 0.0118 to 0.0177 in.	1.20 mm 0.0472 in.
	Oil Rng	0.15 to 0.30 mm 0.0059 to 0.0118 in.	1.20 mm 0.0472 in.

1.6.1 Engine Body (Continued)

Item		Factory Specification	Allowable Limit
Piston Ring to Piston Ring Groove	Second Ring Clearance	0.090 to 0.120 mm 0.00354 to 0.00472 in.	0.15 mm 0.0059 in
	Oil Ring Clearance	0.040 to 0.080 mm 0.0016 to 0.0031 in.	0.15 mm 0.0059 in.
Connecting Rod	Alignment	–	0.05 mm 0.0020 in.
Crankshaft	Side Clearance	0.15 to 0.31 mm 0.0059 to 0.0122 in.	0.50 mm 0.0197 in.
	Alignment	–	0.02 mm 0.0008 in.
Crankpin to Crankpin Bearing	Oil Clearance	0.020 to 0.051 mm 0.00079 to 0.00201 in.	0.15 mm 0.0059 in.
	Crankpin (O.D.)	33.959 to 33.975 mm 1.33697 to 1.33760 in.	–
	Crankpin Bearing (I.D.)	33.995 to 34.010 mm 1.33893 to 1.33898 in.	–
Crankshaft Journal to Crankshaft Bearing1	Oil Clearance	0.034 to 0.106 mm 0.00134 to 0.00417 in.	0.20 mm 0.0079 in.
	Crankshaft Journal (O.D.)	39.934 to 39.950 mm 1.57221 to 1.57284 in.	–
	Crankshaft Bearing1 (I.D.)	39.984 to 40.040 mm 1.57148 to 1.57638 in.	–
Crankshaft Journal to Crankshaft Bearing2 (Flywheel Side)	Oil Clearance	0.028 to 0.051 mm 0.00110 to 0.00201 in.	0.20 mm 0.0079 in.
	Crankshaft Journal (O.D.)	43.934 to 43.950 mm 1.72968 to 1.73031 in.	–
	Crankshaft Bearing2 (I.D.)	43.984 to 44.026 mm 1.73165 to 1.73331 in.	–
Crankshaft Journal to Crankshaft Bearing3 (Intermediate)	Oil Clearance	0.028 to 0.051 mm 0.00110 to 0.00201 in.	0.20 mm 0.0079 in.
	Crankshaft Journal (O.D.)	39.934 to 39.950 mm 1.57221 to 1.57284 in.	–
	Crankshaft Bearing3 (I.D.)	39.984 to 40.026 mm 1.57417 to 1.57583 in.	–
Cylinder Liner	I.D. (Standard)	67.000 to 67.019mm 2.63779 to 2.63854 in.	67.150 mm 2.64370 in.
	I.D. (Oversize) : 0.25mm 0.0098in.	67.250 to 67.269mm 2.64764 to 2.64839 in.	67.400mm 2.65354 in.

1.6.2 Lubricating System

Item		Factory Specification	Allowable Limit
Engine Oil Pressure*	At Idle Speed	More than 49kPa 0.5 kgf/cm^2 / 7 psi	–
	At Rated Speed	196 to 441 kPa 2.0 to 4.5kgf/cm^2 / 28 to 64 psi	147kPa 1.5kgf/cm^2 / 21 psi
Inner Rotor to Outer Rotor	Clearance	0.03 to 0.14 mm 0.0012 to 0.0055 in.	–
Outer Rotor to Pump Body	Clearance	0.07 to 0.15 mm 0.0028 to 0.0059 in.	–
Inner Rotor to Cover	Clearance	0.075 to 0.135 mm 0.00295 to 0.00531 in.	–

*Engines installed in Genesis, Solara and Supra units use an oil pressure safety switch which opens at 105 kPa / 1.06 kgf/cm^2 / 15 psi.

1.6.3 Cooling System

Item		Factory Specification	Allowable Limit
V–Belt	Tension	7.0 to 9.0 mm at 98N 0.28 to 0.35 in. at 98N (10kgf, 22 lbs.)	–
Thermostat	Valve Opening Temperature (At Beginning)	69.5 to 72.5°C 157 to 162.5°F	–
	Valve Opening Temperature (Opened Completely)	85°C 185°F	–
Radiator Cap	Pressure Falling Time	10 seconds or more 88 to 59kPa 0.9 to 0.6 kgf/cm^2 13 to 9 psi	–
Radiator	Leakage Test Pressure	No leaks at specified pressure 157 kPa / 1.6 kgf/cm^2 23 psi	–

1.6.4 Fuel System

Item		Factory Specification	Allowable Limit
Injection Pump	Injection Timing (3600 min^{-1} rpm)	0.33 to 0.37 rad. (19° to 21°) before T.D.C	–
Pump Element	Fuel Tightness	–	13.73 MPa 140 kgf/cm^2 1991 psi
Delivery Valve	Fuel Tightness	10 seconds 13.73 to12.75 MPa 140 to130 kgf/cm^2 1991 to 1849 psi	5 seconds 13.73 to12.75 MPa 140 to130 kgf/cm^2 1991 to 1849 psi
Fuel Injection Nozzle	Injection Pressure	13.73 to 14.71 MPa 140 to 150 kgf/cm^2 1991 to 2134 psi	–
	Valve Seat Tightness	When the pressure is 12.75 MPa (130 kgf/cm^{2,1849} psi) the valve must not pass fuel	–

1.6.5 Electrical System

Item			Factory Specification	Allowable Limit
Glow Plug		Resistance	Approximately 0.9 OHM	–
Starter	Commutator O.D.	CT2-29-TV	28.0 mm 1.1.102 in.	27.0 mm 1.063 in.
		CT3-44-TV	30.0 mm 1.181 in.	29.0 mm 1.142 in.
	Difference of O.D.	CT2-29-TV	Less than 0.05 mm 0.0002 in.	0.4 mm 0.016 in.
		CT3-44-TV	Less than 0.02 mm 0.0008 in.	0.05 mm 0.0020 in.
	Mica	Undercut	0.50 to 0.80 mm 0.0197 to 0.0315 in.	0.20 mm 0.0079 in.
	Brush Length	CT2-29-TV	0.16 mm 0.630 in.	10.5 mm 0.413 in.
		CT3-44-TV	0.14 mm 0.551 in.	9.0 mm 0.354 in.

1.7 CHECK AND MAINTENANCE

1.7.1 Checking Engine Oil Level

1. Refer to Section 3.1

1.7.2 Changing Engine Oil

1. Refer to Section 3.1

1.7.3 Checking Coolant Level

1. Refer to Section 4.1.3

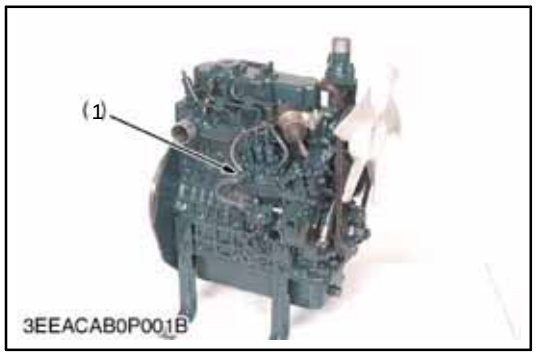
1.7.4 Checking Fuel Hose

1. If the clamp is loose, apply oil to the threads and securely retighten it.
2. The fuel hose is made of rubber and ages regardless of the service period. Change the hose and clamps together every two years.
3. Change the fuel hose and clamps whenever any deterioration or damage is detected.
4. After the fuel hose and clamps have been changed, bleed air out of the fuel system.

⚠ CAUTION

Stop the engine when attempting to check and change the fuel line.

1.7.5 Bleeding Fuel System

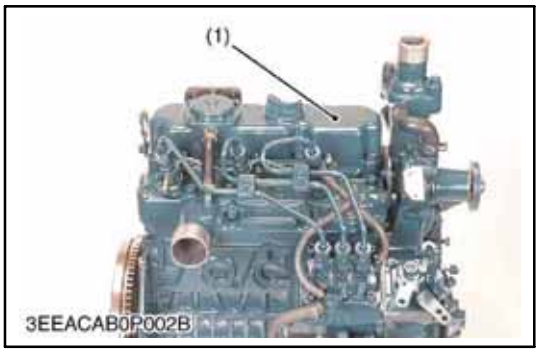


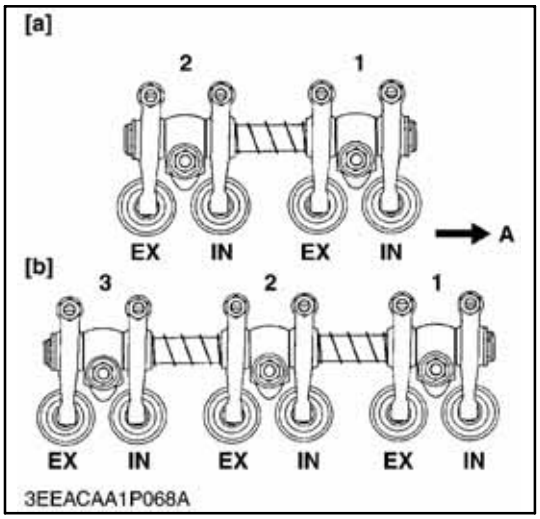
1. Open the air vent cock (1) on top of the fuel injection pump. (Available on Solara, Supra and Genesis units only.)
2. Energize the electric fuel pump for a period of 10 to 15 seconds, or just long enough to expel fuel through the air vent cock.
3. Close the air vent cock (1).

NOTE

Always keep the air vent cock on the fuel injection pump closed except when bleeding the fuel system, or the engine may not run.

1.7.6 Valve Clearance





1. Cylinder Head Cover
2. "1TC" Mark
3. Alignment Mark

A. Gear Case End

a. CT2-29-TV
b. CT3-44-TV

NOTE

Valve clearance must be checked and adjusted when the engine is cold.

1. Remove the valve cover (1).
2. Align the "**1TC**" mark line (2) on the flywheel and projection (3) on the housing so that the Number 1 piston comes to compression top dead center (TDC).
3. Check the following valve clearance marked with "*" (at TDC) using a feeler guage.
4. If the clearance is not within the factory specifications, adjust with the adjusting screw.
5. Then turn the flywheel 6.28 rad (360°), and align the "1TC" mark (2) on the flywheel and alignment mark (3) on the rear end plate so that the No. 1 piston come to the overlap position.
6. Check the following valve clearance marked with "*" (past TDC) using a feeler guage.

CT2-29-TV		Valve Arrangement	
Piston Location in Cylinder		IN.	EX.
When No. 1 piston is at TDC	No. 1	*	*
	No. 2		*
When No. 1 piston is past TDC	No. 1		
	No. 2	*	

CT3-44-TV		Valve Arrangement	
Piston Location in Cylinder		IN.	EX.
When No. 1 piston is at TDC	No. 1	*	*
	No. 2		*
	No. 3	*	
When No. 1 piston is past TDC	No. 1		
	No. 2	*	
	No. 3		*

7. If the clearance is not within the factory specifications, adjust with the adjusting screw.

NOTE

The sequence of cylinder numbers is given as No.1, No.2 and No.3 starting from the gear case end.

After adjusting the valve clearance, secure the adjusting screw with the lock nut.

1.8 SPECIAL TOOLS

Additional tools may be found in the Carrier Transicold Performance Parts Service Tool Catalog Number 62-03213.

1.8.1 Diesel Engine Compression Tester (Glow Plug)

Part No. 07-00179-01 (Assembly)

Application: Use to measure diesel engine compression and diagnosis for major overhaul.

1.8.2 Adapter, Kubota 10 mm

Part No. 07-00179-05
Application: Accessory for 07-00179-01

1.8.3 Tester Injector Nozzle

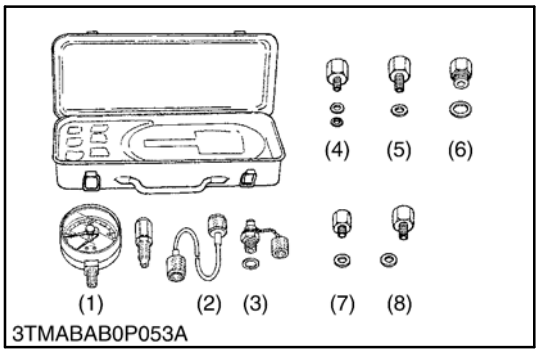
Part No. 07-00140-00
Application: Injector nozzle tester kit used for checking and adjusting of the fuel injectors in diesel engines.

1.8.4 Replacement Bowl, Tester Injector Nozzle

Part No. 07-00140-10
Application: Accessory for 07-00140-00

1.8.5 Adapter, Injector Line

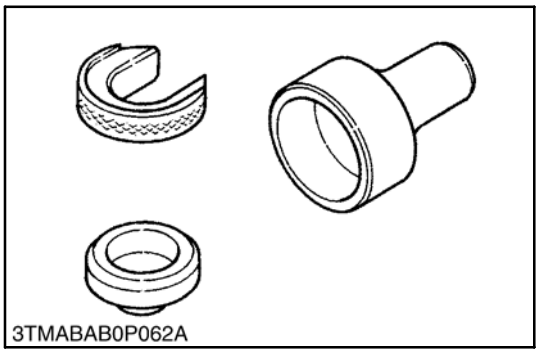
Part No. 07-00036-00
Application: Accessory for 07-00140-00



1. Guage
2. Adapter 2
3. Cable
4. Adapter 3
5. Threaded Joint
6. Adapter 4
7. Adaptor 1
8. Adaptor 3

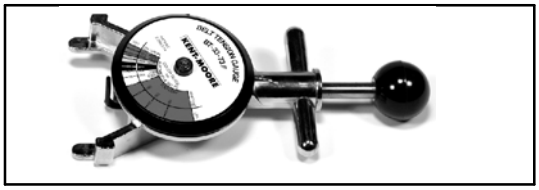
1.8.6 Oil Pressure Tester

Code No. 07916-32032
Application: Use to measure lubricating oil pressure.



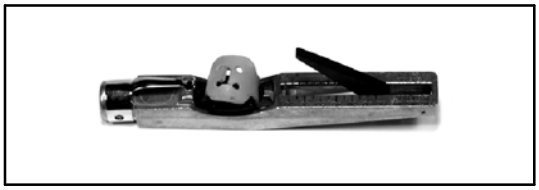
1.8.7 Auxiliary Socket For Fixing Crankshaft Sleeve

Code No. 07916-32091
Application: Use to fix the crankshaft sleeve of the diesel engine.



1.8.8 Guage, Belt Tension

Part No. 07-00203-00
Application: Used to adjust belt tension of all cogged V-belts.



1.8.9 Tester, Belt Tension

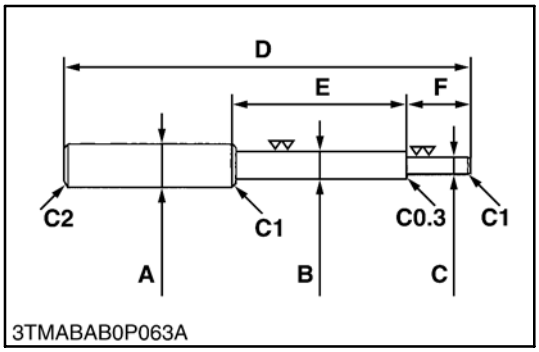
Part No. 07-00253-00
Application: Used to test belt tension.

1.8.10 Rubber Band

Part No. 07-00253-01
Application: Replacement part for belt tension tester (Part No. 07-00253-00)

1.8 SPECIAL TOOLS (Continued)

The following are drawings for special tools that may need to be fabricated.



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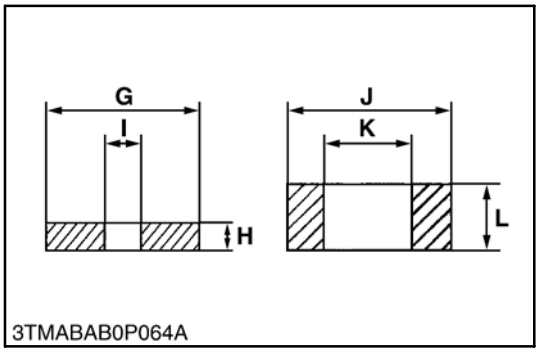

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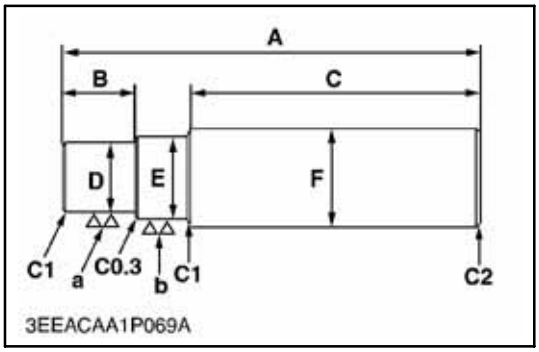
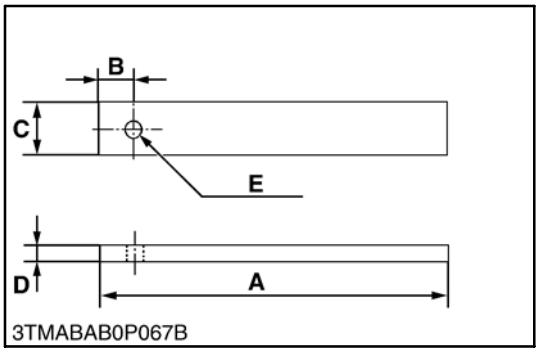


3EEACAA1P069A



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1.8.11 Valve Guide Replacing Tool

Application: Use to press out and press fit the valve guide.

A	20 mm dia. (0.79 in. dia.)
B	11.7 to 11.9 mm dia. (0.460 to 0.468 in. dia.)
C	6.5 to 6.6 mm dia. (0.256 to 0.259 in. dia.)
D	225 mm (8.86 in.)
E	70 mm (2.76 in.)
F	45 mm (1.77 in.)
G	25 mm (0.98 in.)
H	5 mm (0.197 in.)
I	6.7 to 7.0 mm dia. (0.263 to 0.275 in. dia.)
J	20 mm dia. (0.787 in. dia.)
K	12.5 to 12.8 mm dia. (0.492 to 0.504 in. dia.)
L	8.9 to 9.1 mm (0.350 to 0.358 in.)
C1	Chamfer 1.0 mm (0.039in.)
C2	Chamfer 2.0 mm (0.079in.)
C0.3	Chamfer 0.3 mm (0.012in.)

1.8.12 Bushing Replacing Tools

Application: Use to press out and press fit the bushing.

1. For small end bushing.

A	145 mm (5.71 in.)
B	20 mm (0.79 in.)
C	100 mm (3.94 in.)
D	19.90 to 19.95 mm (0.7835 to 0.7854 in.) dia.
E	21.90 to 21.95 mm (0.8622 to 0.8642 in.) dia.
F	25.00 mm (098 in.) dia.
a	6.3 μm (250 μin.)
b	6.3 μm (250 μin.)

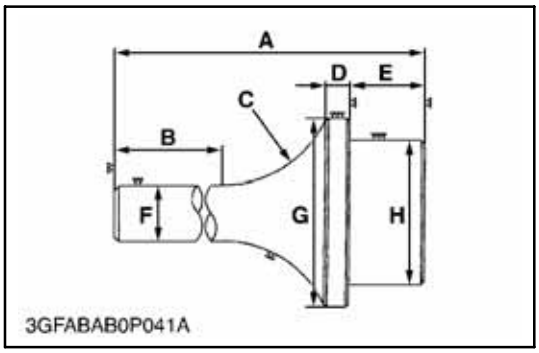
2. For idle gear bushing.

A	150 mm (5.91 in.)
B	20 mm (0.79 in.)
C	100 mm (3.94 in.)
D	19.90 to 19.95.95 mm (0.7835 to 0.7854 in.)
E	21.90 to 21.95 mm (0.8622 to 0.8642 in.) dia.
F	25 mm (0.98 in.)
a	6.3 μm (250 μin.)
b	6.3 μm (250 μin.)

1.8.13 Flywheel Stopper

Application: Use to loosen and tighten the flywheel screw.

A	200 mm (7.87 in.)
B	20 mm (0.79 in.)
C	30 mm (1.18 in.)
D	8 mm (0.31 in.)
E	10 mm (0.39 in.)



1.8.14 Crankshaft Bearing 1 Replacing Tool

Application: Use to press out and press fit the crankshaft bearing No. 1

1. Extracting tool

A	135 mm (5.31 in.)
B	72 mm (2.83 in.)
C	40 mm radius (1.57 in. radius)
D	10 mm (0.39 in.)
E	22 mm (0.87 in.)
F	20 mm dia. (0.79 in. dia.)
G	47.90 to 47.95 mm dia. (1.8858 to 1.8878 in. dia.)
H	43.90 to 43.95 mm dia. (1.7283 to 1.7303 in. dia.)

2. Installing tool

A	130 mm (5.12 in.)
B	72 mm (2.83 in.)
C	40 mm radius (1.57 in. radius)
D	9 mm (0.35 in.)
E	24 mm (0.95 in.)
F	20 mm dia. (0.79 in.dia.)
G	68 mm dia. (2.68 in. dia.)
H	39.90 to 39.95 mm dia. (1.5709 to 1.5728 in. dia.)

SECTION 2

ENGINE BODY

2.1 CHECKING AND ADJUSTING

2.1.1 Compression Pressure

1. Run the engine until it is warmed up.
2. Stop the engine and disconnect the **2P** connector from the stop solenoid to prevent fuel delivery to the engine.
3. Remove the the air cleaner, the muffler and all the glow plugs.
4. Install a compression tester with the adapter in one of the glow plug holes.
5. While cranking the engine with the starter measure the compression pressure.
6. Repeat steps 1 thru 5 for each cylinder.

7. If the measurement is below the allowable limit, add a small amount of oil to the cylinder thru the glow plug hole and measure the compression again.

a. If the compression pressure is still less than the allowable limit, check the top clearance, valves and cylinder head.

b. If the compression pressure increases after applying oil, check the cylinder wall and piston rings.

NOTE

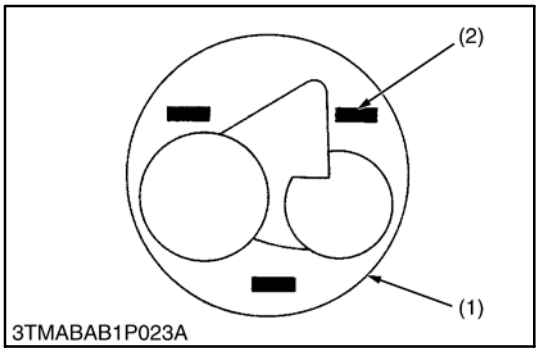
Check the compression pressure with the specified valve clearance

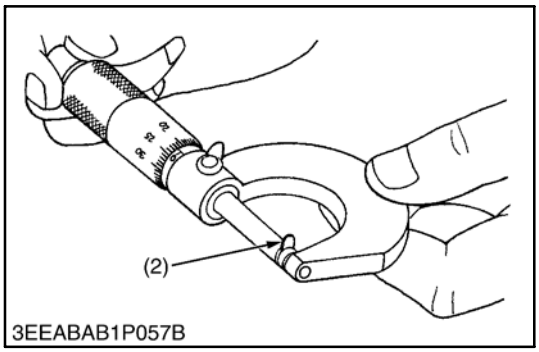
Always use a fully charged battery for performing this test.

Variances in cylinder compression values should be under 10%.

Compression Pressure	Factory Specification	2.84 to 3.24 MPa 29 to 33 kgt/cm^2 412 to 469 psi
	Allowable Limit	2.26 MPa 23 kgt/cm^2 327 psi

2.1.2 Top Clearance





1. Piston
2. Plastigage

1. Remove the valve cover. Refer to 2.2.4.a.
2. Remove the cylinder head.
3. Move the piston (1) up and stick a strip of plastigage (2) on the piston head at three positions shown on the illustration.
4. Lower the piston and install the cylinder head. (Use a new cylinder head gasket and tighten the cylinder head bolts to the proper torque.
5. Turn the flywheel until the piston (1) passes through top dead center.
6. Remove the cylinder head and measure the plastigage .
7. If the measurement is not within the factory specifications, check the clearances between the crank pin and bearing and between the piston pin and bushing.

Top Clearance	Factory Specification	0.50 to 0.70 mm 0.0197 to 0.0276 in.
Tightening Torque	Cylinder Head Bolts	37.3 to 42.2 N·m 3.8 to 4.3 kgf·m 27.5 to 31.1 ft-lbs

2.2 DISASSEMBLING AND ASSEMBLING

2.2.1 Draining Coolant

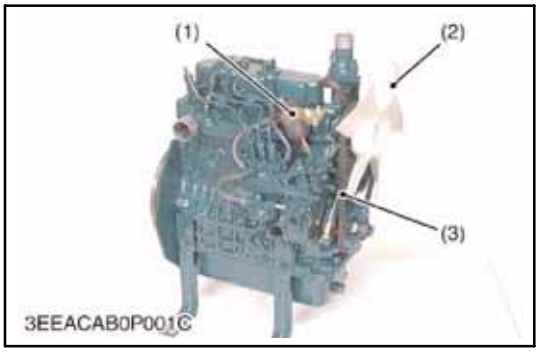
Refer to Section 4.

2.2.2 Draining and Refilling Engine Oil

Refer to Section 3.

2.2.3 External Components

Alternator, Starter and Others



1. Remove the air cleaner and muffler.
2. Remove the engine stop solenoid (1) (if so equipped).
3. Remove the fan (2), fan belt (3), alternator and starter.
4. Remove the alternator.
5. Remove the starter.

When Reassembling

Replace the starter.

Replace the alternator.

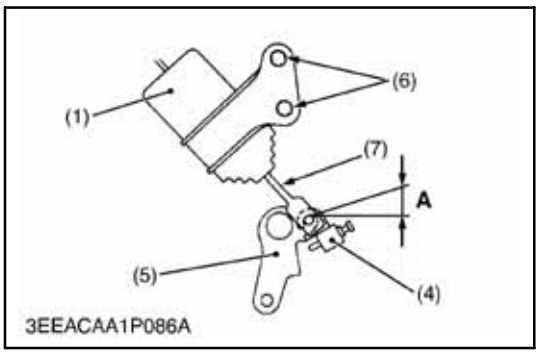
Replace the fan, fan belt, alternator and starter.

NOTE

When reinstalling the fan, make sure that it is seated correctly.

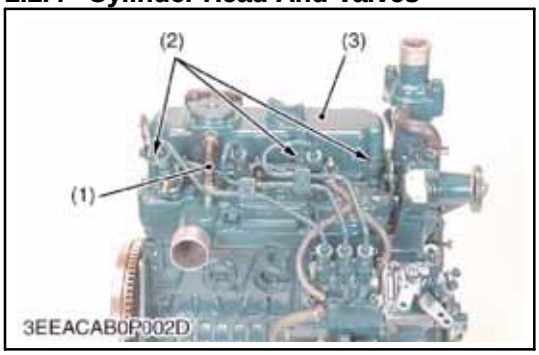
Check to see that there are no cracks in the fan belt.

After reinstaling the fan belt, be sure to adjust the fan belt tension. (Refer to Section 4.1.1.)



Replace the engine stop solenoid (1) (if so equipped) and adjust the linkage so that engine stop lever (5) rests against the stopper (4) when the engine stop solenoid is not energized. There should be no tension on the plunger arm (7) when the engine stop solenoid is not energized. Adjustment is accomplished by loosening the engine stop mounting screws and moving the engine stop solenoid (1).

2.2.4 Cylinder Head And Valves



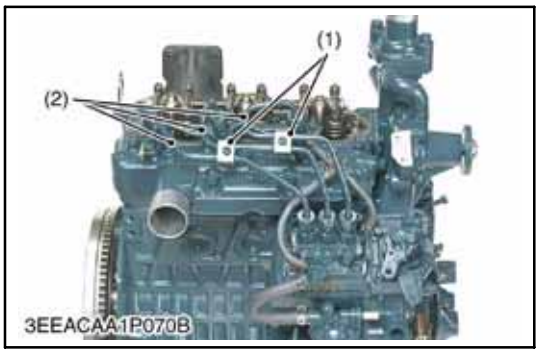
2.2.4.a Valve Cover

1. Remove the breather tube (1).
2. Remove the valve cover bolts (2).
3. Remove the valve cover (3).

When Reassembling

Check to see that the valve cover gasket is in good condition and in place.

Tightening Torque	Valve Cover Bolts	6.86 to 11.3 N·m 0.7 to 1.15 kgf·m 5.1 to 8.32 ft-lbs



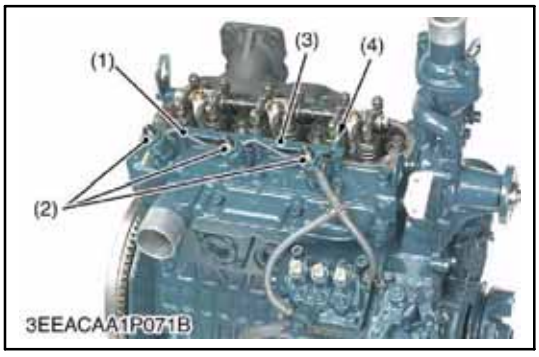
2.2.4.b Injection Pipes

1. Loosen the screws on the pipe clamps (1).
2. Detach the injection pipes (2).

When Reassembling

Blow out any debris that may be in the pipes with compressed air, then reassemble pipes.

Tightening Torque	Injection Pipe Retaining Nut	24.5 to 34.3 N·m 2.5 to 3.5 kgf·m 18.1 to 25.3 ft-lbs



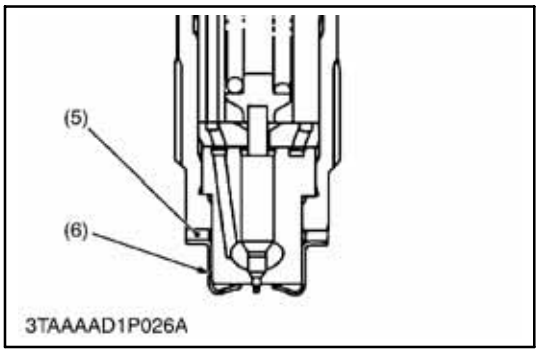
1. Overflow Pipe
2. Nozzle Holder Assembly
3. Glow Plug Bus Bar
4. Glow Plug
5. Copper Gasket
6. Heat Seal

2.2.4.c Nozzle Holder Assembly and Glow Plug

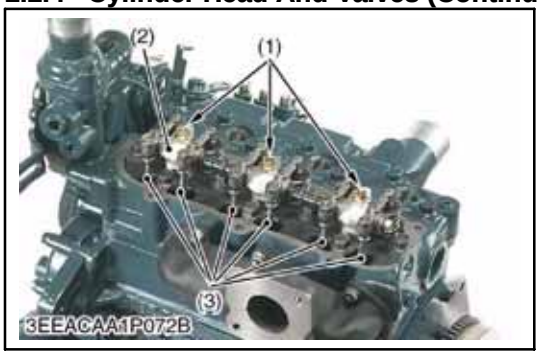
1. Remove the overflow pipe assembly (1).
2. Remove the nozzle holder assemblies (2).
3. Remove the copper gasket (5) and heat seal (6).
4. Remove the glow plug buss bar (3) from the glow plugs (4).
5. Remove the glow plugs (4).

When Reassembling

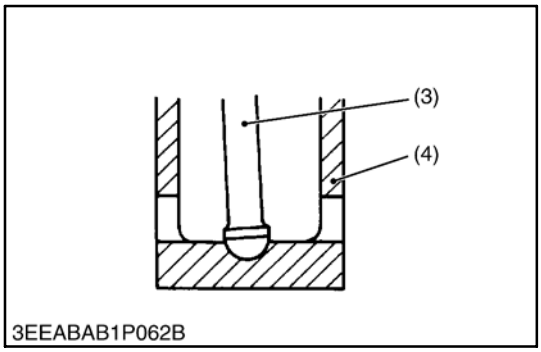
Replace the copper gasket(s) and heat seal(s) with a new one(s).

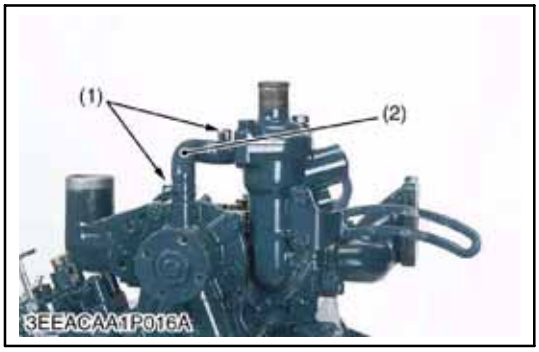


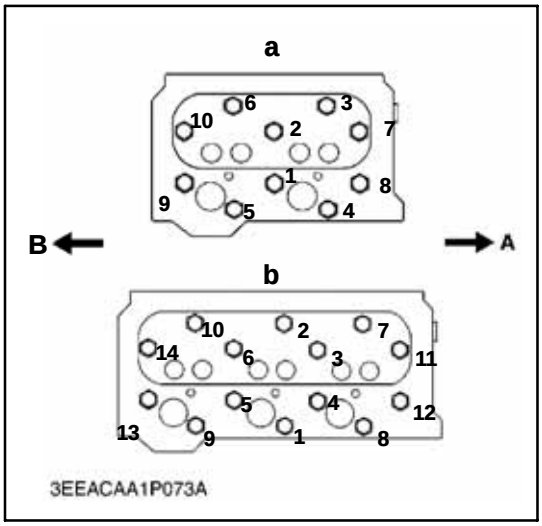
Tightening Torque	Nozzle Holder Assembly	49.0 to 68.6 N·m 5.0 to 7.0 kgf·m 36.2 to 50.6 ft-lbs
	Overflow Pipe Assembly Retaining Nut	19.6 to 24.5 N·m 2.0 to 2.5 kgf·m 14.5 to 18.1 ft-lbs
	Glow Plug	7.85 to 14.7 N·m 0.8 to 1.5 kgf·m 5.8 to 10.8 ft-lbs



1. Rocker Arm Bracket Bolts
2. Rocker Arm Assembly







1. Hose Clamp
2. Water Return Hose
3 O-ring
a. CT2-29-TV
b. CT3-44-TV
A: Gear Case Side
B: Flywheel Side

2.2.4.d Rocker Arm and Push Rod

1. Remove the rocker arm bracket mounting bolts (1).
2. Detach the rocker arm assembly (2).
3. Remove the push rods (3).

When Reassembling

When putting the push rods (3) onto the tappets (4), check to see if the end are properly engaged with the dimples.

NOTE

After instaling the rocker arm, be sure to adjust the valve clearance (Refer to Section 1.7.6).

Tightening Torque	Rocker Arm Bracket Mounting Bolt	9.8 to11.3 N·m 1.00 to 1.15 kgf·m 7.2 to 8.3 ft-lbs

2.2.4.e Cylinder Head

1. Loosen the hose clamps (1), and remove the water return hose (2).
2. Remove the cylinder head bolts in the order of **a: (10 to 1) or b: (14 to 1)**.
3. Lift up the cylinder head and remove.
4. Remove the cylinder head gasket and O-ring (3).

When Reassembling

Replace the cylinder head gasket with a new one.

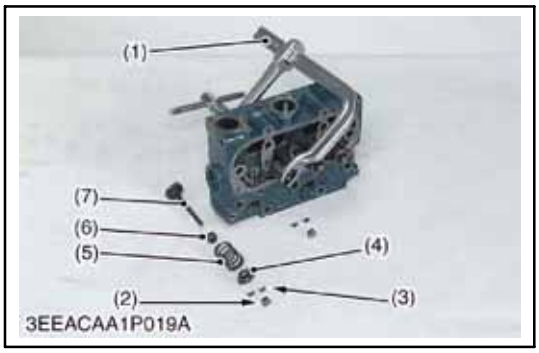
Install the cylinder head, taking care not to damage the O-ring (3).

Apply oil to, then re-install the cylinder head bolts.

Tighten the cylinder head bolts in sequence starting from the center in the order of **a: (1 to 10) or b: (1 to 14)**..

Retighten the head bolts after running the engine for 30 minutes.

Tightening Torque	Cylinder Head Bolt	37.3 to 42.2 N·m 3.8 to 4.3 kgf·m 27.5 to 31.1 ft-lbs



2.2.4.f Tappets

1. Remove the tappets (1) from the crankcase.
2. Visually check the tappets for any abnormal camshaft contact wear pattern. If unusual wear/damage has occurred, replace the tappet.
3. Coat the tappets with engine oil before reinstalling them back into the crankcase.

NOTE

The tappets must always be reinstalled in their original bores.

2.2.4.g Valves

1. Remove the valve caps (2).
2. Remove the valve spring collet (3), pushing the valve spring retainer (4) by the valve spring compressor (1).
3. Remove the valve spring retainer (4), valve spring (5) and valve stem seal (6).
4. Remove the valve (7).

When Reassembling

Clean the valve stem and the valve guide. Apply engine oil to the valve stem when reassembling.

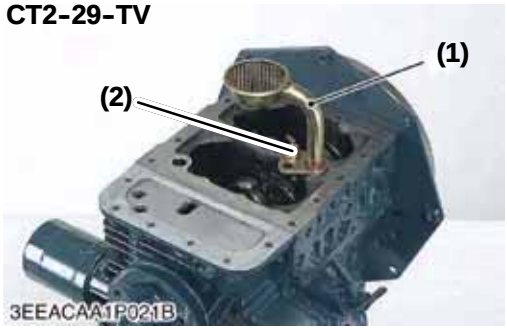
After installing the valve spring collets (3), lightly tap the stem with a plastic hammer to assure the collets have seated on the valve stem.

NOTE

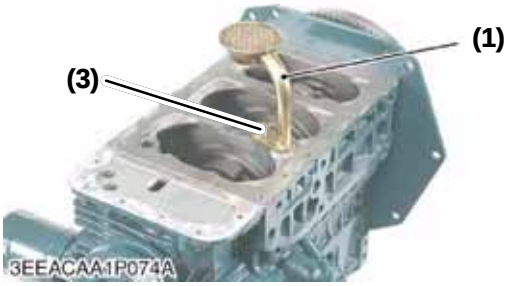
When re-installing valves into the cylinder head, make sure that they are re-installed in their original location.

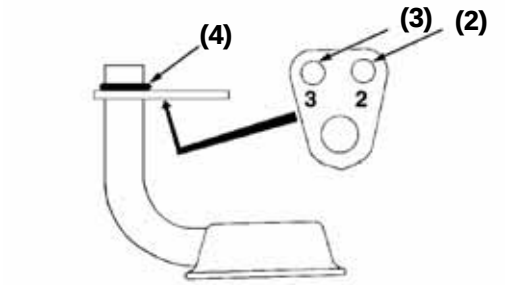
2.2.5 Oil Pan and Oil Pick-up Screen

CT2-29-TV



CT3-44-TV





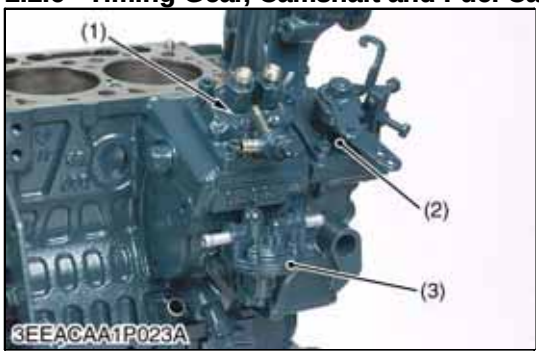
Sealer Location

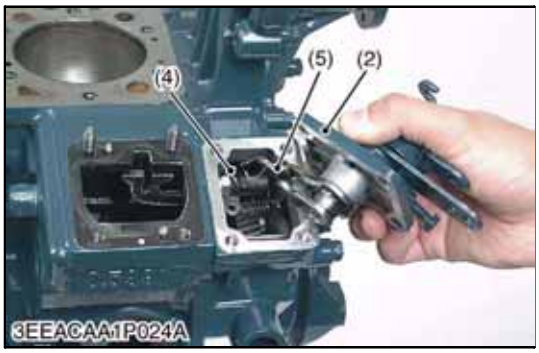
1. Remove the oil pan mounting bolts.
2. Remove the oil pan by lightly tapping the side of the pan with a soft hammer.
3. Scrape off the old adhesive from the mating surfaces of the oil pan and the engine block completely.
4. Remove the oil pick-up screen (1).
5. Clean and Inspect the oil pick-up screen (1) for damage.
6. Visually inspect the oil pick-up screen O-ring (4) for damage, oil it and reinstall.
7. CT2-29-TV engine, use hole labeled 2, CT3-44-TV engine, use hole labeled 3 to install the pick-up screen mounting bolt.
8. Apply gasket cement (sealer) so that the sealer is about 3 to 5 mm (0.12 to 0.20 in.) thick around the flange of the oil pan. Apply the sealer on the center of the flange as well as on the inner wall of each bolt hole.
9. Within 20 minutes after the application of the sealer, replace the oil pan and mounting bolts.

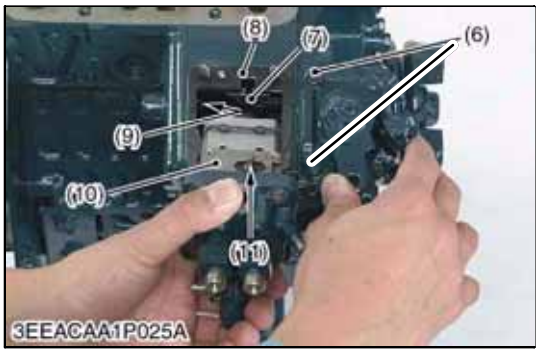
NOTE

Refer to Section 1.4 for proper torque values on all fasteners.

2.2.6 Timing Gear, Camshaft and Fuel Camshaft







1. Injection Pump
2. Speed Control Plate
3. Fuel Feed Pump
4. Governor Spring
5. Governor Lever
6. Screw and Copper Washer
7. Slot (Fork Lever Side)
8. Slot (Crankcase Side)
9. Idling Adjusting Spring
10. Control Rod
11. Pin

2.2.6.a Injection Pump, Fuel Feed Pump and Speed Control Plate (Solara, Supra, Genesis and PC5000 Units Only.)

1. Remove the socket head screws and nuts, and remove the injection pump (1).

2. Remove the screws and separate the speed control plate (2), taking care not to damage the governor spring (4).

3. Disconnect the governor spring (4) and remove the speed control plate (2).

4. Remove the fuel feed pump (3).

When Reassembling

Hook the governor spring (4) to the governor lever (5) first and install the speed control plate (2).

Be sure to replace the copper gaskets underneath two screws (6) in the speed control plate (2).

Position the slot (7) on the fork lever just under the slot (8) on the crankcase.

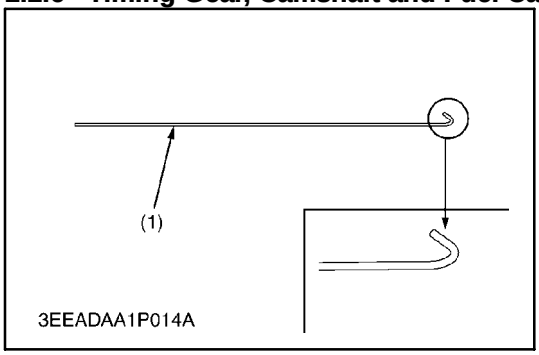
Insert the injection pump (1) so that the control rod (10) should be pushed by the idling adjusting spring (9) at its end and the pin (11) on the rod engages with the slot (7) on the fork lever.

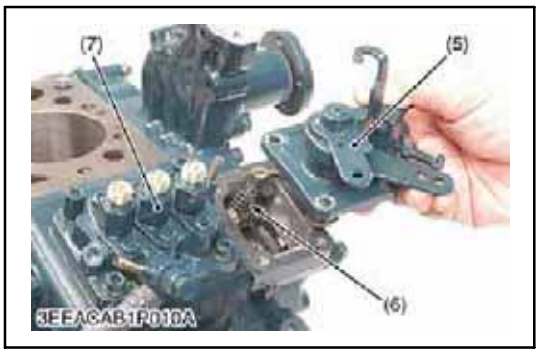
NOTE

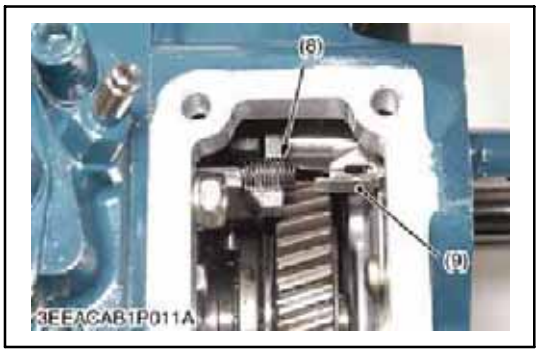
Sealant is applied to both sides of the shims, gasket cement is not required for assembly.

When replacing the old gasket shims with new, always replace with the same thickness and number of gasket shims.

Addition or reduction of shim (0.05 mm / 0.0020 in.) delays or advances the injection timing by approximately 0.5°.







2.2.6.b Injection Pump, Fuel Feed Pump and Speed Control Plate (Z482-E2b-TFX-1 Only)

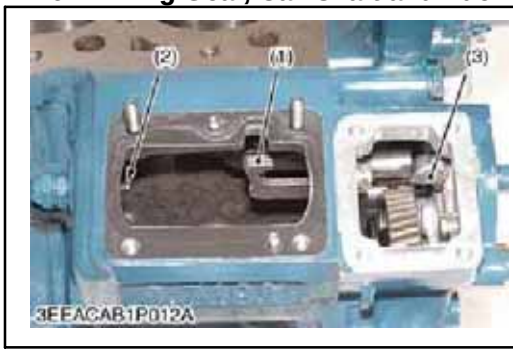
NOTE

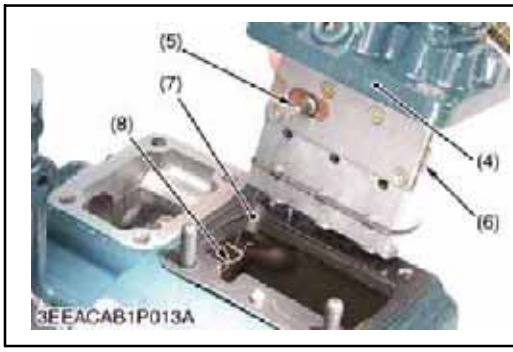
Specific Tool (1): A 1.2mm (.050 inch) diameter wire with a total length of 200mm (8 inch) with the tip bent into a hook as depicted in the illustration is required to hang the governor springs.

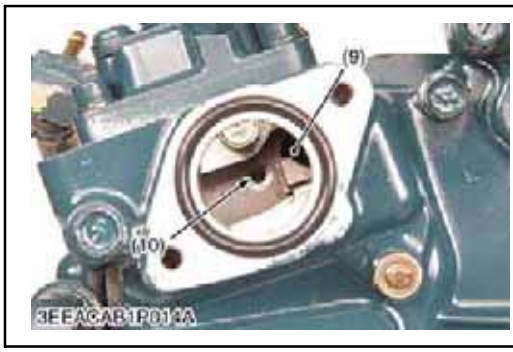
A length of string passed thru the governor spring (6) can be used to retrieve the spring if it unhooks from both the specific tool (1) and the speed control plate

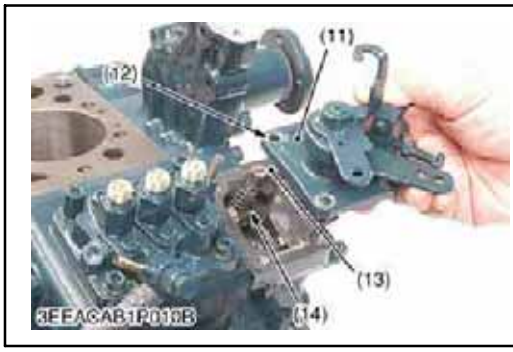
1. Remove the socket head screws (2) and remove the engine stop solenoid (4).
2. Remove the screws and separate the speed control plate (5), taking care not to damage the governor spring (6).
3. Disconnect the governor spring (6) and remove the speed control plate (5) using the specific tool (1).
4. Remove the fuel feed pump (3).
5. Disconnect the start spring (8) from the bracket (9) using the specific tool (1).
6. Remove the socket head screws and nuts, then remove the injection pump (7).

1. Specific Tool
2. Socket Head Screw
3. Fuel Feed Pump
4. Engine Stop Solenoid
5. Speed Control Plate
6. Governor Spring
7. Injection Pump
8. Start Spring
9. Bracket









2.2.6.b Injection Pump, Fuel Feed Pump and Speed Control Plate (Z482-E2b-TFX-1 Only) (Continued)

When Reassembling

1. Move the fork lever (1) to the gear case side.
2. Hook the start spring (7) to the injection pump control rack pin (5).
3. Put the specific tool (8) through the fork lever hole of the cylinder block (9) and hook the start spring (7).
4. Slightly extended the start spring (7) and install the injection pump (4).

NOTE

Make sure the control rod (6) makes contact with the idling adjusting spring (2).

Make sure the injection pump control rack pin (5) engages the fork lever (1).

A length of string passed thru the governor spring (14) can be used to retrieve the spring if it unhooks from both the specific tool and the speed control plate

5. Hook the start spring (7) to the bracket (3) using the specific tool (8).
6. Hook the governor springs (small and large) (14) to the governor lever (13) using the specific tool and install the speed control plate (11). Use copper washers with the two screws (12) when securing the speed control plate.
7. Install the engine stop solenoid rod (15) into the guide of the cylinder block (10) and secure the engine stop solenoid (16) with hex head bolts.

NOTE

Be careful not to stretch the start spring (7) too far or you risk permanently deforming it.

Be sure the start spring (7) is attached to the bracket (3).

Sealant is applied to both sides of the shims, gasket cement is not required for assembly.

When replacing the old gasket shims with new, always replace with the same thickness and number of gasket shims.

Addition or reduction of shim (0.05 mm / 0.0020 in.) delays or advances the injection timing by approximately 0.5°.

1. Fork Lever
2. Idling Adjusting Spring
3. Bracket
4. Injection Pump
5. Injection Pump Control Rack Pin
6. Injection Pump Control Rod
7. Start Spring
8. Specific Tool
9. Fork Lever Hole
10. Guide Hole
11. Speed Control Plate
12. Screw and Copper Washer
13. Governor Lever
14. Governor Spring
15. Engine Stop Solenoid Rod
16. Engine Stop Solenoid

2.2.6.c Fan Drive Pulley

1. Secure the flywheel to keep it from turning.

2. Remove the fan drive pulley bolt.

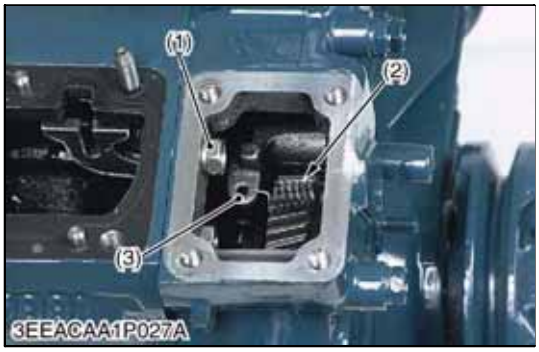
3. Remove the fan drive pulley with a puller.

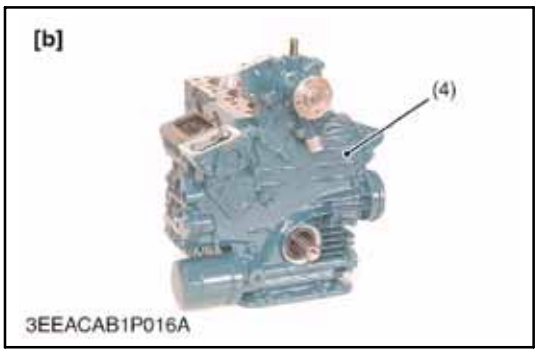
When Reassembling

Install the pulley to the crankshaft, aligning the mark (1) on them.

Apply engine oil to the fan drive pulley retaining bolts and tighten them.

Tightening Torque	Fan Drive Pulley Screw	117.7 to 127.5 N·m 12.0 to 13.0 kgf·m 86.8 to 94.0 ft-lbs





2.2.6.d Gear Case

1. Disconnect the start spring (2) from the fork lever 1 (3).

2. Remove the bolt (1) inside the gear case.

3. Remove the remaining bolts securing the gear case to the engine block.

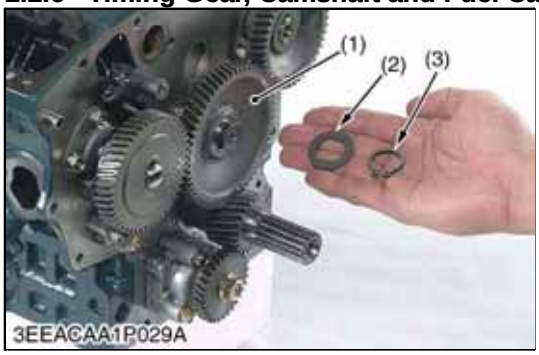
4. Remove the gear case.

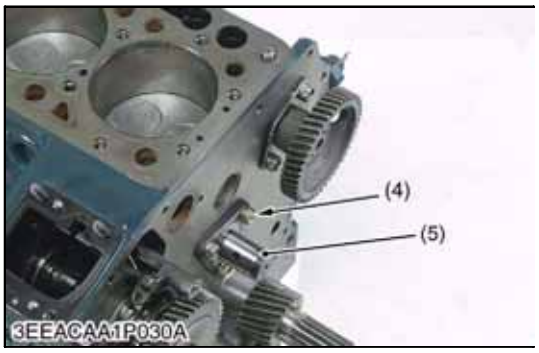
When Reassembling

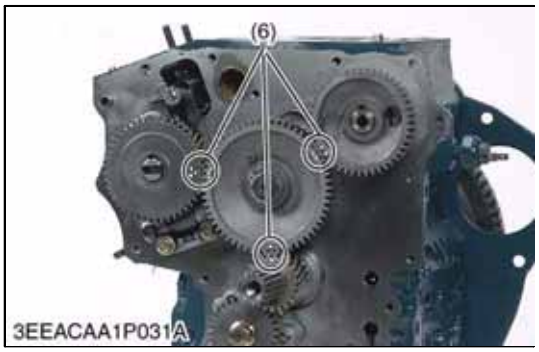
Apply a gasket sealer to both sides of the gear case gasket.

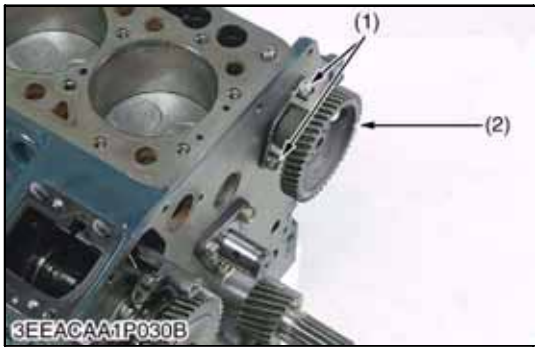
Be sure the three O-rings in the gear case are in place.

1. Bolt (Inside)
2. Start Spring
3. Fork Lever 1
4 Gear Case









2.2.6.e Idle Gear

1. Remove the external snap ring (3), the collar (2) and the idle gear (1).
2. Remove the idle gear shaft mounting bolts (4).
3. Remove the idle gear shaft (5).

When Reassembling

Apply engine oil to the idle gear shaft mounting bolt (4) and tighten them.

Install the idle gear, aligning the marks (6) on the gears. Refer to the illustration.

Tightening Torque	Idle Gear Shaft Mounting Bolt	9.8 to 11.3 N·m 1.00 to 1.15 kgf·m 7.2 to 8.3 ft-lbs

1. Idle Gear
2. Idle Gear Collar
3. External Snap Ring
4. Idle Gear Shaft Mounting Bolt
5. Idle Gear Shaft
6. Alignment Mark

2.2.6.f Camshaft

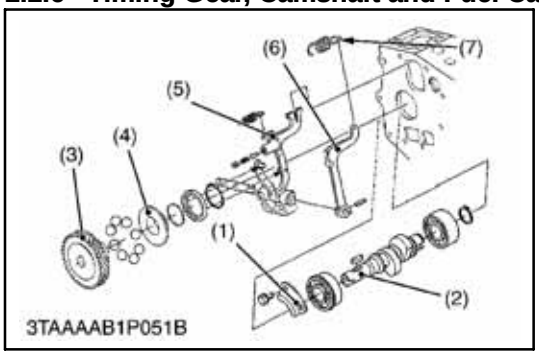
1. Remove the camshaft mounting screws (1) and draw out the camshaft with the gear (2) on it.

When Reassembling

Apply engine oil to the camshaft journals before installing it.

Apply engine oil to the camshaft mounting screws and tighten them.

1. Camshaft Mounting Screw
2. Camshaft Gear



2.2.6.g Fuel Camshaft

1. Remove the retaining plate (1).
2. Remove the fork lever holder mounting bolts (8), then draw out the injection pump gear (3) and fuel camshaft (2) with the governor fork assembly.

When Reassembling

Hook the governor spring (7) to the fork lever 2 (6) as shown in the figure before installing the fork lever assembly to the crankcase.

1. Retaining Plate
2. Fuel Camshaft
3. Injection Pump Gear
4. Governor Sleeve
5. Fork Lever 1
6. Fork Lever 2
7. Governor Spring
8. Fork Lever Holder Mounting Bolt

2.2.6.h Oil Pump and Crankshaft Gears

1. Remove the oil pump gear (6).
2. Remove the oil pump mounting bolts, then the oil pump (5).
3. Remove the collar (4), O-ring (3) and crankshaft oil slinger (2).
4. Remove the crankshaft gear (1) with a puller.

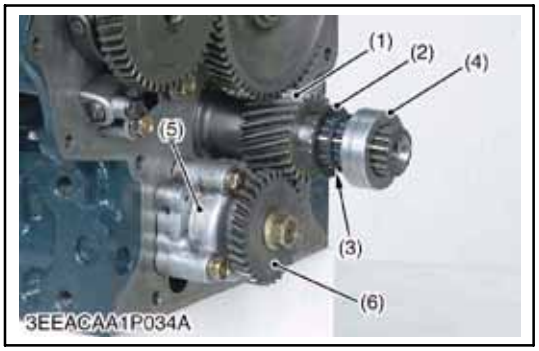
When Reassembling

Begin reassembly by installing the crankshaft gear first.

Install the collar (4) after aligning the marks on the gear. (See 2.2.6.e)

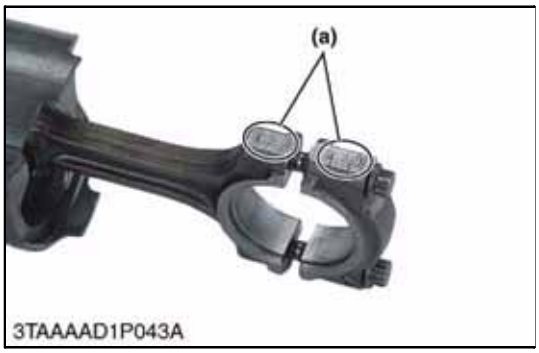
Replace the oil pump.

Tightening Torque	Oil Pump Mounting Bolt	17.7 to 21.6 N·m 1.8 to 2.2 kgf·m 13.0 to 15.9 ft-lbs



1. Crankshaft Gear
2. Crankshaft Oil Slinger
3. O-ring
4. Crankshaft Collar
5. Oil Pump
6. Oil Pump Gear

2.2.7 Piston and Connecting Rod



2.2.7.a Connecting Rod

1. Remove the connecting rod caps (1) using a bihexagonal 8 mm socket.

When Reassembling

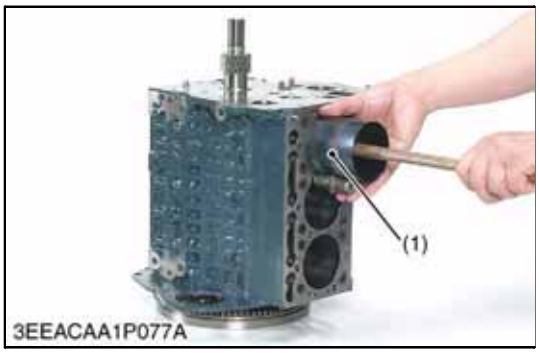
Align the marks (a) with each other. Face the marks toward the injection pump.

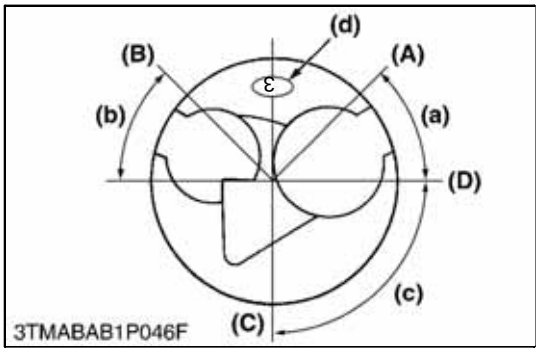
Apply engine oil to the connecting rod bolts and lightly screw them in by hand, then tighten to the specified torque.

If the connecting rod bolt does not screw in smoothly, clean the connecting rod and bolt threads.

Tightening Torque	Connecting Rod Bolt	26.5 to 30.4 N·m 2.7 to 3.1 kgf·m 19.5 to 22.4 ft-lbs

1. Connecting Rod Cap
a. Mark





2.2.7.b Pistons

1. Completely remove the carbon ridge at the top of the cylinder walls.
2. Remove the the connecting rod cap.
3. Turn the flywheel and bring the piston to top dead center.
4. Push the piston out by lightly tapping the connecting rod from the bottom of the crankcase with the grip of a hammer.
5. Repeat the procedure for the other cylinder(s).

When Reassembling

Liberally coat the piston and piston rings with engine oil.

When inserting the piston into the cylinder, face the mark on the connecting rod to the injection pump.

NOTE

If re-installing the original piston assemblies into the engine be sure that they are returned to their original cylinder.

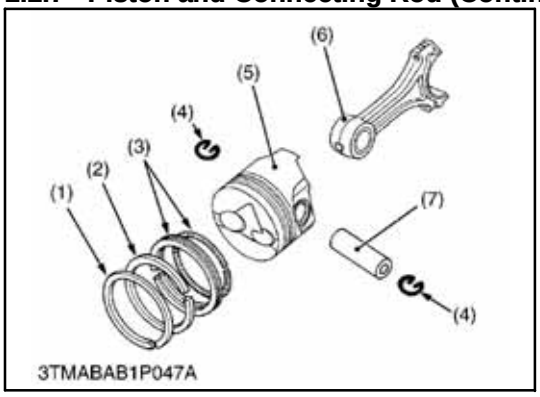
When installing the piston into the cylinder, place the gaps of all the piston rings as shown in the figure.

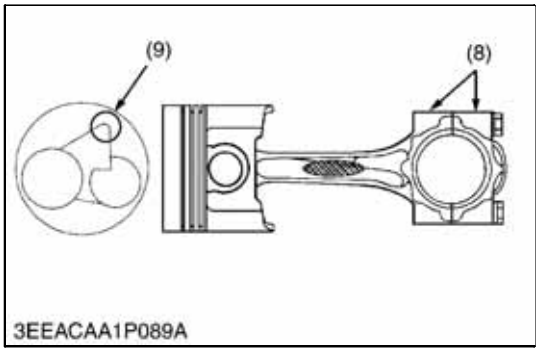
Carefully insert the pistons into the cylinders using the piston ring compressor (1).

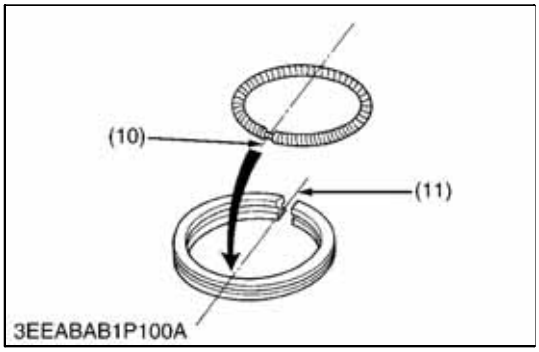
When inserting the piston into the cylinder avoid damaging the molybdenum disulfide coating on the piston skirt. This coating is useful in minimizing the clearance between the piston and cylinder.

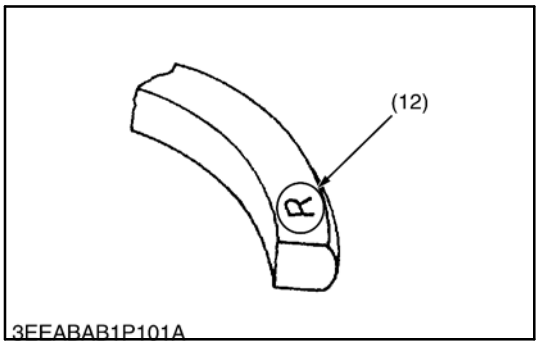
When replacing a piston, use a replacement piston with the same code number. The piston ID mark (d) is on top of the piston.

1. Piston Ring Compressor
(**A**) Top Ring Gap
(**B**) Second Ring Gap
(**C**) Oil Ring Gap
(**D**) Piston Pin Hole
(**a**) 0.785 rad. (45°)
(**b**) 0.785 rad. (45°)
(**c**) 1.57 rad. (90°)
(**d**) Mark









2.2.7.c Piston Ring and Connecting Rod

1. Remove the piston rings (1), (2), (3).

2. Remove the piston pin (7) and then seperate the connecting rod (6) from the piston (5).

NOTE

Mark both the connecting rod and piston so that if they are to be re-used that the original combination of parts will go back together. Do not interchange used parts.

When Reassembling

When installing the ring, assemble the rings so that the manufacturer's mark (12) near the gap faces the top of the piston (5).

When installing the oil control ring (3) onto the piston (5), place the expander joint (10) on the opposite side of the oil ring gap (11).

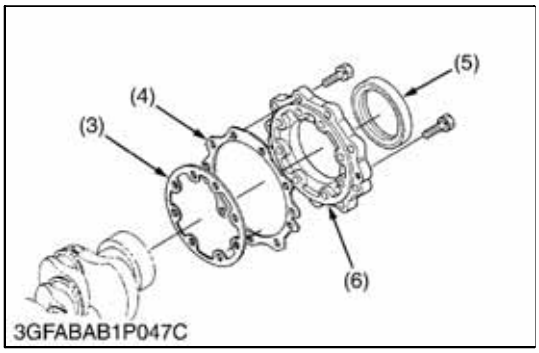
Apply engine oil to the piston pin (7).

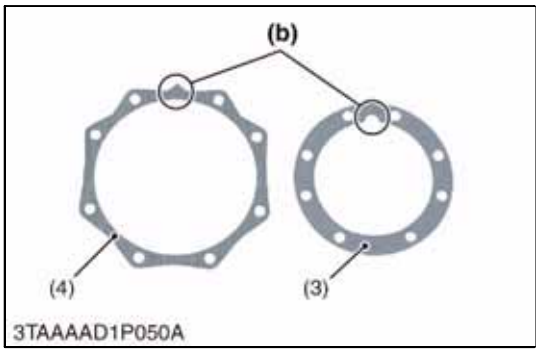
When assembling the connecting rod (6) to the piston (5), immerse the piston (5) in hot oil (80°C / 176°F) for 10 to 15 minutes, then assemble the piston, piston pin, and connecting rod.

When installing the connecting rod to the piston, align the mark (8) on the connecting rod to the fan-shaped concave (9).

1. Top Ring
2. Second Ring
3. Oil Control Ring
4. Piston Snap Ring
5. Piston
6. Connecting Rod
7. Piston Pin
8. Mark
9. Fan Shaped Concave
10. Expander Joint
11. Oil Ring Gap
12. Manufacturer's Mark

2.2.8 Crankshaft





2.2.8.a Flywheel

1. Position the flywheel (2) so that the “1TC” mark (a) on the outer surface of the flywheel aligns horizontally with the alignment mark (b) on the rear end plate.
2. Prevent the flywheel (2) from rotating.
3. Remove all of the flywheel screws (1).
4. Remove the flywheel (2).

When Reassembling

Check to see that the mating surfaces of the crankshaft and flywheel are clean.

Align the “1TC” mark (a) on the outer surface of the flywheel horizontally with the alignment mark (b) on the rear end plate and install the flywheel

Apply engine oil to the flywheel bolts and install.

Tightening Torque	Flywheel Bolts	53.9 to 58.8 N·m 5.5 to 6.0 kgf·m 39.8 to 43.4 ft-lbs

1. Flywheel Bolt
2. Flywheel

a 1TC Mark
b Alignment Mark

2.2.8.b Bearing Case Cover

1. Remove the bearing case cover mounting bolts. First, remove the inside bolts (1) and then the outside screws (2).
2. Screw two of the removed bolts into the bolt hole of the bearing case cover (6) to remove it.

NOTE

The length of the inside and the outside bolts are different. When reassembling reinstall the appropriate bolt in the correct location.

When Reassembling

Fit the bearing case gasket (3) and the bearing case cover gasket (4) to the bearing case cover (6). Orient them correctly.

Install the bearing case cover (6), again orienting it correctly, using the “UP” mark (a).

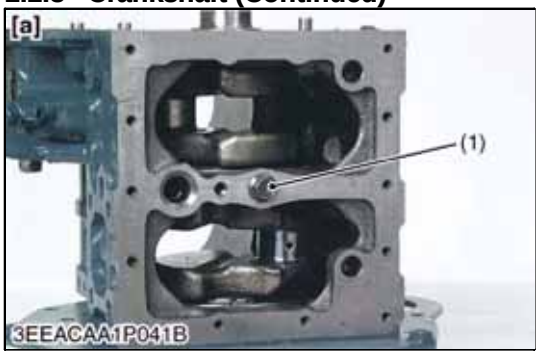
Apply oil to the oil seal, and take care that it is not rolled while being installed.

Tighten the bearing case cover bolts diagonally and evenly.

Tightening Torque	Bearing Case Cover Mounting Screw	9.8 to 11.3 N·m 1.00 to 1.15 kgf·m 7.2 to 8.3 ft-lbs

1. Bearing Case Cover Mounting Bolt (Inside)
2. Bearing Case Cover Mounting Bolt (Outside)
3. Bearing Case Gasket
4. Bearing Case Cover Gasket
5. Oil Seal
6. Bearing Case Cover

(**a**). Top Mark “UP”
(**b**) Upside



2.2.8.c Crankshaft Assembly

NOTE

Before disassembling, check the side clearance of the crankshaft. Check it during reassembly.

1. Remove the two main bearing case bolts (1).
2. Pull out the crankshaft, being careful not to damage the crankshaft bearing.

When Reassembling

Clean the oil passages of the crankshaft with compressed air.

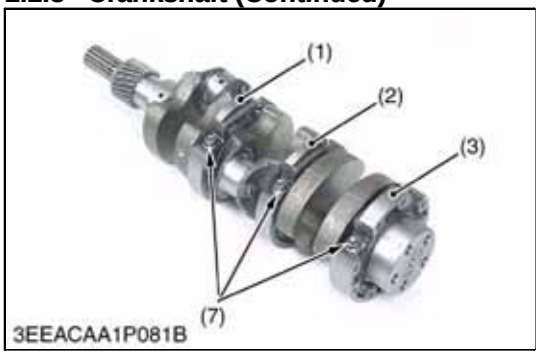
Install the crankshaft assembly, aligning the bolt hole of the main bearing case screw 2 with the bolt hole of the crankcase.

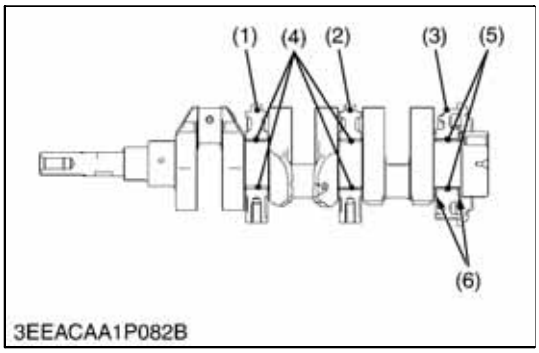
When tightening the main bearing case 2, apply oil to the main bearing case bolt 2 (1) and tighten by hand before tightening to the specific torque. If any resistance is encountered while tightening, re-align the bolt holes.

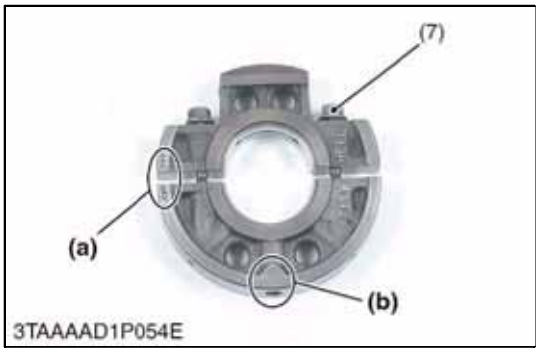
Tightening Torque	Main Bearing Case Bolt 2	26.5 to 30.4 N·m 2.7 to 3.1 kgf·m 19.5 to 22.4 ft-lbs

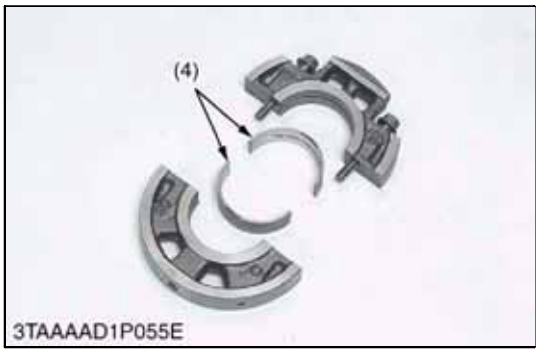
1. Main Bearing Case Bolt 2r

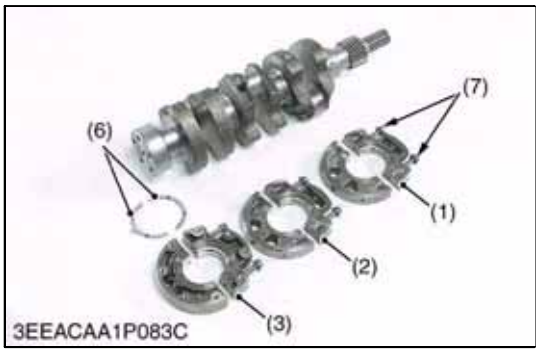
(a).Z482-E2B
(b).D722-E2B











2.2.8.d Main Bearing Case Assembly

1. Remove the two main bearing case screws 1 (7) and remove the main bearing case assembly 1 (1) being careful with crankshaft bearing 3 (4).
2. Remove the main bearing case assembly 2 (2) and the main bearing case assembly (3) as above. Keep in mind that the thrust bearing (6) is installed in the main bearing case assembly (3).

When Reassembling

Clean the oil passages in the main bearing cases.

Apply clean engine oil on the bearings.

Reinstall the main bearing case assemblies into their original positions. Since diameters of main bearing cases vary, install them in order by marking (**b** in the illustration) **(1** for Z482 and **1**, **2** for D722), from the gear case side.

The diameters of the main bearing cases vary. Install them in order from the gear case end according to their markings

Match the alignment numbers (**a**) on the main bearing case assembly 1.

Do the same for the main bearing case assembly 2 (2), and face the mark 'FLYWHEEL' to the flywheel.

Install the thrust bearing (6) with its oil groove facing outward.

Confirm that the main bearing case moves smoothly after tightening the main case bolt 1 to the specified torque.

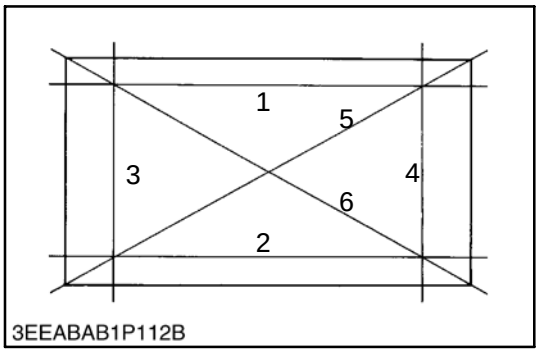
Tightening Torque	Main Bearing Case Screw 1	12.7 to 15.7 N·m 1.3 to 1.6 kgf·m 9.4 to 11.6 ft-lbs

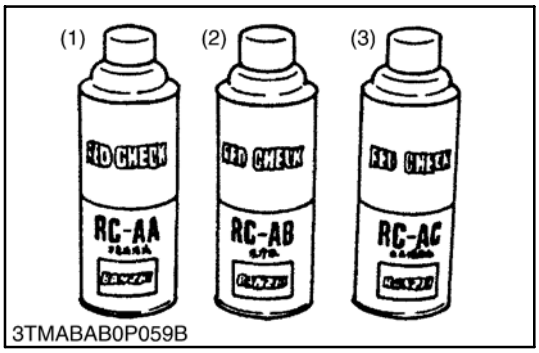
1. Main Bearing Case Assembly 1
2. Main Bearing Case Assembly 2
3. Main Bearing Case Assembly
4. Crankshaft Bearing 3
5. Crankshaft Bearing 2
6. Thrust Bearing 2
7. Main Bearing Case Screw 1

(**a**) Alignment Number
(**b**) Marking (1 or 2)

2.3 SERVICING

2.3.1 Cylinder Head And Valves





1. Red Dye
2. Detergent
3 White Developer

2.3.1.a Cylinder Head Surface Flatness

1. Clean the cylinder head surface.
2. Place a straightedge on the cylinder head surface, in six locations as depicted in the drawing.
3. Measure any clearance between the straightedge and cylinder head with a feeler gauge.
4. If the measurement exceeds the allowable limit, resurface or replace the head.

NOTE

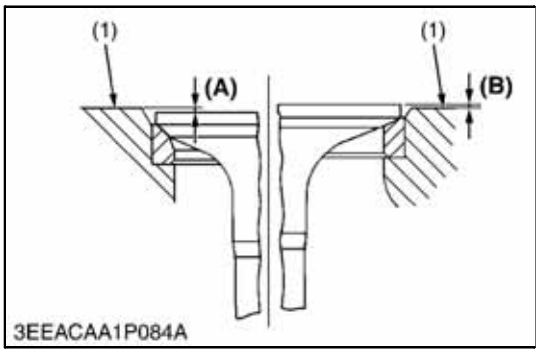
Do not measure the combustion chamber.

Check the valve recessing after after resurfacing the head.

Cylinder Head Surface Flatness	Allowable Limit	0.05mm 0.0020 in.

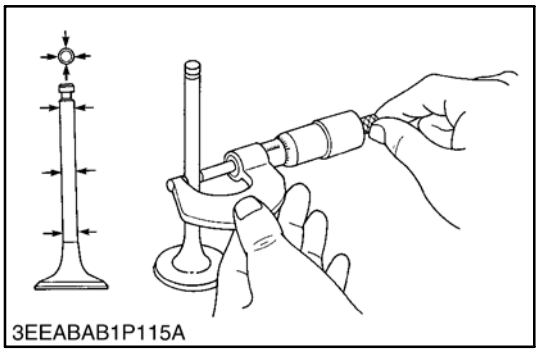
2.3.1.b Cylinder Head Cracks

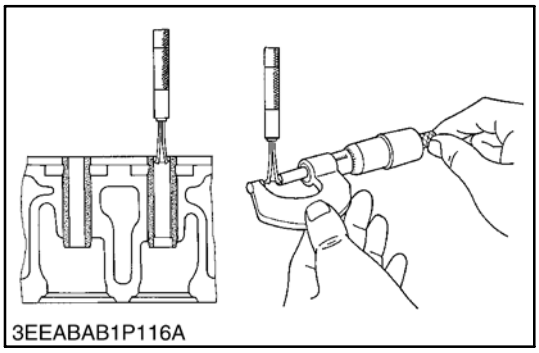
1. Cylinder head crack(s) can be found with using a non–destructive test procedure using a dye/penetrant kit.
2. Clean the cylinder head surface using a good quality degreaser and detergent (2).
3. Spray the cylinder head surface with the red liquid or dye (1). Let it sit on the surface for ten minutes.
4. Wash the dye off the head using the detergent (2) and dry the head.
5. Spray the white developer (3) on to the head.
6. Red marks will bleed through the developer identifying cracks in the head if they are present.



1. Cylinder Head Surface

(A) Recess
(B) Protrusion





2.3.1.c Valve Recessing

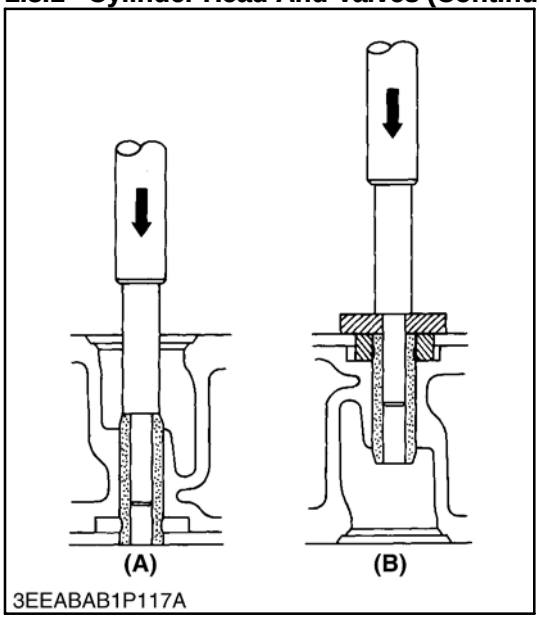
1. Clean the cylinder head surface (1), valve face and valve seat.
2. Insert the valve into the head, making certain that the valve is fully seated.
3. Measure the valve recession (A) with a depth gauge.
4. If the measurement exceeds the allowable limit, replace the valve.
5. If the measurement still exceeds the allowable limit, replace the cylinder head.

Valve Recessing	Factory Specification	0.10 (protrusion) mm to 0.10 (recessing) mm 0.0039(protrusion) in. to 0.0039 (recessing) in.
	Allowable Limit	0.30 (recessing) mm 0.0118 (recessing) in.

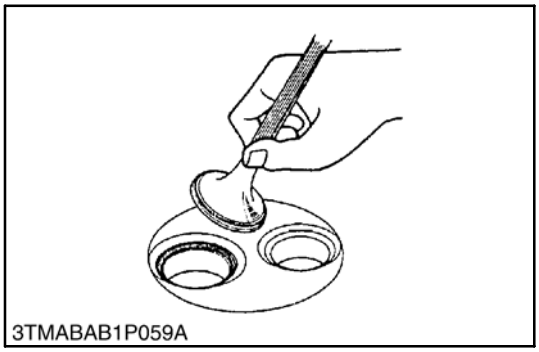
2.3.1.d Clearance Between Valve Stem And Valve Guide

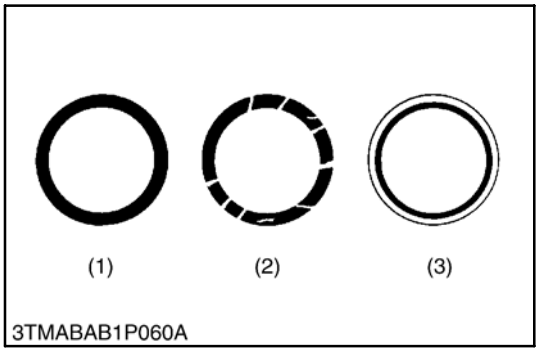
1. Remove carbon from the valve guide section.
2. Measure the valve stem O.D. with a micrometer.
3. Measure the valve guide with a small hole gauge, and calculate the clearance.
4. If the clearance exceeds the the allowable limit, replace the valves. If the clearance still exceeds the allowable limit, replace the valve guide.

Clearance Between Valve Stem and Guide	Factory Specification	0.030 to 0.057 mm 0.00118 to 0.00224 in.
	Allowable Limit	0.10 mm 0.0039 in.
Valve Stem O.D.	Factory Specification	5.968 to 5.980 mm 0.23496 to 0.23543 in.
Valve Guide I.D.	Factory Specification	6.010 to 6.025 mm 0.23661 to 0.23720 in.



(A) When Removing **(B)** When Installing





1. Correct
2. Incorrect
3 Incorrect

2.3.1.e Replacing Valve Guide

(A) (When removing)

1. Press out the used valve guide using a valve guide replacing tool.

(B) (When installing)

1. Clean a new valve guide and valve guide bore, then apply oil to them.
2. Press in a new valve guide using a valve guide replacing tool.
3. Ream the I.D. of the valve guide to the specified dimension (precisely).

Valve Guide I.D. Intake & Exhaust	Factory Specification	6.010 to 6.025 mm 0.2366 to 0.2372 in.

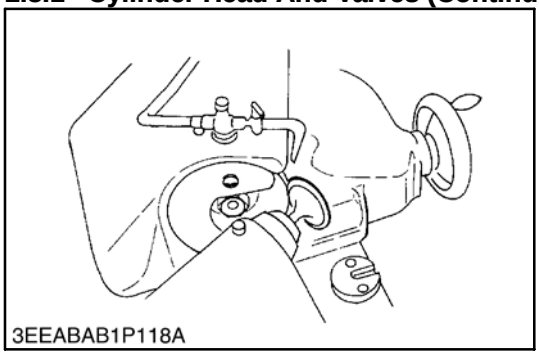
NOTE

Do not hit the valve guide with a hammer during replacement.

2.3.1.f Valve Seating

1. Coat the valve face lightly with prussian blue and put the valve on its seat to check the contact pattern
2. If the valve does not seat all the way around the valve seat, or the contact is less than 70%, correct the valve seating as outlined in 2.3.1.g.
3. If the valve contact does not comply with the reference value, replace the valve or correct the contact of valve seating.

Valve Seat Width	Factory Specification	2.12 mm 0.0835 in.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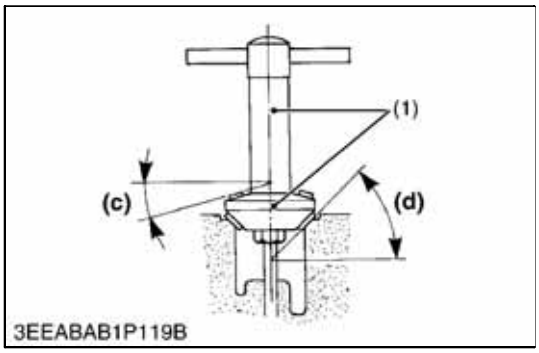

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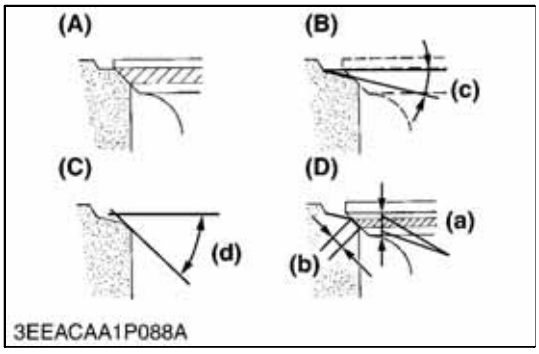

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3EEACAA1P044A

2.3.1.g Correcting Valve and Valve Seat

NOTE

Before correcting the valve seat, make certain that the valve and valve guide are within factory specifications.

After correcting the valve seat, be sure to check the valve recession.

(A) Correcting the Valve

1. Correct the valve with a valve grinder.

Valve Face Angle	Factory Specification	0.785 rad. 45°

(B) Correcting the Valve Seat

1. Slightly correct the valve seat surface with a 0.785 rad. (45°) valve seat cutter.
2. Reinsert the valve, check the contact pattern with prussian blue. A valve seat width should be approximately 70% of the total valve contact area. See (**A**) in the illustration
3. Resurface the seat surface with a 0.262 rad. (15°) valve seat cutter to the valve seat so that (**a**) equals (**b**) in the illustration.
4. Grind the seat with a 0.785 rad (45°) valve seat cutter again, and visually recheck the contact between the valve and the seat.
5. Repeat steps 3 and 4 until the correct contact is achieved.
6. Continue lapping until the seated width becomes more than 70% of the total contact area.

Valve Seat Angle	Factory Specification	0.785 rad. 45°

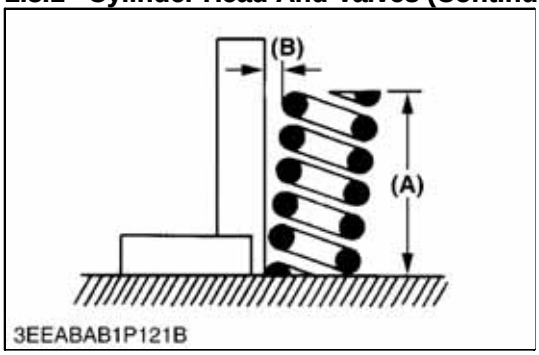
1. Valve Seat Cutter
A. Check Contact
B. Correct Seat Width
C. Correct Seat Surface
D. Check Contact
a. Identical Dimensions
b. Valve Seat Width
c. 0.262 rad (15°)
d 0.785 rad (45°)

2.3.1.h Valve Lapping

1. Apply compound evenly to the valve lapping surface.
2. Insert the valve into the valve guide. Lap the valve onto its seat with a valve lapper.
3. After lapping the valve, wash the compound away and apply oil, then repeat valve lapping with oil.
4. Apply prussian blue to the contact surface to check the contact pattern. If it is less than 70%, repeat valve lapping again.

NOTE

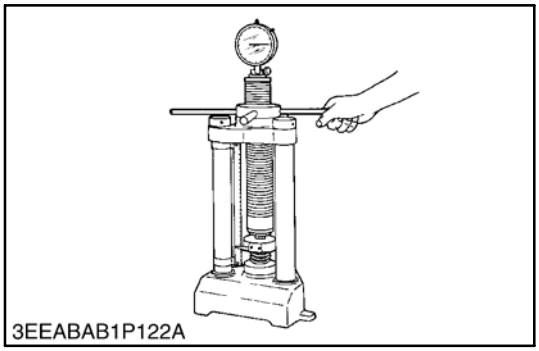
When valve lapping is performed, be sure to check the valve recession and adjust the valve clearance after assembling the valve.



2.3.1.i Free Length and Tilt of Valve Spring

1. Measure the free length **(A)** of the valve spring with vernier calipers. If the measurement is less than the allowable limit, replace the spring.
2. Put the valve spring on a surface plate, place a square on the side of the valve spring.
3. Check to see if the entire side is in contact with the square. Rotate the spring and measure for maximum tilt **(B)**. Check the entire surface of the valve spring for defects. If any are found, replace it.

Free Length **(A)**	Factory Specification	31.3 to 31.8 mm 1.232 to 1.252 in.
	Allowable Limit	28.4 mm 1.118 in.
Tilt **(B)**	Allowable Limit	1.2 mm 0.047 in.



2.3.1.j Valve Spring Setting Load

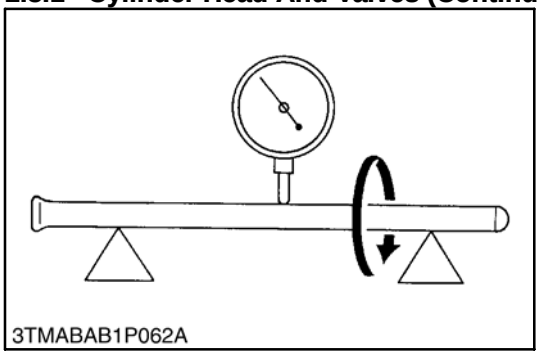
1. Place the valve spring on a tester and compress it to the same length it's actually compressed in the engine.
2. Read the compression load on the gauge.
3. If the measurement is less than the allowable limit, replace it.

Setting Load / Setting Length	Factory Specification	64.7 N / 27.0 mm 6.6 kgf / 27.0 mm. 14.6 lbs. / 1.063 in.
	Allowable Limit	54.9 N / 27.0 mm 5.6 kgf / 27.0 mm. 12.3 lbs. / 1.063 in.

2.3.1.k Oil Clearance Between Rocker Arm and Rocker Arm Shaft

1. Measure the rocker arm shaft O.D. with an outside micrometer.
2. Measure the rocker arm I.D. with a inside micrometer, then calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the rocker arm then measure the oil clearance again. If the clearance is still out of specification, replace the rocker arm shaft.

Oil Clearance Rocker Arm/ Shaft	Factory Specification	0.016 to 0.045 mm 0.00063 to 0.00177 in.
	Allowable Limit	0.15 mm 0.0059 in.
Rocker Arm Shaft O.D.	Factory Specification	10.473 to 10.484 mm 0.41232 to 0.41276 in.
Rocker Arm I.D.	Factory Specification	10.500 to 10.518 mm 0.41339 to 0.41410 in.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3TAAAAD1P061A


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2.3.1.l Push Rod Alignment

1. Place the push rod on V blocks

2. Measure the push rod alignment.

3. If the measurement exceeds the allowable limit, replace the push rod.

Push Rod Alignment	Allowable Limit	0.25 mm 0.0098 in.

2.3.1.m Oil Clearance Between Tappet and Tappet Guide Bore

1. Measure the tappet O.D. with a micrometer.

2. Measure the I.D. of the tappet guide bore with a cylinder gauge and calculate the clearance.

3. If the measurement exceeds the allowable limit, or the tappet is damaged, replace the tappet.

Oil Clearance Tappet/ Tappet Guide Bore	Factory Specification	0.016 to 0.052 mm 0.00063 to 0.00205 in.
	Allowable Limit	0.10 mm 0.0039 in.
Tappet O.D.	Factory Specification	17.966 to 17.984 mm 0.70732 to 0.70803 in.
Tappet Guide I.D.	Factory Specification	18.000 to 18.018 mm 0.70866 to 0.70937 in.

2.3.2 Timing Gears, Camshaft and Fuel Camshaft

2.3.2.a Timing Gear Backlash

1. Set a dial indicator (lever type) with its tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the bearing clearance of the shafts and the gear.
4. If the bearing clearance is proper, replace the gear.

Backlash/ Idle Gear/ Crank Gear	Factory Specification	0.043 to 0.124 mm 0.00169 to 0.00488 in.
	Allowable Limit	0.15 mm 0.0059 in.
Backlash/ Idle Gear/ Cam Gear	Factory Specification	0.047 to 0.123 mm 0.00185 to 0.00484 in.
	Allowable Limit	0.15 mm 0.0059 in.
Backlash/ Idle Gear/ Injection Pump Gear	Factory Specification	0.046 to 0.124 mm 0.00181 to 0.00488 in.
	Allowable Limit	0.15 mm 0.0059 in.
Backlash/ Crank Gear/ Oil Pump Gear	Factory Specification	0.041 to 0.123 mm 0.00161 to 0.00484 in.
	Allowable Limit	0.15 mm 0.0059 in.

2.3.2.b Idle Gear Side Clearance

1. Set a dial indicator with its tip on the idle gear.
2. Move the gear front to rear to measure the side clearance.
3. If the measurement exceeds the allowable limit, replace the idle gear collar.

Idle Gear Side Clearance	Factory Specification	0.20 to 0.51 mm 0.0079 to 0.0201 in.
	Allowable Limit	0.80 mm 0.0315 in.

2.3.2.c Camshaft Side Clearance

1. Set a dial indicator with its tip on the camshaft.
2. Move the camshaft gear front to rear to measure the side clearance.
3. If the measurement exceeds the allowable limit, replace the camshaft stopper.

Camshaft Side Clearance	Factory Specification	0.15 to 0.31 mm 0.0059 to 0.0122 in.
	Allowable Limit	0.50 mm 0.0197 in.

2.3.2.d Camshaft Run-Out

1. Support the camshaft with V blocks on a surface plate at both end journals.
2. Set a dial indicator with its tip on the intermediate journal.
3. Rotate the camshaft and measure for run-out.
4. If the measurement exceeds the allowable limit, replace the camshaft.

Camshaft Run-out	Allowable Limit	0.1 mm 0.0004 in.

2.3.2.e Cam Height

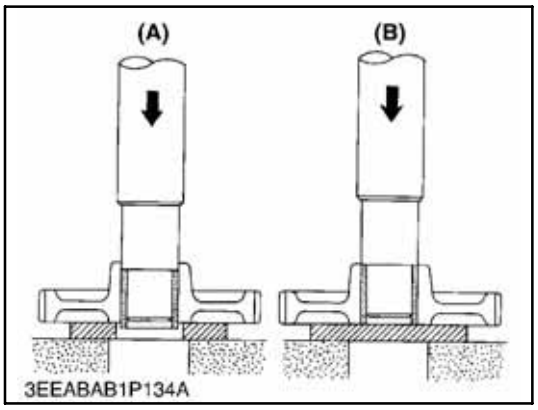
1. Measure the cam lobe at its largest O.D. with an outside micrometer.
2. If the measurement is less than the allowable limit, replace the camshaft.

Cam Height Intake/Exhaust	Factory Specification	26.88 mm 1.0583 in.
	Allowable Limit	26.83 mm 1.0563 in.

2.3.2.f Camshaft Bearing Clearance

1. Measure the camshaft journal O.D. with an outside micrometer.
2. Measure the cylinder block camshaft bore I.D. with a cylinder gauge, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the camshaft.

Camshaft Journal Clearance	Factory Specification	0.050 to 0.091 mm 0.00197 to 0.00358 in.
	Allowable Limit	0.15 mm 0.0059 in.
Camshaft Journal O.D.	Factory Specification	32.934 to 32.950 mm 1.29661 to 1.29724 in.
Camshaft Bore I.D.	Factory Specification	33.000 to 33.025 mm 1.29921 to 1.30020 in.



2.3.2.g Idle Gear Shaft and Idle Gear Bushing Clearance

1. Measure the idle gear shaft O.D. with an outside micrometer.
2. Measure the idle gear shaft bore I.D. with a cylinder gauge, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the bushing.

Idle Gear Journal Clearance	Factory Specification	0.020 to 0.084 mm 0.00079 to 0.00331 in.
	Allowable Limit	0.10 mm 0.0039 in.
Idle Gear Journal O.D.	Factory Specification	19.967 to 19.980 mm 0.78610 to 0.78661 in.
Idle Gear Bore I.D.	Factory Specification	20.000 to 20.051 mm 0.78740 to 0.78941 in.

2.3.2.h Replacing Idle Gear Bushing

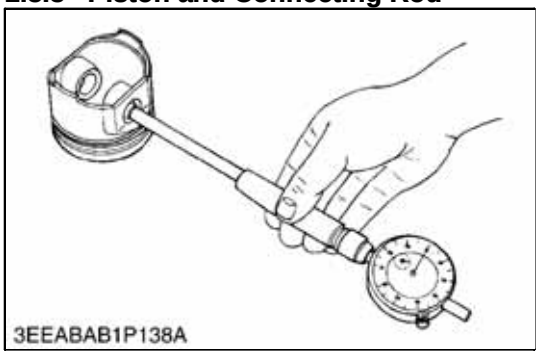
(A) When Removing

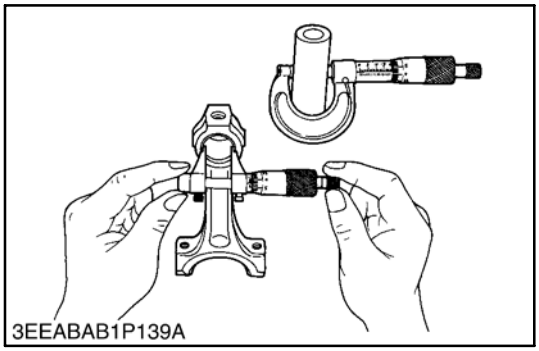
1. Press out the bushing using an Idle Gear Bushing Replacing Tool.

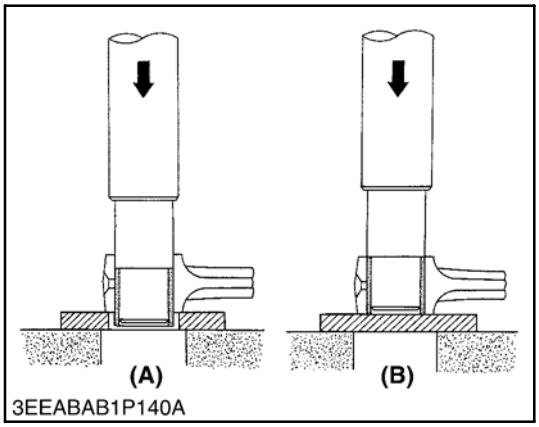
(B) When Installing

1. Clean a new idle gear bushing and the idle gear bore, and apply engine oil to both.
2. Using the idle gear replacing tool, press in the new bushing to the specified dimension (see **B**)

2.3.3 Piston and Connecting Rod

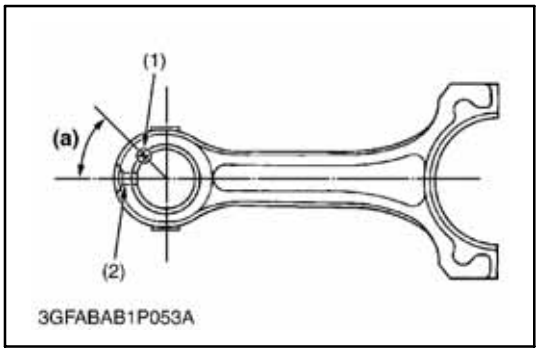






A. When Removing

B. Correct Seat Width



1. Seam
2. Oil Hole

a. 0.785 rad (45°)

2.3.3.a Piston Pin Bore I.D.

1. Measure the piston pin bore I.D. in both the horizontal and vertical directions with a cylinder gauge.
2. If the measurement exceeds the allowable limit, replace the piston.

Piston Pin Bore I.D.	Factory Specification	20.000 to 20.013 mm 0.78740 to 0.78791 in.
	Allowable Limit	20.05 mm 0.7894 in.

2.3.3.b Piston Pin and Bushing Clearance

1. Measure the piston pin O.D. with an outside micrometer.
2. Measure the connecting rod small end bushing I.D. with an inside micrometer.
3. If the clearance exceeds the allowable limit, replace the bushing. If the clearance is still excessive, replace the piston pin.

Piston Pin to Small End Bushing Clearance	Factory Specification	0.014 to 0.038 mm 0.00055 to 0.00150 in.
	Allowable Limit	0.10 mm 0.0039 in.
Piston Pin O.D.	Factory Specification	20.002 to 20.011 mm 0.78748 to 0.78783 in.
Small End Bushing I.D.	Factory Specification	20.025 to 20.040 mm 0.78839 to 0.78897 in.

2.3.3.c Replacing Connecting Rod Small End Bushing

(A) When Removing

1. Press out the small end bushing using a Small End Bushing Replacing Tool.

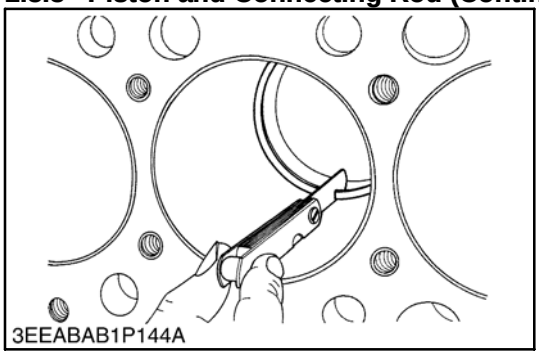
(B) When Installing

1. Clean a new small end bushing and bore, and apply engine oil to both.
2. Using the small end bushing replacing tool, press in the new bushing to the specified dimension (see **B**).

NOTE

Be sure to align the bushing so that the oil hole in the bushing aligns with the oil port in the connecting rod.

Piston Pin to Small End Bushing Clearance (Replacement Parts)	Factory Specification	0.015 to 0.075 mm 0.00059 to 0.00295 in.
	Allowable Limit	0.15 mm 0.0059 in.
Small End Bushing I.D. (Replacement Parts)	Factory Specification	20.026 to 20.77 mm 0.78845 to 0.79043 in.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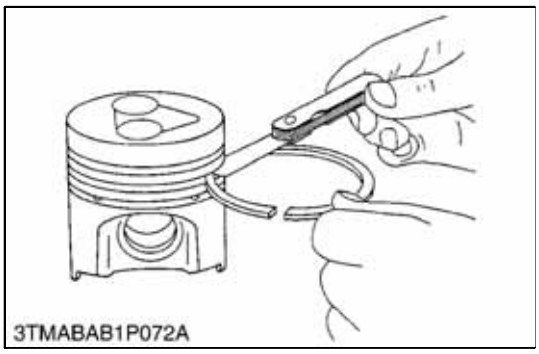
2.3.3.d Piston Ring Gap

1. Insert the piston ring into the lower part of the cylinder (the least worn section). Use the piston to square the ring in the cylinder.
2. Measure the ring gap with a feeler gauge.
3. If the gap exceeds the allowable limit, replace the piston ring.

Top Ring	Factory Specification	0.15 to 0.30 mm 0.0059 to 0.0118 in.
	Allowable Limit	1.20 mm / 0.0472 in.
Second Ring	Factory Specification	0.30 to 0.45 mm 0.0118 to 0.0177 in.
	Allowable Limit	1.20 mm / 0.0472 in.
Oil Control Ring	Factory Specification	0.15 to 0.30 mm 0.0059 to 0.0118 in.
	Allowable Limit	1.20 mm / 0.0472 in.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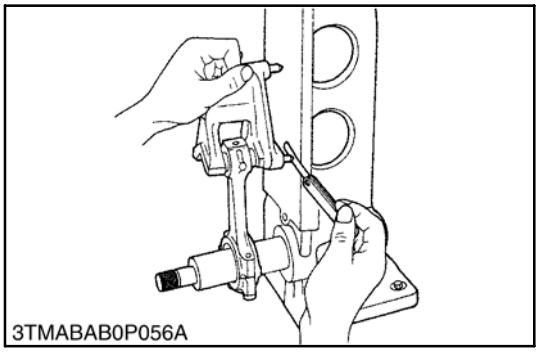
2.3.3.e Piston Ring to Groove Clearance

1. Clean the rings and the ring grooves, and install each ring in its groove.
2. Measure the clearance between the ring and its groove with a feeler gauge.
3. If the clearance exceeds the allowable limit, replace the ring.
4. If the clearance still exceeds the allowable limit after replacing the ring, replace the piston.

Second Ring	Factory Specification	0.090 to 0.120 mm 0.00354 to 0.00472 in.
	Allowable Limit	0.15 mm / 0.0059 in.
Oil Control Ring	Factory Specification	0.040 to 0.080 mm 0.0016 to 0.0031 in.
	Allowable Limit	0.15 mm / 0.0059 in.

2.3.3.f Connecting Rod Alignment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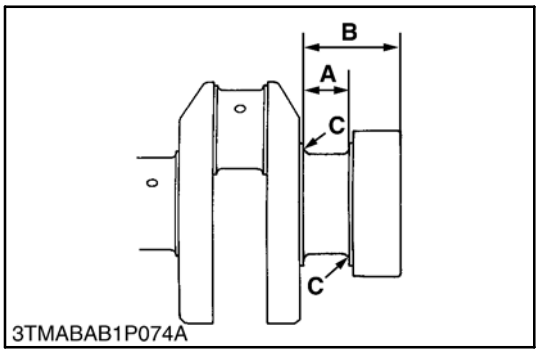
NOTE

Since the I.D. of the connecting rod small end bushing is the basis of this procedure, check the bushing for wear before proceeding.

1. Install the piston pin into the connecting rod.
2. Install the connecting rod on the connecting rod alignment tool.
3. Put a gauge over the piston pin and move it against the face plate.
4. If the gauge does not fit squarely against the face plate, measure the space between the pin of the gauge and the face plate.
5. If the measurement exceeds the allowable limit, replace the connecting rod.

Connecting Rod Alignment	Allowable Limit	0.05 mm / 0.0020 in.

2.3.4 Crankshaft



2.3.4.a Crankshaft End Clearance

1. Push on the end of the crankshaft to seat it toward the flywheel end of the engine block.
2. Attach, then zero a dial indicator on the forward end of the crankshaft.
3. Measure the end play by pulling the crankshaft forward.
4. If the measurement exceeds the allowable limit replace the thrust bearings.
5. If the new thrust bearings do not correct the excessive end clearance condition, over size thrust bearings may be necessary.

Crankshaft Side Clearance	Factory Specification	0.15 to 0.31 mm 0.0059 to 0.0122 in.
	Allowable Limit	0.50 mm 0.0197 in.

(Reference)

Oversize dimensions of thrust bearing.

Oversize	Bearing	Part Number	Marking
0.2 mm 0.008 in.	Thrust Bearing 1 02	25-36430-01	020 OS
	Thrust Bearing 2 02		020 OS

(Reference)

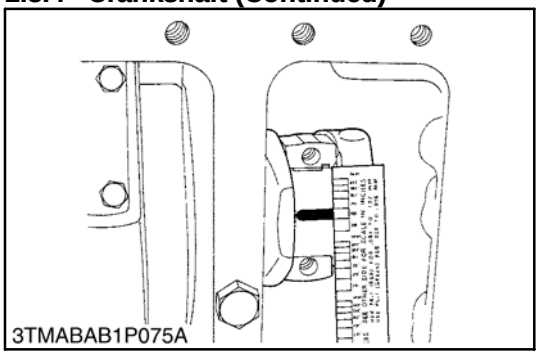
Oversize dimensions of crankshaft journal.

Oversize	0.2mm / 0.0008 in.	0.4mm / 0.0016 in.
Dimension **A**	23.40 to 23.45 mm 0.9134 to 0.9154 in.	23.80 to 23.85 mm 0.9213 to 0.9232 in.
Dimension **B**	46.1 to 46.3 mm 1.815 to 1.823 in.	46.3 to 46.5 mm 1.823 to 1.831 in.
Dimension **C**	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius
The crankshaft journal must be fine-finished to higher than 0.8-S.		

2.3.4.b Crankshaft Alignment

1. Support the crankshaft with V blocks on a surface plate at both end journals. Set a dial indicator with its tip on the intermediate journal, perpendicular to the journal.
2. Rotate the crankshaft on the V blocks and get the misalignment (half of the measurement).
3. If the misalignment exceeds the allowable limit, replace the crankshaft.

Crankshaft Alignment	Allowable Limit	0.02 mm 0.0008 in.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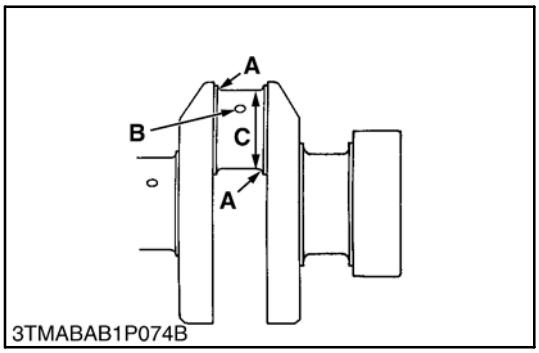

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2.3.4.c Crankpin to Connecting Rod Bearing Clearance

1. Clean the crankpin and the connecting rod bearing.
2. Put a strip of plastigage on the center of the crankpin in each direction as shown in the figure.
3. Install the connecting rod cap and tighten the bolts to the specification. (Refer to Section 2.2.7.b)
4. Remove the cap again.
5. Measure the amount of the flattening with the scale to get the clearance.
6. If the measurement exceeds the allowable limit replace the connecting rod bearing.
7. If the allowable limit is not attainable with a standard size bearing, install an undersize bearing by referring to the table below.

Crankpin/ Connecting Rod Clearance	Factory Specification	0.020 to 0.051 mm 0.00079 to 0.00201 in.
	Allowable Limit	0.15 mm 0.0059 in.

Crankpin O.D.	Factory Specification	33.959 to 33.975 mm 1.33697 to 1.33760 in.
Connecting Rod Bearing I.D.	Factory Specification	33.995 to 34.010 mm 1.33893 to 1.33898 in.

(Reference)

Undersize dimensions of connecting rod bearing.

Undersize	Bearing	Part Number	Marking
0.2 mm 0.008 in.	Connecting Rod Bearing	25-34386-02	020 US
0.4 mm 0.016 in.	Connecting Rod Bearing	25-34386-04	040 US

(Reference)

Undersize dimensions of crankpin journal.

Oversize	0.2mm / 0.008 in.	0.4mm / 0.016 in.
Dimension **A**	2.3 to 2.7 mm 0.091 to 0.106 in.	2.3 to 2.7 mm 0.091 to 0.106 in.
Dimension **B**	1.0 to 1.5 mm dia. 0.0394 to 0.0591 in. dia.	1.0 to 1.5 mm dia. 0.0394 to 0.0591 in. dia.
Dimension **C**	33.759 to 33.775 mm dia. 1.32910 to 1.32973 in. dia.	33.559 to 33.575 mm dia. 1.32112 to 1.32185 in. dia.
The crankshaft journal must be fine-finished to higher than 0.8-S.		


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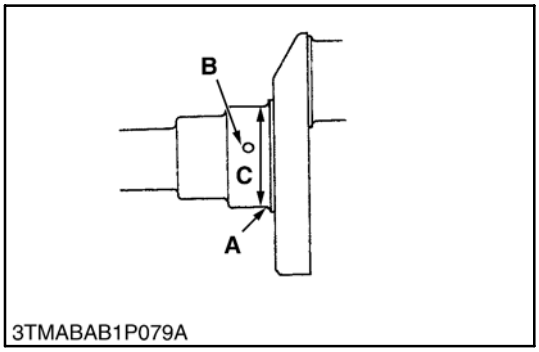

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2.3.4.d Crankshaft Journal to Crankshaft Bearing #1 Clearance

1. Measure the O.D. of the crankshaft journal with an outside micrometer.
2. Measure the I.D. of crankshaft bearing #1 with an inside micrometer and calculate clearance.
3. If the clearance exceeds the allowable limit, replace crankshaft bearing #1.
4. If the allowable limit is not attainable with a standard size bearing, install an undersize bearing by referring to the table below.

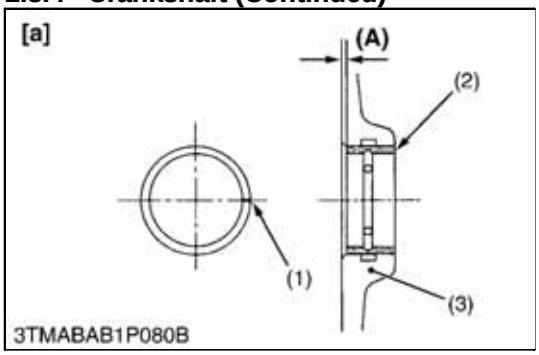
Crankshaft Journal to #1 Bearing Clearance	Factory Specification	0.034 to 0.106 mm 0.00134 to 0.00417 in.
	Allowable Limit	0.20 mm 0.0079 in.
Crankshaft Journal O.D.	Factory Specification	39.934 to 39.950 mm 1.57221 to 1.57284 in.
Crankshaft Bearing Bearing I.D.	Factory Specification	39.984 to 40.040 mm 1.57148 to 1.57638 in.

(Reference) Bearing clearance between crankshaft journal and crankshaft bearing 1.

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankshaft Bearing 1 02	25-34389-02	020 US
0.4 mm 0.016 in.	Crankshaft Bearing 1 04	25-34389-04	040 US

(Reference) Undersize dimensions of crankshaft journal.

Undersize	0.2mm / 0.008 in.	0.4mm / 0.016 in.
Dimension **A**	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius
Dimension **B**	1.0 to 1.5 mm dia. 0.0394 to 0.0591 in. dia	1.0 to 1.5 mm dia. 0.0394 to 0.0591 in. dia
Dimension **C**	39.734 to 39.750 mm dia. 1.56433 to 1.56496 in. dia.	39.534 to 39.550 mm 1.55646 to 1.55709 in. dia.
The crankshaft journal must be fine-finished to higher than 0.8-S.		



1. Seam
2. Crankshaft Bearing#1
3. Cylinder Block
A Dimension

2.3.4.e Replacing Crankshaft Bearing #1

(A) When Removing

1. Press out the crankshaft bearing #1 (2) using a crankshaft bearing replacing tool (Refer to Special Tools 1.8.14).

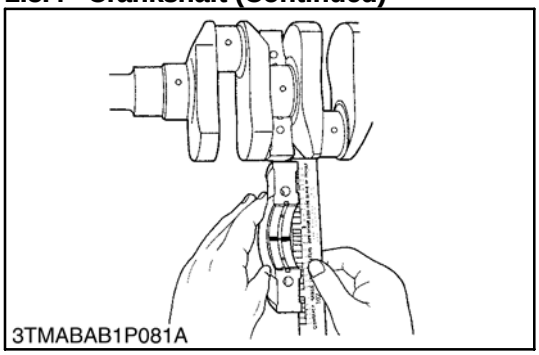
(B) When Installing

1. Clean a new crankshaft bearing #1 (2) and crankshaft journal bore, and apply engine oil to both.
2. Using the crankshaft bearing replacing tool, press in the new bearing #1 (2) so that its seam (1) is toward the exhaust manifold side.

NOTE

Be sure to align the bushing so that the oil hole in the bushing aligns with the oil port.

Dimension **A**	Factory Specification	0.0 to 0.3 mm 0.0 to 0.118 in.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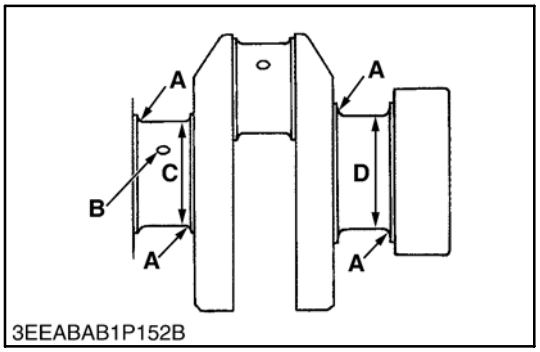

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2.3.4.f Crankshaft Journal to Crankshaft Bearing Clearance

1. Put a strip of plastigage on the center of the crankshaft journal.
2. Install the bearing case and tighten the bolts to specification.
3. Remove the bearing case again.
4. Measure the amount of flattening with the scale to get the clearance.
5. If the measurement exceeds the allowable limit replace crankshaft bearing.
6. If the allowable limit is not attainable with a standard size bearing, install an undersize bearing by referring to the table below.

NOTE

Be sure not to move the crankshaft while the bearing bolts are tightened.

Clearance-Crankshaft Journal to Bearing	Factory Specification	0.028 to 0.051 mm 0.00110 to 0.00201 in.
	Allowable Limit	0.20 mm 0.0079 in.
Crankshaft Journal O.D. (Flywheel Side)	Factory Specification	43.934 to 43.950 mm 1.72968 to 1.73031 in.
Crankshaft Bearing #2 I.D.	Factory Specification	43.984 to 44.026 mm 1.73165 to 1.73331 in.
Crankshaft Journal O.D. (Intermediate)	Factory Specification	39.934 to 39.950 mm 1.57221 to 1.57284 in.
Crankshaft Bearing #3 I.D.	Factory Specification	39.984 to 40.026 mm 1.57417 to 1.57583 in.

(Reference)

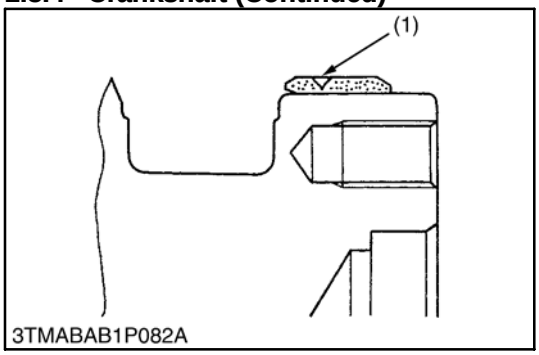
Oversize dimensions of crankshaft bearing 2 and 3 (0.2 mm / 0.008 in.) and (0.4 mm / 0.016 in.).

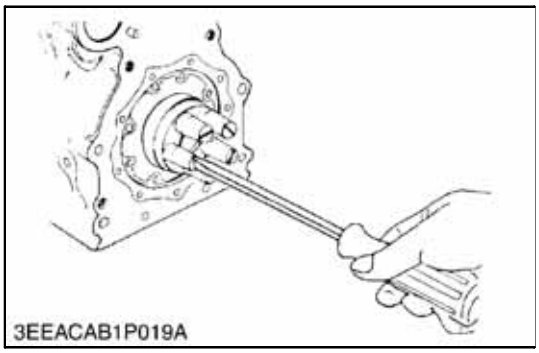
Oversize	Bearing	Part Number	Marking
0.2 mm 0.008 in.	Crankshaft Bearing 2	25-36428-01	020 US
	Crankshaft Bearing 3	25-34390-02	020 US
0.4 mm 0.016 in.	Crankshaft Bearing 2	25-34391-04	040 US
	Crankshaft Bearing 3	25-34390-04	040 US

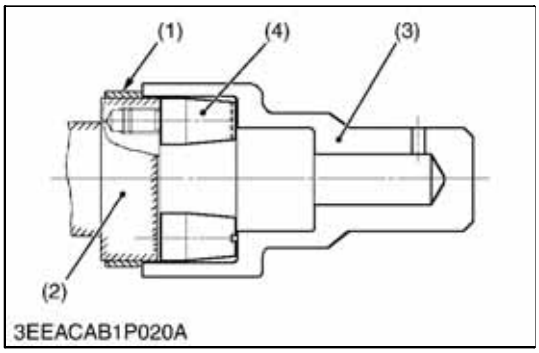
(Reference)

Undersize dimensions of crankshaft journal.

Oversize	0.2mm / 0.008 in.	0.4mm / 0.016 in.
Dimension **A**	1.8 to 2.2 mm radius 0.071 to 0.087 in. radius	1.8 to 2.2 mm radius 0.071 to 0.087 radius
*Dimension **B**	1.0 to 1.5 mm dia. 0.0394 to 0.0591 in. dia.	1.0 to 1.5 mm dia. 0.0394 to 0.0591 in. dia.
Dimension **C**	39.734 to 39.750 mm dia. 1.56433 to 1.56496 in. dia.	39.534 to 39.550 mm dia. 1.55646 to 1.55709 in. dia.
Dimension **D**	43.734 to 43.750 mm dia. 1.72181 to 1.72244 in. dia.	43.534 to 43.550 mm dia. 1.71394 to 1.71470 in. dia.
The crankpin must be fine-finished to higher than 0.8-S. *Holes to be de-burred and edges rounded with relief.		







2.3.4.g Crankshaft Sleeve Wear

1. Check the wear on the crankshaft sleeve (1).
2. If the wear exceeds the allowable limit or if the engine oil leaks, replace the crankshaft sleeve (1).

Sleeve Wear	Allowable Limit	0.1 mm 0.004 in.

2.3.4.h Replacing Crankshaft Sleeve

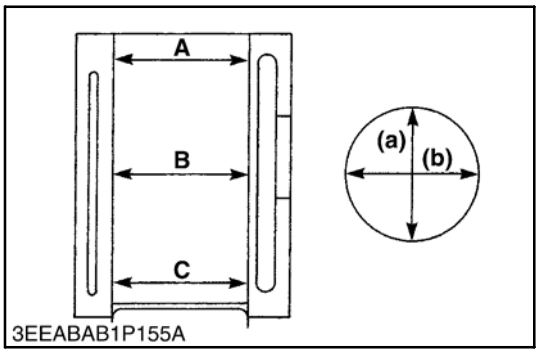
1. Remove the crankshaft sleeve using a special-use puller set.
2. Set the sleeve guide (4) to the crankshaft (2).
3. Heat the new sleeve to a temperature between 150 to 200°C (302 to 392°F), and fix the sleeve on the crankshaft (2) as shown in the figure.
4. Press fit the sleeve using the auxiliary socket for pushing (3).

NOTE

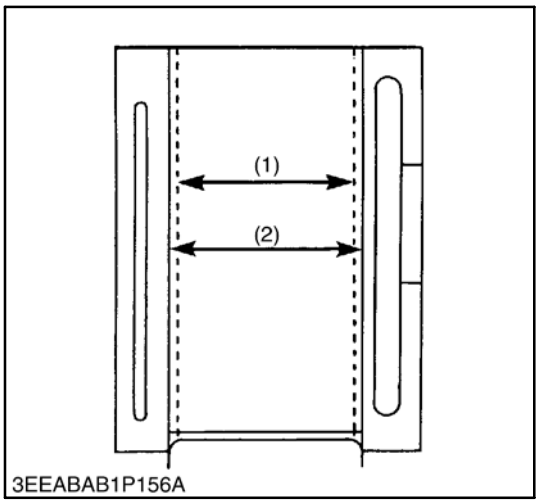
Install the sleeve with the largest chamfered surface facing outward.

1. Crankshaft Sleeve
2. Crankshaft
3. Auxiliary Socket For Pushing
4. Sleeve Guide

2.3.5 CYLINDER



0. Top
A. Middle
B. Bottom (skirt)
a. Right-angled to Piston Pin
b. Piston Pin Direction



1. Cylinder I.D. (before correction)
2. Oversize Cylinder I.D.

2.3.5.a Cylinder Wear

1. Measure the I.D. of the cylinder at the six positions (see figure) with a cylinder gauge to find the maximum and minimum I.D.'s.
2. Determine the difference (maximum wear) between the maximum and minimum I.D.'s.
3. If the wear exceeds the allowable limit, bore and hone to the oversize dimension. (Refer to Section **2.3.5.b)**
4. Visually check the cylinder wall for scratches. If deep scratches are found, the cylinder walls should be bored. (Refer to Section **2.3.5.b**)

Cylinder Wear	Factory Specification	67.000 to 67.019 mm 2.63779 to 2.63854 in.
	Allowable Limit	67.169 mm 2.64445 in.

2.3.5.b Correcting Cylinder (Oversize +0.25 mm)

1. When the cylinder is worn beyond the allowable limit, bore and hone it to the specified dimension.

Cylinder I.D.	Factory Specification	67.250 to 67.269 mm 2.647644 to 2.64839 in.
Maximum Wear	Allowable Limit	67.400 mm 2.65354 in.
Finishing	Hone to 2.2 to 3.0 mm μR max. (0.000087 to 0.00012 in. μR max.)	

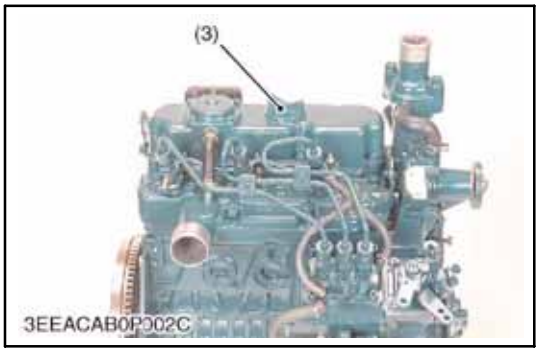
2. Replace the piston and piston rings with oversize ones: (0.25 mm / 0.0098 in.)

Oversize	Part Name	Code Number	Marking
0.25 mm 0.0098 in.	Piston	16851-21900	025
0.25 mm 0.0098 in.	Piston Ring Assembly	16851-21090	025

SECTION 3

LUBRICATING SYSTEM

3.1 CHECKING AND ADJUSTING



3.1.1 Checking Engine Oil Level

1. Level the engine.
2. To check the oil level, draw out the dipstick (2), wipe it clean, reinsert it, and draw it out again. Check to see that the oil level lies between the two notches.
3. If the level is too low, add new oil to the specified level.

NOTE

When adding oil to the crankcase, be sure that the fresh oil is the same type and viscosity as the oil that is already in the crankcase. Never mix two different types of oil. Never over fill a crankcase.

3.1.2 Changing Engine Oil

⚠ CAUTION

Stop the engine when preparing to change the engine oil.

1. Start and warm up the engine for approximately for 5 minutes.
2. Turn the engine off.
3. Place a proper receptacle/bucket under the engine drain plug.
4. Remove the oil drain plug (1) and drain the engine oil into a proper receptacle/bucket.
5. Remove the used oil filter and replace with a new one. (Refer to Section 3.1.3)
6. After draining all of the oil in the engine, replace the drain plug (1).
7. Remove the oil fill cap (3) and add the correct oil to the engine.
8. Add oil until the engine oil level is up to the upper line on the dipstick (2).

NOTE

Replace the engine oil filter with every oil change.

When changing to a different oil manufacturer or viscosity, be sure to remove all of the old oil completely. Never mix different types of oil.

Use only MIL-L-46152 / MIL-L-2104C or API classification CG-4 or CH-4 / CI oils.

Use the proper SAE Engine oil according to the ambient temperatures.

Above 25°C (77°F).....SAE 30 or 15W-40
0° to 25°C (32° to 77°F).....SAE 20 or 10W-30
.....or 10W-40
Below 0°C (32°F).....SAE 10W or 10W-30

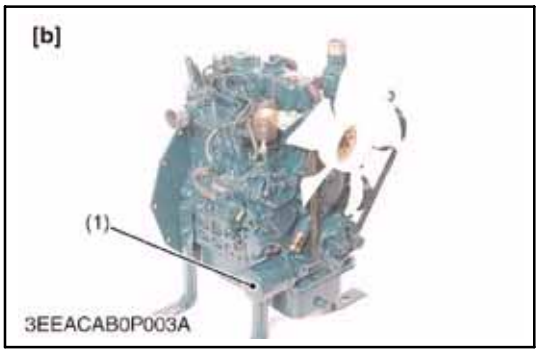
NOTE

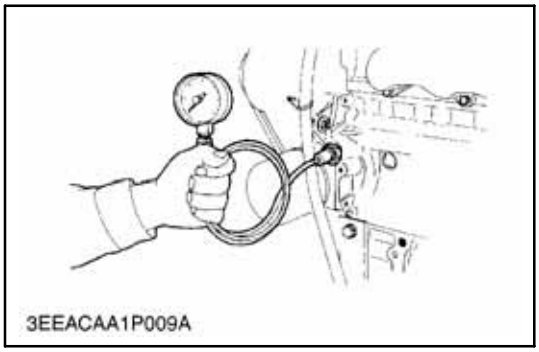
With emission controls now in effect, the CG-4 or CH-4 / CI lubricating oils have been developed for use of a low-sulfur fuel on-road vehicles engines. When an off-road vehicle engine runs on a high-sulfur fuel, it is advisable to employ the CH-4 or CI lubricating oil with a high total base number. If the CG-4 lubricating oil is used with a high sulfur fuel, change the lubricating oil at shorter intervals.

Lubricating oil recommended when a low-sulfur or high-sulfur fuel is employed.

Lubricating Oil Class	Fuel	
	Low-sulfur	High-sulfur
CG-4	O	X
CH-4 or CI	O	X

O : Recommended X : Not Recommended





3.1.3 Changing Oil Filter

⚠ CAUTION

Stop the engine when preparing to change the engine oil filter.

1. Remove the oil filter cartridge (1) with a filter wrench.
2. Apply a slight coat of oil onto the new oil filter cartridge gasket.
3. Install the new oil filter cartridge, screwing it on by hand. Over tightening it may cause deformation of the rubber gasket.
4. After the new oil filter cartridge has been installed start the engine and check for a leak around the oil filter cartridge gasket. Recheck the crankcase oil level (Refer to section 3.1.1) and adjust the engine oil level as necessary.

3.1.4 Engine Oil Pressure

1. Remove the engine oil pressure switch, and install an oil pressure guage.
2. Start the engine. After warming up, read the oil pressure at idling and at rated speeds.
3. If the oil pressure is less than the allowable limit, check the following:
   - Engine oil sufficient
   - Oil pump defective
   - Oil strainer clogged
   - Oil filter cartridge clogged
   - Oil gallery clogged
   - Excessive oil clearance
   - Relief valve stuck

At Idle Speed	Allowable Limit	103 kPa 1.0 kgf/cm^2 15 psi
At Rated Speed	Factory Specification	196 to 441 kPa 2.0 to 4.5 kgf/cm^2 28 to 64 psi
	Allowable Limit	147 kPa 1.5 kgf/cm^2 21 psi

(When Reassembling)

After checking the engine oil pressure, tighten the engine oil pressure switch to the specified torque.

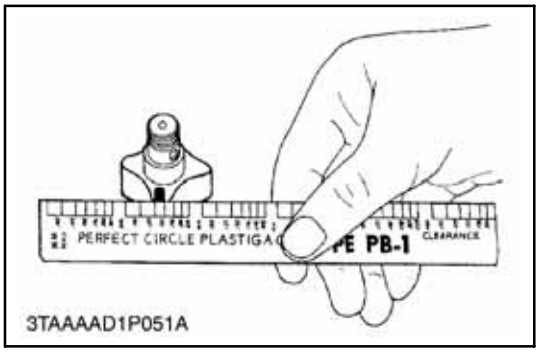
Tightening Torque	Oil Pressure Switch	14.7 to 19.6 N·m 1.5 to 2.0 kgf·m 10.8 to 14.5 ft-lbs.

3.1.5 Relief Valve

1. Remove the oil filter cartridge and the oil filter base (2).
2. Check the relief valve (1) for dirt, and the seat and ball for damage.
3. If damaged, replace.
4. Check the free length of the spring.
5. If it is less than the allowable limit, replace.

Spring Free Length	Factory Specification	32 mm 1.26 in.
	Allowable Limit	28 mm 1.10 in.
Oil Filter Base Tightening Torque	Joint	39.2 to 49.0 N·m 4.0 to 5.0 kgf·m 29.0 to 36.3 ft-lbs.

3.2 OIL PUMP SERVICE



3.2.1 Rotor Lobe Clearance

1. Measure the clearance between lobes of the inner rotor and the outer rotor with a feeler guage.
2. Measure the clearance between the outer rotor and the pump body with a feeler guage.
3. If the clearance exceeds the factory specifications, replace the oil pump rotor assembly.

Inner/Outer Rotor Clearance	Factory Specification	0.03 to 0.14 mm 0.0012 to 0.0055 in.
Outer Rotor/ Pump Body Clearance	Factory Specification	0.07 to 0.15 mm 0.0028 to 0.0059 in.

3.2.2 Rotor to Cover Clearance

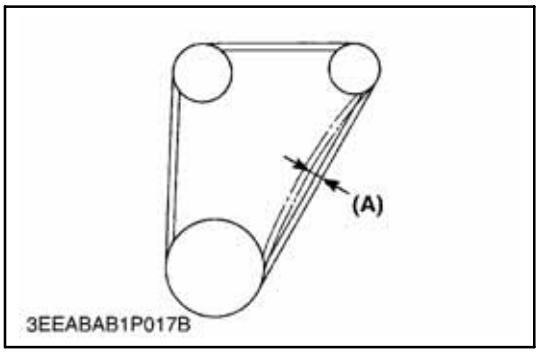
1. Put a strip of plastigage onto the rotor face (use a small dab of grease to hold the plastigage in place).
2. Install the cover and tighten the bolts.
3. Remove the cover carefully, and read the plastigage.
4. If the clearance exceeds the factory specifications, replace the oil pump rotor assembly.

Rotor/Cover Clearance	Factory Specification	0.075 to 0.135 mm 0.00295 to 0.00531 in.

SECTION 4

COOLING SYSTEM

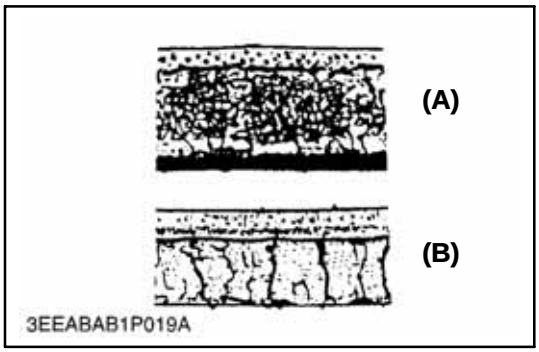
4.1 CHECKING AND ADJUSTING

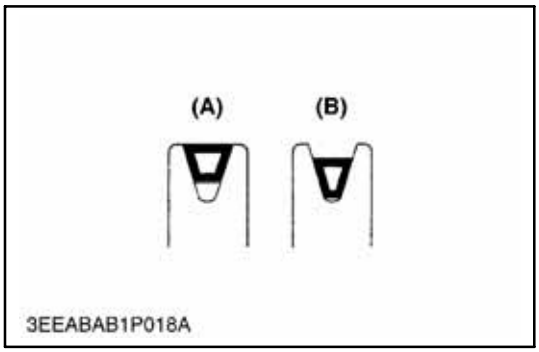


4.1.1 V-Belt Tension

1. Measure the deflection **(A)**, by depressing the belt halfway between the fan drive pulley and alternator pulley at the specified force (Refer to1.6.3).
2. If the tension is not within the factory specifications, loosen the tensioner mounting bolts and adjust the belt tension.

Use of a belt tension gauge (Carrier Part # 07-00203-00) or a belt tension tester (Carrier Part # 07-00253-00) is advised.





4.1.2 Fan Belt Damage and Wear

1. Check the fan belt for damage.
2. If the belt is damage in any way, replace it.
3. Check if the belt is worn and sunk in the pulley groove.
4. If the fan belt is worn and deeply sunk in the pulley groove, replace it.

A. Good **B.** Bad

4.1.3 Checking Coolant Level

NOTE

When the engine is installed in an APU, follow OEM vehicle instructions as to checking/adjusting engine coolant levels.

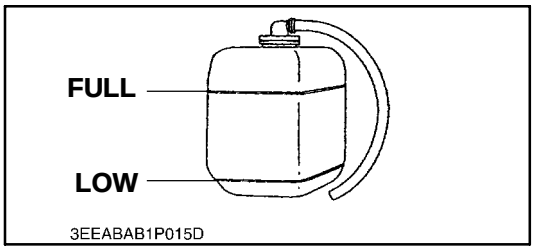
1. Turn the engine off.

⚠ WARNING

When removing the radiator cap, wait at least ten minutes after the engine has stopped and cooled down. Otherwise, hot water may discharge from the radiator, scalding anyone nearby.

2. Remove the radiator cap and check to see that the coolant level is just below the port.

   With the recovery tank: Check to see that the coolant level lies between **FULL** and **LOW**.



3. If the coolant level is too low, check the reason for the lost coolant.
   a. If coolant loss is due to evaporation, add only clean soft water.
   b. If coolant loss is due to a leak, repair the leak and add a coolant mixture of the same type and specification that is in the system. If the coolant brand cannot be identified, drain out all of the remaining coolant and refill with a totally new mix.

NOTE

When adding coolant to the system, air must be vented from the engine coolant passages by jiggling the upper and lower radiator hoses.

When the engine is installed in an APU, An air bleed screw is provided in the thermostat housing.

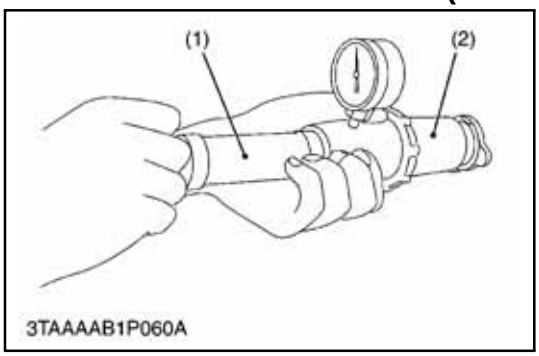
Be sure to close the radiator cap securely. If the cap is loose or improperly closed, coolant may leak out and the engine could overheat.

Do not use an antifreeze and scale inhibitor at the same time.

Never mix different types or brands of coolants.

4.1.4 Draining Coolant

1. Turn the engine off.
2. Remove the radiator cap.

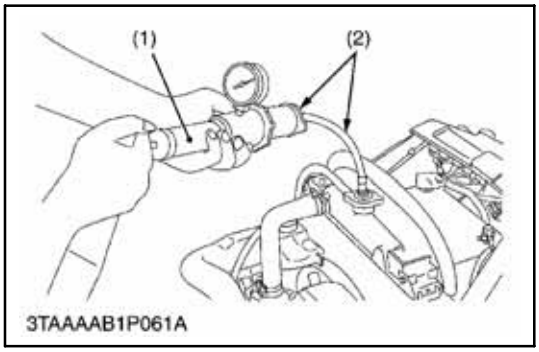


3. Open the coolant drain cock or remove the coolant drain plug and drain the coolant into a proper receptacle/bucket.

4.1.5 Radiator Cap

1. Attach the radiator cap to a pressure tester.
2. Apply pressure and observe the time for the pressure to fall.
3. If the measurement is less than the factory specification, replace the cap.

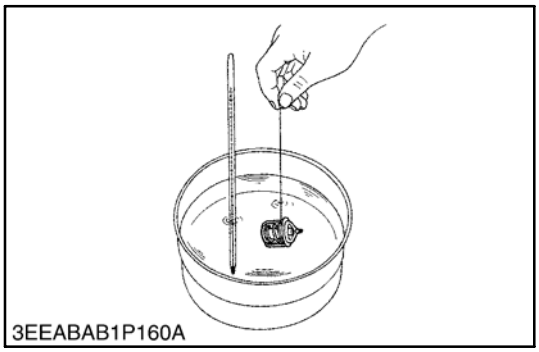
Pressure Falling Time	Factory Specification	More than 10 seconds for pressure fall from 88 to to 59kPa 0.9 to 0.6 kgf/cm^2 13 to 9 psi



4.1.6 Radiator

1. Fill the radiator with water.
2. Attach the pressure tester to the radiator.
3. Apply pressure and look for leaks.
4. Repair/replace as necessary to assure that the specified pressure will hold.

Radiator Leakage Test	Factory Specification	157 kPa 1.6 kgf/cm^2 23 psi

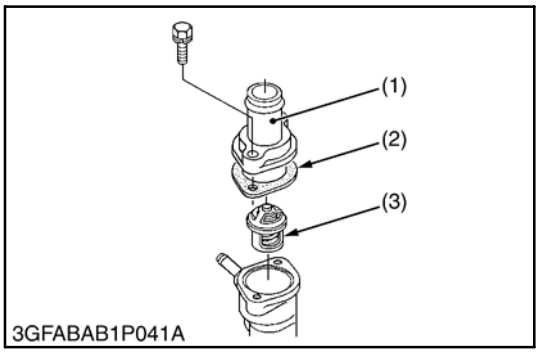


4.1.7 Thermostat Opening Temperature

1. Suspend the thermostat in water by a string with one end of the string inserted between the valve and its seat.
2. Immerse the thermostat in water and raise the temperature of the water gradually.
3. With a thermometer, read the temperature of the water when the valve opens and leaves the string.
4. Continue heating the water, read the temperature of the water when the valve has opened approximately 6mm (0.236 in).
5. If the measurement is not within the factory specifications, replace the thermostat.

Thermostat Opening Temperature	Factory Specification	69.5 to 72.5°C 157.1 to 162.5°F
Thermostat Full Open Temperature	Factory Specification	85°C 185°F

4.2 SERVICING



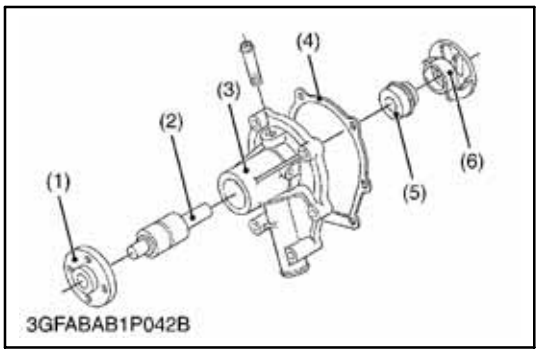
1. Thermostat Cover
2. Thermostat Cover Gasket
3. Thermostat Assembly

4.2.1 Thermostat Assembly

1. Remove the thermostat cover mounting bolts, and remove the thermostat cover (1).
2. Remove the thermostat assembly (3).

(When Reassembling)

Apply a liquid gasket only at the thermostat cover side of the thermostat cover gasket (2).



1. Water Pump Flange
2. Water Pump Shaft
3 Water Pump Body
4. Water Pump Gasket
5. Mechanical Seal
6. Impeller

4.2.2 Water Pump Assembly

1. Remove the fan belt.
2. Remove the water pump pulley.
3. Remove the water pump from the gear case assembly.
4. Remove the water pump flange (1).
5. Press out the water pump shaft (2) with the impeller (6) on it..
6. Remove the impeller from the water pump shaft.
7. Remove the mechanical seal.

(When Reassembling)

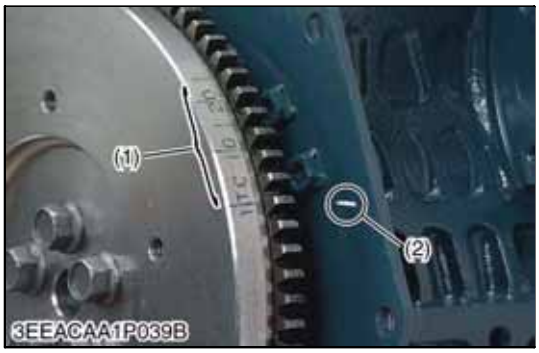
Replace the mechanical seal with a new one.

Apply a liquid gasket to both sides of the gasket (4).

SECTION 5

FUEL SYSTEM

5.1 CHECKING AND ADJUSTING



5.1.1 Injection Timing

1. Remove the injection lines.
2. Remove the engine stop solenoid (when applicable).
3. Turn the flywheel counterclockwise (facing the flywheel) until fuel flows from the delivery valve holder.
4. Turn the flywheel further and stop turning when the fuel level at the tip of the delivery valve holder begins to increase.
5. Check to see which of the timing angle lines (1) on the flywheel is aligned with the alignment mark (2).

Injection Timing	Factory Specification	0.33 to 0.37 rad. 19° to 21° B.T.D.C.

NOTE

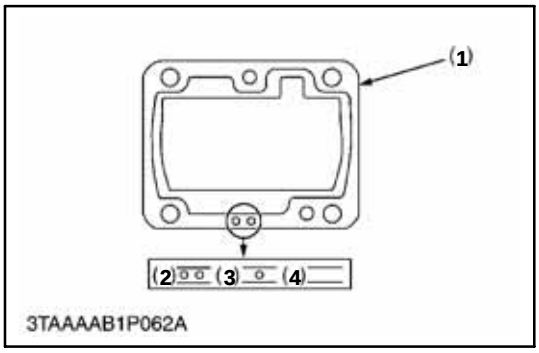
Injection timing adjustment is accomplished by adding or removing shims under the injection pump.

The timing advances by removing one shim and retards by adding the same shim.

The addition or removal of 0.05 mm (0.002 in.) of shim, changes the injection timing by approximately 0.087 rad. (0.5°).

Sealant should be applied to both sides of the soft metal gasket shim.

Injection Timing Map	Rated Speed	Rated Speed Specification
	3000 to 2501	0.30 to 0.33 rad. 17° to 19° B.T.D.C.
	2500 to 2001	0.26 to 0.30 rad. 15° to 17° B.T.D.C.
	Under 2000	0.23 to 0.26 rad. 13° to 15° B.T.D.C.



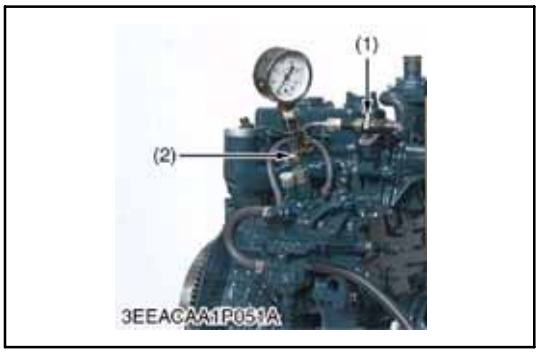
5.1.2 Shim Identification

NOTE

Shims are available in thicknesses of 0.20 mm, 0.25 mm, 0.30 mm, and 0.35mm. Combine shims for adjustments.

Refer to the figure below to check the thickness of shims

1. Shim (soft metal)
2. 2-Holes: 0.20 mm shim
3. 1-Hole: 0.25 mm shim
4. 0-Holes: 0.30 mm shim



5.1.3 Pump Element Fuel Seal

1. Remove the engine stop solenoid (when applicable).
2. Remove the injection lines and glow plugs.
3. Install the injection pump pressure tester to the injection pump.
4. Install the injection nozzle (1) jetted with the proper injection pressure to the injection pump pressure tester (2).
5. Set the speed control lever to the maximum speed position.
6. Engage the starter.
7. If the pressure does not build up, replace the pump element with a new one and test again.

Fuel pump element seal	Allowable Limit	13.73 MPa 140 kgf/cm^2 1991 psi

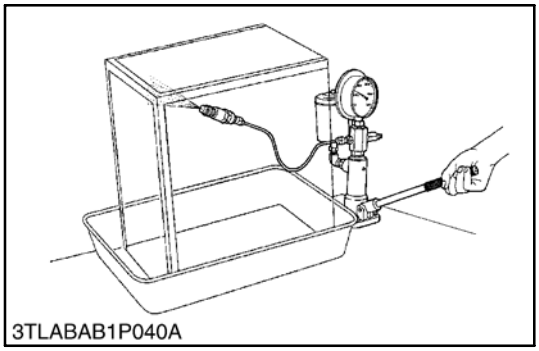
5.1.4 Delivery Valve Fuel Seal

1. Remove the engine stop solenoid (when applicable).
2. Remove the injection lines and glow plugs.
3. Install the injection pump pressure tester to the injection pump.
4. Install the injection nozzle (1) jetted with the proper injection pressure to the injection pump pressure tester (2).
5. Engage the starter.
6. Stop the starter when fuel jets from the injection nozzle. Continue turning the flywheel by hand and raise the pressure to approximately 13.73 MPa (140 kgf/cm^2, 1991 psi.)
7. Now turn the flywheel about half a turn backward by hand to keep the plunger free. Leave the flywheel in this position while recording the time taken for the pressure to drop from 13.73 MPa (140 kgf/cm^2, 1991 psi.) to 12.75 MPa (130 kgf/cm^2, 1849 psi.)
8. If the measurement is less than the allowable limit, replace the pump with a new one.

Delivery valve fuel seal	Factory Specification	10 seconds 13.73 to 12.75 MPa 140 to 130 kgf/cm^2 1991 to 1849 psi
Delivery valve fuel seal	Allowable Limit	5 seconds 13.73 to 12.75 MPa 140 to 130 kgf/cm^2 1991 to 1849 psi

⚠ WARNING

Check the injection nozzle only after confirming that nobody is near the spray. If the spray from the nozzle contacts the human body, cells may be destroyed and blood poisoning may result.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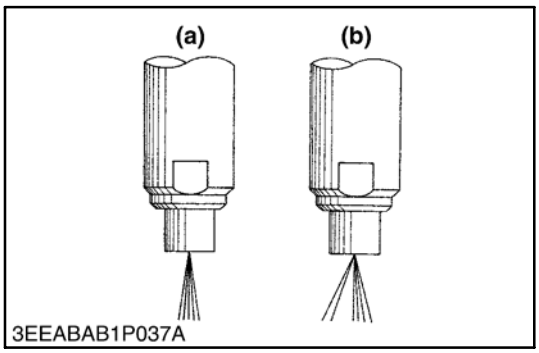

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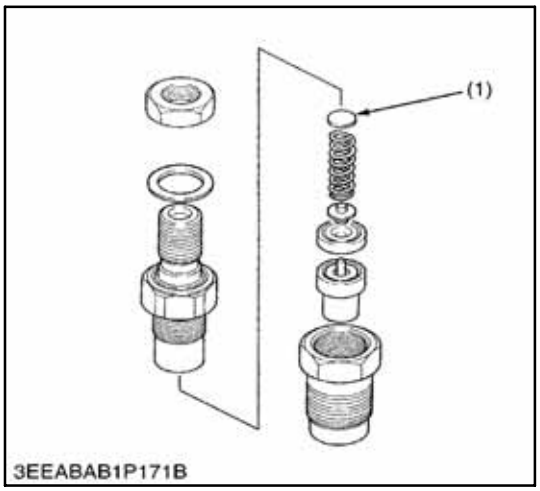
(a) Good **(b) Bad**



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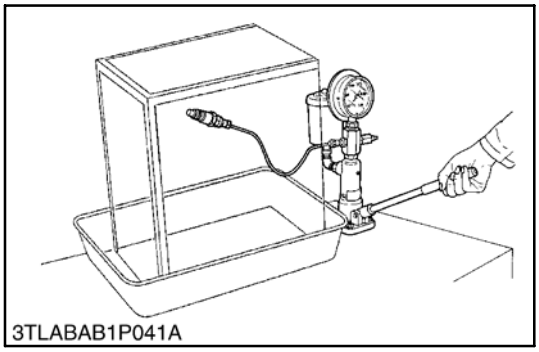
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5.2.1 Nozzle Spraying Condition

1. Set the injection nozzle in a nozzle tester and check the nozzle spraying condition.
2. If the spraying condition is defective, replace the injection nozzle assembly.

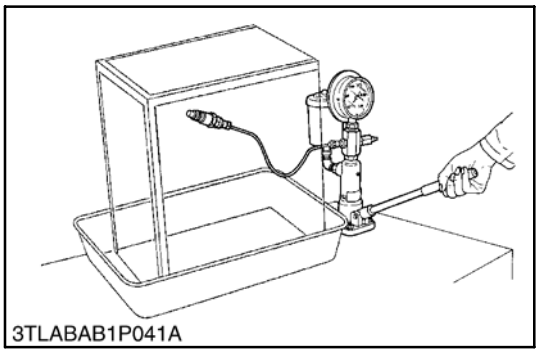
5.2.2 Nozzle Injection Pressure

1. Set the injection nozzle in a nozzle tester.
2. Slowly move the tester handle to measure the pressure at which fuel begins jetting out from the nozzle.
3. If the measurement is not within factory specifications, replace the adjusting washer (1) in the nozzle holder.

Fuel Injection Pressure 1st Stage	Factory Specification	13.73 to 14.71 MPa 140 to 150 kgt/cm^2 1991 to 2133 psi

(Reference)

A washer thickness of 0.01 mm (0.0004 in.) will vary the the nozzle injection pressure by approximately 235 kPa (2.4kgf/cm^2, 34 psi.)



5.2.3 Valve Seat Tightness

1. Set the injection nozzle in a nozzle tester.
2. Raise the fuel pressure, and maintain 12.7MPa (130 kgf/cm^2, 1850 psi) for 10 seconds.
3. If any fuel leak is found or if there is any loss of pressure through the injection nozzle, replace the injection nozzle assembly.

Valve Seat Tightness	Factory Specification	No fuel leak at 12.7MPa 130 kgf/cm^2 1850 psi

5.2.4 Nozzle Holder

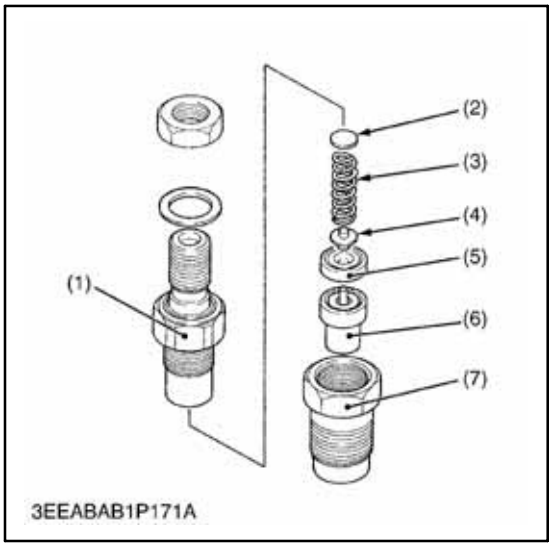
1. Secure the nozzle retaining nut (7) with a vise.
2. Remove the nozzle holder (1), and remove the parts.
3. If any fuel leak is found, replace the injection nozzle assembly.

(When Reassembling)

Assemble the nozzle in clean fuel oil.

Install the push rod (4), noting its direction.

After assembling the nozzle, be sure to adjust the fuel injection pressure.



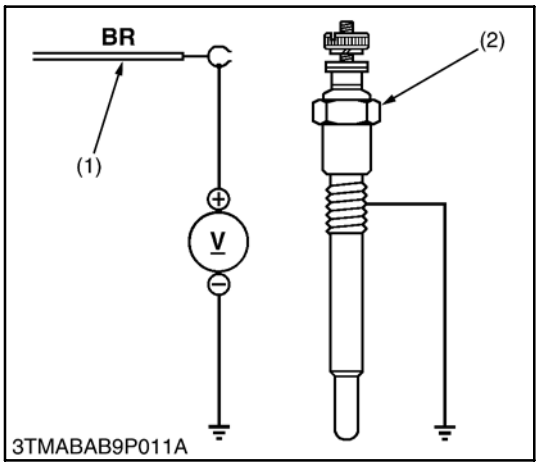
Tightening Torque	Nozzle Holder	34.3 to 39.2 N-m 3.5 to 4.0 kgf-m 25.3 to 28.9 ft-lbs
Tightening Torque	Overflow Pipe Nut	19.6 to 24.5 N-m 2.0 to 2.5 kgf-m 14.5 to 18.1 ft-lbs
Tightening Torque	Nozzle Holder Assembly	49.0 to 68.6 N-m 5.0 to 7.0 kgf-m 36.2 to 50.6 ft-lbs

1. Nozzle Holder
2. Adjusting Washer
3. Nozzle Spring
4. Push Rod
5. Distance Piece
6. Nozzle Piece
7. Nozzle Retaining Nut

SECTION 6

ELECTRICAL SYSTEM

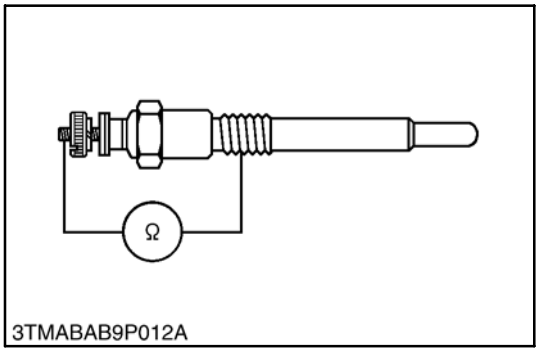
6.1 GLOW PLUG



1. Wiring Lead (Positive) 2 Glow Plug

6.1.1 Lead Terminal Voltage

1. Disconnect the glow plug wiring lead (1) from the glow plug (2).
2. Connect a voltmeter between the glow plug wiring lead (1) and a suitable ground on the engine.
3. Energize the glow plug lead and read the voltage.
4. Energize the glow plug lead, engage the starter at the same time and read the voltage.
5. If the voltage differs from the battery voltage in either case, the wiring harness or the switch or switches are faulty.

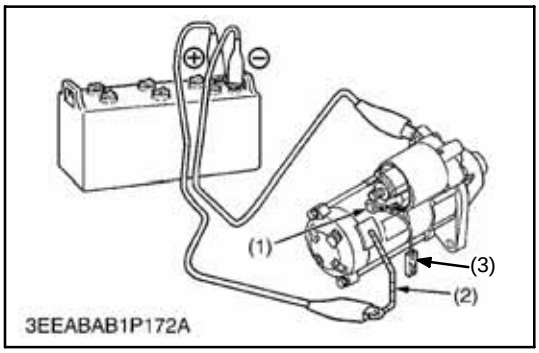


6.1.2 Glow Plug Continuity

1. Disconnect the glow plug wiring lead (1) from the glow plug (2).
2. Measure the resistance between the glow plug terminal and the engine body with an ohmmeter.
3. If 0 ohm is indicated, the glow plug may be short-circuited.
4. If the factory specification is not met the plug is also faulty.

Glow Plug Resistance	Factory Specification	Approximately 0.9 ohm

6.2 STARTER (CT2-29-TV)



1. **C** Terminal
2. Connecting Lead
3. **S** Terminal

6.2.1 Motor Test

⚠ CAUTION

Secure the starter to prevent it from moving when power is applied to it.

1. Disconnect the cable from the negative terminal on the battery
2. Disconnect the the positive cable and leads from the starter.
3. Remove the starter from the engine.
4. Disconnect the the connecting lead (2) from the starter solenoid **C** terminal (1).
5. Connect a jumper lead from the connecting lead (2) to the positive post on the battery.
6. Connect a jumper lead momentarily between the starter motor housing and the negative post on the battery.
7. If the starter does not run, check the motor.

6.2.2 Magnetic Switch Test

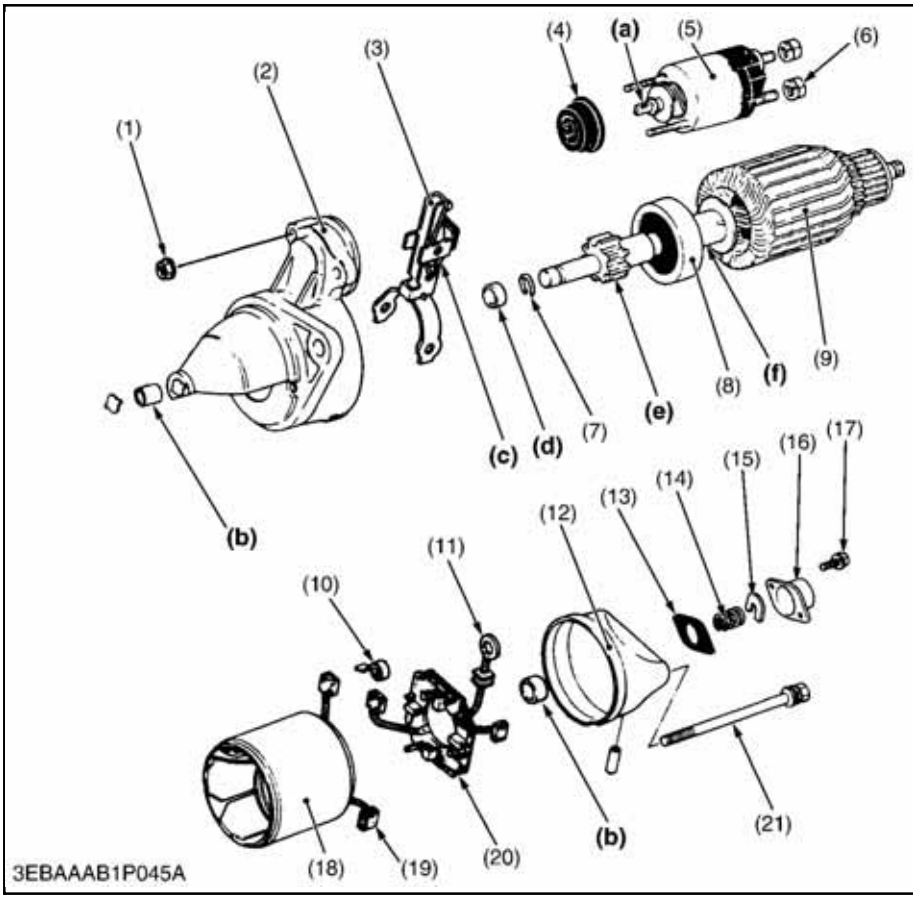
6.2.2.a Pull-in Coil Test

1. Connect a jumper lead from the negative battery post to the starter **C** terminal.
2. The plunger should be attracted strongly when a jumper lead is connected from the battery positive terminal to the **S** terminal.

6.2.2.b Holding Coil Test

1. Connect a jumper lead from the negative battery post to the starter case and and another jumper from the positive battery post to the starter **S** terminal.
2. Push the plunger in by hand and release it. The plunger should stay in.

6.2 STARTER (CT2-29-TV) (Continued)
6.2.3 Assembly



1. Solenoid Switch Mounting Nut
2. Starter Drive Housing
3. Drive Lever
4. Gasket
5. Solenoid Switch
6. C Terminal Nut
7. Snap Ring
8. Overrunning Clutch
9. Armature
10. Brush Spring
11. Connecting Lead
12. Rear End Frame
13. Gasket
14. Break Spring
15. Break Shoe
16. End Frame Cap
17. Screw
18. Yoke
19. Brush
20. Brush Holder
21. Through Bolt

1. Unscrew the C terminal nut (6), and disconnect the connecting lead (11).
2. Unscrew the solenoid switch mounting nuts (1), and remove the solenoid switch (5).
3. Remove the end frame cap (16).
4. Remove the break shoe (15), break spring (14) and gasket (13).
5. Unscrew the through bolts (21), and remove the rear end frame (12).
6. Unscrew the brush from the brush holder while holding the spring up.
7. Remove the brush holder (20).
8. Draw out the yoke (18) from the starter drive housing (2).
9. Draw out the armature (9) with the drive lever (3).

NOTE

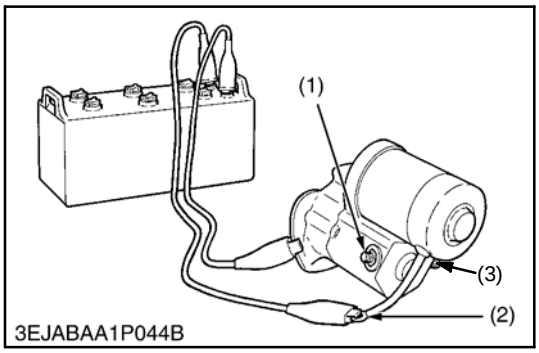
Do not damage the brush and commutator.

When Reassembling

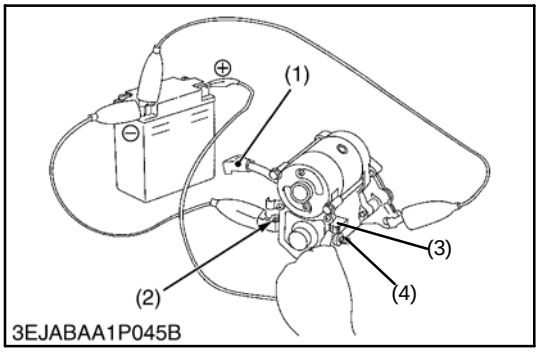
Apply grease (Carrier Part No. 07-00245-00) to the parts indicated in the figure.
- Joint of solenoid switch (a)
- Bushing (b)
- Drive lever (c)
- Collar (d)
- Teeth of pinion gear (e)
- Armature shaft (f)

Tightening Torque	C Terminal Nut	7.8 to 9.8 N·m 0.8 to 1.0 kgf·m 5.8 to 7.2 ft-lbs

6.3 STARTER (CT3-44-TV)



1. **C** Terminal
2. Connecting Lead
3. **B** Terminal



1. Connecting Lead
2. **C** Terminal
3. **S** terminal
4. **B** terminal

6.3.1 Motor Test

CAUTION

Secure the starter to prevent it from moving when power is applied to it.

1. Disconnect the cable from the negative terminal on the battery
2. Disconnect the the positive cable and leads from the starter **B** terminal.
3. Remove the starter from the engine.
4. Disconnect the the connecting lead (2) from the starter solenoid **C** terminal (1).
5. Connect a jumper lead from the connecting lead (2) to the positive post on the battery.
6. Connect a jumper lead momentarily between the starter motor housing and the negative post on the battery.
7. If the starter does not run, check the motor.

Tightening Torque	**B** Terminal Nut	8.8 to 11.8 N·m 0.9 to 1.2 kgf·m 6.5 to 8.7 ft-lbs.

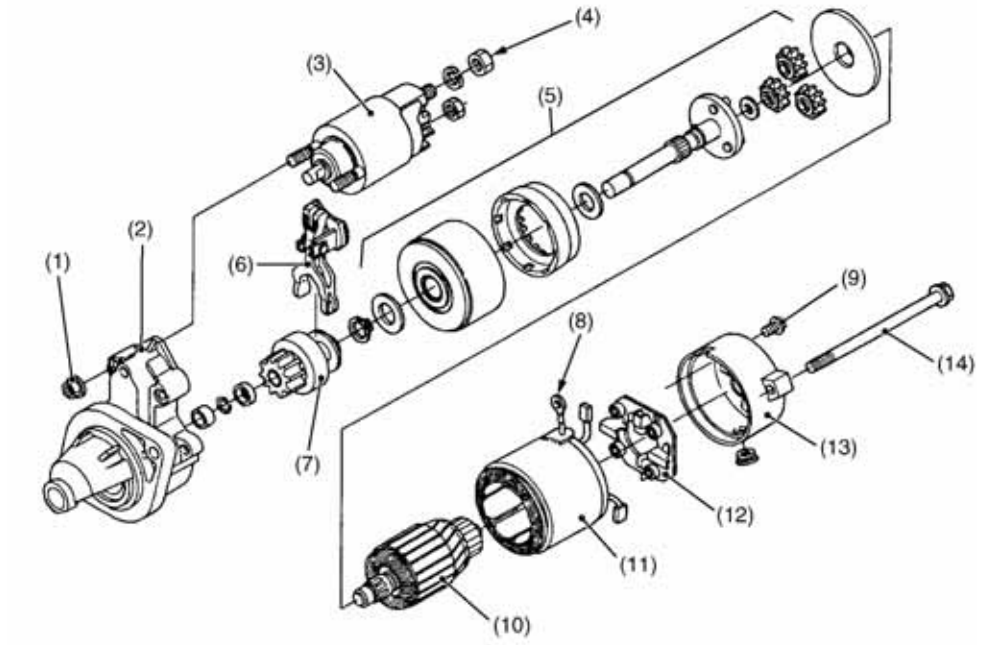
6.3.2 Magnetic Switch Test

1. Disconnect the cable from the negative terminal on the battery
2. Disconnect the positive cable and leads from the starter **B** terminal.
3. Remove the starter from the engine.
4. Disconnect the the connecting lead (1) from the starter solenoid **C** terminal (2).
5. Connect a jumper lead from the starter **S** terminal (3) to the positive battery post.
6. Momentarily, connect a jumper lead between the starter **C** terminal (2) and negative battery terminal.
7. If the pinion gear nose does not pop out, check the magnetic switch.

NOTE

This test should only be carried out for a 3 to 5 second time period and not longer.

6.3 STARTER (CT3-44-TV) (Continued)
6.3.3 Assembly



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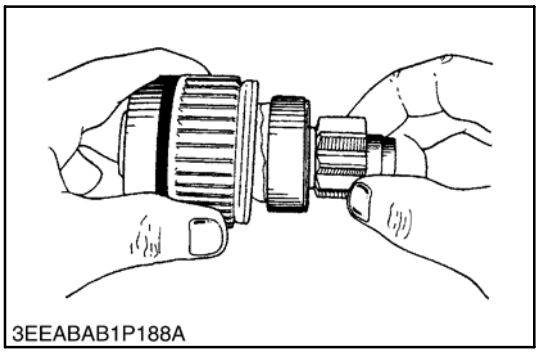
1. Magnetic Switch Mounting Nut
2. Housing
3. Magnetic Switch
4. C Terminal Nut
5. Shaft Assembly
6. Drive Lever
7. Overrunning Clutch
8. Connecting Lead
9. Mounting Screw
10. Armature
11. Yoke
12. Brush Holder
13. Rear End Frame
14. Through Bolt

1. Unscrew the C terminal nut (4), and disconnect the connecting lead (8).
2. Unscrew the magnetic switch mounting nuts (1), and remove the magnetic switch (3) from the housing (2).
3. Unscrew the through bolts (14) and mounting screw (9), and remove the rear end frame (13).
4. Remove the brush from the brush holder while holding the spring up.
5. Remove the brush holder.
6. Draw out the armature (10) and yoke (11) from the housing.
7. Draw out the shaft assembly (5) with the drive lever (6) and overrunning clutch (7) from the housing.

When Reassembling

Tightening Torque	C Terminal Nut	5.9 to 11.8 N·m 0.6 to 1.2 kgf·m 4.3 to 8.7 ft-lbs

6.4 STARTER SERVICING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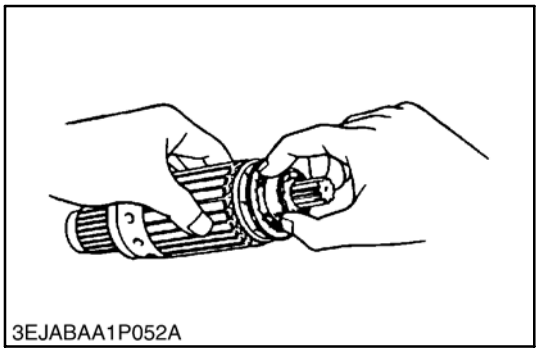
6.4.1 Overrunning Clutch

1. Inspect the pinion for wear or damage.
2. If there is any defect, replace the assembly.
3. Check that the pinion turns freely and smoothly in the overrunning direction and does not slip in the cranking direction.
4. If the pinion slips or does not rotate in both directions, replace the overrunning clutch assembly.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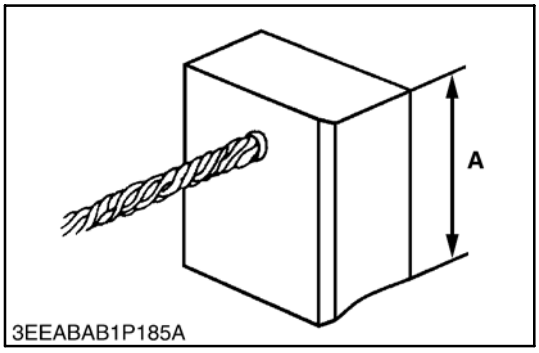
6.4.2 Armature Bearing

1. Check the bearing for smooth rotation.
2. If it does not rotate smoothly, replace it.



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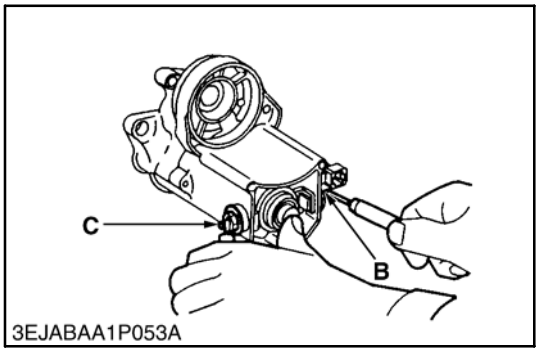
6.4.3 Brush Wear

1. If the contact face of the brush is dirty or dusty, clean it with emery cloth.
2. Measure the brush length "**A**" with a vernier caliper.
3. If the length is less than the the allowable limit, replace the yoke assembly and the brush holder.

Brush Length **A**	CT2-29-TV	Factory Specification	16.0 mm 0.630 in.
		Allowable Limit	10.5 mm 0.413 in.
	CT3-44-TV	Factory Specification	14.0 mm 0.551 in.
		Allowable Limit	9.0 mm 0.354 in.



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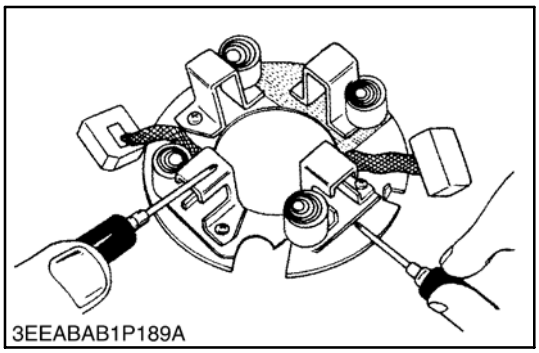
6.4.4 Solenoid

1. Check the continuity across the "**C**" terminal and the "**B**" terminal by pushing the plunger, then measuring resistance with an ohmmeter.
2. If there is no continuity, check the contacts.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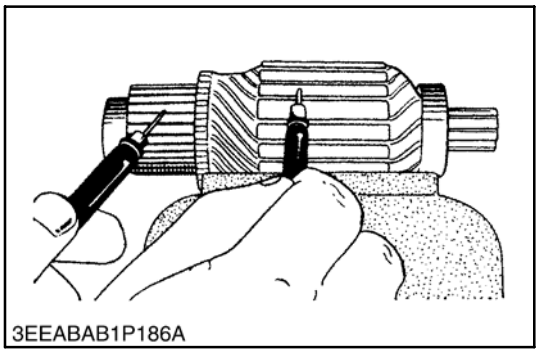
6.4.5 Brush Holder

1. Check the continuity across the brush holder and holder support with an ohmmeter.
2. If there is any continuity, replace the brush holder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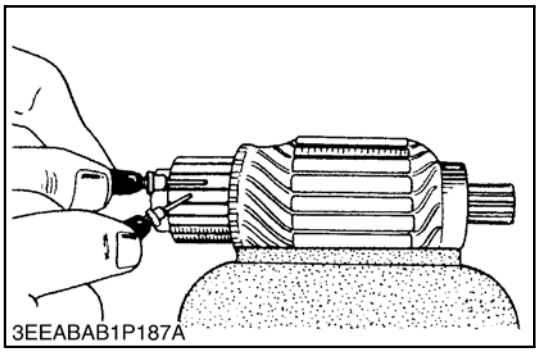
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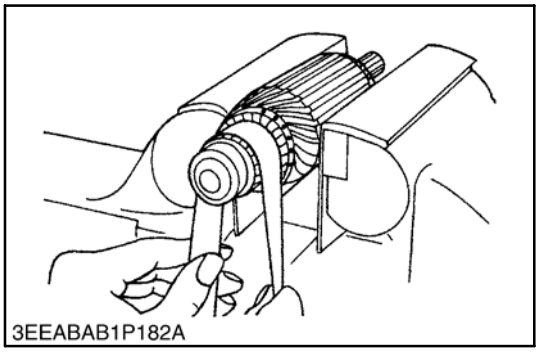
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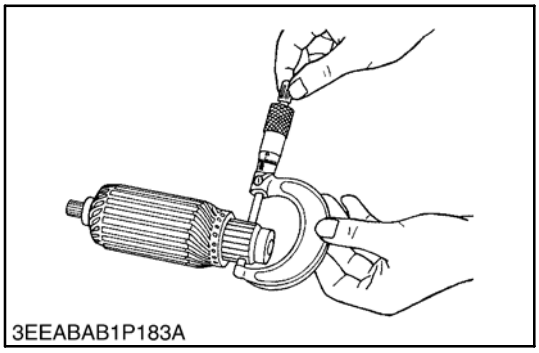
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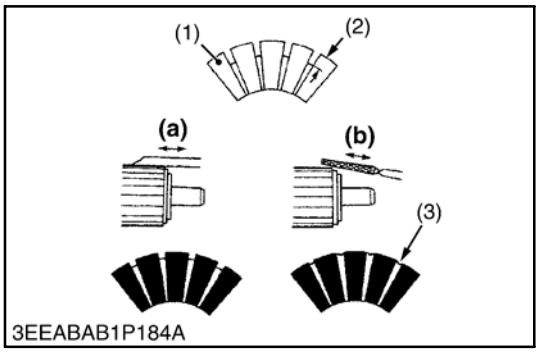

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6.4.6 Armature

6.4.6.a Continuity Check

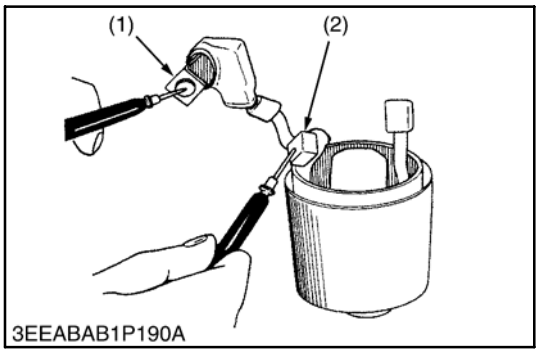
1. Check the continuity across the commutator and the armature with an ohmmeter.
2. If there is continuity, replace the armature.
3. Check the continuity across the segments of the commutator with an ohmmeter.
4. If there is no continuity, replace the armature.

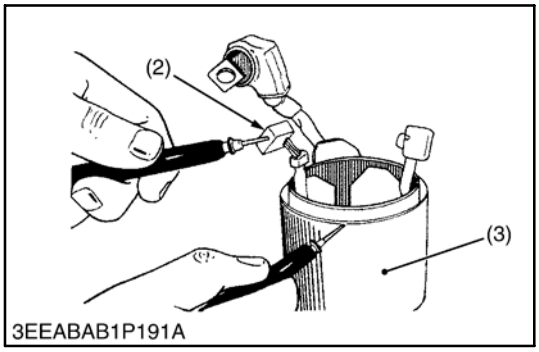
6.4.6.b Commutator and Mica

1. Check the contact pattern of the commutator for wear, and grind the commutator with emery cloth if it is slightly worn.
2. Measure the commutator O.D. with an outside micrometer at several points.
3. If the minimum O.D. is less than the allowable limit, replace the armature.
4. If the difference of the O.D.'s exceeds the allowable limit, correct the commutator on a lathe to the factory specifications.
5. Measure the mica undercut.
6. If the undercut is less than the allowable limit, correct it with a saw blade and chamfer the segment edges.

1. Segment
2. Depth of Mica
3. Mica

(**a**). Correct
(**b**). Incorrect





1. Lead
2. Brush
3. Yoke

6.4.7 Field Coil

1. Check the continuity across the lead (1) and the brush with an ohmmeter.
2. If there is no continuity, replace the yoke assembly.
3. Check the continuity across the brush (2) and the yoke (3) with an ohmmeter.
4. If there is continuity, replace the yoke assembly.

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