Retorno

INDUSTRIAL
DIESEL ENGINE

AA-4BG1T, AA-6BG1
BB-4BG1T, BB-6BG1T
MODELS

WORKSHOP MANUAL

ISUZU MOTORS LIMITED

ISUZU

WORKSHOP MANUAL INDUSTRIAL DIESEL ENGINE AA-4BG1T, AA-6BG1 BB-4BG1T, BB-6BG1T MODELS

FOREWORD

This Workshop Manual is designed to help you perform necessary maintenance, service, and repair procedures on applicable Isuzu industrial engines.

Information contained in this Workshop Manual is the latest available at the time of publication.

Isuzu reserves the right to make changes at any time without prior notice.

The Table of Contents at the right hand side of this page shows you the general arrangement of the material in this Workshop Manual. A more detailed Table of Contents precedes each individual section.

The black spot at the right hand side of some pages indicates the first page of a given section.

This Workshop Manual is applicable to 1999 and later models.

TABLE OF CONTENTS

SECTION 1

GENERAL INFORMATION

TABLE OF CONTENTS

GENERAL REPAIR INSTRUCTIONS

1. Before performing any service operation with the engine mounted, disconnect the grounding cable from the battery.

   This will reduce the chance of cable damage and burning due to short circuiting.
2. Always use the proper tool or tools for the job at hand.

   Where specified, use the specially designed tool or tools.
3. Use genuine ISUZU parts referring ISUZU PARTS CATALOG for the engines surely.
4. Never reuse cotter pins, gaskets, O-rings, lock washers, and self locking nuts. Discard them as you remove them. Replace them with new ones.
5. Always keep disassembled parts neatly in groups. This will ensure a smooth reassembly operation.

   It is especially important to keep fastening parts separate. These parts vary in hardness and design, depending on their installation position.
6. All parts should be carefully cleaned before inspection or reassembly.

   Oil ports and other openings should be cleaned with compressed air to make sure that they are completely free of obstructions.
7. Rotating and sliding part surfaces should be lubricated with oil or grease before reassembly.
8. If necessary, use a sealer on gaskets to prevent leakage.
9. Nut and bolt torque specifications should be carefully followed.
10. Always release the air pressure from any machine-mounted air tank(s) before dismounting the engine or disconnecting pipes and hoses. To not do so is extremely dangerous.
11. Always check and recheck you work. No service operation is complete until you have done this.
12. Information contained in the "Main Data and Specifications" of the Workshop Manual and the Instruction Book may differ. In this case, the information contained in the Instruction Book should be considered applicable.

NOTES ON THE FORMAT OF THIS MANUAL

This Workshop Manual is applicable to the 4BG1, 4BG1T, 6BG1, and 6BG1T family of industrial diesel engines. Unless otherwise specified, these engines have common parts and components as well as data and specifications.

Illustrations used in this Workshop Manual are based on the AA-6BG1 and BB-6BG1T engines.

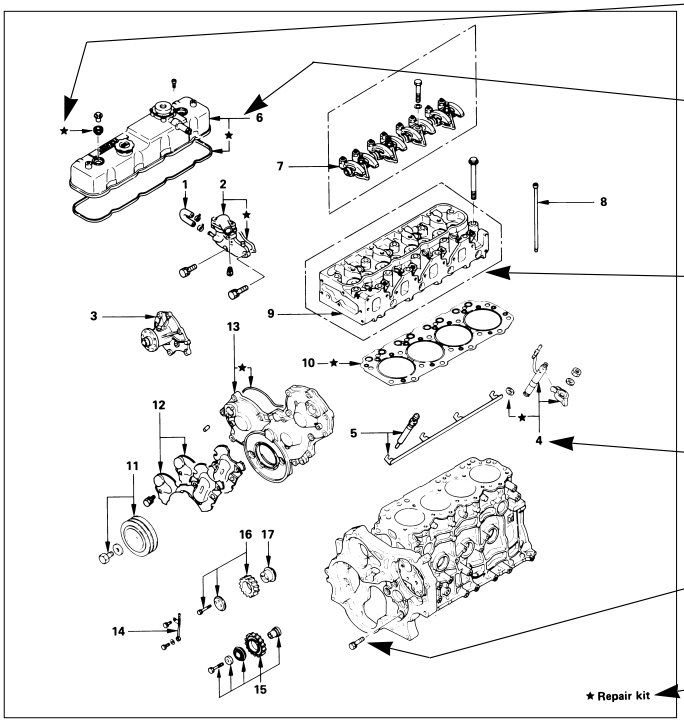
The AA-4BG1T engine and the BB-4BG1T engine are turbocharged.

1. Find the applicable section by referring to the Table of Contents at the beginning of the Manual.
2. Common technical data such as general maintenance items, service specifications, and tightening torques are included in the "General Information" section.
3. Each section is divided into sub-sections dealing with disassembly, inspection and repair, and reassembly.

   The section ENGINE ASSEMBLY is an exception. This part is divided into three sections to facilitates quick indexing.
4. When the same servicing operation is applicable to several different units, the manual will direct you to the appropriate page.
5. For the sake of brevity, self-explanatory removal and installation procedures are omitted.

   More complex procedures are covered in detail.

6. Each service operation section in this Workshop Manual begins with an exploded view of the applicable area. A brief explanation of the notation used follows.



Disassembly Steps - 2

1. Water by-pass hose
2. Thermostat housing
3. Water pump
▲ 4. Injection nozzle holder
5. Glow plug and glow plug connector
6. Cylinder head cover
▲ 7. Rocker arm shaft and rocker arm
8. Push rod
▲ 9. Cylinder head
10. Cylinder head gasket
▲ 11. Crankshaft damper pulley with dust seal
12. Timing gear case cover (Option)
13. Timing gear cover
14. Timing gear oil pipe
15. Idler gear "B" and shaft
▲ 16. Idler gear "A"
17. Idler gear shaft

Inverted Engine

Parts marked with an asterisk (*) are included in the repair kit.

Parts within a square frame are to be removed and installed as a single unit.

All parts within an irregularly shaped frame form a single assembly. They are considered a "major component". Individual parts within the irregularly shaped frame are considered "minor components".

The number tells you the service operation sequence.

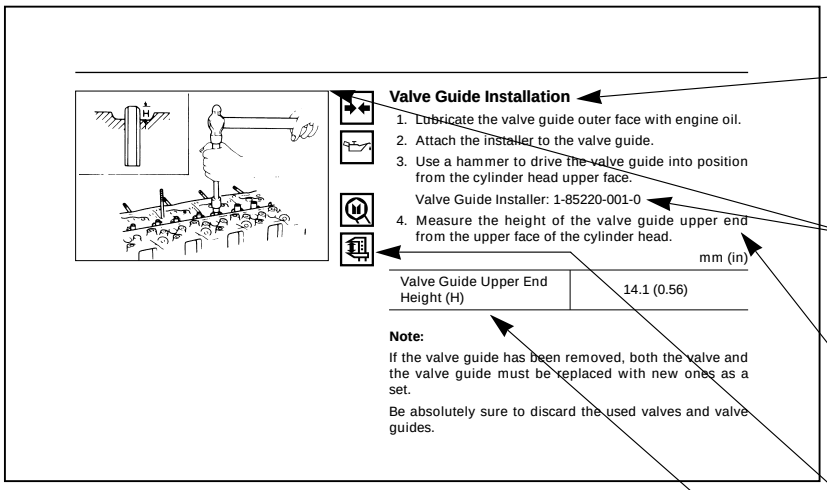
Removal of unnumbered parts is unnecessary unless replacement is required.

The "* Repair Kit" indicates that a repair kit is available.

The parts listed under "Reassembly Steps" or "Installation Steps" are in the service operation sequence.

The removal or installation of parts marked with a triangle (▲) is an important operation. Detailed information is given in the text.

7. Below is a sample of the text of the Workshop Manual.



Valve Guide Installation

1. Lubricate the valve guide outer face with engine oil.
2. Attach the installer to the valve guide.
3. Use a hammer to drive the valve guide into position from the cylinder head upper face.
   Valve Guide Installer: 1-85220-001-0
4. Measure the height of the valve guide upper end from the upper face of the cylinder head.

mm (in)

Valve Guide Upper End Height (H)	14.1 (0.56)

Note:

If the valve guide has been removed, both the valve and the valve guide must be replaced with new ones as a set.

Be absolutely sure to discard the used valves and valve guides.

This is the item shown in the illustration. It is marked with a triangle (▲) on the Major Components page.

Special tools are identified by the tool name and/or number.

The illustration shows how the special tool is to be used.

Letters and numbers contained in a circle refer to the illustration.

Symbols indicate the type of service operation or step to be performed. A detailed explanation of these symbols follows.

Service data and specifications are given in this table.

8. The following symbols appear throughout this Workshop Manual. They tell you the type of service operation or step to perform.

. . . Removal	. . . Adjustment
. . . Installation	. . . Cleaning
. . . Disassembly	. . . Important Operation Requiring Extra Care
. . . Reassembly	. . . Specified Torque (Tighten)
. . . Alignment (Marks)	. . . Special Tool Use Required or Recommended (Isuzu Tool or Tools)
. . . Directional Indication	. . . Commercially Available Tool Use Required or Recommended
. . . Inspection	. . . Lubrication (Oil)
. . . Measurement	. . . Lubrication (Grease)
. . . Sealant Application	

9. Measurement criteria are defined by the terms "standard" and "limit".

   A measurement falling within the "standard" range indicates that the applicable part or parts are serviceable.

   "Limit" should be thought of as an absolute value.

   A measurement which is outside the "limit" indicates that the applicable part or parts must be either repaired or replaced.

10. Components and parts are listed in the singular form throughout the Manual.

11. Directions used in this Manual are as follows:

    Front

    The cooling fan side of the engine viewed from the flywheel.

    Right

    The injection pump side of the engine.

    Left

    The exhaust manifold side of the engine.

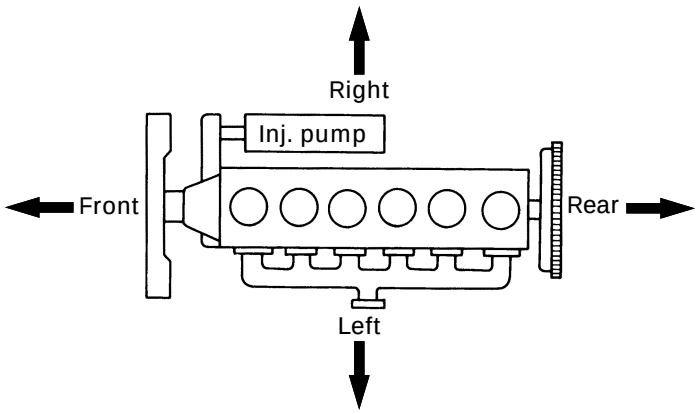
    Rear

    The flywheel side of the engine.

    Cylinder numbers are counted from the front of the engine.

    The front most cylinder is No. 1 and rear most cylinder is No. 4 or No. 6.

    The engine's direction of rotation is counterclockwise viewed from the flywheel.



MAIN DATA AND SPECIFICATIONS

Item \ Engine Model		AA-4BG1T	BB-4BG1T
Engine type		Water cooled, four cycle, vertical in-line overhead valve	
Combustion chamber type		Direct injection	
Cylinder liner type		Dry	
No. of cylinders – bore × stroke	mm (in)	4 – 105 × 125 (4.13 × 4.92)	
Total piston displacement	L (cid)	4.329 (464)	
Compression ratio		18.0 to 1	
* Engine dimensions Length × width × height	mm (in)	904 × 684.8 × 907 (35.6 × 27.0 × 35.7)	
* Engine weight (Dry)	kg (lb)	361 (796)	360 (794)
Fuel injection order		1–3–4–2	
Specified fuel		Diesel fuel (ASTM D975 No. 2D)	
Injection pump		In-line plunger, Bosch A type	
* Governor		Mechanical, RSV type	
Injection nozzle		Multi hole	
Injection starting pressure	MPa kgf/cm^2(psi)	18.1 (185/2,630)	
Fuel filter type		Cartridge (spin-on)	
Water sedimentor	(If so equipped)	Sediment/water level indicating type	
Compression pressure (At warm)	MPa kgf/cm^2 (psi)	3.0 (31/441) at 200 min^{-1} at sea level	
Valve clearances (At cold)	Intake mm (in)	0.40 (0.016)	
	Exhaust mm (in)	0.40 (0.016)	
Lubrication method		Pressurized circulation	
Oil pump		Gear type	
Main oil filter type		Full flow, cartridge (spin-on)	
* Lubricating oil volume	L (US gal)	13.2 (3.5)	13.0 (3.4)
Oil cooler		Water cooled integral type	
Cooling method		Pressurized forced circulation	
Coolant volume (engine only)	L (US gal)	8.5 (2.25)	
Water pump		Belt driven impeller type	
Thermostat type		Wax pellet type	
* Generator	V-A	24–40	
* Starter	V-KW	24–4.5	
* Turbocharger manufacturer		MITSUBISHI	MITSUBISHI
* Turbocharger model		TD04H	TD04H

Note: 1. These specifications are based on the standard engine.
2. Specifications for items marked with an asterisk (*) will vary according to the type of equipment on which the engine is installed.
If you are unable to locate the data applicable to these specifications, please contact Isuzu Motors LTD through your machine supplier.

MAIN DATA AND SPECIFICATIONS

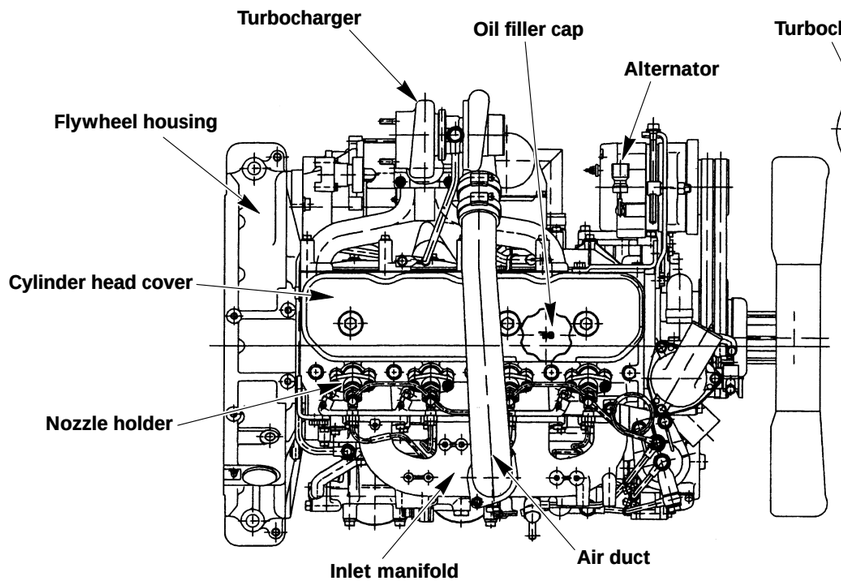
Item \ Engine Model		AA-6BG1	BB-6BG1T
Engine type		Water cooled, four cycle, vertical in-line overhead valve	
Combustion chamber type		Direct injection	
Cylinder liner type		Dry	
No. of cylinders - bore × stroke	mm (in)	6 – 105.0 × 125.0 (4.13 × 4.92)	
Total piston displacement	L (cid)	6.494 (396)	
Compression ratio		18.0 to 1	
* Engine dimensions Length × width × height	mm (in)	1143 × 672 × 797 (45.0 × 26.5 × 31.4)	1204 × 762 × 961 (47.4 × 30.0 × 37.8)
* Engine weight (Dry)	kg (lb)	458 (1009)	484 (1067)
Fuel injection order		1–5–3–6–2–4	
Specified fuel		Diesel fuel (ASTM D975 No. 2D)	
Injection pump		In-line plunger, Bosch AD type	
* Governor		Mechanical, RSV type	
Injection nozzle		Multi hole	
Injection starting pressure	MPa kgf/cm^2 (psi)	18.1 (185/2,630)	
Fuel filter type		Cartridge (spin-on)	
Water sedimentor	(If so equipped)	Sedimenter/water level indicating type	
Compression pressure (At warm)	MPa (kgf/cm^2/psi)	3.0 (31/441) at 200 min^{-1}, at sea level	
Valve clearances (At cold)	Intake mm (in)	0.40 (0.016)	
	Exhaust mm (in)	0.40 (0.016)	
Lubrication method		Pressurized circulation	
Oil pump		Gear type	
Main oil filter type		Cartridge (spin-on)	
* Lubricating oil volume	L (US gal)	13.0 (3.4)	21.5 (5.68)
Oil cooler		Water cooled integral type	
Cooling method		Pressurized forced circulation	
Coolant volume (engine only)	L (US gal)	12 (3.2)	
Water pump		Belt driven impeller type	
Thermostat type		Wax pellet type	
* Generator	V-A	24–25	24–40
* Starter	V-KW	24–4.5	
* Turbocharger manufacturer		–	IHI
* Turbocharger model		–	RHG6

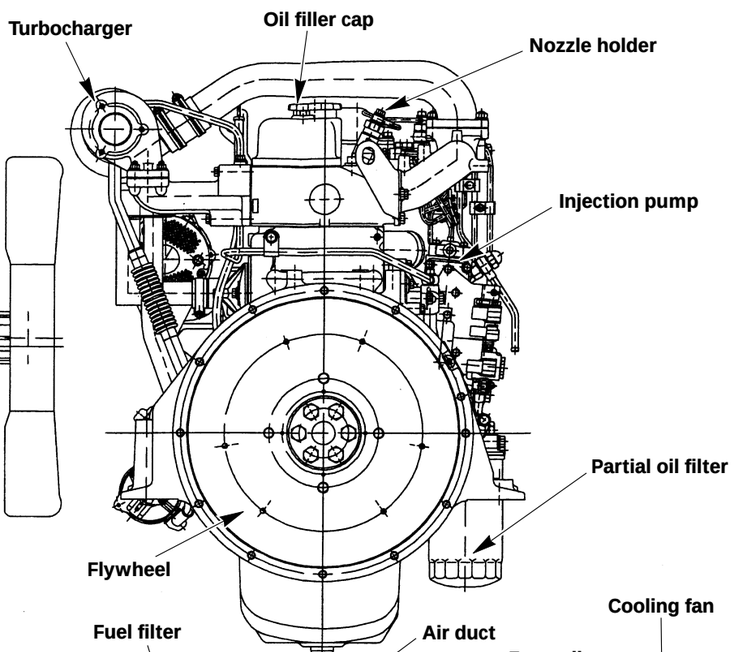
Note: 1. These specifications are based on the standard engine.
2. Specifications for items marked with an asterisk (*) will vary according to the type of equipment on which the engine is installed.
If you are unable to locate the data applicable to these specifications, please contact Isuzu Motors LTD through your machine supplier.

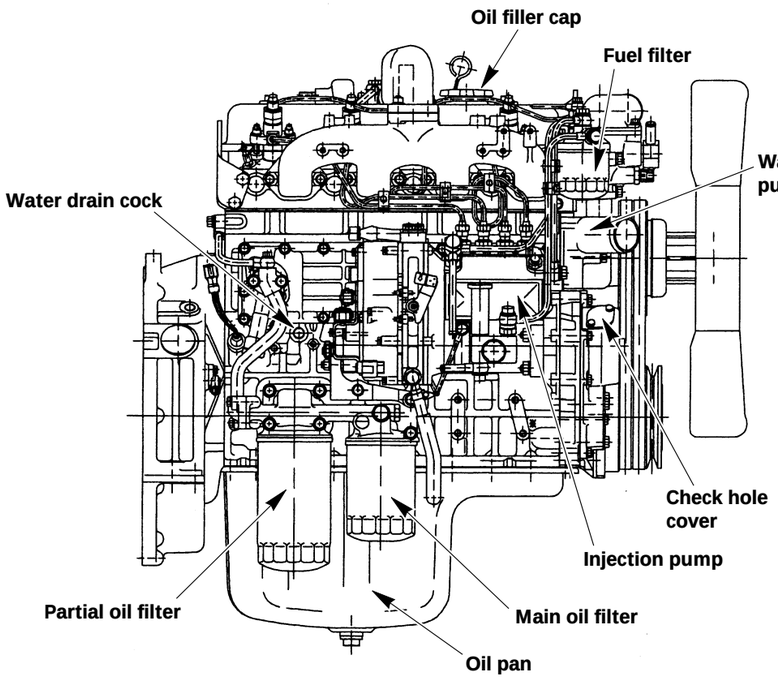
EXTERNAL VIEW

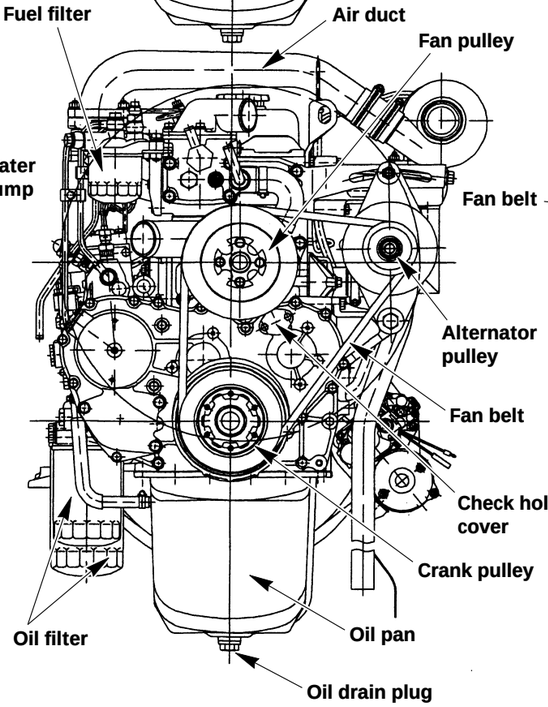
MODEL AA-4BG1T, BB-4BG1T

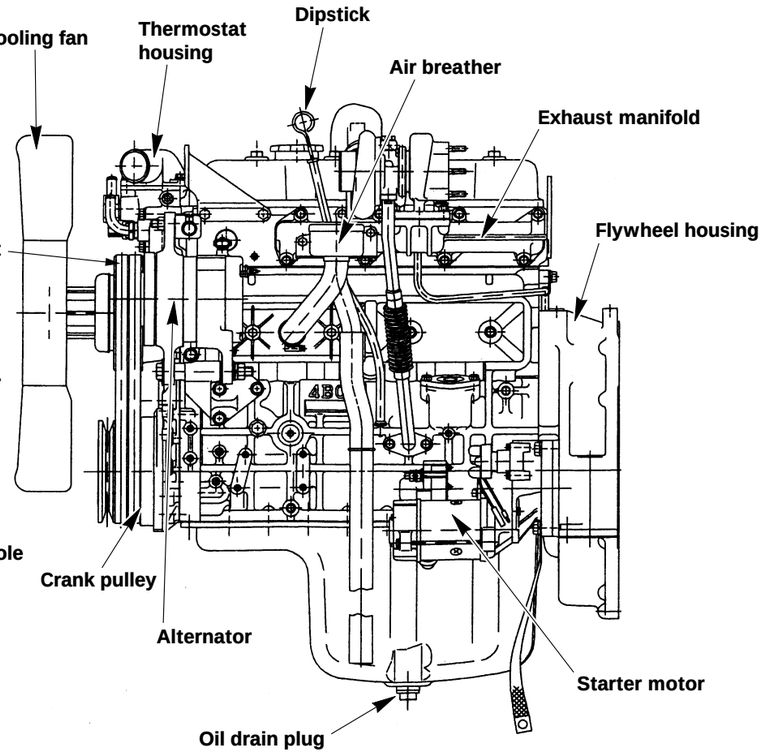
Note:
Engine details may vary depending on the specifications.







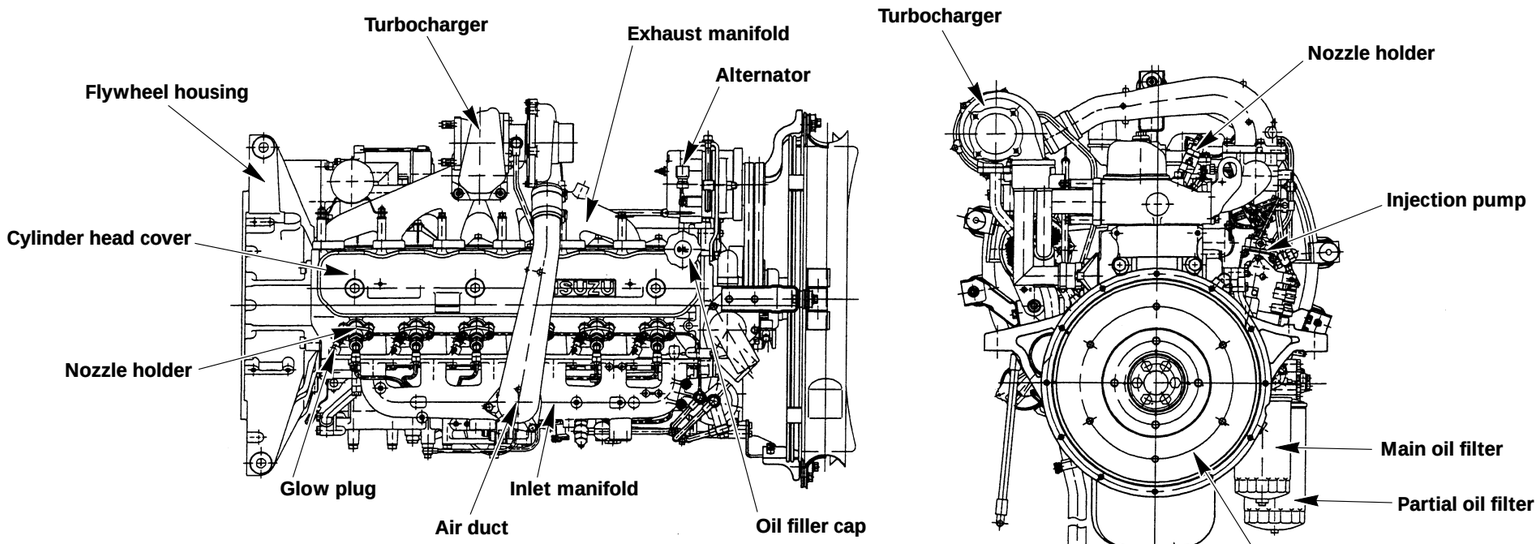


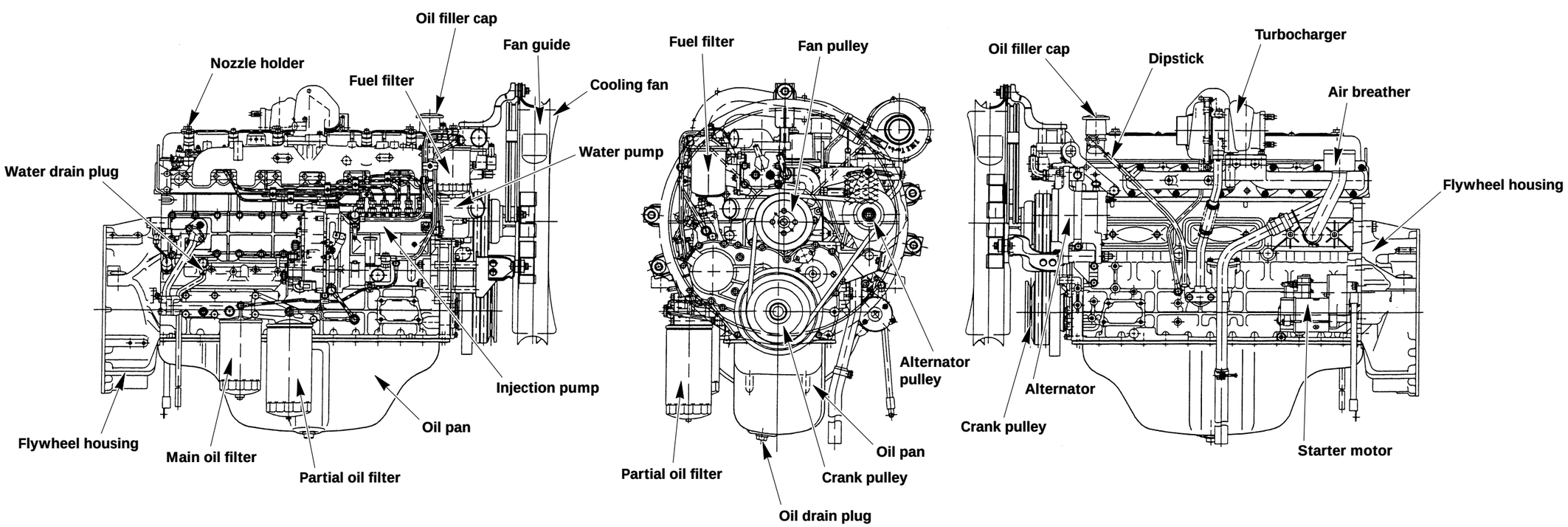


EXTERNAL VIEW

MODEL BB-6BG1T

Note:
Engine details may vary depending on the specifications.

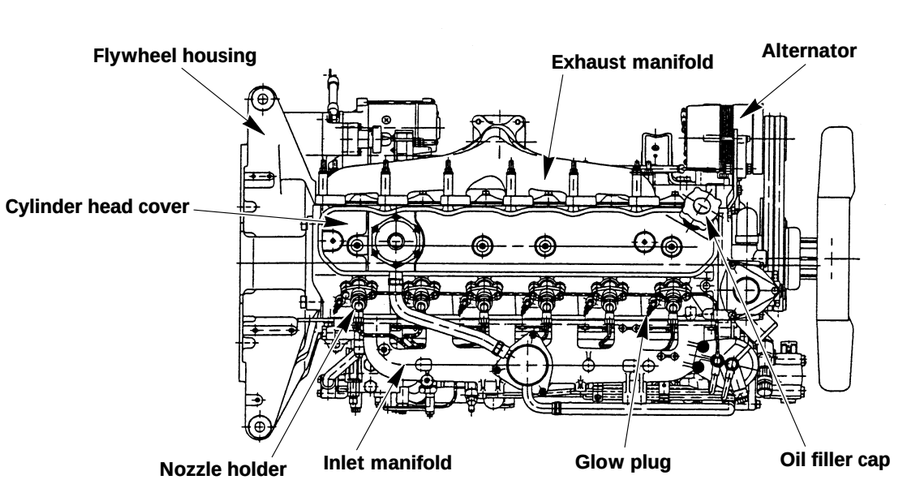


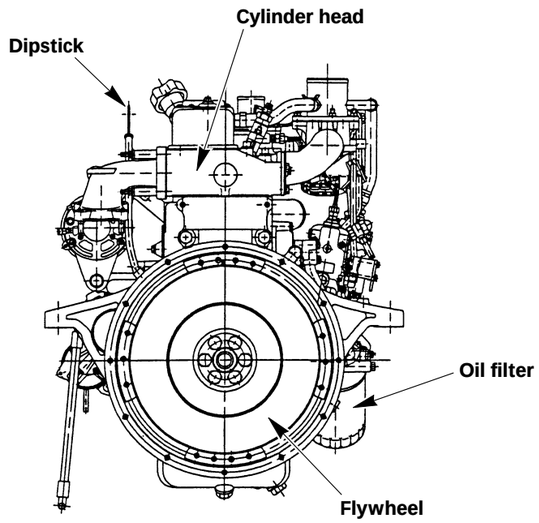


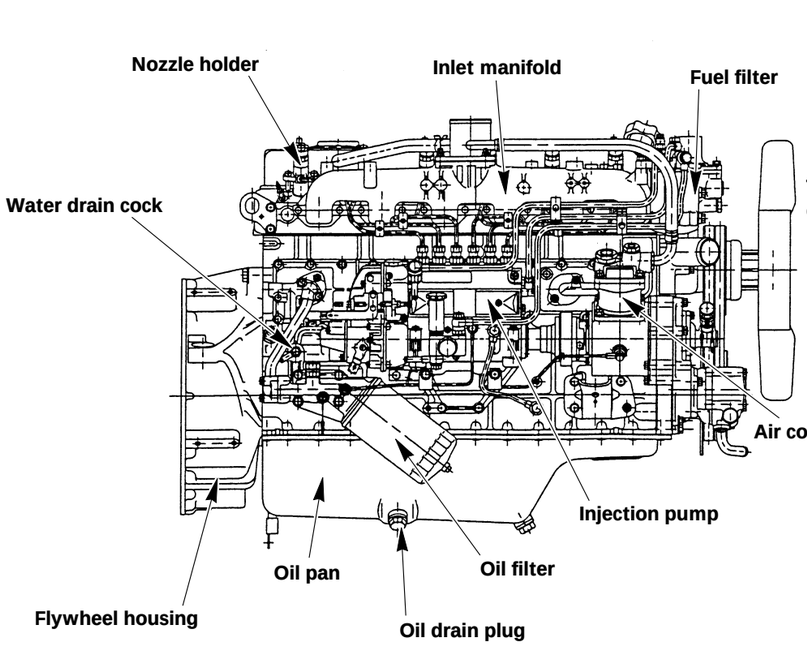
EXTERNAL VIEW

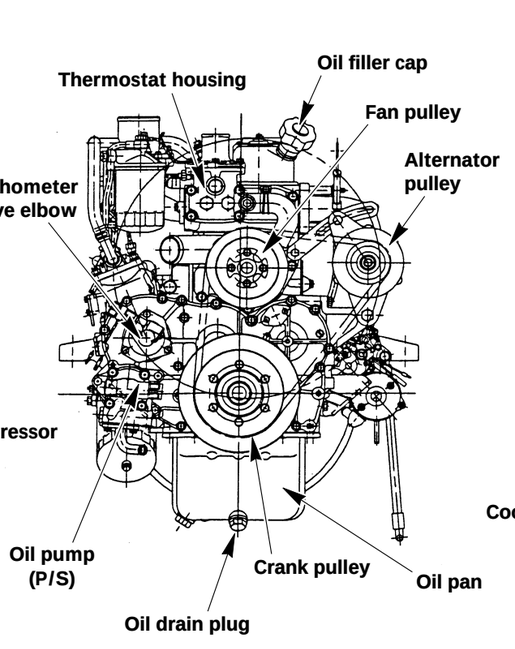
MODEL AA-6BG1

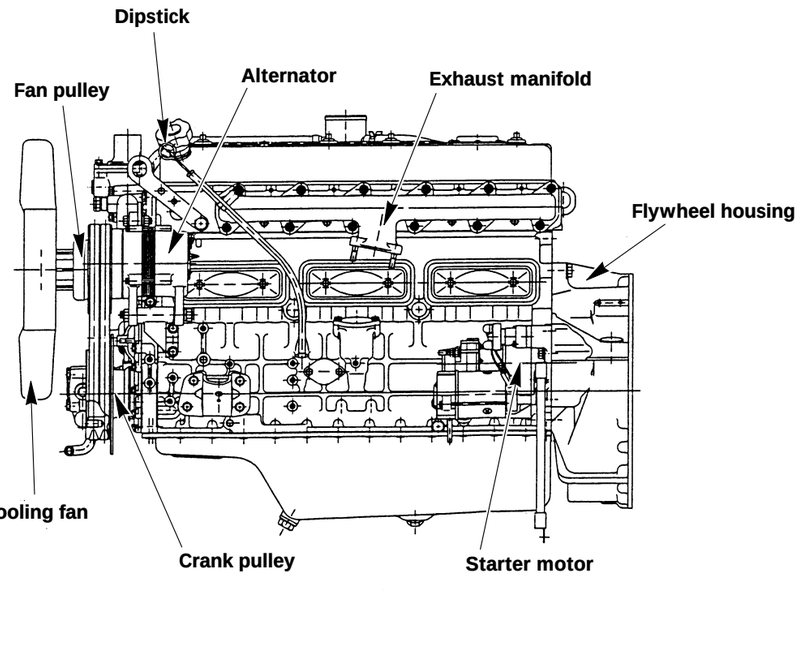
Note:
Engine details may vary depending on the specifications.









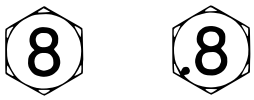
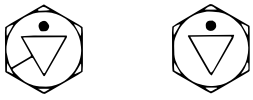


TIGHTENING TORQUE SPECIFICATIONS

The tightening torque values given in the table below are applicable to the bolts unless otherwise specified.

STANDARD BOLT

N·m (kgf·m/lb.ft)

Bolt Identification / Bolt Diameter × pitch (mm)			
			
M 6 × 1.0	3.9–7.8 (0.4–0.8/2.9–5.8)	4.9–9.8 (0.5–1.0/3.6–7.2)	———
M 8 × 1.25	7.8–17.7 (0.8–1.8/5.8–13.0)	11.8–22.6 (1.2–2.3/8.7–16.6)	16.7–30.4 (1.7–3.1/12.3–22.4)
M10 × 1.25	20.6–34.3 (2.1–3.5/5.2–25.3)	27.5–46.1 (2.8–4.7/20.3–33.4)	37.3–62.8 (3.8–6.4/27.5–46.3)
* **M10 × 1.5**	19.6–33.4 (2.0–3.4/14.5–24.6)	27.5–45.1 (2.8–4.6/20.3–33.3)	36.3–59.8 (3.7–6.1/26.8–44.1)
M12 × 1.25	49.1–73.6 (5.0–7.5/36.2–54.2)	60.8–91.2 (6.2–9.3/44.8–67.3)	75.5–114.0 (7.7–11.6/55.7–83.9)
* **M12 × 1.75**	45.1–68.7 (4.6–7.0/33.3–50.6)	56.9–84.4 (5.8–8.6/42.0–62.2)	71.6–107.0 (7.3–10.9/52.8–78.8)
M14 × 1.5	76.5〜115.0 (7.8〜11.7/56.4〜84.6)	93.2–139.0 (9.5–14.2/68.7–103.0)	114.0–.0 (11.6–17.4/83.9–126.0)
* **M14 × 2.0**	71.6–107.0 (7.3–10.9/52.8–78.8)	88.3–131.0 (9.0–13.4/65.1–96.9)	107.0–160.0 (10.9–16.3/78.8–118.0)
M16 × 1.5	104.0–157.0 (10.6–16.0/76.7–115.7)	135.0–204.0 (13.8–20.8/99.8–150.0)	160.0–240.0 (16.3–24.5/118.0–177.0)
* **M16 × 2.0**	100.0–149.0 (10.2–15.2/73.8–110.0)	129.0–194.0 (13.2–19.8/95.5–143.0)	153.0–230.0 (15.6–23.4/113.0–169.0)
M18 × 1.5	151.0–226.0 (15.4–23.0/111.0–166.0)	195.0–293.0 (19.9–29.9/144.0–216.0)	230.0–345.0 (23.4–35.2/169.0–255.0)
* **M18 × 2.5**	151.0–226.0 (15.4–23.0/111.0–166.0)	196.0–294.0 (20.0–30.0/145.0–217.0)	231.0–346.0 (23.6–35.3/171.0–255.0)
M20 × 1.5	206.0–310.0 (21.0–31.6/152.0–229.0)	270.0–405.0 (27.5–41.3/199.0–299.0)	317.0–476.0 (32.3–48.5/234.0–351.0)
* **M20 × 2.5**	190.0–286.0 (19.4–29.2/140.0–211.0)	249.0–375.0 (25.4–38.2/184.0–276.0)	293.0–440.0 (29.9–44.9/216.0–325.0)
M22 × 1.5	251.0–414.0 (25.6–42.2/185.0–305.0)	363.0–544.0 (37.0–55.5/268.0–401.0)	425.0–637.0 (43.3–64.9/313.0–469.0)
* **M22 × 2.5**	218.0–328.0 (22.2–33.4/161.0–242.0)	338.0–507.0 (34.5–51.7/250.0–374.0)	394.0–592.0 (40.2–60.4/291.0–437.0)
M24 × 2.0	359.0–540.0 (36.6–55.0/265.0–398.0)	431.0–711.0 (43.9–72.5/318.0–524.0)	554.0–831.0 (56.5–84.7/409.0–613.0)
* **M24 × 3.0**	338.0–507.0 (34.5–51.7/250.0–374.0)	406.0–608.0 (41.4–62.0/299.0–448.0)	521.0–782.0 (53.1–79.7/384.0–576.0)

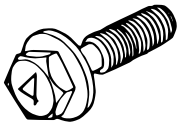
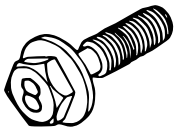
An asterisk (*) indicates that the bolts are used for female threaded parts that are made of soft materials such as casting.

TIGHTENING TORQUE SPECIFICATIONS

The tightening torque values given in the table below are applicable to the bolts unless otherwise specified.

FLANGED HEAD BOLT

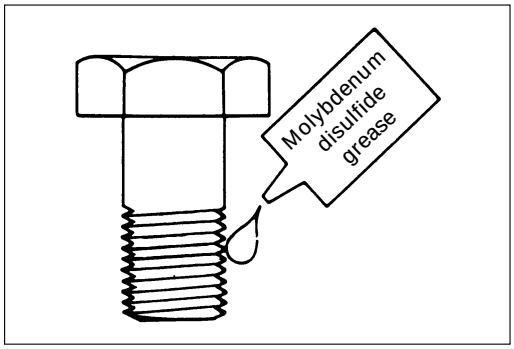
N·m (kgf·m/lb.ft)

Bolt Identification / Bolt Diameter × pitch (mm)			
M 6 × 1.0	4.6–8.5 (0.5–0.9/3.6–6.5)	6.6–12.2 (0.6–1.2/4.3–8.7)	———
M 8 × 1.25	10.5–196 (1.1–2.0/8.0–14.5)	15.3–28.4 (1.6–2.9/11.6–21.0)	18.1–33.6 (2.1–3.4/15.2–25.0)
M10 × 1.25	23.1–38.5 (2.4–3.9/17.4–28.2)	35.4–58.9 (3.6–6.1/26.0–44.1)	42.3–70.5 (4.3–7.2/31.1–52.1)
* **M10 × 1.5**	22.3–37.2 (2.3–3.8/16.6–27.5)	34.5–57.5 (3.5–5.8/25.3–42.0)	40.1–66.9 (4.1–6.8/29.7–49.2)
M12 × 1.25	54.9–82.3 (5.6–8.4/40.1–60.8)	77.7–117.0 (7.9–11.9/57.1–86.1)	85.0–128.0 (8.7–13.0/62.9–94.0)
* **M12 × 1.75**	51.0–76.5 (5.2–7.8/37.6–56.4)	71.4–107.0 (7.3–10.9/52.8–78.8)	79.5–119.0 (8.1–12.2/58.6–88.2)
M14 × 1.5	83.0–125.0 (8.5–12.7/61.5–91.9)	115.0–172.0 (11.7–17.6/84.6–127.0)	123.0–185.0 (12.6–18.9/91.1–137.0)
* **M14 × 2.0**	77.2–116.0 (7.9–11.8/57.1–85.3)	108.0–162.0 (11.1–16.6/80.3–120.0)	116.0–173.0 (11.8–17.7/85.3–128)
M16 × 1.5	116.0–173.0 (11.8–17.7/85.3–128)	171.0–257.0 (17.4–26.2/26.0–190)	177.0–265.0 (18.0–27.1/130.0–196.0)
* **M16 × 2.0**	109.0–164.0 (11.2–16.7/81.0–121.0)	163.0–244.0 (16.6–24.9/120.0–180.0)	169.0–253.0 (17.2–25.8/124.0–187.0)

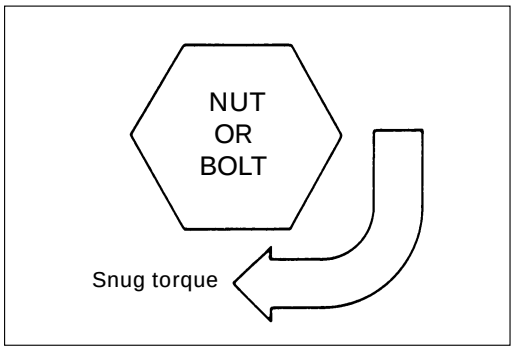
A bolt with an asterisk (*) is used for female screws of soft material such as cast iron.

ANGULAR NUT AND BOLT TIGHTENING METHOD

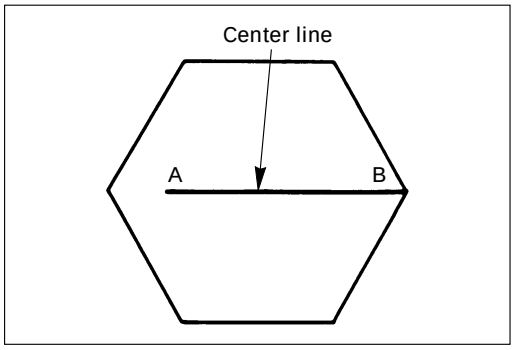
1. Carefully wash the nuts and bolts to remove all oil and grease.



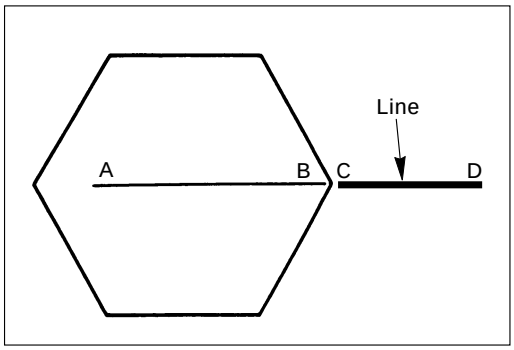
2. Apply a coat of molybdenum disulfide grease to the threads and setting faces of the nuts and bolts.



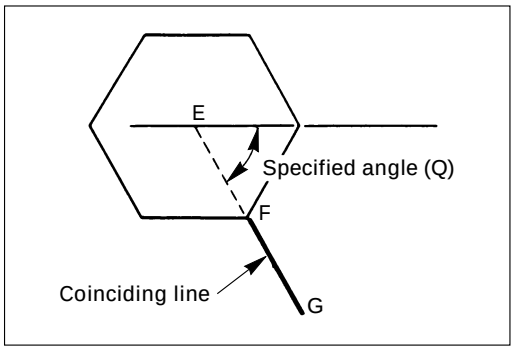
3. Tighten the nuts and bolts to the specified torque (snug torque) with a torque wrench.



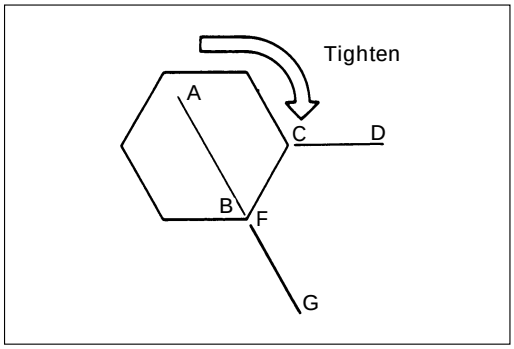
4. Draw a line [A-B] across the center of each bolt.



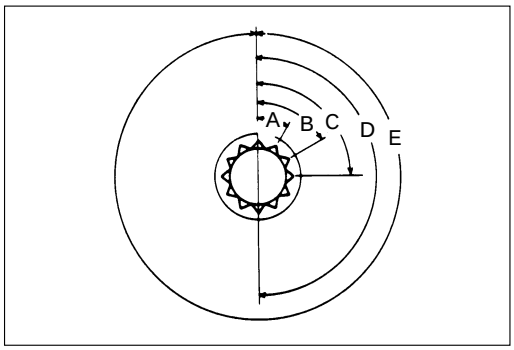
5. Draw another line (C-D) on the face of each of the parts to be clamped. This line should be an extension of the line [A-B].



6. Draw another line [F-G] on the face of each of the parts to be clamped. This line will be in the direction of the specified angle (Q) across the center [E] of the nut or bolt.



7. Use a socket wrench to tighten each nut or bolt to the point where the line [A-B] is aligned with the line [F-G].



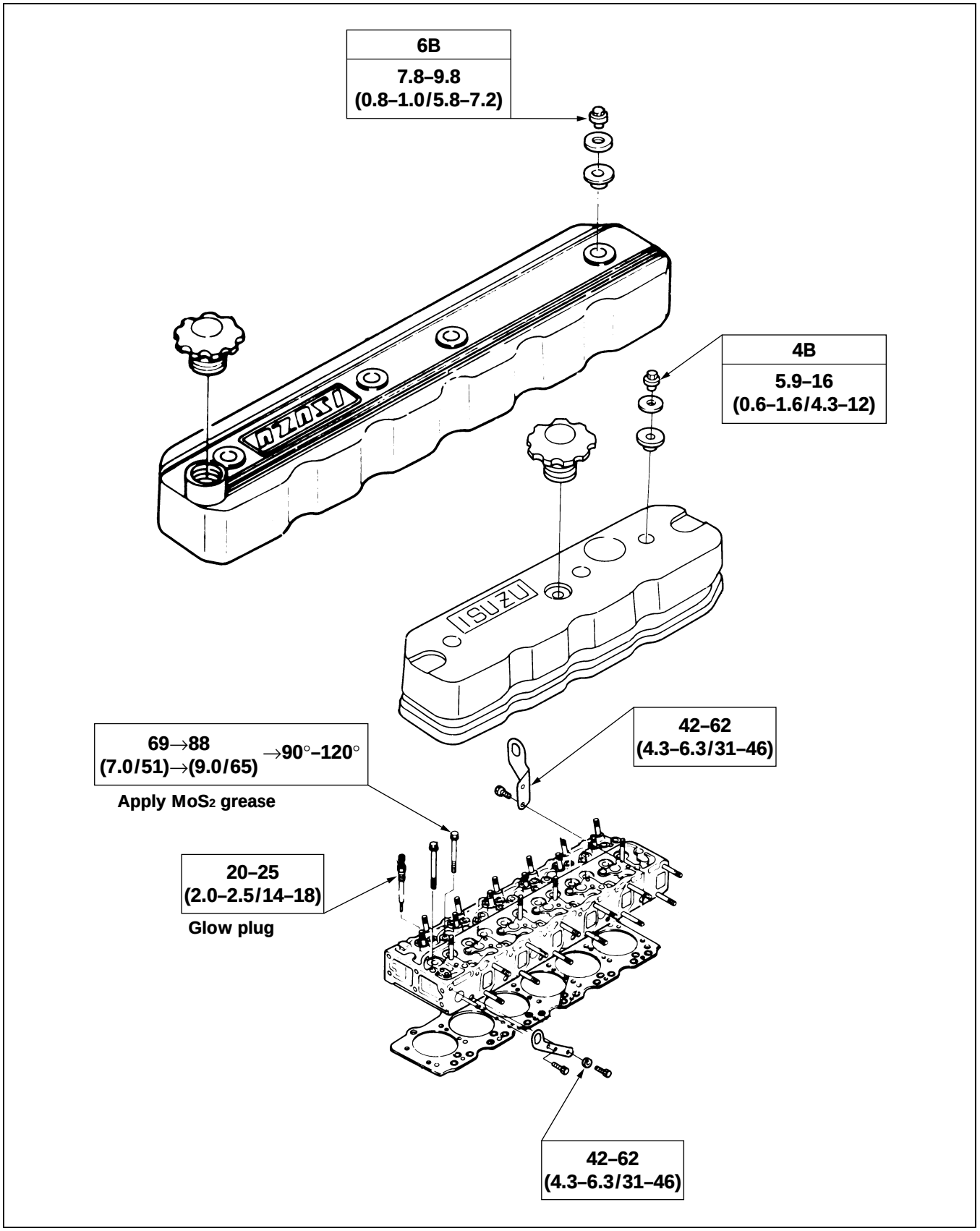
Example: Specified Angle and Tightening Rotation

A	30°	1/12 of a turn
B	60°	1/6 of a turn
C	90°	1/4 of a turn
D	180°	1/2 of a turn
E	360°	One full turn

MAJOR PART FIXING NUTS AND BOLTS

Cylinder Head and Cover

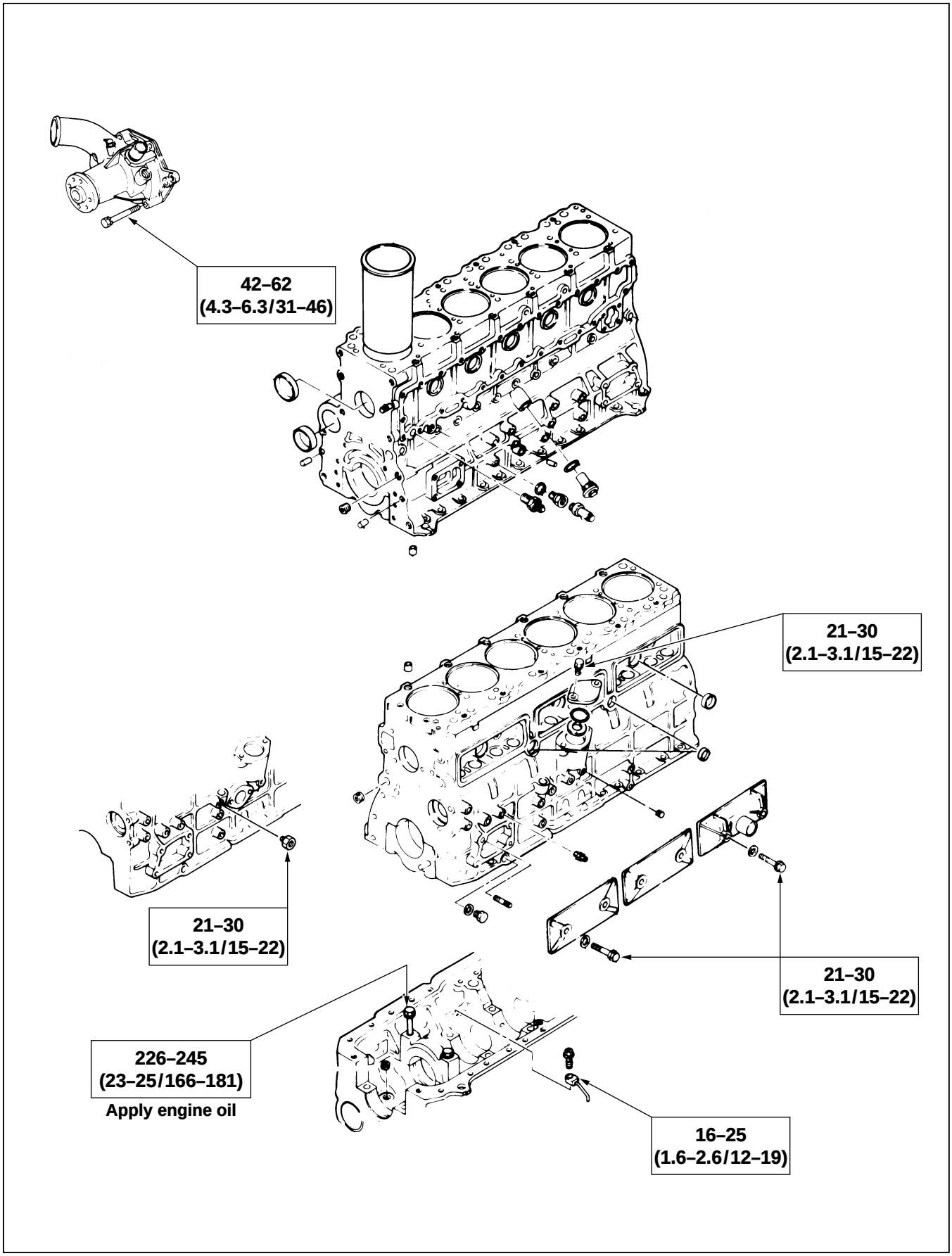
N·m (kgf·m/lb.ft)



Mos2 . . . . . Molybdenum disulfide paste.

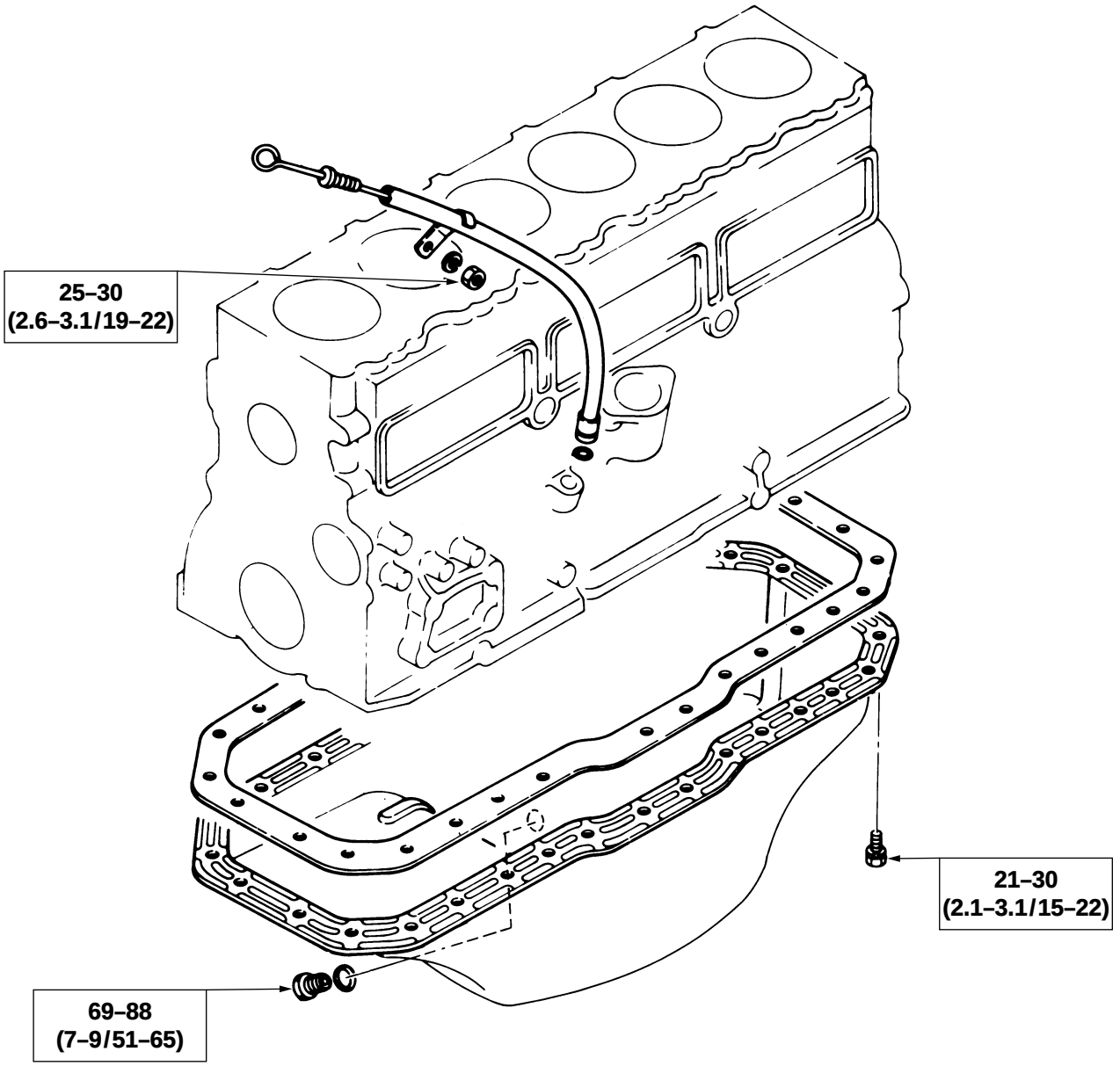
Cylinder Body

N·m (kgf·m/lb.ft)



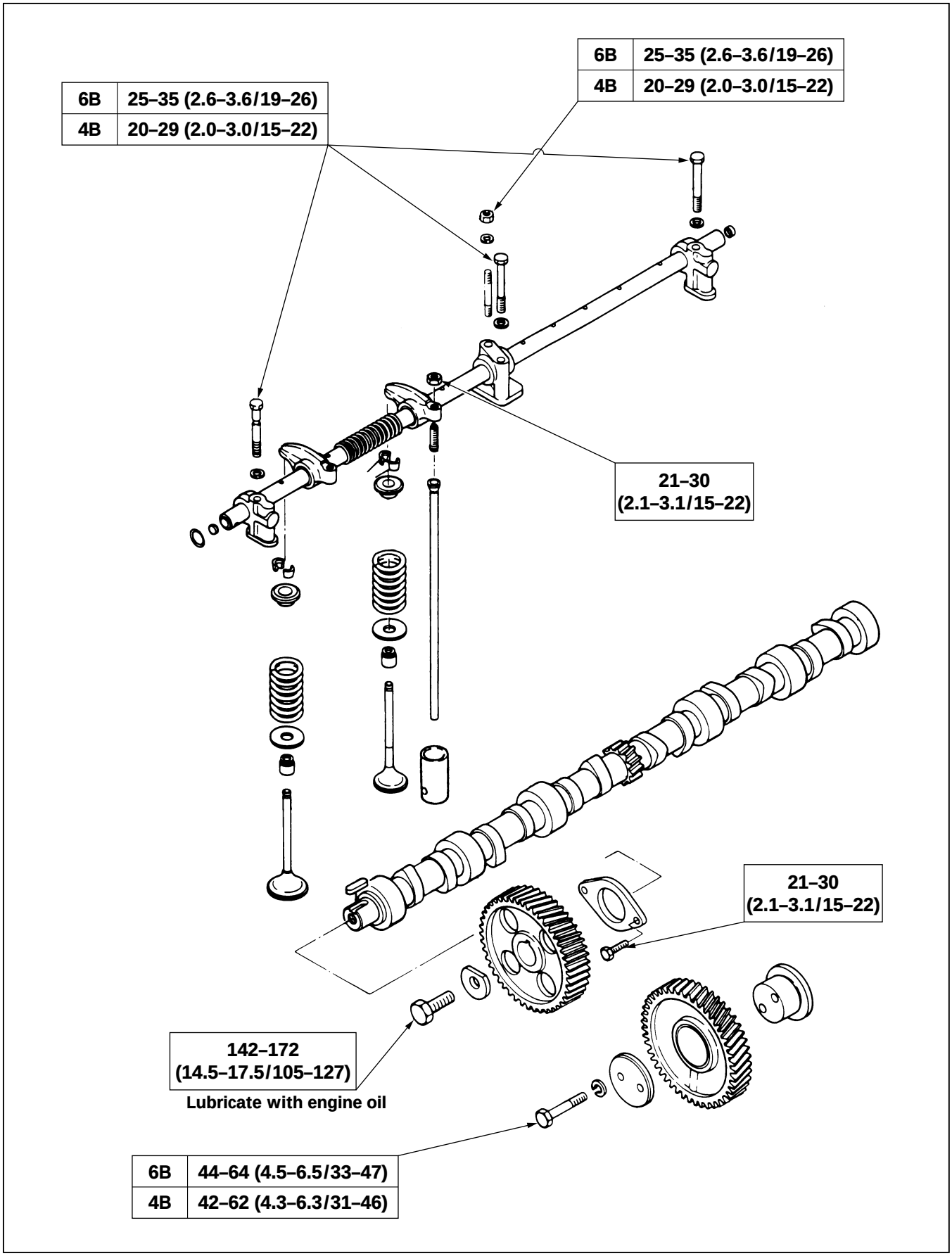
Oil Pan and Dipstick

N·m (kgf·m/lb.ft)



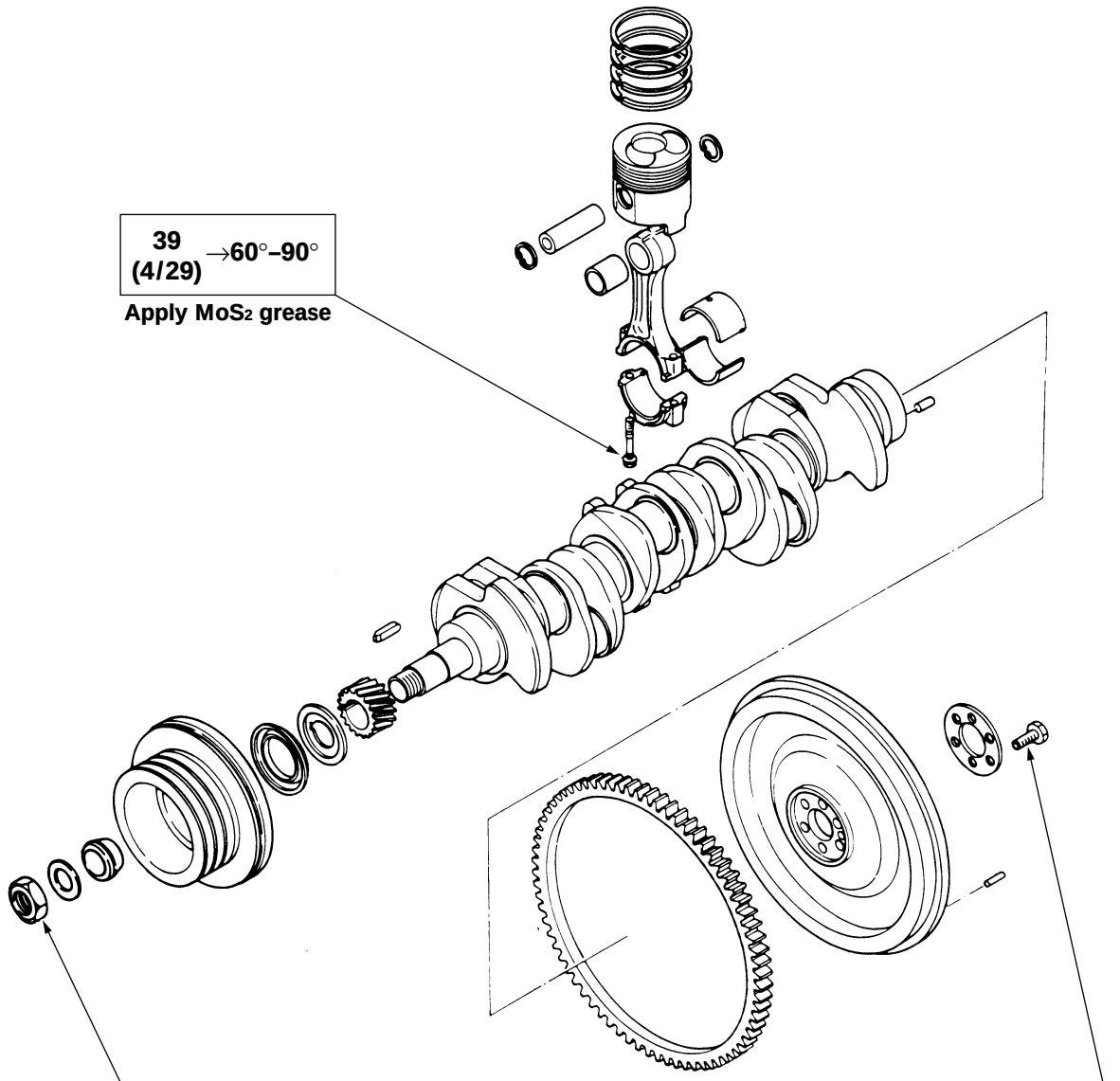
Camshaft and Rocker Arm

N·m (kgf·m/lb.ft)



Crankshaft, Piston, and Flywheel

N·m (kgf·m/lb.ft)



6B	4B
539–637 (55–65/378–470)	382–481 (39–49/282–354)

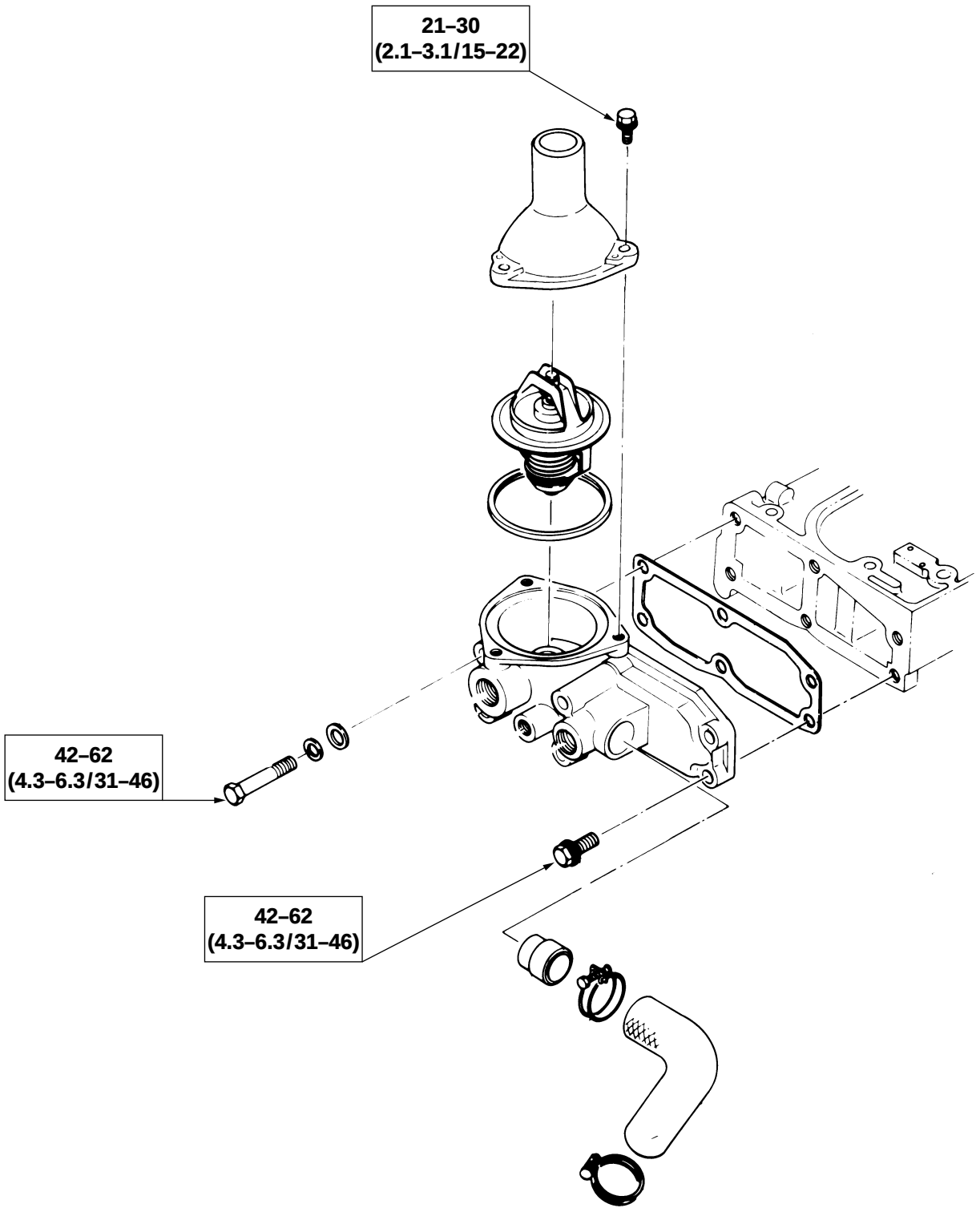
Apply MoS2 grease

6B	4B
197–240 (20.1–24.5/145–177)	142–172 (14.5–17.5/105–127)

Apply engine oil

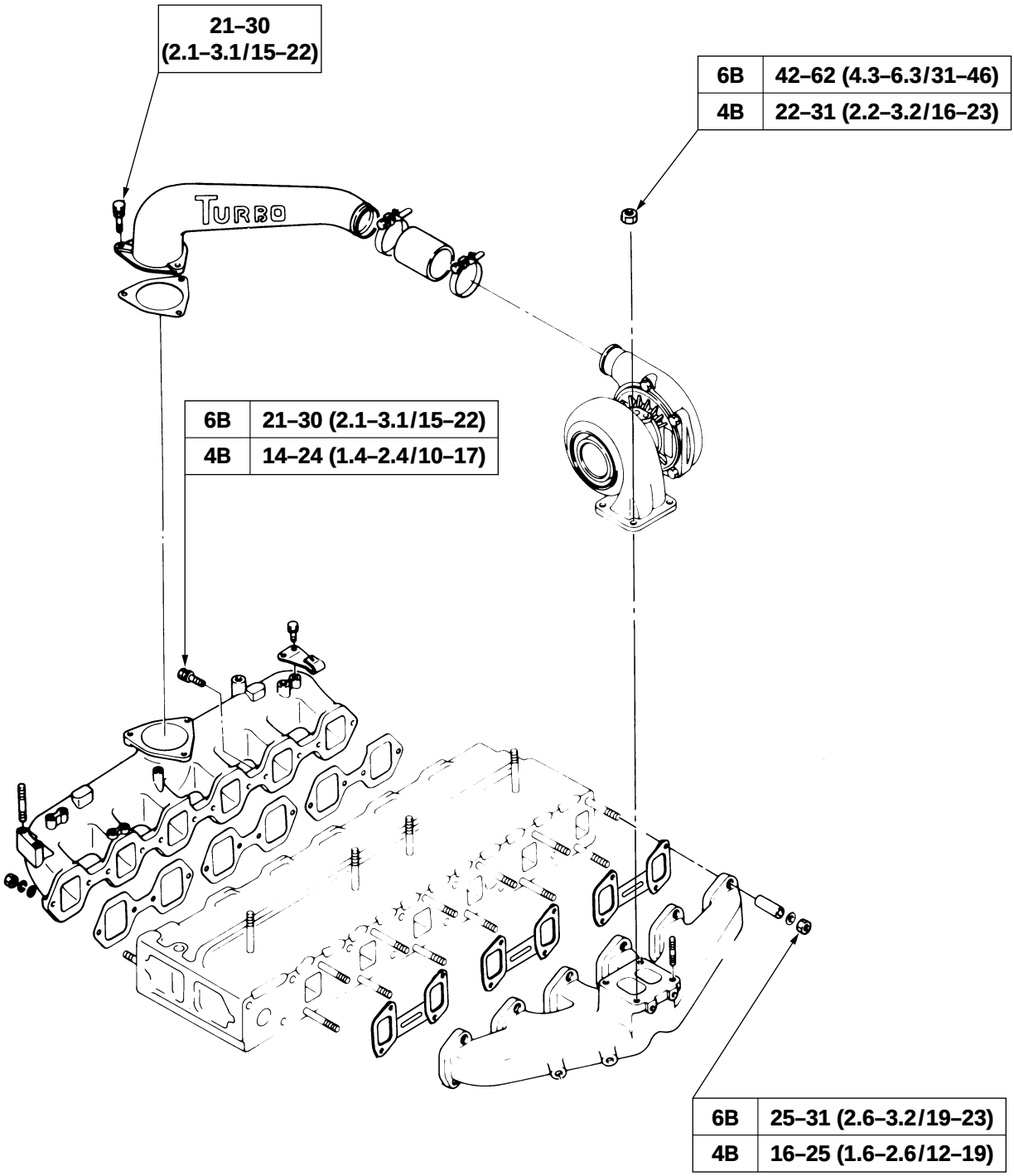
Thermostat and Thermostat Housing

N·m (kgf·m/lb.ft)



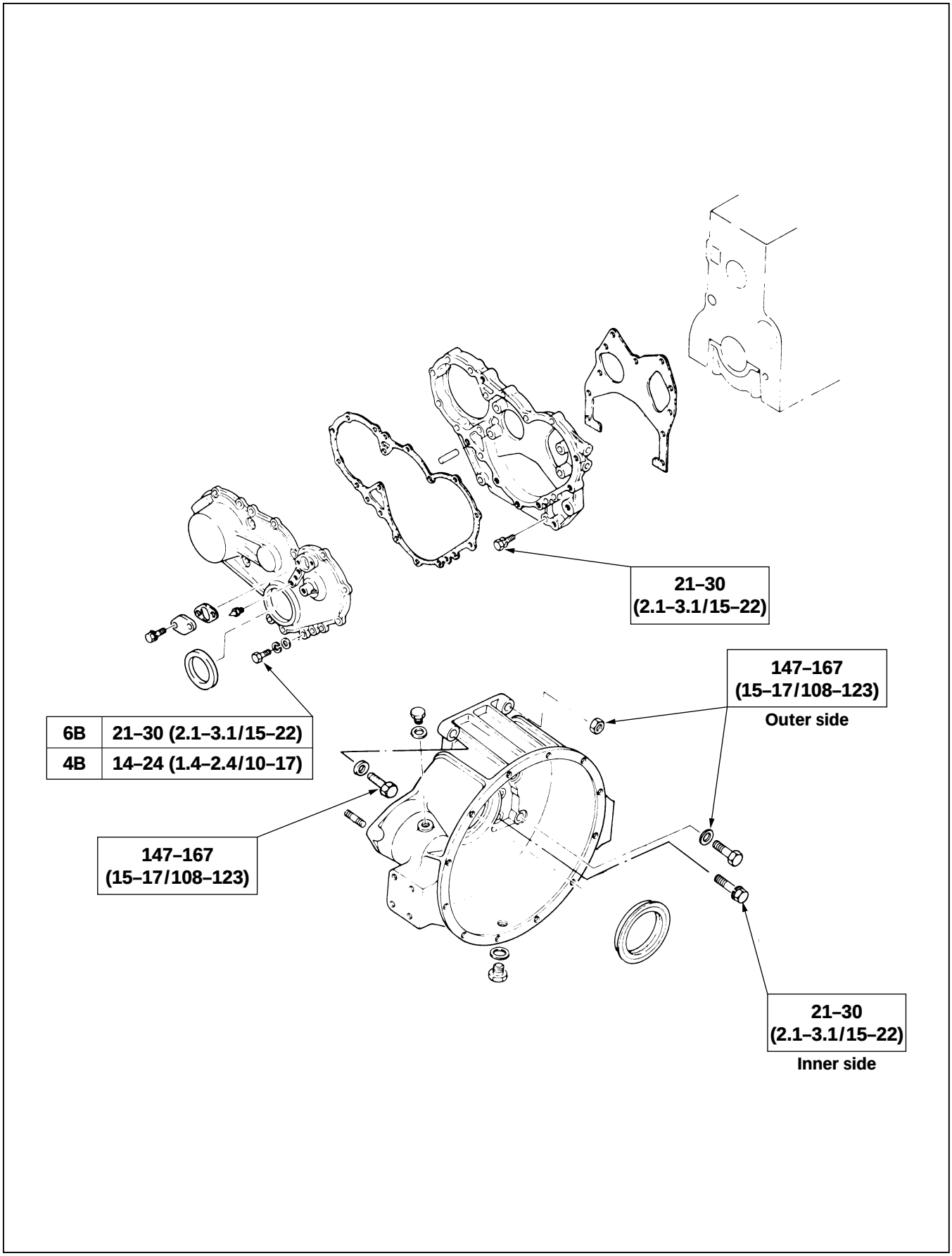
Intake and Exhaust Manifold

N·m (kgf·m/lb.ft)



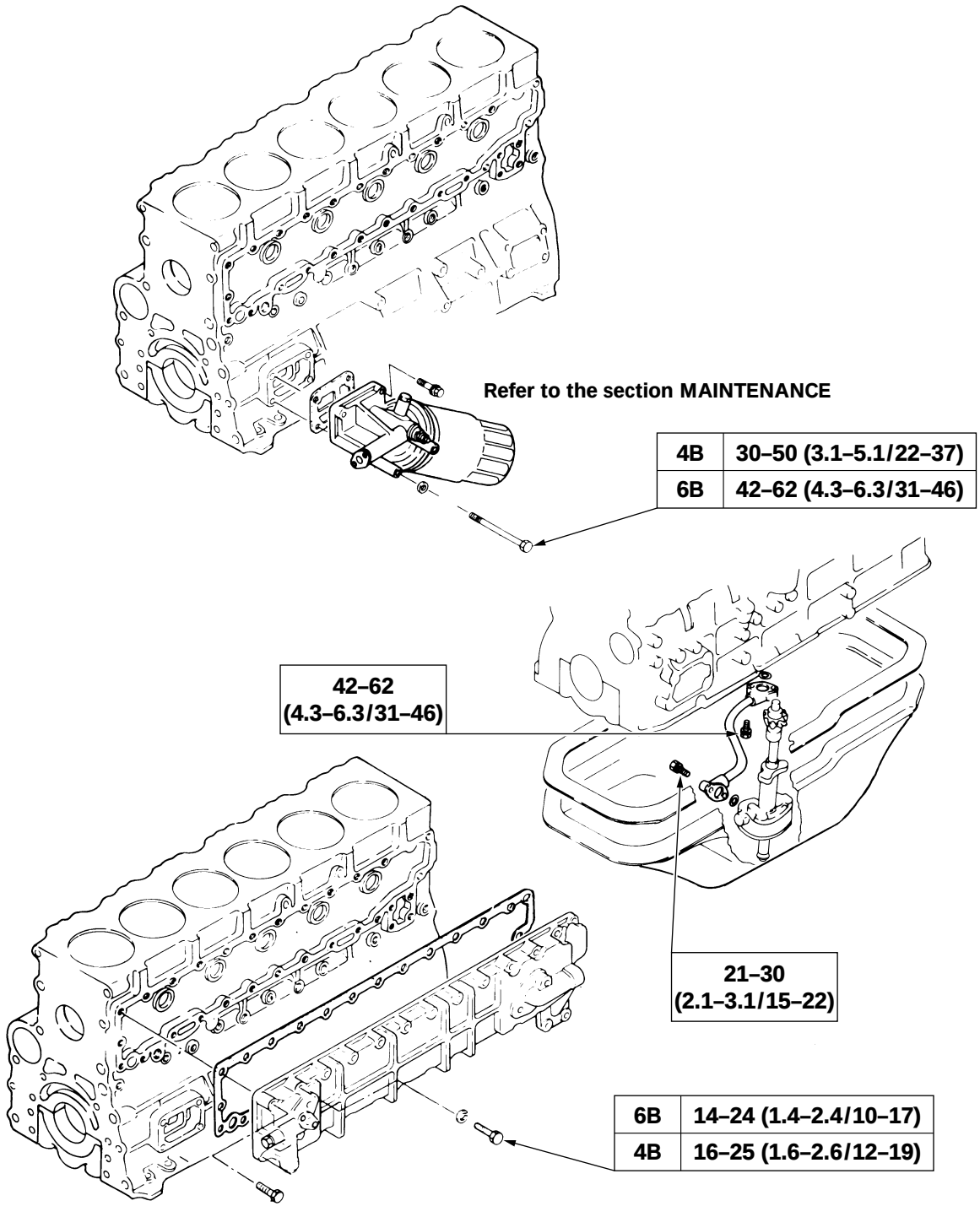
Timing Gear Case and Flywheel Housing

N·m (kgf·m/lb.ft)



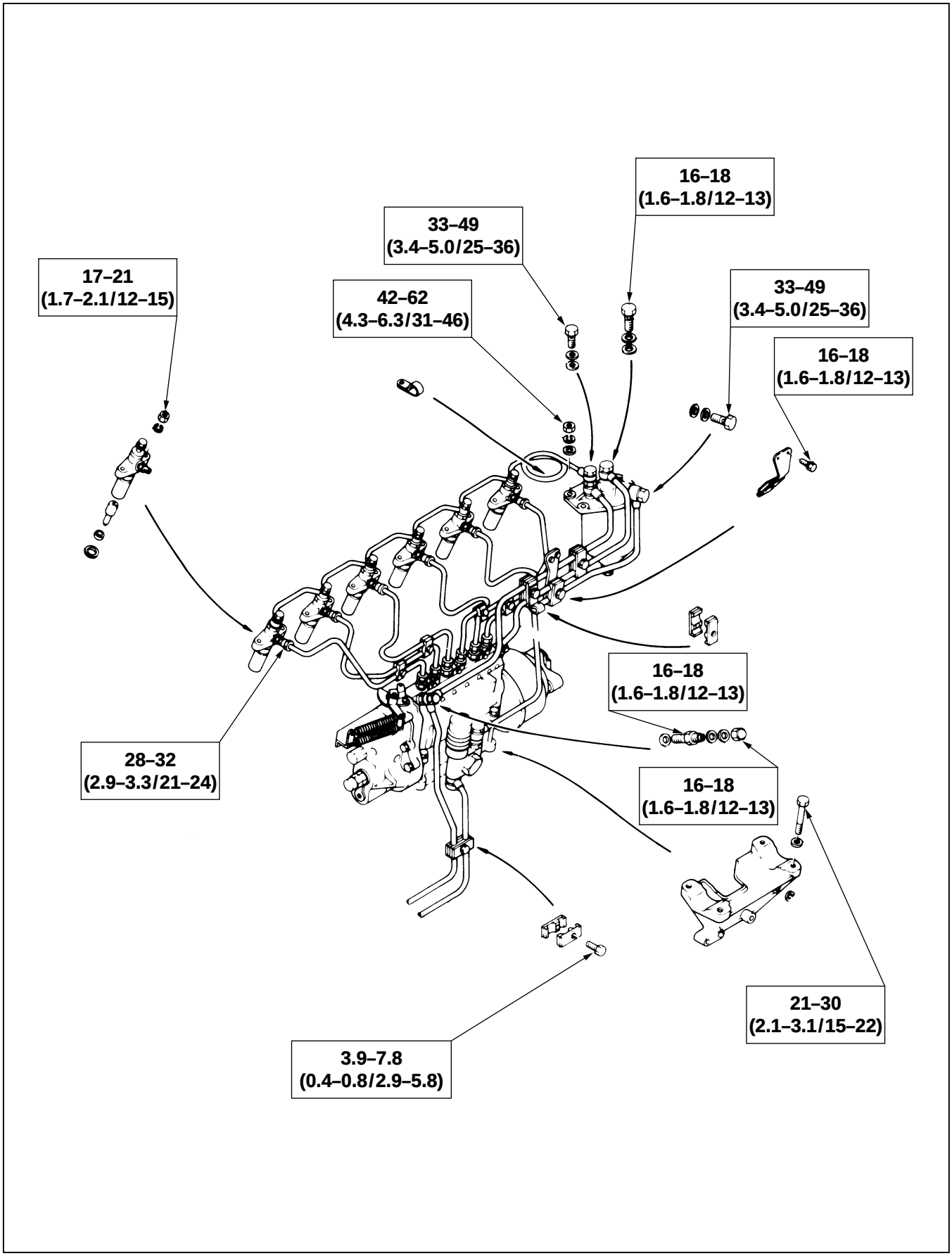
Oil Cooler, Oil Filter, and Oil Pump

N·m (kgf·m/lb.ft)



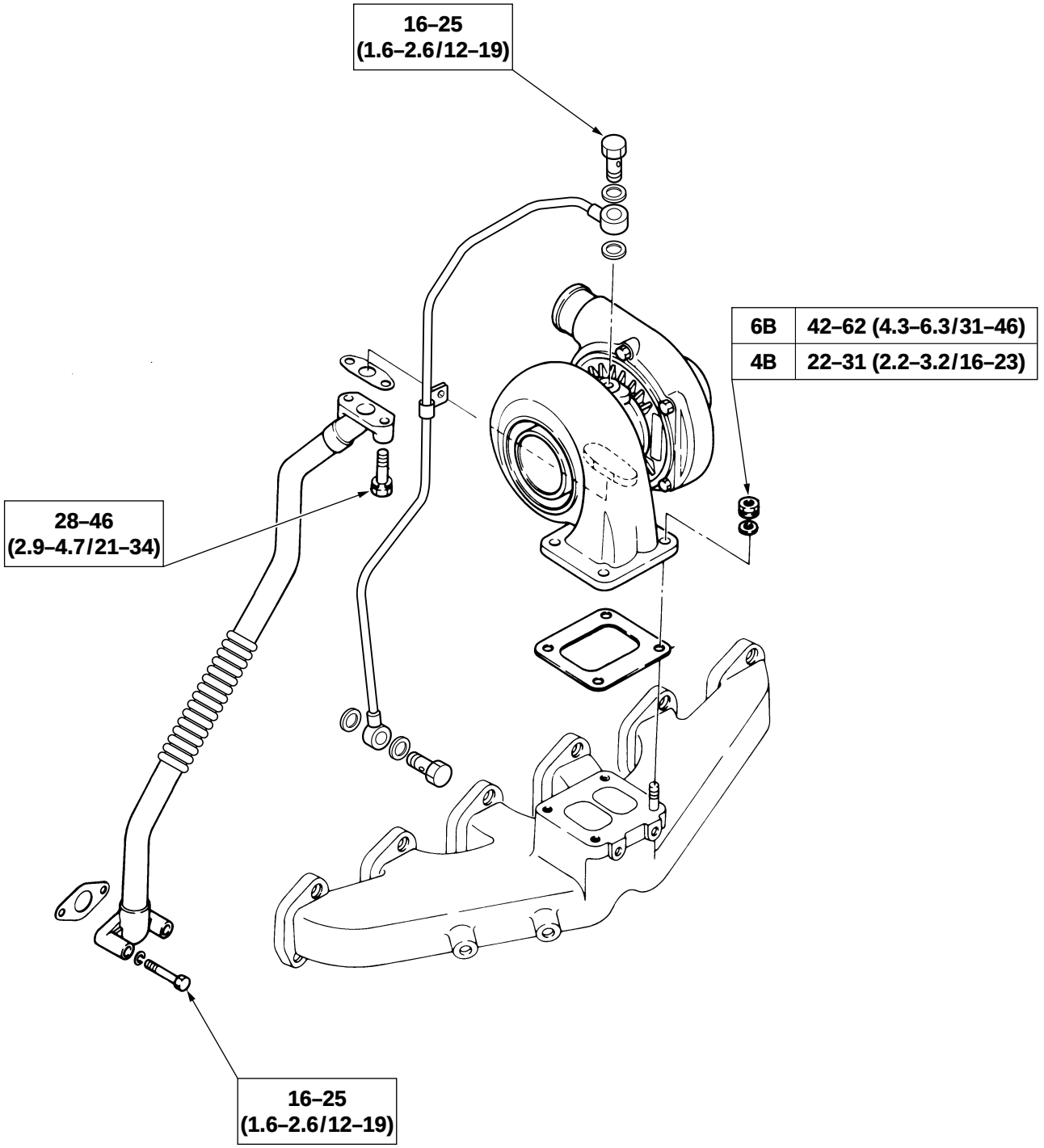
Fuel System

N·m (kgf·m/lb.ft)

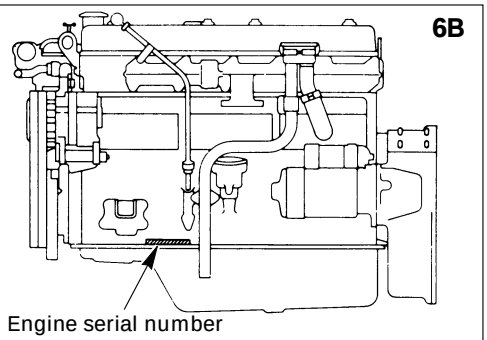


Turbocharger

N·m (kgf·m/lb.ft)



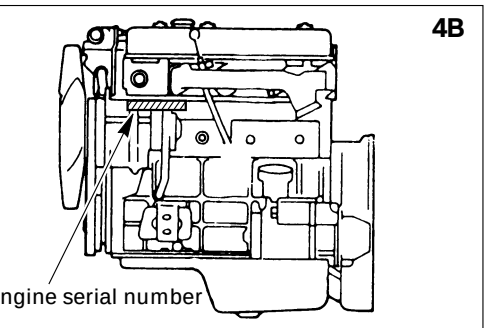
IDENTIFICATIONS



MODEL IDENTIFICATION

Engine Serial Number

The engine number is stamped on the front left hand side of the cylinder body.



INJECTION PUMP IDENTIFICATION

Injection Pump Number

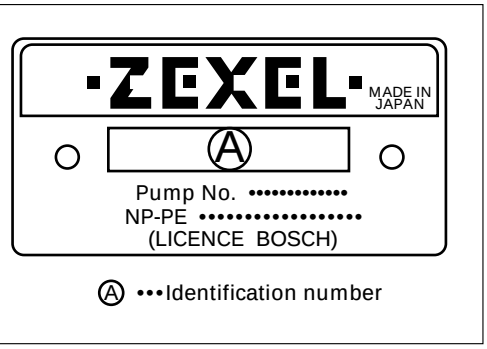
Injection volume should be adjusted after referring to the adjustment data applicable to the injection pump installed.

The injection pump identification number (A) is stamped on the injection pump identification plate.

Note:

Always check the identification number before beginning a service operation.

Applicable service data will vary according to the identification number. Use of the wrong service data will result in reduced engine performance and engine damage.

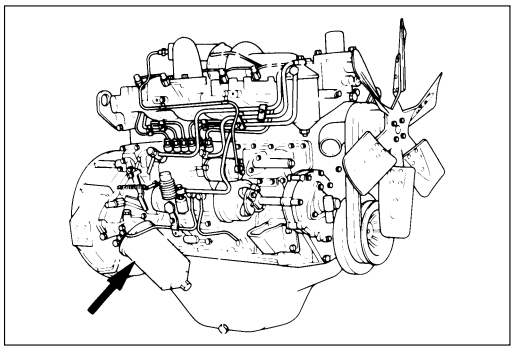


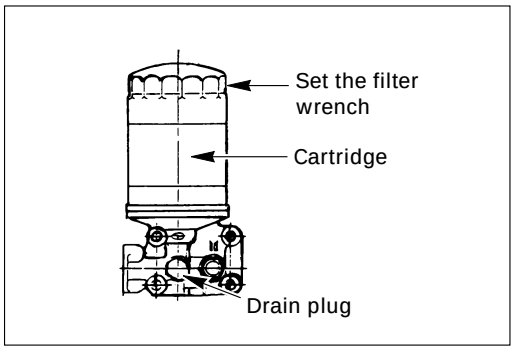
SECTION 2

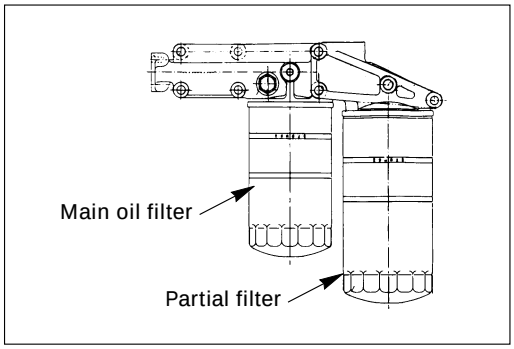
MAINTENANCE

TABLE OF CONTENTS

Note: Maintenance intervals such as fuel or oil filter changes should be referred to INSTRUCTION BOOK.







LUBRICATING SYSTEM

Main Oil Filter Replacement

Cartridge (Spin-On) Type

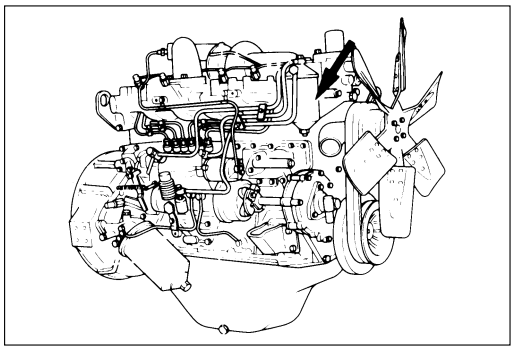
Removal

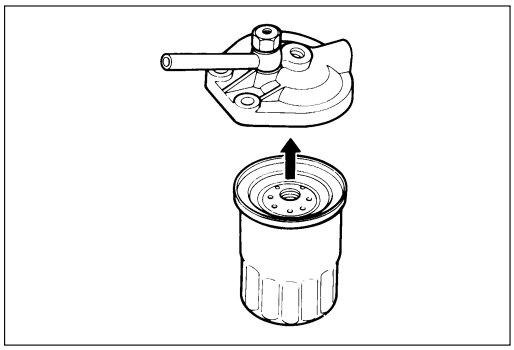
Removal and Installer: Filter Wrench

1. Loosen the used oil filter by turning it counterclockwise with the filter wrench.
2. Discard the used oil filter.

Installation

1. Wipe the oil filter mounting face with a clean rag.
   This will allow the new oil filter to seat properly.
2. Lightly oil the O-ring.
3. Turn in the new oil filter until the sealing face is fitted against the O-ring.
4. Use the filter wrench to turn in the oil filter an additional 3/4 of a turn or one turn.
5. Check the engine oil level and replenish to the specified level if required.
6. Start the engine and check for oil leakage from the oil filter.





FUEL SYSTEM

Fuel Filter Replacement

Cartridge (Spin-On) Type

Removal

1. Loosen the fuel filter by turning it counterclockwise with the filter wrench or your hand. Discard the used filter.

   Filter Wrench

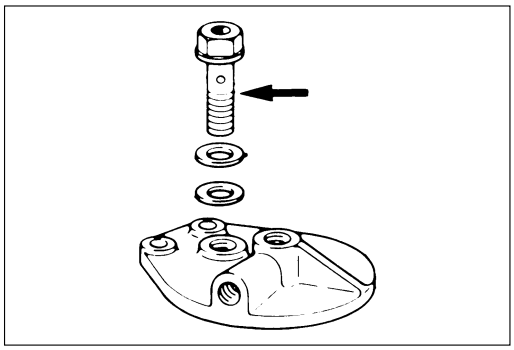
2. Wipe the fuel filter fitting face clean with a rag.

   This will allow the new fuel filter to seat properly.

Installation

1. Apply a light coat of engine oil to the O-ring.
2. Supply fuel to the new fuel filter.

   This will facilitate air bleeding.
3. Turn in the new fuel filter until the filter O-ring is fitted against the sealing face.
4. Use the filter wrench to turn in the fuel filter an additional 2/3 of a turn.



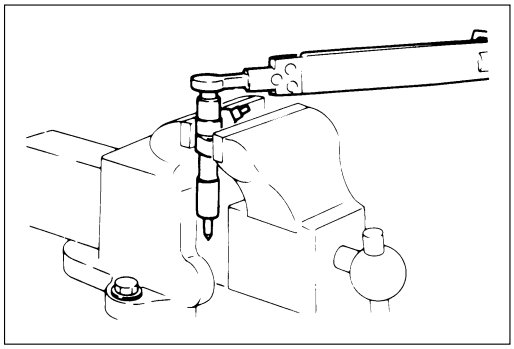
Overflow Valve

Check the overflow valve for clogging.

Check the ball side for suction leakage

kPa (kgf/cm^2/psi)

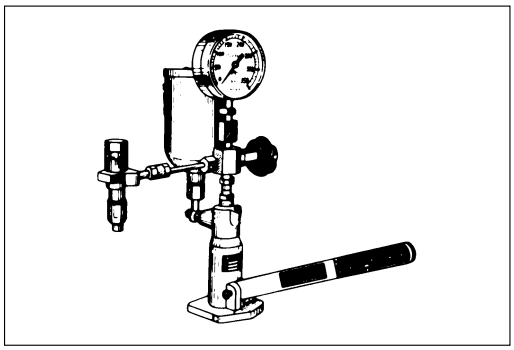
Overflow Valve Opening Pressure (Reference)	147 (1.5/21)



Injection Nozzle

Inspection procedure

1. Clamp the injection nozzle holder in a vise.
2. Use a wrench to remove the injection nozzle holder cap.
3. Remove the injection nozzle holder from the vise.

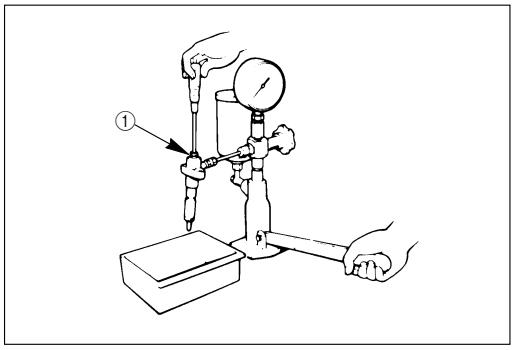


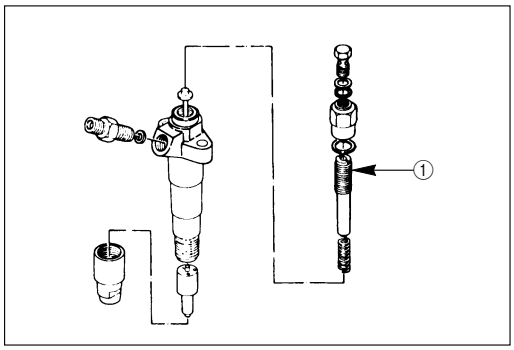
Adjusting Procedure

Injection Starting Pressure Check

1. Attach the injection nozzle holder to the injection nozzle tester.
2. Loosen the adjusting screw ①.
3. Check the injection nozzle starting pressure and the spray condition by operating the injection nozzle tester.
4. Adjust the injection nozzle starting pressure.

   Turn the adjusting screw clockwise while operating the injection nozzle tester handle.

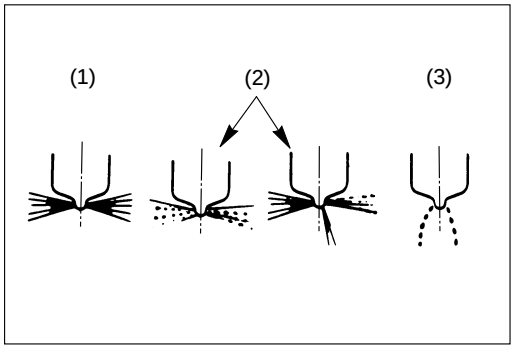




MPa (kgf/cm^2/psi)

Injection Starting Pressure	18.1 (185/2630)

WARNING
TEST FLUID FROM THE NOZZLE TESTER WILL SPRAY OUT UNDER GREAT PRESSURE. IT CAN EASILY PUNCTURE A PERSON'S SKIN. KEEP YOUR HANDS AWAY FROM THE NOZZLE TESTER AT ALL TIMES.

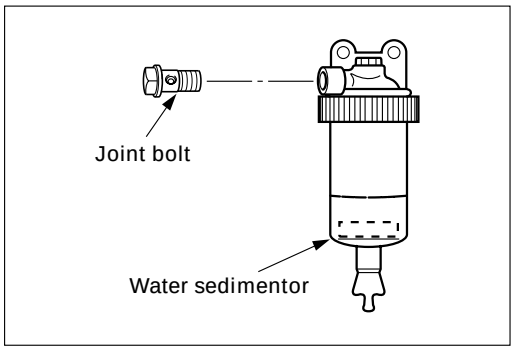


Spray Condition Check (During Injection Nozzle Tester Operation)

1. Tighten the cap nut.
2. Check the injection nozzle starting pressure.
3. Check the injection nozzle spray condition.

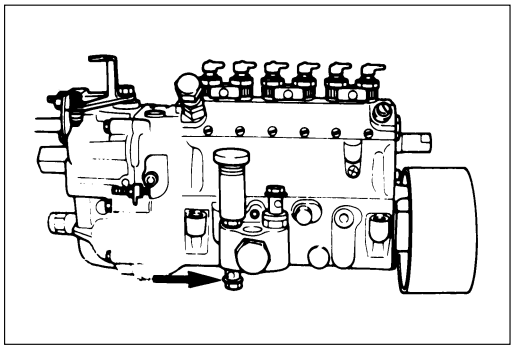
Operate the injection nozzle tester hand lever 4 to 6 times a second while looking for abnormal injection nozzle spray conditions.
Refer to the illustration for different spray conditions.

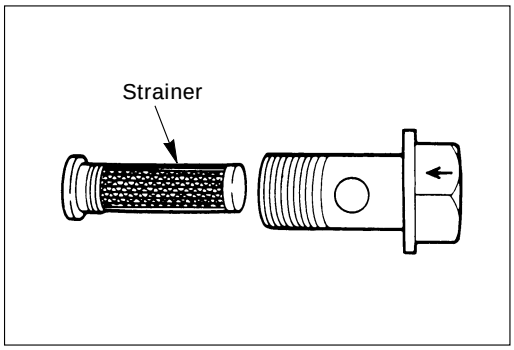
(1) Good
(2) Bad (Restrictions in orifice)
(3) Bad (Dripping)

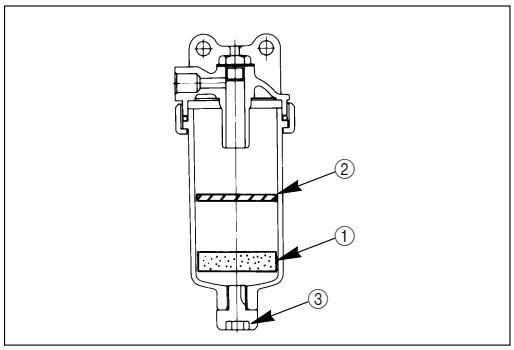


Water Sedimentor and Feed Pump Strainer

1. Remove the joint bolt.
2. Use a screwdriver to remove the strainer.
3. Wash the strainer in clean diesel fuel.







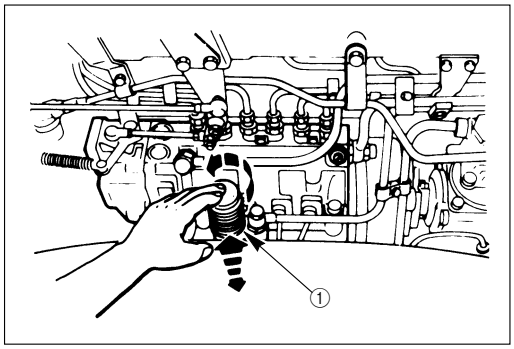
Water Separator (Water Sedimentor) (Optional Equipment)

Check the water separator float ① level.

If the float ① has reached level ②, loosen the drain plug ③ (at the bottom side of the water separator) to drain the water.

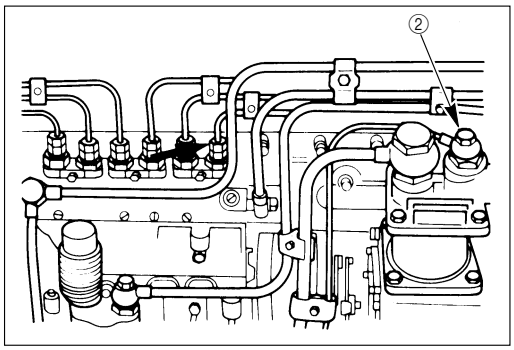
N·m (kgf·m/ft.lb)

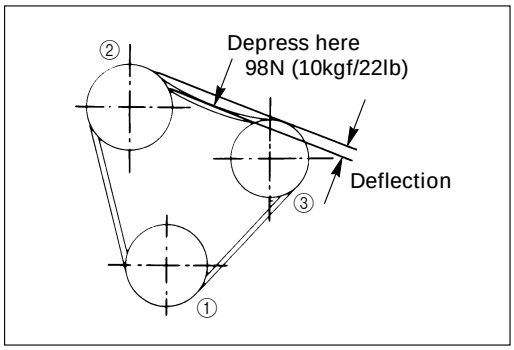
Drain Plug Torque	9–15 (0.9–1.5/7–11)



Air Bleeding

1. Loosen the feed pump cap ① on the injection pump.
2. Loosen the fuel filter fuel return eye bolt ②.
3. Operate the feed pump until there are no more bubbles visible in the fuel being discharged from the fuel filter fuel return eye bolt.
4. Retighten the fuel filter fuel return eye bolt.
5. Operate the feed pump several times and check for fuel leakage around the injection pump and the fuel filter.





COOLING SYSTEM

Cooling Fan Drive Belt

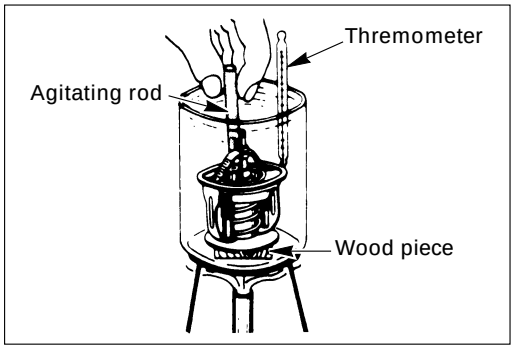
Adjustment

1. Check the cooling fan drive belt for cracking and other damage.
2. Check the drive belt tension by exerting a force of 98N (10kgf/22lb) midway between the fan pulley ② and the alternator ③.
3. Adjust the belt tension by loosening the alternator mounting bolt and the alternator adjusting bolt and pivoting the alternator.

   Be sure to retighten the bolts after adjusting the belt tension.

mm (in)

	4BG1	6BG1
Cooling Fan Drive Belt Deflection	8.0–12.0 (0.3–0.47)	7.0–10.0 (0.28–0.39)



Thermostat

Inspection

Visually inspect the thermostat.

Replace the thermostat if excessive wear or damage is discovered during inspection.

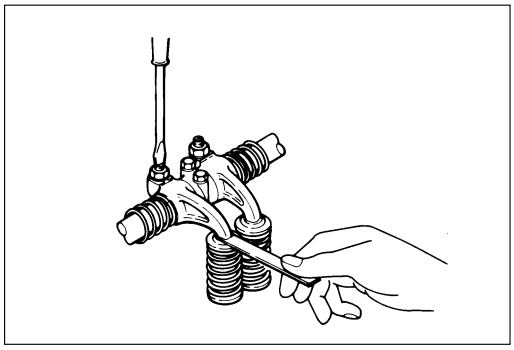
Measure the valve lift.

mm (in)

Amount of Valve Lift at 95°C (203°F)	10.0 (0.39)

°C(°F)

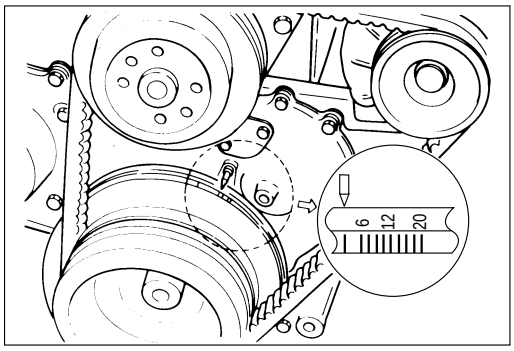
Valve Opening Temperature	80–84 (176–183)



VALVE CLEARANCE AND ADJUSTMENT

Note:

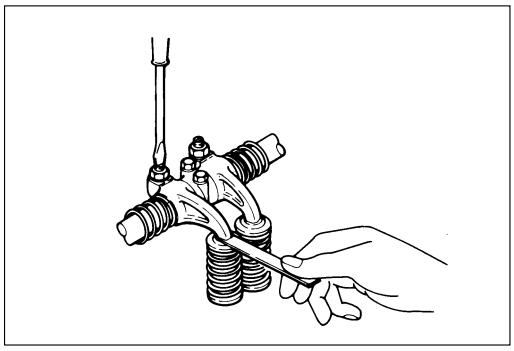
The cylinder head bolts were previously tightened with the "Angular Tightening Method". Therefore, it is not necessary to retighten the cylinder head bolts before adjusting the valve clearance.



1. Bring the piston in either the No. 1 cylinder or the No. 6 cylinder to Top Dead Center on the compression stroke by turning the crankshaft until the TDC notched line on the crankshaft pulley is aligned with the timing pointer.
2. Check to see if there is play in the No. 1 intake and exhaust valve rocker arms.

   If the No. 1 cylinder intake and exhaust valve rocker arms have play, the No. 1 piston is at TDC on the compression stroke.

   If the No. 1 cylinder intake and exhaust valve rocker arms are depressed, the No. 6 piston (No. 4 piston for the 4BG1) is at TDC on the compression stroke.

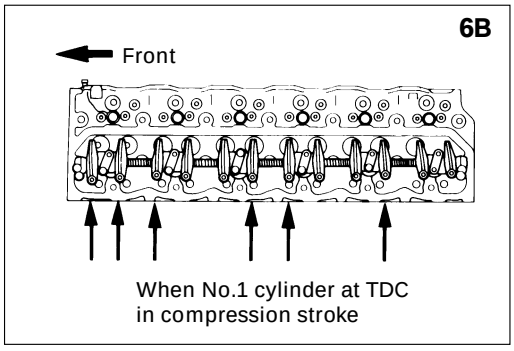


Adjust the No. 1 or the No. 6 (No. 4 for the 4BG1) cylinder valve clearances while their respective cylinders are at TDC on the compression stroke.

mm (in)

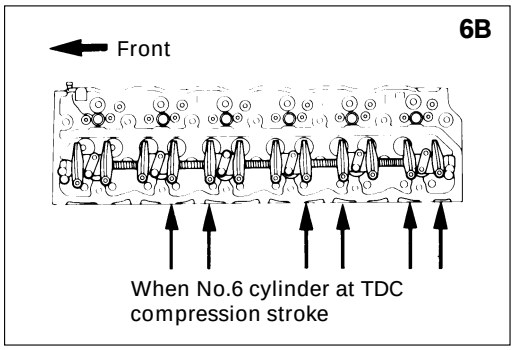
Intake and Exhaust Valve Clearance (cold)	0.40 (0.016)

3. Loosen each valve clearance adjusting screw as shown in the illustration.
4. Insert a 0.40 mm (0.016 in) feeler gauge between the rocker arm and the valve stem end.
5. Turn the valve clearance adjusting screw until a slight drag can be felt on the feeler gauge.
6. Tighten the lock nut securely.



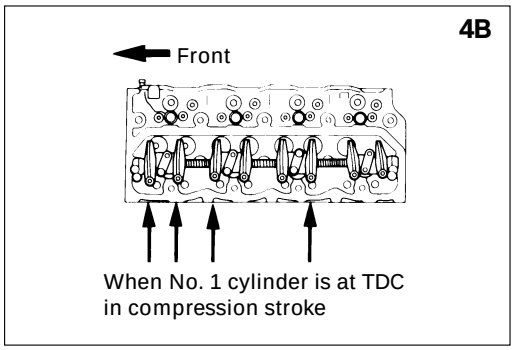
7. Rotate the crankshaft 360°.

   Realign the crankshaft pulley TDC notched line with the timing pointer.
8. Adjust the clearances for the remaining valves as shown in the illustration.



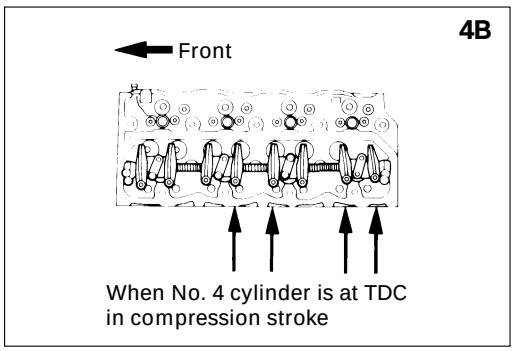
N·m (kgf·m/ft.lb)

Rocker Arm Screw Lock Nut Torque	21–30 (2.1–3.1/15–22)



Note:

The valve clearance adjustment procedure for the 4BG1 engines is identical to that for the 6BG1 engines. Only the number of cylinders is different.



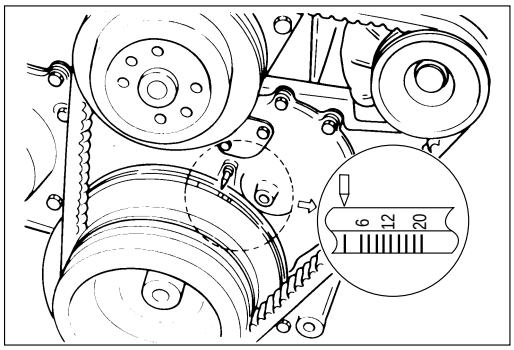
INJECTION TIMING

Note:

Take care to avoid entry of dust or foreign particles into the pump interior when the timing adjustment is made.

FLANGE MOUNTED INJECTION PUMP INJECTION TIMING CHECKING AND ADJUSTMENT

The flange mounted injection pump is installed behind the timing gear case.



Checking Procedure

1. Align the crankshaft pulley TDC mark with the pointer.

   Remove the inspection hole cover at the front of the injection pump on the timing gear case cover.

   Check the alignment between the pointer ④ on the injection pump gear nut lock plate and the projection area mark ③ on the injection pump gear case.

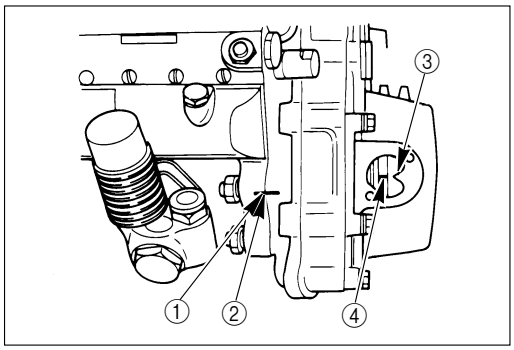
   If it is in misalignment, recheck with turning the crankshaft pulley one more turn to repeat the aforegoing procedure to mark sure that it is in alignment.

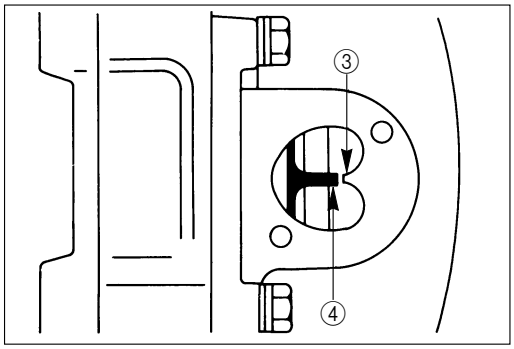
   Check the alignment of the notched lines ① and ②.

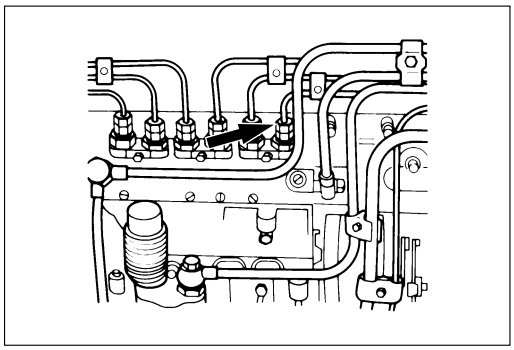
   (These notched lines were aligned at the factory to set the injection pump body and the mounting flange.)

   Next, inspect the crankangle position of the injection starting.

2. Reversely turn the crankshaft pulley counterclockwise about 30° crankangle.

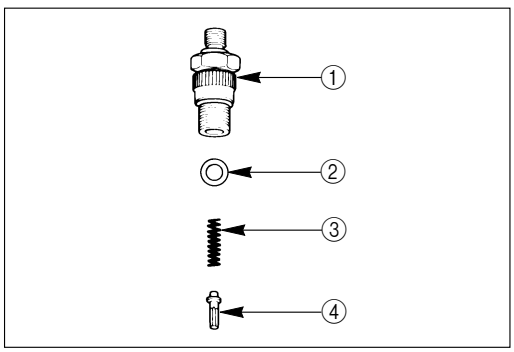






3. Disconnect the injection pipe from the No. 1 plunger.

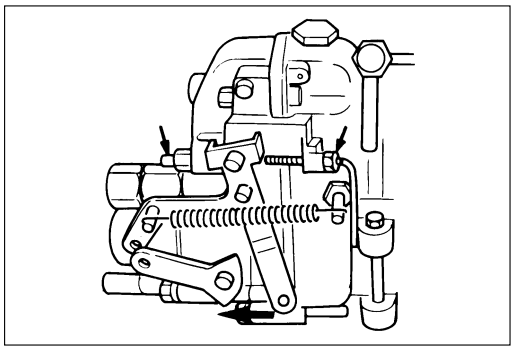
   This will allow you to visually check the full injection starting flow at No. 1 plunger.



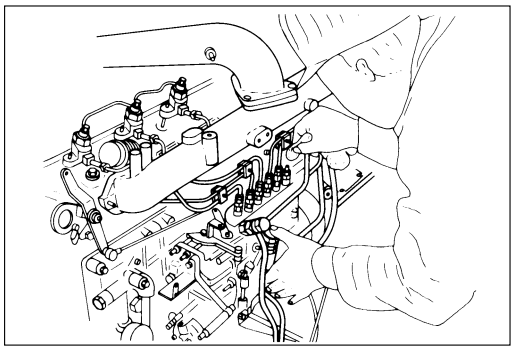
4. Remove the delivery valve holder ①, the valve seat ②, valve spring ③ the delivery valve ④ from the No. 1 plunger.
5. Reinstall the delivery holder ① and tighten it to the specified torque.

   Do not reinstall the delivery valve spring, the valve seat and the delivery valve.

   These parts will be reinstalled later.



6. Hold the fuel control lever at the fully open position.



7. Slowly turn the crankshaft pulley clockwise, at the same time, continue to feed the fuel with pumping the priming pump.

   When the fuel stop to flow out from the No. 1 delivery valve holder, stop the pump instantaneously.

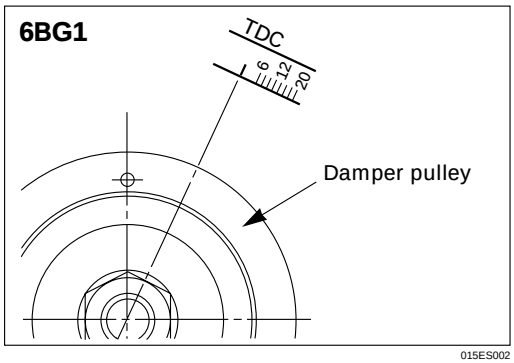
   This crankangle position is the injection starting of the engine.

8. Observe and make sure that mark (injection starting angle line a°) on the crankshaft pulley is aligning with the pointer.

   The timing line shows the injection starting angle of the engine.

   Blow out the remaining fuel from the delivery valve holder.

   Make sure that there is no fuel being delivered from the priming pump.



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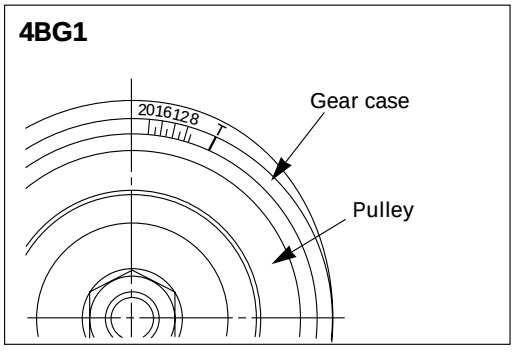


Note

6BG1 engine has eight timing notch lines punched on the crankshaft damper pulley. 4BG1 engine has eight timing notch lines punched on gear case side, and TDC mark on crank pulley.

These notched lines must be aligned for correct engine timing.

Refer to the illustration.

Degree

	6BG1
Injection Timing B.T.D.C	8

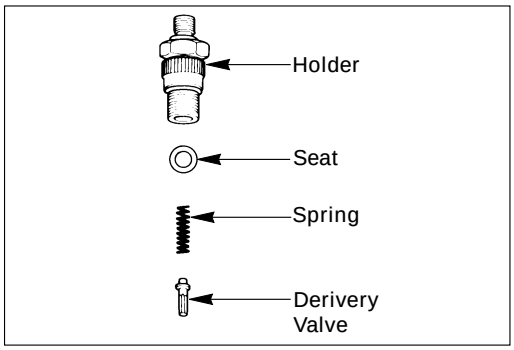
Degree

	4BG1
Injection Timing B.T.D.C	9

Note:

Injection pump injection timing will vary among identical engines contact your machine supplier or nearest ISUZU engine service outlet for the specifications applicable to your engine.

These specifications have been set by ISUZU and the OEM manufacturer.



9. Remove the delivery valve holder from the No. 1 plunger.
10. Reinstall the delivery valve internal parts (seat, spring, and valve) to the delivery valve holder.
11. Reinstall the delivery valve holder assembly to the No. 1 plunger and tighten it to the specified torque.

N·m (kgf·m/ft.lb)

Delivery Valve Holder Torque	39–44 (4–4.5/29–33)

12. Install the No. 1 cylinder injection pipe and tighten it to the specified torque.

N·m (kgf·m/ft.lb)

Injection Pipe Nut Torque	28–32 (2.9–3.3/21–24)

Note:

DO NOT OVERTIGHTEN THE INJECTION PUMP BODY.

THE INJECTION PUMP BODY IS MADE OF ALUMINUM. OVERTIGHTENING WILL DISTORT THE INJECTION PUMP BODY SHAPE AND ADVERSELY AFFECT CONTROL RACK OPERATION.

Adjusting Procedure

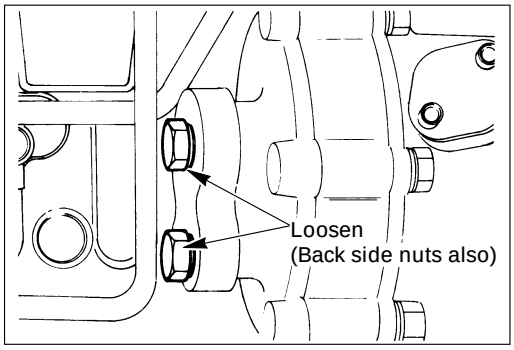
1. Align the pointer and the specified timing mark on the crank pulley.
2. Perform the operations described on page 2-10, 11, paragraphs 3, 4, 5, 6.
3. Loosen the four injection pump fixing nut.
4. To advance the timing

   Pivot the injection pump at the pump driveshaft toward out.

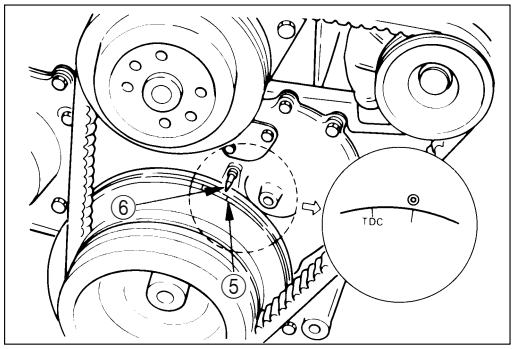
   To retard the timing.

   Pivot the injection pump at the pump driveshaft toward in. (toward the cylinder block)

   Reference; the 1 mm misalignment between the two setting mark lines corresponds to about 2° in crankangle.



5. Do a fine injection pump position adjustment, while continue the pumping operation to feed the fuel, and stop to pivot the injection pump when the fuel stop to flow out from the No. 1 delivery valve holder.
6. Tighten the four injection pump fixing nuts.
7. Once remove the No. 1 delivery valve holder, and reinstall the delivery valve, spring and the valve holder with the specified torque.
8. Install the No. 1 injection pipe and tighten it to the specified torque.



COUPLING DRIVEN INJECTION PUMP TIMING ADJUSTMENT

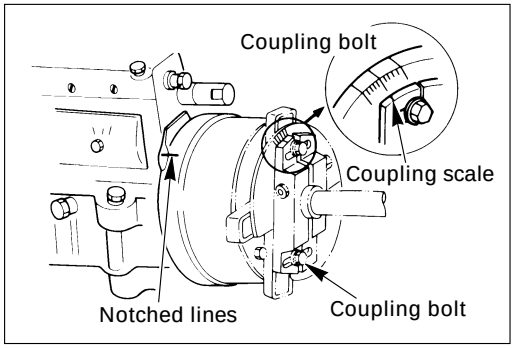
The coupling driven injection pump is installed at the middle of the cylinder body. It is driven by the injection pump drive shaft.

1. Injection timing is initially adjusted by aligning the notched line 5 on the crankshaft damper pulley with the pointer 6.

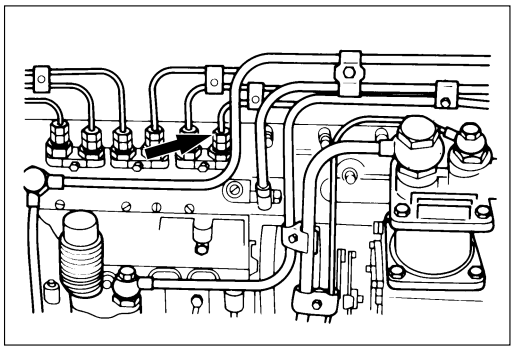
   Fine adjustment is made by rotating the injection pump drive coupling.

   Rotating the injection pump drive coupling counterclockwise will advance the injection timing.

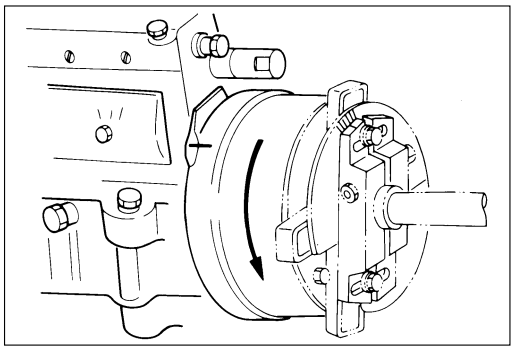
   Rotating the injection pump drive coupling clockwise will retard the injection timing.



2. Loosen the two coupling bolts on the injection pump drive coupling.



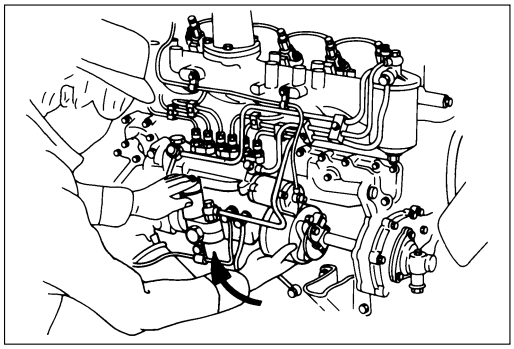
3. Perform the operations described on page 2-10, 11 paragraphs 3, 4, 5, 6.



4. Slowly turn the coupling counterclockwise (viewed from the timing gear case).

   At the same time, operate the priming pump to feed fuel to the No. 1 injection pump plunger.

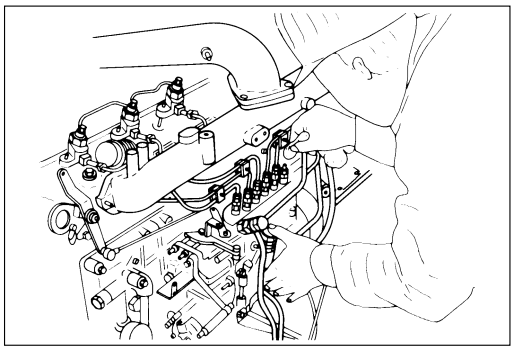
   Visually check that fuel is being fed (from the top of the delivery valve holder).



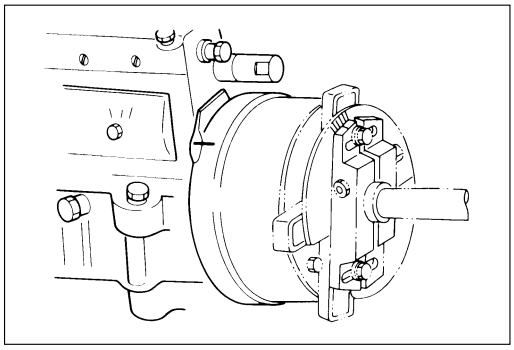
5. Continue to operate the priming pump.

   Turn the coupling counterclockwise until the fuel stops flowing from the delivery valve holder.

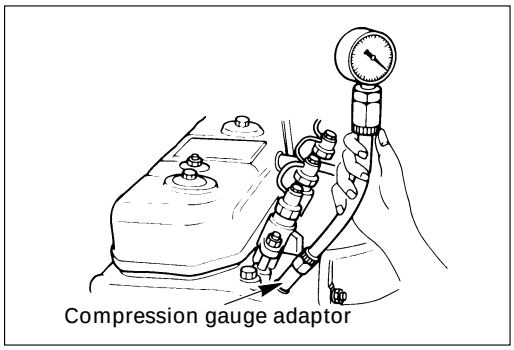
   This is the fuel injection starting point at the No. 1 plunger.



6. Blow out the remaining fuel from the delivery valve holder.
7. Check that there is no fuel being delivered from the priming pump.



8. Retighten two coupling bolts.
9. Perform the operations described on page 2-12 paragraphs 9, 10, 11, 12.



COMPRESSION PRESSURE MEASUREMENT

1. Operate the engine to warm-up until the coolant temperature reaches to 75°C (167°F).
2. Remove all of the glow plugs and the injection pipes.
3. Attach a compression gauge to the No. 1 cylinder glow plug installation threads.

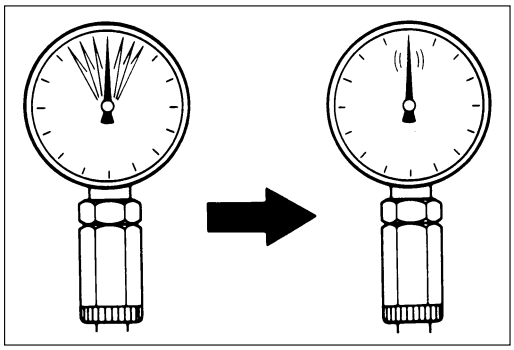
Note:

Compression pressure may be measured starting at any cylinder and in no particular cylinder order. However, it is very important that the compression pressure be measured in each cylinder.

Therefore, start at the No.1 cylinder and work back. In this way, you will be sure to measure the compression pressure in each cylinder.

Compression Gauge:

Compression Gauge Adapter: 5-85317-001-0 (JKM-1015)



4. Crank the engine with the starter motor and take the compression gauge reading.

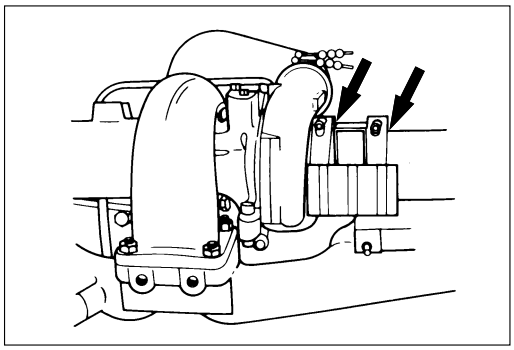
MPa (kgf/cm^2/psi) at 200 min^{-1} at sea level

Standard	Limit
3.0 (31/440)	2.5 (26/370)

5. Repeat the procedure (Steps 2 and 3) for the remaining cylinders.

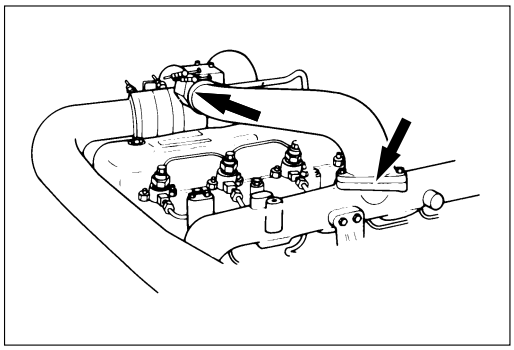
   Compression pressure should be approximately the same for each cylinder. A variation exceeding 200 kPa (2 kgf/cm^2/28 psi) is unacceptable.

   If the measured value exceeds the specified limit, the related parts must be checked.

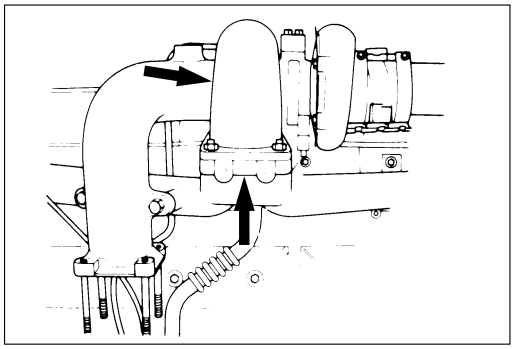


TURBOCHARGER INSPECTION

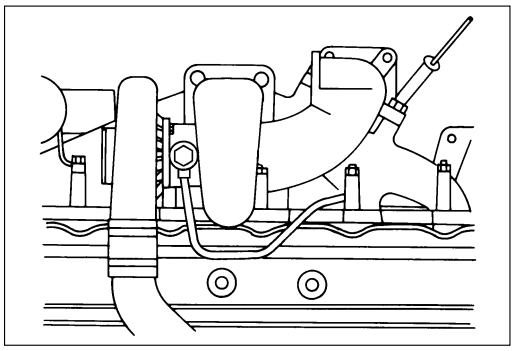
1. Check the air intake duct connections for air leakage.



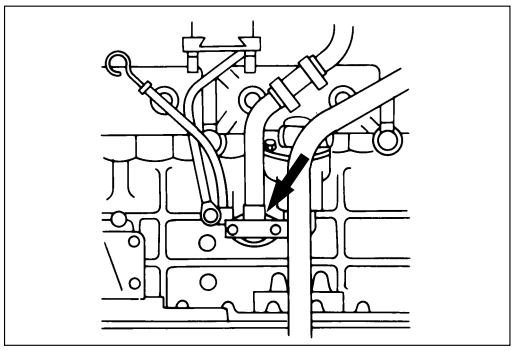
2. Check the air duct connections for air leakage.



3. Check the exhaust duct connections for smoke leakage.
4. Check the turbocharger mounting nuts for looseness.

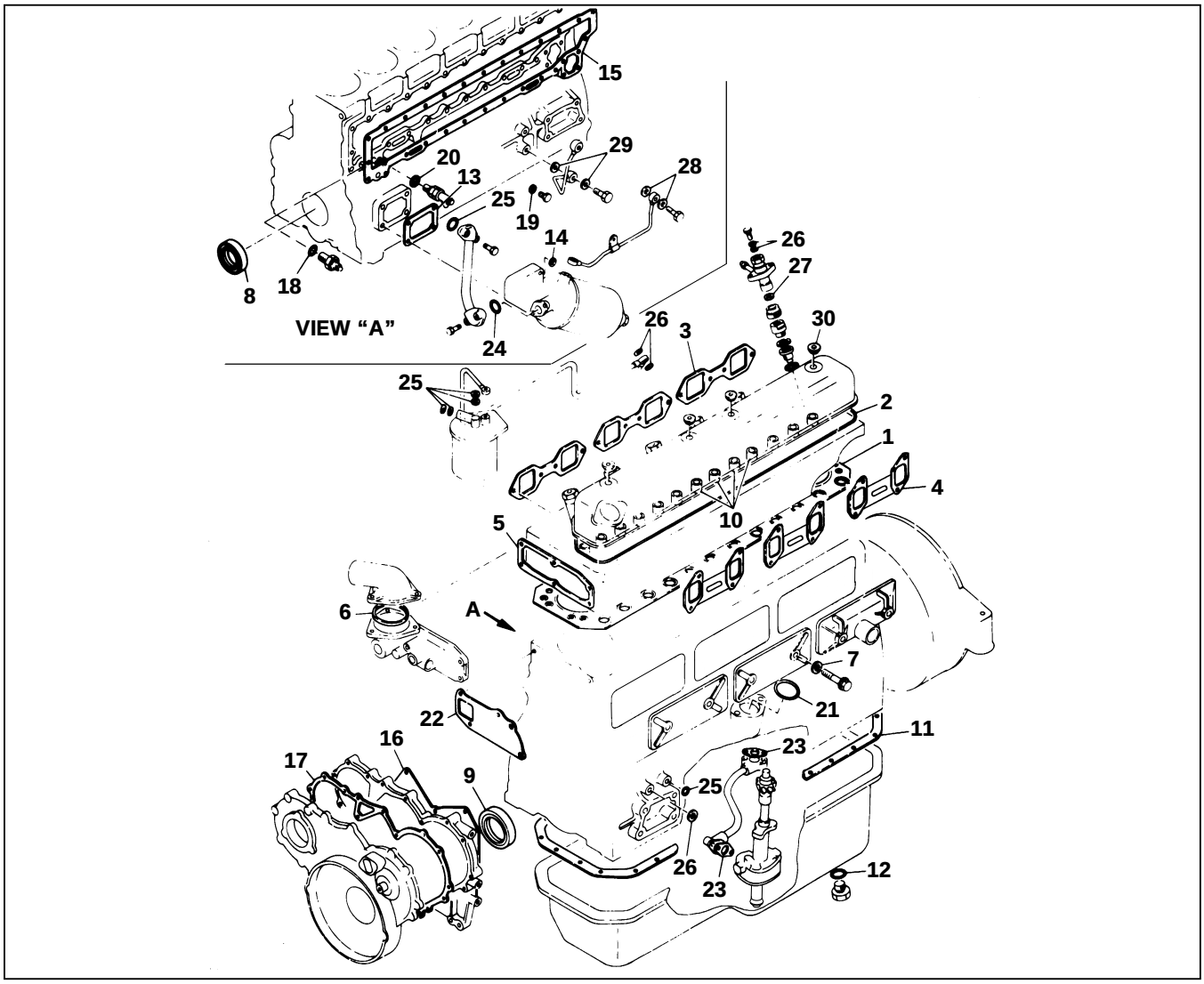


5. Check the oil feed pipe for oil leakage.



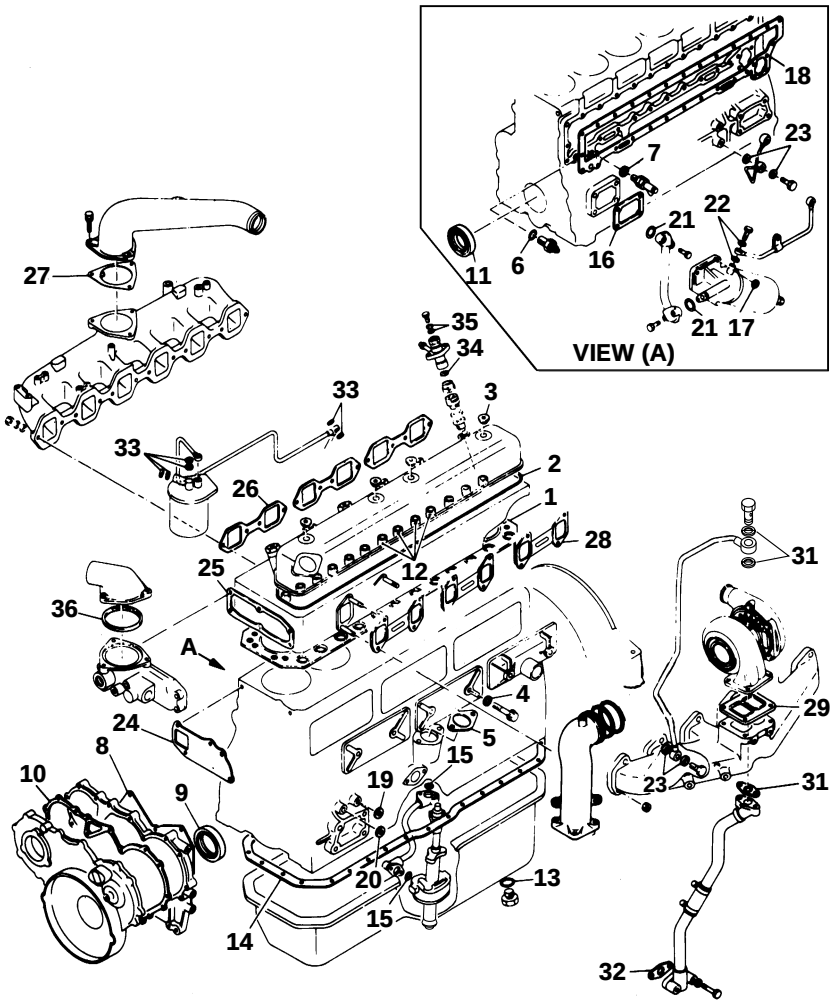
6. Check the oil return pipe joints for oil leakage.

ENGINE REPAIR KIT (FOR NATURALLY ASPIRATED ENGINES)



1. Cylinder head gasket
2. Cylinder head cover gasket
3. Inlet manifold gasket
4. Exhaust manifold gasket
5. Thermostat housing gasket
6. Thermostat gasket
7. Tappet cover fixing bolt gasket
8. Crankshaft rear end oil seal
9. Timing gear case oil seal
10. Valve guide oil seal
11. Oil pan gasket
12. Drain plug gasket
13. Oil filter cover gasket
14. Oil filter fixing bolt gasket
15. Oil cooler gasket
16. Gear case to cylinder block gasket
17. Cover to timing gear case gasket
18. Relief valve O-ring
19. Cylinder block side plug gasket
20. Water drain valve gasket
21. Oil pump hole cover gasket
22. Water pump gasket
23. Oil pipe gasket
24. Oil pipe gasket
25. Fuel pipe joint bolt gasket
26. Leak off pipe joint bolt gasket
27. Injection nozzle gasket
28. Injection pump oil pipe gasket
29. Injection pump oil pipe gasket
30. Cylinder head cover nut gasket

ENGINE REPAIR KIT (FOR TURBOCHARGED ENGINES)

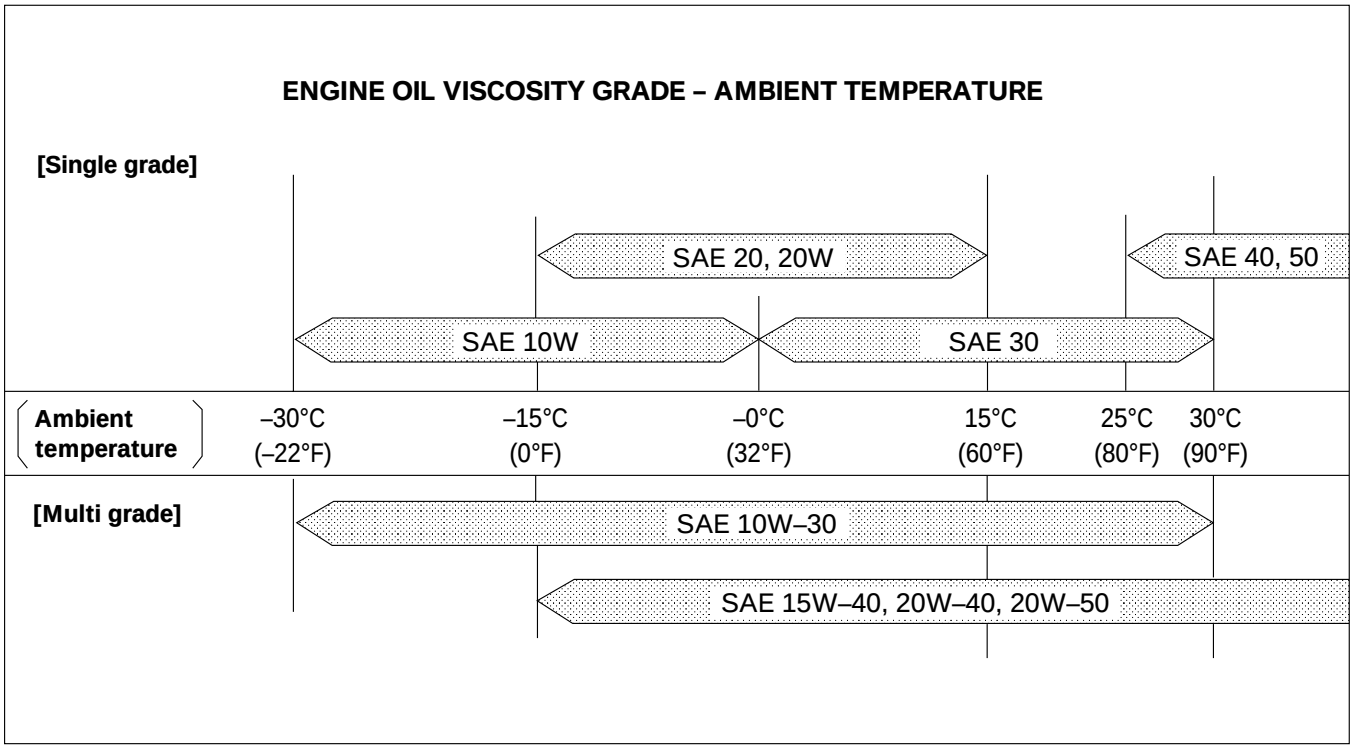


1. Cylinder head gasket
2. Cylinder head cover gasket
3. Cylinder head cover nut gasket
4. Chamber cover fixing bolt gasket
5. Oil pump hole cover gasket
6. Oil relief valve gasket
7. Water drain valve gasket
8. Gear case to cylinder block gasket
9. Crank pulley to gear case oil seal
10. Gear case cover gasket
11. Crankshaft rear end oil seal
12. Valve guide oil seal
13. Drain plug gasket
14. Oil pan gasket
15. Oil pipe gasket
16. Oil filter gasket
17. Oil filter fixing bolt gasket
18. Oil cooler gasket
19. Oil pipe joint gasket
20. Joint bolt gasket
21. Oil pipe gasket
22. Injection pump oil pipe gasket
23. Injection pump oil pipe gasket
24. Water pump gasket
25. Thermostat housing gasket
26. Intake manifold gasket
27. Inlet pipe manifold gasket
28. Exhaust manifold gasket
29. Exhaust manifold to turbocharger gasket
30. Oil feed pipe gasket
31. Oil drain pipe gasket
32. Oil drain pipe gasket
33. Overflow fuel pipe gasket
34. Injection nozzle gasket
35. Injection nozzle leak off pipe gasket
36. Thermostat gasket

RECOMMENDED LUBRICANTS

ENGINE TYPE	TYPES OF LUBRICANTS (API)
Without turbocharger & With turbocharger	Diesel engine oil CD grade

ENGINE OIL VISCOSITY CHART



MEMO

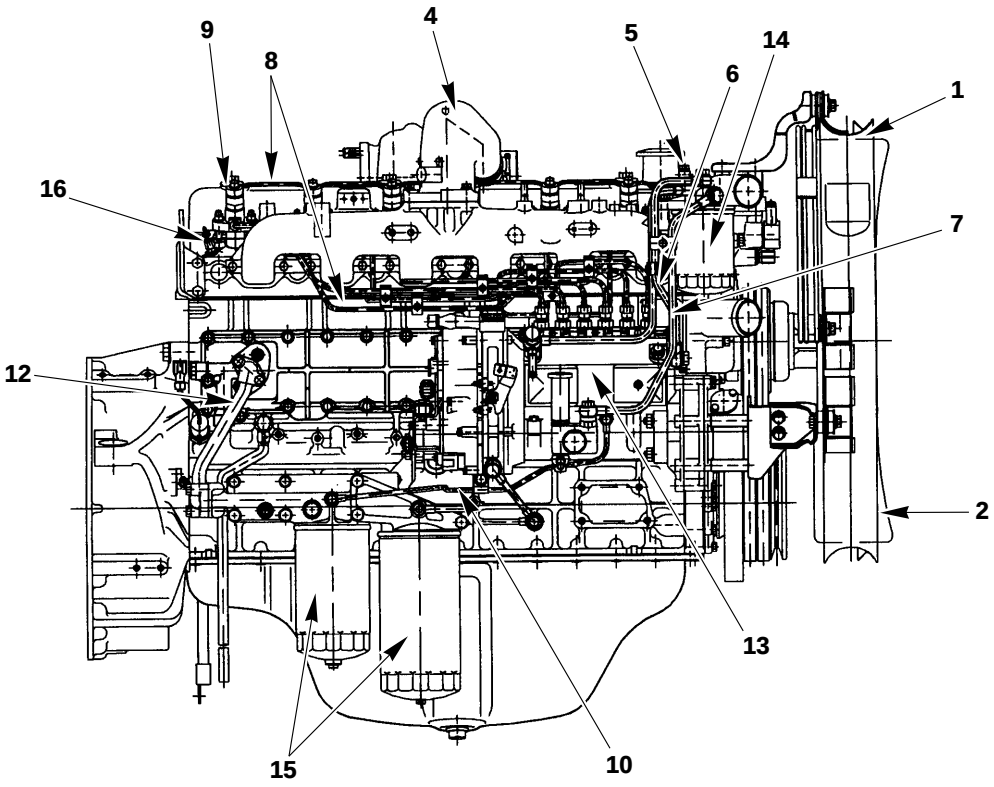
SECTION 3

ENGINE ASSEMBLY I (DISASSEMBLY)

TABLE OF CONTENTS

EXTERNAL PARTS DISASSEMBLY STEPS
(Right-hand side)

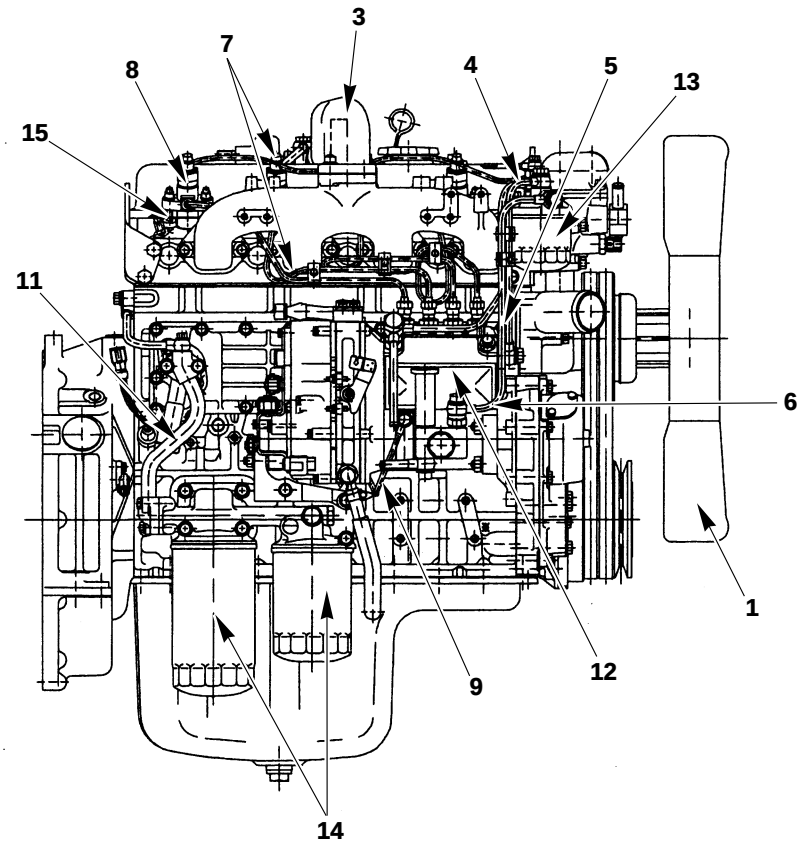
MODEL BB-6BG1T



Disassembly Steps

1. Fan guide
2. Cooling fan
3. Not installed
4. Intake pipe
5. Fuel return pipe
6. Fuel pipe; fuel filter to injection pump
7. Fuel pipe; feed pump to filter
8. Injection pipe and leak off pipe
9. Injection nozzle
10. Oil pipe; injection pump to cylinder body
11. Not installed
12. Oil pipe; filter to oil cooler
- ▲ 13. Injection pump with injection pump gear
14. Fuel filter
15. Oil filter
16. Glow plug

MODEL BB-4BG1T



Disassembly Steps

1. Cooling fan
2. Not installed
3. Intake pipe
4. Fuel return pipe
5. Fuel pipe; fuel filter to injection pump
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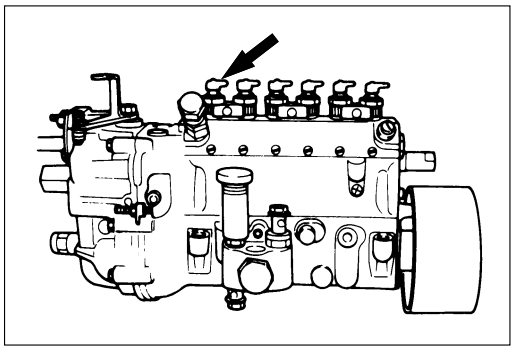
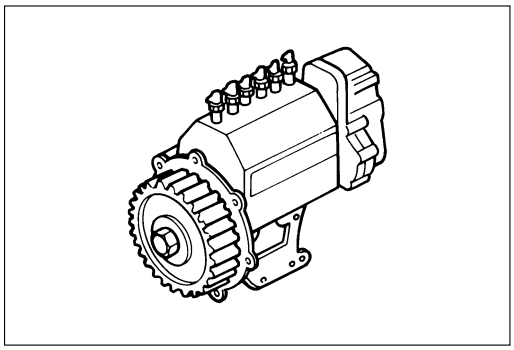
9. Oil pipe; injection pump to cylinder body
10. Not installed
11. Oil pipe; filter to oil cooler
- ▲ 12. Injection pump with injection pump gear
13. Fuel filter
14. Oil filter
15. Glow plug





Important Operations

12. Injection Pump with Injection Pump Gear

Use the shipping plugs (or something similar) to seal the injection pump delivery valve ports. This will prevent the entry of foreign material.

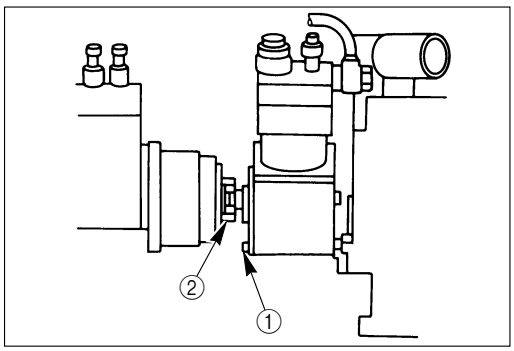
Flange Mounted Injection Pump Removal

1) Remove the injection pump flange bolts.
2) Pull the injection pump with the injection pump drive gear free.

Refer to the illustration.

Coupling Mounted Injection Pump Removal

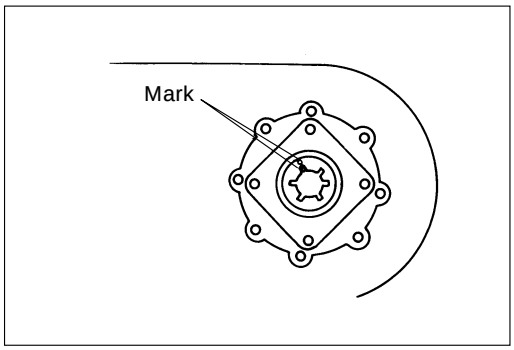
1) Remove the two coupling bolts to disconnect the coupling.
2) Remove the injection pump mounting bolts.
3) Remove either the injection pump bracket bolts or the injection pump fixing bolts.



Remove of the Air Compressor (if so equipped)

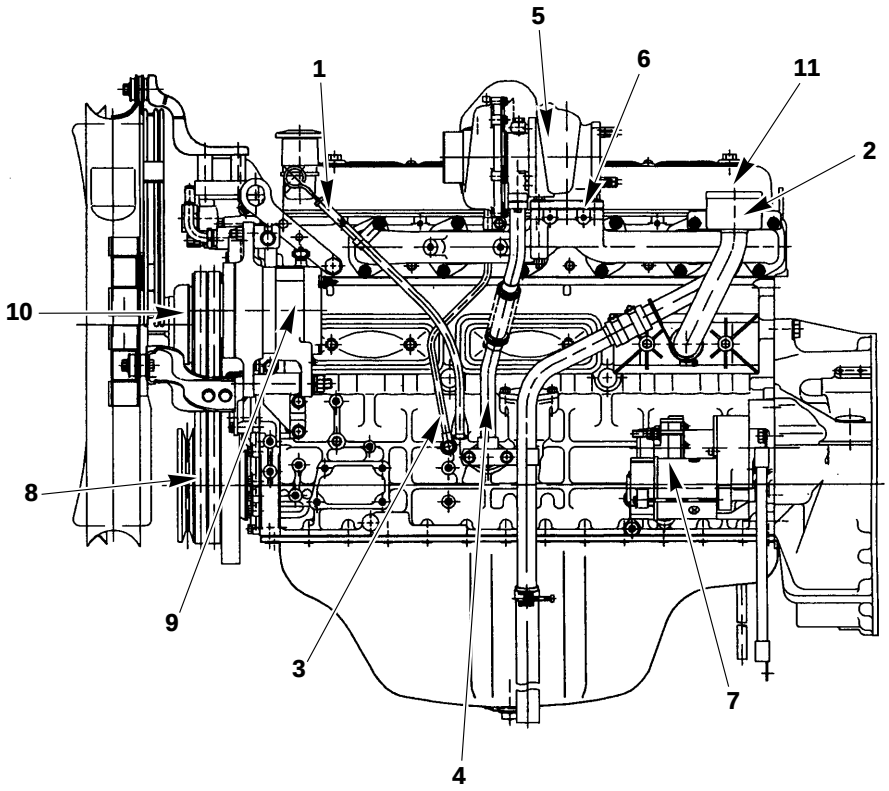
Before the air compressor is removed the injection pump must be unfastened from the mounting bracket to permit the pump to be moved freely on the mounting bracket.

1. Remove the injection pump coupling bolts ②.
2. Remove the injection pump mounting bolts and shift the pump to the rear about 50 mm (2 in).
3. Remove the air compressor mounting bolts ①.
4. Pull out the compressor to the rear about 50 mm (2 in) to pull out the air compressor crankshaft front end spline from the injection pump drive gear.
5. After removal, visually make sure that the crankshaft end spline and the female spline of the injection pump drive gear shaft have fitting marks. Those marks are important for reassembly.



EXTERNAL PARTS DISASSEMBLY STEPS
(Left-hand side)

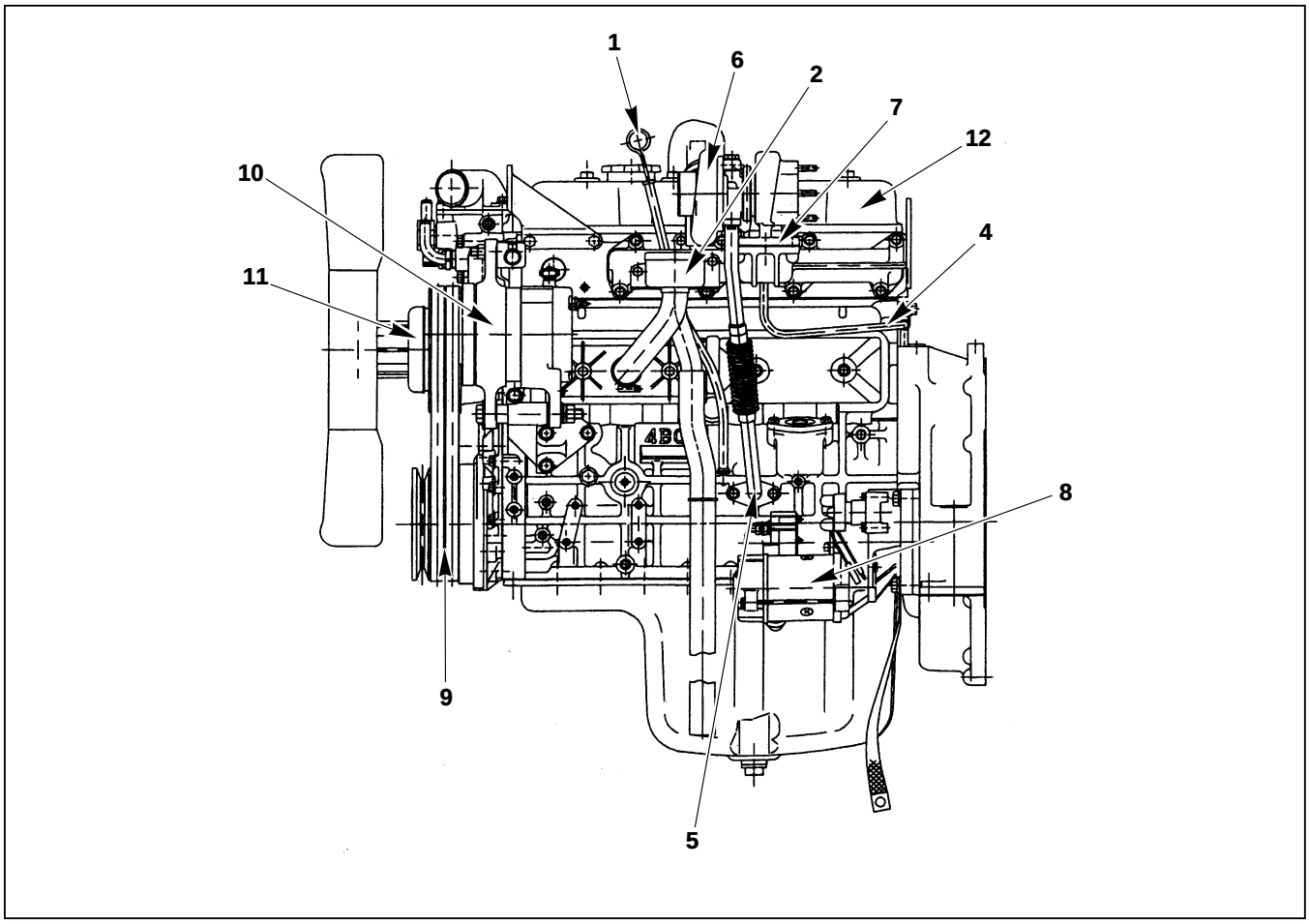
MODEL BB-6BG1T



Disassembly Steps

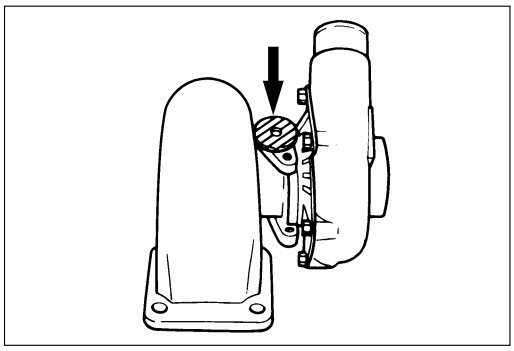
1. Dipstick and guide tube
2. Air breather
3. Oil feed pipe
4. Oil drain pipe
▲ 5. Turbocharger
6. Gasket
7. Starter
8. Fan belt
9. Alternator
10. Fan pulley
11. Cylinder head cover

MODEL BB-4BG1T



Disassembly Steps

1. Dipstick and guide tube
2. Air breather
3. (Not installed)
4. Oil feed pipe
5. Oil drain pipe
▲ 6. Turbocharger
7. Gasket
8. Starter
9. Fan belt
10. Alternator
11. Fan pulley
12. Cylinder head cover

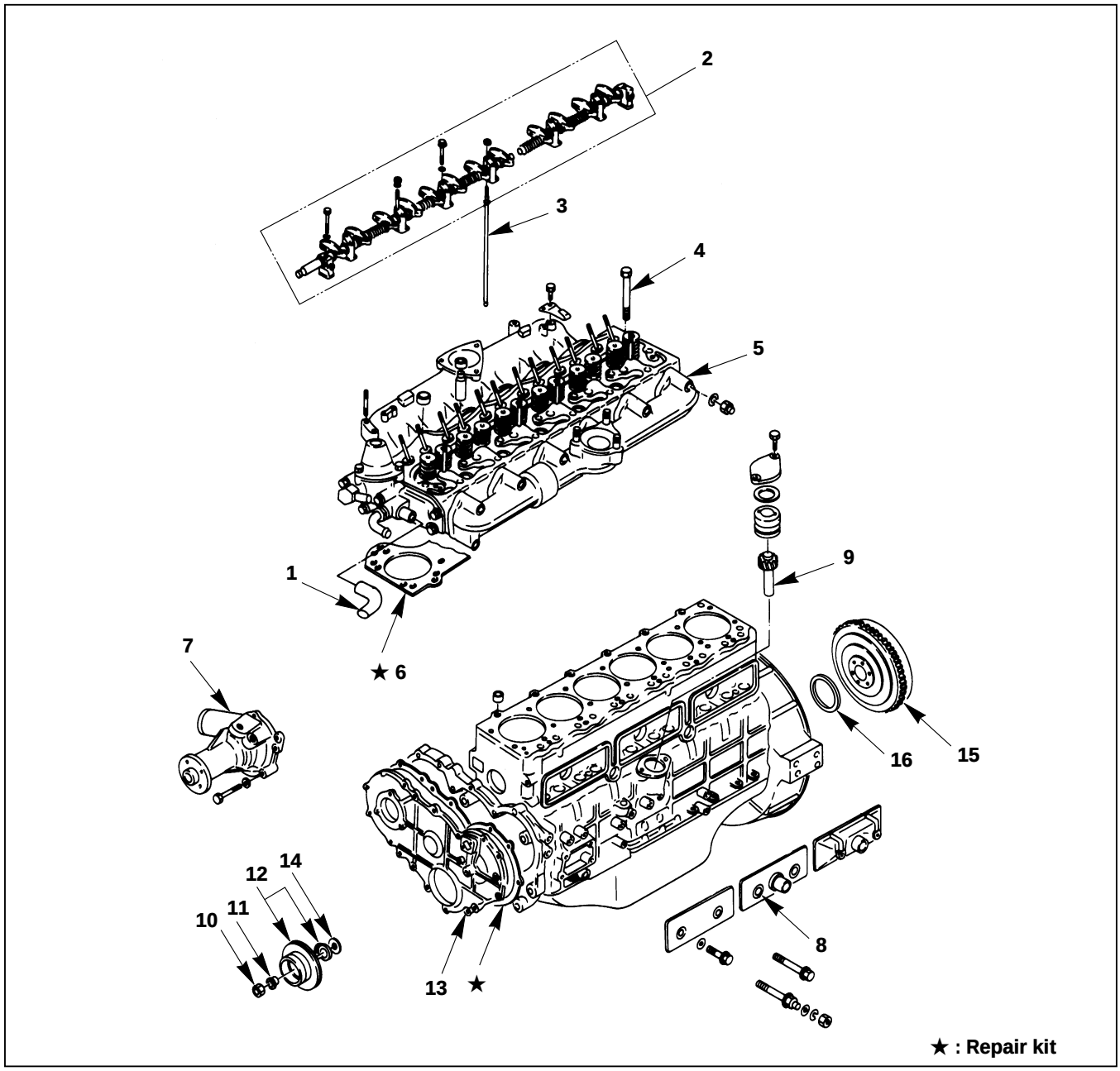


Important Operations

6. Turbocharger

Plug oil ports in turbocharger body immediately after removal of the turbocharger.

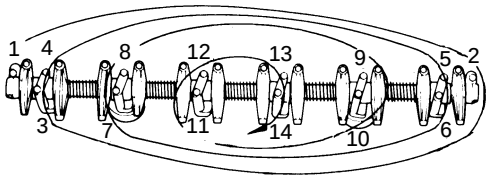
MAJOR COMPONENTS - I



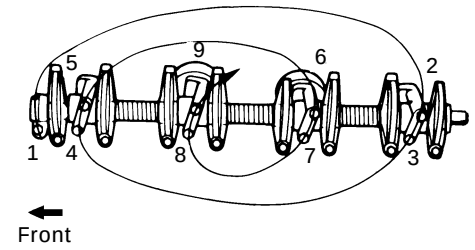
Disassembly Steps

1. Rubber hose ; water by-pass
▲ 2. Rocker arm shaft assembly
3. Push rod
▲ 4. Cylinder head bolt
5. Cylinder head assembly
6. Cylinder head gasket
7. Water pump assembly
8. Tappet chamber cover
9. Oil pump driving pinion
▲ 10. Starting handle nut
▲ 11. Taper bushing
12. Crankshaft pulley and dust thrower
13. Timing gear cover
14. Oil thrower
▲ 15. Flywheel
▲ 16. Rear oil seal

6B series



4B series

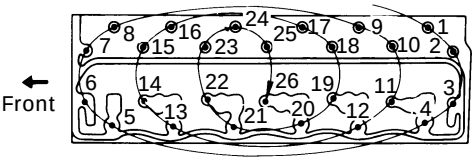


Important Operations

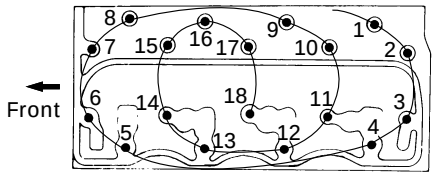
2. Rocker Arm Shaft

Loosen the rocker arm shaft fixing bolts a little at a time in numerical sequence as specified.

6B series



4B series

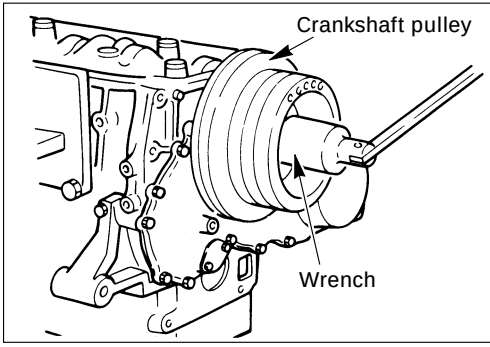


4. Cylinder Head Bolts

Loosen the cylinder head bolts a little at a time in the numerical order shown in the illustration.

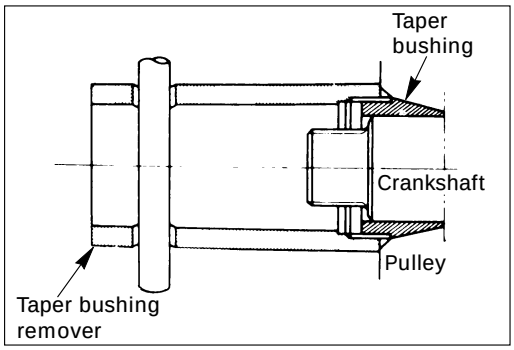
Cylinder head bolt wrench: 1-85111-003-0

10. Crankshaft Pulley Nut



Wrench: 54 mm (2.13 in) for 6B series
Wrench: 42 mm (1.65 in) for 4B series

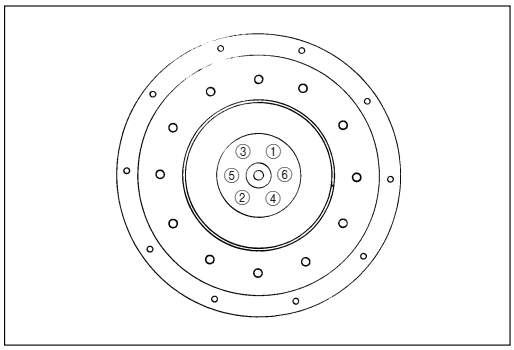
Use an appropriate wrench to remove the crankshaft pulley nut.



11. Taper Bushing (6B series only)

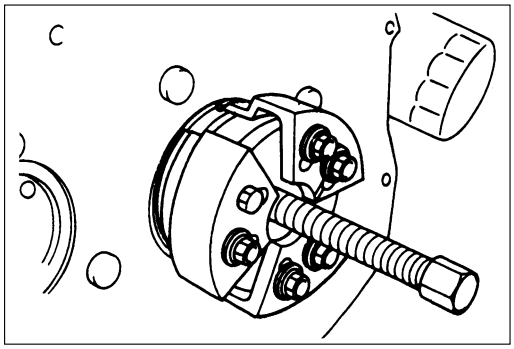
Remover: 9-8521-0122-0

Use the taper bushing remover to remove the crankshaft end taper bushing.



15. Flywheel

Loosen the flywheel bolt a little at a time in the numerical order as specified.

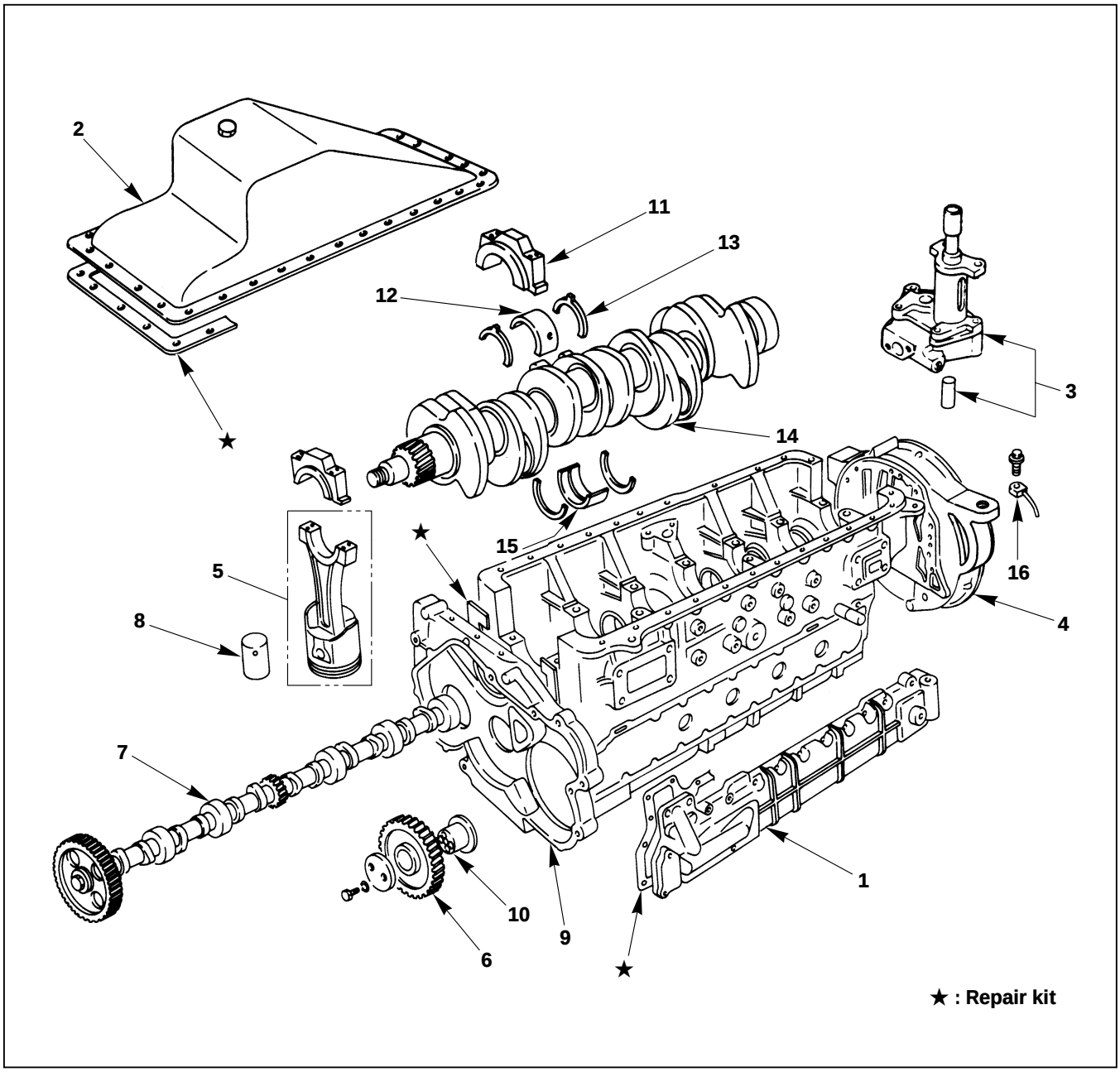


16. Crankshaft Rear Oil Seal (Axial Type)

With the oil seal pushed in deep, install the special tool as shown in the illustration and remove the oil seal.

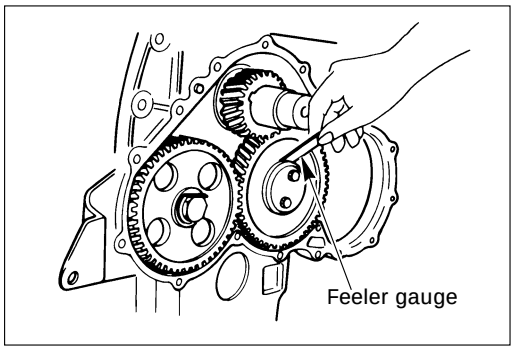
Oil Seal Remover: 5-8840-2360-0

MAJOR COMPONENTS - II



Disassembly Steps

1. Oil cooler
2. Oil pan
3. Oil pump and coupling
4. Flywheel housing
5. Piston and connecting rod
▲ 6. Idler gear
▲ 7. Camshaft
8. Tappet
9. Timing gear case
10. Idler gear shaft
▲ 11. Crankshaft bearing cap
12. Crankshaft bearing (lower half)
13. Thrust bearing
14. Crankshaft
15. Crankshaft bearing (upper half)
16. Oiling jet



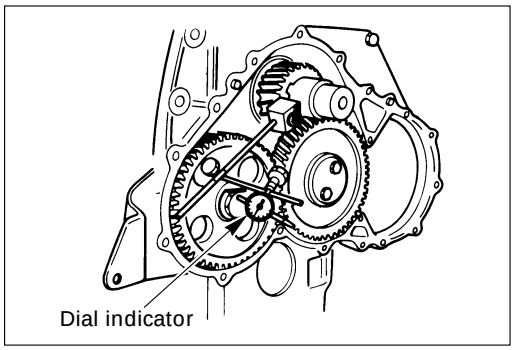
Important Operations

6. Idler Gear

Measure the following points before disassembly.

mm (in)

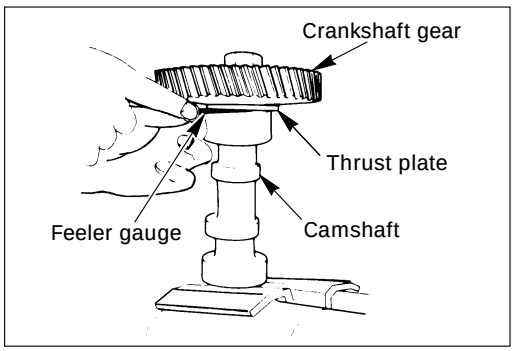
	Standard	Limit
Idler Gear End Play	0.128–0.185 (0.005–0.0070)	0.2 (0.008)



mm (in)

	Standard	Limit
Timing Gears Backlash	0.10–0.17 (0.004–0.007)	0.3 (0.012)

Includes the crankshaft gear, the camshaft gear, and the idler gear.

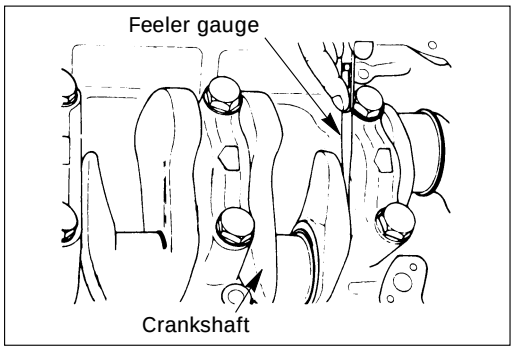


7 Camshaft

Measure the following points before disassembly.

mm (in)

	Standard	Limit
Cam Gear End Play	0.050–0.114 (0.002–0.005)	0.2 (0.008)



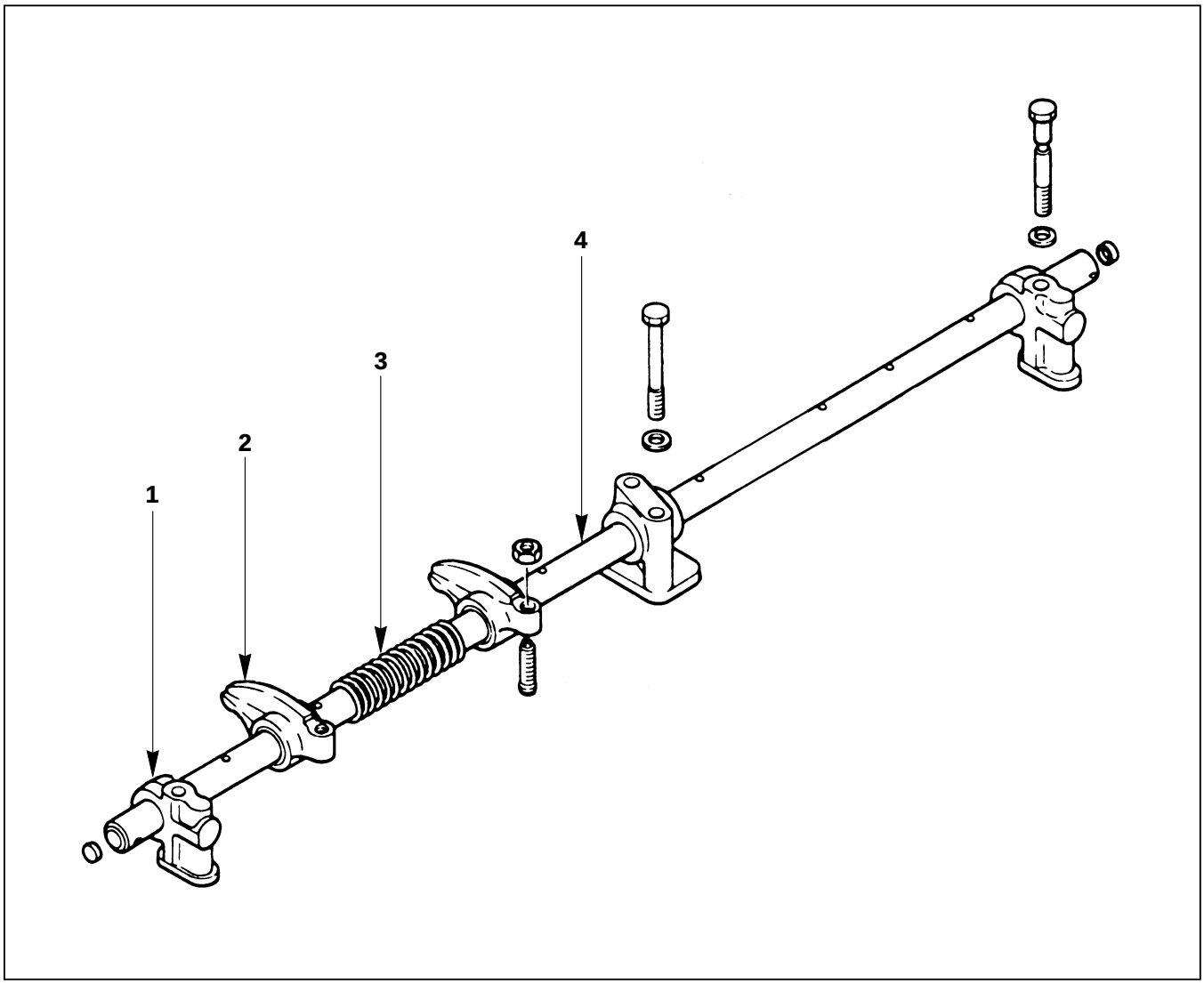
11. Crankshaft Bearing Cap

Measure the crankshaft end play at the thrust bearing (center main bearing) before disassembly.

mm (in)

	Standard	Limit
Crankshaft End Play	0.15–0.33 (0.006–0.013)	0.4 (0.016)

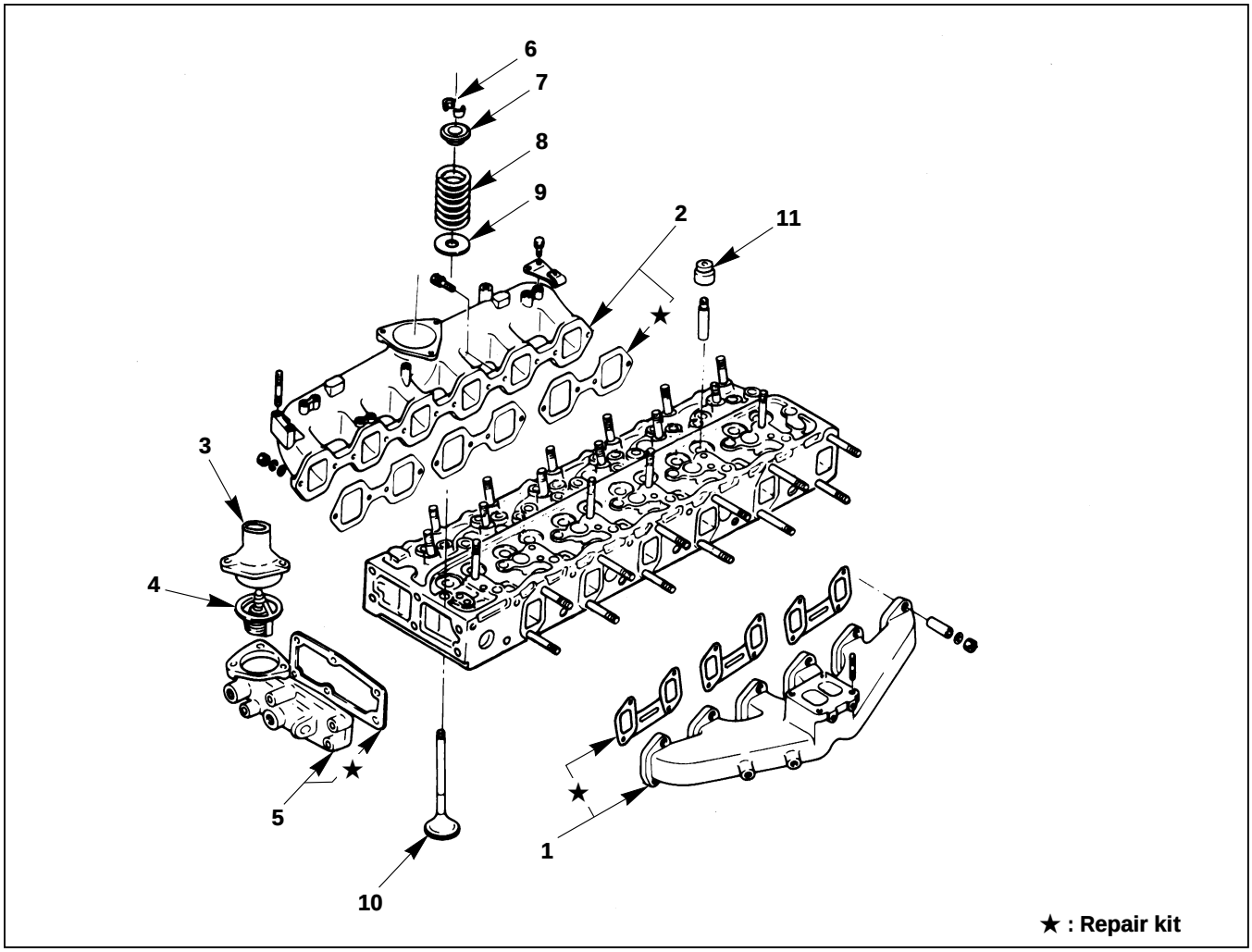
ROCKER ARM, AND ROCKER ARM SHAFT DISASSEMBLY STEPS



Disassembly Steps

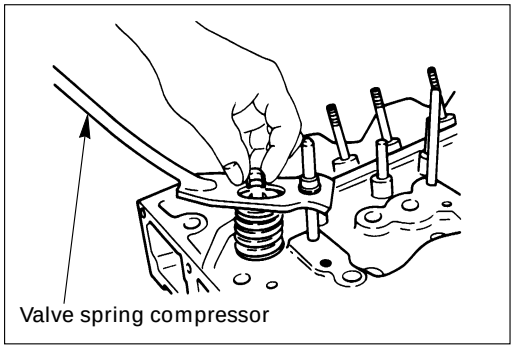
1. Bracket
2. Rocker arm
3. Spring
4. Rocker arm shaft

CYLINDER HEAD DISASSEMBLY STEPS



Disassembly Steps

1. Exhaust manifold and gasket
2. Intake manifold and gasket
3. Water outlet pipe
4. Thermostat
5. Thermostat housing and gasket
▲ 6. Split collar
7. Spring seat (upper) or *Valve rotator (if so equipped)
8. Valve spring
9. Spring seat (lower)
10. Valve
11. Valve stem oil seal



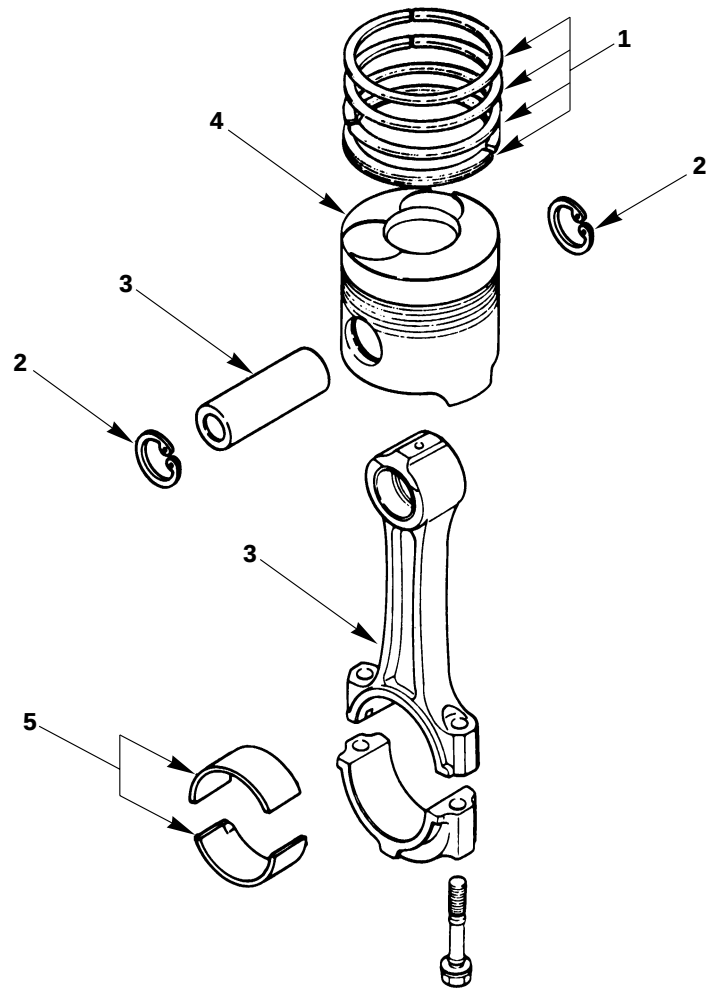
Important Operation

6. Split collar

Use the valve spring compressor to remove the split collar.

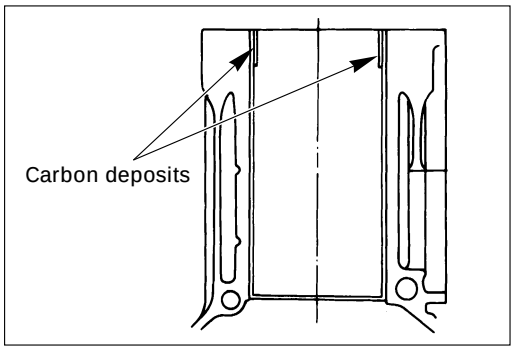
Valve Spring Compressor: 1-85235-006-0

PISTON AND CONNECTING ROD DISASSEMBLY STEPS



Disassembly Steps

▲ 1. Piston rings
▲ 2. Snap ring
▲ 3. Piston pin and connecting rod
4. Piston
5. Connecting rod bearing

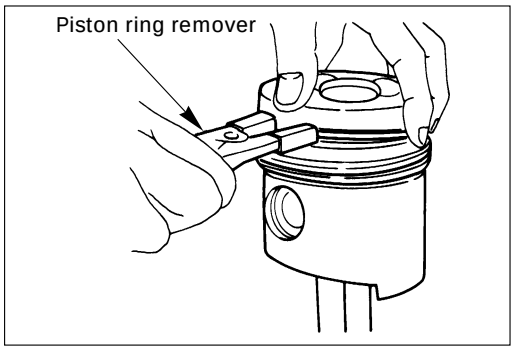


Important Operation

Note:

Remove any carbon deposits from the upper part of the cylinder bore.

This will prevent damage to the piston and the piston rings when they are removed from the cylinder bore.

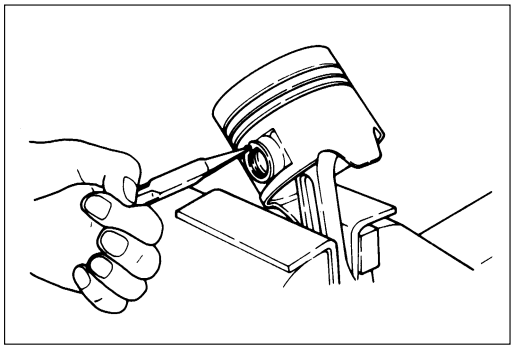


1. Piston Rings

Use a piston ring remover to remove the piston rings.

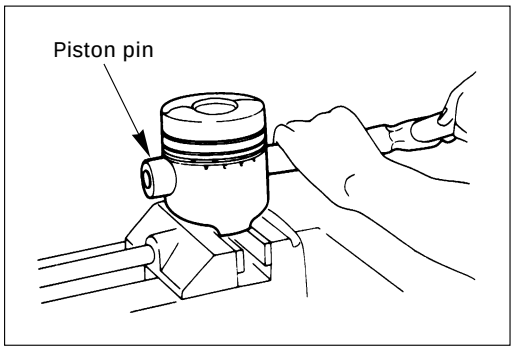
Do not attempt to use some other tool. Piston ring stretching will result in reduced piston ring tension.

Piston ring remover:



2, 3. Snap Ring and Piston Pin

(1) Use a pair of snap ring pliers to remove the snap ring.



(2) Tap the piston pin out with a hammer and brass bar.

MEMO

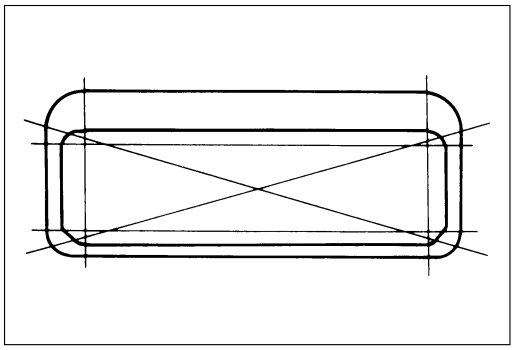
SECTION 4

ENGINE ASSEMBLY II (INSPECTION & REPAIR)

TABLE OF CONTENTS

INSPECTION AND REPAIR

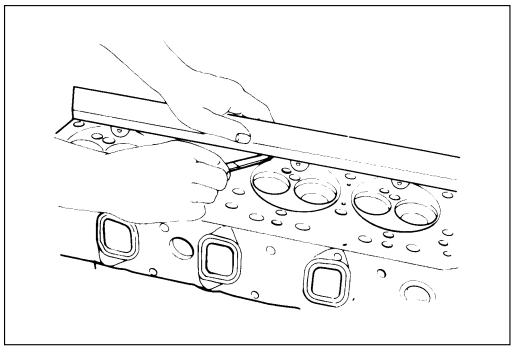
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



CYLINDER HEAD

Cylinder Head Lower Face Warpage

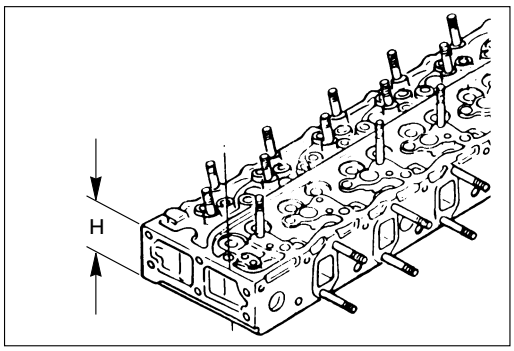
1. Use a straight edge and a feeler gauge to measure the four sides and the two diagonals of the cylinder head lower face.
2. Regrind the cylinder head lower face if the measured values are greater than the specified limit but less than the maximum grinding allowance.



If the measured values exceed the maximum grinding allowance, the cylinder head must be replaced.

Cylinder Head Lower Face Warpage mm (in)

Standard	Limit	Maximum Grinding Allowance
0.075 (0.003) or less	0.2 (0.0079)	0.3 (0.012)

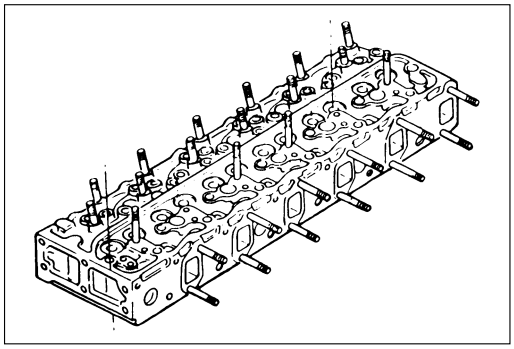


Cylinder Head Height (Reference) mm (in)

Standard	Limit
89.95 (3.541)–90.05 (3.545)	89.65 (3.530)

Note:

If the cylinder head lower face is reground, valve depression must be checked.

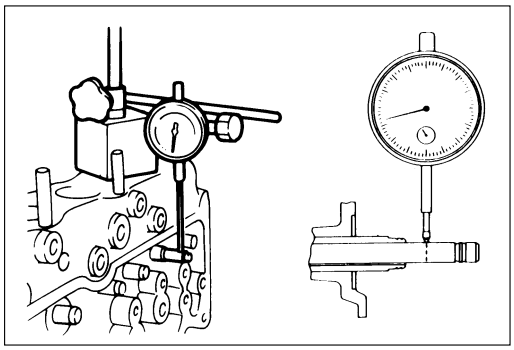


Water Jacket Water Pressure Test

Use the hydraulic gauge to check the water jacket water pressure.

Apply water pressure to the water jacket at 490 kPa (5 kgf/cm^2/71.1 psi) for three minutes.

Check the entire cylinder head for water leakage.



VALVE GUIDE

Valve Stem and Valve Guide Clearance

Measuring Method - 1

1. With the valve stem inserted in the valve guide, set the dial indicator needle to "0".
2. Move the valve head from side to side

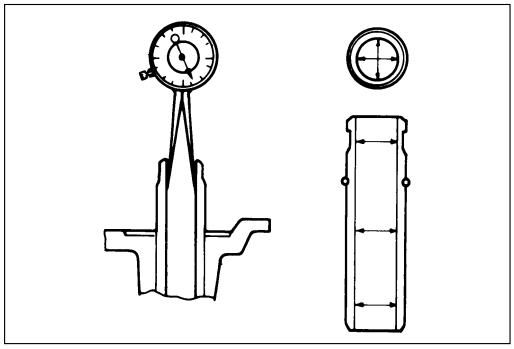
   Note the total dial indicator reading (TIR).

   This value is the clearance between the valve stem and the valve guide.

   If the measured values exceed the specified limit, the valve and the valve guide must be replaced as a set.

Valve Stem Clearance mm (in)

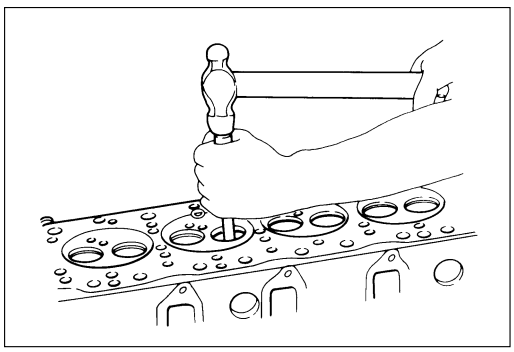
	Standard	Limit
Intake Side TIR	0.039-0.0071 (0.0015-0.0028)	0.20 (0.008)
Exhaust Side TIR	0.064-0.096 (0.0025-0.0038)	0.25 (0.0098)



Measuring Method - II

1. Measure the valve stem outside diameter.
2. Use a caliper calibrator or a telescoping gauge to measure the valve guide inside diameter.

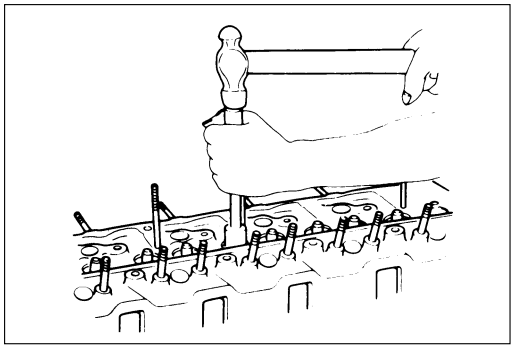
   The difference between the valve stem outside diameter and the valve guide inside diameter is equal to the valve stem clearance.



Valve Guide Replacement

Valve Guide Removal

Use a hammer and the valve guide remover to drive out the valve guide from the cylinder head lower face.
Valve Guide Remover: 9-85220-035-0



Installation

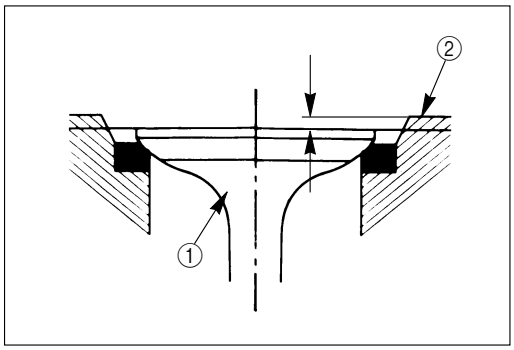
1. Apply clean engine oil the outer periphery of the valve guide.
2. Attach the installer to the valve guide.
3. Use a hammer to drive in the valve guide from the upper face of the head until the installer's lower edge meets the head surface.

   Valve guide installer: 1-85232-001-0

4. After installation, measure the distance (height) from the cylinder head's upper surface to the upper edge of the valve guide.

Height to valve guide upper edge mm (in)

14.1 (0.555)



Valve Depression

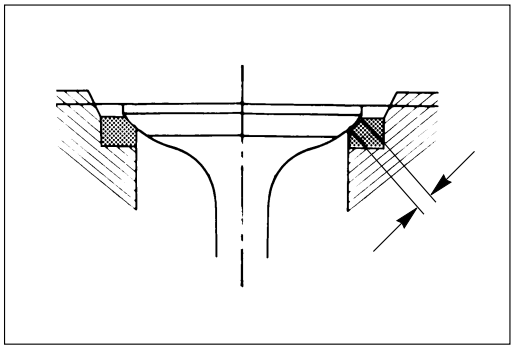
1. Install the valve ① to the cylinder head ②.
2. Use a depth gauge or a straight edge with steel rule to measure the valve depression from the cylinder head lower surface.

   If the measured value exceeds the specified limit, the valve seat insert and/or valve must be replaced.

   If the valve is replaced, the valve guide must be also replaced.

mm (in)

	Standard	Limit
Intake and Exhaust Valve Depression	1.0 (0.039)	2.5 (0.098)



Valve Contact Width

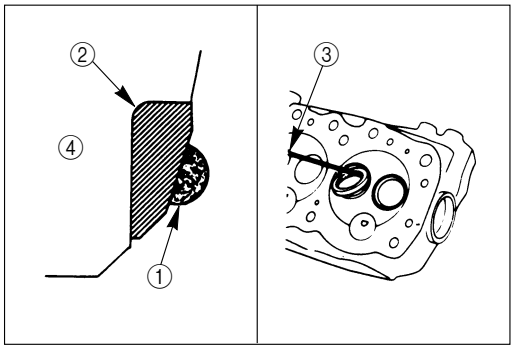
1. Inspect the valve contact faces for roughness and unevenness.

   Make smooth the valve contact surfaces.
2. Measure the valve contact width.

   If the measured value exceeds the specified limit, the valve seat insert must be replaced.

mm (in)

	Standard	Limit
Valve Contact Width	1.5 (0.059)	2.0 (0.079)



Valve Seat Insert Replacement

Valve Seat Insert Removal

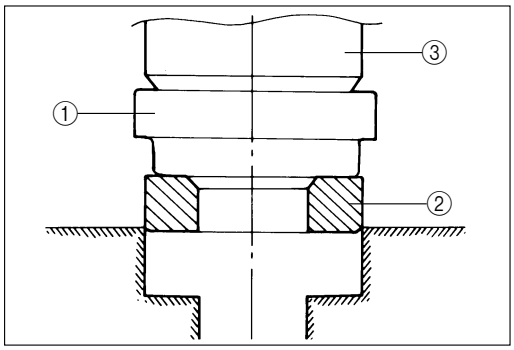
1. Arc weld the entire inside circumference ① of the valve seat insert ②.
2. Allow the valve seat insert to cool for a few minutes.

   This will invite contraction and make removal of the valve seat insert easier.

3. Use a screwdriver ③ to pry the valve seat insert free.

   Take care not to damage the cylinder head ④.

4. Carefully remove carbon and other foreign material from the cylinder head insert bore.



Valve Seat Installation

1. Carefully place the attachment ① (having the smaller outside diameter than the valve seat insert) on the valve seat insert ②.

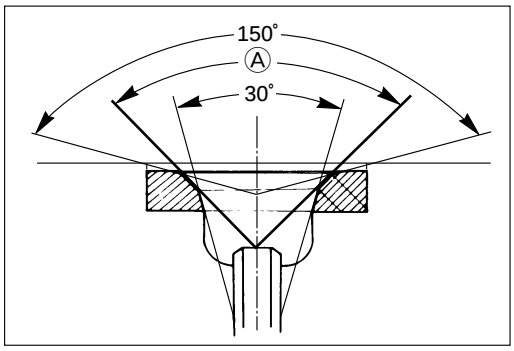
Note:

The smooth side of the attachment must contact the valve seat insert.

2. Use a bench press ③ to slowly apply pressure to the attachment and press the valve seat insert into place. (Amount of pressure needed is more than 25 kN (2,500 kgf/5,512 lb)

Note:

Do not apply an excessive amount of pressure with the bench press. Damage to the valve seat insert will result.

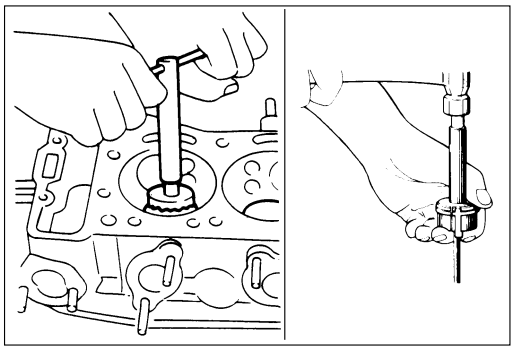


Valve Seat Insert Correction

1. Remove the carbon deposits from the valve seat insert surface.
2. Use valve cutters (15°, 30°, or 75° blades) to remove scratches and other rough areas.

   This will bring the contact width back to the standard value of 90° Ⓐ.

   Remove only the scratches and rough areas. Do not cut away too much. Take care not to cut away unblemished areas of the valve seat surfaces.

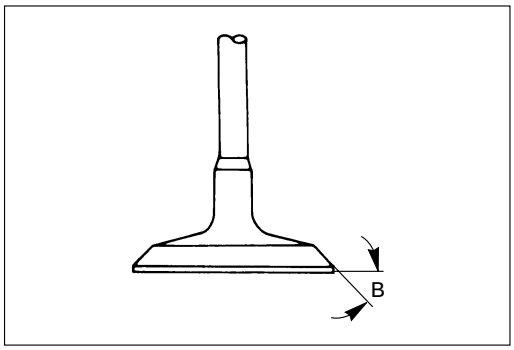


Angle Location	Standard
Intake Valve Seat Angle Ⓑ	45°
Exhaust Valve Seat Angle Ⓑ	45°

Note:

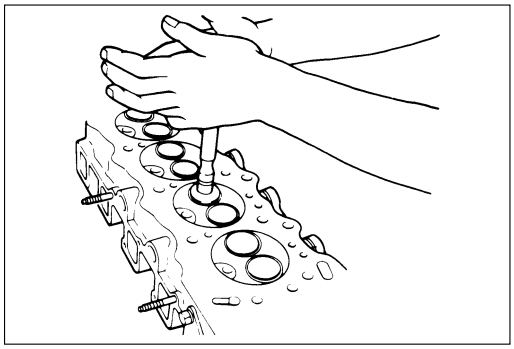
Use an adjustable valve cutter pilot.

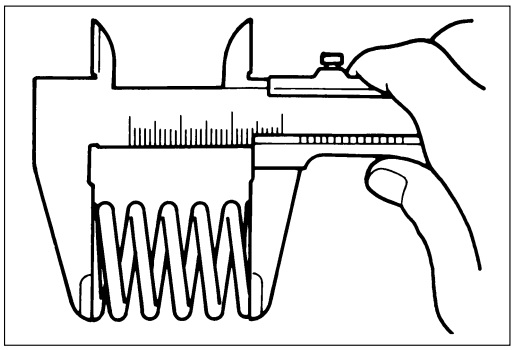
Do not allow the cutter pilot to wobble inside the valve guide.



3. Apply abrasive compound to the valve seat insert surface.
4. Insert the valve into the valve guide.
5. Hand lap the valve and the valve seat with a lapping cup.

   This will provide optimum valve and valve seat contact for effective gas sealing.
6. Check that the valve contact width is correct.
7. Check that the valve seat insert surface is in contact with the entire circumference of the valve.





VALVE SPRING

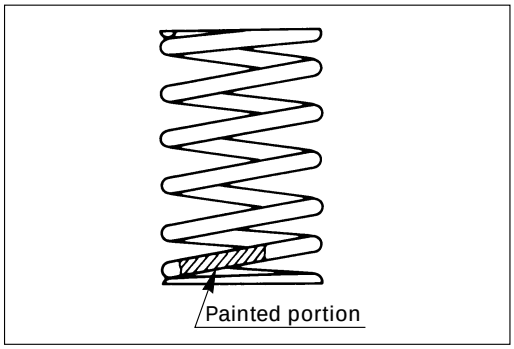
Valve Spring Free Length

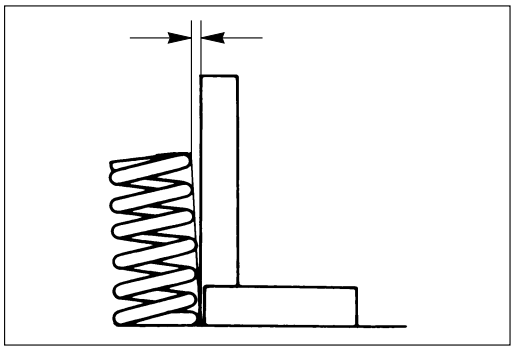
Use a vernier caliper to measure the valve spring free length.

If the measured value is less than the specified limit, the valve spring must be replaced.

mm (in)

	Color	Standard	Limit
Exhaust and Intake Valve Spring Free Length	blue	60.6 (2.39)	58.0 (2.28)





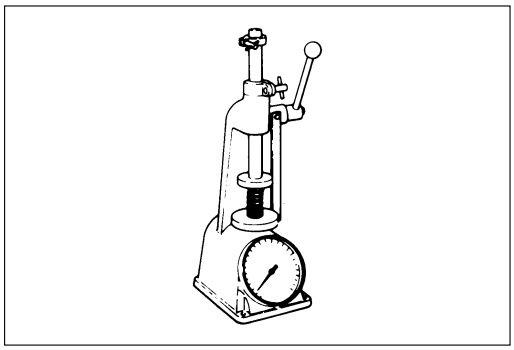
Valve Spring Inclination

Use a surface plate and a square to measure the valve spring inclination.

If the measured value exceeds the specified limit, the valve spring must be replaced.

mm (in)

	Standard	Limit
Valve Spring Inclination	less than 1.9 (0.075)	2.7 (0.106)



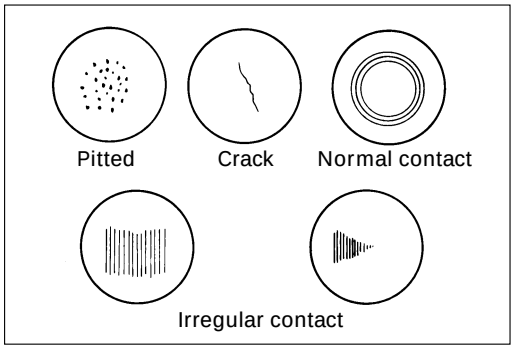
Valve Spring Tension

Use a spring tester to measure the valve spring tension.

If the measured value is less than the specified limit, the valve spring must be replaced.

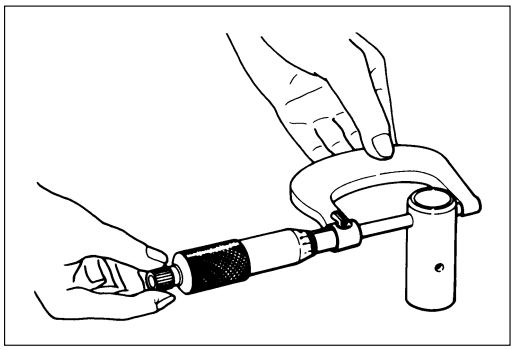
N (kg/lb)

Set Length	Standard	Limit
44.5 mm (1.75 in)	142 (14.5/30.9)	127 (13.0/28.7)



TAPPET (Cam Follower or Valve Lifter)

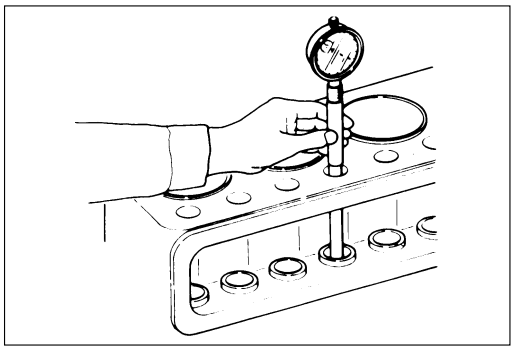
Inspect the tappets for excessive wear, damage and any abnormalities.



Use a micrometer to measure the tappet diameter.

mm (in)

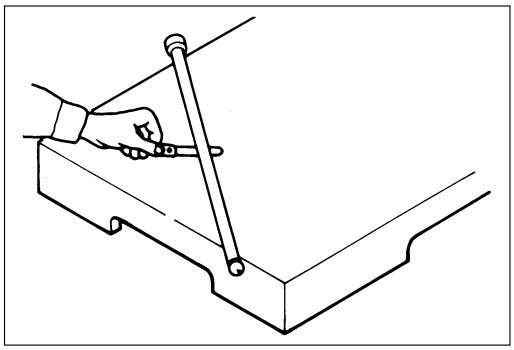
	Standard	Limit
Tappet Diameter	27.97–27.98 (1.1020–1.1024)	27.92 (1.1000)



Use a dial indicator to measure the clearance between the tappet and cylinder body tappet travelling bore.

mm (in)

	Standard	Limit
Tappet and Tappet Travelling Bore Clearance	0.020–0.054 (0.001–0.002)	0.1 (0.004)



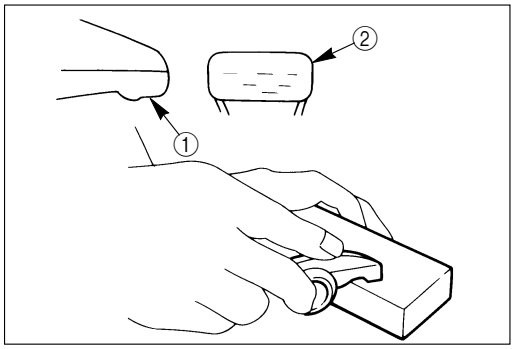
PUSH ROD

Use a filler gauge to measure the valve push rod run out.

Roll the push rod along a smooth flat surface (illustration).

mm (in)

	Limit
Push Rod Run-Out	0.3 (0.012)

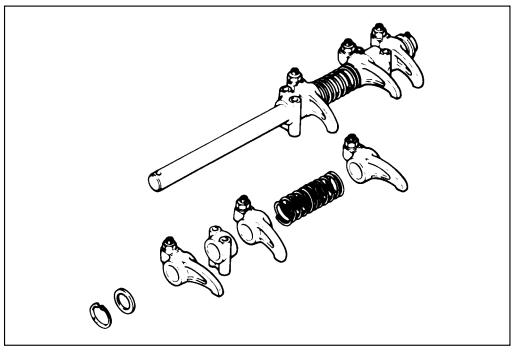


Rocker Arm Correction

Inspect the rocker arm valve stem contact surfaces for ridge ① and scoring ②.

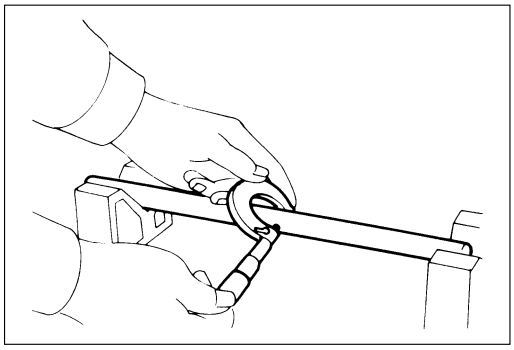
If the surfaces have light ridge or scoring, they may be honed with an oil stone.

If the ridge or scoring is severe, the rocker arm must be replaced.



ROCKER ARM SHAFT AND ROCKER ARM

Inspect all disassembled parts for wear, damage and any abnormalities.



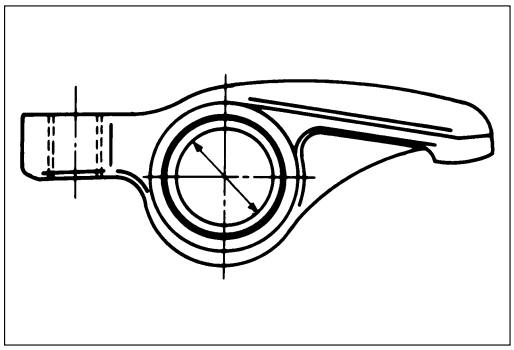
Rocker Arm Shaft Outside Diameter

Use a micrometer to measure the rocker arm outside diameter.

If the measured value is less than the specified limit, the shaft must be replaced.

mm (in)

	Standard	Limit
Rocker Arm Shaft Diameter	18.98–19.00 (0.747–0.748)	18.85 (0.742)



Rocker Arm Shaft and Rocker Arm Clearance

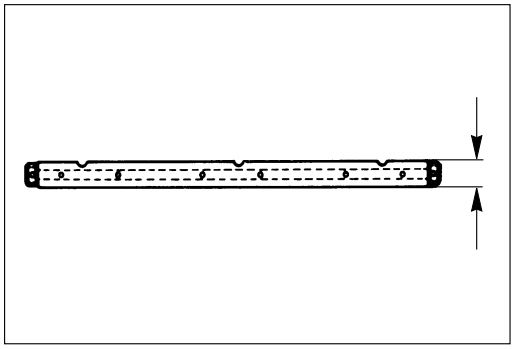
1. Use a vernier caliper to measure the rocker arm bushing inside diameter.

mm (in)

	Standard	Limit
Rocker Arm Bushing Inside Diameter	19.01–19.03 (0.749–0.750)	19.05 (0.751)

2. Measure the rocker arm shaft outside diameter.

   Replace either the rocker arm or the rocker arm shaft if the clearance exceeds the specified limit.

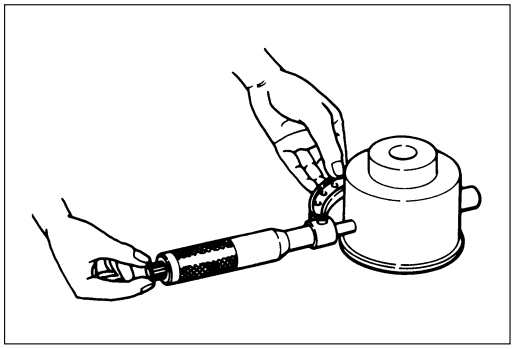


mm (in)

	Standard	Limit
Rocker Arm Bushing and Rocker Arm Shaft Clearance	0.01–0.05 (0.0004–0.0020)	0.2 (0.0079)

3. Check that the rocker arm oil port is free of obstructions.

   If necessary, use compressed air to clean the rocker arm oil port.



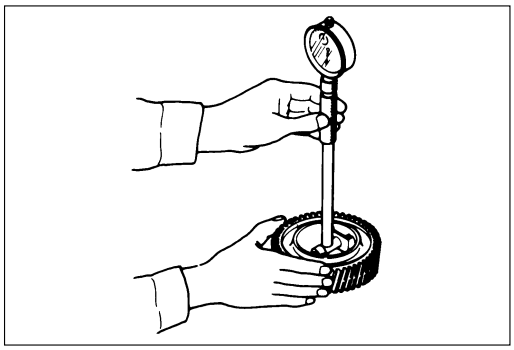
IDLER GEAR AND IDLER GEAR SHAFT

1. Use a micrometer to measure the idler gear shaft outside diameter.

   If measured diameter exceeds specified limit, replace the idler gear shaft.

mm (in)

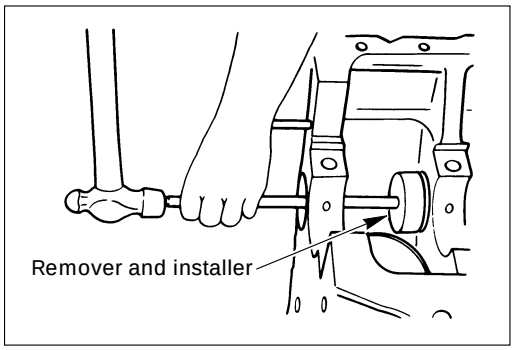
	Standard	Limit
Idler Gear Shaft Outside Diameter	44.945–44.975 (1.769–1.771)	44.9 (1.768)



2. Use a dial indicator to measure the idler gear inside diameter.

mm (in)

	Standard	Limit
Idler Gear and Idler Gear Shaft Clearance	0.025–0.085 (0.001–0.003)	0.2 (0.008)



CAMSHAFT

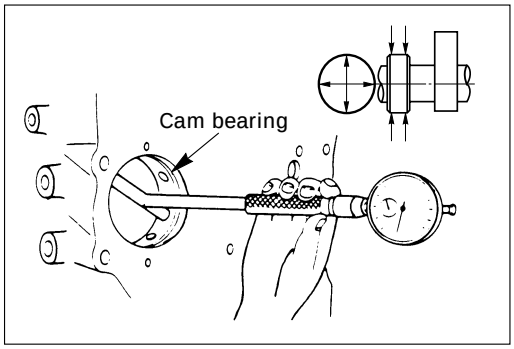
1. Use the camshaft bearing remover and installer to remove camshaft bearing from the cylinder body.

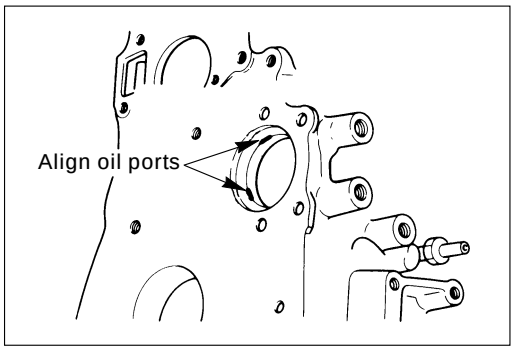
   Camshaft Bearing Remover and Installer: 9-8523-1818-0

2. Measure the clearance between the cam journal and the camshaft bearing.

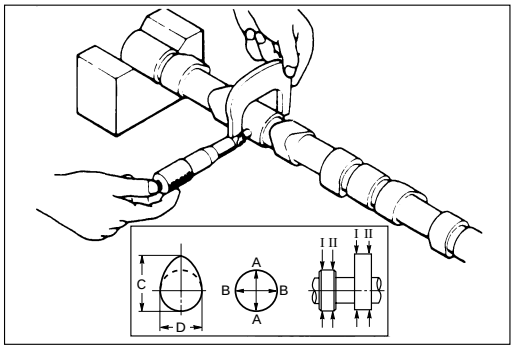
mm (in)

	Standard	Limit
Cam Journal and Cam Bearing Clearance	0.03–0.09 (0.001–0.004)	0.15 (0.006)





3. Align the camshaft bearing oil holes with the mating oil ports (machined on the cylinder body camshaft bearing fitting bore).

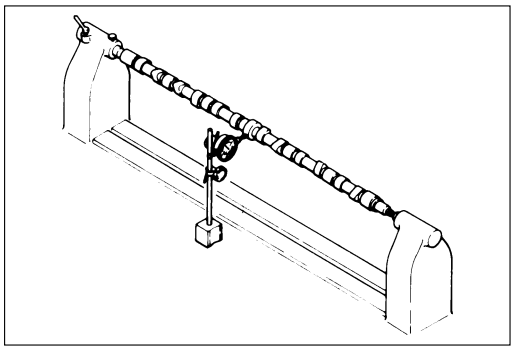


4. Use a micrometer to measure the cam lobe height.

   If the cam lobe height is less than the specified limit, the camshaft must be replaced.

mm (in)

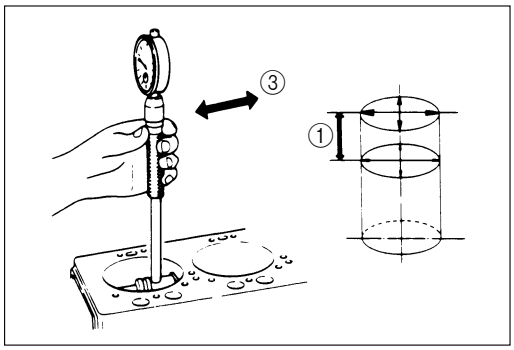
	Standard	Limit
Cam Lobe Height (C-D)	7.71 (0.304)	7.21 (0.284)
Cam Journal Diameter	55.94–55.97 (2.202–2.204)	55.6 (2.189)



5. Place the camshaft on a measuring stand.
   Use a dial indicator to measure the camshaft runout.
   Note the total indicator reading (TIR).
   If the measured run-out exceeds the specified limit, the camshaft must be replaced.

mm (in)

	Limit
Camshaft Run-Out TIR	0.12 (0.005)



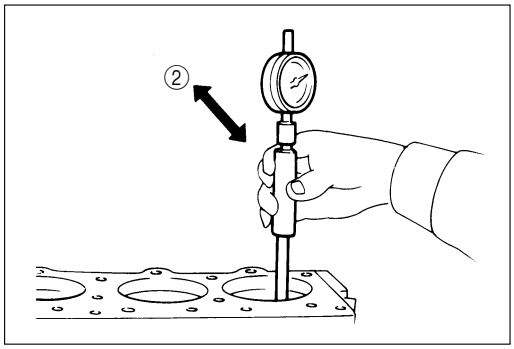
CYLINDER BODY AND LINER

Cylinder Liner Bore Measurement

Use a cylinder indicator to measure the cylinder liner bore at measuring position ① in line with the crankshaft ② and across the crankshaft ③.

Measuring Point ① mm (in): 20.0 (0.79) (Maximum Wear Portion)

If the measured value exceeds the specified limit, the cylinder liner must be replaced.



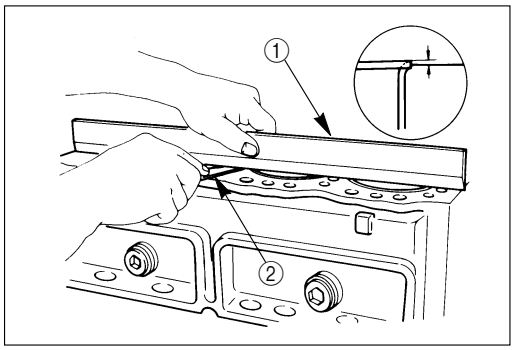
mm (in)

	Standard	Limit
Cylinder Liner Bore Total Indicator Reading	105.021–105.060 (4.1347–4.1362)	105.20 (4.1417)

Note:

The inside of the dry type cylinder liner is chrome plated. It cannot be rebored or honed.

If the inside of the cylinder liner is scored or scorched, the cylinder liner must be replaced.



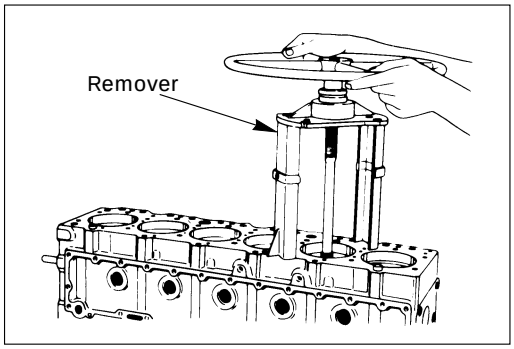
Cylinder Liner Projection Inspection

1. Hold a straight edge ① along the top edge of the cylinder liner to be measured.
2. Use a feeler gauge ② to measure each cylinder liner projection.

mm (in)

	Standard
Cylinder Liner Projection	0.03–0.10 (0.001–0.004)

The difference in the cylinder liner projection height between any two adjacent cylinders must not exceed 0.03 mm (0.001 in).



Cylinder Liner Replacement

Cylinder Liner Removal

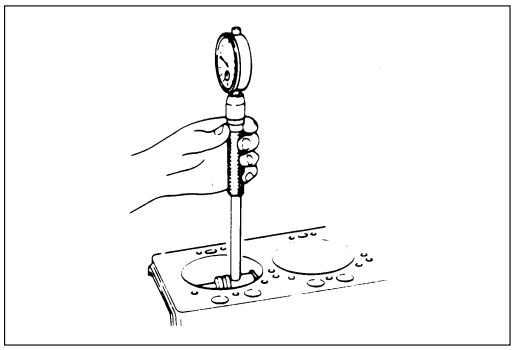
1. Set the cylinder liner remover to the cylinder liner.
2. Check that the remover shaft ankle is firmly gripping the cylinder liner bottom edge.
3. Slowly turn the remover shaft handle counterclockwise to pull the cylinder liner free.

   Cylinder Liner Remover: 5-8840-9038-0

   Cylinder Liner Remover Ankle: 5-8523-1004-0

Note:

Take care not to damage the cylinder body upper face during the cylinder liner removal procedure.



Cylinder Bore Measurement

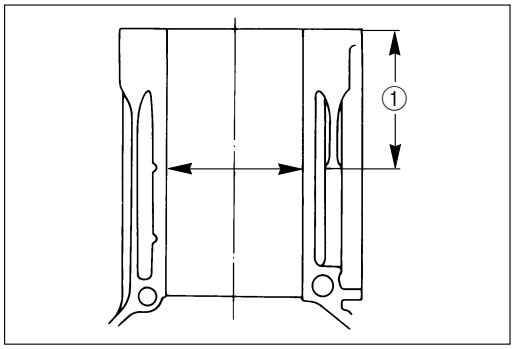
Cylinder Liner Grade Selection

The term "grade" refers to the cylinder body inside diameter and the cylinder liner outside diameter combination.

Measure the cylinder body inside diameter and select the appropriate cylinder liner grade.

Loose fitting cylinder liners (the liner is too small for the cylinder bore) will adversely affect engine cooling efficiency and may lead to serious engine damage.

Cylinder liners which are too large for the cylinder bore will be difficult to install.

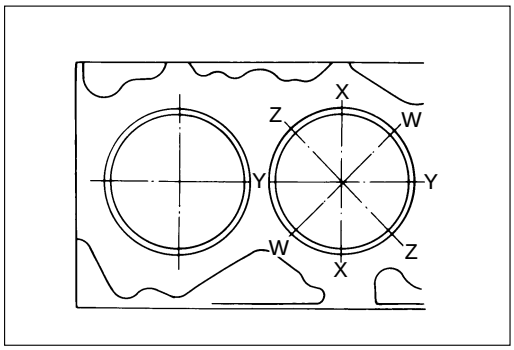


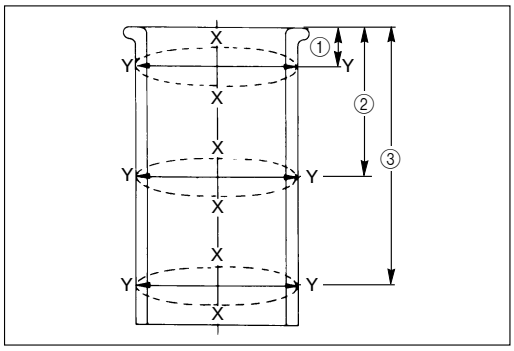
Cylinder Body Inside Diameter Measurement

1. Take measurements at measuring point ① across the positions W–W, X–X, Y–Y, and Z–Z.

   Measuring Point ① : 115 mm (4.531 in)

2. Calculate the average value of the four measurements to determine the correct cylinder liner grade.





Cylinder Liner Outside Diameter Measurement

1. Take measurements at measuring point ①, ②, and ③.

   Measuring Points mm (in):

   ① 20.0 (0.788)

   ② 105.0 (4.137)

   ③ 195.0 (7.683)

2. Calculate the average value of the 6 measurements to determine the correct cylinder liner grade.

mm (in)

Cylinder Liner Fitting Clearance Standard	0.001–0.019 (0.00004–0.0007)

Cylinder Bore and Cylinder Liner Outside Diameter Combinations

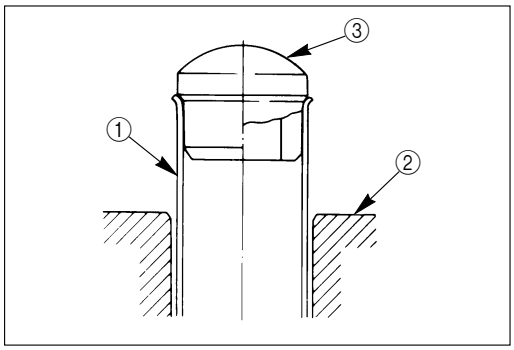
(Reference)

mm (in)

Grade	Cylinder Bore	Cylinder Liner Outside Diameter
1	107.001–107.010 (4.2126–4.2130)	107.011–107.020 (4.2130–4.2134)
2	107.011–107.020 (4.2130–4.2134)	107.021–107.030 (4.2134–4.2138)
3	107.021–107.030 (4.2134–4.2138)	107.031–107.040 (4.2138–4.2142)

Cylinder Liner Installation

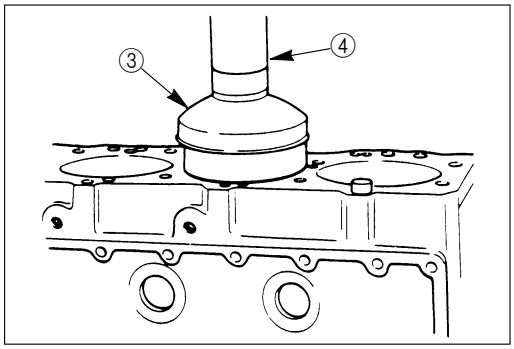
1. Carefully wipe away any foreign material from the cylinder liner inside and outside surfaces and the cylinder bore.
2. Use new kerosene or diesel oil to thoroughly clean the cylinder liner and bore surfaces.
3. Use a clean rag to remove all traces of kerosene or diesel oil from the cylinder liner and bore surfaces.



4. Insert the cylinder liner ① into the cylinder body ② from the top of the cylinder body.
5. Set the cylinder liner installer ③ to the top of the cylinder liner.

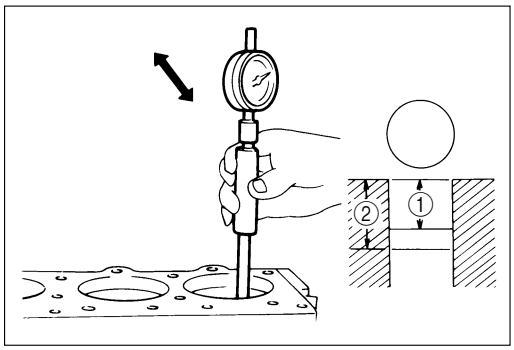
   Cylinder Liner Installer: 5-8522-1018-0
6. Position the cylinder body so that the installer center ③ is directly beneath the bench press shaft center ④.
7. Check that the cylinder liner is set perpendicular to the cylinder.

   Check that the cylinder liner does not wobble.



8. Use the bench press to apply an initial seating force of 5 kN (500 kgf/1,102 lb) to the cylinder liner.
9. Use the bench press to apply a final seating force of 25 kN (2,500 kgf/5,512 lb) to fully seat the cylinder liner.
10. After installing the cylinder liner, measure the cylinder liner projection.

    Refer to "Cylinder Liner Projection Inspection."



Piston Grade Selection

The term "piston grade" refers to the piston diameter and cylinder liner bore combination.

Selection of the proper piston grade will ensure efficient engine operation, free from cylinder liner and piston problems.

Cylinder Liner Bore Measurement

1. Locate the two measuring points.
   Cylinder Liner Measuring Point ①: 20 mm (0.788 in)
   Cylinder Liner Measuring Point ②: 105 mm (4.173 in)
2. Measure the cylinder liner bore at measuring point ① and ② in four different directions (W–W, X–X, Y–Y, and Z–Z).
3. Calculate the average value of the eight measurements.

mm (in)

Cylinder Liner Bore Total Indicator Reading	105.021–105.060 (4.1347–4.1362)

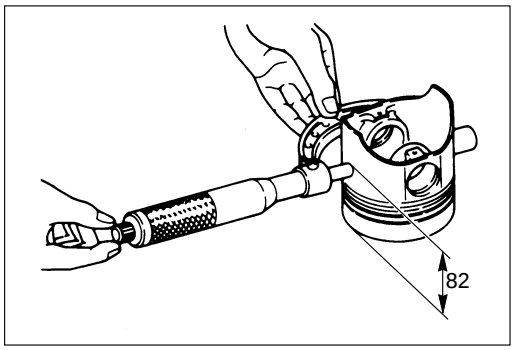
Relation between liner bore and piston grade mm (in)

Liner Bore Diameter	Piston Grade
105.021–105.040 (4.1347–4.1354)	AX
105.041–105.060 (4.1355–4.1362)	CX

Note:

It is most important that the correct piston grade be used. Failure to select the correct piston grade will result in piston seizure.

Always measure the cylinder bore and select the appropriate piston grade.



Piston Outside Diameter

Measure the piston outside diameter at the measuring piston shown in the illustration.

Piston Grade (For service parts) mm (in)

AX	CX
104.959–104.974 (4.1322–4.1328)	104.975–104.990 (4.1329–4.1335)

Cylinder Liner Bore and Piston Clearance

(For service parts) mm (in)

Cylinder Liner Bore and Piston Clearance	0.051–0.085 (0.002–0.0033)

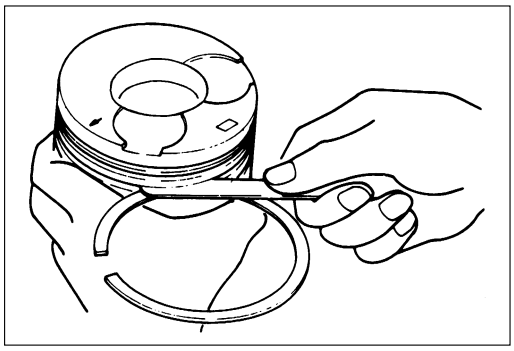
Piston Selection

Select the same grade number as the one for the cylinder liner inside dia meter.

Grade of cylinder inside diameter	Grade of piston	Combination
AX	AX	OK
CX	CX	OK
AX	CX	NG
CX	AX	NG

Note:

Cylinder liner piston kit clearances are preset. However, the cylinder liner installation procedure may result in slight decreases in cylinder liner bore clearances.



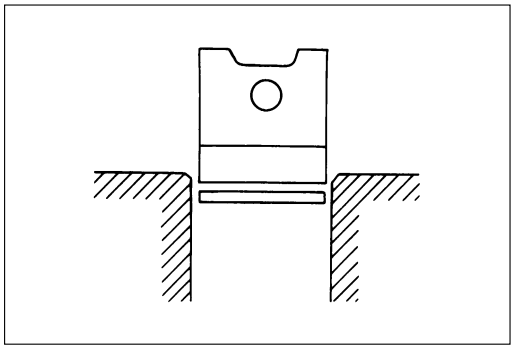
PISTON AND PISTON RING

Piston Ring and Piston Ring Groove Clearance

Use a feeler gauge to measure the clearance between the piston ring and the piston ring groove.

Do this at several points around the piston.

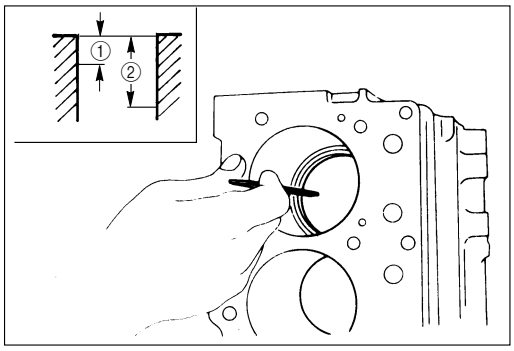
If the clearance between the piston ring and the piston ring groove exceeds the specified limit, the piston ring must be replaced.



Piston Ring and Piston Ring Groove Clearance

mm (in)

	Standard	Limit
1st Compression Ring	—	—
2nd Compression Ring	0.070–0.110 (0.0028–0.0043)	0.15 (0.0059)
3rd Compression Ring	0.050–0.090 (0.0020–0.0035)	0.15 (0.0059)
Oil Ring	0.030–0.070 (0.0012–0.0028)	0.15 (0.0059)



Piston Ring Gap

1. Insert the piston ring horizontally (in the position it would assume if it were installed to the piston) into the cylinder liner.
2. Use an inverted piston to push the piston ring into the cylinder liner until it reaches either measuring point ① or measuring point ②. Cylinder liner diameter is the smallest at these two points.

   Do not allow the piston ring to slant to one side or the other. It must be perfectly horizontal.

   Cylinder Liner Measuring Point ①: 10mm (0.39 in)

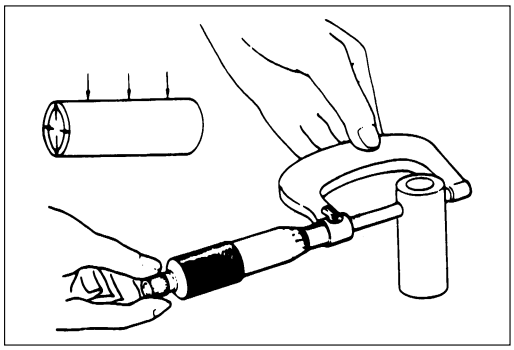
   Cylinder Liner Measuring Point ②: 130mm (5.12 in)
3. Use a feeler gauge to measure the piston ring gap.

   If the measured value exceeds the specified limit, the piston ring must be replaced.

Piston Ring Gap

mm (in)

	Standard	Limit
1st Compression Ring	0.35–0.50 (0.014–0.020)	1.5 (0.059)
2nd Compression Ring	0.60–0.75 (0.0236–0.0295)	
3rd Compression Ring	0.60–0.75 (0.0236–0.0295)	
Oil Ring	0.30–0.50 (0.014–0.020)	



PISTON PIN

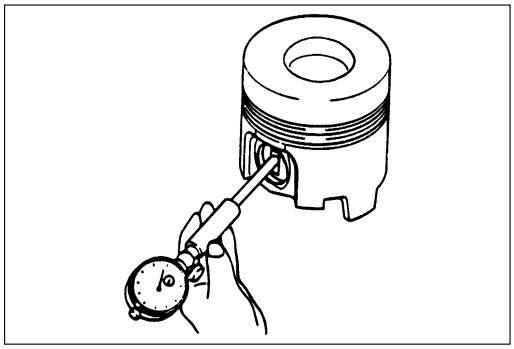
Piston Pin Outside Diameter

Use a micrometer to measure the piston pin outside diameter at several points.

If the measured piston pin outside diameter exceeds the specified limit, the piston pin must be replace.

mm (in)

	Standard	Limit
Piston Pin Outside Diameter	35.000–35.005 (1.3780–1.3781)	34.95 (1.3760)

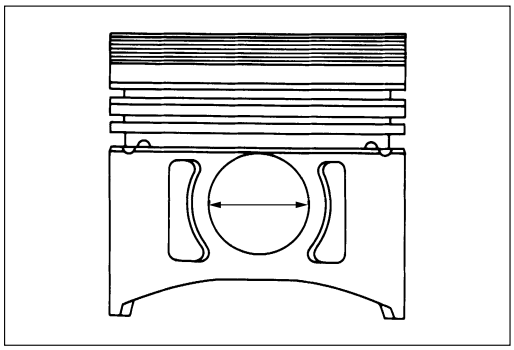


Piston Pin and Piston Clearance

Use an inside dial indicator to measure the piston pin hole.

mm (in)

Piston Pin Hole Diameter	Standard
4BG1, 4BG1T, 6BG1 6BG1T	35.015–35.023 (1.3785–1.3789)

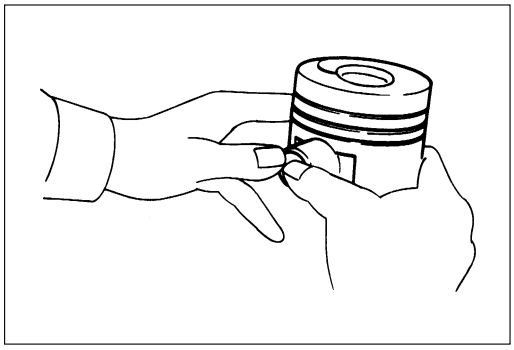


Piston Pin and Piston Pin Hole Clearance

Determine the clearance between the piston pin and the piston pin hole by calculating the difference between the piston pin hole diameter and the piston pin outside diameter.

mm (in)

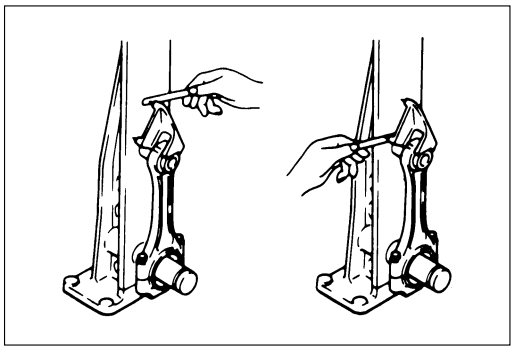
	Standard	Limit
Piston Pin and Piston Pin Hole Clearance	0.010–0.023 (0.00039–0.0009)	0.050 (0.00197)



If an inside dial indicator is not available, use the following procedure to check the piston pin fit.

1. Use a piston heater to heat the piston to approximately 60°C (140°F).
2. Push strongly against the piston pin with your thumbs.

   The piston pin fitting should feel tight.



CONNECTING ROD

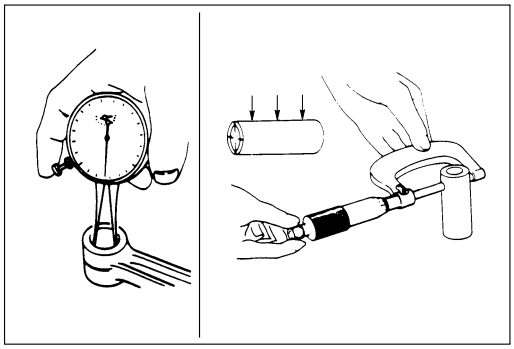
Connecting Rod Alignment

Use a connecting rod aligner to measure the connecting rod's twist distortion and parralelism between the rod's large and small ends.

If the measured value exceeds the limit, replace the connecting rod.

Connecting Rod Alignment
(Per Length of 100 mm (3.94 in) mm (in)

	Standard	Limit
Twist, Parallelism	0.05 (0.002) or less	0.20 (0.0079)



Piston Pin and Connecting Rod Small End Bushing Clearance

Use a caliper calibrator and a micrometer to measure the piston pin and connecting rod small end bushing clearance.

If the clearance between the piston pin and the connecting rod small end bushing exceeds the specified limit, replace either the piston pin or the connecting rod bushing.

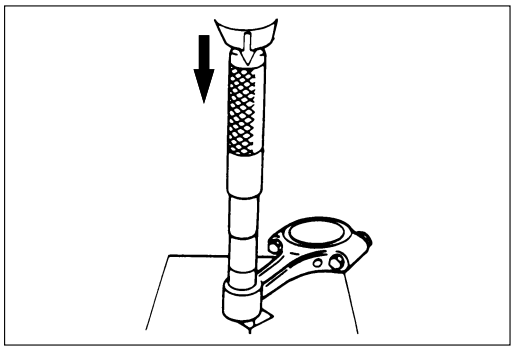
mm (in)

	Standard	Limit
Piston Pin and Connecting Rod Small End Bushing Clearance	0.012–0.025 (0.00047–0.00098)	0.05 (0.00197)

Connecting Rod Bushing Replacement

Connecting Rod Bushing Removal

1. Clamp the connecting rod in a vise.
2. Use a brass bar and a bench press or hammer to remove the connecting rod bushing.



Connecting Rod Bushing Installation

Use the connecting rod bushing installer to install the connecting rod bushing.

Connecting Rod Bushing Installer: 9-8523-1369-0 (J-29765)

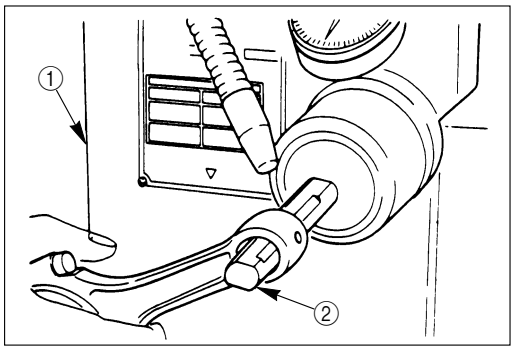
Note:

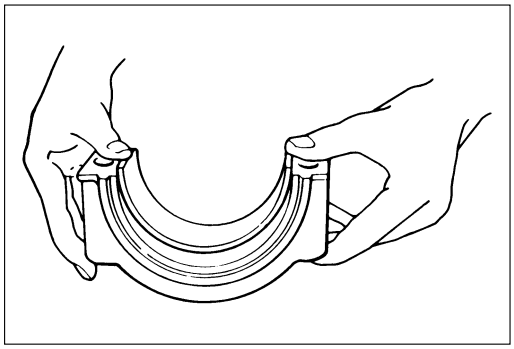
The connecting rod bushing oil port must be aligned with the connecting rod oil port.

3. Use a piston pin hole grinder ① fitted with a reamer ② or an adjustable pilot reamer to ream the piston pin hole.

mm (in)

	Standard
Connecting Rod Bushing Inside Diameter	35.017–35.025 (1.3786–1.3789)





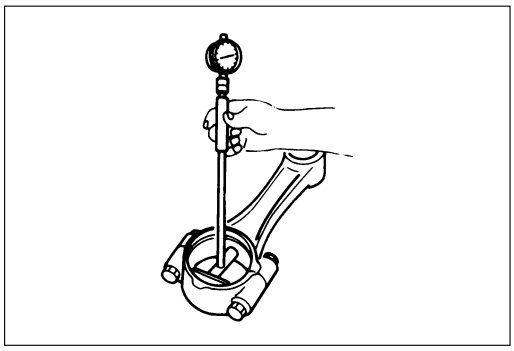
Connecting Rod Bearing Inspection

1. Fit the connecting rod bearing lower half into the connecting rod bearing cap.
2. Check the connecting rod bearing lower half tension.

   If the tension is insufficient, the bearing must be replaced.
3. Tighten the connecting rod and the bearing cap to the specified torque.

N·m (kgf·m/ft.lb)

	1st step	2nd step
Connecting Rod and Bearing Cap Bolt Tightening Torque	39 (4/29)	60°–90°



4. Use an inside dial indicator to measure the connecting rod inside diameter.

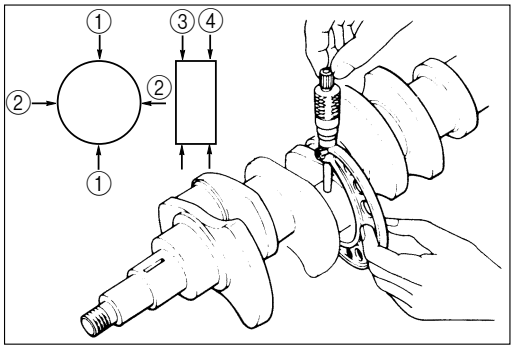
mm (in)

Connecting Rod Bearing Nominal Diameter	64 (2.520)

CRANKSHAFT

Crankshaft and Bearing Inspection

1. Inspect the crankshaft journal surfaces and the crank pin surfaces for excessive wear and damage.
2. Inspect the oil seal fitting surfaces of the crankshaft front and rear ends for excessive wear and damage.
3. Replace or repair the crankshaft if any excessive wear or damage is discovered.
4. Inspect the crankshaft oil ports for obstructions.
5. Use high pressure air to clean the oil ports if necessary.



Crankshaft Journal and Crankpin Outside Diameter

1. Use a micrometer to measure the crankshaft journal outside diameter across points ① – ① and ② – ②.
2. Use the micrometer to measure the crankshaft journal outside diameter at the two points (③ and ④).
3. Repeat steps 1 and 2 to measure the crankshaft outside diameter.

mm (in)

6B Engines only	Position at	Standard
Crankshaft Journal Diameter	Center Bearing Only	79.905–79.925 (3.1459–3.1467)
	Other Bearings	79.919–79.939 (3.1464–3.1472)

mm (in)

4B Engines only	Position at	Standard
Crankshaft Journal Diameter	All Bearings	79.905–79.925 (3.1459–3.1467)

mm (in)

	Standard
Crankshaft Pin Diameter	63.924–63.944 (2.5167–2.5175)

4. Measure the crankshaft journal outside diameter (and/or the crankpin outside diameter) and the bearing inside diameters to determine the bearing clearance.

Crankshaft Journal and Bearing Clearances

If the bearing clearance exceeds the specified limit, the crankshaft must be reground (except 4BD1T, 6BD1T, 6BG1 and 6BG1T) and/or the bearing must be replaced.

mm (in)

6B Engines Only	Position at	Standard	Limit
Crankshaft Journal and Main Bearing Clearance	Center Bearing Only	0.039–0.098 (0.0015–0.0039)	0.11 (0.0043)
	Other Bearings	0.025–0.084 (0.0010–0.0033)	

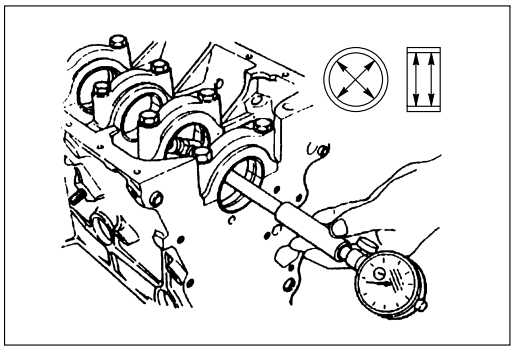
mm (in)

4B Engines Only	Position at	Standard	Limit
Crankshaft Journal and Main Bearing Clearance	All Bearings	0.039–0.098 (0.0015–0.0039)	0.11 (0.0043)

Crankshaft Pin and Bearing Clearance

mm (in)

	Standard	Limit
Crankpin and Connecting Rod Bearing Clearance	0.03–0.073 (0.0012–0.0029)	0.10 (0.0039)



Crankshaft Journal Bearing Inside Diameter

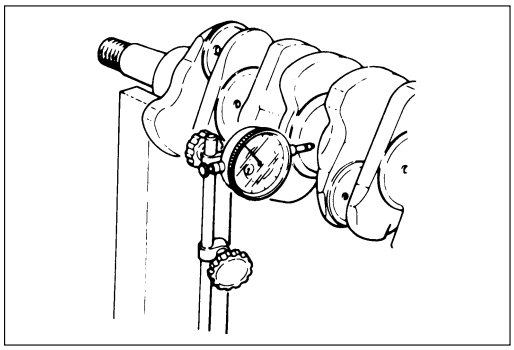
1. Install the main bearing cap with bearings to the cylinder body with the specified torque and facing the arrow mark on the bearing cap toward front. Place them in order of punched cylinder numbers.
2. Use an inside dial indicator to measure the main bearing diameters.

N·m (kgf·m/ft.lb)

Main Bearing Cap Torque	226 – 245 (23 – 25/166 – 181)

mm (in)

Main Bearing Nominal Diameter	80 (3.149)



Crankshaft Run-Out

1. Mount the crankshaft on a set of V-blocks.
2. Set a dial indicator to the center of the crankshaft journal.
3. Gently turn the crankshaft in the normal direction of engine rotation.

   Read the dial indicator (TIR) as you turn the crankshaft.

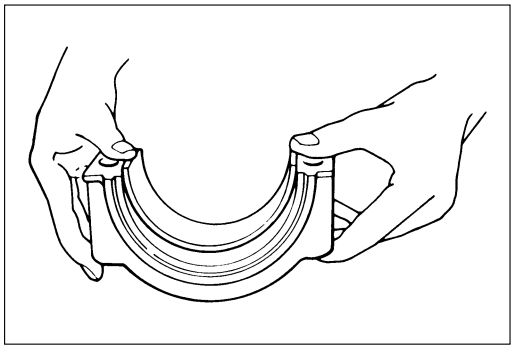
   If the measured value exceeds the specified limit, the crankshaft must be replaced.

mm (in)

	Model	Standard	Limit
Crankshaft Run-Out	6B	0.05 (0.002) or less	0.40 (0.016)
	4B		

If the crankshaft generated a crack after repair, replace the crankshaft.

Crankshaft can not be bench pressed, because it is finished with tufftride method.



Main Bearing and Connecting Rod Bearing Tension

Check to see if the bearing has enough tension, so that good finger pressure is needed to fit the bearing into position.

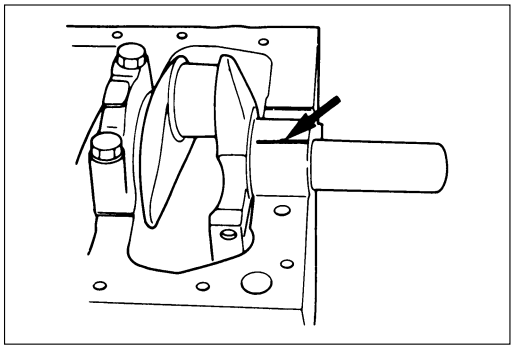
Crankshaft Regrinding

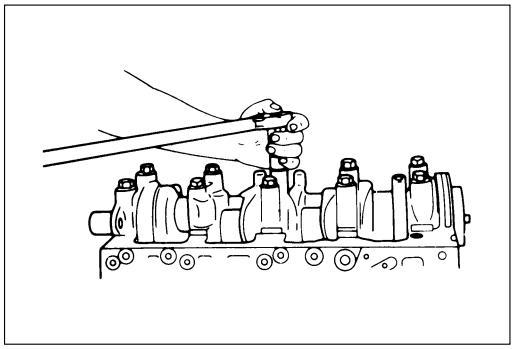
Note:

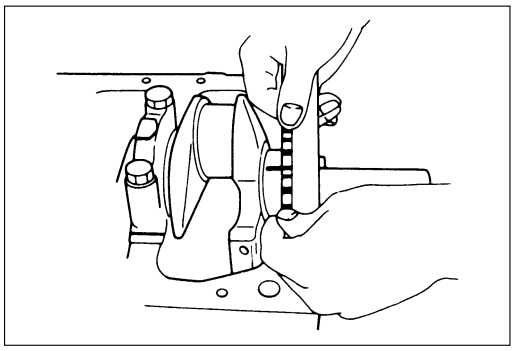
Crankshaft for AA-4BG1T, BB-4BG1T, AA-6BG1 and BB-6BG1T can not be reground because it is finished with TUFFTRIDE method.

For the crankshaft on AA-4BG1T, BB-4BG1T, AA-6BG1 and BB-6BG1T, no attempt should be made to grind finish the faces of the journals and crankpins as they are TUFFTRIDED (Special hardening treatment).

Therefore, the undersize bearings are not prepared:







Plastigage Clearance Measurements

This is another method to measure the crankjournal bearing clearance.

Crankshaft Journal Bearing Clearance

1. Clean the cylinder body, the journal bearing fitting portions, the bearing cap, and the inside the outside surfaces of the bearing.
2. Install the new journal bearing to the cylinder body.
3. Carefully place the crankshaft on the bearing.
4. Rotate the crankshaft approximately 30° to seat the bearing.
5. Place the Plastigage (arrow) over the crankshaft journal across the full width of the bearing.

   Apply engine oil to the Plastigage to keep it from falling.
6. Install the bearing cap with the bearing.
7. Tighten the bearing cap to the specified torque.

   Do not allow the crankshaft to turn during bearing cap installation and tightening.
8. Remove the bearing cap.
9. Compare the width of the plastigage attached to either the crankshaft or the bearing against the scale printed on the plastigage container.

   If the measured value exceeds the limit, perform the following additional steps.

   1) Use a micrometer to measure the crankshaft outside diameter.
   2) Use an inside dial indicator to measure the bearing inside diameter.
   3) Replace the crankshaft and/or the bearing if the measured value(s) exceed the limit.

Crankshaft Pin Bearing Clearance

1. Clean the crankshaft, the connecting rod, the bearing cap, and the bearings.
2. Install the bearing to the connecting rod.

   Do not allow the crankshaft to move when installing the bearing cap.
3. Hold the connecting rod (with the bearing installed) against the crankshaft pin.
4. Attach the plastigage to the crankshaft pin.

   Apply engine oil to the plastigage to keep it from falling.

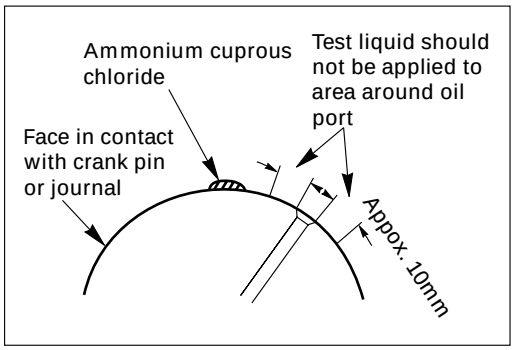
5. Install the connecting rod bearing cap and tighten it to the specified torque.

   Do not allow the connecting rod to move when installing and tightening the bearing cap.
6. Remove the bearing cap.

7. Compare the width of the plastigage attached to either the crankshaft or the bearing against the scale printed on the plastigage container.

   If the measured value exceeds the limit, perform the following additional steps.

   1) Use a micrometer to measure the crankshaft outside diameter.
   2) Use an inside dial indicator to measure the bearing inside diameter.
   3) Replace the crankshaft and/or the bearing if the measured value(s) exceed the limit.



Crankshaft Tufftriding Inspection

Inspection

Model AA-4BG1T, BB-4BG1T, AA-6BG1 and BB-6BG1T

1. Use an organic cleaner to thoroughly clean the crankshaft. There must be no traces of oil on the surfaces to be inspected.
2. Prepare a 10% solution of ammonium cuprous chloride (dissolved in distilled water).
3. Use a spot glass rod to apply the solution to the surface to be inspected.

   Hold the surface to be inspected perfectly horizontal to prevent the solution from running.

Note:

Do not allow the solution to come in contact with the oil ports and their surrounding area.

Judgement

1. Wait for thirty to forty seconds.

   If there is no discoloration after thirty or forty seconds, the crankshaft is usable.

   If discoloration appears (the surface being tested will become the color of copper), the crankshaft must be replaced.

2. Clean the surface being tested with clean water of steam immediately after completing the test.

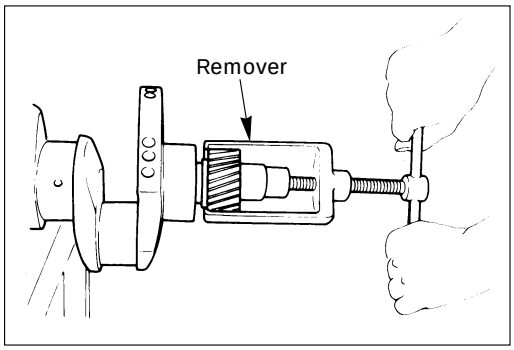
Note:

The ammonium cuprous chloride solution is highly corrosive. Because of this, it is imperative that the surfaces being tested be cleaned immediately after completing the test.

Crankshaft Gear Inspection

Visually inspect the crankshaft gear.

Replace the crankshaft gear if excessive wear or damage is discovered.

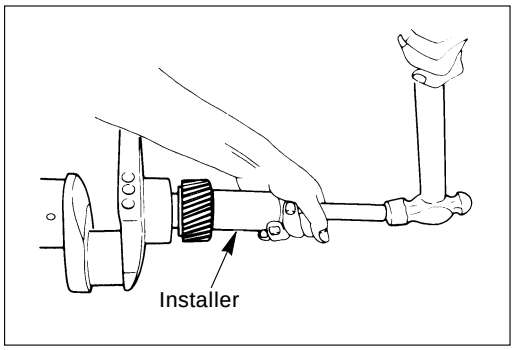


Crankshaft Gear Replacement

Removal

Use the crankshaft gear remover to remove the crankshaft gear.

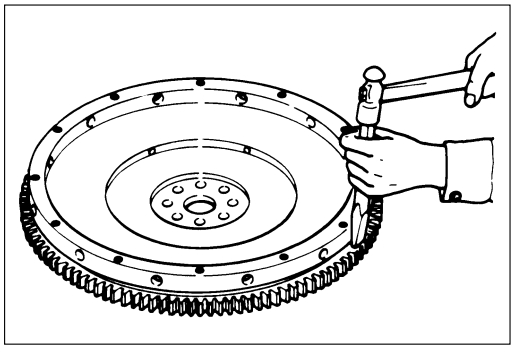
Crankshaft Gear Remover: 9-8521-0141-0



Installation

Use the crankshaft gear installer to install the crankshaft gear.

Crankshaft Gear Installer: 9-8522-0033-0



FLYWHEEL AND FLYWHEEL HOUSING

Ring Gear Inspection

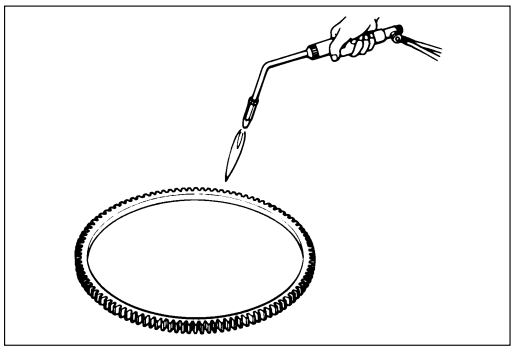
Inspect the ring gear.

If the ring gear teeth are broken or excessively worn, the ring gear must be replaced.

Ring Gear Replacement

Ring Gear Removal

Strike around the edges of the ring gear with a hammer and chisel to remove it.

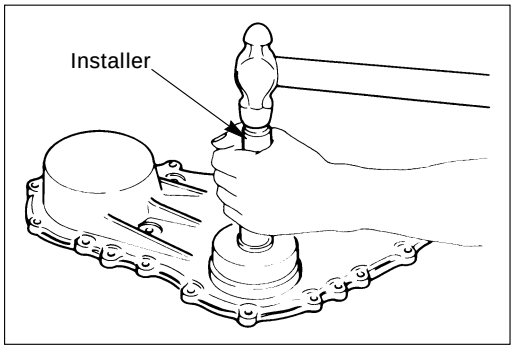


Ring Gear Installation

1. Heat the ring gear evenly with a gas-burner to invite thermal expansion.

   Do not allow the temperature of the ring gear to exceed 200°C (390°F).

2. Use a hammer to install the ring gear when it is sufficiently heated.



TIMING GEAR CASE COVER

Crankshaft Front Oil Seal Replacement

Removal

Use an adapter and a hammer to remove the crankshaft front end oil seal.

Installation

Use the crankshaft front oil seal installer to install the crankshaft front oil seal.

Crankshaft Front Oil Seal Installer: 9-8522-0034-0

MEMO

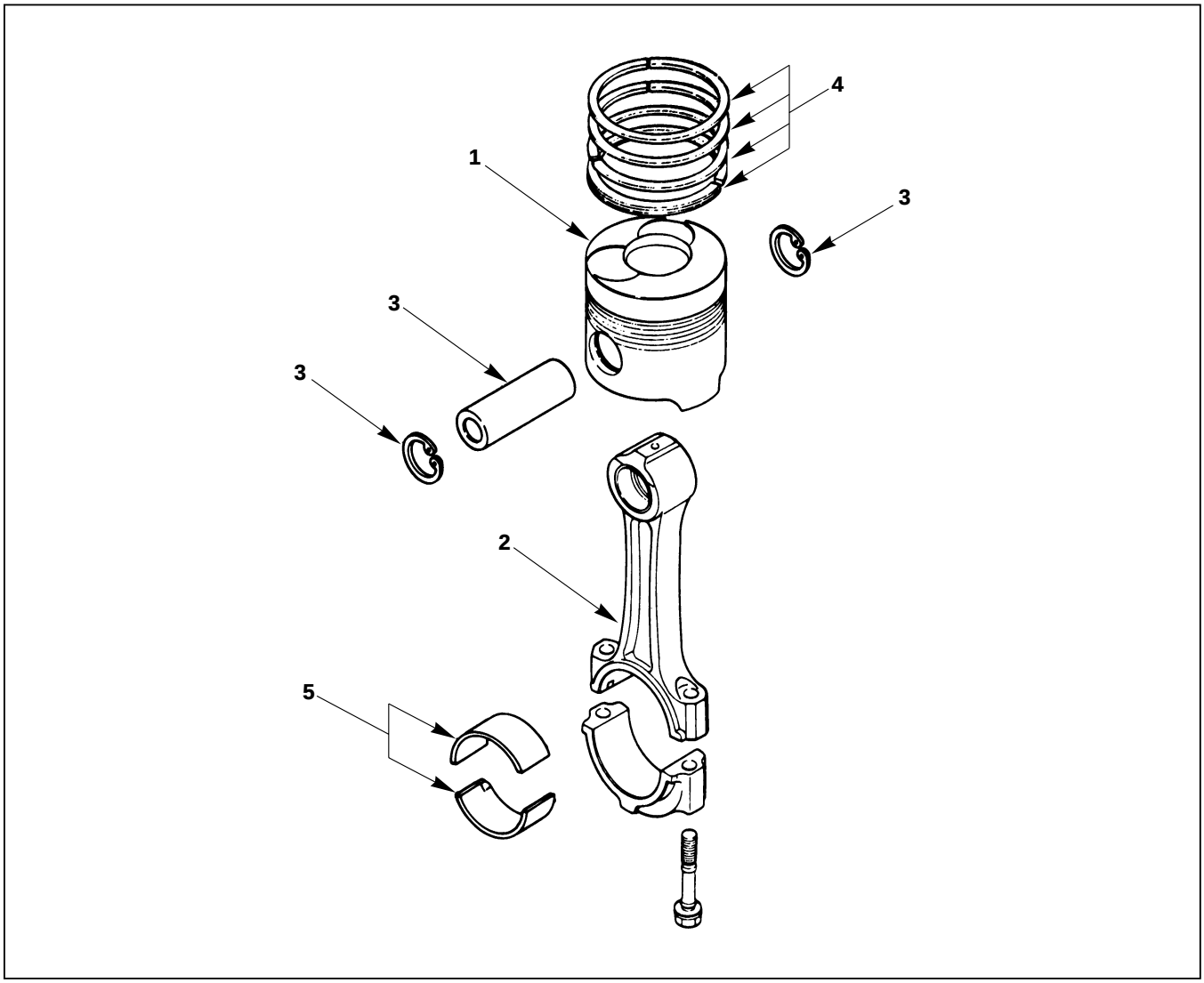
SECTION 5

ENGINE ASSEMBLY III (REASSEMBLY)

TABLE OF CONTENTS

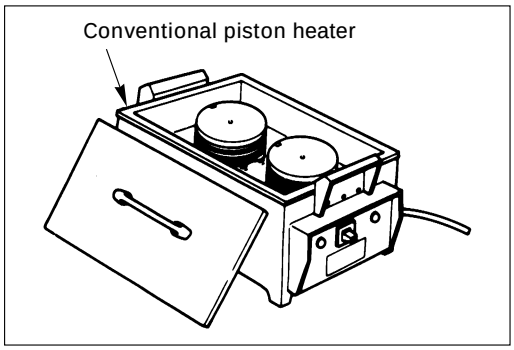
PISTON AND CONNECTING ROD REASSEMBLY STEPS

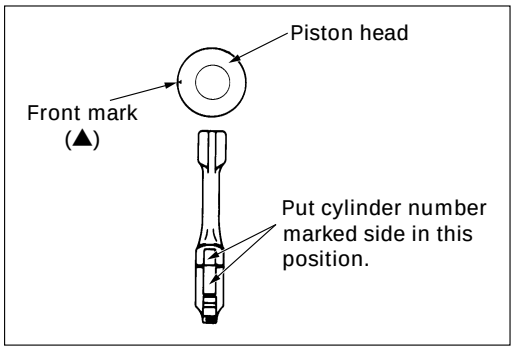
MIRROR COMPONENT

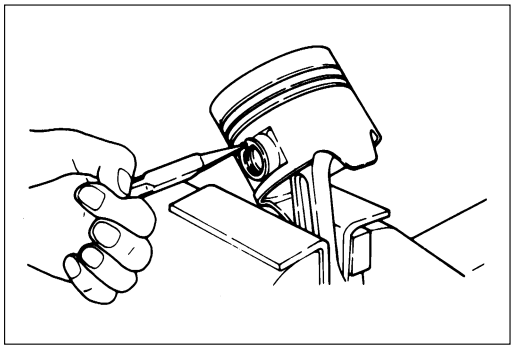


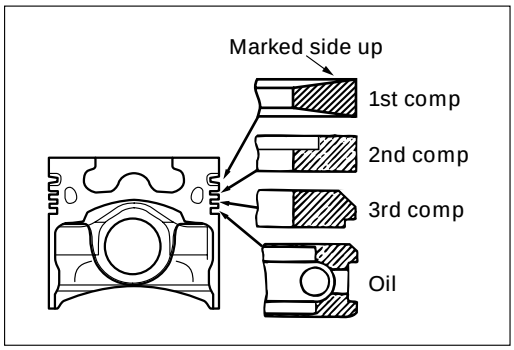
Reassembly Steps

▲ 1. Piston
▲ 2. Connecting-rod
▲ 3. Piston pin, Snap ring
▲ 4. Piston ring
▲ 5. Connecting rod bearing









PISTON AND CONNECTING ROD

Important Operations

1. Piston

Use a piston heater to heat the pistons to approximately 60°C (140°F).

2. Connecting Rod

1) Install the connecting rod to the piston with setting the marks as illustrated.
2) Install the piston pin into the piston and the connecting rod bushing.

Refer the description of piston pin in page 4-19.

3. Piston Pin, Snap Ring

1) Use a pair of snap ring pliers to install the piston pin snap ring.
2) Check that the piston moves smoothly on the piston pin.

4. Piston Ring

1) Use a piston ring installer to install the three piston rings.

   Piston Ring Installer

   Install the piston rings in the following order.

   (1) Oil ring
   (2) 3rd compression ring
   (3) 2nd compression ring
   (4) 1st compression ring

   The marked side of the three compression rings must be facing up.

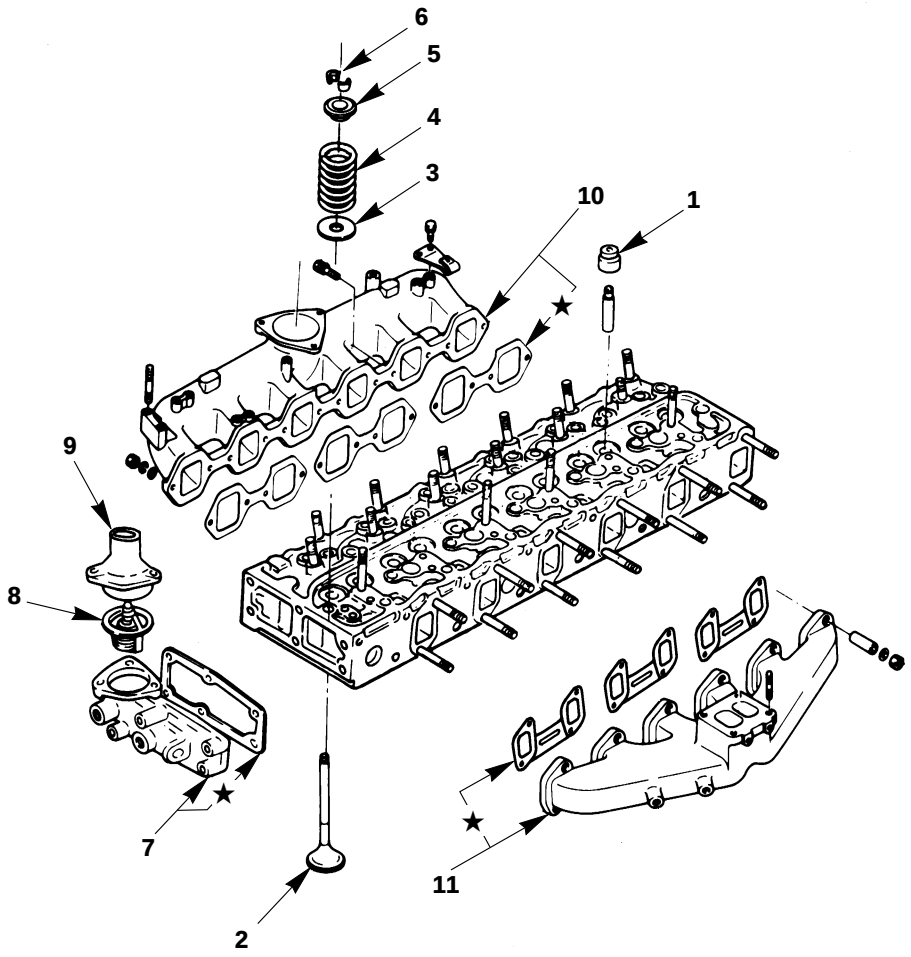
   The undercut side of the 3rd compression ring will be facing down.

   As the oil ring has no any facing mark, it may face in either direction.
2) Lubricate the piston ring surfaces with engine oil.
3) Check that the piston rings rotate smoothly in the piston ring grooves.

5. Connecting Rod Bearing

1) Install the connecting rod bearings to the connecting rod large-end and the connecting rod cap.
2) Install the bearing cap to the connecting rod with semi-tightening the cap bolts.
3) Lubricate the bearing with engine oil.

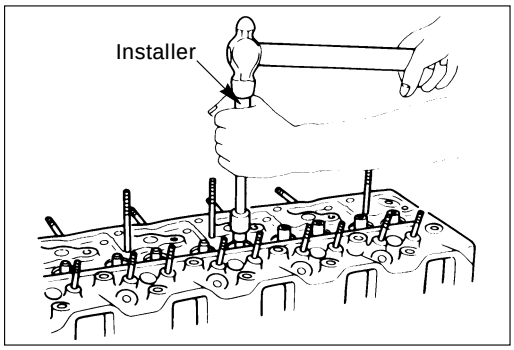
CYLINDER HEAD REASSEMBLY STEPS



★ : Repair kit

Reassembly Steps

- ▲ 1. Valve stem oil seal
- ▲ 2. Intake and exhaust valves
- 3. Spring seat (Lower)
- ▲ 4. Intake and exhaust valve springs
- 5. Spring seat (Upper) or valve rotator
- ▲ 6. Spring seat split collar
- 7. Thermostat housing and gasket
- 8. Thermostat
- 9. Water outlet pipe
- ▲ 10. Intake manifold and gasket
- ▲ 11. Exhaust manifold and gasket

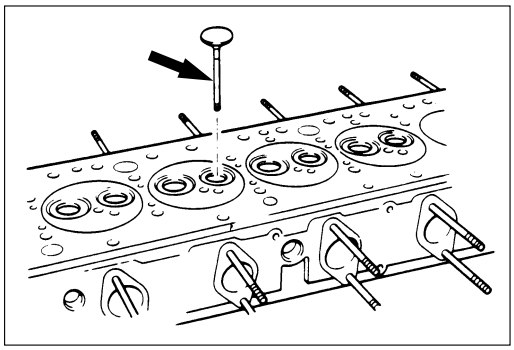


Important Operations

1. Valve Stem Oil Seal

1) Lubricate the oil seals and valve stem sealing areas with engine oil.
2) Use a valve stem oil seal installer to install the oil seal.

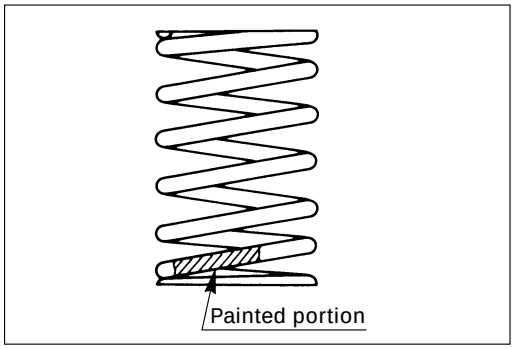
   Valve Stem Oil Seal Installer: 1-85221-005-0



2. Intake and Exhaust Valves

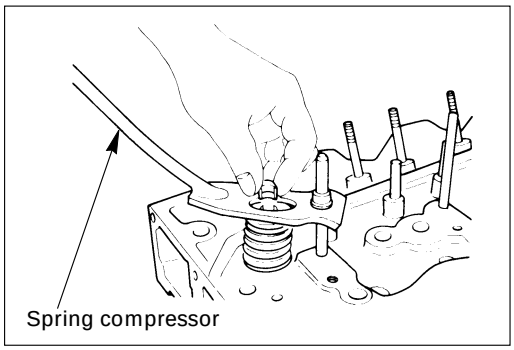
1) Place the cylinder head on a flat wooden surface.
2) Lubricate valve stems with engine oil.
3) Install the valves to the intake or exhaust guides.

   Install the valves to their original lapped valve seats.



4. Intake and Exhaust Valve Springs

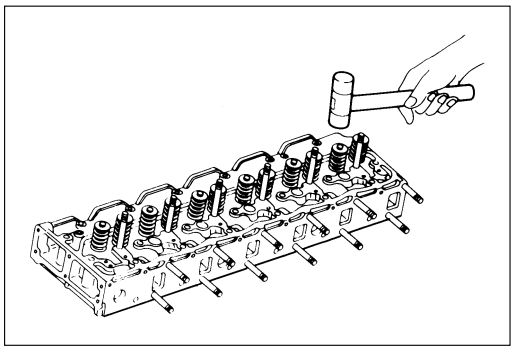
Install the valve springs with their painted end (the close pitched end) facing down.

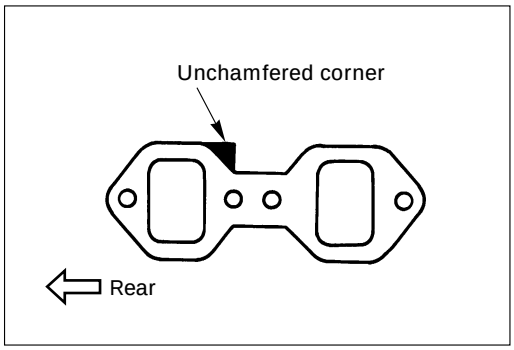


6. Spring Seat Split Collar

1) Use a spring compressor to push the valve spring into position.
2) Install the spring seat split collar.
3) Set the spring seat split collar by tapping lightly around the head of the collar with a rubber hammer.

   Spring Compressor: 1-85235-006-0





10. Intake Manifold and Gasket

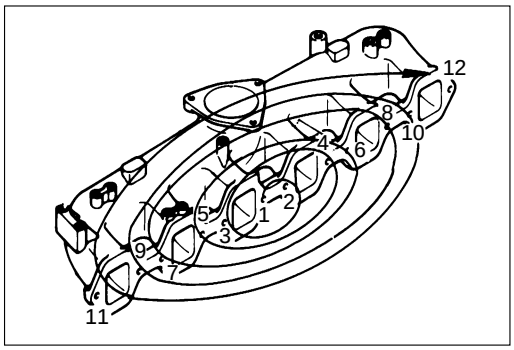
1) Install the intake manifold gasket.

   The intake manifold gasket must be installed with its unchamfered corner facing up and to the front of the engine.

   Refer to the illustration.

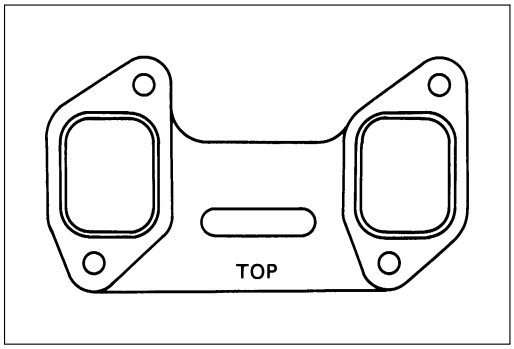
2) Install the intake manifold.

3) Tighten the intake manifold bolts to the specified torque a little at a time in the numerical order shown in the illustration.



N·m (kgf·m/lb.ft)

Intake Monifold Bolt Torque	4B	14–24 (1.4–2.4/10–17)
	6B	21–30 (2.1–3.1/15–22)



11. Exhaust Manifold and Gasket

1) Install the exhaust manifold gasket.

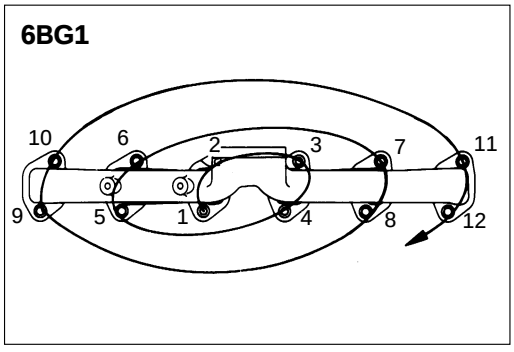
   The "TOP" mark must be facing up.

2) Install the exhaust manifold.

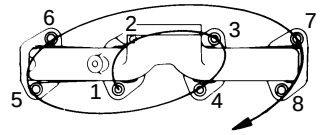
3) Tighten the exhaust manifold bolts to the specified torque a little at a time in the numerical order shown in the illustration.

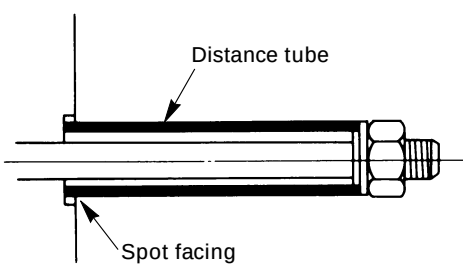
N·m (kgf·m/lb.ft)

Exhaust Manifold Bolt Torque	4B	16–25 (1.6–2.6/12–19)
	6B	25–31 (2.6–3.2/19–23)



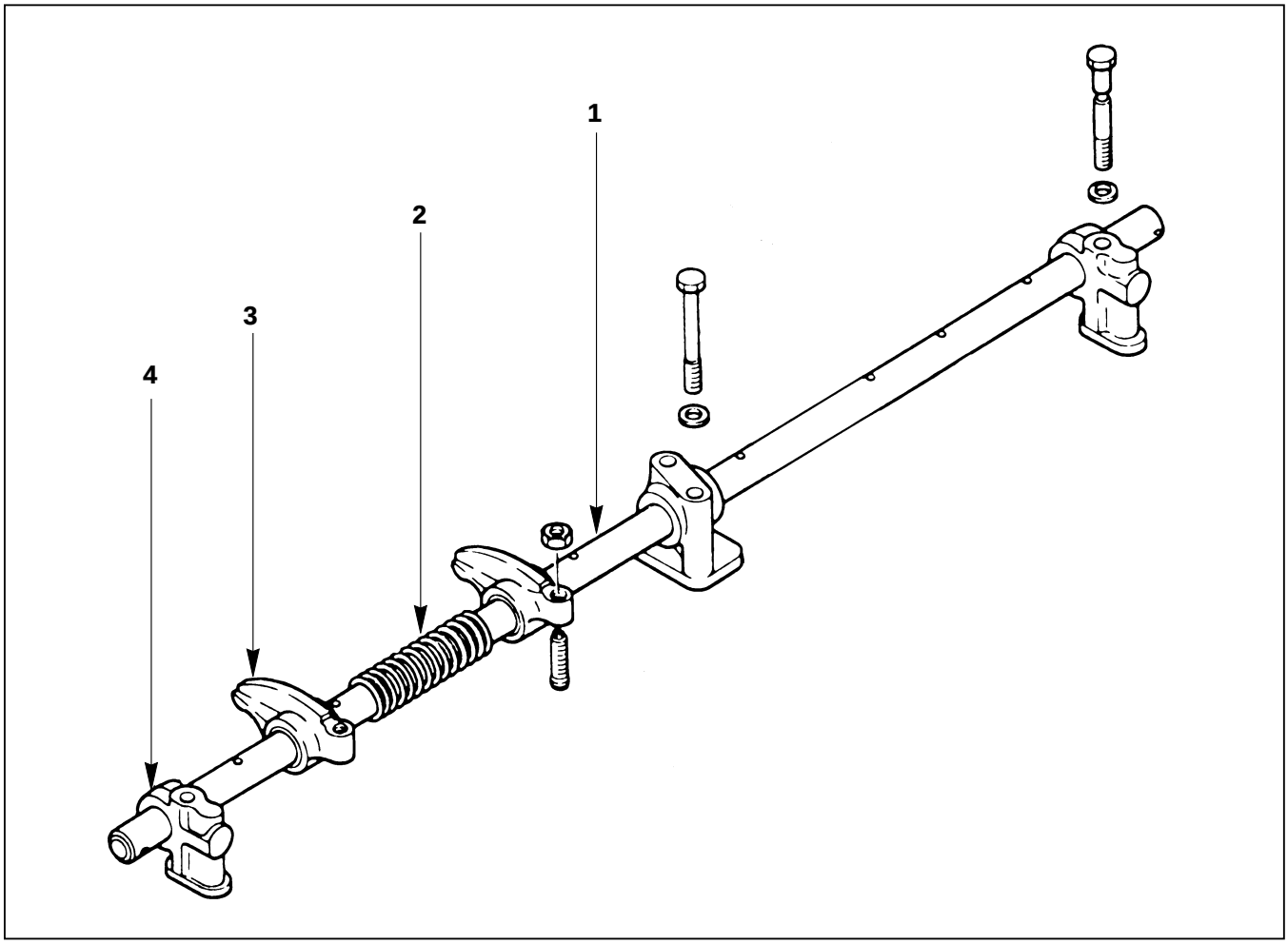
4BG1





4) Install either end of the distance tube to the spot facing (6B series engine only).

ROCKER ARM AND ROCKER ARM SHAFT REASSEMBLY STEPS



Reassembly Steps

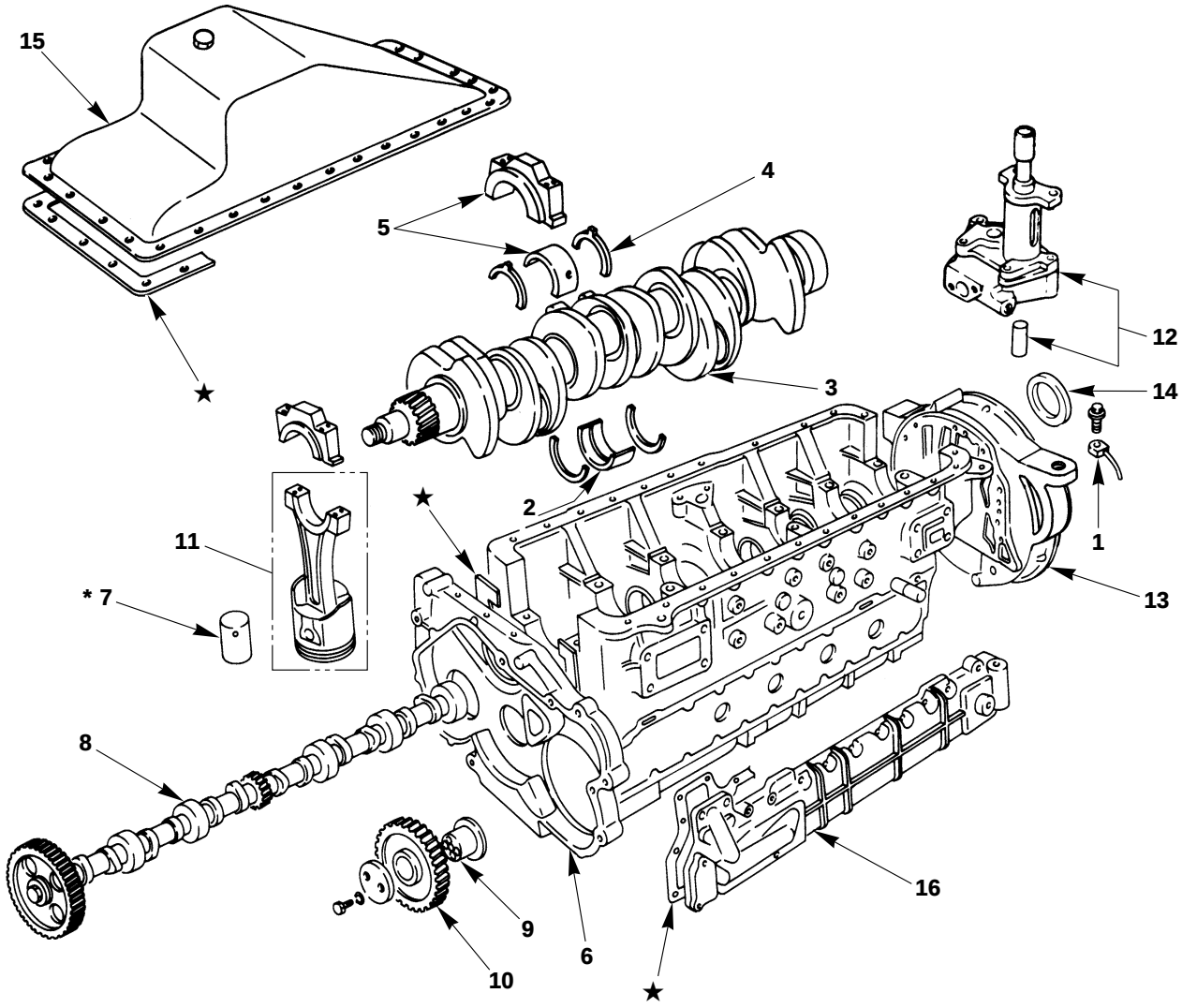
▲ 1. Rocker arm shaft
2. Spring
3. Rocker arm
4. Bracket

Important Operation

1. Rocker Arm Shaft

The rocker arm shaft must be installed with the oil ports facing up.

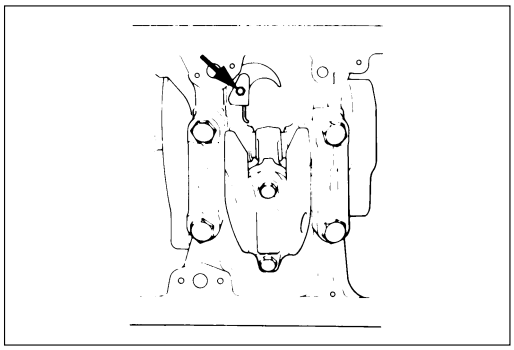
MAJOR COMPONENT REASSEMBLY STEPS I



Reassembly Steps

- ▲ 1. Oil jet
- ▲ 2. Crankshaft bearing (upper half)
- 3. Crankshaft
- ▲ 4. Thrust bearing
- ▲ 5. Crankshaft bearing (lower half) and crankshaft bearing cap
- ▲ 6. Timing gear case
- * 7. Tappet
- ▲ 8. Camshaft
- ▲ 9. Idler gear shaft
- ▲ 10. Idler gear
- ▲ 11. Piston and connecting rod
- ▲ 12. Oil pump and coupling
- ▲ 13. Flywheel housing
- ▲ 14. Rear oil seal
- ▲ 15. Oil pan
- ▲ 16. Oil cooler

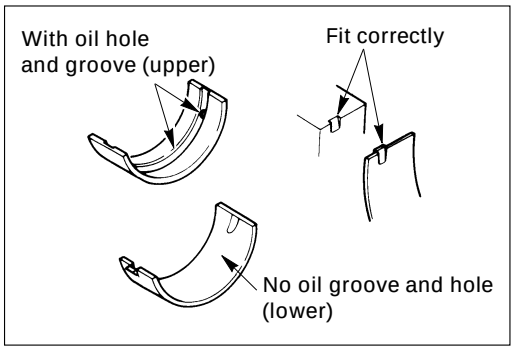
* The tappet must be installed before the camshaft installation.



Important Operations

1. Oil Jet

Install the oil jets taking care not to damage the oil jet nozzles.



N·m (kgf·m/lb.ft)

Oil Jet Torque	16–25 (1.6–2.6/12–19)

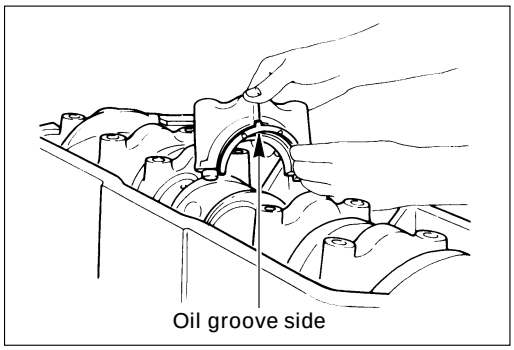
2. Crankshaft Bearing (Upper Half)

5. Crankshaft Bearing (Lower Half) and Crankshaft Bearing Cap

The Crankshaft Bearing Configuration

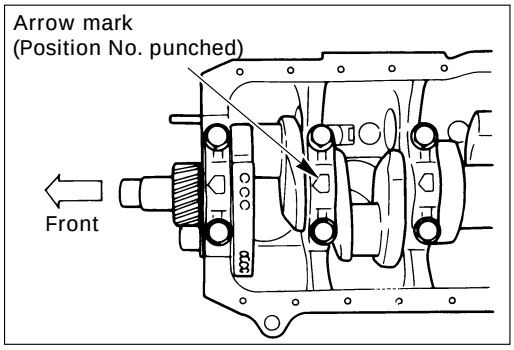
		With Oil Groove	Without Oil Groove
Bearing Upper Half	4B	All Upper Halves	—
	6B	All Upper Halves	—
Bearing Lower Half	4B	All Lower Halves Except Center Bearing	Center Bearing Only
	6B	—	All Lower Halves

Take care not to misinstall the bearing halves.



4. Thrust Bearing

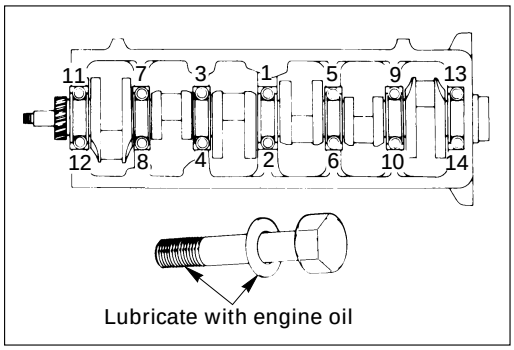
Install the thrust bearings with the oil groove side facing the crankshaft sliding face.



5. Crankshaft Bearing Cap

1) Lubricate the bearing cap bolts with engine oil.
2) Install the bearing caps to the crankshaft.

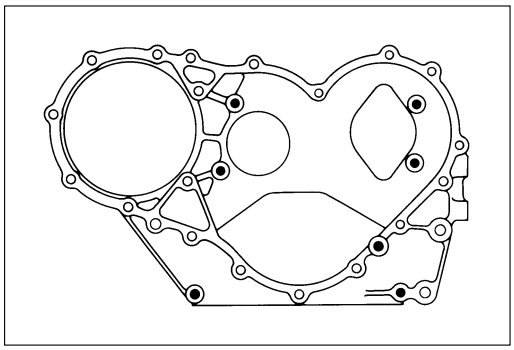
   The arrow mark must be pointing to the front of the engine.
3) Tighten the bearing cap bolts to the specified torque a little at a time in the numerical order shown in the illustration.



N·m (kgf·m/lb.ft)

Crankshaft Bearing Cap Bolt Torque	226–245 (23.0–25.0/166–181)

4) Check that the crankshaft turns smoothly by manually rotating it.

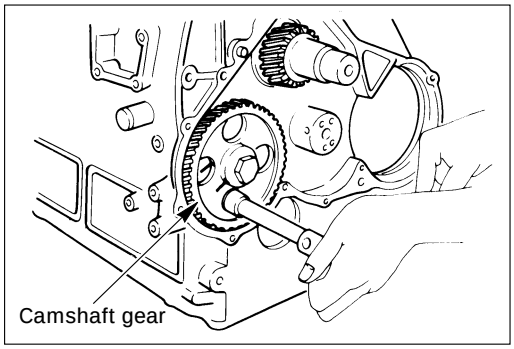


6. Timing Gear Case

1) Apply liquid gasket to the timing gear case surfaces contacting the cylinder body.
2) Tighten the timing gear case bolts to the specified torque.

N·m (kgf·m/lb.ft)

Timing Gear Case Bolt Torque	21–30 (2.1–3.1/15–22)



8. Camshaft

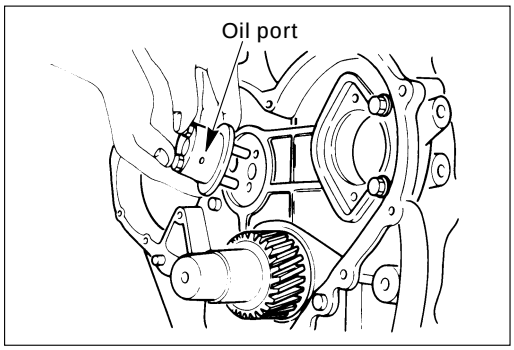
Tighten the thrust plate bolts through the camshaft gear hole.

N·m (kgf·m/lb.ft)

Thrust Plate Bolt Torque	21–30 (2.1–3.1/15–22)

N·m (kgf·m/lb.ft)

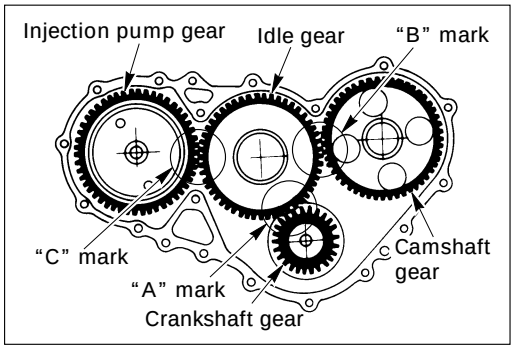
Camshaft Gear Bolt Torque	142–172 (14.5–17.5/105–127)



9. Idler Gear Shaft

Use the thrust collar fixing bolt as a guide to install the idler gear shaft.

The oil port must be facing the camshaft.



10. Idler Gear

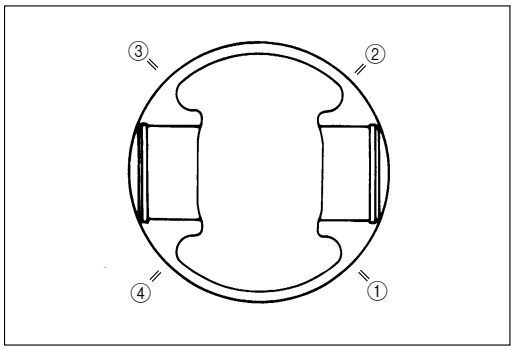
1) Install the idler gear.

   Set the timing marks [A] and [B] as shown in the illustration.
2) Tighten the idler gear bolts seating the thrust collar to the specified torque.

   The thrust collar must be installed with the chamfered side facing the front of the engine.

N·m (kgf·m/lb.ft)

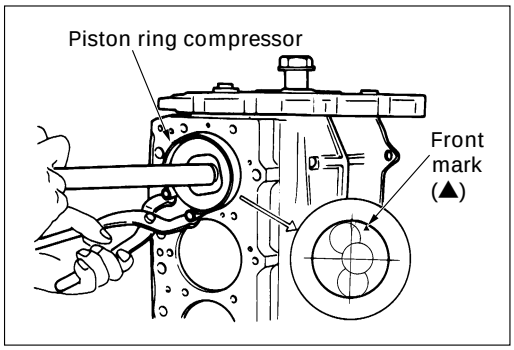
Idle Gear Bolt Torque	4B	42–62 (4.3–6.3/31–46)
	6B	44–64 (4.5–6.5/33–47)



11. Piston and Connecting Rod

Position the piston ring gaps as shown in the illustration.

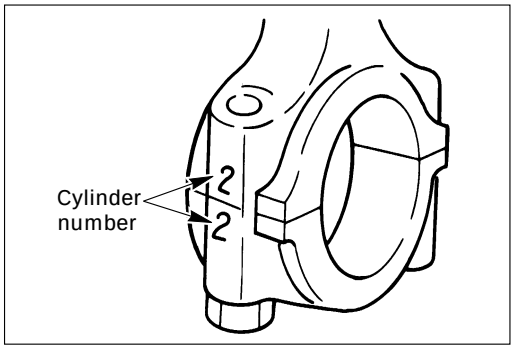
1) Set the piston ring gaps as shown in the illustration.
2) Lubricate the piston, the piston rings, and the connecting rod bearings with engine oil.
3) Position the piston front mark towards the front of the engine.



4) Use the piston ring compressor to compress the piston rings.

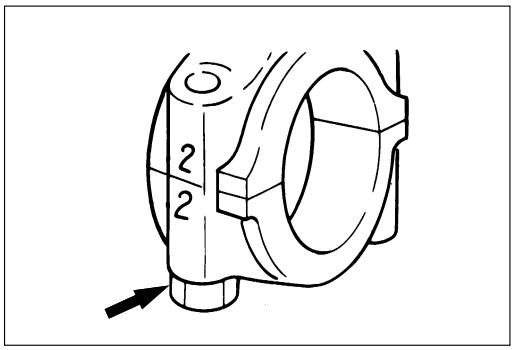
   Piston Ring Compressor: 9-8522-1251-0
5) Use a hammer grip to push the piston in until it makes contact with the crankpin.

   At the same time, rotate the crankshaft until the crankpin reaches its highest point.



6) Set the bearing cap cylinder number marks and the connecting rod cylinder number marks.

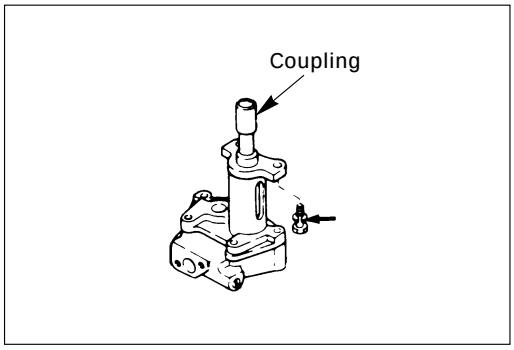
   The marks must be facing the exhaust manifold.



7) Lubricate the connecting rod cap bolt threads and setting fases with Mos grease.
8) Use the angular tightening method to tighten the connecting rod cap bolts to the specified torque.

N·m (kgf·m/lb.ft)

	1st step	2nd step
Connecting Rod Bolt Torque and Angle	39 (4/29)	60°–90°

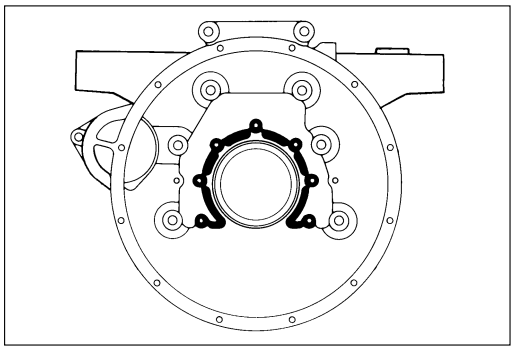


12. Oil Pump and Coupling

1) Lubricate the oil pump with the specified grade of engine oil.
2) Install the oil pump with the coupling.
3) Tighten the oil pump bolts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Pump Bolt Torque	42–62 (4.3–6.4/31–46)



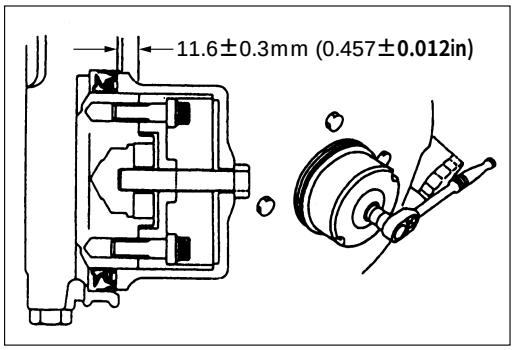
13. Flywheel Housing

1) Apply a sealant to the shaded area of the illustration.
2) Install the flywheel housing.

   Tighten the flywheel housing bolts to the specified torque.

N·m (kgf·m/lb.ft)

Flywheel Housing Bolt Torque	Outer Bolt	147–167(15.0–17.0/108–123)
	Inner Bolt	21–30 (2.1–3.1/15–22)



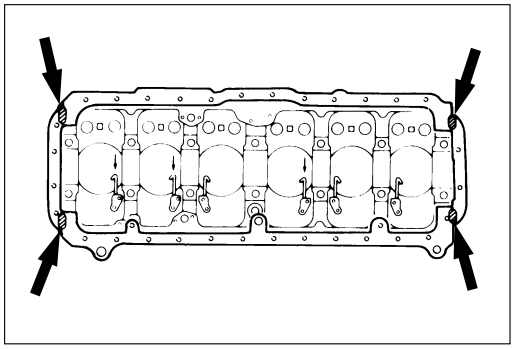
14. Rear Oil Seal (Axial Type)

1) Tighten the adapter to the crankshaft rear and section with 2 bolts.
2) Insert the oil seal into the peripheral section of adapter.
3) Insert the sleeve into the adapter section, and 1) tighten it with a bolt until the adapter section hits the sleeve.
4) Remove the adapter and the sleeve.
5) With the seal pressed in, check the dimension of the oil seal section.

   Standard Dimension = 11.6 ± 0.3 mm
   (0.457 ± 0.012 in)

   Oil Seal Installer:

   4BG1 5-8840-2357-0
   6BG1 5-8840-9025-0



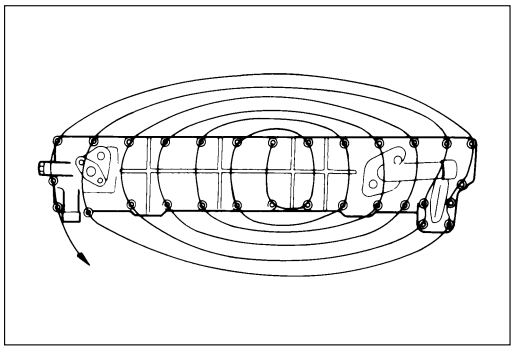
15. Oil Pan

1) Apply sealant to the area indicated by the arrows in the illustration.
2) Install the oil pan gasket
3) Install the oil pan.

   Tighten the oil pan bolts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Pan Bolt Torque	21–30 (2.1–3.1/15–22)



16. Oil Cooler

1) Apply sealant to the oil cooler gasket.
2) Install the oil cooler gasket to the oil cooler body case.
3) Install the oil cooler.

   Tighten the oil cooler bolts to the specified torque.

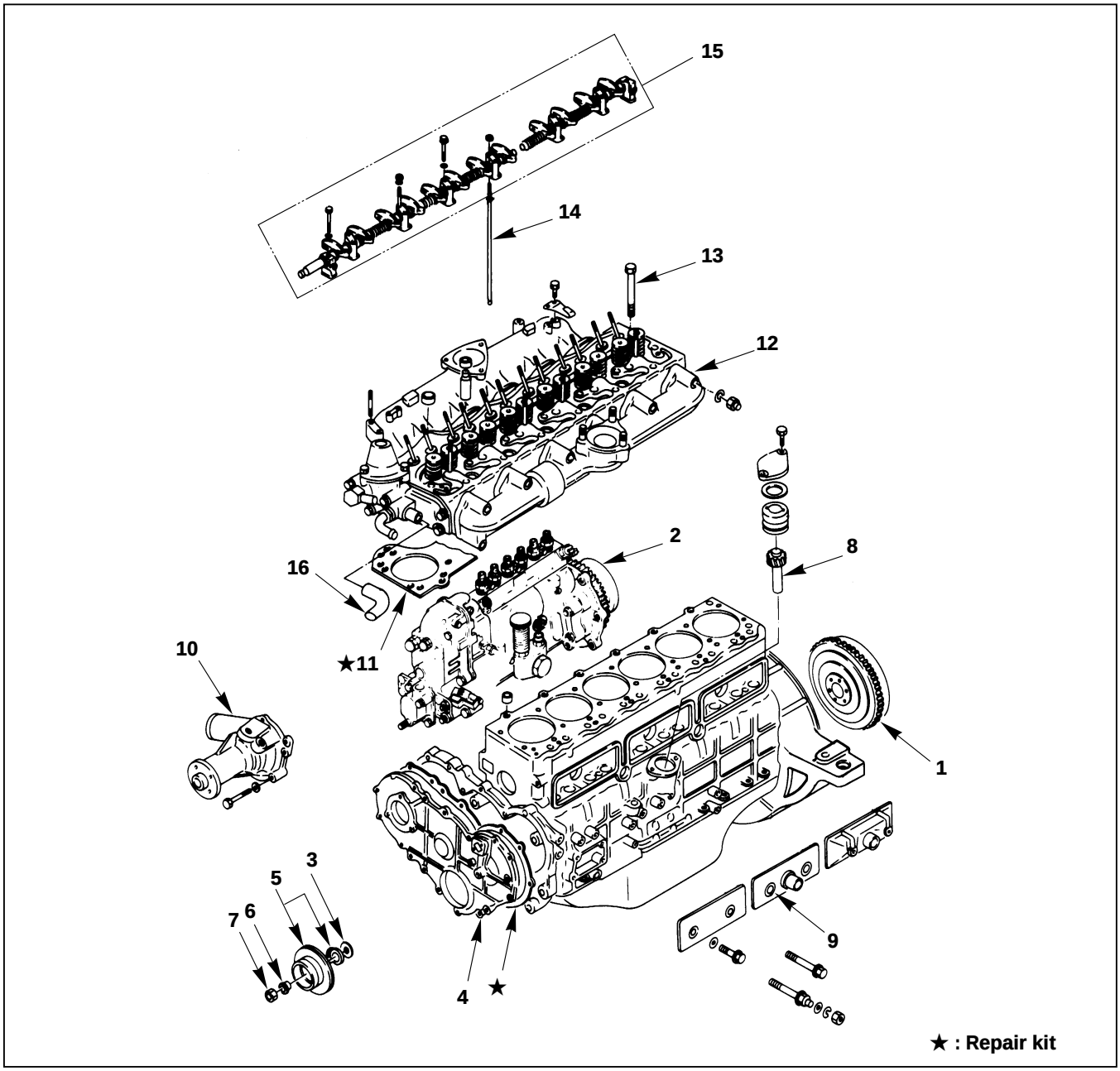
   Start from the middle and work out to either side.

   Refer to the illustration

N·m (kgf·m/lb.ft)

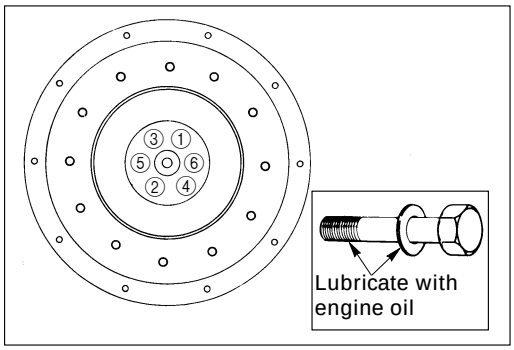
Oil Cooler Torque	4B	16–25 (1.6–2.6/12–19)
	6B	14–24 (1.4–2.4/10–17)

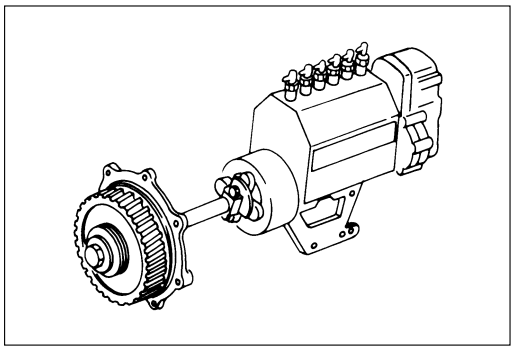
MAJOR COMPONENT REASSEMBLY STEPS II

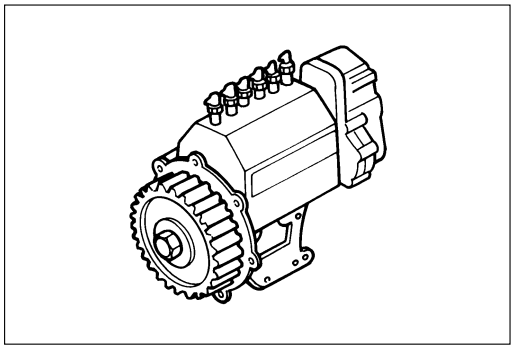


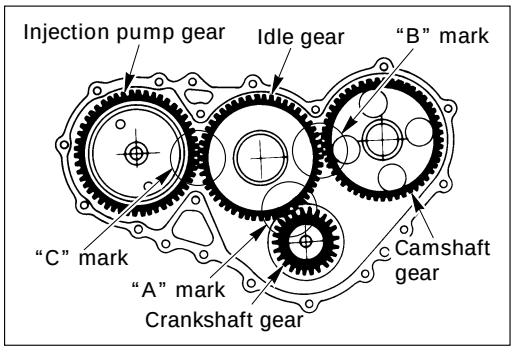
Reassembly Steps

- ▲ 1. Flywheel
- ▲ 2. Injection pump and injection pump gear
- 3. Oil thrower
- 4. Timing gear cover
- 5. Crankshaft pulley and dust thrower
- 6. Taper bushing
- ▲ 7. Crankshaft pulley nut
- 8. Oil pump driving pinion
- ▲ 9. Tappet chamber cover
- ▲ 10. Water pump
- ▲ 11. Cylinder head gasket
- ▲ 12. Cylinder head
- ▲ 13. Cylinder head bolt
- 14. Push rod
- ▲ 15. Rocker arm and rocker arm shaft
- 16. Rubber hose (Water by-pass)









Important Operations

1. Flywheel

1) Lubricate the flywheel bolt threads.
2) Install the flywheel.

   The crankshaft rear end dowel pin and the flywheel dowel hole must be aligned.
3) Tighten the flywheel bolts to the specified torque in the numerical order shown in the illustration.

N·m (kgf·m/lb.ft)

Flywheel Bolt Torque	4B engine	142–172(14.5–17.5/105–127)
	6B engine	197–240(20.1–24.5/145–177)

2. Injection Pump and Injection Pump Gear Assembly

1) Install the injection pump bracket with the injection pump to the timing gear case.

   Dowel the injection pump bracket with the timing gear case.
2) Tighten the injection pump bolts to the specified torque.

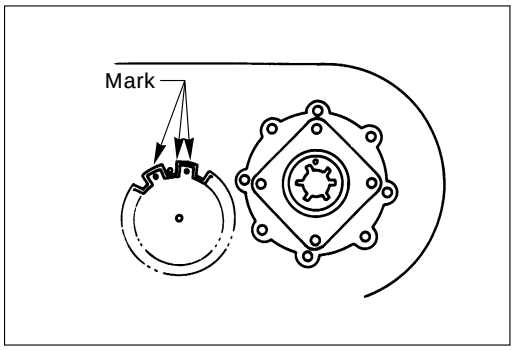
N·m (kgf·m/lb.ft)

Injection Pump Bolt Torque	21 – 30 (2.1 – 3.1/15 – 22)

3) Align the injection pump gear "C" timing mark with the idler gear "C" timing mark.

Air Compressor Installation (If so equipped)

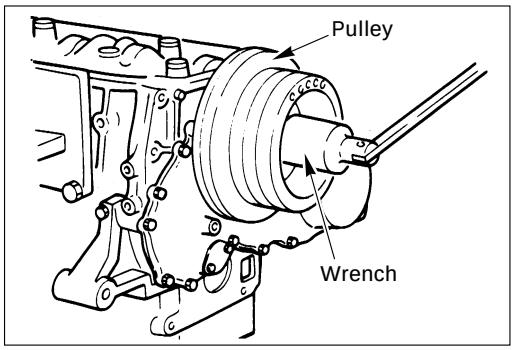
1. Align the air compressor crankshaft spline end marks and the injection pump drive gear shaft female spline marks.



2. Install the air compressor
3. Tighten the air compressor mounting bolts.

After installing the air compressor, perform Step 3 of "Injection Pump and Injection Pump Gear Assembly" (on the following page).

Refer to injection timing in section MAINTENANCE to check the injection timing for correctness.

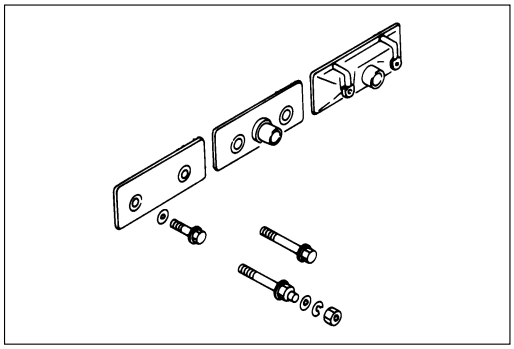


7. Crankshaft Pulley Nut

1) Apply MoS_2 to the crankshaft pulley nut threads and fitting face.
2) Use the appropriate wrench to tighten the crankshaft pulley nut to the specified torque.

N·m (kgf·m/lb.ft)

Crankshaft Pulley Nut Torque	4B	382–481 (39–49/282–354)
	6B	539–637 (55–65/378–470)

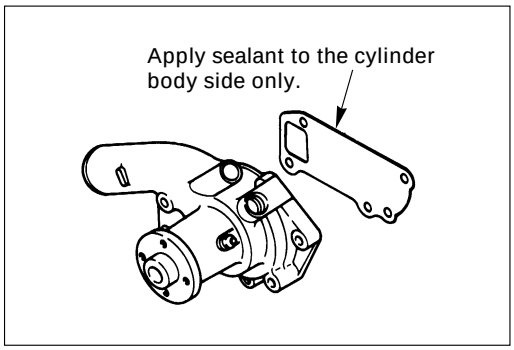


9. Tappet Chamber Cover

1) Apply sealant (TB 1207B) to the tappet chamber cover.
2) Install the tappet chamber cover and tighten the bolts to the specified torque.

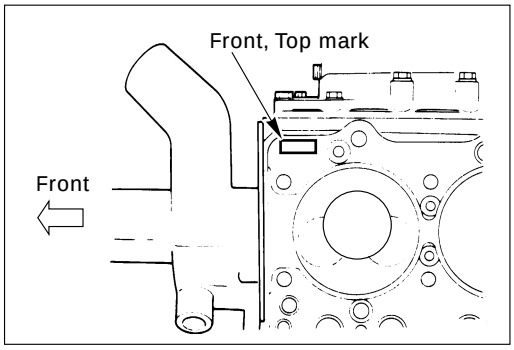
N·m (kgf·m/lb.ft)

Tappet Chamber Cover Bolt Torque	21–30 (2.1 – 3.1/15 – 22)



10. Water Pump

Apply sealant (Belco Bond No. 4) to the water pump gasket before installing the water pump.



11. Cylinder Head Gasket

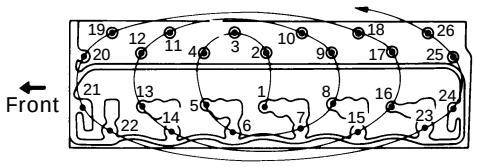
12. Cylinder Head

13. Cylinder Head Bolt

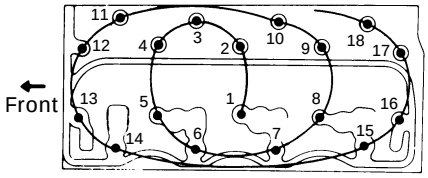
1) Carefully place the cylinder head gasket on the cylinder body upper surface.

   The gasket "TOP" mark must be facing up.
2) Align the cylinder body dowels and the cylinder head dowel holes.

6B series



4B series



3) Carefully place the cylinder head on the cylinder body.
4) Tighten the cylinder head bolt as follows.
   1) As cylinder head bolts have two kinds of length, install them at proper location.

      The shorter ones (4B series; 4 bolts, 6B series; 6 bolts) must be used at the injection pump side.
   2) Follow the numerical sequence shown in the illustrations.
   3) The cylinder head bolt tightening method vary depending on the gasket type to be used.

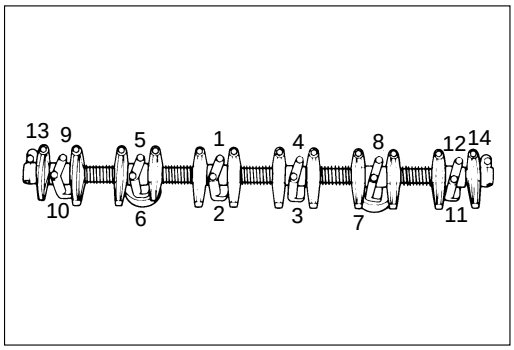
For laminated steel type gasket.

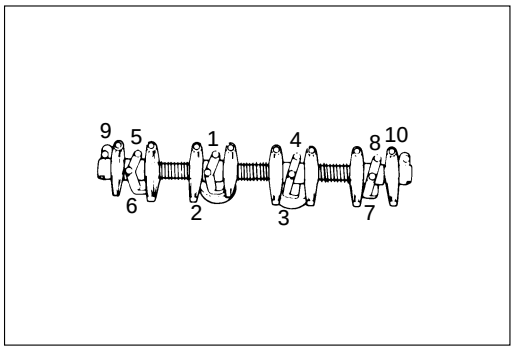
Apply molybdenum disulfide grease to the cylinder head bolt threads and setting faces.

Use the Angular Tightening Method.

N·m (kgf·m/lb.ft)

	1st step	2nd step	3rd step
Bolt Torque	69 (7.0/51)	88 (9.0/65)	90°–120°





15. Rocker Arm and Rocker Arm Shaft

1) Check that the rocker arm shaft bracket lower surface oil port is free from obstruction.
2) Install the rocker arm shaft with the bracket to the cylinder head.
3) Tighten the rocker arm bracket bolts to the specified torque a little at a time in the numerical order shown in the illustration.
4) Lubricate the rocker arm and the rocker arm shaft with engine oil.

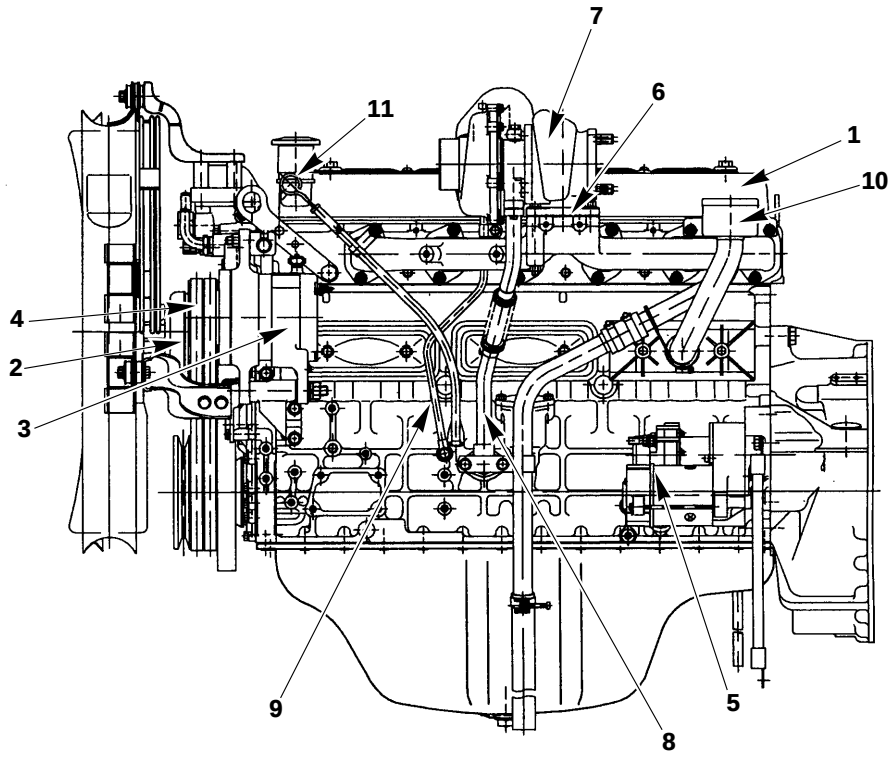
N·m (kgf·m/lb.ft)

Rocker Arm Shaft Bracket Bolt and Nut Torque	6B	25–35 (2.6–3.6/19–26)
	4B	20–29 (2.0–3.0/15–22)

5) Adjust the valve clearance.

   Refer to MAINTENANCE for the valve clearance adjustment procedure.

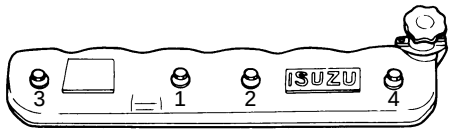
EXTERNAL PARTS REASSEMBLY STEPS (Left-hand side)



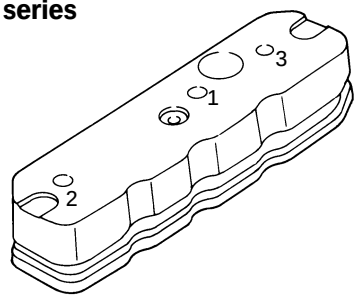
Reassembly Steps

- ▲ 1. Cylinder head cover
- 2. Fan pulley
- 3. Alternator
- ▲ 4. Fan belt
- ▲ 5. Starter
- ▲ 6. Turbocharger mounting flange gasket.
- ▲ 7. Turbocharger
- ▲ 8. Oil drain pipe
- ▲ 9. Oil feed pipe
- 10. Air breather
- 11. Dipstick and guide tube

6B series



4B series



Important Operations

1. Cylinder Head Cover

1) Check that the rocker arms, the rocker arm shafts, and the valve springs are thoroughly lubricated with engine oil.

   If required, relubricate these parts.

2) Place the cylinder head cover gasket on the cylinder head cover.

   Check the head cover gasket for looseness.

3) Tighten the cylinder head cover bolts to the specified torque a little at a time in the sequence shown in the illustration.

6B Series — N·m (kgf·m/lb.ft)

Cylinder Head Cover Bolt Torque	7.8 – 9.8 (0.8 – 1.0/5.8 – 7.2)

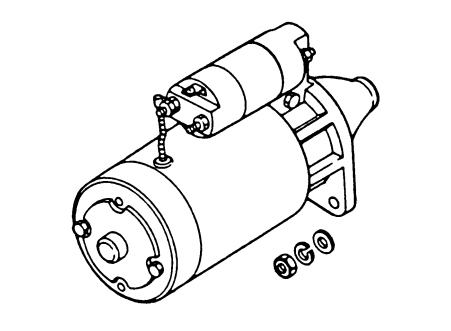
4B Series — N·m (kgf·m/lb.ft)

Cylinder Head Cover Bolt Torque	5.9 – 16 (0.6 – 1.6/4.3 – 12)

4. Fan Belt

Adjust the fan belt tension.

Refer to MAINTENANCE for the fan belt tension adjustment.

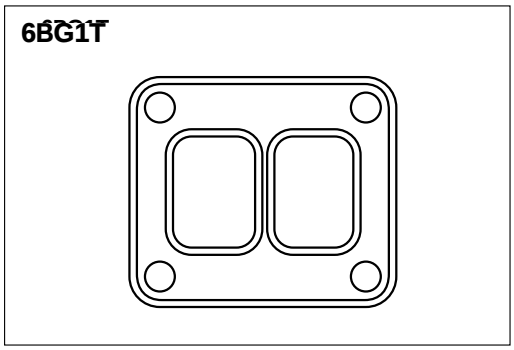


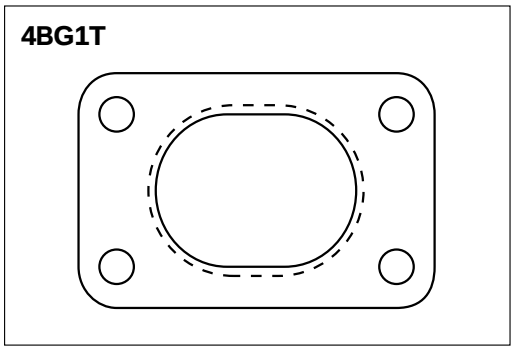
5. Starter

Install the starter to the flywheel housing and tighten the bolts to the specified torque.

N·m (kgf·m/lb.ft)

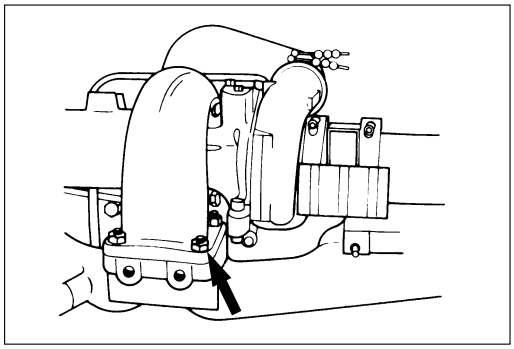
Starter Fixing Bolts Torque	75 – 91 (7.6 – 9.3/55 – 67)





6. Turbocharger Mounting Flange Gasket

Carefully position the gasket with the edged side facing up.



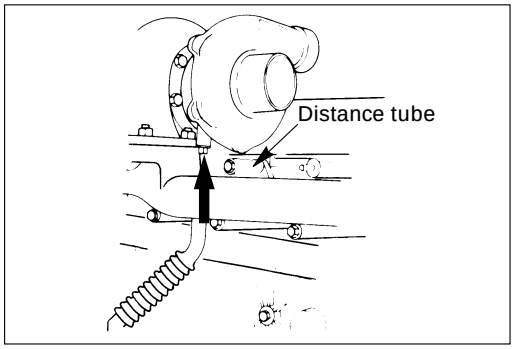
7. Turbocharger (AA-4BG1T, BB-4BG1T, BB-6BG1T)

Semitighten the turbocharger mounting nuts.

The nuts will be fully tightened after installation of the oil pipes.

N·m (kgf·m/lb.ft)

Turbocharger Mounting Nut Torque	6BG1T	42–62(4.3–6.3/31–46)
	4BG1T	22–31(2.2–3.2/16–23)



8. Oil Drain Pipe

1) Remove the exhaust manifold distance tube immediately beneath the turbocharger.

   This will make it easier to install the oil drain pipe.

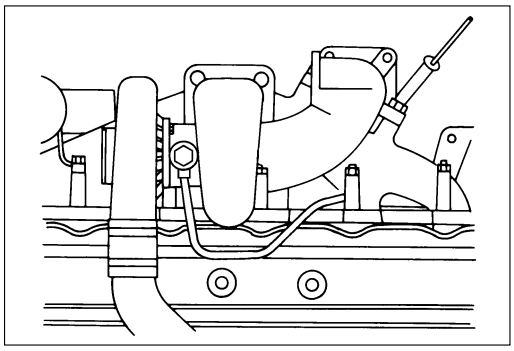
2) Install the oil drain pipe and tighten the oil drain pipe flange nuts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Drain Pipe Torque	28 – 46 (2.9 – 4.7/21 – 34)

3) Reinstall the exhaust manifold distance tube and tighten it to the specified torque.

   Exhaust manifold nut torque is shown in the page 5-6.



9. Oil Feed Pipe

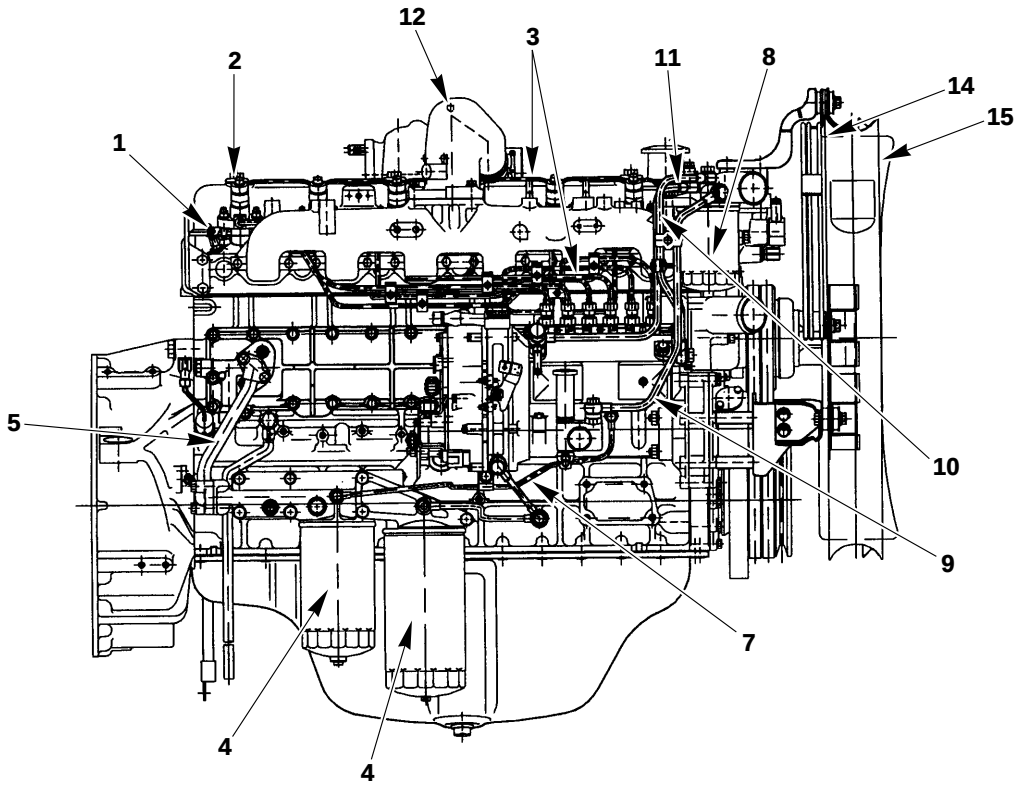
1) Pre-lubricate the turbocharger with CD grade oil through the oil port shown by the arrow in the illustration.
2) Install the oil feed pipe and tighten the pipe flange bolts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Feed Pipe Flange Bolt Torque	16 – 25 (1.6 – 2.6/12 – 19)

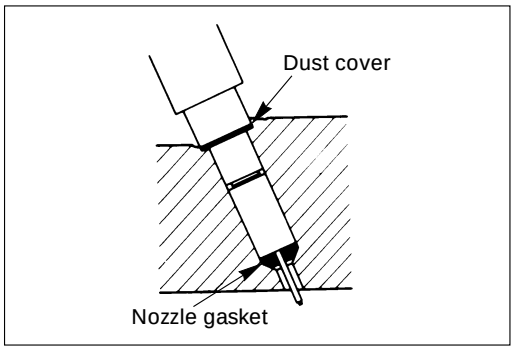
EXTERNAL PARTS REASSEMBLY STEPS (Right-hand Side)

MODEL 6BG1T



Reassembly Steps

1. Glow plug
▲ 2. Injection nozzle
▲ 3. Injection pipe and fuel leak off pipe
▲ 4. Oil filter
5. Oil pipe; filter to cooler
6. Not installed
7. Oil pipe; injection pump to engine body
8. Fuel filter
▲ 9. Fuel pipe; feed pump to fuel filter
▲ 10. Fuel pipe; fuel filter to injection pump
▲ 11. Fuel return pipe
▲ 12. Air duct
13. Not installed
▲ 14. Fan guide
15. Cooling fan



Important Operation

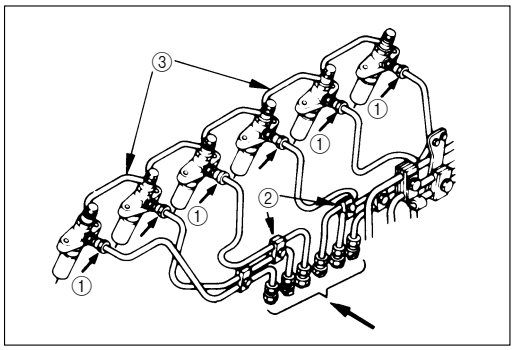
2. Injection Nozzle

Install the injection nozzles with the injection nozzle gaskets.

Be careful not to damage the nozzle tips.

N·m (kgf·m/lb.ft)

Injection Nozzle Bolt Torque	17 – 21 (1.7 – 2.1/12 – 15)



3. Injection Pipe and Fuel Leak Off Pipe

1) Install the fuel injection pipes ① and tighten the bolts to the specified torque.

N·m (kgf·m/lb.ft)

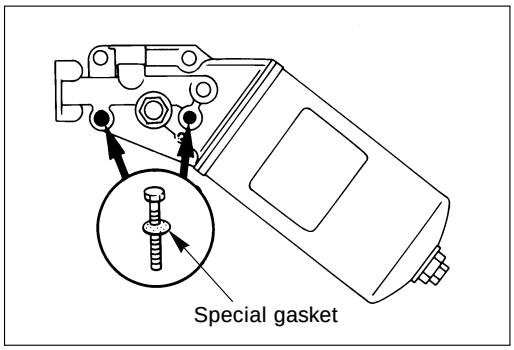
Injection Pipe Torque	28 – 32 (2.9 – 3.3/21 – 24)

2) Carefully position and set the clips ②.

It is very important that each clip be positioned correctly.

An improperly positioned clip will result in objectionable fuel pulsing noise and injection pipe breakage.

3) Install the fuel leak off pipes ③.



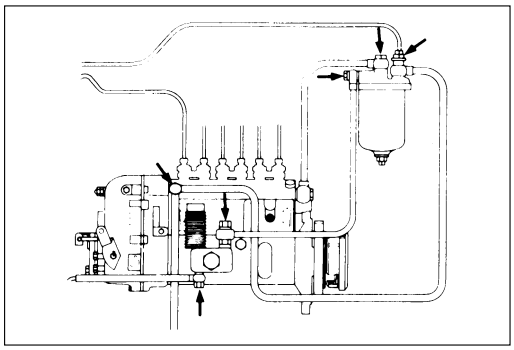
4. Oil filter

(When the oil filter is being removed in an oil filter assembly with the filter cover.)

1) Before the installation, set the special gaskets which are included within the repair kit with the two oil filter mounting bolts.
2) Apply a coat of LOCTITE 271 on the bolt threads to seal the oil leak from the crankcase as illustrated.
3) Install the oil filter assembly with tightening the bolts securely.

N·m (kgf·m/lb.ft)

Oil Filter Assembly Mounting Bolt Torque	4B	30–50 (3.1–5.1/22–37)
	6B	42–62 (4.3–6.3/31–46)



9. Fuel Pipe (Feed Pump to Fuel Filter)

10. Fuel Pipe (Fuel Filter to Injection Pump)

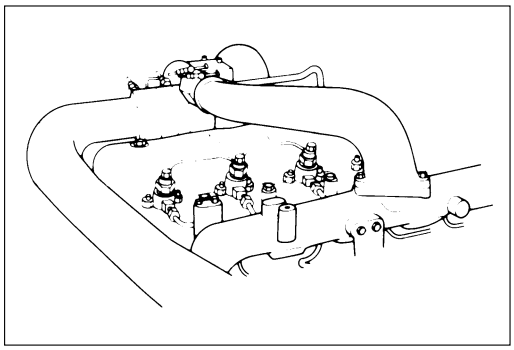
11. Fuel Return Pipe

Install the fuel pipes and tighten the fuel pipe joint bolts to the specified torque.

Take care not to interchange the check valves and joint bolts.

N·m (kgf·m/lb.ft)

Fuel Pipe Joint Bolt Torque	16 – 18 (1.6 – 1.8/12 – 13)

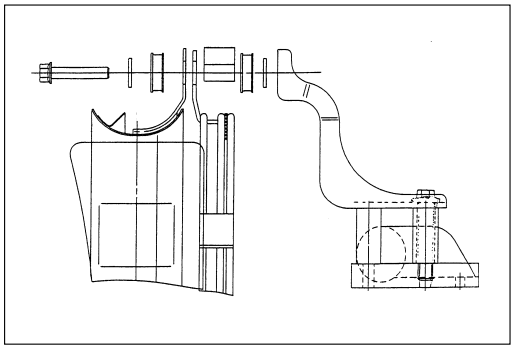


12. Air Duct

Install the air duct and tighten the air duct flange bolts to the specified torque.

N·m (kgf·m/lb.ft)

Intake Pipe Flange Bolt Torque	21 – 30 (2.1 – 3.1/15 – 22)



14. Fan guide

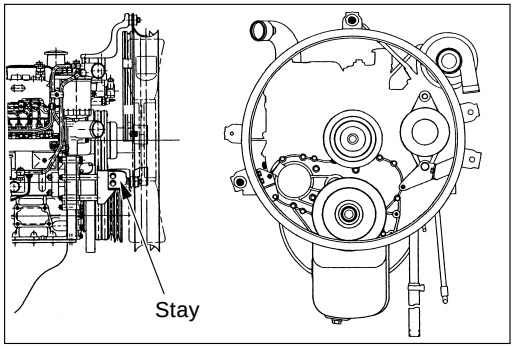
Install the upper bracket, mount rubber, fan guide and fan guard, and tighten the bolts to the specified torque.

N·m (kgf·m/lb.ft)

Mount Rubber Fixing Bolt Torque	30 (3.1/22)

N·m (kgf·m/lb.ft)

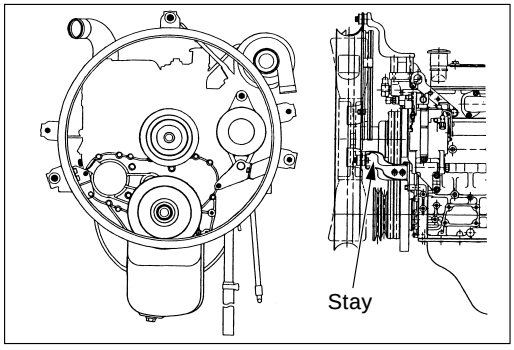
Bracket Fixing Bolt Torgue	40 (4.1/30)



Stay (Right side)

N·m (kgf·m/lb.ft)

Stay Fixing Bolt Torgue	40 (4.1/30)



Stay (Left side)

N·m (kgf·m/lb.ft)

Stay Fixing Bolt Torgue	40 (4.1/30)

Fan and Fan guide clearance

Adjust the clearance between the fan and fan guide.

mm (in)

Clearance between fan and fan guide	4 – 8 (0.157 – 0.315)

Injection Timing Adjustment

Check that the fuel injection timing is correct.

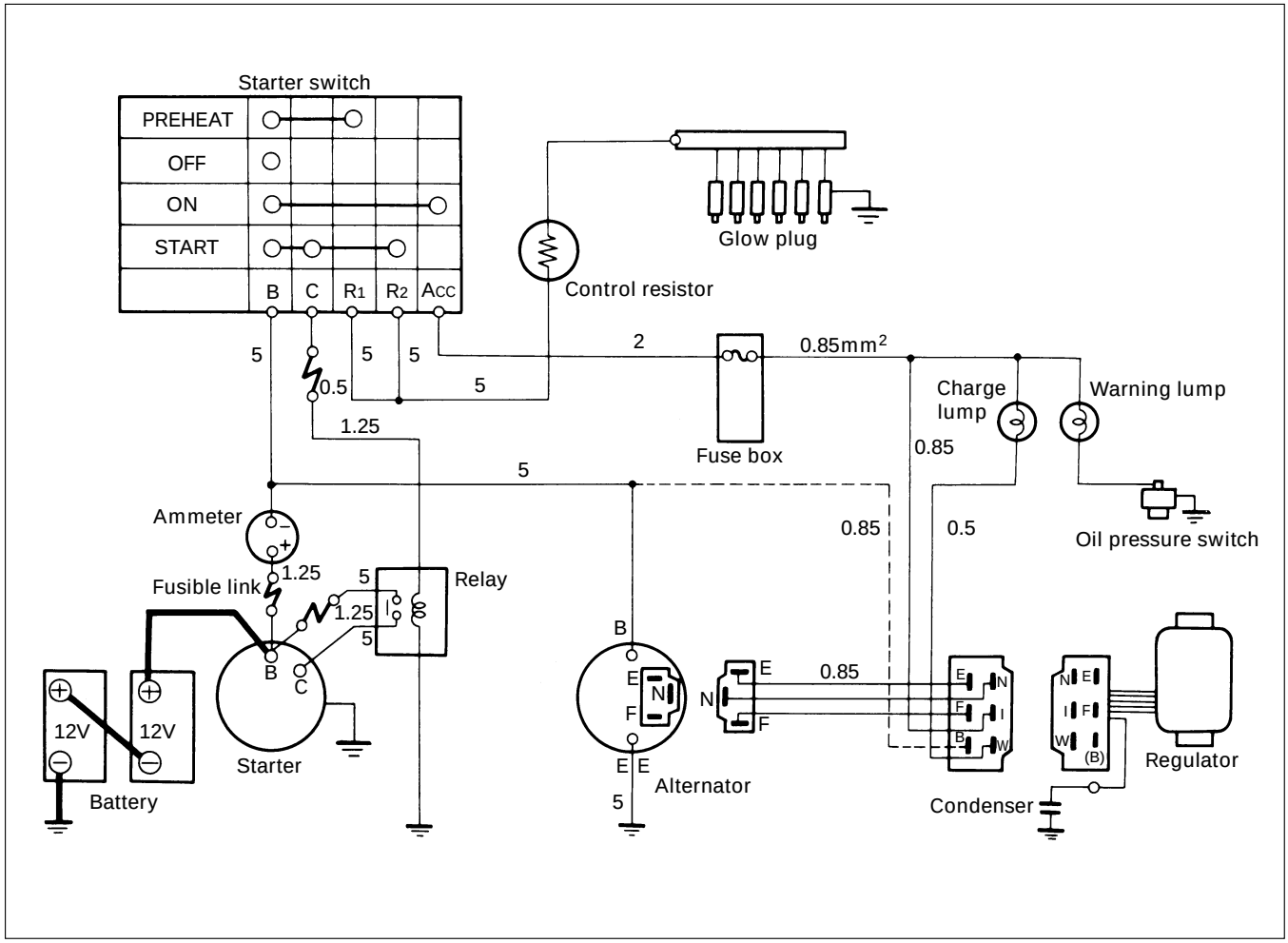
Refer to "MAINTENANCE" for the injection timing adjustment.

ENGINE TUNING OPERATION

After reassembly, the engine must be tuned. This will ensure that the engine operates at its maximum efficiency.

1. Mount the engine on a test bench.
2. Fill the engine with the specified oil.
3. Connect the cooling pipes and the fuel pipes.

Reference



4. Connect the electrical wiring.

   Refer to the wiring diagram.
5. Connect the air intake line to the air cleaner.
6. Connect the exhaust pipe.
7. Manually operate the fuel feed pump to feed fuel to the engine.
8. Bleed the fuel lines of air.

   Refer to Page 2-6 of Section 2 MAINTENANCE for the air bleeding procedure.

9. Crank the engine with the starter (non-ignition operation) for about twenty seconds.

   This will prelubricate the engine internal components.

10. Start the engine and allow it to run at 750 to 800 rpm for five minutes.

11. Remove the cylinder head cover while the engine is running.

12. Check that the engine oil is continuously circulating from the oil pump to the valve rockers through the cylinder head.

    If there is no oil circulation or if the oil circulation is sluggish, stop the engine and make the appropriate repairs or adjustments.

    Reinstall the cylinder head cover.

13. Increase the engine speed to 1,500 rpm to do the engine warming-up operation.

14. Check the engine for oil, fuel, coolant, and air intake leakage.

15. Check for abnormal noise and odor.

16. Check for abnormal electrical charging.

17. Check the engine fastening parts for looseness.

18. When the engine coolant temperature reached to 75°C (167°F) or more, increase the engine speed to 2,000 rpm and allow it to run for twenty minutes.

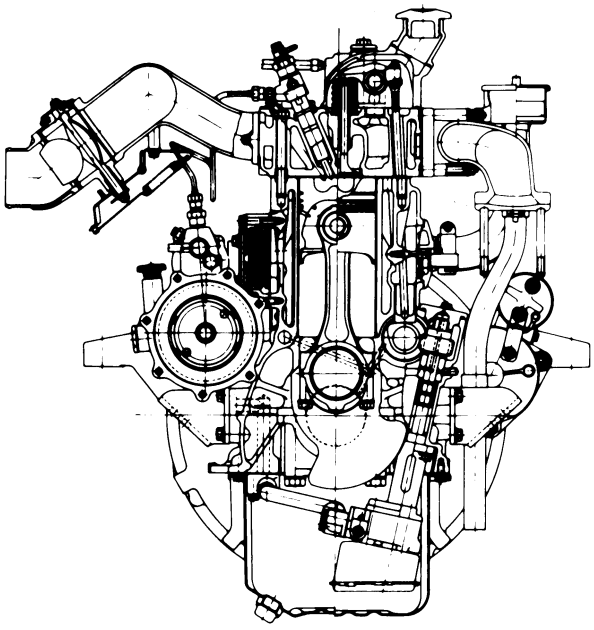
    This will give the engine the essential run-in operating time.

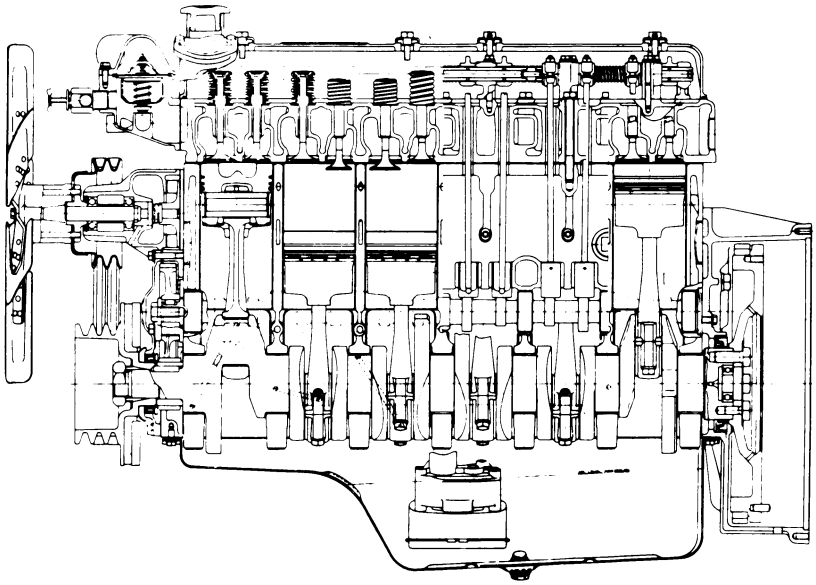
19. Adjust the engine operation speed to the specified value.

20. Stop the engine to complete the tuning procedure.

ENGINE SECTIONAL VIEW

For your reference:





Note: This sectional drawing is based on 6BG1 standard engine.

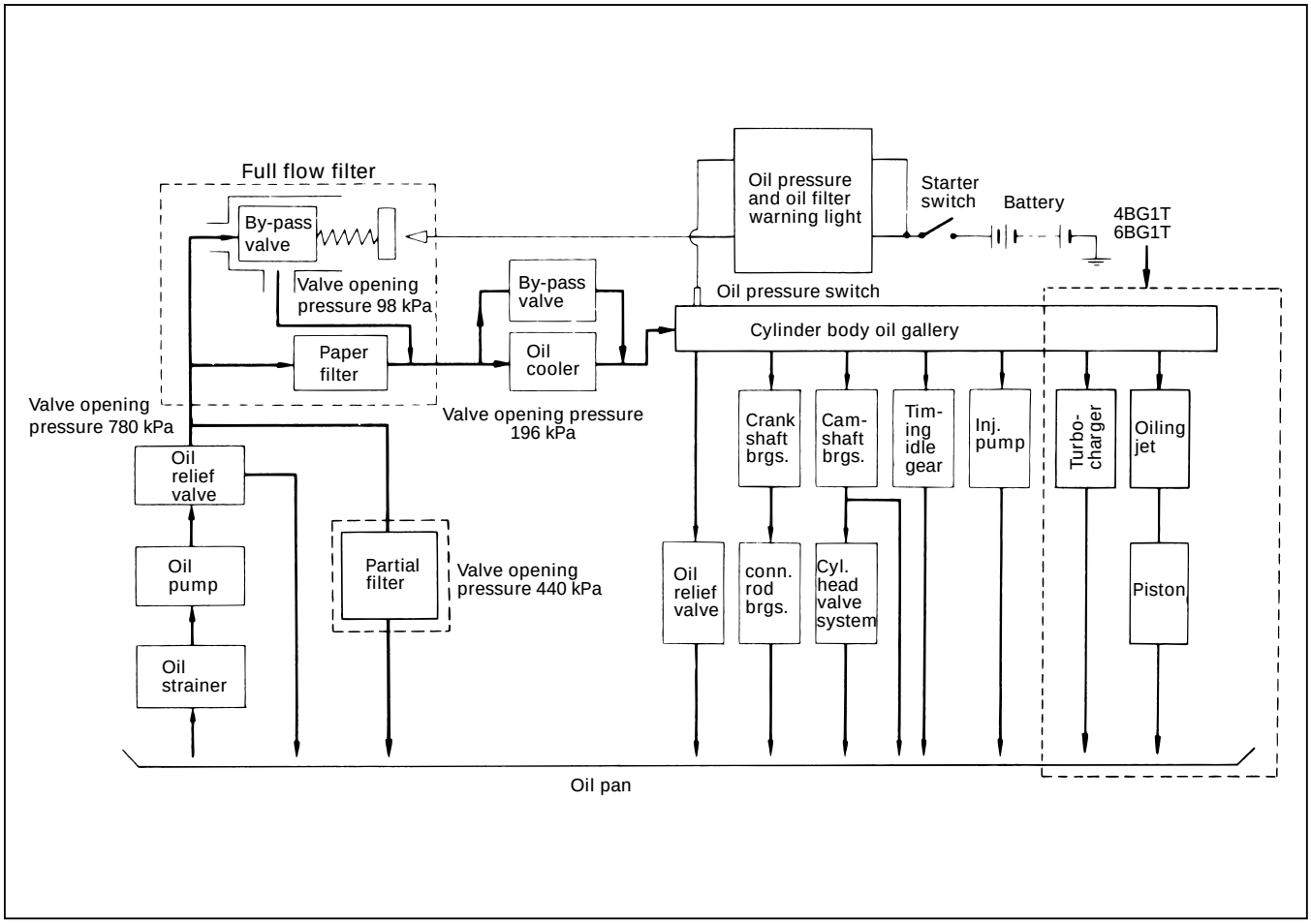
MEMO

SECTION 6

LUBRICATING SYSTEM

TABLE OF CONTENTS

GENERAL DESCRIPTION



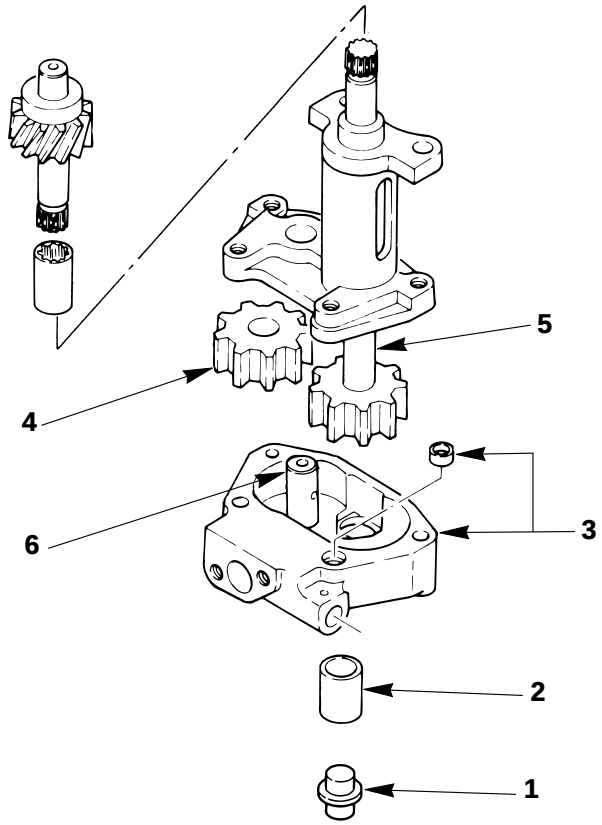
This family of engines uses a normal forced circulation lubricating system.

The gear type oil pump is driven by the camshaft oil pump drive.

The cartridge (spin-on) type oil filter is used.

OIL PUMP

DISASSEMBLY

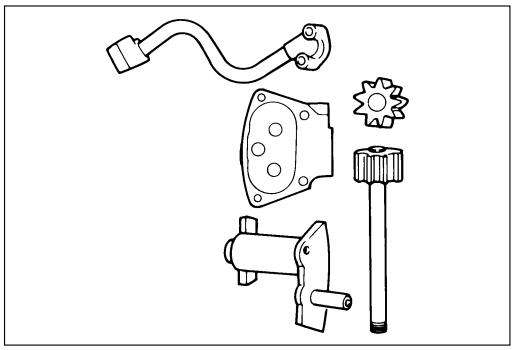


Disassembly Steps

1. Strainer
2. Suction pipe
3. Cover and dowel
4. Driven gear
5. Drive shaft and gear
6. Driven gear shaft

INSPECTION REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

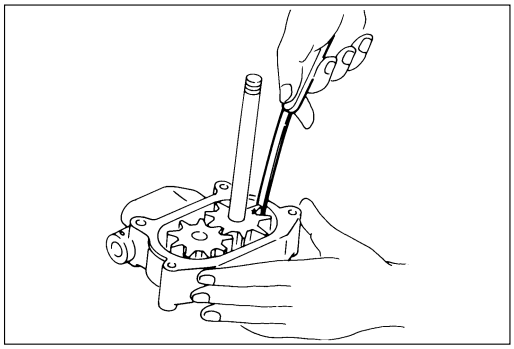


Visually inspect the disassembled parts for excessive wear and damage.

Oil Pump Drive Gear

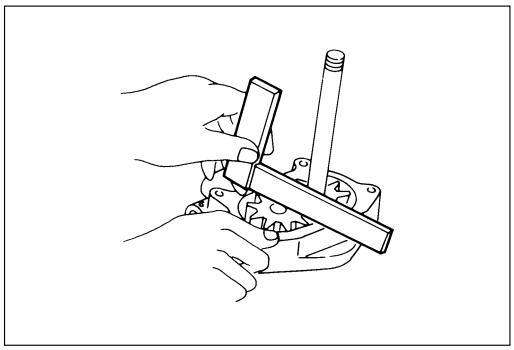
Use a feeler gauge to measure the clearance between the oil pump cover (oil pump case) inside surface and the drive gear.

If the clearance exceeds the specified limit, the drive gear and/or the oil pump cover must be replaced.



mm (in)

	Limit
Oil Pump Cover and Oil Pump Drive Gear Clearance	0.20 (0.0079)



Oil Pump Driven Gear

Use a feeler gauge to measure the clearance between the oil pump case cover inside surface and the driven gear.

If the clearance exceeds the specified limit, the driven gear or the oil pump cover must be replaced.

mm (in)

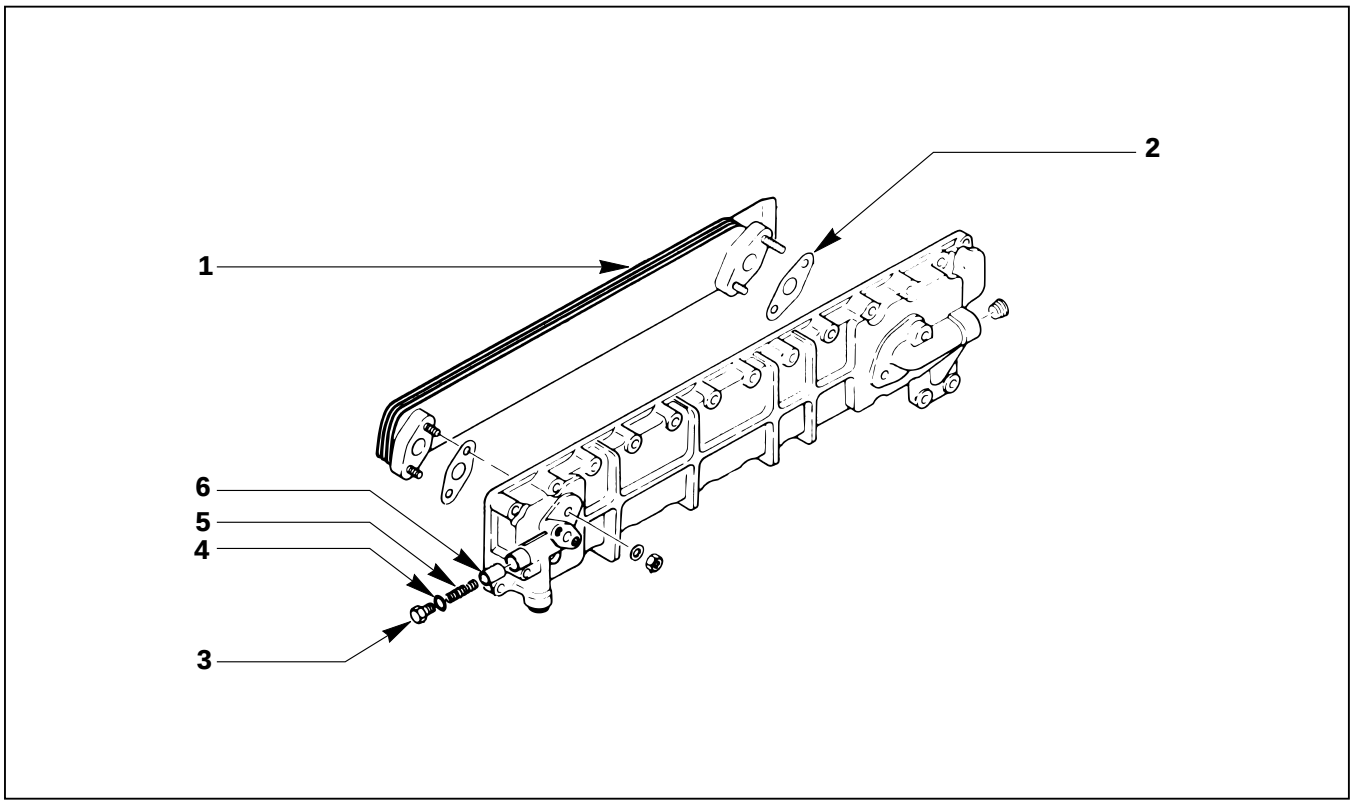
	Limit
Oil Pump Body and Driven Gear Clearance	0.15 (0.0059)

REASSEMBLY

To assemble, follow the disassembly procedures in reverse order.

OIL COOLER

DISASSEMBLY



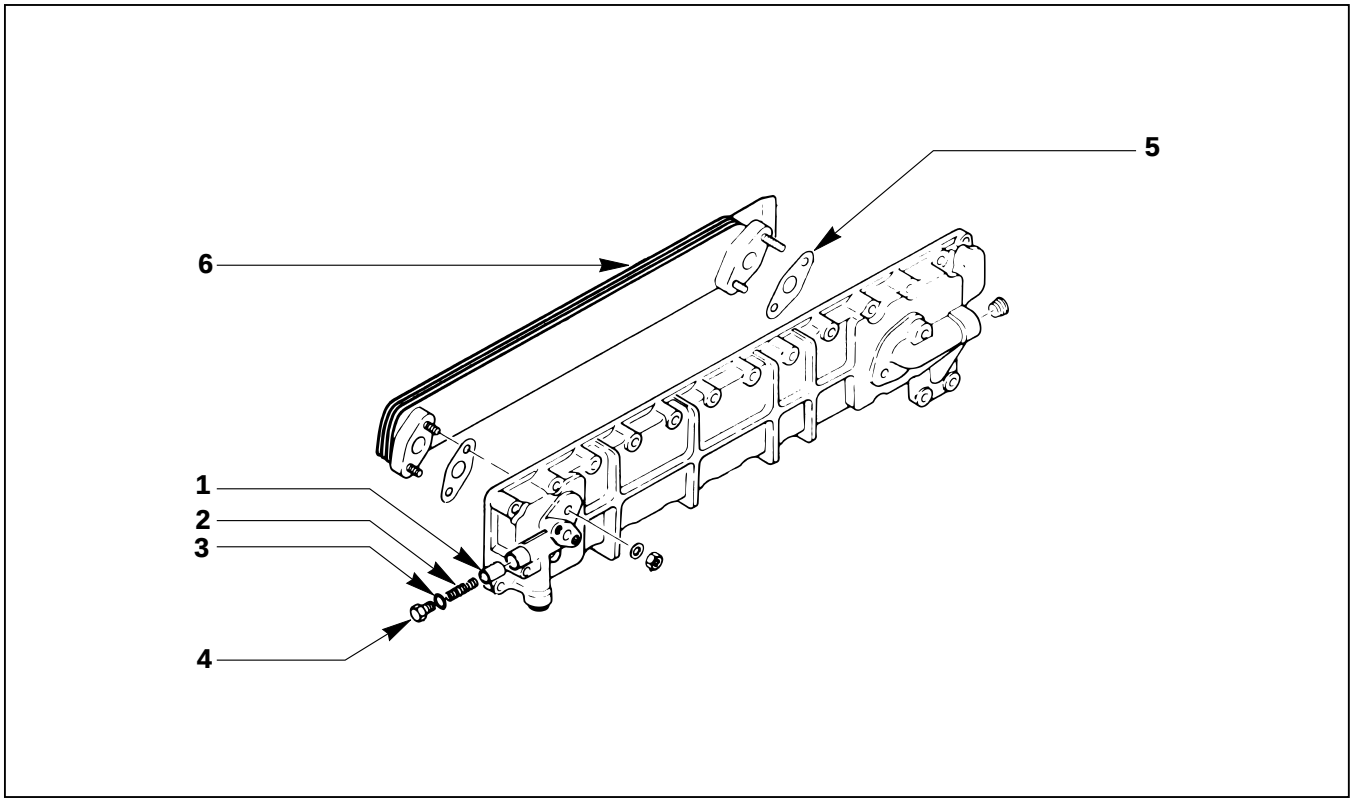
Disassembly Steps

1. Oil cooler element
2. Element gasket
3. By-pass valve plug
4. O-ring; plug
5. By-pass valve spring
6. By-pass valve

INSPECTION AND REPAIR

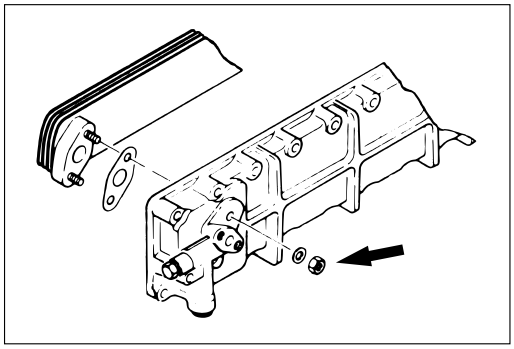
Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

REASSEMBLY



Reassembly Steps

1. By-pass valve
2. By-pass valve spring
3. O-ring; plug
4. By-pass valve plug
5. Element gasket
▲ 6. Oil cooler element



Important Operation

6. Oil Cooler Element

Install the oil cooler element to the oil cooler, and tighten the cooler element fixing nuts to the specified torque.

N·m (kgf·m/lb.ft)

Oil Cooler Element Fixing Nut Torque	6B	14–24 (1.4–2.4/10–17)
	4B	16–25 (1.6–2.6/12–18)

SECTION 7

COOLING SYSTEM

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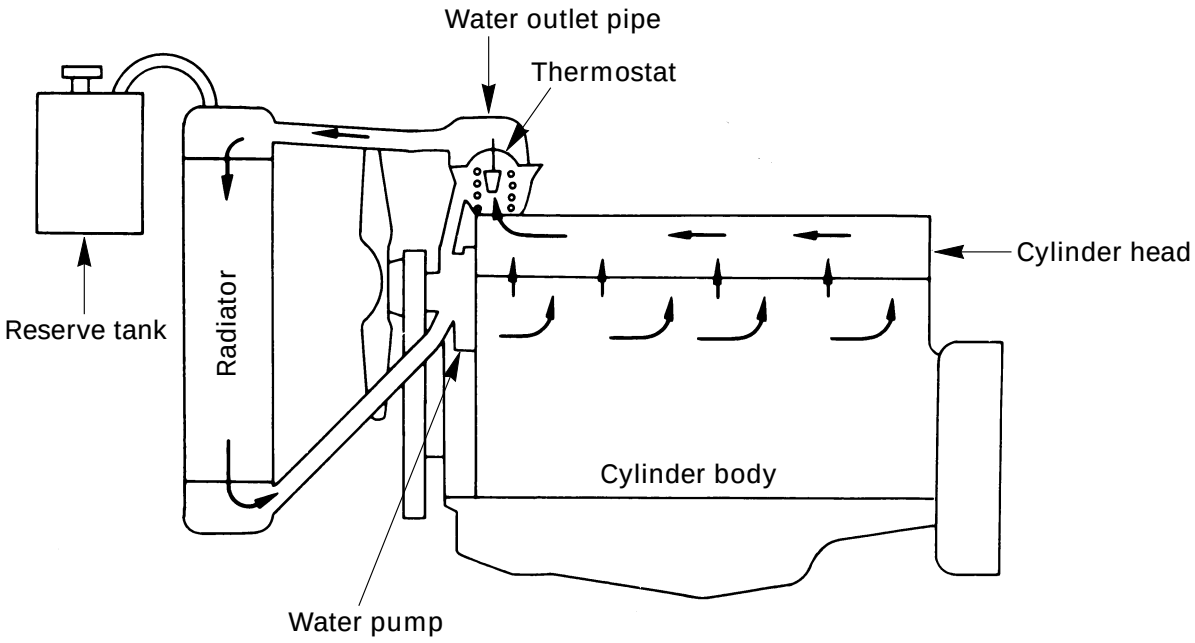
GENERAL DESCRIPTION

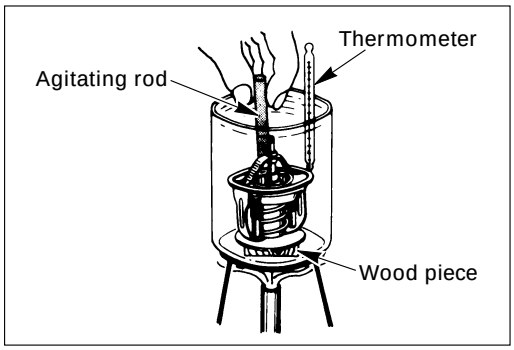


This family of engines uses a pressurized, forced circulation cooling system with a V-belt driven centrifugal water pump and a wax pellet thermostat with jiggle valve.

THERMOSTAT

INSPECTION AND REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



Visually inspect the thermostat function referring Section 2 MAINTENANCE in page 2-7.

MEMO

SECTION 8

FUEL SYSTEM

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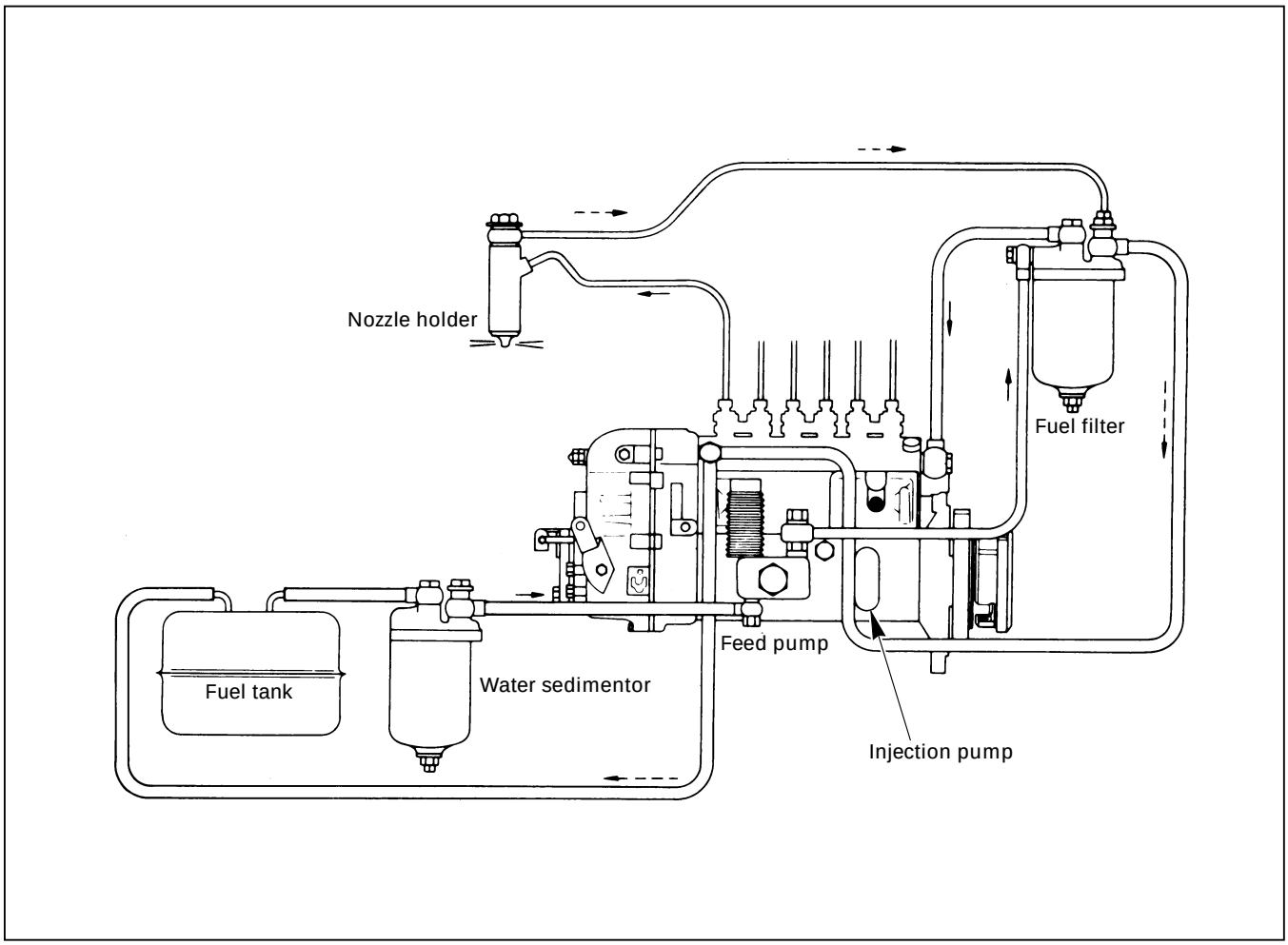
GENERAL DESCRIPTION

This illustration is based on the 6BG1 engines.



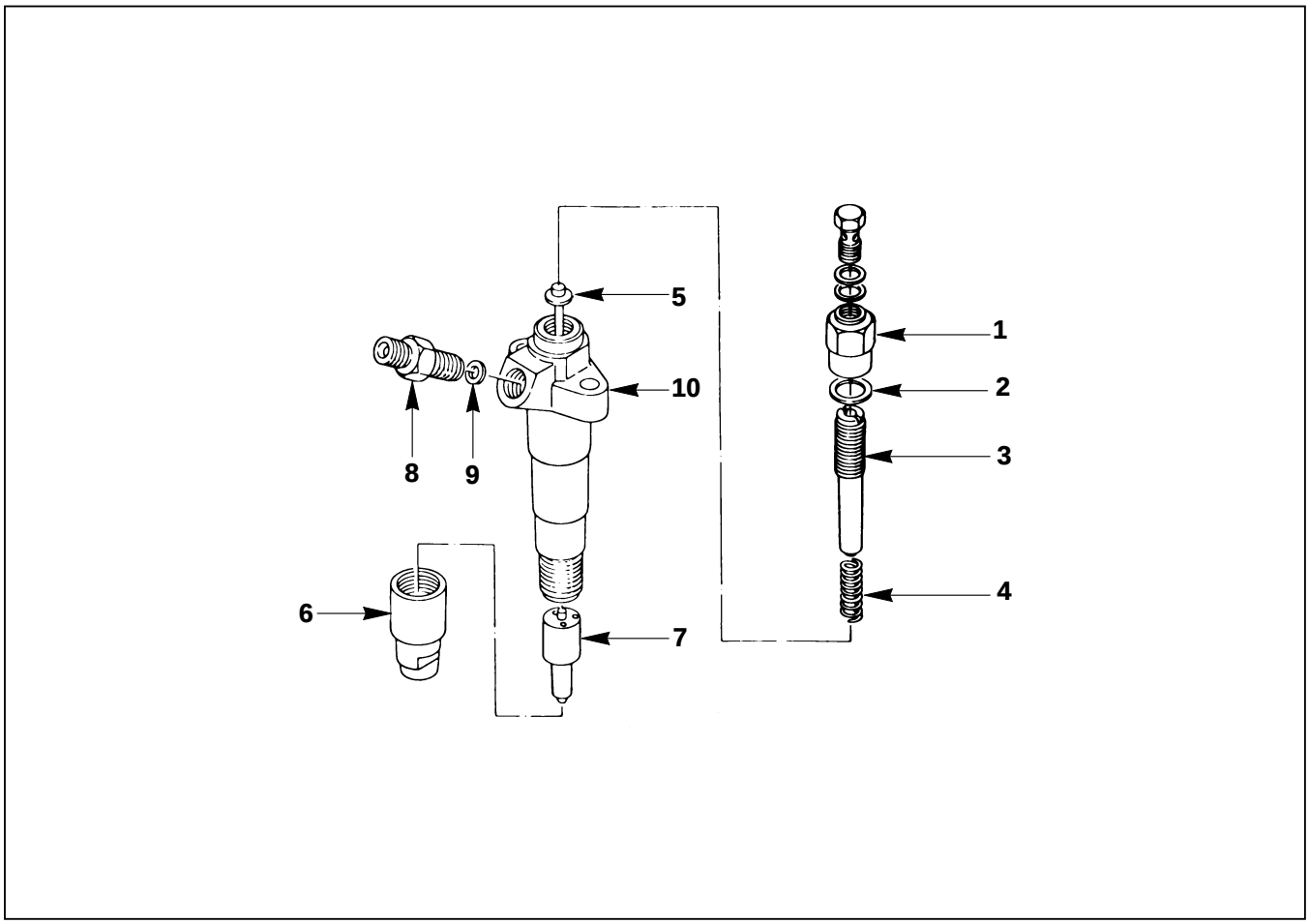
The fuel system consists of the fuel tank, the water sedimentor, the fuel filter, the injection pump, and the injection nozzle.

The fuel from the fuel tank passes through the water sedimentor and the fuel filter where water particles and other foreign material are removed from the fuel.

Fuel, fed by the injection pump plunger, is delivered to the injection nozzle in the measured volume at the optimum timing for efficient engine operation.

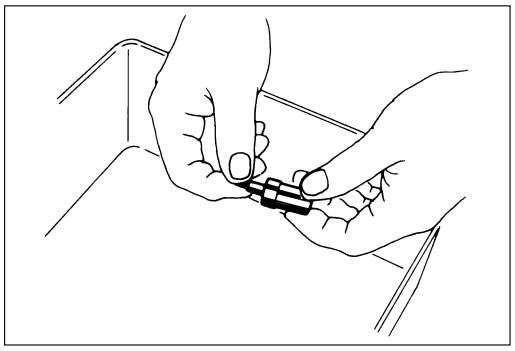
INJECTION NOZZLE

DISASSEMBLY



Disassembly Steps

1. Nozzle holder cap nut
2. Cap nut gasket
3. Nozzle adjusting screw
4. Push rod spring
5. Nozzle holder push rod
6. Retaining nut
▲ 7. Injection nozzle
8. Injection pipe connector
9. Connector gasket
10. Nozzle holder body



Important Operation

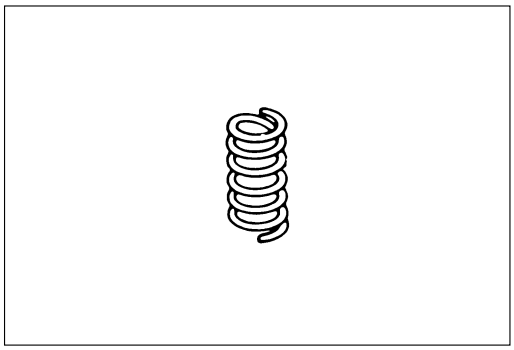
7. Nozzle

Remove the nozzle assembly from the nozzle body.

Keep the parts separately to maintain the proper needle valve to body combination.

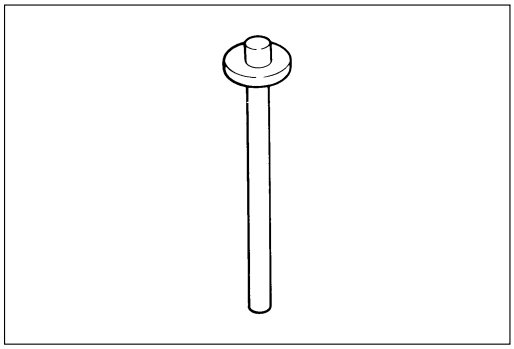
INSPECTION AND REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.



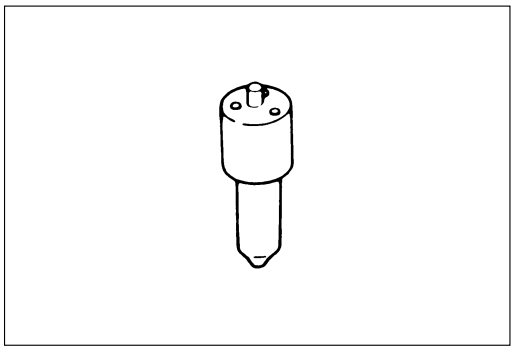
Push Rod Spring

Check the push rod spring for wear, weakness, and corrosion.



Nozzle Holder Push Rod

1. Check the nozzle holder push rod curvature.
2. Check the nozzle holder push rod and needle valve contact surfaces for excessive wear and poor contact.



Injection Nozzle

1. Check the injection nozzle needle valve, the valve seat, and the injection nozzle hole for carbon deposits.

   If carbon deposits are present, the injection nozzle and the needle valve must be replaced.
2. Hold the nozzle body vertically.

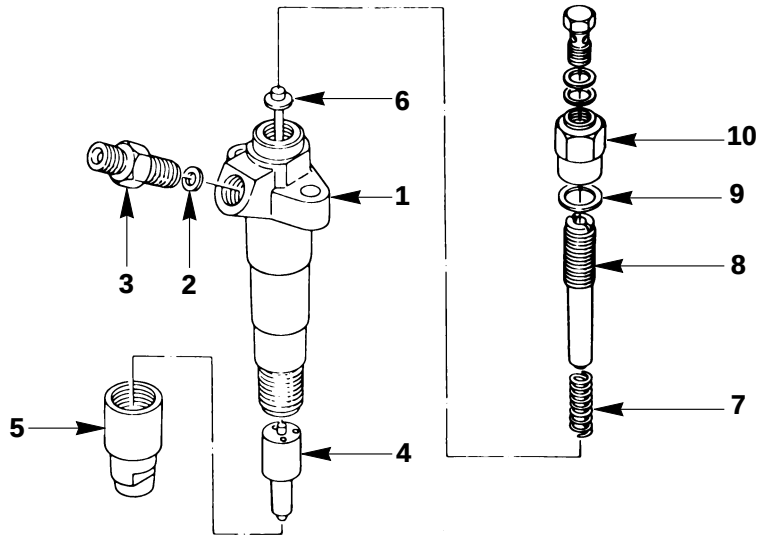
   Pull the needle valve about one-third of the way out of the nozzle body.

   Release the needle valve.

   Check that the needle valve falls back into the nozzle body as far as the valve seat.

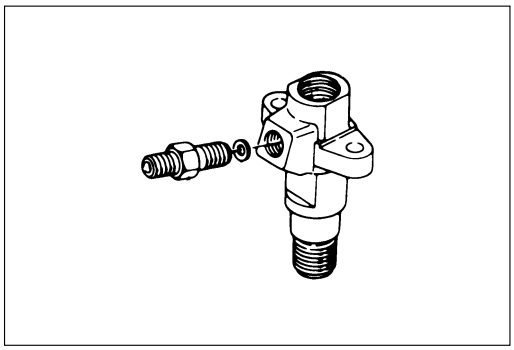
   If the needle valve does not fall back into the nozzle body as far as the valve seat, the injection nozzle and the needle valve must be replaced.

REASSEMBLY



Reassembly Steps

1. Nozzle holder body
2. Connector gasket
▲ 3. Injection pipe connector
▲ 4. Injection nozzle
▲ 5. Retaining nut
6. Nozzle holder push rod
7. Push rod spring
8. Nozzle adjusting screw
9. Cap nut gasket
▲ 10. Nozzle holder cap nut

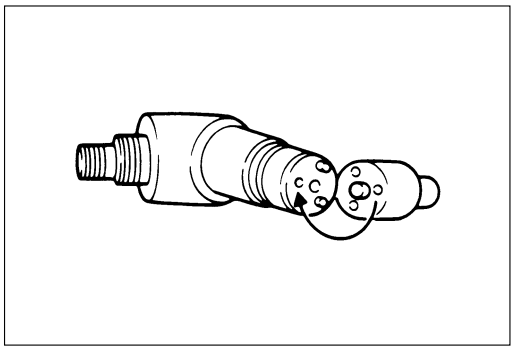


Important Operation

3. Injection Pipe Connector

N·m (kgf·m/lb.ft)

Nozzle Connector Torque	49 – 59 (5.0 – 6.0/36 – 43)

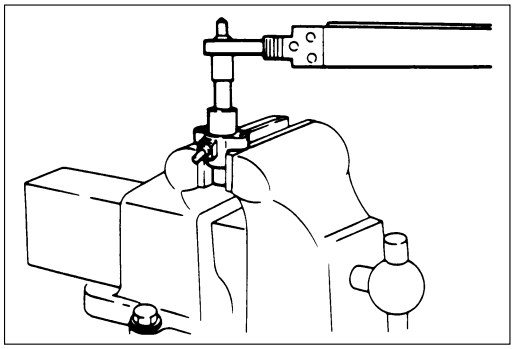


4. Injection Nozzle

There must be no oil on the contact surfaces of the injection nozzle and the injection nozzle holder.

Clean these contact surfaces with diesel fuel before installation.

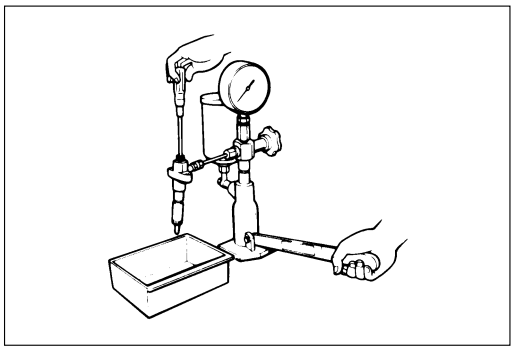
The nozzle dowel pin must be aligned with the dowel hole in the nozzle holder body.



5. Retaining Nut

N·m (kgf·m/lb.ft)

Nozzle Retaining Nut Torque	59 – 78 (6 .0 – 8.0/43 – 58)



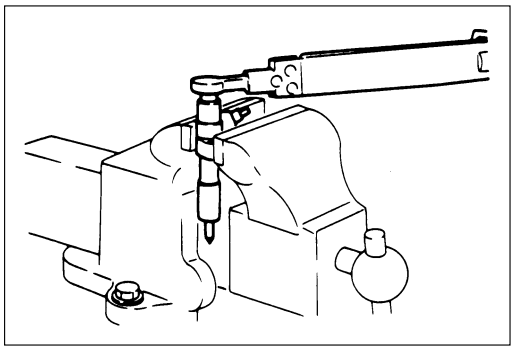
Injection Starting Pressure Adjustment

The injection nozzle injection starting pressure can be adjusted after the adjusting screw is installed.

Refer to "FUEL SYSTEM" on Page 2-5 of the "MAINTENANCE" Section of this Workshop Manual.

MPa (kgf/cm^2/psi)

Injection Starting Pressure	18.1 (185/2630)

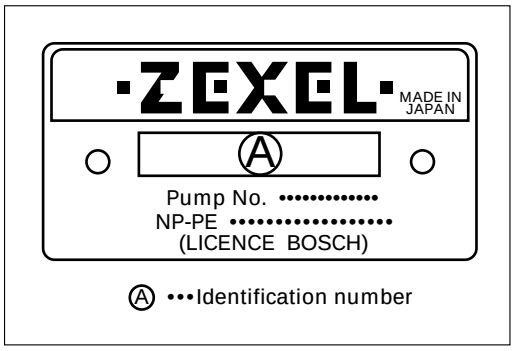


10. Nozzle Holder Cap Nut

N·m (kgf·m/lb.ft)

Cap Nut Torque	29 – 39 (3.0 – 4.0/22 – 29)

INJECTION PUMP CALIBRATION DATA



IDENTIFICATION PLATE AND PRODUCT SERIAL NUMBER

1 . Injection pump adjustment and repair should be made by the nearest ZEXEL CORPORATION or ROBERT BOSCH Authorized Service Outlet.

2. When you ask such authorized service outlet the adjustment or repair, the identification Plate and Product Serial Number will give them a necessary clue to get technical data distributed by the manufacturers previously.

   Without this data, the Service Outlet will be unable to effectively service your injection pump.

   If you are unable to locate the data applicable to your injection pump, please contact ISUZU MOTORS LTD through your machine supplier.

3. Do not remove the Identification Plate and Product Serial Number from the injection pump.

   Keep the Identification Plate and Product Serial Number clean at all times. Do not allow it to rust or become illegible.

Note: Examples of test conditions and calibration data are as follows.

TEST CONDITIONS REQUIRED FOR THE FUEL INJECTION AMOUNT ADJUSTMENT

Injection Nozzle		*ZEXEL No.: 105160-5130 Bosch Type No.: NP-DLLA149SM304
Injection Nozzle Holder		ZEXEL No.: 105030-4750
Injection Starting Pressure	MPa (kgf/cm^2/psi)	18.1 (185/2630)
Injection Line Dimensions	mm (in.)	
Inside Diameter		1.8 (0.071)
Outside Diameter		6.0 (0.236)
Length		600.0 (23.6)
Transfer Pump Pressure	kPa (kgf/cm^2/psi)	157 (1.6/23)
Testing Diesel Fuel		ISO4113 or SAE Standard Test Oil (SAEJ967D)
Operating Temperature	°C (°F)	40 – 45 (104 – 113)
Pump Rotation Direction		Clockwise (Viewed from the drive side)

INJ. PUMP CALIBRATION DATA

ENGINE MODEL 4BG1–T

Ass'y No. 000000–0000
Date : 2
Company : ISUZU
No. 0–00000–0000

Injection pump : PES4A 000000–0000 Governor : EP/RSV 000000–0000 Timing device :

1. Test Conditions :

Pump rotation : clockwise (viewed from drive side)

Nozzle & Nozzle Holder Ass'y : 000000–0000 (BOSCH Type No. EF8511/9A)

Nozzle : 000000–0000 (BOSCH Type No. DN12SD12T) Nozzle Holder : 000000–0000 (BOSCH Type No. EF8511/9)

Nozzle opening pressure : 17.2 MPa (175 kgf/cm^2) ...ump pressure : 157 kPa (1.6 kgf/cm^2)

Injection pipe : Outer Dia. 6 mm × ... – Length 600 mm

Test Oil : ISO4113 or SAE Standar ...9967d) Oil Temp. : 40^{+5} °C

Overflow valve opening pressure : ... a (1.3 kgf/cm^2)

2. Injection Timing :

Pre-stroke : No. 1 Plunger 3.4 ± 0.05 mm Note : Adjust with rack position of mm

Injection order : 1 —(90°±30')— 3 , 1 —(180°±30')— 4 , 1 —(270°±30')— 2

(interval : °± 30')

Plungers are numbered from the Driver side.

Tappet clearance : Bolt adjustment type ; More than 0.3 mm for all cylinders.
Shim adjustment type ; Manually rotate the camshaft 2~3 times and confirm that it rotates smoothly.

4. Injection Quantity :

Adjusting point	Rack Position (mm)	Pump Speed (min^{-1})	Injection q'ty (cm^3/1000 strokes)	Max. var bet. cyl (%)	Fixed	Remarks
A	8.5	1,100	81 ± 1.1	± 2	Lever	Basic
C	Approx. 6.0	475	8.8 ± 1.4	± 14	Rack	
D	–	100	125 ± 5	–	Lever	Rack limit

5. Timing advance specification :

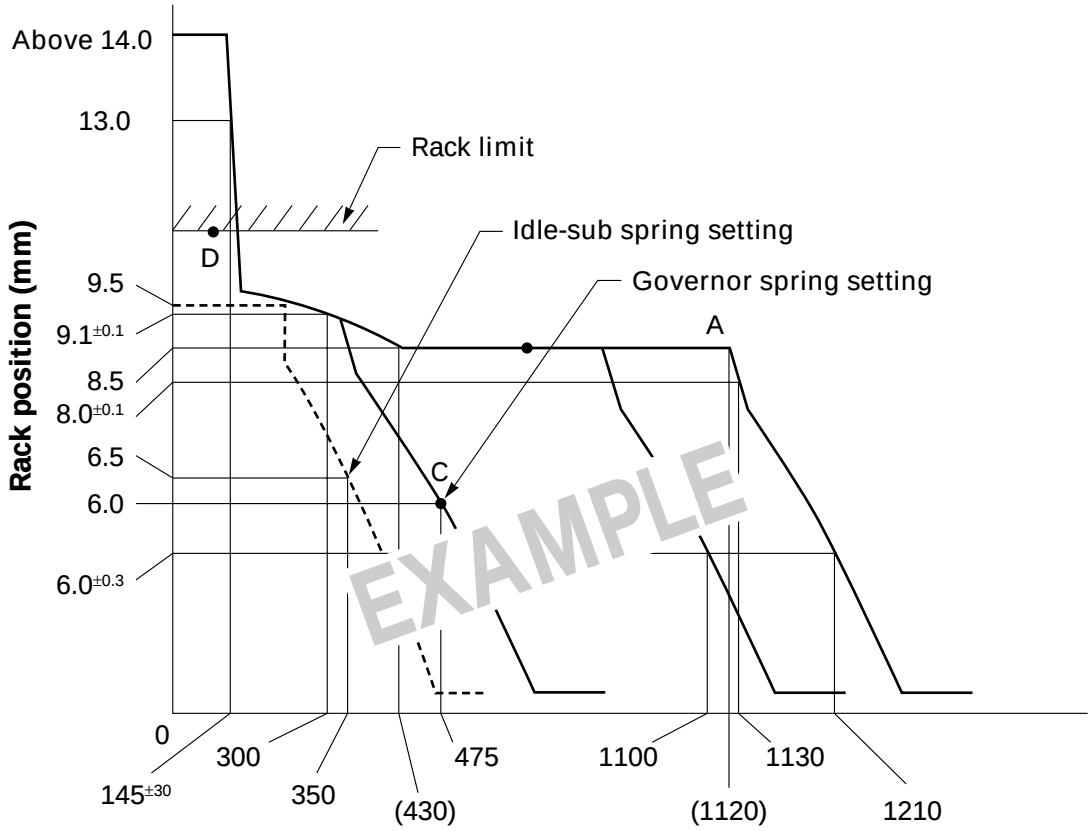
Pump speed (min^{-1})							
Advance angle (°)							

3. Governor adjustment

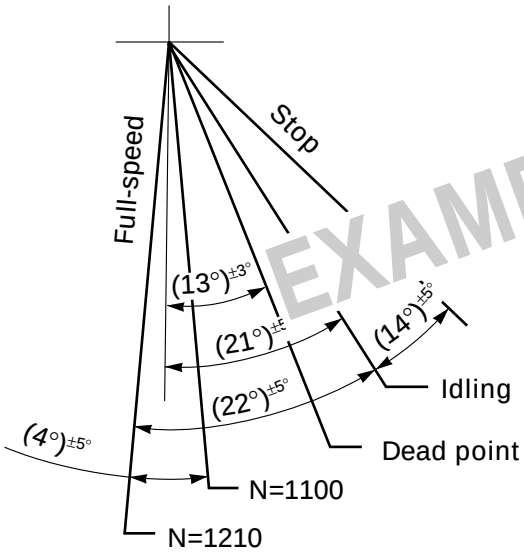
000000–0000

Recommended speed droop adjustment screw position: 12

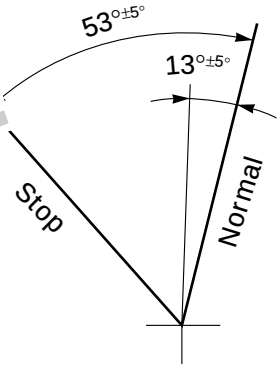
(notches from fully tightened position)



Speed control lever angle



Stop lever angle



SECTION 9

TURBOCHARGER

TABLE OF CONTENTS

Regarding the details of the turbocharger repair, refer the following workshop manual.

Published by: MITSUBISHI HEAVY INDUSTRIES CO., LTD

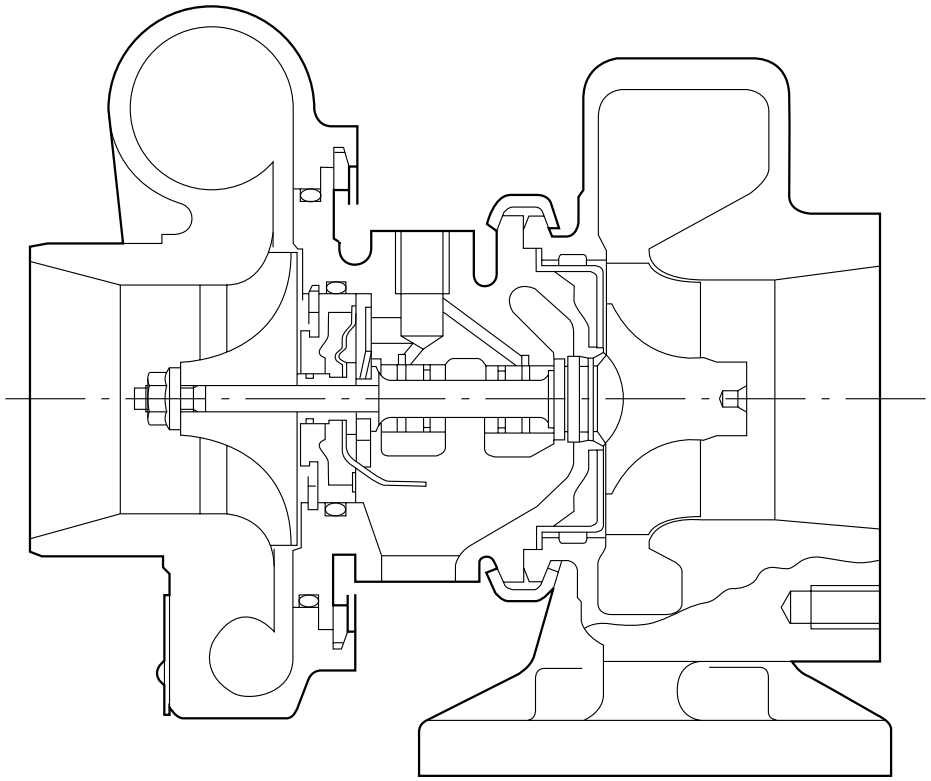
Title of the manual: MITSUBISHI TURBOCHARGERS (TD-04H FOR 4BG1T)

Pub No. 99626-92110

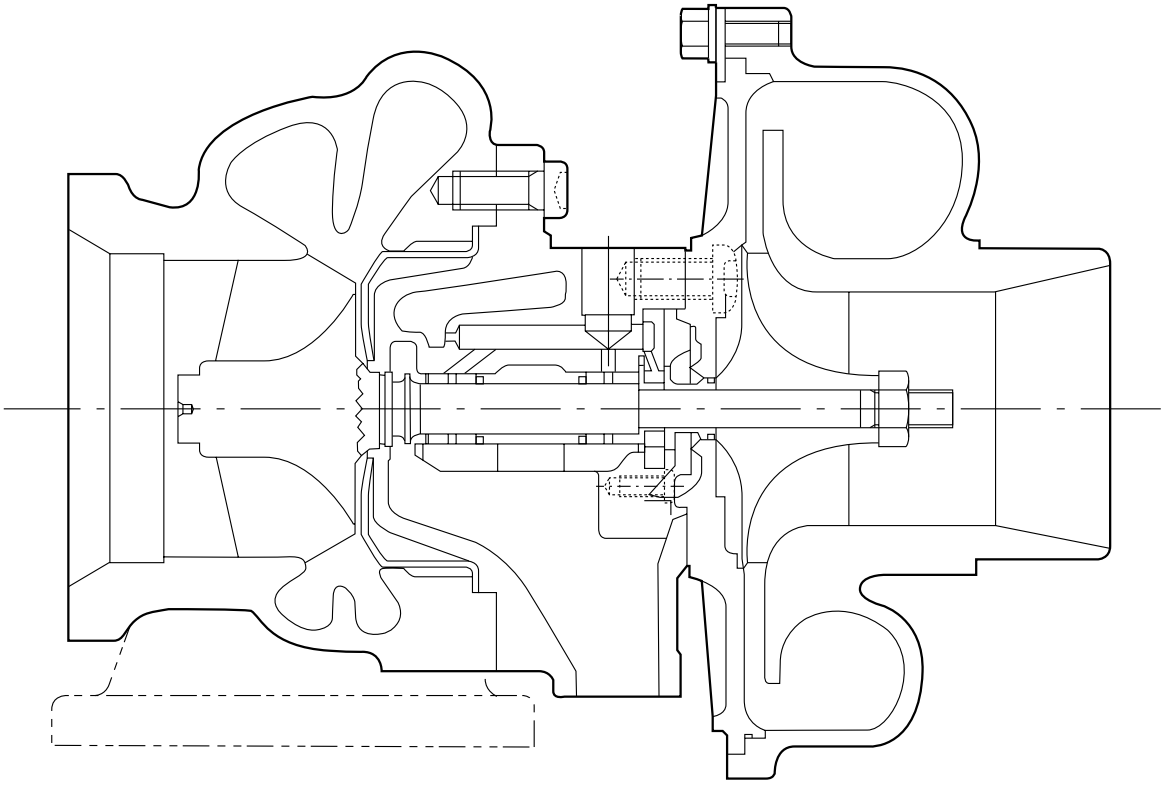
Availability of the manual ISUZU MOTORS LIMITED will send the manual upon request through your machine supplier.

GENERAL DESCRIPTION

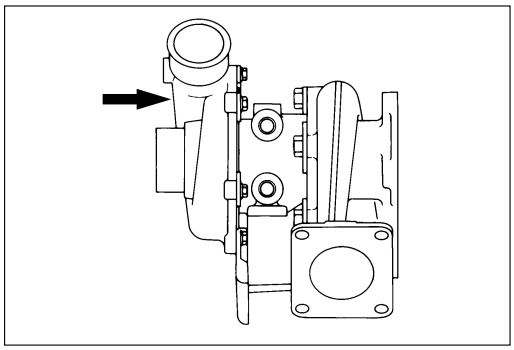
TD04H



RHG6

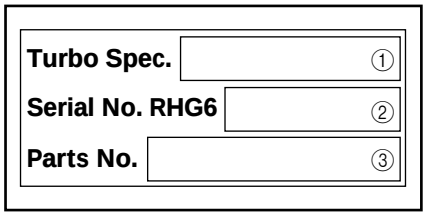


TURBOCHARGER IDENTIFICATION



The IHI Turbocharger nameplate gives the date of manufacture and other important information required to identify the unit when service inquiries or part orders are made.

The arrow in the illustration indicates the location of the Turbocharger nameplate.



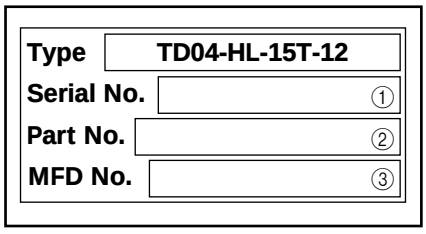
IHI Turbocharger

The turbocharger nameplate has the following information stamped on it. Refer to the illustration at the left.

(1) Turbo Specification Number, Production Year and Month

(2) Production Date, Daily Serial Number

(3) ISUZU Parts Number



MITSUBISHI Turbocharger

(1) Serial Number

(2) ISUZU Part Number

(3) MITSUBISHI Number

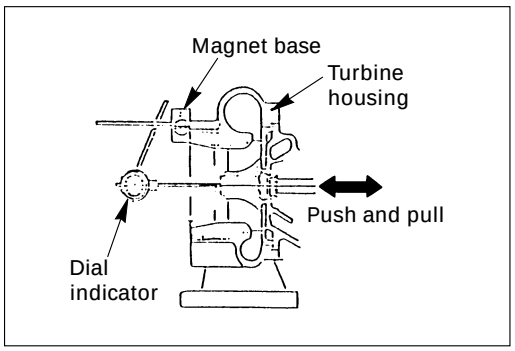
INSPECTION AND REPAIR

If excessive wear or damage is discovered during inspection, the appropriate parts must be adjusted, repaired, or replaced. Damage or improper adjustment of the turbocharger will inhibit sufficient air flow to the engine, preventing it from delivering full performance.

If the engine demonstrates a significant drop in performance, check for engine damage or wear. If no significant engine damage or wear can be found, it is likely that the turbocharger is at fault.

When reduced performance is the result of a faulty turbocharger, contact your nearest IHI or Mitsubishi Service Center for the proper repairs.

The following is primarily a description of the particularly important rotor shaft end play, and bearing clearance standard and limit values.



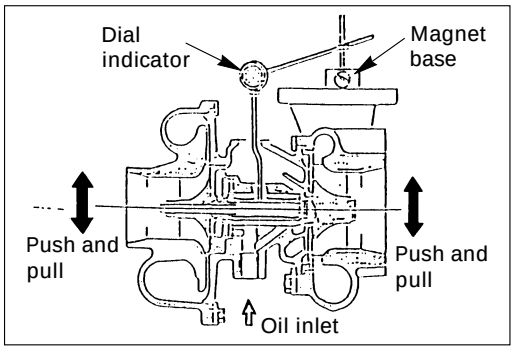
Rotor Shaft Axial Play Measurement

1) Install a dial indicator on the turbine housing as illustrated.
2) Use the dial indicator to measure the rotor shaft axial play with moving the shaft push and pull. Read the total indicator reading (TIR).

mm (in)

IHI RHG6	Limit
Rotor Shaft Axial Play TIR	0.11 (0.0043)

3) If the measured value exceeds the specified limit the shaft must be replaced.



Rotor Shaft Radial Play Measurement

1) Turn over the turbocharger with the turbine exhaust inlet flange facing up.
2) Install a dial indicator to measure the rotor shaft radial play.
3) Use the dial indicator to measure the play. Read the TIR.

mm (in)

IHI RHG6	Limit
Rotor Shaft Radial Play TIR	0.205 (0.0081)

4) If the measured value exceeds the specified limit replace the shaft.

SECTION 10

AIR COMPRESSOR

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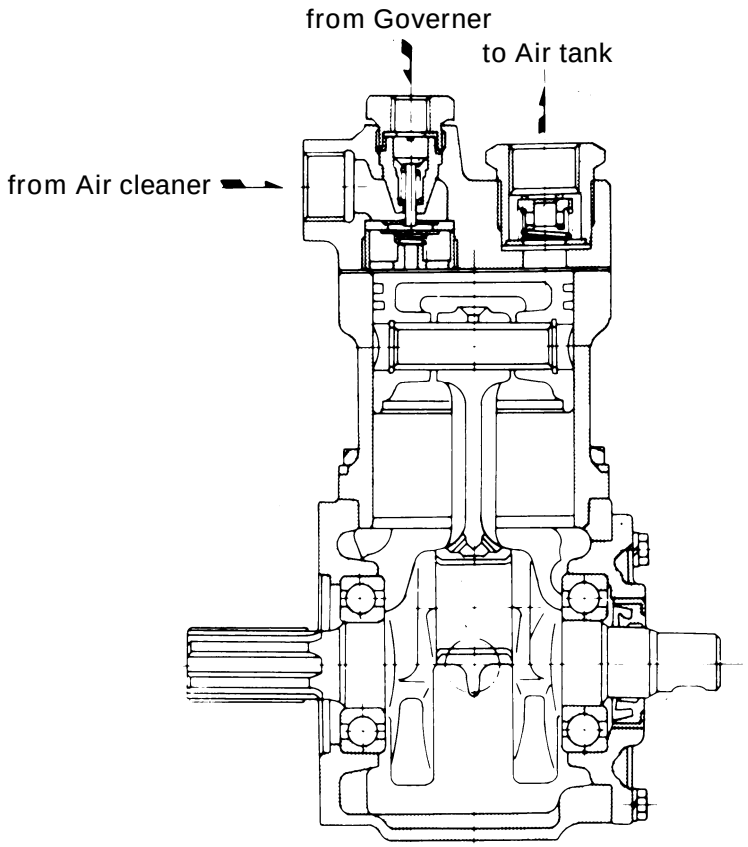
GENERAL DESCRIPTION

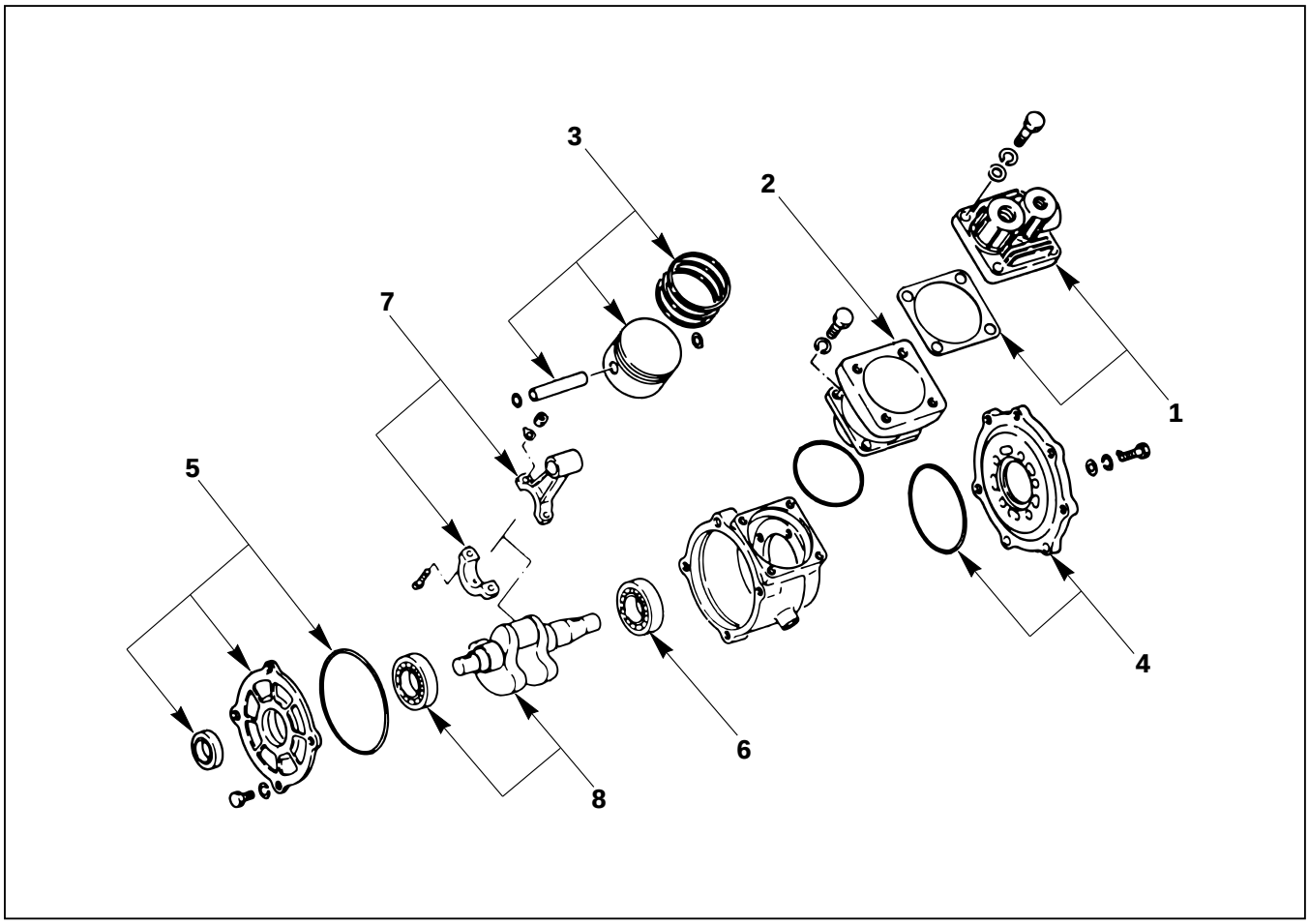
AIR COMPRESSOR SECTIONAL VIEW



Main Data

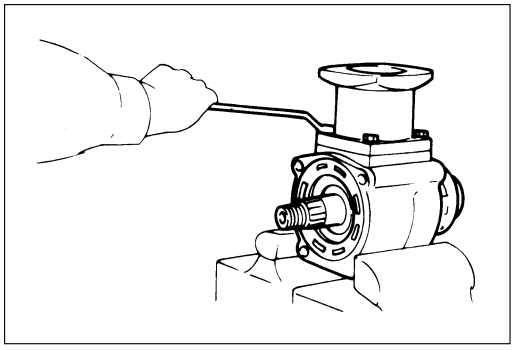
Piston ring configuration		Two compression rings and one oil ring
Theoretical air delivery amount		0.155 L/rev.
Cylinder bore × stroke	mm (in)	70 (2.755) × 40 (1.574)
Maximum operating speed	min^{-1}	1650
Crankshaft rotating ratio to engine		0.5
Weight	kg	7.0

DISASSEMBLY STEPS



Disassembly Steps

1. Cylinder head and gasket
▲ 2. Cylinder body
3. Piston
4. Crankcase flange
5. Bearing cover with oil seal
6. Bearing
7. Connecting rod
8. Crankshaft and bearing



Important Operation

2. Cylinder body

1) Remove the cylinder mounting flange bolts.
2) Remove the cylinder with tapping out from the crankcase.

INSPECTION AND REPAIR

Make the necessary adjustments, repairs, and part replacements if excessive wear or damage is discovered during inspection.

Cylinder

Measure the uneven wear of the cylinder bore at the piston skirt position

mm (in)

	Limit
Cylinder Bore Uneven Wear	0.2 (0.0079)

Measure the piston and the cylinder bore clearance.

mm (in)

	Standard	Limit
Piston and Cylinder Bore Clearance	0.1–0.3 (0.0040–0.0118)	1.0 (0.040)

Note:

The piston outside diameter must be taken at the piston skirt positions.

Measure the piston ring grooves and the piston ring clearances.

mm (in)

	Standard	Limit
Piston Ring and Piston Ring Groove Clearance	0.02–0.05 (0.0008–0.0020)	0.15 (0.0059)

Measure the piston ring gaps.

mm (in)

	Standard	Limit
Piston Ring Gap	0.1–0.3 (0.0040–0.0118)	1.0 (0.039)

Measure the piston and the piston pin hole clearance.

mm (in)

	Standard	Limit
Piston Pin and Piston Pin Hole Clearance	0.002–0.023 (0.00008–0.00091)	0.0040 (0.00016)

Measure the piston pin and the connecting rod small-end clearance.

mm (in)

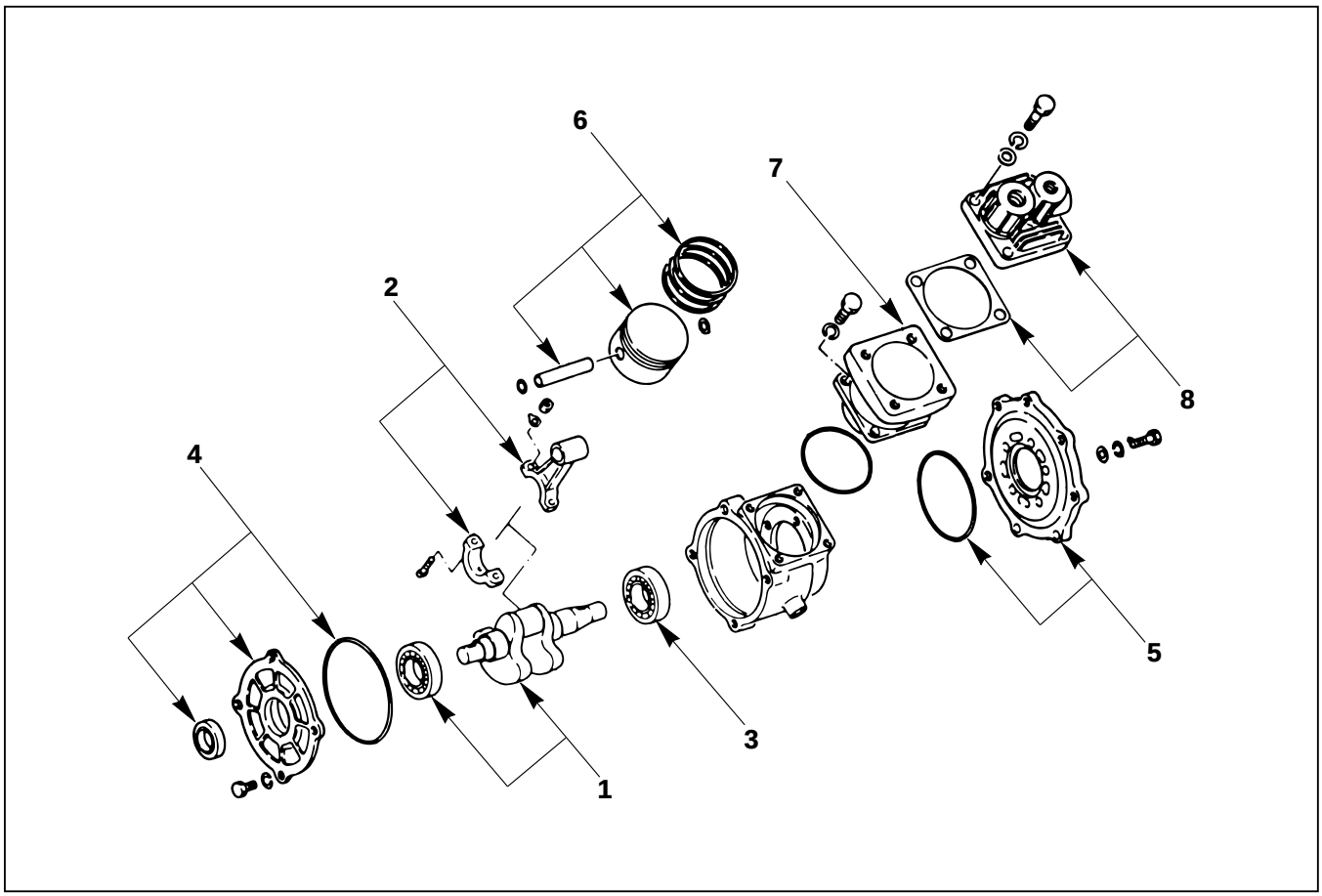
	Standard	Limit
Piston Pin and Connecting Rod Small-end Clearance	0.002–0.026 (0.00008–0.00102)	0.1 (0.0039)

Measure the air compressor crank pin and connecting rod large-end clearance.

mm (in)

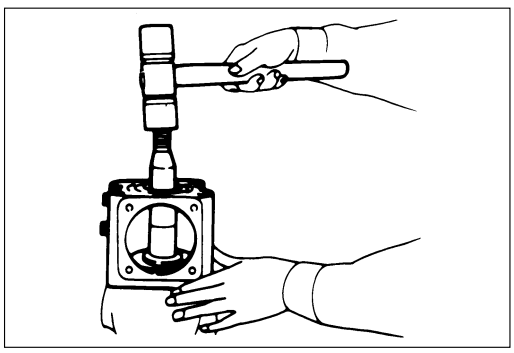
	Standard	Limit
Crankpin and Connecting Rod Large-end Clearance	0.02–0.06 (0.0008–0.0024)	0.15 (0.0059)

REASSEMBLY STEPS



Reassembly Steps

- ▲ 1. Crankshaft and bearing
- ▲ 2. Connecting rod
- 3. Bearing
- ▲ 4. Bearing cover with oil seal
- 5. Crankcase flange
- 6. Piston
- ▲ 7. Cylinder body
- ▲ 8. Cylinder head and gasket



Important Operation

1. Crankshaft and bearings

1) Install the bearings to the crankshaft.
2) Insert the crankshaft into the crankcase from the bearing cover side while tapping it gently with a soft hammer.

2. Connecting rod

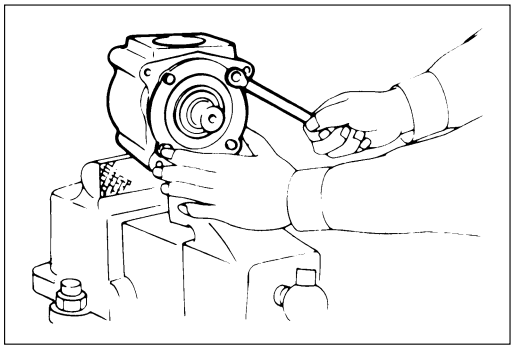
1) Install the connecting rod bearing cap and tighten the cap bolts to the specified torque.

N·m (kgf·m/lb.ft)

Connecting Rod Cap Bolt Torque	25 (2.5/18)

4. Bearing cover

1) Remove the used O-ring from the bearing case and discard it.
2) Lubricate the inner surface of new O-ring with grease.

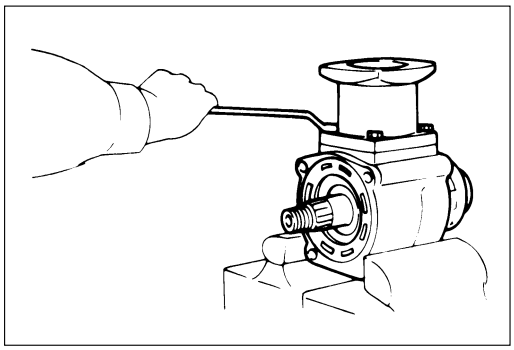


3) Install the O-ring to the bearing cover.
4) Install the bearing cover to the crankcase.

   Tighten the bearing cover bolts to the specified torque.

N·m (kgf·m/lb.ft)

Bearing Cover Bolt Torque	15 (1.5/11)

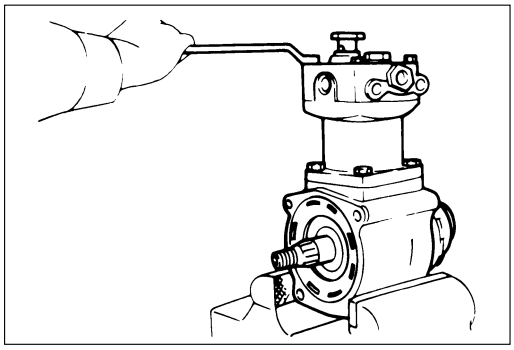


7. Cylinder Body

1) Install the cylinder body to the crankcase.
2) Tighten the cylinder body bolts to the specified torque.

N·m (kgf·m/lb.ft)

Cylinder Body Bolt Torque	29 (3/22)



8. Cylinder Head

1) Apply a coat of liquid gasket (Grease D) to the lower face of the cylinder head gasket.
2) Install the cylinder head to the cylinder body.

   Evenly tighten the cylinder head bolt to the specified torque.

N·m (kgf·m/lb.ft)

Cylinder Head Bolt Torque	49 (5/36)

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SECTION 11

ENGINE ELECTRICALS

TABLE OF CONTENTS

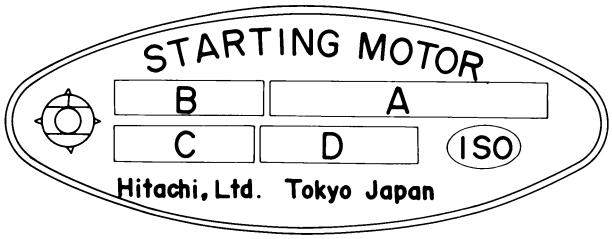
STARTER IDENTIFICATION

The starter identification plate is attached to the starter motor outside yoke. The ISUZU part number, the manufacturer's code number, and other important information are stamped on the plate.

Refer to the identification plate together with the "Main Data and Specifications" Tables and accompanying charts in this Manual when requesting service assistance from a qualified electrical repair shop.

If you are unable to locate the data applicable to your engine, please contact ISUZU MOTORS LIMITED through your machine supplier.

HITACHI IDENTIFICATION PLATE



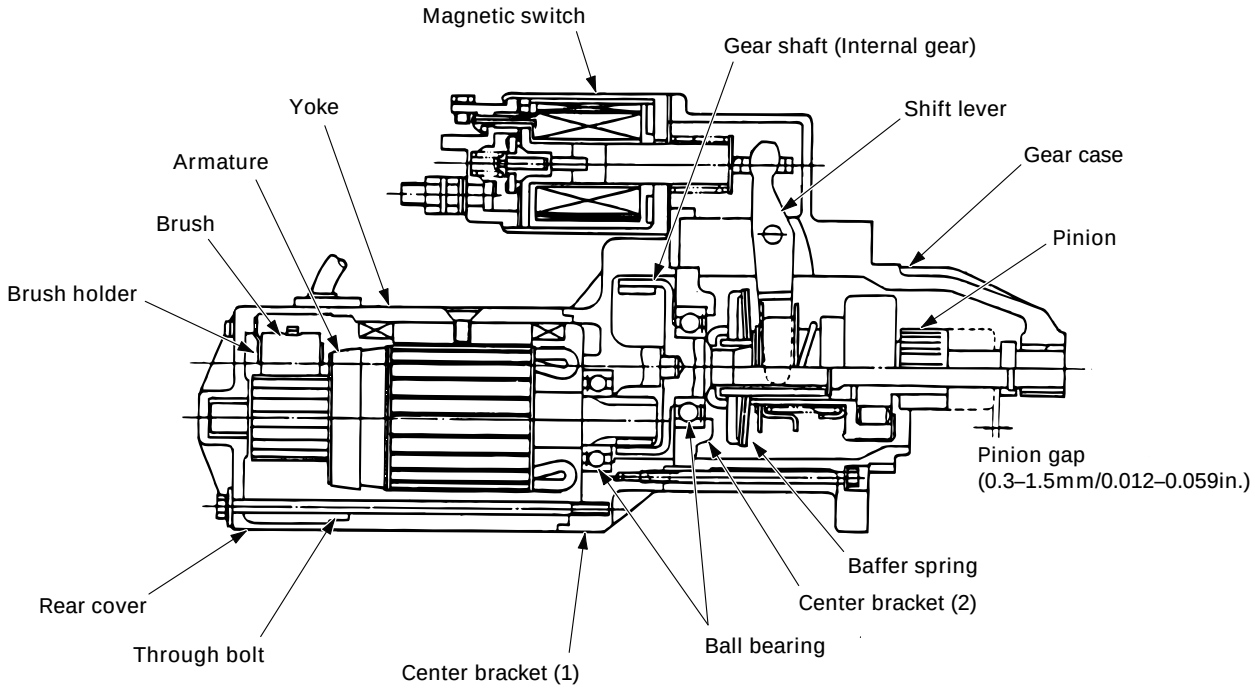
A: Isuzu part number
B: Manufacturer's code number
C: Rated output
D: Manufacturer's production mark

STARTER

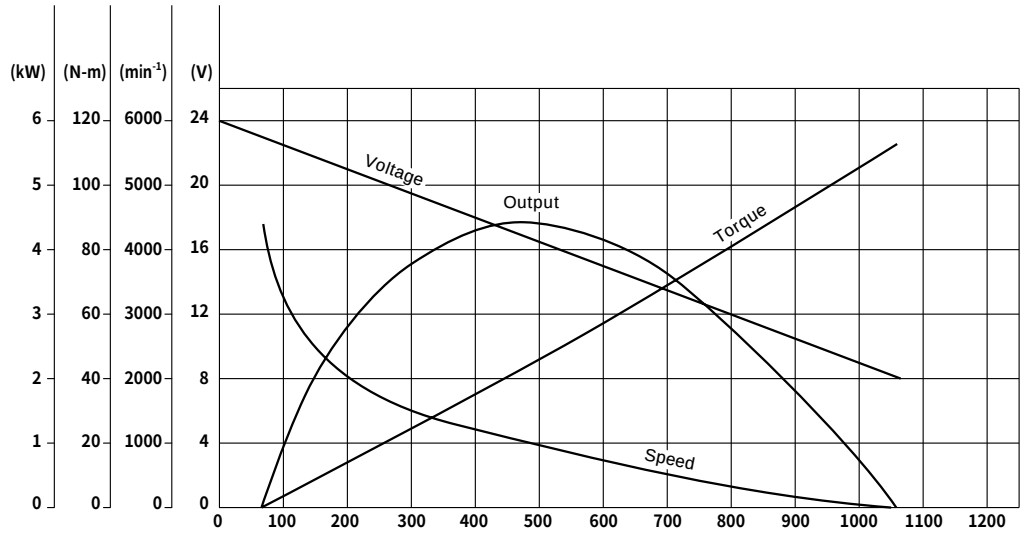
MAIN DATA AND SPECIFICATIONS

Isuzu Part No.		897225-1990	1-81100-3420
Manufacturer's code No. (HITACHI)		S25-177	S25-172
Rated voltage	(V)	24	24
Rated output	(kW)	4.5	4.5
Rating	(Sec)	30	30
Direction of rotation (Viewed from the pinion side)		Clockwise	Clockwise
Clutch type		Roller	Roller
Terminal voltage (No load)	(V)	24	24
Minimum current (No load)	(A)	Less than 100	100
Starter motor minimum operating speed (No load)	(min^{-1})	More than 3500	More than 3500
Pinion gear			
Modules		3	3
Number of teeth		11	11
Outside diameter	mm (in.)	40.64 (1.60)	40.64 (1.60)
Travel distance	mm (in.)	1.5 (0.032)	1.5 (0.032)
Yoke outside diameter	mm (in.)	90 (3.54)	90 (3.54)
Number of poles		4	4
Magnetic switch (at 20°C [68°F])			
Series coil resistance	(Ω)	0.187	0.187
Shunt coil resistance	(Ω)	1.31	1.31
Brush length			
Standard	mm (in.)	22 (0.866)	22 (0.866)
Limit	mm (in.)	14 (0.551)	14 (0.551)
Brush spring standard fitting load	N (kgf/lb.)	38 (3.85/8.49)	38 (3.85/8.49)
Commutator			
Outside diameter			
Standard	mm (in.)	37.0 (1.457)	37.0 (1.457)
Limit	mm (in.)	36.5 (1.437)	36.5 (1.437)
Difference between the largest and smallest diameters (Run-out)			
Limit	mm (in.)	0.1 (0.004)	0.1 (0.004)
Depth of undercut mica			
Standard	mm (in.)	0.5–0.8 (0.020–0.031)	0.5–0.8 (0.020–0.031)
Limit	mm (in.)	0.2 (0.008)	0.2 (0.008)

STARTER MOTOR SECTIONAL VIEW



PERFORMANCE



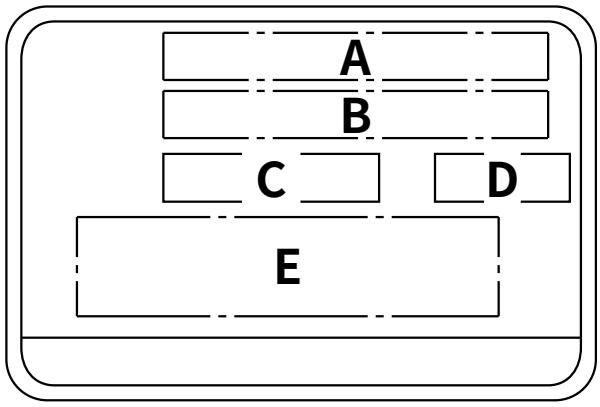
ALTERNATOR IDENTIFICATION

The alternator identification plate is attached to the alternator rear bracket. The ISUZU part number, the manufacturer's code number, and other important information are stamped on the plate.

Refer to the identification plate together with the "Main Data and Specifications" Tables and accompanying charts in this Manual when requesting service assistance from a qualified electrical repair shop.

If you are unable to locate the data applicable to your engine, please contact ISUZU MOTORS LIMITED through your machine supplier.

MITSUBISHI IDENTIFICATION PLATE



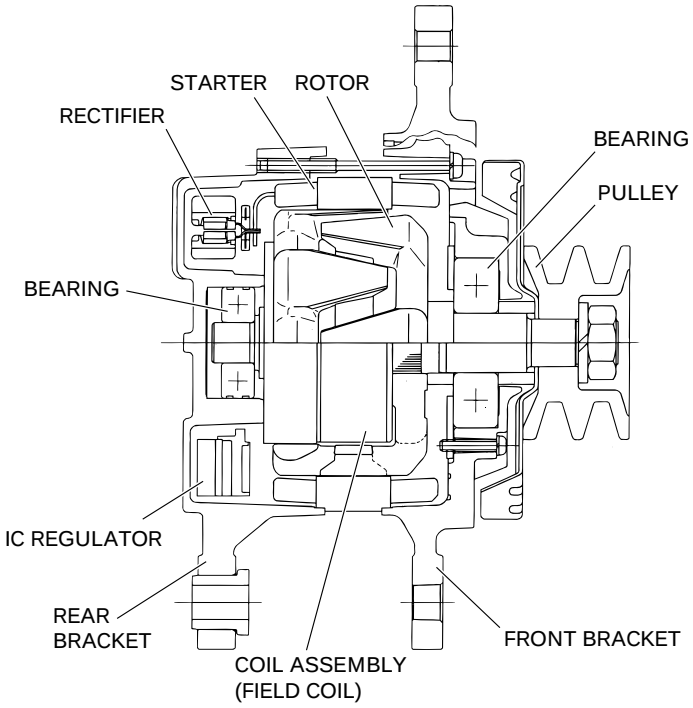
A: Isuzu part number
B: Manufacturer's short type name
C: System voltage output
D: Manufacturer's lot no.
E: Bar code

MAIN DATA AND SPECIFICATIONS

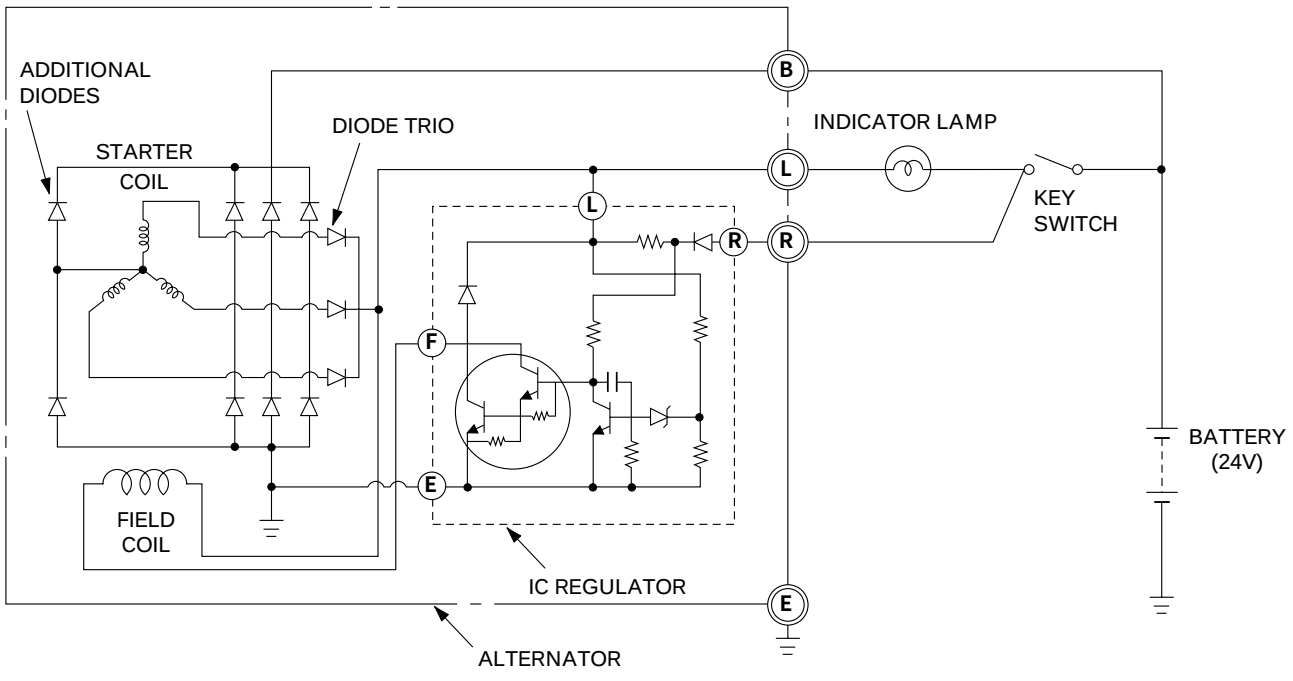
ALTERNATOR

Isuzu Part No.		1-81200-5301
Manufacturer's code No. (MITSUBISHI)		A004T05486
Rated voltage	(V)	24
Rated output	(A)	50
Rated speed	(min^{-1})	5000
Rated output at r.p.m	(Amp./Volt/min^{-1})	50/27/5000
No-load output at 0 Amp.	(Volt/min^{-1})	24/900
Direction of rotation as viewed from pulley side		Clockwise
Polarity grounded		(—)
Pulley diameter	mm (in.)	80 (3.15)
Coil resistance at 20°C		
Field coil	(Ω)	4.4–5.2
Regulator's applicable		
Isuzu part No.		1-81260-0170
Manufacturer's code No.		A866X38282

ALTERNATOR SECTIONAL VIEW



CHARGING CURCUIT



MEMO

SECTION 12

TROUBLESHOOTING

TABLE OF CONTENTS

Note:

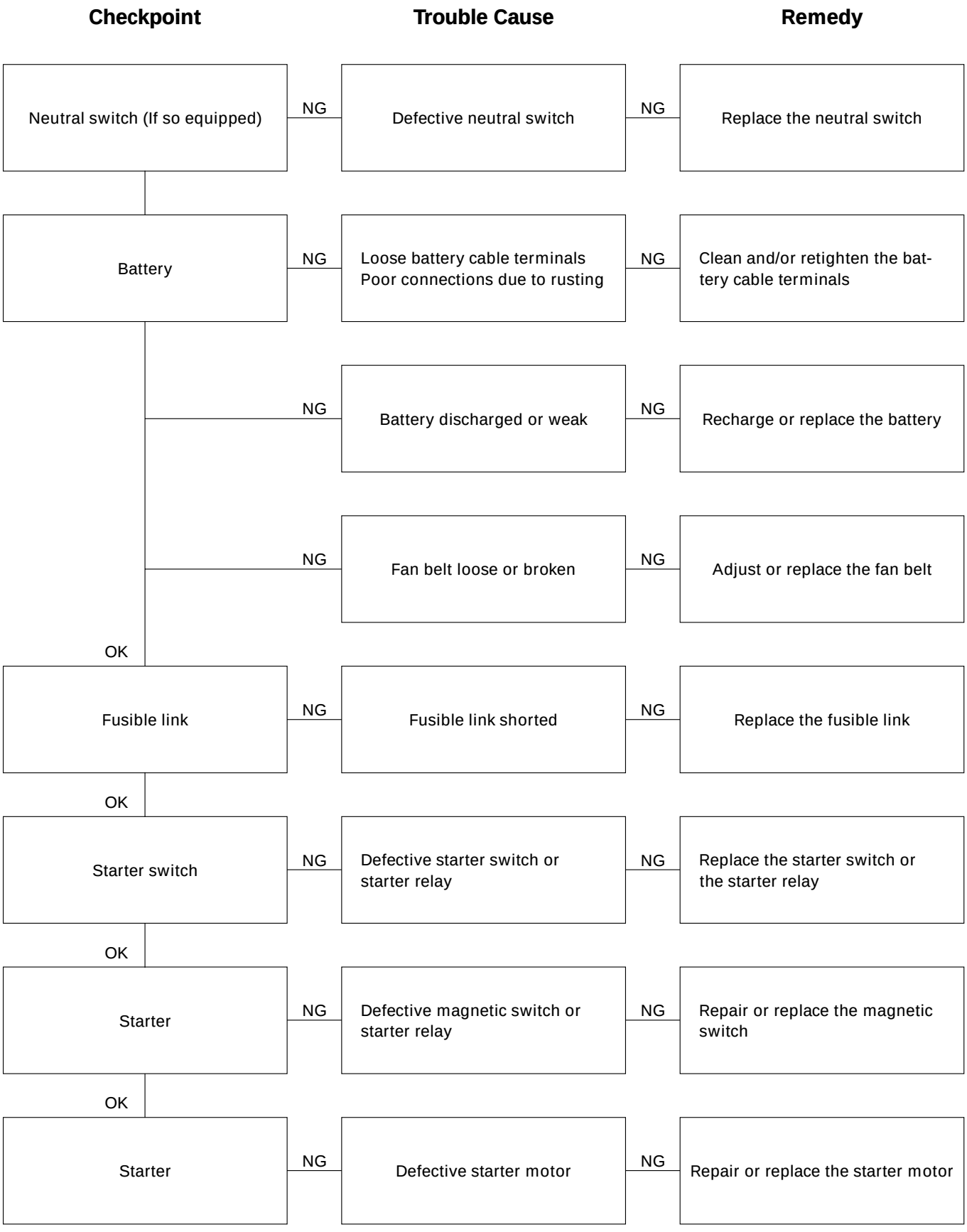
Use this section to quickly diagnose and repair engine failures.

Each troubleshooting chart has three headings arranged from left to right

(1) Check point (2) Trouble cause (3) Remedy

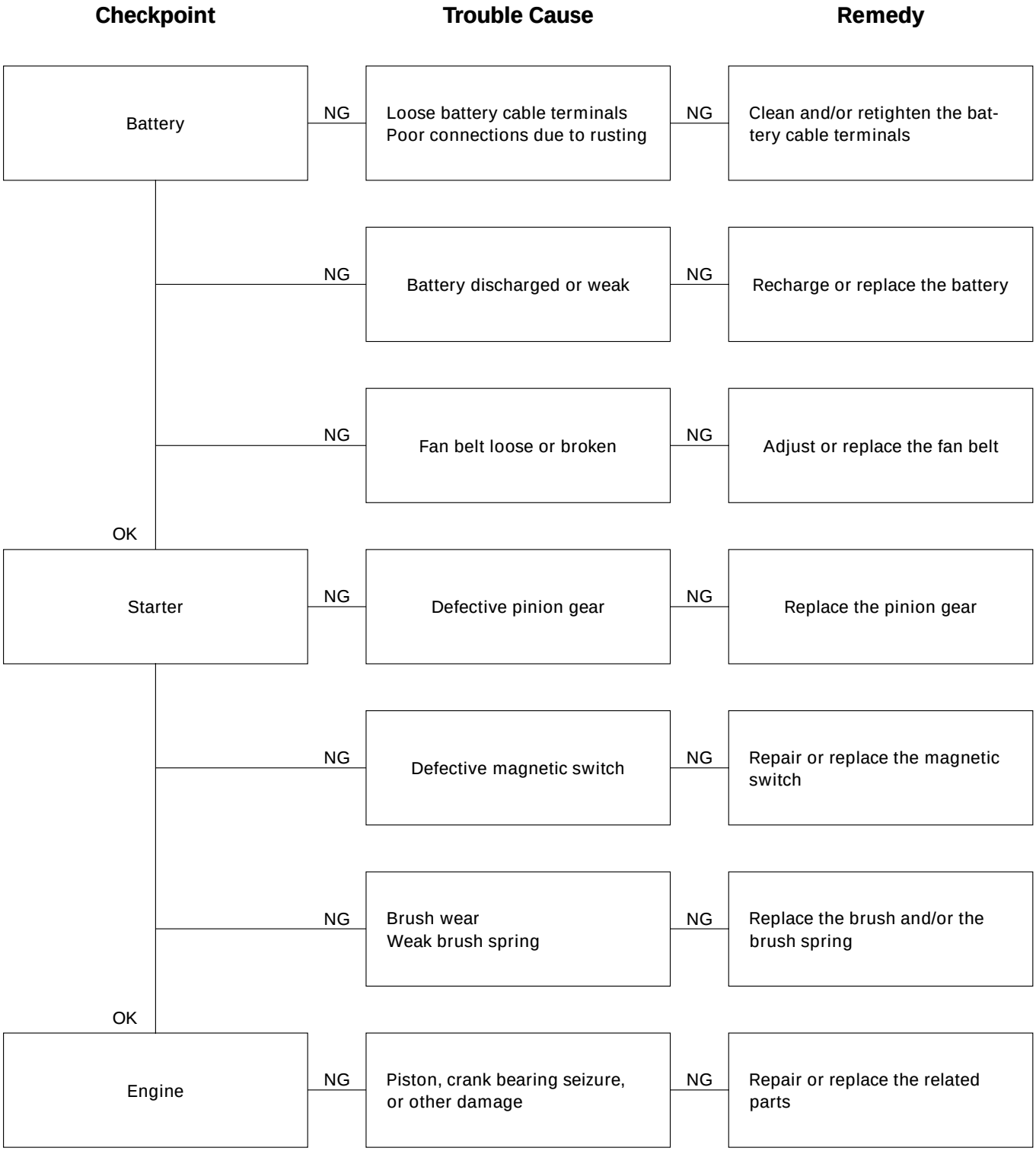
HARD STARTING

1) STARTER INOPERATIVE



HARD STARTING

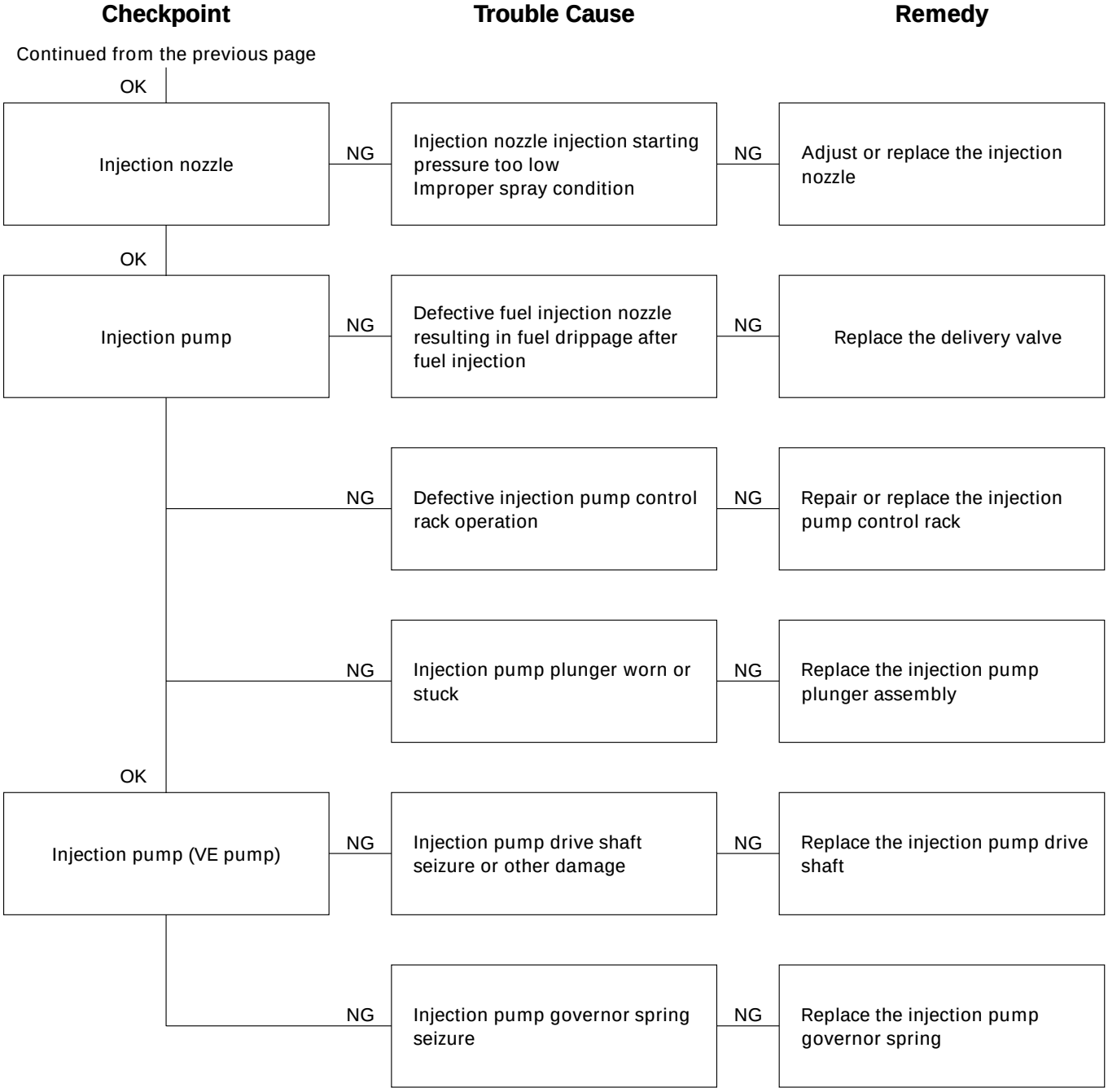
2) STARTER OPERATES BUT ENGINE DOES NOT TURN OVER



HARD STARTING

3) ENGINE TURNS OVER BUT DOES NOT START

FUEL IS BEING DELIVERED TO THE INJECTION PUMP



HARD STARTING

4) ENGINE TURNS OVER BUT DOES NOT START

Checkpoint		Trouble Cause		Remedy
Engine stop mechanism	NG	Defective engine stop mechanism control wire improperly adjusted (In-line pump)	NG	Replace the engine stop mechanism Adjust the control wire
	NG	Defective fuel cut solenoid valve (VE pump)	NG	Replace the fuel cut solenoid valve

FUEL IS NOT BEING DELIVERED TO THE INJECTION PUMP

Fuel	NG	Fuel tank is empty	NG	Fill the fuel tank
OK				
Fuel piping	NG	Clogged or damaged fuel lines Loose fuel line connections	NG	Repair or replace the fuel lines Retighten the fuel line connections
OK				
Fuel filter	NG	Fuel filter overflow valve does not close	NG	Repair or replace the fuel filter overflow valve
	NG	Clogged fuel filter element	NG	Replace the fuel filter element or the fuel filter cartridge
OK				
Fuel system	NG	Air in the fuel system	NG	Bleed the air from the fuel system

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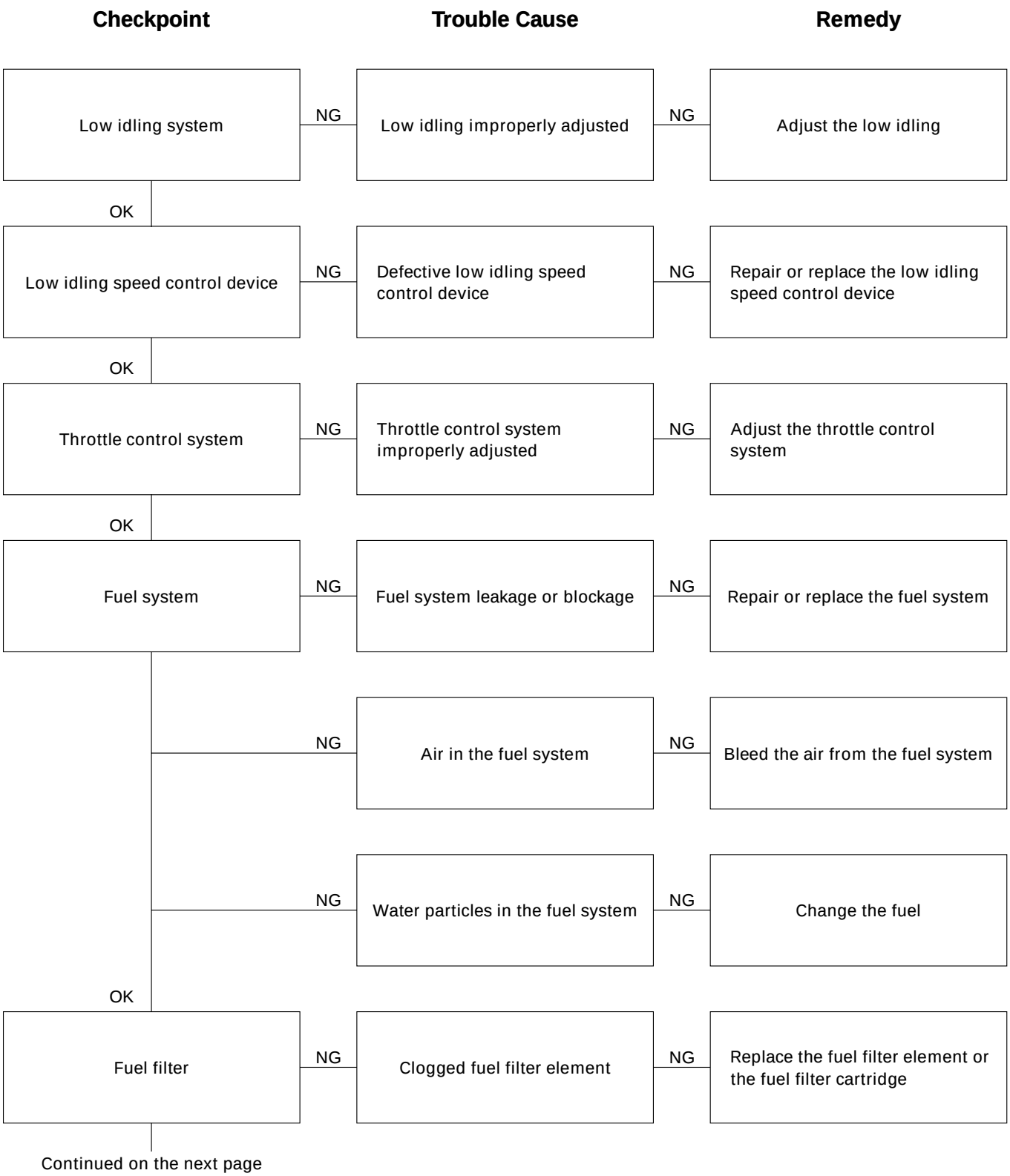
UNSTABLE LOW IDLING



Continued on the next page

UNSTABLE LOW IDLING

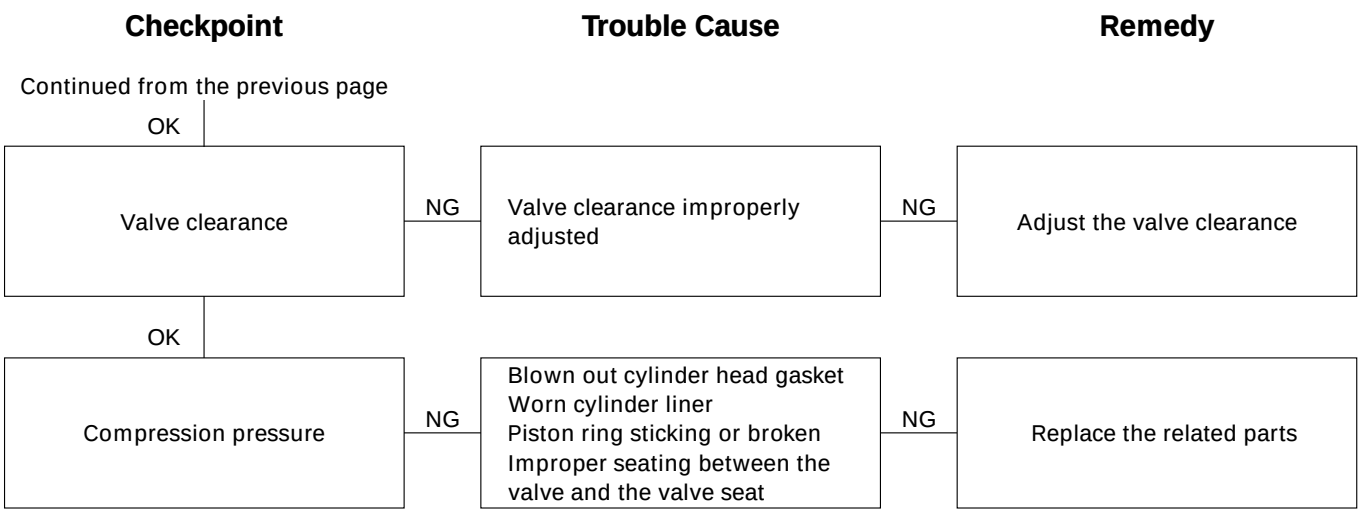
Continued from the previous page

Checkpoint		Trouble Cause		Remedy
Injection pump	NG	Defective governor lever operation	NG	Repair or replace the governor lever
	NG	Regulator valve improperly adjusted (VE pump only)	NG	Adjust or replace the regulator valve
	NG	Broken plunger spring	NG	Replace the plunger spring
	NG	Worn plunger	NG	Replace the plunger assembly
	NG	Worn camshaft (In-line pump only)	NG	Replace the camshaft
	NG	Worn roller tappet (In-line pump only)	NG	Replace the roller tappet
	NG	Worn cam disc (VE pump only)	NG	Replace the cam disc

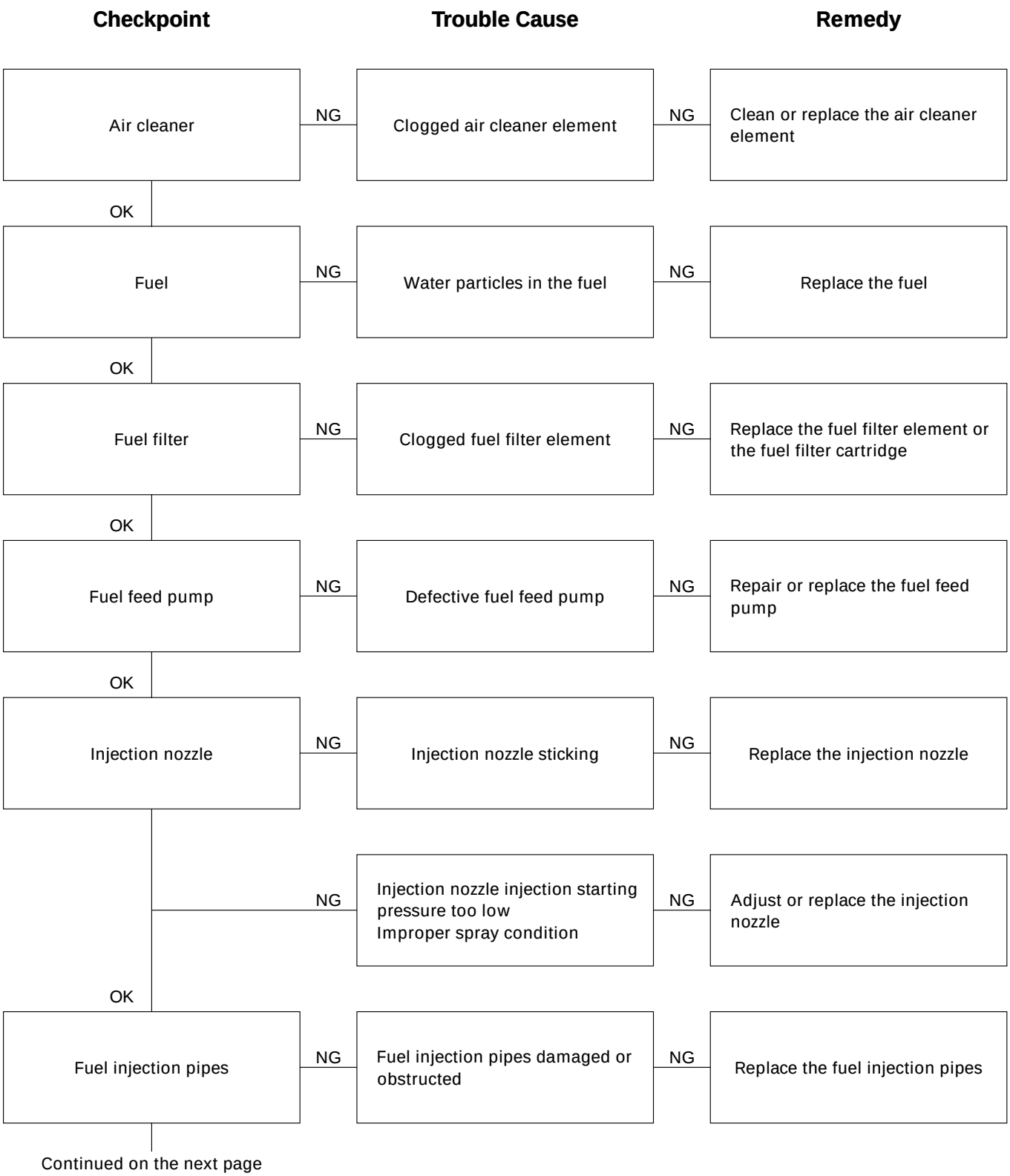
OK

Continued on the next page

UNSTABLE LOW IDLING



INSUFFICIENT POWER



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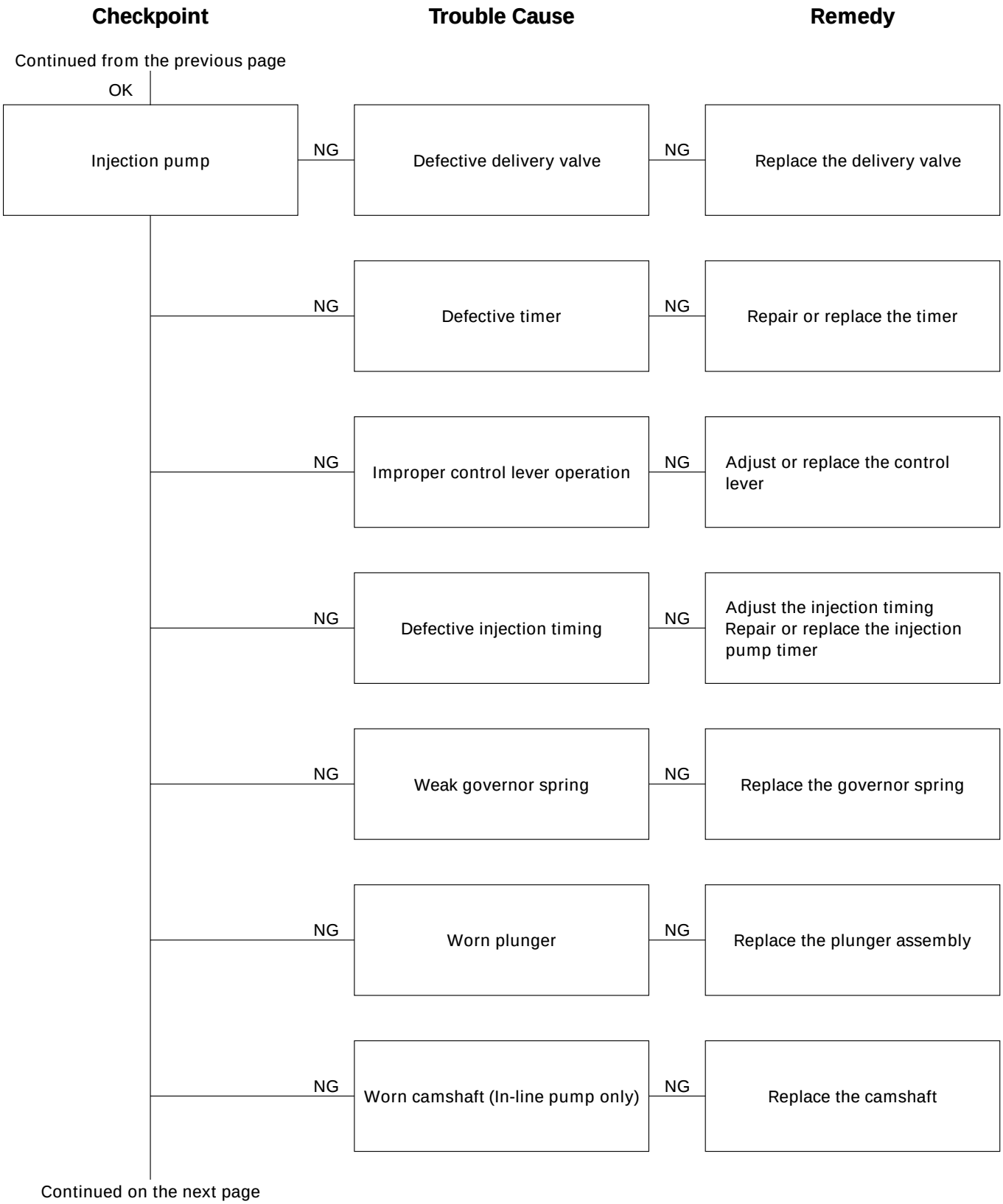
INSUFFICIENT POWER



INSUFFICIENT POWER

Continued from the previous page

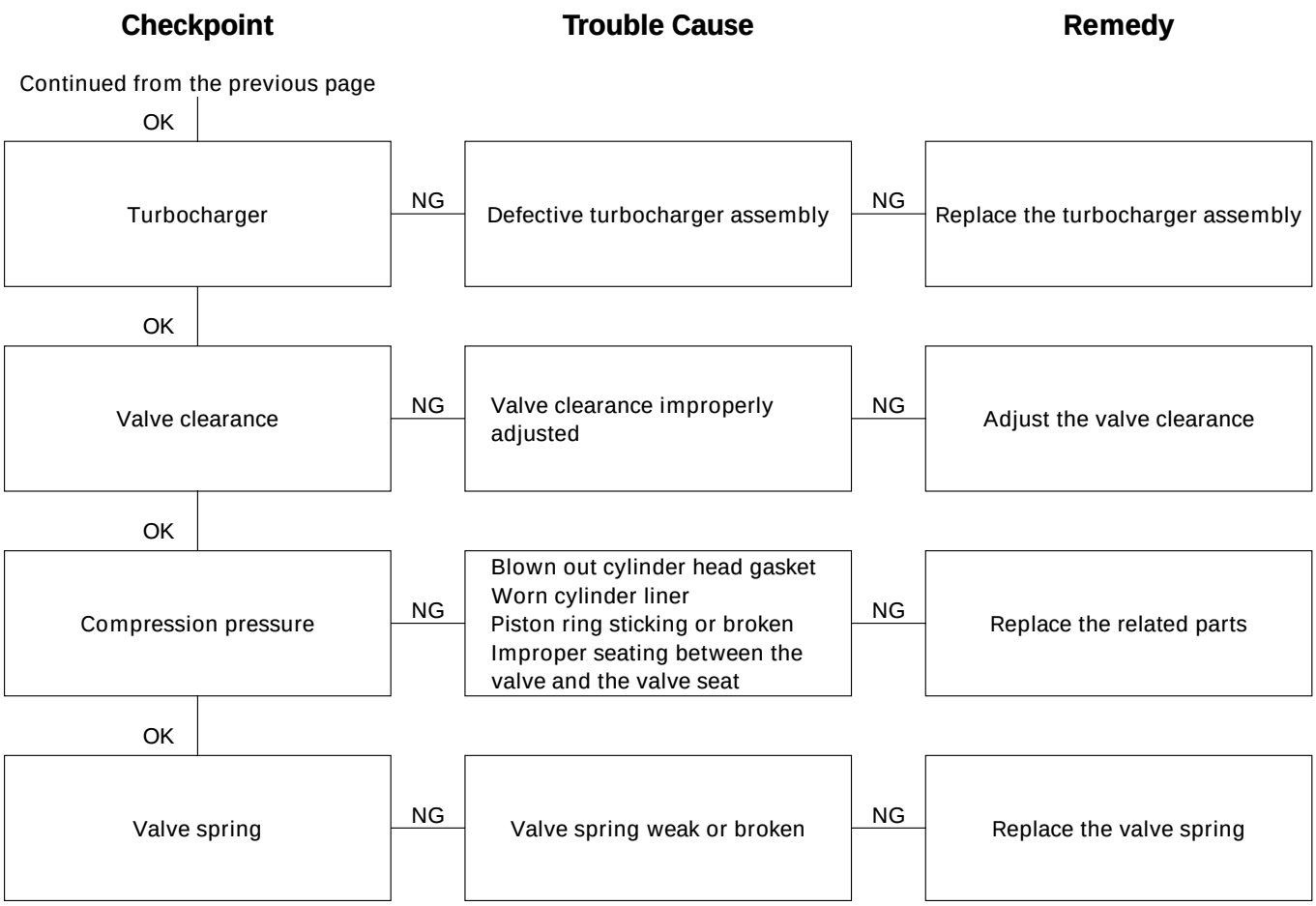
Checkpoint		Trouble Cause		Remedy
Injection pump	NG	Worn roller tappet	NG	Replace the roller tappet
Turbocharger	NG	Exhaust gas leakage from the exhaust system Air leakage from the intake system	NG	Repair or replace the related parts
	NG	Defective turbocharger assembly	NG	Replace the turbocharger assembly
Compression pressure	NG	Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	NG	Replace the related parts
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance
Valve spring	NG	Valve spring weak or broken	NG	Replace the valve spring
Exhaust system	NG	Exhaust pipe clogged	NG	Clean the exhaust pipe
Full load adjusting screw seal	NG	Open and improperly set adjusting screw seal	NG	Adjust and reseal the adjusting screw

EXCESSIVE FUEL CONSUMPTION

Checkpoint		Trouble Cause		Remedy
Fuel system	NG	Fuel leakage	NG	Repair or replace the fuel system related parts
OK				
Air cleaner	NG	Clogged air cleaner element	NG	Clean or replace the air cleaner element
OK				
Low idling speed	NG	Poorly adjusted low idle speed	NG	Adjust the low idle speed
OK				
Injection nozzle	NG	Injection nozzle injection starting pressure too low Improper spray condition	NG	Adjust or replace the injection nozzle
OK				
Fuel injection timing	NG	Fuel injection timing improperly adjusted	NG	Adjust the fuel injection timing
OK				
Injection pump	NG	Defective delivery valve resulting is fuel drippage after fuel injection	NG	Replace the delivery valve
OK				
Turbocharger	NG	Air leakage from the turbocharger intake side	NG	Repair the turbocharger intake side

Continued on the next page

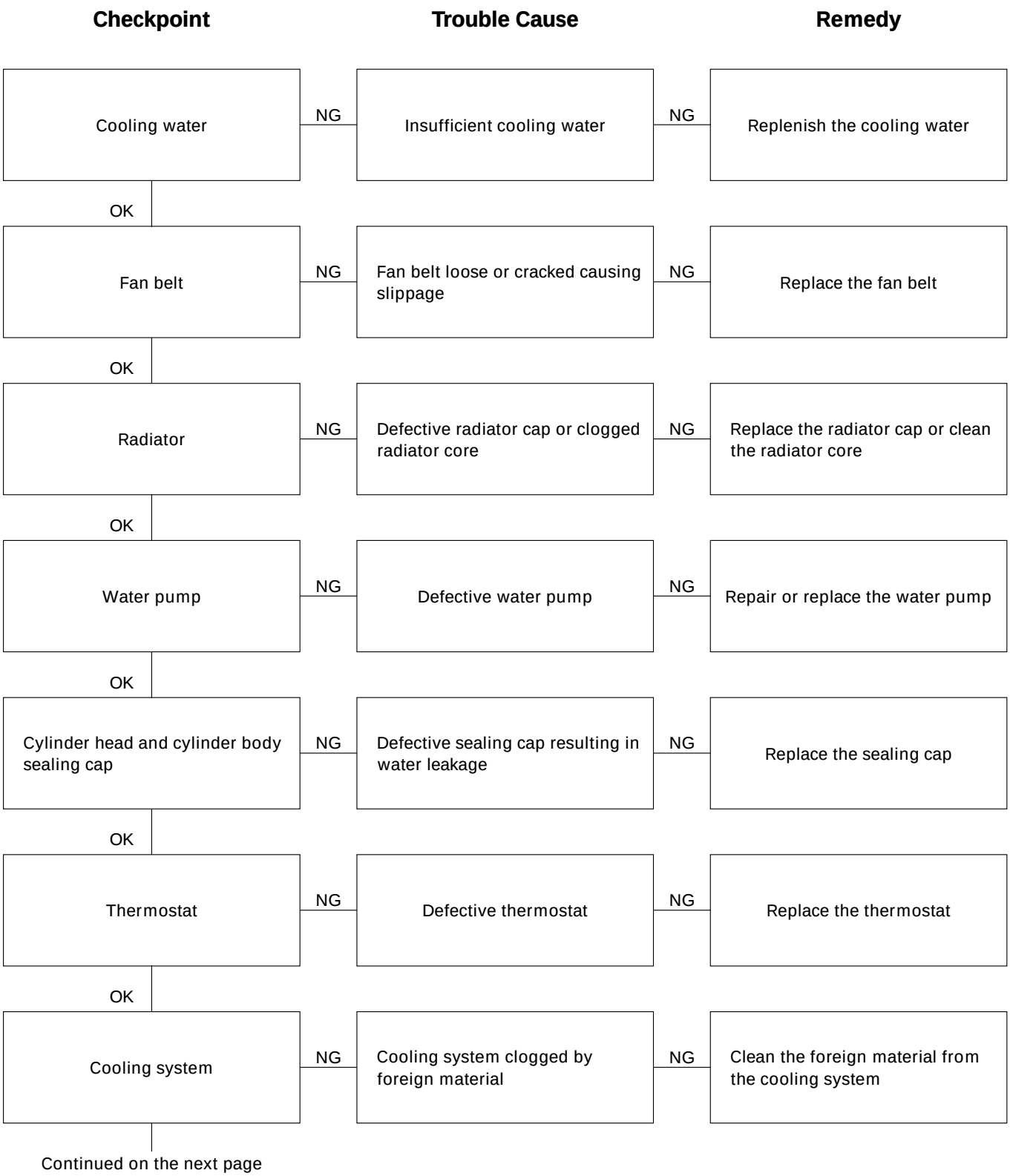
EXCESSIVE FUEL CONSUMPTION



EXCESSIVE OIL CONSUMPTION

Checkpoint		Trouble Cause		Remedy
Engine oil	NG	Engine oil unsuitable Too much engine oil	NG	Replace the engine oil Correct the engine oil volume
OK				
Oil seal and gasket	NG	Oil leakage from the oil seal and/or the gasket	NG	Replace the oil seal and/or the gasket
OK				
Air breather	NG	Clogged air breather	NG	Clean the air breather
OK				
Inlet and exhaust valves Valve seals	NG	Defective valve seals Worn valve stems and valve guides	NG	Replace the valve seals, the valves, and the valve guides
OK				
Piston rings	NG	Piston rings worn, broken or improperly installed	NG	Replace the piston rings or properly install
OK				
Cylinder liners	NG	Cylinder lines scored or worn	NG	Replace the cylinder liners

OVERHEATING



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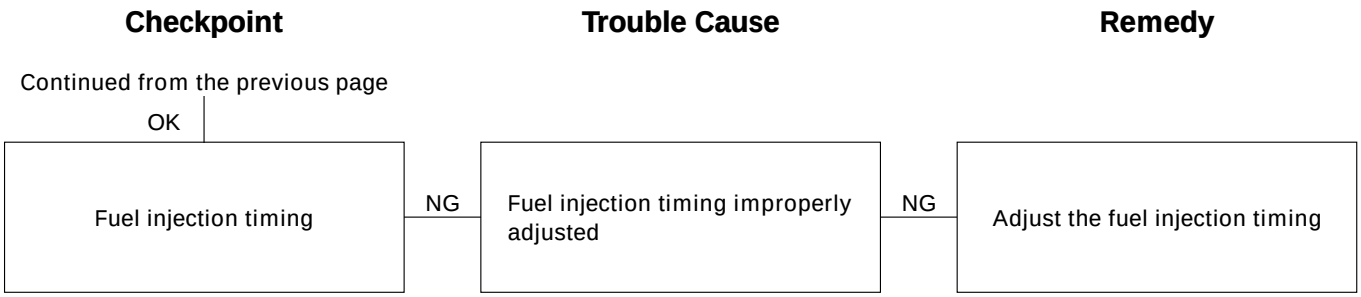
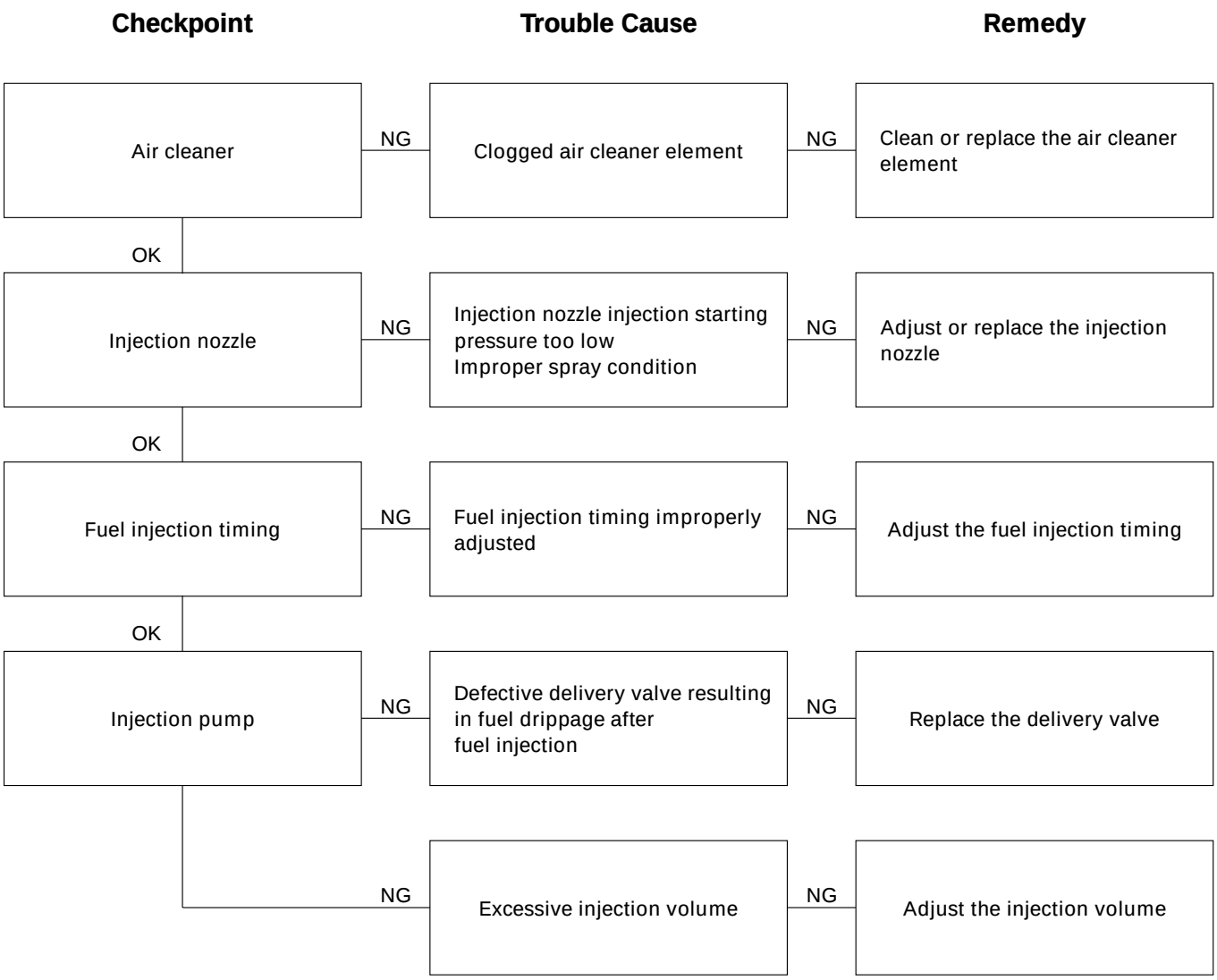
OVERHEATING



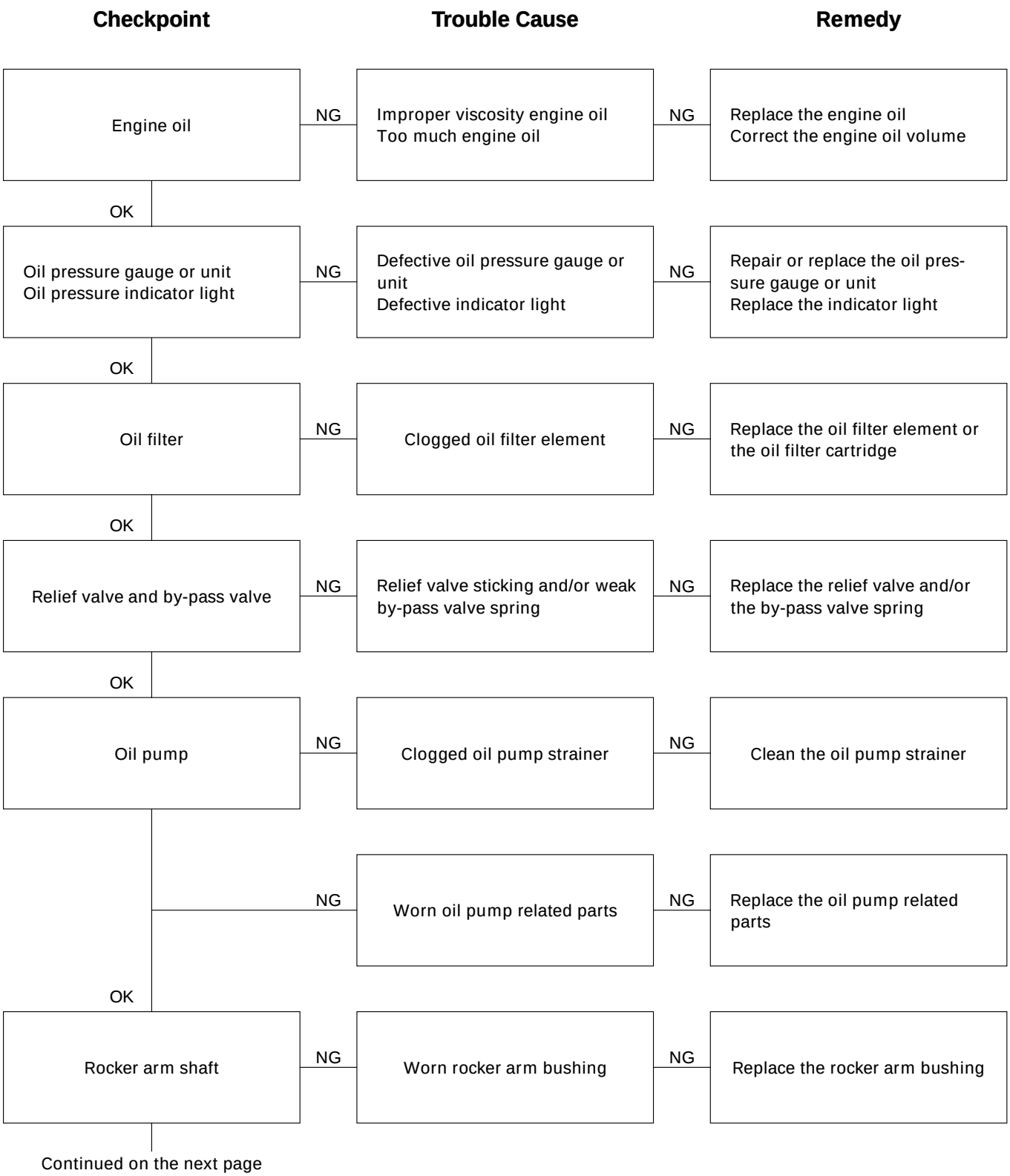
WHITE EXHAUST SMOKE

Checkpoint		Trouble Cause		Remedy
Fuel	NG	Water particles in the fuel	NG	Replace the fuel
OK				
Fuel injection timing	NG	Delayed fuel injection timing	NG	Adjust the fuel injection timing
OK				
Compression pressure	NG	Blown out cylinder head gasket Worn cylinder liner Piston ring sticking or broken Improper seating between the valve and the valve seat	NG	Replace the related parts
OK				
Turbocharger	NG	Defective turbocharger	NG	Replace the turbocharger
OK				
Inlet and exhaust valves Valve seals	NG	Defective valve seals Worn valves stems and valve guides	NG	Replace the valve seals, the valves, and the valve guides
OK				
Piston rings	NG	Piston rings worn, broken or improperly installed	NG	Replace the piston rings or properly install
OK				
Cylinder liners	NG	Cylinder lines scored or worn	NG	Replace the cylinder liners

DARK EXHAUST SMOKE



OIL PRESSURE DOES NOT RISE



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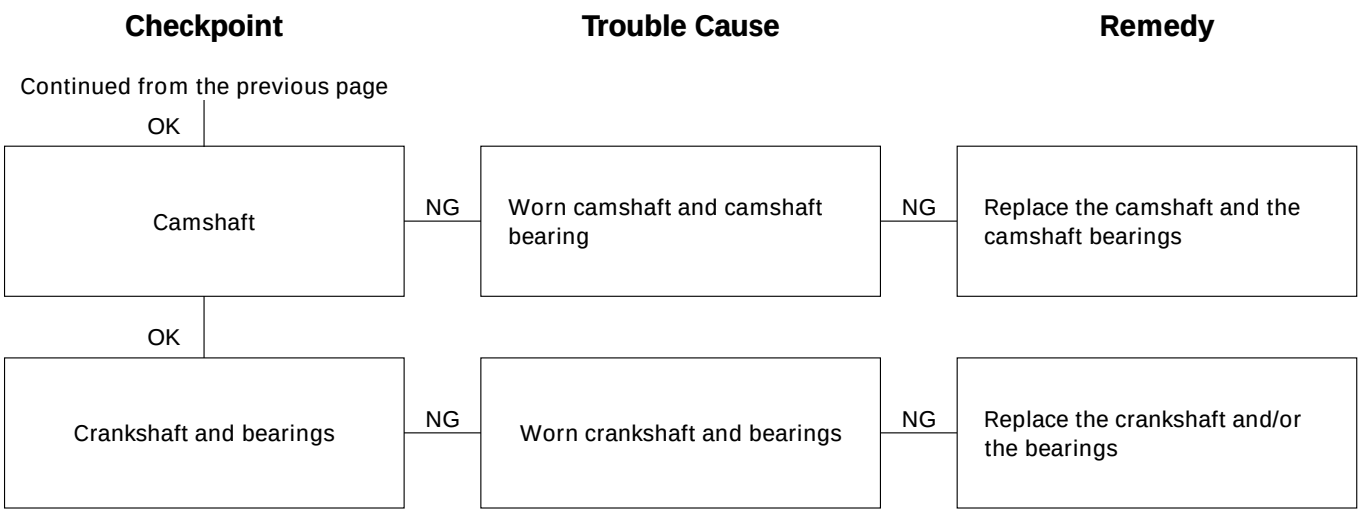
OIL PRESSURE DOES NOT RISE



ABNORMAL ENGINE NOISE

1. Engine Knocking

Checkpoint		Trouble Cause		Remedy
Fuel	NG	Fuel unsuitable	NG	Replace the fuel
OK				
Fuel injection timing	NG	Fuel injection timing improperly adjusted	NG	Adjust the fuel injection timing
OK				
Injection nozzle	NG	Improper injection nozzle starting pressure and spray condition	NG	Adjust or replace the injection nozzle
OK				
Compression pressure	NG	Blown out head gasket Broken piston ring	NG	Replace the head gasket or the piston ring

2. Gas Leakage Noise

Exhaust pipes	NG	Loosely connected exhaust pipes Broken exhaust pipes	NG	Tighten the exhaust pipe connections Replace the exhaust pipes
OK				
Injection nozzles and/or glow plugs	NG	Loose injection nozzles and/or glow plugs	NG	Replace the washers Tighten the injection nozzles and/or the glow plugs

Continued on the next page

ABNORMAL ENGINE NOISE

2. Gas Leakage Noise

Checkpoint		Trouble Cause		Remedy
Continued from the previous page				
OK				
Exhaust manifold	NG	Loosely connected exhaust manifold and/or glow plugs	NG	Tighten the exhaust manifold connections
OK				
Cylinder head gasket	NG	Damaged cylinder head gasket	NG	Replace the cylinder head gasket

3. Continuous Noise

Fan belt	NG	Loose fan belt	NG	Readjust the fan belt tension
OK				
Cooling fan	NG	Loose cooling fan	NG	Retighten the cooling fan
OK				
Water pump bearing	NG	Worn or damaged water pump bearing	NG	Replace the water pump bearing
OK				
Alternator or vacuum pump	NG	Defective alternator or vacuum pump	NG	Repair or replace the alternator or the vacuum pump
OK				
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance

ABNORMAL ENGINE NOISE

4. Slapping Noise

Checkpoint		Trouble Cause		Remedy
Valve clearance	NG	Valve clearance improperly adjusted	NG	Adjust the valve clearance
OK				
Rocker arm	NG	Damaged rocker arm	NG	Replace the rocker arm
OK				
Flywheel	NG	Loose flywheel bolts	NG	Retighten the flywheel bolts
OK				
Crankshaft and thrust bearings	NG	Worn or damaged crankshaft and/or thrust bearings	NG	Replace the crankshaft and/or the thrust bearings
OK				
Crankshaft and connecting rod bearings	NG	Worn or damaged crankshaft and/or connecting rod bearings	NG	Replace the crankshaft and/or the connecting rod bearings
OK				
Connecting rod bushing and piston pin	NG	Worn or damaged connecting rod bushing and piston pin	NG	Replace the connecting rod bushing and/or the piston pin
OK				
Piston and cylinder liner	NG	Worn or damaged piston and cylinder liner Foreign material in the cylinder	NG	Replace the piston and the cylinder liner

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SECTION 13

SPECIAL TOOL LIST

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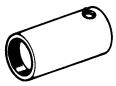
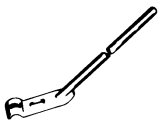
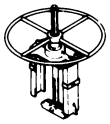
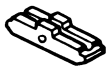
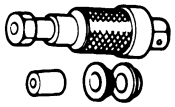
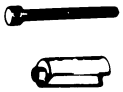
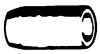
SPECIAL TOOL LIST

ITEM NO.	ILLUSTRATION	PART NO.	PARTS NAME	PAGE
1.		5-85317-001-0	Compression gauge adaptor	2–15
2.		1-85111-003-0	Cylinder head bolt wrench	3–8
3.		9-8521-0122-0	Crankshaft taper bushing remover	3–9
4.		5-8840-2360-0	Rear oil seal remover	3–9
5.		1-85235-0060	Valve spring compressor	3–13 5–5
6.		1-85232-001-0 9-85220-035-0	Valve guide remover and installer	4–3
7.		9-8523-1818-0	Camshaft bearing remover and installer	4–10
8.		5-8840-9038-0	Cylinder liner remover	4–12
9.		5-8523-1004-0	Cylinder liner remover ankle	4–12
10.		5-8522-1018-0	Cylinder liner installer	4–15

ITEM NO.	ILLUSTRATION	PART NO.	PARTS NAME	PAGE
11.		9-8523-1369-0	Connecting rod bushing installer	4–21
12.		9-8521-0141-0	Crankshaft gear remover	4–29
13.		9-8522-0033-0	Crankshaft gear installer	4–29
14.		9-8522-0034-0	Crankshaft front oil seal installer	4–30
15.		1-85221-005-0	Valve stem oil seal installer	5–5
16.		9-8522-1251-0	Piston ring compressor	5–12
17.		6BG1 5-8840-9025-0 4BG1 5-8840-2357-0	Rear oil seal installer	5–13

MEMO

SECTION 14

REPAIR STANDARDS

GENERAL RULES

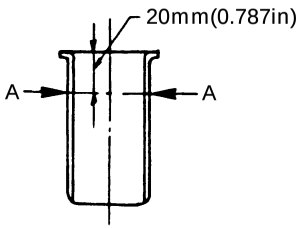
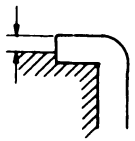
1. These tables provide standards relating the repair of the following diesel engine;

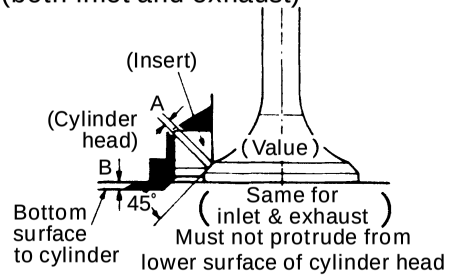
   Model AA-4BG1T, BB-4BG1T, AA-6BG1, BB-6BG1T

2. These Repair Standards are based on inspection items, together with dimensions, assembly standards, limit values, and repair procedures.
   (1) Nominal dimensions are the standard production values.
   (2) Assembly standards considered to be the values used as objectives during the assembly procedures which follow repairs; as a result, they may be somewhat at variance with the assembly dimensions of a new engine.
   (3) Limit values refer to the measured values resulting from wear, etc., beyond which a part must not be used. If a measured value falls beyond the limit value, the part involved must be repaired or replaced.
   (4) "Repair Procedures" indicates normal repair methods.
   (5) Unless otherwise stated, the unit of numerical values in tables should be taken to refer to millimeters. mm (in).

3. Explanation of Terms Used in Tables
   (1) The dimension of "wear" refers to the difference between the dimensions of a part which is not worn (or the "nominal dimension" of a part without wear) and the dimension of the part suffering from the most wear (the dimension of the worn part).
   (2) Uneven wear means the difference between the maximum and minimum wear values.

4. When repairs are requested on the overall engine, first perform bench tests to determine what parts require repairs, then perform the minimum disassembly and repairs required to correct the problems. When repairs on a specific engine part are requested, repairs to be made in reference to the relevant items in accordance with the repair standards listed in this manual.

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Time for engine disassembly and repair		Cylinder compression pressure MPa (kgf/cm^2/psi)	3.0 (31/440)		2.5 (26/370)	Disassemble and repair engine	Water temperature 70 – 85°C, (158 – 185°F) engine speed 200 min^{-1} (varies depending on altitude)
		Fuel consumption L/h	100%		140%		New engine performance is assumed 100%
		Lubricating oil consumption L/h	100%		200%		
Engine Body	Cylinder Block	Wear on liner bore Measured at A–A 	Dia. 105 (4.1339)		Dia 105.2 (4.1417)	Upper step wear must be repaired, or replace with standard dimension liner	(Ref) Cylinder & liner interference 0.001 – 0.019 (0.00004 – 0.0007)
		Liner projection 		0.03 – 0.10 (0.001 – 0.004)		Some projection must be present	Difference in liner projection between neighboring cylinders not to exceed 0.03 (0.001)
		Cylinder block upper face warpage		0.05 or less (0.002)	0.2 (0.0079)	Must be repairable	0.3 (0.0118)
		Pressure test: 3 minutes kPa (kgf/cm^2/psi)		490 (5/71.1)		Leaks require repair or replacement	

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Engine Body	Cylinder Head	Valve seat depression: B (both inlet and exhaust)  		1.0 (0.039)	2.5 (0.098)	Replace insert	Valve seat angle: α 45°
		Contact width with valve seat: A		1.5 (0.059)	2.0 (0.079)	Repair with valve seat cutter	After repair, be sure to lap contact surfaces
		Warpage and flatness of cylinder head lower face (mounting surface)		0.075 or less (0.003)	0.2 0.079	Cannot be repaired: must replace cylinder head	
		Warpage of manifold mounting surface		0.05 or less (0.002)	0.4 (0.016)	repair	
		Water-pressure test, 3 minutes kPa (kgf/cm^2/psi)		490 (5/71.1)		Leaks require repair or replacement	
		Cylinder head bolts tightening torque (angular tightening method) N·m (kgf-m/lb·ft)		69 (7.0/51) ↓ 88 (9.0/65) ↓ 90° – 120°		• Clean bolt mounting surfaces and threads, and apply molybdenum disulfide grease. • Never tighten again after using angular tightening method. • Reuse bolts max. 2 times	

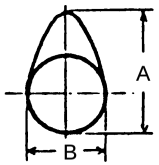
Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Pistons	Clearance with cylinder: grade position from upper face 82 mm (3.228 in)			Clearance with major axis 0.051 – 0.085 (0.002 – 0.0033)			
		Piston pin and piston pin hole clearance			0.010 – 0.023 (0.00039 – 0.0009)	0.05 (0.00197)	Replace piston or piston pin	
		Pin wear			35.000 – 35.005 (1.3780 – 1.3781)	34.95 (1.3760)	Replace piston pin	
	Piston Ring	Piston Ring Gap	No. 1 compression ring		0.35 – 0.50 (0.014 – 0.020)	1.5 (0.059)	Replace rings when performing engine disassembly and repair	Gauge inner standard diameter 105 (4.134)
			No. 2 compression ring		0.60 – 0.75 (0.0236 – 0.0295)			
			No. 3 compression ring		0.60 – 0.75 (0.0236 – 0.0295)			
			Oil ring		0.30 – 0.50 (0.014 – 0.020)			
		Tension N (kgf/lb)	No. 1 compression ring		20.4 – 30.6 (2.08 – 3.12/ 4.59 – 6.88)	9.8 (1.0/2.2)	Replace	Measure with ring compressed to standard ring gap.
			No. 2 compression ring		14.1 – 21.2 (1.44 – 2.16/ 3.17 – 4.76)	4.9 (0.5/1.1)		
			No. 3 compression ring		14.1 – 21.2 (1.44 – 2.16/ 3.17 – 4.76)	4.9 (0.5/1.1)		
			Oil ring		36.3 – 55.9 (3.7 – 5.7/ 8.16 – 12.6	31 (3.2/7.05)	Replace	Measure with expander attached

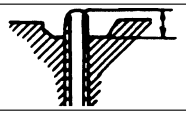
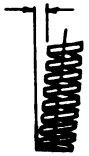
Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Piston Ring	Clearance between piston ring and ring groove	No. 1 compression ring		–	–	Replace rings or piston	When assembling compression rings on piston, be sure ring's marked surface is up. Backwards installation will result in excessive oil consumption. No top/bottom to oil ring.
			No. 2 compression ring		0.070 – 0.110 (0.0028 – 0.0043)	0.15 (0.0059)		
			No. 3 compression ring		0.050 – 0.090 (0.0020 – 0.0035)	0.15 (0.0059)		
			Oil ring		0.030 – 0.070 (0.0012 – 0.0028)	0.15 (0.0059)		
		Ring gap orientation					At 90° intervals	

Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Crankshaft	Uneven wear on journal and pins		Dia. 80 (3.1496) Dia. 64 (2.5197)		0.05 (0.002)	Replace	Do not attempt to grind: always replace with new parts
		Journal Diameter	6BG1	Center Bearing only	79.905 – 79.925 (3.1459 – 3.1467)		Replace	
				Other Bearing	79.919 – 79.939 (3.1464 – 3.1472)			
			4BG1	All Bearing	79.905 – 79.925 (3.1459 – 3.1467)		Replace	
		Pin Diameter			63.924 – 63.944 (2.5167 – 2.5175)		Replace	
		Journal and pin finish precision (taper and ellipse)			Ellipse and taper 0.007 (0.0003)			
		Journal and bearing arc spread					Use those with projection and proper arc; take care with back side fit	
		Clearance between journal and bearing	6BG1	Center Bearing only	0.039 – 0.098 (0.0015 – 0.0039)	0.11 (0.0043)	Replace bearing	
				Other Bearing	0.025 – 0.084 (0.0010 – 0.0033)			
			4BG1	All Bearing	0.039 – 0.098 (0.0015 – 0.0039)			
		Journal bearing undersize					Undersize bearings cannot be used	
		Crankshaft end play			0.15 – 0.33 (0.006 – 0.013)	0.4 (0.016)	Replace thrust bearings	Measure at crankshaft's No. 4 bearing thrust surface
		Crankshaft runout			0.05 or less (0.002)	0.4 (0.016)	Replace	
		Ring gear					Perform lapping on gears with burrs; in cases of severe damage, replace.	
		Crankshaft balance (g-cm)			36 or less		Check dynamic balance	(Ref. value) At ends of journal

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Crankshaft	Crankshaft bearing cap bolt torque N·m (kgf-m/lb·ft)		226 – 245 (23 – 25/166 – 181)		Apply engine oil to threads and seating areas of bolts before tightening	Do not catch foreign matter in bolts
		Crankshaft rear oil seal wear				In case of oil leak, replace oil seal	Check for oil seal collapse

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Connecting Rod	Connecting rod bearing arc spread				Use those with projection and proper arc; take care work back side fit	
		Clearance between connecting rod bearing and crankpin		0.030 – 0.073 (0.0012 – 0.0029)	0.10 (0.0039)	Replace bearing or crankshaft	Take special care with crankpin precision
		Contact between connecting rod bearing and crankpin				Replace parts with poor contact or abrasions	
		Clearance between smallend bushing and piston pin		0.012 – 0.025 (0.00047 – 0.00098)	0.05 (0.00197)	Replace bushing or pin	Sufficient gap to allow smooth rotation when holding big end
		Connecting rod bearing undersize					Crank must not be ground (no undersizes available)
		Connecting rod and crankpin end play		0.17 – 0.30 (0.0067 – 0.011)	0.35 (0.014)	Replace connecting rod	
		Center distance between big end and small end (mm)	192 (7.559)				Reference value
		Big end to small end hole twist (per 100 mm)		0.05 or less (0.002)	0.2 (0.0079)	Repair or replace	
		Big end to small end hole parallelism (per 100 mm)		0.05 or less (0.002)	0.2 (0.0079)	Repair or replace	
		Piston weight difference after assembly g		20 or less		Repair or replace	
		Bearing cap bolt tightening torque (angular tightening method) N·m (kgf-m/lb·ft)	39 (4.0/29) ↓ 60° – 90°			Apply molybdenum disulfide grease to bolts before tightening	

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Main Operating Parts	Camshaft	Journal uneven wear	Dia. 56 (2.205)		0.05 (0.002)	Replace camshaft	
		Clearance between journal and bearing		0.03 – 0.09 (0.001 – 0.004)	0.15 (0.006)	Replace camshaft or bearing	
		Journal wear	Dia. 56 (2.205)	Dia. 55.94 – 55.97 (2.202 – 2.204)	Dia. 55.6 (2.189)	Replace camshaft	
		Cam height: A – B 	7.71 (0.304)		7.21 (0.284)	Replace camshaft	Minor step wear on cams can be repaired
		Camshaft runout			0.12 (0.005)	Replace camshaft	Measure with dial gauge at No. 3 or No. 4 journal, runout during one rotation.
		Camshaft play (front-back direction)		0.050 – 0.114 (0.002 – 0.005)	0.2 (0.008)		

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Valve System	Valves	Inlet valve stem wear	Dia. 9 (0.3543)		Dia. 8.88 (0.3496)	Replace valve and valve guide together	Measure valve stem at three positions
		Exhaust valve stem wear					
		Clearance between inlet valve stem and valve guide		0.039 – 0.071 (0.0015 – 0.0028)	0.20 (0.008)	Replace valve and valve guide together	
		Clearance between exhaust valve stem and guide		0.064 – 0.096 (0.0025 – 0.0038)	0.25 (0.0098)		
		Interference between valve guide and cylinder head		0.024 (0.0009)			Apply oil to valve guide and press in
		Valve thickness 	1.5 (0.059)		1.00 (0.039)	Replace valve and valve guide together	
		Height of valve guide above cylinder head 	14.1 (0.555)				Reference value
		Valve stem oil seal lip	Dia. 8.5 (0.335)		Dia. 8.8 (0.346)	Replace oil seal	Don’t damage lip.
	Valve spring	Tension N (kgf/lb) (When compressed to installed length) 44.5mm(1.752in)		142 (14.5/30.9)	127 (13.0/28.7)	Replace valve spring	
		Free height mm (in)		60.6 (2.39)	58.0 (2.28)		
		Inclination  mm (in)		less than 1.9 (0.075)	2.7 (0.106)		

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Valve System	Valves	Valve clearance (inlet & exhaust) (cold)		0.4 (0.016)		Adjust	
		Clearance between rocker arm shaft and rocker arm		0.01 – 0.05 (0.0004 – 0.002)	0.2 (0.0079)	Replace bushing or shaft	
		Rocker arm shaft wear		18.98 – 19.00 (0.747 – 0.748)	Dia. 18.85 (0.742)	Replace	
Intake System	Air cleaner	Air cleaner element condition					Special order item from manufacturer

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Lubricating System	Oil pressure	Lubricating oil pressure kPa (kgf/cm^2/psi)		290 – 590 (3.0 – 6.0/43 – 85)	196 (2.0/28)		
	Oil Ipump and Relief valve	Clearance between pump body inner wall and gear teeth mm		0.075 – 0.150 (0.003 – 0.0059)	0.2 (0.0079)	Replace bushing, gear or body	
		Pumping rate L/min (1650 min^{-1}, SAE #30, pumping pressure 392 kPa (4 kgf/cm^2/57 psi) oil temp. 80°C (176°F))		53.3			
		End gap between pump cover and gear		0.040 – 0.094 (0.0016 – 0.0037)	0.15 (0.0059)	Replace gear or cover	
		Clearance between drive shaft and pump body		0.032 – 0.070 (0.0013 – 0.0028)	0.15 (0.0059)		
		Clearance between drive shaft and bushing		0.045 – 0.078 (0.0018 – 0.0031)	0.15 (0.0059)	Replace bushing	
		Diameter of drive shaft	Dia. 16 (0.6299)		Dia 15.9 (0.626)	Replace shaft	
		Initial operating pressure of relief valve kPa (kgf/cm^2/psi) Oil gallery		441 (4.5/64)			Reference value
		Initial operating pressure of relief valve kPa (kgf/cm^2/psi) Oil pump		785 (8/114)			
	Oil filter	Clogging and damage to oil filter				Replace	Replace cartridge every 500 hours of operation
		Initial operating pressure of main oil filter relief valve kPa (kgf/cm^2/psi)		196 (2.0/28)			

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Cooling System	Water pump	Water pump ball bearing chatter (radial direction)		0.008 – 0.010 (0.0003 – 0.0004)	0.2 (0.0079)	Replae	#6305 (2) #6205 (1)
		Pumping rate L/min (pumping speed 3720 min^{-1}, water temp 30°C (86°F) Total head 13.5m(531.5in) or more)		300			
		Clearance between pump impeller and pump body mm (in)		0.3 – 1.0 (0.0118 – 0.039)		Repair or replace if impeller and pump body are touching	
		Fan belt deflection (Press with finger) mm (in) — 6BG1		About 7 – 10 (0.276 – 0.394)		Adjust	(Reference) 98N (10kgf/22lb)
		Fan belt deflection (Press with finger) mm (in) — 4BG1		About 8 – 12 (0.315 – 0.472)			
		Initial thermostat operating temperature (at sea level)		82 ± 2°C (179.6 ± 35.6°F)			Replace thermostat if operation is incorrect.
		Thermostat full-open temperature (at sea level)		95°C (203°F)		Temperature at which thermostat lift reaches 10mm(0.394in) or more.	
		Fan center and bearing shaft interference		0.07 – 0.11 (0.003 – 0.004)		Replace water pump ASM	
		Bearing shaft and impeller interference		0.020 – 0.060 (0.0008 – 0.0024)		Replace water pump ASM	
		Pulley and fan center clearance		0.14 or less (0.006)		Replace water pump ASM	

Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Piping, etc.	Clogged, cracked, loose fuel pipes, injection pipes, nozzle holders; defective seals.					Repair or replace	
		Fuel filter element clogging or damage					Replace	Cartridge type
	Injection pump	Delivery valve	Delivery valve wear				Inspect for damage to valve's piston and seat; replace in case of severe vertical cracks on piston or impact scars on seat with loss of finish gloss. Immerse delivery valve in clean diesel fuel, then lightly press lower part of valve seat with finger and release; replace assembly if valve does not return to original state when finger is released.	

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Injectipn pump						

	Pump Part No. / Adjustment Item		1-15603-328-0
Adjustment Conditions	Rotation Direction		Clockwise (viewed from drive side)
	Nozzle		105780-0000 (BOSCH Type No. DN12SD12T)
	Nozzle holder assembly		105780-2080 (BOSCH Type No. EF8511/9)
	Nozzle opening pressure	MPa (kgf/cm^2/psi)	17.2 (175/2490)
	Fuel pumping pressure	kPa (kgf/cm^2/psi)	157 (1.6/23)
	Pipe (o.d. x i.d. x lenght)	mm (in)	Dia. 6(0.236) x Dia. 2(0.079) x 600(23.62)
	Test fuel		ISO4113 or SAE Standard Oil (SAE J967d)
	Fuel temperature	°C (°F)	40 – 45 (104 – 113)

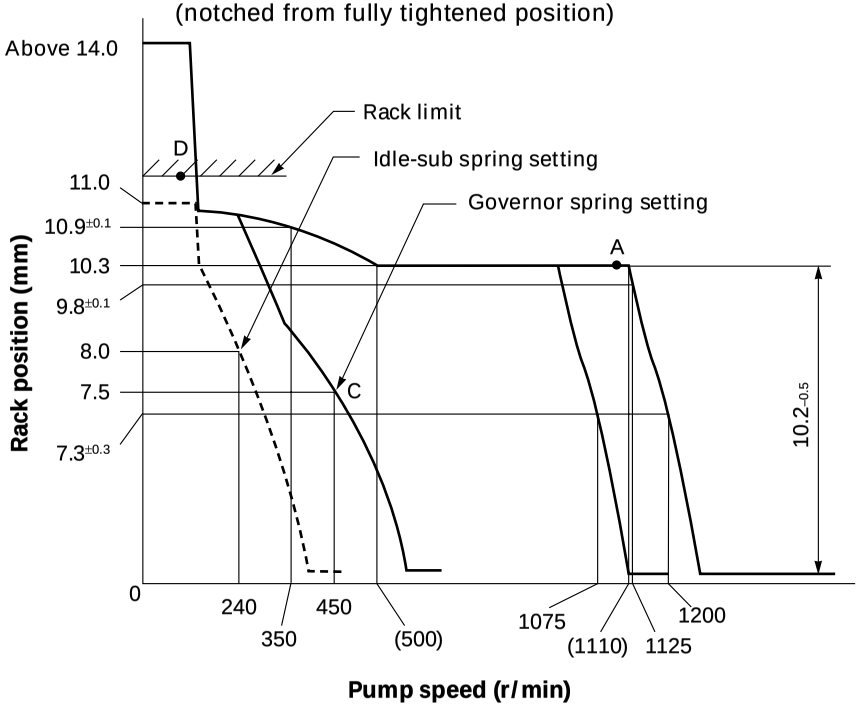
Injection adjustment

Adjustment point	Rack position mm (in)	Pump speed (min^{-1})	Injection q'ty (mm^3/1000 strokes)	Max. var bet. cyl (%)	Fixed	Remarks
A	10.3 (0.4449)	1075	89 ± 1.5	± 2	Lever	Basic
C	Approx 7.5 (0.295)	450	9 ± 1.3	± 14	Rack	
D	–	100	150 ± 5	–	Lever	Rack limit

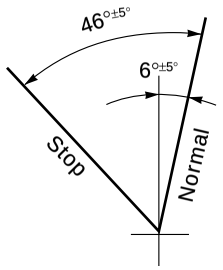
Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel System	Injectipn pump						

Governor perfomance curve

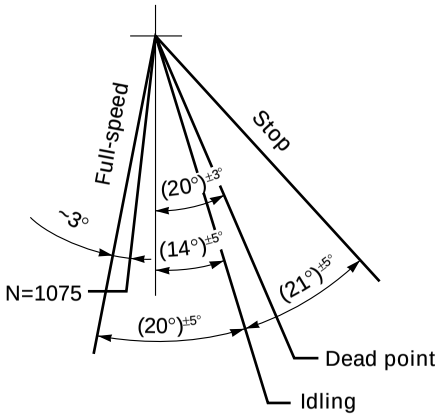
Recommended speed droop adjustment screw position:9
(notched from fully tightened position)



Stop lever angle



Speed lever angle



Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Fuel system	Injection Nozzle	Technology Needle valve seat: 7.8MPa (80 kgf/cm^2/138psi)				Repair or replace parts with leaks from seat area	
		Needle valve shaft seat: seconds (Impress fuel pressure of 29.4MPa (300kgf/cm^2/4267psi) (nozzle starting pressure and measure time required for pressure to drop from 24.5MPa (250kgf/cm^2 /3556psi) to19.6MPa (200kgf/cm^2/2845psi).)		5.0 or more		Replace	Fuel used: diesel fuel; clay (Redwood); 37 – 40 seconds 120°C (248°F)
		Fuel spray and injection (Impress fuel pressure of Adjust needls valve opening pressure to 19.1MPa (195kgf/cm^2/2770psi))	① Visually inspect, no relatively large drops scattered. ② No drops scattered to one side. ③ No unevenness of spray from jets.			Replace faulty parts	
Electrical	Charge/ Discharge indication	Warning lamp indication				If warning indicator lights when engine is operating at normal speeds, check and repair electrical system.	
	Wiring	Check for looseness, cuts or damaged insulation to wiring.				Repair	
	Alternator 24V, 50A (MITSUBISHI 1-81200-530-1)	Rotor: Shaft runout		0.06 or less (0.0024)	0.1 (0.0038)	Replace rotor	
		Rotor: Bearing chatter				Replace bearings	Rotate by hand and check for smooth rotation; no abnormal sound or resis-tance should be felt.
		Perform-ance: Rated output current 27 V (5000 min^{-1})		50A			

Major Category	Name of Part	Inspection Item		Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Electrical	Starter 24V, 7.4 kW (HITACHI 1-81100-342-0)	Loose mount					Repair	
		Brush height			22 (0.866)	14 (0.551)	Replace	
		Magnetic switch	Series coil resistance value (Ω)		0.187 20°C (68°F)			If coil resistance value is severely abnormal, replace switch.
			Shant coil resistance value (Ω)		1.31 20°C (68°F)			
		Commutator	O.D.	Dia. 37 (1.457)		Dia. 36.5 (1.437)	Replace armature	
			Undercut depth		0.5 – 0.8 (0.02 – 0.031)	0.2 (0.008)	Repair	
		Ball bearings	Rear side (armature)	Dia. 28 (1.102)			6001 D	Replace if rotation is not smooth or if abnormal sounds are heard.
			Front (armature)	Dia. 16 (0.630)			6905 D	
			Pinion shaft (shaft)	Dia. 16 (0.630)				
		Performance	Unloaded characteristics (24V, 100A or less)		3500 min^{-1}			Smooth pinion operation without noise
	Preheater	Control register, glow plug					Replace if cut wiring or shorts are found	
	Battery	Battery terminals						Special order from original manufacturer; manufacturer's specs.
		Plates, separator plates, container, etc.						
		Electrolyte turbidity						

Major Category	Name of Part	Inspection Item	Nominal Dimension	Assembly Standard Value	Limit	Repair Procedure	Comments
Electrical	Battery	Electrolyte specific gravity (at recharging, 20°C)					Special order from original manufacturer
		Capacity (20 hours)					
		Electrode voltage					
		Electrolye surface height					
Final Inspection		Engine run-in operation				30 minutes or more	
		Cylinder compression pressure MPa (kgf/cm^2/psi) [water temp. 70 – 85°C, (158 – 185°F) about 200 min^{-1}]		3.0 (31/441)	2.5 (26/370)	Inspect	Warm engine
		Difference in compression between cylinders kPa (kgf/cm^2/psi) [water temp. 70 – 85°C, (158 – 185°F) about 200 min^{-1}]			290 (3.0/43)	Inspect	Warm engine
		Lubricating oil pressure kPa (kgf/cm^2/psi)		290 – 590 (3.0 – 6.0/43 – 85)	200 or less (2.0/28)	Adjust	
		Output check		85% or more			When new engine output is 100%
		Fuel consumption check		110% or less			

MEMO

SECTION 15

CONVERSION TABLE

TABLE OF CONTENTS

LENGTH

MILLIMETERS TO INCHES

mm	in.	mm	in.	mm	in.	mm	in.
1	0.0394	26	1.0236	51	2.0079	76	2.9921
2	0.0787	27	1.0630	52	2.0472	77	3.0315
3	0.1181	28	1.1024	53	2.0866	78	3.0709
4	0.1575	29	1.1417	54	2.1260	79	3.1102
5	0.1969	30	1.1811	55	2.1654	80	3.1496
6	0.2362	31	1.2205	56	2.2047	81	3.1890
7	0.2756	32	1.2598	57	2.2441	82	3.2283
8	0.3150	33	1.2992	58	2.2835	83	3.2677
9	0.3543	34	1.3386	59	2.3228	84	3.3071
10	0.3937	35	1.3780	60	2.3622	85	3.3465
11	0.4331	36	1.4173	61	2.4016	86	3.3858
12	0.4724	37	1.4567	62	2.4409	87	3.4252
13	0.5118	38	1.4961	63	2.4803	88	3.4646
14	0.5512	39	1.5354	64	2.5197	89	3.5039
15	0.5906	40	1.5748	65	2.5591	90	3.5433
16	0.6299	41	1.6142	66	2.5984	91	3.5827
17	0.6693	42	1.6535	67	2.6378	92	3.6220
18	0.7087	43	1.6929	68	2.6772	93	3.6614
19	0.7480	44	1.7323	69	2.7165	94	3.7008
20	0.7874	45	1.7717	70	2.7559	95	3.7402
21	0.8268	46	1.8110	71	2.7953	96	3.7795
22	0.8661	47	1.8504	72	2.8346	97	3.8189
23	0.9055	48	1.8898	73	2.8740	98	3.8583
24	0.9449	49	1.9291	74	2.9134	99	3.8976
25	0.9843	50	1.9685	75	2.9528	100	3.9370

101	3.9764	111	4.3701	121	4.7638	131	5.1575
102	4.0157	112	4.4094	122	4.8031	132	5.1969
103	4.0551	113	4.4488	123	4.8425	133	5.2362
104	4.0945	114	4.4882	124	4.8819	134	5.2756
105	4.1339	115	4.5276	125	4.9213	135	5.3150
106	4.1732	116	4.5669	126	4.9606	136	5.3543
107	4.2126	117	4.6063	127	5.0000	137	5.3937
108	4.2520	118	4.6457	128	5.0394	138	5.4331
109	4.2913	119	4.6850	129	5.0787	139	5.4724

INCHES TO MILLIMETERS

in.	mm	in.	mm
1/64	0.3969	33/64	13.0969
1/32	0.7938	17/32	13.4938
3/64	1.1906	35/64	13.8906
1/16	1.5875	9/16	14.2875
5/64	1.9844	37/64	14.6844
3/32	2.3813	19/32	15.0813
7/64	2.7781	39/64	15.4781
1/8	3.1750	5/8	15.8750
9/64	3.5719	41/64	16.2719
5/32	3.9688	21/32	16.6688
11/64	4.3656	43/64	17.0656
3/16	4.7625	11/16	17.4625
13/64	5.1594	45/64	17.8594
7/32	5.5563	23/32	18.2563
15/64	5.9531	47/64	18.6531
1/4	6.3500	3/4	19.0500
17/64	6.7469	49/64	19.4469
9/32	7.1438	25/32	19.8438
19/64	7.5406	51/64	20.2406
5/16	7.9375	13/16	20.6375
21/64	8.3344	53/64	21.0344
11/32	8.7313	27/32	21.4313
23/64	9.1281	55/64	21.8281
3/8	9.5250	7/8	22.2250
25/64	9.9219	57/64	22.6219
13/32	10.3188	29/32	23.0188
27/64	10.7156	59/64	23.4156
7/16	11.1125	15/16	23.8125
29/64	11.5094	61/64	24.2094
15/32	11.9063	31/32	24.6063
31/64	12.3031	63/64	25.0031
1/2	12.7000	1	25.4000

15–2 CONVERSION TABLE

LENGTH

FEET TO METERS

ft.	0	1	2	3	4	5	6	7	8	9	ft.
	m	m	m	m	m	m	m	m	m	m	
—	—	0.305	0.610	0.914	1.219	1.524	1.829	2.134	2.438	2.743	—
10	3.048	3.353	3.658	3.962	4.267	4.572	4.877	5.182	5.486	5.791	10
20	6.096	6.401	6.706	7.010	7.315	7.620	7.925	8.230	8.534	8.839	20
30	9.144	9.449	9.754	10.058	10.363	10.668	10.973	11.278	11.582	11.887	30
40	12.192	12.497	12.802	13.106	13.411	13.716	14.021	14.326	14.630	14.935	40
50	15.240	15.545	15.850	16.154	16.459	16.764	17.069	17.374	17.678	17.983	50
60	18.288	18.593	18.898	19.202	19.507	19.812	20.117	20.422	20.726	21.031	60
70	21.336	21.641	21.946	22.250	22.555	22.860	23.165	23.470	23.774	24.079	70
80	24.384	24.689	24.994	25.298	25.603	25.908	26.213	26.518	26.822	27.127	80
90	27.432	27.737	28.042	28.346	28.651	28.956	29.261	29.566	29.870	30.175	90
100	30.480	30.785	31.090	31.394	31.699	32.004	32.309	32.614	32.918	33.223	100

METERS TO FEET

m	0	1	2	3	4	5	6	7	8	9	
	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft.	
—	—	3.2808	6.5617	9.8425	13.1234	16.4042	19.6850	22.9659	26.2467	29.5276	—
10	32.8084	36.0892	39.3701	42.6509	45.9318	49.2126	52.4934	55.7743	59.0551	62.3360	10
20	65.6168	68.8976	72.1785	75.4593	78.7402	82.0210	85.3018	88.5827	91.8635	95.1444	20
30	98.4252	101.7060	104.9869	108.2677	111.5486	114.8294	118.1102	121.3911	124.6719	127.9528	30
40	131.2336	134.5144	137.7953	141.0761	144.3570	147.6378	150.9186	154.1995	157.4803	160.7612	40
50	164.0420	167.3228	170.6037	173.8845	177.1654	180.4462	183.7270	187.0079	190.2887	193.5696	50
60	196.8504	200.1312	203.4121	206.6929	209.9738	213.2546	216.5354	219.8163	223.0971	226.3780	60
70	229.6588	232.9396	236.2205	239.5013	242.7822	246.0630	249.3438	252.6247	255.9055	259.1864	70
80	262.4672	265.7480	269.0289	272.3097	275.5906	278.8714	282.1522	285.4331	288.7139	291.9948	80
90	295.2756	298.5564	301.8373	305.1181	308.3990	311.6798	314.9606	318.2415	321.5223	324.8032	90
100	328.0840	331.3648	334.6457	337.9265	341.2074	344.4882	347.7690	351.0499	354.3307	357.6116	100

MILES TO KILOMETERS

miles	0	1	2	3	4	5	6	7	8	9	
	km	km	km	km	km	km	km	km	km	km	
—	—	1.609	3.219	4.828	6.437	8.047	9.656	11.265	12.875	14.484	—
10	16.093	17.703	19.312	20.921	22.531	24.140	25.749	27.359	28.968	30.577	10
20	32.187	33.796	35.405	37.015	38.624	40.234	41.843	43.452	45.062	46.671	20
30	48.280	49.890	51.499	53.108	54.718	56.327	57.936	59.546	61.155	62.764	30
40	64.374	65.983	67.592	69.202	70.811	72.420	74.030	75.639	77.248	78.858	40
50	80.467	82.076	83.686	85.295	86.904	88.514	90.123	91.732	93.342	94.951	50
60	96.560	98.170	99.779	101.388	102.998	104.607	106.216	107.826	109.435	111.044	60
70	112.654	114.263	115.872	117.482	119.091	120.701	122.310	123.919	125.529	127.138	70
80	128.747	130.357	131.966	133.575	135.185	136.794	138.403	140.013	141.622	143.231	80
90	144.841	146.450	148.059	149.669	151.278	152.887	154.497	156.106	157.715	159.325	90
100	160.934	162.543	164.153	165.762	167.371	168.981	170.590	172.199	173.809	175.418	100

KILOMETERS TO MILES

km	0	1	2	3	4	5	6	7	8	9	
	miles	miles	miles	miles	miles	miles	miles	miles	miles	miles	
—	—	0.621	1.243	1.864	2.485	3.107	3.728	4.350	4.971	5.592	—
10	6.214	6.835	7.456	8.078	8.699	9.321	9.942	10.563	11.185	11.806	10
20	12.427	13.049	13.670	14.292	14.913	15.534	16.156	16.777	17.398	18.020	20
30	18.641	19.262	19.884	20.505	21.127	21.748	22.369	22.991	23.612	24.233	30
40	24.855	25.476	26.098	26.719	27.340	27.962	28.583	29.204	29.826	30.447	40
50	31.069	31.690	32.311	32.933	33.554	34.175	34.797	35.418	36.039	36.661	50
60	37.282	37.904	38.525	39.146	39.768	40.389	41.010	41.632	42.253	42.875	60
70	43.496	44.117	44.739	45.360	45.981	46.603	47.224	47.845	48.467	49.088	70
80	49.710	50.331	50.952	51.574	52.195	52.816	53.438	54.059	54.681	55.302	80
90	55.923	56.545	57.166	57.787	58.409	59.030	59.652	60.273	60.894	61.516	90
100	62.137	62.758	63.380	64.001	64.622	65.244	65.865	66.487	67.108	67.729	100

AREA

SQUARE INCHES TO SQUARE CENTIMETERS

in^2	0	1	2	3	4	5	6	7	8	9	in^2
	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	cm^2	
—	—	6.452	12.903	19.355	25.806	32.258	38.710	45.161	51.613	58.064	—
10	64.516	70.968	77.419	83.871	90.322	96.774	103.226	109.677	116.129	122.580	10
20	129.032	135.484	141.935	148.387	154.838	161.290	167.742	174.193	180.645	187.096	20
30	193.548	200.000	206.451	212.903	219.354	225.806	232.258	238.709	245.161	251.612	30
40	258.064	264.516	270.967	277.419	283.870	290.322	296.774	303.225	309.677	316.128	40
50	322.580	329.032	335.483	341.935	348.386	354.838	361.290	367.741	374.193	380.644	50
60	387.096	393.548	399.999	406.451	412.902	419.354	425.806	432.257	438.709	445.160	60
70	451.612	458.064	464.515	470.967	477.418	483.870	490.322	496.773	503.225	509.676	70
80	516.128	522.580	529.031	535.483	541.934	548.386	554.838	561.289	567.741	574.192	80
90	580.644	587.096	593.547	599.999	606.450	612.902	619.354	625.805	632.257	638.708	90
100	645.160	651.612	658.063	664.515	670.966	677.418	683.870	690.321	696.773	703.224	100

SQUARE CENTIMETERS TO SQUARE INCHES

cm^2	0	1	2	3	4	5	6	7	8	9	cm^2
	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	in^2	
—	—	0.155	0.310	0.465	0.620	0.775	0.930	1.085	1.240	1.395	—
10	1.550	1.705	1.860	2.015	2.170	2.325	2.480	2.635	2.790	2.945	10
20	3.100	3.255	3.410	3.565	3.720	3.875	4.030	4.185	4.340	4.495	20
30	4.650	4.805	4.960	5.115	5.270	5.425	5.580	5.735	5.890	6.045	30
40	6.200	6.355	6.510	6.665	6.820	6.975	7.130	7.285	7.440	7.595	40
50	7.750	7.905	8.060	8.215	8.370	8.525	8.680	8.835	8.990	9.145	50
60	9.300	9.455	9.610	9.765	9.920	10.075	10.230	10.385	10.540	10.695	60
70	10.850	11.005	11.160	11.315	11.470	11.625	11.780	11.935	12.090	12.245	70
80	12.400	12.555	12.710	12.865	13.020	13.175	13.330	13.485	13.640	13.795	80
90	13.950	14.105	14.260	14.415	14.570	14.725	14.880	15.035	15.190	15.345	90
100	15.500	15.655	15.810	15.965	16.120	16.275	16.430	16.585	16.740	16.895	100

VOLUME

CUBIC INCHES TO CUBIC CENTIMETERS

in^3	0	1	2	3	4	5	6	7	8	9	in^3
	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	cm^3(cc)	
—	—	16.387	32.774	49.161	65.548	81.935	98.322	114.709	131.097	147.484	—
10	163.871	180.258	196.645	213.032	229.419	245.806	262.193	278.580	294.967	311.354	10
20	327.741	344.128	360.515	376.902	393.290	409.677	426.064	442.451	458.838	475.225	20
30	491.612	507.999	524.386	540.773	557.160	573.547	589.934	606.321	622.708	639.095	30
40	655.483	671.870	688.257	704.644	721.031	737.418	753.805	770.192	786.579	802.966	40
50	819.353	835.740	852.127	868.514	884.901	901.289	917.676	934.063	950.450	966.837	50
60	983.224	999.611	1015.998	1032.385	1048.772	1065.159	1081.546	1097.933	1114.320	1130.707	60
70	1147.094	1163.482	1179.869	1196.256	1212.643	1229.030	1245.417	1261.804	1278.191	1294.578	70
80	1310.965	1327.352	1343.739	1360.126	1376.513	1392.900	1409.288	1425.675	1442.062	1458.449	80
90	1474.836	1491.223	1507.610	1523.997	1540.384	1556.771	1573.158	1589.545	1605.932	1622.319	90
100	1638.706	1655.093	1671.481	1687.868	1704.255	1720.642	1737.029	1753.416	1769.803	1786.190	100

CUBIC CENTIMETERS TO CUBIC INCHES

cm^3(cc)	0	1	2	3	4	5	6	7	8	9	cm^3(cc)
	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	in^3	
—	—	0.0610	0.1220	0.1831	0.2441	0.3051	0.3661	0.4272	0.4882	0.5492	—
10	0.6102	0.6713	0.7323	0.7933	0.8543	0.9153	0.9764	1.0374	1.0984	1.1594	10
20	1.2205	1.2815	1.3425	1.4035	1.4646	1.5256	1.5866	1.6476	1.7086	1.7697	20
30	1.8307	1.8917	1.9527	2.0138	2.0748	2.1358	2.1968	2.2579	2.3189	2.3799	30
40	2.4409	2.5019	2.5630	2.6240	2.6850	2.7460	2.8071	2.8681	2.9291	2.9901	40
50	3.0512	3.1122	3.1732	3.2342	3.2952	3.3563	3.4173	3.4783	3.5393	3.6004	50
60	3.6614	3.7224	3.7834	3.8444	3.9055	3.9665	4.0275	4.0885	4.1496	4.2106	60
70	4.2716	4.3326	4.3937	4.4547	4.5157	4.5767	4.6377	4.6988	4.7598	4.8208	70
80	4.8818	4.9429	5.0039	5.0649	5.1259	5.1870	5.2480	5.3090	5.3700	5.4310	80
90	5.4921	5.5531	5.6141	5.6751	5.7362	5.7972	5.8582	5.9192	5.9803	6.0413	90
100	6.1023	6.1633	6.2243	6.2854	6.3464	6.4074	6.4684	6.5295	6.5905	6.6515	100

VOLUME

GALLONS (U.S.) TO LITERS

U.S. gal.	0	1	2	3	4	5	6	7	8	9	U.S.gal.
	liters	liters	liters	liters	liters	liters	liters	liters	liters	liters	
—	—	3.7854	7.5709	11.3563	15.1417	18.9271	22.7126	26.4980	30.2834	34.0688	—
10	37.8543	41.6397	45.4251	49.2106	52.9960	56.7814	60.5668	64.3523	68.1377	71.9231	10
20	75.7085	79.4940	83.2794	87.0648	90.8502	94.6357	98.4211	102.2065	105.9920	109.7774	20
30	113.5628	117.3482	121.1337	124.9191	128.7045	132.4899	136.2754	140.0608	143.8462	147.6317	30
40	151.4171	155.2025	158.9879	162.7734	166.5588	170.3442	174.1296	177.9151	181.7005	185.4859	40
50	189.2714	193.0568	196.8422	200.6276	204.4131	208.1985	211.9839	215.7693	219.5548	223.3402	50
60	227.1256	230.9110	234.6965	238.4819	242.2673	246.0528	249.8382	253.6236	257.4090	261.1945	60
70	264.9799	268.7653	272.5507	276.3362	280.1216	283.9070	287.6925	291.4779	295.2633	299.0487	70
80	302.8342	306.6196	310.4050	314.1904	317.9759	321.7613	325.5467	329.3321	333.1176	336.9030	80
90	340.6884	344.4739	348.2593	352.0447	355.8301	359.6156	363.4010	367.1864	370.9718	374.7573	90
100	378.5427	382.3281	386.1136	389.8990	393.6844	397.4698	401.2553	405.0407	408.8261	412.6115	100

LITERS TO GALLONS (U.S.)

liters	0	1	2	3	4	5	6	7	8	9	liters
	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	
—	—	0.2642	0.5283	0.7925	1.0567	1.3209	1.5850	1.8492	2.1134	2.3775	—
10	2.6417	2.9059	3.1701	3.4342	3.6984	3.9626	4.2268	4.4909	4.7551	5.0193	10
20	5.2834	5.5476	5.8118	6.0760	6.3401	6.6043	6.8685	7.1326	7.3968	7.6610	20
30	7.9252	8.1893	8.4535	8.7177	8.9818	9.2460	9.5102	9.7744	10.0385	10.3027	30
40	10.5669	10.8311	11.0952	11.3594	11.6236	11.8877	12.1519	12.4161	12.6803	12.9444	40
50	13.2086	13.4728	13.7369	14.0011	14.2653	14.5295	14.7936	15.0578	15.3220	15.5861	50
60	15.8503	16.1145	16.3787	16.6428	16.9070	17.1712	17.4354	17.6995	17.9637	18.2279	60
70	18.4920	18.7562	19.0204	19.2846	19.5487	19.8129	20.0771	20.3412	20.6054	20.8696	70
80	21.1338	21.3979	21.6621	21.9263	22.1904	22.4546	22.7188	22.9830	23.2471	23.5113	80
90	23.7755	24.0397	24.3038	24.5680	24.8322	25.0963	25.3605	25.6247	25.8889	26.1530	90
100	26.4172	26.6814	26.9455	27.2097	27.4739	27.7381	28.0022	28.2664	28.5306	28.7947	100

GALLONS (IMP.) TO LITERS

Imp gal.	0	1	2	3	4	5	6	7	8	9	Imp gal.
	liters	liters	liters	liters	liters	liters	liters	liters	liters	liters	
—	—	4.5459	9.0918	13.6377	18.1836	22.7295	27.2754	31.8213	36.3672	40.9131	—
10	45.4590	50.0049	54.5508	59.0967	63.6426	68.1885	72.7344	77.2803	81.8262	86.3721	10
20	90.9180	95.4639	100.0098	104.5557	109.1016	113.6475	118.1934	122.7393	127.2852	131.8311	20
30	136.3770	140.9229	145.4688	150.0147	154.5606	159.1065	163.6524	168.1983	172.7442	177.2901	30
40	181.8360	186.3819	190.9278	195.4737	200.0196	204.5655	209.1114	213.6573	218.2032	222.7491	40
50	227.2950	231.8409	236.3868	240.9327	245.4786	250.0245	254.5704	259.1163	263.6622	268.2081	50
60	272.7540	277.2999	281.8458	286.3917	290.9376	295.4835	300.0294	304.5753	309.1212	313.6671	60
70	318.2130	322.7589	327.3048	331.8507	336.3966	340.9425	345.4884	350.0343	354.5802	359.1261	70
80	363.6720	368.2179	372.7638	377.3097	381.8556	386.4015	390.9474	395.4933	400.0392	404.5851	80
90	409.1310	413.6769	418.2228	422.7687	427.3146	431.8605	436.4064	440.9523	445.4982	450.0441	90
100	454.5900	459.1359	463.6818	468.2277	472.7736	477.3195	481.8654	486.4113	490.9572	495.5031	100

LITERS TO GALLONS (IMP.)

liters	0	1	2	3	4	5	6	7	8	9	liters
	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	gal.	
—	—	0.2200	0.4400	0.6599	0.8799	1.0999	1.3199	1.5399	1.7598	1.9798	—
10	2.1998	2.4198	2.6398	2.8597	3.0797	3.2997	3.5197	3.7397	3.9596	4.1796	10
20	4.3996	4.6196	4.8396	5.0595	5.2795	5.4995	5.7195	5.9395	6.1594	6.3794	20
30	6.5994	6.8194	7.0394	7.2593	7.4793	7.6993	7.9193	8.1393	8.3592	8.5792	30
40	8.7992	9.0192	9.2392	9.4591	9.6791	9.8991	10.1191	10.3391	10.5590	10.7790	40
50	10.9990	11.2190	11.4390	11.6589	11.8789	12.0989	12.3189	12.5389	12.7588	12.9788	50
60	13.1988	13.4188	13.6388	13.8587	14.0787	14.2987	14.5187	14.7387	14.9586	15.1786	60
70	15.3986	15.6186	15.8386	16.0585	16.2785	16.4985	16.7185	16.9385	17.1584	17.3784	70
80	17.5984	17.8184	18.0384	18.2583	18.4783	18.6983	18.9183	19.1383	19.3582	19.5782	80
90	19.7982	20.0182	20.2382	20.4581	20.6781	20.8981	21.1181	21.3381	21.5580	21.7780	90
100	21.9980	22.2180	22.4380	22.6579	22.8779	23.0979	23.3179	23.5379	23.7578	23.9778	100

MASS

POUNDS TO KILOGRAMS

lbs.	0	1	2	3	4	5	6	7	8	9	lbs.
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—	—	0.454	0.907	1.361	1.814	2.268	2.722	3.175	3.629	4.082	—
10	4.536	4.989	5.443	5.897	6.350	6.804	7.257	7.711	8.165	8.618	10
20	9.072	9.525	9.979	10.433	10.886	11.340	11.793	12.247	12.701	13.154	20
30	13.608	14.061	14.515	14.968	15.422	15.876	16.329	16.783	17.236	17.690	30
40	18.144	18.597	19.051	19.504	19.958	20.412	20.865	21.319	21.772	22.226	40
50	22.680	23.133	23.587	24.040	24.494	24.947	25.401	25.855	26.308	26.762	50
60	27.215	27.669	28.123	28.576	29.030	29.483	29.937	30.391	30.844	31.298	60
70	31.751	32.205	32.658	33.112	33.566	34.019	34.473	34.926	35.380	35.834	70
80	36.287	36.741	37.194	37.648	38.102	38.555	39.009	39.462	39.916	40.370	80
90	40.823	41.277	41.730	42.184	42.637	43.091	43.545	43.998	44.452	44.905	90
100	45.359	45.813	46.266	46.720	47.173	47.627	48.081	48.534	48.988	49.441	100

KILOGRAMS TO POUNDS

kg	0	1	2	3	4	5	6	7	8	9	kg
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	
—	—	2.205	4.409	6.614	8.818	11.023	13.228	15.432	17.637	19.842	—
10	22.046	24.251	26.455	28.660	30.865	33.069	35.274	37.479	39.683	41.888	10
20	44.092	46.297	48.502	50.706	52.911	55.116	57.320	59.525	61.729	63.934	20
30	66.139	68.343	70.548	72.752	74.957	77.162	79.366	81.571	83.776	85.980	30
40	88.185	90.389	92.594	94.799	97.003	99.208	101.413	103.617	105.822	108.026	40
50	110.231	112.436	114.640	116.845	119.049	121.254	123.459	125.663	127.868	130.073	50
60	132.277	134.482	136.686	138.891	141.096	143.300	145.505	147.710	149.914	152.119	60
70	154.323	156.528	158.733	160.937	163.142	165.347	167.551	169.756	171.960	174.165	70
80	176.370	178.574	180.779	182.983	185.188	187.393	189.597	191.802	194.007	196.211	80
90	198.416	200.620	202.825	205.030	207.234	209.439	211.644	213.848	216.053	218.257	90
100	220.462	222.667	224.871	227.076	229.280	231.485	233.690	235.894	238.099	240.304	100

KILOGRAMS TO NEWTON

kg	0	1	2	3	4	5	6	7	8	9	kg
	N	N	N	N	N	N	N	N	N	N	
—	—	9.81	19.61	29.42	39.23	49.03	58.84	68.65	78.45	88.26	—
10	98.07	107.87	117.68	127.49	137.29	147.10	156.91	166.71	176.52	186.33	10
20	196.13	205.94	215.75	225.55	235.36	245.17	254.97	264.78	274.59	284.39	20
30	294.20	304.01	313.81	323.62	333.43	343.23	353.04	362.85	372.65	382.46	30
40	392.27	402.07	411.88	421.69	431.49	441.30	451.11	460.91	470.72	480.53	40
50	490.34	500.14	509.95	519.76	529.56	539.37	549.18	558.98	568.79	578.60	50
60	588.40	598.21	608.02	617.82	627.63	637.44	647.24	657.05	666.86	676.66	60
70	686.47	696.28	706.08	715.89	725.70	735.50	745.31	755.12	764.92	774.73	70
80	784.54	794.34	804.15	813.96	823.76	833.57	843.38	853.18	862.99	872.80	80
90	882.60	892.41	902.22	912.02	921.83	931.64	941.44	951.25	961.06	970.86	90
100	980.67	990.48	1000.28	1010.09	1019.90	1029.70	1039.51	1049.32	1059.12	1068.93	100

NEWTON TO KILOGRAMS

N	0	10	20	30	40	50	60	70	80	90	N
	kg	kg	kg	kg	kg	kg	kg	kg	kg	kg	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
100	10.197	11.217	12.237	13.256	14.276	15.296	16.316	17.335	18.355	19.375	100
200	20.394	21.414	22.434	23.454	24.473	25.493	26.513	27.532	28.552	29.572	200
300	30.592	31.611	32.631	33.651	34.670	35.690	36.710	37.730	38.749	39.769	300
400	40.789	41.809	42.828	43.848	44.868	45.887	46.907	47.927	48.947	49.966	400
500	50.986	52.006	53.025	54.045	55.065	56.085	57.104	58.124	59.144	60.163	500
600	61.183	62.203	63.223	64.242	65.262	66.282	67.302	68.321	69.341	70.361	600
700	71.380	72.400	73.420	74.440	75.459	76.479	77.499	78.518	79.538	80.558	700
800	81.578	82.597	83.617	84.637	85.656	86.676	87.696	88.716	89.735	90.755	800
900	91.775	92.795	93.814	94.834	95.854	96.873	97.893	98.913	99.933	100.952	900
1000	101.972	102.992	104.011	105.031	106.051	107.071	108.090	109.110	110.130	111.149	1000

15–6 CONVERSION TABLE

PRESSURE

POUNDS PER SQUARE INCHES TO KILOGRAMS PER SQUARE CENTIMETERS

lb/in^2	0	1	2	3	4	5	6	7	8	9	lb/in^2
(psi)	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	(psi)
—	—	0.0703	0.1406	0.2109	0.2812	0.3515	0.4218	0.4921	0.5625	0.6328	—
10	0.7031	0.7734	0.8437	0.9140	0.9843	1.0546	1.1249	1.1952	1.2655	1.3358	10
20	1.4061	1.4764	1.5468	1.6171	1.6874	1.7577	1.8280	1.8983	1.9686	2.0389	20
30	2.1092	2.1795	2.2498	2.3201	2.3904	2.4607	2.5311	2.6014	2.6717	2.7420	30
40	2.8123	2.8826	2.9529	3.0232	3.0935	3.1638	3.2341	3.3044	3.3747	3.4450	40
50	3.5154	3.5857	3.6560	3.7263	3.7966	3.8669	3.9372	4.0075	4.0778	4.1481	50
60	4.2184	4.2887	4.3590	4.4293	4.4996	4.5700	4.6403	4.7106	4.7809	4.8512	60
70	4.9215	4.9918	5.0621	5.1324	5.2027	5.2730	5.3433	5.4136	5.4839	5.5543	70
80	5.6246	5.6949	5.7652	5.8355	5.9058	5.9761	6.0464	6.1167	6.1870	6.2573	80
90	6.3276	6.3979	6.4682	6.5386	6.6089	6.6792	6.7495	6.8198	6.8901	6.9604	90
100	7.0307	7.1010	7.1713	7.2416	7.3119	7.3822	7.4525	7.5228	7.5932	7.6635	100

KILOGRAMS PER SQUARE CENTIMETERS TO POUNDS PER SQUARE INCHES

kg/cm^2	0	1	2	3	4	5	6	7	8	9	kg/cm^2
	lb/in^2(psi)	lb/in^2(psi)	lb/in^2(psi)	lb/in^2(psi)	lb/in^2(psi)	lb/in^2(psi)	lb/in^2(psi)	lb/in^2(psi)	lb/in^2(psi)	lb/in^2(psi)	
—	—	14.22	28.45	42.67	56.89	71.12	85.34	99.56	113.78	128.01	—
10	142.23	156.45	170.68	184.90	199.12	213.35	227.57	241.79	256.01	270.24	10
20	284.46	298.68	312.91	327.13	341.35	355.58	369.80	384.02	398.24	412.47	20
30	426.69	440.91	455.14	469.36	483.58	497.81	512.03	526.25	540.47	554.70	30
40	568.92	583.14	597.37	611.59	625.81	640.04	654.26	668.48	682.70	696.93	40
50	711.15	725.37	739.60	753.82	768.04	782.27	796.49	810.71	824.93	839.16	50
60	853.38	867.60	881.83	896.05	910.27	924.50	938.72	952.94	967.16	981.39	60
70	995.61	1009.83	1024.06	1038.28	1052.50	1066.73	1080.95	1095.17	1109.39	1123.62	70
80	1137.84	1152.06	1166.29	1180.51	1194.73	1208.96	1223.18	1237.40	1251.62	1265.85	80
90	1280.07	1294.29	1308.52	1322.74	1336.96	1351.19	1365.41	1379.63	1393.85	1408.08	90
100	1422.30	1436.52	1450.75	1464.97	1479.19	1493.42	1507.64	1521.86	1536.08	1550.31	100

KILOGRAMS PER SQUARE CENTIMETERS TO KILO PASCAL

kg/cm^2	0	1	2	3	4	5	6	7	8	9	kg/cm^2
	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	KPa	
—	—	98.1	196.1	294.2	392.3	490.3	588.4	686.5	784.5	882.6	—
10	980.7	1078.7	1176.8	1274.9	1372.9	1471.0	1569.1	1667.1	1765.2	1863.3	10
20	1961.3	2059.4	2157.5	2255.5	2353.6	2451.7	2549.7	2647.8	2745.9	2843.9	20
30	2942.0	3040.1	3138.1	3236.2	3334.3	3432.3	3530.4	3628.5	3726.5	3824.6	30
40	3922.7	4020.7	4118.8	4216.9	4314.9	4413.0	4511.1	4609.1	4707.2	4805.3	40
50	4903.4	5001.4	5099.5	5197.6	5295.6	5393.7	5491.8	5589.8	5687.9	5786.0	50
60	5884.0	5982.1	6080.2	6178.2	6276.3	6374.4	6472.4	6570.5	6668.6	6766.6	60
70	6864.7	6962.8	7060.8	7158.9	7257.0	7355.0	7453.1	7551.2	7649.2	7747.3	70
80	7845.4	7943.4	8041.5	8139.6	8237.6	8335.7	8433.8	8531.8	8629.9	8728.0	80
90	8826.0	8924.1	9022.2	9120.2	9218.3	9316.4	9414.4	9512.5	9610.6	9708.6	90
100	9806.7	9904.8	10002.8	10100.9	10199.0	10297.0	10395.1	10493.2	10591.2	10689.3	100

KILO PASCAL TO KILOGRAMS PER SQUARE CENTIMETERS

KPa	0	100	200	300	400	500	600	700	800	900	KPa
	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	kg/cm^2	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
1000	10.197	11.217	12.237	13.256	14.276	15.296	16.316	17.335	18.355	19.375	1000
2000	20.394	21.414	22.434	23.454	24.473	25.493	26.513	27.532	28.552	29.572	2000
3000	30.592	31.611	32.631	33.651	34.670	35.690	36.710	37.730	38.749	39.769	3000
4000	40.789	41.809	42.828	43.848	44.868	45.887	46.907	47.927	48.947	49.966	4000
5000	50.986	52.006	53.025	54.045	55.065	56.085	57.104	58.124	59.144	60.163	5000
6000	61.183	62.203	63.223	64.242	65.262	66.282	67.302	68.321	69.341	70.361	6000
7000	71.380	72.400	73.420	74.440	75.459	76.479	77.499	78.518	79.538	80.558	7000
8000	81.578	82.597	83.617	84.637	85.656	86.676	87.696	88.716	89.735	90.755	8000
9000	91.775	92.795	93.814	94.834	95.854	96.873	97.893	98.913	99.933	100.952	9000
10000	101.972	102.992	104.011	105.031	106.051	107.071	108.090	109.110	110.130	111.149	10000

TORQUE

FOOT POUNDS TO KILOGRAMMETERS

ft. lbs.	0	1	2	3	4	5	6	7	8	9	ft lbs.
	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	
—	—	0.138	0.277	0.415	0.553	0.691	0.830	0.968	1.106	1.244	—
10	1.383	1.521	1.659	1.797	1.936	2.074	2.212	2.350	2.489	2.627	10
20	2.765	2.903	3.042	3.180	3.318	3.457	3.595	3.733	3.871	4.010	20
30	4.148	4.286	4.424	4.563	4.701	4.839	4.977	5.116	5.254	5.392	30
40	5.530	5.669	5.807	5.945	6.083	6.222	6.360	6.498	6.636	6.775	40
50	6.913	7.051	7.190	7.328	7.466	7.604	7.743	7.881	8.019	8.157	50
60	8.296	8.434	8.572	8.710	8.849	8.987	9.125	9.263	9.402	9.540	60
70	9.678	9.816	9.955	10.093	10.231	10.370	10.508	10.646	10.784	10.923	70
80	11.061	11.199	11.337	11.476	11.614	11.752	11.890	12.029	12.167	12.305	80
90	12.443	12.582	12.720	12.858	12.996	13.135	13.273	13.411	13.549	13.688	90
100	13.826	13.964	14.103	14.241	14.379	14.517	14.656	14.794	14.932	15.070	100

KILOGRAMMETERS TO FOOT POUNDS

kg-m	0	1	2	3	4	5	6	7	8	9	kg-m
	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	ft. lbs.	
—	—	7.23	14.47	21.70	28.93	36.17	43.40	50.63	57.86	65.10	—
10	72.33	79.56	86.80	94.03	101.26	108.50	115.73	122.96	130.19	137.43	10
20	144.66	151.89	159.13	166.36	173.59	180.83	188.06	195.29	202.52	209.76	20
30	216.99	224.22	231.46	238.69	245.92	253.16	260.39	267.62	274.85	282.09	30
40	289.32	296.55	303.79	311.02	318.25	325.49	332.72	339.95	347.18	354.42	40
50	361.65	368.88	376.12	383.35	390.58	397.82	405.05	412.28	419.51	426.75	50
60	433.98	441.21	448.45	455.68	462.91	470.15	477.38	484.61	491.84	499.08	60
70	506.31	513.54	520.78	528.01	535.24	542.48	549.71	556.94	564.17	571.41	70
80	578.64	585.87	593.11	600.34	607.57	614.81	622.04	629.27	636.50	643.74	80
90	650.97	658.20	665.44	672.67	679.90	687.14	694.37	701.60	708.83	716.07	90
100	723.30	730.53	737.77	745.00	752.23	759.47	766.70	773.93	781.16	788.40	100

KILOGRAMMETERS TO NEWTONMETERS

kg-m	0	1	2	3	4	5	6	7	8	9	kg-m
	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	N-m	
—	—	9.81	19.61	29.42	39.23	49.03	58.84	68.65	78.45	88.26	—
10	98.07	107.87	117.68	127.49	137.29	147.10	156.91	166.71	176.52	186.33	10
20	196.13	205.94	215.75	225.55	235.36	245.17	254.97	264.78	274.59	284.39	20
30	294.20	304.01	313.81	323.62	333.43	343.23	353.04	362.85	372.65	382.46	30
40	392.27	402.07	411.88	421.69	431.49	441.30	451.11	460.91	470.72	480.53	40
50	490.34	500.14	509.95	519.76	529.56	539.37	549.18	558.98	568.79	578.60	50
60	588.40	598.21	608.02	617.82	627.63	637.44	647.24	657.05	666.86	676.66	60
70	686.47	696.28	706.08	715.89	725.70	735.50	745.31	755.12	764.92	774.73	70
80	784.54	794.34	804.15	813.96	823.76	833.57	843.38	853.18	862.99	872.80	80
90	882.60	892.41	902.22	912.02	921.83	931.64	941.44	951.25	961.06	970.86	90
100	980.67	990.48	1000.28	1010.09	1019.90	1029.70	1039.51	1049.32	1059.12	1068.93	100

NEWTONMETERS TO KILOGRAMMETERS

N-m	0	10	20	30	40	50	60	70	80	90	N-m
	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	kg-m	
—	—	1.020	2.039	3.059	4.079	5.099	6.118	7.138	8.158	9.177	—
100	10.197	11.217	12.236	13.256	14.276	15.296	16.315	17.335	18.355	19.374	100
200	20.394	21.414	22.433	23.453	24.473	25.493	26.512	27.532	28.552	29.571	200
300	30.591	31.611	32.630	33.650	34.670	35.690	36.709	37.729	38.749	39.768	300
400	40.788	41.808	42.827	43.847	44.867	45.887	46.906	47.926	48.946	49.965	400
500	50.985	52.005	53.024	54.044	55.064	56.084	57.103	58.123	59.143	60.162	500
600	61.182	62.202	63.221	64.241	65.261	66.281	67.300	68.320	69.340	70.359	600
700	71.379	72.399	73.418	74.438	75.458	76.478	77.497	78.517	79.537	80.556	700
800	81.576	82.596	83.615	84.635	85.655	86.675	87.694	88.714	89.734	90.753	800
900	91.773	92.793	93.812	94.832	95.852	96.872	97.891	98.911	99.931	100.950	900
1000	101.970	102.990	104.009	105.029	106.049	107.069	108.088	109.108	110.128	111.147	1000

15–8 CONVERSION TABLE

TEMPERATURE

FAHRENHEIT TO CENTIGRADE

°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
-60	-51.1	-2	-18.9	56	13.3	114	45.6	172	77.8	230	110.0	288	142.2	346	174.4
-58	-50.0	0	-17.8	58	14.4	116	46.7	174	78.9	232	111.1	290	143.3	348	175.6
-56	-48.9	2	-16.7	60	15.6	118	47.8	176	80.0	234	112.2	292	144.4	350	176.7
-54	-47.8	4	-15.6	62	16.7	120	48.9	178	81.1	236	113.3	294	145.6	352	177.8
-52	-46.7	6	-14.4	64	17.8	122	50.0	180	82.2	238	114.4	296	146.7	354	178.9
-50	-45.6	8	-13.3	66	18.9	124	51.1	182	83.3	240	115.6	298	147.8	356	180.0
-48	-44.4	10	-12.2	68	20.0	126	52.2	184	84.4	242	116.7	300	148.9	358	181.1
-46	-43.3	12	-11.1	70	21.1	128	53.3	186	85.6	244	117.8	302	150.0	360	182.2
-44	-42.2	14	-10.0	72	22.2	130	54.4	188	86.7	246	118.9	304	151.1	362	183.3
-42	-41.1	16	-8.9	74	23.3	132	55.6	190	87.8	248	120.0	306	152.2	364	184.4
-40	-40.0	18	-7.8	76	24.4	134	56.7	192	88.9	250	121.1	308	153.3	366	185.6
-38	-38.9	20	-6.7	78	25.6	136	57.8	194	90.0	252	122.2	310	154.4	368	186.7
-36	-37.8	22	-5.6	80	26.7	138	58.9	196	91.1	254	123.3	312	155.6	370	187.8
-34	-36.7	24	-4.4	82	27.8	140	60.0	198	92.2	256	124.4	314	156.7	372	188.9
-32	-35.6	26	-3.3	84	28.9	142	61.1	200	93.3	258	125.6	316	157.8	374	190.0
-30	-34.4	28	-2.2	86	30.0	144	62.2	202	94.4	260	126.7	318	158.9	376	191.1
-28	-33.3	30	-1.1	88	31.1	146	63.3	204	95.6	262	127.8	320	160.0	378	192.2
-26	-32.2	32	0.0	90	32.2	148	64.4	206	96.7	264	128.9	322	161.1	380	193.3
-24	-31.1	34	1.1	92	33.3	150	65.6	208	97.8	266	130.0	324	162.2	382	194.4
-22	-30.0	36	2.2	94	34.4	152	66.7	210	98.9	268	131.1	326	163.3	384	195.6
-20	-28.9	38	3.3	96	35.6	154	67.8	212	100.0	270	132.2	328	164.4	386	196.7
-18	-27.8	40	4.4	98	36.7	156	68.9	214	101.1	272	133.3	330	165.6	388	197.8
-16	-26.7	42	5.6	100	37.8	158	70.0	216	102.2	274	134.4	332	166.7	390	198.9
-14	-25.6	44	6.7	102	38.9	160	71.1	218	103.3	276	135.6	334	167.8	392	200.0
-12	-24.4	46	7.8	104	40.0	162	72.2	220	104.4	278	136.7	336	168.9	400	204.4
-10	-23.3	48	8.9	106	41.1	164	73.3	222	105.6	280	137.8	338	170.0	410	210.0
-8	-22.2	50	10.0	108	42.2	166	74.4	224	106.7	282	138.9	340	171.1	420	215.6
-6	-21.1	52	11.1	110	43.3	168	75.6	226	107.8	284	140.0	342	172.2	430	221.1
-4	-20.0	54	12.2	112	44.4	170	76.7	228	108.9	286	141.1	344	173.3	440	226.7

CENTIGRADE TO FAHRENHEIT

°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
-50	-58.0	-18	-0.4	14	57.2	46	114.8	78	172.4	110	230.0	142	287.6	174	345.2
-49	-56.2	-17	1.4	15	59.0	47	116.6	79	174.2	111	231.8	143	289.4	175	347.0
-48	-54.4	-16	3.2	16	60.8	48	118.4	80	176.0	112	233.6	144	291.2	176	348.8
-47	-52.6	-15	5.0	17	62.6	49	120.2	81	177.8	113	235.4	145	293.0	177	350.6
-46	-50.8	-14	6.8	18	64.4	50	122.0	82	179.6	114	237.2	146	294.8	178	352.4
-45	-49.0	-13	8.6	19	66.2	51	123.8	83	181.4	115	239.0	147	296.6	179	354.2
-44	-47.2	-12	10.4	20	68.0	52	125.6	84	183.2	116	240.8	148	298.4	180	356.0
-43	-45.4	-11	12.2	21	69.8	53	127.4	85	185.0	117	242.6	149	300.2	181	357.8
-42	-43.6	-10	14.0	22	71.6	54	129.2	86	186.8	118	244.4	150	302.0	182	359.6
-41	-41.8	-9	15.8	23	73.4	55	131.0	87	188.6	119	246.2	151	303.8	183	361.4
-40	-40.0	-8	17.6	24	75.2	56	132.8	88	190.4	120	248.0	152	305.6	184	363.2
-39	-38.2	-7	19.4	25	77.0	57	134.6	89	192.2	121	249.8	153	307.4	185	365.0
-38	-36.4	-6	21.2	26	78.8	58	136.4	90	194.0	122	251.6	154	309.2	186	366.8
-37	-34.6	-5	23.0	27	80.6	59	138.2	91	195.8	123	253.4	155	311.0	187	368.6
-36	-32.8	-4	24.8	28	82.4	60	140.0	92	197.6	124	255.2	156	312.8	188	370.4
-35	-31.0	-3	26.6	29	84.2	61	141.8	93	199.4	125	257.0	157	314.6	189	372.2
-34	-29.2	-2	28.4	30	86.0	62	143.6	94	201.2	126	258.8	158	316.4	190	374.0
-33	-27.4	-1	30.2	31	87.8	63	145.4	95	203.0	127	260.6	159	318.2	191	375.8
-32	-25.6	0	32.0	32	89.6	64	147.2	96	204.8	128	262.4	160	320.0	192	377.6
-31	-23.8	1	33.8	33	91.4	65	149.0	97	206.6	129	264.2	161	321.8	193	379.4
-30	-22.0	2	35.6	34	93.2	66	150.8	98	208.4	130	266.0	162	323.6	194	381.2
-29	-20.2	3	37.4	35	95.0	67	152.6	99	210.2	131	267.8	163	325.4	195	383.0
-28	-18.4	4	39.2	36	96.8	68	154.4	100	212.0	132	269.6	164	327.2	196	384.8
-27	-16.6	5	41.0	37	98.6	69	156.2	101	213.8	133	271.4	165	329.0	197	386.6
-26	-14.8	6	42.8	38	100.4	70	158.0	102	215.6	134	273.2	166	330.8	198	388.4
-25	-13.0	7	44.6	39	102.2	71	159.8	103	217.4	135	275.0	167	332.6	199	390.2
-24	-11.2	8	46.4	40	104.0	72	161.6	104	219.2	136	276.8	168	334.4	200	392.0
-23	-9.4	9	48.2	41	105.8	73	163.4	105	221.0	137	278.6	169	336.2	210	410.0
-22	-7.6	10	50.0	42	107.6	74	165.2	106	222.8	138	280.4	170	338.0	220	428.0
-21	-5.8	11	51.8	43	109.4	75	167.0	107	224.6	139	282.2	171	339.8	230	446.0
-20	-4.0	12	53.6	44	111.2	76	168.8	108	226.4	140	284.0	172	341.6	240	464.0
-19	-2.2	13	55.4	45	113.0	77	170.6	109	228.2	141	285.8	173	343.4	250	482.0

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