

ENGINE [SUPPLEMENT]

PF series

PF6TB AND PF6TC

SERVICE MANUAL

ENGINE SERVICE MANUAL [SUPPLEMENT]

MODELS PF6TB and PF6TC

Applicable Engine Numbers
PF6-160129B —

FOREWORD

This service manual supplement contains additional information concerning maintenance procedures and relevant data for the PF6TB engine installed in vehicle models CKB457/459, CWB457/459 and CGB457 and PF6TC engine installed in vehicle models CKB45A, CWB45A, CGB45A.

For information other than that contained in this supplement, refer to the separately issued engine service manual PF series "MODELS PF6, PF6T, PF6TA & PF6TB" (Pub. No. SMEPFS2E00).

Accordingly, always use this supplement in conjunction with the general service manual.

The right is reserved to make changes in specifications and methods at any time without notice.

QUICK REFERENCE INDEX

GENERAL	GE
MAINTENANCE	MA
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ENGINE DISASSEMBLY AND REASSEMBLY	DR
ENGINE PROPER	EP
CYLINDER HEAD AND VALVE MECHANISM	HV
LUBRICATION SYSTEM	LB
COOLING SYSTEM	EC
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AIR INTAKE AND EXHAUST SYSTEM	IE
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AUXILIARY EQUIPMENT	EA

HOW TO USE THIS MANUAL

- This supplement is designed to provide you with the new service procedures, service data and specifications for the PF6TB engine on the CKB457/459, CWB457/459 and CGB457 models and PF6TC engine on the CKB45A, CWB45A, CGB45A models.
- However, this supplement contains only new service procedures and relevant data, etc.
For information which is not included in this manual, refer to the general service manual mentioned below.
Service Manual: PF series "MODELS PF6, PF6T, PF6TA & PF6TB" (Pub. No. **SMEPFS2E00**)
- Please be sure to follow the instruction below when using this supplement.
1) See the specified section titles in the QUICK REFERENCE INDEX of this supplement, and check whether the background is black or white.

ENGINE SERVICE MANUAL [SUPPLEMENT]

MODELS
PF6TB and PF6TC

Applicable Engine Numbers
PF6-160129B —

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LUBRICATION SYSTEM	LB

White:

No change. Please refer to the engine service manual PF series "MODELS PF6, PF6T, PF6TA & PF6TB" (Pub. No. SMEPFS2E00).

Black:

Service procedures and service data have been added.
Only the new or revised information is described.

- 2) Only those items containing supplementary information are specified in the CONTENTS of each section.

FUEL SYSTEM

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EF

SUPPLEMENTAL OUTLINE

- Addition of service data, injection pump assembly, nozzle and nozzle holder due to introduction of a new vehicle model.

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White:

No change. Please refer to the engine service manual PF series "MODELS PF6, PF6T, PF6TA & PF6TB" (Pub. No. SMEPFS2E00).

Black:

Service procedures and service data have been added.
Only the new or revised information is described.

GENERAL

CONTENTS

SPECIFICATIONS	GE-1- 1	ENGINE SPECIFICATIONS	GE-1- 1
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SUPPLEMENTAL OUTLINE

- Addition of specifications due to introduction of the PF6TB-21 engine in the CKB, CWB and CGB457 series.
- Addition of specifications due to introduction of the PF6TB-22 engine in the CKB459 and CWB459 series.
- Addition of specifications due to introduction of the PF6TC engine in the CKB, CWB and CGB45A series.

SPECIFICATIONS

SPECIFICATIONS

ENGINE SPECIFICATIONS

Item			Engine model	PF6TB-21	PF6TB-22	PF6TC				
Max. output (SAE)			kW {PS}/rpm	257 {350}/2,100		279 {380}/2,100				
Type				Diesel						
Aspiration system				Turbocharger with intercooler						
Cooling method				Water cooled						
Number of cylinders and cylinder arrangement				6, in-line						
Stroke cycle				4						
Combustion chamber				Direct fuel injection						
Valve mechanism				Overhead						
Cylinder liner				Dry						
Bore x stroke			mm (in)	133.0 x 150.0 (5.24 x 5.91)						
Total displacement			cm ³ (cu in)	12,503 (763)						
Compression ratio				16.5						
Cylinder compression			kPa {kgf/cm ² , psi}/rpm	3,040 {31, 441}/200±20						
Max. engine speed under full load conditions				2,480		2,300				
Idle speed				430 - 530	550 - 570	510 - 610				
Number of piston rings		Compression ring		2						
		Oil ring		1						
Valve timing		Intake	Open (B.T.D.C.)	16°						
			Closed (A.B.D.C.)	20°						
		Exhaust	Open (B.B.D.C.)	52°						
			Closed (A.T.D.C.)	12°						
		Lubrication system	Valve clearance		mm (in)		Intake		0.30 - 0.40 (0.012 - 0.016)	
Exhaust							0.30 - 0.40 (0.012 - 0.016)			
Lubrication system			Forced-circulation type							
Oil pump			Type		Gear pump					
			Discharge amount		ℓ (Imp gal)/rpm			174 (38-1/4)/2,300		
			Relief valve opening pressure		kPa {kgf/cm ² , psi}			1,177 {12.0, 171}		
Oil filter			Type	Full-flow		Paper element type				
				By-pass		Paper element type				
			Replacement method		Disassembly type					
			Short valve opening pressure		kPa {kgf/cm ² , psi}			98 - 137 {1.0 - 1.4, 14 - 20}		
Oil cooler			Type		Water cooled flat tube type					
			Number of cores		5					
			Short valve opening pressure		kPa {kgf/cm ² , psi}			304 - 343 {3.1 - 3.5, 44 - 50}		
Regulator valve opening pressure			kPa {kgf/cm ² , psi}		392 - 432 {4.0 - 4.4, 57 - 63}					
Lubrication oil capacity			ℓ (Imp gal)		System total capacity		29 (6-3/8)			
							Oil pan		H-level	
					L-level				14 (3-1/8)	

SPECIFICATIONS

Item			Engine model	PF6TB-21	PF6TB-22	PF6TC
Cooling system	Cooling system			Water cooled, forced circulation		
	Radiator type			Corrugated fin		
	Cooling fan	Number of fins		6		
	Fan clutch	Type		ON-OFF type (FD2000-C)		Linear type (FDL2300)
		Changeover temperature °C (°F)		60 - 70 (140 - 158)		60±10 - 75±5 (140±18 - 167±9)
	Water pump	Type		Centrifugal		
		Drive		Gear drive		
		Number of impellers		6		
	Thermostat	Type		Wax pellet		
		Valve opening temperature °C (°F) - Number		76.5 (170) - 1		
Cooling water capacity ℓ (Imp gal)			37 (8-1/8)			
Fuel system	Ignition system			Compression ignition		
	Fuel injection timing (B.T.D.C.)			3°	2°	0°
	Ignition order			1-4-2-6-3-5		
	Fuel filter	Main		Cartridge type		
		Primary		Center bolt type		
	Fuel injection pump	Type		Bosch		
		Plunger diameter	mm (in)	12.0 (0.472)		
		Governor		Electrical RED-III type		
		Timer		Centrifugal (Mechanical SDG type)		
	Fuel injection nozzle	Nozzle holder		Flange type		
		Nozzle type		Multi-hole type		
		Nozzle holder	Number	6		7
			Diameter	mm (in)	0.31 (0.0122) [K4]	0.27 (0.0106) [K6]
		Valve opening pressure kPa {kgf/cm ² , psi}		22,556 {230, 3,271}		
	Overflow valve opening pressure kPa {kgf/cm ² , psi}	Injection pump outlet		255 {2.6, 37}		
		Fuel filter		108 - 147 {1.1 - 1.5, 16 - 21}		
Air intake and exhaust system	Air cleaner			Paper element (Dry: Dual type)		
	Turbocharger	Model		TD45	GT45	GT42
		Turbine type		Radial-flow turbine (With variable plate)	Radial-flow turbine	
		Compressor type		Centrifugal		
		Lubrication method		Engine oil circulation type		
		Bearing type		Full floating		
	Intercooler	Type		Air to air		
		Intercooler		Corrugated fin		
	Exhaust shutter	Type		Cylinder		
		Operation		Air		

SPECIFICATIONS

Item		Engine model		PF6TB-21	PF6TB-22	PF6TC
Electrical system	Starting motor	Type		Shift		
		Model		0350 602 0381	350 602 0460	
				0350 602 0460		
		Output V-kW		24-6.0		
	Alternator	Type		AC, diode-rectified		
		Model		0202 102 1943	0201 152 1130	0201 102 4510
				0202 152 0044 (0202 152 0043)		
		Output V-A	0202 102 1943	24-40	—	—
			0202 152 0044 (0202 152 0043)	24-50		
			0201 152 1130	—	24-50	—
			0201 102 4510	—	—	24-40
		Regulator		IC-transistor type		
	Air heater	Type		Ribbon		
		Voltage (V) x Current (A) - Number		11.0 x 85 - 2		
		Model		F9560W12		
Auxiliary equipment	Air compressor	Theoretical discharge cm ³ (cu in)		425 (26)		
		Normal maximum discharge pressure kPa {kgf/cm ² , psi}		834 {8.5, 121}		
		Cooling system		Water cooled (Forced circulation type)		
	Vacuum pump	Type		Vane	—	
		Model		VD-30	—	

MAINTENANCE

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SERVICE DATA	MA-1- 1	BASIC MECHANICAL SYSTEM	MA-3- 1
SERVICE DATA	MA-1- 1	FAN CLUTCH	MA-3- 1
TIGHTENING TORQUE	MA-1- 2	FUEL SYSTEM	MA-3- 2
TOOLS	MA-2- 1	INTAKE AND EXHAUST SYSTEM	MA-3- 5
MAINTENANCE PROCEDURE	MA-3- 1		

SUPPLEMENTAL OUTLINE

- Addition of service data and maintenance procedure due to introduction of a new vehicle model.
- The fuel injection timing has been changed.
- The idle speed has been changed.
- The tightening torque of the injection pump coupling mounting bolt has been changed.
- Addition of fuel injection timing and idle speed maintenance standards for the PF6TB-22 and PF6TC engines.
- Addition of a model GT42, 45 turbocharger.

SERVICE DATA

SERVICE DATA

Unit: mm (in)

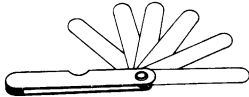
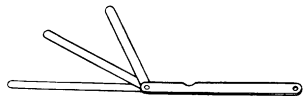
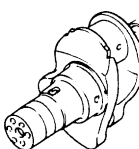
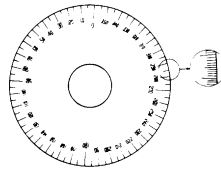
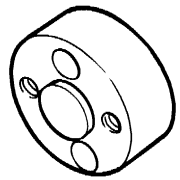
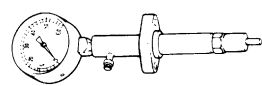
Item				Maintenance standard	Service limit	Remarks
Basic mechanical system	Valve clearance	Intake		0.30 - 0.40 (0.012 - 0.016)	—	When engine is cold
		Exhaust		0.30 - 0.40 (0.012 - 0.016)	—	
	Valve timing	Intake	Open	16° B.T.D.C.	—	
			Closed	20° A.B.D.C.	—	
		Exhaust	Open	52° B.B.D.C.	—	
			Closed	12° A.T.D.C.	—	
	Cylinder compression pressure kPa {kgf/cm ² , psi}				3,040 {31, 441}	1,961 {20, 284}
Compression pressure difference kPa {kgf/cm ² , psi}				Less than 392 {4, 57}	—	
Cooling system	Water tank cap operating pressure kPa {kgf/cm ² , psi}			49 - 69 {0.5 - 0.7, 7 - 10}	—	Pressure side
	Deflection of V-belt	Fan pulley - Tension pulley		8 - 12 (0.31 - 0.47)	—	With a force of about 98 N {10 kgf, 22 lbf} applied to the mid part
		Idler (cooler compres- sor) pulley - Alternator pulley		15 - 18 (0.59 - 0.71)	—	
	Thermostat	Valve opening tem- perature °C (°F)		74.5 - 78.5 (166 - 173)	73.0 - 80.0 (163 - 176)	
		Valve lift/temperature mm/°C (in/°F)		More than 10/90 (0.39/194)	More than 8.5/90 (0.335/194)	
	Fuel system	Fuel injection timing B.T.D.C.	PF6TB-21		3°	—
PF6TB-22			2°	—		
PF6TC			0°	—		
Idle speed rpm		PF6TB-21		430 - 530	—	
		PF6TB-22		550 - 570	—	
		PF6TC		510 - 610	—	

TIGHTENING TORQUE

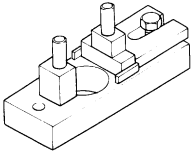
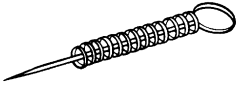
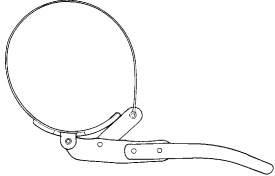
Unit: N·m {kgf·m, ft·lbf}

Item				Tightening torque	Remarks
Basic mechanical system	Valve clearance adjusting screw lock nut			34 - 44 {3.5 - 4.5, 25 - 33}	
	Cylinder head bolt	Snug torque (1st)		88 - 98 {9.0 - 10.0, 65 - 72}	
		Tightening angle (2nd)	L = 147 mm (5.79 in)	85° - 95°	
			L = 119 mm (4.69 in)	70° - 80°	
	Cylinder head sub bolt	1st		34 {3.5, 25}	
		2nd		44 - 54 {4.5 - 5.5, 33 - 40}	
	Air intake manifold mounting bolt and nut			49 - 54 {5.0 - 5.5, 36 - 40}	
	Exhaust manifold mounting nut			29 - 44 {3.0 - 4.5, 22 - 33}	
	Crank damper mounting bolt			98 - 108 {10.0 - 11.0, 72 - 80}	
Compression gauge bolt			25 - 29 {2.5 - 3.0, 18 - 22}		
Lubrication system	Oil pan drain plug			98 - 127 {10.0 - 13.0, 72 - 94}	
	Oil filter	Full-flow type	Center bolt	59 - 69 {6.0 - 7.0, 43 - 51}	
			Drain plug	16 - 22 {1.6 - 2.2, 12 - 16}	
		Bypass type	Center bolt	59 - 69 {6.0 - 7.0, 43 - 51}	
			Drain plug	16 - 22 {1.6 - 2.2, 12 - 16}	
Fuel system	Injection pump drive coupling	Coupling bolt and nut		103 - 113 {10.5 - 11.5, 76 - 83}	
		Cotter bolt		147 - 167 {15.0 - 17.0, 108 - 123}	
	Injection nozzle retaining nut			59 - 78 {6.0 - 8.0, 43 - 58}	
	Nozzle holder assembly mounting bolt			25 - 29 {2.5 - 3.0, 18 - 22}	
	Fuel filter	Cartridge type		Apply film of engine oil to gasket and screw on until gasket contacts engine, then tighten 3/4 turn by hand or UD genuine filter wrench	
		Bypass type	Center bolt	59 - 69 {6.0 - 7.0, 43 - 51}	
Drain plug			16 - 22 {1.6 - 2.2, 12 - 16}		
Air intake and exhaust system	Turbocharger	Model TD45	Turbine housing and center housing mounting V-band lock nut N·m {kgf·m, ft·lbf}	17.0 {1.73, 12.5} → Loosen → 13.7 {1.40, 10.1}	
			Compressor housing and back plate clamp mounting bolt N·m {kgf·m, ft·lbf}	9.0 - 11.3 {0.92 - 1.15, 6.7 - 8.3}	
		Model GT45	Turbine housing and center housing mounting V-band lock nut N·m {kgf·cm, in·lbf}	12.7 - 14.7 {130 - 150, 113 - 130}	
			Compressor housing and back plate mounting bolt N·m {kgf·cm, in·lbf}	10.3 - 12.3 {105 - 125, 91 - 109}	
		Model GT42	Turbine housing and center housing mounting V-band lock nut N·m {kgf·cm, in·lbf}	12.7 - 14.7 {130 - 150, 113 - 130}	
			Compressor housing and back plate mounting bolt N·m {kgf·cm, in·lbf}	10.3 - 12.3 {105 - 125, 91 - 109}	

TOOLS

Tool name and number	Description	Shape
Feeler gauge 99541 Z5000	For adjusting valve clearance Thickness mm (in) 0.25 (0.0098), 0.3 (0.012), 0.35 (0.0138), 0.4 (0.016), 0.45 (0.0177), 0.5 (0.020)	 ET14-049
Feeler gauge 99541 Z0001	For adjusting valve clearance Thickness mm (in) 0.2 (0.008), 0.3 (0.012), 0.4 (0.016)	 ET14049A
Timing plate 99646 Z5001	For measuring valve timing  ZMA121A	 ET14-053
Adapter 99808 96500	Used when measuring valve timing as a set including the timing plate (99646 Z5001)	 WMA148A
Compression gauge 99640 96000	For measuring compression pressure	 ET14050B
Compression gauge hose 99644 97000	Used with the compression gauge (99640 96000) when the gauge cannot be installed directly due to interference with the air duct, etc.	 ET14-051

TOOLS

Tool name and number	Description	Shape
Plate 157944-9520	For fixing nozzle holder NOTE ● Tool number designated by ZEXEL CORPORATION	 WMA001A
Pin vice 99727 Z5005	For cleaning nozzle orifice	 EP14-121
Nozzle cleaner 99726 Z5000	For removal of carbon from rear of nozzle orifice	 ET14-072
Filter wrench 99755 00Z01	For removal of fuel filter (Only when replacing cartridge type element)	 WMA027A

MAINTENANCE PROCEDURE

BASIC MECHANICAL SYSTEM

VALVE CLEARANCE

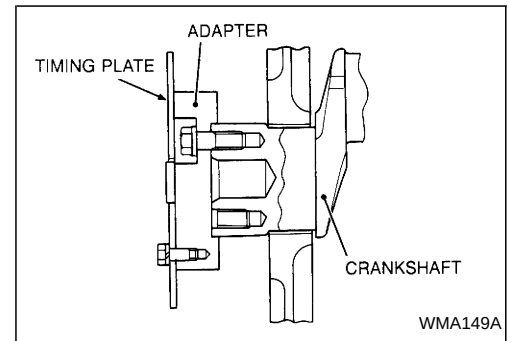
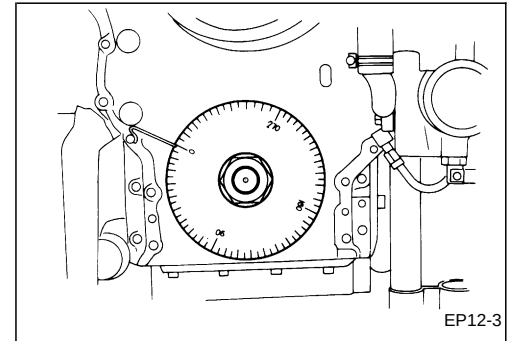
Procedure for checking valve timing

1. Remove the V-belt, cooling fan and crank pulley assembly.
2. Turn the flywheel in the normal direction until the No. 1 piston is at the top dead center on the compression stroke.

NOTE

- If the flywheel has been rotated excessively, rotate it backwards beyond the desired position then gradually rotate it back in the normal direction until it is set in the proper position.

3. Attach the timing plate (99646 Z5001) and adapter (99808 96500) to the end of the crankshaft. Also attach a needle pointer utilizing the front cover mounting bolt, and align the needle to "0".
4. Set a dial gauge so that the contact arm is in contact with the upper valve spring seats of the intake valve and exhaust valve.



FAN CLUTCH

Unit: C° (F°)

Item		Run the engine continuously	Operating temperatures
FDL2300-C	Linear type	2,300 rpm	60±10 - 75±5 (140±18 - 167±9)

FUEL SYSTEM

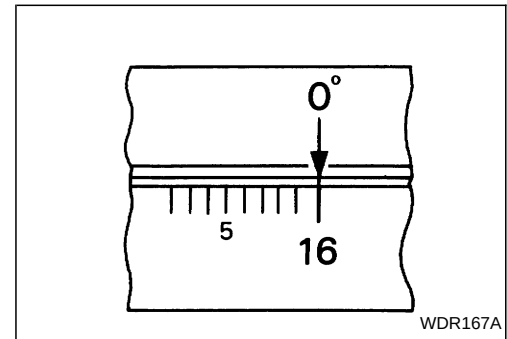
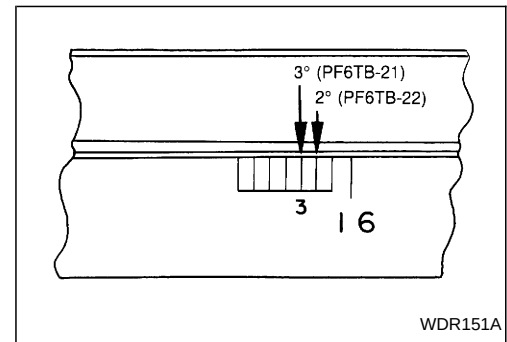
INJECTION TIMING

1. Remove the pointer cover. Secure the pointer to the flywheel housing using bolts.
2. Crank the engine in the standard direction by turning the flywheel with a lever until the pointer is aligned with the timing mark.

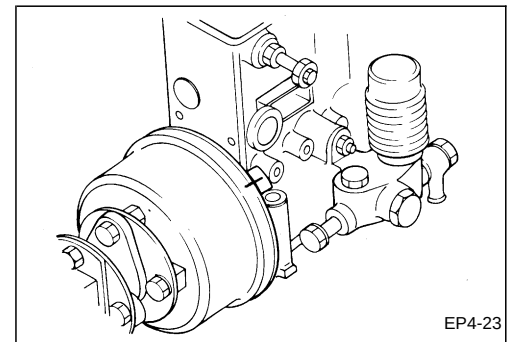
NOTE

- If the mark goes past the pointer, move it back past the pointer and turn again in the standard direction until alignment is made.

Item		Maintenance standard	Service limit
Fuel injection timing (B.T.D.C.)	PF6TB-21	3°	—
	PF6TB-22	2°	—
	PF6TC	0°	—



3. If the timer marks are not aligned as shown in the figure, adjust as follows:



Adjustment of fuel injection timing

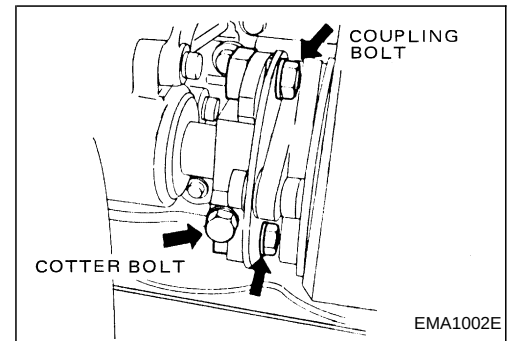
1. Make sure the pointer points to the specified injection timing graduation on the outer periphery of the flywheel and loosen the coupling bolts (2 places).
2. Back the timer off a little in the reverse direction of the normal timer direction. Turn the timer in the normal direction to adjust the pointer to the mark.
3. Tighten the coupling bolts and cotter bolt.

Coupling bolt and nut

T : 103 - 113 N·m {10.5 - 11.5 kgf·m, 76 - 83 ft·lbf}

Cotter bolt

T : 147 - 167 N·m {15.0 - 17.0 kgf·m, 108 - 123 ft·lbf}



IDLE SPEED

NOTE

- **When checking engine idle speed ensure that the engine idle control knob inside the cab is set to the low-speed position.**
1. Start the engine and warm it up to the normal operating temperature.
 2. Allow the engine to idle and observe the engine speed on the tachometer.
 3. If idle speed is not within specified range, adjust as follows:

NOTE

- **If equipped with an air conditioner, the air conditioner switch must be turned off when checking idle speed.**

Unit: rpm

Item		Maintenance standard	Service limit
Idle speed	PF6TB-21	430 - 530	—
	PF6TB-22	550 - 570	—
	PF6TC	510 - 610	—

Idle speed adjustment

1. Loosen the lock nut on the idle adjusting bolt.
2. Turn the idle adjusting bolt to obtain the correct idle speed.
3. Tighten the lock nut on the idle adjusting bolt.

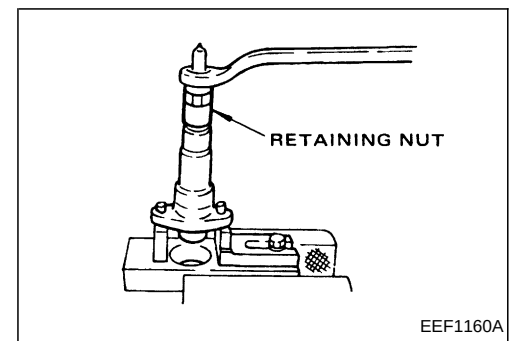
NOTE

- **Accelerate the engine two or three times. Allow the engine to return to idle speed and observe the tachometer reading. If the idle speed is not within the specified range, check the accelerator linkage for binding and repeat idle adjustment.**

NOZZLE (INJECTOR PRESSURE AND PATTERN)

Cleaning nozzle

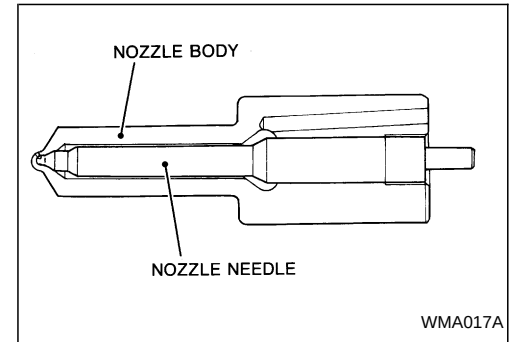
1. Remove the nozzle holder assembly from the engine. Refer to the "ENGINE DISASSEMBLY AND REASSEMBLY" section for details.
 2. Clamp the nozzle holder in a vise with a holder plate (157944-9520).
-
3. Loosen the retaining nut, and then remove the nozzle from the nozzle holder. Do not drop the nozzle needle.



4. Pull the nozzle needle from the nozzle body.

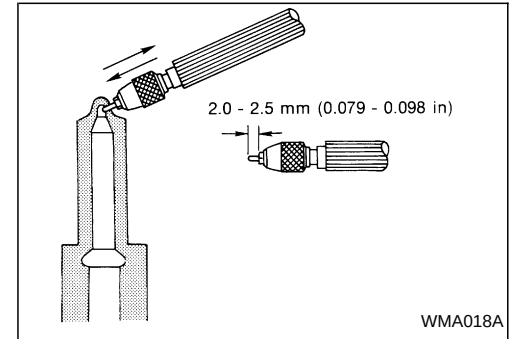
NOTE

- **Do not use the nozzle needle in another nozzle body.**
5. Remove carbon from around the openings by using the corner of a hard piece of wood. Do not use waste or any other material to push carbon into the openings.



6. Removing carbon in openings
Use the pin vice (99727 Z5005) and wire to clean the openings.
Unit: mm (in)

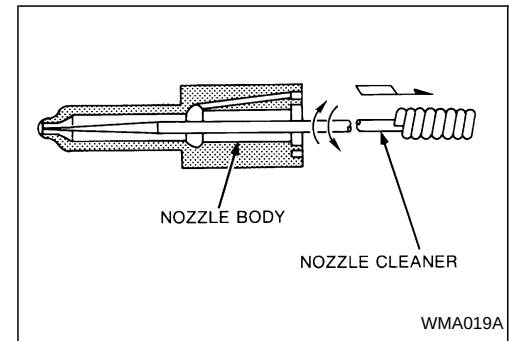
Nozzle identification mark	Number of injection nozzle holes	Injection nozzle hole diameter	Wire diameter
K4	6	0.31 (0.0122)	0.29 (0.0114)
K6		0.27 (0.0106)	0.26 (0.0102)
K8	7	0.26 (0.0102)	0.25 (0.0098)



- Allowing too much wire to protrude at the tip of the holder will permit the wire to bend inside the nozzle, in which case withdrawal proves difficult. The wire should protrude no more than 2.0 to 2.5 mm (0.079 to 0.098 in).
- Carefully push the carbon into the nozzle. Too much force will bend the wire. Proceed slowly.

- Remove carbon at the inside end of the openings with the nozzle cleaner (99726 Z5000). Exercise care to avoid damaging the surface which the nozzle needle contacts. The use of compressed air may clog the openings with foreign particles.
7. Tighten the retaining nut.

T : 59 - 78 N·m {6.0 - 8.0 kgf·m, 43 - 58 ft·lbf}



INTAKE AND EXHAUST SYSTEM

TURBOCHARGER

NOTE

- Before attempting any servicing of the turbocharger, clean its entire exterior surface.
- Never use a caustic solution. Caustic solutions attack aluminum.

To clean the compressor side

1. Remove the turbocharger from the engine.
2. Remove the compressor housing and check the condition of the impeller (compressor wheel). If it is not excessively dirty, clean the impeller and the inner surface of the housing with a brush and a cloth dampened with diesel fuel.

CAUTION

- Do not use a wire brush or scraper.
3. If the impeller is excessively dirty, overhaul and clean. Refer to the ENGINE "IE" section for cleaning instructions.
 4. When the impeller is wet with cleaning solvent, dry with compressed air.

CAUTION

- Hold the impeller by hand to prevent it from turning while drying.

5. Install the compressor housing in its original position.

-  : Model TD45
9.0 - 11.3 N·m {0.92 - 1.15 kgf·m, 6.7 - 8.3 ft·lbf}
-  : Model GT42, 45
10.3 - 12.3 N·m {105 - 125 kgf·cm, 91 - 109 in·lbf}

To clean the turbine side

1. Remove the turbine housing and check the condition of the turbine. If the turbine is not excessively dirty, clean the turbine and the inner surface of the turbine housing in a manner similar to that outlined under "To clean the compressor side".
2. If the turbine is excessively dirty, overhaul and clean.
3. When the impeller is wet with cleaning solvent, dry with compressed air.

CAUTION

- Hold the impeller with your hand to prevent it from turning while cleaning.

4. Install the turbine housing in its original position.

-  : Model TD45
17.0 N·m {1.73 kgf·m, 12.5 ft·lbf}
→ Loosen
→ 13.7 N·m {1.40 kgf·m, 10.1 ft·lbf}
-  : Model GT42, 45
12.7 - 14.7 N·m {130 - 150 kgf·cm, 113 - 130 in·lbf}

5. Check that the turbine wheel rotates smoothly by your hand. Install the turbocharger on the engine and check for gas or air leakage.

ENGINE DISASSEMBLY AND REASSEMBLY

CONTENTS

SERVICE DATA	DR-1- 1	DISASSEMBLY	
TIGHTENING TORQUE	DR-1- 1	AND REASSEMBLY	DR-4- 1
TOOLS	DR-2- 1	OUTSIDE OF ENGINE	DR-4- 1
CONSTRUCTION	DR-3- 1	ENGINE PROPER	DR-4- 4
ENGINE	DR-3- 1		

SUPPLEMENTAL OUTLINE

- Addition of tightening torque due to introduction of a new vehicle model.

SERVICE DATA

TIGHTENING TORQUE

Unit: N·m {kgf·m, ft·lbf}

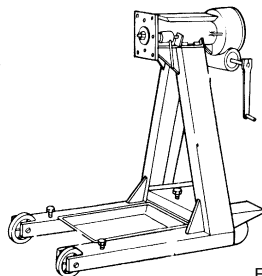
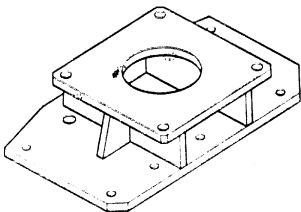
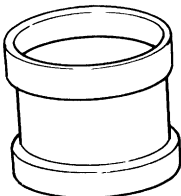
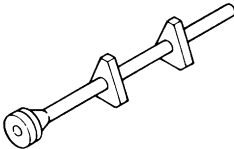
Item			Tightening torque	Remarks
Nozzle holder assembly mounting bolt			25 - 34 {2.5 - 3.5, 18 - 25}	
Spill tube mounting bolt			10 - 18 {1.0 - 1.8, 7.2 - 13.0}	
Injection tube	Pump side		29 - 39 {3.0 - 4.0, 22 - 29}	
	Nozzle side		25 - 34 {2.5 - 3.5, 18 - 25}	
Fuel tube and fuel return tube			25 - 29 {2.5 - 3.0, 18 - 22}	
Crank pulley mounting bolt			177 - 196 {18.0 - 20.0, 130 - 145}	
Fan pulley mounting bolt			186 - 196 {19.0 - 20.0, 137 - 145}	
Cooling fan mounting nut			16 - 19 {1.6 - 1.9, 12 - 14}	
Hydraulic pump drive gear mounting nut			59 - 78 {6.0 - 8.0, 43 - 58}	
Alternator mounting bolt			59 - 78 {6.0 - 8.0, 43 - 58}	
Oil pan drain plug			98 - 127 {10.0 - 13.0, 72 - 94}	
Exhaust manifold mounting nut			29 - 44 {3.0 - 4.5, 22 - 33}	
Oil outlet pipe mounting bolt			13 - 14 {1.30 - 1.45, 9.4 - 10.5}	
Oil inlet tube connector bolt			13 - 14 {1.30 - 1.45, 9.4 - 10.5}	
Oil cooler housing mounting bolt and nut	Bolt		29 - 54 {3.0 - 5.5, 22 - 40}	
	Nut		54 - 93 {5.5 - 9.5, 40 - 69}	
Turbocharger mounting bolt			34 - 44 {3.5 - 4.5, 25 - 33}	
Air intake manifold mounting nut			49 - 54 {5.0 - 5.5, 36 - 40}	
Air compressor mounting bolt			30 - 41 {3.1 - 4.2, 22 - 30}	
Starting motor mounting bolt			69 {7.0, 51}	
Injection pump bracket mounting bolt			30 - 41 {3.1 - 4.2, 22 - 30}	
Injection pump mounting bolt			48 - 62 {4.9 - 6.3, 35 - 46}	
Injection pump coupling mounting bolt	Coupling bolt		103 - 113 {10.5 - 11.5, 76 - 83}	
	Cotter bolt		147 - 167 {15.0 - 17.0, 108 - 123}	
Injection pump oil tube connector	Feed side		10 - 18 {1.0 - 1.8, 7.2 - 13.0}	
	Return side	Pump side	15 - 34 {1.5 - 3.5, 11 - 25}	
		Block side	25 - 41 {2.5 - 4.2, 18 - 30}	
		Engine mounting bracket mounting bolt		
Engine lifter mounting bolt			74 - 93 {7.5 - 9.5, 54 - 69}	
Cylinder head sub bolt	1st		34 {3.5, 25}	
	2nd		44 - 54 {4.5 - 5.5, 33 - 40}	
Cylinder head bolt	Snug torque (1st)		88 - 98 {9.0 - 10.0, 65 - 72}	
	Tightening angle (2nd)	L = 147 mm (5.79 in)	85° - 95°	
		L = 119 mm (4.69 in)	70° - 80°	
Rocker shaft bracket mounting bolt			34 - 49 {3.5 - 5.0, 25 - 36}	

Unit: N·m {kgf·m, ft·lbf}

Item		Tightening torque	Remarks
Oil jet connector bolt		29 - 39 {3.0 - 4.0, 22 - 29}	
Main bearing cap bolt		265 - 294 {27.0 - 30.0, 195 - 217}	
Connecting rod cap nut		230 - 245 {23.5 - 25.0, 170 - 181}	
Front gear case mounting bolt		25 - 34 {2.5 - 3.5, 18 - 25}	
Injection pump drive gear mounting nut		392 - 441 {40.0 - 45.0, 289 - 325}	
Camshaft gear mounting nut		245 - 265 {25.0 - 27.0, 181 - 195}	
Camshaft locating plate mounting bolt		20 - 24 {2.0 - 2.4, 14 - 17}	
Cam chamber cover mounting bolt		15 - 29 {1.5 - 3.0, 11 - 22}	
Idler gear mounting bolt		18 - 22 {1.8 - 2.2, 13 - 16}	
Idler gear shaft bolt		49 - 57 {5.0 - 5.8, 36 - 42}	
Air compressor drive gear mounting nut		186 - 206 {19.0 - 21.0, 137 - 152}	
Oil pump mounting bolt		30 - 41 {3.1 - 4.2, 22 - 30}	
Oil screen and oil outlet pipe mounting bolt		16 - 21 {1.6 - 2.1, 12 - 15}	
Flywheel housing mounting bolt	M12	78 - 98 {8.0 - 10.0, 58 - 72}	
Stiffener mounting bolt	Housing side	74 - 88 {7.5 - 9.0, 54 - 65}	
	Block side	98 - 137 {10.0 - 14.0, 72 - 101}	
Oil pan mounting bolt		21 {2.1, 15}	
Flywheel mounting bolt		255 - 304 {26.0 - 31.0, 188 - 224}	
Crank damper mounting bolt		98 - 108 {10.0 - 11.0, 72 - 80}	
Rear PTO idler shaft mounting bolt		127 {13.0, 94}	
Engine rear PTO companion flange nut		392 - 412 {40.0 - 42.0, 289 - 304}	

TOOLS

TOOLS

Tool name and number	Description	Shape
Engine stand 99550 96001 Head assembly 99551 96001	For disassembling and reassembling engine proper	 ET14-001
Engine stand attachment 99554 96001	For disassembling and reassembling engine proper To be used together with engine stand	 EDR1074A
Piston insert tool 99631 96502	For inserting piston into cylinder	 ET14045C
Injection pump bracket setting tool 99720 95500	For centering of injection pump bracket	 ETL2-003

CONSTRUCTION

ENGINE

Cylinder block flatness

- Ⓜ : Longitudinal direction
Less than 0.10 mm (0.0039 in)
Transverse direction
Less than 0.02 mm (0.0008 in)

Valve clearance

- Ⓜ : Intake
0.30 - 0.40 mm (0.0118 - 0.0157 in)
Exhaust
0.30 - 0.40 mm (0.0118 - 0.0157 in)

Clearance between piston and cylinder liner

- Ⓜ : 0.07 - 0.09 mm
(0.0028 - 0.0035 in)

RIGHT SIDE

LEFT SIDE

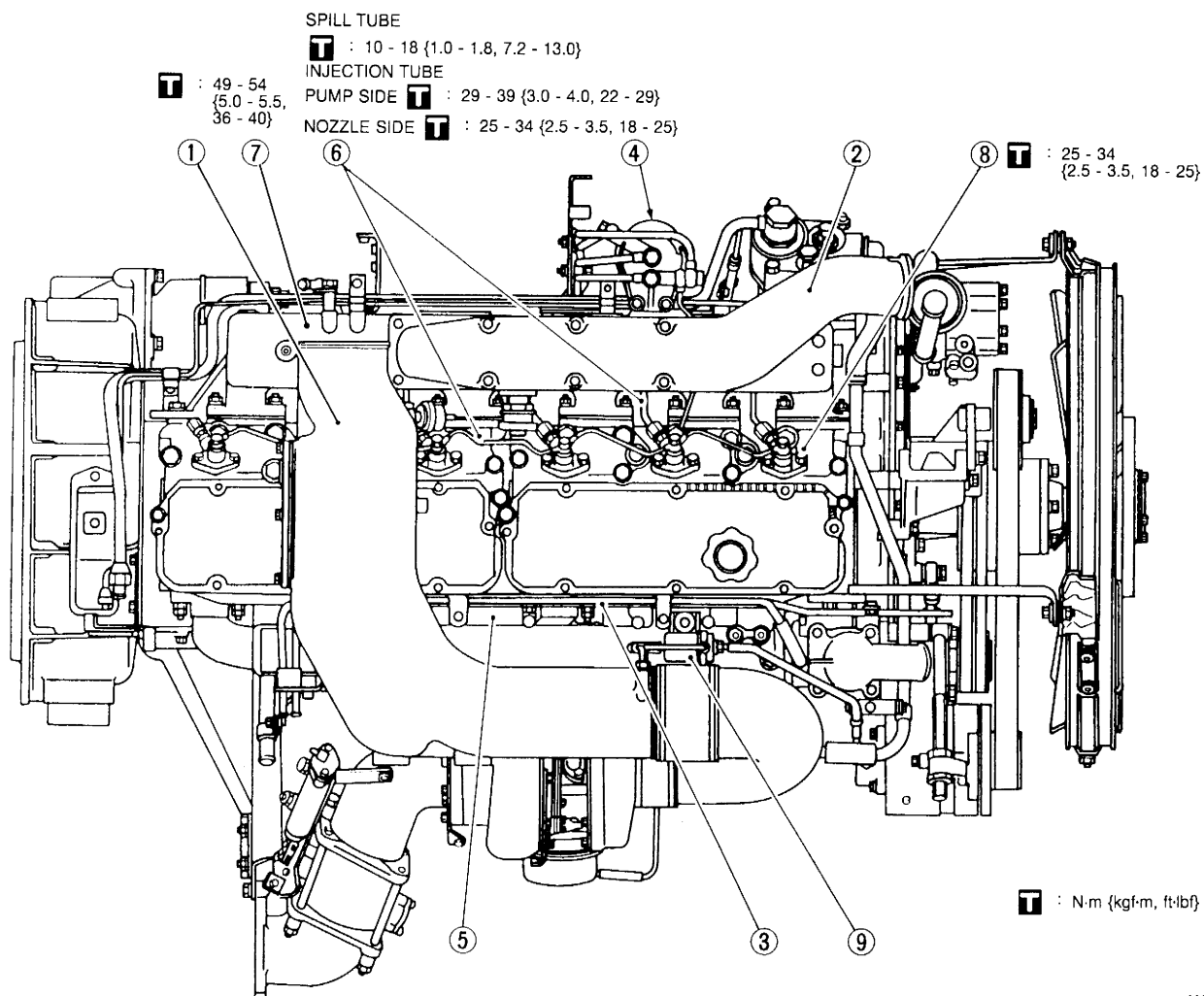
Ⓜ : Maintenance standard

WDR148A

DISASSEMBLY AND REASSEMBLY

OUTSIDE OF ENGINE

UPPER SIDE OF ENGINE



WDR149A

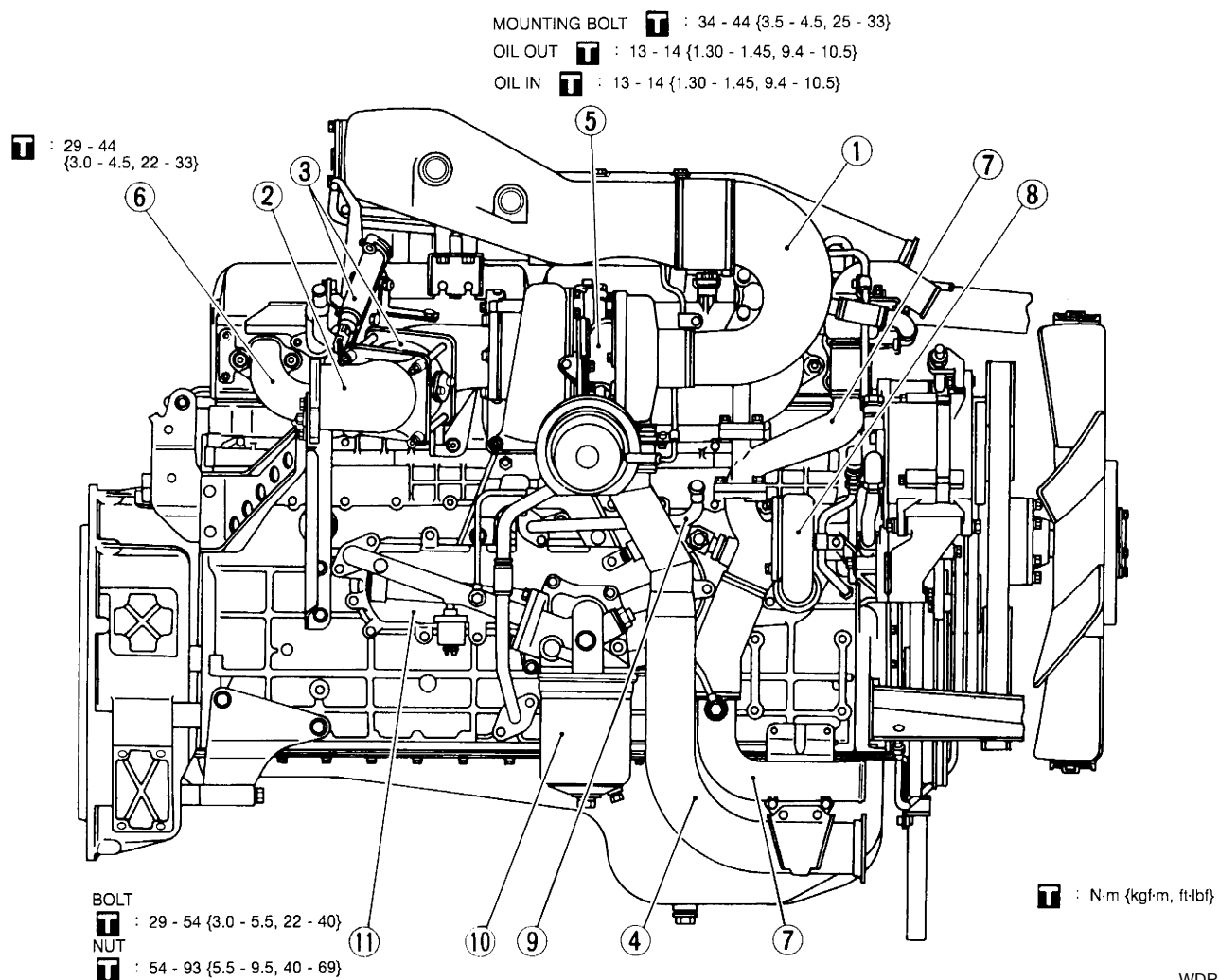
Disassembly sequence (Reassembly sequence is the reverse of disassembly.)

- ① Air intake duct
- ② Air intake
- ③ Water tube

- ④ Fuel filter
- ⑤ Water manifold
- ⑥ Nozzle tube

- ⑦ Air intake manifold
- ⑧ Nozzle holder assembly
- ⑨ PCM valve

RIGHT SIDE OF ENGINE



WDR150A

Disassembly sequence (Reassembly sequence is the reverse of disassembly.)

- | | | |
|-------------------|--------------------|-------------------|
| ① Air intake duct | ⑤ Turbocharger | ⑨ Car heater pipe |
| ② Exhaust outlet | ⑥ Exhaust manifold | ⑩ Oil filter |
| ③ Exhaust shutter | ⑦ Water duct | ⑪ Oil cooler |
| ④ Air pipe | ⑧ Water pump | |

LEFT SIDE OF ENGINE

Key points of reassembly

④ Injection pump

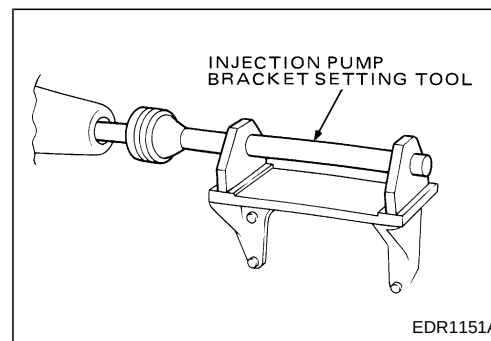
When the injection pump bracket has been removed, center it using the following procedure:

1. Fasten the injection pump bracket.

T : 30 - 41 N·m {3.1 - 4.2 kgf·m, 22 - 30 ft·lbf}

2. Centering the injection pump bracket

Set a bracket setting tool (99720 95500) in place. Then check to make sure that the shaft of the injection pump support enters the hole on the end of the shaft smoothly.

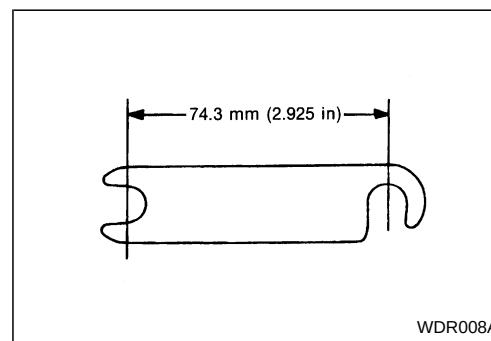


3. If it does not enter smoothly, adjust by changing the thickness of the injection pump bracket shims.

Shim thickness [mm (in)]: 0.05 (0.0020)

: 0.10 (0.0039)

: 0.20 (0.0079)

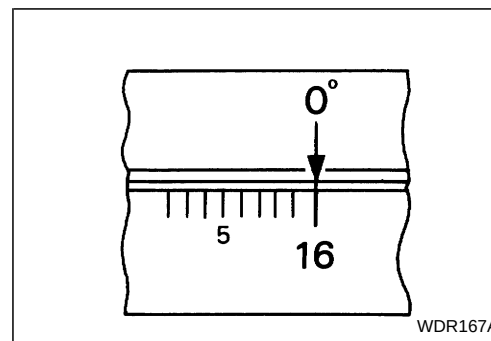
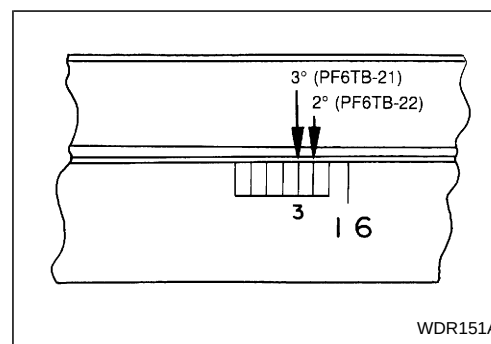


4. Install the injection pump.

T : 48 - 62 N·m {4.9 - 6.3 kgf·m, 35 - 46 ft·lbf}

5. Turn the flywheel in the standard direction of rotation to align the scribed line of the injection timer on the No. 1 cylinder with the pointer. If not aligned properly, rotate the flywheel in the reverse direction sufficiently, and realign.

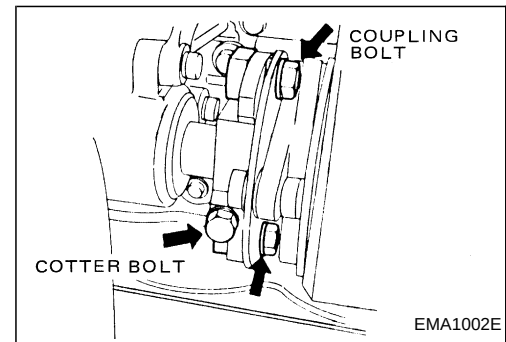
Item		Maintenance standard	Service limit
Fuel injection timing (B.T.D.C.)	PF6TB-21	3°	—
	PF6TB-22	2°	—
	PF6TC	0°	—



6. Align the mark on the injection pump with the scribed line on the timer, then connect the coupling.

Unit: N·m {kgf·m, ft·lbf}

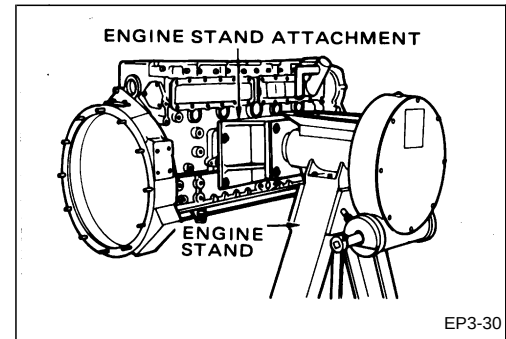
Item	Tightening torque
Coupling bolt	103 - 113 {10.5 - 11.5, 76 - 83}
Cotter bolt	147 - 167 {15.0 - 17.0, 108 - 123}



ENGINE PROPER

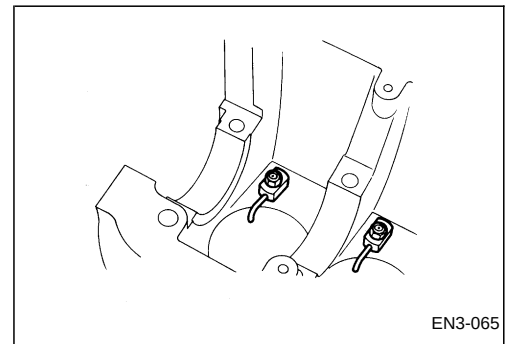
Key points of reassembly

1. Attach the engine stand attachment (99554 96001), then raise the cylinder block using a crane or other devices, and mount it on the engine stand (99550 96001).



2. Install the oil jet.

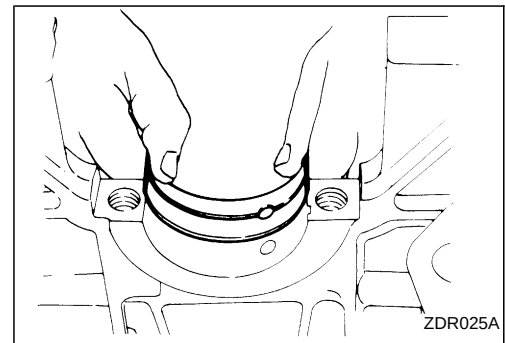
T : 29 - 39 N·m {3.0 - 4.0 kgf·m, 22 - 29 ft·lbf}



3. Install the main bearing upper shell.

NOTE

- Be sure to install the main bearing upper shell in the original position before disassembly.



4. Attach the upper thrust washer to both side of the No. 7 main bearing and measure the end play of the crankshaft. If the measured value exceeds the service limit, replace the thrust washer with a new one.

Unit: mm (in)

Maintenance standard	Service limit
0.05 - 0.14 (0.0020 - 0.0055)	0.5 (0.020)

Unit: mm (in)

Thrust washer	A	3.995 - 4.025 (0.1573 - 0.1585)	Standard
	B	3.970 - 4.000 (0.1563 - 0.1575)	
	C	3.945 - 3.975 (0.1553 - 0.1565)	
	0.15 O.S.	4.100 - 4.150 (0.1614 - 0.1634)	O.S.: Oversize
	0.30 O.S.	4.250 - 4.300 (0.1673 - 0.1693)	

NOTE

- Be sure the oil groove side of the thrust washer faces toward the crankshaft.

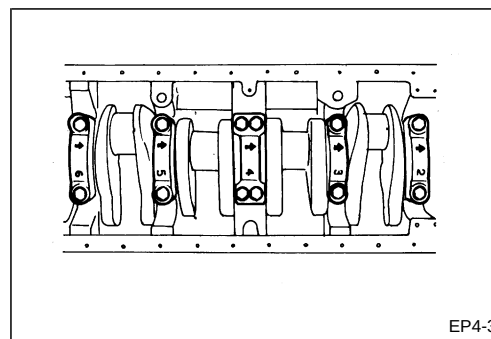
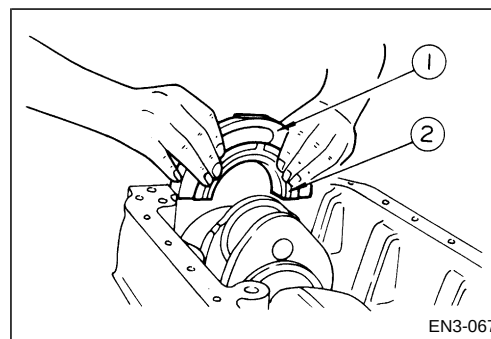
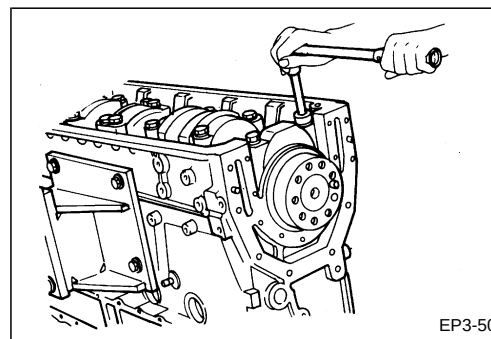
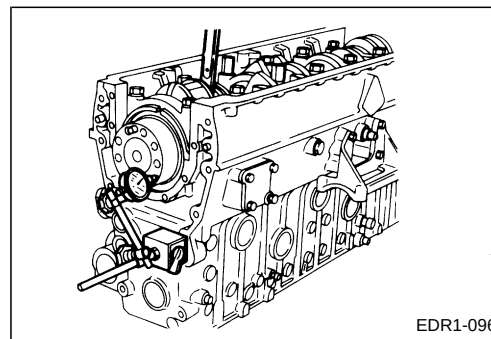
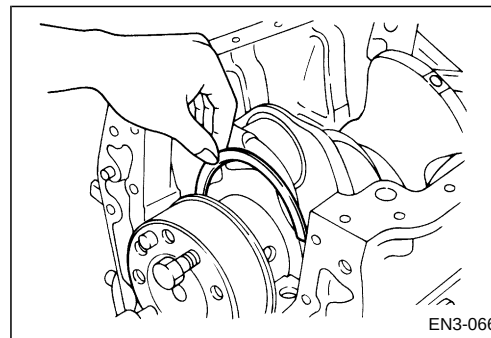
5. Fit the main bearing lower shell into the main bearing cap, and install the main bearing cap. Install the lower thrust washer onto both sides of the No. 7 main bearing cap.

T : 265 - 294 N·m {27.0 - 30.0 kgf·m, 195 - 217 ft·lbf}

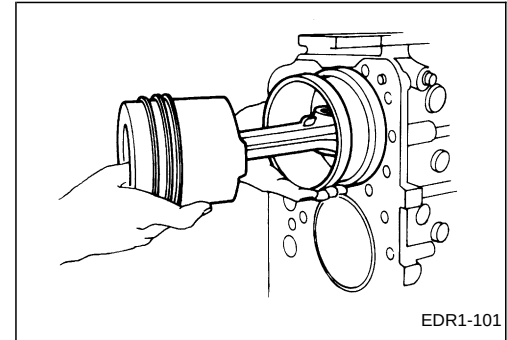
- ① No. 7 main bearing cap
② Lower thrust washer

NOTE

- Make sure the main bearing cap is installed following the stamped numbers with the mark "➡" indicating the engine front side.
- The thrust washer has an oil groove which should face the crankshaft when installed. Be careful not to interchange the upper and lower washers.

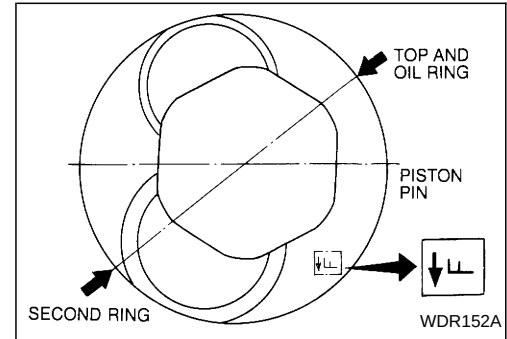


6. Using a piston insert tool (99631 96502) insert the piston, connecting rod and bearing upper shell into the cylinder liner.



NOTE

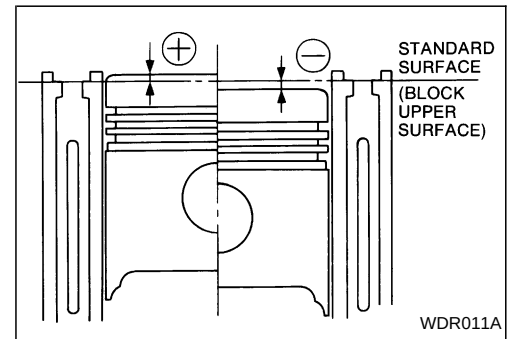
- Do not install the piston rings in such a way that their gaps face the direction of the piston pin and are in a vertical direction. Moreover install them so that their gaps are located exactly on opposite sides to each other. Also make sure that the mark "F" at the top of the piston faces the engine front side and the stamped mark at the large end of the connecting rod is on the injection pump side.



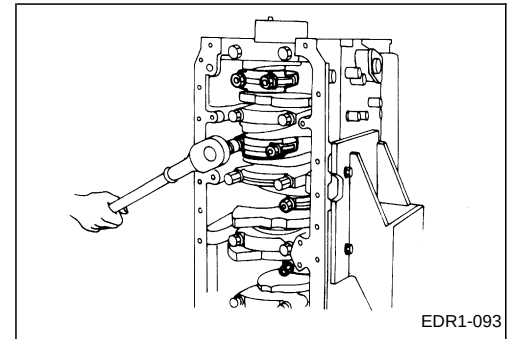
NOTE

- Place each piston at its top dead center, and check to make sure that the piston top clearance at this position is within the maintenance standard. If any abnormality is noted, disassemble again and inspect each part.

Unit: mm (in)	
Maintenance standard	Service limit
$\oplus 0.32 - \oplus 0.72$ ($\oplus 0.0126 - \oplus 0.0283$)	—

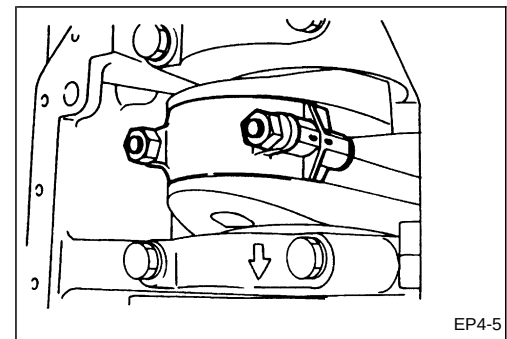


7. Install the connecting rod cap and bearing lower shell.



NOTE

- Make sure stamped mark at the large end of the connecting rod aligns with that on the connecting rod cap.
- T** : 230 - 245 N·m {23.5 - 25.0 kgf·m, 170 - 181 ft·lbf}



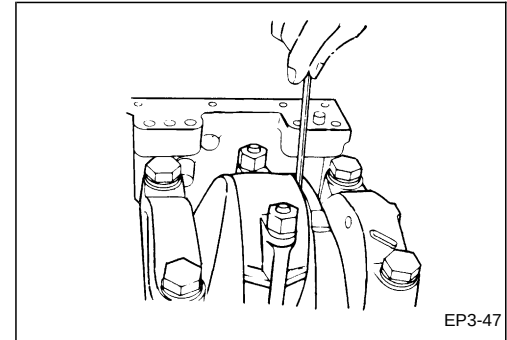
8. Make sure the side clearance at the connecting rod large end is within the service limit.

NOTE

- Side clearance for every cylinder should be measured.

Unit: mm (in)

Maintenance standard	Service limit
0.1 - 0.3 (0.004 - 0.012)	1.0 (0.039)



9. Install the front gear case and oil jet.

Front gear case mounting bolt

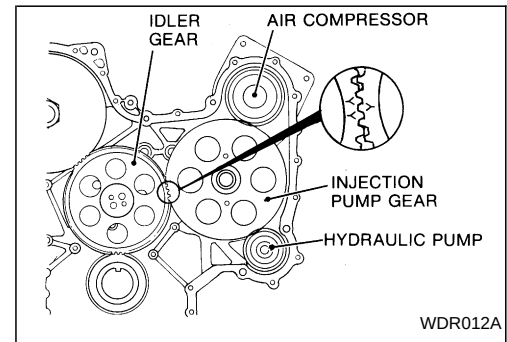
T : 25 - 34 N·m {2.5 - 3.5 kgf·m, 18 - 25 ft·lbf}

10. Install the injection pump gear.

NOTE

- When installing, align the timing marks "Y" and "YY".

T : 392 - 441 N·m {40.0 - 45.0 kgf·m, 289 - 325 ft·lbf}



11. Install the camshaft assembly together with the gears.

NOTE

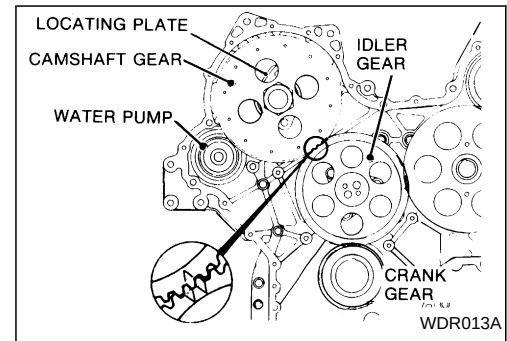
- When installing, align the timing marks "V" and "VV".

Camshaft locating plate mounting bolt

T : 20 - 24 N·m {2.0 - 2.4 kgf·m, 14 - 17 ft·lbf}

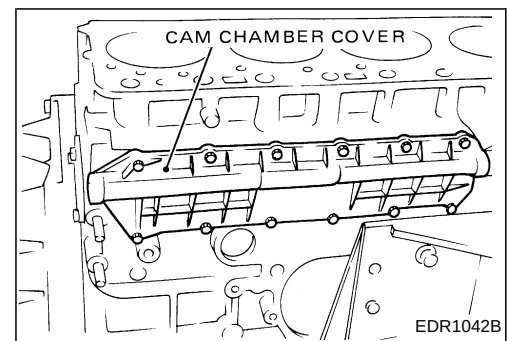
Camshaft gear mounting nut

T : 245 - 265 N·m {25.0 - 27.0 kgf·m, 181 - 195 ft·lbf}



12. Install the cover for the cam chamber.

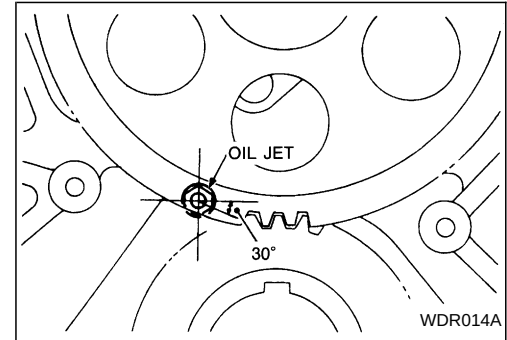
T : 15 - 29 N·m {1.5 - 3.0 kgf·m, 11 - 22 ft·lbf}



13. Install the oil jet.

NOTE

- It should be installed with the injection orifices facing the crank gear and idler gear contacting point (so that they point 30 degrees below the horizontal).



14. Install the idler gear and idler gear shaft.

NOTE

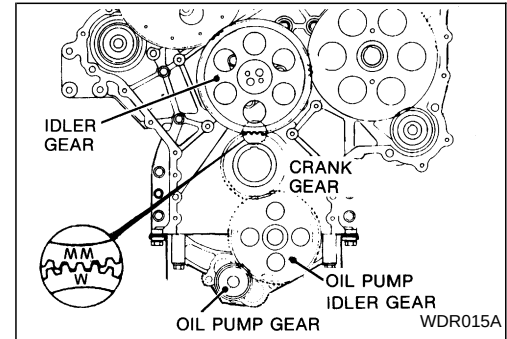
- Install the idler gear aligning the timing marks "W" and "WW".

Mounting bolt

T : 18 - 22 N·m {1.8 - 2.2 kgf·m, 13 - 16 ft·lbf}

Idler gear shaft

T : 49 - 57 N·m {5.0 - 5.8 kgf·m, 36 - 42 ft·lbf}



15. Install the air compressor drive gear.

T : 186 - 206 N·m {19.0 - 21.0 kgf·m, 137 - 152 ft·lbf}

16. Install the oil pump assembly.

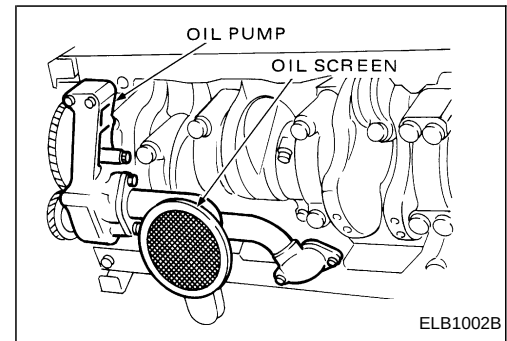
T : 30 - 41 N·m {3.1 - 4.2 kgf·m, 22 - 30 ft·lbf}

17. Install the oil outlet pipe.

T : 16 - 21 N·m {1.6 - 2.1 kgf·m, 12 - 15 ft·lbf}

18. Install the oil screen.

T : 16 - 21 N·m {1.6 - 2.1 kgf·m, 12 - 15 ft·lbf}



19. Measure the end play of the idler gear and oil pump idler gear.
Check that the end play is within the service limit.

Unit: mm (in)

Item	Maintenance standard	Service limit
Idler gear	0.05 - 0.12 (0.0020 - 0.0047)	0.3 (0.012)
Oil pump idler gear	0.08 - 0.15 (0.0031 - 0.0059)	—

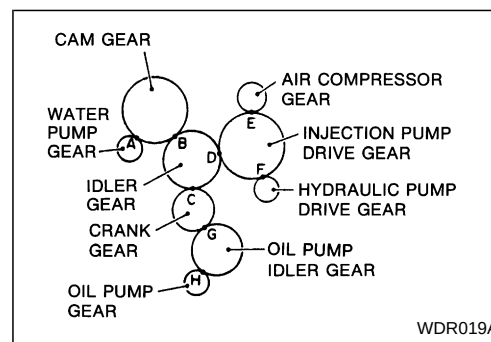
20. Measure the backlash of the gear train.

NOTE

- Measure the backlash by inserting fuse wire between the gears.
- When the air compressor and water pump have been removed, temporarily install them and measure the gear backlash.
- Check that the backlash for each gear is within the service limit.

Unit: mm (in)

Location	Maintenance standard	Service limit
A.B.C.D.E.F	0.065 - 0.135 (0.0026 - 0.0053)	—
G.H	0.085 - 0.215 (0.0033 - 0.0085)	—



21. Install the rear oil slinger and flywheel housing.

M8

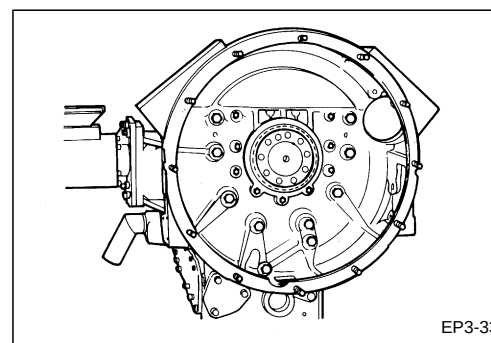
T : 21 N·m {2.1 kgf·m, 15 ft·lbf}

M12

T : 71 N·m {7.2 kgf·m, 52 ft·lbf}

NOTE

- When an engine rear PTO is equipped, be sure to install the special PTO parts prior to installing the flywheel housing.
- Install the flywheel housing by suspending it with a belt using a hoist.



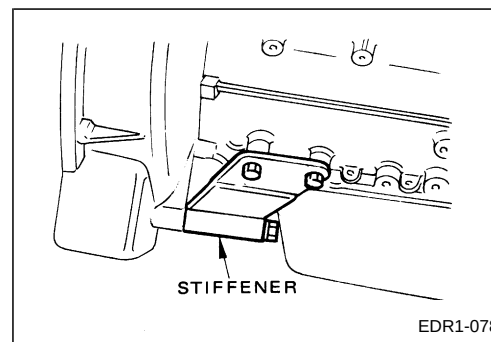
22. Install the right and left stiffeners.

Housing side

T : 74 - 88 N·m {7.5 - 9.0 kgf·m, 54 - 65 ft·lbf}

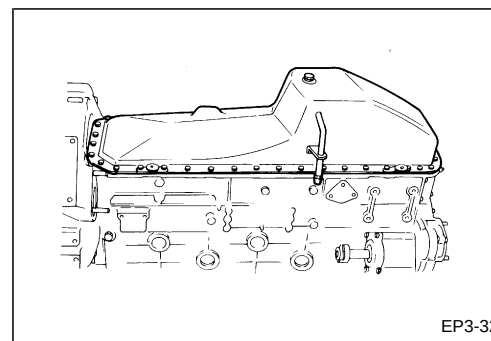
Block side

T : 98 - 137 N·m {10.0 - 14.0 kgf·m, 72 - 101 ft·lbf}



23. Turn the engine upside down and install the oil pan. Apply a coat of liquid gasket to the contacting surfaces. Fasten twice.

T : 21 N·m {2.1 kgf·m, 15 ft·lbf}



ENGINE PROPER

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SERVICE DATA	EP-1- 1	REPAIR AND REPLACEMENT	EP-4- 1
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CRANKSHAFT	EP-3- 1	CRANKSHAFT ACCESSORIES	
MAIN BEARING SHELL	EP-3- 1	REPLACEMENT	EP-4- 2
CAMSHAFT	EP-3- 2	FLYWHEEL CORRECTION	EP-4- 4
FLYWHEEL	EP-3- 2		

SUPPLEMENTAL OUTLINE

- Addition of service data due to introduction of a new vehicle model.
- Change in the shape of the rear oil seal and removal and installation procedures.

SERVICE DATA

Unit: mm (in)

Position	Item		Maintenance standard	Service limit	Remarks
Cylinder block	Flatness of the top surface	Longitudinal direction	Less than 0.10 (0.0039)	0.10 (0.0039)	
		Transverse direction	Less than 0.02 (0.0008)	0.10 (0.0039)	
	Roundness of the liner engaging inner wall		Less than 0.02 (0.0008)	—	
	Clearance between main bearing cap and cylinder block		0.05 T - 0.02 L (0.0020 T - 0.0008 L)	—	T: Tight L: Loose
Crankshaft	Outside diameter of journal		99.87 - 99.89 (3.9319 - 3.9327)	98.87 (3.8925)	
	Outside diameter of crankshaft pin		89.89 - 89.90 (3.5390 - 3.5394)	88.89 (3.4996)	
	Out-of-roundness of journal and crank pin		Less than 0.01 (0.0004)	0.06 (0.0024)	
	Taper of journal and crank pin		Less than 0.01 (0.0004)	—	
	Journal grinding dimensions	0.25 U.S.	99.62 - 99.64 (3.9220 - 3.9228)	—	U.S.: Undersize
		0.50 U.S.	99.37 - 99.39 (3.9122 - 3.9130)	—	
		0.75 U.S.	99.12 - 99.14 (3.9024 - 3.9031)	—	
		1.00 U.S.	98.87 - 98.89 (3.8925 - 3.8933)	—	
	Crank pin grinding dimensions	0.25 U.S.	89.64 - 89.66 (3.5291 - 3.5299)	—	
		0.50 U.S.	89.39 - 89.41 (3.5193 - 3.5201)	—	
		0.75 U.S.	89.14 - 89.16 (3.5094 - 3.5102)	—	
		1.00 U.S.	88.89 - 88.91 (3.4996 - 3.5004)	—	

SERVICE DATA

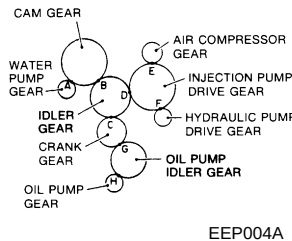
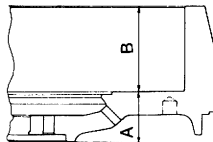
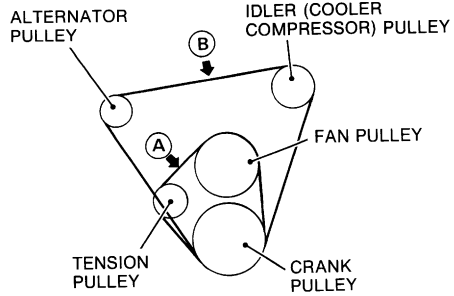
Unit: mm (in)

Position	Item		Maintenance standard	Service limit	Remarks
Crankshaft	Runout	Journal location (A)	Less than 0.07 (0.0028)	0.10 (0.0039)	Support the No. 2 and No. 6 journals
		Oil seal location (B)	Less than 0.04 (0.0016)	0.10 (0.0039)	
		Flywheel location (C)	Less than 0.02 (0.0008)	0.10 (0.0039)	
	End play		0.05 - 0.14 (0.0020 - 0.0055)	0.50 (0.0197)	
	Thrust washer types	A	3.995 - 4.025 (0.1573 - 0.1585)	—	Standard
		B	3.970 - 4.000 (0.1563 - 0.1575)	—	
		C	3.945 - 3.975 (0.1553 - 0.1565)	—	
		0.15 O.S.	4.100 - 4.150 (0.1614 - 0.1634)	—	O.S.: Oversize
		0.30 O.S.	4.250 - 4.300 (0.1673 - 0.1693)	—	
	Clearance between main bearing shell and crankshaft journal		0.04 - 0.13 (0.0016 - 0.0051)	0.20 (0.0079)	

Unit: mm (in)

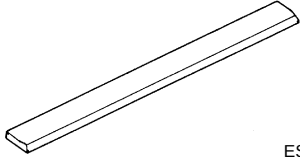
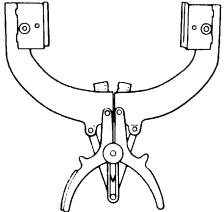
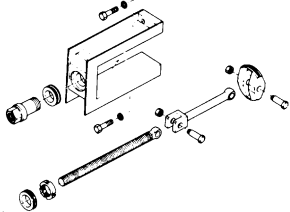
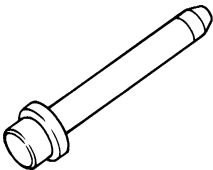
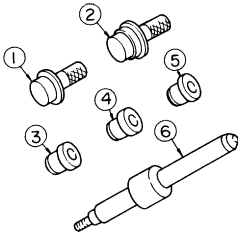
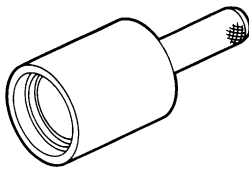
Position		Item	Maintenance standard	Service limit	Remarks	
Cylinder liner	Inside diameter (without dismounting it from the cylinder block)		133.00 - 133.03 (5.2362 - 5.2374)	133.25 (5.2461)	Measure at 25, 50, 75, 125, 175 and 245 mm (0.98, 1.97, 2.95, 4.92, 6.89 and 9.65 in) positions from the top surface of the block	
	Out-of-roundness		Less than 0.02 (0.0008)	—		
	Taper		Less than 0.03 (0.0012)	—		
	Protrusion of cylinder liner flange above cylinder block		0.02 - 0.10 (0.0008 - 0.0039)	—		
	Gap between adjoining cylinders		Less than 0.05 (0.0020)	—	Between cylinders #1 and #2, #2 and #3, #4 and #5, #5 and #6	
Piston and connecting rod	Piston	Outside diameter		132.92 - 132.95 (5.2331 - 5.2342)	—	Measure at 20 mm (0.787 in) position from bottom surface, perpendicular to piston pin
		Clearance between piston and cylinder liner		0.07 - 0.09 (0.0028 - 0.0035)	—	
		Inside diameter of piston pin		50.00 - 50.02 (1.9685 - 1.9693)	50.10 (1.9724)	
		Top clearance		0.32 - 0.72 (0.0126 - 0.0283)	—	Upper surfaces of piston and cylinder block
	Piston ring	Clearance between the piston ring and ring groove	2nd ring	0.08 - 0.12 (0.0031 - 0.0047)	0.40 (0.0157)	
			Oil ring	0.02 - 0.06 (0.0008 - 0.0024)	0.20 (0.0079)	
		End gap of each piston ring	1st ring 2nd ring Oil ring	0.40 - 0.60 (0.0157 - 0.0236)	2.00 (0.0787)	
	Piston pin	Outside diameter		49.99 - 50.00 (1.9681 - 1.9685)	49.90 (1.9646)	
		Clearance between piston pin and piston pin bore		0 - 0.03 (0 - 0.0012)	0.10 (0.0039)	
		Clearance between connecting rod small end bushing and piston pin		0.03 - 0.05 (0.0012 - 0.0020)	0.10 (0.0039)	
	Connecting rod	Inside diameter of small end bushing		50.03 - 50.04 (1.9697 - 1.9701)	—	
		Clearance between large end bearing and crank pin		0.05 - 0.11 (0.0020 - 0.0043)	0.20 (0.0079)	
		Bend		Less than 0.06 (0.0024)	—	When the distance between pins is 100 mm (3.94 in)
		Twist		Less than 0.08 (0.0031)	—	
		Side clearance between connecting rod and crank pin		0.10 - 0.30 (0.0039 - 0.0118)	1.00 (0.0394)	Measure with one side set to zero

Unit: mm (in)

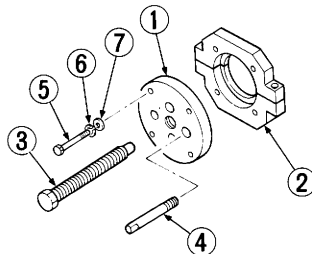
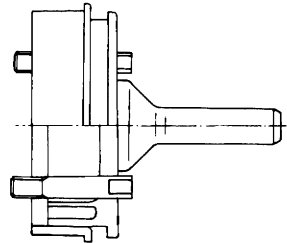
Position	Item		Maintenance standard	Service limit	Remarks	
Camshaft	End play		0.05 - 0.25 (0.0020 - 0.0098)	0.50 (0.0197)		
	Outside diameter of journal	No. 1	62.72 - 62.74 (2.4693 - 2.4701)	—		
		No. 2	62.52 - 62.54 (2.4614 - 2.4622)	—		
		No. 3	62.32 - 62.34 (2.4535 - 2.4543)	—		
		No. 4	62.12 - 62.14 (2.4457 - 2.4465)	—		
		No. 5	61.92 - 61.94 (2.4378 - 2.4386)	—		
	Clearance between journal and bushing		0.030 - 0.116 (0.0012 - 0.0046)	0.20 (0.0079)		
	Height of cam profile	Intake	53.0275 - 53.0675 (2.0877 - 2.0893)	—		
Exhaust		50.505 - 50.545 (1.9884 - 1.9900)	—			
Runout		Less than 0.03 (0.0012)	0.06 (0.0024)	Support the No. 2 and No. 4 journals		
Gear train	Gear train backlash	A, B, C, D, E, F	0.065 - 0.135 (0.0026 - 0.0053)	—		
		G, H	0.085 - 0.215 (0.0033 - 0.0085)	—		
	Idler gear end play		0.05 - 0.12 (0.0020 - 0.0047)	0.30 (0.0118)		
	Clearance between idler gear bushing and shaft		0.025 - 0.061 (0.0010 - 0.0024)	0.20 (0.0079)		
Flywheel	Lateral runout of clutch disc surface		Less than 0.10 (0.0039)	0.15 (0.0059)		
	Thickness (A)		53.5 (2.106)	51.5 (2.028)		
	Standard depth from flange end face (B)		91.4 (3.598)	—		
V-belt	Deflection of V-belt [when applied with 98 N {10 kgf, 22 lbf} force at midpoint]	A	8 - 12 (0.31 - 0.47)			
		B	15 - 18 (0.59 - 0.71)			

TOOLS

TOOLS

Tool name and number	Description	Shape
Straight edge 99645 Z5001	For measuring flatness of cylinder block and cylinder head gasketed surfaces	 ES14-8
Piston ring tool 99630 Z0001	For removal and installation of piston ring	 EP14-111
Cylinder liner tool 99600 96500	For removal and installation of cylinder liner	 EP14-109
Cam bush tool assembly 99590 95500	For removal of cam bushing	 ET14010A
Cam bush tool assembly 99590 96003 ① 99594 96000 ② 99594 96001 ③ 99595 96005 ④ 99595 96006 ⑤ 99595 96007 ⑥ 99597 96000	For installation of cam bushing Cam bush replacer ① For No. 1 ② For No. 5 ③ For No. 2 ④ For No. 3 ⑤ For No. 4 Replace bar ⑥ For No. 2 - 4	 ET14012E
Collar replacer 99718 96006	For pressing front oil seal	 JTL009A

TOOLS

Tool name and number	Description	Shape
Puller assembly 99690 96002 — ① 99696 97001 — ② 99697 96000 — ③ 99532 Z6002 — ④ 99687 97002 — ⑤ 81-91070-1A — ⑥ 89-15540-1A — ⑦ 89-15140-1A	For removal of rear oil seal ① Puller plate ② Holder ③ Puller bolt ④ Guide bolt ⑤ Bolt ⑥ Plain washer ⑦ Lock washer	 WEP037A
Oil seal replacer 99691 96004	For installation of rear oil seal	 WEP038A

INSPECTION

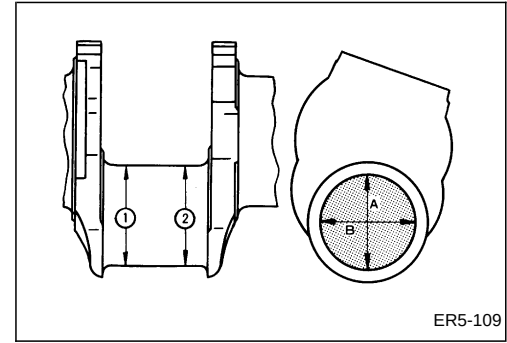
CRANKSHAFT

Outside diameter of the crankshaft pin

Measure and record the outside diameter of the crankshaft pin. If the measured value has reached the service limit, grind the pin to the undersize, and install the undersize bearing shell.

Unit: mm (in)

Item	Maintenance standard	Service limit	Remarks
S.T.D.	89.89 - 89.91 (3.5390 - 3.5398)	88.89 (3.4996)	S.T.D.: Standard U.S.: Undersize
0.25 U.S.	89.64 - 89.66 (3.5291 - 3.5299)	—	
0.50 U.S.	89.39 - 89.41 (3.5193 - 3.5201)	—	
0.75 U.S.	89.14 - 89.16 (3.5094 - 3.5102)	—	
1.00 U.S.	88.89 - 88.91 (3.4996 - 3.5004)	—	

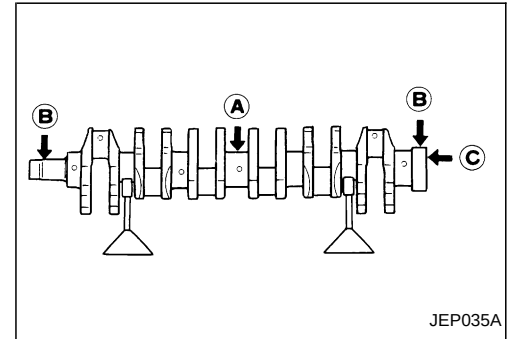


Runout

Support the No. 2 and No. 6 journals and measure the runout of each part.

Unit: mm (in)

Item	Maintenance standard	Service limit
Journal location (A)	Less than 0.07 (0.0028)	0.10 (0.0039)
Oil seal location (B)	Less than 0.04 (0.0016)	0.10 (0.0039)
Flywheel location (C)	Less than 0.02 (0.0008)	0.10 (0.0039)



MAIN BEARING SHELL

Clearance between main bearing shell and crankshaft journal

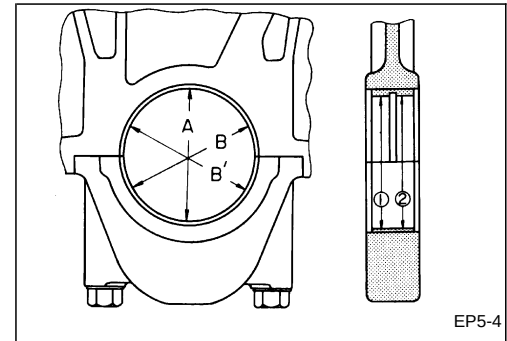
With the main bearing shell assembled to the cylinder block, tighten the main bearing cap to the specified torque and measure the inside diameter of the main bearing shell.

Calculate the clearance between the journal O.D. and main bearing shell I.D. from the measured values.

T : 265 - 294 N·m {27.0 - 30.0 kgf·m, 195 - 217 ft·lbf}

Unit: mm (in)

Maintenance standard	Service limit
0.04 - 0.13 (0.0016 - 0.0051)	0.20 (0.0079)



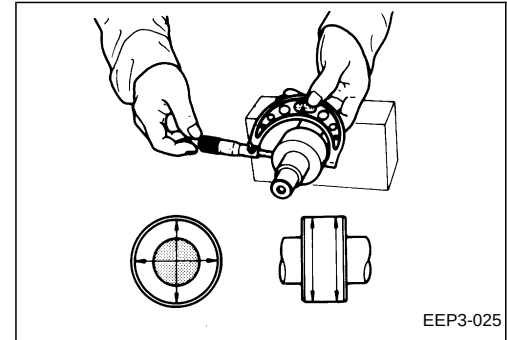
CAMSHAFT

Outside diameter of the journal

Measure the outside diameters of each journal.

Unit: mm (in)

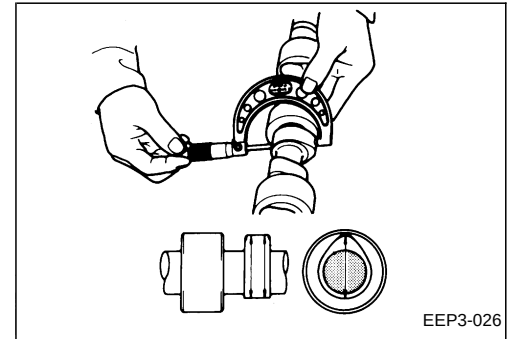
Journal No.	Maintenance standard	Service limit
No. 1	62.72 - 62.74 (2.4693 - 2.4701)	—
No. 2	62.52 - 62.54 (2.4614 - 2.4622)	—
No. 3	62.32 - 62.34 (2.4535 - 2.4543)	—
No. 4	62.13 - 62.14 (2.4461 - 2.4465)	—
No. 5	61.93 - 61.94 (2.4382 - 2.4386)	—



Height of cam profile

Unit: mm (in)

Type	Maintenance standard	Service limit
Intake	53.0275 - 53.0675 (2.0877 - 2.0893)	—
Exhaust	50.505 - 50.545 (1.9884 - 1.9900)	—



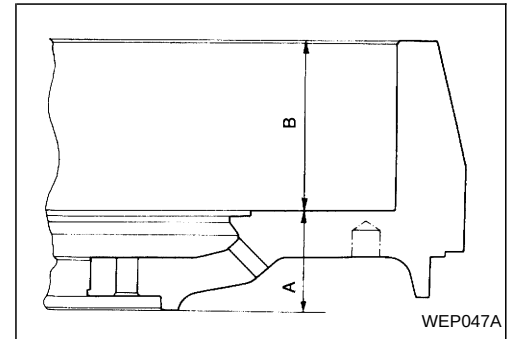
FLYWHEEL

Wear of the clutch disc surface

Replace the flywheel if it has been dressed once and exceeds the specified dimension (Thickness "A"), even though it may not exceed the specified height (Standard depth from flange end face "B").

Unit: mm (in)

Item	Maintenance standard	Service limit
Thickness (A)	53.5 (2.106)	51.5 (2.028)
Standard depth from flange end face (B)	91.4 (3.598)	—



REPAIR AND REPLACEMENT

CYLINDER LINER REPLACEMENT

- Using a cylinder liner tool (99600 96500), remove the faulty cylinder liner and install a new one.

NOTE

- Prior to insertion, be sure to clean the inside wall of the cylinder block and the outer surface of the cylinder thoroughly and lightly apply a coat of engine oil to them.
- After installing the cylinder liner, make sure that the inside diameter, out-of-roundness, taper and flange projection are all within the maintenance standards.

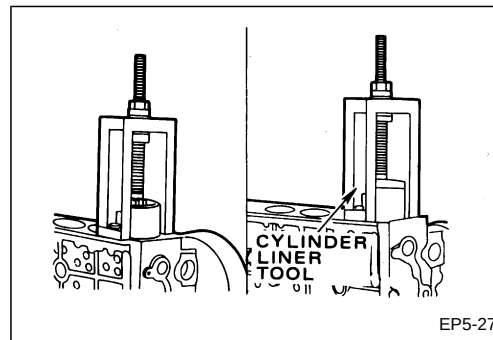
NOTE

- Before measuring these, be sure to tighten the main bearing cap to the specified torque.

T : 265 - 294 N·m {27.0 - 30.0 kgf·m, 195 - 217 ft·lbf}

Unit: mm (in)

Item	Maintenance standard	Service limit	Remarks
Inside diameter	133.00 - 133.03 (5.2362 - 5.2374)	133.25 (5.2461)	Measure at 25, 50, 75, 125, 175 and 245 mm (0.98, 1.97, 2.95, 4.92, 6.89 and 9.65 in) positions from the top surface of the block
Out-of-roundness	Less than 0.02 (0.0008)	—	
Taper	Less than 0.03 (0.0012)	—	
Protrusion of cylinder liner flange above block	0.02 - 0.10 (0.0008 - 0.0039)	—	
Gap between adjoining cylinder	Less than 0.05 (0.0020)	—	Between cylinders #1 and #2, #2 and #3, #4 and #5, #5 and #6



CRANKSHAFT CORRECTION

Pin

Unit: mm (in)

Size identification mark	Grinding dimension of journal	Remarks
S.T.D.	Grinding not necessary	S.T.D.: Standard U.S.: Undersize
0.07 U.S.		
0.25 U.S.	89.64 - 89.66 (3.5291 - 3.5299)	
0.50 U.S.	89.39 - 89.41 (3.5193 - 3.5201)	
0.75 U.S.	89.14 - 89.16 (3.5094 - 3.5102)	
1.00 U.S.	88.89 - 88.91 (3.4996 - 3.5004)	

CRANKSHAFT ACCESSORIES REPLACEMENT

CRANK GEAR

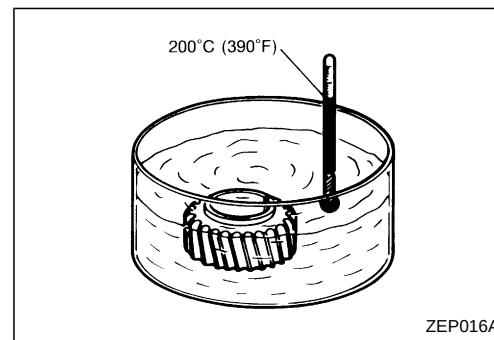
1. Warm the crank gear, then remove it.
2. Warm the crank gear in a bath of oil maintained at approx. 200°C (390°F), and install it onto the crankshaft by aligning its keyway with the straight pin.

WARNING

- Be careful not to touch the crank gear with bare hands because it is hot; otherwise, you may be burned.

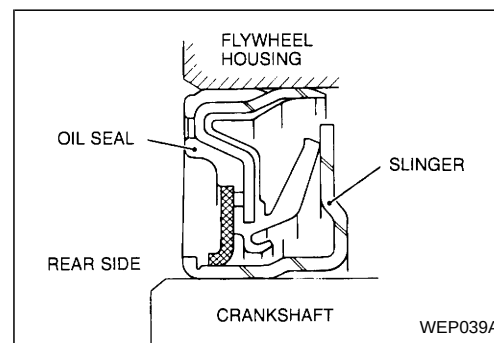
NOTE

- Be sure to install the crank gear with “W” stamped on the end face facing toward the front side.



REAR OIL SEAL (WITH SLINGER)

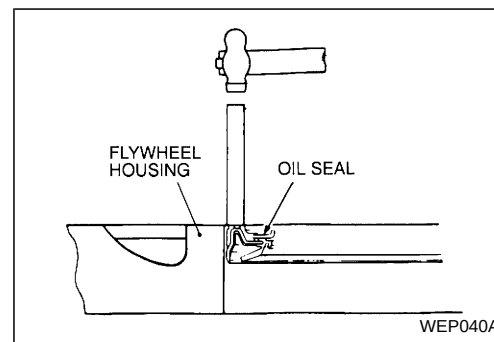
1. Remove the flywheel housing together with the oil seal.



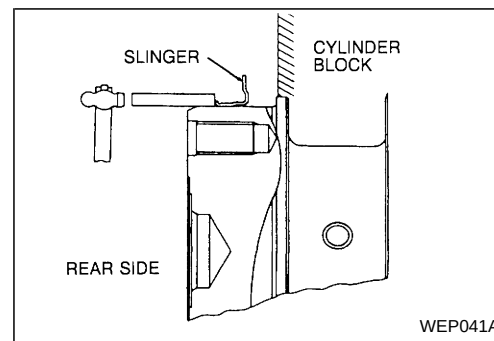
2. Remove the oil seal from the flywheel housing.

NOTE

- Remove foreign matter from the oil seal mounting surface of the flywheel housing and wipe clean.



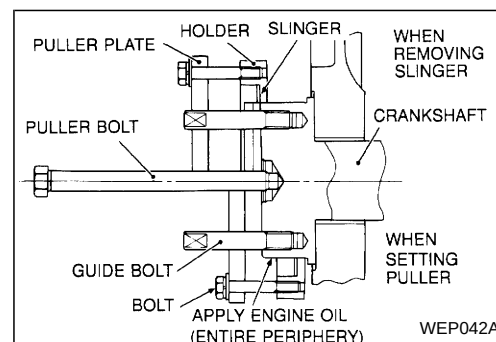
3. Remove the slinger from the crankshaft side. Evenly tap the slinger end face to separate the slinger from the crankshaft which is stuck by sealant. Stop tapping when the slinger begins to move in the axial direction.



4. Remove the slinger using the puller assembly (99690 96002).

NOTE

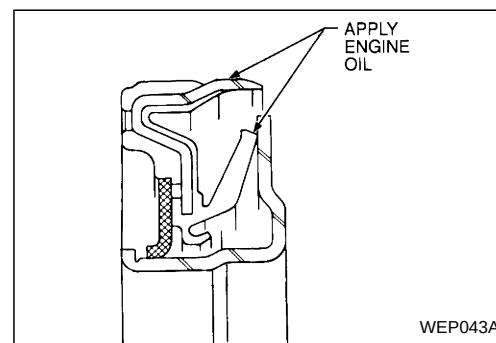
- Before setting the puller assembly to the slinger, apply engine oil to the entire periphery of the rear end of the crankshaft.
- Remove foreign matter such as sealant from the crankshaft and wipe clean.



5. Install the flywheel housing with the gasket in place.

T : 78 - 98 N·m {8.0 - 10.0 kgf·m, 58 - 72 ft·lbf}

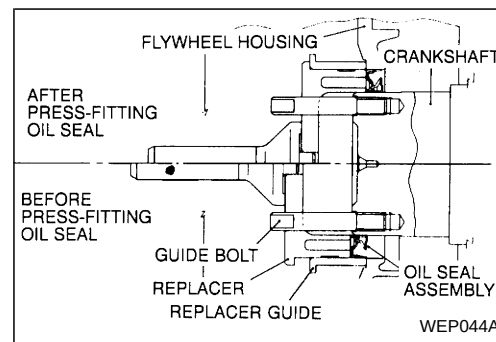
6. Install the oil seal assembly together with the slinger.
- Apply a thin coat of engine oil to the outer periphery of the oil seal and the entire periphery of the oil seal lip (contacting surface with the slinger).



- Apply LOCTITE No. 222 (or equivalent) to the entire periphery of the oil seal (with slinger) installation position on the crankshaft. Press-fit the oil seal assembly (with slinger) to the crankshaft using an oil seal replacer.

NOTE

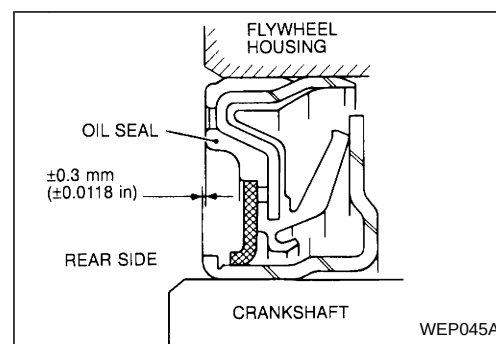
- When driving in the oil seal assembly (with slinger), slowly and lightly drive it in. Do not force it in as this may cause dislocation of the slinger and oil seal, resulting in oil leakage.
- Do not disassemble the oil seal and slinger.



- Using the oil seal replacer (99691 96004), press-fit the oil seal assembly (one unit of the crankshaft and front cover side oil seal) until it is flush with the front cover end face.

NOTE

- Be sure to gradually press-fit the oil seal assembly.
- If the oil seal assembly is press-fitted forcefully, the slinger side and outside seal side may be dislocated causing oil leakage.
- The outside oil seal side should not be separated from the slinger side.



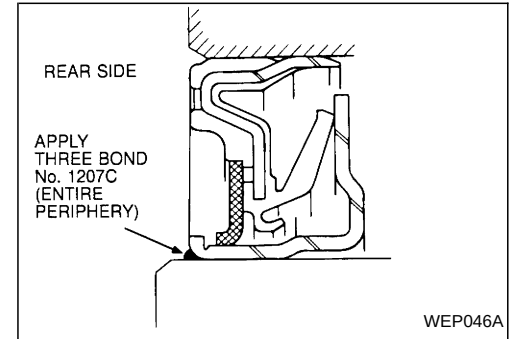
<Without using the special tool>

- After driving in the oil seal, measure the difference in dimension of the slinger end face and oil seal end face.

Difference in dimension of the slinger end face and oil seal end face	± 0.30 mm (± 0.0118 in)
---	----------------------------------

NOTE

- If the measured value is not within specification, adjust the slinger side using the oil seal end face (flush with the housing end face) as a reference.
7. Apply THREE BOND No. 1207C to the entire periphery of the contact surfaces of the crankshaft and slinger.

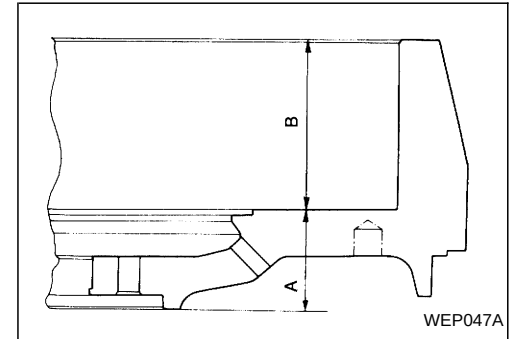


FLYWHEEL CORRECTION

Grind or machine the clutch disc so that the runout of the contacting surface will be within the maintenance standards. However, replace the flywheel with a new one when the runout of the clutch disc contacting surface has exceeded the service limit.

Unit: mm (in)

Item	Maintenance standard	Service limit
Lateral runout of clutch disc surface	Less than 0.10 (0.0039)	0.15 (0.0059)
Thickness (A)	53.5 (2.106)	51.5 (2.028)
Standard depth from flange end face (B)	91.4 (3.598)	—



CYLINDER HEAD AND VALVE MECHANISM

CONTENTS

SERVICE DATA	HV-1-1	CONSTRUCTION	HV-3-1
SERVICE DATA	HV-1-1	INSPECTION	HV-4-1
TIGHTENING TORQUE	HV-1-2	REASSEMBLY	HV-5-1
TOOLS	HV-2-1		

SUPPLEMENTAL OUTLINE

- Addition of service data due to introduction of a new vehicle model.

SERVICE DATA

SERVICE DATA

Unit: mm (in)

Position	Item		Maintenance standard	Service limit	Remarks
Cylinder head	Cylinder head height		110 (4.33)	109.5 (4.311)	Grinding tolerance: 0.5 mm (0.020 in)
	Flatness	Longitudinal direction	Less than 0.05 (0.0020)	0.20 (0.0079)	
		Transverse direction	Less than 0.02 (0.0008)	0.20 (0.0079)	
Valve insert	Seat angle	Intake	30° - 30°15'	—	
		Exhaust	45° - 45°30'	—	
	Contacting width	Intake	2.66 (0.1047)	3.0 (0.118)	
		Exhaust	2.83 (0.1114)	3.0 (0.118)	
Valve	Valve face angle	Intake	30° - 30°15'	—	
		Exhaust	45° - 45°30'	—	
	Outside diameter of valve stem	Intake	11.960 - 11.975 (0.4709 - 0.4715)	—	
		Exhaust	11.925 - 11.940 (0.4695 - 0.4701)	—	
	Valve head thickness	Intake	3.0 (0.118)	—	
		Exhaust	1.9 (0.075)	—	
	Distance between valve and bottom surface of the cylinder head		Intake	-0.214 to +0.314 (-0.0084 to +0.0124)	0.70 (0.0276)
			Exhaust	0.75 - 1.25 (0.0295 - 0.0492)	—
	Valve clearance		Intake	0.30 - 0.40 (0.0118 - 0.0157)	When engine is cold
			Exhaust	0.30 - 0.40 (0.0118 - 0.0157)	
Valve guide	Inside diameter	Intake	12.00 - 12.02 (0.4724 - 0.4732)	12.17 (0.4791)	Dimensions after installed into the cylinder head
		Exhaust	12.00 - 12.02 (0.4724 - 0.4732)	12.16 (0.4787)	
	Valve guide and valve stem clearance	Intake	0.025 - 0.060 (0.0010 - 0.0024)	0.15 (0.0059)	
		Exhaust	0.060 - 0.095 (0.0024 - 0.0037)	0.15 (0.0059)	
	Projection from top of cylinder head	Intake	21.0 (0.827)	—	
		Exhaust	21.0 (0.827)	—	
Valve spring	Free length	Outer	85.10 (3.3504)	—	Intake and exhaust
		Inner	80.50 (3.1693)	—	
	Tension N {kgf, lbf}	Outer	351.1 - 388.4 {35.8 - 39.6, 78.9 - 87.3}	—	When compressed to 50.7 mm (1.996 in) Intake and exhaust
		Inner	199.1 - 220.7 {20.3 - 22.5, 44.8 - 49.6}	—	When compressed to 49.0 mm (1.929 in) Intake and exhaust
	Squareness		—	2.5 (0.098)	Intake and exhaust Inner and outer
Rocker shaft	Outside diameter		19.99 - 20.00 (0.7870 - 0.7874)	19.90 (0.7835)	
	Runout		Less than 0.03 (0.0012)	0.05 (0.0020)	
	Inside diameter of valve rocker bushing		20.02 - 20.04 (0.7882 - 0.7890)	20.10 (0.7913)	
	Clearance between rocker shaft and valve rocker bushing		0.02 - 0.05 (0.0008 - 0.0020)	0.20 (0.0079)	
	Free length of inside spring		80.0 (3.150)	—	
	Tension of inside spring N {kgf, lbf}		19.6 - 29.4 {2.0 - 3.0, 4.4 - 6.6}	16.7 {1.7, 3.7}	When compressed to 57.0 mm (2.244 in)

SERVICE DATA

Unit: mm (in)

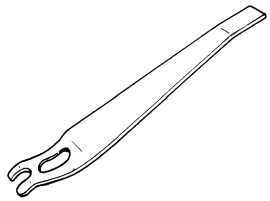
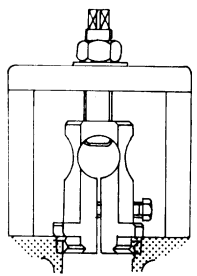
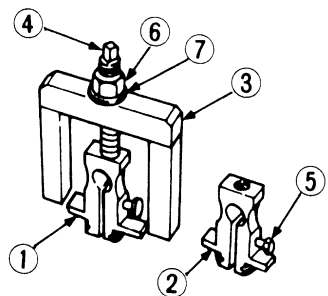
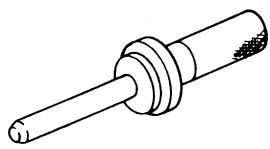
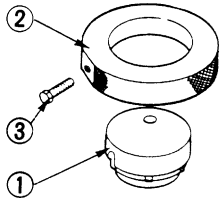
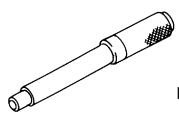
Position	Item	Maintenance standard	Service limit	Remarks
Push rod	Length	236.73 (9.3201)		
	Deviation	Less than 0.3 (0.012)	0.5 (0.020)	
Cam follower	Outside diameter	23.945 - 23.965 (0.9427 - 0.9435)	23.85 (0.9390)	
	Clearance between cam follower and hole	0.03 - 0.08 (0.0012 - 0.0031)	0.20 (0.0079)	
Others	Valve clearance adjusting sequence			
	Cylinder No.	1	2	3
		4	5	6
	Valve arrangement	1	2	3
		4	5	6
		IN	EX	IN
	No. 1 piston at TDC on compression stroke	•	•	•
	No. 6 piston at TDC on compression stroke	•	•	•

TIGHTENING TORQUE

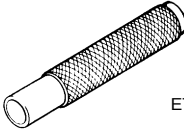
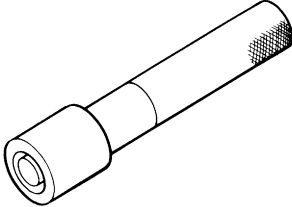
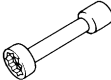
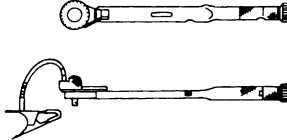
Unit: N·m {kgf·m, ft·lbf}

Item			Tightening torque
Cylinder head bolt	Snug torque (1st)		88 - 98 {9.0 - 10.0, 65 - 72}
	Tightening angle (2nd)	L = 147 mm (5.79 in)	85° - 95°
		L = 119 mm (4.69 in)	70° - 80°
Cylinder head sub bolt		1st	34 {3.5, 25}
		2nd	44 - 54 {4.5 - 5.5, 33 - 40}
Rocker shaft mounting bolt			34 - 49 {3.5 - 5.0, 25 - 36}
Exhaust manifold mounting nut			29 - 44 {3.0 - 4.5, 22 - 33}
Air intake manifold mounting nut			49 - 54 {5.0 - 5.5, 36 - 40}
Nozzle holder assembly mounting bolt			25 - 34 {2.5 - 3.5, 18 - 25}
Injection tube		Pump side	29 - 39 {3.0 - 4.0, 22 - 29}
		Nozzle side	25 - 34 {2.5 - 3.5, 18 - 25}
Spill tube mounting bolt			10 - 18 {1.0 - 1.8, 7.2 - 13.0}
Turbocharger mounting nut			34 - 44 {3.5 - 4.5, 25 - 33}
Rocker arm adjusting screw lock nut			34 - 44 {3.5 - 4.5, 25 - 33}
Rocker shaft stopper bolt			8 - 13 {0.8 - 1.3, 5.8 - 9.4}

TOOLS

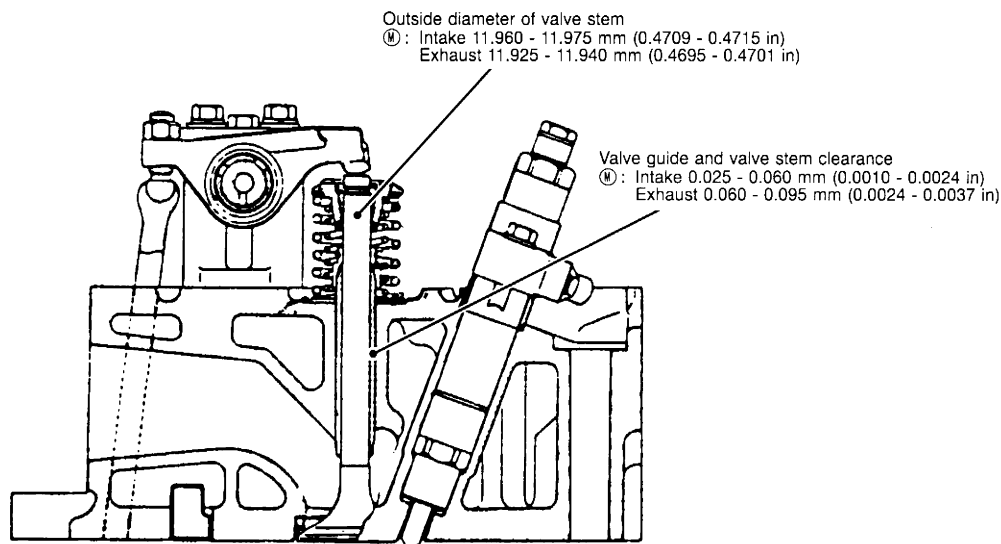
Tool name and number	Description	Shape
Split collar tool 99624 Z5001	Used to remove and install the split collar. 	 ET14044A ET14043A
Valve insert puller assembly 99660 96003 ① 99669 96009 ② 99669 96008 ③ 99668 95000 ④ 99532 95000 ⑤ 99531 Z6000 ⑥ 89-11246-1A ⑦ 89-15446-1A	For removal of valve insert ① Puller (for exhaust) ② Puller (for inlet) ③ Bridge ④ Puller bolt ⑤ Bolt (M8 x 1.25) ⑥ Nut (M16 x 1.5) ⑦ Plain washer 	 ETL1-022
Valve insert replacer 99665 96002	For installation of valve insert (cold fitting) (Intake)	 ETL1023A
Valve insert replacer 99665 96003	For installation of valve insert (cold fitting) (Exhaust)	
Caulking tool assembly 99670 96002 ① 99675 96002 ② 99676 96001 ③ 81-20616-1A	Used to caulk after the exhaust valve insert has been fitted to the cylinder head. ① Caulking tool ② Guide ③ Bolt 	ETL14-033
Valve guide remover 99667 96000	For removal of valve guide (Both intake and exhaust)	 ETL2-004

TOOLS

Tool name and number	Description	Shape
Reamer 99662 96000	For finishing of valve guide inside diameter (Both intake and exhaust)	 ER14-150
Stem seal replacer 99674 97013	Used to install the valve stem seal into the valve guide.	 ET14031B
Valve guide replacer 99666 96002	For installation of valve guide (Both intake and exhaust)	 ER14-114
Cylinder head bolt socket wrench 99664 96000	For removal, installation and retightening of cylinder head bolts	 ETL2-005
Angle wrench 1800 WQL	Used for tightening cylinder head bolts (preset torque, tighten- ing angle)	 EHV003A

CONSTRUCTION

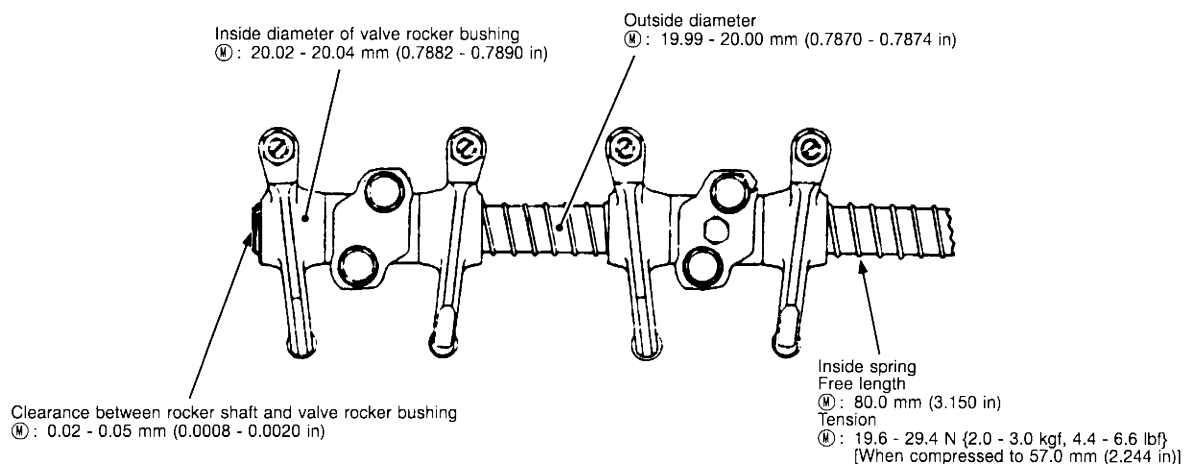
CYLINDER HEAD ASSEMBLY



(M) : Maintenance standard

WHV035A

ROCKER SHAFT ASSEMBLY



(M) : Maintenance standard

WHV036A

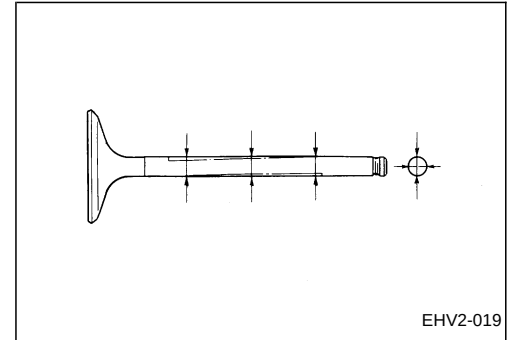
INSPECTION

VALVE

Outside diameter of valve stem

Unit: mm (in)

Item	Maintenance standard	Service limit
Intake	11.960 - 11.975 (0.4709 - 0.4715)	—
Exhaust	11.925 - 11.940 (0.4695 - 0.4701)	—

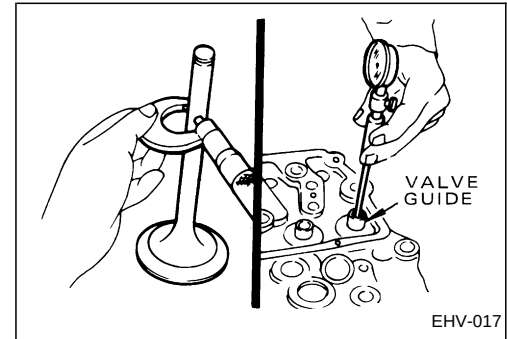


VALVE GUIDE

Valve guide and valve stem clearance

Unit: mm (in)

Item	Maintenance standard	Service limit
Intake	0.025 - 0.060 (0.0010 - 0.0024)	0.15 (0.0059)
Exhaust	0.060 - 0.095 (0.0024 - 0.0037)	0.15 (0.0059)



ROCKER SHAFT

Clearance between rocker shaft and valve rocker bushing

Unit: mm (in)

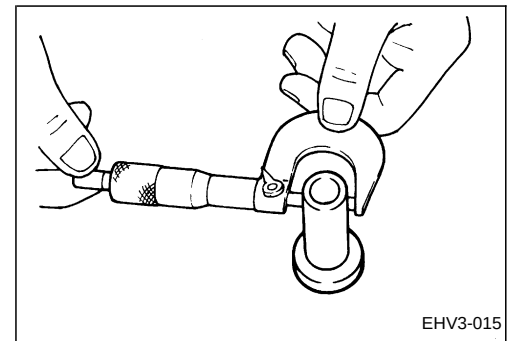
Maintenance standard	Service limit
0.02 - 0.05 (0.0008 - 0.0020)	0.20 (0.0079)

CAM FOLLOWER

Outside diameter

Unit: mm (in)

Maintenance standard	Service limit
23.945 - 23.965 (0.9427 - 0.9435)	23.85 (0.9390)



REASSEMBLY

CYLINDER HEAD

Key points of reassembly

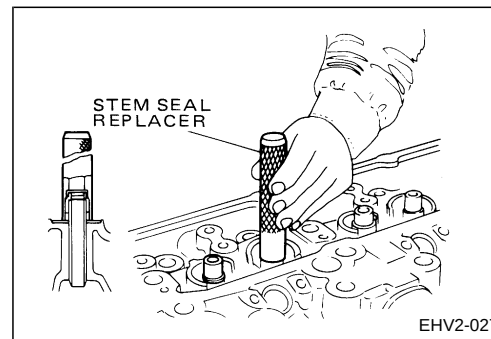
- Before reassembling, be sure to apply engine oil to each sliding surface.

⑤ Valve stem seal

1. Install the lower spring seat.
2. Using a special valve stem seal replacer (99674 97013), install the stem seal to the valve guide.

NOTE

- Be sure to push in the stem seal by hand.

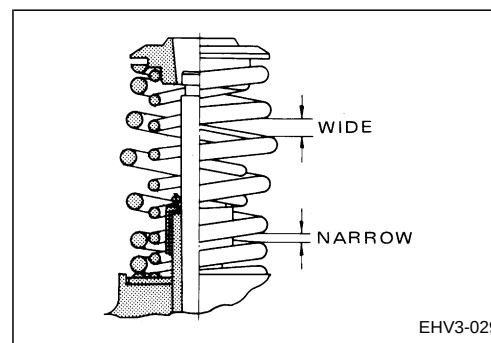


④ Outer valve spring, ③ Inner valve spring

Install the inner and outer valve springs and upper spring seat.

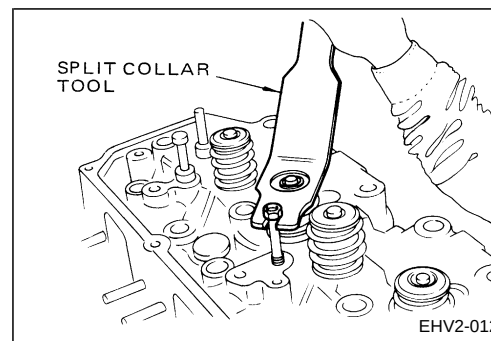
NOTE

- When installing the inner and outer springs, be sure to install them so that the side which has a smaller spring winding pitch (i.e. the side painted in green) faces the lower spring seat side.



① Split collar

1. Using a split collar tool (99624 Z5001), install the split collar.



2. Measure the distance between the valve and the bottom surface of the cylinder head and check to make sure that it does not exceed the maintenance standard.

Unit: mm (in)

Item		Maintenance standard	Service limit
Distance between the valve and bottom surface of the cylinder head	Intake	-0.214 to +0.314 (-0.0084 to +0.0124)	0.70 (0.0276)
	Exhaust	0.75 - 1.25 (0.0295 - 0.0492)	—

LUBRICATION SYSTEM

CONTENTS

SERVICE DATA	LB-1-1	CONSTRUCTION	LB-2-1
SPECIFICATIONS	LB-1-1	DISASSEMBLY	LB-2-2
SERVICE DATA	LB-1-2	INSPECTION	LB-2-3
TIGHTENING TORQUE	LB-1-3	OIL FILTER	LB-3-1
LUBRICATION SYSTEM	LB-1-4	CONSTRUCTION	LB-3-1
OIL PUMP	LB-2-1	INSPECTION	LB-3-2

SUPPLEMENTAL OUTLINE

- The tightening torque of the oil pan mounting bolt has been changed.
- The oil pump and oil filter have been changed.

SERVICE DATA

SPECIFICATIONS

Lubrication system			Forced-circulation type	
Oil pump	Type		Gear pump	
	Discharge amount ℓ (Imp gal)/rpm		174 (38-1/4)/2,300	
	Relief valve opening pressure kPa {kgf/cm ² , psi}		1,177 {12.0, 171}	
Oil filter	Type	Full-flow	Paper element type	
		By-pass	Paper element type	
	Replacement method		Disassembling type	
	Short valve opening pressure kPa {kgf/cm ² , psi}		98 - 137 {1.0 - 1.4, 14 - 20}	
Oil cooler	Type		Water cooled flat tube type	
	Number of cores		5	
Regulator valve opening pressure kPa {kgf/cm ² , psi}			392 - 432 {4.0 - 4.4, 57 - 63}	
Lubrication oil capacity ℓ (Imp gal)	System total capacity (With oil filter)		29 (6-3/8)	
	Oil pan	H-level	21 (4-5/8)	
		L-level	14 (3-1/8)	

SERVICE DATA

Unit: mm (in)

Item		Maintenance standard	Service limit	Remarks
Oil pump	Side clearance (Clearance between side faces of gear and case)	0.05 - 0.11 (0.0020 - 0.0043)	0.15 (0.0059)	
	Tip clearance (Clearance between tooth crest and case)	0.07 - 0.19 (0.0028 - 0.0075)	—	
	Idler gear and head gear backlash	0.085 - 0.215 (0.0033 - 0.0085)	0.50 (0.0197)	
	Clearance between spindle and idler gear bushing	0.01 - 0.04 (0.0004 - 0.0016)	0.20 (0.0079)	
	Relief valve	Valve opening pressure kPa {kgf/cm ² , psi}	1,079 - 1,275 {11.0 - 13.0, 156 - 185}	—
		Spring free length	50.2 (1.976)	—
		Spring tension N {kgf, lbf}	352.1 - 410.9 {35.9 - 41.9, 79.2 - 92.4}	— When compressed to 44.0 mm (1.732 in)
Oil cooler	Side clearance between idler gear and spindle	0.10 - 0.27 (0.0039 - 0.0106)	0.50 (0.0197)	
	Short valve opening pressure kPa {kgf/cm ² , psi}	304 - 343 {3.1 - 3.5, 44 - 50}	—	
	Water pressure test on the element kPa {kgf/cm ² , psi}	981 {10, 142}	—	
Oil filter	Short valve	Valve opening pressure kPa {kgf/cm ² , psi}	98 - 137 {1.0 - 1.4, 14 - 20}	—
		Spring free length	74.5 (2.933)	—
		Spring tension N {kgf, lbf}	39.2 {4.0, 8.8}	— When compressed to 40.0 mm (1.575 in)
Regulator valve	Valve opening pressure kPa {kgf/cm ² , psi}	392 - 432 {4.0 - 4.4, 57 - 63}	—	
	Spring free length	44.4 (1.748)	—	
	Spring tension N {kgf, lbf}	62.8 {6.4, 14.1}	—	When compressed to 37.5 mm (1.476 in)
Oil jet	Valve opening pressure kPa {kgf/cm ² , psi}	177 - 216 {1.8 - 2.2, 26 - 31}	—	

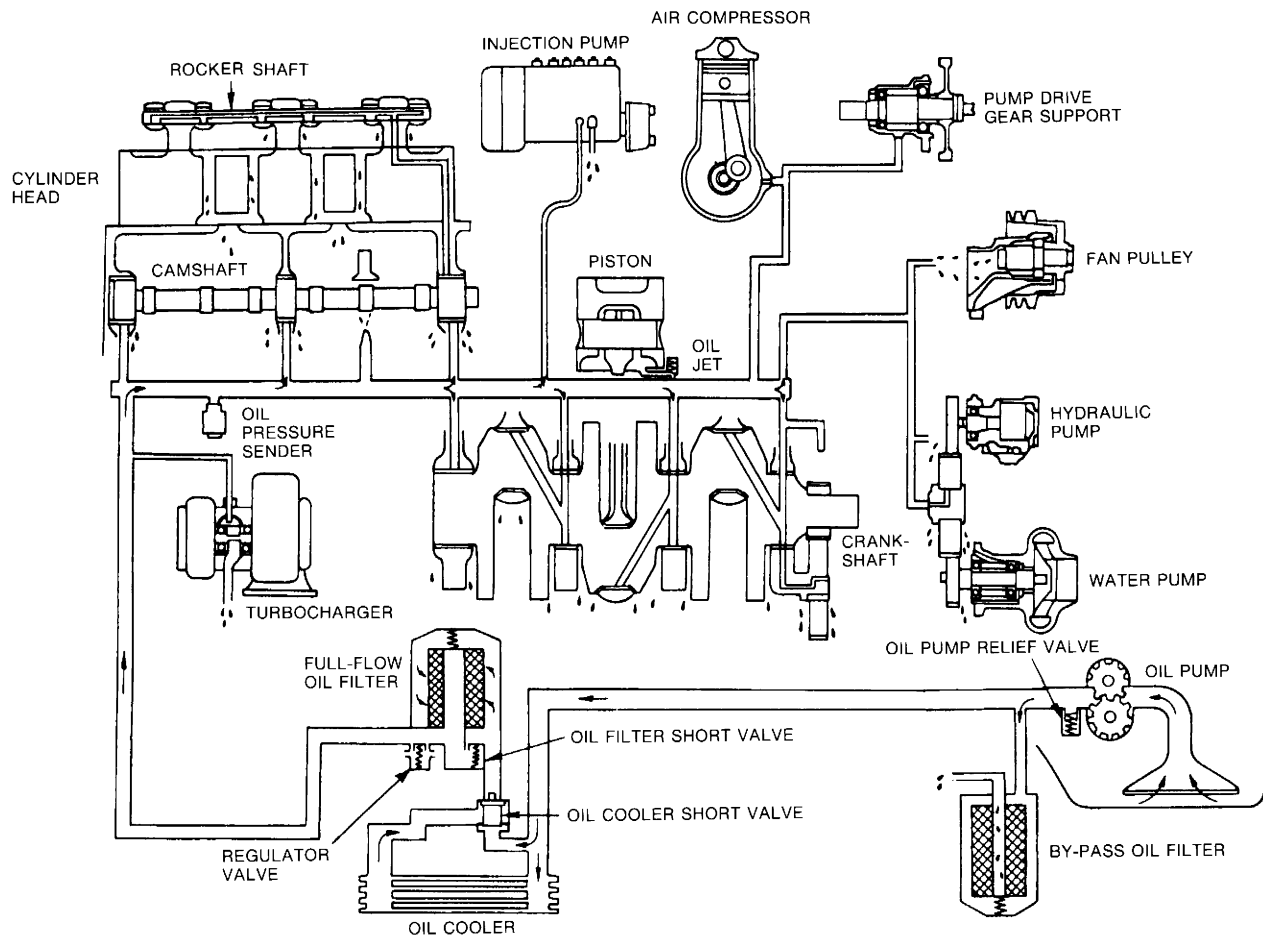
TIGHTENING TORQUE

Unit: N·m {kgf·m, ft·lbf}

Item		Tightening torque
Oil pump mounting bolt		30 - 41 {3.1 - 4.2, 22 - 30}
Oil screen and oil outlet pipe mounting bolt		16 - 21 {1.6 - 2.1, 12 - 15}
Oil pan mounting bolt		21 {2.1, 15}
Oil pan drain plug		98 - 127 {10.0 - 13.0, 72 - 94}
Oil cooler housing mounting bolt and nut	Nut	54 - 93 {5.5 - 9.5, 40 - 69}
	Bolt	29 - 54 {3.0 - 5.5, 22 - 40}
Oil jet connector bolt		29 - 39 {3.0 - 4.0, 22 - 29}
Oil pump	Cover mounting bolt	25 - 39 {2.6 - 4.0, 19 - 29}
	Oil pump idler gear mounting nut	59 - 78 {6.0 - 8.0, 43 - 58}
Oil cooler	Element mounting nut	20 - 29 {2.0 - 3.0, 14 - 22}
Full-flow oil filter	Plug	25 - 34 {2.5 - 3.5, 18 - 25}
	Connector	25 - 34 {2.5 - 3.5, 18 - 25}
	Center bolt	59 - 69 {6.0 - 7.0, 43 - 51}
	Drain plug	16 - 22 {1.6 - 2.2, 12 - 16}
By-pass oil filter	Center bolt	59 - 69 {6.0 - 7.0, 43 - 51}
	Drain plug	16 - 22 {1.6 - 2.2, 12 - 16}

LUBRICATION SYSTEM

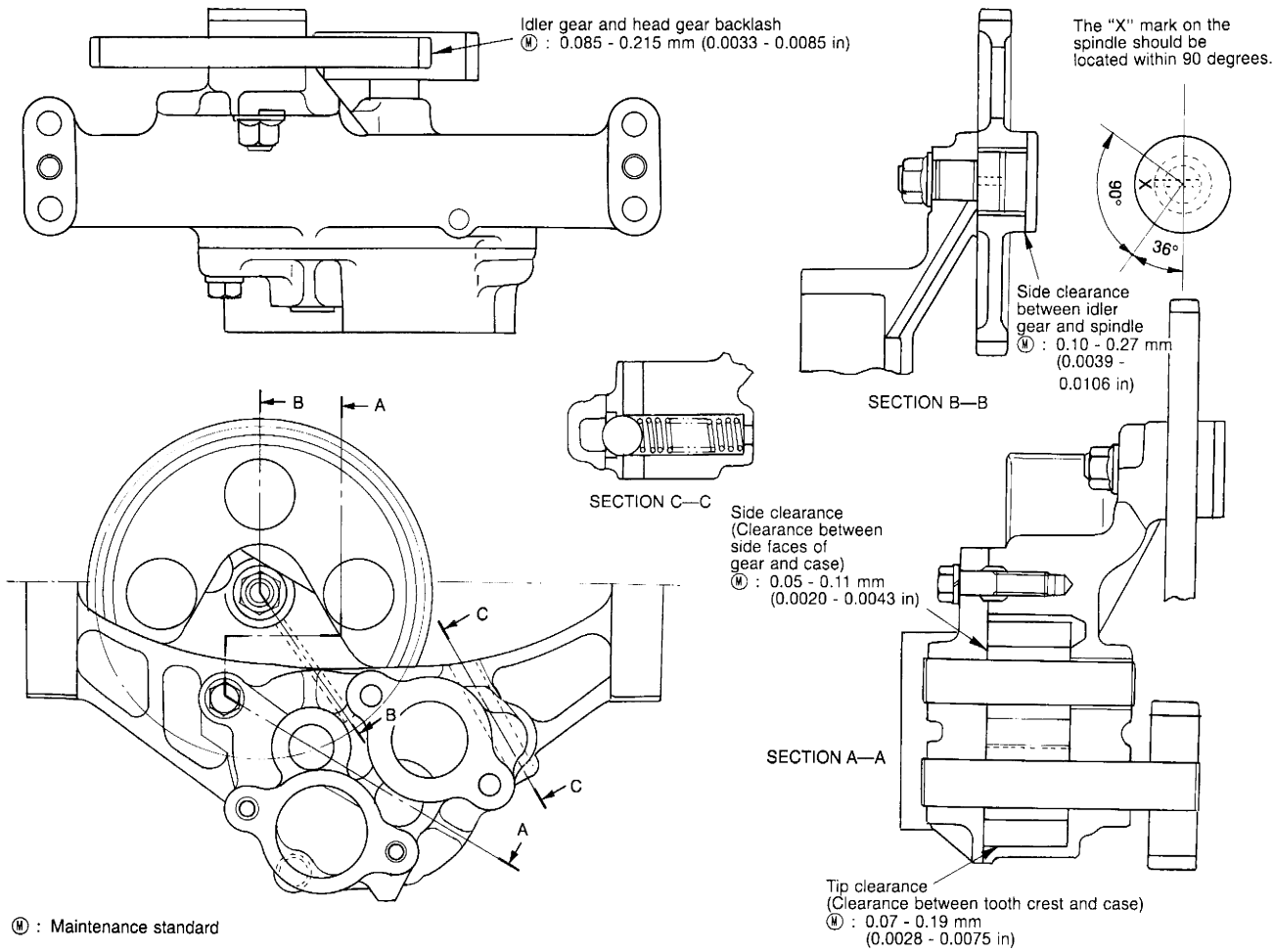
LUBRICATION SYSTEM DIAGRAM



WLB062A

OIL PUMP

CONSTRUCTION

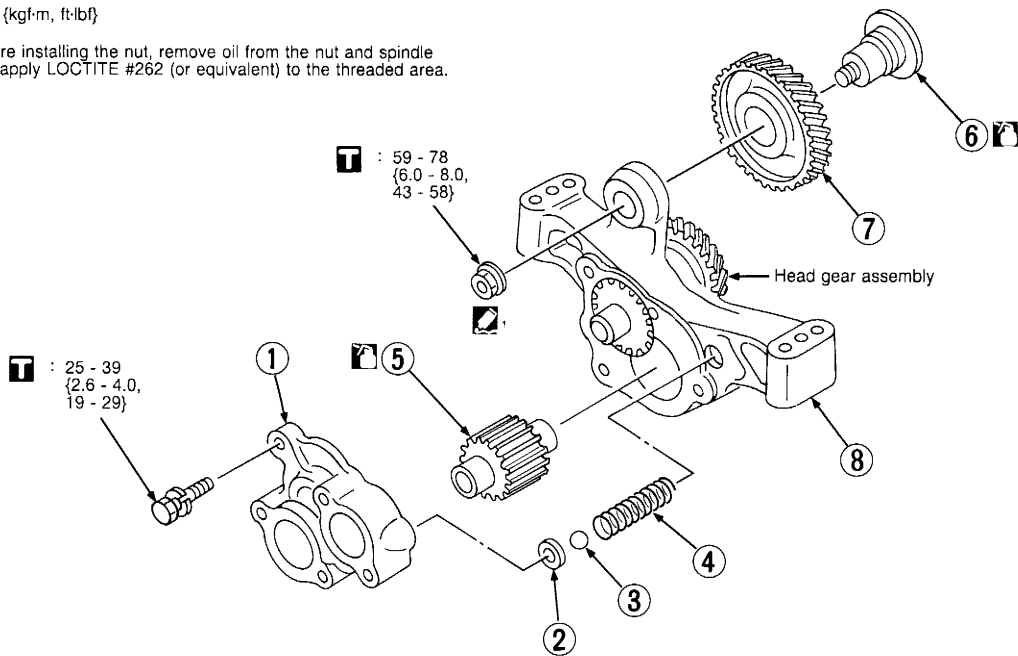


WLB063A

DISASSEMBLY

T : N·m {kgf·m, ft·lbf}

 : Before installing the nut, remove oil from the nut and spindle and apply LOCTITE #262 (or equivalent) to the threaded area.



WLB064A

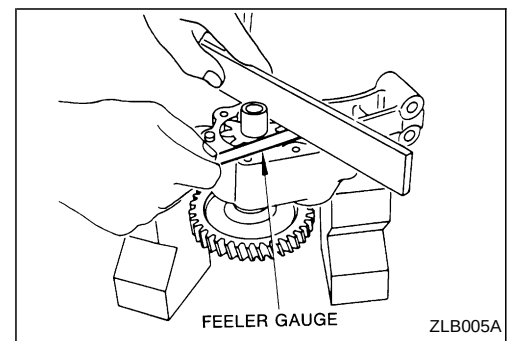
Disassembly sequence (Reassembly sequence is the reverse of disassembly.)

- | | | |
|---------------|------------------------|-----------------------|
| ① Cover | ④ Spring | ⑦ Idler gear assembly |
| ② Spring seat | ⑤ Driven gear assembly | ⑧ Case assembly |
| ③ Steel ball | ⑥ Spindle | |

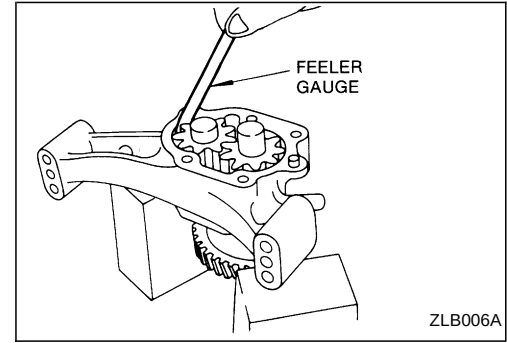
Key points of disassembly

The oil pump drive gear is shrinkage-fitted into the drive shaft, and the idler shaft is pressed into the case. Stop disassembling the oil pump, therefore, after separating the relief valve and idler gear assembly.

- Measure the side clearance between the pump gears (both the drive and idler gears) and the cover and record it.



- Measure the tip clearance between the tips of the pump gears (the drive and idler gears) and the body, and record it.



- Stick a fuse on a tooth surface of the idler gear and rotate the gear. Then calculate the backlash of the pump gear from the squeezed amount of the fuse, and record it.

INSPECTION

- Clean all disassembled parts in cleaning solvent. Check for scratches, cracks or damage and replace faulty parts.
- If measurement indicates that the service limit has exceeded, repair or replace faulty parts.

Clearances and backlash of pump gears

Unit: mm (in)

Item	Maintenance standard	Service limit
Side clearance (Clearance between side faces of gear and case)	0.05 - 0.11 (0.0020 - 0.0043)	0.15 (0.0059)
Tip clearance (Clearance between tooth crest and case)	0.07 - 0.19 (0.0028 - 0.0075)	—
Idler gear and head gear backlash	0.085 - 0.215 (0.0033 - 0.0085)	0.50 (0.0197)

Clearance between spindle and idler gear bushing

Unit: mm (in)

Maintenance standard	Service limit
0.01 - 0.04 (0.0004 - 0.0016)	0.20 (0.0079)

Relief valve spring

Item	Maintenance standard	Service limit	Remarks
Tension N {kgf, lbf}	352.1 - 410.9 {35.9 - 41.9, 79.2 - 92.4}	—	When spring is compressed to 44.0 mm (1.732 in)
Free length mm (in)	50.2 (1.976)	—	

Side clearance between idler gear and spindle

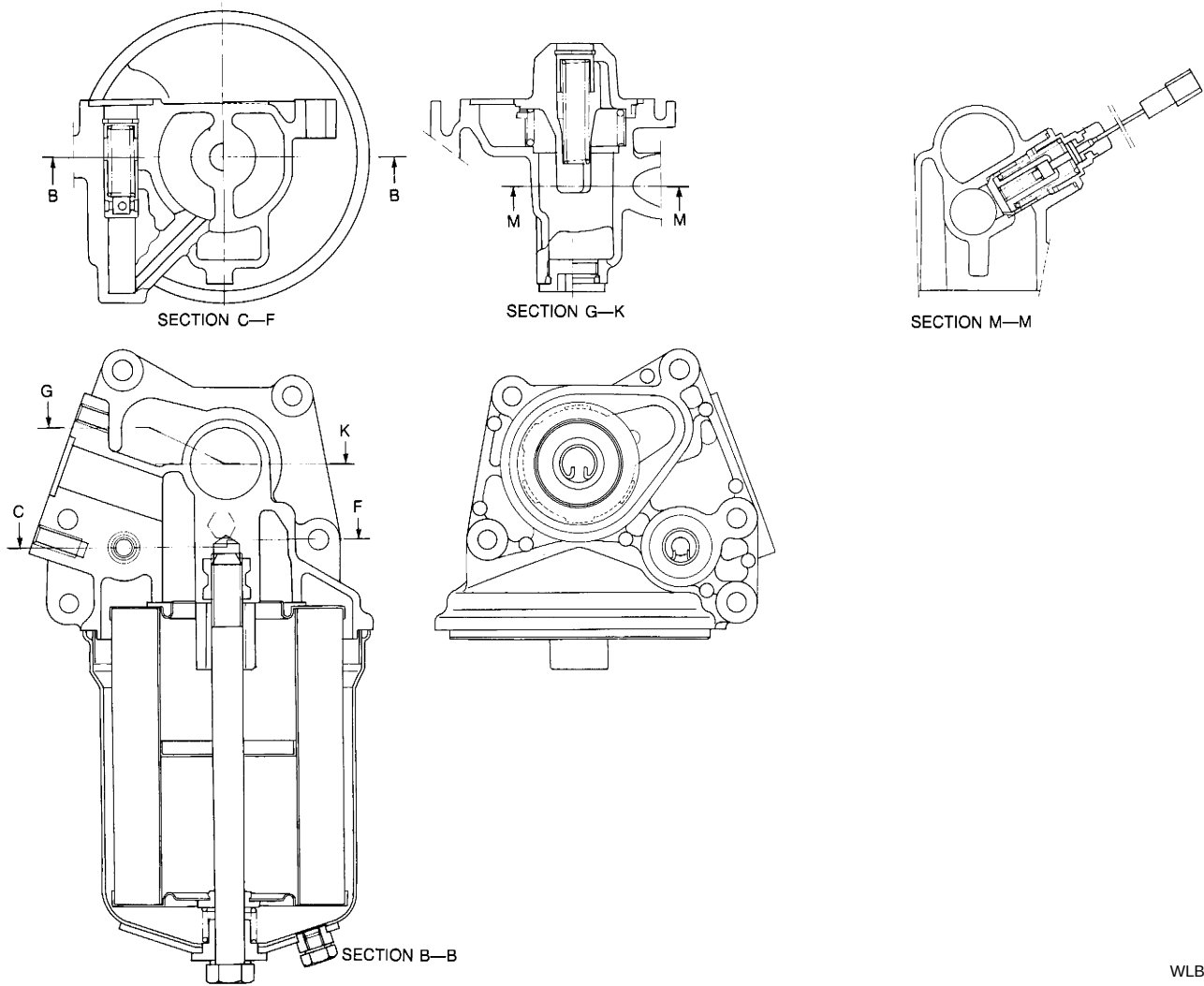
Unit: mm (in)

Maintenance standard	Service limit
0.10 - 0.27 (0.0039 - 0.0106)	0.50 (0.0197)

OIL FILTER

CONSTRUCTION

Full-flow oil filter



WLB065A

INSPECTION

- Clean all disassembled parts in cleaning solvent. Check for scratches, cracks or damage and replace faulty parts.
- If measurement indicates that the service limit has exceeded, repair or replace faulty parts.

Short valve spring

Unit: mm (in)

Item	Maintenance standard	Service limit	Remarks
Free length	74.5 (2.933)	—	
Tension N {kgf, lbf}	39.2 {4.0, 8.8}	—	When compressed to 40.0 mm (1.575 in)

Regulator valve spring

Unit: mm (in)

Item	Maintenance standard	Service limit	Remarks
Free length	44.4 (1.748)	—	
Tension N {kgf, lbf}	62.8 {6.4, 14.1}	—	When compressed to 37.5 mm (1.476 in)

COOLING SYSTEM

CONTENTS

SERVICE DATA	EC-1- 1	TENSION PULLEY	EC-3- 1
SPECIFICATIONS	EC-1- 1	CONSTRUCTION	EC-3- 1
TIGHTENING TORQUE	EC-1- 1	DISASSEMBLY	EC-3- 1
FAN PULLEY BRACKET	EC-2- 1	FAN CLUTCH	EC-4- 1
CONSTRUCTION	EC-2- 1	CONSTRUCTION	EC-4- 1
DISASSEMBLY	EC-2- 1	REMOVAL	EC-4- 2
		INSPECTION	EC-4- 2
		INSTALLATION	EC-4- 2

SERVICE DATA

SPECIFICATIONS

Item		Engine model	PF6TC
Cooling method			Water cooled, forced circulation
Radiator			Corrugated fin
Fan clutch	Linear type		FDL2300-C
	Changeover temperature of fan clutch °C (°F)		60±10 - 75±5 (140±18 - 167±9)
Water pump	Type		Centrifugal
	Drive		Gear drive
Thermostat	Type		Wax pellet
	Valve opening temperature °C (°F) × Number		76.5 (170) × 1
Cooling water capacity		ℓ (Imp gal)	37 (8-1/8)

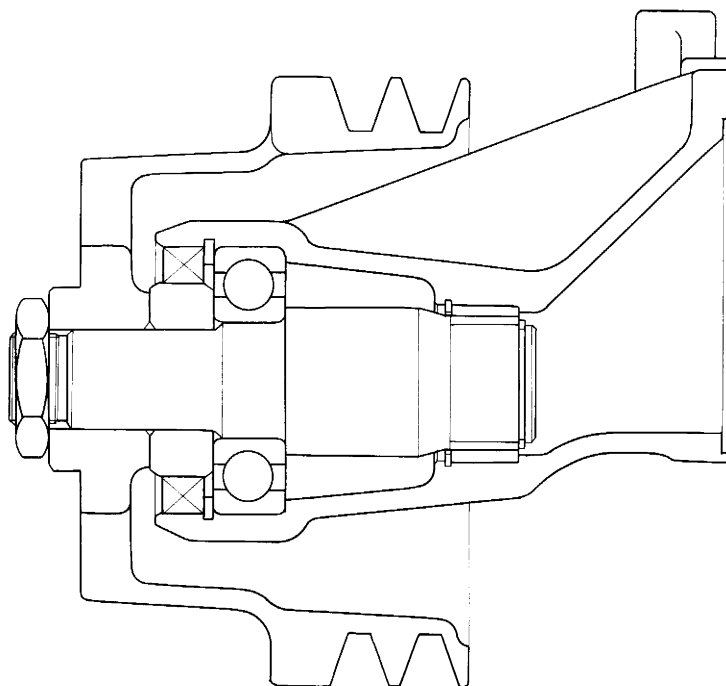
TIGHTENING TORQUE

Unit: N·m {kgf·m, ft·lbf}

Item	Tightening torque
Puller mounting nut	186 - 196 {19.0 - 20.0, 137 - 145}
Tension pulley assembly mounting nut	98 - 118 {10.0 - 12.0, 72 - 87} → Loosen → 98 - 118 {10.0 - 12.0, 72 - 87}
Alternator bracket mounting bolt	98 - 118 {10.0 - 12.0, 72 - 87} → Loosen → 98 - 118 {10.0 - 12.0, 72 - 87}

FAN PULLEY BRACKET

CONSTRUCTION



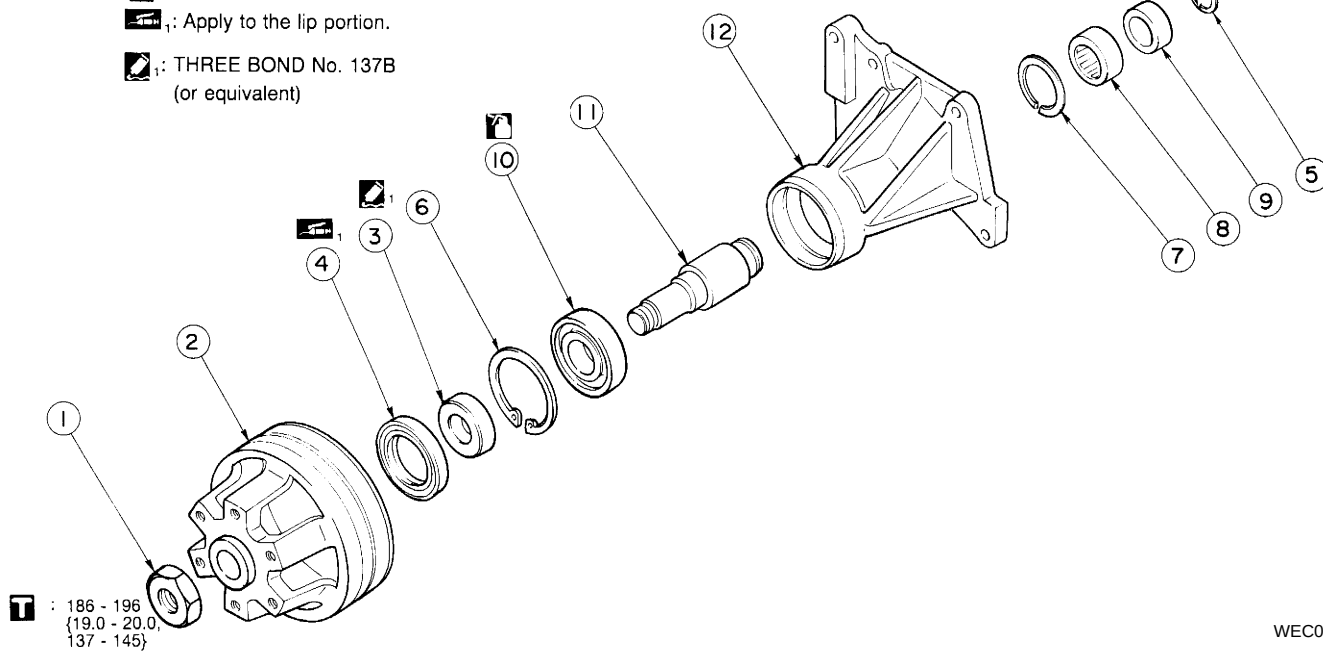
WEC057A

DISASSEMBLY

T : N·m {kgf·m, ft·lbf}

1 : Apply to the lip portion.

1 : THREE BOND No. 137B
(or equivalent)



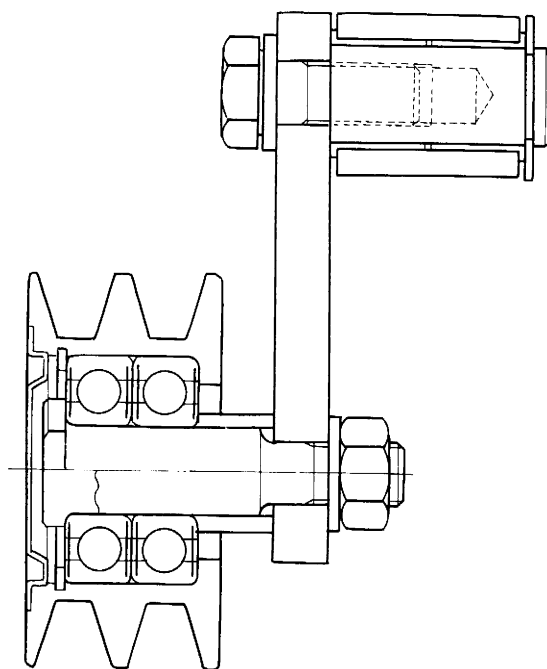
WEC058A

Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

- | | | |
|------------|----------------------|----------------|
| ① Nut | ⑥ Clip | ⑨ Cooler |
| ② Pulley | ⑦ Clip | ⑩ Ball bearing |
| ③ Sleeve | ⑧ Needle bearing | ⑪ Shaft |
| ④ Oil seal | ⑨ - ⑪ Shaft assembly | ⑫ Bracket |
| ⑤ Clip | | |

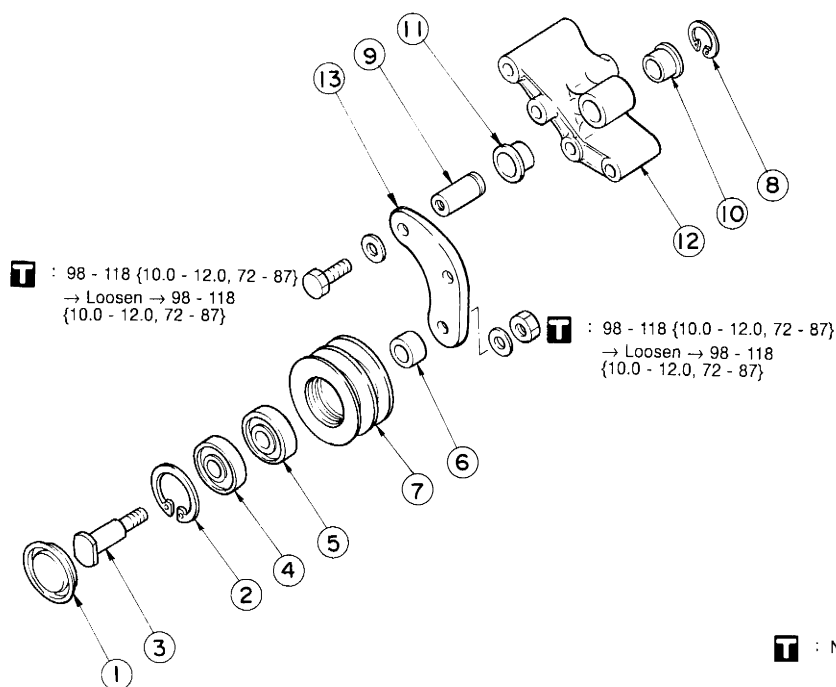
TENSION PULLEY

CONSTRUCTION



WEC059A

DISASSEMBLY



WEC060A

Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

- | | | |
|------------------|------------------|----------------------|
| ① Dust cover | ⑥ Spacer | ⑩ Bushing |
| ② Retaining ring | ⑦ Tension pulley | ⑪ Bushing |
| ③ Tension shaft | ⑧ Retaining ring | ⑫ Alternator bracket |
| ④ Ball bearing | ⑨ Shaft | ⑬ Tension arm |
| ⑤ Ball bearing | | |

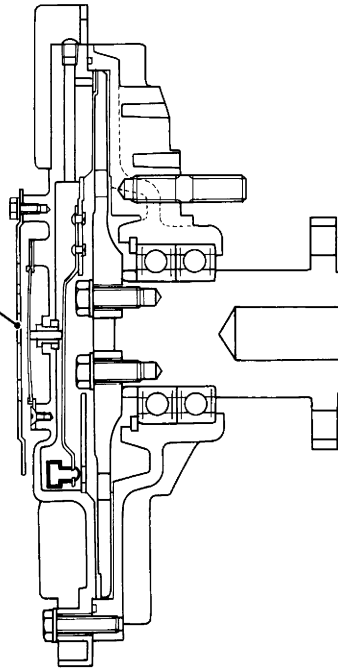
FAN CLUTCH

CONSTRUCTION

LINEAR TYPE

Model: FDL2300-C

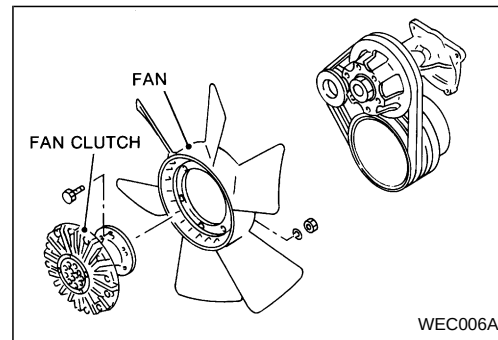
Fan clutch changeover
temperatrue
 $60 \pm 10 - 75 \pm 5^{\circ}\text{C}$
($140 \pm 18 - 167 \pm 9^{\circ}\text{F}$)



WEC005A

REMOVAL

1. Remove the fan and the fan clutch assembly as a unit.
2. Remove the fan from the fan clutch assembly.



INSPECTION

- Clean all disassembled parts in cleaning solvent. Check for scratches, cracks or damage and replace faulty parts.
- If measurement indicates that the service limit has exceeded, repair or replace faulty parts.

NOTE

- Care should be taken lest the bimetal is damaged or deformed during removal and inspection.

Operation temperature check

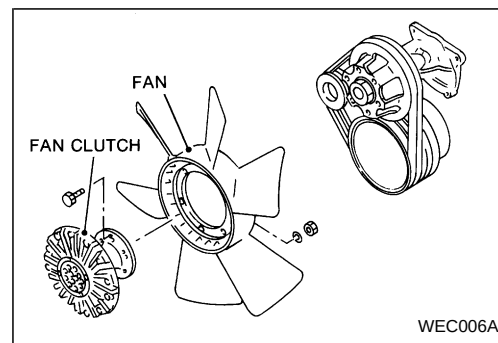
1. Install the fan onto the fan clutch. Then run the fan drive shaft continuously at a constant speed in the range from 2,000 to 3,000 rpm.
2. Install a thermometer and a drier, then blow hot air at the bimetal.
3. Check to make sure that the speed of the fan changes from low to high when the thermometer is indicating the following temperature.

Unit: °C (°F)

Item			Maintenance standard	Service limit
Fan clutch changeover temperature	FDL2300-C	Linear type	60±10 - 75±5 (140±18 - 167±9)	—

INSTALLATION

1. Install the fan onto the fan clutch assembly.
T : 16 - 19 N·m {1.6 - 1.9 kgf·m, 12 - 14 ft·lbf}
2. Install the fan and the fan clutch assembly as a unit.
T : 30 - 36 N·m {3.1 - 3.7 kgf·m, 22 - 27 ft·lbf}



FUEL SYSTEM

CONTENTS

SERVICE DATA	EF-1- 1	NOZZLE AND NOZZLE HOLDER	EF-4- 1
SPECIFICATIONS	EF-1- 1	CONSTRUCTION	EF-4- 1
SERVICE DATA	EF-1- 2	REMOVAL	EF-4- 1
TIGHTENING TORQUE	EF-1- 2	DISASSEMBLY	EF-4- 2
FUEL SYSTEM	EF-1- 3	REASSEMBLY	EF-4- 4
TOOLS	EF-2- 1	ADJUSTMENT	EF-4- 4
INJECTION PUMP ASSEMBLY	EF-3- 1	INSTALLATION	EF-4- 5
INJECTION PUMP PROPER	EF-3- 1	ENGINE CONTROL SYSTEM	EF-5- 1
FEED PUMP	EF-3- 9	CONSTRUCTION	EF-5- 1
TIMER	EF-3-10	ELECTRICAL ENGINE CONTROL	
GOVERNOR	EF-3-12	SYSTEM	EF-6- 1
ACTUATOR HOUSING	EF-3-13		
ADJUSTMENT	EF-3-14		

SUPPLEMENTAL OUTLINE

- Addition of service data, injection pump assembly, nozzle and nozzle holder due to introduction of a new vehicle model.

SERVICE DATA

SPECIFICATIONS

Engine model		PF6TB-21	PF6TB-22	PF6TC
Item				
Ignition system		Compression ignition		
Fuel injection timing (B.T.D.C.)		3°	2°	0°
Ignition order		1-4-2-6-3-5		
Fuel filter	Main	Cartridge type		
	Primary	Center bolt type		
Fuel injection pump	Type	Bosch		
	Plunger diameter mm (in)	12.0 (0.472)		
	Governor	Electrical RED-III type		
	Timer	Centrifugal (Mechanical SDG type)		
Nozzle	Nozzle holder		Flange type	
	Nozzle		Multi-hole type	
	Nozzle hole	Number	6	7
		Diameter mm (in)	0.31 (0.0122) [K4]	0.27 (0.0106) [K6] 0.26 (0.0102) [L2]
	Valve opening pressure kPa {kgf/cm ² , psi}		22,556 {230, 3,271}	
Over flow valve opening pressure kPa {kgf/cm ² , psi}		Injection pump out-let	255 {2.6, 37}	
		Fuel filter	108 - 147 {1.1 - 1.5, 16 - 21}	

SERVICE DATA

SERVICE DATA

	Item	Maintenance standard	Service limit	Remarks
Nozzle	Valve opening pressure kPa {kgf/cm ² , psi}	22,556 {230, 3,271}	—	
	Valve adjusting pressure kPa {kgf/cm ² , psi}	23,046 - 23,831 {235 - 243, 3,342 - 3,455}	—	

TIGHTENING TORQUE

INJECTION PUMP ASSEMBLY

Unit: N·m {kgf·m, ft·lbf}

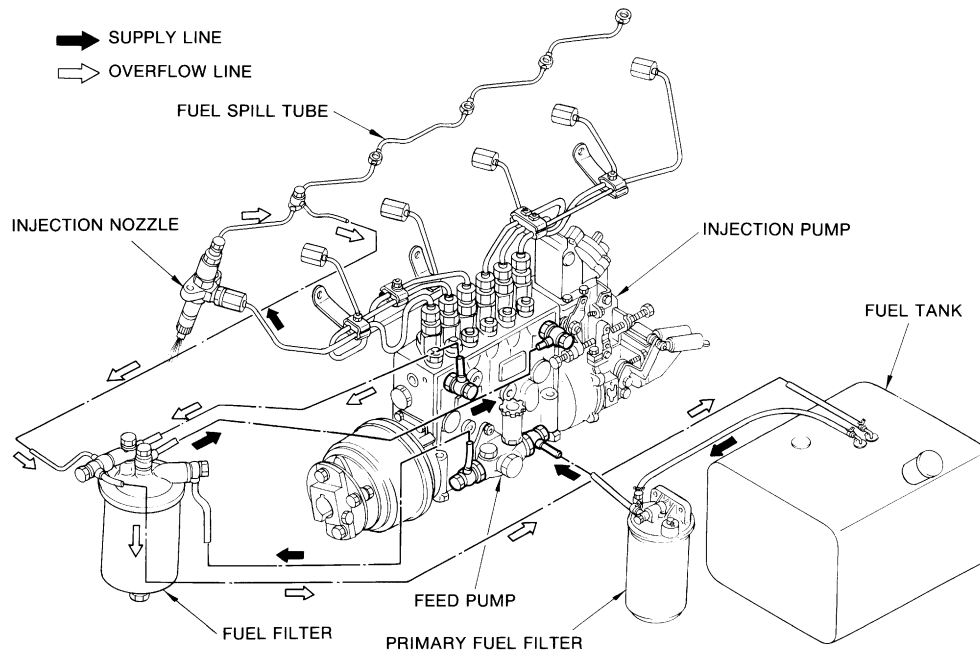
Item		Tightening torque
Injection pump proper	Delivery valve holder	127 - 137 {13.0 - 14.0, 94 - 101}
	Delivery valve holder lock nut	39 - 44 {4.0 - 4.5, 29 - 33}
	Screw bushing	39 - 59 {4.0 - 6.0, 29 - 43}
	Bearing cover setting screw	7 - 9 {0.7 - 0.9, 5.1 - 6.5}
Timer	Timer special nut	83 - 93 {8.5 - 9.5, 61 - 69}
Governor	Governor housing setting screw	6 - 7 {0.6 - 0.7, 4.3 - 5.1}
	Governor cover setting screw	7 - 9 {0.7 - 0.9, 5.1 - 6.5}
	Governor actuator eyebolt	25 - 41 {2.5 - 4.2, 18 - 30}
	Copper plate setting screw	5 - 7 {0.5 - 0.7, 3.6 - 5.1}
	Sensing gear round nut	49 - 59 {5.0 - 6.0, 36 - 43}
	Spring seat setting screw	5 - 7 {0.5 - 0.7, 3.6 - 5.1}

NOZZLE AND NOZZLE HOLDER

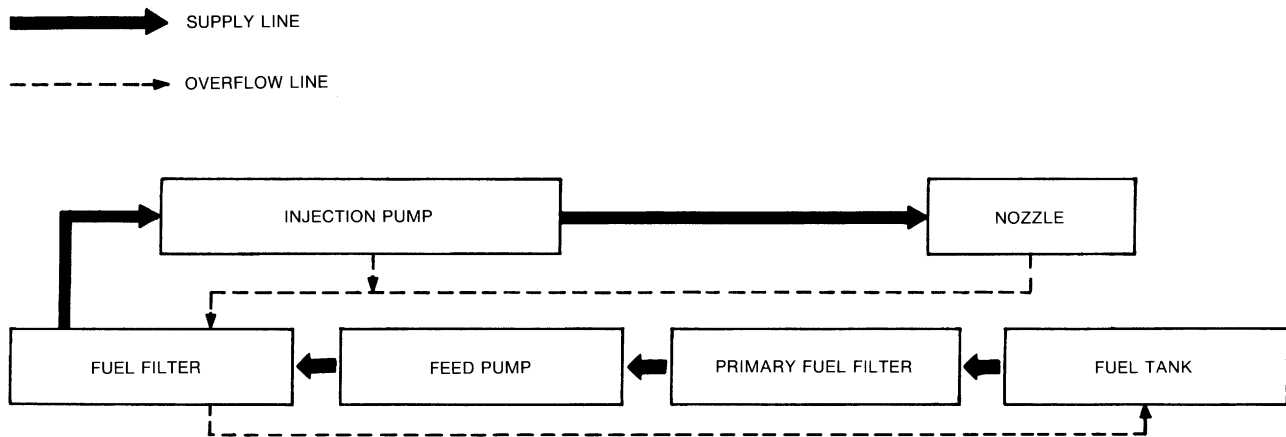
Unit: N·m {kgf·m, ft·lbf}

Item	Tightening torque
Nozzle holder assembly mounting bolt	25 - 34 {2.5 - 3.5, 18 - 25}
Nozzle retaining nut	59 - 78 {6.0 - 8.0, 43 - 58}

FUEL SYSTEM



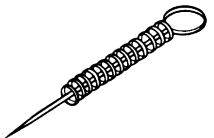
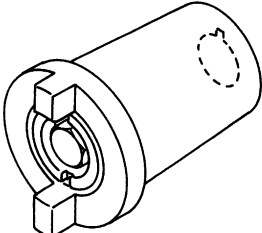
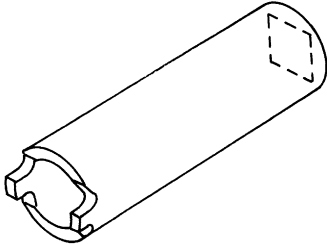
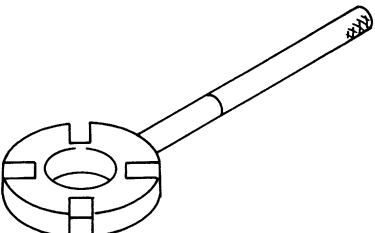
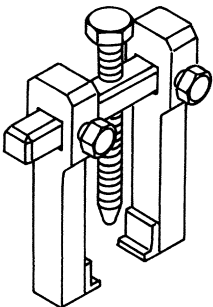
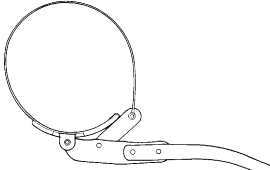
WEF002A



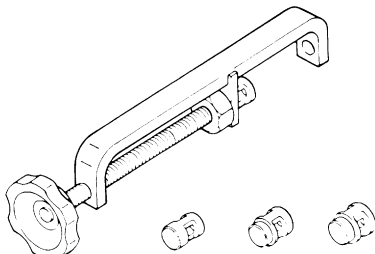
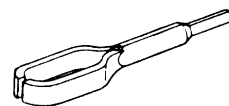
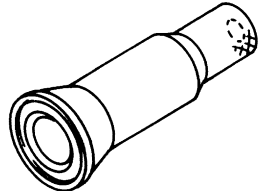
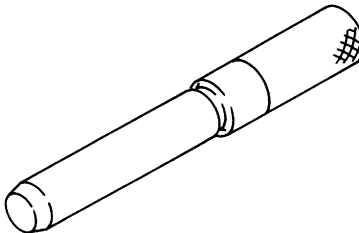
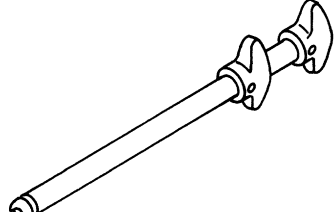
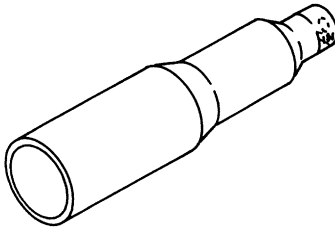
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TOOLS

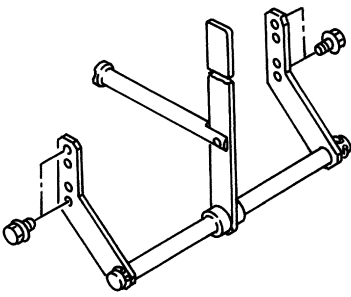
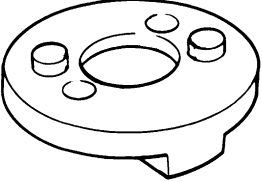
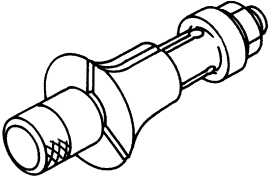
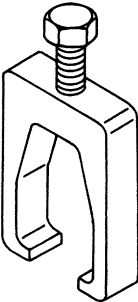
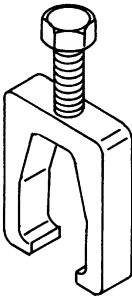
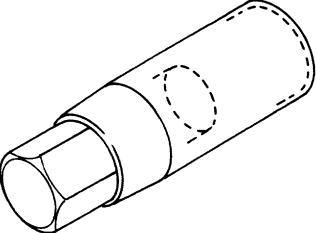
TOOLS

Tool name and number	Description	Shape
Pin vice 99727 Z5005	For cleaning nozzle orifice	 EP14-121
Nozzle cleaner 99726 Z5000	For removal of carbon from rear of nozzle orifice	 EP14-122
● Tool numbers are designated by Zexel Co.		
Coupling 157843-2720	For disassembly/reassembly [shaft dia: 30 mm (1.18 in)]	 ZEF309A
Special wrench 157913-6000	For removing/installing screw bushing (timing rod)	 ZEF443A
Spanner 157916-5420	For preventing coupling rotation	 ZEF310A
Extractor 157920-7720	For removing bearing cover	 ZEF311A
Filter wrench 99756 00Z01	For removal of fuel filter (Only when replacing cartridge type element)	 WMA027A

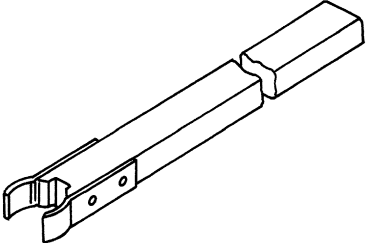
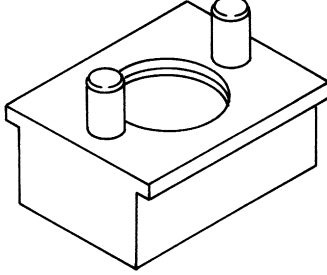
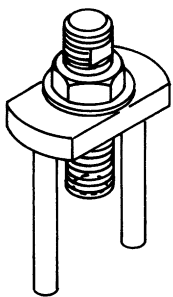
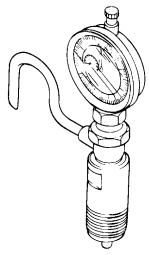
TOOLS

Tool name and number	Description	Shape
Spring compressor 157921-9820	For disassembling and reassembling the flyweight assembly (Timer)	 ETL1-003
Extractor 157921-5620	For inserting plunger	 ER14-181
O-ring guide 157922-3700	For removing/installing plunger barrel O-ring (lower)	 ZEF441A
Plunger guide 157922-3920	For inserting plungers	 ZEF444A
Plunger inserter 157922-4721	For removing/installing plungers	 ZEF438A
O-ring guide 157923-8100	For removing/installing plunger barrel O-ring (upper)	 ZEF442A

TOOLS

Tool name and number	Description	Shape
Tappet inserter 157923-9620	For removing/installing tappets	 ZEF436A
Base 157924-2520	For disassembling and reassembling the timer	 ER14-145
Extractor 157925-0720	For removing bearing's outer race	 ZEF313A
Extractor 157929-0020	For removing bearing's outer race (governor side)	 ZEF315A
Extractor 157929-0220	For removing bearing's inner race (drive side)	 ZEF314A
Oil seal guide 157992-3300	For protecting oil seal lip [dia: 30 mm (1.18 in)]	 ZEF312A

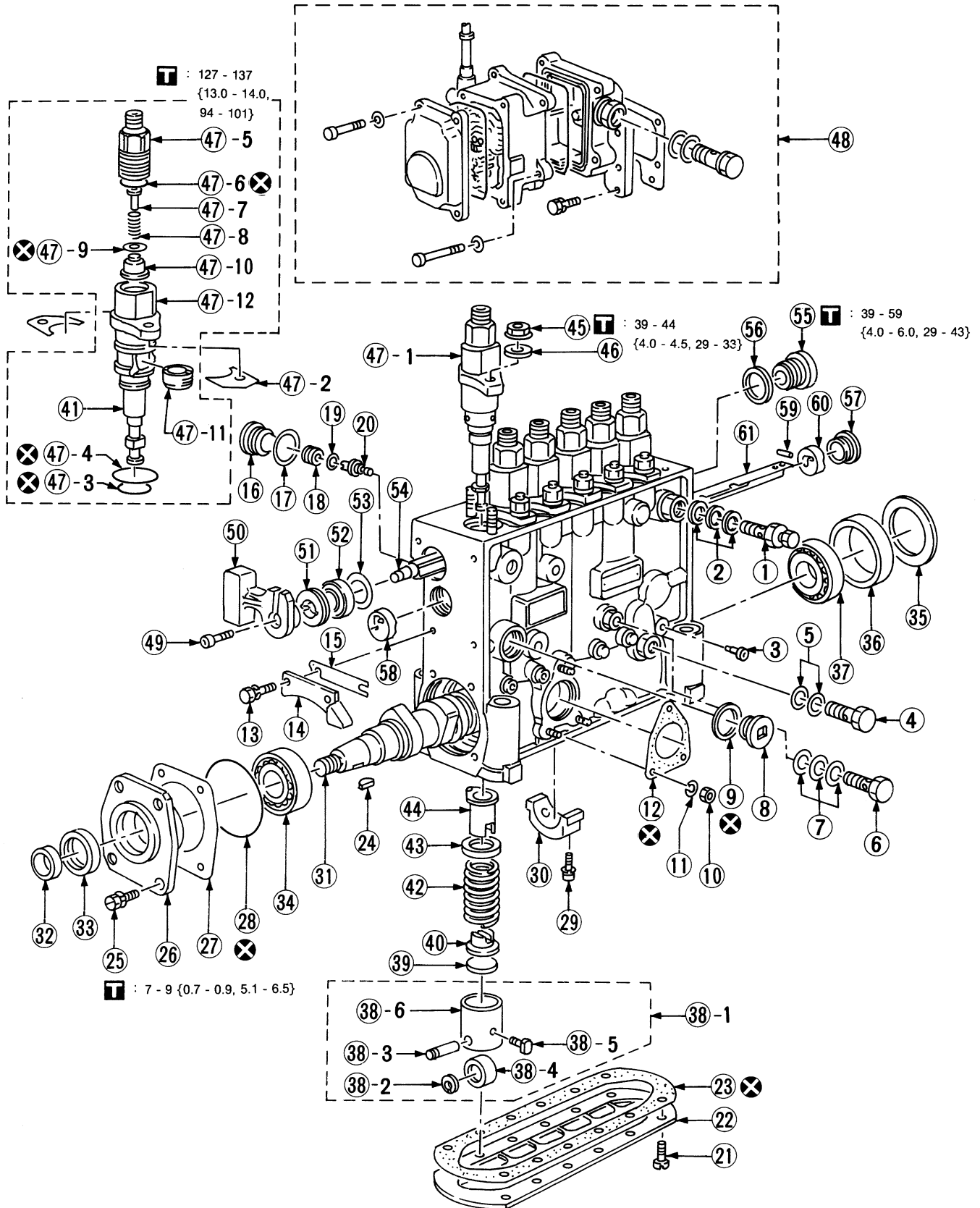
TOOLS

Tool name and number	Description	Shape
Clamp 157931-7620	For inserting tappets	 ZEF437A
Plate 157944-3521	For disassembly of plunger block assembly	 ZEF440A
Extractor 105792-0030	For removing plunger block assembly	 ZEF439A
Measuring device 105782-4371	For plunger pre-stroke	 WEF055A

- MEMO -

INJECTION PUMP ASSEMBLY

INJECTION PUMP PROPER DISASSEMBLY & REASSEMBLY



T : N·m {kgf·m, ft·lbf}

Disassembly sequence (Reassembly sequence is in the reverse of disassembly.)

- | | | |
|------------------|-----------------------|-------------------------------|
| ① Overflow valve | ⑳ Shim | ☆★④⑦-1 Plunger block assembly |
| ② Washer | ㉑ O-ring | ④⑦-2 Plate |
| ③ Plug | ㉒ Bolt | ☆★④⑦-3 O-ring |
| ④ Eyebolt | ㉓ Center bearing | ☆★④⑦-4 O-ring |
| ⑤ Washer | ☆★㉔ Camshaft | ☆④⑦-5 Delivery valve holder |
| ⑥ Eyebolt | ★㉕ Outer race | ④⑦-6 O-ring |
| ⑦ Washer | ☆㉖ Oil seal | ④⑦-7 Stopper |
| ⑧ Plug | ★㉗ Bearing | ④⑦-8 Spring |
| ⑨ Gasket | ㉘ Shim | ④⑦-9 Gasket |
| ⑩ Nut | ㉙ Ring | ④⑦-10 Delivery valve |
| ⑪ Washer | ★㉚ Bearing | ④⑦-11 Timing sleeve |
| ⑫ Gasket | ☆★㉛-1 Tappet assembly | ④⑦-12 Plunger block |
| ⑬ Bolt | ㉜-2 Snap ring | ④⑧ Actuator assembly |
| ⑭ Plate | ㉜-3 Pin | ④⑧ Bolt |
| ⑮ Plate | ㉜-4 Roller | ⑤① Connector |
| ⑯ Plug | ㉜-5 Guide | ⑤① Bushing |
| ⑰ Gasket | ㉜-6 Tappet | ⑤② Bearing |
| ⑱ Lock screw | ㉝ Shim | ⑤③ Washer |
| ⑲ Conical washer | ④① Spring seat | ⑤④ Timing rod |
| ⑳ Eccentric pin | ☆★④① Plunger | ⑤⑤ Screw bushing |
| ㉑ Screw | ☆★④② Spring | ⑤⑥ Washer |
| ㉒ Cover | ④③ Spring seat | ★⑤⑦ Bushing |
| ㉓ Gasket | ★④④ Control sleeve | ⑤⑧ Bushing |
| ㉔ Key | ☆㉕ Nut | ⑤⑨ Pin |
| ㉕ Bolt | ㉖ Washer | ⑥① Bushing |
| ★㉖ Bearing cover | | ⑥② Control rod |

Marks “★” and “☆” indicate that the key points of operation are explained in the text.

DISASSEMBLY

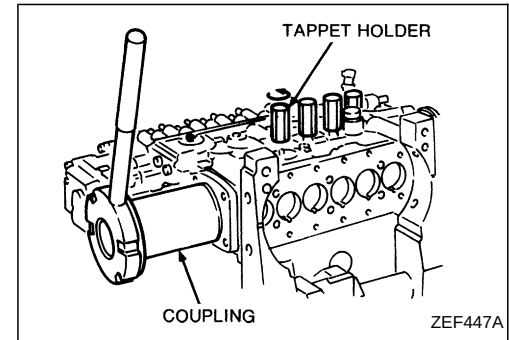
Key point of disassembly

②⑥ Bearing cover ③① Camshaft

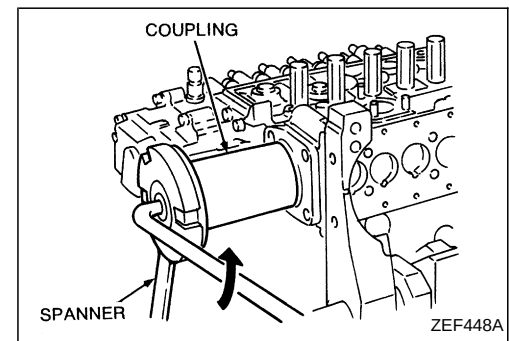
- 1) Rotate the coupling (157843-2720) until the tappets are in the top dead center position and then insert the tappet holders in order from either the drive side or the governor side. Then turn the tappet holders through 180° to separate the tappets from the camshaft.

NOTE

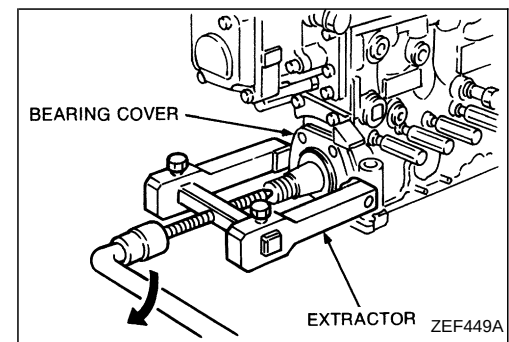
- Insert the end marked “L = 1”.
- If inserted in the injection order, the tappet holders cannot be turned through 180°.



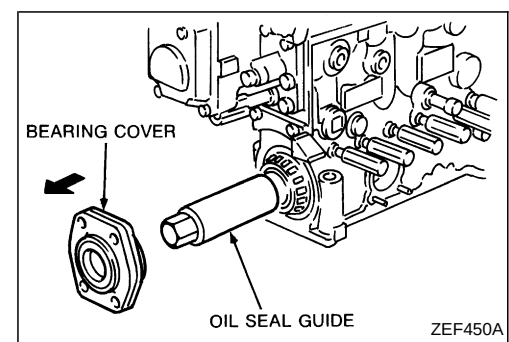
- 2) Remove the coupling using the spanner (157916-5420) to prevent camshaft rotation.



- 3) Loosen the bearing cover using the extractor (157920-7720).

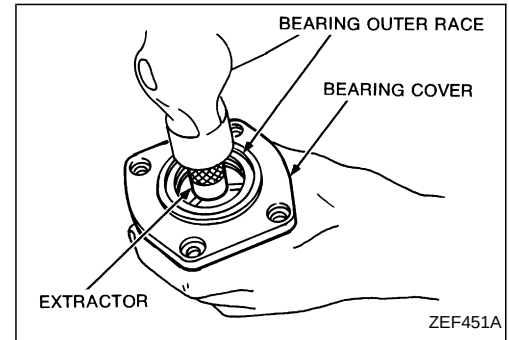


- 4) Attach the oil seal guide (157992-3300) to the end of the camshaft.



③② Outer race

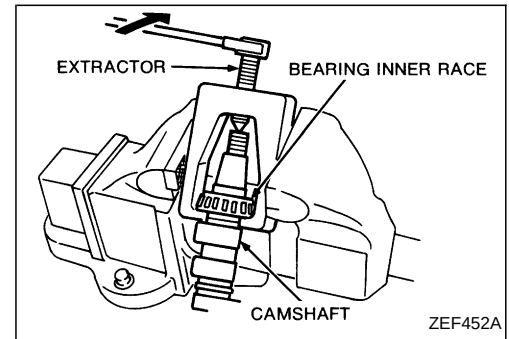
When it is necessary to remove the bearing outer race, use the extractor (157925-0720) to remove it from the bearing cover.



③④, ③⑦ Bearing

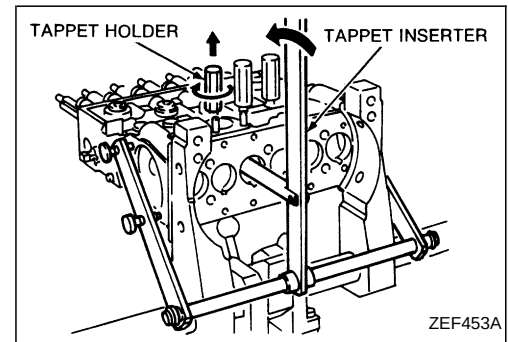
When it is necessary to remove the bearing's inner races, use an extractor to remove them from the camshaft.

Extractor part no.	Remarks
157929-0220	For drive side removal
157929-0020	For governor side removal

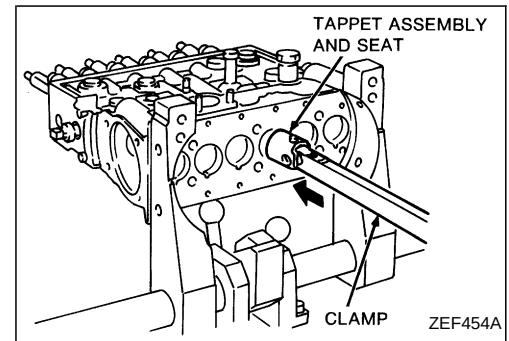


③⑧ Tappet assembly

- 1) Attach the tappet inserter (157923-9620) to the ends of the pump housing.
- 2) Operate the tappet inserter to push the tappets up. Then, remove the tappet holders.



- 3) Remove the tappet assemblies and the seats from the pump housing using the clamp (157931-7620).

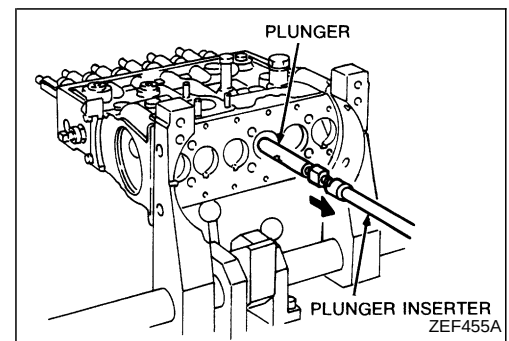


④① Plunger

Remove the plungers from the pump housing using the plunger inserter (157922-4721).

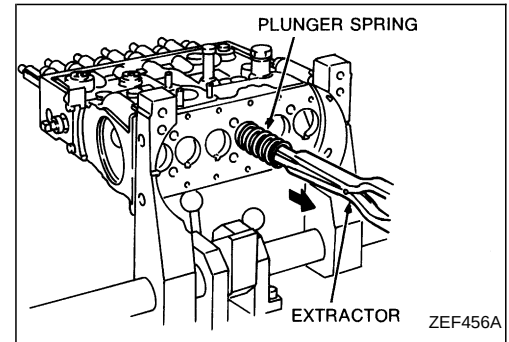
NOTE

- The plungers must not contact the housing.



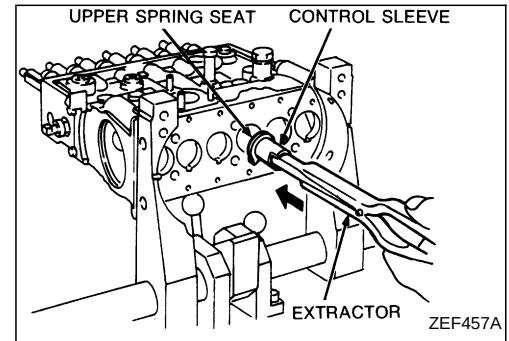
④② Spring

Remove the plunger springs using the extractor (157921-5620).



④④ Control sleeve

Remove the control sleeves and the upper spring seats using an extractor (157921-5620).

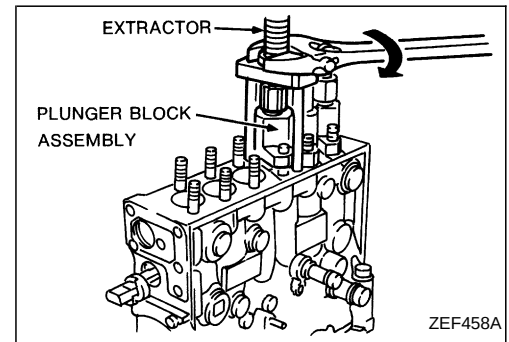


④⑦-1 Plunger block assembly

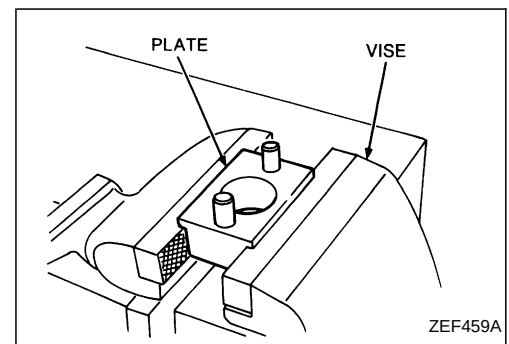
- 1) Screw the extractor (105792-0030) onto the delivery valve holder.

NOTE

- Put the plunger assemblies together with their corresponding plungers in clean fuel oil. If it is necessary to disassemble the plunger block assemblies, refer to "Plunger block disassembly" below.

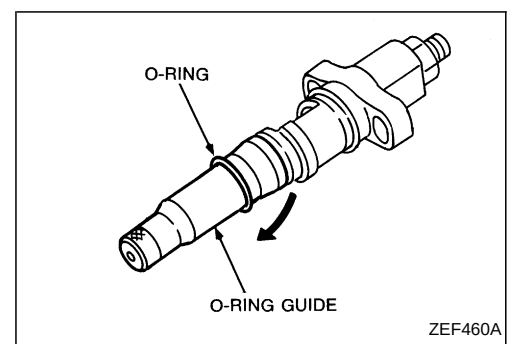


- 2) Secure the plate (157944-3521) in the vise.



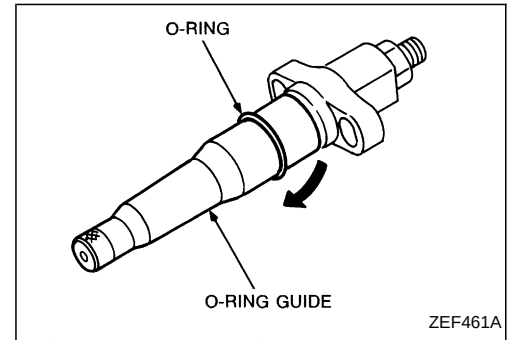
④⑦-3 O-ring

Remove the O-ring using the O-ring guide (157922-3700).



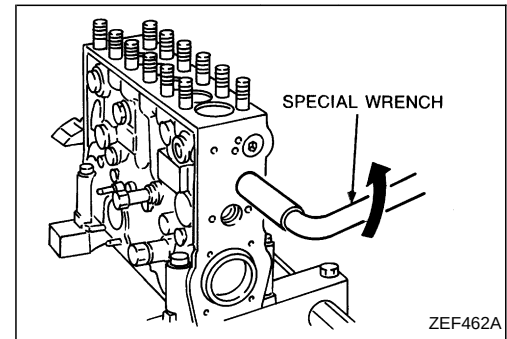
④⑦-4 O-ring

Remove the other O-ring using the O-ring guide (157923-8100).



⑤⑦ Bushing

Remove the governor side screw bushing using the special wrench (157913-6000).

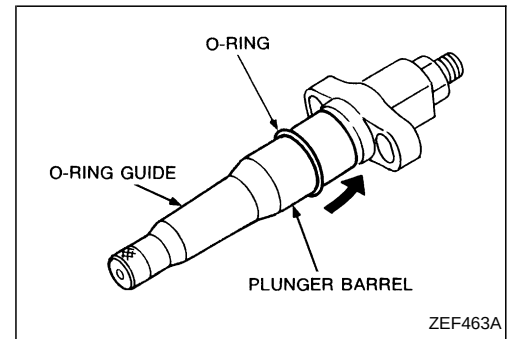


REASSEMBLY

Key point of reassembly

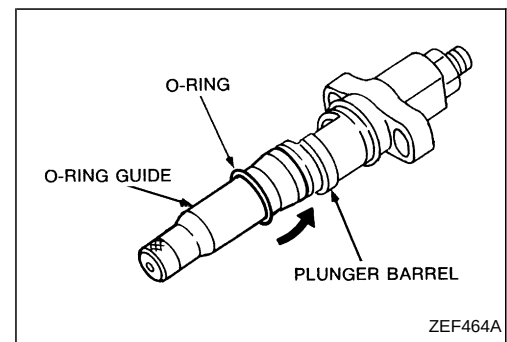
④⑦-4 O-ring

Install a new upper O-ring on the plunger barrel using the O-ring guide (157923-8100).



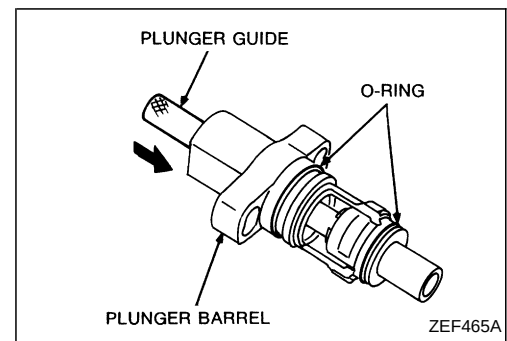
④⑦-3 O-ring

Install a new lower O-ring on the plunger barrel using the O-ring guide (157922-3700).



④⑦-1 Plunger block assembly

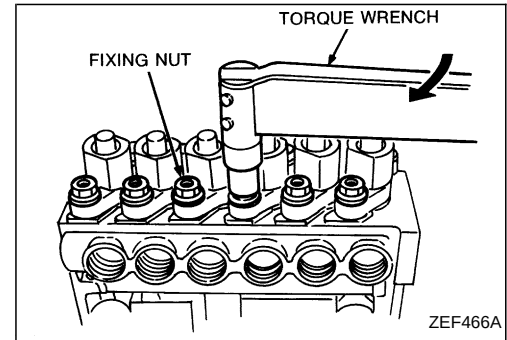
Insert the plunger guide (157922-3920) into the plunger barrel. Apply a little grease to each plunger barrel O-ring.



④⑤ Nut

Gradually and evenly tighten the sleeve flanges' two fixing nuts to the specified torque using a torque wrench.

T : 39 - 44 N·m {4.0 - 4.5 kgf·m, 29 - 33 ft·lbf}

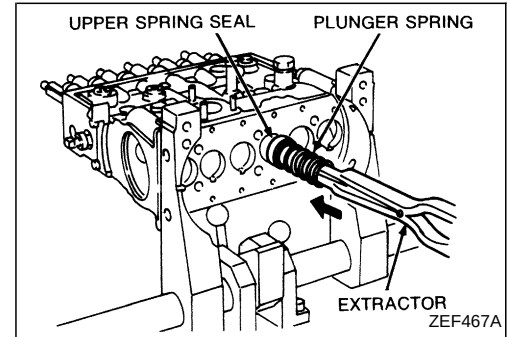


④② Spring

Attach the upper spring seat to the plunger spring and then insert them into the pump housing using the extractor (157921-5620).

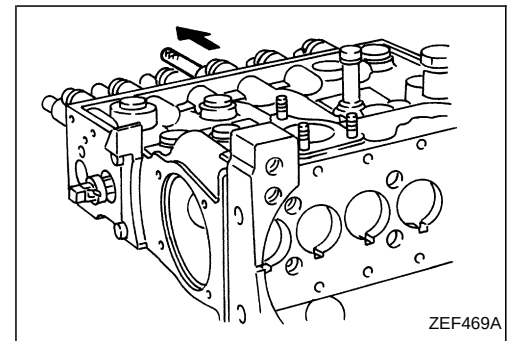
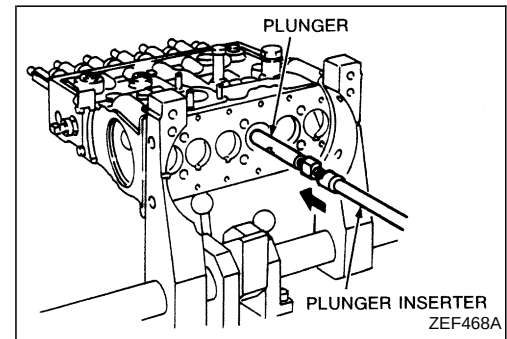
NOTE

- If the upper spring seats are not inserted straight into the pump housing, they will catch during insertion and cannot be withdrawn.
Do not scratch the housing during the above procedure.



④① Plunger

Partially insert the plunger into the plunger barrel using the plunger inserter (157922-4721) and push out the plunger guide (157922-3920) by pushing the plunger.

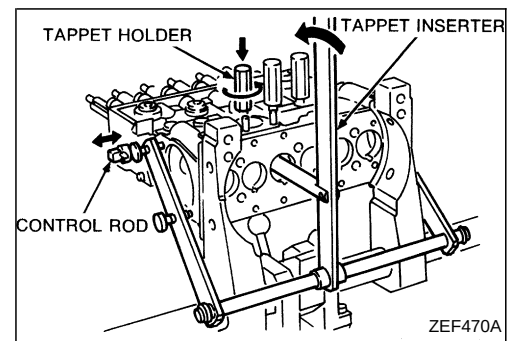


③⑧ Tappet assembly

Operate the tappet inserter lever and move the control rod backwards and forwards while pushing the tappet assembly until the plunger collar enters the control sleeve groove.

NOTE

- If the seat drops down between the lower spring seat and the tappet, repeat the above procedure.

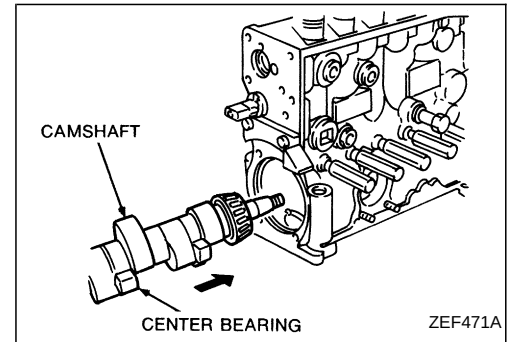


③① Camshaft

Install the camshaft together with the center bearings in the pump housing.

NOTE

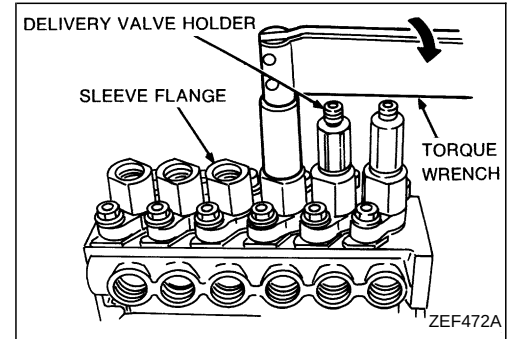
- The camshaft must be installed with the larger diameter shaft [30 mm (1.18 in) dia.] on the injection pump drive side.



④⑦-5 Delivery valve holder

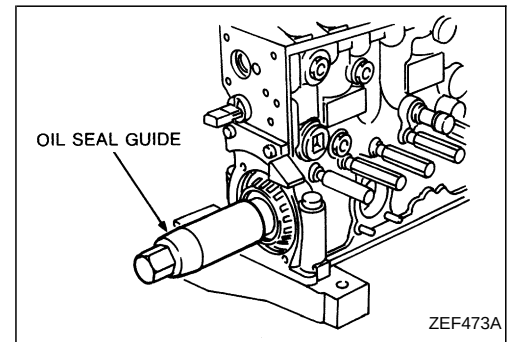
Tighten the delivery valve holder to the specified torque using a torque wrench.

T : 127 - 137 N·m {13.0 - 14.0 kgf·m, 94 - 101 ft·lbf}

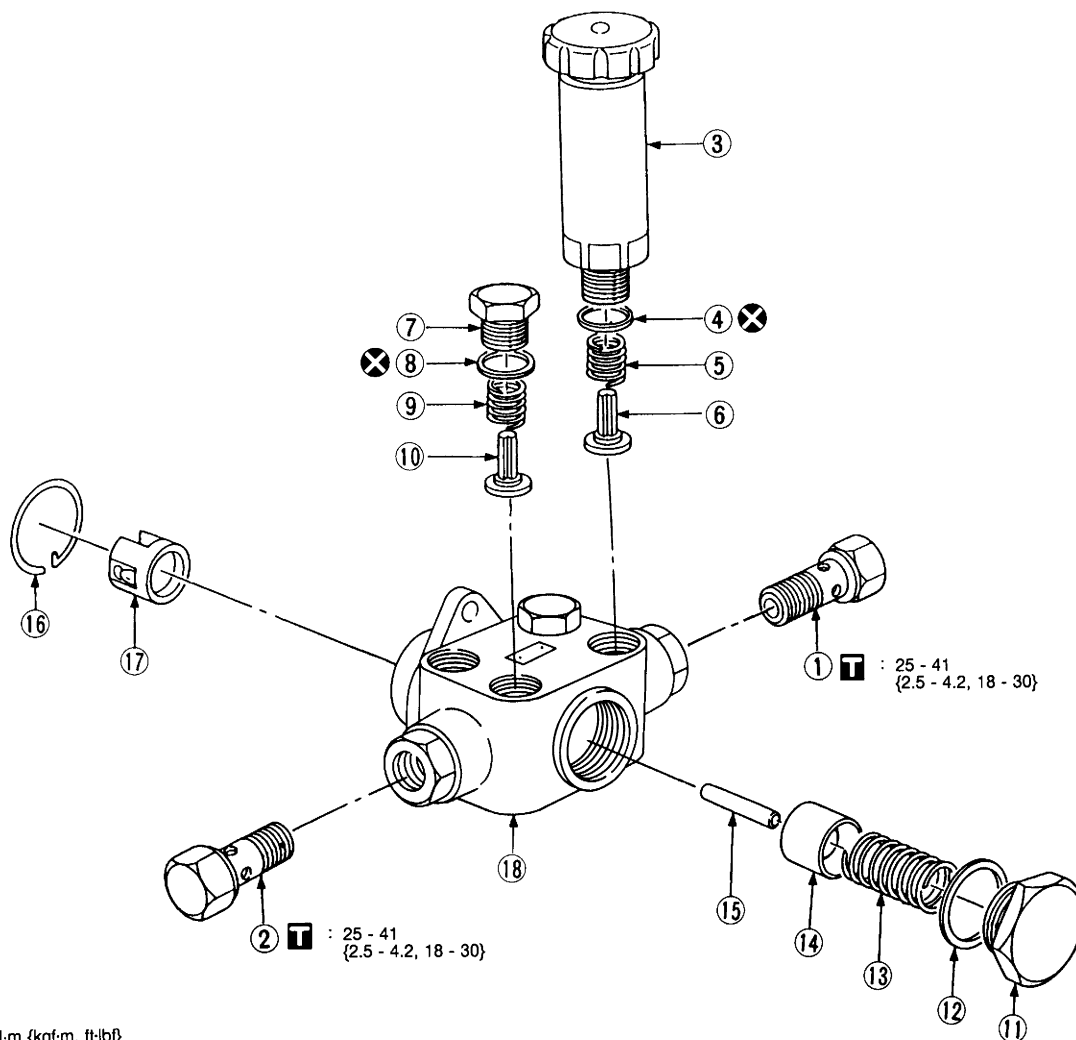


③③ Oil seal

Attach the oil seal guide (157992-3300) to the camshaft's drive side.



FEED PUMP DISASSEMBLY



T : N·m {kgf·m, ft·lb}

WEF482A

Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

- ① Eye bolt
- ② Eye bolt
- ③ Priming pump
- ④ Gasket
- ⑤ Spring
- ⑥ Valve

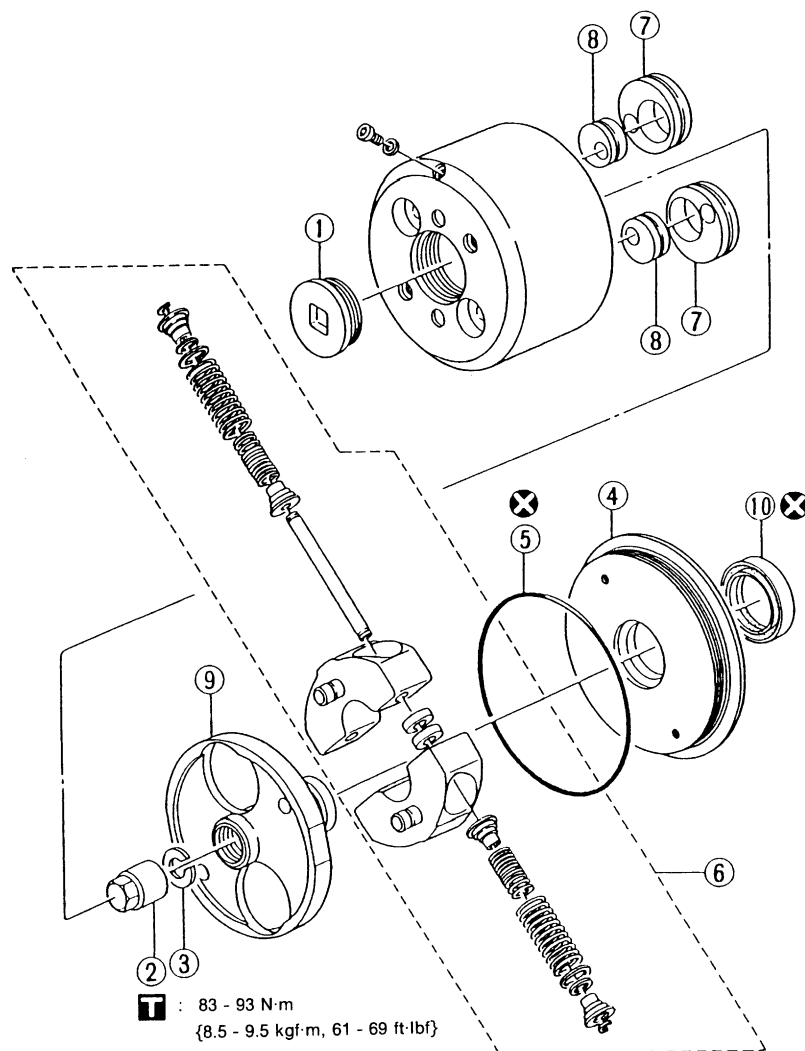
- ⑦ Plug
- ⑧ Gasket
- ⑨ Spring
- ⑩ Valve
- ⑪ Plug
- ⑫ Gasket

- ⑬ Spring
- ⑭ Piston
- ⑮ Rod
- ⑯ Snap ring
- ⑰ Tappet
- ⑱ Housing

TIMER

DISASSEMBLY & REASSEMBLY

SDG timer



WEF098A

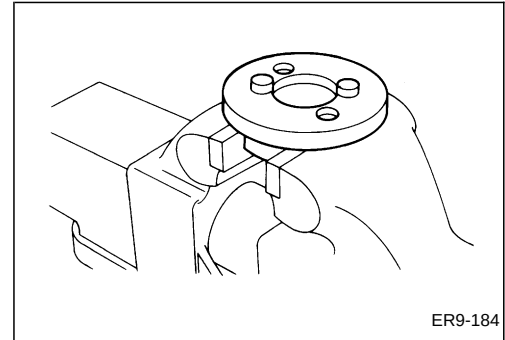
Disassembly sequence (Reassembly sequence is in the reverse of disassembly.)

- | | | |
|-----------------|-------------------------|-----------------|
| ① Cap | ⑤ O-ring | ⑧ Eccentric cam |
| ② Nut | ★☆☆⑥ Flyweight assembly | ⑨ Flange |
| ③ Spring washer | ⑦ Eccentric cam | ⑩ Oil seal |
| ④ Cover | | |

Marks “★” and “☆☆” indicate that the key points of operation are explained in the text.

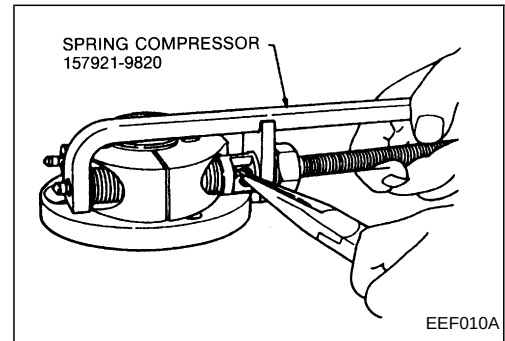
Key points of disassembly & reassembly

- Clamp the base (157924-2520) in a vise, then install the timer on the base.

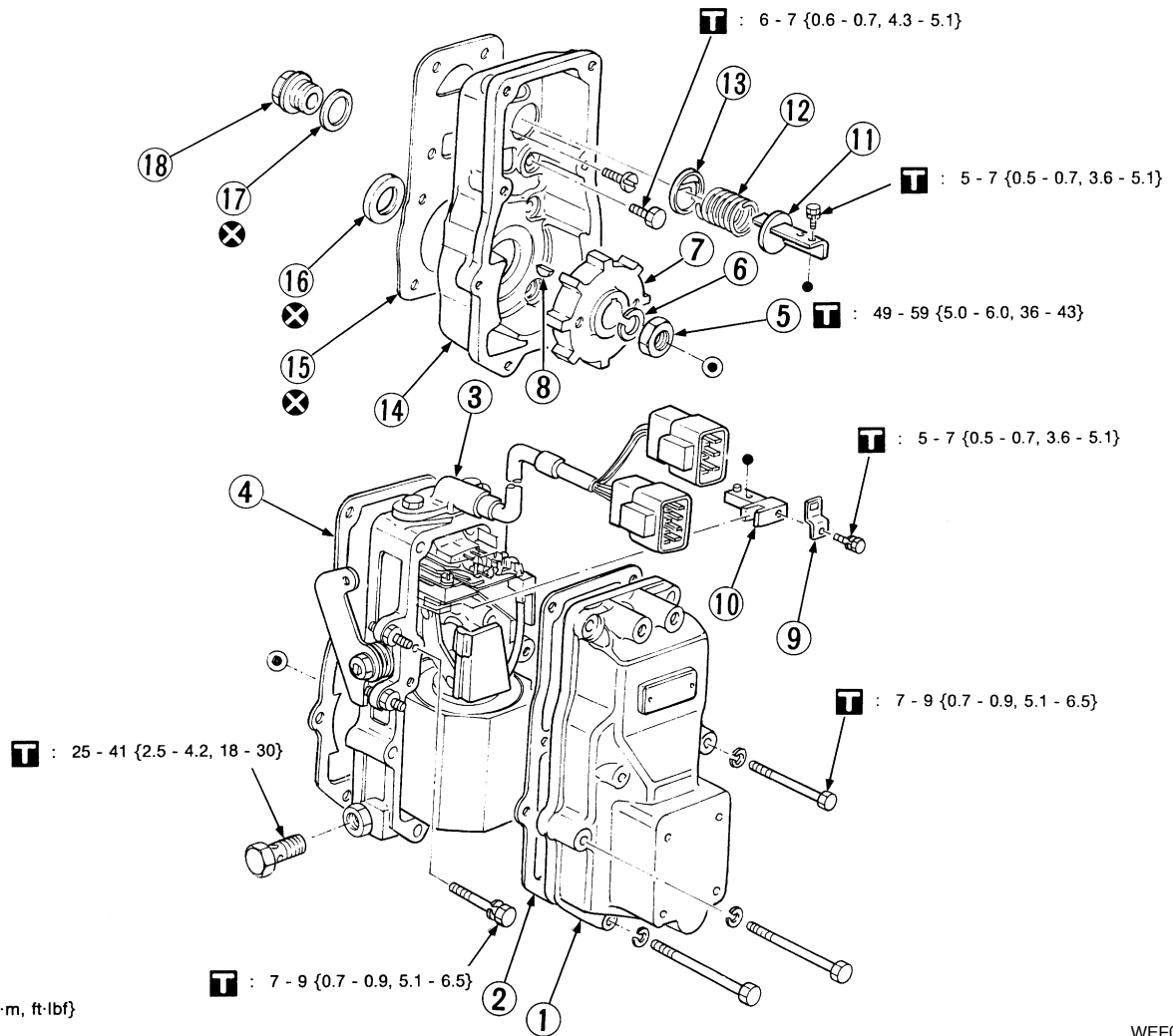


⑥ Flyweight assembly

To remove the snap ring, compress the springs using the spring compressor (157921-9820).



GOVERNOR

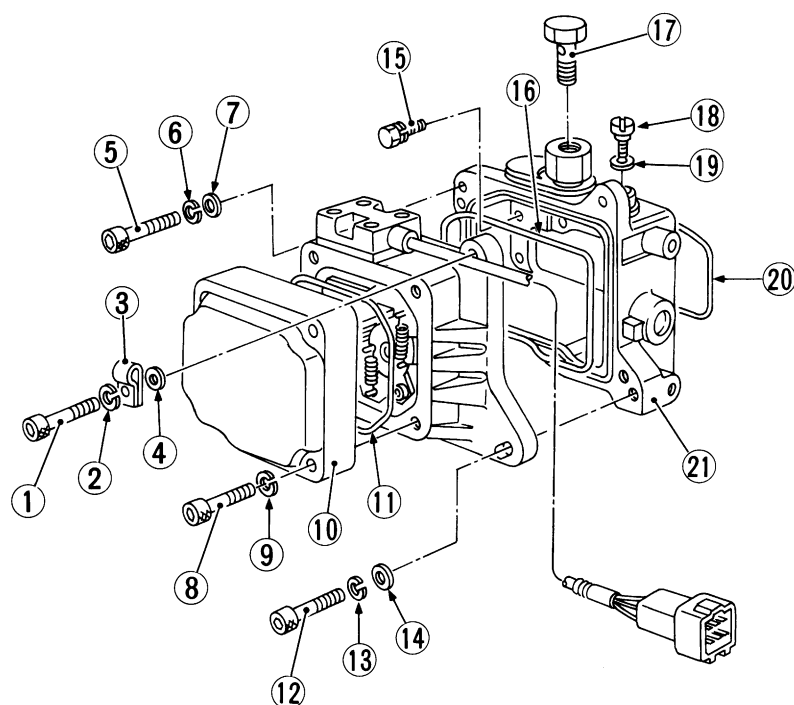


WEF097A

Disassembly sequence (Reassembly sequence is the reverse of disassembly.)

- | | | |
|---------------------|----------------|--------------------|
| ① Governor cover | ⑦ Sensing gear | ⑬ Spring seat |
| ② Gasket | ⑧ Key | ⑭ Governor housing |
| ③ Governor actuator | ⑨ Copper plate | ⑮ Gasket |
| ④ Gasket | ⑩ Connector | ⑯ Oil seal |
| ⑤ Round nut | ⑪ Spring seat | ⑰ Gasket |
| ⑥ Lock washer | ⑫ Spring | ⑱ Cap |

ACTUATOR HOUSING



EEF3199A

Disassembly sequence (Reassembly sequence is the reverse of disassembly.)

- ① Socket head bolt
- ② Spring washer
- ③ Harness clamp
- ④ Washer
- ⑤ Socket head bolt
- ⑥ Spring washer
- ⑦ Washer

- ⑧ Socket head bolt
- ⑨ Spring washer
- ⑩ Cover
- ⑪ Seal ring
- ⑫ Socket head bolt
- ⑬ Spring washer
- ⑭ Washer

- ⑮ Bolt
- ⑯ Seal ring
- ⑰ Eye bolt
- ⑱ Bolt
- ⑲ Gasket
- ⑳ Seal ring
- ㉑ Housing

ADJUSTMENT

When the injection pump has been disassembled, plungers or plunger springs have been replaced, or other reasons exist, use a pump tester and adjust the injection pump.

INJECTION PUMP PREPARATIONS

Remove the cap of the control rack and install the dial gauge.

INITIAL INJECTION TIMING ADJUSTMENT

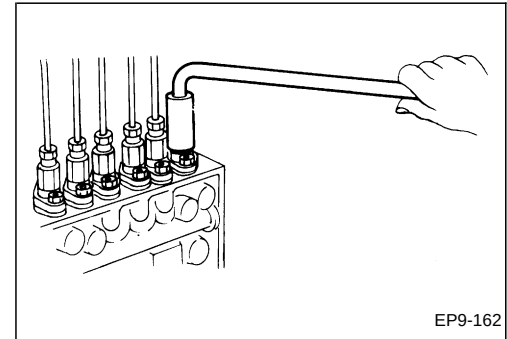
The start of injection is considered as the time at which the top of the plunger covers the fuel intake hole of the barrel. The pump tester must be capable of developing a pressure in the range of 3,138 to 4,707 kPa {32 to 48 kgf/cm², 455 to 683 psi} in order to overcome tension of the delivery valve spring (to force the delivery valve open).

Installing injection pump

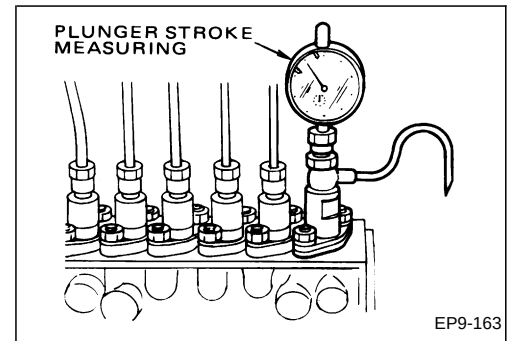
1. Attach the injection pump to the tester and connect the fuel system lines. Arrange so that the camshaft angle can be read on the tester angle scale plate.
2. Secure the control lever at the full injection position.

Adjusting the injection timing of the standard cylinder

1. Removing the 1st cylinder delivery valve holder. To do this, use the socket wrench. The delivery valve spring, delivery valve and gasket can then be taken out.
2. Install the special tool "Plunger stroke measuring tool (105782-4371)" to the flange sleeve by turning it as far as it will go.
3. Rotate the camshaft to bring the tappet for No. 1 cylinder in the bottom dead center position, zero the dial indicator.
4. Proper position is indicated by the stop of fuel flowing out of the end of the nozzle pipe when turning the camshaft to raise the plunger, if the tappet lift reads 3.90 ± 0.05 mm (0.1535 ± 0.0020 in), the pump is set for the start of injection of No. 1 cylinder. The engine is then set to the proper position for injection on that cylinder.



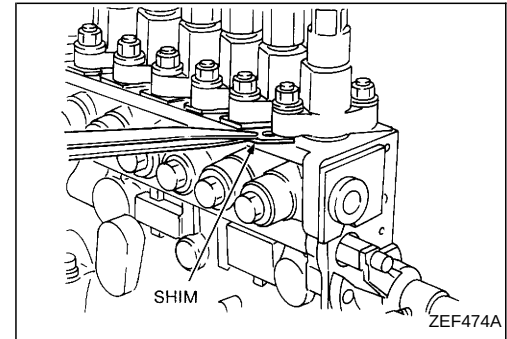
EP9-162



EP9-163

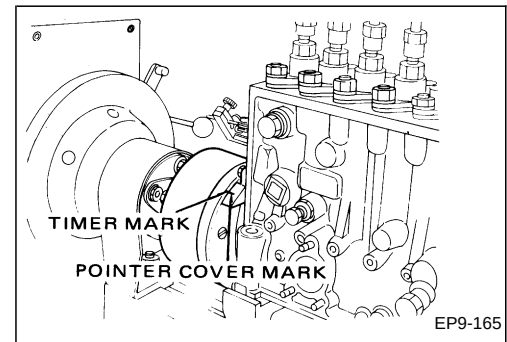
5. When fuel injection does not stop even when the tappet has risen more than 3.90 ± 0.05 mm (0.1535 ± 0.0020 in), pull out the plunger block assembly, and remove adjusting shims until the fuel flow stops at a lift of 3.90 ± 0.05 mm (0.1535 ± 0.0020 in).

6. When the fuel flow stops before the tappet is raised 3.90 ± 0.05 mm (0.1535 ± 0.0020 in), pull out the plunger block assembly and add adjusting shims until the fuel flow stops at a lift of 3.20 ± 0.05 mm (0.1260 ± 0.0020 in).



Checking timer mark

Under conditions described in "Installing injection pump" and "Adjusting the injection timing of the standard cylinder" above, the position of initial injection of the reference plunger must appear when the mark of the flyweight holder and that of the bearing cover (pump body) coincide. If these marks do not coincide at this time, the timer flyweight holder mark must be shifted. When the timer has been replaced, alignment must also be made to the bearing cover mark after adjusting initial injection timing for the reference cylinder.



Adjusting injection interval

1. After completing adjustment of initial injection timing of the reference No. 1 cylinder (timer side), turn the camshaft to the right (as viewed from the drive end) and set the injection interval for the remaining cylinders by adjusting shims. See the table below.
2. Adjust the cylinder injection intervals within $\pm 30'$.

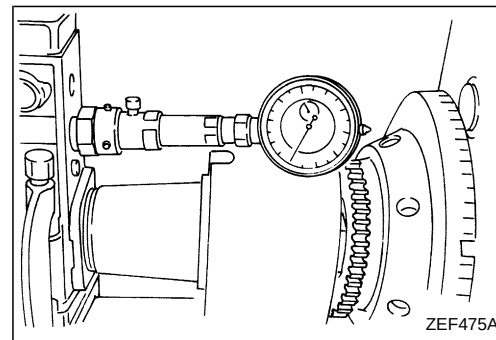
Injection order	1	—	4	—	2	—	6	—	3	—	5	—	1
Injection interval	60°		60°		60°		60°		60°		60°		60°
Scale plate indication	0°	—	60°	—	120°	—	180°	—	240°	—	300°	—	360°

Setting the control rod's zero position

1. Remove the bushing on the pump's drive side and then mount the dial gauge used for setting the control rod position.

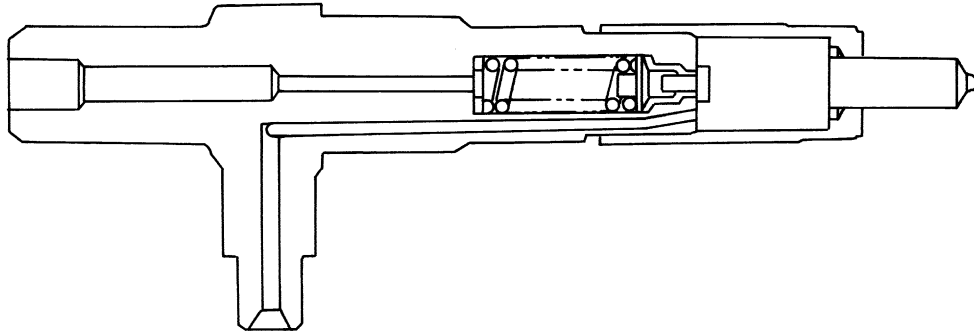
NOTE

- If a boost compensator is installed on the pump's drive side, remove it and then mount the measuring device.



NOZZLE AND NOZZLE HOLDER

CONSTRUCTION

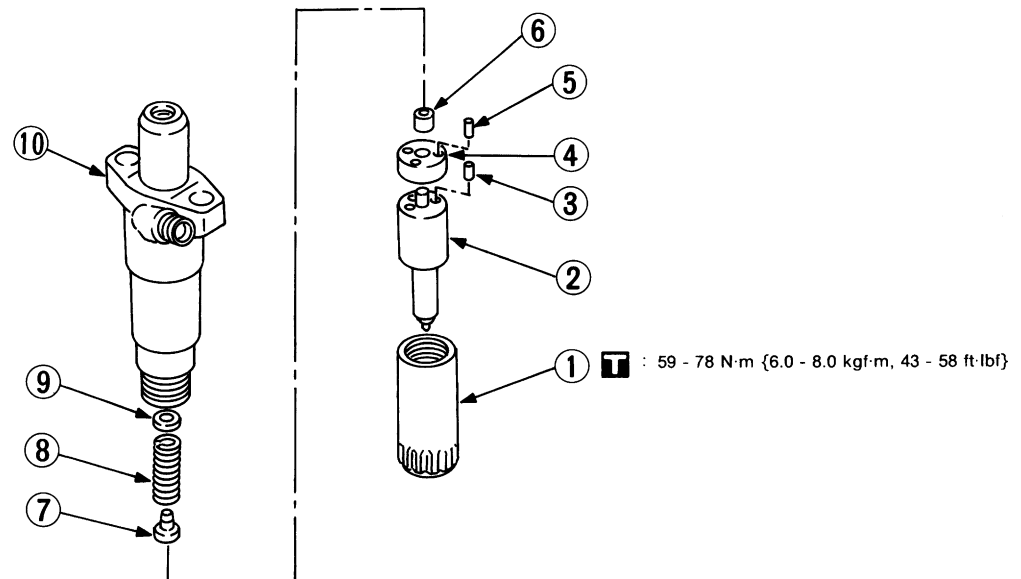


ZEF476A

REMOVAL

1. Chock the wheels and tilt the cab.
2. Turn the key switch off and disconnect the cable from the negative terminal of the battery.
3. Disconnect the injection nozzle tube and spill tube, remove the nozzle holder assembly from the cylinder head.

DISASSEMBLY



ZEF477A

Disassembly sequence (Reassembly sequence is the reverse of disassembly.)

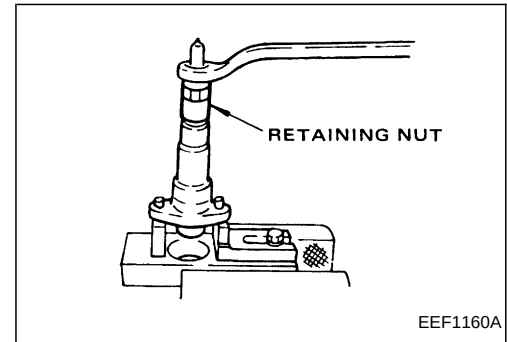
- | | | |
|--------------------|---------------|------------------|
| ★① Retaining nut | ⑤ Pin | ⑧ Nozzle spring |
| ★② Nozzle assembly | ⑥ Lift piece | ⑨ Adjusting shim |
| ③ Pin | ⑦ Spring seat | ⑩ Nozzle holder |
| ④ Spacer | | |

Marks “★” and “☆” indicate that the key points of operation are explained in the text.

Key point of disassembly

① Retaining nut

Reverse the nozzle holder position by facing the nozzle-side up, and remove the retaining nut with a appropriate wrench.

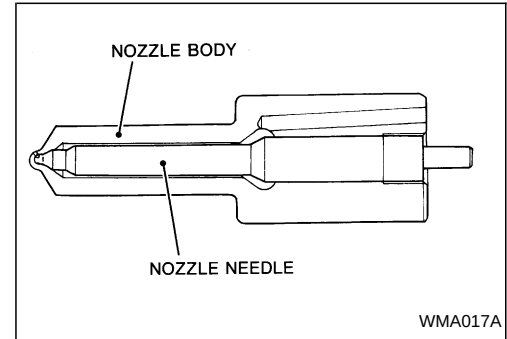


② Nozzle assembly

Remove the nozzle needle from the nozzle body.

NOTE

- Do not use the nozzle needle in another nozzle body.



INSPECTION

- Clean all disassembled parts in cleaning solvent. Check for scratches, cracks or damage and replace faulty parts.
- If measurement indicates that the service limit has exceeded, repair or replace faulty parts.

NOTE

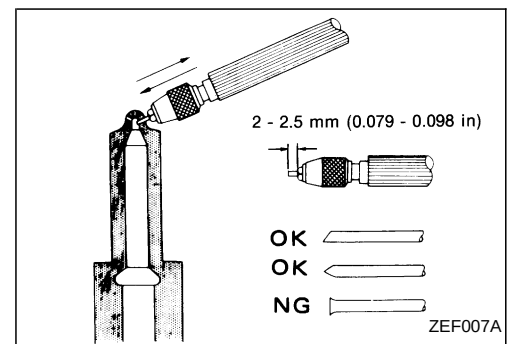
- Remove carbon from around nozzle jets using a wire brush.

Cleaning of nozzle body and nozzle

- Remove carbon from around nozzle jets using the pin vise (99727 Z5005).

Unit: mm (in)

Nozzle identification mark	Number of injection nozzle holes	Injection nozzle hole diameter	Wire diameter
K4	6	0.31 (0.0122)	0.29 (0.0114)
K6		0.27 (0.0106)	0.26 (0.0102)
L2	7	0.26 (0.0102)	0.25 (0.0098)



NOTE

- Do not extend tip of the holder more than 2 to 2.5 mm (0.079 to 0.098 in). Otherwise, it may bend inside the nozzle body and it cannot be removed.
- Carefully push the holder into the inside of the nozzle to remove carbon.
- Use an oil stone to grind the wire tip of the holder until it is shaped as shown in the figure.

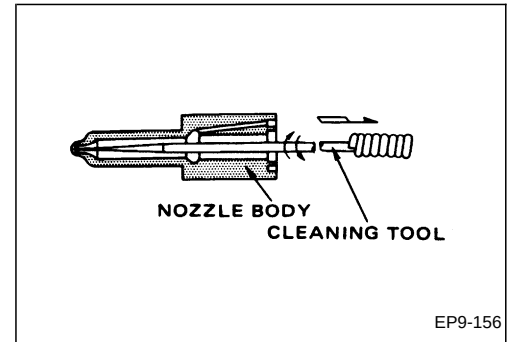
2. Clean remaining carbon off the back of the nozzle jet using the nozzle cleaner (99726 Z5000).

NOTE

- **Be careful not to scratch the seating surface of the nozzle jet and the nozzle needle.**
Do not use compressed air to remove carbon because this may introduce foreign matter into the jet.

3. Install the needle on the nozzle body while immersing both in clean diesel fuel.

4. Visually check the needle valve seat, guide shaft and injection shaft for damage or carbon accumulation.
5. Position the nozzle body vertically. Pull out the needle so that it protrudes approximately 1/3 its total length beyond the top of the nozzle body. Then release it to ensure that it drops to the valve seat under its own weight.



REASSEMBLY

To reassemble, reverse the order of the above removal procedures. Observe the following:

NOTE

- **Clean the mating surfaces of the nozzle and nozzle holder and the retaining nut in clean diesel fuel before installation.**
- **Use new gaskets.**

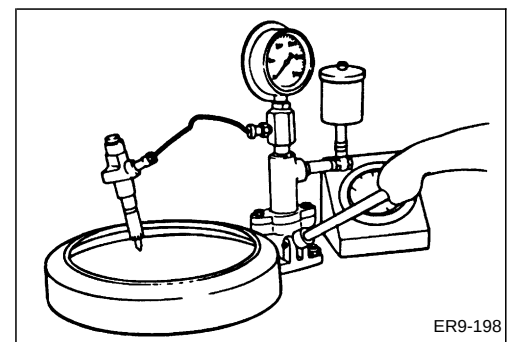
ADJUSTMENT

Valve adjusting pressure adjustment

1. Using a nozzle tester (equipped with a 49,035 kPa {500 kgf/cm², 7,110 psi} gauge), measure valve adjusting pressure.
Unit: kPa {kgf/cm², psi}

Item	Maintenance standard
Valve adjusting pressure	23,046 - 23,831 {235 - 243, 3,342 - 3,455}

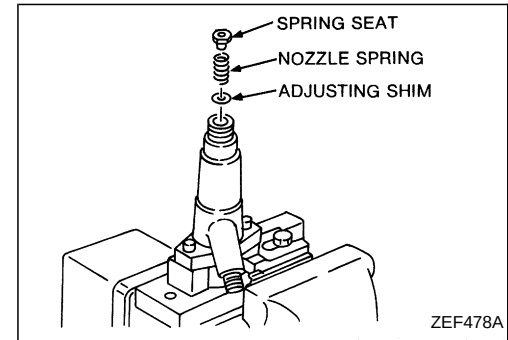
2. If the valve opening pressure is outside specifications, replace the adjustment shim with a suitable one until the specified opening pressure is obtained.



NOTE

- When using a shim, always measure the thickness of the shim with a micrometer before assembling.
- Adding a 0.01 mm (0.0004 in) thick shim corresponds to a change of approximately 118 kPa {1.2 kgf/cm², 17 psi} in valve opening pressure.

Adjusting shim thickness mm (in)	0.40 (0.0157), 0.50 (0.0197), 0.52 (0.0205), 0.54 (0.0213), 0.56 (0.0220), 0.58 (0.0228), 0.60 (0.0236), 0.70 (0.0276)
-------------------------------------	--



WARNING

- Be extremely careful not to direct fuel spray to hands, etc. while adjusting fuel injection. It may penetrate into blood vein through the skin and cause toxic symptoms.

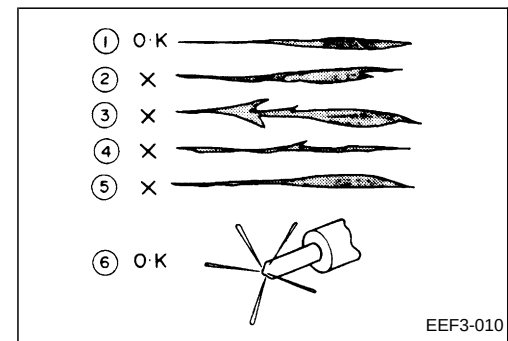
- After adjusting injection pressure to specifications, install the retaining nut. Recheck injection pressure.

T : 59 - 78 N·m {6.0 - 8.0 kgf·m, 43 - 58 ft·lbf}

Checking spray and fuel leakage

While adjusting injection pressure, check the spray pattern. Also check for signs of fuel leakage or obstruction. If inspection reveals slight wear on the seating surfaces of the nozzle body and needle, lap both using lapping compound. If either part requires replacement, replace both parts as a unit.

- Equal, symmetrical fuel spray pattern
- Asymmetrical fuel spray pattern
- Incorrect fuel spray pattern
- Lean fuel spray pattern
- Stepped fuel spray pattern
- Equal fuel spray (from 5 jets)

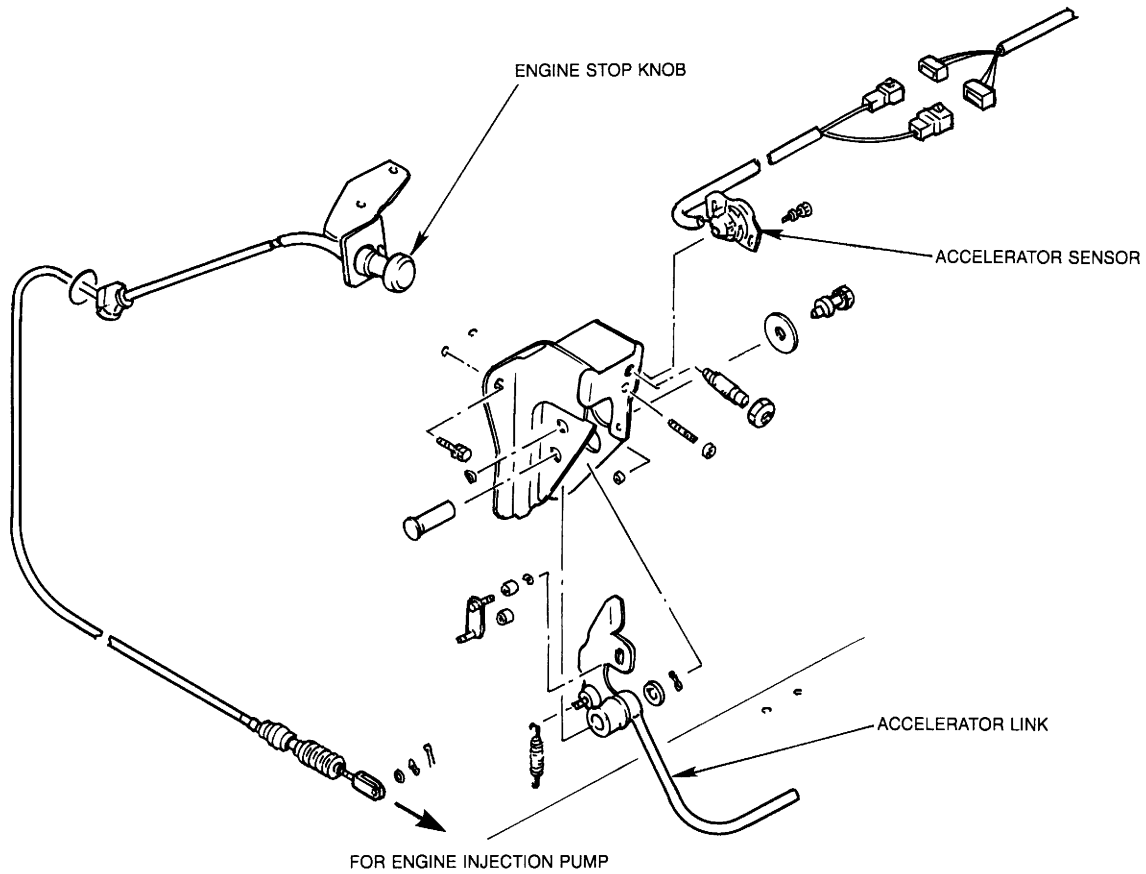


INSTALLATION

- Install the nozzle holder assembly on the cylinder head.
T : 25 - 29 N·m {2.5 - 3.0 kgf·m, 18 - 22 ft·lbf}
- Connect the spill tube and injection nozzle tube.
- Bleed air from the fuel system. (Refer to the "MA" section for procedures.)

ENGINE CONTROL SYSTEM

CONSTRUCTION Schematic diagram



WEF483A

- MEMO -

ELECTRICAL ENGINE CONTROL SYSTEM

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HOW TO USE THIS SECTION

This section describes the inspection and service procedures for the “electronic governor system”, which is a control system for the PF6TB engine.

This section contains the system’s main control functions, additional functions, and structure and operation of each unit in the system.

This section also contains the action to be taken at the time of an abnormal status or diagnosis, and for troubleshooting.

Basic procedures for inspections and services are described under “BASIC OPERATION”. Inspection and maintenance work should be done according to the described procedures.

Abbreviations used in this section

Abbr.	Description		Abbr.	Description
OSC	Oscillate		W/L	Warning light
MDL	Middle (Midpoint)		M/V	Magnetic valve
SIG	Signal		P/L	Pilot light
GND	Ground		SW	Switch
SLD	Shield		PCM	Pressure control modulator valve
ACT	Actuator			

Engine model

Type	Engine model
Type I	PF6TB-21
Type II	PF6TB-22
Type III	PF6TC

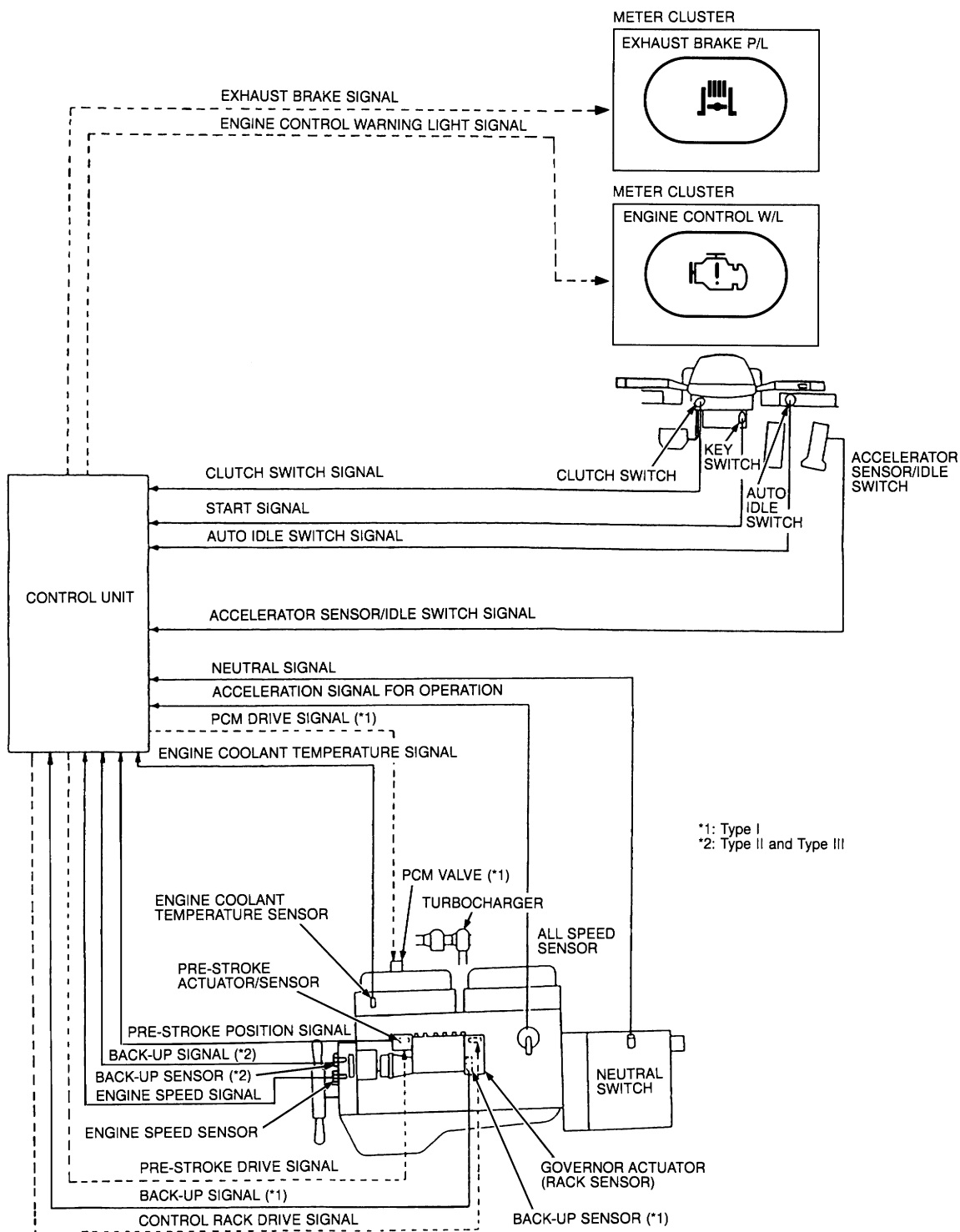
SYSTEM OVERVIEW

The HD-TICS system (timing & injection rate control system) regulates both the fuel feed rate (fuel injection rate) and fuel injection timing under varying engine operating conditions. Control of the fuel feed rate and injection timing is accomplished by a variable, fuel-feed rate, fuel injection pump. The fuel injection pump controls plunger sleeve movement electronically. The system design makes clean exhaust gases compatible with high diesel power output. This system is provided with additional functions to control the exhaust brake system and VNT (variable nozzle turbocharger) system:

<u>HD</u>	—	<u>TICS</u>
Code		Timing & Injection rate Control System

The HD-TICS system consists of a control unit, pre-stroke actuator, sensors, switches, lamps and electrical wiring which connect these parts. The pre-stroke actuator is operated by a signal sent from the control unit. Sensors come in four types — the pre-stroke sensor, rack position sensor, engine speed sensor and engine coolant temperature sensor. These four sensors sense the operating condition of various engine units/parts, sending their respective signals to the control unit.

SYSTEM DIAGRAM

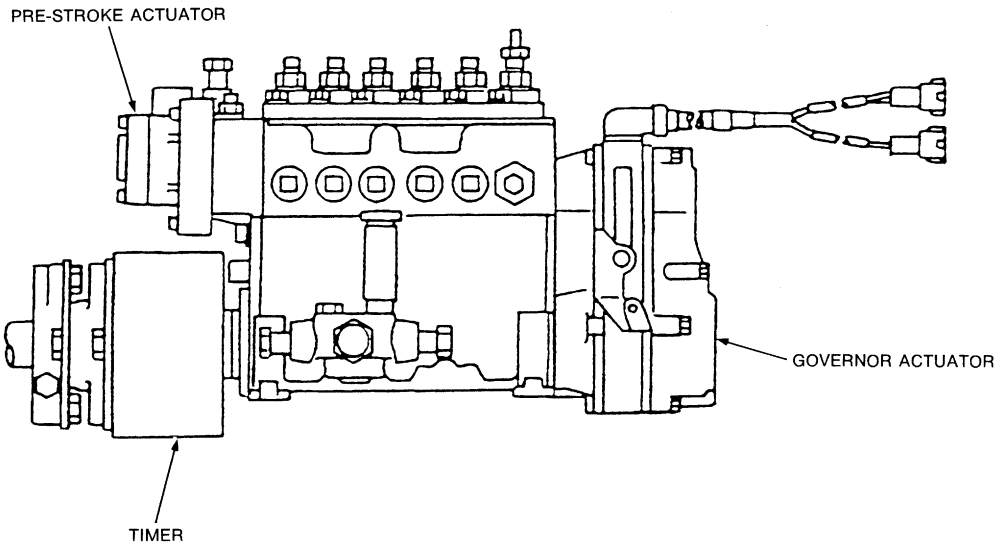


WEF484A

SYSTEM UNITS

VARIABLE, FUEL-FEED RATE, FUEL INJECTION PUMP

The variable, fuel-feed rate, fuel injection pump consists essentially of a pre-stroke actuator, electronic governor, pump unit and mechanical timer (SDG).



EEF037A

CONTROL UNIT

The control unit is located on the unit bracket directly below the front passenger's seat. It provides the various control functions listed below:

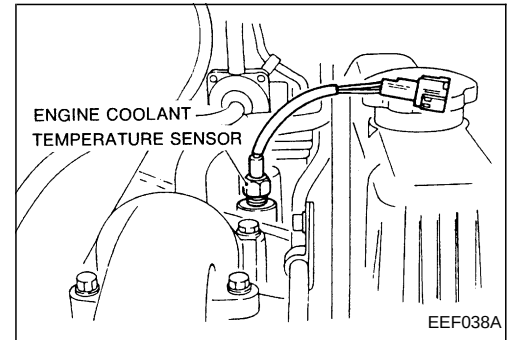
MAIN CONTROL FUNCTION	● FUEL INJECTION CONTROL (ELECTRONIC GOVERNOR SYSTEM) ● FUEL INJECTION RATE CONTROL ● FUEL INJECTION TIMING CONTROL ● VNT (VARIABLE NOZZLE TURBOCHARGER) SYSTEM [TYPE I ONLY] ● EMERGENCY DRIVING (LIMP FORM) FUNCTION ● SELF-DIAGNOSTIC FUNCTION
ADDITIONAL FUNCTION	● WHITE-SMOKE REDUCTION DURING WARM-UP ● OVERRUNNING PREVENTION FUNCTION ● AUTOMATIC ENGINE SPEED CONTROL FUNCTION ● AUTOMATIC ENGINE SPEED ADJUSTING FUNCTION ● EXHAUST BRAKE RELEASE FUNCTION

SENSORS

Engine coolant temperature sensor

The engine coolant temperature sensor is a variable resistor (Thermistor type) in which resistance varies with the change in the engine coolant temperature. The sensor detects the engine coolant temperature as change in the resistance, and sends a signal to the control unit.

The engine coolant temperature sensor is installed on the water manifold and detects the engine coolant temperature.



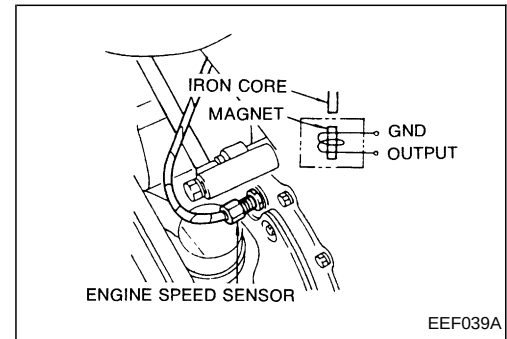
Engine speed sensor

The engine speed sensor is the electromagnetic pickup type. The sensor is installed on the front cover.

The engine speed sensor detects the electric potential difference generated when the pins on the edge of the camshaft gear (12 pins located at equal intervals) pass the tip of the sensor, and send a signal to the control unit.

CAUTION

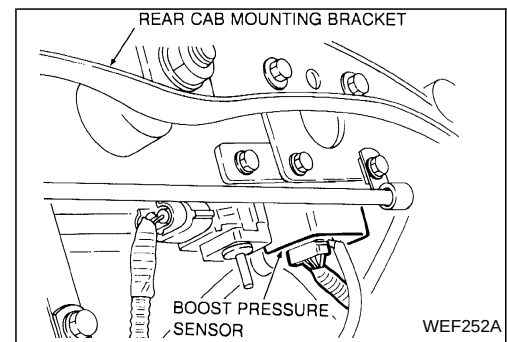
- The sensor tip-to-pin clearance must be properly set (to the specification). If the clearance is too large, the electrical potential difference becomes small and the signal becomes difficult to detect. If the clearance is too small, the sensor and the pin can interfere with each other. Therefore, the clearance must be set properly.
- Install the sensor referring to "BASIC OPERATION (Page EF-6-117)".



Boost pressure sensor

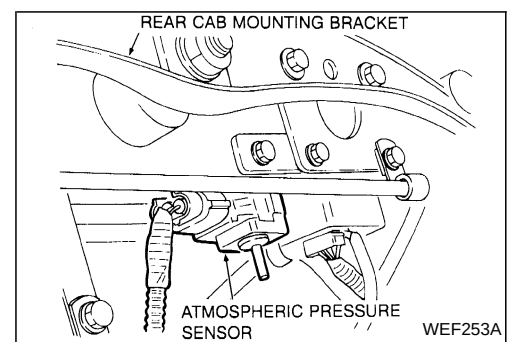
The boost pressure sensor is connected to the intake manifold with a rubber hose. It detects the boost pressure in the intake manifold and feeds it back to the control unit.

The boost sensor is a relative pressure sensor which uses a Wheatstone bridge (strain gauge). It applies to the control unit a voltage which is changed by boost pressure from a basic control unit voltage of 5 volts.



Atmospheric pressure sensor (If so equipped)

The atmospheric pressure sensor installed under the cab mount (rear side) translates the pressure in the engine intake manifold into electrical signals.

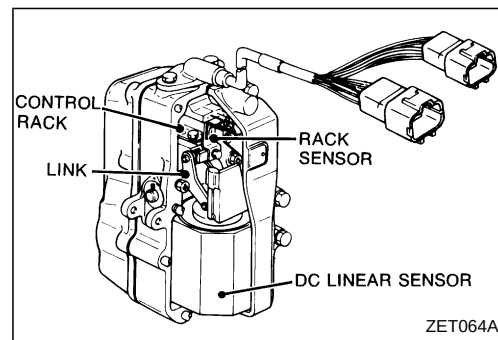


Rack sensor

The rack sensor is incorporated in the fuel injection pump governor.

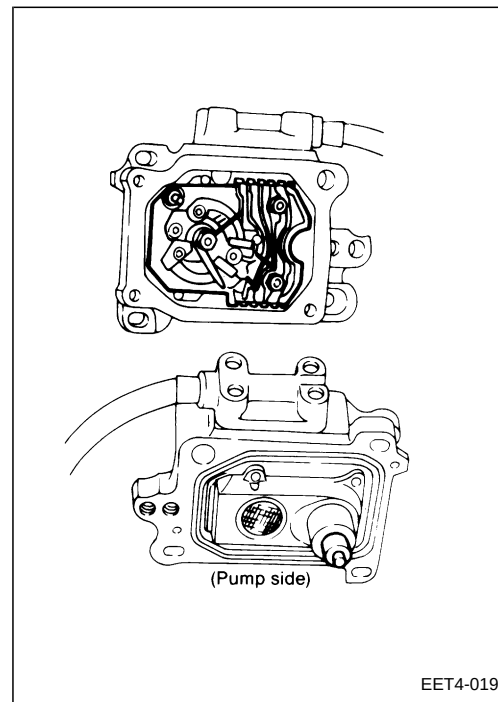
The governor actuator (DC linear motor) is actuated by the signals from the control unit to change the fuel injection amount.

The rack sensor monitors the change in the rack position which changes in accordance with the change in the fuel injection amount, and sends the result to the control unit.



Pre-stroke sensor

The pre-stroke sensor is inside the pre-stroke actuator. It compares the target position instructed from the pre-stroke control unit with the actual position to detect if the position is correct, and feeds this information back to the control unit.



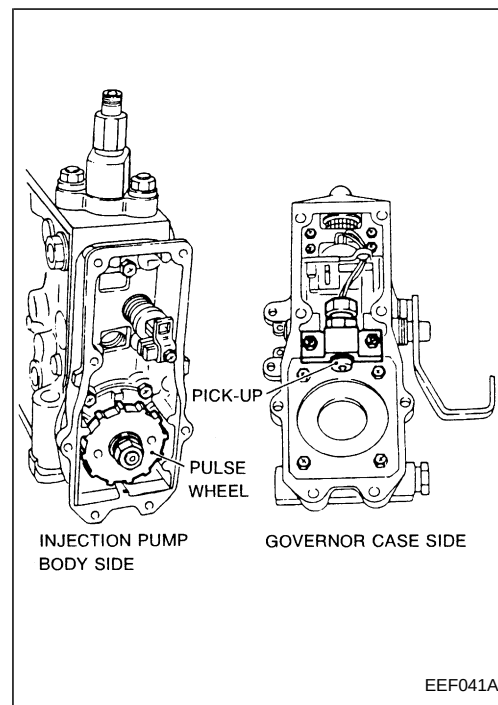
Back-up sensor

<Type I>

When the engine speed sensor has an error, the back-up sensor sends the engine speed signal to the control unit.

The back-up sensor is installed in the governor of the injection pump.

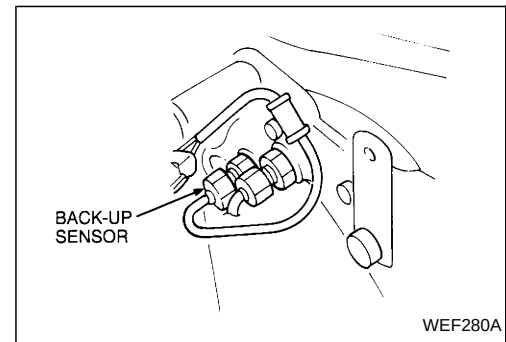
This sensor detects the pulses generated when the cam gear projection crosses the sensor, and sends the signal (pulses) to the control unit.



<Type II and type III>

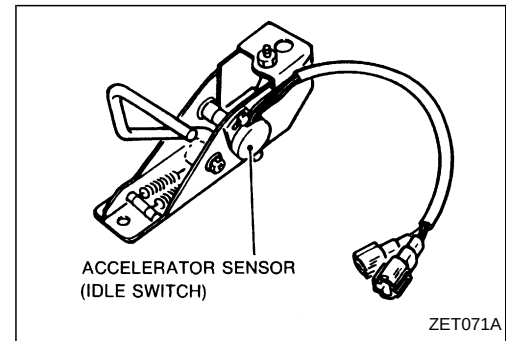
When the engine speed sensor has an error, the back-up sensor sends the engine speed signal to the control unit.

The back-up sensor is installed to the front cover of the engine. This sensor detects the pulses generated when the cam gear projection crosses the sensor, and sends the signal (pulses) to the control unit.



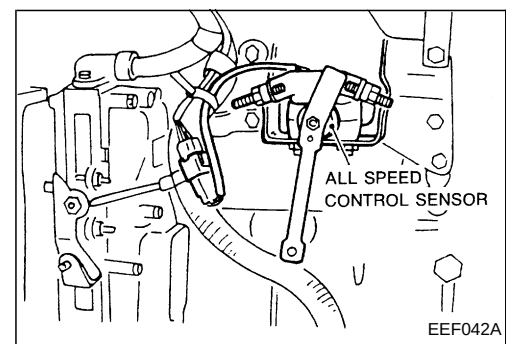
Accelerator sensor

The accelerator sensor is installed in the accelerator pedal. It is a resistor converting the depression of the accelerator pedal into voltage. The accelerator sensor converts the depression of the accelerator pedal into the load, and sends it to the control unit as a signal.



All speed control sensor

The all speed control sensor is installed in the left rear portion of the engine. It sends a signal in place of the driving accelerator sensor to the control unit depending on the position of the governor select switch.

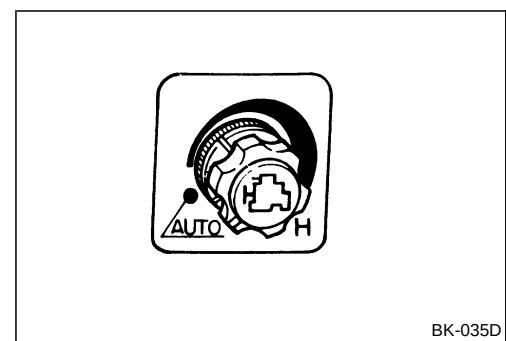


SWITCHES

Idle volume switch

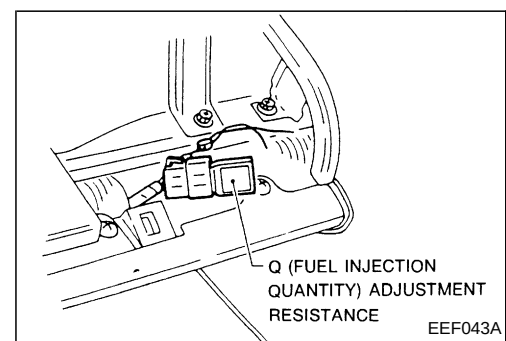
The idle volume switch is a variable resistor with the following 2 functions.

1. Automatic idle: Adjusts the engine speed automatically according to the engine coolant temperature.
2. Manual idle: Allows operators to adjust the engine speed at any degree.



Q (fuel injection quantity) adjustment resistance

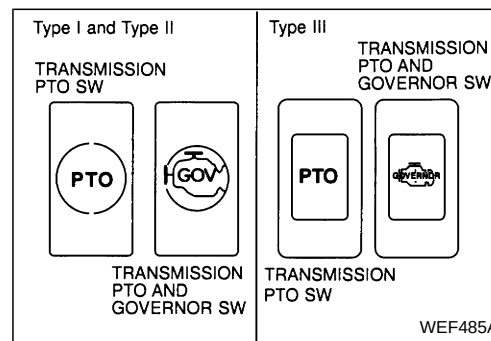
Manufactured engines have slight variations in the maximum output or the maximum torque even if they have the same injection quantity. The Q adjustment resistance compensates these variations individually. In the mechanical governor type, these variations are compensated by the Q adjusting screw before shipment. In the electronic governor type, however, each adjusting item is saved in the control unit, and cannot be changed. Therefore, the variations mentioned above should be compensated by changing the Q adjustment resistance. The Q adjustment resistance is coordinated and concealed before shipment.



No.	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Rack position compensation mm (in)	-0.44 (-0.0173)	-0.38 (-0.0150)	-0.31 (-0.0122)	-0.25 (-0.0098)	-0.19 (-0.0075)	-0.13 (-0.0051)	-0.06 (-0.0024)	0 (0)	+0.06 (+0.0024)	+0.13 (+0.0051)	+0.19 (+0.0075)	+0.25 (+0.0098)	+0.31 (+0.0122)	+0.38 (+0.0150)	+0.44 (+0.0173)
Resistance value (Ω)	267	383	511	649	825	1.02k	1.30k	1.62k	2.00k	2.55k	3.32k	4.22k	5.62k	8.25k	15.00k
Part No.	16803 97002	16803 97003	16803 97004	16803 97005	16803 97006	16803 97007	16803 97008	16803 97009	16803 97010	16803 97011	16803 97012	16803 97013	16803 97014	16803 97015	16803 97016

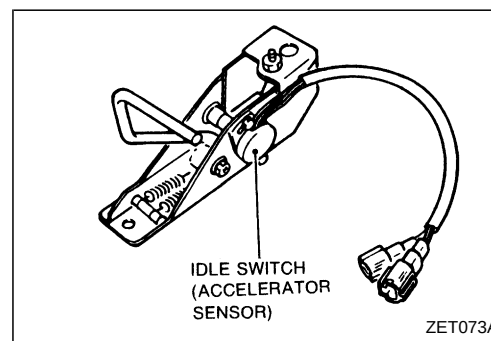
Governor select switch

The governor select switch is built into the PTO switch on the instrument panel inside the cabin. It selects either a drive signal or a service signal for the accelerator signal to be sent to the control unit.



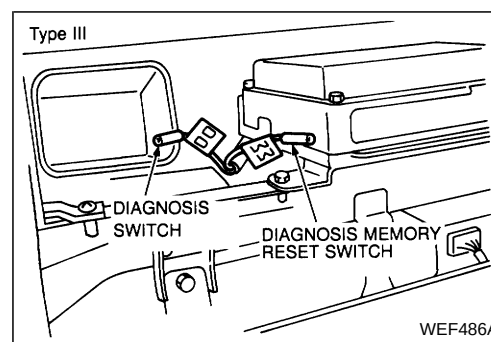
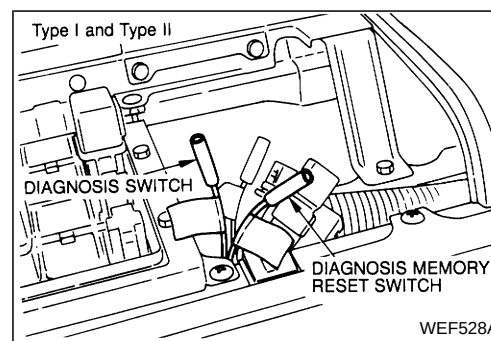
Idle switch

The idle switch is installed at the same place as the accelerator sensor. It detects the accelerator pedal OFF status.



Diagnosis switch

Diagnosis switch performs the trouble diagnosis of the electronic control system. It consists of 2 plug receptacles for the diagnosis switch and the diagnosis memory reset switch. This switch is installed near the control unit harness (by the connector). The diagnosis switch is located inside the instrument pad.



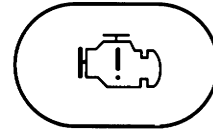
Warning light

The warning light is located in the meter cluster. It turns on to warn the driver of a malfunctioning HD-TICS system. It is also used in connection with the self-diagnostic function of the control unit to perform system diagnoses.

A malfunctioning HD-TICS is identified by the engine control warning light (ON, OFF or flashing) in the user mode.

In the dealer mode, existing problems are identified by the engine control warning light while those in the past are identified by the operation of the engine coolant water warning light.

METER CLUSTER
(Engine control W/L)



WEF487A

METER CLUSTER
(Engine coolant water W/L)



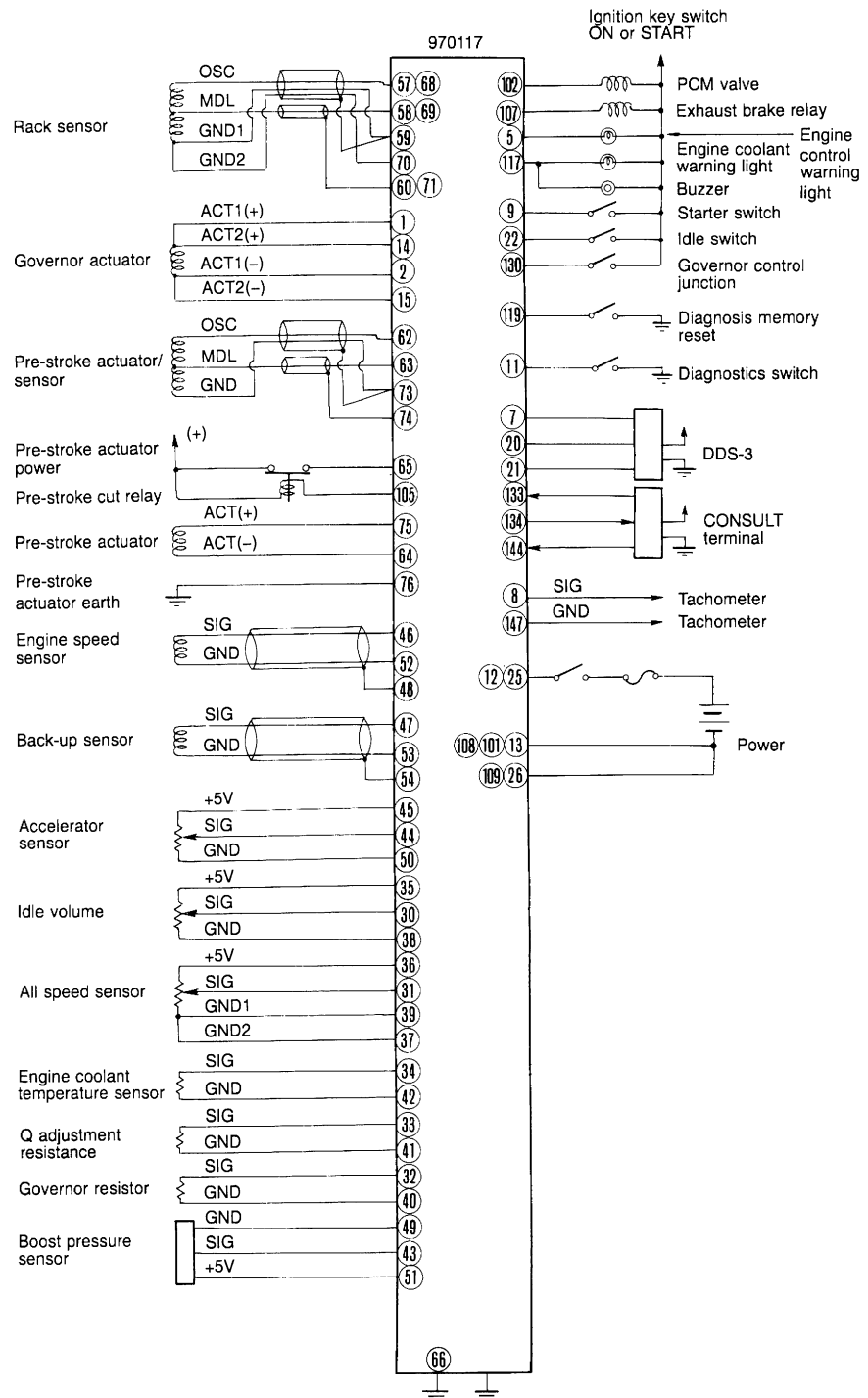
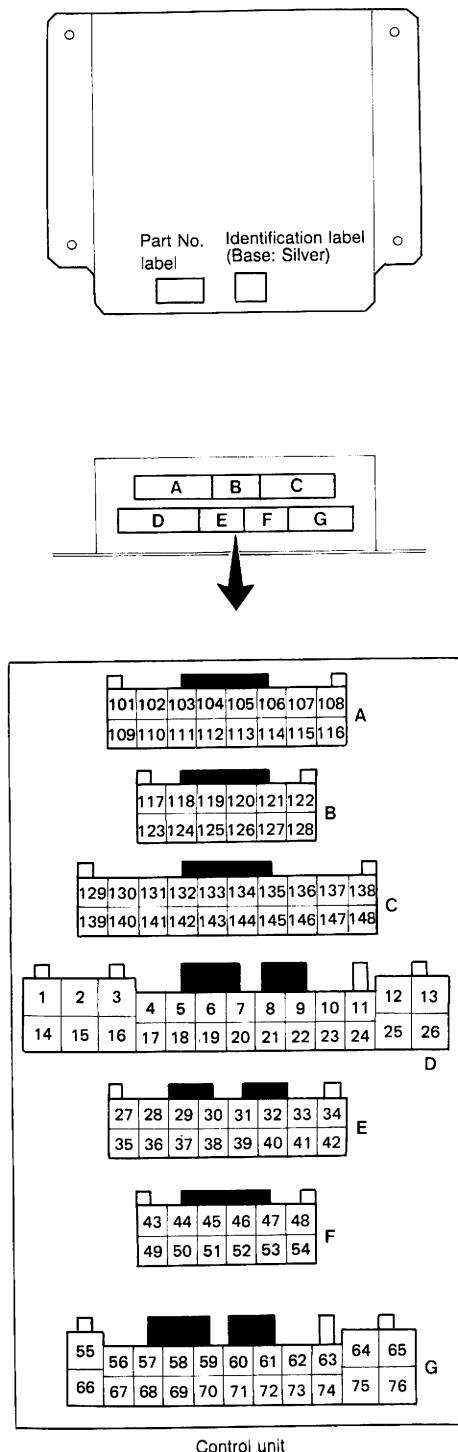
WEF488A

MAIN CONTROL FUNCTIONS

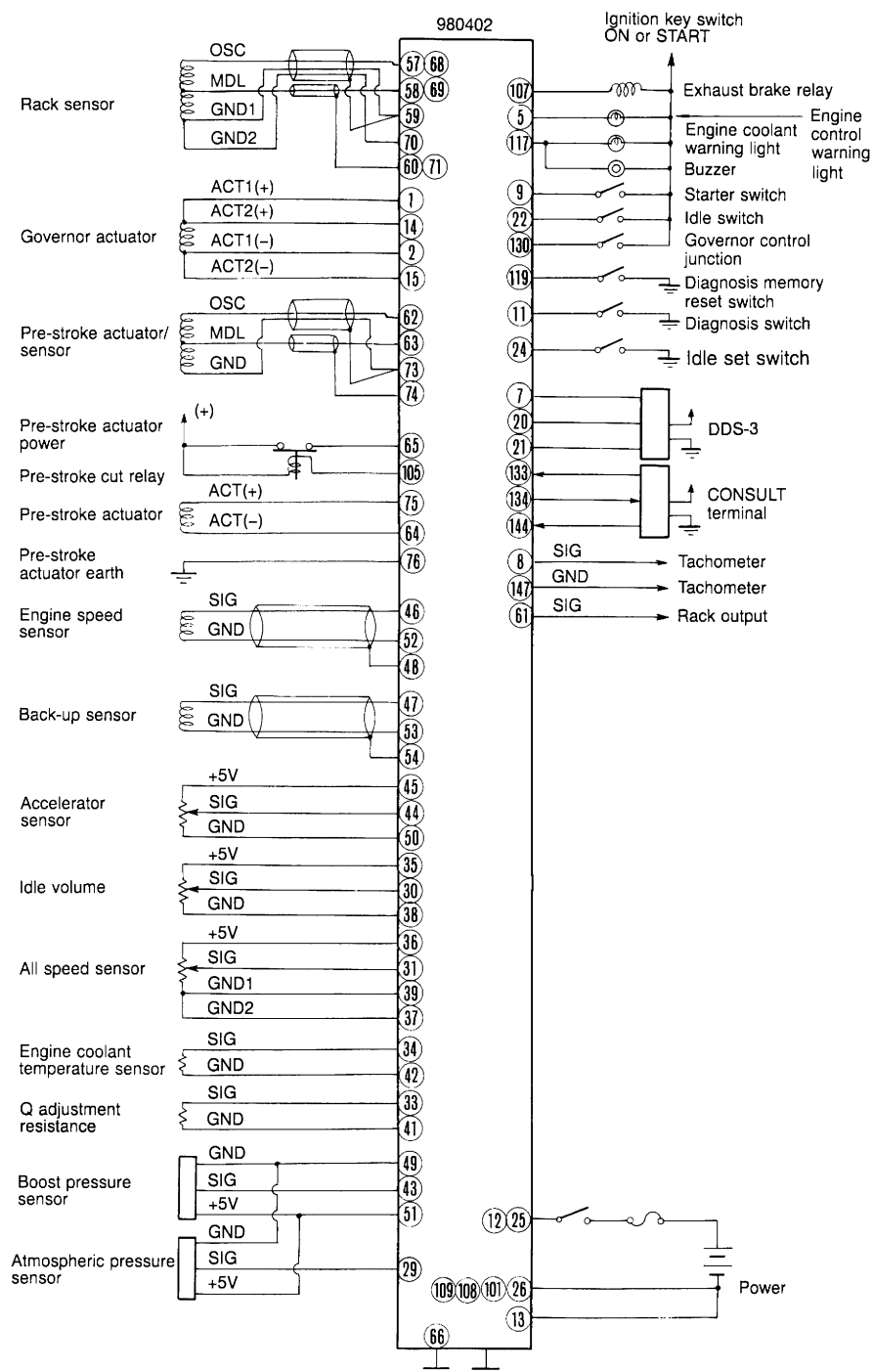
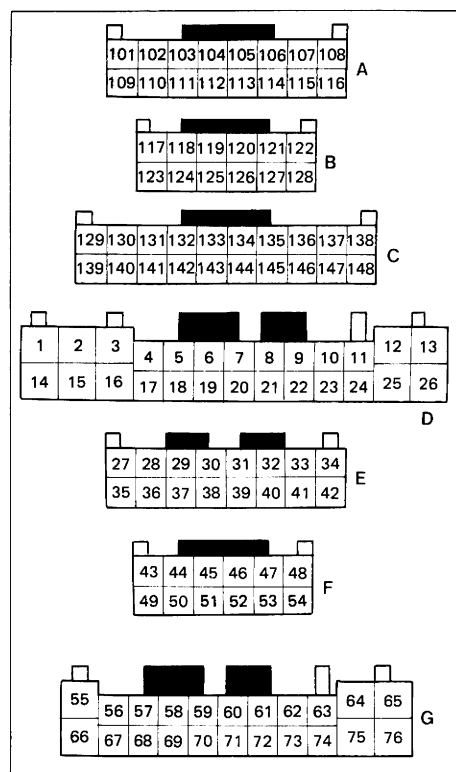
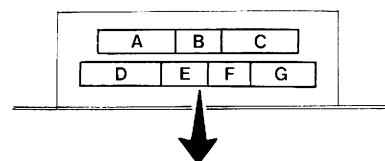
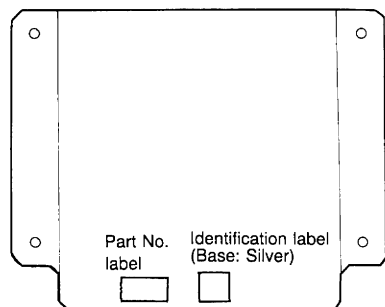
MAIN CONTROL FUNCTION

The control unit detects the engine operation status from input signals from such sources as the engine speed sensor, engine coolant temperature sensor, backup sensor, rack sensor, and accelerator sensor. The control unit compares and controls them with the memory program value stored in the microcomputer (Ideal status of engine operation).

<Type I>

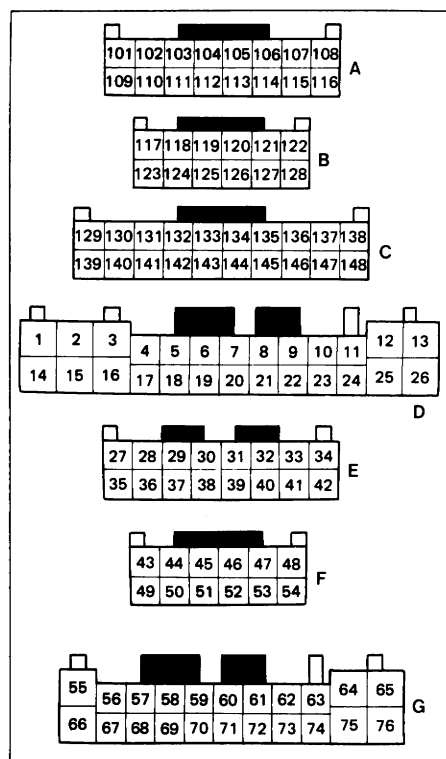
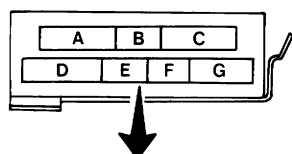
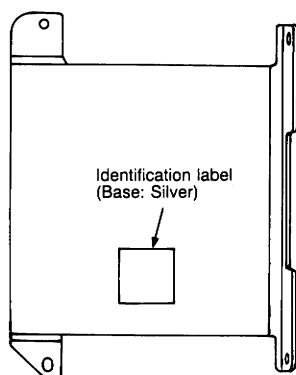


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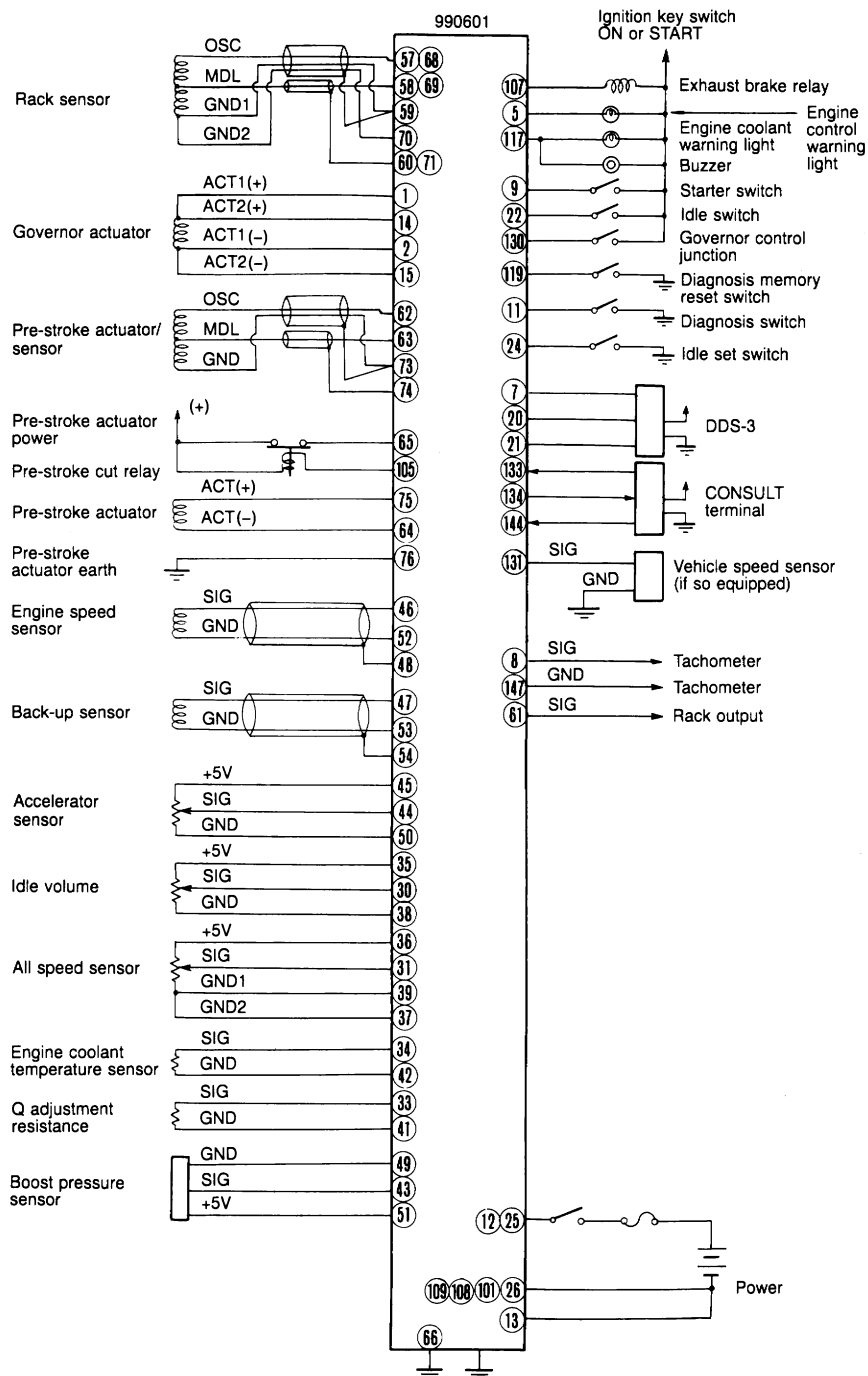


WEF278A

<Type III>



Control unit



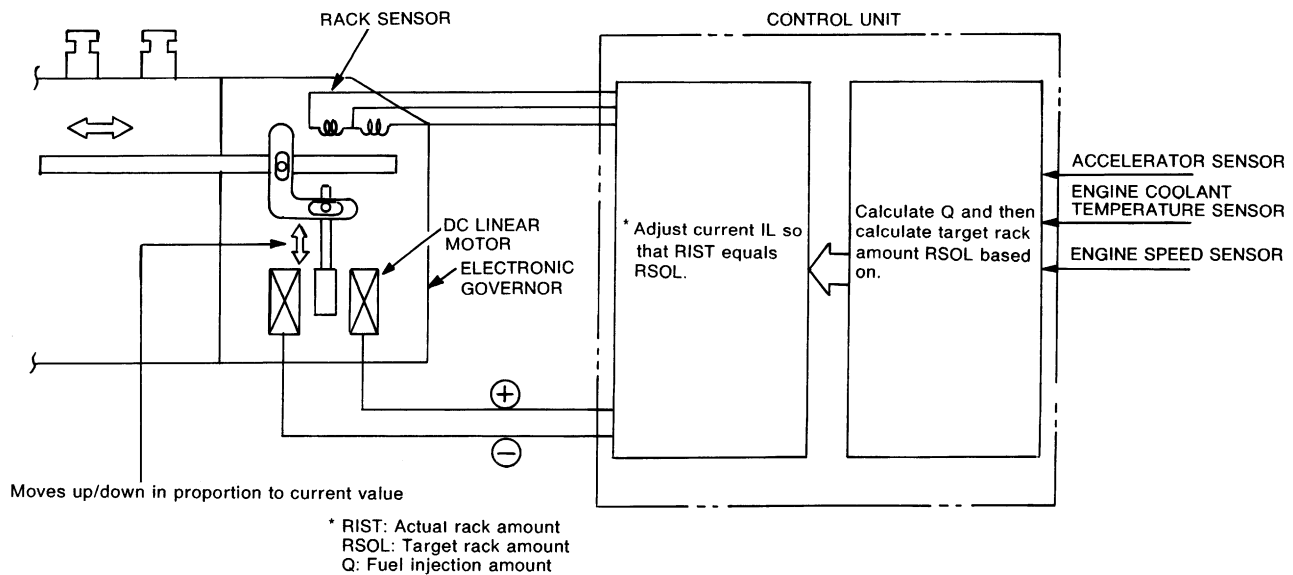
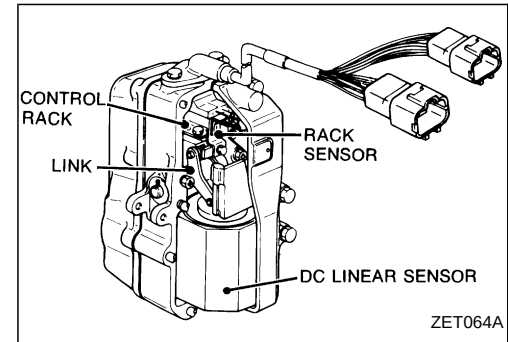
WEF489A

FUEL INJECTION CONTROL (ELECTRONIC GOVERNOR SYSTEM)

The electronic governor system electrically controls the amount of fuel injected from the fuel injection pump. It receives a signal from the control unit and regulates governor actuator movement (electronic governor) accordingly. The control unit receives, from various sensors, information signals related to engine operating conditions, control positions, etc., in advance.

The governor actuator consists basically of a DC linear motor, link and rack position sensor. The DC linear motor is activated by a signal sent from the control unit. Operation of the DC linear motor is conveyed via the link to the control rack. The rack position sensor senses the current control rack position.

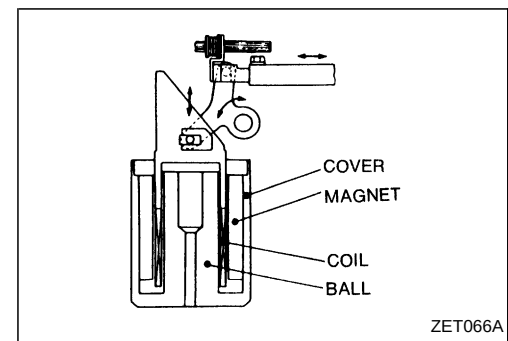
The amount of fuel injected or adjusted is performed by rotating the plunger with the control rack. This type of fuel injection or adjustment method is identical to those which are used with ordinary fuel injection pump equipped engines.



ZET065A

DC linear motor

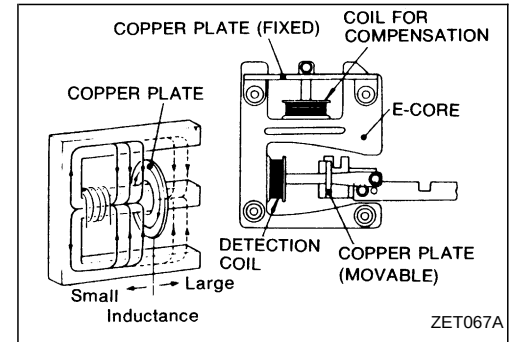
The DC linear motor consists of the cover and the coil. Operation principles of the DC linear motor is the same as that of the ordinary rotary motor. However, while an ordinary motor is in continuous rotary motion, the DC linear motor is in linear motion in the vertical direction, based on Fleming's left-hand rule.



Rack sensor

The rack sensor is a non-contact type displacement gauge. It outputs the AC (Sine wave) current from terminal OSC (Oscillate terminal) on the control unit, and detects the rack position by the MDL (Midpoint) signal generated by the change in the inductance (Self-induction) between the two coils.

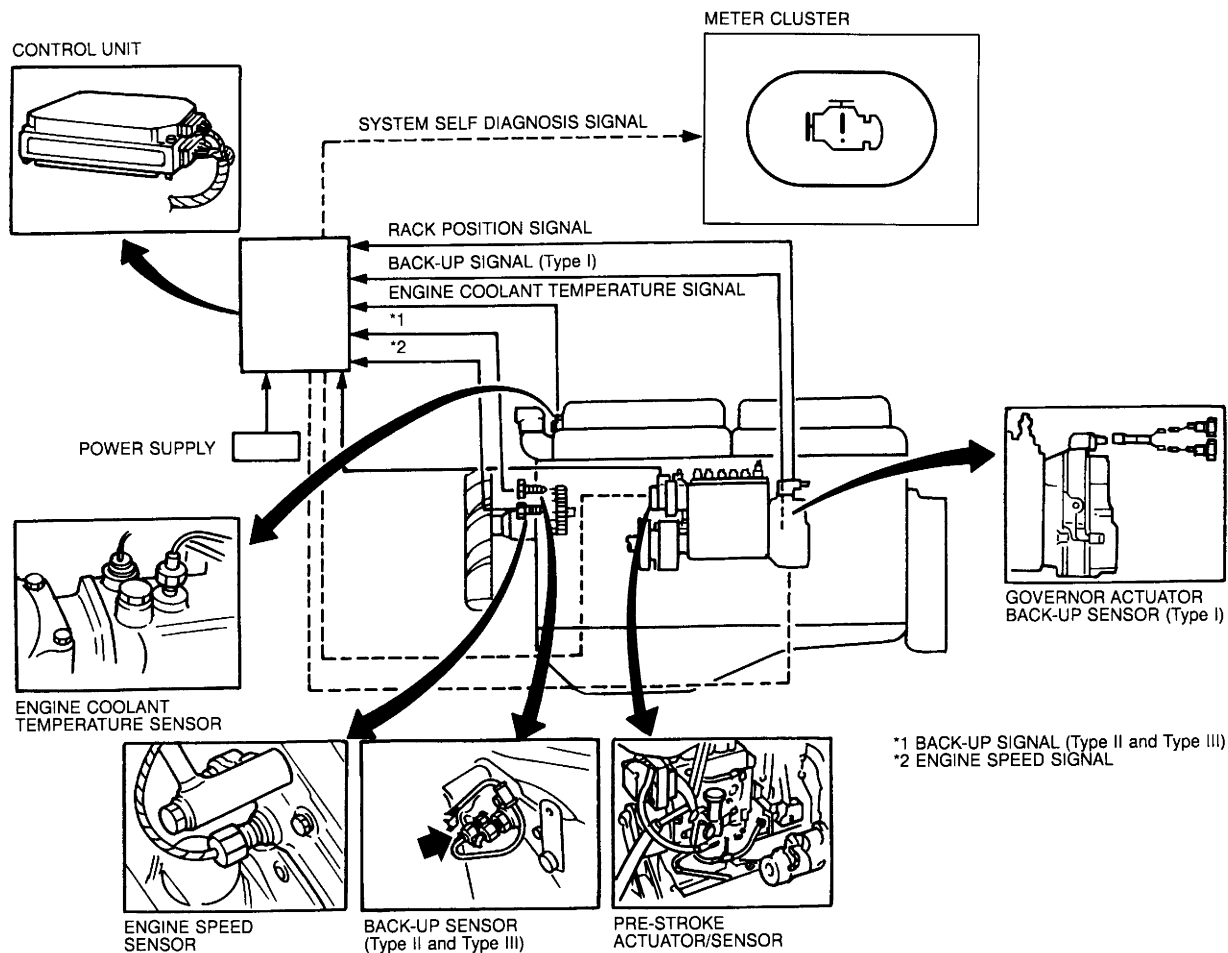
The rack sensor is equipped with a shield wire for noise prevention. The shield wire prevents the detected signals from being blocked by other signals, and sets the measuring criteria. If an open circuit or excessively high/low resistance is caused by poor contact of the shield wire connection (at the connector) or poor connection of the control unit case to the ground, an abnormal status such as engine stall may result. Therefore, the connection of the rack sensor harness and the connection between the control unit to the ground must be secure.



Pre-stroke control system (governing injection timing and fuel feed rate)

The pre-stroke control system provides a means of regulating the fuel injection timing and fuel feed rate (the amount of feed fuel) electrically. It operates in conjunction with the electronic governor system to perform control jobs.

The pre-stroke system consists essentially of a control unit, pre-stroke actuator and various sensors, warning lights, electric wiring and tubing which connect these units/parts. The pre-stroke actuator controls both fuel injection timing and fuel feed rate. There are five types of sensors — the engine speed sensor, back-up sensor, pre-stroke sensor, rack position sensor and engine coolant temperature sensor. With this system design, pre-programmed ideal fuel injection timing and fuel feed rates under varying operating conditions are compared with current engine conditions at all times, allowing the pre-stroke control system to provide optimal fuel injection rate and fuel injection timing.



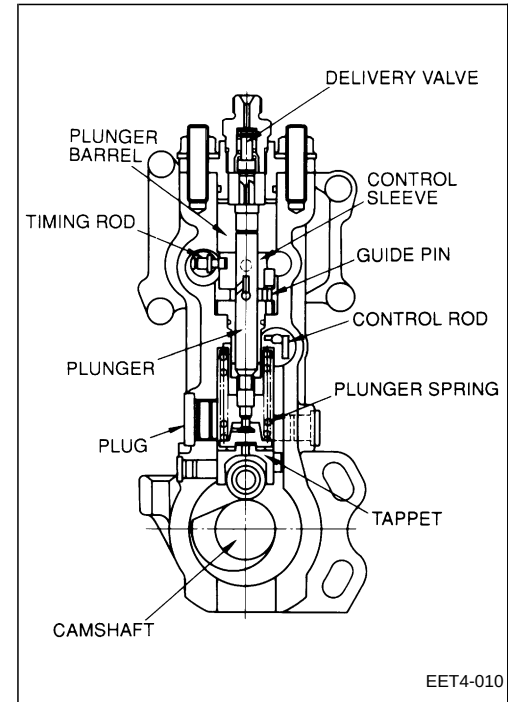
WEF490A

FUEL INJECTION RATE CONTROL

With the present type of injection pump, the pre-stroke is fixed. However, with the variable injection rate injection pump, the operating condition of the engine and control condition of the driver are detected by various sensors, and the information signal is processed by the control unit. Based on the control signal from the control unit, the control sleeve installed in the fuel chamber of the barrel portion is moved up and down by the pre-stroke actuator to change the pre-stroke and control the fuel injection rate.

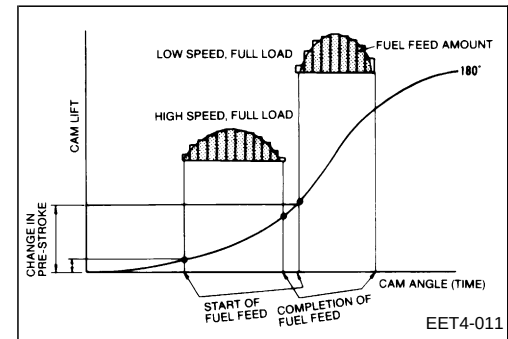
NOTE

- Hereafter in this text, from the point of explaining the action with the operation diagrams, the expression “fuel injection rate” is not used. The term “fuel feed rate” is used instead.



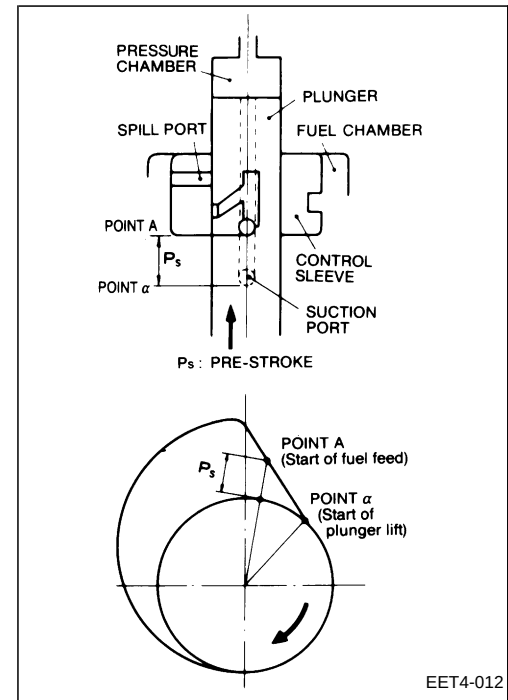
<Fuel Feed Rate (proportion of fuel supplied per unit of time)>

When supplying a fixed amount of fuel, if the feed timing is long, a smaller amount of fuel is supplied per unit time, and this gives a low fuel feed rate. On the other hand, if the feed timing is short, a larger amount of fuel is supplied per unit time, and this gives a high fuel feed rate.



<Pre-stroke>

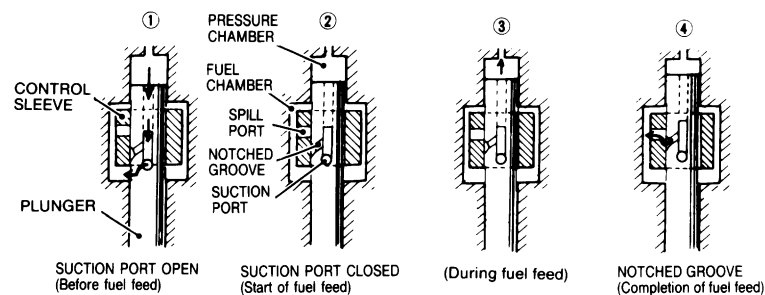
The amount of cam lift when the injection pump cam rotates and moves from the plunger lift starting point α to the fuel feed starting point A is called the pre-stroke.



PRE-STROKE CONTROL MECHANISM

<Fuel Feed Mechanism>

The operation of the fuel feed for the variable fuel feed rate injection pump is as follows.



EET4-013

1) Before fuel feed

Until the plunger rises and the suction port is blocked by the control sleeve, the fuel in the pressure chamber passes through the suction port and flows out to the fuel chamber. Therefore, the pressure in the pressure chamber does not rise.

2) Start of fuel feed

When the plunger rises further and the suction port is blocked by the bottom end of the control sleeve, the fuel feed operation starts.

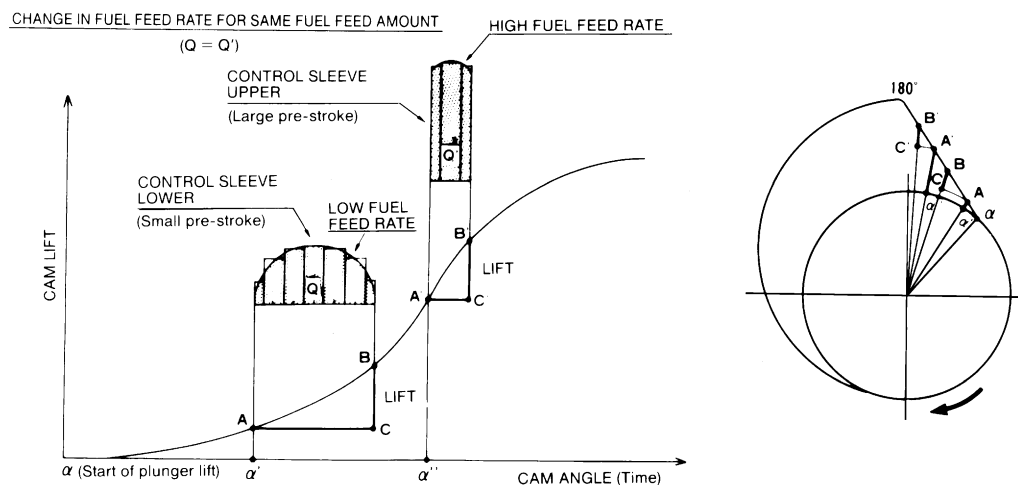
3) During fuel feed

While the suction port is between the bottom of the control sleeve and the spill port, the fuel continues to be fed.

4) Completion of fuel feed

When the suction port and the notched groove (lead) of the plunger are connected with the spill port of the control sleeve, the high pressure fuel in the pressure chamber is drained through the spill port to the fuel chamber, and this completes the fuel feed.

<Relation between Fuel Feed Rate and Position of Control Sleeve>



EET4-014

Change in fuel feed rate for same fuel feed amount

When the control sleeve is at the top, the pre-stroke is at its maximum, and as the plunger lift speed is fast, the fuel feed time can be made shorter. This means that the amount of fuel fed per unit time is larger and the fuel feed rate is higher.

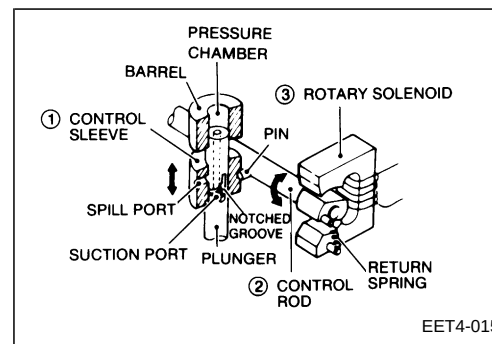
On the other hand, when the control sleeve is at the bottom, the pre-stroke is at its minimum, and as the plunger lift speed is slow, the fuel feed time is longer. This means that the amount of fuel fed per unit time is smaller and the fuel feed rate is lower.

Under normal operating conditions, for low speed, the control sleeve is at the top to give a high fuel feed rate, and at high speed, the control sleeve is moved to the bottom to prevent the fuel feed rate from becoming too high.

<Pre-stroke Control Mechanism>

The pre-stroke control mechanism consists of the following.

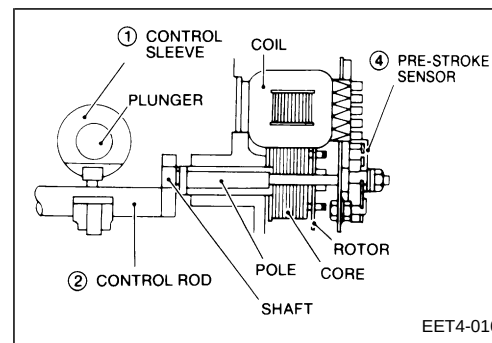
- ① The control sleeve that is moved up and down by the control rod inside the barrel
- ② The control rod that rotates and moves the control sleeve with a pin
- ③ The rotary solenoid that rotates the control rod



EET4-015

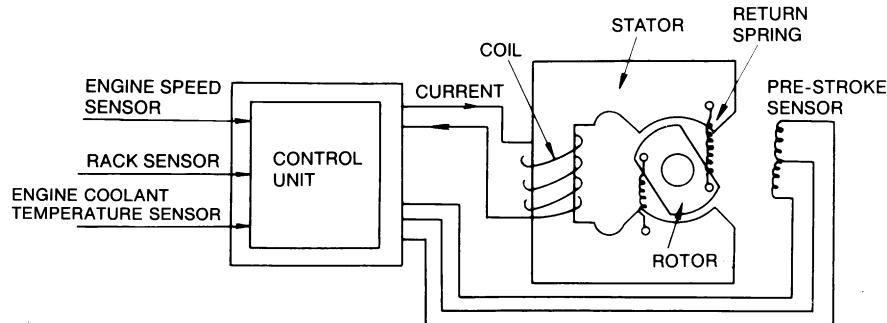
- ④ The pre-stroke sensor that always feeds back the movement of the rotary solenoid to the control unit

When the control sleeve goes up, the pre-stroke becomes larger, and when it goes down, the pre-stroke becomes smaller.



EET4-016

<Pre-stroke Actuator>



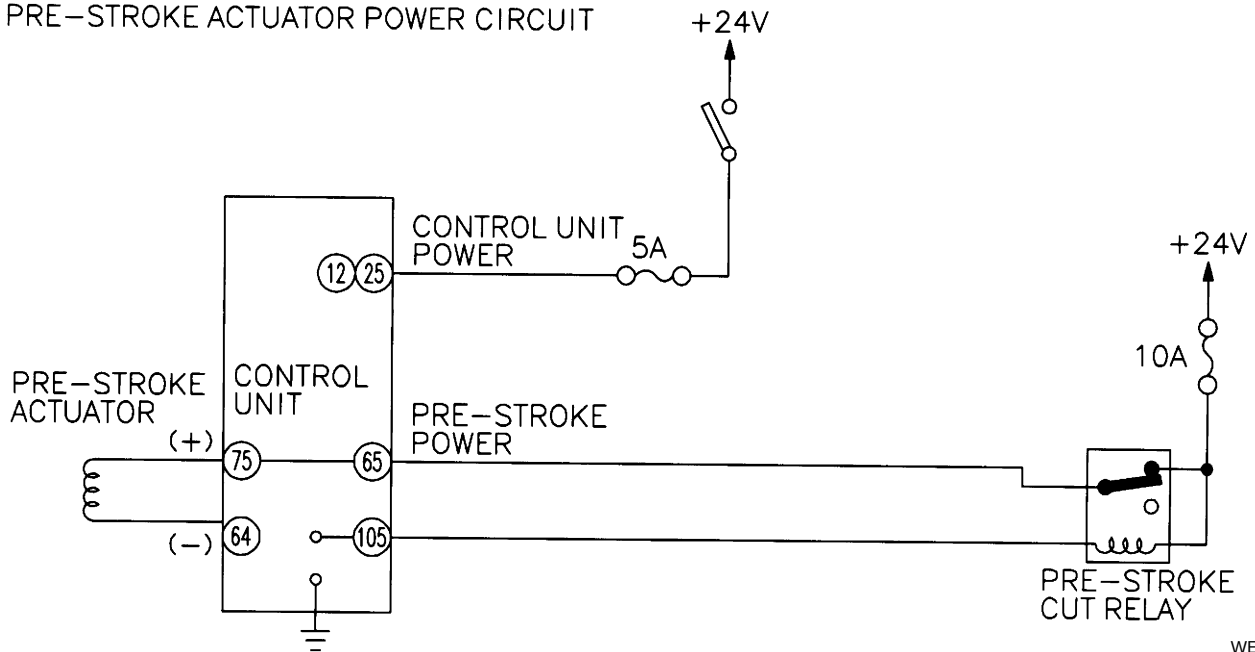
EET4-017

The pre-stroke actuator has a shape that forms three sides of a square, and consists of an iron core with a coil wound around it. A rotor is placed between the jaws of the actuator, and a magnetic force proportional to the control signal (current) from the control unit is generated by the rotary solenoid. The action of this magnetic force then causes the rotor to rotate. The control sleeve is interconnected, so it moves up or down.

<Power Circuit>

The power source for the pre-stroke actuator has a separate circuit. If there is any abnormality in the pre-stroke servo system, this circuit functions to stop the control, and at the same time it opens the pre-stroke cut relay to cut the power for the pre-stroke actuator.

PRE-STROKE ACTUATOR POWER CIRCUIT



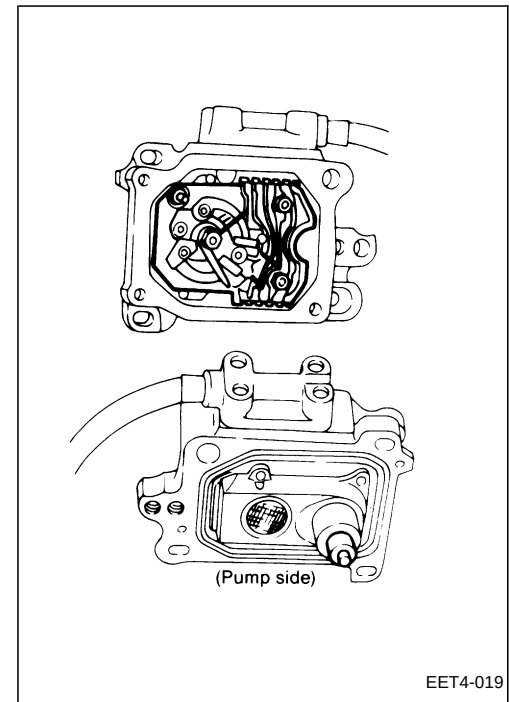
WEF255A

<Pre-stroke Sensor>

The pre-stroke sensor compares the target position sent from the control unit and detects if the pre-stroke actuator is actually in the correct position.

Like the rack sensor, it is a non-contact displacement meter, and sends out an alternating wave current (sine wave) from the OSC terminal (oscillation terminal) of the control unit. It detects the position of the pre-stroke actuator (control sleeve) from the MDL (middle) signal generated by the change in the impedance (self-induction) between the two coils, and sends this to the control unit. The pre-stroke sensor harness is equipped with a shielding wire to prevent noise.

The shielding wire acts to prevent the influence of any outside interference, thereby protecting the signal detected by the sensor; it also acts to set the measurement standard. If there is improper connection of the shielding wire (particularly at the connector), or there is improper grounding of the control unit case, this may cause disconnections or resistance (increased or reduced) which will cause abnormalities in the pre-stroke control. To prevent this, please be sure to carry out the grounding connection of the control unit and the pre-stroke sensor wiring harness properly.



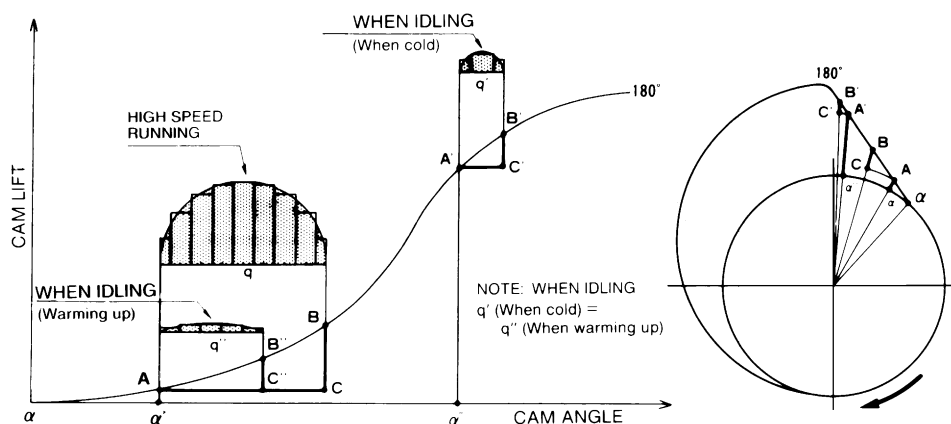
EET4-019

FUEL INJECTION TIMING CONTROL

The timing for the start of fuel injection from the variable fuel feed rate injection pump is interconnected with the control of the pre-stroke.

If the fuel feed rate is made high, the pre-stroke will become larger, so this will result in retarding the timing for the start of fuel injection; if the fuel feed rate is made low, the pre-stroke will become smaller, so this will result in advancing the timing for the start of fuel injection.

Under actual operating conditions, the fuel feed rate is set high when the engine is rotating at low speed, such as during warming-up operations, and is set low when the engine is rotating at high speed. Therefore, the timing for the start of fuel injection is also delayed when the engine speed is low and is advanced when the engine speed is high, which is more or less the same action as with the present timer. In addition, when the weather is cold, to prevent white smoke, control is carried out by the control unit in accordance with the operating condition of the engine to give the optimum fuel feed rate and timing for the start of injection.

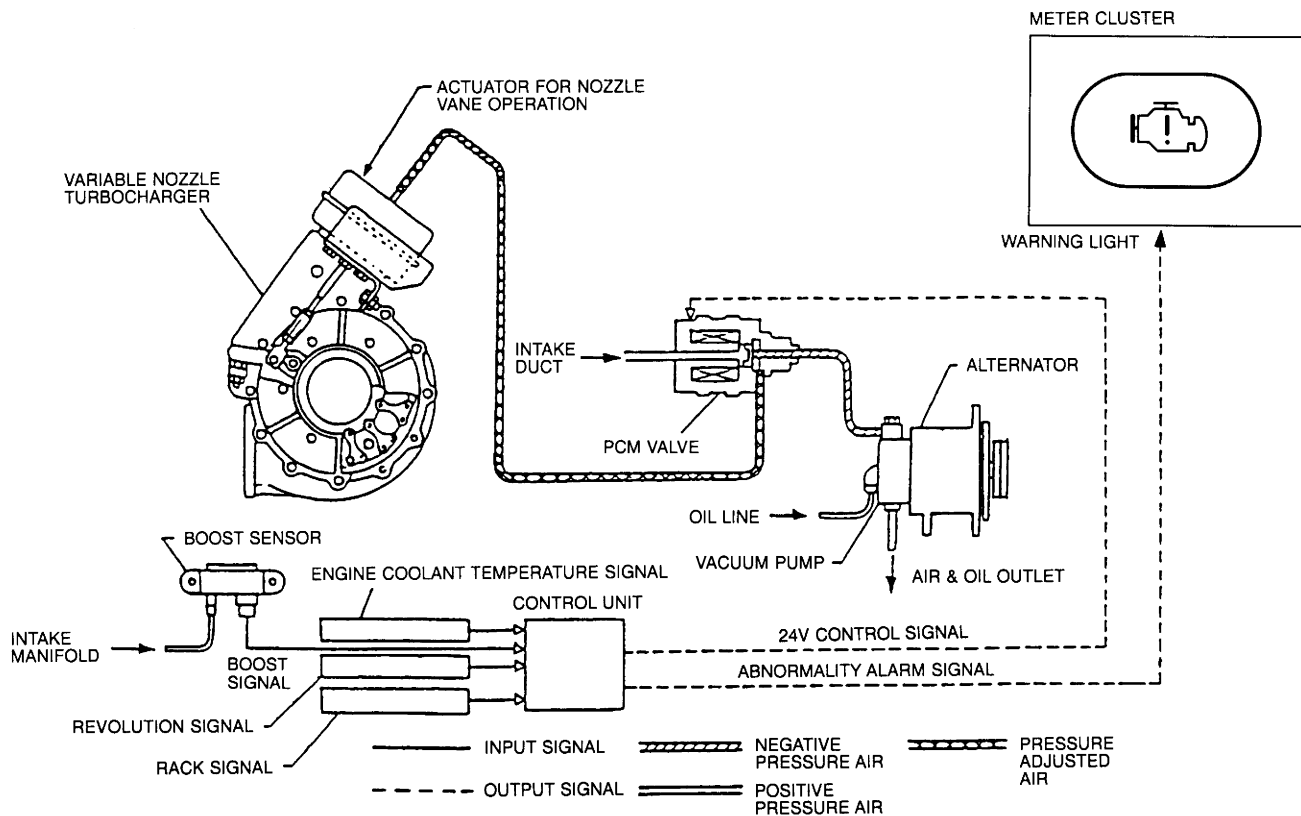


EET4-020

VNT (VARIABLE NOZZLE TURBOCHARGER) SYSTEM [TYPE I ONLY]

The electronic control variable nozzle turbocharger (VNT) system provides optimum intake air flow rate for the engine running condition. This system consists essentially of a control unit, turbocharger assembly, actuator, pressure control modulator (PCM) valve, vacuum pump, various sensors, warning lights, electrical wiring and tubing which connect these units/parts.

The turbocharger assembly has built-in vanes to control the amount of supercharged air. The actuator provides the open-close operation of the vane. The pressure control modulator (PCM) valve supplies vacuum pressure to the actuator when the vane is open. The vacuum pump generates vacuum pressure used to activate the actuator. There are five types of sensors used. They are an engine speed sensor, timing (back-up) sensor, rack position sensor, engine coolant temperature sensor and boost sensor. These sensors sense the operating condition of their respective areas of the engine and send signals to the control unit. With this system design, pre-programmed ideal supercharging characteristics under varying operating conditions are compared with current engine conditions, electronically controlling the turbocharger vane angle and providing an optimal supercharged state.



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VNT OPERATING PRINCIPLE

During low-speed and high-load operation, exhaust gases are produced in small quantities which is not enough for the turbine to rotate at fast speeds. Under this condition, the required amount of air cannot be supplied to the engine. To maintain the required amount of air, it is necessary to rotate the turbine at fast speeds with a small quantity of exhaust gases.

During high-speed and low-load operation, on the other hand, exhaust gases are produced in large quantities. Under this condition, the turbine is forced to rotate too fast so that an excess amount of air is supplied to the engine. The result is an increased "pumping loss". To solve this problem, the turbine should be made to rotate at slower speeds.

The VNT system has been designed to compensate for the problems mentioned above. Its operating principle is explained below, using a water wheel as an example.

- To rotate the water wheel (= turbine) at fast speeds, a large amount of air must be quickly drawn into the water tank. As shown in Figure A below, the outlet end of the hose is throttled by hand.

Water discharged from the outlet of the hose quickly strikes against the edge of the water vanes, one after another. The water wheel then rotates at fast speeds.

- To rotate the water wheel (= turbine) at slow speeds, a small amount of air must be drawn into the water tank. As shown in Figure B below, the outlet end of the hose is not throttled.

Water discharged from the outlet end slowly strikes against the edge of the water vanes, one after another. The water wheel then rotates at slow speeds.

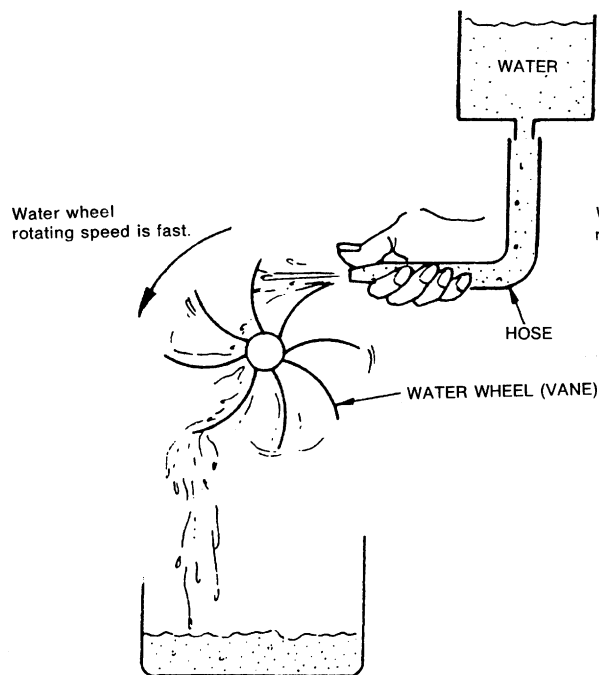


Figure A - Water makes the water wheel rotate at fast speeds

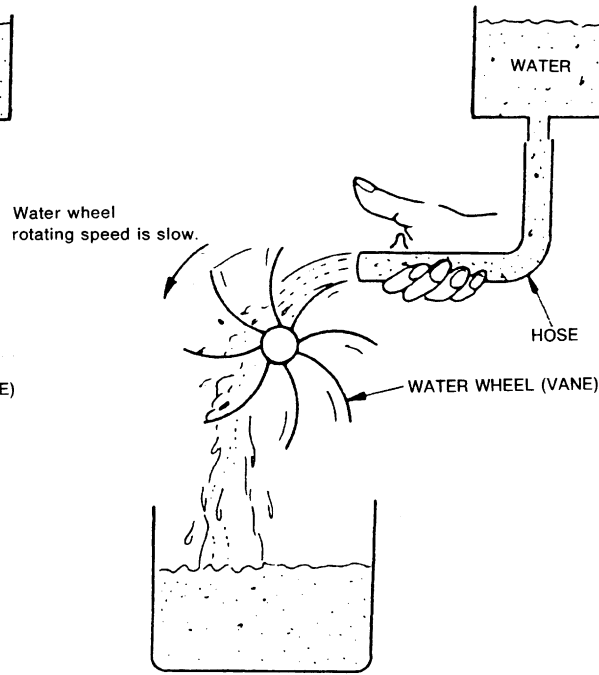
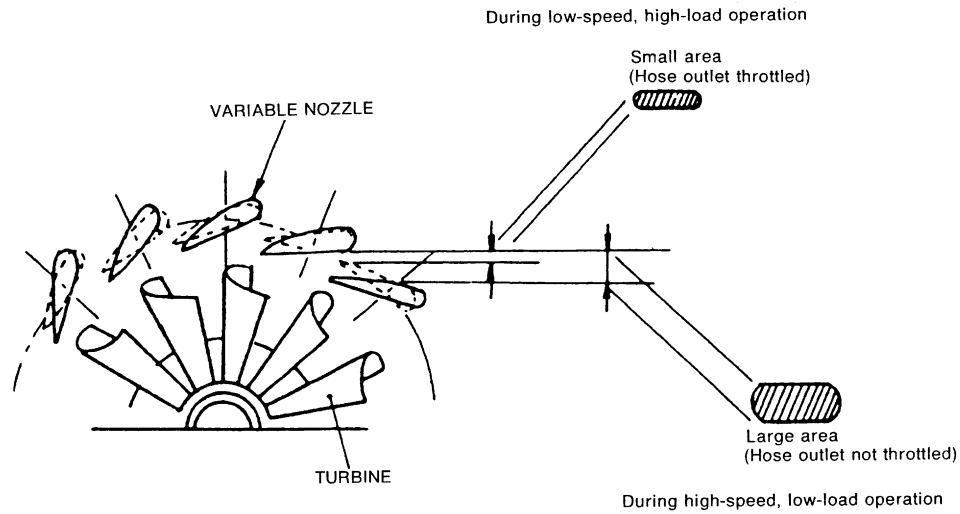


Figure B - Water makes the water wheel rotate at slow speeds

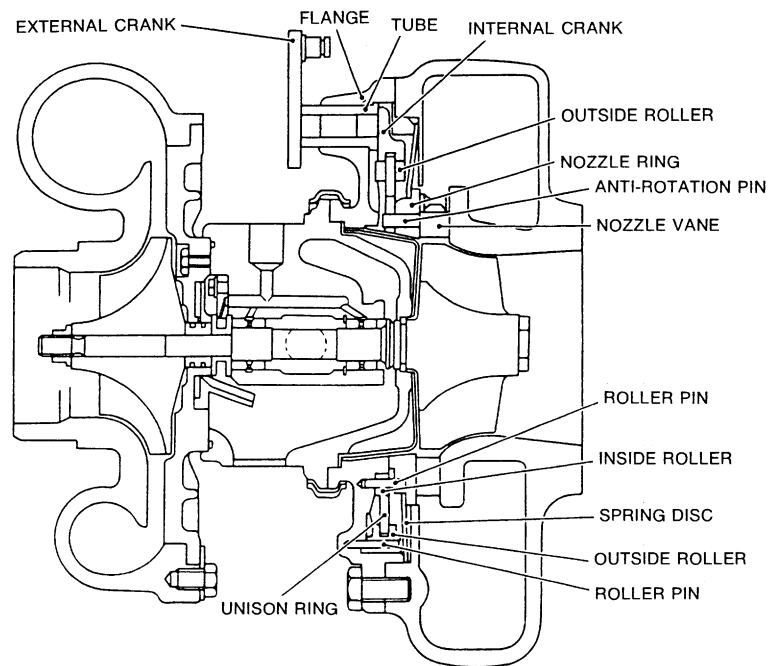
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*: Refers to a resistance loss that is caused during exhaust gas discharge/intake air supply. In other words, the greater the air supplied by the turbocharger, the greater the pumping loss.



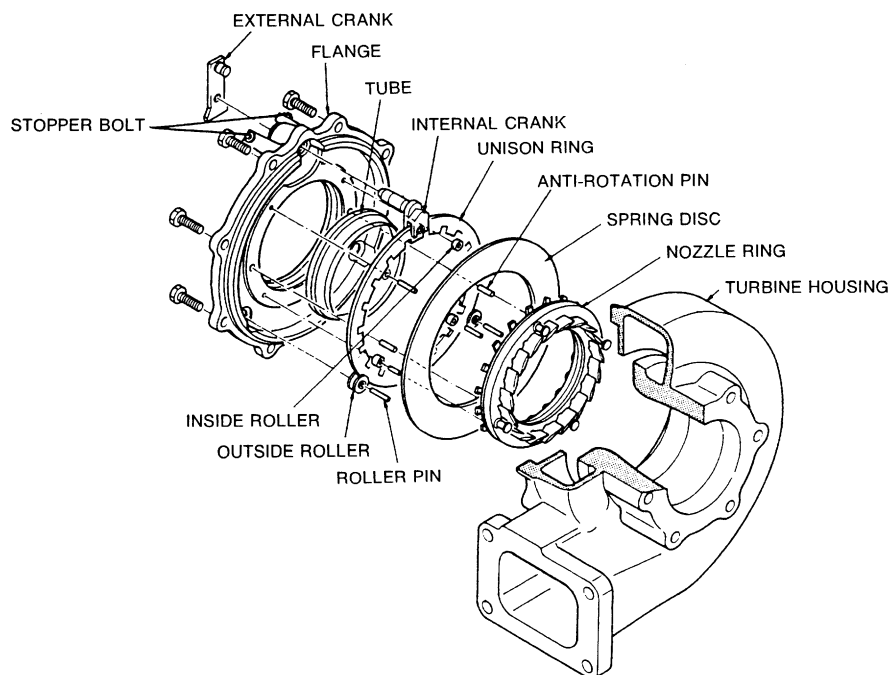
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Cross-sectional view of the turbocharger



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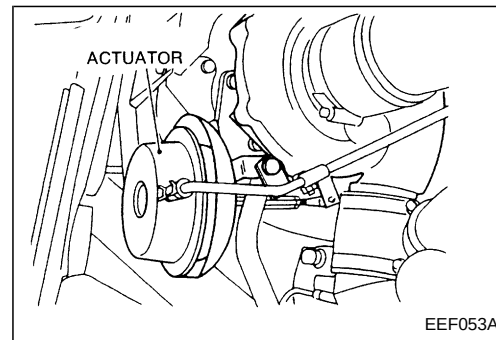
Disassembled view of the turbocharger



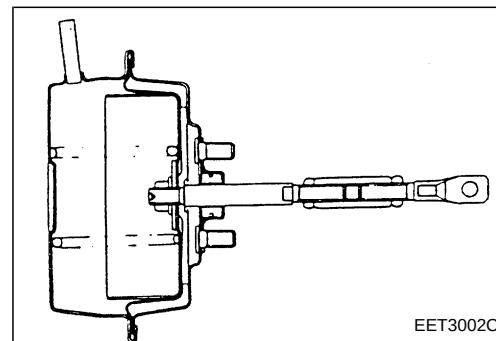
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Actuator

The actuator is a critical part that directly controls the turbocharger vanes. It uses a highly reliable diaphragm.

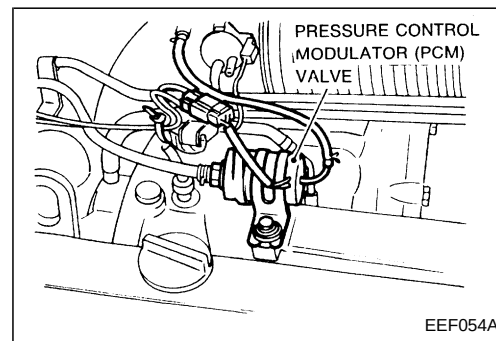


A turnbuckle is installed in the middle portion of the actuator rod. Its design makes it possible to adjust the turbocharger external crank position.



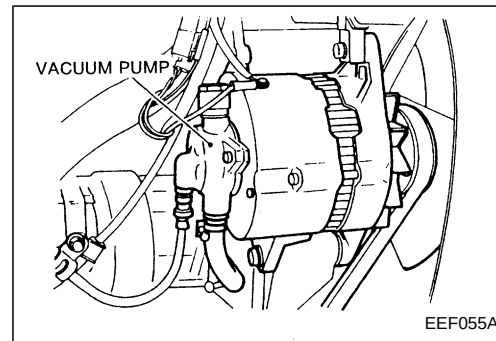
PCM (Pressure control modulator) valve

The PCM valve controls the negative pressure from the vacuum pump according to the control signals from the control unit. By controlling the intensity of negative pressure working on the actuator, it controls the actuator rod movement.



Vacuum pump

The vacuum pump is a vane type and is located on the rear end of the alternator. It generates the negative pressure that operates the actuator. The vacuum pump is force-fed by lubrication oil from the engine.



EMERGENCY DRIVING (LIMP FORM) FUNCTION

If the engine control warning light flashes and the engine stops, for example, at a railroad crossing or on a freeway, the vehicle must be moved to a safe spot immediately. The emergency driving system allows the engine to start temporarily when the vehicle is immobilized, making it possible to move the vehicle to a safe spot.

NOTE

- **Note that the emergency driving system activates only when the governor servo system or the control rack sensor system is malfunctioning.**

Emergency driving system operational procedures

1. If the engine control warning light flashes and the engine stops, turn the key to the OFF position. Try to start the engine by turning the key to the START position.
2. If the engine still fails to start (Error 1-1 and/or 1-3), depress the accelerator pedal all the way to the floor with the key set to the ON position, then turn the key to the START position.
3. After starting the engine, drive the vehicle to a safe spot.

NOTE

- **Do not drive the vehicle for an extended period of time in the emergency driving mode since the engine is operating erroneously.**
 - **The vehicle may be driven from idling to 1500 rpm in the emergency driving mode.**
 - **Note that more black smoke will be emitted than under normal circumstances in the emergency driving mode.**
4. Drive the vehicle to a safe spot and stop the engine as soon as possible.

Emergency driving system operation

When the engine is stopped using the engine stop switch and the key is not turned to the OFF position with the accelerator pedal depressed all the way to the floor and the key is then turned to the START position, the engine will start in the emergency driving mode. Under this condition, however, the vehicle cannot be driven.

Emergency driving system release procedures

If the emergency driving system is activated accidentally, immediately turn the key to the OFF position which stops the engine or grounds the diagnostic switch.

SELF-DIAGNOSTIC FUNCTION

The self-diagnostic system provides a means of checking the operation of respective systems/units of the engine and sending a signal corresponding to a malfunctioning system/unit. This system also has a function of retaining past problems in memory. These are indicated by illumination of the engine coolant warning light.

Diagnostic result memory

The diagnostic result memory function permits the retention of past problems. These problems can be recalled and identified by the number of engine coolant warning light flashes unless they have been erased using the specified erasure procedure.

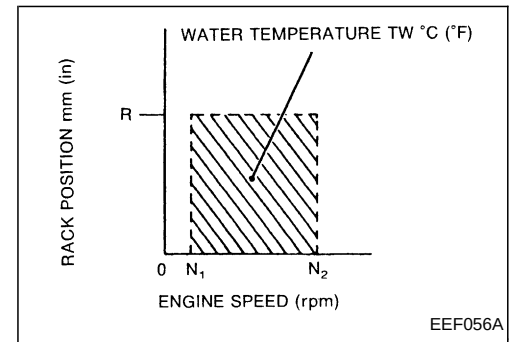
ADDITIONAL FUNCTIONS

ADDITIONAL FUNCTIONS

WHITE-SMOKE REDUCTION DURING WARM-UP

The white-smoke reduction function provides a means of reducing white smoke during starts or warm-up. When the engine coolant temperature is lower than the specified level, the turbocharger actuator closes the nozzle vane completely (duty ratio: 100%), reducing white-smoke emission to a minimum.

N_1	200 rpm
N_2	503 rpm
Control rack position R	10.65 mm (0.4193 in)
Engine coolant temperature TW	10°C (50°F) or less



OVERRUNNING PREVENTION FUNCTION

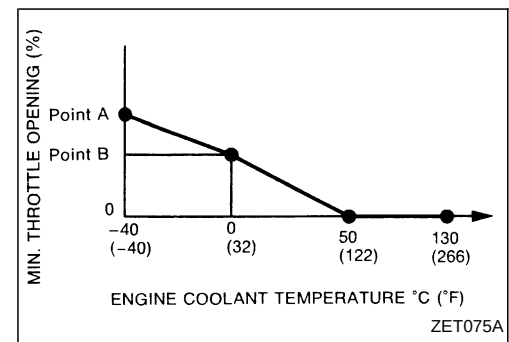
The overrunning prevention function fixes the rack position to 0 mm (0 in) to prevent the overrunning of the engine (excessive rotation) when the engine speed N_e exceeds the specification.

Unit: rpm

Operating point	2,900
Recovery point	2,750

AUTOMATIC ENGINE SPEED CONTROL FUNCTION

A minimal throttle position is determined in response to the engine coolant temperature during idling.



AUTOMATIC ENGINE SPEED ADJUSTING FUNCTION

The automatic engine speed adjustment function permits the selection and setting of optional idle speeds as required in the specified auto idle speed range.

Automatic engine speed adjustment procedure

1. Set the automatic idle adjusting harness (99731 Z0009) to the terminal ② (idle set switch) working from behind the control unit connector in advance.
2. Ground the diagnosis switch to the body (dealer mode status) using the diagnosis check harness (99731 Z0007). Within 5 seconds, ground the automatic idle adjusting harness set in step 1) to the body using the diagnosis reset check harness (99731 Z0008). The idle volume is switched from the normal mode to the target engine speed adjusting volume of the automatic idling.
3. In this status, adjust any engine speed in the manual area of the volume and disconnect terminal ② from the ground. The engine speed at this time is recorded in the control unit to return the idle volume to the normal mode.

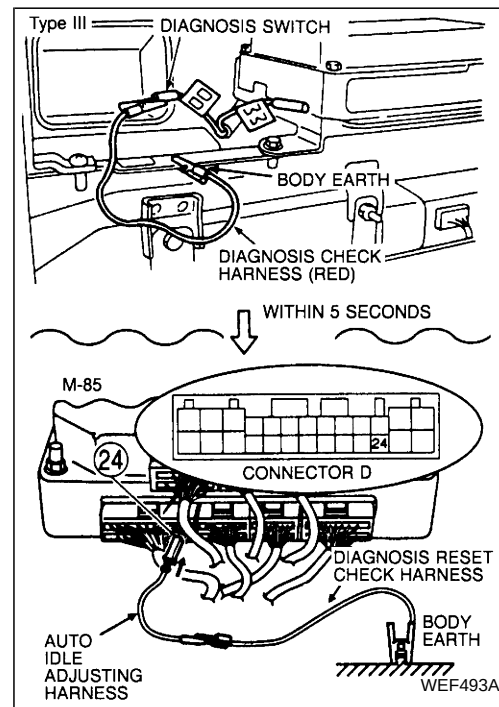
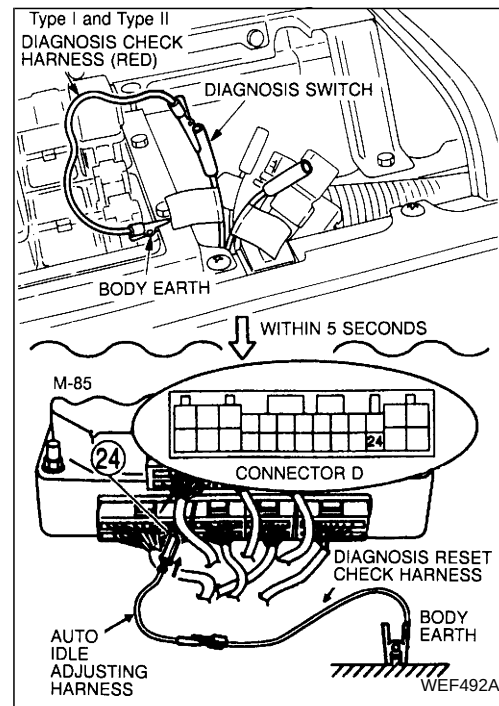
If the idle volume operation is performed in the automatic area, it resumes the initial basic engine speed.

When the setting operation of the idle volume is performed while the idle volume system error occurs (diagnostic trouble code: 3-1), it resumes the initial basic engine speed.

Unit: rpm

Item	Automatic engine speed adjusting range	Basic engine speed
Type I	430 - 530	480
Type II		
Type III	550 - 570	560

4. After procedures 1. and 2. have been completed, turn the ignition key to OFF.
5. When the vehicle restarts, the automatic engine speed control is operated based on the newly recorded engine speed.

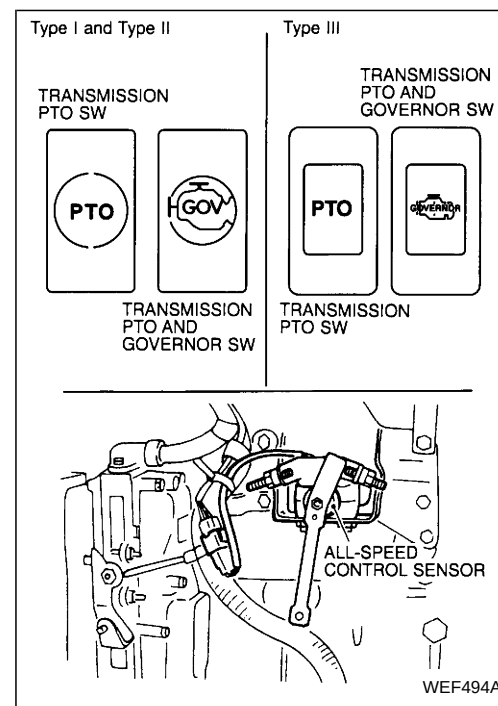


ALL-SPEED GOVERNOR SELECT FUNCTION

This function provides a means of setting governor characteristics in the all-speed control mode when the PTO (power takeoff) is in operation.

<Governor control characteristic select procedures>

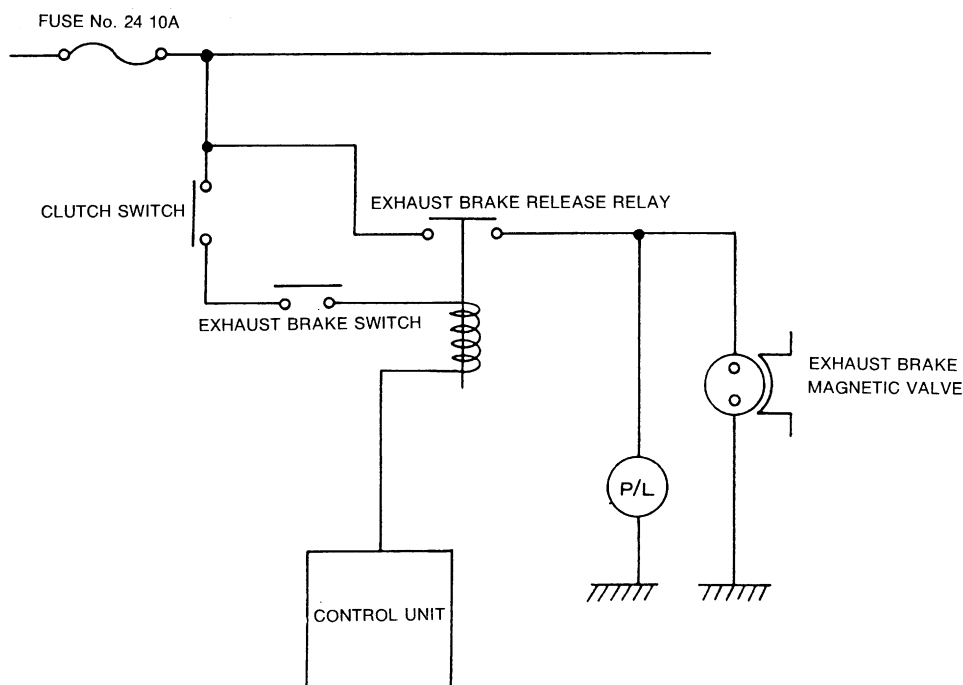
An accelerator sensor signal voltage is switched to an all-speed sensor signal voltage and, at the same time, changes governor control characteristics. This is accomplished by means of the PTO switch.



EXHAUST BRAKE RELEASE FUNCTION

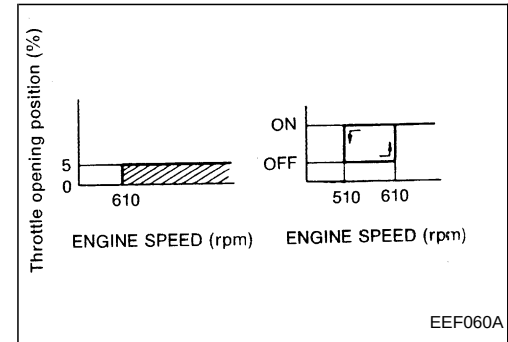
This function generates the control signal for releasing the exhaust brake according to the engine load and engine revolution conditions.

Exhaust brake system



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The exhaust brake release system is not provided with an exhaust brake acceleration switch. When the exhaust brake switch (located within reach of the driver) is ON, the control unit automatically provides the on-off operation of the exhaust brake release system provided that engine throttle opening position is 4% or less and engine speed is greater than 510 rpm.



RESPONSE TO ABNORMAL STATUS

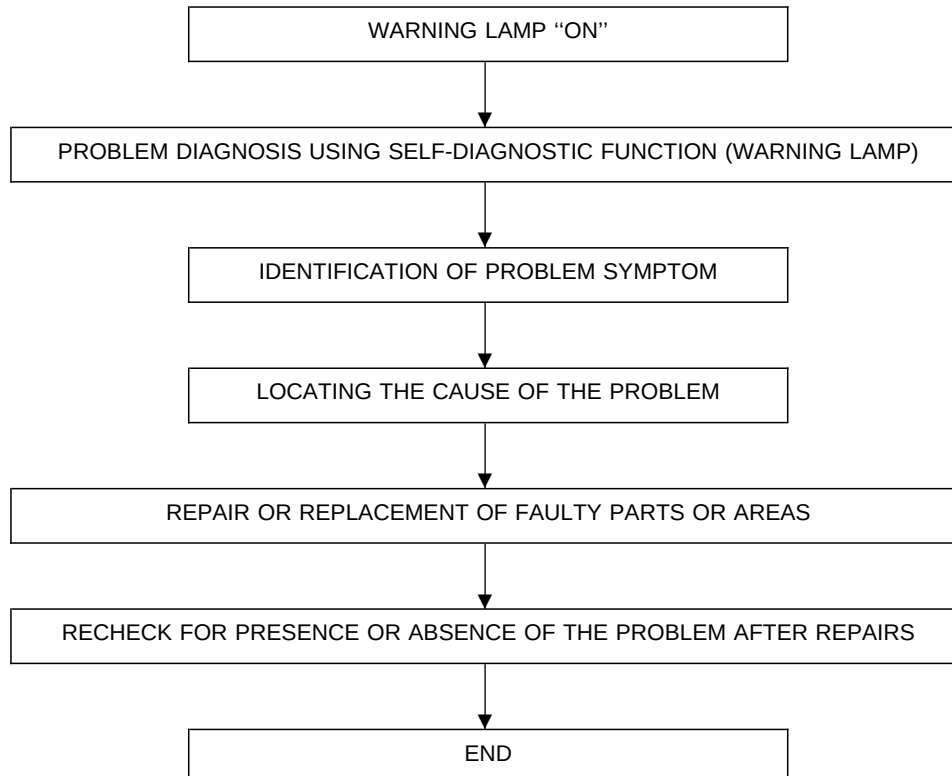
SELF-DIAGNOSTIC SYSTEM

The self-diagnostic system checks for the presence or absence of abnormalities in various systems/units of the engine, based on signals sent from various sensors. If a problem is detected, the warning light located in the cluster meter area lights to indicate that a system or unit is malfunctioning.

The designed to operate safety so that no undue stress is imposed upon the engine when problems occur in the engine. It is equipped with a back-up system which utilizes alternate signals, making it possible to drive the vehicle in a manner similar to normal driving.

REMEDIAL PROCEDURES

To service the system, follow the remedial procedures listed below.



CHECKING THE ELECTRONIC CONTROL SYSTEM ERROR

Check the electronic control system error with the number and intervals of flashes of the engine control warning light and the engine coolant warning light on the gauges in the instrument cluster. The flashing of the engine control warning light and the engine coolant warning light varies with grounding and opening of the diagnosis switch to or from the body.

Normally, checking the electronic control system error is performed with these 2 warning lights open (user mode). Though the driver can check the system error of the electronic control in this status, checking it with the diagnosis switch shorted (dealer mode) is recommended in order to determine the abnormality more accurately. If the diagnosis switch is shorted, the present diagnostic trouble code is indicated by the engine control warning light, and the past diagnostic trouble code is indicated by the engine coolant warning light.

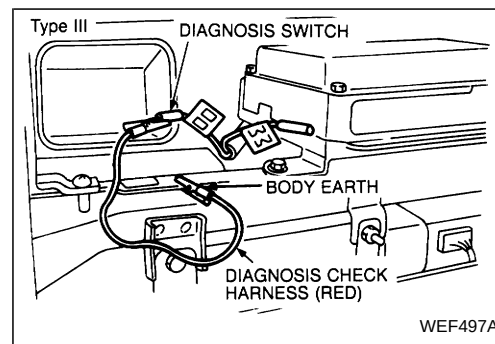
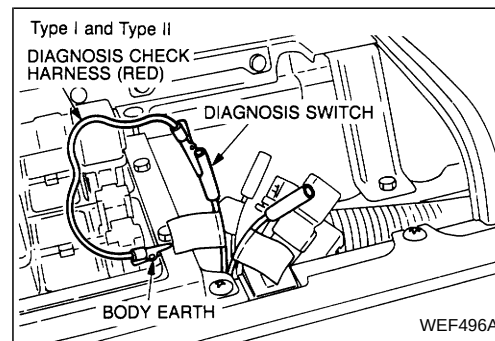
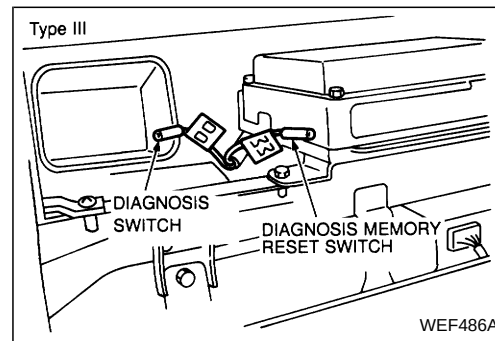
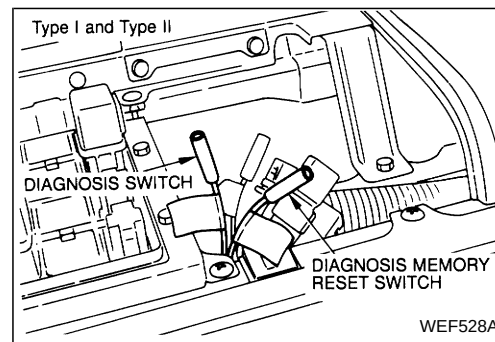
	Trouble status		Error indication	
	Present	Past	Engine control warning light	Engine coolant warning light
User mode (Diagnosis switch open status)	Normal	Normal	OFF	Engine coolant warning light function
	Normal	Trouble	OFF	
	Trouble	Normal	ON or flashing	
	Trouble	Trouble	ON or flashing	
Dealer mode (Diagnosis switch shorted status)	Normal	Normal	Normal code	OFF
	Normal	Trouble	Normal code	Past code
	Trouble	Normal	Present code	OFF
	Trouble	Trouble	Present code	Past code

TROUBLE CODE (MORSE CODE) INDICATION PROCEDURES

1. Connect the diagnostic check harness (99731 Z0007) to the diagnostic switch.
2. Connect the open end of the diagnostic check harness to ground.

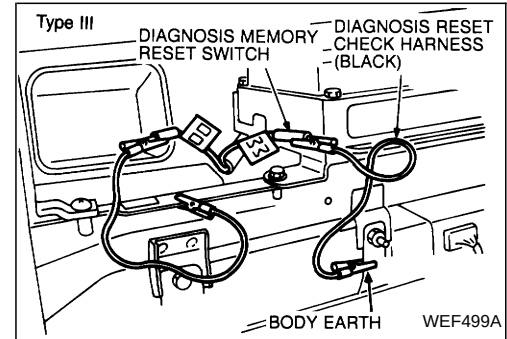
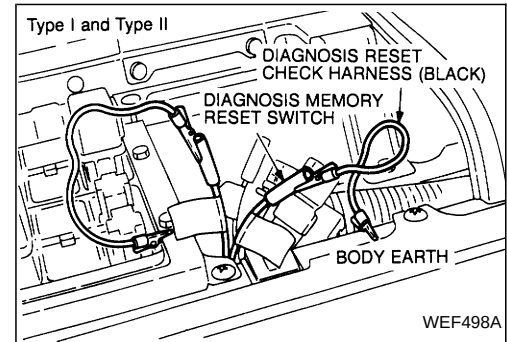
The way the diagnosis switch is shorted to ground is referred to as the dealer mode.

Current trouble codes are indicated by the number of engine control warning light flashes while trouble codes experienced in the past are indicated by the number of engine coolant warning light flashes.



TROUBLE CODE ERASURE PROCEDURES

1. Connect the diagnostic reset check harness (99731 Z0008) to the diagnostic memory reset switch in the dealer mode.
2. Connect the open end of the diagnostic reset check harness to ground. In this manner, trouble codes retained in memory will be erased.



HOW TO READ DIAGNOSTIC TROUBLE CODE

Check the diagnostic trouble code by the flashing light (Morse code) [Refer to "How to display diagnostic trouble code (Morse signal) (Page EF-6-37)" for confirmation].

Flashing patterns of the warning light are read as follows.

1. The warning light begins to flash (Morse code) 2.4 seconds after the electronic control system determines the problem.
2. The code number indicates the number of flashes.

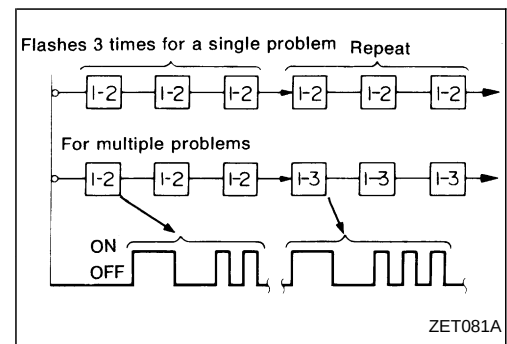
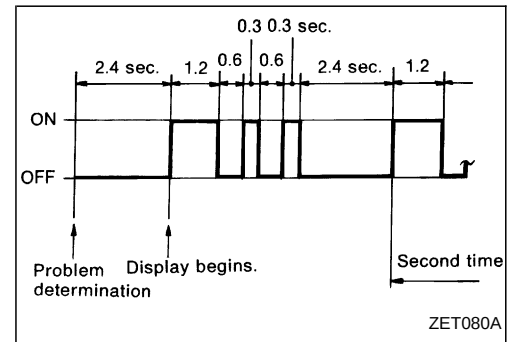
Duration:

First number (second digit): ON for 1.2 seconds, OFF for 0.6 second.

Last number (first digit): ON for 0.3 second, OFF for 0.6 second.

Mode interval: OFF for 2.4 seconds.

3. The warning light flashes 3 times for one diagnostic trouble code. After that, another diagnostic trouble code is displayed. When there is no diagnostic trouble code, the first diagnostic trouble code is displayed.



DIAGNOSIS

When any errors are found in the electronic control system, identify which system has the error and the cause of the error through the following diagnosis.

DIAGNOSIS USING WARNING LIGHT (INCLUDING DIAGNOSIS MEMORY)

Ground the diagnosis switch (dealer mode) to perform diagnosis using warning light. Errors are indicated by flashes (Morse code). When the diagnosis switch circuit is open (user mode), errors can be roughly indicated by light ON, light flash, or light OFF.

The diagnosis must be done with engine running.

Error indication		Error	Cause	Backup function	Return ability	Remarks
User mode (open)	Dealer mode (short)					
Light OFF	0 - 1	Normal	—	—	—	During engine operation
Light ON	0 - 1		—	—	—	During engine off
Light OFF	Light OFF	Power voltage is abnormal	Low battery voltage Fuse is blown	—	Equipped	Engine does not start

Diagnosis of sensor system

Error indication		Error	Cause	Backup function	Return ability	Remarks
User mode (open)	Dealer mode (short)					
Light ON	1 - 3	Rack sensor system	Rack voltage is below 0.5V or above 4.5V	Electronic governor: stop engine Prestroke: fix rack position VNT: PCM valve OFF (vane full open) [Type I only]	Not equipped	Driving is possible in limp home mode
Light flash	1 - 4	Timing (back-up) sensor system	The pulse number of timing (back-up) sensor is less than the pulse number of engine speed sensor	Electronic governor: Normal control	Equipped	No pulse or short circuit of the sensor
Light flash	1 - 6		Circuit resistance including harness is above 10 kΩ			Open circuit of sensor system, not detected during engine operation
Light flash	1 - 5	Engine speed sensor system	The pulse number of timing (back-up) sensor is less than the pulse number of engine speed sensor	Electronic governor: Normal control by calculating engine speed with backup sensor	Equipped	No pulse or short circuit of the sensor, one engine revolution per 6 pulses
Light flash	1 - 7		Circuit resistance including harness is above 10kΩ			Open circuit of sensor system, not detected during engine operation
Light flash	2 - 1	Engine coolant temperature sensor system	Sensor voltage is below 0.1V or above 4.88V	Control by fixing engine coolant temperature at 80°C (176°F)	Equipped	
Light flash	2 - 2	All-speed sensor system	Sensor voltage is below 0.1V or above 4.65V	Run by constant acceleration (roughly equal to idling)	Not equipped	Detect during PTO operation

Error indication		Error	Cause	Backup function	Return ability	Remarks
User mode (open)	Dealer mode (short)					
Light flash	2 - 3	Acceleration sensor system	Sensor output is below 0.7V even with idle switch OFF	Control only by acceleration sensor disregarding idle switch	Equipped	Detect when PTO is not operating
Light flash	2 - 4		Sensor voltage is below 0.1V or above 4.65V	Electronic governor: Accelerator opening angle is fixed at 0% with idle switch ON, and gradually increased to 1,000 rpm with idle switch OFF		
Light flash	4 - 4		Sensor voltage is above 1.4V even with idle switch ON			
Light flash	3 - 1	Idle volume system	Idle volume voltage is below 0.1V or above 4.65V	Control by fixing at the automatic idle	Equipped	
Light flash	3 - 2	Boost pressure sensor system	Boost pressure sensor voltage is below 0.1V or above 4.9V	Control by fixing boost pressure sensor voltage at 0V	Equipped	
Light flash	3 - 4	Q-adjustment resistance system	Resistance system voltage is below 0.1V or above 4.7V	Control by fixing the Q-adjustment resistance at No. 50 <standard> among 15 levels	Equipped	
Light flash	3 - 5	Pre-stroke sensor system	Pre-stroke sensor voltage is below 0.8V or above 3.4V	Electronic governor: restrict the maximum rack position Pre-stroke control: cut off pre-stroke power by pre-stroke cut relay (stop control)	Equipped	
Light flash	4 - 5	No pulse generated at startup	No pulse generated from engine speed and timing (back-up) sensors with start switch ON for more than 2.5 seconds	Engine stop (stop control)	Equipped	
Light flash	3 - 8	Atmospheric pressure sensor system	Atmospheric pressure sensor voltage is below 0.1V or above 4.9V	Control by fixing atmospheric pressure sensor voltage at 0V	Equipped	

Diagnosis of control system

Error indication		Error	Cause	Backup function	Return ability	Remarks
User mode (open)	Dealer mode (short)					
Light ON	1 - 1	Governor servo system	Gap between target and actual rack positions is 1mm (0.04 in) or more	Electronic governor: stop engine Pre-stroke control: fix rack position VNT control: PCM valve OFF (vane full open) [Type I only]	Not equipped	Driving is possible in limp home mode
Light flash	1 - 2	Pre-stroke servo system	Gap between target and actual pre-stroke is more than 0.204V	Electronic governor: restrict the maximum rack position Pre-stroke control: cut off pre-stroke power by pre-stroke cut relay (stop control)	Not equipped	Not detected when pre-stroke sensor is abnormal
	3 - 6	Pre-stroke learning function	Pre-stroke sensor voltage is below 0.94V or above 1.51V	Control assuming that pre-stroke sensor output characteristics is ideal		
	3 - 7	Pre-stroke power voltage system	Pre-stroke power voltage is below 1.6V	Electronic governor: restrict the maximum rack position Pre-stroke control: stop control	Equipped	Not detected power cut when pre-stroke cut relay is operating
Light flash	4 - 1	VNT control system (over boost) [Type I only]	Actual boost pressure is greater than the target by more than 15.6 kPa {117 mmHg, 4.61 inHg}	Electronic governor: restrict the maximum rack position VNT control: PCM valve OFF (vane full open)	Equipped	Not detect in either of the following status ① Ne 2,200 rpm Ne < 900 rpm ② Rack position ≤11 mm (0.43 in) ③ At idling (duty ratio 0% or 100%) ④ When boost pressure sensor system error is detected ⑤ When rack sensor system error is detected
Light flash			When boost pressure is above 180.0 kPa {1,350 mmHg, 53.15 inHg} with 1,300 rpm < Ne < 2,200 rpm			
Light flash	4 - 2	VNT control system (under boost) [Type I only]	When actual boost pressure is smaller than the target by less than 15.6 kPa {117 mmHg, 4.61 inHg}	Control by fixing boost pressure sensor voltage at 0V VNT control: PCM valve OFF (vane full open)		
Light flash			When either of the following status ① or ② repeats and returns more than five times ① Target boost pressure 53.3 kPa {400 mmHg, 15.75 inHg} ② Actual boost pressure < 26.7 kPa {200 mmHg, 7.87 inHg} continues more than five seconds			

- When any trouble occurs with engine stopped in the user mode, light will flash at the same time that diagnosis starts.
- When return ability is equipped, indication will return to the normal status by itself, and when it is not equipped, trouble will not return by itself and back-up will function.

ERROR INDICATION AND KEY POSITION

Refer to the following chart to start diagnosis. Diagnosis is not possible if the key position is not proper.

○: Error indication is possible
X: Error indication is not possible

Error	Error indication code (dealer mode)	Key switch (when turning from OFF to ON)	Key switch ON after cranking	When vehicle driving
Normal	0 - 1	○	○	○
Governor servo system	1 - 1	○	○	
Pre-stroke servo system	1 - 2	○	○	○
Pre-stroke learning function	3 - 6	○	○	○
Pre-stroke power voltage system	3 - 7	○	○	○
Rack sensor system	1 - 3	○	○	○
Timing (back-up) sensor system	1 - 4	X	○	○
	1 - 6	○	X	X
Engine speed sensor system	1 - 5	X	○	○
	1 - 7	○	X	X
No pulse generated at startup	4 - 5	X	○	
Acceleration sensor system	2 - 3	○	○	○
	2 - 4	○	○	○
	4 - 4	○	○	○
All-speed sensor system	2 - 2	○	○	○
Engine coolant temperature sensor system	2 - 1	○	○	○
Idle volume system	3 - 1	○	○	○
Boost pressure sensor system	3 - 2	○	○	○
Q-adjustment resistance system	3 - 4	○	○	○
Pre-stroke sensor system	3 - 5	○	○	○
VNT control system [Type I only]	Over boost	X	X	○
	Under boost	X	X	○
Atmospheric pressure sensor system	3 - 8	○	○	○

PROBLEMS AND ACTION

This manual describes proper action for each problem in the sequence of inspection items, operation step, and operation procedures. Problems must be solved following the operation step except when the problem is visibly evident. Measurement tools and wiring diagrams must be ready in advance since they will be necessary for some actions.

1. NOTES ON HANDLING WIRING HARNESSSES	EF-6-	42
2. ABNORMAL POWER VOLTAGE, BURNT-OUT WARNING LIGHT BULB		
[LIGHT OFF]	EF-6-	43
3. ACTION FOR GOVERNOR SERVO SYSTEM ERROR		
[LIGHT ON: 1-1, 1-3]	EF-6-	48
4. ACTION FOR PRE-STROKE SERVO SYSTEM ERROR		
[LIGHT FLASH: 1-2, 3-5, 3-6, 3-7]	EF-6-	55
5. ACTION FOR BACK-UP SENSOR ERROR		
[LIGHT FLASH: 1-4, 1-6]	EF-6-	64
6. ACTION FOR ENGINE SPEED SENSOR ERROR		
[LIGHT FLASH: 1-5, 1-7]	EF-6-	70
7. ACTION FOR NO PULSE GENERATED AT STARTUP		
[LIGHT FLASH: 4-5]	EF-6-	75
8. ACTION FOR ENGINE COOLANT TEMPERATURE SENSOR ERROR		
[LIGHT FLASH: 2-1]	EF-6-	76
9. ACTION FOR ALL-SPEED SENSOR ERROR [LIGHT FLASH: 2-2]	EF-6-	79
10. ACTION FOR ACCELERATOR SENSOR ERROR		
[LIGHT FLASH: 2-3, LIGHT FLASH: 2-4, 4-4]	EF-6-	84
11. ACTION FOR ABNORMAL IDLE VOLUME [LIGHT FLASH: 3-1]	EF-6-	89
12. ACTION FOR BOOST PRESSURE SENSOR ERROR		
[LIGHT FLASH: 3-2]	EF-6-	93
13. ACTION FOR ABNORMAL Q-ADJUSTMENT RESISTANCE		
[LIGHT FLASH: 3-4]	EF-6-	96
14. ACTION FOR OVER BOOST ERROR		
[LIGHT FLASH: 4-1] (TYPE I ONLY)	EF-6-	99
15. ACTION FOR UNDER BOOST ERROR		
[LIGHT FLASH: 4-2] (TYPE I ONLY)	EF-6-	104
16. ACTION FOR ATMOSPHERIC PRESSURE SENSOR ERROR		
[LIGHT FLASH: 3-8] (TYPE II ONLY)	EF-6-	108

1. NOTES ON HANDLING WIRING HARNESSSES

Many electronic parts used in the IC (integrated circuit) in the control unit are weak against excessive voltage and current. Therefore, each system unit is not grounded to the body, but grounded in the control unit by the two-wire circuit. Be sure to follow the notes below.

Arc welding to body

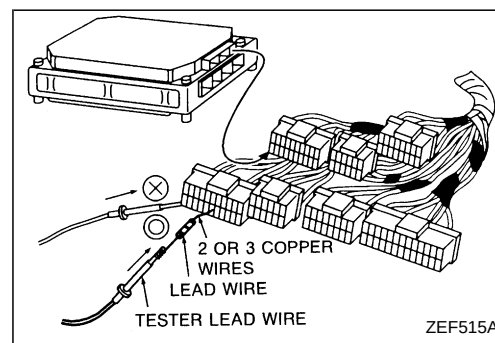
When arc welding is done for installation and so on, disconnect all harness connectors from the control unit and the minus terminal of the battery. Arc welding must be grounded to a position near the welding.

Resistance measurement and continuity confirmation at connector

When resistance is measured and continuity is confirmed in the harness connector (especially the connector for the control unit), the tester lead must not be put into the connector terminal directly. If forcing the lead to the terminal, the connector terminals (receptacle) will be widened causing poor contact. Use the check harness and lead wire to prevent this.

Measurement of power voltage and resistance

When sensor and input power are measured by the tester, the tester range has to be set within specification. Improper tester range causes control unit problems.

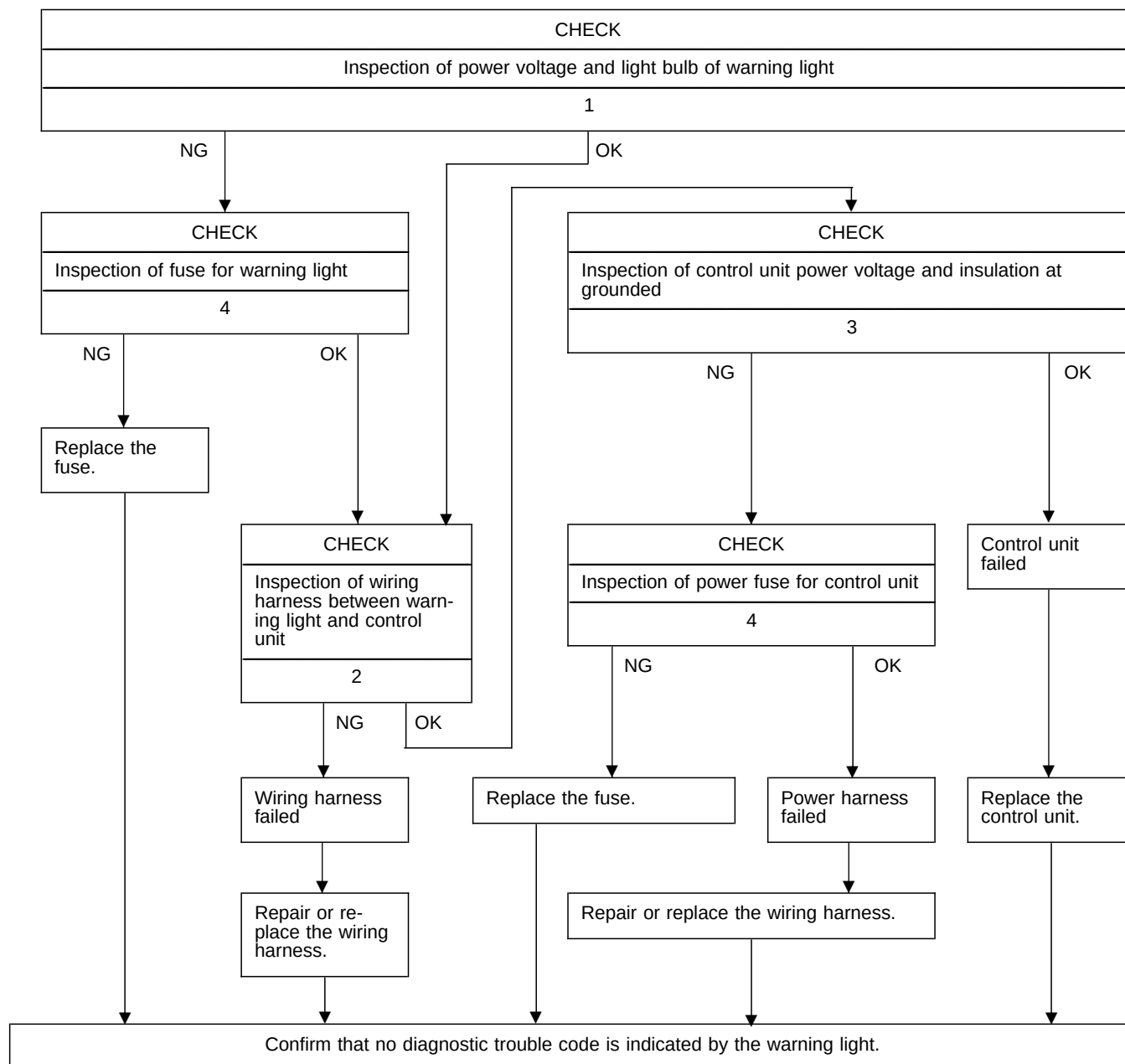


2. ABNORMAL POWER VOLTAGE, BURNT-OUT WARNING LIGHT BULB [LIGHT OFF]

[1] Inspection items

- Warning light power voltage, burnt-out bulb
- Control unit power voltage
- Fuse
- Wiring harness (open/short circuit)

[2] Operation procedure



[3] Operation procedure

CHECK 1 Inspection of power voltage and light bulb of warning light

- 1) Disconnect the connectors from the control unit. Turn the key switch to ON and measure the voltage between ⊕ terminal of the connector and the body. Check the warning light for burnt bulb.

Control unit connector No.	Terminal No.
M-93	⑤ - Body ground

NOTE

- **Voltage check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.**
- 2) Judgment
 - **Power voltage (Reference battery voltage: 20 - 28 [V])**
 - Voltage is normal. → Light bulb is normal. → Go to CHECK 2.
 - Voltage is abnormal. → Check the warning light fuse. → Go to CHECK 4.
 - Light bulb burnt. → Replace the light bulb. → Go to CHECK 4.

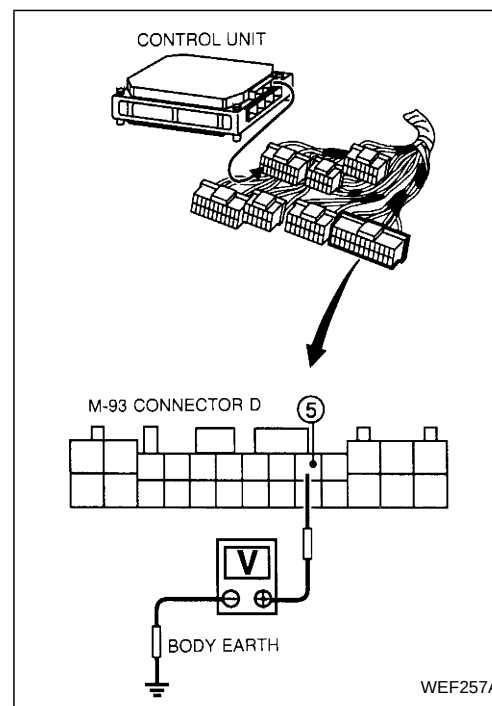
CHECK 2 Inspection of wiring harness between control unit and warning light

- 1) Check for open/short circuit between the main harness connector and the control unit connector.

Control unit		Main harness		Remarks
Connector No.	Terminal No.	Connector No.	Terminal No.	
M-93	⑤	M-55	①	RHD model (Type I and Type III)
		M-99	①	LHD model (Type I and Type II)

NOTE

- **Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.**
- **Open/short circuit in wiring harness between the fuse block and the gauge cluster connector must also be checked.**



CHECK
3

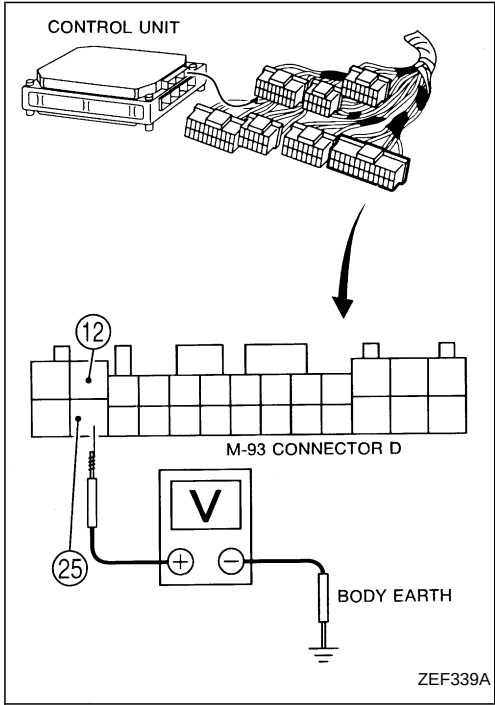
Inspection of control unit power voltage and insulation at grounded

- 1) Disconnect the connectors from the control unit. Turn the key switch to ON, and check power voltage at each connector terminal and insulation at grounded.

Control unit connector No.	Voltage check	Insulation at ground
M-88 M-93	⑫ ⑫ ⑫ } Body ground	⑬ ⑮ ⑮ ⑮ ⑮ } Body ground

NOTE

- Voltage check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.



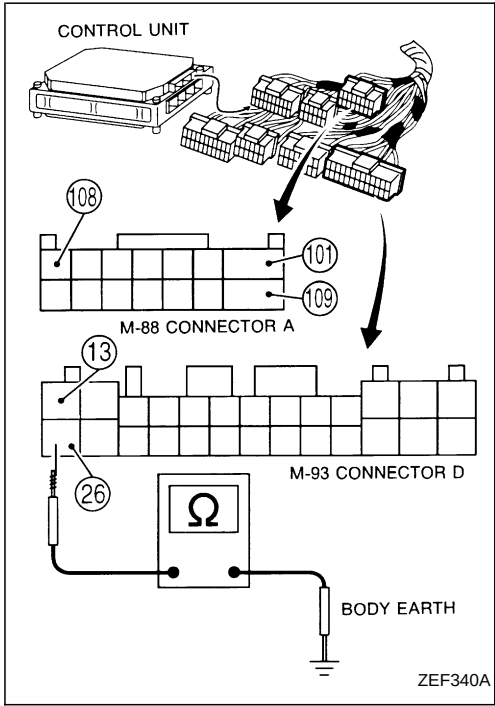
- 2) Judgment

Power voltage (Reference battery voltage: 20 - 28 [V])

- Voltage is normal. Insulation resistance at grounded part is approximately 0Ω. → Control unit failed. → Replace the control unit.
- Voltage is normal, but poor ground detected. → Open/short circuit in wiring harness between the control unit and the ground. → Repair or replace the wiring harness.
- Insulation resistance at grounded part is approximately 0Ω, but abnormal voltage is detected. → Check the power fuse for control unit CHECK 4.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.



CHECK
4

Inspection of Fuse

- 1) Inspection of power fuse for control unit
 - Check if the power fuse for control unit (No. 14 or 30) is blown. Also measure the voltage at the fuse.
- 2) Judgment

Power voltage (Reference battery voltage: 20 - 28 [V])

- Fuse is blown. Abnormal voltage is detected. → Replace the fuse. Check the battery. Check the wiring harness between the fuse and the battery and repair as necessary.
- Fuse is normal. → Open/short circuit in the power harness. → Repair or replace the wiring harness.

NOTE

- If the fuse is blown again after it is replaced, short circuit may present in the actuator circuit connected to the control unit. Check wiring harnesses in the actuator system.

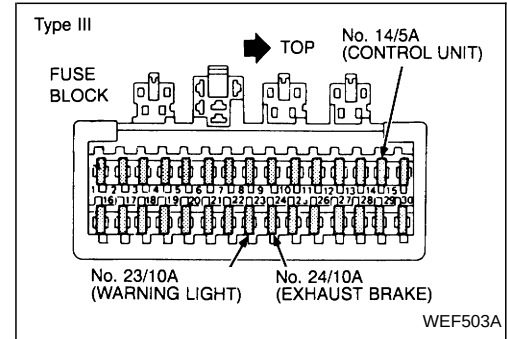
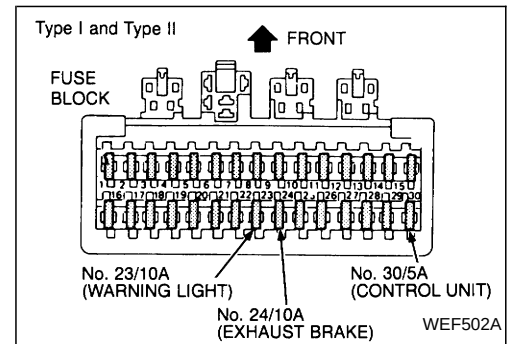
- 3) Inspection of fuse for warning light
 - Check if the fuse for warning light (No. 23) is blown. Also measure the voltage at the fuse.
- 4) Judgment

Power voltage (Reference battery voltage: 20 - 28 [V])

- Fuse is blown. Abnormal voltage is detected. → Replace the fuse. Check the battery. Check the wiring harness between the fuse and the battery and repair as necessary. → Go to CHECK
2.
- Fuse is normal. → Go to CHECK
2.

NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.



3. ACTION FOR GOVERNOR SERVO SYSTEM ERROR

[LIGHT ON: 1-1, 1-3]

The governor servo system error will be indicated when the gap between the target and actual rack positions is large. Therefore, the troubleshooting procedure is divided into two ways: troubleshooting for actuator system and troubleshooting for sensor system.

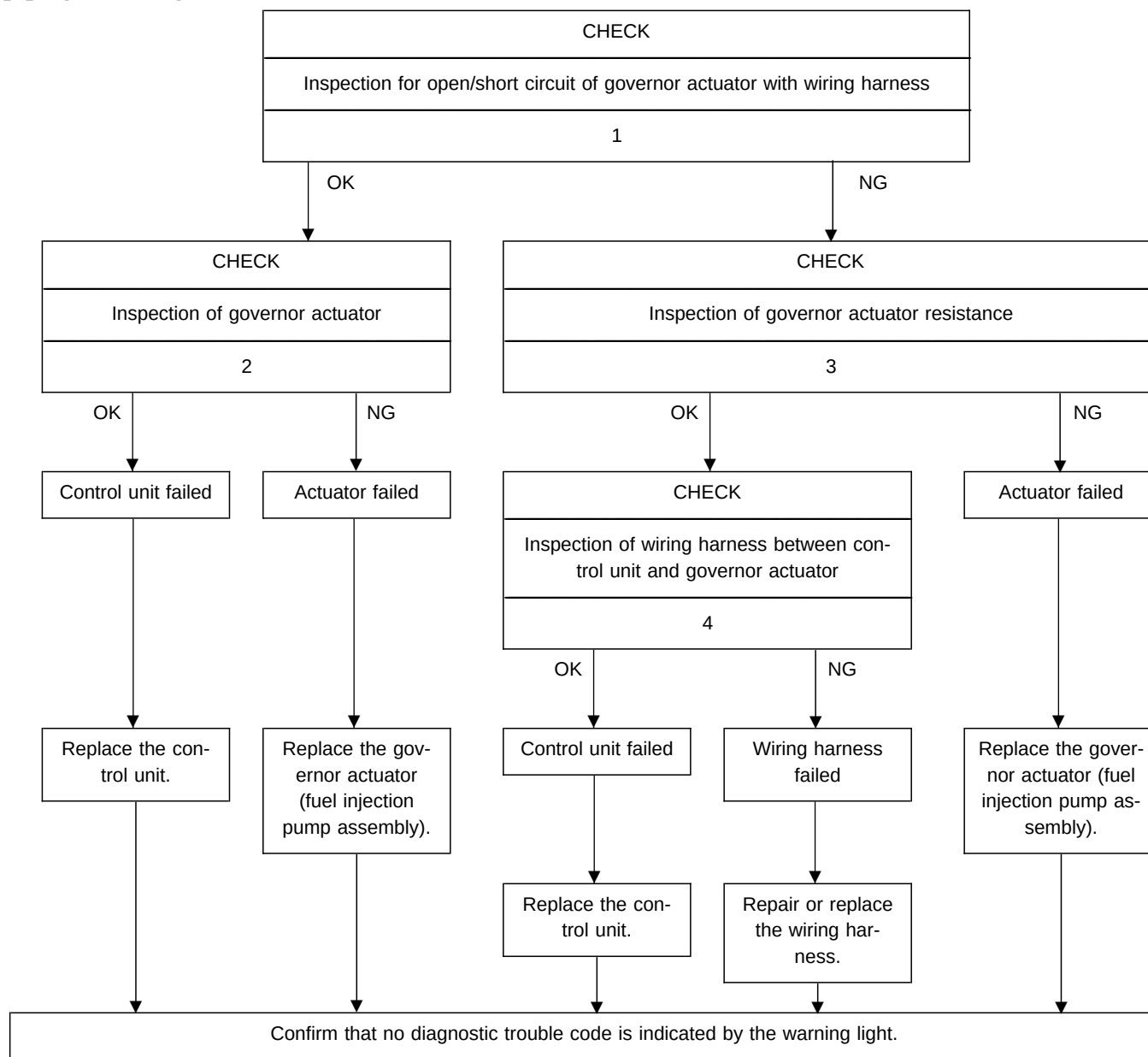
3-1. ACTION FOR GOVERNOR ACTUATOR ERROR

[LIGHT ON: 1-1]

[1] Inspection items

- Governor actuator
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

Inspection for open/short circuit of governor actuator with wiring harness

- 1) Check that the emergency engine stop lever is fully released.
- 2) Turn the key switch to OFF and disconnect the connectors from the control unit.
- 3) Measure the resistance and insulation between each pair of terminals of the connector.

NOTE

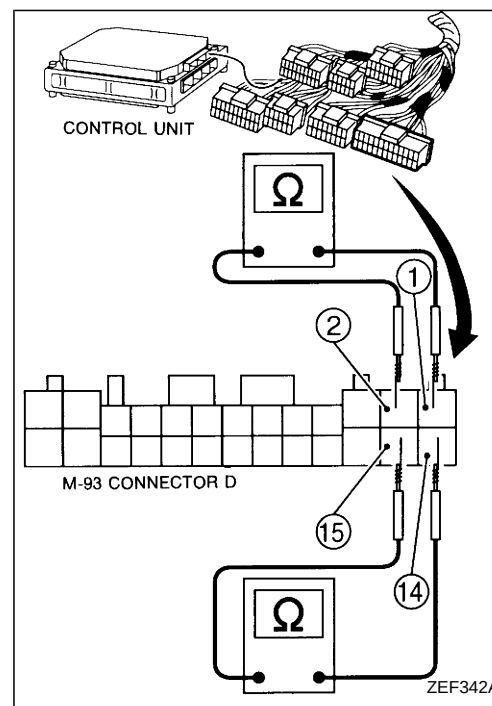
- Resistance check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.

Control unit connector No.	Terminal No.	Resistance [Ω]
M-93	① - ② (ACT 1 side)	9 - 10
	⑭ - ⑮ (ACT 2 side)	9 - 10
	All terminals - Body ground	∞

4) Judgment

Resistance: Refer to above.

- Resistance is normal. → Check operation of the governor actuator. Go to **CHECK 2**.
- Open/short circuit in the wiring harness, or the resistance is abnormal. → Check resistance of the governor actuator. Go to **CHECK 3**.



Inspection of governor actuator

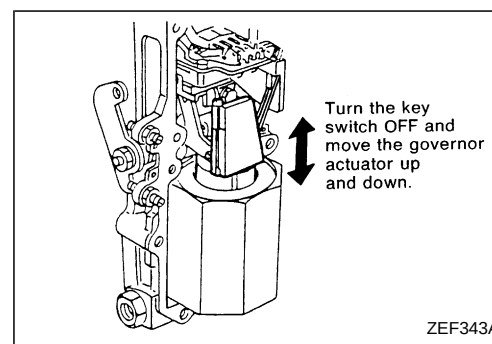
- 1) Check the fuel injection pump for smooth operation of the governor actuator.
 - Remove the cover at the rear of the fuel injection pump body.
 - Move the control rack forward/backward and check for smooth operation.

2) Judgment

- Control rack moves smoothly. → Control unit failed. → Replace the control unit.
- Control rack does not move smoothly. → Replace the governor actuator (fuel injection pump assembly).

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.



CHECK
3

Inspection of governor actuator resistance

- 1) Because the governor actuator and the rack sensor are installed onto the fuel injection pump rear end, all related wiring harnesses must also be checked.
 - Turn the key switch to OFF. Disconnect connectors E-34 and E-35 at the rear of the fuel injection pump.
 - Measure resistance between all the pairs of terminals at both connectors. Check for insulation between each terminal and the fuel pump body.

	Terminal No.	Resistance [Ω]	Remarks
Governor actuator	ACT1 $\oplus$ - ACT1 $\ominus$	9 - 10	
	ACT2 $\oplus$ - ACT2 $\ominus$	9 - 10	
	ACT1 $\oplus$ - ACT2 $\oplus$	Approx. 0	
	ACT1 $\ominus$ - ACT2 $\ominus$	Approx. 0	
Rack sensor	OSC - MDL	14 - 16	
	MDL - GND1	19 - 21	
	MDL - GND2	19 - 21	
	OSC - GND1	30 - 37	
	OSC - GND2	30 - 37	
	GND1 - GND2	Approx. 0	
Back-up sensor	SIG - GND	2.1 k - 2.5 k	Type I only
All terminals - Fuel injection pump body		∞	
All terminals - Positions other than above terminals		∞	

2) Judgment

Resistance: Refer to above.

- Resistance is normal. → Check wiring harness. Go to CHECK
4.
- Open/short circuit in the wiring harness or the resistance is abnormal. → Governor actuator failed. → Replace the governor actuator (fuel injection pump assembly).

NOTE

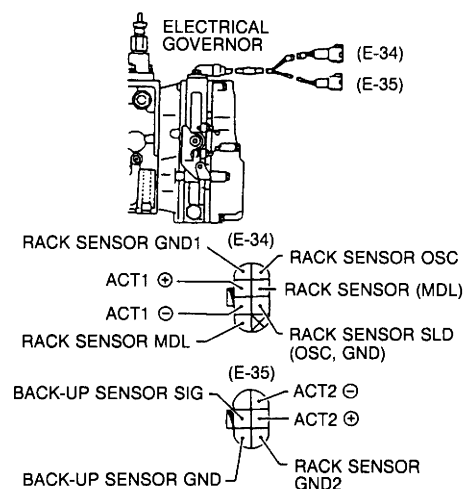
- Replacement of the fuel injection pump assembly must be done following the procedures in BASIC OPERATION, item 2, Alignment of marks.
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK
4

Inspection of wiring harness between control unit and governor actuator

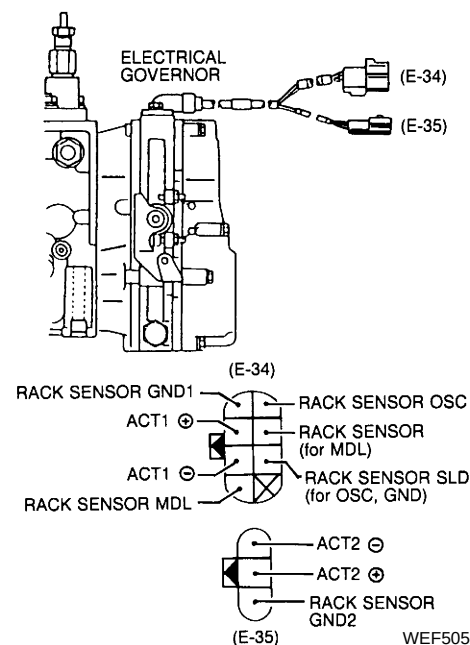
- 1) Turn the key switch to OFF.
- 2) Disconnect the wiring harness connectors from the control unit.
- 3) Check for open/short circuit in the wiring harnesses between the main harness connector terminals and the engine harness connector terminals.

Type I



WEF504A

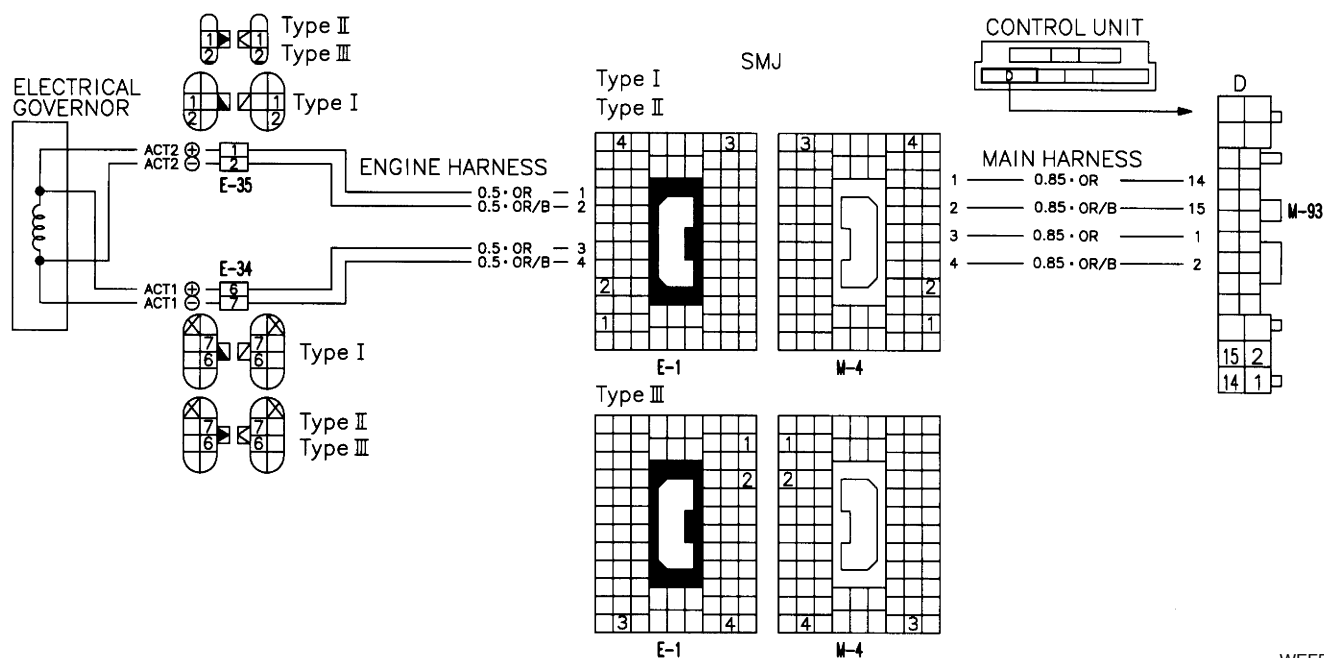
Type II and Type III



WEF505A

NOTE

- **Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.**



WEF506A

4) Judgment

- Wiring harness is open/shorted. → Repair or replace the wiring harness.
- Wiring harness is normal. → Control unit failed. → Replace the control unit.

NOTE

- **When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.**
- **After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.**

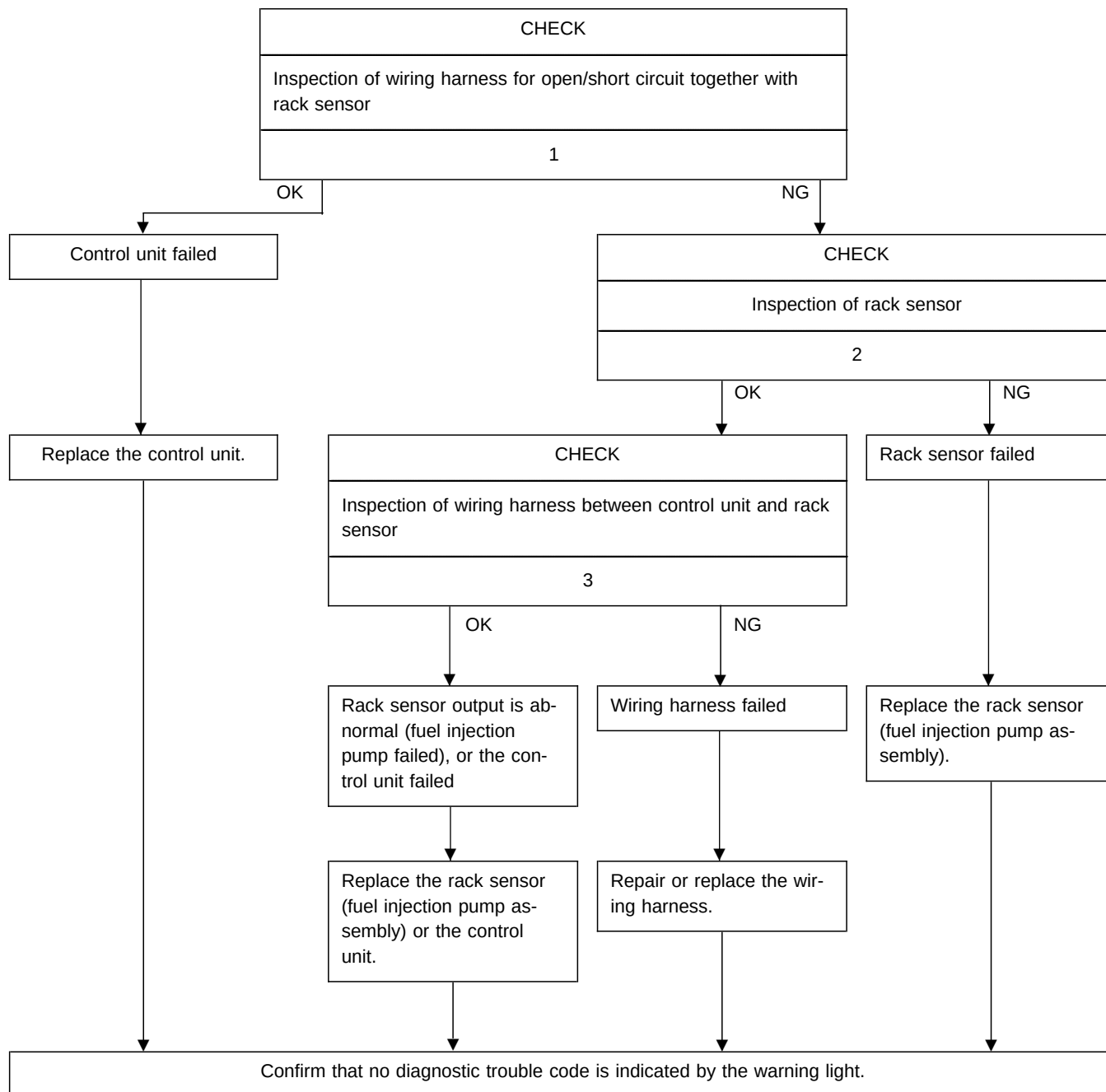
3-2. ACTION FOR RACK SENSOR ERROR

[LIGHT ON: 1-3]

[1] Inspection items

- Rack sensor
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

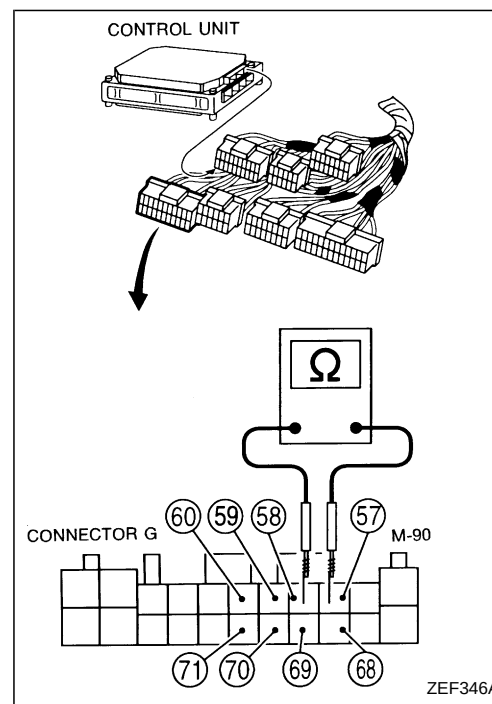
CHECK 1 Inspection for open/short circuit of rack sensor with wiring harness

- 1) Turn the key switch to OFF.
- 2) Disconnect the connectors from the control unit.
- 3) Measure the resistance and insulation between terminals of the connector.

NOTE

- Resistance check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.

Control unit connector No.	Terminal No.	Resistance [Ω]
M-90	(57) or (60) - (58) or (69)	14 - 16
	(59) - (58) or (69)	19 - 21
	(70) - (58) or (69)	19 - 21
	(59) - (57) or (60)	30 - 37
	(70) - (57) or (60)	30 - 37
	(59) - (70)	Approx. 0
	(60) - (57)	Approx. 0
	(58) - (69)	Approx. 0
	Between (60) or (70) and all above terminals	Approx. 0
	All terminals - Body ground	∞



4) Judgment

Resistance: Refer to above.

- Resistance is normal. → Control unit failed. → Replace the control unit.
- Open/short circuit in the wiring harness, or the resistance is abnormal. → Check the rack sensor. Go to **CHECK 2**.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK 2 Inspection of rack sensor

- 1) For the details of the procedure and the resistance, refer to 3-1, Action for governor actuator error **CHECK 5**.

2) Judgment

- Resistance is normal. → Check the wiring harness. Go to **CHECK 3**.
- Open/short circuit in the wiring harness, or the resistance is abnormal. → Rack sensor failed. → Replace the rack sensor (fuel injection pump assembly).

NOTE

- Replacement of the fuel injection pump assembly must be done following the procedures in BASIC OPERATION, item 2, Alignment of marks.
- After completing each operation, carry out trouble-

shooting with the diagnostic light and confirm that there is no abnormality.

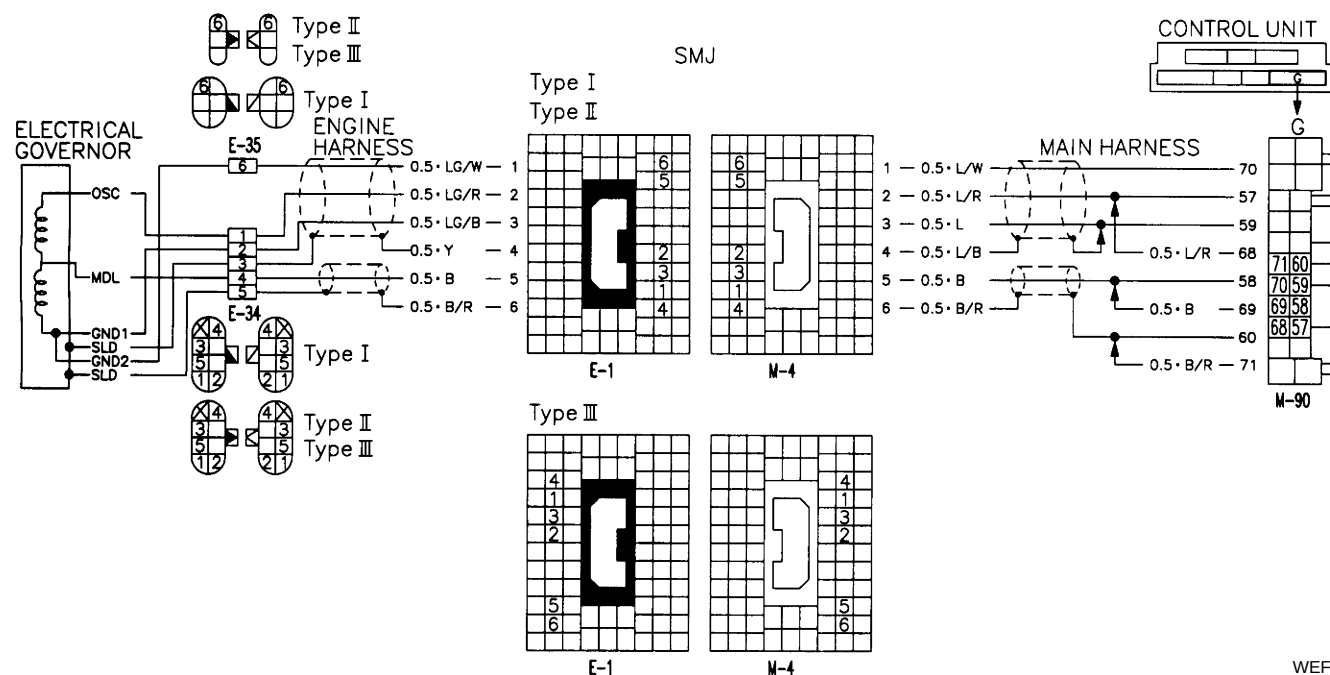
CHECK
5

Inspection of wiring harness between control unit and rack sensor

- 1) Turn the key switch to OFF.
- 2) Disconnect the wiring harness connector from the control unit.
- 3) Check for open/short circuit between main harness connector and the engine harness connector.

NOTE

- **Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.**



WEF507A

- 4) Judgment
 - Wiring harness is open/shorted. → Repair or replace the wiring harness.
 - Rack sensor is normal. → Rack sensor output voltage is abnormal (fuel injection pump failed), or the control unit failed. → Replace the rack sensor (fuel injection pump assembly) or the control unit.

NOTE

- If the resistance, insulation, and wiring harness of the rack sensor have no abnormalities, the rack sensor output voltage (poor setting) or the control unit may be faulty.
- When installing the vehicle, confirmation of the rack sensor output voltage is possible by following the procedure in BASIC OPERATION, item 3, Inspection of rack sensor output voltage.
- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

4. ACTION FOR PRE-STROKE SERVO SYSTEM ERROR

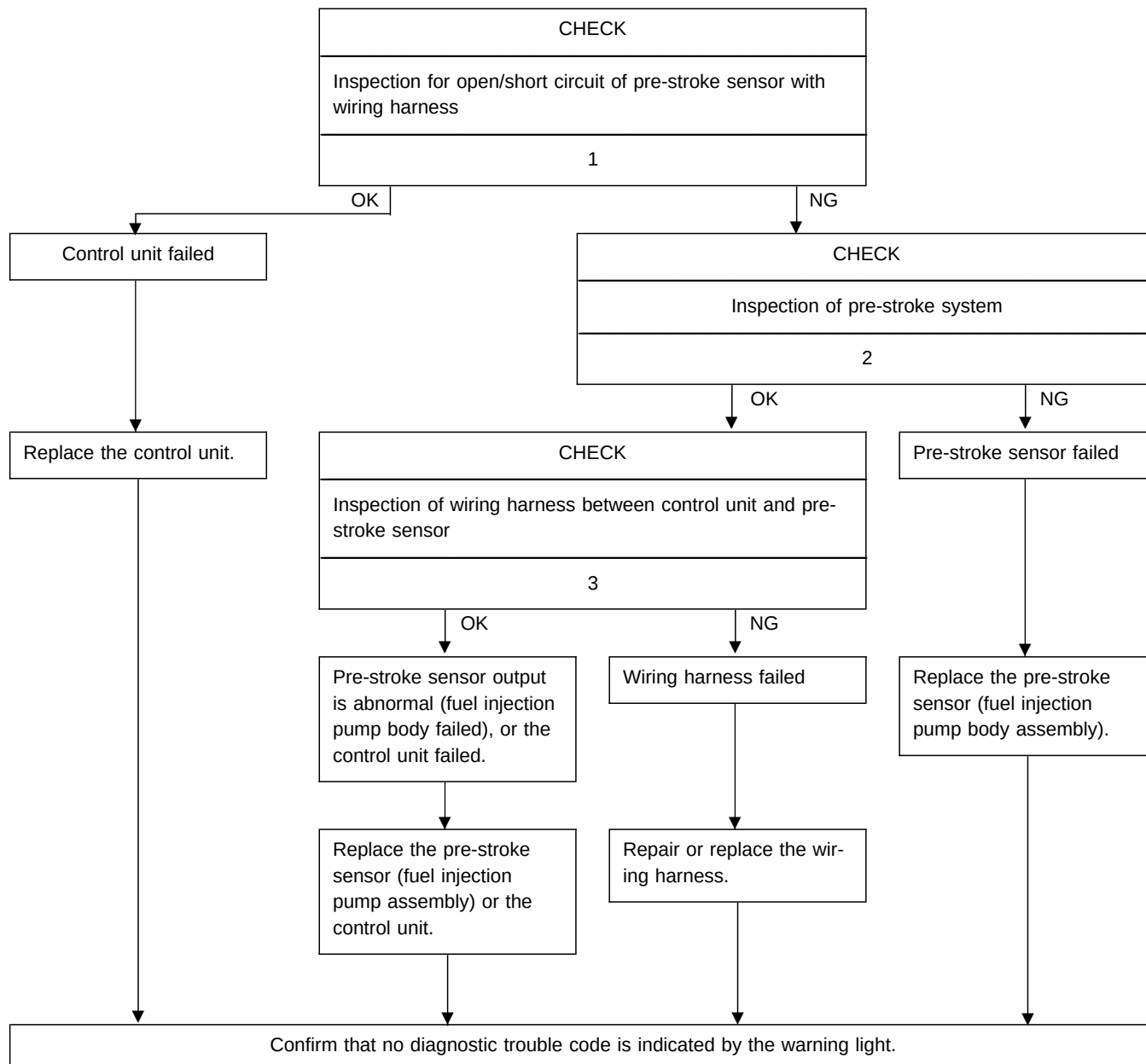
[LIGHT FLASH: 1-2, 3-5, 3-6, 3-7]

4-1. ACTION FOR PRE-STROKE SENSOR ERROR [LIGHT FLASH: 3-5]

[1] Inspection items

- Pre-stroke sensor
- Wiring harness (open/shorted)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

Inspection for open/short circuit of the pre-stroke sensor with wiring harness

- 1) Turn the key switch to OFF.
- 2) Disconnect the connector from the control unit.
- 3) Measure the resistance and insulation between terminals of the connector.

NOTE

- Resistance check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.

Control unit connector No.	Terminal No.	Resistance [Ω]
M-90	(62) - (63)	5 - 7
	(63) - (73)	5 - 7
	(62) - (73)	10 - 14
	All terminals - Body ground	∞

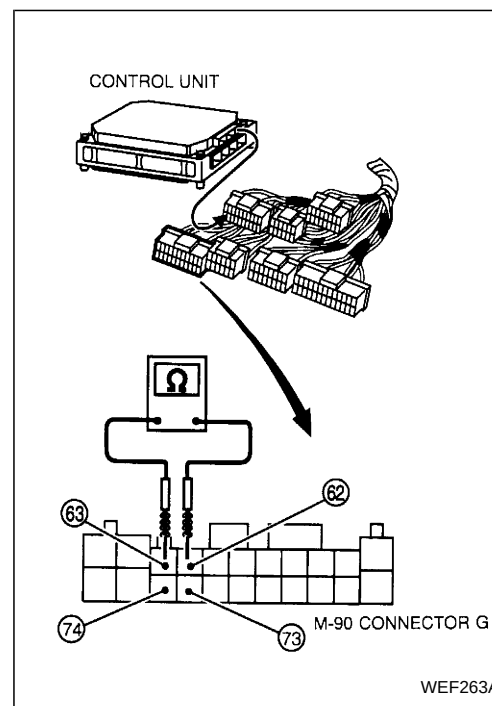
4) Judgment

Resistance: Refer to above.

- Resistance is normal. → Control unit failed. → Replace the control unit.
- Open/short circuit in the wiring harness, or the resistance is abnormal. → Check pre-stroke sensor. Go to .

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.



CHECK
2

Inspection of pre-stroke sensor

- 1) Because the pre-stroke sensor body and the pre-stroke actuator body are installed onto the fuel injection pump side, all the related wiring harnesses must also be checked, even if they are inspected individually.
- Turn the key switch to OFF, and disconnect the connector E-32 from upper part of the fuel injection pump.
- Measure resistance between all terminals of both connectors. Check the insulation between each terminal and the fuel pump body.

	Terminal	Resistance [Ω]
Pre-stroke sensor	OSC - MDL	5 - 7
	MDL - GND	5 - 7
	OSC - GND	10 - 14
Pre-stroke actuator	ACT $\oplus$ - ACT $\ominus$	2.5 - 2.9
All terminals - Fuel injection pump body		∞

2) Judgment

- Resistance is normal. → Check the wiring harness. Go to [CHECK 3](#).
- Wiring harness is open/shorted, or the resistance is abnormal. → Pre-stroke sensor failed. → Replace the pre-stroke sensor (fuel injection pump assembly).

NOTE

- Replacement of the fuel injection pump assembly must be done following the procedures in BASIC OPERATION, item 2, Alignment of marks.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

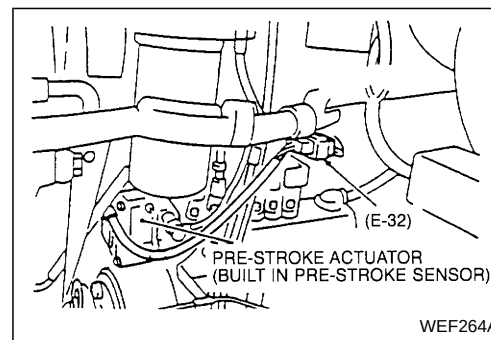
CHECK
3

Inspection of wiring harness between control unit and pre-stroke sensor

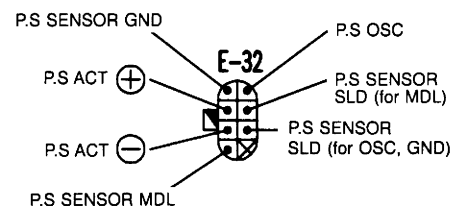
- 1) Turn the key switch to OFF.
- 2) Disconnect the harness connector from the control unit.
- 3) Check for open/short circuit between each terminal of the main harness connector and engine harness connector.

NOTE

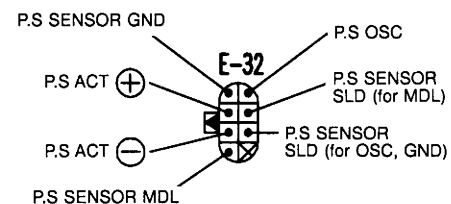
- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.



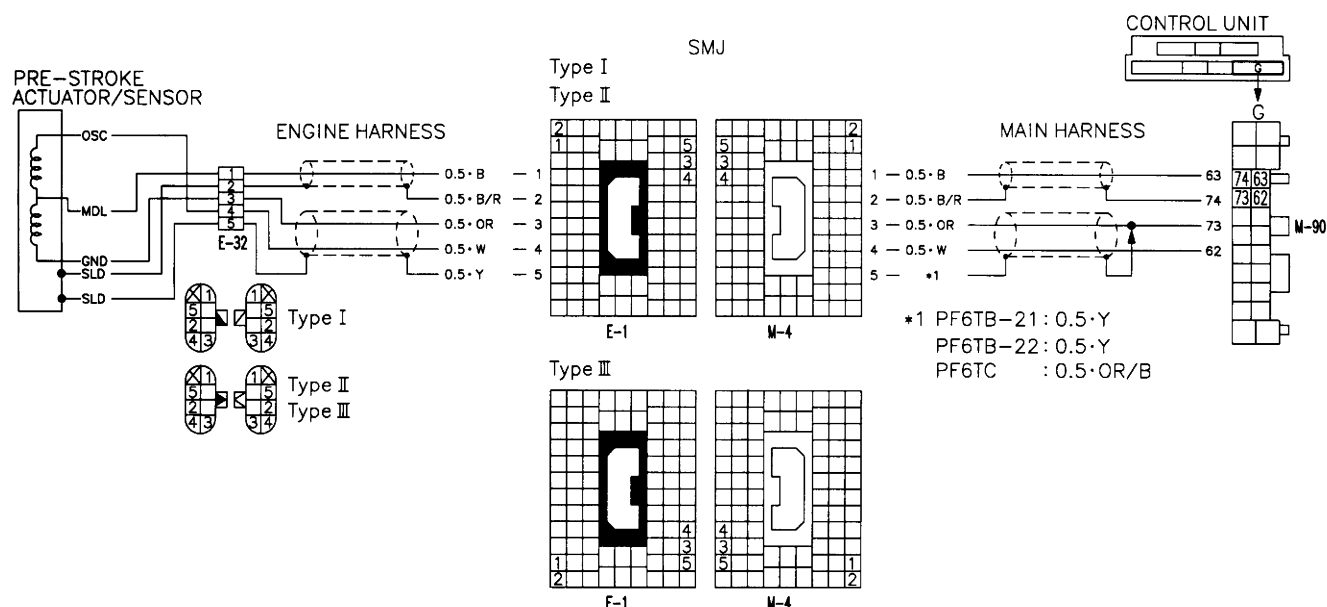
Type I



Type II and Type III



WEF508A



WEF509A

4) Judgment

- Wiring harness is open/shorted. → Repair or replace the wiring harness.
- Wiring harness is normal. → Pre-stroke sensor output voltage is abnormal (fuel injection pump body failed), or the control unit failed. → Replace the pre-stroke sensor (fuel injection pump assembly) or the control unit.

NOTE

- Replacement of the fuel injection pump must be done following the procedures in BASIC OPERATION, item 2, Alignment of marks.
- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

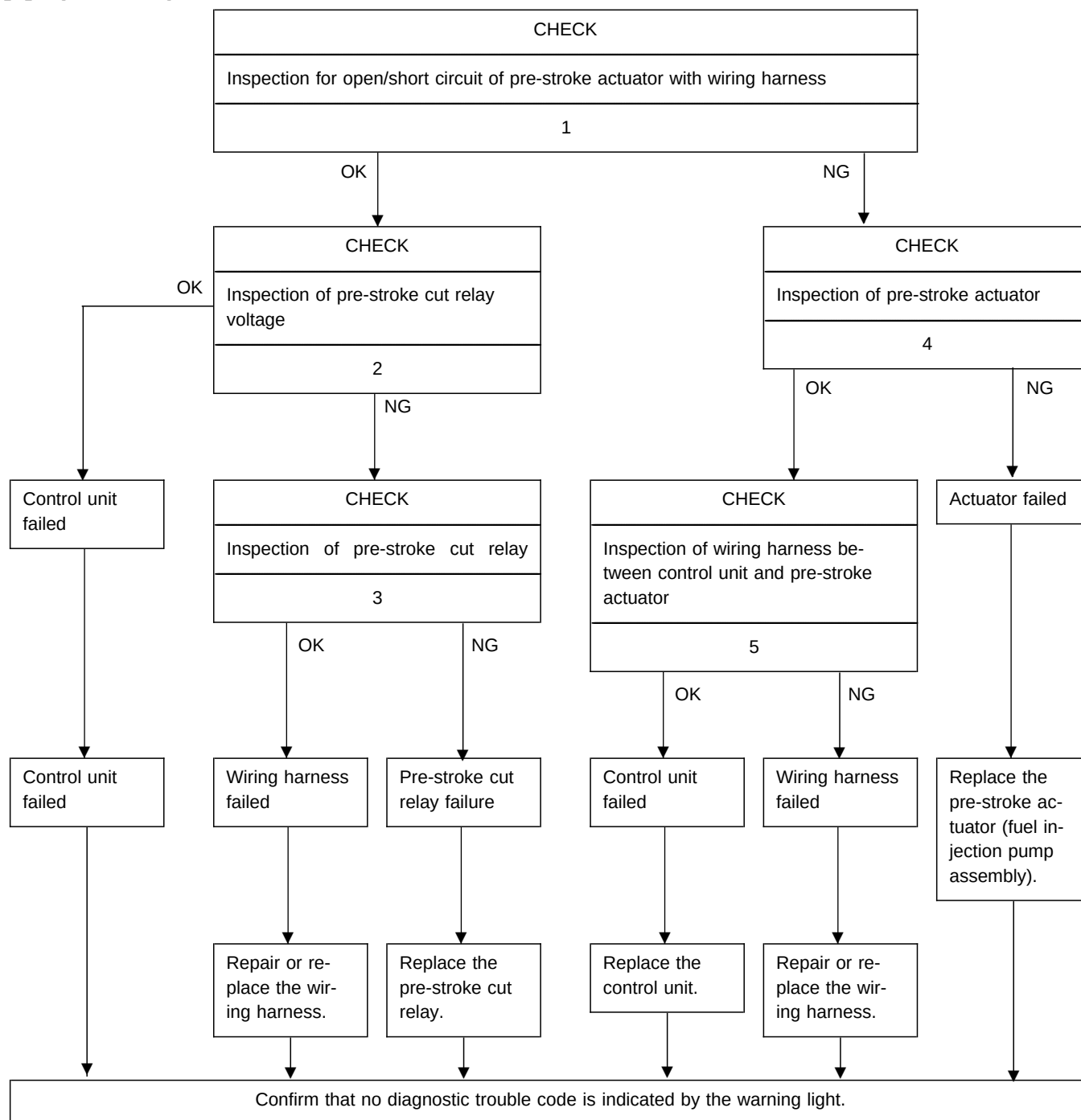
4-2. ACTION FOR PRE-STROKE ACTUATOR ERROR

[LIGHT FLASH: 1-2, 3-6, 3-7]

[1] Inspection items

- Pre-stroke actuator
- Wiring harness (open/shorted)
- Pre-stroke cut relay
- Final confirmation

[2] Operation procedure



[3] Operation procedure

Inspection for open/short circuit of pre-stroke sensor with wiring harness

- 1) Turn the key switch to OFF.
- 2) Disconnect the connector from the control unit.
- 3) Measure the resistance and insulation between each terminal of the connector.

NOTE

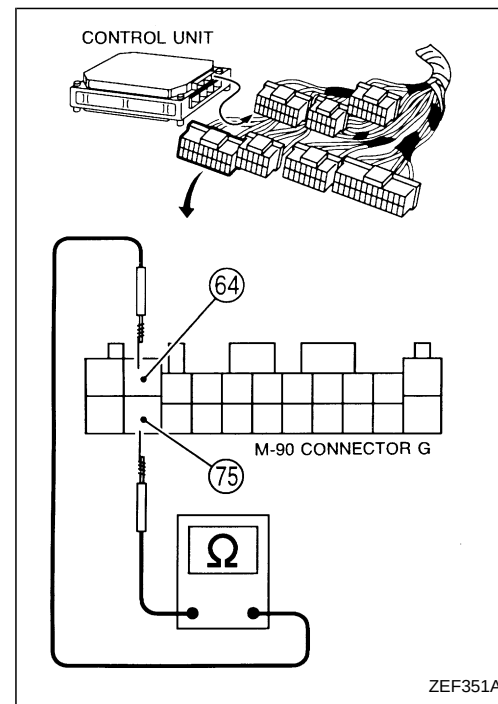
- **Resistance check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.**

Control unit connector No.	Terminal No.	Resistance [Ω]
M-90	⑥4 - ⑦5	2.5 - 2.9
	All terminals - Body ground	∞

4) Judgment

Resistance: Refer to above.

- Resistance is normal. → Check the pre-stroke cut relay voltage. Go to **CHECK 2**.
- Wiring harness is open/shorted, or resistance is abnormal. → Check the pre-stroke actuator. Go to **CHECK 4**.



Inspection of pre-stroke cut relay voltage

- 1) Turn the key switch to OFF.
- 2) Disconnect the connector from the control unit.
- 3) Turn the key switch to ON, and measure voltage between each terminal of the connector and body ground.

NOTE

- **Voltage check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.**

Control unit connector No.	Terminal No.
M-90	⑥5 - Body ground,
M-88	⑩5 - Body ground

4) Judgment

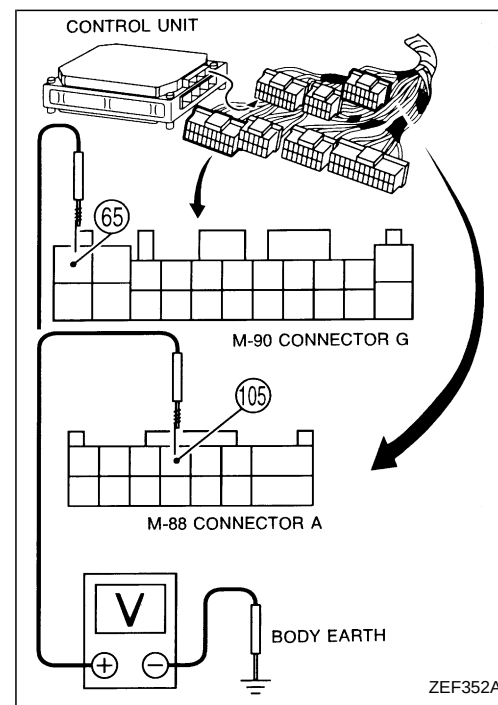
Voltage (Reference battery voltage: 20 - 28 [V])

- Voltage is normal. → Control unit failed. → Replace the control unit.
- Voltage is abnormal. → Check the operation of the pre-stroke cut relay. Go to **CHECK 3**.

NOTE

- **When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.**

EF-6-60



- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK 3 Inspection of pre-stroke cut relay

- 1) Remove the pre-stroke cut relay from the relay box.
- 2) Check the relay operation.
- 3) Judgment
 - Operation is normal. → Wiring harness failed. → Repair or replace the wiring harness.
 - Operation is abnormal. → Relay failed. → Replace the pre-stroke cut relay.

NOTE

- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK 4 Inspection of pre-stroke actuator

- 1) For the details of the operation method and resistance value, refer to 4-1, Action for pre-stroke sensor error **CHECK 2**.
- 2) Judgment
 - Resistance is normal. → Check the wiring harness. Go to **CHECK 5**.
 - Wiring harness is open/shorted, or resistance is abnormal. → Pre-stroke actuator failed. → Replace the pre-stroke actuator (fuel injection pump assembly).

NOTE

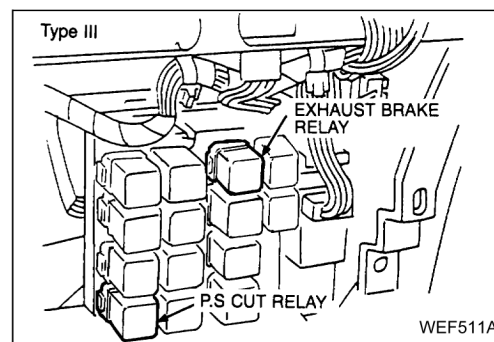
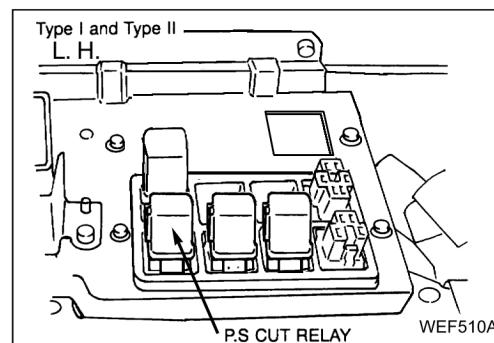
- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 2, Alignment of marks.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

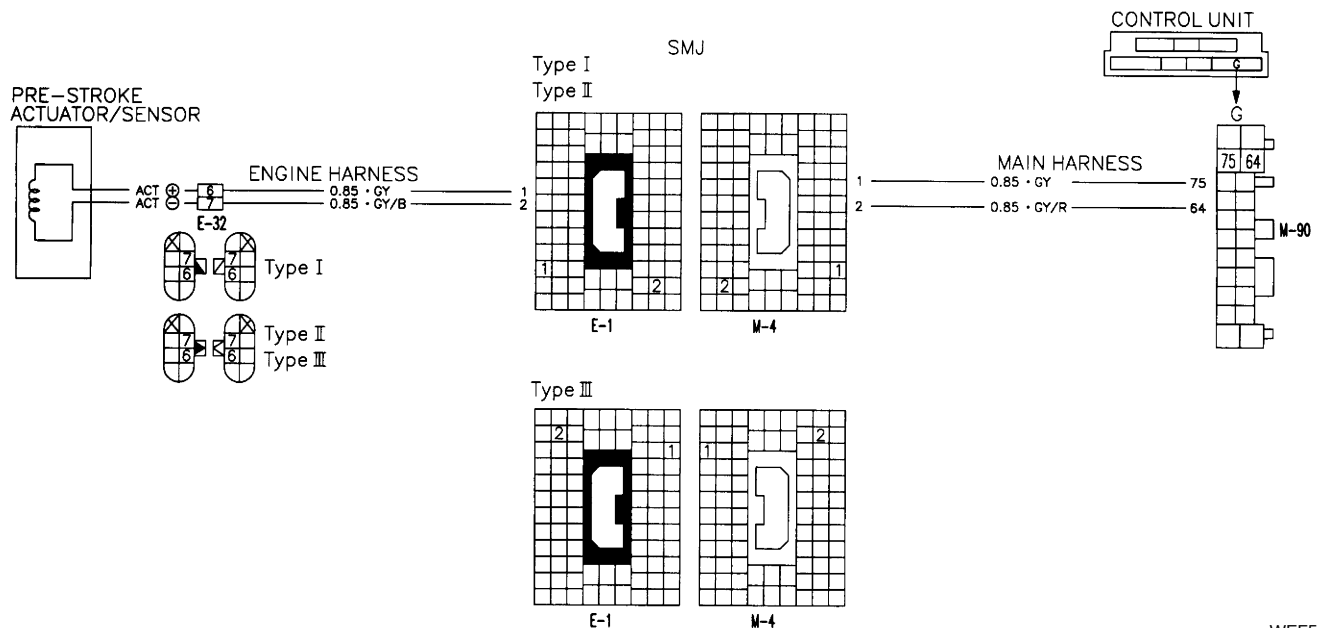
CHECK 5 Inspection of wiring harness between control unit and pre-stroke actuator

- 1) Turn the key switch to OFF.
- 2) Disconnect the harness connector from the control unit.
- 3) Check for open/short circuit between each pair of terminals of the main harness connector and engine harness connector.

NOTE

- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.





WEF512A

- 4) Judgment
 - Wiring harness is open/shorted. → Repair or replace the wiring harness.
 - Wiring harness is normal. → Control unit failed. → Replace the control unit.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

4-3. ACTION FOR PRE-STROKE SETTING LEARNING ERROR [LIGHT FLASH: 3-6]

[1] Pre-stroke setting learning

Pre-stroke sensor carries out the following actions with the key switch ON (engine stopped) to confirm that the pre-stroke sensor position is 0 (setting value).

- ① Pre-stroke actuator is not activated.
- ② Pre-stroke sensor displays the pre-stroke position.

The control unit learns the sensor output voltage as 0 position (set value). After the engine is started, the control unit controls the pre-stroke value, based on this setting value and various input data (engine speed, rack position, and boost pressure).

[2] Action for pre-stroke setting learning error

- 1) When the pre-stroke sensor 0 position (set value) exceeds the position which the control unit records (possible learning range), 3-6 error will be displayed.
When the pre-stroke power system does not fail and open/short circuit in the pre-stroke sensor system does not occur, the setting failure of the pre-stroke sensor body or the poor operation of the pre-stroke actuator system may be the cause.

- 2) Judgment (3-6 error occurred)
 - Pre-stroke power system error (3-7) occurs simultaneously. →

Recheck the error code after the pre-stroke power system is repaired.

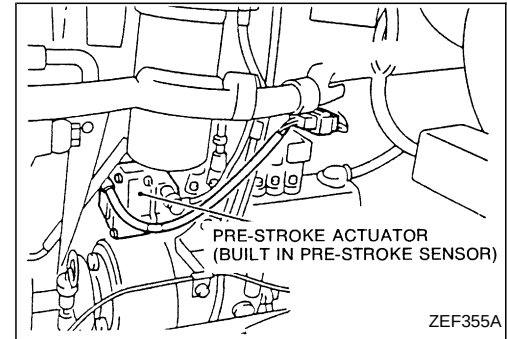
- Pre-stroke learning error (3-6) occurs independently. → Pre-stroke sensor setting failure, poor operation of pre-stroke actuator. → Replace the fuel injection pump assembly.

NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

NOTE

- When replacing the fuel injection pump assembly due to 3-6 error, connect only the connector (8-pin) of the new fuel injection pump pre-stroke sensor system, and confirm that 3-6 error does not occur with the key switch ON. Then, proceed to the replacement operation.



5. ACTION FOR BACK-UP SENSOR ERROR

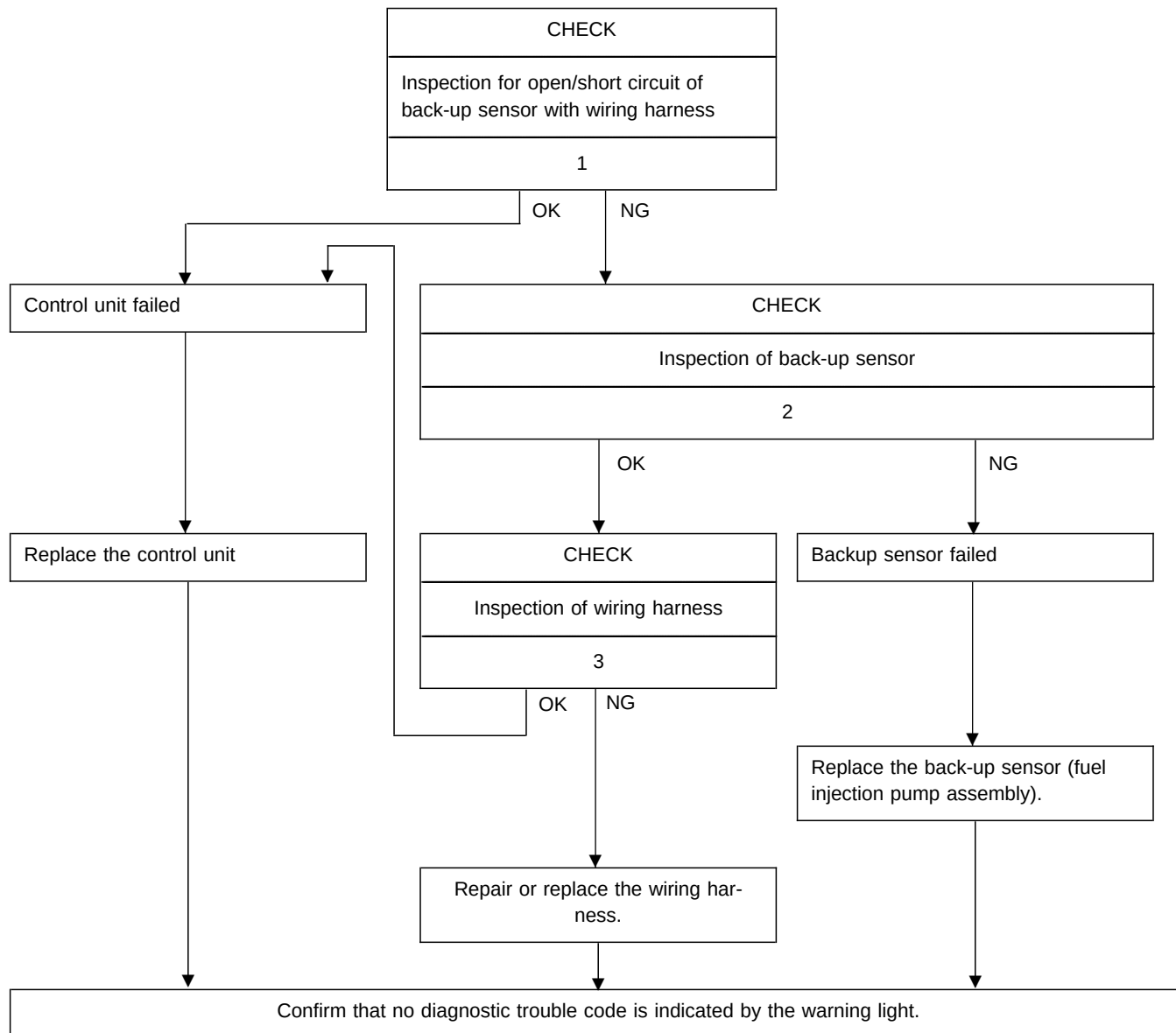
[LIGHT FLASH: 1-4, 1-6]

[1] Inspection items

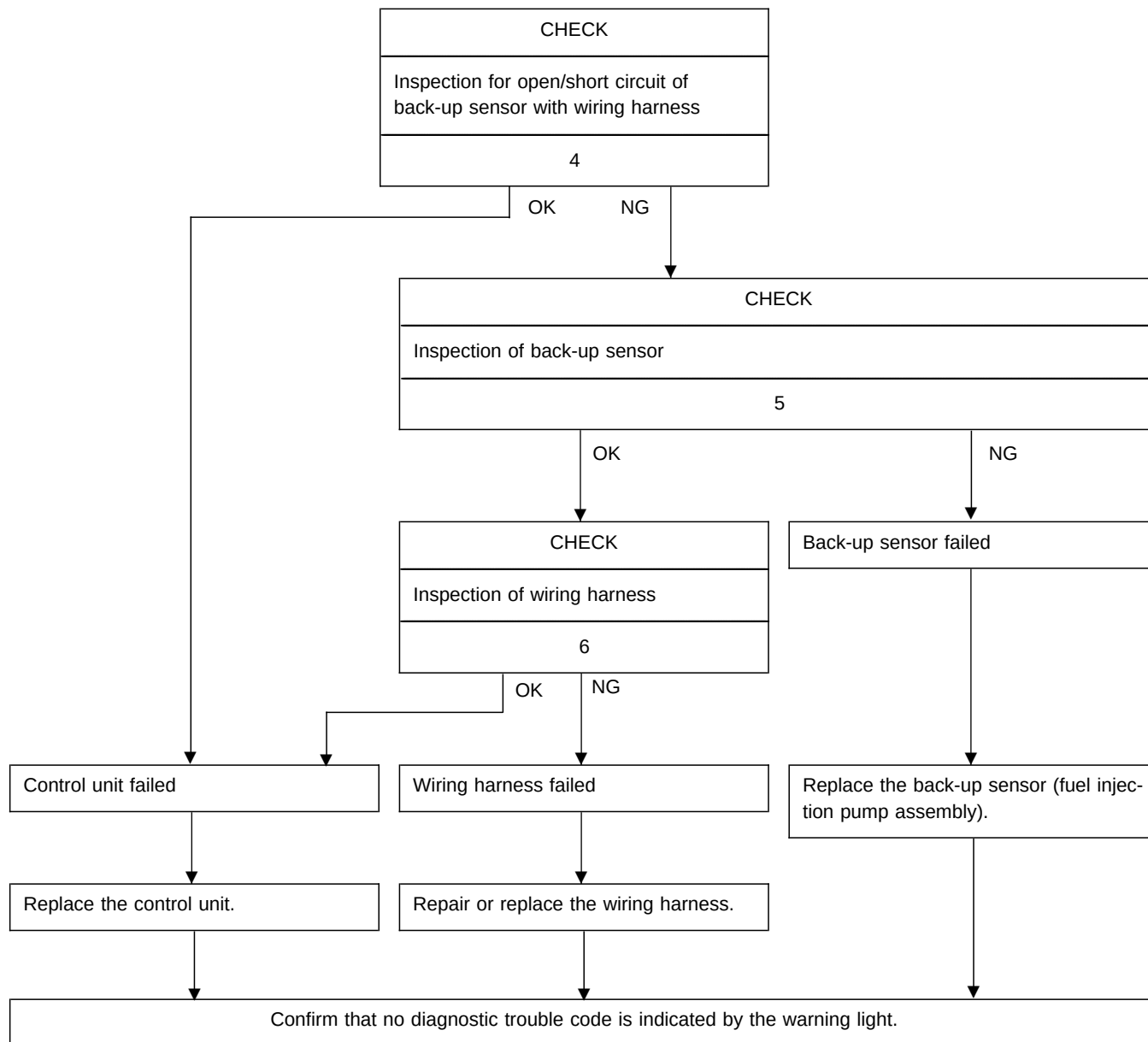
- Back-up sensor (open/short circuit, resistance)
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure

(1) When the diagnostic trouble code 1-4 is indicated (shorted or no pulse)



(2) When the diagnostic trouble code 1-6 is indicated (open circuit)



[3] Operation procedure

CHECK 1 Inspection for open/short circuit of back-up sensor with wiring harness

- 1) Turn the key switch to OFF.
- 2) Disconnect the harness connector from the control unit.
- 3) Measure the insulation resistance between terminals of the connector.

NOTE

- **Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.**

Control unit connector No.	Terminal No.	Resistance [Ω]
M-91	(47) (53) - Body ground	∞
	(47) - (54)	∞
	(53) - (54)	
	(47) - (53)	2.1 k - 2.5 k

- 4) Judgment
 - Resistance is normal. → Control unit failed. → Replace the control unit.
 - Short circuit. (approx. 0Ω) → Check the back-up sensor. Go to **CHECK 2**.

NOTE

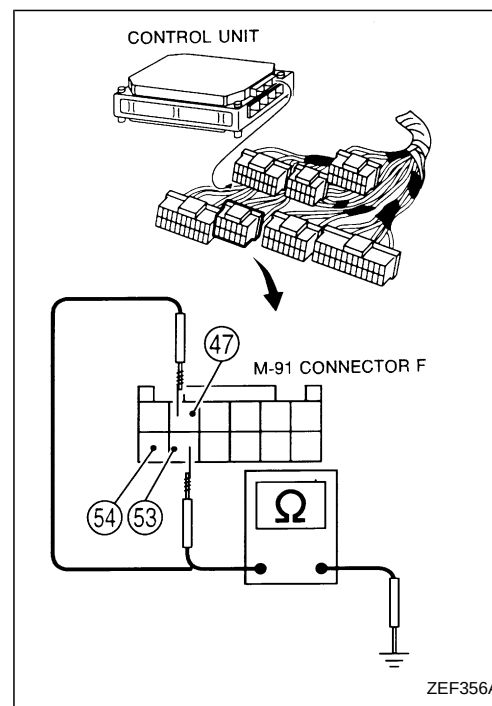
- **When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.**
- **After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.**

CHECK 2 Inspection of back-up sensor (Type I only)

- 1) For the details of operation method and resistance value, refer to 3-1, Action for governor actuator error **CHECK 3**.
- 2) Judgment
 - Resistance is normal. → Back-up sensor is normal. → Check the wiring harness. Go to **CHECK 3**.
 - Wiring harness is open/shorted, or resistance is abnormal. → Back-up sensor failed. → Replace the back-up sensor (fuel injection pump assembly).

NOTE

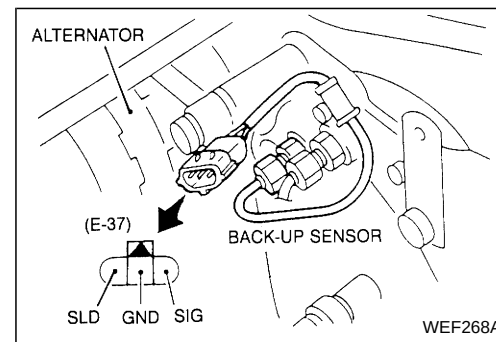
- **Replacement of the fuel injection pump assembly must be done following the procedures in BASIC OPERATION, item 2, Alignment of marks.**
- **After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.**



CHECK 2 Inspection of back-up sensor (Type II and Type III only)

- 1) Disconnect the connector from the back-up sensor and measure the resistance and insulation between the terminals of the back-up sensor side connector.

Terminal	Resistance [Ω]
SIG - GND	2.1 k - 2.5 k
SIG - SLD	∞
GND - SLD	
All terminal - Body ground	∞



- 2) Judgment
 - Resistance is normal. → Back-up sensor is normal. → Check the wiring harness. Go to **CHECK 3**.
 - Wiring harness is open/shorted, or resistance is abnormal. → Back-up sensor failed. → Replace the back-up sensor.

NOTE

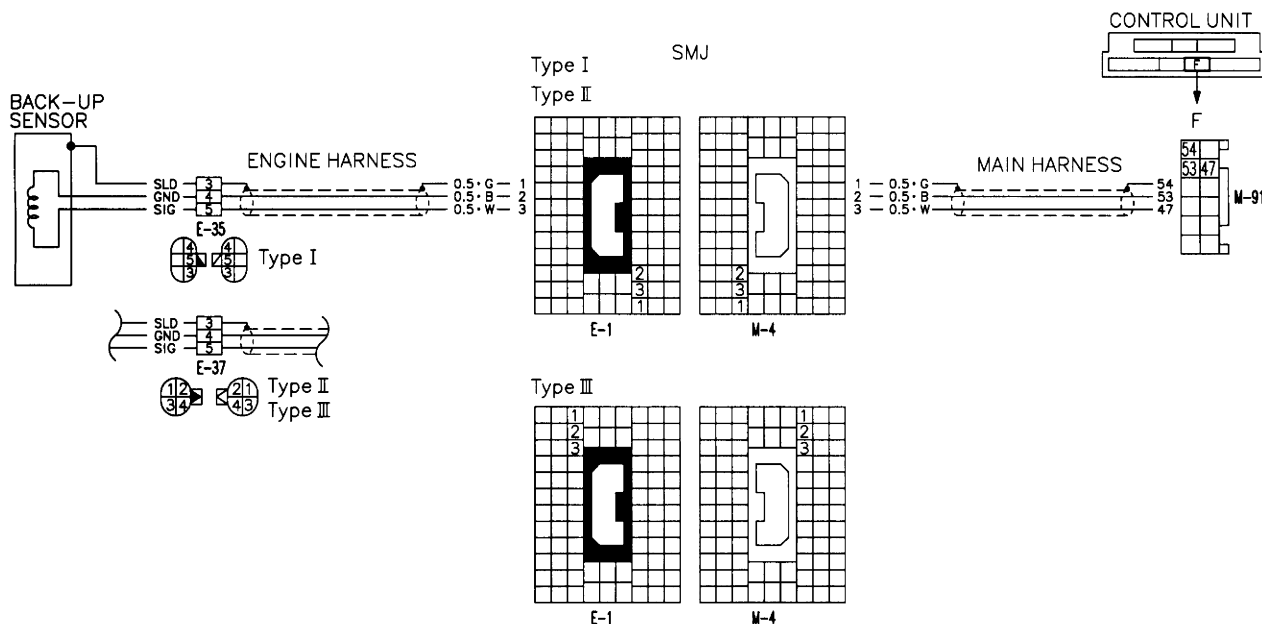
- When replacing the back-up sensor, follow the procedures for setting the back-up sensor described in BASIC OPERATION.

CHECK 3 Inspection of wiring harness between control unit and back-up sensor

- 1) Check for open/short circuit between terminals of the main harness connector and engine harness connector.

NOTE

- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.



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- 2) Judgment
 - Wiring harness is open/shorted. → Repair or replace the wiring harness.

- Wiring harness is normal. → Control unit failed. → Replace the control unit.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK 4 Inspection for open circuit of back-up sensor with wiring harness

- 1) Turn the key switch to OFF.
- 2) Disconnect the harness connector from the control unit.
- 3) Measure the resistance between connector terminals.

NOTE

- Resistance check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.

Control unit connector No.	Terminal No.	Resistance [kΩ]
M-91	(47) - (53)	2.1 - 2.5

4) Judgment

Resistance: Refer to above.

- Resistance is normal. → Control unit failed. → Replace the control unit.
- Open harness, or the resistance is abnormal. → Check the back-up sensor. Go to **CHECK 5**.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK 5 Inspection of back-up sensor (Type I only)

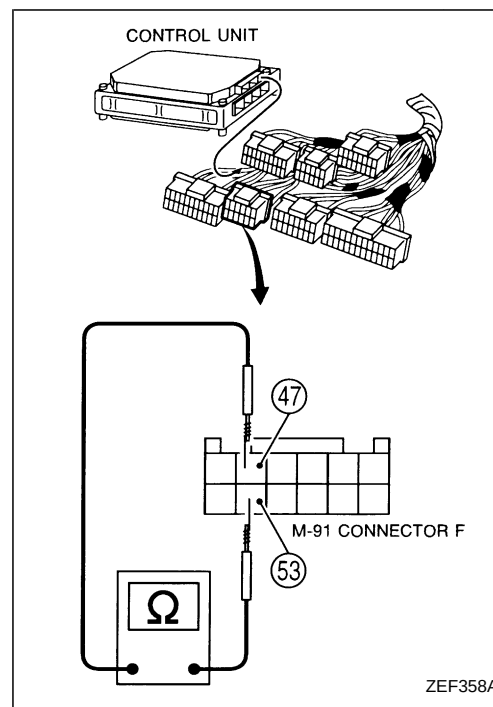
- 1) For the measurement method and resistance value, refer to 3-1, Action for governor actuator error **CHECK 3**.
- 2) Judgment
 - Resistance is normal. → Go to **CHECK 6**.
 - Wiring harness is open/shorted, or the resistance is abnormal. → Back-up sensor failed. → Replace the fuel injection pump assembly.

NOTE

- Replacement of the fuel injection pump assembly must be done following the procedures in BASIC OPERATION, item 2, Alignment of marks.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK 5 Inspection of back-up sensor (Type II and Type III only)

- 1) For the measurement method and resistance value, refer to Inspection of back-up sensor (Type II and Type III only) **CHECK 2**.



2) Judgment

- Resistance is normal. → Go to

CHECK
6

.
- Wiring harness is open/shorted, or the resistance is abnormal.
→ Back-up sensor failed. → Replace the fuel injection pump assembly.

NOTE

- **After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.**



Inspection of wiring harness

- For the wiring harness replacement procedure, refer to

CHECK
3

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6. ACTION FOR ENGINE SPEED SENSOR ERROR

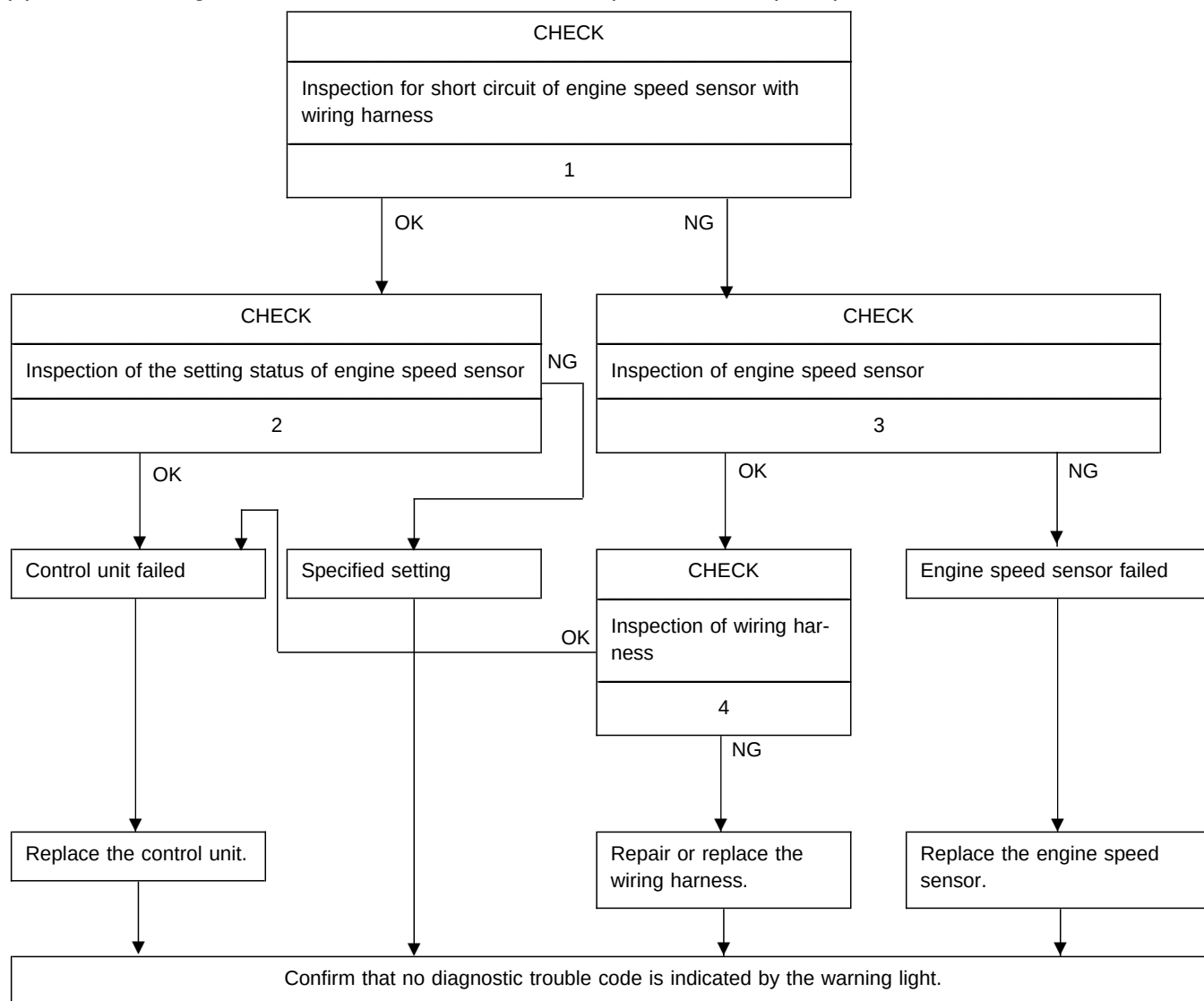
[LIGHT FLASH: 1-5, 1-7]

[1] Inspection items

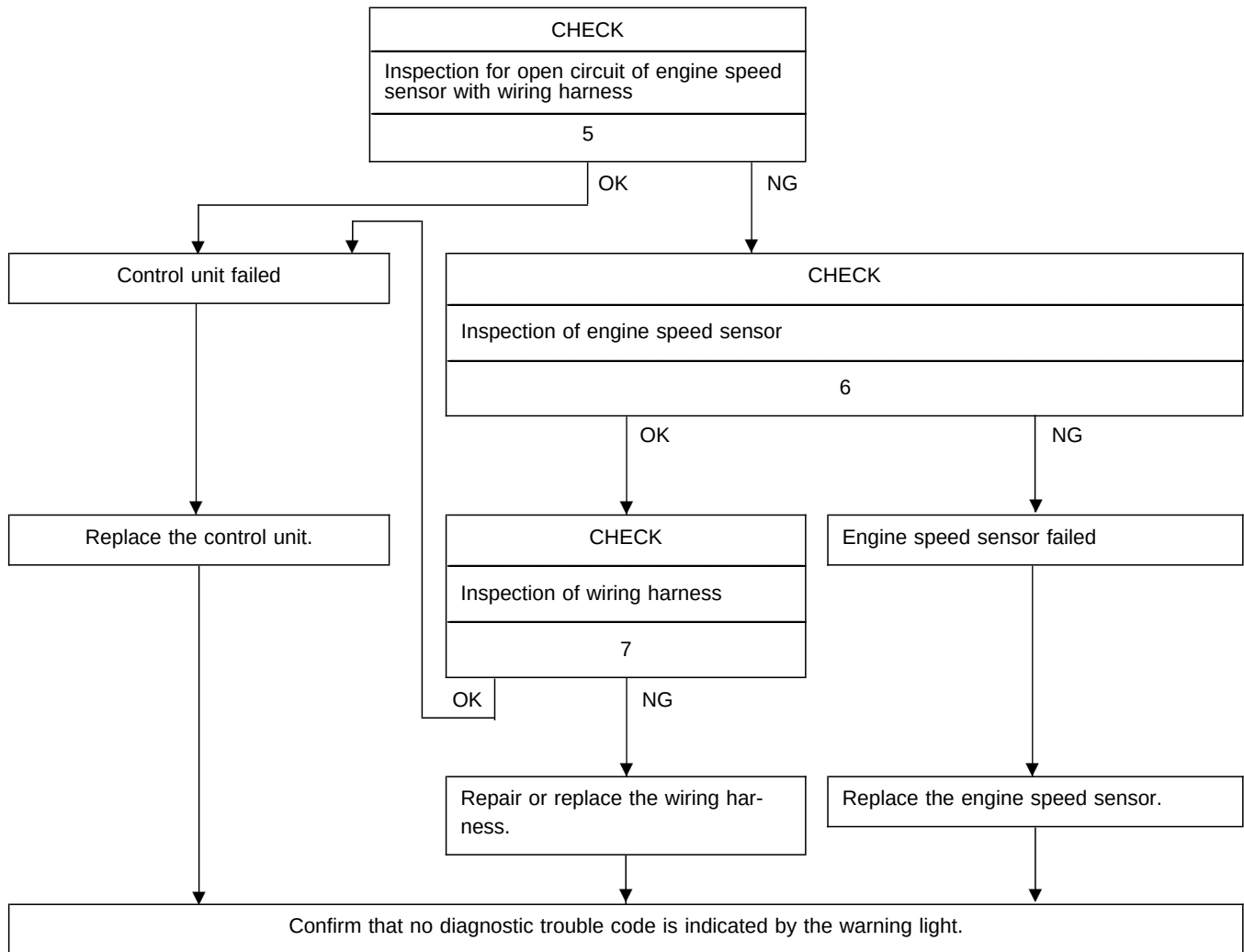
- Engine speed sensor (open/short circuit, resistance value)
- Setting status of engine speed sensor
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure

(1) When the diagnostic trouble code 1-5 is indicated (shorted or no pulse)



(2) When the diagnostic trouble code 1-7 is indicated (open)



[3] Operation procedure

CHECK 1 Inspection for short circuit of engine speed sensor with wiring harness

- 1) Turn the key switch to OFF.
- 2) Disconnect the harness connector from the control unit.
- 3) Measure the insulation resistance between each pair of terminals of the connector.

NOTE

- Resistance check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.

Control unit connector No.	Terminal No.	Resistance [Ω]
M-91	④⑥ - Body ground, ⑤② - Body ground	∞
	④⑥ - ④⑧	∞
	⑤② - ④⑧	
	④⑥ - ⑤②	2.1 k - 2.5 k

- 4) Judgment
 - Wiring harness and sensor are normal. → Check the setting status of engine speed sensor. Go to **CHECK 2**.
 - Short circuit is present in the wiring harness (approx. 0Ω). → Check the engine speed sensor. Go to **CHECK 3**.

CHECK 2 Inspection of setting status of engine speed sensor

- 1) Check the setting status of engine speed sensor.
- 2) Judgment
 - Specified setting. → Control unit failed. → Replace the control unit.
 - Out of specification. → Set the engine speed sensor to the specification.

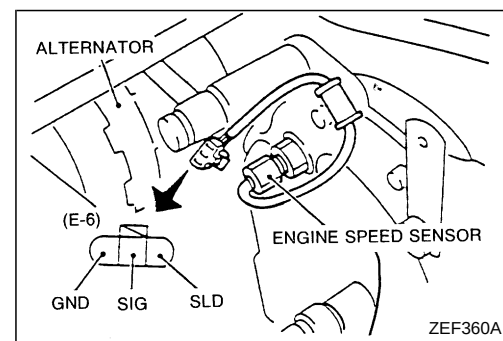
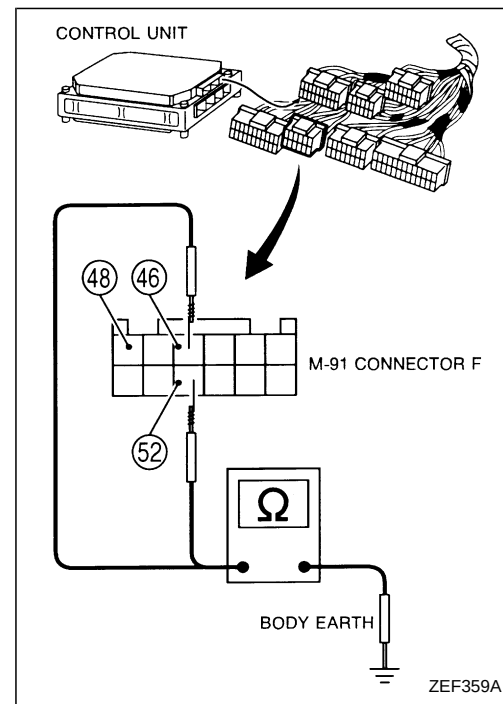
NOTE

- Setting status inspection must be done following the procedures in BASIC OPERATION, item 4, Setting procedure of engine speed sensor.
- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK 3 Inspection of engine speed sensor

- 1) Disconnect the connector from the engine speed sensor, and measure the resistance and insulation between each terminal of the engine speed sensor side connector.

Measuring terminal	Resistance [Ω]
SIG - GND	2.1 k - 2.5 k
SIG - SLD	∞
GND - SLD	
All terminals - Body ground	∞



2) Judgment

Specified resistance: Refer to above.

- Resistance is normal. → Engine speed sensor is normal. → Go to CHECK
4.
- Open/short circuit, or the resistance is abnormal. → Engine speed sensor failure. → Replace engine speed sensor.

NOTE

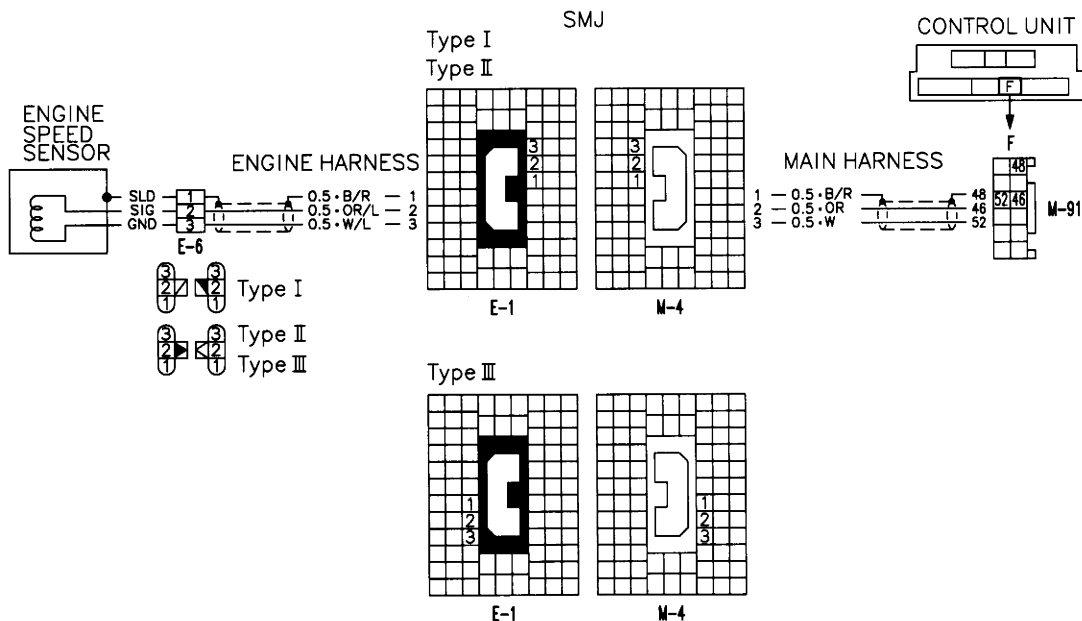
- Replacement of engine speed sensor must be done following the procedures in BASIC OPERATION, item 4, Setting procedure of engine speed sensor.
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK
4 Inspection of wiring harness between control unit and engine speed sensor

- 1) Check for open/short circuit in the wiring harnesses between each terminal of the main harness connectors, and the engine harness connectors.

NOTE

- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.



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2) Judgment

- Wiring harness is open/shorted. → Repair or replace the wiring harness.
- Wiring harness is normal. → Control unit failed. → Replace the control unit.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK
5

Inspection for open circuit of engine speed sensor with wiring harness

- 1) Turn the key switch to OFF.
- 2) Disconnect the connector from the control unit.
- 3) Measure the resistance between each pair of terminals of the connectors.

NOTE

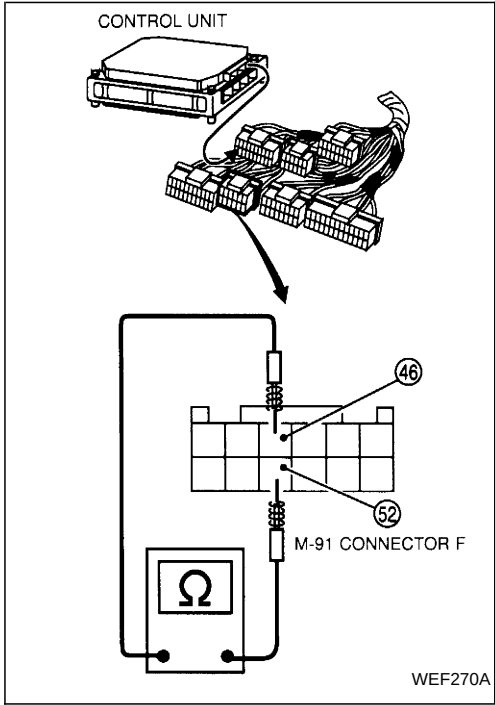
- Resistance check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.

Control unit connector No.	Terminal No.	Resistance [kΩ]
M-91	(46) - (52)	2.1 - 2.5

4) Judgment

Resistance value: Refer to above.

- Resistance is normal. → Control unit failed. → Replace the control unit.
- Open circuit, or the resistance is abnormal. → Check the engine speed sensor. Go to CHECK 6.



CHECK
6

Inspection of engine speed sensor

- 1) Refer to CHECK 3 for measurement method and resistance value of the engine speed sensor.
- 2) Judgment
 - Resistance is normal. → Go to CHECK 7.
 - Wiring harness is open/shorted, or the resistance is abnormal. → Engine speed sensor failed → Replace the engine speed sensor.

NOTE

- Replacement of engine speed sensor must be done following the procedures in BASIC OPERATION, item 4, Setting procedure of engine speed sensor.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK
7

Inspection of wiring harness

- Refer to CHECK 4 for details.

7. ACTION FOR NO PULSE GENERATED AT STARTUP

[LIGHT FLASH: 4-5]

[1] Inspection items

- Engine speed sensor, back-up sensor
- Back-up sensor
- Setting status of engine speed sensor
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure

Refer to “5. Action for back-up sensor error” and “6. Action for engine speed sensor error”.

[3] Operation procedure

Refer to “5. Action for back-up sensor error” and “6. Action for engine speed sensor error”.

NOTE

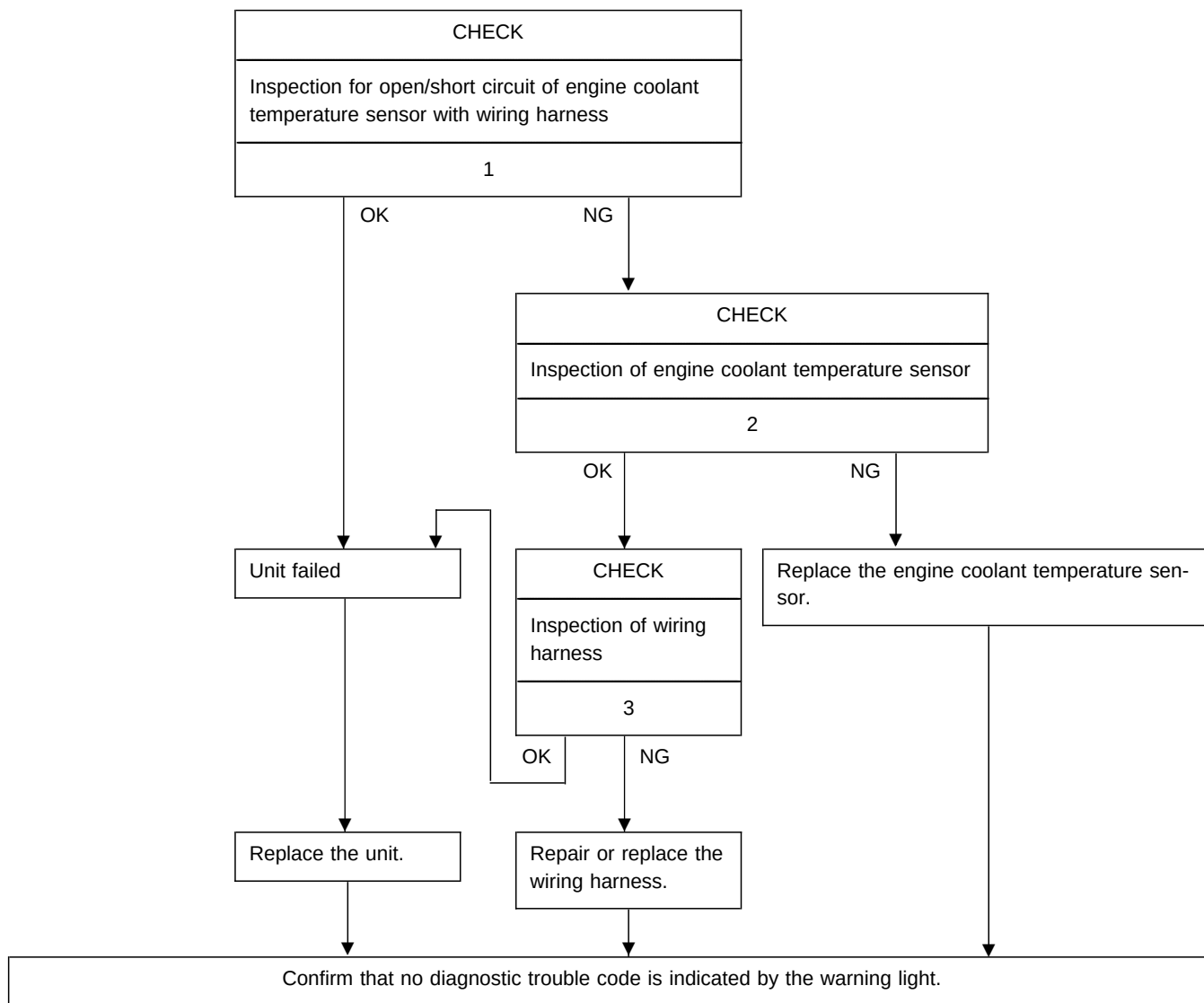
- **After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.**

8. ACTION FOR ENGINE COOLANT TEMPERATURE SENSOR ERROR [LIGHT FLASH: 2-1]

[1] Inspection items

- Engine coolant temperature sensor (open/short circuit, resistance)
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

CHECK
1

Inspection for open/short circuit of engine coolant temperature sensor with wiring harness

- 1) Turn the key switch to OFF.
- 2) Disconnect the connector from the control unit.
- 3) Measure the resistance and insulation between each pair of terminals of the connector.

NOTE

- Resistance measurement at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.

Control unit connector No.	Terminal No.	Resistance [Ω]
M-92	③④ - ④②	Refer to graph on the next page
	All terminals - Body ground	∞

4) Judgment

<Resistance value of engine coolant temperature sensor>

Relation between the engine coolant temperature and the resistance value in the engine coolant temperature sensor is shown in the figure.

Engine coolant temperature °C (°F)	40 (104)	60 (140)
Resistance k Ω	1.011 - 1.411	0.505 - 0.805

- Resistance value corresponding to the engine coolant temperature. → Engine coolant temperature sensor is normal. → Control unit failed. → Replace the control unit.
- Open/short circuit, or the resistance value does not correspond to the engine coolant temperature. → Check the engine coolant temperature sensor. Go to CHECK
2.

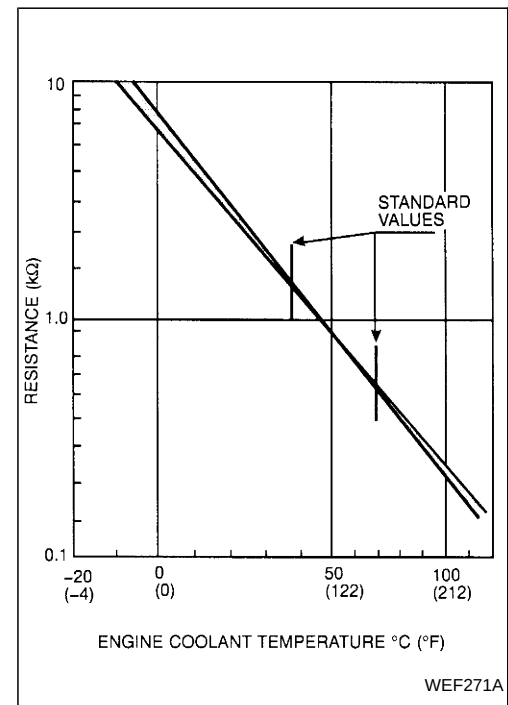
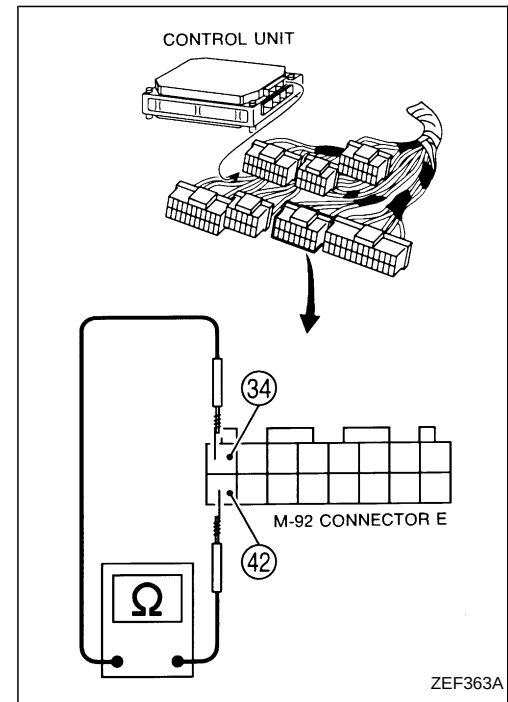
NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK
2

Inspection of engine coolant temperature sensor

- 1) Disconnect the connector from the engine coolant temperature sensor, and measure the resistance between the terminals of the sensor.
Measure the resistance value in room temperature and with the sensor body heated by the hot air blower, and confirm the resistance value changes smoothly.



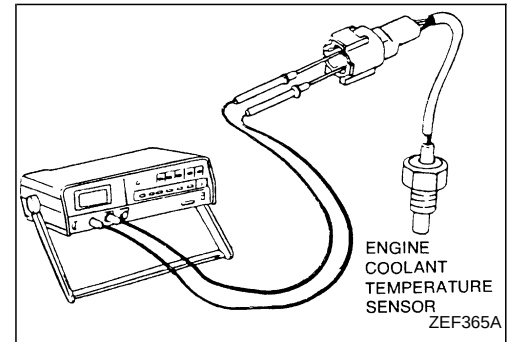
2) Judgment

Resistance value: Refer to above graph.

- Resistance value corresponds to the engine coolant temperature. → Engine coolant temperature sensor is normal. → Check the wiring harness. → Go to **CHECK 3**.
- Resistance value does not correspond to the engine coolant temperature. → Engine coolant temperature sensor failed. → Replace the engine coolant temperature sensor.

NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

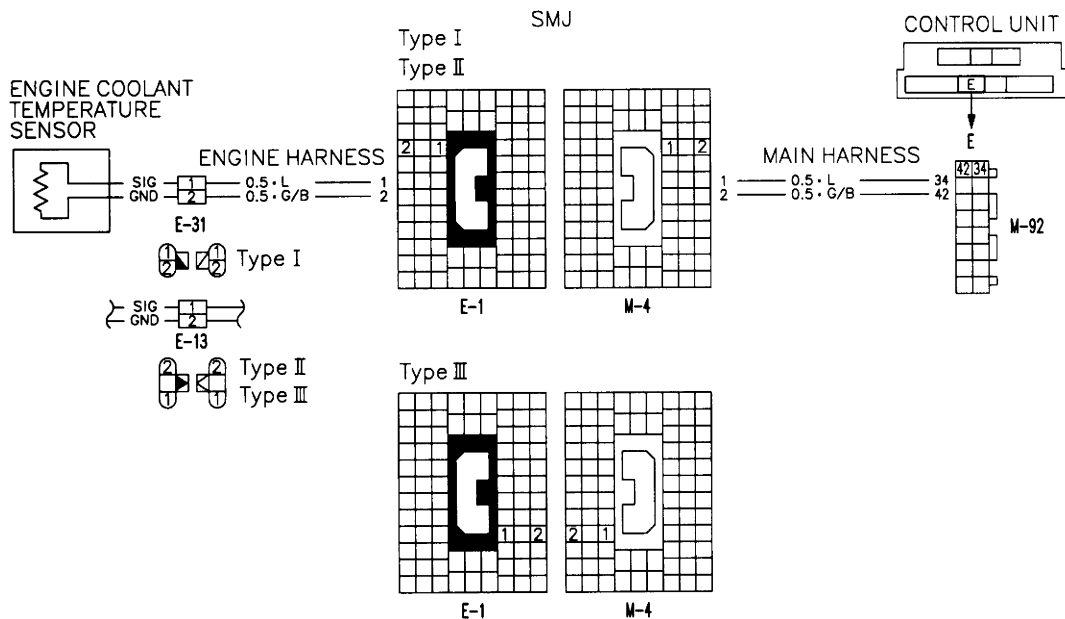


CHECK 3 Inspection of wiring harness between control unit and engine coolant temperature sensor

- 1) Check for open/short circuit in the wiring harnesses between each terminal of the governor harness and the engine harness.

NOTE

- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.



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2) Judgment

- Wiring harness failed (open/short circuit, etc.). → Repair or replace the wiring harness.
- Wiring harness is normal. → Control unit failed. → Replace the control unit.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

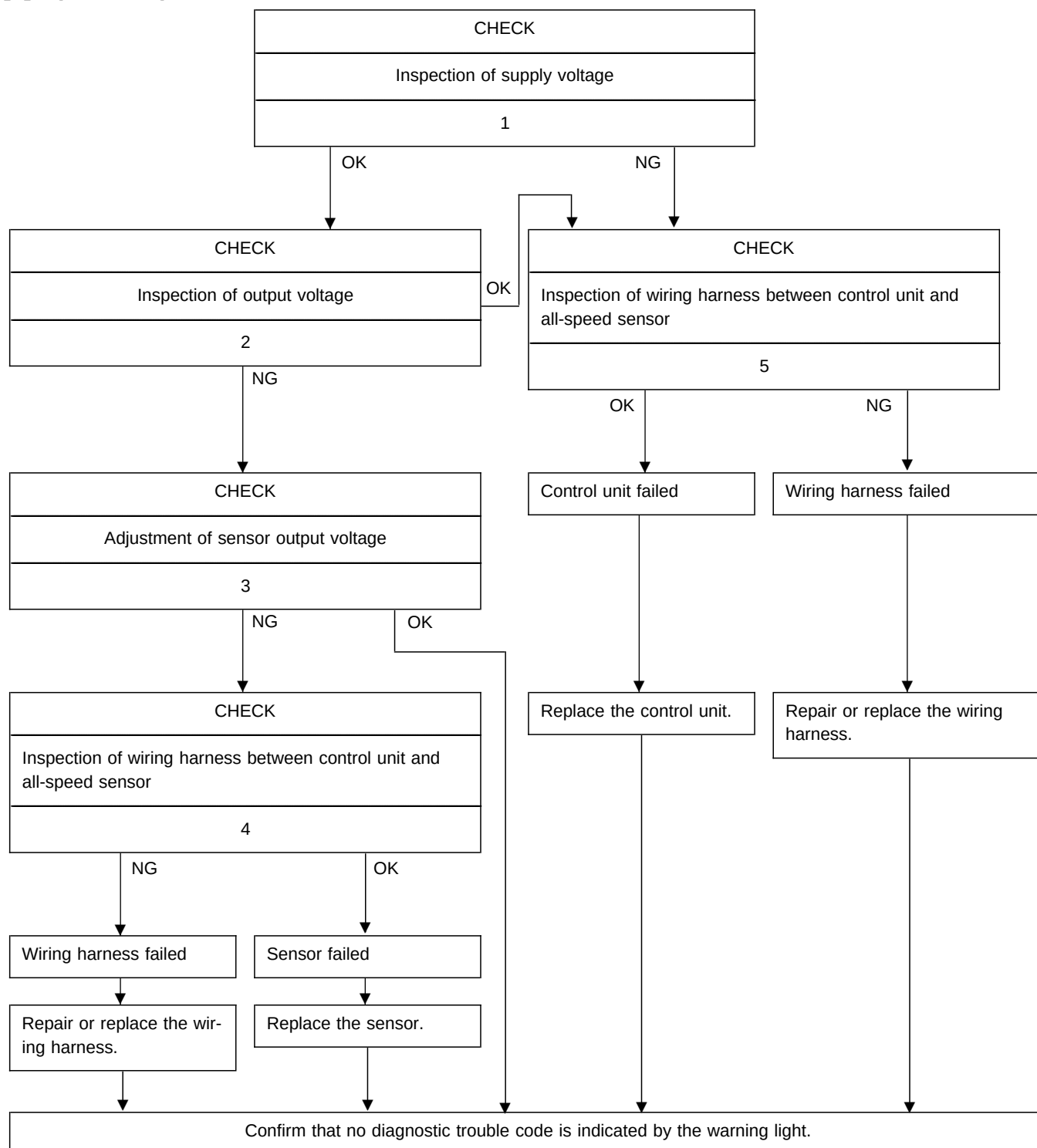
9. ACTION FOR ALL-SPEED SENSOR ERROR

[LIGHT FLASH: 2-2]

[1] Inspection items

- All-speed sensor (supply voltage and output voltage)
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

CHECK 1 Inspection of supply voltage

- 1) Check the voltage supplied to the all-speed sensor.
 - Turn the key switch to OFF.
 - Disconnect the all-speed sensor connector (4-pin).
 - Connect the check harness between the disconnected connectors.

Tool name	Type I	Type II and Type III
All-speed sensor check harness	99731 Z0000	99731 Z0012

- Turn the key switch and the PTO switch to ON.
 - Set the tester to the DCV measurement range (capable of measuring voltage greater than 5V). Connect the positive lead of the tester to terminal ①, and the negative lead to terminal ② or ③ to measure the voltage.
- 2) Judgment

Specified voltage: 5 ± 0.25 [V]

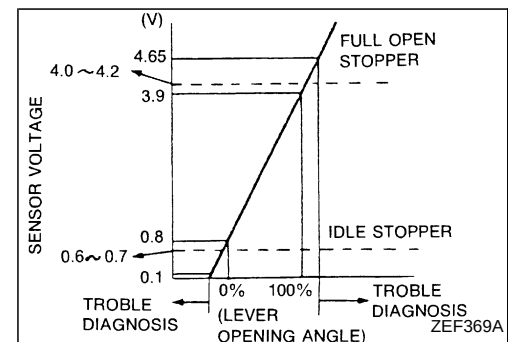
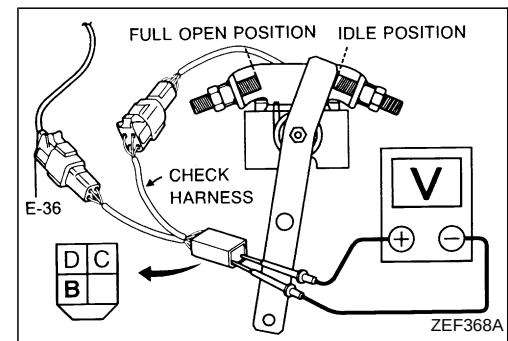
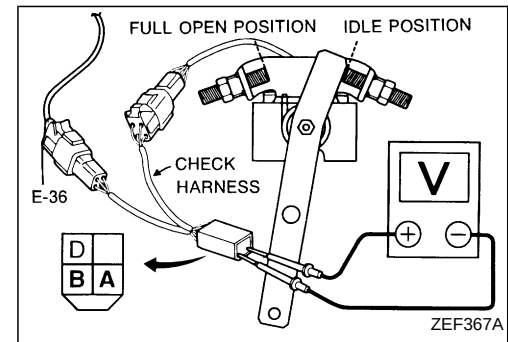
- Supply voltage is normal. → Check the output voltage. → Go to CHECK 2.
- Supply voltage is abnormal. → Check the wiring harness. → Go to CHECK 5.

CHECK 2 Inspection of output voltage

- 1) Check the output voltage of the all-speed sensor.
 - Turn the key switch to OFF.
 - Disconnect the all-speed sensor connector (4-pin).
 - Connect the check harness between the main harness and the all-speed sensor connectors.

Tool name	Type I	Type II and Type III
All-speed sensor check harness	99731 Z0000	99731 Z0012

- Turn the key switch to ON.
 - Set the tester to the DCV range. Connect the positive lead of the tester to terminal ③, and the negative lead to terminal ② or ④ to measure the voltage.
 - Turn the all-speed sensor to the full position and to the idle position. Check that the output voltages are within the specification at both positions.
- 2) Judgment
- Output voltage is normal. → Check the wiring harness. → Go to CHECK 5.
 - Output voltage is abnormal. → Adjust the output voltage. → Go to CHECK 3.



CHECK
3

Adjustment of output voltage

- 1) Turn the key switch to OFF. Disconnect the all-speed sensor connector.
- 2) Connect the check harness between the main harness and the all-speed sensor connectors.

Tool name	Type I	Type II and Type III
All-speed sensor check harness	99731 Z0000	99731 Z0012

- 3) Turn the key switch to ON.
- 4) Set the tester to the DCV range. Connect the positive lead of the tester to terminal ③, and the negative lead to terminal ② or ① to measure the voltage.
- 5) Turn the accelerator lever for service to the idle position, and measure the output voltage.
- 6) Turn the accelerator lever for service to the full position, and measure the output voltage at the position of the full stopper bolt of the all-speed sensor.

NOTE

- The lever opening angle may not be 0% in the idle position and 100% in the full position. Verify that the output values are within the specification.
- 7) If the output values are not within the specification, loosen the lot bolt and make adjustment.
 - 8) Tighten the lot bolt to the specification. Turn the accelerator lever for service to the full position and to the idle position and recheck the output voltages.
 - 9) Turn the key switch to OFF. Disconnect the check harness and reconnect the all-speed sensor connector.
 - 10) Judgment
 - All-speed sensor adjustable. → Adjust the sensor.
 - All-speed sensor not adjustable. → Check the wiring harness.
- Go to CHECK
4.

NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

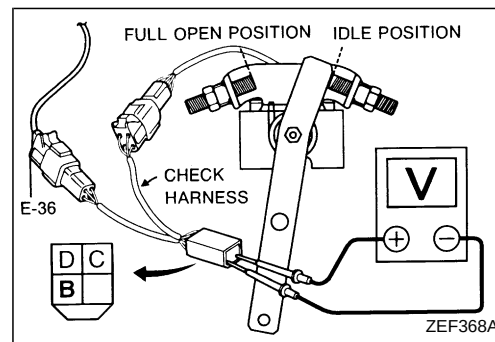
CHECK
4

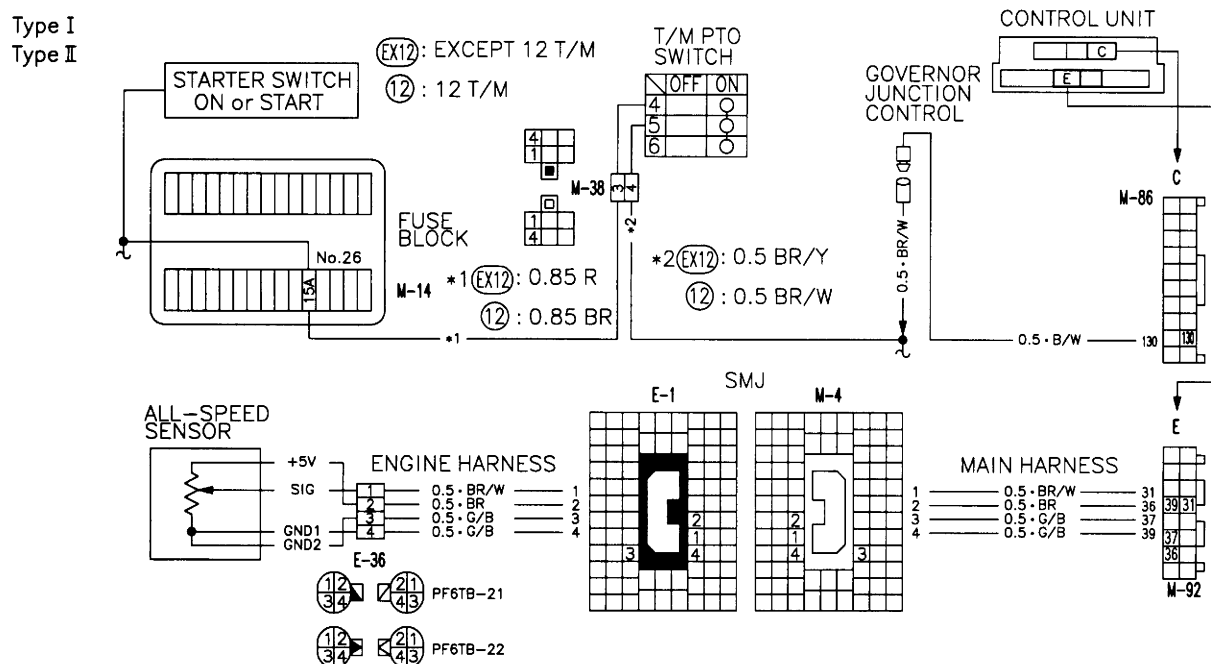
Inspection of wiring harness between control unit and all-speed sensor

- 1) Turn the key switch to OFF. Disconnect the connector from the control unit.
- 2) Disconnect the all-speed sensor connector.
- 3) Check for open/short circuit in the wiring harnesses between each terminals of the control unit and the all-speed sensor, and at the terminals of the junction for governor control.

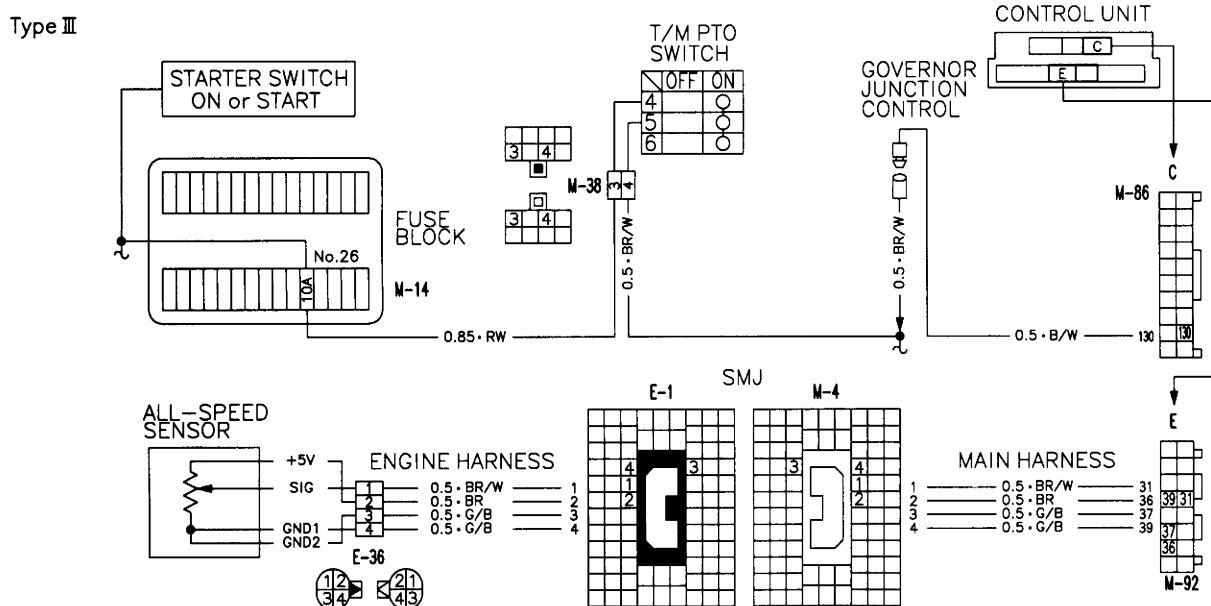
NOTE

- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.





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4) Judgment

- Wiring harness failed (open/short circuit, etc.). → Repair or replace the wiring harness.
- Wiring harness is normal. → All-speed sensor failed. → Replace the all-speed sensor.

NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

5 Inspection of wiring harness between control unit and all-speed sensor

- 1) For inspection procedure, refer to **4**.

2) Judgment

- Wiring harness failed (open/short circuit, etc.). → Repair or replace the wiring harness.
- Wiring harness is normal. → Control unit failed. → Replace the control unit.

NOTE

- **When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.**
- **After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.**

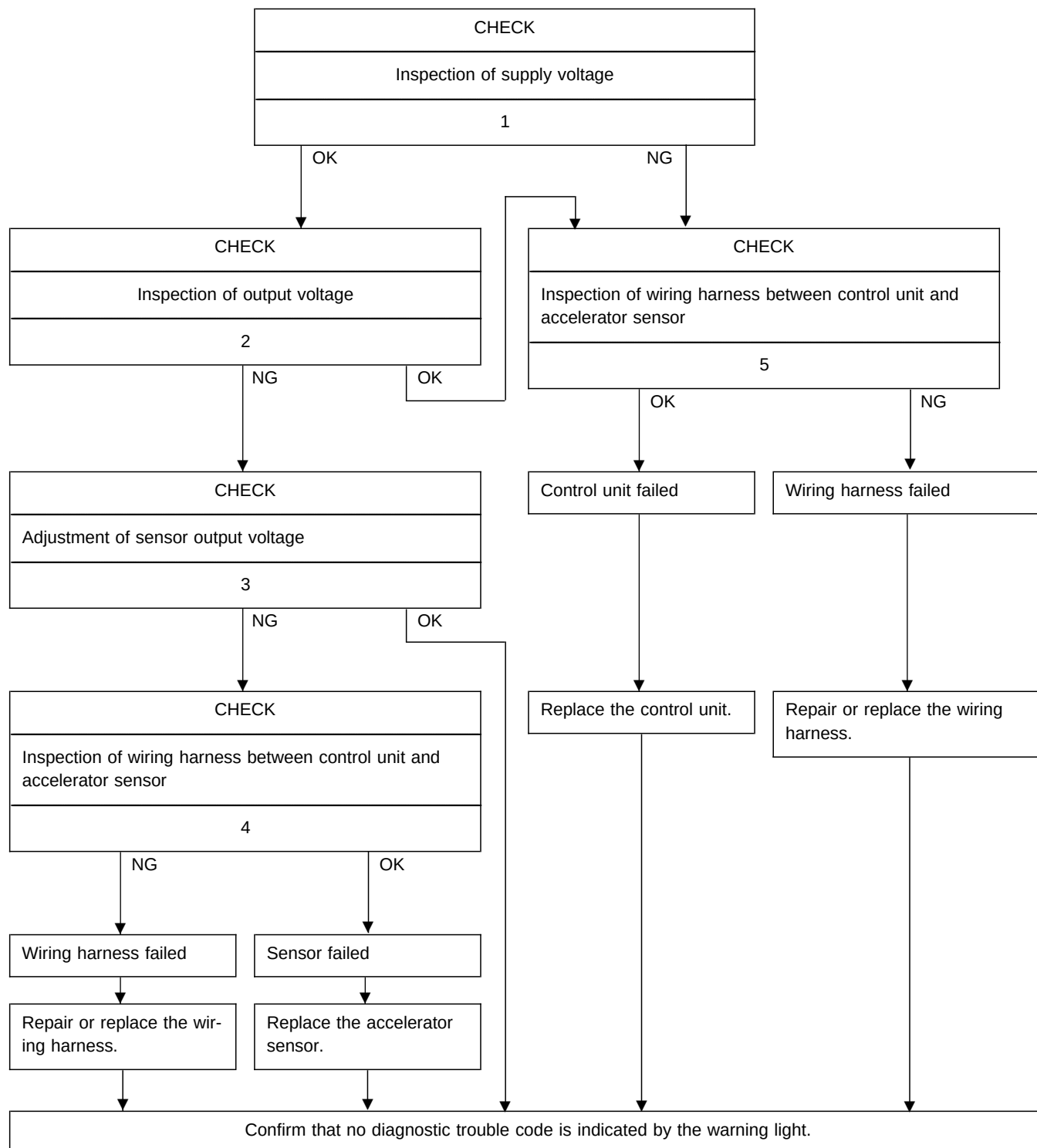
10. ACTION FOR ACCELERATOR SENSOR ERROR

[LIGHT FLASH: 2-3, LIGHT FLASH: 2-4, 4-4]

[1] Inspection items

- Accelerator sensor (supply voltage and output voltage)
- Idle switch (supply voltage and output voltage)
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

Inspection of supply voltage

- 1) Check the supply voltage to the accelerator sensor.
 - Turn the key switch to OFF.
 - Disconnect the harness connectors (3-pin) from the accelerator sensor.
 - Connect the check harness between the disconnected connectors, and turn the key switch to ON.

Tool name	Type I and Type III	Type II
Accelerator sensor check harness	99732 Z0001	99732 Z0006

- Set the tester to the DCV measurement range (capable of measuring voltage greater than 5V). Connect the negative lead of the tester to terminal ①, and the positive lead to terminal ③ to measure the voltage.

2) Judgment

Supply voltage: 5 ± 0.25 [V]

- Supply voltage is normal. → Check the output voltage. Go to **CHECK 2**.
- Supply voltage is abnormal. → Check the wiring harness. Go to **CHECK 5**.

3) Check the supply voltage to the idle switch.

- Turn the key switch to OFF.
- Disconnect the harness connectors (2-pin) from the idle switch.
- Connect the check harness between the disconnected connectors, and turn the key switch to ON.

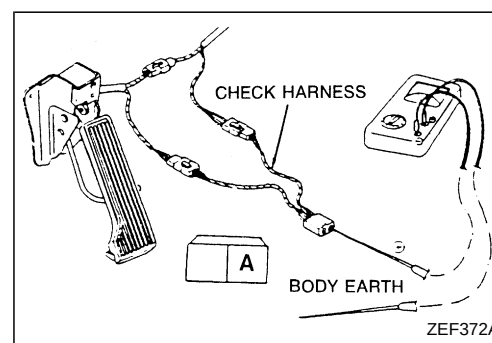
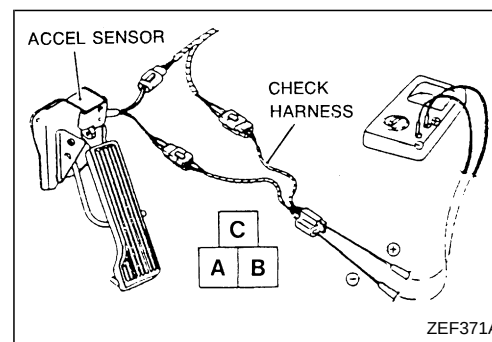
Tool name	Type I and Type III	Type II
Idle switch check harness	99732 Z0002	99732 Z0007

- Set the tester to the DCV measurement range (capable of measuring voltage greater than 24V). Connect the positive lead of the tester to terminal ①, and the negative lead to the body ground to measure the voltage.

4) Judgment

Supply voltage: (Reference to battery voltage 20 - 28 [V])

- Supply voltage is normal. → Check the idle switch. Go to **CHECK 2**.
- Supply voltage is abnormal. → Check the wiring harness. Go to **CHECK 5**.



CHECK
2

Inspection of accelerator sensor and idle switch for output voltage

- 1) Check the accelerator sensor output voltage.
 - Turn the key switch to OFF.
 - Disconnect the harness connectors from the accelerator sensor.
 - Connect the check harness between the disconnected connectors.

Tool name	Type I and Type III	Type II
Accelerator sensor check harness	99732 Z0001	99732 Z0006

- Turn the key switch to ON.
- Set the tester to the DCV measurement range (capable of measuring voltage greater than 5V). Connect the positive lead of the tester to terminal ②, and the negative lead to terminal ① to measure the voltage.
- Depress the accelerator pedal from the full throttle position to the idle position to confirm that the output voltage of the accelerator sensor in each position is within the specification.

NOTE

- Accelerator pedal should not be contacted to the accelerator stopper with the accelerator sensor in full throttle position. (Accelerator pedal should be stopped at the sensor side.)
- If the output voltage is deviated from the specification, the idle cannot be maintained or insufficient output may be caused.

2) Judgment

- Output voltage is normal. → Check the wiring harness. Go to

CHECK
5

- Output voltage is abnormal. → Adjust the output voltage. Go to

CHECK
3

3) Inspection of idle switch

- Turn the key switch to OFF.
- Disconnect the harness connectors from the idle switch.
- Connect the idle switch check harness.

Tool name	Type I and Type III	Type II
Idle switch check harness	99732 Z0002	99732 Z0007

- Leave the harness connector of the main harness side disconnected.
- Set the tester to the resistance measurement range, and check the continuity between ① and ② of the check harness connector.
- Depress the accelerator pedal from the full position to the idle position to confirm that the resistance is 0 [Ω] at the full position and ∞ [Ω] at the idle position.

4) Judgment

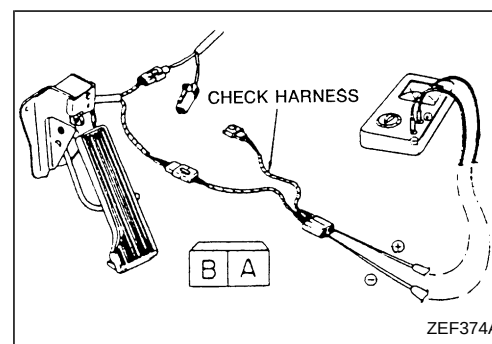
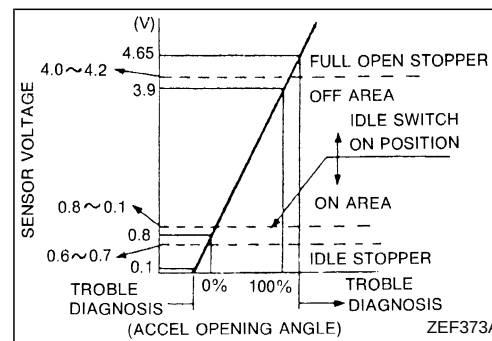
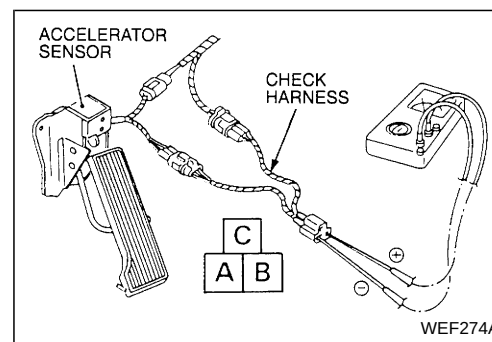
- Continuity is normal. → Check the wiring harness. Go to

CHECK
5

- Continuity is abnormal. → Replace the idle switch.

NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.



CHECK
3

Adjustment of accelerator sensor output voltage

- 1) Turn the key switch to OFF, and disconnect the accelerator sensor harness connector.
- 2) Remove the accelerator sensor assembly from the carb.
- 3) Connect the check harness between the main harness and the sensor harness connector.

Tool name	Type I and Type III	Type II
Accelerator sensor check harness	99732 Z0001	99732 Z0006

- 4) Turn the key switch to ON.
- 5) Set the tester to the DCV measurement range, and connect the positive lead of the tester to terminal (B), and the negative lead to terminal (A).
- 6) Turn the accelerator lever to the idle position, loosen the accelerator lever retaining screws, and adjust the accelerator lever to the idle output to the specification. Then, partially tighten the screws.
- 7) Turn the accelerator lever to the full position, and loosen the accelerator sensor full stopper bolt to adjust the accelerator lever to the full output specification. Then, hand tighten the screws.
- 8) Turn the accelerator lever to the idle position again, and confirm that the output is within the specification. Then, tighten the retaining screws. If the output is out of specification, go to the step 6 to readjust it.
- 9) Turn the accelerator lever to the full position again, confirm that the output is within the specification, and tighten the stopper bolt.
- 10) After tightening the screw, recheck the output voltage when the accelerator lever is turned from the full position to the idle position.
- 11) Turn the key switch to OFF, disconnect the check harness. Install the accelerator sensor to the cab, and connect the harness connectors.
- 12) Judgment
 - Accelerator sensor adjustment is possible. → Adjust the accelerator sensor to the specification.
 - Accelerator sensor adjustment is impossible. → Check the wiring harness. Go to CHECK
4.

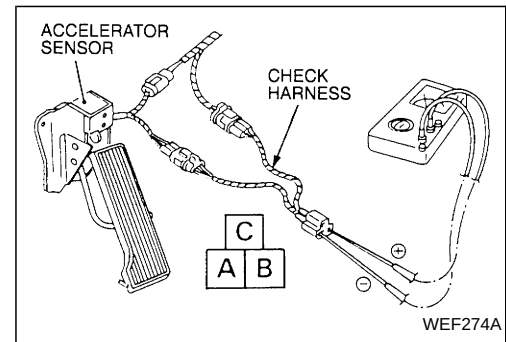
NOTE

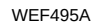
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK
4

Inspection of wiring harness between control unit and accelerator sensor

- 1) Turn the key switch to OFF, and disconnect the harness connector from the control unit.
- 2) Disconnect the sensor connector and switch connector from the accelerator sensor.
- 3) Check the wiring harness for open/short circuit between each pair of terminals of the control unit and the accelerator sensor harness, and between that of the control unit and the idle switch harness.





- Wiring harness is open/shorted. → Repair or replace the wiring harness.
- Wiring harness is normal. → Accelerator sensor failed (idle switch). → Replace the accelerator sensor.

- **After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.**

CHECK
5

- 1) For inspection procedure, refer to

CHECK
4

.

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

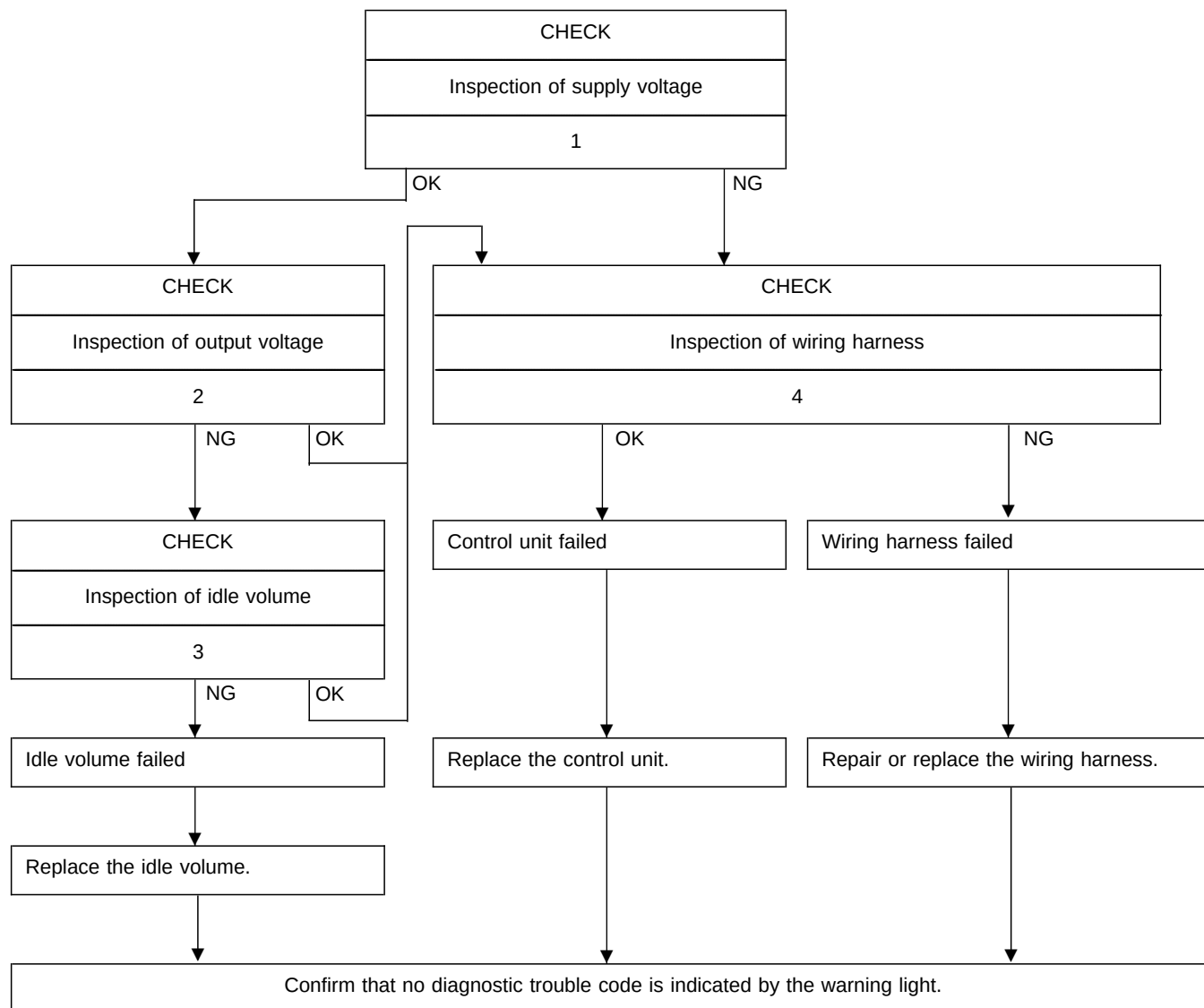
11. ACTION FOR ABNORMAL IDLE VOLUME

[LIGHT FLASH: 3-1]

[1] Inspection items

- Idle volume (supply voltage and output voltage)
- Idle volume body
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

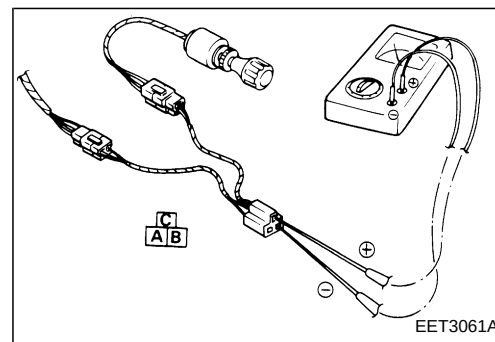
Inspection of supply voltage

- 1) Measure the supply voltage to the idle volume.
 - Turn the key switch to OFF, and disconnect the idle volume harness connector (4-pin).
 - Connect the check harness (99733 Z0000) between the idle volume and the wiring harness.
 - Turn the key switch to ON, and connect the positive lead of the tester to terminal ③, and the negative lead to terminal ② to measure the voltage.

2) Judgment

Supply voltage: 5 ± 0.25 [V]

- Supply voltage is normal. → Check the output voltage. Go to **CHECK 2**.
- Supply voltage is abnormal. → Check the wiring harness. Go to **CHECK 4**.

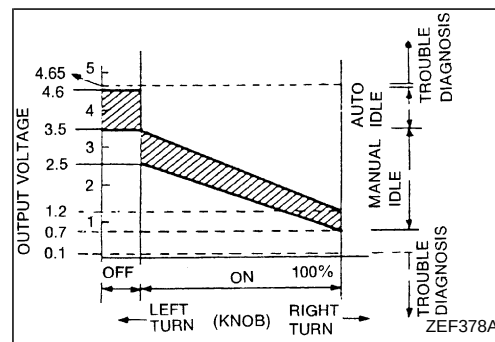
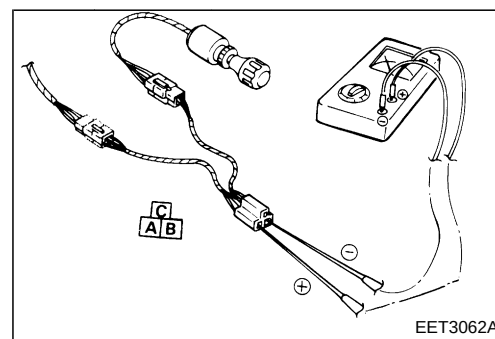


Inspection of output voltage

- 1) Measure the output voltage of the idle volume.
 - Turn the key switch to OFF, and disconnect the idle volume harness connector.
 - Connect the check harness (99733 Z0000) between the idle volume and the wiring harness.
 - Turn the key switch to ON, and connect the positive lead of the tester to terminal ①, and the negative lead to terminal ② to measure the voltage.

2) Judgment

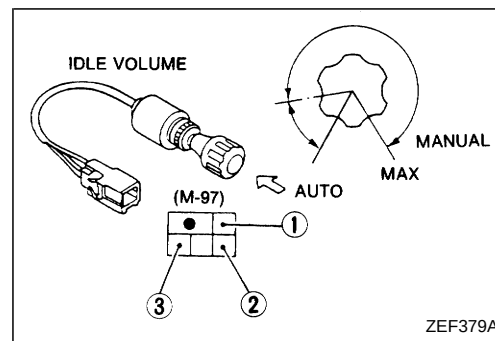
- Output voltage is normal. → Check the wiring harness. Go to **CHECK 4**.
- Output voltage is abnormal. → Check the idle volume. Go to **CHECK 3**.



Inspection of idle volume

- 1) Measure the resistance of the idle volume.
 - Turn the key switch to OFF, and disconnect the idle volume harness connector.
 - Connect the tester lead between each pair of terminals of the idle volume connector, and measure the resistance of the idle volume at the automatic idle, manual MAX, and whole range of manual idle.

2) Judgment



<Resistance value of idle volume>

Knob position	Terminal	Resistance [kΩ]
Auto	① - ③	7.4 - 8.8
	② - ③	9.3 - 10.9
Manual MAX	① - ③	0.8 - 1.2
	② - ③	4.4 - 5.6
Manual whole range	① - ③	3.6 - 0.8

- Resistance is normal. → Check the wiring harness. Go to

CHECK 4

.
- Resistance is abnormal. → Idle volume failed. → Replace the idle volume.

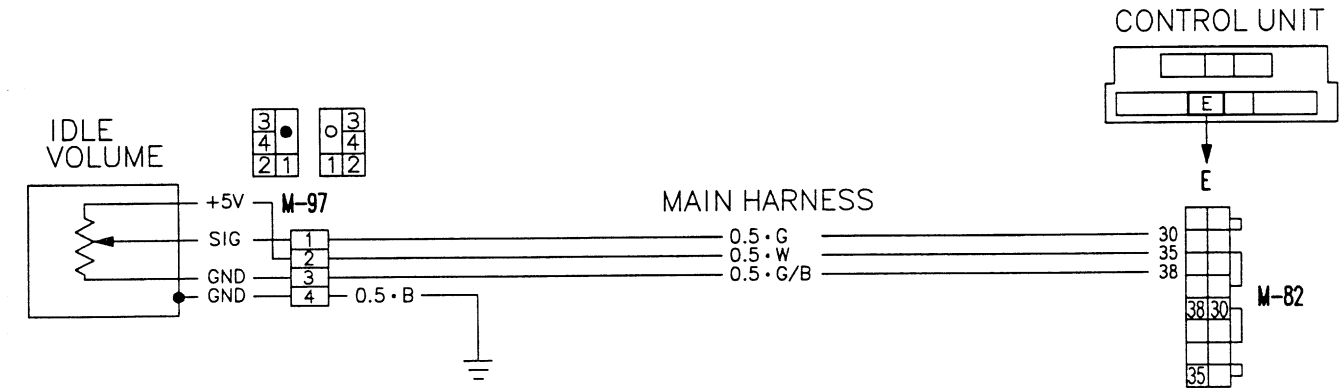
NOTE

- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK 4

 Inspection of wiring harness between control unit and idle volume

- 1) Turn the key switch to OFF, and disconnect the harness connector from the control unit.
- 2) Disconnect the idle volume harness connector.
- 3) Check for open/short circuit between each pair of terminals at both connectors.



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- 4) Judgment
- Wiring harness is normal. → Control unit failed. → Replace the control unit.
 - Wiring harness is open/shorted. → Repair or replace the wiring harness.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

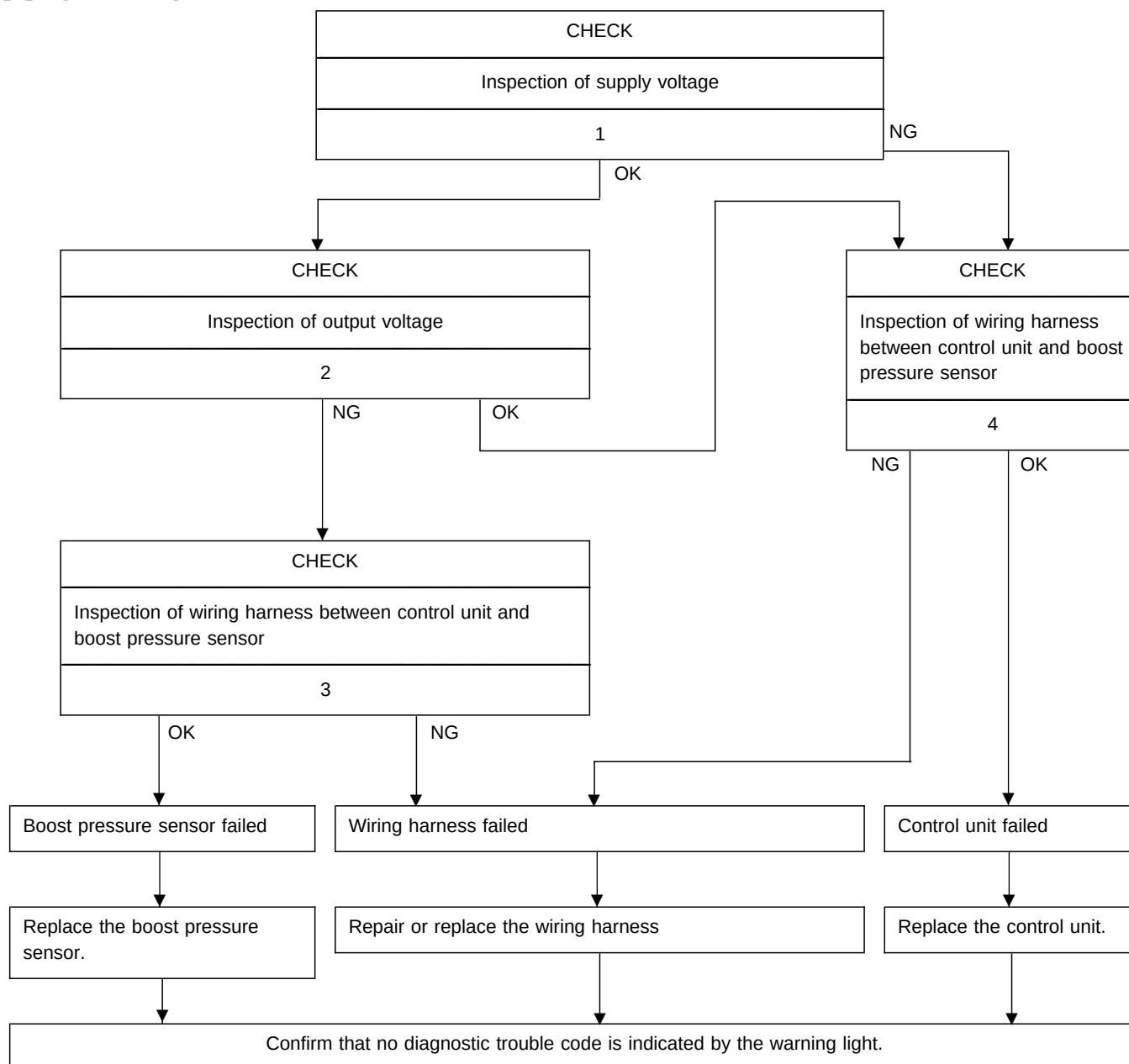
12. ACTION FOR BOOST PRESSURE SENSOR ERROR

[LIGHT FLASH: 3-2]

[1] Inspection items

- Boost pressure sensor (supply voltage and output voltage)
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

CHECK 1 Inspection of supply voltage

- 1) Check the supply voltage to the boost pressure sensor.
 - Turn the key switch to OFF, and disconnect the harness connector (3-pin) from the boost pressure sensor.
 - Connect the check harness (99732 Z0000) between disconnected connectors, and turn the key switch to ON.
 - Set the tester to the DCV measurement range (capable of measuring voltage greater than 5V). Connect the tester lead to the check harness connector to measure the voltage.
- 2) Judgment

Supply voltage: 5 ± 0.25 [V]

- Supply voltage is normal. → Check the output voltage. Go to **CHECK 2**.
- Supply voltage is abnormal. → Check the wiring harness. Go to **CHECK 4**.

NOTE

- Do not measure the resistance because the boost pressure sensor is open by the faint current.

CHECK 2 Inspection of output voltage

- 1) Check the output voltage of the boost pressure sensor.
 - Turn the key switch to OFF, and disconnect the harness connector from the boost pressure sensor.
 - Connect the check harness (99732 Z0000) between disconnected connectors, and turn the key switch to ON.
 - Set the tester to the DCV measurement range, and measure the output voltage.
- 2) Judgment

Output voltage: Approx. 0.5V (atmospheric pressure)

 - Output voltage is normal. → Check the wiring harness. Go to **CHECK 4**.
 - Output voltage is abnormal. → Check the wiring harness. Go to **CHECK 3**.

NOTE

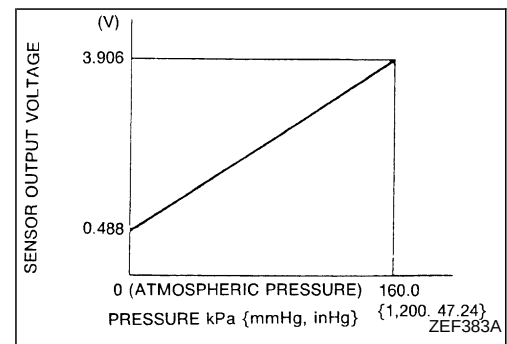
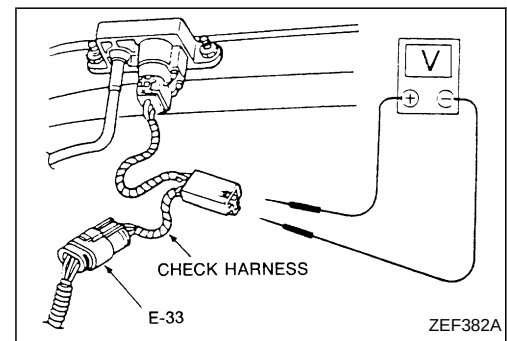
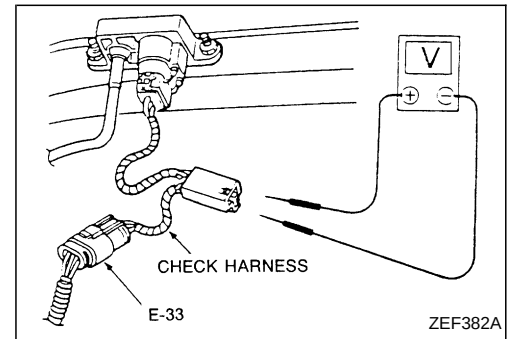
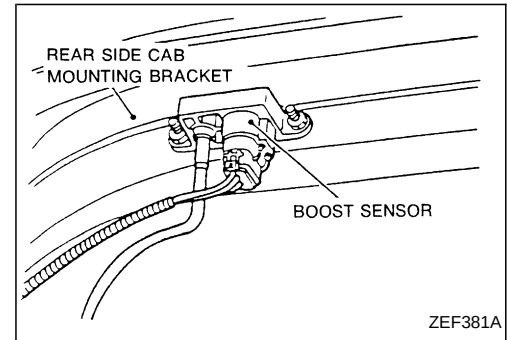
- Do not measure the resistance because the boost pressure sensor wire is open by the faint current.

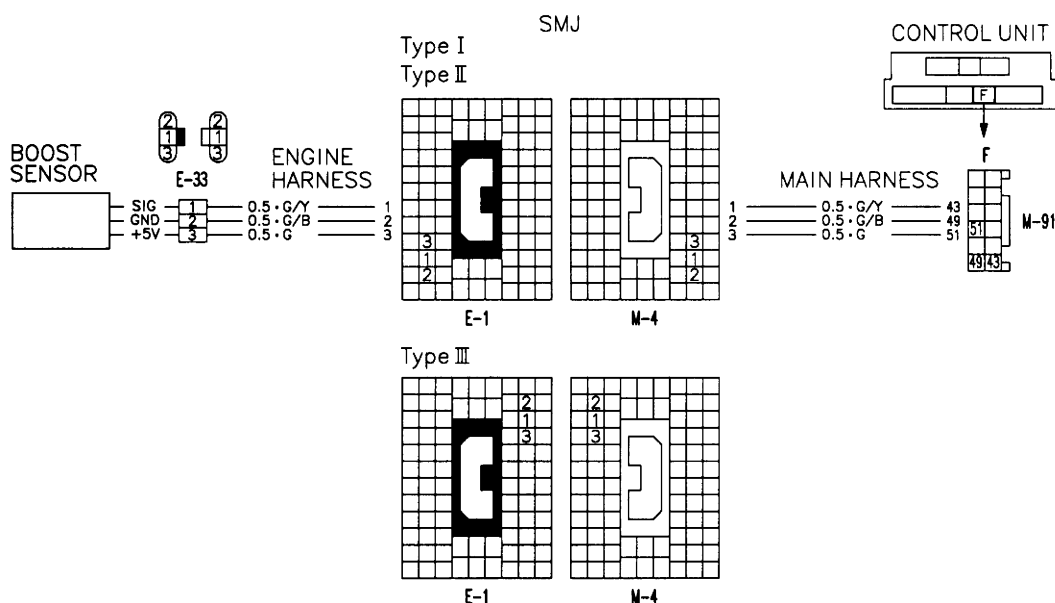
CHECK 3 Inspection of wiring harness between control unit and boost pressure sensor

- 1) Turn the key switch to OFF, and disconnect the harness connector from the control unit.
- 2) Disconnect the harness connector from the boost pressure sensor.
- 3) Check for open/short circuit between each pair of terminals at both connectors.

NOTE

- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harnesses.





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4) Judgment

- Wiring harness is normal. → Boost pressure sensor failed. → Replace the boost pressure sensor.
- Wiring harness is open/shorted. → Repair or replace the wiring harness.

NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK
4

Inspection of wiring harness between control unit and boost pressure sensor

- 1) For inspection procedure, refer to CHECK
5.
- 2) Judgment
 - Wiring harness is normal. → Replace the control unit.
 - Wiring harness is open/shorted. → Repair or replace the wiring harness.

NOTE

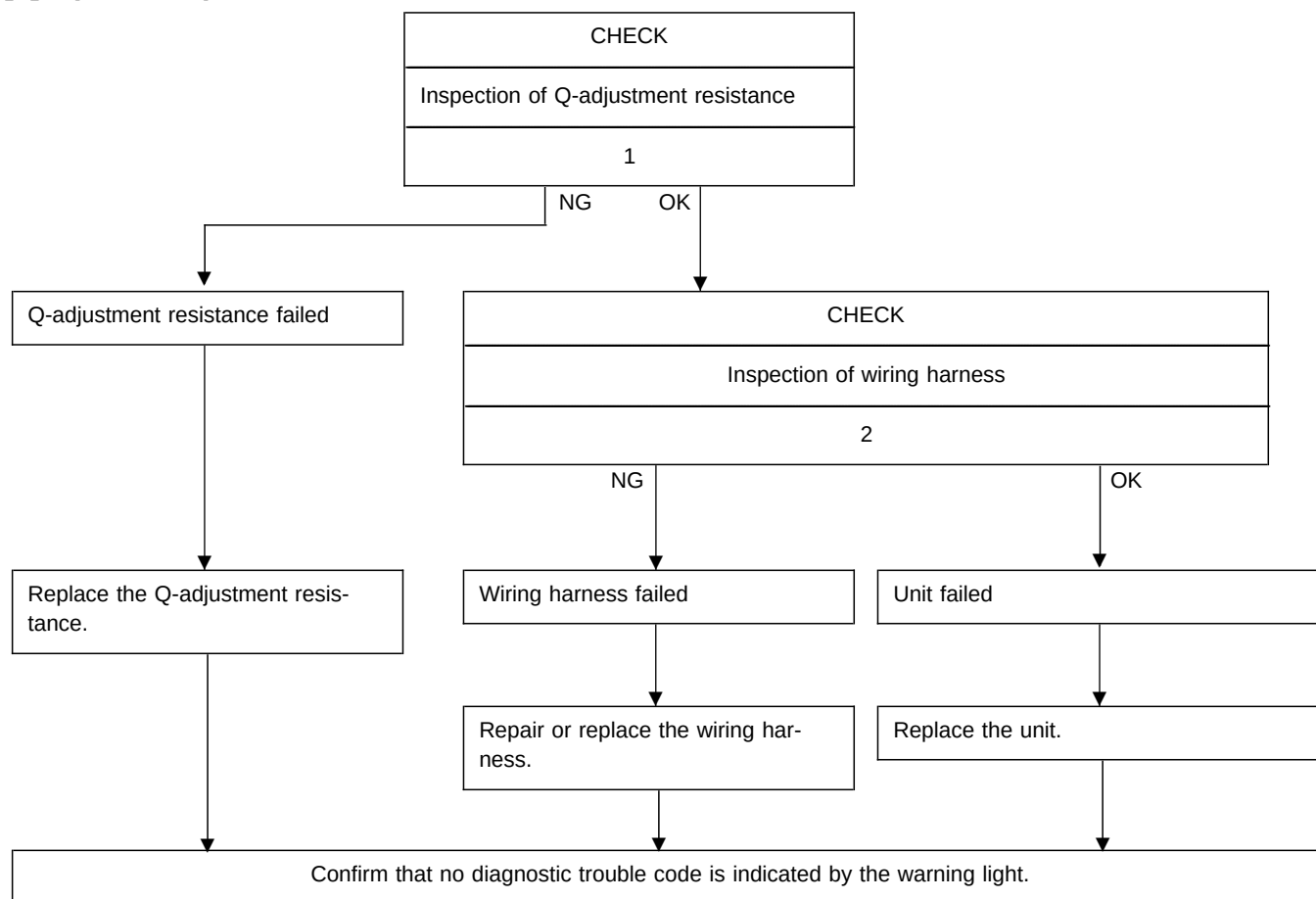
- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

13. ACTION FOR ABNORMAL Q-ADJUSTMENT RESISTANCE [LIGHT FLASH: 3-4]

[1] Inspection items

- Q-adjustment resistance
- Wiring harness (open/short circuit)
- Final confirmation

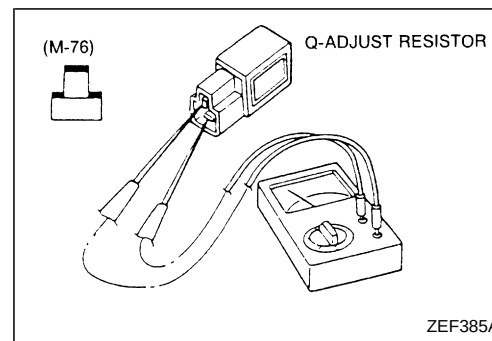
[2] Operation procedure



[3] Operation procedure

CHECK 1 Inspection of Q-adjustment resistance

- 1) Measure the resistance of the Q-adjustment resistance.
 - Turn the key switch to OFF.
 - Disconnect the Q-adjustment resistance, and measure the resistance between each pair of the terminals of the Q-adjustment resistance using the tester.
- 2) Judgment



<Resistance of Q-adjustment resistance>

No.	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57
Rack position compensation mm (in)	-0.44 (-0.0173)	-0.38 (-0.0150)	-0.31 (-0.0122)	-0.25 (-0.0098)	-0.19 (-0.0075)	-0.13 (-0.0051)	-0.06 (-0.0024)	0 (0)	+0.06 (+0.0024)	+0.13 (+0.0051)	+0.19 (+0.0075)	+0.25 (+0.0098)	+0.31 (+0.0122)	+0.38 (+0.0150)	+0.44 (+0.0173)
Resistance [Ω]	267	383	511	649	825	1.02 k	1.30 k	1.62 k	2.00 k	2.55 k	3.32 k	4.22 k	5.62 k	8.25 k	15.00 k

- Resistance is normal. → Check the wiring harness. Go to

CHECK 2

.
- Resistance is abnormal. → Q-adjustment resistance is abnormal. → Replace the Q-adjustment resistance.

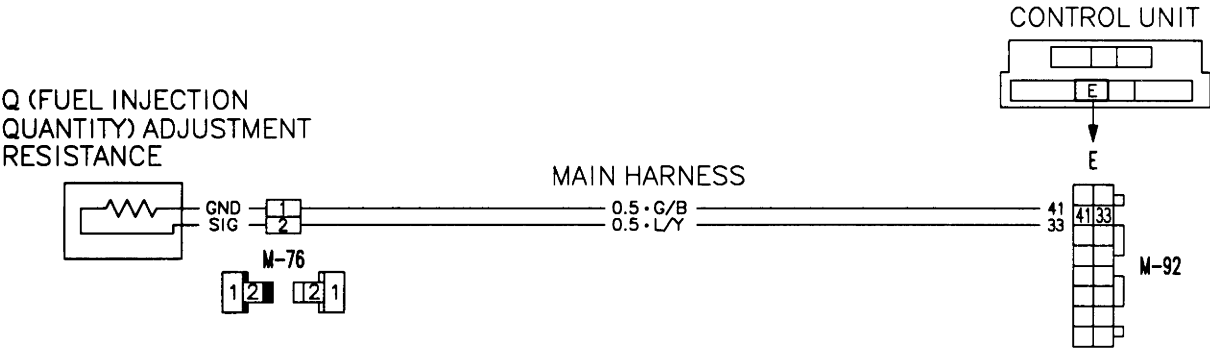
NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK 2

Inspection of wiring harness between control unit and Q-adjustment resistance

- Turn the key switch to OFF, and disconnect the harness connector from the control unit.
- Remove the Q-adjustment resistance from the wiring harness.
- Check for open/short circuit between each pair of terminals at connectors of the control unit and the Q-adjustment resistance.



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- Judgment
 - Wiring harness is normal. → Control unit failed. → Replace the control unit.
 - Wiring harness is open/shorted. → Repair or replace the wiring harness.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

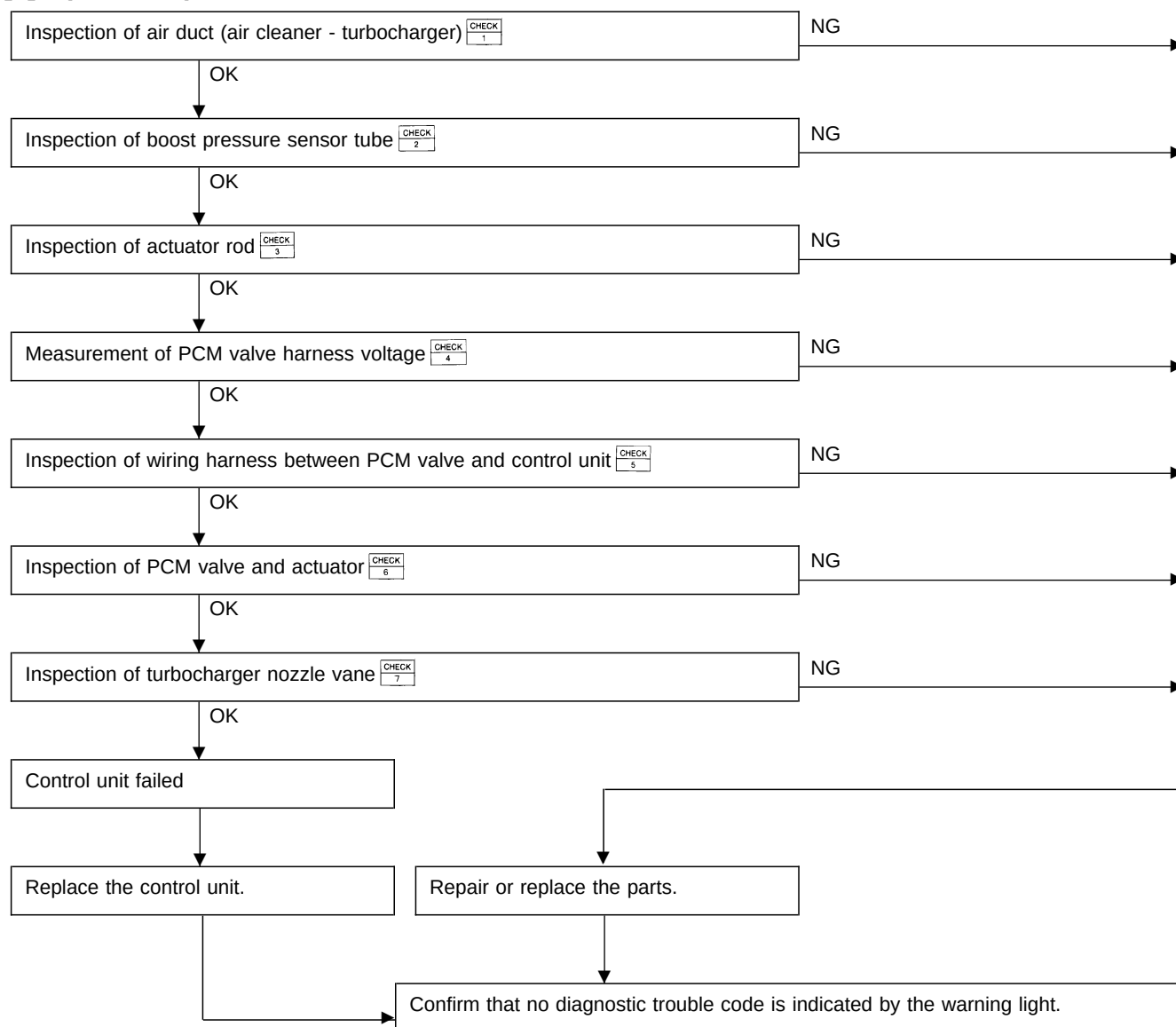
14. ACTION FOR OVER BOOST ERROR

[LIGHT FLASH: 4-1] (TYPE I ONLY)

[1] Inspection items

- Air duct
- Boost pressure sensor tube
- Actuator rod
- PCM valve body
- Turbocharger body

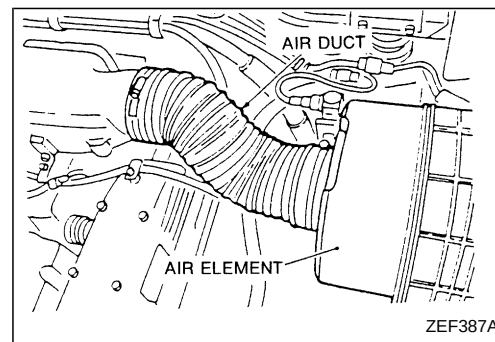
[2] Operation procedure



[3] Operation procedure

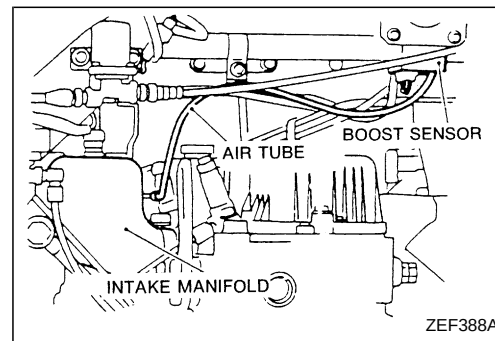
CHECK 1 Inspection of air duct (air cleaner - turbocharger)

- 1) Check the duct and tube between the air cleaner and the turbocharger for breakage, disconnection, or clogging.
- 2) Judgment
 - Air duct is normal. → Check the boost pressure sensor tube. Go to **CHECK 2**.
 - If the air duct is broken, replace the air duct. If the air duct is disconnected or clogged, repair it.



CHECK 2 Inspection of boost pressure sensor tube

- 1) Check the boost pressure sensor tube for leakage resulting from the kinks or the breakage (cracks).
 - Check that the air tube shown in the figure is connected properly.
 - If the air tube is connected properly, check for breakage, cutting, or kinks.
 - Check the boost pressure sensor tube connection at the intake manifold for clogging.
- 2) Judgment
 - Boost pressure sensor tube is normal. → Check the actuator rod. Go to **CHECK 3**.
 - If the boost pressure sensor tube is broken, replace it. If the boost pressure sensor tube is disconnected or clogged, repair it.

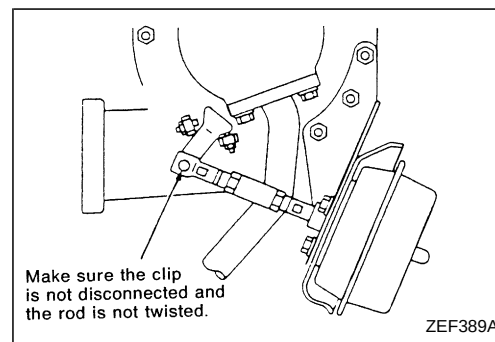


NOTE

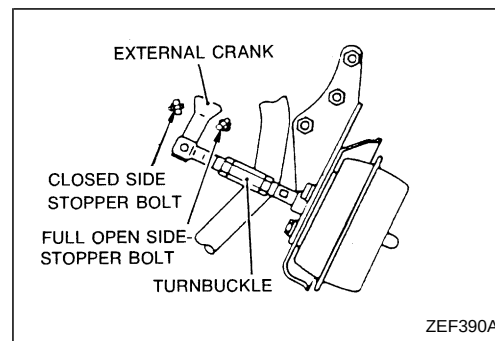
- **Never use vinyl hose when replacing the tube. Use only the specified one.**

CHECK 3 Inspection of actuator rod

- 1) Check the actuator rod status.
 - Visually check that the actuator rod is disconnected from the external crank pin, or is installed in the wrong direction.



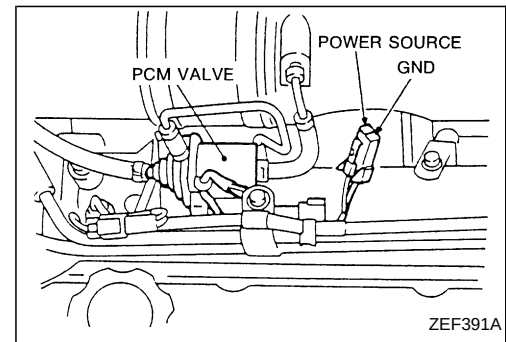
- Visually check that the external crank makes contact with to the full-open side stopper bolt with the engine stopped.
- 2) Judgment
 - Actuator rod is normal. → Measure the harness voltage. Go to **CHECK 4**.
 - When the rod is disconnected and the rod length is adjusted improperly, set the rod following the procedures in BASIC OPERATION, item 5, Setting of actuator for VNT control.
 - When the rod is kinked, remove the rod, and set it again following the procedures in BASIC OPERATION, item 5, Setting of actuator for VNT control.



CHECK
4

Measurement of PCM valve harness voltage

- 1) Turn the key switch to OFF, and disconnect the connector from the PCM valve.
- 2) Turn the key switch to ON, and measure the voltage of the power side of the connector terminal at the harness side of the PCM valve.
- 3) Judgment
 - Power voltage (Reference battery voltage: 20 - 28 [V])
 - Voltage is normal. → Check the wiring harness. Go to CHECK 5.
 - Voltage is abnormal. → Wiring harness is open/shorted. → Repair or replace the wiring harness.



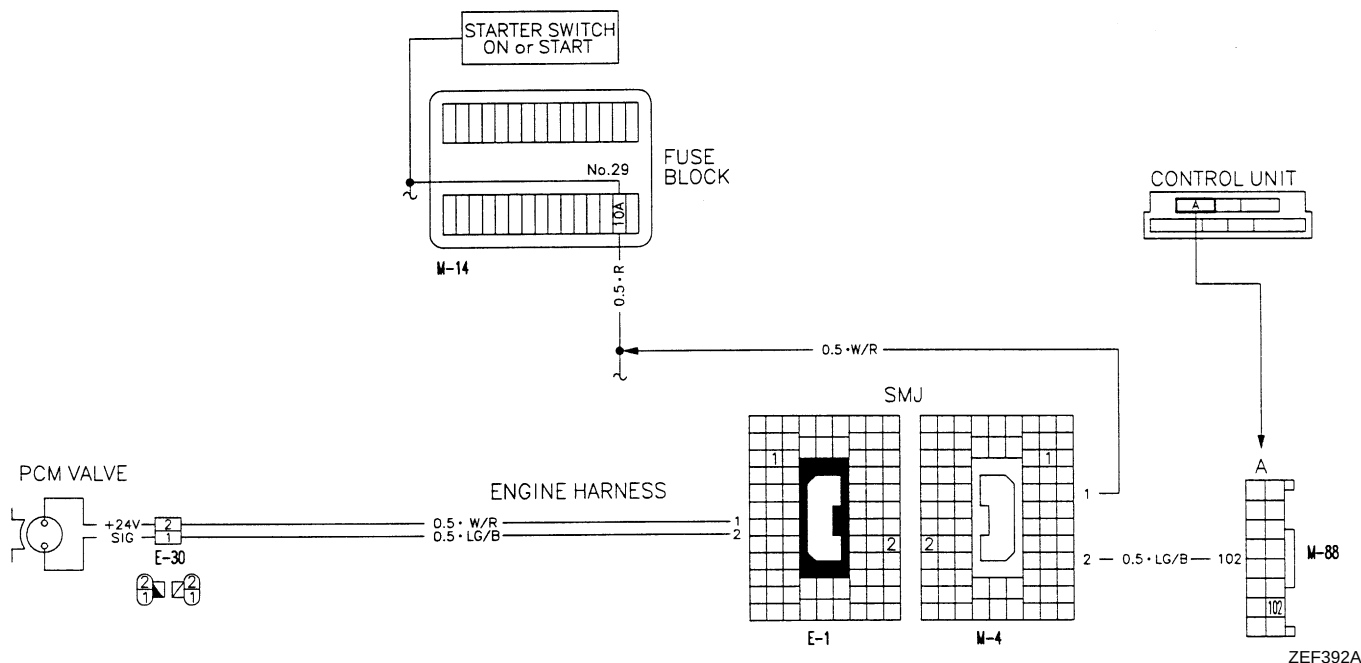
NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

CHECK
5

Inspection of wiring harness between PCM valve and control unit

- 1) Turn the key switch to OFF.
- 2) Check for open/short circuit between the connectors of the PCM valve and the control unit.



- 3) Judgment
 - Wiring harness is open/shorted. → Repair or replace the wiring harness.
 - Wiring harness is normal. → Check the PCM valve and actuator. Go to CHECK 6.

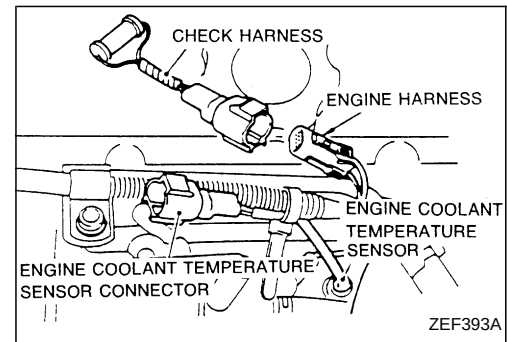
NOTE

- After completing each operation, carry out troubleshooting with the diagnostic light and confirm that there is no abnormality.

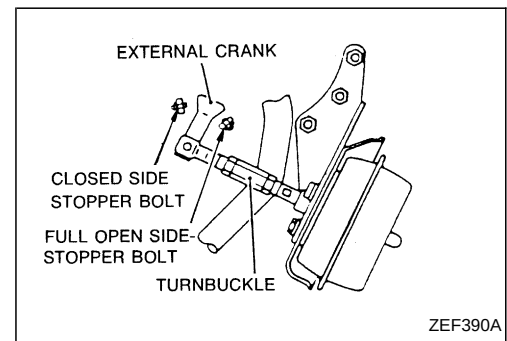
CHECK
6

Inspection of PCM valve and actuator

- 1) Check that the engine is warmed up sufficiently, and idle the engine.
Disconnect the engine coolant temperature sensor connector. Repeatedly connect/disconnect the check harness (99731 Z0005) or apply/stop applying the resistance (approx. 10 k Ω) to the harness connector. Visually check resultant actuator movement.
- 2) Judgment
 - Actuator rod moves smoothly (connected → fully closed, disconnected → fully open), and contacts with the full-closed or the full-open stopper. → Actuator rod is normal.
 - Actuator rod does not contact with the stopper. → Check the actuator movement.



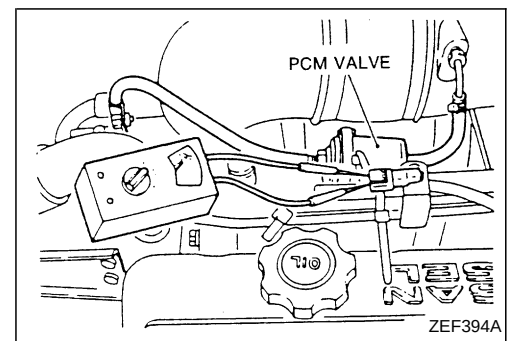
- 3) Inspection of actuator movement
 - Disconnect the vacuum hoses between the actuator and the PCM valve, and between the vacuum pump and the PCM valve.
 - Disconnect the vacuum hose between the PCM valve and the intake manifold. At this time, check the hoses for clogging.
- 4) Connect/disconnect the hose between the PCM valve and the actuator to the hose between the vacuum pump and PCM valve directly, and check the actuator movement.
- 5) Judgment
 - Actuator rod moves smoothly (connected → fully closed, disconnected → fully open), and contacts with the full-closed or the full-open stopper. → Actuator is normal. → Check the PCM valve. → Go to CHECK
6.
 - Actuator rod does not contact with the stopper. → Actuator failed. → Replace the actuator.



- 6) Inspection of PCM valve
 - Measure the resistance between each pair of terminals of the PCM valve connector.

Resistance: Approx. 29 Ω

- Check the PCM valve air tube of the air release side for clogging.
- 7) Judgment
 - PCM valve is open/shorted. → Replace the PCM valve.
 - PCM valve is clogged. → Repair, or replace the PCM valve.
 - PCM valve is normal. → Check the turbocharger nozzle vane.
- Go to CHECK
7.





Inspection of turbocharger nozzle vane

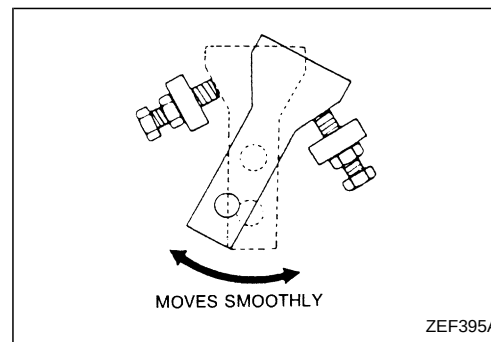
- 1) Check the movement of the nozzle vane.
 - Remove the actuator from the turbocharger, and check that the external crank moves forward and backward with the engine stopped.

NOTE

- **Because the turbocharger is heated just after the engine stops, inspection should be performed confirming that the engine is cold.**
- 2) Judgment
 - If the turbocharger nozzle vane is not caught excessively, and it contacts with the full-closed and full-open stopper, the turbocharger nozzle vane is normal. → Control unit failed. → Replace the control unit.
 - The turbocharger nozzle vane has some catches or abnormal travel to the stopper. → Replace the turbocharger assembly.

NOTE

- **When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.**
- **Never disassemble the internal parts, because the turbocharger has very complex structure.**
- **After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.**



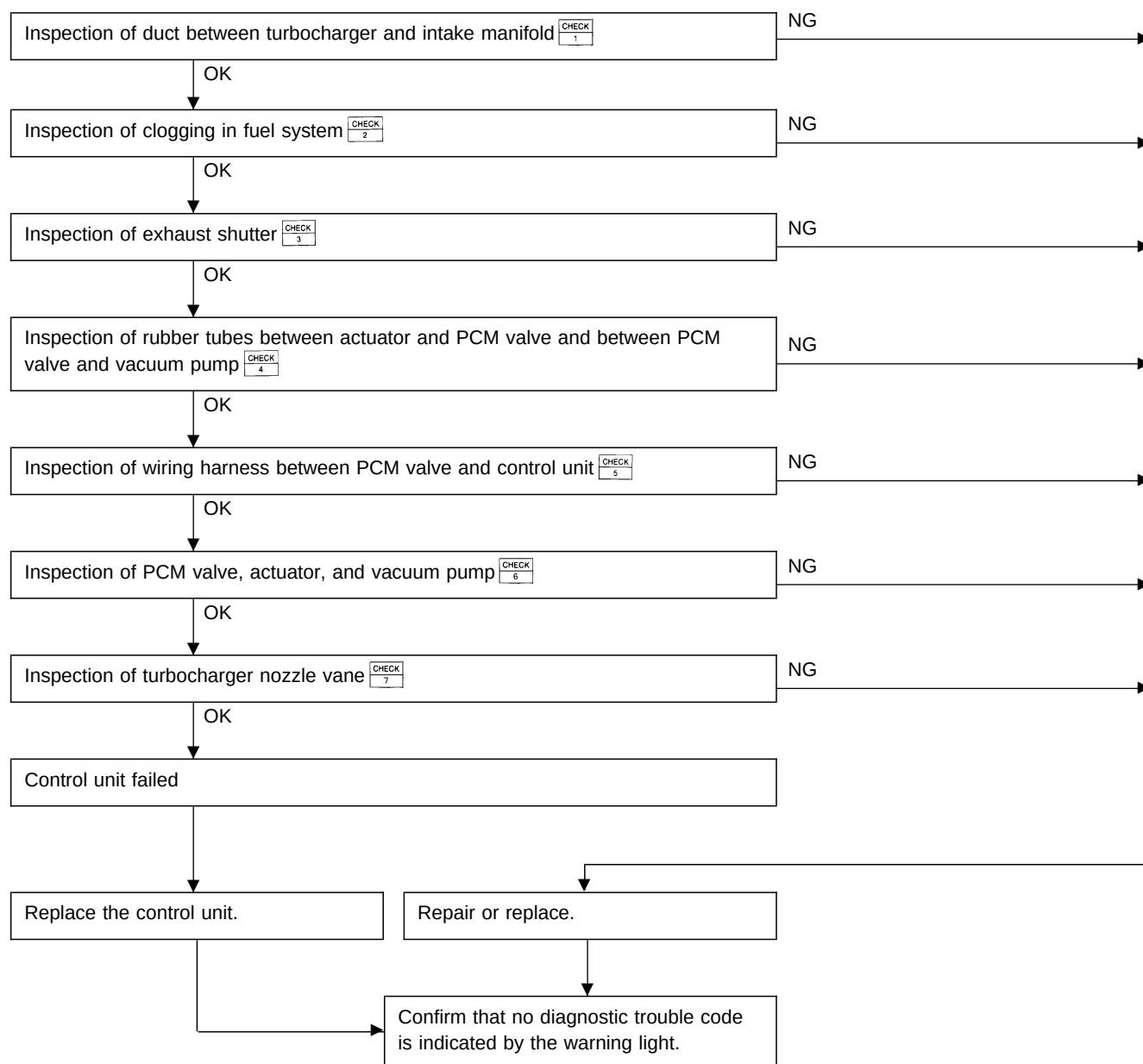
15. ACTION FOR UNDER BOOST ERROR

[LIGHT FLASH: 4-2] (TYPE I ONLY)

[1] Inspection items

- Air duct
- PCM valve tube
- Wiring harness (open/short circuit)
- Actuator rod
- Vacuum pump
- Fuel injection pump
- Fuel filter
- Exhaust shutter

[2] Operation procedure



[3] Operation procedure

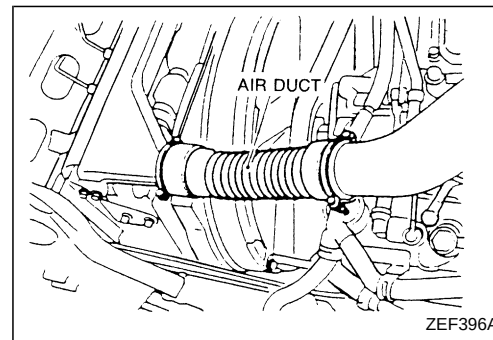
CHECK
1

Inspection of duct between turbocharger and intake manifold

- 1) Visually check the air duct from the turbocharger (including the upper and lower ducts for intercooler and the hose) for disconnection, breakage, or cracks.

NOTE

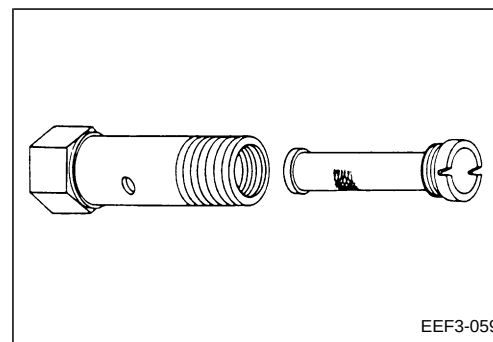
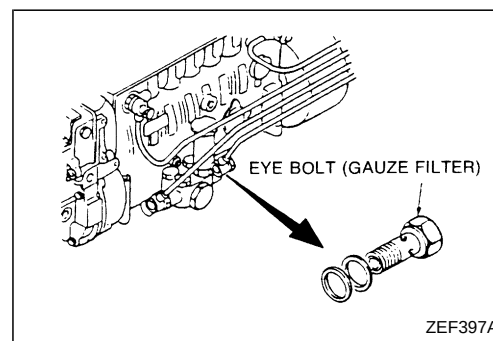
- The under boost error will not occur unless the damage of the air duct is severe.
 - When the under boost error occurs, the air leaking noise may be heard while driving. Do not mistake this noise for the air leaking noise from the relief valve during the over boost state.
- 2) Judgment
 - Air duct is normal. → Check the fuel system for clogging. Go to CHECK
2.
 - Air duct is disconnected. → Repair disconnection.
 - Air duct is damaged. → Replace as necessary.



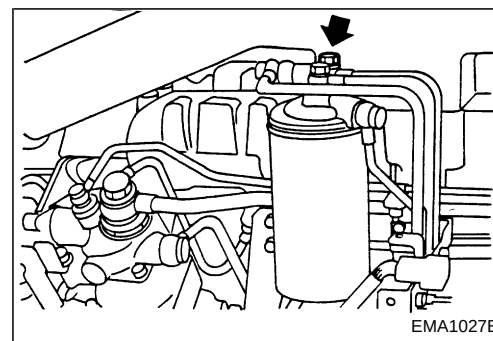
CHECK
2

Inspection of clogging in fuel system

- 1) Inspection of fuel injection pump gauze filter
 - Remove the eye bolt with gauze filter from the priming pump.
 - Remove the gauze filter from the eyebolt, using the screwdriver.
 - Clean the gauze filter and the eye bolt with cleaning fluid.



- 2) Inspection of overflow valve and fuel filter
 - Remove the overflow valve from the injection pump, and check the function of the overflow valve.
 - Remove the fuel filter, and check the element for clogging, and check the function of the overflow valve.
- 3) Judgment
 - Overflow valve and fuel filter are normal. → Check the exhaust shutter. Go to CHECK
3.
 - Overflow valve and fuel filter are abnormal. → Repair or replace.



CHECK
3

Inspection of exhaust shutter

- 1) Start the engine and turn the exhaust brake power switch on.
- 2) Depress the accelerator pedal and increase the engine speed to 1,500 rpm.
- 3) Release the accelerator pedal. The exhaust shutter is normal when its operation noise starts just after the accelerator pedal is released, and the noise stops while the engine speed returns to the idle speed.
- 4) Judgment
 - Exhaust shutter is normal. → Check the rubber tubes between actuator and PCM valve and between PCM valve and vacuum pump. Go to CHECK 4.
 - Exhaust shutter failed. → Refer to ACTION WHEN ADDITIONAL FUNCTION FAILED, and repair it.

CHECK
4

Inspection of rubber tubes between actuator and PCM valve, and between PCM valve and vacuum pump

- 1) Check the connections of the rubber tubes from the actuator to the vacuum pump. Visually check the eye connector for looseness and the rubber tube for breakage of crack.
- 2) Judgment
 - Rubber tubes are normal. → Check the wiring harness between PCM valve and, control unit. Go to CHECK 5.
 - Rubber tube is disconnected, or eye connector is loose. → Repair the joint
 - Rubber tube is damaged. → Replace the damaged tube.

CHECK
5

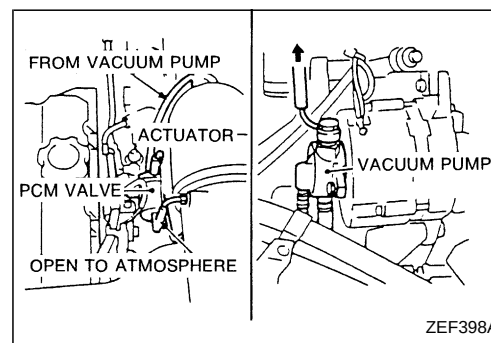
Inspection of wiring harness between PCM valve and control unit

- 1) Check for open/short circuit in the wiring harness between the PCM valve and the control unit. Check that the connectors are connected properly. Refer to 14. Action for over boost error CHECK 5 for the procedure.
- 2) Judgment
 - Wiring harness is normal. → Check the PCM valve, actuator, and vacuum pump. Go to CHECK 6.
 - Wiring harness is open. → Replace the wiring harness.

CHECK
6

Inspection of PCM valve, actuator, and vacuum pump

- 1) Refer to 14. Action for over boost error CHECK 5 for inspection of the PCM valve and the actuator.
- 2) If the actuator rod does not move when the PCM valve and the actuator are inspected, the vacuum pump failed.
- 3) Judgment
 - PCM valve, actuator, and vacuum pump are normal. → Check the turbocharger nozzle vane. Go to CHECK 7.
 - PCM valve, actuator, and/or vacuum pump failed. → Repair or replace as necessary.





Inspection of turbocharger nozzle vane

- 1) Check the operation of the nozzle vane at the turbocharger external crank. Refer to 14. Action for over boost error  for the procedure.
- 2) Judgment
 - Nozzle vane is normal. → Control unit failed. → Replace the control unit.
 - Nozzle vane failed. → Replace the turbocharger assembly.

NOTE

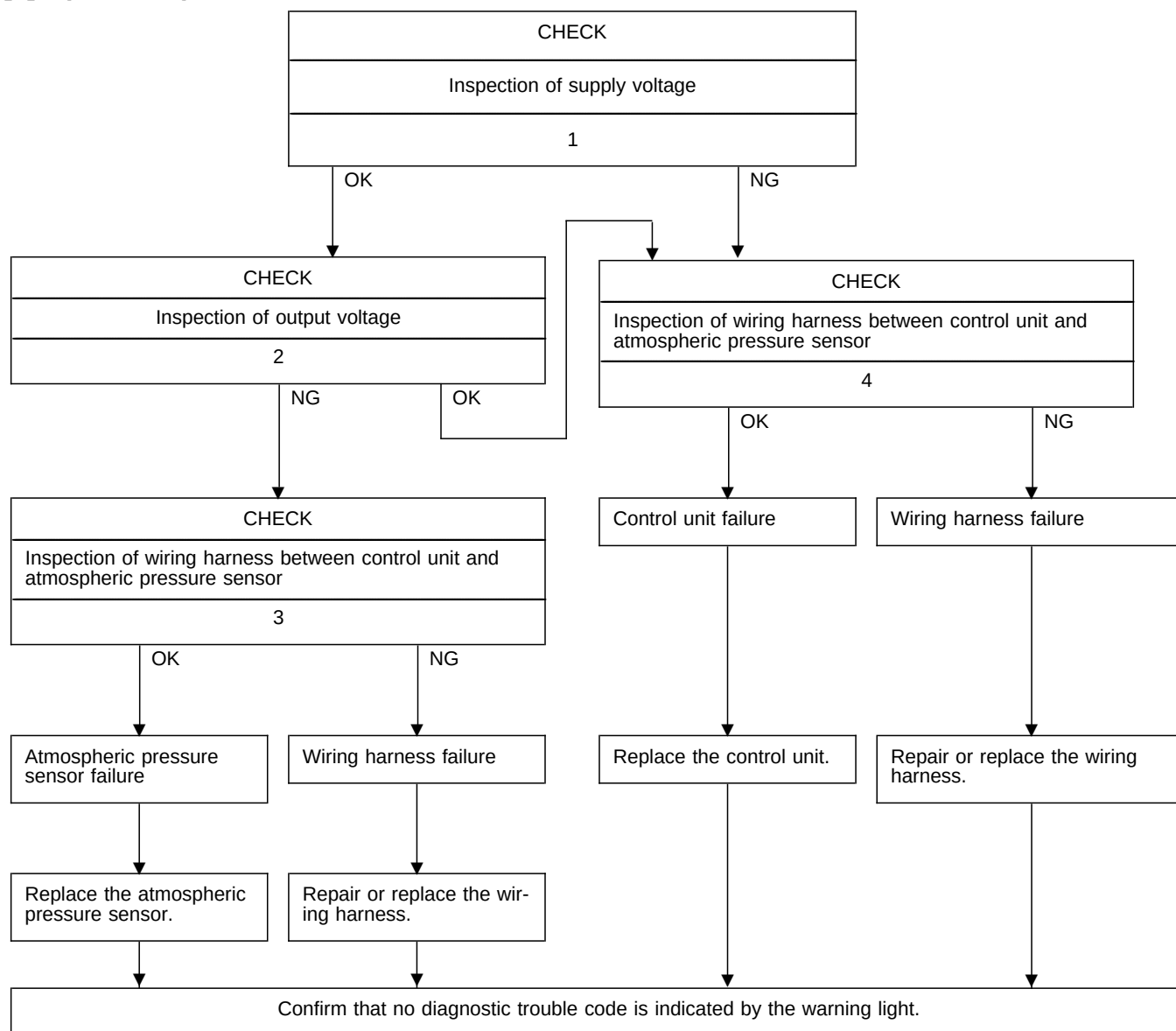
- **When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.**
- **After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.**

16. ACTION FOR ATMOSPHERIC PRESSURE SENSOR ERROR [LIGHT FLASH: 3-8] (TYPE II ONLY)

[1] Inspection items

- Atmospheric pressure sensor (supply voltage and output voltage)
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure

CHECK 1 Inspection of supply voltage

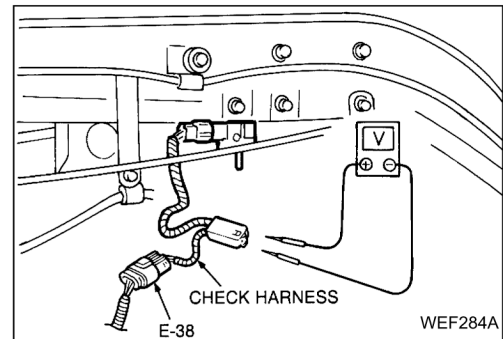
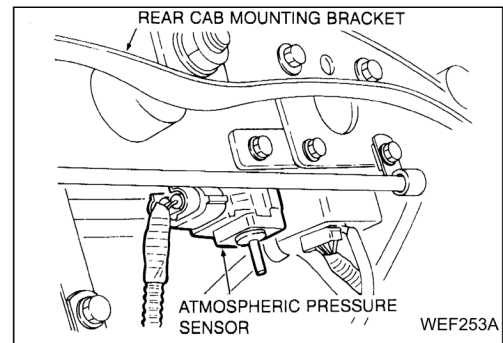
- 1) Check the supply voltage to the atmospheric pressure sensor.
 - Turn the key switch to OFF, and disconnect the harness connector (3-pin) from the atmospheric pressure sensor.
 - Connect the check harness (99732 Z0009) between disconnected connectors, and turn the key switch to ON.
 - Set the tester to the DCV measurement range (capable of measuring voltage greater than 5V). Connect the tester lead to the check harness connector to measure the voltage.
- 2) Judgment

Supply voltage: 5 ± 0.25 [V]

 - Supply voltage is normal. → Check the output voltage. Go to CHECK 2.
 - Supply voltage is abnormal. → Check the wiring harness. Go to CHECK 4.

NOTE

- Do not measure the resistance because the atmospheric pressure sensor is open by a faint current.



CHECK 2 Inspection of output voltage

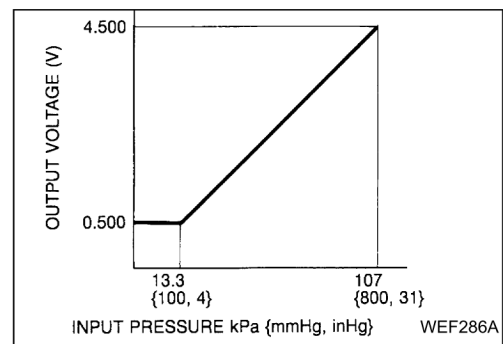
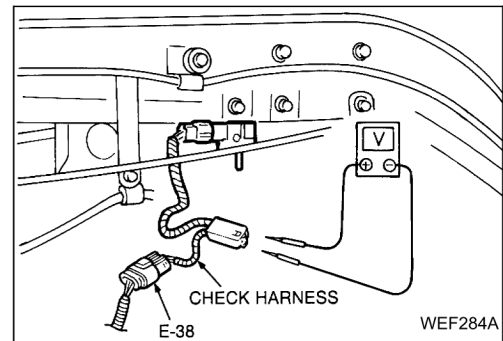
- 1) Check the output voltage of the atmospheric pressure sensor.
 - Turn the key switch to OFF, and disconnect the harness connector from the atmospheric pressure sensor.
 - Connect the check harness (99732 Z0009) between disconnected connectors, and turn the key switch to ON.
 - Set the tester to the DCV range, and measure the output voltage.
- 2) Judgment

Output voltage: 0.5 ~ 4.5 V (Refer to the figure WE286A)

 - Output voltage is normal → Check the wiring harness. Go to CHECK 4.
 - Output voltage is abnormal → Check the wiring harness. Go to CHECK 3.

NOTE

- Do not measure the resistance because the atmospheric pressure sensor is open by a faint current.

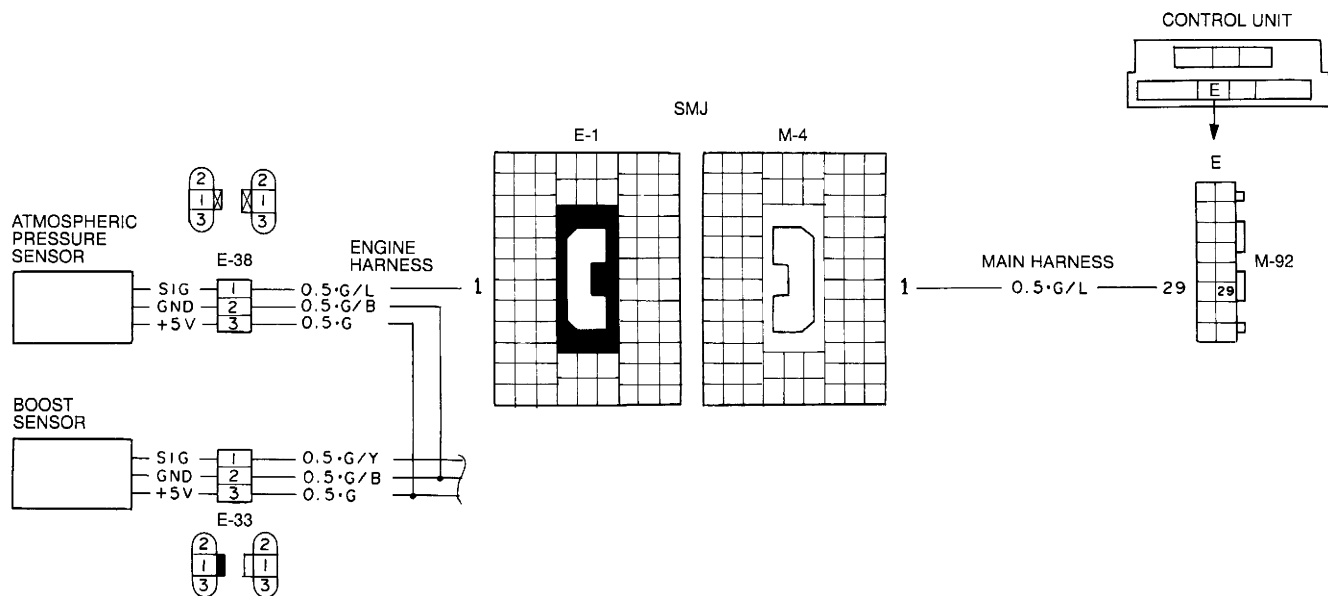


CHECK 3 Inspection of wiring harness between control unit and atmospheric pressure sensor

- 1) Turn the key switch to OFF, and disconnect the harness connector from the control unit.
- 2) Disconnect the harness connector from the atmospheric pressure sensor.
- 3) Check for open/short circuit between each pair of terminals at both connectors.

NOTE

- Harness check at the connector must be done following the procedures in BASIC OPERATION, item 1, Inspection of wiring harness.



WEF287A

4) Judgment

- Wiring harness is normal → Atmospheric pressure sensor failed. → Replace the atmospheric pressure sensor.
- Wiring harness is abnormal (open, shorted, etc.) → Repair or replace the wiring harness.

NOTE

- After replacing the atmospheric pressure sensor, or repairing or replacing the wiring harness, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

CHECK 4 Inspection of wiring harness between control unit and atmospheric pressure sensor

- 1) For inspection procedure, refer to CHECK 5.
- 2) Judgment
 - Wiring harness is normal. → Control unit is abnormal. → Replace the control unit.
 - Wiring harness is abnormal. → Repair or replace the wiring harness.

NOTE

- After repairing or replacing the wiring harness, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.

ACTION FOR ADDITIONAL FUNCTION ERROR

ACTION FOR EXHAUST BRAKE RELEASE FUNCTION ERROR

1-1. EXHAUST BRAKE RELEASE FUNCTION

The exhaust brake release function is activated by the acceleration signal (accelerator sensor output) and the engine rpm signal (engine speed sensor output). Therefore, the function will be affected when the accelerator sensor, engine speed sensor, or the control unit is failed.

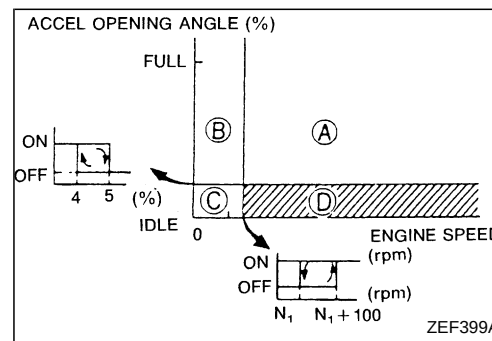
[1] Operation of exhaust brake release function

When the exhaust brake release function is working normally, the exhaust brake will be released in ranges (A), (B), and (C) in the figure. (The exhaust brake will operate in range (D) only.)

N_1 in the figure varies (500 - 800 rpm) with the minimum throttle-opening angle, which is determined by the control unit according to the idle volume and the engine coolant temperature sensor signal.

[2] Type of failure and operation of exhaust brake

Type of failure		Operation of exhaust brake
1	Control unit power failed	Engine does not start, and the exhaust brake does not operate
2	Control unit failed	Operation of the exhaust brake may be affected
3	Accelerator sensor failed	Control by turning the idle switch on/off
4	Engine speed sensor failed	Calculate the engine speed by the back-up sensor for normal control.
5	Both engine speed sensor and accelerator sensor failed	Combination of items 3 and 4 above will occur
6	Both engine speed sensor and back-up sensor failed, or no pulse generated at startup	Engine stops, exhaust brake does not operate

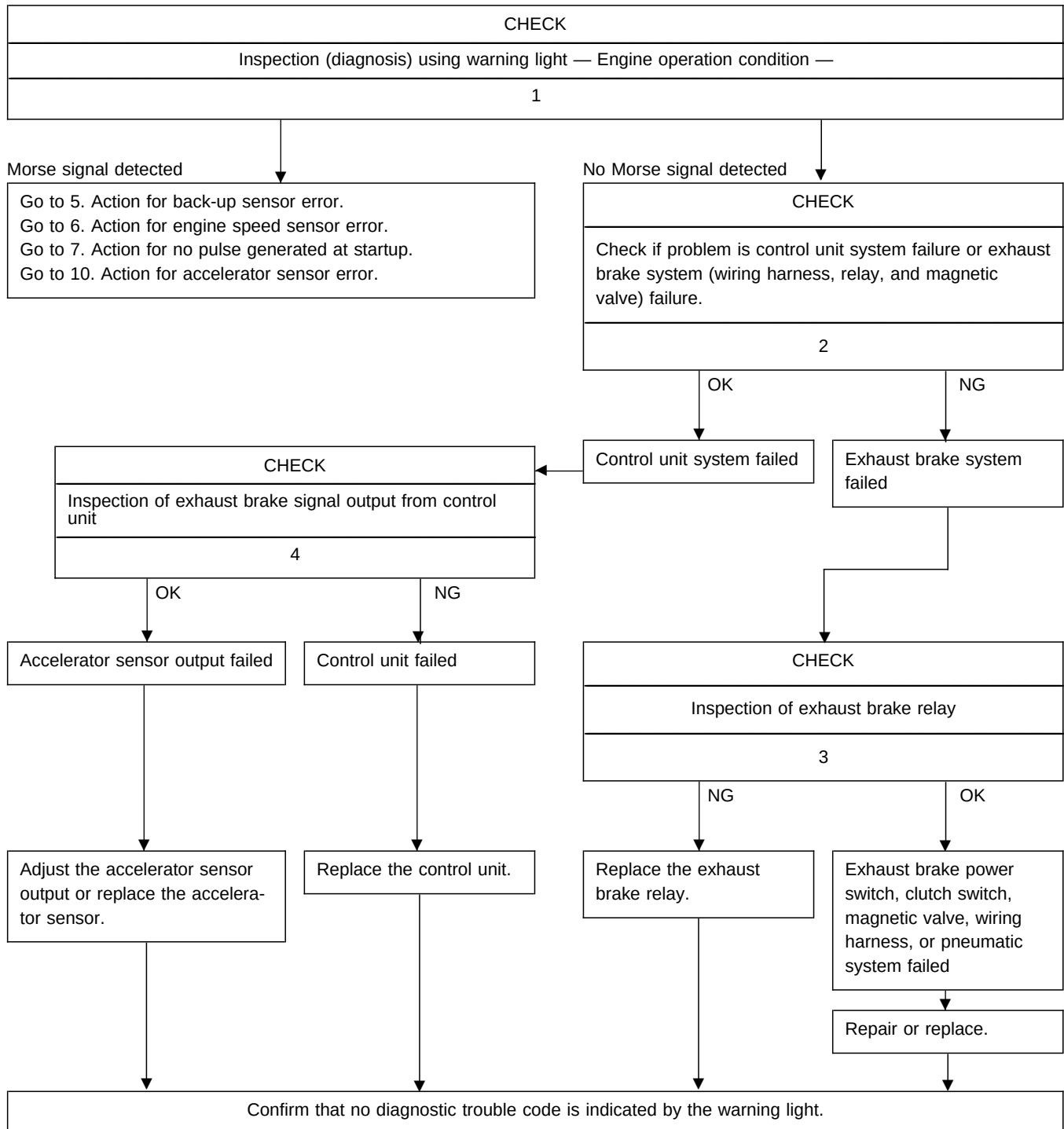


1-2. ACTION FOR POOR EXHAUST BRAKE OPERATION

[1] Inspection items

- Judgment of control unit system failure or exhaust brake system failure
- Exhaust brake relay
- Accelerator sensor output voltage
- Wiring harness (open/short circuit)
- Final confirmation

[2] Operation procedure



[3] Operation procedure



Inspection (diagnosis) by using warning light

- 1) With the engine running, ground the diagnosis switch to the vehicle body.
- 2) Use the warning light to check that the back-up sensor error (code: 1-6), engine speed sensor error (code: 1-7), accelerator sensor error (code: 2-4, 4-4), and/or no pulse generated at startup (code: 4-5) are not indicated.

NOTE

- When any of the above codes is indicated, proceed to the inspection following each action (5. Action for back-up sensor error, 6. Action for engine speed sensor error, 7. Action for no pulse generated at startup, and 10. Action for accelerator sensor error).
- When no diagnostic trouble code is indicated, go to .

CHECK
2

Check if problem is control unit system failure or exhaust brake system failure

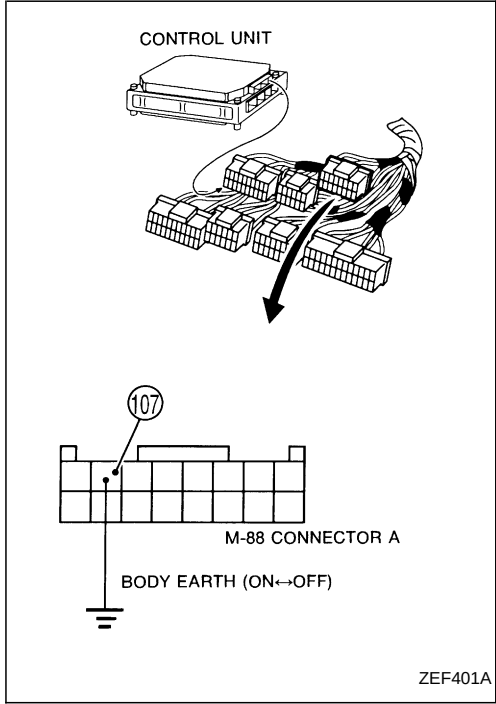
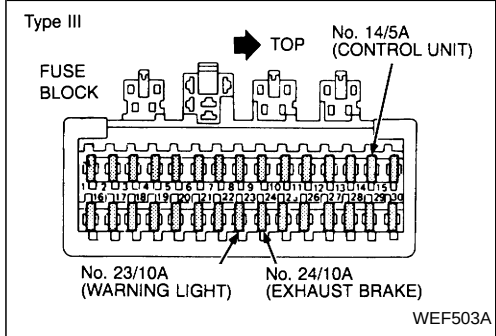
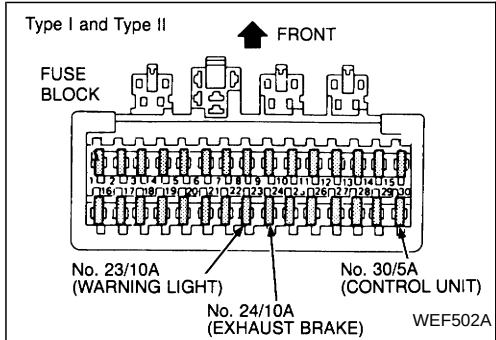
- 1) Check that the exhaust brake system fuses are normal.
- 2) With the key switch in OFF position, disconnect the control unit connector.
- 3) Ground the connector terminal to the vehicle body. Turn the key switch to ON and the exhaust brake power switch on, then connect/disconnect the ground.

Control unit connector No.	Terminal No.
M-88	107

4) Judgment

<Exhaust brake operation noise>

- Air noise is heard at the exhaust brake. → Control unit system failed or connector improperly connected. Go to CHECK 4.
- Air noise is not heard at the exhaust brake. → Exhaust brake electrical system failed. → Check the exhaust brake relay. Go to CHECK 3.



CHECK
3

Inspection of exhaust brake relay

- 1) Replace the exhaust brake relay and perform steps 2) and 3) of
- 2) Judgment

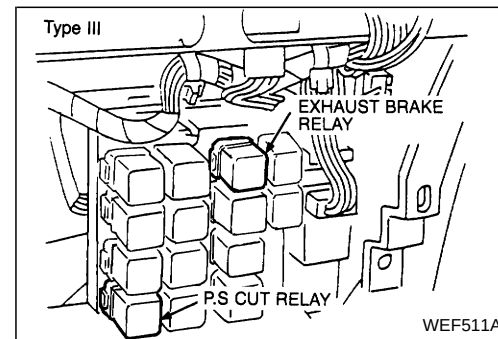
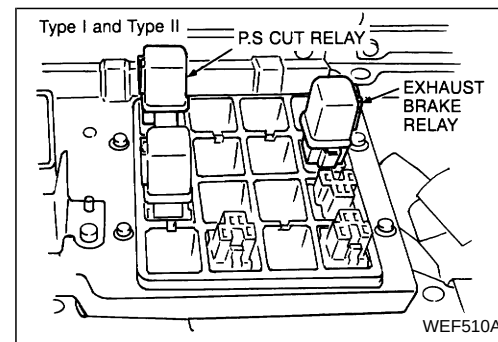
CHECK
2

<Exhaust brake operation noise>

- Exhaust brake operation noise is heard. → Exhaust brake relay failed. → Replace the exhaust brake relay.
- Exhaust brake operation noise is not heard. → Failure exists in other than the exhaust brake relay. → Repair or replace the exhaust brake power switch, magnetic valve, or wiring harness.

NOTE

- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.



CHECK
4

Inspection of exhaust brake signal output from control unit

- 1) Remove the exhaust brake relay from the relay box. Measure the resistance between the relay socket terminal and the body ground.

Terminal No.	Exhaust brake relay
	② - Body ground

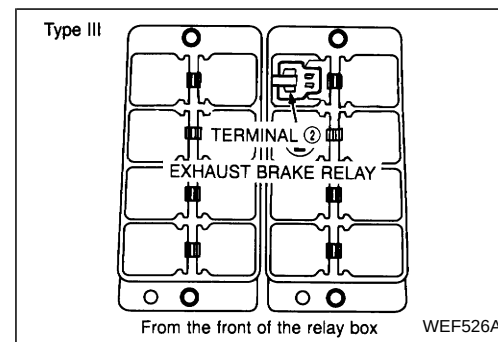
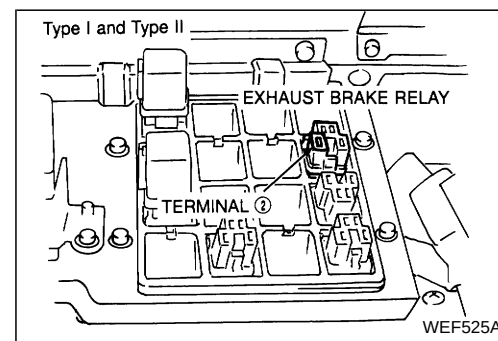
- 2) In the conditions in the step 1), turn the exhaust brake power switch on. With the engine idling, depress and release the accelerator pedal once, and read the change in the continuity.
- 3) Judgment

<Resistance change>

- Continuity is abnormal. → Control unit failed. → Replace the control unit.
- Continuity and no continuity are repeated alternately. → Accelerator sensor output is abnormal. → Adjust the accelerator sensor output or replace the accelerator sensor.

NOTE

- When the control unit is failed, be sure to find the cause of trouble and repair it before replacing the control unit.
- After completing each operation, carry out trouble-shooting with the diagnostic light and confirm that there is no abnormality.



Q (FUEL INJECTION QUANTITY) CONTROL FUNCTION IN ERROR STATUS

The Q control function in error status is activated to control the fuel injection amount when the engine speed is judged the overrun status.

<Overrun prevention function>

The overrun prevention function is activated when the engine speed exceeds 2,900 rpm while driving. This function reduces the fuel injection amount to zero to reduce the engine speed. When the engine speed falls below 2,750 rpm, the normal fuel injection resumes.

BASIC OPERATION

Following is the procedures for the basic operations in the electronic control system inspection/service. The electronic control system will not operate correctly unless each function of the system is correctly set according to the correct procedure. Therefore, inspection and adjustment of each part must be carried out correctly.

1. INSPECTION OF WIRING HARNESSES	EF-6-118
2. ALIGNMENT OF MARKS	EF-6-119
3. INSPECTION OF RACK SENSOR OUTPUT VOLTAGE	EF-6-120
4. SETTING OF BACK-UP SENSOR	EF-6-121
5. SETTING OF ENGINE SPEED SENSOR	EF-6-122
6. SETTING OF ACTUATOR FOR VNT CONTROL (TYPE I ONLY)	EF-6-123

1. INSPECTION OF WIRING HARNESSES

Prior to carrying out the inspection of the wiring harnesses, refer to the wiring diagrams at the end of this section and identify the harness connector marks and the terminal numbers.

Points to be noted during the inspection of the wiring harnesses are as follows.

[1] Harness connector marks and terminal numbers

The harness connector marks and the terminal numbers in the figures correspond to the marks and numbers in the wiring diagrams at the end of this section.

[2] Points likely to fail

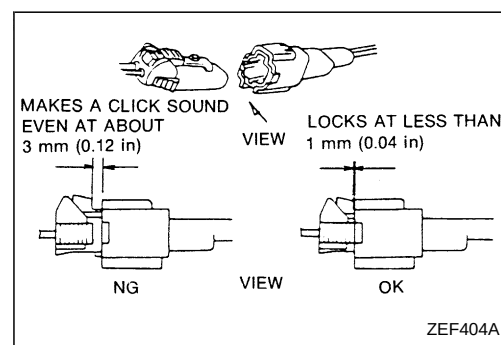
Problems related to the wiring harness such as open, short or poor contact occur mostly at the connectors. Lead wires in the wiring harness seldom open or short. However, they can be grounded to the body by interfering with other parts.

When checking the wiring harnesses, especially note for the following items.

- 1) Are connectors (couplers) connected securely?

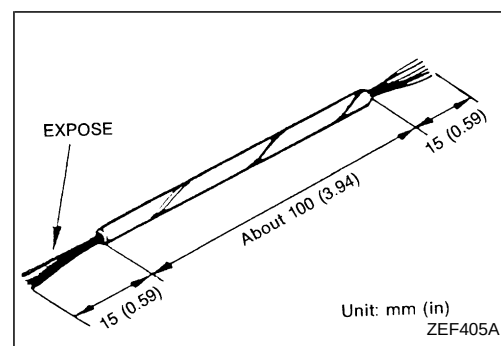
NOTE

- **Z type connectors can make a “click” sound before it is completely connected. After connection, check that the Z type connector is securely locked, not only by the click sound.**
 - **Using a screwdriver or pliers to disconnect the Z type connector can deform the connector. A deformed connector will not be locked securely, and can cause poor contact.**
- 2) Are pins and receptacles free of deformation?
 - 3) Are connectors free of binding of foreign materials and patina?
 - 4) Are connections of the wiring harnesses to the connectors (couplers) free of open or short?
 - 5) Are connectors securely grounded?
 - 6) Are wiring harnesses free of poor insulation caused by interference with other parts?



[3] Resistance and continuity check at connectors

- 1) The terminal cavities are small. When checking the resistance and continuity at the connector terminals, expose the read wires and insert two or three wires into the terminal cavity so that they contact securely.
- 2) Do not insert the tester lead directly into the terminal cavity. Otherwise, the terminal (receptacle) is enlarged and it may causes poor contact.



2. ALIGNMENT OF MARKS

After the fuel injection pump is replaced or the nuts at the coupling are loosened, alignment of the marks must be checked and adjusted as described below.

[1] Alignment check

- 1) Remove the pointer cover on the upper part of the flywheel housing. Secure the pointer to the flywheel housing with the bolts.
- 2) Crank the flywheel in the engine rotation direction by using a lever, and align the pointer with the fuel injection timing mark (BTDC) on the outer circumference of the flywheel.

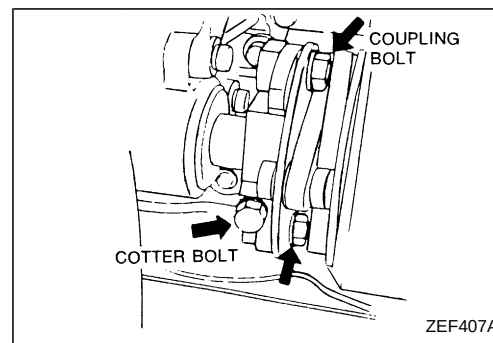
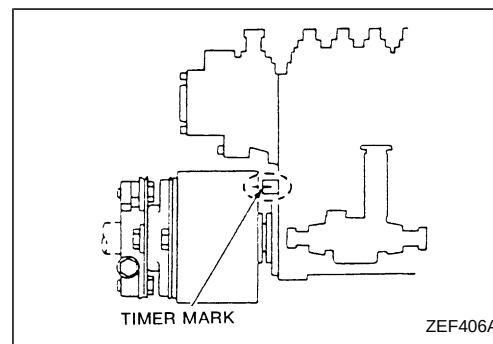
Engine model	Fuel injection timing (BTDC)
Type I	3°
Type II	2°
Type III	0°

NOTE

- When alignment is failed, return the flywheel and repeat step 2). If the mark on the flyweight is located at 180 degrees opposite side, the cylinders are in the exhaust stroke.
- 3) Check that the marks on the flyweight and on the fuel injection pump are aligned. If not, adjust according to the following procedure.

[2] Adjustment

- 1) Check that the pointer is aligned with the fuel injection timing mark on the outer circumference of the flywheel. Loosen the coupling bolts (two).
- 2) Slightly turn the flyweight counterclockwise, then align the marks by turning the flyweight clockwise.



3) Tighten the coupling bolts.

Unit: N·m {kgf·m, ft·lbf}

Item	Tightening torque
Coupling bolt	103 - 113 {10.5 - 11.5, 76 - 83}
Cotter bolt	147 - 167 {15.0 - 17.0, 108 - 123}

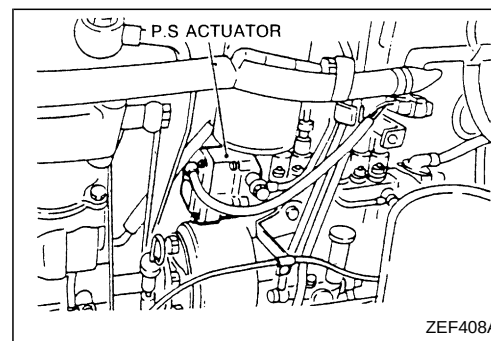
[3] Replacement of fuel injection pump

(1) Removal

- 1) Disconnect connectors from the rack sensor, governor actuator, back-up sensor, and pre-stroke actuator.
- 2) Disconnect the fuel injection tube.
- 3) Disconnect the fuel injection pump oil tube.
- 4) Remove the flyweight coupling bolts.
- 5) Remove the fuel injection pump.

(2) Installation

Install the fuel injection pump in reverse order of the removal. Align marks following the procedures described in [1] Alignment check, and [2] Adjustment.

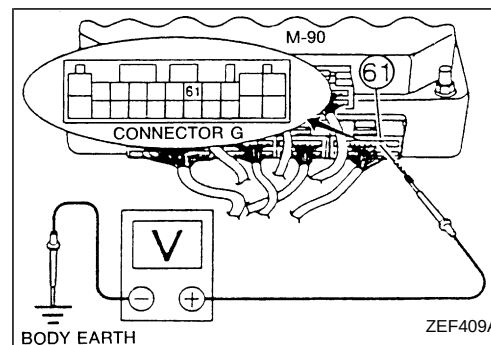


3. INSPECTION OF RACK SENSOR OUTPUT VOLTAGE

The rack sensor reads the movement of the fuel injection pump control rack (Full ↔ Idle) as the change in the voltage, and outputs the voltage accordingly. Therefore, judgment of the fuel injection pump is possible by checking the rack sensor output voltage and by comparing it with the set position of the sensor and actual rack movement.

[1] On-vehicle inspection of rack sensor output voltage

- 1) Start the engine and increase/decrease the engine speed between the idle speed and the full speed. Apply heavy load to the engine so that the rack moves largely.
- 2) Measure the voltage between terminal ⑥ and the body ground from rear side of connector M-85 on the control unit.



3) Judgment

Output voltage	At full position	Approx. 1V 19 mm (0.75 in)	(Reference)
	When engine stopped	Approx. 3.4V 3 mm (0.12 in)	

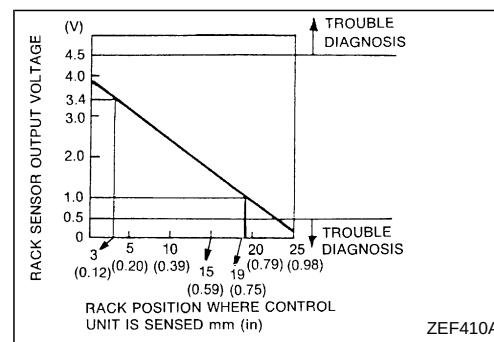
- Output voltage is normal (within the above specification). → Rack sensor position is normal.
- Output voltage is abnormal (over 4.5V or below 0.5V). → Replace the fuel injection pump assembly.

NOTE

- When the output voltage is abnormal, the wiring harness may be open (below 0.5V) or shorted (over 4.5V), or the rack sensor may be improperly set.

[2] Adjustment of rack sensor output voltage

When the output voltage is abnormal, on-vehicle adjustment is not possible. Remove the fuel injection pump assembly.



4. SETTING OF BACK-UP SENSOR

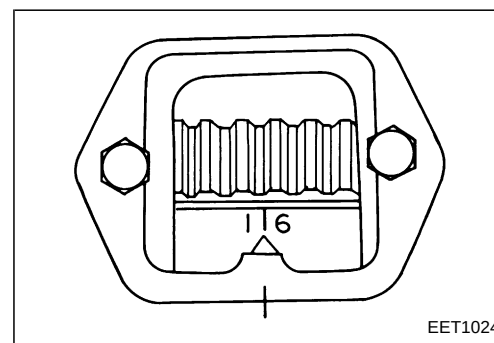
When the back-up sensor is to be replaced, set it in the following procedure.

[1] Setting of engine speed sensor

- 1) Crank the engine and align the 1-6 top dead center of the flywheel to the pointer.
- 2) Remove the back-up sensor and clean the installation hole.

NOTE

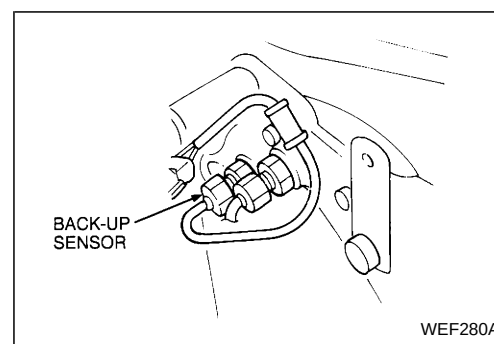
- The sensor cannot be set accurately when the old liquid gasket remaining on the threads.
- Check that the pin projection on the edge of the cam gear is enlarged with the sensor installation hole.
- Check that the tip of the sensor and the pulsar projection are free of deformation.



- 3) Apply liquid gasket (Three Bond #1324) to the threads of the back-up sensor and screw the sensor into the installation hole until it touches the projection.

NOTE

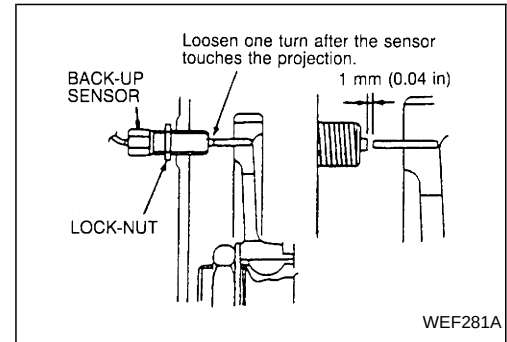
- The engine speed sensor must be screwed in by hand. Using a spanner can damage the tip of the sensor.



- 4) When the sensor touched the projection, loosen the sensor for one turn, and secure it with a locknut.

NOTE

- The pitch of the sensor threads is 1 mm (0.04 in). Loosening the sensor for one turn sets the clearance between the tip of the sensor and the projection by 1 mm (0.04 in).



5. SETTING OF ENGINE SPEED SENSOR

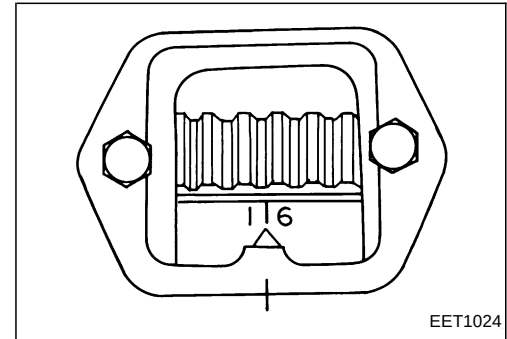
When the engine speed sensor is to be replaced, set it in the following procedure.

[1] Setting of engine speed sensor

- 1) Crank the engine and align the 1-6 top dead center of the flywheel to the pointer.
- 2) Remove the engine speed sensor and clean the installation hole.

NOTE

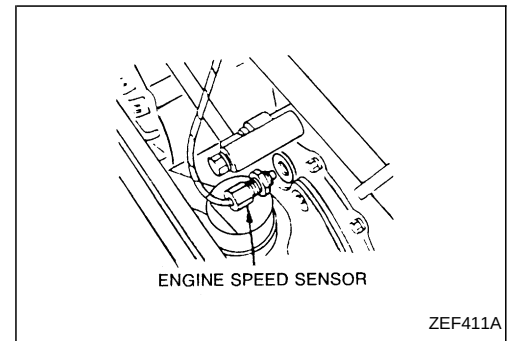
- The sensor cannot be set accurately when the old liquid gasket remaining on the threads.
- Check that the pin projection on the edge of the cam gear is enlarged with the sensor installation hole.
- Check that the tip of the sensor and the pulsar projection are free of deformation.



- 3) Apply liquid gasket (Three Bond #1324) to the threads of the engine speed sensor and screw the sensor into the installation hole until it touches the projection.

NOTE

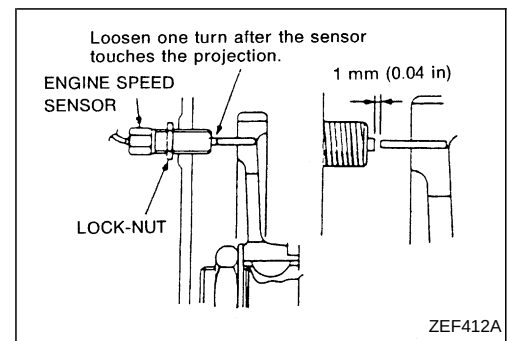
- The engine speed sensor must be screwed in by hand. Using a spanner can damage the tip of the sensor.



- 4) When the sensor touched the projection, loosen the sensor for one turn, and secure it with a locknut.

NOTE

- The pitch of the sensor threads is 1 mm (0.04 in). Loosening the sensor for one turn sets the clearance between the tip of the sensor and the projection by 1 mm (0.04 in).



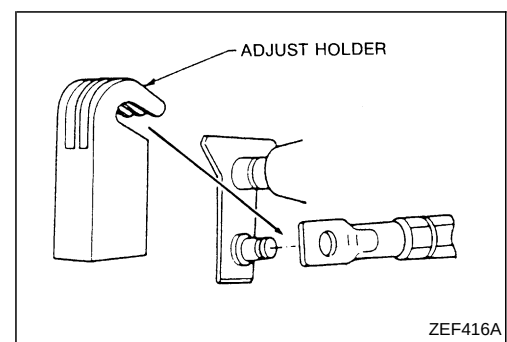
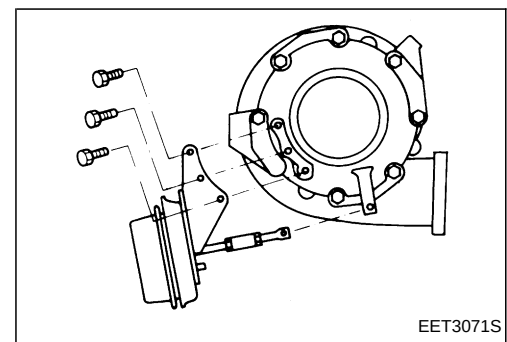
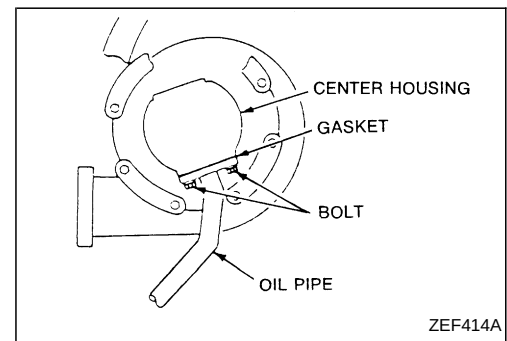
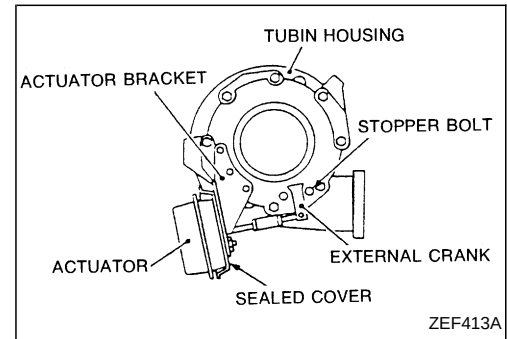
6. SETTING OF ACTUATOR FOR VNT CONTROL (TYPE I ONLY)

The actuator rod for VNT control is adjusted by the turbocharger. When the external crank or the stopper bolt on the turbocharger is damaged or loose, the turbine housing assembly must be replaced.

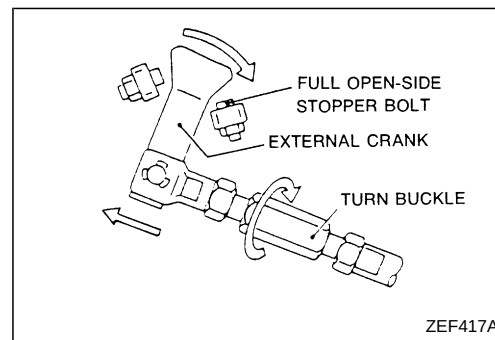
[1] Adjustment of actuator rod when turbocharger is replaced

(1) Installation

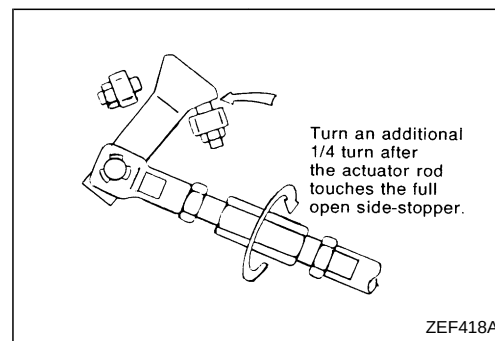
- 1) Install the oil drain pipe to the center housing.
T : 21 - 23 N·m {2.1 - 2.3 kgf·m, 15 - 17 ft·lbf}
- 2) Install the actuator on the actuator bracket using nuts.
T : 13.2 - 14.2 N·m {1.35 - 1.45 kgf·m, 9.8 - 10.5 ft·lbf}
- 3) Install the actuator subassembly to the turbocharger.
T : 10.3 - 12.3 N·m {1.05 - 1.25 kgf·m, 7.6 - 9.0 ft·lbf}
- 4) Insert the external crank pin into the hole in the tip of the actuator rod.
- 5) Install the adjuster holder (99779 95500) to the actuator rod and the external crank.



- 6) Extend the actuator rod by turning the turn buckle clockwise. Turn the actuator rod by hand until the external crank touches the full open-side stopper.

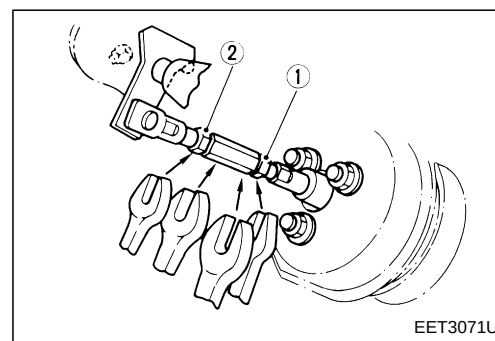


- 7) Continuously turn the actuator rod 1/4 turn, using a wrench.

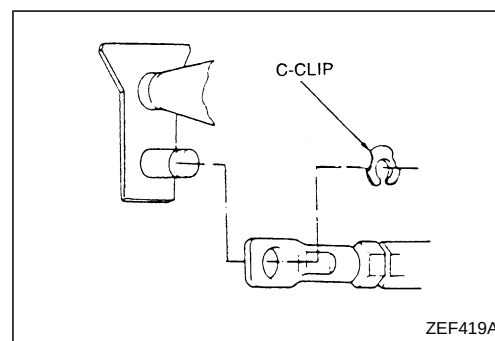


- 8) Tighten turnbuckle lock nuts ① and ②.

T : 11 - 13 N·m {1.1 - 1.3 kgf·m, 8 - 9 ft·lbf}

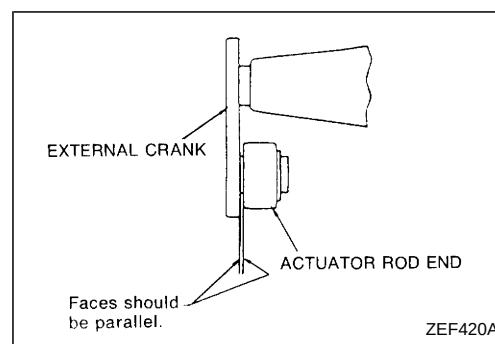


- 9) Install the C-clip to the external crank pin. Remove the adjuster holder.



NOTE

- Before fastening the actuator rod, make sure that the external crank and the actuator rod are parallel.
- Never loosen the external crank stopper bolt that is installed and adjusted on the turbine assembly.

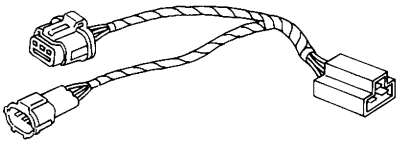
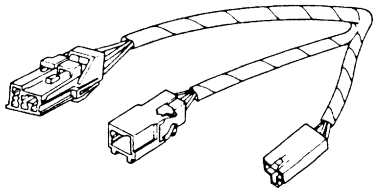
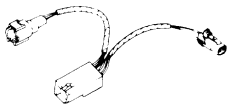
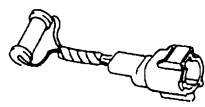
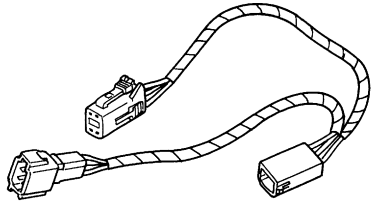
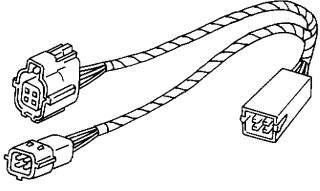


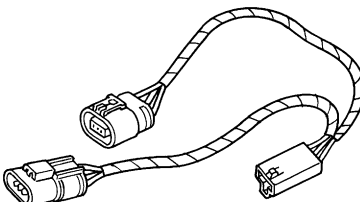
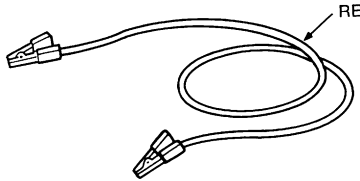
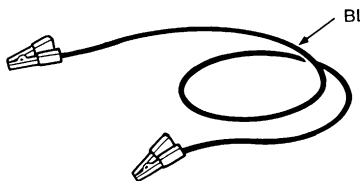
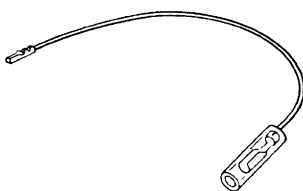
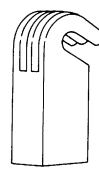
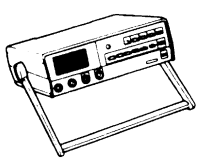
SERVICE DATA

SPECIFICATIONS

Item		Measured at:		Specification
Control unit	Power voltage [V]	⑫ ⑮ - Body ground		Battery voltage (20 - 28)
Governor actuator	Resistance [Ω]	ACT1 ⊕ - ACT1 ⊖ ACT2 ⊕ - ACT2 ⊖		9 - 10
		ACT1 ⊕ - ACT2 ⊕ ACT1 ⊖ - ACT2 ⊖		Approx. 0
	Insulation [Ω]	All terminals - Fuel injection pump		∞
Rack sensor	Resistance [Ω]	OSC - MDL		14 - 16
		MDL - GND1		19 - 21
		MDL - GND2		19 - 21
OSC - GND1		30 - 37		
OSC - GND2		30 - 37		
GND1 - GND2		Approx. 0		
Insulation [Ω]	All terminals - Fuel injection pump		∞	
Pre-stroke sensor	Resistance [Ω]	OSC - MDL		5 - 7
		MDL - GND		5 - 7
		OSC - GND		10 - 14
Insulation [Ω]	All terminals - Fuel injection pump		∞	
Pre-stroke actuator	Resistance [Ω]	Pre-stroke ACT ⊕ - Pre-stroke ACT ⊖		2.5 - 2.9
	Insulation [Ω]	All terminals - Fuel injection pump		∞
Back-up sensor	Resistance [kΩ]	SIG - GND		2.1 - 2.5
	Insulation [Ω]	SIG - SLD		∞
		GND - SLD		
		All terminals - Body ground		
Engine speed sensor	Resistance [kΩ]	SIG - GND		2.1 - 2.5
	Insulation [Ω]	SIG - SLD		∞
		GND - SLD		
		Clearance to projection [mm (in)]		
Engine coolant temperature sensor	Resistance [Ω]	SIG - GND		Refer to “Engine coolant temperature and resistance” (Page EF-6-6)
	Insulation [Ω]	All terminals - Body ground		
All-speed sensor and accelerator sensor	Supply voltage [V]		5±0.25	
	Output voltage [V]	Full position		4.0 - 4.2
		Idle position		0.6 - 0.7
Idle volume	Supply voltage [V]		5±0.25	
	Output voltage [V]		Refer to “Idle volume output characteristics” (Page EF-6-8)	
	Resistance [kΩ]	Auto	① - ③	7.4 - 8.8
			② - ③	9.3 - 10.9
		Manual MAX	① - ③	0.8 - 1.2
			② - ③	4.4 - 5.6
Manual all range	① - ③	3.0 - 0.8		
Boost and atmospheric pressure sensor	Supply voltage [V]		5±0.25	
	Output voltage [V]		Approx. 0.5 (Atmospheric pressure)	
Q-adjustment resistance	Resistance [Ω]		Refer to “Q adjustment resistance” (Page EF-6-8)	
Fuel injection timing (BTDC)			Type I	3°
			Type II	2°
			Type III	0°

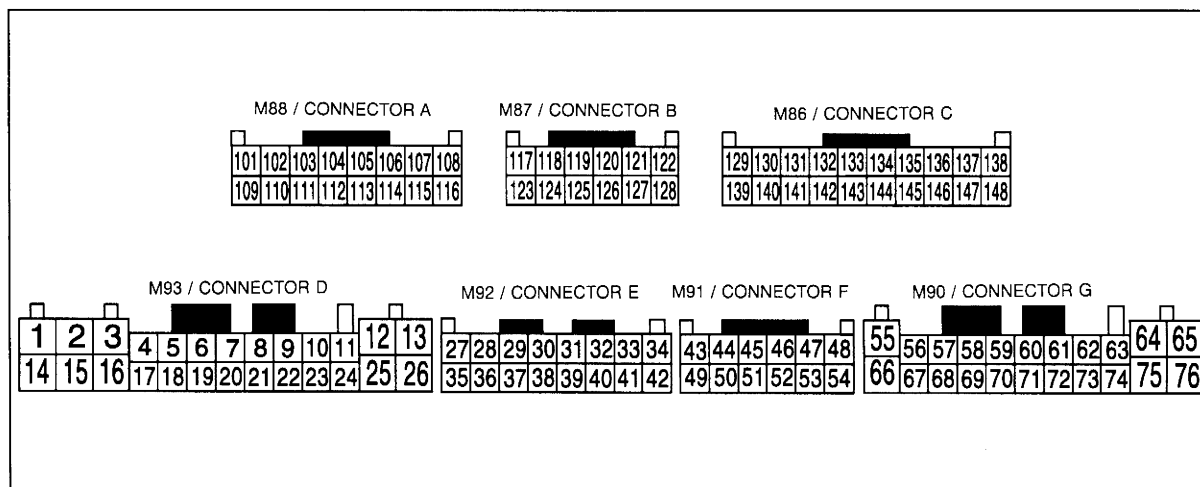
TOOLS AND EQUIPMENT NECESSARY FOR INSPECTION/ADJUSTMENT

Name	Purpose	Part No.	Shape	Type I	Type II	Type III
Accelerator sensor check harness	Checks and adjusts accelerator sensor output	99732 Z0001	 EET2061	○	—	○
		99732 Z0006	 YEL051C	—	○	—
Idle volume check harness	Checks and adjusts idle volume output	99733 Z0000	 EET2061A	○	○	○
Idle switch check harness	Checks idle switch output	99732 Z0002	 EET1042L	○	—	○
		99732 Z0007		—	○	—
Engine coolant temperature sensor check harness	Checks engine coolant temperature sensor operation	99731 Z0005	 EET1042M	○	—	—
All-speed sensor check harness	Checks and adjusts all-speed sensor output	99731 Z0000	 YEL226A	○	—	—
		99731 Z0012	 YEL053C	—	○	○

Name	Purpose	Part No.	Shape	Type I	Type II	Type III
Boost pressure sensor check harness	Checks boost pressure sensor output	99732 Z0000	 YEL227A	○	○	○
Atmospheric pressure sensor check harness	Checks atmospheric pressure sensor output	99732 Z0009		—	○	—
Diagnosis check harness	Indicates diagnostic trouble code and adjusts auto idle speed	99731 Z0007	 RED ZEF516A	○	○	○
Diagnosis reset check harness	Delete diagnostic trouble code memory and adjusts auto idle speed	99731 Z0008	 BLACK ZEF517A	○	○	○
Auto idle adjustment harness	Adjusts auto idle speed	99731 Z0009	 YEL246A	○	○	○
Adjuster holder	Checks the position of actuator for VNT control and corrects setting of actuator for VNT control	99779 95500	 YEL529A	○	—	—
Digital voltmeter (Circuit tester)	Reads sensor output and measures resistance (For check and adjustment)	Available in the market	 EET1033D	○	○	○
Lead wire	Checks voltage, continuity, and insulation at harness connectors	Prepare yourself.	 EET1033F	○	○	○

WIRING DIAGRAM

CONNECTION OF CONTROL UNIT TERMINALS



Terminal numbers of control unit

WEF276A

No.		Re- marks	Connected to	Type I	Type II	Type III
M- 93/D	1	—	Governor actuator (ACT1 ⊕)	○	○	○
	2	—	Governor actuator (ACT1 ⊖)	○	○	○
	5	Au	Engine control W/L (SIG)	○	○	○
	7	Au	DDS-3	○	○	○
	8	Au	Tachometer (SIG)	○	○	○
	9	Au	Starter switch	○	○	○
	11	Au	Diagnosis switch	○	○	○
	12	—	Battery (+)	○	○	○
	13	—	Battery (−)	○	○	○
	14	—	Governor actuator (ACT2 ⊕)	○	○	○
	15	—	Governor actuator (ACT2 ⊖)	○	○	○
	20	Au	DDS-3	○	○	○
	21	Au	DDS-3	○	○	○
	22	Au	Idle switch (SIG)	○	○	○
	24	Au	Idle set switch (For auto- matic idle adjustment)	○	○	○
	25	—	Battery (+)	○	○	○
	26	—	Battery (−)	○	○	○

No.	Re- marks	Connected to	Type I	Type II	Type III	
M- 92/E	29	Au	Atmospheric pressure sen- sor (SIG)	—	○	—
	30	Au	Idle volume (SIG)	○	○	○
	31	Au	All-speed sensor (SIG)	○	○	○
	32	Au	Governor resistor (SIG)	○	—	—
	33	Au	Q adjustment resistance (SIG)	○	○	○
	34	Au	Engine coolant temperature sensor (SIG)	○	○	○
	35	Au	Idle volume (+5V)	○	○	○
	36	Au	All-speed sensor (+5V)	○	○	○
	37	Au	All-speed sensor (GND2)	○	○	○
	38	Au	Idle volume (GND)	○	○	○
	39	Au	All-speed sensor (GND1)	○	○	○
	40	Au	Governor resistor (GND)	○	—	—
	41	Au	Q adjustment resistance (GND)	○	○	○
	42	Au	Engine coolant temperature sensor (GND)	○	○	○

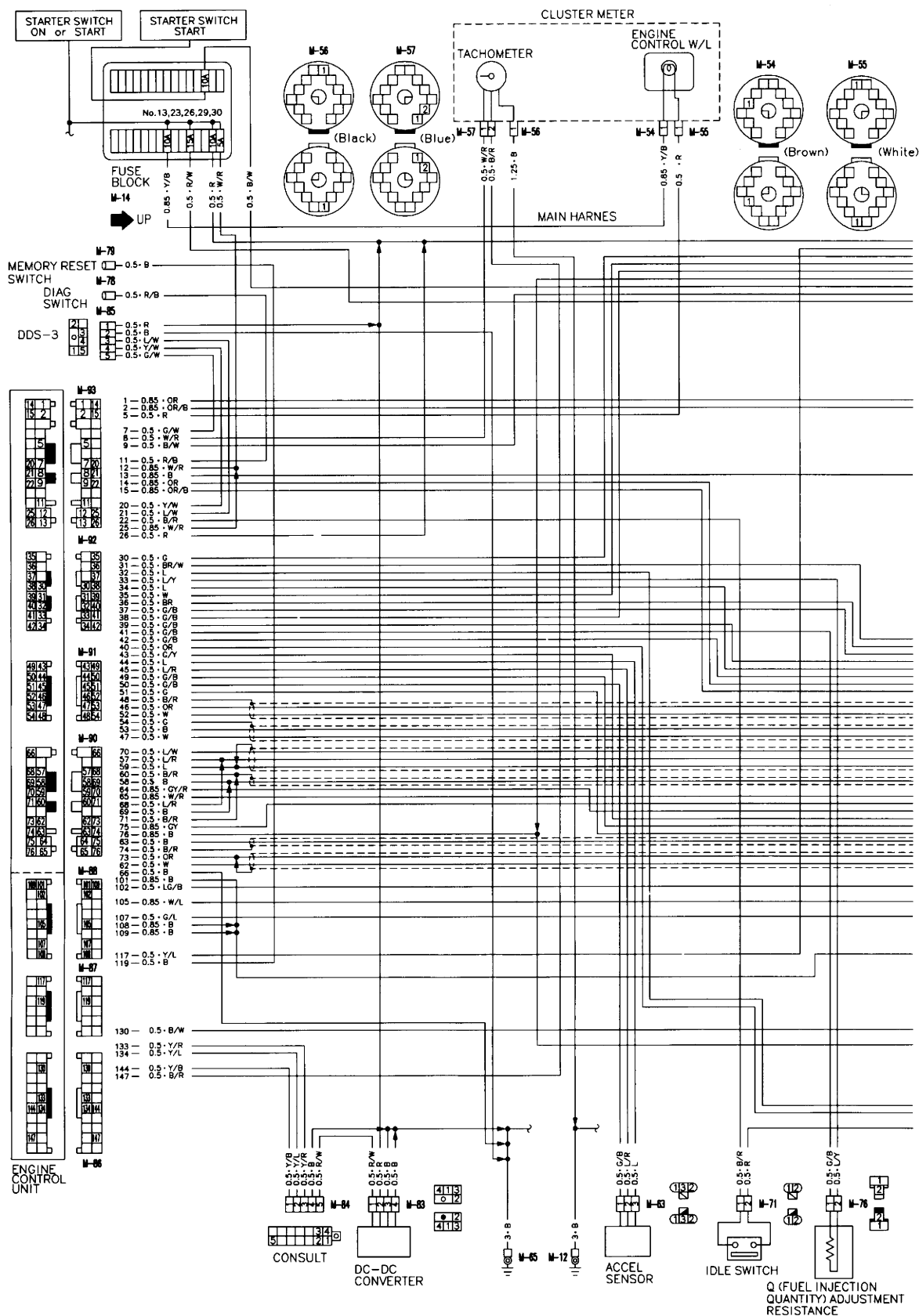
No.		Re- marks	Connected to	Type I	Type II	Type III
M- 91/F	43	Au	Boost pressure sensor (SIG)	○	○	○
	44	Au	Accelerator sensor (SIG)	○	○	○
	45	Au	Accelerator sensor (+5V)	○	○	○
	46	Au	Engine speed sensor (SIG)	○	○	○
	47	Au	Back-up sensor (SIG)	○	○	○
	48	Au	Engine speed sensor (SLD)	○	○	○
	49	Au	Boost pressure sensor (GND)	○	—	○
			Boost pressure and atmo- spheric pressure sensor (GND)	—	○	—
	50	Au	Accelerator sensor (GND)	○	○	○
	51	Au	Boost pressure sensor (+5V)	○	—	○
			Boost pressure and atmo- spheric pressure sensor (+5V)	—	○	—
	52	Au	Engine speed sensor (GND)	○	○	○
	53	Au	Back-up sensor (GND)	○	○	○
	54	Au	Back-up sensor (SLD)	○	○	○
M- 90/G	57	Au	Rack sensor (OSC)	○	○	○
	58	Au	Rack sensor (MDL)	○	○	○
	59	Au	Rack sensor (GND1)	○	○	○
	60	Au	Rack sensor (SLD)	○	○	○
	61	Au	Rack output (SIG)	○	○	○
	62	Au	Pre-stroke sensor (OSC)	○	○	○
	63	Au	Pre-stroke sensor (MDL)	○	○	○
	64	—	Pre-stroke actuator (–)	○	○	○
	65	—	Pre-stroke actuator power (+)	○	○	○
	66	—	Case ground (GND)	○	○	—
	68	Au	Rack sensor (OSC)	○	○	○
	69	Au	Rack sensor (MDL)	○	○	○
	70	Au	Rack sensor (GND2)	○	○	○
	71	Au	Rack sensor (SLD)	○	○	○
	73	Au	Pre-stroke sensor (GND)	○	○	○
	74	Au	Pre-stroke sensor (SLD)	○	○	○
	75	Au	Pre-stroke actuator (+)	○	○	○
	76	Au	Pre-stroke actuator power (–)	○	○	○

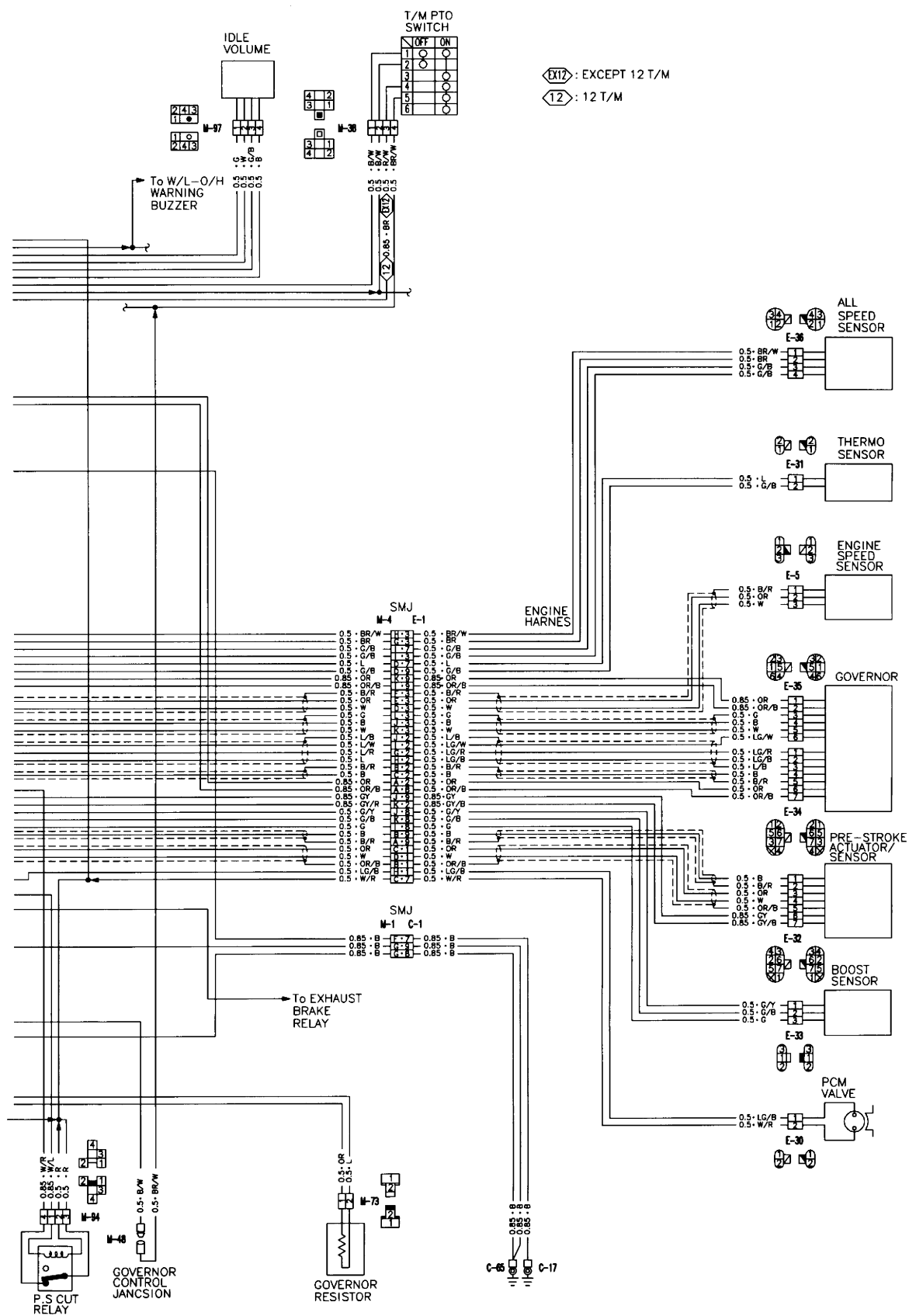
No.		Re- marks	Connected to	Type I	Type II	Type III
M- 88/A	101	—	Battery (—)	○	○	○
	102	—	Pressure control modulator valve	○	—	—
	105	—	Pre-stroke cut relay	○	○	○
	107	—	Exhaust brake relay	○	○	○
	108	—	Battery (—)	○	○	○
	109	—	Battery (—)	○	○	○
M- 87/B	117	Au	Coolant warning light	○	○	○
	119	Au	Diagnosis memory reset switch	○	○	○
M- 86/C	130	Au	Governor control junction	○	○	○
	131	Au	Vehicle speed sensor	—	—	○
	133	Au	Consult	○	○	○
	134	Au	Consult	○	○	○
	144	Au	Consult	○	○	○
	147	Au	Tachometer (GND)	○	○	○

NOTE

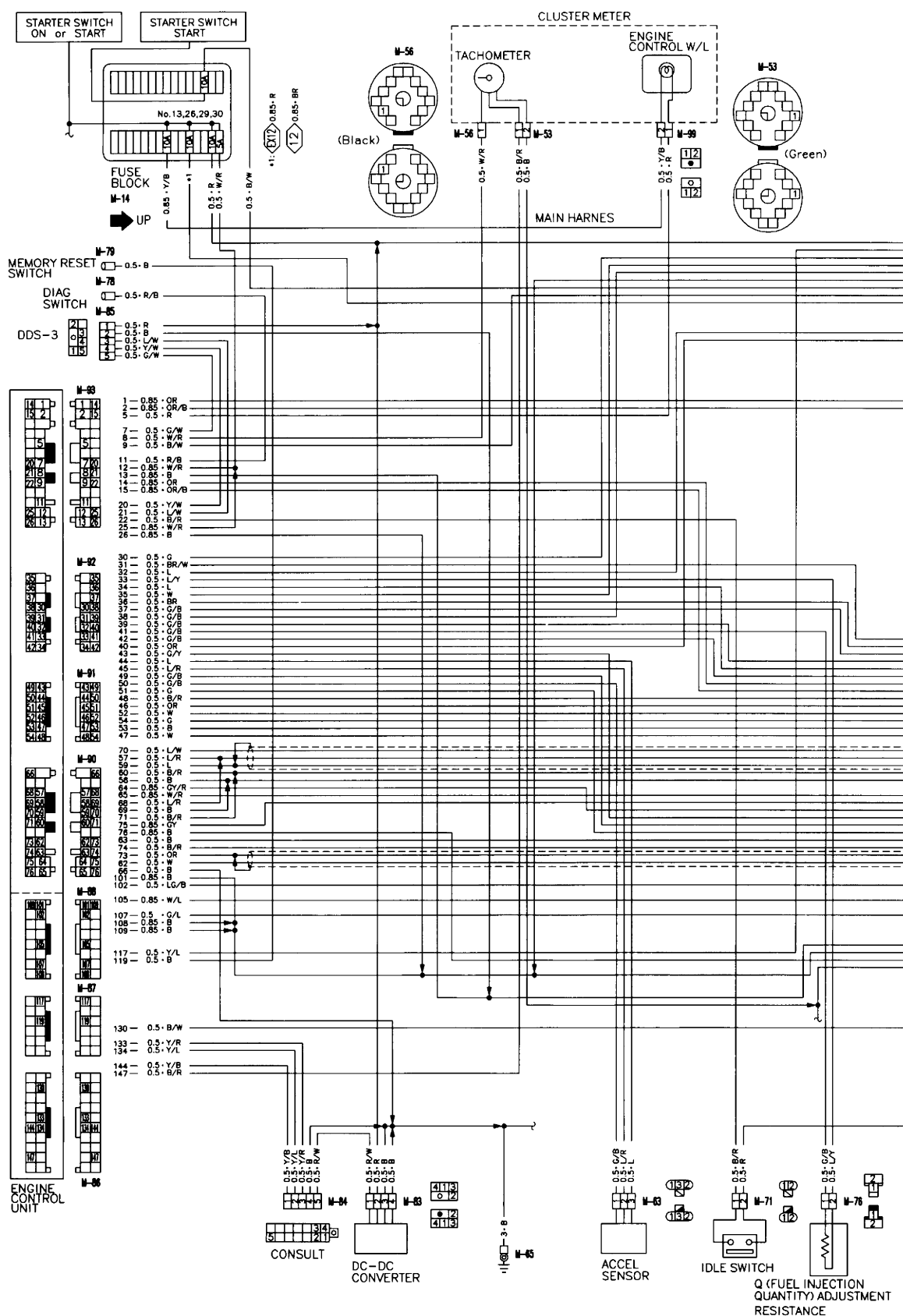
- **Au: Gold-plated terminal**

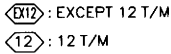
WIRING DIAGRAM RHD model (Type I)



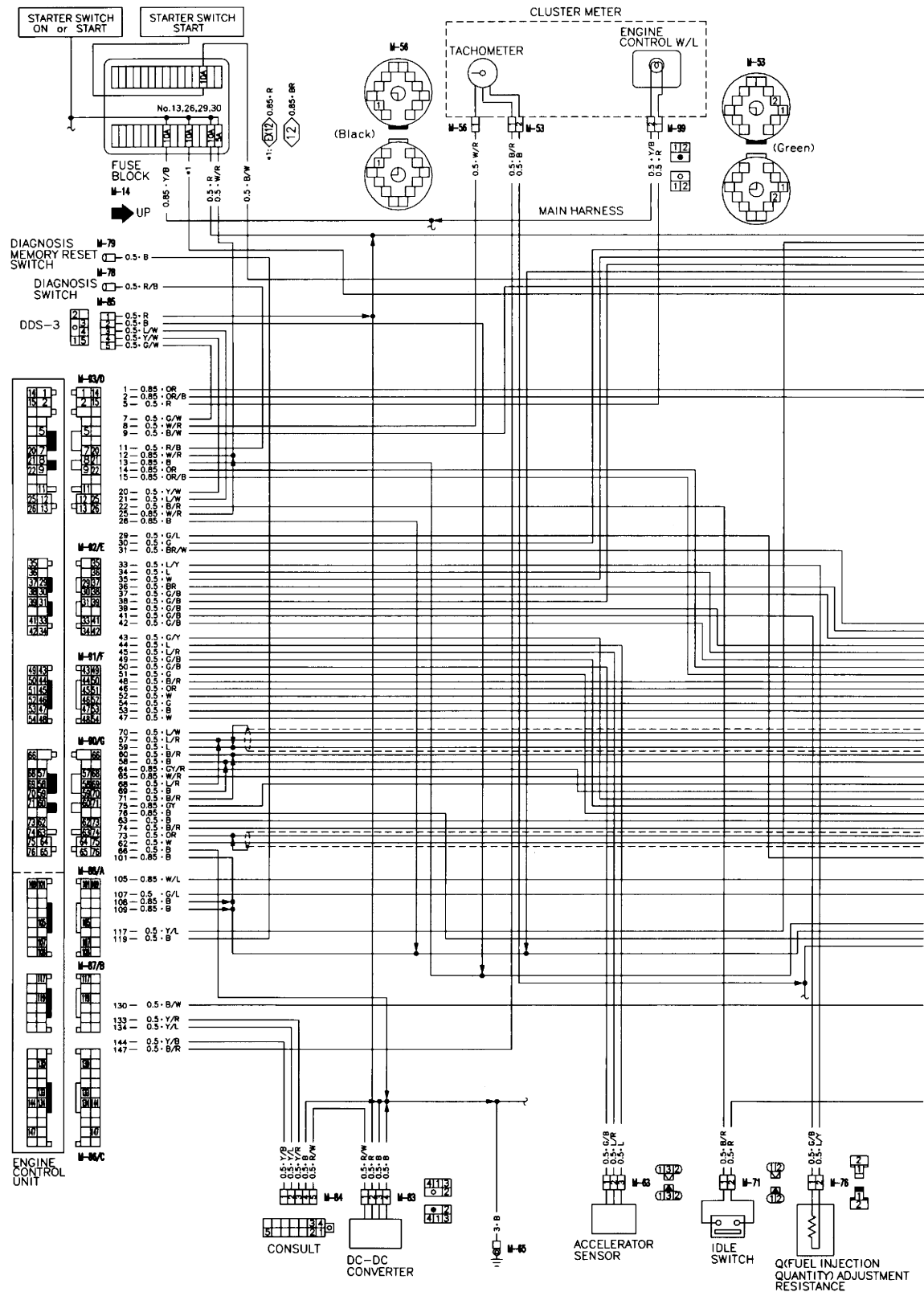


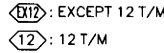
LHD model (Type I)



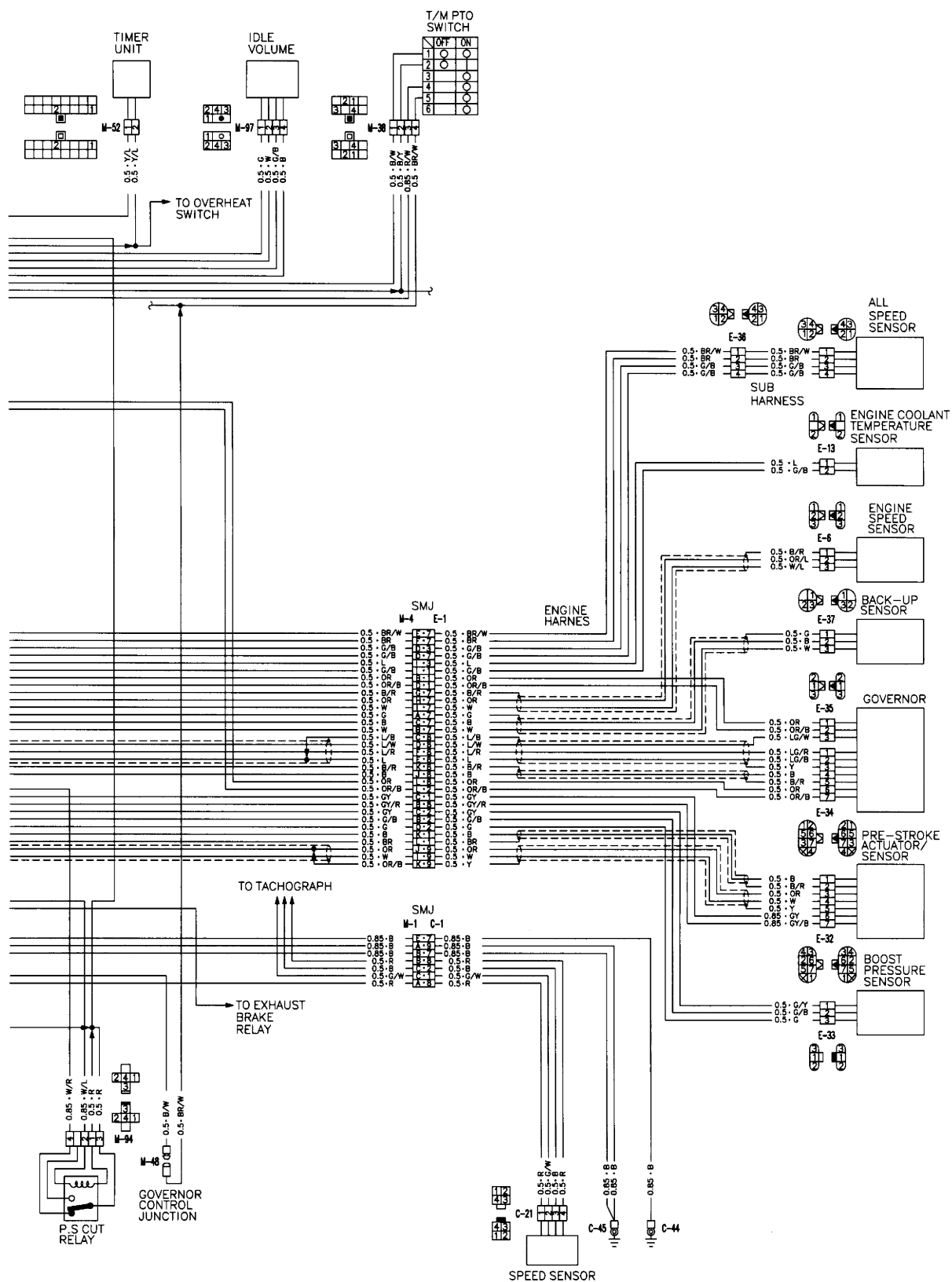


LHD model (Type II)





RHD model (Type III)



AIR INTAKE AND EXHAUST SYSTEM

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= MODEL TD45 =		INSPECTION	IE- 5- 1
CONSTRUCTION	IE- 4- 1	EXHAUST BRAKE	IE- 6- 1
REMOVAL	IE- 4- 1	CONSTRUCTION	IE- 6- 1
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SUPPLEMENTAL OUTLINE

- The type of the turbocharger has been changed due to addition of a new vehicle model.
- A model GT42, 45 turbocharger has been added.

SERVICE DATA

SPECIFICATIONS

Item		PF6TB-21	PF6TB-22	PF6TC
Air cleaner	Type	Paper element (Dry: Dual type)		
	Air cleaner type	Type IV	Type V	
Turbocharger	Model	TD45	GT45	GT42
	Turbine type	Radial-flow turbine (With variable guide plate)	Radial-flow turbine	
	Compressor type	Centrifugal		
	Lubrication method	Engine oil circulation type		
	Bearing type	Full floating		
Intercooler	Type	Air to air		
	Intercooler	Corrugated fin		
Exhaust shutter	Type	Cylinder		
	Operation	Air		
	Exhaust shutter type	Type III	Type I	

SERVICE DATA

TURBOCHARGER

Model TD45

Unit: mm (in)

Item		Maintenance standard	Service limit	Remarks
Play in shaft axial direction		0.025 - 0.080 (0.0010 - 0.0031)	—	
Inside diameter of center housing	Bearing part	—	20.19 (0.7949)	
	Piston ring part	—	20.93 (0.8240)	
Outside diameter of turbine wheel shaft	Journal part	—	12.99 (0.5114)	
	Piston ring part	—	17.48 (0.6882)	
Outside diameter of turbine wheel shaft hub		—	19.89 (0.7831)	
Piston ring groove width of shaft		—	1.74 (0.0685)	
Runout of shaft		0.01 (0.0004)	—	
Inside diameter of back plate		—	17.49 (0.6886)	
Thrust collar groove width		—	4.44 (0.1748)	
Inside diameter of thrust collar		—	7.95 (0.3130)	
Outside diameter of thrust spacer		—	17.06 (0.6717)	
Inside diameter of thrust spacer		—	7.95 (0.3130)	
Piston ring groove width of thrust spacer		—	1.77 (0.0697)	
Thrust bearing thickness		—	4.36 (0.1717)	
Outside diameter of journal bearing		—	20.07 (0.7902)	
Inside diameter of journal bearing		—	13.04 (0.5134)	
Compressor wheel inside diameter		—	7.94 (0.3126)	

SERVICE DATA

Model GT42, 45

Unit: mm (in)

Item		Maintenance standard	Service limit	Remarks
Turbine wheel shaft axial play		0.025 - 0.090 (0.0010 - 0.0035)	—	
Actuator set pressure kPa {mmHg, inHg}	GT42	137 - 143 {1,025 - 1,075, 40 - 42}	—	Value measured when actuator rod stroke length is 0.38 mm (0.0150 in)
	GT45	123 - 130 {925 - 975, 36 - 38}		

INTERCOOLER

Unit: kPa {kgf/cm², psi}

Item	Maintenance standard	Service limit	Remarks
Intercooler check pressure (air)	294 {3.0, 43}	—	

EXHAUST BRAKE

Unit: mm (in)

Item		Maintenance standard	Service limit	Remarks
Air cylinder spring tension N {kgf, lbf}		77.5 {7.9, 17.4}	—	When compressed to 113.2 mm (4.457 in)
Valve movement in the axial direction when closing the valve		More than 0.7 (0.028)	—	
Clearance between valve and body	One side	0.1 - 0.4 (0.004 - 0.016)	—	When an air pressure of 637 kPa {6.5 kgf/cm ² , 92 psi} is applied to the air cylinder and the valve is fully closed
	Both sides	0.2 - 0.5 (0.008 - 0.020)	—	
Clearance between air cylinder shaft and clevis		More than 1.0 (0.039)	—	

TIGHTENING TORQUE

TURBOCHARGER

Model TD45

Unit: N·m {kgf·m, ft·lbf}

Item	Tightening torque
Oil inlet adapter mounting bolt	21 - 26 {2.1 - 2.7, 15 - 20}
Oil drain pipe mounting bolt	21 - 23 {2.1 - 2.3, 15 - 17}
Thrust bearing mounting screw	3.4 - 3.9 {0.35 - 0.40, 2.5 - 2.9}
Back plate and center housing mounting bolt	10.2 - 11.9 {1.04 - 1.21, 7.5 - 8.8}
Compressor wheel mounting nut	3.6 - 4.7 {0.37 - 0.48, 2.7 - 3.5} → Tighten (120°)
Clamp mounting bolt	9.0 - 11.3 {0.92 - 1.15, 6.7 - 8.3}
Turbine housing and center housing mounting V-band lock nut	17.0 {1.73, 12.5} → Loosen → 13.7 {1.40, 10.1}
Turbocharger assembly mounting bolt	34 - 44 {3.5 - 4.5, 25 - 33}
Turnbuckle lock nut	11 - 13 {1.1 - 1.3, 8 - 9}
Actuator subassembly	10.3 - 12.3 {1.05 - 1.25, 7.6 - 9.0}
Actuator bracket nut	13 - 15 {1.3 - 1.5, 9 - 11}

Model GT42, 45

Unit: N·m {kgf·cm, in·lbf}

Item	Tightening torque
Compressor housing and back plate mounting bolt	10.3 - 12.3 {105 - 125, 91 - 109}
Turbine housing and center housing mounting V-band lock nut	12.7 - 14.7 {130 - 150, 113 - 130}
Actuator bracket assembly mounting bolt	10.3 - 12.3 {105 - 125, 91 - 109}
Actuator nut	8.8 - 12.7 {90 - 130, 78 - 113}
Actuator bracket nut	5.4 - 7.4 {55 - 75, 48 - 65}

EXHAUST BRAKE

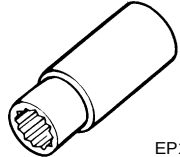
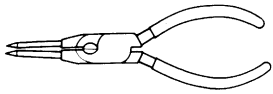
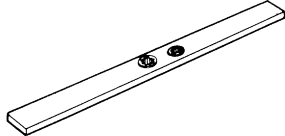
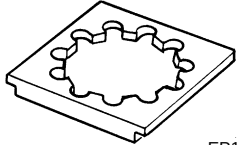
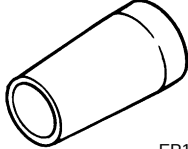
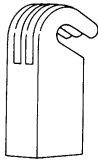
Unit: N·m {kgf·m, ft·lbf}

Item	Tightening torque
Shield plate (plate) to air cylinder mounting bolt and nut	21 - 25 {2.1 - 2.6, 15 - 19}
Body-to-plate mounting nut (Type I only)	21 - 25 {2.1 - 2.6, 15 - 19}
Lever mounting nut (Type I only)	10 - 16 {1.0 - 1.6, 7 - 12}
Stopper bolt lock nut (Type I only)	10 - 16 {1.0 - 1.6, 7 - 12}
Clevis-to-air cylinder (or lever) lock nut (Type III only)	Lightly tighten the nut to the incompletely threaded portion and tighten the lock nut to 5 to 7 {0.5 to 0.7, 3.6 to 5.1}.
Air cylinder cover mounting bolt	10 - 16 {1.0 - 1.6, 7 - 12}
Cylinder shaft nut	10 - 16 {1.0 - 1.6, 7 - 12}

TOOLS

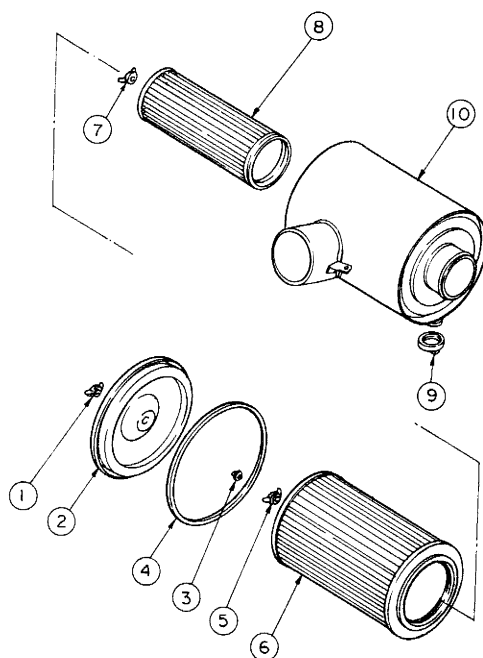
TOOLS

TURBOCHARGER Model TD45

Tool name and number	Description	Shape
Turbocharger tool kit 99760 96004	Used when disassembling and reassembling the turbocharger.	—
Deep socket 99535 96000	Used to tighten and remove the nut of the V-band.	 EP15-061
Retaining ring plier 99546 96000	Used when removing the retaining ring at the center housing.	 EP15-064
T-handle 99773 96000	Used to remove and install the impeller lock nut.	 EP15-066
Holding fixture 99768 96009	Used when disassembling and reassembling the rotating assembly.	 EP15-099
Piston ring guide 99763 96000	Used when inserting the piston ring to the turbine wheel.	 EP15-056
Pick 99767 96003	Used when fitting the piston ring of the shaft to the center housing.	 EP15-062
Adjuster holder 99779 95500	Checks the position of actuator for VNT control and corrects setting of actuator for VNT control.	 YEL529A

AIR CLEANER

DISASSEMBLY Type IV



WIE092A

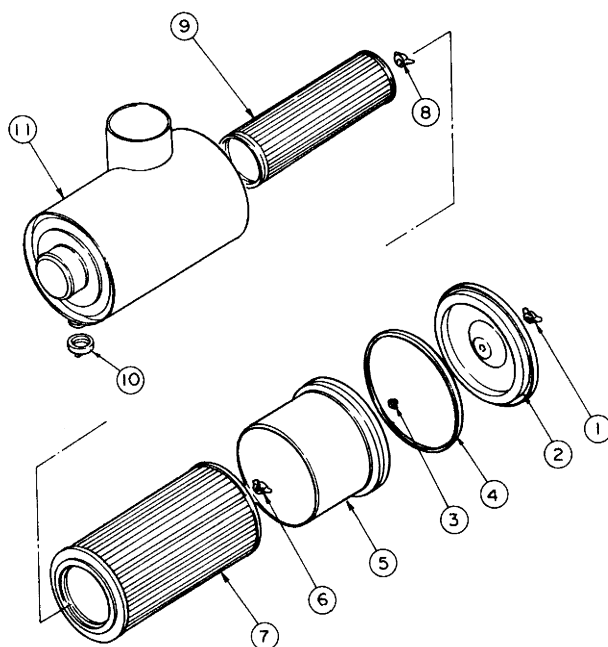
Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

- ① Wing nut
- ② Cover
- ③ Clip
- ④ Packing

- ⑤ Wing nut
- ⑥ Outer element
- ⑦ Wing nut

- ⑧ Inner element
- ⑨ Evacuator valve
- ⑩ Body assembly

Type V



WIE093A

Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

- ① Wing nut
- ② Cover
- ③ Clip
- ④ Packing

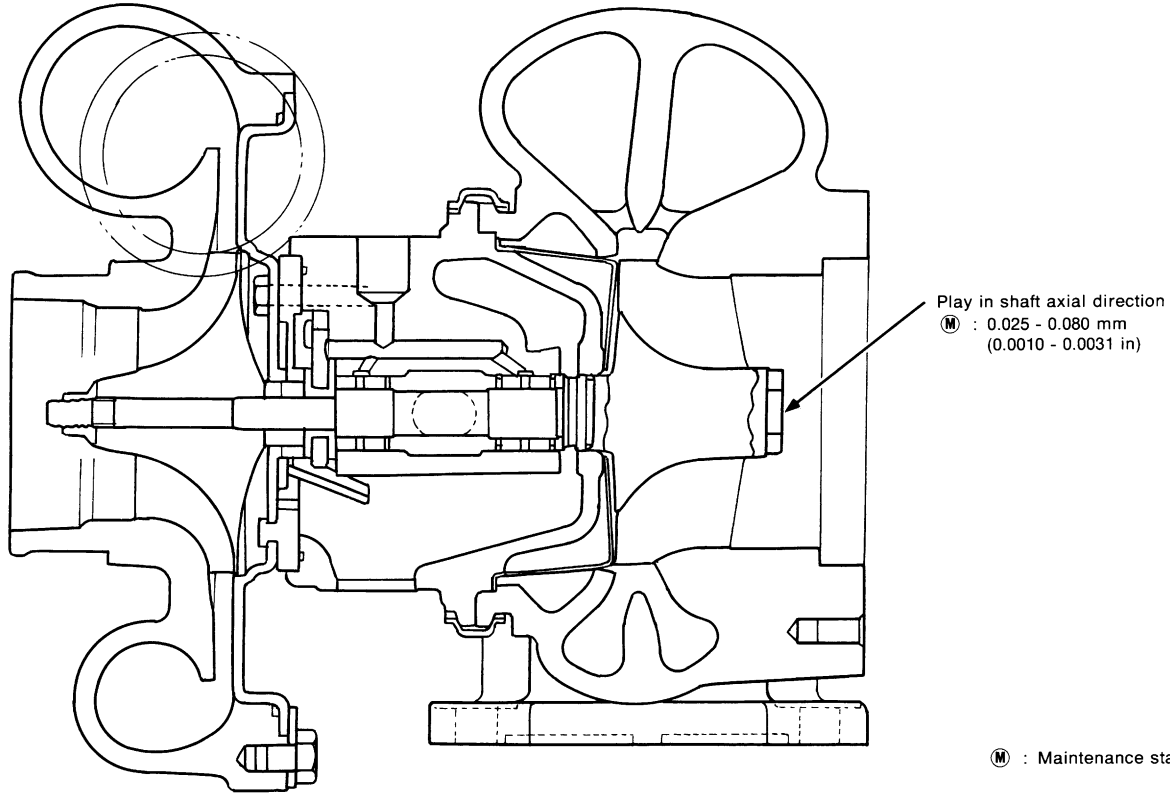
- ⑤ Adapter
- ⑥ Wing nut
- ⑦ Outer element
- ⑧ Wing nut

- ⑨ Inner element
- ⑩ Evacuator valve
- ⑪ Body assembly

For inspection and maintenance procedures, refer to the "MA" section.

TURBOCHARGER

= MODEL TD45 =
CONSTRUCTION



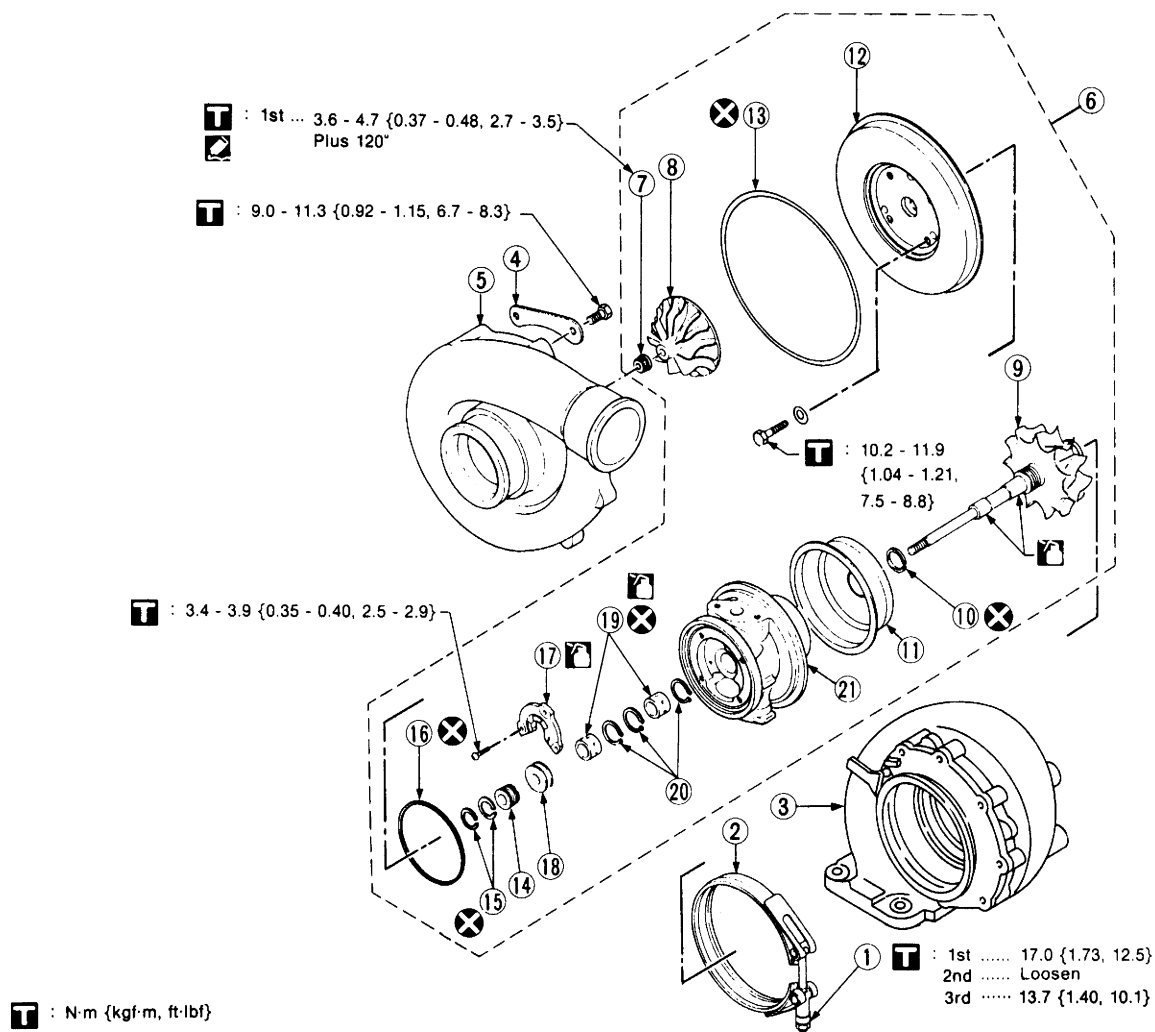
WIE001A

REMOVAL

WARNING

- To avoid being burned, do not touch the exhaust pipe, turbocharger and muffler while the engine is running or immediately thereafter. Check that the engine has cooled before starting work.

DISASSEMBLY



WIE102A

Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

- | | | |
|------------------------|-------------------------|---------------------|
| ① Lock nut | ☆★⑧ Compressor wheel | ☆★⑮ Piston ring |
| ② V-band | ☆⑨ Turbine wheel | ⑯ Seal ring |
| ☆★③ Turbine housing | ☆★⑩ Piston ring | ☆★⑰ Thrust bearing |
| ④ Clamp | ⑪ Shroud wheel | ☆★⑱ Thrust collar |
| ☆★⑤ Compressor housing | ★⑫ Back plate | ☆★⑲ Journal bearing |
| ★⑥ Rotating assembly | ⑬ O-ring (Type II only) | ☆⑳ Retaining ring |
| ⑦ Lock nut | ☆★⑭ Thrust spacer | ㉑ Center housing |

Marks "★" and "☆" indicate that the key points of operation are explained in the text.

INSPECTION BEFORE DISASSEMBLY

Place the turbocharger on a level surface, and turn the compressor wheel with finger tip to determine whether it operates smoothly. Then use the following procedure to measure both axial play.

Measuring play in the axial direction

The purpose of this procedure is to determine whether it is necessary to replace or repair the thrust bearing and/or rotating assembly of the center housing rotating assembly.

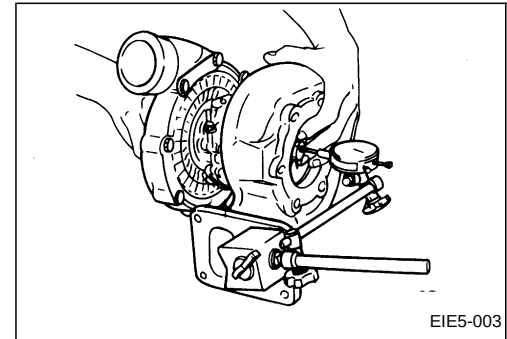
1. Set the dial gauge to the magnet base at the turbine wheel end of the turbocharger.
2. Move the turbine wheel axially back and forth by hand. (being careful not to rock turbine wheel)
3. Measure the play in the axial direction and record the results.

NOTE

- When measuring the axial play, do not turn the turbine wheel as this will cause the measurement error to become large.

Unit: mm (in)

Maintenance standard	Service limit
0.025 - 0.080 (0.0010 - 0.0031)	—



Key point of disassembly

Prior to starting disassembly, spread a piece of clean oil paper or cardboard on the work bench and make matching marks at the connection sections of the turbine housing, center housing, and compressor housing so that there will be no mistakes during reassembly.

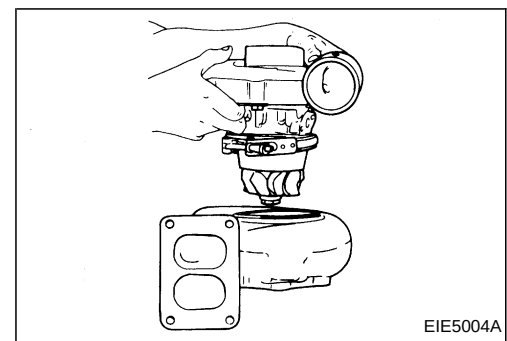
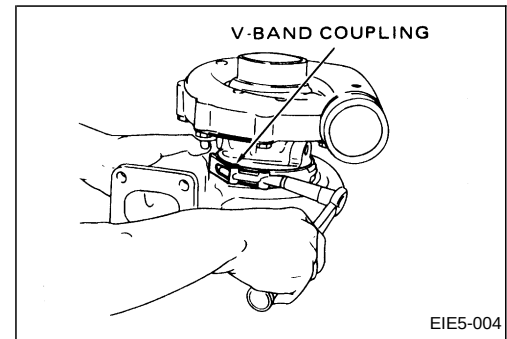
Since the turbocharger is a precision device, disassemble it with the utmost care.

③ Turbine housing

Remove the turbine housing. Loosen the lock nut as required to disengage the V-band coupling from the flange of the turbine housing and center housing.

NOTE

- If the turbine housing, center housing have stuck, apply "Thread release" oil to the register dia., then remove it, being careful not to damage the turbine wheel. If necessary, tap the turbine housing with a wooden hammer.

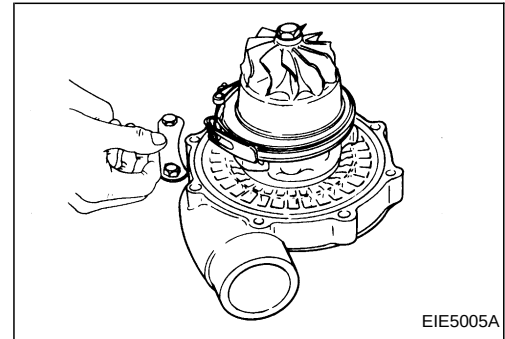
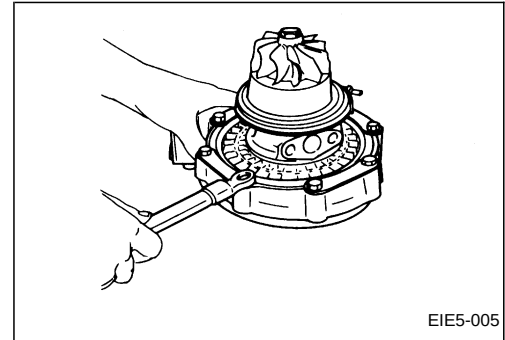


⑤ Compressor housing

Remove the compressor housing.
Loosen the compressor bolt and remove the clamp.

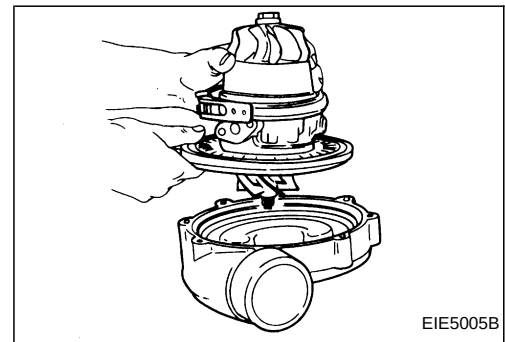
NOTE

- Be careful not to damage the compressor wheel.



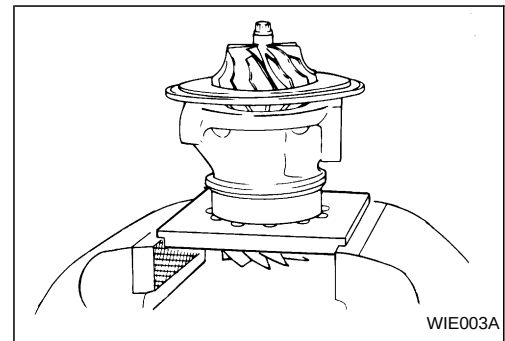
NOTE

- The compressor wheel and turbine wheel are precisely dynamically balanced and cannot be repaired. Therefore, they must be handled with extra special care.



⑥ Rotating assembly

Place Holding Fixture (99768 96009) in a vise, and set the turbine wheel on it with the compressor wheel on it with the turbine wheel side facing downward.

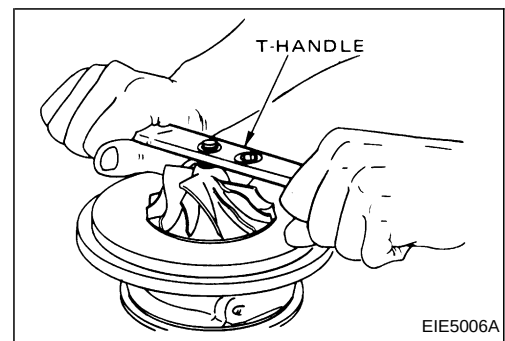


⑧ Compressor wheel

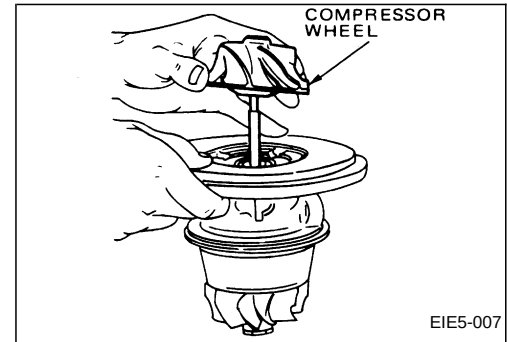
1. Remove the compressor wheel.
- Using a T-handle (99773 96000), remove the lock nut, and then remove the compressor wheel by hand.

NOTE

- Since bending of the turbine wheel is also related to the life of the turbocharger, be careful not to bend it.
- Support the turbine wheel by hand while loosening the lock nut.



2. Remove the compressor wheel by hand.

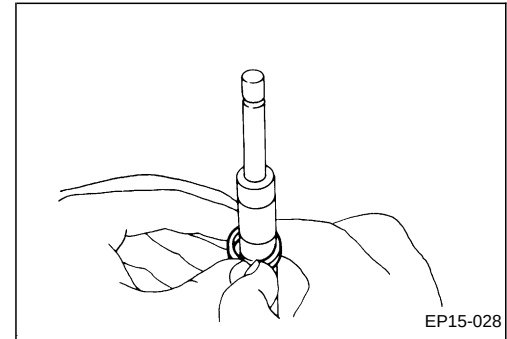


⑩ Piston ring

Remove the piston ring.

NOTE

- Once removed, the piston ring must always be replaced with a new piston ring when reassembling. However, since the turbine wheel can be reused, be careful not to damage it.



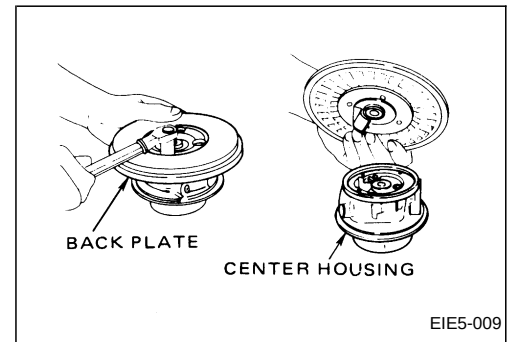
⑫ Back plate

Remove the backplate.

Loosen the backplate bolt, remove the washer and remove the backplate.

NOTE

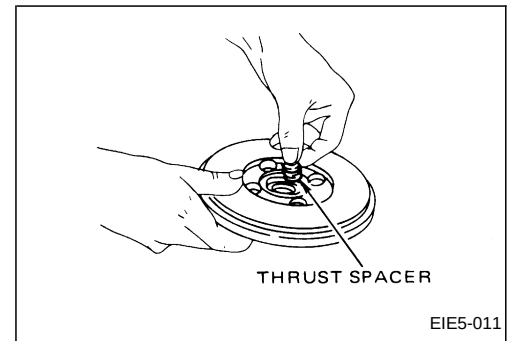
- When the backplate cannot be removed by hand, tap the center housing lightly with a wooden mallet and then remove.



⑭ Thrust spacer, ⑮ Piston ring

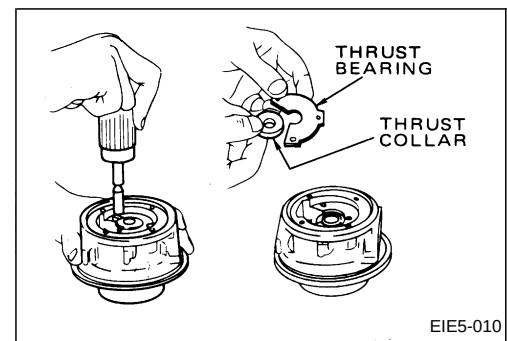
Pull out the thrust spacer from center of the backplate and remove the piston ring from the thrust spacer.

The piston ring can be removed by hand.



⑰ Thrust bearing, ⑱ Thrust collar

Loosen the thrust bearing bolt, then remove the thrust collar and thrust bearing.



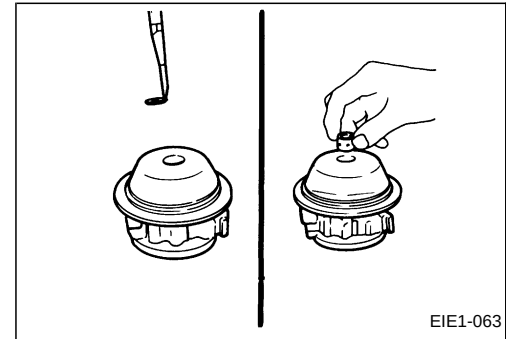
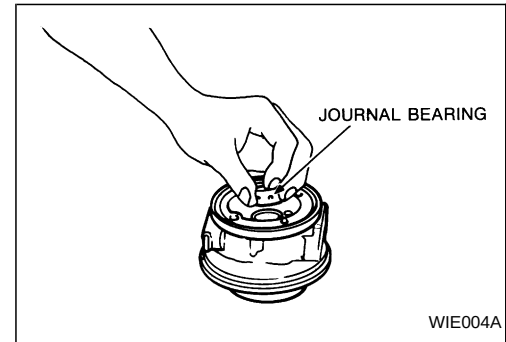
⑪ **Journal bearing**

1. Remove the journal bearing.

NOTE

- **Be careful not to damage the center housing when removing the retainer ring.**

2. Using retaining ring pliers (99546 96000), remove the compressor wheel side retaining ring and journal bearing.
3. Using retaining ring pliers (99546 96000), remove the turbine wheel side retaining ring and journal bearing.
4. Remove the two retaining rings located in the rear of the center housing.



INSPECTION

INSPECTION BEFORE CLEANING

Turbocharger failure may sometimes be due to faulty engine parts. It is, therefore advisable to closely inspect parts for accumulation of carbon, presence of dirt or dust, obstruction of oil passages, etc. prior to cleaning, so that the cause of problems may be located easily.

CLEANING

After soaking all the parts in clean detergent for about 20 to 30 minutes, remove dirt and grime with a rough brush and then blow dry with compressed air.

NOTE

- **Be extremely careful not to damage parts. Avoid filing any rotating parts. Also be sure to clean parts completely. Failure to observe these points may cause the parts to become imbalanced.**

Contents of inspection	Inspection point
Carbon accumulation (check whether parts are jammed)	● Turbine wheel journal parts. ● Outside periphery of center housing. ● Inside periphery of heat shroud. ● Inside wall of center housing. ● Surface of blades of turbine wheel.
Lubrication (wear, burning, discoloration etc.)	● Turbine wheel journal parts. ● Journal bearing. ● Center housing bore part. ● Thrust collar. ● Thrust bearing.
Oil leakage	● Inside and outside periphery of turbine housing. ● Inside periphery of heat shroud. ● Inside of compressor housing. ● Surface of back plate. ● Surface of blades of turbine wheel. ● Rear surface of compressor wheel.
Foreign matter (Also check for obstruction while cleaning parts.)	● Inside of center housing. ● Inside of turbine case. ● Inside of compressor case.
Clogging	● Center housing of oil hole. ● Oil inlet adapter. ● Oil outlet adapter. ● Thrust bearing of oil hole.

INSPECTION

Inspect parts visually, replacing as necessary.

Contents of inspection	Inspection point
V-band coupling	● Deformity, elongation and damage.
Compressor housing	● Scratches caused by interference with impeller. ● Scratches on contact surfaces with V-band coupling and back plate. ● Cracks or dents.
Clamp	● Corrosion, deterioration and damage.
Turbine housing	● Scratches caused by interference with shaft wheel. ● Burrs caused by rust formation. ● Thermal deformity and cracks.
Compressor wheel	● Corrosion. ● Scratches caused by interference with housing. ● Blade breakage and deformity. ● Gauging in shaft holes.
Turbine wheel	● Scratches from interference with turbine housing. ● Blade breakage, deformity and cracks. ● Shaft bent. ● Discolored journals and blades. ● Worn and scratched journals. ● Worn and damaged piston rings.
Back plate	● Worn bore. ● Wear and damage on contact surface of thrust collar. ● Scratches on rear face of impeller.
Thrust spacer	● Damage and wear on outer surface. ● Thermal discoloration. ● Worn and damaged piston rings.
Thrust collar	● Thermal discoloration. ● Wear and scratches on contact surface.
Thrust bearing	● Thermal discoloration. ● Scratches and wear on contact surface of thrust collar.
Center housing	● Wear and scratches on journal bores and inner surfaces of piston rings. ● Obstruction in oil hole.
Heat shroud	● Scratches caused by contact. ● Thermal discoloration and corrosion.

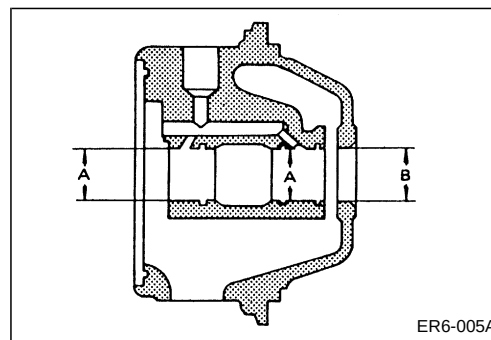
NOTE

- If the measured value exceeds the maintenance standard, replace the part.

Inside diameter of center housing

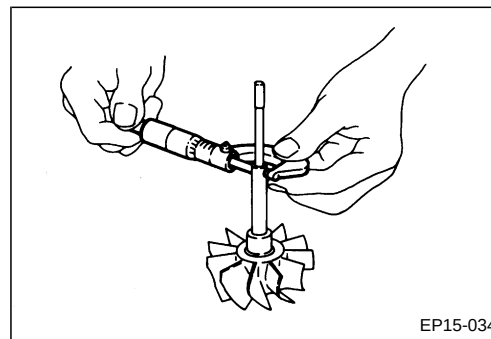
Unit: mm (in)

Item	Maintenance standard	Service limit
Bearing part (A)	—	20.19 (0.7949)
Piston ring part (B)	—	20.93 (0.8240)


Outside diameter of turbine wheel shaft

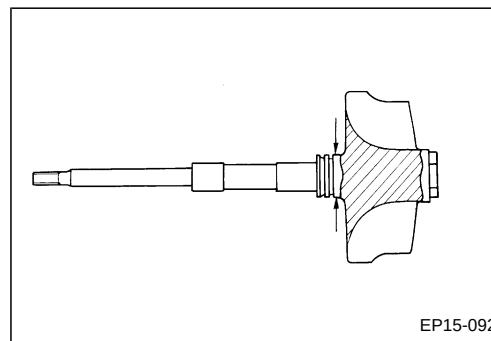
Unit: mm (in)

Item	Maintenance standard	Service limit
Journal part	—	12.99 (0.5114)
Piston ring part	—	17.48 (0.6882)


Outside diameter of turbine wheel shaft hub

Unit: mm (in)

Maintenance standard	Service limit
—	19.89 (0.7831)


Piston ring groove width of shaft

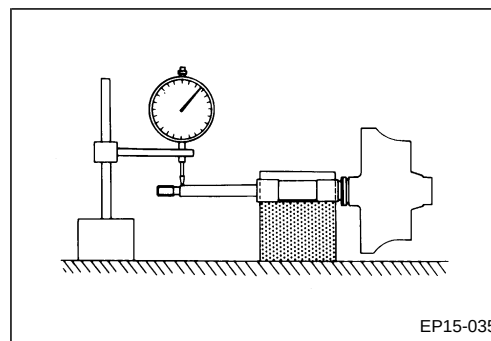
Unit: mm (in)

Maintenance standard	Service limit
—	1.74 (0.0685)

Runout of shaft

Unit: mm (in)

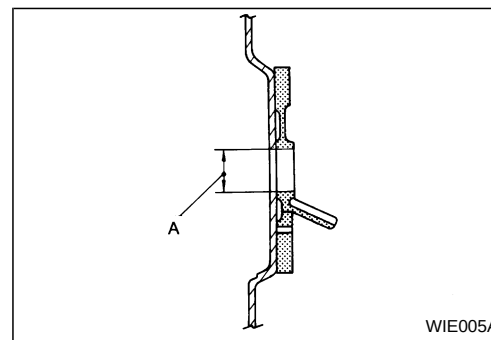
Maintenance standard	Service limit
0.01 (0.0004)	—



Inside diameter of back plate

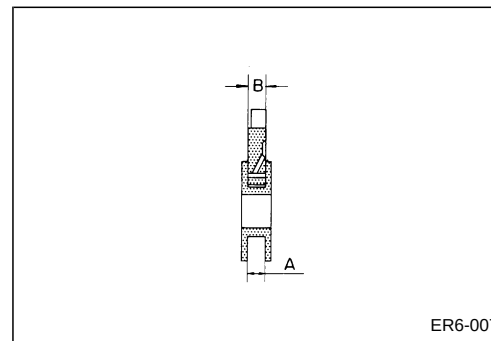
Unit: mm (in)

Item	Maintenance standard	Service limit
Back plate seal bore diameter (measurement A)	—	17.49 (0.6886)


Thrust collar

Unit: mm (in)

Item	Maintenance standard	Service limit
Groove width (A)	—	4.44 (0.1748)


Inside diameter of thrust collar

Unit: mm (in)

Maintenance standard	Service limit
—	7.95 (0.3130)

Outside diameter of thrust spacer

Unit: mm (in)

Maintenance standard	Service limit
—	17.06 (0.6717)

Inside diameter of thrust spacer

Unit: mm (in)

Maintenance standard	Service limit
—	7.95 (0.3130)

Piston ring groove width of thrust spacer

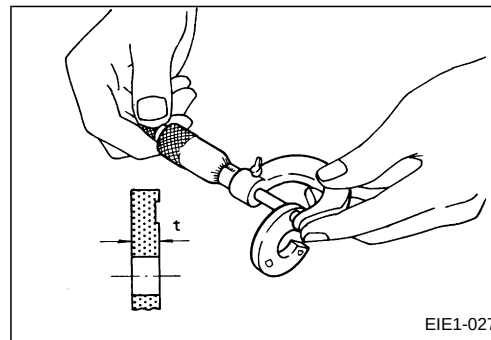
Unit: mm (in)

Maintenance standard	Service limit
—	1.77 (0.0697)

Thrust bearing thickness

Unit: mm (in)

Maintenance standard	Service limit
—	4.36 (0.1717)



EIE1-027

Journal bearing

Unit: mm (in)

Item	Maintenance standard	Service limit
Outside diameter	—	20.07 (0.7902)
Inside diameter	—	13.04 (0.5134)

Compressor wheel inside diameter

Unit: mm (in)

Maintenance standard	Service limit
—	7.94 (0.3126)

REASSEMBLY

Preparations before reassembly

Repair light damage by polishing. Aluminum parts must be polished with a polishing cloth using silicon carbide.

Moreover, steel parts must be polished with a polishing cloth using polishing powder. Always replace the following parts.

Part name	Quantity
Turbine V-band lock nut	1
Bolt (Compressor housing)	6
Lock nut (Compressor wheel)	1
Piston ring (Turbine wheel)	1
Bolt (Back plate)	4
Seal ring	1
Piston ring (Thrust spacer)	2
Screw (Thrust bearing)	3
Thrust bearing	1
Journal bearing	2
Retaining ring	3

Key point of reassembly

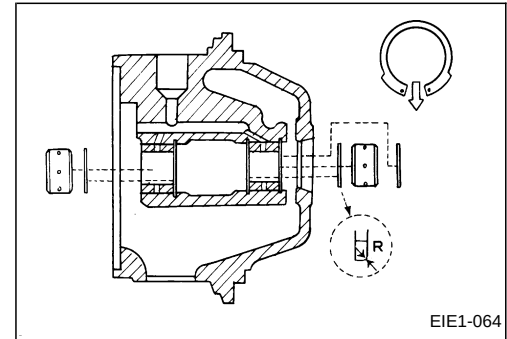
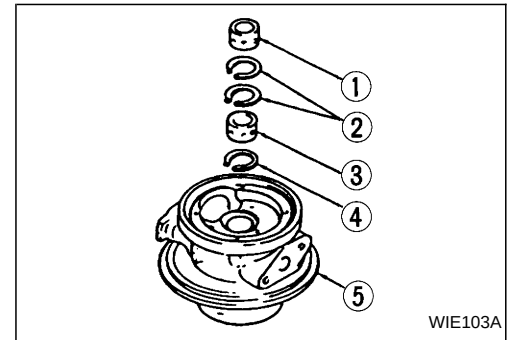
⑳ Retaining ring, ⑲ Journal bearing

Using retaining ring pliers (99546 96000), install the retaining rings in the rear of the center housing, then install the journal bearing and the outer retaining ring.

- | | |
|-------------------|------------------|
| ① Journal bearing | ④ Retaining ring |
| ② Retaining ring | ⑤ Center housing |
| ③ Journal bearing | |

NOTE

- Ensure that the open end of the retaining ring faces the oil outlet and the round portion faces the journal bearing.
- Be careful not to damage the center housing when installing the retaining ring.
- Coat the inner and outer periphery of journal bearing with engine oil.
- Replace the journal bearing with a new one.

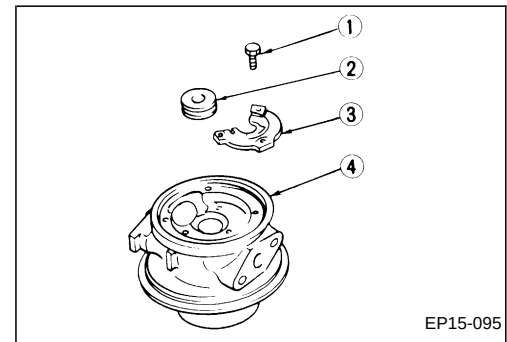


⑱ Thrust collar, ⑰ Thrust bearing

Coat the thrust bearing pads with engine oil and then install the thrust bearing and thrust collar into the center housing with three screws.

- | | |
|-----------------|------------------|
| ① Screw | ③ Thrust bearing |
| ② Thrust collar | ④ Center housing |

T : 3.4 - 3.9 N·m {0.35 - 0.40 kgf·m, 2.5 - 2.9 ft·lbf}

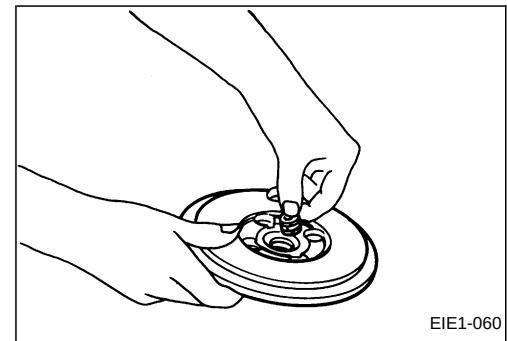


⑮ Piston ring, ⑭ Thrust spacer

1. Install the piston rings on the thrust spacer.
2. Install the thrust spacer assembly to the back plate.

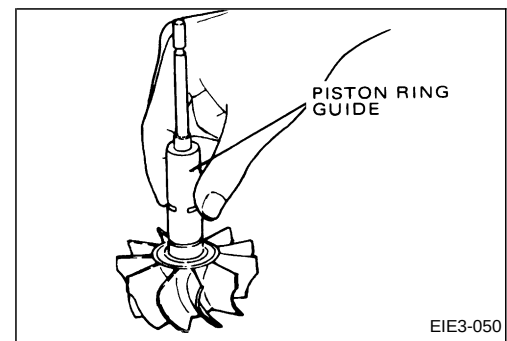
NOTE

- Ensure that the open end of the turbine side piston ring faces the oil outlet and the open end of the compressor side piston ring faces the oil inlet.



⑩ Piston ring

Using a piston ring guide (99763 96000), insert the piston ring into the turbine wheel.

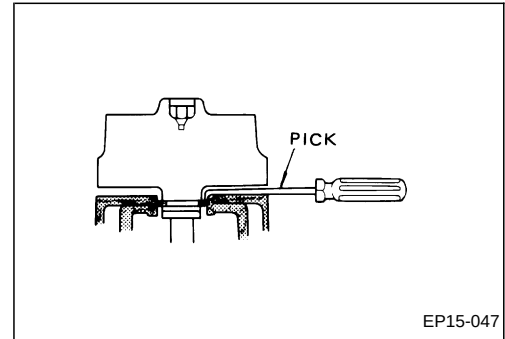
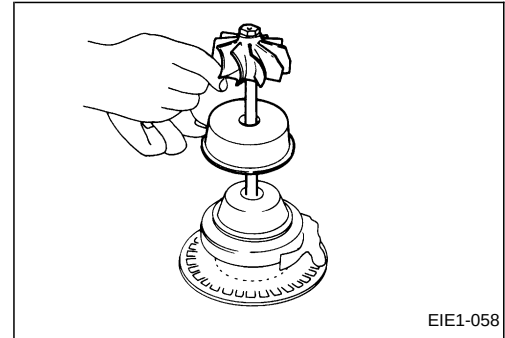


⑨ Turbine wheel

1. Place the center housing assembly on the compressor housing.
2. Apply a coat of engine oil to the turbine wheel journal, and carefully insert the turbine wheel into the bore in the center housing.
Use a pick (99767 96003) to compress the piston ring and install it while rotating the wheel shaft.

NOTE

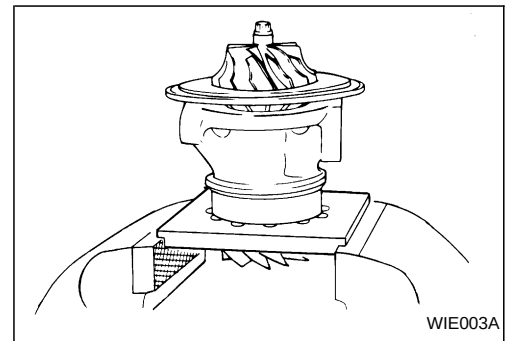
- Be careful not to scratch or break the piston ring.
- Ensure that the open end of the piston ring faces the oil inlet.



⑧ Compressor wheel

- Before installing the compressor wheel, clean the parts and check carefully the tightening surface for dust or foreign matter.

- Coat the compressor wheel mounting and screw section of the turbine wheel and the surface of the lock nut seat with a thin coat of seizure preventative.
- Fit the compressor wheel into the turbine wheel and tighten the lock nut temporarily.
- Attach the rotating assembly to a holding fixture (99768 96009) which has been placed in a vise.

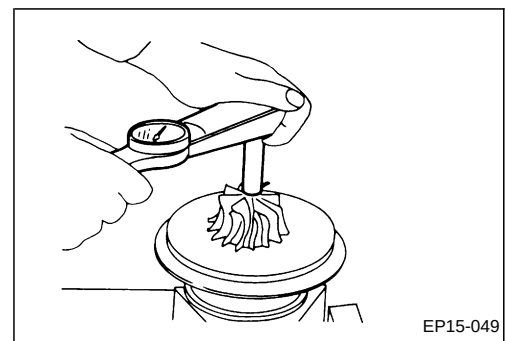


1. Using a torque wrench, tighten the lock nut temporarily.

T : 3.6 - 4.7 N·m {0.37 - 0.48 kgf·m, 2.7 - 3.5 ft·lbf}

NOTE

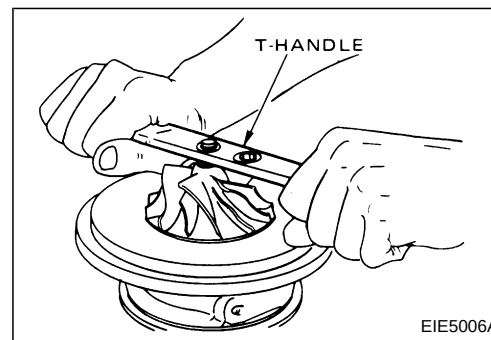
- When tightening the nut, be careful not to give the bending force to the shaft.



2. Tighten the lock nut completely with T-handle (99773 96000) by turning nut 120° further than the temporary position.

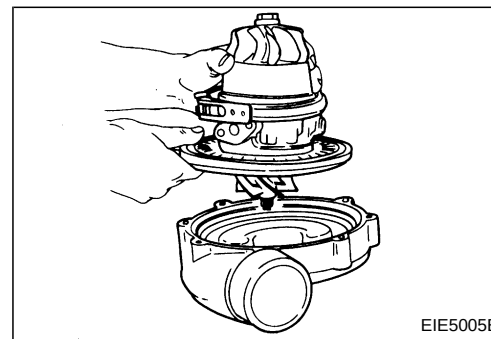
NOTE

- Keep the rated tightening torque and tightening angle.


⑤ Compressor housing

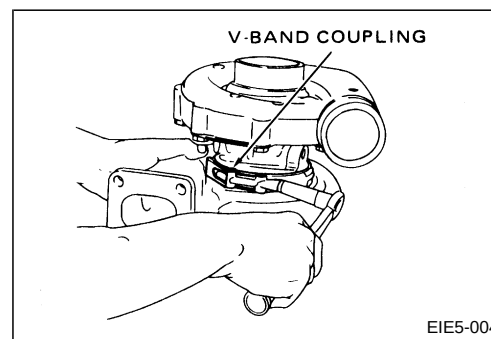
Attach the compressor housing to the back plate by properly aligning their marks, then tighten the bolts with the clamps.

T : 9.0 - 11.3 N·m {0.92 - 1.15 kgf·m, 6.7 - 8.3 ft·lbf}


③ Turbine housing

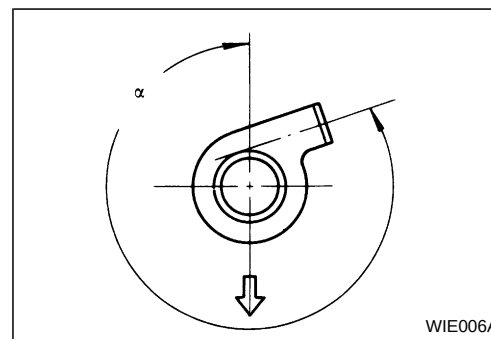
1. Install the turbine housing to the center housing by aligning the alignment marks. Using a deep socket (99535 96000), tighten the V-band.

T : 1st ... 17.0 N·m {1.73 kgf·m, 12.5 ft·lbf}
 2nd ... Loosen
 3rd ... 13.7 N·m {1.40 kgf·m, 10.1 ft·lbf}



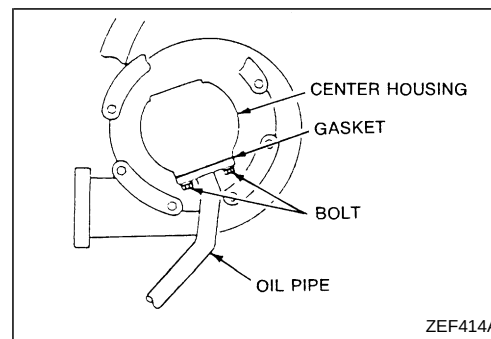
2. Compressor housing assembly angle (View from the air intake side)

Value α
200°


INSTALLATION

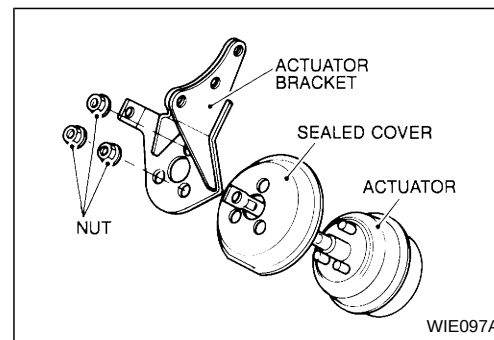
1. Install the oil drain pipe to the center housing.

T : 21 - 23 N·m {2.1 - 2.3 kgf·m, 15 - 17 ft·lbf}

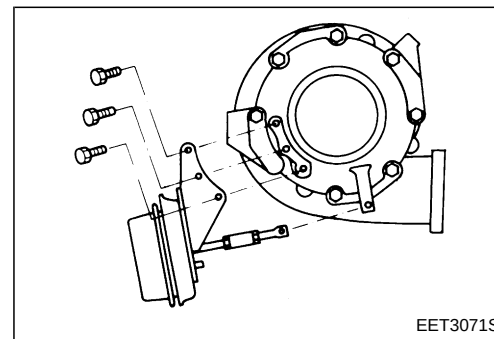


2. Install the actuator on the actuator bracket using nuts.

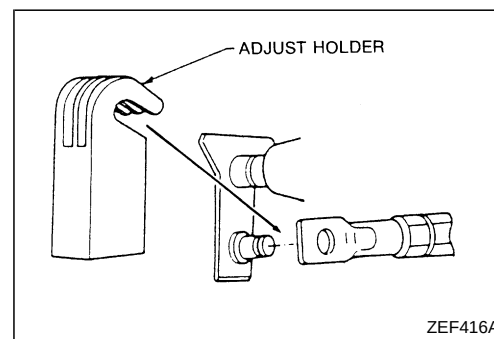
T : 13 - 15 N·m {1.3 - 1.5 kgf·m, 9 - 11 ft·lbf}



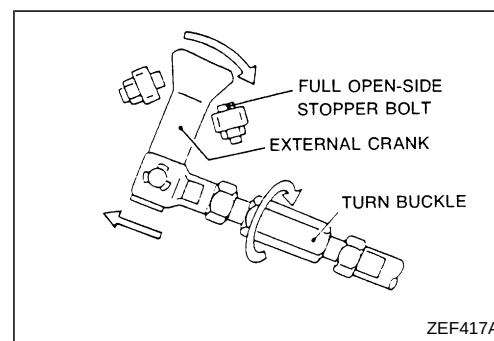
3. Install the actuator subassembly to the turbocharger.
- T** : 10.3 - 12.3 N·m {1.05 - 1.25 kgf·m, 7.6 - 9.0 ft·lbf}
4. Insert the external crank pin into the hole in the tip of the actuator rod.



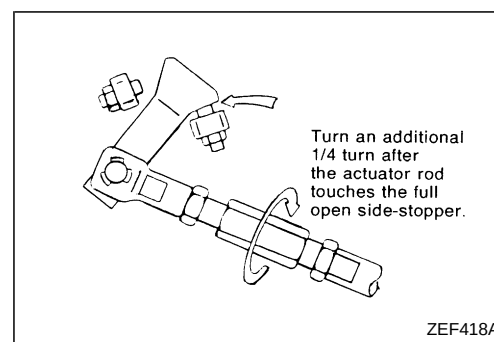
5. Install the adjuster holder (99779 95500) to the actuator rod and the external crank.



6. Extend the actuator rod by turning the turnbuckle clockwise. Turn the actuator rod by hand until the external crank touches the full open-side stopper.

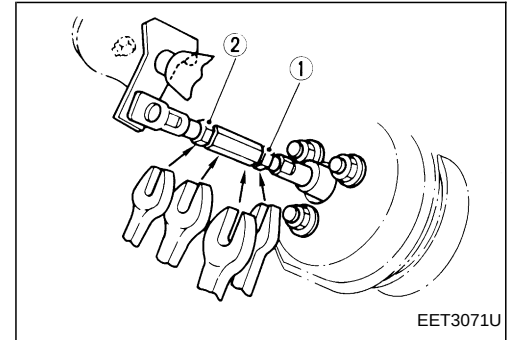


7. Continuously turn the actuator rod 1/4 turn, using a wrench.

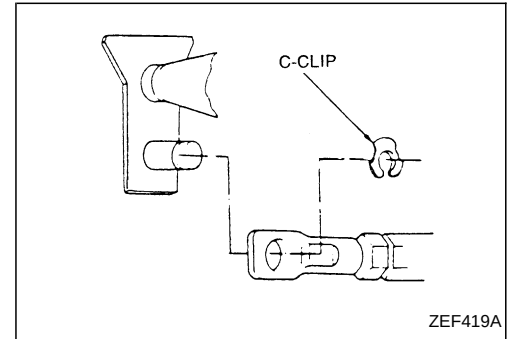


8. Tighten turnbuckle lock nuts ① and ②.

T : 11 - 13 N·m {1.1 - 1.3 kgf·m, 8 - 9 ft·lbf}

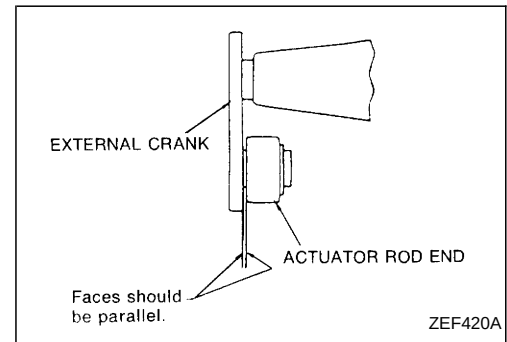


9. Install the C-clip to the external crank pin. Remove the adjuster holder.



NOTE

- Before fastening the actuator rod, make sure that the external crank and the actuator rod are parallel.
- Never loosen the external crank stopper bolt that is installed and adjusted on the turbine assembly.

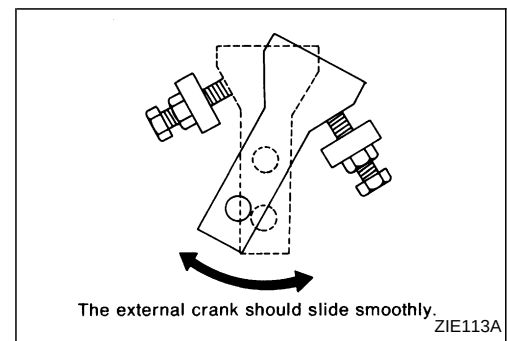


10. Check shaft wheel axial play.

Unit: mm (in)

Maintenance standard	Service limit
0.025 - 0.080 (0.0010 - 0.0031)	—

11. Place the turbocharger assembly on a flat surface. The impeller should turn smoothly by hand.
12. Also, check that the external crank slides smoothly.



13. Install the turbocharger assembly on the exhaust manifold using a gasket.

T : 34 - 44 N·m {3.5 - 4.5 kgf·m, 25 - 33 ft·lbf}

NOTE

- Mounting nuts are heat-resistant types. Do not confuse them with conventional nuts.

14. Install the exhaust connector using a gasket and spacer to the turbocharger assembly.

T : 34 - 44 N·m {3.5 - 4.5 kgf·m, 25 - 33 ft·lbf}

NOTE

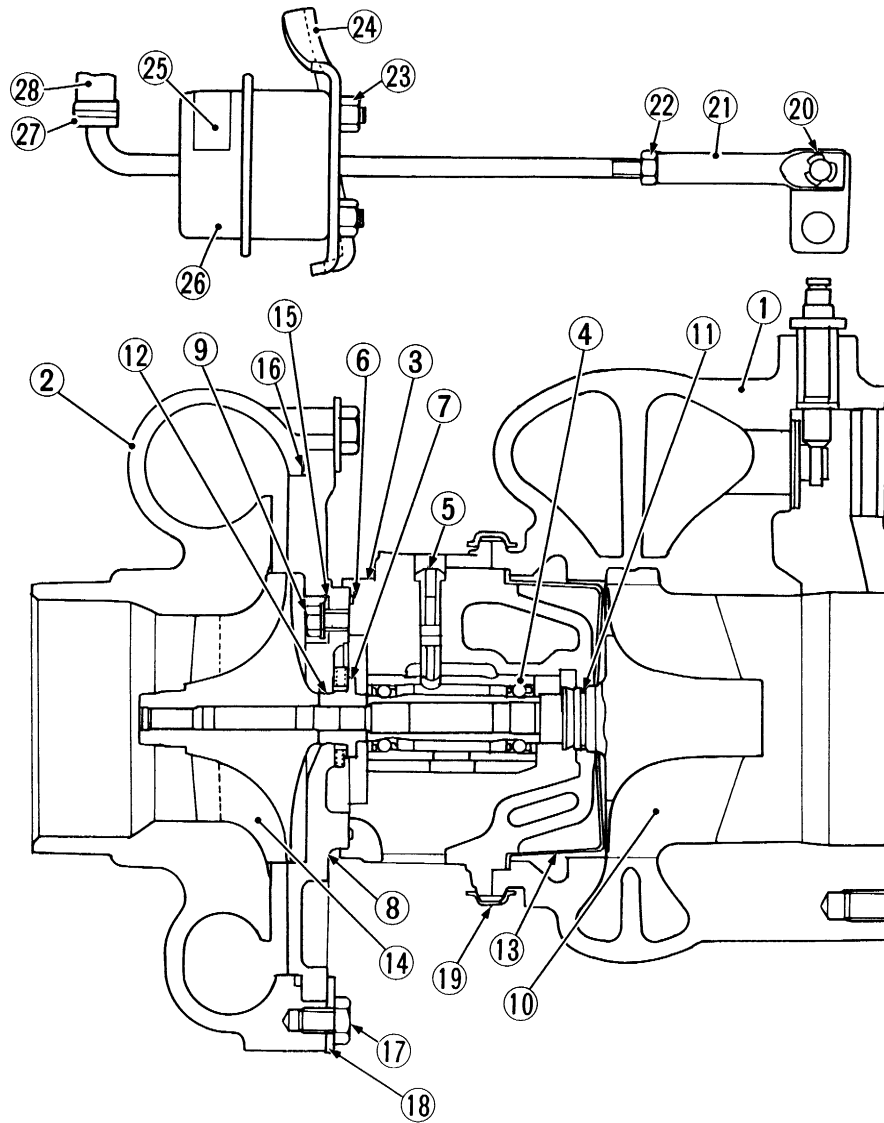
- Mounting nuts are heat-resistant types. Do not confuse them with conventional nuts.

15. Install the oil pipe.

T : 21 - 26 N·m {2.1 - 2.7 kgf·m, 15 - 20 ft·lbf}

16. Install the turbocharger shield plate, shield bracket and exhaust connector shield plate.
17. Connect the air intake duct and exhaust pipe using a gasket.
18. After installing the turbocharger assembly, crank the engine using the sub-starter switch. Crank for approximately 10 to 20 seconds while pulling the engine stop lever. Crank the engine until the oil pressure gauge activates, since oil is not distributed to the oil line.

= MODEL GT42, 45 = CONSTRUCTION



- ① Turbine housing with waste gate assembly
- ② Compressor housing assembly
- ③ Center housing
- ④ Ball bearing cartridge assembly
- ⑤ Locating pin
- ⑥ Seal ring
- ⑦ Spacer
- ⑧ Back plate assembly
- ⑨ Bolt

- ⑩ Turbine wheel assembly
- ⑪ Piston ring (Turbine side)
- ⑫ Piston ring (Compressor side)
- ⑬ Shroud wheel
- ⑭ Compressor wheel
- ⑮ Seal washer
- ⑯ O-ring
- ⑰ Bolt (Compressor side)
- ⑱ Clamp plate

- ⑲ V-band (Turbine side)
- ⑳ E-ring
- ㉑ Actuator rod end
- ㉒ Actuator rod end nut
- ㉓ Actuator nut
- ㉔ Actuator bracket
- ㉕ Caution label
- ㉖ Actuator assembly
- ㉗ Actuator hose clamp
- ㉘ Actuator hose

WIE151A

NOTE

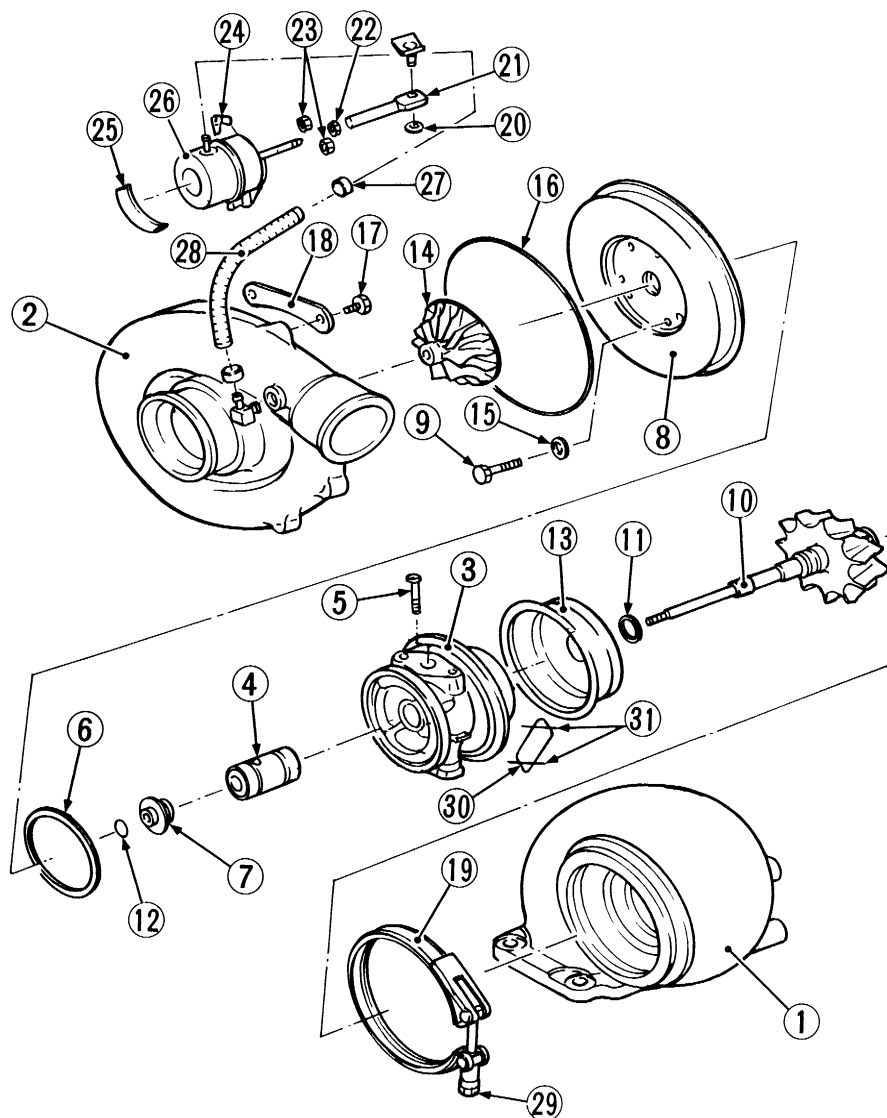
- Center housing rotating assembly ③ to ⑱ cannot be disassembled. When reassembling, replace with the center housing rotating assembly.

REMOVAL

WARNING

- To avoid being burned, do not touch the exhaust pipe, turbocharger and muffler while the engine is running or immediately thereafter. Check that the engine has cooled before starting work.

DISASSEMBLY



WIE152A

- | | | |
|--|----------------------------------|-------------------------------|
| ① Turbine housing with waste gate assembly | ⑪ Piston ring (Turbine side) | ⑳ Actuator rod end |
| ② Compressor housing assembly | ⑫ Piston ring (Compressor side) | ㉑ Actuator rod end nut |
| ③ Center housing | ⑬ Shroud wheel | ㉒ Actuator nut (2 pcs) |
| ④ Ball bearing cartridge assembly | ⑭ Compressor wheel | ㉓ Actuator bracket |
| ⑤ Locating pin | ⑮ Seal washer | ㉔ Caution label |
| ⑥ Seal ring | ⑯ O-ring | ㉕ Actuator assembly |
| ⑦ Spacer | ⑰ Bolt (Compressor side) (8 pcs) | ㉖ Actuator hose clamp (2 pcs) |
| ⑧ Back plate assembly | ⑱ Clamp plate (4 pcs) | ㉗ Actuator hose |
| ⑨ Bolt (4 pcs) | ㉘ V-band (Turbine side) | ㉙ Lock nut (Turbine side) |
| ⑩ Turbine wheel assembly | ㉚ E-ring | ㉛ Name plate |
| | | ㉜ Screw drive (2 pcs) |

NOTE

- Center housing rotating assembly ③ to ⑯ cannot be disassembled. When reassembling, replace with the center housing rotating assembly.
- Numbers before part names do not indicate the disassembly sequence.

NOTE

- The compressor housing is treated with abradable spray coating. The purpose of this treatment is to minimize the clearance between the rotating part (compressor wheel) and stationary part (compressor housing), minimize compressed air leaks and improve turbocharger performance. Due to the application of this treatment, a trace of minor interference scratches may remain on the surface of the compressor wheel and the contour section of the compressor housing. However, this does not indicate a problem with the turbocharger itself.

INSPECTION BEFORE DISASSEMBLY

1. Manually rotate the shaft wheel to make sure the turbine wheel rotates smoothly without binding, and that the specified clearance is maintained between the turbine wheel and housing.

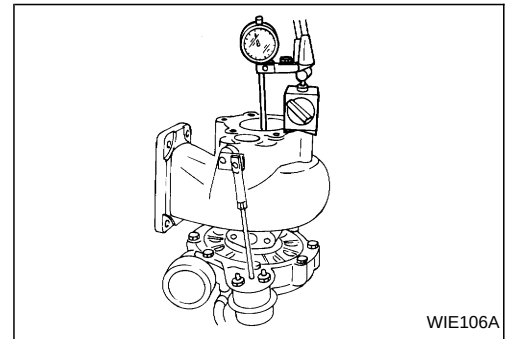
2. Measure the turbine wheel shaft axial play.

NOTE

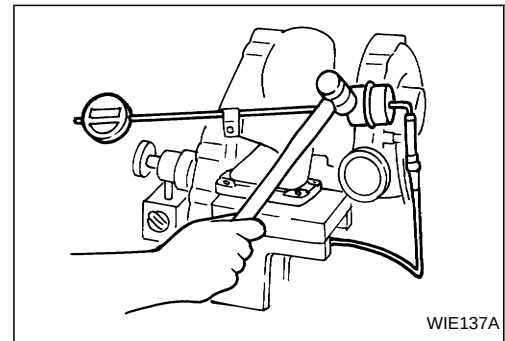
- If the axial play is not within the specified maintenance standard range, disassemble and repair the turbocharger or replace the turbocharger assembly with a new one if necessary.

Unit: mm (in)

Item	Maintenance standard	Service limit
Turbine wheel shaft axial play	0.025 - 0.090 (0.0010 - 0.0035)	—


ACTUATOR CALIBRATION CONFIRMATION

1. Remove the actuator hose and install an external pressure-application air hose in its place.
2. Move the actuator rod over the entire stroke end.
3. Reset the air pressure value to zero "0".
4. Attach a dial gauge coaxially to the rod end. Reset the dial gauge to zero "0".
5. Gradually increase air pressure to the actuator through a pressure regulator to move the rod until the dial gauge indicator registers 0.38 mm (0.0150 in). During pressure application, lightly tap the actuator with a plastic hammer.
6. Read the pressure gauge indication when the actuator rod end moves a stroke length of 0.38 mm (0.0150 in).



Unit: kPa {mmHg, inHg}

Item		Maintenance standard	Service limit	Remarks
Actuator set pressure	GT42	137 - 143 {1,025 - 1,075, 40 - 42}	—	Value measured when actuator rod stroke length is 0.38 mm (0.0150 in)
	GT45	123 - 130 {925 - 975, 36 - 38}		

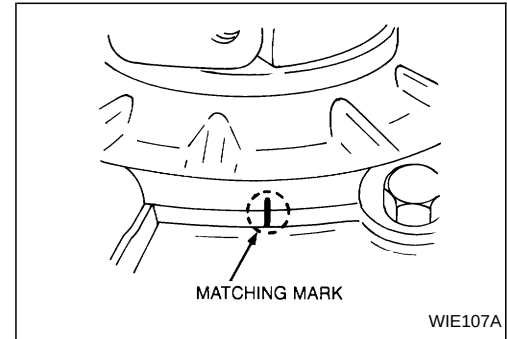
7. Decrease air pressure to zero "0". Make sure the dial gauge is reset to zero "0".

NOTE

- **Do not abruptly increase air pressure. Damage to the diaphragm built into the actuator may result.**
- **If the actuator rod end moves beyond the specified stroke length of 0.38 mm (0.0150 in), reset air pressure to zero "0". Repeat steps 1 through 7 above.**

DISASSEMBLY

The turbocharger is built with a high degree of accuracy and must be disassembled with utmost care. It is mounted on the engine at a specified angle. Before disassembling the turbocharger, be sure to scribe an alignment mark on the mating parts where necessary. To disassemble the turbocharger, proceed as follows:



1. Clean the external surface of the turbocharger.
2. Remove the E-ring and actuator rod end from the waste gate crank.

NOTE

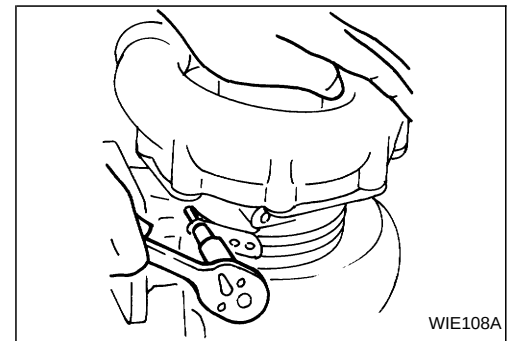
- **Be careful not to drop the E-ring into the turbocharger housing during removal.**
3. Remove the actuator hose and hose clamp from the actuator assembly.
 4. Separate the actuator assembly from the compressor housing.

5. [① Turbine housing with waste gate assembly]

Remove the V-band nuts securing the turbine housing to the center housing, then remove the turbine housing. The nuts on the turbine side are exposed to high temperatures during operation and may be jammed. If these nuts are difficult to remove, do not attempt to remove them forcefully as damage may result. To facilitate removal procedures, first spray a suitable penetration agent to jammed nuts and wait approximately 20 minutes before removal.

NOTE

- **Be careful not to scratch the turbine wheel while separating the turbine housing from the center housing. If the turbine housing is difficult to remove, lightly tap it with a plastic hammer.**

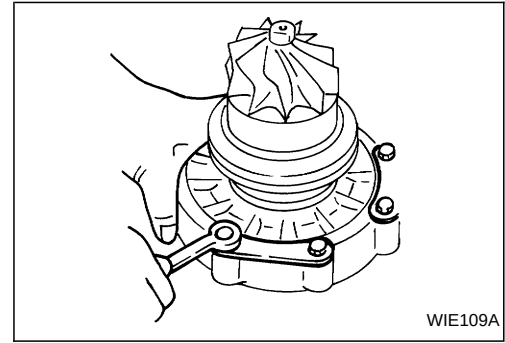


6. [② Compressor housing assembly]

Remove the bolts securing the compressor housing to the back plate, then remove the compressor housing.

NOTE

- **Be careful not to scratch the compressor wheel while separating the compressor housing from the back plate. If the compressor housing is difficult to remove, lightly tap it with a plastic hammer.**



INSPECTION

CLEANING

1. Inspection before cleaning

Before cleaning all disassembled parts, visually check for any trace of chars, wear interference, foreign particles, carbon accumulation or damage. These abnormalities are difficult to confirm after cleaning. If the turbocharger is out of order, carefully check and locate the cause of the problem.

2. If, through visual inspection, parts are found to be “unfit for further use”, they must be discarded. Clean the parts fit for re-use and measure the dimensions/sizes.

Out of the turbocharger components, the following are considered to be re-usable components unless otherwise damaged. Components/parts other than those listed below must be replaced with new ones.

Turbine housing, compressor housing, actuator bracket, actuator assembly, rod end, etc.

To clean the turbocharger components/parts, it is best to use the cleaning methods and cleaning solvents identical to those used for cleaning conventional internal engines. Sandpaper, steel-wire brushes and corrosive solvents must not be used to clean the turbocharger components/parts.

Oil contamination, foreign particles, etc., which are in contact with the joining sections of parts, oil passages, flanged surfaces, intake and exhaust ports, must be completely removed using nylon lint-free cloth, oil stone, nylon brush and plastic scraper, as required.

After cleaning all disassembled parts, clean the internal area of each part using dry compressed air.

NOTE

- **Visually check the oil passage on the center housing using an inspection light to make sure it is clean and free from foreign particles.**
- **Be extremely careful not to scratch or corrode any cleaned parts.**
- **Check to make sure the turbine wheel and compressor wheel is completely clean and free from foreign particles. If these components are assembled without removing all foreign particles, the original balanced performance built into these parts will not be achieved.**

INSPECTION

Although major turbocharger components are visually judged to be in good order, their dimensions must be measured to finally determine whether or not they are suitable for further use. If specified service limits are exceeded, affected components must be replaced with new ones.

Inspection position	Inspection item	Remarks
Compressor housing	● Replace faulty parts if excessive interference with the compressor wheel is noted. ● There should be no traces of deformation or damage to the back plate mating surface. ● There should be no traces of deformation or damage to the inlet and outlet connections. ● There should be no damage to bolt hole threads.	
Turbine housing	● There should be no traces of interference with the turbine wheel. ● There should be no cracks on the cast-housing surface. ● There should be no traces of corrosion or oxidation on the inner wall. ● Re-usable if cracked points are no more than five points over the entire perimeter of the divider and are spaced more than 25 cm (0.98 in) from one another. ● There should be no deformation on each flanged surface. ● There should be no damage to the bolt hole.	
Compressor wheel Turbine wheel	● There should be no traces of bending, cracks, corrosion or damage to the blade. ● There should be no traces of interference between the blade and housing.	
Actuator assembly	● There should be no traces of dents on the actuator body and cover. ● There should be no rod bending. ● There should be no cracks in the hose. ● Conduct air leak tests to make sure the actuator assembly is airtight.	

REASSEMBLY

PREPARATIONS BEFORE REASSEMBLY

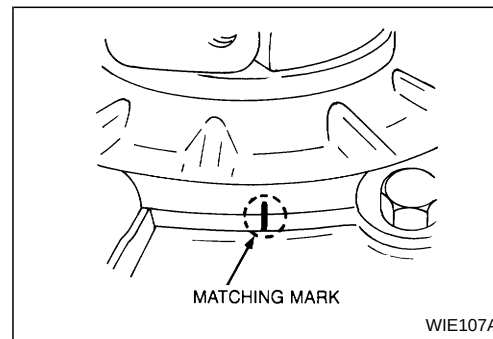
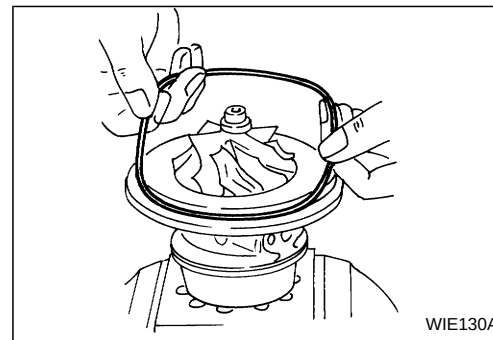
If conventional parts are found to be not suitable for further use during inspection, discard them and replace with new ones. The following table lists the specific parts requiring replacement if damaged. These parts are manufactured by GARRETT TURBO INC. Whenever new parts are installed, use specified genuine parts.

Part name	Quantity
Lock nut (Turbine side)	1
Clamp plate	4
Bolt (Compressor side)	8
Actuator hose clamp	2
Actuator nut	2
Actuator hose	1
Name plate	1
Screw drive	2

REASSEMBLY

1. [② Compressor housing assembly]

- (1) Align the alignment mark previously scribed on the back plate and compressor housing.



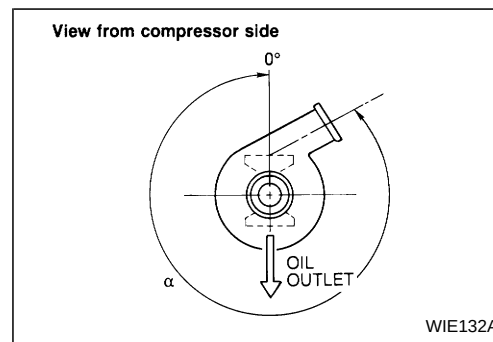
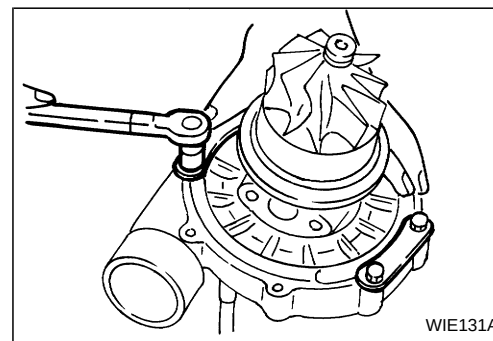
- (2) Tighten the bolts and clamps to secure the back plate to the compressor housing.

T : 10.3 - 12.3 N·m {105 - 125 kgf·cm, 91 - 109 in·lbf}

NOTE

- After placing the compressor housing onto the back plate, do not attempt to rotate the compressor housing abruptly as this may twist the O-ring or damage other parts.
- Before installing the compressor housing, carefully check to make sure the compressor wheel blades are free from scratches, bends or damage.
- If the compressor housing has no alignment mark scribed for some reason (part replacement, etc.), first adjust the relative position of the housing and the engine using the α -angle method.

$$\alpha = 180^\circ \pm 1^\circ$$



2. [① **Turbine housing with waste gate assembly**]

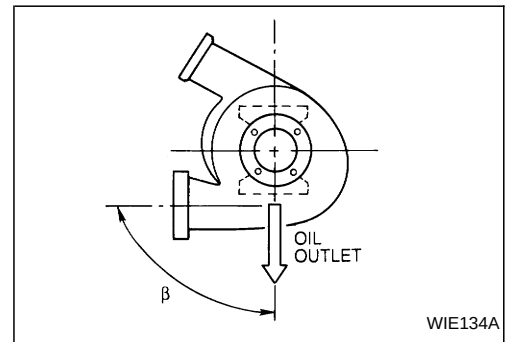
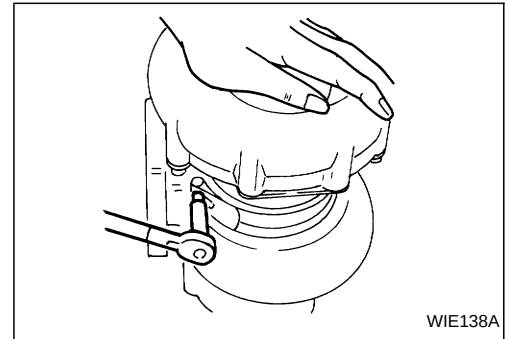
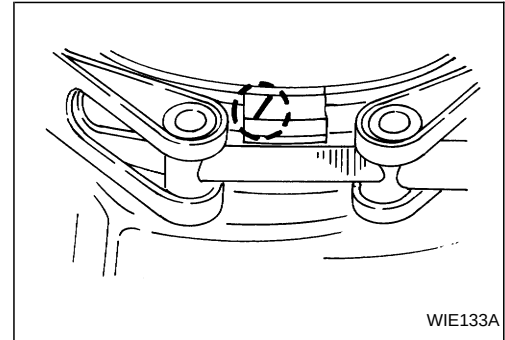
- (1) Align the alignment mark previously scribed on the turbine housing with the alignment mark on the center housing.
- (2) Tighten the V-band to secure the turbine housing to the center housing.

T : 12.7 - 14.7 N·m {130 - 150 kgf·cm, 113 - 130 in·lbf}

NOTE

- Be extremely careful not to scratch, bend or damage turbine wheel blades during reassembly.
- If the turbine housing has no alignment mark scribed due to some reason (such as part replacement, etc.), first adjust the relative position of the housing and the engine using the β -angle method, then install the housing to the engine.

$$\beta = 90^\circ \pm 1^\circ$$



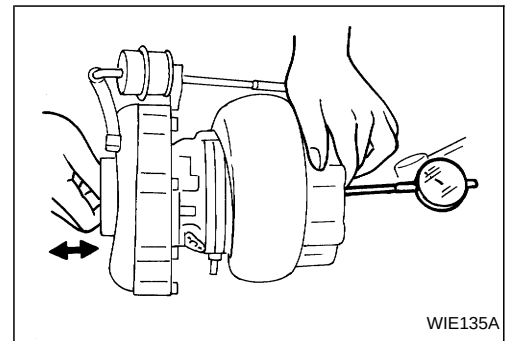
3. Measure the turbine wheel axial play. To do this, place a dial gauge on the magnet base and attach the dial gauge to the end of the turbine shaft. Move the shaft back and forth by hand to check the axial play.

Unit: mm (in)

Item	Maintenance standard	Service limit
Turbine wheel shaft axial play	0.025 - 0.090 (0.0010 - 0.0035)	—

NOTE

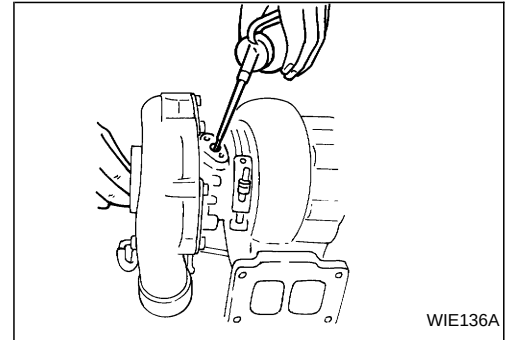
- If the axial play is outside the specifications, disassemble the turbocharger and measure the dimensions of respective parts to determine the cause of the problem. Take corrective measures as required.



4. Sufficiently pour new engine oil into the center housing through the oil inlet. Manually rotate the compressor wheel and turbine wheel to make sure the two wheels rotate smoothly without binding.

NOTE

- Also check the rotating direction of the turbocharger. The turbocharger must rotate counterclockwise when viewed from the turbine side.



5. Install the actuator assembly and actuator bracket on the compressor housing, then tighten with bolts.

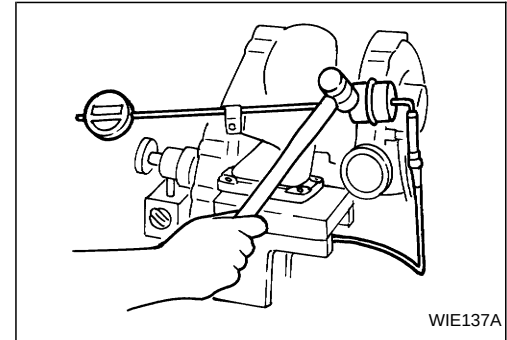
T : 10.3 - 12.3 N·m {105 - 125 kgf·cm, 91 - 109 in·lbf}

ACTUATOR CALIBRATION ADJUSTMENT

1. Install an external air hose to the hose connection of the actuator assembly.
2. Apply air pressure to the actuator through the air hose until the actuator rod end enters the waste gate crank hole. Install the E-ring.
3. Reset air pressure to zero "0".
4. Attach a dial gauge coaxially to the actuator rod end. Reset the dial gauge to zero "0".
5. Gradually increase air pressure to the actuator through a pressure regulator to move the actuator rod until the dial gauge registers 0.38 mm (0.0150 in). During pressure application, lightly tap the actuator with a plastic hammer.
6. Read the pressure gauge indication when the actuator rod end moves a stroke length of 0.38 mm (0.0150 in). The pressure gauge indication must be within the specified range.

Unit: kPa {mmHg, inHg}

Item		Maintenance standard	Service limit	Remarks
Actuator set pressure	GT42	137 - 143 {1,025 - 1,075, 40 - 42}	—	Value measured when actuator rod stroke length is 0.38 mm (0.0150 in)
	GT45	123 - 130 {925 - 975, 36 - 38}		



7. Reset air pressure to zero "0".

NOTE

- Do not abruptly increase air pressure. If the actuator rod moves more than a stroke length of 0.38 mm (0.0150 in), reset air pressure to zero "0" and repeat steps 2 through 6 above.
- If the air pressure gauge indication is not within the specified range at a dial gauge reading of 0.38 mm (0.0150 in), remove the rod end from the waste gate crank and replace it with an adjustable rod end. Repeat steps 2 through 7 above.
- Upon completion of step 7 above, make sure the dial gauge returns to zero "0". If the dial gauge does not return, repeat steps 2 through 7 above. Make sure air pressure is correct.
- When moving the turbocharger from one place to another, do not hold the rod end.
- On the original turbocharger, if the air pressure indicator does not register the specified range, first undo the staked section of the rod end and adjust the actuator set pressure.

INTERCOOLER

INSPECTION

Remove the intercooler. If mud, insects, etc. are attached to the front surface of the intercooler core, remove them using a copper wire or the like exercising care not to damage the tube.

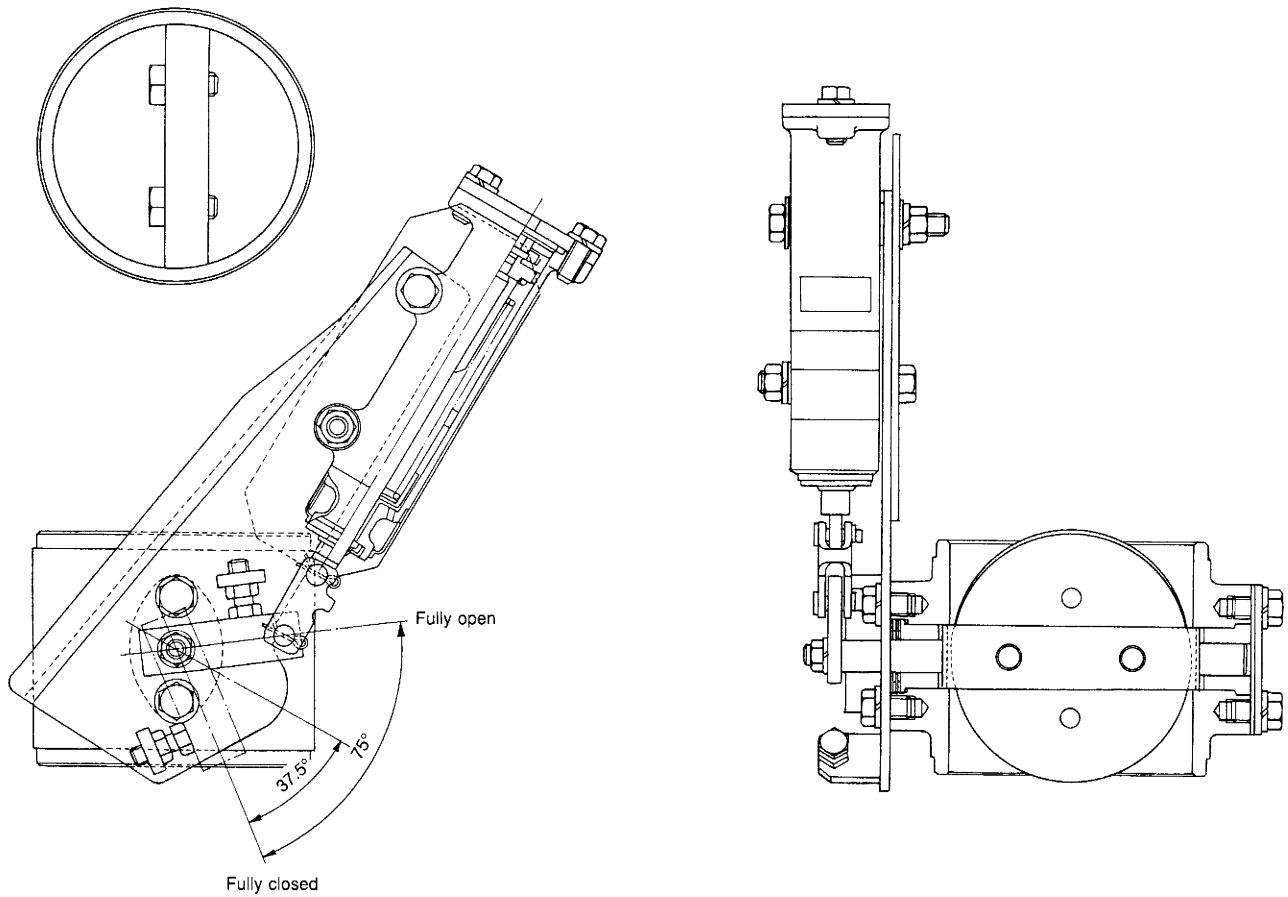
Water pressure test

Seal one of the air intakes on the intercooler with a lid and connect a hose to the other intake. Then submerge the intercooler under water in a tank and blow compressed air through the hose to the specified pressure to check for air leakage.

Intercooler check pressure (air): 294 kPa {3.0 kgf/cm², 43 psi}

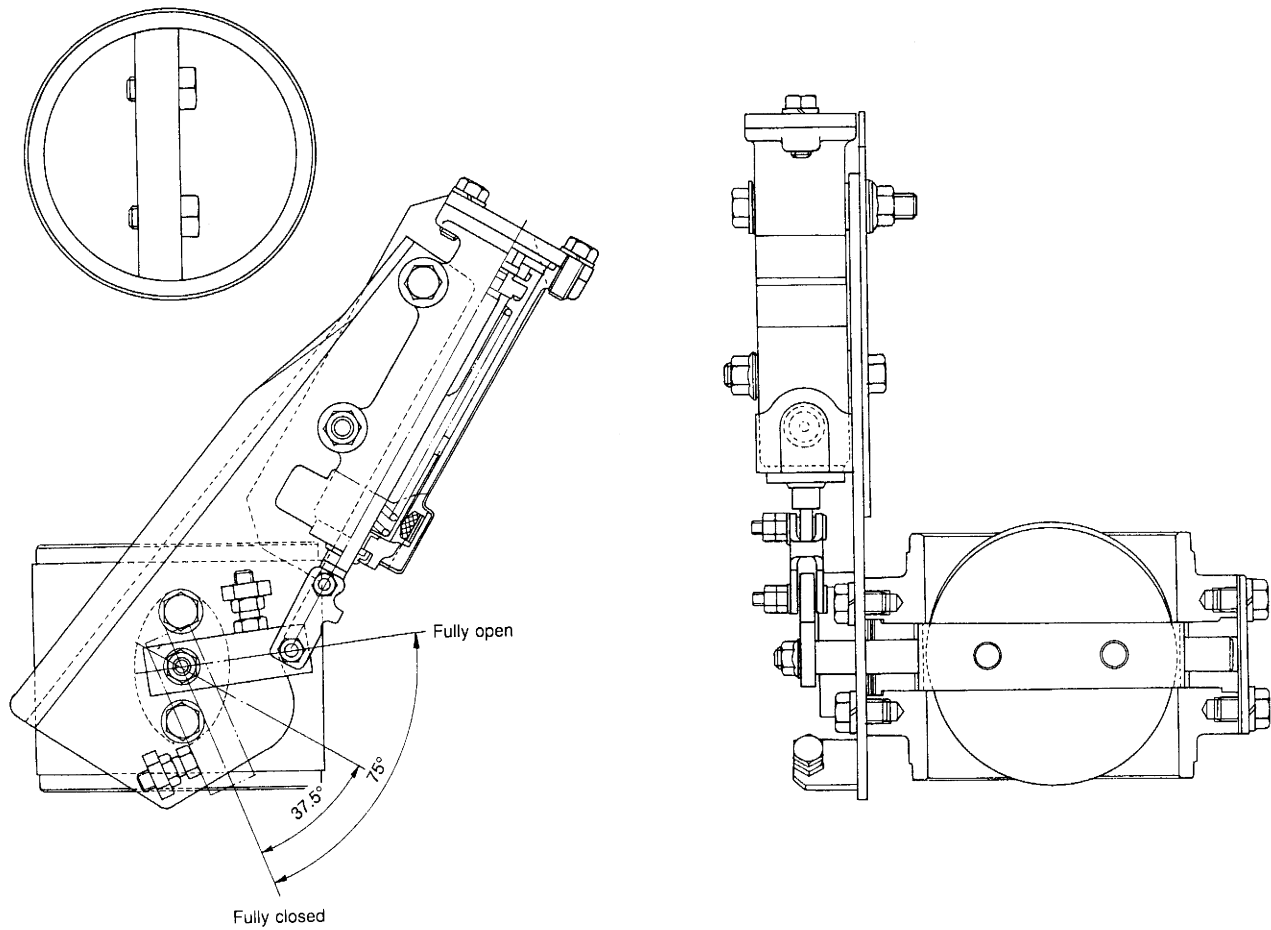
EXHAUST BRAKE

CONSTRUCTION EXHAUST SHUTTER Type I



WIE094A

Type III



WIE095A

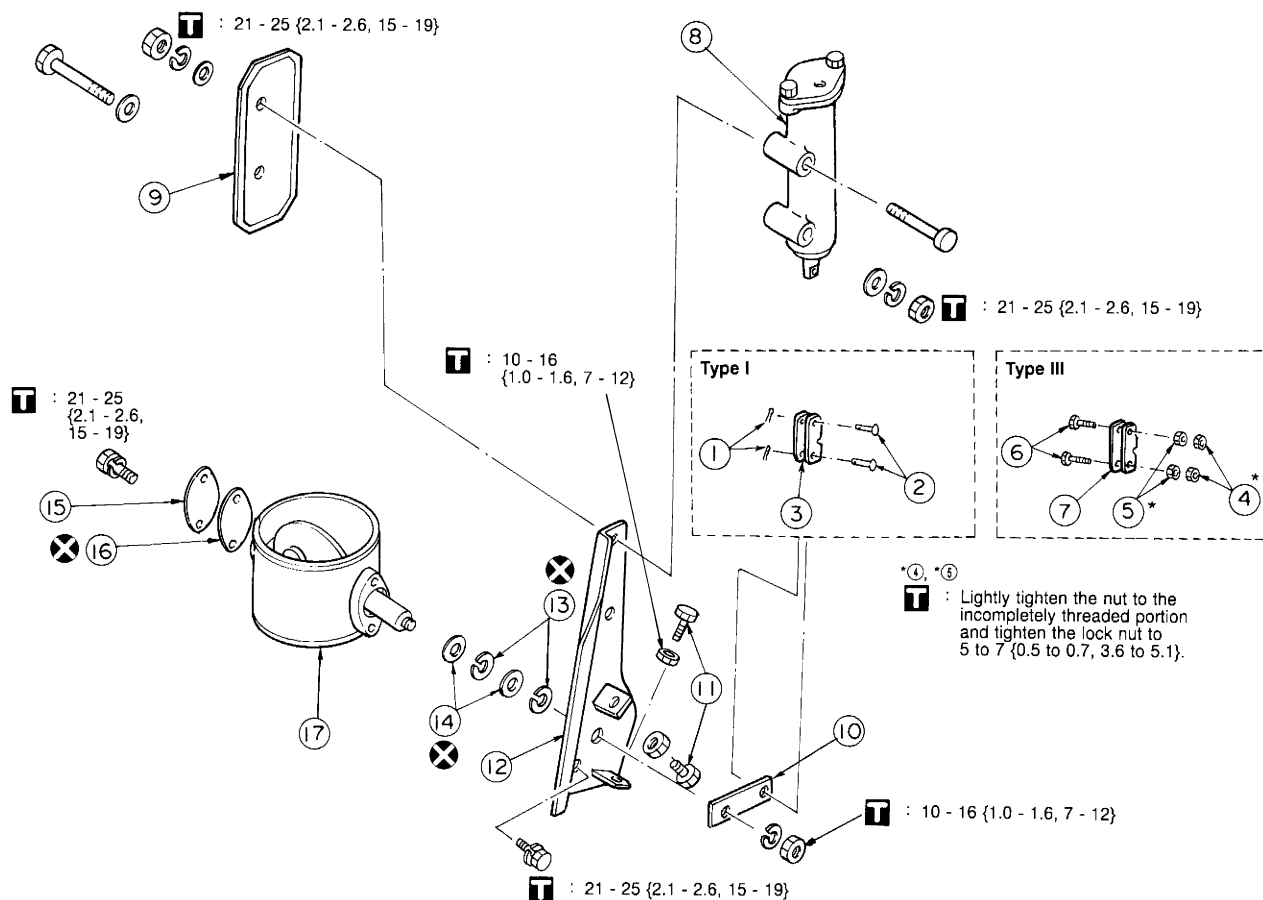
DISASSEMBLY

WARNING

- **Before disassembling the exhaust system, ensure that the engine is cool. If it is hot, wait until it cools off to prevent scalding yourself.**

EXHAUST SHUTTER

Type I and Type III



T : N·m {kgf·m, ft·lbf}

WIE096A

Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

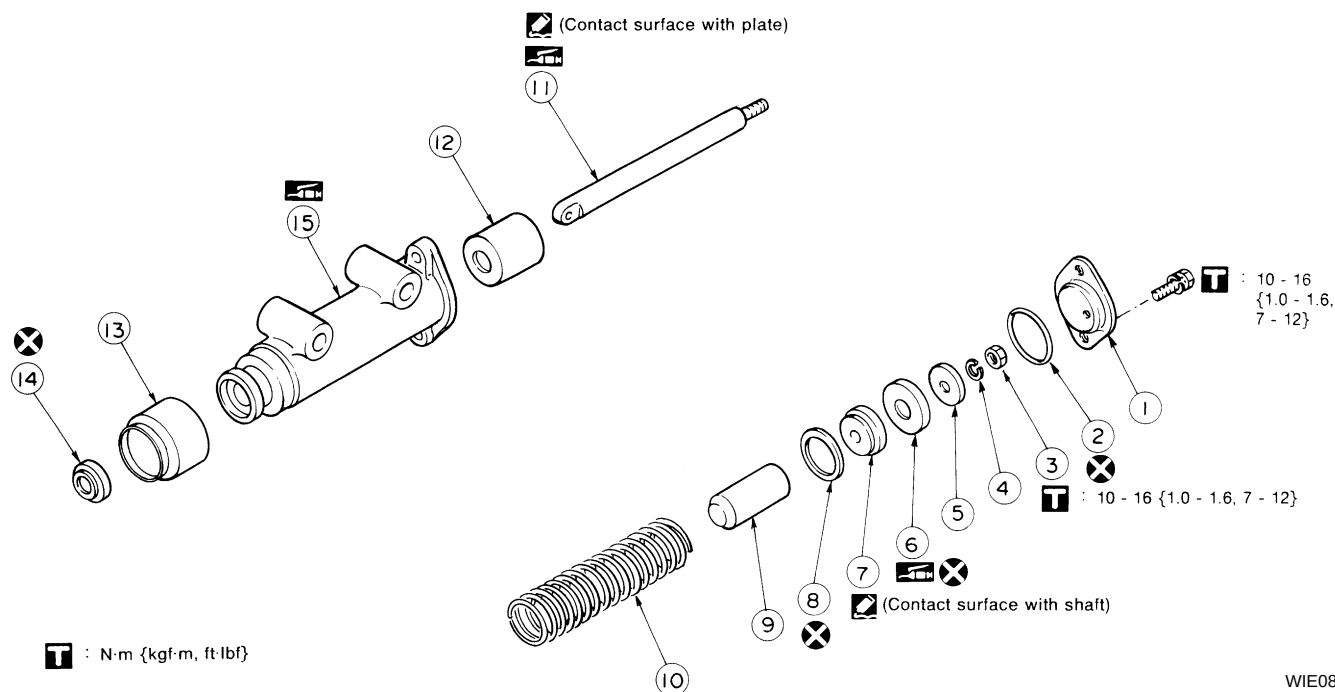
- | | | |
|------------|----------------|----------------------------|
| ① Snap pin | ☆⑦ Clevis | ⑫ Plate |
| ② Pin | ⑧ Air cylinder | ☆⑬ Seal ring |
| ☆③ Clevis | ⑨ Shield plate | ☆⑭ Seal ring |
| ④ Nut | ⑩ Lever | ⑮ Cover |
| ⑤ Lock nut | ⑪ Stopper bolt | ⑯ Gasket |
| ⑥ Bolt | | ⑰ Exhaust shutter assembly |

Marks “★” and “☆” indicates that the key points of operation are explained in the text.

CAUTION

- Do not disassemble the exhaust shutter (parts ⑩ to ⑰) for type III. Never loosen the stopper bolt.

AIR CYLINDER



Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

- | | | |
|------------|-------------|--------------|
| ① Cover | ⑥ Packing | ⑪ Shaft |
| ② O-ring | ⑦ Plate | ⑫ Guide |
| ③ Nut | ⑧ Wear ring | ⑬ Cover |
| ④ Washer | ⑨ Protector | ⑭ Dust cover |
| ⑤ Retainer | ★⑩ Spring | ⑮ Cylinder |

Marks “★” and “☆” indicate that the key points of operation are explained in the text.

Key point of disassembly

⑩ Spring

Remove the cover and detach the spring and shaft assembly from the cylinder.

NOTE

- Be careful not to allow the shaft assembly to jump out because the cover is spring-loaded.

INSPECTION

- Clean all disassembled parts in cleaning solvent. Check for scratches, cracks or damage and replace faulty parts.
- If measurement indicates that the service limit has exceeded, repair or replace faulty parts.

AIR CYLINDER

Spring tension

Unit: N {kgf, lbf}

Maintenance standard	Service limit	Remarks
77.5 {7.9, 17.4}	—	When compressed to 113.2 mm (4.457 in)

EXHAUST SHUTTER

Valve movement in the axial direction when closing the valve

Unit: mm (in)

Maintenance standard	Service limit
More than 0.7 (0.028)	—

REASSEMBLY

EXHAUST SHUTTER

Key point of reassembly

⑬, ⑭ Seal ring

Position the spindle, valve and bushing in the body and attach the seal rings on the spindle.

NOTE

- Alternately install different types of seal rings.

Adjustment of clearance between the valve and body

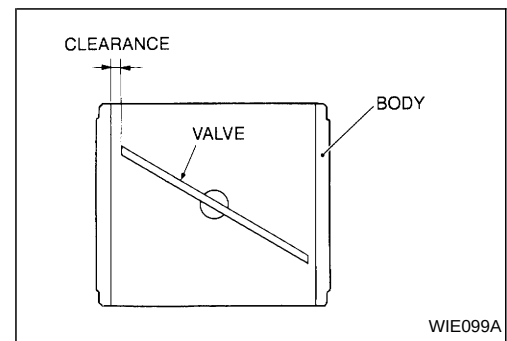
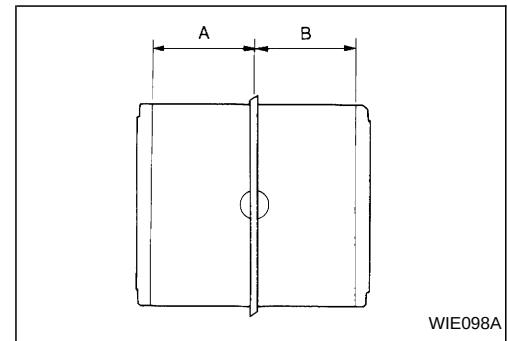
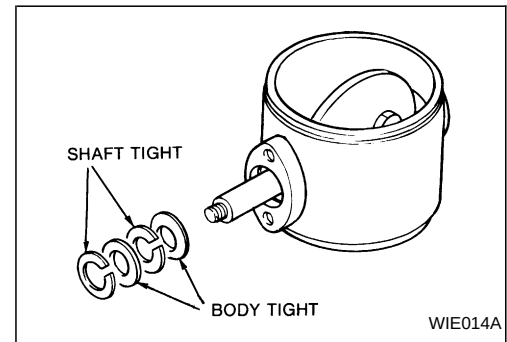
Move the lever toward the full-open side. When the lever contacts the stopper bolt, adjust the stopper bolt so that clearances A and B are equal. Move the lever toward the full-close side. When the lever contacts the stopper bolt, adjust the stopper bolt so that the clearance between the valve and body is within specifications. After adjusting the clearance, tighten the stopper bolt with the lock nut.

T : 10 - 16 N·m {1.0 - 1.6 kgf·m, 7 - 12 ft·lbf}

Unit: mm (in)

Item	Maintenance standard	Service limit	Remarks
Clearance between valve and body	One side 0.1 - 0.4 (0.004 - 0.016)	—	(*)
	Both total 0.2 - 0.5 (0.008 - 0.020)	—	

(*) When an air pressure of 637 kPa {6.5 kgf/cm², 92 psi} is applied to the control cylinder and the valve is fully closed

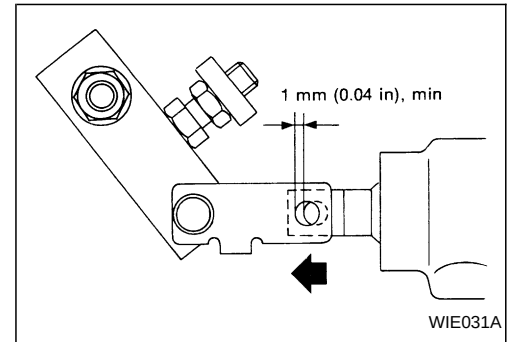


- ③ **Clevis (Type I)**
- ⑦ **Clevis (Type III)**

Connect the shaft of the cylinder assembly and clevis using a pin. Move the lever toward the full-open side until it contacts the stopper bolt. From that position, pull out the shaft 1 mm (0.04 in), min. to ensure that the hole in the shaft is aligned with the clevis hole.

Stopper bolt lock nut (at spindle)

■ : 10 - 16 N·m {1.0 - 1.6 kgf·m, 7 - 12 ft·lbf}



ELECTRICAL SYSTEM

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SERVICE DATA	EE-1-1	ADJUSTMENT	EE-2-8
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STARTING MOTOR	EE-2-1	AND 0201 152 1130, 0201 102 4510 =	
= MODEL NAME 0350 602 =		CONSTRUCTION	EE-3-1
CONSTRUCTION	EE-2-1	TROUBLESHOOTING	EE-3-2
TROUBLESHOOTING	EE-2-2	DISASSEMBLY	EE-3-4
DISASSEMBLY	EE-2-3	INSPECTION	EE-3-5
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SERVICE DATA

SPECIFICATIONS STARTING MOTOR

Item	Model	0350 602 0381	0350 602 0460
Type		Shift	
Output	V-kW	24 - 6.0	
Rated time	Second	30	
Manufacturer		Sawafuji	

ALTERNATOR

Item	Model	0202 102 1943	0202 152 0044 (0202 152 0043)	0201 152 1130	0201 102 4510
Output	V-A	24 - 40	24 - 50		24 - 40
Type of regulator		IC-transistor type			
Vacuum pump model		1290 009 00 (VD-30)		—	
Manufacturer		Sawafuji			

AIR HEATER

Type		Ribbon	
Rated current	V-A	11.0 - 85	
Rated time	Second	Less than 60	

SERVICE DATA
STARTING MOTOR
Model 0350 602

Unit: mm (in)

Item		Maintenance standard	Service limit	Remarks
Brush	Brush height	20.0 (0.787)	14.0 (0.551)	
	Brush spring tension N {kgf, lbf}	29.4 {3.0, 6.6}	20.6 {2.1, 4.6}	When spring is set
Commutator	Outside diameter	40.0 (1.575)	38.0 (1.496)	
	Runout	Less than 0.05 (0.0020)	0.1 (0.004)	
	Undercut depth	0.5 - 0.8 (0.020 - 0.031)	0.2 (0.008)	
Gear shaft	Shaft runout	Less than 0.05 (0.0020)	0.1 (0.004)	
	Thrust gap	0.1 - 0.5 (0.004 - 0.020)	—	
Bracket	Front bearing (metal) inside diameter	17.0 (0.669)	17.2 (0.677)	
	Center bearing (metal) inside diameter	28.0 (1.102)	28.2 (1.110)	
	Commutator bearing fit section inside diameter	32.0 (1.260)	32.1 (1.264)	
	Gear bearing fit section inside diameter	52.0 (2.047)	52.1 (2.051)	
Armature, field coil	Insulation resistance MΩ	More than 1.0	0.5	
Brush holder	Insulation resistance MΩ	More than 1.0	0.5	
Magnetic switch	Series coil resistance Ω	0.12 - 0.15	—	
	Shunt coil resistance Ω	0.6 - 0.8	—	
	Contact point deflection	1.0 - 2.0 (0.039 - 0.079)	—	
Pinion gear	Clearance between pinion gear and pinion stopper	0.5 - 3.0 (0.020 - 0.118)	—	
Adjustment	Dimension L	0.3 - 1.5 (0.012 - 0.059)	—	
Performance test (no load)	Current A	Less than 120	—	Terminal voltage 24V
	Motor speed rpm	More than 3,500	—	
	Pinion pop out voltage V	Less than 16	—	

ALTERNATOR
Model 0202 102 1943, 0202 152 0044 (0202 152 0043) and 0201 152 1130, 0201 102 4510

Unit: mm (in)

Item			Maintenance standard	Service data	Remarks
Stator coil	Resistance Ω	0202 102 1943	0.36 - 0.44	—	Between two phases [At 20°C (68°F)]
		0202 152 0044 (0202 152 0043)	0.19 - 0.24	—	
		0201 152 1130	0.18 - 0.22	—	
		0201 102 4510	0.285 - 0.315	—	
Field coil	Resistance Ω	0202 102 1943	7.0 - 9.0	—	At 20°C (68°F)
		0202 152 0044 (0202 152 0043)	5.0 - 7.0	—	
		0201 152 1130	5.6 - 6.8	—	
		0201 102 4510	7.5 - 8.3	—	
Rotor assembly	Shaft outside diameter of the front part		25.0 (0.9843)	Less than 24.98 (0.9835)	
	Shaft outside diameter of the rear part	0202 102 1943	16.0 (0.6299)	Less than 15.98 (0.6291)	
		0202 152 0044 (0202 152 0043)			
		0201 152 1130	17.0 (0.6693)	Less than 16.98 (0.6685)	
		0201 102 4510			
Front cover	Inside diameter of front bearing fitting hole		62.0 (2.441)	More than 62.1 (2.445)	
Housing	Inside diameter of rear bearing fitting hole		23.8 (0.937)	More than 23.80 (0.9370)	
Performance test	Output current A	0202 102 1943	More than 40	—	28V, 5,000 rpm [At 20°C (68°F)]
		0202 152 0044 (0202 152 0043)	More than 50	—	
		0201 152 1130	More than 50	—	
		0201 102 4510	More than 40	—	
	Regulating voltage V		28.0 - 29.0	—	At 20°C (68°F)
	Speed required to increase voltage to 27 rpm volts	0202 102 1943 0202 152 0044 (0202 152 0043) 0201 102 4510	Less than 900	—	At 20°C (68°F)
		0201 152 1130	Less than 950	—	

TIGHTENING TORQUE

STARTING MOTOR

Model 0350 602

Unit: N·m {kgf·m, ft·lbf}

Item	Tightening torque
C terminal	1.9 - 2.5 {0.19 - 0.25, 1.4 - 1.8}
B and M terminals	16.2 - 22.1 {1.65 - 2.25, 11.9 - 16.3}
Magnetic switch mounting bolt	14 - 16 {1.4 - 1.6, 10 - 12}
Through bolt	14 - 16 {1.4 - 1.6, 10 - 12}
Brush holder mounting bolt	3.6 - 4.9 {0.37 - 0.50, 2.7 - 3.6}

ALTERNATOR

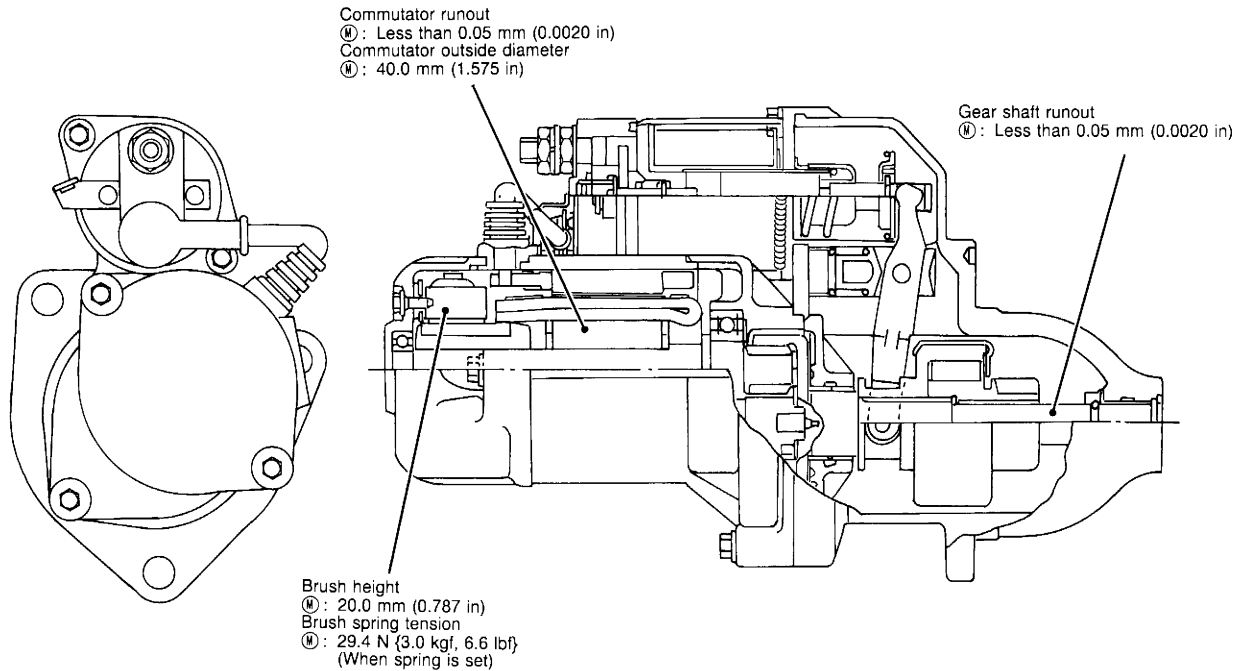
Model 0202 102 1943, 0202 152 0044 (0202 152 0043) and 0201 152 1130, 0201 102 4510

Unit: N·m {kgf·m, ft·lbf}

Item		Tightening torque
Screw	Size M5	1.9 - 2.5 {0.19 - 0.25, 1.4 - 1.8}
Pulley mounting nut	0202 102 1943 0202 152 0044 (0202 152 0043) 0201 102 4510	96 - 127 {9.8 - 13.0, 71 - 94}
	0201 152 1130	127 - 157 {13.0 - 16.0, 94 - 116}
Terminals	M6	3.2 - 4.4 {0.33 - 0.45, 2.4 - 3.3}
	M8	8 - 11 {0.8 - 1.1, 5.8 - 8.0}
Through bolt		6 - 9 {0.6 - 0.9, 4.3 - 6.5}

STARTING MOTOR

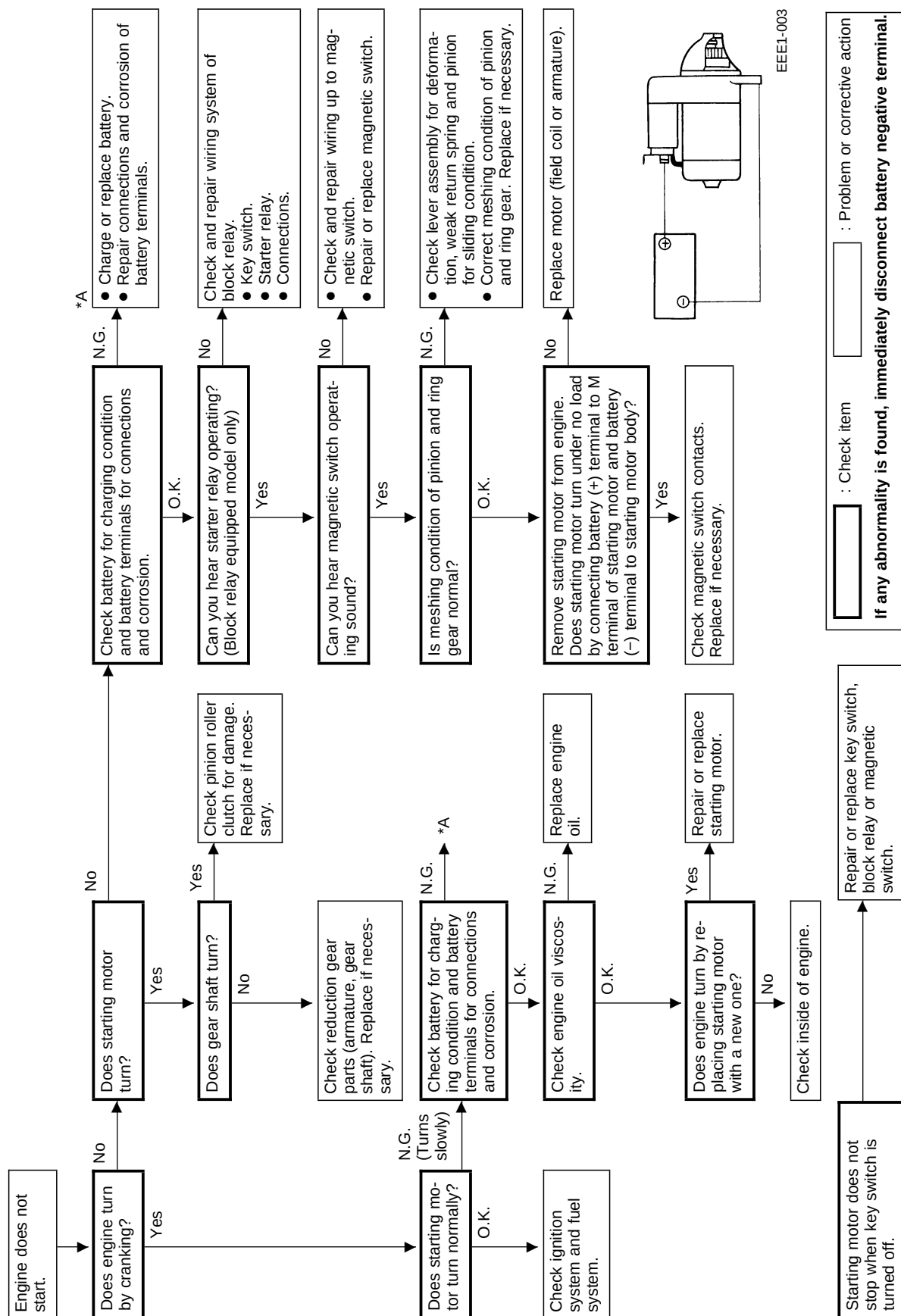
= MODEL 0350 602 =
CONSTRUCTION



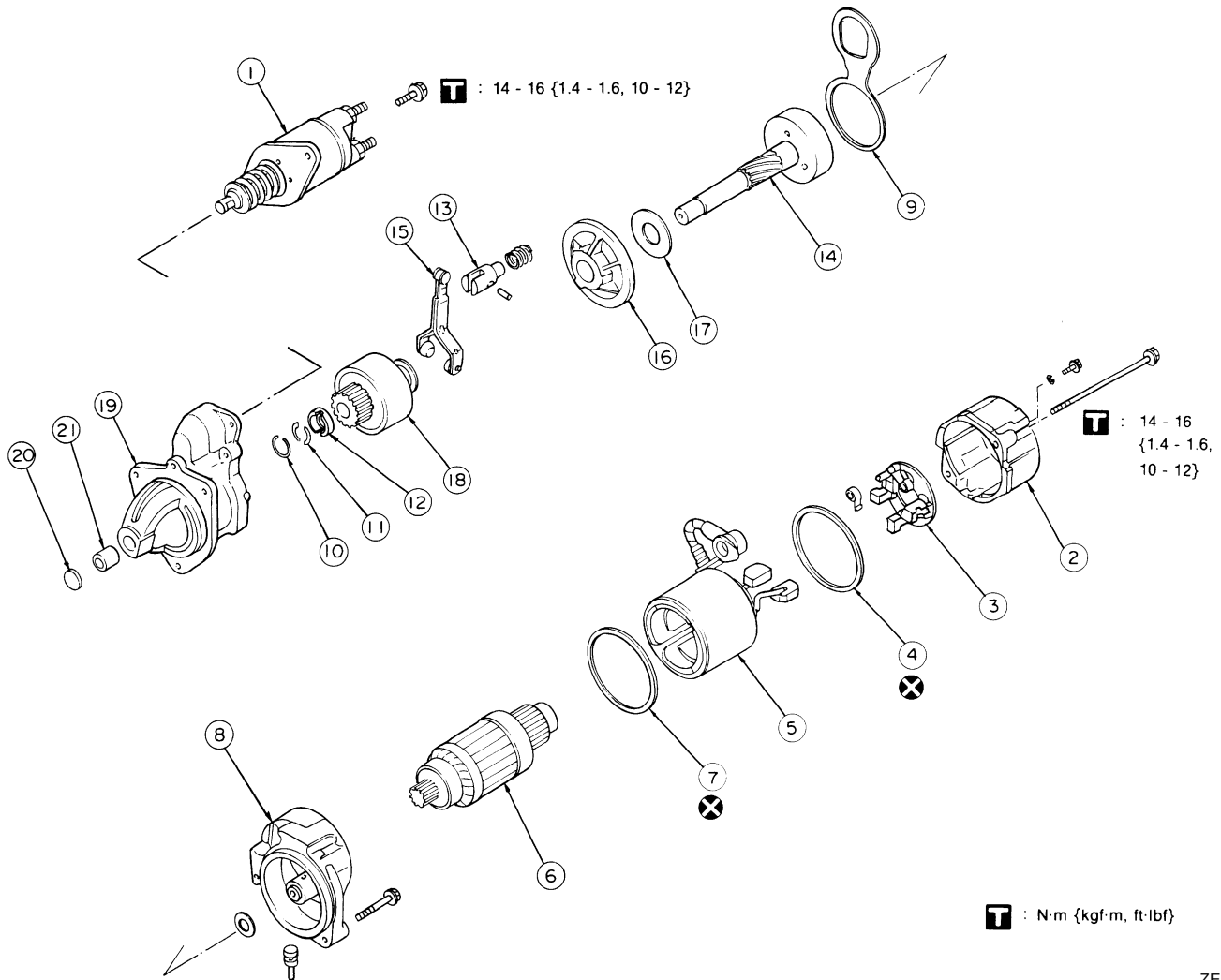
Ⓜ: Maintenance standard

WEE043A

TROUBLESHOOTING



DISASSEMBLY



ZEE057A

- | | | |
|----------------------------|-------------------|-------------------|
| ① Magnetic switch assembly | ⑧ Gear case | ⑮ Lever assembly |
| ② Rear bracket | ⑨ Packing | ⑯ Center holder |
| ★③ Brush holder assembly | ⑩ Retaining ring | ⑰ Shim washer |
| ④ O-ring | ⑪ Hook | ⑱ Pinion assembly |
| ⑤ Yoke assembly | ★⑫ Pinion stopper | ⑲ Pinion case |
| ⑥ Armature assembly | ⑬ Holder | ⑳ Cover |
| ⑦ O-ring | ⑭ Shaft | ㉑ Metal |

Marks “★” and “☆” indicate that key points of operation are explained in the text.

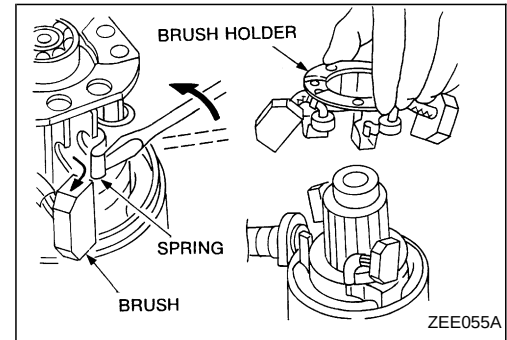
NOTE

- Numbers before part names do not indicate the disassembly sequence.

Key point of disassembly

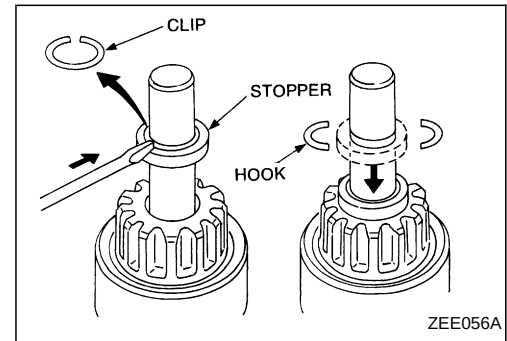
③ Brush holder assembly

- Raise the brush spring and remove the brush from the brush holder.
- Remove the brush holder from the armature commutator.



⑫ Pinion stopper

- Remove the clip from inside the stopper. (Push the clip inward from the groove in the stopper using a flat-blade screwdriver and pry off the clip.)
- Push the stopper and remove the two hooks.
- Remove the stopper from the shaft.



INSPECTION

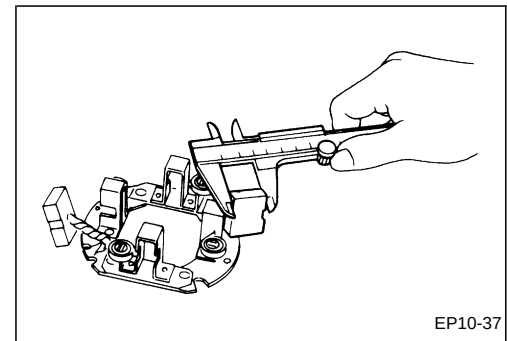
- Clean all disassembled parts in cleaning solvent. Check for scratches, cracks or damage and replace faulty parts.
- If measurement indicates that the service limit has exceeded, repair or replace faulty parts.

BRUSH

Brush height

Unit: mm (in)

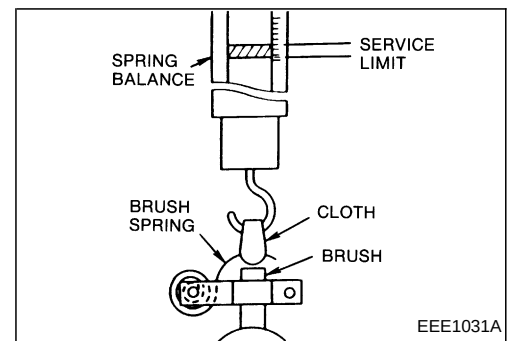
Maintenance standard	Service limit
20.0 (0.787)	14.0 (0.551)



Brush spring tension

Unit: N {kgf, lbf}

Maintenance standard	Service limit	Remarks
29.4 {3.0, 6.6}	20.6 {2.1, 4.6}	When spring is set



COMMUTATOR

Outside diameter

Unit: mm (in)

Maintenance standard	Service limit
40.0 (1.575)	38.0 (1.496)

NOTE

- If the commutator surface is rough, grind with No. 500 to 600 sandpaper and then measure the outside diameter.

Runout

Unit: mm (in)

Maintenance standard	Service limit
Less than 0.05 (0.0020)	0.1 (0.004)

Undercut depth

Unit: mm (in)

Maintenance standard	Service limit
0.5 - 0.8 (0.020 - 0.031)	0.2 (0.008)

GEAR SHAFT

Shaft runout

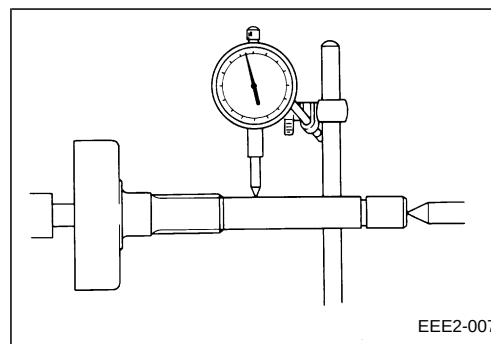
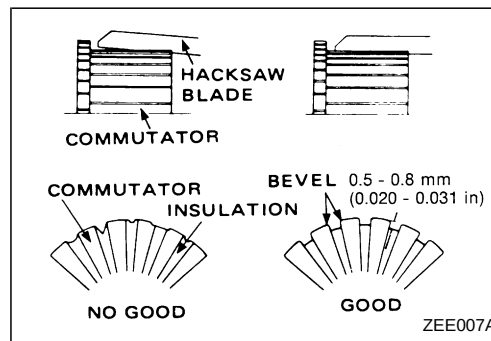
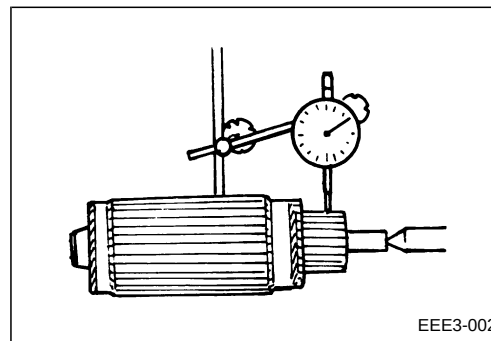
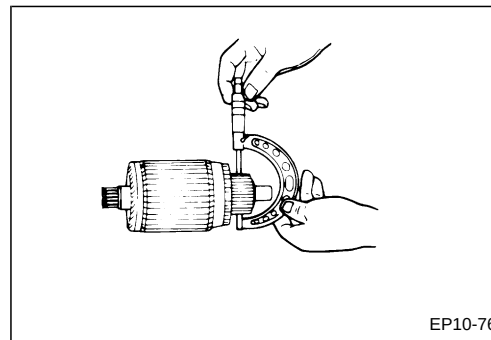
Unit: mm (in)

Maintenance standard	Service limit
Less than 0.05 (0.0020)	0.1 (0.004)

Thrust gap

Unit: mm (in)

Maintenance standard	Service limit
0.1 - 0.5 (0.004 - 0.020)	—



BRACKET

Front bearing (metal) inside diameter

Unit: mm (in)

Maintenance standard	Service limit
17.0 (0.669)	17.2 (0.677)

Center bearing (metal) inside diameter

Unit: mm (in)

Maintenance standard	Service limit
28.0 (1.102)	28.2 (1.110)

Commutator bearing fit section inside diameter

Unit: mm (in)

Maintenance standard	Service limit
32.0 (1.260)	32.1 (1.264)

Gear bearing fit section inside diameter

Unit: mm (in)

Maintenance standard	Service limit
52.0 (2.047)	52.1 (2.051)

ARMATURE COIL

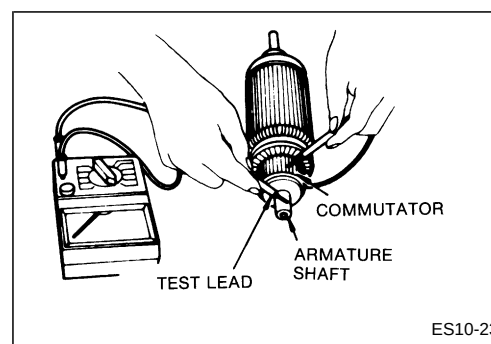
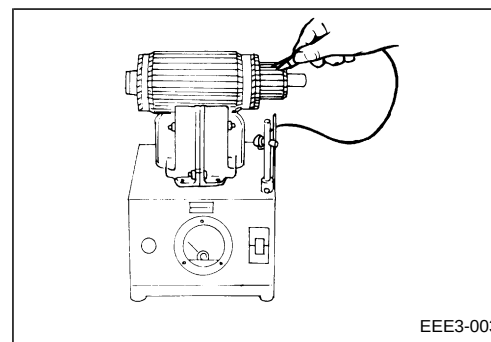
Continuity test

Make sure there is no continuity between the commutator and armature assembly.

Insulation test (Insulation resistance)

Unit: MΩ

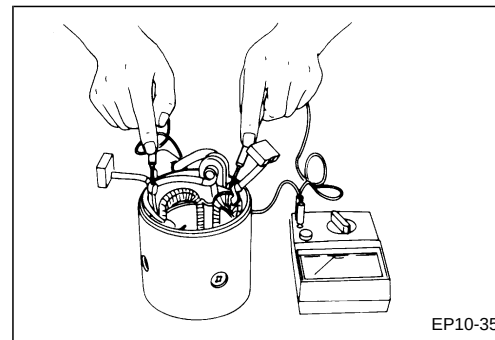
Maintenance standard	Service limit
More than 1.0	0.5



FIELD COIL

Continuity test

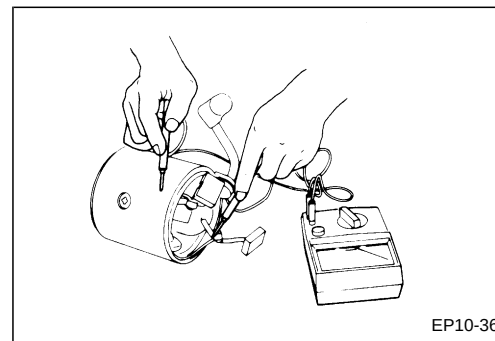
Make sure there is continuity between the field coil terminals.



Insulation test (Insulation resistance)

Unit: MΩ

Maintenance standard	Service limit
More than 1.0	0.5

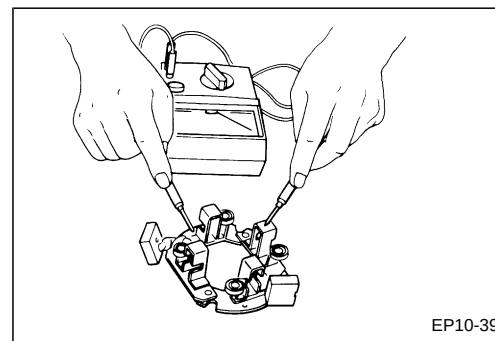


BRUSH HOLDER

Insulation test (Insulation resistance)

Unit: MΩ

Maintenance standard	Service limit
More than 1.0	0.5



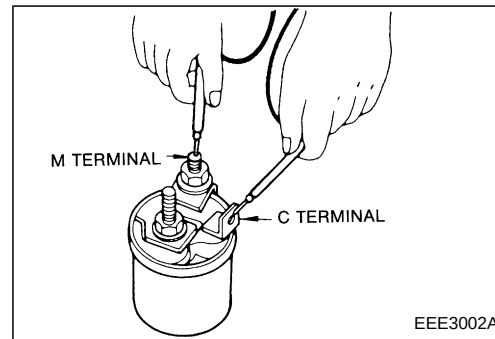
MAGNETIC SWITCH

Continuity test (Series coil resistance)

Perform the continuity test between the M and C terminals.

Unit: Ω

Maintenance standard	Service limit
0.12 - 0.15	—

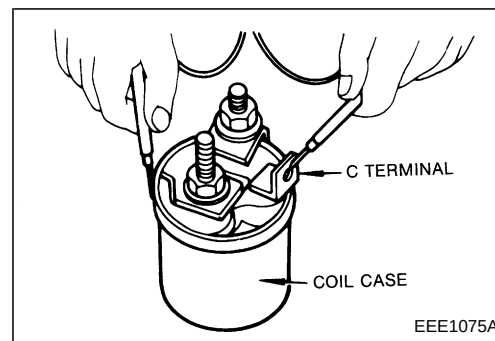


Continuity test (Shunt coil resistance)

Check the continuity between the C terminal and coil case.

Unit: Ω

Maintenance standard	Service limit
0.6 - 0.8	—



Contactor point deflection

Check deflection when the contactor makes contact.

Unit: mm (in)

Maintenance standard	Service limit
1.0 - 2.0 (0.039 - 0.079)	—

PINION GEAR

Clearance between pinion gear and pinion stopper

Unit: mm (in)

Maintenance standard	Service limit
0.5 - 3.0 (0.020 - 0.118)	—

ADJUSTMENT

Measure dimension L moved towards the thrust direction of the pinion when the magnetic switch pushes out the pinion.

1. Connect the S terminal to the battery positive terminal through the magnetic switch. Ground the M terminal midway and then connect it to the battery negative terminal.

2. Turn on the switch and make sure the magnetic switch pushes out the pinion. Then, push back the pinion lightly and measure dimension L.

Unit: mm (in)

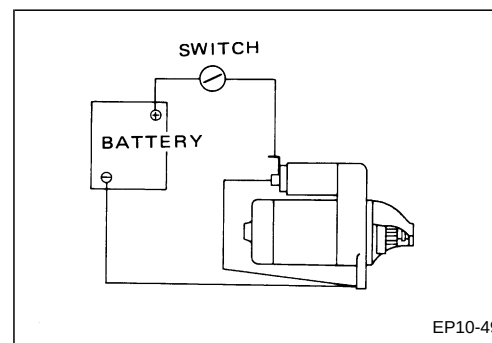
Item	Maintenance standard	Service limit
Dimension L	0.3 - 1.5 (0.012 - 0.059)	—

3. If dimension L exceeds the maintenance standard, replace the starting motor assembly with a new one.

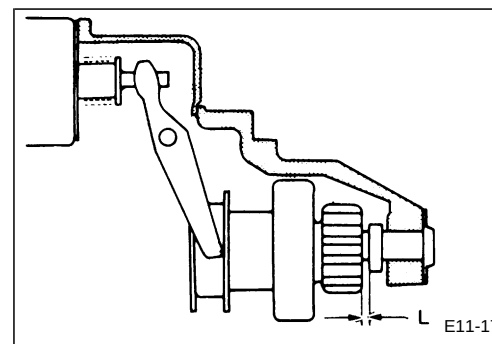
PERFORMANCE TEST (NO LOAD)

1. Connect as shown in the illustration. Turn off the key switch and turn the starting motor. Under these conditions, measure the current and the number of rotations. (Terminal voltage: 24 volts)

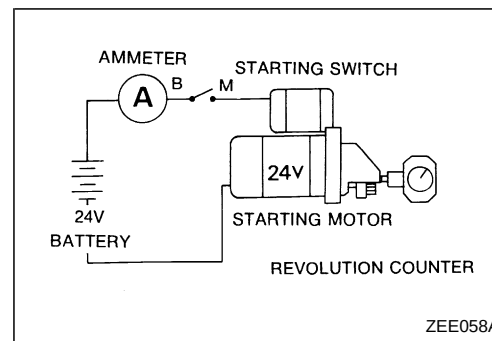
Item	Maintenance standard	Service limit
Current	A	Less than 120
Motor speed	rpm	More than 3,500



EP10-49



E11-17



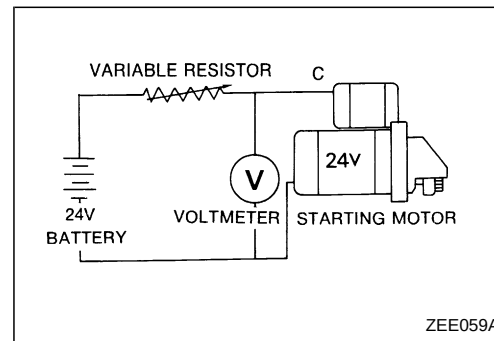
ZEE058A

2. Check that the pinion gear pops smoothly out and in when the switch is turned on and off.

3. Measure the minimum voltage which is necessary for the pinion to pop out. Prepare a variable resistor and battery voltmeter as testing equipment. Set the resistance higher at first so that a lower voltage applies to the starting motor. Then, slowly lower the resistance and measure the voltage when the pinion pops out.

Unit: V

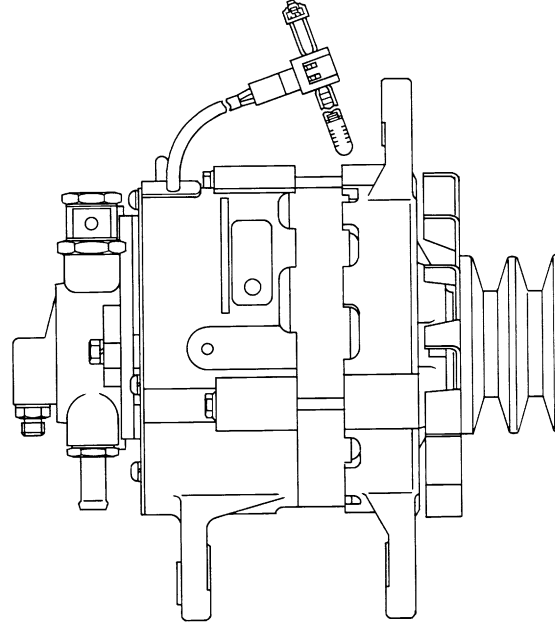
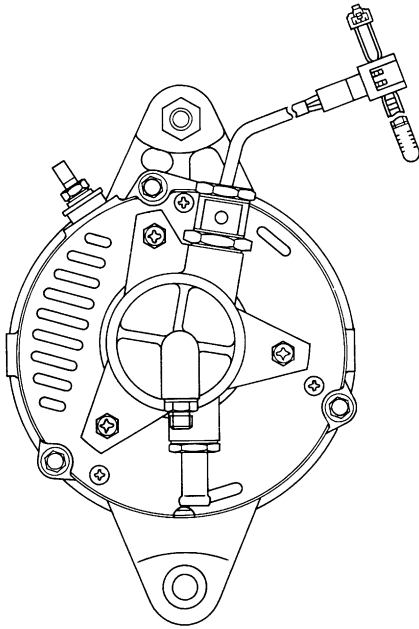
Maintenance standard	Service limit
Less than 16	—



ALTERNATOR

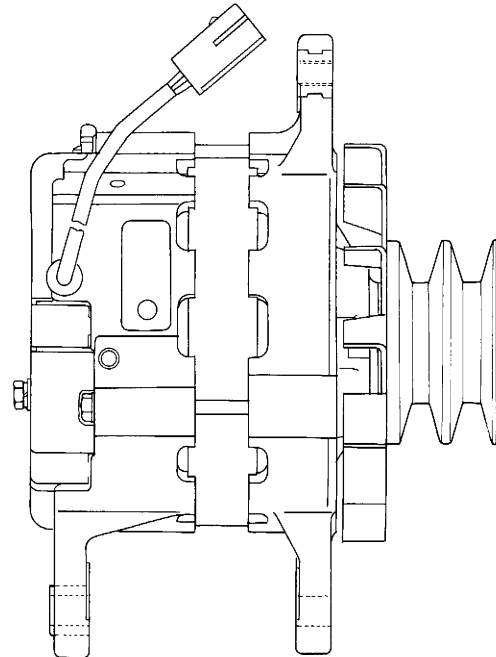
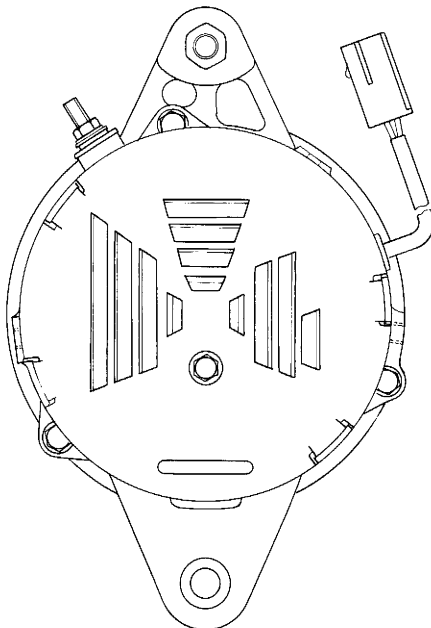
= MODEL 0202 102 1943, 0202 152 0044 (0202 152 0043), 0201 152 1130, 0201 102 4510 =
CONSTRUCTION

MODEL 0202 102 1943 AND 0202 152 0044 (0202 152 0043)



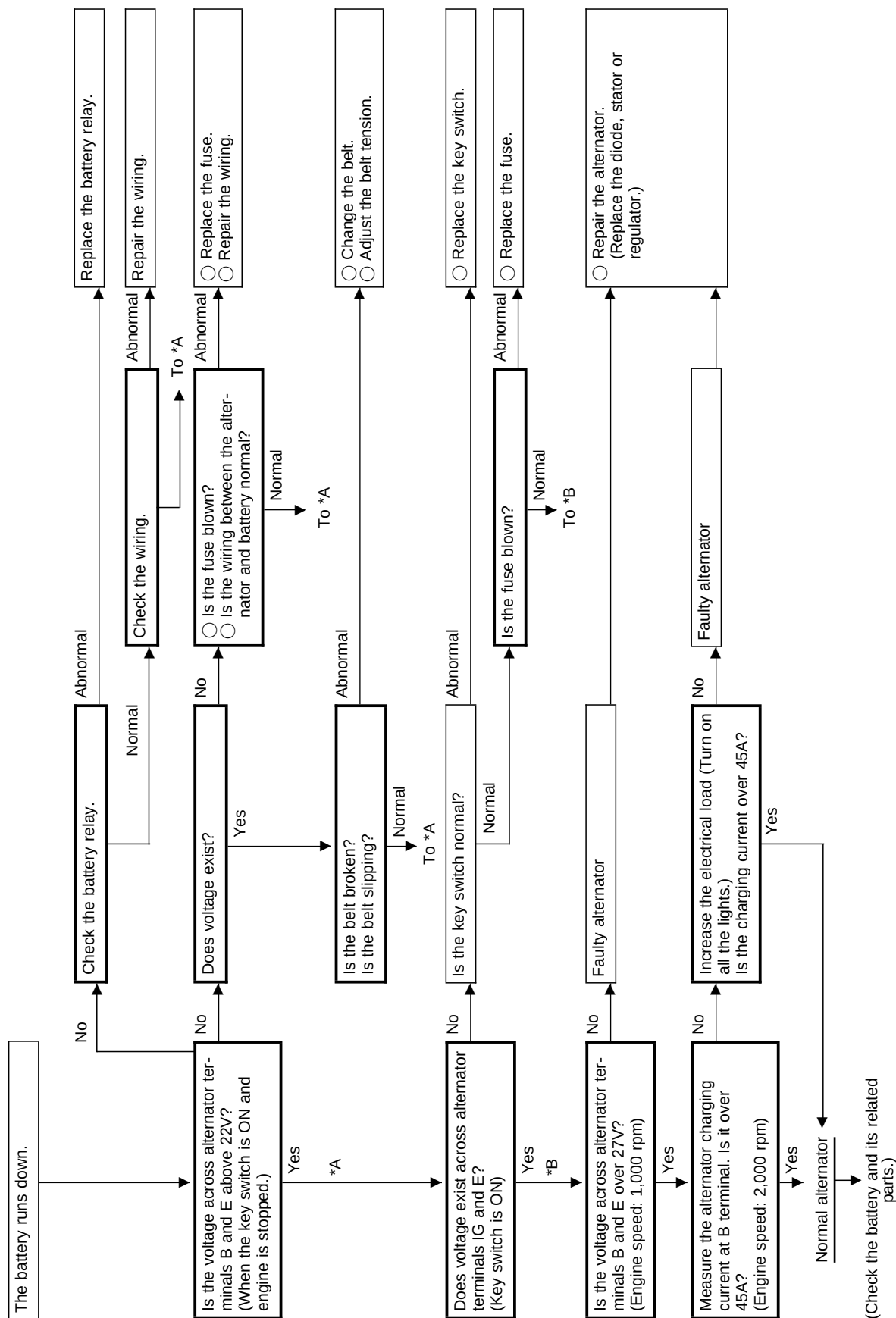
ZEE013A

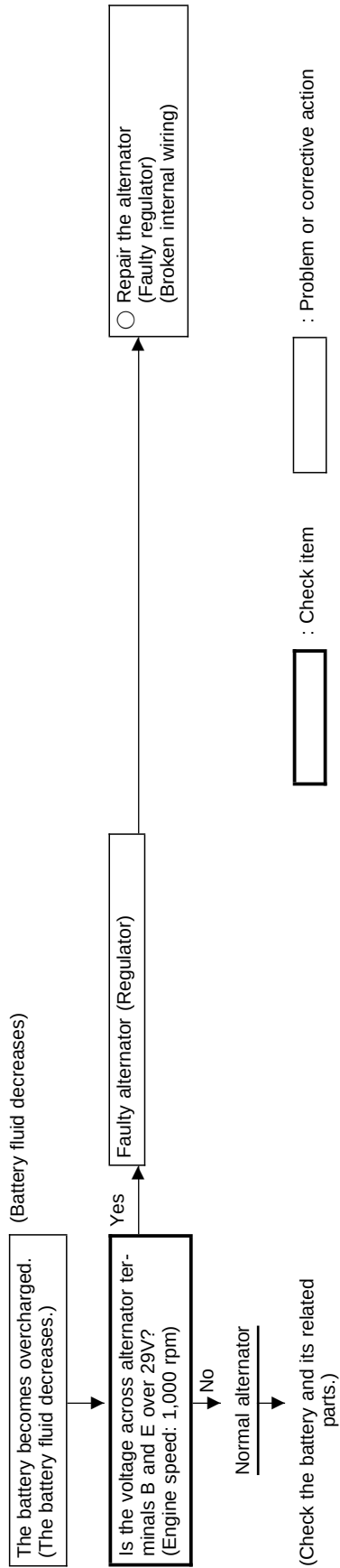
MODEL 0201 152 1130 AND 0201 102 4510



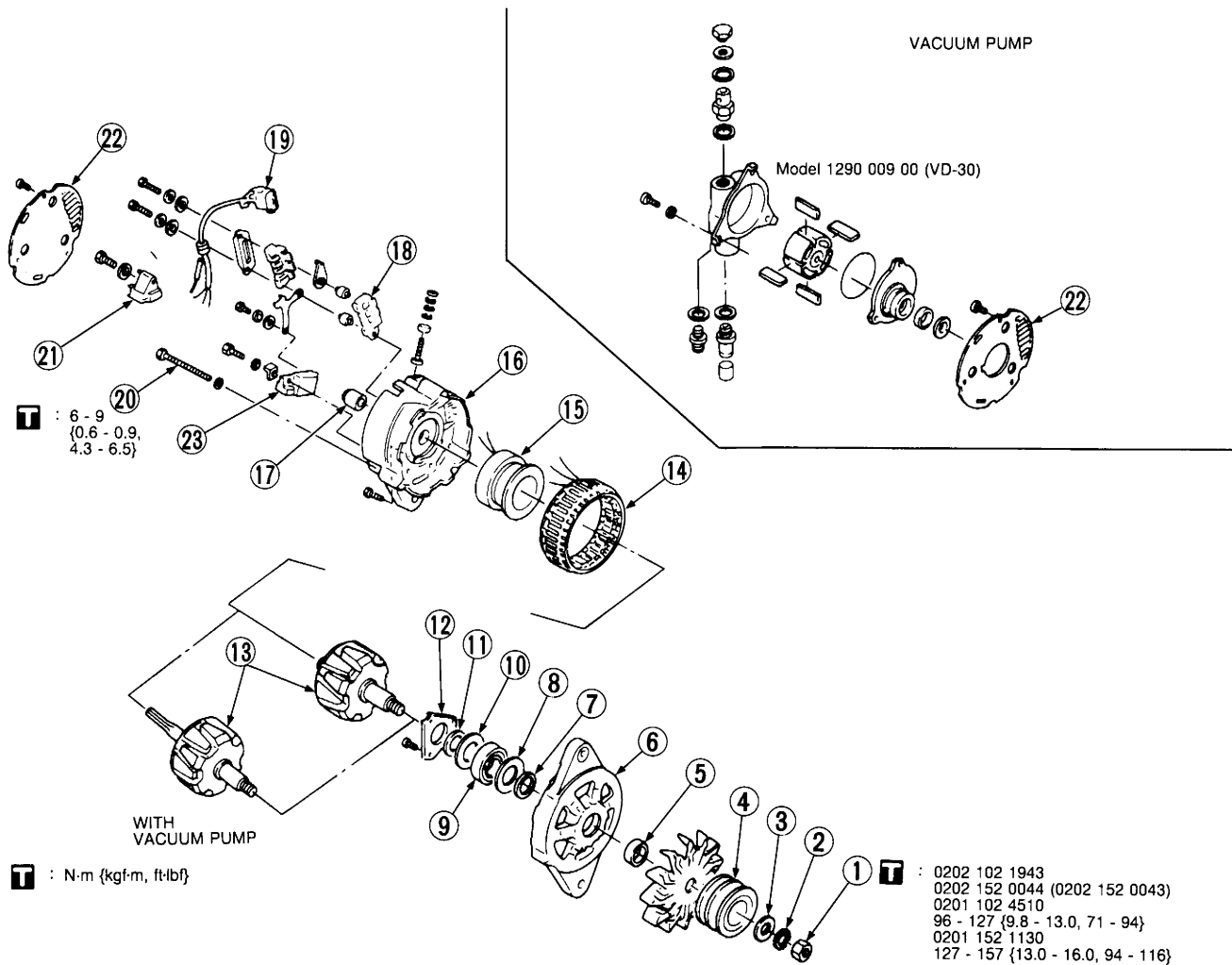
WEE044A

TROUBLESHOOTING





DISASSEMBLY



WEE052A

- | | | |
|--------------------|-----------------------|---------------------------------|
| ① Nut | ⑨ Ball bearing | ⑰ Rubber cap |
| ② Lock washer | ⑩ Washer | ⑱ Heat sink |
| ③ Washer | ⑪ Oil seal | ⑲ Terminal |
| ★④ Pulley assembly | ⑫ Cover | ⑳ Through bolt |
| ⑤ Spacer | ⑬ Rotor assembly | ㉑ Charge light circuit assembly |
| ★⑥ Front cover | ⑭ Stator assembly | ㉒ Cover |
| ⑦ Oil seal | ⑮ Field coil assembly | ㉓ Regulator |
| ⑧ Washer | ⑯ Housing | |

Marks "★" and "☆" indicate that key points of operation are explained in the text.

NOTE

- Numbers before part names do not indicate the disassembly sequence.

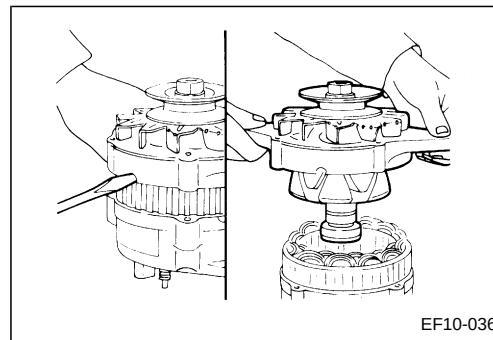
Key point of disassembly

⑥ Front cover

To separate the front cover assembly, insert a screwdriver into the clearance between the front cover and stator core.

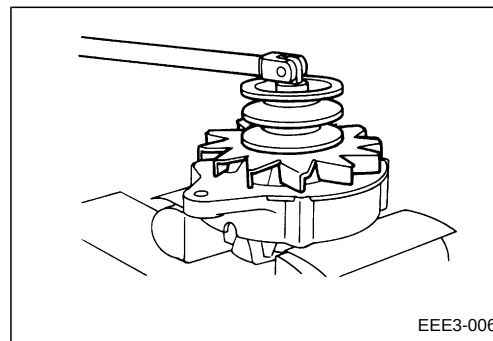
NOTE

- Be careful not to damage the stator coil with the screwdriver tip.



④ Pulley assembly

When separating the pulley assembly, secure the rotor periphery with a vise. Then, remove the pulley nut, pulley assembly and spacer. If the pulley assembly is difficult to remove, use a general-purpose puller.



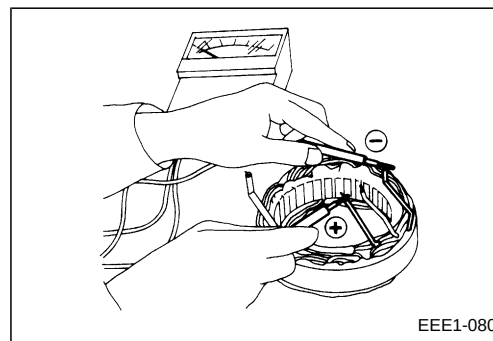
INSPECTION

STATOR COIL

Continuity test of the stator coil

Unit: Ω

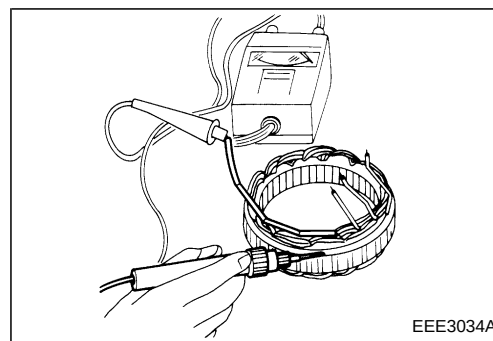
	Item	Maintenance standard	Service limit	Remarks
Resistance	0202 102 1943	0.36 - 0.44	—	Between two phases [At 20°C (68°F)]
	0202 152 0044 (0202 152 0043)	0.19 - 0.24	—	
	0201 152 1130	0.18 - 0.22	—	
	0201 102 4510	0.285 - 0.315	—	



If there is no continuity, the stator coil may be broken. Replace the stator coil as an assembly.

Insulation test of the stator coil

Make sure there is no continuity. If there is continuity, the stator coil may be shorted. Replace the stator coil as an assembly.



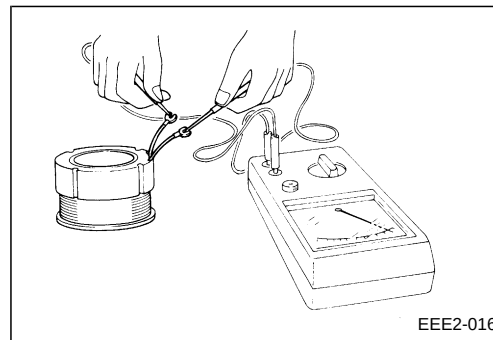
FIELD COIL

Continuity test of the field coil

Unit: Ω

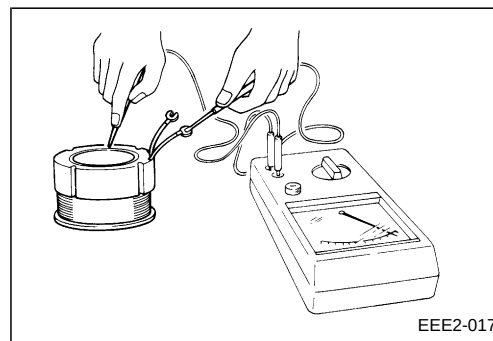
	Item	Maintenance standard	Service limit	Remarks
Resistance	0202 102 1943	7.0 - 9.0	—	At 20°C (68°F)
	0202 152 0044 (0202 152 0043)	5.0 - 7.0	—	
	0201 152 1130	5.6 - 6.8	—	
	0201 102 4510	7.5 - 8.3	—	

If there is no continuity, the field coil may be broken. Replace the field coil as an assembly.



Insulation test of the field coil

Make sure there is no continuity. If there is continuity, the field coil may be shorted. Replace the field coil as an assembly.



ROTOR ASSEMBLY

Shaft outside diameter of the front part

Unit: mm (in)

Maintenance standard	Service limit
25.0 (0.9843)	Less than 24.98 (0.9835)

Shaft outside diameter of the rear part

Unit: mm (in)

Item	Maintenance standard	Service limit
0202 102 1943 0202 152 0044 (0202 152 0043)	16.0 (0.6299)	Less than 15.98 (0.6291)
0201 152 1130 0201 102 4510	17.0 (0.6693)	Less than 16.98 (0.6685)

FRONT COVER

Inside diameter of front bearing fitting hole

Unit: mm (in)

Maintenance standard	Service limit
62.0 (2.441)	More than 62.1 (2.445)

HOUSING

Inside diameter of rear bearing fitting hole

Unit: mm (in)

Maintenance standard	Service limit
23.8 (0.9373)	More than 23.80 (0.9370)

PERFORMANCE TEST

NOTE

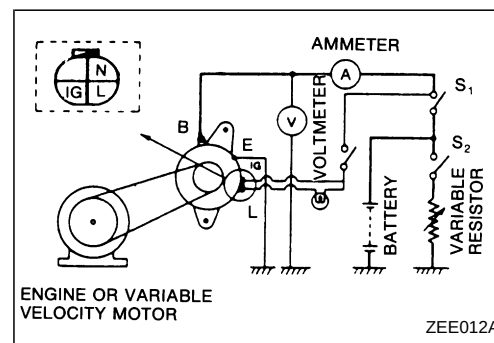
- Use leads with a cross-sectional area greater than 8 mm² (0.0124 sq in) and a length less than 2.5 m (8.2 ft) to connect the line between the alternator's B terminal and positive battery terminal, the E terminal and battery ground terminal, and the L terminal and battery ground terminal.
- Use switches with as small a contact resistance as possible in the circuit.
- Conduct performance test in areas where ambient temperature is maintained at 20°C (68°F).

Start-up revolution

1. Install the alternator on a vehicle or connect to a variable velocity motor and connect the leads as shown in the figure.
2. Turn switches SW1 and SW2 "ON", then gradually increase alternator speed.
3. When the voltmeter registers a voltage higher than the voltage when the alternator is stopped, turn switch SW1 "OFF".
4. While observing the voltmeter, increase alternator speed.
5. Read alternator speed (rpm) when the voltmeter registers 27 volts.

Unit: rpm

Item		Maintenance standard	Service limit	Re- marks
Speed required to increase voltage to 27 volts	0202 102 1943 0202 152 0044 (0202 152 0043) 0201 102 4510	Less than 900	—	At 20°C (68°F)
	0201 152 1130	Less than 950	—	



Measuring of regulating voltage

Turn switch SW1 off and turn switch SW2 on. Increase the alternator speed up to the rated rpm of 5,000. Then, measure the voltage.

Unit: V

Maintenance standard	Service limit	Remarks
28.0 - 29.0	—	At 20°C (68°F)

Measuring output current

1. Adjust the variable resistor to zero and turn switches SW1 and SW2 on.
2. Keep the alternator speed at the rated rpm and adjust the variable resistor so that the terminal voltage is at the specified value. Then, read the current.

Terminal voltage: 28V - 5,000 rpm

Unit: A

Part number	Maintenance standard	Service limit	Remarks
0202 102 1943 0201 102 4510	More than 40	—	At 20°C (68°F)
0202 152 0044 (0202 152 0043) 0201 152 1130	More than 50	—	

AUXILIARY EQUIPMENT

CONTENTS

SERVICE DATA	EA-1- 1	CONSTRUCTION	EA-2- 1
SPECIFICATIONS	EA-1- 1	DISASSEMBLY	EA-2- 2
SERVICE DATA	EA-1- 1	INSPECTION	EA-2- 2
VACUUM PUMP	EA-2- 1	REASSEMBLY	EA-2- 3

SERVICE DATA

SPECIFICATIONS

VACUUM PUMP

Model		1290 009 00 (VD-30)
Type		Vane
Theoretical discharge		cm ³ (cu in)/rev
		30 (1.83)
Max. operating speed		rpm
		7,800
Vacuum performance	Time required to reach 66.7 kPa {500 mmHg, 19.69 inHg}/Engine speed	Less than 40 seconds/1,000 rpm
		Less than 10 seconds/5,000 rpm
	Max. degree of vacuum/Engine speed	More than 90.6 kPa {680 mmHg, 26.77 inHg}/5,000 rpm
Alternator model		0202 102 1943/0202 152 0044 (0202 152 0043)

SERVICE DATA

VACUUM PUMP

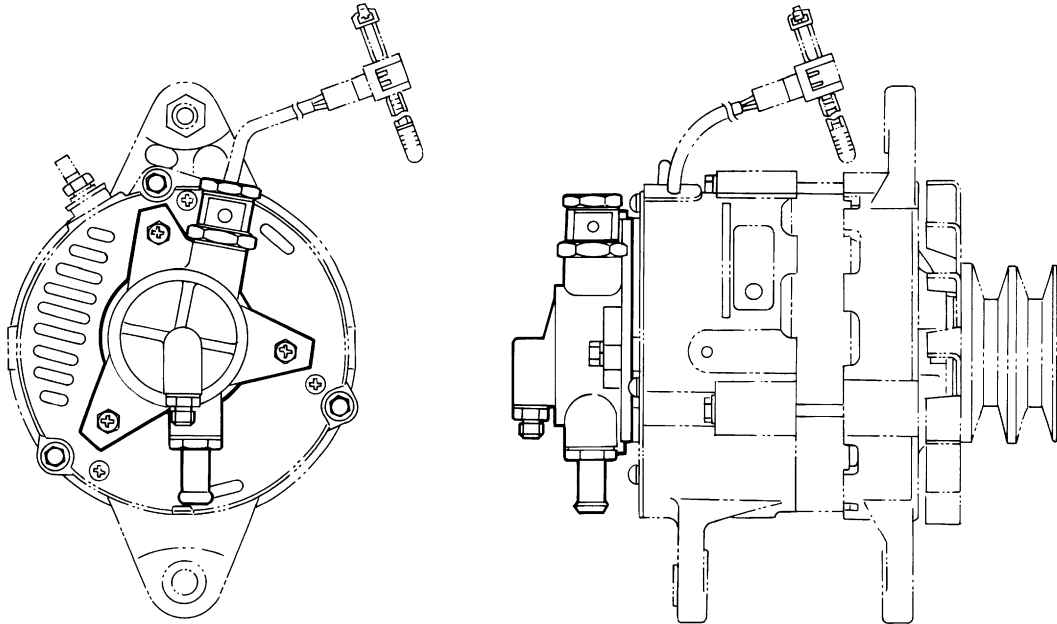
Unit: mm (in)

Item	Maintenance standard	Service limit	Remarks
Vane height	13.5 (0.531)	13.0 (0.512)	

VACUUM PUMP

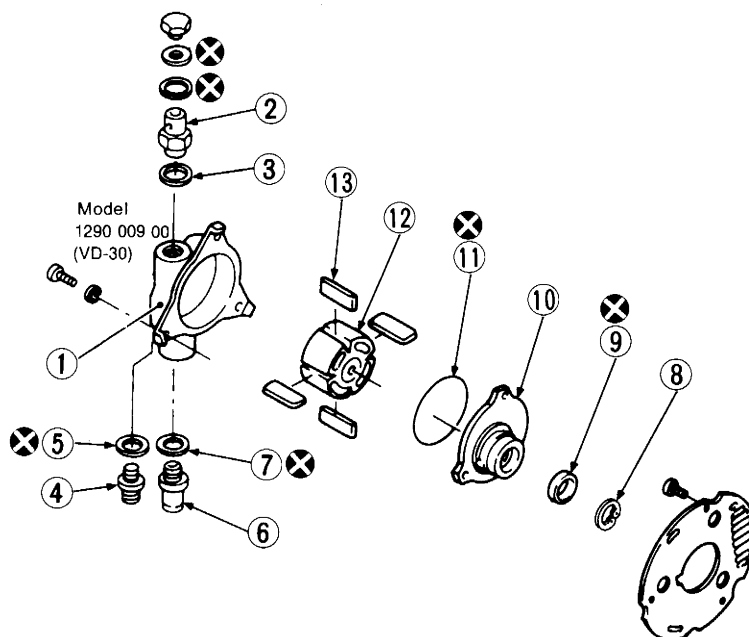
CONSTRUCTION

Model 1290 009 00 (VD-30)



WEA045A

DISASSEMBLY



WEA056A

Disassembly sequence (Reassembly sequence is in the reverse order of disassembly.)

- | | | |
|-------------|------------------|-------------------|
| ① Housing | ⑥ Connector | ☆⑩ Center plate |
| ② Valve | ⑦ Packing | ⑪ O-ring |
| ③ Packing | ⑧ Retaining ring | ☆⑫ Rotor assembly |
| ④ Connector | ⑨ Oil seal | ☆⑬ Vane |
| ⑤ Packing | | |

Marks “★” and “☆” indicate that the key points of operation are explained in the text.

INSPECTION

- Clean all disassembled parts in cleaning solvent. Check for scratches, cracks or damage and replace faulty parts.
- If measurement indicates that the service limit has exceeded, repair or replace faulty parts.

VANE

Unit: mm (in)

Item	Maintenance standard	Service limit
Height	13.5 (0.531)	13.0 (0.512)

CENTER PLATE

Check for damage at the sliding surface with the rotor and replace when worn or damaged.

HOUSING

Inspect the sliding surface with the rotor for damage and replace when worn or damaged, especially when the inside diameter is worn or damaged.

OTHERS

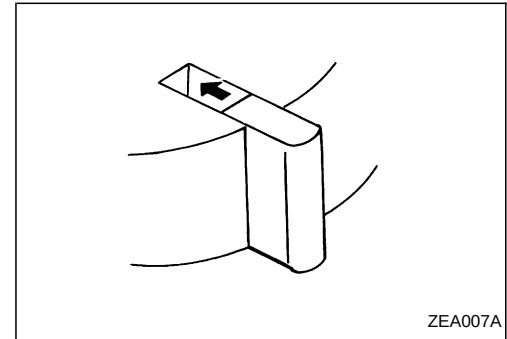
- Replace the O-ring at each disassembly.
- Replace and discolored copper packing. Moreover, check the threads of each part for damaged and replace when damaged beyond use.

REASSEMBLY

Key point of reassembly

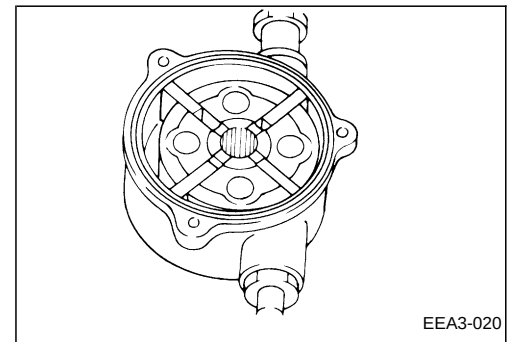
⑬ Vane

Assemble the four vanes with the end having the round chamfer at the outside.



⑫ Rotor assembly, ⑩ Center plate

1. Insert the rotor into the housing. The side which has “no crossed oil groove” should face the center plate.
2. Position the center plate on the housing. Make sure a gasket is used between both parts.



3. Position the vacuum pump assembly so that it is horizontal when the center plate is placed downward. Make sure that the hole in the center plate is aligned with the hole in the rotor shaft when looking through the rotor's hole from the floor side.

