YANMAR
SERVICE MANUAL

INDUSTRIAL DIESEL ENGINE

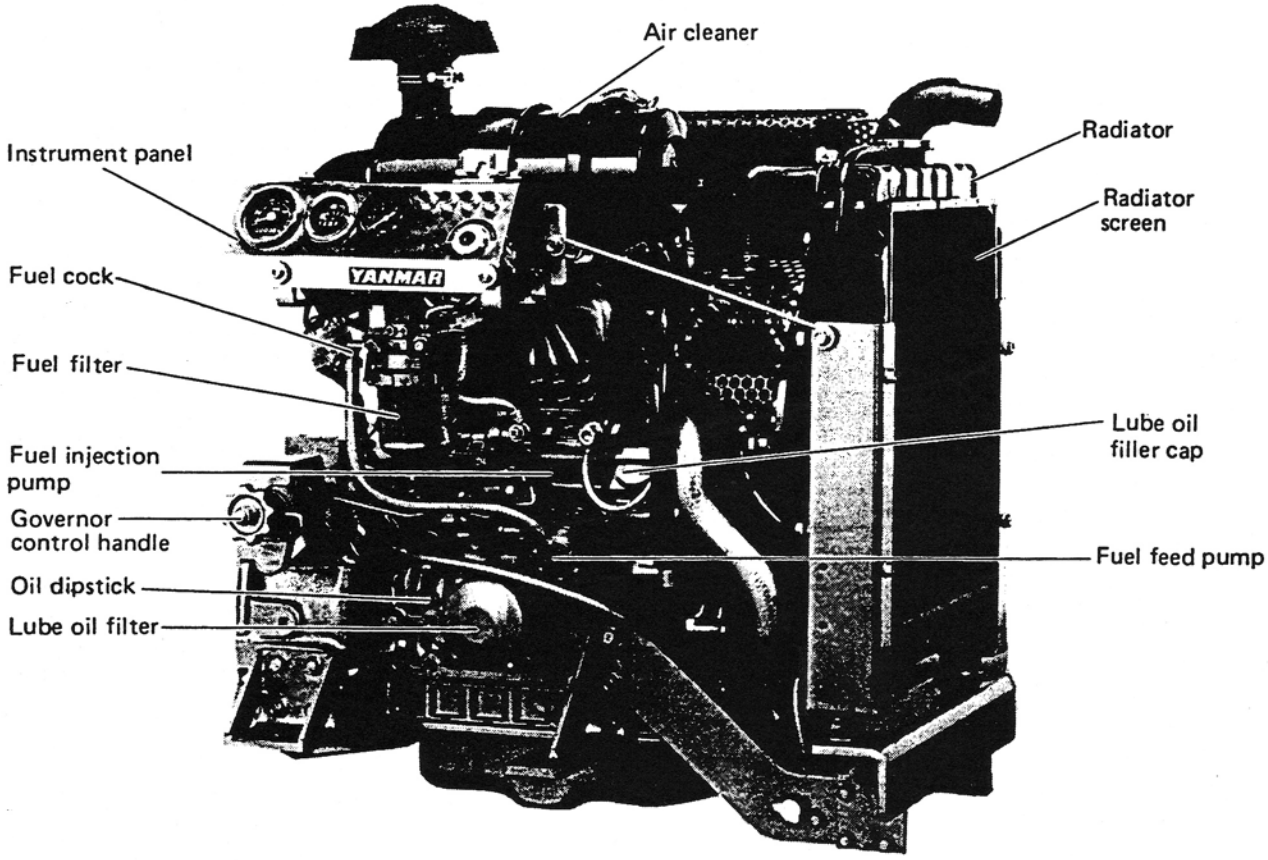
Models

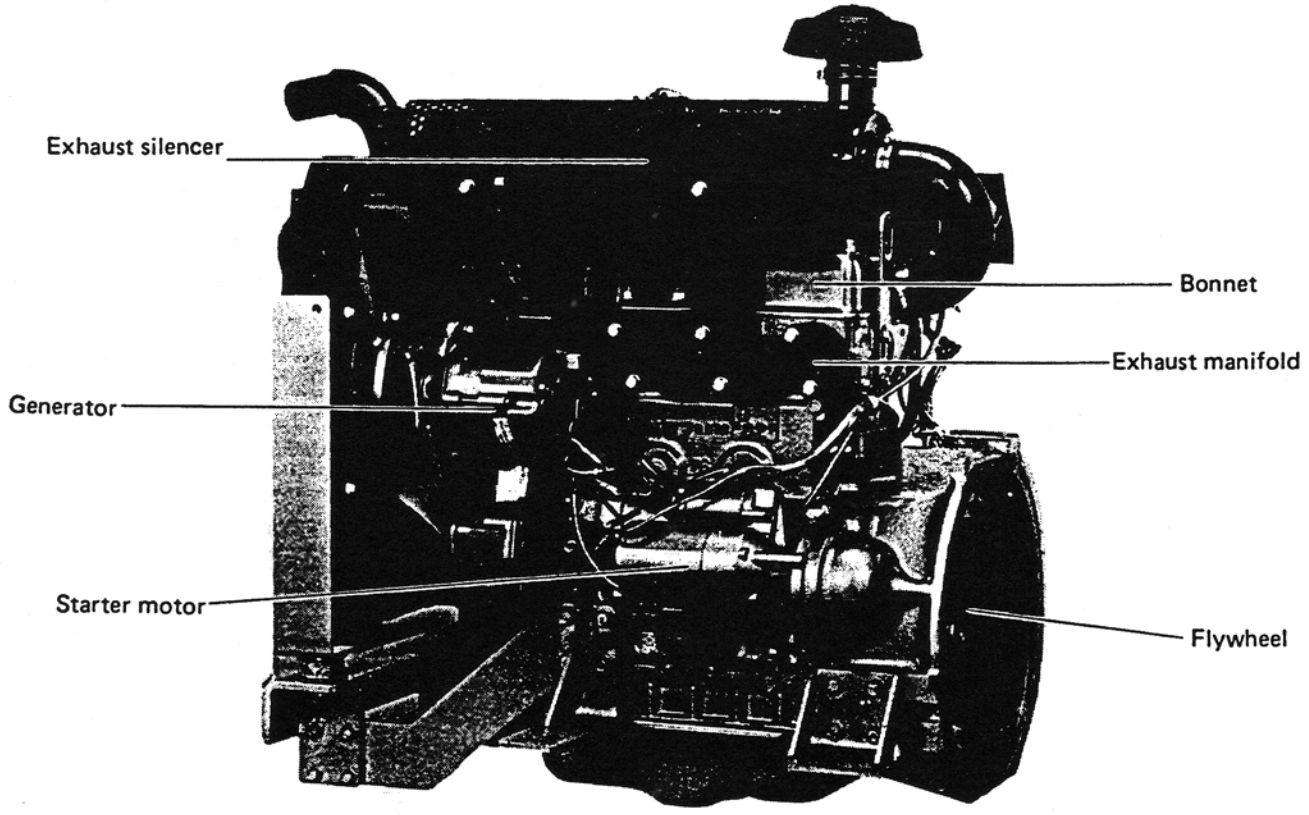
2TN66E•3TN66E•3TNA72E•3TN75E•3TNC78E•
3TN82E•3TN82TE•4TN82E•4TN82TE•3TN84E•
3TN84TE•4TN84E•4TN84TE

Models

2TN66E•3TN66E•3TNA72E•3TN75E•3TNC78E•3TN82E•3TN82TE•4TN82E•4TN82TE•3TN84E•3TN84TE•4TN84E•4TN84TE

1. External Views





2. Specifications

Model			2TN66E		3TN66E		3TNA72E		3TN75E		
Application			VM	CH	S	G2	S	G2	S	G1	G2
Type			4 stroke cycle water-cooled diesel engine								
Combustion system			Swirl pre-combustion						Direct injection		
Aspiration			Natural aspiration								
No. of cylinders			2		3						
Bore x Stroke		mm (in)	66 x 64.2 (2.60) x (2.53)		66 x 64.2 (2.60) x (2.53)		72 x 72 (2.83) x (2.83)		75 x 75 (2.95) x (2.95)		
Displacement		liter (cu. in)	0.439 (26.79)		0.658 (40.15)		0.879 (53.64)		0.994 (60.66)		
Output JIS B8002 BS 5514	Continuous rating	HP/rpm		8.5/3000 1 0/3600	–	13/3000 15/3600	–	17/3000 19/3600	–	9.5/1500 11.5/1800	19.5/3000 22.0/3600
	1hr-rating	HP/rpm	9.4/3000	9.4/3000 11/3600	14.3/3000	14.3/3000 16.5/3600	19.0/3000	19/3000 21/3600	21.5/3000	10.5/1500 12.7/1800	21.5/3000 24.5/3600
Compression ratio			23		23		22.3		17.61		
Firing order			1-2		1-3-2						
Fuel injection timing (FID)		degree (b TDC)	14°±1°		14°±1°	18°±1°	16°±1°	18°±1°	16°±1°		26°±1°
Fuel injection pressure		kg/cm² (PSI)	11.76 MPa 120(1706)						19.61 MPa 200 (2844)		
Direction of rotation			Counterclockwise (viewed from flywheel)								
Power take off			Flywheel								
Cooling system			Liquid cooling/Radiator								
Cooling water capacity	Engine	liter (US qt)	0.6 (0.63)		0.9 (0.95)		1.1 (1.162)		1.8 (1.902)		
	Radiator	liter (US qt)	1.7 (1.8)	1.9 (2.0)	2.3 (2.43)		2.3 (2.43)	2.5 (2.64)	1.4 (1.5)		
	Rad. hose										
Cooling fan	Pusher	No. of blade-mm dia	5-270		5-, 290		5-310		5-,310		
Lubricating system			Forced lubrication with trochoid pump								
Lubricating oil capacity	Effect	liter (US qt)	0.6 (0.63)		0.8 (0.85)	1.0 (1.06)	1.0 (1.06)	1.4 (1.48)	1.3 (1.374)		
	Max	liter (US qt)	1.6 (1.69)		2.2 (2.33)	3.0 (3.17)	2.4 (2.54)	3.3 (3.49)	3.1 (3.28)		5.2 (5.50)
Recommended oil			API CC or CD SAE 10W 30, 30 or 40								
Recommended fuel			Diesel fuel BS2869 A1, ASTM D975 No. 2-D (Cetane No. >45)								
Air cleaner			Dry paper element								
Governor			Mechanical centrifugal governor								
Starter motor		KW/V	0.8/12		1.0/12	0.8/12	1.0/12		1.2/12	1.3/12	1.2/12
Alternator		A/V	15/12		20/12						
Weight (dry)		kg (lbs)	65 (143)	65 (143)	85 (187)	70 (154)	118 (260)	103 (227)	160 (353)	150 (331)	140 (309)
Dimensions *	L	mm (in)	382 (15.0) *	382 (15.0) *	612 (24.09)	576 (22.68)	631 (24.84)	576 (22.68)	673 (26.50)	637 (25.08)	632 (24.88)
	W	mm (in)	412 (16.2) *	406 (16.0) *	585 (23.03)	585 (23.03)	548.5 (21.59)	537.5 (21.16)	559 (22.0)	553 (21.77)	553 (21.77)
	H	mm (in)	489 (19.3) *	525 (20.7) *	718 (28.27)	718 (28.27)	712 (28.03)	737 (29.02)	767 (30.82)	788 (31.02)	813 (32.01)

Note: * shows the dimensions of Basic engine from the fan to the flywheel.

Model			3TNC78E			3TN82E			3TN82TE	
Application			VM	CL	CH	S	G1	G2	S	G1
Type			4 stroke cycle water-cooled diesel engine							
Combustion system			Direct injection							
Aspiration			Natural aspiration						Turbocharger	
No. of cylinders			3						3	
Bore x Stroke		mm (in)	78 x 80 (3.07x 3.15)			82 x 86 (3.23) x (3.39)			82 x 86 (3.23 x 3.39)	
Displacement		liter (cu. in)	1.146 (69.93)			1.362 (83.11)			1.362 (83.11)	
Output JIS B8002 BS 5514	Continu-ous rating	HP/rpm	–	11.5/1500 13.8/1800	22.9/3000 27.3/3600	–	13.5/1500 16.5/1800	27.0/3000 31.5/3600	–	16.3/1500 20.0/1800
	1hr-rating	HP/rpm	25.2/3000	12.6/1500 15.2/1800	25.2/3000 30.0/3600	30.0/3000	15.0/1500 18.2/1800	30.0/3000 35.0/3600	36.0/3000	18.0/1500 22.0/1800
Compression ratio			18.0			18.06			18.1	
Firing order			1-3-2			1-3-2			1-3-2	
Fuel injection timing (FID)		degree (b TDC)	16°±1°		26°±1°	16°±1°		26°±1°	15°±1°	14°±1°
Fuel injection pressure		kg/cm² (PSI)	19.61 MPa 200 (2844)							
Direction of rotation			Counterclockwise (viewed from flywheel)							
Power take off			Flywheel							
Cooling system			Liquid cooling/Radiator							
Cooling water capacity	Engine	liter (US qt)	1.8 (1.902)			2.0 (2.113)			2.0 (2.113)	
	Radiator	liter (US qt)	1.2 (1.3)			2.5 (2.64)	1.5 (1.6)	2.5 (2.64)	2.5 (2.64)	1.2 (1.3)
	Rad. hose									
Cooling fan	Pusher	No. of blade-mm dia	6-335			6-, 335			6-335	
Lubricating system			Forced lubrication with trochoid pump							
Lubricat-ing oil capacity	Effect	liter (US qt)	1.3 (1.374)			1.8 (1.90)		2.1 (2.22)	1.8 (1.90)	
	Max	liter (US qt)	3.1 (3.28)		5.2 (5.50)	4.7 (4.97)		6.9 (7.29)	4.7 (4.97)	
Recommended oil			API CC or CD SAE 10W 30, 30 or 40							
Recommended fuel			Diesel fuel BS2869 A1, ASTM D975 No. 2-D (Cetane No. >45)							
Air cleaner			Dry paper element							
Governor			Mechanical centrifugal governor							
Starter motor		KW/V	1.2/12	1.3/12	1.2/12	1.8/12				
Alternator		A/V	15/12			20/12				
Weight (dry)		kg (lbs)	123 (271)	133 (293)	120 (265)	190 (419)	180 (397)	170 (375)	195 (430)	185 (408)
Dimen-sions *	L	mm (in)	542 (21.3) *	567 (22.3) *		719 (28.31)	694.5 (27.34)	692 (27.24)	730 (28.7)	711 (28.0)
	W	mm (in)	489 (19.3) *	489 (19.3) *	489 (19.3) *	574.5 (22.62)	574.5 (22.62)	574.5 (22.62)	562 (22.1)	562 (22.1)
	H	mm (in)	565 (22.2) *	565 (22.2) *	612 (24.1) *	817 (32.17)	817 (32.17)	854 (33.62)	839 (33.0)	839 (33.0)

Note: * shows the dimensions of Basic engine from the fan to the flywheel.

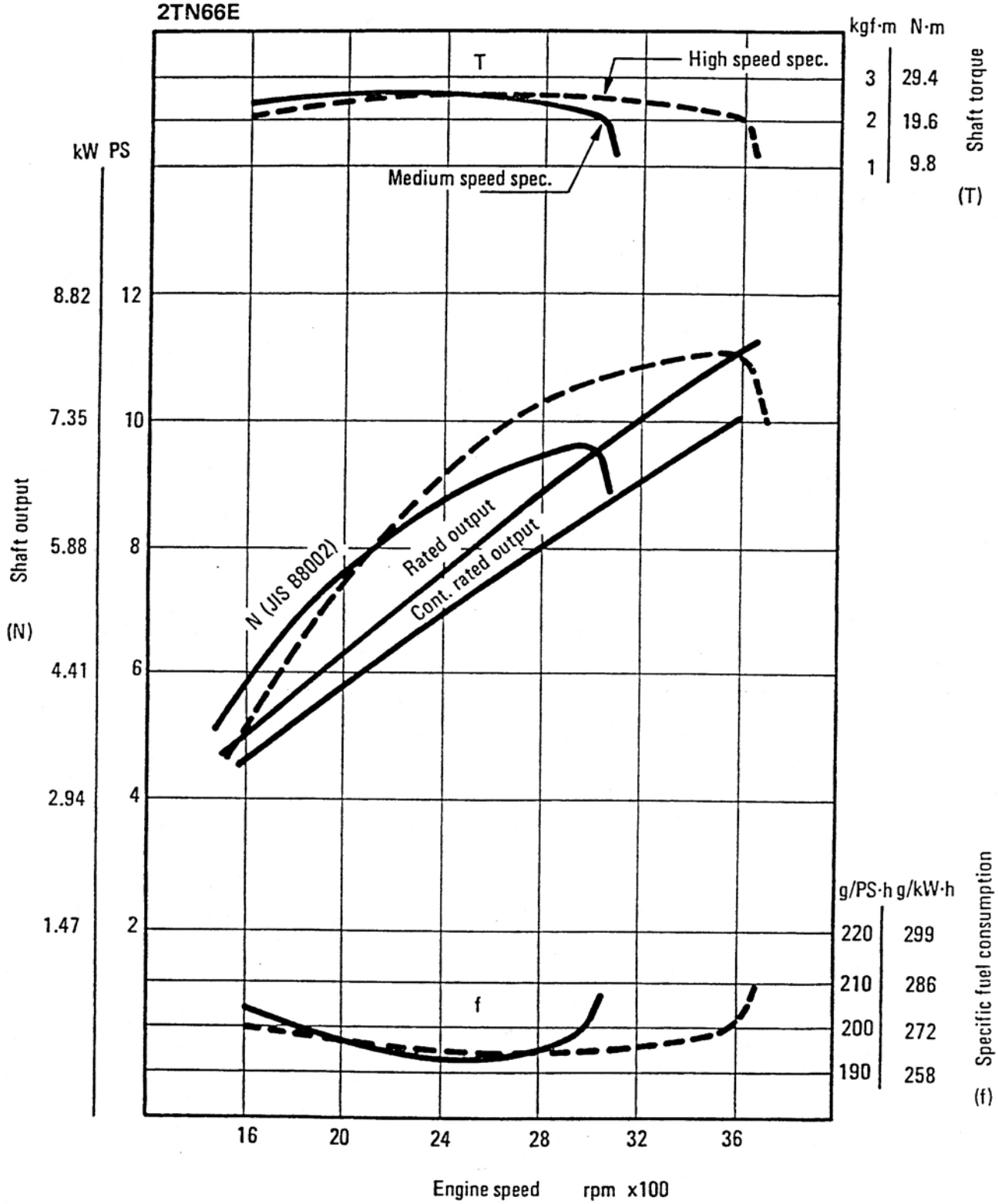
Model			4TN82E			4TN82TE			3TN84E		
Application			S	G1	G2	S	G1		VM	CL	CH
Type			4 stroke cycle water-cooled diesel engine								
Combustion system			Direct injection								
Aspiration			Natural aspiration			T/C			Natural aspiration		
No. of cylinders			4						3		
Bore x Stroke		mm (in)	82 x 86 (3.23) x (3.39)			82 x 86 (3.23) x (3.39)			84 x 86 (3.31 x 3.39)		
Displacement		liter (cu. in)	1.816 (110.82)			1.816 (110.80)			1.429 (87.20)		
Output JIS B8002 BS 5514	Continuous rating	HP/rpm	–	18.0/1500 22.0/1800	36.5/3000 42.5/3600	–	22/1500 26/1800		–	14.3/1500 17.0/1800	28.5/3000 33.0/3600
	1hr-rating	HP/rpm	40.5/3000	20.0/1500 24.2/1800	40.5/3000 47.0/3600	48/3000	24/1500 29/1800		31.5/3000	15.7/1500 19.0/1800	31.5/3000 36.5/3600
Compression ratio			18.06						18.0		
Firing order			1-3-4-2						1-3-2		
Fuel injection timing (FID)		degree (b TDC)	16°±1°		26°±1°	15°±1°	14°±1°		16°±1°		26°±1°
Fuel injection pressure		kg/cm² (PSI)	19.61 MPa 200 (2844)						200 (2844)		
Direction of rotation			Counterclockwise (viewed from flywheel)								
Power take off			Flywheel								
Cooling system			Liquid cooling/Radiator								
Cooling water capacity	Engine	liter (US qt)	2.7 (2.853)			2.7 (2.85)			2.0 (2.113)		
	Radiator	liter (US qt)	3.8 (4.02)	1.5 (1.6)	3.8 (4.02)	3.8 (4.02)			2.2 (2.3)	1.2 (1.3)	2.5 (2.6)
	Rad. hose										
Cooling fan	Pusher	No. of blade-mm dia	6-, 370	6-, 335	6-, 370	6-, 370			6-335	←	←
Lubricating system			Forced lubrication with trochoid pump								
Lubricating oil capacity	Effect	liter (US qt)	2.3 (2.43)		2.5 (2.64)	2.3 (2.43)			1.8 (1.90)		2.1 (2.22)
	Max	liter (US qt)	5.8 (6.13)		7.0 (7.40)	5.8 (6.13)			4.7 (4.97)		6.9 (7.29)
Recommended oil			API CC or CD SAE 10W 30, 30 or 40								
Recommended fuel			Diesel fuel BS2869 A1, ASTM D975 No. 2-D (Cetane No. >45)								
Air cleaner			Dry paper element								
Governor			Mechanical centrifugal governor								
Starter motor		KW/V	2.0/12	1.8/12	2.0/12	2.0/12	1.8/12		1.8/12		
Alternator		A/V	20/12						15/12		
Weight (dry)		kg (lbs)	230 (507)	220 (485)	210 (463)	235 (518)	225 (496)		153 (337)	158 (348)	145 (320)
Dimensions*	L	mm (in)	824 (32.44)	766.5 (30.18)	755 (29.72)	824 (32.44)	766.5 (30.18)		564 (22.2)*	589 (23.2)*	564 (22.2)*
	W	mm (in)	596.5 (23.48)	596.5 (23.48)	596.5 (23.48)	596.5 (23.48)	596.5 (23.48)		486 (191)*	486 (19.1)*	486 (19.1)*
	H	mm (in)	818 (32.20)	818 (32.20)	850 (33.46)	818 (32.02)	818 (32.20)		623 (24.5)*	623 (24.5)*	655 (25.8)*

Note: * shows the dimensions of Basic engine from the fan to the flywheel.

Model			3TN84TE			4TN84E			4TN84TE		
Application			VM	CL	CH	VM	CL	CH	VM	CL	CH
Type			4 stroke cycle water-cooled diesel engine								
Combustion system			Direct injection								
Aspiration			Turbocharger			Natural aspiration			Turbocharger		
No. of cylinders			3			4					
Bore x Stroke		mm (in)	84 x 86 (3.31 x 3.39)			84 x 86 (3.31 x 3.39)			84 x 86 (3.31 x 3.39)		
Displacement		liter (cu. in)	1.429 (87.20)			1.906 (116.31)					
Output JIS B8022 BS 5514	Continuous rating	HP/rpm	–	17.0/1500 21.0/1800	34.5/3000 36.4/3600	–	19.0/1500 22.7/1800	37.7/3000 44.5/3600	–	26.0/1500 33.0/1800	46.1/3000 51.8/3600
	1 hr-rating	HP/rpm	38.0/3000	19.0/1500 23.0/1800	38.0/3000 40.0/3600	41.5/3000	21.0/1500 25.0/1800	41.5/3000 49.0/3600	50.7/3000	28.6/1500 36.6/1800	50.7/3000 57.0/3600
Compression ratio			17.8		17.0	18.0			17.8		17.0
Firing order			1-3-2			1-3-4-2					
Fuel injection timing (FID)		degree (b TDC)	15°±1°	14°±1°	19°±1°	16°±1°		26°±1°	15°±1°	12°±1°	19°±1°
Fuel injection pressure		kg/cm² (PSI)	200 (2844)								
Direction of rotation			Counterclockwise (viewed from flywheel)								
Power take off			Flywheel								
Cooling system			Liquid cooling/Radiator								
Cooling water capacity	Engine	liter (US qt)	2.0 (2.113)			2.7 (2.853)			2.7 (2.853)		
	Radiator	liter (US qt)	2.2 (2.3)	1.2 (1.3)	2.2 (2.3)	3.5 (3.7)	1.2 (1.3)	3.5 (3.7)	3.5 (3.7)	←	←
	Rad. hose										
Cooling fan	Pusher	No. of blade-mm dia	6-335	←	←	6-370	6-335	6-370	6-370	←	←
Lubricating system			Forced lubrication with trochoid pump								
Lubricating oil capacity	Effect	liter (US qt)	1.8 (1.90)		2.1 (2.22)	2.3 (2.43)		2.5 (2.64)	2.3 (2.43)		2.5 (2.64)
	Max	liter (US qt)	4.7 (4.97)		6.9 (7.29)	5.8 (6.13)		7.0 (7.40)	5.8 (6.13)		7.0 (7.40)
Recommended oil			API CC or CD SAE 10W 30, 30 or 40								
Recommended fuel			Diesel fuel BS2869 A1, ASTM D975 No. 2-D (Cetane No. >45)								
Air cleaner			Dry paper element								
Governor			Mechanical centrifugal governor								
Starter motor		KW/V	1.8/12			2.0/12	1.8/12	2.0/12	2.0/12	1.8/12	2.0/12
Alternator		A/V	15/12			15/12			15/12		
Weight (dry)		kg (lbs)	158 (348)	163 (359)	150 (331)	194 (428)	195 (430)	182 (401)	199 (439)	200 (441)	187 (412)
Dimensions *	L	mm (in)	564 (22.2)	589 (23.2)	564 (22.2)	649 (25.6)	683 (26.9)	649 (25.6)	649 (25.6)	674 (26.5)	649 (25.6)
	W	mm (in)	540 (21.3)	540 (21.3)	535 (21.1)	499 (19.6)	499 (19.6)	499 (19.6)	515 (20.3)	515 (20.3)	515 (20.3)
	H	mm (in)	630 (24.8)	630 (24.8)	758 (29.8)	618 (24.3)	618 (24.3)	650 (25.6)	714 (28.1)		746 (29.4)

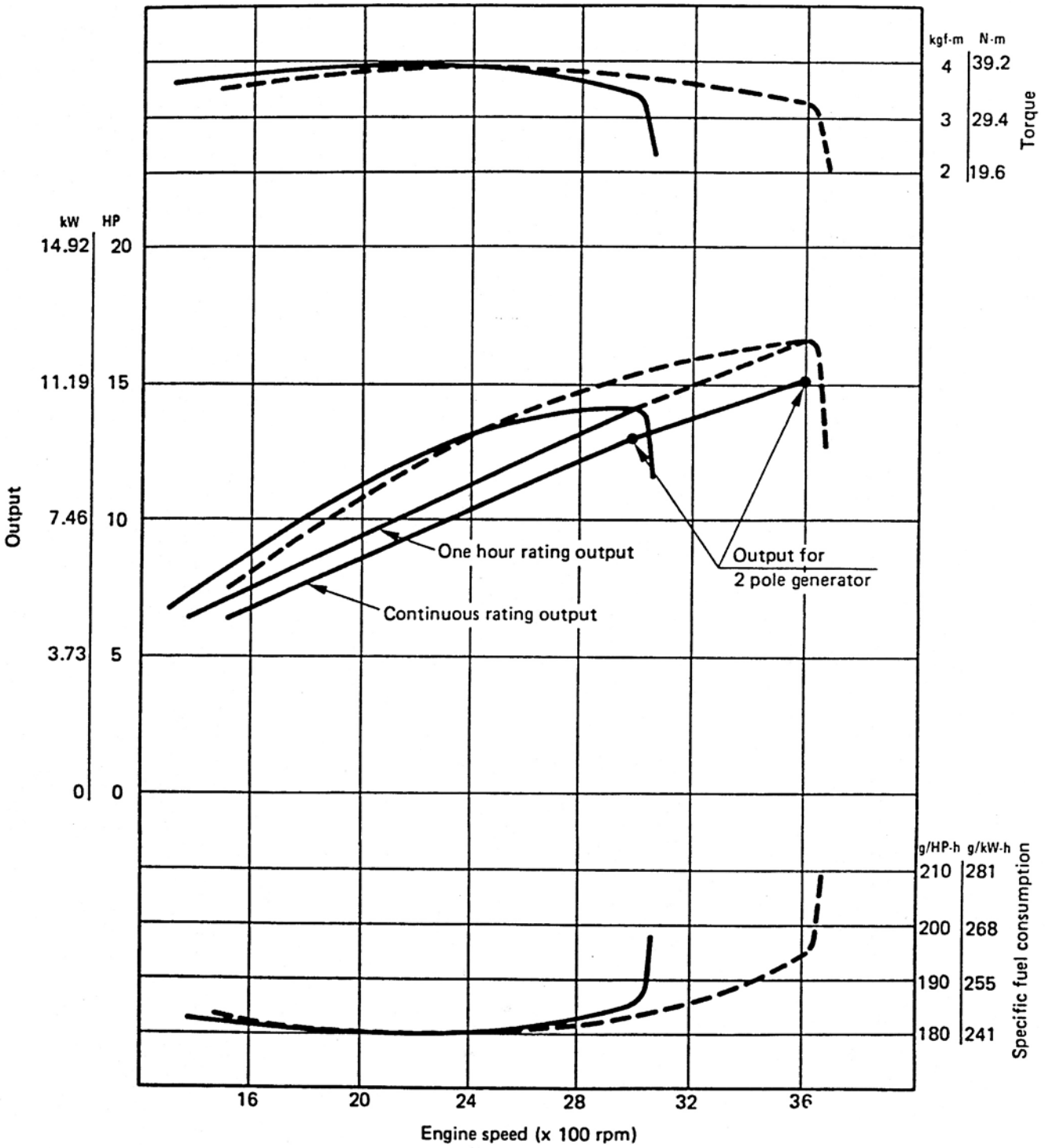
Note: * shows the dimensions of Basic engine from the fan to the flywheel.

3. Performance Curves



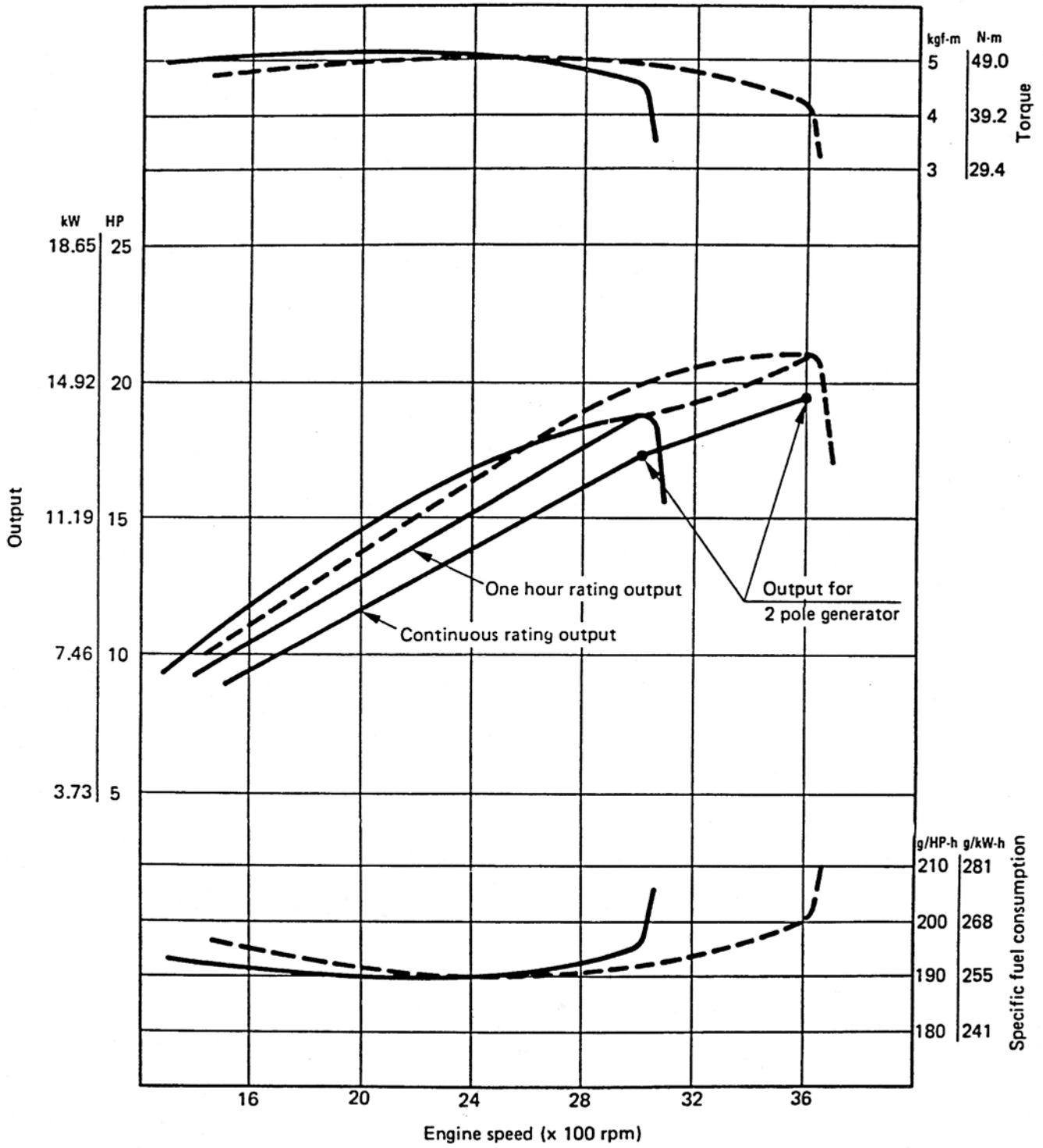
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

3TN66E



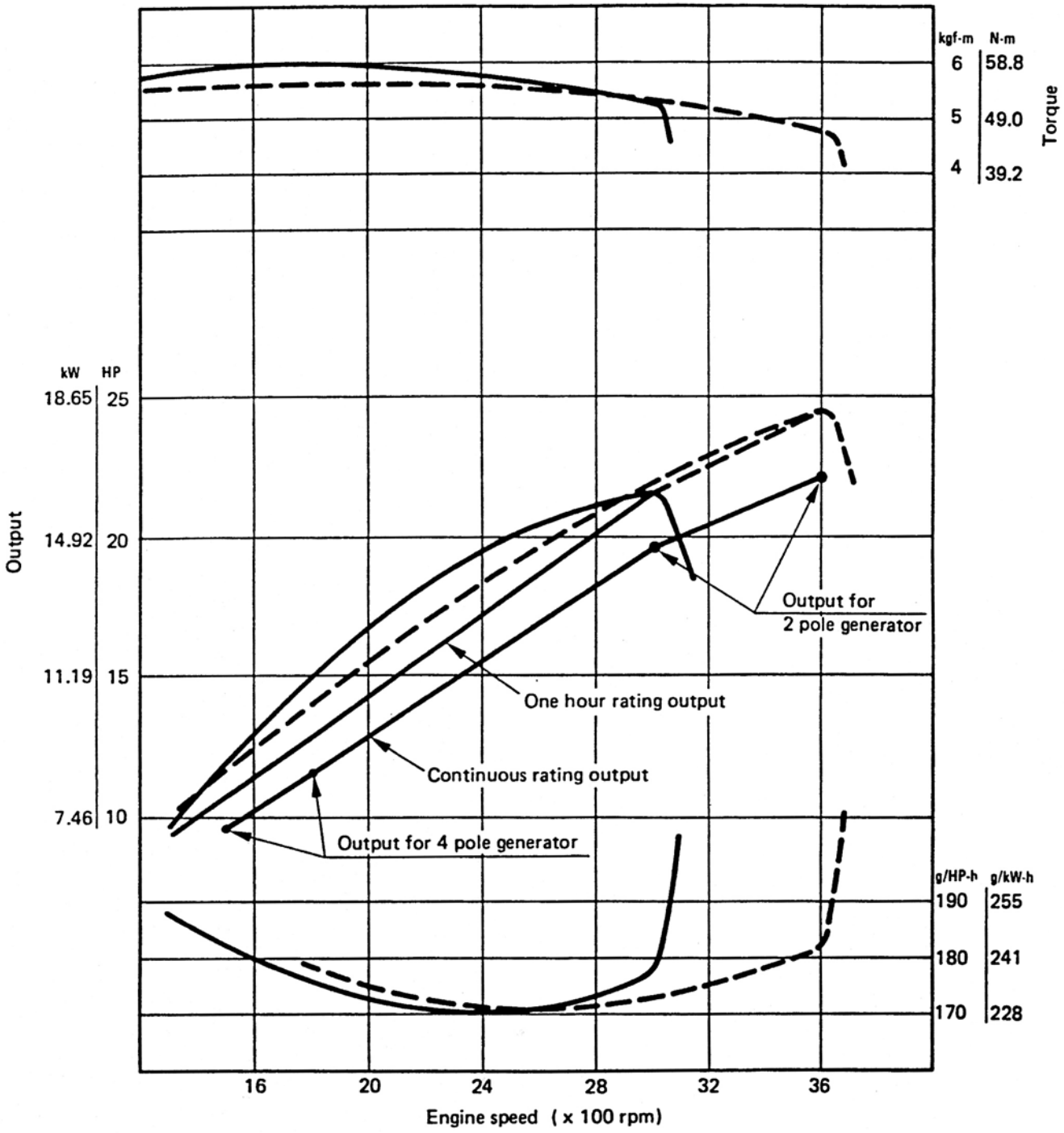
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

3TNA72E



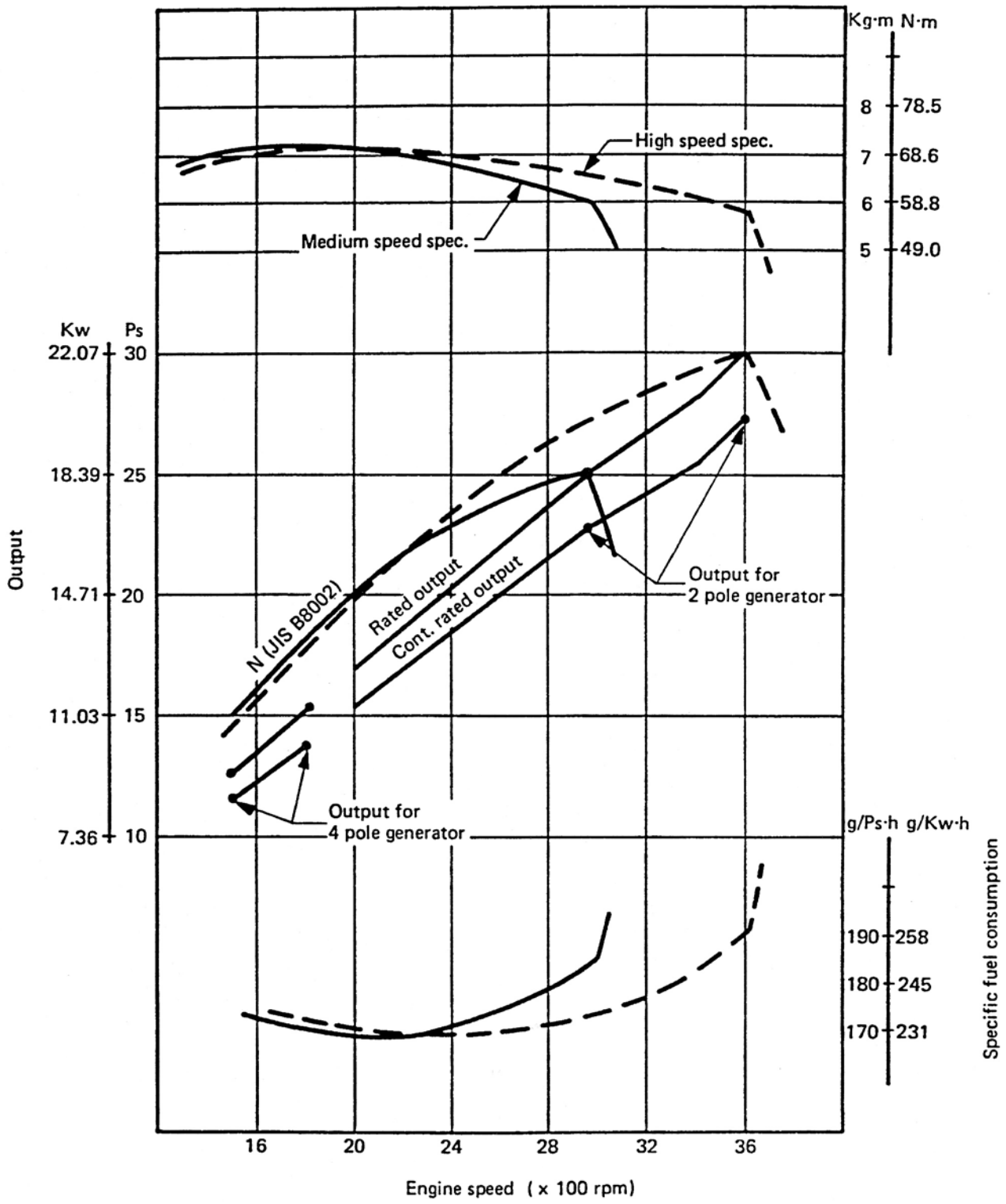
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

3TN75E



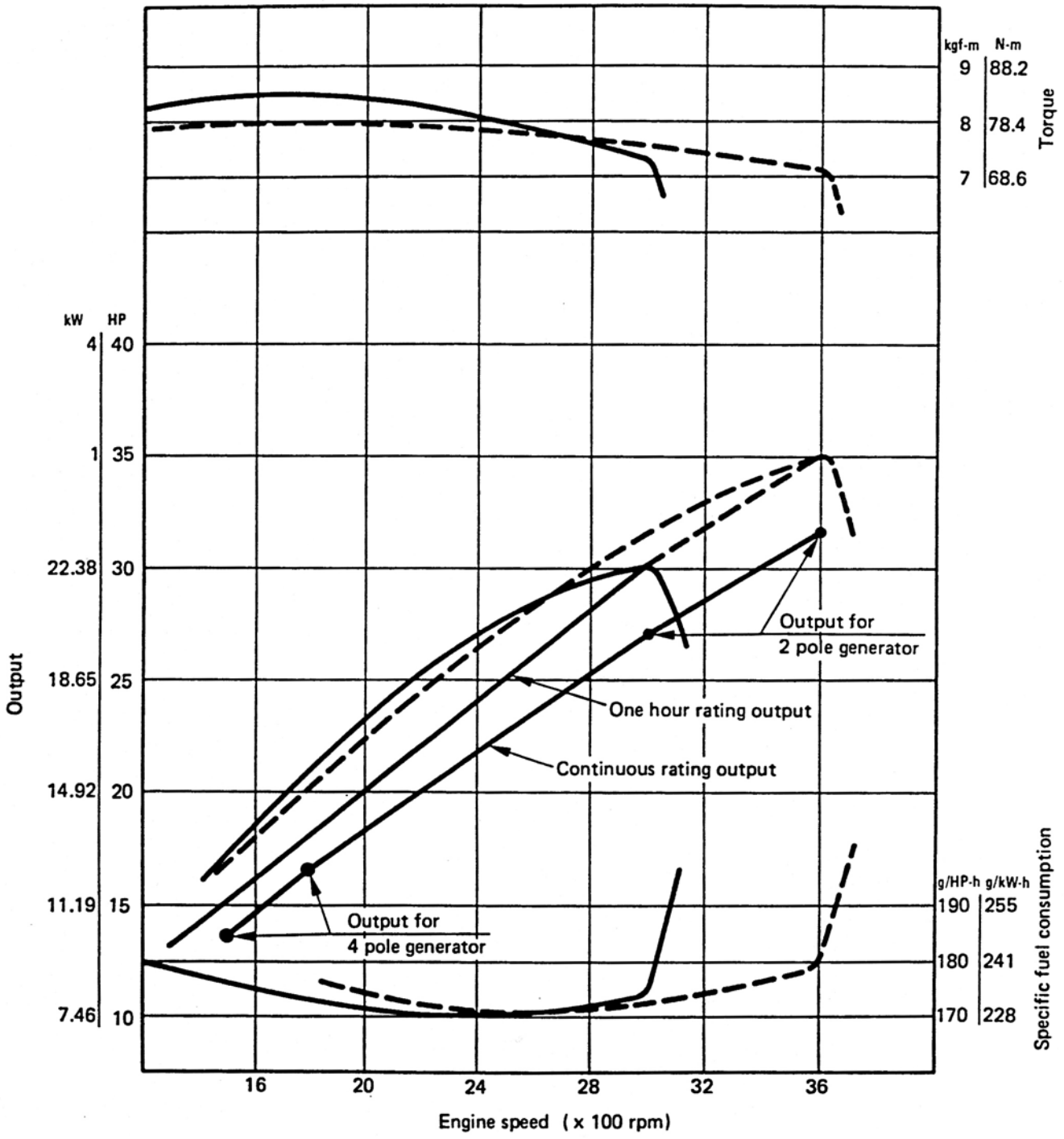
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

3TNC78E



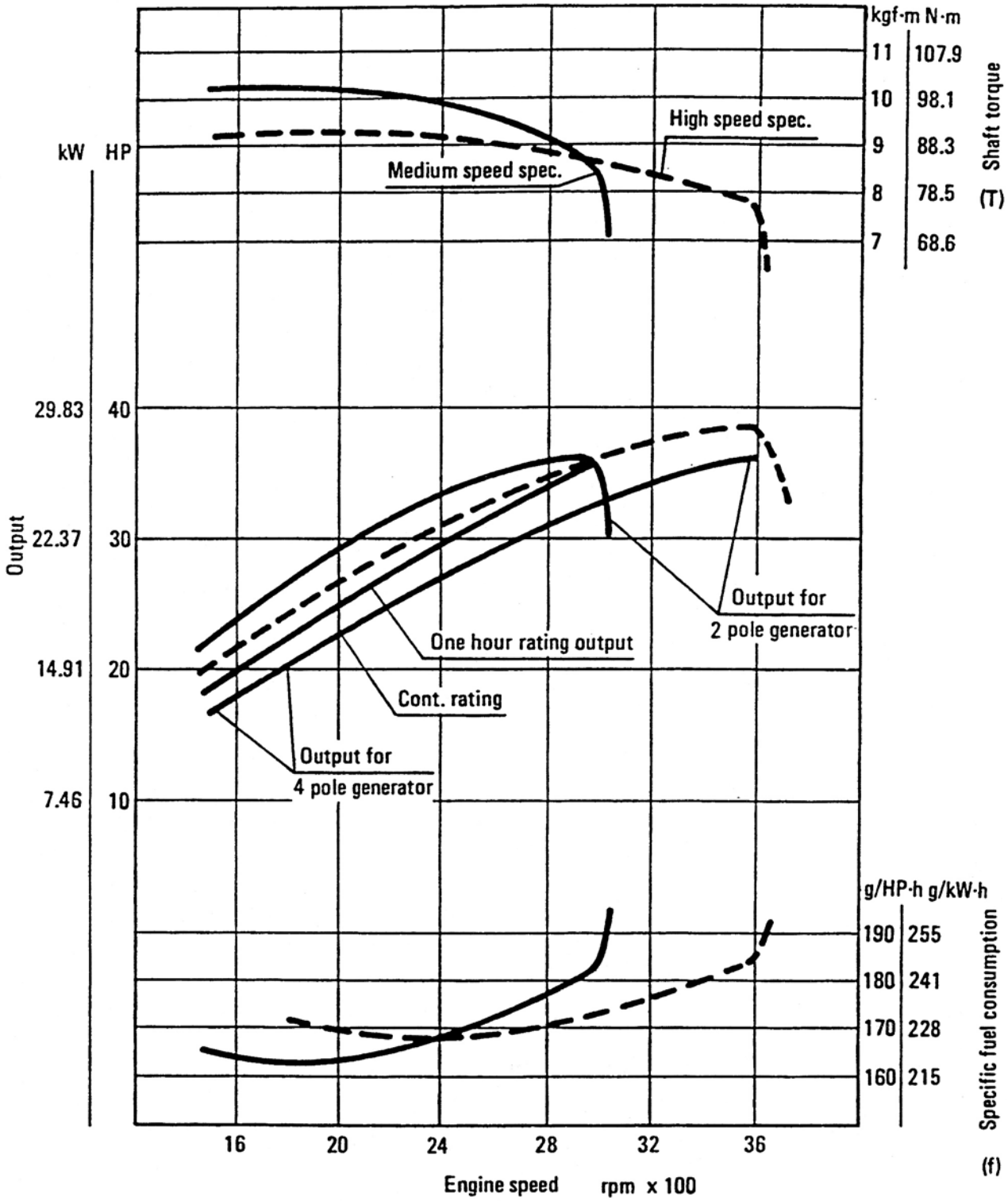
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

3TN82E



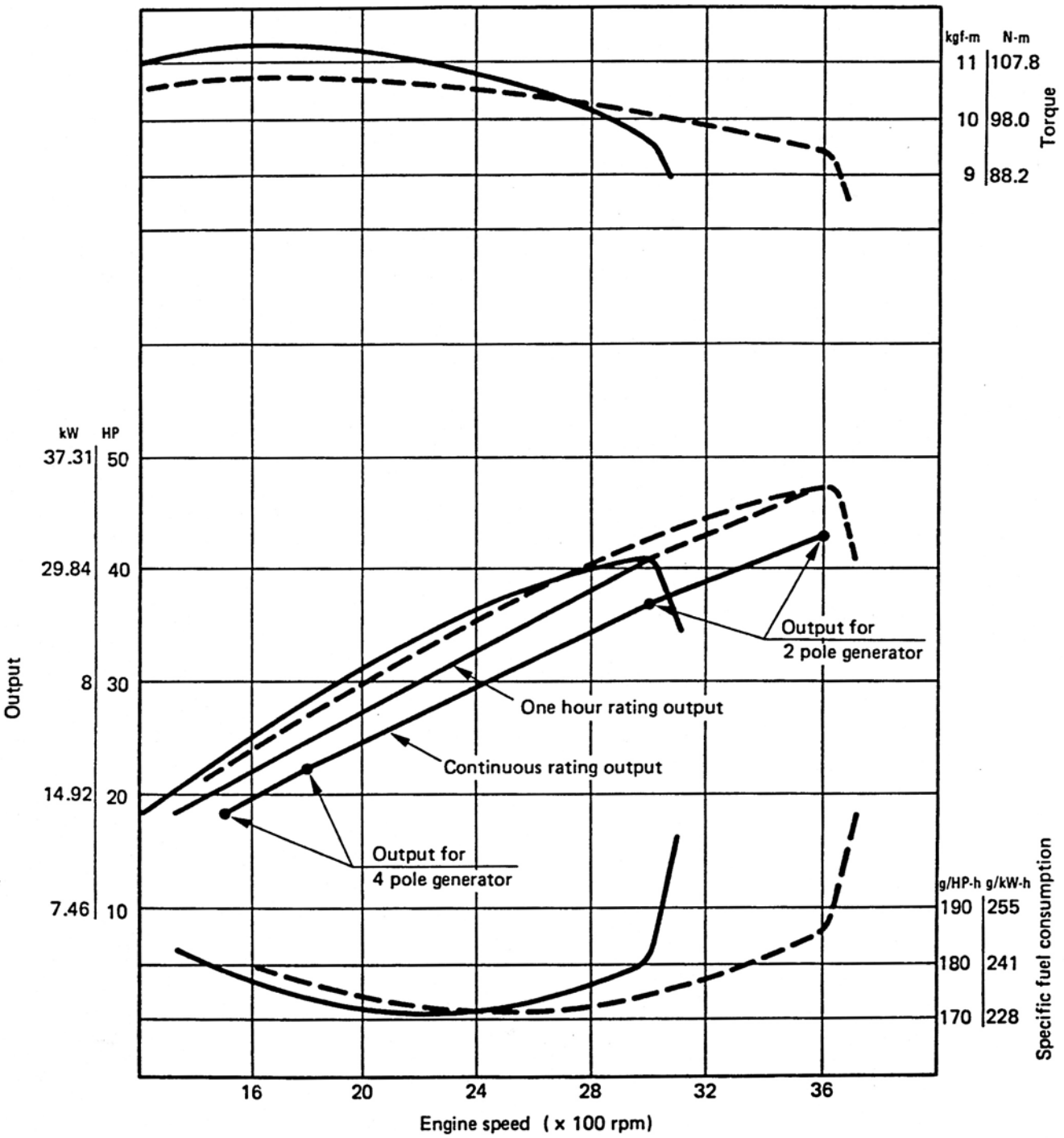
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

3TN82TE



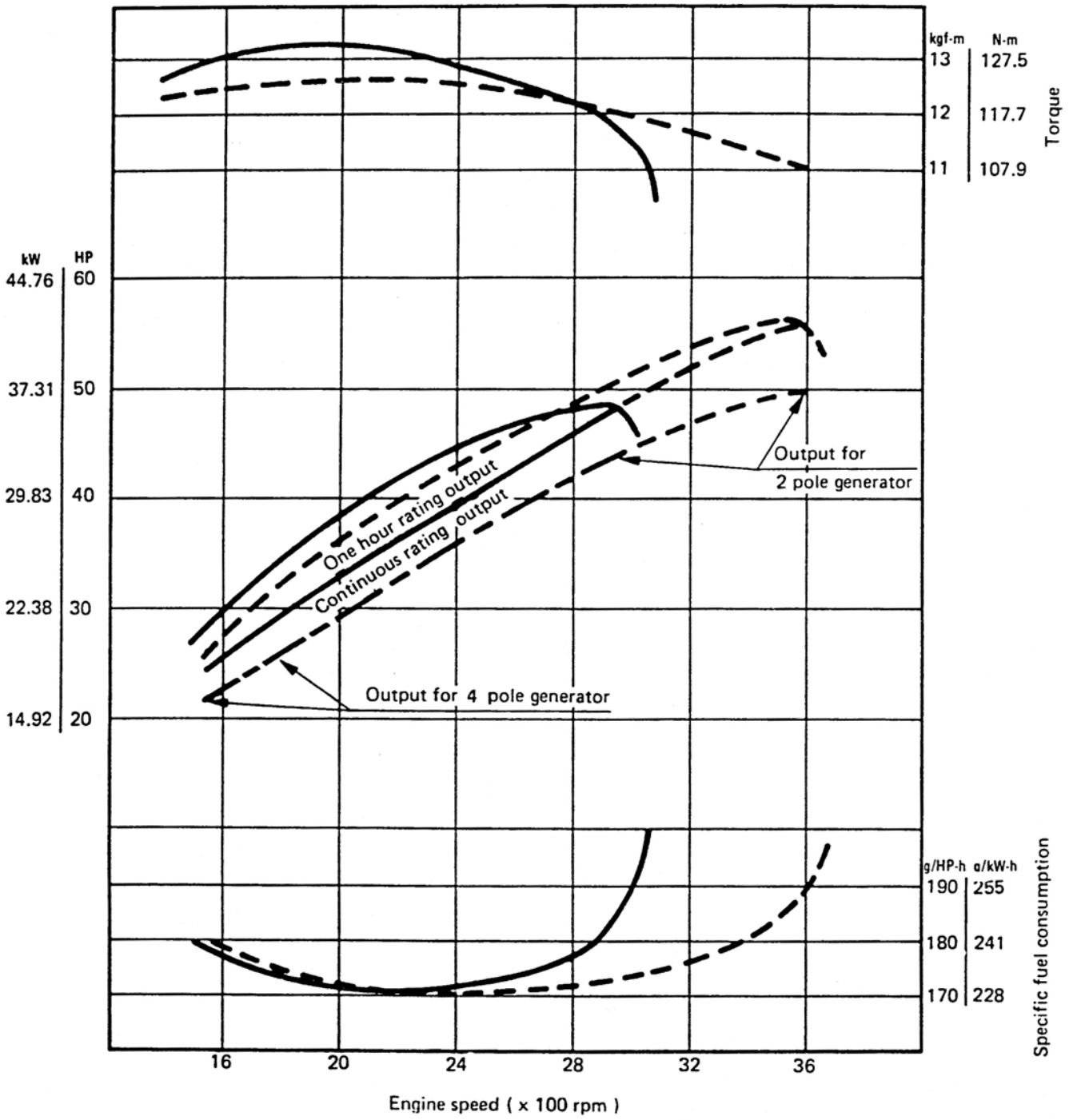
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

4TN82E

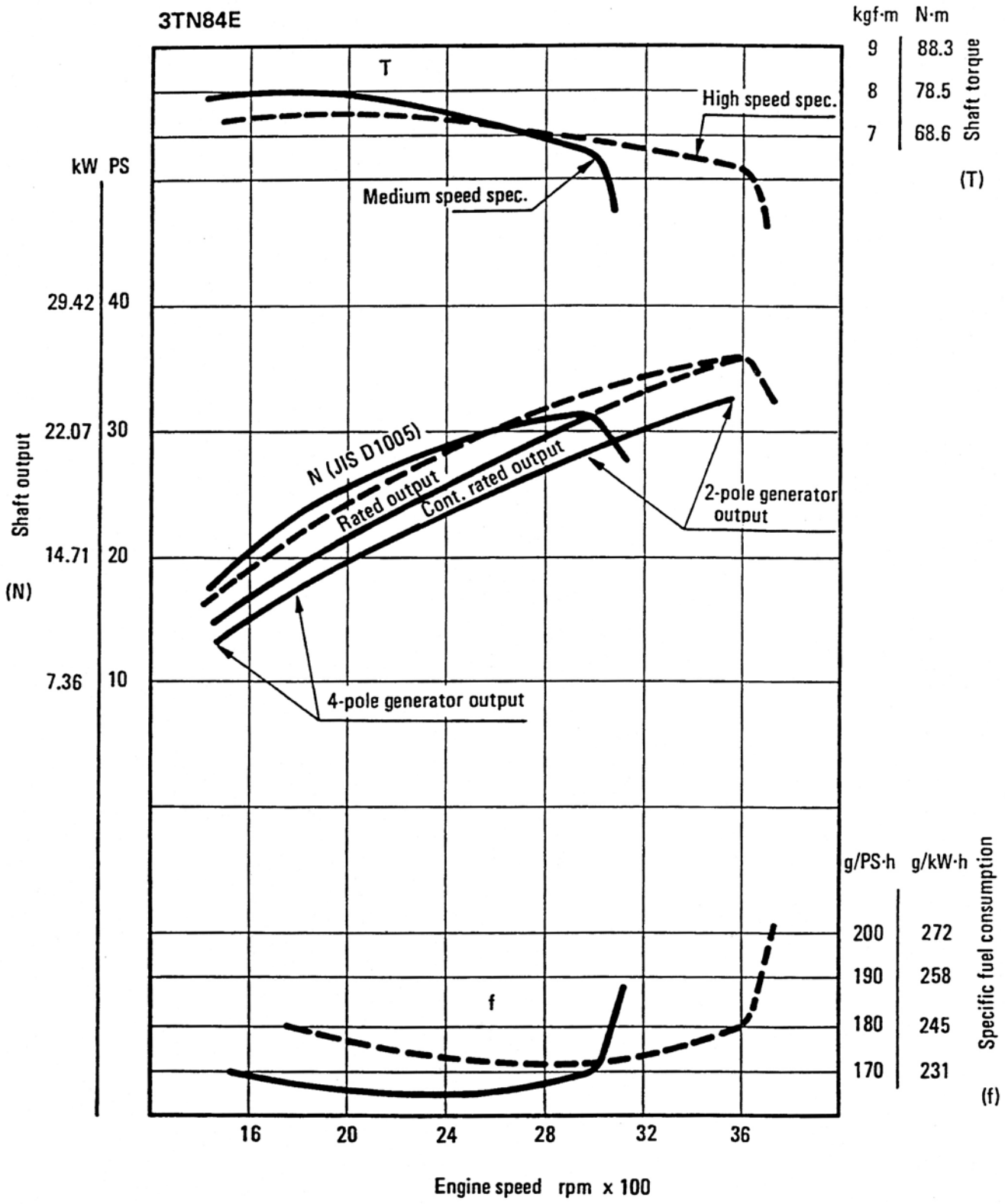


Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

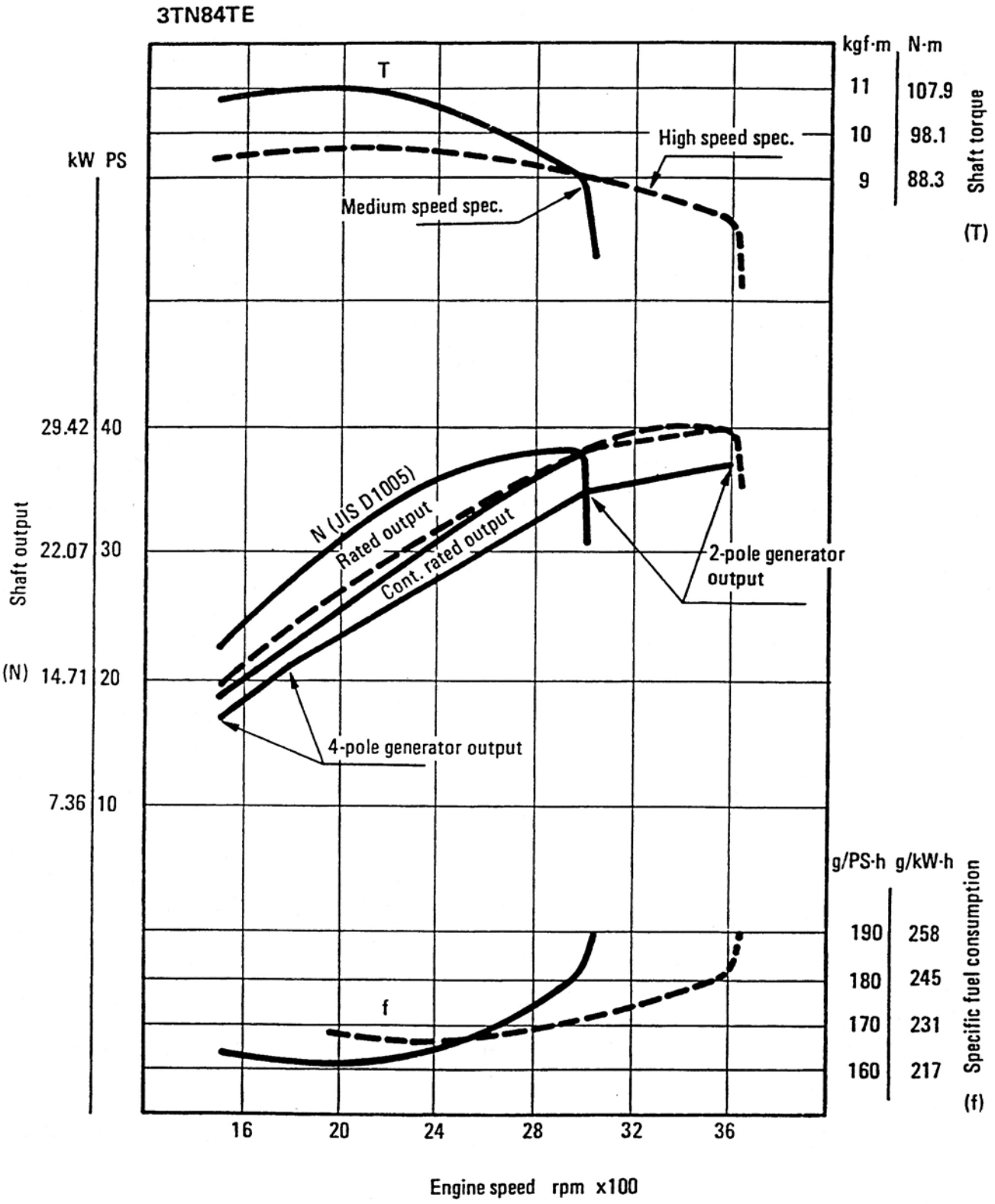
4TN82TE



Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

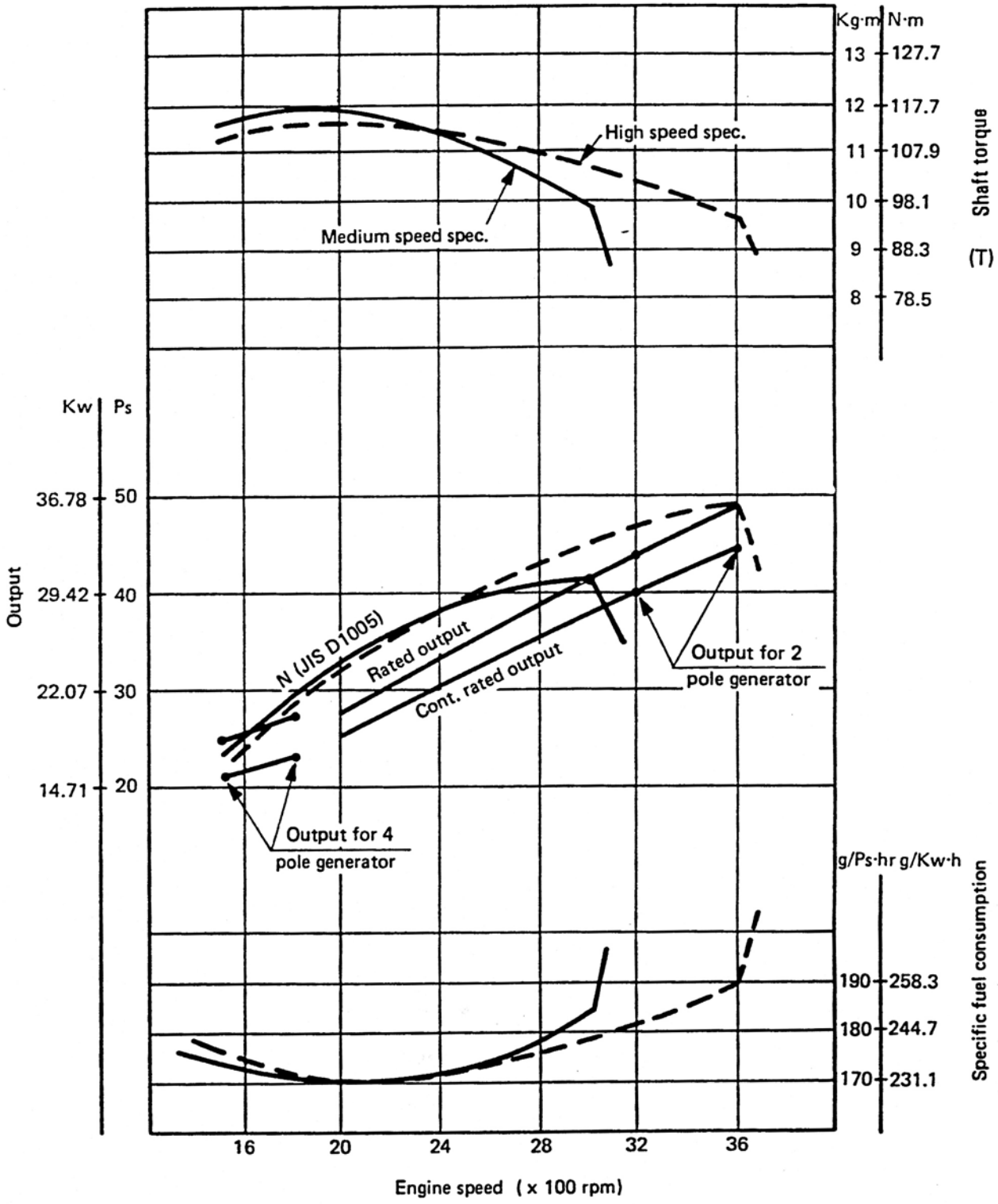


Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.



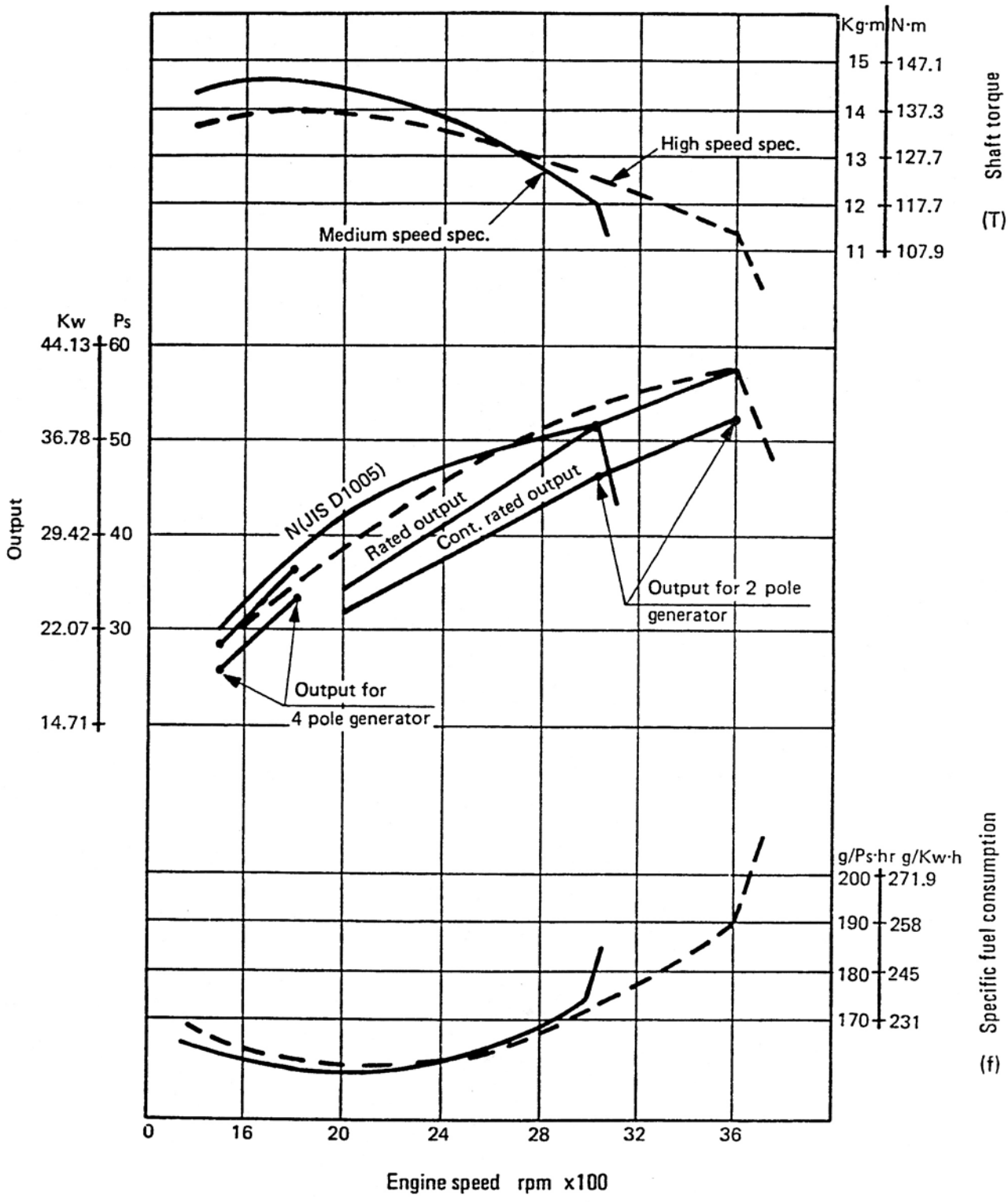
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

4TN84E



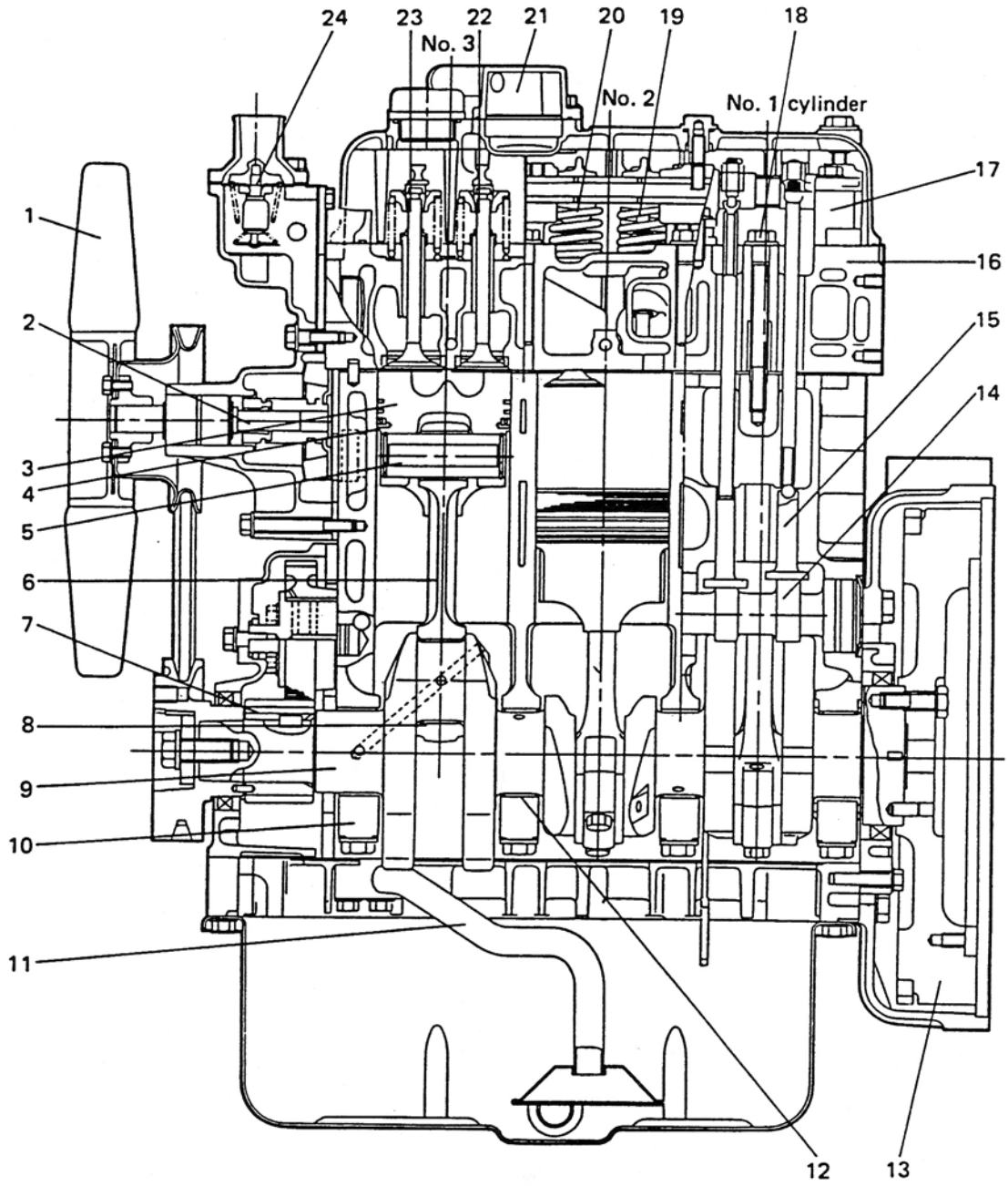
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run-in.

4TN84TE

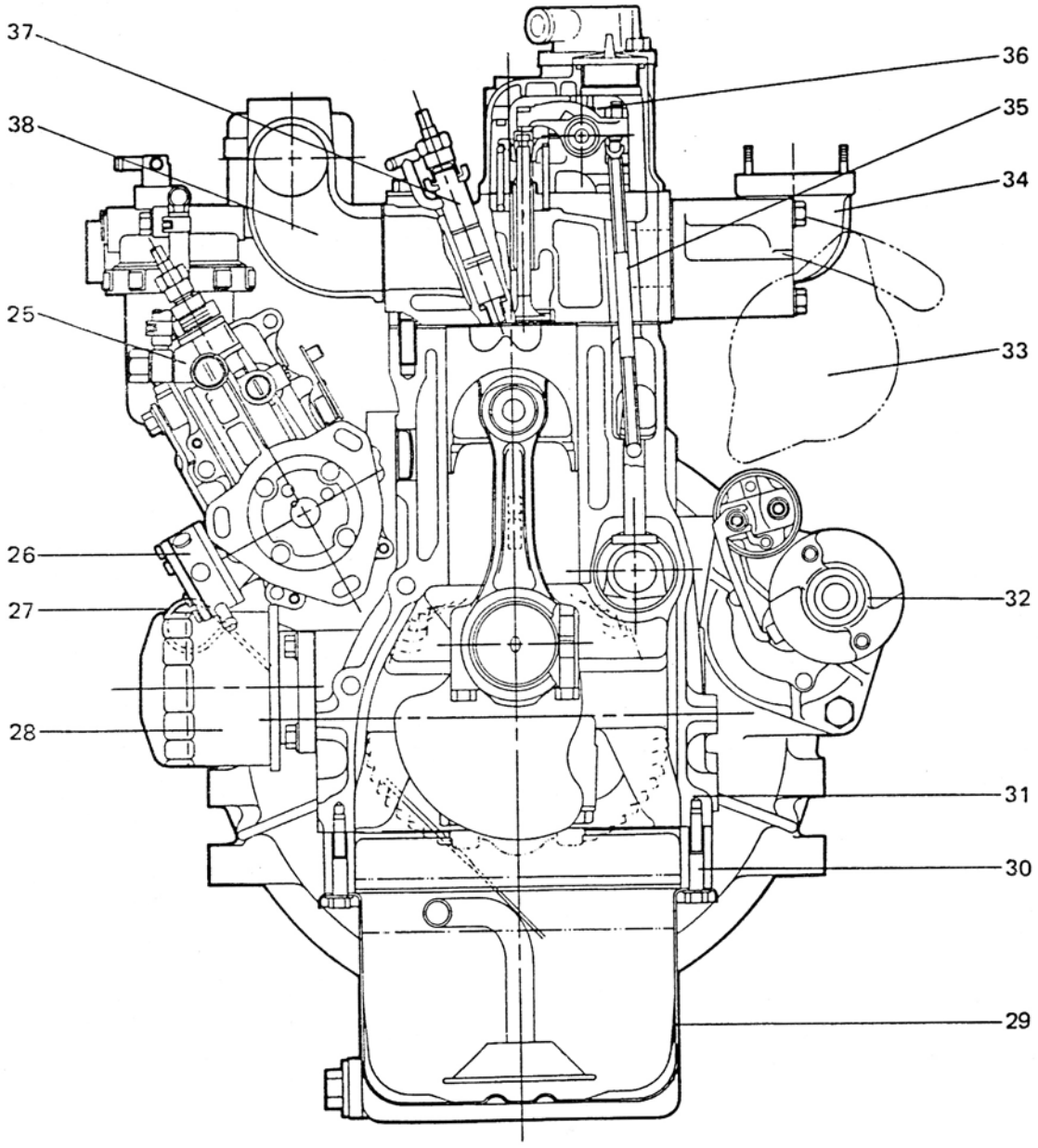


Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514
Intake air temperature: 27°C
Barometric pressure: 750 mmHg
Relative humidity: 60%
The curves show performance after 30 hours run in.

4. Cross Sectional Views



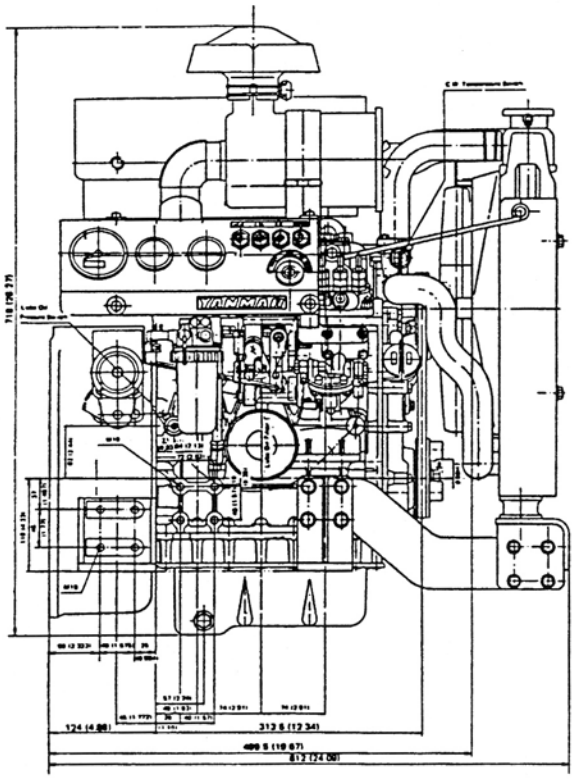
1 Cooling fan
2 Cooling water pump
3 Piston
4 Piston ring
5 Piston pin
6 Connecting rod
7 Crank gear
8 Crank pin bushing
9 Crank shaft
10 Main bearing cap
11 Lubricating oil inlet pipe
12 Main bearing
13 Flywheel
14 Camshaft
15 Tappet
16 Cylinder head
17 Valve rocker arm shaft support
18 Cylinder head bolt
19 Valve spring
20 Valve rocker arm shaft
21 Breather
22 Exhaust valve
23 Intake valve
24 Thermostat

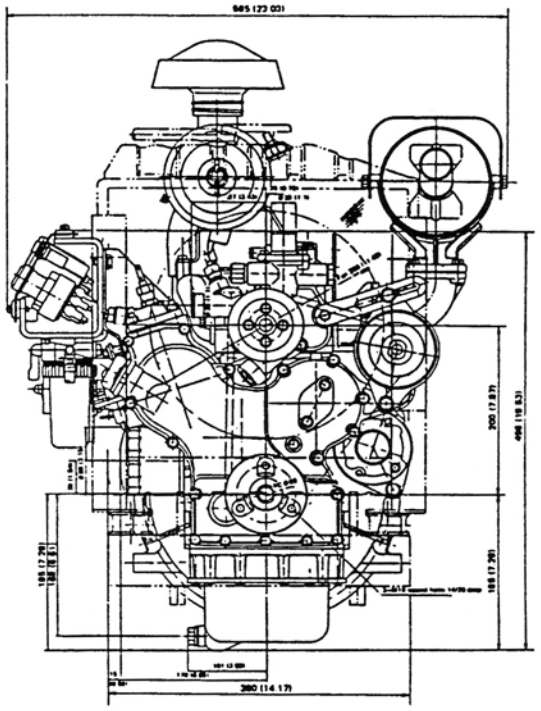


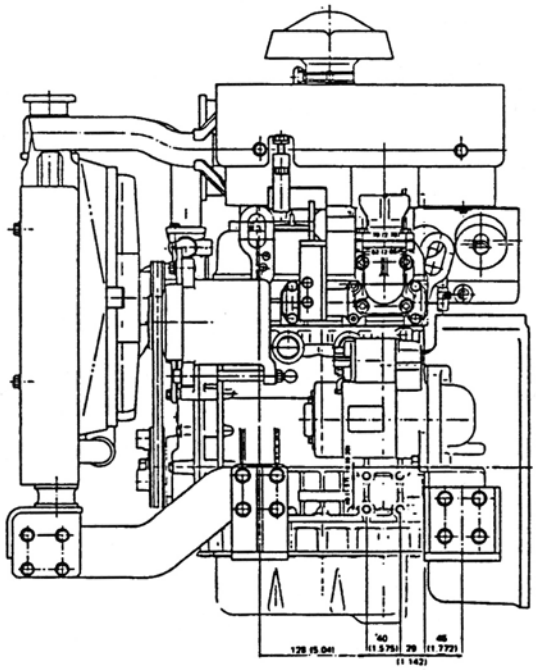
25 Fuel injection pump
26 Fuel feed pump
27 Dipstick
28 Lubricating oil filter
29 Oil pan
30 Oil pan spacer
31 Cylinder block
32 Starting motor
33 Alternator
34 Exhaust manifold
35 Push rod
36 Valve rocker arm
37 Fuel injection nozzle
38 Intake manifold

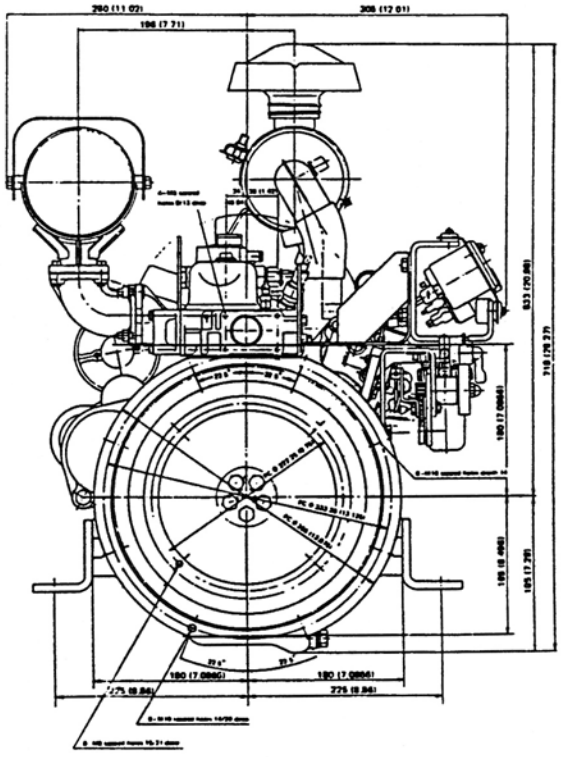
5. Dimensions

3TN66E–S

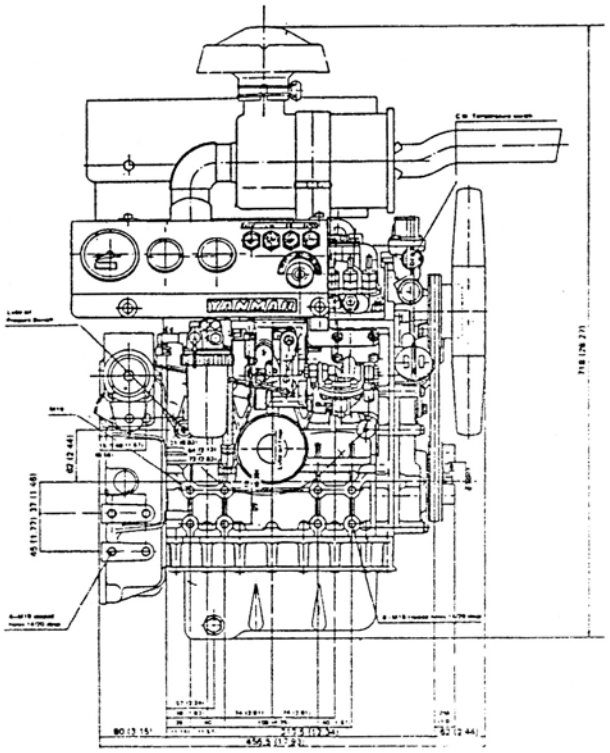


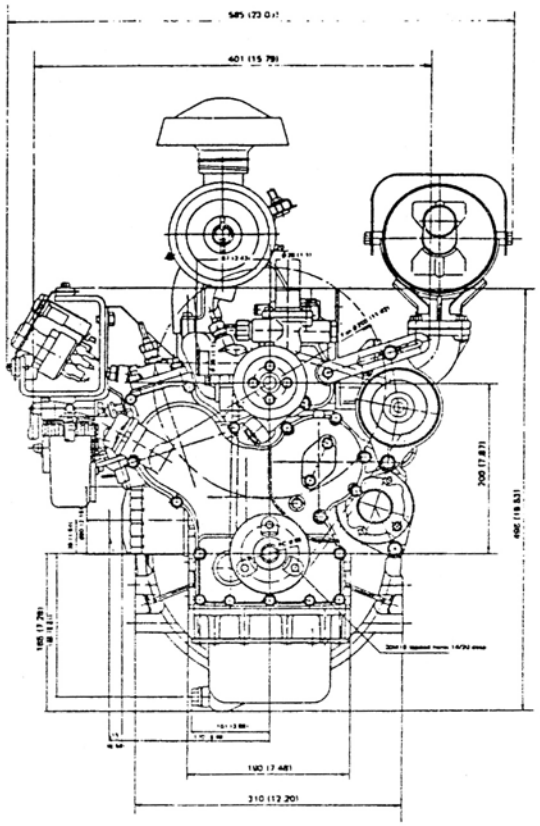


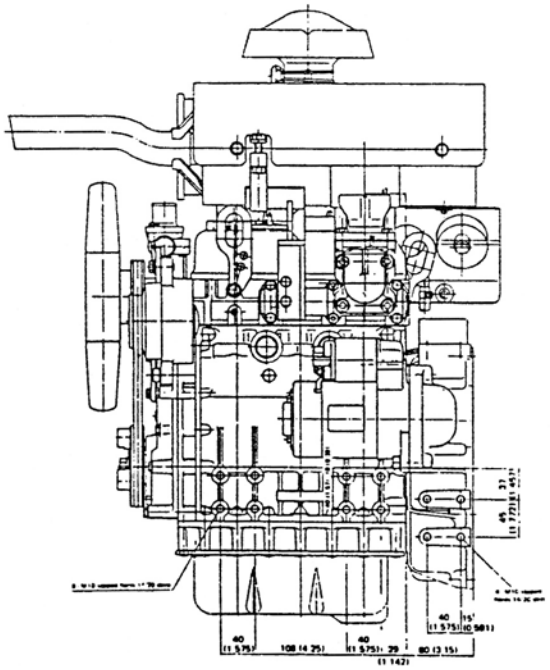


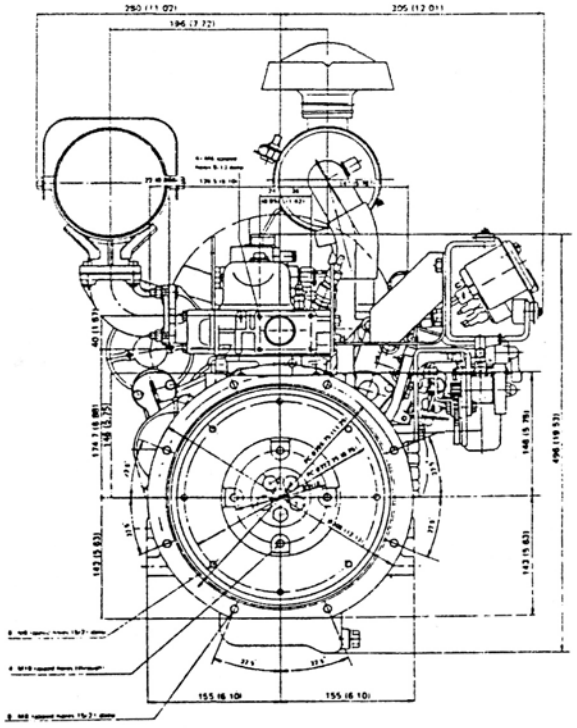


3TN66E–G2

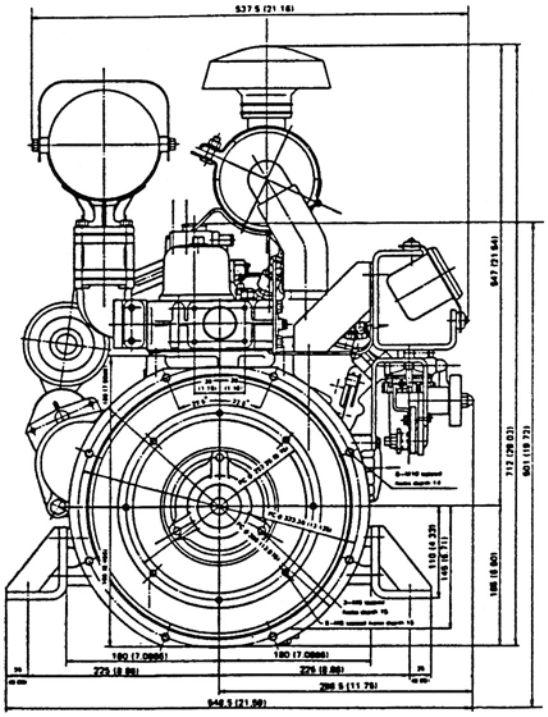


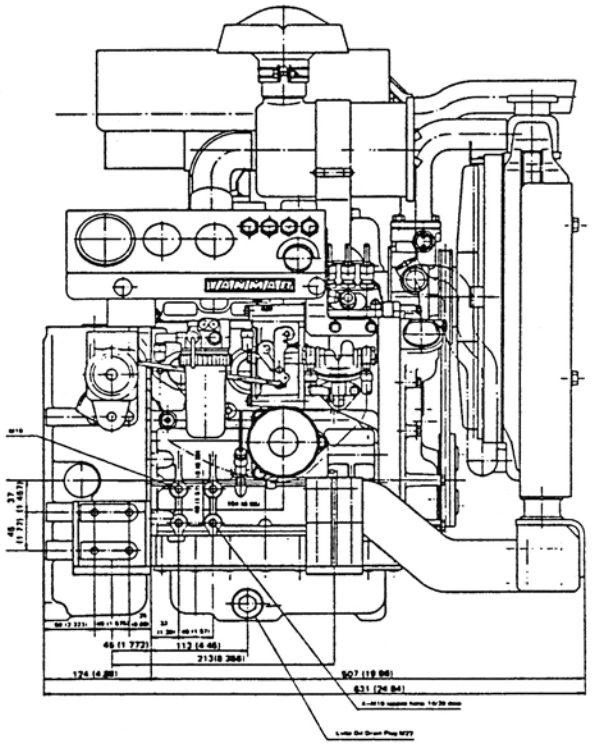






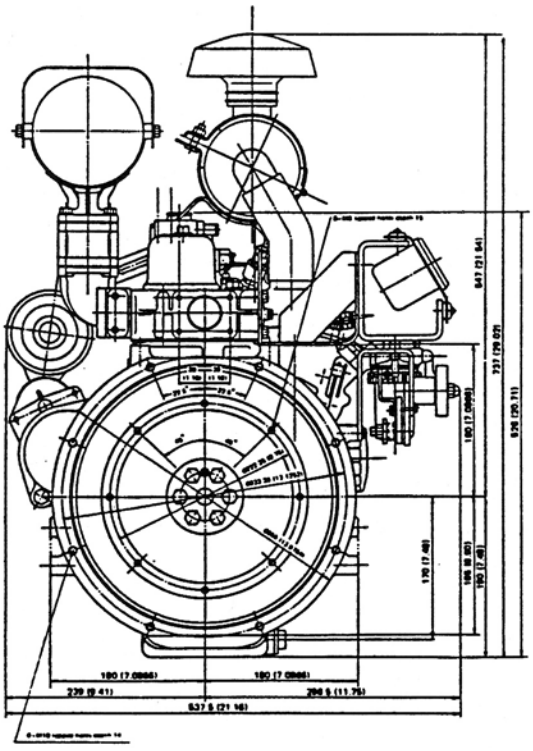
3TNA72E–S

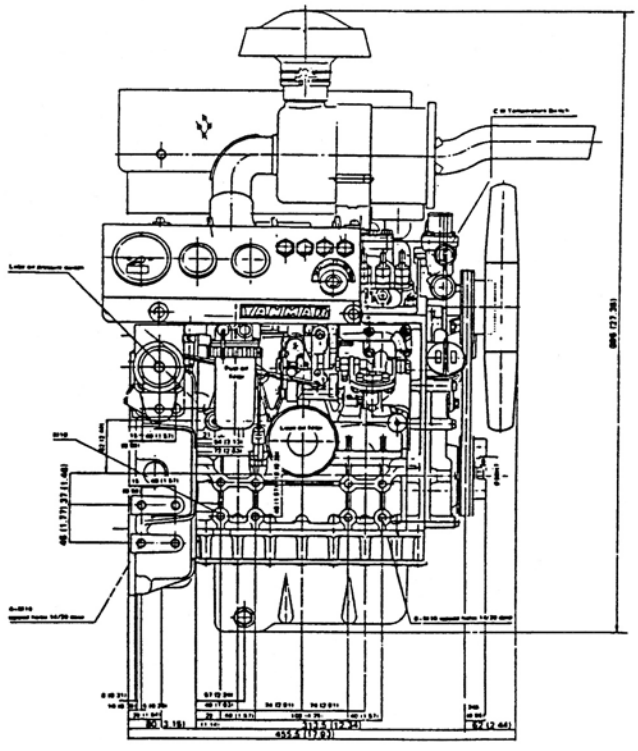




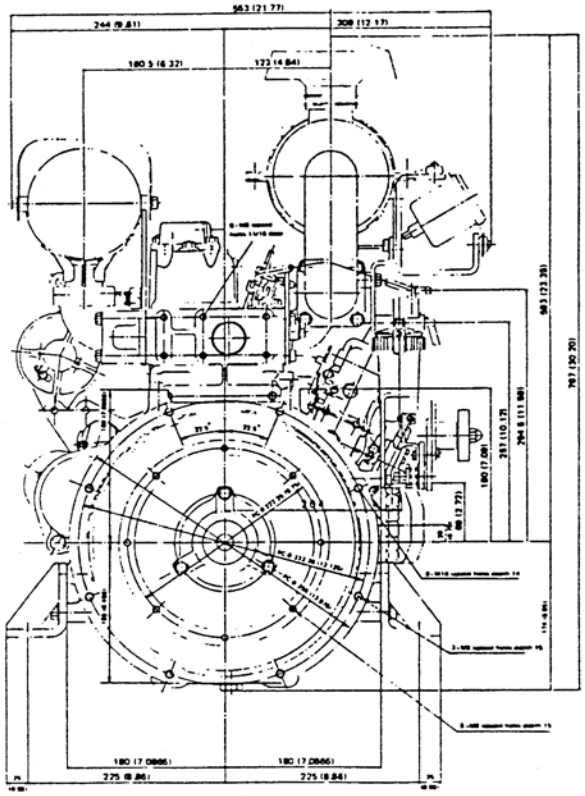
3TNA72E–G2

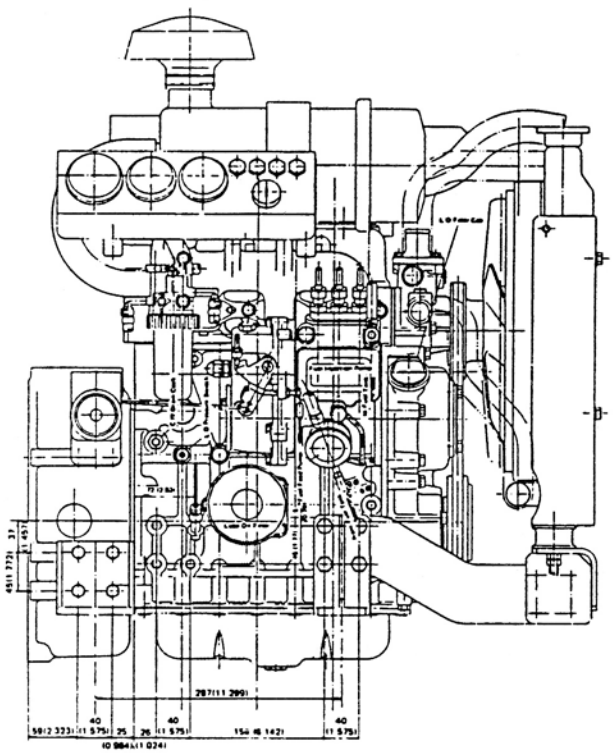
(Power pack)





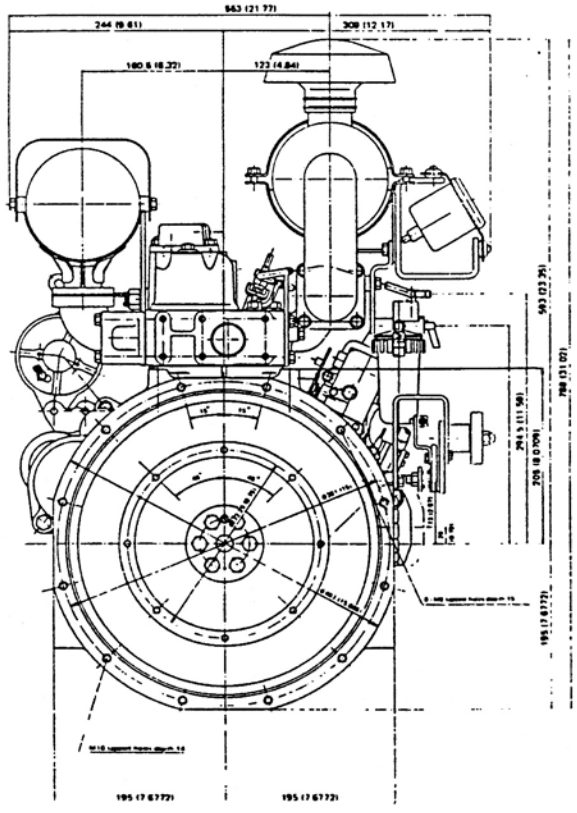
3TN75E–S

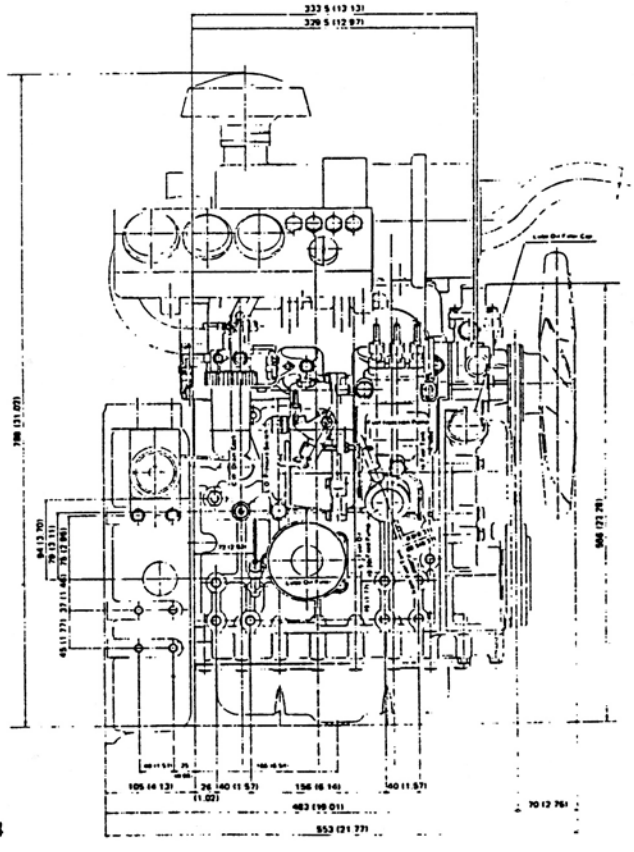




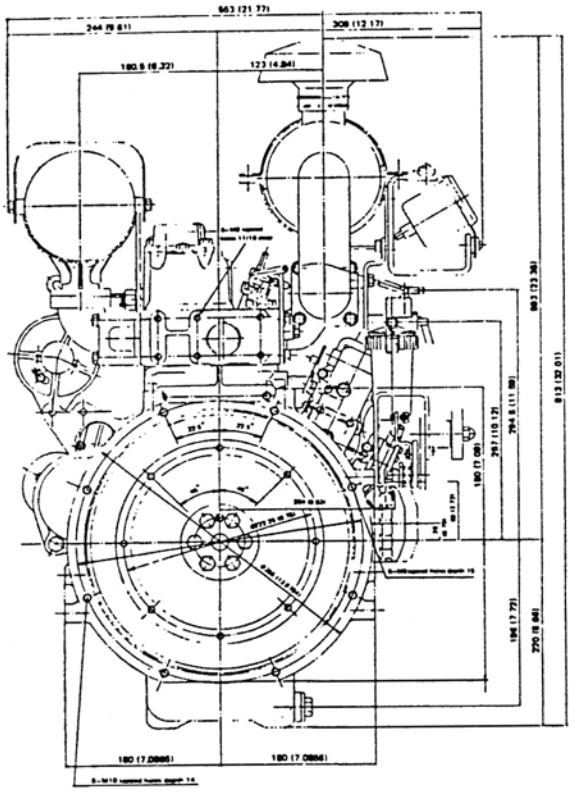
3TN75E–G1

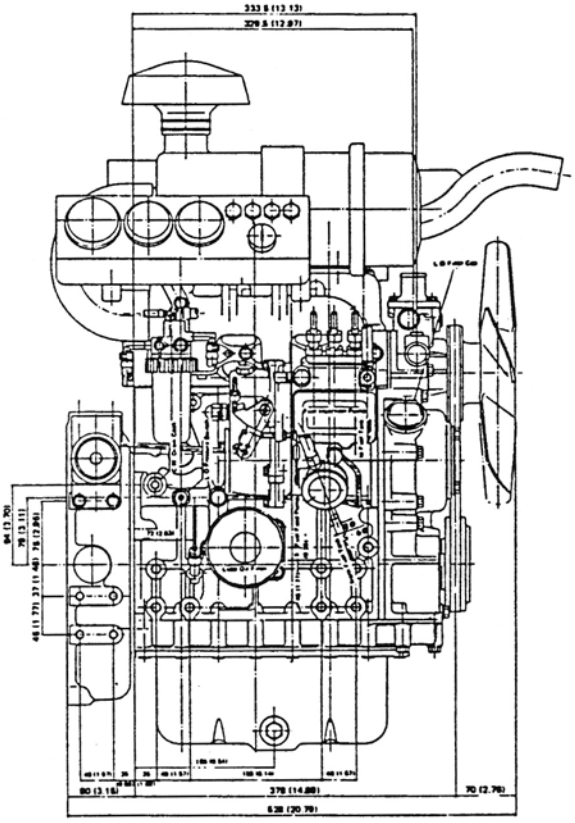
(Power pack)



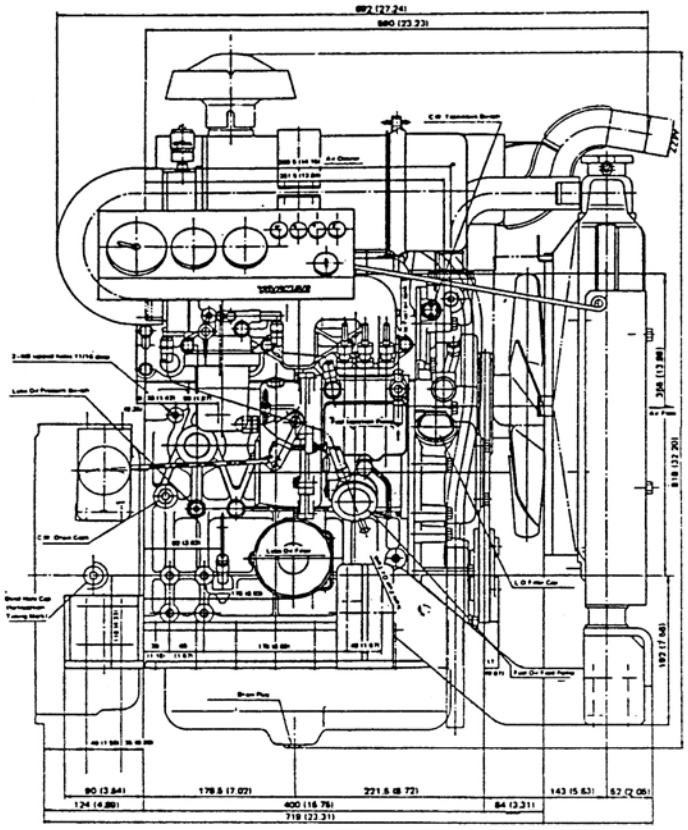


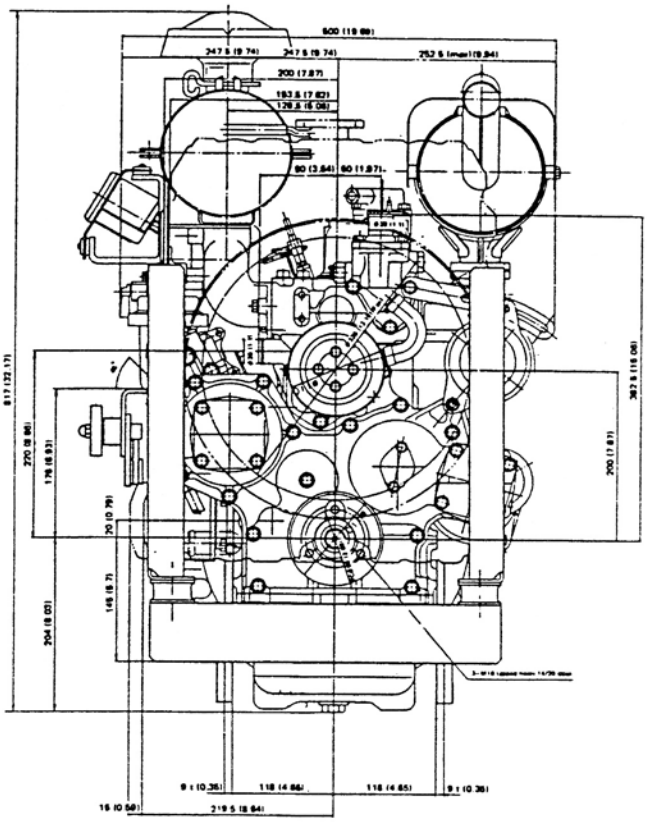
3TN75E–G2

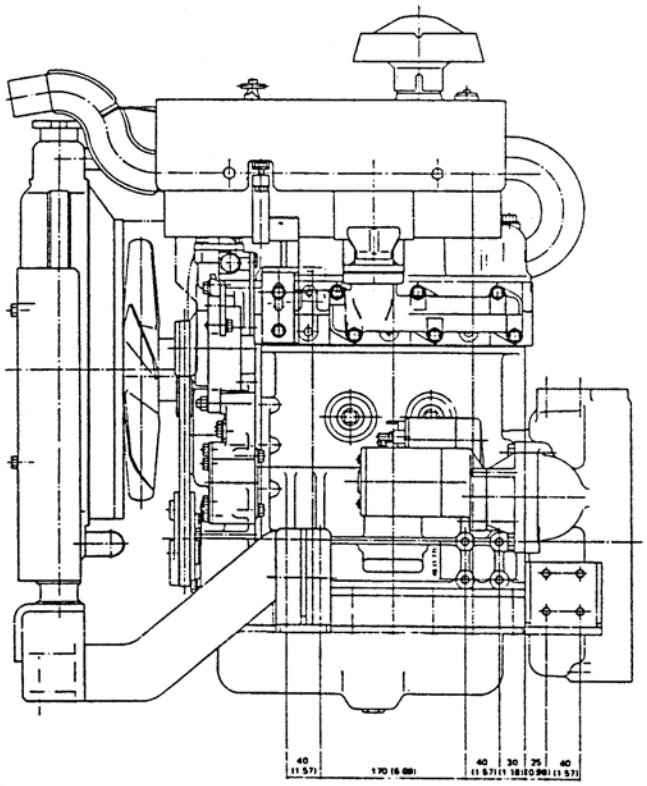


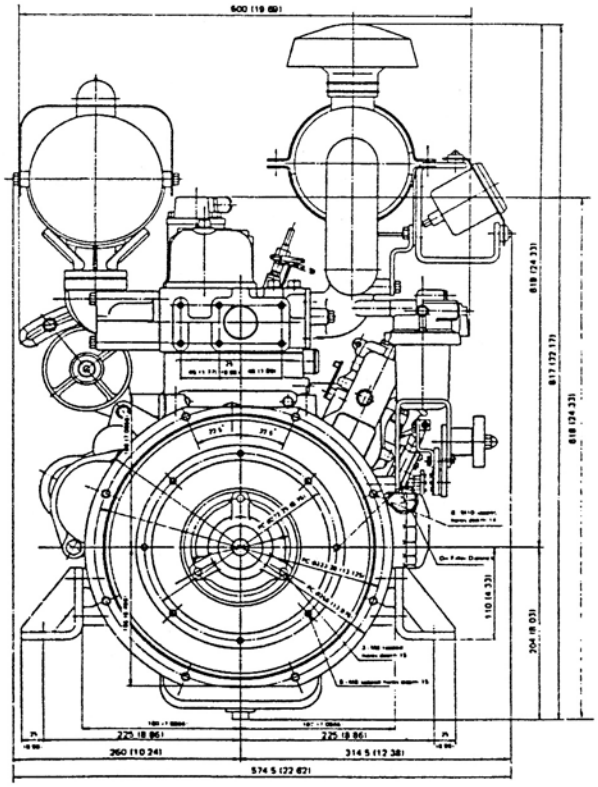


3TN82E–S

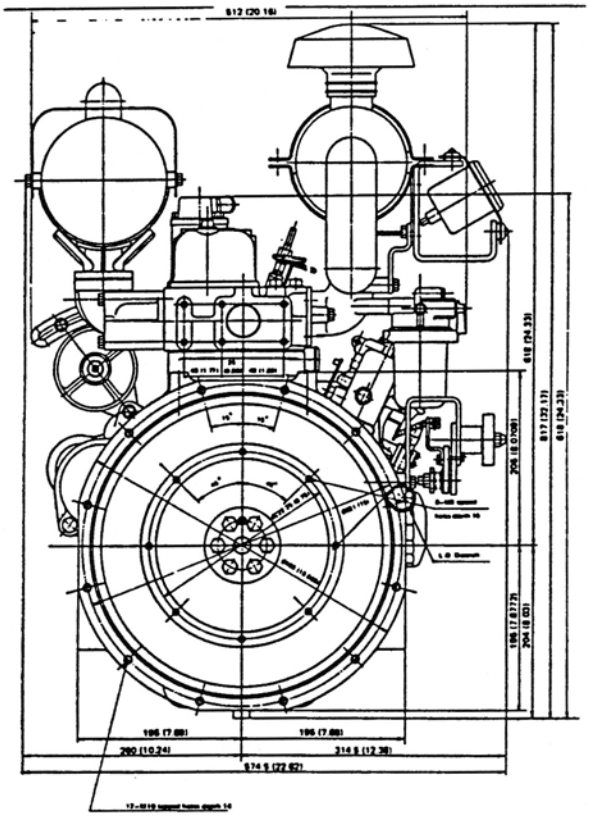


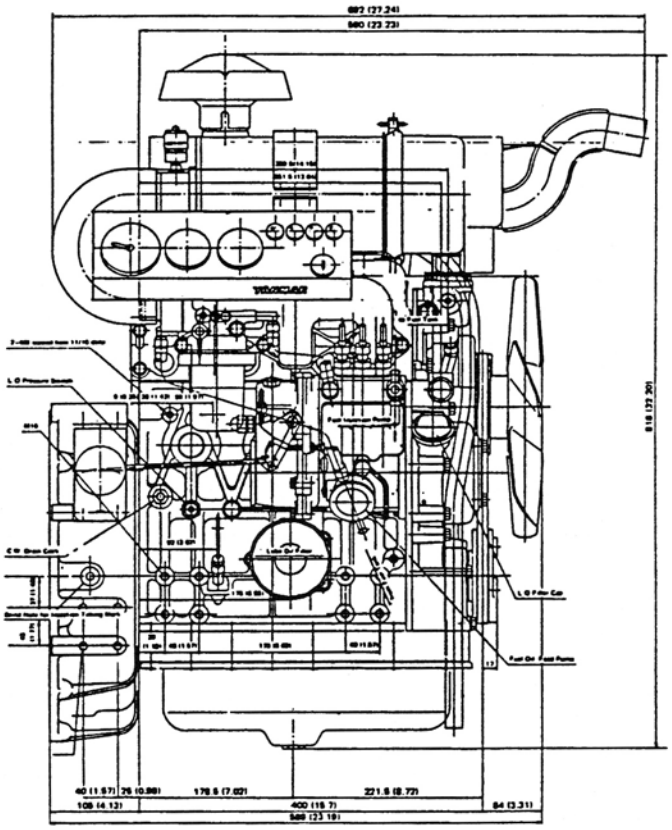




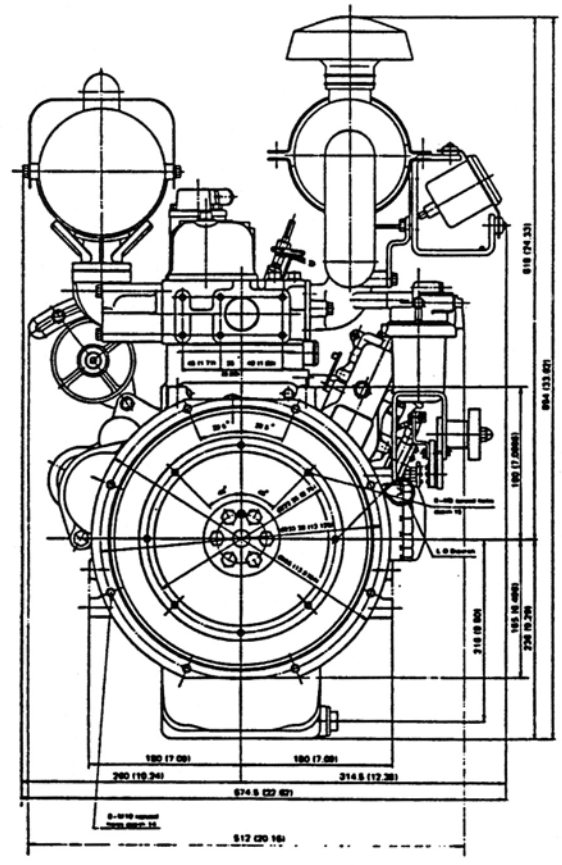


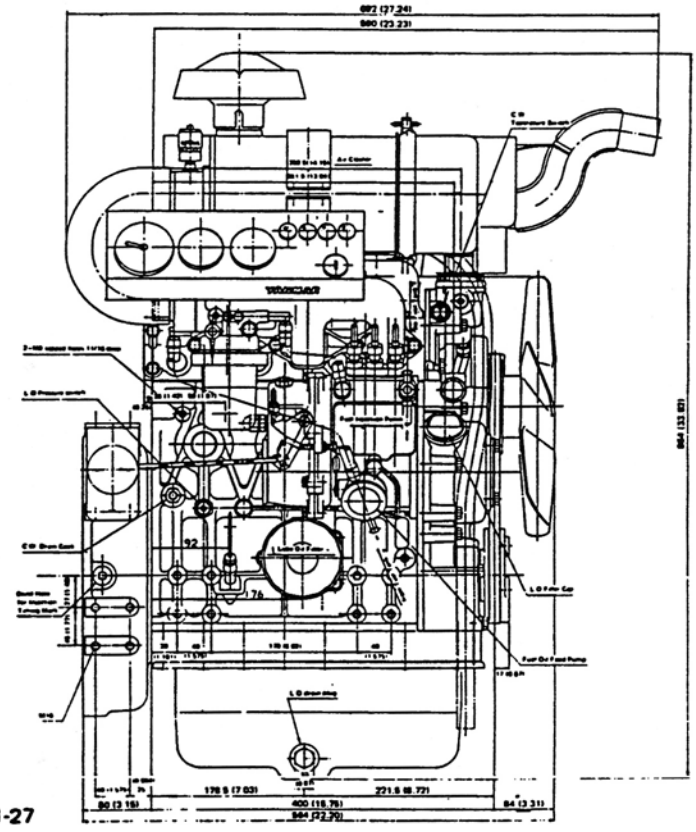
3TN82E–G1



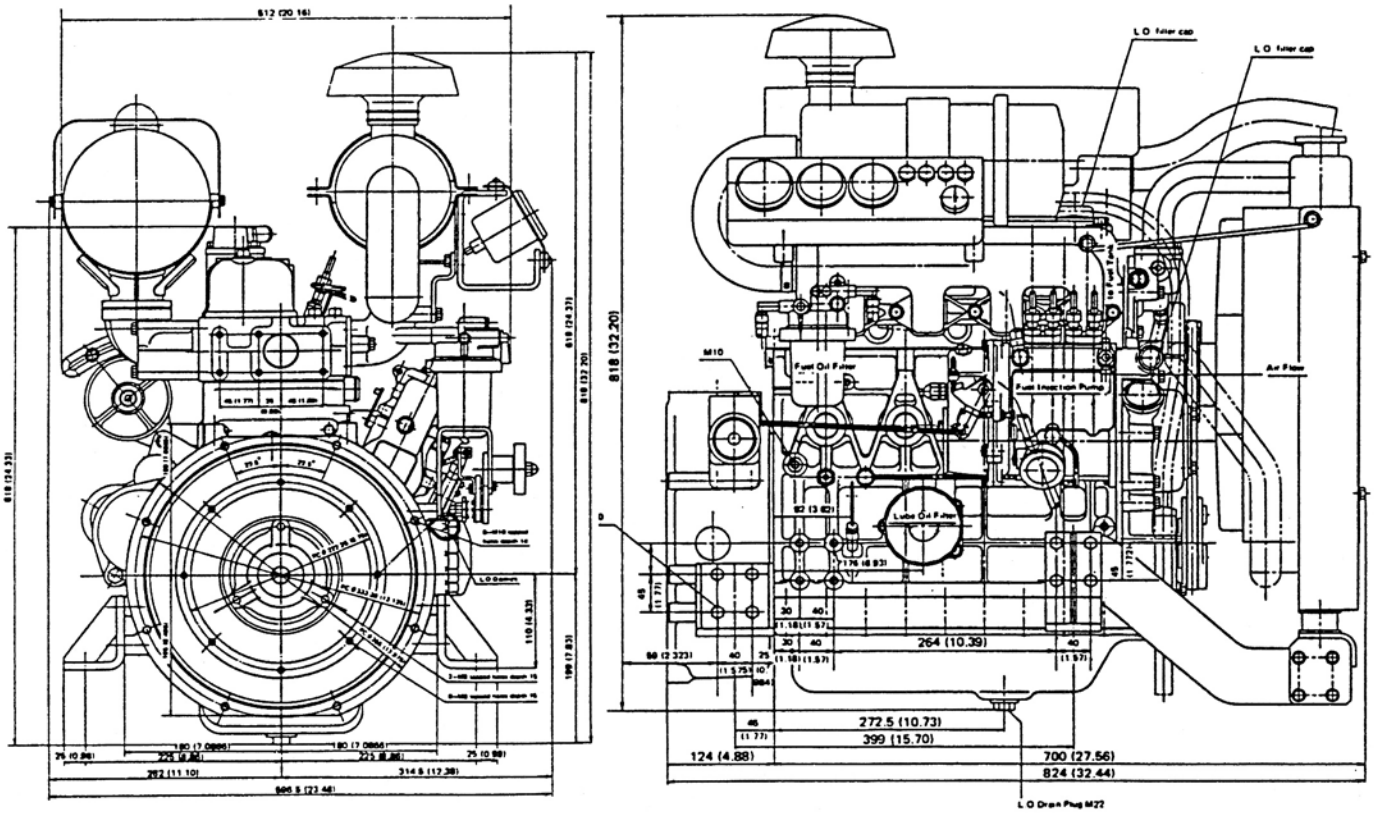


3TN82E–G2
(Power pack)

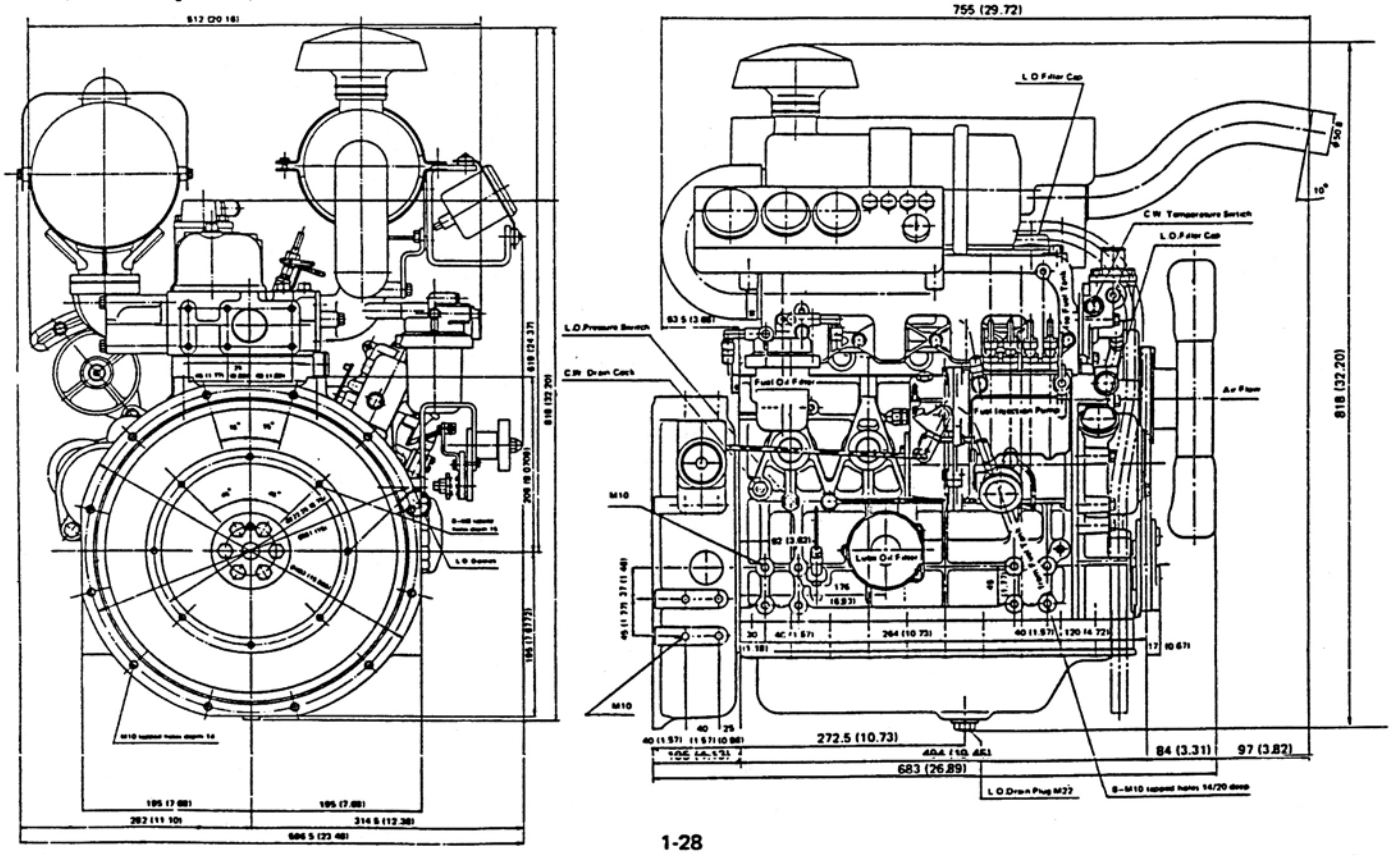




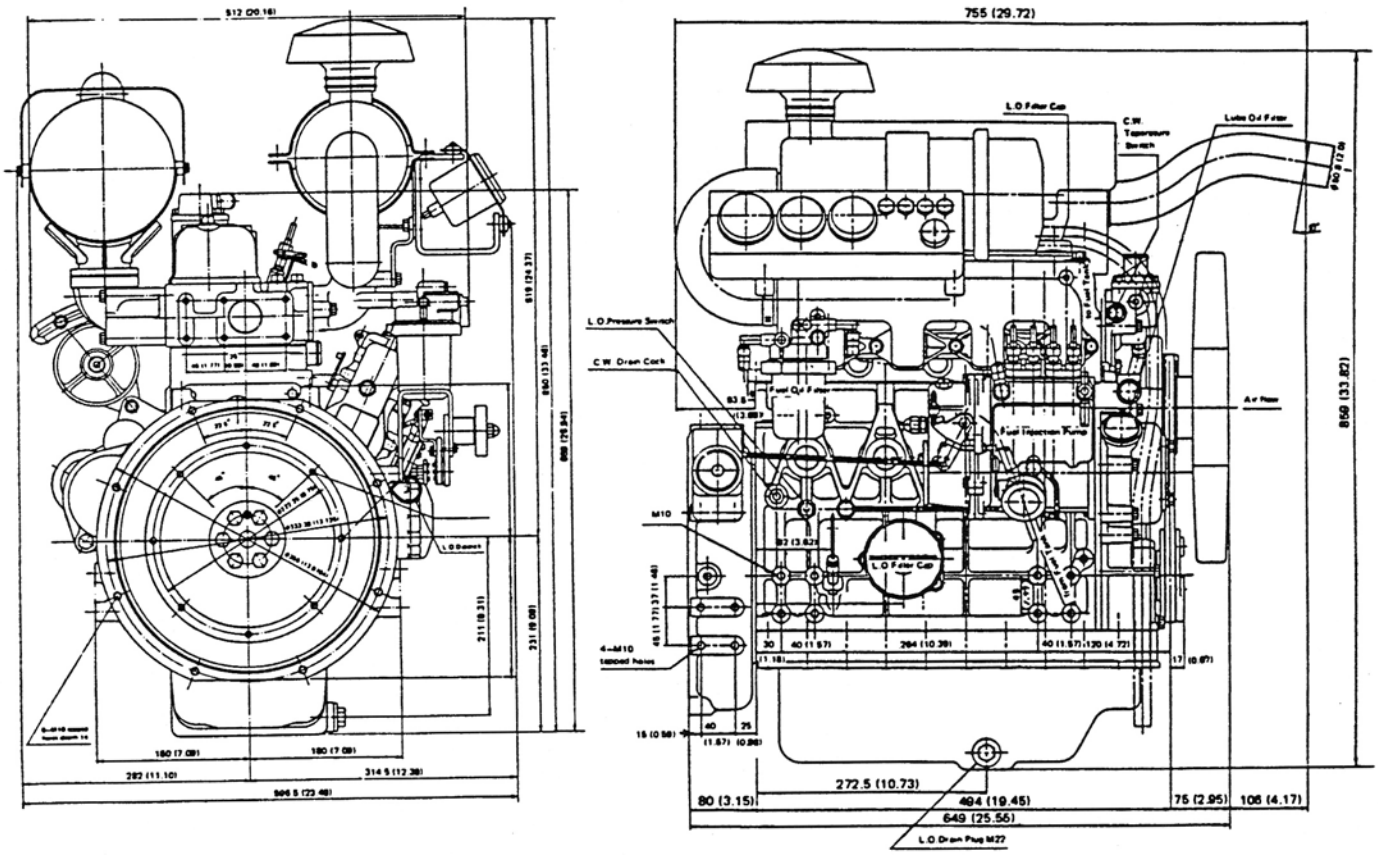
4TN82E–S



4TN82E–G1
(Power pack)



4TN82E–G2


755 (29.72)
L.O Filter Cap
C.W Temperature Switch
Lube Oil Filter
L.O Pressure Switch
C.W Drain Cock
Air Flow
M10
4-M10 tapped holes
859 (33.82)
272.5 (10.73)
80 (3.15)
494 (19.45)
75 (2.95)
106 (4.17)
649 (25.56)
L.O Drain Plug M22

MEMO:

MEMO.

6. Maintenance

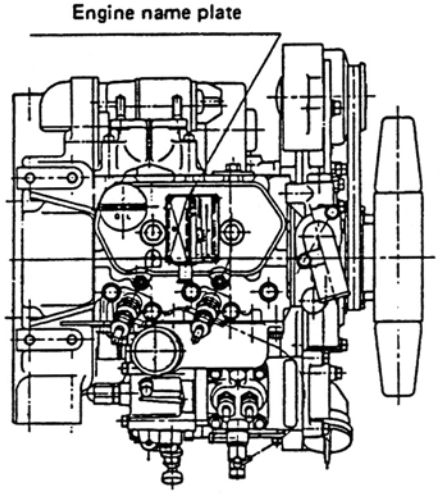
o Maintenance Schedule

In order to insure maximum, trouble-free engine performance at all times, regular inspection, adjustment and maintenance are vital.

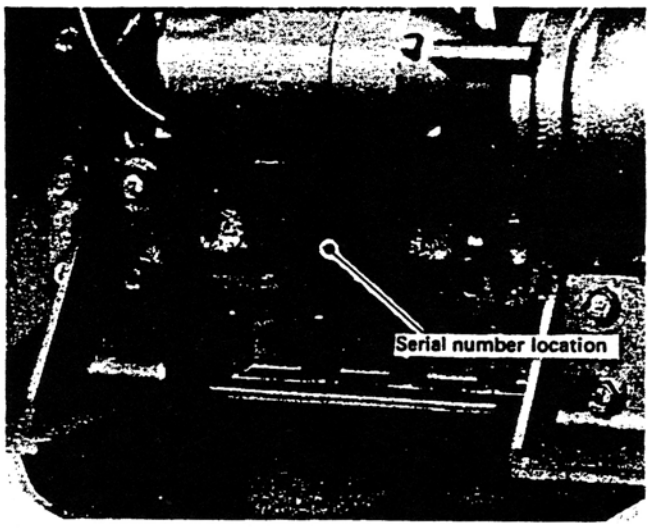
Inspection		Daily	Every 50 hours	Every 100 hours	Every 150 hours	Every 300 hours	Every 500 hours
Fuel System	Check the oil level; fill	O					
	Remove sediment from fuel tank	O					
	Clean and replace the fuel filter element			O First time		O Clean	O Replace
Lubrication system	Check the oil level-crankcase; fill	O					
	Change the lubricating oil		O First time		O		
	Replace the lubricating oil filter element		O First time			O	
Cooling Water	Fill with cooling water, and check for leakage	O					
	Clean the water jacket line					O Clean inside	
	Clean the radiator fins			O			
	Adjust V-belt tension		O First time	O			
Electrical System	Check the battery fluid level; fill	O					
	Check the warning lamps	O					
Air Cleaner	Clean and replace the element			O Clean (every 50 hrs. in dusty areas)			O Replace (every 250 hrs. in dusty areas)
Cylinder Heads, etc.	Retighten all nuts and bolts		O First time (Retighten every 2 years)				
	Adjust intake/exhaust valve clearances					O	
Fuel Injection System	Check for any abnormal fuel injection sound	O					
	Check the injection nozzles					O	
	Check fuel injection timing						O
Retighten all major nuts and bolts			O First time (Retighten every 2 years)				

7. SERIAL NUMBER LOCATION

The serial number is stamped on the engine name plate. Always specify this number when inquiring about the ordering parts in order to get correct parts for the engine being serviced.

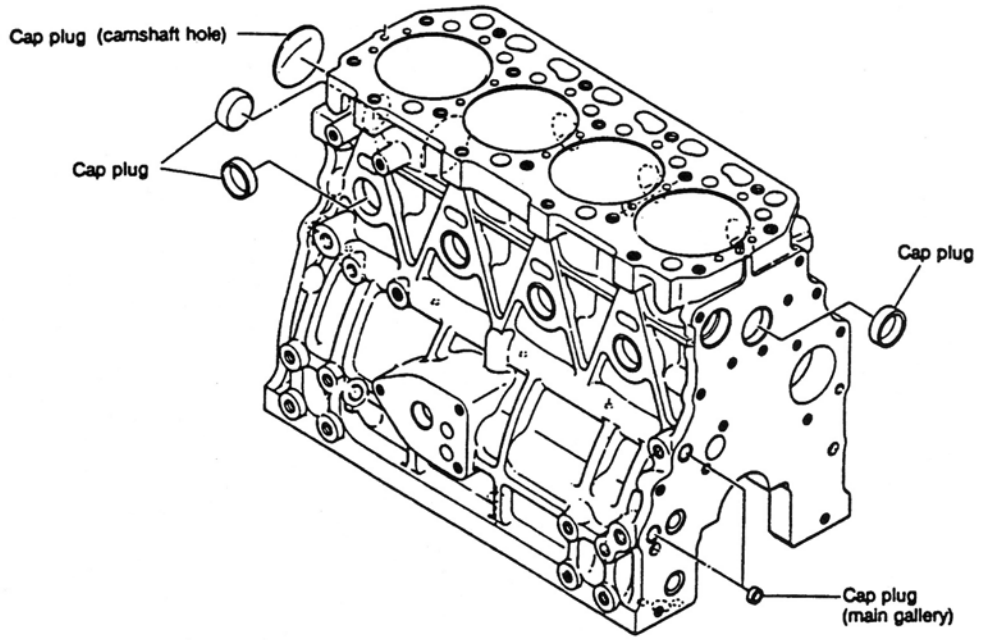


Serial number location of engine supplied to specific OEM



1. Cylinder Block

The cylinder block is thin-skinned, (low-weight), short skirt type with rationally placed ribs. The side walls are wave shaped to maximize ridigity for strength and low noise.



1-1 Inspection of parts

Make a visual inspection to check for cracks on engines that have frozen up, overturned or otherwise been subjected to undue stress. Perform a color check on any portions that appear to be cracked, and replace the cylinder block if the crack is not repairable.

1-2 Cleaning of oil holes

Clean all oil holes, making sure that none are clogged up and the blind plugs do not come off.

Color check kit
Part code No. 97550-004560

	Quantity
Penetrant	1
Developer	2
Cleaner	3

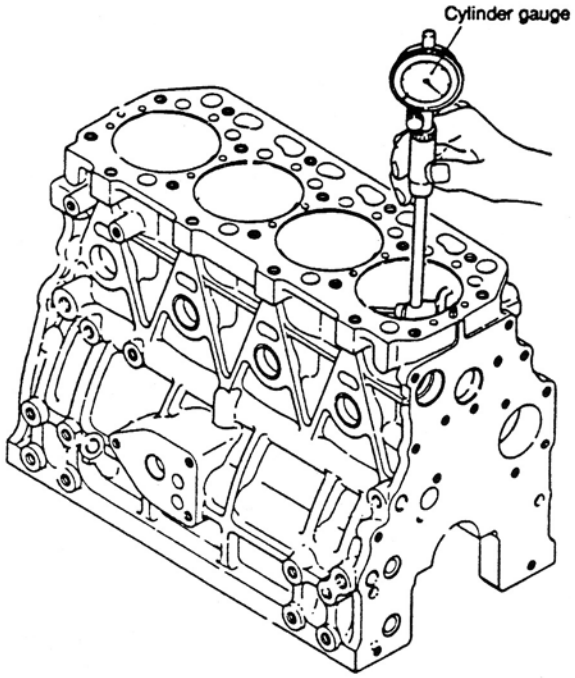
1-3 Color check procedure

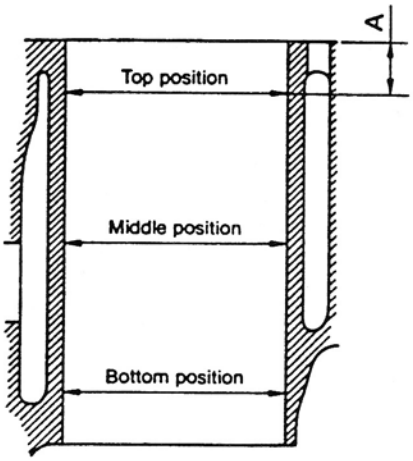
(1) Clean the area to be inspected.
(2) Color check kit
The color check test kit consists of an aerosol cleaner, penetrant and developer.
(3) Clean the area to be inspected with the cleaner.
Either spray the cleaner on directly and wipe, or wipe the area with a cloth moistened with cleaner.
(4) Spray on red penetrant
After cleaning, spray on the red penetrant and allow 5 ~ 10 minutes for penetration. Spray on more red penetrant if it dries before it has been able to penetrate.
(5) Spray on developer
Remove any residual penetrant on the surface after the penetrant has penetrated, and spray on the developer. If there are any cracks in the surface, red dots or a red line will appear several minutes after the developer dries.
Hold the developer 300 ~ 400mm (11.8110 ~ 15.7480in.) away from the area being inspected when spraying, making sure to coat the surface uniformly.
(6) Clean the surface with the cleaner.

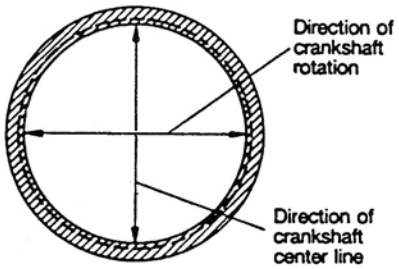
Note: Be sure to read the instruction for the color kit before use.

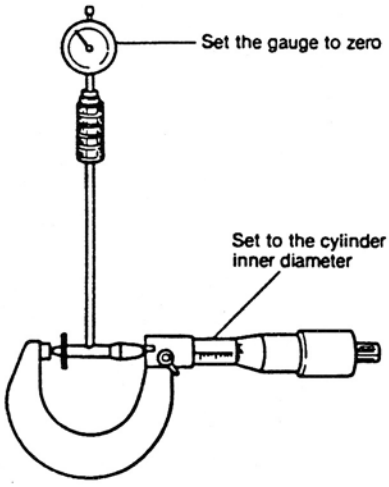
1-4 Cylinder bore measurement

Measure the bore diameter with a cylinder gauge at the positions shown in the figure.
Replace the cylinder bore when the measured value exceeds the wear limit. Measurement must be done at least at 3 positions as shown in the figure, namely, top, middle and bottom positions in both directions along the crankshaft rotation and crankshaft center lines.









mm (in.)

	Standard	Wear limit
Cylinder bore dia.	*See separate service data (Page 2-30, 31)*	
Cylinder roundness		

1-5 Sleeveless cylinder

1-5.1 Features of sleeveless construction

(1) Improved reliability for tightness of combustion gas, cooling water, and lubricating oil.
The sleeveless design permits tightening a cylinder head gasket evenly between the flat surface of the cylinder block and of the cylinder head, thereby improving tightness.
(2) The sleeveless design has eliminated increase in lubricating oil consumption and blow-by caused by deformed or defective sleeves, thus assuring stabilized engine performance.
(3) "Sleeveless" cooling improves the cooling efficiency of the piston and ring, with enhanced engine durability.

1-5.2 Durability of the sleeveless engine

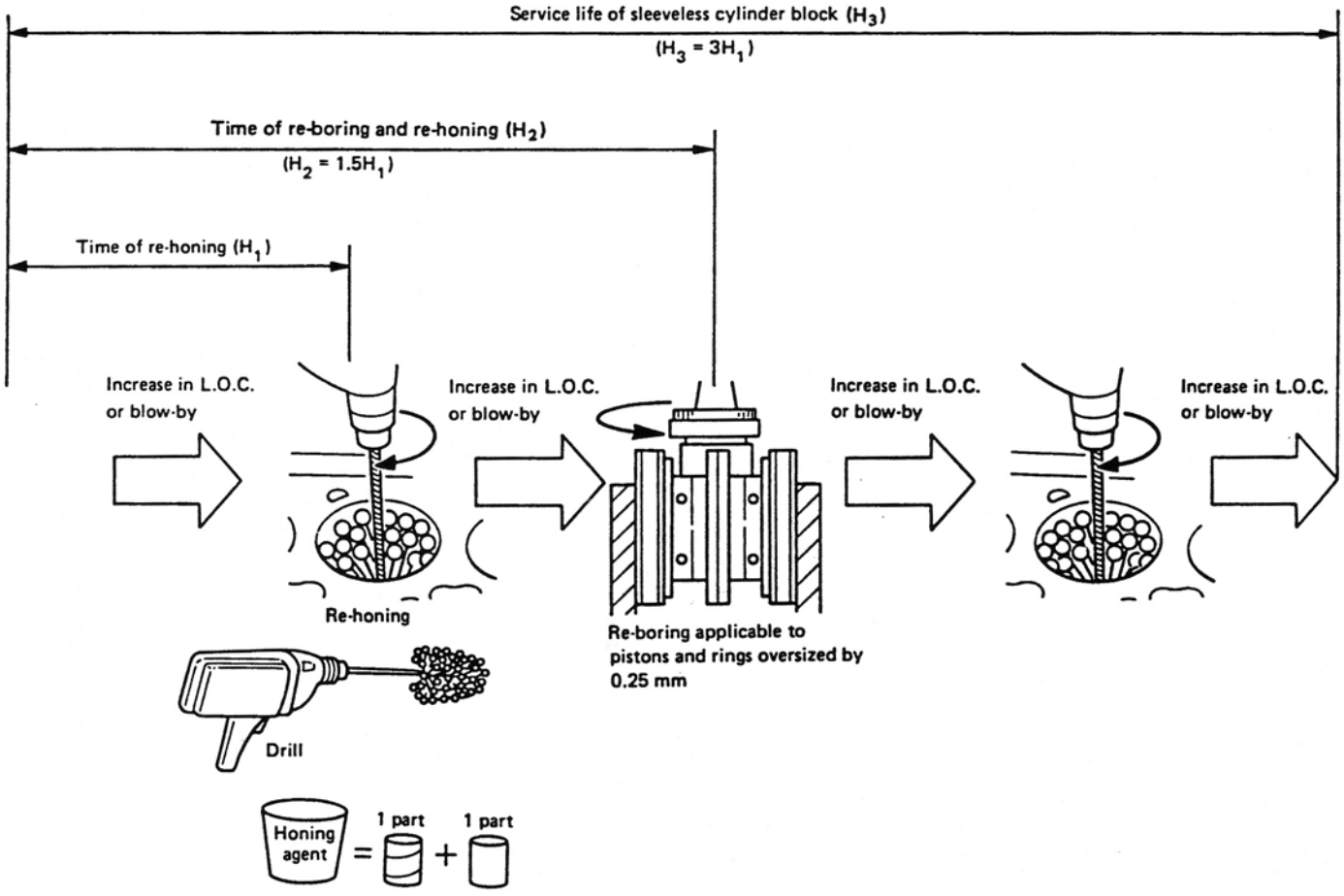
The conventional models of engine (T and TH Series) are equipped with wet liners or sleeves to the standard specification. Tests in Yanmar Laboratory have proven that the sleeveless engine is improved in wear resistance by about 20% as compared with the conventional T and TH Series engine, which have long and widely been used and marked fair durability in the market.
A decision should be made as to whether the sleeveless engine requires overhauling by checking increase in lubricating oil consumption or blow-by indicates rapid change.

1-5.3 Overhaul procedure

Following figure shows the time of the first to third overhauling and, the service life of the sleeveless cylinder together with necessary honing or boring.

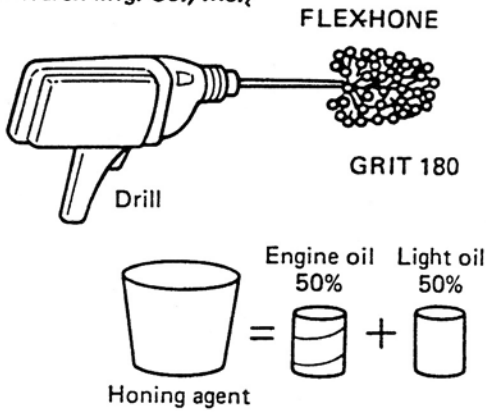
(1) How to re-hone the sleeveless cylinder
Prepare a motor-driven drill, "Flex-Hone", and honing fluid.

Overhaul of Cylinder

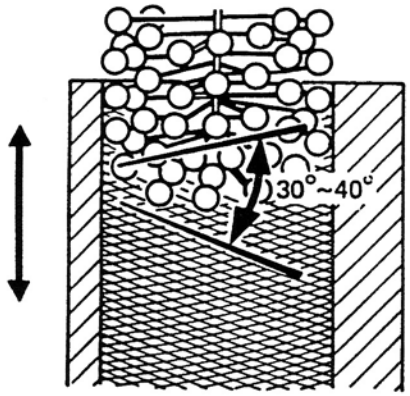


Rehorning tool / Model	Size type	Grain size	FLEX-HONE Granular grindstone type	Applicable boring dia. (mm)
2·3TN66E	GB70	GRIT 180	Silicon carbide (for cast iron)	63–70
3TNA72E 3TN75E	GB76			70 – 76
3TNC78E 3,4TN82E 3,4TN82TE 3,4TN84 (T)E	GB89			76 – 89

The "Flex-Hone" is commercially available, and is ready for shipment from Yanmar on request. (Manufacturer: Brush Research Mfg. Co., Inc.)



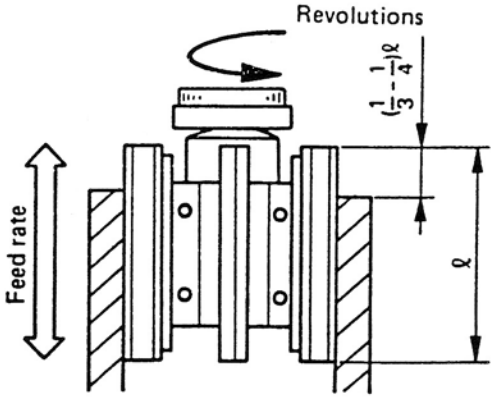
Applying the honing fluid to the Flex-Hone. Insert the Flex-Hone while turning it, and move it up and down for about 30 sec so that a cross hatch angle becomes 30° to 40°. Extract the Flex-Hone while turning it.



(2) How to re-bore the sleeveless cylinder.
Carry out fine boring before honing.
Use a hone consisting of the GC grain (green carborundum) of grain size of #300, and vitrified bond (bonding agent). Select the revolutions and feed rate of honing according to the following table.

	Revolutions (rpm)	Feed Rate (m/min)
2·3TN66E	300 – 330	18 – 21.5
3TNA72E	280 – 310	
3TN75E 3TNC78E	250 – 290	
3,4TN82(T)E 3,4TN84(T)E	230 – 260	

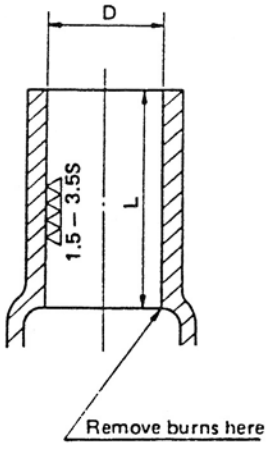
(The above table provides a cross hatch angle of 35° ±5°)



NOTE: Commence honing when 1/3 – 1/4 of the length of the grinding wheel protrudes from the top of the cylinder, and continue until 1/3 – 1/4 protrudes from the bottom.

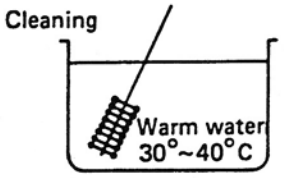
Finally bore the cylinder and hone to the cylinder inside diameter, D, in the following table.

	Cylinder I.D. after fine boring (mm)	Cylinder I.D.(D) after honing (mm)	Length along cylinder I.D. (L) (mm)
2,3TN66E	66.22	$66.25^{+0.030}_{0}$	108.3
3TNA72E	72.22	$72.25^{+0.030}_{0}$	122.7
3TN75E	75.22	$75.25^{+0.030}_{0}$	138.7
3TNC78E	78.22	$78.25^{+0.030}_{0}$	138.7
3,4TN82(T)E	82.22	$82.25^{+0.030}_{0}$	150.5
3,4TN84(T)E	84.22	$84.25^{+0.03}_{0}$	150.5

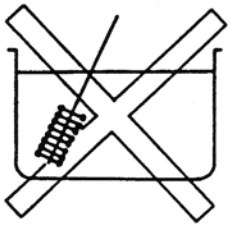


1-5.4 Handling of FLEX-HONE

- Use the Flex Hone by mounting it on a motor-driven (stepless variable speed,) drill.
- Use soluble type grinding fluid for grinding. Do not employ dry type grinding. Use neither emulsion type grinding fluid nor patroleum-base (wash oil) grinding fluid.
- After grinding, be sure to clean the grain ball in warm water of about 30° – 40°C using a bristled brush or the like. Do not store the grain ball with chipping powder or worn grain particles left deposited. Otherwise, grinding capacity decreases.
- The Flex Hone is intended only for wet type grinding. Nover use it for the dry type grinding purpose.



- Never keep the Flex Hone immersed in thinner, gasoline, gas oil, etc. Be sure to keep it dry for storage. Otherwise, the binder of grain particles is inversely influenced.



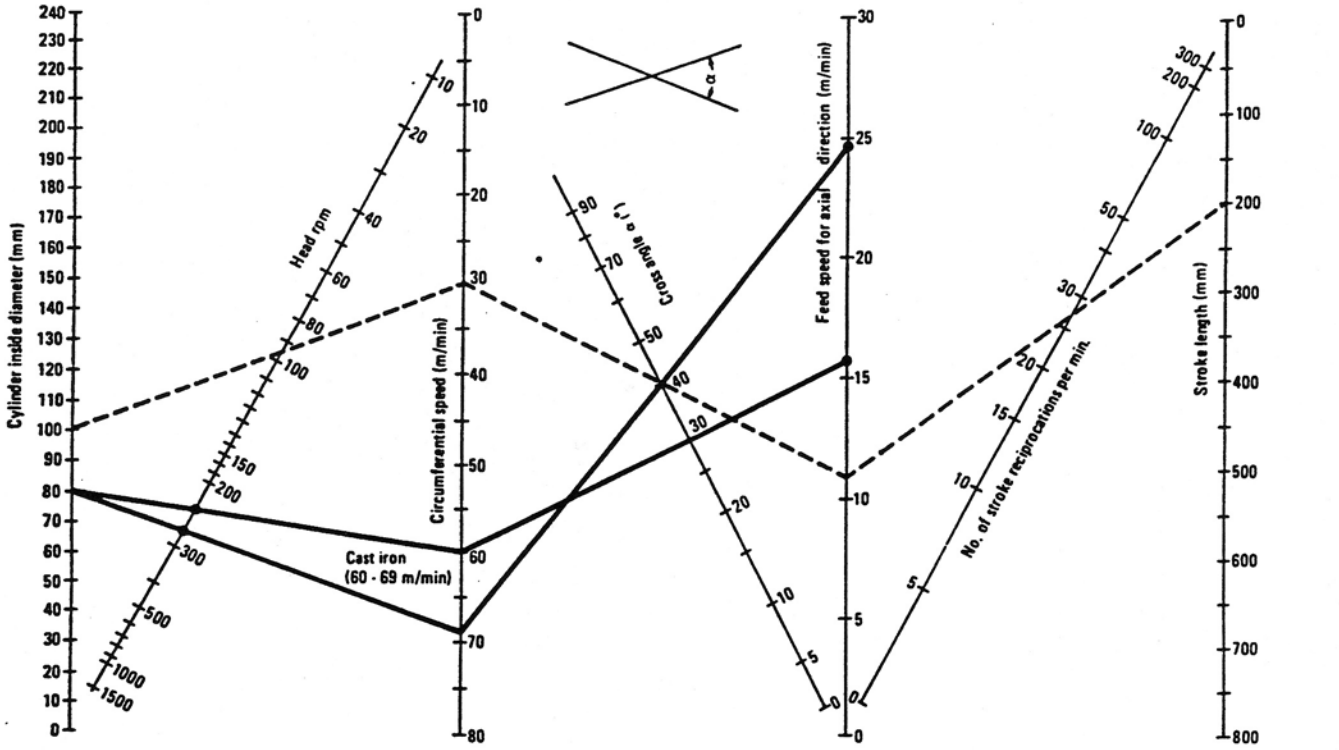
1-5.5 Calculation diagram for obtaining crosshatch angle

Calculation diagram for obtaining crosshatch angle cross-hatching varies with circumferential speed and axial speed. The following diagram is a calculation diagram for obtaining a crosshatch angle.

[EXAMPLE] Where a workpiece is 100 mm in inside diameter and is rotated at a head speed of 95 r.p.m., a broken line connecting the two extends to 29.8 m/min on the circumferential speed axis. Where a stroke is 200 mm in length and number of stroke reciprocations is 27.5/min, an axial speed of 11.0 m/min is obtained. When the point (29.8 m/min at an axial speed), a crosshatch angel of 40° is obtained in the center.

Part list for Oversize piston and piston ring
Oversize: 0.25 mm:

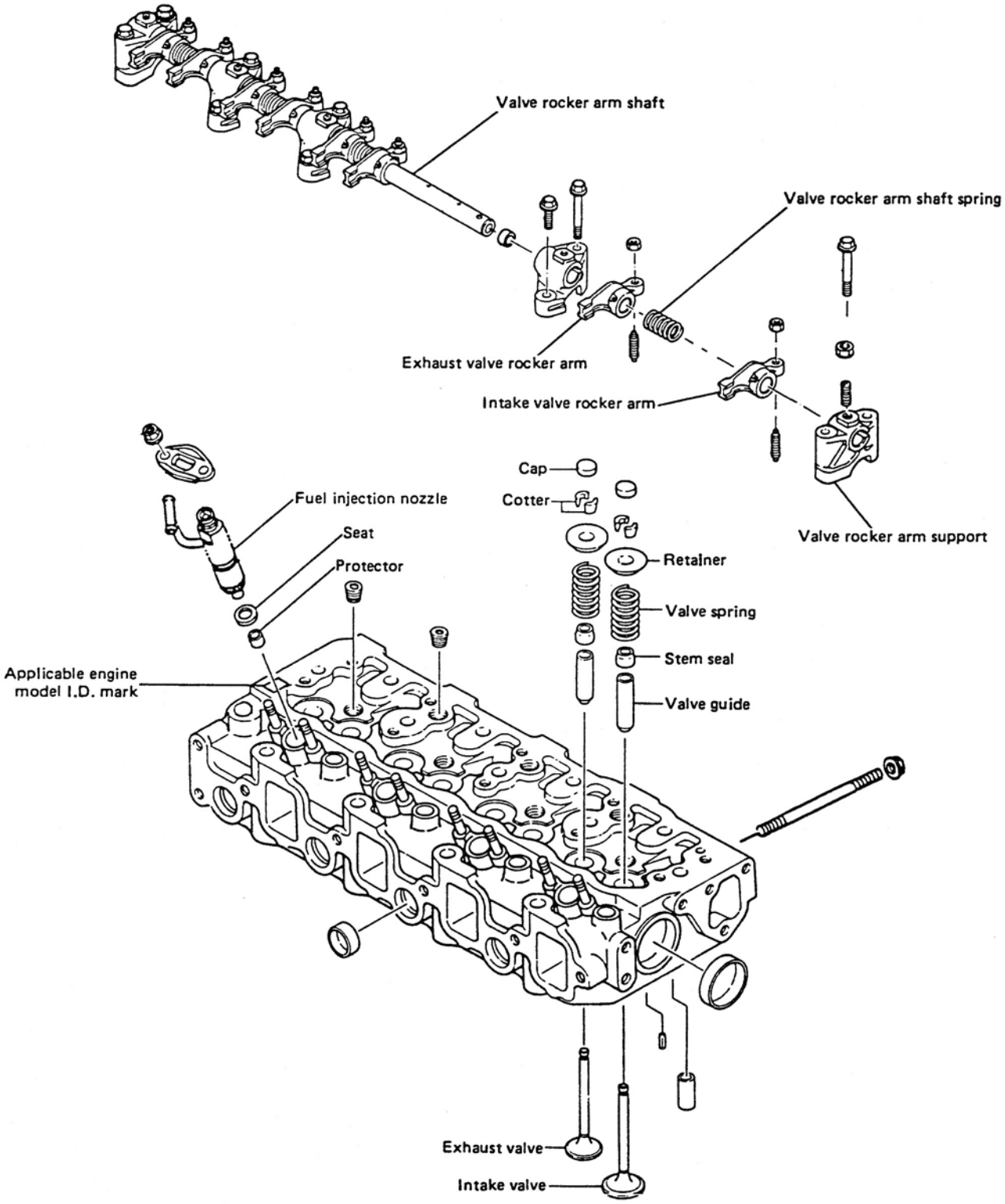
Refer to the parts catalogs.



2. Cylinder Head

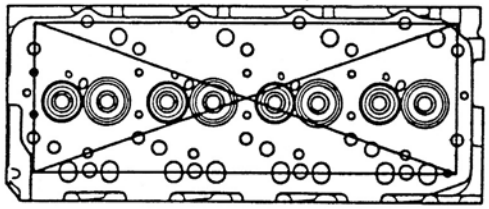
The cylinder head is 3- or 4-cylinder integral construction. The area between the intake port and exhaust port is cooled by a water jet.

IMPORTANT:
Cylinder head assembly differs among engine models. If an incorrect cylinder head is installed, combustion performance will drop. Be sure to check the applicable engine model identification mark (I. D. Mark) on the cylinder head assembly to insure use of the correct part.



2-1 Inspecting the cylinder head

The cylinder head is subjected to severe operating conditions with repeated high pressure, high temperature and cooling. Thoroughly remove all the carbon and dirt after disassembly and carefully inspect all parts.



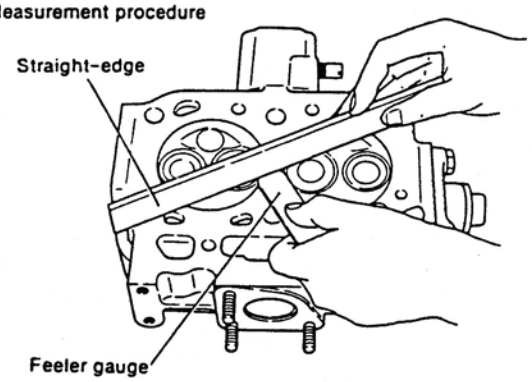
2-1.1 Distortion of the combustion surface

Carefully check for cylinder head distortion as this leads to gasket damage and compression leaks.

(1) Clean the cylinder head surface.

(2) Place a straight-edge along each of the four sides and each diagonal. Measure the clearance between the straight-edge and combustion surface with a feeler gauge.

Measurement procedure

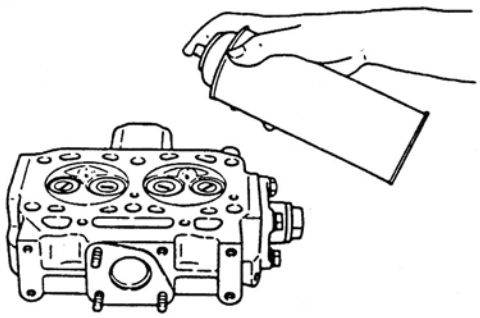


mm (in.)

	Standard	Wear limit
Cylinder head distortion	*See separate service data (Page 2-30, 31)*	

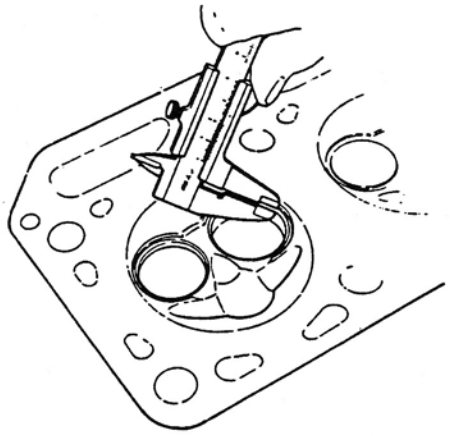
2-1.2 Checking for cracks in the combustion surface

Remove the fuel injection nozzle, intake and exhaust valve and clean the combustion surface. Check for discoloration or distortion and conduct a color check test to check for any cracks.



2-1.3 Checking the intake and exhaust valve seats

Check the surface and width of the valve seats.
If they are too wide, or if the surfaces are rough, correct to the following standards:



Seat angle	Intake	120°
	Exhaust	90°

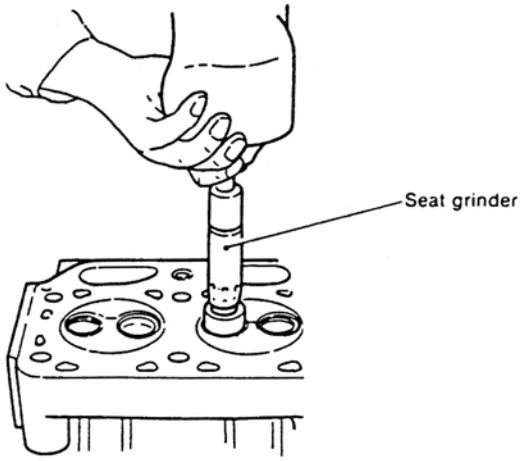
mm (in.)

Seat width	Standard	Wear limit
Intake	*See separate service data (Page 2-30, 31)*	
Exhaust		

2-2 Valve seat correction procedure

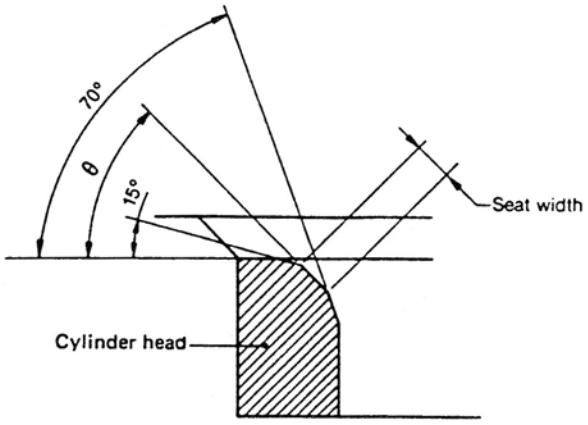
The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

(1) Use a seat grinder to make the surface even.
First, use 70° grinder, then grind the seat to the standard dimension with a 15° grinder.



Seat grinder	Intake valve	30°
	Exhaust valve	45°

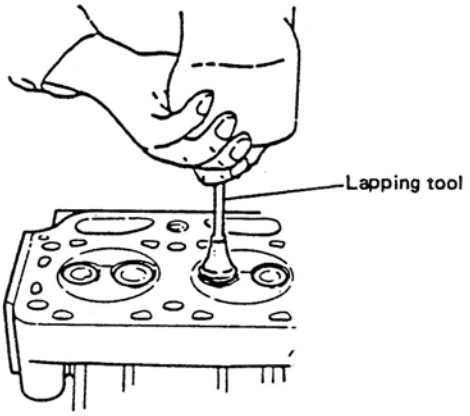
NOTE: When seat adjustment is necessary, be sure to check the valve and valve guide. If the clearance exceeds the tolerance, replace the valve or the valve guide, and then grind the seat.



(2) Knead valve compound with oil and finish the valve seat with a lapping tool.
(3) Final finishing should be done with oil only.

Lapping tool
Use a rubber cap type lapping tool for cylinders without a lapping tool groove slit.

NOTE: Clean the valve and cylinder head with light oil or the equivalent after valve seat finishing is completed, and make sure that there are no grindings remaining.

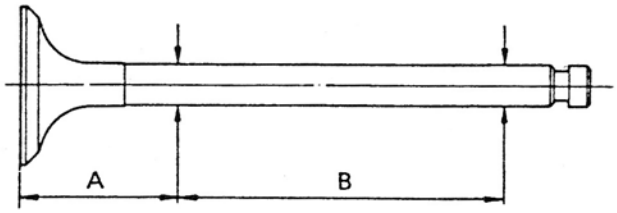


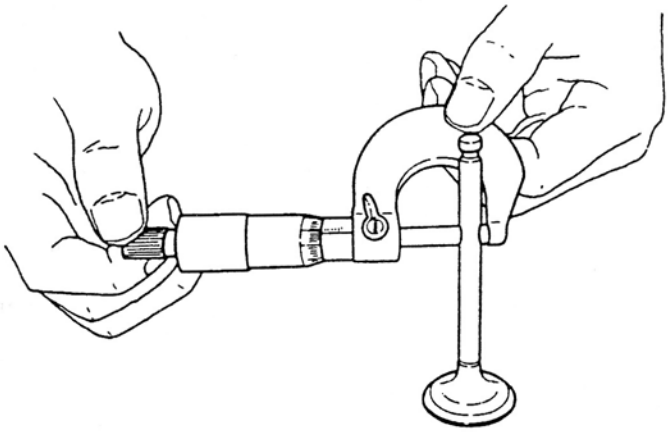
NOTE: 1. Insert adjusting shims between the valve spring and cylinder head when seats have been refinished with a seat grinder.
2. Measure valve distortion after valve seat refinishing has been completed, and replace the valve and valve seat if it exceeds the tolerance.

2-3 Intake/exhaust valves, valve guides

2-3.1 Wearing and corrosion of valve stem

Replace the valve if the valve stem is excessively worn or corroded.





mm (in.)

Valve stem outside dia.	Standard	Wear limit
Intake	*See separate service data (Page 2-30, 31)*	
Exhaust		

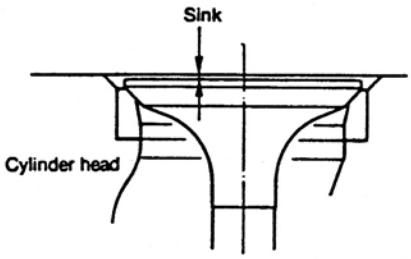
2-3.2 Inspection of valve seat wear and contact surface

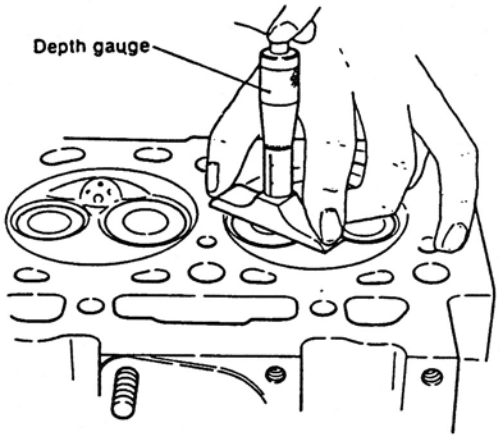
Inspect for valve seat scratches and excessive wear. Check to make sure the contact surface is normal. The seat angle must be checked and adjusted if the valve seat contact surface is smaller than the width of the valve seat.

Note: Keep in mind that the intake and exhaust valve have different dimameters.

2-3.3 Valve sinking

Over long periods of use and repeated lappings, combustion efficiency may drop. Measure the sinking distance and replace the valve and valve seat if the valve sink exceeds the tolerance.





mm (in.)

	Standard	Wear limit
Valve sink	*See separate service data (Page 2-30, 31)*	

2-3.4 Valve guide

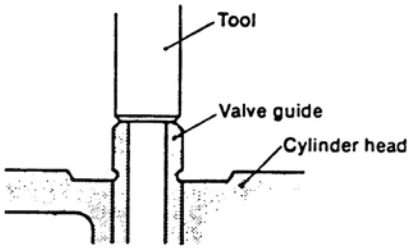
(1) Measuring inner diameter of valve guide.
Measure the inner diameter of the valve guide and replace it if it exceeds the wear limit.

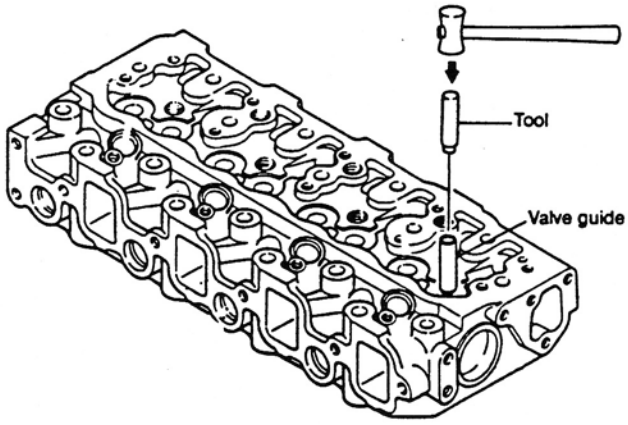
mm (in.)

		Standard	Wear limit
Valve guide inside dia.	Intake	*See separate service data (Page 2-30, 31)*	
	Exhaust		

NOTE: The inner diameter standard dimensions assume a pressure fit.

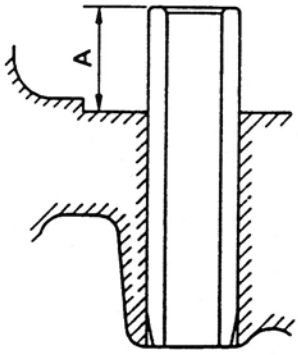
(2) Replacing the valve guide
Use the insertion tool and tap in the guide with a mallet.





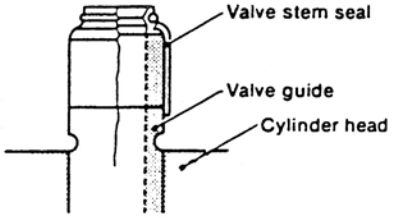
The intake valve guide and exhaust valve guide are of different shapes/dimensions. The one with a groove around it is the exhaust valve guide and the one without is the intake valve guide.

(3) Valve guide projection
The valve guide should project the following "A" from the top of the cylinder head.



Valve guide projection A	See separate service data *(Page 2-30, 31)*

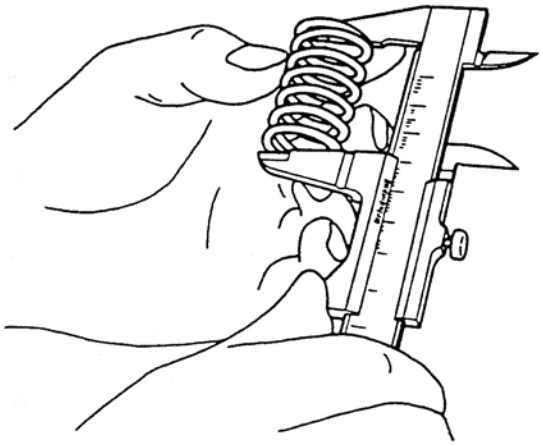
(4) Valve stem seals
The valve stem seals in the intake/exhaust valve guides cannot be re-used once they are removed—be sure to replace them.
When assembling the intake/exhaust valves, apply an adequate amount of engine oil on the valve stem before inserting them.



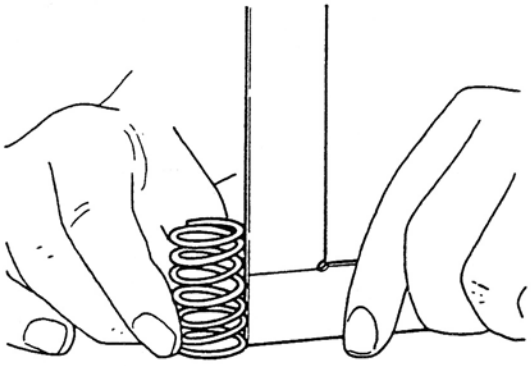
2-4 Valve springs

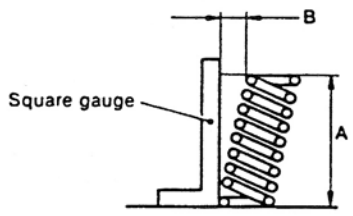
2-4.1 Checking valve springs

(1) Check the spring for scratches or corrosion.
(2) Measure the free length of the spring.

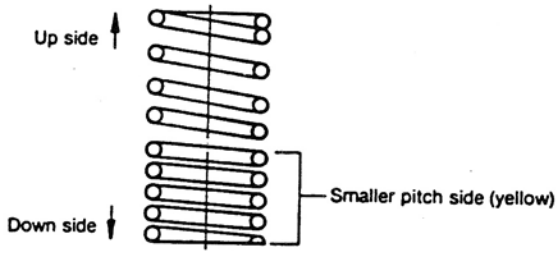


(3) Measure inclination.





(4) Assembling valve springs
The side with the smaller pitch (painted yellow) should face down (cylinder head).



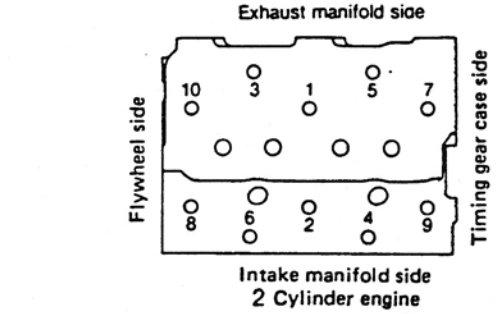
NOTE: The pitch of the valve spring is not even. The side with the smaller pitch (yellow) should face down (cylinder head) when assembled.

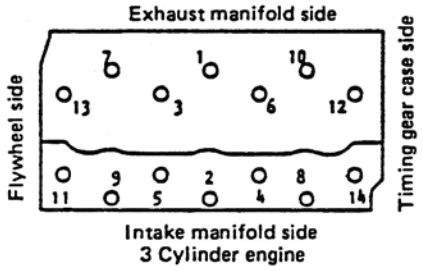
(5) Spring retainer and spring cotter
Inspect the inside face of the spring retainer, the outside surface of the spring cotter, the contact area of the spring cotter inside surface and the notch in the head of the valve stem. Replace the spring retainer and spring cotter when the contact area is less than 70%, or when the spring cotter has been recessed because of wear.

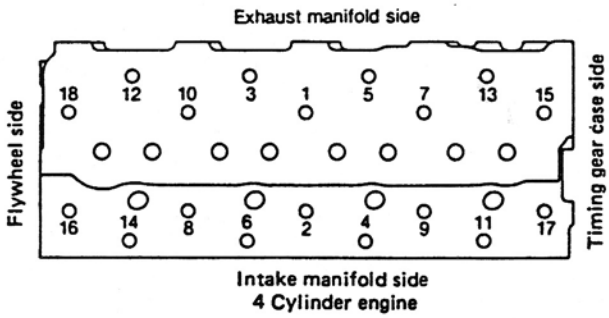
2-5 Assembling the cylinder head

Partially tighten the bolts in the specified order and then tighten to the specified torque, being careful not to distort the head.

(1) Clean out the cylinder head bolt holes.
(2) Check for foreign matter on the cylinder head surface that comes in contact with the block.
(3) Coat the head bolt threads and nut seats with lube oil.
(4) Use the positioning pins to line up the head gasket with the cylinder block.
(5) Match up the cylinder head with the head gasket and mount.





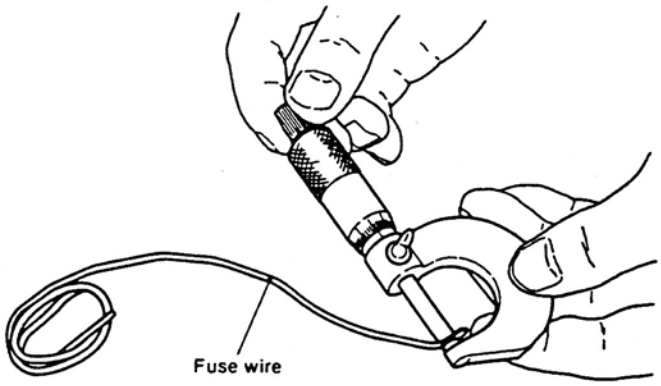


kg-m (ft-lb)

	First	Final
Tightening torque	*See separate service data (Page 2-30, 31)*	

2-6 Measuring top clearance

(1) Place a high quality fuse (ø1.5mm (0.0591in.), 10mm (0.3937in.) long) in three positions on the flat part of the piston head.
(2) Assemble the cylinder head gasket and the cylinder block and tighten the bolts in the specified order to the specified torque.
(3) Turn the crank, (in the direction of engine revolution), and press the fuse against the piston until it breaks.
(4) Remove the head and take out the broken fuse.
(5) Measure the three positions where each fuse is broken and calculate the average.
(0.71 ~ 0.75mm (0.0280 ~ 0.0295in.) is ideal)

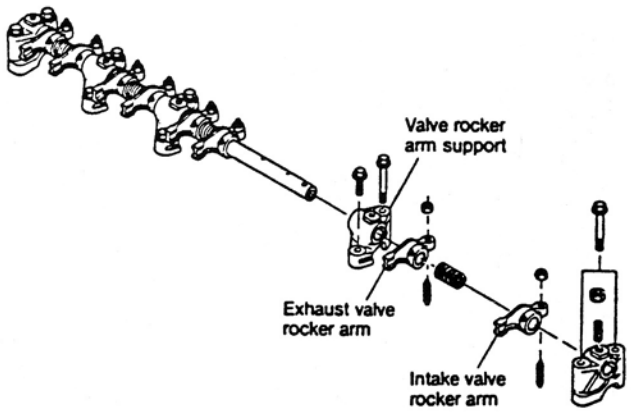


mm (in.)

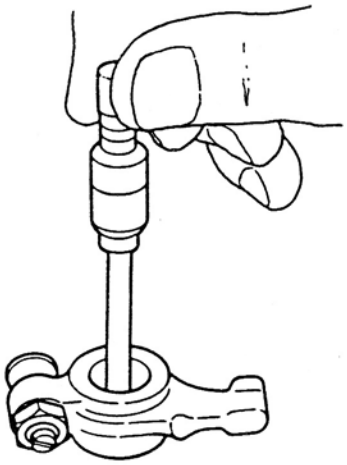
Top clearance	*See separate service data (Page 2-30, 31)*

2-7 Intake and exhaust valve arms

Valve arm and valve arm bushing wear may alter opening/closing timing of the valve, and may in turn affect engine performance according to the extent of the change.



(1) Valve arm shaft and valve arm bushing
Measure the outer diameter of the shaft and the inner diameter of the bearing, and replace if wear exceeds the limit.



mm (in.)

	Standard	Wear limit
Intake and exhaust valve rocker arm shaft outside dia.	*See separate service data (Page 2-30, 31)*	
Intake and exhaust valve rocker arm bushing inside dia. (assembled)		
Valve rocker arm shaft and bushing clearance at assembly		

Replace the valve arm shaft bushing if it moves and replace the entire valve arm if there is no tightening clearance.

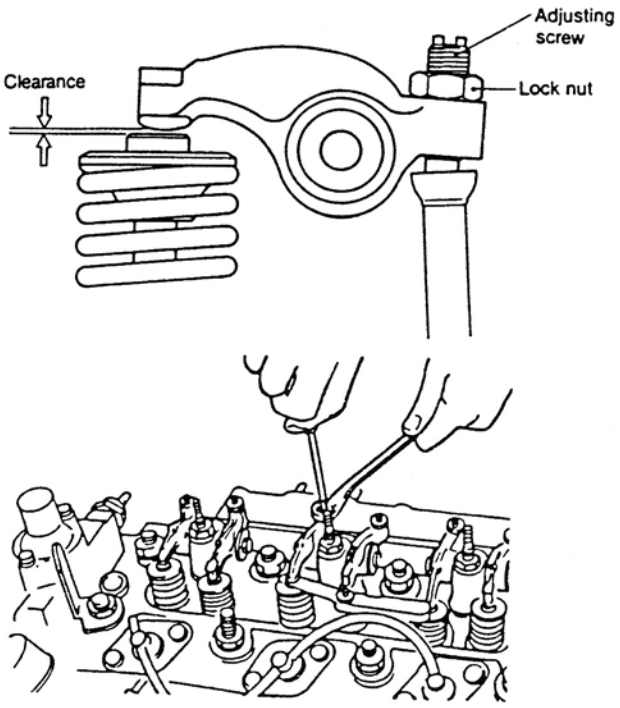
(2) Valve arm spring
Check the valve arm spring and replace it if it is corroded or worn.
(3) Valve arm and valve top retainer wear
Inspect the contact surface of the valve arm and replace it if there is abnormal wear or flaking.
(4) Inspect the contact surface of the valve clearance adjustment screw and push rod and replace if there is abnormal wear or flaking.

2-8 Adjustment of valve head clearance

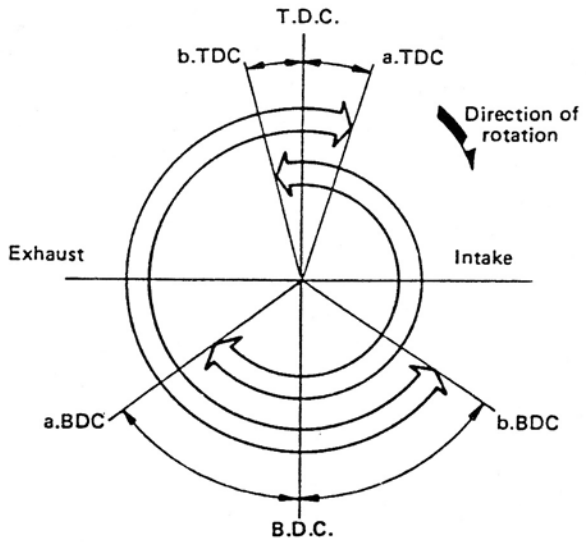
(1) Make adjustments when the engine is cool.

mm (in.)

Intake and exhaust valve clearance	0.2 (0.0079)



(2) Do not fail to adjust the opening and closing angles for both intake and exhaust valves when reassembling the timing gear.



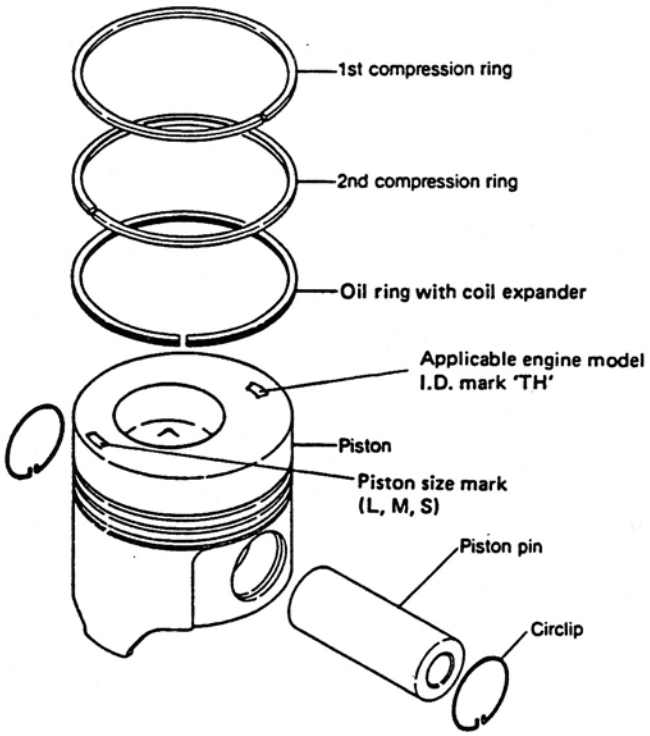
Intake valve open	b.TDC	*See separate service data (Page 2-30, 31)*
Intake valve closed	a.BDC	
Exhaust valve open	b.BDC	
Exhaust valve closed	a.TDC	

3. Piston and Piston Pins

The piston is made up of an aluminum alloy with less thermal expansion.
There is a clearance between the outside diameter of the piston and the inside diameter of the cylinder. The clearance is an important factor that has influence on the lubricity between the piston and cylinder, lubricating oil consumption, the noise level of the cylinder.
In Yanmar engines, both piston and cylinder have identification marks to ensure proper clearance between the piston and cylinder on respective top surfaces.
In Yanmar factory, the piston is assembled into the cylinder block with the same identification mark.
The following shows combinations of identification marks for the piston and cylinder block.

		Identification of piston			
		L	ML	MS	S
Cylinder block	L	O	O	X	X
	M	X	O	O	X
	S	X	X	O	O

Note 1: O ..... Fixed
X ..... Do not fix



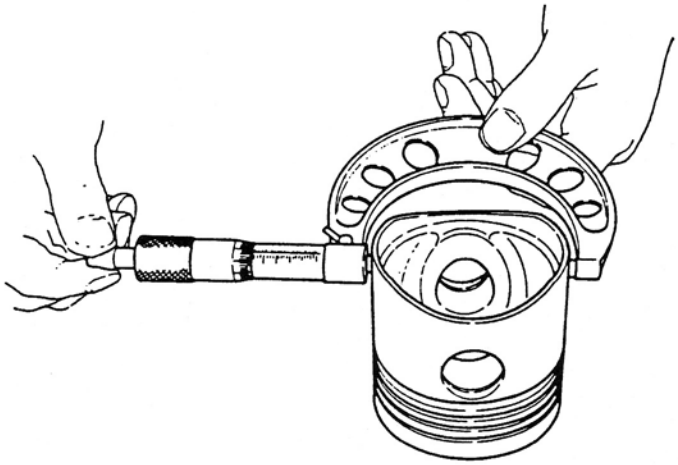
3-1 Piston

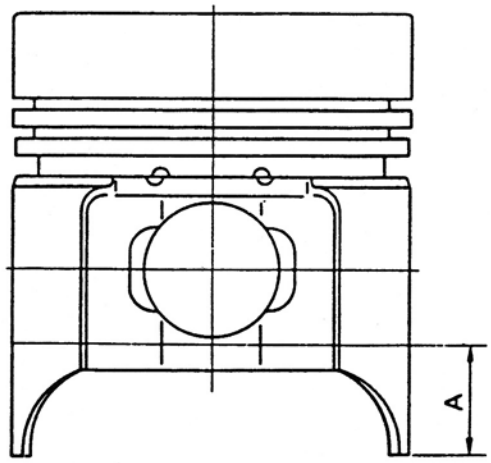
3-1.1 Piston head and combustion surface

Remove the carbon that has accumulated on the piston head and combustion surface, taking care no to scratch the piston. Check the combustion surface for any damage.

3-1.2 Measurement of piston outside diameter/inspection

(1) Replace the piston if the outside of the piston or ring grooves are worn.
(2) Measure the piston O.D. of location "A" from the bottom at right angles to the piston pin.



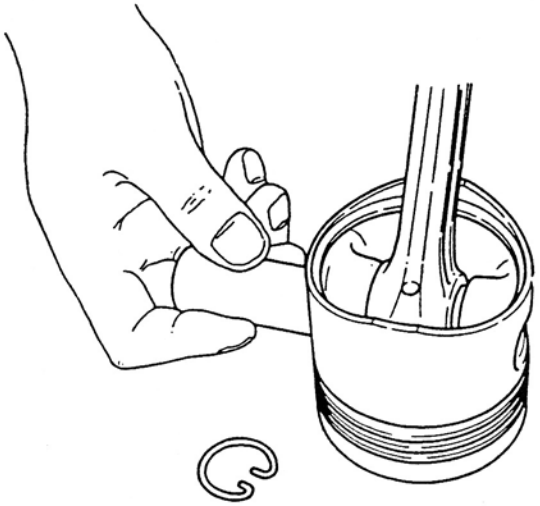


mm (in.)

Standard	Wear limit
See separate service data (Page 2-32, 33)	

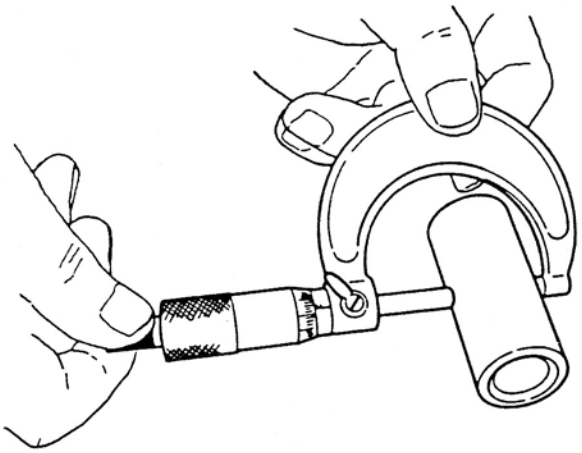
3-1.3 Replacing the piston

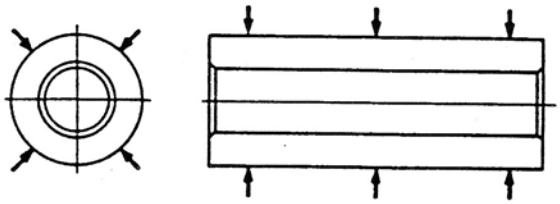
A floating type piston pin is used in this engine. The piston pin can be pressed into the piston pin hole at room temperature (coat with oil to make it slide in easily).



3-2 Piston pin

Measure the outer diameter and replace the pin if it is excessively worn.



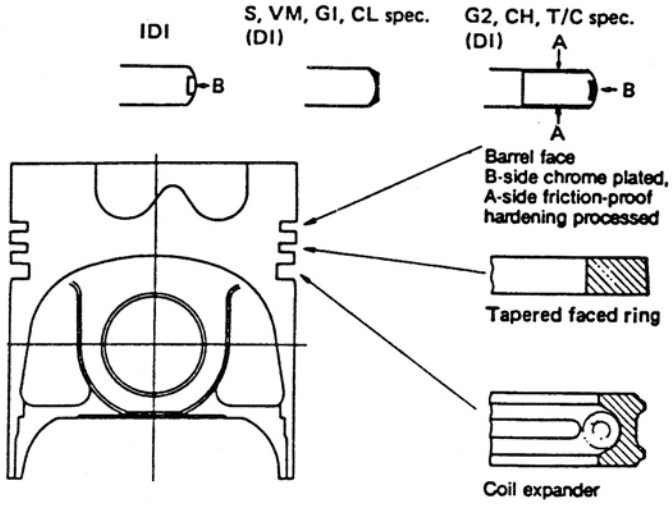


mm (in.)

	Standard	Wear limit
Piston pin insert hole dia.	*See separate service data (Page 2-32, 33)*	
Piston pin outside dia.		
Standard clearance		

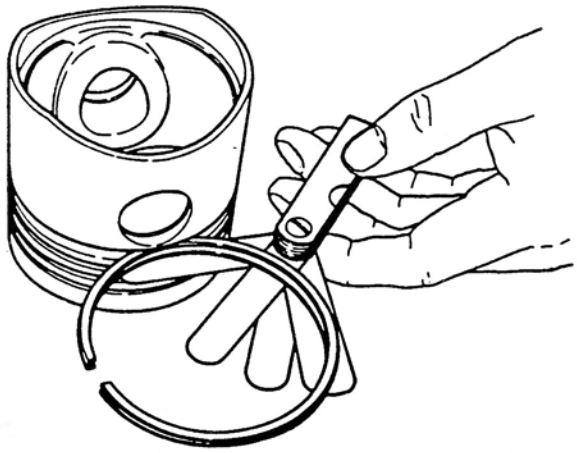
3-3 Piston rings

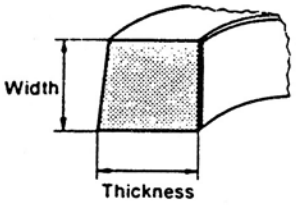
There are 2 compression rings and 1 oil ring.
The absence of an oil ring on the piston skirt prevents oil from being kept on the thrust surface and in turn provides good lubrication.



3.3.1 Measuring the rings

Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceeds the limit.



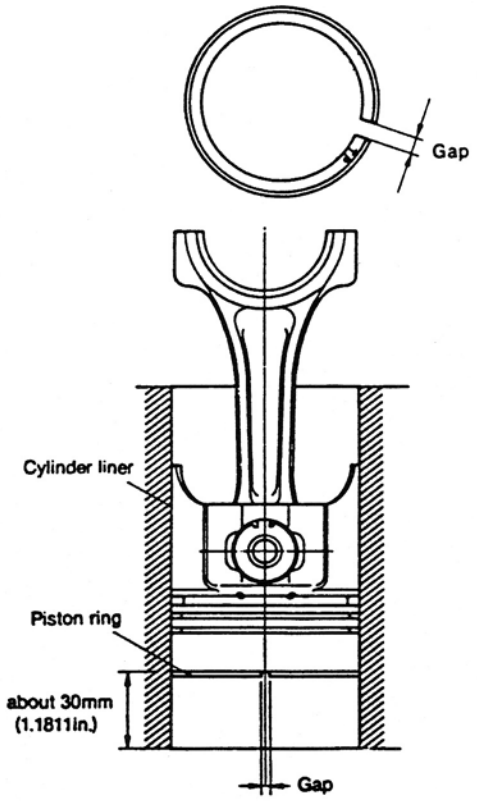


mm (in.)

		Standard	Wear limit
First piston ring	Groove width	See separate service data (Page 2-32, 33)	
	Ring width		
	Groove and ring clearance		
Second piston ring	Groove width		
	Ring width		
	Groove and ring clearance		
Oil ring	Groove width		
	Ring width		
	Groove and ring clearance		

3-3.2 Measuring piston ring gap

Press the piston ring onto a cylinder and measure the piston ring gap with a gauge.
Press on the ring about 30 mm (1.1811 in.) from the bottom of the cylinder.

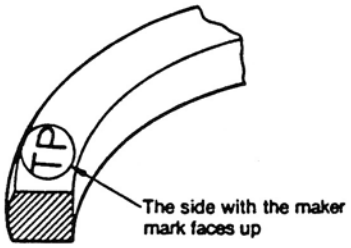


mm (in.)

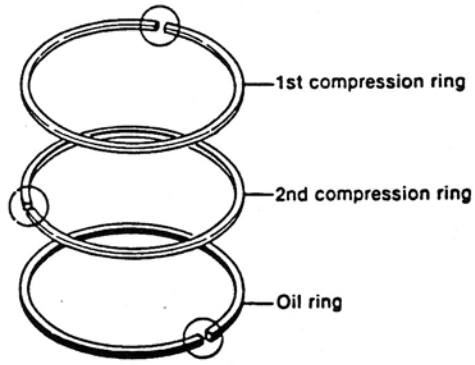
	Standard	Wear limit
First piston ring gap	See separate service data (Page 2-32, 33)	
Second piston ring gap		
Oil ring gap		

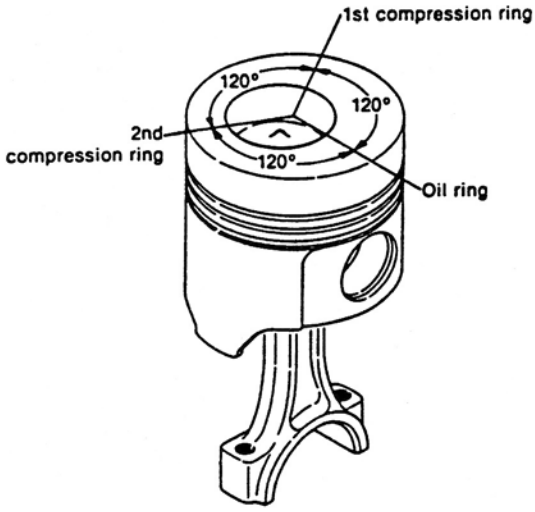
3-3.3 Replacing the piston rings

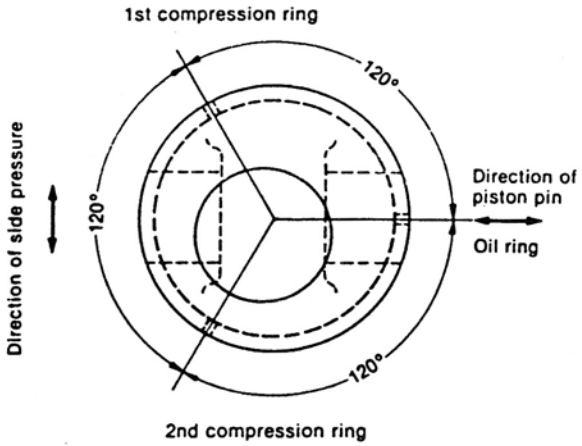
(1) Thoroughly clean the ring grooves when replacing piston rings.
(2) The side with the manufacturer's mark (near piston ring gap) should face up.



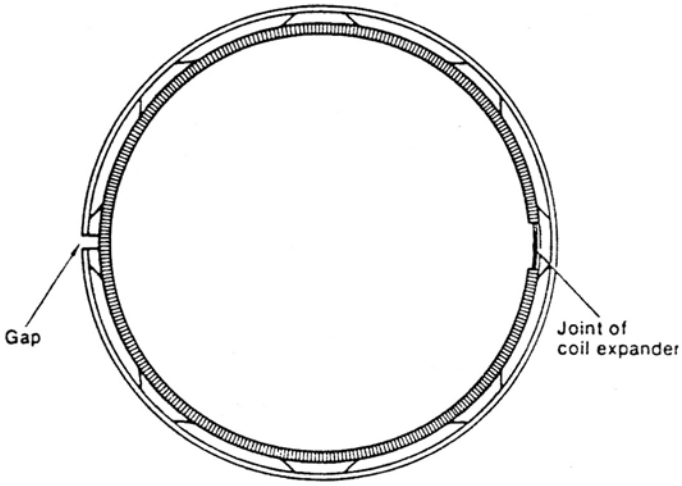
(3) After fitting the piston ring, make sure it moves easily and smoothly.
(4) Stagger the piston rings at 120° intervals, making sure none of them line up with the piston.





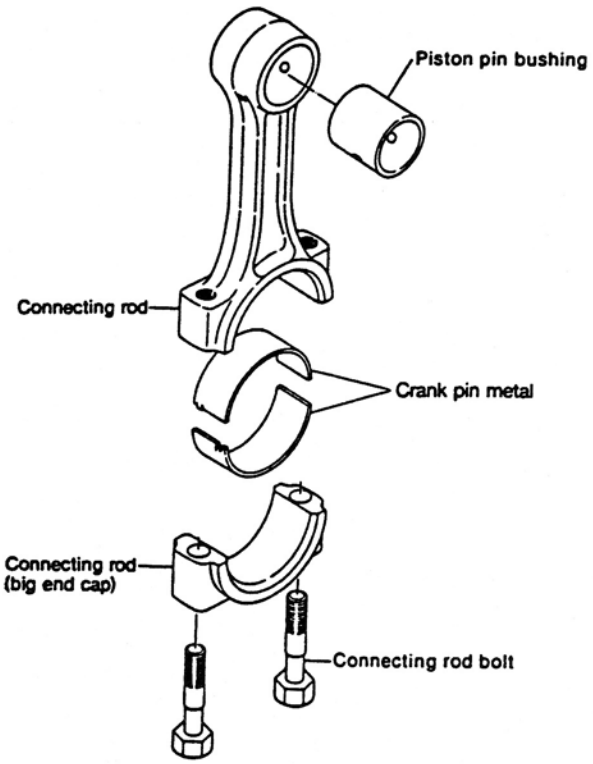


(5) The oil ring is provided with a coil expander. The coil expander joint should be opposite (staggered 180°) the oil ring gap.



4. Connecting Rod

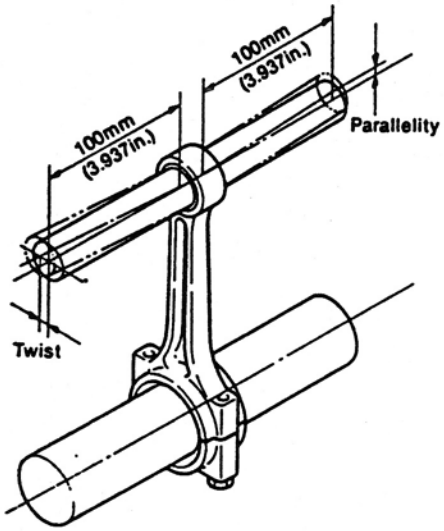
The connecting rod is made of high-strength forged carbon steel.
The large end with the special aluminum-alloy metal can be separated into two and the small end has a copper alloy coil bushing.

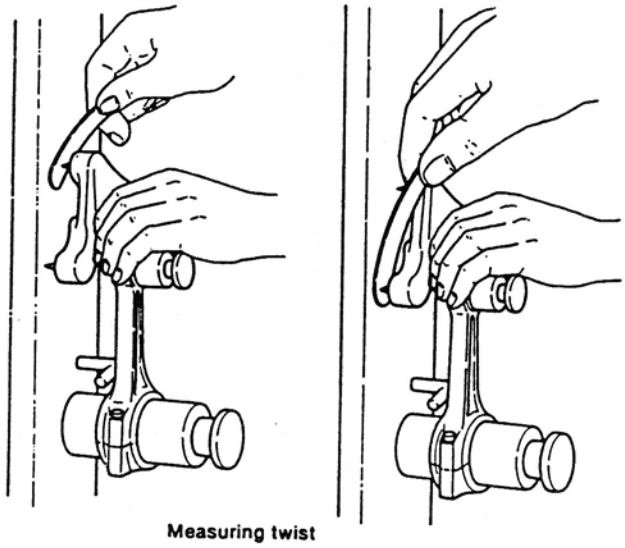


4-1 Inspecting the connection rod

4-1.1Twist and parallelism of the large and small ends

Insert the measuring tool into the large and small ends of the connecting rod. Measure the extent of twist and parallelism and replace if they exceed the tolerance.



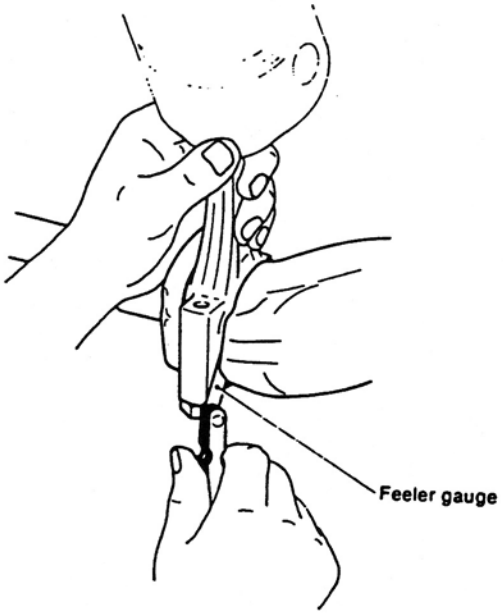

Measuring twist

mm (in.)

	Standard	Wear limit
Connecting rod twist and parallelity	*See separate service data (Page 2-32, 33)*	

4-1.2 Checking thrust clearance

Fit the respective crank pins to the connecting rod and check to make sure that the clearance in the crankshaft direction is correct.



mm (in.)

	Standard	Wear limit
Connecting rod side clearance	*See separate service data (Page 2-32, 33)*	

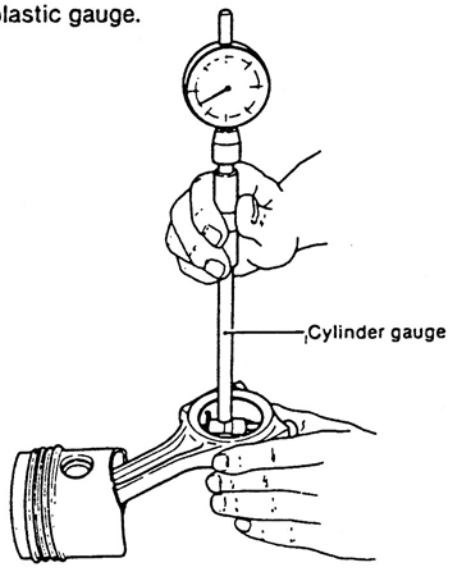
4-2 Crank pin bushing

4-2.1 Checking crank pin bushing

Check for flaking, melting or seizure on the contact surface.

4-2.2 Measuring crank pin oil clearance

Use a plastic gauge.



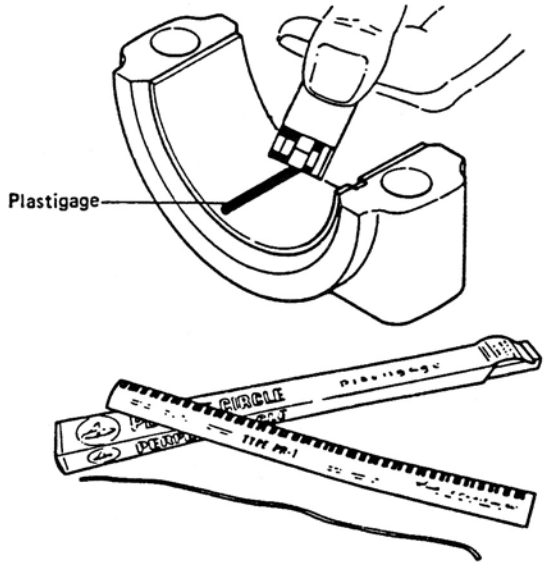
Procedure

(1) Use the press gauge (Plastigage) for measuring oil clearance in the crank pin.

(2) Mount the connecting rod on the crank pin (tighten to specified torque).

Connecting rod tightening torque	*See separate service data (Page 2-32, 33)*

(3) Remove the connecting rod and measure the broken plastigauge with measuring scale. (Plastigauge)

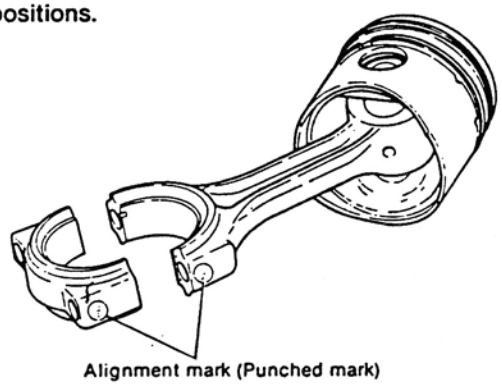


4-2.3 Precautions on replacement of crank pin bushing

(1) Wash the crank pin bushing.

(2) Wash the large end cap, mount the crank pin bushing and make sure that it fits tightly on the large end cap.

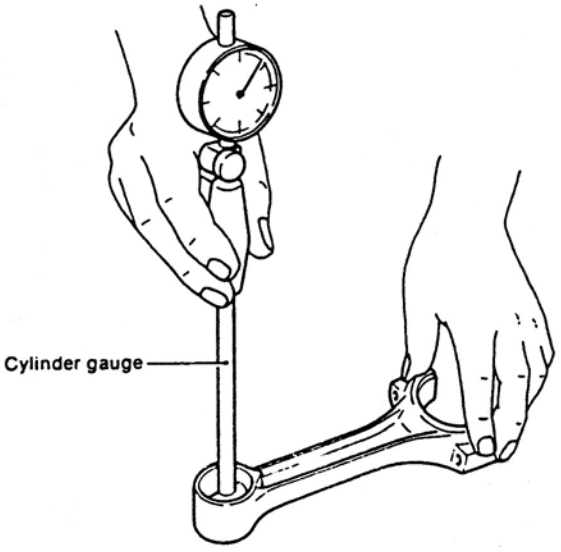
(3) When assembling the connecting rod, match up the large end and large end cap number. Coat the bolts with engine oil and gradually tighten them alternately to the specified torque.
If a torque wrench is not available, make match marks on the bolt heads and large end cap (to indicate the proper torque position) and retighten the bolts to those positions.



(4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.

4-3 Piston pin bushing

(1) Measuring piston pin clearance
Excessive piston pin bushing wear may result in damage to the piston pin or the piston itself.

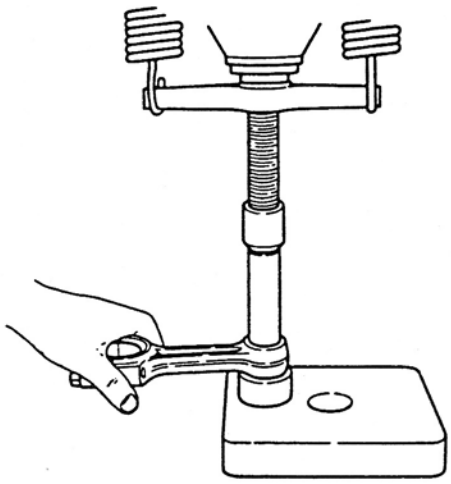


mm (in.)

	Standard	Wear limit
Piston pin bushing inside dia.	*See separate service data (Page 2-32, 33)*	
Piston pin and bushing oil clearance		

(2) Replacing piston pin bushing

1) When the bushing for the connecting rod piston pin is either worn out or damaged, replace it by using the "piston pin extracting tool" installed on a press.

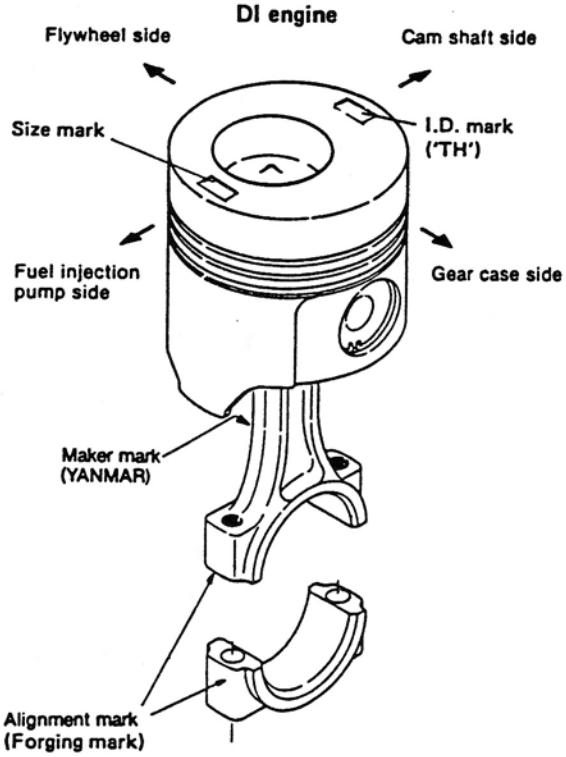


NOTE: Force the piston pin bushing into position so that its oil hole coincides with the hole on the small end of the connecting rod.

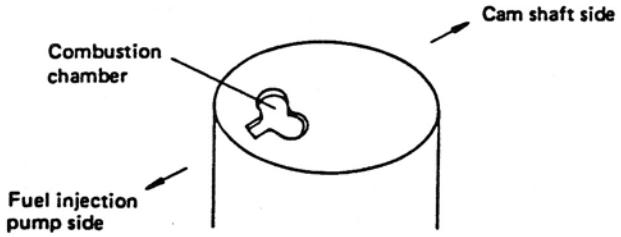
4-4 Assembling piston and connecting rod

The piston and connecting rod should be assembled so that the match mark on the connecting rod large end faces the fuel injection pump side and the combustion chamber above the piston is close to the fuel injection pump.

DI engine

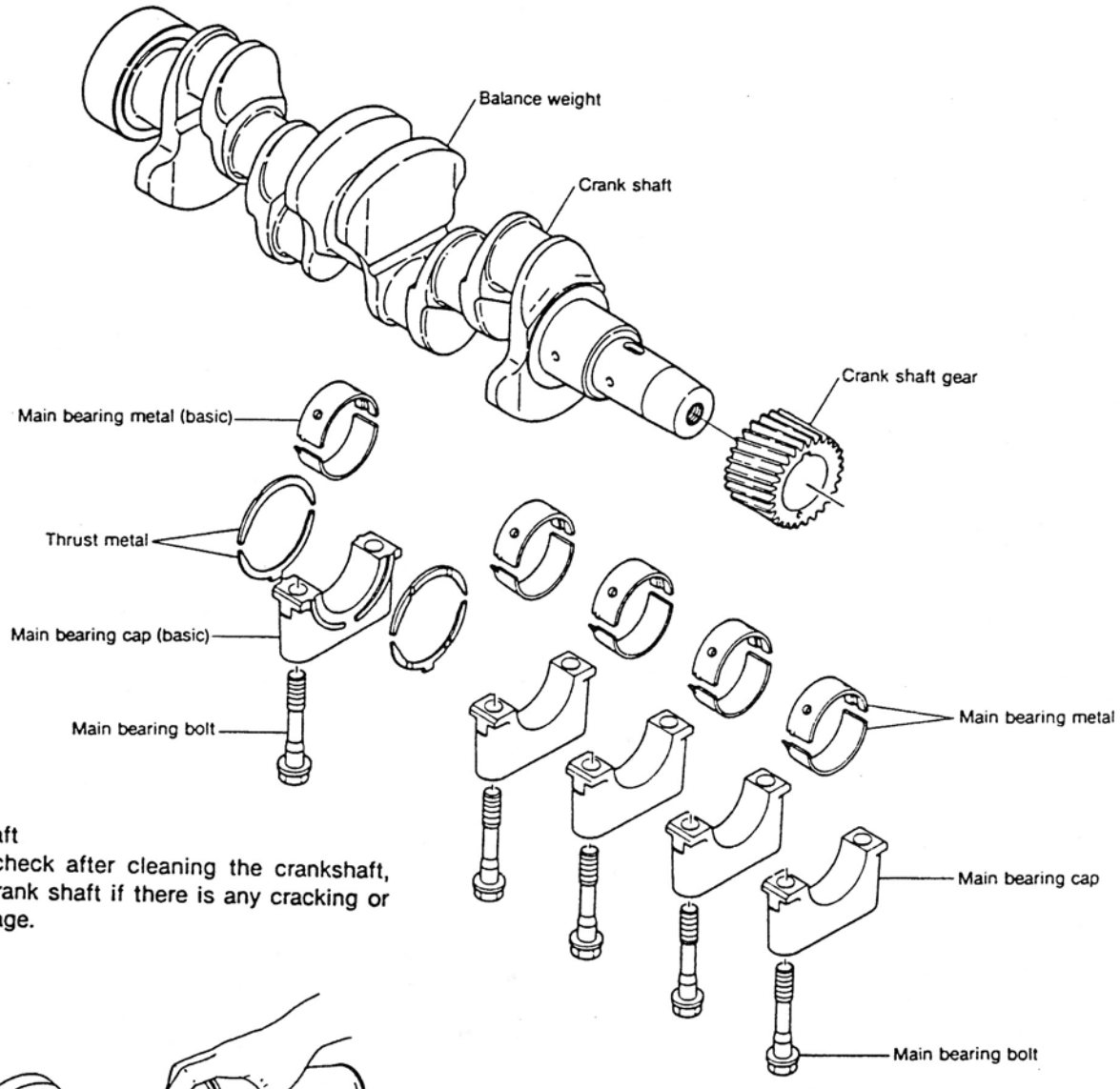


IDI engine



5. Crankshaft and Main Bearing

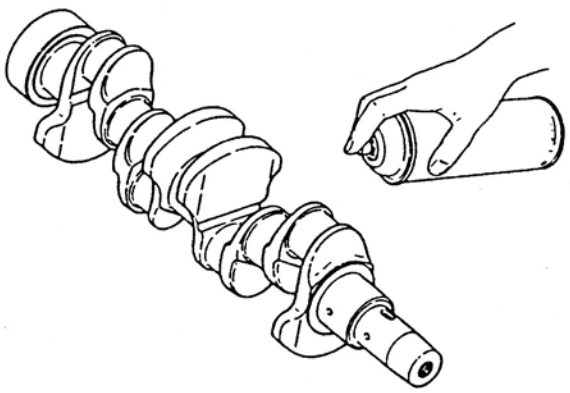
The crank pin and crank journal have been high-frequency hardened for superior durability, and the crankshaft is provided with four balance weights for optimal balance. The crankshaft main bearing is of the hanger type, with the upper metal (cylinder block side) provided with an oil groove, and with no oil groove on the lower metal (bearing cap side). The bearing cap (location cap) of the flywheel side has a thrust metal which supports the thrust load.



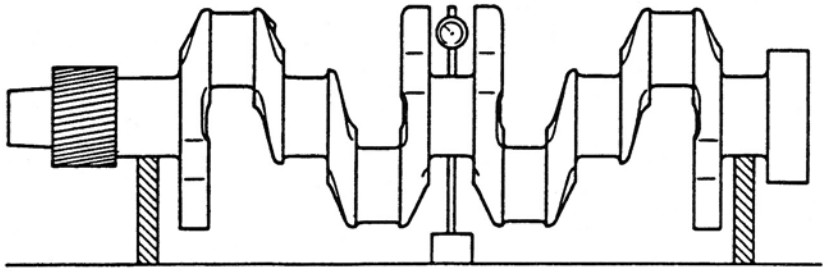
5-1 Crankshaft

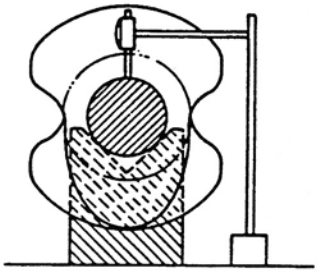
(1) Color check of shaft

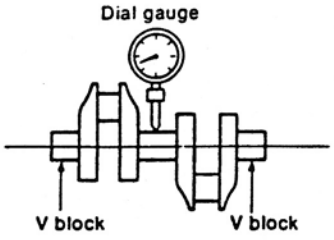
Perform a color check after cleaning the crankshaft, and replace the crank shaft if there is any cracking or considerable damage.

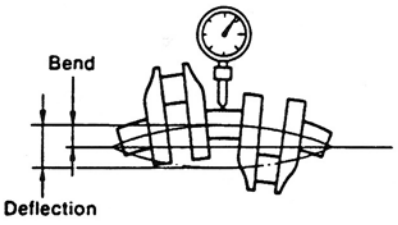


(2) Bending of the crankshaft
Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check the extent of crankshaft bending.



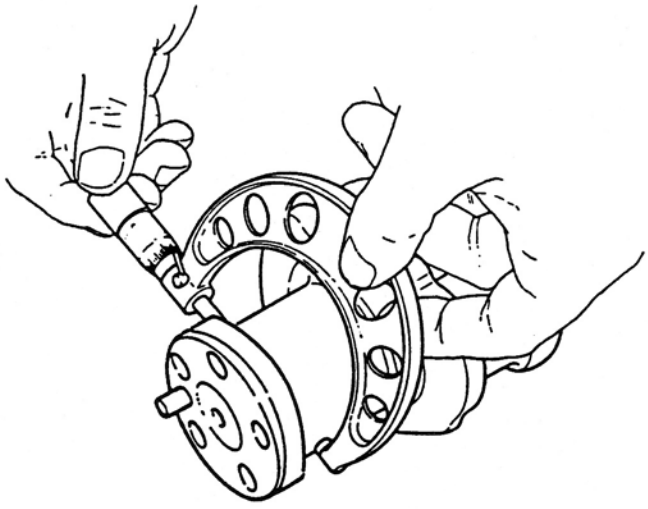


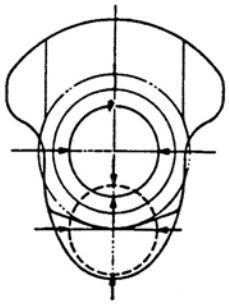


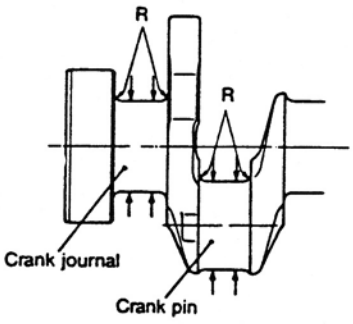


Crankshaft bend	Less than 0.02mm (0.0007 in.)

(3) Measuring the crank pin and journal
Measure the extent of journal wear (roundness, taper). Regrind it to the proper shape if it is within the outer diameter limit, and replace if not.







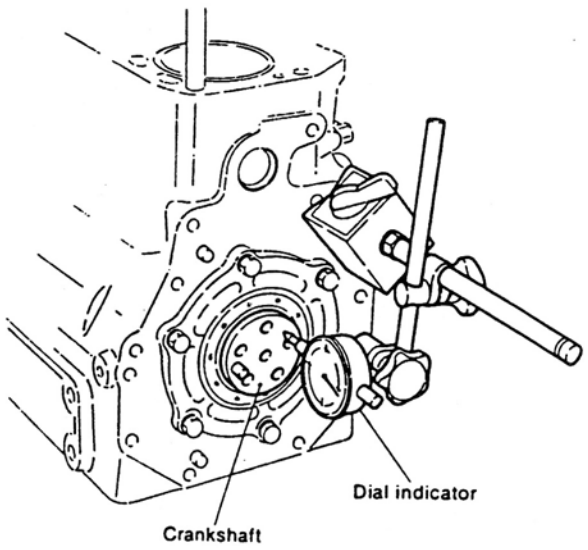
mm (in.)

		Standard	Wear limit
Crank pin	Outside dia.	*See separate service data* *(Page 2-32, 33, 34, 35)*	
	Bushing inside dia.		
	Crank pin and bushing oil clearance		
Crank journal	Outside dia.		
	Bushing inside dia.		
	Crank journal and bushing oil clearance		
Fillet rounding of crank pin and journal			

(4) Checking side clearance of the crankshaft
After assembling the crankshaft, tighten the main bearing cap to the specified torque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.
This measurement can also be effected by inserting the gauge directly into the clearance between the thrust bearing and crankshaft thrust surface.
Replace the thrust bearing if it is worn beyond the limit.

mm (in.)

	Standard	Wear limit
Crankshaft side gap	*See separate service data (Page 2-34, 35)*	

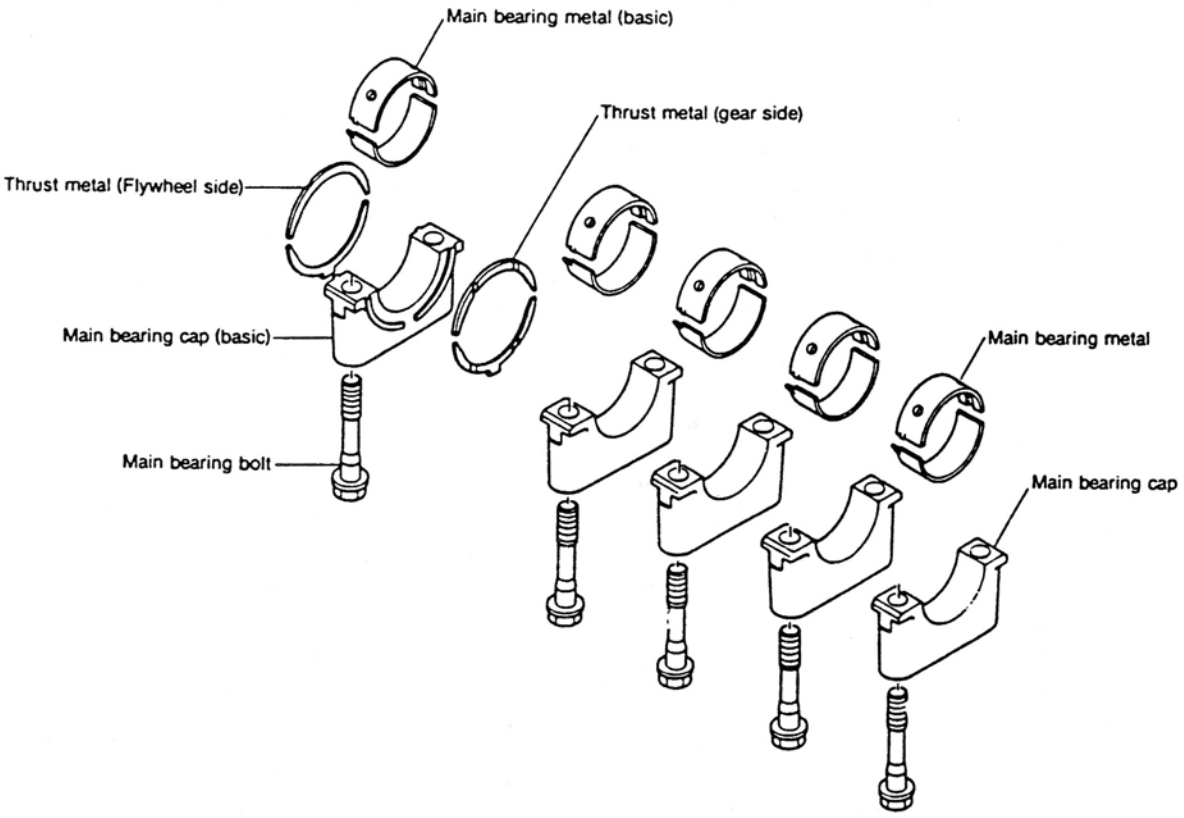


5-2 Main bearing

(1) Inspecting the main bearing
Check for flaking, seizure or burning of the contact surface and replace if necessary.
(2) Measuring the inner diameter of metal
Tighten the cap to the specified torque and measure the inner diameter of the metal.

Bearing cap bolt tightening torque	*See separate service data (Page 2-34, 35)*

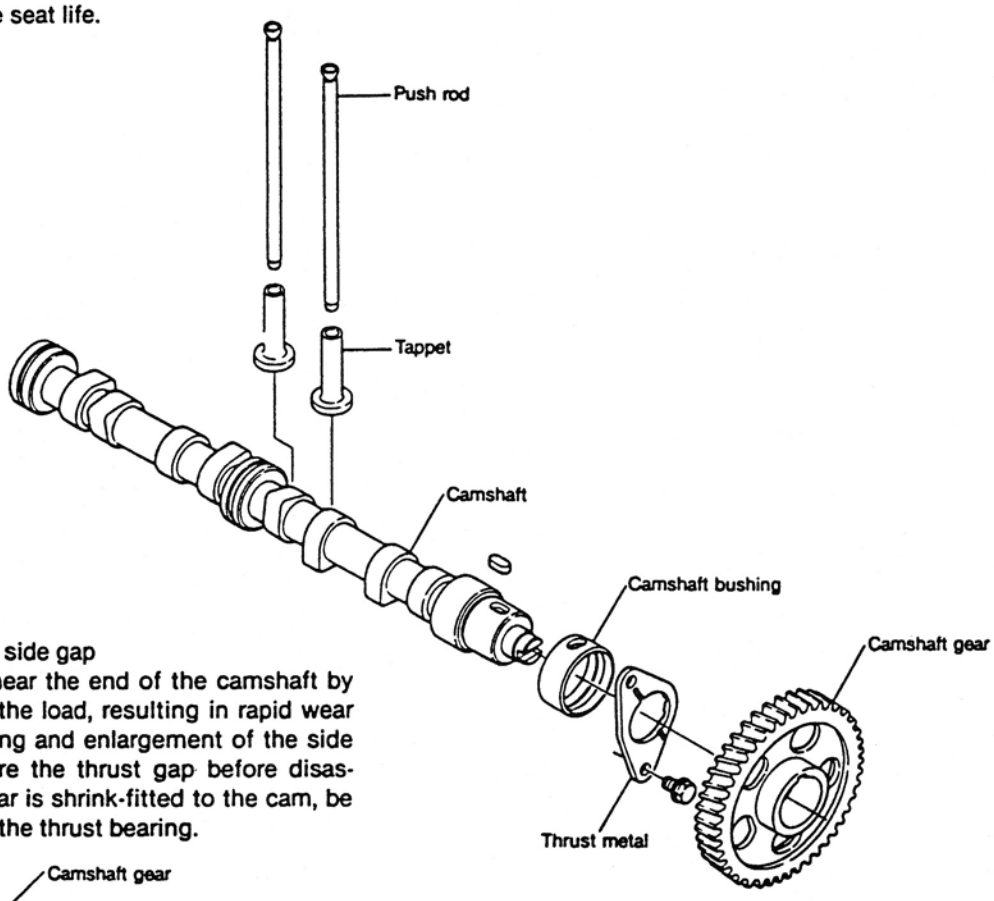
NOTE: When assembling the bearing cap, keep the following in mind.
1) The lower metal (cap side) has no oil groove.
2) The upper metal (cylinder block side) has an oil groove.
3) Check the cylinder block alignment No.
4) The "FW" on the cap lies on the flywheel side.



6. Camshaft and Tappets

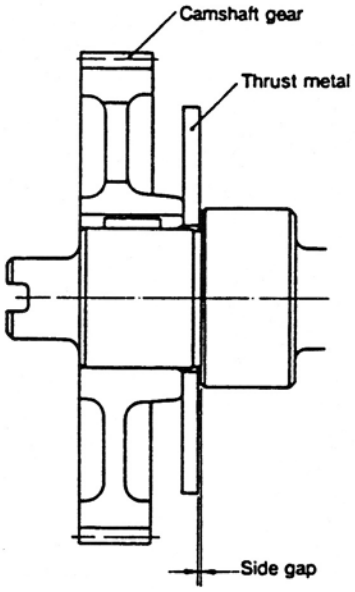
6-1 Camshaft

The camshaft is normalized and the cam and bearing surfaces are surface hardened and ground. The cams have a curve that minimizes the repeated shock on the valve seats and maximizes valve seat life.



(1) Checking the camshaft side gap

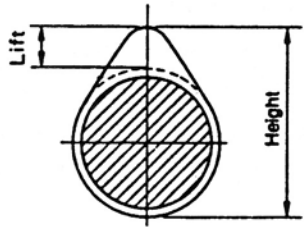
The standard bearing near the end of the camshaft by the cam gear receives the load, resulting in rapid wear of the end of the bearing and enlargement of the side gap. Therefore, measure the thrust gap before disassembly. As the cam gear is shrink-fitted to the cam, be careful when replacing the thrust bearing.



mm (in.)

	Standard	Wear limit
Camshaft side gap	*See separate service data (Page 2-34, 35)*	

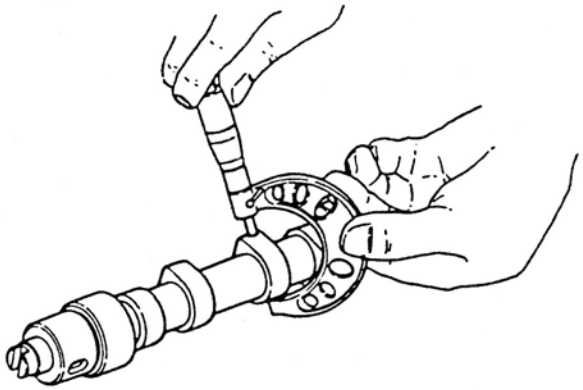
(2) Measure the camshaft height, and replace the cam if it is worn beyond the limit.



mm (in.)

Camshaft height	Standard	Wear limit
Intake cam	*See separate service data (Page 2-34, 35)*	
Exhaust cam		

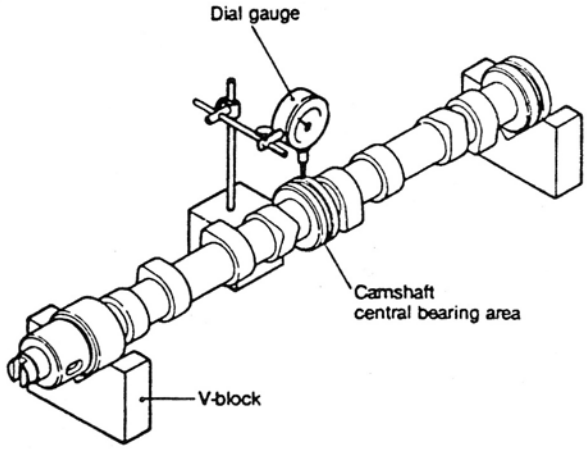
(3) Measure the camshaft outer diameter and the camshaft bearing inner diameter. Replace if they exceed the wear limit or are damaged.



mm (in.)

	Standard			Wear limit
	Gear case side	Intermediate	Flywheel side	
Camshaft journal outside dia.	*See separate service data (Page 2-34, 35)*			
Camshaft journal bushing inside dia.				
Cylinder block bearing inside dia.				
Oil clearance				

(4) Bending of the camshaft
Support both ends of the camshaft with V-blocks, place a dial gauge against the central bearing areas and measure bending. Replace if excessive.



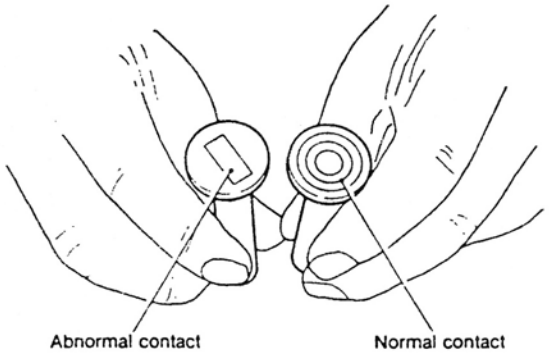
NOTE: The reading on the dial gauge is divided by two to obtain the extent of bending.

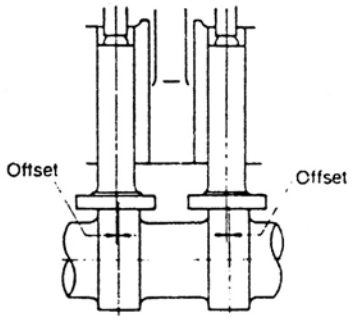
mm (in.)

	Wear limit
Camshaft deflection	*See separate service data (Page 2-34, 35)*

6-2 Tappets

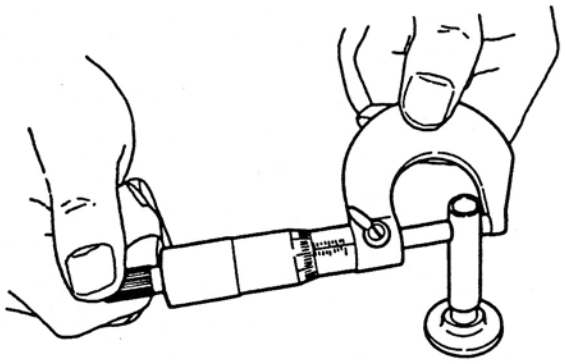
(1) The tappets are offset to rotate during operation and thereby prevent uneven wearing. Check the contact of each tappet and replace if excessively or unevenly worn.





NOTE: When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.

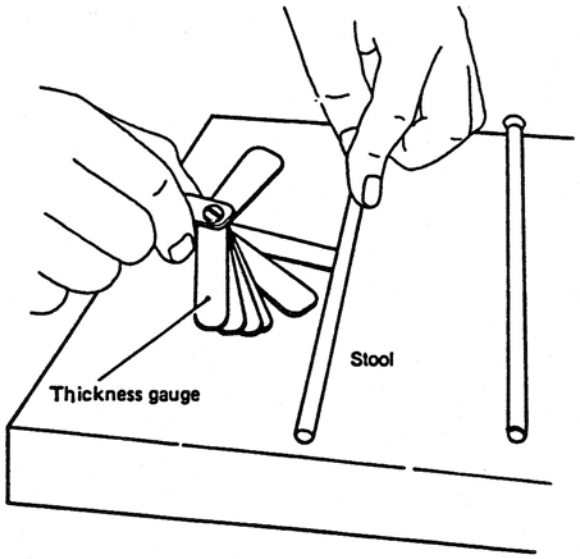
(2) Measure the outer diameter of the tappet, and replace if worn beyond the limit.



mm (in.)

	Standard	Wear limit
Tappet stem outside dia.	*See separate service data (Page 2-34, 35)*	
Tappet guide hole inside dia. (cylinder block)		
Tappet stem and guide hole oil clearance		

(3) Measuring push rods.
Measure the length and bending of the push rods.

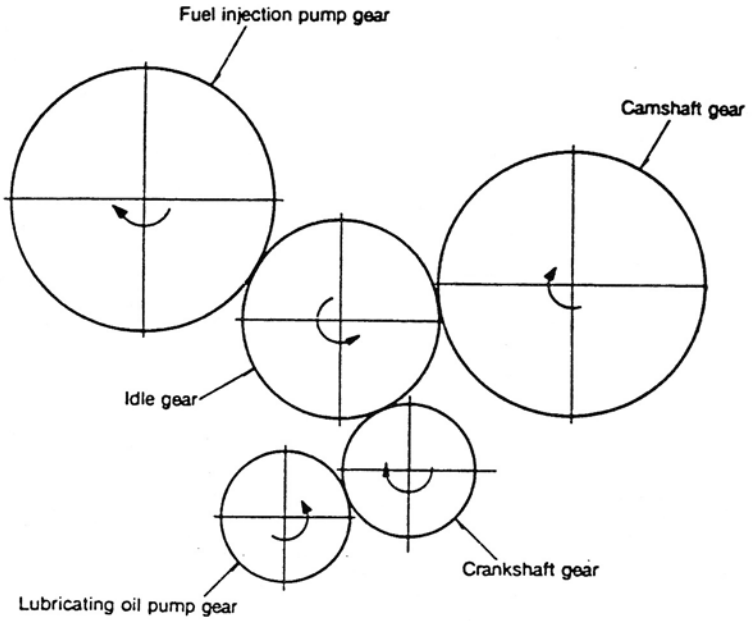


mm (in.)

	Standard	Wear limit
Push rod length	*See separate service data (Page 2-34, 35)*	
Push rod bend		
Push rod dia.		

7. Timing Gear

The timing gear is helical type for minimum noise and specially treated for high durability.



mm (in.)

	No. of teeth	Face width	Helical angle	Back lash	Back lash Wear limit
Camshaft gear	*See separate service data (Page 2-36, 37)*				
Idle gear					
Crankshaft gear					
Lubricating oil pump gear					
Idle gear					
Fuel injection pump gear					

7-1 Inspecting the gears

(1) Inspect the gears and replace if the teeth are damaged or worn.

(2) Measure the backlash of all gears that mesh, and replace the meshing gears as a set if wear exceeds the limit.

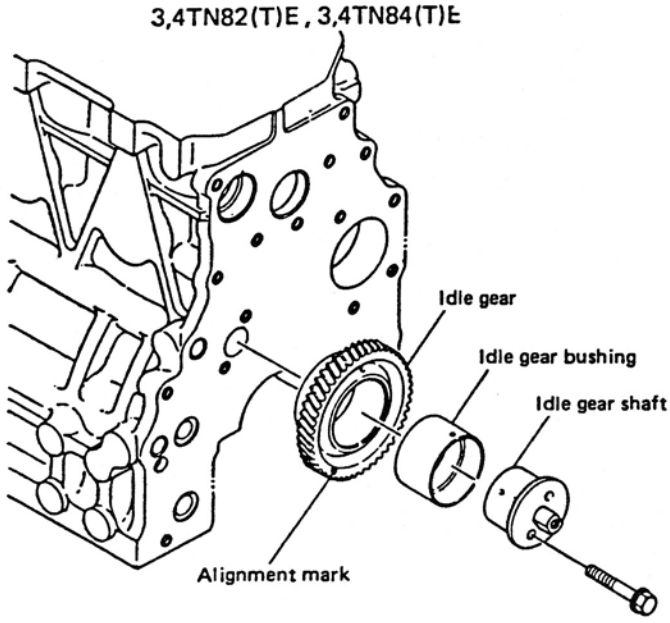
NOTE: If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.

(3) Idling gear

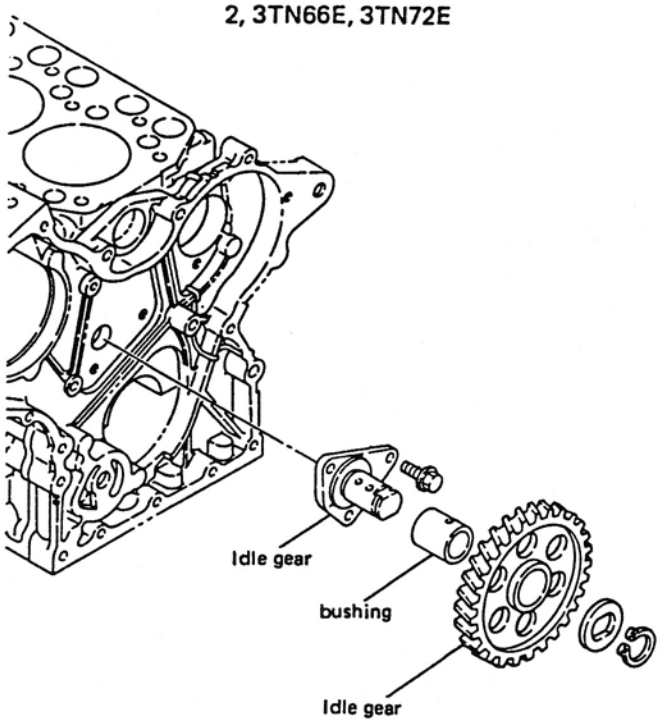
The bushing is pressure fitted into the idling gear. Measure the bushing inner diameter and the outer diameter of the shaft, and replace the bushing or idling gear shaft if the oil clearance exceeds the wear limit.

A, B and C are inscribed on the end of the idling gear. When assembling, these marks should align with those on the cylinder block.

3TN75E, 3TNC78E,
3,4TN82(T)E, 3,4TN84(T)E



2, 3TN66E, 3TN72E

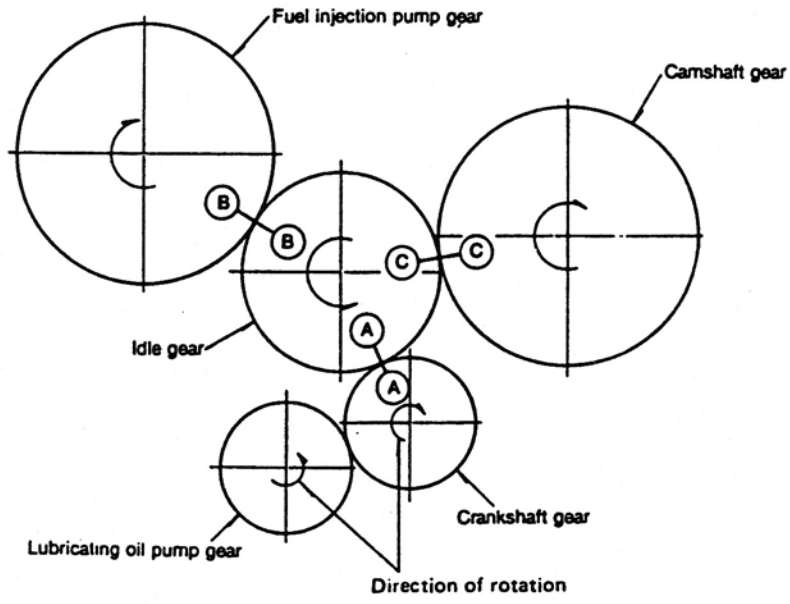


mm (in.)

	Standard	Wear limit
Idle shaft dia.	*See separate service data (Page 2-34, 35)*	
Idle shaft bushing inside dia.		
Idle shaft and bushing oil clearance		

7-2 Gear timing marks

Match up the timing marks on each gear when assembling (A, B and C).

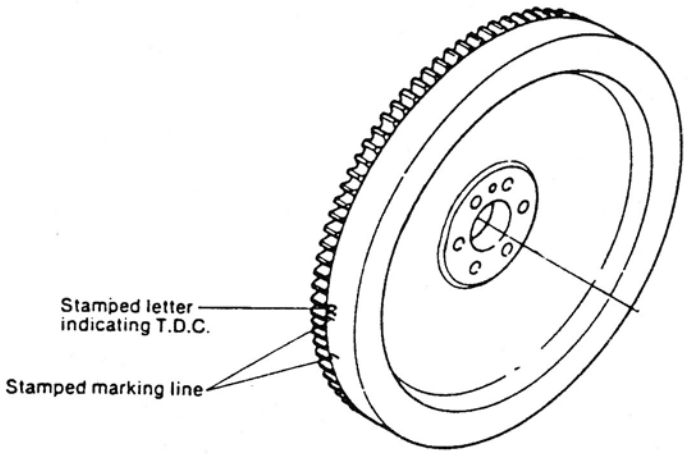


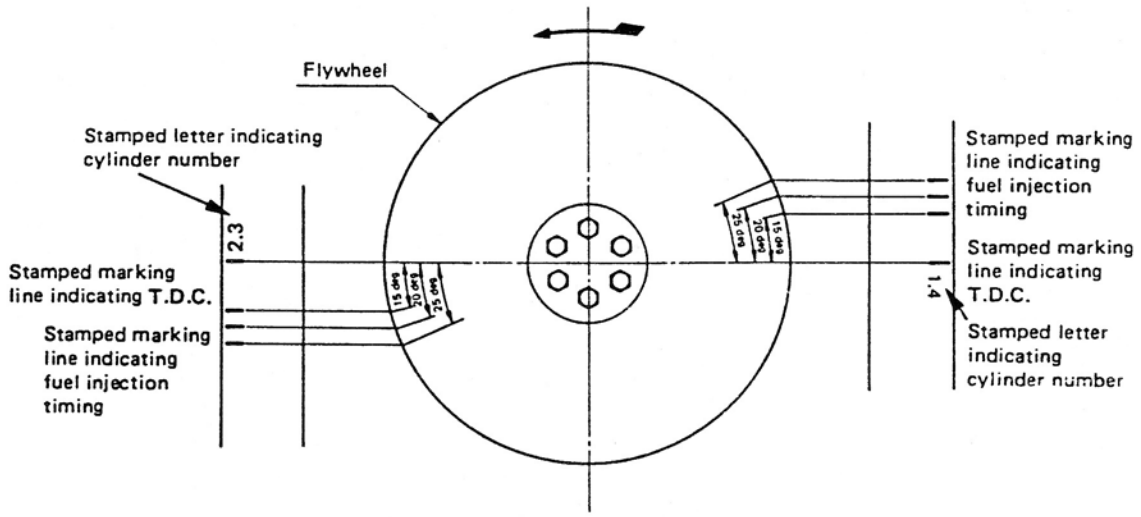
8. Flywheel

The flywheel used in the 3TN82E, 3TN82TE, 3TN84E, and 3TN84TE incorporate an unbalance mass in order to reduce engine vibrations by 1st-mode inertia couple produced by the reciprocation of the piston assembly, piston pin and small end of the connecting rod. The 2TN66E, 3TN66E, 3TNA72E, 3TN75E, 3TNC78E, and 4TN series engines, however, employ a balanced flywheel. The timing marks are punched on the circumference of the flywheel. These marks are used for checking the fuel injection timing.

8-1 Position of top dead center and fuel injection timing

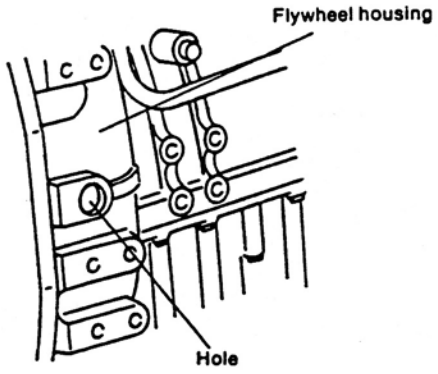
(1) Marking

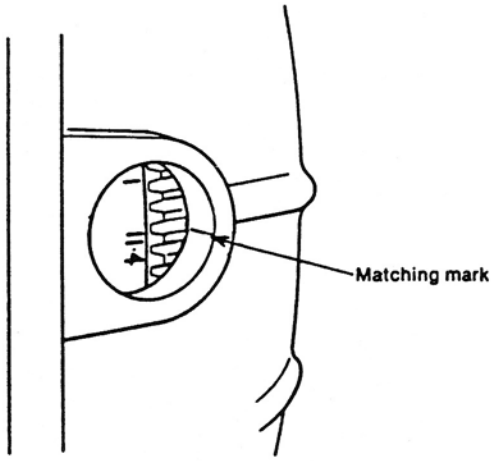




4 cylinder engine

(2) Matching mark

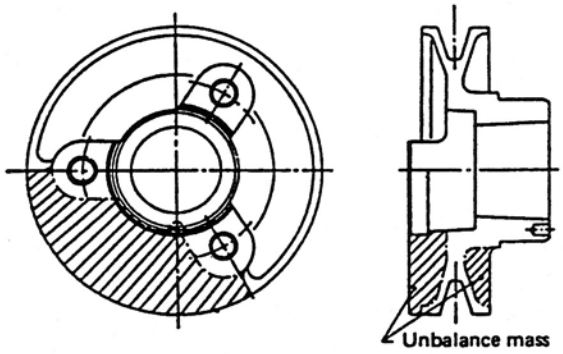




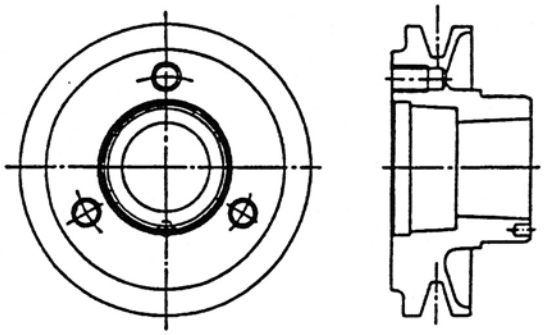
The matching mark is made at the hole of the flywheel housing.

9. Crankshaft pulley

The crankshaft pulley of the 3TN82E, 3TN82TE, 3TN84E, and 3TN84TE employ the unbalance mass design in order to reduce engine vibrations by offsetting the 1st-mode inertia couple produced by the reciprocating mass. The 2TN66E, 3TN66E, 3TNA72E, 3TN75E, 3TNC78E, and 4TN series engines, however, employ a balanced pulley.



Unbalanced pulley



Balanced pulley

9. Service Data

Item		Unit	2,3TN66E		3TNA72E		3TN75E	
			Standard	Wear limit	Standard	Wear limit	Standard	Wear limit
Cylinder block								
Cylinder bore dia.		mm (in)	66.00 – 66.03 (2.599 – 2.600)	66.20 (2.606)	72.00 – 72.03 (2.835 – 2.8360)	72.20 (2.843)	75.00 – 75.03 (2.953 – 2.954)	75.2 (2.961)
Cylinder roudness		mm (in)	0 – 0.01 (0 – 0.0004)	0.02 (0.001)	0 – 0.01 (0 – 0.0004)	0.02 (0.001)	0 – 0.01 (0 – 0.0004)	0.02 (0.008)
Top position A		mm (in)	10 (0.394)	–	20 (0.79)	–	20 (0.787)	–
Cylinder head								
Cylinder head distortion		mm (in)	0.05 and less (0.002)	0.15 (0.006)	0.05 and less (0.002)	0.15 (0.006)	0.05 and less (0.002)	0.15 (0.006)
Seat angle	Intake	deg.	120	–	120	–	120	–
	Exhaust	deg.	90	–	90	–	90	–
Seat width	Intake	mm (in)	1.15 (0.045)	1.65 (0.065)	1.44 (0.057)	1.98 (0.078)	1.36 – 1.53 (0.054 – 0.060)	1.98 (0.078)
	Exhaust	mm (in)	1.41 (0.056)	1.91 (0.075)	1.77 (0.070)	2.27 (0.089)	1.66 – 1.87 (0.065 – 0.074)	2.27 (0.089)
Seat grinder (valve seat angle) θ	Intake	deg.	30	–	30	–	30	–
	Exhaust	deg.	45	–	45	–	45	–
Valve stem outside dia.	Intake	mm (in)	5.460 – 5.475 (0.215 – 0.216)	5.40 (0.213)	6.945 – 6.96 (0.273 – 0.274)	6.90 (0.272)	6.945 – 6.960 (0.273 – 0.274)	6.90 (0.272)
	Exhaust	mm (in)	5.445 – 5.460 (0.214 – 0.215)	5.40 (0.213)	6.945 – 6.960 (0.273 – 0.274)	6.90 (0.272)	6.94 – 6.955 (0.273 – 0.274)	6.90 (0.272)
Position A (valve stem O.D. measuring point)		mm (in)	20 (0.787)	–	25 (0.984)	–	30 (1.181)	–
Position B (valve stem O.D. measuring point)		mm (in)	40 (1.575)	–	45 (1.772)	–	50 (1.969)	–
Valve sink	Intake	mm (in)	0.4 (0.016)	–	0.5 (0.02)	–	0.3 – 0.5 (0.012 – 0.020)	1.0 (0.039)
	Exhaust	mm (in)	0.85 (0.034)	–	0.85 (0.033)	–	0.3 – 0.5 (0.012 – 0.020)	1.0 (0.039)
Valve guide inside dia.	Intake	mm (in)	5.5 – 5.515 (0.2165 – 0.217)	5.58 (0.220)	7.005 – 7.020 (0.2758 – 0.2764)	7.08 (0.279)	7.00 – 7.015 (0.2756 – 0.2762)	7.08 (0.279)
	Exhaust	mm (in)	5.5 – 5.515 (0.2165 – 0.217)	5.58 (0.220)	7.005 – 7.020 (0.2758 – 0.2764)	7.08 (0.279)	7.00 – 7.015 (0.2756 – 0.2763)	7.08 (0.279)
Valve guide projection A		mm (in)	7 (0.276)	–	9 (0.354)	–	12 (0.472)	–
Valve spring	Free length (A)	mm (in)	28 (1.102)	–	37.4 (1.472)	– –	42 (1.654)	–
	Inclination (B)	mm (in)	–	0.8 (0.032)	–	1.0 (0.04)	–	1.1 (0.044)
Cylinder head tightening torque (Tighten separately with 2 – 3 times)	First	kg-m (ft-lb)	1.6 – 1.9 (11.57 – 13.74)	–	3.0 – 3.3 (21.69 – 23.86)	–	3.4 – 3.6 (24.58 – 26.03)	–
	Final	kg-m (ft-lb)	3.3 – 3.7 (23.87 – 26.76)	–	6.0 – 6.5 (43.38 – 47.00)	–	6.8 – 7.2 (49.17 – 52.06)	–
Top clearance		mm (in)	0.59 – 0.74 (0.0232 – 0.029)	–	0.61 – 0.79 (0.0240 – 0.0311)	–	0.59 – 0.77 (0.0232 – 0.0303)	–
Intake & exhaust valve rocker arm shaft outside dia.		mm (in)	9.97 – 9.99 (0.3925 – 0.3933)	9.955 (0.392)	11.966 – 11.984 (0.471 – 0.472)	11.955 (0.471)	15.966 – 15.984 (0.629 – 0.629)	15.955 (0.628)
Intake & exhaust valve rocker arm bushing inside dia.		mm (in)	10.00 – 10.02 (0.3937 – 0.3945)	10.09 (0.397)	12.00 – 12.02 (0.472 – 0.473)	12.09 (0.476)	16.000 – 16.020 (0.630 – 0.631)	16.090 (0.633)
Valve rocker arm shaft & bushing clearance at assembly		mm (in)	0.01 – 0.05 (0.0004 – 0.0020)	0.135 (0.0053)	0.016 – 0.054 (0.0006 – 0.0021)	0.135 (0.0053)	0.016 – 0.054 (0.0006 – 0.0021)	0.135 (0.0053)
Intake & exhaust valve clearance		mm (in)	0.2 (0.0079)	–	0.2 (0.0079)	–	0.2 (0.0079)	–
Intake valve open bTDC		deg.	5 – 15	–	7 – 17	–	10 – 20	–
Intake valve closed aBDC		deg.	37 – 47	–	35 – 45	–	40 – 50	–
Exhaust valve open bBDC		deg.	37 – 47	–	40 – 50	–	51 – 61	–
Exhaust valve closed a TDC		deg.	5 – 15	–	8 – 18	–	13 – 23	–

Item		Unit	3TNC78E		3,4TN82E/3,4TN82TE		3,4TN84E/3,4TN84TE	
			Standard	Wear limit	Standard	Wear limit	Standard	Wear limit
Cylinder block								
Cylinder bore dia.		mm (in)	78.00 – 78.03 (3.071 – 3.072)	78.2 (3.079)	82.00 – 82.03 (3.228 – 3.230)	82.2 (3.236)	84.00 – 84.03 (3.307 – 3.308)	84.2 (3.315)
Cylinder roudness		mm (in)	0 – 0.01 (0 – 0.0004)	0.02 (0.0008)	0 – 0.01 (0 – 0.0004)	0.02 (0.0008)	0 – 0.01 (0 – 0.0004)	0.02 (0.0008)
Top position A		mm (in)	20 (0.787)	–	20 (0.787)	–	20 (0.787)	–
Cylinder head								
Cylinder head distortion		mm (in)	0.05 and less (0.002)	0.15 (0.006)	0.05 and less (0.002)	0.15 (0.006)	0.05 and less (0.002)	0.15 (0.006)
Seat angle	Intake	deg.	120	–	120	–	120	–
	Exhaust	deg.	90	–	90	–	90	–
Seat width	Intake	mm (in)	1.36 – 1.53 (0.054 – 0.060)	1.98 (0.078)	1.07 – 1.24 (0.042 – 0.049)	1.74 (0.069)	1.07 – 1.24 (0.042 – 0.049)	1.74 (0.069)
	Exhaust	mm (in)	1.66 – 1.87 (0.065 – 0.074)	2.27 (0.089)	1.24 – 1.45 (0.049 – 0.057)	1.94 (0.076)	1.24 – 1.35 (0.049 – 0.053)	1.94 (0.076)
Seat grinder (valve seat angle) θ	Intake	deg.	30	–	30	–	30	–
	Exhaust	deg.	45	–	45	–	45	–
Valve stem outside dia.	Intake	mm (in)	6.945 – 6.960 (0.273 – 0.274)	6.90 (0.272)	7.960 – 7.975 (0.313 – 0.314)	7.90 (0.311)	7.960 – 7.975 (0.313 – 0.314)	7.90 (0.311)
	Exhaust	mm (in)	6.94 – 6.955 (0.273 – 0.274)	6.90 (0.272)	7.955 – 7.970 (0.313 – 0.314)	7.90 (0.311)	7.955 – 7.970 (0.313 – 0.314)	7.90 (0.311)
Position A (valve stem O.D. measuring point)		mm (in)	30 (1.181)	–	30 (1.181)	–	30 (1.181)	–
Position B (valve stem O.D. measuring point)		mm (in)	50 (1.969)	–	60 (2.362)	–	60 (2.362)	–
Valve sink	Intake	mm (in)	0.3 – 0.5 (0.012 – 0.020)	1.0 (0.039)	0.3 – 0.5 (0.012 – 0.020)	1.0 (0.039)	0.3 – 0.5 (0.012 – 0.020)	1.0 (0.039)
	Exhaust	mm (in)	0.3 – 0.5 (0.012 – 0.020)	1.0 (0.039)	0.3 – 0.5 (0.012 – 0.020)	1.0 (0.039)	0.3 – 0.5 (0.012 – 0.020)	1.0 (0.039)
Valve guide inside dia.	Intake	mm (in)	7.00 – 7.015 (0.2756 – 0.2762)	7.08 (0.279)	8.010 – 8.025 (0.3154 – 0.316)	8.10 (0.319)	8.010 – 8.025 (0.3154 – 0.316)	8.10 (0.319)
	Exhaust	mm (in)	7.00 – 7.015 (0.2756 – 0.2763)	7.08 (0.279)	8.015 – 8.030 (0.3156 – 0.316)	8.10 (0.319)	8.015 – 8.030 (0.3156 – 0.316)	8.10 (0.319)
Valve guide projection A		mm (in)	12 (0.472)	–	15 (0.591)	–	15 (0.591)	–
Valve spring	Free length (A)	mm (in)	42 (1.654)	–	40 (1.575)	39.5 (1.55)	40 (1.575)	39.5 (1.55)
	Inclination (B)	mm (in)	–	1.1 (0.044)	–	1.1 (0.044)	–	1.1 (0.044)
Cylinder head tightening torque (Tighten separately with 2 – 3 times)	First	kg-m (ft-lb)	3.4 – 3.6 (24.58 – 26.03)	–	3.5 – 4.3 (25.23 – 31.10)	–	3.5 – 4.3 (25.23 – 31.10)	–
	Final	kg-m (ft-lb)	6.8 – 7.2 (49.17 – 52.06)	–	7.5 – 8.5 (54.23 – 61.46)	–	7.5 – 8.5 (54.23 – 61.46)	–
Top clearance		mm (in)	0.63 – 0.77 (0.0248 – 0.0303)	–	0.64 – 0.82 (0.0252 – 0.0323)	–	0.64 – 0.82 (0.0252 – 0.0323)	–
Intake & exhaust valve rocker arm shaft outside dia.		mm (in)	15.966 – 15.984 (0.6286 – 0.6293)	15.955 (0.628)	15.966 – 15.984 (0.6286 – 0.6293)	15.955 (0.628)	15.966 – 15.984 (0.6286 – 0.6293)	15.955 (0.628)
Intake & exhaust valve rocker arm bushing inside dia.		mm (in)	16.000 – 16.020 (0.630 – 0.631)	16.090 (0.634)	16.000 – 16.020 (0.630 – 0.631)	16.090 (0.634)	16.000 – 16.020 (0.630 – 0.631)	16.090 (0.634)
Valve rocker arm shaft & bushing clearance at assembly		mm (in)	0.016 – 0.054 (0.0006 – 0.0021)	0.135 (0.0053)	0.016 – 0.054 (0.0006 – 0.0021)	0.135 (0.0053)	0.016 – 0.054 (0.0006 – 0.0021)	0.135 (0.0053)
Intake & exhaust valve clearance		mm (in)	0.2 (0.0079)	–	0.2 (0.0079)	–	0.2 (0.0079)	–
Intake valve open bTDC		deg.	10 – 20	–	10 – 20	–	10 – 20	–
Intake valve closed aBDC		deg.	40 – 50	–	40 – 50	–	40 – 50	–
Exhaust valve open bBDC		deg.	51 – 61	–	51 – 61	–	51 – 61	–
Exhaust valve closed a TDC		deg.	13 – 23	–	13 – 23	–	13 – 23	–

Item		Unit	2,3TN66E		3TNA72E		3TN75E	
			Standard	Wear limit	Standard	Wear limit	Standard	Wear limit
Piston & Piston pin								
Piston outside dia.		mm (in)	65.927 – 65.957 (2.596 – 2.597)	65.65 (2.593)	71.922 – 71.952 (2.832 – 2.833)	71.81 (2.827)	74.913 – 74.943 (2.949 – 2.951)	74.81 (2.945)
Position A (piston O.D. measuring point)		mm (in)	5 (0.197)	–	8 (0.315)	–	12.5 (0.492)	–
Piston pin hole dia. of piston		mm (in)	20.000 – 20.008 (0.787 – 0.788)	20.02 (0.788)	21.0 – 21.009 (0.8268 – 0.8271)	21.02 (0.828)	23.000 – 23.009 (0.9055 – 0.9059)	23.02 (0.906)
Piston pin outside dia.		mm (in)	19.991 – 20.000 (0.787 – 0.7874)	19.975 (0.786)	20.991 – 21.0 (0.826 – 0.827)	20.975 (0.826)	22.991 – 23.000 (0.905 – 0.906)	22.90 (0.902)
Piston and piston pin clearance		mm (in)	0 – 0.017 (0 – 0.0007)	0.045 (0.0018)	0 – 0.018 (0 – 0.0007)	0.045 (0.0018)	0 – 0.018 (0 – 0.0007)	0.045 (0.0018)
First piston ring	Groove width	mm (in)	1.555 – 1.570 (0.061 – 0.062)	–	1.565 – 1.58 (0.0616 – 0.0622)	–	2.065 – 2.080 (0.081 – 0.082)	–
	Ring width	mm (in)	1.47 – 1.49 (0.058 – 0.059)	–	1.47 – 1.49 (0.058 – 0.059)	–	1.97 – 1.99 (0.0776 – 0.0783)	–
	Clearance	mm (in)	0.065 – 0.1 (0.0026 – 0.0039)	0.2 (0.0079)	0.075 – 0.11 (0.0030 – 0.0043)	0.2 (0.0079)	0.070 – 0.105 (0.0028 – 0.0041)	0.25 (0.0098)
2nd piston ring	Groove width	mm (in)	1.52 – 1.535 (0.0598 – 0.0604)	–	1.520 – 1.535 (0.0598 – 0.0604)	–	2.035 – 2.050 (0.080 – 0.081)	–
	Ring width	mm (in)	1.47 – 1.49 (0.0579 – 0.0587)	–	1.47 – 1.49 (0.058 – 0.059)	–	1.97 – 1.99 (0.0776 – 0.0783)	–
	Clearance	mm (in)	0.03 – 0.065 (0.0012 – 0.0026)	0.2 (0.0079)	0.03 – 0.065 (0.0012 – 0.0026)	0.2 (0.0079)	0.035 – 0.070 (0.0014 – 0.0028)	0.25 (0.0098)
Oil ring	Groove width	mm (in)	3.51 – 3.525 (0.1382 – 0.1388)	–	3.510 – 3.525 (0.138 – 0.139)	–	4.015 – 4.030 (0.158 – 0.159)	–
	Ring width	mm (in)	3.47 – 3.49 (0.1366 – 0.1374)	–	3.47 – 3.49 (0.1366 – 0.1374)	–	3.975 – 3.990 (0.1565 – 0.1571)	–
	Clearance	mm (in)	0.02 – 0.055 (0.0008 – 0.0022)	0.2 (0.0079)	0.02 – 0.055 (0.0008 – 0.0022)	0.2 (0.0079)	0.030 – 0.060 (0.0012 – 0.0024)	0.2 (0.0078)
First ring gap		mm (in)	0.15 – 0.35 (0.006 – 0.014)	1.5 (0.059)	0.1 – 0.25 (0.004 – 0.010)	1.5 (0.059)	0.20/0.25 – 0.40 (0.08/0.010 – 0.016)	1.5 (0.059)
2nd ring gap		mm (in)	0.25 – 0.40 (0.010 – 0.016)	1.5 (0.059)	←	1.5 (0.059)	0.20 – 0.40 (0.008 – 0.016)	1.5 (0.059)
Oil ring gap		mm (in)	0.15 – 0.35 (0.006 – 0.014)	1.5 (0.059)	0.15 – 0.35 (0.006 – 0.014)	1.5 (0.059)	0.20 – 0.40 (0.008 – 0.016)	1.5 (0.059)
Connecting rod								
Connecting rod twist and parallelity		mm (in)	0.05/100 and less (0.002/3.937)	0.08 (0.003)	0.05/100 and less (0.002/3.937)	0.08 (0.003)	0.03/100 and less (0.001/3.937)	0.08 (0.003)
Connecting rod side clearance		mm (in)	0.2 – 0.4 (0.0079 – 0.0157)	0.55 (0.0217)	0.2 – 0.4 (0.0079 – 0.0158)	0.55 (0.0217)	0.2 – 0.4 (0.0079 – 0.0158)	0.55 (0.0217)
Connecting rod tightening torque		kg-m (ft-lb)	2.3 – 2.8	–	2.1 – 2.4 (15.18 – 17.35)	–	3.8 – 4.2 (27.48 – 30.37)	–
Piston pin bushing inside dia.		mm (in)	20.025 – 20.038 (0.788 – 0.789)	20.1 (0.791)	21.025 – 21.038 (0.828 – 0.828)	21.1 (0.831)	23.025 – 23.038 (0.9065 – 0.907)	23.1 (0.909)
Piston pin and bushing oil clearance		mm (in)	0.025 – 0.047 (0.0010 – 0.0019)	0.11 (0.0043)	0.025 – 0.047 (0.0010 – 0.0019)	0.11 (0.0043)	0.025 – 0.047 (0.0010 – 0.0019)	0.11 (0.0043)
Crankshaft and main bearing								
Crankshaft bend		mm (in)	Less than 0.02 (0.001)	–	Less than 0.02 (0.001)	–	Less than 0.02 (0.001)	–
Crank pin outside dia.		mm (in)	35.97 – 35.98 (1.416 – 1.417)	35.92 (1.414)	39.97 – 39.98 (1.5736 – 1.574)	39.92 (1.572)	42.952 – 42.962 (1.691 – 1.6914)	42.91 (1.689)
Crank pin busing inside dia.		mm (in)	36.00 – 36.042 (1.417 – 1.419)	37.07 (1.420)	40.00 – 40.042 (1.575 – 1.577)	40.07 (1.578)	43.00 – 43.042 (1.693 – 1.695)	43.07 (1.696)
Crank pin and bushing oil clearance		mm (in)	0.020 – 0.0072 (0.0008 – 0.0028)	0.15 (0.0059)	0.020 – 0.072 (0.0008 – 0.0028)	0.15 (0.0059)	0.038 – 0.090 (0.0015 – 0.0035)	0.16 (0.0063)
Crank journal outside dia.		mm (in)	39.97 – 39.98 (1.5736 – 1.574)	39.92 (1.572)	43.97 – 43.98 (1.731 – 1.732)	43.92 (1.729)	46.952 – 46.962 (1.8485 – 1.8489)	46.91 (1.847)
Crank journal bushing inside dia.		mm (in)	40.00 – 40.042 (1.575 – 1.577)	40.07 (1.578)	44.00 – 44.042 (1.732 – 1.734)	44.07 (1.735)	47.00 – 47.045 (1.850 – 1.852)	47.10 (1.854)

Item		Unit	3TNC78E		3,4TN82E/3,4TN82TE		3,4TN84E/3,4TN84TE	
			Standard	Wear limit	Standard	Wear limit	Standard	Wear limit
Piston & Piston pin								
Piston outside dia.		mm (in)	77.895 – 77.925 (3.067 – 3.068)	77.8 (3.063)	81.898 – 81.928 (3.224 – 3.226)	81.8 (3.221)	83.898 – 83.928 (3.303 – 3.304)	83.8 (3.299)
Position A (piston O.D. measuring point)		mm (in)	23	–	24 (0.945)	–	24 (0.945)	–
Piston pin hole dia. of piston		mm (in)	23.000 – 23.009 (0.9055 – 0.9059)	23.02 (0.906)	26.000 – 26.009 (1.0236 – 1.024)	26.02 (1.024)	26.000 – 26.009 (1.0236 – 1.024)	26.02 (1.024)
Piston pin outside dia.		mm (in)	22.991 – 23.000 (0.9052 – 0.9055)	22.90 (0.902)	25.987 – 26.000 (1.023 – 1.024)	25.90 (1.020)	25.987 – 26.000 (1.023 – 1.024)	25.90 (1.020)
Piston and piston pin clearance		mm (in)	0 – 0.018 (0 – 0.0007)	0.045 (0.0018)	0 – 0.022 (0 – 0.0009)	0.045 (0.0018)	0 – 0.022 (0 – 0.0009)	0.045 (0.0018)
First piston ring	Groove width	mm (in)	2.060 – 2.075 (0.0811 – 0.0817)	–	2.065 – 2.080 (0.081 – 0.082)	–	2.065 – 2.080 (0.081 – 0.082)	–
	Ring width	mm (in)	1.975/1.97 – 1.99 (0.0778/0.0776 – 0.0783)	–	1.975/1.970 – 1.990 T/C (0.0776 – 0.0783)	–	1.970 – 1.990 (0.0776 – 0.0783)	–
	Clearance	mm (in)	0.070 – 0.105/0.100 (0.0028 – 0.0041/0.0039)	0.25 (0.010)	0.075 – 0.110/0.105 (0.0030 – 0.0043) T/C	0.25 (0.00118)	0.075 – 0.110 (0.0030 – 0.0043) T/C	0.25 (0.010)
2nd piston ring	Groove width	mm (in)	2.025 – 2.040 (0.0797 – 0.0803)	–	2.035 – 2.050 (0.080 – 0.081)	–	2.035 – 2.050 (0.080 – 0.081)	–
	Ring width	mm (in)	1.975 – 1.990 (0.0778 – 0.0783)	–	1.970 – 1.990 (0.0776 – 0.0783)	–	1.970 – 1.990 (0.0776 – 0.0783)	–
	Clearance	mm (in)	0.035 – 0.065 (0.0014 – 0.0026)	0.25 (0.010)	0.045 – 0.080 (0.0018 – 0.0031)	0.25 (0.0098)	0.045 – 0.080 (0.0018 – 0.0031)	0.25 (0.0098)
Oil ring	Groove width	mm (in)	4.020 – 4.035 (0.1583 – 0.1589)	–	4.015 – 4.030 (0.158 – 0.159)	–	4.015 – 4.030 (0.158 – 0.159)	–
	Ring width	mm (in)	3.975 – 3.990 (0.1565 – 0.1571)	–	3.970 – 3.990 (0.156 – 0.157)	–	3.970 – 3.990 (0.156 – 0.157)	–
	Clearance	mm (in)	0.030 – 0.060 (0.0012 – 0.0024)	0.2 (0.008)	0.025 – 0.060 (0.0010 – 0.0024)	0.2 (0.0079)	0.025 – 0.060 (0.0010 – 0.0024)	0.2 (0.0079)
First ring gap		mm (in)	0.25 – 0.40 (0.010 – 0.016)	1.5 (0.059)	0.25/0.20–0.40/0.35 (0.010/0.008–0.016/0.014)	1.5 (0.059)	0.20/0.25–0.40/0.45 (0.008/0.010–0.016/0.018)	1.5 (0.059)
2nd ring gap		mm (in)	0.25 – 0.40 (0.010 – 0.016)	1.5 (0.059)	0.20 – 0.35 (0.008 – 0.014)	1.5 (0.059)	0.20 – 0.40 (0.008 – 0.016)	1.5 (0.059)
Oil ring gap		mm (in)	0.20 – 0.40 (0.008 – 0.016)	1.5 (0.059)	←	1.5 (0.059)	0.25 – 0.45 (0.010 – 0.018)	1.5 (0.059)
Connecting rod								
Connecting rod twist and parallelity		mm (in)	0.03/100 and less (0.0012/3.937)	0.08 (0.003)	0.03/100 and less (0.0012/3.937)	0.08 (0.003)	0.03/100 and less (0.0012/3.937)	0.08 (0.003)
Connecting rod side clearance		mm (in)	0.20 – 0.40 (0.0079 – 0.0157)	0.55 (0.0217)	0.20 – 0.40 (0.0079 – 0.0157)	0.55 (0.0217)	0.20 – 0.40 (0.0079 – 0.0157)	0.55 (0.0217)
Connecting rod tightening torque		kg-m (ft-lb)	3.8 – 4.2 (27.48 – 30.37)	–	4.5 – 5.0 (32.53 – 36.15)	–	4.5 – 5.0 (32.53 – 36.15)	–
Piston pin bushing inside dia.		mm (in)	23.025 – 23.038 (0.9065 – 0.907)	23.1 (0.909)	26.025 – 26.038 (1.0246 – 1.0251)	26.1 (1.028)	26.025 – 26.038 (1.0246 – 1.0251)	26.1 (1.028)
Piston pin and bushing oil clearance		mm (in)	0.025 – 0.047 (0.0010 – 0.0019)	0.11 (0.0043)	0.025 – 0.051 (0.0010 – 0.0020)	0.11 (0.0043)	0.025 – 0.051 (0.0010 – 0.0020)	0.11 (0.0043)
Crankshaft and main bearing								
Crankshaft bend		mm (in)	Less than 0.02 (0.001)	–	Less than 0.02 (0.001)	–	Less than 0.02 (0.001)	–
Crank pin outside dia.		mm (in)	42.952 – 42.962 (1.691 – 1.6914)	42.91 (1.689)	47.952 – 47.962 (1.8879 – 1.8883)	47.91 (1.886)	47.952 – 47.962 (1.8879 – 1.8883)	47.91 (1.886)
Crank pin busing inside dia.		mm (in)	43.00 – 43.042 (1.693 – 1.695)	43.07 (1.696)	48.000 – 48.042 (1.888 – 1.891)	48.07 (1.893)	48.000 – 48.042 (1.888 – 1.891)	48.07 (1.893)
Crank pin and bushing oil clearance		mm (in)	0.038 – 0.090 (0.0015 – 0.0035)	0.16 (0.0063)	0.038 – 0.090 (0.0015 – 0.0035)	0.16 (0.0063)	0.038 – 0.090 (0.0015 – 0.0035)	0.16 (0.0063)
Crank journal outside dia.		mm (in)	46.952 – 46.962 (1.8485 – 1.8489)	46.91 (1.847)	49.952 – 49.962 (1.9666 – 1.967)	49.90 (1.965)	49.952 – 49.962 (1.967 – 1.967)	49.90 (1.965)
Crank journal bushing inside dia.		mm (in)	47.00 – 47.045 (1.850 – 1.852)	47.10 (1.854)	50.000 – 50.045 (1.969 – 1.970)	50.10 (1.972)	50.000 – 50.045 (1.969 – 1.970)	50.10 (1.972)

Item		Unit	2,3TN66E		3TNA72E		3TN75E	
			Standard	Wear limit	Standard	Wear limit	Standard	Wear limit
Crank journal and bushing oil clearance		mm (in)	0.020 – 0.072 (0.0008 – 0.0028)	0.15 (0.0059)	0.020 – 0.072 (0.0008 – 0.0028)	0.15 (0.0059)	0.038 – 0.093 (0.0015 – 0.0037)	0.15 (0.0059)
Fillet rounding of crank pin and journal		mm (in)	3.0 – 3.3 (0.118 – 0.130)	–	3.0 – 3.3 (0.118 – 0.130)	–	3.5 – 3.8 (0.138 – 0.150)	–
Crankshaft side gap		mm (in)	0.095 – 0.266 (0.004 – 0.011)	0.33 (0.013)	0.09 – 0.271 (0.004 – 0.011)	0.33 (0.013)	0.09 – 0.271 (0.004 – 0.011)	0.33 (0.013)
Main Bearing cap bolt tightening torque		kg-m (ft-lb)	5.3 – 5.7 (38.32 – 41.21)	–	7.8 – 8.2 (56.40 – 59.29)	–	7.8 – 8.2 (56.40 – 59.29)	–
Camshaft and tappets								
Camshaft side gap		mm (in)	0.05 – 0.15 (0.002 – 0.006)	0.4 (0.016)	0.05 – 0.15 (0.002 – 0.006)	0.4 (0.016)	0.05 – 0.20 (0.002 – 0.008)	0.4 (0.016)
Camshaft height	Intake cam	mm (in)	29.97 – 30.03 (1.180 – 1.182)	29.75 (1.171)	33.95 – 34.05 (1.337 – 1.341)	33.75 (1.329)	38.635 – 38.765 (1.521 – 1.526)	38.4 (1.512)
	Exhaust cam	mm (in)	29.97 – 30.03 (1.180 – 1.182)	29.75 (1.171)	33.95 – 34.05 (1.337 – 1.341)	33.75 (1.329)	38.635 – 38.765 (1.521 – 1.526)	38.4 (1.512)
Camshaft journal outside dia.	Gearcase side	mm (in)	35.94 – 35.96 (1.415 – 1.416)	35.85 (1.411)	39.94 – 39.96 (1.572 – 1.573)	39.85 (1.569)	44.925 – 44.950 (1.769 – 1.770)	44.8 (1.764)
	Intermidiate	mm (in)	35.91 – 35.935 (1.414 – 1.415)	35.85 (1.411)	39.910 – 39.935 (1.571 – 1.572)	39.85 (1.569)	44.910 – 44.935 (1.768 – 1.769)	44.8 (1.764)
	Flywheel side	mm (in)	35.94 – 35.96 (1.415 – 1.416)	35.85 (1.411)	39.94 – 39.96 (1.572 – 1.573)	40.1 (1.579)	44.925 – 44.950 (1.769 – 1.770)	44.8 (1.764)
Camshaft journal bushing inside dia.	Gearcase side	mm (in)	36.00 – 36.065 (1.417 – 1.420)	36.1 (1.421)	40.00 – 40.065 (1.575 – 1.577)	40.1 (1.579)	44.990 – 45.055 (1.771 – 1.774)	–
	Middle	mm (in)	–	–	–	–	–	–
	Flywheel side	mm (in)	–	–	–	–	–	–
Cylinder block camshaft bearing inside dia.	Gearcase side	mm (in)	–	–	–	–	–	–
	Middle	mm (in)	36.00 – 36.025 (1.417 – 1.418)	36.1 (1.421)	40.00 – 40.025 (1.575 – 1.576)	40.1 (1.579)	45.000 – 45.025 (1.772 – 1.773)	–
	Flywheel side	mm (in) in)	36.00 – 36.025 (1.417 – 1.418)	36.1 (1.421)	40.00 – 40.025 (1.575 – 1.576	40.1 (1.579)	45.000 – 45.025 (1.772 – 1.773)	–
Camshaft bearing oil clearance	Gearcase side	mm (in)	0.040 – 0.125 (0.0016 – 0.0049)	–	0.040 – 0.125 (0.0016 – 0.0049)	–	0.040 – 0.130 (0.0015 – 0.0050)	0.2 (0.0078)
	Middle	mm (in)	0.065 – 0.115 (0.0026 – 0.0045)	–	0.065 – 0.115 (0.0026 – 0.0045)	–	0.065 – 0.115 (0.0025 – 0.0045)	0.2 (0.0078)
	Flywheel side	mm (in)	0.040 – 0.085 (0.0016 – 0.0033)	–	0.040 – 0.085 (0.0016 – 0.0033)	–	0.050 – 0.100 (0.0019 – 0.0039)	0.2 (0.0078)
Camshaft deflection		mm (in)	0.02 (0.001)	–	0.02 (0.001)	–	0.02 (0.001)	–
Tappet stem outside dia.		mm (in)	17.95 – 17.968 (0.7067 – 0.7074)	17.93 (0.706)	20.927 – 20.96 (0.824 – 0.825)	20.93 (0.824)	11.975 – 11.990 (0.471 – 0.472)	11.93 (0.470)
Tappet guide hole inside dia.		mm (in)	18.00 – 18.018 (0.7087 – 0.7094)	18.05 (0.711)	21.00 – 21.021 (0.827 – 0.828)	21.05 (0.829)	12.000 – 12.018 (0.472 – 0.473)	12.05 (0.474)
Tappet stem and guide hole oil clearance		mm (in)	0.032 – 0.068 (0.0013 – 0.0027)	–	0.04 – 0.094 (0.0016 – 0.0037)	–	0.010 – 0.043 (0.0003 – 0.0016)	–
Pushrod length		mm (in)	114.0 – 115.0 (4.488 – 4.528)	–	141 – 142 (5.55 – 5.59)	–	146.65 – 147.35 (7.018 – 7.037)	–
Pushrod bend		mm (in)	Less than 0.075 (0.003)	–	Less than 0.075 (0.003)	–	Less than 0.03 (0.001)	0.3 (0.012)
Pushrod dia.		mm (in)	5 (0.197)	–	5 (0.197)	–	8 (0.315)	–
Timing gear								
Idle shaft dia.		mm (in)	19.959 – 19.980 (0.786 – 0.787)	19.93 (0.785)	19.959 – 19.98 (0.786 – 0.787)	19.93 (0.785)	45.950 – 45.975 (1.809 – 1.810)	45.93 (1.808)
Idle shaft bushing inside dia.		mm (in)	20.00 – 20.021 (0.786 – 0.788)	–	20.00 – 20.021 (0.787 – 0.788)	–	46.000 – 46.025 (1.811 – 1.812)	46.03 (1.812)
Idle shaft and bushing oil clearance		mm (in)	0.02 – 0.062 (0.001 – 0.002)	0.15 (0.0059)	0.02 – 0.062 (0.0008 – 0.0024)	0.15 (0.0059)	0.025 – 0.075 (0.0009 – 0.0029)	0.15 (0.0059)

Item		Unit	3TNC78E		3,4TN82E/3,4TN82TE		3,4TN84E/3,4TN84TE	
			Standard	Wear limit	Standard	Wear limit	Standard	Wear limit
Crank journal and bushing oil clearance		mm (in)	0.038 – 0.093 (0.0015 – 0.0037)	0.15 (0.0059)	0.038 – 0.093 (0.0015 – 0.0037)	0.15 (0.0059)	0.038 – 0.093 (0.0015 – 0.0037)	0.15 (0.0059)
Fillet rounding of crank pin and journal		mm (in)	3.5 – 3.8 (0.138 – 0.150)	–	3.500 – 3.800 (0.138 – 1.150)	–	3.500 – 3.800 (0.138 – 1.150)	– –
Crankshaft side gap		mm (in)	0.09 – 0.271 (0.004 – 0.011)	0.33 (0.013)	0.090 – 0.271 (0.004 – 0.011)	0.33 (0.013)	0.090 – 0.271 (0.004 – 0.011)	0.33 (0.013)
Main Bearing cap bolt tightening torque		kg-m (ft-lb)	7.8 – 8.2 (56.40 – 59.29)	–	9.5 – 10.5 (68.69 – 75.92)	–	9.5 – 10.5 (68.69 – 75.92)	–
Camshaft and tappets								
Camshaft side gap		mm (in)	0.05 – 0.20 (0.002 – 0.008)	0.4 (0.016)	0.05 – 0.20 (0.002 – 0.008)	0.4 (0.016)	0.05 – 0.20 (0.002 – 0.008)	0.4 (0.016)
Camshaft height	Intake cam	mm (in)	38.635 – 38.765 (1.521 – 1.526)	38.4 (1.512)	38.635 – 38.765 (1.521 – 1.526)	38.4 (1.512)	38.635 – 38.765 (1.521 – 1.526)	38.4 (1.512)
	Exhaust cam	mm (in)	38.635 – 38.765 (1.521 – 1.526)	38.4 (1.512)	38.635 – 38.765 (1.521 – 1.526)	38.4 (1.512)	38.635 – 38.765 (1.521 – 1.526)	38.4 (1.512)
Camshaft journal outside dia.	Gearcase side	mm (in)	44.925 – 44.950 (1.769 – 1.770)	44.8 (1.764)	44.925 – 44.950 (1.769 – 1.770)	44.8 (1.764)	44.925 – 44.950 (1.769 – 1.770)	44.8 (1.764)
	Intermidiate	mm (in)	44.910 – 44.935 (1.768 – 1.769)	44.8 (1.764)	44.910 – 44.935 (1.768 – 1.769)	44.8 (1.764)	44.910 – 44.935 (1.768 – 1.769)	44.8 (1.764)
	Flywheel side	mm (in)	44.925 – 44.950 (1.769 – 1.770)	44.8 (1.764)	44.925 – 44.950 (1.769 – 1.770)	44.8 (1.764))	44.925 – 44.950 (1.769 – 1.770)	44.8 (1.764)
Camshaft journal bushing inside dia.	Gearcase side	mm (in)	44.990 – 45.055 (1.771 – 1.774)	–	44.990 – 45.055 (1.771 – 1.774)	–	44.990 – 45.055 (1.771 – 1.774)	–
	Middle	mm (in)	–	–	–	–	–	–
	Flywheel side	mm (in)	–	–	–	–	–	–
Cylinder block camshaft bearing inside dia.	Gearcase side	mm (in)	–	–	–	–	–	–
	Middle	mm (in)	45.000 – 45.025 (1.772 – 1.773)	–	45.000 – 45.025 (1.772 – 1.773)	–	45.000 – 45.025 (1.772 – 1.773)	–
	Flywheel side	mm (in) in)	4.5000 – 45.025 (1.772 – 1.773)	–	45.000 – 45.025 (1.772 – 1.773)	–	45.000 – 45.025 (1.772 – 1.773)	–
Camshaft bearing oil clearance	Gearcase side	mm (in)	0.040 – 0.130 (0.0015 – 0.0050)	0.2 (0.0078)	0.040 – 0.130 (0.0016 – 0.0051)	0.2 (0.0079)	0.040 – 0.130 (0.0016 – 0.0051)	0.2 (0.0079)
	Middle	mm (in)	0.065 – 0.115 (0.0025 – 0.0045)	0.2 (0.0078)	0.065 – 0.115 (0.0026 – 0.0045)	0.2 (0.0079)	0.065 – 0.115 (0.0026 – 0.0045)	0.2 (0.0079)
	Flywheel side	mm (in)	0.050 – 0.100 (0.0019 – 0.0039)	0.2 (0.0078)	0.050 – 0.100 (0.0020 – 0.0039)	0.2 (0.0079)	0.050 – 0.100 (0.0020 – 0.0039)	0.2 (0.0079)
Camshaft deflection		mm (in)	0.02 (0.001)	–	0.02 (0.001)	–	0.02 (0.001)	–
Tappet stem outside dia.		mm (in)	11.975 – 11.990 (0.471 – 0.472)	11.93 (0.470)	11.975 – 11.990 (0.4715 – 0.472)	11.93 (0.470)	11.975 – 11.990 (0.472 – 0.472)	11.93 (0.470)
Tappet guide hole inside dia.		mm (in)	12.000 – 12.018 (0.472 – 0.473)	12.05 (0.474)	12.000 – 12.018 (0.472 – 0.473)	12.05 (0.474)	12.000 – 12.018 (0.472 – 0.473)	12.05 (0.474)
Tappet stem and guide hole oil clearance		mm (in)	0.010 – 0.043 (0.003 – 0.0016)	–	0.010 – 0.043 (0.0004 – 0.0017)	–	0.010 – 0.043 (0.0004 – 0.0017)	–
Pushrod length		mm (in)	146.65 – 147.35 (7.018 – 7.037)	–	178.25 – 178.75 (7.018 – 7.037)	–	178.25 – 178.75 (7.018 – 7.037)	–
Pushrod bend		mm (in)	Less than 0.03 (0.001)	0.3 (0.012)	Less than 0.03 (0.001)	–	Less than 0.03 (0.001)	–
Pushrod dia.		mm (in)	8 (0.315)	–	8 (0.315)	–	8 (0.315)	–
Timing gear								
Idle shaft dia.		mm (in)	45.950 – 45.975 (1.809 – 1.810)	45.93 (1.808)	45.950 – 45.975 (1.809 – 1.810)	45.93 (1.808)	45.950 – 45.975 (1.809 – 1.810)	45.93 (1.808)
Idle shaft bushing inside dia.		mm (in)	46.000 – 46.025 (1.811 – 1.812)	46.03 (1.812)	46.000 – 46.025 (1.811 – 1.812)	46.08 (1.814)	46.000 – 46.025 (1.811 – 1.812)	46.08 (1.814)
Idle shaft and bushing oil clearance		mm (in)	0.025 – 0.075 (0.0009 – 0.0029)	0.15 (0.0059)	0.025 – 0.075 (0.0010 – 0.0030)	0.15 (0.0059)	0.025 – 0.075 (0.0010 – 0.0030)	0.15 (0.0059)

Timing Gear			2,3TN66E		3TNA72E		3TN75E, 3TNC78E	
Item		Unit	Standard	Wear limit	Standard	Wear limit	Standard	Wear limit
Camshaft gear	No. of teeth		42		44		56	
	Face width		12		15		18	
	Helical angle		left		left		left	
	Backlash between camgear and idle gear		0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)
Idle gear	No. of teeth		47		47		43	
	Face width		12		15		18	
	Helical angle		right		right		right	
	Backlash between idle gear and crankshaft gear		0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	0.04 – 0.12 (0.0016 – 0.0047)	(0.0079)	0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)
Crankshaft gear	No. of teeth		21		22		28	
	Face width		29		37		40	
	Helical angle		left		left		left	
	Backlash between crankshaft gear and oil pump gear		0.11 – 0.19 (0.0043 – 0.0075)	0.2 (0.0079)	0.11 – 0.19 (0.0043 – 0.0075)	0.2 (0.0079)	0.11 – 0.19 (0.0043 – 0.0075)	0.20 (0.0079)
Lubricating oil pump gear	No. of teeth		25		25		29	
	Face width		6		6		8	
	Helical angle		right		right		right	
Idle gear	No. of teeth		47		47		43	
	Face width		12		15		18	
	Helical angle		right		right		right	
	Backlash between idle gear and fuel injection pump		0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)
Fuel injection pump gear	No. of teeth		42		44		56	
	Face width		8		10		10	
	Helical angle		left		left		left	

Timing Gear			3,4TN82E, 3,4TN84E		3,4TN82TE, 3,4TN84TE		
Item		Unit	Standard	Wear limit	Standard	Wear limit	
Camshaft gear	No. of teeth Face width Helical angle Backlash between camgear and idle gear		56 18 left 0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	56 18 left 0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	
Idle gear	No. of teeth Face width Helical angle Backlash between idle gear and crankshaft gear		43 18 right 0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	43 18 right 0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	
Crankshaft gear	No. of teeth Face width Helical angle Backlash between crankshaft gear and oil pump gear		28 40 left 0.04 – 0.12 (0.0043 – 0.0075)	0.2 (0.0079)	28 40 left 0.04 – 0.12 (0.0043 – 0.0075)	0.2 (0.0079)	
Lubricating oil pump gear	No. of teeth Face width Helical angle		29 8 right		29 8 right		
Idle gear	No. of teeth Face width Helical angle Backlash between idle gear and fuel injection pump		43 18 right 0.04 - 0.12 (0.0016 - 0.0047)	0.2 (0.0079)	43 18 right 0.04 – 0.12 (0.0016 – 0.0047)	0.2 (0.0079)	
Fuel injection pump gear	No. of teeth Face width Helical angle		56 10 left		56 10 left		

10. Over-size and Under-size Parts

		2,3TN66E	3TNA72E	3TN75E 3TNC78E	3,4TN82E 3,4TN82TE	3,4TN84TE 3,4TN84TE
Piston	Outder diameter (at measuring point) mm (in)	66,177 – 66,207 (2.6054 – 2.6066)	72,172 – 72,202 (2.8414 – 2.8426)	75E: 75.168 – 75.183 (2.9594 – 2.9600) 78E: 78.150 – 78.165 (3.0768 – 3.0774)	82,153 – 82,168 (3.2344 – 3.2350)	84.150 – 84.165 (3.3130 – 3.3136)
	Identification	OS25	OS25	OS25	OS25	OS25
Crank-journal metal	Inner diameter mm (in)	39,750 – 39,792 (1.565 – 1.5666)	43,750 – 43,792 (1.7224 – 1.7241)	46,75 – 46,795 (1.8406 – 1.8423)	49,75 – 49,795 (1.9587 – 1.9604)	49,75 – 49,795 (1.9587 – 1.9604)
	Identification	US25	US25	–	–	–
Crank-pin metal	Inner diameter mm (in)	35,750 – 35,792 (1.4075 – 1.4091)	39,750 – 39,792 (1.565 – 1.5666)	42,75 – 42,792 (1.6831 – 1.6847)	47,75 – 47,795 (1.8799 – 1.8817)	47,75 – 47,795 (1.8799 – 1.8817)
	Identification	US25	US25	–	–	–
Piston pin metal*	Inner diameter (after in compressed) mm (in)	20,024 – 20,085 (0.7883 – 0.7907)	21,024 – 21,085 (0.8277 – 0.8301)	23,024 – 23,085 (0.9065 – 0.9089)	26,024 – 26,085 (1.0246 – 1.0270)	26,024 – 26,085 (1.0246 – 1.0270)
	Identification	w/oil hole	w/oil hole	w/oil hole	w/oil hole	w/oil hole

NOTE : 1) Under-sized piston pin should be unprepared.
Use a standard parts in case of up to service limit.
2) Marked Piston pin metal are finishing of the inside-diameter unnecessary, and it is pressed-in to the connecting rod only.*
3) Refer to the parts catalogs concerning the parts code numbers.

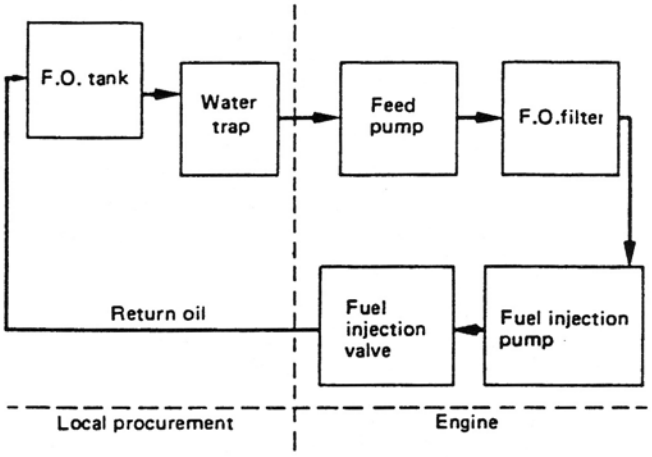
1. Fuel Supply System

1. Fuel Supply System

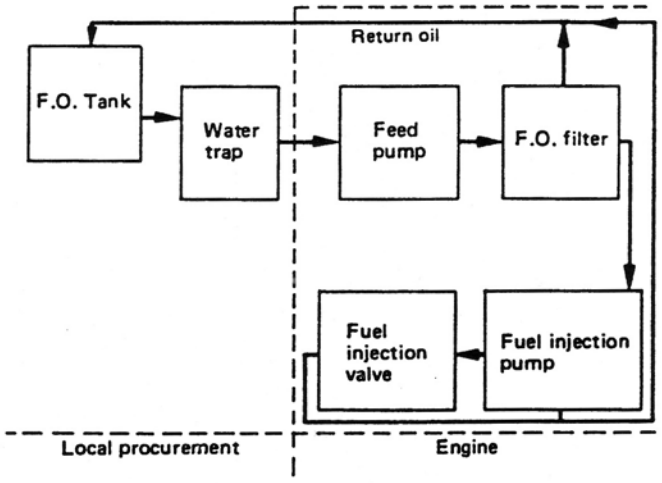
There are two types of TN series fuel injection pump. Models YPES and YPFR. (YPFR in 2TN66E, 3TN66E and 3TNA72E engines. YPES in 3TN75E, 3TNC78E, 3TN82(84)E, 4TN82(84)E, 3TN82(84)TE, and 4TN82(84)TE engines). Both of these fuel injection pumps are Bosch in-line type with the camshaft driven by engine gears via the timing gears. The feed pump is driven by the camshaft of the fuel injection pump. The filtered fuel is fed to the reservoir in the pump housing. The plunger increases the pressure, and the fuel passes through the injection pipe to be injected into each cylinder by the fuel injection nozzle.

Fuel Line

2,3TN66E, 3TNA72E (IDI engine)

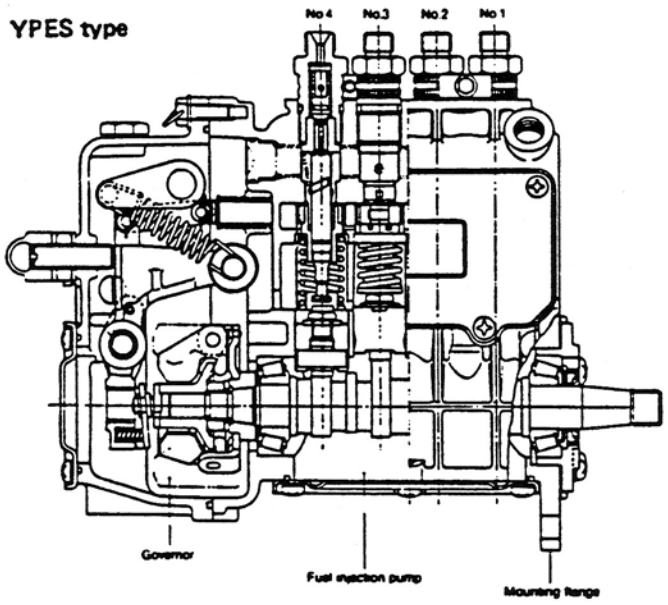


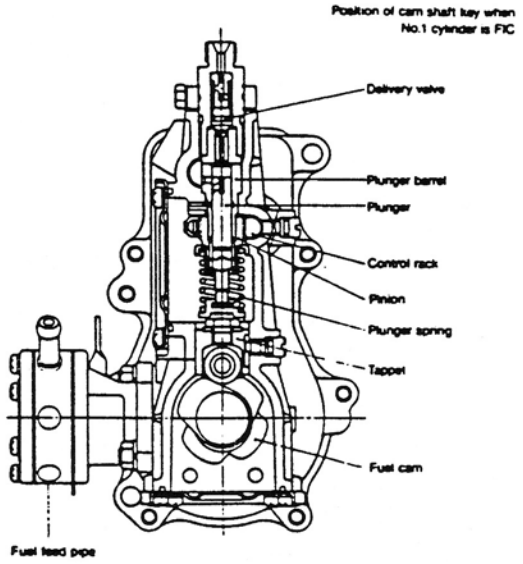
3TN75E, 3TNC78E, 3,4TN82(T)E, 3,4TN84(T)E (DI engine)

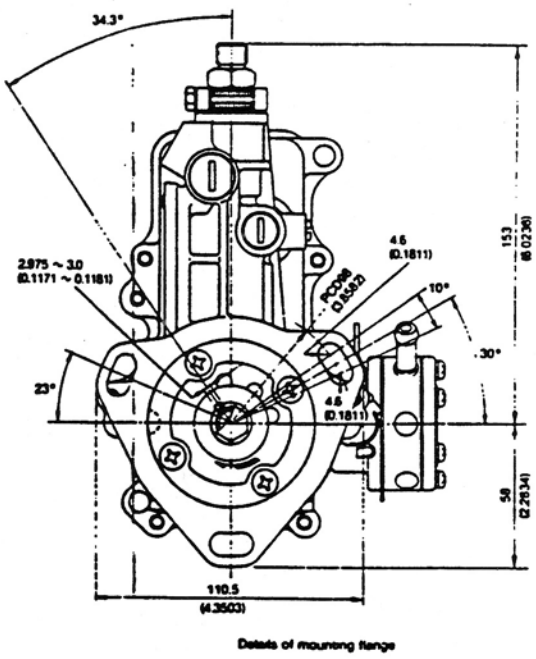


1-1 Fuel Injection Pump Construction

YPES type

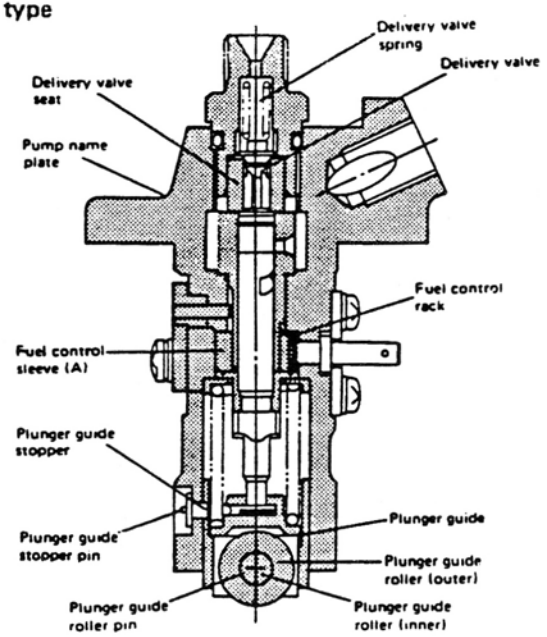


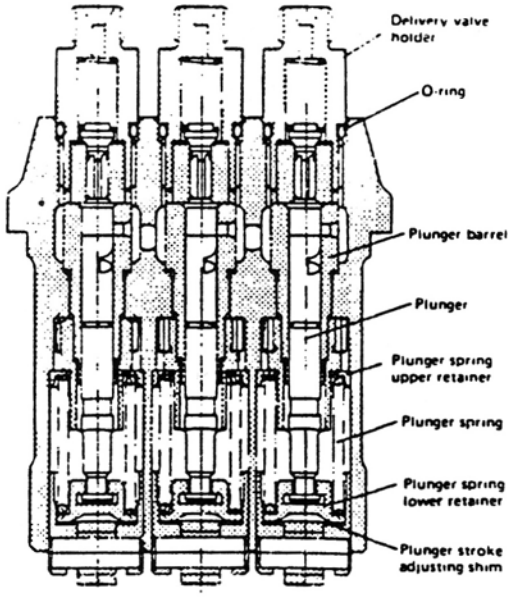




Details of mounting flange

YPFR type


Delivery valve spring
Delivery valve
Delivery valve seat
Pump name plate
Fuel control rack
Fuel control sleeve (A)
Plunger guide stopper
Plunger guide
Plunger guide stopper pin
Plunger guide roller (outer)
Plunger guide roller pin
Plunger guide roller (inner)


Delivery valve holder
O-ring
Plunger barrel
Plunger
Plunger spring upper retainer
Plunger spring
Plunger spring lower retainer
Plunger stroke adjusting shim

Bosch type fuel injection pump is an in-line type pump with a governor incorporated.

A camshaft is built into the fuel injection pump, which has a drive cam for the fuel feed pump and tappet-drive cams for the plunger.

A timing gear and drive gear are mounted on the drive side of the camshaft, and a governor weight on the opposite side.

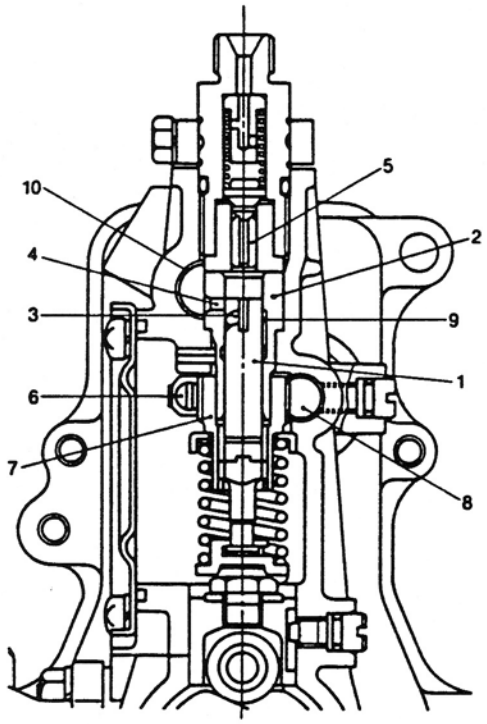
As the plunger rises, the fuel oil opens the delivery valve and goes through the high pressure pipe to the fuel injection nozzles.

When the control rack connected to the governor lever moves, the pinion turns the plunger. This changes the fuel discharge and intake positions and in turn controls the amount of fuel injected.

1-2 Fuel injection pump specifications

Type	YPFR	YPES-CL
Specifications	*See separate service data (Page 3-60, 61)*	

1-3 Functioning of fuel injection pump



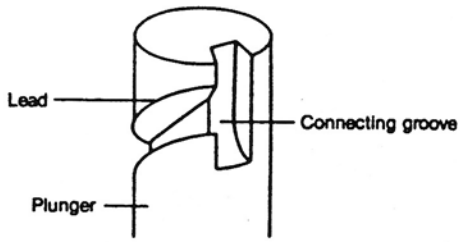
1. Plunger
2. Plunger barrel
3. Lead groove
4. Intake port
5. Delivery valve
6. Control sleeve
7. Control pinion
8. Control rack
9. Fuel leak return groove
10. Protector

The fuel injection pump supplies pressurized fuel to the injection nozzles through the action of the plunger. The plunger reciprocates in the plunger barrel through a fixed stroke and is lapped for a precise fit. A lead groove is helically cut in the plunger, and this leads to a connecting groove which goes to the top of the plunger.

There is a port in the plunger barrel which serves as both an intake and discharge port. The fuel comes through this port into the plunger chamber, is pressurized by the plunger, opens the delivery valve, flows to the fuel injection nozzle through the fuel injection pipe and is injected into the combustion chamber. Fuel injection terminates after the pressurized fuel has been discharged. This happens when the lead groove lines up with the discharge groove as the plunger rises and the pressure in the fuel injection pipe drops.

The control sleeve groove is fitted to the plunger flange. The control sleeve is secured to the control pinion and the pinion teeth and rack gear teeth are engaged.

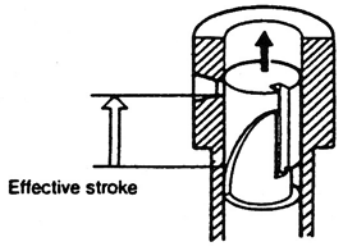
The plunger is controlled by the rack, enabling continuous changing of the volume of fuel injected from zero to maximum. A fuel leak return hole is provided in the plunger barrel. This returns fuel leaking from the gap between the plunger and the barrel to the fuel lines. This prevents dilution of the lubricant in the cam chamber.



1-4 Injection volume control

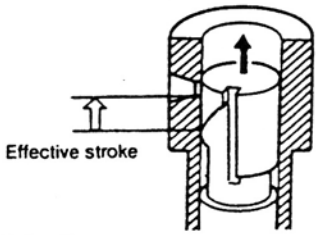
(1) Full injection volume position

When the rack is set at the maximum setting, fuel injection starts earlier. It occurs when the widest part of the lead groove on the upper part of plunger lines up with the intake port in the barrel. At this time, the nar-

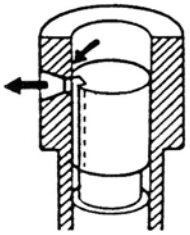


rowest part of the lower lead groove lines up with the discharge port, prolonging the length of injection and increasing the volume of fuel injected.
This setting is normally used for starting and max. output operation.

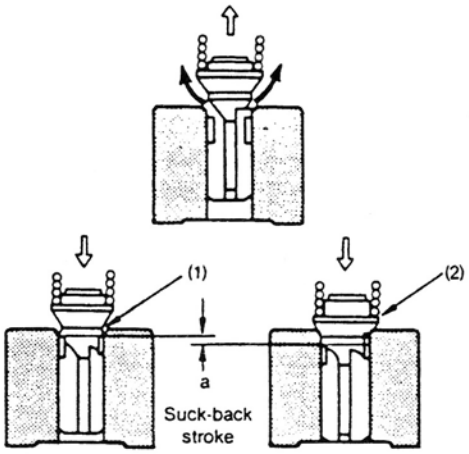
(2) Half injection volume position
When the rack is returned towards zero from the maximum setting, discharge starts later and ends earlier, decreasing the volume of fuel injected.



(3) No fuel injection
When the rack is set near zero, the intake/discharge port in the barrel is always open, so no fuel is pressurized (even though the plunger continues to reciprocate).



The delivery valve at the top of the plunger prevents fuel in the fuel injection pipe from flowing back to the plunger and sucks up fuel from the nozzle valve to prevent after drip.
When the plunger lead lines up with the discharge port of the plunger barrel, the injection pressure drops, and the delivery valve is brought down by the delivery valve spring.



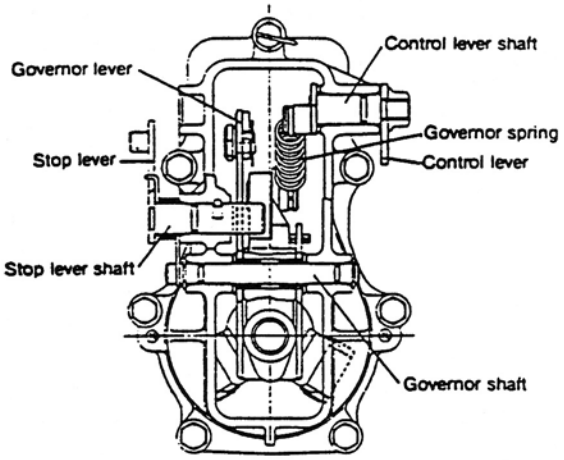
At this time, the suck-back collar (1) blocks off the fuel injection pipe and the delivery chamber, and the valve continues to descend until the seat (2) comes in contact with the barrel. The fuel oil pressure in the fuel injection pipe decreases proportionately with the lowering of the valve (due to increased volume).
This accelerates closing of the nozzle valve, and sucks up fuel from the nozzle to prevent it from dripping.
This increases nozzle life and improves combustion efficiency.

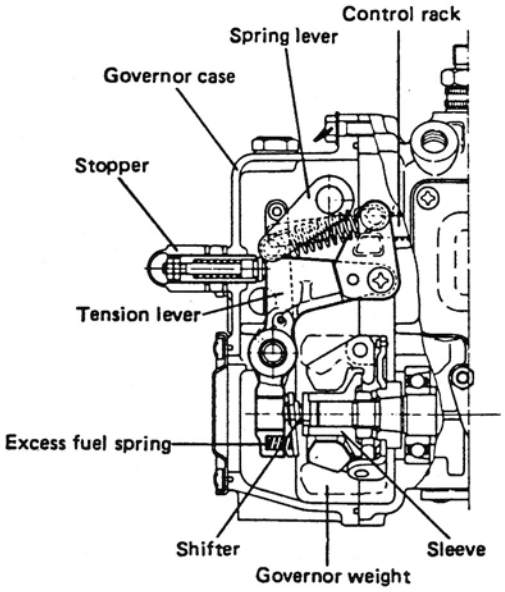
1-5 Governor construction

Usage conditions of diesel engines are extremely varied, with a wide range of loads and rpms. The governor plays an important role in the operation of the engine by quickly adjusting the position of the control rack to control the amount of fuel injected according to changes in rpm.
It also automatically controls the engine to prevent engine rpm from exceeding the maximum, and keeps the engine from stopping.

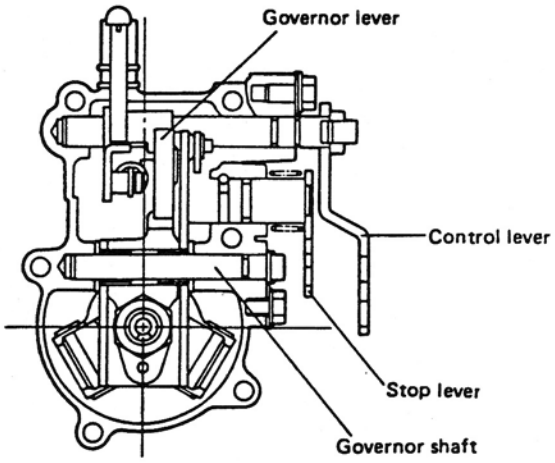
Injection pump is equipped with the all speed governor. The construction will be explained accordingly to the cut- way views.

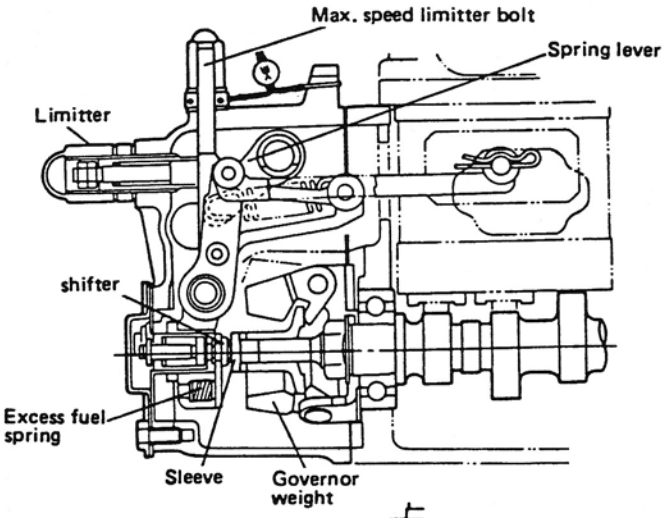
(YPES type)

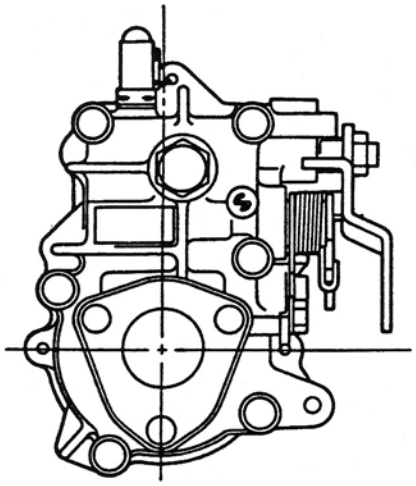


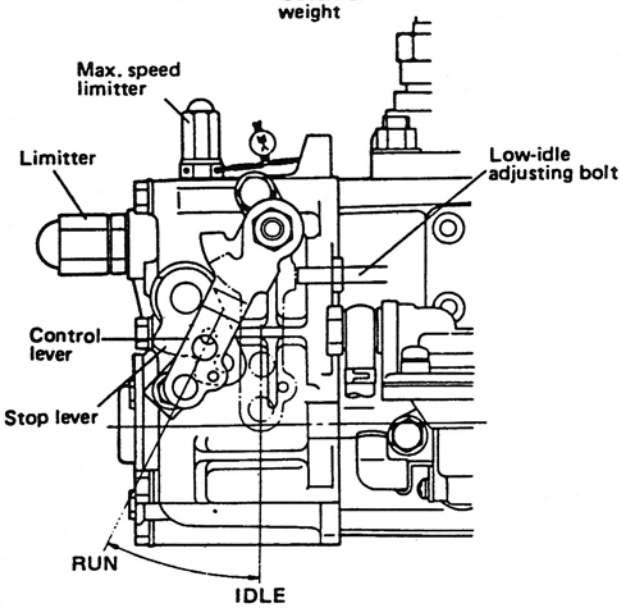


(YPFR type)









The governor weight mounted on the end of the fuel injection pump cam shaft rotates around the governor support pin, driven by the cam shaft, and is forced outwards by the centrifugal force acting on the weight.

The thrust force acting on the cam shaft due to this centrifugal force acts on the lower part of the tension lever through the sleeve. A starting excess fuel spring is mounted on the bottom of the tension lever.

One end of the governor spring is hooked to the right upper end of the tension lever, and the other end to the spring lever of the control lever shaft.

As the spring lever and control lever are mounted on the same shaft, when the control lever is turned towards full, the governor spring is pulled and the load gradually increases.

Since the tension lever can move freely around the governor shaft on the player bearing, as speed increases and the shifter is pushed to the left, the tension lever rotates clockwise, and when speed decreases, the tension lever rotates counterclockwise.

The governor lever rotates smoothly on the same governor shaft. The bottom part of this lever is in contact with the sleeve througn the shifter, which is in contact with the bottom of the tension lever through the excess fuel spring. It therefore moves with the tension lever according to increases/decreases in engine speed.

The top of the governor lever is connected to the fuel pump control rack through the governor link. The movement of the lever controls the volume of fuel injected by the pump. When speed increases the lever rotates clockwise to cause the control rack to reduce fuel, and when speed decreases the lever rotates counterclockwise to cause the control rack to increase fuel, thus engine speed is controled.

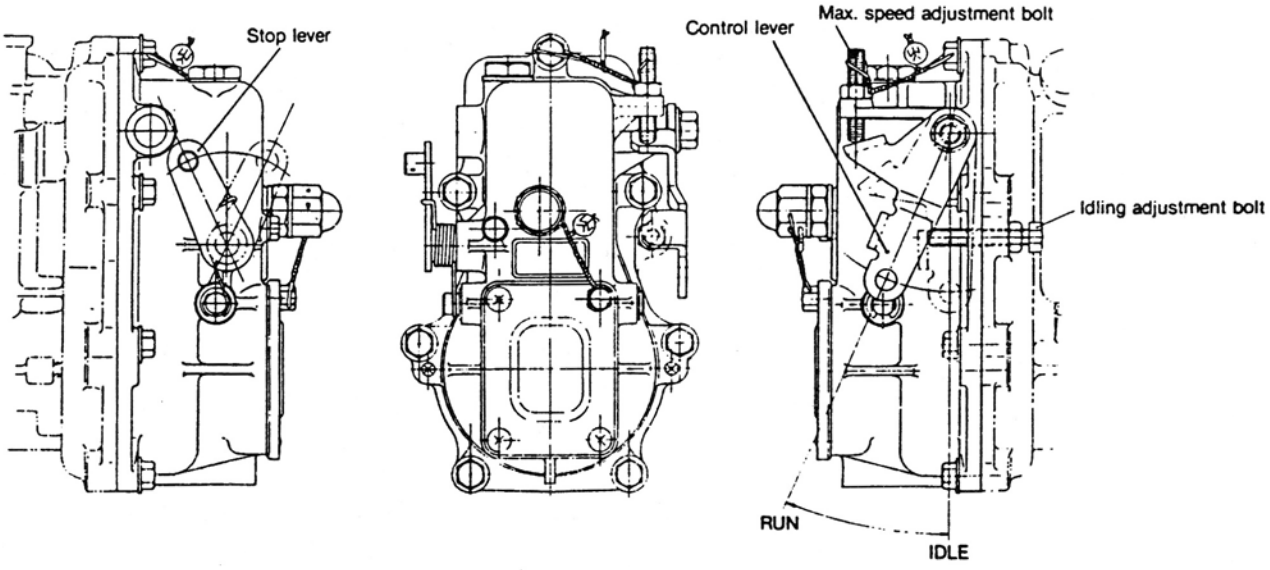
The top of the tension lever comes in contact with the stopper built into the top of the governor case to limit the maximum fuel injection volume.

Types of governors according to their different structures

Governors that are equipped with a YPES-CL series fuel injection pump come in a number of variations. The governor is designed in accordance with individual engine structures and parts.

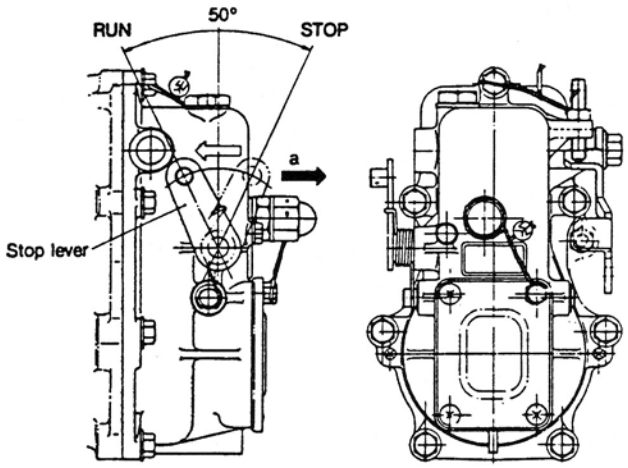
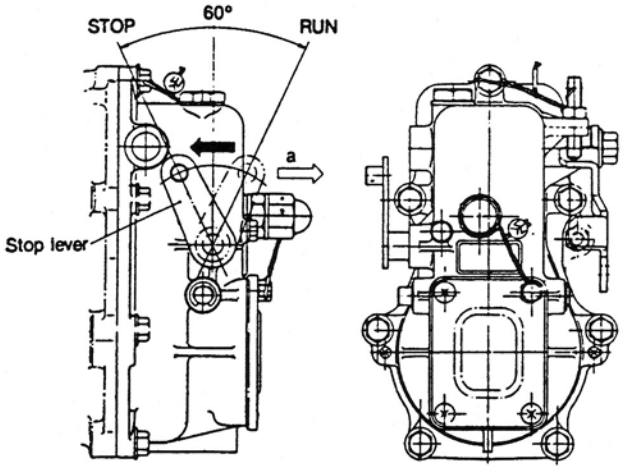
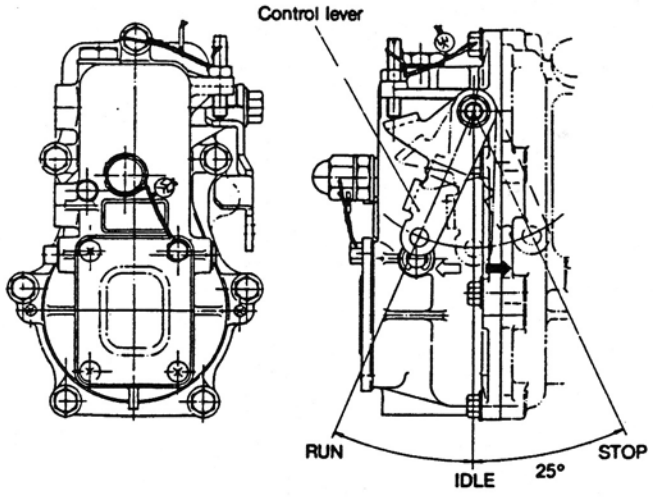
(1) Shape of control and stop levers

The control and stop levers that operate the governor have different shapes depending on engine design and method of attachment, as seen in the pictures below. The motion of the control lever is regulated by the maximum speed adjustment bolt and the idling adjustment bolt. This maintains the necessary engine speed.



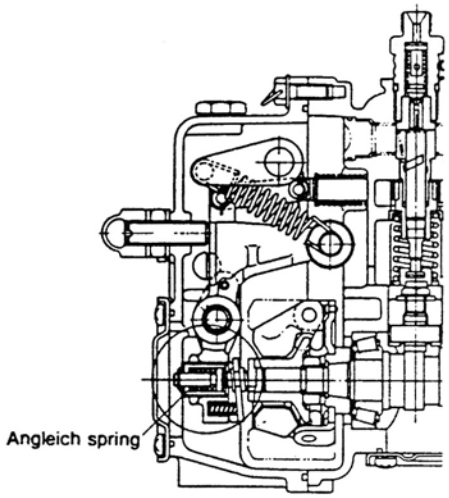
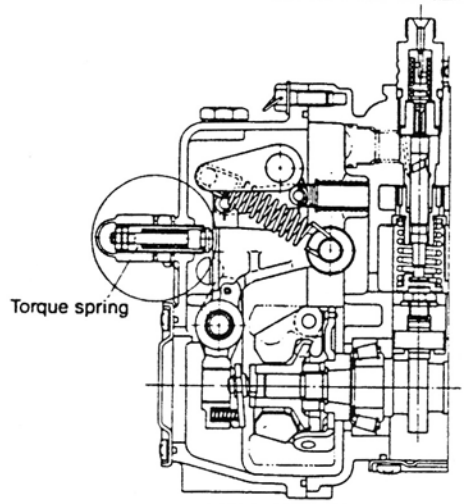
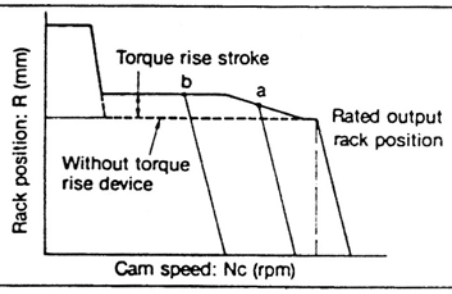
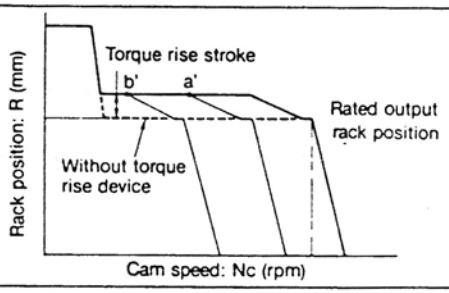
(2) Engine stop device

The stop lever can be operated by a push-pull cable, magnetic solenoid or a stop motor. The governor is equipped in one of three designs depending on the intended purpose.

A		The engine can be stopped by pulling the stop lever in direction A either manually or electrically with a; (1) Push-pull cable. (2) Stop motor. (3) Magnetic solenoid.
B		This method always requires an electromagnetic solenoid. The engine is started by pulling in direction toward A, which is opposite that in method A above. When the engine current ceases, the engine is stopped automatically by the solenoid return spring.
C		This one lever control method has no stop lever. The engine is stopped only by returning the control itself from the idle position. (The idling adjustment mechanism must be installed outside of the governor.)

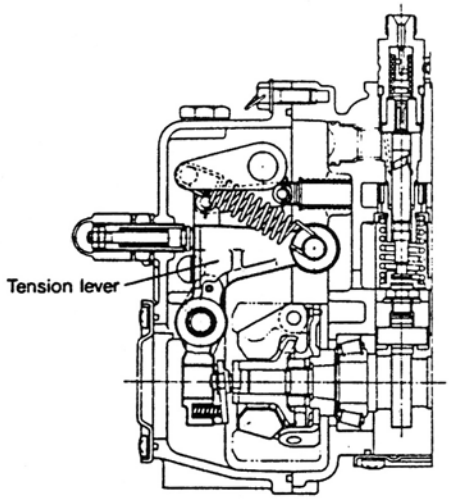
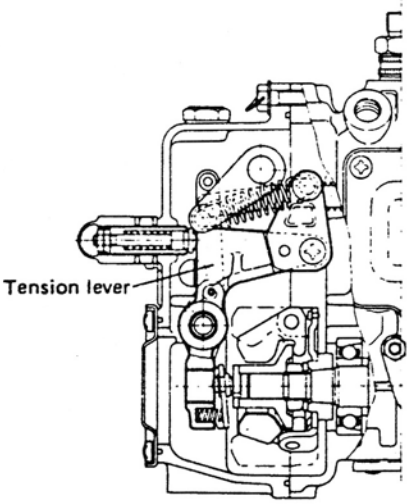
(3) Torque rise equipment

As mentioned before, this governor has a structure that allows you to equip it with an angleich spring and/or torque spring as torque rise equipment. In this way the requirements for different engines can be fulfilled.

	With angleich spring	With torque spring
Structure		
Function		
	Optimum partial return percentage assured.	Smooth torque rise characteristics obtained.

(4) Tension lever shape

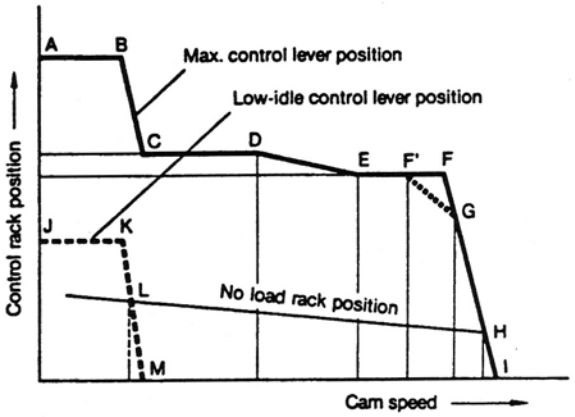
The governor has a design which allows you to adjust the speed compensation rate for partial loads. This can be done by changing the governor spring hook position of the tension lever and with the adaptable tension lever of the governor spring. This is a very valuable feature for engines in which performance depends on low speed torque. It also promotes better use of generator engines using 50 Hz/60 Hz.

	Type A	Type B
Structure		

1-6 Function of Governor

(1) Function of governor

Following is a representation of the movement characteristics of the control rack at respective speeds, with the speed rising from 0, with the governor control lever at the maximum speed position.



A-B: Fuel volume condition during starting. Volume is controlled by excess fuel spring.

B-C: The rack moves towards decrease after engine starts and speed increase as the load of the excess fuel spring is overcome by the centrifugal force of the governor weight.

C-D: High torque at low speed is developed by increasing fuel injection volume equivalent to the angleich stroke.

D-E: Condition when the thrust force exceeds that of the angleich spring force on the bottom of the tension lever and it gradually pushes the rack to decrease fuel when engine speed increases.

E-F: Condition when both right and left ends of the shifter come in contact with the sleeve and the bottom of the tension lever, and the control rack is kept at the normal position by the stopper. (max. injection volume position on models not equipped with an angleich spring)

F: Point when governor spring starts to take effect. This is the rated output of the engine.

F': Point when governor starts to take effect on models with torque spring.

G: Continuous rating point (usually 85—90% injection volume of F point).

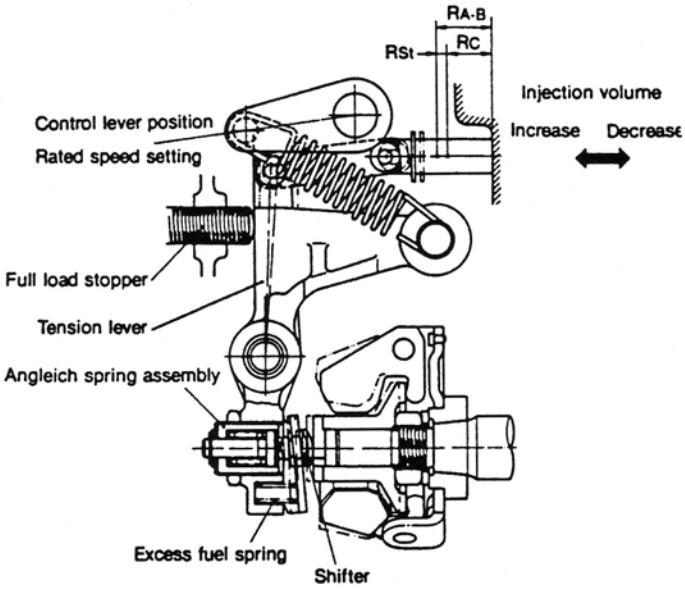
H: No load max. speed

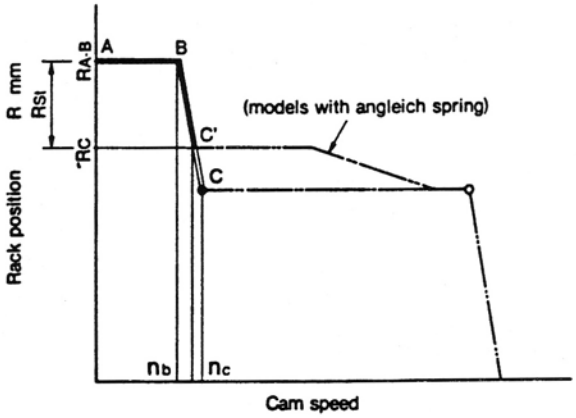
L: Low-idle position

(2) Starting control

Moving the control lever to the max. speed position pulls the governor spring, and moves the tension lever until it comes in contact with the control stopper. When this is done, the excess fuel spring located in between the tension lever and governor lever holds the control rack at the max. starting injection volume position $R_{A\text{-}B}$.

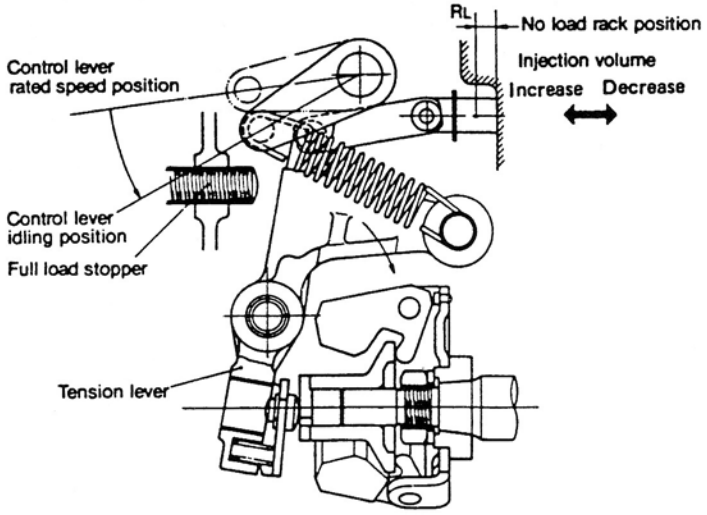
After the engine is started, the excess fuel spring is compressed when the centrifugal force of the governor weight overcomes the set load of the excess fuel spring as speed exceeds N_b, speed goes from B to C' (on models with angleich spring) or B to C (on models without angleich spring). The rack reaches the position of R_C where the governor lever and tension lever are interlocked.





(3) Idling

Idling is controlled by the governor spring and excess fuel spring as this governor is not equipped with an idling spring. When the control lever is returned to the idling position after the engine is started, the governor spring tension decreases and the tension lever descends clockwise, and the governor weight load keeps the governor spring and the excess fuel spring load in equilibrium to maintain idling speed at (R_L).

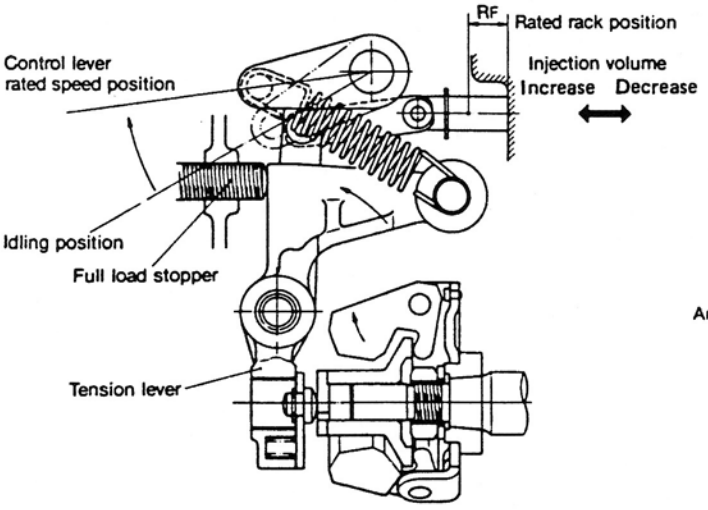


NOTE: Depending on specifications, the governor can be provided with an idling spring.

(4) Maximum speed

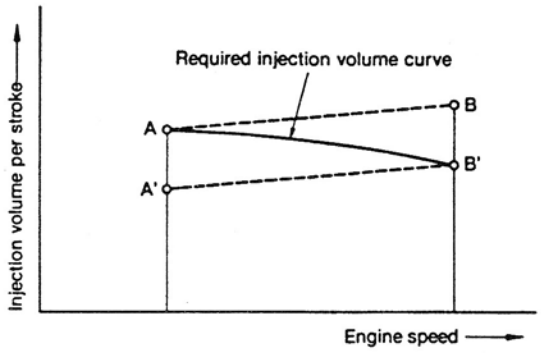
The angle of the control lever is set at determined engine speed. The governor keeps engine speed constant by adjusting speed when load changes.

For example, if the operator moves the control lever with the link from the idling position to max. output, governor spring tension increases, the tension lever is pulled until it comes in contact with the full load stopper, the movement of the governor lever is transmitted to the control rack via the link, maintaining the full load rack position, and engine speed increases until the governor weight thrust load and governor spring tension come into equilibrium at full load max. speed.



(5) Necessity and function of angleich

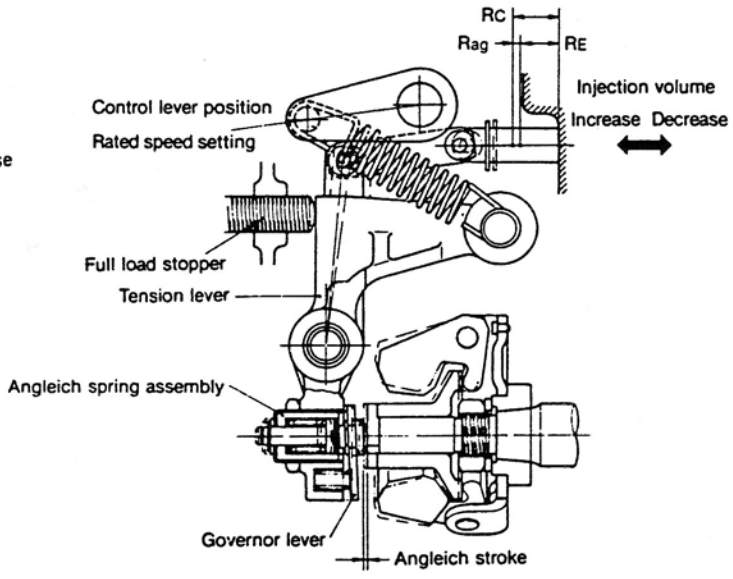
Engine air intake efficiency decreases as speed increases, while the pump injection characteristics tend to increase as speed rises, at the same rack position. Accordingly, the governor must satisfy the required injection curves represented in the diagram below in order to obtain sufficient output at low speed, and not emit black smoke at high speed. The angleich spring was devised to provide for maximum torque at low speed by setting injection volume at point A, and shifting injection volume to point B' at high engine speed.

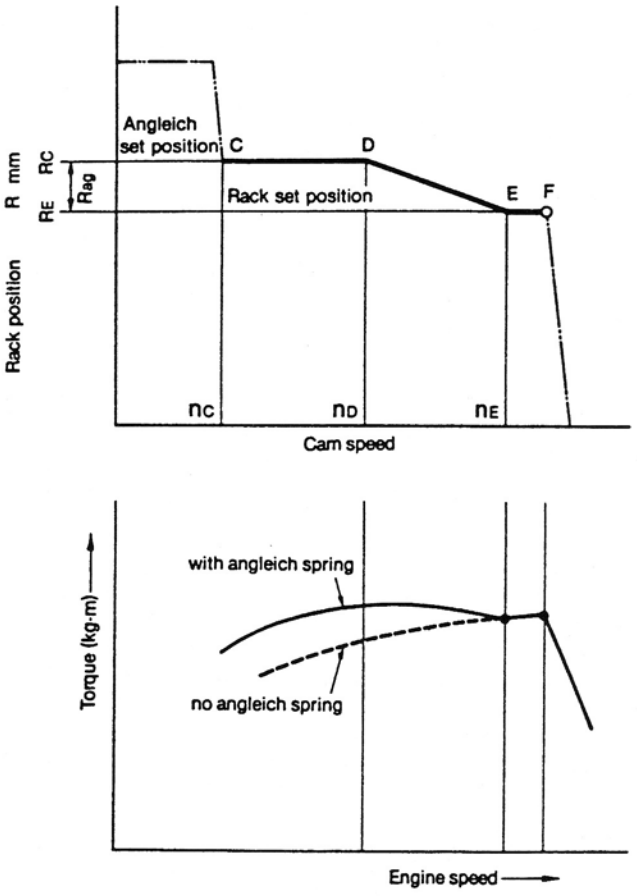


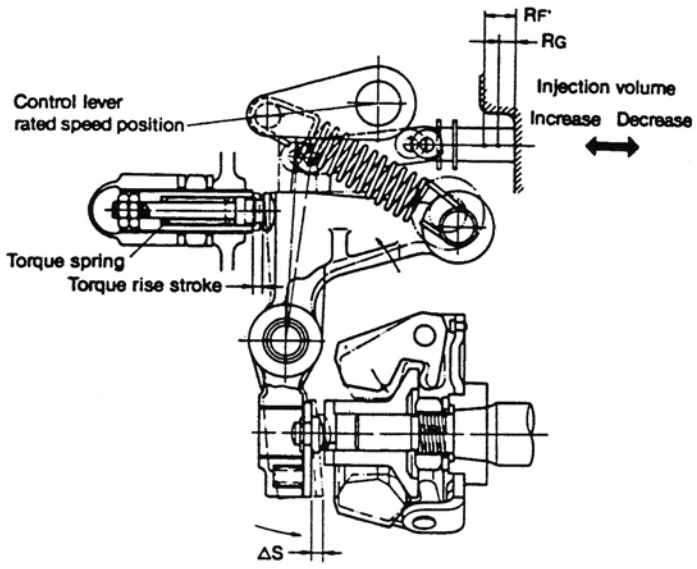
The angleich spring is mounted to the lower part of the tension lever (however some engines are not equipped with an angleich spring depending on usage and speed range utilized).

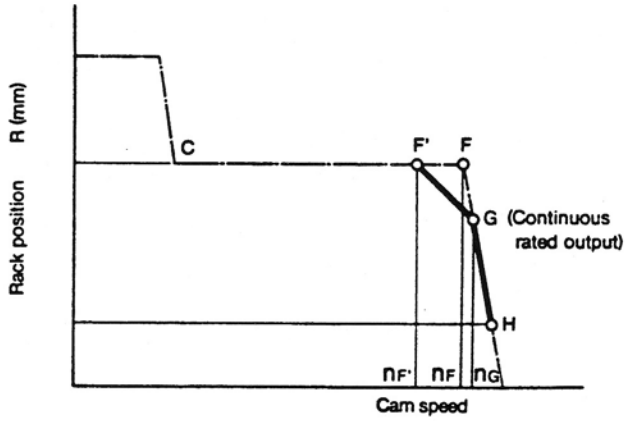
When engine speed is low, the governor weight cannot compress the angleich spring as the angleich spring load is larger than the governor weight thrust load, and the control rack is held at a position (R_C) to increase injection volume.

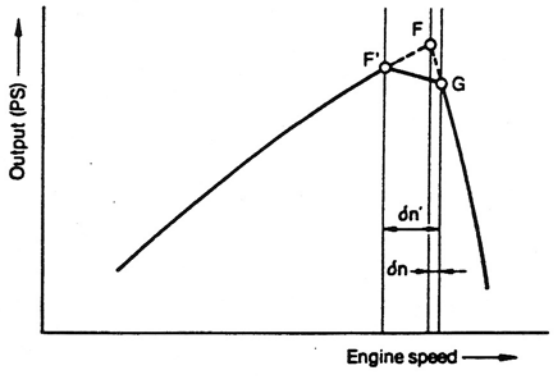
Furthermore, as engine speed rises, the angleich spring is gradually compressed as governor weight thrust load increases and exceeds angleich load, before high speed control is effected. When the governor lever and the bottom of the tension lever come into contact (end of angleich stroke), injection volume is reduced by that amount, and the rack reaches the rated position (R_E).











(6) Necessity of torque spring and function

Engines used in construction machinery are subjected to sudden loads which cause a decrease in speed and sometimes results in stopping of the engine. A torque spring is provided to move the control rack towards injection volume increase when engine speed decreases, to increase torque to withstand overloads, and in turn prevent the engine from stopping. The governor control lever is fixed at point G in the diagram at right, the continuous rated output position. At this time, when engine is loaded, the tension lever encompasses the torque spring, the control rack comes away from full load stopper, and fluctuates between G and H according to engine load.

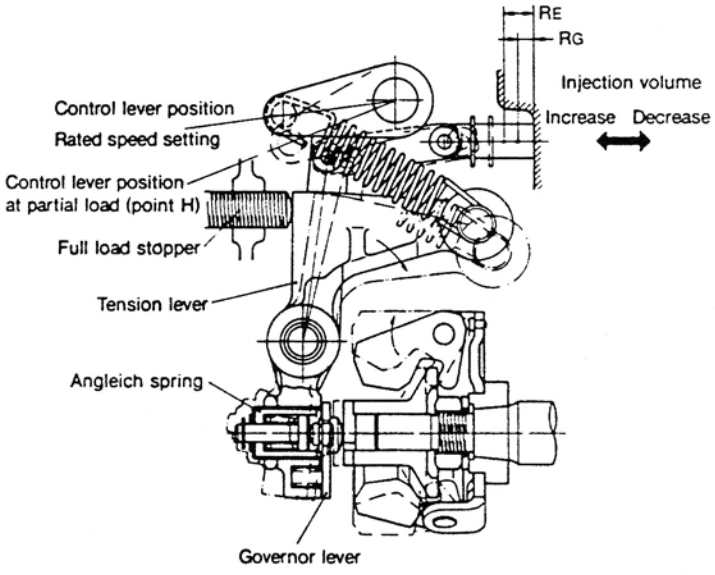
When the load on the engine exceeds the continuous rated output, speed decreases, governor spring tension exceeds the governor weight thrust load and overcomes the torque spring set load. The tension lever then gradually causes the control rack to move towards injection volume increase via the governor lever and link, and the torque rise stroke ends when the control rack reaches F'.

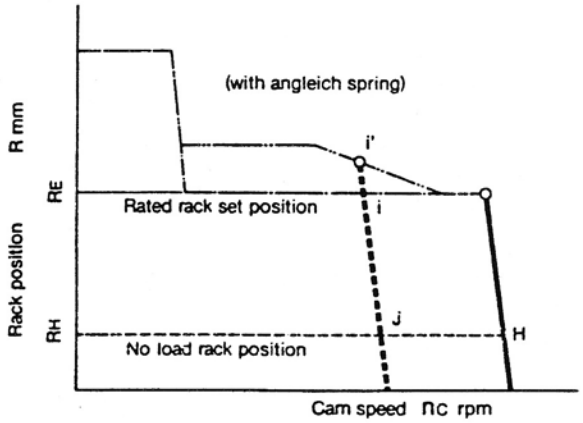
The torque spring thus provides for increasing injection volume when speed decreases to increase engine torque and in turn prevent engine stopping due to sudden increases in load, which also provides for strong engine output characteristics.

(7) No-load maximum speed

When the load decreases from full load max. speed and engine speed increases, the increased thrust load of the governor weight acting on the governor spring through the tension lever exceeds the set load of the spring, the tension lever and governor lever descend clockwise; the control rack is pushed to the no-load injection volume position (R_H) and the engine is operated at no-load max. speed.

When the engine is being used at a partial load, the governor spring functions in the same way at a lower speed (i, i''–j) as for full load max. speed, as the governor spring set load is smaller.





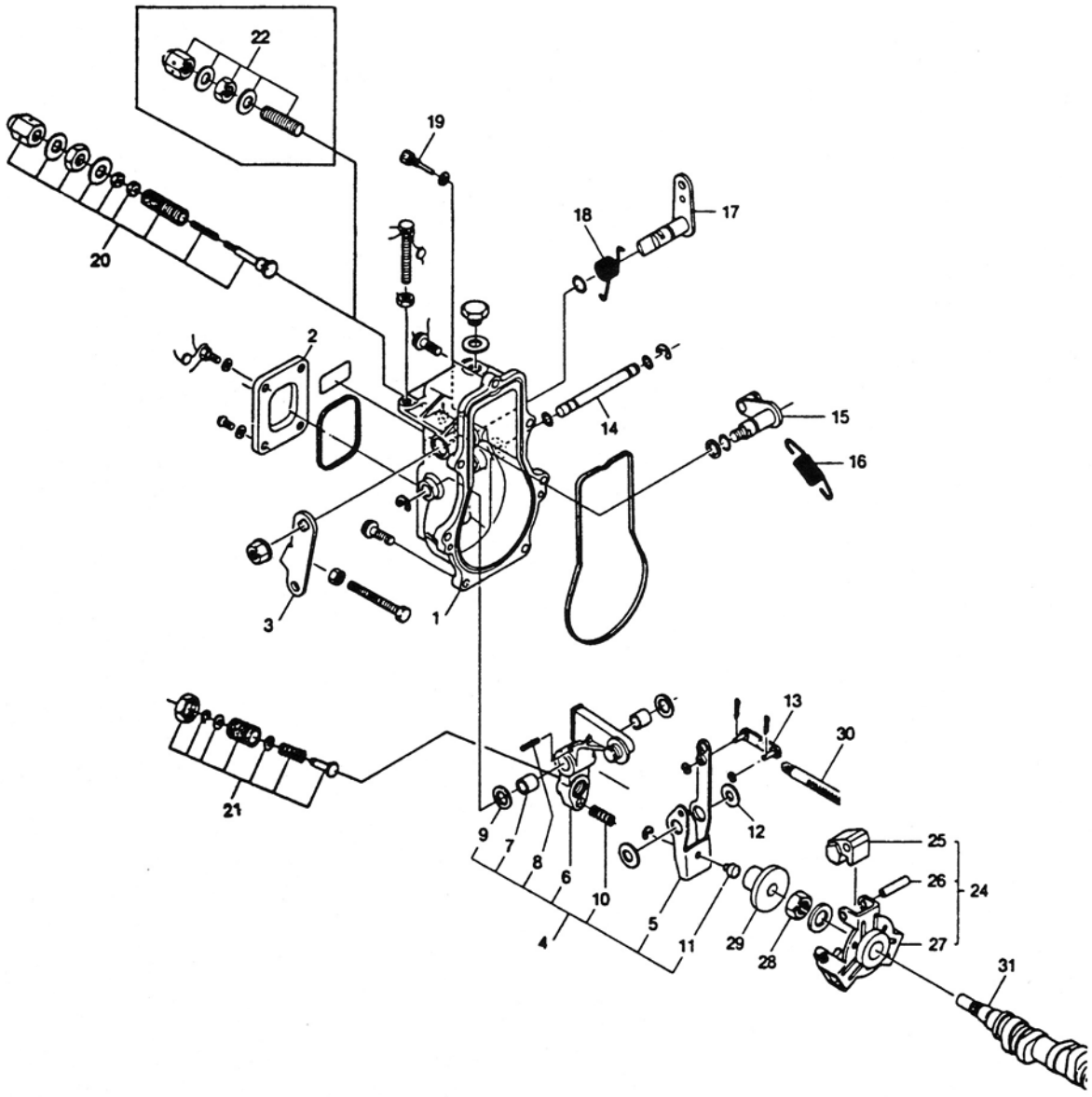
(8) Stopping engine

The engine stops when you turn the governor control lever all the way towards stop.

On engines equipped with a stop device, the engine can be stopped by moving the control rack to the stop position, regardless of the control lever position.

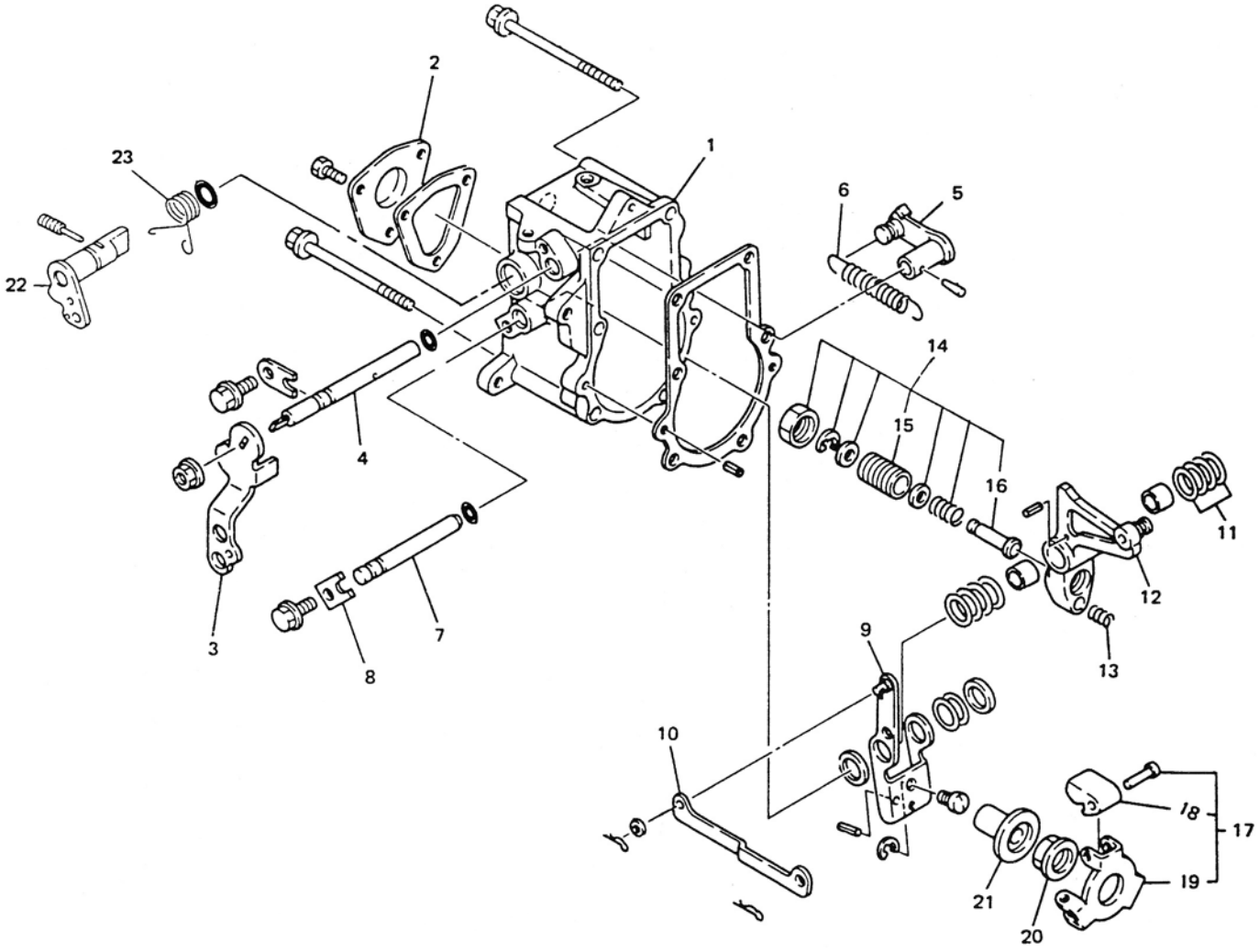
2. Disassembly, Reassembly and Inspection of Governor

Governor for YPES type pump



1	Governor case	12	Washer	23	Adjusting spring assembly
2	Governor case cover	13	Governor link	24	Governor weight assembly
3	Control lever	14	Governor shaft	25	Governor weight
4	Governor lever assembly	15	Control lever shaft	26	Pin
5	Governor lever	16	Governor spring	27	Governor weight support
6	Tension lever	17	Stop lever	28	Governor weight nut
7	Bushing	18	Stop lever return spring	29	Governor sleeve
8	Spring pin	19	Stop lever stop pin	30	Control rack
9	Shim	20	Torque spring assembly	31	Fuel pump cam shaft
10	Throttle spring	21	Angleich spring assembly		
11	Shifter	22	Fuel stopper (limit bolt) assembly		

Governor for YPFR type pump

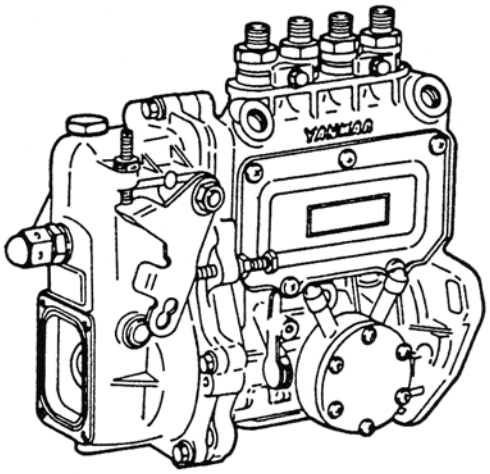


1	Governor case	9	Governor lever	17	Governor weight assy.
2	Governor case cover	10	Governor link	18	Governor weight
3	Control lever handle	11	Plunger shim packing	19	Governor weight support
4	Control lever shaft	12	Tension lever	20	Governor support nut
5	Control lever	13	Excess fuel spring	21	Governor sleeve
6	Control lever spring	14	Angleich assy.	22	Stop lever assy.
7	Governor lever shaft	15	Angleich case	23	Stop lever return spring
8	Governor lever retainer	16	Angleich shifter		

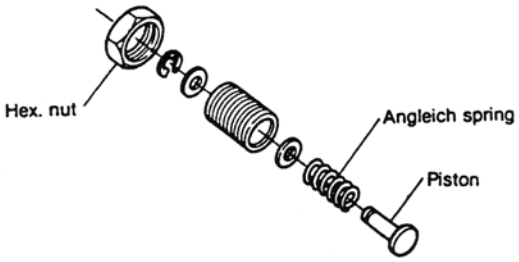
2-1 Governor disassembly

The basic construction of the YPES type and YPFR type governors is identical except for the stop lever and control lever positions. (YPFR TYPE - see P 3-14)

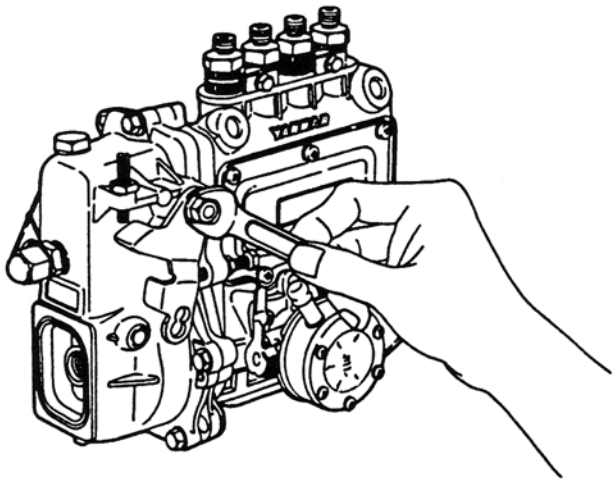
(1) Remove the governor case cover.



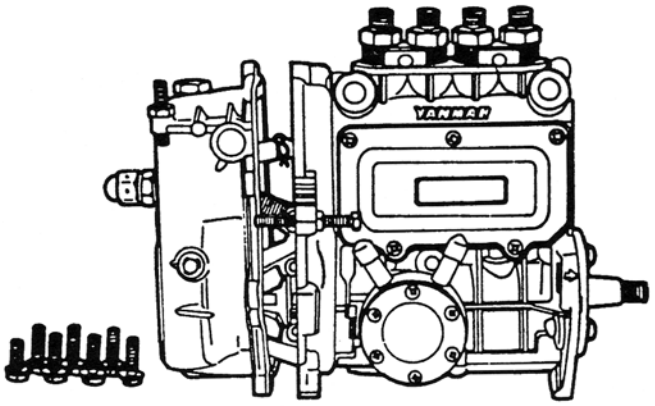
NOTE: Loosen the hex bolt on models with an angleich spring.



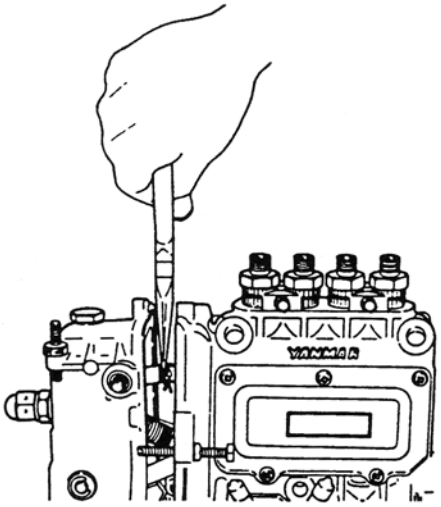
(2) Remove the control lever hex nut, and pull out the control lever from the control lever shaft.



(3) Remove the governor case bolt. Remove the governor case (parallel pin) from the fuel pump unit while lightly tapping the governor case with a wood hammer. Create a gap between the governor case and fuel pump by moving only the moving parts of the governor lever.

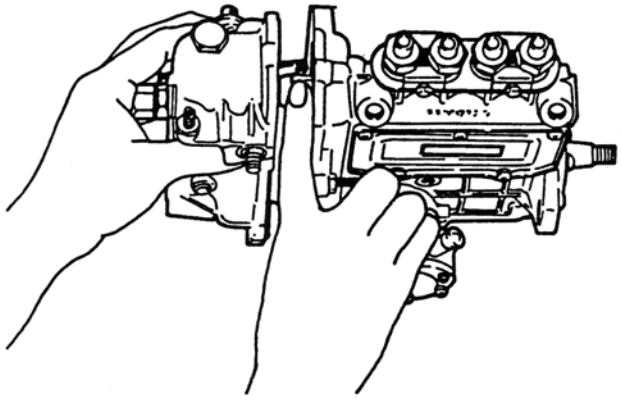


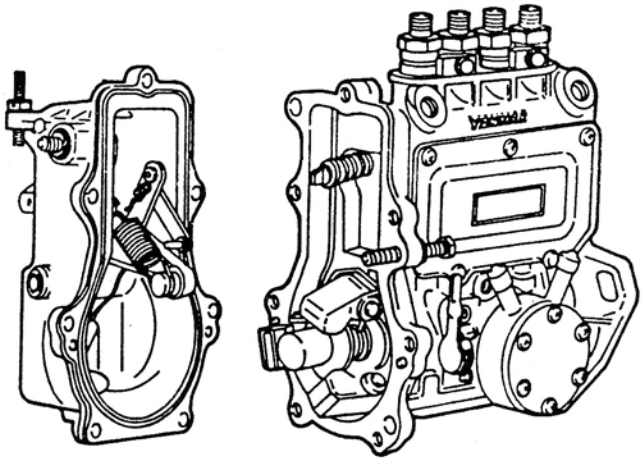
(4) Pull out the governor link snap pin by inserting needle nosed pliers between the fuel pump and governor case.



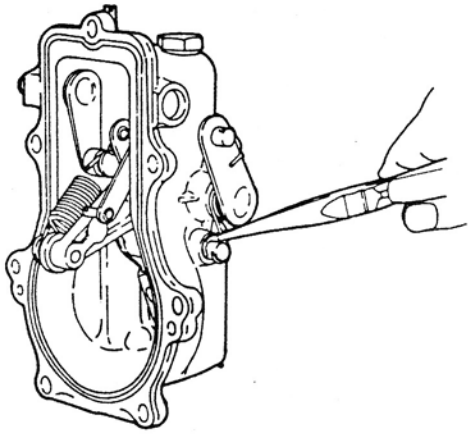
(5) The governor and fuel pump come apart by sliding the governor case and fuel pump apart and pulling out the link pin of the fuel control rack.

YPFR type: Remove the cover at the side of the fuel injection pump and pull out the governor link snap pin.

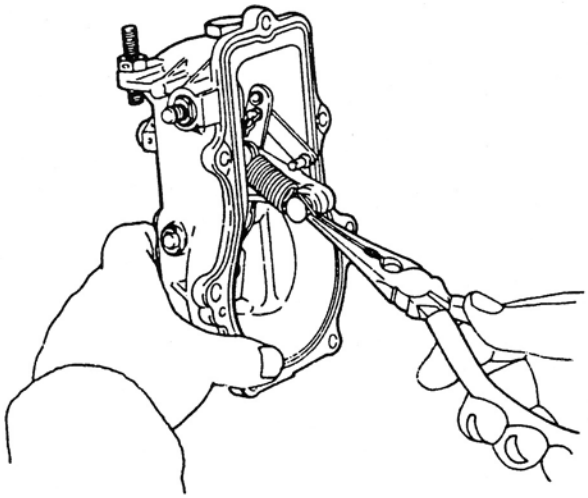




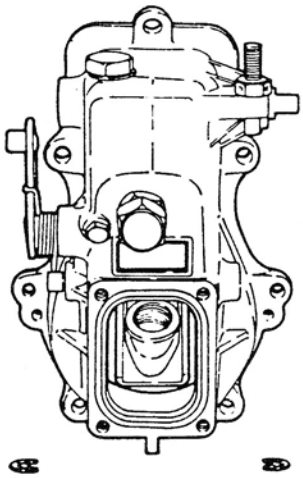
(6) Remove the stop lever return spring from the governor lever shaft.



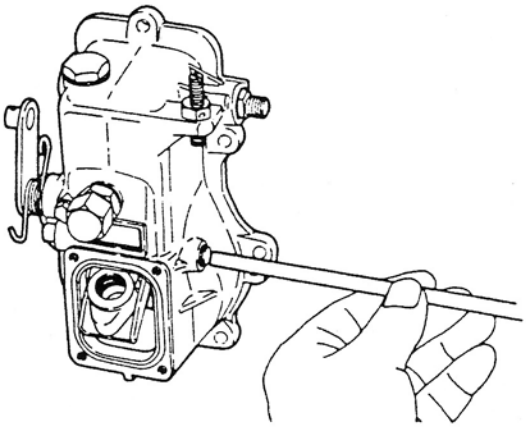
(7) Use needle nosed pliers to unhook the governor spring from the tension lever and control lever shaft.



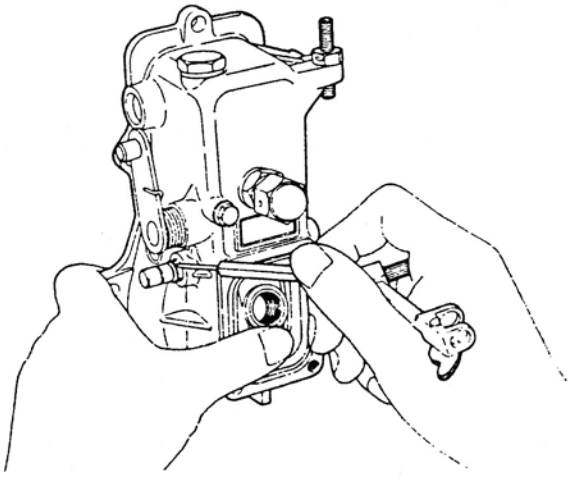
(8) Remove the snap-rings on both ends of the governor lever shaft.

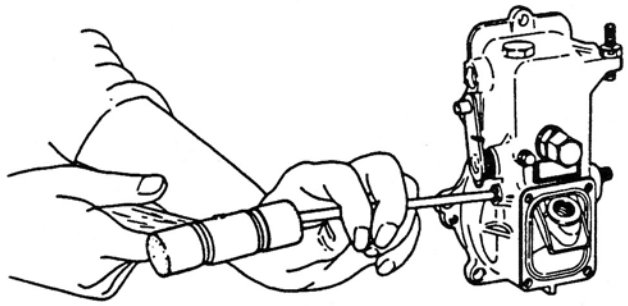


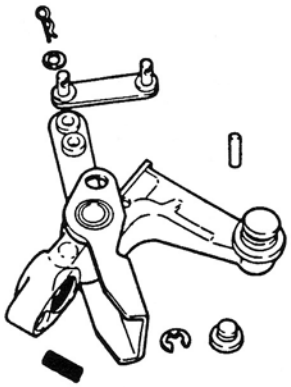
(9) Put a rod 8mm (0.3150in.) in dia. or less in one end of the governor lever shaft, and tap the governor shaft until the O-ring comes out the other side of the governor case.



(10) After you remove the O-ring, lightly tap the end of the shaft that you removed the O-ring from, and remove the governor lever shaft. Then remove the governor shaft assembly and washer.

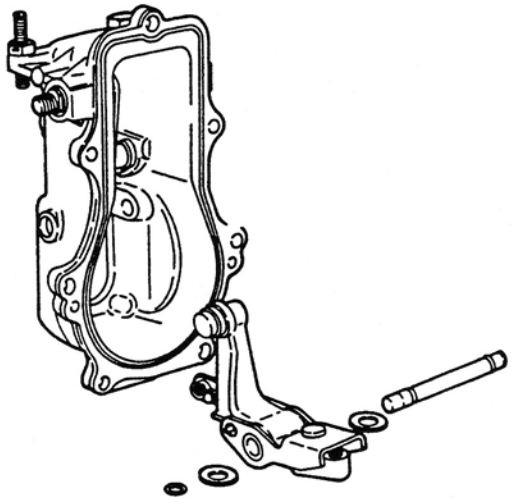


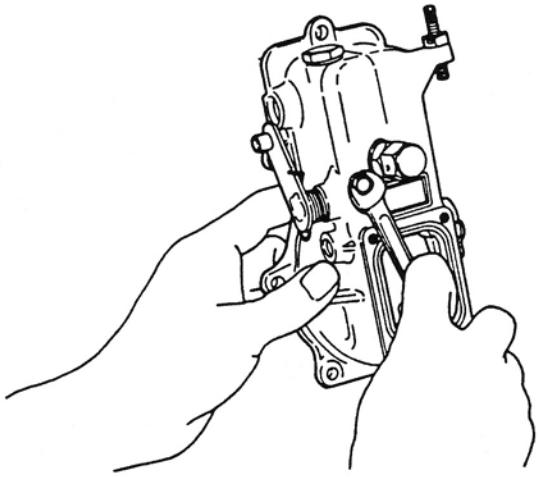




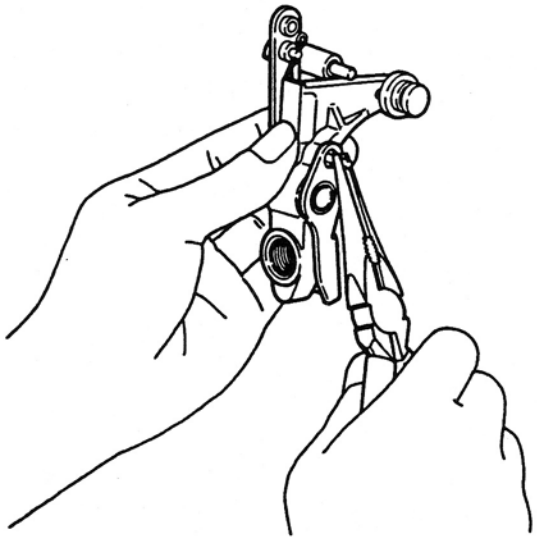
NOTE: The governor assembly consists of the governor lever, tension bar, bushing, throttle spring and shifter, and is normally not disassembled.
The spring pin is removed when you replace the shifter or throttle spring.

(12) When you need to pull out the stop lever, remove the stop lever shaft stop pin, and lightly tap the inside of the governor case.

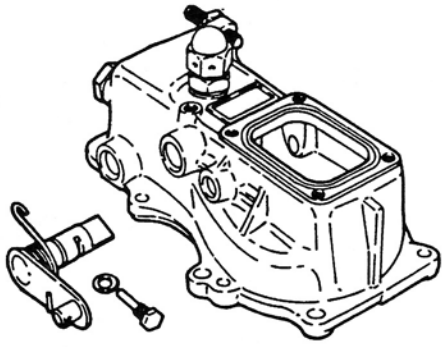




(11) Remove the governor link from the governor lever.

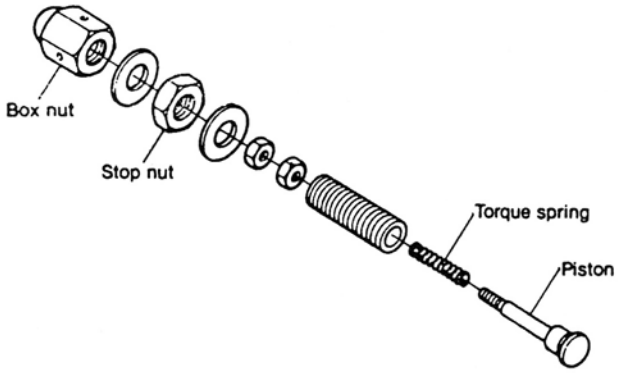


(13) When you need to pull out the control lever shaft, tap the end of the shaft with a wood hammer.

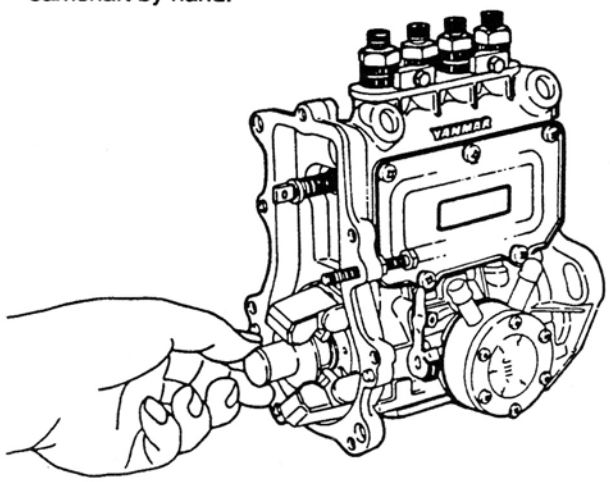


NOTE: 1. Do not remove the fuel limit nut from the governor case unless necessary.

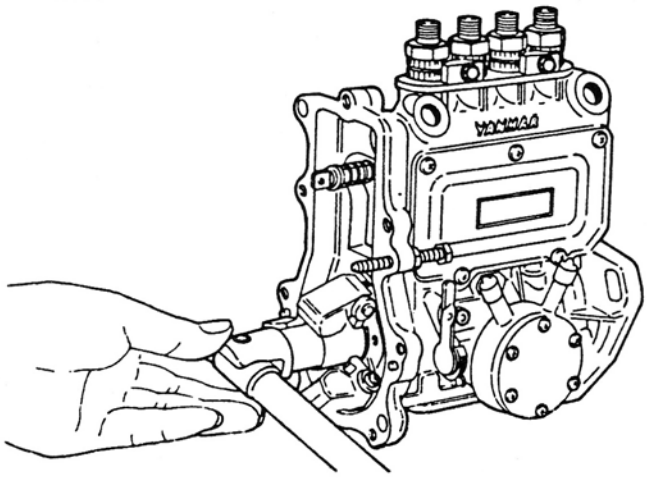
2. On models with torque springs, first remove the box nut and stop nut, and then the torque spring assembly.



(14) Pull out the governor sleeve on the end of the fuel camshaft by hand.

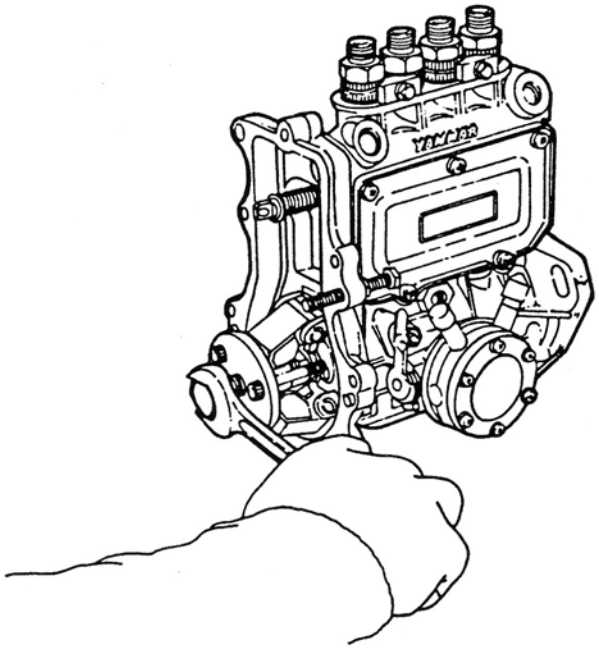


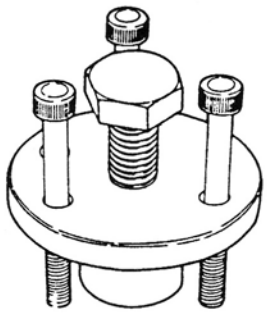
(15) Turn the governor weight with a box spanner two or three times to loosen it, stopping it with the hole in the fuel coupling ring or holding the coupling with a vise.

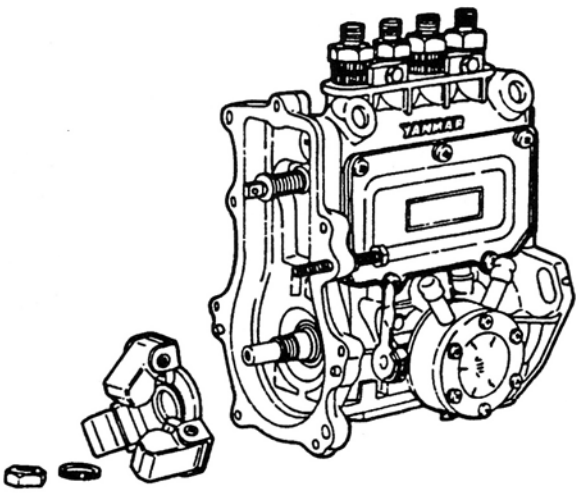


NOTE: When the taper fit comes apart after you have removed the nut, the governor weight may fly out —Be Careful.

(16) Remove the governor weight assembly from the fuel pump cam using the governor weight pulling tools.





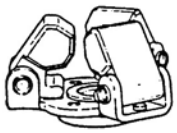


NOTE: The governor weight assembly is made up of the governor weight, support and pin. Do not disassemble.

2-2 Inspection of governor

Inspection of governor weight assembly

(1) Replace the governor weight if it does not open and close smoothly.

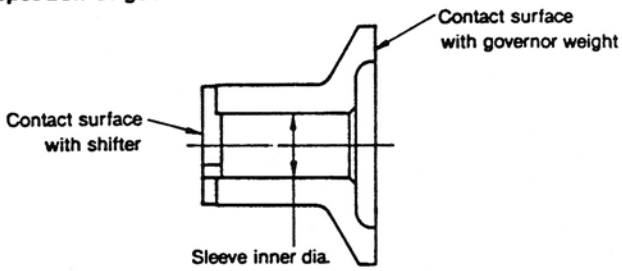


(2) Replace the governor weight if the contact surface with governor sleeve is extremely worn.

(3) Replace if there is governor weight support/pin wear or the caulking is loose.

(4) Replace if the governor weight support stopper is excessively worn.

Inspection of governor sleeve



(1) Replace the governor sleeve if the contact surface with governor weight is worn or there is pitching.

(2) Replace the governor sleeve if the contact surface with shifter is considerably worn or there is pitching.

(3) If the governor sleeve does not move smoothly above the cam shaft due to governor sleeve inner dia. wear or other reasons, replace.

Inspection of governor lever assembly

(1) Measure the clearance between the governor shaft and bushing, and replace if it exceeds the limit.

mm (in.)

	Standard Dimension	Standard Clearance	Limit
Governor shaft outer dia.	7.986 ~ 7.995 (0.3144 ~ 0.3147)	0.065 ~ 0.124 (0.0025 ~ 0.0048)	0.5 (0.0196)
Bushing inner dia.	8.060 ~ 8.110 (0.3173 ~ 0.3192)		

(2) Inspect the shifter contact surface, and replace the shifter (always by removing the pin to disassemble) if it is worn or scorched.

(3) Disassemble and replace excess fuel springs that are settled, broken or corroded by pulling the spring pin.

(4) Check link parts for bends or kinks that will cause malfunctioning, and replace any parts as necessary.

NOTE: 1. Side gap on top of governor lever shaft.

mm (in.)

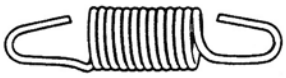
Standard side gap	0.4 (0.0157)

2. Replace the governor lever, tension bar, bushing, shifter and throttle spring as an assembly.

(5) Inspection of springs

1) Check the governor spring and other springs and replace if they are broken, settled or corroded.

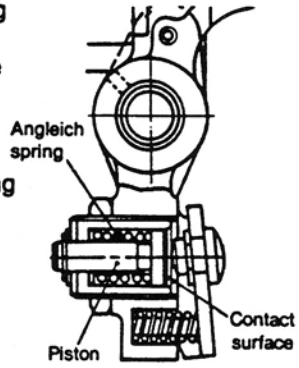
2) Measure the free length of the governor spring, and replace if it exceeds the limit.
See service data sheet for free length of governor spring.



(6) Inspection of angleich spring assembly

1) Inspect the sliding surface of piston and the contact surface with shifter, and replace if necessary.

2) Replace the angleich spring assembly if it is broken.

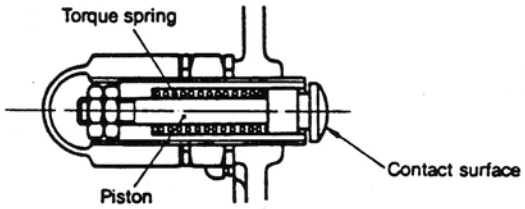


Sectional view of angleich spring.

(7) Inspection of torque spring assembly

1) Inspect the tip of the piston and contact surface for wear and replace if necessary.

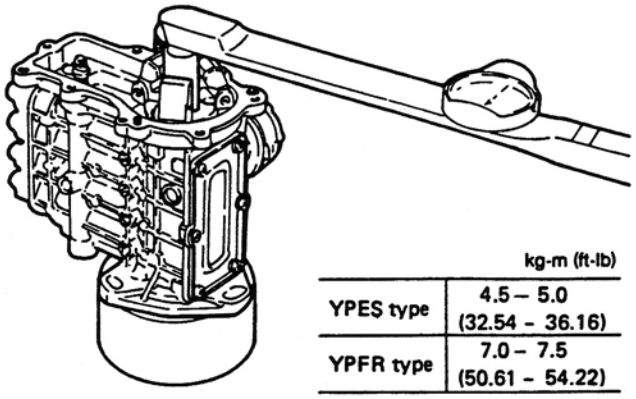
2) Replace the assembly if the torque spring is broken.



2-3 Assembling governor

Inspect all parts after disassembly and replace any parts as necessary. Before starting reassembly, clean new parts and parts to be reused, and put them in order.
Make sure to readjust the unit after reassembly to obtain the specified performance.

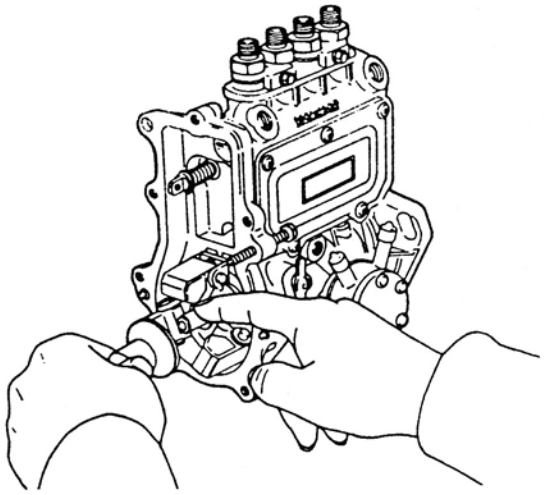
(1) Insert the governor weight assembly in the taper portion at the end of the fuel pump camshaft, stopping it with the hole in the fuel coupling ring or holding the coupling with a vise, mount the rest, and tighten the governor weight nut.



kg-m (ft-lb)

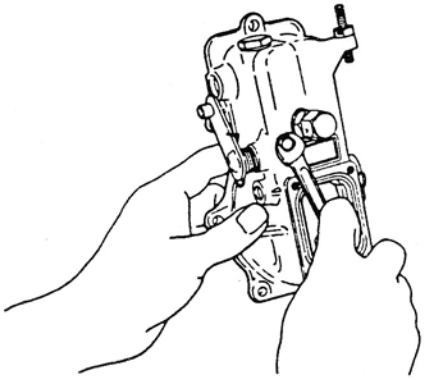
YPES type	4.5 – 5.0 (32.54 - 36.16)
YPFR type	7.0 – 7.5 (50.61 - 54.22)

(2) Open the governor weight to the outside, and insert the sleeve in the end of the fuel pump camshaft.



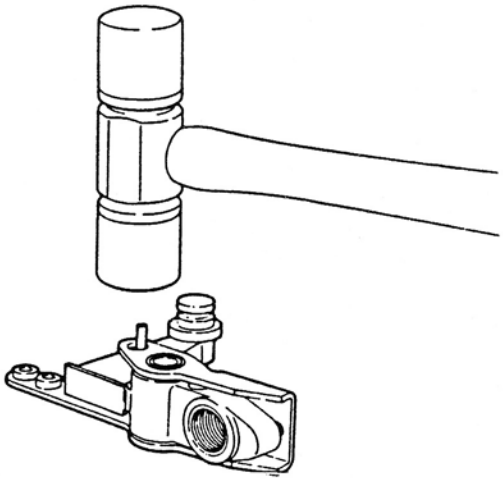
NOTE: Make sure that the sleeve moves smoothly after inserting it.

(3) When the stop lever has been disassembled, mount the stop lever return spring on the stop lever, tap the stop lever lightly with a wooden hammer to insert it, and tighten the stop lever stop pin.

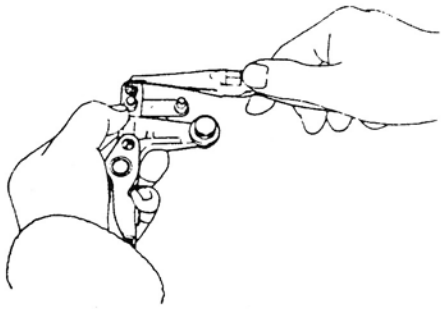


(4) When the control lever shaft has been removed, lightly tap the control lever shaft and washer from inside the governor case, using an appropriate plate.

(5) If the governor has been disassembled, tap in the spring pin.

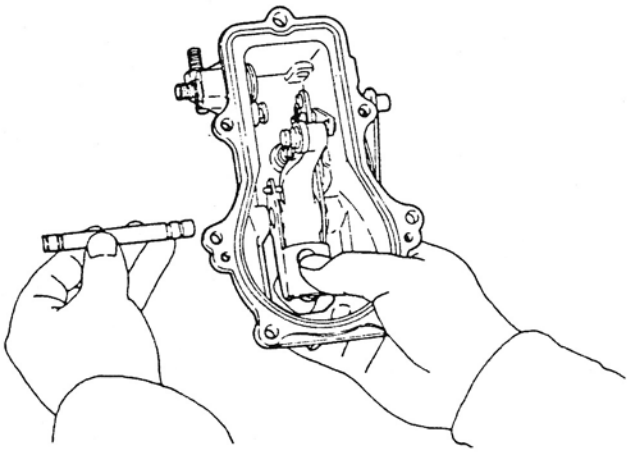


(6) Mount the governor lever assembly to the governor link.

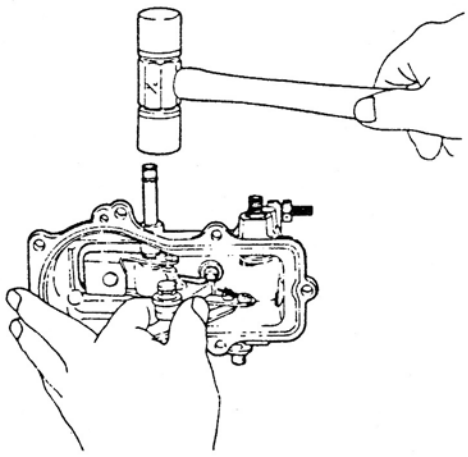


NOTE: 1. Make sure that the correct governor link mounting holes are used, and that it is mounted in the correct direction.
2. Make sure that the governor link moves smoothly.

(7) Put the governor lever shaft assembly in the governor case, insert the governor lever shaft, and tap it in until the O-ring groove comes out the opposite side of the governor case.

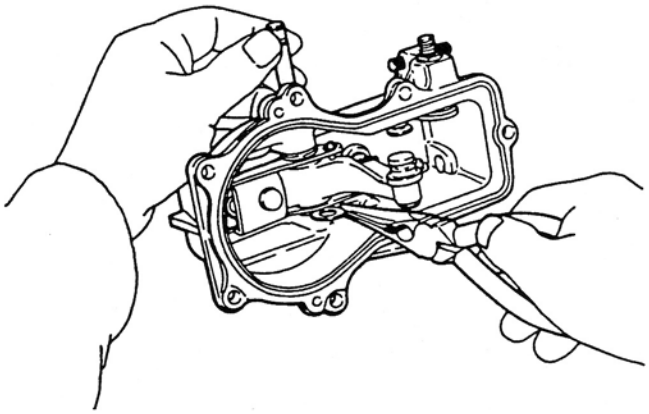


NOTE: 1. Fit the O-ring to the side you have tapped in.

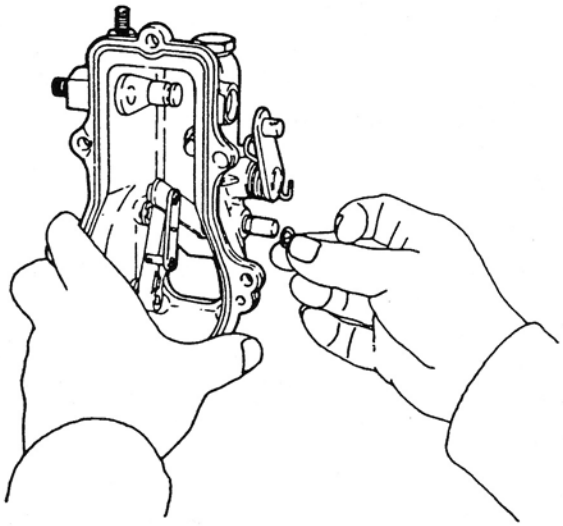


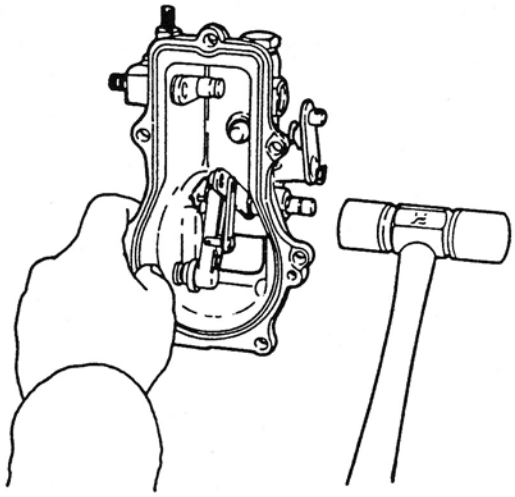
2. Make sure to insert the governor lever shaft in the correct direction.

3. Don't forget to mount the washers to both sides of the governor lever.



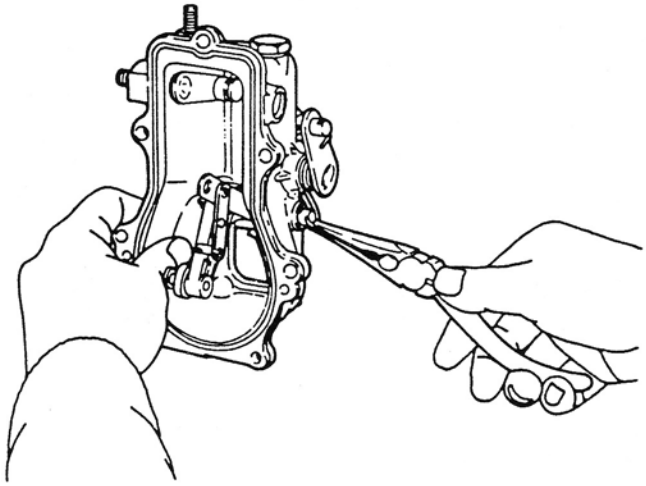
(8) After you have mounted the O-ring, tape the governor lever in the opposite direction, and mount the E-shaped stop rings on the grooves at both ends.



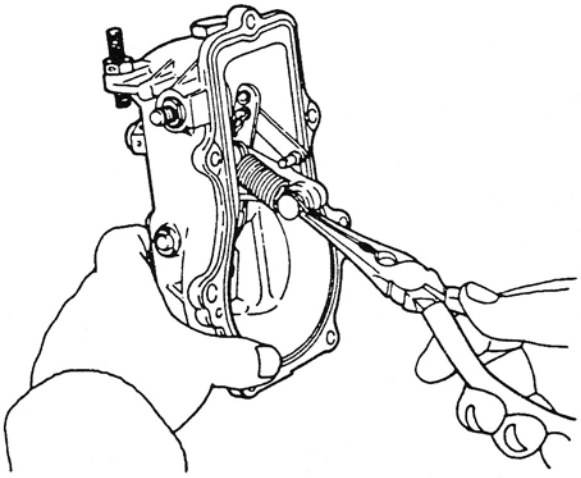


NOTE: After mounting the governor lever assembly, make sure the governor lever assembly moves smoothly.

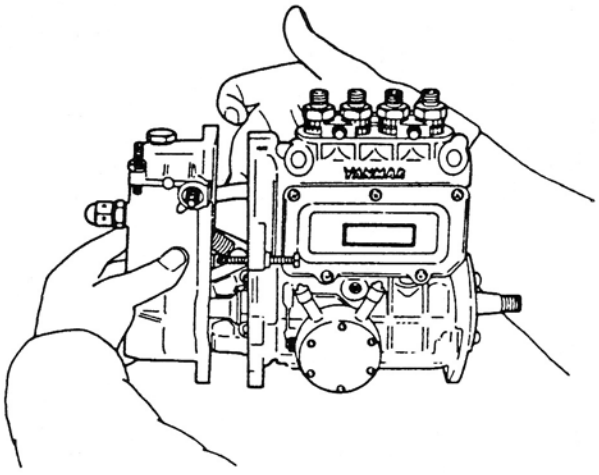
(9) Fit the stop lever return spring to the end of the governor lever shaft.



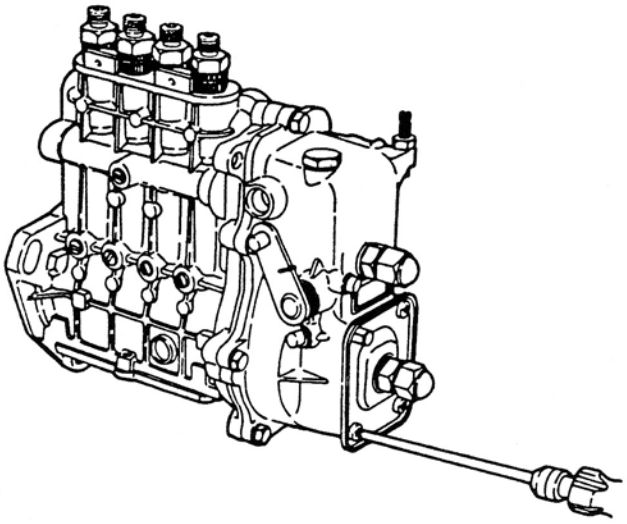
(10) Hook the governor spring on the control lever shaft and tension lever hook with radio pliers.



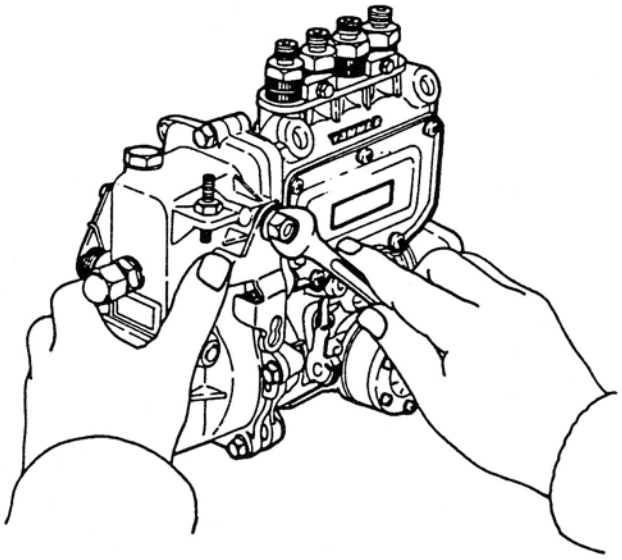
(11) Pull the governor link as far as possible towards the governor case mounting surface, insert the governor link pin in the fuel control rack pin hole and fit the snap pin on it.



(12) Mount the governor case to the fuel pump unit while lightly tapping it with a wooden hammer, and tighten the bolts.
(13) Place the adjusting spring and adjusting rod on the governor case cover adjusting bolt, and mount the governor case cover.



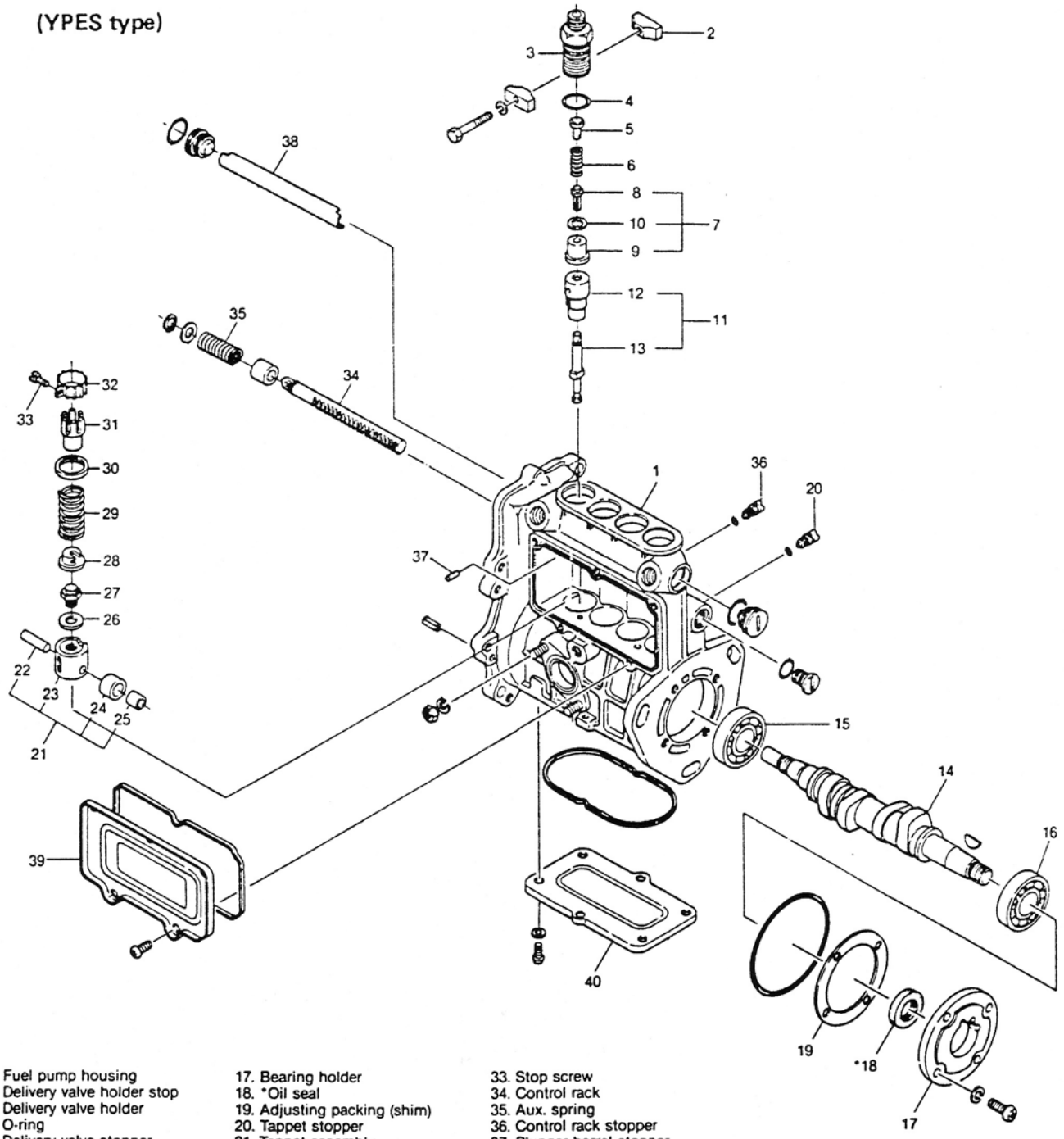
(14) Insert the control lever in the control lever shaft, and tighten the nut.



NOTE: Move the control lever back and forth to make sure that the entire link moves smoothly.

3. Disassembly, Reassembly and Inspection of Fuel Injection Pump

(YPES type)

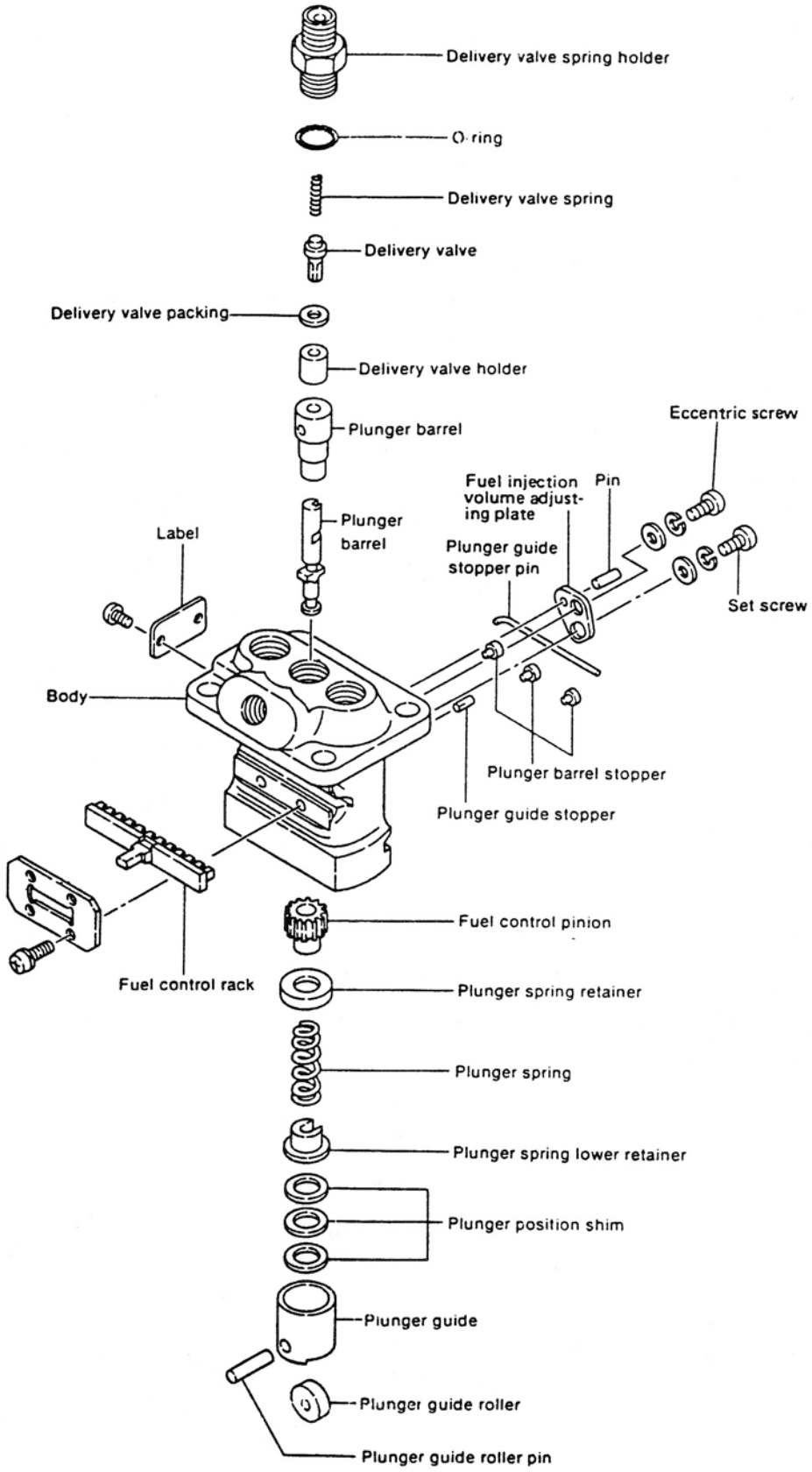


1. Fuel pump housing
2. Delivery valve holder stop
3. Delivery valve holder
4. O-ring
5. Delivery valve stopper
6. Delivery valve spring
7. Delivery valve assembly
8. Delivery valve
9. Delivery valve seat
10. Delivery packing
11. Plunger assembly
12. Plunger barrel
13. Plunger
14. Fuel pump camshaft
15. Bearing
16. Bearing
17. Bearing holder
18. *Oil seal
19. Adjusting packing (shim)
20. Tappet stopper
21. Tappet assembly
22. Pin
23. Roller guide
24. Roller (outer)
25. Roller (inner)
26. Adjusting shim
27. Adjusting bolt
28. Plunger spring seat B
29. Plunger spring
30. Plunger spring seat A
31. Control sleeve
32. Control pinion B
33. Stop screw
34. Control rack
35. Aux. spring
36. Control rack stopper
37. Plunger barrel stopper
38. Deflector
39. Pump side cover
40. Pump bottom cover

NOTE: 1. Some models are equipped with ball bearings and some with taper roller bearings.

*2. *Oil seal: Some models are equipped with oil seals and some are not. The shape of the bearing holder differs for models with and without oil seals.*

(YPFR type)

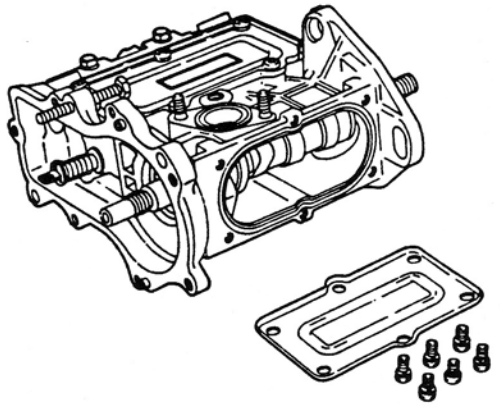

Delivery valve spring holder
O-ring
Delivery valve spring
Delivery valve
Delivery valve packing
Delivery valve holder
Plunger barrel
Eccentric screw
Fuel injection volume adjusting plate
Pin
Plunger barrel
Label
Plunger guide stopper pin
Set screw
Body
Plunger barrel stopper
Plunger guide stopper
Fuel control pinion
Fuel control rack
Plunger spring retainer
Plunger spring
Plunger spring lower retainer
Plunger position shim
Plunger guide
Plunger guide roller
Plunger guide roller pin

3-1 Disassembly of fuel injection pump

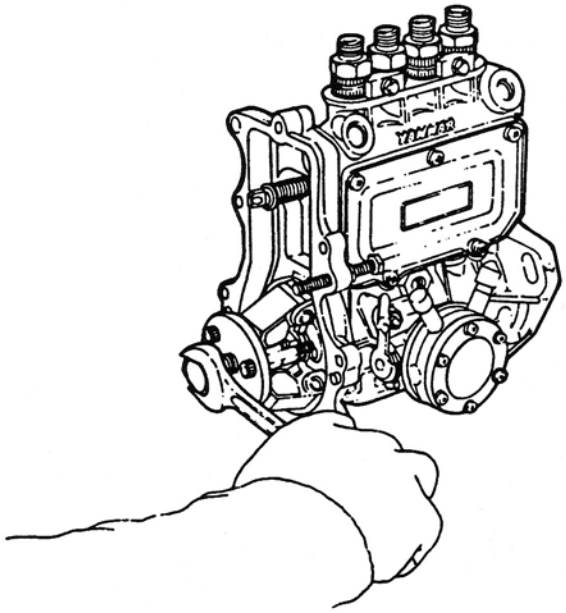
When disassembling the fuel pump, separate the parts for each cylinder and be careful not to get them mixed up.
Be especially careful to keep the plunger/plunger barrel, delivery valve/delivery valve seat and other assemblies separate for each cylinder (the parts of each assembly must be kept with that assembly and put back in the same cylinder).

Preparation (YPES type)

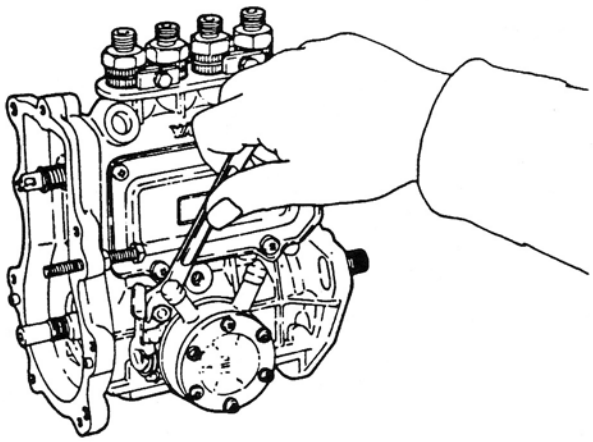
1. Wash off the dirt and grease on the outside of the pump with cleaning oil (kerosene or diesel oil) before disassembly.
2. Perform work in a clean area.
3. Take off the fuel pump bottom cover and remove lubricant oil.
4. Turn the fuel pump upside down to drain fuel oil.

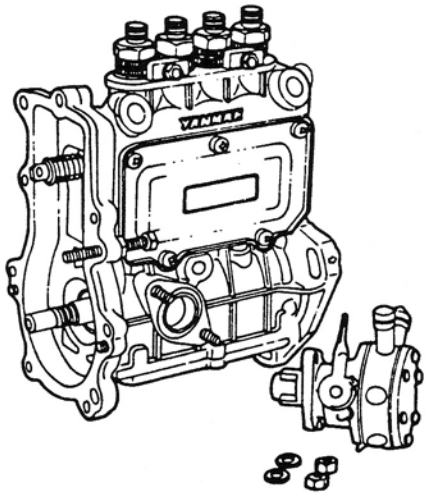


(1) Loosen the nut with a box spanner and take it off, holding it with the hole in the fuel coupling ring or holding the coupling with a vise and take out the governor weight assembly.

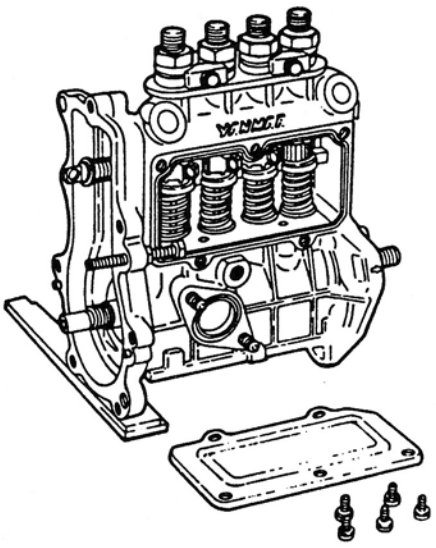


(2) Remove the fuel feed pump.
NOTE: Do not disassemble the fuel feed pump. See instructions for fuel feed pump for details.

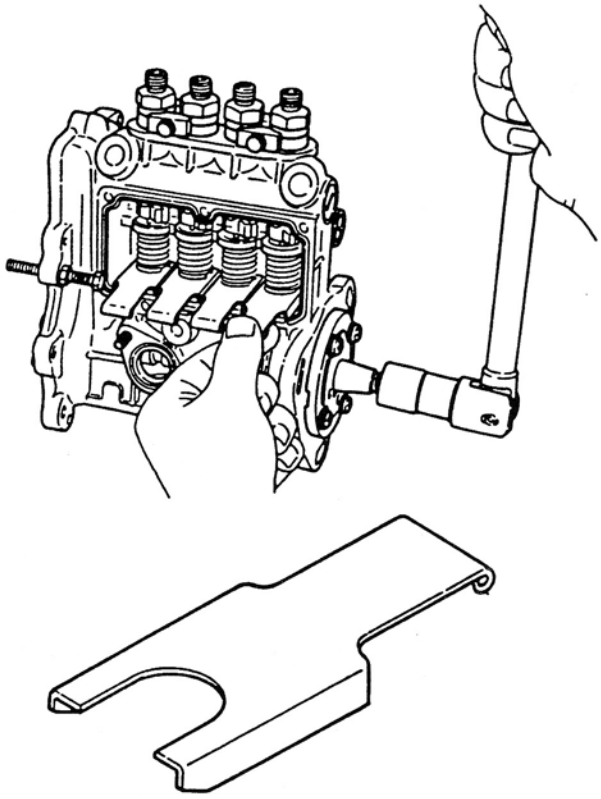




(3) Remove the fuel pump side cover.



(4) Turn the camshaft until the roller guide is at the maximum head, and insert the plunger spring support plate in between the plunger spring washer B (lower side) and fuel pump unit.

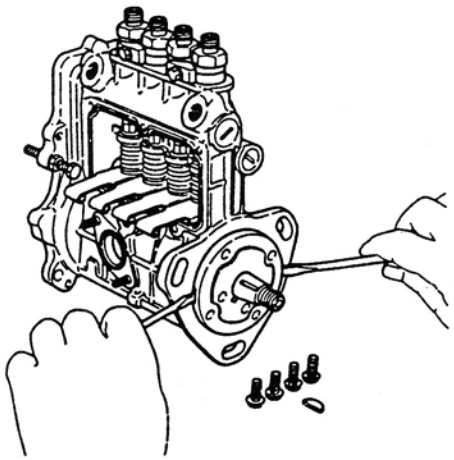


Plunger spring support plate

NOTE: If the camshaft does not turn, put double nuts on the end of the cam shaft or remove the coupling.

(5) Remove the camshaft woodruff key.

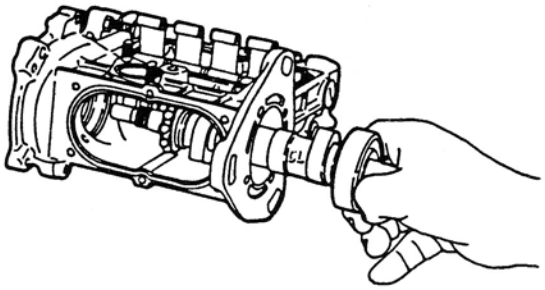
(6) Put a screwdriver in the two grooves on the camshaft bearing holder mounting surface, and pull out the camshaft bearing holder.



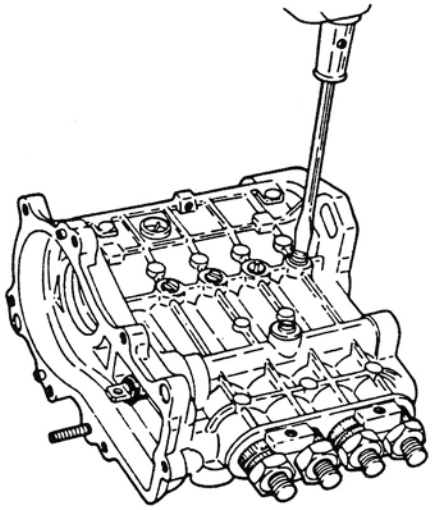
NOTE: 1. Make sure not to damage the oil seal with the threaded part of the camshaft.
2. Be careful not to loose the shims in between the pump and bearing holder.

(7) Turn the fuel pump upside down, move all the roller guides to the plunger side, and then put the pump on its side. Turn the camshaft to a position so that none of the cylinder cams hit the tappets.

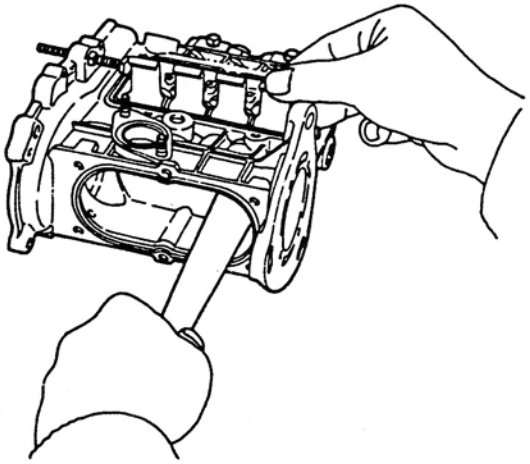
(8) Put a plate against the governor end side of the camshaft and lightly tap it, and pull out the camshaft and drive side bearing.



(9) Remove the roller guide stop.

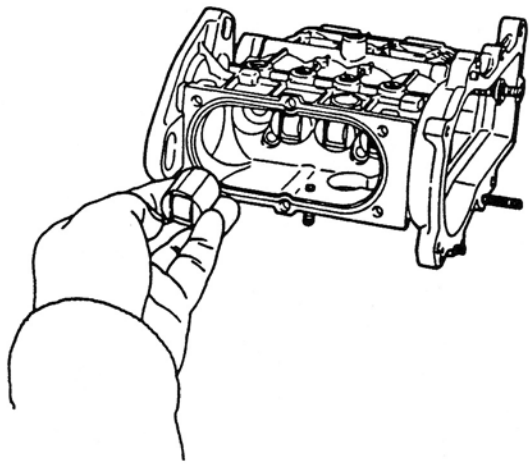


(10) Use a hammer handle or the like to push up the roller guide from the bottom of the pump, and remove the plunger spring support plate.

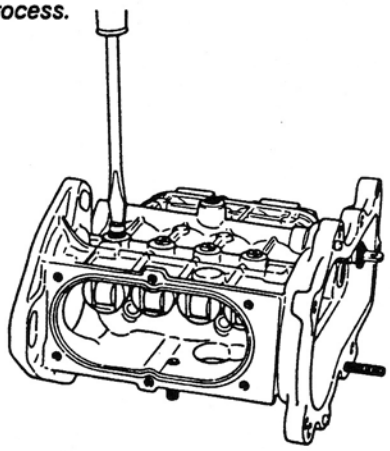


NOTE: The plunger spring may make the roller guide and plunger, etc. fly out when the plunger support plate is removed.

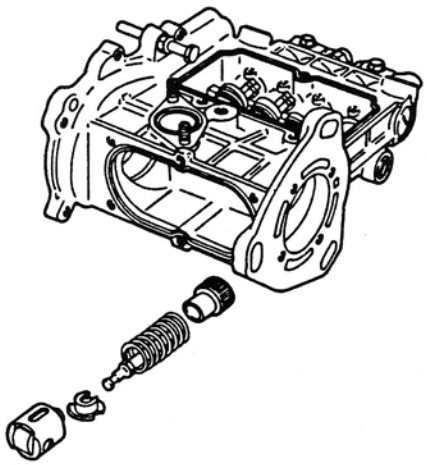
(11) Remove the roller guide.



NOTE: When you stand the fuel pump up, all of the roller guides drop out at one time. Therefore, first remove the stop bolt for one cylinder at a time, and then the roller guide for each cylinder—continue this process.

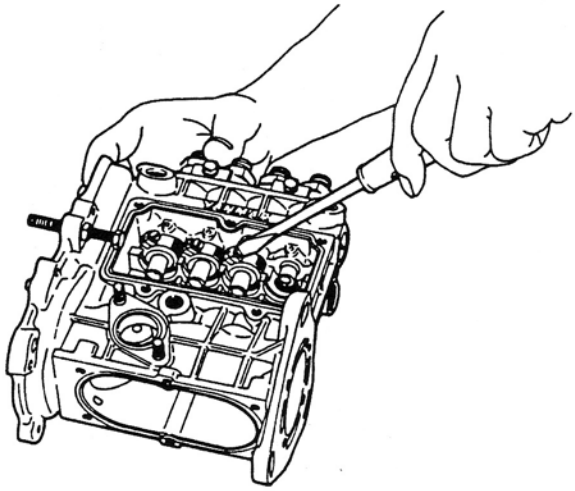


(12) Remove the plunger, plunger spring and lower washer from the lower part of the pump.

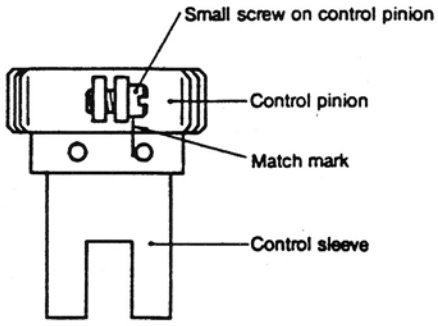


NOTE: Keep the parts separate for each cylinder.

(13) Loosen the small screw on control pinion.

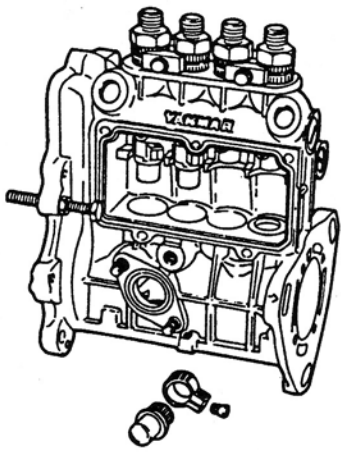


NOTE: 1. Check to make sure the match marks on the pinion/sleeve are correct before loosening the small screw on the control pinion, as the pinion and sleeve come apart when the screw is loosened. If the mark is hard to read or off center, lightly inscribe a new mark. This will serve as a guide when adjusting injection volume later.



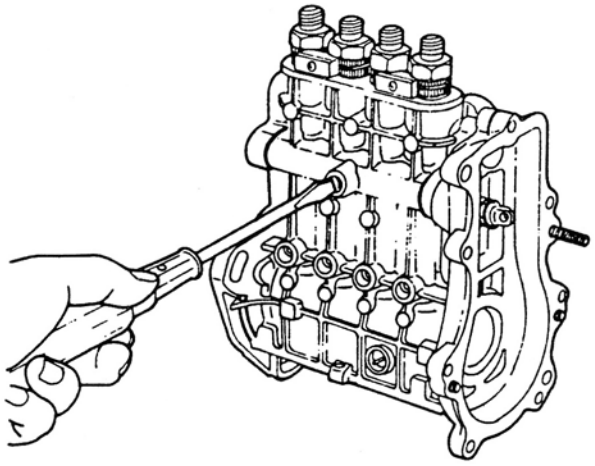
2. Keep parts separate for each cylinder.

(14) Remove the control pinion, sleeve and upper rest.

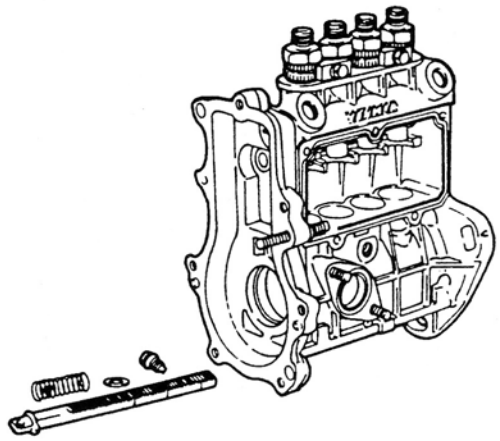


NOTE: Keep parts separate for each cylinder.

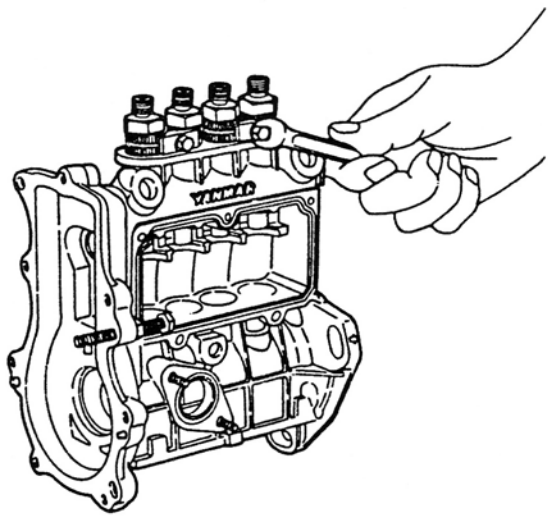
(15) Remove the control rack stop bolt and remove the rack.



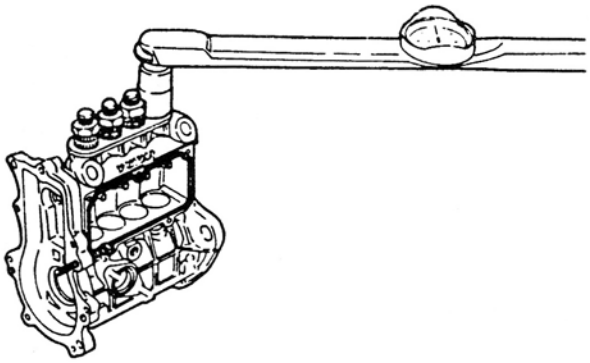
Note: Be careful not to lose the spring on the control rack.



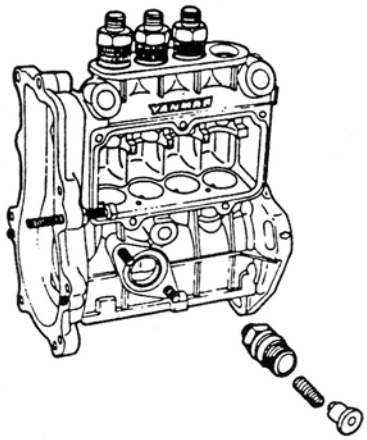
(16) Loosen the delivery valve retainer stop bolt, and remove the delivery valve holder stop.



(17) Remove the delivery valve holder.

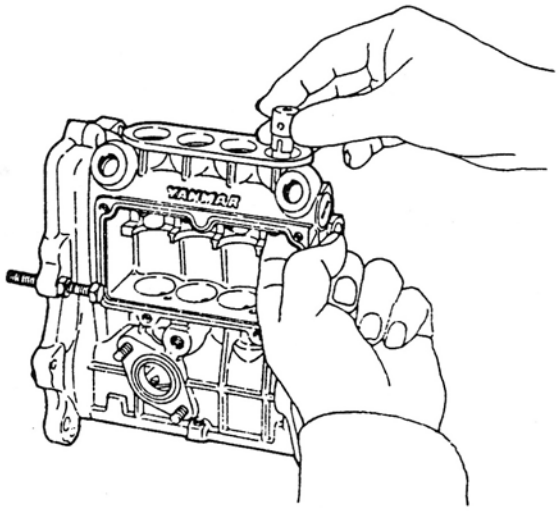


(18) Remove the delivery valve assembly.



NOTE: 1. Be careful not to lose the delivery valve packing, delivery valve spring, delivery valve stopper or other small parts.
2. Keep the delivery valve assemblies for each cylinder clearly separated.

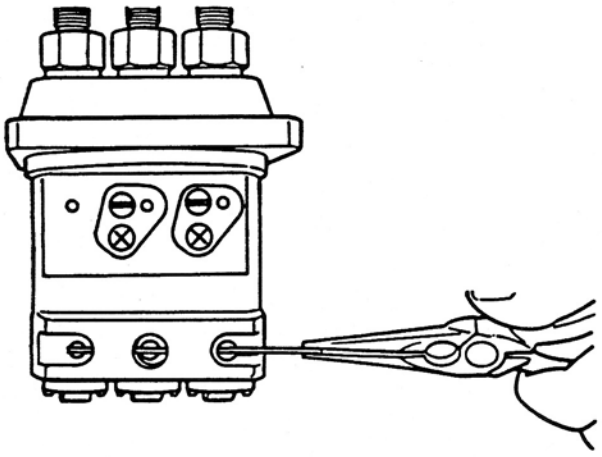
(19) Take the plunger barrel out from the top of pump.



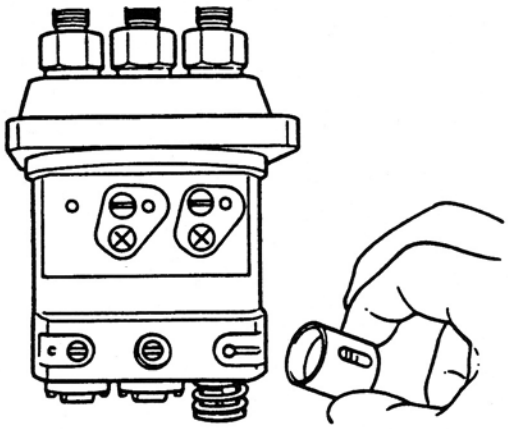
NOTE: Keep it as a set with the plunger that was removed earlier.

Preparation (YPFR type)

(1) Remove the pump from the engine.
(2) Remove the plunger guide stopper pin and the stoppers.

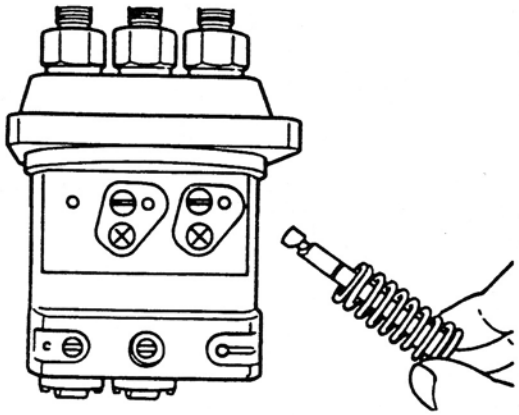


(3) Remove the right plunger guide.

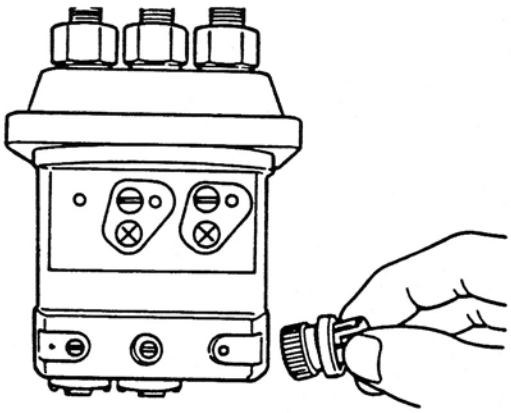


Note: Keep the plunger stroke adjusting shims placed in the plunger guides for each cylinder clearly separated.

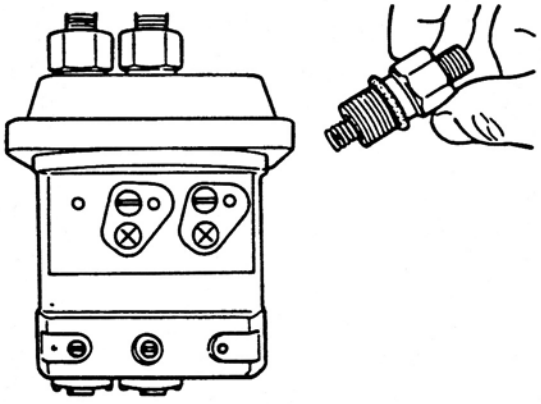
(4) Remove the plunger spring and its lower retainer.



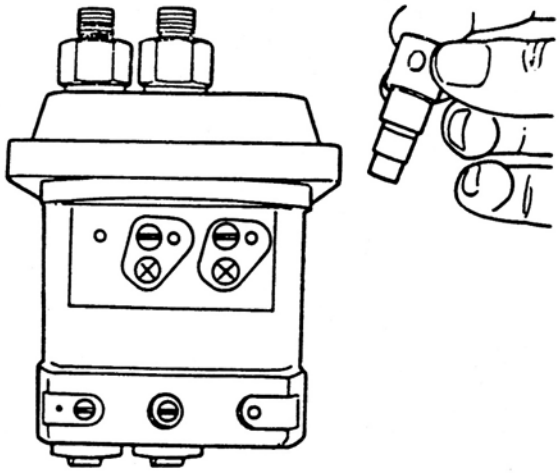
(5) Remove the plunger spring upper retainer and the fuel control sleeve.



(6) Remove the rack.
(7) Remove the delivery valve holders, the delivery valve springs, and the delivery valves.



(8) Remove the plunger barrels.



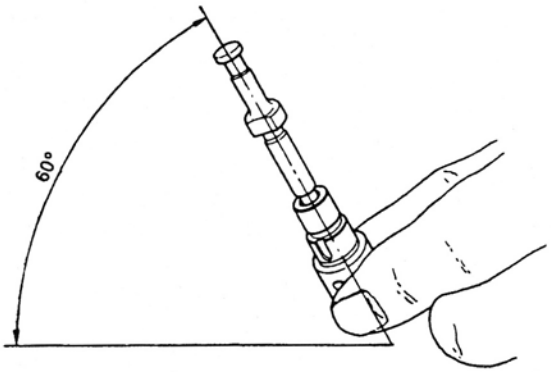
(9) Remove the plunger barrel packing.

Caution: Don't loosen the adjust screw and the adjust plate fixing bolt. If they are loosened, fuel output test is impossible without a pump tester stand.

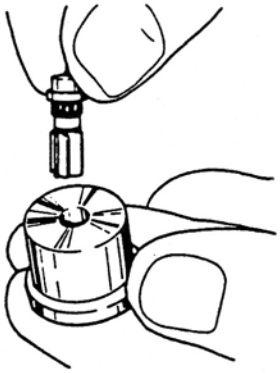
3-2 Inspection of fuel injection pump

(1) Inspection of plunger

1) Thoroughly wash the plungers, and replace plungers that have scratches on the plunger lead or are discolored.
2) The plunger is in good condition if it slides down smoothly when it is tilted about 60°. Repeat this several times while turning the plunger. Repair or replace if it slides down too quickly or if it stops part way.



(2) Inspection of delivery valve



1) Replace as a set if the delivery valve suck-back collar or seat is scratched, scored, scuffed, worn, etc.
2) The valve is in good condition if it returns when released after being pushed down with your finger (while the holes in the bottom of the delivery guide seat are covered). Replace if necessary.
3) Likewise, the valve should completely close by its own weight when you take your finger off the holes in the bottom of the delivery guide sheet.

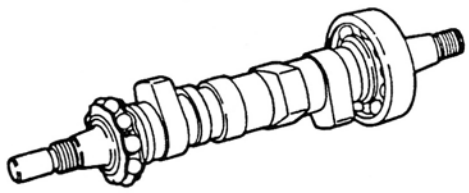
NOTE: When fitting new parts, wash with diesel oil and perform the above inspection.

(3) Inspection of pump

1) Inspect for extreme wear of roller guide sliding surface. Scratches on the roller pin sliding surface are not a problem.
2) Inspect the plunger barrel seat.
If there are burrs or discoloration, repair or replace as this will lead to dilution of the lubricant.

(4) Inspection of fuel camshaft and bearings

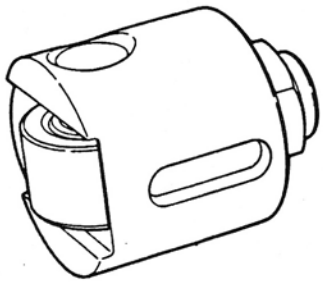
1) Fuel camshaft
Inspect for scratches or wear of camshaft, deformation of key grooves and deformation of screws on both ends, and replace if necessary.
2) Bearings
Replace if the taper rollers or outer race surface is flaked or worn.



NOTE: Replace fuel camshafts and bearings together.

(5) Inspection of roller guide assembly

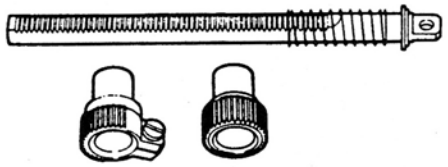
1) Roller



Replace if the surface is worn or flaked.
2) Roller Guide
Replace if the outer roller pin hole is extensively worn or there are many scratches.
3) Replace if the play of the roller guide assembly pin/roller is 0.2mm (0.0078in.) or more.
4) Injection timing adjustment bolt
Replace if the surface in contact with the plunger side is unevenly or excessively worn.

(6) Inspection of rack and pinion

1) Rack



Inspect for bending of rack and wear or deformation of fit with pinion.
2) Pinion
Inspect for wear or deformation of fit with rack.

NOTE: If the tooth surface or sliding surface is not in good working order, rack resistance increases, affecting the condition of the engine (rough rpm, over running, etc.).

(7) Inspection of plunger spring and delivery spring

Inspect springs for scratches, cracks, breakage, uneven wear and rust.

(8) Inspection of oil seals
Inspect oil seals to see if they are burred or scratched.

(9) Inspection of roller guide stop
Inspect the side of the tip, replace if excessively worn.

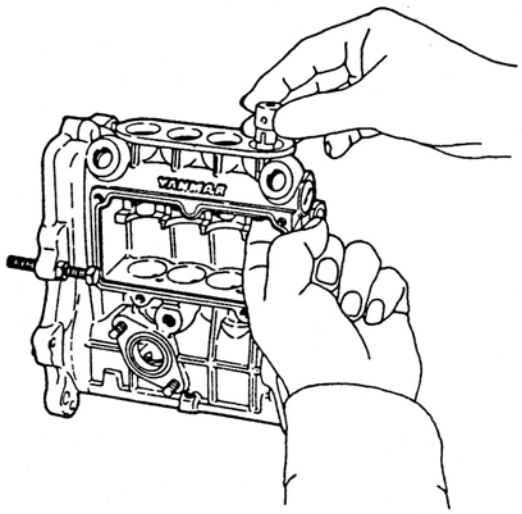
(10) Inspection of O-rings
Inspect and replace if they are burred or cracked.

3-3 Reassembly of fuel injection pump

Preparation (YPES type)

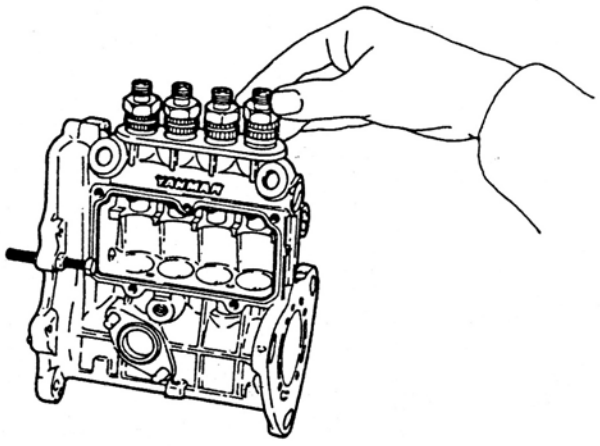
After inspection, put all parts in order and clean.
See Inspection of Fuel Pump for inspection procedure.

(1) Put in the plunger barrel from the top of pump.



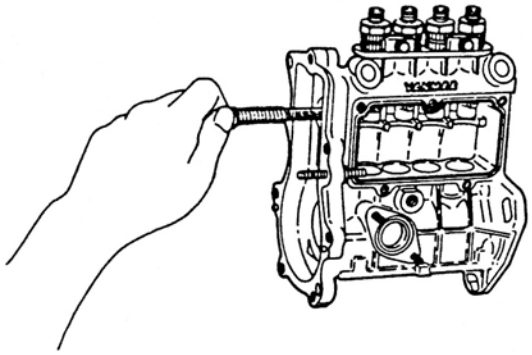
NOTE: Make sure the barrel key groove is fitted properly to the barrel stop pin.

(2) Place the delivery valve assembly, packing, spring and stopper from the top of the pump, in this order.



NOTE: Replace the delivery valve packing and O-ring.

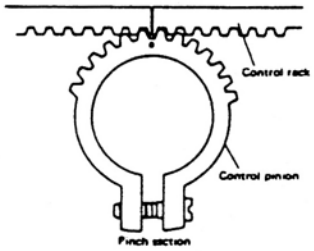
(3) Place the control rack, and tighten the control rack stop bolt.



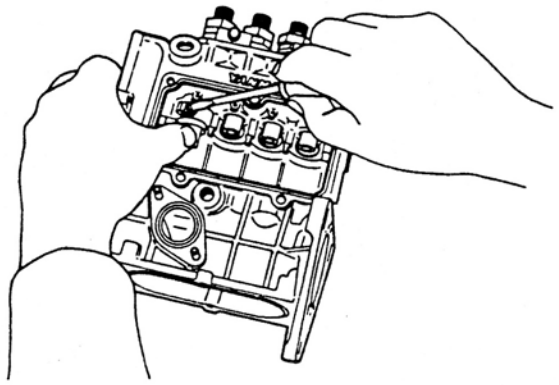
NOTE: 1. Do not forget the rack aux. spring.
2. Make sure the rack moves smoothly through a full cycle.

(4) Place the rack set screw (using the special tool) in the rack stop bolt screw hole to fix the rack.

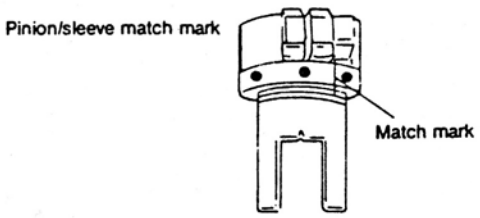
(5) Looking from the bottom of pump, align the match marks on the rack and pinion.



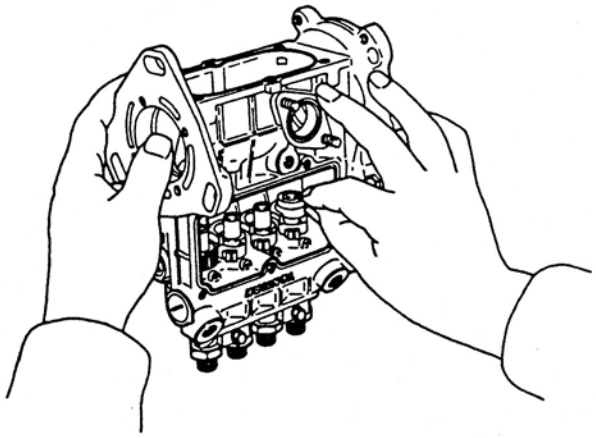
(6) While holding the pinion with one hand and keeping it aligned with the match mark, fit in the sleeve, and lightly tighten the small pinion screw.



NOTE: Fitting of sleeve; Face towards small pinion screws and align with match mark.



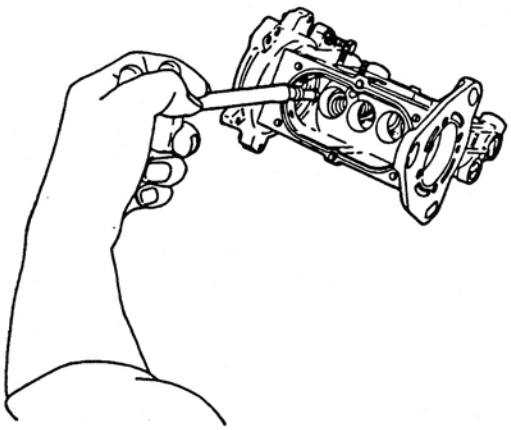
(7) Mount the plunger spring upper rest.



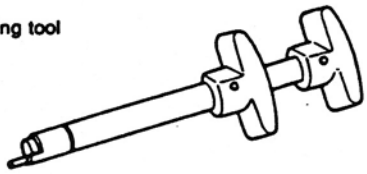
NOTE: 1. Make sure to mount the upper rest with the hollow side facing down.
2. Recheck to make sure that the rack moves easily.

(8) Mount the plunger spring.

(9) Mount the lower rest on the head of the plunger, and fit the plunger in the lower part of pump while aligning the match marks on the plunger flange and the sleeve.

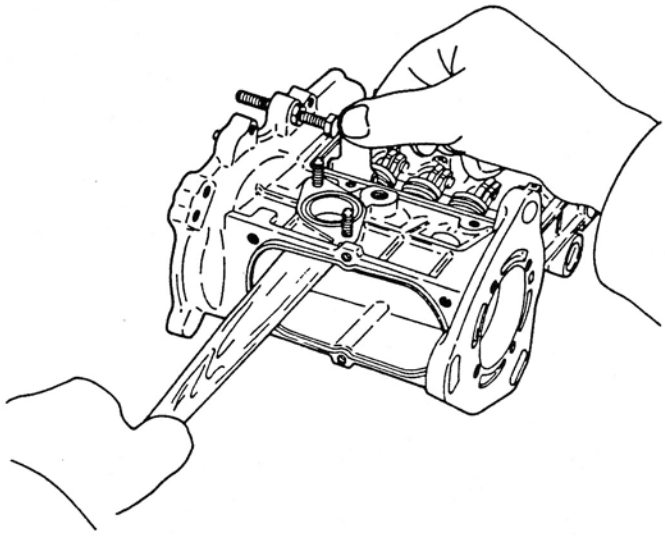


Plunger inserting tool

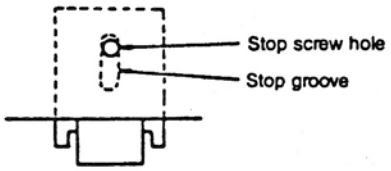


NOTE: If the plunger is mounted in the opposite direction, the injection volume will increase abnormally and cannot be adjusted.

(10) Insert the plunger spring support plate between the plunger spring seat B (lower) and fuel pump, by putting the handle of a hammer in the lower part of pump and pushing the roller guide up.



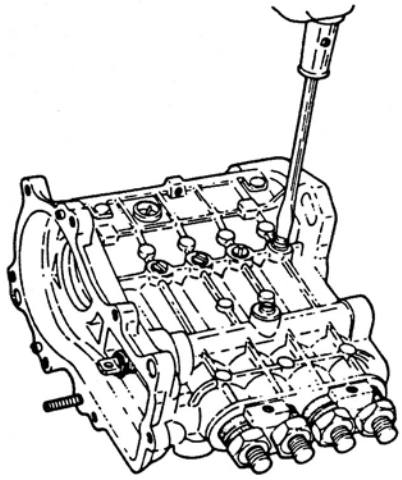
NOTE: 1. Face the roller guide stop groove up, and align with stop screw hole on pump.



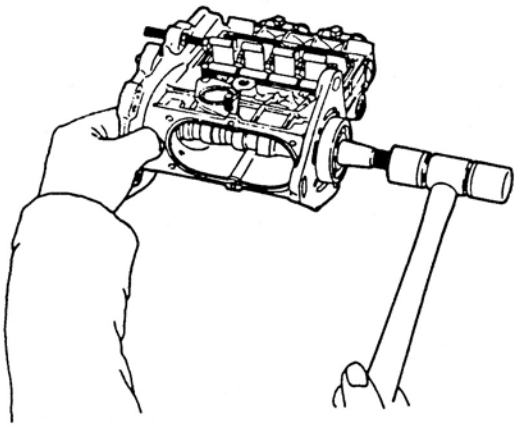
2. Check movement of rack. The plunger spring may be out of place if movement is heavy—insert a screwdriver and bring to correct position.
3. When replacing the roller guide assembly, fit shims and lightly tighten:

Standard shim thickness	*See separate service data*
Part code number	

(11) Make sure that roller guide stop groove is in correct position, and tighten roller guide stop bolt.

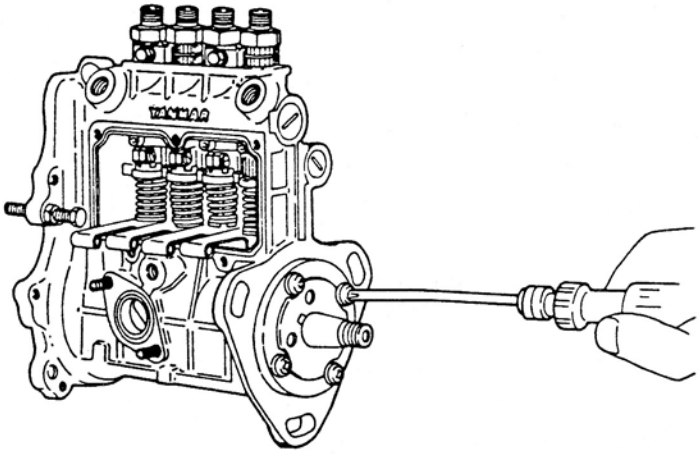


(12) Fit the bearings to both ends of the camshaft, and insert from drive side by lightly tapping.



NOTE: Turn pump upside down, and tap camshaft in while moving roller guide to plunger spring side.

(13) Fit the oil seal on the inside of the bearing retainer and mount the bearing retainer.



NOTE: Coat the camshaft and oil seal with oil to prevent the oil seal from being scratched.

(14) Fix the pump, lightly tap both ends of the cam shaft with a wood hammer, and adjust the cam shaft side clearance with the adjustment shims while checking with side clearance gauge.

mm (in.)

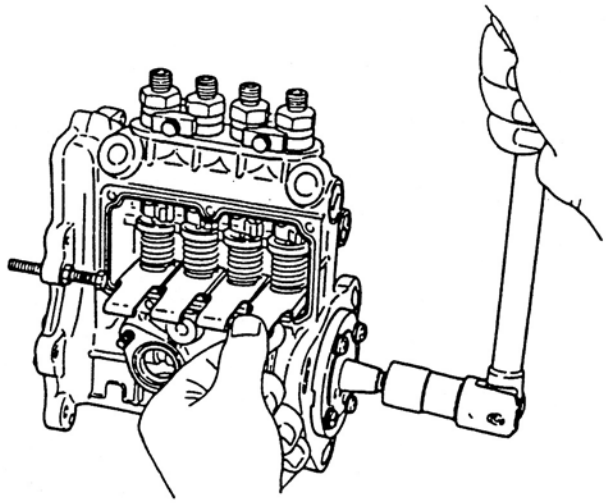
Camshaft side clearance	0.02 ~ 0.05 (0.0007 ~ 0.0019)

Adjusting
Pull out adjusting shims if clearance is too small, and add adjusting shims if it is too large.

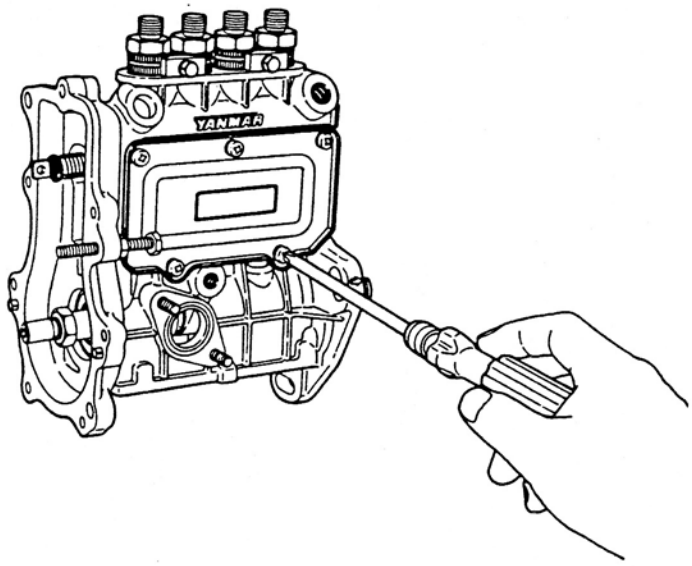
mm (in.)

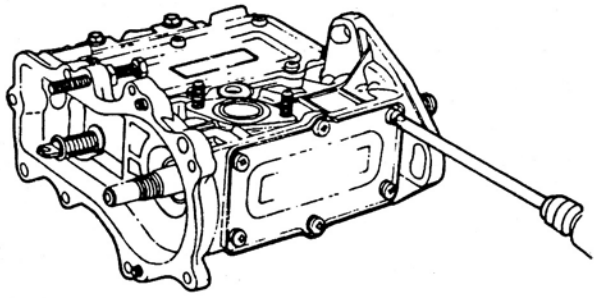
Adjusting shim thickness	0.50 (0.0196) 0.40 (0.0157) 0.30 (0.0118) 0.15 (0.0059)

(15) Turn the camshaft, and pull out the plunger spring support plate.



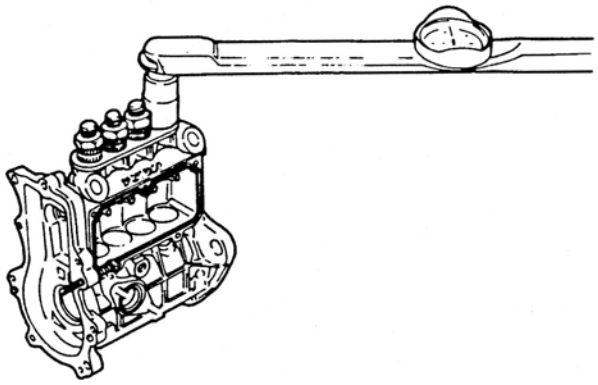
(16) Mount the fuel pump side cover.
(17) Tap in the camshaft wood ruff key.





NOTE: Fit double nuts to turn the camshaft.

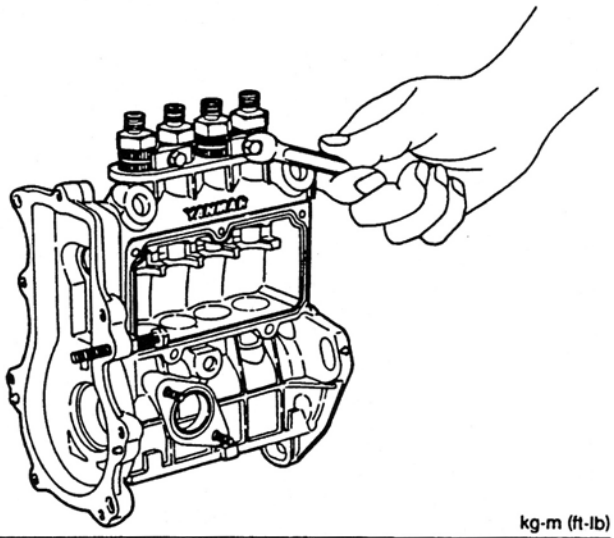
(18) Tighten delivery valve retainer.



	kg-m (ft-lb)
Tightening torque	3.5 ~ 4.0 (25.31 ~ 28.93)

NOTE: 1. Tighten the retainer as far as possible by hand—if the bolt gets hard to turn part way, the packing or delivery valve are out of place. Remove, correct, and start tightening again.
2. Overtightening can result in malfunctioning of the rack.

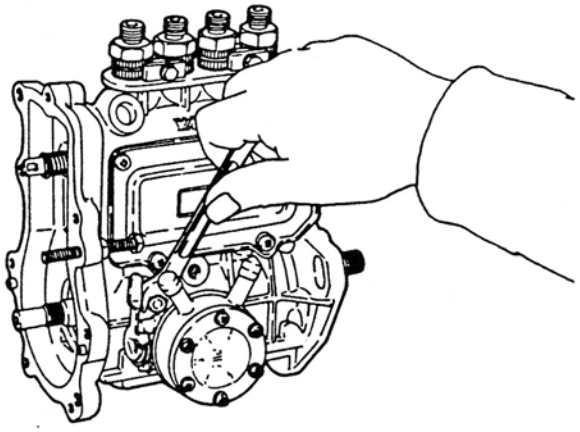
(19) Fit the delivery retainer stop and tighten the stop bolt.



	kg-m (ft-lb)
Tightening torque	0.3 (2.16)

NOTE: Overtightening can upset the delivery retainer and cause oil leakage.

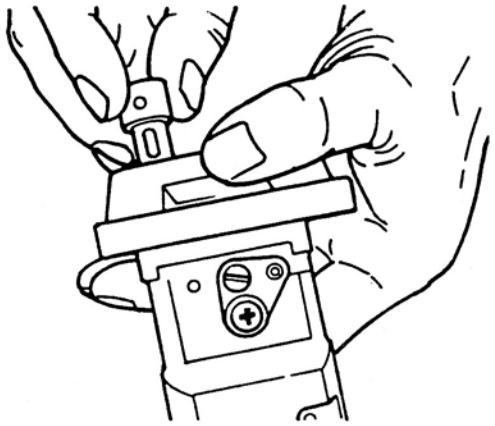
(20) Mount the fuel feed pump



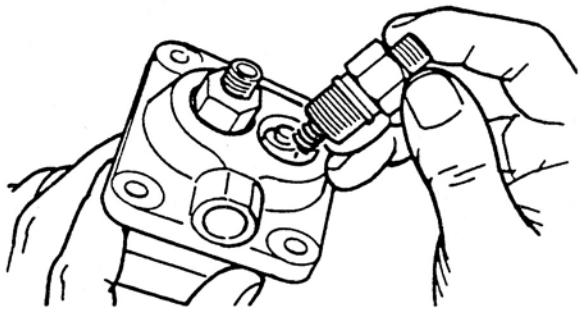
NOTE: See the item explaining reassembly of the fuel feed pump.

Preparation (YPFR type)

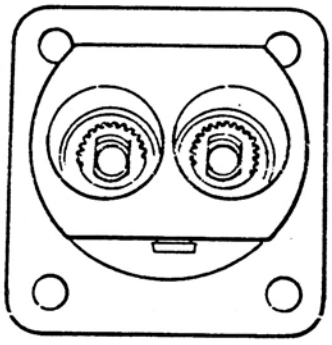
(1) Place the plunger barrel packing in position.
(2) Install the plunger barrel.

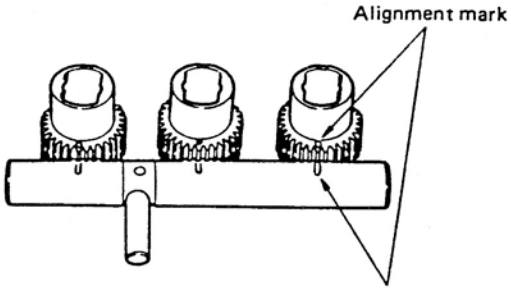


(3) Install the delivery valve assembly and the delivery spring.

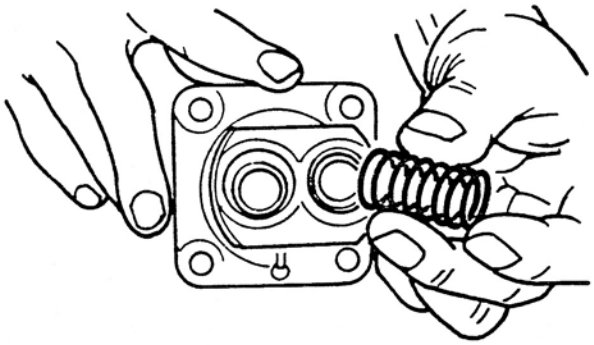


(4) Install the delivery valve holder, then tighten it tentatively.
(5) Install the control rack and the control sleeve.
By matching the alignment mark on the fuel control pinion with that on the fuel control rack.

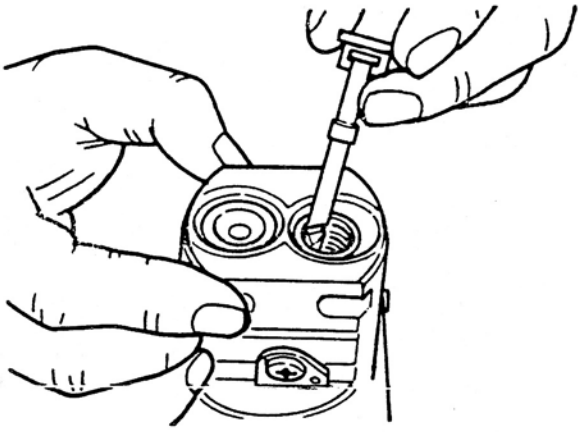


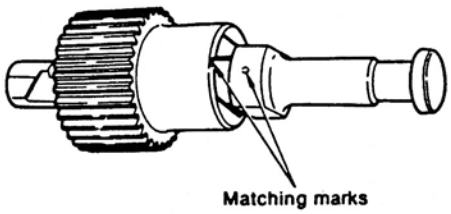


(6) Install the upper spring retainer and the plunger spring.



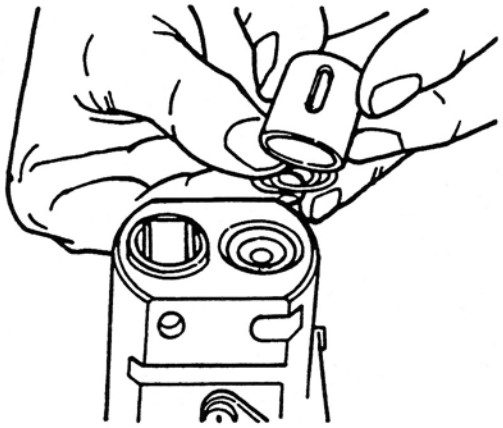
(7) Install the plunger and the lower spring retainer.





Note: Match the plunger's match mark with the mark of control sleeve.

(8) Place the plunger location adjusting shim, then install the plunger guide.



(9) Install the plunger guide stop. Set the stop by pressing the plunger by hand.
(Press the plunger guide by moving the rack so that the plunger collar can be fixed into the groove of the regulating gear teeth.)

(10) Set the plunger guide stopper pin.

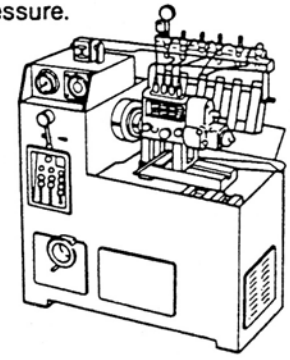
4. Adjustment of Fuel Injection Pump and Governor

Adjust the fuel injection pump after you have completed reassembly. The pump itself must be readjusted with a special pump tester when you have replaced major parts such as the plunger assembly, roller guide assembly, fuel camshaft, etc. Procure a pump tester like the one illustrated below.

4-1 Preparations (YPES type)

Prepare for adjustment of the fuel injection pump as follows:

(1) Adjusting nozzle assembly and inspection of injection starting pressure.



kg/cm² (lb/in.²)

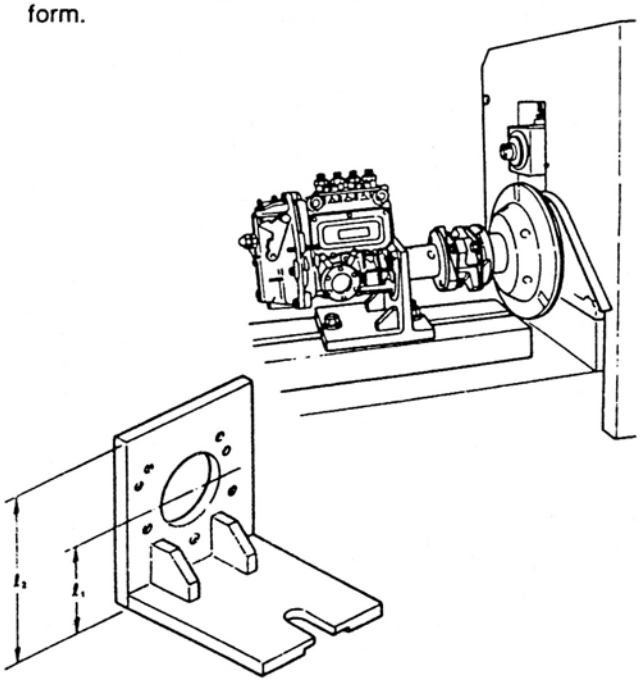
Adjusting nozzle type	YDN-12SD12
Injection starting pressure	165 ~ 175 (2346.85 ~ 2489.08)

(2) Adjusting injection pipe.

mm (in.)

Inner dia./outer dia. × length	2.0/6.0 × 600 (0.0787/0.2362 × 23.6220)
Minimum bending radius	25 (0.9842)

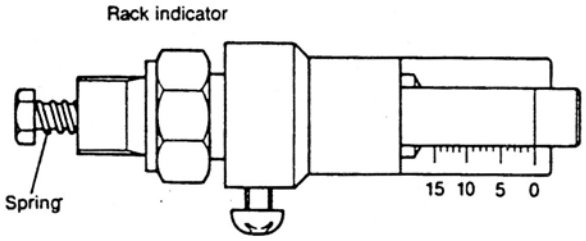
(3) Mount the fuel injection pump on the pump tester platform.

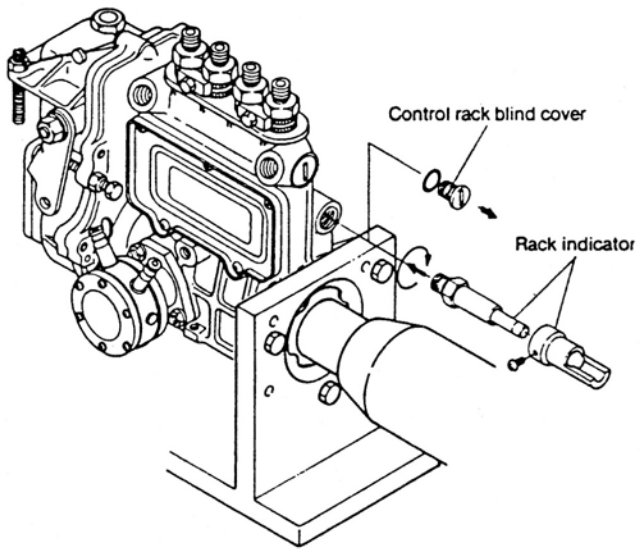


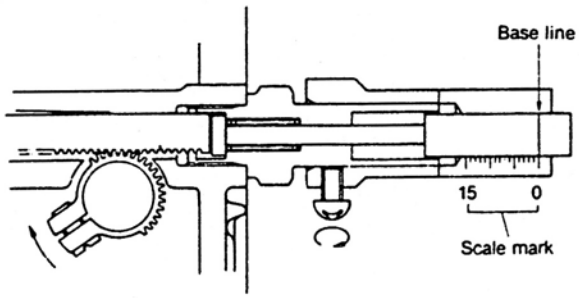
mm (in.)

Tester used	l_1	l_2	Part code number
Yanmar	110 (4.3307)	150 (5.9055)	158090-51010
Robert Bosch	125 (4.9212)	165 (6.4960)	158090-51020

(4) Remove the control rack blind cover and fit the rack indicator.
Next, turn the pinion from the side of the pump until the control rack is at the maximum drive side position, and set it to the rack indicator scale standard position.
Then make sure that the control rack and rack indicator slide smoothly.





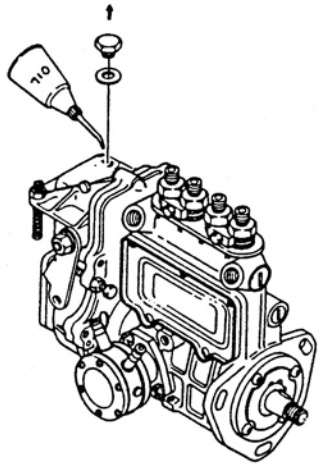


Part code number	158090-51500

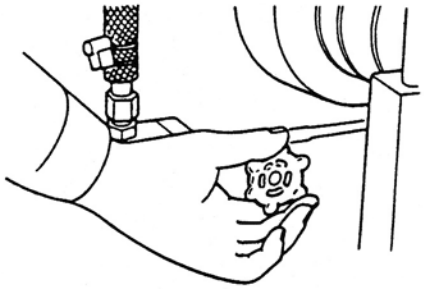
(5) Check control rack stroke
Make sure the rack position is at 11.5 ~ 12.5mm (0.4527 ~ 0.4921in.) on the indicator scale when the governor control lever is set at the maximum operating position. If it is not at this value, change the link connecting the governor and control rack to adjust it.

NOTE: Links are availabe in 1mm (0.0394in.) increments.

(6) Remove the plug in the oil fill hole on the top of the governor case, and fill the pump with about 200cc of pump oil or engine oil.

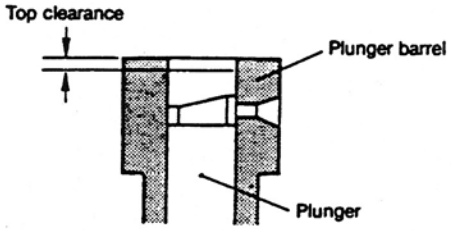


(7) Complete fuel oil piping and operate the pump tester to purge the line of air.
(8) Set the pressure of oil feed from pump tester to injection pump at 0.2 – 0.3 kg/cm² (2.84 – 4.26 lb/in²)



4-2 Adjustment of top clearance

Adjust the top clearance (clearance between top of plunger and top of barrel with cam at top dead point) of each cylinder plunger to bring it to the specified value by changing the thickness of the shims.



mm (in.)

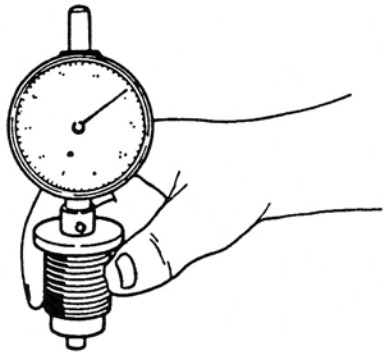
Top clearance	*See separate service data (Page 3-62, 63)*
Pre-stroke	
Standard shim thickness	

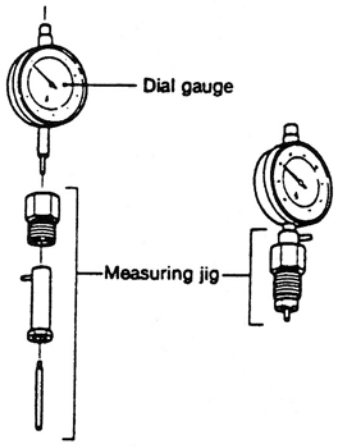
Relation between top clearance, standard shim thickness and pre-stroke.

mm (in.)

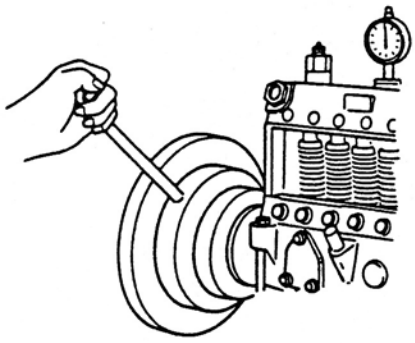
Adjusting shim thickness	1.0 (0.0394) 1.2 (0.0472) 1.3 (0.0512) 1.4 (0.0551) 1.5 (0.0591) 1.6 (0.0630)
Part Code No.	129155–51600

(1) Place the top clearance gauge on a level surface and set the gauge to zero.



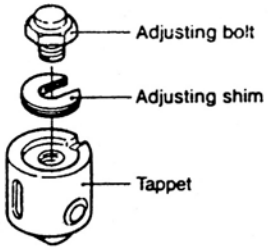


(2) Remove the injection pump delivery retainer, take out the delivery valve assembly, insert the top clearance gauge and tighten by hand.

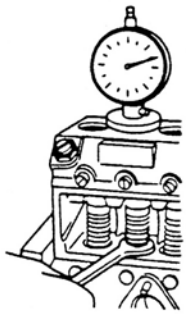


(3) Turn the camshaft, and bring cam to top dead point while watching gauge needle.

(4) Read the gauge at this position, and adjust until the clearance is at the specified value by changing adjusting shims.
Tighten the adjusting screw after completing adjustment.



(Greater shim thickness decreases top clearance and smaller shim thickness increases top clearance).



NOTE: Adjust while watching gauge, and then tighten.

(5) After adjustment is completed, insert the delivery valve assembly and tighten the delivery retainer.

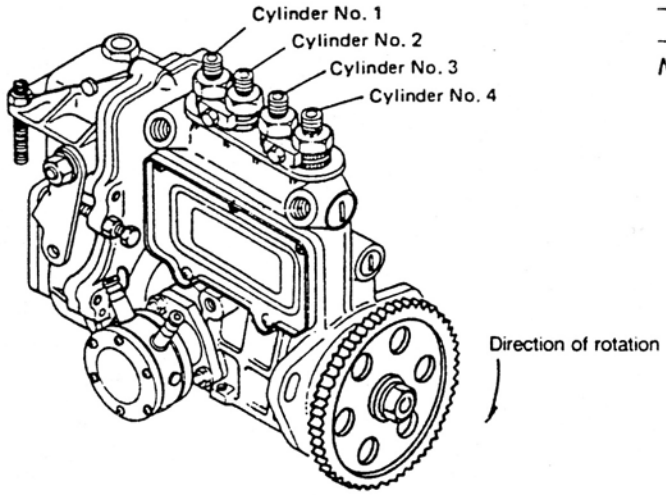
kg-m (ft-lb)

Delivery retainer tightening torque	3.5 ~ 4.0 (25.31 ~ 28.93)

Repeat the above procedure to adjust the top clearance of each cylinder.

4-3 Adjusting of injection timing

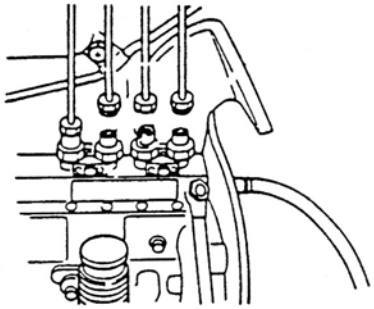
After adjusting the top clearance for all cylinders, check/adjust the injection timing.



(1) Set the governor control lever to the operating position and fix (bring plunger to the effective injection range), turn the camshaft clockwise, and check the injection starting time (FID) of cylinder No.1 (start of discharge of fuel from the delivery retainer).

Cylinder no.	Count from the drive side
Direction of rotation	Right looking from drive side

(2) In the above state, set the tester needle to a position easy to read on the flywheel scale, and check the injection timing several times by reading the flywheel scale, according to the injection order.



No. of cylinder	4	3
Injection order	1—3—4—2—1	1—3—2—1
Injection timing	90°	120°
Allowable deviation	±30′	± 30′

(3) Readjust the top clearance of cylinders that are not within the allowable deviation (increasing adjusting shim thickness makes injection timing faster, and decreasing makes it slower).
The change in injection timing effected by adjusting shims is as follows:

Change in shim thickness	Change in injection timing	
	Cam angle	Crank angle
0.1mm (0.0039in.)	0.5°	1.0°

(4) When you have readjusted top clearance, make sure it is within allowable values after completing adjustment.

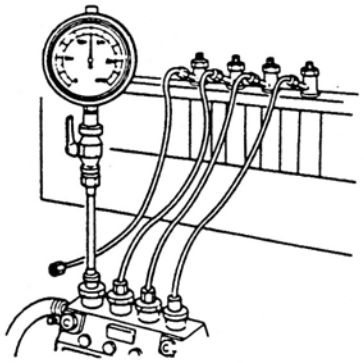
mm (in.)

Allowable top clearance	0.3 (0.0118)

NOTE: 1. All cylinders must be readjusted if one shows less than the allowable value.
2. If the top clearance is less than the allowable value, the plunger will hit the delivery valve or the plunger flange will hit the plunger barrel.

4-4 Plunger pressure test

(1) Mount the pressure gauge to the delivery retainer of the cylinder to be tested.



Max. pressure gauge reading	1000 kg/cm² (14223 lb/in.²)
Connecting screw dimensions	M12 × 1.5

(2) Set the governor control lever to the stop position, operate the injection pump at about 200 rpm, and make sure that the pressure gauge reading is 500 kg/cm² (7110 lb/in.²) or more while lightly moving the control pinion gear towards full throttle (drive side) from the pump.

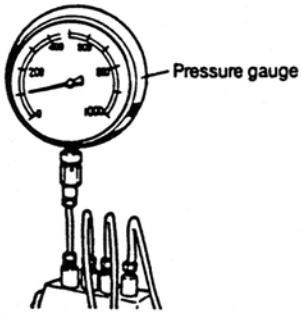
Replace the plunger if the pressure does not reach this value.

(3) Immediately release the gear after pressure rises to stop injection.

At the same time, check to see that oil is not leaking from the delivery retainer or fuel injection piping, and that there is no extreme drop in pressure.

4-5 Delivery valve pressure test

(1) Perform the plunger pressure test in the same way, bringing the pressure to about 120 kg/cm² (1706 lb/in.²), and then stopping injection.



(2) After pressure rises to the above value, measure the time it takes to drop from 100 ~ 90 kg/cm² (1422 ~ 2702 lb/in.²).

100 ~ 90 kg/cm² (1422 ~ 2702 lb/in.²)	5 seconds (to drop 10 kg/cm² (142 lb/in.²))

If the pressure drops faster than this, wash the delivery valve, and retest. Replace the delivery valve if the pressure continues to drop rapidly.

4-6 Adjusting injection volume (uniformity of each cylinder)

The injection volume is determined by the fuel injection pump rpm and rack position. Check and adjust to bring to specified value.

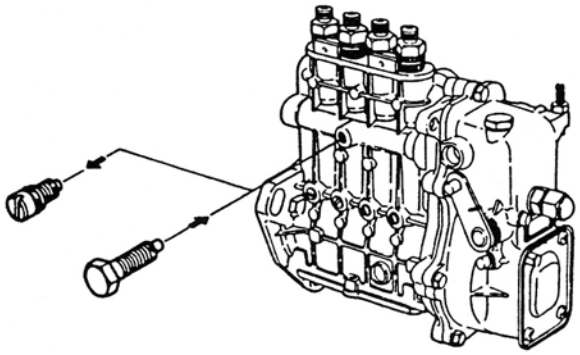
4-6.1 Measuring injection volume

(1) Preparation

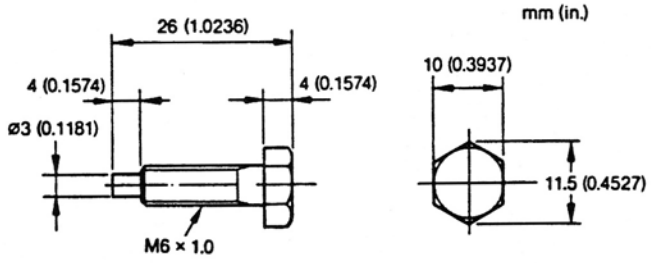
Set the pump rpm, rack position and measuring stroke to the specified value and measure:

Pump RPM	*See separate service data*
Pump rotating direction	Right looking from drive side
Rack indicator scale reading	*See separate service data (Page 3-62, 63)*

Remove the rack stop bolt behind the pump and screw in the rack fixing bolt to fix rack.



mm (in.)



Part Code No.	158090-51510

(2) Measuring injection volume

Measure the injection volume at the standard stroke, and adjust as follows if it is not within the specified value.

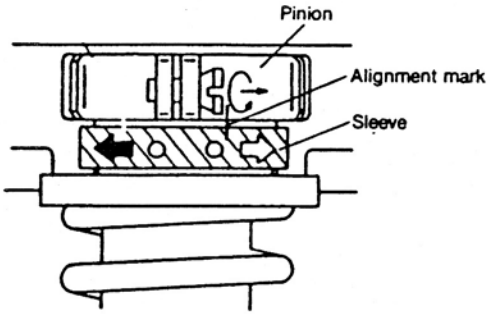
Measuring stroke	1,000 st
Specified injection volume at standard rack position	See injection pump service data *(Page 3-62, 63)*
Nonuniformity of cylinders	±3%

4-6.2 Adjustment of injection volume

Compare the injection volume collected in measuring cylinders for each cylinder, and adjust if necessary to obtain specified value.

(1) Push the control rack all the way to the drive side, stop with rack fixing bolt, and loosen the pinion/sleeve fixing bolt 1/3 revolution.

(2) When the control sleeve is turned to the right or left, the plunger is turned through the same angle to increase or decrease injection volume.
The injection volume is increased when the control sleeve is turned in the direction of the right arrow (→) on fig. and is decreased when turned in the direction of the left arrow (←) on the figure.



(3) Measure the injection volume of each cylinder again. Repeat this process until the injection volume for every cylinder is the same (within specified limit).
(4) Next, measure the injection volumes under different conditions, and make sure the injection volume for every cylinder is within specifications.
Replace the plunger if the injection volume is not within specifications.

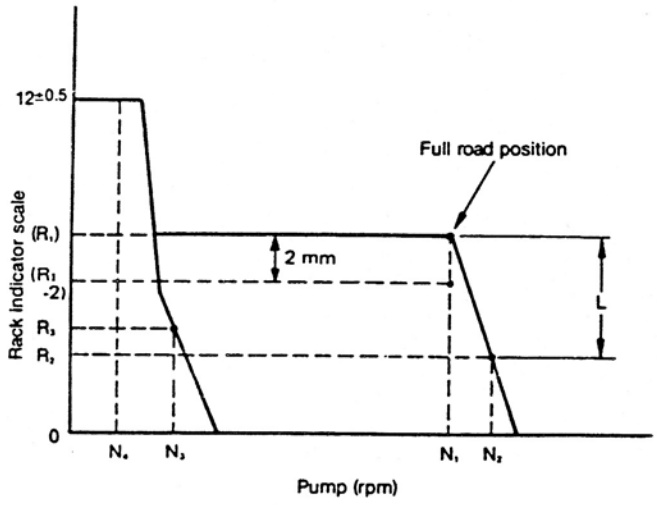
NOTE: See adjustment data for the specified injection volume value at other measuring points.

(5) After completing measurement, firmly tighten the pinion/sleeve fixing screw.
(6) If not aligned with match mark, make a new match mark.

4-7 Adjustment of governor

4-7.1 Adjusting fuel limit bolt

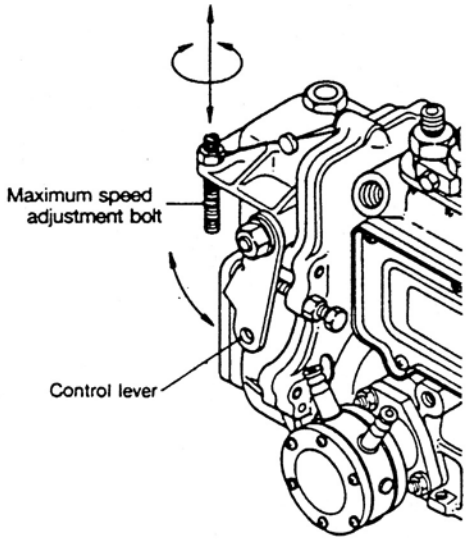
(1) Adjust the tightness of the fuel limit bolt to bring the rack position to the specified value (R_1) with the governor control lever all the way down towards the fuel increase position, while keeping the pump at rated rpm N_1.



(2) Measure fuel injection volume at rack position (R_1). Tightening of fuel limit bolt.
(3) If the injection volume is at the specified value, tighten the fuel limit bolt lock nut at that position.

4-7.2 Adjusting RPM limit bolt

(1) Gradually loosen the governor control lever while keeping the pump drive condition in the same condition as when the fuel limit bolt was adjusted, and adjust the tightness of the RPM limit bolt to the point where the rack position just exceeds the specified value (R_1).

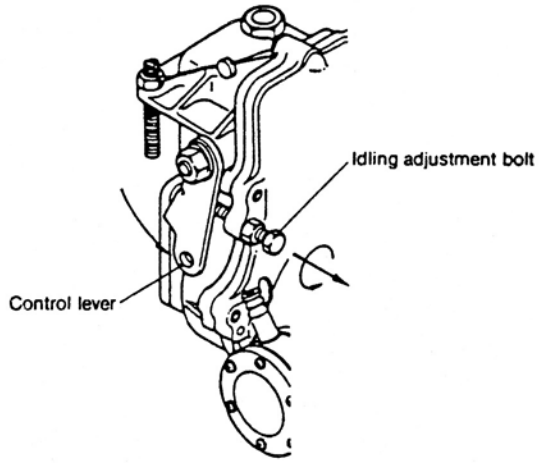


(2) Check maximum RPM at no load
Further increase rpm, and make sure that rack position ($R_2 = R_1 - L$) corresponding to maximum rpm at no load is within specified value (N_2).

No load max. RPM (Pump RPM)	*See separate service data (Page 3-62, 63)*

4-7.3 Adjusting idling

(1) Maintain the pump rpm at specified rpm (N_3).



Idling rpm (Pump RPM)	*See separate service data (Page 3-62, 63)*

(2) Measure the injection volume while lowering the governor control lever to the idling position, and adjust the position of the control lever with the idling adjustment bolt to bring it to specified value.

Measuring stroke	*See separate service data (Page 3-62, 63)*
Idling injection volume	

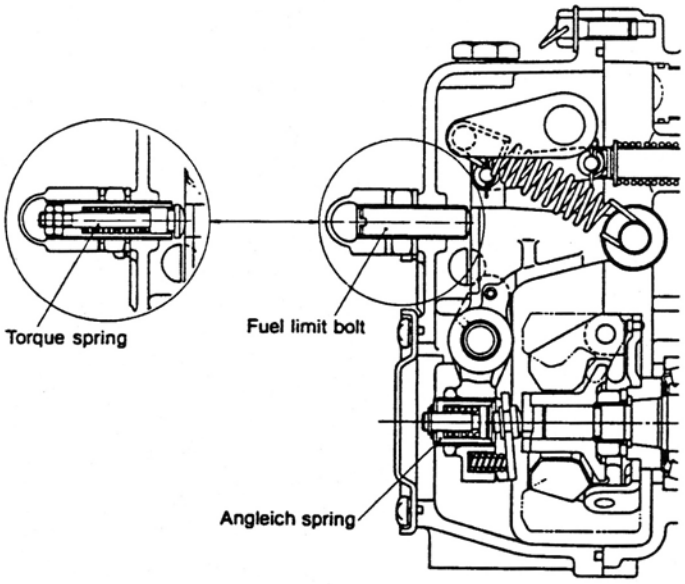
4-7.4 Check injection volume when starting

(1) Make sure the control rack moves smoothly while gradually reducing idling rpm.
(2) Next, fix the governor control lever at full load position with the pump at specified rpm (N_4). Make sure that control rack is at maximum rack position.
Measure the injection volume and check to make sure it is within the specified value.

Pump rpm (N_4)	200 rpm
Rack indicator scale	11.5~12.5mm(0.4527~0.4921 in.)
Measuring stroke	1000 st
Injection volume	*See separate service data (Page 3-62, 63)*

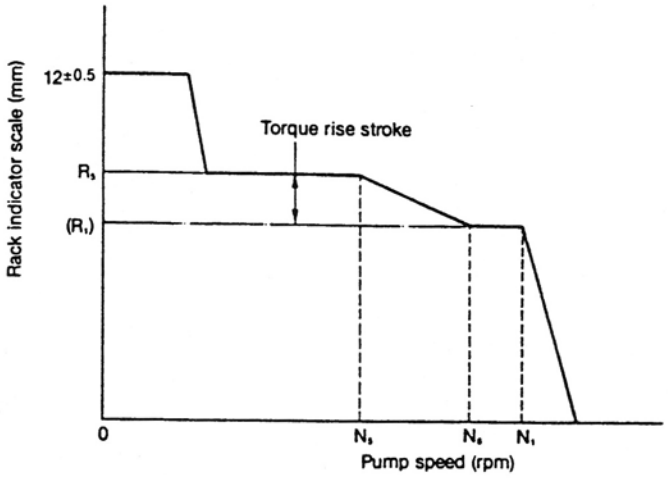
4-8 Adjustment of torque rise

There are some models which obtain torque rise with angleich and torque springs incorporated in the fuel injection pump as an injection volume increasing mechanism.



4-8.1 Models with angleich spring

For models with angleich spring, perform, this adjustment after finishing speed limit bolt adjustment.
(1) The angleich spring is used as an assembly.
(2) Bring the governor control lever to the full load position, and keep pump speed at the specified peak torque (N_5).
(3) Remove governor case cover in this state and screw angleich spring assembly to tension lever. Screw in from contact position with governor lever (when control lever starts to move), so that injection volume at torque rise is within specified values (θ deg.)



(4) After completing above, tighten lock nut to specified torque, and mount governor case cover.

kg-m (lb-ft)

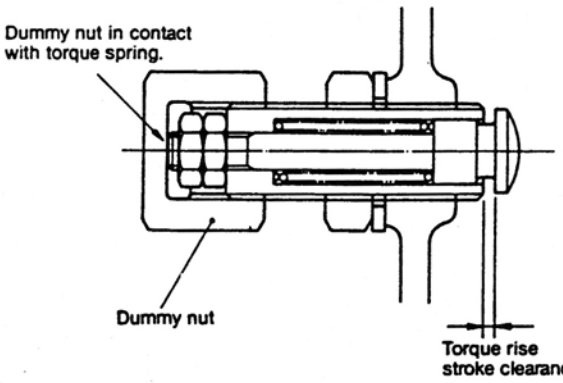
Lock nut tightening torque	2.5 ~ 3 (18.08 ~ 21.69)

NOTE: Make sure that the angleich bolt does not turn with the locknut when tightening it.

(5) Bring fuel injection pump to rated speed again, make sure that control rack smoothly displaces torque rise stroke, and that rack position (R_1) and injection value are with inspecified value at (N_1) rpm.

4-8.2 Models with torque spring

The torque rise spring is corporated in the fuel limit bolt, and is used as an assembly.



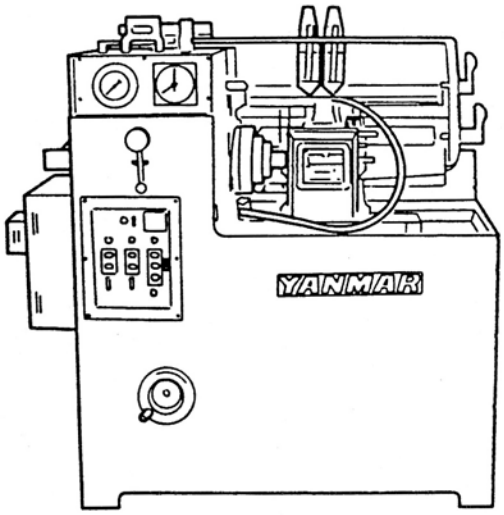
Use the dummy nut during adjustment as shown in fig., without torque rise stroke, and remove it after completing adjustment.

Check injection stop
Drive the pump at rated rpm (N_1) and standard rack position (R_1) with governor control lever at full load position, operate the stop lever on the back of the governor case, and make sure that injection to all cylinders is stopped.

NOTE: Be sure to remove the rack fixing bolt when doing this.

4-8 Injection pump adjustment (YPFR type)

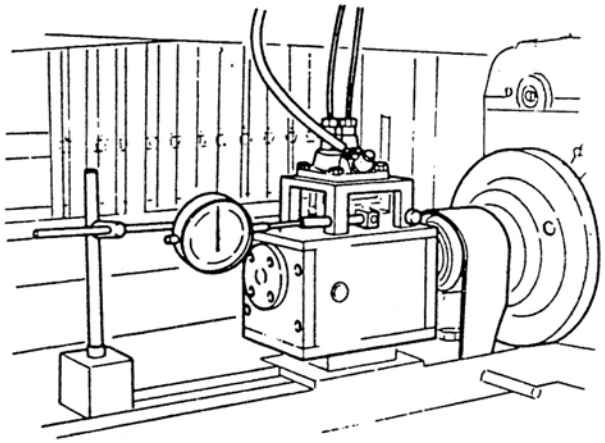
The injection pump is adjusted with an injection pump tester after reassembly.



4-8.1 Setting pump on tester

(1) After the injection pump has been disassembled and reassembled, install it on a pump tester
...cam lift: 7mm (0.276in.).

(2) Confirm that the control rack slides smoothly. If it does not, inspect the injection pump and repair it so that the rack slides smoothly
...control rack full stroke: 15mm (0.5905in.).

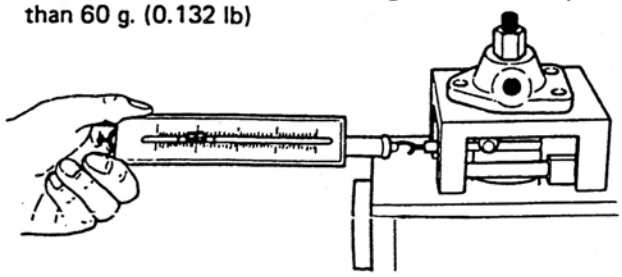


(3) Run the pump tester at low speed, loosen the air bleeder screw, and bleed the air from the injection pump.

4-8.2 Measuring the sliding resistance of the fuel control rack

Measure the sliding resistance of the fuel control rack with a spring scale (balance).

(1) Number of pump rotations/sliding resistance: 0 rpm/less than 60 g. (0.132 lb)



NOTE: If the sliding resistance is unsatisfactory, disassemble, inspect and repair the fuel control ra

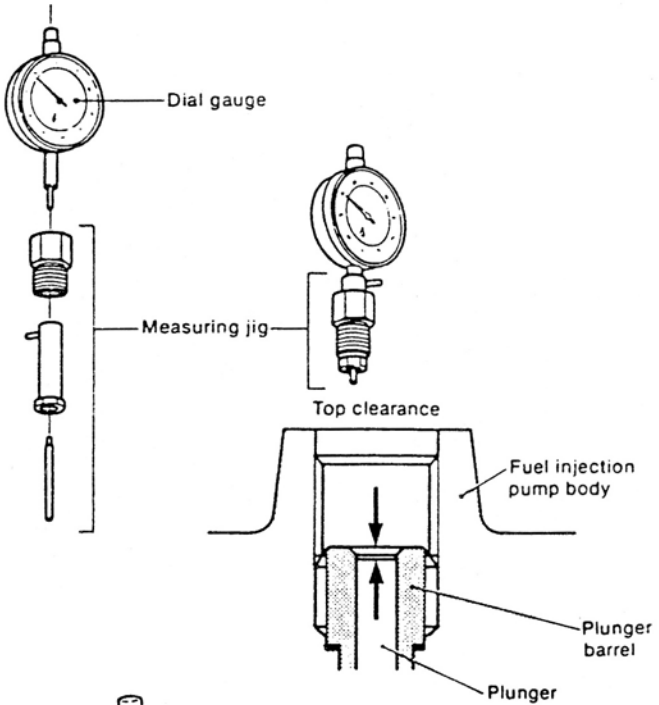
4-8.3 Adjusting the plunger top clearance

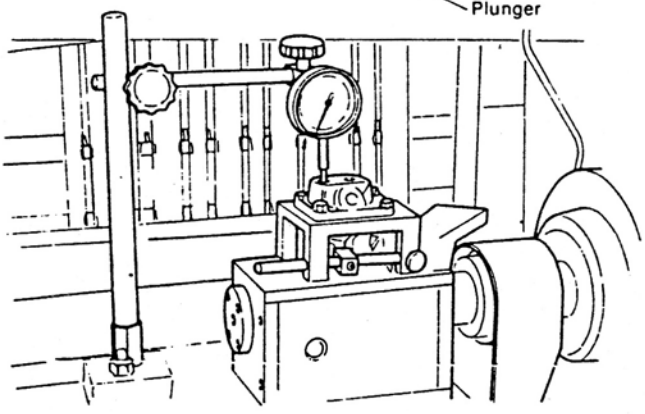
(1) Set the pump installation dimension (flange of the pump body when the roller is on the cam base cycle) at 69 ±0.05 mm (2.7146 - 2.7185 in.), remove the delivery valve holder and delivery valve, and set the plunger to top dead center by turning the camshaft. Measure the difference in height (head gap) between the end of the plunger and the end of the plunger barrel using a dial gauge.

mm (in.)

Plunger top clearance	1.0 ±0.05 (0.0374 ~ 0.0398)

(2) Using the plunger top clearance measuring jig
1) Install a dial gauge on the measuring jig.
2) Stand the measuring jig on a stool and set the dial gauge pointer to O.
3) Remove the pump delivery valve and install the measuring jig.
4) Turn the camshaft to set the plunger to top dead center and read the dial gauge [cam lift 7 mm (0.27559 in.)]. The value given is the plunger top clearance.





(3) When the plunger top clearance is larger than the prescribed value, remove the plunger guide and insert plunger shims between the plunger spring lower retainer and the plunger guide. Adjust each pump in the same manner.

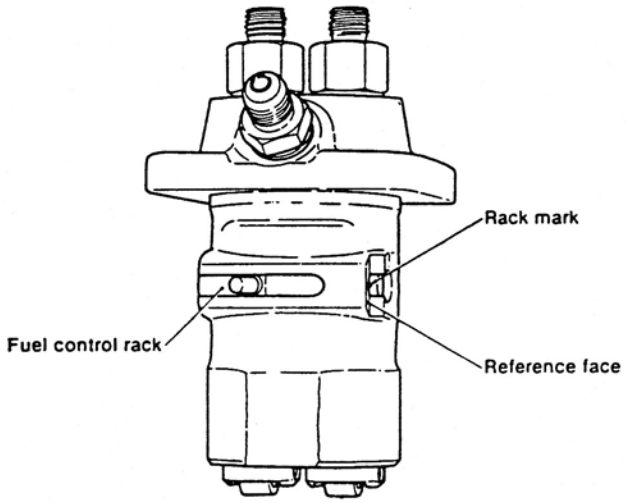
Plunger shim thickness	0.1mm (0.004in.)	119620-51250
	0.2mm (0.008in.)	
	0.3mm (0.012in.)	

(4) After rechecking adjustment, install the delivery valve.

Delivery valve holder tightening torque	4.0 ~ 4.5 kg-m (29 ~ 32.6 lb-ft)

4-8.4 Checking the cylinder injection interval

(1) Align the control rack punch mark with the pump reference face.



(2) Turn the pump by hand to check the No.1 cylinder injection timing.
(3) Turn the pump in the prescribed direction and check the No.2/3 cylinder injection timing.
(4) Using the plunger shims, adjust each cylinder injection timing interval.

	For crankshaft angle	For camshaft angle
3TN66E, 3TNA72E	240° 240° 240° 1 ~ 3 ~ 2 ~ 1	120° 120° 120° 1 ~ 3 ~ 2 ~ 1

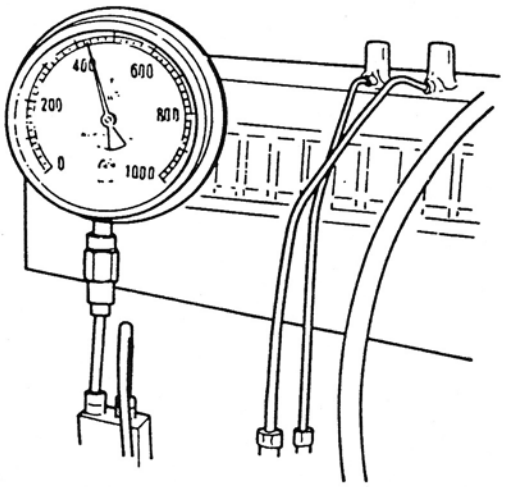
4-8.5 Delivery valve oil-tight test

(1) Install a 1,000 kg/cm² (14,223 lb/in.²) pressure gauge on the delivery valve holder.
(2) Drive the fuel pump to apply a pressure of approximately 120 kg/cm² (1,707 lb/in.²) and measure the time required for the pressure to drop from 100 kg/cm² (1,422 lb/in²) to 90 kg/cm² (1280 lb/in.²)

Pump speed	200 rpm
Pressure drop standard	20 sec. or more
Pressure drop limit	5 sec. or less

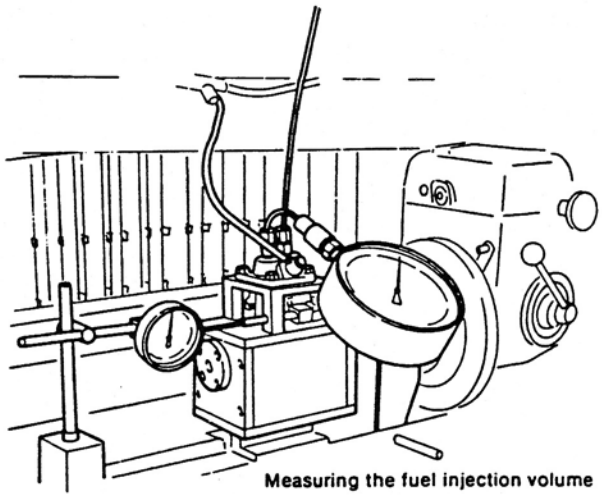
(3) If both the plunger and the delivery valve fail the test, replace them.

4-8.6 Plunger pressure test

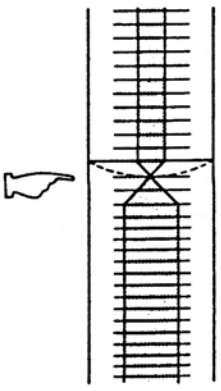


(1) Install a 1,000 kg/cm² (14,223 lb/in.²) pressure gauge on the delivery valve holder.
(2) Check that there is no oil leaking from the delivery valve holder and high pressure pipe mountings, and that the pressure does not drop suddenly when raised to 500 kg/cm² (7,112 lb/in.²) or higher.
Pressure gauge AVT 1/2 × 150 × 1,000 kg/cm²

4-8.7 Measuring the fuel injection volume



Measuring the fuel injection volume



(1) Set the fuel pump camshaft speed.
(2) Check the injection nozzle.

Pump speed	*See separate service data (Page 3-62, 63)*
Plunger diameter × stroke	
Injection nozzle type	
Pressure for fuel injection	
Amount of injection at rack mark position	
Allowable error between cylinders	
Stroke	

NOTE: Maintain the pressure for feeding oil to the injection pump at 0.5 kg/cm² (7.1 lb/in.²).

4-3.8 Adjustment of injection volume for each cylinder

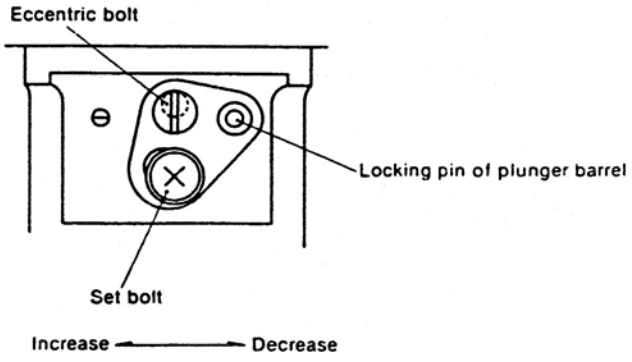
(1) Fluctuation of injection volume
The injection volumes of each cylinder must be adjusted to within 3% of each other.

$$\text{Average injection volume} = \frac{\text{total volume of all cylinder injection}}{\text{number of cylinders}}$$

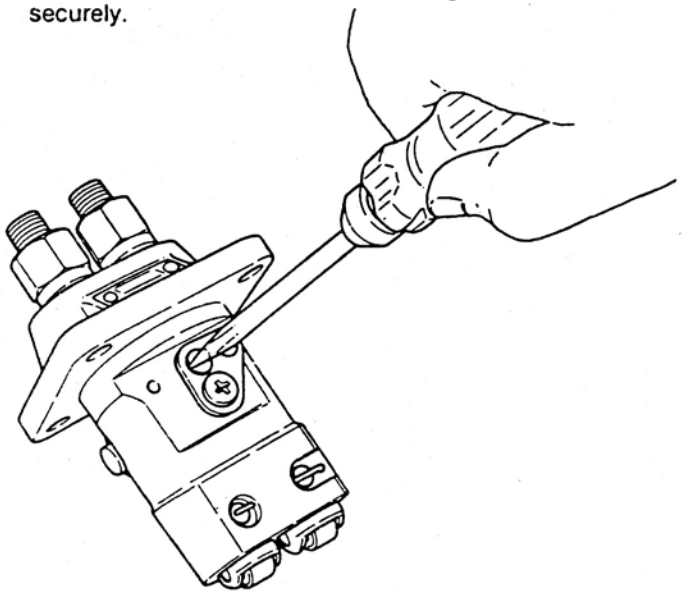
$$\text{Difference} = \frac{\text{Maximum injection volume} - \text{average injection volume}}{\text{Average injection volume}} \times 100$$

When the difference exceeds 3%, adjust the injection volume by sliding the control sleeve and pinion, when the difference exceeds 3%, the engine output will drop and/or one cylinder will overheat.

(2) Adjustment of injection volume
In order to adjust the fluctuation of injection volume for each cylinder, alter the position of the injection volume adjusting plate at the side of the fuel injection of pump body.
The injection volume adjusting plate is operated by the eccentric bolt which is integrated with the locking pin of the plunger barrel and changes the position of the plunger barrel. When the plunger barrel is turned, the relative position of the suction hole with respect to the lower lead of the plunger, changes the injection volume.

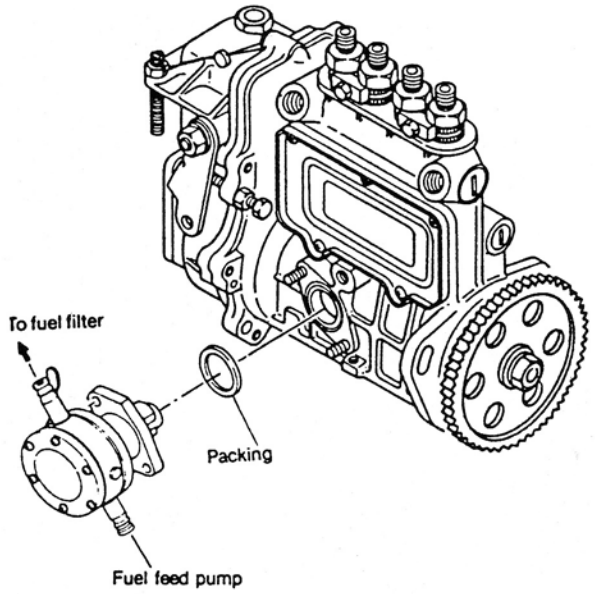


By loosening the set bolt and turning the eccentric bolt clockwise, the position of the pin moves to the leftside to increase the injection volume, and by turning the eccentric bolt counterclockwise, the pin moves to the rightside to decrease the injection volume.
After adjusting the injection volume, tighten the set bolt securely.



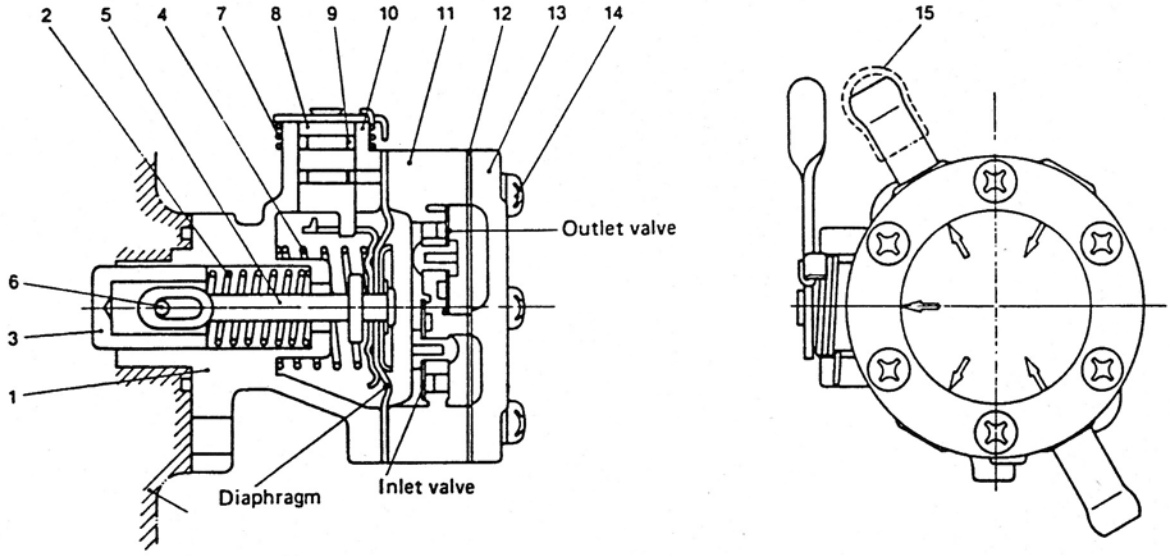
5. Fuel Feed Pump

The fuel feed pump pumps fuel from the fuel tank, passes it through the fuel filter element, and supplies it to the fuel injection pump.
The fuel feed pump is mounted on the side of the engine. and is driven by the (eccentric) cam of the fuel pump camshaft. It is provided with a manual priming lever so that fuel can be supplied when the engine is stopped.



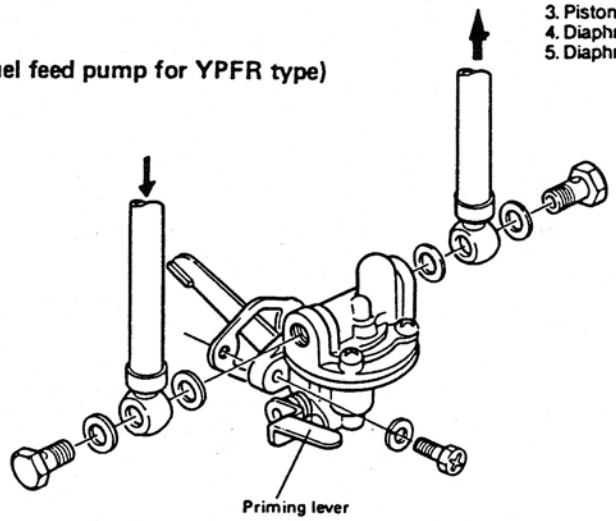
5-1 Construction of fuel feed pump

(Fuel feed pump for YPES type)



1. Bottom body
2. Piston spring
3. Piston
4. Diaphragm spring
5. Diaphragm assembly
6. Pin
7. Lever return spring
8. Lever assembly
9. O-ring
10. Stop pin
11. Top body assembly
12. Packing
13. Cover
14. Small screw
15. Cap

(Fuel feed pump for YPFR type)



5-2 Fuel feed pump specifications (YPES)

Suction head	0.8 m (2.57 ft)
Discharge volume	230 cc/min (14.03 in.³/min) at 1500 cam rpm, discharge pressure of 0.2 kg/cm² (2.84 lb/in.²)
Closed off pressure	0.3 kg/cm² (4.26 lb/in.²) or more (at 400 cam rpm)

(YPFR)

Feed pressure	0.1 kgf/cm² (0.1 Bar/1.4 psi)
Discharge volume	300 cc/min at 1000 rpm
Suction head	0.5 m (1.6 ft)

5-3 Disassembly and reassembly of fuel feed pump

5-3.1 Disassembly

(1) Remove the fuel feed pump mounting nut, and take the fuel feed pump off the fuel injection pump.
(2) Clean the fuel feed pump assembly with fuel oil.
(3) After checking the orientation of the arrow on the cover, make match marks on the upper body and cover, remove the small screw, and disassemble the cover, upper body and lower body.

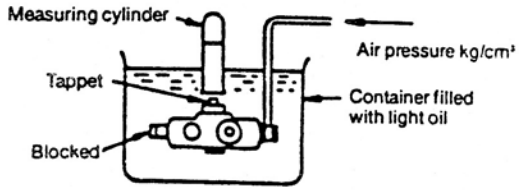
5-3.2 Reassembly

(1) Clean all parts with fuel oil, inspect, and replace any defective parts.
(2) Replace any packings on parts that have been disassembled.
(3) Make sure that the intake valve and discharge valve on upper body are mounted in the proper direction, and that you don't forget the valve packing.
(4) Assemble the diaphragm into the body, making sure the diaphragm mounting holes are lined up (do not force).
(5) Align the match marks on the upper body of the pump and cover, and tighten the small screws evenly.

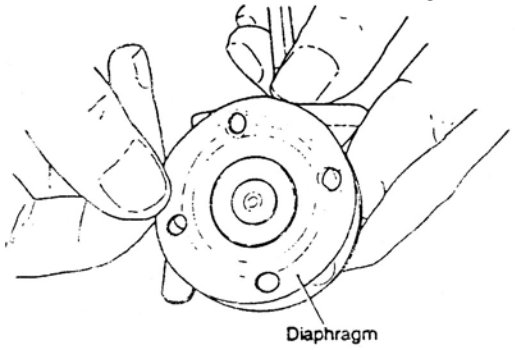
	kg-cm (ft-lb)
Tightening torque	15 ~ 25 (1.08 ~ 1.80)

5-4 Fuel feed pump inspection

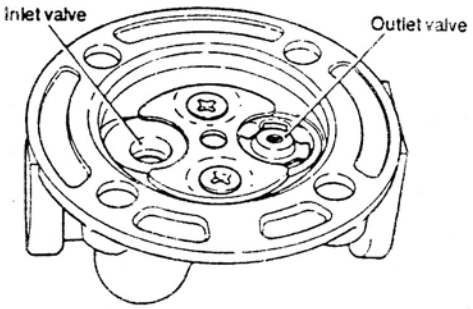
(1) Place the fuel feed pump in kerosene, cover the discharge port with your finger, move the priming lever and check for air bubbles (Repair or replace any part which emits air bubbles).



(2) Attach a vinyl hose to the fuel feed pump intake, keep the pump at the specified depth from the fuel oil surface, move the priming lever by hand and check for sudden spurts of fuel oil from the discharge port.
If oil does not spurt out, inspect the diaphragm and diaphragm spring and repair/replace as necessary.
(3) Diaphragm inspection
Parts of the diaphragm that are repeatedly burned will become thinner or deteriorate over a long period of time. Check diaphragm and replace if necessary.



(4) Valve contact/mounting
Clean the valve seat and valve with air to remove any foreign matter.



(5) Inspect the diaphragm spring and piston spring for settling and the piston for wear, and replace as necessary.

NOTE: Replace parts as an assembly.

6. Fuel Injection Nozzle

When fuel oil pumped by the fuel injection pump reaches the injection nozzle, it pushes up the nozzle valve (held down by spring), and is injected into the combustion chamber at high pressure.
The fuel is atomized by the nozzle to mix uniformly with the air in the combustion chamber. How well the fuel is mixed with high temperature air directly affects combustion efficiency, engine performance and fuel economy.
Accordingly, the fuel injection nozzles must be kept in top condition to maintain performance and operating efficiency.

6-1 Functioning of fuel injection nozzle

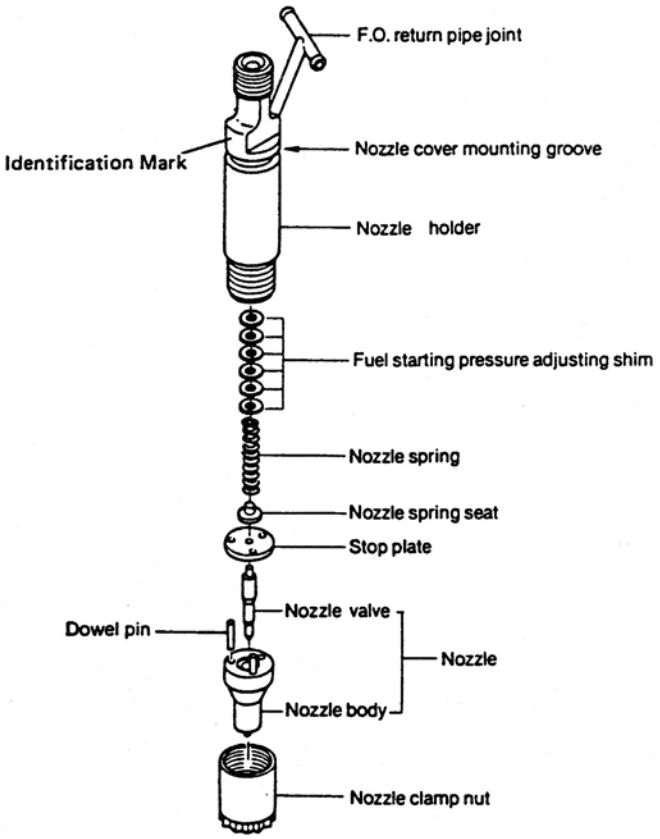
Fuel from the fuel injection pump passes through the oil port in the nozzle holder, and enters the nozzle body reservoir.
When oil reaches the specified pressure, it pushes up the nozzle valve (held by the nozzle spring), and is injected through the small hole on the tip of the nozzle body.
The nozzle valve is automatically pushed down by the nozzle spring and closed after fuel is injected.
Oil that leaks from between the nozzle valve and nozzle body goes from the hole on top of the nozzle spring through the oil leakage fitting and back into the fuel tank.
Adjustment of injection starting pressure is effected with the adjusting shims.

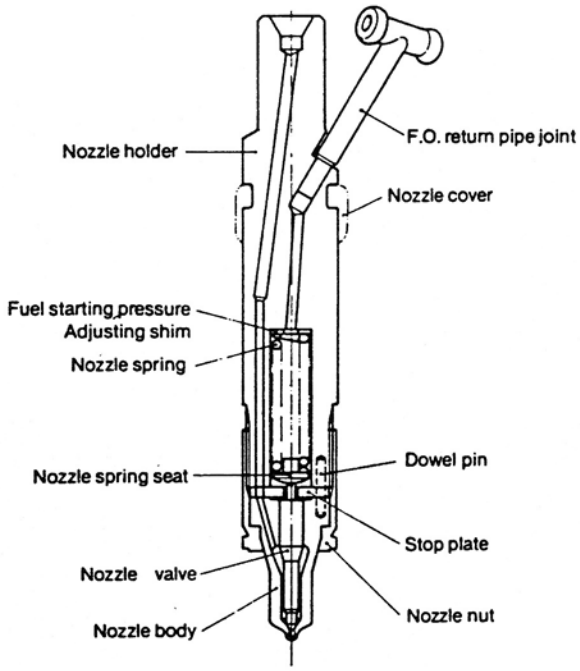
6-2 Type/construction of fuel injection nozzle

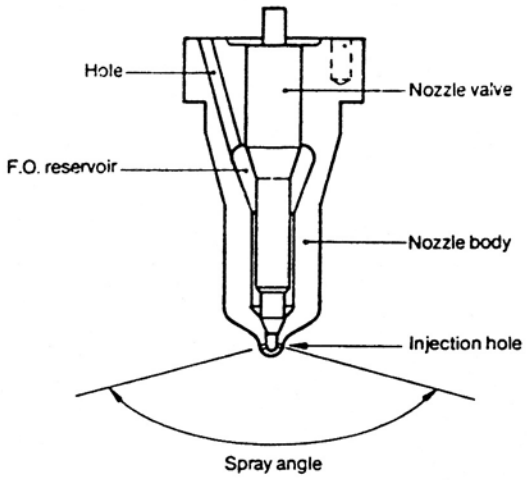
There are two types of fuel injection nozzles. Direct injection engines are equipped with the hole type, and indirect injection engines with the pintle type.

The YPES-CL fuel injection pump is designed for use with both direct and indirect injection engines. The hole type/ pintle type of fuel injection nozzles are used according to the engine type.
The type of fuel injection nozzle used depends on the type of engine.

(1) Hole type fuel injection nozzle

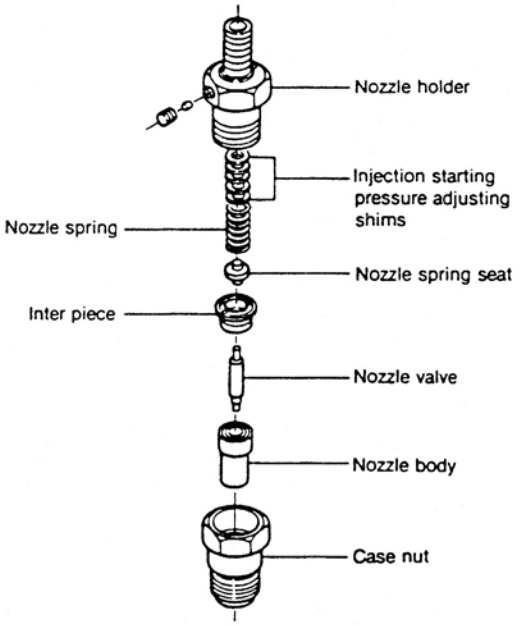


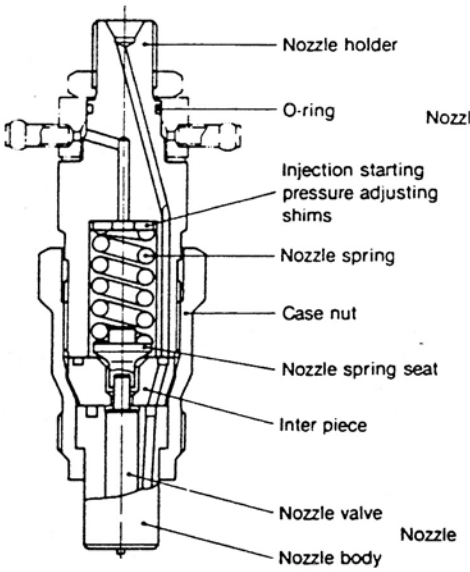


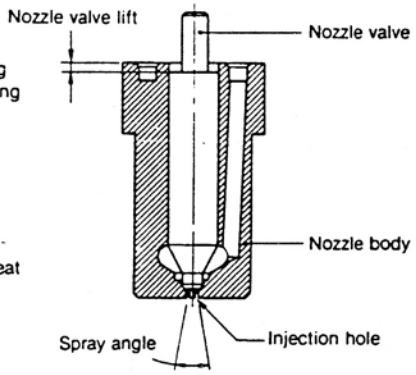


Nozzle opening pressure	*See separate service data (Page 3-62, 63)*
Nozzle angle	
No. of nozzles × dia.	
Identification No. (Nozzle type)	
Engine model	

(2) Pintle type fuel injection nozzle





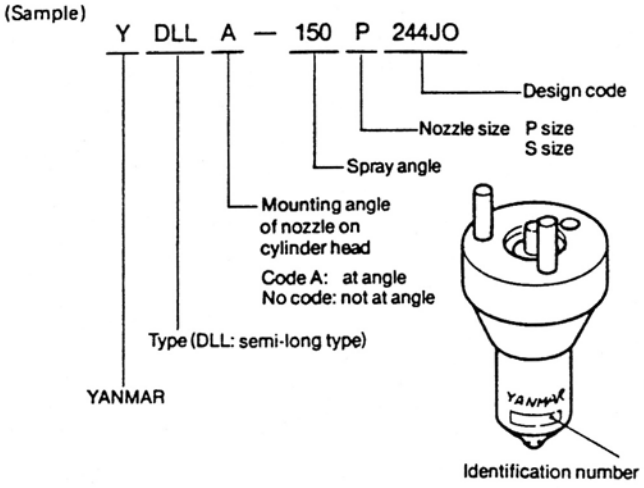


Nozzle type	YDN-PD
Nozzle opening pressure	120 kg/cm²
Identification No.	YDN-OPD2

(3) Nozzle body identification number
The type of nozzle can be determined from the number inscribed on the outside of the nozzle body.

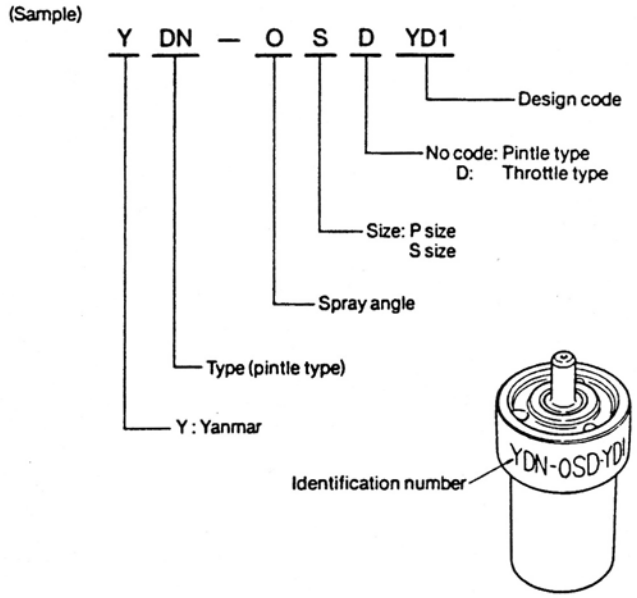
1) Hole type fuel injection nozzles

(Sample)



2) Pintle type fuel injection nozzles

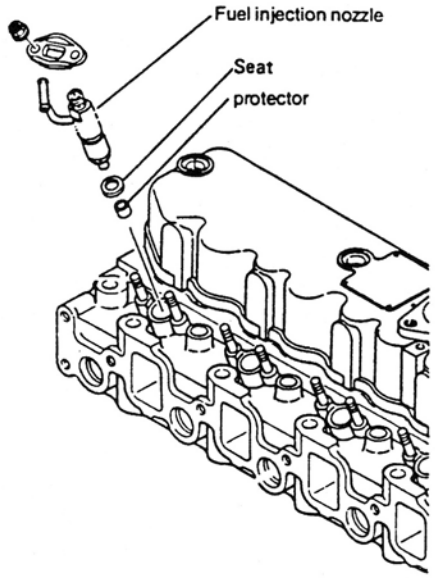
(Sample)



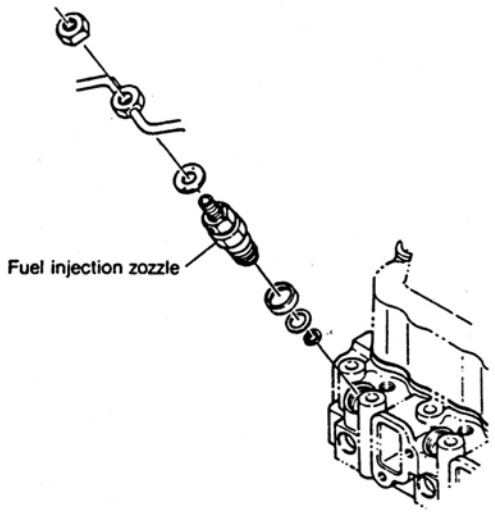
6-3 Fuel injection nozzle disassembly

NOTE: 1. Disassemble fuel injection nozzle in a clean area as for fuel injection pump.
2. When disassembling more than one fuel injection nozzle, keep the parts for each injection nozzle separate for each cylinder (i.e. the nozzle for cylinder 1 must be remounted in cylinder 1).

(1) When removing the injection nozzle from the cylinder head, remove the high pressure fuel pipe, fuel leakage pipe, etc., the injection nozzle retainer nut, and then the fuel injection nozzle.



Hole type

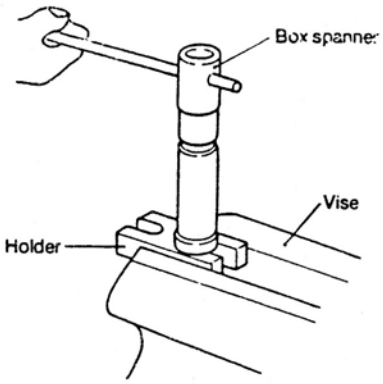


Throttle type

(2) Put the nozzle in a vise

NOTE: Use the special nozzle holder for the hole type injection nozzle so that the high pressure mounting threads are not damaged.

(3) Remove the nozzle nut



NOTE: Use a special box spanner for the hole type (the thickness of the two nozzle nuts is 15mm (0.5906in.)).

(4) Remove the inner parts

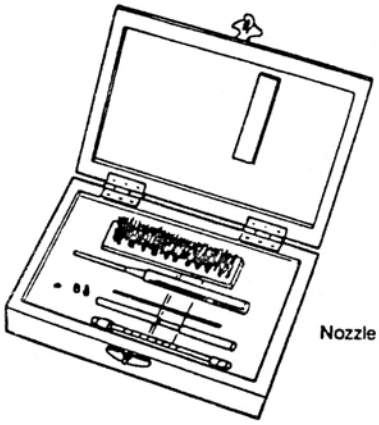
NOTE: Be careful not to loosen the spring seat, adjusting shims or other small parts.

6-4 Fuel injection nozzle inspection

6-4.1 Washing

(1) Make sure to use new diesel oil to wash the fuel injection nozzle parts.

(2) Wash the nozzle in clean diesel oil with the nozzle cleaning kit.

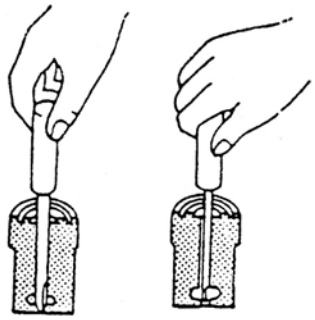


1) Diesel Kiki nozzle cleaning kit:
Type NP-8486B No. 5789-001

2) Anzen Jidosha Co., Ltd. nozzle cleaning kit:
Type NCK-001

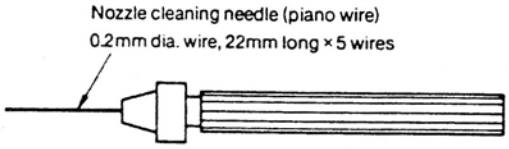
(3) Clean off the carbon on the outside of the nozzle body with a brass brush.

(4) Clean the nozzle seat with cleaning spray.



(5) Clean off the carbon on the tip of nozzle with a piece of wood.

(6) Clean hole type nozzles with a nozzle cleaning needle.



Part code no.	28210-000010

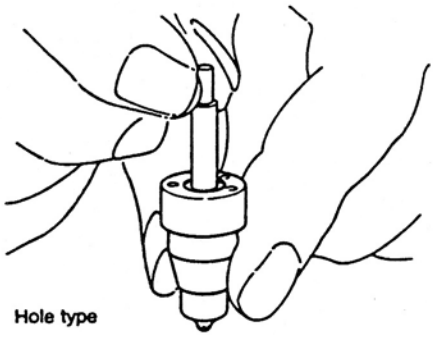
(7) Clean pintle type nozzles with a cleaning needle.

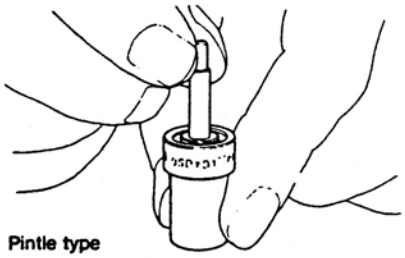
6-4.2 Nozzle inspection

(1) Inspect for scratches/wear
Inspect oil seals for abnormal scratches or wear and replace nozzle if the nozzle sliding surface or seat are scratched or abnormally worn.

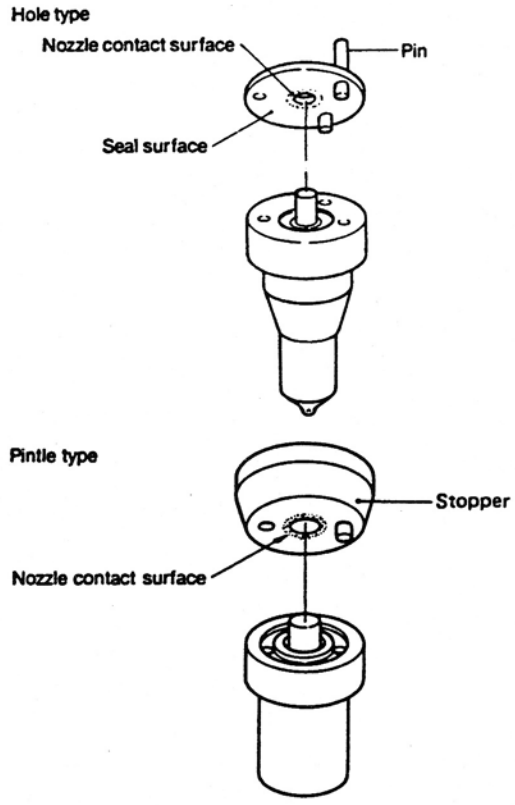
(2) Check nozzle sliding
Wash the nozzle and nozzle body in clean diesel oil, and make sure that when the nozzle is pulled out about half way from the body, it slides down by itself when released.

Rotate the nozzle a little; replace nozzle/nozzle body as a set if there are some places where it does not slide smoothly.





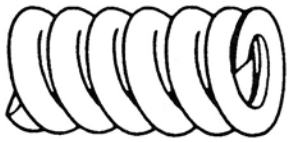
(3) Inspecting stopper
Check for scratches/wear in seals on both ends, check for abnormal wear on the surface where it comes in contact with the nozzle; replace if stop plate is excessively worn.



mm (in.)

Nozzle contact surface wear limit	0.1 (0.0039)

(4) Inspecting nozzle spring
Replace the nozzle spring if it is extremely bent, or the surface is scratched or rusted.



(5) Nozzle holder
Check oil seal surface for scratches/wear; replace if wear is excessive.

6-5 Fuel injection nozzle reassembly

The fuel injection nozzle is reassembled in the opposite order to disassembly.

(1) Insert the adjusting shims, nozzle spring and nozzle spring seat in the nozzle holder, mount the stop plate with the pin, insert the nozzle body/nozzle set and tighten the nut.

(2) Use the special holder when tightening the nut for the hole type nozzle as in disassembly.

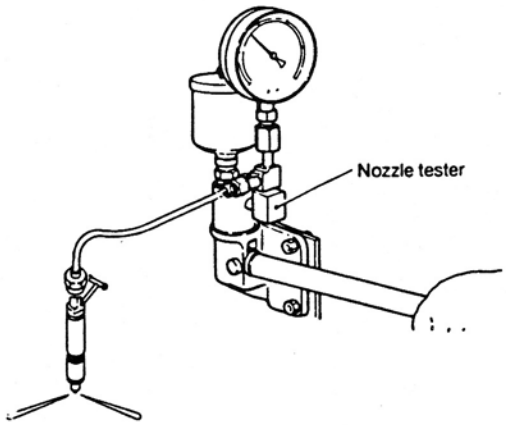
Nozzle nut tightening torque — kg-m (ft-lb)

Hole type nozzle	4 ~ 4.5 (28.9 ~ 32.5)
Pintle type nozzle	4 – 4.5 (28.9 – 32.5)

6-6 Adjusting fuel injection nozzle

6-6.1 Adjusting opening pressure

Mount the fuel injection nozzle on the nozzle tester and use the handle to measure injection starting pressure. If it is not at specified pressure, use the adjusting shims to increase/decrease pressure (both hole and pintle types).



Injection starting pressure

kg/cm² (lb/in.²)

Hole type	195 ~ 205 (2773 ~ 2915)
Pintle type	115 - 125 (1635 - 1778)

6-6. 2 Injection test

After adjusting the nozzle to the specified starting pressure, check the fuel spray condition and seat oil tightness.

(1) Check seat oil tightness

After two or three injections, gradually increase the pressure up to 20 kg/cm² (284 lb/in.²) before reading the starting pressure, maintain the pressure for 5 seconds, and make sure that no oil is dripping from the tip of the nozzle.

Test the injection with a nozzle tester; retighten and test again if there is excessive oil leakage from the overflow coupling.

Replace the nozzle as a set if oil leakage is still excessive.

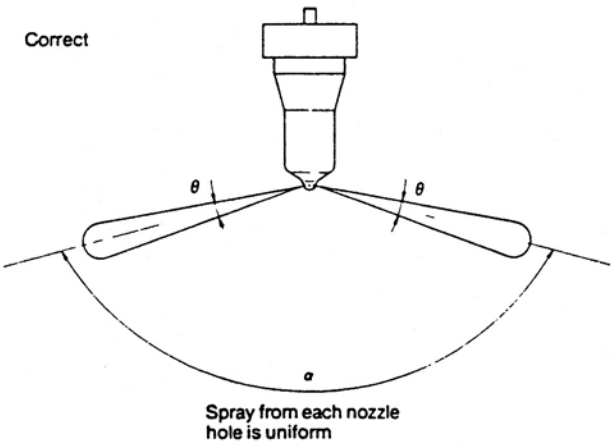
(2) Injection spray condition

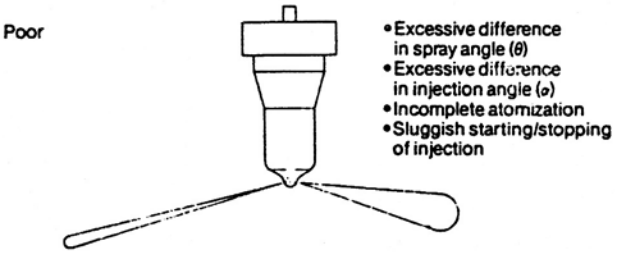
Operate the nozzle tester lever once or twice a second and check for abnormal injection.

1) Hole type nozzles

Replace hole type nozzles that do not satisfy the following conditions:

- Proper spray angle (θ)
- Correct injection angle (α)
- Complete atomization of fuel
- Prompt starting/stopping of injection





2) Pintle nozzle

Slowly operate nozzle tester and observe spray condition.

(1) The injection should not come in a stream or be off-center.

(2) A straight conical spray pattern should form along the center line of the nozzle. The cone angle should be 5—10 degrees.

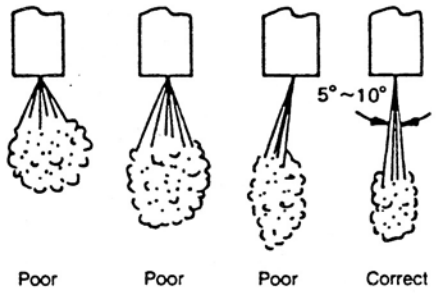
(3) Place a sheet of white paper 30cm below the nozzle. The injection spray should form a perfect circle.

(4) No oil should drip from the nozzle after injection.

(5) Oil should not spread from the injection hole when pressure is brought to a little less than 10 kg/cm².

(6) Test the injection with a nozzle tester; retighten and test again if there is excessive oil leakage from the Overflow coupling.

Replace the nozzle as a set if oil leakage is still excessive.



7. Troubleshooting

1. Troubleshooting of fuel injection pump

Complete repair means not only replacing defective parts, but finding and eliminating the cause of the trouble as well. The cause of the trouble may not necessarily be in the pump itself, but may be in the engine or the fuel system. If the pump is removed prematurely, the true cause of the trouble may never be known. Before removing the pump from the engine, at least go through the basic check points given here.

Basic check points

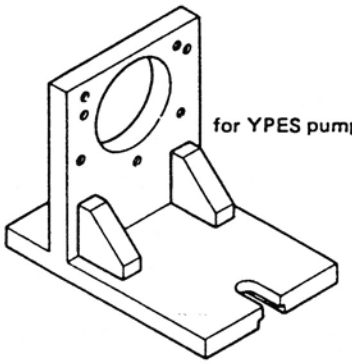
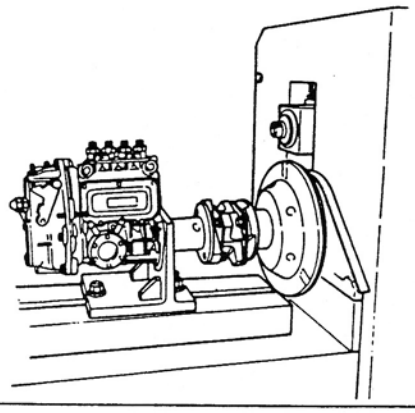
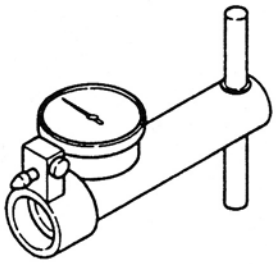
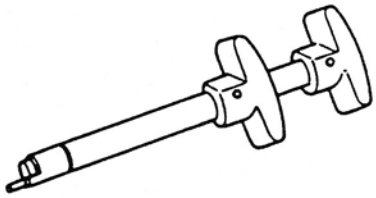
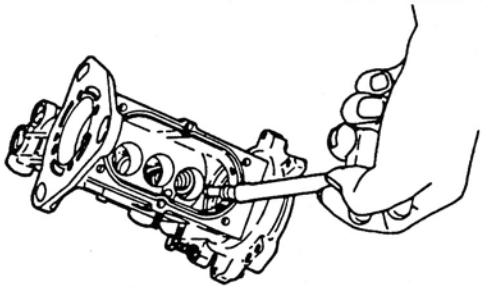
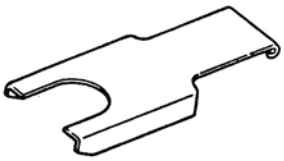
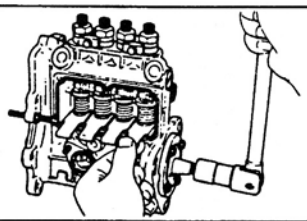
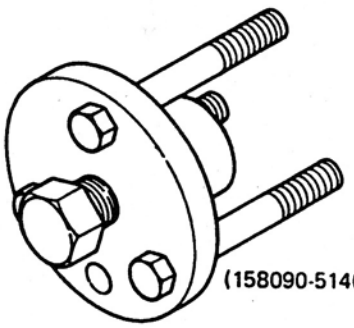
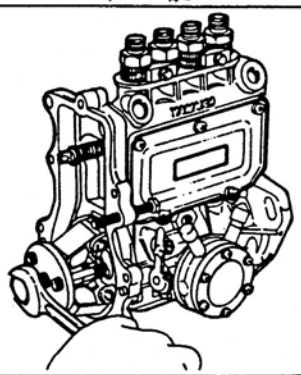
- Check for breaks or oil leaks throughout the fuel system, from the fuel tank to the nozzle.
- Check the injection timings for all cylinders. Are they correctly adjusted? Are they too fast or too slow?
- Check the nozzle spray.
- Check the fuel delivery. Is it in good condition? Loosen the fuel pipe connection at the injection pump inlet, and test operate the fuel feed pump.

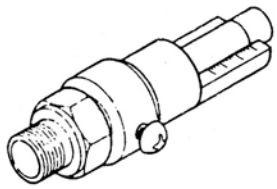
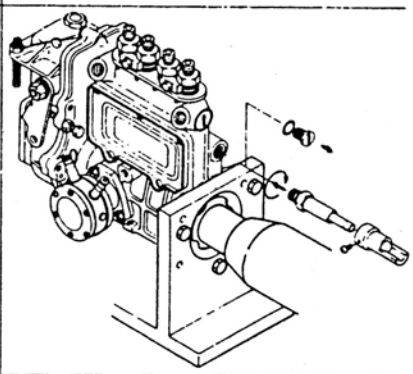
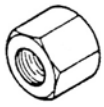
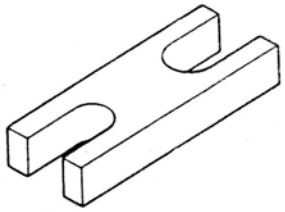
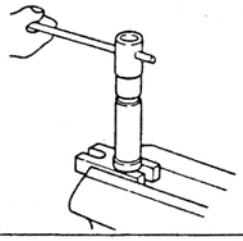
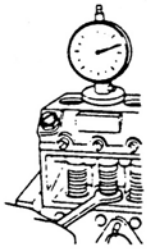
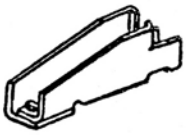
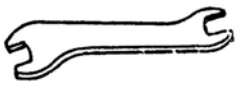
2. Major faults and troubleshooting

Fault		Cause	Remedy
1. Engine won't start.	Fuel not delivered to injection pump.	(1) No fuel in the fuel tank.	Resupply
		(2) Fuel tank cock is closed.	Open
		(3) Fuel pipe system is clogged.	Clean
		(4) Fuel filter element is clogged.	Disassemble and clean, or replace element
		(5) Air is sucked into the fuel due to defective connections in the piping from the fuel tank to the fuel pump.	Repair
		(6) Defective valve contact of feed pump	Repair or replace.
		(7) Piston spring of feed pump is broken.	Replace
		(8) Inter-spindle or tappets of feed pump are stuck.	Repair or replace
	Fuel delivered to injection pump.	(1) Defective connection of control lever and accel. rod of injection pump.	Repair or adjust
		(2) Plunger is worn out or stuck.	Repair or replace
		(3) Delivery valve is stuck.	Repair or replace
		(4) Control rack doesn't move.	Repair or replace
		(5) Injection pump coupling is damaged, or the key is broken.	Replace
	Nozzle doesn't work.	(1) Nozzle valve doesn't open or close normally.	Repair or replace
		(2) Nozzle seat is defective.	Repair or replace
		(3) Case nut is loose.	Inspect and tighten
		(4) Injection nozzle starting pressure is too low.	Adjust
		(5) Nozzle spring is broken.	Replace
		(6) Fuel oil filter is clogged.	Repair or replace
		(7) Excessive oil leaks from the nozzle sliding area.	Replace the nozzle assembly
	Injection timing is defective.	(1) Injection timing is retarded due to failure of the coupling.	Adjust
		(2) Camshaft is excessively worn.	Replace camshaft
		(3) Roller guide incorrectly adjusted or excessively worn.	Adjust or replace
		(4) Plunger is excessively worn.	Replace plunger assembly
2. Engine starts, but immediately stops.		(1) Fuel pipe is clogged.	Clean
		(2) Fuel filter is clogged.	Disassemble and clean, or replace the element.
		(3) Improper air-tightness of the fuel pipe connection, or pipe is broken and air is being sucked in.	Replace packing; repair pipe
		(4) Insufficient fuel delivery from the feed pump.	Repair or replace

Fault		Cause	Remedy
3. Engine's output is insufficient.	Defective injection timing, and other failures.	(1) Knocking sounds caused by improper (too fast) injection timing.	Inspect and adjust
		(2) Engine overheats or emits large amount of smoke due to improper (too slow) injection timing.	Inspect and adjust
		(3) Insufficient fuel delivery from feed pump.	Repair or replace
	Nozzle movement is defective	(1) Case nut is loose	Inspect and retighten
		(2) Defective injection nozzle performance.	Repair or replace nozzle
		(3) Nozzle spring is broken.	Replace
		(4) Excessive oil leaks from nozzle.	Replace nozzle assembly
	Injection pump is defective.	(1) Max. delivery limit bolt is screwed in too far.	Adjust
		(2) Plunger is worn.	Replace
		(3) Injection amount is not uniform.	Adjust
		(4) Injection timings are not even.	Adjust
		(5) The 1st and 2nd levers of the governor and the control rack of the injection pump are improperly lined up.	Repair
		(6) Delivery stopper is loose.	Inspect and retighten
		(7) Delivery packing is defective.	Replace packing
		(8) Delivery valve seat is defective.	Repair or replace
		(9) Delivery spring is broken.	Replace
4. Idling is rough.		(1) Movement of control rack is defective.	
		1) Stiff plunger movement or sticking.	Repair or replace
		2) Rack and pinion fitting is defective.	Repair
		3) Movement of governor is improper.	Repair
		4) Delivery stopper is too tight.	Inspect and adjust
		(2) Uneven injection volume.	Adjust
		(3) Injection timing is defective.	Adjust
		(4) Plunger is worn and fuel injection adjustment is difficult.	Replace
		(5) Governor spring is too weak.	Replace
		(6) Feed pump can't feed oil at low speeds.	Repair or replace
		(7) Fuel supply is insufficient at low speeds due to clogging of fuel filter.	Disassemble and clean, or replace element
5. Engine runs at high speeds, but cuts out at low speeds.		(1) The wire or rod of the accelerator is caught.	Inspect and repair
		(2) Control rack is caught and can't be moved.	Inspect and repair
6. Engine doesn't reach max. rpm.		(1) Governor spring is broken or excessively worn.	Replace
		(2) Injection performance of nozzle is poor.	Repair or replace
7. Loud knocking.		(1) Injection timing is too fast or too slow.	Adjust
		(2) Injection from nozzle is improper. Fuel drips after each injection.	Adjust
		(3) Injection nozzle starting pressure is too high.	Adjust
		(4) Uneven injection.	Adjust
		(5) Engine overheats, or insufficient compression.	Repair
8. Engine emits too much smoke.	When exhaust smoke is black:	(1) Injection timing is too fast.	Adjust
		(2) Air volume intake is insufficient.	Inspect and repair
		(3) The amount of injection is uneven.	Adjust
		(4) Injection from nozzle is improper.	Repair or replace
	When exhaust smoke is white:	(1) Injection timing is too slow.	Adjust
		(2) Water is mixed in fuel.	Inspect fuel system, and clean
		(3) Shortage of lube oil in the engine.	Repair
		(4) Engine is over-cooled.	Inspect

8. Tools

Name of tool	Shape and size	Application
Pump mounting scale (YPES) for Yanmar tester 158090-51010 for Bosch (tester) 158090-51020 (YPFR) 121120-51280		
Measuring device (cam backlash) 158090-51050		
Plunger insert 158090-51100		
Tappet holder 158090-51200		
Weight extractor 158090-51400 for 3 pcs. governor weight 158090-51450 for 4 pcs. governor weight		

Name of tool	Shape and size	Application
Rack indicator 158090-51500		
Rack lock screw 158090-51510		
Dummy nut 158090-51520		
Nozzle plate 158090-51700		
Plunger gauge 121820-92540		
Top clearance gauge 158090-51300		
P & B extractor 158090-51150		
Wrench 12 158090-51350		

9. Fuel Filter

The fuel filter, which is located between the fuel feed pump and the fuel injection pump, removes any impurities from the fuel. It has a replaceable paper type element to ensure consistent fuel filtration.
The sucking action of the fuel injection pump draws fuel from the fuel tank and into the filter element to remove dirt particles. Clean fuel flows to the interior of the filter element, up through the central passage, into the outlet passage, and to the fuel injection pump.

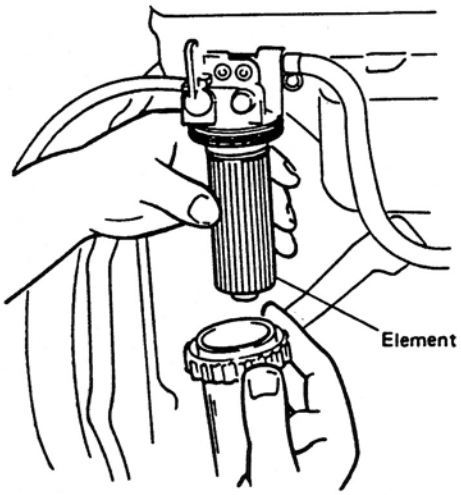
Inspection

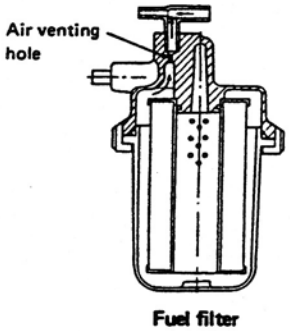
Check and completely clean the fuel filter with clean fuel oil if it is contaminated with deposits, water, etc. The filter element should be replaced every 500 service hours, or sooner if it is stained or broken. If the fuel appears to be contaminated, check the filter carefully and replace it even if the maximum number of service hours has not been reached.

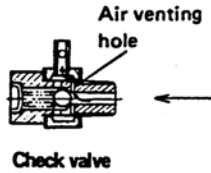
Cleaning the inside filter	Every 300 service hours	100 hours (First time)
Replacing of filter element	Every 500 hours	

Specifications

Applicable model	2,3TN66E 3TNA72E	3TN75E, 3TNC78E 3,4TN82(84)(T)E
Type	Paper	←
Filtration area	432 cm^2 (67 in^2)	3TN75E, 3TNC78E 432 cm^2 (67 in^2) 3,4TN82(84)(T)E 900 cm^2 (139.5 in^2)
Filtration grain dia.	10 – 15μ	8 – 9μ
Air venting method	plug	Auto-air venting
Element code	124550-55700	3TN75E, 3TNC78E 119810-55650 3,4TN82(84)(T)E 129100-55650



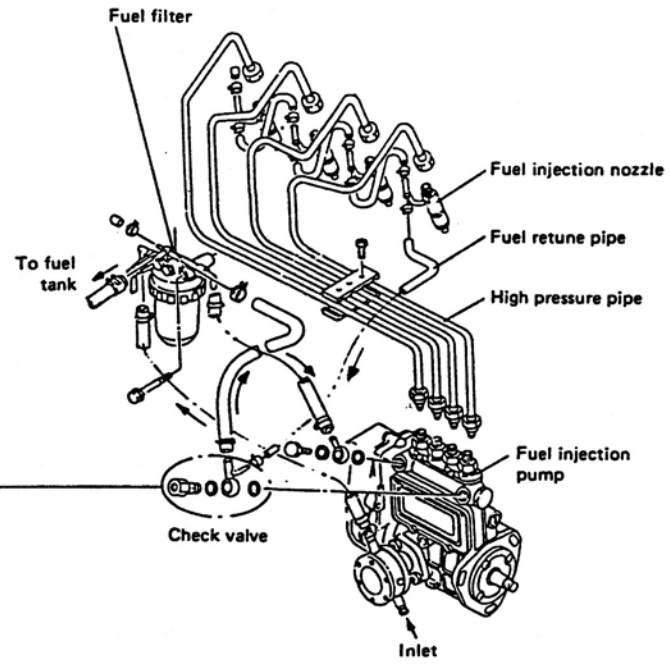




10. Air Venting System

[DI engine]

The DI engine is equipped with an automatic air venting system. The check valve attached between the fuel filter and the fuel injection pump has an air venting hole. The air accumulated in the fuel line when fuel is fed by the fuel feed pump is vented through the air venting hole out of the fuel line. For the IDI engine, air is vented with an air venting plug.



11. Service Data

Model					2TN66E		3TN66E		3TNA72E		3TN75E		
					VM	CH	S	G2	S	G2	S	G1	G2
Fuel injection equipment assembly (1)+(2)+(3) code number				–			719225-51100		719621-51100		719810-51370 T664	719810-51300 T655	719888-51410 T666
(1)	Fuel injection pump	Assembly code number					719225-51700	719225-51700	719621-51700	719621-51700	–	–	–
		Plunger barrel assembly	Plunger diameter	mm	ϕ5	ϕ5	ϕ5	ϕ5	ϕ6	ϕ6	ϕ7	ϕ7	ϕ7
			Lead angle	deg	45° lower lead (left)	45° lower lead (left)	45° lower lead (left)	45° lower lead (left)	30° lower lead (left)	30° lower lead (left)	37° lower lead (right)	37° lower lead (right)	40° lower lead (right)
		Delivery valve assembly	Suck back volume: Qr	mm^3/st	16.2	16.2	16.2	16.2	23.5	23.5	23.6	23.6	23.6
			Angleich cut	mm	–	–	–	–	–	–	0.1	0.1	0.1
			Identification								GM	GM	GM
(2)	Governor	Governor spring	Spring constant	kg/mm	0.463		0.463		0.463	0.463	0.281	0.136	0.350
			Free length	mm	37		37		37	37	41	39	38.5
		Tension lever (length between the supporting points)			Type A	Type A	Type A	Type A	Type A	Type A	Type B (R=67)	Type B (R=73)	Type B (R=73)
		Torque rise device	Type		Angleich Torque spring	←	Angleich Torque spring	←	Angleich Torque spring	←	Angleich Torque spring	–	–
		Engine stop device			Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A + C
(3)	Fuel feed pump	Type			Diaphragm	Diaphragm	Diaphragm	Diaphragm	Diaphragm	Diaphragm	Diaphragm type	Diaphragm type	Diaphragm type

Model					3TNC78E			3TN82E			3TN82TE	
					VM	CL	CH	S	G1	G2	S	G1
Fuel injection equipment assembly (1)+(2)+(3) code number				–				729102-51370 T775	729102-51300 T766	729188-51410 T778		
(1)	Fuel injection pump	Assembly code number		–	–			–	–	–	–	–
		Plunger barrel assembly	Plunger diameter	mm	ϕ7.5			ϕ7.5	ϕ7.5	ϕ7.5	ϕ8	ϕ8
			Lead angle	deg	35° lower lead (right)			35° lower lead (right)	35° lower lead (right)	37° lower lead (right)	30° lower lead (right)	30° lower lead (right)
		Delivery valve assembly	Suck back volume: Qr	mm^3/st	23.6			23.6	23.6	23.6	23.6	23.6
			Angleich cut	mm	0.1			0.1	0.1	0.1	0.13	0.13
			Identification		GM			GM	GM	GM	H	H
(2)	Governor	Governor spring	Spring constant	kg/mm	0.253			0.281	0.136	0.351	0.281	0.136
			Free length	mm	40			41	39	38.5	41	39
		Tension lever (length between the supporting points)			Type B			Type B (R=67)	Type B (R=73)	Type B (R=73)	Type B	Type B
		Torque rise device	Type		Torque spring			Torque spring	–	–	Torque spring	–
		Engine stop device			Type A			Type A	Type A	Type A + C	Type A	Type A
(3)	Fuel feed pump	Type			←			Diaphragm type	Diaphragm type	Diaphragm type	←	←

Model					4TN82E			4TN82TE		3TN84E		
					S	G1	G2	S	G1	VM	CL	CH
Fuel injection equipment assembly (1)+(2)+(3) code number				–	729402-51370 T830	729402-51300 T811	729188-51410 T834	729488-51370 T839	729404-51300 T819			
(1)	Fuel injection pump	Assembly code number		–	–	–	–	–	–	–	–	–
		Plunger barrel assembly	Plunger diameter	mm	ϕ7.5	ϕ7.5	ϕ7.5	ϕ8	ϕ8	ϕ7.5	ϕ7.5	ϕ7.5
			Lead angle	deg.	35° lower lead (right)	35° lower lead (right)	37° lower lead (right)	30° lower lead (right)	30° lower lead (right)	35° lower lead (right)	35° lower lead (right)	37° lower lead (right)
		Delivery valve assembly	Suck back volume: Qr	mm^3/st	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6
			Angleich cut	mm	0.1	0.1	0.1	0.13	0.13	0.1	0.1	0.1
			Identification		GM	GM	GM	H	H	GM	GM	GM
(2)	Governor	Governor spring	Spring constant	kg/mm	0.281	0.136	0.350	0.281	0.136	0.253	0.136	0.351
			Free length	mm	41	39	38.5	41	39	40	39	38.5
		Tension lever (length between the supporting points)			Type B (R=67)	Type B (R=73)	Type B (R=73)	Type B (R=67)	Type B (R=73)	Type B (R=67)	Type B (R=73)	Type B (R=73)
		Torque rise device	Type		Torque spring	–	–	Torque spring	–	Torque spring	–	–
		Engine stop device			Type A	Type A	Type A + C	Type A	Type A	Type A	Type A	Type A + C
(3)	Fuel feed pump	Type			Diaphragm type	Diaphragm type	Diaphragm type	Diaphragm type	Diaphragm type	Diaphragm type	Diaphragm type	Diaphragm type

Model					3TN84TE		4TN84E			4TN84TE	
					VM	CL	VM	CL	CH	VM	CL
Fuel injection equipment assembly (1)+(2)+(3) code number				–							
(1)	Fuel injection pump	Assembly code number			–	–	–	–	–	–	–
		Plunger barrel assembly	Plunger diameter	mm	φ8	φ8	φ7.5	φ7.5	φ7.5	φ8	φ8
			Lead angle	deg.	30° lower lead (right)	30° lower lead (right)	35° lower lead (right)	35° lower lead (right)	37° lower lead (right)	30° lower lead (right)	30° lower lead (right)
		Delivery valve assembly	Suck back volume: Qr	mm^3/st	23.6	23.6	23.6	23.6	23.6	23.6	23.6
			Angleich cut	mm	0.13	0.13	0.1	0.1	0.1	0.13	0.13
			Identification		H	H	GM	GM	GM	H	H
(2)	Governor	Governor spring	Spring constant	kg/mm	0.253	0.136	0.253	0.136	0.350	0.253	0.136
			Free length	mm	40	39	40	39	38.5	40	39
		Tension lever (length between the supporting points)			Type B	Type B	Type B (R=67)	Type B (R=73)	Type B (R=73)	Type B (R=67)	Type B (R=73)
		Torque rise device	Type		Torque spring	–	Torque spring	–	–	Torque spring	–
		Engine stop device			Type A	Type A	Type A	Type A	Type A + C	Type A	Type A
(3)	Fuel feed pump	Type			Diaphragm type	Diaphragm type	Diaphragm type	Diaphragm type	Diaphragm type	Diaphragm type	Diaphgram type

Model				2TN66E, 3TN66E-S 3TN66E-G2		3TNA72E-S 3TNA72E-G2		3TN75E-S 3TN75E-G1 3TN75E-G2	
Adjustment specification				Engine spec.	Calibration spec.	Engine spec.	Calibration spec.	Engine spec.	Calibration spec.
Nozzle type				YDN-OPD2	DN-12SD12	YDN-OPD2	DN-12SD12	(S) 150P214 HAO (G1) 150P184 HAO (G2) 150P214 HAO	DN-12SD12 DN-12SD12 DN-12SD12
Injection start pressure			kg/cm²	115 – 125	165 – 175	115 – 125	165 – 175	195 – 205	165 – 175
Fuel injection pipe D/d x L			mm	6/1.6 x 280 (2TN) 6/1.6 x 260 (3TN)	6/2 x 600	6/2 x 260	6/2 x 600	6/1.6 x 360	6/2 x 600
Top clearance (prestroke)			mm	0.95 – 1.05 (2.5)		0.95 – 1.05 (2.5)		0.95 – 1.05 (2.5)	
Rated load	Pump speed: N1		rpm	1612		1600		(S) 1500 (G1) 900, 750 (G2) 1800, 1500	(S) 1500, (G1) 900 (G2) 1800
	Rack position (indicator scale): R1		mm	Match mark		Match mark		(S) 7, (G1) 7, (G2) 6	
	Measuring stroke		st	1000		1000		1000	
	Injection volume: Q1		cc	12.8		18	15.8	(S) 17 (G1) 16.5 (G2) 16.5	(S) 24 (G1) 18.4 (G2) 19.6
	Variation			±0.3 cc		±0.3 cc		±3 %	
No load max. speed	Pump speed: N2		rpm	(VM) (S) < 1620 (CH) (G2) < 1575, < 1890		←		(S) < 1583 (G1) < 788, 935 (G2) < 1575, 1870	
	Rack position (indicator scale): R2		mm						
Idling or at R1-2 mm position	Pump speed: N3 or N1		rpm	(VM) (S) < 450 (CH) (G2) < 650	1612 (N1)	(S) < 450 (G2) < 650	1600 1600 (N1)	(S) < 400 (G1) < 600 (G2) < 750	(S) 400(N3) (G1) 900(N1) (G2) 1800(N1)
	Measuring stroke		st	1000		1000		1000	
	Injection volume: Q3		cc	–	–	–	–	–	–
	Variation at (R1-2mm) rack position (between cylinder)				⩽0.6 cc		⩽0.6 cc		⩽1.5 cc
Starting	Pump speed: N4		rpm					200	
	Rack position (indicator scale): R4		mm					11.5 – 12.5	
	Measuring stroke		st					1000	
	Injection volume: Q4		cc					(S)59.5 – 60.5 (G1)55 – 65 (G2)55 – 65	(S) 55.2 (G1)57.1 (G2)57.5
Torque rise	Angleich spring	Pump speed: N5	rpm					–	
		Screw-in angle: θ	deg					–	
		Measuring stroke	st					–	
		Injection volume: Q5	cc					–	–
	Torque spring	Pump speed: N5	rpm					(S) 1000	
		Torque rise stroke	mm					(S) 0.25	
		Measuring stroke	st					(S) 1000	
		Injection volume: Q5	cc					–	(S) 27

Model				3TNC78E		3TN82E-S 3TN82E-G1 3TN82E-G2		3TN82TE-S/3TN82TE-G1	
Adjustment specification				Engine spec.	Calibration spec.	Engine spec.	Calibration spec.	Engine spec.	Calibration spec.
Nozzle type				150P214 HAO	DN-12SD12	(S) 150P234 HAO (G1) 150P204 HAO (G2) 150P244 HCO	DN-12SD12 DN-12SD12 DN-12SD12	(S) 150P254 HBO (G1) 150P234 HAO	DN-12SD12 DN-12SD12
Injection start pressure			kg/cm²	195 – 205	165 – 175	195 – 205	165 – 175	195 – 205	165 – 175
Fuel injection pipe D/d x L			mm	6/1.6 x 360	6/2 x 600	6/1.6 x 360	6/2 x 600	(S) 6/1.6 x 400 (G1) 6/1.6 x 400	6/2 x 600 6/2 x 600
Top clearance (prestroke)			mm	0.95 – 1.05 (2.5)		0.95 – 1.05 (2.5)		0.95 – 1.05 (2.5)	
Rated load	Pump speed: N1		rpm	(S) 1500	(S) 1500	Equivalent to 3TN75E value	(S) 1500, (G1) 900 (G2) 1800	(S) 1500 (G1) 750, 900	(S) 1500, (G1) 900
	Rack position (indicator scale): R1		mm	7		(S) 7, (G1) 7, (G2) 6		(S) 7, (G1) 7	
	Measuring stroke		st	1000		1000		1000	
	Injection volume: Q1		cc			(S) 24 (G1) 23.5 (G2) 23.5	(S) 31.4 (G1) 29.7 (G2) 27.6	(S) 28.5 (G1) 28	(S) (G1)
	Variation			±3%		±3 %		±3%	
No load max. speed	Pump speed: N2		rpm	<1583		Equivalent to 3TN75E value		(S) < 1583 (G1) < 788, 935	
	Rack position (indicator scale): R2		mm						
Idling or at R1-2 mm position	Pump speed: N3 or N1		rpm	<400	400(N3)	Equivalent to 3TN75E value	(S) 400 (N3), (G1) 900 (N1) (G2) 1800 (N1)	(S) < 1583 (G1) < 788, 935	(S) 400 (N3) (G1) 900 (N1)
	Measuring stroke		st	1000		1000		1000	
	Injection volume: Q3		cc	–	–	–	–		
	Variation at R1-2 mm rack position (between cylinder)				<1,5cc		<1.5 cc		<1.5 cc
Starting	Pump speed : N4		rpm	200		200		200	
	Rack position (indicator scale): R4		mm	11.5 – 12.5		11.5 – 12.5		11.5 – 12.5	
	Measuring stroke		st	1000		1000		1000	
	Injection volume: Q4		cc	59.5 – 60.5	55.2	(S) 60–70 (G1)60–70 (G2)60–70	(S) 74 (G1)71.5 (G2)59.7	(S) 60–70 (G1) 60–70	(S) 74 (G1) 71.5
Torque rise	Angleich spring	Pump speed: N5	rpm	–		–		–	
		Screw-in angle: θ	deg	–		–		–	
		Measuring stroke	st	–		–		–	
		Injection volume: Q5	cc	–	–	–	–	–	–
	Torque spring	Pump speed: N5	rpm	1000		(S) 1000		(S) 1000	
		Torque rise stroke	mm	0.25		(S) 0.25		(S) 0.25	
		Measuring stroke	st	1000		(S) 1000		(S) 1000	
		Injection volume: Q5	cc	–	27	–	(S) 35.9	–	(S) 35.9

Model				4TN82E-S 4TN82E-G1 4TN82E-G2		4TN82TE-S 4TN82TE-G1	
Adjustment specification				Engine spec.	Calibration spec	Engine spec.	Calibration spec.
Nozzle type				(S) 150P234 HAO (G1) 150P204 HAO (G2) 150P224 HCO	DN-12SD12 DN-12SD12 DN-12SD12	(S) 150P254 HBO (G1) 150P234 HAO	DN-12SD12 DN-12SD12
Injection start pressure			kg/cm²	195 – 205	165 – 175	195 – 205	165 – 175
Fuel injection pipe D/d x L			mm	(S) 6/1.6 x 360 (G1)6/1.6 x 400 (G2)6/1.8 x 400	6/2 x 600 6/2 x 600 6/2 x 600	(S) 6/1.6 x 360 (G1)6/1.6 x 400	6/2 x 600 6/2 x 600
Top clearance (prestroke)			mm	0.95 – 1.05 (2.5)		0.95 – 1.05 (2.5)	
Rated load	Pump speed: N1		rpm	Equivalent to 3TN75E value	(S) 1500, (G1) 900, (G2) 1800	(S) 1500 (G1) 750, 900	(S) 1500, (G1) 900
	Rack position (indicator scale): R1		mm	(S) 7, (G1) 7, G2) 6		(S) 7, (G1) 7	
	Measuring stroke		st	1000		1000	
	Injection volume: Q1		cc	(S) 24 (G1) 23.5 (G2) 23.5	(S) 31.4 (G1) 29.7 (G2) 27.4	(S) – (G1) 29	(S) (G1)
	Variation			±3 %		±3 %	
No load max. speed	Pump speed: N2		rpm	←		(S) < 1583 (G1) < 788, 935	
	Rack position (indicator scale): R2		mm				
Idling or at R1-2 mm position	Pump speed: N3 or N1		rpm	←		(S) < 1583 (G1) < 788, 935	(S) 400 (N3) (G1) 900 (N1)
	Measuring stroke		st	1000		1000	
	Injection volume: Q3		cc	–	–		
	Variation at R1-2 mm rack position (between cylinder)				≤ 1.5 cc		≤ 1.5 cc
Starting	Pump speed : N4		rpm	200		200	
	Rack position (indicator scale): R4		mm	11.5 – 12.5		11.5 – 12.5	
	Measuring stroke		st	1000		1000	
	Injection volume: Q4		cc	(S) 60–70 (G1)60–70 (G2)60–70	(S) 74 (G1)71.5 (G2)59.7	(S) 60–70 (G1)60–70	(S) 74 (G) 71.5
Torque rise	Angleich spring	Pump speed: N5	rpm	–		–	
		Screw-in angle: θ	deg.	–		–	
		Measuring stroke	st	–		–	
		Injection volume: Q5	cc	–	–	–	–
	Torque spring	Pump speed: N5	rpm	(S) 1000		(S) 1000	
		Torque rise stroke	mm	(S) 0.25		(S) 0.25	
		Measuring stroke	st	(S) 1000		(S) 1000	
		Injection volume: Q5	cc	–	(S) 35.9	–	(S) 35.9

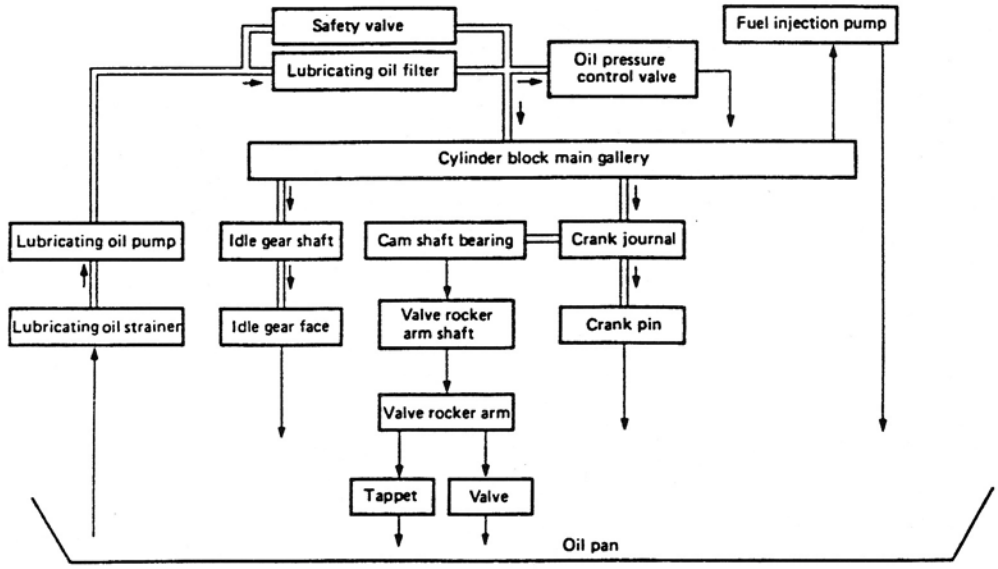
1. Lubrication System

Lubricating oil is important for lubricating the reciprocating oi moving parts of the crankshaft, camshaft, cylinder-piston, etc. The lube oil also cools, cleans and prevents corrosion of these parts. The engine's durability is largely dependent on the quality and viscosity of the lube oil. Since the lube oil degenerates according to the use of the engine, it is important to replace the oil periodically. Lubricating oil is pumped up from the oil pan through the lubricating oil strainer and suction pipe by the lube oil pump, and is fed to the lubricating oil filter through drilled hole of the cylinder block and the filter bracket.
The lubricating oil is filtered by the filter element and pressure controlled by the oil pressure control valve, and then fed to the main gallery of the cylinder.

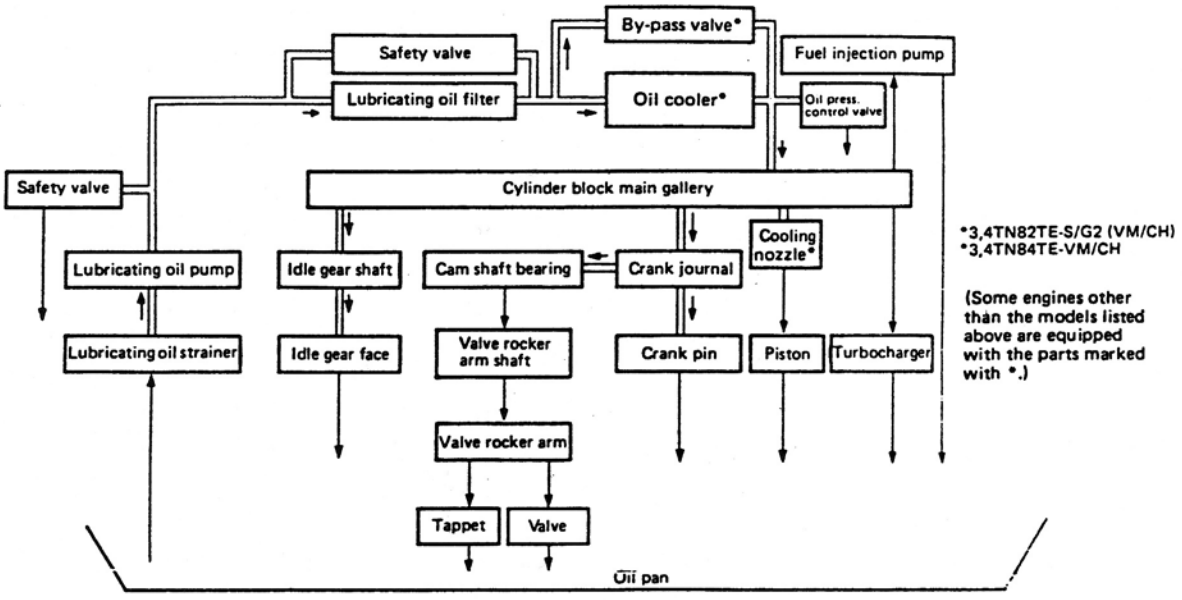
The lubricating oil in the main gallery is distributed among the crank journal, idle gear shaft, and fuel injection pump.

(1) The lubricating oil in the crank journal lubricates the crank pin, and is partly fed to the camshaft bearing on the gear housing side. The lubricating oil which has passed through the drill hole of the cylinder body and of the cylinder head is fed to the valve rocker arm shaft and to lubricate the rocker arm and valve actuating system.
(2) The lubricating oil fed to the idle gear shaft through the drill hole lubricates idle gear faces through idle gear bearing.
(3) The lubricating oil in the main gallery is also fed to the fuel injection pump through piping.

2,3TN66E, 3TNA72E, 3TN75E, 3TNC78E, 3TN82E, 4TN82E, 3TN84E, 4TN84E

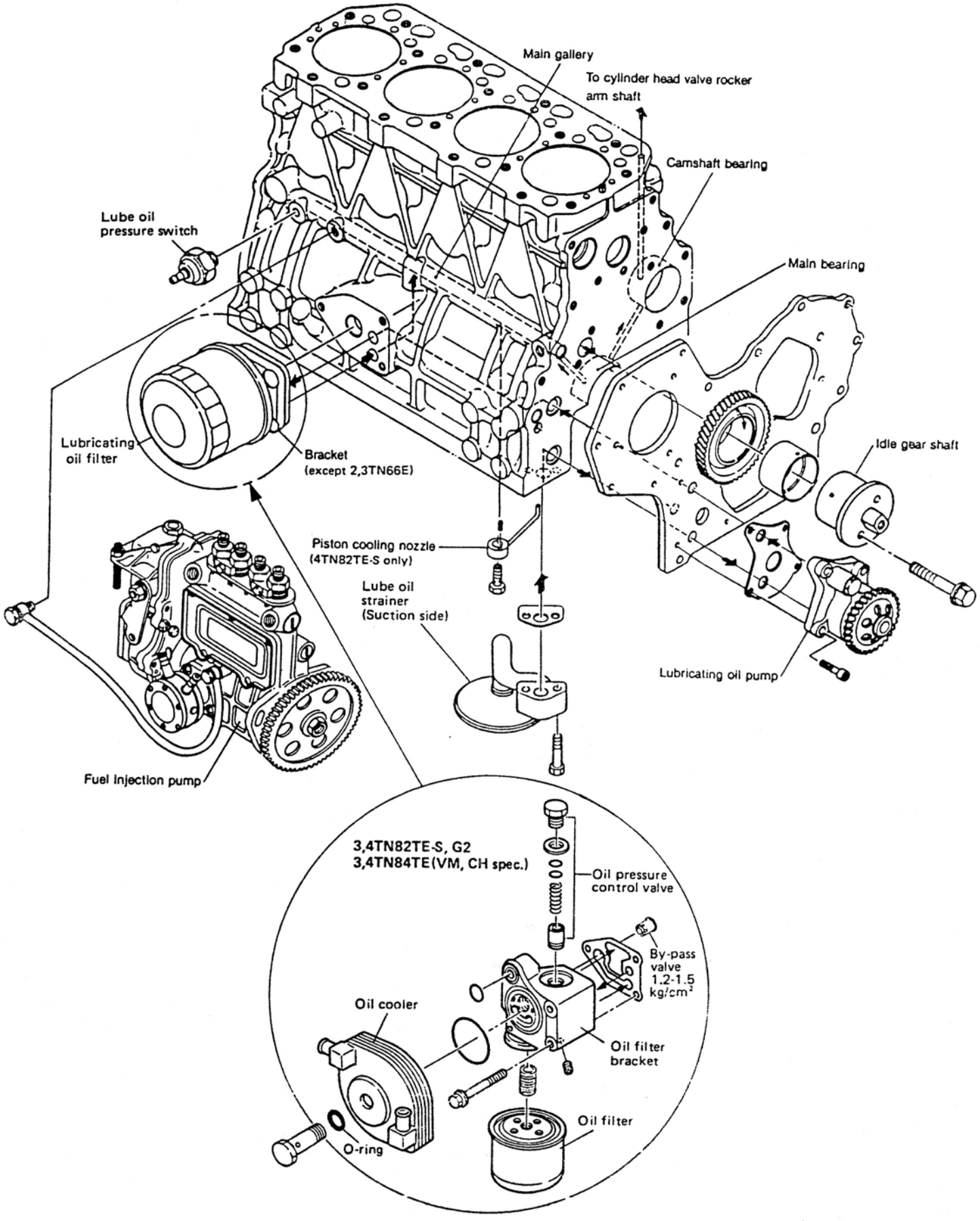


3TN82TE, 4TN82TE, 3TN84TE, 4TN84TE



*3,4TN82TE-S/G2 (VM/CH)
*3,4TN84TE-VM/CH

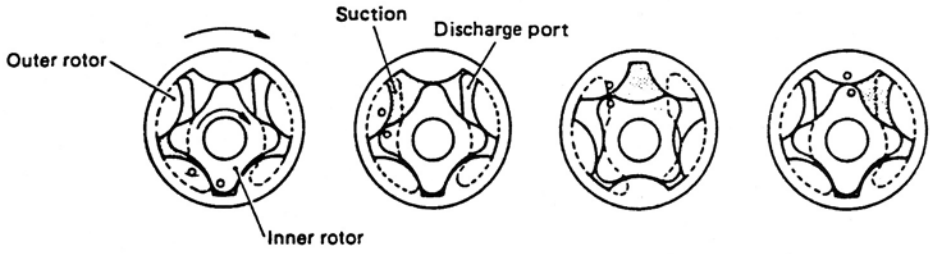
(Some engines other than the models listed above are equipped with the parts marked with *.)

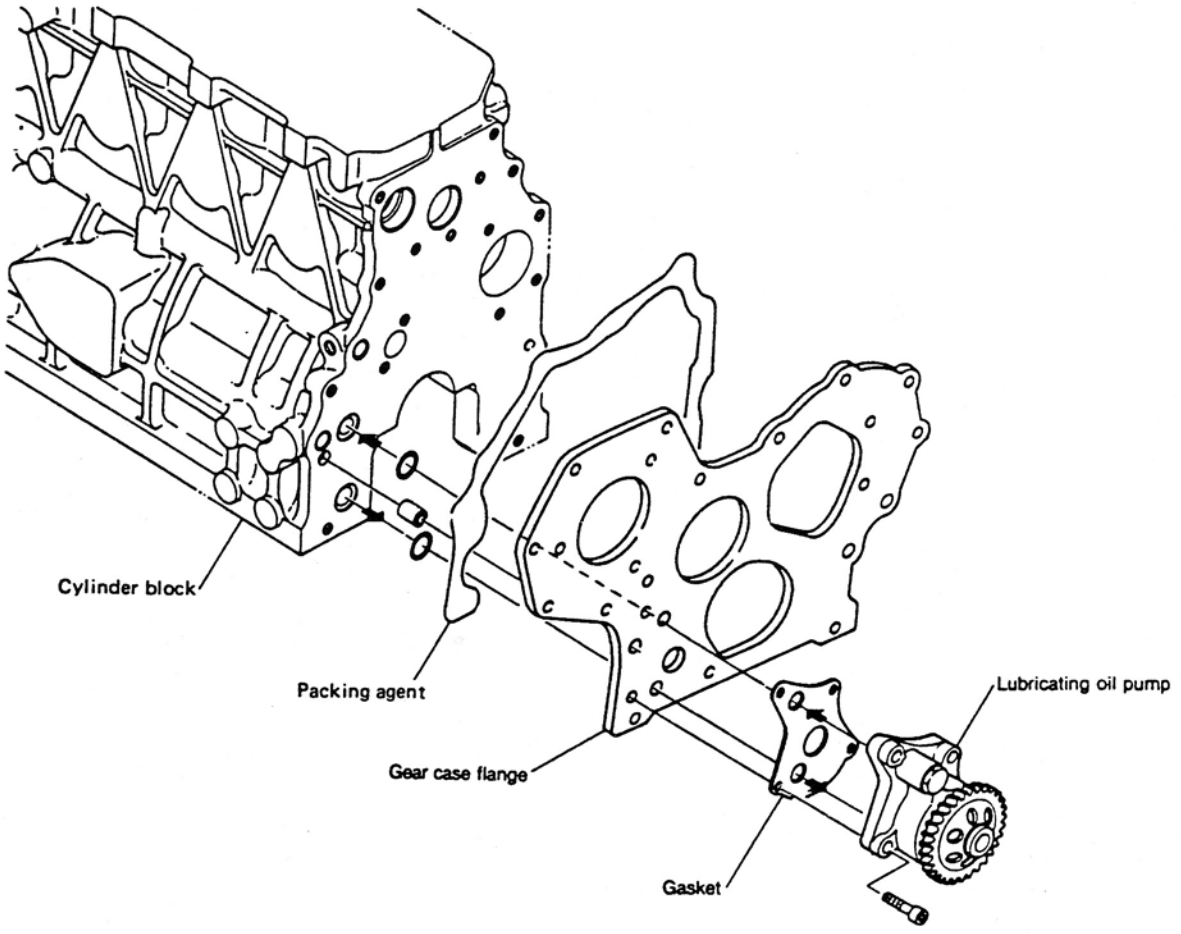

Main gallery
To cylinder head valve rocker arm shaft
Camshaft bearing
Lube oil pressure switch
Main bearing
Lubricating oil filter
Bracket (except 2,3TN66E)
Idle gear shaft
Piston cooling nozzle (4TN82TE-S only)
Lube oil strainer (Suction side)
Lubricating oil pump
Fuel injection pump
3,4TN82TE-S, G2
3,4TN84TE(VM, CH spec.)
Oil pressure control valve
By-pass valve 1.2-1.5 kg/cm²
Oil cooler
Oil filter bracket
Oil filter
O-ring

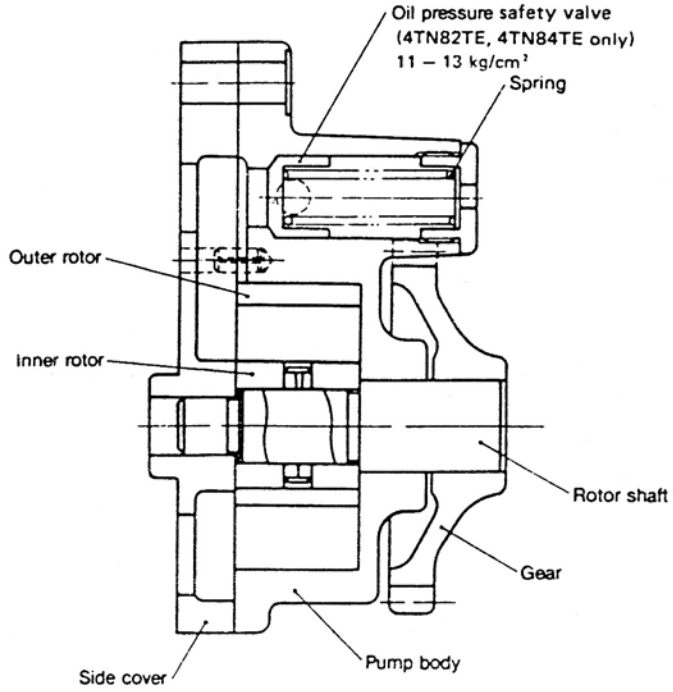
2. Lube Oil Pump

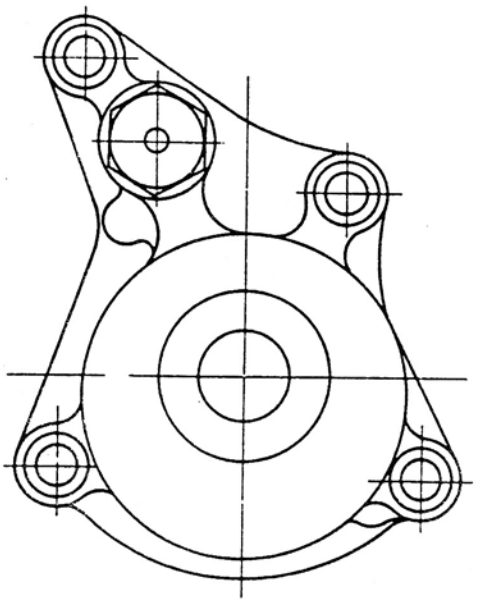
2-1 Lube oil pump construction

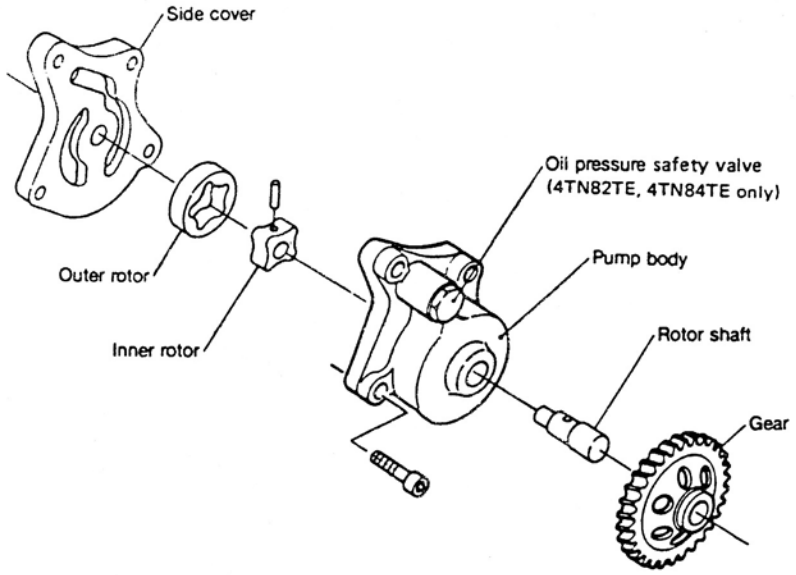
The trochoid type lube oil pump is mounted on the gear case side engine plate, and the rotor shaft gear is driven by the crankshaft gear.
The lube oil flows from the intake filter mounted on the bottom of the cylinder body through the holes in the cylinder body and engine plate, and out from the holes in the engine plate and cylinder body to the discharge filter.











2-2 Specifications of lube oil pump

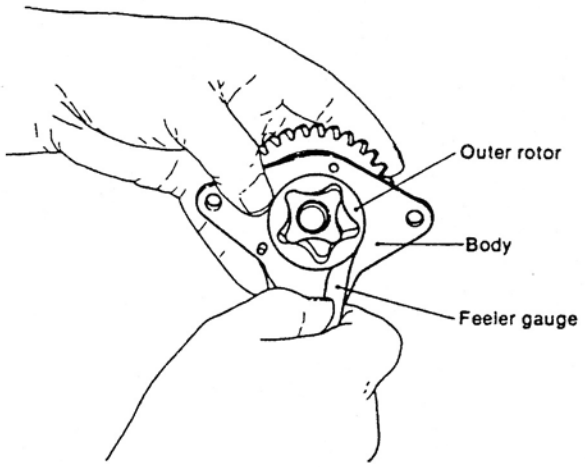
Engine speed	*See separate service data (Page 4-10, 11)*
Gear ratio (crank gear/pump gear)	
Pump speed	
Discharge volume	
Discharge pressure	
Recommended lube oil : SAE #30, temperature 55 - 65°C (131 – 149°F)	

2-3 Lube oil pump disassembly

(1) Remove the lube oil pump assembly from the engine plate.
(2) The lube oil pump cover may be disassembled, but do not disassemble the rotor, rotor shaft or drive gear. The oil pressure regulating valve plug is coated with adhesive and screwed in, so it cannot be disassembled. These parts cannot be reused after disassembly. Replace if necessary as an assembly.

2-4 Lube oil pump inspection

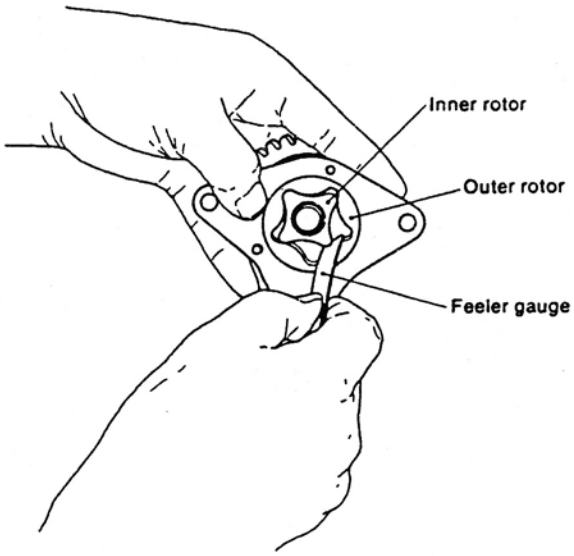
(1) Clearance between outer rotor and pump body
Insert a feeler gauge between the outer rotor and pump body to measure the clearance, and replace if it exceeds the limit.

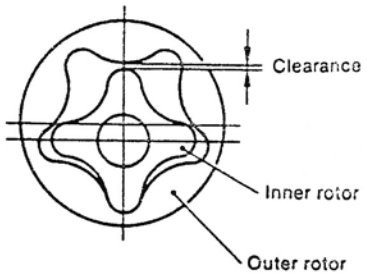


mm (in.)

	Standard	Wear limit
Outer rotor and pump body clearance	*See separate service data (Page 4-10, 11)*	

(2) Clearance between outer rotor and inner rotor
To measure clearance, insert a feeler gauge between the top of the inner rotor tooth and the top of the outer rotor tooth, and replace if it exceeds the limit.

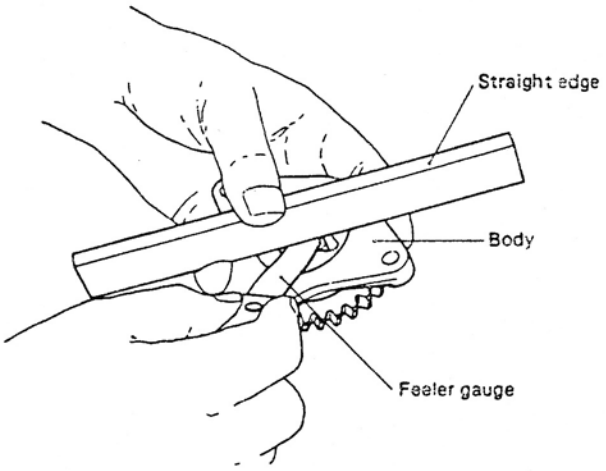




mm (in.)

	Standard	Wear limit
Outer rotor and inner rotor clearance	*See separate service data (Page 4-10,11)*	

(3) Clearance between pump body and inner rotor side of outer rotor
Place a straight-edge against the end of the pump body and insert a feeler gauge between the straight-edge and the rotor to measure side clearance. Replace the assembly if the clearance exceeds the limit.



mm (in.)

	Standard	Wear limit
Pump body and inner rotor, outer rotor clearance	*See separate service data (Page 4-10,11)*	

(4) Clearance between rotor shaft and side cover
Measure the rotor shaft outer diameter and the side cover hole diameter, and replace the entire assembly if the clearance exceeds the limit.

mm (in.)

	Standard	Wear limit
Rotor shaft and body clearance	*See separate service data (Page 4-10,11)*	

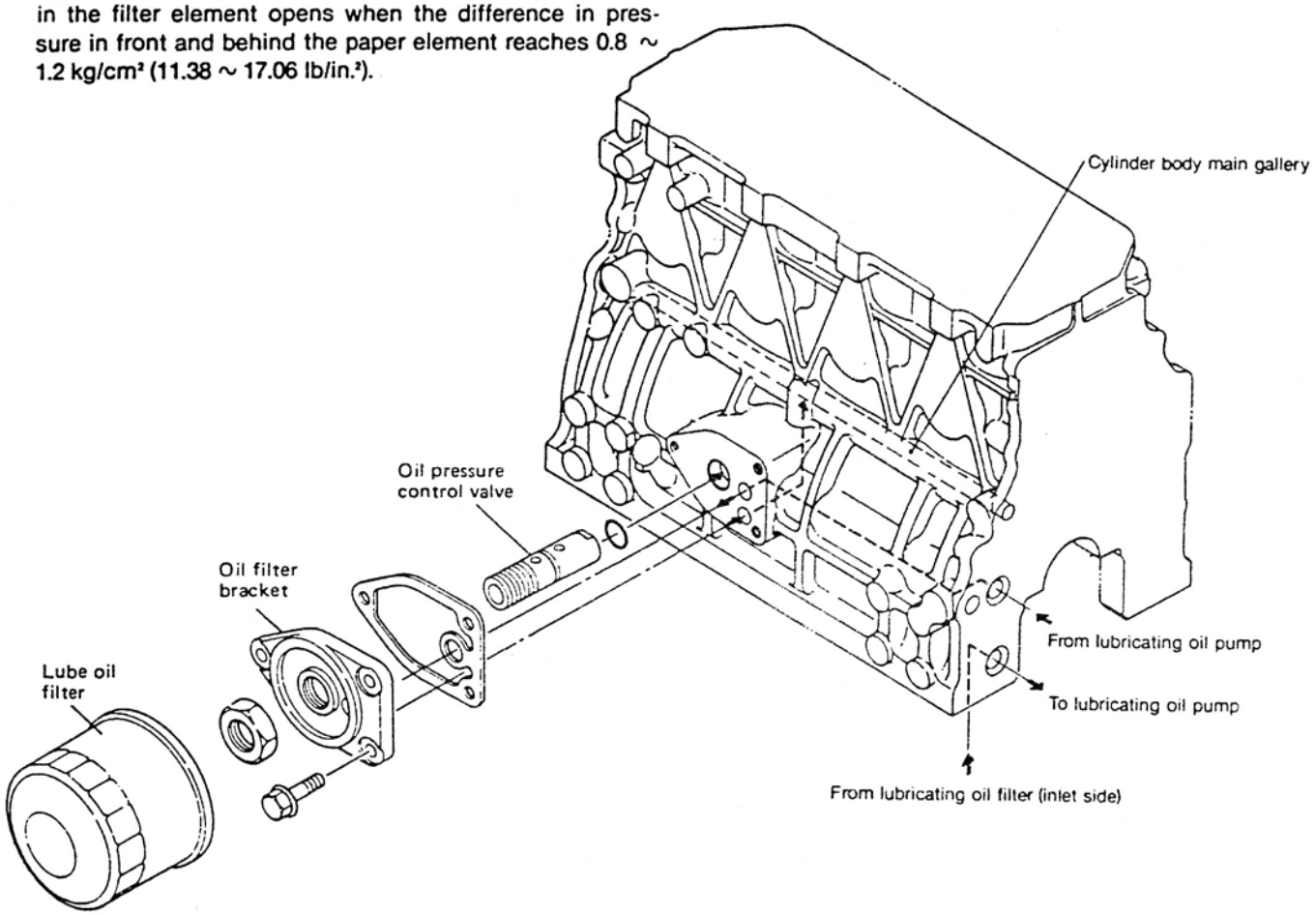
(5) Check for looseness of driver gear/rotor shaft fitting, and replace the entire assembly if loose or wobbly.
(6) Push the oil pressure regulating valve piston from the oil hole side, and replace the assembly if the piston does not return due to spring breakage, etc.
(7) Make sure that the rotor shaft rotates smoothly and easily when the drive gear is rotated.

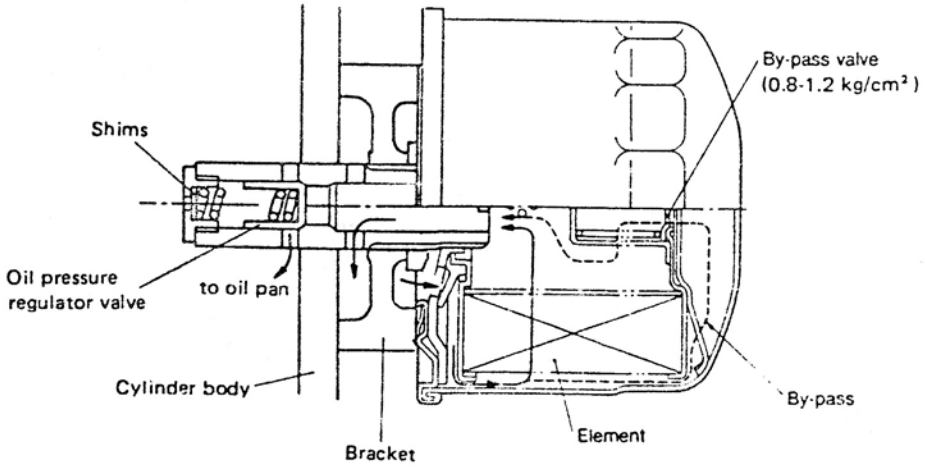
Turning torque	less than 1.5 kg-cm (0.108 ft-lb)

3. Lube Oil Filter & Oil Pressure Control Valve

3-1 Lube oil filter construction

The lube oil filter is a full-flow paper element type, mounted to the side of the cylinder body with the filter bracket. It is an easy to remove cartridge type filter.
To prevent seizure in the event of the filter clogging up, a bypass circuit is provided in the oil filter. The bypass valve in the filter element opens when the difference in pressure in front and behind the paper element reaches 0.8 ~ 1.2 kg/cm² (11.38 ~ 17.06 lb/in.²).





Type	*See separate service data (Page 4-10, 11)*
Filtration area	
Discharge volume	
Pressure loss	
By-pass valve regulating pressure	

3-2 Lube oil filter replacement

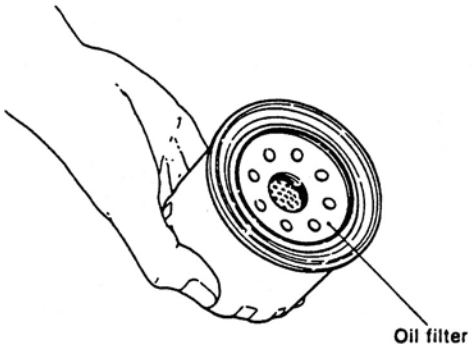
(1) Period

The paper element will get clogged up with dirt after long hours of usage, and eventually unfiltered oil will be fed to the engine through the bypass circuit. Replace the filter according to the following standard, as the dirt in unfiltered oil will of course have a detrimental affect on the engine.

Oil filter replacement period	Every 300 hours of engine operation

(2) Replacement

1) Remove the lube oil filter with the special tool.
2) Clean the filter mounting surface on the filter bracket and mounting screws.
3) Coat the filter rubber packing with lube oil.
4) Screw in the filter until the rubber packing comes in contact with the bracket mounting surface, and then 2 ~ 3 turns more.
5) Run the engine after mounting the filter, and make sure that there is no oil leakage.

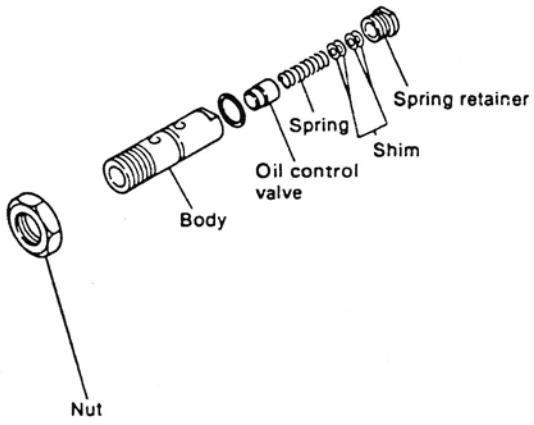


3-3 Oil pressure control valve replacement

The control valve has been adjusted and assembled at the factory, so it should not be disassembled without good reason.

If the oil pressure control valve is disassembled due to spring trouble, etc., mount a pressure gauge to the cylinder body main gallery, and adjust the pressure with adjustment shims until it is at the specified value.

Regulating pressure	*See separate service data (Page 4-10, 11)*



4. Oil Cooler

A high oil temperature causes significant degeneration of the oil. For this reason, the max. oil temperature is kept below 115°C by the oil cooler. The oil cooler is also an important component for maintaining the lube oil quality and for engine durability.
The 3·4TN82TE-S, G2 and 3·4TN84TE (VM, CH spec.) turbocharged engines have been equipped with the oil cooler.

Specification

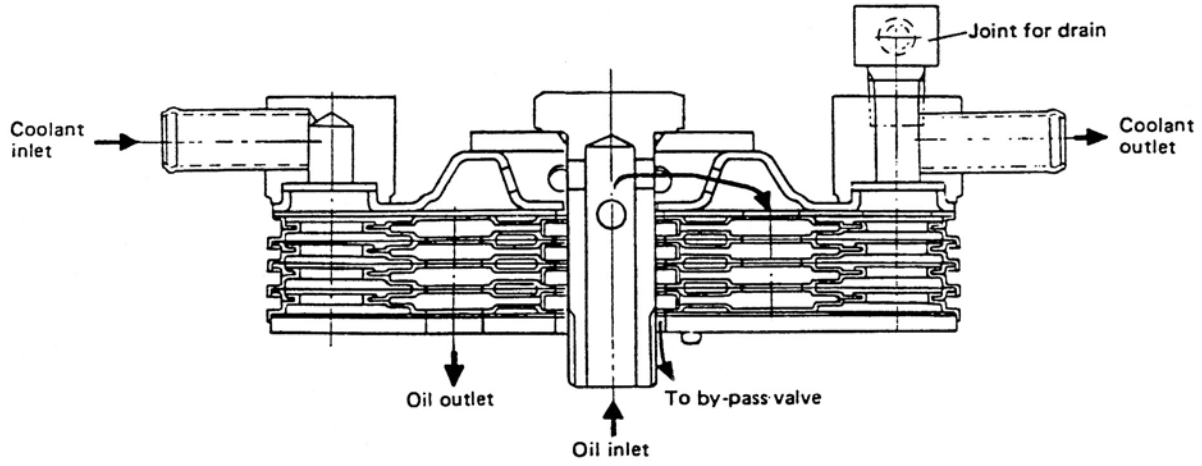
Type	Core/Plate fin
Cooling system	Fresh water
Area of cooling surface	0.078 m^2
Capacity	⩾3600 kcal/hr under Flow rate: Water . . . . . 30ℓ/min. Oil . . . . . 14ℓ/min. Temperature: Water . . . . . 80°C Oil . . . . . 120°C

(1) Oil passage

After passing through the oil filter all the engine oil is sent to the oil cooler where it is cooled, then flows into the cylinder block main gallery via the filter bracket.
The filter bracket has a built-in oil pressure control valve, and the part of the engine oil to which a pressure of 3.5 to 4.5 kg/cm^2 is applied, is sent back into the crankcase via this valve.
The filter bracket also contains the by-pass valve for the oil cooler. When scale has been developed on the inner wall of the oil passage to certain extent, and when the oil pressure difference between at the inlet and outlet of the oil cooler reaches 1.2 to 1.5 kg/cm^2 (17 to 21.3 psi), part of the engine oil flows into the cylinder block main gallery via the by-pass valve instead of passing in the oil cooler.
The by-pass valve prevents the oil passage from being obstructed, and the oil supply to the engine sliding parts from being decreased.

(2) Coolant passage

The coolant flows from the cylinder block to the oil cooler and comes back into the water pump. It is not full of the passage.

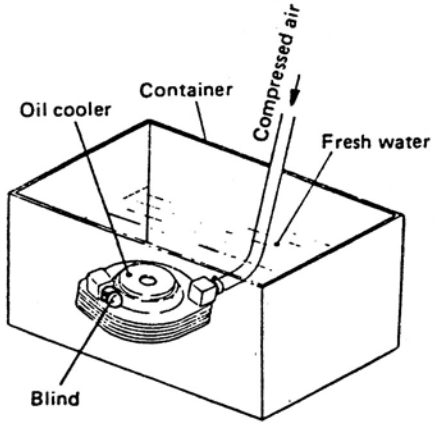


Caution:

(1) Replace the gasket packing and "O" ring with new ones when disassembling or reassembling the oil cooler.

(2) Descale inside the oil cooler with a scale removing agent when disassembling it for periodic inspections.

(3) Check for air or oil leakage from the cooling tube, obstruct one end of the cooling tube, apply an air pressure of 2 to 5 kg/cm^2 (28 to 71 psi) to other end, and dip the oil cooler into the water to check for ieakage.
Repair or replace the cooling tube if it has any defect.



5. Piston Cooling Nozzle (for 3·4TN82TE-S, G2 and 3·4TN84TE (VM, CH spec.) only)

5-1 Piston cooling nozzle

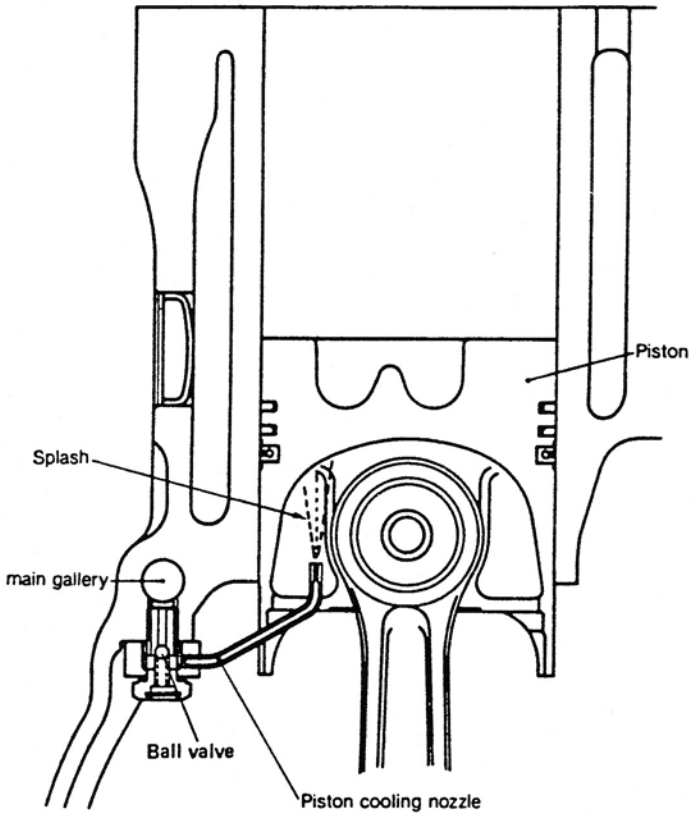
The piston cooling nozzle lowers the piston temperature and decreases its thermal load. It also reduces thermal expansion and carbon deposits in the piston ring grooves.

A steel piping nozzle is mounted on the lower part of the cylinder block main gallery. Lube oil from the main gallery is passed through the check valve, and sprayed out in a jet from the steel pipe nozzle (ϕ1.77 mm ID). This jet spray hits the piston inner surface and cools the piston as a whole.

The check valve is of fall type, and its opening pressue is factory-set at 2 ±0.5 kg/cm² (21.5 – 35.5 psi).

Oil jetting amount	21.3ℓ/min. at an oil pressure of 3.5 kg/cm²

Note: The cooling nozzle and the oil cooler are provided on the 3·4TN82TE-S, G2 and the 3·4TN84TE (VM, CH spec.) only as the regular equipment prior to the engine shipment from the factory.



5-2 Inspection of piston cooling nozzle and check valve

(1) Check the nozzle hole and the valve for clogging with dirt or other foreign matter, and clean them.

(2) Check the steel piping soldered section for coming off or becoming loose due to vibration, etc., and replace the steel piping if it has such defects.

6. Service Data

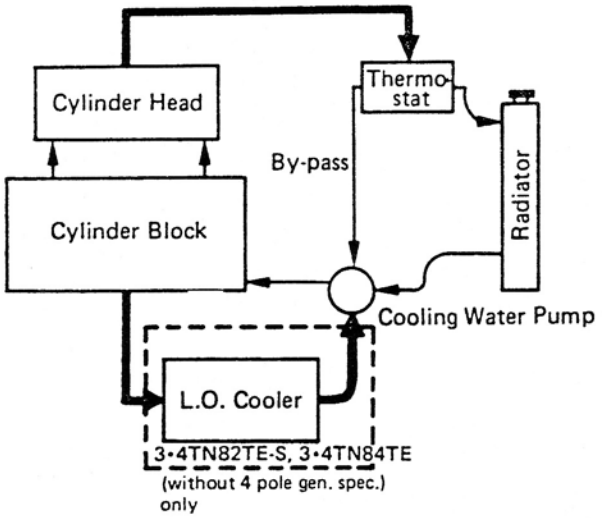
Model			2,3TN66E			3TNA72E			3TN75E/3TNC78E			
Application code			S/VM	G2/CH		S	G2		S/VM	G1	G2	
		Unit	Standard		Wear limit	Standard		Wear limit	Standard			Wear limit
Specifications of lube oil pump	Engine speed	rpm	3000	3600	–	3000	3600	–	3000	1800	3600	–
	Gear ratio	–	21/25	21/25	–	22/25	22/25	–	28/29	28/29	28/29	–
	Pump speed	rpm	2520	3024	–	2640	3168	–	2897	1738	3476	–
	Discharge volume	ℓ/min (US gal. /min)	9.9 (2.615)	11.9 (3.143)	–	13.2 (3.486)	15.8 (4.173)	–	16.34 (4.315)	9.8 (2.588)	19.6 (5.176)	–
	Discharge pressure	kg/cm² (PSI)	3 (42.66)	3 (42.66)	–	3 (42.66)	3 (42.66)	–	3 (42.66)	3 (42.66)	3 (42.66)	–
Outer rotor and pump body clearance		mm (in)	0.10 – 0.16 (0.0039 – 0.0063)		0.25 (0.0098)	0.10 – 0.16 (0.0039 – 0.0063)		0.25 (0.0098)	0.09 – 0.16 (0.0035 – 0.0063)			0.25 (0.0098)
Outer rotor and inner rotor tip clearance		mm (in)	–		0.15 (0.0059)	–		0.15 (0.0059)	0.02 – 0.04 (0.0008 – 0.0016)			0.15 (0.0059)
Pump body and inner rotor, outer rotor side clearance		mm (in)	0.03 – 0.09 (0.0012 – 0.0035)		0.13 (0.0051)	0.03 – 0.09 (0.0011 – 0.0035)		0.13 (0.0051)	0.05 – 0.10 (0.0020 – 0.0039)			0.15 (0.0059)
Rotor shaft and body clearance		mm (in)	0.015 – 0.048 (0.0006 – 0.0019)		0.2 (0.0078)	0.015 – 0.048 (0.0006 – 0.0035)		0.2 (0.0078)	0.016 – 0.049 (0.0006 – 0.0019)			0.2 (0.0078)
Lube oil filter	Type	–	Full flow, paper element		–	Full flow, paper element		–	Full flow, paper element			–
	Filtration area	m² (in²)	0.081 (126)		–	0.081 (126)		–	0.10 (155)			–
	Max. discharge volume	ℓ/min (US gal. /min)	2TN66E: 10 (2.64) 3TN66E: 16 (4.226)		–	16 (4.226)		–	30 (7.923)			–
	Pressure loss	kg/cm² (PSI)	0.1 – 0.3 (1.42 – 4.26)		–	0.1 – 0.3 (1.42 – 4.26)		–	0.3 – 0.5 (4.27 – 7.11)			–
	By-pass valve regulating pressure	kg/cm² (PSI)	0.8 – 1.2 (11.37 – 17.05)		–	0.8 – 1.2 (11.37 – 17.05)		–	0.8 – 1.2 (11.38 – 17.06)			–
Regulating pressure		kg/cm² (PSI)	3.0 – 4.0 (42.66 – 56.88)		–	3.0 – 4.0 (42.66 – 56.88)		–	3.0 – 4.0 (42.66 – 56.88)			–

Model			3,4TN82E/3,4TN84E				4TN82TE/4TN84TE			
Application code			S/VM	G1/CL	G2/CH		S/VM	G1/CL		
		Unit	Standard			Wear limit	Standard		Wear limit	
Specifications of lube oil pump	Engine speed	rpm	3000	1800	3600	–	3000	1800	–	
	Gear ratio	–	28/29	28/29	28/29	–	28/29	28/29	–	
	Pump speed	rpm	2897	1738	3476	–	2897	1738	–	
	Discharge volume	ℓ/min (US gal /min)	30.0 (7.923)	18.0 (4.754)	36.0 (9.508)	–	30.0 (7.923)	18.0 (4.754)	–	
	Discharge pressure	kg/cm² (PSI)	3 (42.66)	3 (42.66)	3 (42.66)	–	3 (42.66)	3 (42.66)	–	
Outer rotor and pump body clearance		mm (in)	0.10 – 0.17 (0.0039 – 0.0067)			0.25 (0.0098)	0.10 – 0.17 (0.0039 – 0.0067)		0.25 (0.0098)	
Outer rotor and inner rotor tip clearance		mm (in)	0.05 – 0.105 (0.0019 – 0.0041)			0.15 (0.0059)	0.05 – 0.105 (0.0019 – 0.0041)		0.15 (0.0059)	
Pump body and inner rotor, outer rotor side clearance		mm (in)	0.03 – 0.09 (0.0011 – 0.0035)			0.15 (0.0059)	0.03 – 0.09 (0.0011 – 0.0035)		0.15 (0.0059)	
Rotor shaft and body clearance		mm (in)	0.015 – 0.048 (0.0006 – 0.0035)			0.2 (0.0078)	0.015 – 0.048 (0.0006 – 0.0035)		0.2 (0.0078)	
Lube oil filter	Type	–	Full flow, paper element			–	Full flow, paper element		–	
	Filtration area	m^2 (in^2)	0.10 (155)			–	0.10 (155)		–	
	Max. discharge volume	ℓ/min (US gal. /min)	30 (7.923)			–	30 (7.923)		–	
	Pressure loss	kg/cm² (PSI)	0.3 – 0.5 (4.27 – 7.11)			–	0.3 – 0.5 (4.27 – 7.11)		–	
	By-pass valve regulating pressure	kg/cm² (PSI)	0.8 – 1.2 (11.38 – 17.06)			–	0.8 – 1.2 (11.38 – 17.06)		–	
Regulating pressure		kg/cm² (PSI)	3.0 – 4.0 (42.66 – 56.88)			–	3.0 – 4.0 (42.66 – 56.88)		–	

1. Cooling System

The engine employs the forced circulation radiator cooling system, which includes a thermostat in the circuit.
Cooling water is forcibly circulated by the cooling water pump. Cooling water cooled by the radiator is sucked from the radiator lower tank by the cooling water pump and is circulated to each part under a pressure.

1-1 Cooling water circuit



(1) Cooling water pump
If the drain plug leaks, replace the mechanical seal.

(2) Sub-tank
As the engine is operated, cooling water temperature rises. Water temperature rise is inhibited by the radiator. Overload operation or extended continuous operation further raises cooling water temperature and steam pressure in the cooling system. When the steam pressure exceeds 0.9 kg/cm^2 the pressure cap opens, exhausts steam, and consumes cooling water in the cooling system. The sub-tank prevents cooling water consumption. Supply the sub-tank with fresh water so that the sub-tank water level is kept between the LOW mark and FULL mark in cold state.

2. Radiator

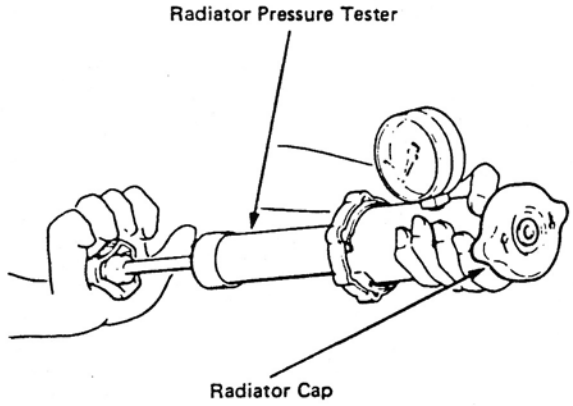
2-1 Radiator specifications

Coolant capacity	Engine	*See separate service data (Page 5-6, 7)*
	Radiator	
Cooling water pump type		
Radiator capacity		
Thermostat		
Radiator fan pusher		
Radiator cap working pressure		
Fan belt tension		
Thermoswitch		

2-2 Cap check

(1) Attach the cap to the tester.
(2) Operate the water pump of the tester to build up water pressure. The cap is working if the gauge needle stays within the normal pressure range for 6 seconds. If the water pressure does not rise, or if it drops immediately after it has risen, either the cap packing is worn, cracked or broken, or the cap spring has deteriorated. Replaced the cap.

Testing cap



(3) Remove the cap, turn it 180°, and retest it. This is to eliminate any possibility of an inaccurate measurement. Remove and test the cap twice.

Cap working pressure	0.9 kgf/cm^2 (0.9 Bar/12.8 psi)

2-3 Check for leaks in the radiator and cooling water system

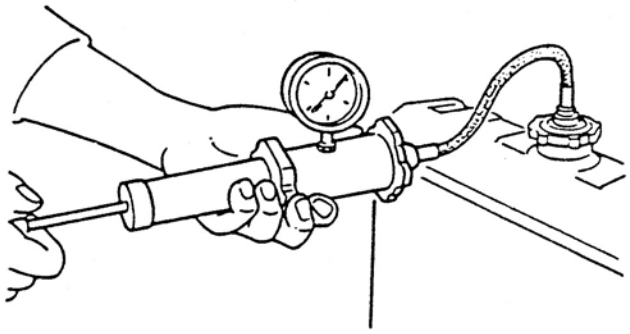
It is advisable to perform this check with the engine warmed up.

(1) Wait until the engine is cooled, then carefully remove the radiator cap.
(2) Fill the radiator with coolant up to the normal water level.
(3) Connect the adaptor furnished with a tester unit. Connect the tip to the adaptor to the water filler port.
(4) Operate the pump and apply the amount of pressure indicated on the radiator cap. Excessive pressure may break the radiator and/or hose.

Applied pressure	0.9 kgf/cm^2 (0.9 Bar/12.8 psi)

(5) With pressure applied, check the following:
- Hose connections
- Radiator cooling water pump packing
- Radiator coolant drain plug

Pressure testing



(6) If the gauge indicates a drop in pressure, but no coolant leakage is detected, coolant may be leaking from the cooling water system and/or gaskets of the cylinder block and cylinder head. The engine must be disassembled for the check.

3. Radiator Fan Belt

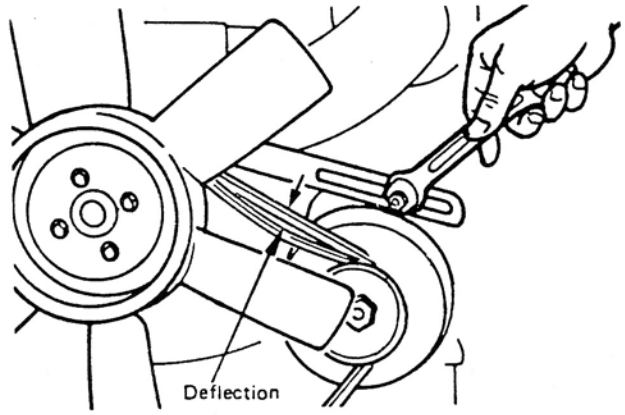
The radiator fan belt is subject to stretching, the wet and other possible damage after a long period of service.

3-1 Fan belt Tension

(1) If the belt is loose, it will slip, causing the battery to be undercharged, the cooling system to malfunction, and the V-belt groove to wear abnormally. Check the tension periodically and adjust it if required.

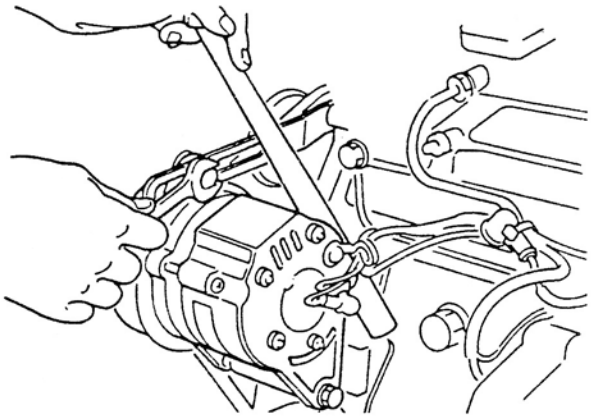
Belt tention	Press hard with the fingers to get a play of 10 – 15 mm (0.4 – 0.6 in.)

Measuring belt tension



(2) Loosen the charging generator bolts and shift the generator until the belt has the proper tension. When the belt has been replaced, check the tension for any damage after 20 and 50 hours.

Adjusting belt tension



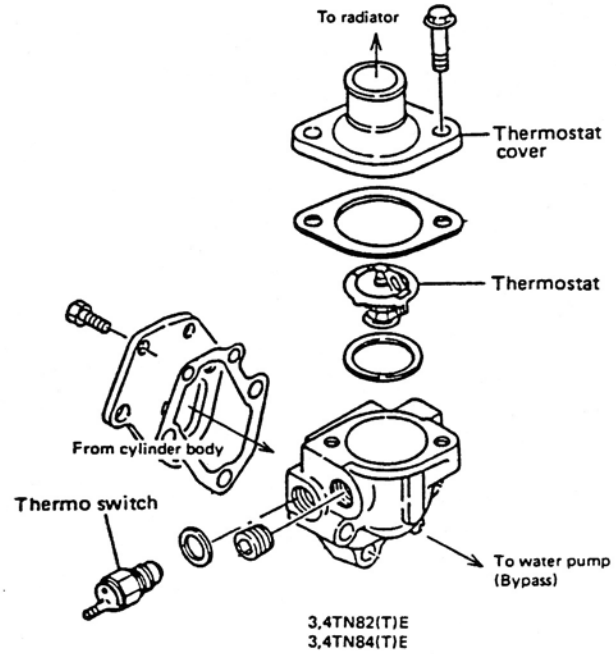
Fan belt specifications:

Model	Belt type x size
3TN66E	*See separate service data (Page 5-6, 7)*
3TNA72E	
3TN75E	
3TN82E	
4TN82E	
4TN82TE	

4. Thermostat

4-1 Thermostat inspection

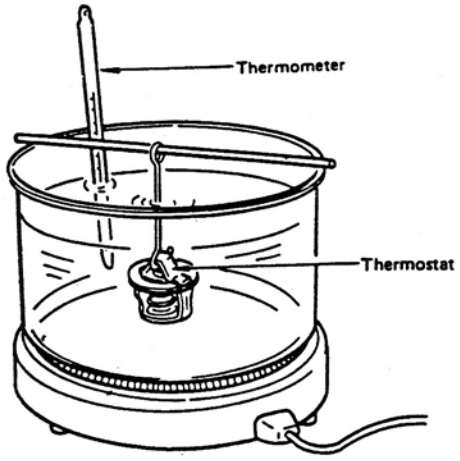
Remove the thermostat cover and take out the thermostat. Clean off scale and rust, then inspect the thermostat. Replace with new one, if the characteristics (performance) have changed, and check the spring etc. for damage and corrosion.



3,4TN82(T)E
3,4TN84(T)E

4-2 Testing Thermostat

(1) Replace the thermostat if it opens at room temperature.
(2) Suspend the thermostat in a container filled with water.



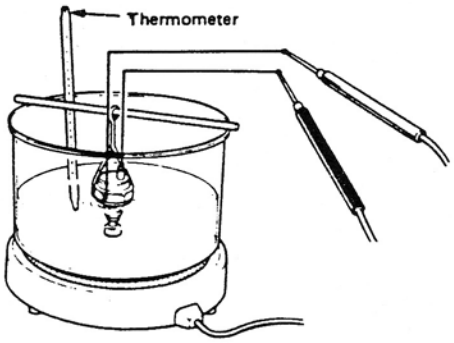
(3) Heat the water and measure the water temperature with a thermometer. Check temperature at which the thermostat first opens and at full lift.

Note: Do not let the thermostat touch the bottom of the hot container.

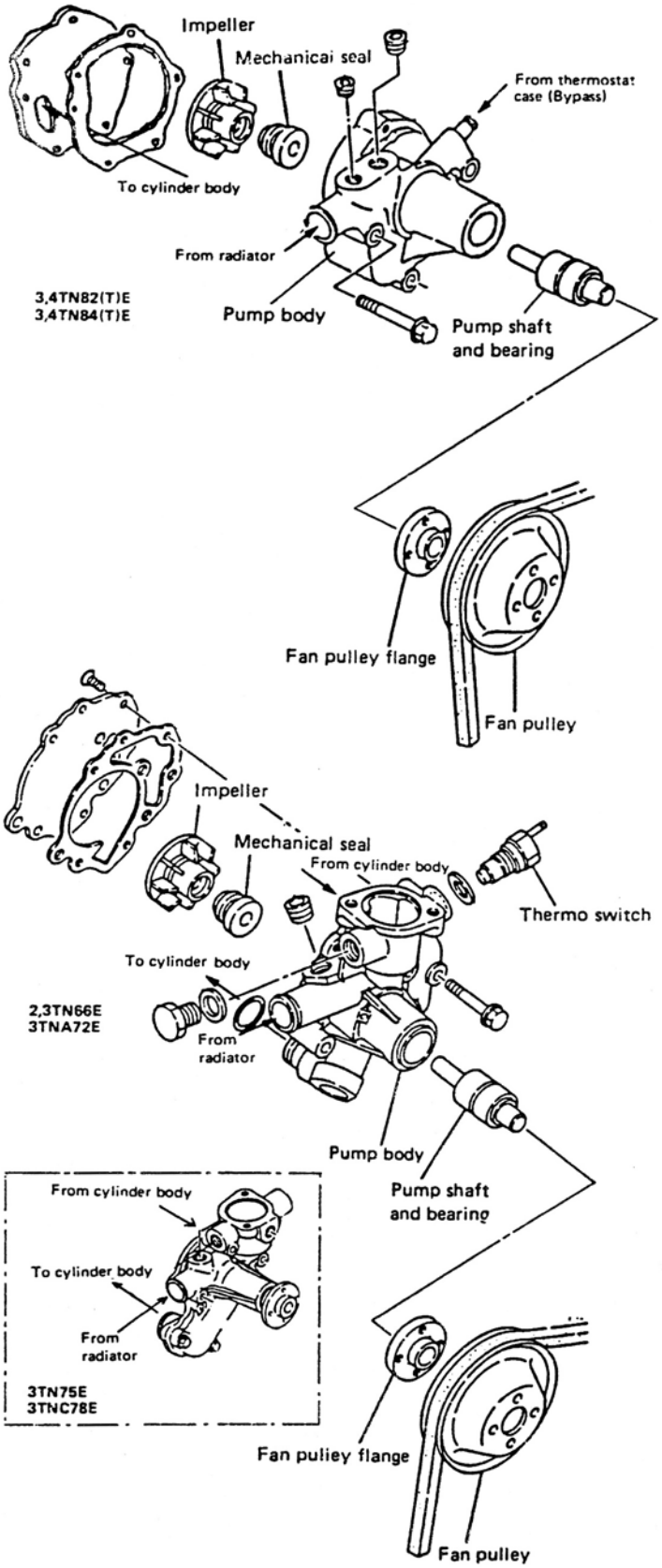
(4) Measure the lift height of the thermostat when fully open.

4-3 Thermoswitch

Thermoswitch inspection
(1) Connect the lead wires and suspend the thermoswitch in a container with oil.
(2) Heat the oil and measure the oil temperature with a thermometer when the continuity occurs.
Temperature for continuity: 110°C (230°F)
(3) After the measurement, remove extraneous oil away on the thermoswitch.



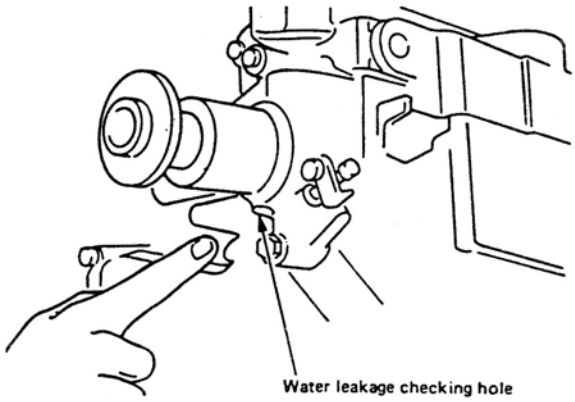
5. Cooling Water Pump



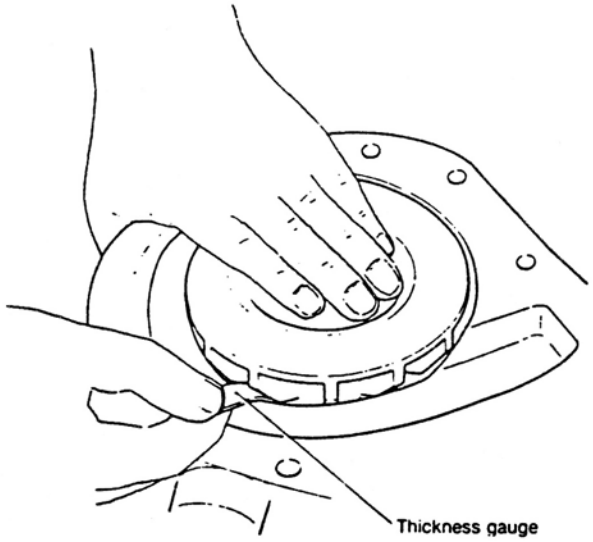
5-1 Cooling water pump inspection

(1) Make sure that the pump shaft rotates smoothly.
(2) Make sure that there is no "play" on the pump shaft. If there is excessive play, disassemble the pump and replace the pump shaft with bearing.
(3) Make sure that cooling water does not leak from the hole in the lower section of the pump unit during operation. If there is leakage, the mechanical seal in the hole may be broken. Disassemble the pump and replace the mechanical seal.
(4) Measure the clearance between the impeller and the pump body.

Checking mechanical seal leakage



Measuring clearance between impeller and pump body



mm (in.)

	Standard	Wear limit
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)	1.5 (0.0590)

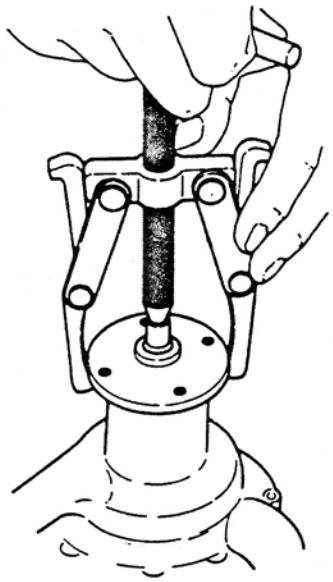
5-2 Water pump disassembly

(1) Remove the water pump
(2) Remove the impeller using a gear puller.

Removing impeller

(3) Remove the mechanical seal.
(4) Remove the fan pulley flange using a gear puller.

Removing pulley flange



(5) Remove the snap ring.
(6) Press the pump shaft and bearing assembly out from the impeller end to the fan pulley end.
(7) Reassemble in the reverse order of disassembly.
(8) Install the water pump.

6. Service Data

Model			3TN66E		3TNA72E		3TN75E		
Application code			S/VM	G2/CH	S	G2	S/VM	G1/CL	G2/CH
Coolant capacity	Engine	ℓ (US qt.)	0.9 (0.95)		1.1 (1.16)		1.8 (1.90)		
	Radiator	ℓ (US qt.)	1.9 (2.0)		2.0 (2.1)	2.2 (2.3)	1.1 (1.2)		
Cooling water pump type		–	Centrifugal						
Radiator capacity		K cal/h	19700		20500	24200	16200		
Thermostat		–	Wax pellet type, open: 71°C(160°F) Full open: 85°C (185°F) Lift height Min. 4.5mm(0.18 in)		Wax pellet type, open : 71°C (160°F) Full open : 85°C (185°F) Lift height Min. 8 mm (0.31 in)				
Radiator fan		Type, blade, mm dia. Identification	Pusher type, 5, 290 Ident. L		Pusher type, 5, 310 Ident. D		Pusher type, 5,310 Ident. D		
Radiator cap working pressure	kg/cm² (PSI)		0.9 (12.8)						
Fan belt tension	mm (in)		Deflection 10 – 15 (0.4 – 0.6)						
Thermoswitch (Water temperature sender switch)			ON: 107 – 113°C (225 – 235°F)						
			OFF: Hysteresis 10°C or less (18° F or less)						

Model			2TN66E		3TNC78E		
Application code			VM	CH	VM	CL	CH
	Engine	ℓ(US qt.)	0.6 (0.63)		1.8 (1.90)		
	Radiator	ℓ(US qt.)	1.7 (1.8)	1.9 (2.0)	1.2 (1.3)		
Cooling water pump type		–	Centrifugal		←		
Radiator capacity		K cal/h	12300	19700	19600		
Thermostat		–	Wax pellet type, open: 71°C(160°F) Full open: 85°C(185°F) Lift height Min. 4.5mm(0.18 in)		Wax pellet type, open: 71°C (160°F) Full open: 85°C (185°F) Lift height Min. 8mm (0.31 in)		
Radiator fan		Type, blade, mm dia. Identification	Pusher type, 5,270 Ident. LK		Pusher type 6,335 Ident. HF		
Radiator cap working pressure	kg/cm² (PSI)		0.9 (12.8)				
Fan belt tension	mm (in)		Deflection 10 – 15 (0.4 – 0.6)				
Thermoswitch (Water temperature sender switch)			ON: 107 – 113°C (225 – 235°F)				
			OFF: Hysteresis 10°C or less (18° F or less)				

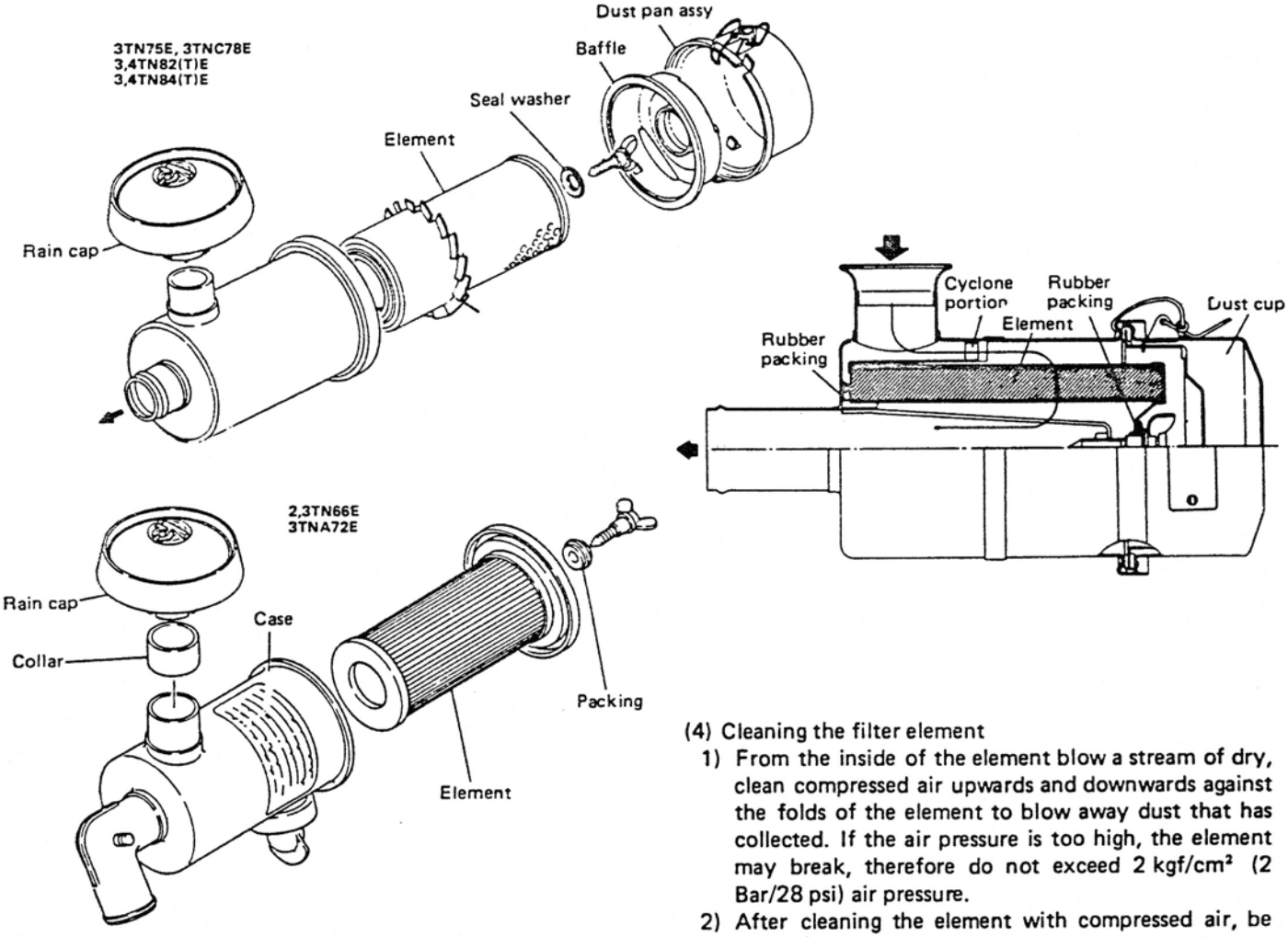
Model			3TN82E/3TN84E			4TN82E/4TN84E			4TN82TE/4TN84TE		3TN82TE/3TN84TE	
Application code			S/VM	G1/CL	G2/CH	S/VM	G1/CL	G2/CH	S/VM	G1/CL	S/VM	G1/CL
Coolant capacity	Engine	ℓ (US qt.)	2.0 (2.11)			2.7 (2.85)			2.7 (2.85)		2.0 (2.11)	
	Radiator	ℓ (US qt.)	2.2 (2.3)	1.2 (1.3)	2.2 (2.3) 2.5 (2.6)*	3.5 (3.7)	1.2 (1.3)	3.5 (3.7)	3.5 (3.7)	3.5 (3.7)	2.2 (2.3)	1.2 (1.3)
Cooling water pump type		–	Centrifugal									
Radiator capacity		K cal/h	24200	19600	24200 29200**	29200	19600	29200	29200 35500**	29200	24200	19600
Thermostat		–	Wax pellet type, open : 71°C (160°F) Full open : 85°C (185°F) Left height Min. 8 mm (0.31 in)									
Radiator fan		Type, blade, mm dia. Identification	Pusher type, 6, 335 Ident. NF			Pusher 6,370 Ident. E	Pusher 6,335 Ident. NF	Pusher 6,370 Ident. E	Pusher type, 6,370 Ident. E		Pusher type 6,355 Ident. NF	
Radiator cap working pressure	kg/cm^2 (PSI)		0.9 (12.8)									
Fan belt tension	mm (in)		Deflection 10 – 15 (0.4 – 0.6)									
Thermoswitch (Water temperature sender switch)			ON: 107 – 113°C (225 – 235°F)									
			Hysteresis 10°C or less (50°F or less)									

*: 3TN84E-CH
**: 4TN82(84)TE-VM

1. Air Cleaner

1-1 Description

The air cleaner is an important engine component that promotes longer diesel engine life. The engine intakes air into the air cleaner, and the filter element removes dust and grit from the air to prevent cylinder and piston wear.



1-2 Maintenance

(1) If the outer surface of the filter element is clogged with dust, there will be a reduction in the amount of air and a drop in horsepower. If the engine is operated in a dusty area, clean the air element every-50 hours.
(2) If the engine is used in a relatively dust free area, clean it every 100 hours.
(3) Replace the filter element as follows:
  1) Every 250 hours of operation in dusty area.
  2) Every 500 hours in relatively dust free areas.
  3) Replace it yearly whether or not the specified duration has been reached.

(4) Cleaning the filter element
  1) From the inside of the element blow a stream of dry, clean compressed air upwards and downwards against the folds of the element to blow away dust that has collected. If the air pressure is too high, the element may break, therefore do not exceed 2 kgf/cm² (2 Bar/28 psi) air pressure.
  2) After cleaning the element with compressed air, be sure to check it for pinholes, as well as for breakdown or deformation.
  3) Do not use any oil in the dry-type air cleaner's dust-cup.

(5) Precautions for replacing the element
  1) Check the rubber-lined washer and rubber packing. If the rubber part of the rubber-lined washer or rubber packing is broken or deformed, replace the defective part.
  2) Check for damage to the suction port pipe on the air cleaner, which is attached to the engine, and be sure the hose band is tight.
  3) Check the condition of the suction port pipe on the air cleaner which is coupled to the engine, and be sure the hose band is tight.

Caution on maintenance

1. Perform the maintenance of the air cleaner at appropriate intervals. (If the air cleaner is equipped with the dust indicator, maintenance should preferably be performed after a clogging alarm is raised.)

   Note that unnecessary maintenance is useless and may rather cause damage.
   - o For example, dust is introduced while the element is mounted or removed.
   - o The element is flawed or deformed.

2. Be sure to stop the engine before removing the element. Do not start the engine with the element left removed.

3. Carefully prevent dust deposits on the element from entering the secondary side (the air cleaner outlet) when taking out the element.

4. If the element has pinholes, replace it with a new one.

5. To clean the element, blow air into the element or flush the element. (some elements allows flushing with the specified detergent.)
   Do not strike the air cleaner to protect the element from a shock or impact.
   Be sure to blow air from the inside of the element to the outside. After flushing the element, rinse it carefully and allow it to thoroughly dry before use.

6. Check the element with cyclon vanes for larger dust particles deposited on the element and vanes and for deformation.

7. Never remove the cyclon vane from the element when cleaning the element.
   Carefully clean the element, and dust on the element is sufficiently removed.

8. In the case of the element with the unloader valve, check for trouble such as hardened rubber parts.

9. Check to see if: –
   1) the element is tightly sealed in the body.
   2) the seal washer (tightening the element) is sufficiently air-tight.
   3) the paper element is securely bonded to plates on both ends. (Poor bonding may cause dust to leak.)
   4) there is an excessive clearance between the body and the periphery of the element. (The allowable clearance is 1 mm or less.)
      An excessive clearance causes the element to run out under vibration, and dust may leak along the packing of the element.
   5) the unloader valve is properly attached in the downward direction.
   6) the notch of the baffle plate properly faces upward.

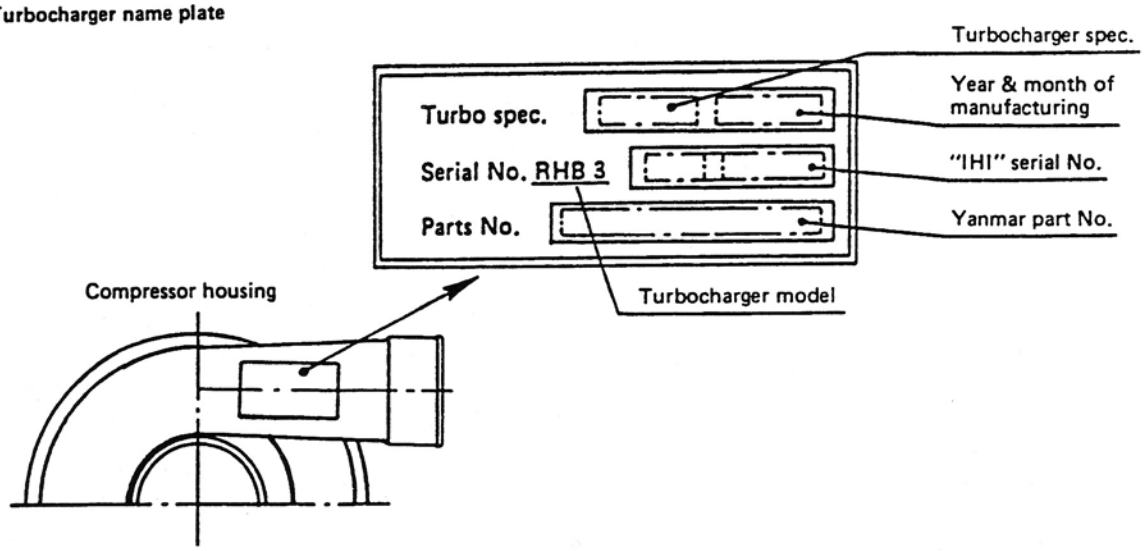
2. Turbocharger

1 Specifications

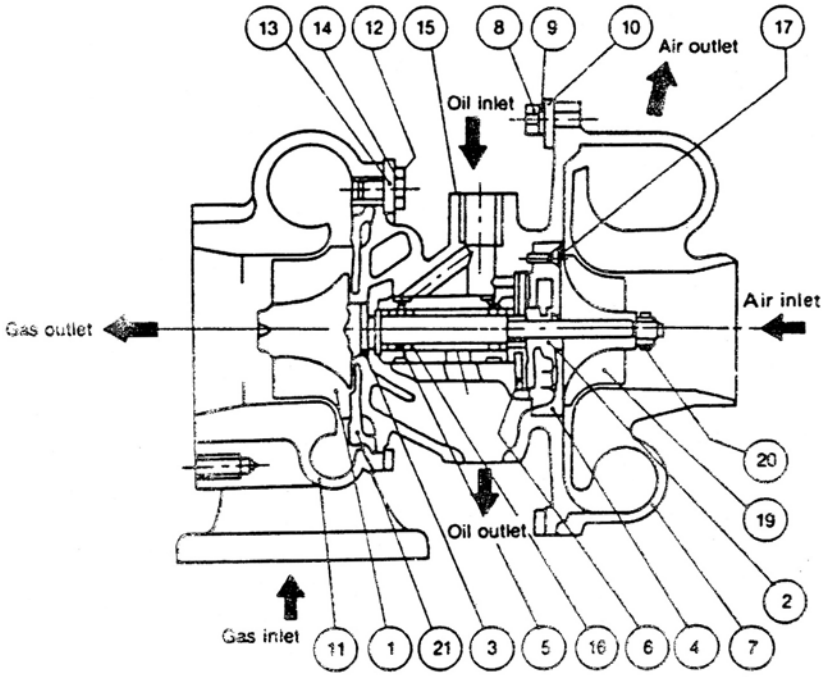
Turbocharger maker	ISHIKAWAJIMA-HARIMA HEAVY INDUSTRIAL CO.,LTD. (I H I)		
Turbine type	Radial flow	Radial flow, Waste gate	Radial flow, w/Waste gate
Blower type	Centrifugal		
Bearing type	Full floating		
Lubrication method	Forced lubrication from cylinder block main gallery		
Cooling method	Air cooled		
Max. intermittent allowable rpm	250,000		180,000
Max. gas inlet temp. (intermittent allowable)	750°C		
Dry weight, approx.	2.0 kg (4.4 lbs)		3.7 kg (8.2 lbs)
Turbocharger model	RH B31		RH B51
Applicable engine model	3·4TN84TE(CL), 3·4TN82TE-G1	3TN84TE(VM) 3TN82TE-S	4TN82TE-S, 4TN84TE(VM)

Note: The specifications of the turbine and compressor are difference between the turbochargers for the engine models.

Turbocharger name plate

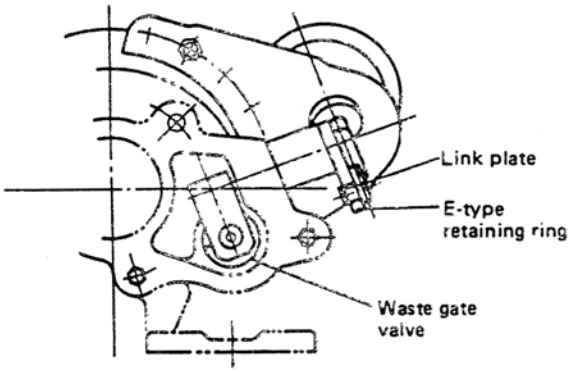


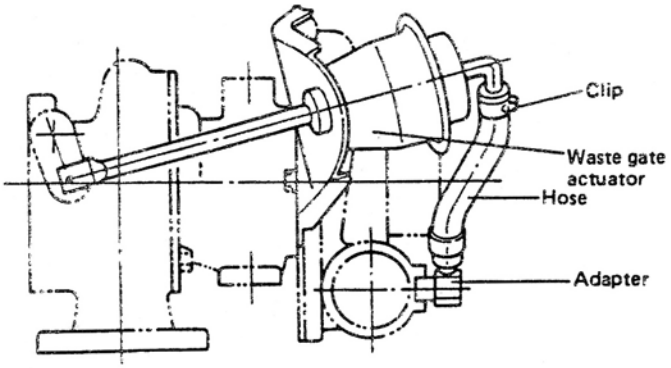
2 Construction



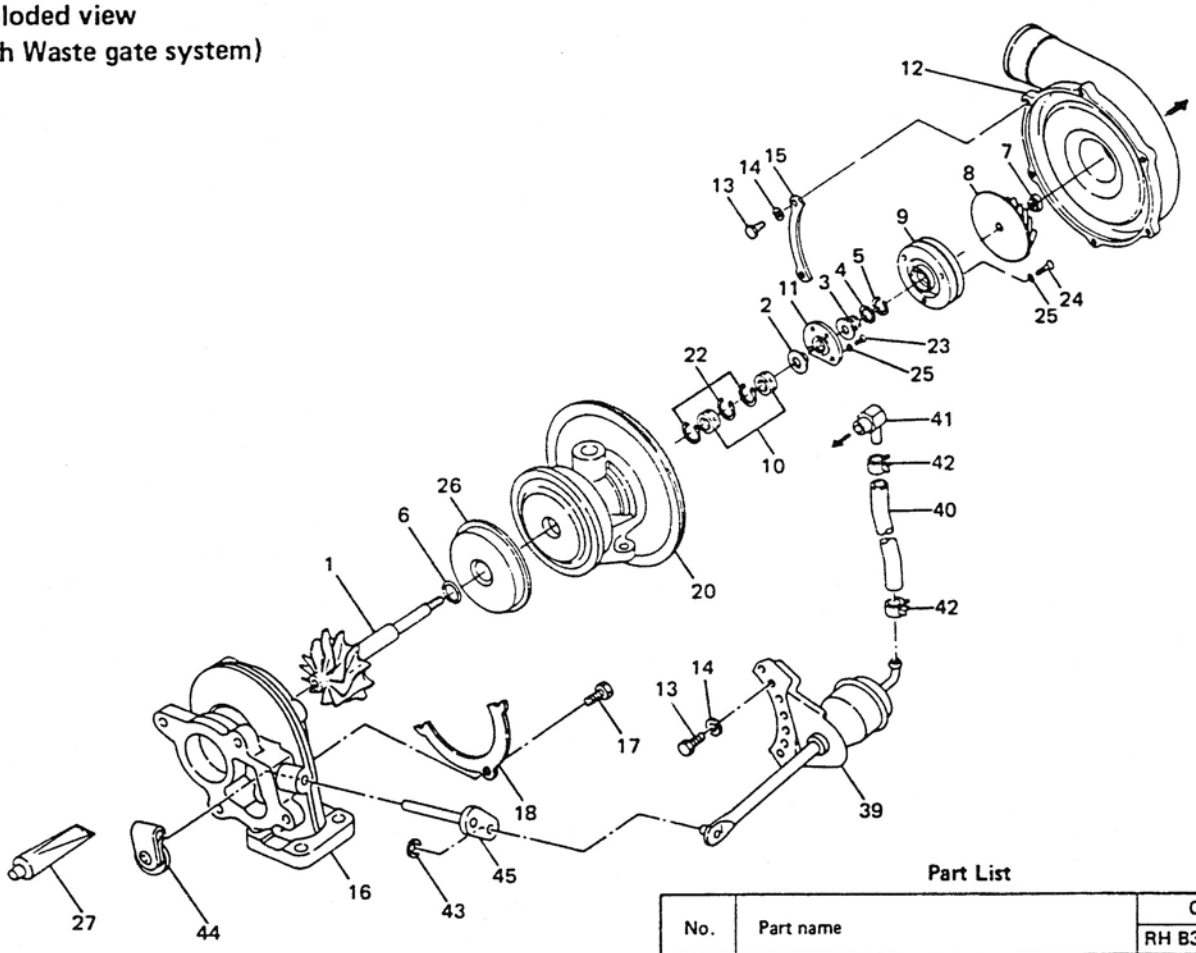
1. Turbine shaft
2. Oil thrower
3. Turbine side seal ring
4. Seal plate
5. Journal bearing
6. Thrust bearing
7. Compressor housing
8. M5 hexagonal bolt
9. M5 lock washer
10. Compressor side clamp
11. Turbine housing
12. M6 hexagonal bolt
13. Turbine side clamp
14. Lock washer
15. Bearing housing
16. Retaining ring
17. Screw M3
19. Compressor wheel lock nut
20. Compressor wheel
21. Heat protector

Waste Gate:





3. Exploded view
(with Waste gate system)



4 Tightening torque (RH B5 & B3)
(Turbine housing M8, etc.)

Part No.	Part name	Size	Torque kg-cm	
			RH B5	RH B3
17	Bolt for turbine housing	(M8) (M6)	285±10 125± 5	125 ±5
13	Bolt for compressor housing	(M5)	45 ± 5	←
23	Screw for thrust bearing	(M3)	13 ± 1	←
24	Screw for seal plate	(M3)	13 ± 1	←
7	Lock nut		20 ± 2	10 ±1

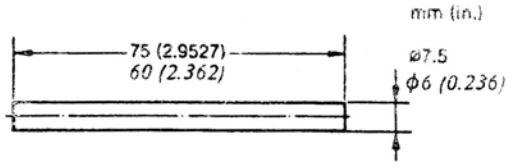
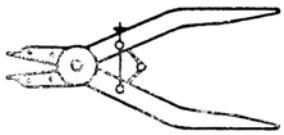
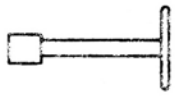
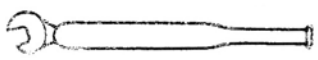
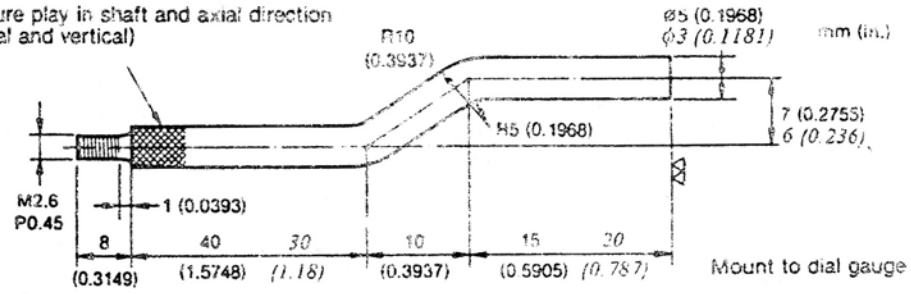
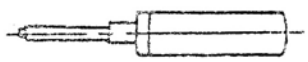
Part List

No.	Part name	Q'ty	
		RH B3	RH B5
1	Turbine wheel and shaft	1	1
2	Thrust bush	1	1
3	Oil thrower	1	1
4	Seal ring (Compressor side, Large)	1	1
5	Seal ring (Compressor side, Small)	1	1
6	Seal ring (Turbine side)	1	1
7	Lock nut	1	1
8	Compressor wheel	1	1
9	Seal plate	1	1
10	Journal bearing	2	2
11	Thrust bearing	1	1
12	Compressor housing	1	1
13	Bolt (M5)	4	6
14	Spring washer (M5)	–	6
15	Clamp (Compressor side)	2	2
16	Turbine housing	1	1
17	Bolt (M8) (B3: M6)	4	4
18	Clamp (Turbine side)	4	2
20	Bearing housing	1	1
22	Retaining ring	3	3
23	Screw (M3)	2	4
24	Screw (M3)	2	3
25	Toothed lock washer (M3)	–	7
26	Heat protector	1	1
27	Liquid gasket	–	–
39	Waste gate actuator	1	1
40	Hose	1	1
41	Adapter	1	1
42	Clip	2	2
43	E-type retaining ring	1	1
44	Waste gate valve	1	1
45	Link plate	1	1
46	Spacer	3	–

5. DISASSEMBLY AND REASSEMBLY

5-1 Preparations for disassembly

The following special tools are required for disassembly of the turbocharger, in addition to the standard tools.

Name of tool	Use	Illustration
Bar	To remove thrust metal and thrust bushings	 Material: Copper or brass
Pliers*	To remove floating bushing stop ring	
Pliers*	To remove seal ring	
Box wrench	To tighten turbine shaft 10mm (0.3937in.) x dodecagonal *7mm (0.2756in.) x dodecagonal*	 Box only may be used
Torque wrench	For following bolts M8: 13mm (0.5118in.) – 285kg-cm (20.61ft-lbs) M6: 10mm (0.3937in.) – 125kg-cm (9.04ft-lbs) M5: 8mm (0.3149in.) – 45kg-cm (3.25ft-lbs) M5: 8mm (0.3149in.) – 20kg-cm (1.45ft-lbs) *7mm (0.2756in.) – 10kg-cm (0.72ft-lbs)*	
Gauge wire	To measure play in shaft and axial direction (horizontal and vertical)	
Torque driver	To tighten screws (5 Kg-cm, 30 Kg-cm)	

NOTE : Italic letter are shows RH B5 type (include)*

5-2 Disassembly

Prior to the disassembly, put mate marks on the turbine housing and the bearing housing as well as the compressor housing and the bearing housing.

1. Take out E-type retaining ring for W/G link.
2. Take out rod end of W/G actuator.
3. Remove W/G actuator.
4. Loosen bolts of housings.
5. Remove compressor housing.
   1) Tap the housing lightly with plastic hammer.

NOTE:

Care is needed not to bend or deform compressor wheel blades.

6. Remove turbine housing.
   1) If it is stuck on, tap the housing with plastic hammer.
7. Remove lock nut.

NOTE:

Left handed screw.

8. Take out turbine wheel and shaft.
   1) If shaft is binded, tap the shaft-end lightly with plastic hammer.
9. Take off heat protector.
10. Take out seal plate.
    1) Pull seal plate with 2 screw (M3).
11. Take out thrust bearing.
    1) Push out from turbine side with copper bar or wood bar.
12. Take out thrust bushing.
13. Take out retaining ring.
    1) With circlip pliers.
14. Take out journal bearing.

5-3 Reassembly

1. Preparation.
   1) Followings are prepared.
      (1) Liquid gasket (ex. Three Bond No. 1215)
      (2) Anti-loosing agent (ex. Lock Tight)

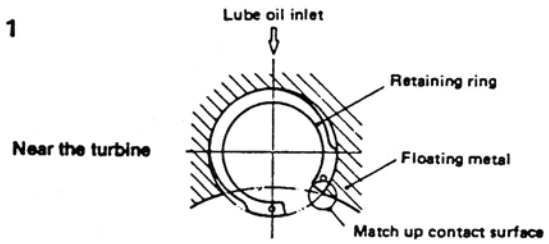
NOTE:

Following parts should be used new ones.

(1) All seal rings.	(5) Journal bearings.
(2) All screws and bolts.	(6) Thrust bearings.
(3) Toothed lock washers.	(7) All clamps.
(4) E-type retaining ring.	(8) Retaining rings.

2. Assemble journal bearing. (Turbine side)
   1) Lubricate bearing with clean engine oil.
3. Assemble retaining ring. (Turbine side)
   1) Push the ring with a finger or stick.
   2) The opening of the ring should be fitted in correct direction as shown in Fig. 1.

Fig. 1



Viewed from blower (compressor) side (B3)
Viewed from turbo. turbine side (B5)

NOTE:

Make sure that the ring is well fitted in the groove.

Bevelled edge of the ring should be fitted towards bearing.

The opening direction as shown in Fig. 1 is applied to the only one ring nearest turbine.
The others are towards oil outlet side.

4. Assemble heat protector.
5. Fit seal ring into groove of turbine shaft.
   1) Carefully fit new one.
6. Assemble turbine wheel and shaft.
   1) The opening of the seal ring should be fitted towards the side of oil inlet port.
   2) Turbine and shaft should be pushed with a snap.
   3) Place the assembled unit keeping the wheel down.
7. Assemble journal bearing. (Compressor side).
8. Assemble thrust bushing.

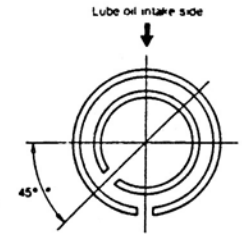
NOTE:

Make sure the direction.

9. Assemble thrust bearing.
   1) Lubricate the bearing with clean engine oil.
   2) Anti-loosening agent should be fitted on the screw.
   3) Screw tightening torque. 13± 1 Kg-cm.
10. Fit seal ring into grooves of oil thrower.
    1) Carefully fit new ones.

11. Assemble oil thrower into seal plate.
    1) The opening of these rings should be fitted in correct position as shown in Fig. 2.
    2) Oil thrower had better to push strongly with a snap.

Fig.2



Looking from compressor side

12. Assemble seal plate.
    1) Coat sealing liquid on the surface of bearing housing.
       Thickness of liquid is estimated 0.1 – 0.2 mm.
    2) Before fitting screws, turn the plate a little.
    3) Screw tightening torque: 13 ± 1 Kg-cm.
    4) Anti-loosening agent should be fitted on the screws.
13. Assemble compressor wheel.
    1) Tighten the lock nut in this case, the mate marks on the nuts and compressor wheel shall be aligned with that marks on the turbine shaft end.
    2) Tightening torque: 20 ± 2 Kg-cm.
       (RH B3: 10±1 kg-cm)
    3) Confirm the rotor rotate smoothly, by hand, after tightening the unit.

NOTE:
Left handed screw.

14. Assemble turbine housing.
    1) When parts are renewed, locating of oil inlet/outlet and exhaust gas inlet should be confirmed.
    2) Tightening torque: 285±10 Kg-cm (M8) or 125±5 Kg-cm (M6)

NOTE:
Bolt is made of heat resistant steel.
Be carefull not to mix them with others.

15. Assemble compressor housing.
    1) Fit the sealing liquid on the frange of bearing housing.
    2) Turn the compressor housing a little, after fitting.
    3) Tightening torque: 45 ± 5 Kg-cm.
16. Assemble W/G actuator.
    1) Tightening torque: 45 ± 5 Kg-cm

NOTE:
Don't forget to fit the E-type retaining ring.

17. Assemble hose for W/G actuator.
18. Confirmation.
    1) Play in axcial direction of rotor.
    2) Play in radial direction of rotor.

5-4 Reassembly of the waste gate actuator

1. Details of reassembly procedure

1-1 Waste gate actuator is to be reassembled on compressor housing with two or three bolts.

Tightening torque is 45 ± 5 kg-cm.

1-2 Put the turbocharger on surface plate with gas inlet flange turning down

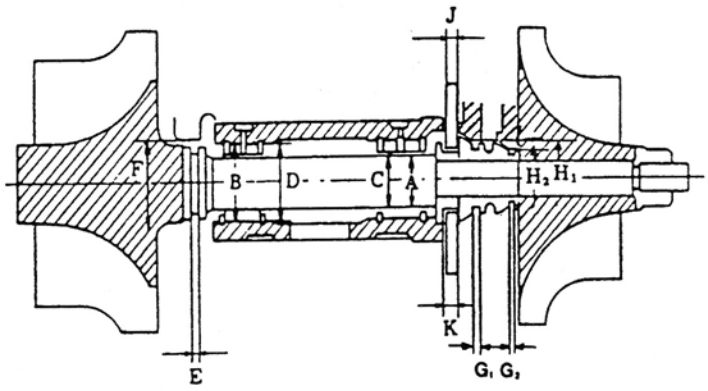
1-3 Set the dial-gauge perpendicular to rod end in order to measure the stroke.

1-4 Supply air pressure through boost pressure port and measure air pressure with 2 mm and 4 mm strokes. The pressure value is to be as follow:
Pressure at 2 mm stroke is to be less than 592 mmHg.

1-5 If air pressure values are higher than those mentioned above, diaassemble actuator again and reassemble with spacer plate(s) between actuator and compressor housing.

1-6 Confirm that retaining ring is locking rod end with link plate.

6. Service Standard



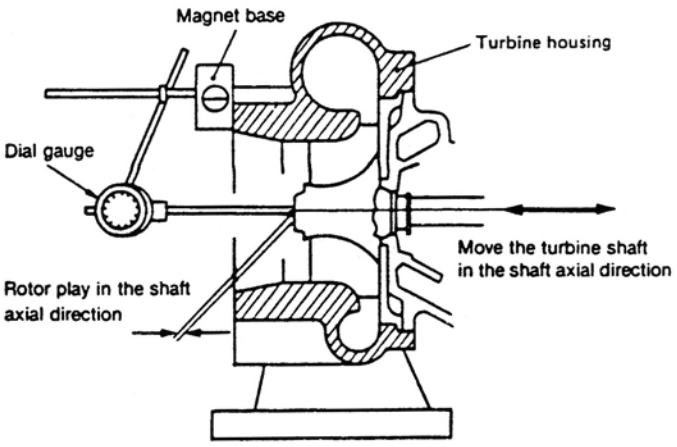
mm

	Items to check		Standard	Wear limit
Turbine shaft	Turbine shaft journal outer dia. (A)		7.99 ~ 8.00 (6.257 – 6.263)	7.980 (6.25)
	Turbine side seal ring groove width (E)		1.25 ~ 1.28 (1.038 - 1.062)	1.290 (1.07)
	Compressor side oil thrower groove width	(G_1)	1.22 ~ 1.23 (1.02 - 1.03)	1.310 (1.04)
		(G_2)	1.02 ~ 1.03 (0.82 - 0.83)	1.110 (0.84)
	Deflection of turbine shaft		0.01 (0.002)	0.011 (0.005)
Bearing	Journal bearing inner dia. (C)		8.01 ~ 8.03 (6.275 - 6.285)	8.040 (6.29)
	Journal bearing inner dia. (D)		12.32 ~ 12.33 (9.940 - 9.946)	12.310 (9.93)
	Bearing housing inner dia. (B)		12.40 ~ 12.41 (9.995 – 10.005)	12.420 (10.01)
Thrust bearing	Thrust bearing width (J)		3.99 ~ 4.01 (3.59 - 3.61)	3.980 (3.58)
	Thrust bushing groove dimension (K)		4.04 ~ 4.05 (3.632 – 3.642)	4.070 (3.65)
Seal ring fixing area	Turbine side (bearing housing) (F)		15.00 ~ 15.02 (11.00 – 11.018)	15.050 (11.03)
	Compressor side (seal plate)	(H_1)	12.40 ~ 12.42 (9.987 - 10.025)	12.450 (10.04)
		(H_2)	10.00 ~ 10.02 (7.968 - 8.00)	10.050 (0.3956)
Play of rotor in shaft axial direction			0.03 ~ 0.06 (0.022 - 0.053)	0.090 (0.07)
Play of rotor in radial direction			0.08 ~ 0.13 (0.061 - 0.093)	0.170 (0.12)

NOTE: Model RH B31 values are shown in parenthesis.

7. Checking of rotor play

(1) Play in axial direction

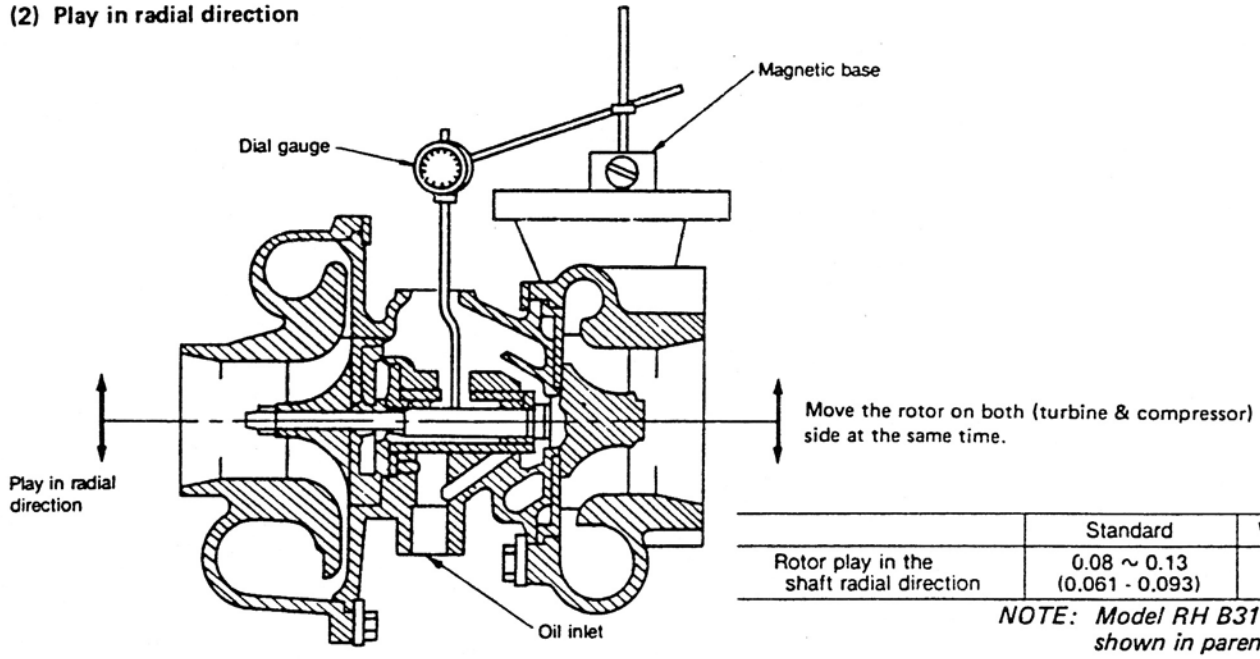


mm

	Standard	Wear limit
Rotor play in shaft axial direction	0.03 – 0.06 (0.022 – 0.053)	0.09 (0.07)

NOTE: Model RH B31 values are shown in parenthesis.

(2) Play in radial direction

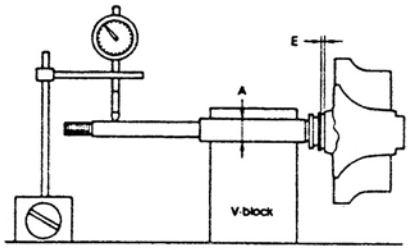


	Standard	Wear limit
Rotor play in the shaft radial direction	0.08 ~ 0.13 (0.061 - 0.093)	0.17 (0.120)

NOTE: Model RH B31 values are shown in parenthesis.

8 Inspection of oil seals

(1) Turbine wheel and shaft

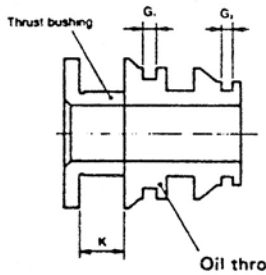


mm

		Wear limit
Journal outer dia.	A	7.98 (6.25)
Seal ring groove width	E	1.29 (1.07)

NOTE: Model RH B31 values are shown in parenthesis.

(2) Thrust bushing



mm

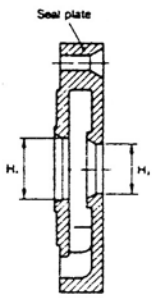
		Wear limit
Thrust bush groove clearance	K	4.07 (3.65)

mm

		Wear limit
Seal ring groove width	G_1	1.31 (1.04)
	G_2	1.11 (0.84)

NOTE: Model RH B31 values are shown in parenthesis.

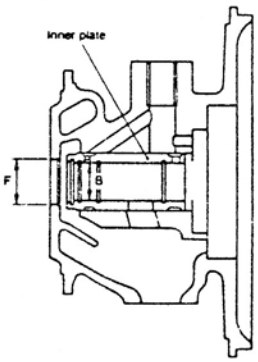
(3) Seal plate



		Wear limit
Blower side seal ring area inner dia.	H_1	12.45 (10.04)
	H_2	10.05 (8.010)

NOTE: Model RH B31 values are shown in parenthesis.

(4) Bearing housing

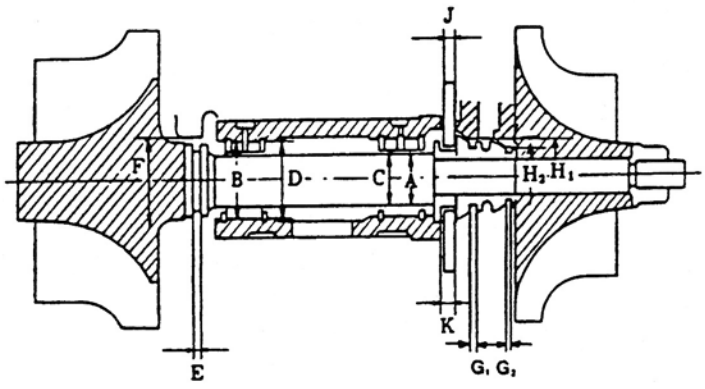


mm

		Wear limit
Bearing chamber inner dia.	B	12.42 (10.01)
Turbine side seal ring area inner dia.	F	15.05 (11.03)

NOTE: Model RH B31 values are shown in parenthesis.

9. Measuring devices



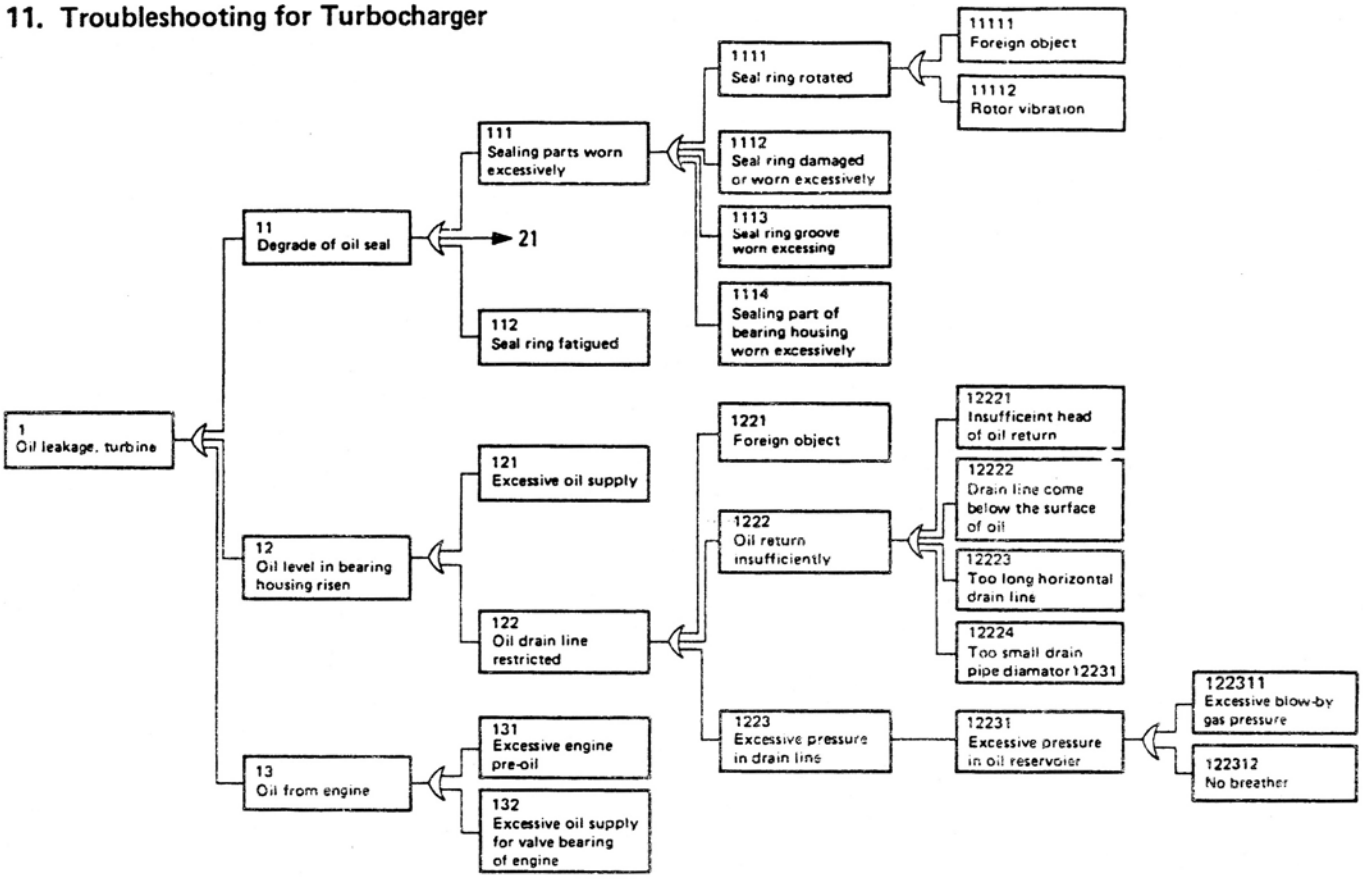
Part or location		(Symbol)	Measuring devices
Turbine shaft	Bearing journal dia.	(A)	External micrometer
	Groove width	(E)	Block gauge
	Deflection of turbine shaft		Dial indicator
Groove width of oil thrower		(G1)	Block gauge
		(G2)	Block gauge
Journal bearing	Inside dia.	(C)	Cylinder gauge
	Outside dia.	(D)	External micrometer
Bearing housing inside dia.		(B)	Cylinder gauge
Thrust bearing width		(J)	External micrometer
Thrust bushing		(K)	Block gauge
Bearing housing		(F)	Cylinder gauge
Seal plate inside dia.		(H1)	Cylinder gauge
		(H2)	Cylinder gauge
Play in axial direction			Dial indicator
Play in radial direction			Dial indicator

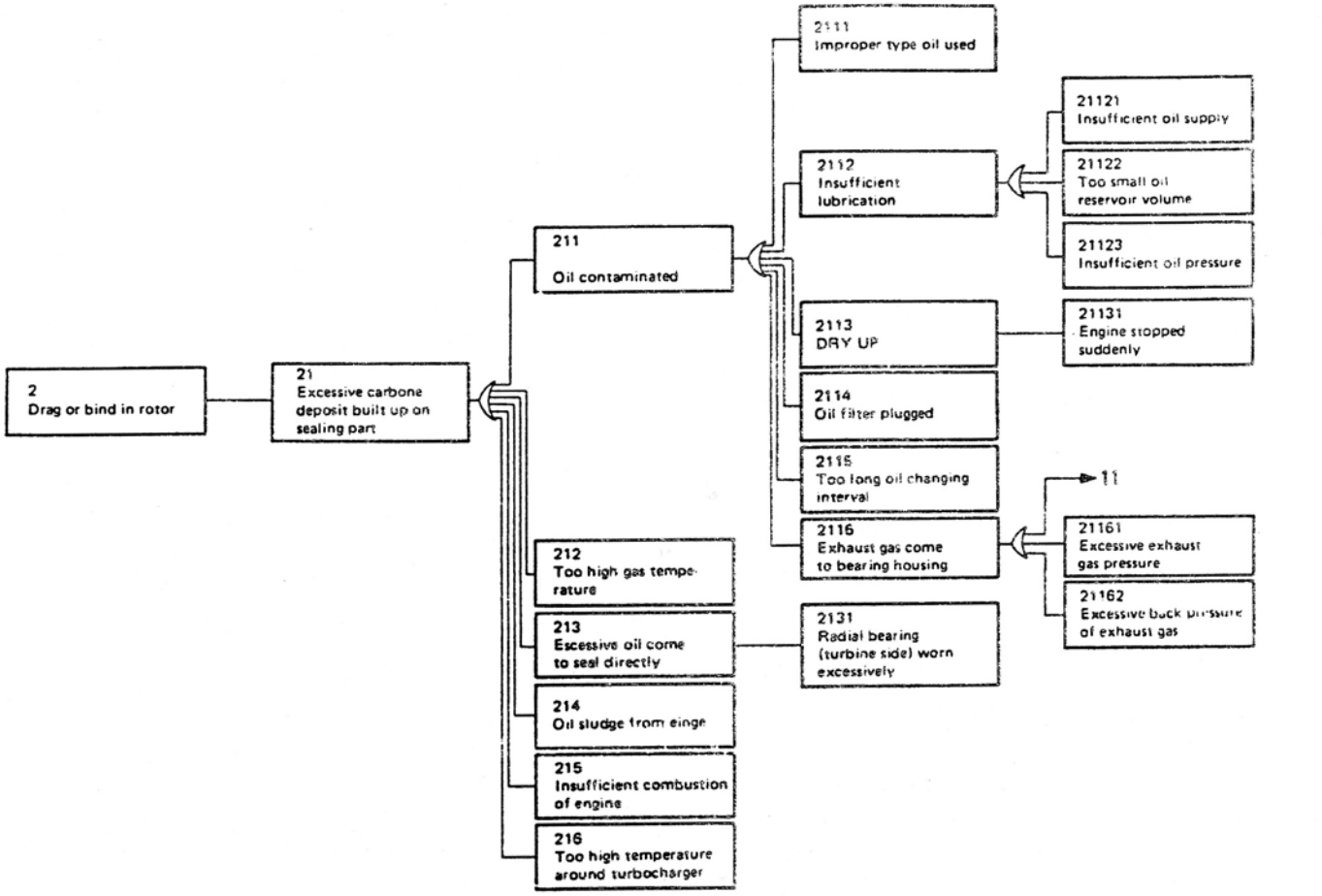
10. Washing procedure

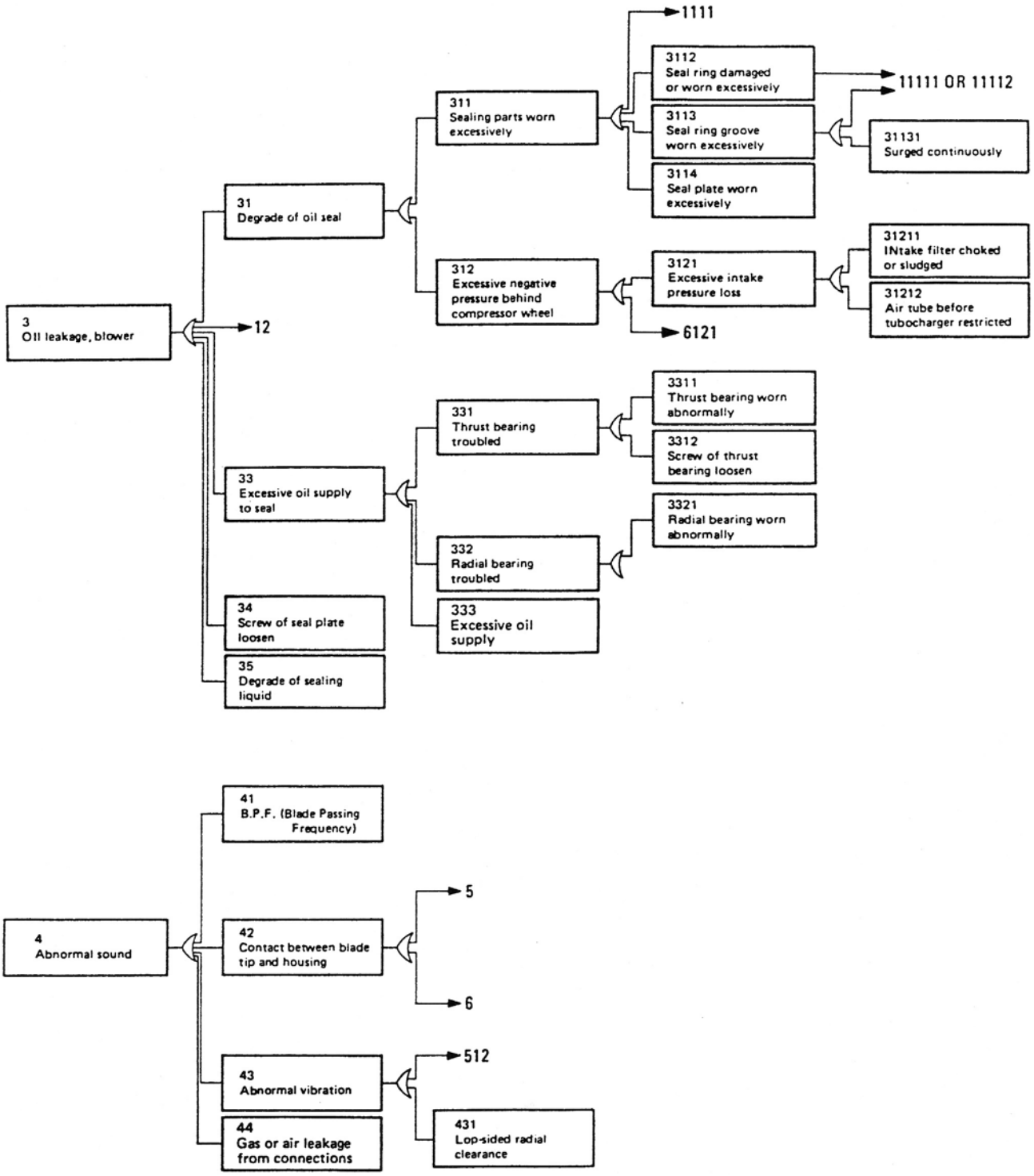
Keep the following in mind when washing the parts.

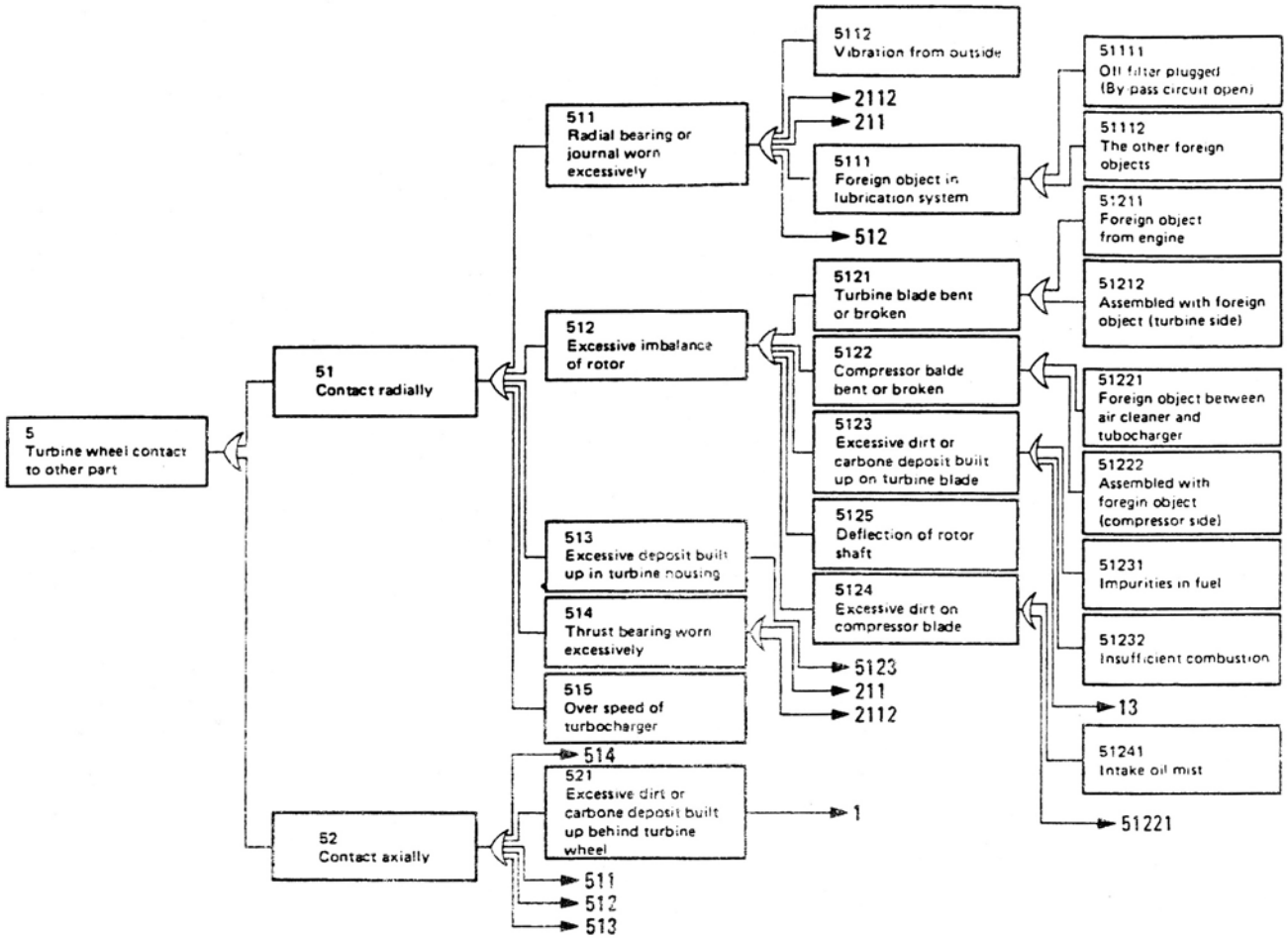
Item	Tools/Cleaning Agent	Procedure
(1) Turbine shaft	1. Tools (1) Bucket (500 × 500) (2) Heat source steam or gas burner (3) Plastic scrubber or hard hair brush 2. Cleaning agent Standard carbon removing agent	(1) Boil the turbine shaft in the washing bucket. Do not hit the blade to remove the carbon. (2) Soak in the cleaning agent until the carbon and other materials adhering to the surface become soft. (3) Use a plastic scrubber or hard hair brush to remove the softened foreign matter. (4) Be very careful not to scratch the turbine shaft bearing surface or the seal ring grooves. (5) Any foreign matter will unbalance the turbine shaft, so be sure to clean it well. Do not use a wire brush.
(2) Turbine chamber	1. Tools same as for turbine shaft 2. Cleaning agent same as for turbine shaft	(1) Boil the turbine chamber in the washing bucket. (2) Soak in the cleaning agent until all the material adhering to the surface becomes soft. (3) Use a plastic scrubber or hard hair brush to remove the foreign matter.
(3) Blower blade, blower chamber		(1) Soak in the cleaning agent until the foreign matter adhering to the surface becomes soft. (2) Use a plastic scrubber or hard hair brush to remove the softened foreign matter. Do not use a wire brush.
(4) Other parts	(1) Wash all other parts with diesel fuel oil. (2) Clean all lube oil lines with compressed air. (3) Be careful not to scratch parts or allow them to rust.	

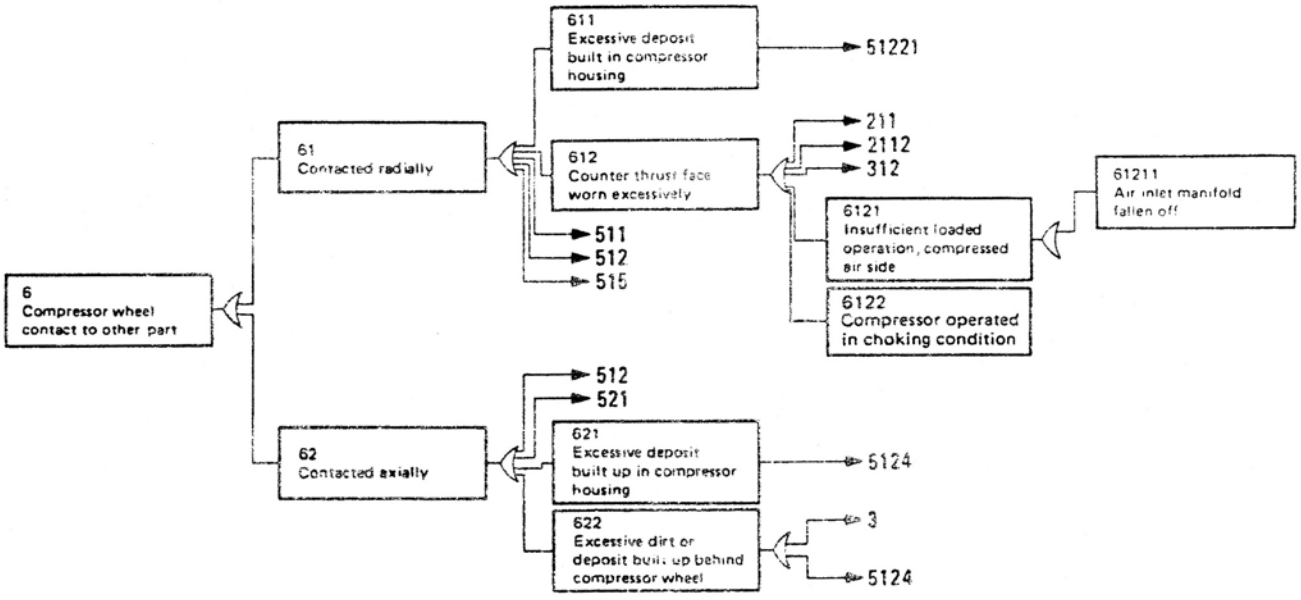
11. Troubleshooting for Turbocharger

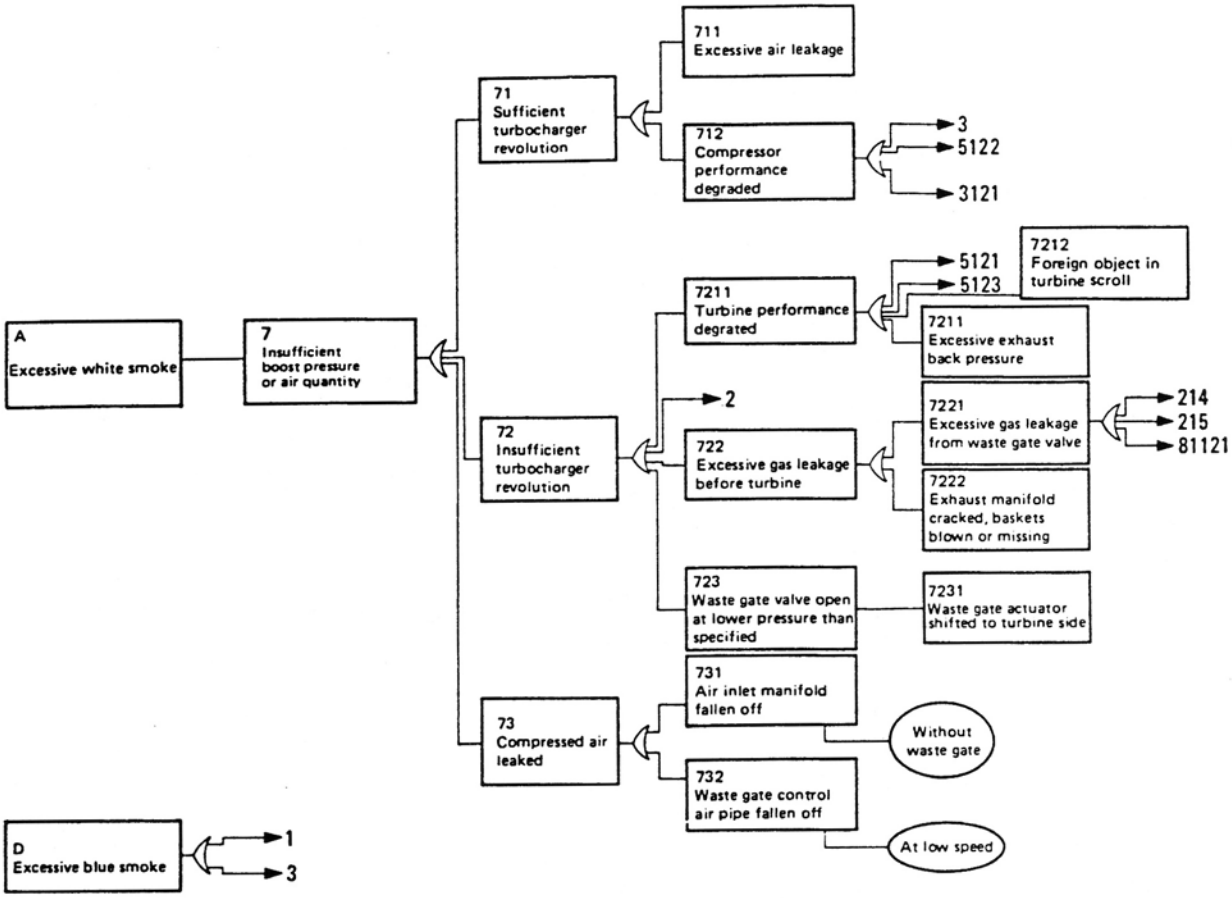


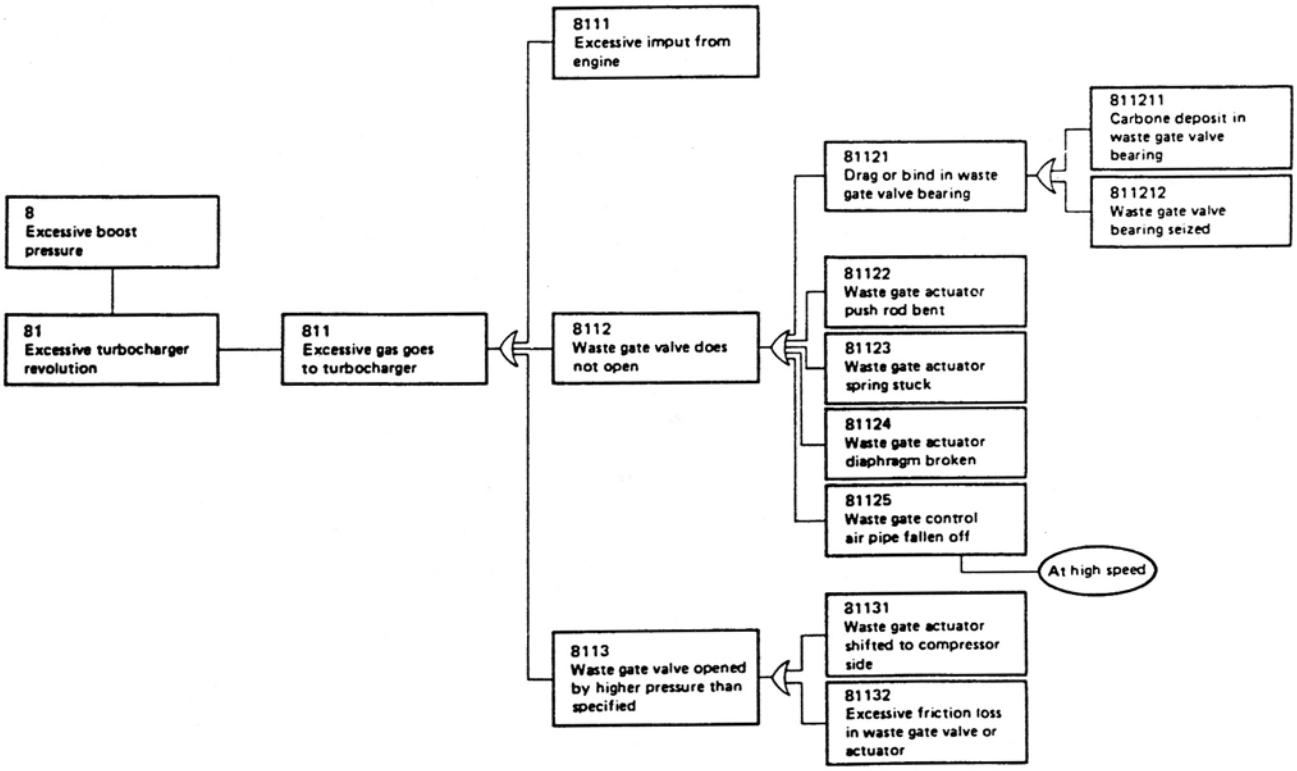


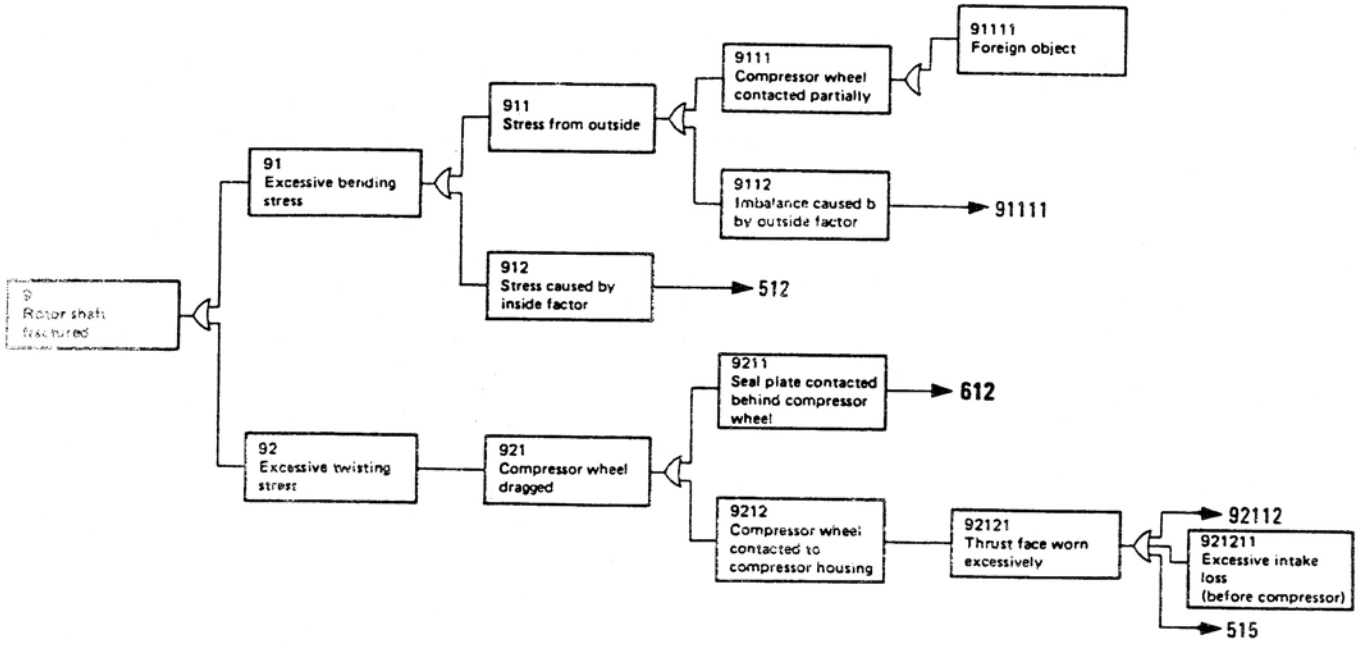

3
Oil leakage, blower
31
Degrade of oil seal
311
Sealing parts worn excessively
3112
Seal ring damaged or worn excessively
3113
Seal ring groove worn excessively
3114
Seal plate worn excessively
1111
11111 OR 11112
31131
Surged continuously
312
Excessive negative pressure behind compressor wheel
3121
Excessive intake pressure loss
31211
INtake filter choked or sludged
31212
Air tube before tubocharger restricted
6121
12
33
Excessive oil supply to seal
331
Thrust bearing troubled
3311
Thrust bearing worn abnormally
3312
Screw of thrust bearing loosen
332
Radial bearing troubled
3321
Radial bearing worn abnormally
333
Excessive oil supply
34
Screw of seal plate loosen
35
Degrade of sealing liquid
4
Abnormal sound
41
B.P.F. (Blade Passing Frequency)
42
Contact between blade tip and housing
5
6
43
Abnormal vibration
512
431
Lop-sided radial clearance
44
Gas or air leakage from connections


5
Turbine wheel contact to other part
51
Contact radially
52
Contact axially
511
Radial bearing or journal worn excessively
512
Excessive imbalance of rotor
513
Excessive deposit built up in turbine housing
514
Thrust bearing worn excessively
515
Over speed of turbocharger
521
Excessive dirt or carbone deposit built up behind turbine wheel
5112
Vibration from outside
5111
Foreign object in lubrication system
51111
Oil filter plugged (By pass circuit open)
51112
The other foreign objects
5121
Turbine blade bent or broken
5122
Compressor balde bent or broken
5123
Excessive dirt or carbone deposit built up on turbine blade
5125
Deflection of rotor shaft
5124
Excessive dirt on compressor blade
51211
Foreign object from engine
51212
Assembled with foreign object (turbine side)
51221
Foreign object between air cleaner and tubocharger
51222
Assembled with foregin object (compressor side)
51231
Impurities in fuel
51232
Insufficient combustion
51241
Intake oil mist
2112
211
512
5123
211
2112
514
1
511
512
513
13
51221


6
Compressor wheel contact to other part
61
Contacted radially
62
Contacted axially
611
Excessive deposit built in compressor housing
612
Counter thrust face worn excessively
621
Excessive deposit built up in compressor housing
622
Excessive dirt or deposit built up behind compressor wheel
6121
Insufficient loaded operation, compressed air side
6122
Compressor operated in choking condition
61211
Air inlet manifold fallen off
51221
211
2112
312
511
512
515
512
521
5124
3
5124

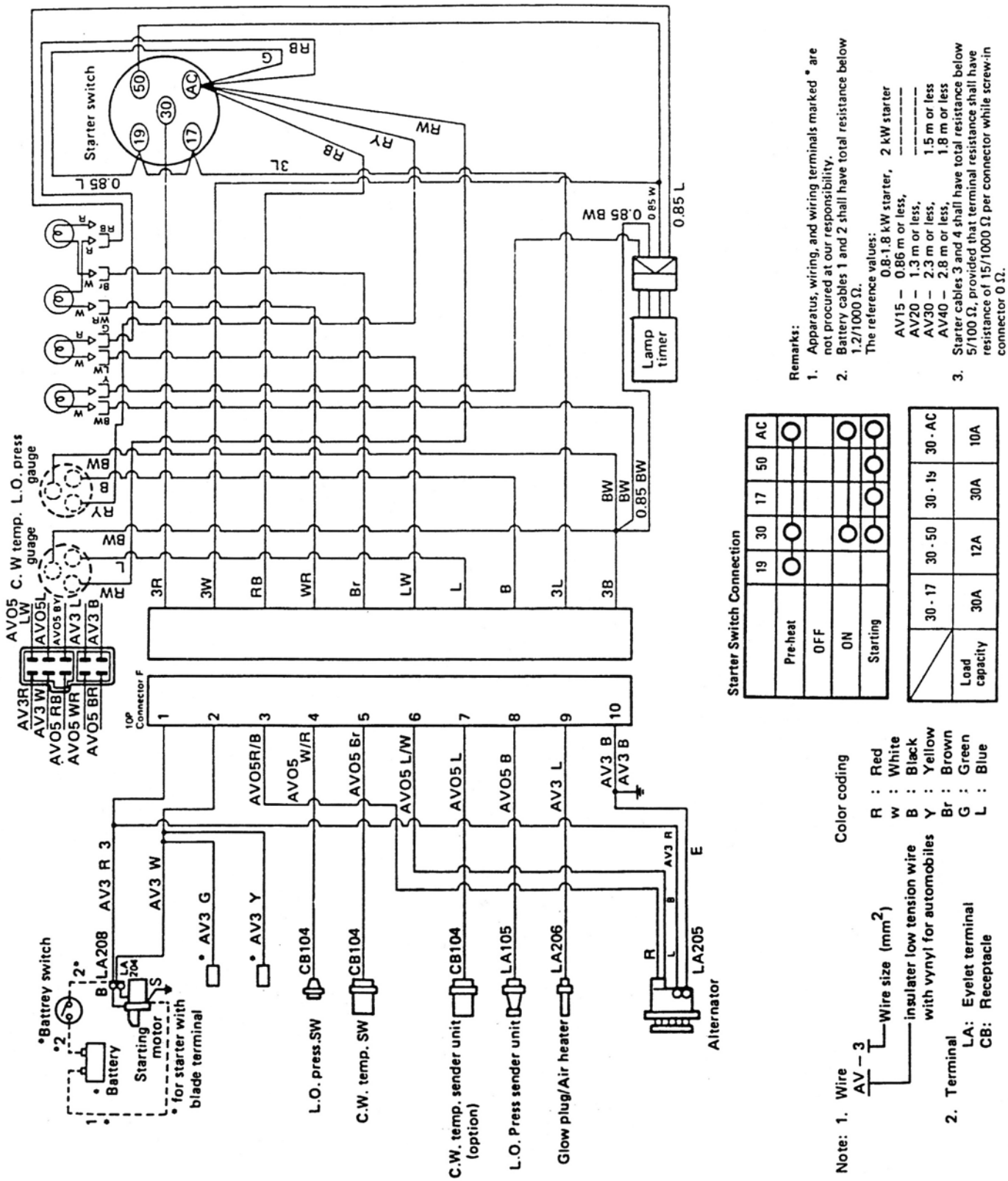

A
Excessive white smoke
7
Insufficient boost pressure or air quantity
71
Sufficient turbocharger revolution
711
Excessive air leakage
712
Compressor performance degraded
3
5122
3121
72
Insufficient turbocharger revolution
7211
Turbine performance degrated
5121
5123
7212
Foreign object in turbine scroll
7211
Excessive exhaust back pressure
2
722
Excessive gas leakage before turbine
7221
Excessive gas leakage from waste gate valve
214
215
81121
7222
Exhaust manifold cracked, baskets blown or missing
723
Waste gate valve open at lower pressure than specified
7231
Waste gate actuator shifted to turbine side
73
Compressed air leaked
731
Air inlet manifold fallen off
Without waste gate
732
Waste gate control air pipe fallen off
At low speed
D
Excessive blue smoke
1
3


8
Excessive boost pressure
81
Excessive turbocharger revolution
811
Excessive gas goes to turbocharger
8111
Excessive imput from engine
8112
Waste gate valve does not open
81121
Drag or bind in waste gate valve bearing
811211
Carbone deposit in waste gate valve bearing
811212
Waste gate valve bearing seized
81122
Waste gate actuator push rod bent
81123
Waste gate actuator spring stuck
81124
Waste gate actuator diaphragm broken
81125
Waste gate control air pipe fallen off
At high speed
8113
Waste gate valve opened by higher pressure than specified
81131
Waste gate actuator shifted to compressor side
81132
Excessive friction loss in waste gate valve or actuator


9
Rotor shaft fractured
91
Excessive bending stress
911
Stress from outside
9111
Compressor wheel contacted partially
91111
Foreign object
9112
Imbalance caused b by outside factor
91111
912
Stress caused by inside factor
512
92
Excessive twisting stress
921
Compressor wheel dragged
9211
Seal plate contacted behind compressor wheel
612
9212
Compressor wheel contacted to compressor housing
92121
Thrust face worn excessively
92112
921211
Excessive intake loss (before compressor)
515

1. Wiring Diagram

The electrical parts is composed of the starter motor, starting aid units, alternator and safety system. Wiring diagram shows as below.



Starter Switch Connection

	19	30	17	50	AC
Pre-heat	○	○			○
OFF					
ON		○		○	○
Starting		○		○	○

	30 - 17	30 - 50	30 - 19	30 - AC
Load capacity	30A	12A	30A	10A

Remarks:

1. Apparatus, wiring, and wiring terminals marked * are not procured at our responsibility.
2. Battery cables 1 and 2 shall have total resistance below 1.2/1000 Ω.
   The reference values:
   0.8-1.8 kW starter, 2 kW starter
   AV15 – 0.86 m or less, ---
   AV20 – 1.3 m or less, ---
   AV30 – 2.3 m or less, 1.5 m or less
   AV40 – 2.8 m or less, 1.8 m or less
3. Starter cables 3 and 4 shall have total resistance below 5/100 Ω, provided that terminal resistance shall have resistance of 15/1000 Ω per connector while screw-in connector 0 Ω.

Color coding

R : Red
w : White
B : Black
Y : Yellow
Br : Brown
G : Green
L : Blue

Note: 1. Wire

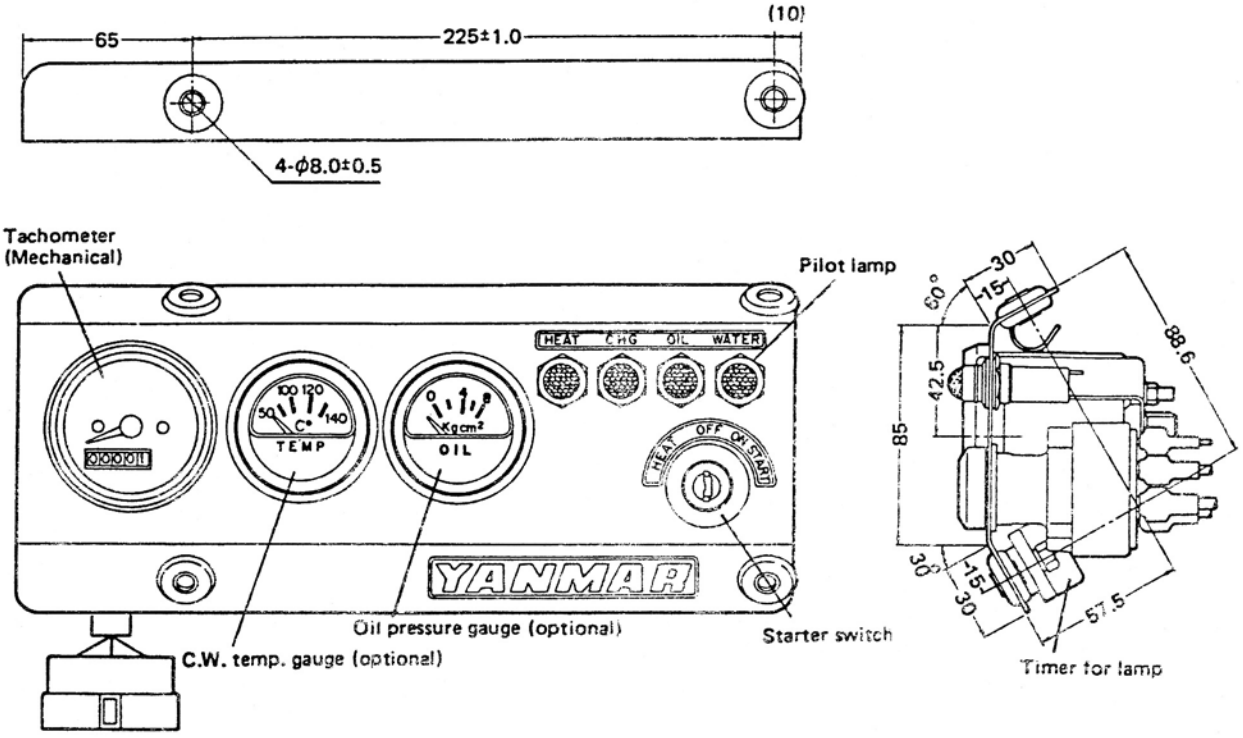
AV – 3 — Wire size (mm^2)

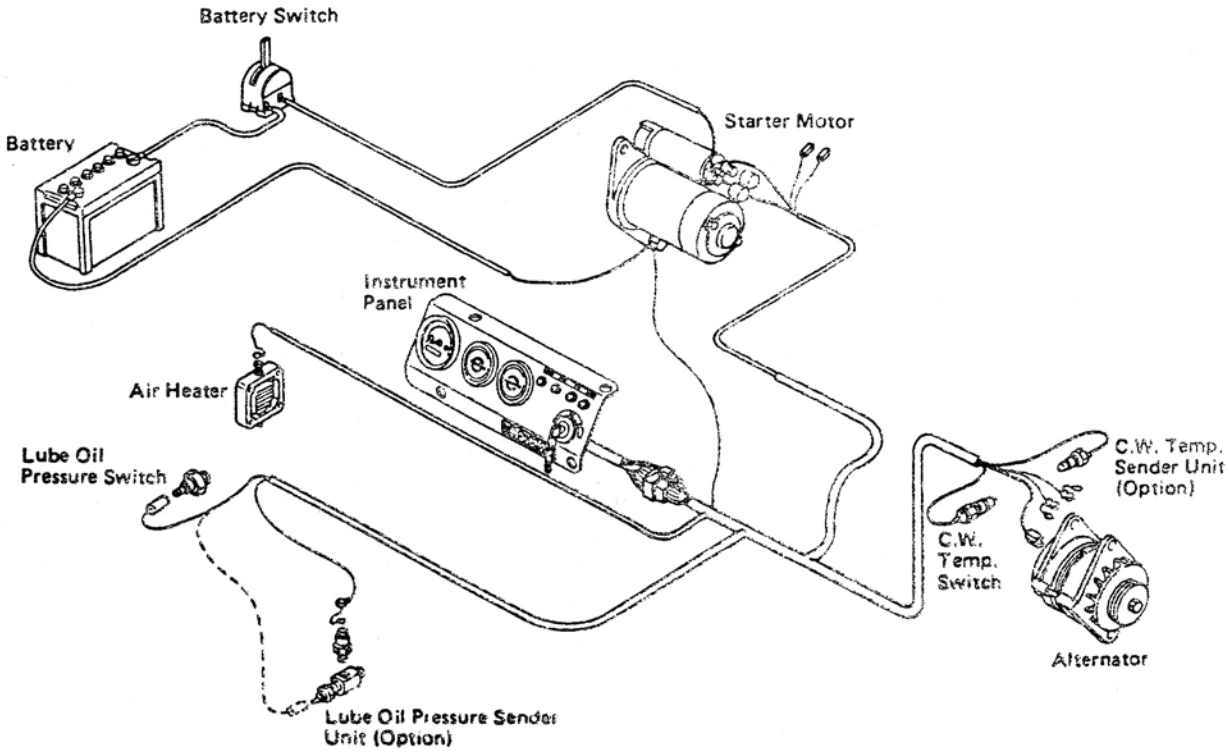
insulater low tension wire with vynyl for automobiles

2. Terminal

LA: Eyelet terminal
CB: Receptacle

Instrument Panel





Wiring Diagram Optional List

	Fig. 1	Fig. 2	Fig. 3	Fig. 4	Fig. 5	Fig. 6	Fig. 7	Fig. 8	Fig. 9	Fig. 10
Applicable Model	3TN75E, 3TNC78E, 3,4TN82(T)E, 3,4TN84(T)E					2,3TN66E, 3TNA72E		3TN66E, 3TNA72E		
Starter motor	O	O	O	O	O	O	O	O	O	O
Key switch	O	O	O	O	O	O	O	O	O	O
Generator	Magneto generator	←	←	Alternator	←	Magneto generator	←	←	Alternator	←
Regulator	O	O	O	Built-in alternator	←	O	O	O	Built-in alternator	←
Starting aids unit	Air heater 400W	Air heater 400W Timer Pilot lamp	←	Air heater 400W	Air heater 400W Timer Pilot lamp	Glow plug	Glow plug Timer Pilot lamp	←	Glow plug	Glow plug Timer Pilot lamp
Lube oil pressure switch	O	O	O	O	O	O	O	O	O	O
C.W. temperature switch	O	O	O	O	O	O	O	O	O	O
Charging indicator	X	O	O	X	X	X	O	O	X	X
Charging lamp	O	O	O	O	O	O	O	O	O	O
Safety relay	X	O	O	X	O	X	O	O	X	O
Stop solenoid	X	X	O	X	X	X	X	O	X	X
Emergency relay	X	X	O	X	X	X	X	O	X	X
Power relay	X	X	O	X	X	X	X	O	X	X

O marks: equipped
X marks: not equipment

Fig. 1

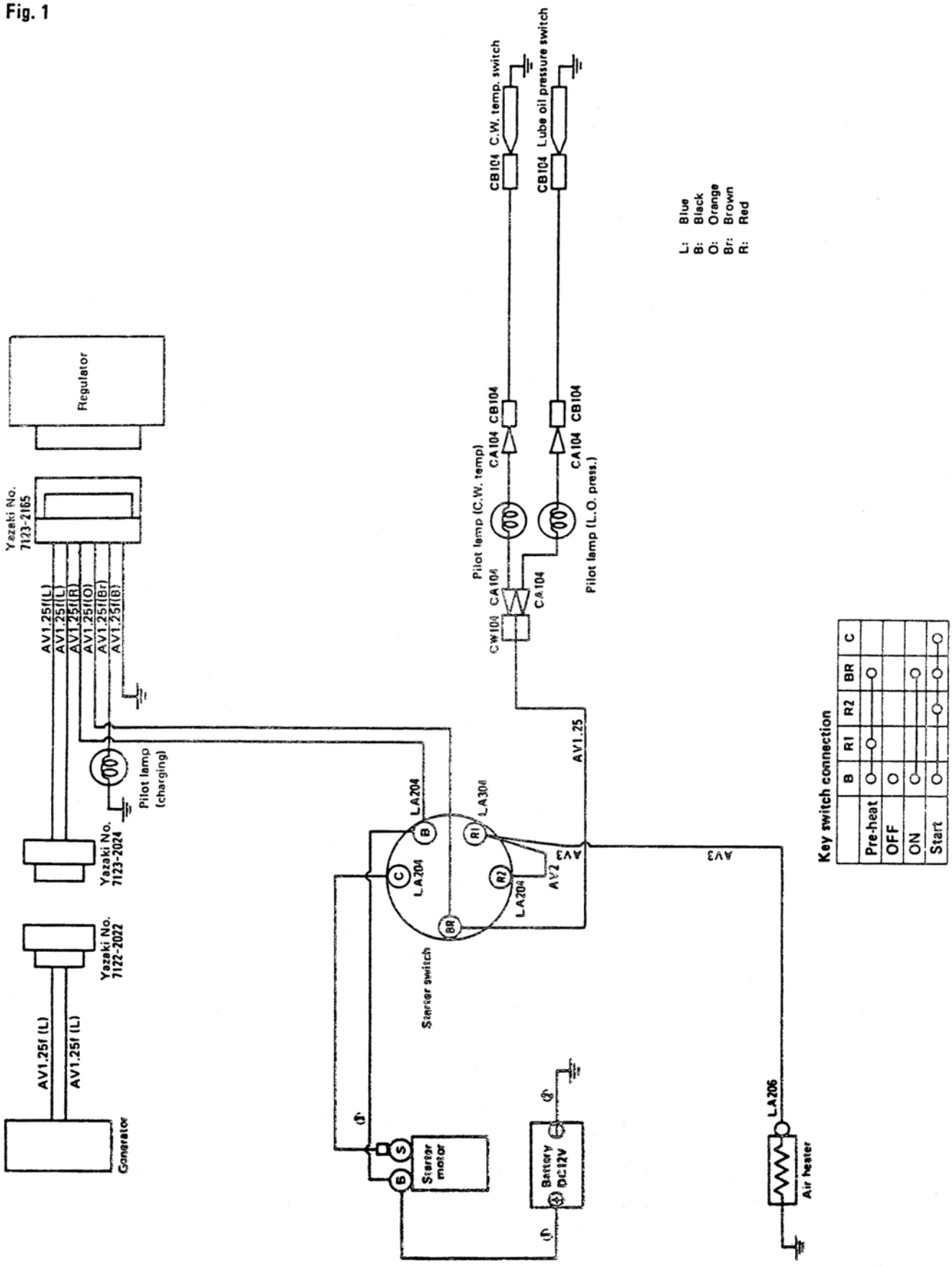

Regulator
Yazaki No. 7123-2165
AV1.25f(L)
AV1.25f(L)
AV1.25f(R)
AV1.25f(O)
AV1.25f(Br)
AV1.25f(B)
Pilot lamp (charging)
Yazaki No. 7123-2024
Yazaki No. 7122-2022
AV1.25f (L)
AV1.25f (L)
Generator
CB104 C.W. temp. switch
CB104 Lube oil pressure switch
Pilot lamp (C.W. temp)
Pilot lamp (L.O. press.)
CA104 CB104
CW104 CA104
CA104
AV1.25
LA204
LA308
AV2
AV3
Starter switch
Starter motor
Battery DC12V
LA206
Air heater
L: Blue
B: Black
O: Orange
Br: Brown
R: Red
Key switch connection
B
R1
R2
BR
C
Pre-heat
OFF
ON
Start

Fig. 2

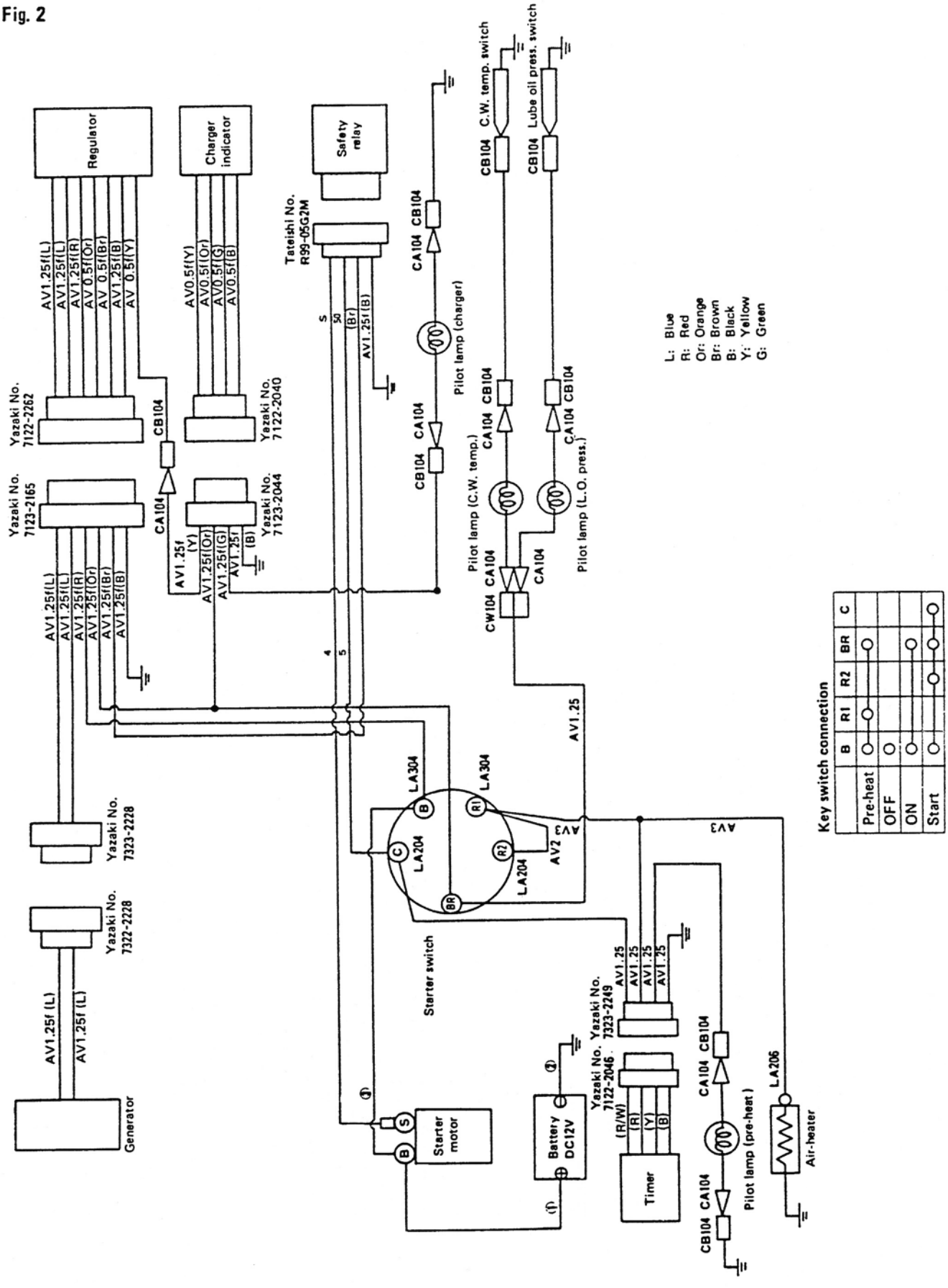

Regulator
Charger indicator
Safety relay
Tateishi No. R99-05G2M
C.W. temp. switch
Lube oil press. switch
Yazaki No. 7122-2262
Yazaki No. 7122-2040
Yazaki No. 7123-2165
Yazaki No. 7123-2044
Yazaki No. 7323-2228
Yazaki No. 7322-2228
Yazaki No. 7323-2249
Yazaki No. 7122-2046
Pilot lamp (charger)
Pilot lamp (C.W. temp.)
Pilot lamp (L.O. press.)
Pilot lamp (pre-heat)
Starter switch
Starter motor
Battery DC12V
Timer
Air-heater
Generator
L: Blue
R: Red
Or: Orange
Br: Brown
B: Black
Y: Yellow
G: Green
Key switch connection
B
R1
R2
BR
C
Pre-heat
OFF
ON
Start

Fig. 3

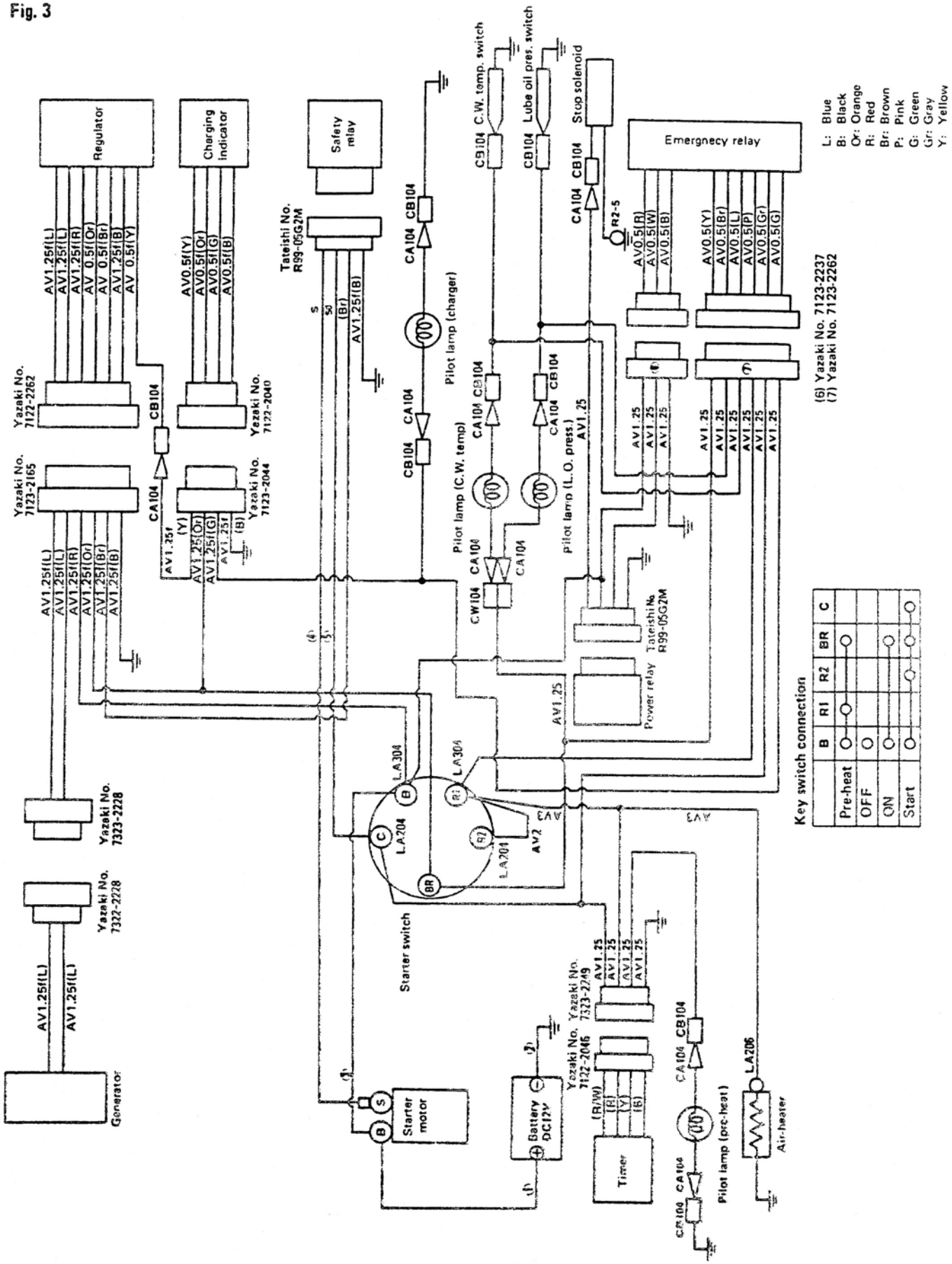

Regulator
Charging indicator
Safety relay
Emergency relay
C.W. temp. switch
Lube oil pres. switch
Stop solenoid
Pilot lamp (charger)
Pilot lamp (C.W. temp)
Pilot lamp (L.O. press.)
Power relay
Starter switch
Starter motor
Battery DC12V
Timer
Pilot lamp (pre-heat)
Air-heater
Generator
Yazaki No. 7122-2262
Yazaki No. 7123-2165
Yazaki No. 7122-2040
Yazaki No. 7123-2044
Yazaki No. 7323-2228
Yazaki No. 7322-2228
Yazaki No. 7122-2046
Yazaki No. 7323-2249
Tateishi No. R99-05G2M
(6) Yazaki No. 7123-2237
(7) Yazaki No. 7123-2262
L: Blue
B: Black
Or: Orange
R: Red
Br: Brown
P: Pink
G: Green
Gr: Gray
Y: Yellow
Key switch connection
B
R1
R2
BR
C
Pre-heat
OFF
ON
Start

Fig. 4

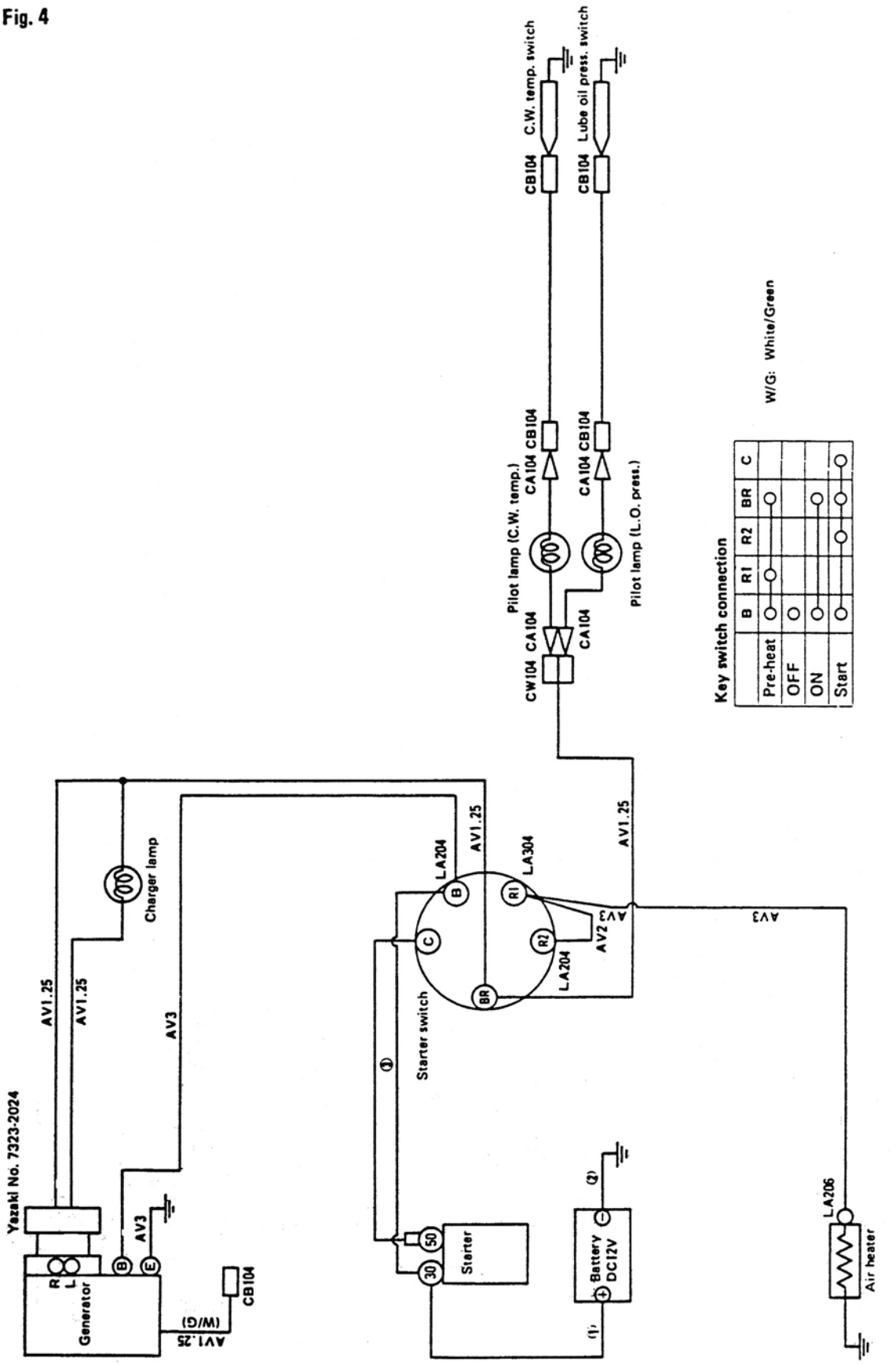

C.W. temp. switch
Lube oil press. switch
CB104
CB104
Pilot lamp (C.W. temp.)
Pilot lamp (L.O. press.)
CA104 CB104
CA104 CB104
CW104 CA104
CA104
W/G: White/Green
Key switch connection
B R1 R2 BR C
Pre-heat
OFF
ON
Start
Charger lamp
AV1.25
AV1.25
AV3
AV1.25
LA204
LA304
AV1.25
AV2
AV3
AV3
LA204
Starter switch
Yazaki No. 7323-2024
R
L
Generator
B
E
AV3
AV1.25 (W/G)
CB104
50
30
Starter
Battery DC12V
LA206
Air heater

Fig. 5

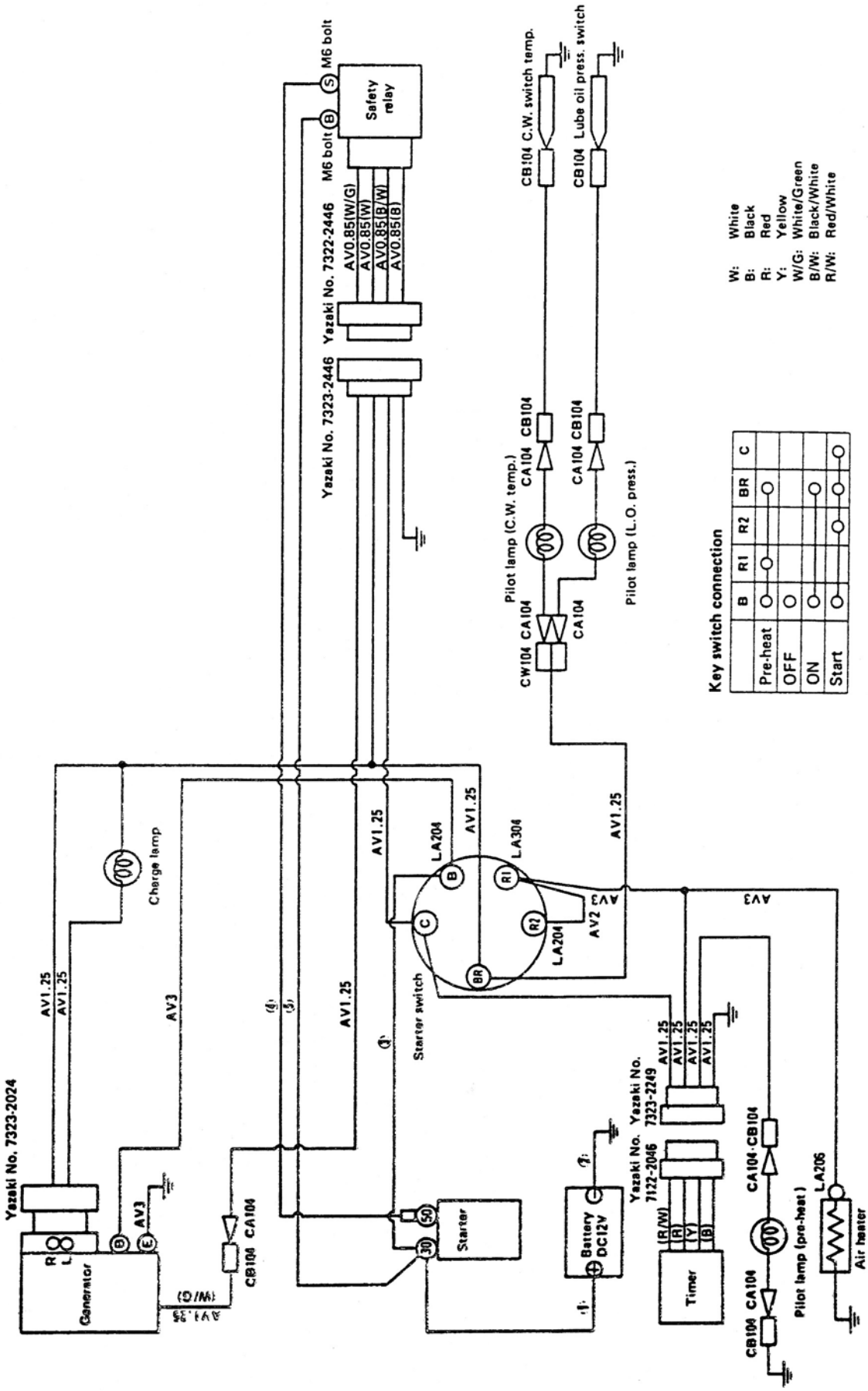

Safety relay
M6 bolt
Yazaki No. 7322-2446
Yazaki No. 7323-2446
AV0.85(W/G)
AV0.85(W)
AV0.85(B/W)
AV0.85(B)
CB104 C.W. switch temp.
CB104 Lube oil press. switch
Pilot lamp (C.W. temp.)
Pilot lamp (L.O. press.)
CW104 CA104
CA104 CB104
CA104
W: White
B: Black
R: Red
Y: Yellow
W/G: White/Green
B/W: Black/White
R/W: Red/White
Key switch connection
B R1 R2 BR C
Pre-heat
OFF
ON
Start
Charge lamp
AV1.25
AV3
LA204
LA304
AV2
Starter switch
Yazaki No. 7323-2024
Generator
R
L
CB104 CA104
Starter
Battery DC12V
Yazaki No. 7323-2249
Yazaki No. 7122-2046
Timer
(R/W)
(R)
(Y)
(B)
CA104 CB104
Pilot lamp (pre-heat)
LA206
Air heater

Fig. 6

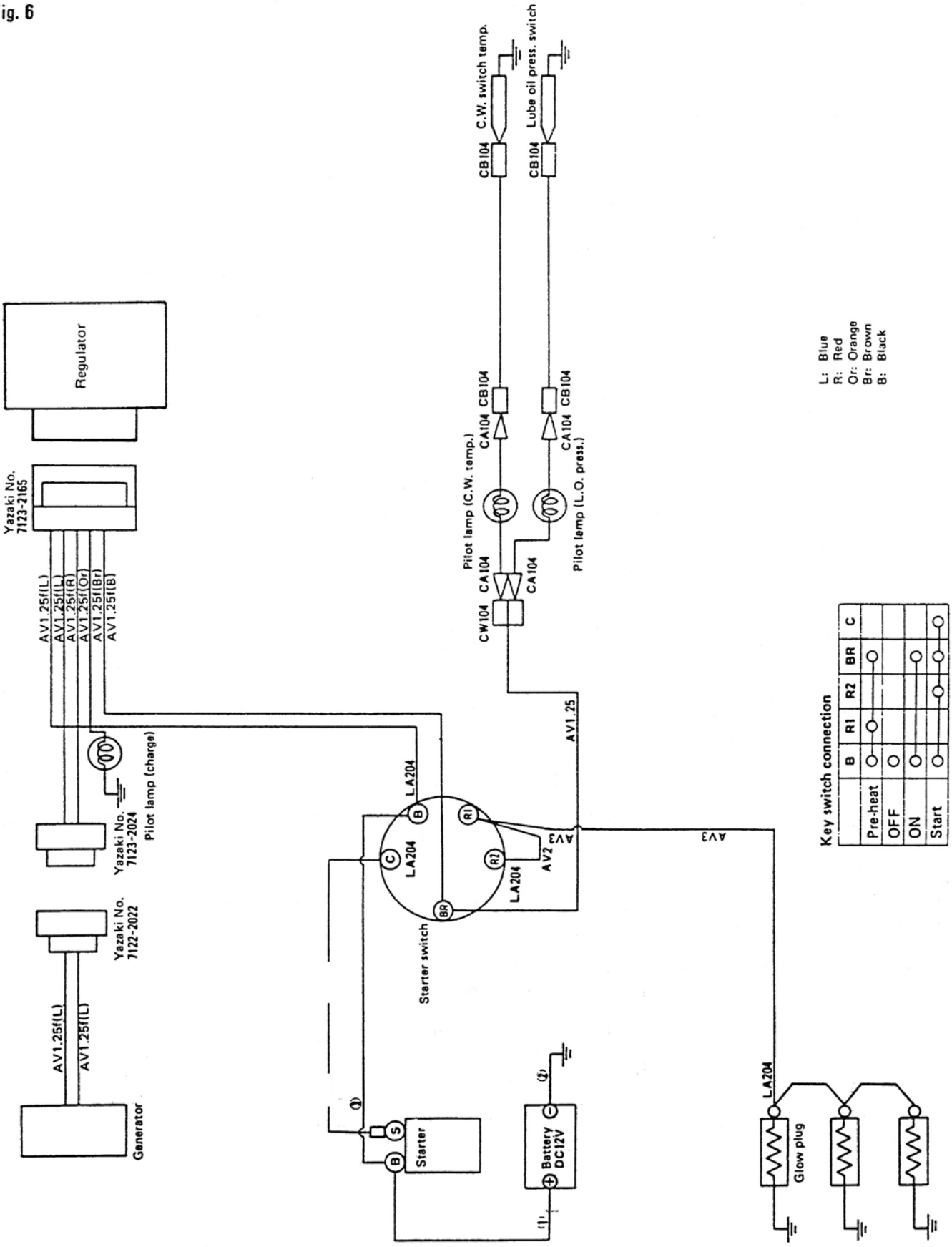

Regulator
Yazaki No. 7123-2165
AV1.25f(L)
AV1.25f(L)
AV1.25f(R)
AV1.25f(Or)
AV1.25f(Br)
AV1.25f(B)
Pilot lamp (charge)
Yazaki No. 7123-2024
Yazaki No. 7122-2022
AV1.25f(L)
AV1.25f(L)
Generator
C.W. switch temp.
Lube oil press. switch
CB104
CB104
CA104 CB104
CA104 CB104
Pilot lamp (C.W. temp.)
Pilot lamp (L.O. press.)
CA104
CA104
CW104
AV1.25
LA204
LA204
LA204
AV2
AV3
AV3
Starter switch
Starter
Battery DC12V
LA204
Glow plug
L: Blue
R: Red
Or: Orange
Br: Brown
B: Black
Key switch connection
B R1 R2 BR C
Pre-heat
OFF
ON
Start

Fig. 7

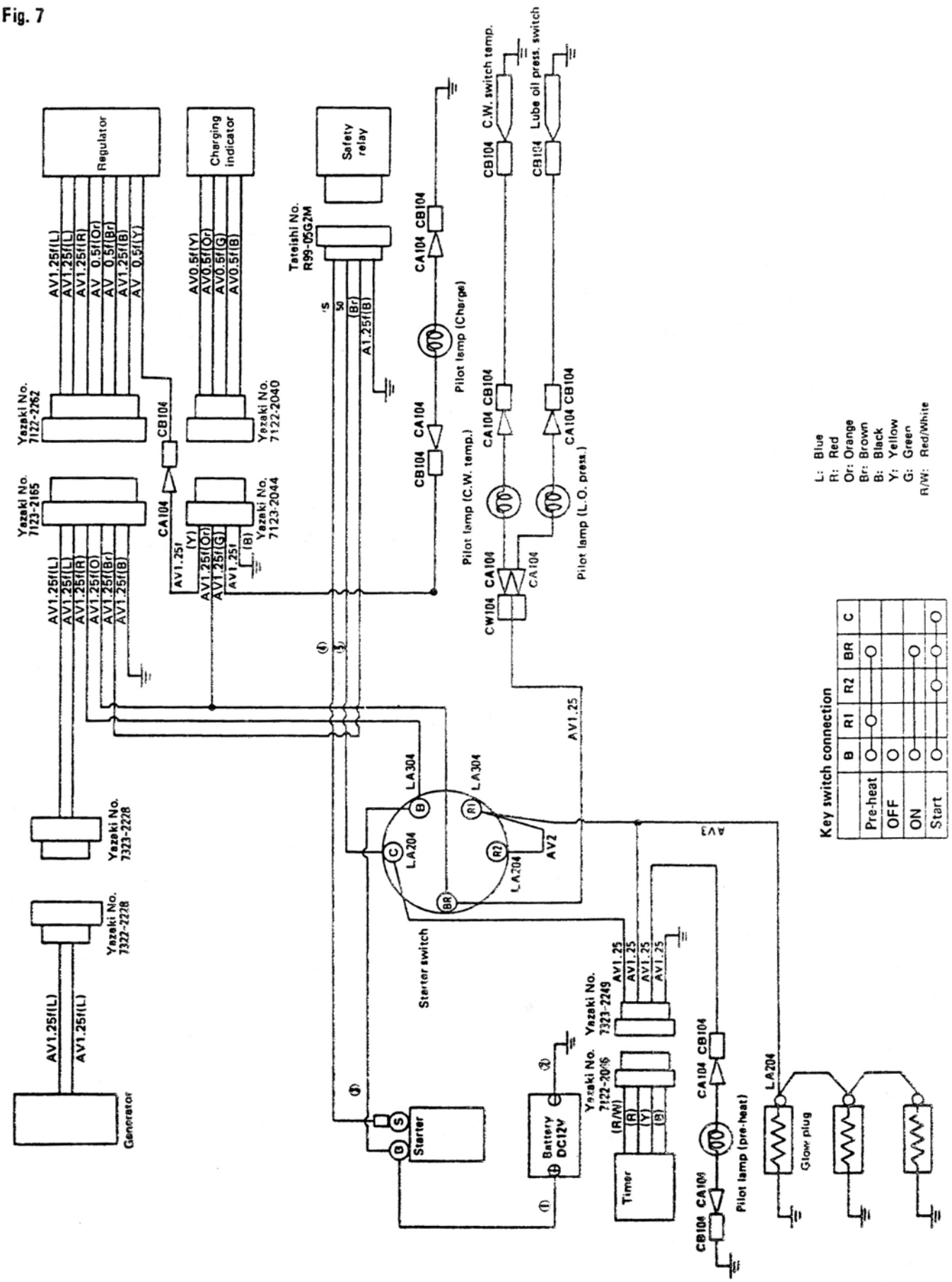

Regulator
Charging indicator
Safety relay
Tateishi No. R99-05G2M
C.W. switch temp.
Lube oil press. switch
Yazaki No. 7122-2262
Yazaki No. 7122-2040
Yazaki No. 7123-2165
Yazaki No. 7123-2044
Yazaki No. 7323-2228
Yazaki No. 7322-2228
Yazaki No. 7323-2249
Yazaki No. 7122-2046 (R/W)
CB104
CA104
CW104
LA304
LA204
AV2
AV3
AV1.25
Pilot lamp (C.W. temp.)
Pilot lamp (Charge)
Pilot lamp (L.O. press.)
Pilot lamp (pre-heat)
Starter switch
Starter
Battery DC12V
Timer
Glow plug
Generator
L: Blue
R: Red
Or: Orange
Br: Brown
B: Black
Y: Yellow
G: Green
R/W: Red/White
Key switch connection
Pre-heat
OFF
ON
Start
B
R1
R2
BR
C

Fig. 8

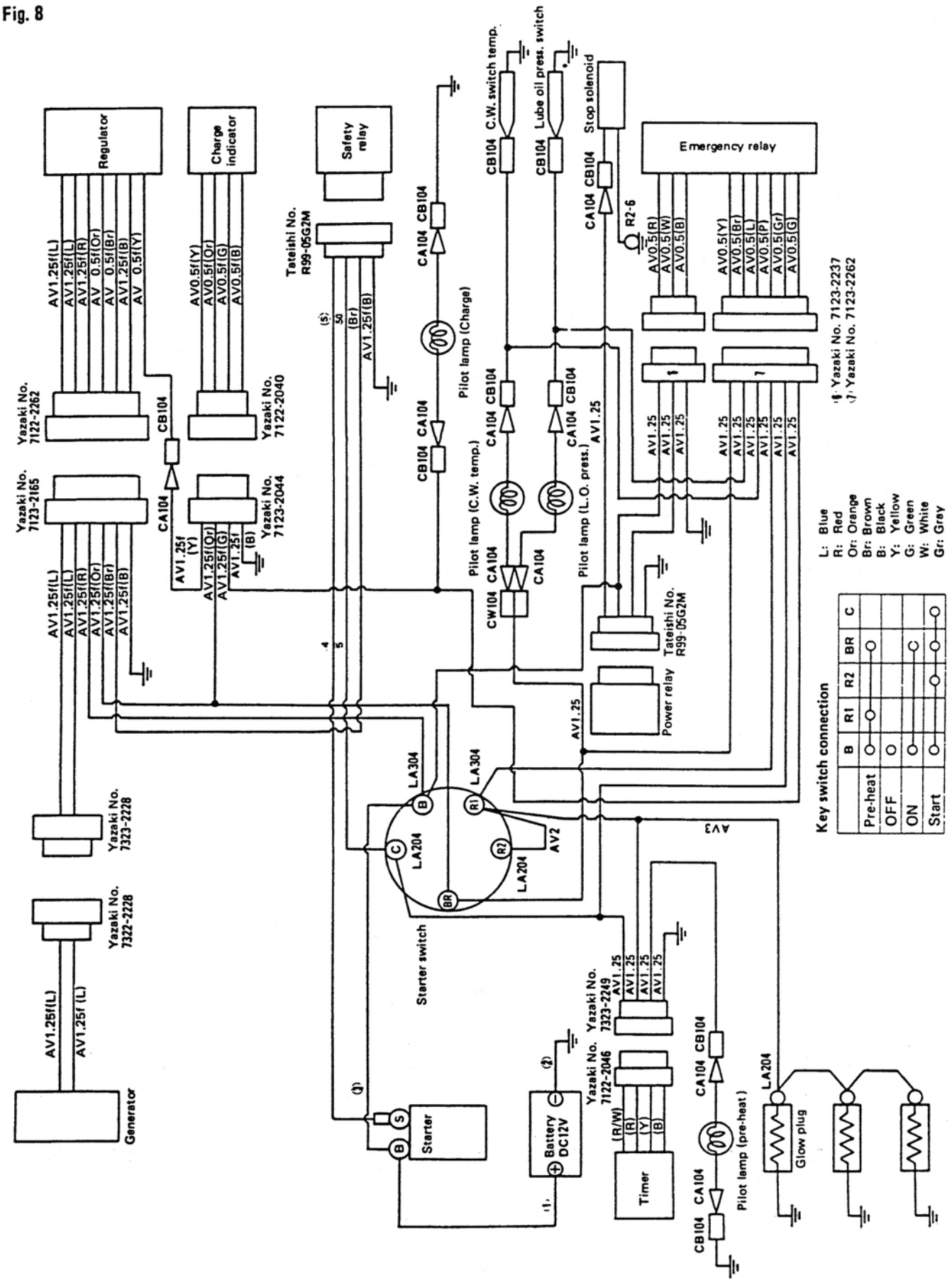

Regulator
Charge indicator
Safety relay
Emergency relay
C.W. switch temp.
Lube oil press. switch
Stop solenoid
Yazaki No. 7122-2262
Yazaki No. 7122-2040
Yazaki No. 7123-2165
Yazaki No. 7123-2044
Tateishi No. R99-05G2M
Pilot lamp (Charge)
Pilot lamp (C.W. temp.)
Pilot lamp (L.O. press.)
Power relay
Tateishi No. R99-05G2M
Yazaki No. 7123-2237
Yazaki No. 7123-2262
Yazaki No. 7323-2228
Yazaki No. 7322-2228
Generator
Starter switch
Starter
Battery DC12V
Yazaki No. 7323-2249
Yazaki No. 7122-2046
Timer
Pilot lamp (pre-heat)
Glow plug
L: Blue
R: Red
Or: Orange
Br: Brown
B: Black
Y: Yellow
G: Green
W: White
Gr: Gray
Key switch connection
Pre-heat
OFF
ON
Start

Fig. 9

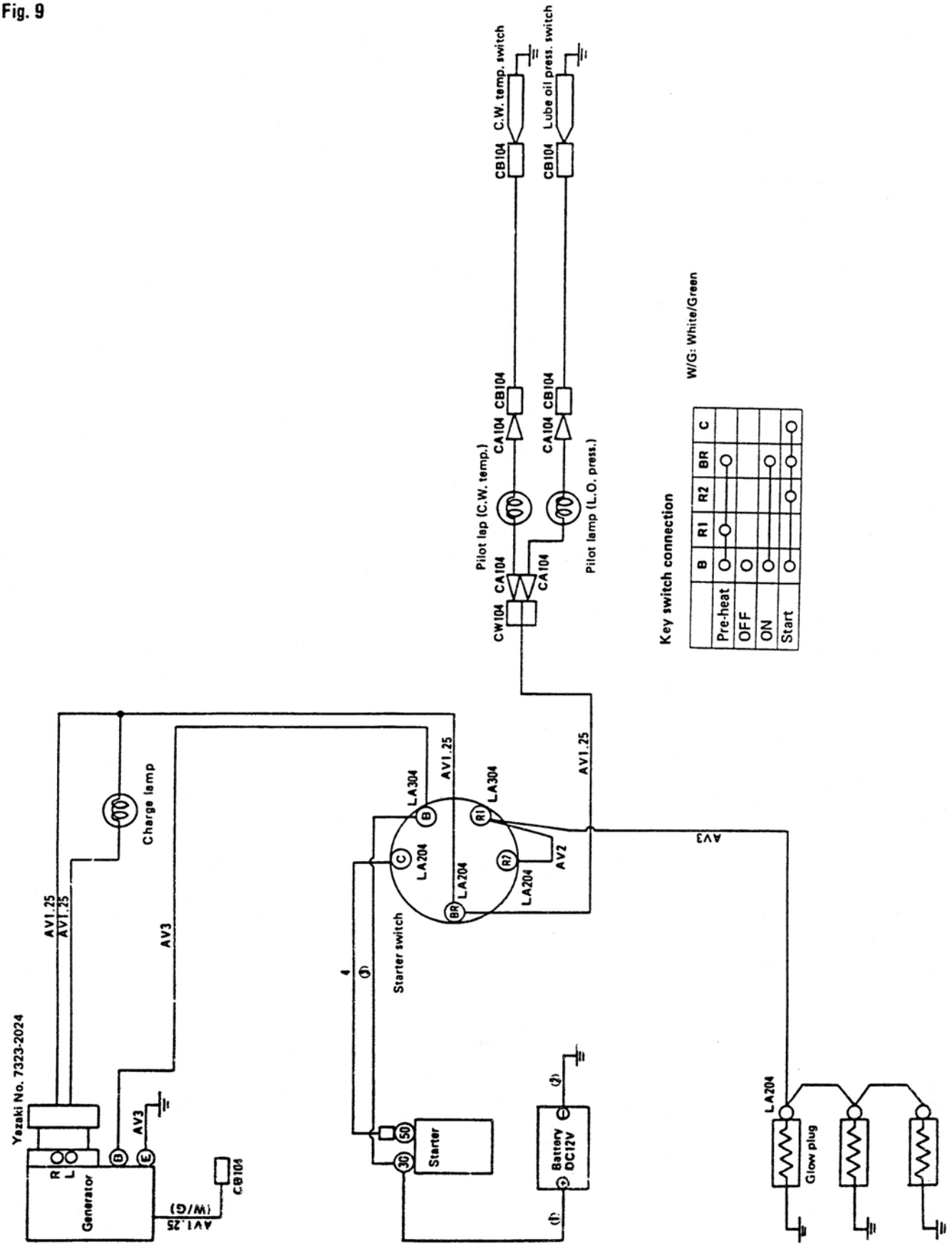
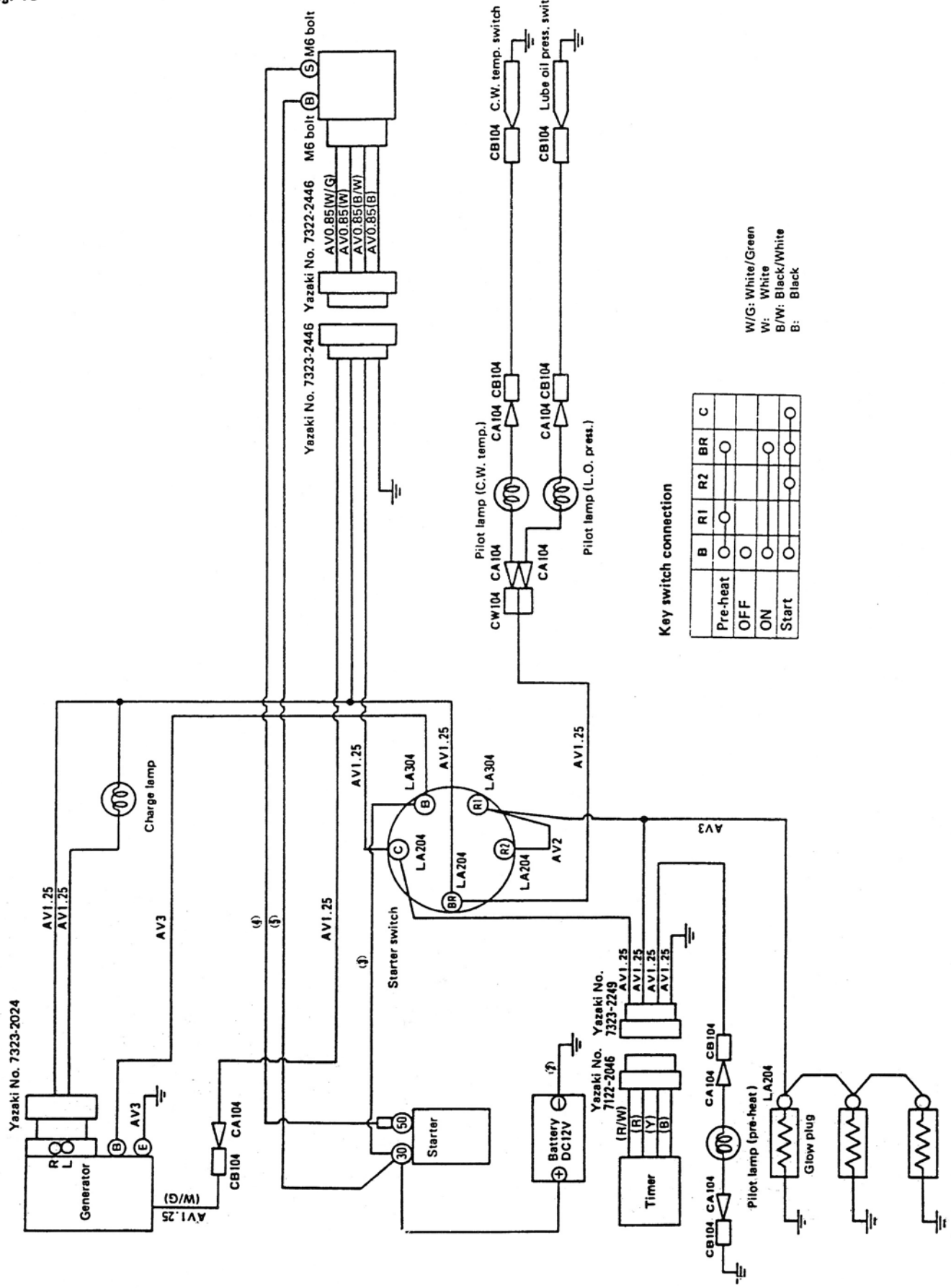

C.W. temp. switch
Lube oil press. switch
CB104
CB104
CA104 CB104
CA104 CB104
Pilot lap (C.W. temp.)
Pilot lamp (L.O. press.)
CA104
CA104
CW104 CA104
W/G: White/Green
Key switch connection
B R1 R2 BR C
Pre-heat
OFF
ON
Start
AV1.25
AV1.25
AV3
Charge lamp
LA304
LA304
AV1.25
AV1.25
LA204
LA204
LA204
AV2
AV3
Starter switch
Yazaki No. 7323-2024
R
L
Generator
AV3
(W/G)
AV1.25
CB104
Starter
Battery DC12V
LA204
Glow plug

Fig. 10


Yazaki No. 7323-2024
Generator
Charge lamp
Starter switch
Starter
Battery DC12V
Yazaki No. 7322-2446
Yazaki No. 7323-2446
M6 bolt
Yazaki No. 7323-2249
Yazaki No. 7122-2046
Timer
C.W. temp. switch
Lube oil press. switch
Pilot lamp (C.W. temp.)
Pilot lamp (L.O. press.)
Pilot lamp (pre-heat)
Glow plug
Key switch connection
Pre-heat
OFF
ON
Start
W/G: White/Green
W: White
B/W: Black/White
B: Black

2. Starter Motor

The starter motor is installed on the flywheel housing. When the starting key switch is turned on, the starter motor pinion flies out and engages the ring gear of the flywheel. Then the main contact is closed, current flows, and the engine is started.
After the engine starts, the pinion automatically returns to its initial position when the starting key switch is released. Once the engine starts, the starting key switch should be released immediately. Otherwise, the starter motor may be damaged or burned out.

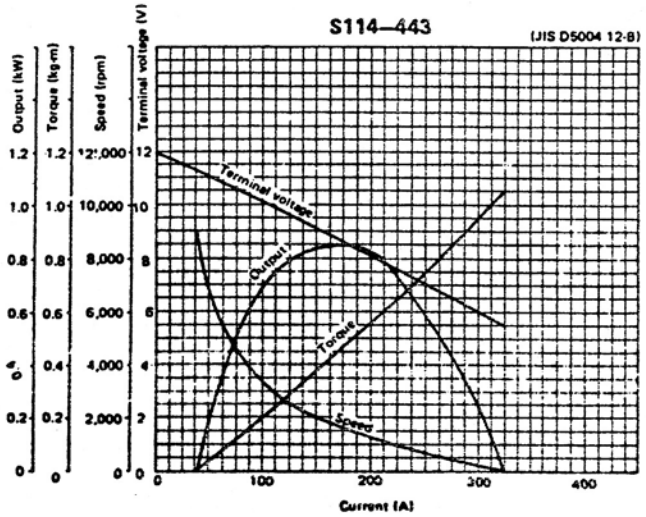
2.1 Specification and Performance.

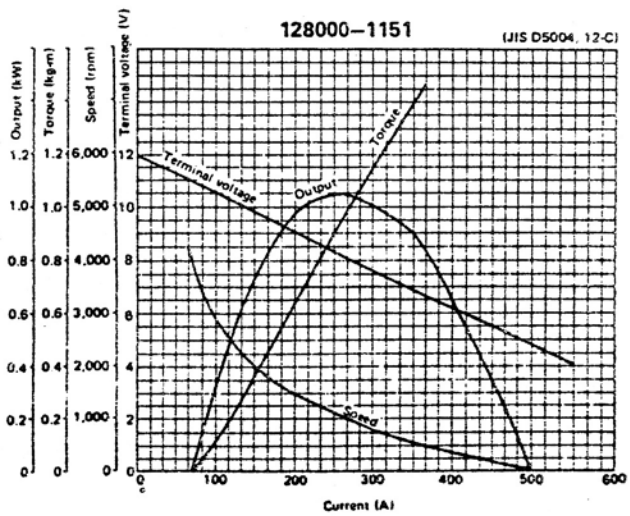
Engine model		
Model		*See separate service data (Page 7-45, 46)*
Rating (sec.)		
Output (kW)		
Direction of rotation (viewed from pinion side)		
Weight kg (lb.)		
Clutch system		
Engagement system		
No. of pinion teeth		
Pinion coming out voltage		
No-load	Terminal voltage (V)	
	Current (A)	
	Speed (rpm)	
Loaded characteristics	Terminal voltage (V)	
	Current (A)	
	Torque kg-m (ft.-lb.)	

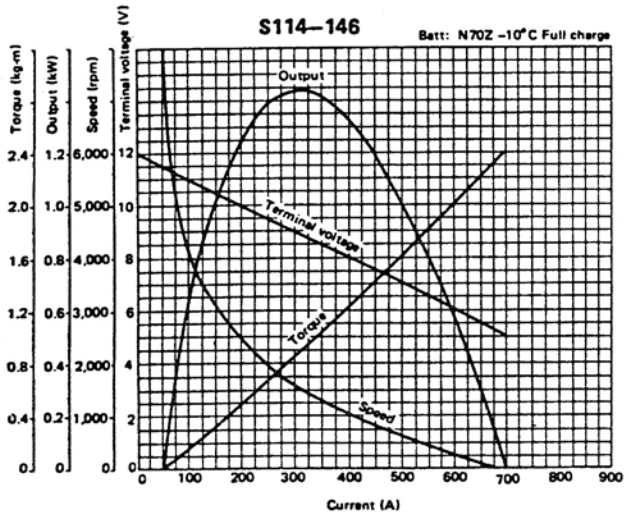
(1) Identification of the starter motor.

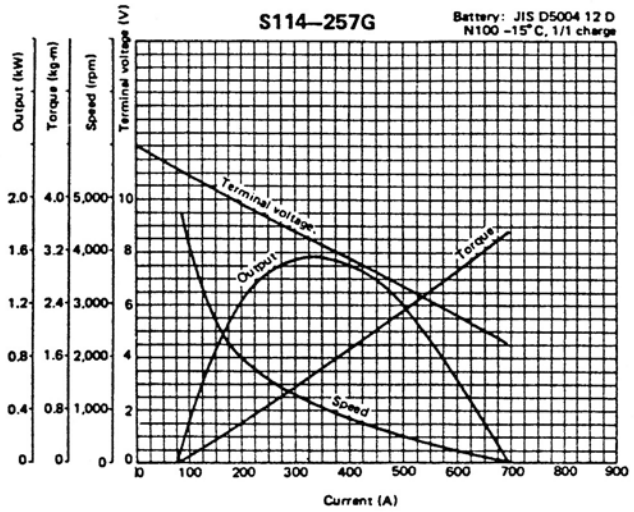
Engine model		Starter model (Mfg.)	Type
3TN66E	S	128000-1151 (Nippon Denso)	Reduction
	G2	S114-443 (Hitachi)	Conventional
3TNA72E	S	128000-1151 (Nippon Denso)	Reduction
	G2	128000-1151 (Nippon Denso)	↑
3TN75E	S	S114-349A (Hitachi)	↑
	G2	S114-349A (Hitachi)	↑
	G1	S114-146 (Hitachi)	Conventional
3TN82(T)E 3TN84(T)E	S	S114-257G (Hitachi)	Reduction
	G2/CH	S114-257G (Hitachi)	↑
	G1/CL/VM	S12-77A (Hitachi)	Conventional
4TN82(T)E 4TN84(T)E	S	S13-94 (Hitachi)	Reduction
	G2/CH	S13-94 (Hitachi)	↑
	G1/CL/VM	S12-77A (Hitachi)	Conventional
2TN66E		S114-443 (Hitachi)	Conventional
3TNC78E	VM, CH	S114-349A (Hitachi)	Reduction
	CL	S114-146 (Hitachi)	Conventional

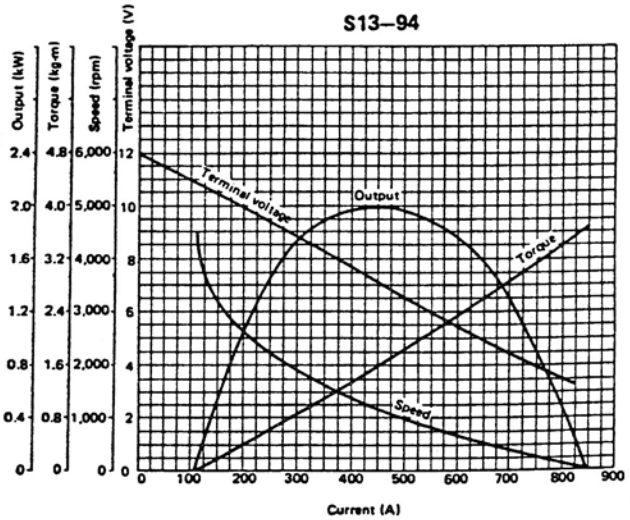
(2) Characteristics Curve

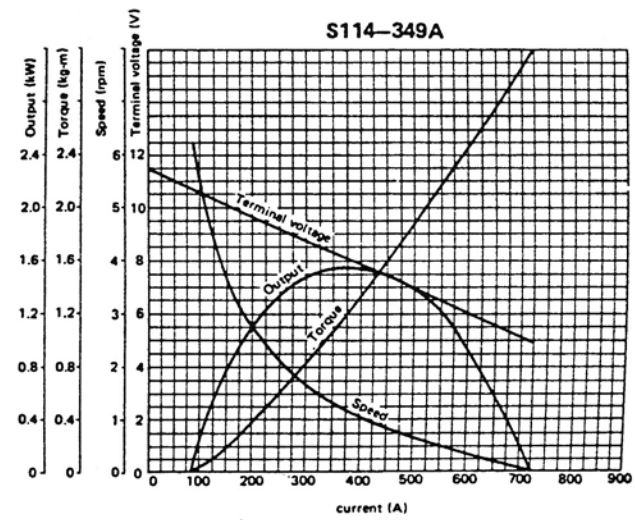


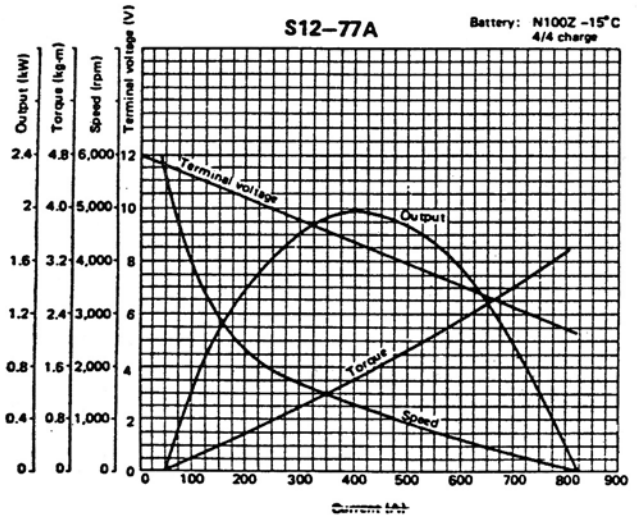



S114–146
Batt: N70Z –10°C Full charge
Torque (kg-m)
Output (kW)
Speed (rpm)
Terminal voltage (V)
Output
Terminal voltage
Torque
Speed
Current (A)


S114–257G
Battery: JIS D5004 12 D
N100 –15°C, 1/1 charge
Output (kW)
Torque (kg-m)
Speed (rpm)
Terminal voltage (V)
Terminal voltage
Output
Torque
Speed
Current (A)


S13–94
Output (kW)
Torque (kg-m)
Speed (rpm)
Terminal voltage (V)
Terminal voltage
Output
Torque
Speed
Current (A)


S114–349A
Output (kW)
Torque (kg-m)
Speed (rpm)
Terminal voltage (V)
Terminal voltage
Output
Torque
Speed
current (A)


S12–77A
Battery: N100Z –15°C
4/4 charge
Output (kW)
Torque (kg-m)
Speed (rpm)
Terminal voltage (V)
Terminal voltage
Output
Torque
Speed

2-2 Construction

The starter motor described in this section is a conventional pre-engaged 4-brush 4-pole starter motor with a screw roller drive clutch.

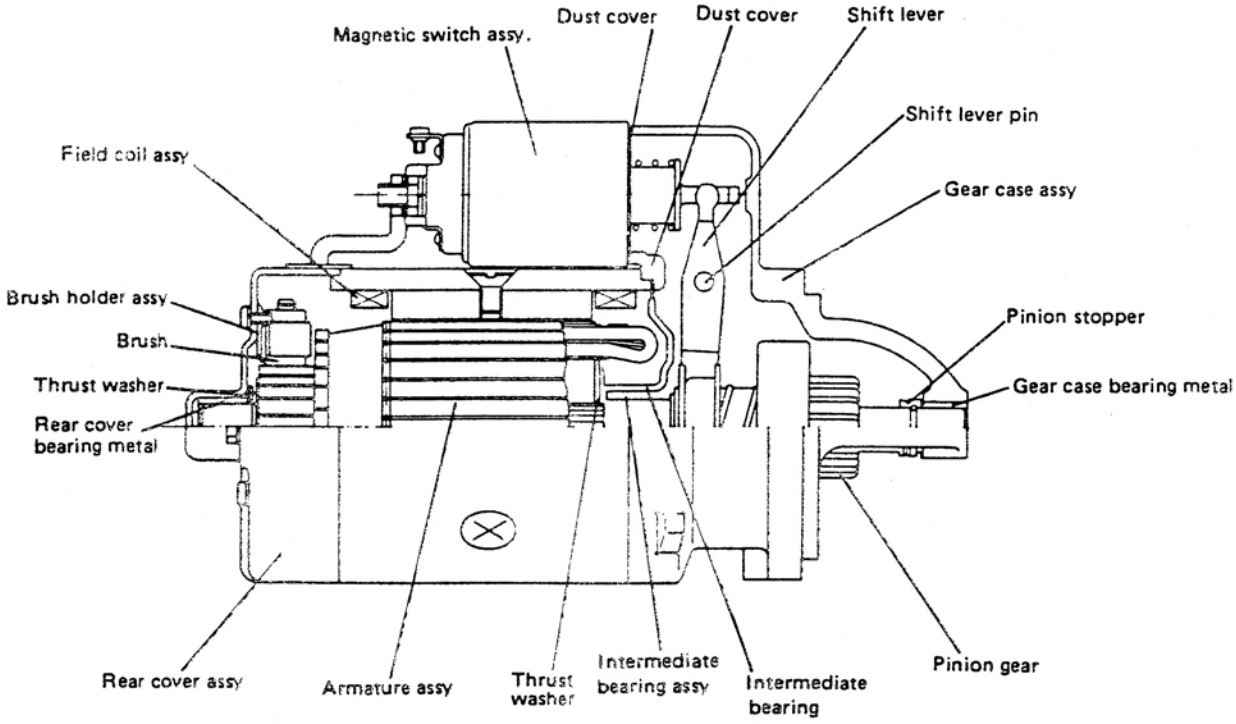
The starter motor is composed of three major parts, as follows:

(1) Magnetic switch
Moves plunger to engage and disengage pinion and, through the engagement lever, opens and closes the main contact (moving contact) to stop the starter motor.

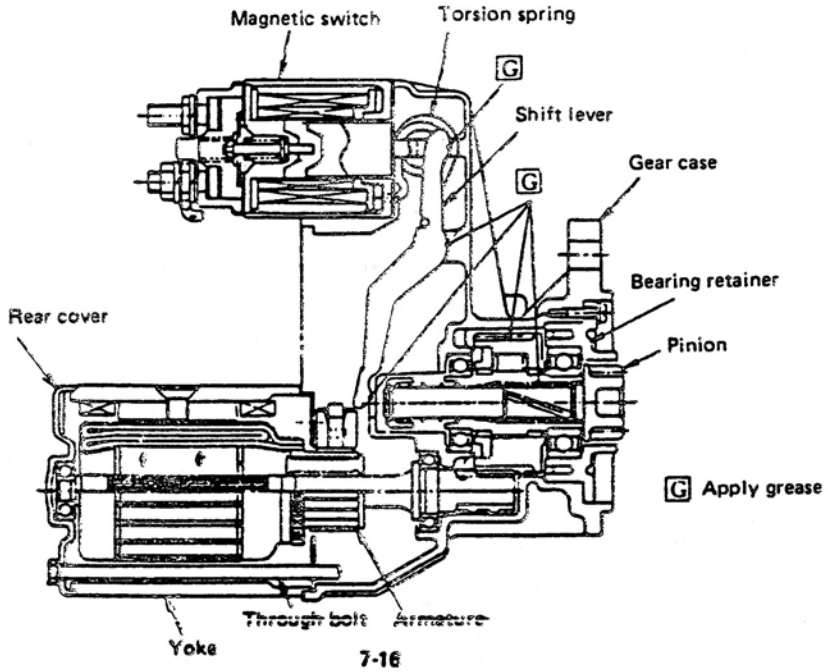
(2) Motor
A continuous current series motor which generates rotational drive power.

(3) Pinion
Transfers driving power from motor to ring gear. An overspeed clutch is employed to prevent damage if the engine should run too fast.

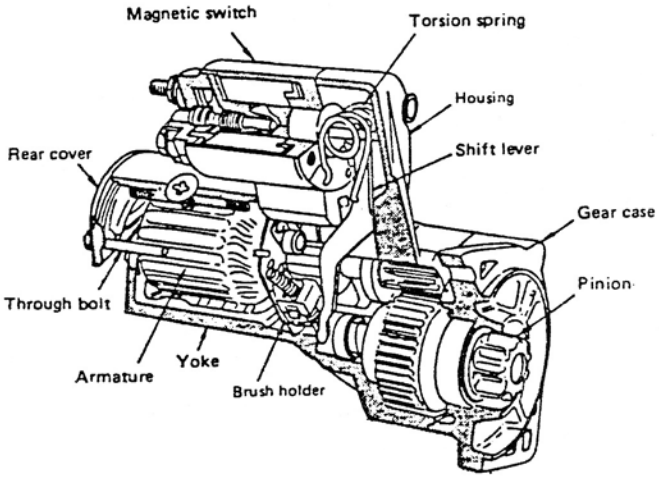
2-2.1 Conventional type starter motor



2-2.2 Reduction type Starter Motor

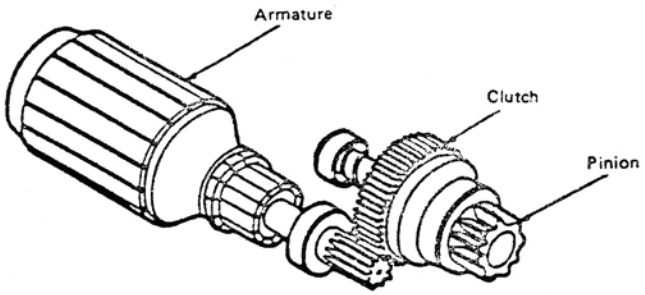


(1) Construction of the reduction type Starter Motor
This motor is equipped with reduction gears between the armature and pinion; the reduction gears increase the torque of the motor before transmitting the torque to the pinion.
The pinion and pinion shaft are shifted by the magnetic switch but the clutch assembly is left not shifted. While the engine is being cranked, the motor will be emitting a slightly loud sound because of the built-in reduction gears. This does not mean, of course, a sign of trouble.



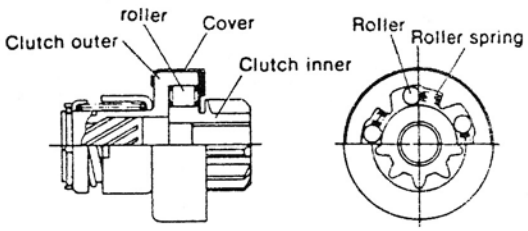
1) Circumscribed type
The armature shaft is equipped with a small gear at the end, which is constantly engaged with a large gear on the circumference of the clutch. Thus, the revolution of the armature is transmitted to the pinion through the reduction gears and the clutch assembly.

2) Internal structure of reduction type
Illustration above shows the internal structure of the reduction type starting motor. This motor, as its name implies, is equipped with a built-in reduction mechanism, though this motor resembles the magnetic shift type motor in principle.
In general type of starting motor, the armature is so designed to turn at the same rpm as the pinion. However, the reduction type motor has its internal resistance reduced to about 25% – 33% of the conventional motor to a high-speed low-torque motor while being a high torque motor by use of reduction gears.

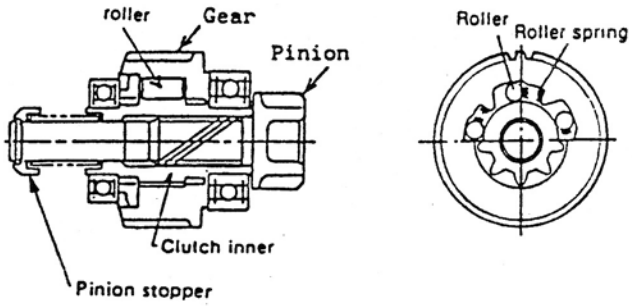


To prevent the motor receiving a shock when the engine starts and over-runs, the starter motor has an over-running clutch.

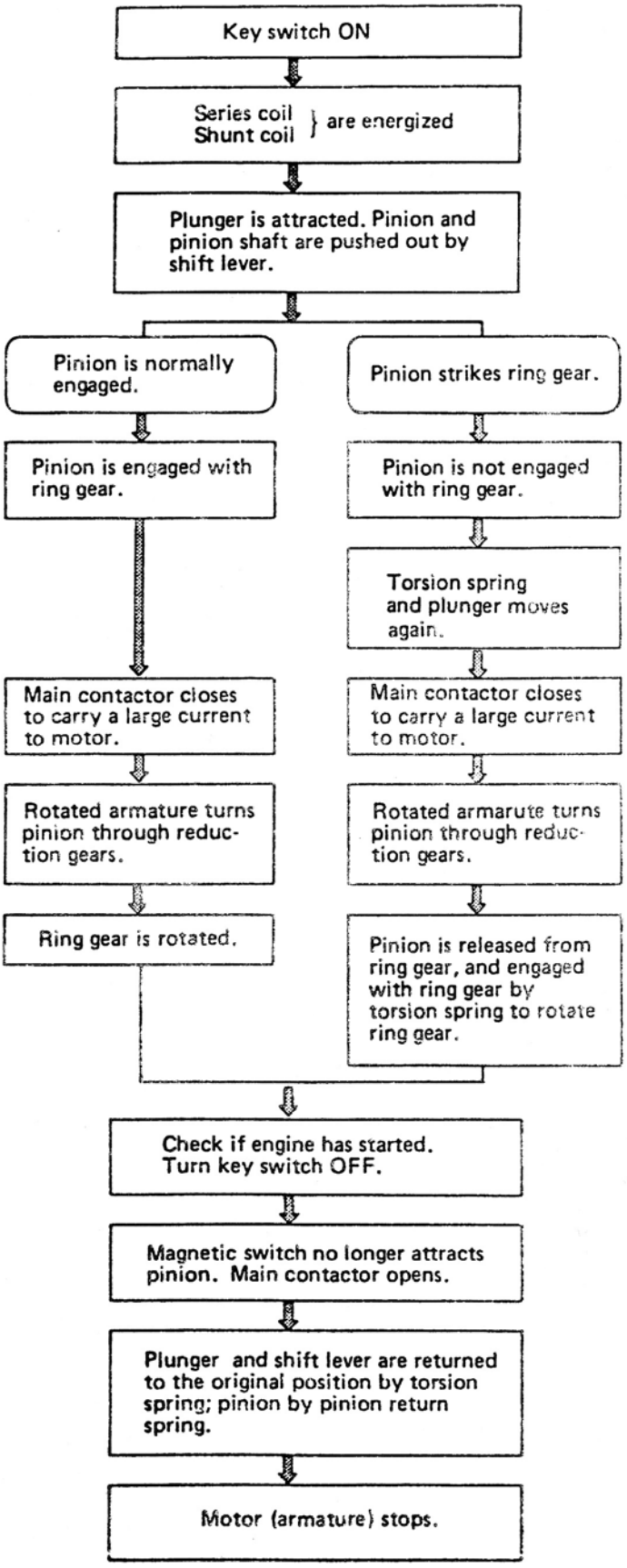
Over-running clutch (conventional)

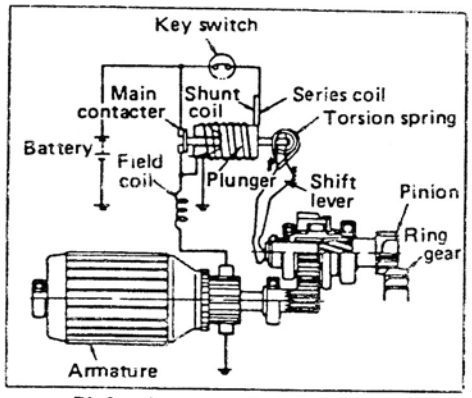


Over-running clutch (reduction type)

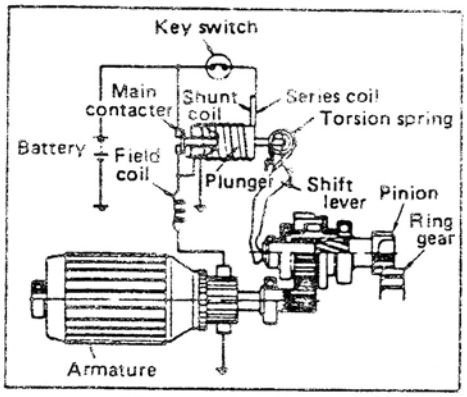


(2) Operation

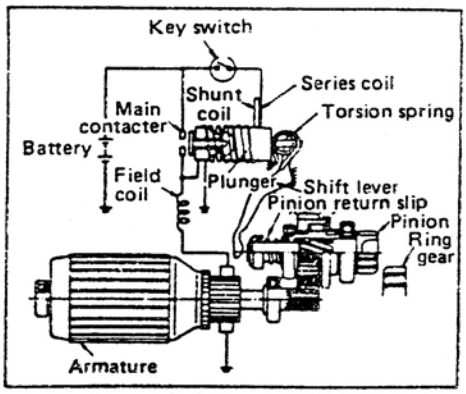




Pinion is engaged with ring gear



Ring gear is rotated



Key switch is turned OFF

2-3 Adjustment and performance test

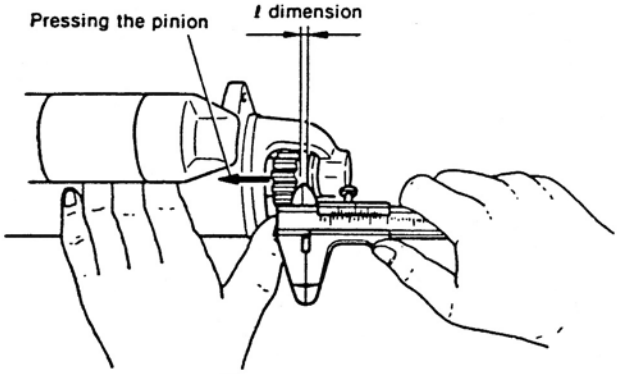
2-3.1 L-size measurement (gap between pinion and pinion stopper)

[Conventional starter motor]

When the pinion is at the projected position, measure gap between pinion and pinion stopper. This check should be made with the pinion pressed back lightly to take up any play in the engagement linkage.

mm (in.)

Starter motor	ℓ dimension
See separate service data (Page 7-45, 46)	



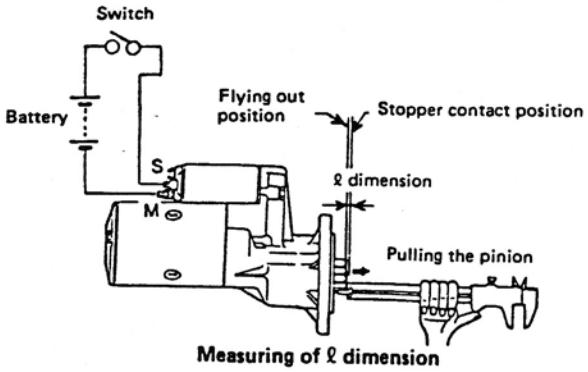
Measuring of ℓ dimension

[Reduction type]

Connect the wiring as shown in the sketch below. Turn on the switch and measure the " " distance in the pinion thrust direction.

mm (in.)

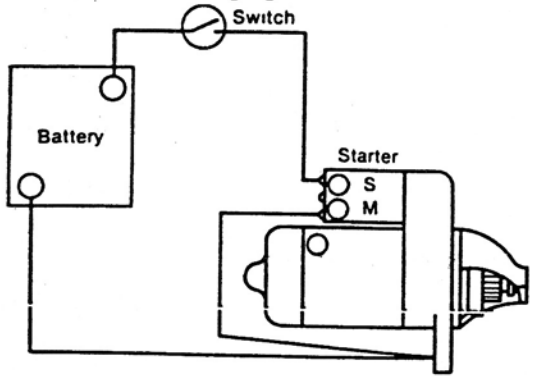
Starter motor	ℓ dimension
0.3 – 1.5 (0.012 – 0.059)	



Measuring of ℓ dimension

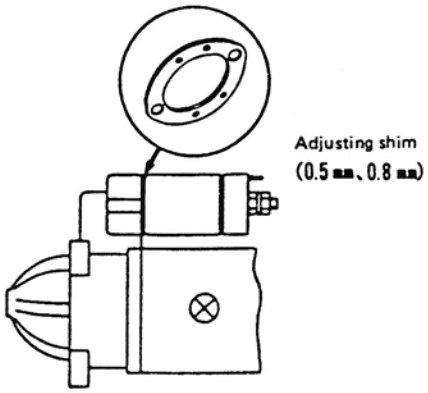
2-3.2 Pinion movement

After complete assembly of the startermotor, connect up the motor as in following figures.



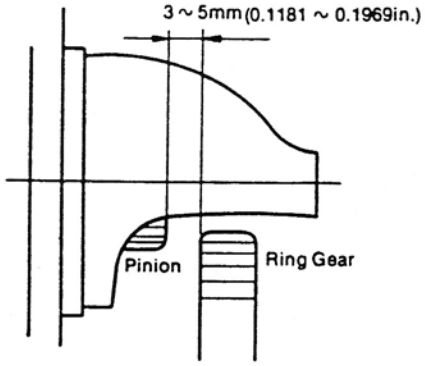
2-3.3 Plunger movement

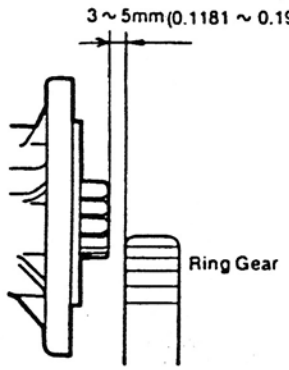
Adjustment made by adjusting stroke of magnetic plunger to the prescribed value. Adjust the ℓ-dimension installing shim (Adjust plate) at the magnetic switch section.
There are two kind of shim [Thickness 0.5 mm (0.0197 in.), 0.8 mm (0.0315 in.)]



2-3.4 Mesh clearance

Mesh clearance is the distance between the flywheel ring gear and starter motor pinion in the rest position. This clearance should be between 3mm (0.1181in.) to 5mm (0.1969in.).



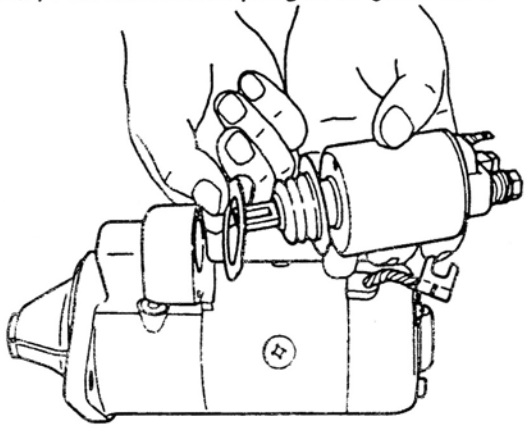


2-4 Disassembly

[Conventional starter motor]

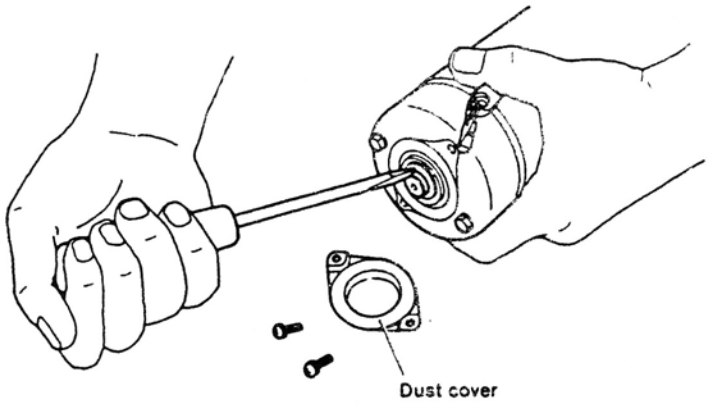
2-4.1 Magnetic switch

(1) Disconnect magnetic switch wiring.
(2) Remove magnetic switch mounting bolt.
(3) Remove magnetic switch.
(4) Separate the switch shift lever.
(5) Remove the torsion spring. (for Reduction type Starter Motor) Pull out torsion spring on magnetic switch.

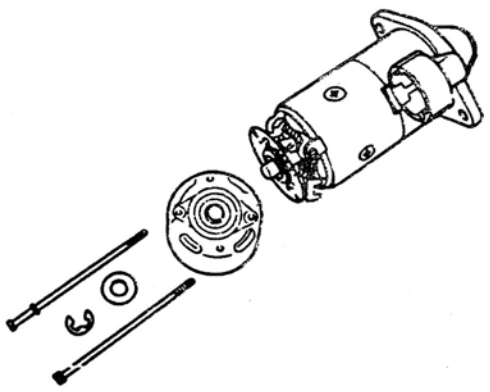


2-4.2 Rear cover

(1) Remove dust cover.



(2) Remove E-ring, and remove thrust washer (be careful not to lose the washer and shim).
(3) Remove the two through bolts holding the rear cover and the two screws holding the brush holder.
(4) Remove rear cover.

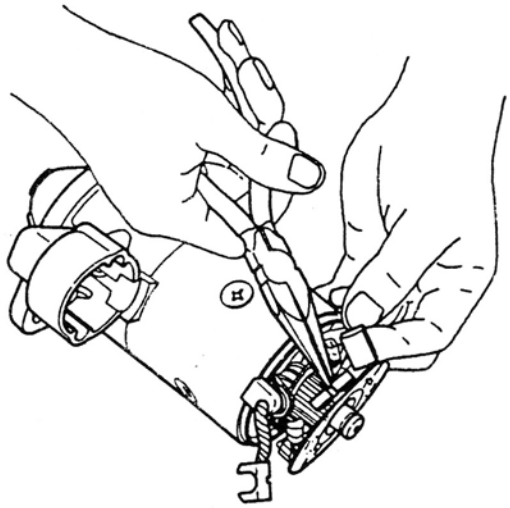


2-4.3 Brush holder

(1) Lift (-) brush from the commutator.
(2) Remove (+)brush from the brush holder.
(3) Remove brush holder.

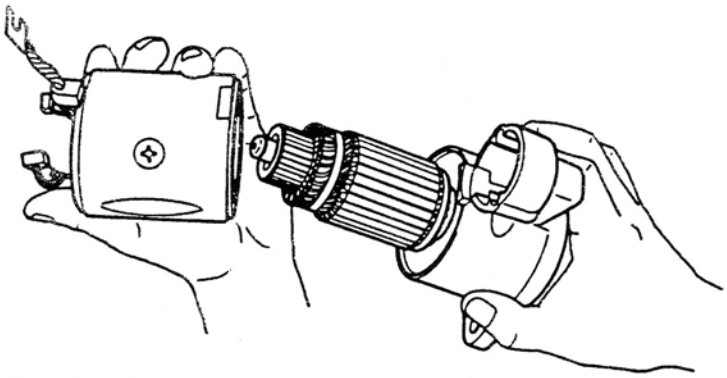
For Reduction type:

(1) Removing yoke, armature, and brush holder.
Pull out yoke, armature, and brush holder simultaneously. Gently pull out brush and commutator so that they may not interfere with the surrounding section.



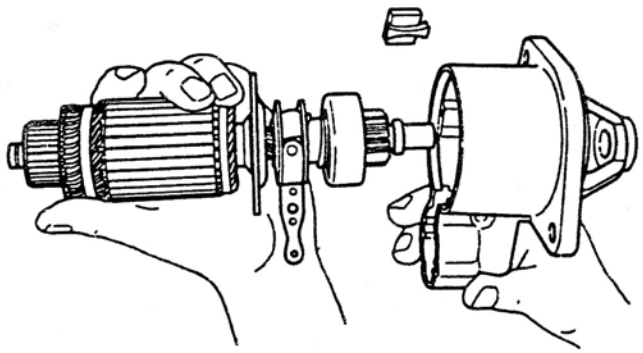
2-4.4 Yoke

(1) Remove yoke. Pull it out slowly so that it does not strike against other parts.



2-4.5 Armature

(1) Slide pinion stopper to pinion side.



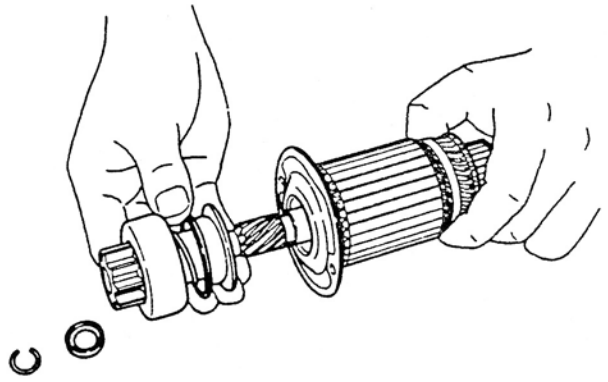
(2) Remove the pinion stopper clip.

2-4.6 Gear case (for Reduction type starter motor)

(1) Remove the three through bolts fixed the gear case and housing.
(2) By removing bolts, separates the gear case and center housing.

2-4.7 Pinion

(1) Slide the pinion stopper to the pinion side.
(2) Remove the pinion stopper clip.
(3) Remove the pinion from the armature.

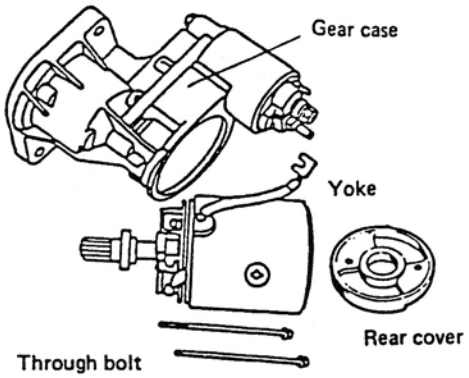


[Reduction type]

(2-4 Disassembly)

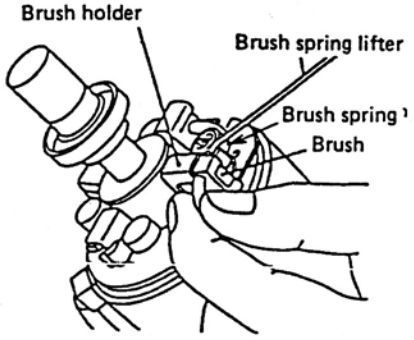
2-4-a Rear cover and Yoke

(1) Disconnect magnetic switch wiring.
(2) Remove rear cover.
(3) Remove the two through bolts.
(4) Remove the rear cover and yoke.

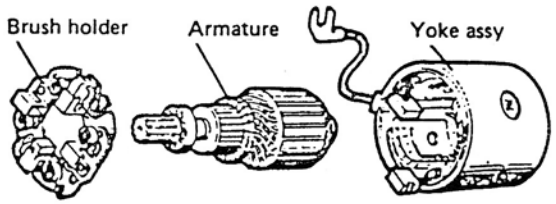


2-4-b Brush holder

(1) Lift the brush spring using the brush spring lifter. Touch the brush spring to the side of the (-) brush and float the brush from the commutator.
(2) Remove the (+) brush from the brush holder.

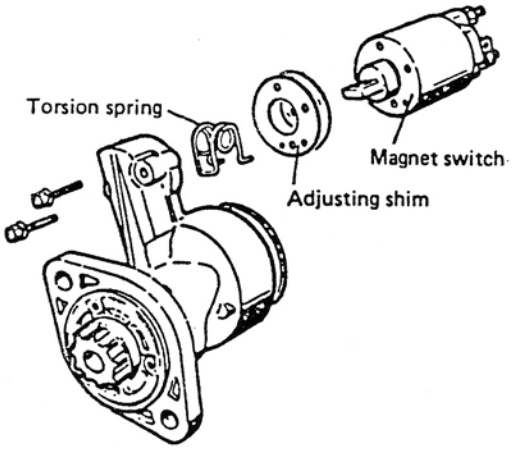


(3) Remove the brush holder.
(4) Remove the armature, and yoke.



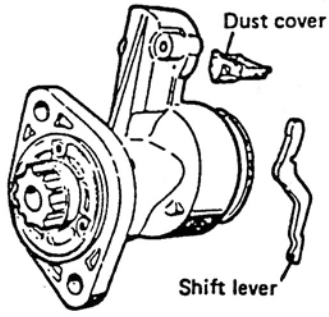
2-4-c Magnetic switch

(1) Remove the magnetic switch mounting bolts.
(2) Separate the torsion spring from the magnetic switch.



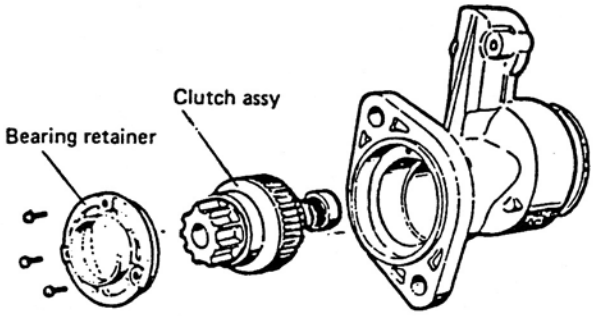
2-4-d Shift lever

(1) Separate the dust cover and shift lever.



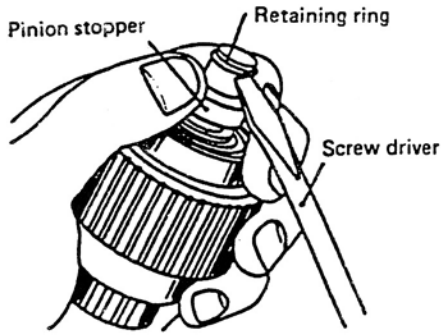
2-4-e Gear case

(1) Remove the bearing retainer mounting screws.
(2) Remove the bearing retainer and clutch assy from the gear case.

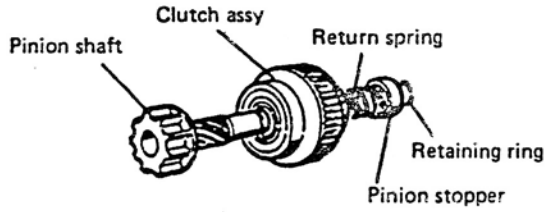


2-4-f Pinion shaft and clutch assy

(1) Move the pinion stopper toward the pinion and remove the retaining ring with a minus screw driver.



(2) Remove the pinion stopper, return spring, and pinion shaft from the clutch assy.

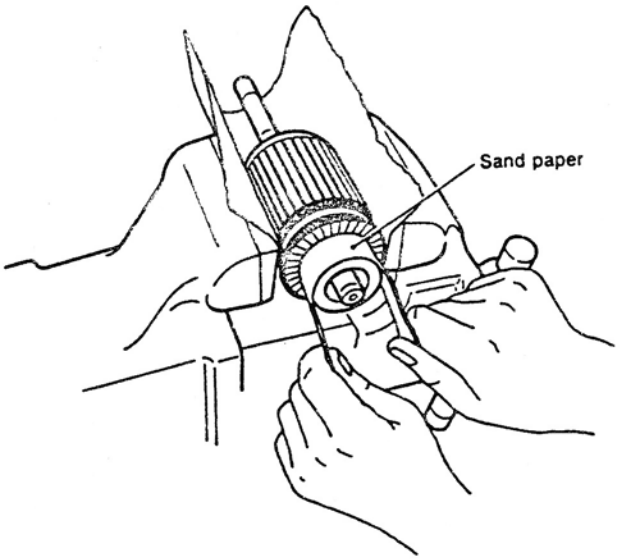


2-5 Inspection

2-5.1 Armature

(1) Commutator

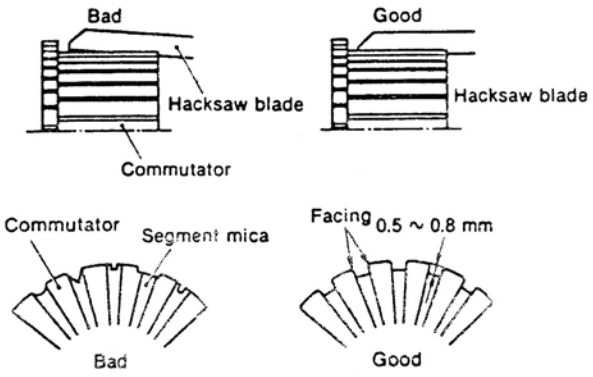
Inspect the surface of the commutator. If corroded or pitted, sand with #500 ~ #600 sandpaper. Replace the commutator if damage is irreparable.



	Maintenance standard	Wear limit
Commutator outside diameter	*See separate service data (Page 7-45,46)*	
Commutator run-out		
Difference between maximum diameter and minimum diameter		

(2) Mica undercut

Check the mica undercut, correct with a hacksaw blade when the undercut is too shallow.



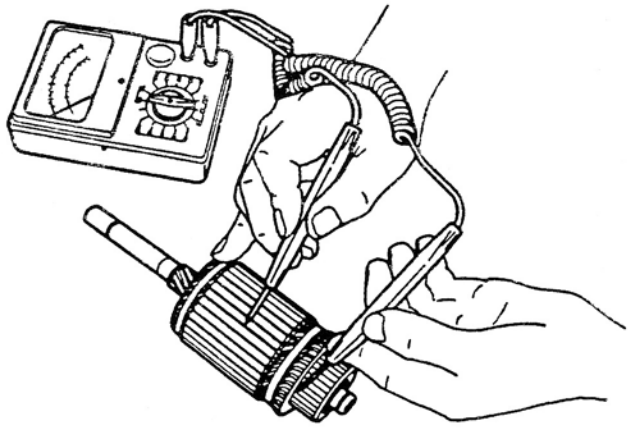
mm (in.)

	Maintenance standard	Repair limit
Mica undercut	*See separate service data (Page 7-45, 46)*	

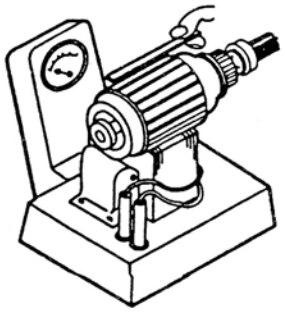
(3) Armature coil ground test

Using a circuit tester, check for the insulation between the commutator piece and the shaft (or armature core).

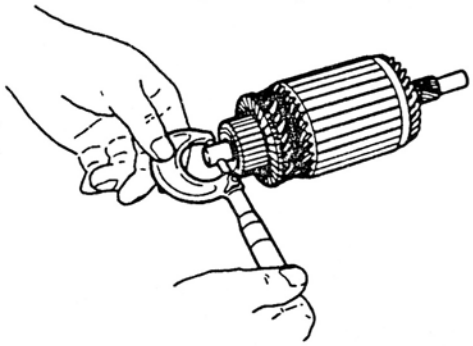
If there is continuity, replace the armature.



Armature coil short test
Place the iron piece on the armature fitted to the layer short tester and turn the armature. If the iron piece vibrates, there is a short circuit and the armature should be replaced.

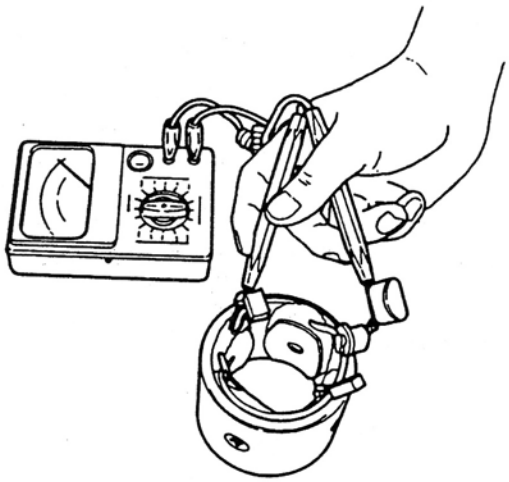


(4) Armature shaft outside diameter
Measure the outside diameter of the armature shaft at four locations: front, center, end, and pinion. Replace the armature if the shaft is excessively worn.
Check the bend of the shaft; replace the armature if the bend exceeds 0.08mm (0.0031in.)



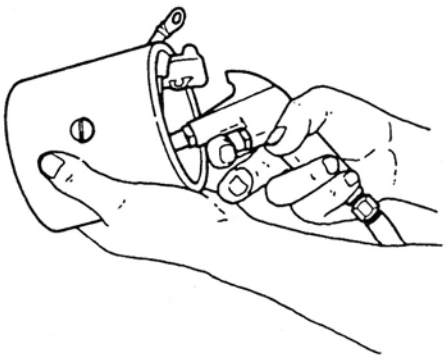
2-5.2 Field coil

(1) Open test
Check for continuity between the terminals of the field coil. If there is no continuity, the coil is open and must be replaced.



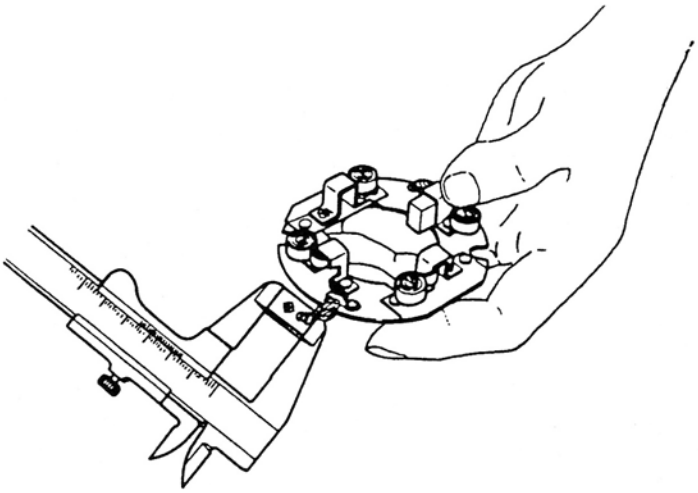
(2) Short test
Check for continuity between the yoke and any field coil terminal. If there is continuity, the coil is shorted and it must be replaced.

(3) Cleaning the inside of the yoke
If any carbon powder or rust has collected on the inside of the yoke, blow the yoke out with dry compressed air.
*Do not remove the field coil from the yoke.

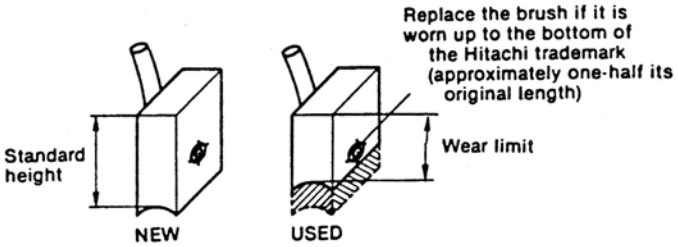


2-5.3 Brush

The brushes are quickly worn down by the motor. When the brushes are defective, the output of the motor will drop.



(1) Brush dimensions
Replace brushes which have been worn beyond the specified wear limit.

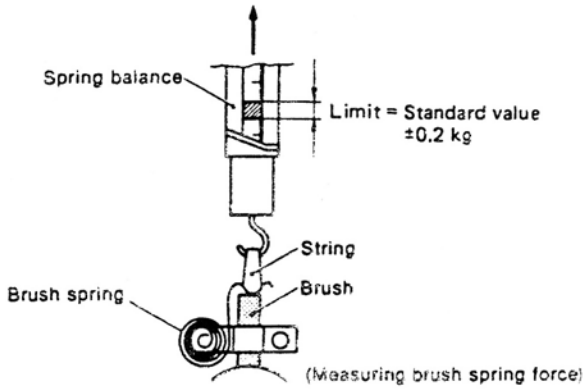


mm (in.)

Brush standard height	*See separate service data (Page 7-45, 46)*
Wear limit	

(2) Brush appearance and movement in brush holder
If the outside of the brush is damaged, replace it. If the movement of the brushes in the brush holder is hampered because the holder is rusted, repair or replace the holder.

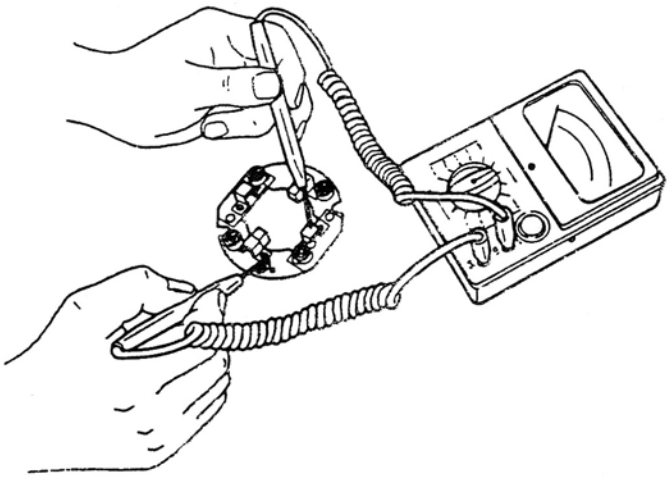
(3) Brush spring
Since the brush spring pushes the brush against the commutator while the motor is running, a weak or defective spring will cause excessive brush wear, resulting in sparking between the brush and the commutator during operation. Measure the spring force with a spring balance; replace the spring when the difference between the standard value and the measured value exceeds ±0.2kg.



(Measuring brush spring force)

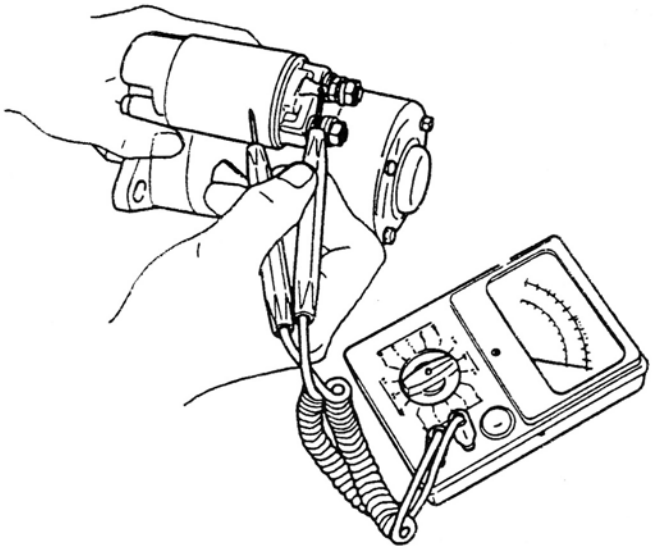
Standard spring load	*See separate service data (Page 7-45, 46)*

(4) Brush holder ground test
Check for continuity between the insulated brush holder and the base of the brush holder assembly. Continuity indicates that these two points are grounded and that the holder must be replaced.



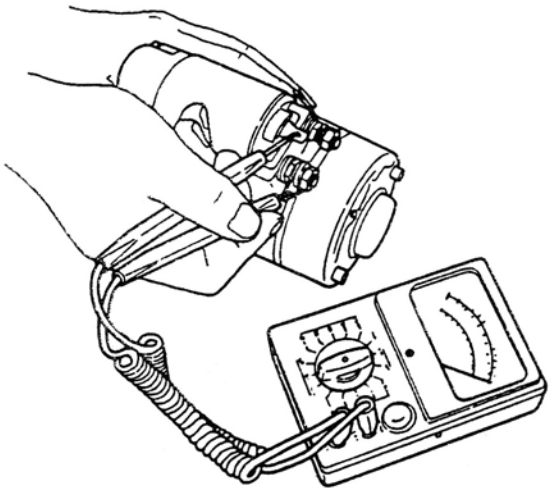
2-5.4 Magnetic switch

(1) Shunt coil continuity test
Check for continuity between the S terminal and the magnetic switch body (metal part). If discontinuity, the coil is open and the switch must be replaced.



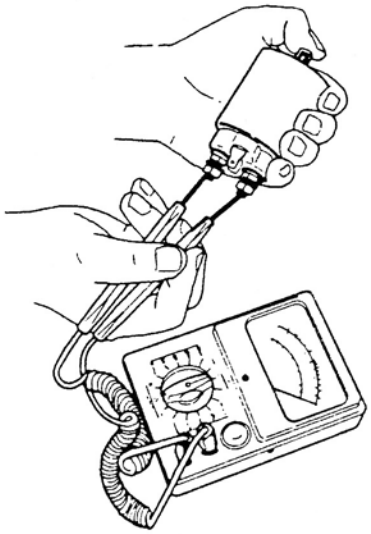
Coil resistance (at 20°C)	*See separate service data (Page 7-45, 46)*

(2) Series coil continuity test
Check for continuity between the S terminal and M terminal. If discontinuity, the coil is open and that it must be replaced.



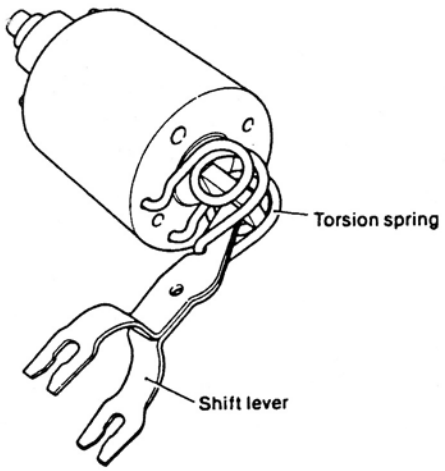
Resistance value (at 20°C)	*See separate service data (Page 7-45, 46)*

(3) Contactor contact test
Push the plunger with your finger and check for continuity between the M terminal and B terminal. If discontinuity, the contact is faulty and that the contactor must be replaced.

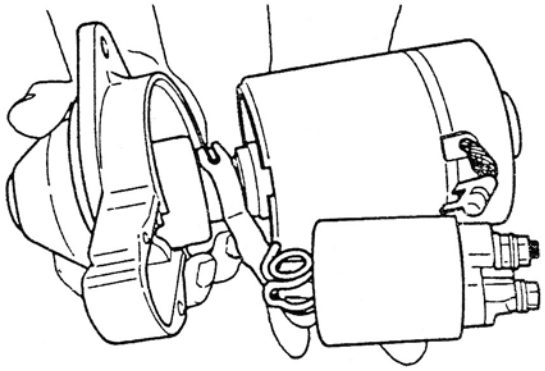


2-5.5 Pinion
(1) Inspect the pinion teeth and replace the pinion if the teeth are excessively worn or damaged.
(2) Check if the pinion slides smoothly; replace the pinion if faulty.
(3) Inspect the springs and replace if faulty.
(4) Replace the clutch if it slips or seizes.

2-6 Reassembly precautions
Reassemble the starter motor in the reverse order of disassembly, paying particular attention to the following:
(1) Torsion spring and shift lever
Hook the torsion spring into the hole in the magnetic switch and insert the shift lever into the notch in the plunger of the magnetic switch (through the torsion spring).



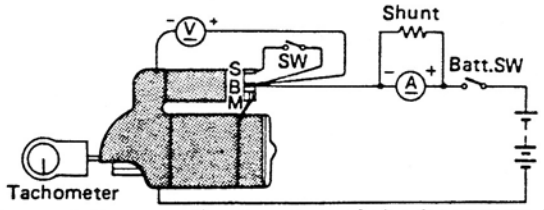
(2) Mounting the magnetic switch
Attach the shift lever to the pinion; assemble the gear case as shown below.
Do not forget to install the dust cover before assembling the gear case.
After reassembly, check by conducting no-load operation



(3) Lubrication
Lubricate each bearing and spline (points indicated in the figure below) with high quality "Hitachi Electrical Equipment Grease A"
The following lubricants may be used in place of Hitachi Electrical Equipment Grease A.

Magnetic switch plunger	Shell	Aeroshell No. 7
Bearing and spline	Shell	Albania Grease No. 2

2-7 Testing
2-7.1 No load test
Test procedure
(1) Connect the positive side of the ammeter (A) to the positive terminal of the battery, and connect the negative side of the ammeter to the B terminal of the starter.



(2) Connect the negative terminal of the battery to the body of the starter.
(3) Connect the positive side of the voltmeter (V) to the B terminal of the starter, and connect the negative side of the voltmeter to the body of the starter.
(4) Attach the tachometer.
(5) Connect the switch between the B terminal and S terminal of the starter.

- The magnetic switch should begin operation, and the speed, current, and voltage should be at the prescribed values.
- A fully charged battery must be used.
- Since a large current flows when the starter is operated, close the protection circuit switch before initial operation, then open the switch and measure the current after the starter reaches a constant speed.
- The test should be carried out immediately because the rating of the starter motor is 30 seconds.

2-8 Maintenance standard

Brush	Standard spring load		kg (lb)	*See separate service data (Page 7-45, 46)*
	Standard height		mm (in.)	
	Wear limit		mm (in.)	
Magnetic switch	Series coil resistance		Ω	
	Shunt coil resistance		Ω	
Commutator	Outside diameter	Maintenance standard	mm (in.)	
		Wear limit	mm (in.)	
	Difference between minimum diameter and maximum diameter	Repair limit	mm (in.)	
		Repair accuracy	mm (in.)	
	Mica undercut	Maintenance standard	mm (in.)	
		Repair limit	mm (in.)	
Standard dimension	Rear side bearing	Shaft diameter	mm (in.)	
		Bearing inside diameter	mm (in.)	
	Intermediate bearing	Shaft diameter	mm (in.)	
		Bearing inside diameter	mm (in.)	
	Pinion sliding section	Shaft diameter	mm (in.)	
		Pinion inside diameter	mm (in.)	
	Pinion side bearing	Shaft diameter	mm (in.)	
		Bearing inside diameter	mm (in.)	

2-9 Various problems and their remedies

(1) Pinion fails to advance when the starting switch is closed

Problem	Cause	Corrective action
Wiring	Open or loose battery or switch terminal	Repair or retighten
Starting switch	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Repair contacts, or replace switch
Starter motor	Threaded part connected to pinion section of armature shaft is damaged, and the pinion does not move	Replace
Magnetic switch	Plunger of magnetic switch malfunctioning or coil shorted	Repair or replace

(2) Pinion is engaged and motor rotates, but rotation is not transmitted to the engine

Problem	Cause	Corrective action
Starting motor	Faulty over-running clutch	Replace

(3) Motor rotates at full power before pinion engages ring gear

Problem	Cause	Corrective action
Starter motor	Torsion spring permanently strained	Replace

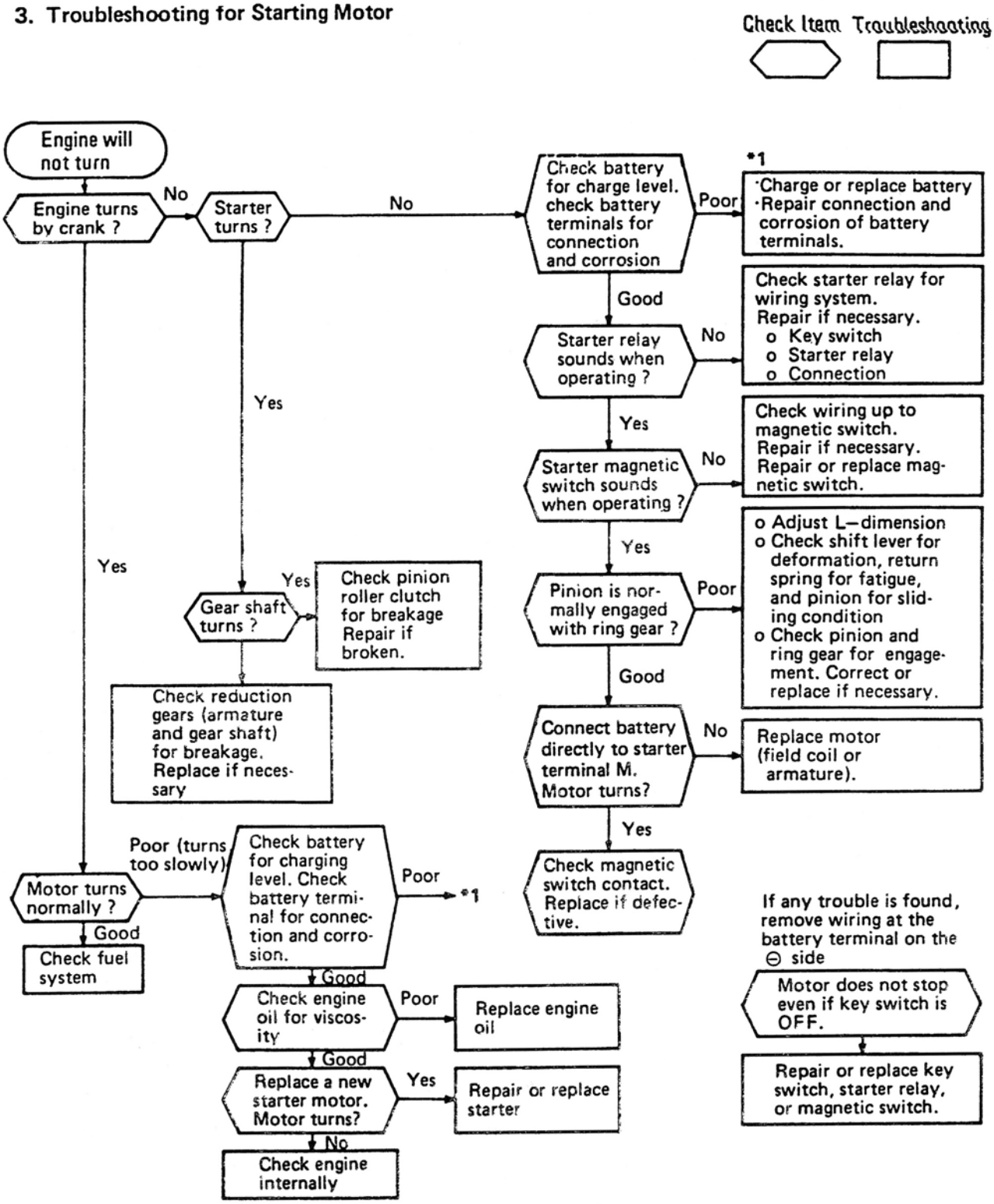
(4) Pinion engages ring gear, but starter motor fails to rotate

Problem	Cause	Corrective action
Wiring	Wires connecting battery and magnetic switch open or wire connecting ground, magnetic switch and motor terminals loose	Repair, retighten, or replace wire
Starter motor	Faulty pinion and ring gear engagement Faulty motor mounting Faulty brush worn or contacting brush spring Dirty commutator Faulty armature, field coil Loose field coil and brush connection	Replace Remount Replace Repair Repair or replace Retighten
Magnetic switch	Faulty contactor contact Pitted contactor contacts	Replace Replace

(5) Motor fails to stop when starting switch is opened after engine starts

Problem	Cause	Corrective action
Starting switch	Faulty switch	Replace
Magnetic switch	Faulty switch	Replace

3. Troubleshooting for Starting Motor



3. Charging Equipment

[A] ALTERNATOR (12V-20A/12V-35A)

The alternator serves to keep the battery constantly charged. It is installed on the cylinder block by a bracket, and is driven from the V-pulley at the end of the crankshaft by a V-belt.

The type of alternator used in this engine is ideal for high speed engines with a wide range of engine speeds. It contains diodes that convert AC to DC, and an IC regulator that keep the generated voltage constant even when the engine speed changes.

3-1 Features

The alternator contains a regulator using an IC, and has the following features.

(1) The IC regulator is self-contained, and has no moving parts (mechanical contact points). It therefore has superior features such as freedom from vibration, no fluctuation of voltage during use, and no need for readjustment.
Also, it is of the over-heating compensation type and can automatically adjust the voltage to the most suitable level depending on the operating temperature.

(2) The regulator is integrated within the alternator to simplify external wiring.

(3) It is an alternator designed for compactness, lightness of weight, and high output.

(4) A newly developed U-shaped diode is used to provide increased reliability and easier checking and maintenance.

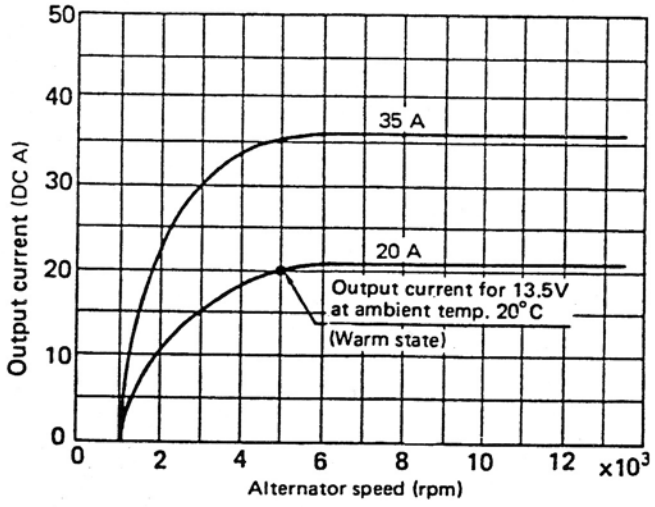
3-2 Specifications

Model of alternator	LR120–15C	LR135-91
Model of IC regulator	TRIZ–63	←
Battery voltage	12 V	12V
Nominal output	12 V/20 A	12V/35A
Earth polarity	Negative earth	←
Direction of rotation (viewed from pulley end)	Clockwise	←
Weight	3.4 kg	3.5 kg
Rated speed	5000 rpm	←
Operating speed	1000 – 13500	←
Speed at 13.5 V	1000 or less	←
Output current at 20°C	over 20 A	35±2A
Regulated voltage	14.5 ± 0.3 V (Standard temperature voltage gradient, –0.01/°C)	
Permissible ambient	–30°C - +80°C (–22°F - 176°F)	

Pulley ratio

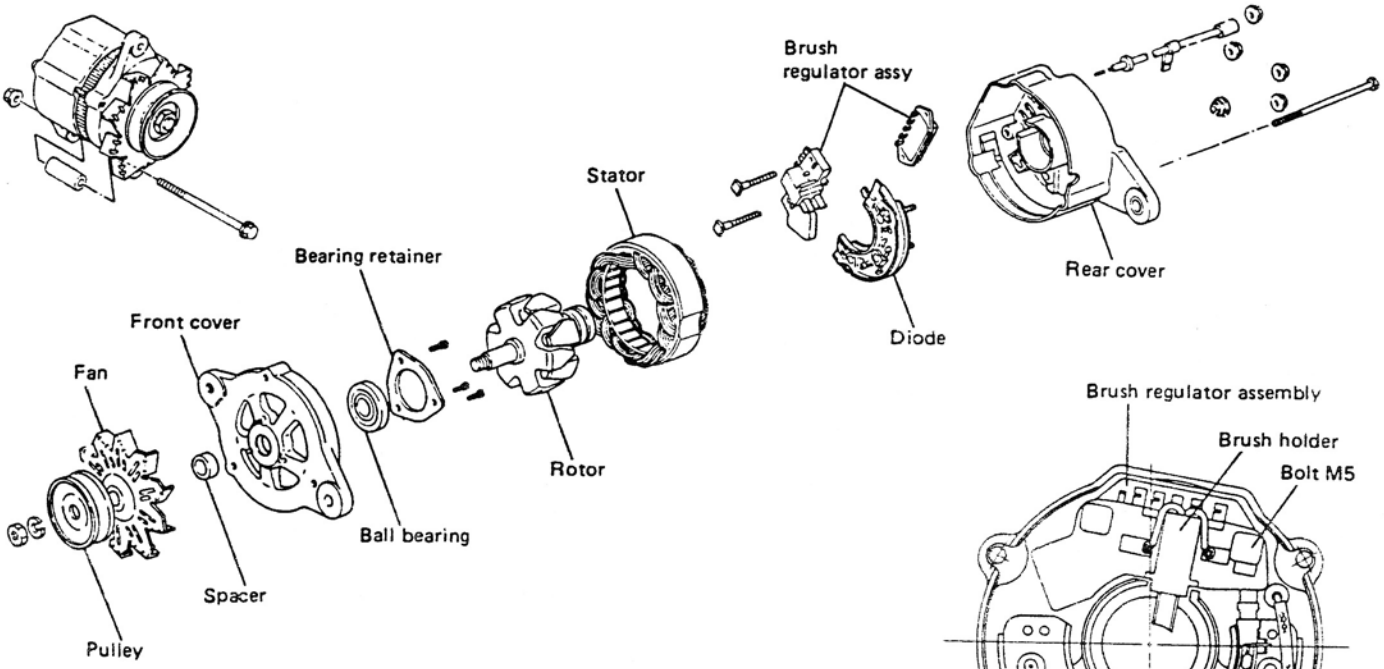
Specification		Pulley ratio
3TN66E		1.53
3TNA72E		1.78
3TN75E, 3TNC78E 3,4TN82E(TE) 3,4TN84E(TE)	S, G2	1.61
3TN75E, 3TNC78E 3,4TN82E(TE) 3,4TN84E(TE)	G1	1.76

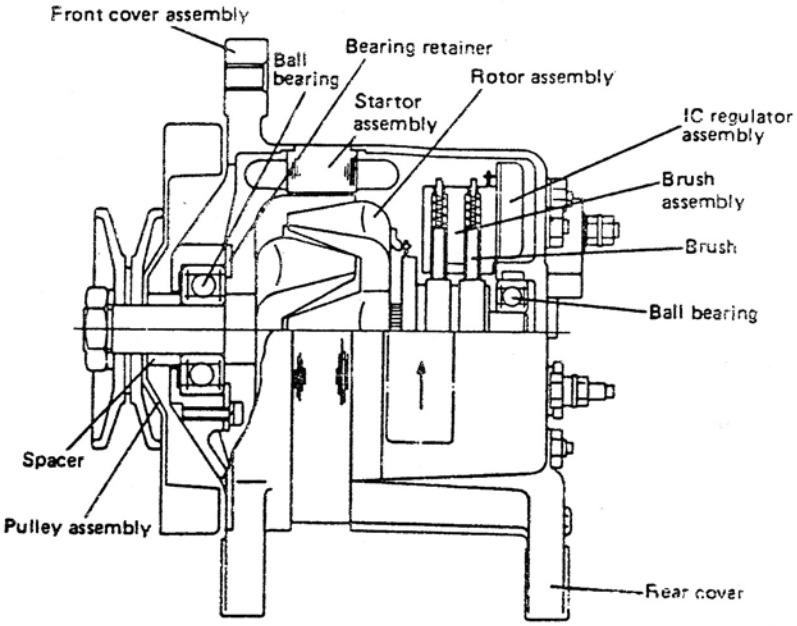
3-3 Characteristics

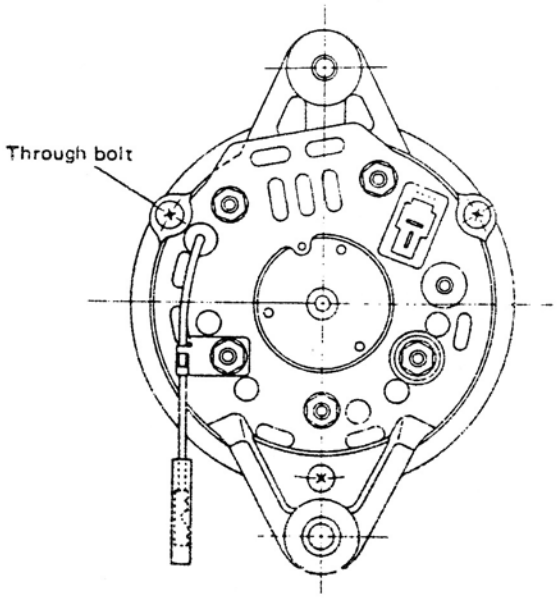


3-4 Construction

This is a standard rotating field type three-phase alternator. It consists of six major parts: the pulley, fan, front cover, rotor, stator and rear cover. The IC regulator is an integral part of the alternator.







3-5 Alternator functioning

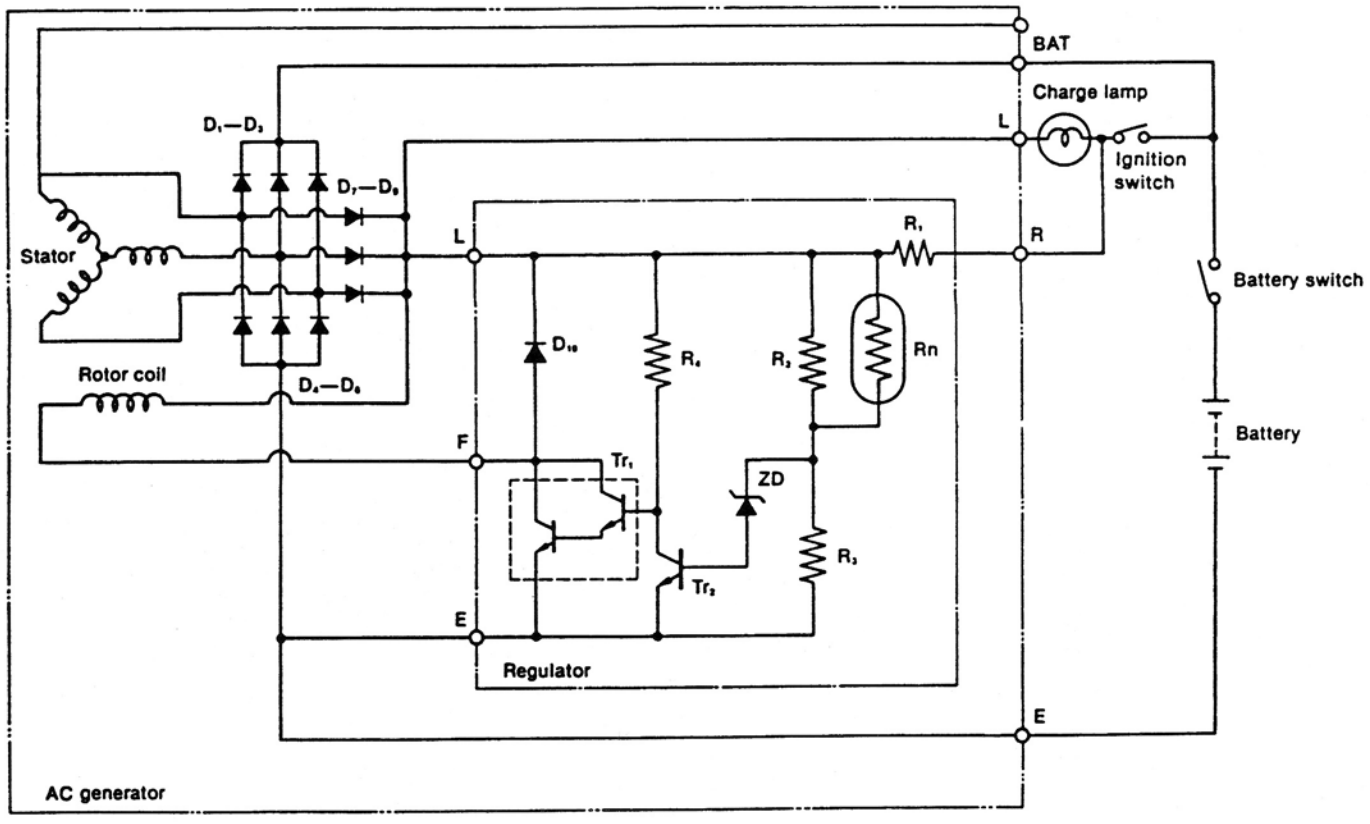
(1) IC regulator
The IC regulator is the transistor (Tr_1) which is series-connected with the rotor. The IC regulator controls the output voltage of the generator by breaking or conducting the rotor coil (exciting) current.
When the output voltage of the generator is within the standard value, the transistor (Tr_1) turns on. When the voltage exceeds the standard value, the Zener diode goes on and the transistor (Tr_1) turns off.
With the repeated turning on and off of the transistor, the output voltage is kept at the standard value. (Refer to the circuit diagram below.)

(2) Charge lamp
When the transistor (Tr_1) is on, the charge lamp key switch is turned to ON, and current flows to R_1, R_4 and to Tr_1 to light the lamp. When the engine starts to run and output voltage is generated in the stator coil, the current stops flowing to this circuit, turning off the charge lamp.

(3) Circuit diagram

3-6 Handling precautions

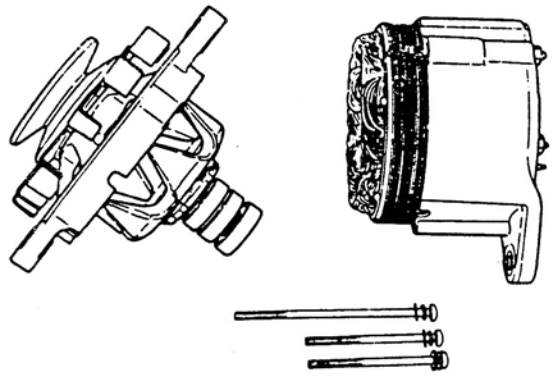
(1) Be careful of the battery's polarity (+, − terminals), and do not connect the wrong terminals to the wrong cables, or the battery will be short-circuited by the generator diode.
In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.
(2) Make sure of the correct connection of each terminal.
(3) When quick-charging, etc., disconnect either the battery terminal on the AC generator or the terminal on the battery.
(4) Do not short-circuit the terminals.
(5) Do not conduct any tests using high tension insulation resistance. (The diodes and IC regulator will burn out.)



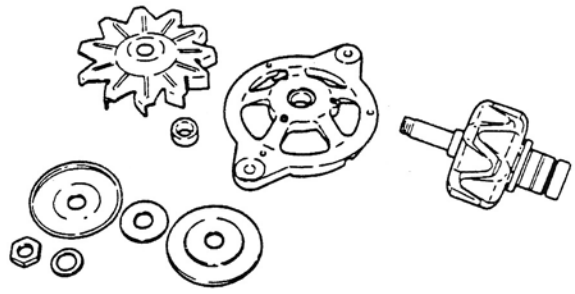
BAT:	Generator output terminal	D_1—D_6:	Output commutation diode
D_{10}:	IC protecting diode	R_1—R_4:	Resistor
L:	Charge lamp terminal	D_7—D_9:	Auxiliary diode
ZD:	Zener diode	Rn:	Thermistor (Temperature gradient resistance)
E:	Earth		
Tr_1, Tr_2:	Transistor		

3-7 Disassembling the alternator

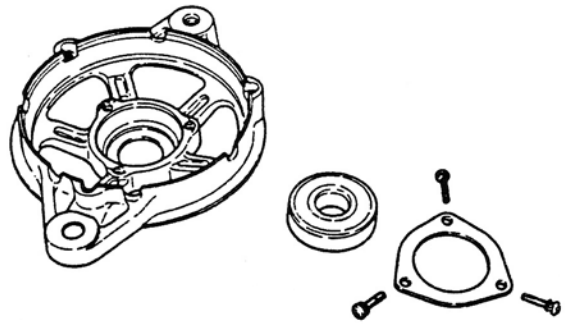
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



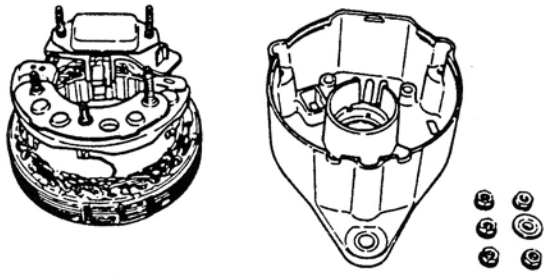
(2) Remove the pulley nut, and pull out the rotor from the front cover.



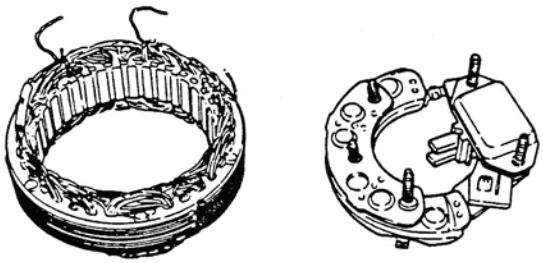
(3) Remove the screw from the front cover, and then remove the ball bearing.



(4) Remove the nut, the brush-holder, and diode fixing nut at the BAT, and the terminal screws of the rear cover. Separate the rear cover from the stator (with the diode and brush holder).

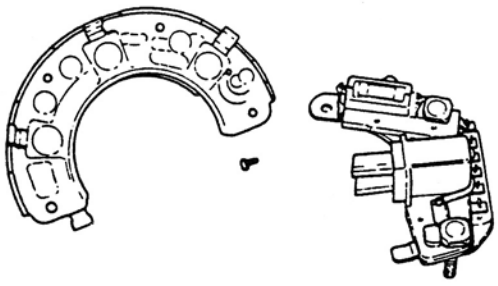


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.

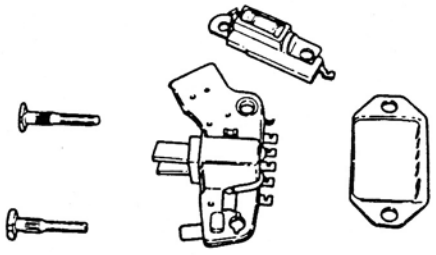


(6) Separating the regulator

1) To separate the regulator, remove the rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



2) To replace the IC regulator, disconnect the soldered joint of the IC regulator and pull out the two bolts. Do not remove these two bolts except when replacing the IC regulator.

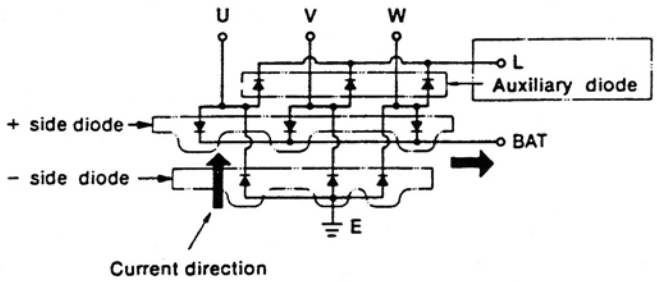


3-8 Inspection and adjustment

(1) Diode

Between terminals		BAT (+ side diode)	
	Tester wire	+ side	− side
U.V.W.	+ side		No continuity
	− side	Continuity	

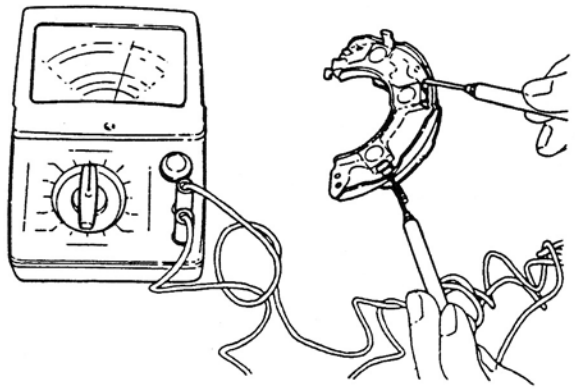
Between terminals		E (− side diode)	
	Tester wire	+ side	− side
U.V.W.	+ side		Continuity
	− side	No continuity	



U.V.W.: terminal from the stator coil

Current flows only in one direction in the diode as shown above. Accordingly, when there is continuity between each terminal (e.g. BAT and U), the diode is in normal condition. When there is no continuity, the diode is defective.
When the tester is connected in the reverse of above, there should be no continuity. If there is, the diode is defective.

After repeating the above test, if any diode is found to be defective, replace the diode assembly. Since there is no terminal on the auxiliary diode, check the continuity between both ends of the diode.



CAUTION: Do not use high tensile insulation resistance instrument such as meggers, etc. for testing. The diode may burn out.

(2) Rotor
Inspect the slip ring surface, rotor coil continuity and insulation.

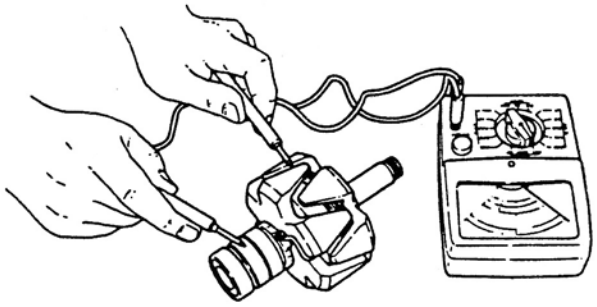
1) Inspecting the slip ring surface
Check if the surface of the slip ring is sufficiently smooth. If the surface is rough, grind the surface with No. 500—600 sand paper. If it is contaminated with oil, etc., wipe the surface clean with alcohol.

	Standard	Wear limit
Slip ring outer dia.	ø31.6mm (1.2441in.)	ø30.6mm (1.2049in.)

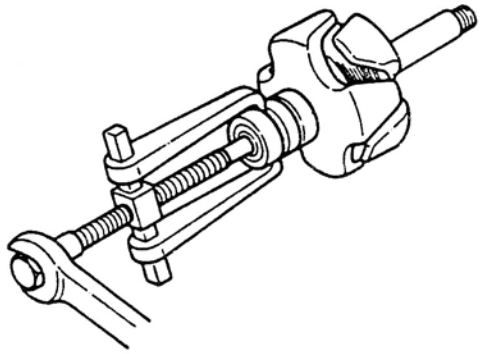
2) Rotor coil continuity test
Check the continuity in the slip ring with the tester. If there is no continuity, there is a wire break. Replace the rotor coil.

Resistance value	Approx. 5.17Ω at 20°C (LR120)
	Approx. 3.1Ω at 20°C (LR135)

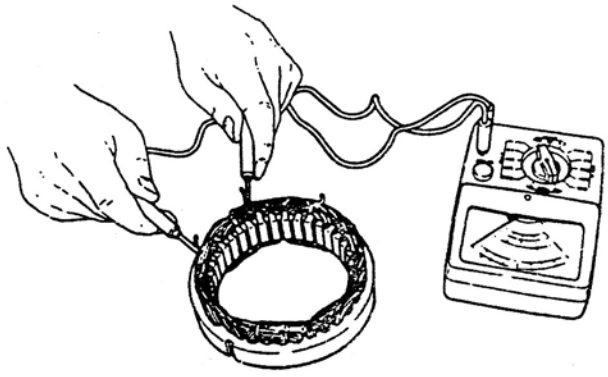
3) Rotor coil insulation test
Check the continuity between the slip ring and the rotor core, or the shaft. If there is continuity, insulation inside the rotor is defective, causing a short with the earth circuit. Replace the rotor coil.



4) Check the rear side ball bearing. If the rotation of the bearing is heavy, or produces abnormal sounds, replace the ball bearing.



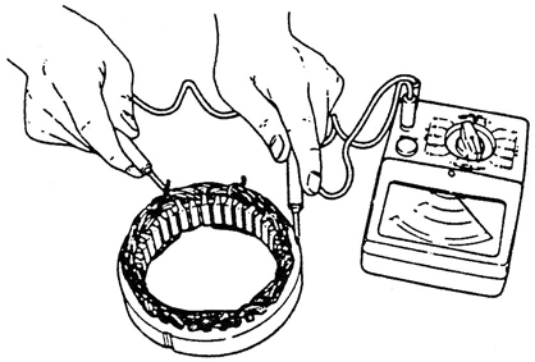
(3) Stator
1) Stator coil continuity test
Check the continuity between each terminal of the stator coil. If there is no continuity, there is a wire break in the stator coil. Replace the stator coil.



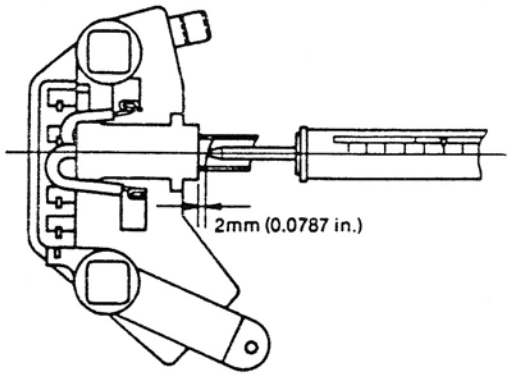
Resistance value	Approx. 0.21Ω at 20°C (LR120)
	Approx. 0.14Ω at 20°C (LR135)

(1-phase resistance)

2) Stator coil insulation test
Check the continuity between the terminals and the stator core. If there is continuity, insulation of the stator coil is defective. This will cause a short-circuit with the earth core. Replace the stator coil.

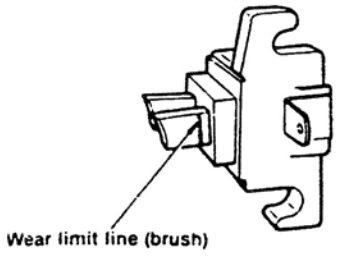


(4) Brush
The brush is hard and wears slowly, but when it is worn beyond the allowable limit, replace it. When replacing the brush, also check the strength of the brush spring.
To check, push the spring down to 2mm (0.0787in.) from the end of the brush holder, and read the gauge.



Brush spring strength	255—345g (0.56 ~ 0.76lb.)

(5) Brush wear
Check the brush length.
The brush wears very little, but replace the brush if worn over the wear limit line printed on the brush.



mm (in.)

	Maintenance standard	Wear limit
Brush length	16 (0.6299)	9 (0.3543)

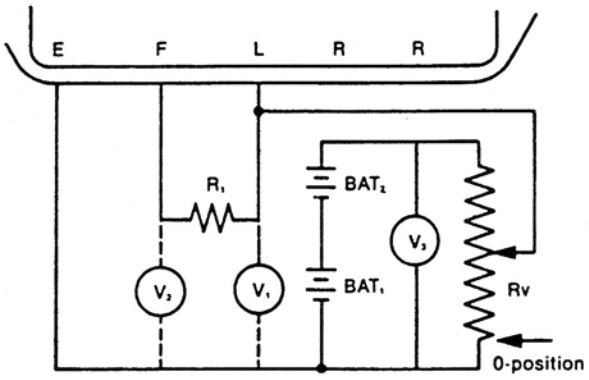
(6) IC regulator

Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the following wiring.

1) Use the following measuring devices.

Resistor (R_1)	100Ω, 2W, 1pc.
Variable resistor (Rv)	0—300Ω, 12W, 1pc.
Battery (BAT_1, BAT_2)	12V, 2pcs.
DC voltmeter	0—30V, 0.5 class 1pc. (measure at 3 points)

2) Check the regulator in the following sequence, according to the diagram.
   a) Check V_3 (BAT_1 + BAT_2 voltage). If the voltage is 20—26V, both BAT_1 and BAT_2 are normal.
   b) While measuring V_2 (F-E terminal voltage), move Rv gradually from the 0-position. Check if there is a point where the V_2 voltage rises sharply from below 2.0V to over 2.0V. If there is no such point, the regulator is defective. Replace the regulator. If there is a sharp voltage rise when testing, return the Rv to the 0-position, and connect the voltmeter to the V_1 position.
   c) While measuring V_1 (voltage between L-E terminals), move Rv gradually from the 0-position. There should be a point where the voltage of V_1 rises sharply by 2—6V. Measure the voltage of V_1 just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V_1 is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.

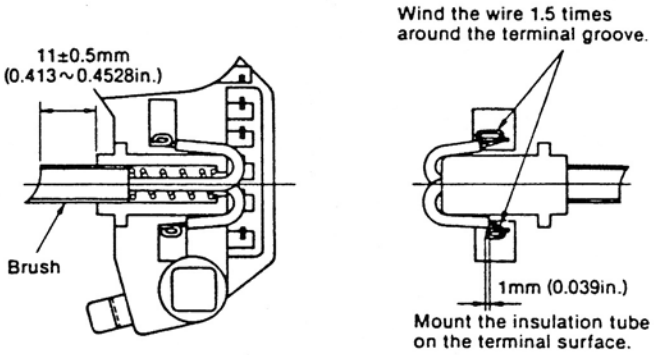


3-9 Reassembling the alternator

Reassembly is done in the reverse order of disassembly. For reassembly, be careful of the following points. (Refer to 3–7 disassembling alternator).

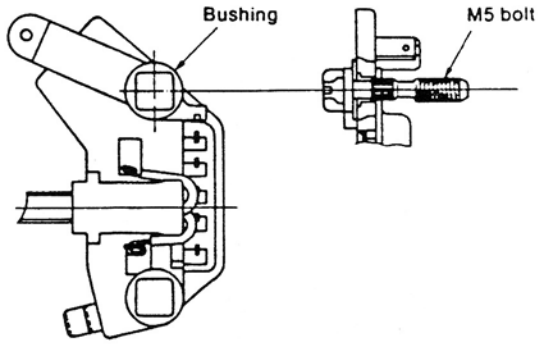
(1) Assembling the brush regulator

1) Solder the brush.
   Position the brush as shown in the drawing and solder it. Be careful not to let the solder drip into the pig tail (lead wire).



NOTES: 1. Use non-acid type paste.
2. The soldering iron temperature is 300 ~ 350°C.

2) Mount the IC regulator on the brush holder as illustrated, and press in the M5 bolt. Do not forget to assemble the bushing and the connecting plate at the same time.
   (If the bushing is left out, the output terminal will be earthed and the battery short-circuited).



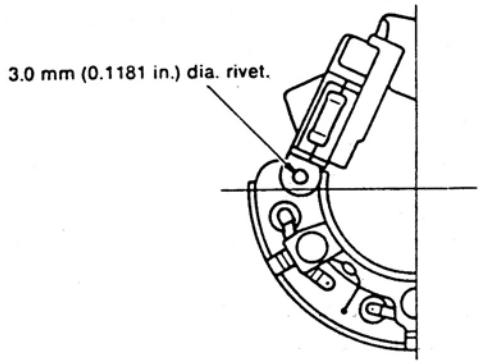
NOTES: 1. Insertion pressure is 100kg (220.5 lbs.)
2. Insert vertically.

(2) Connecting the brush regulator assembly and diode

1) Check the rivets
   Place the rivets as shown in the figure, and then calk them using the calking tool.

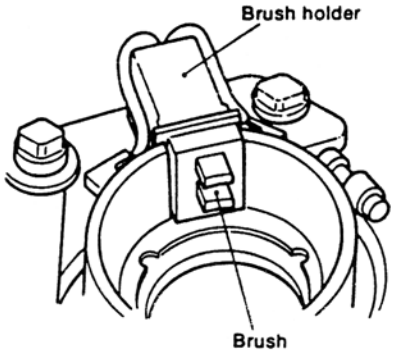
Calking torque	500kg (1102 lbs.)

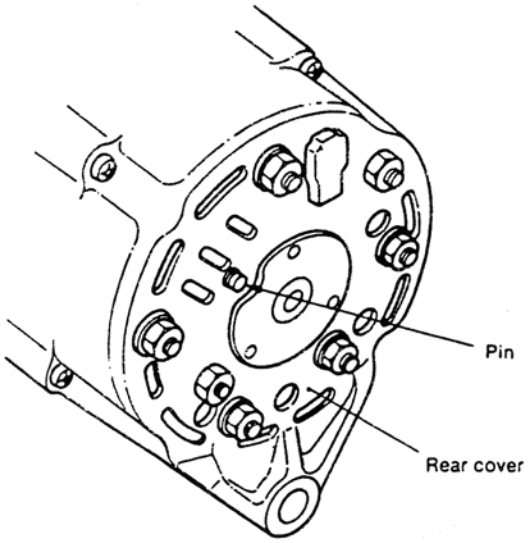
2) Connect the brush to the diode.
   Insert the brush side terminal into the diode terminal, calk it, and then solder into place.



Rivetting pressure	500kg (1102 lbs.)

(3) Assembling the rear cover
Insert pins from the outside of the rear cover. Install the brush on the brush holder, then attach the rear cover. After assembly, pull out the pins.



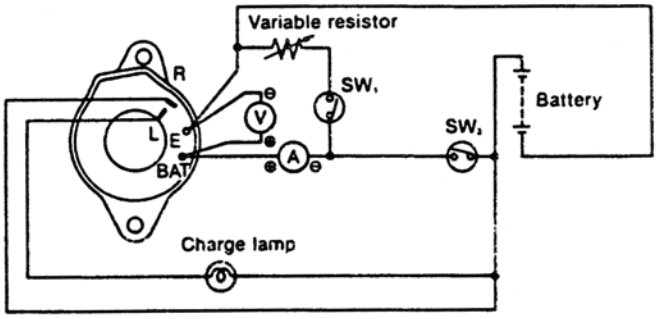


(4) Tightening torques

Positions		Tightening torque kg-cm (ft-lb)
Brush holder fixing	(M5)	32–40 (2.31 ~ 2.89)
Diode fixing	(M5)	32–40 (2.31 ~ 2.89)
Bearing retainer fixing	(M4)	16–20 (1.16 ~ 1.45)
Pulley nut tightening	(M14)	450 – 550 (32.5 ~ 40)
Through-bolt tightening	(M5)	32–40 (2.31 ~ 2.89)

3-10 Performance test

Conduct a performance test on the reassembled AC generator as follows. The following is the circuit for the performance test.



(1) Measuring devices

Battery	Fully charged 12V battery
DC voltmeter	0–30V, 0.5 Class, 1 pc.
DC ammeter	0–50A, 1.0 Class, 1 pc.
Variable resistor	0–1Ω, 1 kW, 1 pc.
Lamp	12V, 3W
Switch	Capacity 40 Amps.

(2) Speed measurement at 13.5 V
1) Start the alternator slowly after opening SW1 and closing SW2.
2) After the alternator has reached a speed of approximately 500 rpm, open switch SW2.
3) Gradually increase the alternator speed while watching the voltmeter, and read the speed on the tachometer when the voltage reaches 13.5 V.
4) The speed at this time is 1,000 rpm or less, and is the 13.5 V rise speed.

(3) Output measurement
1) Set the variable resistor to the maximum resistance value, close the SW1 and SW2, and start the alternator.
2) Revolve the alternator at 5,000 rpm while keeping a voltage 13.5 V with the variable resistor.
3) Measure the current with an ammeter when the alternator speed at 5,000 rpm.
4) The current at this time is the standard value. (20A or more at 13.5 V)

(4) Performance test precautions
1) Connect the alternator BAT terminal and battery (+) terminal, and the E terminal and battery (–) terminal using 2.5 m or less of wiring having a crosssectional area of 8 mm² or more.
2) Check the wires for correct or loose connection.

[B] Magneto-Generator

The magneto-generator is standard to the VM, CL, and CH specifications, though the standard alternator 12 V/20 A is furnished to the S, G1, and G2 specifications.

1. Specifications

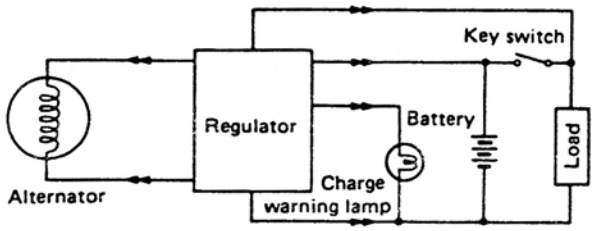
Output (V/A)				12/15	12/20
Manufacturer				Kokusan	←
Manufacturer's code				GP8138	GP9165
Yanmar code				171301-77201	129150-77202
Combinated regulator	Manufacturer's code			RS5118	K2A34
	Yanmar code	*	A	119660-77710	129150-77710
			B	171301-77700	119640-77710
	Regulated voltage (V)			14 – 15	←
Combinated safety relay		*		–	–
				121522-77101	←
Conbinated charge indicator		*	A	–	–
			B	121522-77721	←
Usable speed (rpm)				900 – 6500	1300 – 4800
Max speed (rpm)				7000	4800
Output current (A)/Voltage (V) - speed (rpm)				14-15/12-7000	20/12-4500
Permissible ambient temperature °C (°F)				-40 – +80 (-40 – 176)	-25 – +65 (-13 – 149)
Ground polarity/Weight <kg (lb)>				Negative/1.6 (3.5)	Negative
Pulley	Belt/Pulley outer dia <mm (in.)>			A single/65 (2.56) or HM single	←
Shaft	Drive end	Outer dia. <mm(in.)>/Bearing		12 (0.47)/6201ZZC3	←
	Rear end	Outer dia. <mm(in.)>/Bearing			

* *marks: Use regulator B in combination with safety relay B and charge indicator B.*

(2) Construction

The magneto-generator is composed of the starter coil, rotor magnet, drive shaft/pulley, bearings, etc.
The magneto-generator is kept excited by the magneto. This requires the regulator to limit a greater current as compared with the alternator.
In addition, the magneto-generator must be sufficiently cooled because of a greater calorific value developed.
The magneto-generator shows a little larger horsepower loss than the alternator. The magneto-generator has a simple configulation, smaller size, lighter weight, and is less expensive than the alternator.

Wiring diagram



(3) Disassembly procedure

1) Disconnect the generator from the engine.
2) Remove the cap and the M10 hexagonal nut.
3) Fix the end of the shaft. Do not fix the flywheel.
4) Pull out the rotor magnet.
   Tap the threaded end (M10) of the shaft with a mallet or the like.
5) Clamp the lead-wire to the coil plate.
   Remove an M4 screw and the coupler.
6) Remove the stator coil from the coil plate.
   Remove 2-M4 screws.

(4) Reassembly procedure

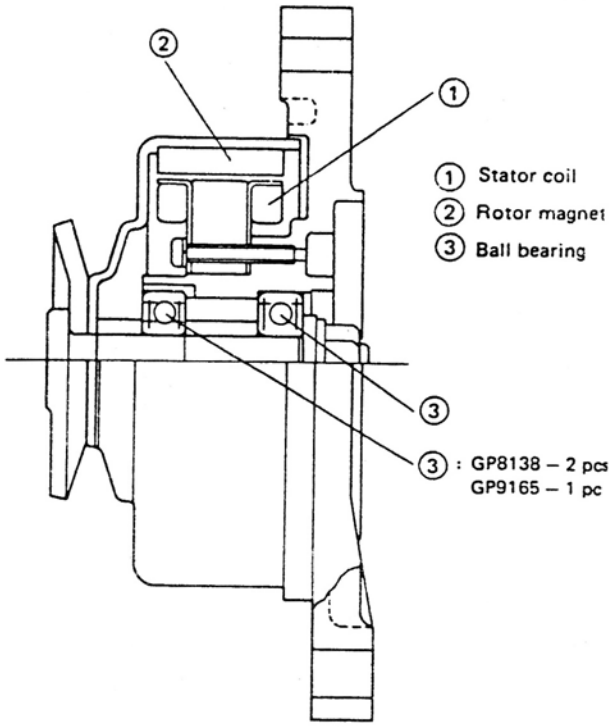
1) To reassemble the magneto-generator, reverse the steps indicated in Disassembly procedure.
2) Tighten the M10 hexagonal nut to a torque of 300 – 350 kg-cm.

(5) Generator check

Follow the next directions to check if the generator works abnormally.

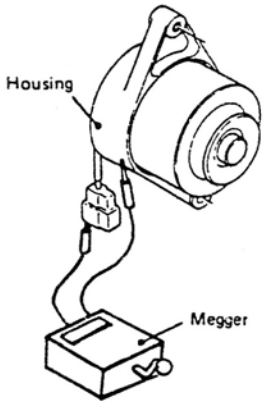
1) Disconnect the generator output wiring to the regulator, with the generator left coupled with the engine.
2) Extend the generator output wiring and connect it to a volt/ammeter.
3) Set the volt/ammeter to the 100 VAC range.
4) Start the engine and check the volt/ammeter for readings.
5) When the specified voltage is proven on the volt/ammeter, the generator is in normal operation.

GP8138: Approx. 15.7 V(AC) at 3000 rpm (gen.)
GP9165: Approx. 24.8 V(AC) at 3000 rpm (gen.)



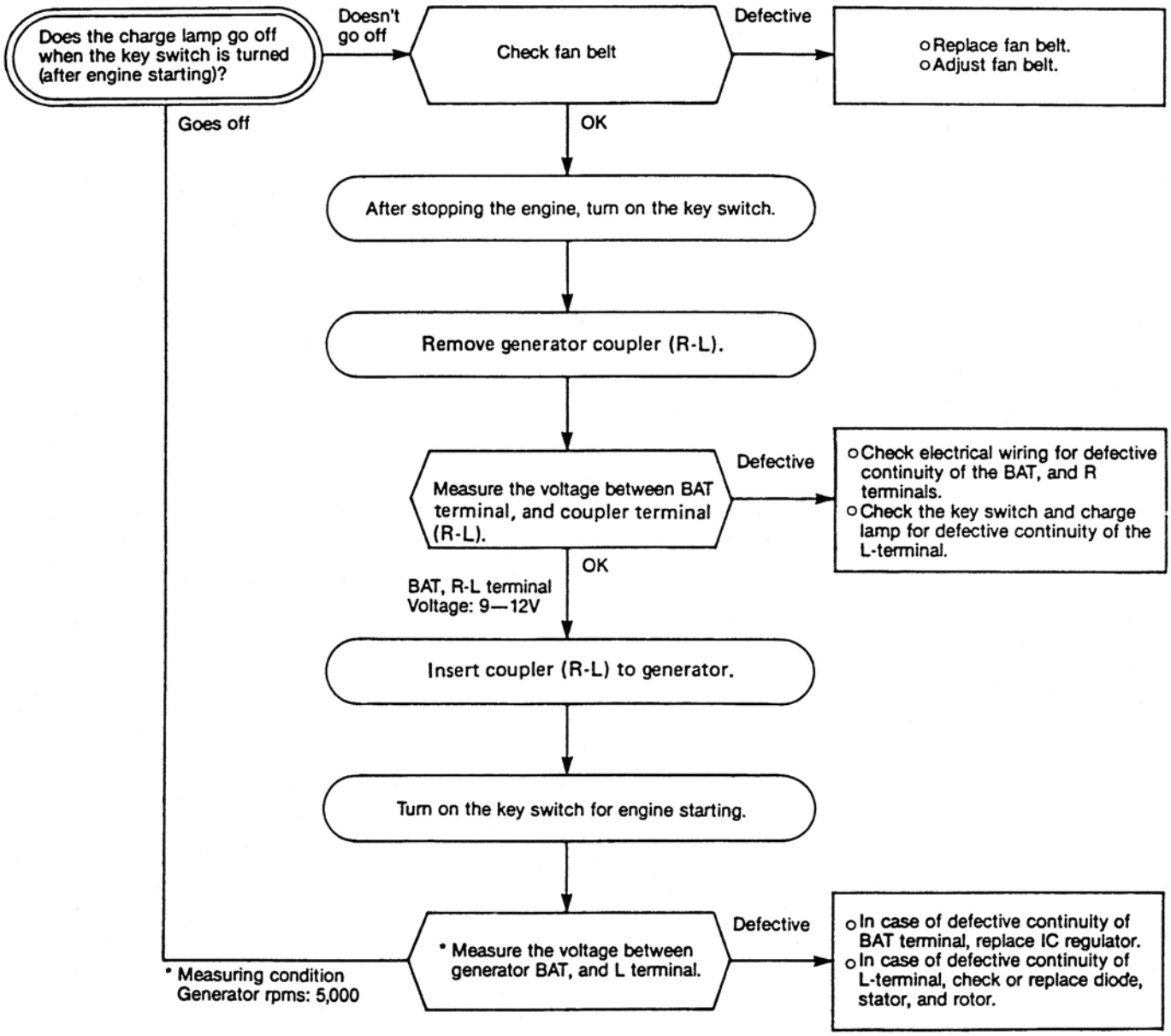
(6) Stator coil continuity test

1) Connect a wire of the megger to the terminal.
2) Contact the other wire of the megger to the housing for not more than 1 second, and check the indicator of the megger.
   If there is continuity (the resistance is zero), replace the stator coil.



4-11 Troubleshooting

(1) Charging failure



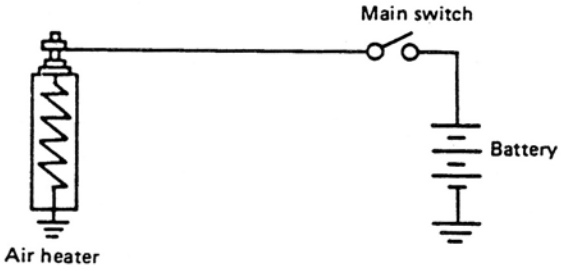
4. Starting Aids

4-1 Air heater (DI engine)

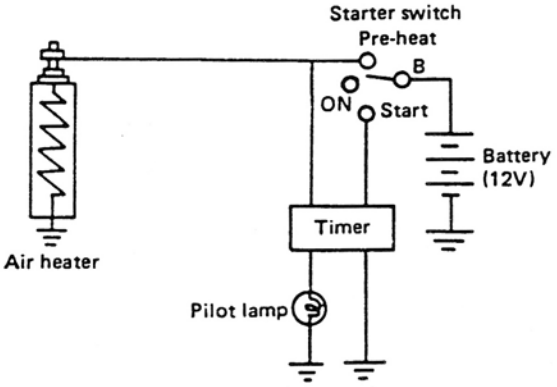
An air heater is available for warming intake air during starting in cold weather. The air heater is mounted on the end of the intake manifold.
The device is operated by the key switch on the instrument panel.

A timer is equipped for the pre-heating. When this device is initially turned ON by the key switch, the pilot lamp lights. The timer is set so that the pilot lamp goes off 15 sec after the system is turned ON. When the pilot lamp goes off, once turn the key switch to OFF. Then, turn the key switch to START to start the engine.
Air heater system circuit: Air heater Pilot lamp Timer

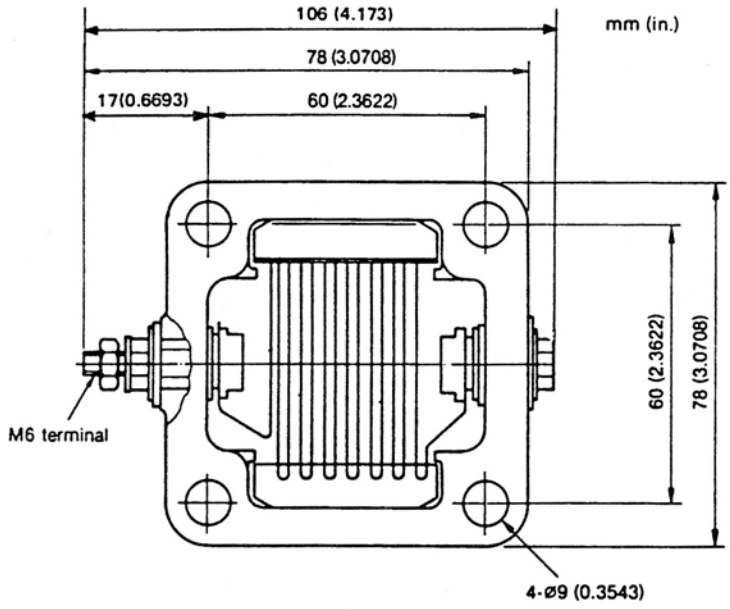
Air heater system circuit (without Timer)



Air heater circuit (with Timer)



Connection while starting:
B — Start — Pre-heat



Rated output	400W
Rated current	33.3A
Rated voltage	DC 12V
Rated operating time	Pre-heating: 15 sec. Engine operation: 30 sec. max. Engine stop: 30 sec.
Range of operating temperature	-30°C (-22°F) or higher
Earth polarity	Negative earth/Body earth

4-2 Glow Plug System (IDI engine)

(1) Description

This system consists of glow plugs, switch, timer, pilot lamp, etc., and is designed to help easy starting in cold weather.

When the key switch is turned on toward heat side, the battery power flows to each glow plug installed in the combustion chamber and heats the combustion chamber to ease starting. The pilot lamp lights while the glow plug are being heated.

The timer is set so that the pilot lamp goes off 15 sec. after the system is turned ON. When the pilot lamp goes off, turn the key switch to OFF. Turn the key switch to START to start the engine.

(2) Precaution for handling the glow plug system

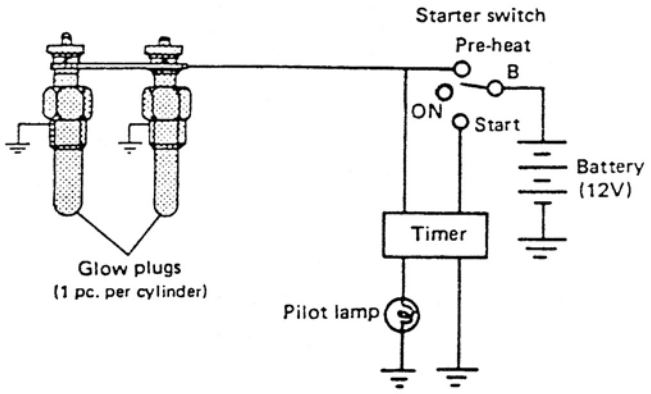
1) Use the glow plug system only when the weather is extremely cold.
2) Do not heat the glow plug continuously or they will burn out.

(3) Glow plug inspection

1) Remove the glow plug and check for carbon deposit or damage. Replace the glow plug if necessary.
2) Check for continuity between the glow plug terminal and body using a volt/ammeter.Replace the glow plug if there is no continuity.

Glow plug resistance	1.35 Ω – 1.65 Ω

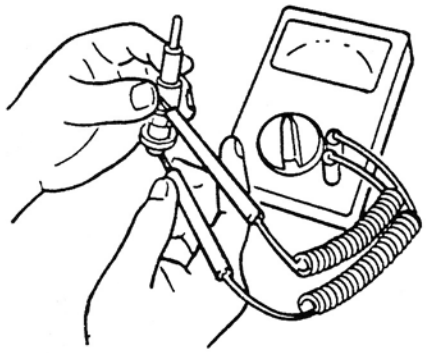
Glow plug system circuit



Connection while starting:

B – Start – Pre-heat

Glow plug continuity test



5. Battery

5.1 Battery capacity and battery cables

5.1.1 Battery capacity

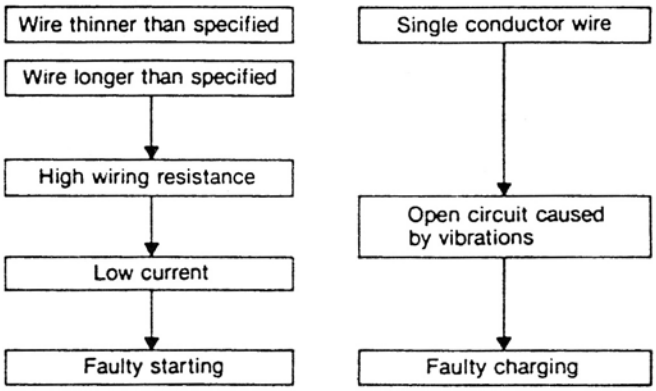
Recommended battery capacity

	Standard (recommended)				For cold starting
Atmospheric temperature	More than -5°C (23°F)				See TN series Application manual (Use battery more than standard battery capacity)
JIS standard Capacity	36B20R	46B24R	55B24R	55D26R	
5 hrs. rating/20 hrs. rating (AH)	28/(35)	36/(45)	←	48/(60)	
2,3TN66E	○				
3TNA72E		○			
3TN75E, 3TNC78E		○			
3TN82(T)E, 3TN84(T)E			○		
4TN82(T)E, 4TN84(T)E				○	

5.1.2 Battery cable

Wiring must be performed with the specified electric wire. Thick, short wiring should be used to connect the battery to the starter, (low-voltage cables for automobile [AV wire]).
Using wire other than that specified may cause the following troubles:

The starter motor circuits, excluding motor, relay, and solenoid, shall be designed so that the difference between the voltage at the storage battery terminals and the starter motor terminals including connections shall not exceed those shown in the following table.



Permissible length of battery cable (m) Max.

Cable	Nominal conductor cross section area (mm^2) ( ): calculated area	Rated voltage	12 V			Conductor resistance of cable (Ohm/m)
		Starter capacity	Below 2 KW	2 KW (incl.) and more		
		Battery switch	Present or not	None	Present	
*AV cable	15 (13.36)		≤ 0.86 m			0.001380
	20 (20.61)		≤ 1.30 m			0.000887
	30 (35.19)		≤ 2.30 m	≤ 1.5 m	≤ 0.76 m	0.000520
	40 (42.73)		≤ 2.80 m	≤ 1.8 m	≤ 0.90 m	0.000428
	50 (54.29)		≤ 3.50 m	≤ 2.3 m	≤ 1.20 m	0.000337
	60 (63.84)		≤ 4.10 m	≤ 2.7 m	≤ 1.40 m	0.000287
	85 (84.96)		≤ 5.50 m	≤ 3.7 m	≤ 1.80 m	0.000215
	100 (109.1)		≤ 7.10 m	≤ 4.7 m	≤ 2.40 m	0.000168
	Permissible resistance of cable (Ohm)		0.0012	0.0008	0.0004	
	Permissible resistance of starter motor circuit (Ohm)		0.002 (0.2 V/100A)	0.0012 (0.12V/100A)		

* JIS C 3406, Low-boltage cales for automobile.

Notes: 1. Find the cable length in the following equation:

$$\text{Cable length} = \frac{\text{permissible cable resistance}}{\text{permissible cable conductor resistance}}$$

5.2 Battery inspection

The quality of the battery governs the starting performance of the engine. Therefore the battery must be routinely inspected to ensure that it functions perfectly at all times.
Check the electrolyte level in each cell. If the level is low, add distilled water to bring the level to the UPPER level.
Check the battery case for loose parts, cracked case or top.
Check the battery terminals for looseness or rusting.
Check the battery cap for the clogged vent holes.
Test each cell by drawing electrolyte into the hydrometer.

SPECIFIC GRAVITY: 1.270–1.290 (Type II)
1.260–1.280 (Type I)

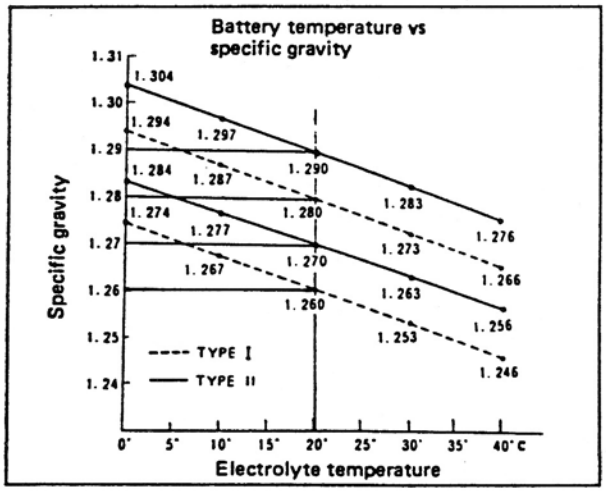
WARNING

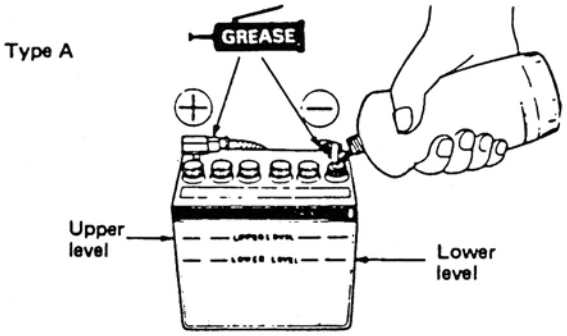
The battery contains sulfuric acid. Avoid contact with skin, eyes, or clothing.
Antidote: Flush with water and get prompt medical attention.

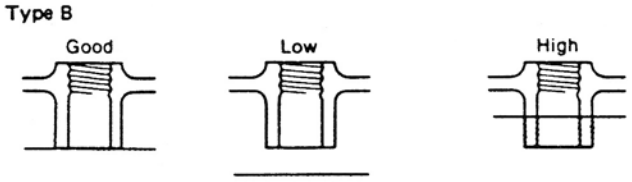
NOTE:

- Do not overfill the battery. Wipe up spilled electrolyte at once and flush well with water.
- The specific gravity varies with the temperature as shown in the accompanying table.
- The battery must be replaced if sulfation is evident.
- The battery must be replaced if there are pastes settled on the bottom of each cell.

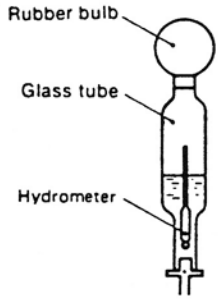
Variation of Specific Gravity with Temperature

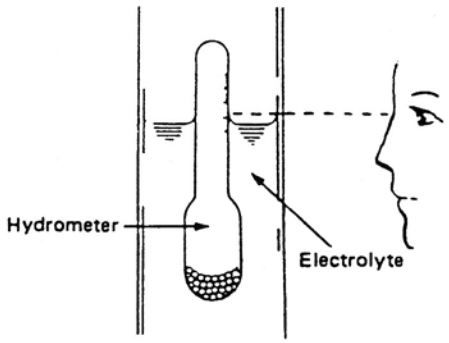






Check the electrolyte level every 7 to 10 days. The electrolyte must always be 10 – 20 mm (0.3937 – 0.7874 in.) over the top of the plates.





5.3 Battery Charging

Remove the battery; remove the cap from each cell.
Connect the charger positive (+) cable to the battery positive terminal.
Connect the charger negative (–) cable to the battery negative terminal.

Charging current:

Battery current 20 hrs. rating – 10 hrs. rating.

Example: 20 hrs. rating 45 AH, battery
(45 ÷ 20) – (45 ÷ 10) = 2.25A – 4.5A

Charging:
Charging the battery until specific gravity is 1.270 – 1.290 at 20°C (68°F). (Incase of the battery of Type 1: 1.260 – 1.280)

Warning

- **Before charging remove the cap from each cell.**
- **Keep fire and sparks from a charging battery.**
- **Turn power ON/OFF at the chager, not at the battery terminals.**
- **Discontinue charging if the electrolyte temperature exceeds 45°C (117°F).**

CAUTION:

Quick-charging should only be done in an emergency; slow-charging is preferred.

After installing the battery, coat the terminals with clean grease.

6. Service Data

Applicable model			2TN66E 3TN66E-G2		3TN66E-S 3TNA72E-G2 3TNA72E-S		3TN75E-S 3TN75E-G2 3TNC78E		3TN75E-G1 3TNC78E(CL)		3TN82E-S 3TN82E-G2 3TN84(T)E(CH)	
			Stand-ard	Wear limit	Stand-ard	Wear limit	Stand-ard	Wear limit	Stand-ard	Wear limit	Stand-ard	Wear limit
Starter motor model			S114-443		128000-1151		S114-349A		S114-146		S114-257G	
Rating		sec	30		30		30		30		30	
Output		kW	0.8		1.0		1.2		1.3		1.8	
Direction of rotation (viewed from pinion side)		–	Clockwise		←		←		Clockwise		←	
Weight		kg(lb)	4.3 (9.9)		3.9 (8.6)		4.5 (9.9)		6.0 (13.2)		5.0 (11.0)	
Clutch system		–	Over running		←		←		Overrunning		←	
Engagement		–	Magnetic shift		←		←		Magnetic shift		←	
No. of pinion teeth		–	8		11		15		15		15	
Pinion coming out voltage		V	8		8		8		8		8	
No-load	Terminal voltage	V	11.5		11.5		12		12		12	
	Current	A	<60		<90		<120		<60		<100	
	Speed	rpm	>7000		>3000		>5000		>6000		>4300	
Loaded characteristics	Terminal voltage	V	8		8		8.9		8.5		9.8	
	Current	A	200		230		300		350		200	
	Torque/rpm	kg-m/rpm (ft-lb)	0.46(3.326)/>1290		0.65(4.7)/>1180		0.8(5.78)/>1500		0.5 (3.615)		0.46(3.326)/>1900	
L-dimnsion (gap between pinion and pinion stoper)		mm (in)	0.3 – 1.5 (0.012 – 0.059)		←		0.3 – 1.5 (0.012 – 0.059)		←		←	
Commutator outside diameter		mm (in)			30 (1.181)	29 (1.142)	30 (1.181)	29 (1.142)	40 (1.575)	39 (1.536)	30 (1.181)	29 (1.142)
Commutator run-out		mm (in)	0.05 (0.002)	0.4 (0.016)	0.05 (0.002)	0.4 (0.016)	0.03 (0.001)	0.2 (0.008)	0.05 (0.002)	0.4 (0.016)	0.05 (0.002)	0.4 (0.016)
Mica undercut		mm (in)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)
Brush height		mm (in)			11 (0.433)	7.7 (0.303)	16 (0.630)	11 (0.433)	16 (0.630)	11.5 (0.453)	16 (0.630)	11 (0.472)
Standard spring load		kg (lb)					1.6 (3.5)		1.6 (3.5)		1.6 (3.527)	
Shunt coil resistance at 20°C (68°F)		ohm			0.1		0.6		0.695		0.74	
Series coil resistance at 20°C		ohm			0.1		0.33		0.325		0.35	
Rear side bearing	Shaft diameter	mm (in)					–		12.45 – 12.468 (0.490 – 0.491)		–	
	Bearing inside diameter	mm (in)					–		12.5 – 12.572 (0.492 – 0.493)		–	
Intermediate bearing	Shaft diameter	mm (in)					–		–		–	
	Bearing inside diameter	mm (in)					–		–		–	
Pinion sliding section	Shaft diameter	mm (in)					15.55 – 15.58 (0.612 – 0.613)		12.45 – 12.468 (0.490 – 0.491)		16.35 – 16.368 (0.6437 – 0.6444)	
	Pinion inside diameter	mm (in)					15.6 – 15.61 (0.614 – 0.615)		12.53 – 12.55 (0.493 – 0.494)		16.4 – 16.418 (0.6457 – 0.6464)	
Pinion side bearing	Shaft diameter	mm (in)					15.55 – 15.58 (0.612 – 0.613)		12.45 – 12.468 (0.490 – 0.491)		6904 ZZ	
	Pinion inside diameter	mm (in)					15.6 – 15.61 (0.614 – 0.615)		12.5 – 12.527 (0.492 – 0.493)		6004 ZZ	

Applicable model			3TN82E-G1 4TN82E-G1 3·4TN84(T)E(CL/VM)		4TN82E-S 4TN82E-G2 4TN84(T)E(CH)		4TN82TE-S 4TN84(T)E		4TN82TE-G1		
			Stand-ard	Wear limit	Stand-ard	Wear limit	Stand-ard	Wear limit	Stand-ard	Wear limit	
Starter motor model			S12-77A		S13-94		S13-94		S12-77A		
Rating		sec	30		30		30		30		
Output		kW	1.8		2.0		2.0		1.8		
Direction of rotation (viewed from pinion side)		–	Clockwise		←		←		←		
Weight		kg(lb)	9.3 (20.5)		5.3 (11.7)		5.3 (11.7)		9.3 (20.5)		
Clutch system		–	Over running		←		←		←		
Engagement			Magnetic shift		←		←		←		
No. of pinion teeth		–	15		15		15		15		
Pinion flyout voltage		V	8		8		8		8		
No-load	Terminal voltage	V	12		11		11		12		
	Current	A	<90		<140		<140		<90		
	Speed	rpm	>4000		>3900		>3900		>4000		
Loaded charac-teristics	Terminal voltage	V	8.5		8.76		8.76		8.5		
	Current	A	420		300		300		420		
	Torque/rpm	kg-m/rpm (ft-lb)	1.35(9.76)/>1100		0.7(5.062)/>1700		0.7(5.062)/>1700		1.35(9.76)/>1100		
L-dimnsion (gap between pinion and pinion stoper)		mm (in)	0.3 – 1.5 (0.012 – 0.059)		0.3 – 1.5 (0.012 – 0.059)		0.3 – 1.5 (0.012 – 0.059)		0.3 – 1.5 (0.012 – 0.059)		
Commutator outside diameter		mm (in)	43 (1.693)	42 (1.654)	36.5 (1.437)	35.5 (1.398)	36.5 (1.437)	35.5 (1.398)	43 (1.693)	42 (1.654)	
Commutator run-out		mm (in)	0.05 (0.002)	0.4 (0.016)	0.03 (0.001)	0.2 (0.008)	0.03 (0.001)	0.2 (0.008)	0.05 (0.002)	0.4 (0.016)	
Mica undercut		mm (in)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)	0.5–0.8 (0.020 – 0.032)	0.2 (0.008)	
Brush height		mm (in)	22 (0.866)	14 (0.551)	15 (0.591)	9 (0.354)	15 (0.591)	9 (0.354)	22 (0.866)	14 (0.551)	
Standard spring load		kg (lb)	0.85 (1.874)		2.7 – 3.3 (5.952 – 7.275)		2.7 – 3.3 (5.952 – 7.275)		0.85 (1.874)		
Shunt coil resistance at 20°C (68°F)		ohm	0.590		1.74		1.74		0.590		
Series coil resistance at 20°C		ohm	0.267		0.20		0.20		0.267		
Rear side bearing	Shaft diameter	mm (in)	14.950 – 14.968 (0.5886 – 0.5893)		6903 Z		6903 Z		14.950 – 14.968 (0.5886 – 0.5893)		
	Bearing inside dia-meter	mm (in)	15.000 – 15.018 (0.5906 – 0.5913)		608 Z		608 Z		15.000 – 15.018 (0.5906 – 0.5913)		
Inter-mediate bearing	Shaft diameter	mm (in)	20.350 – 20.368 (0.801 – 0.802)		6004 Z		6004 Z		20.350 – 20.368 (0.801 – 0.802)		
	Bearing inside diameter	mm (in)	20.500 – 20.518 (0.807 – 0.808)		6904 Z		6904 Z		20.500 – 20.518 (0.807 – 0.808)		
Pinion sliding section	Shaft diameter	mm (in)	13.950 – 13.968 (0.549 – 0.550)		16.35 – 16.368 (0.6437 – 0.6444)		16.35 – 16.368 (0.6437 – 0.6444)		13.950 – 13.968 (0.549 – 0.550)		
	Pinion inside diameter	mm (in)	14.030 – 14.050 (0.552 – 0.553)		15.6 – 15.7 (0.614 – 0.618)		15.6 – 15.7 (0.614 – 0.618)		14.030 – 14.050 (0.552 – 0.553)		
Pinion side bearing	Shaft diameter	mm (in)	13.950 – 13.968 (0.5492 – 0.550)		15.55 – 15.58 (0.612 - 0.613)		15.55 – 15.58 (0.612 - 0.613)		13.950 – 13.968 (0.549 – 0.550)		
	Pinion inside diameter	mm (in)	14.000 – 14.018 (0.551 – 0.552)		15.6 – 15.7 (0.614 – 0.618)		15.6 – 15.7 (0.162 – 0.618)		14.000 – 14.018 (0.551 – 0.552)		

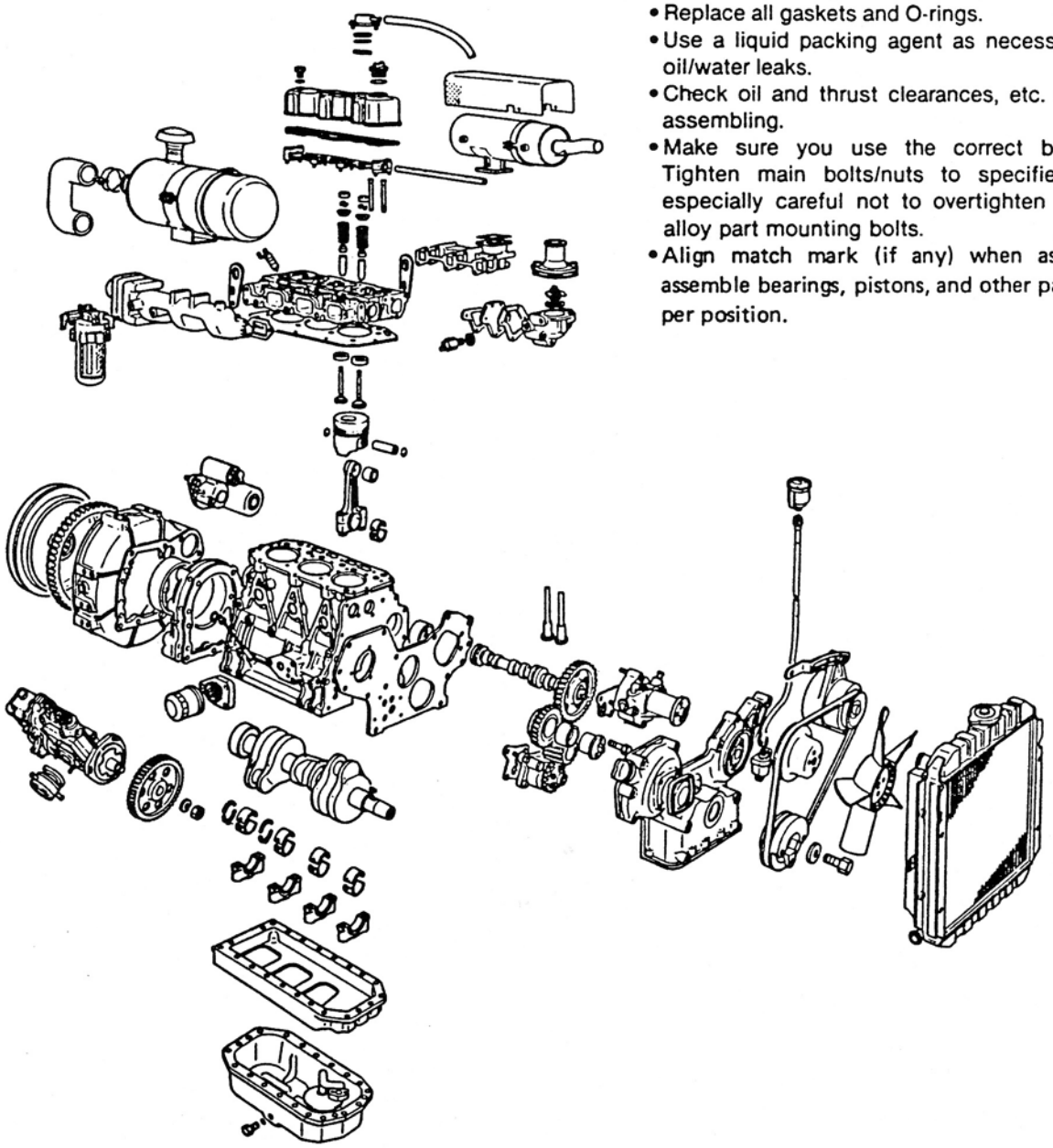
1. Disassembly and Reassembly Precautions

1-1 Disassembly

- Take sufficient time to accurately pin-point the cause of the trouble, and disassemble only those parts which are necessary.
- Be careful to keep all disassembled parts in order.
- Prepare disassembly tools.
- Prepare a cleaner and cleaning can.
- Clear an adequate area for parts and prepare container(s).
- Drain colling water and lube oil.

1-2 Reassembly

- Sufficiently clean and inspect all parts to be assembled.
- Coat sliding and rotating parts with new engine oil when assembling.
- Replace all gaskets and O-rings.
- Use a liquid packing agent as necessary to prevent oil/water leaks.
- Check oil and thrust clearances, etc. of parts when assembling.
- Make sure you use the correct bolt/nut/washer. Tighten main bolts/nuts to specified torque. Be especially careful not to overtighten the aluminum alloy part mounting bolts.
- Align match mark (if any) when assembling. Reassemble bearings, pistons, and other parts in the proper position.

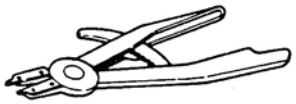


2. Disassembly and Reassembly Tools

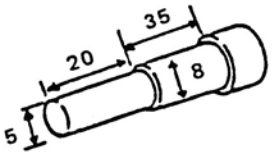
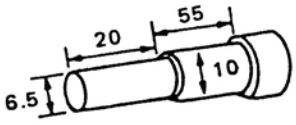
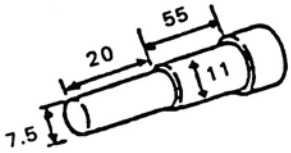
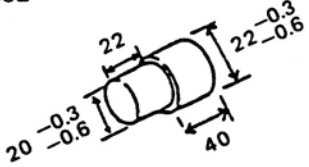
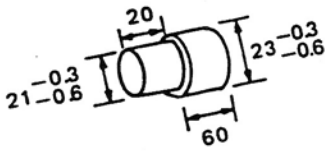
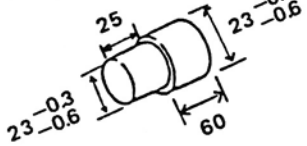
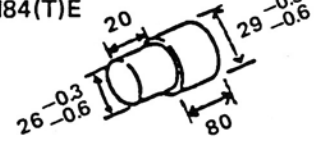
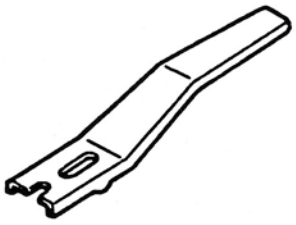
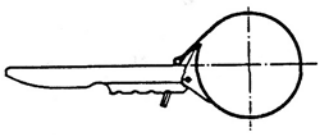
2-1 Tools, Instruments, and Service Accessories

Standard Tools

(The following tools are provided with your engine as standard tools.

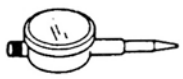
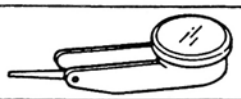
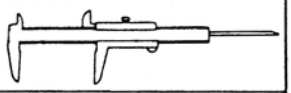
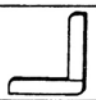
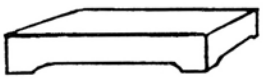
Tool	Remarks (Yanmar code No.)	Illustration
Yanmar service tool set	Set A (65 tools) (95500-000001) Set B (46 tools) (95500-000002)	
Piston insertion ring	Type 2476N (ϕ60 ~ ϕ125) (95550–002476) Type 2476H (ϕ90 ~ ϕ175) (95550–002477)	
Hole plier	(28190-000130) (Included in Yanmar service tool set)	
Shaft plier	(28190-000020) (Included in Yanmar service tool set)	
Piston ring remover	(135410-92140)	

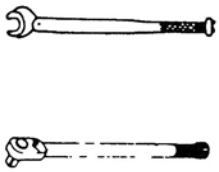
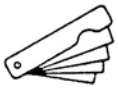
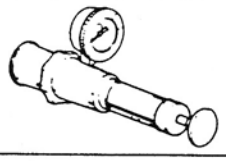
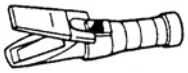
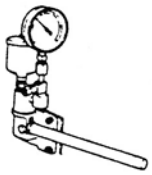
Disassembly & Reassembly Special Service Tools

Valve guide remover	2,3TN66E  3TNA72E, 3TN75E, 3TNC78E  3,4TN82(T)E, 3,4TN84(T)E 
Connecting rod bushing remover	2,3TN66E  3TNA72E  3TN75E, 3TNC78E  3,4TN82(T)E, 3,4TN84(T)E 
Valve guide compressor	
Filter wrench	

2-2 Meters, Instruments, and Service Accessories

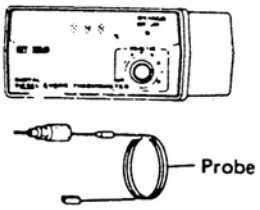
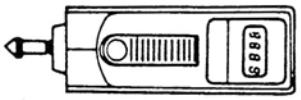
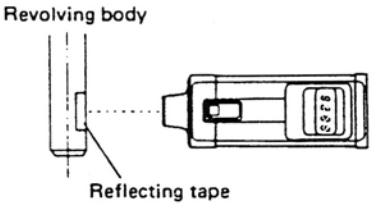
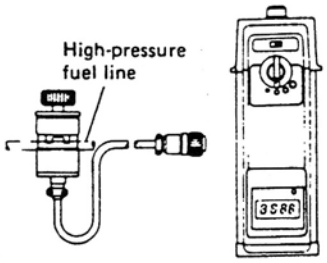
(Required for servicing medium – or small size engines)
– Only representative sizes –

Nomenelature	Remarks	Illustration
Dial indicator	1 div.: 0.01 mm, Range: 0–5 mm, 0–10 mm — To measure the straightness of shafts, flatness of planes, and gap widths.	
Test indicator	1 div.: 0.01 mm, Range: 0–0.8 mm — To measure positions too narrow and too deep for normal dial indicators.	
Magnet stand	Trunk bar (dia. x length) (mm) / Branch bar (dia. x length) (mm): 12 x 176 / 10 x 165; 14 x 183 / 12 x 165 — To attach dial indicators to various positions for easy accurate viewing.	
Micrometer	Range (mm): 0–25, 25–50, 50–75, 50–100 — To measure the O.D. of the crankshaft, pistons, and piston pins.	
Cylinder gauge	Range (mm): 10–18, 18–35, 35–60, 50–100 — To measure the I.D. of the cylinder liners and main bearings.	
Vernier calipers	1 div.: 0.05 mm, Range: 0–150 mm — To measure various O.D., depths, thicknesses, and widths.	
Depth micrometer	Range (mm): 0–25 — To measure valve sinkage and liner projection.	
Square	Size: 100 mm — To measure the inclination of valve springs and squareness of various parts.	
V-block	Size: 100x50x55 mm — To be used when measuring the straightness of a shaft.	
Level block	Size: 600x600 mm	

Instrument (Yanmar code No.)	Remarks	Illustration
Torque wrench	Bolt/nut size (mm) / Range (kg-cm): 6 – 14 / 4 – 30, 31 – 80; 17, 19, 21 / 31 – 160. To be used when tightening bolts and nuts with specified torques. Range (kg-cm): 40–120, 100–450, 400–1800, 400–2800	
Clearance gauge	Length 75 x 9 sheets. To measure clearances between piston rings and piston grooves or between shaft couplings during installation.	
Radiator cap tester (95500-005500)	Model RCT-2A, Range: 0–2 kg/cm^2. To inspect the watertightness of cooling water lines and the radiator cap.	
Battery electrolyte tester (95500-000013)	Model UFB-N_2. To inspect electrolyte specific gravity and charging condition.	
Nozzle tester (737600-93401) High pressure tube	Pressure gauge 0 – 500 kg/cm^2. To inspect spray condition and the injection pressure of the fuel injection valve. Injection-valve side nut M12 x 1.5 capnut	
Color check (for flaw detection) Set product (6 bottles) (97550-004560)	Penetrant (450 cc) (97550-00451) Developer (450 cc) (97550-004520) Cleaning agent (450 cc) (97550-004530). To be used in detecting flaws.	

2-3 Instruments

(Select the appropriate thermometer and tachometer from among the following types.)

Instrument (Yanmar code No.)		Remarks	Illustration
Thermo-meter	Digital type Model BT-888 (955000-08000) Probe (955000-08640)	Instantaneously measures in each cylinder temperature using a changeover switch. CA-64	
Tacho-meter	Mechanical type Model HT-330 (95500-001033)	The shaft end of the tachometer touches the center of the rotating shaft to measure RPMs.	
	Photoelectric type (non-contacting) Model HT-441 (95500H-T4410) Reflecting tape (10 pieces) (955000-01041)	Reflecting tape is applied to the outside of the rotating parts to measure RPMs. Capable of measuring RPM of reduction gears, step-up gears, and pulleys.	
	High-pressure fuel pipe cramping type Model GE-450 (955000-01045)	Measure engine RPM's using pulse system.	
	Circuit tester	To measure resistance, DC voltage, AC voltage, DC current and continuity test.	

2-4 Other Service Accessories

Chemicals		Volume	Yanmar code No.	Features and applications
Liquid packing	Three Bond No. 1	100 g (200 g and 1 kg also available)	97777-100100	Wet viscous liquid packing. Non-solvent type. Highly resistant to seawater and easy to remove. Applicable to all contacting surfaces.
	Three Bond No. 2	100 g (200 g and 1 kg also available)	97777-200100	Wet viscous liquid packing. Easy to apply and highly resistant to seawater and oil. Especially durable with gasoline.
	Three Bond No. 3	150 g	97777-300150	Drying film type forms a thin film with low viscosity. Suitable for the contact surfaces of precision parts.
	Three Bond No. 4	100 g(200 g and 1 kg also available)	97777-400100	Semi-drying visco-elastic type. Applicable to distorted areas with poor flatness. Highly resistent to heat, water and oil.
	Three Bond	100 g	97777-001212	Non-solvent type silicone packing.
Locking agent for metals	Neji Lock	200 g	97777-700200	Prevents screws and bolts from loosening, leaking air, and rusting. This agent can be loosened by applying greater torque than specified.
	Neji Lock Super	50 g	97777-800010	Secures bolts semi-permanently with strong adhesion.
Three Bond Seal Tape		5 m roll	97777-900500	Applicable to thread sections of piping. Temperature range: −150°C – +200°C
O-ring kit (with storage bag)		1.9 mm dia. 1pc. 2.4 mm dia. 1pc. 3.1 mm dia 2 pcs. 3.5 mm dia. 1 pc. 5.7 mm dia. 1 pc.	97777-057000	To be used with O-ring made on-site in emergency situations. (includes adhesive, release agent, cutter, and jig.)
Extreme-pressure lubricant (Molybdenum disulfide)	Rohcol paste	50 g	97775-400050	Used when assembling engine cylinders, pistons, bearings, and shafts. Spray-type is easy to apply.
	Paste Spray	330 g	97775-300330	
	Molypaste H	50 g	97775-500050	Prevents screws and bolts from seizure at high temperatures.

Chemicals		Volume	Yanmar code No.	Features and applications
Descaling agent	Unicon 146	1 case (4 kg x 4) with a PH testing sheet.	97410-001460	o Removes scale quickly. (1-10 hours). o Dissolve one part Unicon in 10 parts water by weight and mix thoroughly. o Dipping disassembled parts removes scale from them. Removes scale: removal is accelerated by engine revolution. o Test the PH – or effectiveness – of descaling agent. If litmus paper turns red, the agent is still effective.
		5 cases (4 kg x 4 x 5) with a PH testing sheet.	97410-001465	
	Neutralizing agent (caustic soda)	1 case (2 kg x 4)	97410-002001	
	Litmus paper		97410-003000	
Rust prevention agent		2ℓ	97410-004200	Effective for 6 months when added to cooling water at a ratio of 1 : 10.
Yanmar Super Freeze (antifreeze agent)		2ℓ x 1 can 18ℓ x 1 can 200ℓ x 1 can		No replacement is required for two years because this agent acts as anti-freeze in winter and coolant in summer. Can be used with anti-rust agent.

Temperature	-5°C	-10°C	-15°C	-20°C	-25°C	-30°C	-35°C	-40°C
Volumes mixing ratio	15%	25%	30%	35%	40%	45%	50%	55%

Cleaning agent (Metal Clean Y	1 kg x 20	97560-002000	o Powerful cleaning action capable of removing carbon build-up. o Safely heated for extremely powerful cleaning action. o Does not corrode most metals (also prevents rust from forming.) o 1 kg of Metal Clean Y should be dissolved in 40ℓ of water. o When the Cleaner is used, heating the solution to 60-80°C gives higher cleaning ability.

3. Disassembly and Reassembly

3-1 Disassembly

Disassembly procedure should be undertaken only after the following parts have been removed.

* Battery cables
* Fuel pipe (Fuel tank to fuel feed pump)
* Control panel
* Power take off shaft
* Electrical wiring
* Cable (for speed control and for engine emergency stop)

(1) Cooling water

1) Remove the water drain plug on the cylinder block side and drain the cooling water.
2) Drain the water in the radiator.
3) Tighten the drain plug and close the drain cock.

(2) Lubricating oil

1) Remove the drain plug on the oil pan, and drain the lubricating oil.
2) Tighten the drain plug after draining the lubricating oil.

(3) Radiator

1) Disconnect the cooling water hoses.
2) Remove the radiator mounts and stay.
3) Remove the radiator.

(4) Removing the turbocharger (turbocharged engine only)

1) Remove the air hose.
2) Remove the lube pipe for the turbocharger.
3) Remove the tuubocharger.

(5) Exhaust silencer

Remover the silencer.

(6) Air cleaner

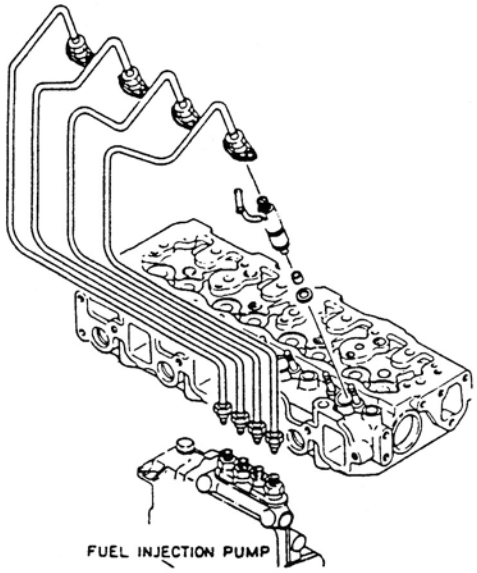
Remove the air cleaner together with the bracket and intake hose.

(7) Exhaust manifold

Remove the exhaust manifold.

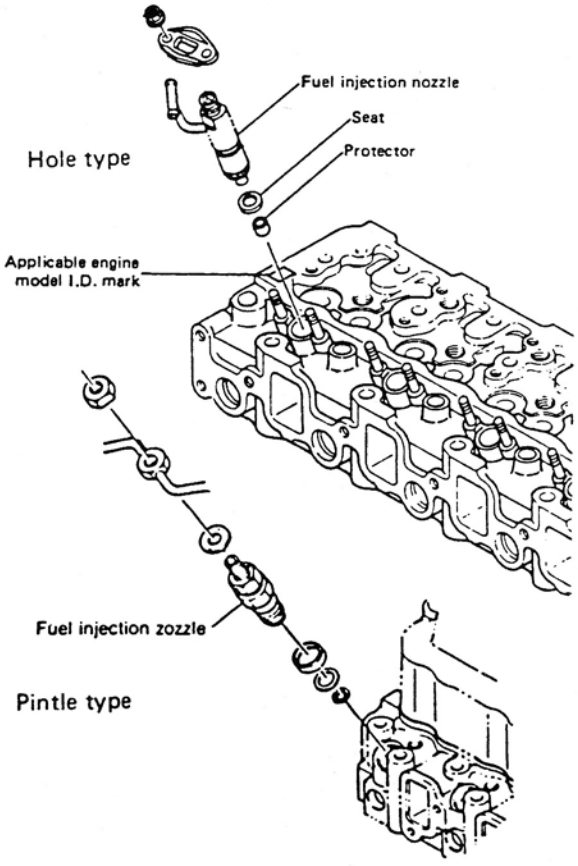
(8) Removing the high pressure fuel pipe.

1) Loosen the box nuts on both ends of the fuel injection pipe and remove the fuel injection pipe.
2) Remove the fuel oil return pipe.
(fuel injection nozzle - fuel injection pump)



(9) Removing the fuel injection nozzles

Remove the fuel injection nozzle retainer nut, and pull out the fuel injection nozzle retainer and fuel injection nozzle.

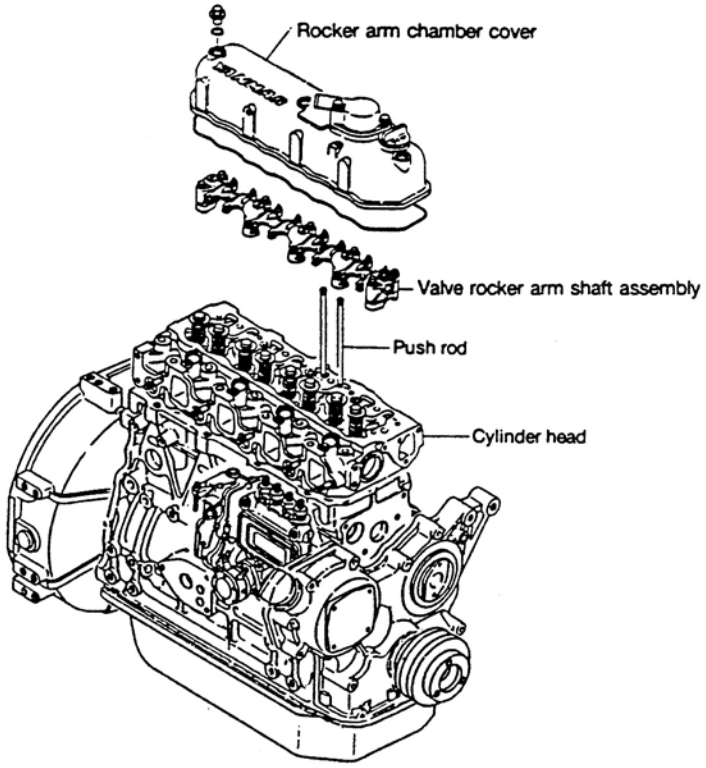


(10) Removing the valve rocker arm shaft assembly

1) Remove the valve rocker arm cover.
2) Remove the valve rocker arm shaft mounting bolts, and remove the rocker arm shaft assembly.

3) Pull out the push rods.

NOTE: Verify the cylinder No., and indicate intake or exhaust (for reassembly purposes)

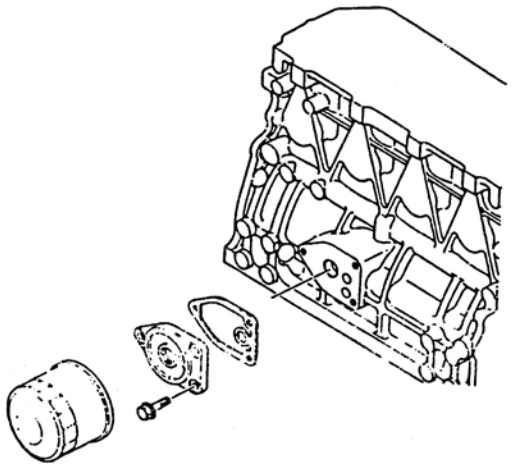


(11) Alternator

1) Remove the radiator fan bolt and radiator fan.
2) Remove the belt adjusting bolt and loosen the alternator pivot bolt.
3) Remove the fanbelt.
4) Remove the alternator pivot bolt and alternator.

(12) Removing the lube oil filter

1) Remove the filter bracket with lube oil filter element from the cylinder block.
2) Remove the lube oil dipstick.

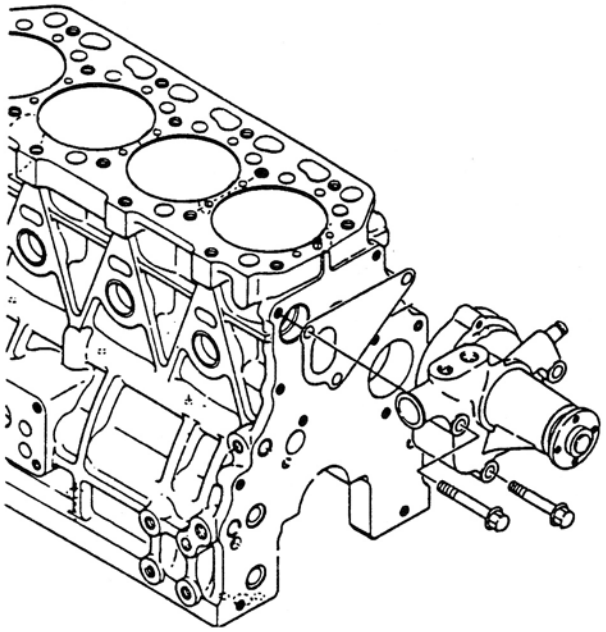


(13) Intake manifold

1) Remove the fuel pipe.
(fuel filter - fuel injection pump)
2) Remove the fuel filter
3) Remove the intake manifold.

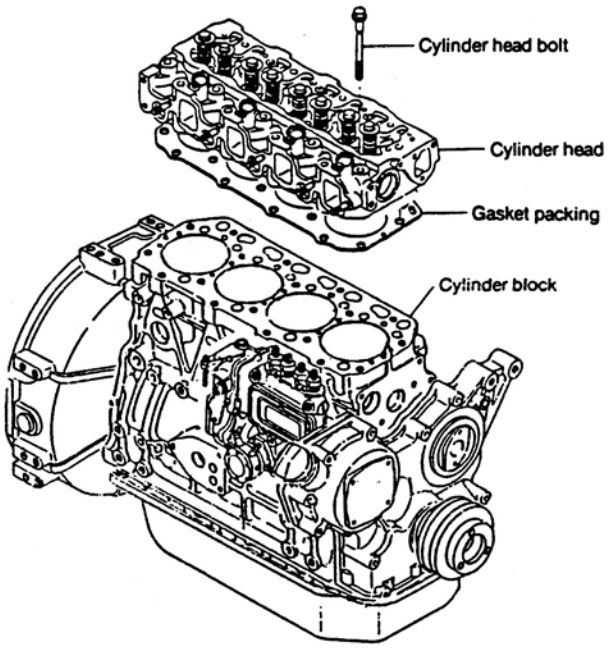
(14) Removing the cooling water pump

1) Loosen the water hose clamp and disconnect the hose.
2) Remove the thermostat cover.
3) Remove the cooling water pump.



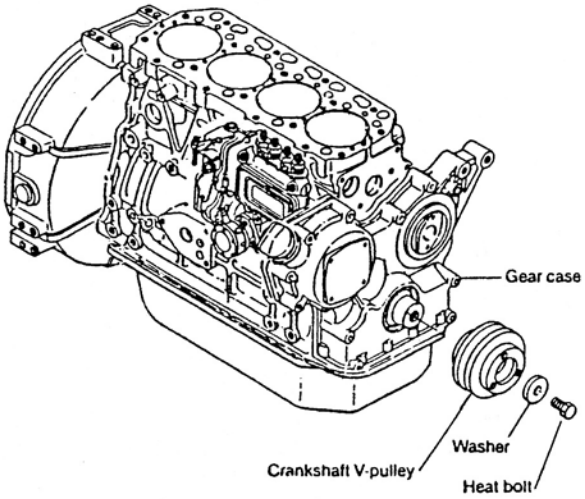
(15) Remvoing the cylinder head

(1) Remove the cylinder head bolts with a torque wrench, and remove the cylinder head.
(2) Remove the cylinder gasket packing.



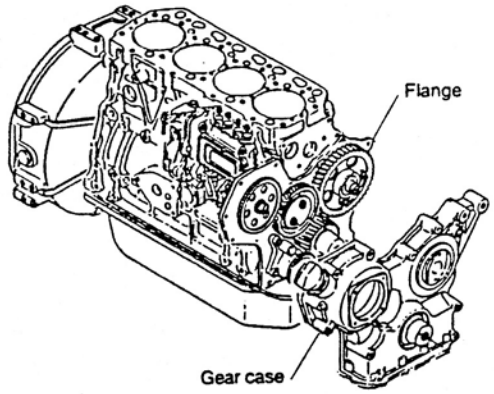
(16) Removing the crankshaft V-pulley

Remove the hex bolts holding the crankshaft V-pulley, and remove the crankshaft V-pulley with an extraction tool.



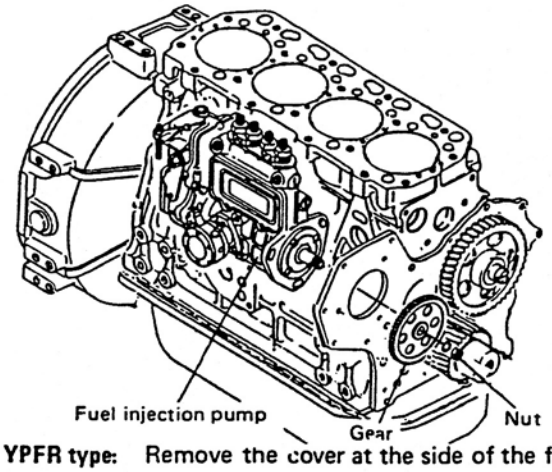
(17) Removing the gear case

Remove the gear case mounting bolts, and remove the gear case from the cylinder block.



(18) Removing the fuel injection pump

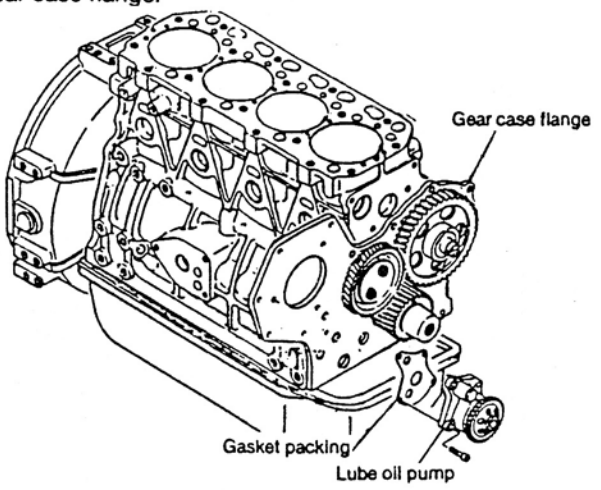
1) Remove the nut, and pull out the fuel injection pump driving gear with an extraction tool.
2) Remove the fuel injection pump and O-ring from the gear case flange.



YPFR type: Remove the cover at the side of the fuel injection pump and pull out the governor link snap pin.

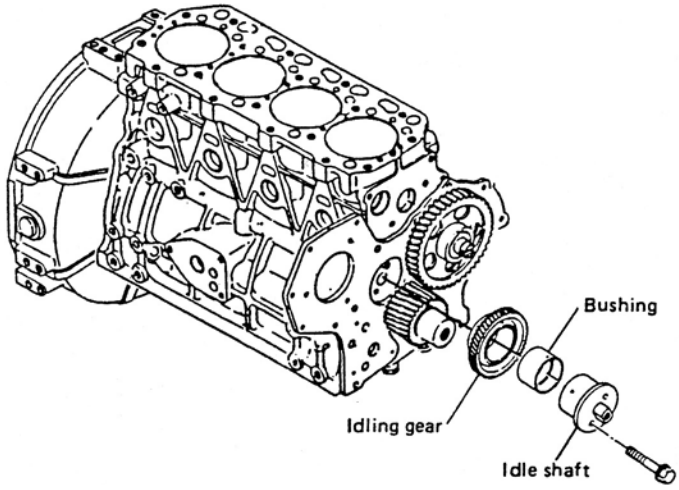
(19) Removing the lube oil pump

Remove the lube oil pump and gasket packing from the gear case flange.



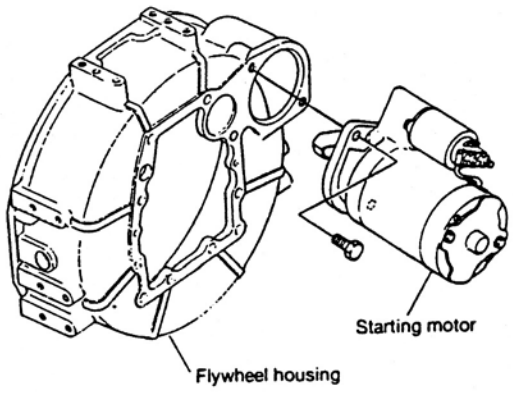
(20) Removing the idling gear

Remove the two hex bolts holding the idling shaft, and pull out the idling gear and idling shaft.



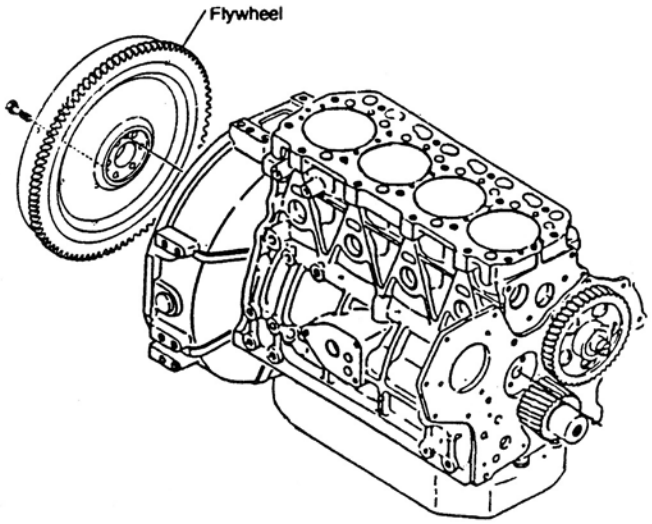
(21) Removing the starting motor

Remove the starting motor from the flywheel housing.



(22) Removing the flywheel

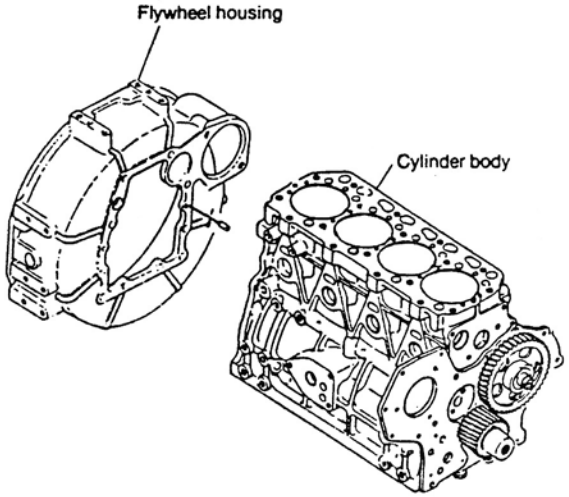
Remove the flywheel mounting bolts and then the flywheel.



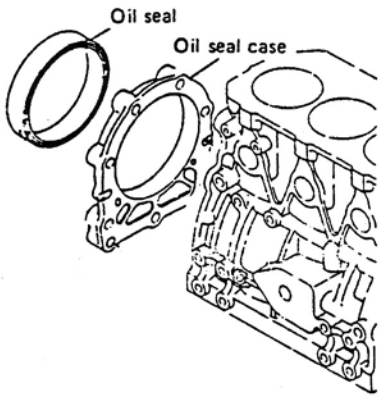
NOTE: Be careful not to scratch the ring gear.

(23) Removing the flywheel housing

Remove the flywheel housing from the cylinder block.



(24) Remove the oil seal and oil seal case.



(25) Removing the oilpan

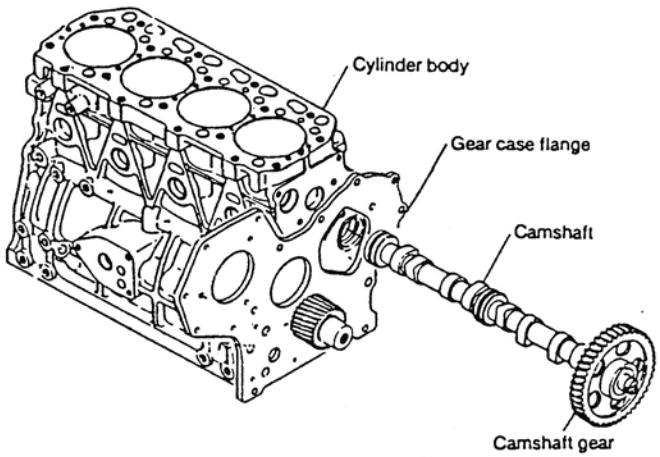
Remove the oil pan and oil pan spacer.

(26) Removing the camshaft

(1) Loosen the thrust rest mounting bolts out of the holes in the camshaft gear, and remove.
(2) Pull out the camshaft gear and camshaft assembly from the cylinder block.

- Pull out the 3TN66E and 3TNA72E tappets before pulling out their camshaft.

NOTE: The camshaft gear and camshaft are shrunk fit. They must be heated to 180—200°C to disassemble.

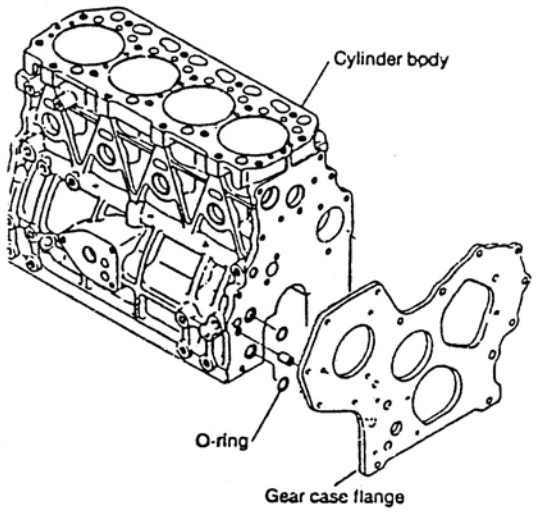


(27) Removing the tappets

Remove the tappets from the tappet holes in the cylinder block.

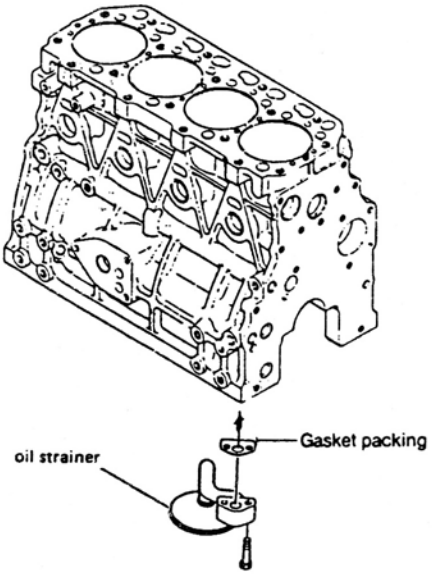
(28) Removing the gear case flange

(1) Remove the gear case flange from the cylinder block.
(2) Remove the two O-rings from the lube oil passage.



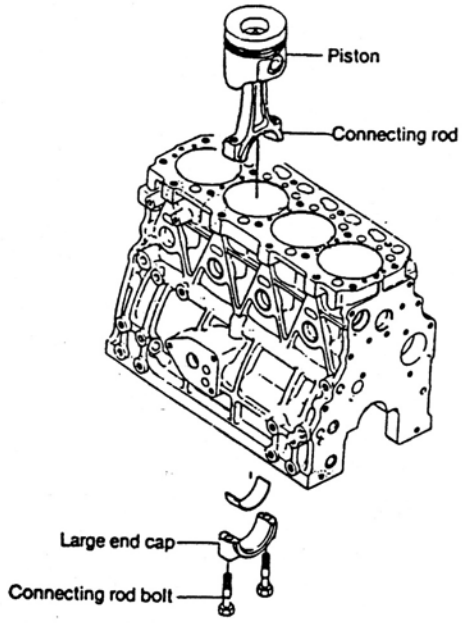
(29) Removing the oil strainer

Remove the lube oil intake pipe and gasket packing.



(30) Removing the piston and connecitng rods

(1) Remove the connecting rod bolt and the large end cap.
(2) Push the connecting rod from the bottom and pull out the piston connecting rod assembly.

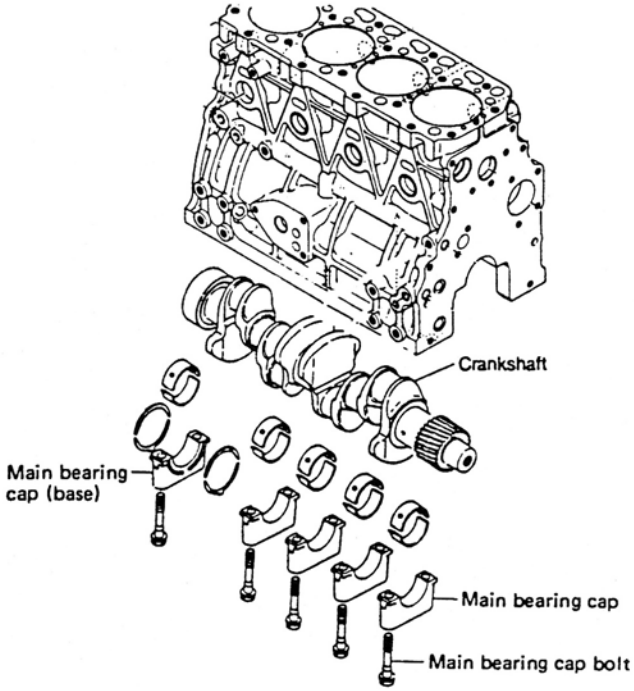


NOTE: Place a tool against the piston cooling nozzle to make sure the nozzle position does not change and it does'nt get scratches.

(31) Removing the main bearing

(1) Remove the main bearing bolts.
(2) Remove the main bearing cap and lower main bearing metal.

NOTE: The thrust metal (lower) is mounted to the standard main bearing cap. Be sure to differentiate between mounting surfaces.



(32) Removing the crankshaft

(1) Remove the crankshaft

NOTE: 1. The thrust metal (upper) is mounted to the standard main bearing. However, in some cases the thrust metal (upper) may be mounted to the crankshaft.
2. Remove the main bearing metal (upper) from the cylinder block.

3-2 Reassembly

(1) Inserting the tappets

Coat the inside of the cylinder block tappet holes and the outside circumference of the tappets with engine oil, and insert the tappets in the cylinder block.

- Insert the tappets before inserting their camshaft.

NOTE: Separate the tappets to make sure that they are reassembled in the same cylinder, intake/exhaust manifold as they came from.

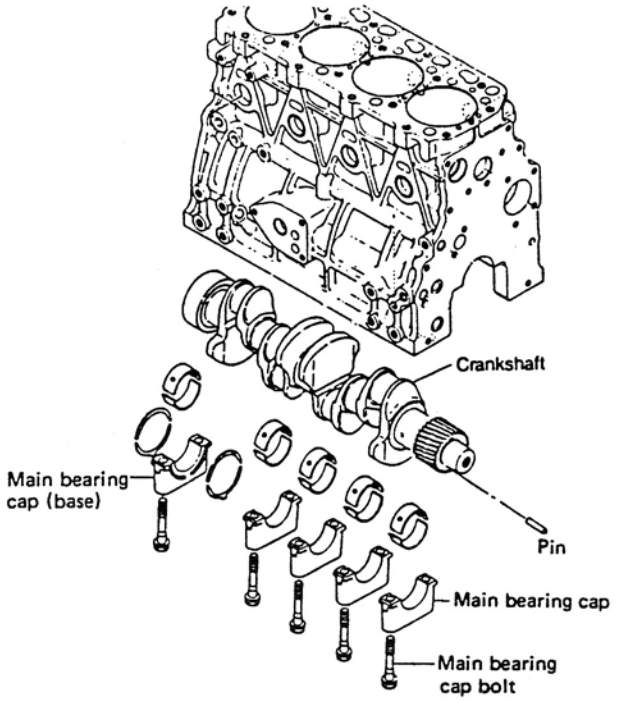
(2) Mounting the crankshaft

1) The crankshaft and crankshaft gear are shrink fitted. If the crankshaft and crankshaft gear have been disassembled, they have to be shrink fitted [heat the crank shaft gear to 180°—200°C (356—392°F) in the hot oil and press fit].
2) Coat the cylinder block crank journal holes and upper part of the main bearing metal with oil and fit the upper main bearing metal onto the cylinder block.

NOTE: 1. Be sure not to confuse the upper and lower main bearing metals. The upper metal has an oil groove.
2. When mounting the thrust metal, fit it so that the surface with the oil groove slit faces outwards, (crankshaft side).

3) Coat the crank pin and crank journal with engine oil and place them on top of the main bearing metal.

NOTE: 1. Align the crankshaft gear and camshaft gear with the "A" match mark.
2 Position so that the crankshaft gear is on the gear case side.
3. Be careful not to let the thrust metal drop.



(3) Mounting the main bearing metal with engine oil, and mounting the main bearing cap.

NOTE: 1. The lower main bearing metal does not have an oil groove.
2. The standard bearing thrust metal is fitted with the oil groove slit facing outwards.

1) Coat the main bearing cap bolt washer contact surface and threads with engine oil, place them on the crankshaft journal, and tighten the main bearing bolts to the specified torque.

kg-m (ft-lb)

Main bearing bolt tightening torque	*See separate service data (P.8-22)*

NOTE: 1. The main bearing cap should be fitted with the arrow near the embossed letters "FW" on the cap pointing towards the flywheel.
2. Make sure you have the correct cylinder alignment no.

2) Measure the crankshaft side clearance.

mm (in.)

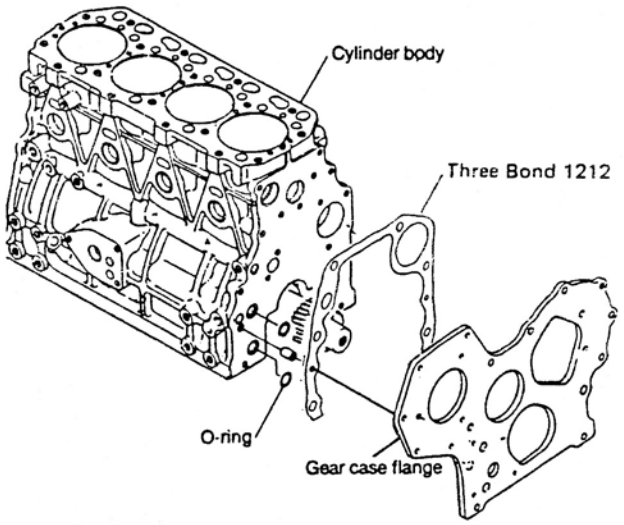
Crankshaft side clearance	0.090 ~ 0.271 (0.0035 ~ 0.0107)

3) Make sure that the crankshaft rotates smoothly and easily.

(4) Mounting the gear case flange.

Mount the gear case flange, and the O-ring for oil line onto the cylinder block.

NOTE: 1. When mounting the gear case flange, match up the two cylinder block knock pins.
2. Be sure to coat the cylinder block lube O-ring with grease when assembling, so that it does not get out of place.
3. Seal with the Three Bond 1212 between cylinder block and gear case flange.

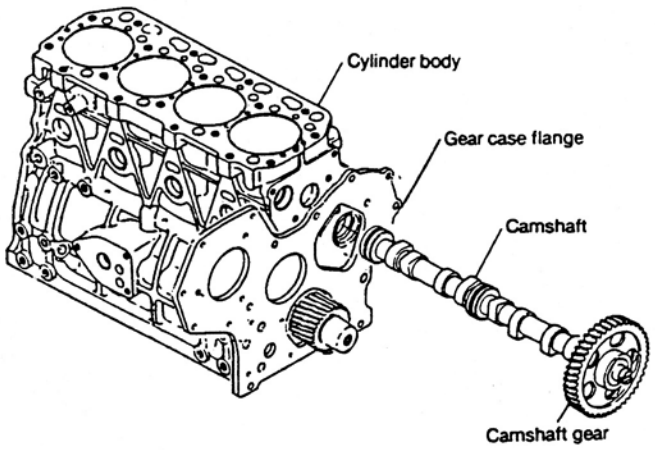


(5) Mounting the camshaft

1) If the camshaft and camshaft gear have been disassembled, shrink fit the camshaft and camshaft gear [heat the camshaft gear to 180—200°C (356—392°F) in the hot oil and press fit].

NOTE: When mounting the camshaft and camshaft gear, be sure not to forget assembly of the thrust rest. Also make sure they are assembled with the correct orientation.

2) Coat the cylinder block camshaft bearings and camshaft with engine oil, insert the camshaft in the cylinder block, and mount the thrust plate with the bolt.



3) Measure the camshaft side gap.

mm (in.)

Camshaft side gap	*See separate service data (Page 1-34, 35)*

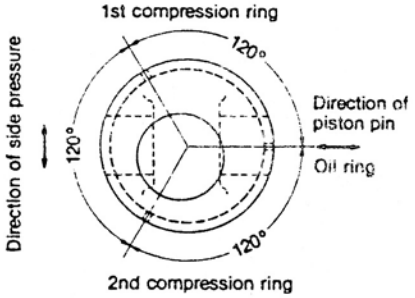
4) Make sure that the camshaft rotates smoothly.

(6) Mounting the piston and connecting rod

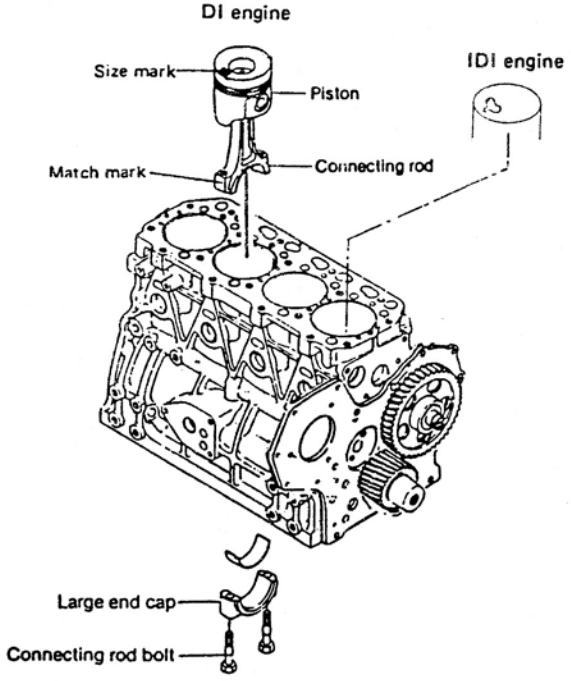
1) Reassemble the piston and connecting rod.

NOTE: When reassembling the piston and connecting rod, make sure that the parts are assembled with the correct orientation.

2) Each ring opening (piston/oil rings) should be staggered at gaps of 120°



3) Coat the outside of the piston and the inside of the connecting rod crank pin metal with engine oil and insert the piston with the piston insertion tool.



Note: DI engine

1. *Before inserting the piston, confirm that both the piston size mark and the connecting rod match mark are located at fuel pump side, and the identification mark is at the connecting rod section I with the mark facing the flywheel.*
2. *After inserting the piston, make sure the piston size mark is facing the fuel injection pump, looking from the top of the piston.*

IDI engine

1. *Before inserting the piston, confirm that the piston size mark is located at the exhaust side, and the connecting rod match mark is located at fuel pump side.*
2. *After inserting the piston, make sure the piston size mark is facing the exhaust manifold, looking from the top of piston.*

4) Align the large end match mark, mount the cap, and tighten the connecting rod bolts.

kg-m (ft-lb)

Connecting rod bolt tightening torque	*See separate service data (P. 8-22)*

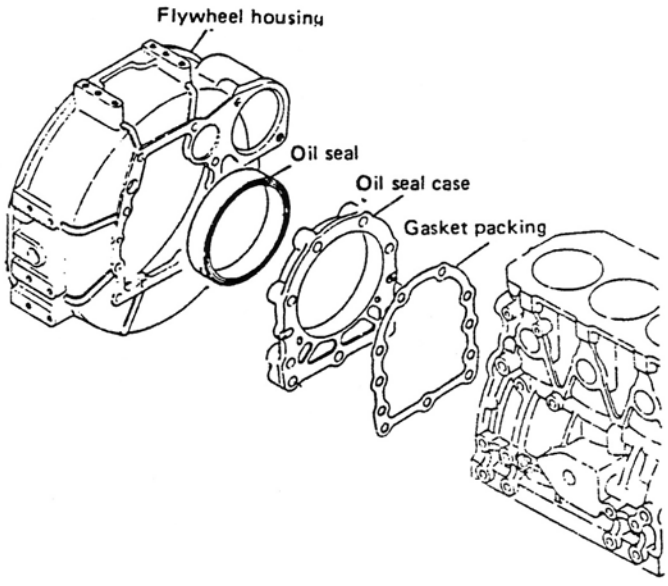
NOTE: If a torque wrench is not available, match up with the mark made before disassembly.

(7) Mounting the oil seal case

1) Press fit the oil seal in the oil seal case, and coat the lip of the oil seal with engine oil.
2) Mount the oil seal case, matching them up with the cylinder block positioning pins.

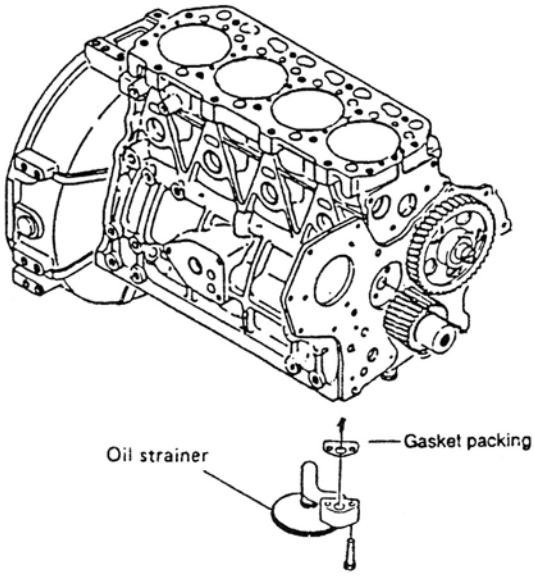
(8) Mounting the flywheel housing

Mount the flywheel housing, matching them up with the cylinder block positioning pins.



(9) Mounting the lube oil suction pipe

Mount the lube oil intake pipe on the bottom of the cylinder block, using new packing

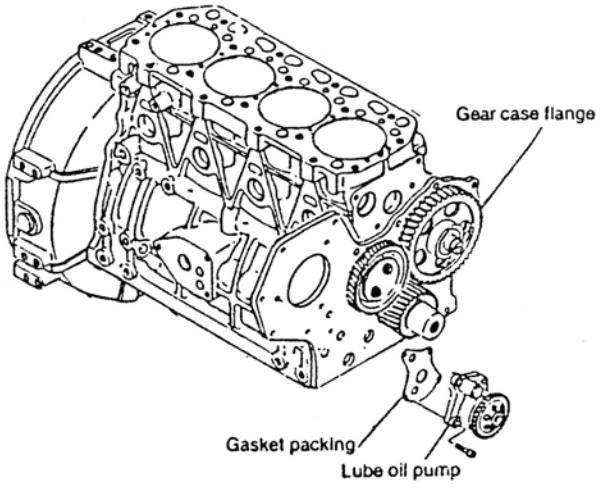


(10) Mounting the oil pan

1) Mount the oil pan and oil pan spacer.
2) Seal with the Three Bond 1212 among the cylinder block, oil pan spacer and oil pan.

(11) Mounting the lube oil pump

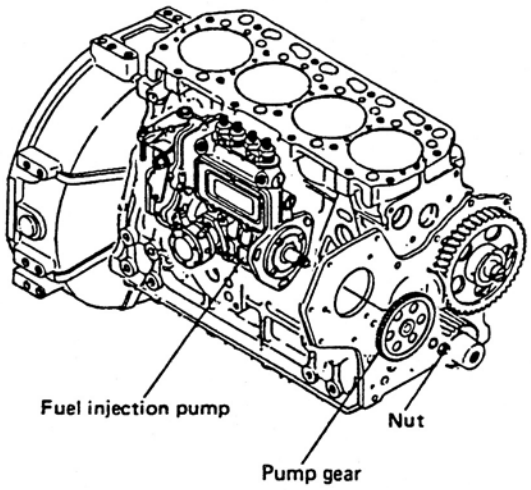
1) Mount the lube oil pump on the gear case flange.
2) Measure the backlash of the lube oil pump drive gear.



(12) Mounting the fuel injection pump

Lightly fit the fuel injection pump on the gear case.

NOTE: 1. Be careful not to scratch the O-ring between the fuel injection pump and gear case flange.
2. Tighten the fuel injection pump all the way after adjusting injection timing.



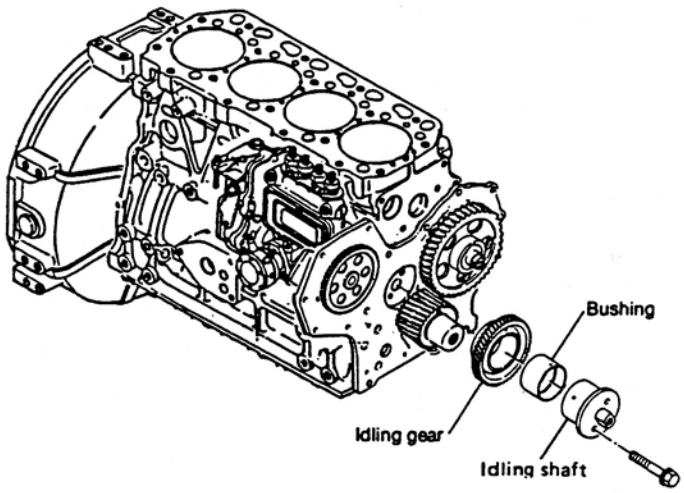
Tighten the nut for the fuel injection pump gear to the specified torque.

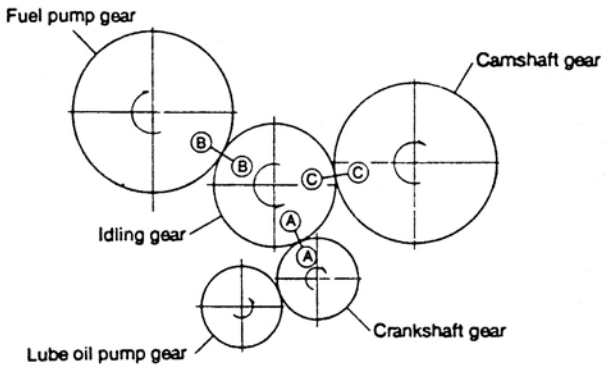
kg-m (ft-lb)

Nut tightening torque	6 – 7 (43.3 – 50.6)

(13) Mounting the idling gear

1) Fit the idling gear so that the side of the idling shaft with two oil holes faces up.
2) Align the "A" and "C" camshaft gear and crankshaft gear match marks, match up with idling shaft retaining plate, and tighten the bolts.
3) Measure the idling gear, camshaft gear and crankshaft gear bachlash.
4) Align the "B" match marks on the fuel injection pump drive gear and idling gear.
5) Measure the backlash of the fuel injection pump drive gear.

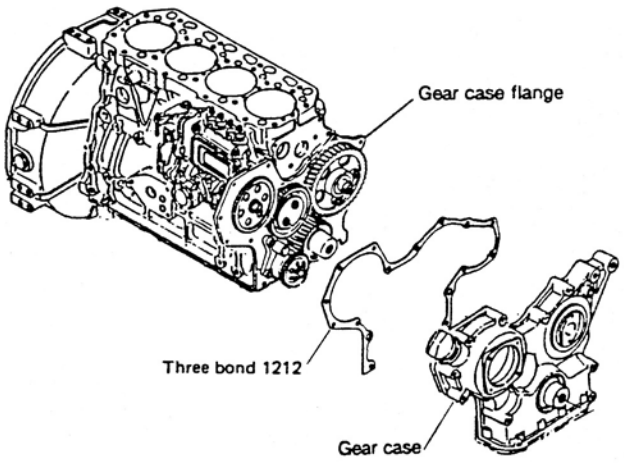




Looking from gear case side

(14) Mounting the gear case

1) Coat the inside and outside of the seals with engine oil, and press fit them into the gear case.
2) Position the two pipe knock pins, and tighten the bolts holding the gear case.
3) Seal with Three Bond 1212 between the gear case flange and gear case.

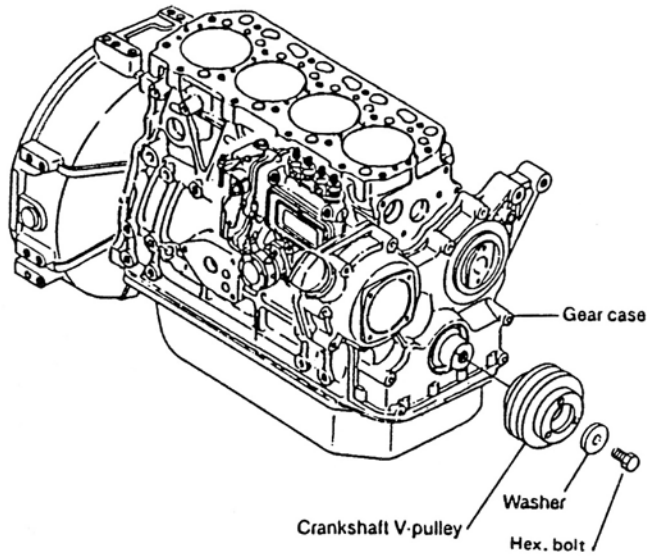


(15) Mounting the crank V-pullev

(1) Coat the oil seal and the section of the shaft with which it comes in contact with oil.

(2) Fit the pin pressed into the crank gear in the pin hole of the V-pulley (DI engine).

(3) Tighten to the specfied torque.



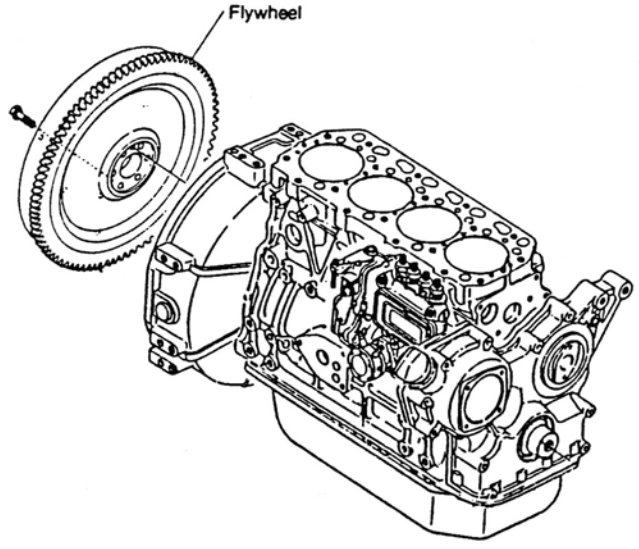
kg-m (ft-lb)

V-pulley tightening torque	*See separate service data (P.8-22)*

(16) Mounting the flywheel

(1) Coat the flywheel mounting bolt threads with engine oil.

(2) Align the positioning pins, and tighten the flywheel bolts to the specified torque.



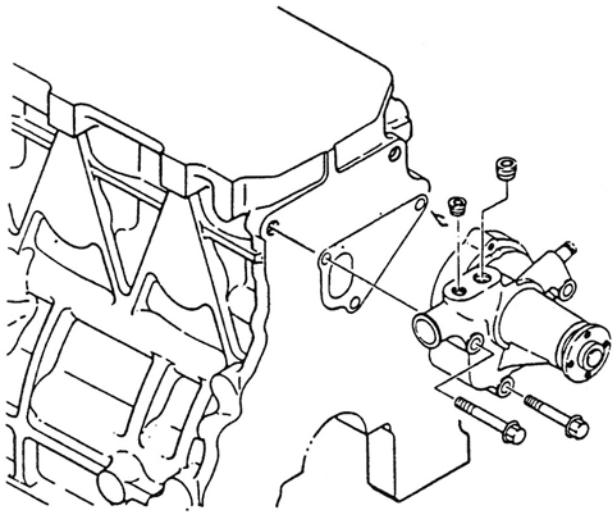
kg-m (ft-lb)

Flywheel mounting bolt tightening torque	*See separate service data (P. 8-22)*

(17) Mouning the cooling water pump

1) Thoroughly coat both sides of the packing with adhevive.

2) Replace the O-ring for the connecting pipe which is inserted in the cylinder block, and tighten the cooling water pump to the specified torque.



kg-m (ft-lb)

Cooling water pump tightening torque	*1.8 – 2.3 (13 – 16.7)*

3) Mount the thermostat case.

4) Mount the V-pulley.

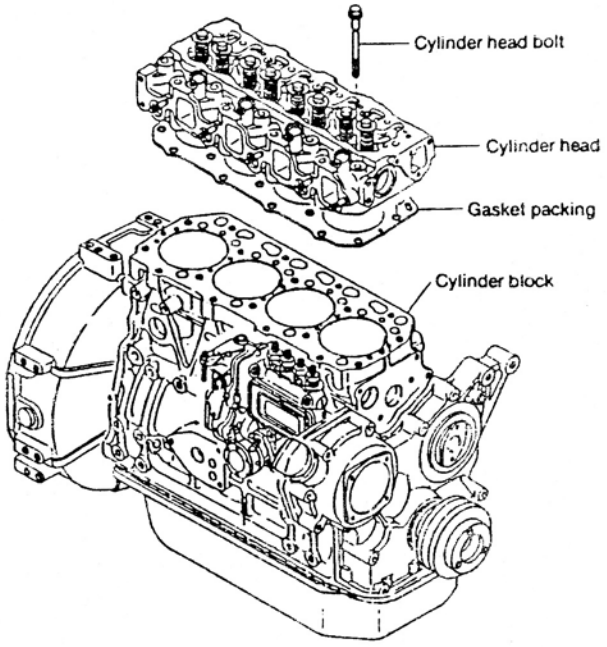
(18) Mounting the cylinder head

(1) Fit the gasket packing against the cylinder block, aligning it with the cylinder block positioning pins.

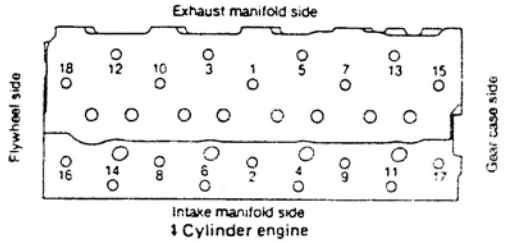
NOTE: The side on which the engine model is inscribed should face up (cylinder head side).

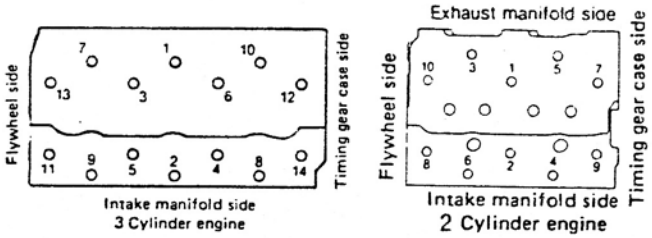
(2) Lift the cylinder head horizontally and mount, aligning with the cylinder head gasket.

(3) Coat the mounting bolt washers and threads with engine oil, and lightly tighten the bolts in the specified order. Then tighten completely, in the same order.



Tightening order





kg-m (ft-lb)

	Partial	Complete
Cylinder bolt tightening torque	*See separate service data (Page 8-22)*	

(4) Measure the top clearance.

mm (in.)

Top clearance	*See separate service data (Page 2-30, 31)*

(19) Mounting the valve rocker arm shaft assembly, pushrod

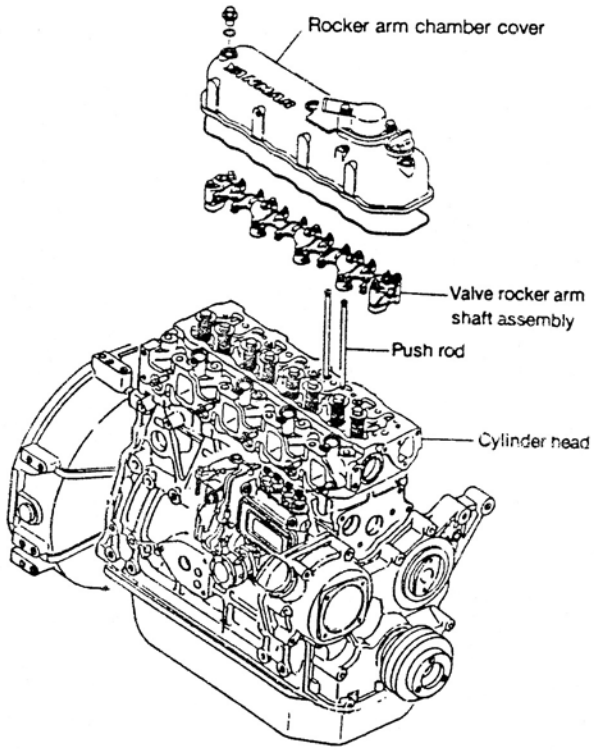
(1) Fit the pushrod to the tappet.

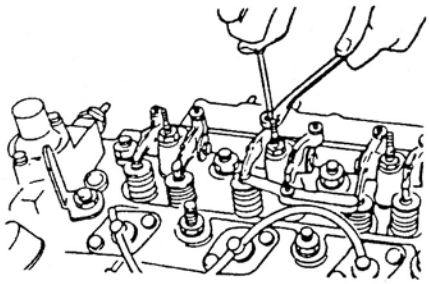
(2) Mount the valve rocker arm shaft assembly.

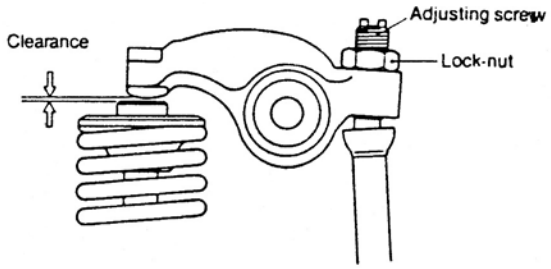
kg-m (ft-lb)

Valve rocker arm shaft support tightening torque	*2.3 – 2.9 (16.6 – 21)*

(3) Adjust valve clearance.







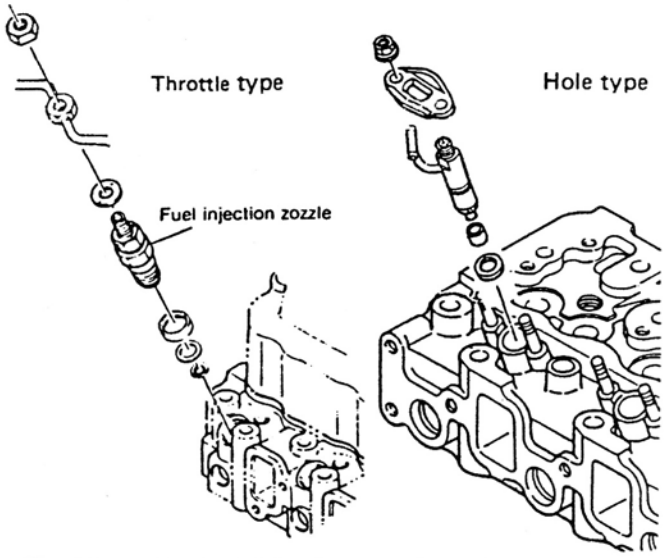
mm (in.)

Intake/exhaust valve clearance	0.2 (0.0079)

(4) Coat the valve rocker arm and valve spring with engine oil, and mount the valve rocker arm chamber cover.

(20) Mounting the injection nozzle

1) Insert the fuel injection nozzle assemblies into the nozzle holes.



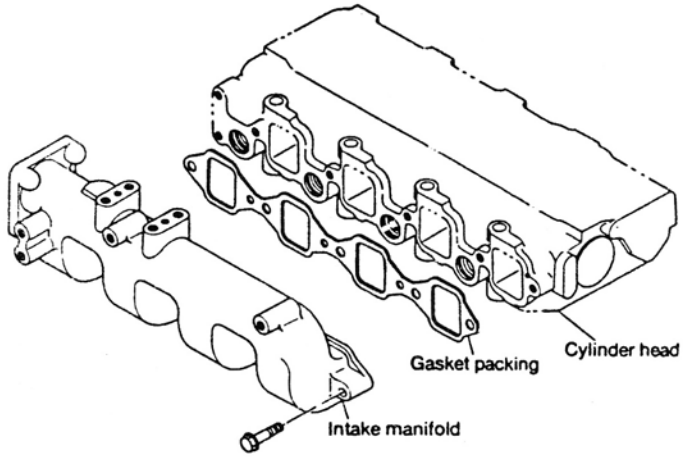
2) Tighten the fuel injection nozzle retainer nut to the specified torque.

kg-m (ft-lb)

Fuel injection nozzle retainer tightening torque	*See separate service data (P. 8-22)*

(21) Mounting the intake manifold

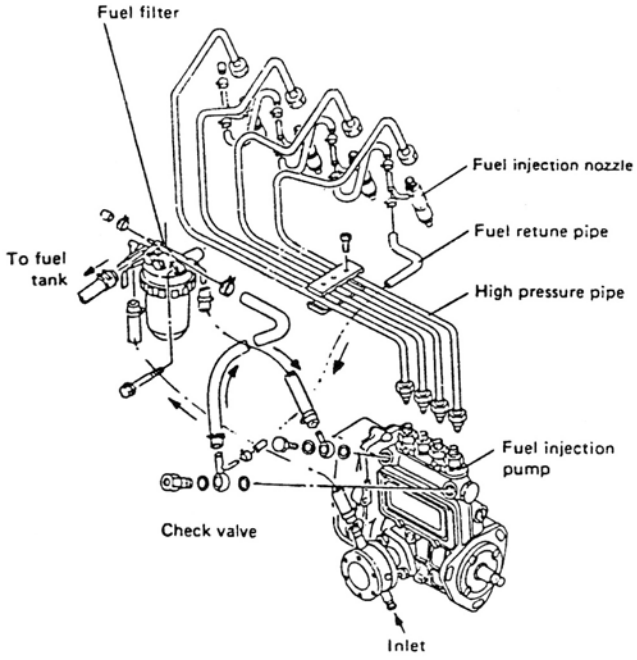
Thoroughly clean the inside of the intake manifold, and mount the gasket packing and intake manifold.



(22) Mounting the high pressure fuel pipe and fuel oil return pipe

Mount the high pressure fuel pipe and then the high pressure fuel pipe vibration stop.

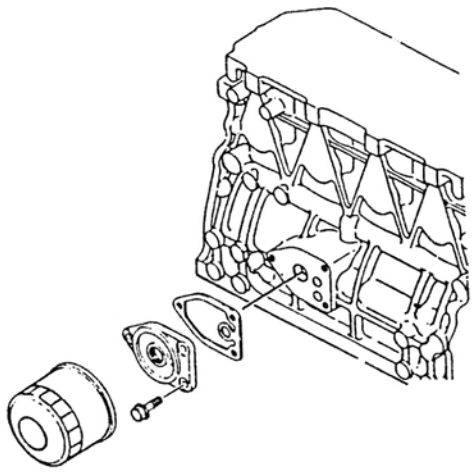
NOTE: Lightly tighten the box nuts on both ends of the high pressure fuel pipe. Completely tighten after adjusting the injection timing.



(23) Mounting the lube oil filter

(1) Mount the filter bracket and packing on the cylinder block.

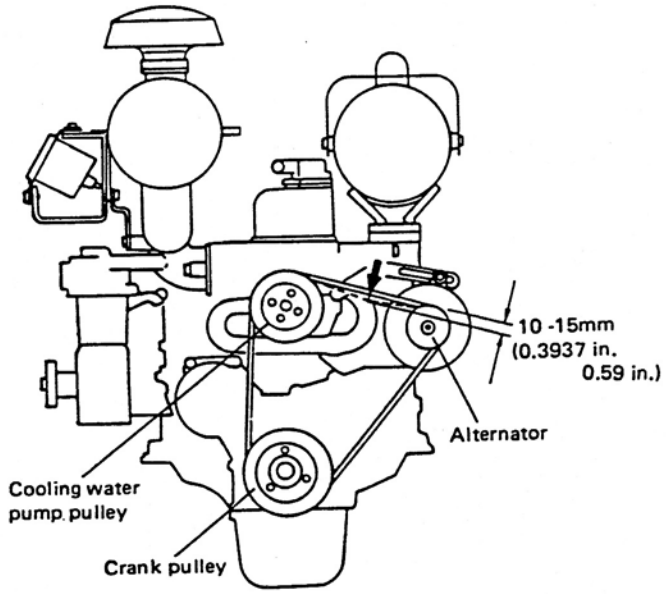
(2) Mount the filter element with the filter remover mounting tool.



(24) Mounting the Alternator

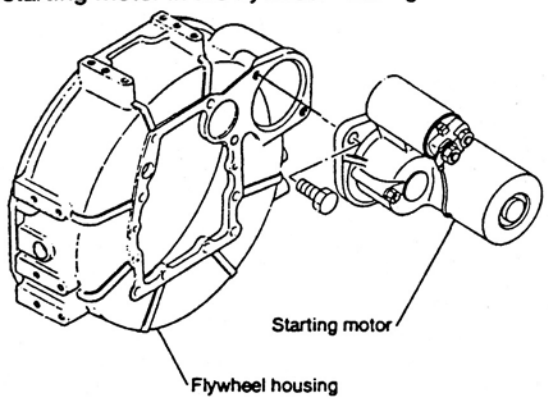
1) Mount the adjuster, the distance piece on the gear case, and then the Alternator.

2) Adjust V-belt tension with the adjuster, and tighten the mounting bolts.



(25) Mounting the starting motor

Fit the starting motor in the flywheel housing.



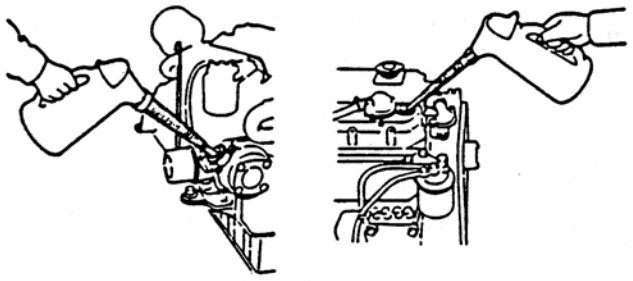
(26) Mounting the fuel oil filter & fuel oil pipe

(27) Mounting the turbocharger

(28) Filling with lube oil

Fill the engine with lube oil from the fillter port on top of the gear case.

	ℓ (in.³)
Lube oil capacity	*See separate service data (Page 1-2, 3)*

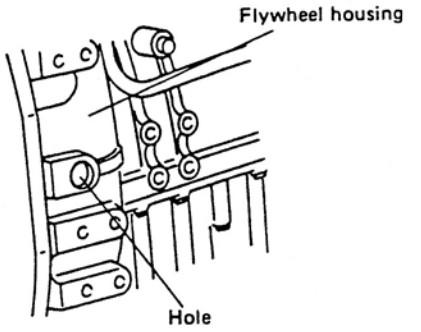


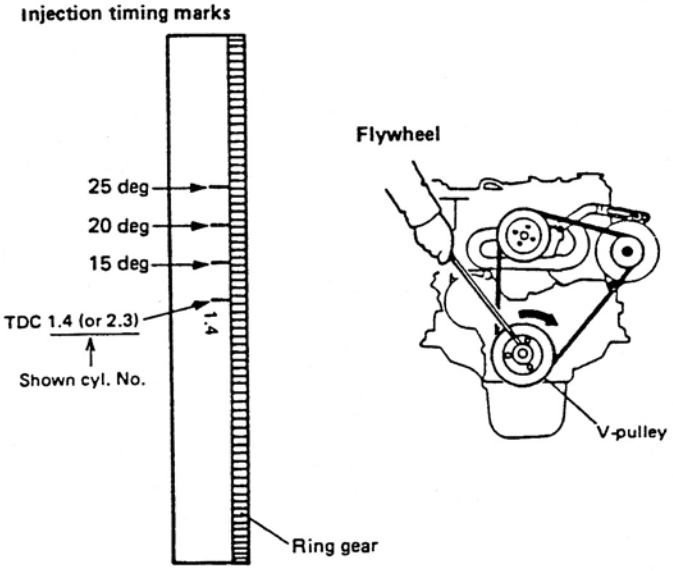
(29) Filling with cooling water

1) Open the radiator cap and fill with water.
2) Fill with water until the level in the sub tank is between the full and low marks.

(30) Check the fuel injection timing

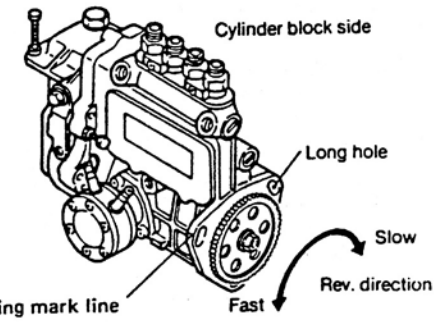
1) Check injection timing by turning the flywheel and looking through the inspection hole in the flywheel housing.





2) If injection timing is off, change the mounting position using the long hole in the injection pump mounting flange.
Turning the fuel feed pump towards the cylinder block slows timing down, while movement in the other direction makes it faster.

Fuel injection timing (FID)	*See separate service data (Page 1-2, 3)*



4. Bolt/Nut Tightening Torque

1. Main bolt/nut tightening torque

kg-m (ft-lbs)

Item		2,3TN66E	3TNA72E	3TN75E 3TNC78E	3,4TN82(84)E 3,4TN82(84)TE	
Cylinder head clamping bolt[a]	Thread dia. x pitch Tighting torque	M 8 x 1.25 3.3 – 3.7 (23.9 – 26.8)	M 9 x 1.25 6.0 – 6.5 (43.4 – 47)	M 9 x 1.25 6.8 – 7.2	M10 x 1.25 7.5 – 8.5 (54.2 – 65.1)	
Connecting rod clamping bolt[a]	Thread dia. x pitch Tighting torque	M 7 x 1 2.3 – 2.8 (16.6 – 20.3)	M 7 x 1.0 2.3 – 2.8 (16.6 – 20.3)	M 8 x 1 3.8 – 4.2 (27.5 – 30.4)	M 9 x 1 4.5 – 5.0 (32.6 – 36.2)	
Flywheel clamping bolt[a]	Thread dia. x pitch Tighting torque	M10 x 1.25 8.2 – 8.8 (59.3 – 63.6)	M10 x 1.25 8.2 – 8.8 (59.3 – 63.6)	M10 x 1.25 8.5 – 9.0 (61.5 – 65.2)	M10 x 1.25 8.5 – 9.0 (61.5 – 65.2)	
Main bearing clamping bolt[a]	Thread dia. x pitch Tighting torque	M 9 x 1.25 5.3 – 5.7 (38.3 – 41.2)	M10 x 1.25 7.5 – 8.5 (54.2 – 65.1)	M10 x 1.25 7.8 – 8.2 (56.5 – 59.4)	M12 x 1.25 9.5 – 10.5 (68.7 – 76.0)	
Crankshaft V-pulley clamping bolt[a]	Thread dia. x pitch Tighting torque	M12 x 1.5 8.5 – 9.5 (61.5 – 68.7)[b]	M12 x 1.5 8.5 – 9.5 (61.5 – 68.7)[b]	M14 x 1.5 11 – 13 (79.6 – 94.1)	M14 x 1.5 11 – 13 (79.6 – 94.1)	
Fuel injection nozzle case nut/Holder	Thread dia. x pitch Tighting torque	0.605-40UNS-2A 4.0 – 4.5 (29.0 – 32.6)	0.605-40UNS-2A 4.0 – 4.5 (29.0 – 32.6)	4 – 4.5 (29.0 – 32.6)	4 – 4.5 (29.0 – 32.6)	
Fuel injection nozzle	Thread dia. x pitch Tighting torque	M20 x 1.5 5.0 – 5.4 (36.2 – 39.1)	M20 x 1.5 5.0 – 5.4 (36.2 – 39.1)	M6 x 2 0.4 – 0.5 (2.9 – 3.6)	M6 x 2 0.4 – 0.5 (2.9 – 3.6)	
Fuel pump driving gear nut[a]	Thread dia. x pitch Tighting torque	Shrinkage fit	←	5.0 – 7.0 (36.2 – 50.7)	5.0 – 7.0 (36.2 – 50.7)	
Glow plug	Thread dia. x pitch Tighting torque	M10 x 1.25 1.5 – 2 (10.8 – 14.5)	M10 x 1.25 1.5 – 2 (0.8 – 14.5)	–	–	
Stub shaft bolt	Thread dia. x pitch Tighting torque	M10 x 1.5 5.5 – 6.5 (39.8 – 47)	M10 x 1.5 5.5 – 6.5 (39.8 – 47)	–	–	
Governor weight support nut[a]	Tighting torque Tighting torque	M12 x 1.25 7.0 – 7.5 (50.6 – 54.2)	M12 x 1.25 7.0 – 7.5 (50.6 – 54.2)	4.5 – 5 (32.5 – 36.2)	4.5 – 5 (32.5 – 36.2)	

a Apply lubricating oil to the seat of bolt and threads of bolts and nuts before tightening. Do not apply molybdeum disulfide lubricants to bolts and nuts.

b In case of the steel mode V-pulley: 11.5 – 12.5 kg-m (83.1 – 90.3 ft-lbs)

2. Standard bolt tightening torque

NOTE: 1. Tighten all other clamping bolts not specified in the preceeding Table in accordance with the following Table.

2. When bolting the aluminum parts, tighten the bolts about 80% of the tightening torque specified in the Table.

Hexagon headed bolt (7T)/Nut kg-m (ft-lb)

	All models
Thread dia. x pitch Tighting torque	M 6 x 1 1.0 – 1.2 (7.2 – 8.7)
Thread dia. x pitch Tighting torque	M 8 x 1.25 2.3 – 2.9 (16.6 – 21)
Thread dia. x pitch Tighting torque	M10 x 1.5 4.5 – 5.5 (33 – 40)
Thread dia. x pitch Tighting torque	M12 x 1.75 8.0 – 10.0 (58 – 72)
Thread dia. x pitch Tighting torque	M14 x 1.5 13.0 – 15.0 (94 – 108)
Thread dia. x pitch Tighting torque	M16 x 1.5 21.5 – 24.5 (155 – 177)

Tapered screw plug

kg-m (ft-lbs)

Thread	
PT 1/8	1.0 (7.2)
PT 1/4	2.0 (14.4)
PT 3/8	3.0 (21.5)
PT 1/2	6.0 (43.3)

Ball joint bolt

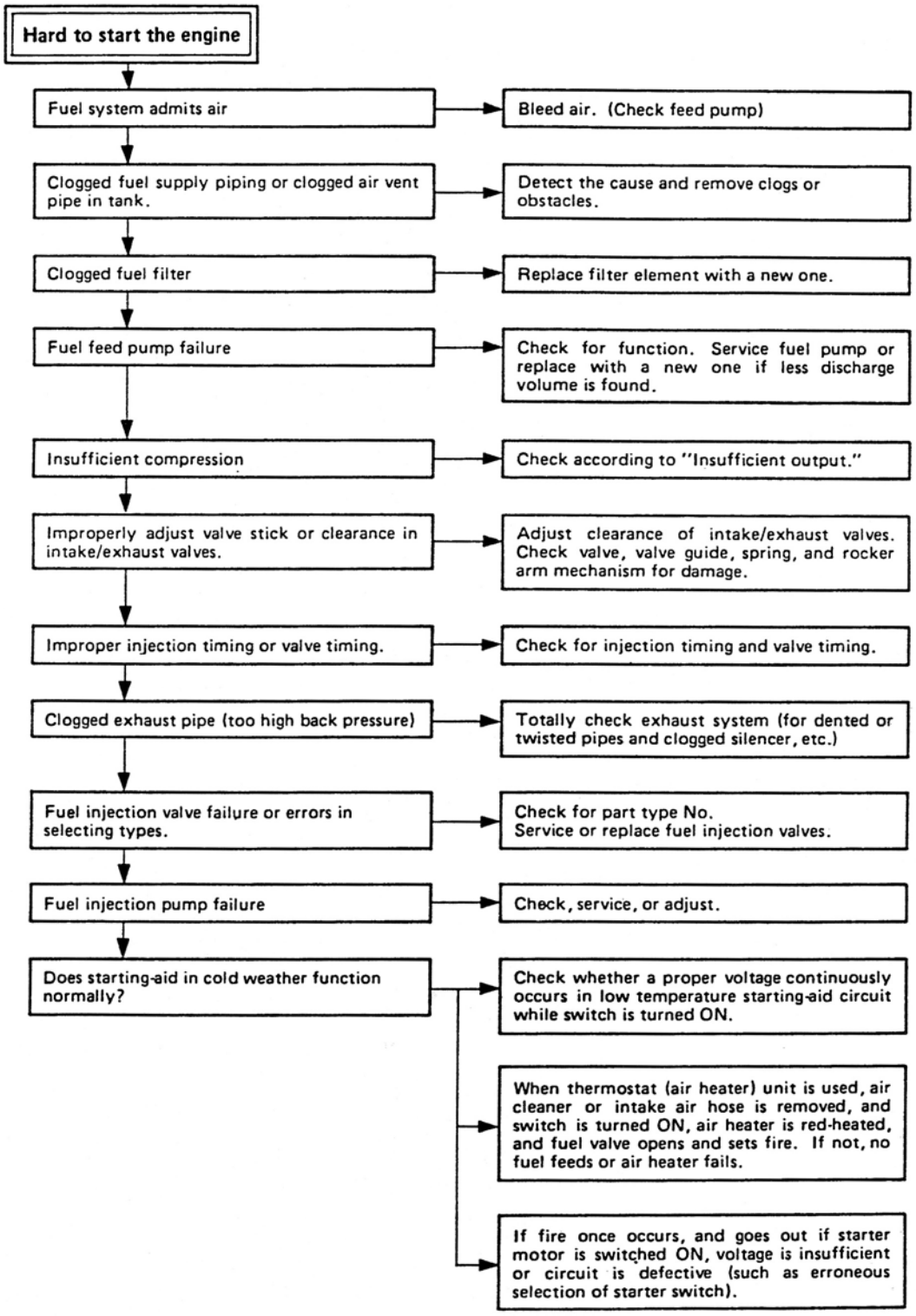
kg-m (ft-lbs)

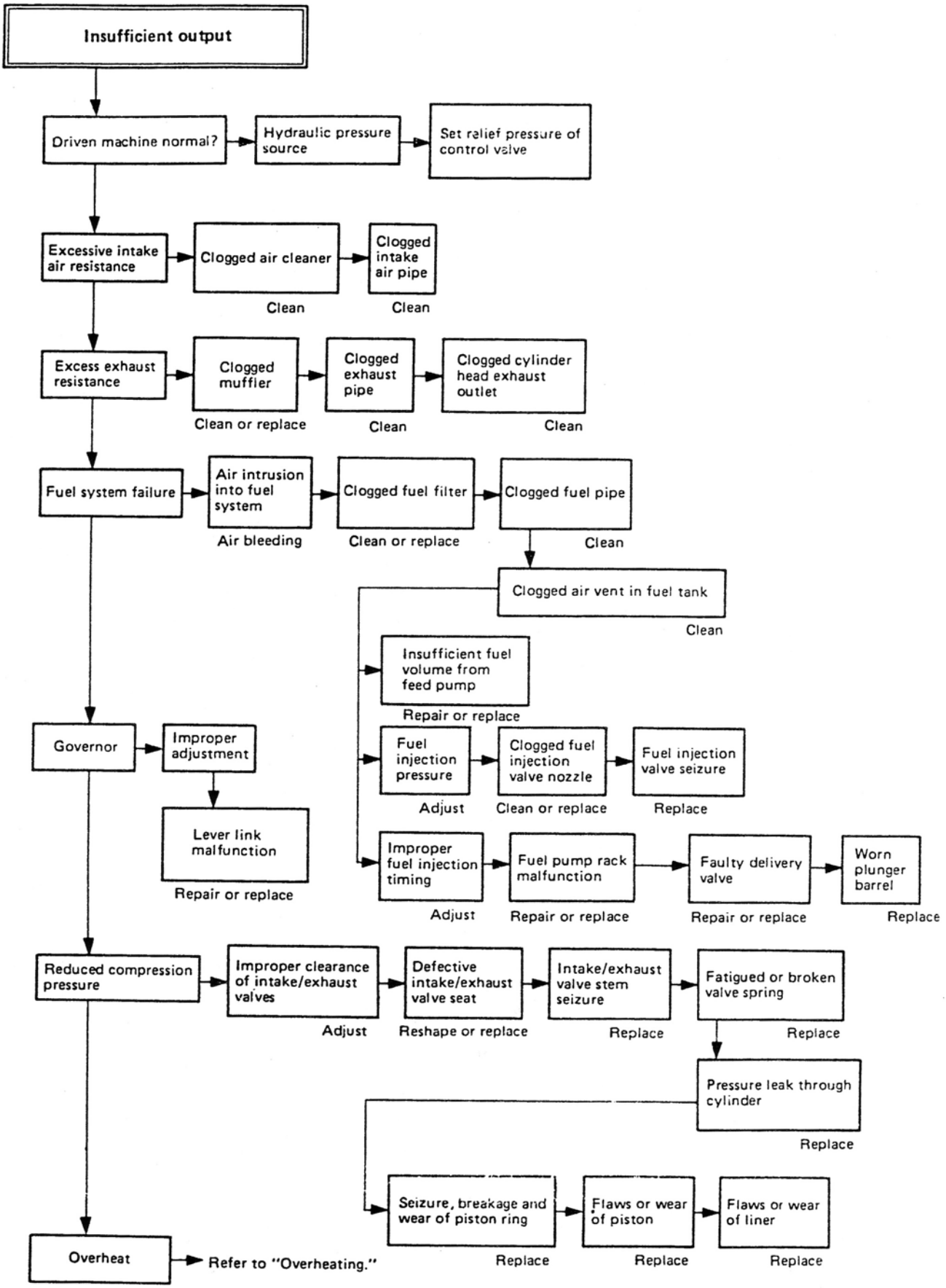
Thread	
M8	1.3 – 1.7 (9.4 – 12.2)
M12	2.5 – 3.5 (18 – 25)
M14	4 – 5 (29 – 36)
M16	5 – 6 (36 – 43)

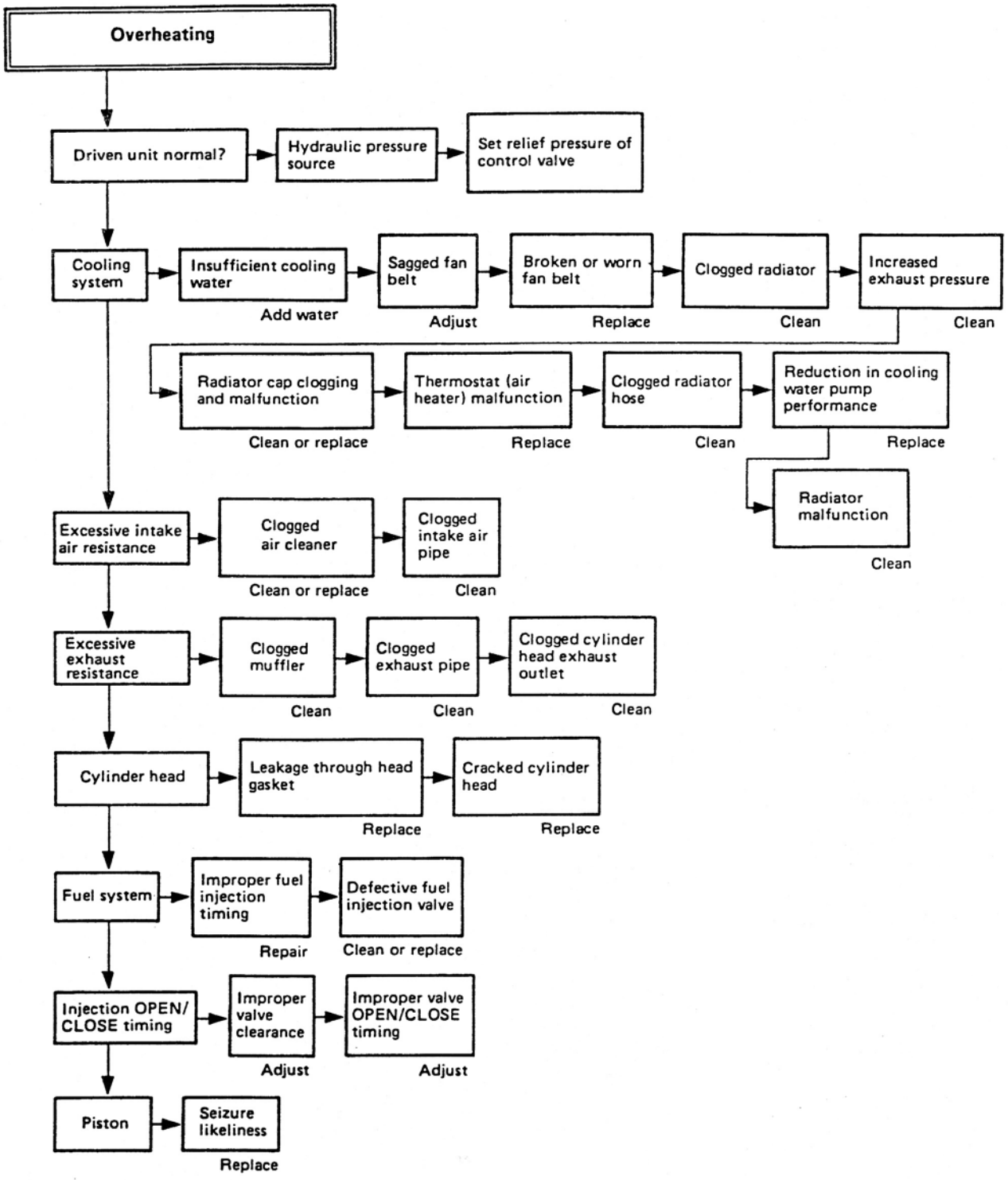
5. Troubleshooting

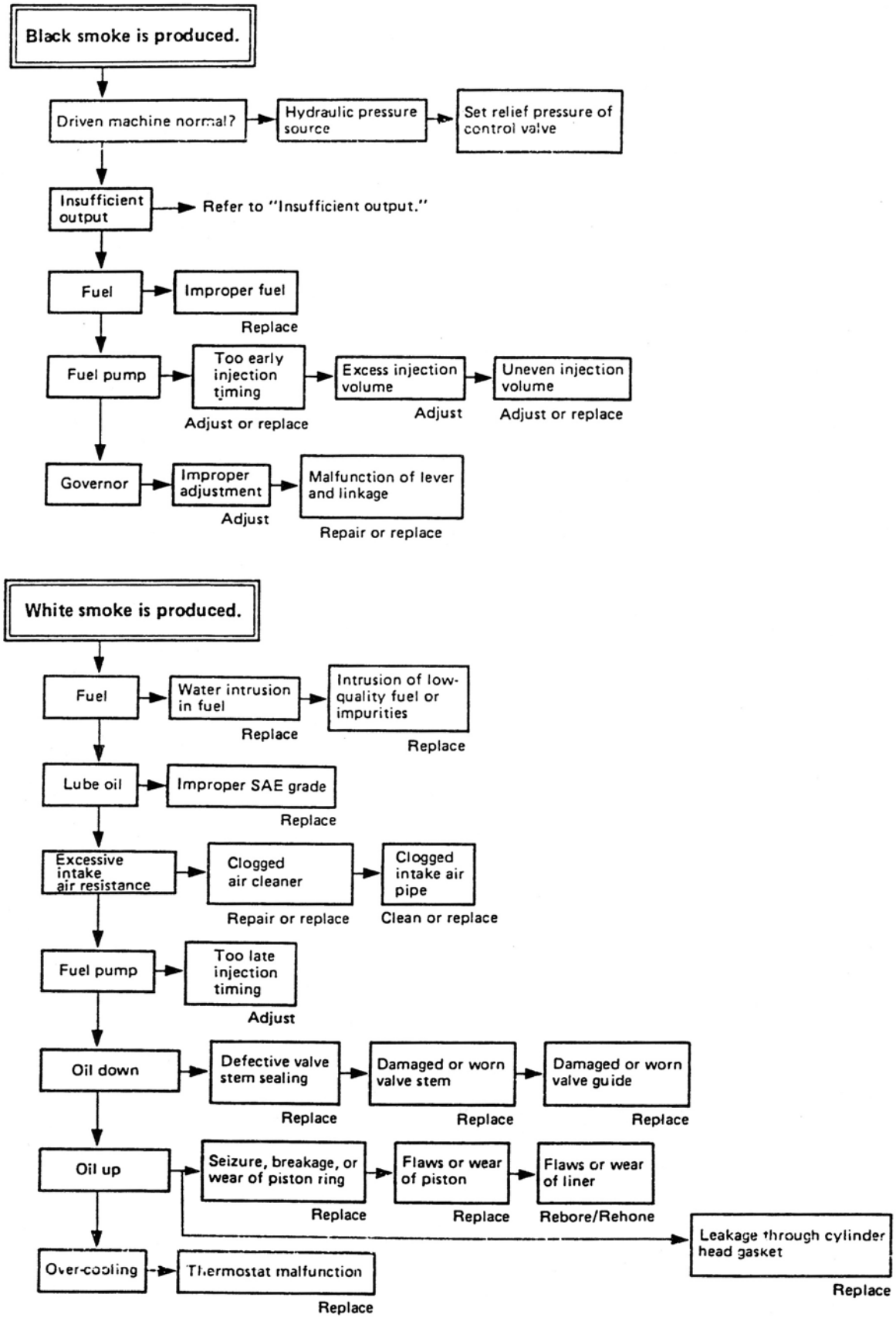
The following description summarizes the probable cause of and remedy for general failure by item.

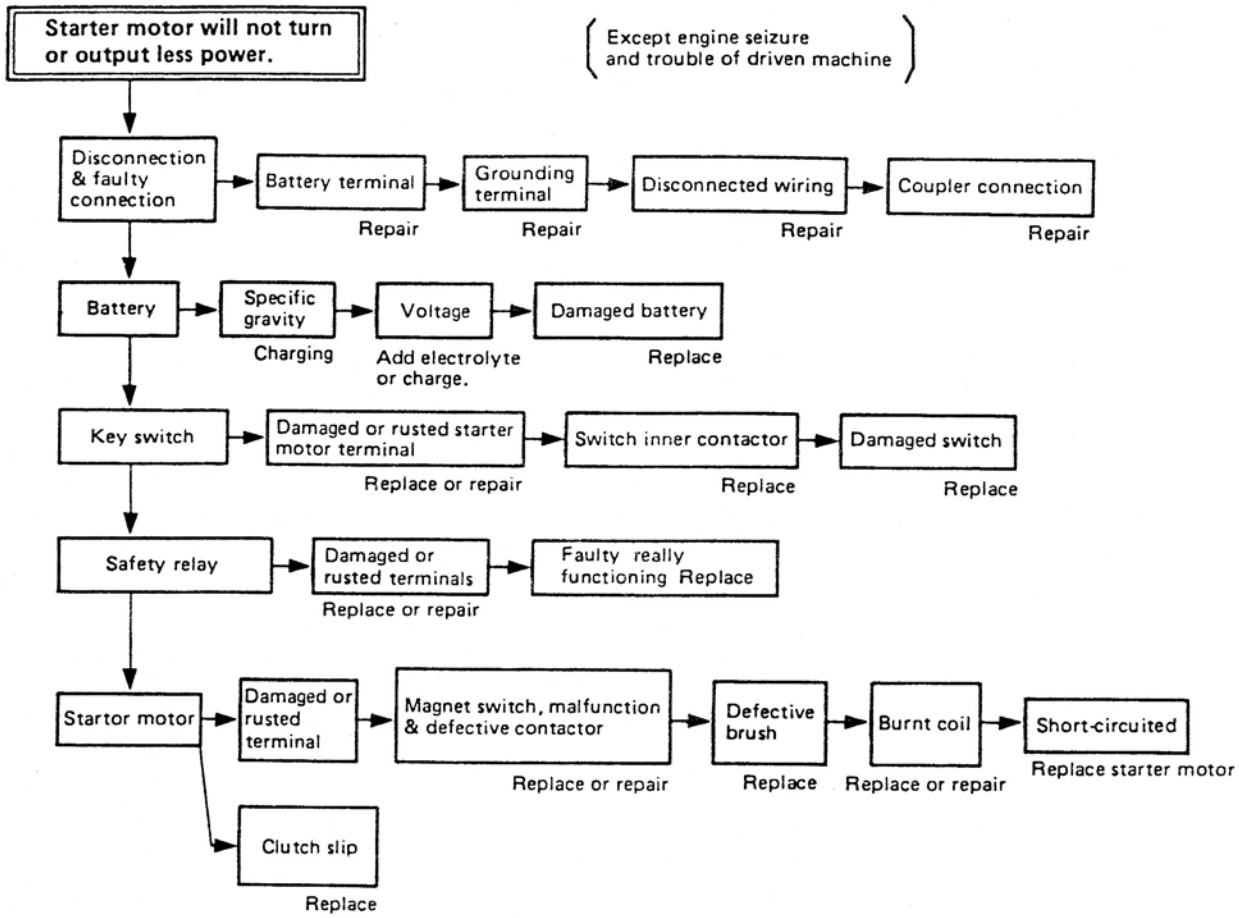
Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.



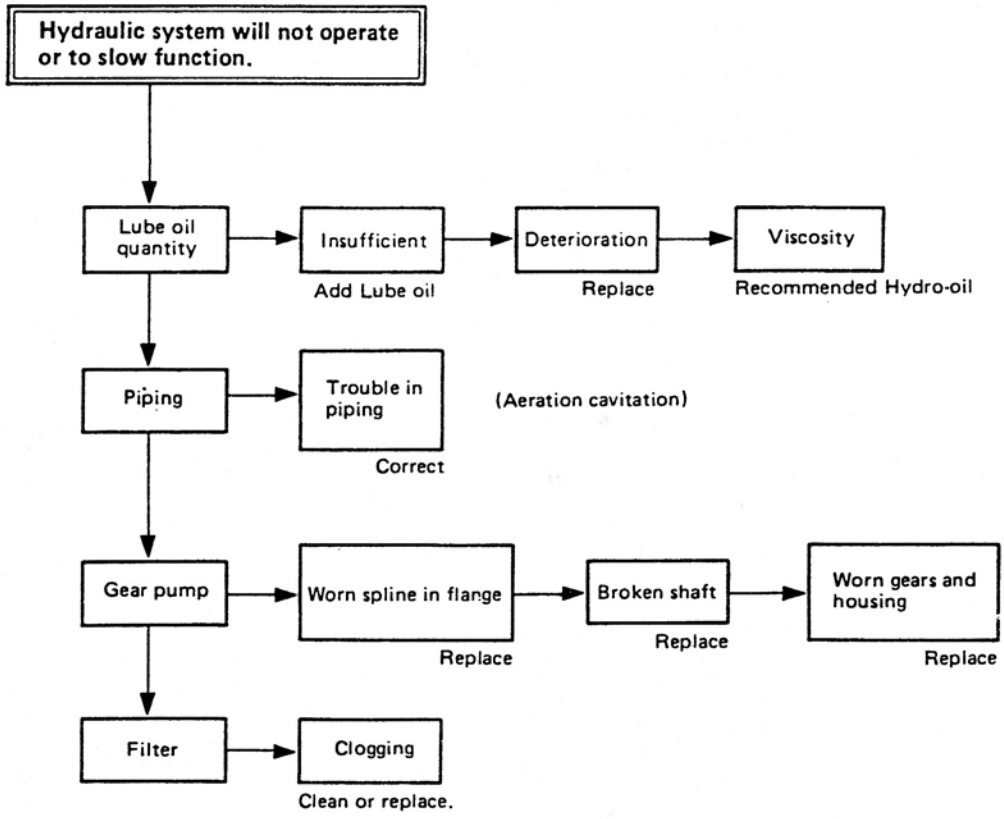

Insufficient output
Driven machine normal?
Hydraulic pressure source
Set relief pressure of control valve
Excessive intake air resistance
Clogged air cleaner
Clean
Clogged intake air pipe
Clean
Excess exhaust resistance
Clogged muffler
Clean or replace
Clogged exhaust pipe
Clean
Clogged cylinder head exhaust outlet
Clean
Fuel system failure
Air intrusion into fuel system
Air bleeding
Clogged fuel filter
Clean or replace
Clogged fuel pipe
Clean
Clogged air vent in fuel tank
Clean
Insufficient fuel volume from feed pump
Repair or replace
Governor
Improper adjustment
Lever link malfunction
Repair or replace
Fuel injection pressure
Adjust
Clogged fuel injection valve nozzle
Clean or replace
Fuel injection valve seizure
Replace
Improper fuel injection timing
Adjust
Fuel pump rack malfunction
Repair or replace
Faulty delivery valve
Repair or replace
Worn plunger barrel
Replace
Reduced compression pressure
Improper clearance of intake/exhaust valves
Adjust
Defective intake/exhaust valve seat
Reshape or replace
Intake/exhaust valve stem seizure
Replace
Fatigued or broken valve spring
Replace
Pressure leak through cylinder
Replace
Seizure, breakage and wear of piston ring
Replace
Flaws or wear of piston
Replace
Flaws or wear of liner
Replace
Overheat
Refer to "Overheating."

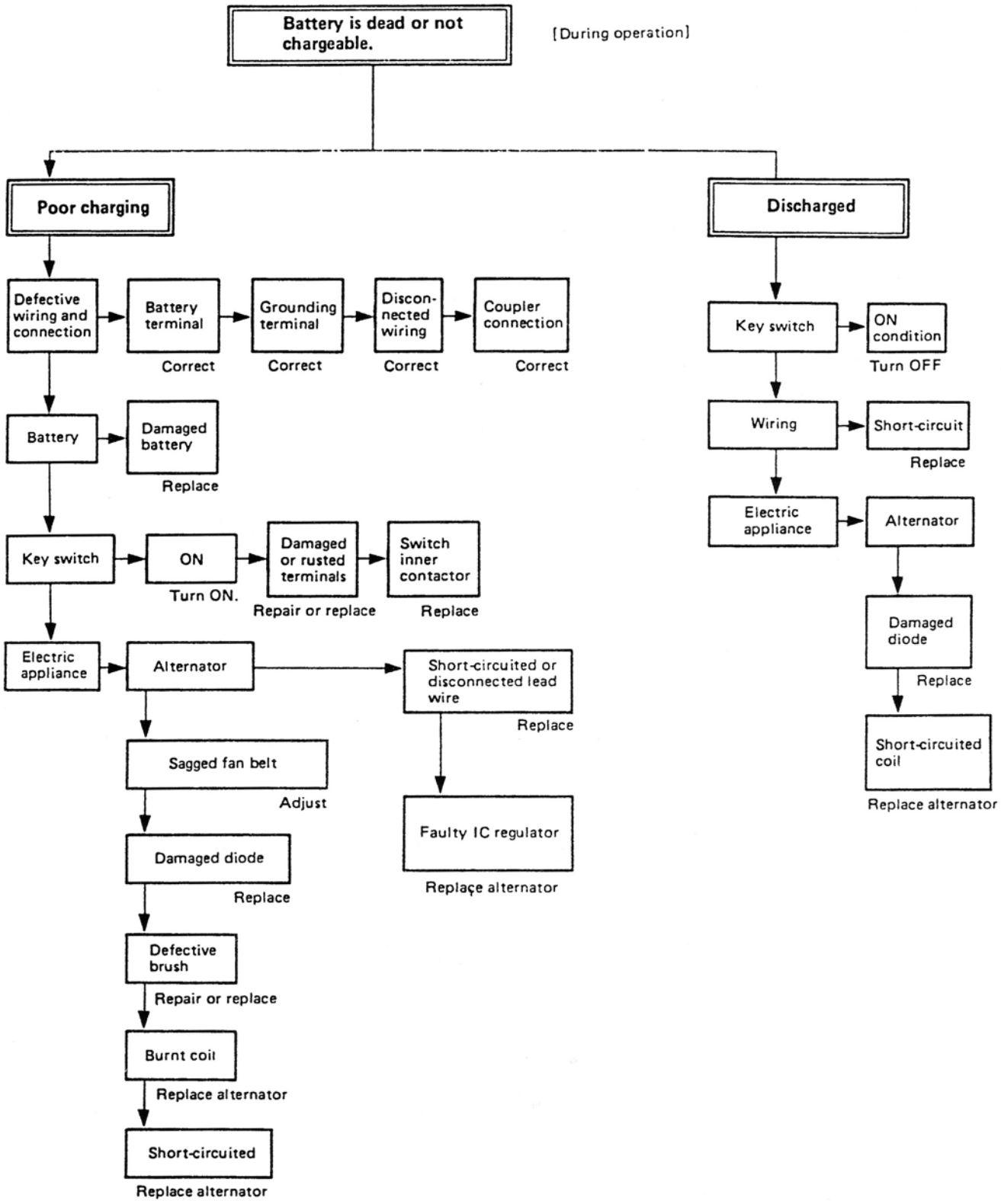

Overheating
Driven unit normal?
Hydraulic pressure source
Set relief pressure of control valve
Cooling system
Insufficient cooling water
Add water
Sagged fan belt
Adjust
Broken or worn fan belt
Replace
Clogged radiator
Clean
Increased exhaust pressure
Clean
Radiator cap clogging and malfunction
Clean or replace
Thermostat (air heater) malfunction
Replace
Clogged radiator hose
Clean
Reduction in cooling water pump performance
Replace
Radiator malfunction
Clean
Excessive intake air resistance
Clogged air cleaner
Clean or replace
Clogged intake air pipe
Clean
Excessive exhaust resistance
Clogged muffler
Clean
Clogged exhaust pipe
Clean
Clogged cylinder head exhaust outlet
Clean
Cylinder head
Leakage through head gasket
Replace
Cracked cylinder head
Replace
Fuel system
Improper fuel injection timing
Repair
Defective fuel injection valve
Clean or replace
Injection OPEN/ CLOSE timing
Improper valve clearance
Adjust
Improper valve OPEN/CLOSE timing
Adjust
Piston
Seizure likeliness
Replace


Black smoke is produced.
Driven machine normal?
Hydraulic pressure source
Set relief pressure of control valve
Insufficient output
Refer to "Insufficient output."
Fuel
Improper fuel
Replace
Fuel pump
Too early injection timing
Adjust or replace
Excess injection volume
Adjust
Uneven injection volume
Adjust or replace
Governor
Improper adjustment
Adjust
Malfunction of lever and linkage
Repair or replace
White smoke is produced.
Fuel
Water intrusion in fuel
Replace
Intrusion of low-quality fuel or impurities
Replace
Lube oil
Improper SAE grade
Replace
Excessive intake air resistance
Clogged air cleaner
Repair or replace
Clogged intake air pipe
Clean or replace
Fuel pump
Too late injection timing
Adjust
Oil down
Defective valve stem sealing
Replace
Damaged or worn valve stem
Replace
Damaged or worn valve guide
Replace
Oil up
Seizure, breakage, or wear of piston ring
Replace
Flaws or wear of piston
Replace
Flaws or wear of liner
Rebore/Rehone
Leakage through cylinder head gasket
Replace
Over-cooling
Thermostat malfunction
Replace



Hydraulic pressure source




Battery is dead or not chargeable.
[During operation]
Poor charging
Discharged
Defective wiring and connection
Battery terminal
Correct
Grounding terminal
Correct
Discon-nected wiring
Correct
Coupler connection
Correct
Battery
Damaged battery
Replace
Key switch
ON
Turn ON.
Damaged or rusted terminals
Repair or replace
Switch inner contactor
Replace
Electric appliance
Alternator
Short-circuited or disconnected lead wire
Replace
Sagged fan belt
Adjust
Damaged diode
Replace
Defective brush
Repair or replace
Burnt coil
Replace alternator
Short-circuited
Replace alternator
Faulty IC regulator
Replaçe alternator
Key switch
ON condition
Turn OFF
Wiring
Short-circuit
Replace
Electric appliance
Alternator
Damaged diode
Replace
Short-circuited coil
Replace alternator

6. Identification of Parts for each Application

IDENTIFICATIONS OF PARTS FOR EACH APPLICATION

Model	2TN66E		3TN66E		3TNA72E		3TN75E			3TNC78E			3TN82E		
Application	VM	CH	S	G2	S	G2	S	G1	G2	VM	CL	CH	S	G1	G2
Cylinder head	–	–	–	–	–	–	M	L	SH	M	L	SH	M	M	SH
Valve seat	–	–	–	–	–	o	–	–	O	–	–	o	–	–	O
Radiator fan	LK	LK	L	L	D	D	D	D	D	NF	NF		NF	NF	NF
Fuel injection nozzle	YDN-OPD2	←	←	←	←	←	EB	EG	EB	EF			EC	EA	GB
Turbocharger	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Driving gear, F.I. Pump	C	C	C	C	C	C	B	B	b	B	B	b	B	B	b
Piston	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Model	3TN82TE		4TN82E			4TN82TE			3TN84E			3TN84TE		
Application	S	G1	S	G1	G2	S	G1	G2	VM	CL	CH	VM	CL	CH
Cylinder head	SH	SH	M	M	SH	SH	SH	SH	M	M	SH	SH	SH	SH
Valve seat	O	O	–	–	O	O	O	O	–	–	O	O	O	O
Radiator fan	NF	NF	E	NF	E	E	E	E	NF	NF	NF	NF	NF	NF
Fuel injection nozzle	GC	EC	EC	EA	GB	GC	EC	GD	EC	EA	GB	GC	EC	GD
Turbocharger	RHB31 w/waste gate	RHB31	–	–	–	RHB51 w/waste gate	RHB31	RHB51	–	–	–	RHB31 w/waste gate	RHB31	RHB51
Driving gear, F.I. Pump	B	B	B	B	b	B	B	B	B	B	b	B	B	B
Piston	–	–	–	–	–	–	–	TH	–	–	–	–	–	TH

Model	4TN84E			4TN84TE		
Application	VM	CL	CH	VM	CL	CH
Cylinder head	M	M	SH	SH	SH	SH
Valve seat	–	–	O	O	O	O
Radiator fan	E	NF	E	E	E	E
Fuel injection nozzle	EC	EA	GB	GC	EC	GD
Turbocharger	–	–	–	RHB51 w/waste gate	RHB31	RHB52
Driving gear, F.I. Pump	B	B	b	B	B	B
Piston	–	–	–	–	–	TH

O: provided

7. Conversion Tables

Units	To convert	Into	Multiply by	Reference
Length	mm	inch	0.03937	1 ft = 12 in.
	cm	foot	0.03281	1 yd = 3 ft.
	m	yard	1.09361	= 36 in.
	km	mile	0.62137	
	inch	mm	25.4	
	foot	cm	30.48	
	yard	m	0.9144	
	mile	km	1.6093	
Area	cm^2	$in.^2$	0.155	1 ft^2 = 144 $in.^2$
	m^2	ft^2	10.76	1 yd^2 = 9 ft^2
	km^2	$mile^2$	0.3861	= 1296 $in.^2$
	are	acre	0.0247	
	$in.^2$	cm^2	6.4516	
	ft^2	m^2	0.0929	
	$mile^2$	km^2	2.59	
	acre	are	40.4686	
Volume	cm^3	$in.^3$	0.06102	★Great Britain (UK)
	dm^3 (liter)	$in.^3$	61.0236	1 fl oz = 0.028413 dm^3
	dm^3 (liter)	ft^3	0.03531	1 pt = 4 gills
	m^3	ft^3	35.315	= 0.56826 dm^3
	m^3	yd^3	1.30795	1 qt = 2 pt
	$in.^3$	cm^3	16.3871	= 1.13652 dm^3
	$in.^3$	dm^3 (liter)	0.01639	1 gal = 34 qt
	ft^3	m^3	0.02832	= 4.5461 dm^3
	yd^3	m^3	0.76456	
				★United States (US)
				1 fl oz = 0.029574 dm^3
				1 liq pt = 4 gills
				= 0.47318 dm^3
				1 liq qt = 2 liq pt
				= 0.94635 dm^3
				1 gal = 231 $in.^3$
				= 4 liq qt
				= 3.7854 dm^3
Weight (Units of mass)	g	oz	0.03527	
	kg	lb	2.2046	1 lb = 16 oz
	oz	g	28.3495	= 453.592 g
	lb	kg	0.45359	= 0.45359 kg
Force	gf	N (newton)	0.009807	1 pdℓ (poundal)
	kgf	N	9.80665	= 0.138255N
	lbf	N	4.44822	= force which accelerates a mass of lb by 1 ft/s^2
	N	gf	101.972	
	N	kgf	0.101972	
	N	lbf	0.224809	

Units	To convert	Into	Multiply by	Reference
Pressure and stress	kgf/cm^2	Bar	0.98066	1 at = 1 kgf/cm^2
	kgf/cm^2	N/m^2 (Pa)	98066.5	1 Pa = 1 N/m^2
	kgf/cm^2	$lbf/in.^2$	14.2233	10 m H_2O = 1 kgf/cm^2
	$lbf/in.^2$	Bar	0.0689	1 mmHg = 1 Torr
	$lbf/in.^2$	N/m^2 (Pa)	6894.76	
	Bar	kgf/cm^2	1.01972	
	N/m^2 (Pa)	kgf/cm^2	1.0197×10^{-5}	
	$lbf/in.^2$	kgf/cm^2	0.07031	
	Bar	$lbf/in.^2$	14.5037	
	N/m^2 (Pa)	lbf/in^2	1.4504×10^{-4}	
Energy	J	kcal	238.8×10^{-6}	
	J	kwh	277.8×10^{-9}	
	J	BTU	947.8×10^{-6}	
	kcal	BTU	3.9683	
	BTU	kcal	0.252	
Work	kgf-m	N-m	9.80665	
	lbf-ft	N-m	1.356	
	kgf-m	lbf-ft	7.233	
	lbf-ft	kgf-m	0.138	
	N-m	kgf-m	0.102	
	N-m	lbf-ft	0.738	
Power	kw	PS	1.3596	1PS = 75 kg-m/sec
	kw	HP	1.3410	1HP = 550 lb-ft/sec
	PS	kw	0.7355	
	HP	kw	0.7457	
	PS	HP	0.98632	
	HP	PS	1.01387	
Velocity	m/sec	ft/min	196.86	
	ft/min	m/sec	0.0051	
	km/h	mile/h	0.62137	
	mile/h	km/h	1.09361	
Acceleration	m/sec^2	ft/sec^2	3.281	
	ft/sec^2	m/sec^2	0.3048	
Fuel consumption	g/PS-h	g/kw-h	1.3596	
	g/HP-h	g/kw-h	1.3410	
	lb/PS-h	g/kw-h	599.96	
	lb/HP-h	g/kw-h	608.277	
	g/kw-h	g/PS-h	0.7355	
	g/kw-h	g/HP-h	0.7457	
	g/kw-h	lb/PS-h	0.00167	
	g/kw-h	lb/HP-h	0.00164	
Temperature	°C	°F	$C = \frac{5}{9}(F - 32)$	
	°C	K (Kelvin)	$C = K - 273.15$	
	°F	°C	$F = 1.8 \times C + 32$	
	°F	°R (Rankine)	$F = R - 459.67$	
	K	°C	$K = C + 273.15$	
	°R	°F	$R = F + 459.67$	

YANMAR DIESEL ENGINE CO.,LTD.

YANMAR DIESEL AMERICA CORP.,

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