

**YANMAR**  
**SERVICE MANUAL**

**INDUSTRIAL DIESEL ENGINE**

**MODEL TN series**

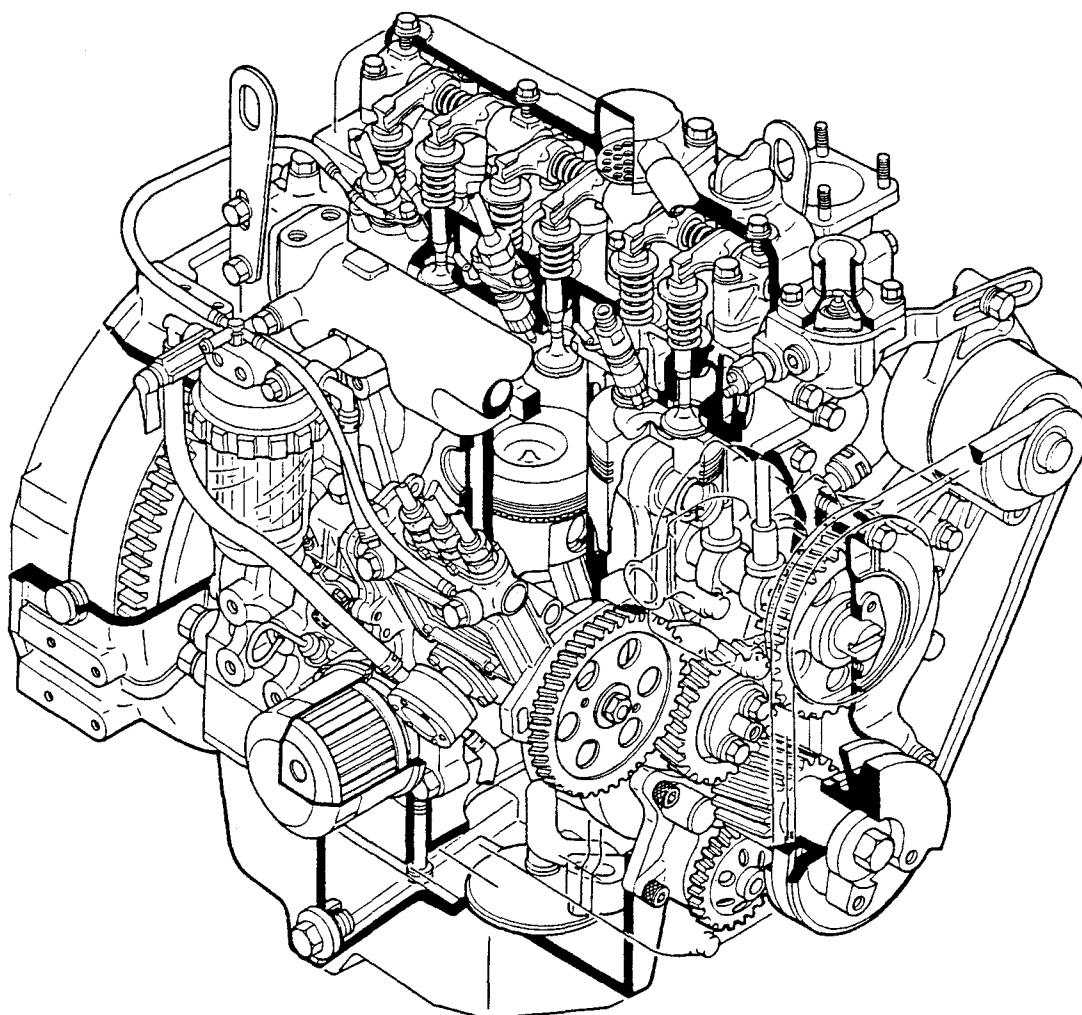
## PREFACE

*This service manual covers the construction, function and servicing procedures of the YANMAR Diesel Engine 2TN66E, 3TN66E, 3TNA72E, 3TN75E, 3TNC78E, 3TN82E, 3TN82TE, 4TN82E, 4TN82TE, 3TN84E, 3TN84TE, 4TN84E and 4TN84TE. You are encouraged to read this manual to make the most of the outstanding performance and durability features of these engines and to perform proper servicing to maintain them in tip-top running condition.*

*This service manual contains the latest information available as of April, 1989. For any changes thereafter, you are requested to consult the YANMAR Service Bulletin.*

*YANMAR reserves the right to make changes at any time without notice and without incurring any obligations.*

YANMAR DIESEL ENGINE CO., LTD.



Models

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

**CHAPTER**

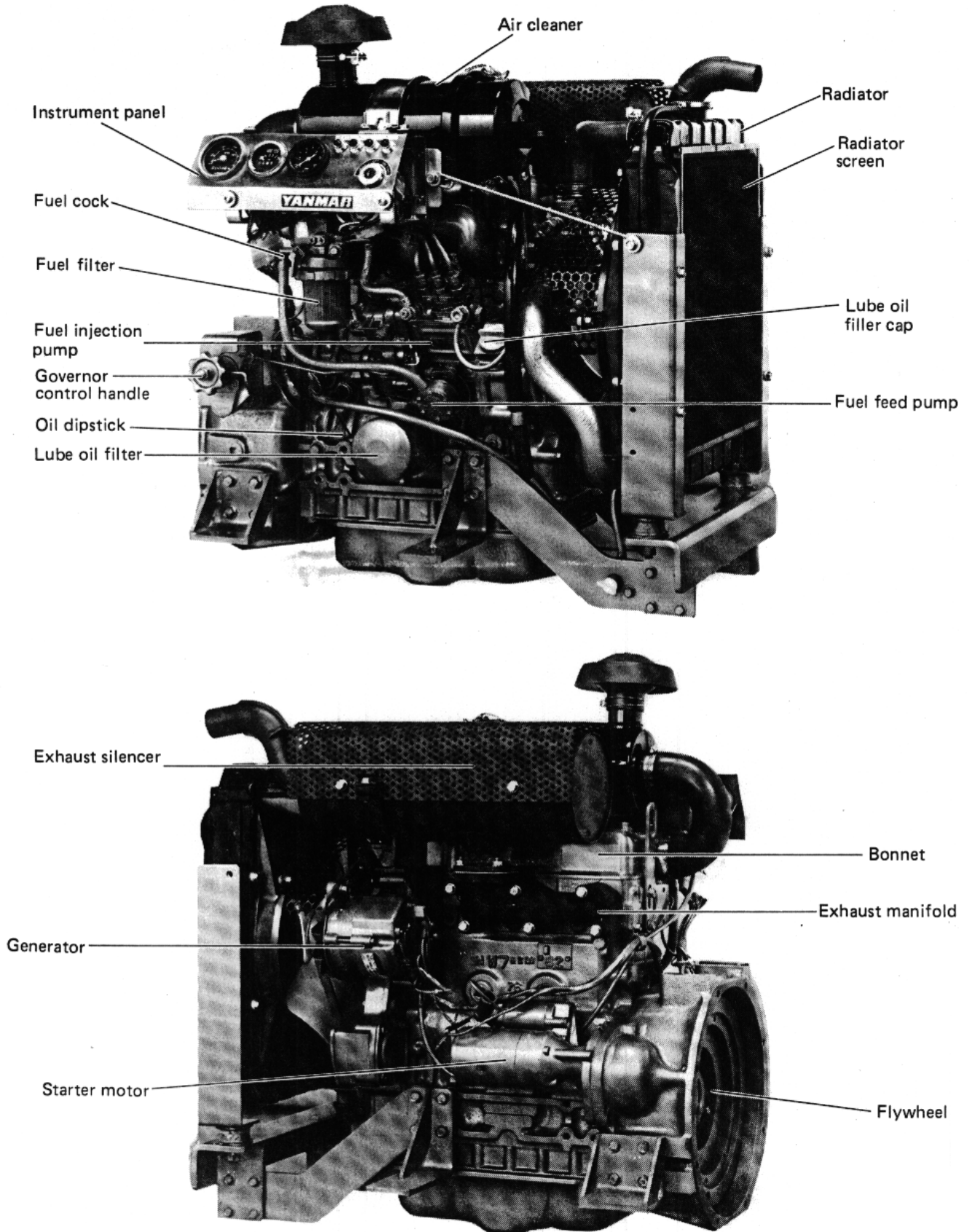
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CHAPTER 1

# GENERAL

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# 1. External Views



## 2. Specifications

## 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	Continu- ous rating	HP/rpm	8.5/3000 10/3600		—	13/3000 15/3600		—	17/3000 19/3600	
	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	
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°	
Fuel injection pressure		kg/cm <sup>2</sup> (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)		2.3 (2.43)		2.3 (2.43)		2.5 (2.64)	
	Rad. hose	liter (US qt)	1.9 (2.0)						1.4 (1.5)	
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)
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
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)
* Dimen- sions	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)
	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)
	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)

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

## 2. Specifications

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		78 x 80 (3.07x 3.15)			82 x 86 (3.23) x (3.39)			82 x 86 (3.23 x 3.39)		
Displacement		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)		16° ± 1°		26° ± 1°	16° ± 1°		26° ± 1°	15° ± 1°	14° ± 1°	
Fuel injection pressure		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 Rad. hose	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)
Cooling fan	Pusher	No. of blade-mm dia	6-335			6-, 335			6-335	
Lubricating system		Forced lubrication with trochoid pump								
Lubricating 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		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		1.816 (110.82)			1.816 (110.80)			1.429 (87.20)			
Output JIS B8002 BS 5514	Continu- ous 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 24.2/1800	20.0/1500 47.0/3600	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/cm <sup>2</sup> (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 Rad. hose	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)
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)	
* Dimen- sions	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 (19.1) *	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.

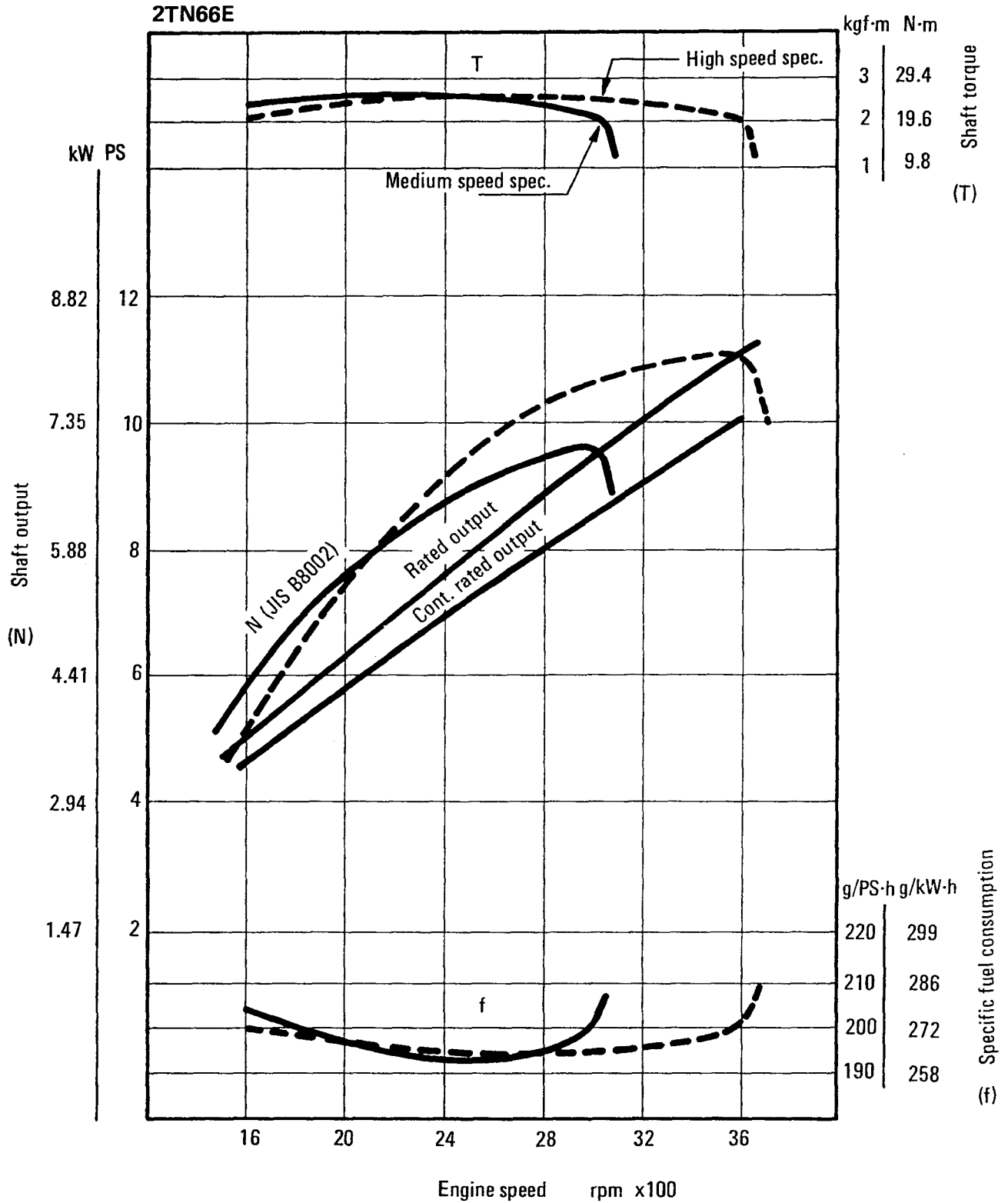


## 1. Cylinder Block

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	Continu- ous 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/cm <sup>2</sup> (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 Rad. hose	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)	←	←
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								
Lubricat- ing 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)
Dimen- sions	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)

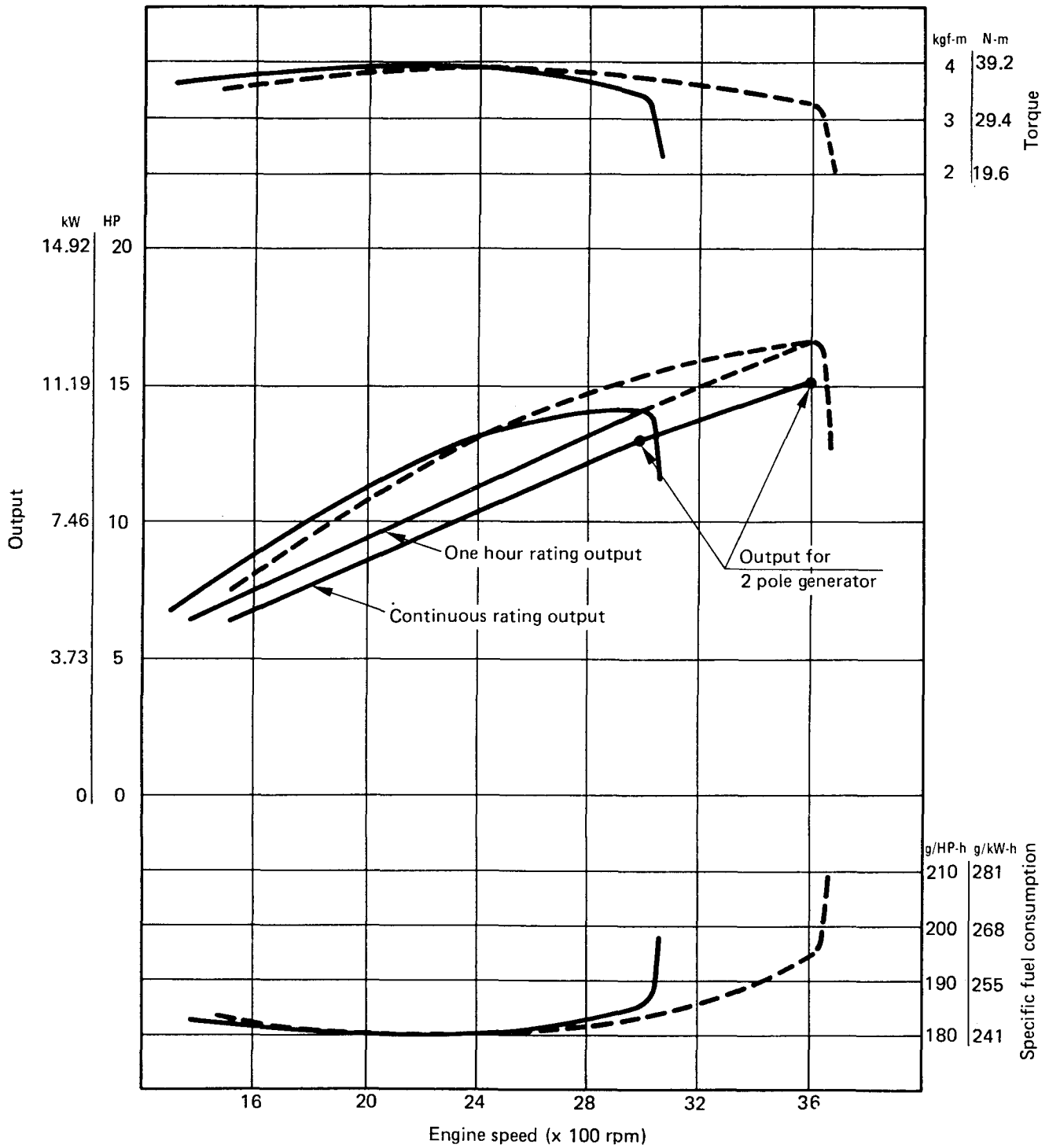
Note: \* shows the dimensions of Basic engine from the fan to the flywheel.

# 3. Performance Curves



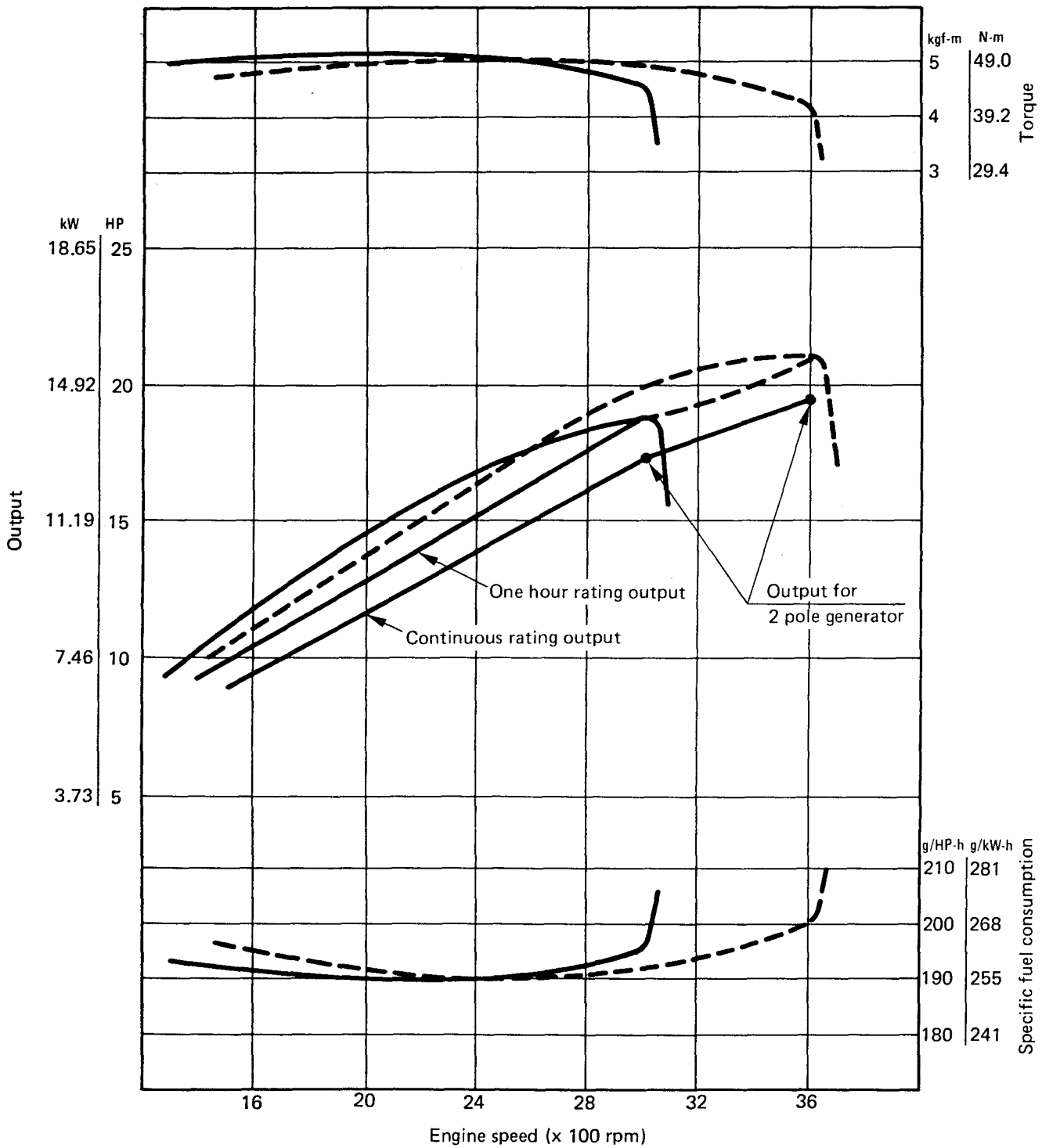
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.

3TN66E



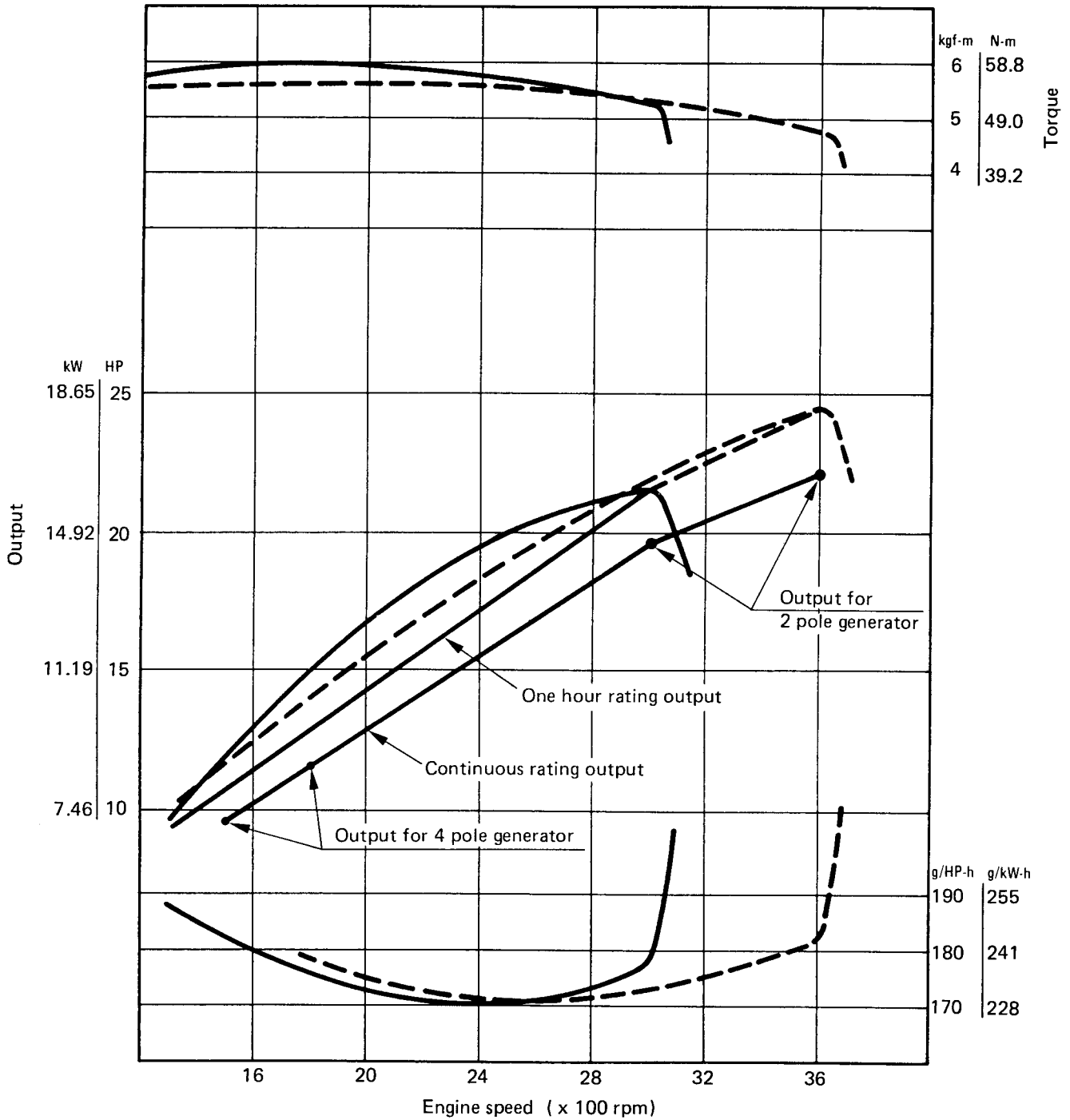
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 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.

3TNA72E



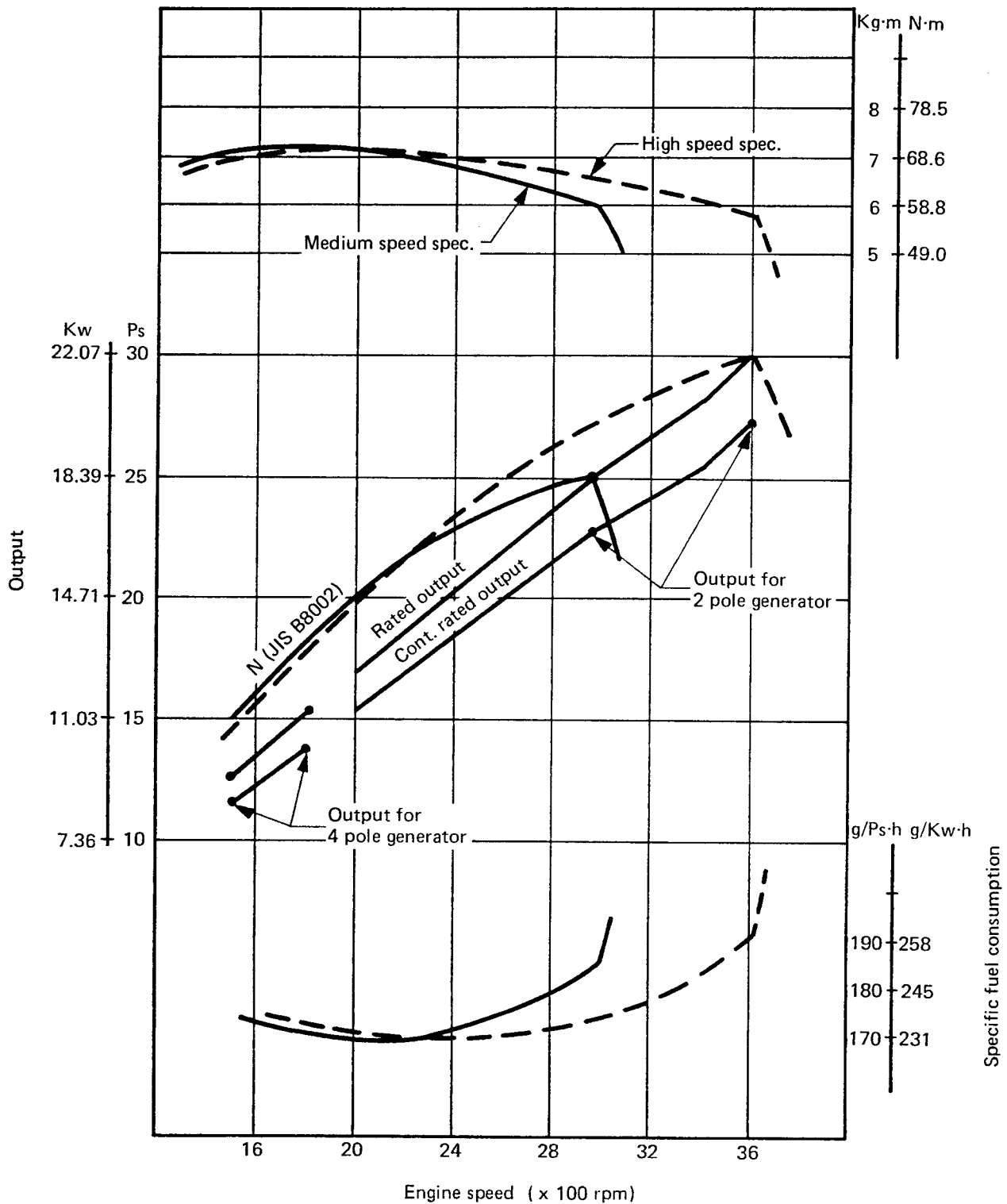
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.

3TN75E



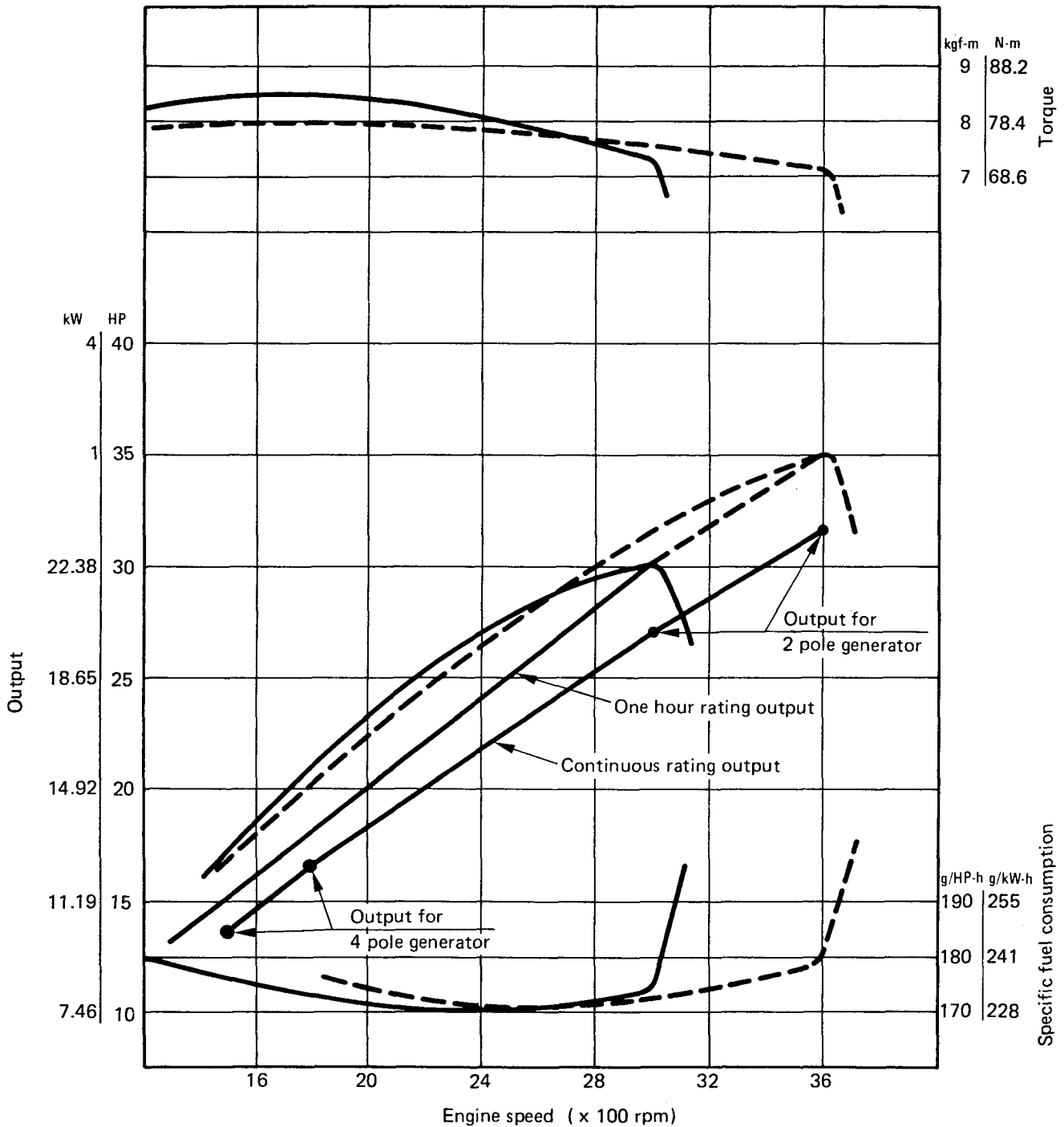
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.

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



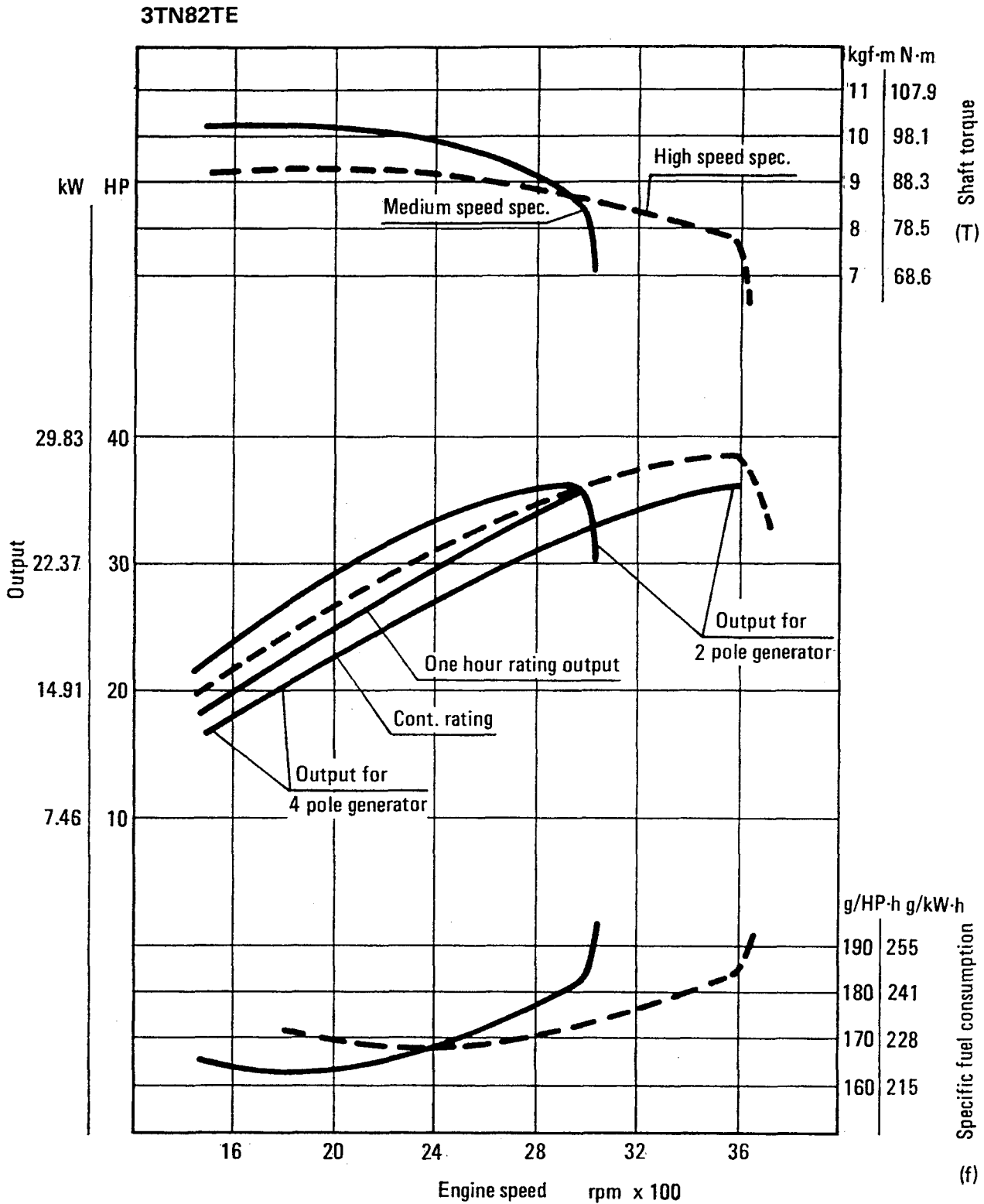
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.

Intake air temperature: 27°C

Barometric pressure: 750 mmHg

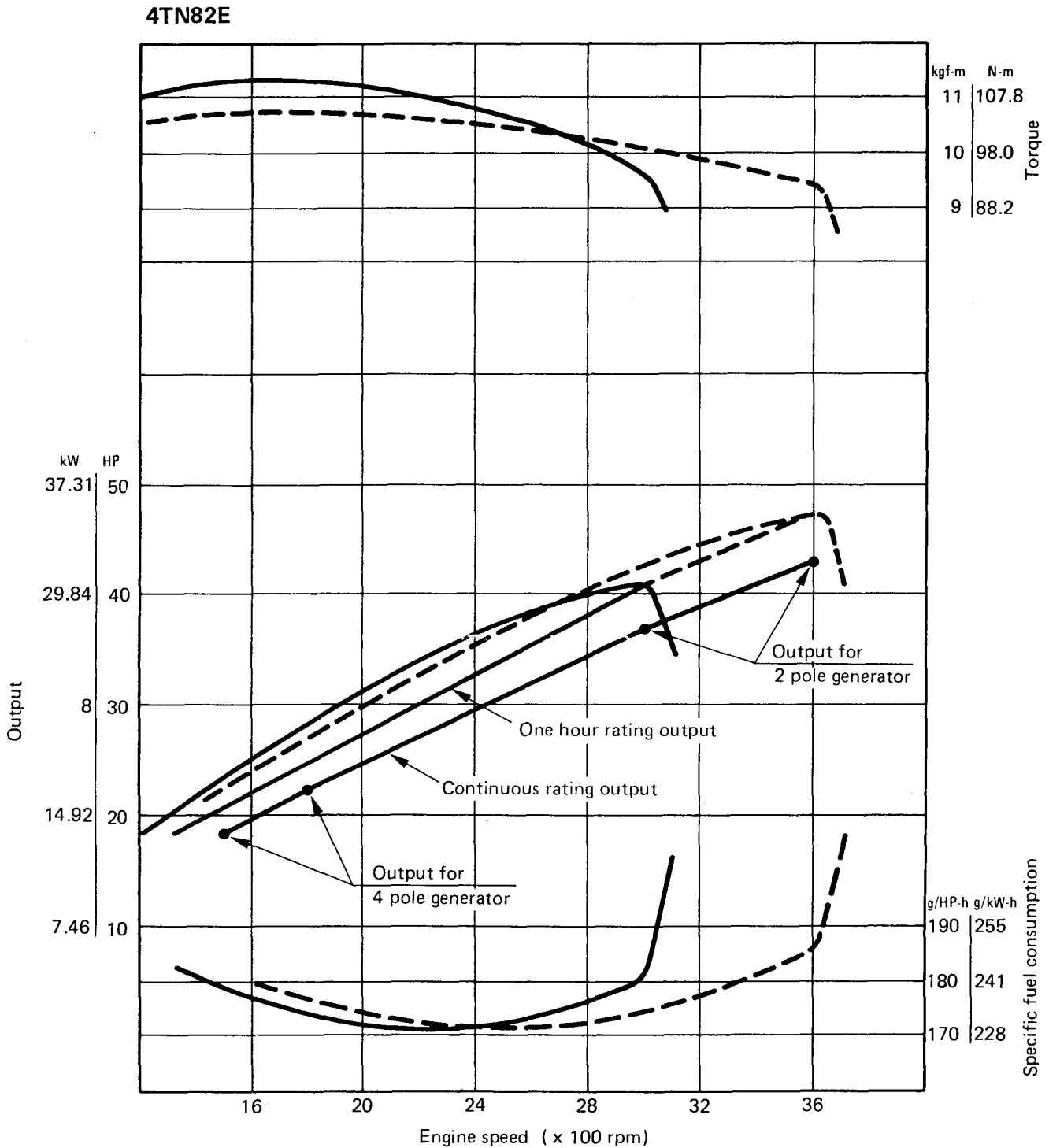
Relative humidity: 60%

The curves show performance after 30 hours run-in.



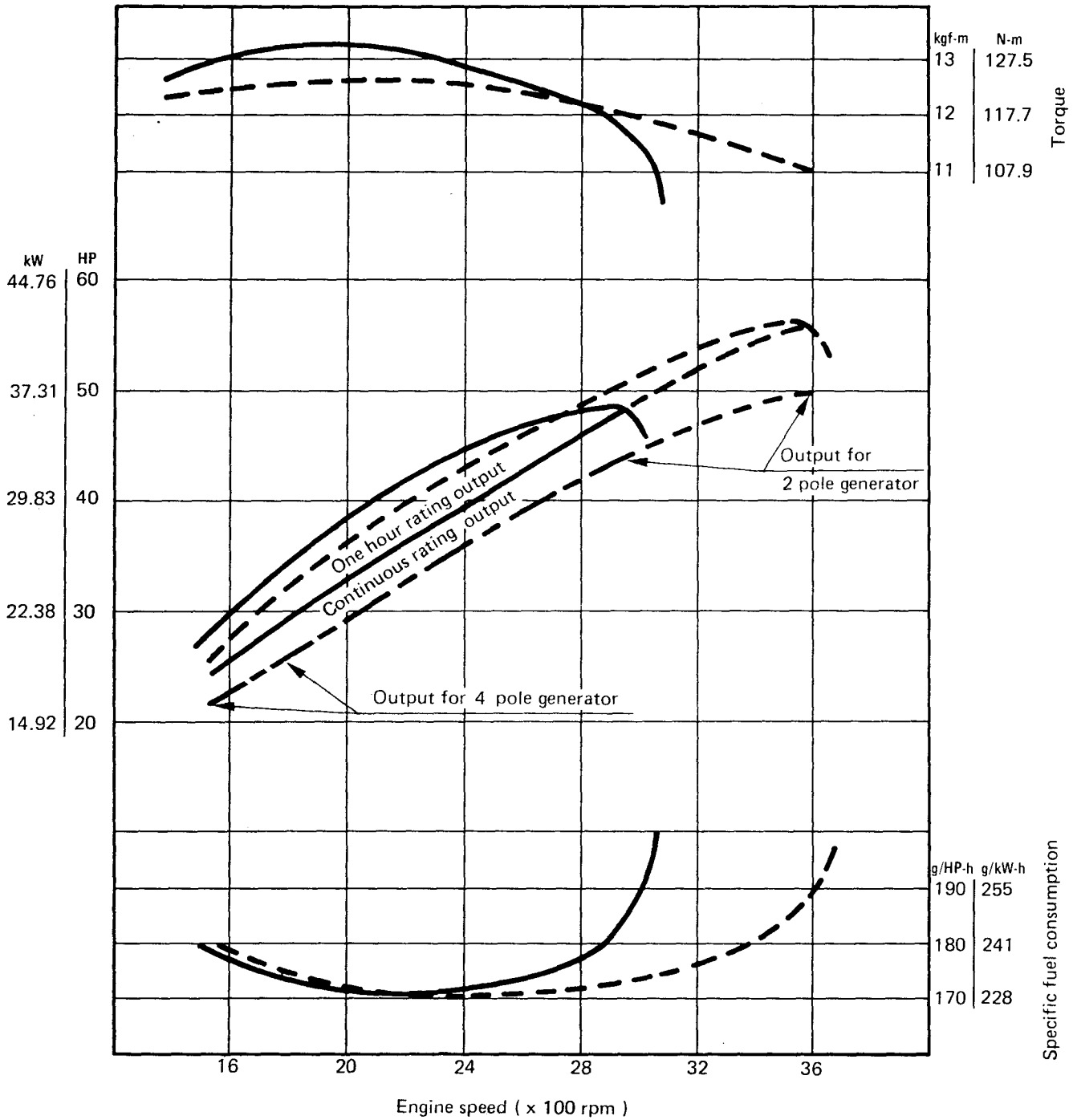
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514,  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.



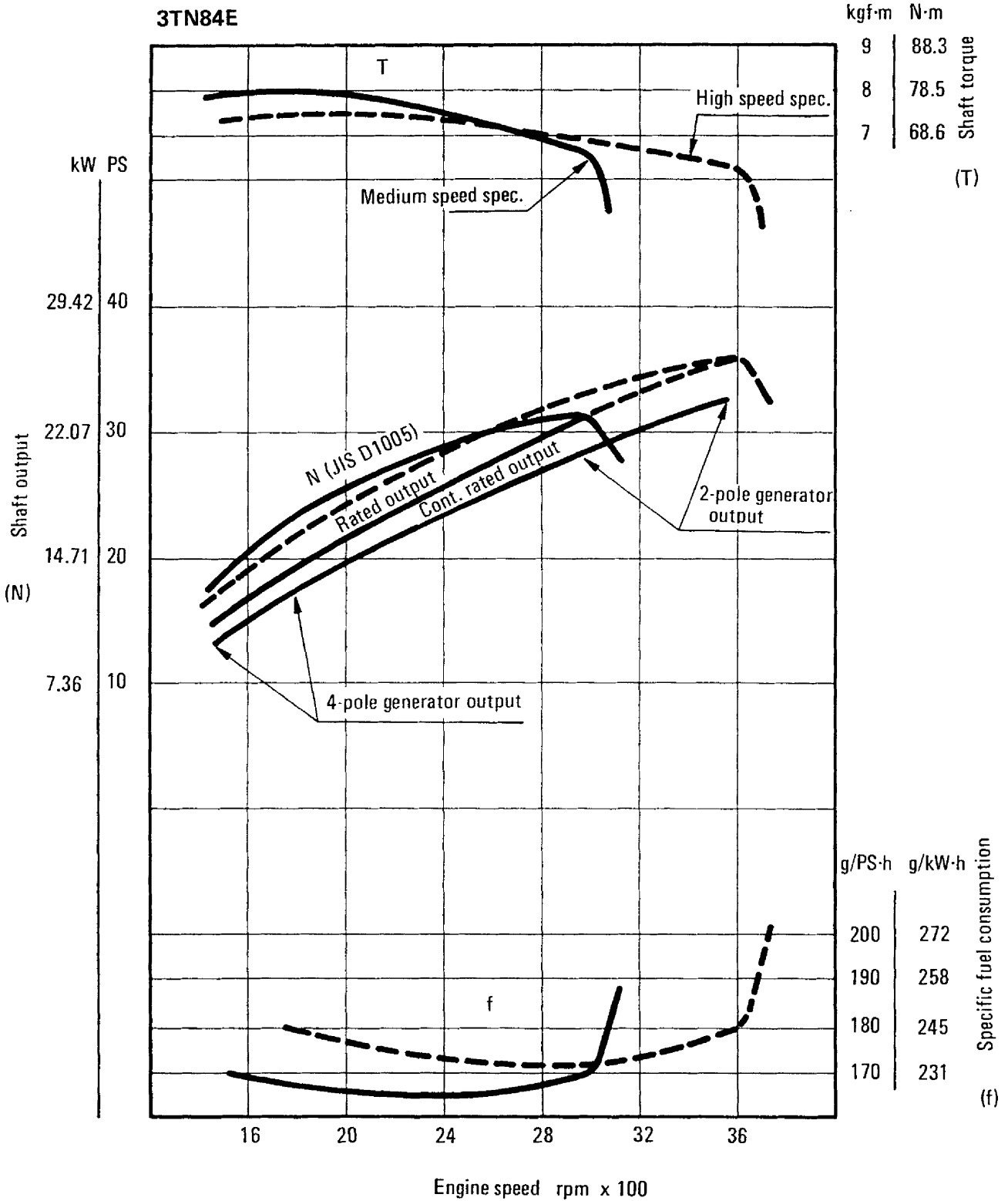


Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.

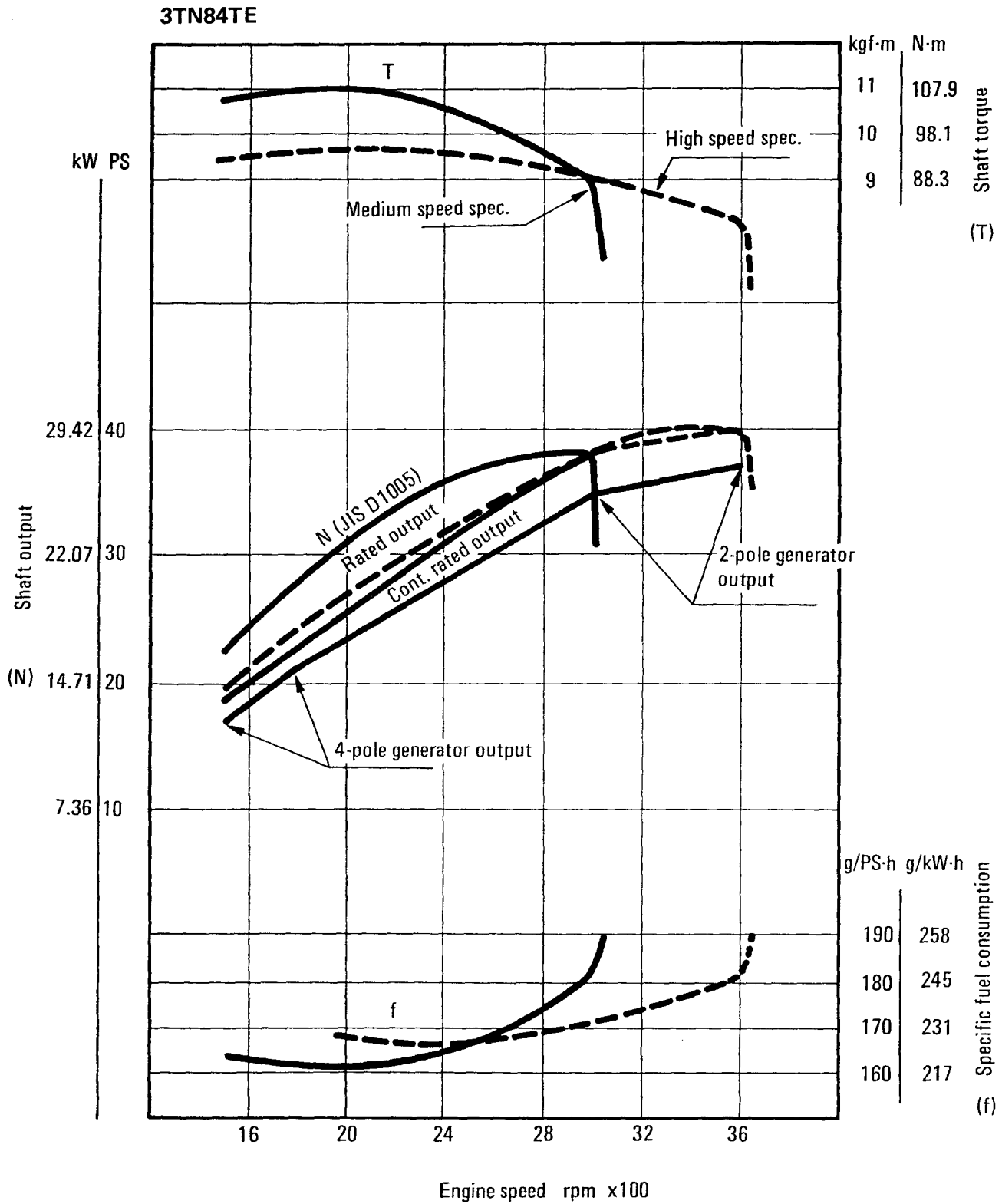
4TN82TE



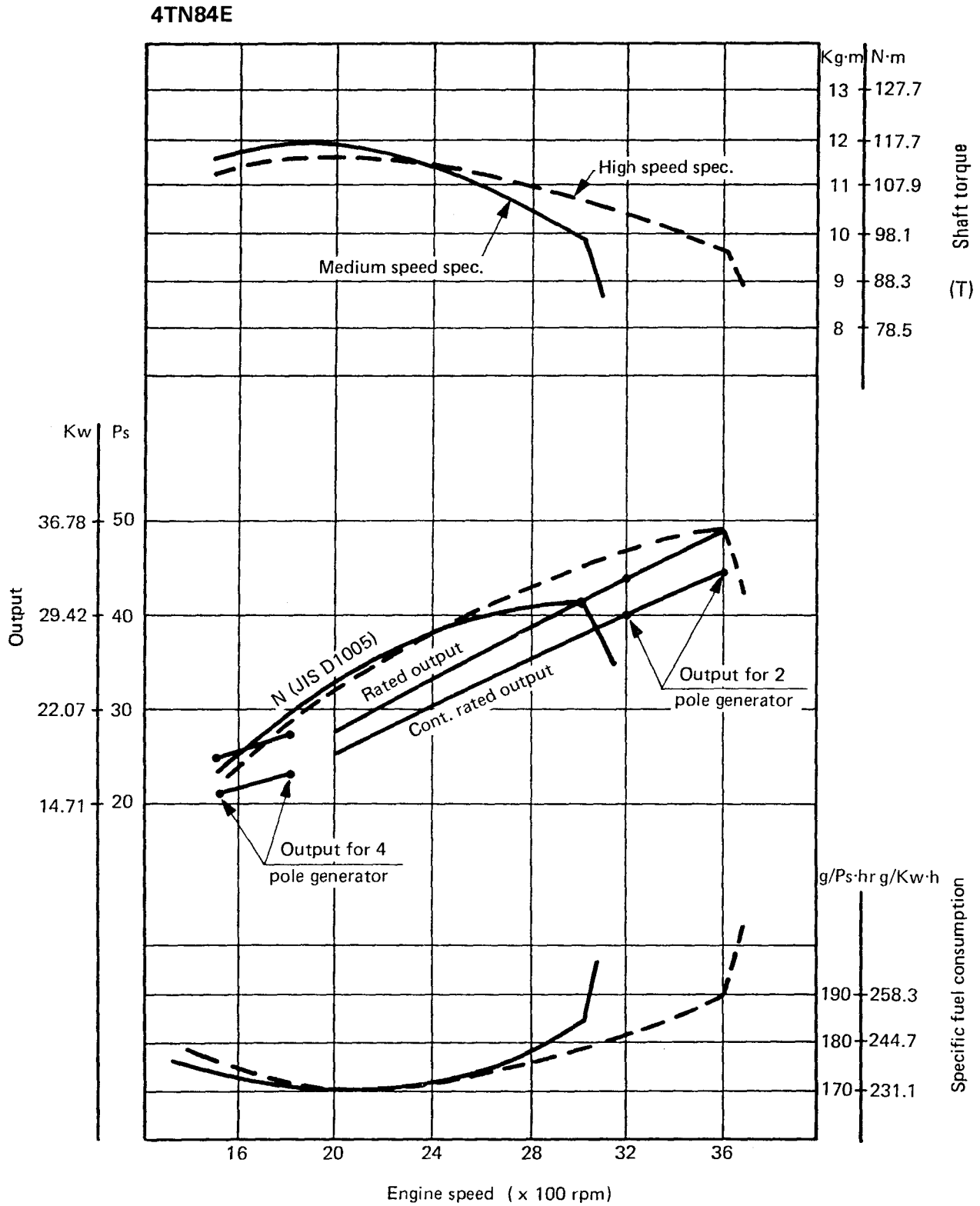
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.



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.

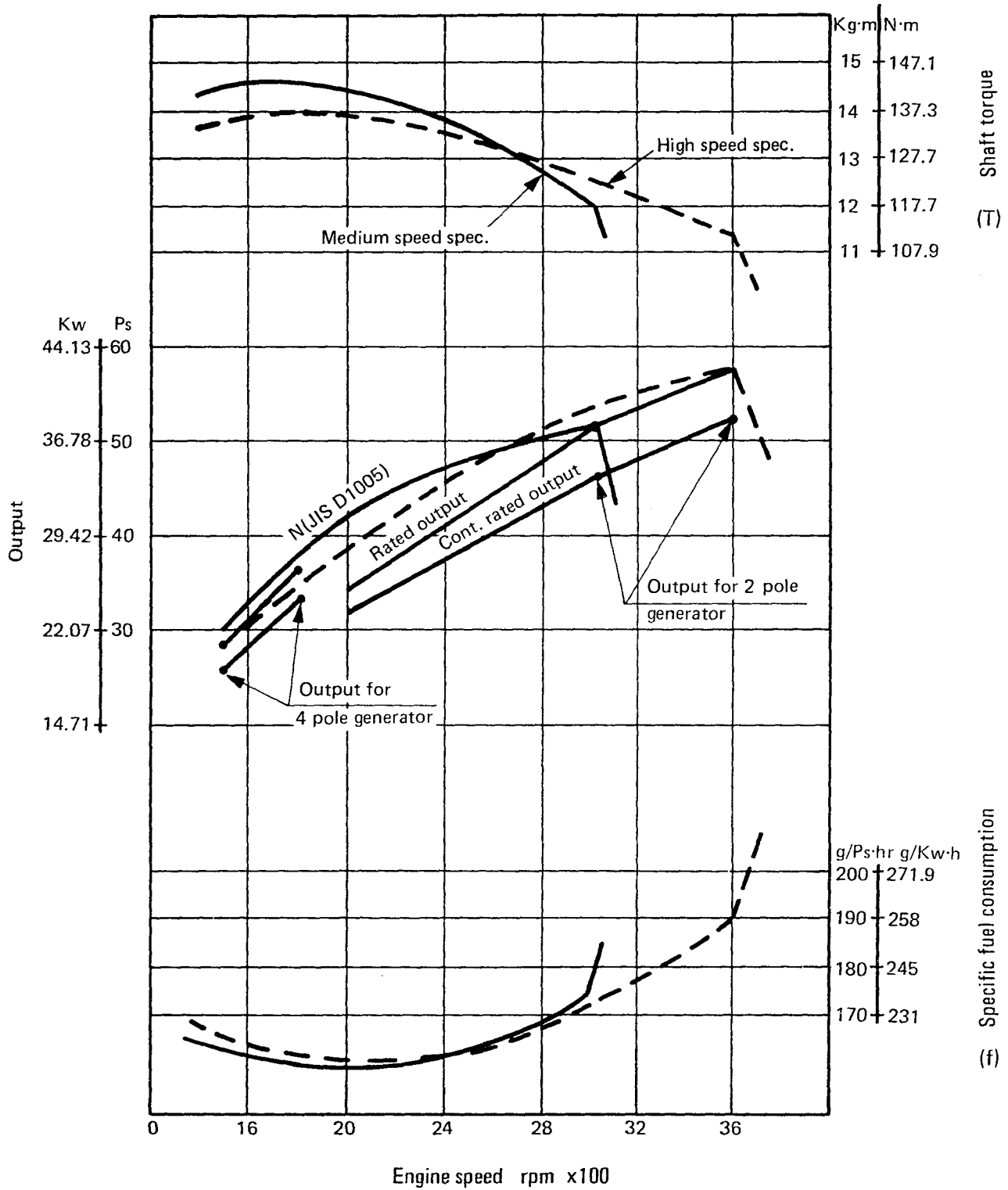


Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.



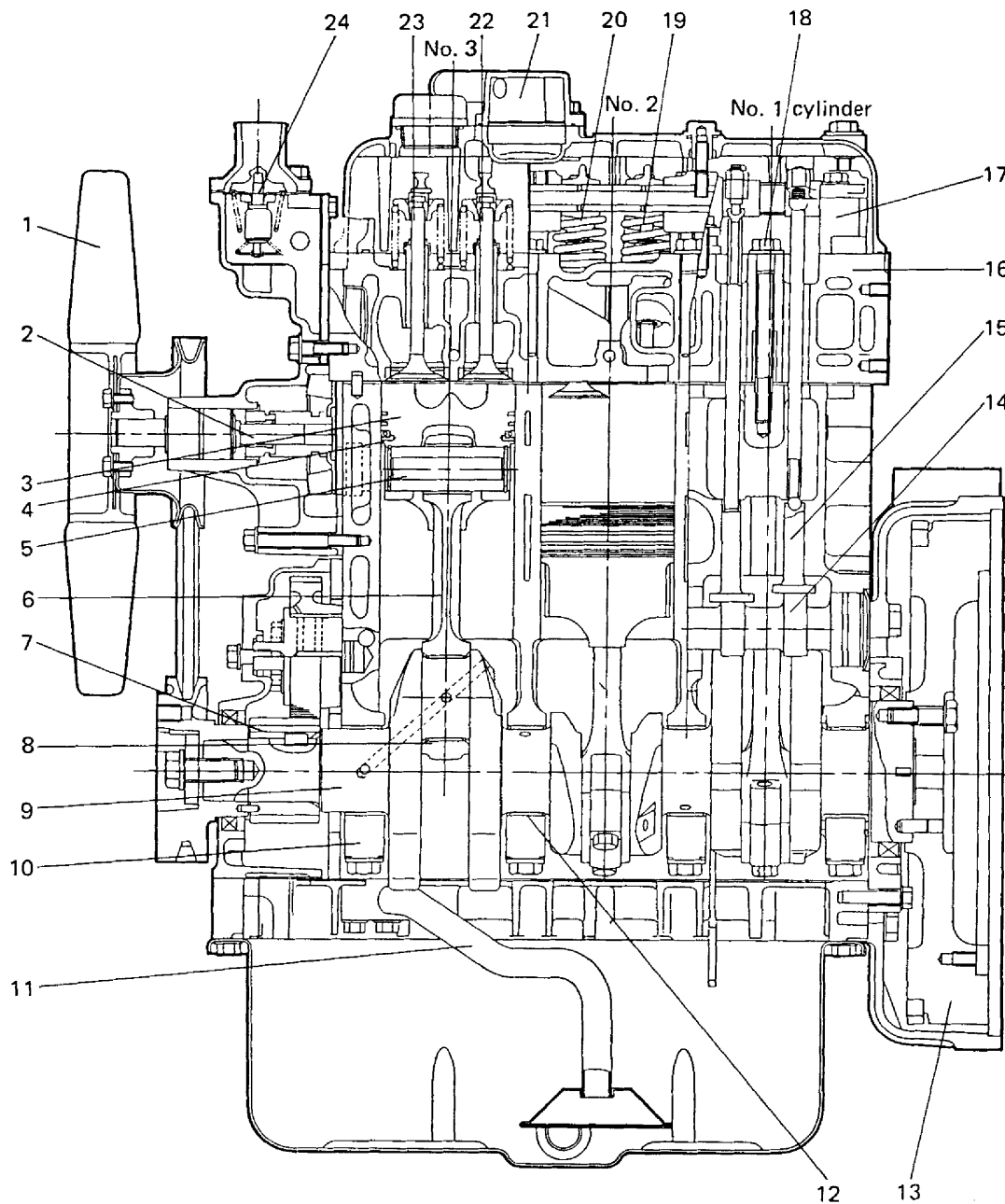
Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.

4TN84TE

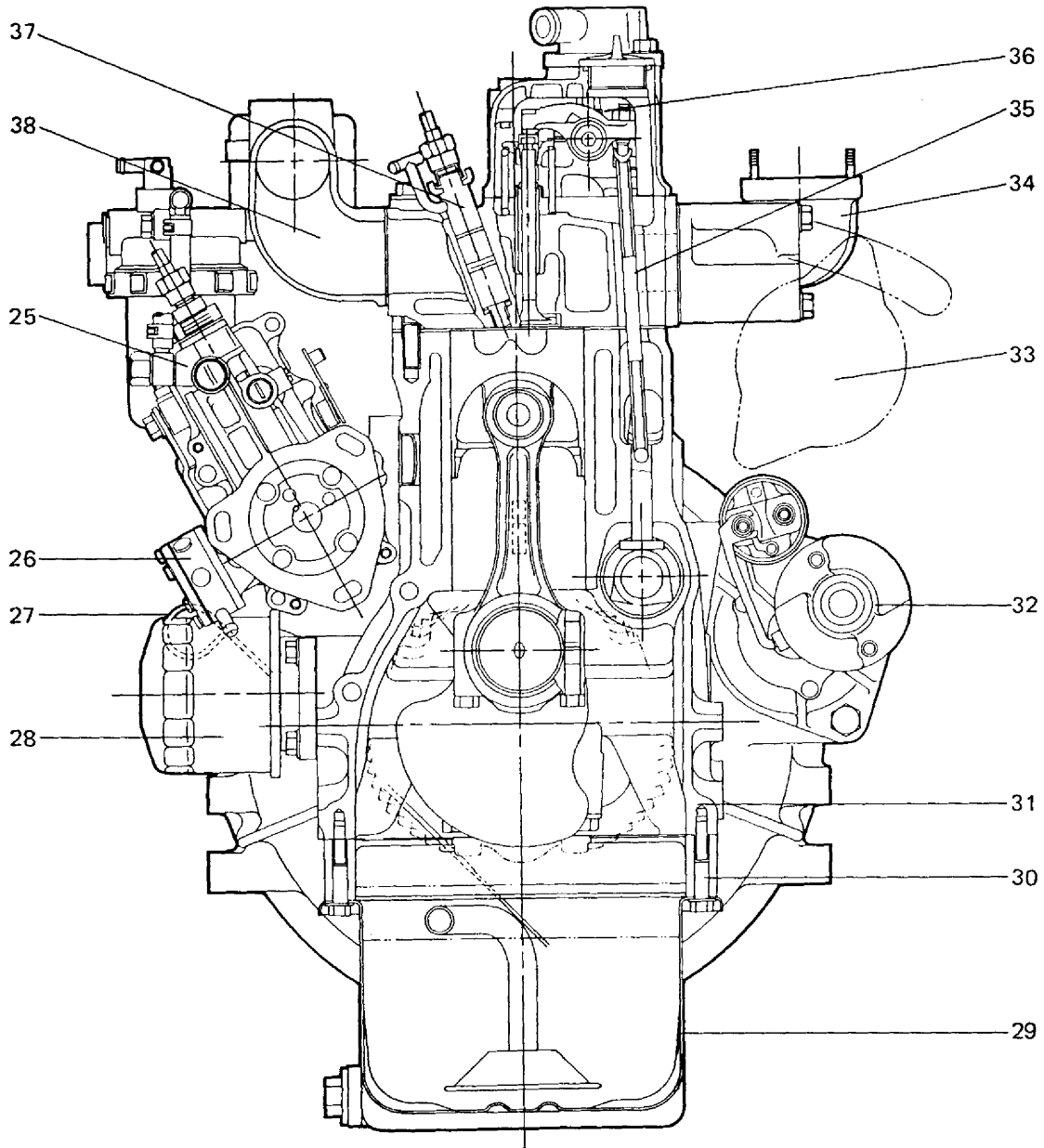


Conditions for performance curves are in accordance with JIS B8002, ISO 3046/1, BS5514.  
 Intake air temperature: 27°C  
 Barometric pressure: 750 mmHg  
 Relative humidity: 60%  
 The curves show performance after 30 hours run-in.

## 4. Cross Sectional Views



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



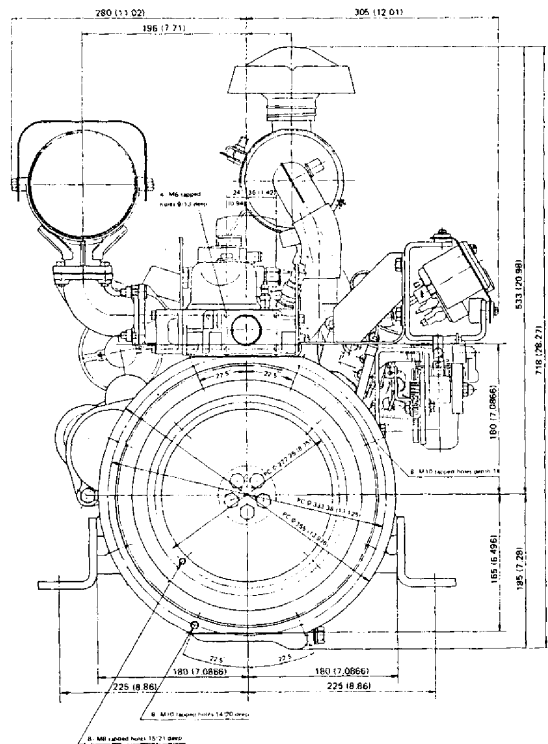
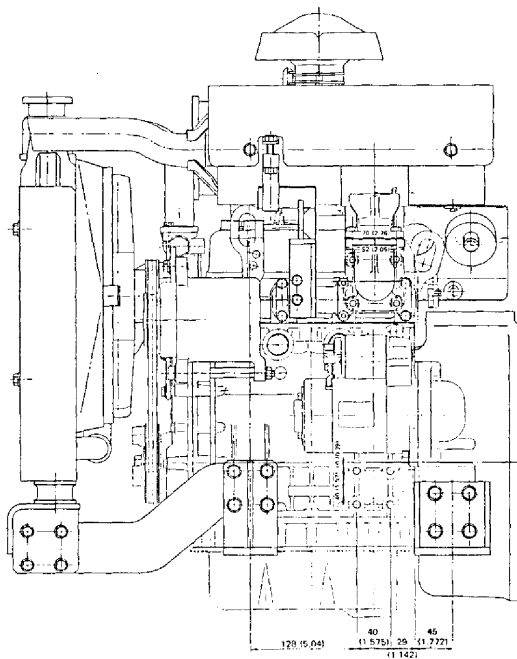
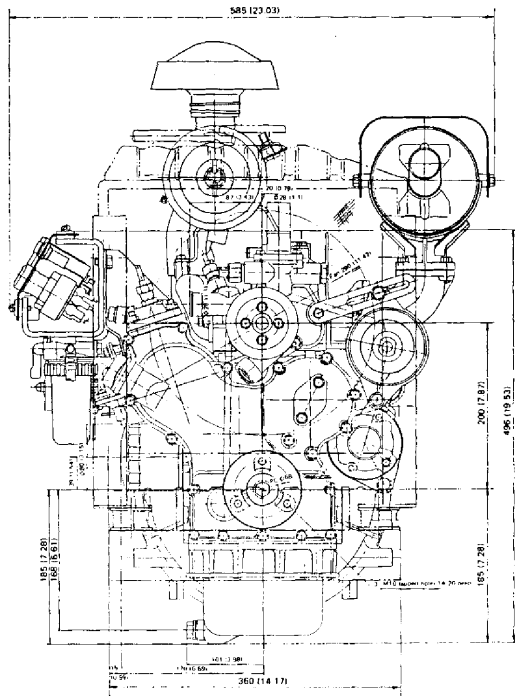
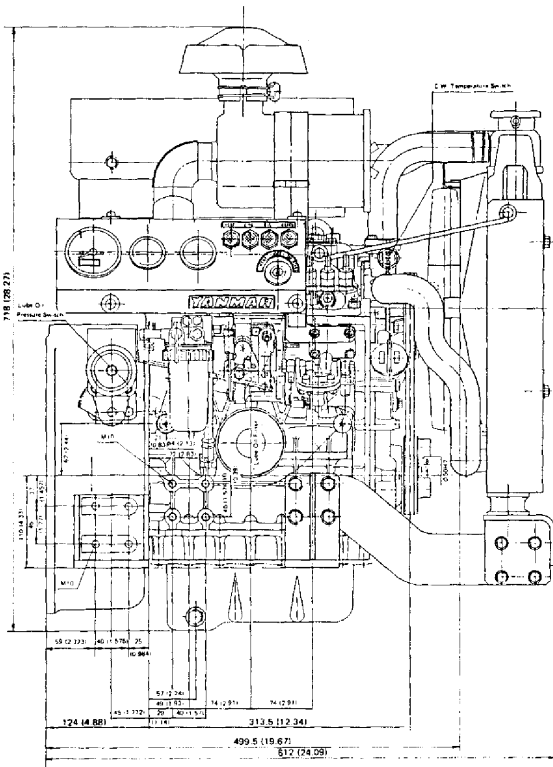
- |                           |                          |
|---------------------------|--------------------------|
| 25 Fuel injection pump    | 32 Starting motor        |
| 26 Fuel feed pump         | 33 Alternator            |
| 27 Dipstick               | 34 Exhaust manifold      |
| 28 Lubricating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



5. Dimensions

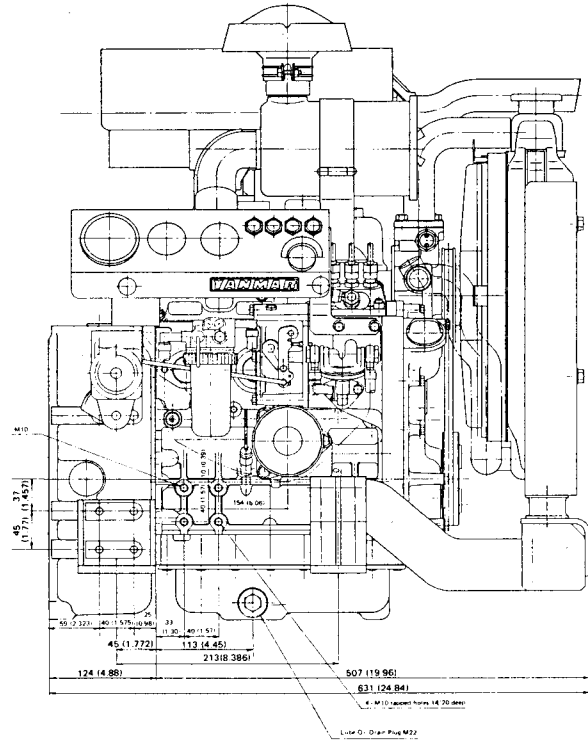
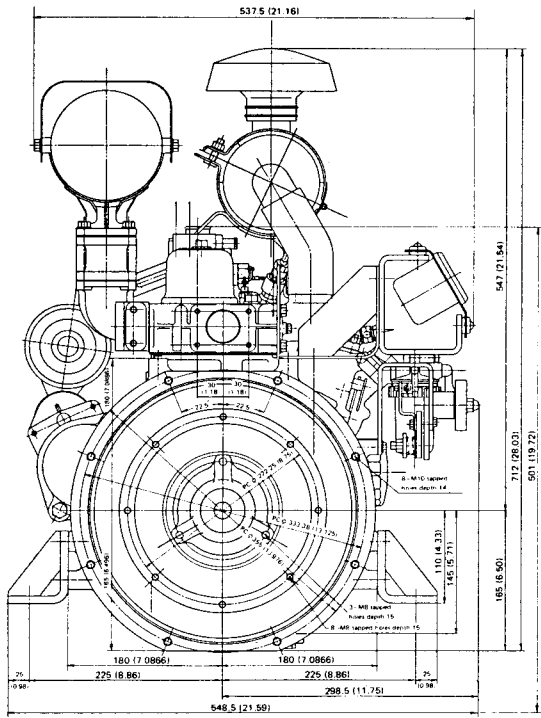
# 5. Dimensions

3TN66E-S

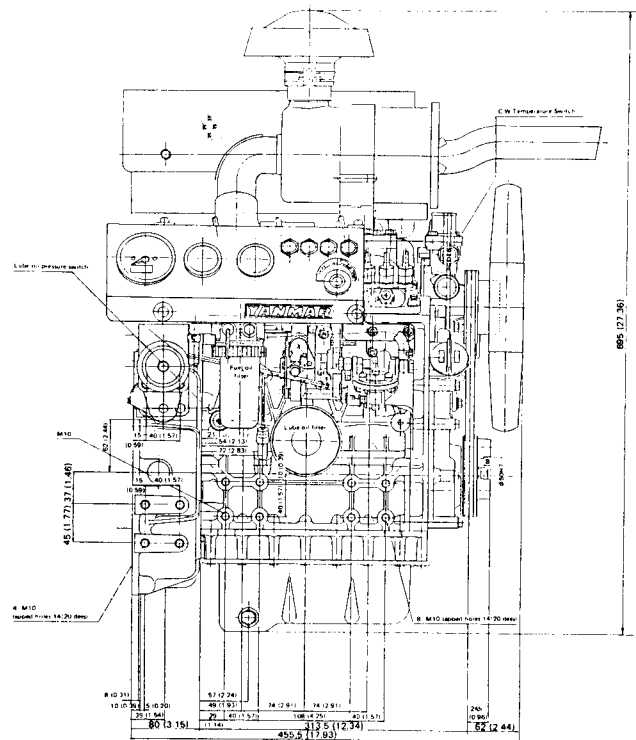
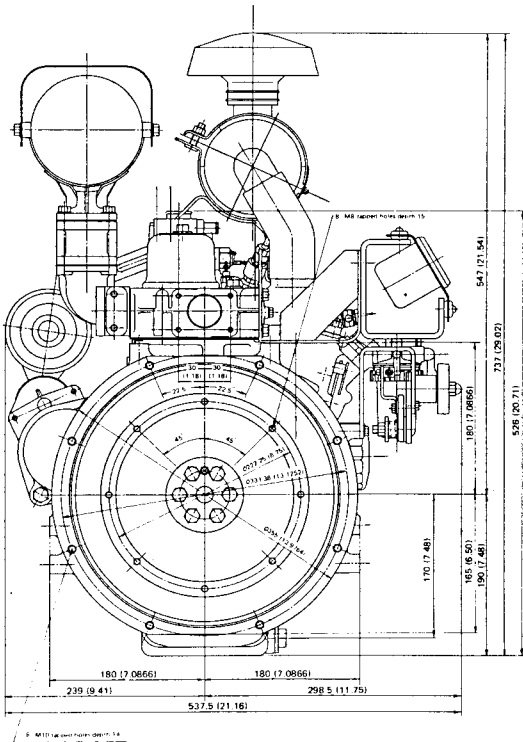




3TNA72E-S

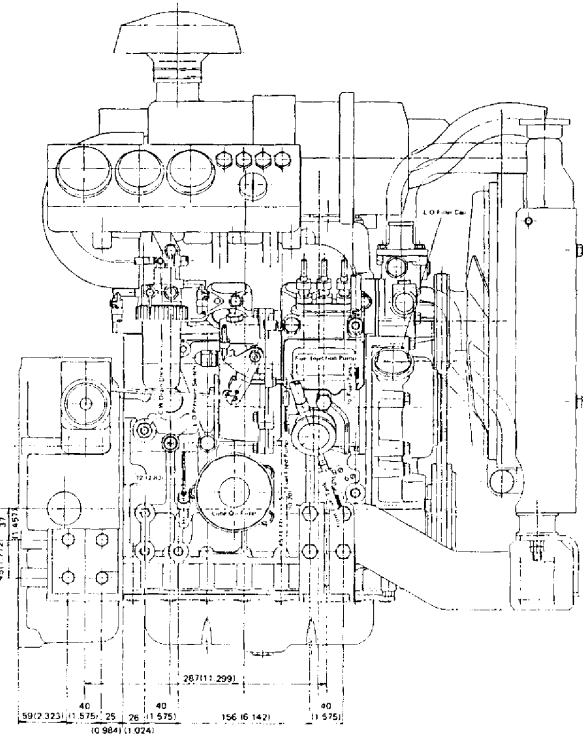
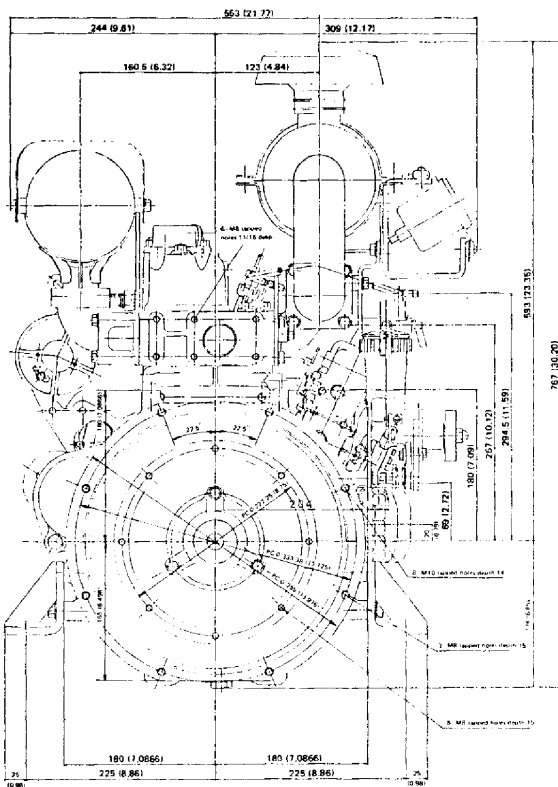


3TNA72E-G2  
(Power pack)



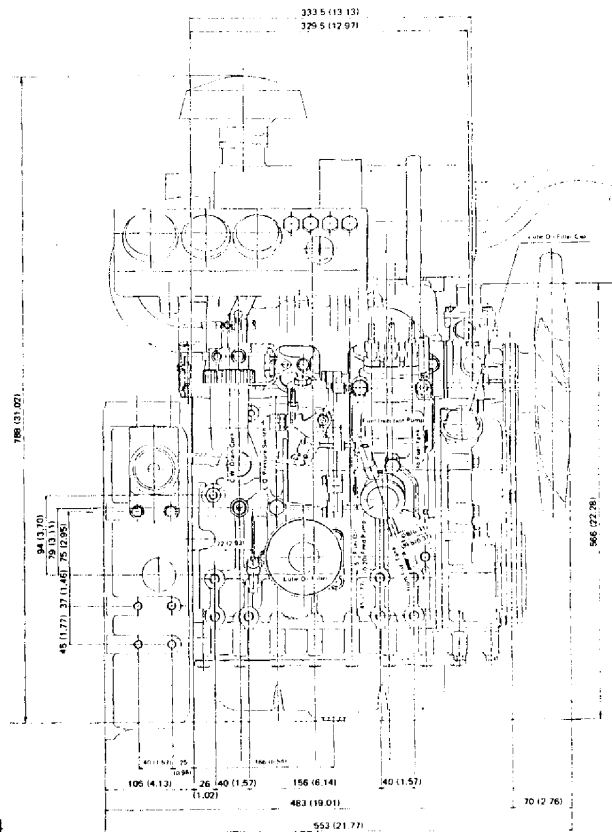
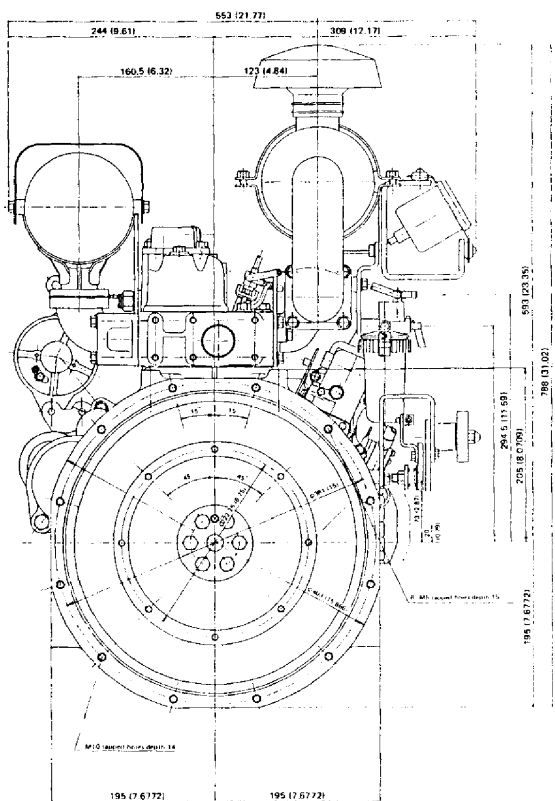
5. Dimensions

3TN75E-S



3TN75E-G1

(Power pack)

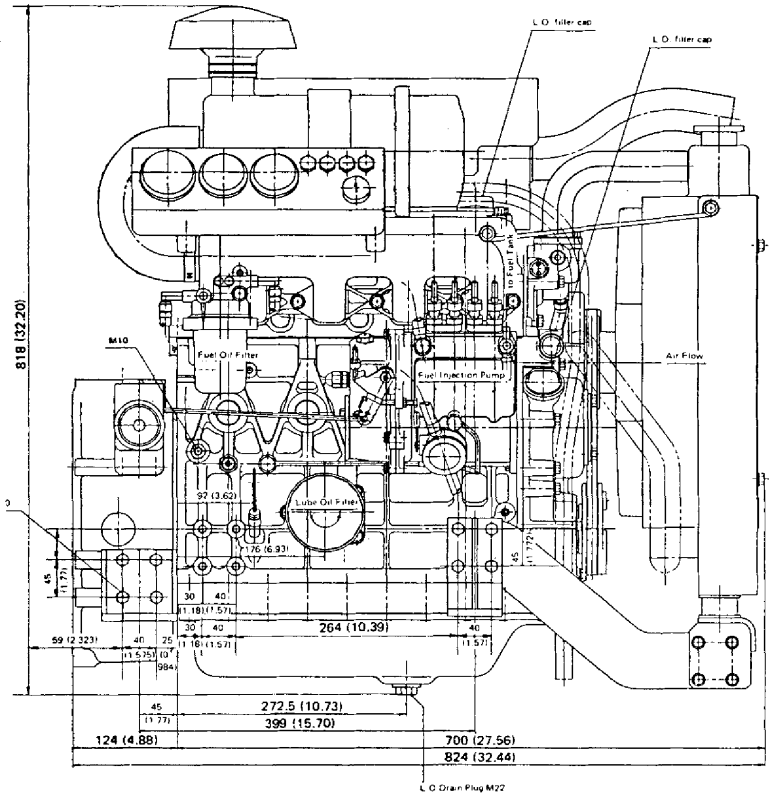
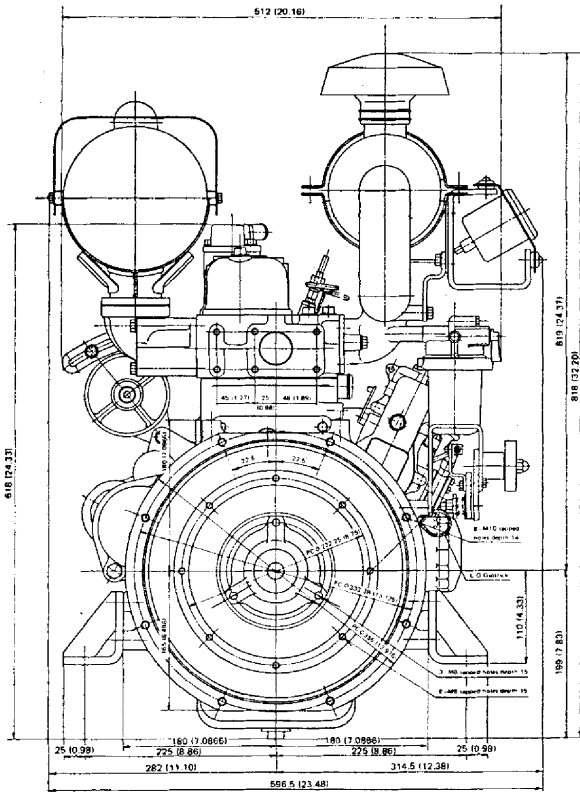




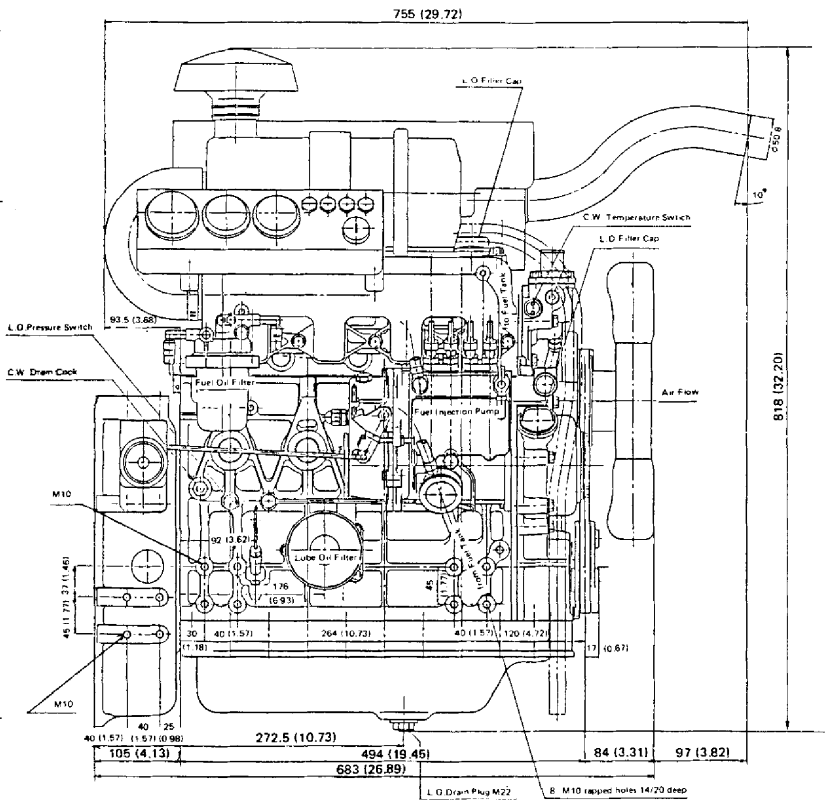
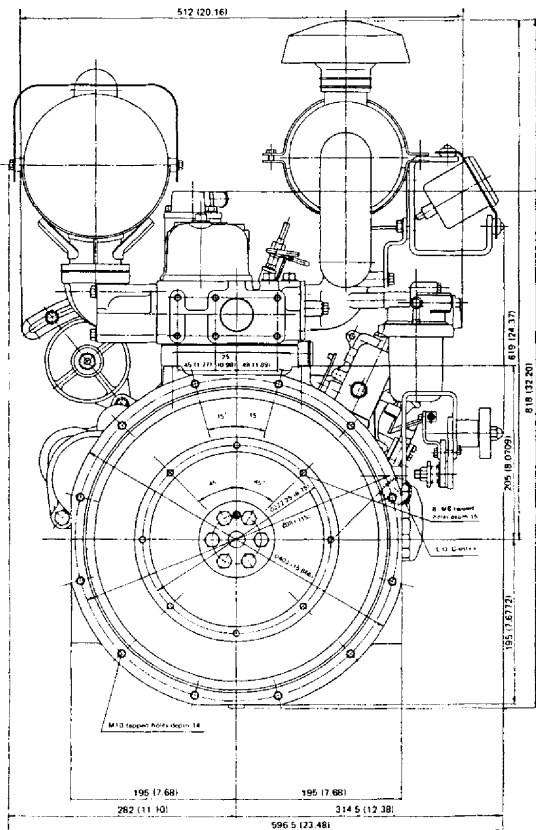




4TN82E-S

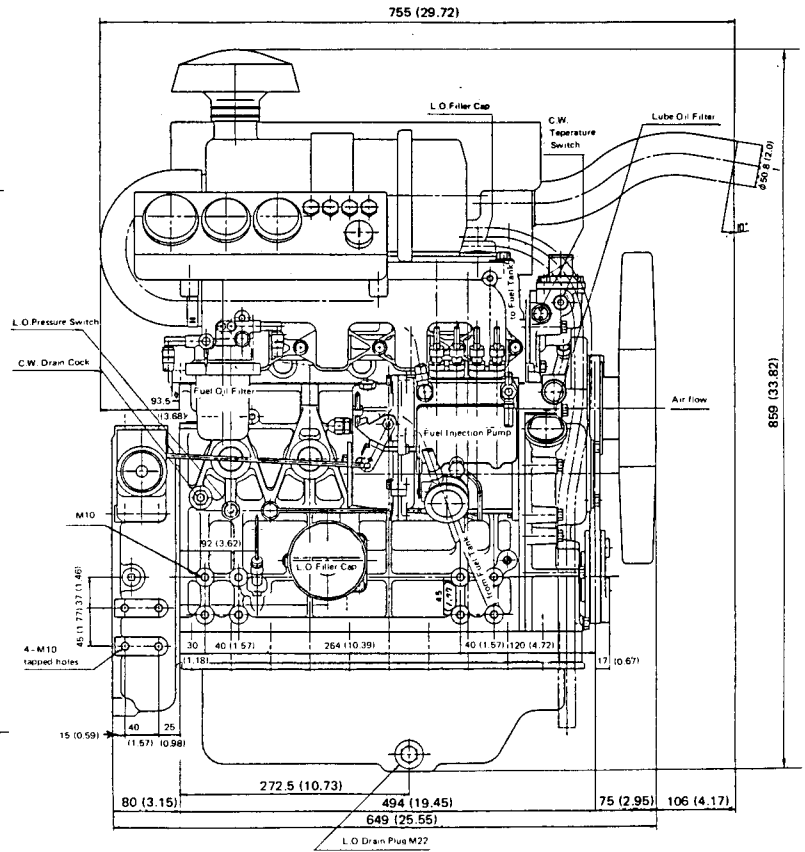
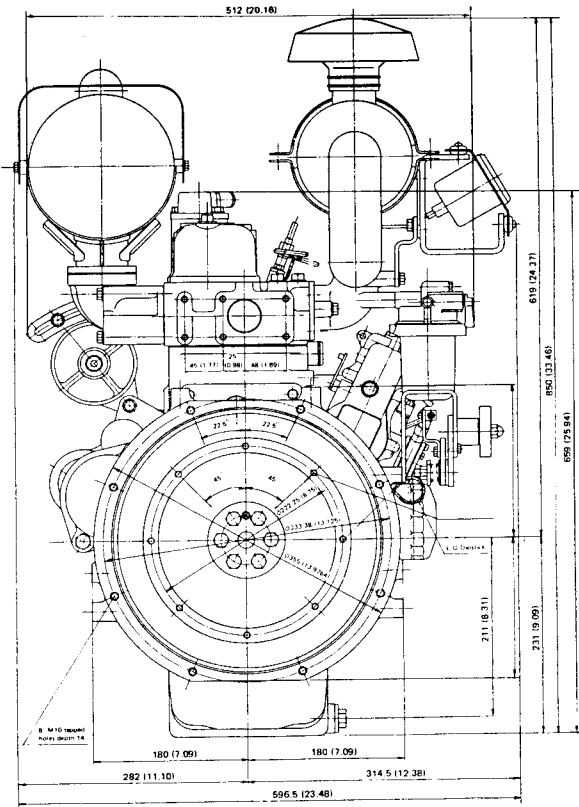


4TN82E-G1  
(Power pack)





4TN82E-G2



**MEMO:**

**MEMO.**

# 6. Maintenance

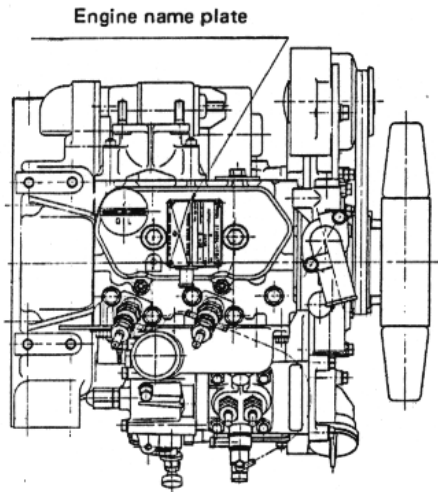
## o Maintenance Schedule

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

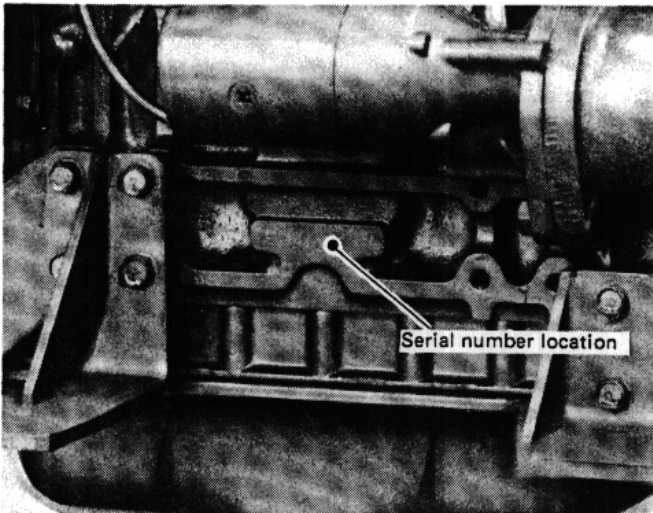
Inspection		Daily	Every 50 hours	Every 100 hours	Every 150 hours	Every 300 hours	Every 500 hours
Fuel System	Check the oil level; fill	<input type="radio"/>					
	Remove sediment from fuel tank	<input type="radio"/>					
	Clean and replace the fuel filter element			<input type="radio"/> First time		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



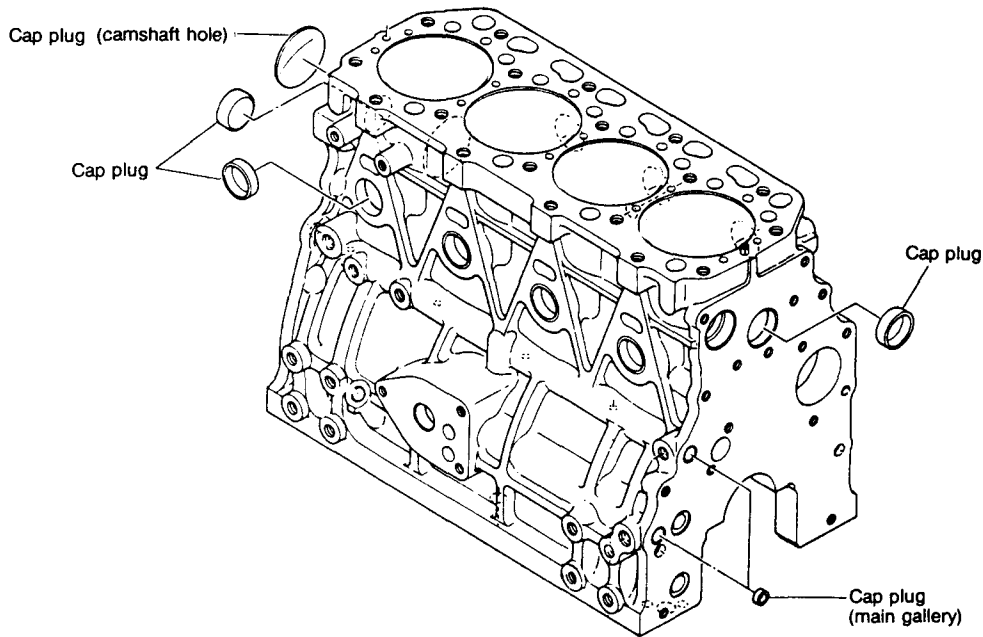
CHAPTER 2  
**BASIC ENGINE**

1. Cylinder block . . . . .	2-1
2. Cylinder head . . . . .	2-6
3. Piston and piston pins . . . . .	2-13
4. Connecting rod . . . . .	2-17
5. Crankshaft and main bearing . . . . .	2-20
6. Camshaft and tappets . . . . .	2-23
7. Timing gear . . . . .	2-26
8. Flywheel . . . . .	2-28
9. Service data . . . . .	2-30
10. Over-size and Under-size parts . . . . .	2-38

1. Cylinder Block

# 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 rigidity for strength and low noise.



### 1-1 Inspection of parts

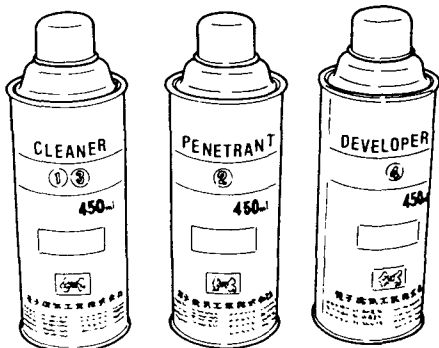
Make a visual inspection to check for cracks on engines that have frozen up, overturned or otherwise been subjected to undue stress. Perform a color check on any portions that appear to be cracked, and replace the cylinder block if the crack is not repairable.

### 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.

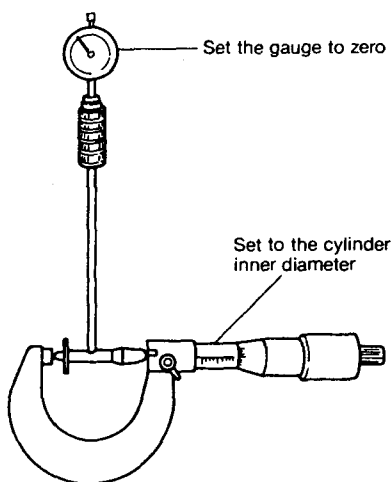
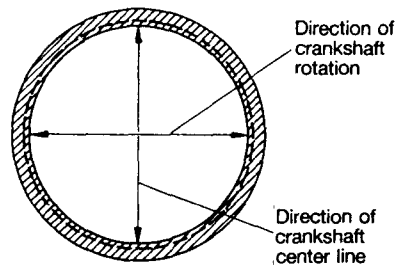
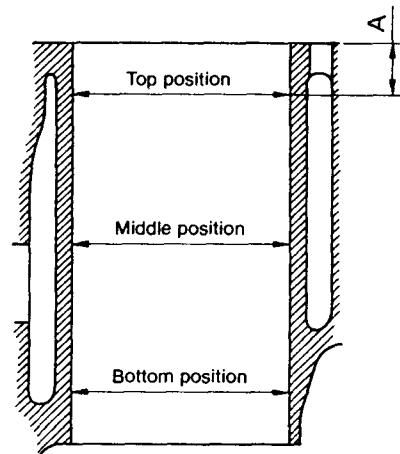
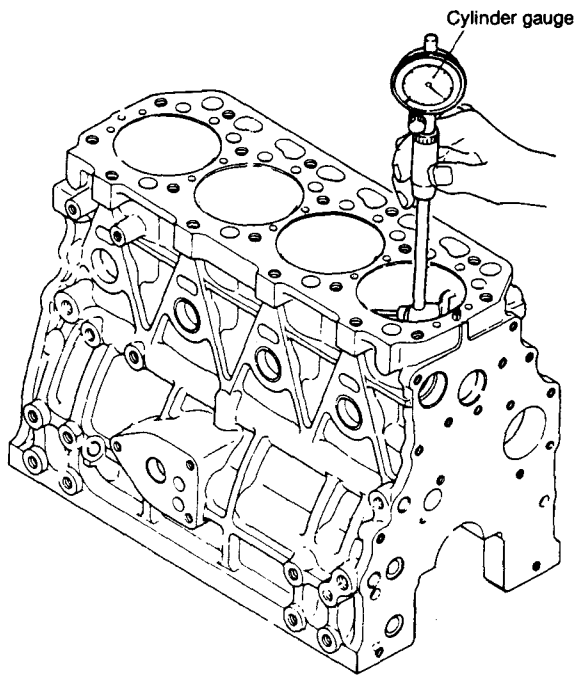
*Note: Be sure to read the instruction for the color kit before use.*

1. Cylinder Block

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.	<i>See separate service data</i>	
Cylinder roundness	<i>(Page 2-30, 31)</i>	



1. Cylinder Block

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

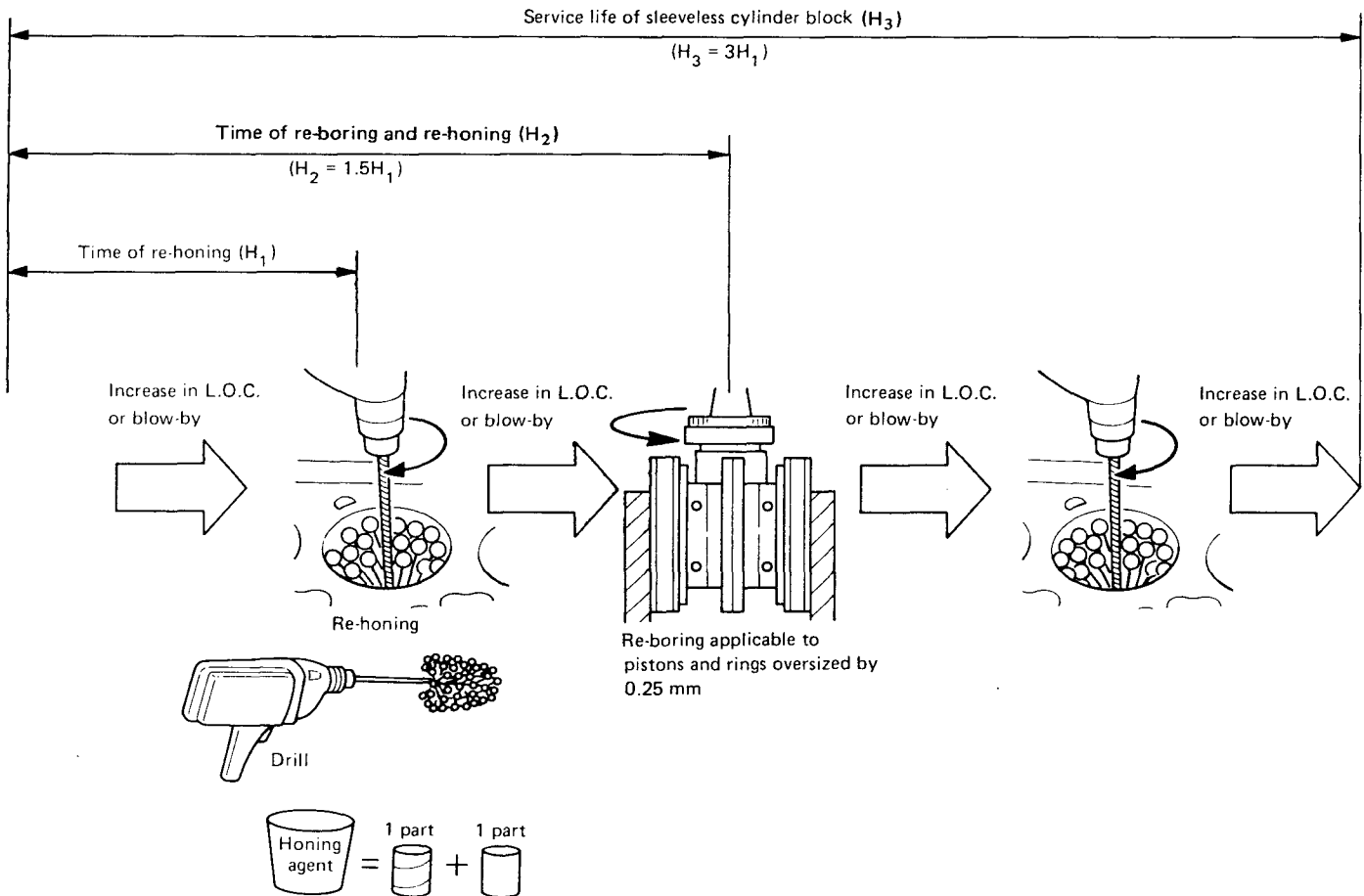
The conventional models of engine (T and TH Series) are equipped with wet liners or sleeves to the standard specification. Tests in Yanmar Laboratory have proven that the sleeveless engine is improved in wear resistance by about 20% as compared with the conventional T and TH Series engine, which have 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.

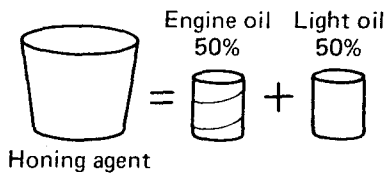
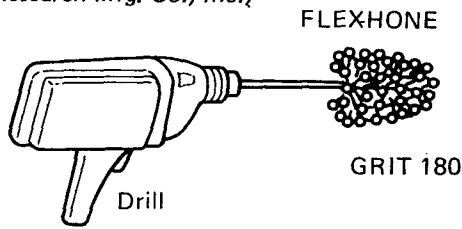
Overhaul of Cylinder



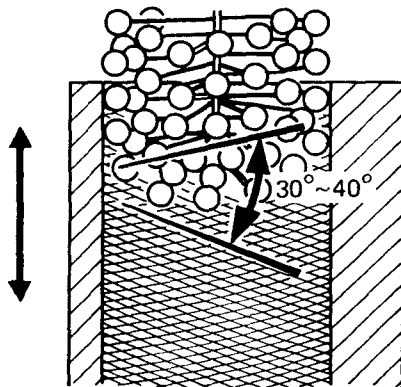
1. Cylinder Block

Rehoming 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.

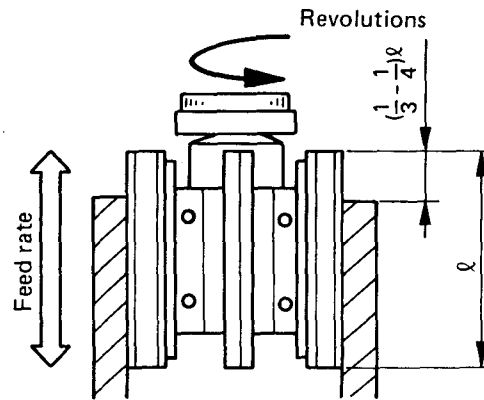


(2) How to re-bore the sleeveless cylinder.

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	250 - 290	
3TNC78E	250 - 290	
3,4TN82(T)E 3,4TN84(T)E	230 - 260	

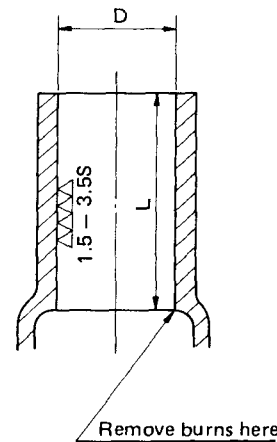
(The above table provides a cross hatch angle of 35° ± 5°)



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.

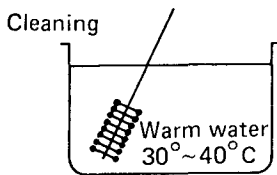
Finally bore the cylinder and hone to the cylinder inside diameter, D, in the following table.

	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 $\begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$	108.3
3TNA72E	72.22	72.25 $\begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$	122.7
3TN75E	75.22	75.25 $\begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$	138.7
3TNC78E	78.22	78.25 $\begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$	138.7
3,4TN82(T)E	82.22	82.25 $\begin{smallmatrix} +0.030 \\ 0 \end{smallmatrix}$	150.5
3,4TN84(T)E	84.22	84.25 $\begin{smallmatrix} +0.03 \\ 0 \end{smallmatrix}$	150.5

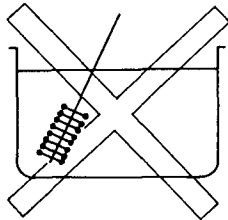


1-5.4 Handling of FLEX-HONE

- 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 petroleum-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. Never 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.



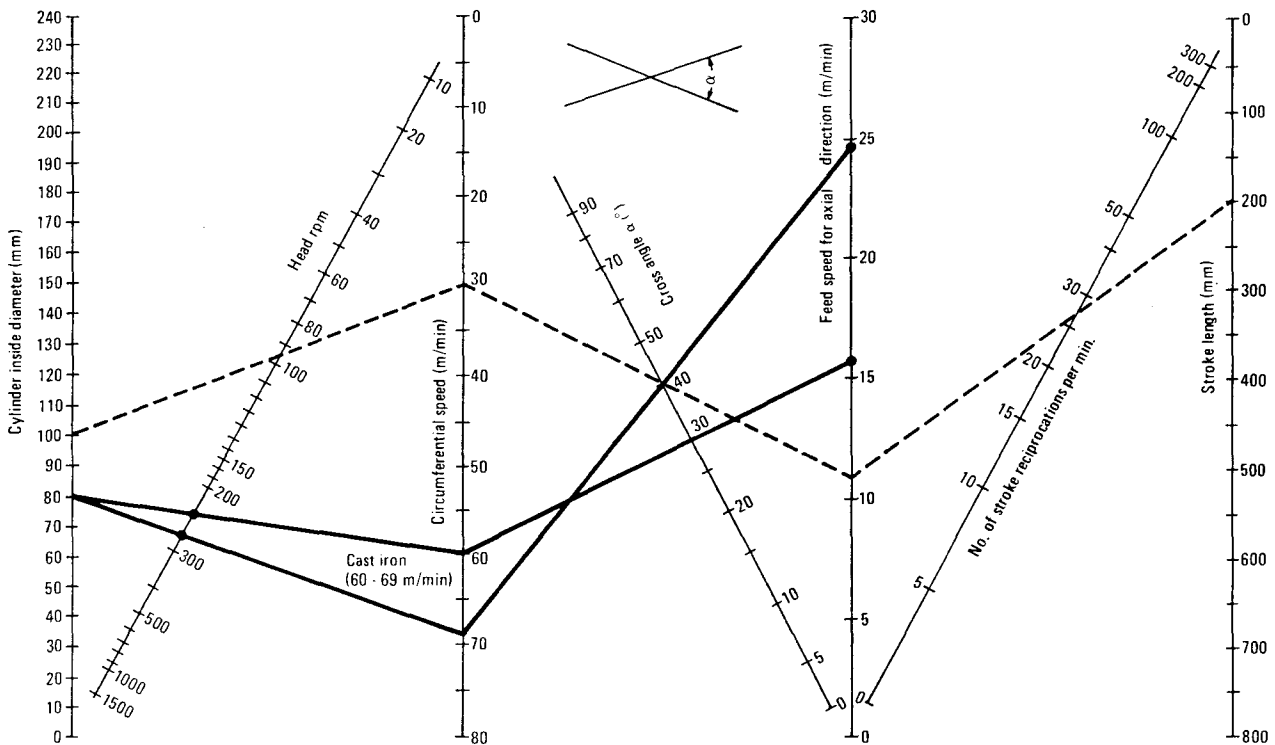
1-5.5 Calculation diagram for obtaining crosshatch angle

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:

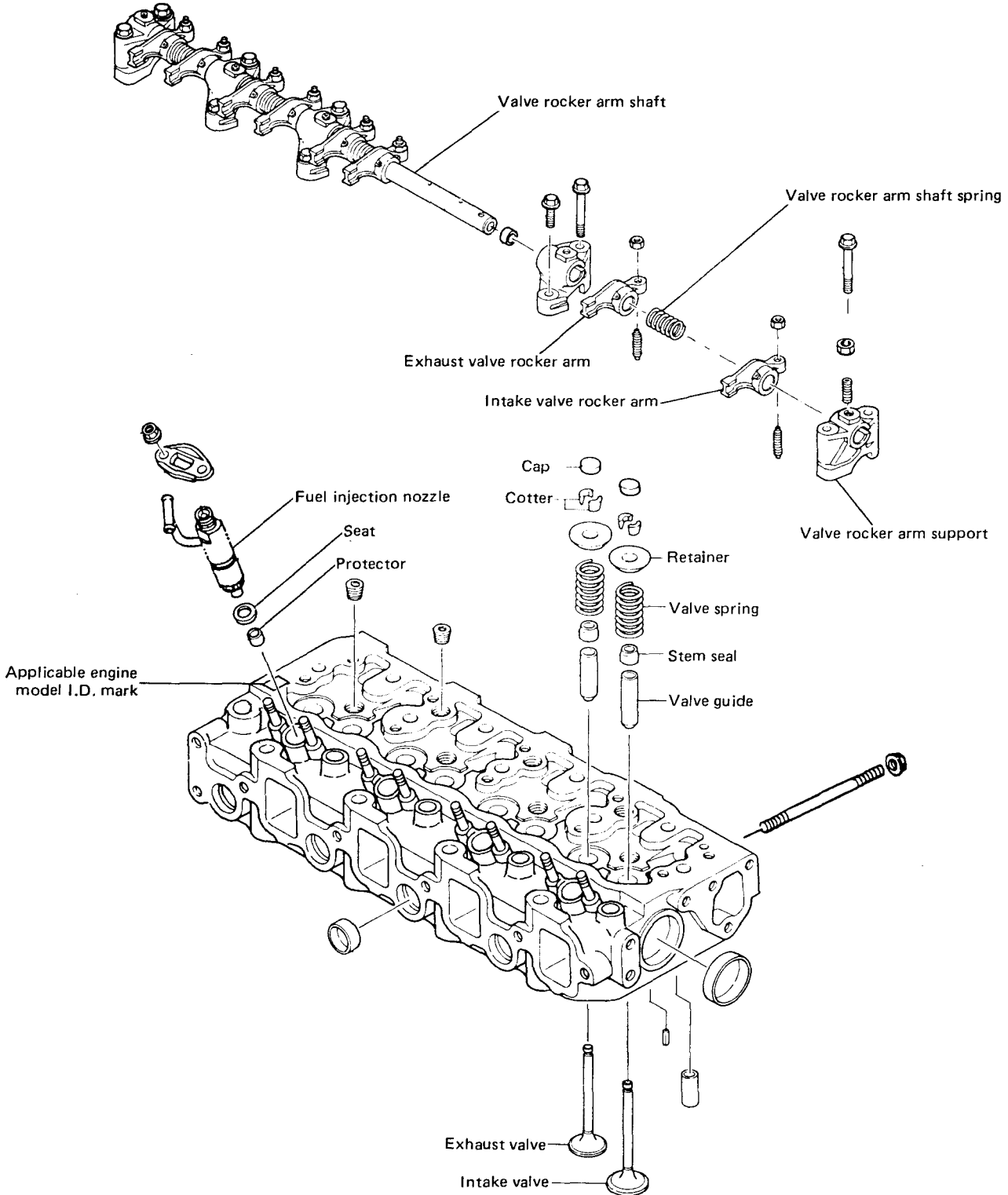
Refer to the parts catalogs.



## 2. Cylinder Head

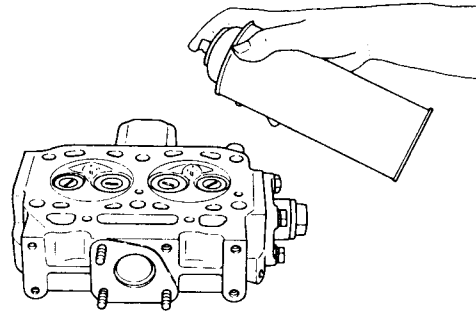
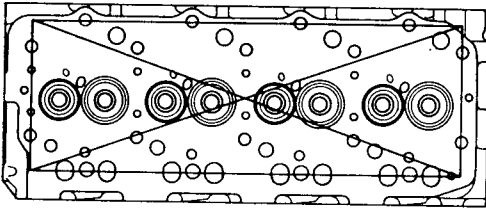
The cylinder head is 3- or 4-cylinder integral construction. The area between the intake port and exhaust port is cooled by a water jet.

**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.

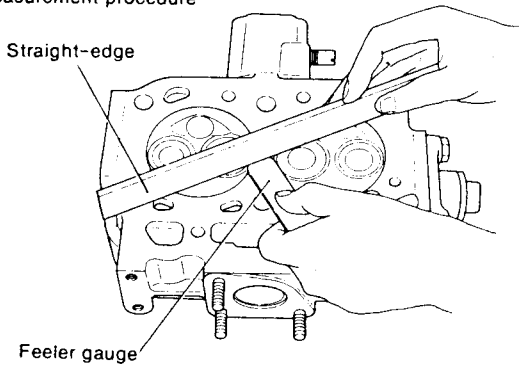


#### 2-1.1 Distortion of the combustion surface

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.

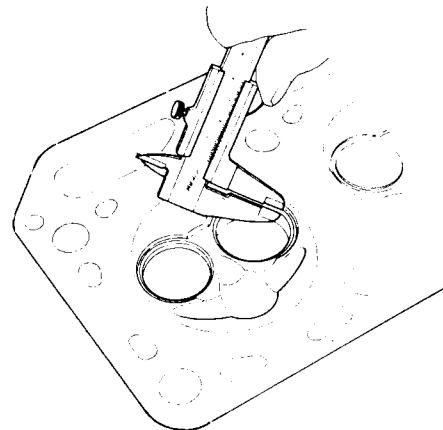
Measurement procedure



	mm (in.)	
	Standard	Wear limit
Cylinder head distortion	<i>See separate service data (Page 2-30, 31)</i>	

#### 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	<i>See separate service data (Page 2-30, 31)</i>	
Exhaust		

#### 2-1.2 Checking for cracks in the combustion surface

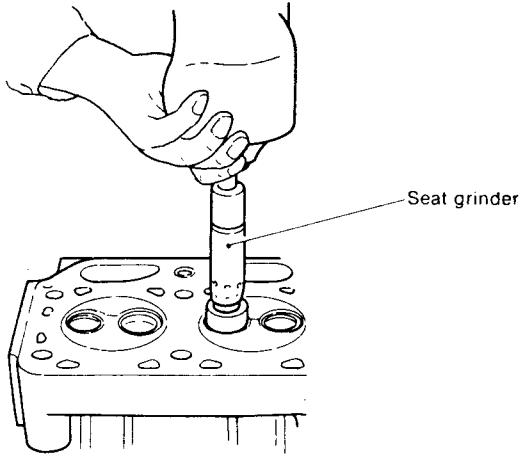
Remove the fuel injection nozzle, intake and exhaust valve and clean the combustion surface. Check for discoloration or distortion and conduct a color check test to check for any cracks.

2. Cylinder Head

2-2 Valve seat correction procedure

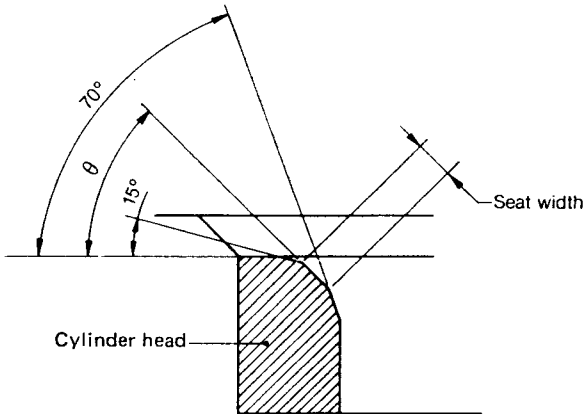
The most common method for correcting unevenness of the seat surface with a seat grinder is as follows:

- (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.

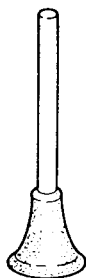


Seat grinder	Intake valve	30°
	Exhaust valve	45°

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.

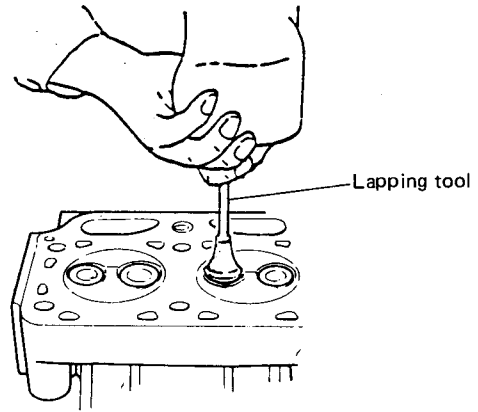


- (2) Knead valve compound with oil and finish the valve seat with a lapping tool.
- (3) Final finishing should be done with oil only.



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.

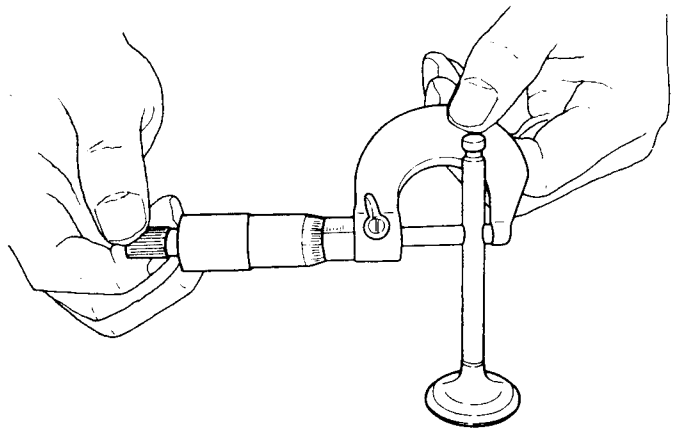
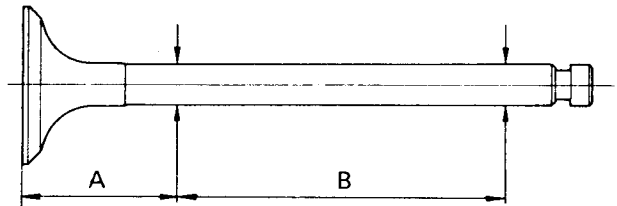


- NOTE: 1. Insert adjusting shims between the valve spring and cylinder head when seats have been re-finished with a seat grinder.
- 2. Measure valve distortion after valve seat re-finishing has been completed, and replace the valve and valve seat if it exceeds the tolerance.

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. Cylinder Head

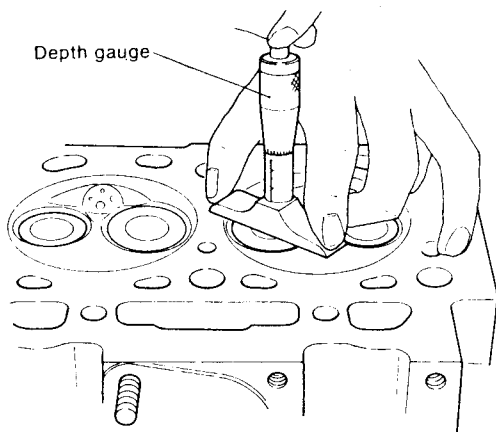
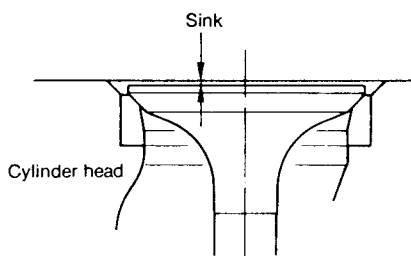
2-3.2 Inspection of valve seat wear and contact surface

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 diameters.*

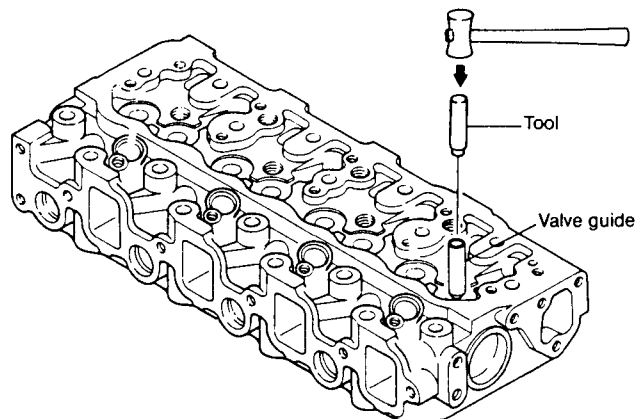
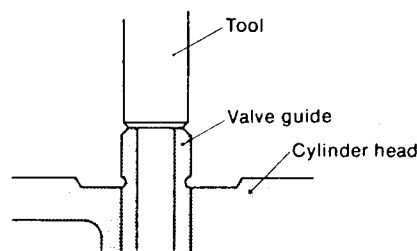
2-3.3 Valve sinking

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.



(2) Replacing the valve guide

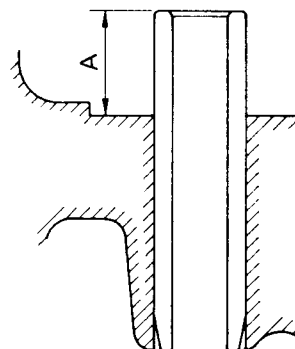
Use the insertion tool and tap in the guide with a mallet.



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)
--------------------------	--

	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		

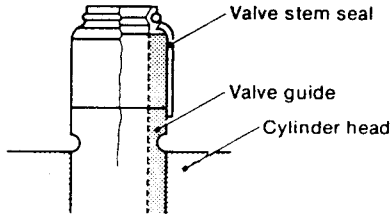
**NOTE:** The inner diameter standard dimensions assume a pressure fit.

2. Cylinder Head

(4) Valve stem seals

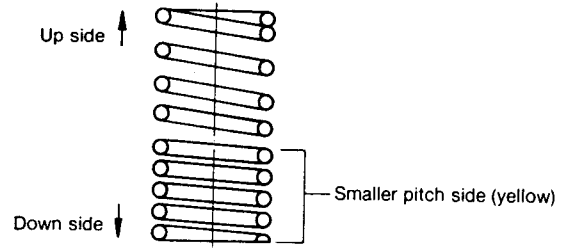
The valve stem seals in the intake/exhaust valve guides cannot be re-used once they are removed—be sure to replace them.

When assembling the intake/exhaust valves, apply an adequate amount of engine oil on the valve stem before inserting them.



(4) Assembling valve springs

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

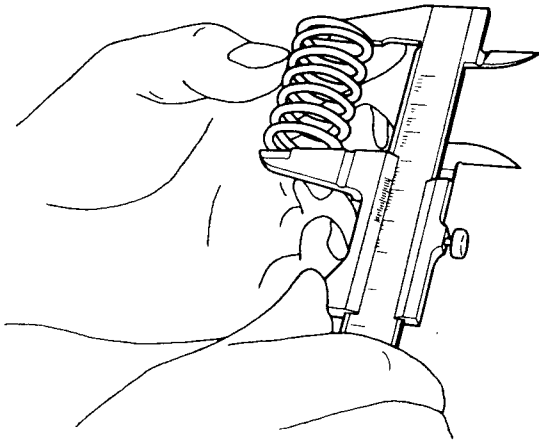


**NOTE:** The pitch of the valve spring is not even. The side with the smaller pitch (yellow) should face down (cylinder head) when assembled.

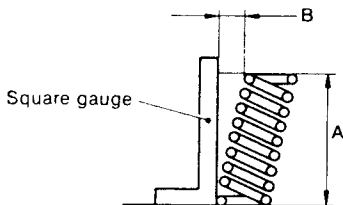
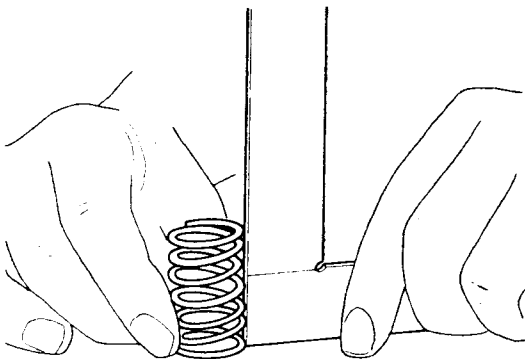
2-4 Valve springs

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.



(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.

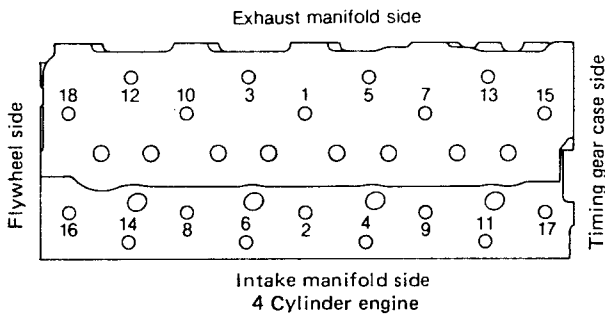
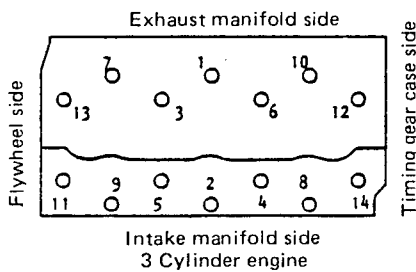
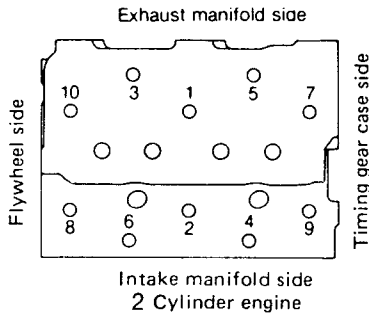


2. Cylinder Head

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.

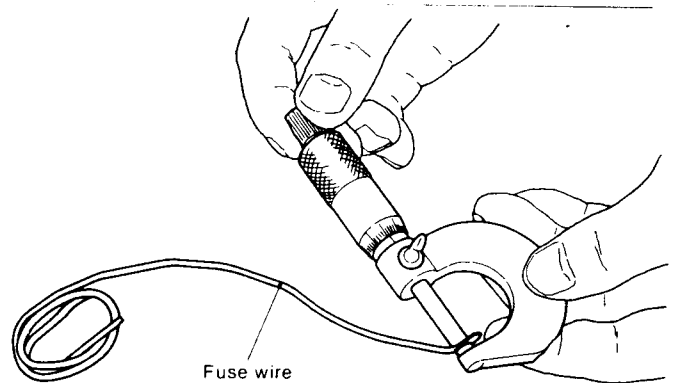


	kg·m (ft·lb)	
	First	Final
Tightening torque	<i>See separate service data</i> (Page 2-30, 31)	

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.

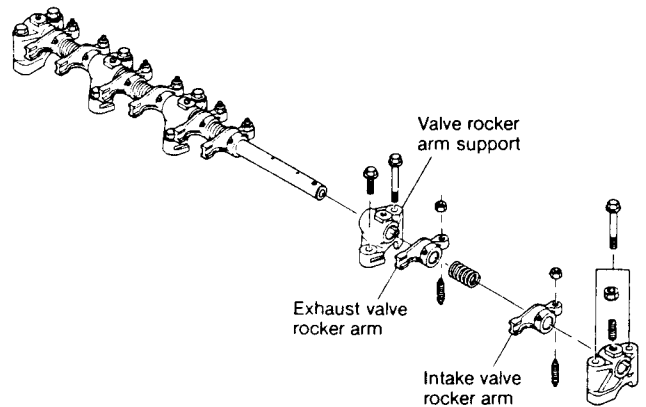
- (5) Measure the three positions where each fuse is broken and calculate the average.  
(0.71 ~ 0.75mm (0.0280 ~ 0.0295in.) is ideal)



mm (in.)	
Top clearance	<i>See separate service data</i> (Page 2-30, 31)

2-7 Intake and exhaust valve arms

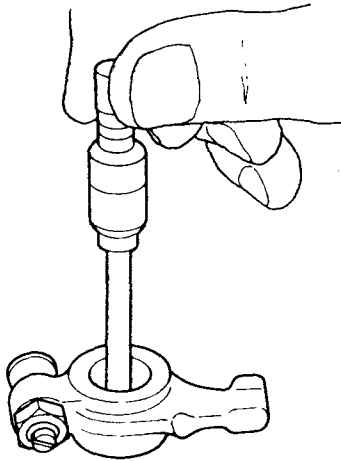
Valve arm and valve arm bushing wear may alter opening/closing timing of the valve, and may in turn affect engine performance according to the extent of the change.



2. Cylinder Head

(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.	<i>See separate service data (Page 2-30, 31)</i>	
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

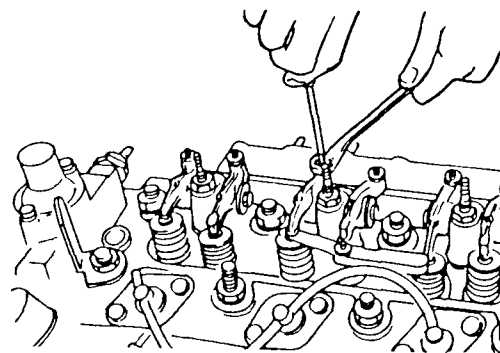
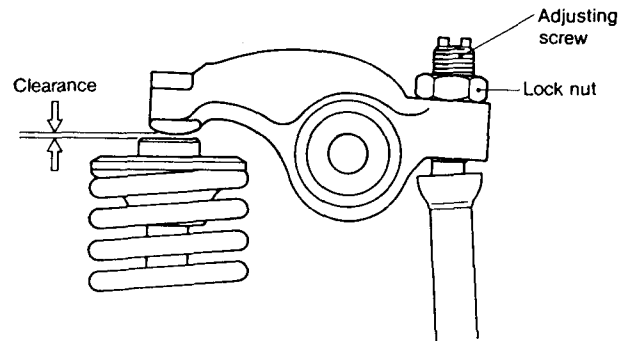
Inspect the contact surface of the valve arm and replace it if there is abnormal wear or flaking.

(4) Inspect the contact surface of the valve clearance adjustment screw and push rod and replace if there is abnormal wear or flaking.

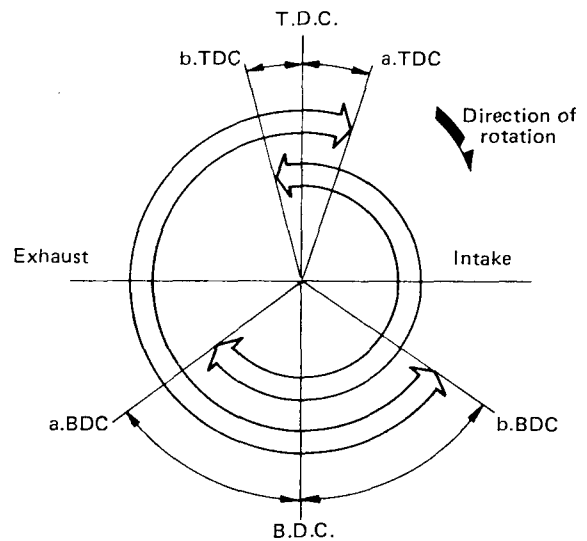
2-8 Adjustment of valve head clearance

(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	<i>See separate service data (Page 2-30, 31)</i>
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	○	○	×	×
	M	×	○	○	×
	S	×	×	○	○

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

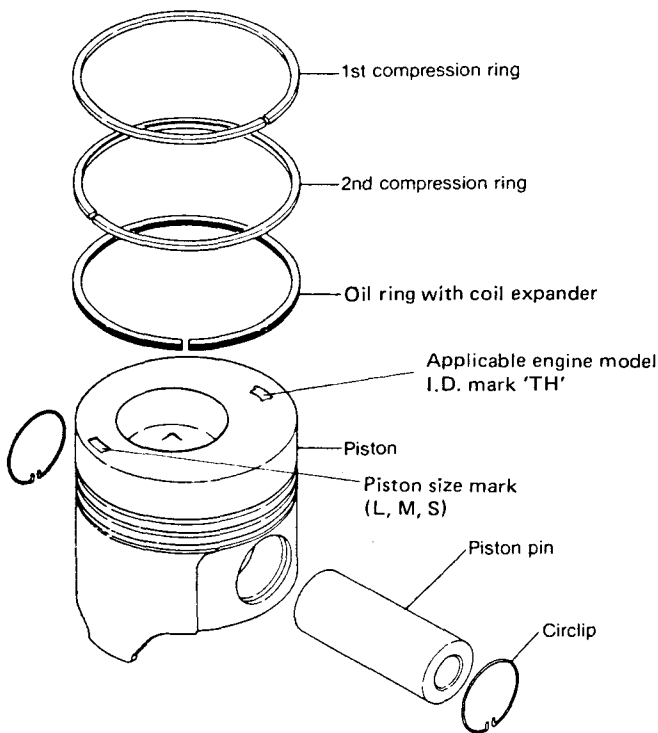
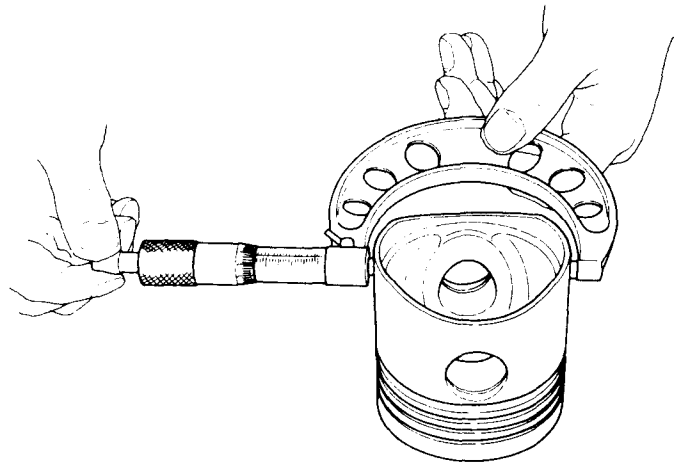
### 3-1 Piston

#### 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.

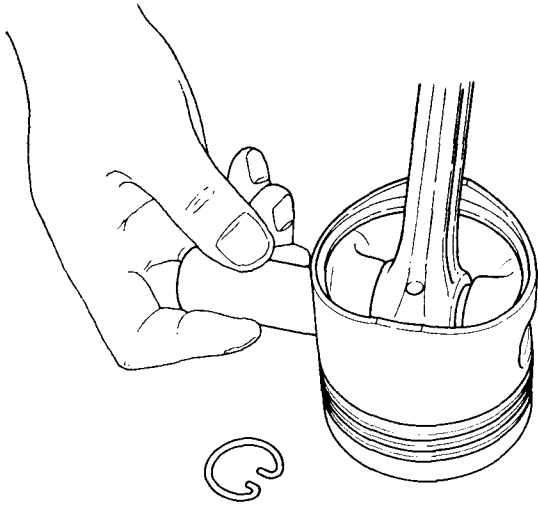


mm (in.)	
Standard	Wear limit
<i>See separate service data (Page 2-32, 33)</i>	

3. Piston and Piston Pins

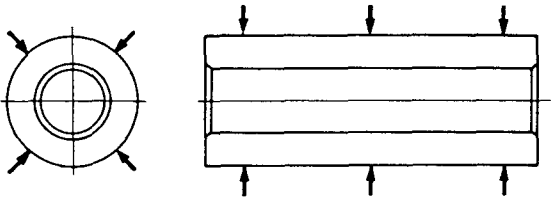
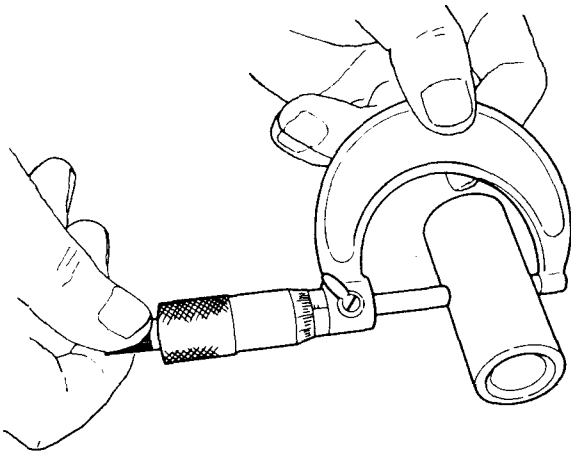
3-1.3 Replacing the piston

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

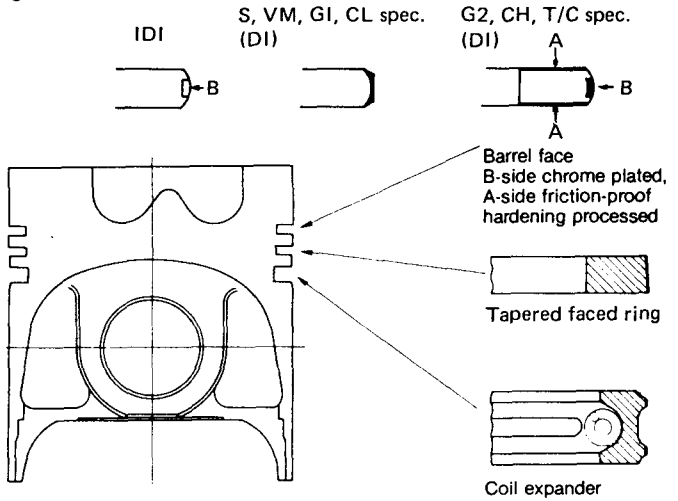
Measure the outer diameter and replace the pin if it is excessively worn.



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

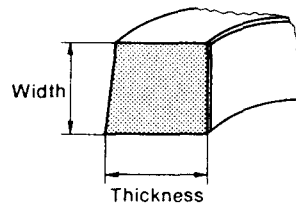
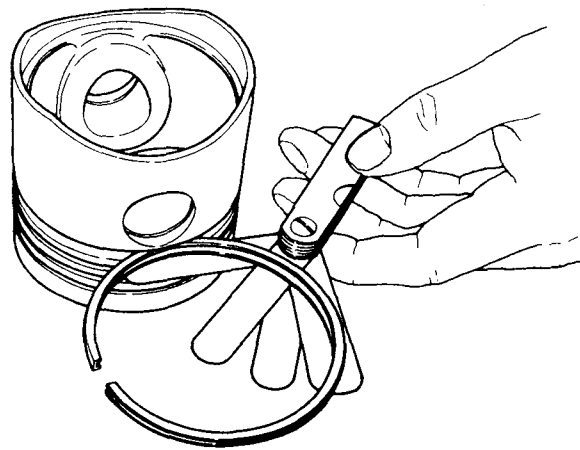
3-3 Piston rings

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

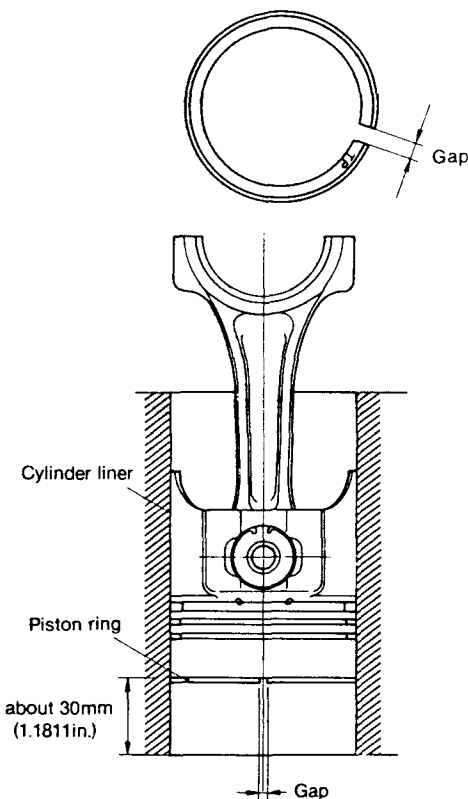
Measure the thickness and width of the rings, and the ring-to-groove clearance after installation. Replace if wear exceeds the limit.



		mm (in.)	
		Standard	Wear limit
First piston ring	Groove width	<i>See separate service data (Page 2-32, 33)</i>	
	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

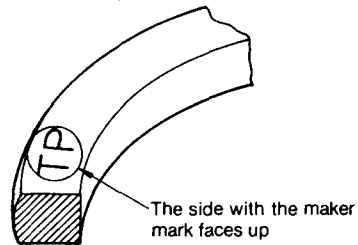
Press the piston ring onto a cylinder and measure the piston ring gap with a gauge.  
Press on the ring about 30 mm (1.1811 in.) from the bottom of the cylinder.



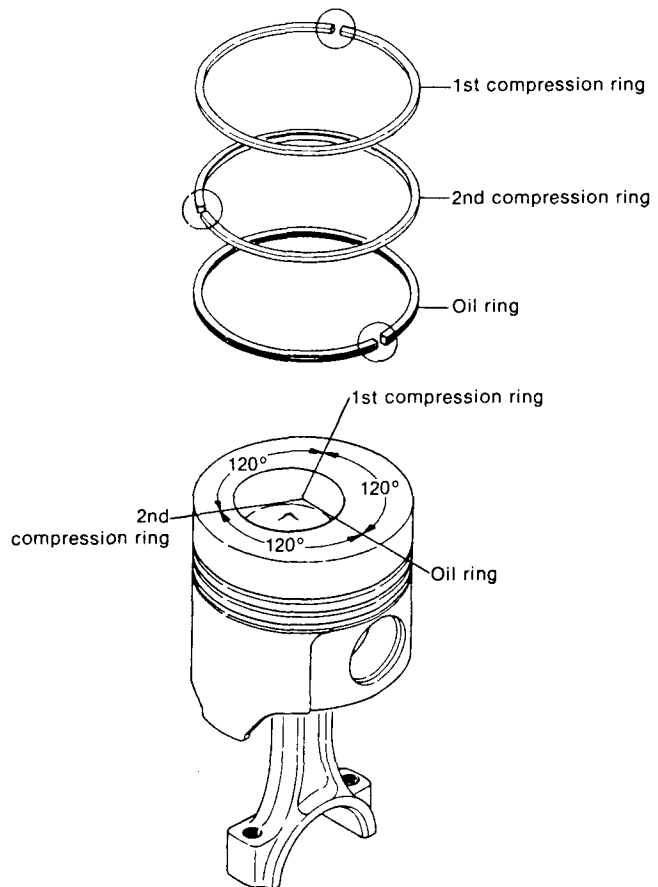
		mm (in.)	
		Standard	Wear limit
First piston ring gap	<i>See separate service data (Page 2-32, 33)</i>		
Second piston ring gap			
Oil ring gap			

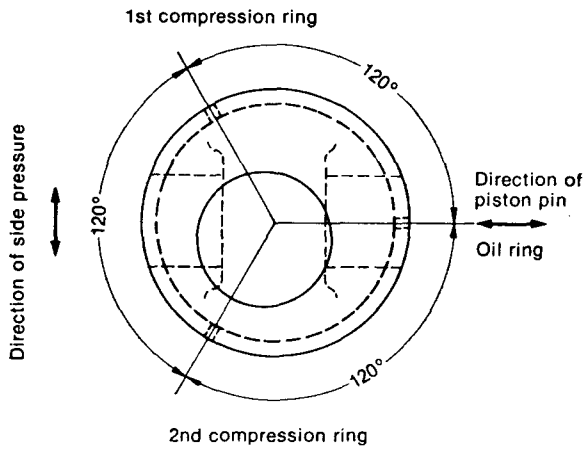
### 3-3.3 Replacing the piston rings

- (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.

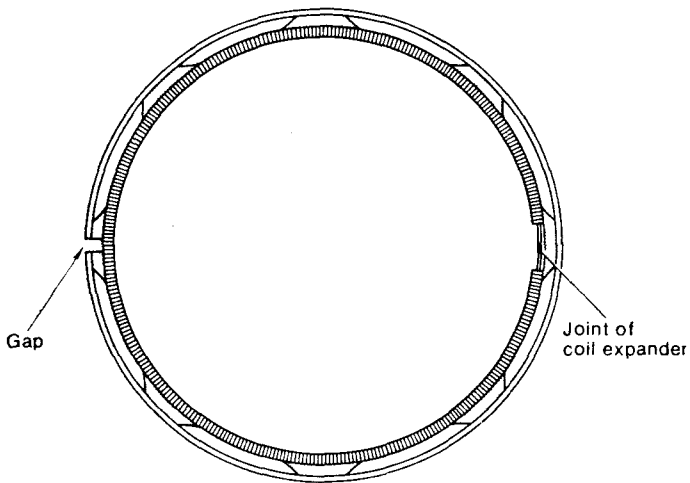


- (3) After fitting the piston ring, make sure it moves easily and smoothly.
- (4) Stagger the piston rings at 120° intervals, making sure none of them line up with the piston.





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

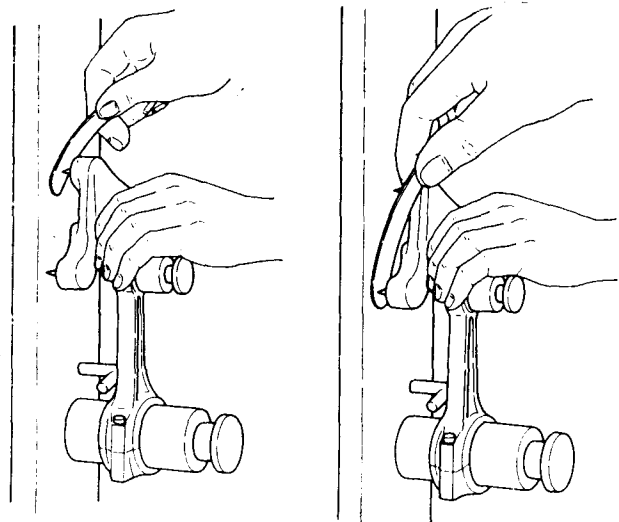
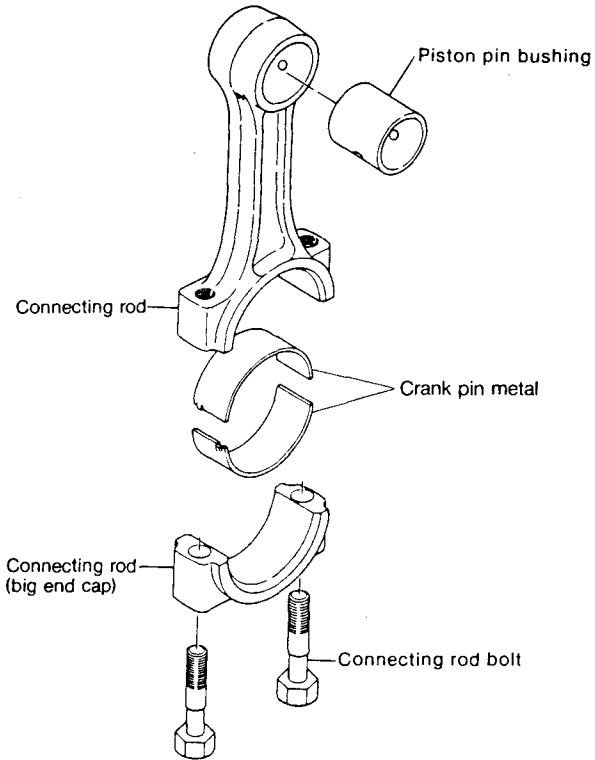


4. Connecting Rod

# 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.

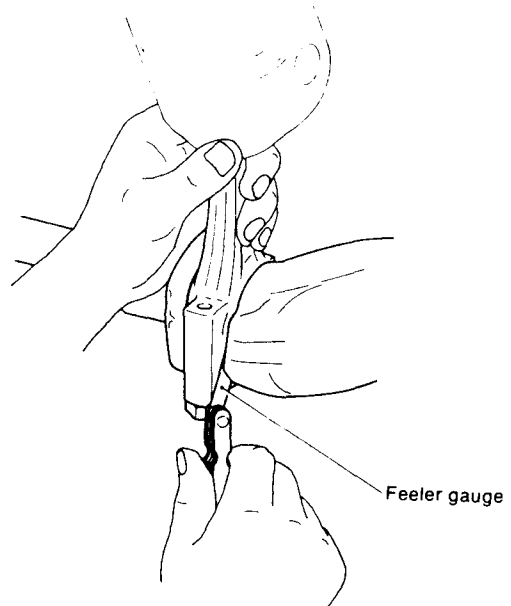


Measuring twist

	mm (in.)	
	Standard	Wear limit
Connecting rod twist and parallelity	<i>See separate service data (Page 2-32, 33)</i>	

### 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.

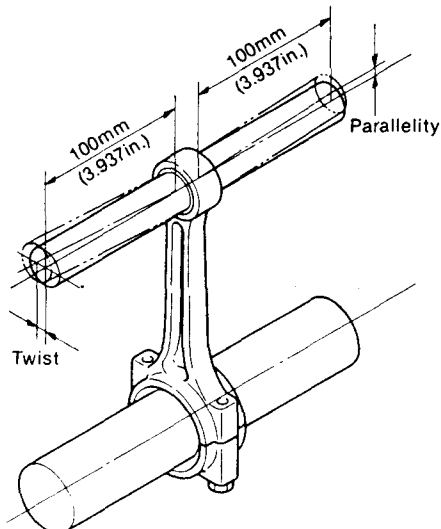


	mm (in.)	
	Standard	Wear limit
Connecting rod side clearance	<i>See separate service data (Page 2-32, 33)</i>	

### 4-1 Inspecting the connection rod

#### 4-1.1 Twist 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.



4. Connecting Rod

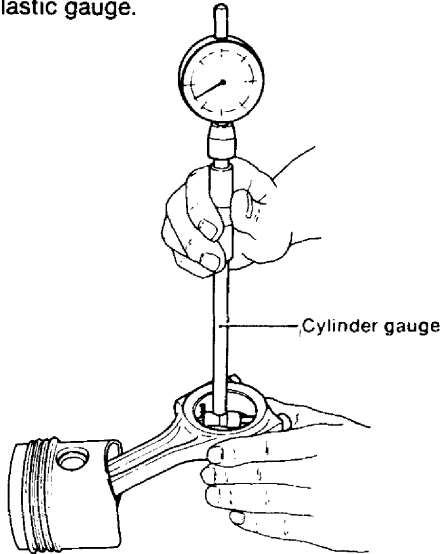
4-2 Crank pin bushing

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.

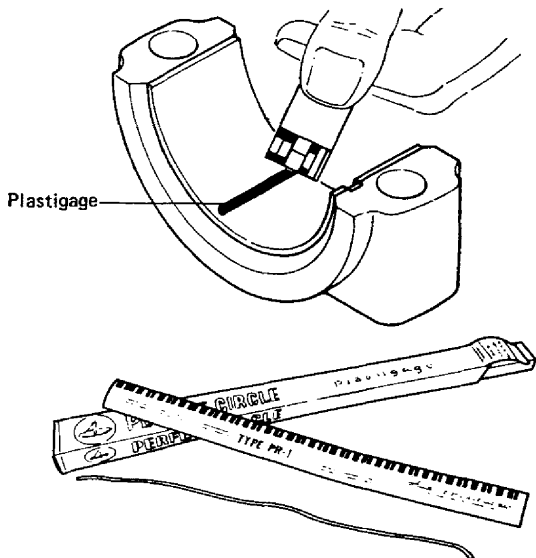


Procedure

- (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).

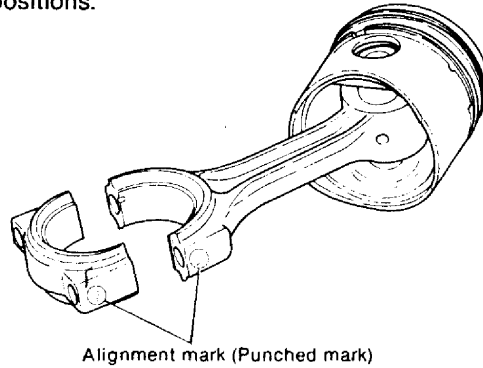
Connecting rod tightening torque	See separate service data (Page 2-32, 33)
----------------------------------	---

- (3) Remove the connecting rod and measure the broken plastigage with measuring scale. (Plastigage)



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.

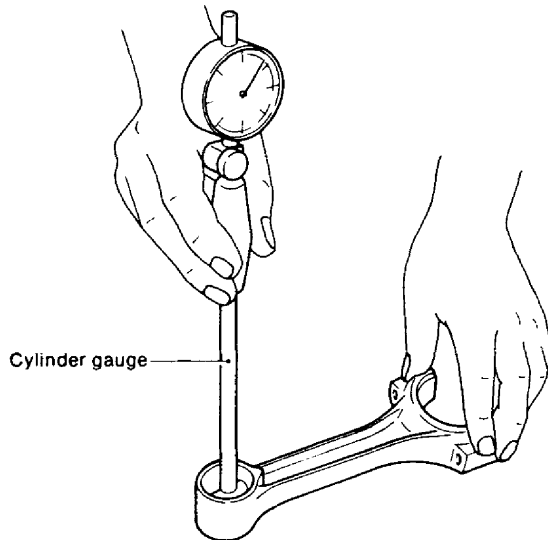


- (4) Make sure there is no sand, metal cuttings or other foreign matter in the lube oil, and that the crankshaft is not scratched. Take special care in cleaning the oil holes.

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.



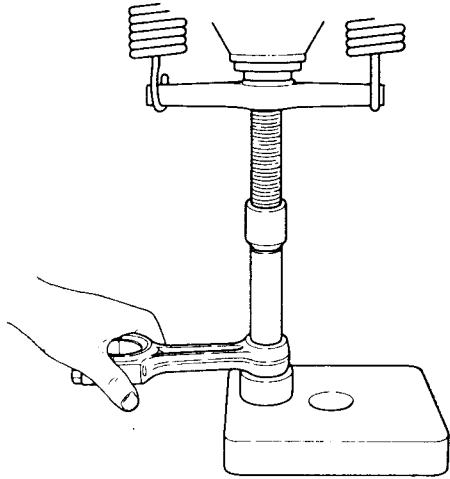


4. Connecting Rod

	mm (in.)	
	Standard	Wear limit
Piston pin bushing inside dia.	<i>See separate service data (Page 2-32, 33)</i>	
Piston pin and bushing oil clearance		

(2) Replacing piston pin bushing

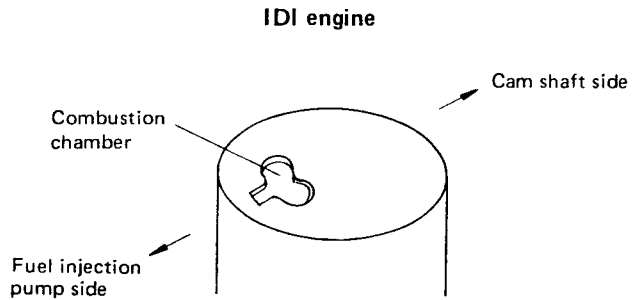
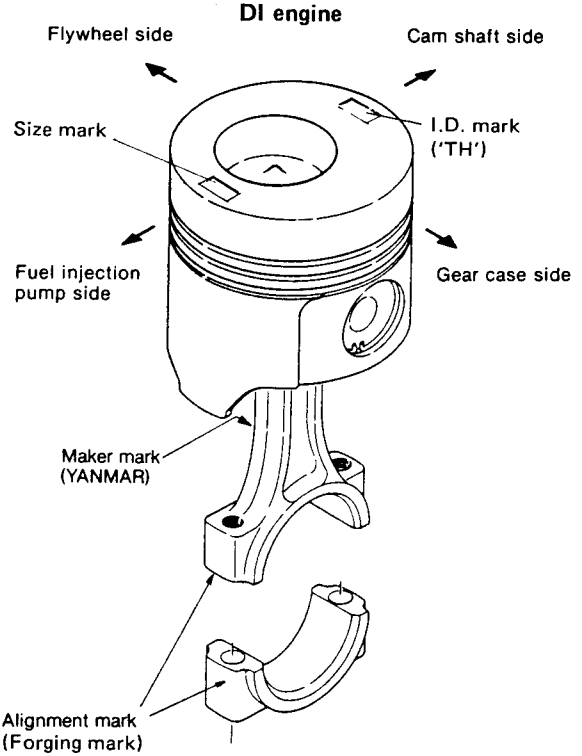
1) When the bushing for the connecting rod piston pin is either worn out or damaged, replace it by using the "piston pin extracting tool" installed on a press.



**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

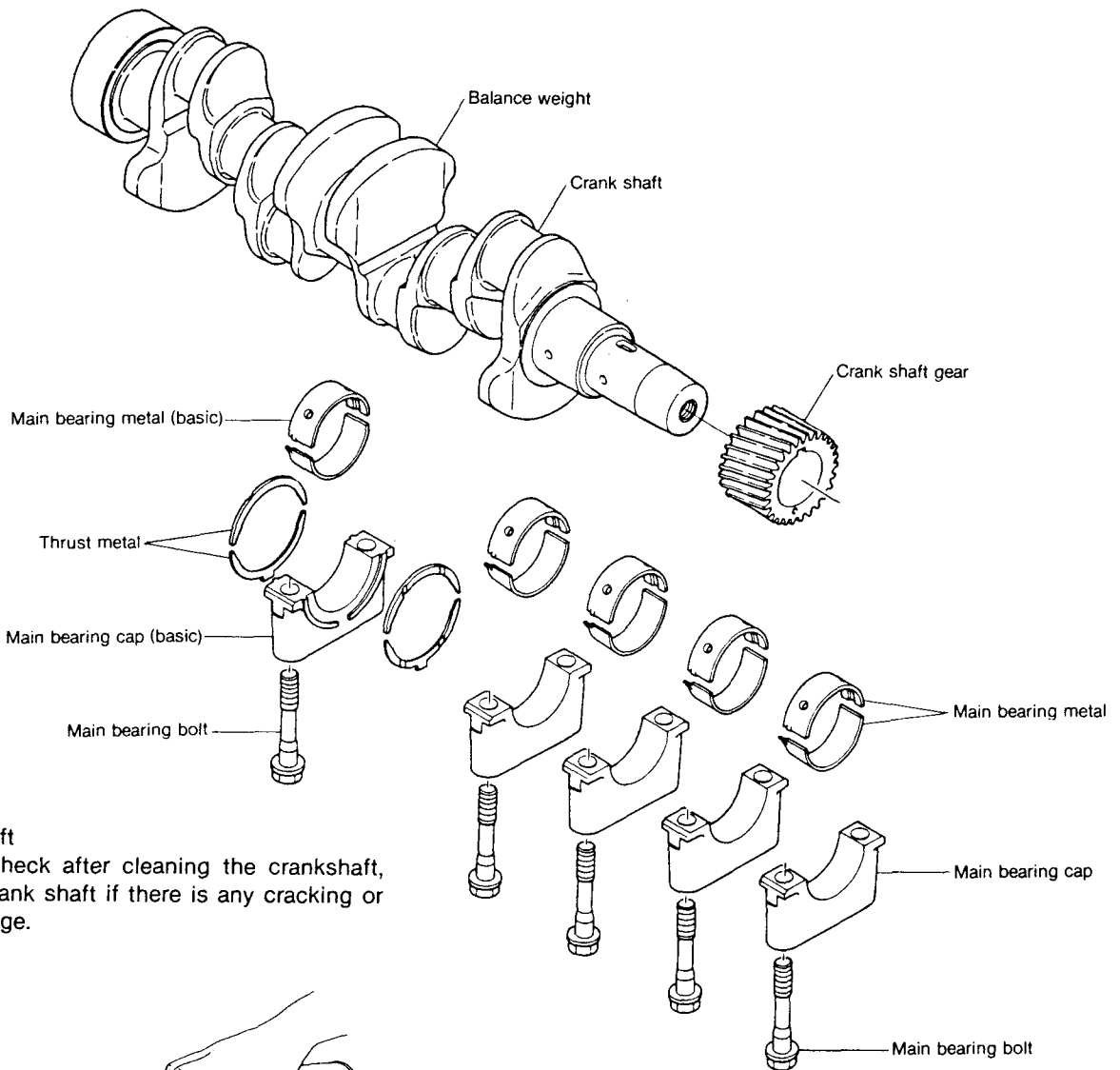
The piston and connecting rod should be assembled so that the match mark on the connecting rod large end faces the fuel injection pump side and the combustion chamber above the piston is close to the fuel injection pump.



# 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

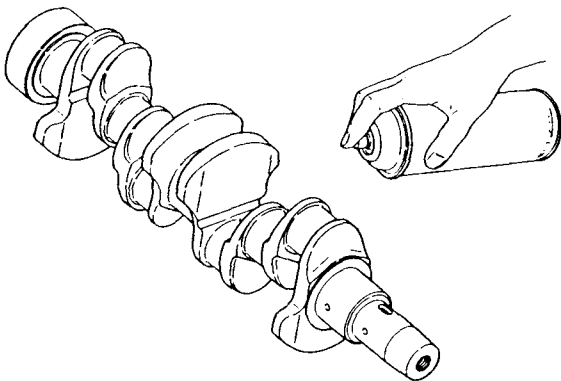
the upper metal (cylinder block side) provided with an oil groove, and with no oil groove on the lower metal (bearing cap side). The bearing cap (location cap) of the flywheel side has a thrust metal which supports the thrust load.



## 5-1 Crankshaft

### (1) Color check of shaft

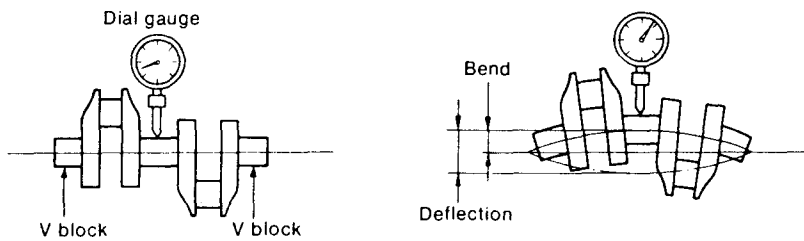
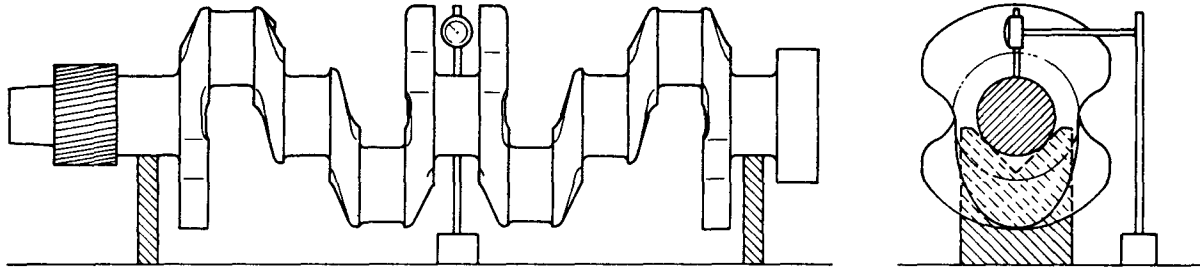
Perform a color check after cleaning the crankshaft, and replace the crank shaft if there is any cracking or considerable damage.



5. Crankshaft and Main Bearing

(2) Bending of the crankshaft

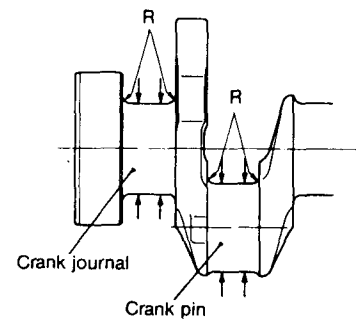
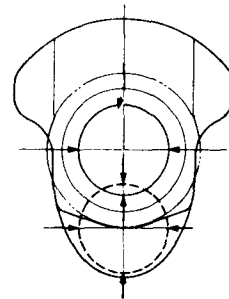
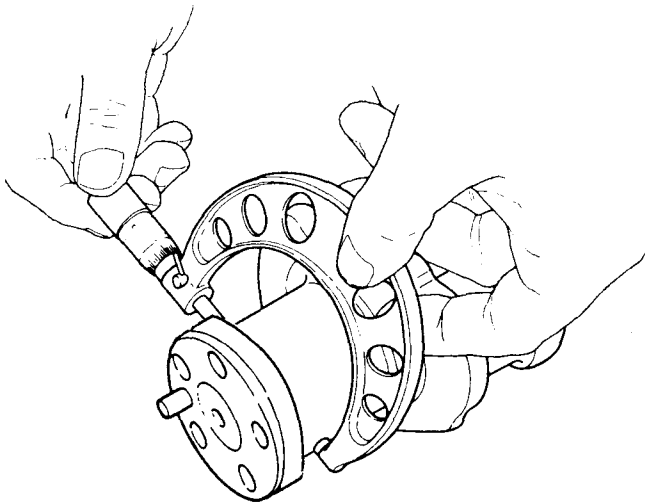
Support the crankshaft with V-blocks at both ends of the journals. Measure the deflection of the center journal with a dial gauge while rotating the crankshaft to check the extent of crankshaft bending.



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.	<i>See separate service data (Page 2-32, 33, 34, 35)</i>	
	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			

5. Crankshaft and Main Bearing

(4) Checking side clearance of the crankshaft

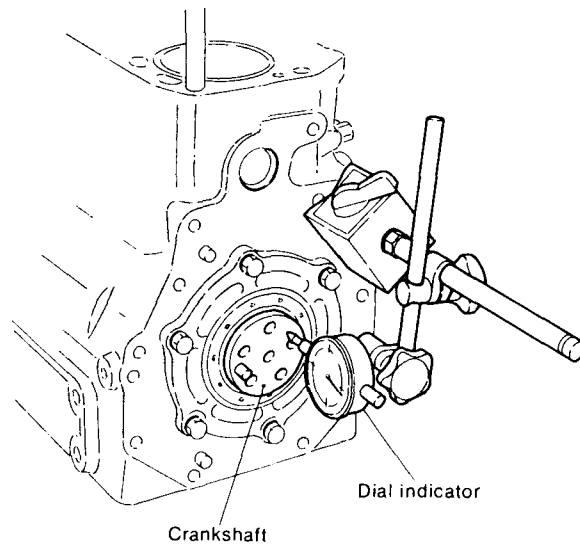
After assembling the crankshaft, tighten the main bearing cap to the specified torque, and move the crankshaft to one side, placing a dial gauge on one end of the shaft to measure thrust clearance.

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.

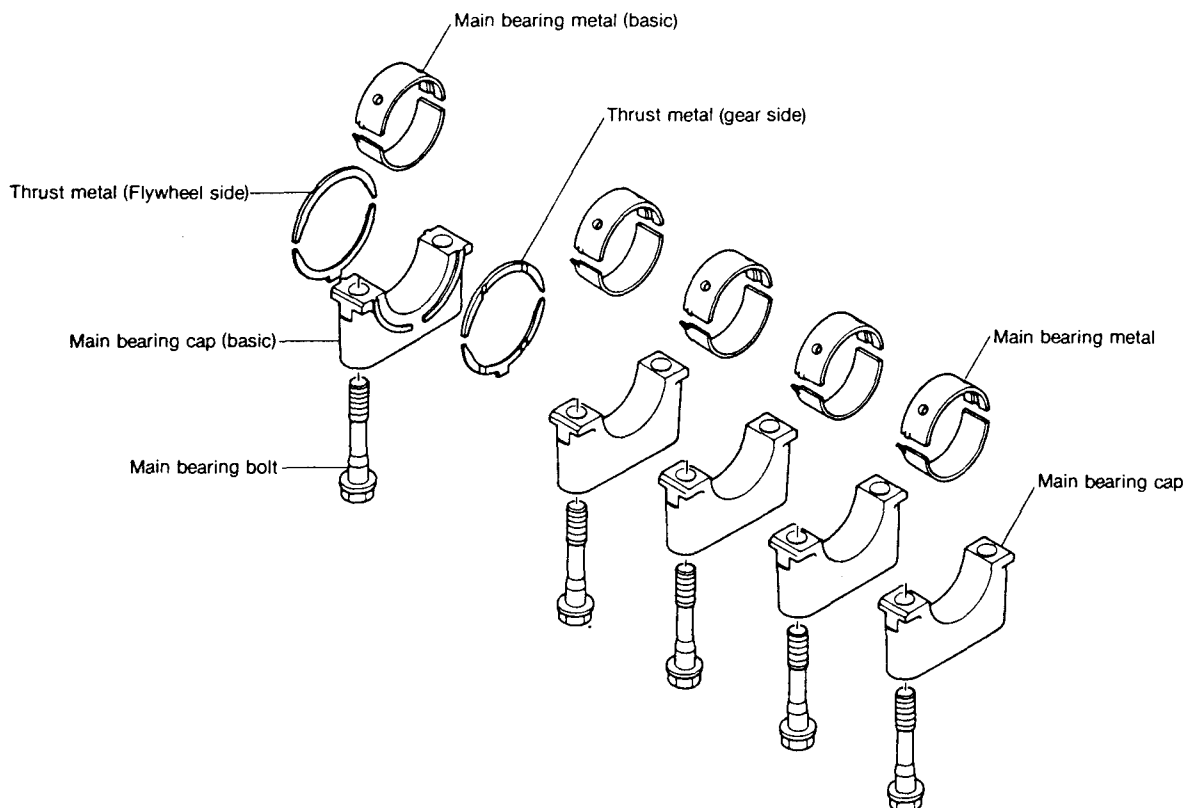
(2) Measuring the inner diameter of metal

Tighten the cap to the specified torque and measure the inner diameter of the metal.

**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.

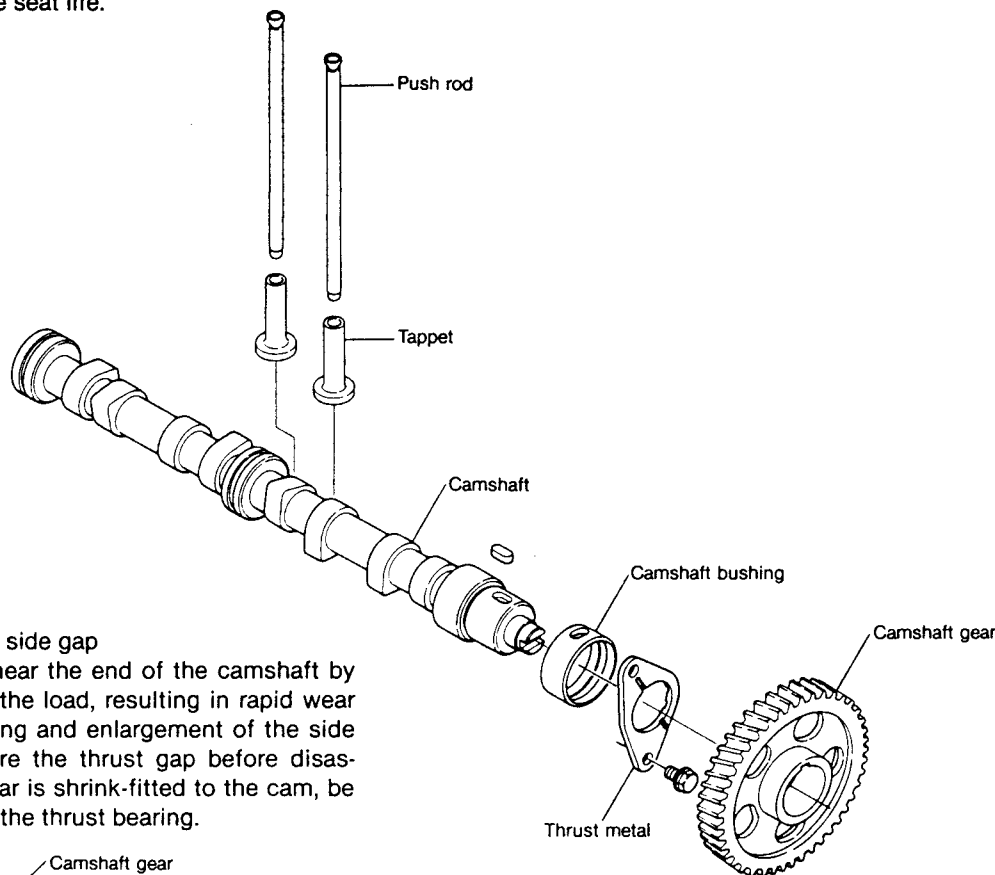
Bearing cap bolt tightening torque	See separate service data (Page 2-34, 35)
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# 6. Camshaft and Tappets

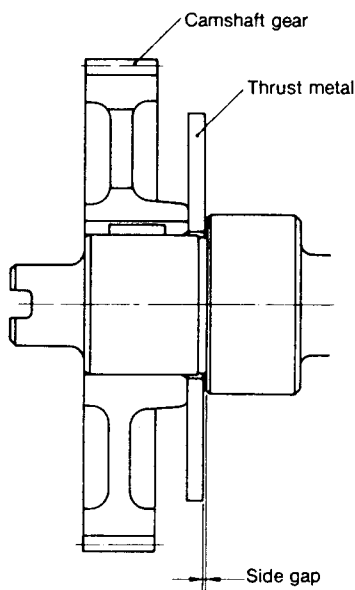
## 6-1 Camshaft

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.

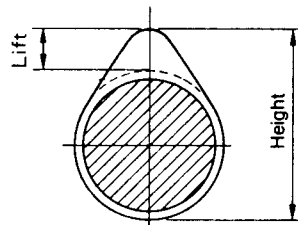


**(1) Checking the camshaft side gap**

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.



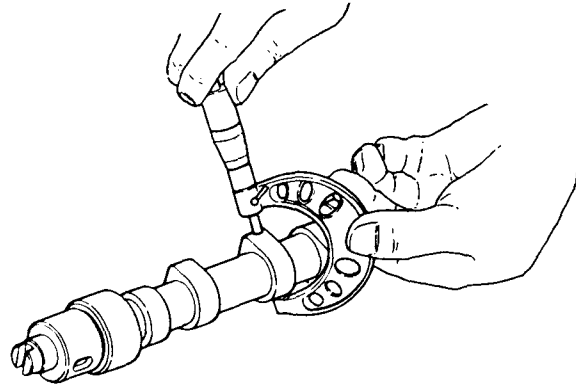
**(2) Measure the camshaft height, and replace the cam if it is worn beyond the limit.**



mm (in.)		
Camshaft height	Standard	Wear limit
Intake cam	<i>See separate service data (Page 2-34, 35)</i>	
Exhaust cam		

mm (in.)		
	Standard	Wear limit
Camshaft side gap	<i>See separate service data (Page 2-34, 35)</i>	

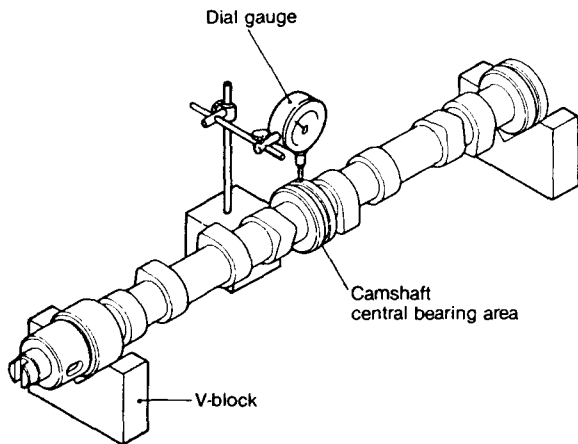
- (3) Measure the camshaft outer diameter and the camshaft bearing inner diameter. Replace if they exceed the wear limit or are damaged.



mm (in.)

	Standard			Wear limit
	Gear case side	Intermediate	Flywheel side	
Camshaft journal outside dia.	<i>See separate service data (Page 2-34, 35)</i>			
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.



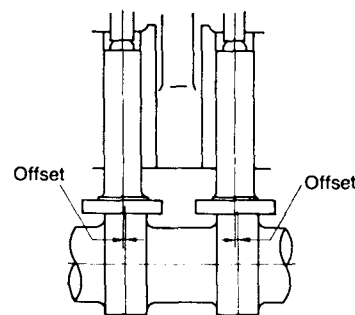
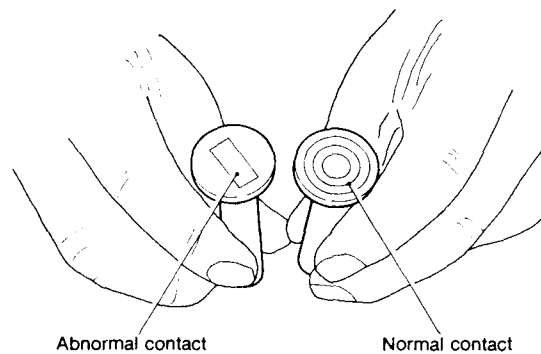
**NOTE:** The reading on the dial gauge is divided by two to obtain the extent of bending.

	Wear limit
Camshaft deflection	<i>See separate service data (Page 2-34, 35)</i>

mm (in.)

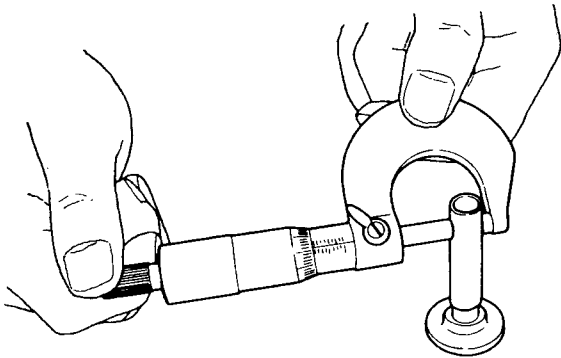
### 6-2 Tappets

- (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.



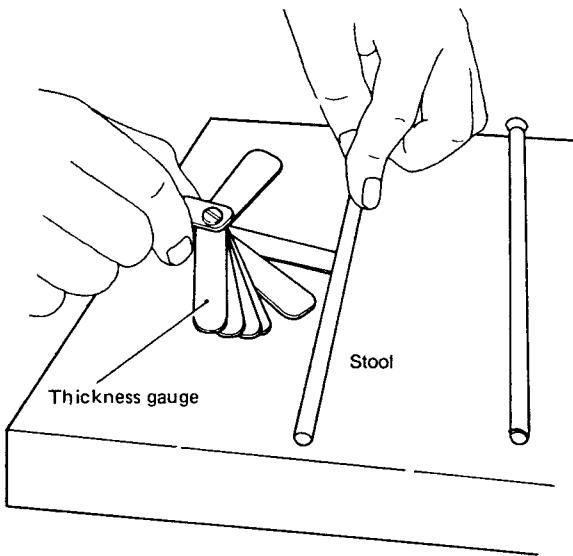
**NOTE:** When removing tappets, be sure to keep them separate for each cylinder and intake/exhaust valve.

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



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

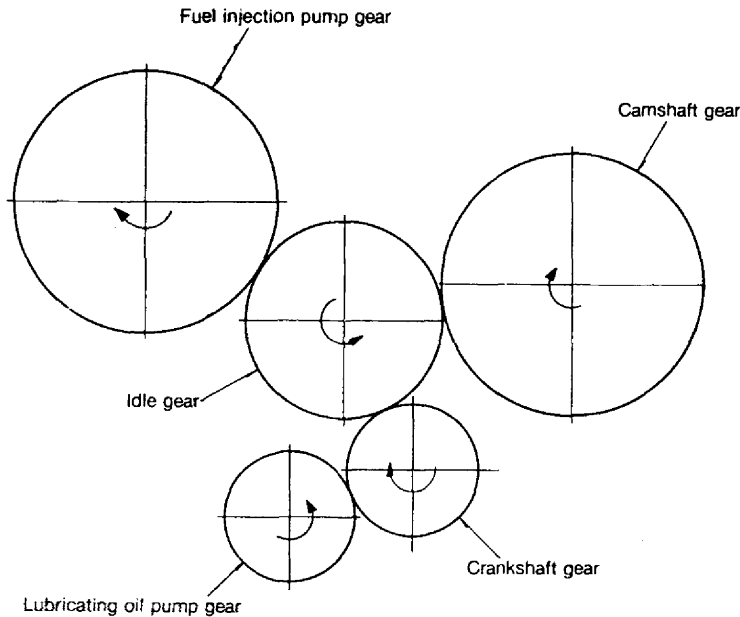
(3) Measuring push rods.  
Measure the length and bending of the push rods.



	mm (in.)	
	Standard	Wear limit
Push rod length	<i>See separate service data (Page 2-34, 35)</i>	
Push rod bend		
Push rod dia.		

# 7. Timing Gear

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



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

mm (in.)

## 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.

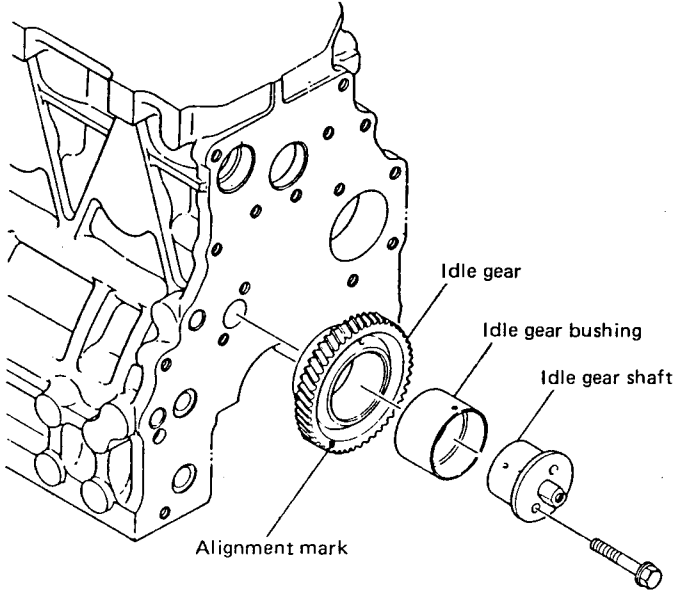
### (3) Idling gear

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.

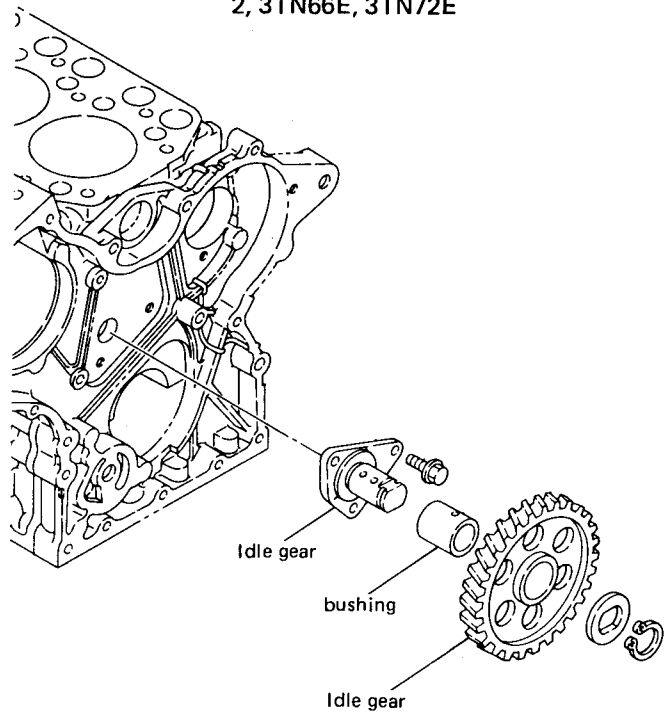
**NOTE:** If backlash is excessive, it will not only result in excessive noise and gear damage, but also lead to bad valve and fuel injection timing and a decrease in engine performance.



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



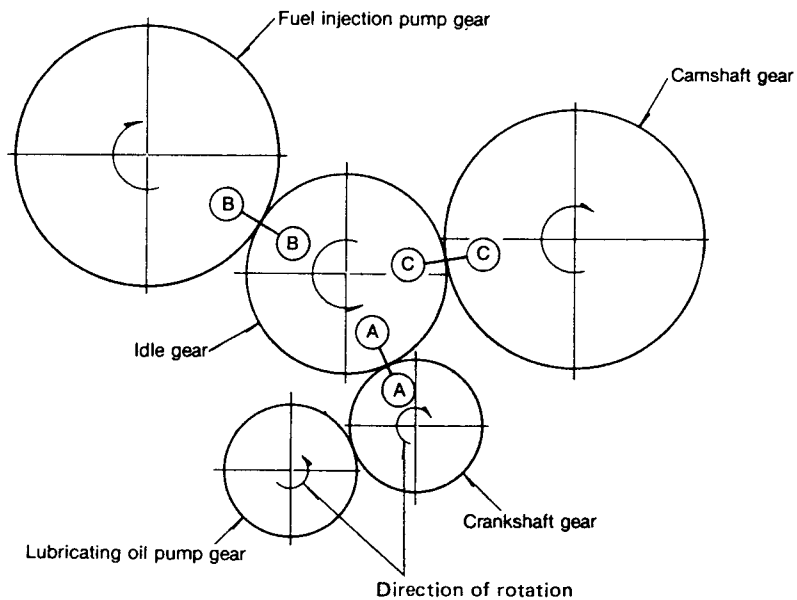
2, 3TN66E, 3TN72E



	mm (in.)	
	Standard	Wear limit
Idle shaft dia.	<i>See separate service data (Page 2-34, 35)</i>	
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).

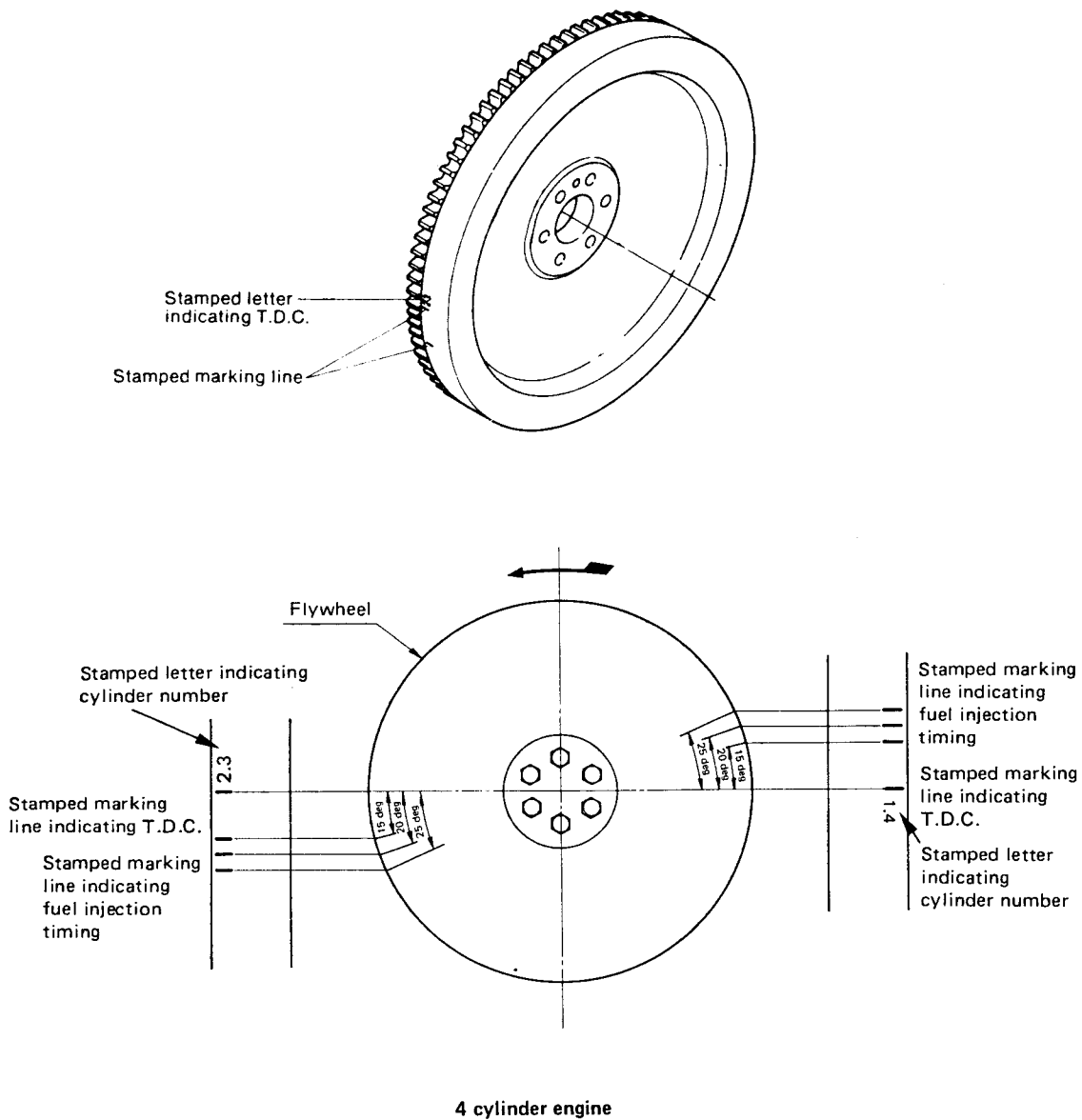


# 8. Flywheel

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.

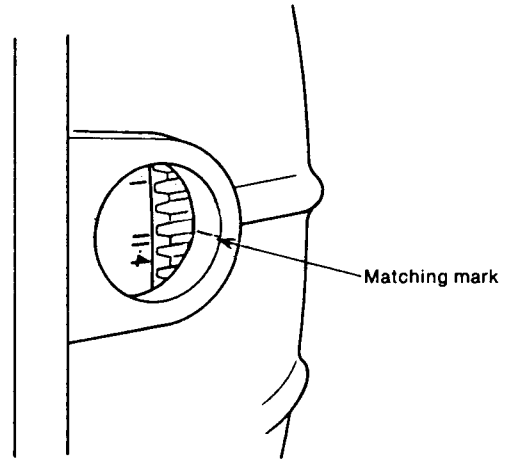
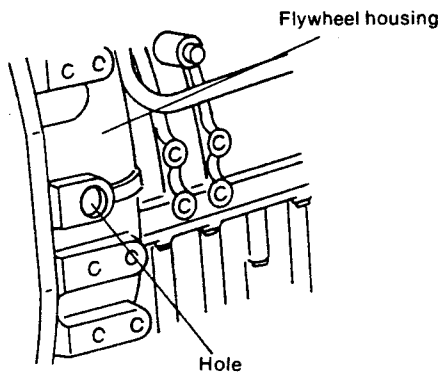
## 8-1 Position of top dead center and fuel injection timing

### (1) Marking



8. Flywheel

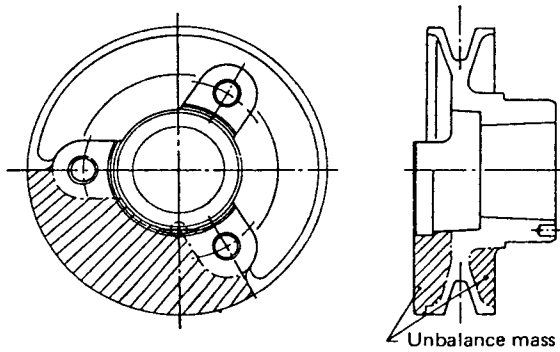
(2) Matching mark



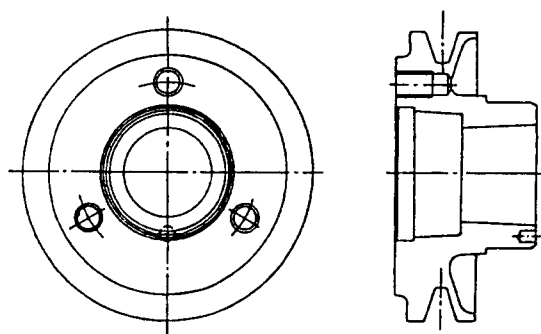
The matching mark is made at the hole of the flywheel housing.

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	Sear 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 roundness	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) $\theta$	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 tighten- ing torque (Tighten sepa- rately 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	–	

## 9. Service Data

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 roundness	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) $\theta$	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 tighten- ing torque (Tighten sepa- rately 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	–	

## 9. Service Data

Item	Unit	2,3TN66E		3TNA72E		3TN75E		
		Standard	Wear limit	Standard	Wear limit	Standard	Wear limit	
<b>Piston &amp; Piston pin</b>								
Piston outside dia.	mm (in)	65.927 – 65.957 (2.596 – 2.597)	65.85 (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)	
<b>Connecting rod</b>								
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)	
<b>Crankshaft and main bearing</b>								
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 bushing 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
<b>Piston &amp; Piston pin</b>							
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
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)
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)
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)
<b>Connecting rod</b>							
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)
<b>Crankshaft and main bearing</b>							
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 bushing 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)

## 9. Service Data

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)
	Intermediate	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)	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)	



9. Service Data

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 – 0.150)	–	3.500 – 3.800 (0.138 – 0.150)	–	
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)	–	
<b>Camshaft and tappets</b>								
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)
	Intermediate	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)	45.000 – 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)	–	
<b>Timing gear</b>								
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)	0.2 (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		56		56		
	Face width		18		18		
	Helical angle		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)	
Idle gear	No. of teeth		43		43		
	Face width		18		18		
	Helical angle		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)	0.2 (0.0079)	
Crankshaft gear	No. of teeth		28		28		
	Face width		40		40		
	Helical angle		left		left		
	Backlash between crankshaft gear and oil pump gear		0.04 – 0.12 (0.0043 – 0.0075)	0.2 (0.0079)	0.04 – 0.12 (0.0043 – 0.0075)	0.2 (0.0079)	
Lubricating oil pump gear	No. of teeth		29		29		
	Face width		8		8		
	Helical angle		right		right		
Idle gear	No. of teeth		43		43		
	Face width		18		18		
	Helical angle		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)	
Fuel injection pump gear	No. of teeth		56		56		
	Face width		10		10		
	Helical angle		left		left		

# 10. Over-size and Under-size Parts

		2,3TN66E	3TNA72E	3TN75E 3TNC78E	3,4TN82E 3,4TN82TE	3,4TN84TE 3,4TN84TE
Piston	Outer diameter mm (in) (at measuring point)	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 mm (in) (after in compressed)	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.*

CHAPTER 3

# FUEL INJECTION EQUIPMENT

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1. Fuel Supply System

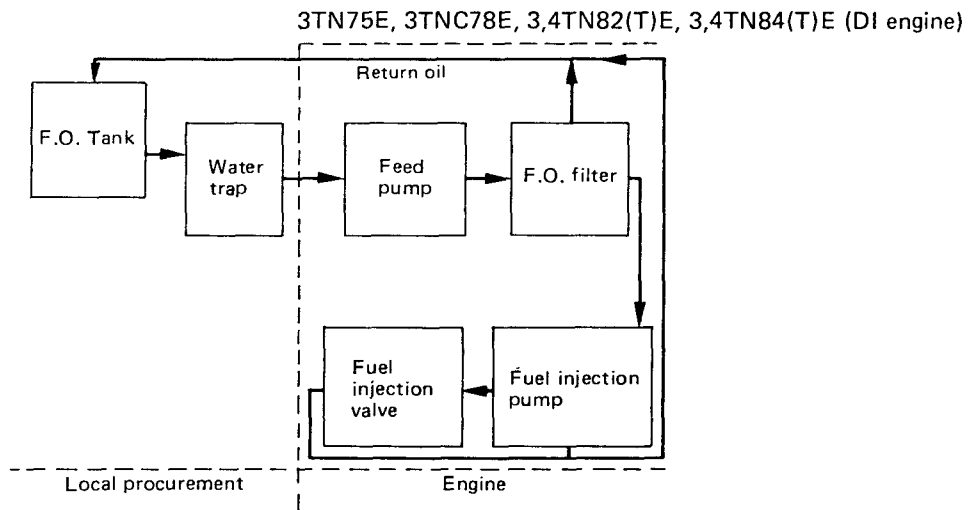
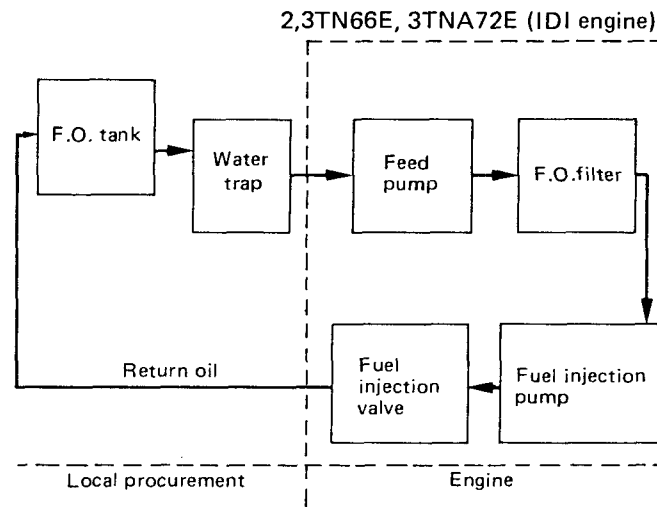
# 1. Fuel Supply System

## 1. Fuel Supply System

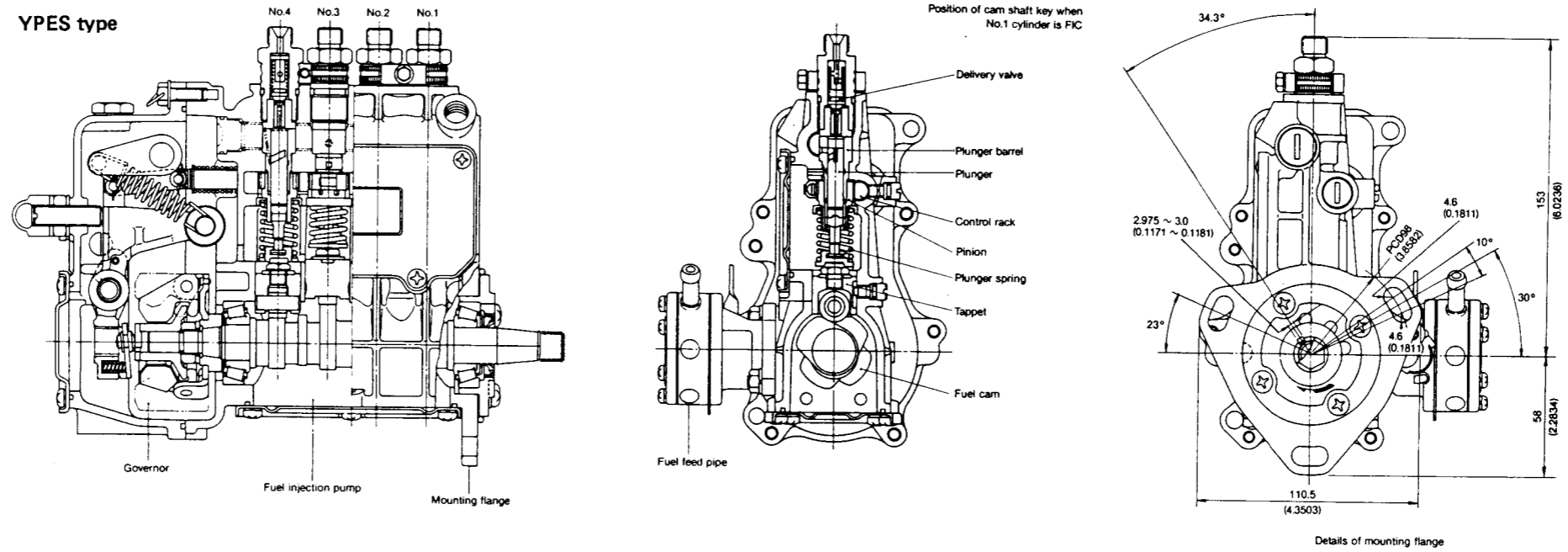
There are two types of TN series fuel injection pump. Models YPES and YPFR. (YPFR in 2TN66E, 3TN66E and 3TNA72E engines. YPES in 3TN75E, 3TNC78E, 3TN82(84)E, 4TN82(84)E, 3TN82(84)TE, and 4TN82(84)TE engines). Both of these fuel injection pumps are Bosch in-line type with the camshaft driven

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.

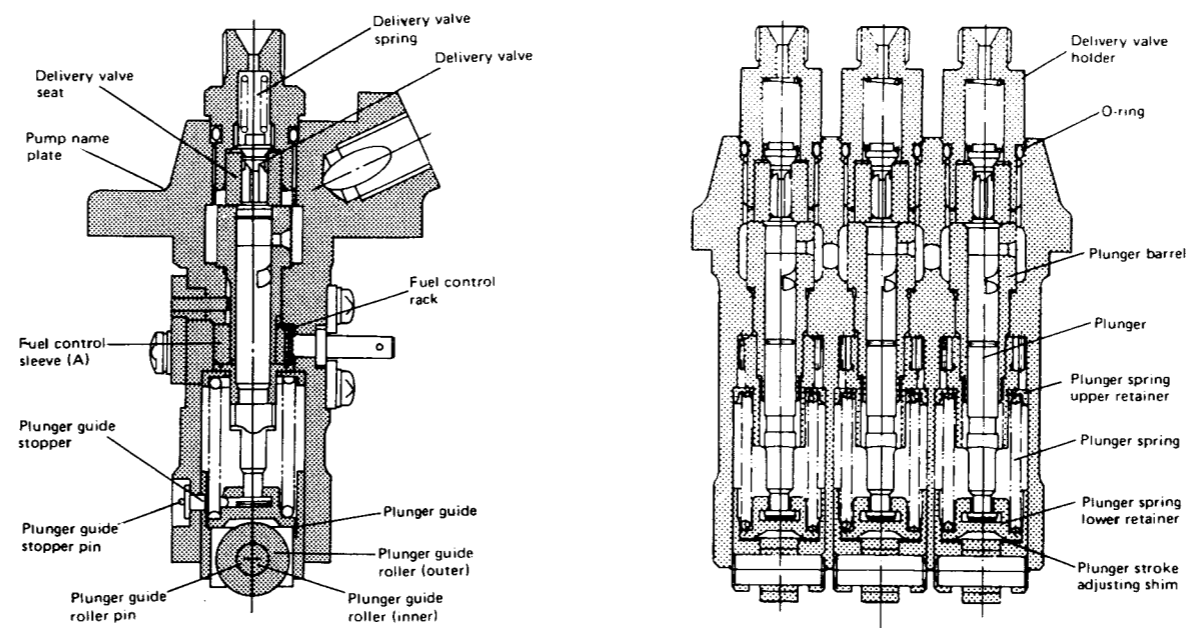
### Fuel Line



1-1 Fuel Injection Pump Construction



**YPFR type**



1. Fuel Supply System

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)	

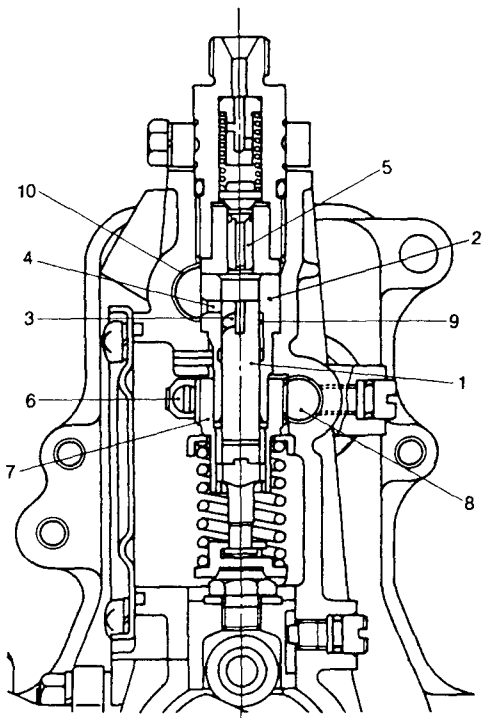
The fuel injection pump supplies pressurized fuel to the injection nozzles through the action of the plunger. The plunger reciprocates in the plunger barrel through a fixed stroke and is lapped for a precise fit. A lead groove is helically cut in the plunger, and this leads to a connecting groove which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

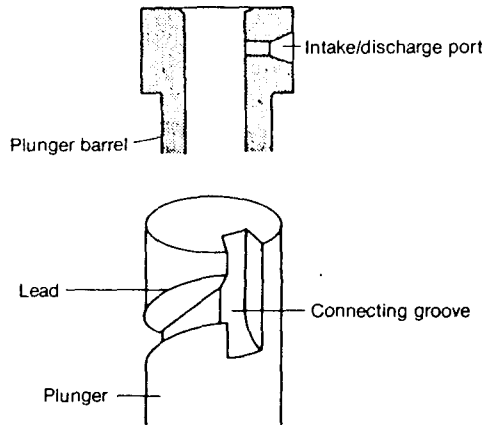
The control sleeve groove is fitted to the plunger flange. The control sleeve is secured to the control pinion and the pinion teeth and rack gear teeth are engaged.

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.

1-3 Functioning of fuel injection pump



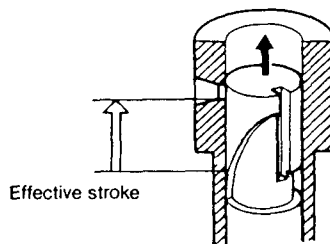
- 1. Plunger
- 2. Plunger barrel
- 3. Lead groove
- 4. Intake port
- 5. Delivery valve
- 6. Control sleeve
- 7. Control pinion
- 8. Control rack
- 9. Fuel leak return groove
- 10. Protector



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-





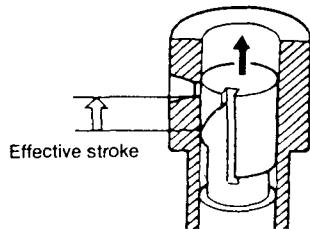
1. Fuel Supply System

lowest 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.

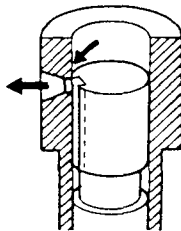
(2) Half injection volume position

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

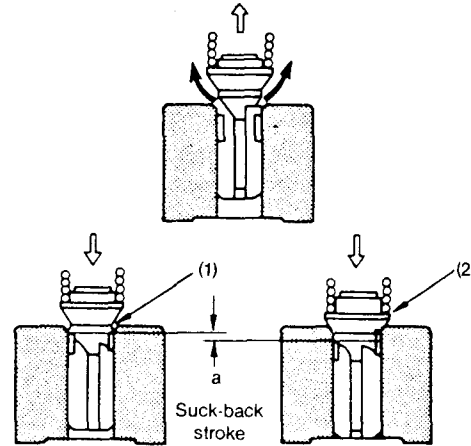
When the rack is set near zero, the intake/discharge port in the barrel is always open, so no fuel is pressurized (even though the plunger continues to reciprocate).



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

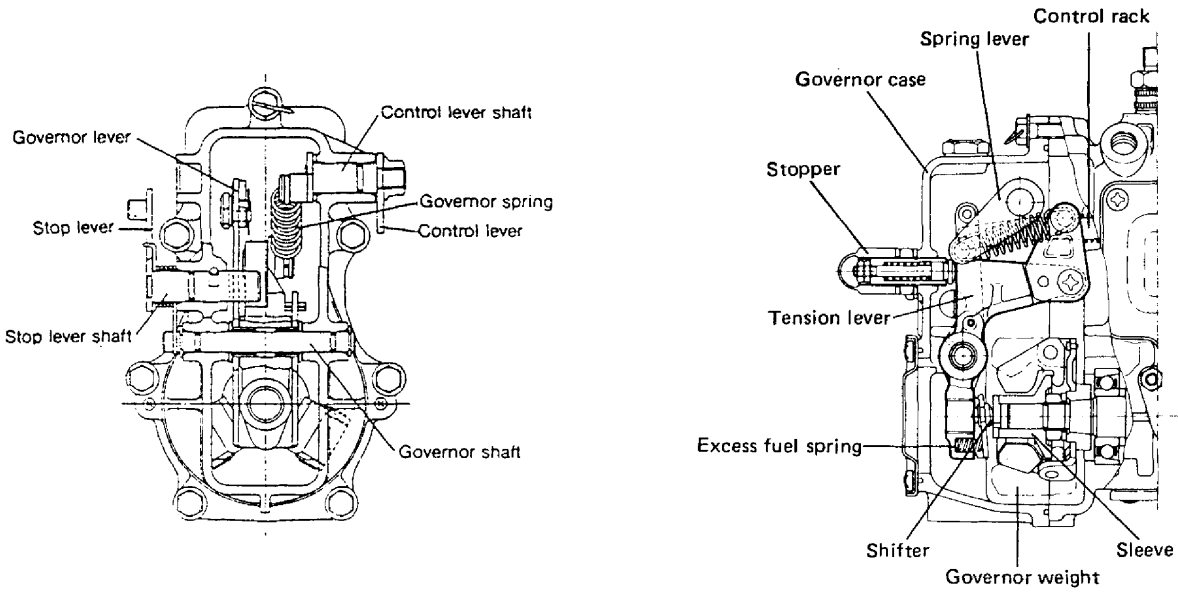
Usage conditions of diesel engines are extremely varied, with a wide range of loads and rpms. The governor plays an important role in the operation of the engine by quickly adjusting the position of the control rack to control the amount of fuel injected according to changes in rpm.

It also automatically controls the engine to prevent engine rpm from exceeding the maximum, and keeps the engine from stopping.

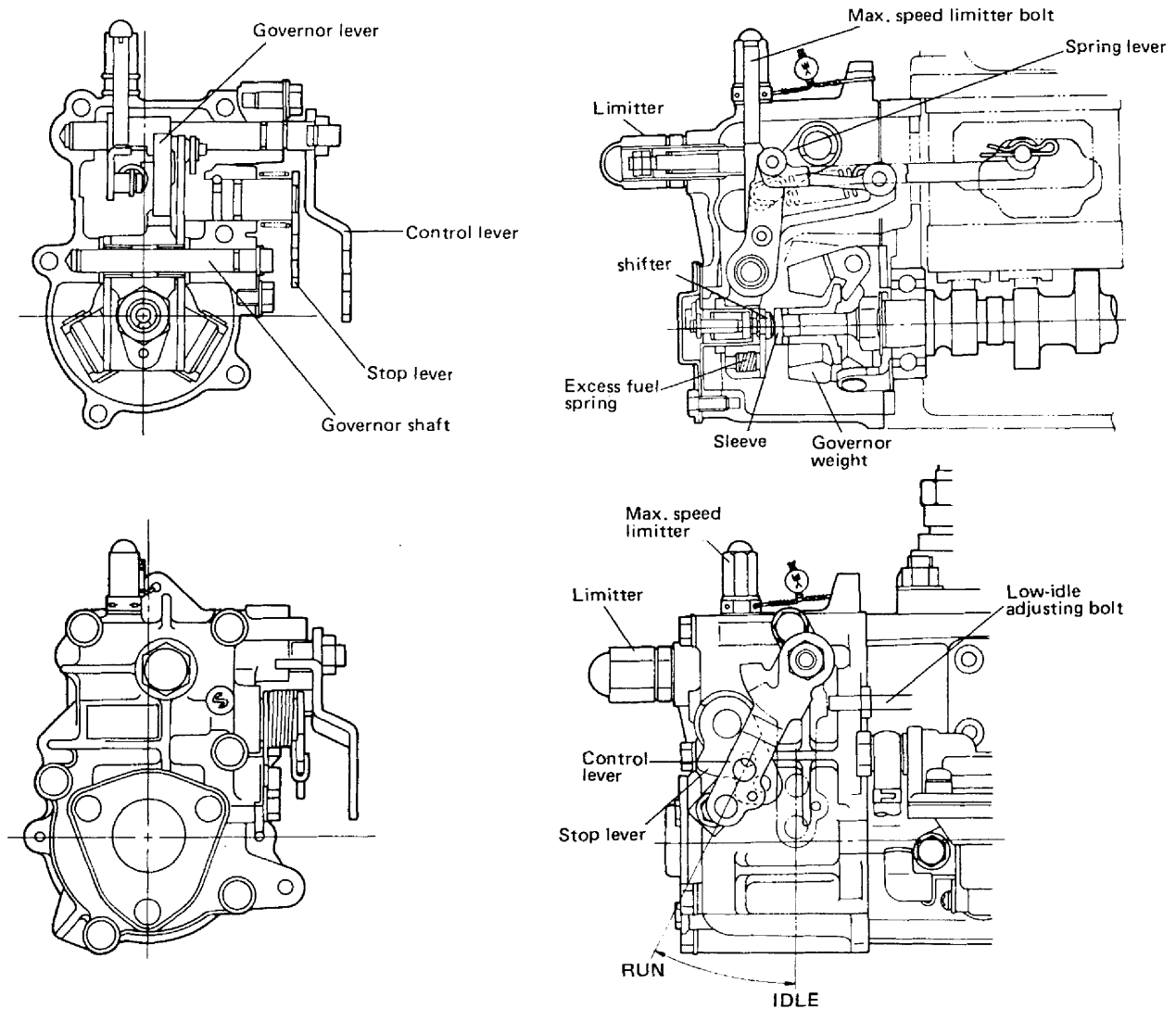
Injection pump is equipped with the all speed governor. The construction will be explained accordingly to the cut- way views.

1. Fuel Supply System

(YPES type)



(YPFR type)



## 1. Fuel Supply System

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 through 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 controlled.

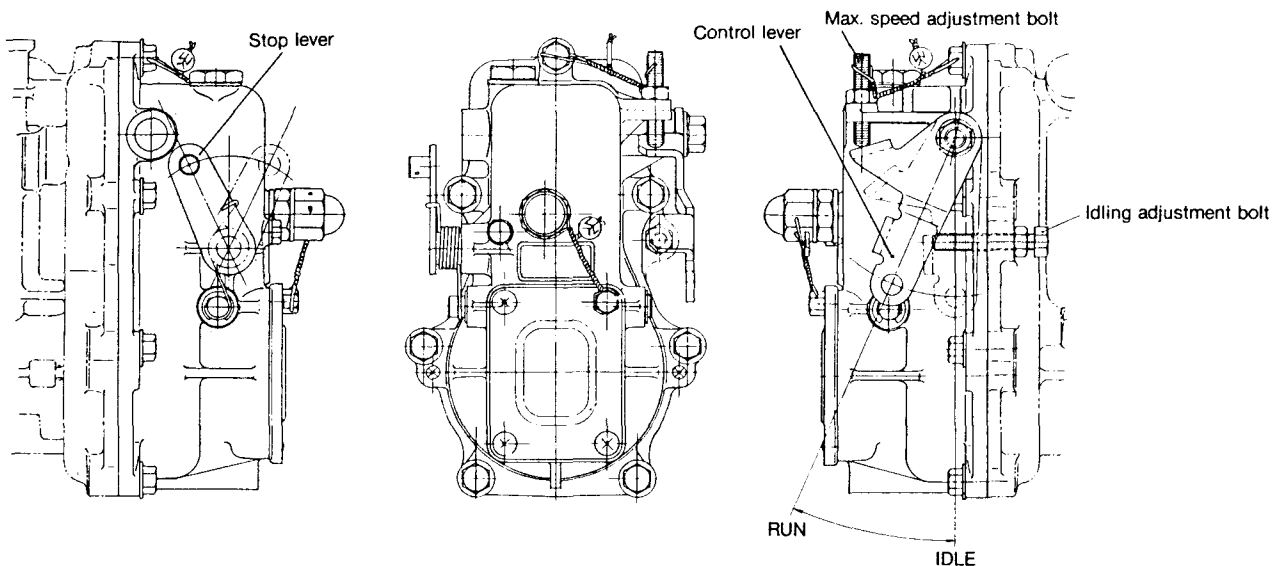
The top of the tension lever comes in contact with the stopper built into the top of the governor case to limit the maximum fuel injection volume.

## 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.



1. Fuel Supply System

(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.

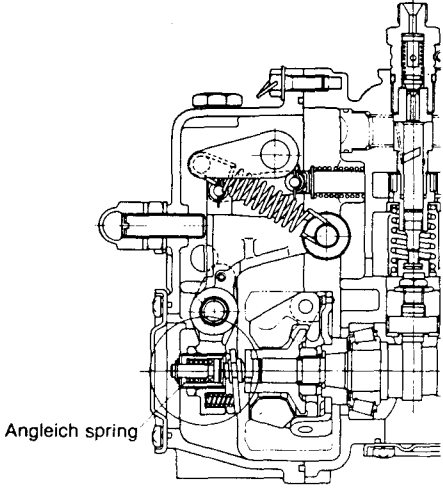
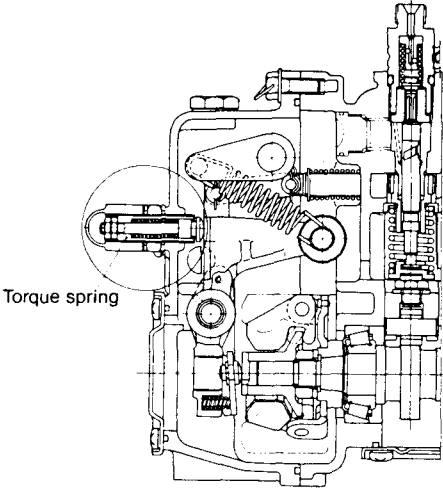
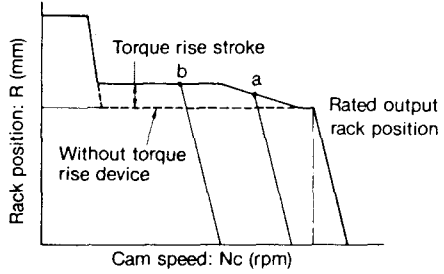
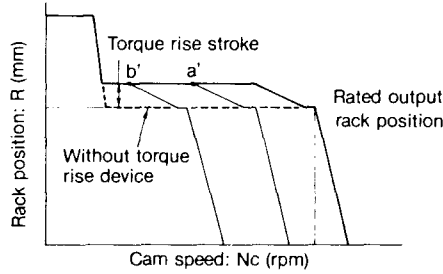
<p>A</p>		<p>The engine can be stopped by pulling the stop lever in direction A either manually or electrically with a;</p> <ol style="list-style-type: none"> <li>(1) Push-pull cable.</li> <li>(2) Stop motor.</li> <li>(3) Magnetic solenoid.</li> </ol>
<p>B</p>		<p>This method always requires an electromagnetic 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.</p>
<p>C</p>		<p>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.)</p>

1. Fuel Supply System

(3) Torque rise equipment

As mentioned before, this governor has a structure that allows you to equip it with an angleich spring and/or

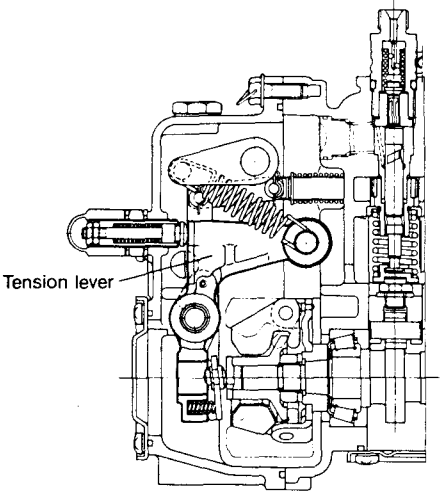
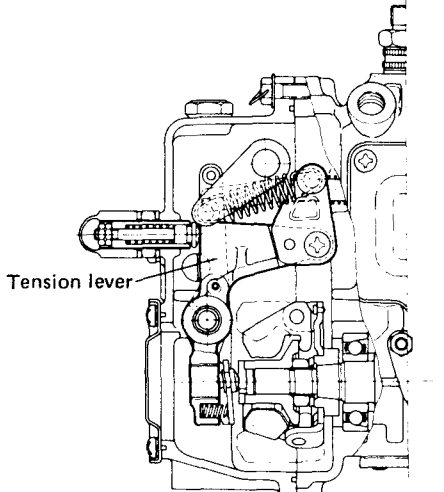
torque spring as torque rise equipment. In this way the requirements for different engines can be fulfilled.

	With angleich spring	With torque spring
Structure	 <p>Angleich spring</p>	 <p>Torque spring</p>
Function	 <p>Rack position: R (mm)</p> <p>Torque rise stroke</p> <p>Without torque rise device</p> <p>Rated output rack position</p> <p>Cam speed: Nc (rpm)</p>	 <p>Rack position: R (mm)</p> <p>Torque rise stroke</p> <p>Without torque rise device</p> <p>Rated output rack position</p> <p>Cam speed: Nc (rpm)</p>
	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

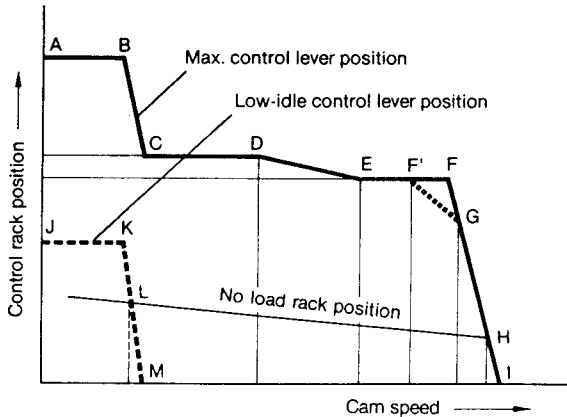
lever of the governor spring. This is a very valuable feature for engines in which performance depends on low speed torque. It also promotes better use of generator engines using 50 Hz/60 Hz.

	Type A	Type B
Structure	 <p>Tension lever</p>	 <p>Tension lever</p>

### 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.

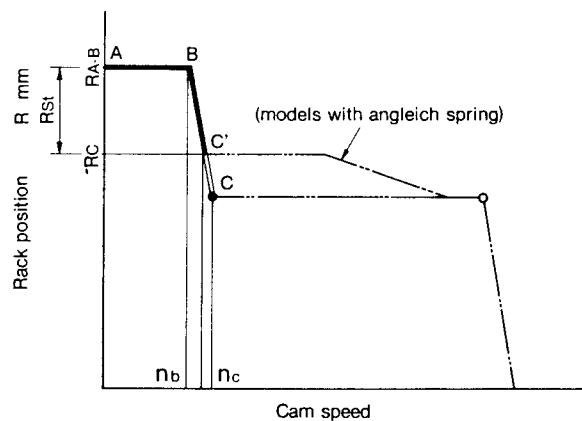
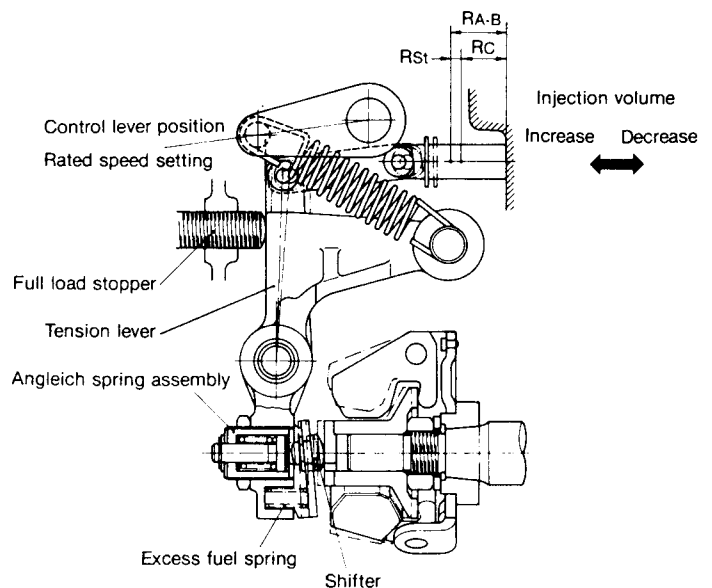


- A-B: Fuel volume condition during starting. Volume is controlled by excess fuel spring.
- B-C: The rack moves towards decrease after engine starts and speed increase as the load of the excess fuel spring is overcome by the centrifugal force of the governor weight.
- C-D: High torque at low speed is 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  $R_{A-B}$ .

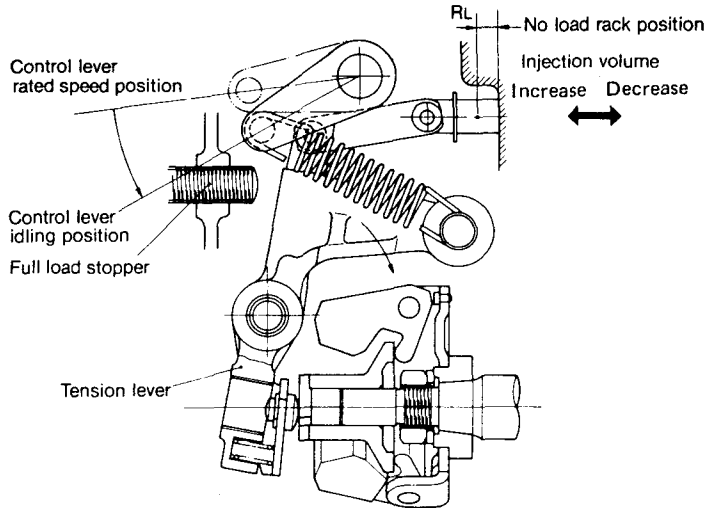
After the engine is started, the excess fuel spring is compressed when the centrifugal force of the governor weight overcomes the set load of the excess fuel spring as speed exceeds  $N_b$ , speed goes from B to C' (on models with angleich spring) or B to C (on models without angleich spring). The rack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



1. Fuel Supply System

(3) Idling

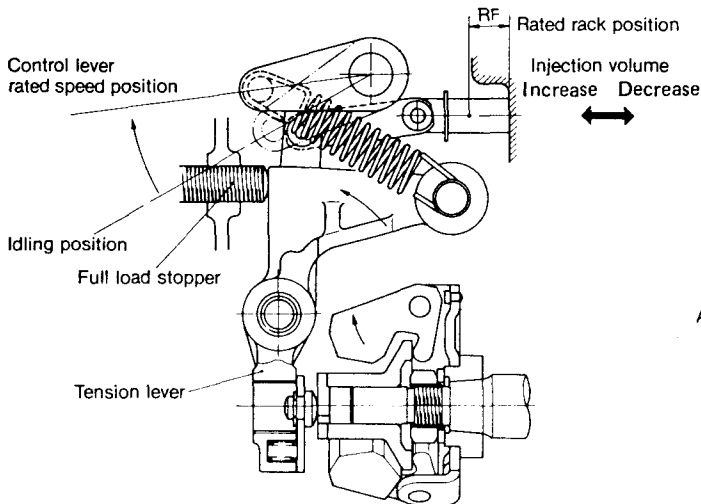
Idling is controlled by the governor spring and excess fuel spring as this governor is not equipped with an idling spring. When the control lever is returned to the idling position after the engine is started, the governor spring tension decreases and the tension lever descends clockwise, and the governor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



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

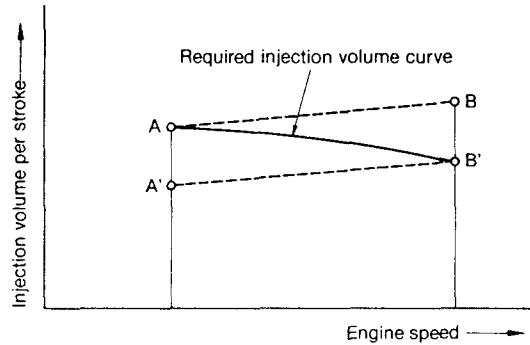
(4) Maximum speed

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

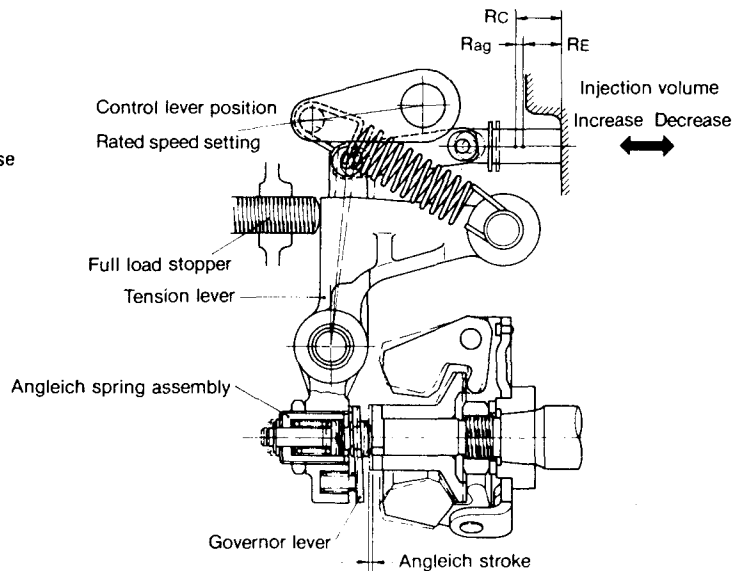
Engine air intake efficiency decreases as speed increases, while the pump injection characteristics tend to increase as speed rises, at the same rack position. Accordingly, the governor must satisfy the required injection curves represented in the diagram below in order to obtain sufficient output at 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.

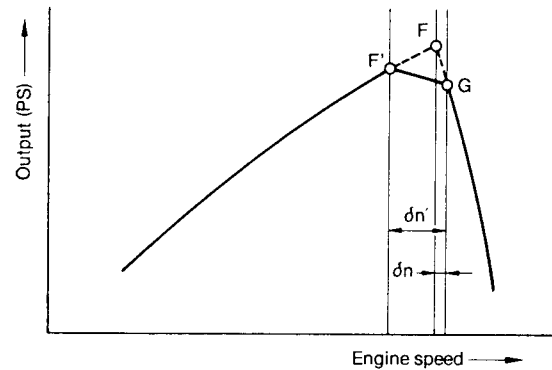
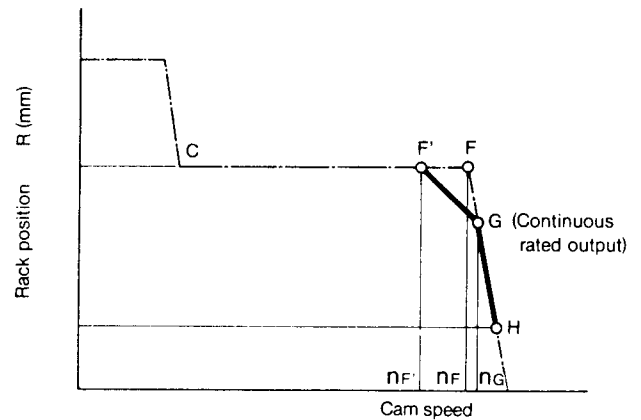
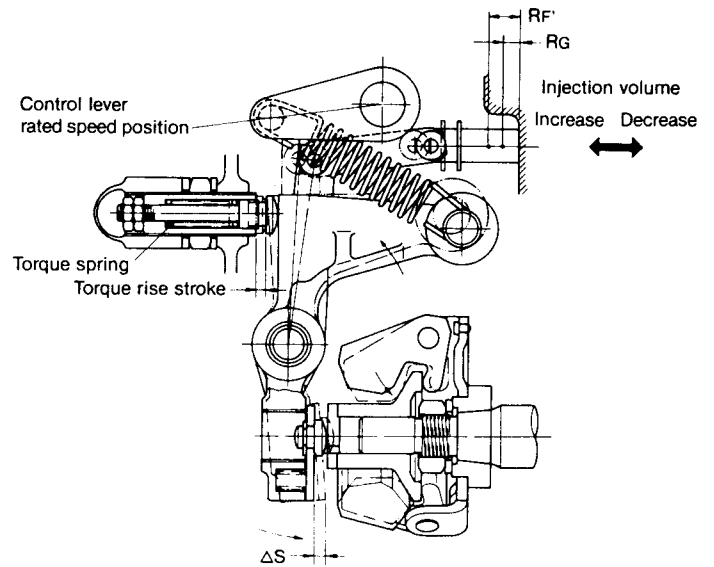
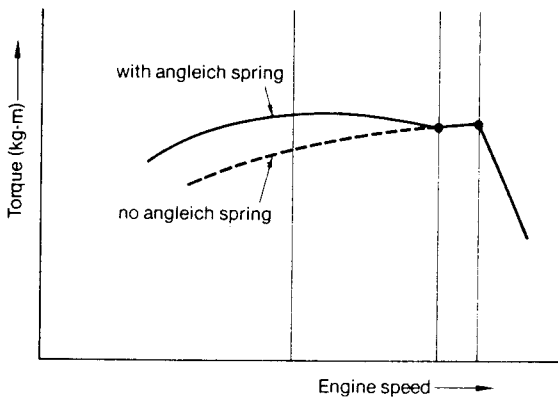
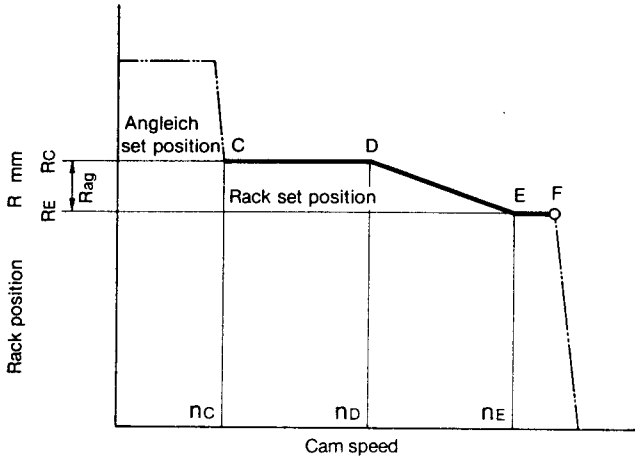


The angleich spring is mounted to the lower part of the tension lever (however some engines are not equipped with an angleich spring depending on usage and speed range utilized).

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 (Rc) 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 (Re).





**(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**

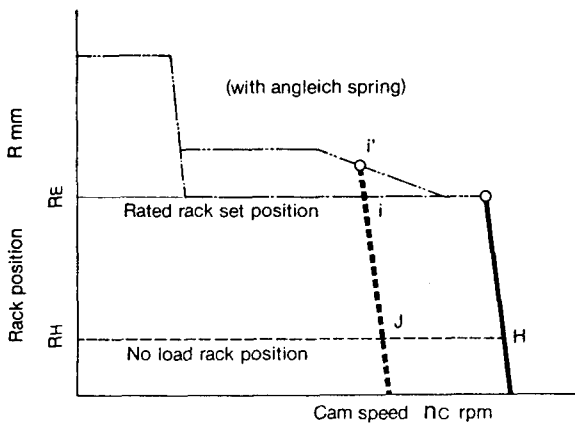
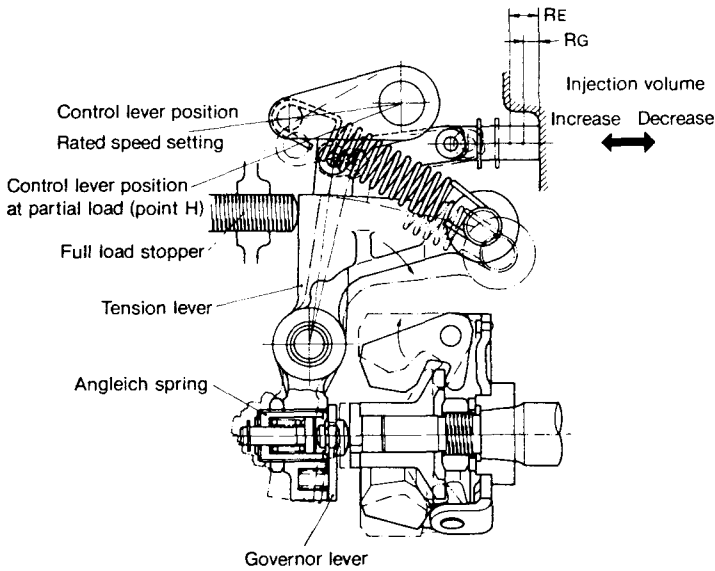
When the load decreases from full load max. speed and engine speed increases, the increased thrust load of the governor weight acting on the governor spring through the tension lever exceeds the set load of the spring, the tension lever and governor lever descend clockwise; the control rack is pushed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

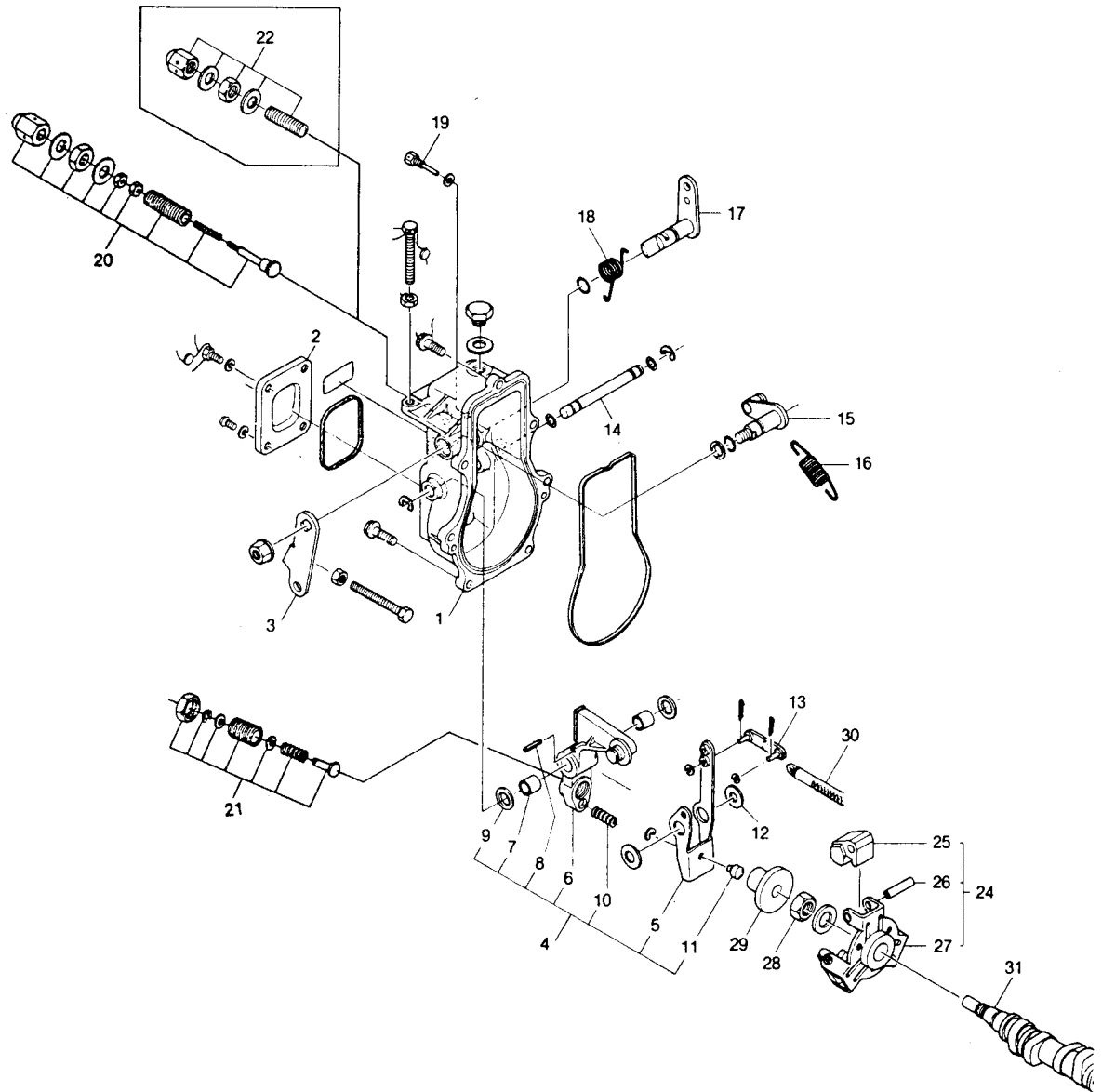
The engine stops when you turn the governor control lever all the way towards stop.

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

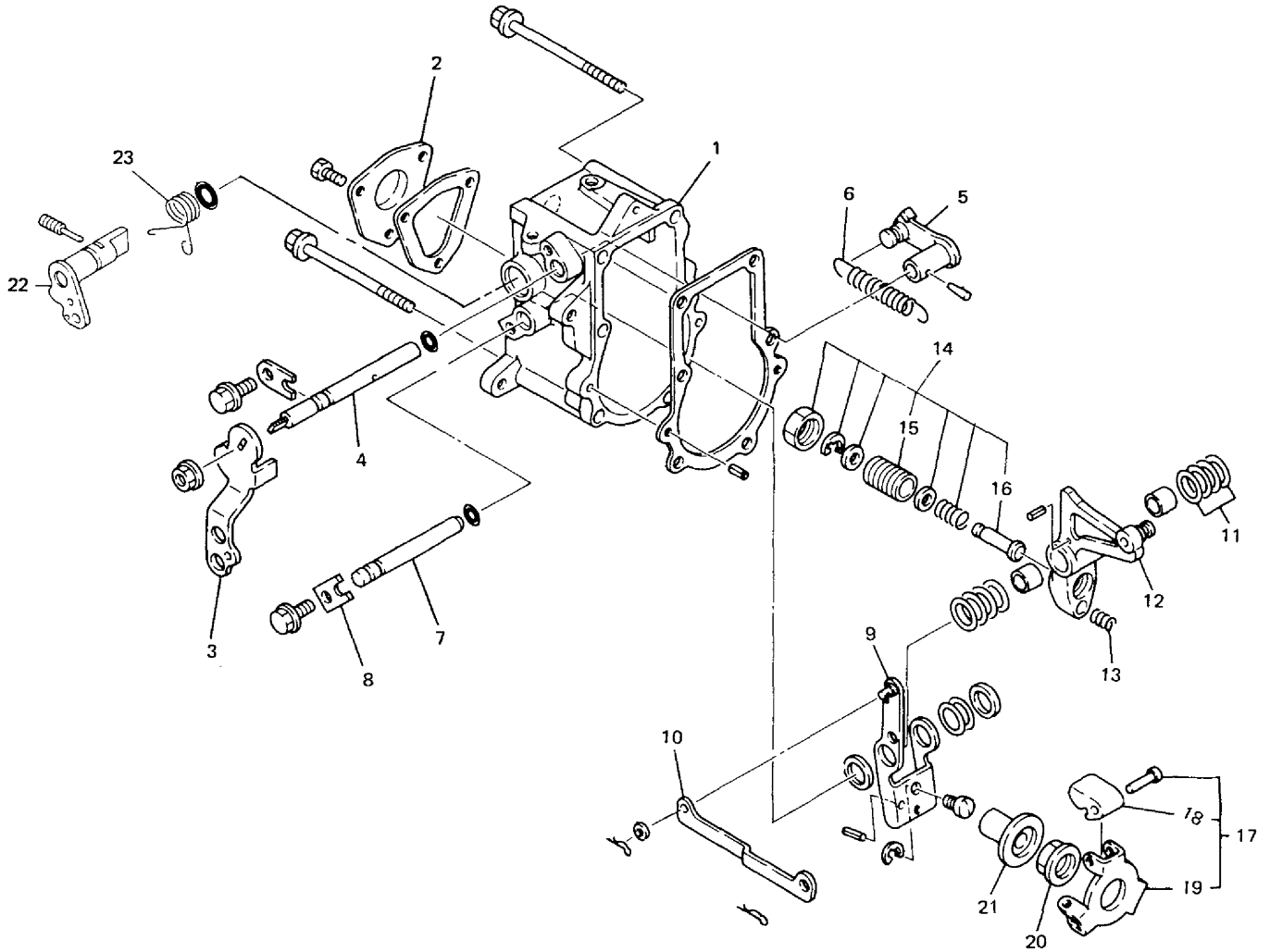
Governor for YPES type pump



- |    |                         |    |                                    |    |                           |
|----|-------------------------|----|------------------------------------|----|---------------------------|
| 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 |    |                           |

2. Disassembly, Reassembly and Inspection of Governor

Governor for YPFR type pump



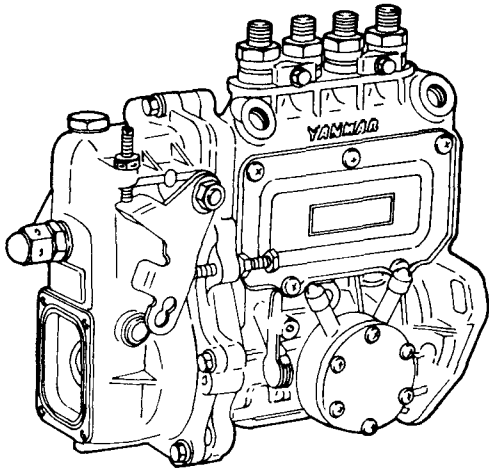
- |   |                         |    |                      |    |                          |
|---|-------------------------|----|----------------------|----|--------------------------|
| 1 | Governor case           | 9  | Governor lever       | 17 | Governor weight assy.    |
| 2 | Governor case cover     | 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. Disassembly, Reassembly and Inspection of Governor

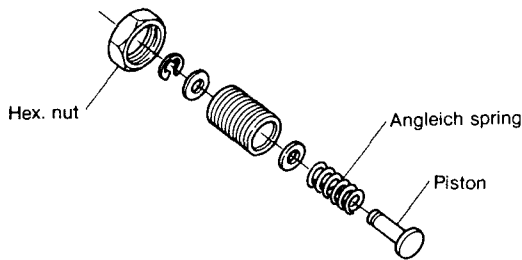
2-1 Governor disassembly

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)

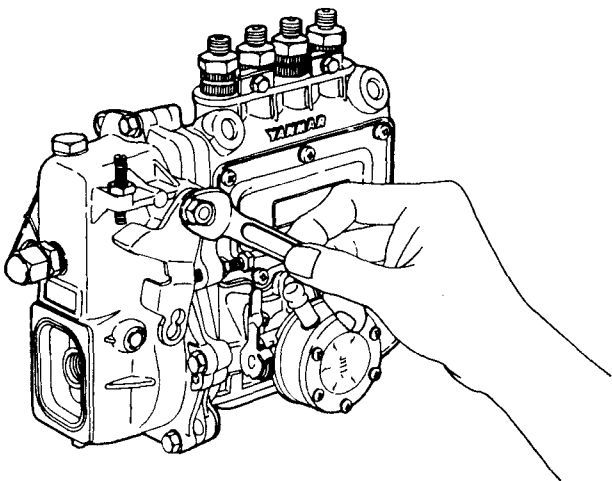
- (1) Remove the governor case cover.



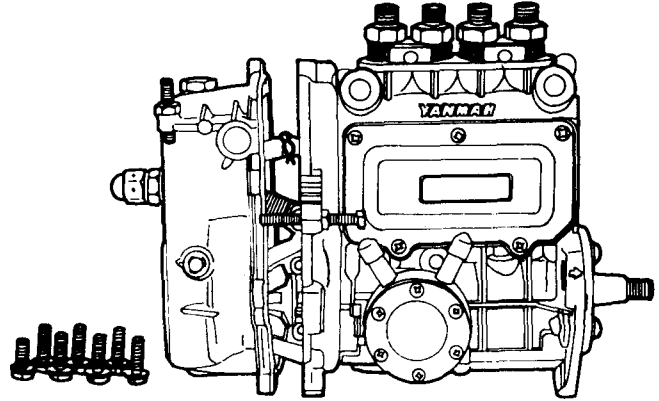
NOTE: Loosen the hex bolt on models with an angleich spring.



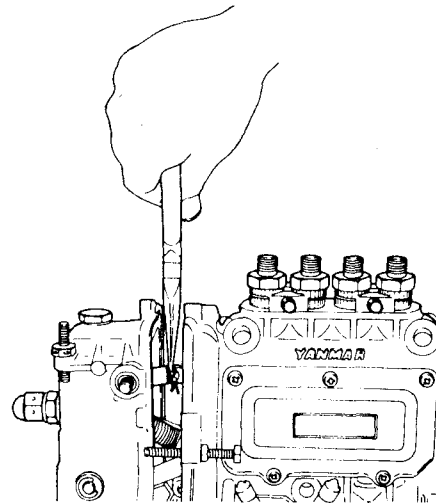
- (2) Remove the control lever hex nut, and pull out the control lever from the control lever shaft.



- (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.

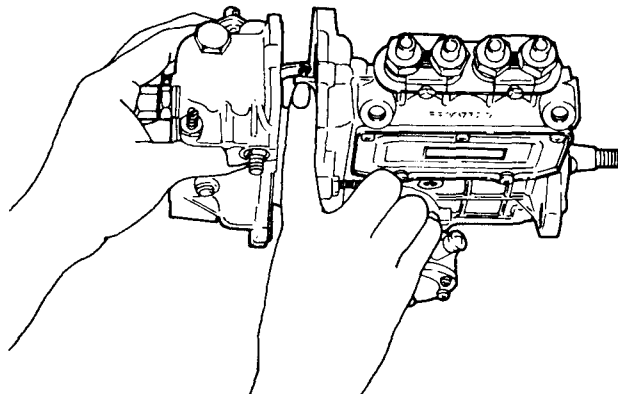


- (4) Pull out the governor link snap pin by inserting needle nosed pliers between the fuel pump and governor case.



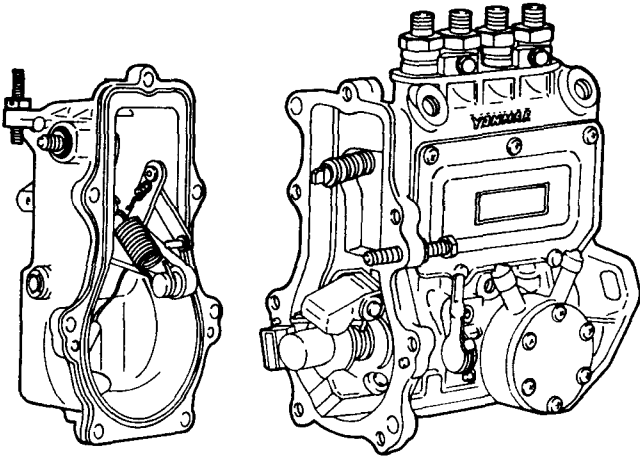
- (5) The governor and fuel pump come apart by sliding the governor case and fuel pump apart and pulling out the link pin of the fuel control rack.

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

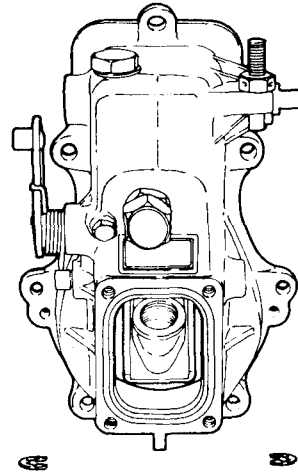


2. Disassembly, Reassembly and Inspection of Governor

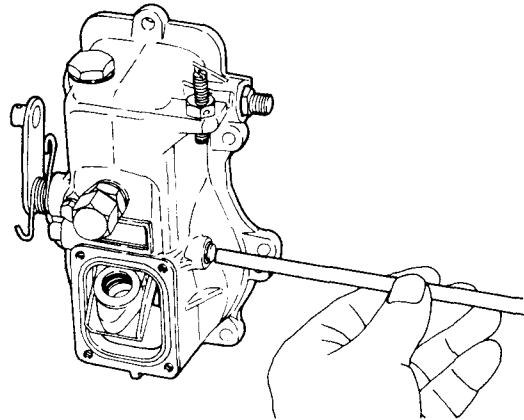
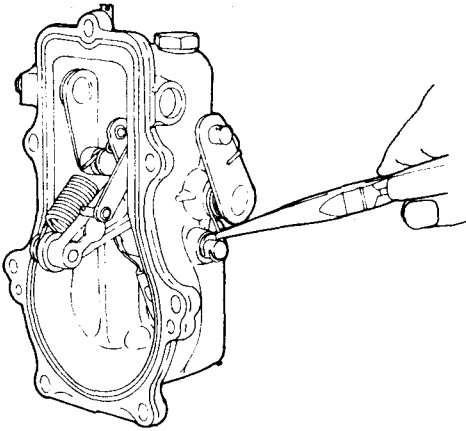
- (8) Remove the snap-rings on both ends of the governor lever shaft.



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

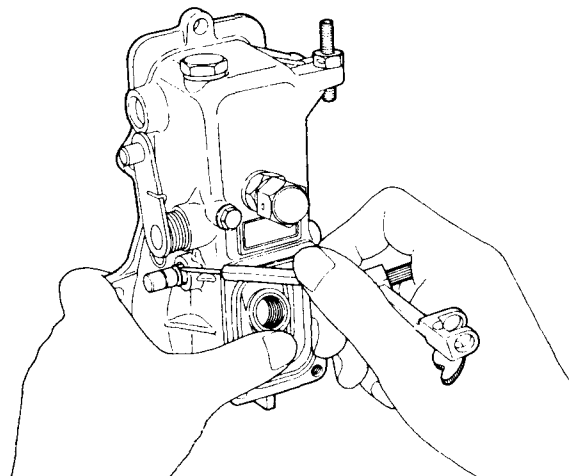
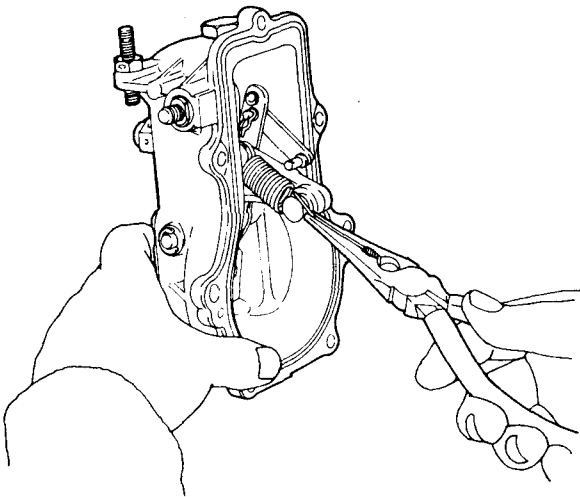


- (9) Put a rod 8mm (0.3150in.) in dia. or less in one end of the governor lever shaft, and tap the governor shaft until the O-ring comes out the other side of the governor case.

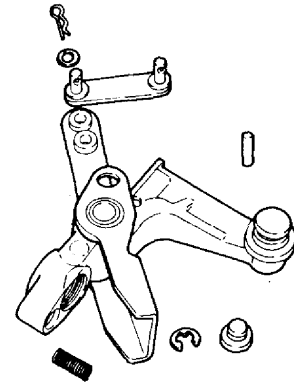
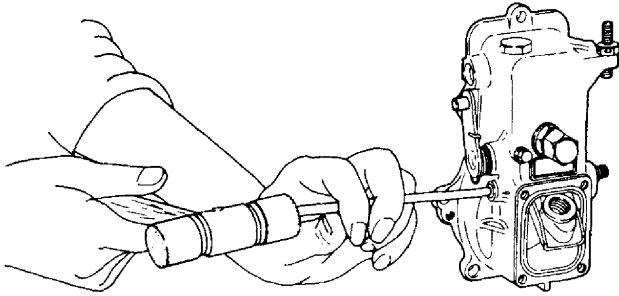


- (7) Use needle nosed pliers to unhook the governor spring from the tension lever and control lever shaft.

- (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.

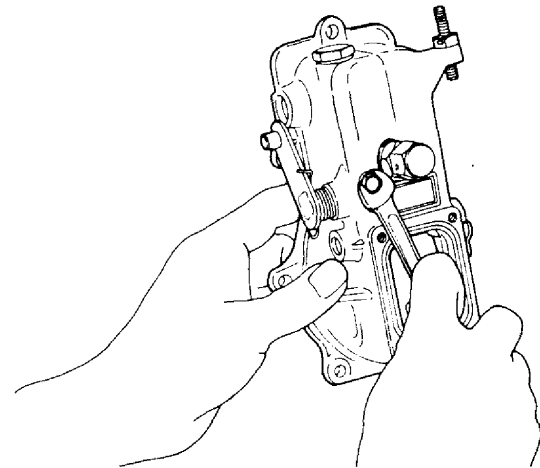
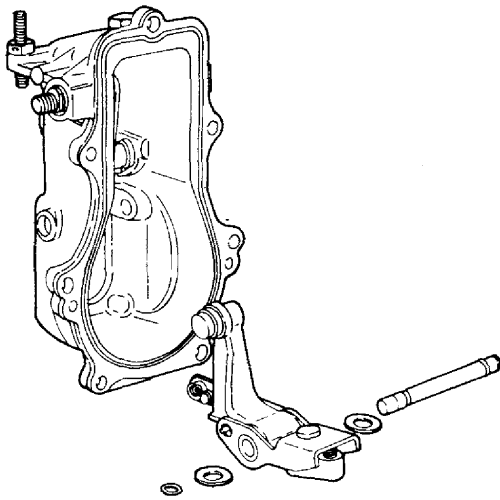


2. Disassembly, Reassembly and Inspection of Governor



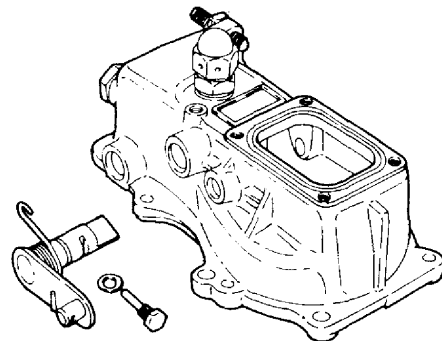
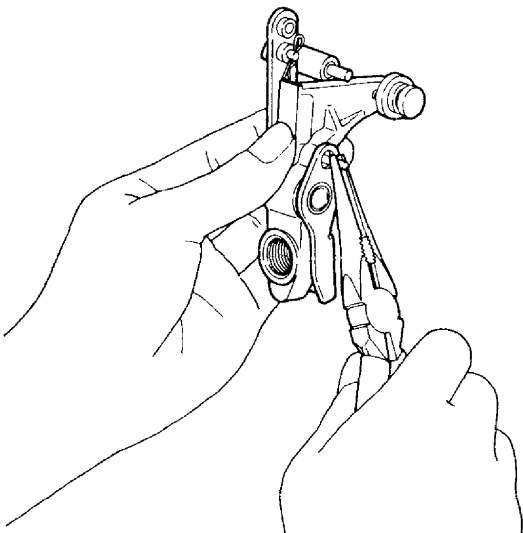
**NOTE:** The governor assembly consists of the governor lever, tension bar, bushing, throttle spring and shifter, and is normally not disassembled. The spring pin is removed when you replace the shifter or throttle spring.

- (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.

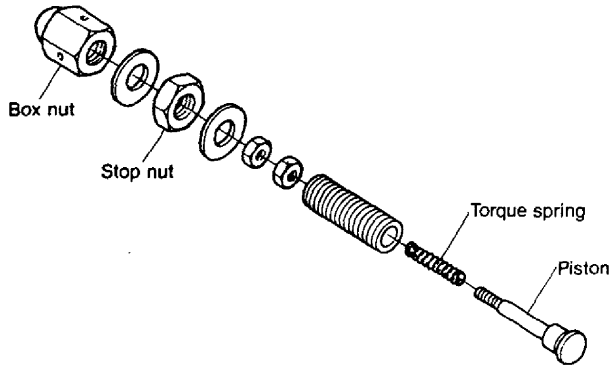
- (13) When you need to pull out the control lever shaft, tap the end of the shaft with a wood hammer.



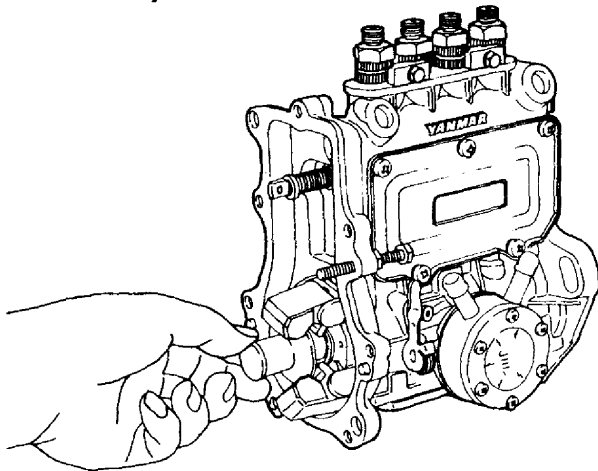
**NOTE:** 1. Do not remove the fuel limit nut from the governor case unless necessary.

2. Disassembly, Reassembly and Inspection of Governor

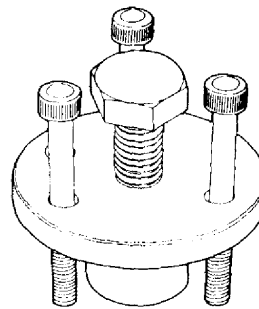
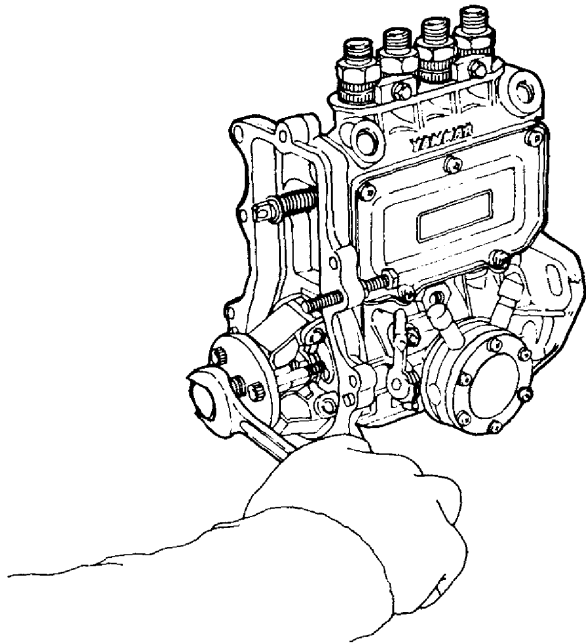
2. On models with torque springs, first remove the box nut and stop nut, and then the torque spring assembly.



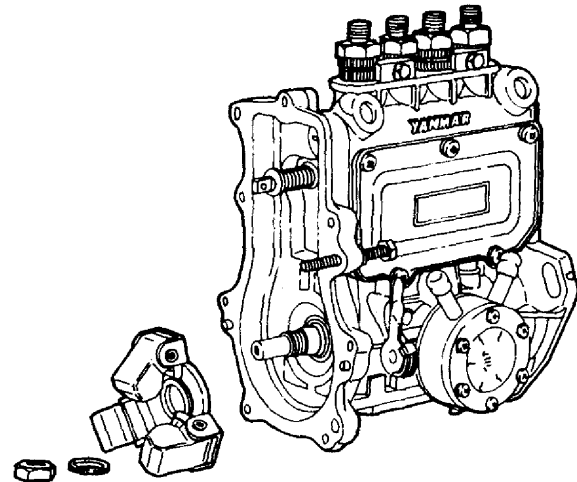
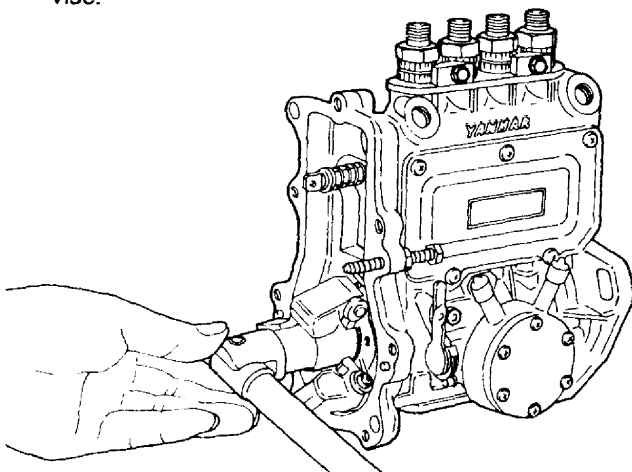
(14) Pull out the governor sleeve on the end of the fuel camshaft by hand.



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



(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.

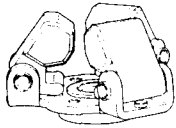
NOTE: The governor weight assembly is made up of the governor weight, support and pin. Do not disassemble.

2. Disassembly, Reassembly and Inspection of Governor

2-2 Inspection of governor

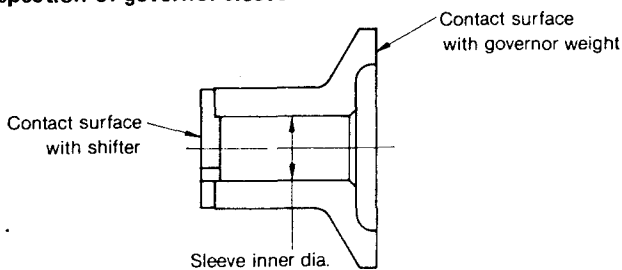
Inspection of governor weight assembly

- (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.

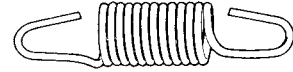
mm (in.)	
Standard side gap	0.4 (0.0157)

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

(5) Inspection of springs

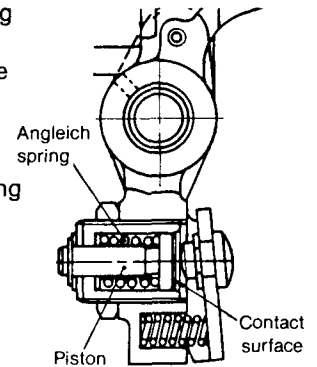
- 1) Check the governor spring and other springs and replace if they are broken, settled or corroded.

- 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

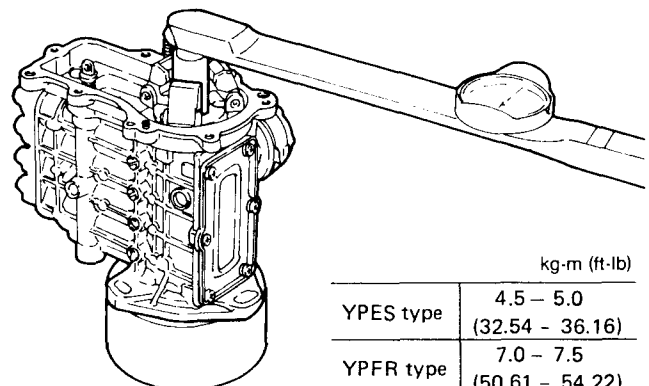
- 1) Inspect the tip of the piston and contact surface for wear and replace if necessary.
- 2) Replace the assembly if the torque spring is broken.



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.

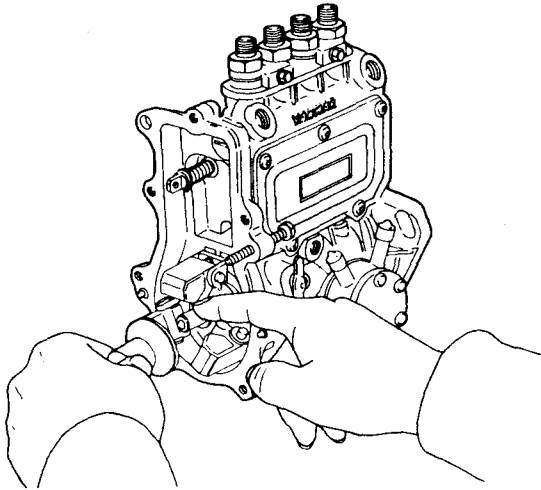


	kg-m (ft-lb)
YPES type	4.5 - 5.0 (32.54 - 36.16)
YPFR type	7.0 - 7.5 (50.61 - 54.22)



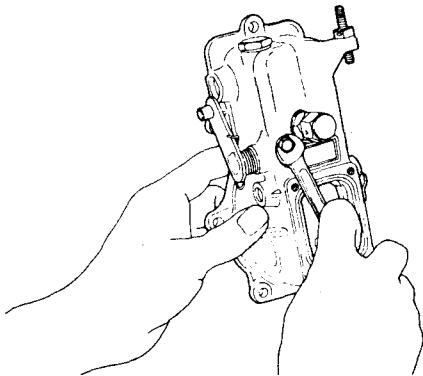
2. Disassembly, Reassembly and Inspection of Governor

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



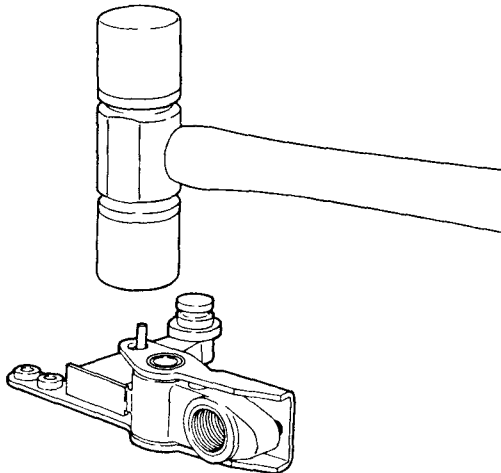
**NOTE:** Make sure that the sleeve moves smoothly after inserting it.

- (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.

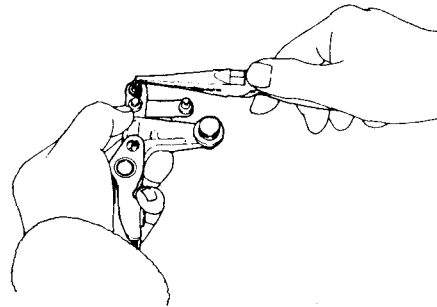


- (4) When the control lever shaft has been removed, lightly tap the control lever shaft and washer from inside the governor case, using an appropriate plate.

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



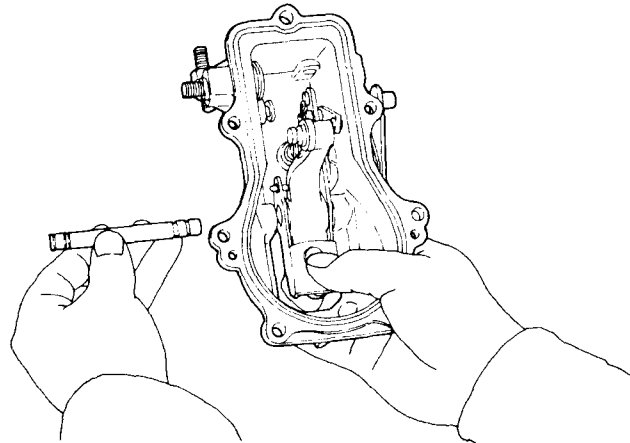
- (6) Mount the governor lever assembly to the governor link.



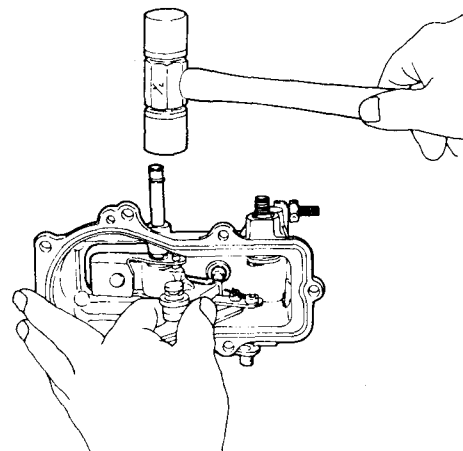
**NOTE:** 1. Make sure that the correct governor link mounting holes are used, and that it is mounted in the correct direction.

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.



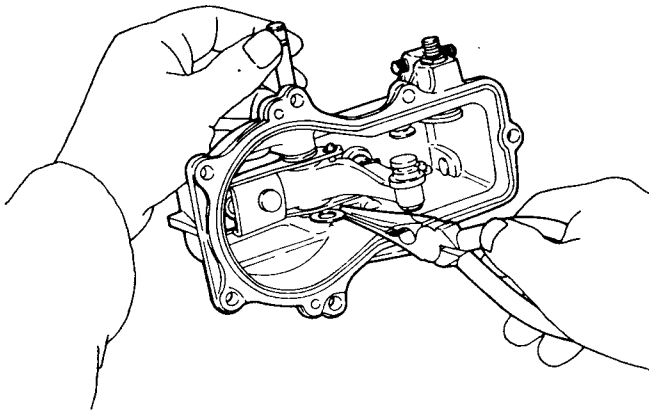
**NOTE:** 1. Fit the O-ring to the side you have tapped in.



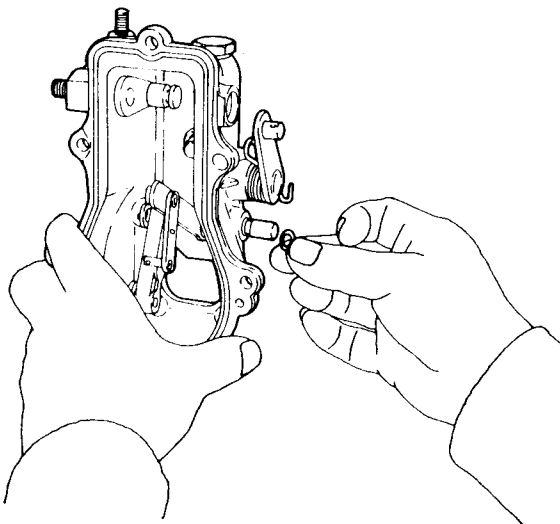
2. Make sure to insert the governor lever shaft in the correct direction.

2. Disassembly, Reassembly and Inspection of Governor

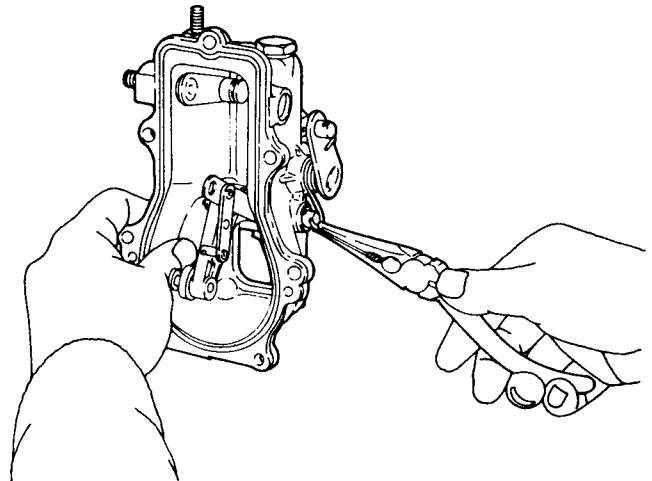
3. Don't forget to mount the washers to both sides of the governor lever.



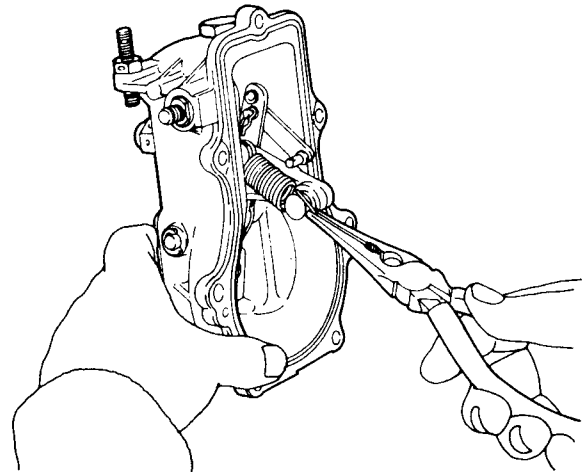
(8) After you have mounted the O-ring, tape the governor lever in the opposite direction, and mount the E-shaped stop rings on the grooves at both ends.



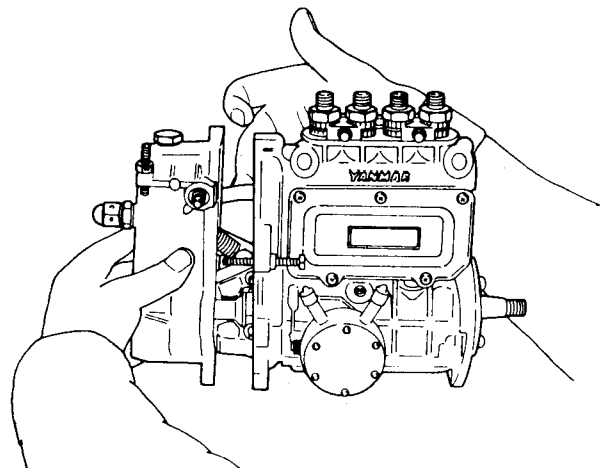
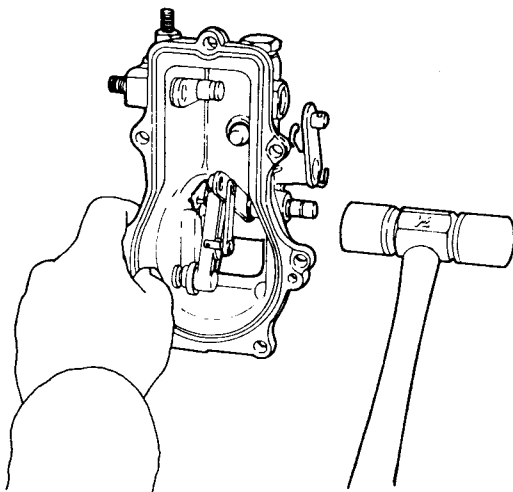
(9) Fit the stop lever return spring to the end of the governor lever shaft.



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



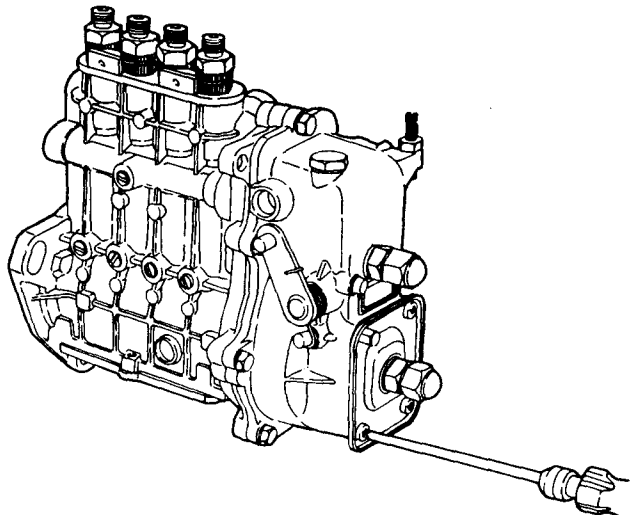
(11) Pull the governor link as far as possible towards the governor case mounting surface, insert the governor link pin in the fuel control rack pin hole and fit the snap pin on it.



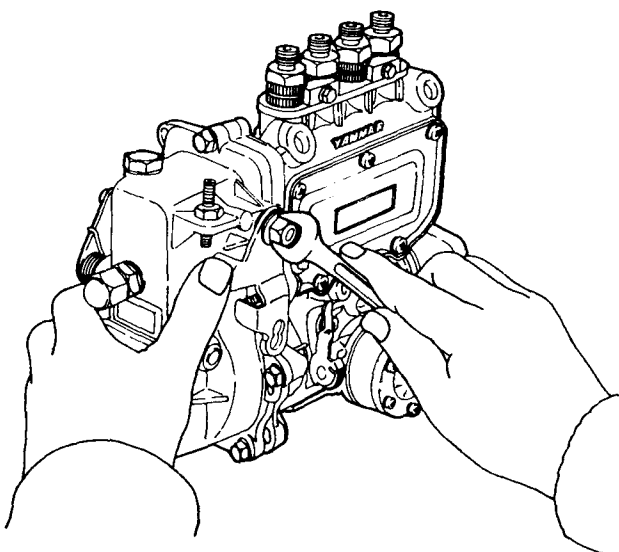
**NOTE:** After mounting the governor lever assembly, make sure the governor lever assembly moves smoothly.

2. Disassembly, Reassembly and Inspection of Governor

- (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.



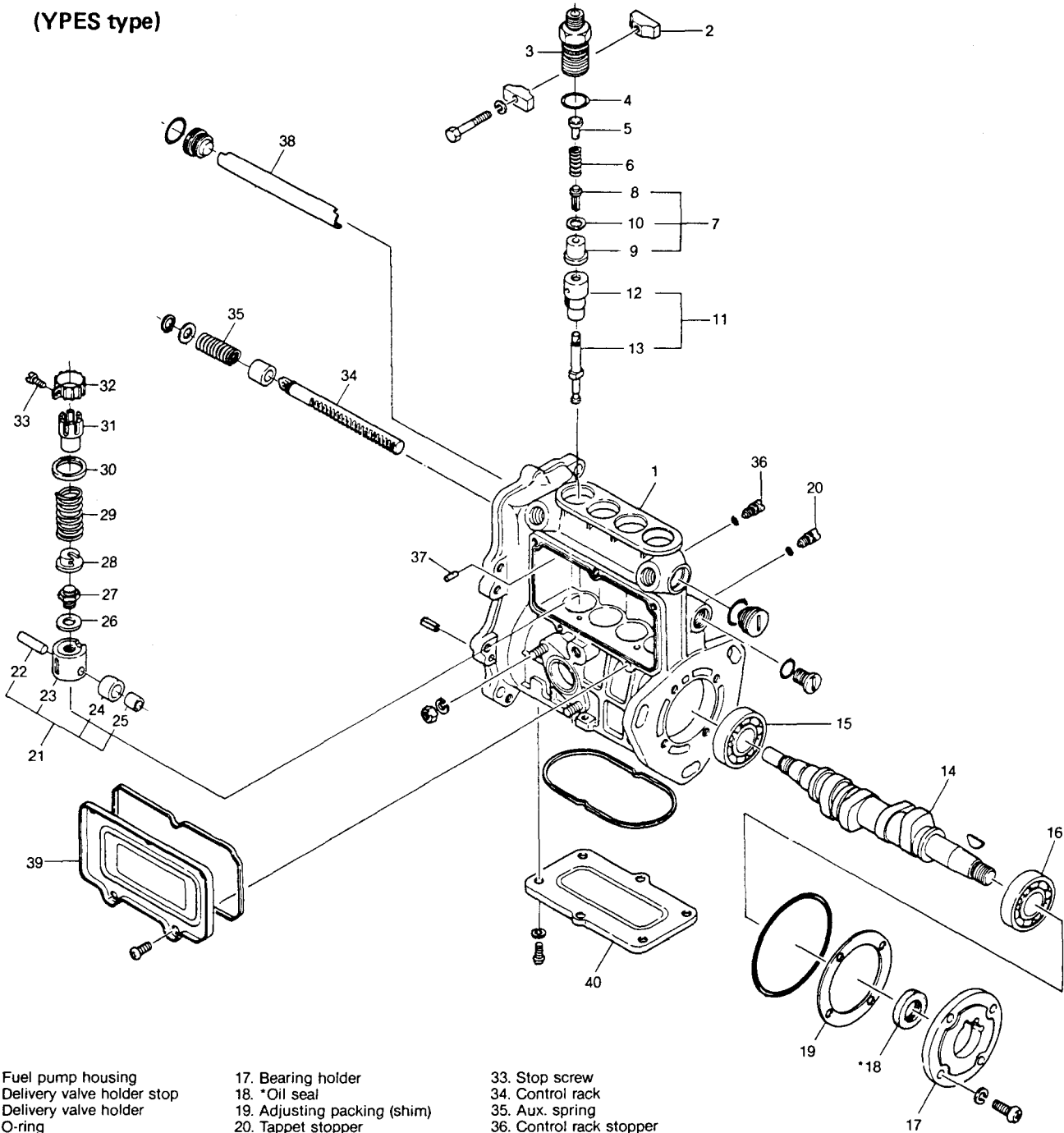
- (14) Insert the control lever in the control lever shaft, and tighten the nut.



**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)



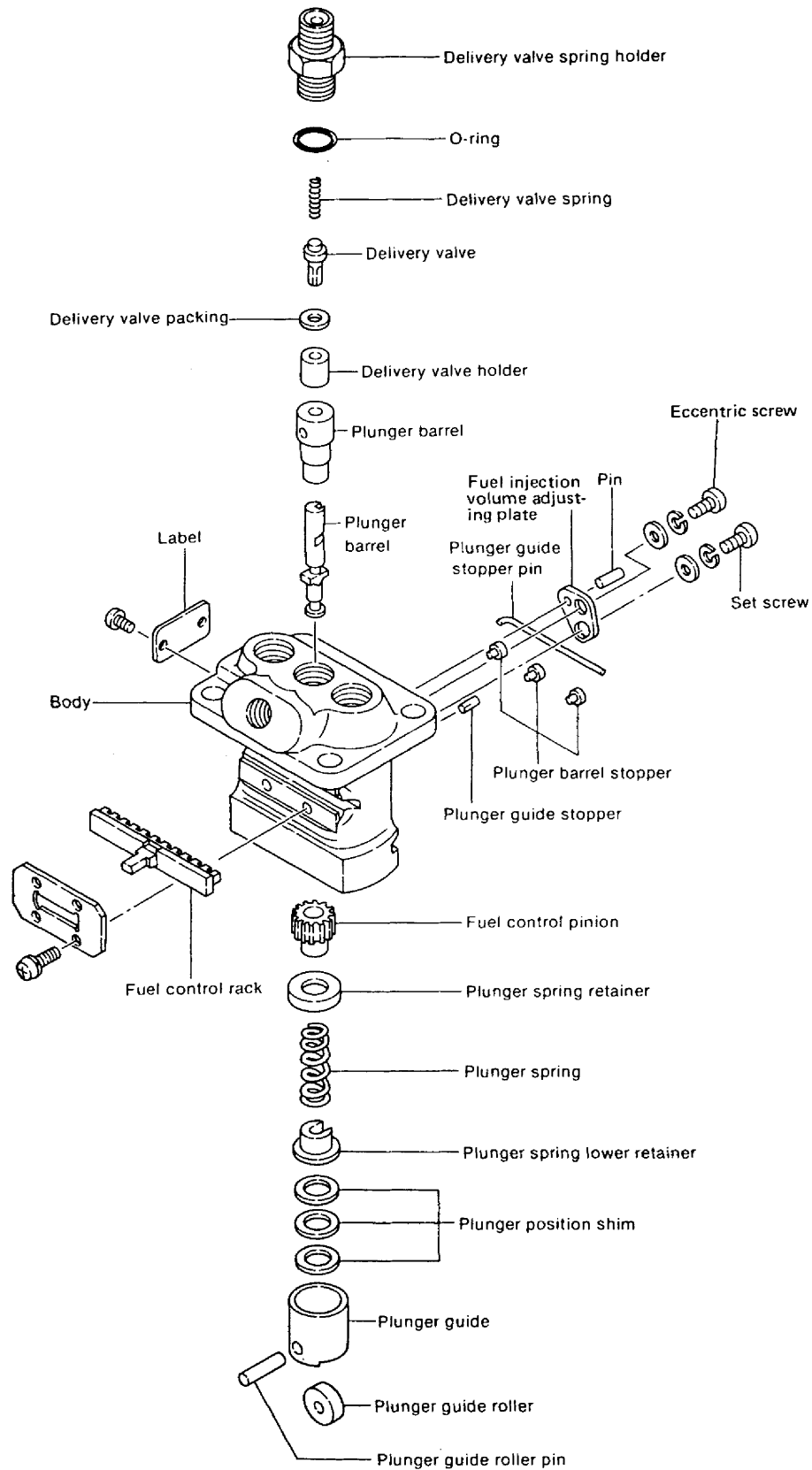
- 1. Fuel pump housing
- 2. Delivery valve holder stop
- 3. Delivery valve holder
- 4. O-ring
- 5. Delivery valve stopper
- 6. Delivery valve spring
- 7. Delivery valve assembly
- 8. Delivery valve
- 9. Delivery valve seat
- 10. Delivery packing
- 11. Plunger assembly
- 12. Plunger barrel
- 13. Plunger
- 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)

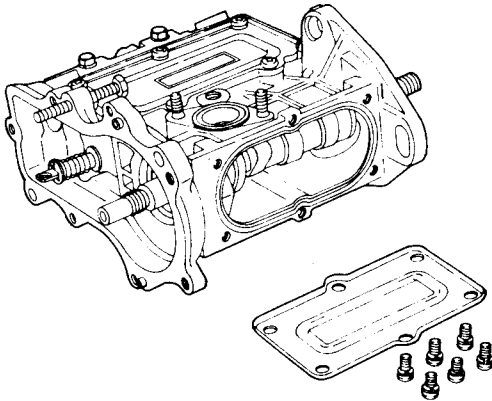


### 3-1 Disassembly of fuel injection pump

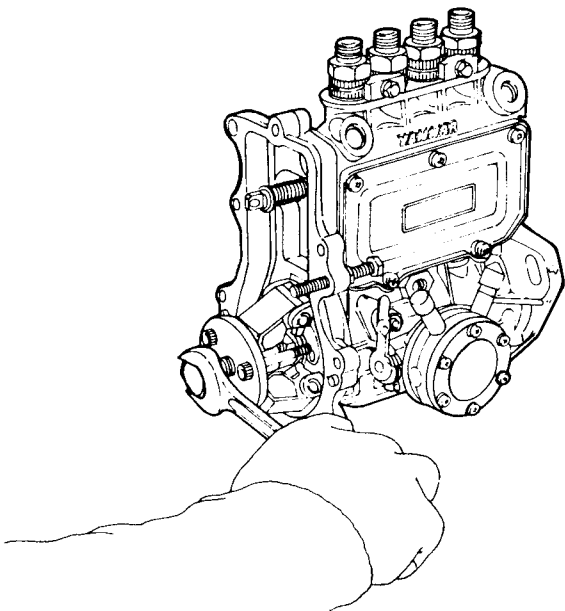
When disassembling the fuel pump, separate the parts for each cylinder and be careful not to get them mixed up. Be especially careful to keep the plunger/plunger barrel, delivery valve/delivery valve seat and other assemblies separate for each cylinder (the parts of each assembly must be kept with that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

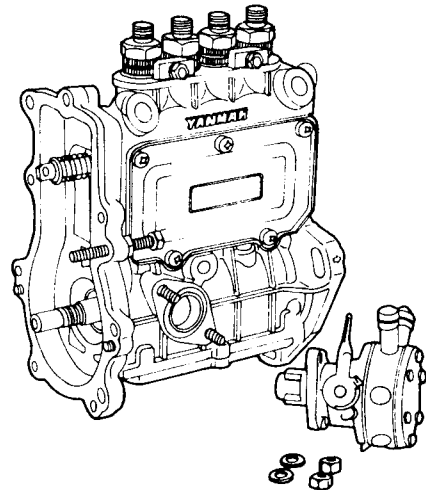
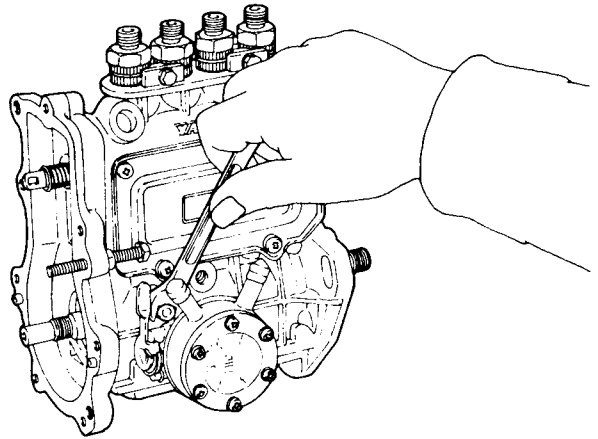


- (1) Loosen the nut with a box spanner and take it off, holding it with the hole in the fuel coupling ring or holding the coupling with a vise and take out the governor weight assembly.

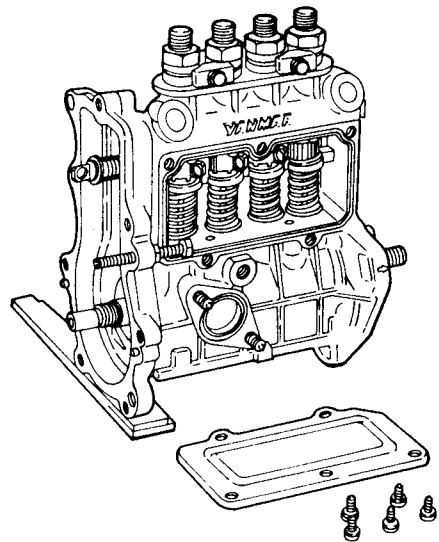


- (2) Remove the fuel feed pump.

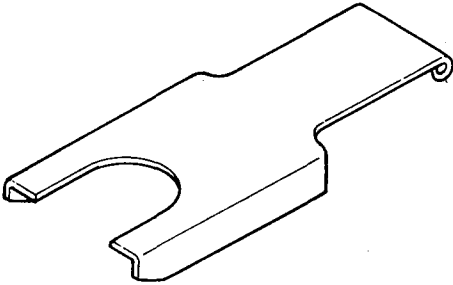
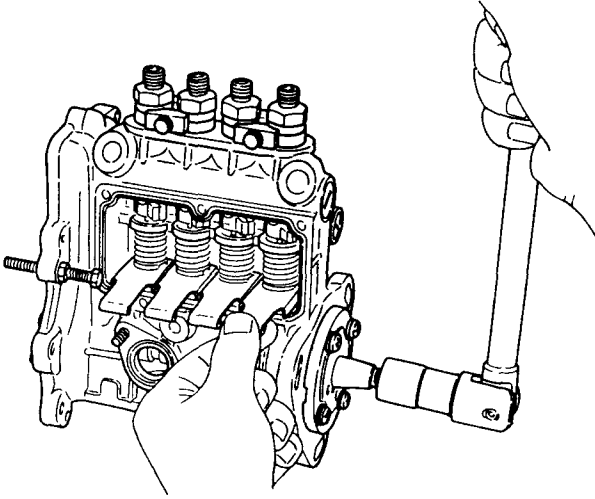
**NOTE:** Do not disassemble the fuel feed pump. See instructions for fuel feed pump for details.



- (3) Remove the fuel pump side cover.



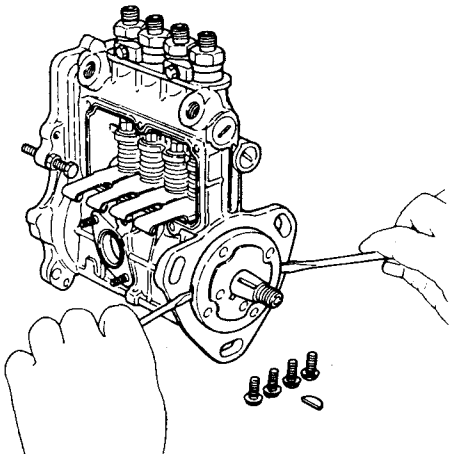
- (4) Turn the camshaft until the roller guide is at the maximum head, and insert the plunger spring support plate in between the plunger spring washer B (lower side) and fuel pump unit.



Plunger spring support plate

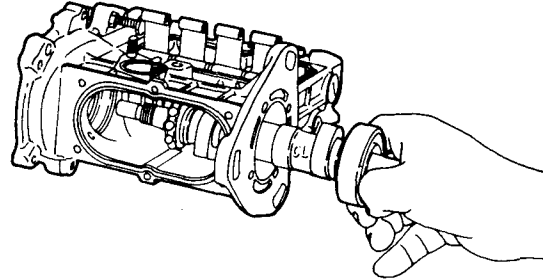
**NOTE:** If the camshaft does not turn, put double nuts on the end of the cam shaft or remove the coupling.

- (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.

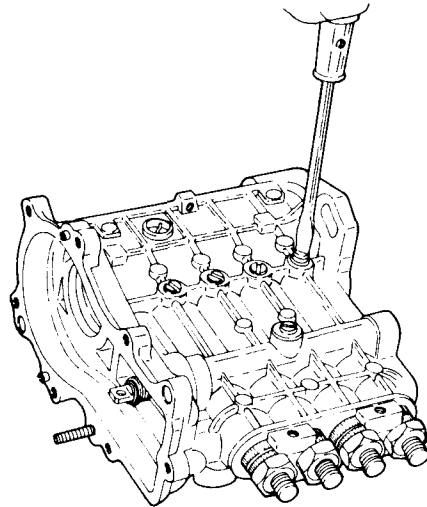


**NOTE:** 1. Make sure not to damage the oil seal with the threaded part of the camshaft.  
2. Be careful not to loose the shims in between the pump and bearing holder.

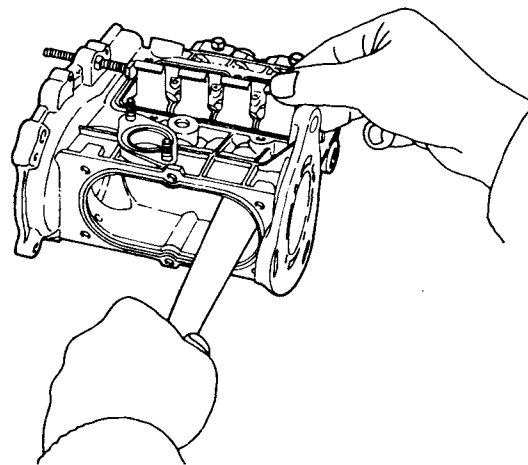
- (7) Turn the fuel pump upside down, move all the roller guides to the plunger side, and then put the pump on its side. Turn the camshaft to a position so that none of the cylinder cams hit the tappets.  
(8) Put a plate against the governor end side of the camshaft and lightly tap it, and pull out the camshaft and drive side bearing.



- (9) Remove the roller guide stop.

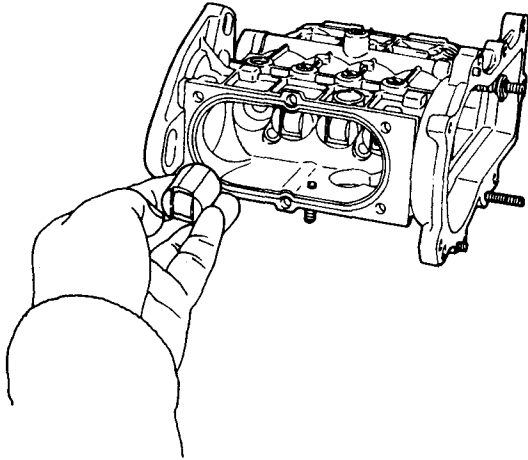


- (10) Use a hammer handle or the like to push up the roller guide from the bottom of the pump, and remove the plunger spring support plate.

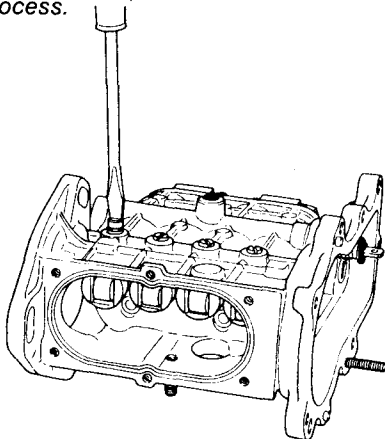


**NOTE:** The plunger spring may make the roller guide and plunger, etc. fly out when the plunger support plate is removed.

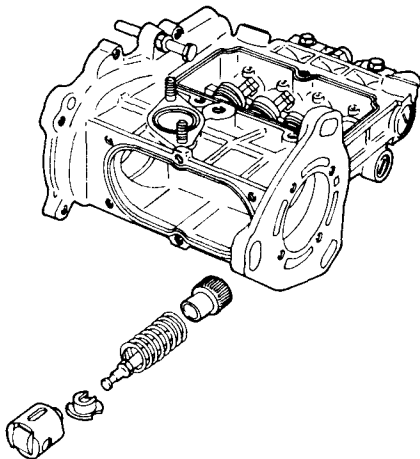
(11) Remove the roller guide.



**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.

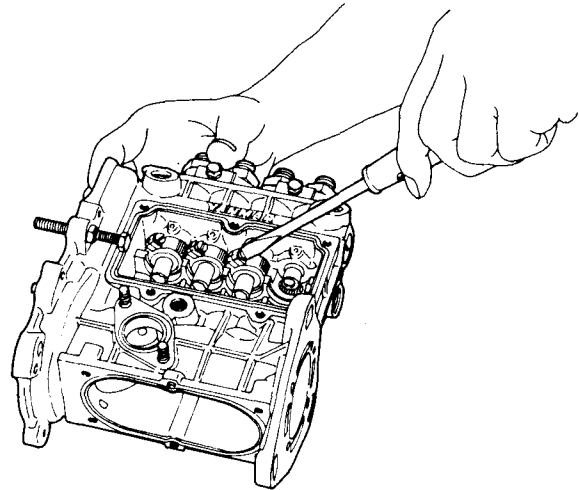


(12) Remove the plunger, plunger spring and lower washer from the lower part of the pump.

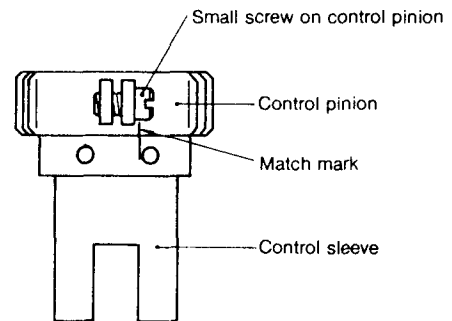


**NOTE:** Keep the parts separate for each cylinder.

(13) Loosen the small screw on control pinion.

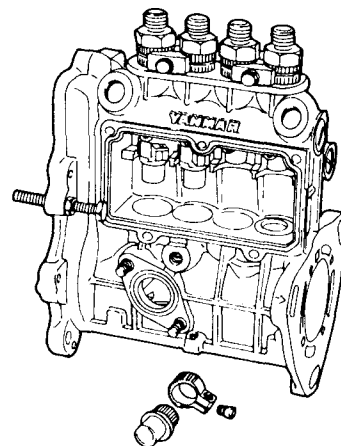


**NOTE:** 1. Check to make sure the match marks on the pinion/sleeve are correct before loosening the small screw on the control pinion, as the pinion and sleeve come apart when the screw is loosened. If the mark is hard to read or off center, lightly inscribe a new mark. This will serve as a guide when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



2. Keep parts separate for each cylinder.

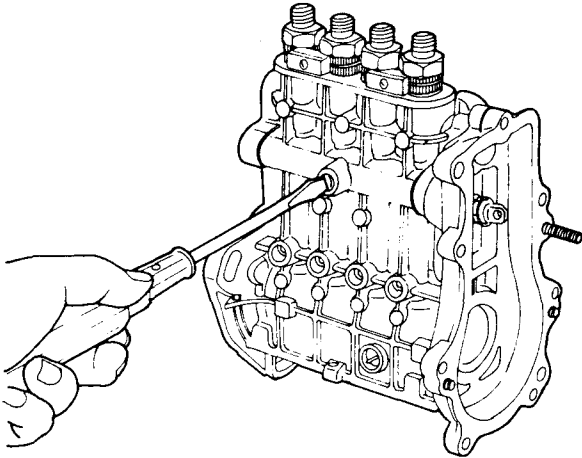
(14) Remove the control pinion, sleeve and upper rest.



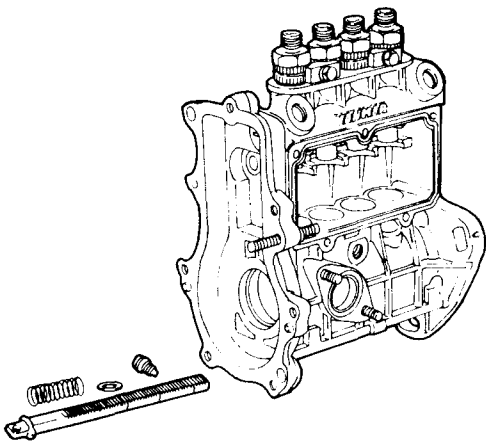
**NOTE:** Keep parts separate for each cylinder.



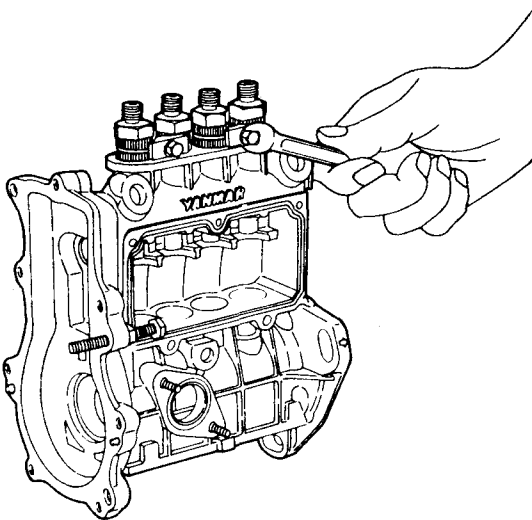
(15) Remove the control rack stop bolt and remove the rack.



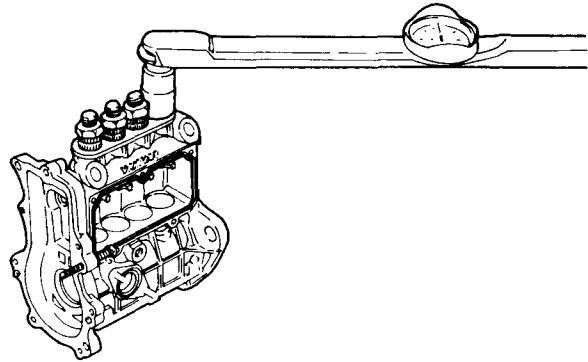
*Note:* Be careful not to lose the spring on the control rack.



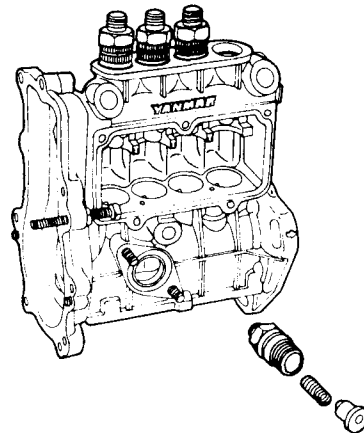
(16) Loosen the delivery valve retainer stop bolt, and remove the delivery valve holder stop.



(17) Remove the delivery valve holder.



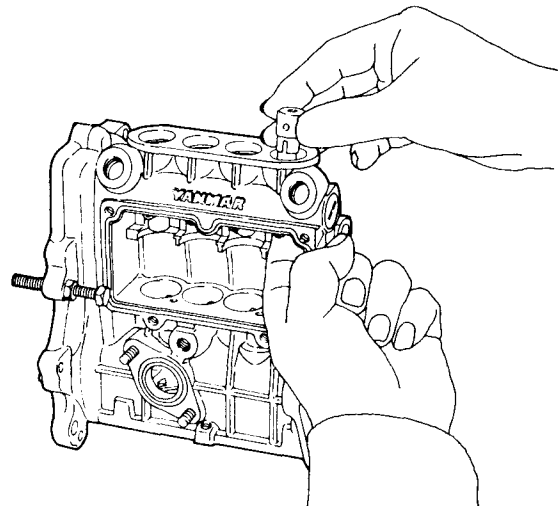
(18) Remove the delivery valve assembly.



*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.

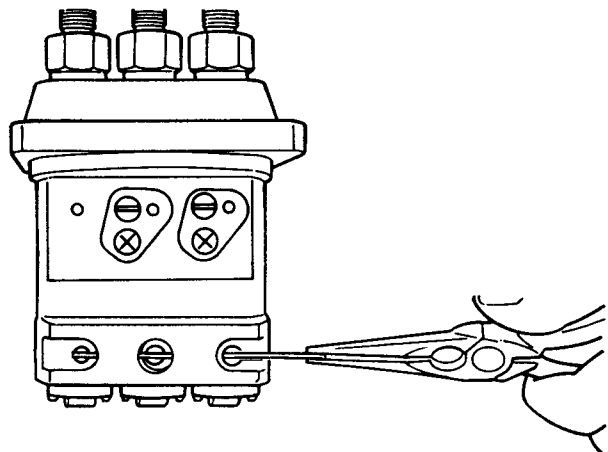


*NOTE:* Keep it as a set with the plunger that was removed earlier.

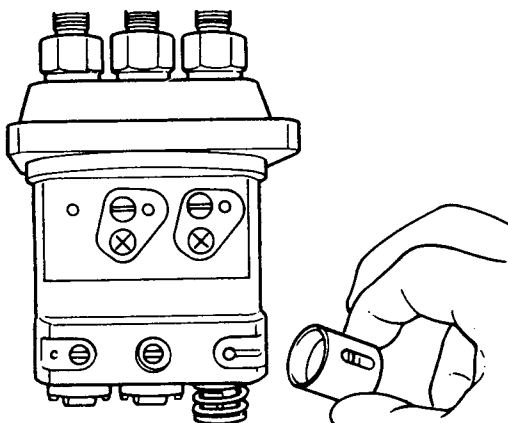
3. Disassembly, Reassembly and Inspection

Preparation (YPFR type)

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

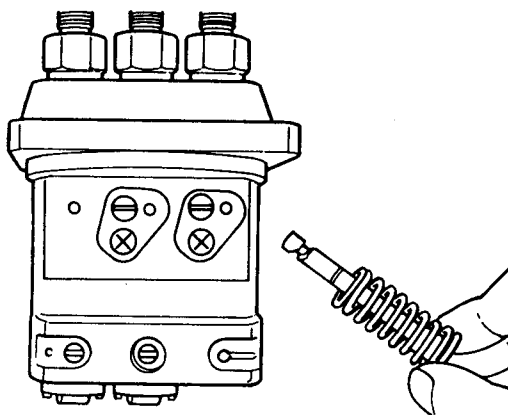


- (3) Remove the right plunger guide.

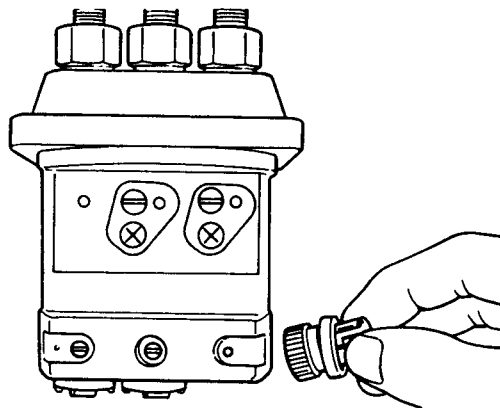


*Note: Keep the plunger stroke adjusting shims placed in the plunger guides for each cylinder clearly separated.*

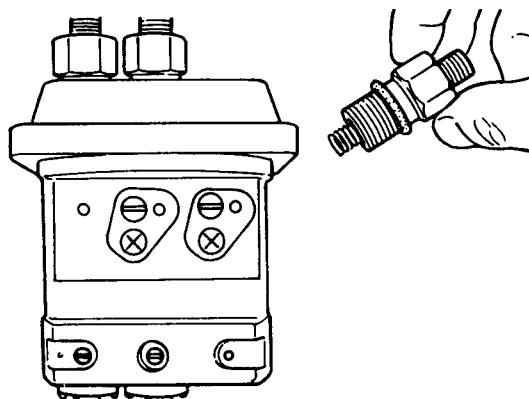
- (4) Remove the plunger spring and its lower retainer.



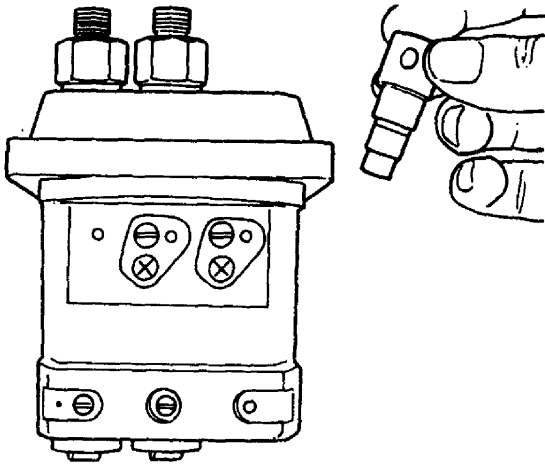
- (5) Remove the plunger spring upper retainer and the fuel control sleeve.



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



- (8) Remove the plunger barrels.



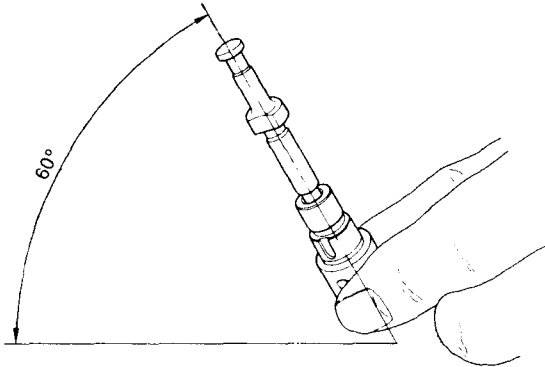
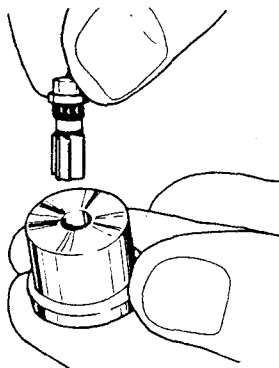
- (9) Remove the plunger barrel packing.

*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. Disassembly, Reassembly and Inspection

**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.

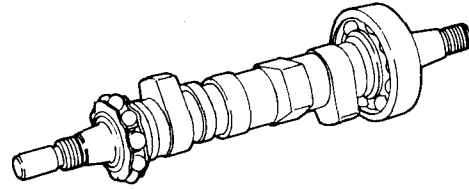
**(4) Inspection of fuel camshaft and bearings**

- 1) Fuel camshaft  
Inspect for scratches or wear of camshaft, deformation

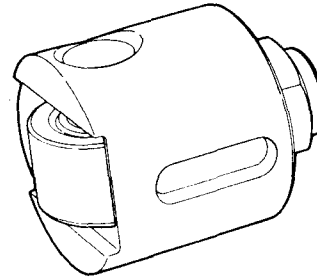
of key grooves and deformation of screws on both ends, and replace if necessary.

**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**

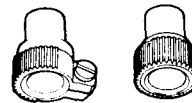
Replace if the surface is worn or flaked.

**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.

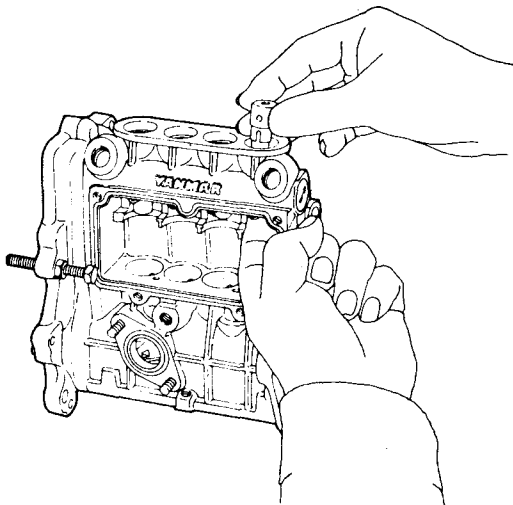
- (8) **Inspection of oil seals**  
 Inspect oil seals to see if they are burred or scratched.
- (9) **Inspection of roller guide stop**  
 Inspect the side of the tip, replace if excessively worn.
- (10) **Inspection of O-rings**  
 Inspect and replace if they are burred or cracked.

**3-3 Reassembly of fuel injection pump**

**Preparation (YPES type)**

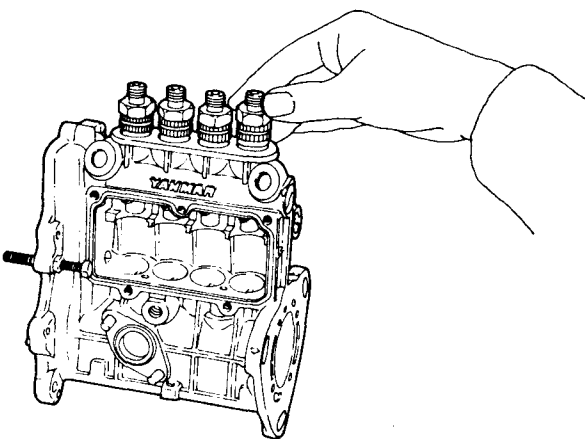
After inspection, put all parts in order and clean.  
 See Inspection of Fuel Pump for inspection procedure.

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



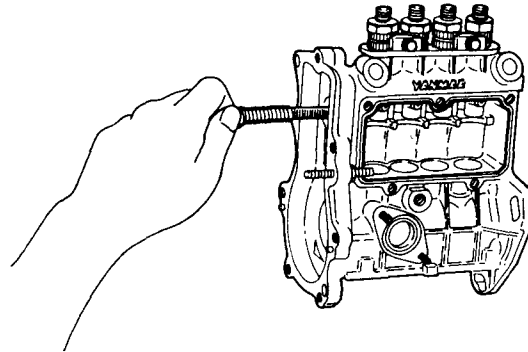
**NOTE:** Make sure the barrel key groove is fitted properly to the barrel stop pin.

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



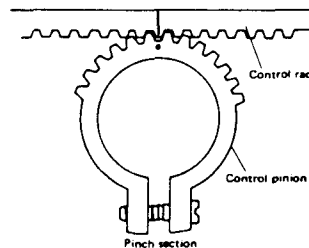
**NOTE:** Replace the delivery valve packing and O-ring.

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

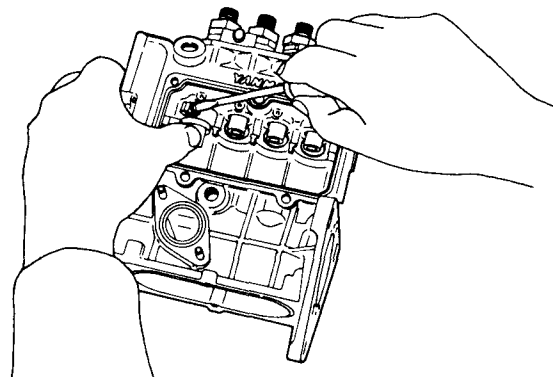


**NOTE:** 1. Do not forget the rack aux. spring.  
 2. Make sure the rack moves smoothly through a full cycle.

- (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.

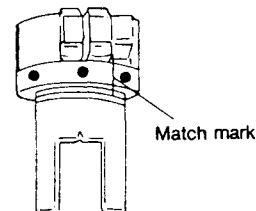


- (6) While holding the pinion with one hand and keeping it aligned with the match mark, fit in the sleeve, and lightly tighten the small pinion screw.

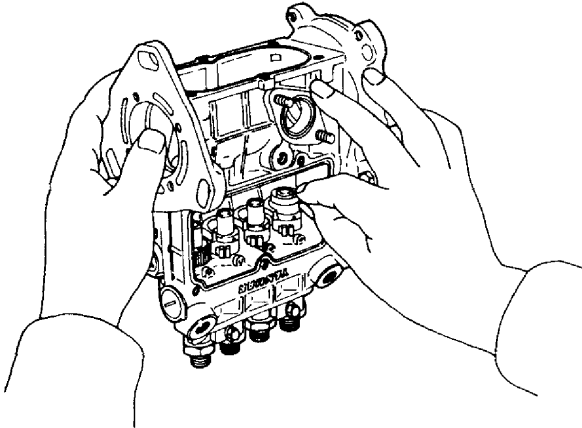


**NOTE:** Fitting of sleeve; Face towards small pinion screws and align with match mark.

Pinion/sleeve match mark



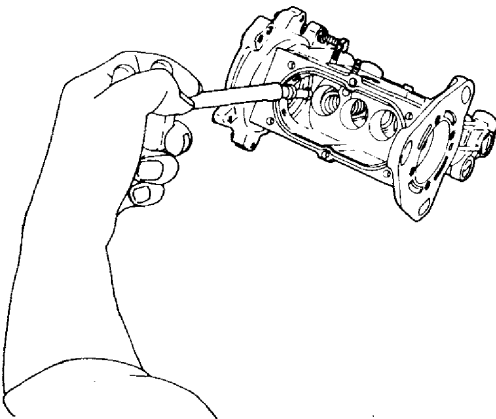
(7) Mount the plunger spring upper rest.



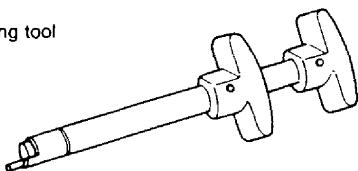
**NOTE:** 1. Make sure to mount the upper rest with the hollow side facing down.  
 2. Recheck to make sure that the rack moves easily.

(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.

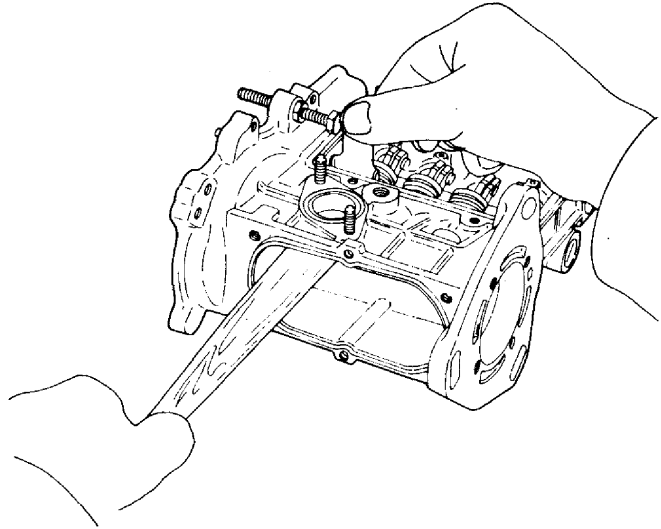


Plunger inserting tool

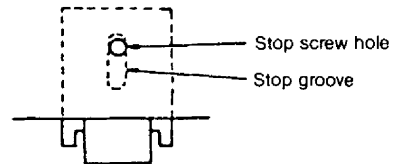


**NOTE:** If the plunger is mounted in the opposite direction, the injection volume will increase abnormally and cannot be adjusted.

(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.

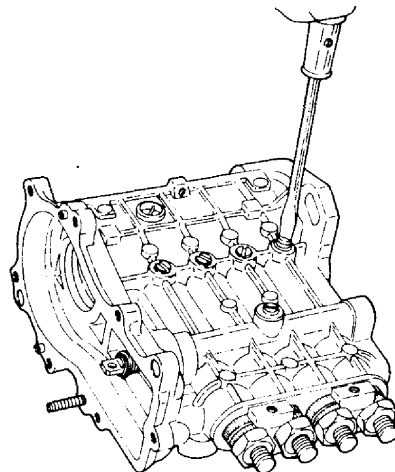


2. Check movement of rack. The plunger spring may be out of place if movement is heavy—insert a screwdriver and bring to correct position.

3. When replacing the roller guide assembly, fit shims and lightly tighten:

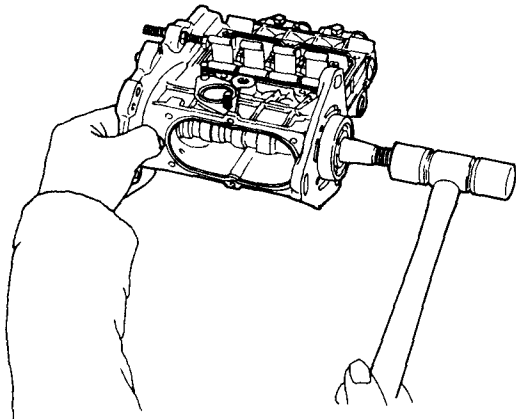
Standard shim thickness	See separate service data
Part code number	

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

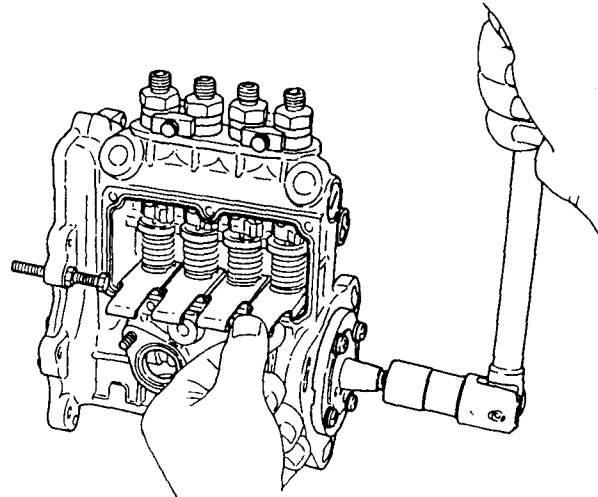


3. Disassembly, Reassembly and Inspection

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

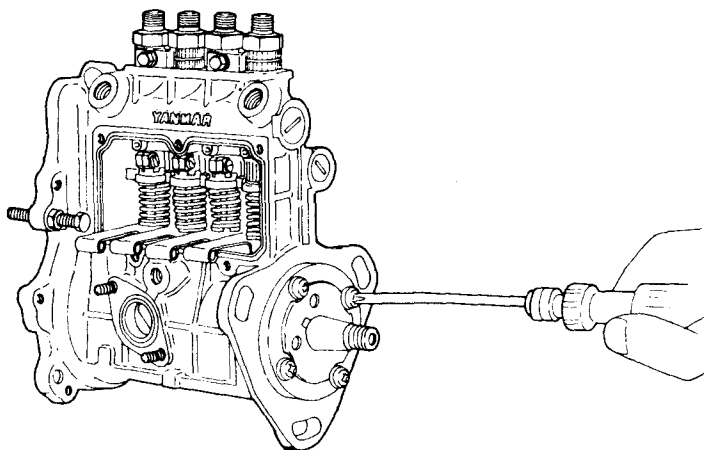


(15) Turn the camshaft, and pull out the plunger spring support plate.

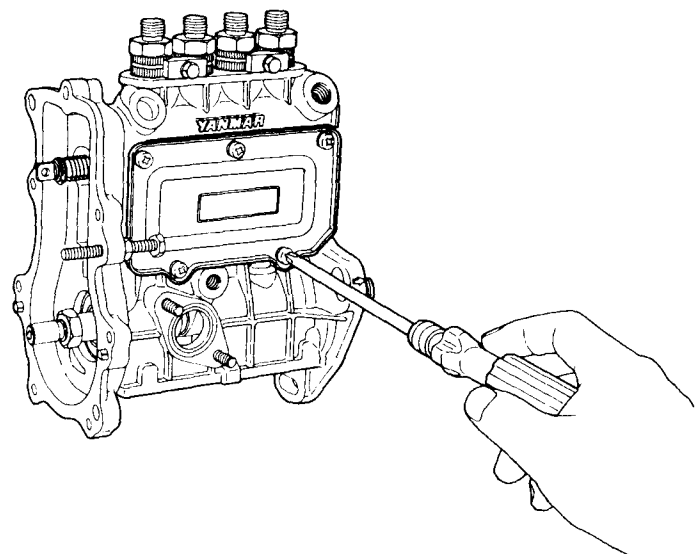


**NOTE:** Turn pump upside down, and tap camshaft in while moving roller guide to plunger spring side.

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

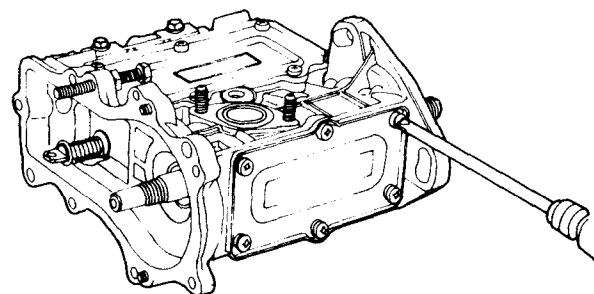


(16) Mount the fuel pump side cover.  
(17) Tap in the camshaft wood ruff key.



**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)

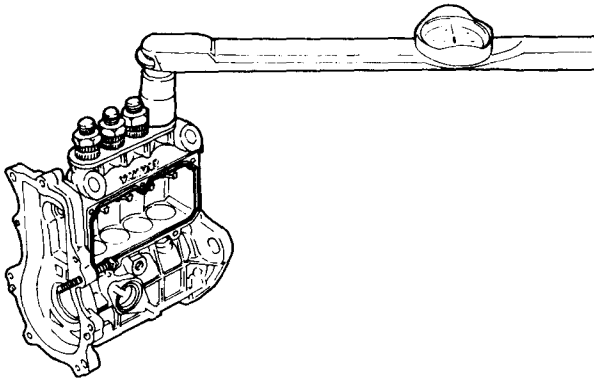
Adjusting

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)

**NOTE:** Fit double nuts to turn the camshaft.

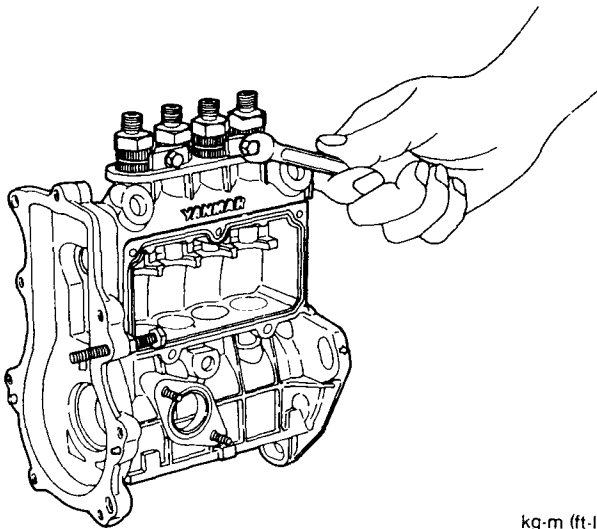
(18) Tighten delivery valve retainer.



	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.

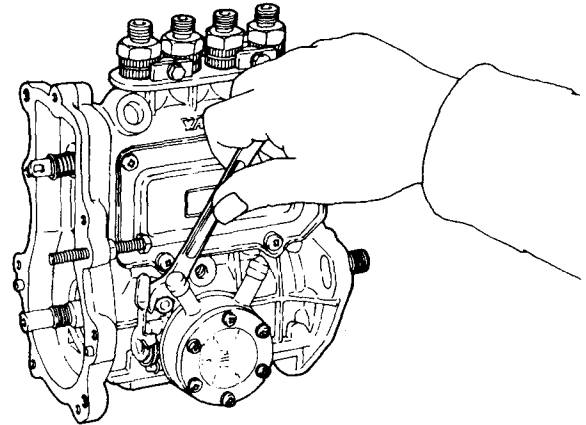
(19) Fit the delivery retainer stop and tighten the stop bolt.



	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

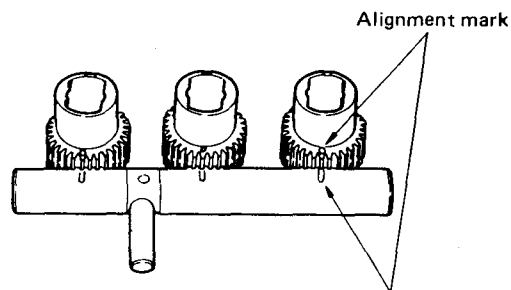
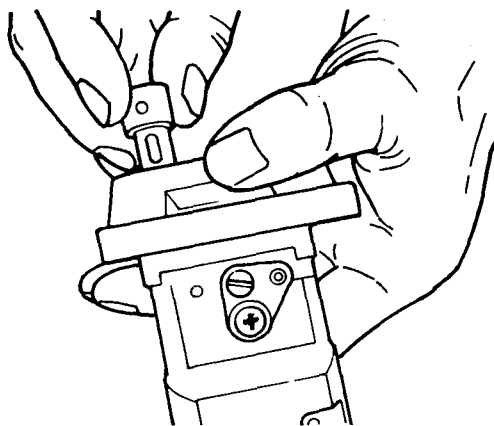


**NOTE:** See the item explaining reassembly of the fuel feed pump.



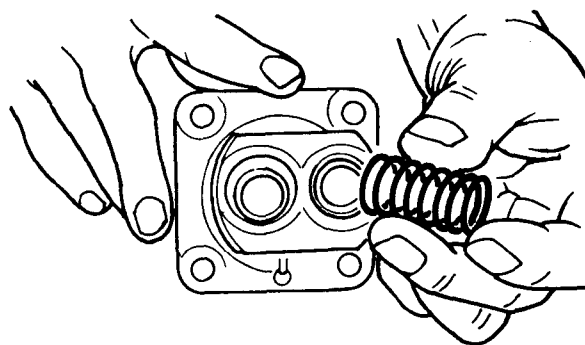
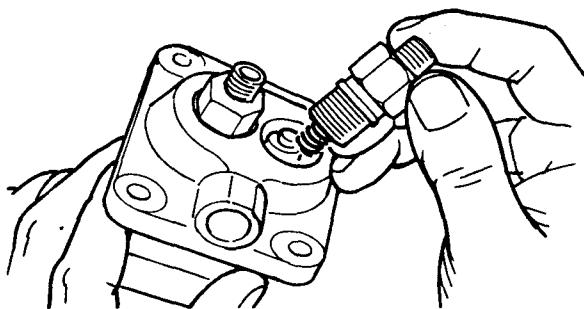
Preparation (YPFR type)

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



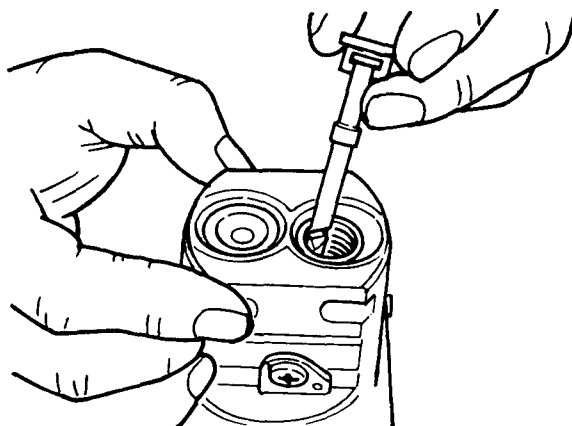
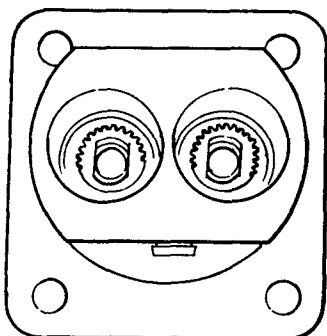
- (6) Install the upper spring retainer and the plunger spring.

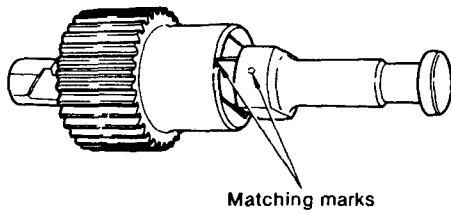
- (3) Install the delivery valve assembly and the delivery spring.



- (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.

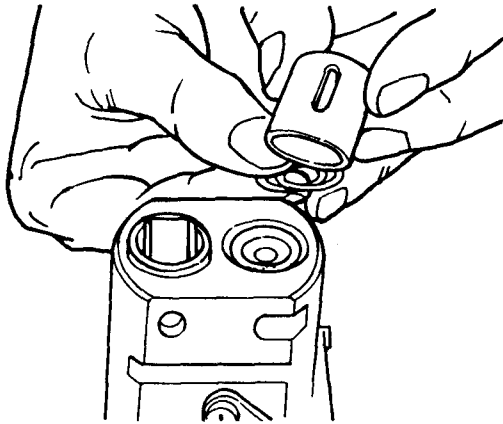
- (7) Install the plunger and the lower spring retainer.





*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.

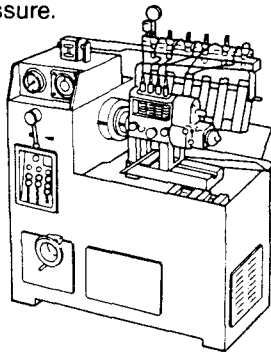
# 4. Adjustment of Fuel Injection Pump and Governor

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/cm<sup>2</sup> (lb/in.<sup>2</sup>)

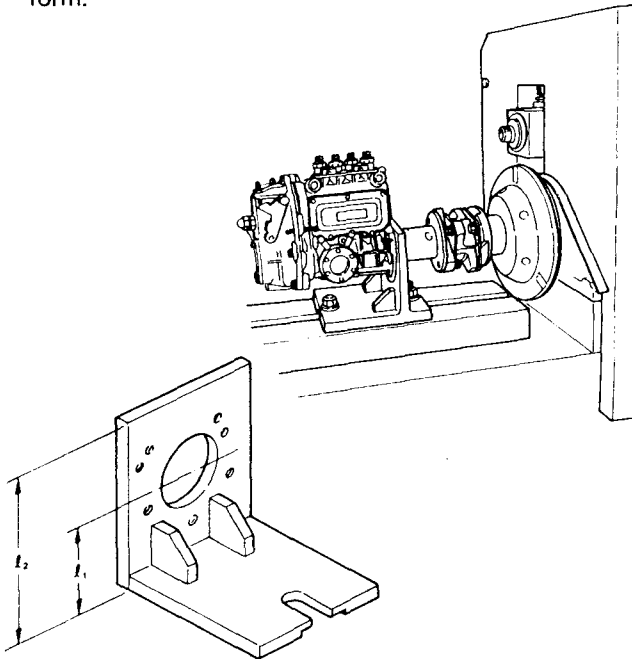
Adjusting nozzle type	YDN-12SD12
Injection starting pressure	165 ~ 175 (2346.85 ~ 2489.08)

- (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)

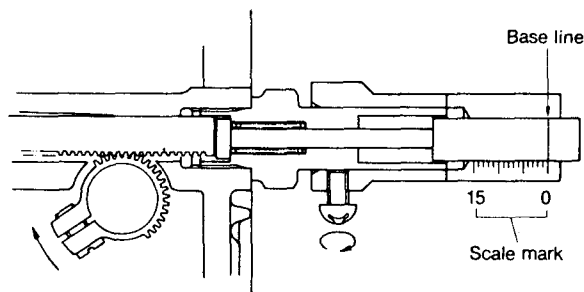
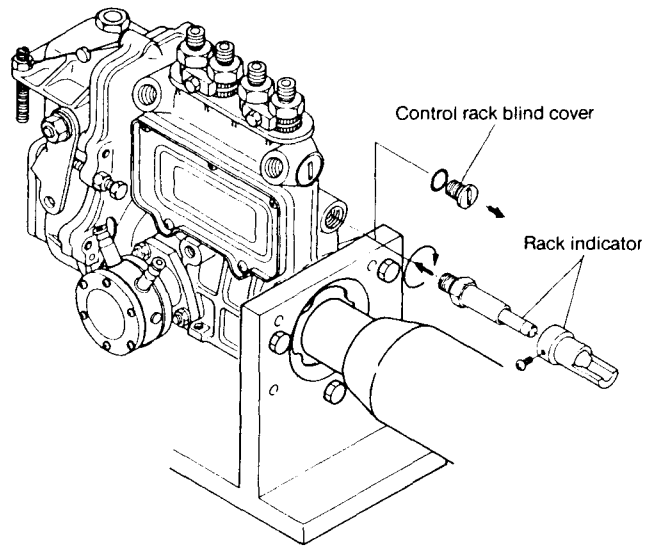
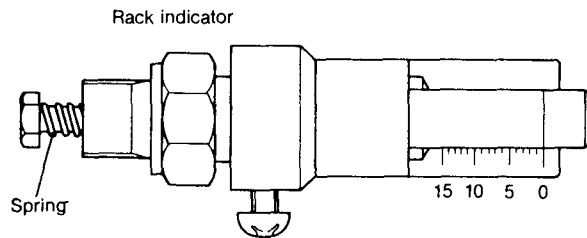
- (3) Mount the fuel injection pump on the pump tester platform.



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
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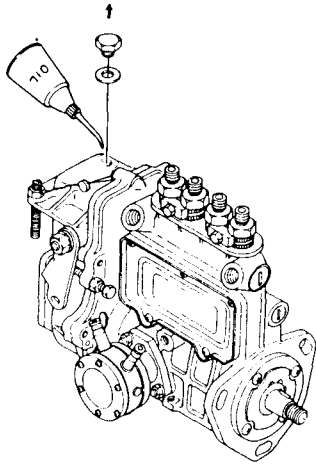
4. Adjustment of Fuel Injection Pump and Governor

(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.

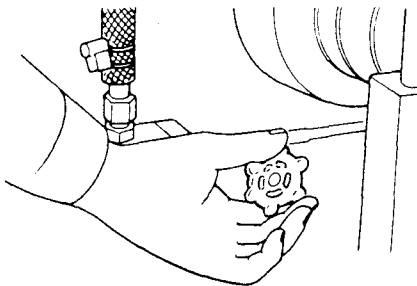
NOTE: Links are available in 1mm (0.0394in.) increments.

(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.

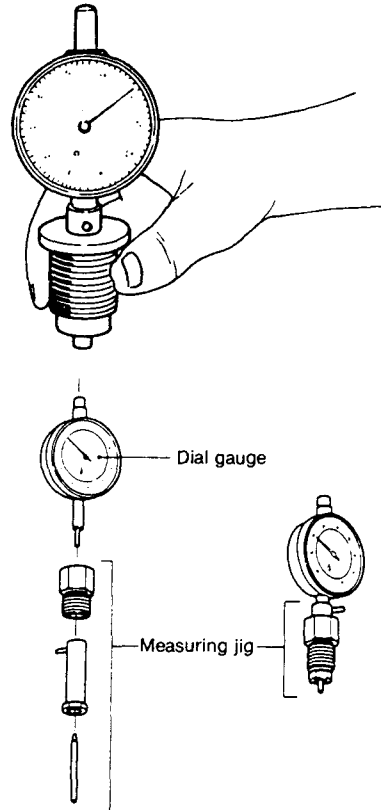
(8) Set the pressure of oil feed from pump tester to injection pump at 0.2 – 0.3 kg/cm<sup>2</sup> (2.84 – 4.26 lb/in<sup>2</sup>)



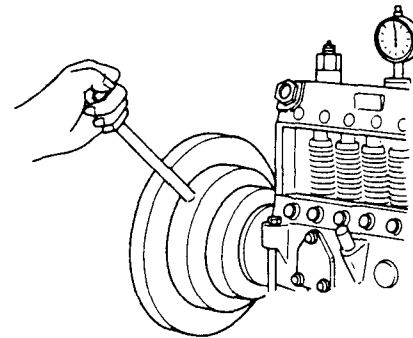
Relation between top clearance, standard shim thickness and pre-stroke.

Adjusting shim thickness	mm (in.)
	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.



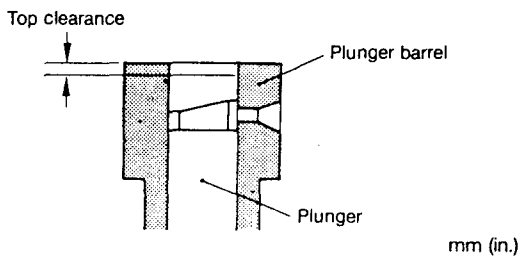
(2) Remove the injection pump delivery retainer, take out the delivery valve assembly, insert the top clearance gauge and tighten by hand.



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

4-2 Adjustment of top clearance

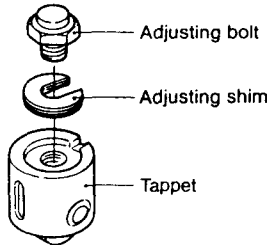
Adjust the top clearance (clearance between top of plunger and top of barrel with cam at top dead point) of each cylinder plunger to bring it to the specified value by changing the thickness of the shims.



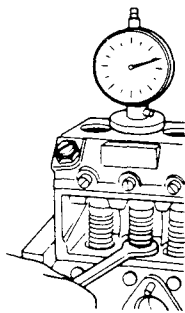
Top clearance	See separate service data (Page 3-62, 63)
Pre-stroke	
Standard shim thickness	

4. Adjustment of Fuel Injection Pump and Governor

- (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.

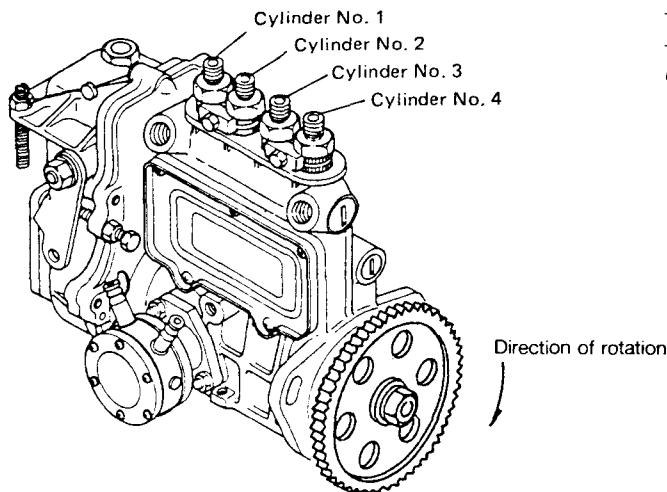
- (5) After adjustment is completed, insert the delivery valve assembly and tighten the delivery retainer.

Delivery retainer tightening torque	kg-m (ft-lb) 3.5 ~ 4.0 (25.31 ~ 28.93)
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Repeat the above procedure to adjust the top clearance of each cylinder.

4-3 Adjusting of injection timing

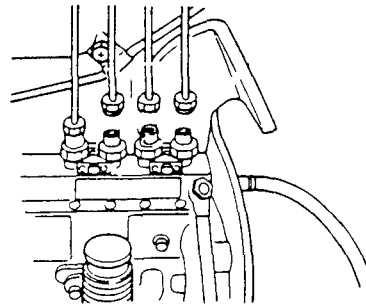
After adjusting the top clearance for all cylinders, check/adjust the injection timing.



- (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.

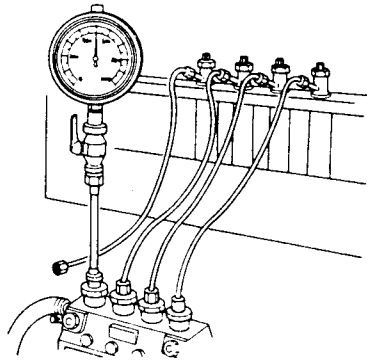
Allowable top clearance	mm (in.) 0.3 (0.0118)
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- NOTE: 1. All cylinders must be readjusted if one shows less than the allowable value.  
2. If the top clearance is less than the allowable value, the plunger will hit the delivery valve or the plunger flange will hit the plunger barrel.

4. Adjustment of Fuel Injection Pump and Governor

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/cm <sup>2</sup> (14223 lb/in. <sup>2</sup> )
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/cm<sup>2</sup> (7110 lb/in.<sup>2</sup>) or more while lightly moving the control pinion gear towards full throttle (drive side) from the pump.

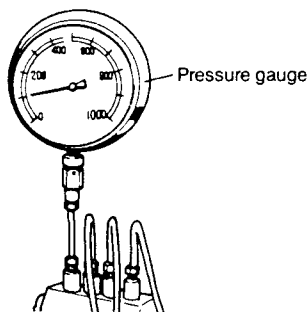
Replace the plunger if the pressure does not reach this value.

(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/cm<sup>2</sup> (1706 lb/in.<sup>2</sup>), and then stopping injection.



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

100 ~ 90 kg/cm <sup>2</sup> (1422 ~ 2702 lb/in. <sup>2</sup> )	5 seconds (to drop 10 kg/cm <sup>2</sup> (142 lb/in. <sup>2</sup> ))
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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.

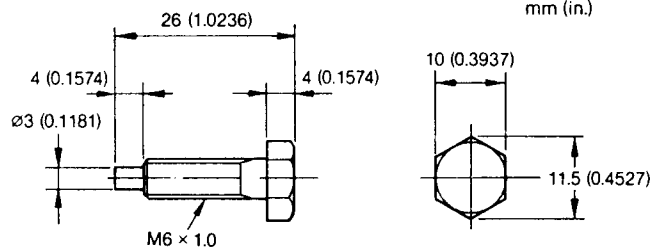
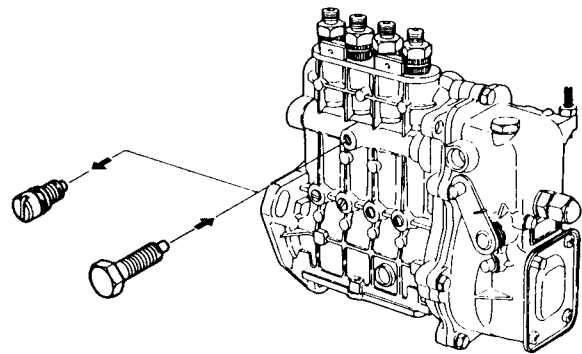
4-6.1 Measuring injection volume

(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.



Part Code No.	158090-51510
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(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

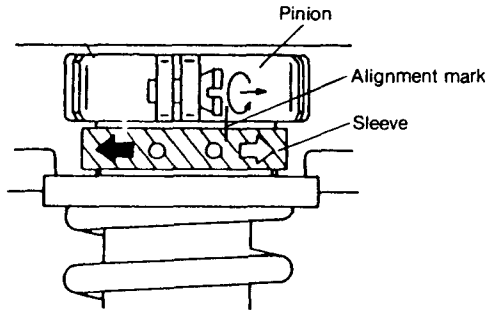
Compare the injection volume collected in measuring cylinders for each cylinder, and adjust if necessary to obtain specified value.

(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.

4. Adjustment of Fuel Injection Pump and Governor

- (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.

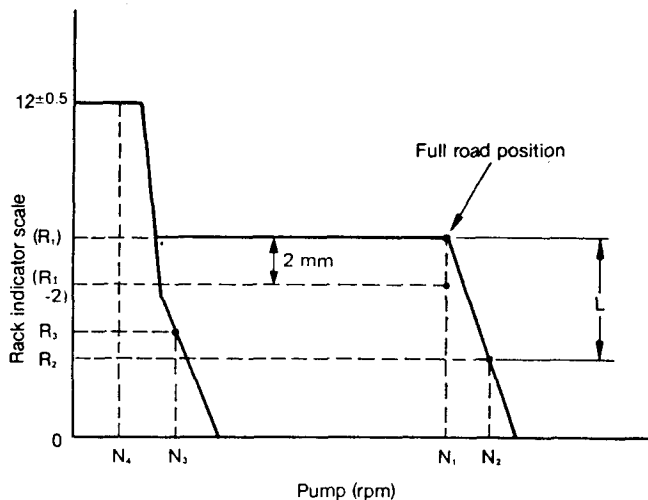
- (5) After completing measurement, firmly tighten the pinion/sleeve fixing screw.

- (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  $N_1$ .

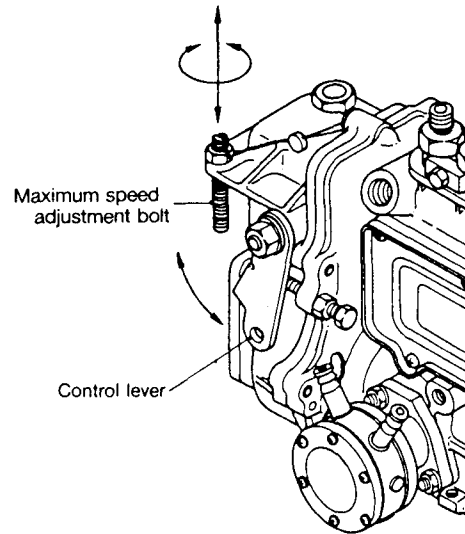


- (2) Measure fuel injection volume at rack position ( $R_1$ ). Tightening of fuel limit bolt.

- (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 ( $R_1$ ).



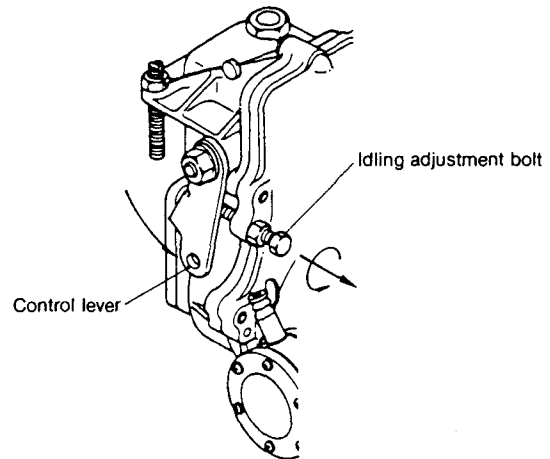
- (2) Check maximum RPM at no load

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)
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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)
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4. Adjustment of Fuel Injection Pump and Governor

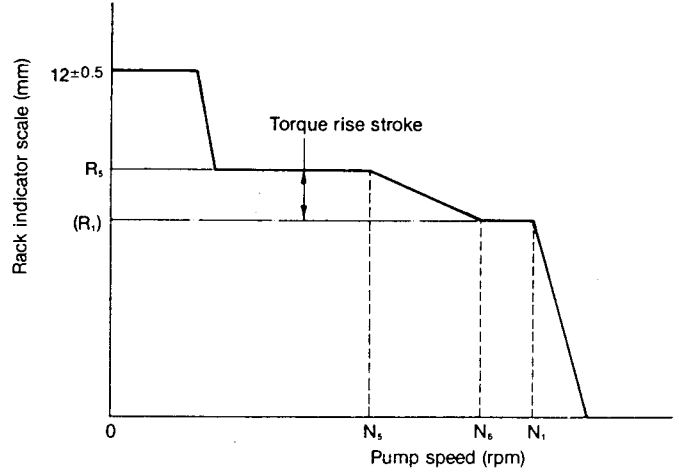
- Measure the injection volume while lowering the governor control lever to the idling position, and adjust the position of the control lever with the idling adjustment bolt to bring it to specified value.

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

4-7.4 Check injection volume when starting

- Make sure the control rack moves smoothly while gradually reducing idling rpm.
- 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)



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

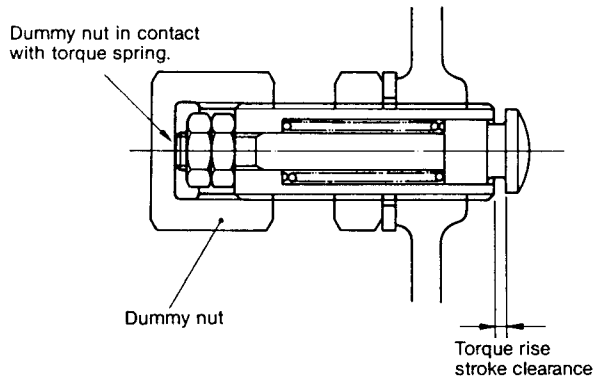
Lock nut tightening torque	2.5 ~ 3 (18.08 ~ 21.69) kg-m (lb-ft)
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NOTE: Make sure that the angleich bolt does not turn with the locknut when tightening it.

- 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 incorporated 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.

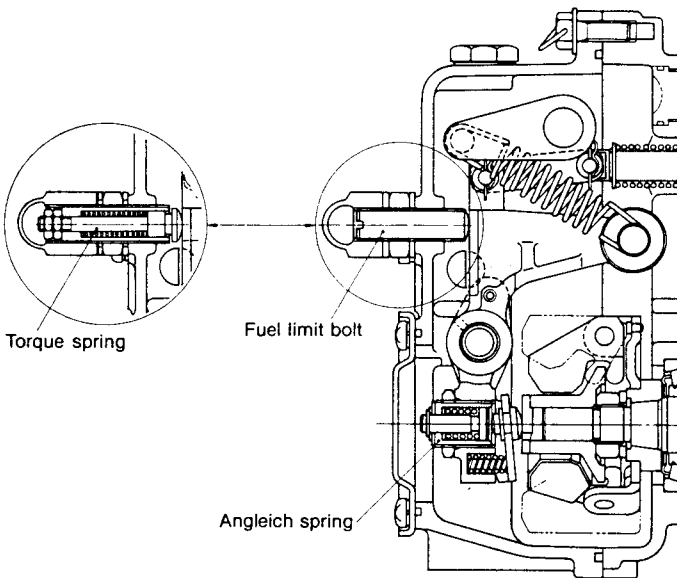
Check injection stop

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 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.

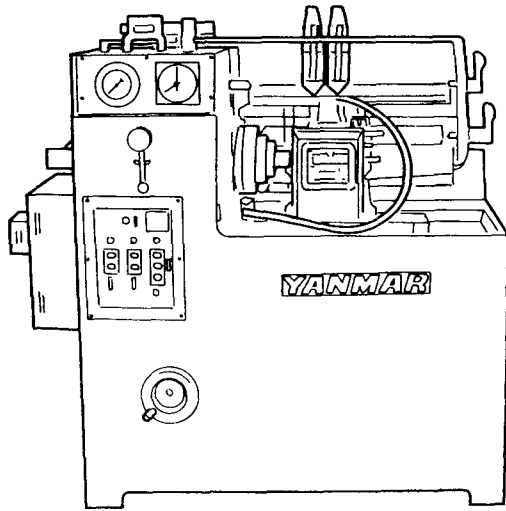
- The angleich spring is used as an assembly.
- Bring the governor control lever to the full load position, and keep pump speed at the specified peak torque ( $N_5$ ).
- Remove governor case cover in this state and screw angleich spring assembly to tension lever. Screw in from contact position with governor lever (when control lever starts to move), so that injection volume at torque rise is within specified values ( $\theta$  deg.)



4. Adjustment of Fuel Injection Pump and Governor

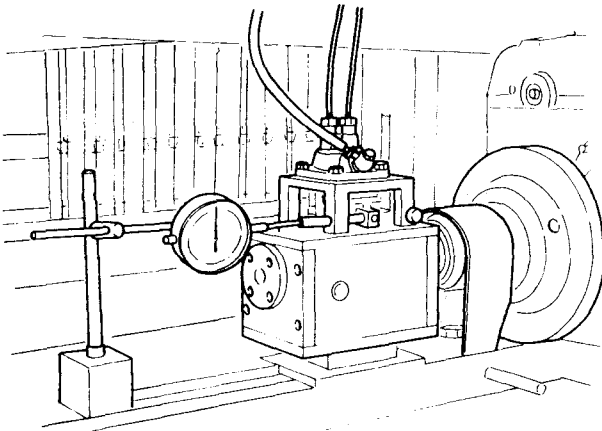
4-8 Injection pump adjustment (YPFR type)

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.).

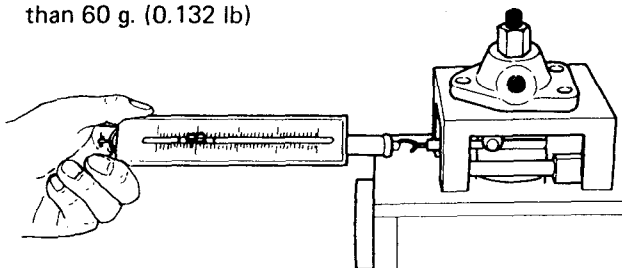


- (3) Run the pump tester at low speed, loosen the air bleeder screw, and bleed the air from the injection pump.

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)



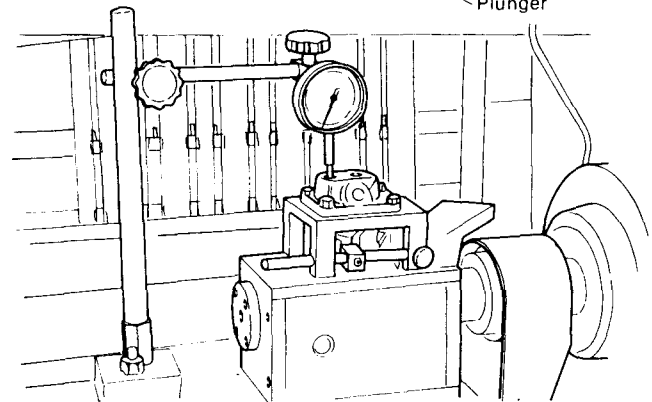
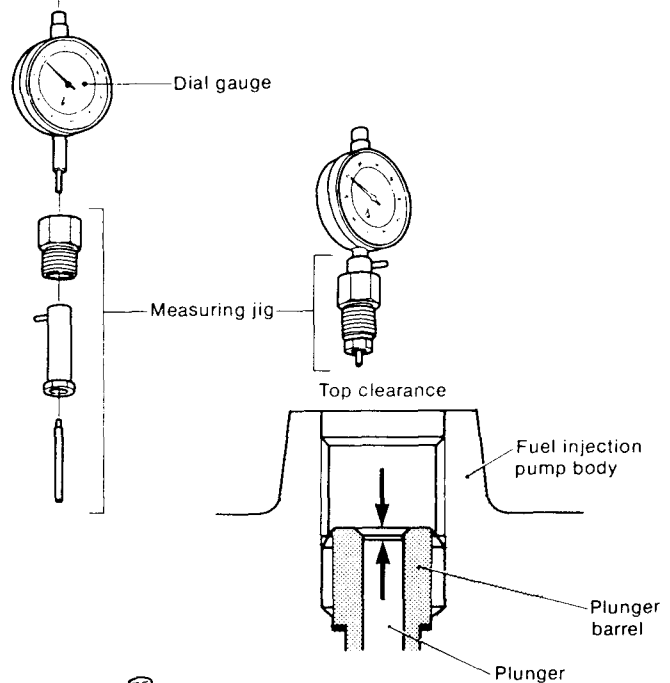
NOTE: If the sliding resistance is unsatisfactory, disassemble, inspect and repair the fuel control rack.

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  $69 \pm 0.05$  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	$1.0 \pm 0.05$ (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 0.
  - 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.



4. Adjustment of Fuel Injection Pump and Governor

- (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.

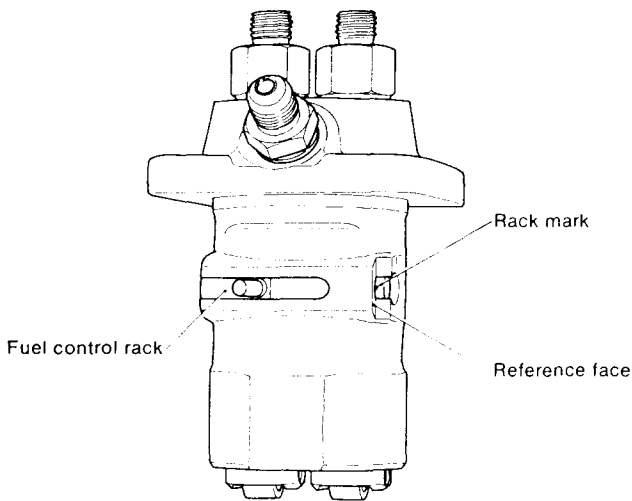
Plunger shim thickness	0.1mm (0.004in.)	119620-51250
	0.2mm (0.008in.)	
	0.3mm (0.012in.)	

- (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

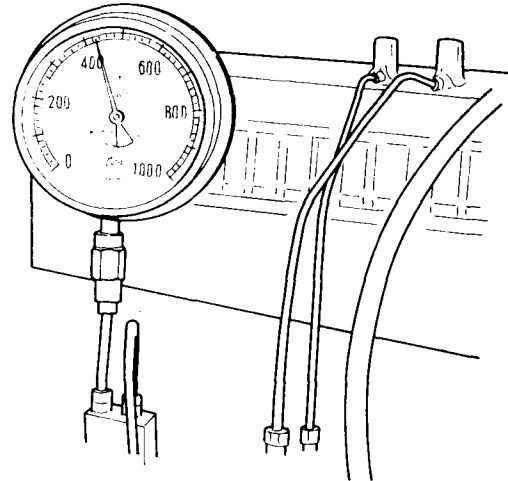
4-8.5 Delivery valve oil-tight test

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

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

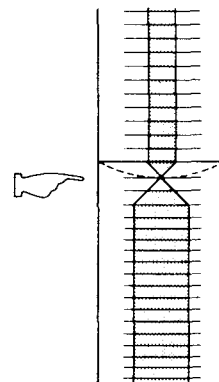
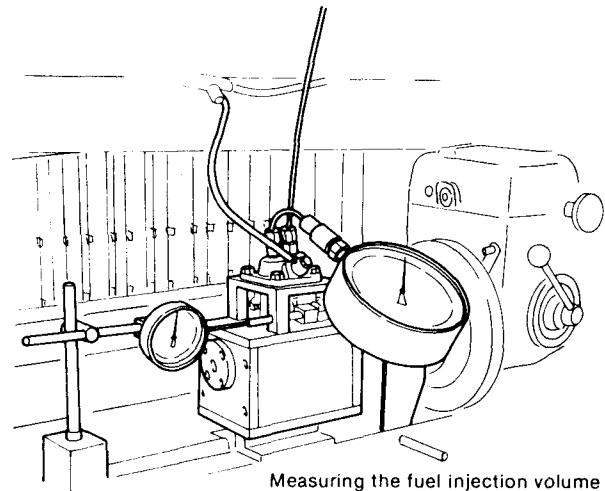
- (3) If both the plunger and the delivery valve fail the test, replace them.

4-8.6 Plunger pressure test



- (1) Install a 1,000 kg/cm<sup>2</sup> (14,223 lb/in.<sup>2</sup>) 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/cm<sup>2</sup> (7,112 lb/in.<sup>2</sup>) or higher.  
 Pressure gauge AVT 1/2 × 150 × 1,000 kg/cm<sup>2</sup>

4-8.7 Measuring the fuel injection volume



4. Adjustment of Fuel Injection Pump and Governor

- (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/cm<sup>2</sup> (7.1 lb/in.<sup>2</sup>).

4-8.8 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.

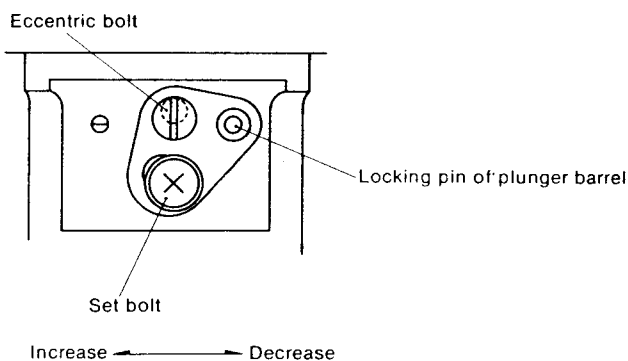
$$\text{Average injection volume} = \frac{\text{total volume of all cylinder injection}}{\text{number of cylinders}}$$

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

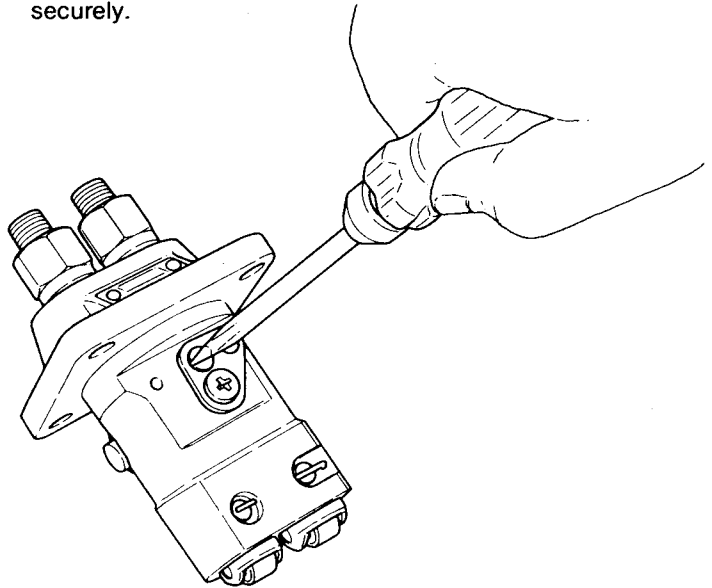
When the difference exceeds 3%, adjust the injection volume by sliding the control sleeve and pinion, when the difference exceeds 3%, the engine output will drop and/or one cylinder will overheat.

- (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.



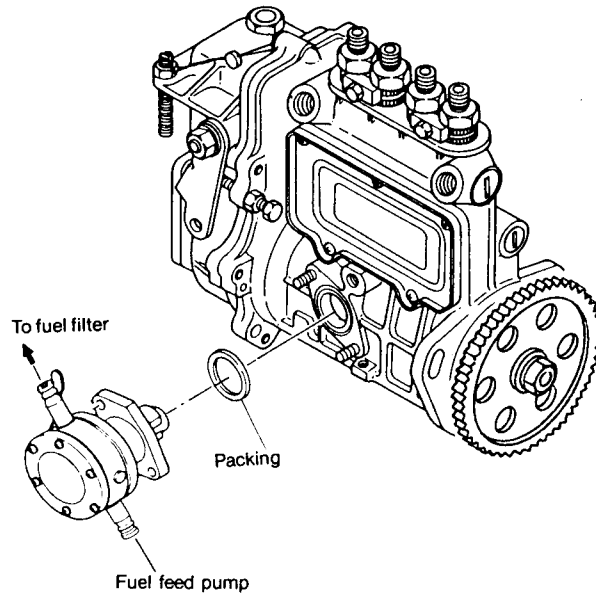
By loosening the set bolt and turning the eccentric bolt clockwise, the position of the pin moves to the leftside to increase the injection volume, and by turning the eccentric bolt counterclockwise, the pin moves to the rightside to decrease the injection volume. After adjusting the injection volume,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



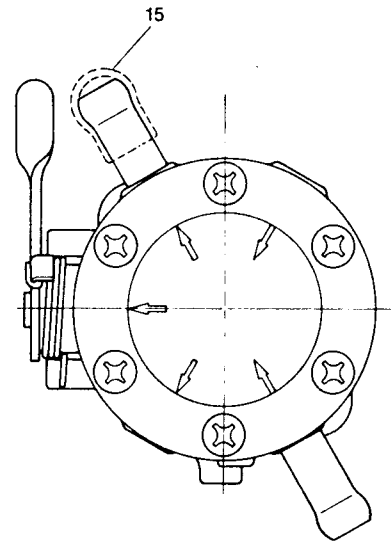
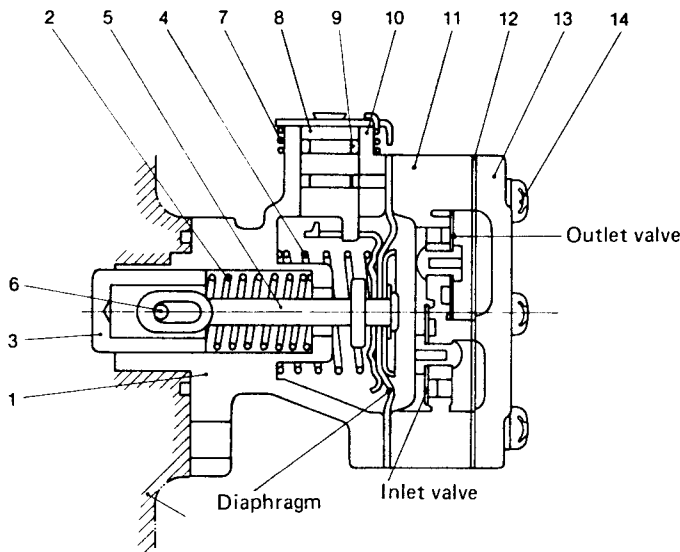
# 5. Fuel Feed Pump

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.

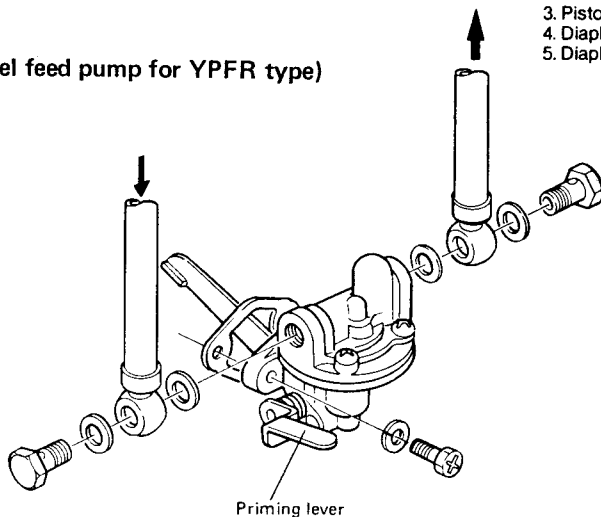


## 5-1 Construction of fuel feed pump (Fuel feed pump for YPES type)



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

## (Fuel feed pump for YPFR type)



5. Fuel Feed Pump

5-2 Fuel feed pump specifications

(YPES)

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

(YPFR)

Feed pressure	0.1 kgf/cm <sup>2</sup> (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.

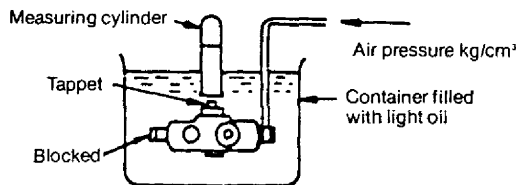
5-3.2 Reassembly

- (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

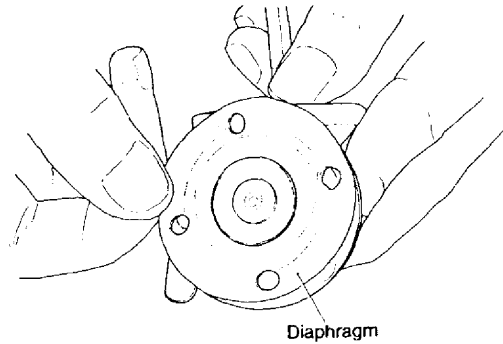
- (1) Place the fuel feed pump in kerosene, cover the discharge port with your finger, move the priming lever and check for air bubbles (Repair or replace any part which emits air bubbles).



- (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.

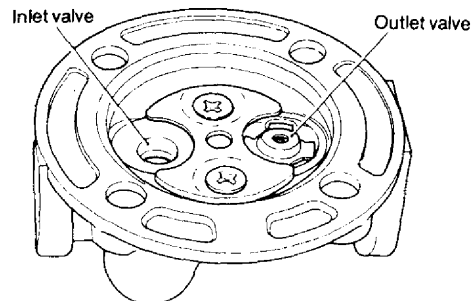
(3) Diaphragm inspection

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.

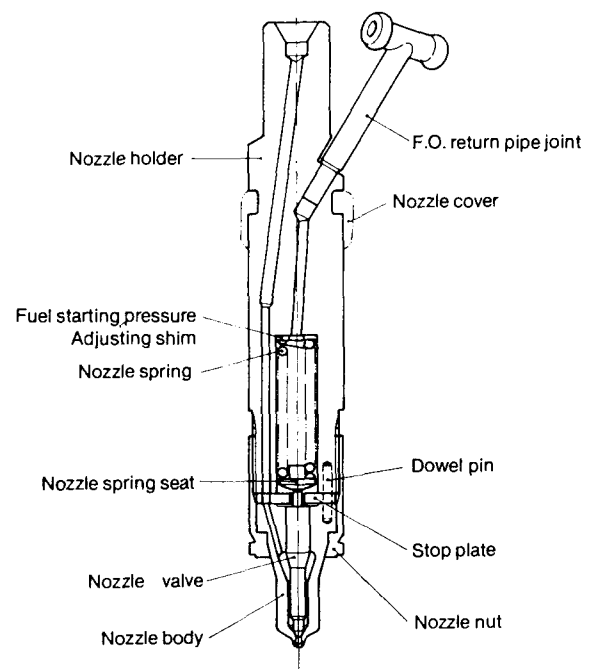
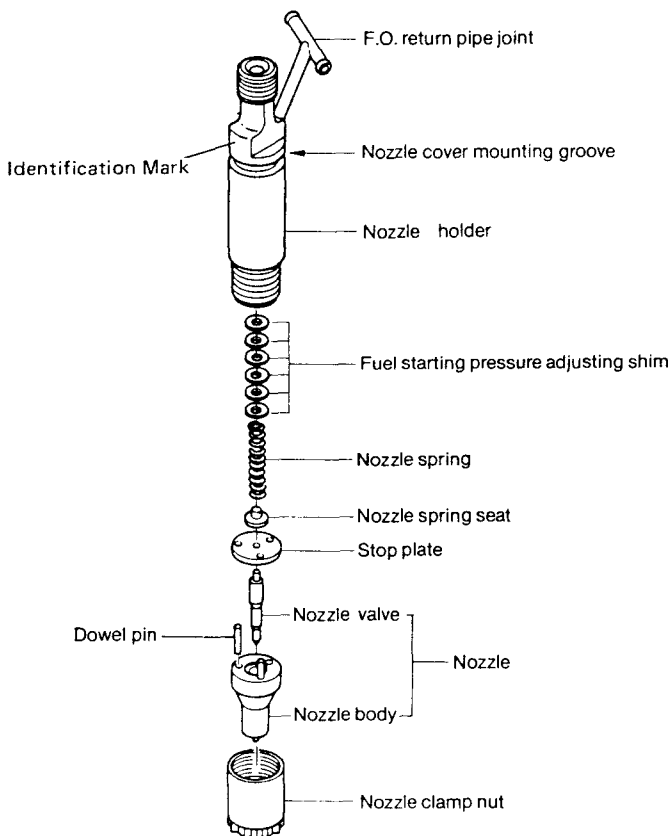
## 6-2 Type/construction of fuel injection nozzle

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.

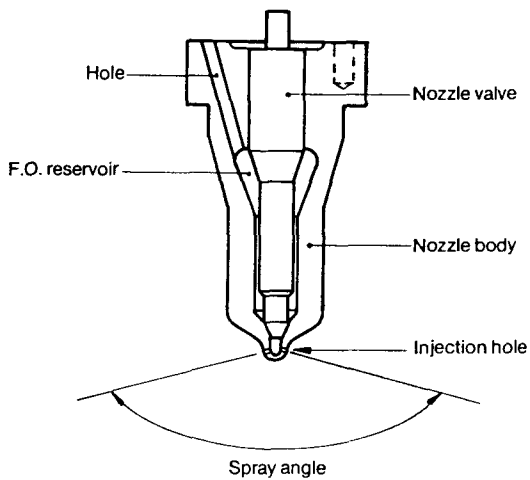
The YPES-CL fuel injection pump is designed for use with both direct and indirect injection engines. The hole type/pintle type of fuel injection nozzles are used according to the engine type.

The type of fuel injection nozzle used depends on the type of engine.

### (1) Hole type fuel injection nozzle

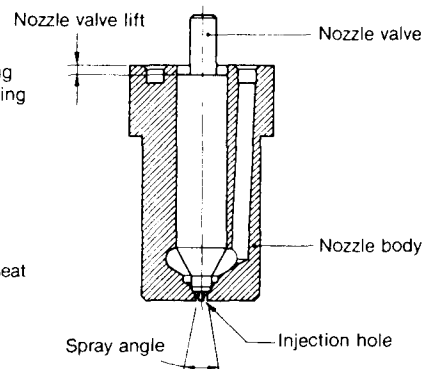
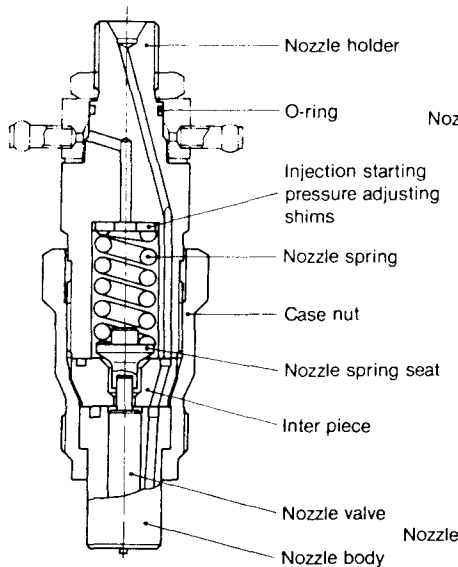
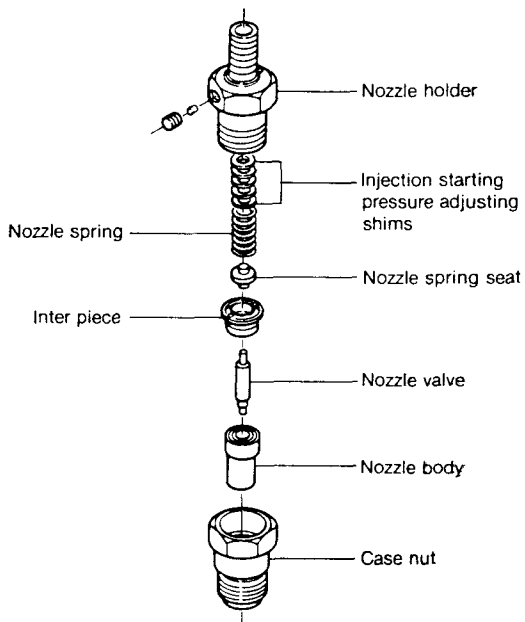


6. Fuel Injection Nozzle



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

(2) Pintle type fuel injection nozzle



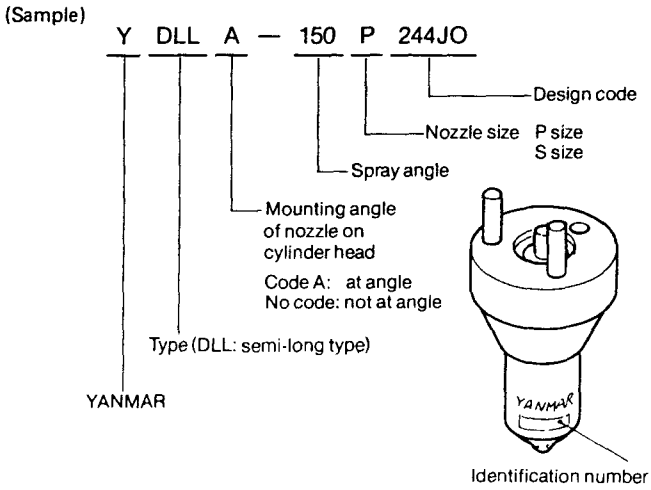
Nozzle type	YDN-PD
Nozzle opening pressure	120 kg/cm <sup>2</sup>
Identification No.	YDN-OPD2

6. Fuel Injection Nozzle

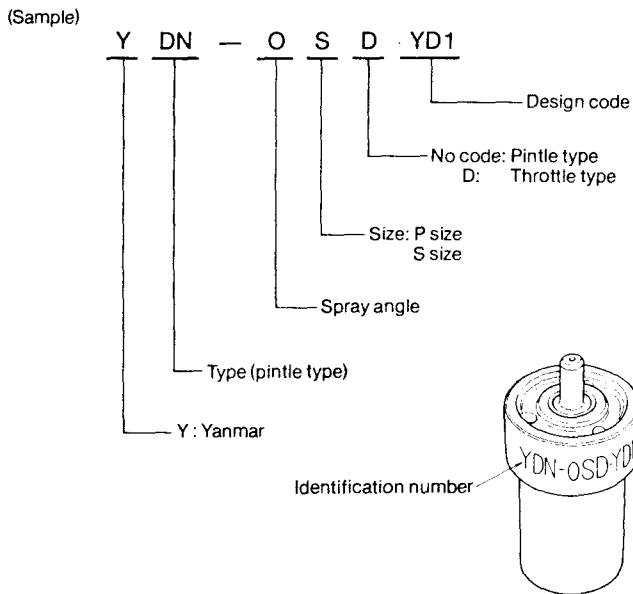
(3) Nozzle body identification number

The type of nozzle can be determined from the number inscribed on the outside of the nozzle body.

1) Hole type fuel injection nozzles



2) Pintle type fuel injection nozzles

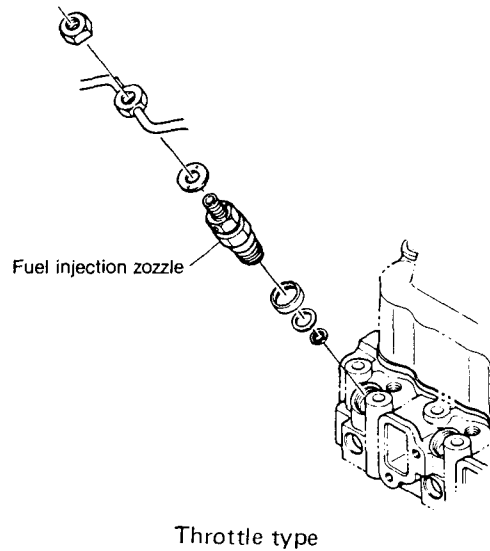
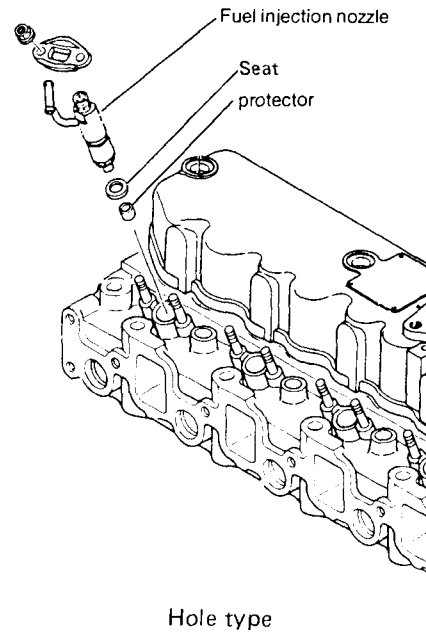


6-3 Fuel injection nozzle disassembly

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.

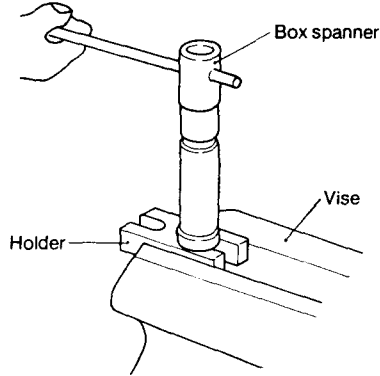




(2) Put the nozzle in a vise

**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.)).

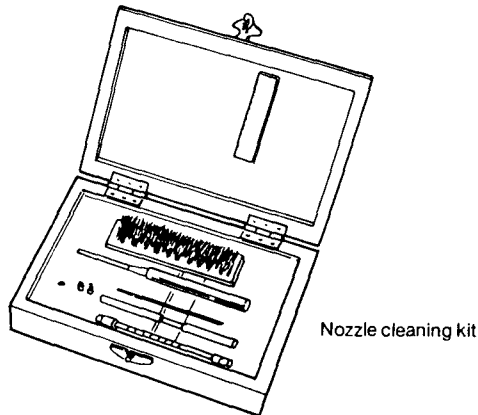
(4) Remove the inner parts

**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

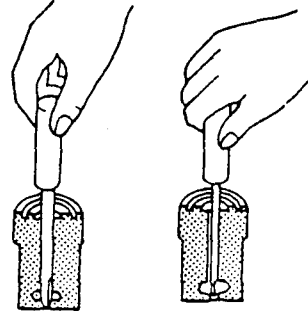
- (1) Make sure to use new diesel oil to wash the fuel injection nozzle parts.
- (2) Wash the nozzle in clean diesel oil with the nozzle cleaning kit.



- 1) Diesel Kiki nozzle cleaning kit:  
Type NP-8486B No. 5789-001
- 2) Anzen Jidosha Co., Ltd. nozzle cleaning kit:  
Type NCK-001

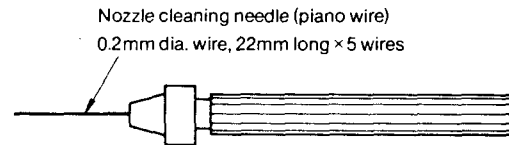
(3) Clean off the carbon on the outside of the nozzle body with a brass brush.

(4) Clean the nozzle seat with cleaning spray.



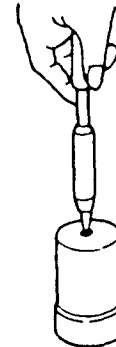
(5) Clean off the carbon on the tip of nozzle with a piece of wood.

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



Part code no.	28210-000010
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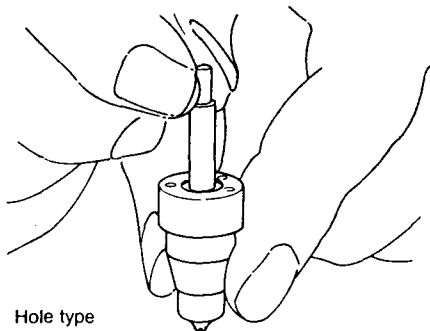
(7) Clean pintle type nozzles with a cleaning needle.



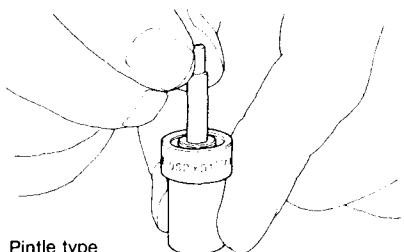
### 6-4.2 Nozzle inspection

- (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.

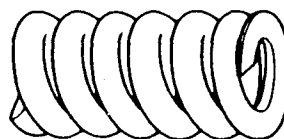


Hole type



Pintle type

- (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.

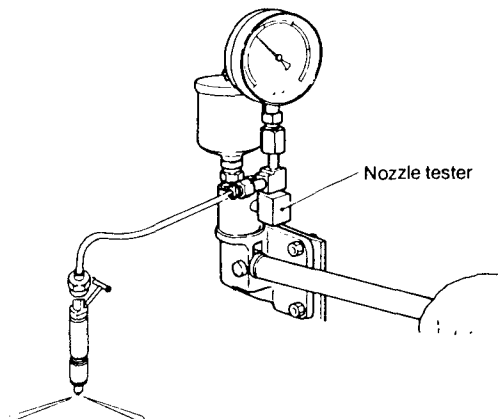
- (1) Insert the adjusting shims, nozzle spring and nozzle spring seat in the nozzle holder, mount the stop plate with the pin, insert the nozzle body/nozzle set and tighten the nut.
- (2) Use the special holder when tightening the nut for the hole type nozzle as in disassembly.

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

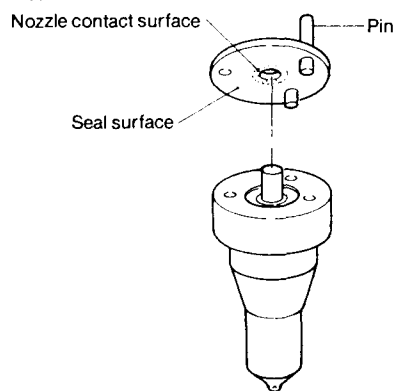
#### 6-6.1 Adjusting opening pressure

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).

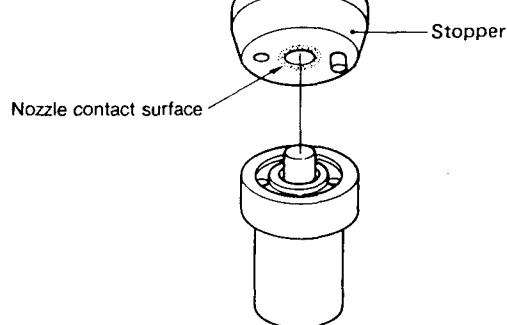


- (3) Inspecting stopper  
Check for scratches/wear in seals on both ends, check for abnormal wear on the surface where it comes in contact with the nozzle; replace if stop plate is excessively worn.

Hole type



Pintle type



mm (in.)

Nozzle contact surface wear limit	0.1 (0.0039)
-----------------------------------	--------------

6. Fuel Injection Nozzle

Injection starting pressure

	kg/cm <sup>2</sup> (lb/in. <sup>2</sup> )
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/cm<sup>2</sup> (284 lb/in.<sup>2</sup>) 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:

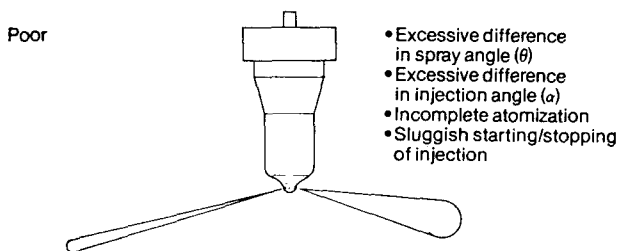
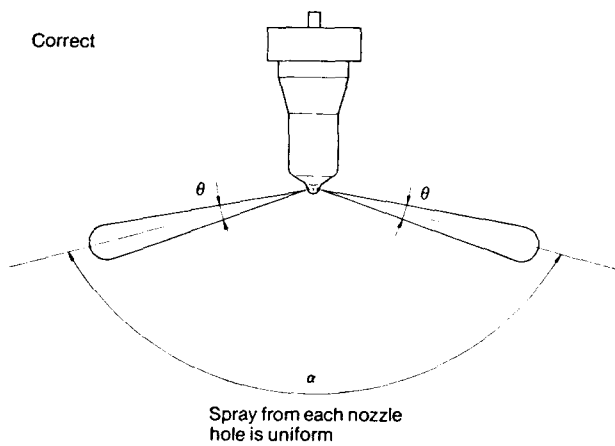
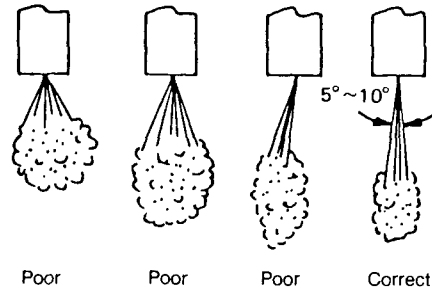
- Proper spray angle ( $\theta$ )
- Correct injection angle ( $\alpha$ )
- Complete atomization of fuel
- Prompt starting/stopping of injection

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/cm<sup>2</sup>.
- (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.

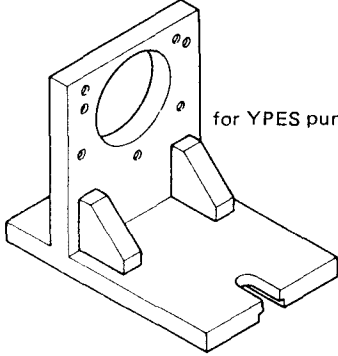
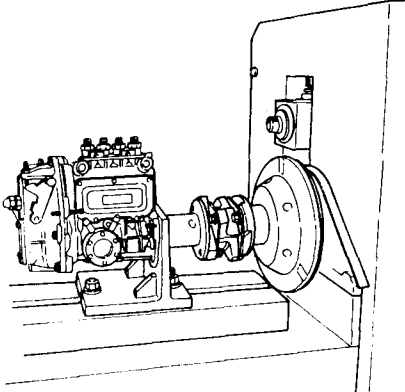
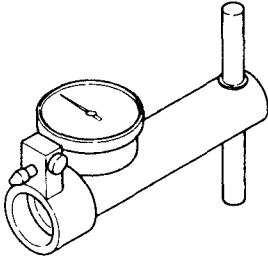
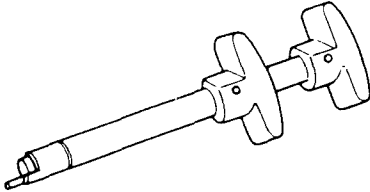
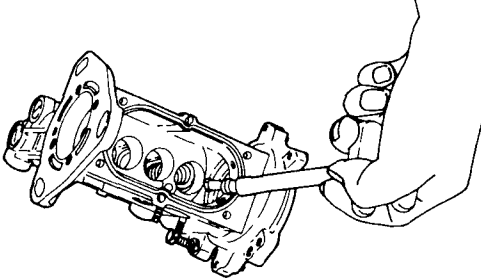
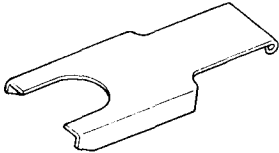
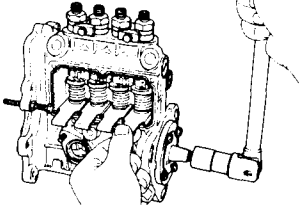
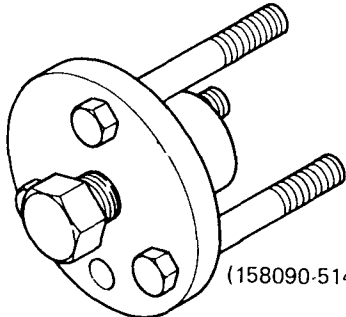
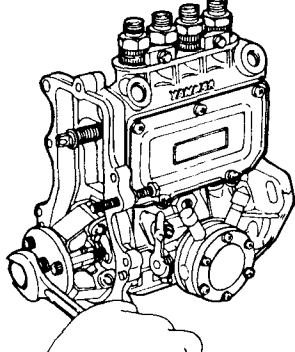
### 2. Major faults and troubleshooting

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

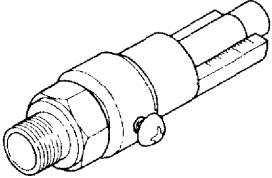
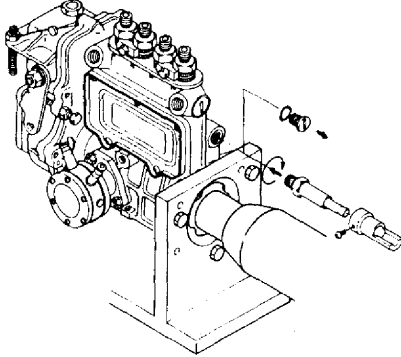
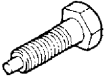
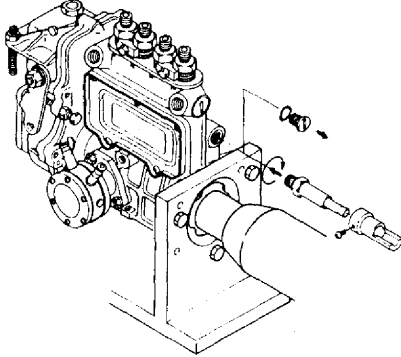

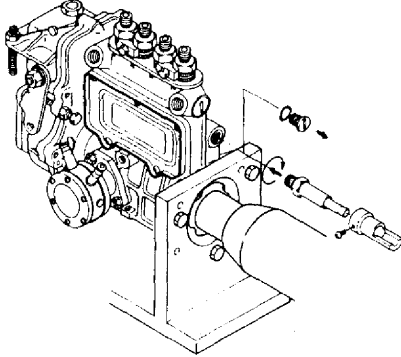
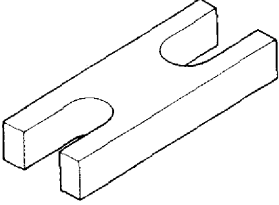
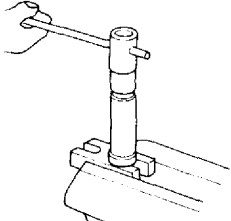
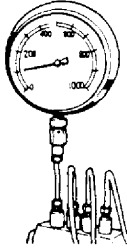
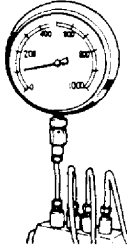
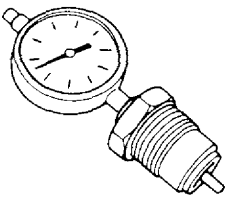
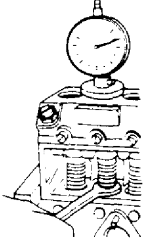
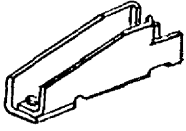
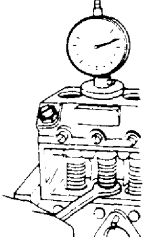
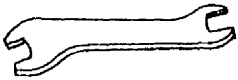
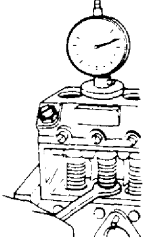
## 7. Troubleshooting

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

# 8. Tools

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

8. Tools

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

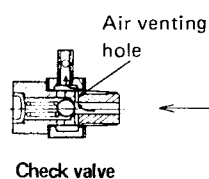
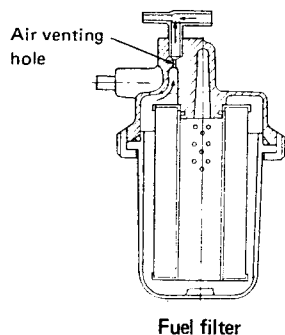
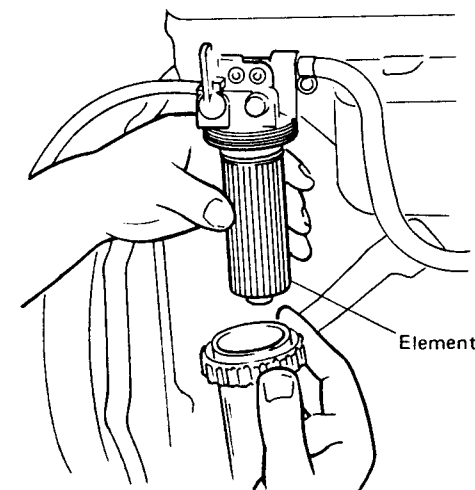
The fuel filter, which is located between the fuel feed pump and the fuel injection pump, removes any impurities from the fuel. It has a replaceable paper type element to ensure consistent fuel filtration.

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	



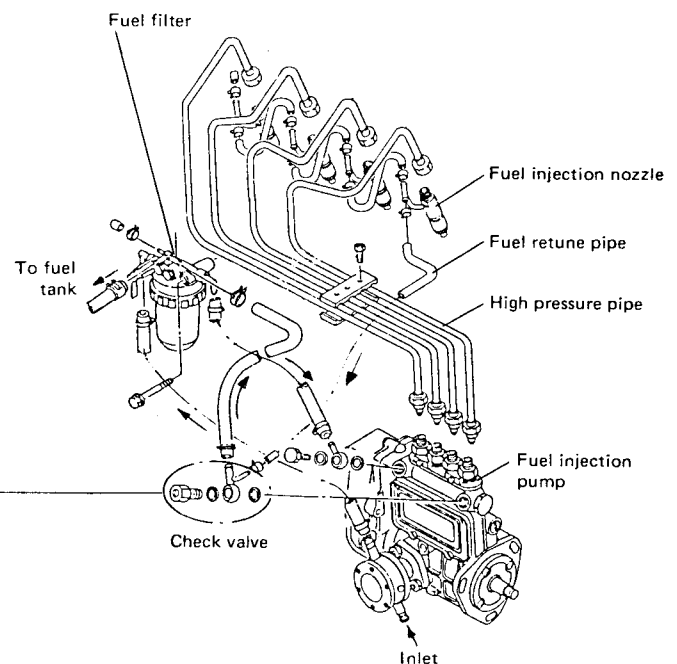
### Specifications

Applicable model	2,3TN66E 3TNA72E	3TN75E, 3TNC78E 3,4TN82(84)(T)E
Type	Paper	←
Filtration area	432 cm <sup>2</sup> (67 in <sup>2</sup> )	3TN75E, 3TNC78E 432 cm <sup>2</sup> (67 in <sup>2</sup> ) 3,4TN82(84)(T)E 900 cm <sup>2</sup> (139.5 in <sup>2</sup> )
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 <sup>3</sup> /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 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 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	←	Angleich Torque spring	-	-	
	Engine stop device			Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A	Type A + C
(3)	Fuel feed pump	Type	Dia-phragm	Dia-phragm	Dia-phragm	Dia-phragm	Dia-phragm	Dia-phragm	Dia-phragm	Dia-phragm type	Dia-phragm type	Dia-phragm 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 <sup>3</sup> /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		←			Dia-phragm type	Dia-phragm type	Dia-phragm 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	729488-51410 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 <sup>3</sup> /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	Dia-phragm type	Dia-phragm type	Dia-phragm type	Dia-phragm type	Dia-phragm type	Dia-phragm type	Dia-phragm type	Dia-phragm 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 <sup>3</sup> /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	Diaphragm type		

10. Service Data

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/cm <sup>2</sup>	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)	
	Measuring stroke	st	1000		1000		1000	
	Injection volume: Q3	cc	–	–	–	–	–	
	Variation at (R1-2mm) rack position (between cylinder)			≤0.6 cc		≤0.6 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	
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					–

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	(S) 150P254 HBO (G1) 150P234 HAO	DN-12SD12  DN-12SD12		
Injection start pressure	kg/cm <sup>2</sup>	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 posi- tion	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: $\theta$	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

10. Service Data

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/cm <sup>2</sup>	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	Angleish spring	Pump speed: N5	rpm	–		–	
		Screw-in angle: $\theta$	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

# LUBRICATING SYSTEM

1. Lubrication system . . . . .	4-1
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1. Lubrication System

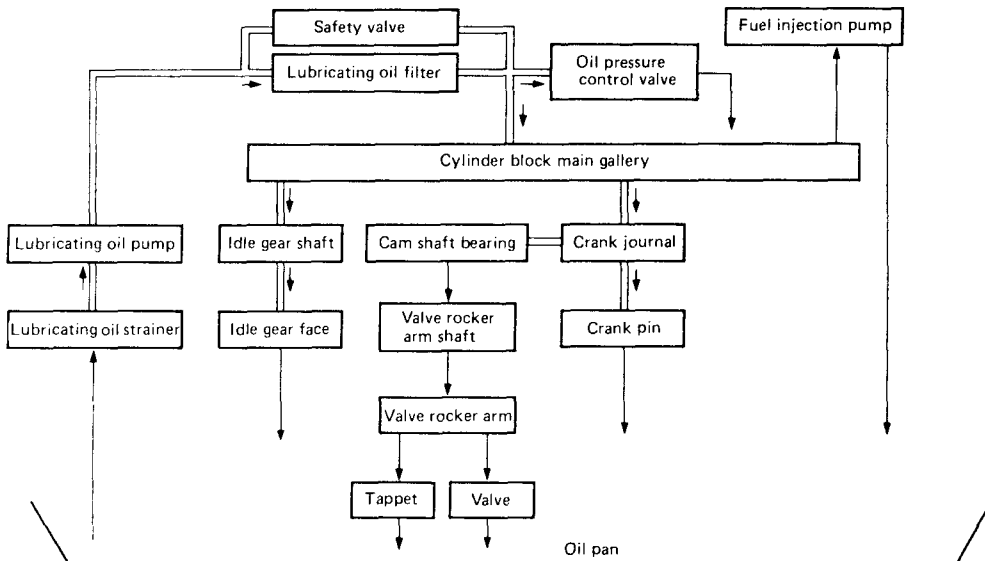
# 1. Lubrication System

Lubricating oil is important for lubricating the reciprocating or 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.

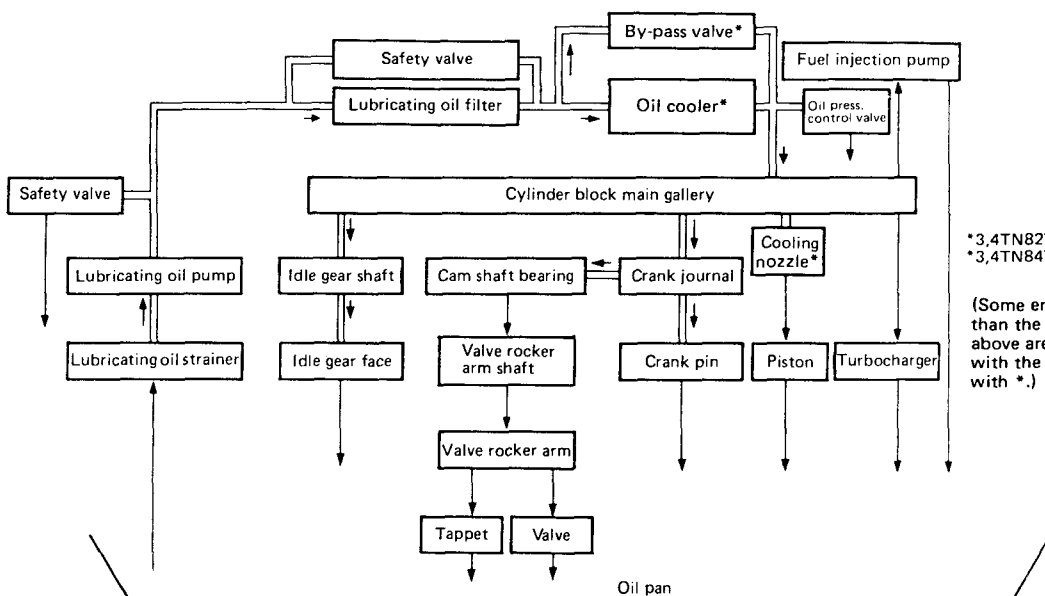
The lubricating oil in the main gallery is distributed among the crank journal, idle gear shaft, and fuel injection pump.

- (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

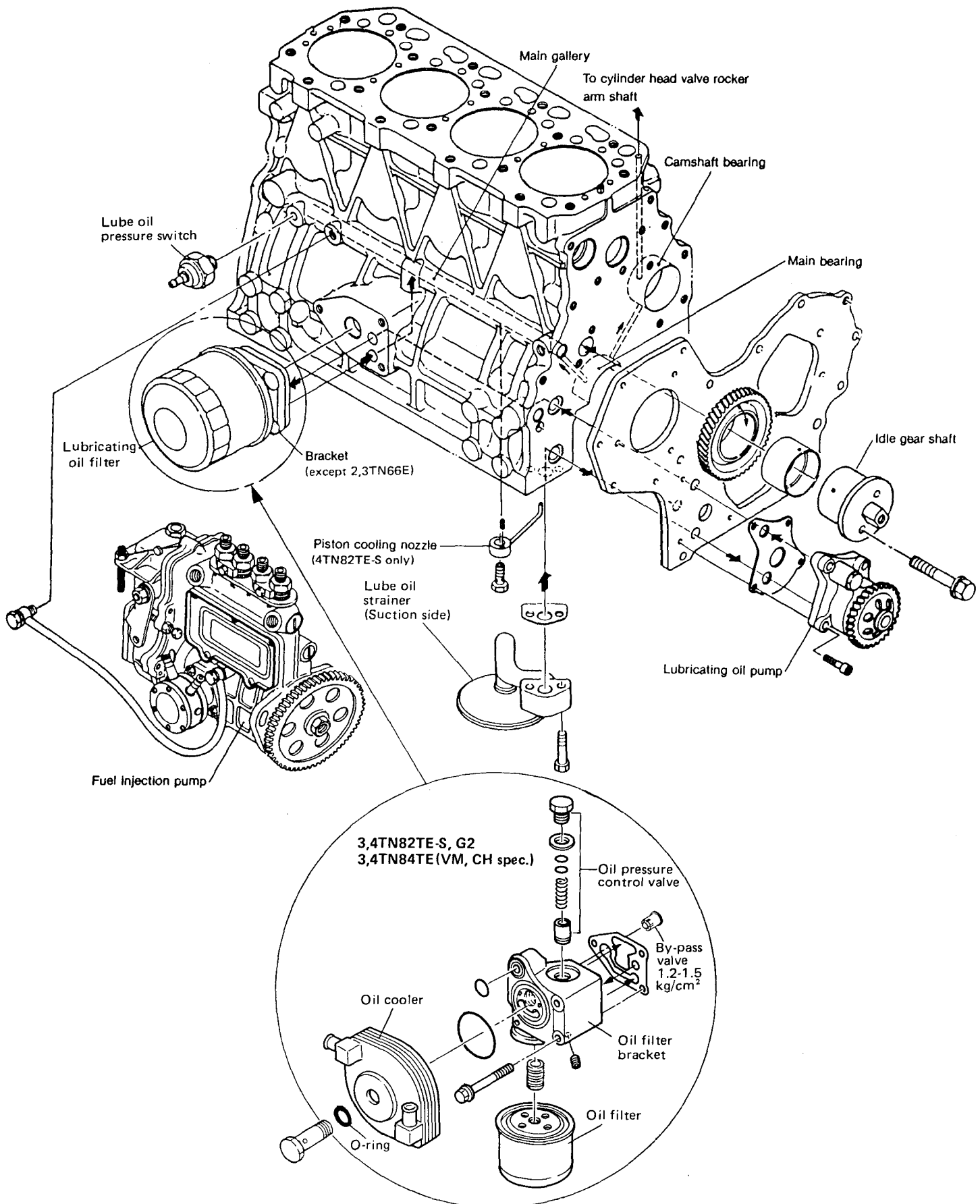


3TN82TE, 4TN82TE, 3TN84TE, 4TN84TE



\*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 \*.)



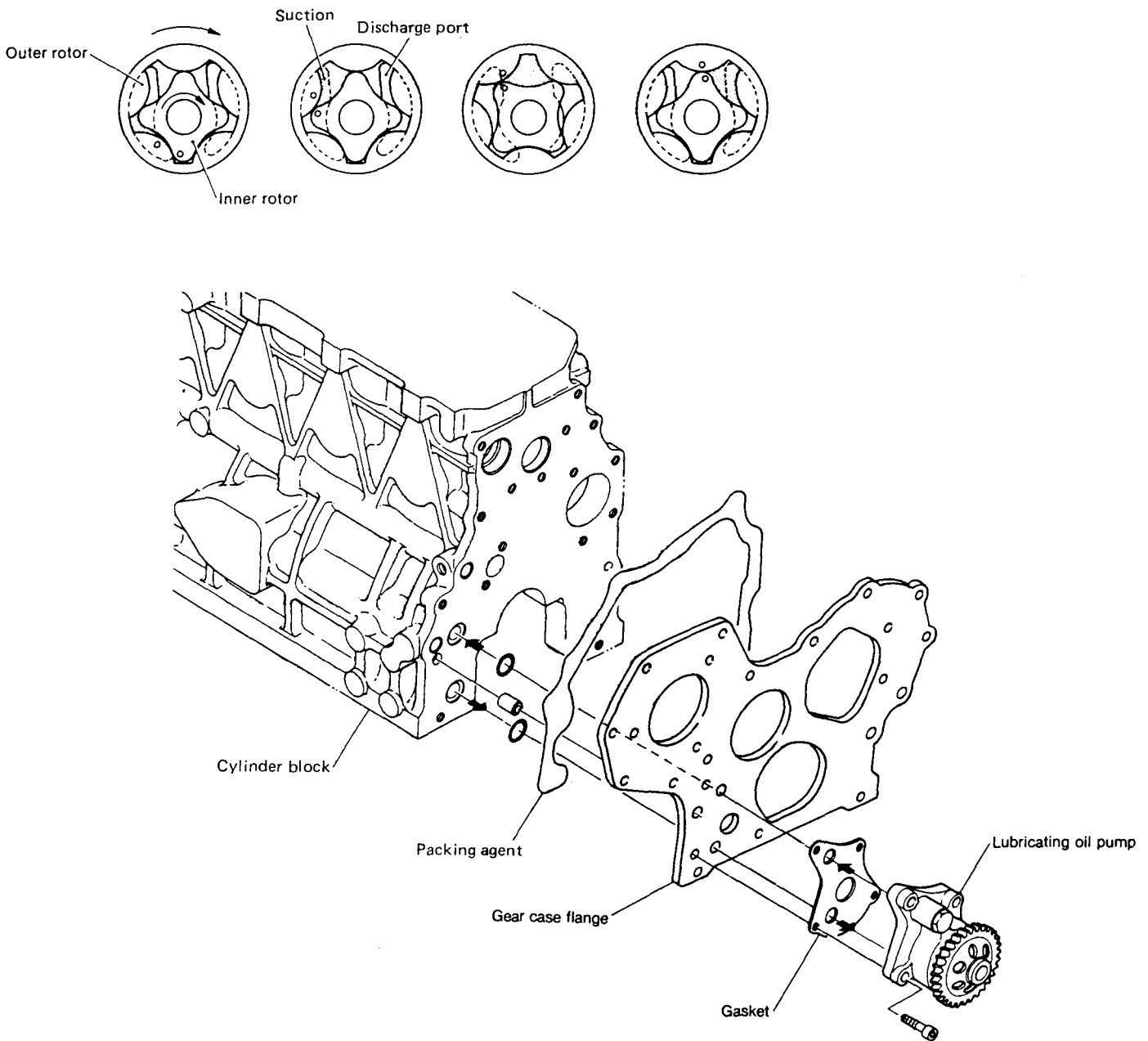
2. Lube Oil Pump

# 2. Lube Oil Pump

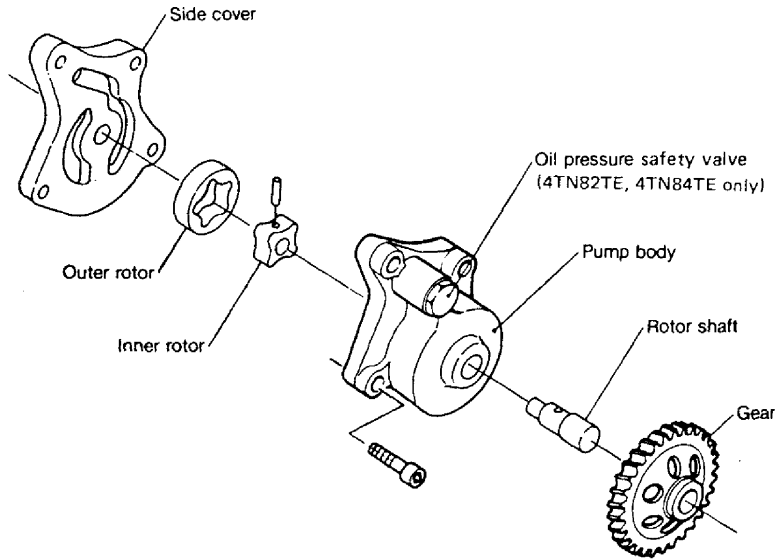
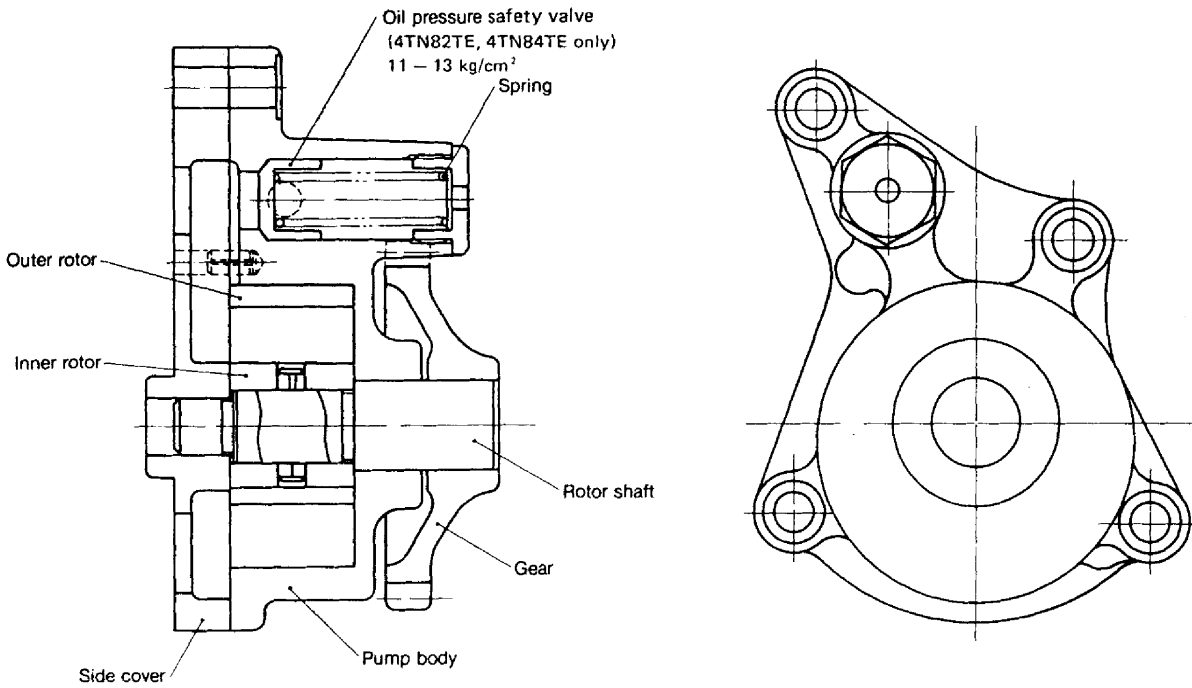
## 2-1 Lube oil pump construction

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. Lube Oil Pump



2-2 Specifications of lube oil pump

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

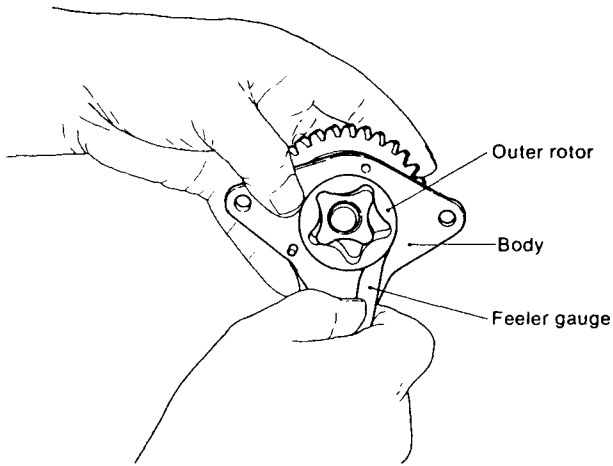
2. Lube Oil Pump

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.

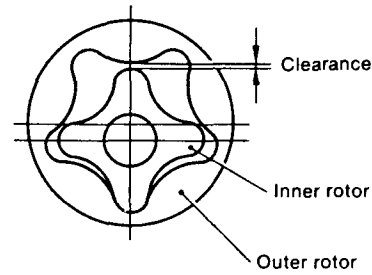
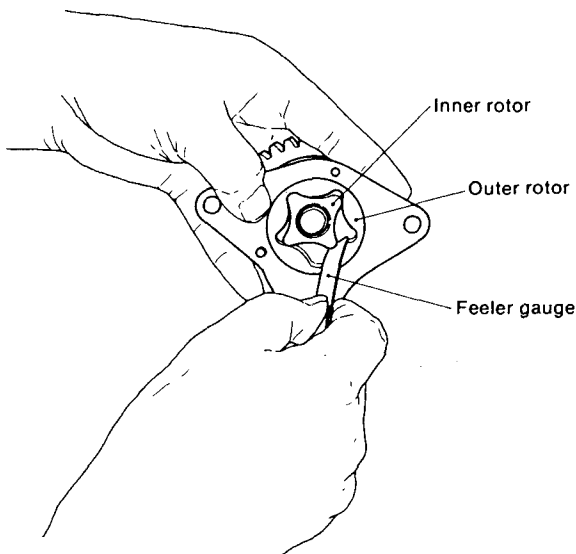
2-4 Lube oil pump inspection

- (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.



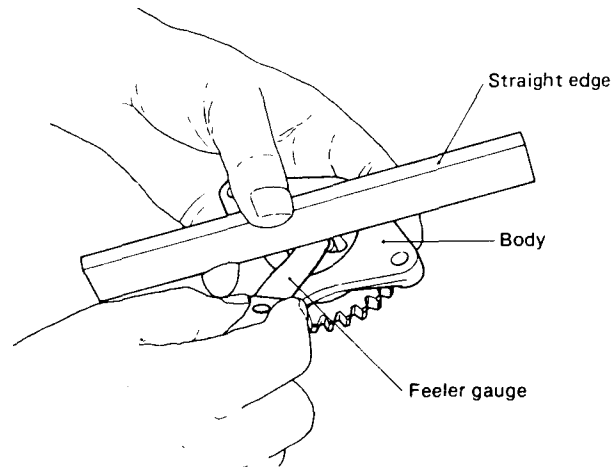
mm (in.)		
	Standard	Wear limit
Outer rotor and pump body clearance	<i>See separate service data (Page 4-10, 11)</i>	

- (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	<i>See separate service data (Page 4-10, 11)</i>	

- (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	<i>See separate service data (Page 4-10, 11)</i>	

- (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	<i>See separate service data (Page 4-10, 11)</i>	

- (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.

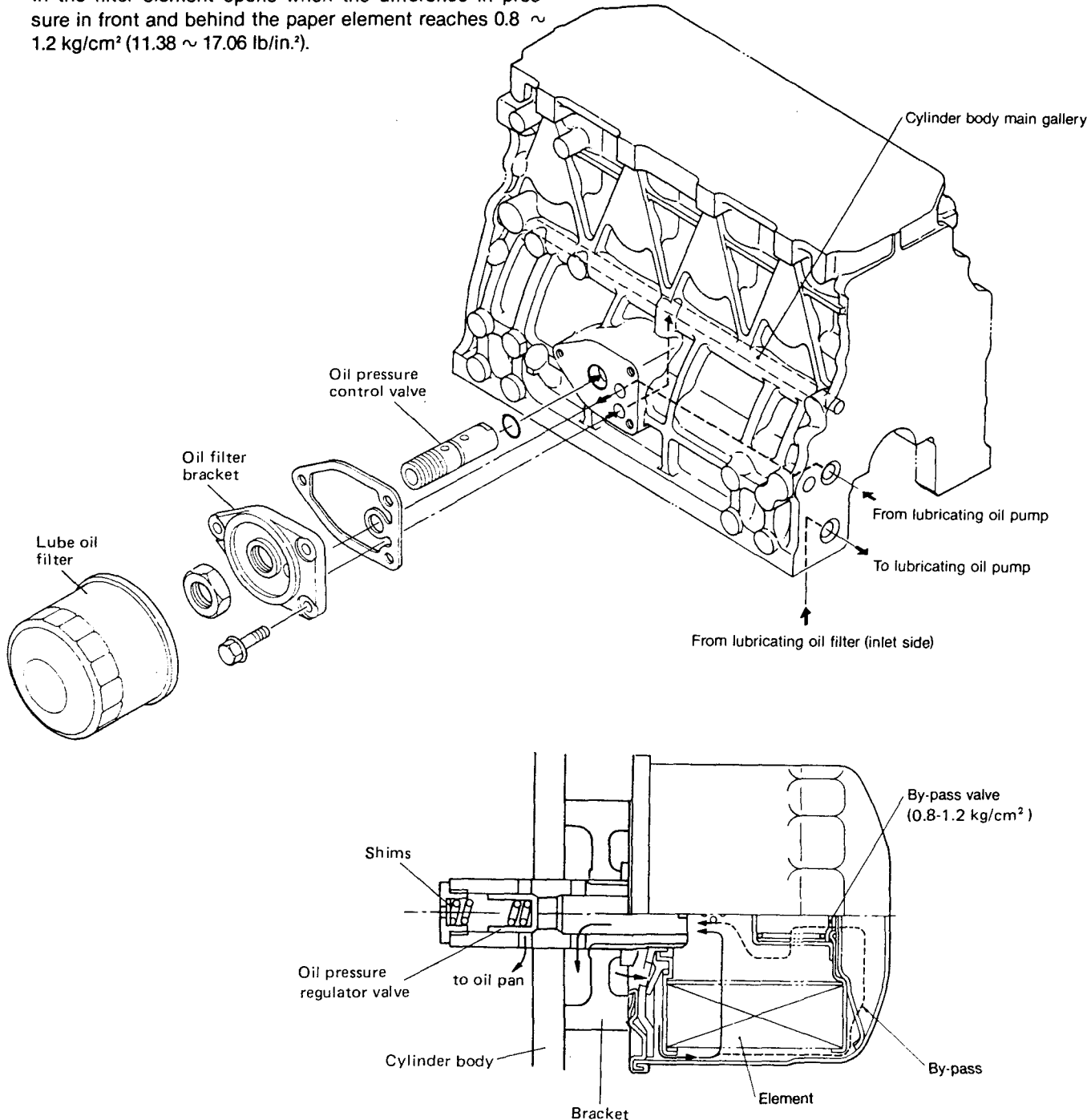
Turning torque	less than 1.5 kg-cm (0.108 ft-lb)	
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# 3. Lube Oil Filter & Oil Pressure Control Valve

## 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  $0.8 \sim 1.2 \text{ kg/cm}^2$  ( $11.38 \sim 17.06 \text{ lb/in.}^2$ ).



3. Lube Oil Filter & Oil Pressure Control Valve

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

3-2 Lube oil filter replacement

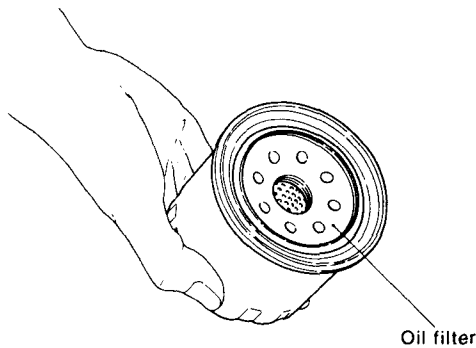
(1) Period

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.

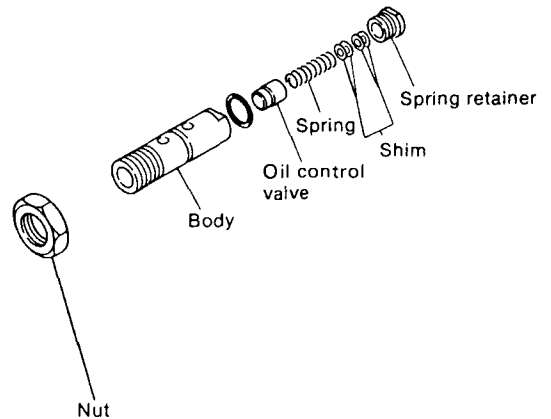


3-3 Oil pressure control valve replacement

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	<i>See separate service data (Page 4-10, 11)</i>
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4. Oil Cooler

# 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 <sup>2</sup>
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.

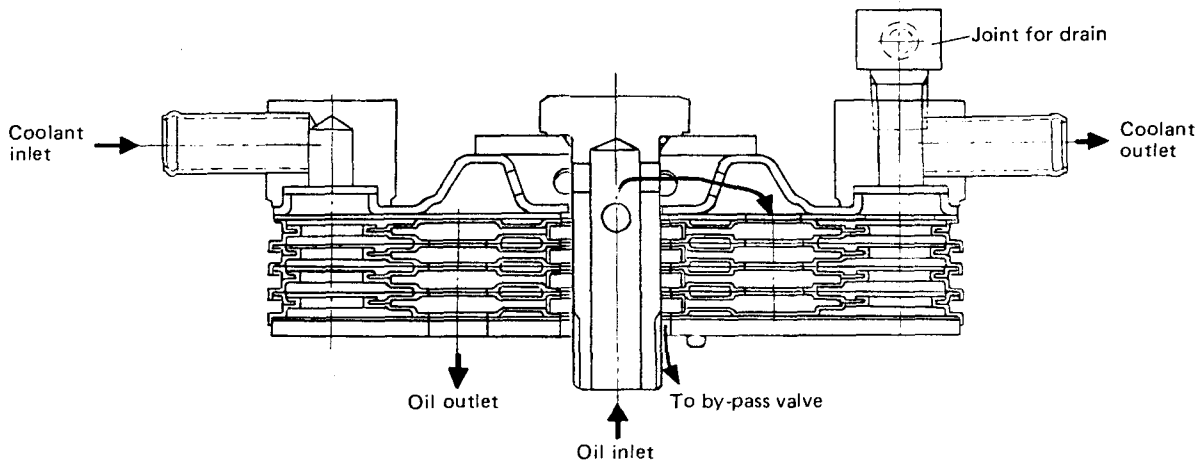
The filter bracket has a built-in oil pressure control valve, and the part of the engine oil to which a pressure of 3.5 to 4.5 kg/cm<sup>2</sup> is applied, is sent back into the crankcase via this valve.

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<sup>2</sup> (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.

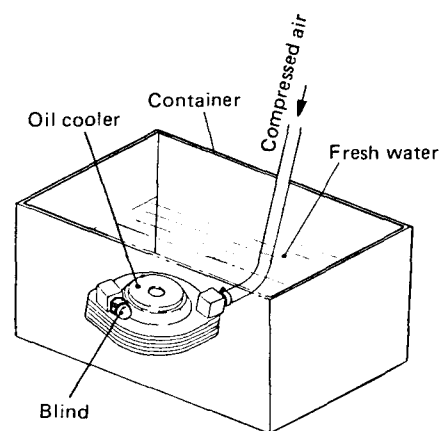
**(2) Coolant passage**

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<sup>2</sup> (28 to 71 psi) to other end, and dip the oil cooler into the water to check for leakage. 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

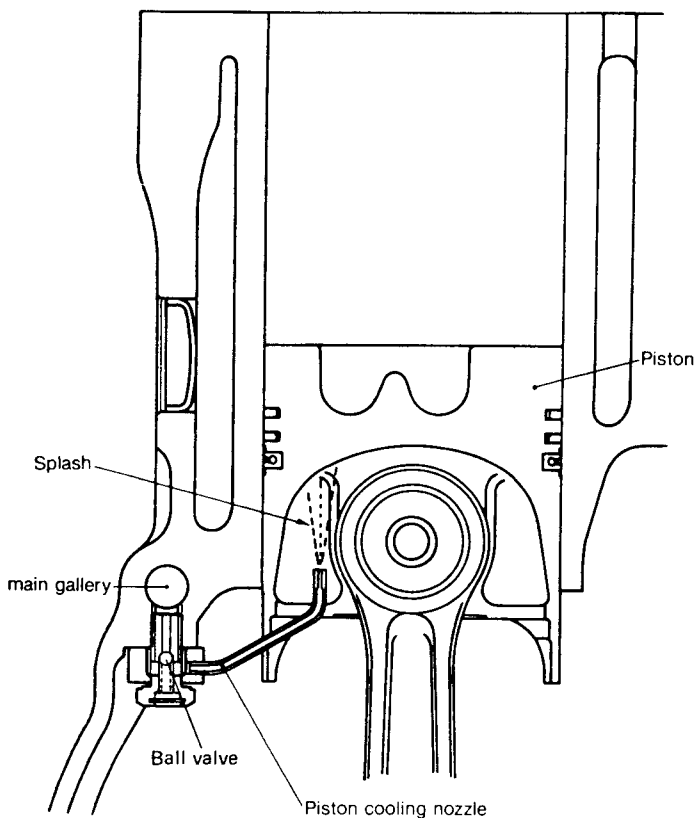
The piston cooling nozzle lowers the piston temperature and decreases its thermal load. It also reduces thermal expansion and carbon deposits in the piston ring grooves.

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 ( $\phi 1.77$  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 pressure is factory-set at  $2 \pm 0.5$  kg/cm<sup>2</sup> (21.5 – 35.5 psi).

Oil jetting amount	21.3l/min. at an oil pressure of 3.5 kg/cm <sup>2</sup>
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*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

## 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/cm <sup>2</sup> (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	m <sup>2</sup> (in <sup>2</sup> )	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/cm <sup>2</sup> (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/cm <sup>2</sup> (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/cm <sup>2</sup> (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)			—	

## 4. Service Data

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/cm <sup>2</sup> (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 <sup>2</sup> (in <sup>2</sup> )	0.10 (155)			—	0.10 (155)		—	
	Max. discharge volume	ℓ/min (US gal./min)	30 (7.923)			—	30 (7.923)		—	
	Pressure loss	kg/cm <sup>2</sup> (PSI)	0.3 – 0.5 (4.27 – 7.11)			—	0.3 – 0.5 (4.27 – 7.11)		—	
	By-pass valve regulating pressure	kg/cm <sup>2</sup> (PSI)	0.8 – 1.2 (11.38 – 17.06)			—	0.8 – 1.2 (11.38 – 17.06)		—	
Regulating pressure		kg/cm <sup>2</sup> (PSI)	3.0 – 4.0 (42.66 – 56.88)			—	3.0 – 4.0 (42.66 – 56.88)		—	

## CHAPTER 5

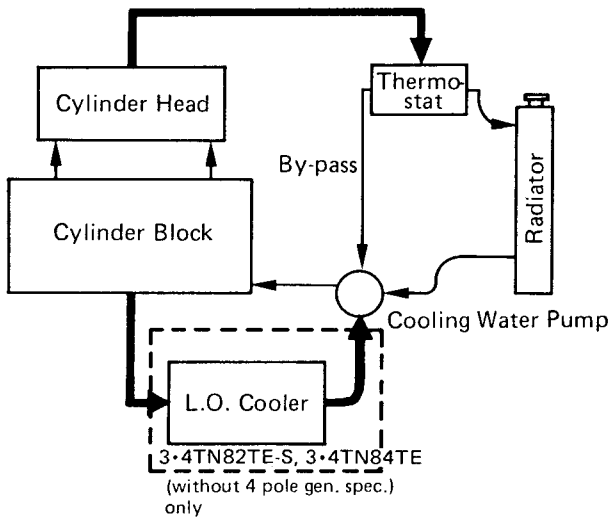
# COOLING SYSTEM

1. Cooling system . . . . .	5-1
2. Radiator . . . . .	5-1
3. Radiator fan belt . . . . .	5-2
4. Thermostat . . . . .	5-3
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# 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<sup>2</sup> 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

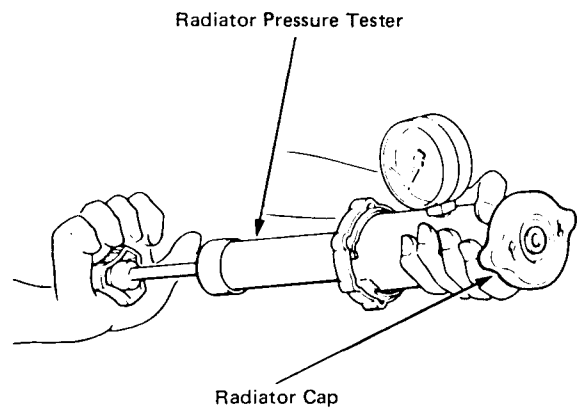
## 2-1 Radiator specifications

Coolant capacity	Engine	<i>See separate service data (Page 5-6, 7)</i>
	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 <sup>2</sup> (0.9 Bar/12.8 psi)
----------------------	---

3. Radiator Fan Belt

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

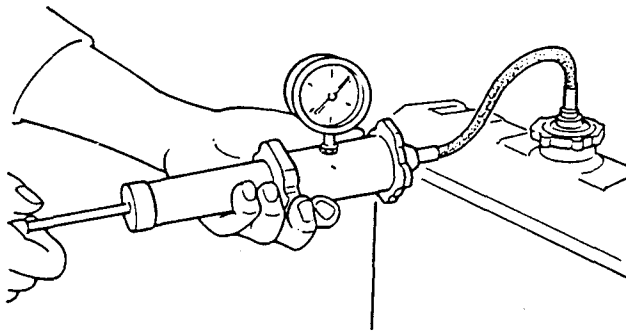
It is advisable to perform this check with the engine warmed up.

- (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 <sup>2</sup> (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

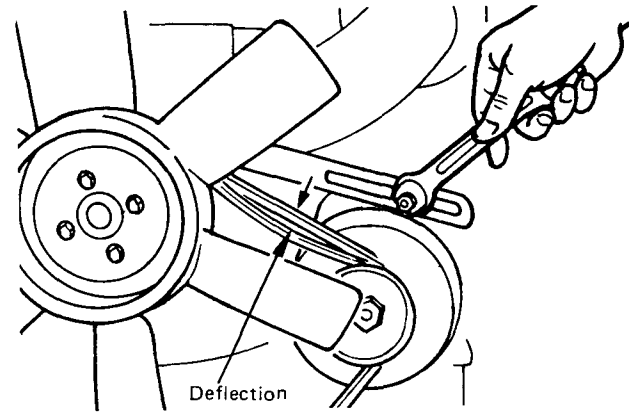
The radiator fan belt is subject to stretching, the wet and other possible damage after a long period of service.

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.

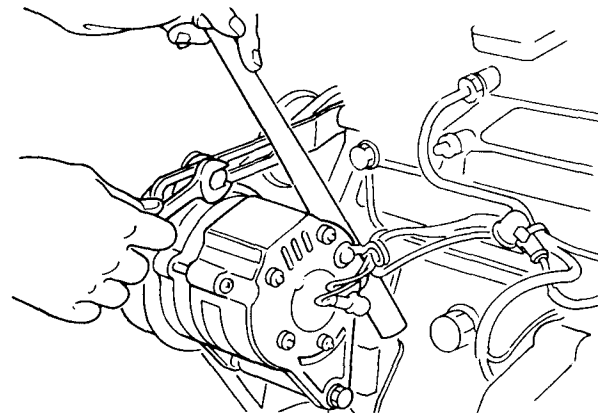
Belt tension	Press hard with the fingers to get a play of 10 – 15 mm (0.4 – 0.6 in.)
--------------	---

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:

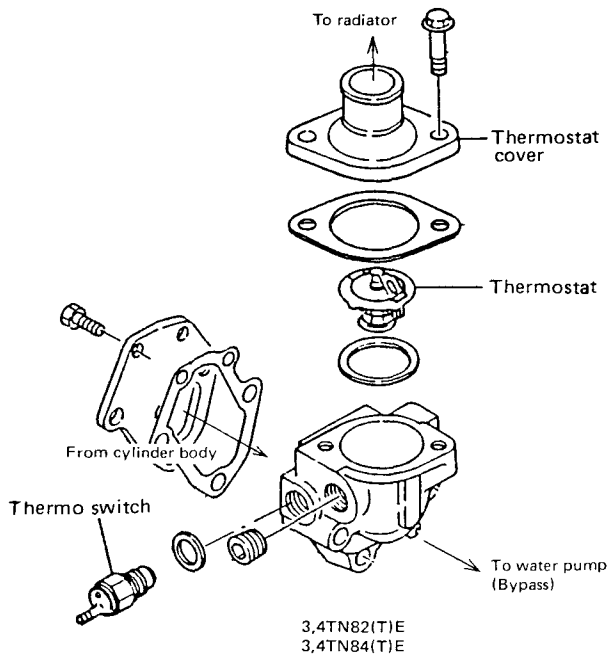
Model	Belt type x size
3TN66E	<i>See separate service data (Page 5-6, 7)</i>
3TNA72E	
3TN75E	
3TN82E	
4TN82E	
4TN82TE	

## 4. Thermostat

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

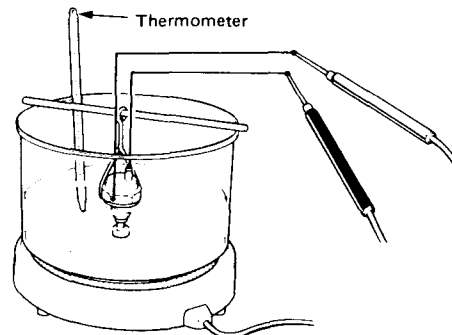
*Note: Do not let the thermostat touch the bottom of the hot container.*

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

## 4-3 Thermoswitch

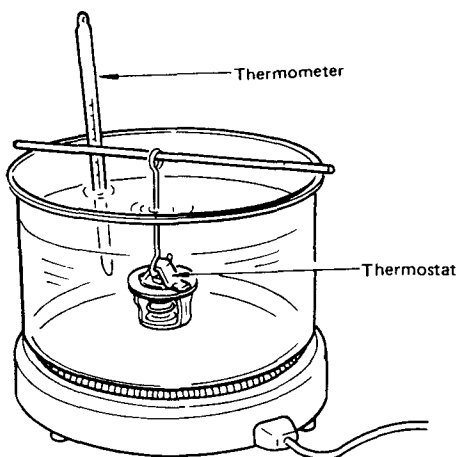
Thermoswitch inspection

- (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.

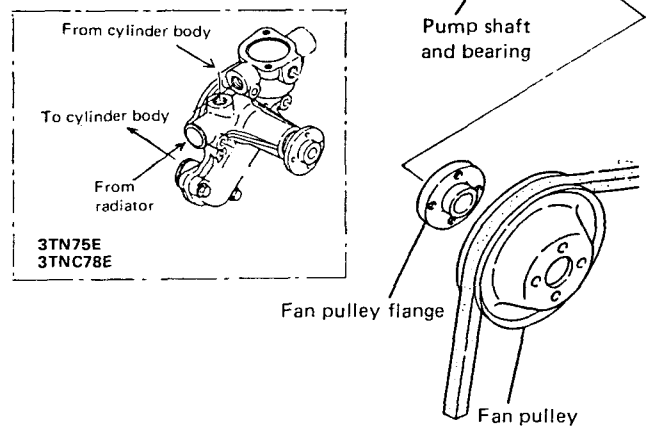
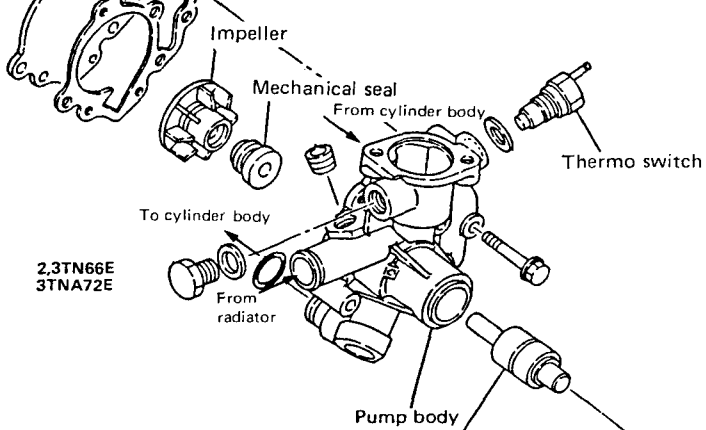
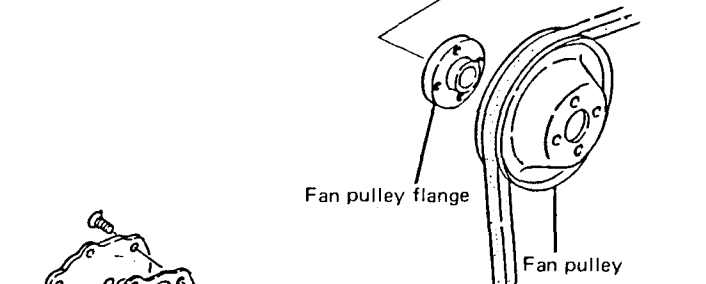
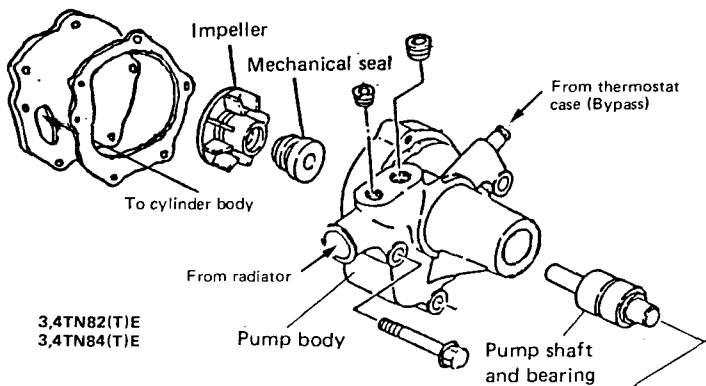


## 4-2 Testing Thermostat

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



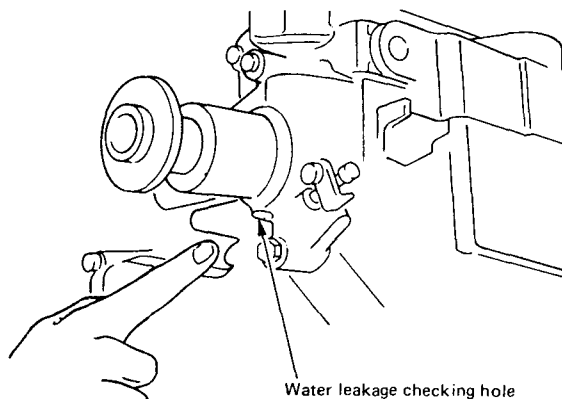
# 5. Cooling Water Pump



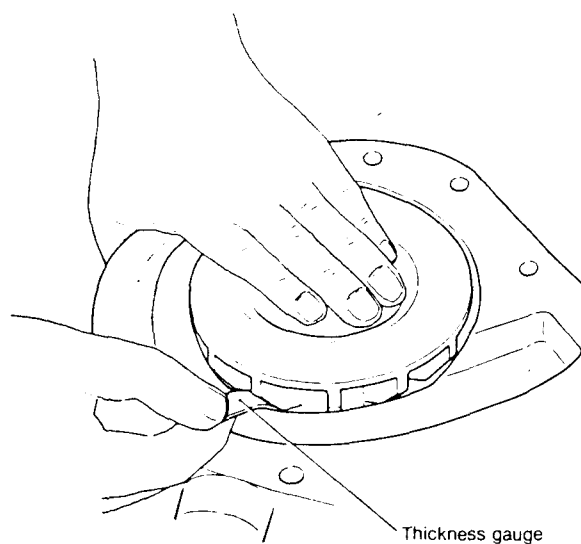
## 5-1 Cooling water pump inspection

- (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



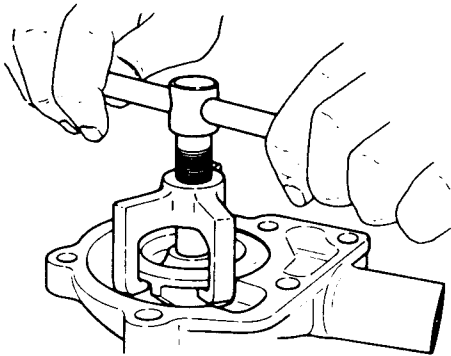
	mm (in.)	
	Standard	Wear limit
Clearance between impeller and body	0.3 ~ 1.1 (0.0118 ~ 0.0433)	1.5 (0.0590)



## 5-2 Water pump disassembly

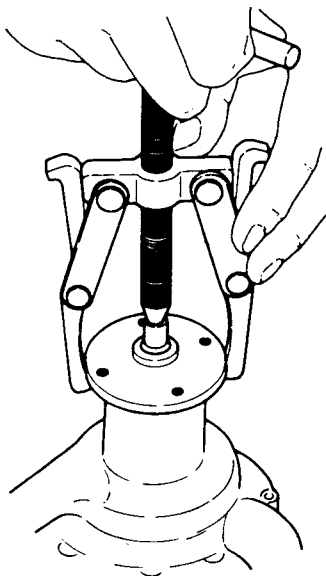
- (1) Remove the water pump
- (2) Remove the impeller using a gear puller.

### 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

## 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/cm <sup>2</sup> (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/cm <sup>2</sup> (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)			

## 6. Service Data

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 <sup>2</sup> (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

CHAPTER 6

# AIR INDUCTION SYSTEM

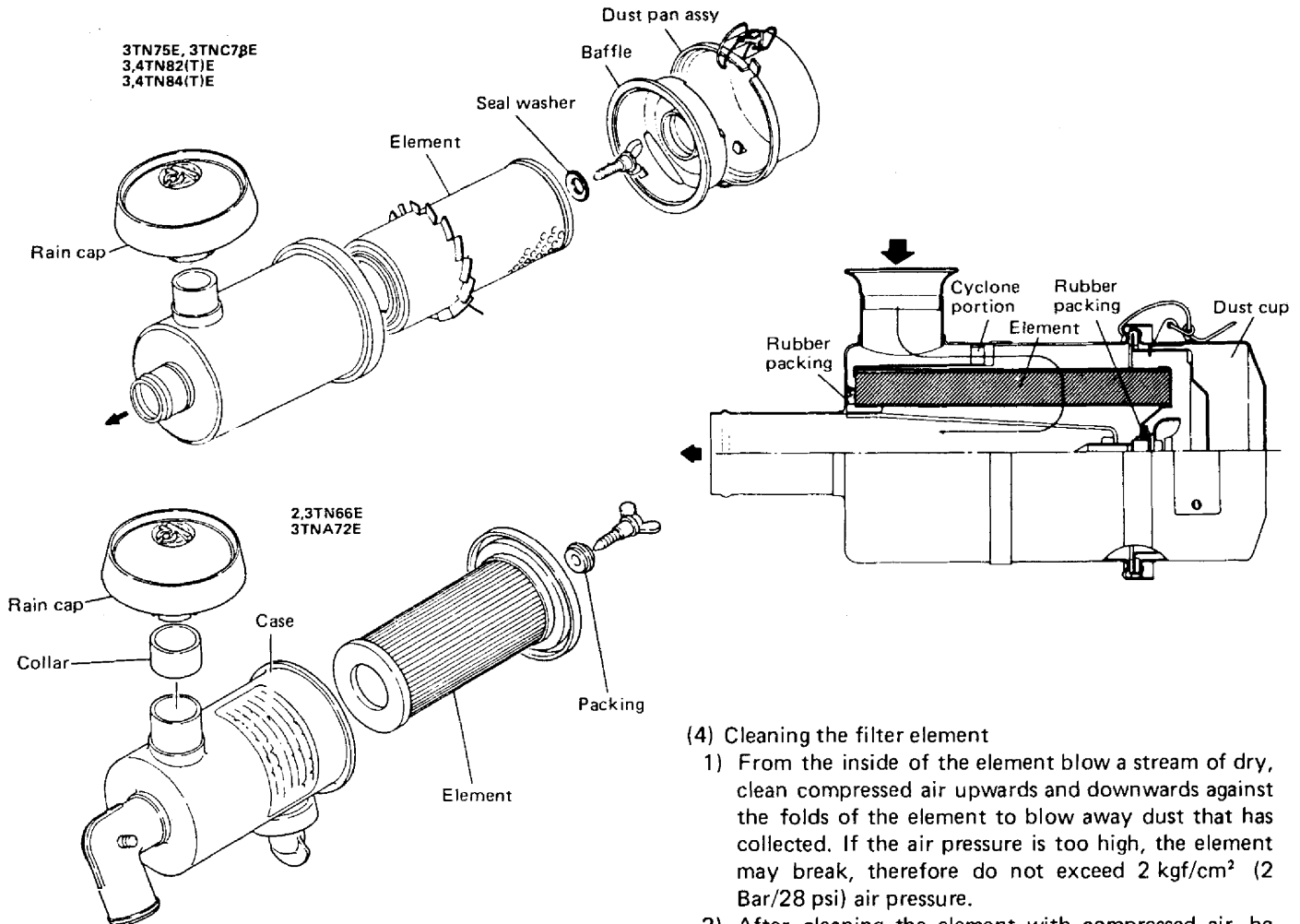
1. Air cleaner .....	6-1
2. Turbocharger .....	6-3

## 1. Air Cleaner

## 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/cm<sup>2</sup> (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.

## 1. Air cleaner

### 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

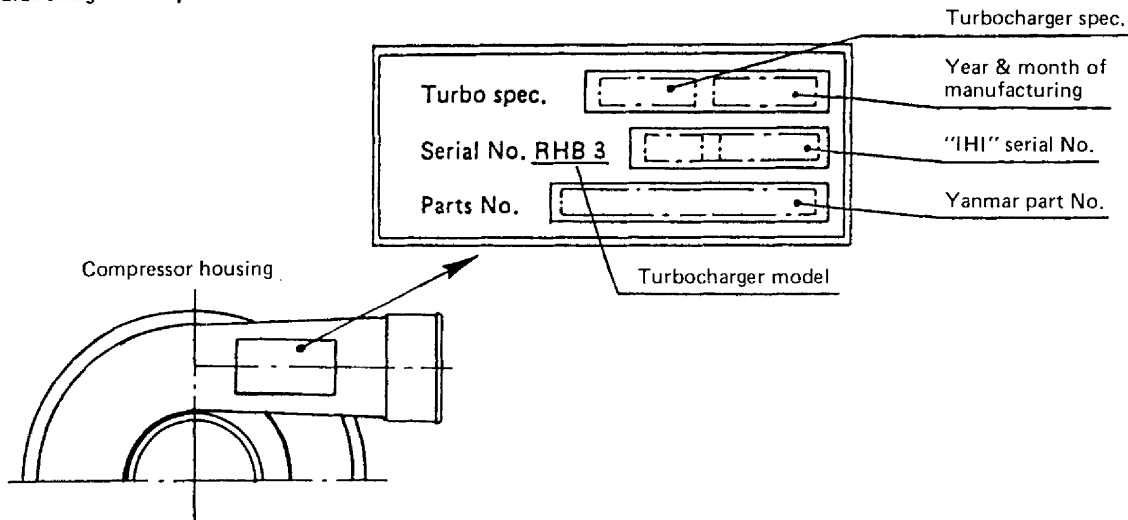
# 2. Turbocharger

## 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)

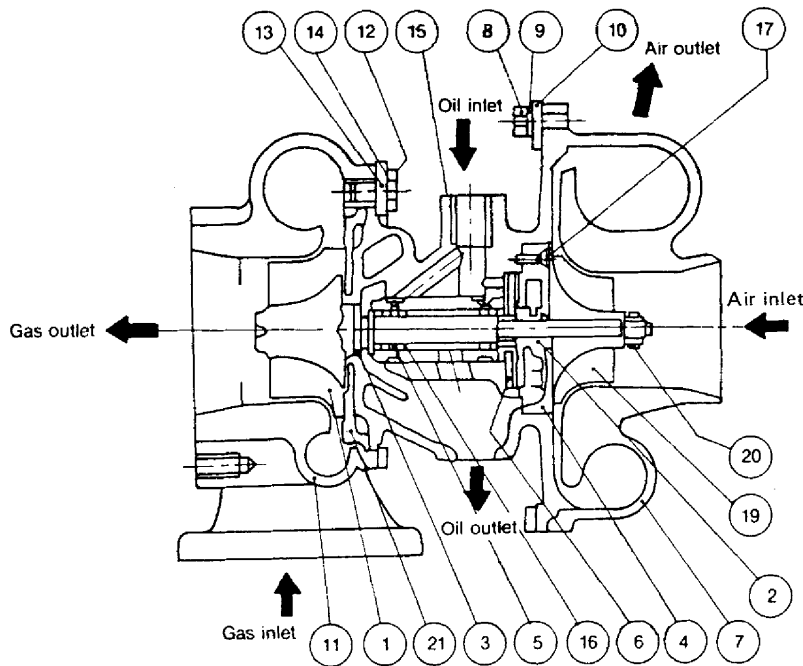
Note: The specifications of the turbine and compressor are difference between the turbochargers for the engine models.

Turbocharger name plate



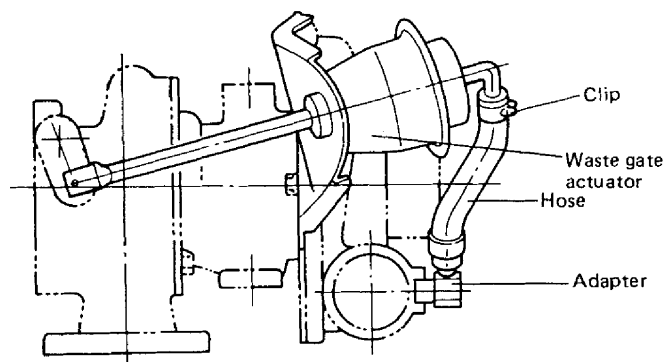
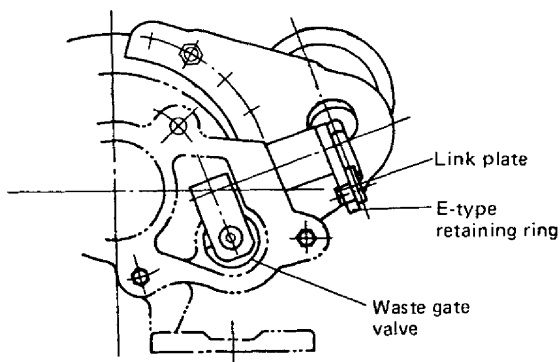
2. Turbocharger

2 Construction



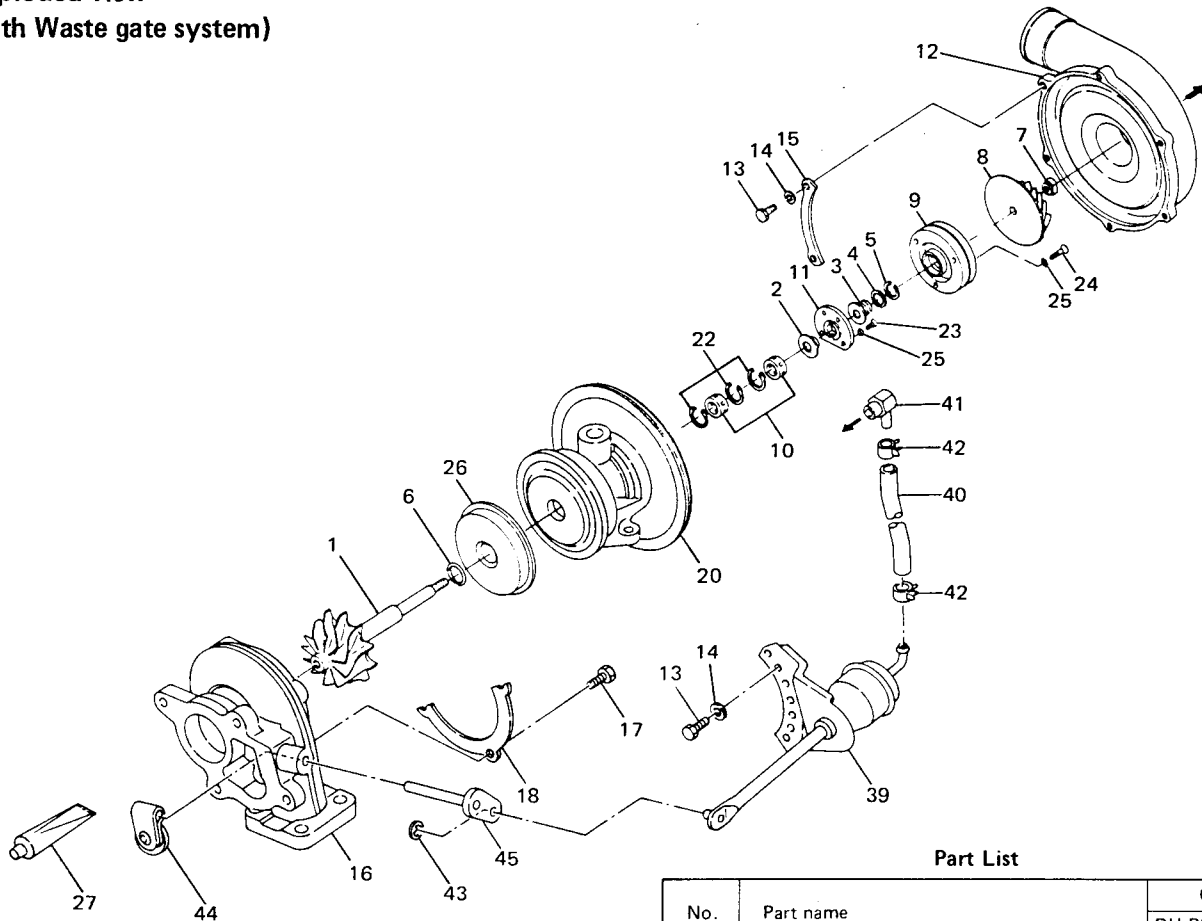
- 1. Turbine shaft
- 2. Oil thrower
- 3. Turbine side seal ring
- 4. Seal plate
- 5. Journal bearing
- 6. Thrust bearing
- 7. Compressor housing
- 8. M5 hexagonal bolt
- 9. M5 lock washer
- 10. Compressor side clamp
- 11. Turbine housing
- 12. M6 hexagonal bolt
- 13. Turbine side clamp
- 14. Lock washer
- 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)



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	—

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

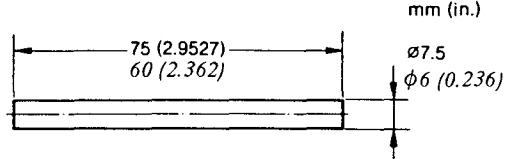
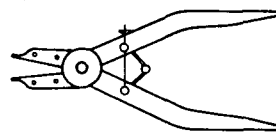
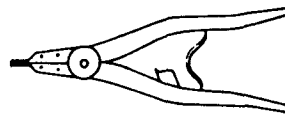
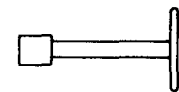
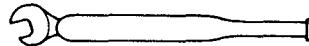
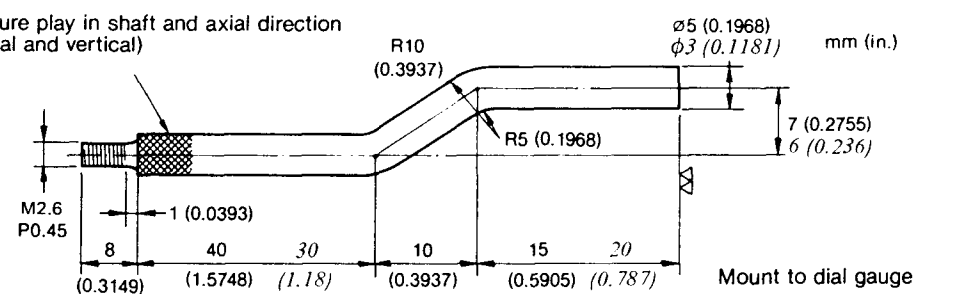
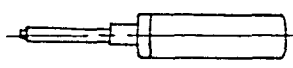
Part No.	Part name	Size	Torque kg-cm	
			RH B5	RH B3
17	Bolt for turbine housing	(M8) (M6)	285±10 125± 5	125 ±5
13	Bolt for compressor housing	(M5)	45 ± 5	←
23	Screw for thrust bearing	(M3)	13 ± 1	←
24	Screw for seal plate	(M3)	13 ± 1	←
7	Lock nut		20 ± 2	10 ±1

2. Turbocharger

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	 <p>mm (in.)  <math>\phi 7.5</math>  <math>\phi 6 (0.236)</math></p> <p>Material: Copper or brass</p>
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	 <p>Box only may be used</p>
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)	 <p>mm (in.)  <math>\phi 5 (0.1968)</math>  <math>\phi 3 (0.1181)</math></p> <p>Mount to dial gauge</p>
Torque driver	To tighten screws (5 Kg-cm 30 Kg-cm)	

NOTE : *Italic letter are shows RH B3 type. (include\*)*

## 2. Turbocharger

### 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 binned, 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:**

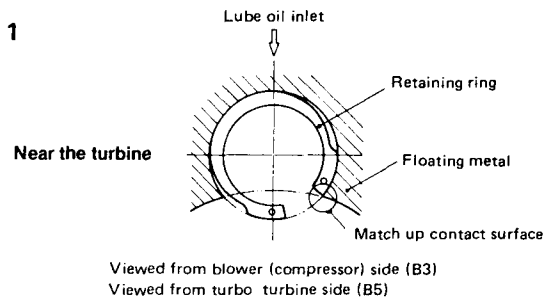
Following parts should be used new ones.

- |                            |                       |
|----------------------------|-----------------------|
| (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



**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.

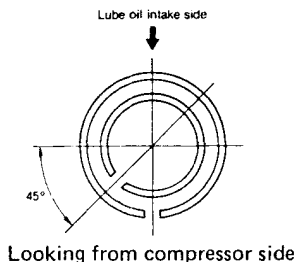
4. Assemble heat protector.
  5. Fit seal ring into groove of turbine shaft.
    - 1) Carefully fit new one.
  6. Assemble turbine wheel and shaft.
    - 1) The opening of the seal ring should be fitted towards the side of oil inlet port.
    - 2) Turbine and shaft should be pushed with a snap.
    - 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.  $13 \pm 1$  Kg-cm.
  10. Fit seal ring into grooves of oil thrower.
    - 1) Carefully fit new ones.

## 2. Turbocharger

## 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



## 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:  $13 \pm 1$  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:  $20 \pm 2$  Kg-cm.  
(RH B3:  $10 \pm 1$  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:  $285 \pm 10$  Kg-cm (M8) or  $125 \pm 5$  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:  $45 \pm 5$  Kg-cm.

## 16. Assemble W/G actuator.

- 1) Tightening torque:  $45 \pm 5$  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 axial 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  $45 \pm 5$  kg-cm.

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

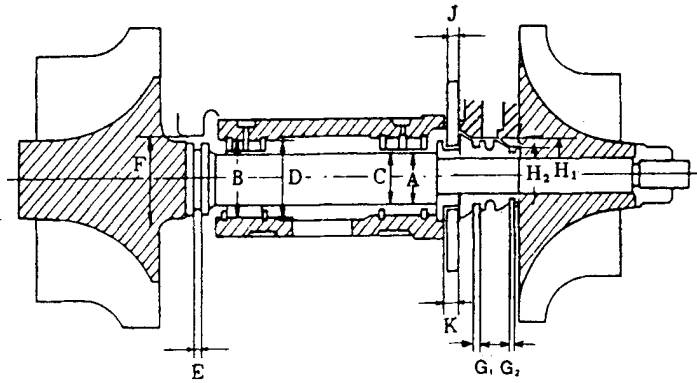
- 1-3 Set the dial-gauge perpendicular to rod end in order to measure the stroke.

- 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

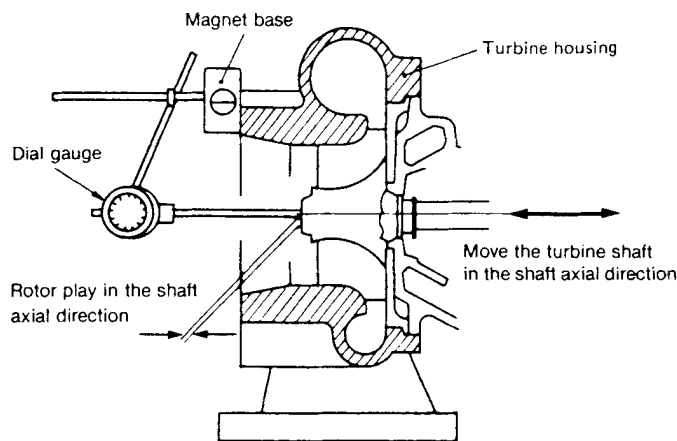


				mm	
	Items to check	Standard	Wear limit		
Turbine shaft	Turbine shaft journal outer dia. (A)	7.99 ~ 8.00 (6.257 - 6.263)	7.980 (6.25)		
	Turbine side seal ring groove width (E)	1.25 ~ 1.28 (1.038 - 1.062)	1.290 (1.07)		
	Compressor side oil thrower groove width	(G <sub>1</sub> )	1.22 ~ 1.23 (1.02 - 1.03)	1.310 (1.04)	
		(G <sub>2</sub> )	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 <sub>1</sub> )	12.40 ~ 12.42 (9.987 - 10.025)	12.450 (10.04)	
		(H <sub>2</sub> )	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

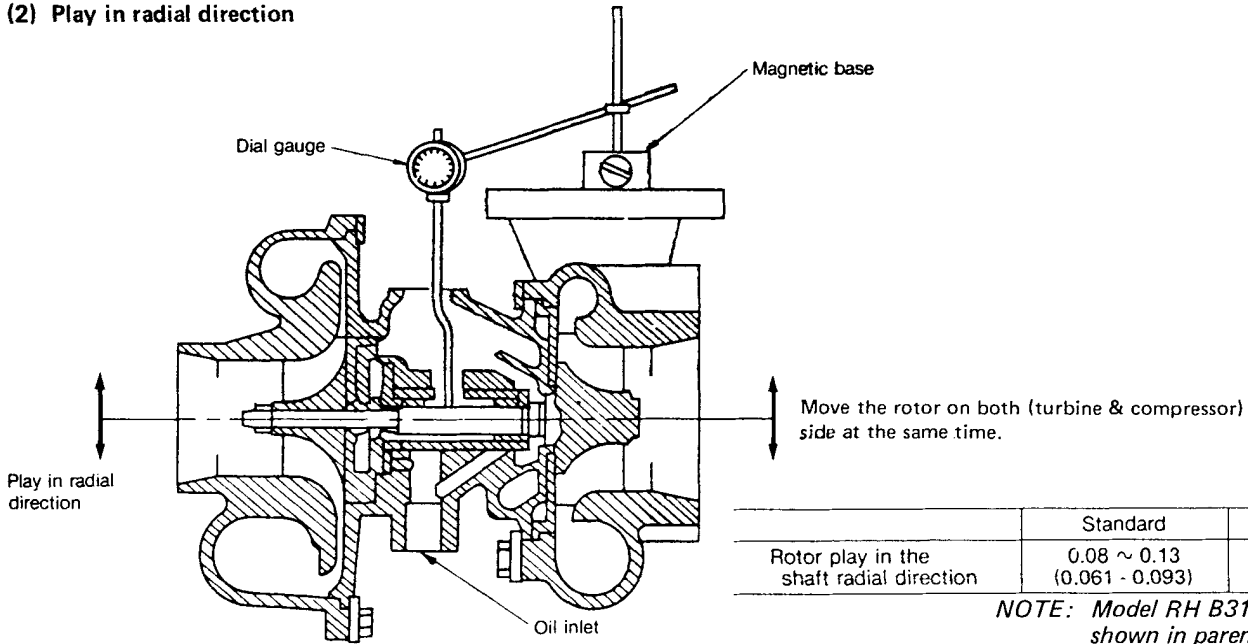
(1) Play in axial direction



			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

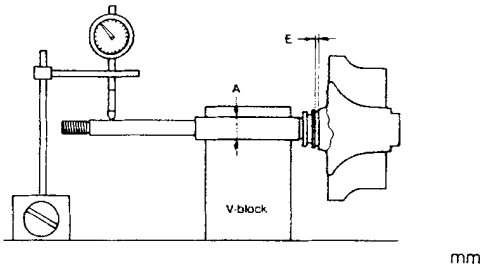


	Standard	Wear limit
Rotor play in the shaft radial direction	0.08 ~ 0.13 (0.061 - 0.093)	0.17 (0.120)

NOTE: Model RH B31 values are shown in parenthesis.

8 Inspection of oil seals

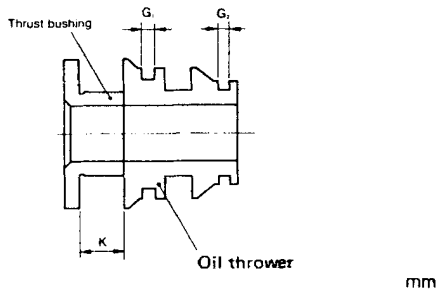
(1) Turbine wheel and shaft



		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

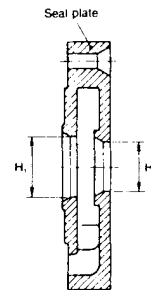


		Wear limit
Thrust bush groove clearance	K	4.07 (3.65)

		Wear limit
Seal ring groove width	G <sub>1</sub>	1.31 (1.04)
	G <sub>2</sub>	1.11 (0.84)

NOTE: Model RH B31 values are shown in parenthesis.

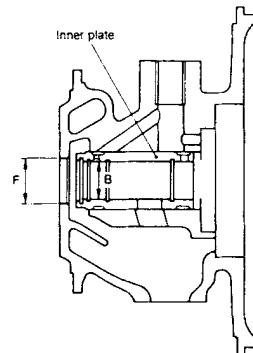
(3) Seal plate



		Wear limit
Blower side seal ring area inner dia.	H <sub>1</sub>	12.45 (10.04)
	H <sub>2</sub>	10.05 (8.010)

NOTE: Model RH B31 values are shown in parenthesis.

(4) Bearing housing

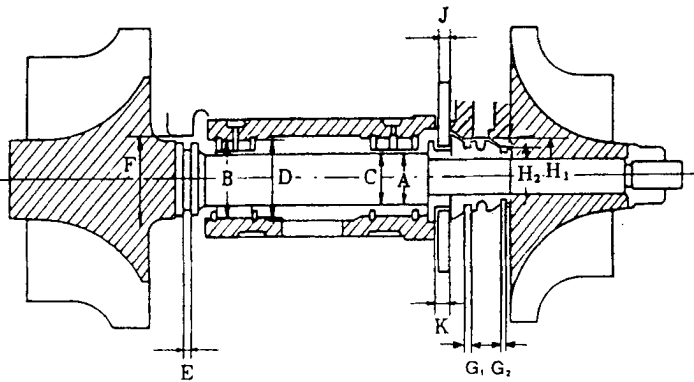


		Wear limit
Bearing chamber inner dia.	B	12.42 (10.01)
Turbine side seal ring area inner dia.	F	15.05 (11.03)

NOTE: Model RH B31 values are shown in parenthesis.

2. Turbocharger

9. Measuring devices



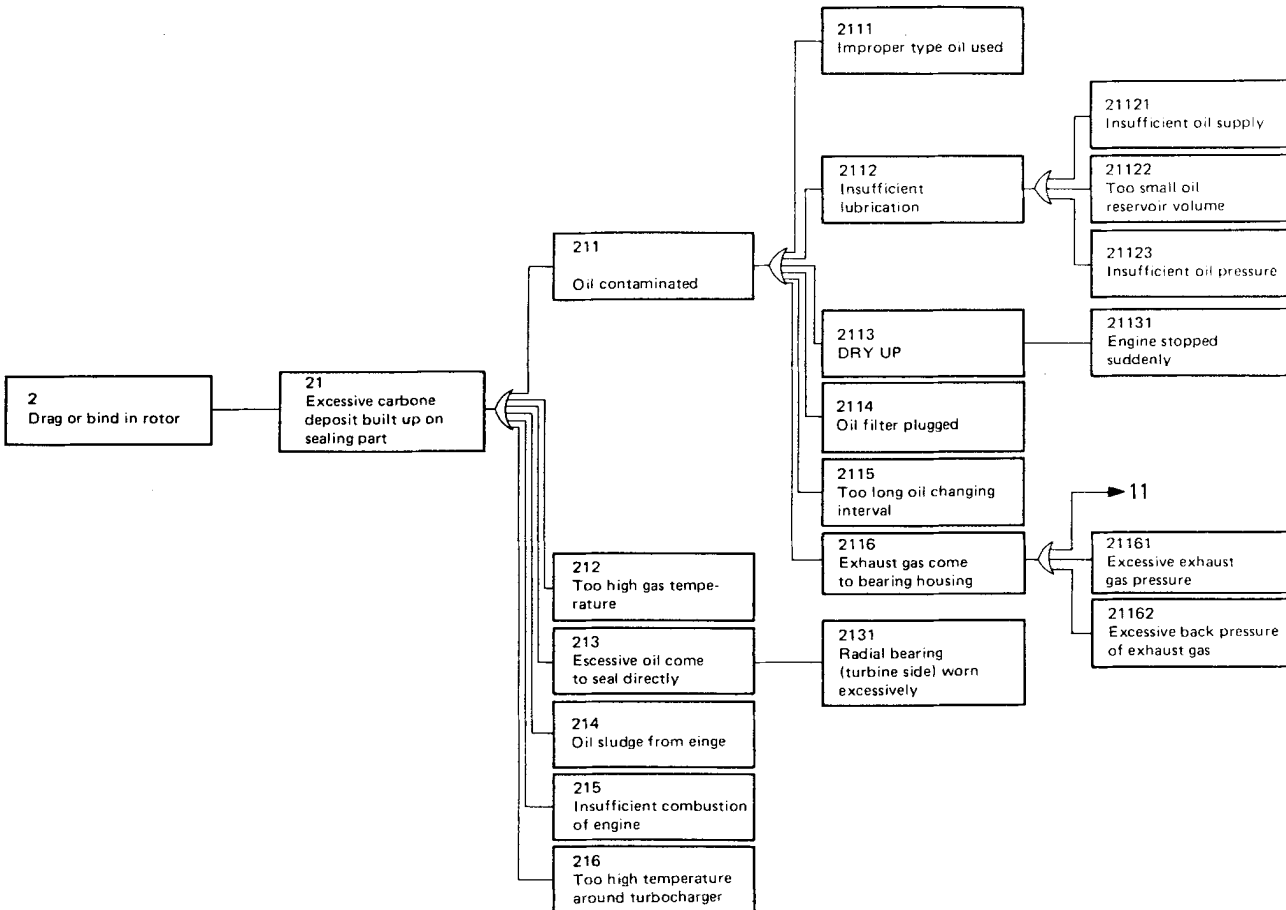
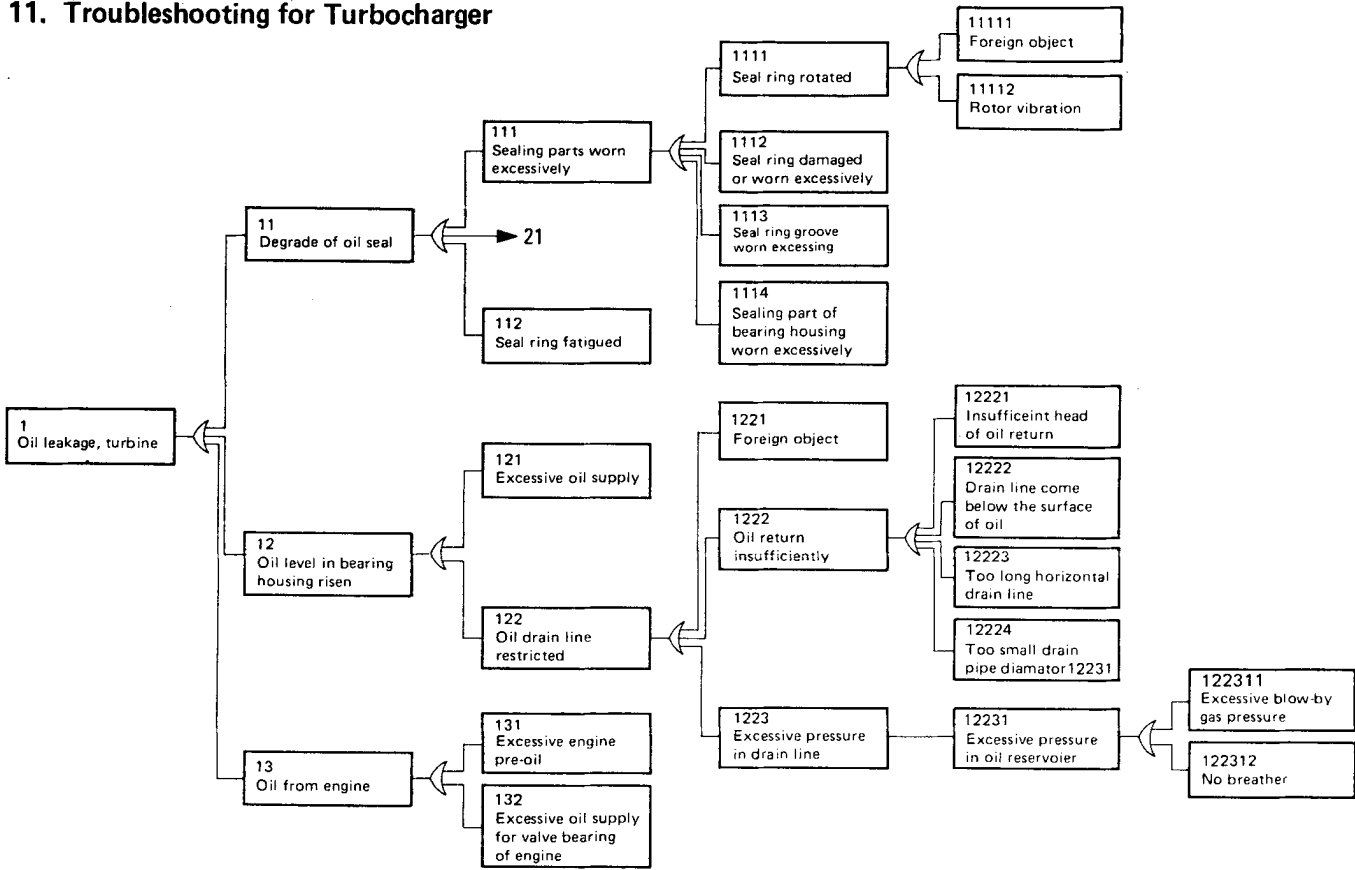
Part or location		(Symbol)	Measuring devices
Turbine shaft	Bearing journal dia.	(A)	External micrometer
	Groove width	(E)	Block gauge
	Deflection of turbine shaft		Dial indicator
Groove width of oil thrower		(G1)	Block gauge
		(G2)	Block gauge
Journal bearing	Inside dia.	(C)	Cylinder gauge
	Outside dia.	(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

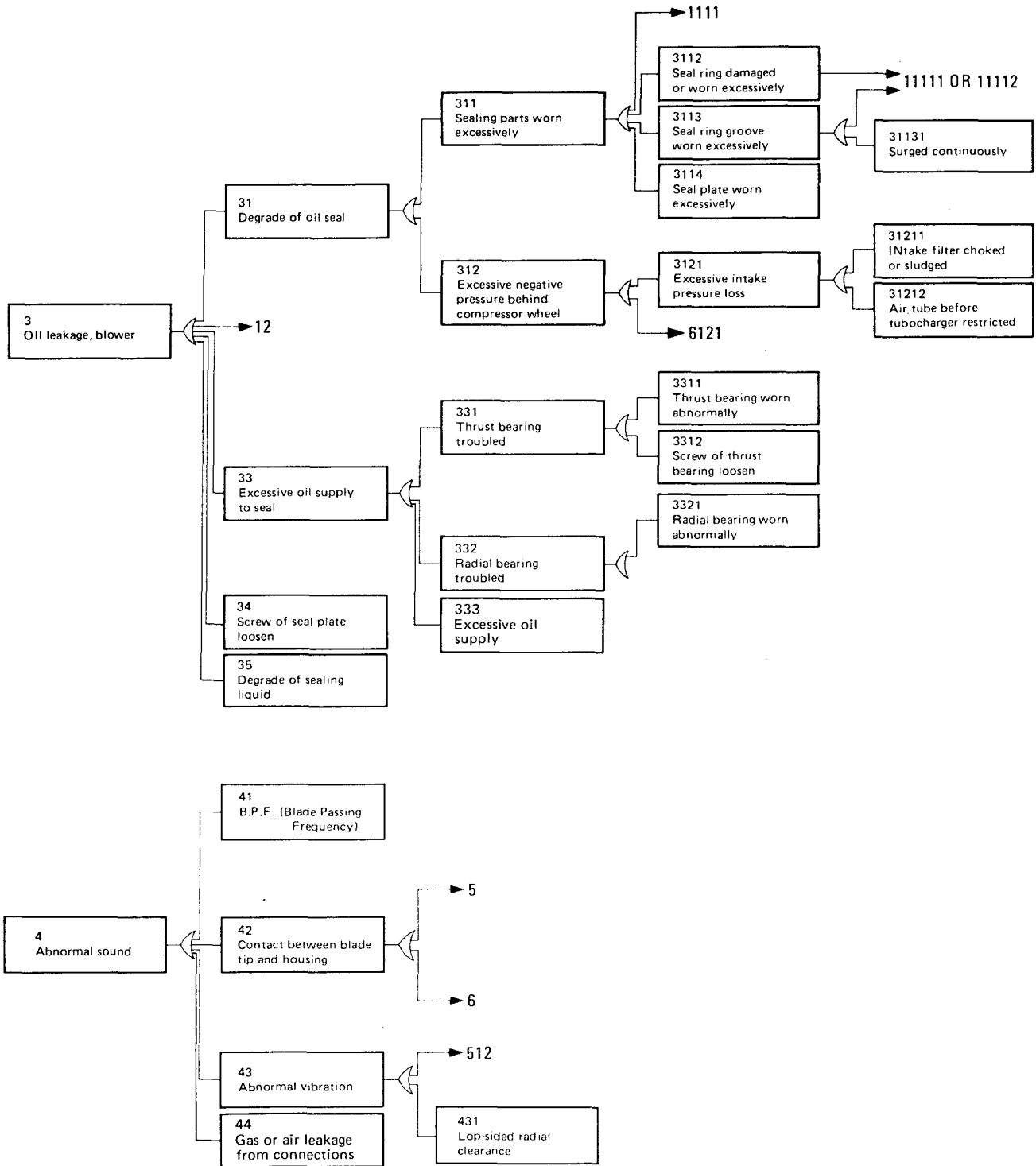
Keep the following in mind when washing the parts.

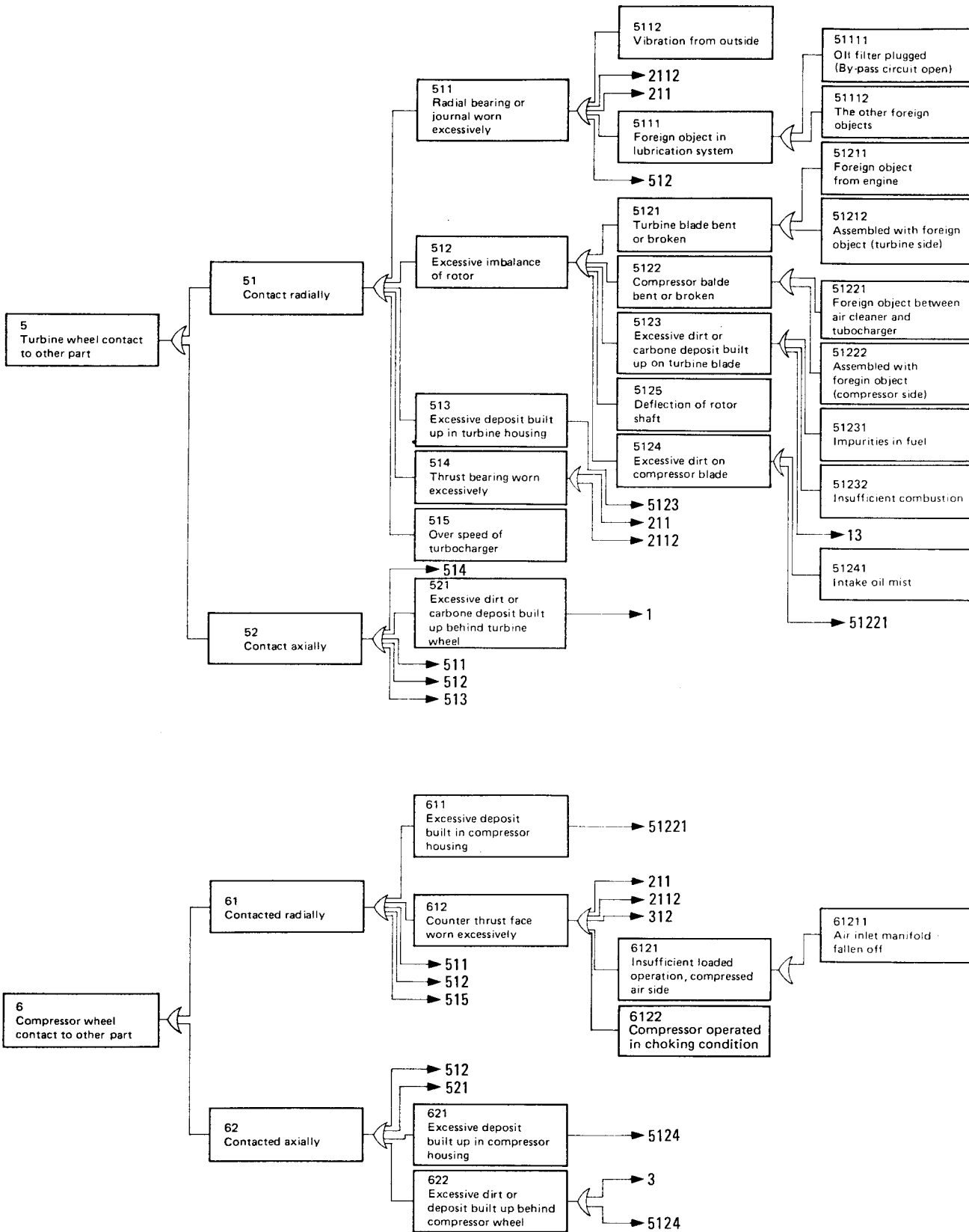
Item	Tools/Cleaning Agent	Procedure
(1) Turbine shaft	1. Tools (1) Bucket (500 × 500) (2) Heat source steam or gas burner (3) Plastic scrubber or hard hair brush 2. Cleaning agent Standard carbon removing agent	(1) Boil the turbine shaft in the washing bucket. Do not hit the blade to remove the carbon. (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.	

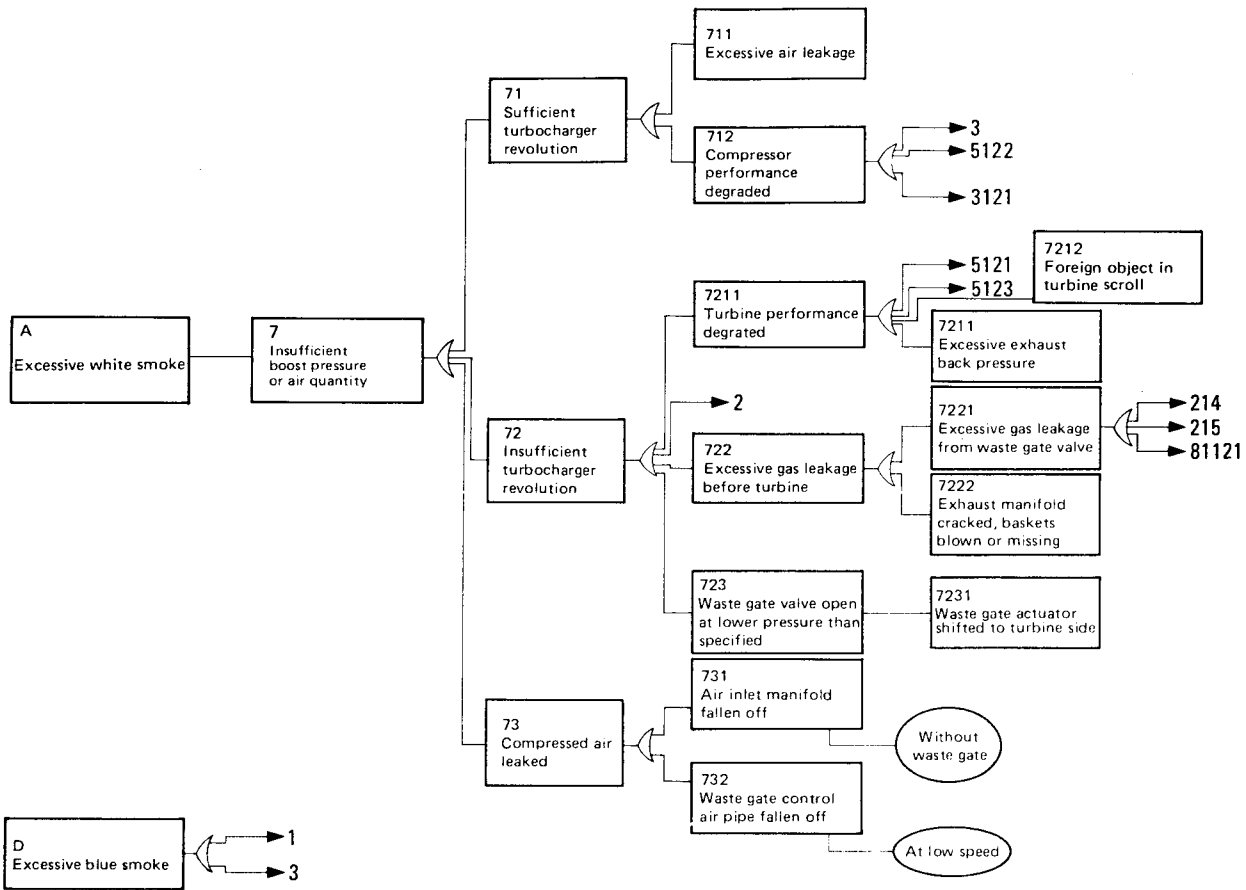
11. Troubleshooting for Turbocharger

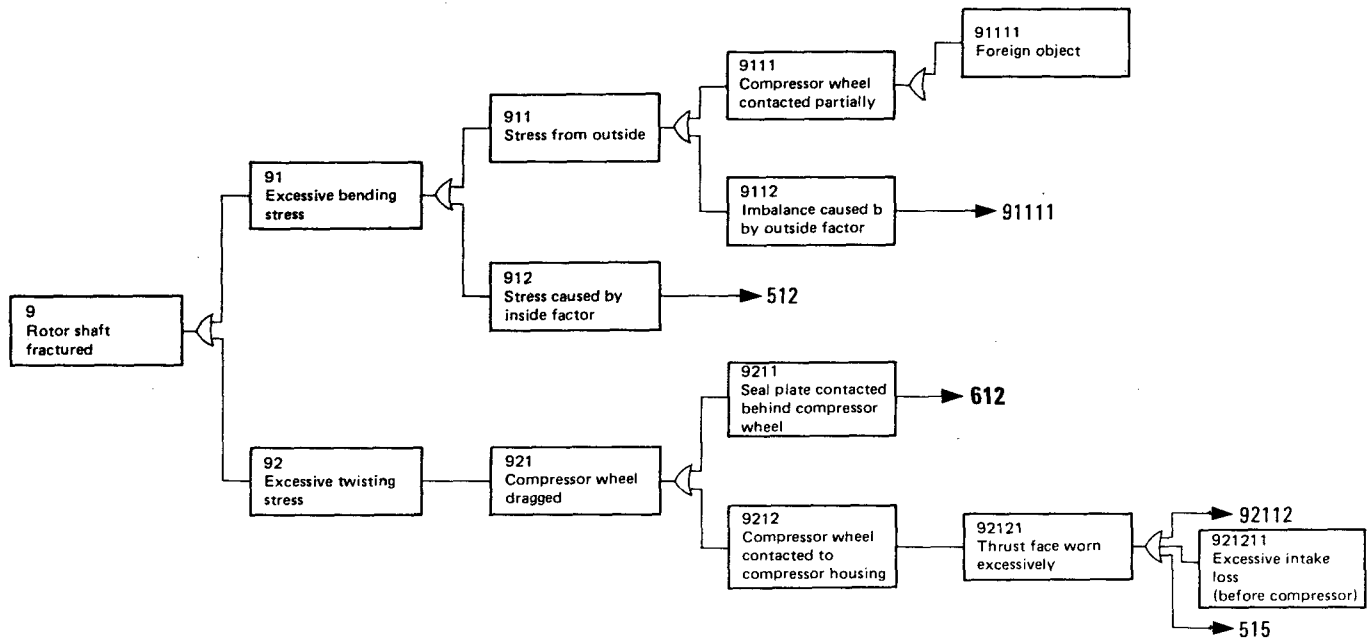










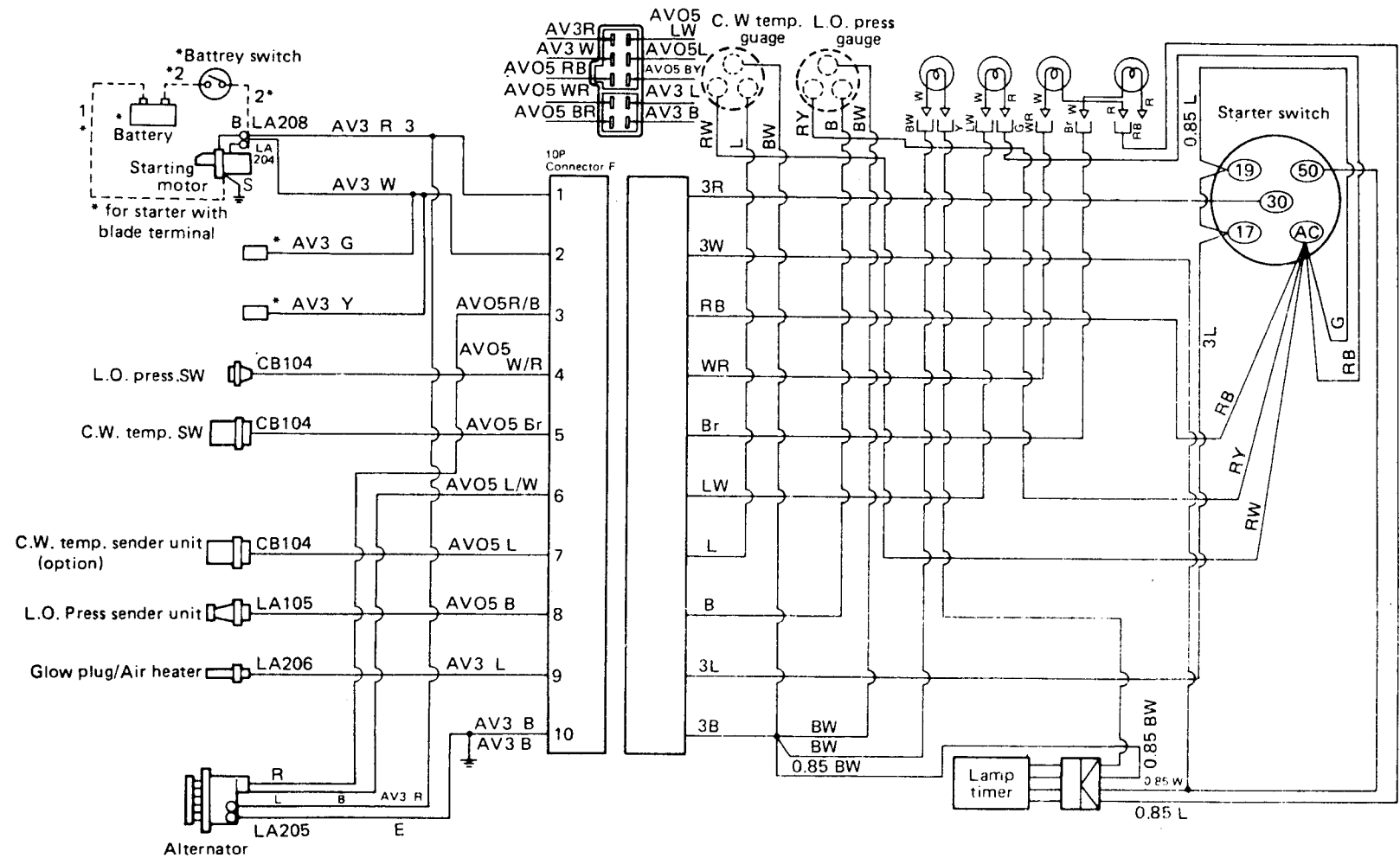


# ELECTRICAL SYSTEM

1. Wiring Diagram .....	7-1
2. Starter motor .....	7-14
3. Charging equipment .....	7-29
4. Starting Aids .....	7-40
5. Battery .....	7-42
6. Service data .....	7-45

# 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		○	○	○	○

Remarks:

- Apparatus, wiring, and wiring terminals marked \* are not procured at our responsibility.
- 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
- 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.

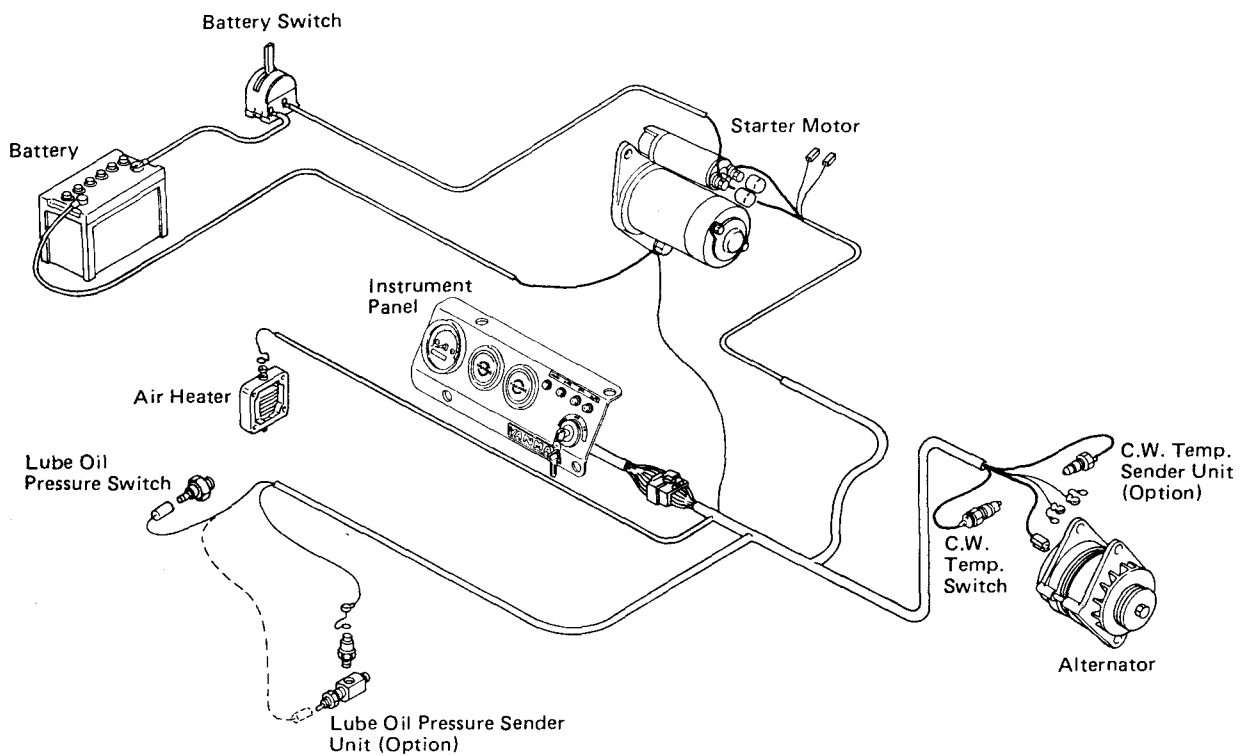
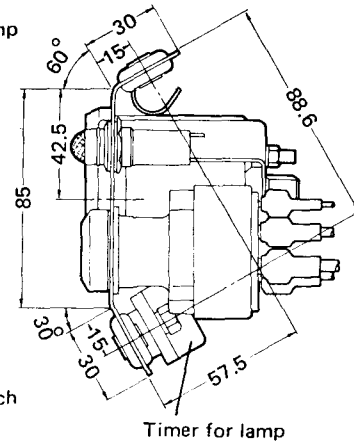
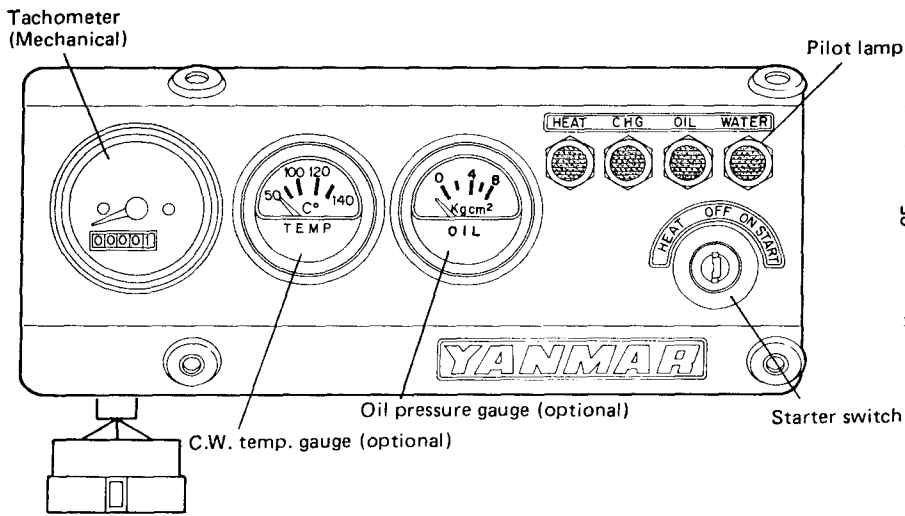
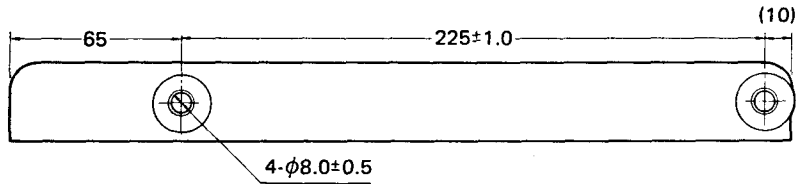
Color coding

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

- Note: 1. Wire AV - 3  
 Wire size (mm<sup>2</sup>)  
 insulator low tension wire with vinyl for automobiles
2. Terminal  
 LA: Eyelet terminal  
 CB: Receptacle

	30 - 17	30 - 50	30 - 15	30 - AC
Load capacity	30A	12A	30A	10A

Instrument Panel



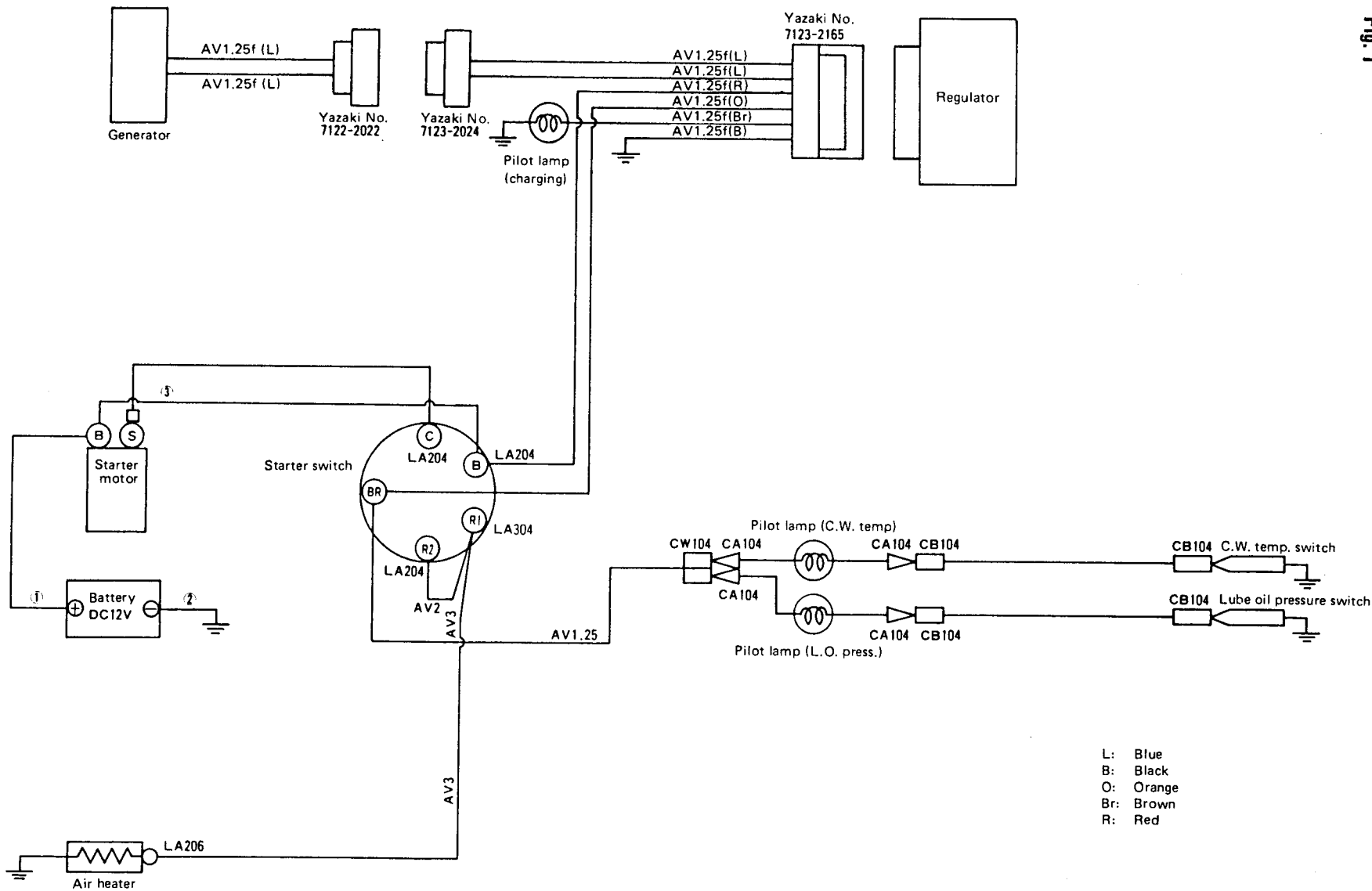
**Wiring Diagram Optional List**

	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	○	○	○	○	○	○	○	○	○	○
Key switch	○	○	○	○	○	○	○	○	○	○
Generator	Magneto generator	←	←	Alternator	←	Magneto generator	←	←	Alternator	←
Regulator	○	○	○	Built-in alternator	←	○	○	○	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	○	○	○	○	○	○	○	○	○	○
C.W. temperature switch	○	○	○	○	○	○	○	○	○	○
Charging indicator	X	○	○	X	X	X	○	○	X	X
Charging lamp	○	○	○	○	○	○	○	○	○	○
Safety relay	X	○	○	X	○	X	○	○	X	○
Stop solenoid	X	X	○	X	X	X	X	○	X	X
Emergency relay	X	X	○	X	X	X	X	○	X	X
Power relay	X	X	○	X	X	X	X	○	X	X

○ marks: equipped  
X marks: not equipment



Fig. 1

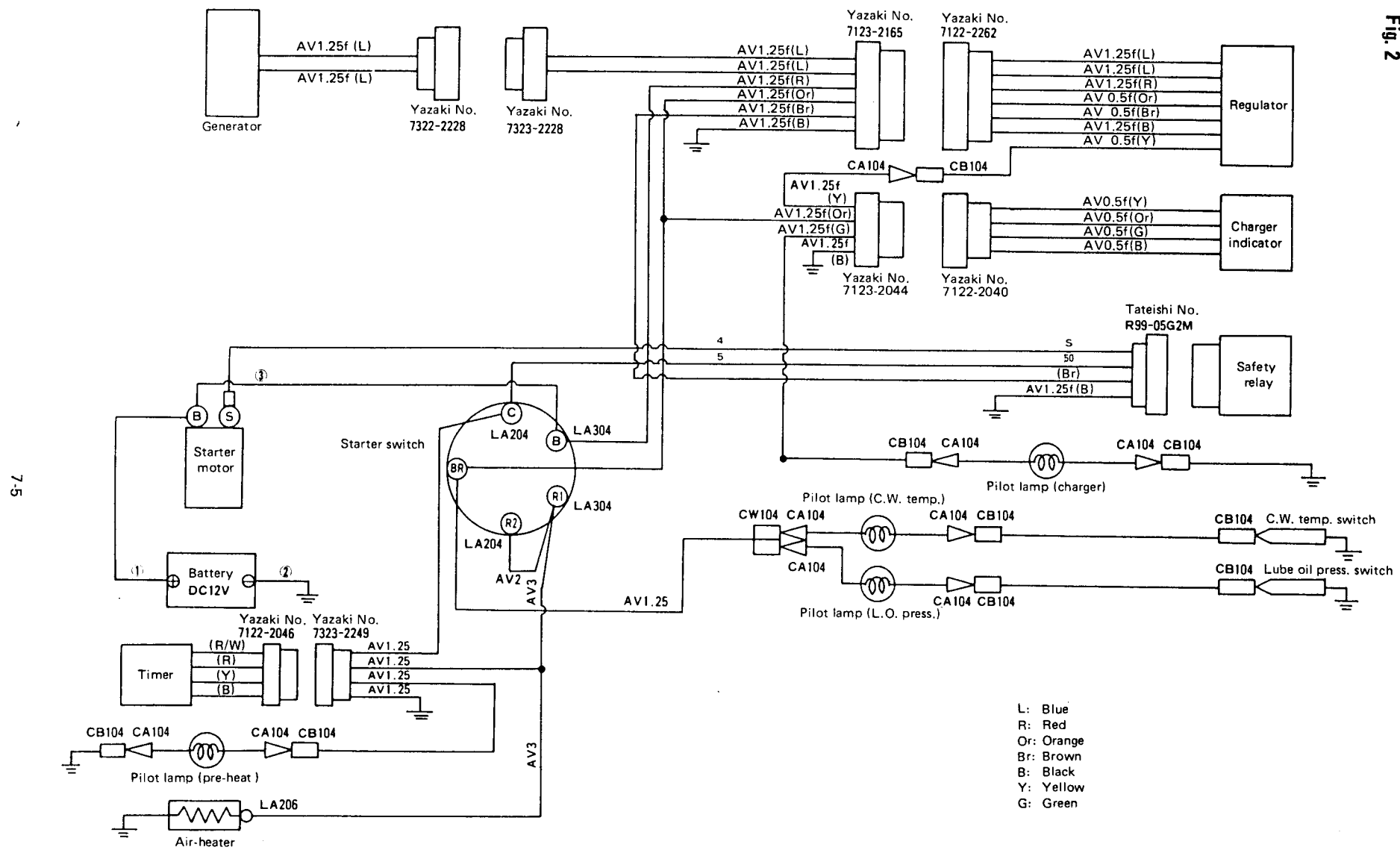


L: Blue  
B: Black  
O: Orange  
Br: Brown  
R: Red

Key switch connection

	B	R1	R2	BR	C
Pre-heat	○	○	○	○	
OFF	○				
ON	○			○	
Start	○	○	○	○	○

Fig. 2



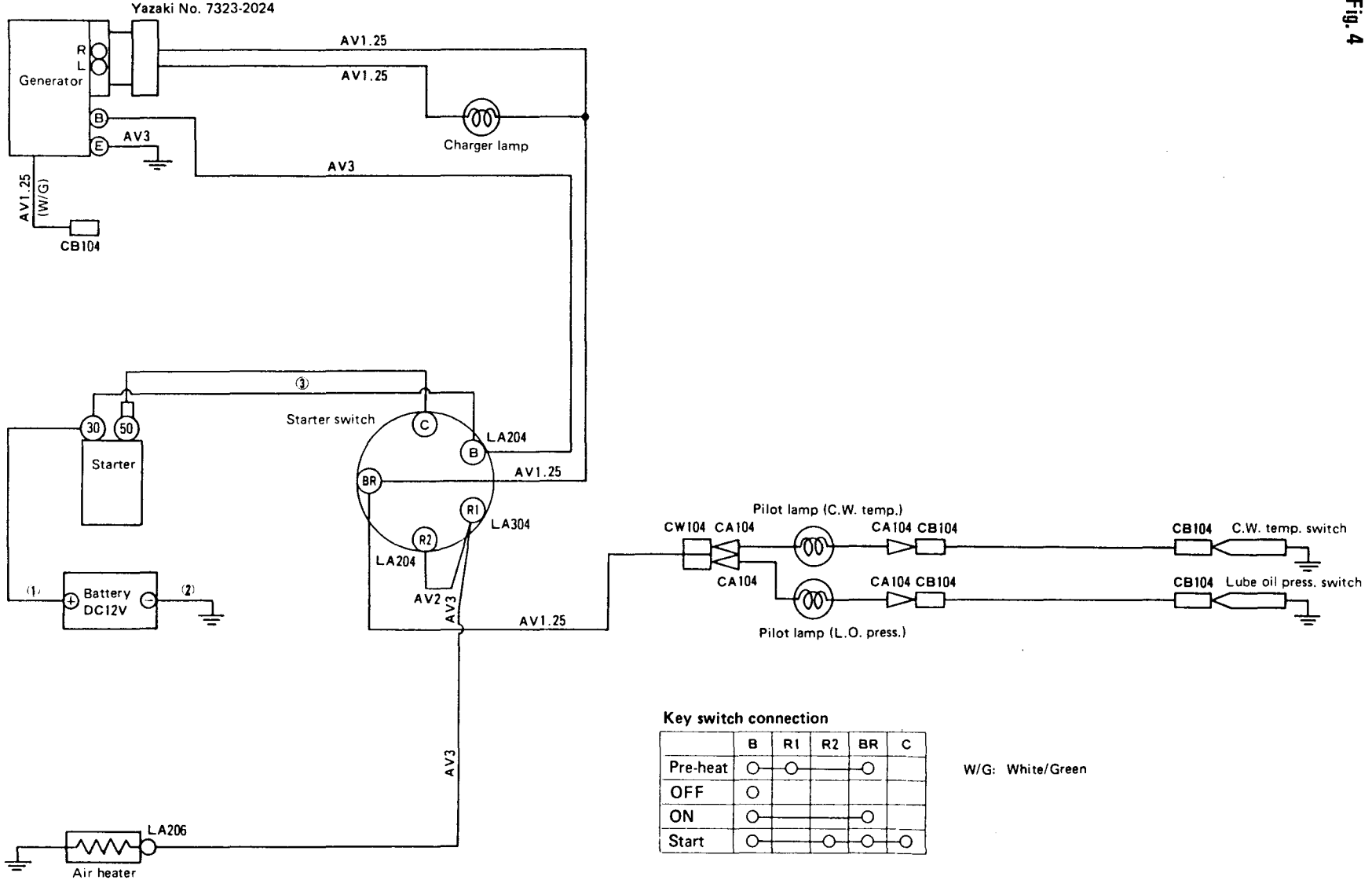
7-5

Key switch connection

	B	R1	R2	BR	C
Pre-heat	○	○	○	○	
OFF	○				
ON	○			○	
Start	○	○	○	○	○



Fig. 4



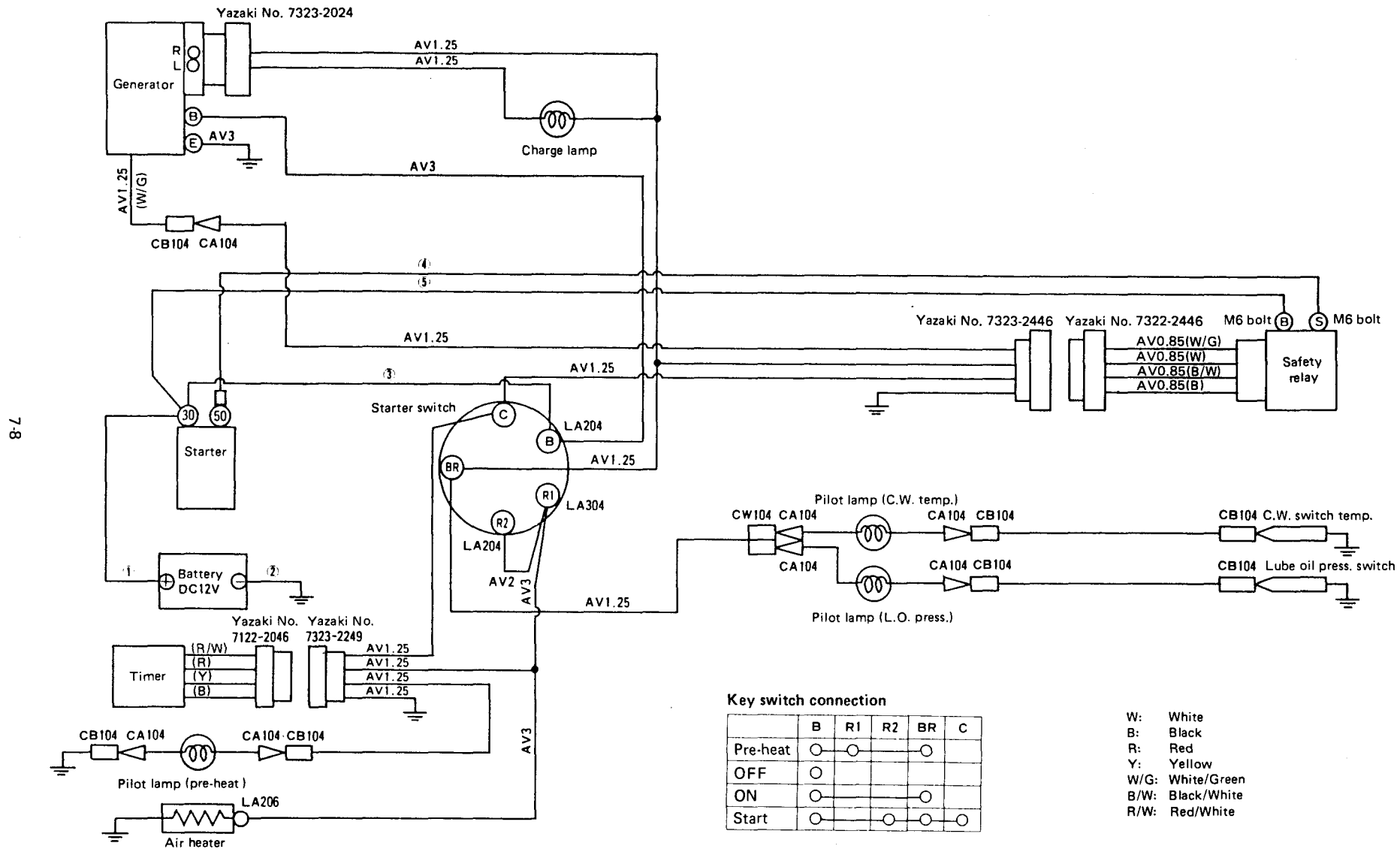
**Key switch connection**

	B	R1	R2	BR	C
Pre-heat	○	○		○	
OFF	○				
ON	○			○	
Start	○		○	○	○

W/G: White/Green

7-7

Fig. 5



7-8

Fig. 6

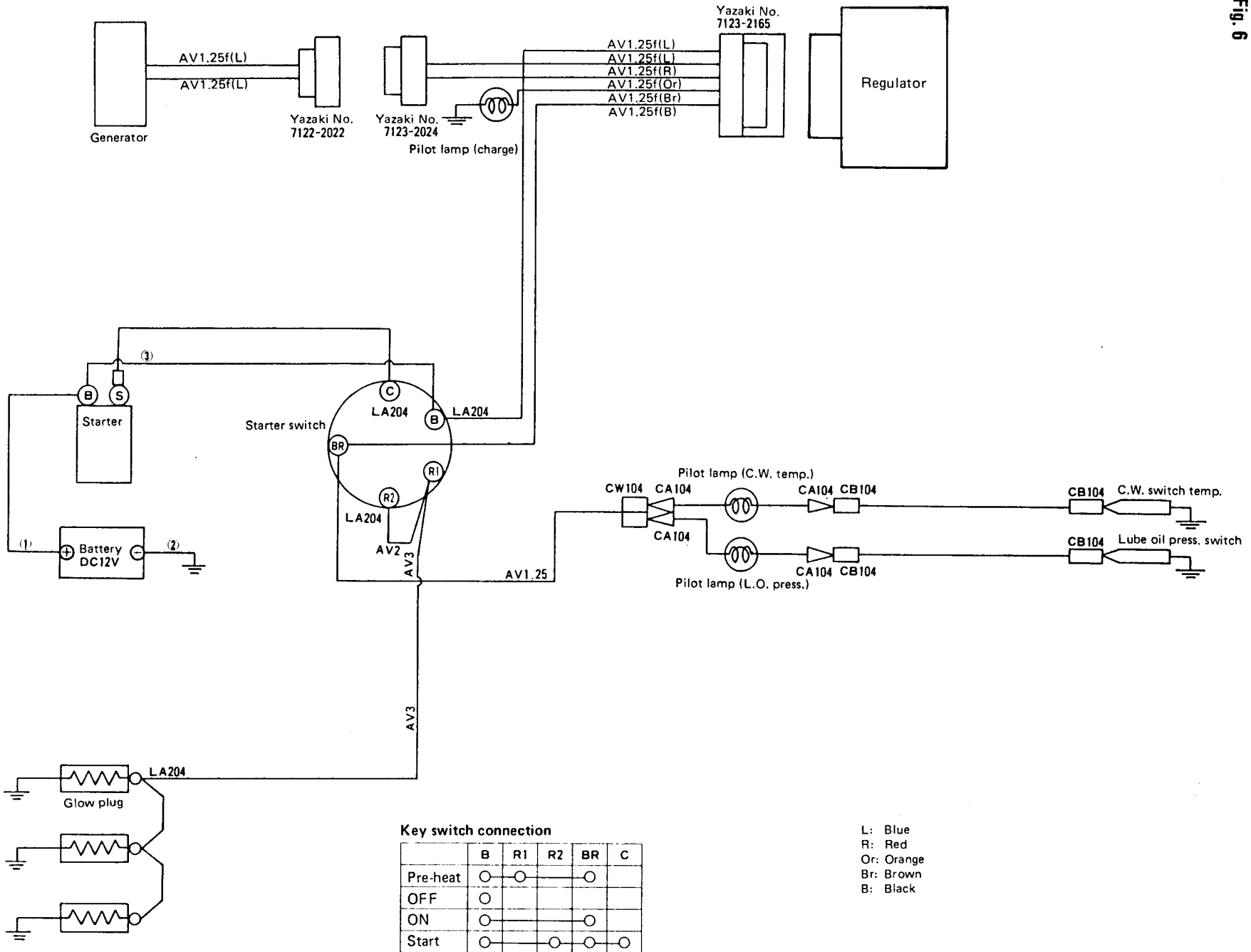


Fig. 7

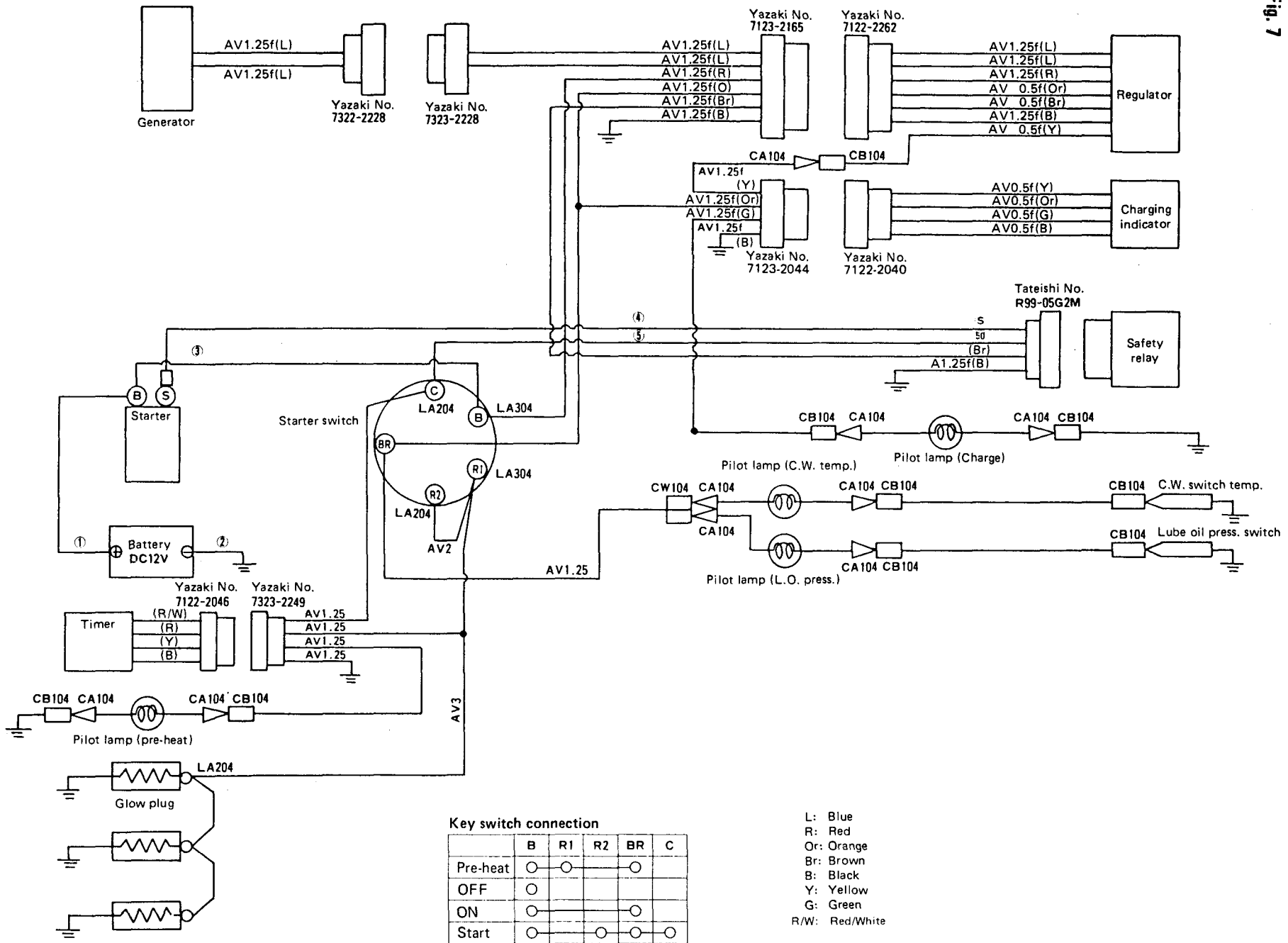
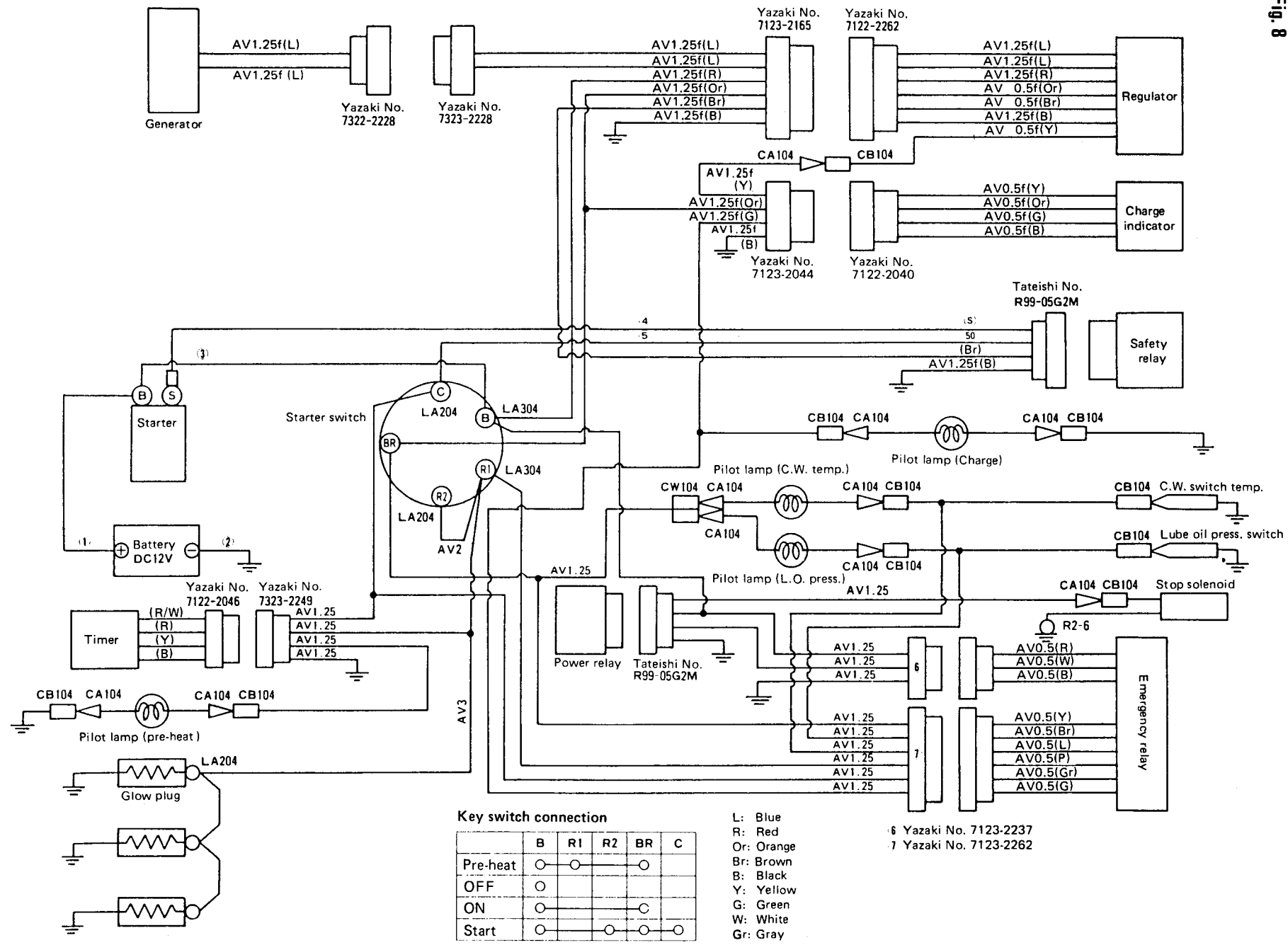


Fig. 8



**Key switch connection**

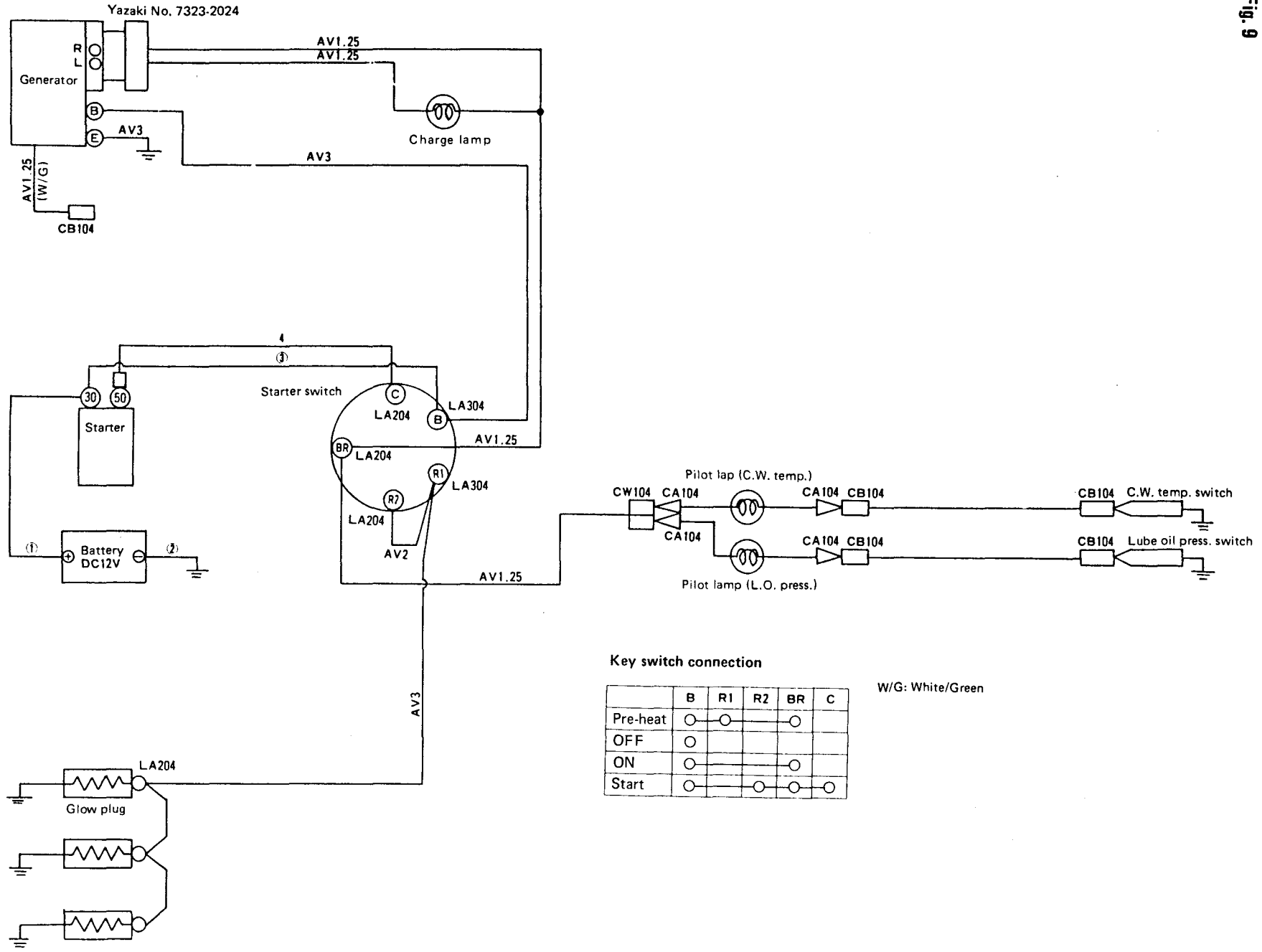
	B	R1	R2	BR	C
Pre-heat	○	○		○	
OFF	○				
ON	○			○	
Start	○	○	○	○	○

- L: Blue
  - R: Red
  - Or: Orange
  - Br: Brown
  - B: Black
  - Y: Yellow
  - G: Green
  - W: White
  - Gr: Gray
- 6 Yazaki No. 7123-2237  
7 Yazaki No. 7123-2262

7-11

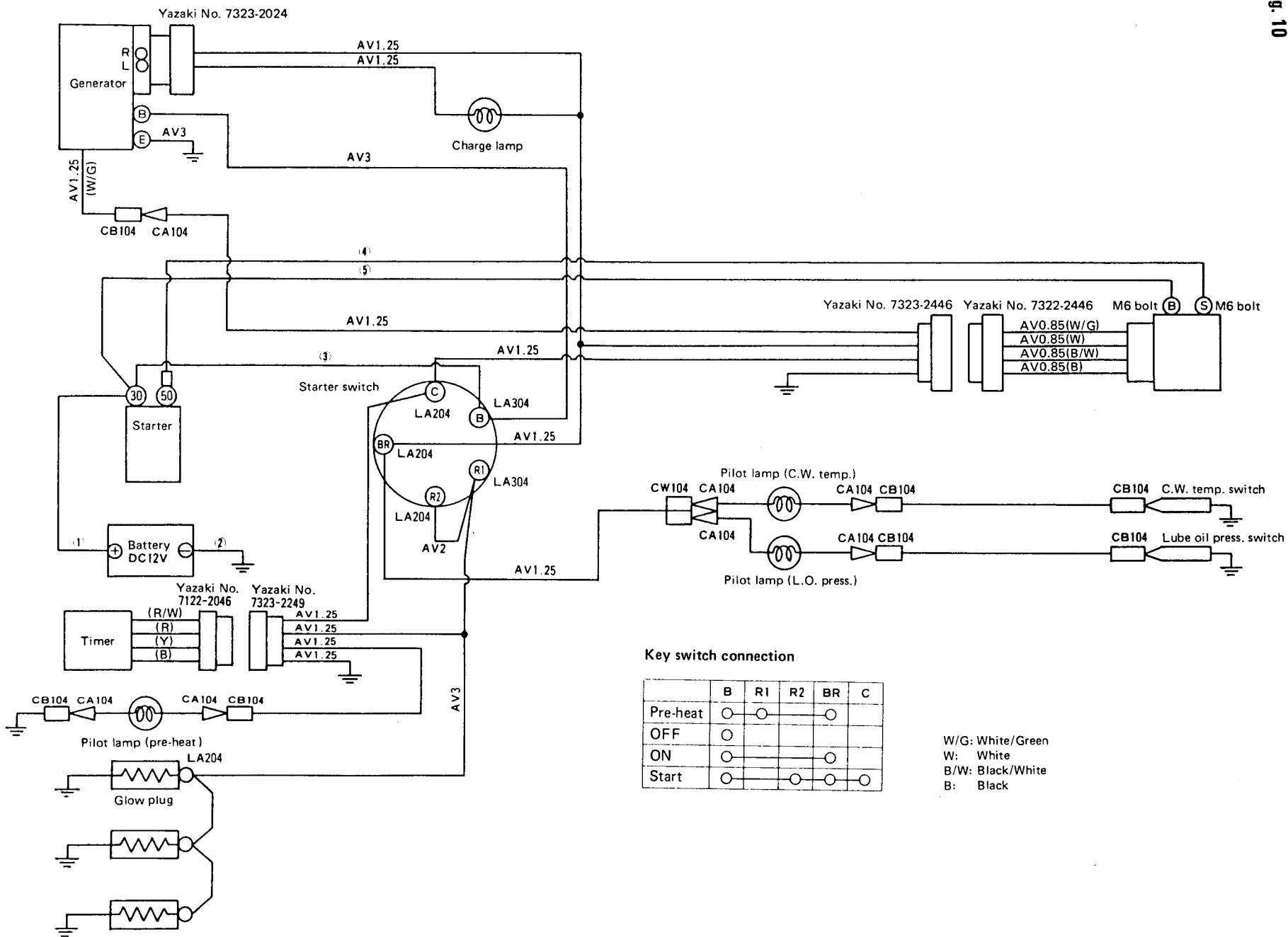


Fig. 9



7-12

Fig. 10



7-13

2. Starter Motor

# 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.

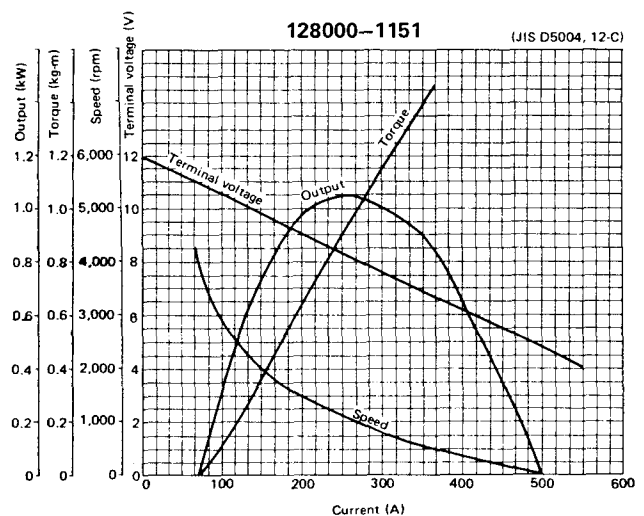
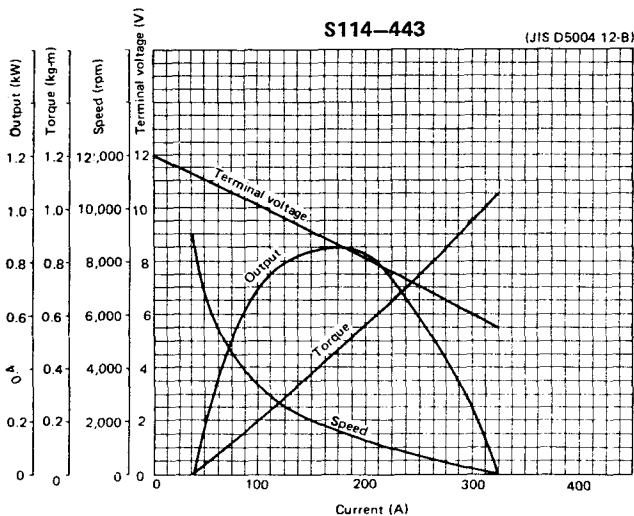
Engine model	
Model	
Rating (sec.)	
Output (kW)	
Direction of rotation (viewed from pinion side)	
Weight kg (lb.)	
Clutch system	
Engagement system	
No. of pinion teeth	
Pinion coming out voltage	
No-load	Terminal voltage (V)
	Current (A)
	Speed (rpm)
Loaded characteristics	Terminal voltage (V)
	Current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

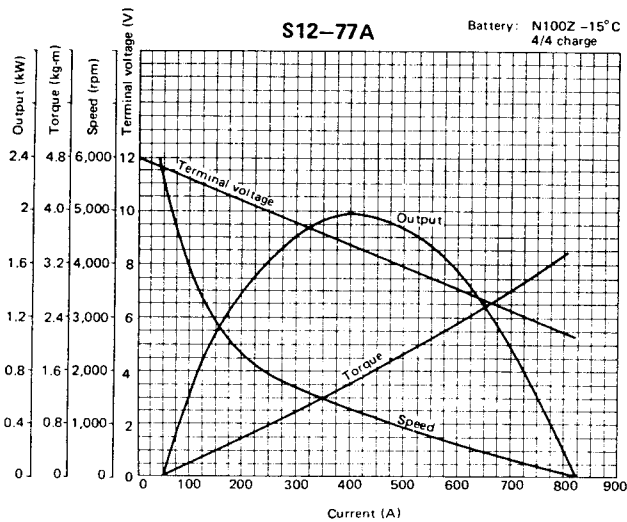
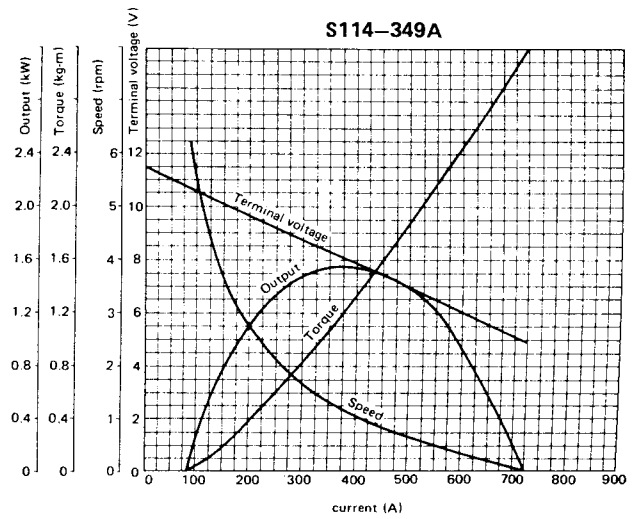
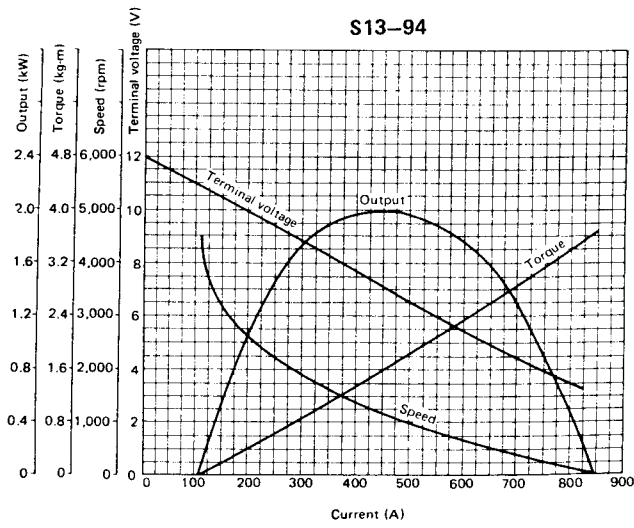
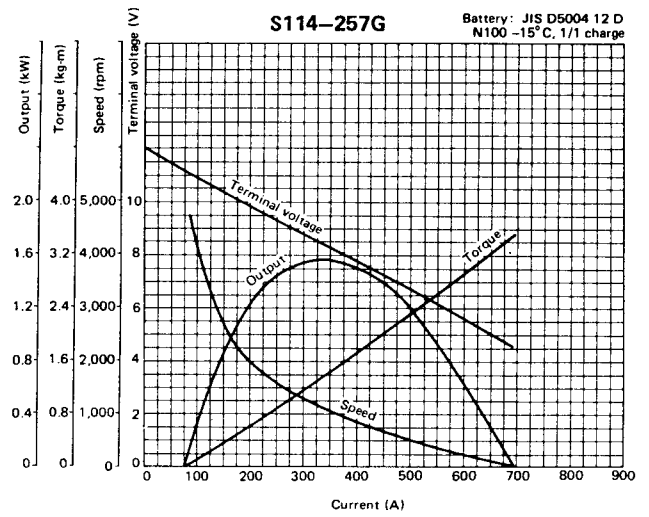
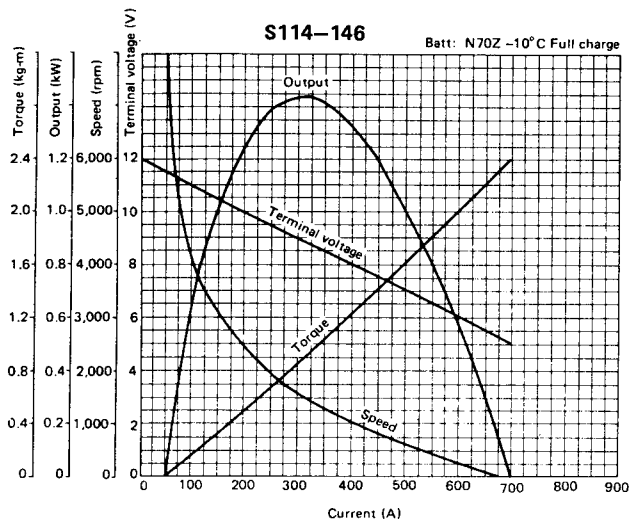
See separate service data (Page 7-45, 46)

### (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





2. Starter Motor

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.

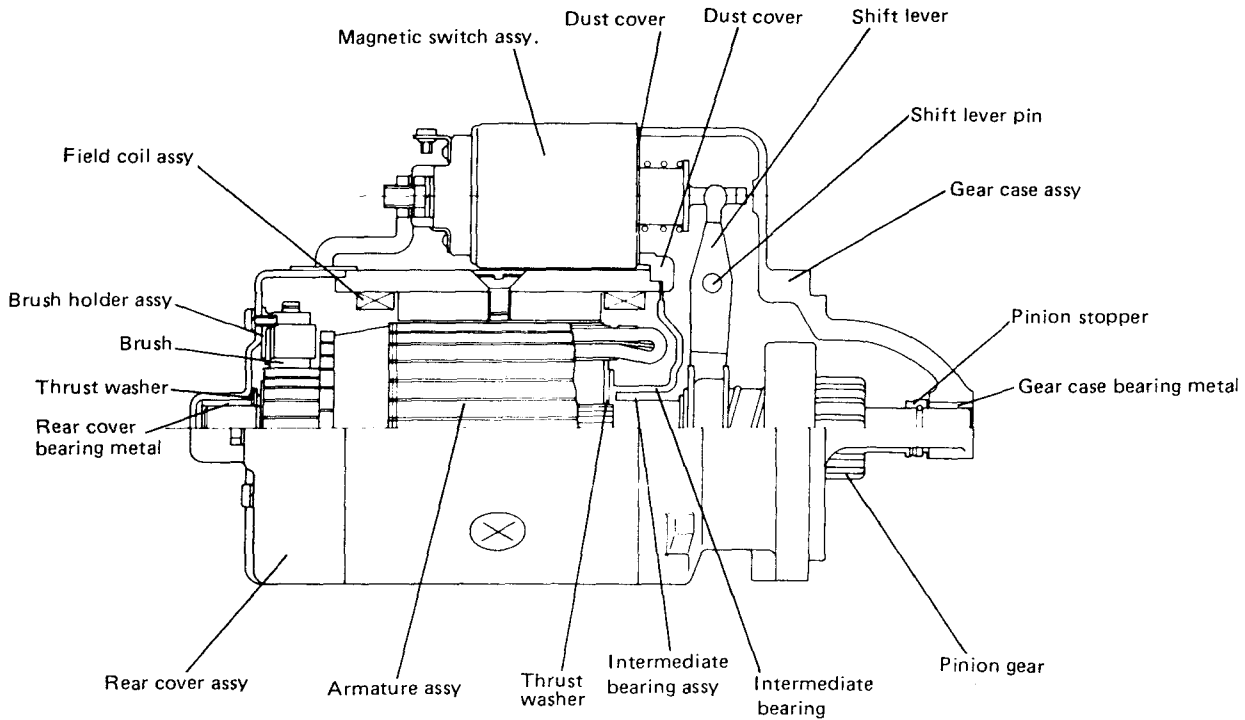
(2) Motor

A continuous current series motor which generates rotational drive power.

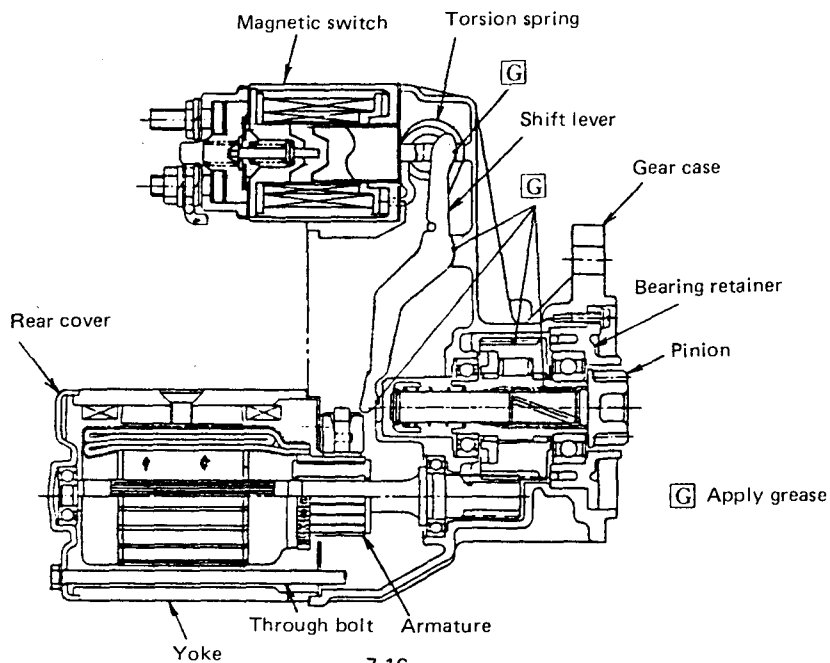
(3) Pinion

Transfers driving power from motor to ring gear. An over-speed 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

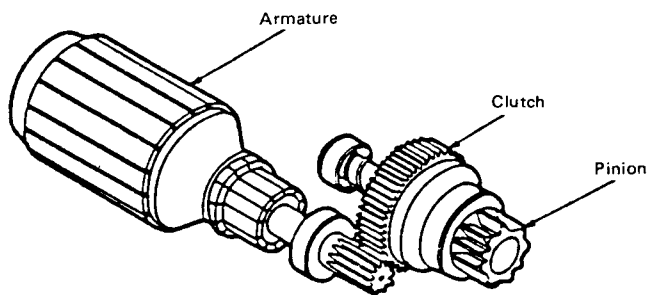
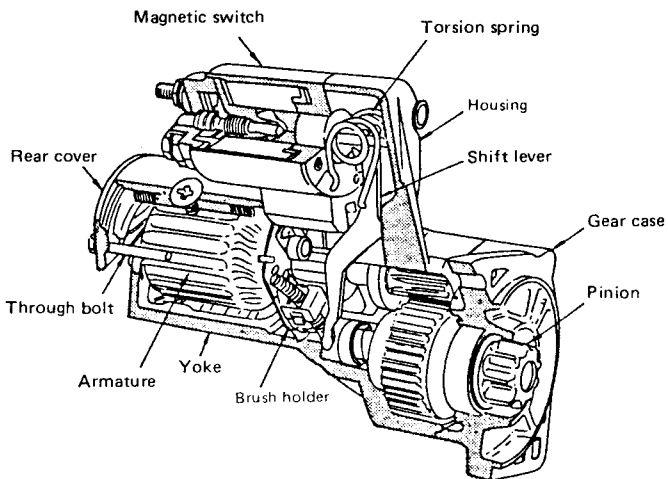


2. Starter Motor

(1) Construction of the reduction type Starter Motor

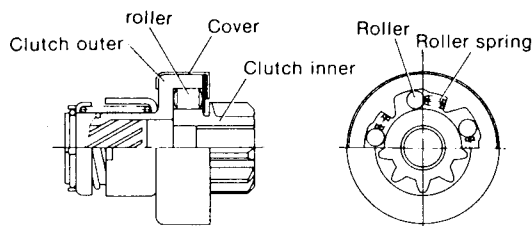
This motor is equipped with reduction gears between the armature and pinion; the reduction gears increase the torque of the motor before transmitting the torque to the pinion.

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.



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)



1) Circumscribed type

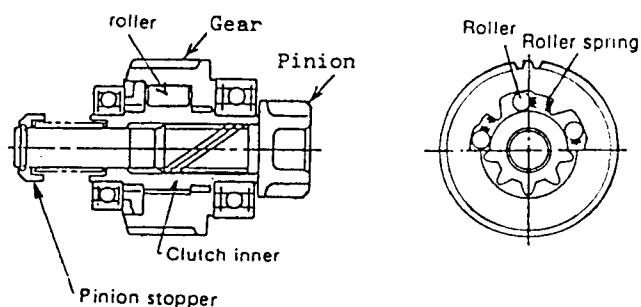
The armature shaft is equipped with a small gear at the end, which is constantly engaged with a large gear on the circumference of the clutch. Thus, the revolution of the armature is transmitted to the pinion through the reduction gears and the clutch assembly.

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.

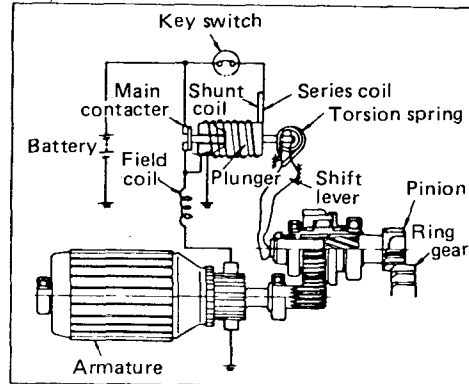
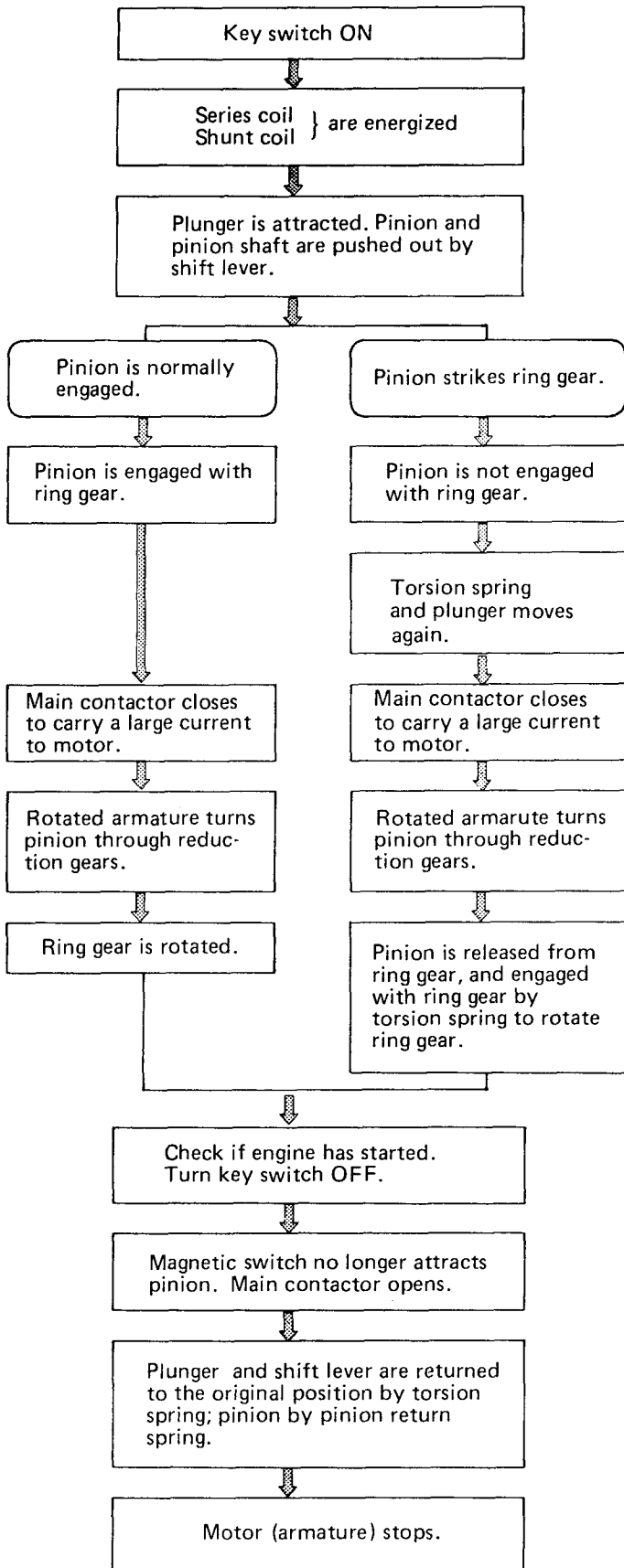
In general type of starting motor, the armature is so designed to turn at the same rpm as the pinion. However, the reduction type motor has its internal resistance reduced to about 25% – 33% of the conventional motor to a high-speed low-torque motor while being a high torque motor by use of reduction gears.

Over-running clutch (reduction type)

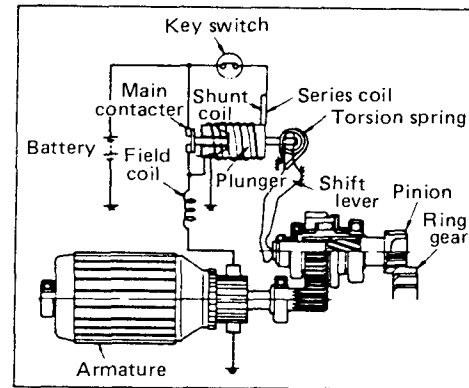


2. Starter Motor

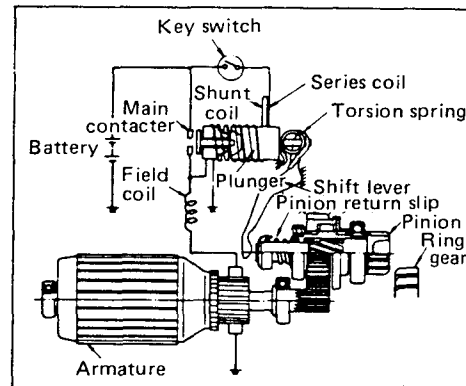
(2) Operation



Pinion is engaged with ring gear



Ring gear is rotated



Key switch is turned OFF

2. Starter Motor

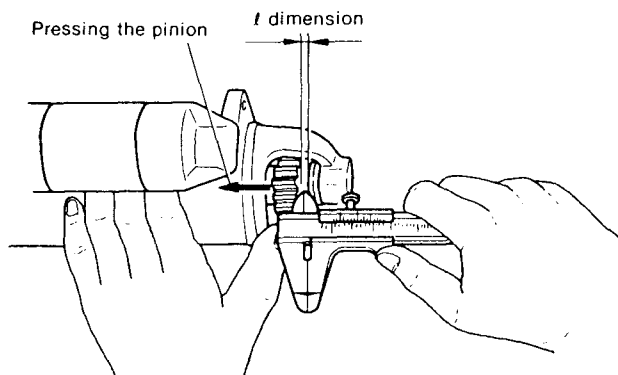
2-3 Adjustment and performance test

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	t dimension
See separate service data (Page 7-45, 46)	

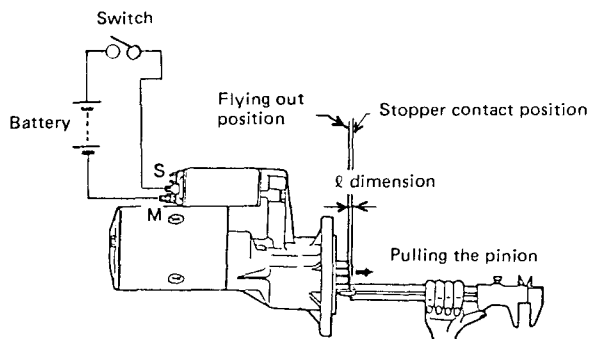


Measuring of t dimension

[Reduction type]

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

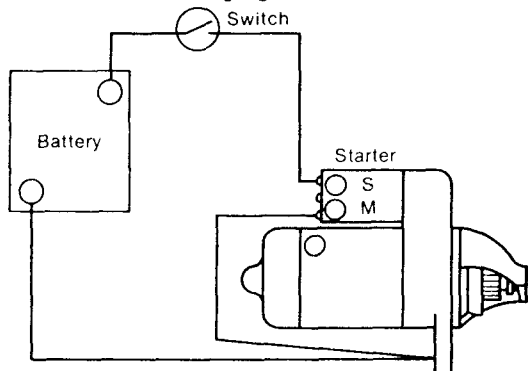
mm (in.)	
Starter motor	ℓ dimension
0.3 - 1.5 (0.012 - 0.059)	



Measuring of ℓ dimension

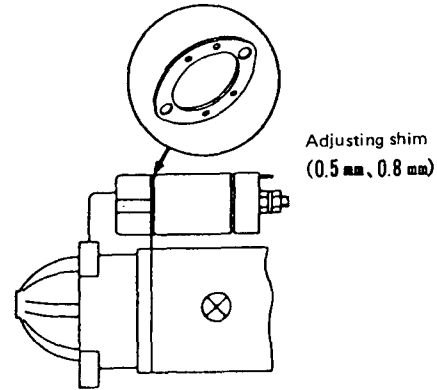
2-3.2 Pinion movement

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



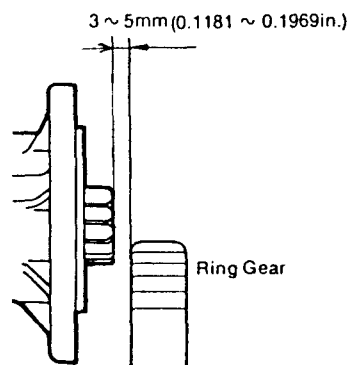
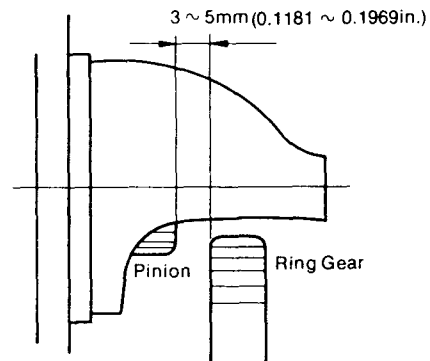
2-3.3 Plunger movement

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.).





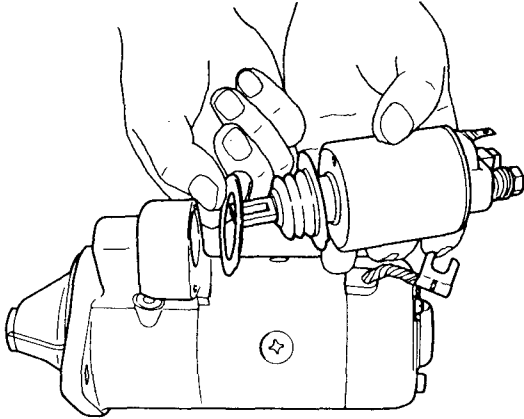
## 2. Starter Motor

## 2-4 Disassembly

## [Conventional starter motor]

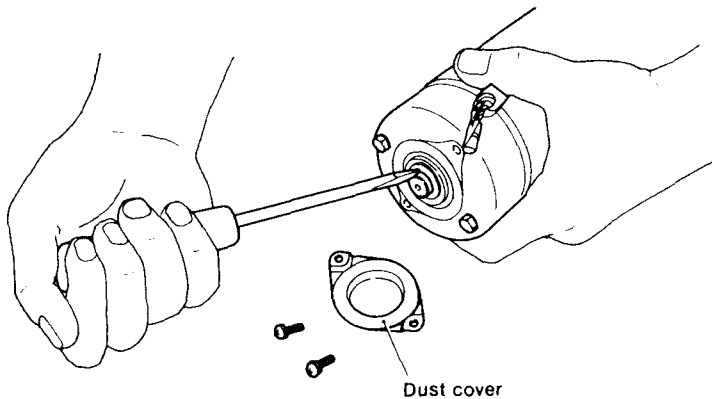
## 2-4.1 Magnetic switch

- (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.

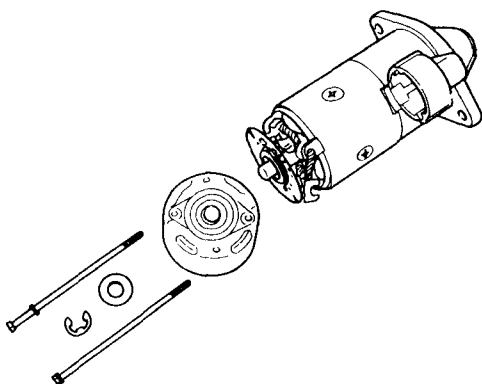


## 2-4.2 Rear cover

- (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.

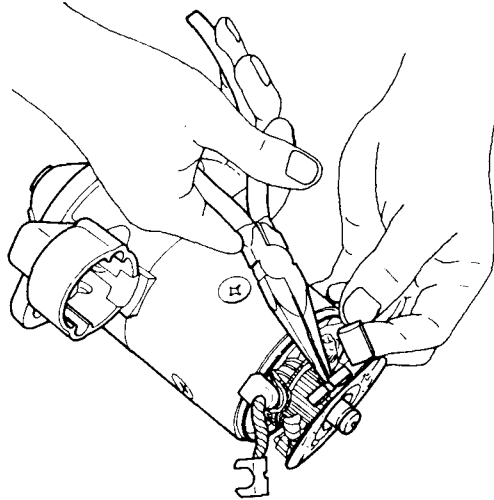


## 2-4.3 Brush holder

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

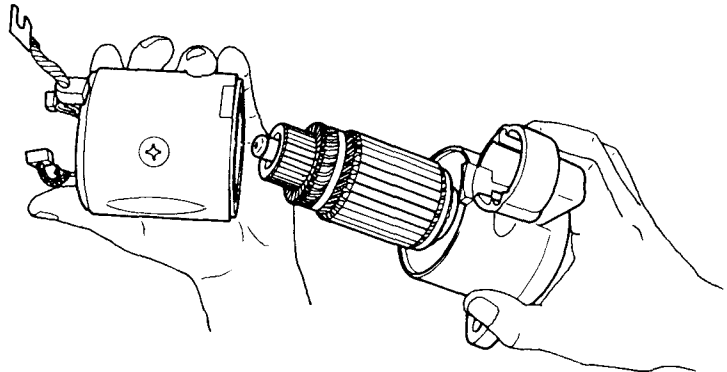
For Reduction type:

- (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.



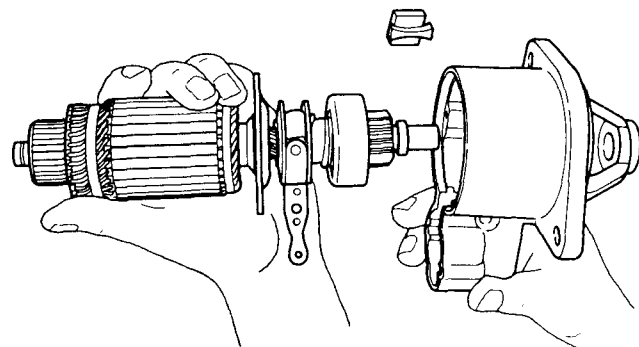
## 2-4.4 Yoke

- (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.

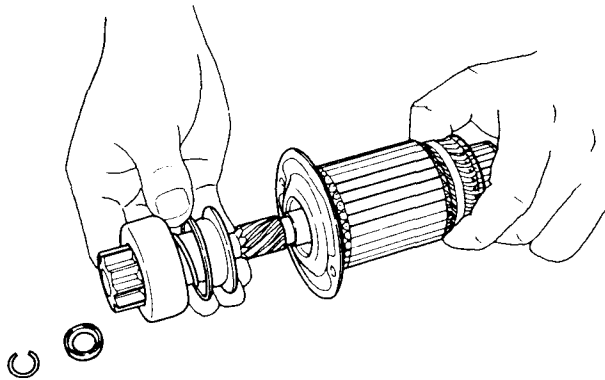
2. Starter Motor

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

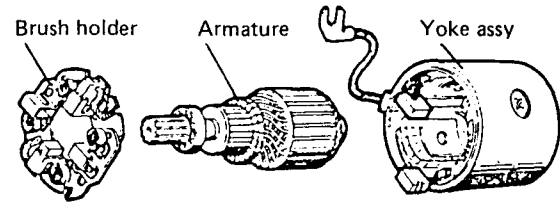
- (1) Remove the three through bolts fixed the gear case and housing.
- (2) By removing bolts, separates the gear case and center housing.

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.

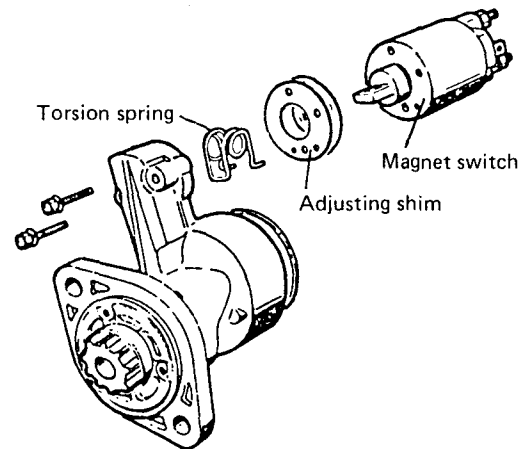


- (3) Remove the brush holder.
- (4) Remove the armature, and yoke.



2-4-c Magnetic switch

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

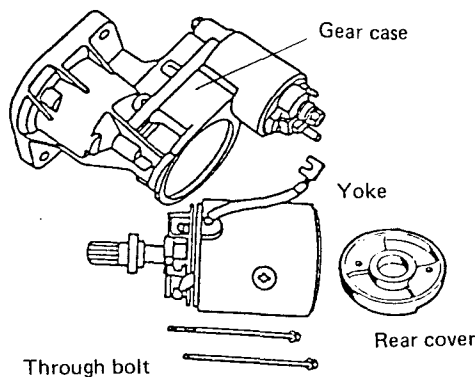


[Reduction type]

(2-4 Disassembly)

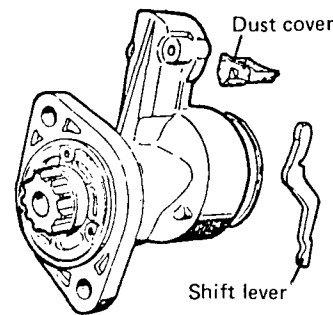
2-4-a Rear cover and Yoke

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



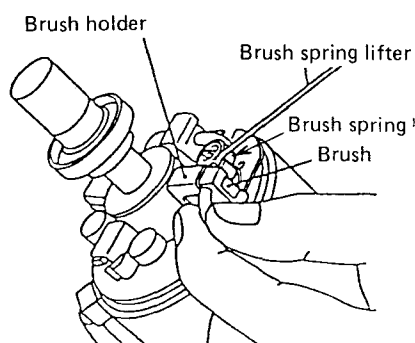
2-4-d Shift lever

- (1) Separate the dust cover and shift lever.



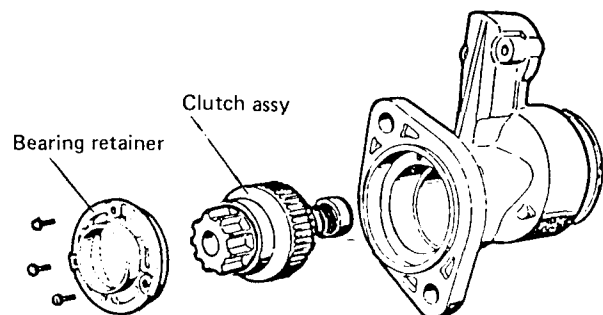
2-4-b Brush holder

- (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.



2-4-e Gear case

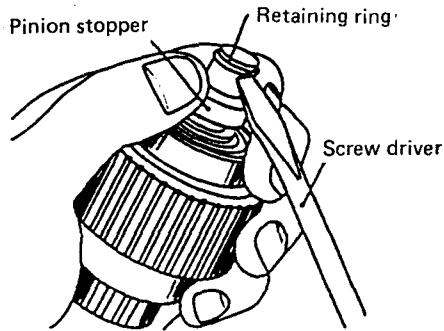
- (1) Remove the bearing retainer mounting screws.
- (2) Remove the bearing retainer and clutch assy from the gear case.



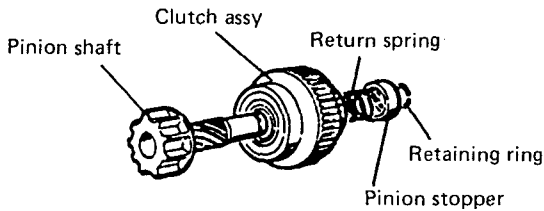
2. Starter Motor

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.

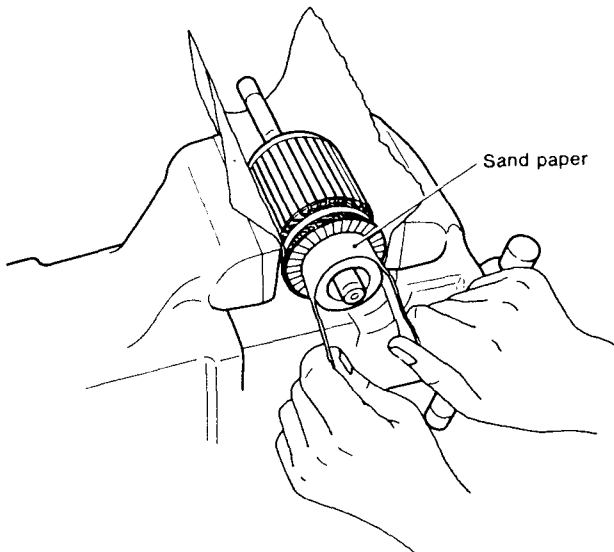


2-5 Inspection

2-5.1 Armature

(1) Commutator

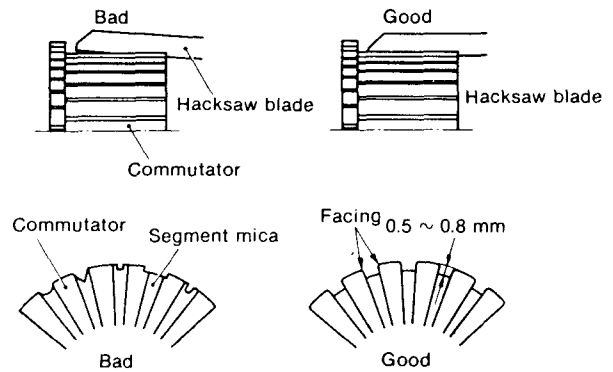
Inspect the surface of the commutator. If corroded or pitted, sand with #500 ~ #600 sandpaper. Replace the commutator if damage is irreparable.



	Maintenance standard	Wear limit
Commutator outside diameter	<i>See separate service data (Page 7-45,46)</i>	
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.



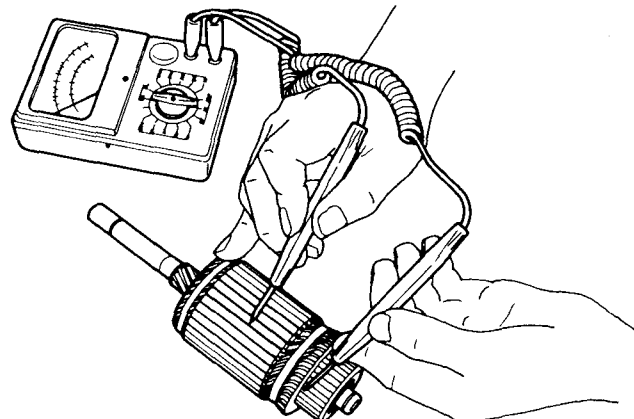
mm (in.)

	Maintenance standard	Repair limit
Mica undercut	<i>See separate service data (Page 7-45, 46)</i>	

(3) Armature coil ground test

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

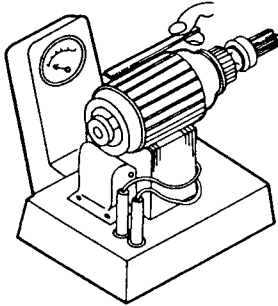
If there is continuity, replace the armature.



2. Starter Motor

**Armature coil short test**

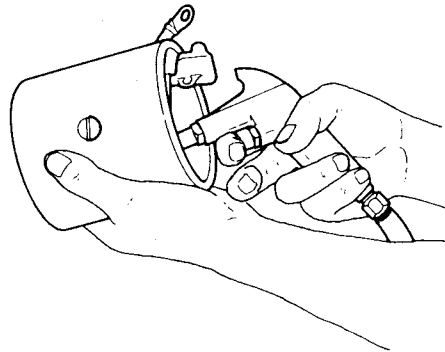
Place the iron piece on the armature fitted to the layer short tester and turn the armature. If the iron piece vibrates, there is a short circuit and the armature should be replaced.



(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.

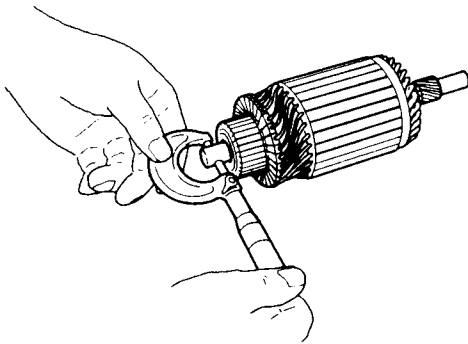
\*Do not remove the field coil from the yoke.



(4) Armature shaft outside diameter

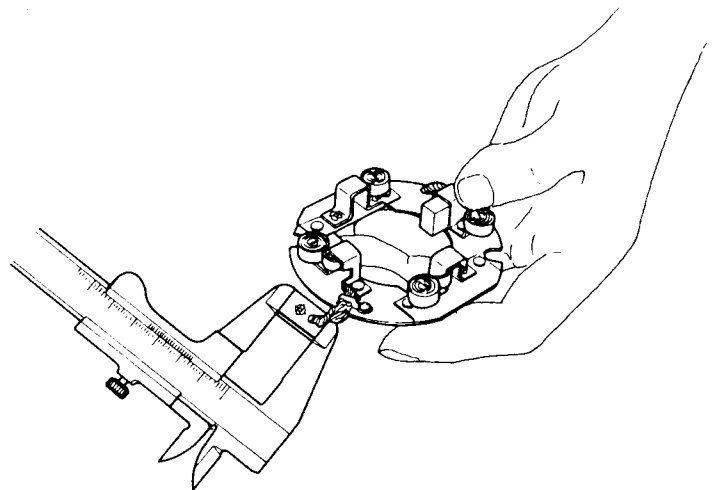
Measure the outside diameter of the armature shaft at four locations: front, center, end, and pinion. Replace the armature if the shaft is excessively worn.

Check the bend of the shaft; replace the armature if the bend exceeds 0.08mm (0.0031in.)



**2-5.3 Brush**

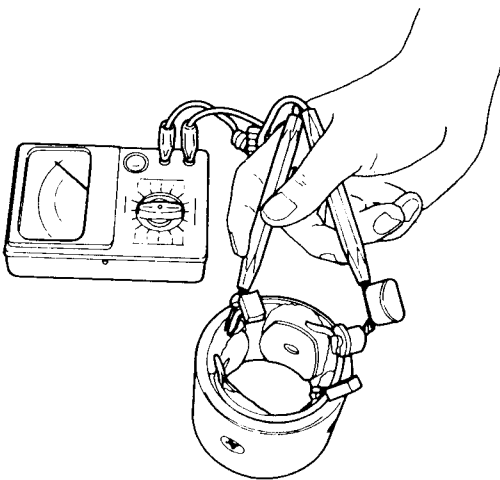
The brushes are quickly worn down by the motor. When the brushes are defective, the output of the motor will drop.



**2-5.2 Field coil**

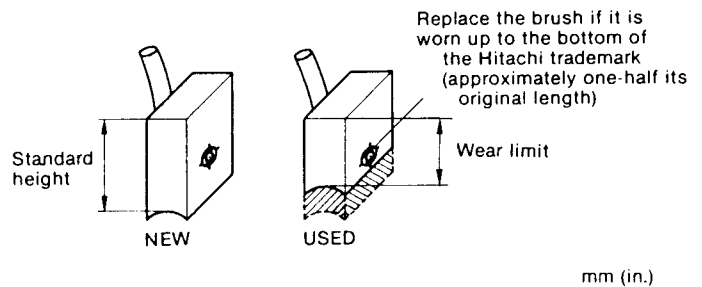
(1) Open test

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



(1) Brush dimensions

Replace brushes which have been worn beyond the specified wear limit.



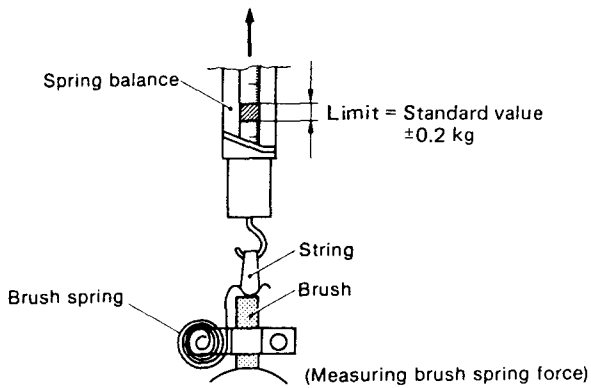
(2) Short test

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

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

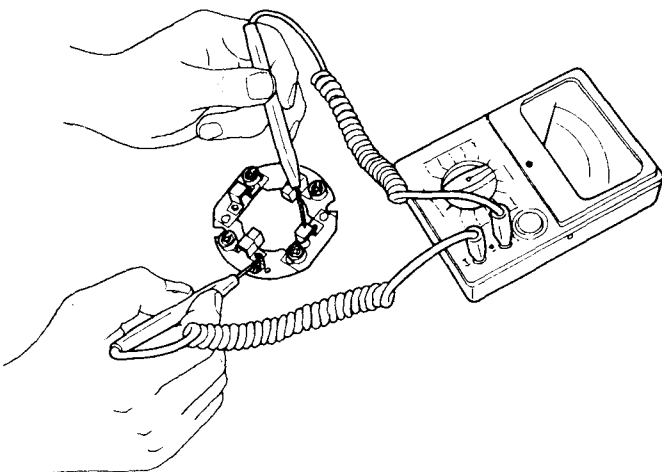
2. Starter Motor

- (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  $\pm 0.2\text{kg}$ .



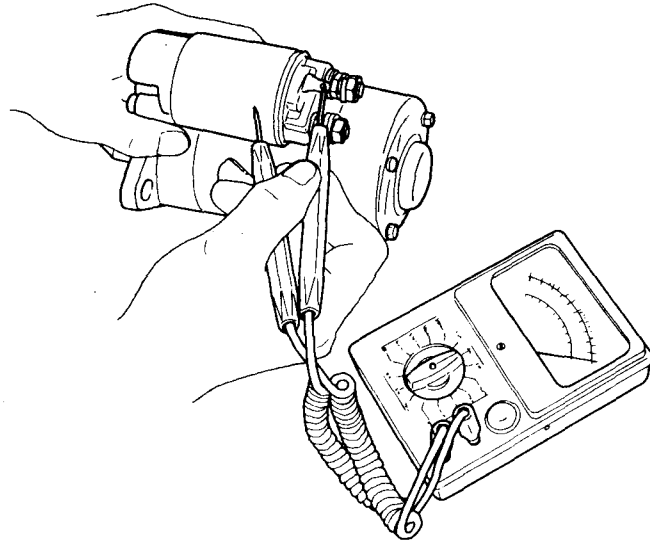
	See separate service data (Page 7-45, 46)
Standard spring load	

- (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.



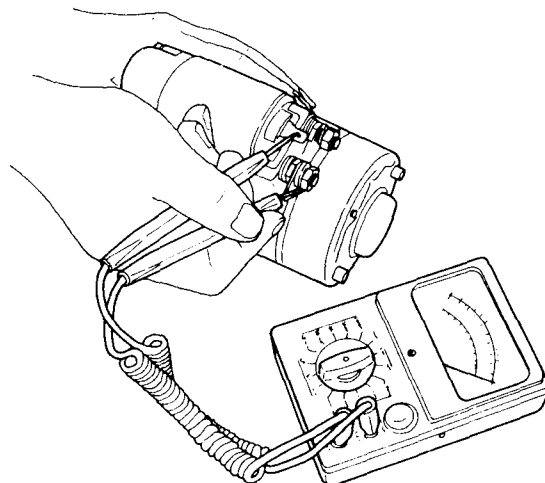
2-5.4 Magnetic switch

- (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.



	See separate service data (Page 7-45, 46)
Coil resistance (at 20°C)	

- (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.

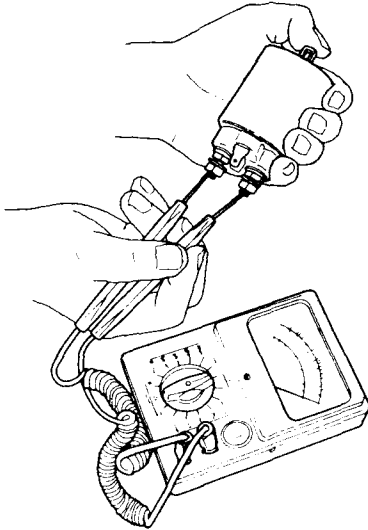


	See separate service data (Page 7-45, 46)
Resistance value (at 20°C)	

2. Starter Motor

(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.

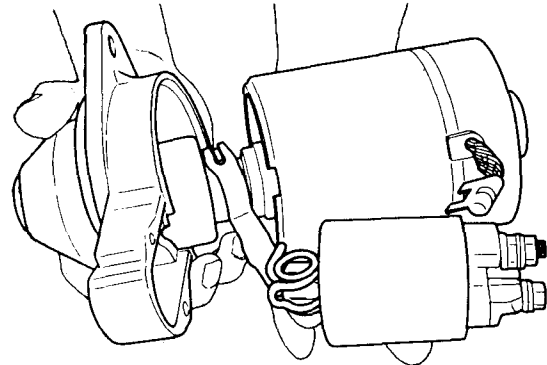


(2) Mounting the magnetic switch

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

2-5.5 Pinion

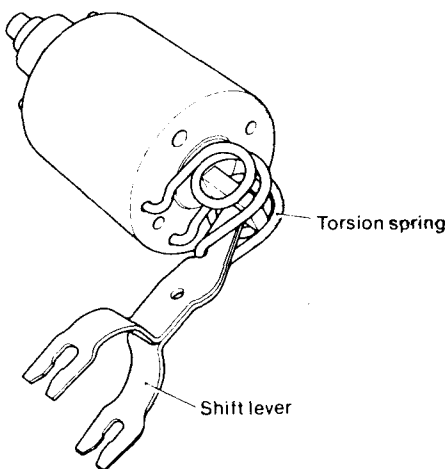
- (1) Inspect the pinion teeth and replace the pinion if the teeth are excessively worn or damaged.
- (2) Check if the pinion slides smoothly; replace the pinion if faulty.
- (3) Inspect the springs and replace if faulty.
- (4) Replace the clutch if it slips or seizes.

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).

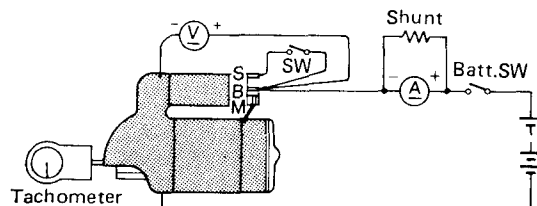


2-7 Testing

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. Starter Motor

2-8 Maintenance standard

Brush	Standard spring load		kg (lb)
	Standard height		mm (in.)
	Wear limit		mm (in.)
Magnetic switch	Series coil resistance		$\Omega$
	Shunt coil resistance		$\Omega$
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.)

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

## 2. Starter Motor

## 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

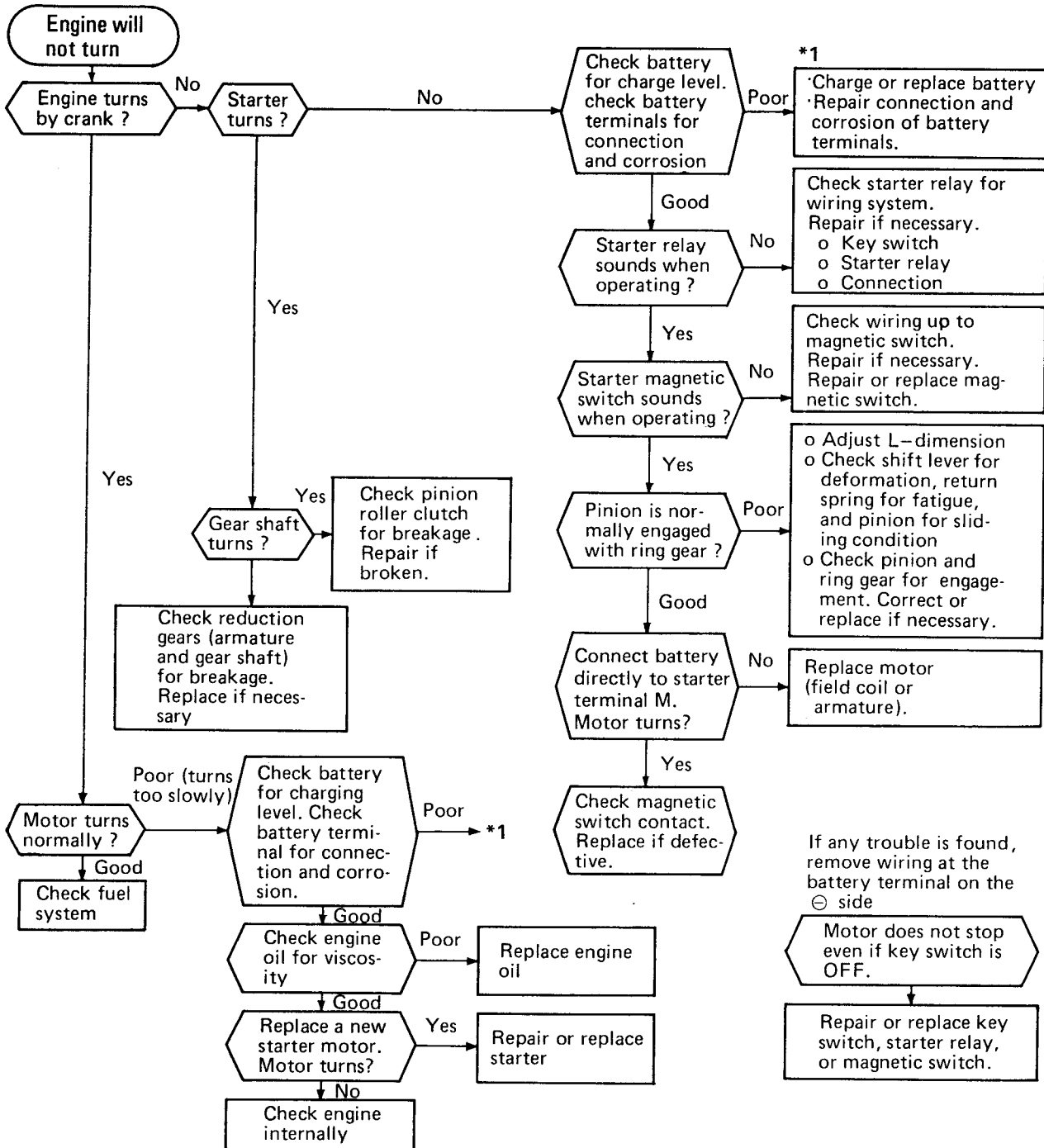
Problem	Cause	Corrective action
Starting switch	Faulty switch	Replace
Magnetic switch	Faulty switch	Replace



2. Starter Motor

3. Troubleshooting for Starting Motor

Check Item Troubleshooting



3. Charging Equipment

# 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.

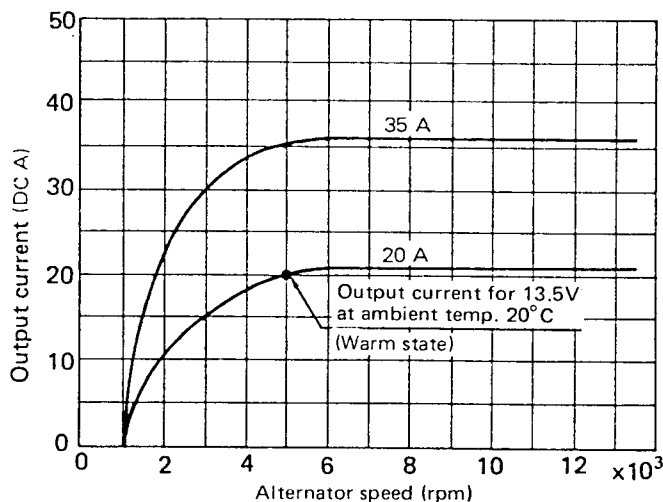
### 3-2 Specifications

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 ± 0.3V (Standard temperature voltage gradient, -0.01/°C)	
Permissible ambient	-30°C - +80°C (-22°F - 176°F)	

### Pulley ratio

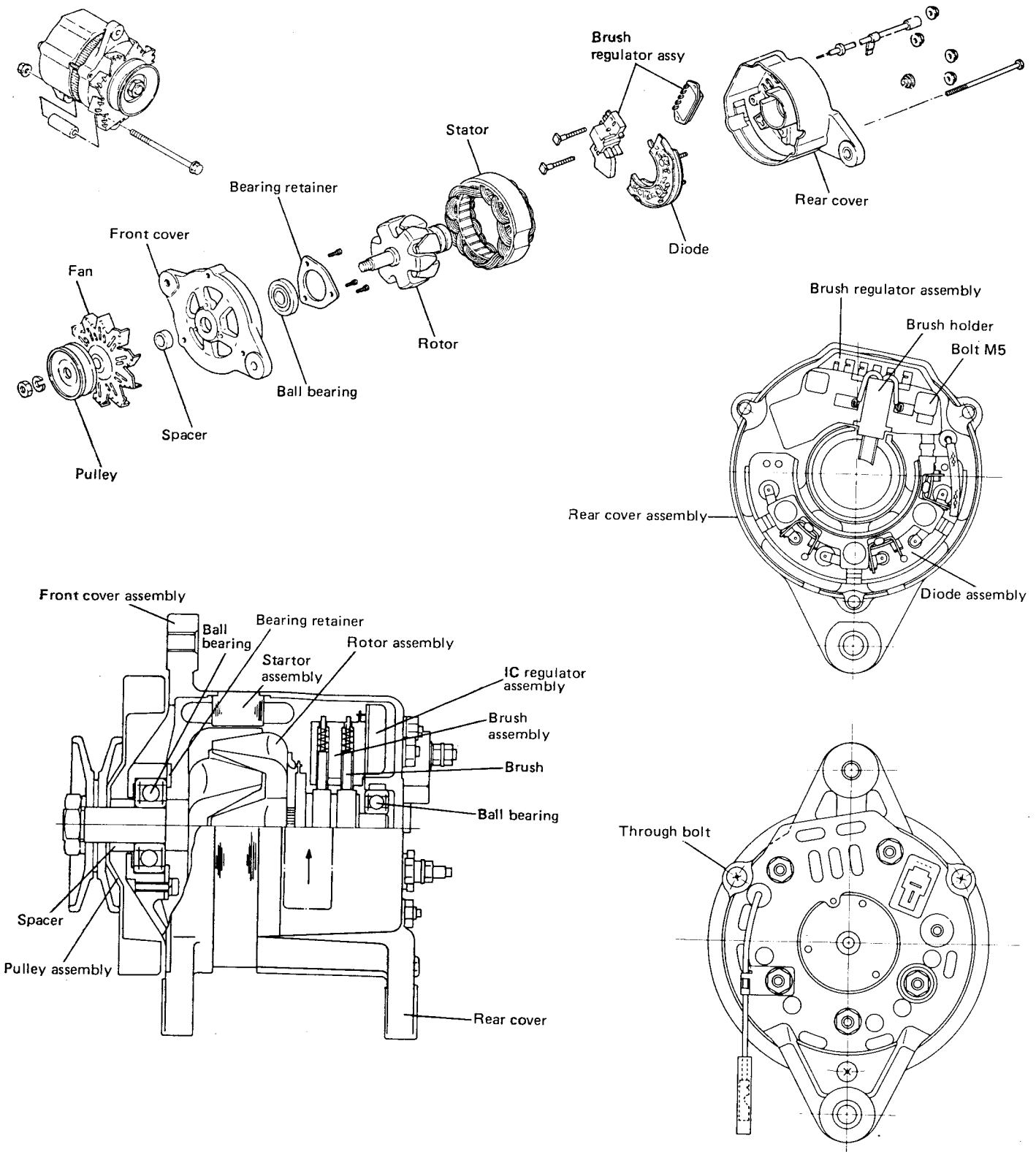
Specification		Pulley ratio
3TN66E		1.53
3TNA72E		1.78
3TN75E, 3TNC78E 3,4TN82E(TE) 3,4TN84E(TE)	S, G2	1.61
3TN75E, 3TNC78E 3,4TN82E(TE) 3,4TN84E(TE)	G1	1.76

### 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. Charging Equipment

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.

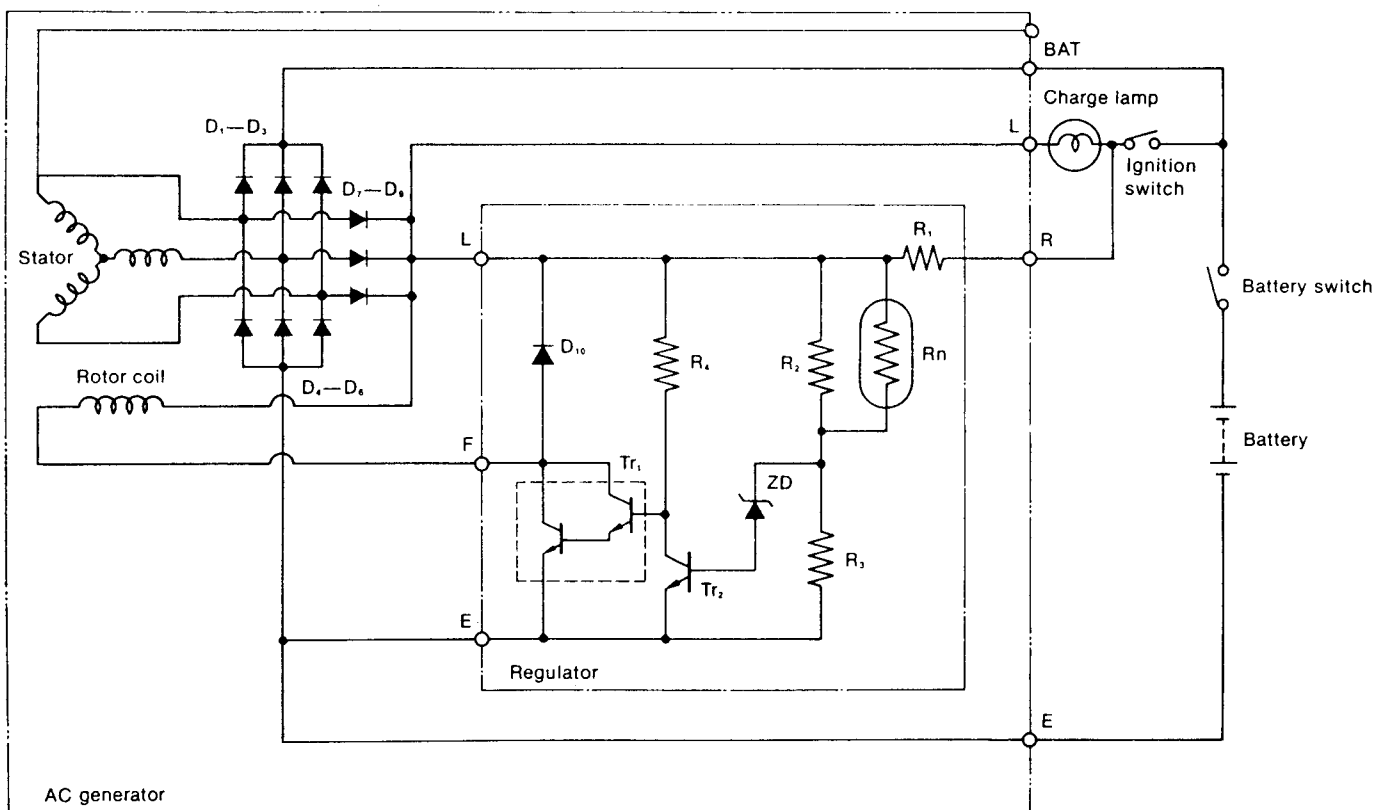
In this case too much current will flow, the IC regulator and diodes burn out, and the wire harness will burn.

(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.)

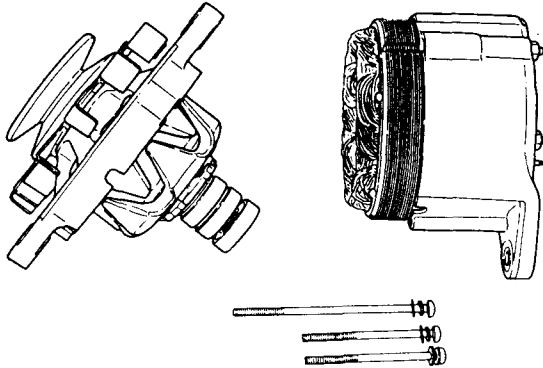


- |                |                           |                |  |
|----------------|---------------------------|----------------|--|
| BAT:           | Generator output terminal | $D_1-D_6$ :    | Output commutation diode                     |
| $D_{10}$ :     | IC protecting diode       | $R_1-R_4$ :    | Resistor                                     |
| L:             | Charge lamp terminal      | $D_7-D_{10}$ : | Auxiliary diode                              |
| ZD:            | Zener diode               | $R_n$ :        | Thermistor (Temperature gradient resistance) |
| E:             | Earth                     |                |  |
| $Tr_1, Tr_2$ : | Transistor                |                |  |

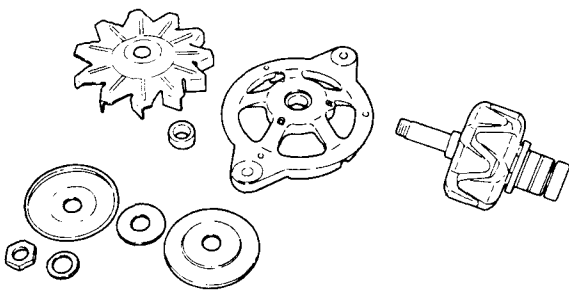
3. Charging Equipment

3-7 Disassembling the alternator

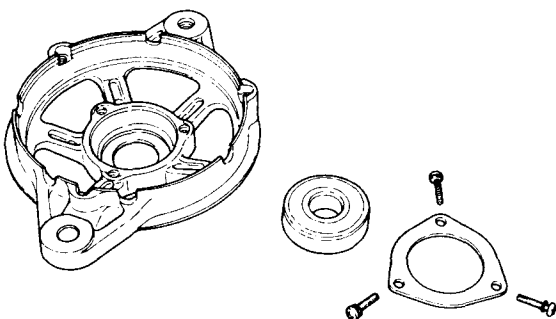
(1) Remove the through-bolt, and separate the front assembly from the rear assembly.



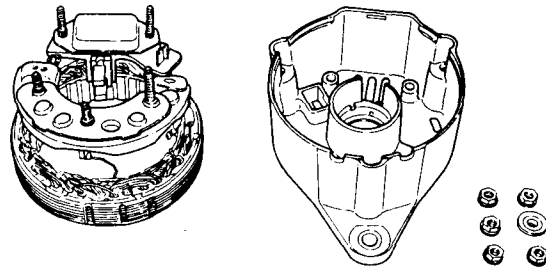
(2) Remove the pulley nut, and pull out the rotor from the front cover.



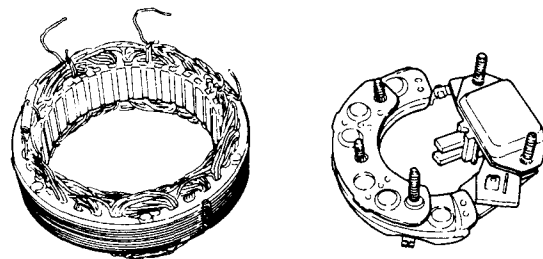
(3) Remove the screw from the front cover, and then remove the ball bearing.



(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).

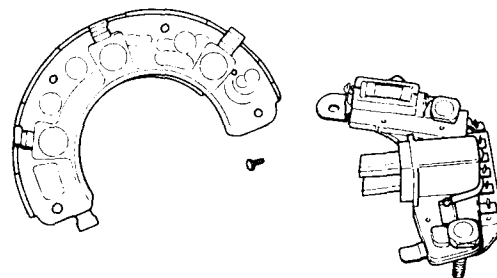


(5) Disconnect the soldered joint of the stator lead wire, and remove the diode and brush regulator assemblies from the stator at the same time.

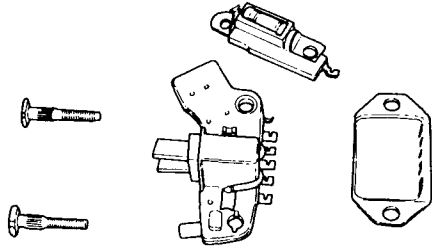


(6) Separating the regulator

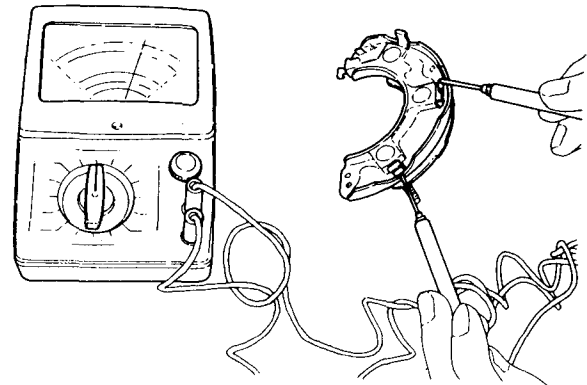
1) To separate the regulator, remove the rivet which keeps the diode assembly and the brushless regulator in place, and the soldered joint of the L-terminal.



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.



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.



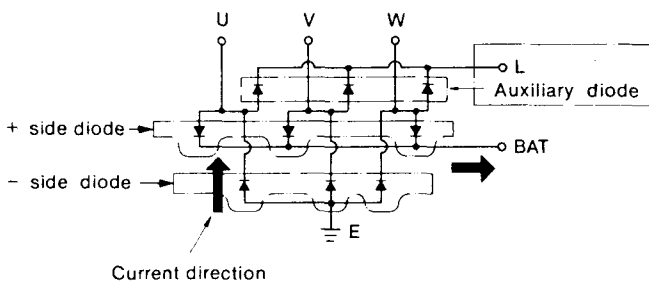
**CAUTION:** Do not use high tensile insulation resistance instrument such as meggers, etc. for testing. The diode may burn out.

### 3-8 Inspection and adjustment

#### (1) Diode

Between terminals		BAT (+ side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	Continuity	No continuity
	- side		No continuity

Between terminals		E (- side diode)	
	Tester wire	+ side	- side
U.V.W.	+ side	No continuity	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.

#### (2) Rotor

Inspect the slip ring surface, rotor coil continuity and insulation.

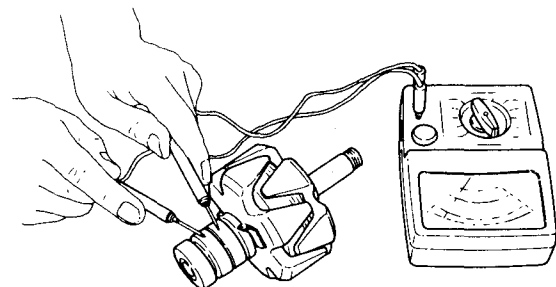
##### 1) Inspecting the slip ring surface

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.

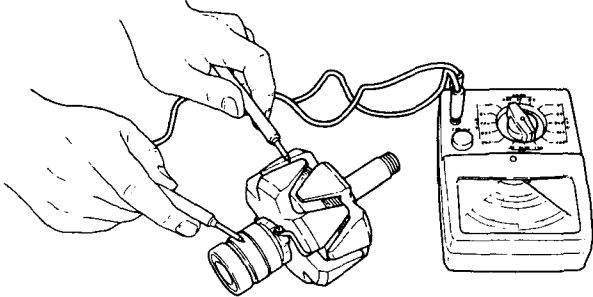


Resistance value	Approx. 5.17Ω at 20°C (LR120)
	Approx. 3.1Ω at 20°C (LR135)

3. Charging Equipment

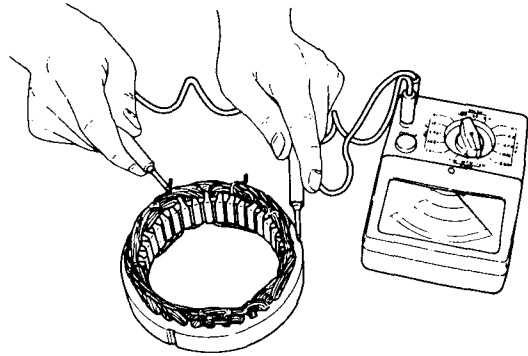
3) Rotor coil insulation test

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.

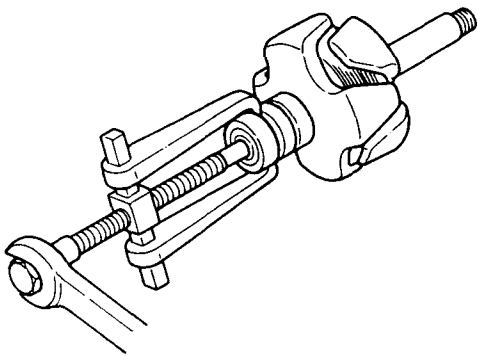


2) Stator coil insulation test

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.

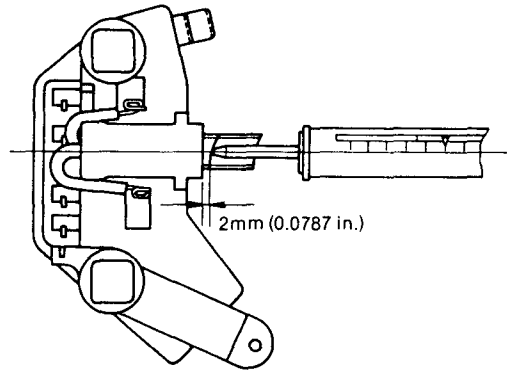


4) Check the rear side ball bearing. If the rotation of the bearing is heavy, or produces abnormal sounds, replace the ball bearing.



(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.

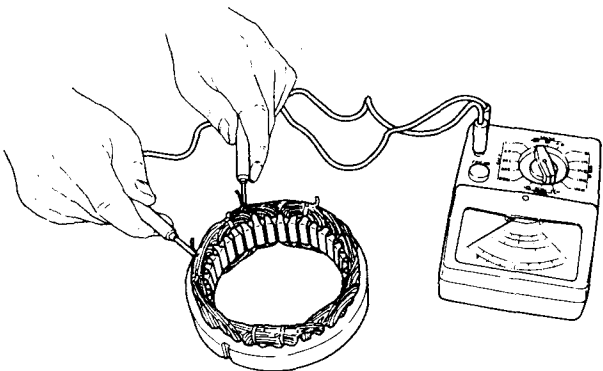


Brush spring strength	255—345g (0.56 ~ 0.76lb.)
-----------------------	---------------------------

(3) Stator

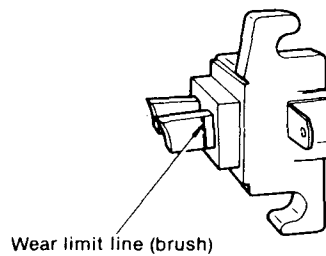
1) Stator coil continuity test

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.



(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)

Resistance value	Approx. 0.21Ω at 20°C (LR120)
	Approx. 0.14Ω at 20°C (LR135)
(1-phase resistance)	

3. Charging Equipment

(6) IC regulator

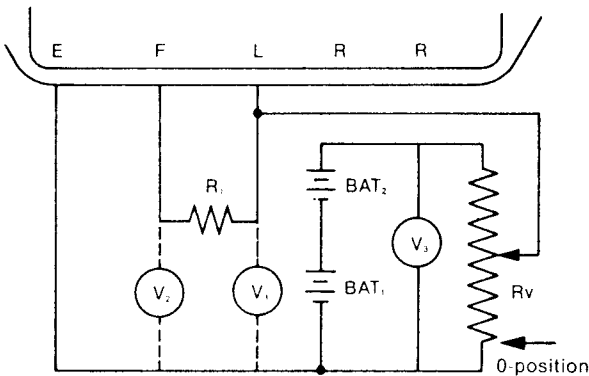
Connect the variable resistance, two 12V batteries, resistor, and voltmeter as shown in the following wiring.

1) Use the following measuring devices.

- Resistor (R<sub>1</sub>)            100Ω, 2W, 1pc.
- Variable resistor (R<sub>v</sub>)   0—300Ω, 12W, 1pc.
- Battery (BAT<sub>1</sub>, BAT<sub>2</sub>)   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<sub>3</sub> (BAT<sub>1</sub> + BAT<sub>2</sub> voltage). If the voltage is 20—26V, both BAT<sub>1</sub> and BAT<sub>2</sub> are normal.
- b) While measuring V<sub>2</sub> (F-E terminal voltage), move R<sub>v</sub> gradually from the 0-position. Check if there is a point where the V<sub>2</sub> 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 R<sub>v</sub> to the 0-position, and connect the voltmeter to the V<sub>1</sub> position.
- c) While measuring V<sub>1</sub> (voltage between L-E terminals), move R<sub>v</sub> gradually from the 0-position. There should be a point where the voltage of V<sub>1</sub> rises sharply by 2—6V. Measure the voltage of V<sub>1</sub> just before this sharp voltage rise. This is the regulating voltage of the regulator. If this voltage of V<sub>1</sub> is within the standard limit, the regulator is normal. If the voltage deviates from the limit, the regulator is defective. Replace the regulator.



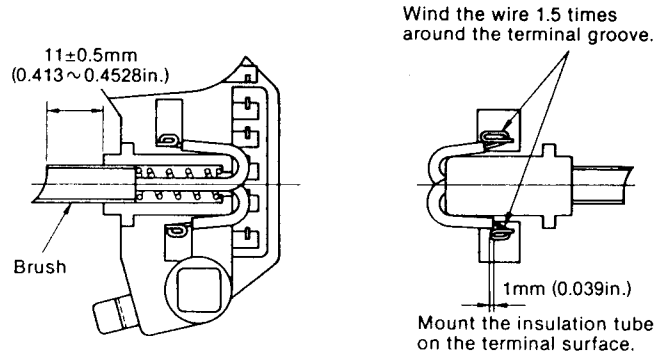
3-9 Reassembling the alternator

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).

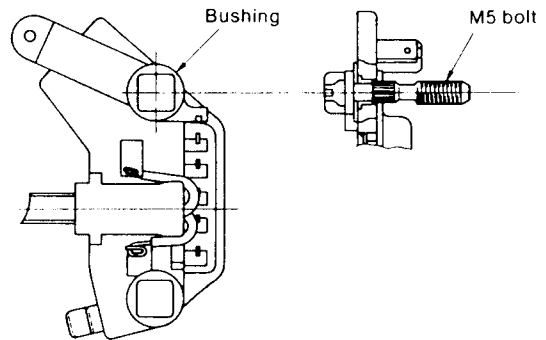


NOTES: 1. Use non-acid type paste.

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

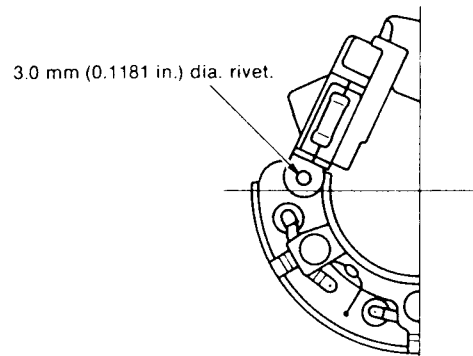
1) Check the rivets

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.



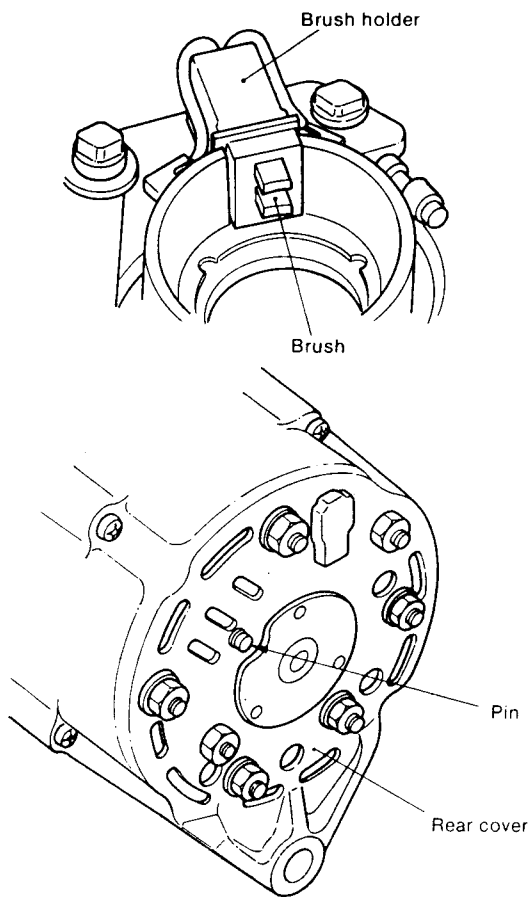
Riveting pressure	500kg (1102 lbs.)
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3. Charging Equipment

(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.

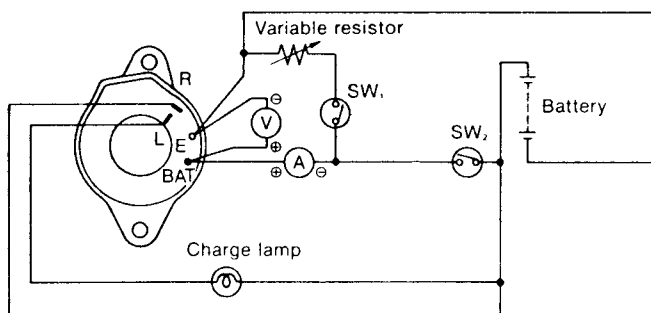


(4) Tightening torques

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 cross-sectional area of 8 mm<sup>2</sup> or more.
- 2) Check the wires for correct or loose connection.

## 3. Charging Equipment

**[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
	Yanmar code	A	119660-77710
		B	171301-77700
	Regulated voltage (V)		14 – 15
Combinated safety relay		←	←
Combinated charge indicator		A	←
		B	←
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	

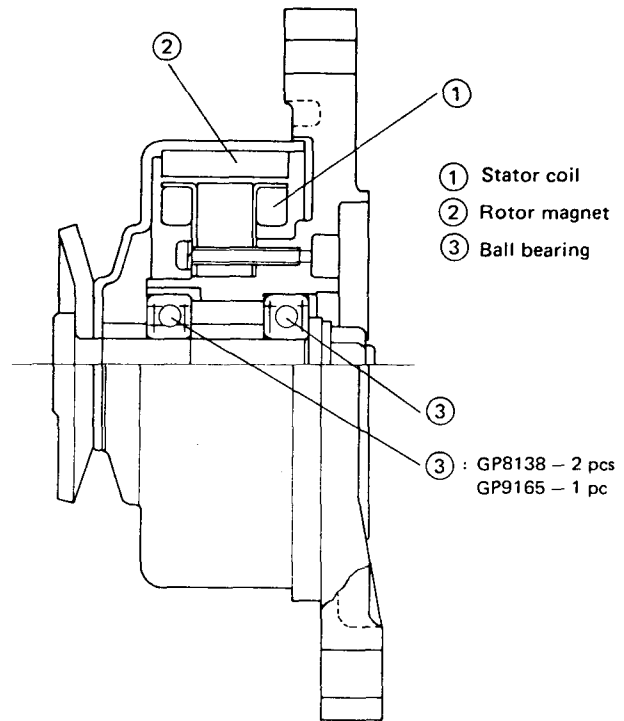
\* marks: Use regulator B in combination with safety relay B and charge indicator B.

**(2) Construction**

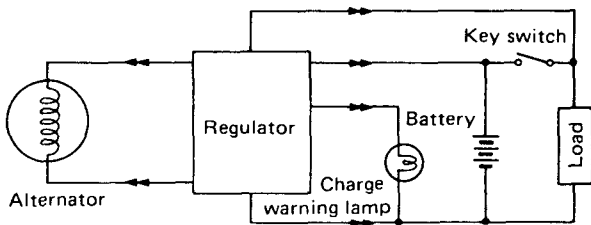
The magneto-generator is composed of the starter coil, rotor magnet, drive shaft/pulley, bearings, etc.

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 configuration, 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.

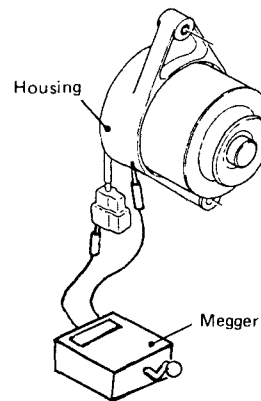
- 1) Disconnect the generator output wiring to the regulator, with the generator left coupled with the engine.
- 2) Extend the generator output wiring and connect it to a volt/ammeter.
- 3) Set the volt/ammeter to the 100 VAC range.
- 4) Start the engine and check the volt/ammeter for readings.
- 5) 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**

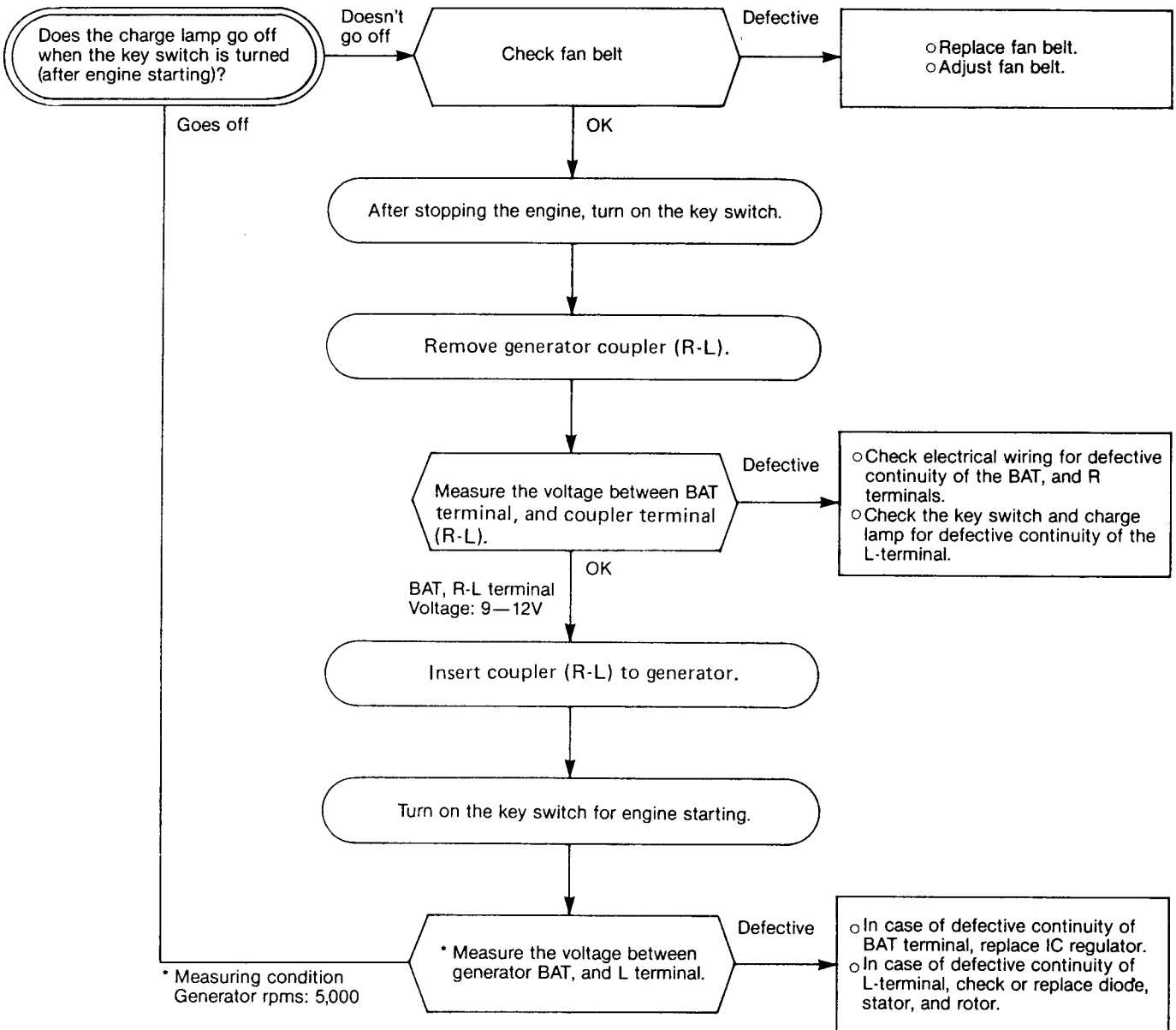
- 1) Connect a wire of the megger to the terminal.
- 2) Contact the other wire of the megger to the housing for not more than 1 second, and check the indicator of the megger.  
If there is continuity (the resistance is zero), replace the stator coil.



3. Charging Equipment

4-11 Troubleshooting

(1) Charging failure



# 4. Starting Aids

## 4-1 Air heater (DI engine)

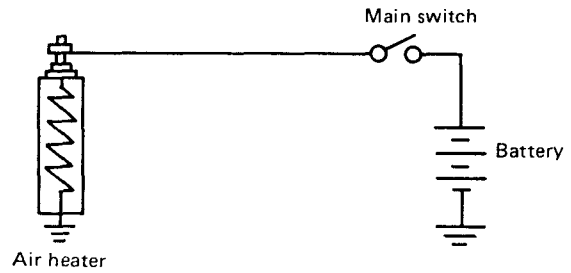
An air heater is available for warming intake air during starting in cold weather. The air heater is mounted on the end of the intake manifold.

The device is operated by the key switch on the instrument panel.

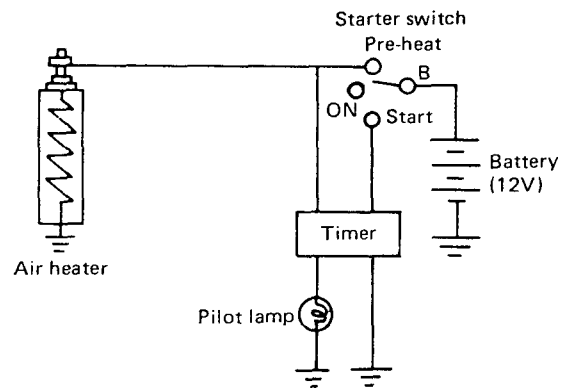
A timer is equipped for the pre-heating. When this device is initially turned ON by the key switch, the pilot lamp lights. The timer is set so that the pilot lamp goes off 15 sec after the system is turned ON. When the pilot lamp goes off, once turn the key switch to OFF. Then, turn the key switch to START to start the engine.

Air heater system circuit: Air heater Pilot lamp Timer

Air heater system circuit (without Timer)

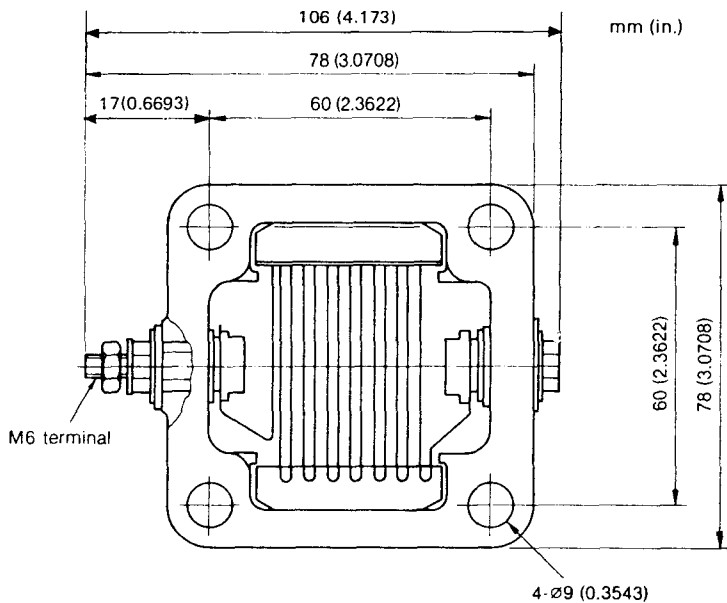


Air heater circuit (with Timer)



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. Starting Aids

## 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.

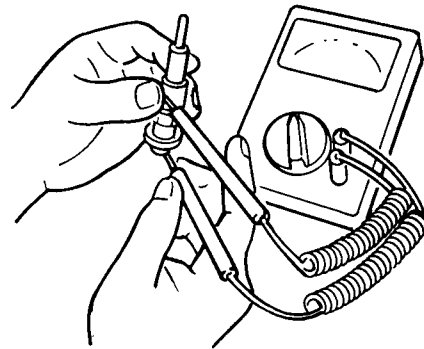
- 2) Do not heat the glow plug continuously or they will burn out.

## (3) Glow plug inspection

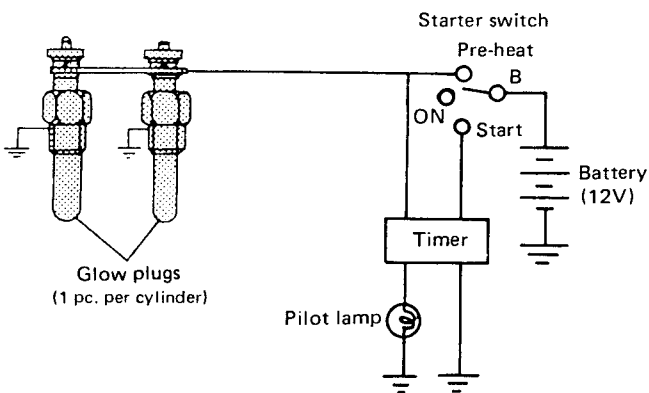
- 1) Remove the glow plug and check for carbon deposit or damage. Replace the glow plug if necessary.
- 2) Check for continuity between the glow plug terminal and body using a volt/ammeter. Replace the glow plug if there is no continuity.

Glow plug resistance	1.35 $\Omega$ – 1.65 $\Omega$
----------------------	-------------------------------

## Glow plug continuity test



## Glow plug system circuit



Connection while starting:

B – Start – Pre-heat

# 5. Battery

## 5.1 Battery capacity and battery cables

### 5.1.1 Battery capacity

Recommended battery capacity

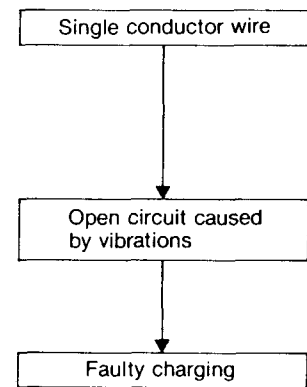
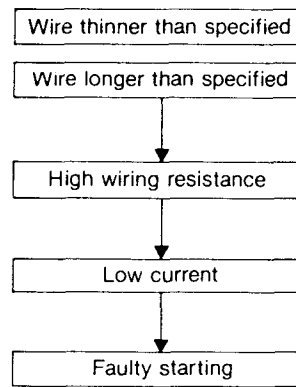
	Standard (recommended)				For cold starting
Atmospheric temperature	More than -5°C (23°F)				See TN series Application manual (Use battery more than standard battery capacity)
JIS standard Capacity ty,	36B20R	46B24R	55B24R	55D26R	
5 hrs. rating/20 hrs. rating (AH)	28/(35)	36/(45)	←	48/(60)	
2,3TN66E	○				
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 <sup>2</sup> )	Rated voltage		12 V			Conductor resistance of cable (Ohm/m)	
		Starter capacity	Battery switch	2 KW (incl.) and more				
				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 (0.2V/100A)	0.0012 (0.12V/100A)		

\* JIS C 3406, Low-voltage cables 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. Battery

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)

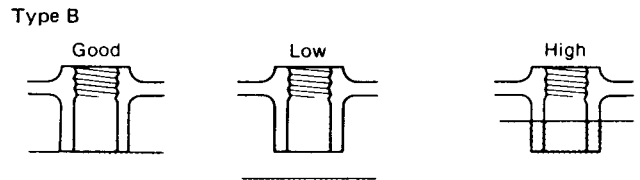
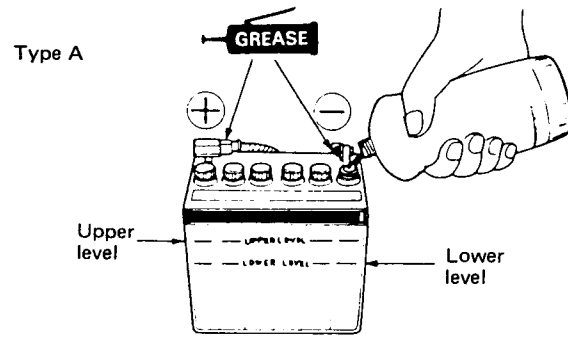
WARNING

The battery contains sulfuric acid. Avoid contact with skin, eyes, or clothing.

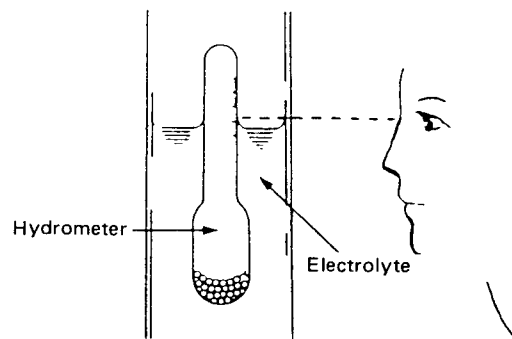
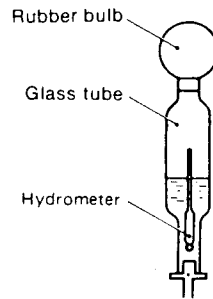
Antidote: Flush with water and get prompt medical attention.

NOTE:

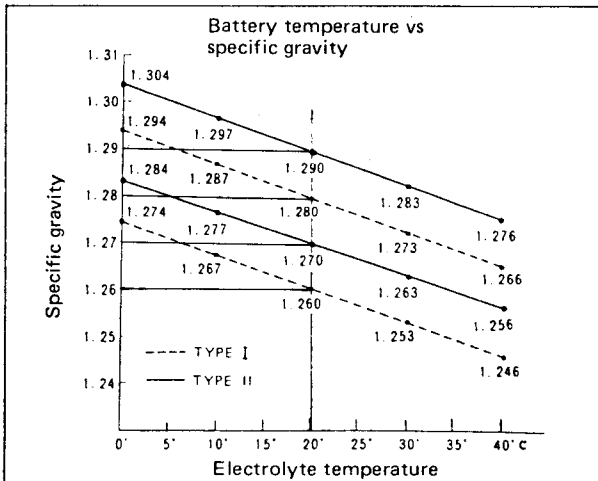
- Do not overfill the battery. Wipe up spilled electrolyte at once and flush well with water.
- The specific gravity varies with the temperature as shown in the accompanying table.
- The battery must be replaced if sulfation is evident.
- The battery must be replaced if there are pastes settled on the bottom of each cell.



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.



Variation of Specific Gravity with Temperature





## 5. Battery

## 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  
 $(45 \div 20) - (45 \div 10) = 2.25A - 4.5A$

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 charger, 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

## 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 charac- teristics	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 dia- meter	mm (in)					—		12.5 – 12.572 (0.492 – 0.493)		—	
Inter- mediate 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	

## 6. Service Data

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)	

CHAPTER 8

# DISASSEMBLY AND REASSEMBLY

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# 1. Disassembly and Reassembly Precautions

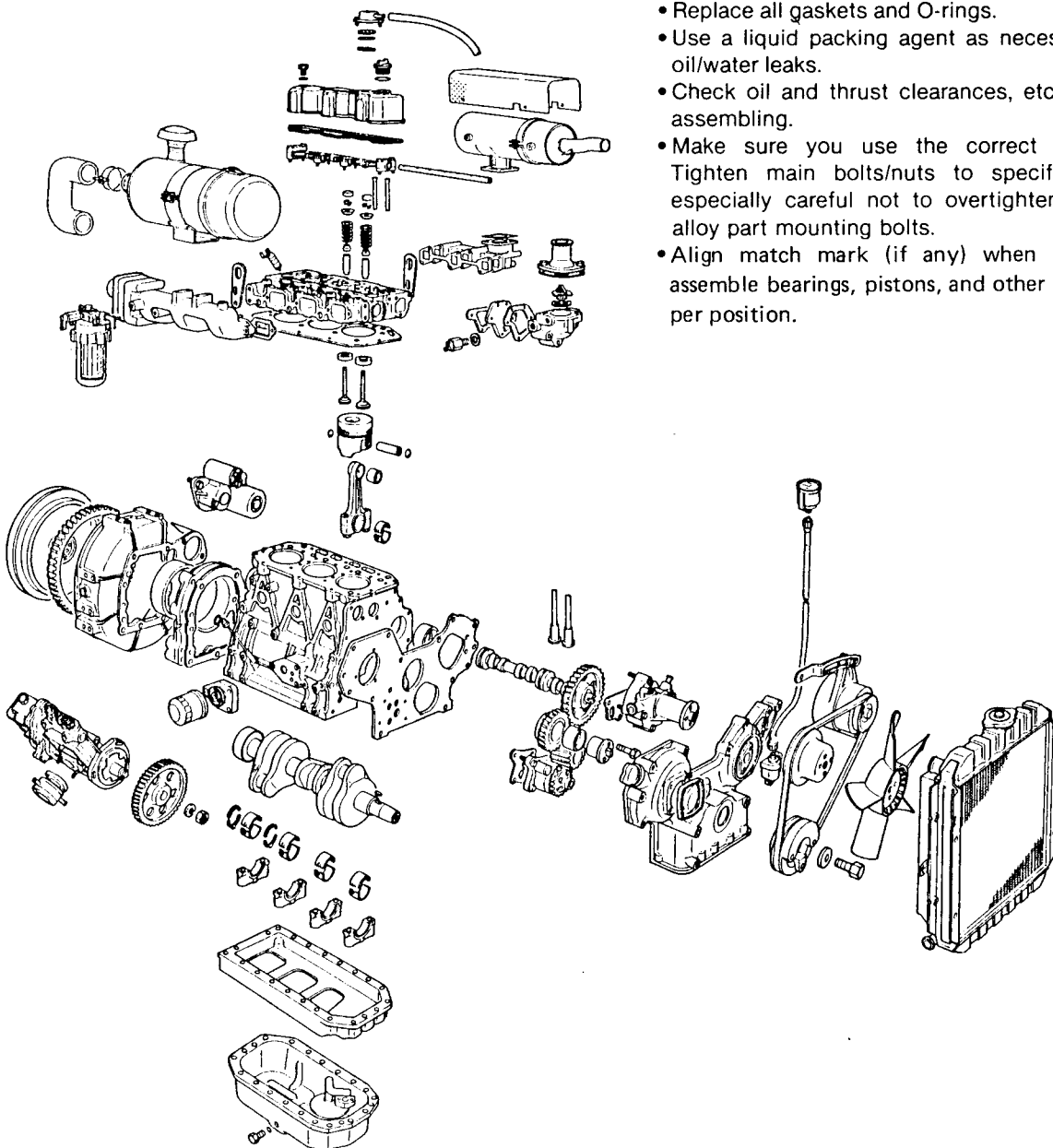
## 1-1 Disassembly

- 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

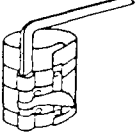
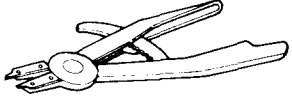


- Sufficiently clean and inspect all parts to be assembled.
- Coat sliding and rotating parts with new engine oil when assembling.
- Replace all gaskets and O-rings.
- Use a liquid packing agent as necessary to prevent oil/water leaks.
- Check oil and thrust clearances, etc. of parts when assembling.
- 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.



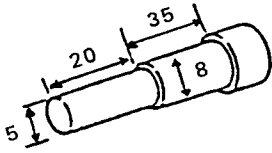
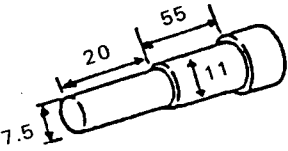
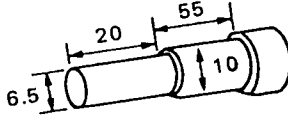
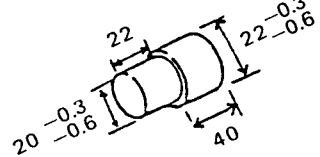
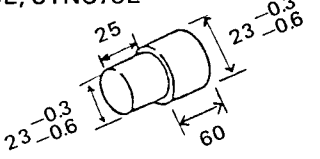
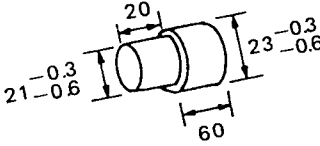
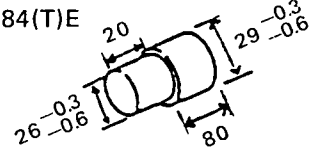
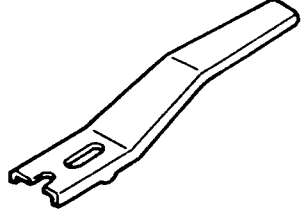
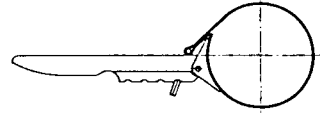
## 2. Disassembly and Reassembly Tools

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 ( $\phi 60 \sim \phi 125$ ) (95550-002476) Type 2476H ( $\phi 90 \sim \phi 175$ ) (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

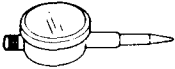
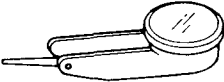
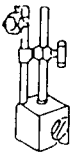
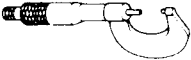
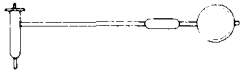

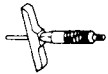


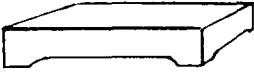
<p>Valve guide remover</p>	<p>2,3TN66E</p>  <p>3,4TN82(T)E, 3,4TN84(T)E</p> 	<p>3TNA72E, 3TN75E, 3TNC78E</p> 
<p>Connecting rod bushing remover</p>	<p>2,3TN66E</p>  <p>3TN75E, 3TNC78E</p> 	<p>3TNA72E</p>  <p>3,4TN82(T)E, 3,4TN84(T)E</p> 
<p>Valve guide compressor</p>		
<p>Filter wrench</p>		

## 2. Disassembly and Reassembly Tools

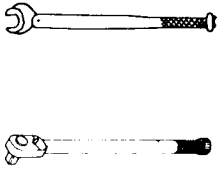
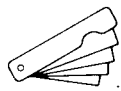
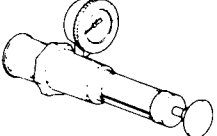
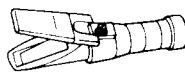
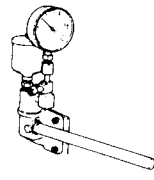
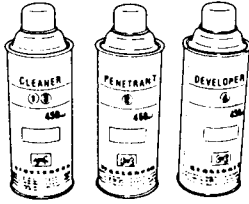
## 2-2 Meters, Instruments, and Service Accessories

(Required for servicing medium – or small size engines)

– Only representative sizes –

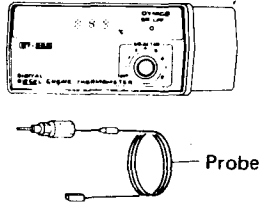
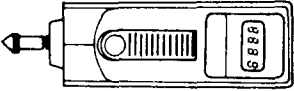
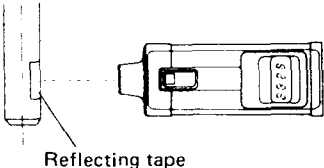
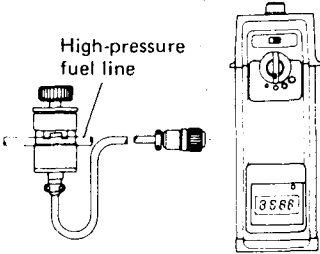
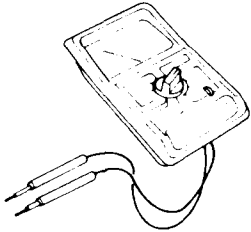
Nomenclature	Remarks		Illustration						
Dial indicator	1 div.: 0.01 mm, Range: 0–5 mm, 0–10 mm	To measure the straightness of shafts, flatness of planes, and gap widths.							
Test indicator	1 div.: 0.01 mm, Range: 0–0.8 mm	To measure positions too narrow and too deep for normal dial indicators.							
Magnet stand	<table border="1"> <thead> <tr> <th>Trunk bar (dia. x length) (mm)</th> <th>Branch bar (dia. x length) (mm)</th> </tr> </thead> <tbody> <tr> <td>12 x 176</td> <td>10 x 165</td> </tr> <tr> <td>14 x 183</td> <td>12 x 165</td> </tr> </tbody> </table>	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.	
Trunk bar (dia. x length) (mm)	Branch bar (dia. x length) (mm)								
12 x 176	10 x 165								
14 x 183	12 x 165								
Micrometer	Range (mm) 0–25 50–75 25–50 50–100	To measure the O.D. of the crankshaft, pistons, and piston pins.							
Cylinder gauge	Range (mm) 10–18 35–60 18–35 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	<table border="1"> <tr> <th>Bolt/nut size (mm)</th> <th>Range (kg-cm)</th> </tr> <tr> <td>6 – 14</td> <td>4 – 30 31 – 80</td> </tr> <tr> <td>17, 19, 21</td> <td>31 – 160</td> </tr> </table>	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	
Bolt/nut size (mm)	Range (kg-cm)								
6 – 14	4 – 30 31 – 80								
17, 19, 21	31 – 160								
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 <sup>2</sup>	To inspect the watertightness of cooling water lines and the radiator cap.							
Battery electrolyte tester (95500-000013)	Model UFB-N <sub>2</sub>	To inspect electrolyte specific gravity and charging condition.							
Nozzle tester (737600-93401)  High pressure tube	Pressure gauge 0 – 500 kg/cm <sup>2</sup>  Injection-valve side nut  M12 x 1.5 capnut	To inspect spray condition and the injection pressure of the fuel injection valve.							
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.	Revolving body 
High-pressure fuel pipe cramping type Model GE-450 (955000-01045)	Measure engine RPM's using pulse system.	High-pressure fuel line 
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 resistant 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	<ul style="list-style-type: none"> <li>○ Removes scale quickly. (1-10 hours).</li> <li>○ Dissolve one part Unicon in 10 parts water by weight and mix thoroughly.</li> <li>○ Dipping disassembled parts removes scale from them. Removes scale: removal is accelerated by engine revolution.</li> <li>○ Test the PH – or effectiveness – of descaling agent. If litmus paper turns red, the agent is still effective.</li> </ul>																		
		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.																		
				<table border="1" style="width: 100%; border-collapse: collapse; text-align: center;"> <thead> <tr> <th>Temperature</th> <th>-5°C</th> <th>-10°C</th> <th>-15°C</th> <th>-20°C</th> <th>-25°C</th> <th>-30°C</th> <th>-35°C</th> <th>-40°C</th> </tr> </thead> <tbody> <tr> <td>Volumes mixing ratio</td> <td>15%</td> <td>25%</td> <td>30%</td> <td>35%</td> <td>40%</td> <td>45%</td> <td>50%</td> <td>55%</td> </tr> </tbody> </table>	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%
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	<ul style="list-style-type: none"> <li>○ Powerful cleaning action capable of removing carbon build-up.</li> <li>○ Safely heated for extremely powerful cleaning action.</li> <li>○ Does not corrode most metals (also prevents rust from forming.)</li> <li>○ 1 kg of Metal Clean Y should be dissolved in 40ℓ of water.</li> <li>○ When the Cleaner is used, heating the solution to 60-80°C gives higher cleaning ability.</li> </ul>																		

## 3. Disassembly and Reassembly

## 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

Remove the silencer.

## (6) Air cleaner

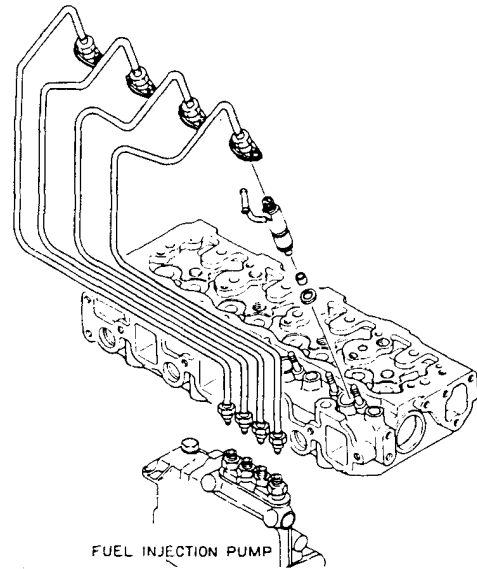
Remove the air cleaner together with the bracket and intake hose.

## (7) Exhaust manifold

Remove the exhaust manifold.

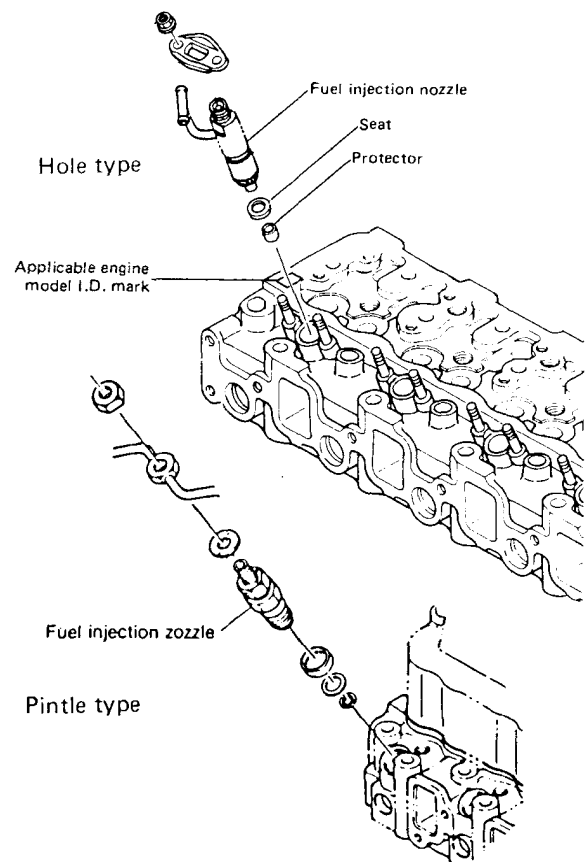
## (8) Removing the high pressure fuel pipe.

- 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.



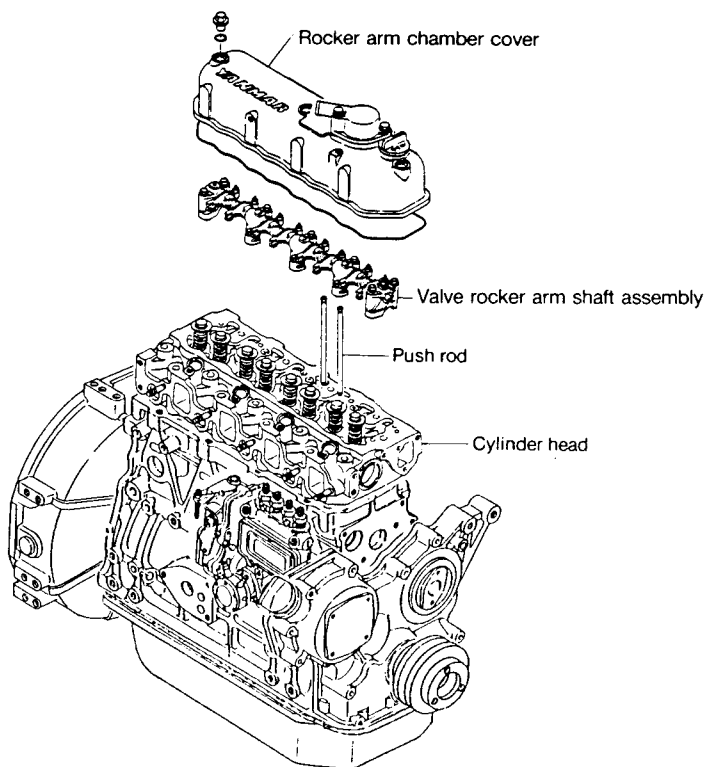
## (10) Removing the valve rocker arm shaft assembly

- 1) Remove the valve rocker arm cover.
- 2) Remove the valve rocker arm shaft mounting bolts, and remove the rocker arm shaft assembly.

3. Disassembly and Reassembly

3) Pull out the push rods.

*NOTE: Verify the cylinder No., and indicate intake or exhaust (for reassembly purposes)*

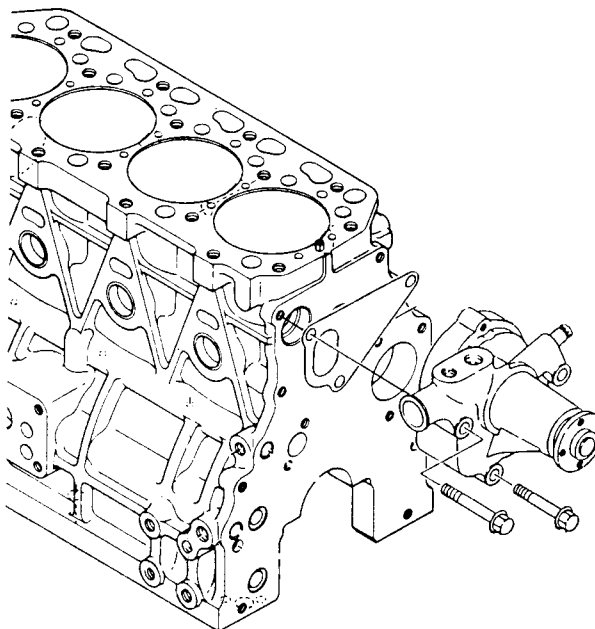


**(13) Intake manifold**

- 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.

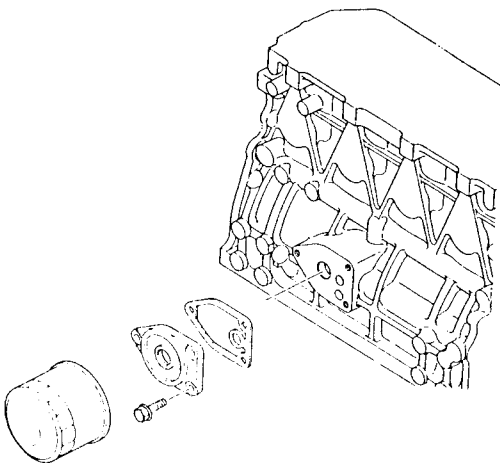


**(11) Alternator**

- 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.

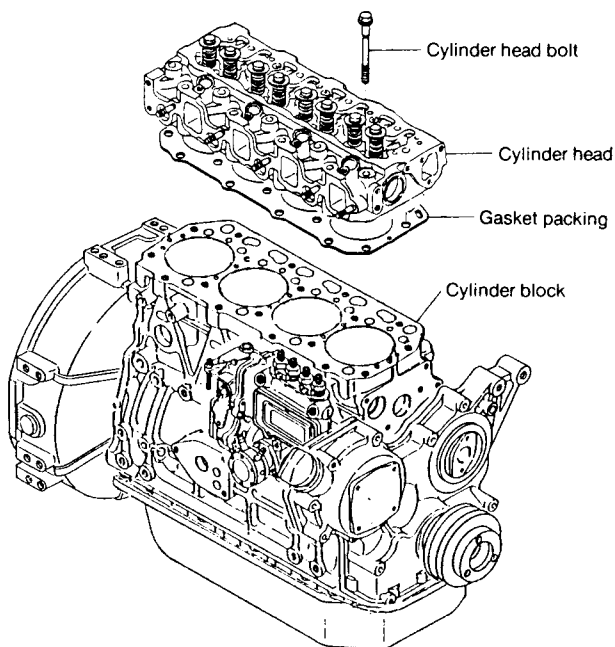
**(12) Removing the lube oil filter**

- 1) Remove the filter bracket with lube oil filter element from the cylinder block.
- 2) Remove the lube oil dipstick.



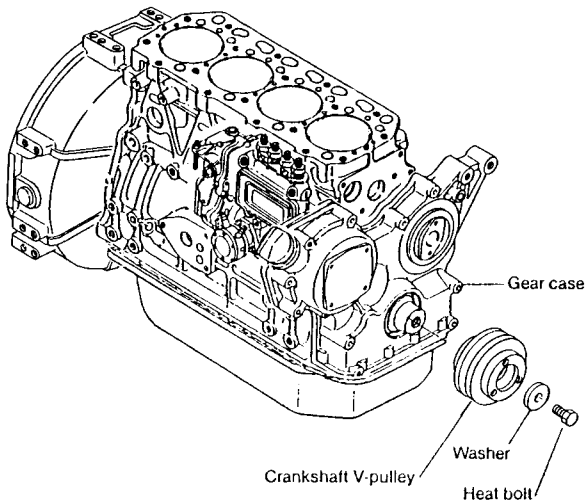
**(15) Removing the cylinder head**

- 1) Remove the cylinder head bolts with a torque wrench, and remove the cylinder head.
- 2) Remove the cylinder gasket packing.



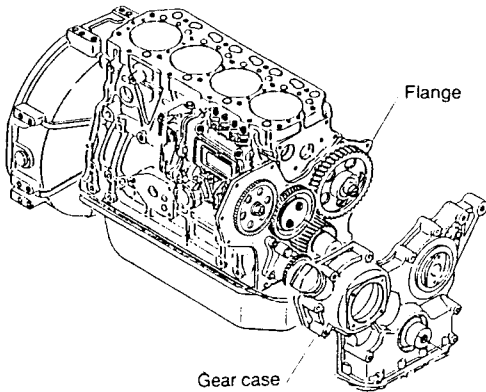
**(16) Removing the crankshaft V-pulley**

Remove the hex bolts holding the crankshaft V-pulley, and remove the crankshaft V-pulley with an extraction tool.



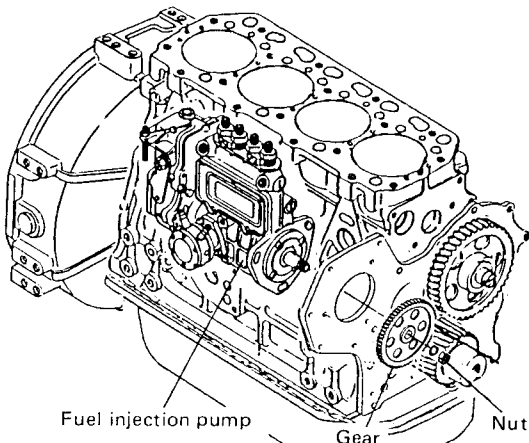
**(17) Removing the gear case**

Remove the gear case mounting bolts, and remove the gear case from the cylinder block.



**(18) Removing the fuel injection pump**

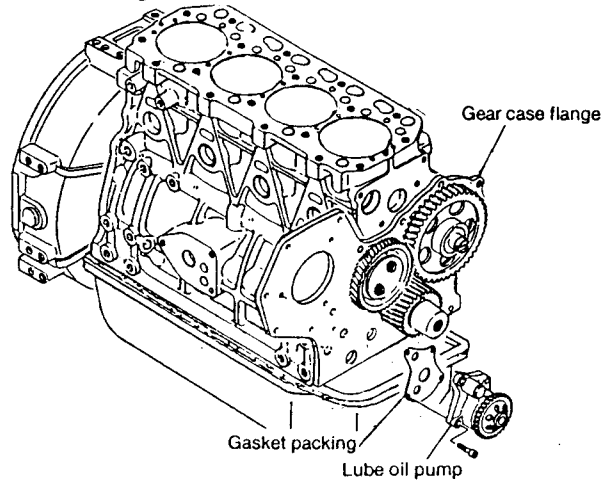
- 1) Remove the nut, and pull out the fuel injection pump driving gear with an extraction tool.
- 2) Remove the fuel injection pump and O-ring from the gear case flange.



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

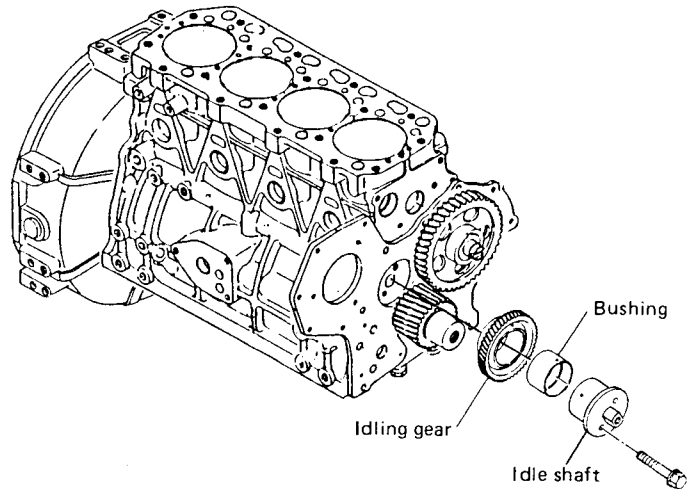
**(19) Removing the lube oil pump**

Remove the lube oil pump and gasket packing from the gear case flange.



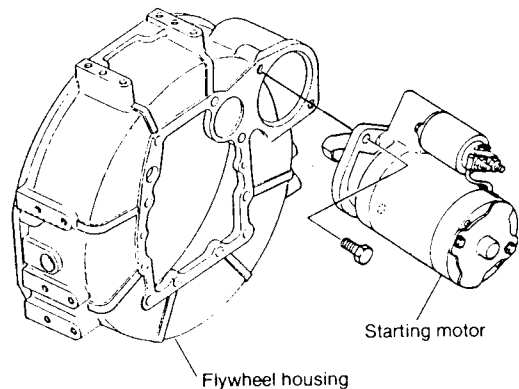
**(20) Removing the idling gear**

Remove the two hex bolts holding the idling shaft, and pull out the idling gear and idling shaft.



**(21) Removing the starting motor**

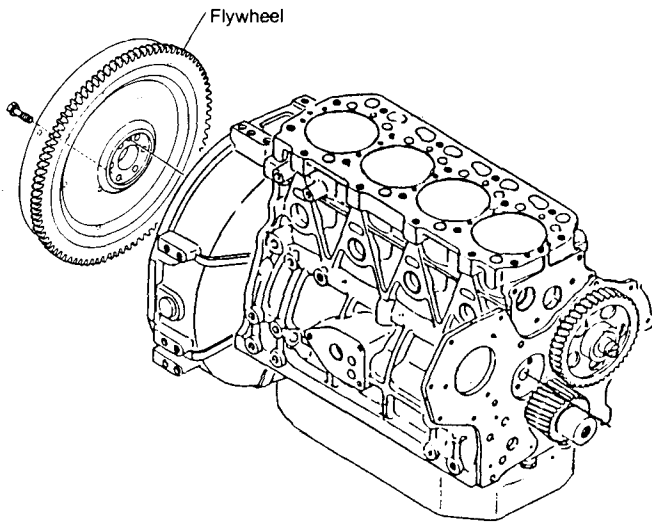
Remove the starting motor from the flywheel housing.



3. Disassembly and Reassembly

(22) Removing the flywheel

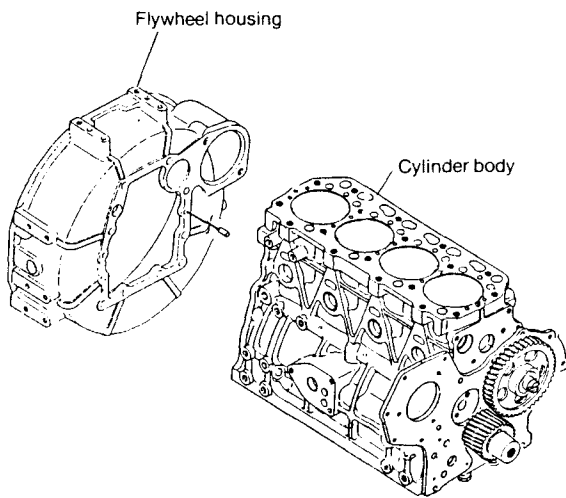
Remove the flywheel mounting bolts and then the flywheel.



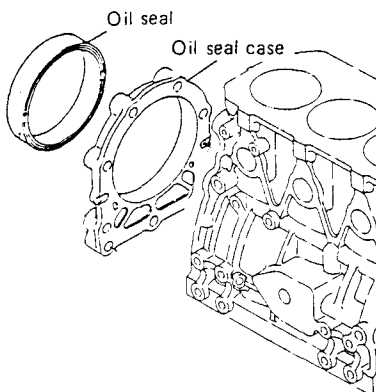
NOTE: Be careful not to scratch the ring gear.

(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

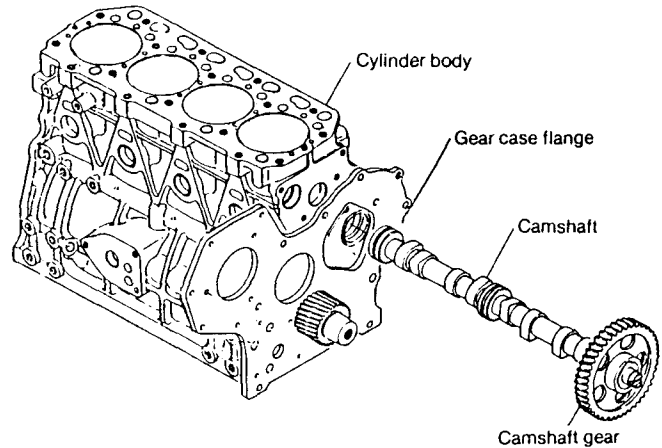
Remove the oil pan and oil pan spacer.

(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.

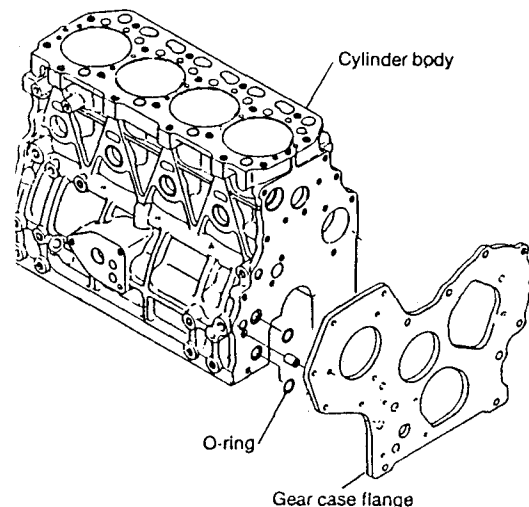


(27) Removing the tappets

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.

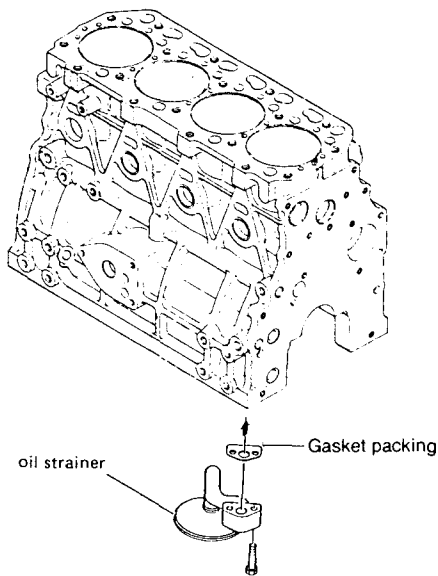




3. Disassembly and Reassembly

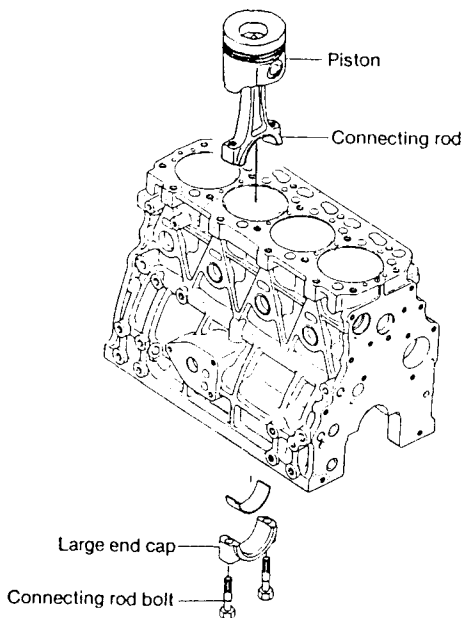
**(29) Removing the oil strainer**

Remove the lube oil intake pipe and gasket packing.



**(30) Removing the piston and connecting rods**

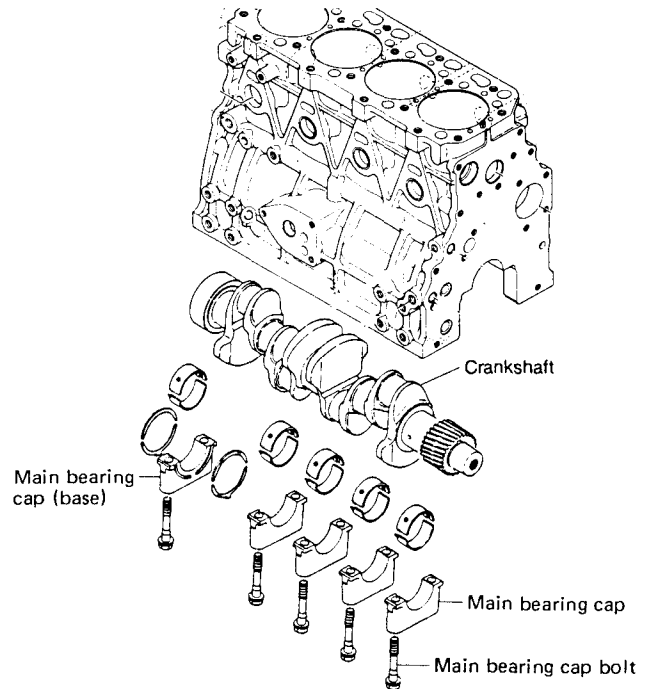
- (1) Remove the connecting rod bolt and the large end cap.
- (2) Push the connecting rod from the bottom and pull out the piston connecting rod assembly.



**(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.

**NOTE:** Place a tool against the piston cooling nozzle to make sure the nozzle position does not change and it doesn't get scratches.

3. Disassembly and Reassembly

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.

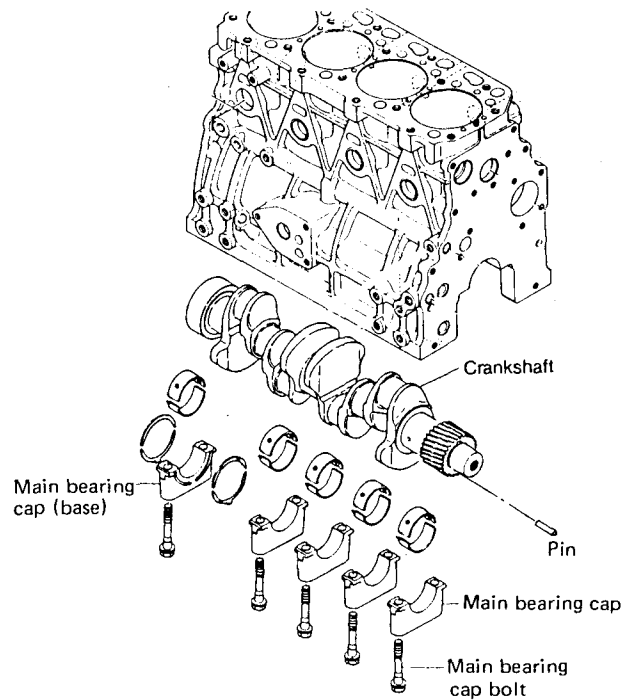
2. When mounting the thrust metal, fit it so that the surface with the oil groove slit faces outwards, (crankshaft side).

- 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)
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**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)
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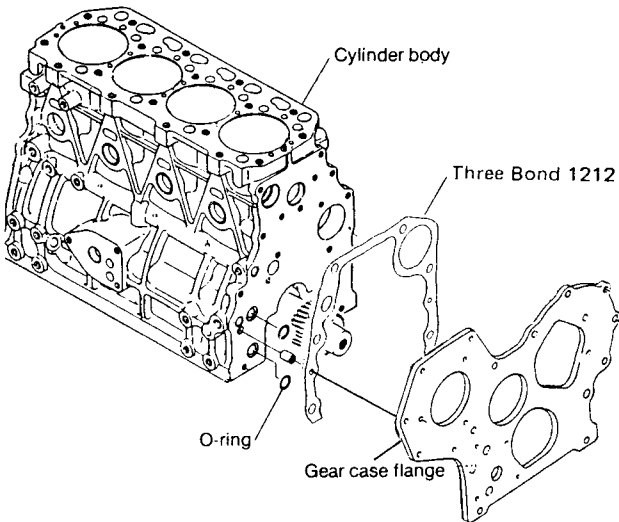
- 3) Make sure that the crankshaft rotates smoothly and easily.

3. Disassembly and Reassembly

(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.

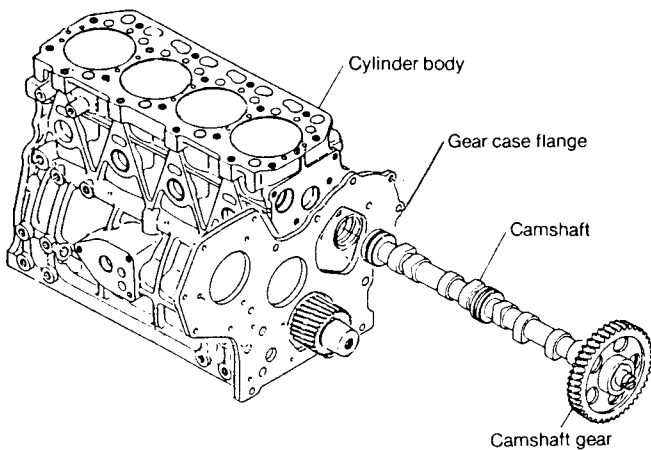


(5) Mounting the camshaft

- 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.

Camshaft side gap	mm (in.) <b>See separate service data</b> (Page 1-34, 35)
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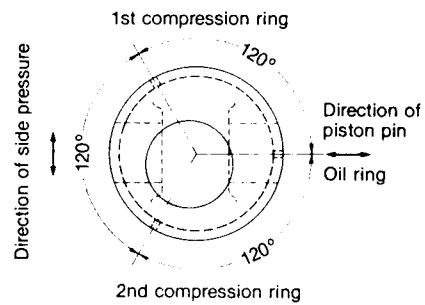
- 4) Make sure that the camshaft rotates smoothly.

(6) Mounting the piston and connecting rod

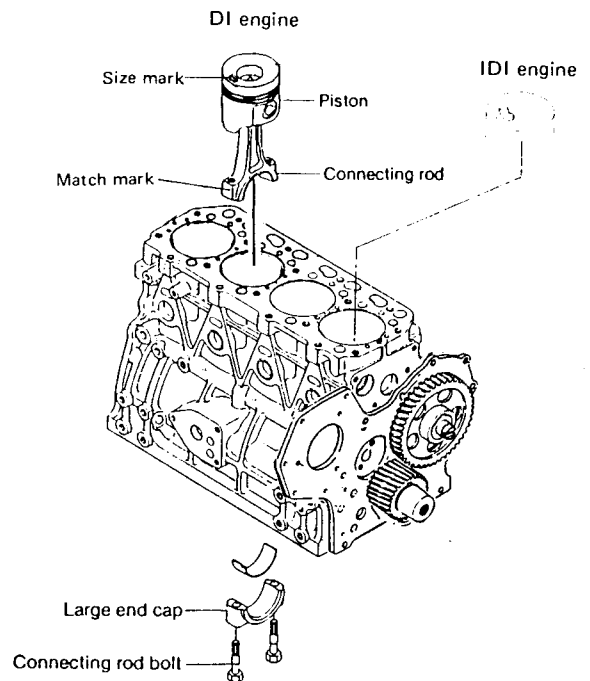
- 1) Reassemble the piston and connecting rod.

**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.



## 3. Disassembly and Reassembly

**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)
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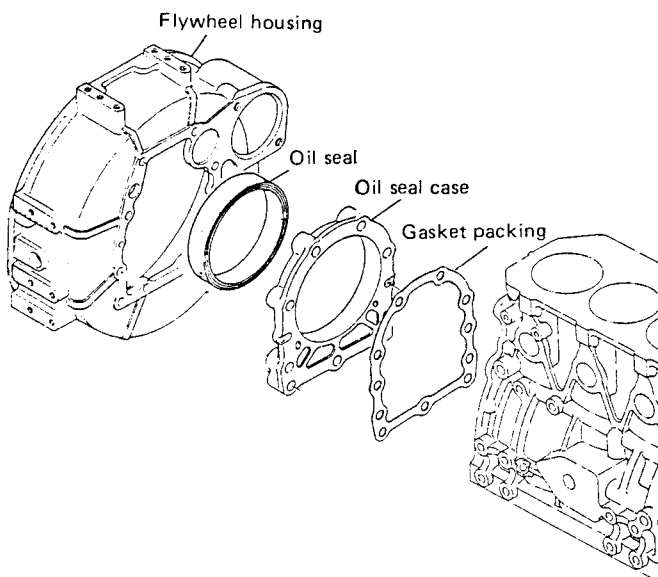
**NOTE:** If a torque wrench is not available, match up with the mark made before disassembly.

**(7) Mounting the oil seal case**

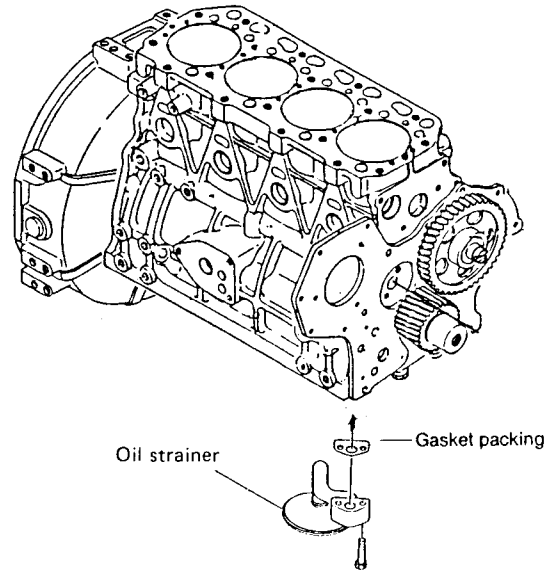
- 1) Press fit the oil seal in the oil seal case, and coat the lip of the oil seal with engine oil.
- 2) Mount the oil seal case, matching them up with the cylinder block positioning pins.

**(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**

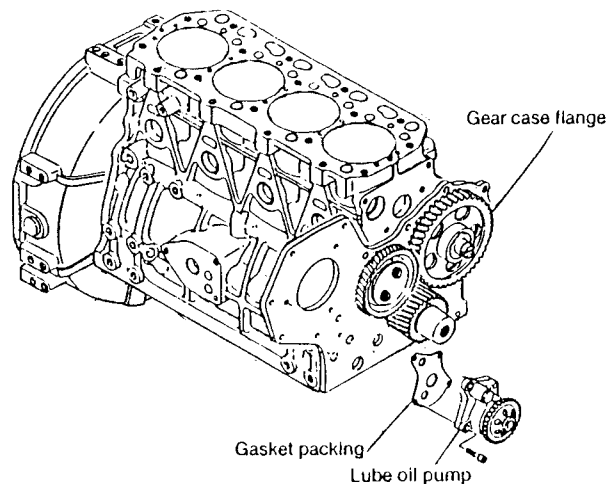
Mount the lube oil intake pipe on the bottom of the cylinder block, using new packing.

**(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**

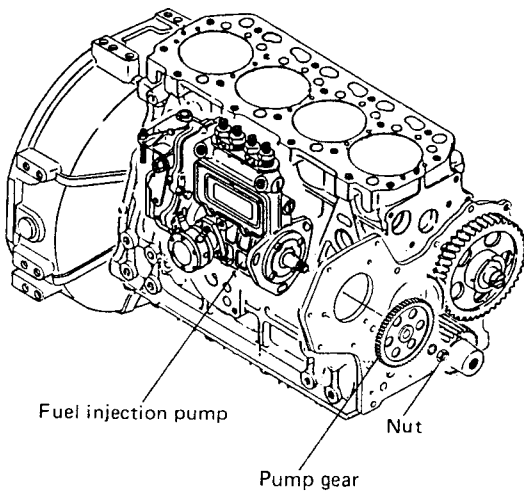
- 1) Mount the lube oil pump on the gear case flange.
- 2) Measure the backlash of the lube oil pump drive gear.

**(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.

3. Disassembly and Reassembly

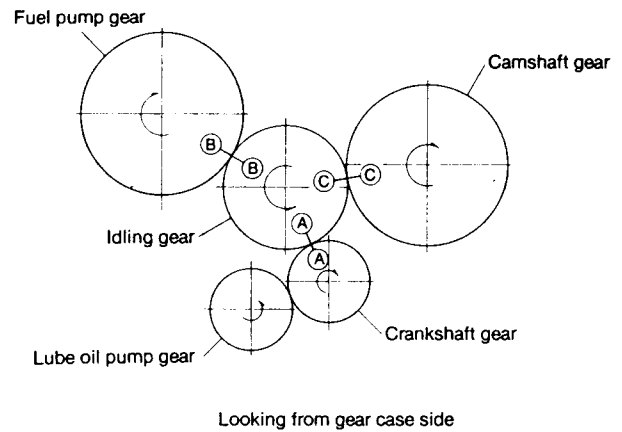
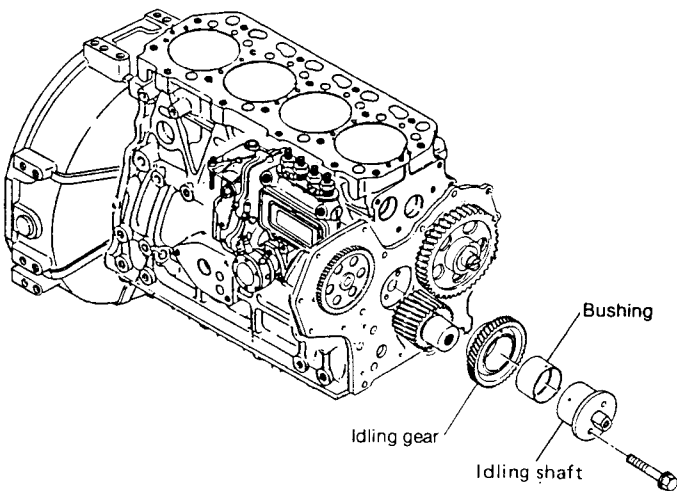


Tighten the nut for the fuel injection pump gear to the specified torque.

	kg-m (ft-lb)
Nut tightening torque	6 – 7 (43.3 – 50.6)

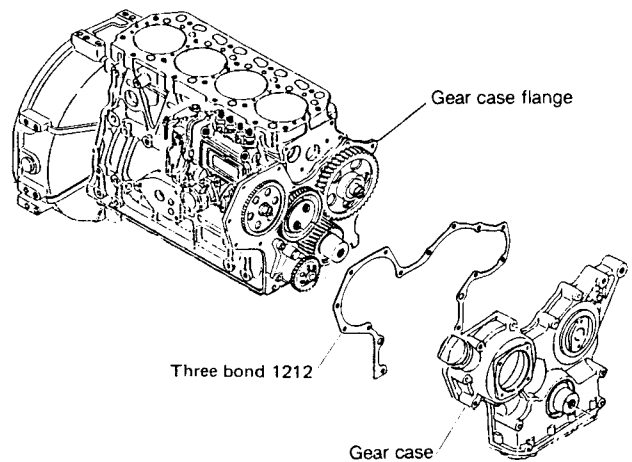
(13) Mounting the idling gear

- 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 backlash.
- 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.



(14) Mounting the gear case

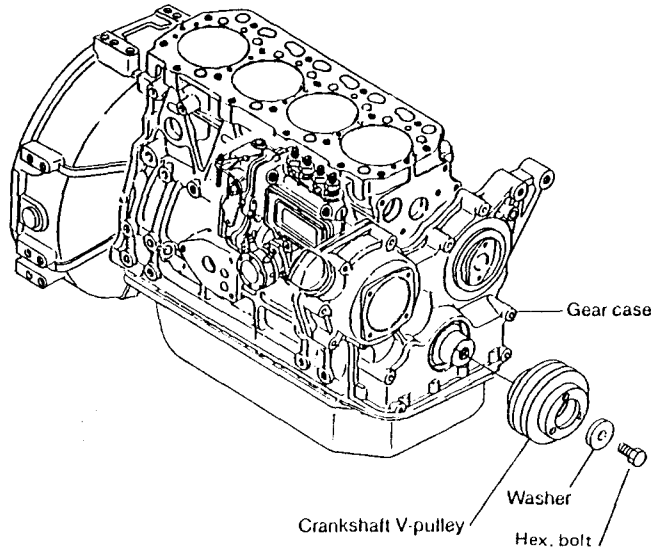
- 1) Coat the inside and outside of the seals with engine oil, and press fit them into the gear case.
- 2) Position the two pipe knock pins, and tighten the bolts holding the gear case.
- 3) Seal with Three Bond 1212 between the gear case flange and gear case.



3. Disassembly and Reassembly

(15) Mounting the crank V-pulley

- (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 specified torque.

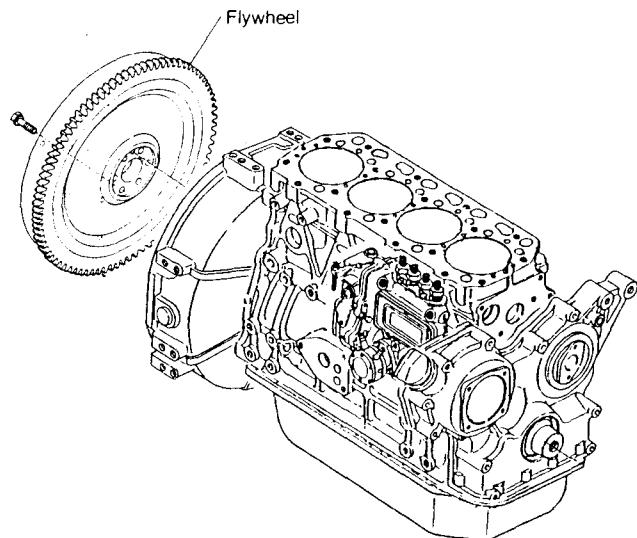


kg-m (ft-lb)

V-pulley tightening torque	See separate service data (P. 8-22)
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(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.

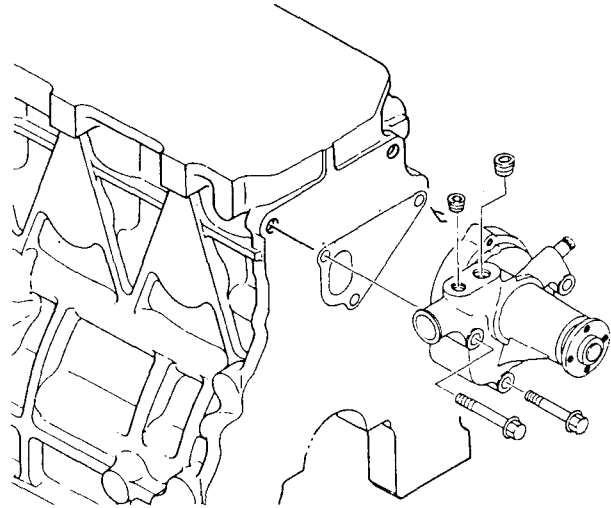


kg-m (ft-lb)

Flywheel mounting bolt tightening torque	See separate service data (P. 8-22)
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(17) Mounting the cooling water pump

- 1) Thoroughly coat both sides of the packing with adhesive.
- 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)
--------------------------------------	-----------------------

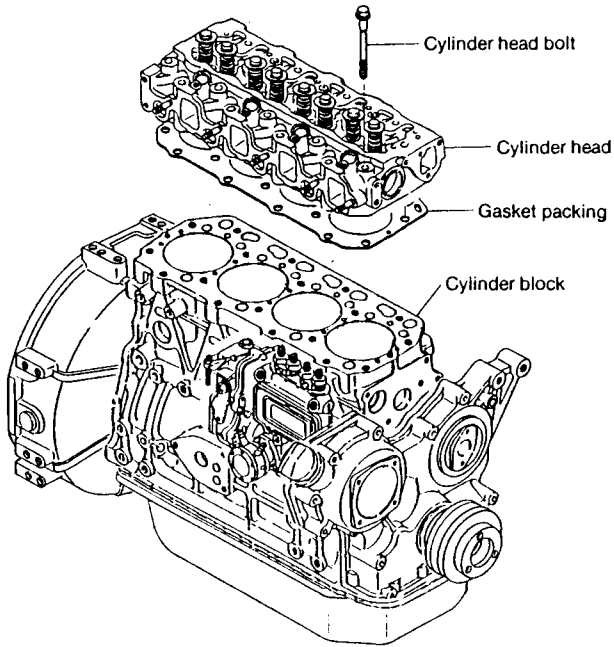
- 3) Mount the thermostat case.
- 4) Mount the V-pulley.

(18) Mounting the cylinder head

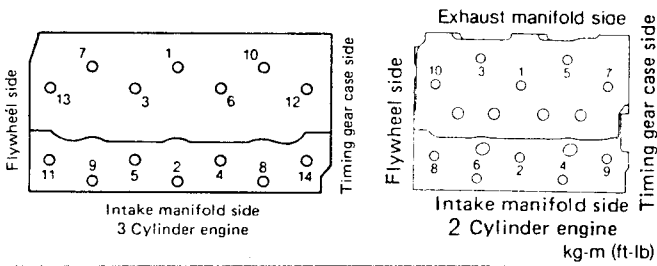
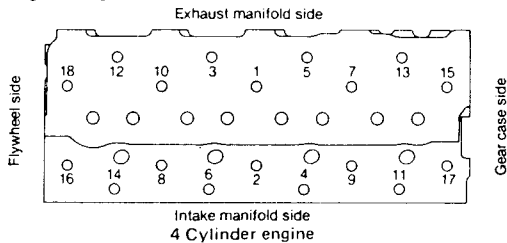
- (1) Fit the gasket packing against the cylinder block, aligning it with the cylinder block positioning pins.

**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**



Cylinder bolt tightening torque	Partial	Complete
	<i>See separate service data (Page 8-22)</i>	

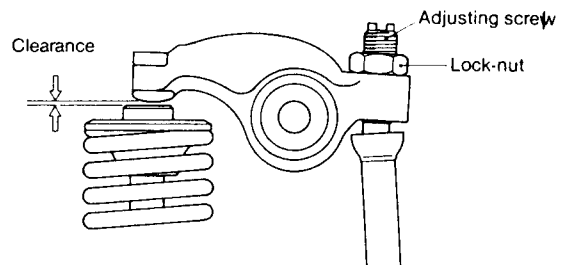
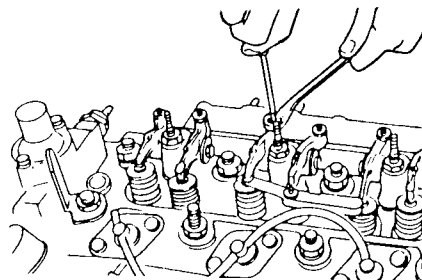
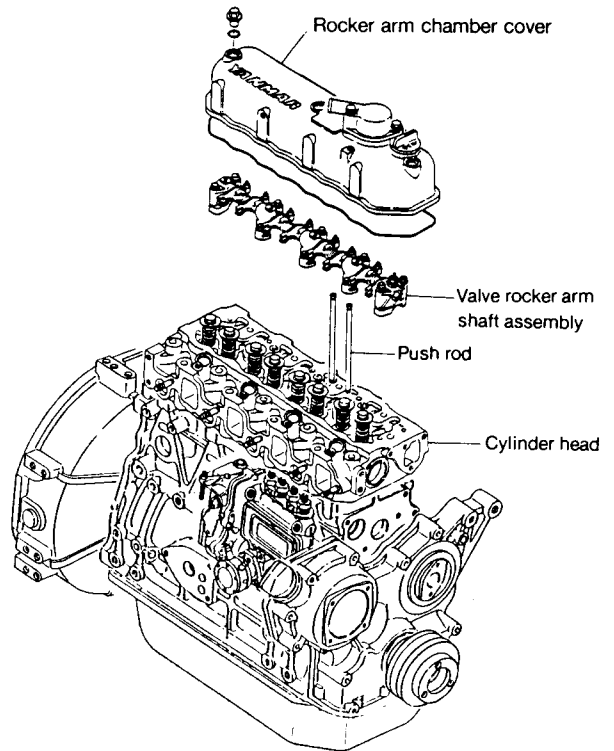
**(4) Measure the top clearance.**

Top clearance	mm (in.)
	<i>See separate service data (Page 2-30, 31)</i>

**(19) Mounting the valve rocker arm shaft assembly, pushrod**

- (1) Fit the pushrod to the tappet.
  - (2) Mount the valve rocker arm shaft assembly.
- | Valve rocker arm shaft support tightening torque | kg-m (ft-lb)          |
|--|-----------------------|
|  | 2.3 – 2.9 (16.6 – 21) |

**(3) Adjust valve clearance.**



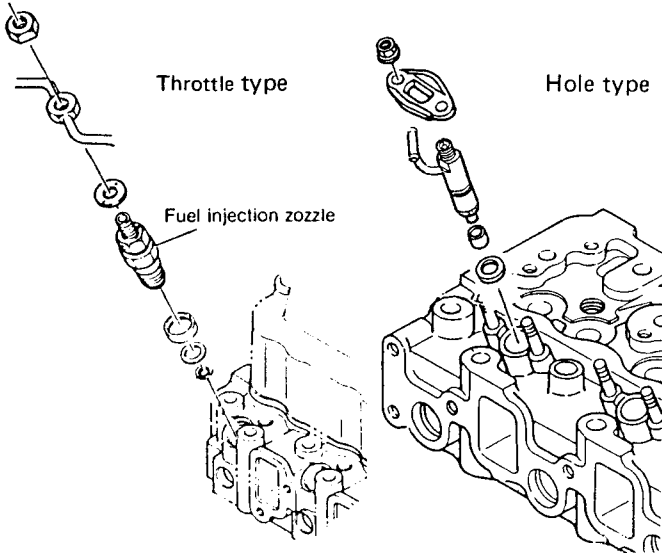
	mm (in.)
Intake/exhaust valve clearance	0.2 (0.0079)

- (4) Coat the valve rocker arm and valve spring with engine oil, and mount the valve rocker arm chamber cover.

3. Disassembly and Reassembly

**(20) Mounting the injection nozzle**

1) Insert the fuel injection nozzle assemblies into the nozzle holes.



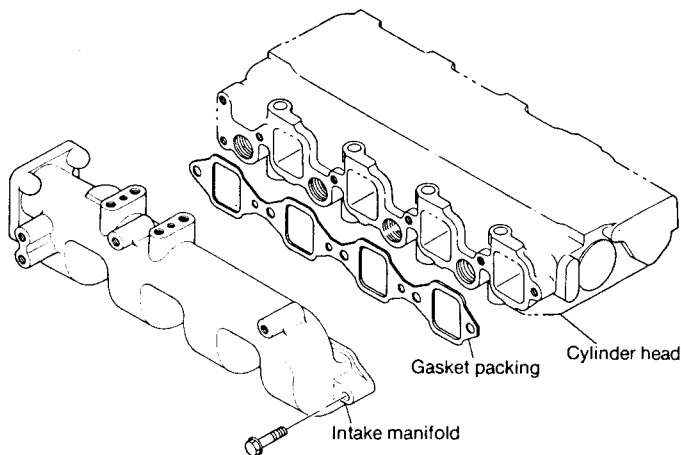
2) Tighten the fuel injection nozzle retainer nut to the specified torque.

kg·m (ft·lb)

Fuel injection nozzle retainer tightening torque	See separate service data (P. 8-22)
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**(21) Mounting the intake manifold**

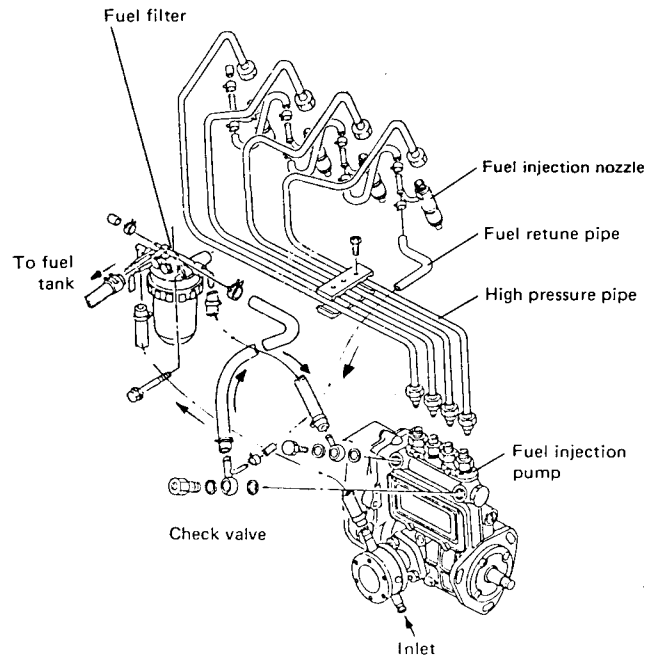
Thoroughly clean the inside of the intake manifold, and mount the gasket packing and intake manifold.



**(22) Mounting the high pressure fuel pipe and fuel oil return pipe**

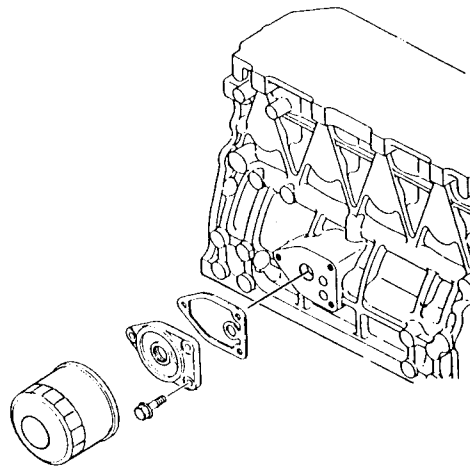
Mount the high pressure fuel pipe and then the high pressure fuel pipe vibration stop.

*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.

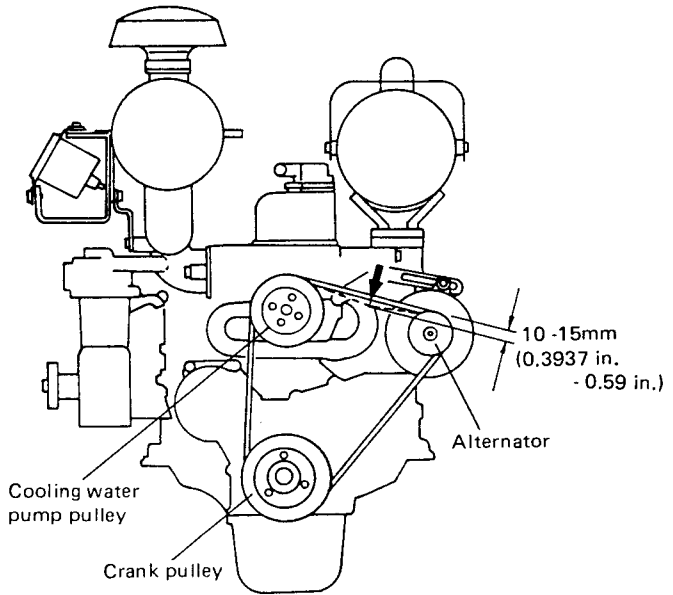


**(24) Mounting the Alternator**

- 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.

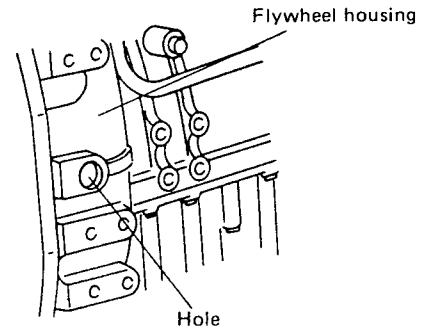


3. Disassembly and Reassembly



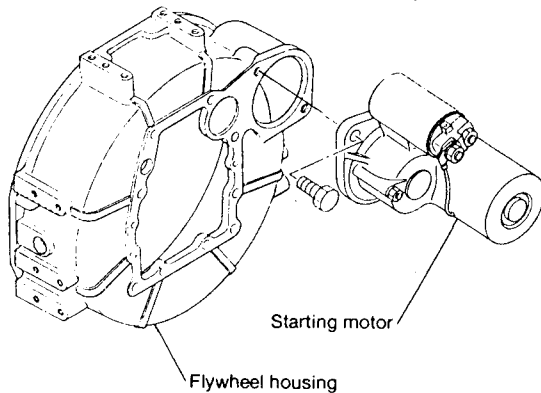
(30) Check the fuel injection timing

- 1) Check injection timing by turning the flywheel and looking through the inspection hole in the flywheel housing.

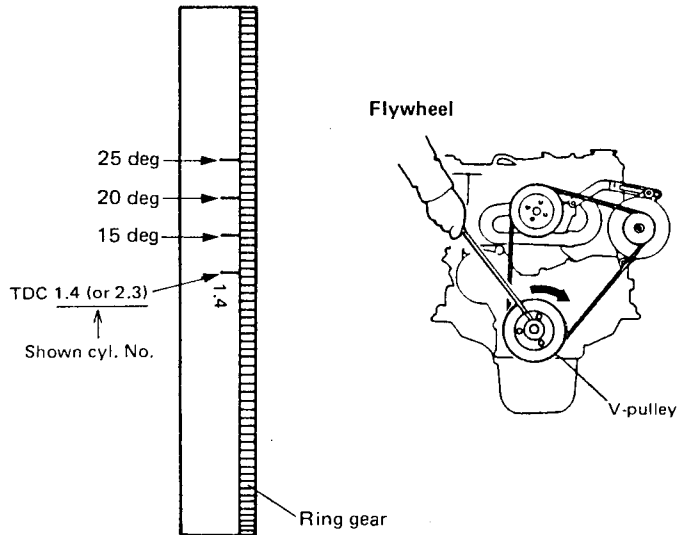


(25) Mounting the starting motor

Fit the starting motor in the flywheel housing.



Injection timing marks



(26) Mounting the fuel oil filter & fuel oil pipe

(27) Mounting the turbocharger

(28) Filling with lube oil

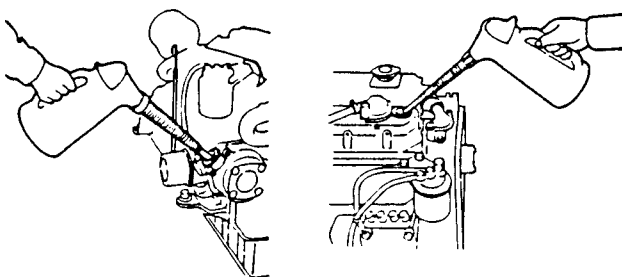
Fill the engine with lube oil from the filler port on top of the gear case.

- 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.

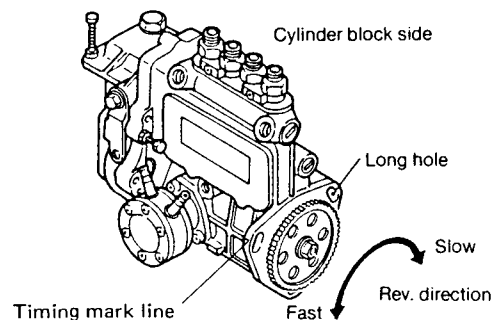
Lube oil capacity	1 (in.) <i>See separate service data</i> (Page 1-2, 3)
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Fuel injection timing (FID)	<i>See separate service data</i> (Page 1-2, 3)
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(29) Filling with cooling water

- 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.



4. Bolt/nut tightening torque

# 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 <sup>a</sup>	Thread dia. x pitch	M 8 x 1.25 3.3 – 3.7	M 9 x 1.25 6.0 – 6.5	M 9 x 1.25 6.8 – 7.2	M10 x 1.25 7.5 – 8.5
	Tightening torque	(23.9 – 26.8)	(43.4 – 47)		(54.2 – 65.1)
Connecting rod clamping bolt <sup>a</sup>	Thread dia. x pitch	M 7 x 1 2.3 – 2.8	M 7 x 1.0 2.3 – 2.8	M 8 x 1 3.8 – 4.2	M 9 x 1 4.5 – 5.0
	Tightening torque	(16.6 – 20.3)	(16.6 – 20.3)	(27.5 – 30.4)	(32.6 – 36.2)
Flywheel clamping bolt <sup>a</sup>	Thread dia. x pitch	M10 x 1.25 8.2 – 8.8	M10 x 1.25 8.2 – 8.8	M10 x 1.25 8.5 – 9.0	M10 x 1.25 8.5 – 9.0
	Tightening torque	(59.3 – 63.6)	(59.3 – 63.6)	(61.5 – 65.2)	(61.5 – 65.2)
Main bearing clamping bolt <sup>a</sup>	Thread dia. x pitch	M 9 x 1.25 5.3 – 5.7	M10 x 1.25 7.5 – 8.5	M10 x 1.25 7.8 – 8.2	M12 x 1.25 9.5 – 10.5
	Tightening torque	(38.3 – 41.2)	(54.2 – 65.1)	(56.5 – 59.4)	(68.7 – 76.0)
Crankshaft V-pulley clamping bolt <sup>a</sup>	Thread dia. x pitch	M12 x 1.5 8.5 – 9.5	M12 x 1.5 8.5 – 9.5	M14 x 1.5 11 – 13	M14 x 1.5 11 – 13
	Tightening torque	(61.5 – 68.7) <sup>b</sup>	(61.5 – 68.7) <sup>b</sup>	(79.6 – 94.1)	(79.6 – 94.1)
Fuel injection nozzle case nut/Holder	Thread dia. x pitch	0.605-40UNS-2A 4.0 – 4.5	0.605-40UNS-2A 4.0 – 4.5	4 – 4.5	4 – 4.5
	Tightening torque	(29.0 – 32.6)	(29.0 – 32.6)	(29.0 – 32.6)	(29.0 – 32.6)
Fuel injection nozzle	Thread dia. x pitch	M20 x 1.5 5.0 – 5.4	M20 x 1.5 5.0 – 5.4	M6 x 2 0.4 – 0.5	M6 x 2 0.4 – 0.5
	Tightening torque	(36.2 – 39.1)	(36.2 – 39.1)	(2.9 – 3.6)	(2.9 – 3.6)
Fuel pump driving gear nut <sup>a</sup>	Thread dia. x pitch	Shrinkage fit	←	5.0 – 7.0	5.0 – 7.0
	Tightening torque			(36.2 – 50.7)	(36.2 – 50.7)
Glow plug	Thread dia. x pitch	M10 x 1.25 1.5 – 2	M10 x 1.25 1.5 – 2	–	–
	Tightening torque	(10.8 – 14.5)	(0.8 – 14.5)		
Stub shaft bolt	Thread dia. x pitch	M10 x 1.5 5.5 – 6.5	M10 x 1.5 5.5 – 6.5	–	–
	Tightening torque	(39.8 – 47)	(39.8 – 47)		
Governor weight support nut <sup>a</sup>	Tightening torque	M12 x 1.25 7.0 – 7.5	M12 x 1.25 7.0 – 7.5	4.5 – 5	4.5 – 5
	Tightening torque	(50.6 – 54.2)	(50.6 – 54.2)	(32.5 – 36.2)	(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 preceding 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	M 6 x 1
Tightening torque	1.0 – 1.2 (7.2 – 8.7)
Thread dia. x pitch	M 8 x 1.25
Tightening torque	2.3 – 2.9 (16.6 – 21)
Thread dia. x pitch	M10 x 1.5
Tightening torque	4.5 – 5.5 (33 – 40)
Thread dia. x pitch	M12 x 1.75
Tightening torque	8.0 – 10.0 (58 – 72)
Thread dia. x pitch	M14 x 1.5
Tightening torque	13.0 – 15.0 (94 – 108)
Thread dia. x pitch	M16 x 1.5
Tightening torque	21.5 – 24.5 (155 – 177)

### Tapered screw plug

kg-m (ft-lbs)

Thread	kg-m (ft-lbs)
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

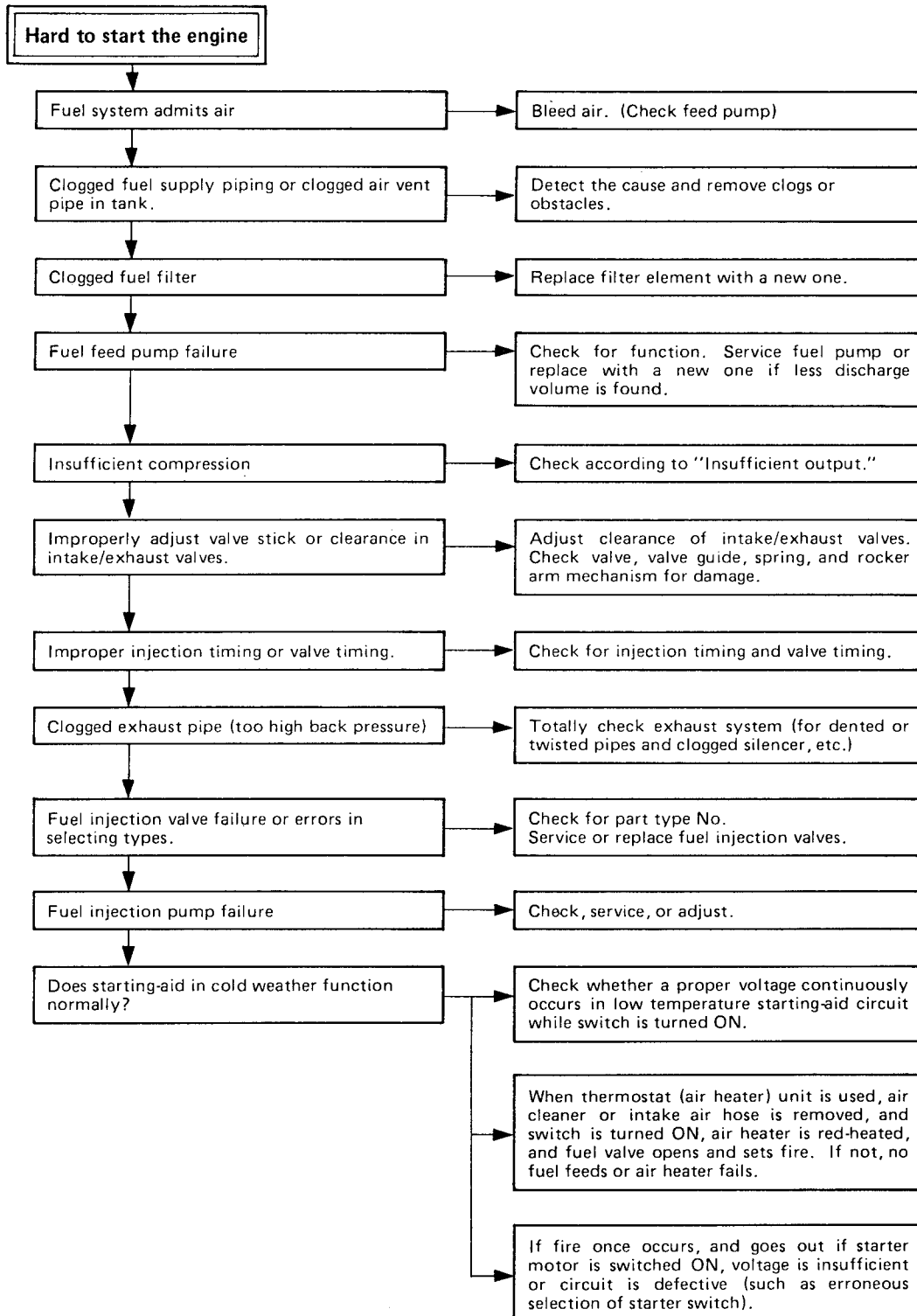
kg-m (ft-lbs)

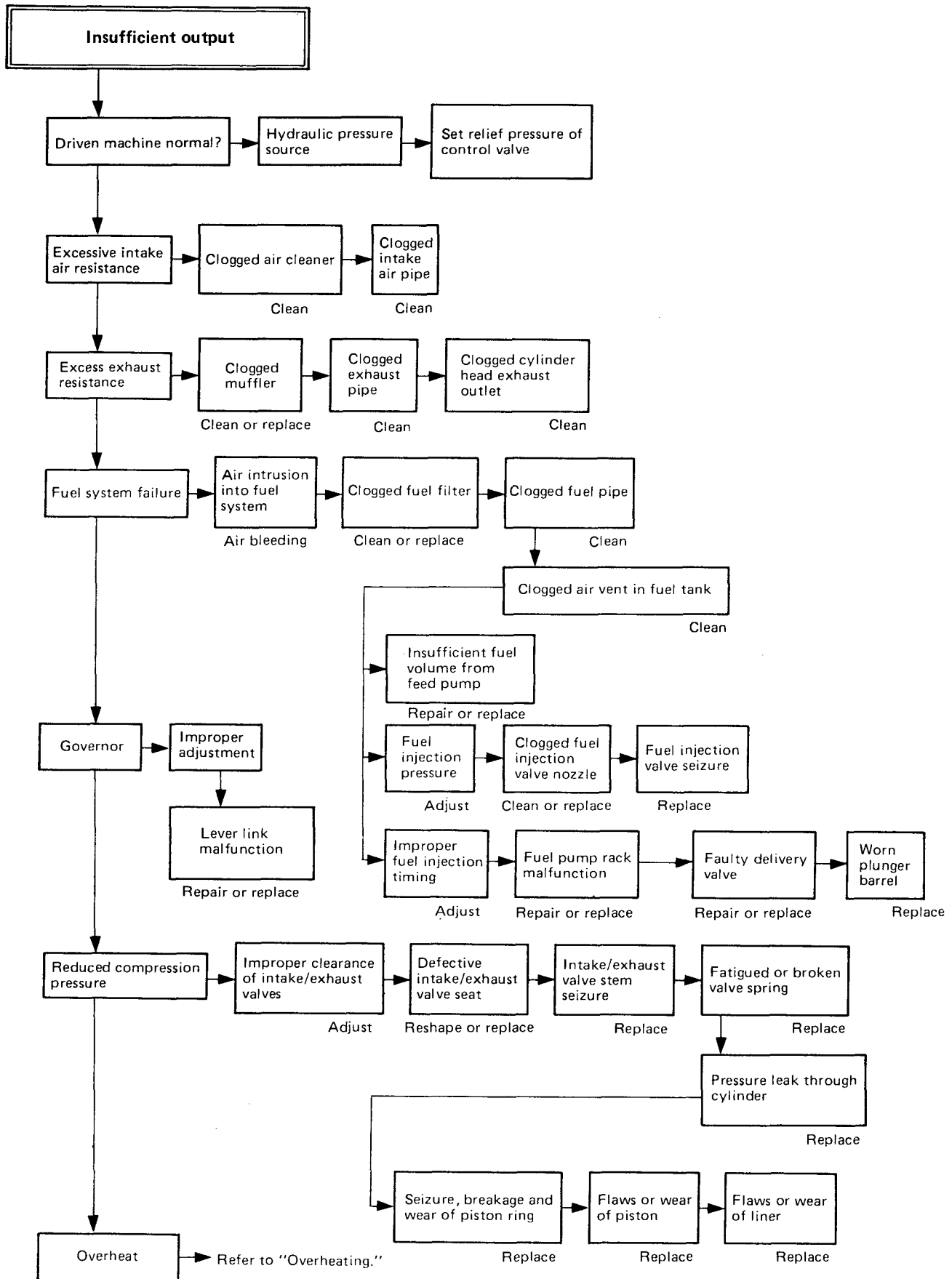
Thread	kg-m (ft-lbs)
M8	1.3 – 1.7 (9.4 – 12.2)
M12	2.5 – 3.5 (18 – 25)
M14	4 – 5 (29 – 36)
M16	5 – 6 (36 – 43)

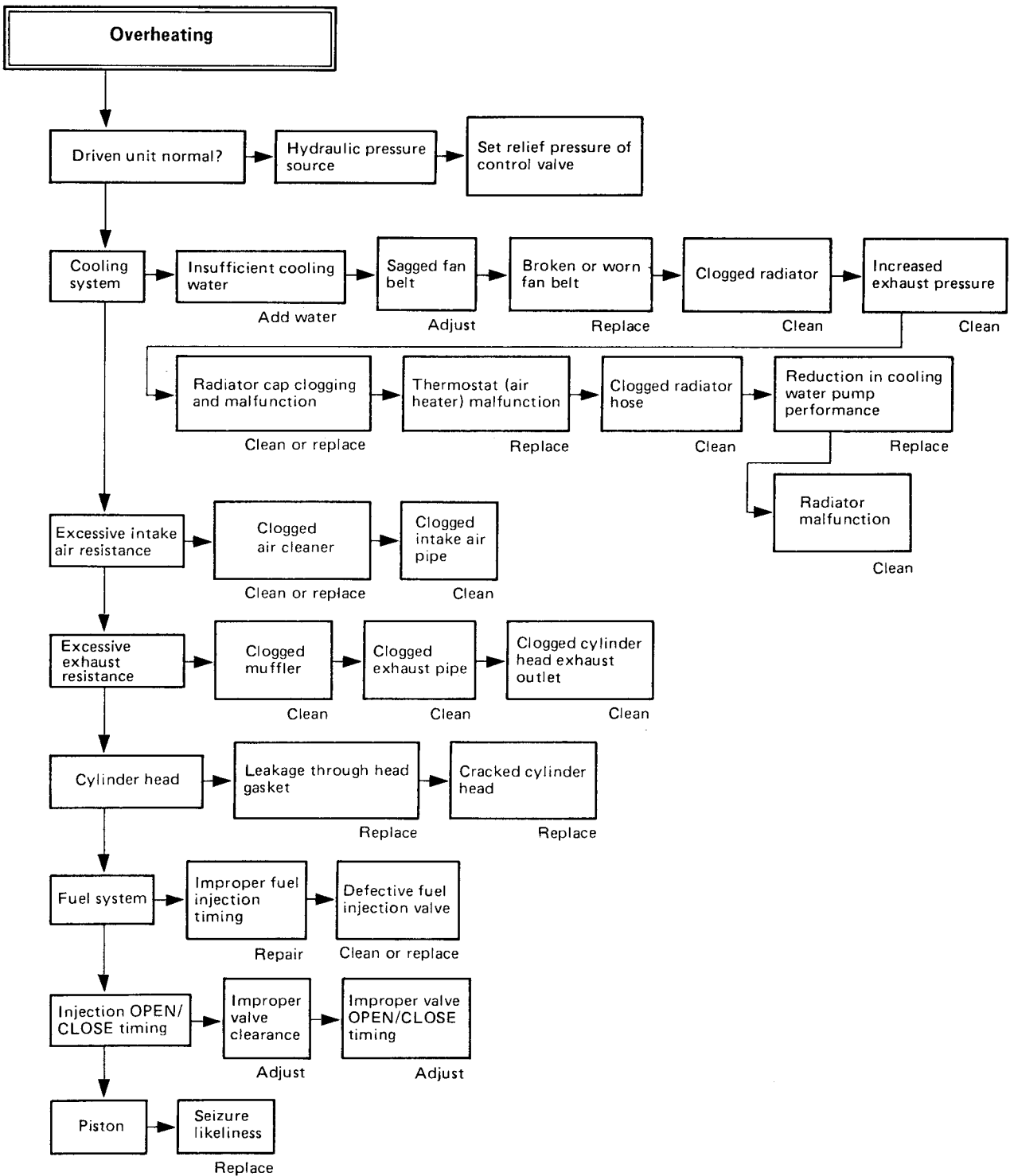
# 5. Troubleshooting

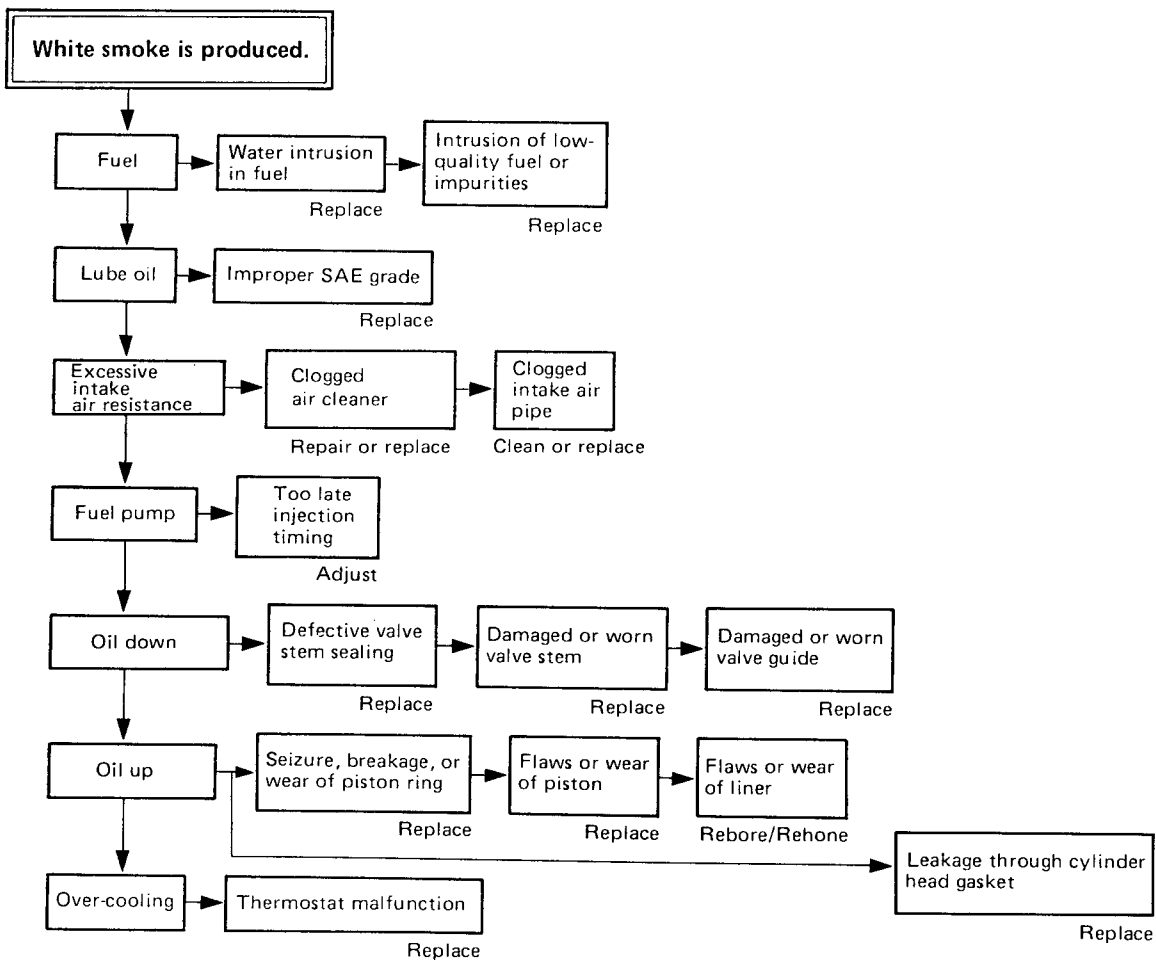
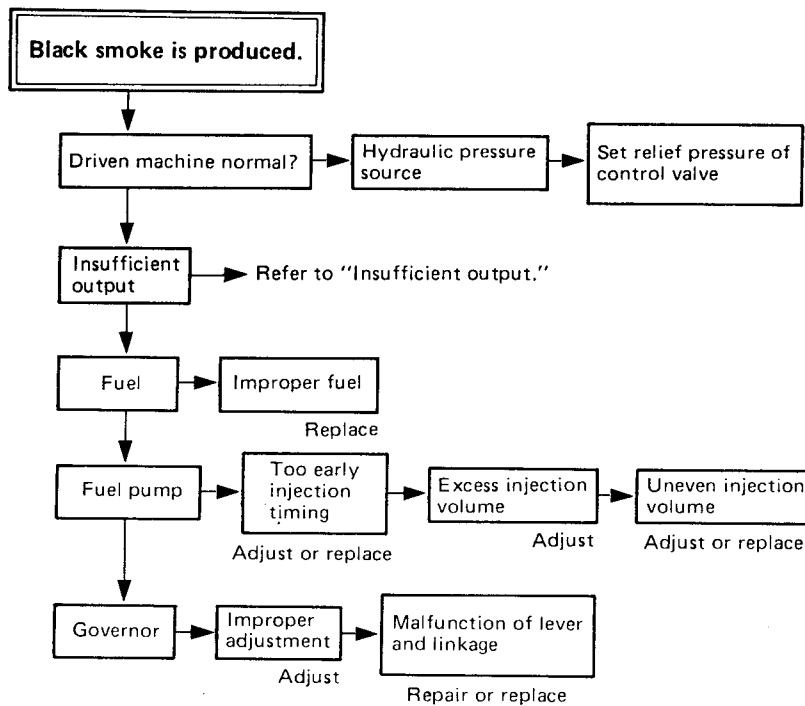
The following description summarizes the probable cause of and remedy for general failure by item.

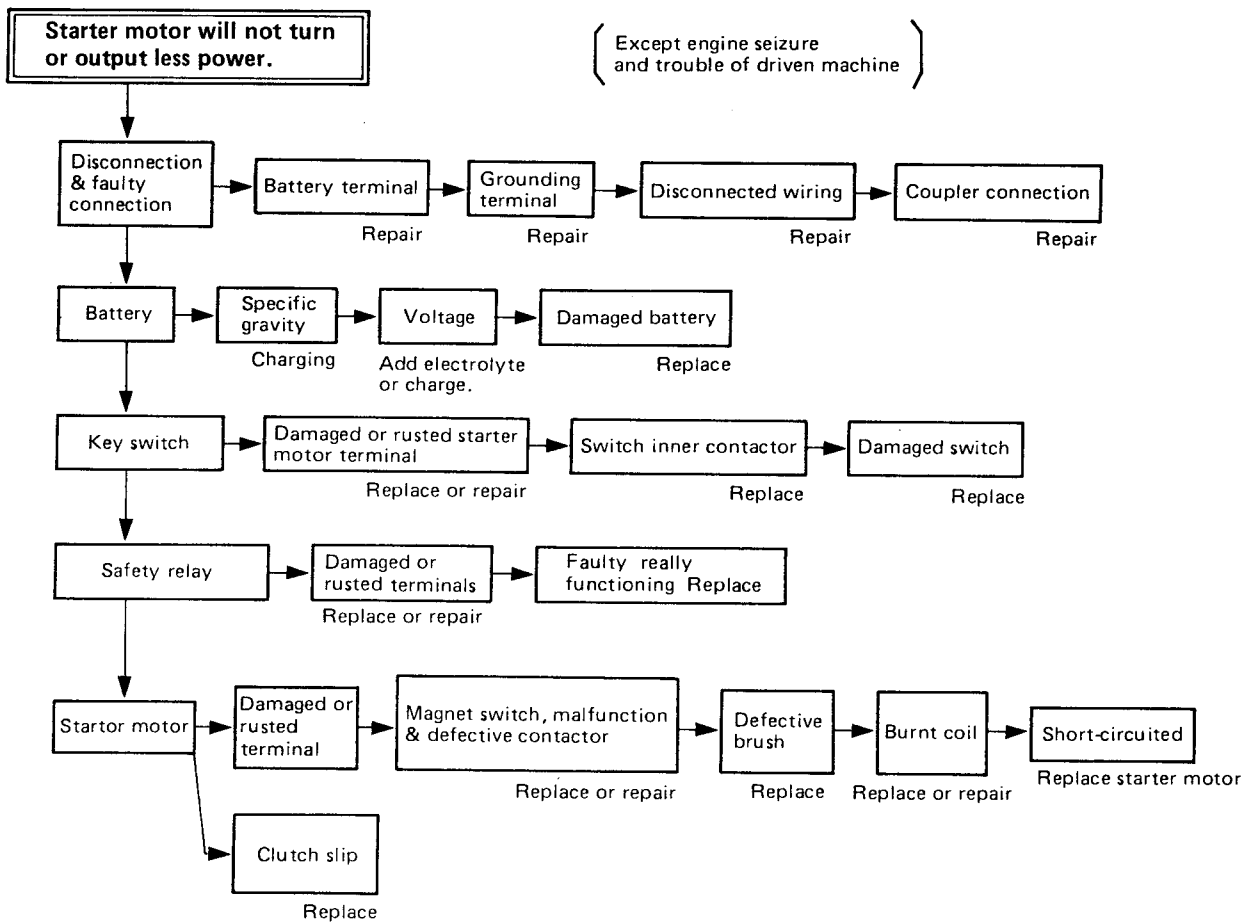
Immediate countermeasures should be taken before a failure is inflamed if any symptom is detected.



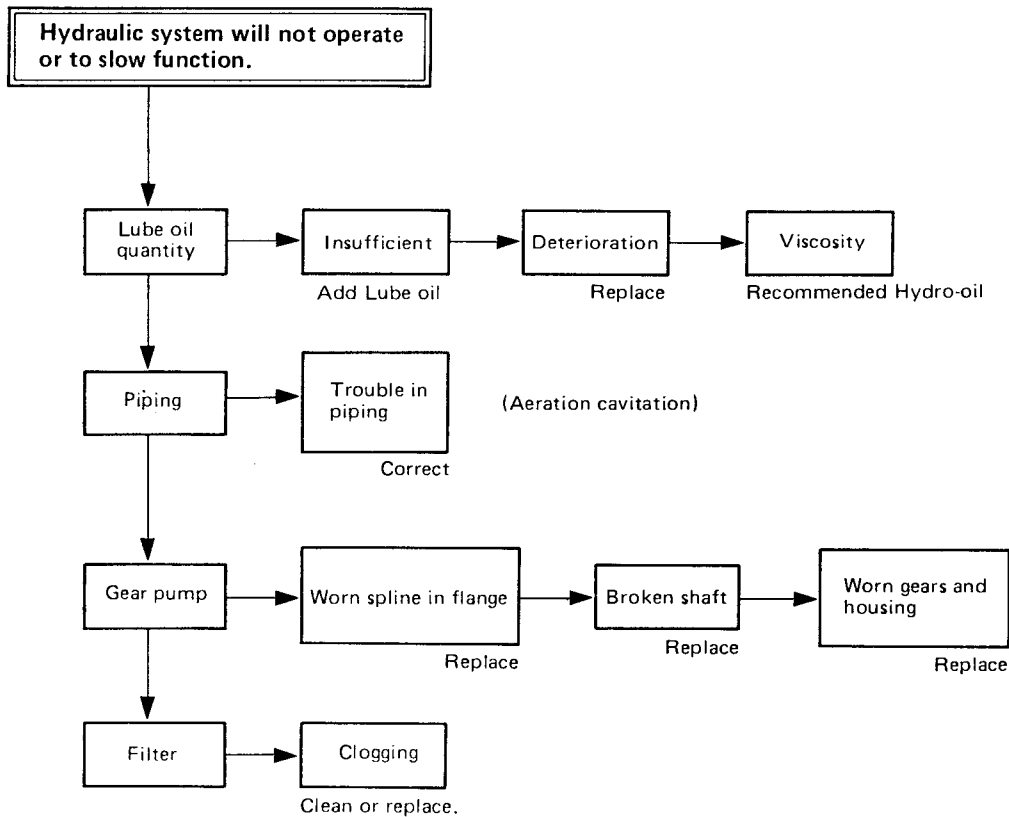


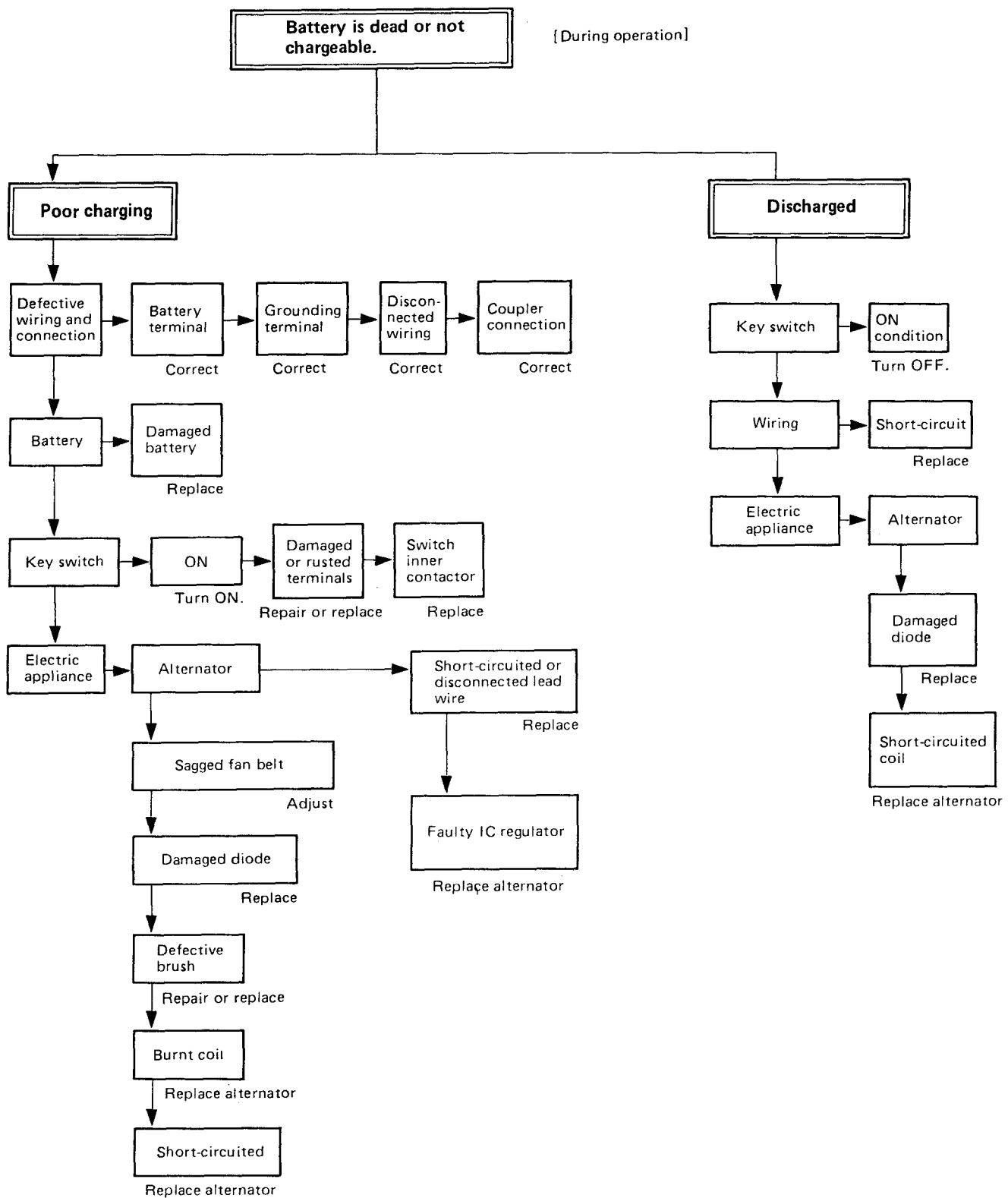






**Hydraulic pressure source**







## 6. Identification of Parts for each Application

### IDENTIFICATIONS OF PARTS FOR EACH APPLICATION

Model Application	2TN66E		3TN66E		3TNA72E		3TN75E			3TNC78E			3TN82E		
	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	—	—	—	—	—	○	—	—	○	—	—	○	—	—	○
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 Application	3TN82TE		4TN82E			4TN82TE			3TN84E			3TN84TE		
	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	○	○	—	—	○	○	○	○	—	—	○	○	○	○
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 Application	4TN84E			4TN84TE		
	VM	CL	CH	VM	CL	CH
Cylinder head	M	M	SH	SH	SH	SH
Valve seat	—	—	○	○	○	○
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

○: provided

## 7. Conversion Tables

## 7. Conversion Tables

Units	To convert	Into	Multiply by	Reference
Length	mm	inch	0.03937	1 ft = 12 in. 1 yd = 3 ft. = 36 in.
	cm	foot	0.03281	
	m	yard	1.09361	
	km	mile	0.62137	
	inch	mm	25.4	
	foot	cm	30.48	
	yard	m	0.9144	
	mile	km	1.6093	
Area	cm <sup>2</sup>	in. <sup>2</sup>	0.155	1 ft <sup>2</sup> = 144 in. <sup>2</sup> 1 yd <sup>2</sup> = 9 ft <sup>2</sup> = 1296 in. <sup>2</sup>
	m <sup>2</sup>	ft <sup>2</sup>	10.76	
	km <sup>2</sup>	mile <sup>2</sup>	0.3861	
	are	acre	0.0247	
	in. <sup>2</sup>	cm <sup>2</sup>	6.4516	
	ft <sup>2</sup>	m <sup>2</sup>	0.0929	
	mile <sup>2</sup>	km <sup>2</sup>	2.59	
	acre	are	40.4686	
Volume	cm <sup>3</sup>	in. <sup>3</sup>	0.06102	★Great Britain (UK) 1 fl oz = 0.028413 dm <sup>3</sup> 1 pt = 4 gills = 0.56826 dm <sup>3</sup> 1 qt = 2 pt = 1.13652 dm <sup>3</sup> 1 gal = 34 qt = 4.5461 dm <sup>3</sup>  ★United States (US) 1 fl oz = 0.029574 dm <sup>3</sup> 1 liq pt = 4 gills = 0.47318 dm <sup>3</sup> 1 liq qt = 2 liq pt = 0.94635 dm <sup>3</sup> 1 gal = 231 in. <sup>3</sup> = 4 liq qt = 3.7854 dm <sup>3</sup>
	dm <sup>3</sup> (liter)	in. <sup>3</sup>	61.0236	
	dm <sup>3</sup> (liter)	ft <sup>3</sup>	0.03531	
	m <sup>3</sup>	ft <sup>3</sup>	35.315	
	m <sup>3</sup>	yd <sup>3</sup>	1.30795	
	in. <sup>3</sup>	cm <sup>3</sup>	16.3871	
	in. <sup>3</sup>	dm <sup>3</sup> (liter)	0.01639	
	ft <sup>3</sup>	m <sup>3</sup>	0.02832	
	yd <sup>3</sup>	m <sup>3</sup>	0.76456	
	Weight (Units of mass)	g	oz	
kg		lb	2.2046	
oz		g	28.3495	
lb		kg	0.45359	
Force	gf	N (newton)	0.009807	1 pdℓ (poundal) = 0.138255N = force which accelerates a mass of lb by 1 ft/s <sup>2</sup>
	kgf	N	9.80665	
	lbf	N	4.44822	
	N	gf	101.972	
	N	kgf	0.101972	
	N	lbf	0.224809	

Units	To convert	Into	Multiply by	Reference
Pressure and stress	kgf/cm <sup>2</sup>	Bar	0.98066	1 at = 1 kgf/cm <sup>2</sup> 1 Pa = 1 N/m <sup>2</sup> 10 m H <sub>2</sub> O = 1 kgf/cm <sup>2</sup> 1 mmHg = 1 Torr
	kgf/cm <sup>2</sup>	N/m <sup>2</sup> (Pa)	98066.5	
	kgf/cm <sup>2</sup>	lbf/in. <sup>2</sup>	14.2233	
	lbf/in. <sup>2</sup>	Bar	0.0689	
	lbf/in. <sup>2</sup>	N/m <sup>2</sup> (Pa)	6894.76	
	Bar	kgf/cm <sup>2</sup>	1.01972	
	N/m <sup>2</sup> (Pa)	kgf/cm <sup>2</sup>	1.0197 x 10 <sup>-5</sup>	
	lbf/in. <sup>2</sup>	kgf/cm <sup>2</sup>	0.07031	
	Bar	lbf/in. <sup>2</sup>	14.5037	
N/m <sup>2</sup> (Pa)	lbf/in. <sup>2</sup>	1.4504 x 10 <sup>-4</sup>		
Energy	J	kcal	238.8 x 10 <sup>-6</sup>	
	J	kwh	277.8 x 10 <sup>-9</sup>	
	J	BTU	947.8 x 10 <sup>-6</sup>	
	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 1HP = 550 lb-ft/sec
	kw	HP	1.3410	
	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 <sup>2</sup>	ft/sec <sup>2</sup>	3.281	
	ft/sec <sup>2</sup>	m/sec <sup>2</sup>	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	°C	$R = F + 459.67$	
	°R	°F		
	°F	°R		

Note: All data subject to alteration without notice.

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**YANMAR DIESEL ENGINE CO.,LTD.**



**OVERSEAS OPERATIONS DIVISION**

1-1, 2-chome, Yaesu, Chuo-ku, Tokyo 104, Japan

Telex: 0222-4733 Telephone: 03-275-4933

Facsimile: 03-272-0687 Cable: YANMAR TOKYO