YANMAR®

SERVICE MANUAL

L40-L100 AIR COOLED LA SERIES

INDUSTRIAL DIESEL ENGINES

INTRODUCTION

This Service Manual offers instructions on standard service procedures (disassembly and reassembly) for Yanmar Diesel Engine models L40AE, L48AE, L60AE, L70AE, L75AE, L90AE and L100AE. More detailed information is given particularly in the sections of the construction and function of each engine part.

Before servicing these engines, make sure you read this manual carefully.

The information contained in this manual will be updated periodically to incorporate improvements in the quality and performance of our engines.

Before beginning your service work:

To insure efficient service and repairs, the following pre-service steps should be taken:

1. **Check your customer control book**
   (1) When was the engine last serviced?
   (2) What is the engine's service history?
      a. How often was the engine serviced (after how many months or hours of operation)?
      b. What problems has the engine had in the past?

2. **Stock control (spare parts)**
   (1) Keep a good stock of engine parts and other items necessary for efficient servicing.
   (2) Keep a copy of the check/service parts list and plenty of parts cards on hand.

3. **Keep an accurate service record (diary, notes, etc.)**
   (1) Work (manpower) table
   (2) Check list (including service parts list)
   (3) Parts measurement data
   (4) Operation data
   } Maintenance of performance and quality

4. **Tools and equipment required for service**
   (1) Tools
   (2) Meters and instruments
   (3) Others

Service Information

1. GENERAL SAFETY

WARNING

STOP THE ENGINE BEFORE SERVICING

1) PREVENTING FIRES

- Never add fuel to the fuel tank while the engine is running. Wipe away all fuel spills with a clean cloth.
- Keep gasoline, kerosene, matches, other explosives and inflammables away from the engine, since the temperature around the exhaust silencer is very high during operation.
- To prevent fire hazards and to provide adequate ventilation, keep the engine at least 3 ft (1m) away from the building and other equipment during operation.

2) PREVENTING EXHAUST GAS INHALATION

- Note that exhaust gas contains carbon monoxide (CO), nitrogen oxide (NOx), hydrocarbon (HC), sulfar oxide (SOx), and particulates.
- Never use the engine in poorly ventilated locations such as indoors, inside of tunnels and so on. If indoor operation is unavoidable, provide proper ventilation so that people and cattle will not be affected.

3) PREVENTING BURNS

- Never touch the exhaust silencer, muffler cover or engine body while the engine is running or hot.

4) PRECAUTIONS FOR THE BATTERY

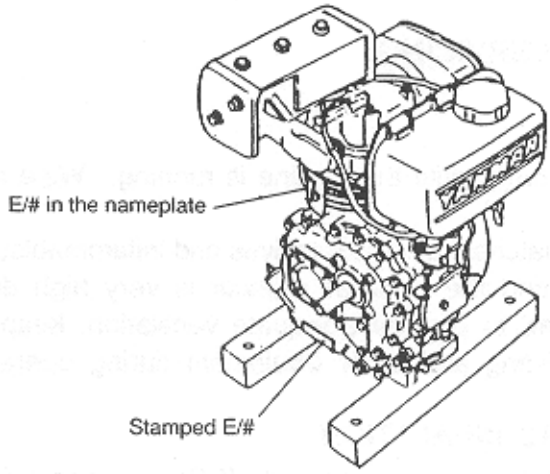
- The battery electrode is essentially dilute sulfuric acid, which injures the human body and damages clothes. Should it touch the body or clothes, immediately wash it away. If it enters your eye, hasten to consult the doctor.
- Never use fire near the battery during charging, which generates hydrogen.
- Charge the battery in a well ventilated place.

5) OTHERS

- Wear safety shoes, working clothes, etc. before servicing the engine.
- Do not service the engine under the influence of alcohol.
- Keep children and pets away from the engine in operation.
- Do not have access to rotary part during operation, which is extremely dangerous.

2. SERIAL NUMBER LOCATION

Engine serial number (E/#) is indicated in the engine nameplate, and is stamped on the crankcase cover. Before ordering service parts, be sure to check serial number and identify necessary parts by nos. (Parts may not have interchangeability as a result of a change in the specification.)



3. SERVICE RULES

1. Use genuine YANMAR parts. Parts that do not meet YANMAR's design specification may damage the engine.
2. In disassembling the engine in trouble, exactly locate the cause of trouble.
   Remove or disassemble only the parts specified in the troubleshooting procedure.
3. Use the special tools designed for this engine.
4. Install new gasket, O-ring, cotter pins, etc. when reassembling.
5. When torquing bolts or nuts, tighten them to the specified torque diagonally.
6. Clean parts in cleaning solvent upon disassembly.
   Lubricate any sliding surfaces before reassembly.
7. After reassembly, check all parts for proper installation and operation.

CONTENTS

1. Specifications

1.1 Specifications

Item \ Model			L40AE –				L48AE –			
			D	S	DE	SE	D	S	DE	SE
Type			Single-cylinder, vertical-4 cycle air-cooled diesel							
Cooling system			Forced air cooling by flywheel fan							
Combustion system			Direct injection system							
Starting system			Recoil starter		Starting motor with recoil starter		Recoil starter		Starting motor with recoil starter	
Number of cylinders - Bore × Stroke		mm (in.)	1-68 × 55 (2.677 × 2.165)				1-70 × 55 (2.756 × 2.165)			
Displacement		ℓ (cu.in.)	0.199 (12.14)				0.211(12.88)			
Output	Continuous	kW (HP)	2.8 (3.8)				3.1 (4.2)			
	Maximum		3.1 (4.2)				3.5 (4.7)			
Speed (PTO shaft)		rpm	3600	1800	3600	1800	3600	1800	3600	1800
Speed at no-load, max/min		rpm	$3800^{\pm 50}$ / 1200	$1900^{\pm 15}$ / 600	$3800^{\pm 50}$ / 1200	$1900^{\pm 15}$ / 600	$3800^{\pm 50}$ / 1200	$1900^{\pm 15}$ / 600	$3800^{\pm 50}$ / 1200	$1900^{\pm 15}$ / 600
Compression ratio			20.0				19.9			
PTO shaft	PTO position		Crank	Cam	Crank	Cam	Crank	Cam	Crank	Cam
	Direction of revolution		Counterclockwise viewed from PTO shaft							
Fuel oil	Fuel injection pump		Bosch type, YANMAR PFE-M type							
	Fuel injection timing (FID)	bTDC	$14^{\pm 1}$							
	Fuel injection nozzle		Hole nozzle, YANMAR YDLLA-P type							
	Fuel injection pressure	Mpa (kgf/cm²)	19.6 (200)							
	Fuel oil selection		Diesel fuel BS 2869 A1 or equivalent							
	Fuel oil filter		Paper element, FO tank built-in type							
	Fuel oil tank capacity	ℓ(US gal.)	2.5 (0.66)							
Lubicating oil	Type of lubrication		Forced lubrication via trochoid pump; splash lubrication for valve rocker arm chamber							
	Lubricating oil filter		Resin, 60 mesh							
	Lubricating oil selection		SAE 10W30, API grade CC or higher							
	Lubricating oil capacity	ℓ(US gal.)	0.80 (0.21) effective 0.25 (0.07)							
Air cleaner			Wet type paper element filter (Oil-bath type: Option)							
Exhaust silencer			Expansion silencer with cover							
Governor			All speed type, mechanical							
Engine dimensions (Length × Width × Height)		mm (in.)	D-spec. 332 × 384 × 416 (13.071 × 15.118 × 16.378) S-spec. 324 × 384 × 416 (12.756 × 15.118 × 16.378)							
Dry weight		kg (lb)	25.5 (56.2)		31.0 (68.3)		25.5 (56.2)		31.0 (68.3)	
Permissible angle of inclination		deg.	20 (momentary 30)							
Balancer shaft			Single shaft							

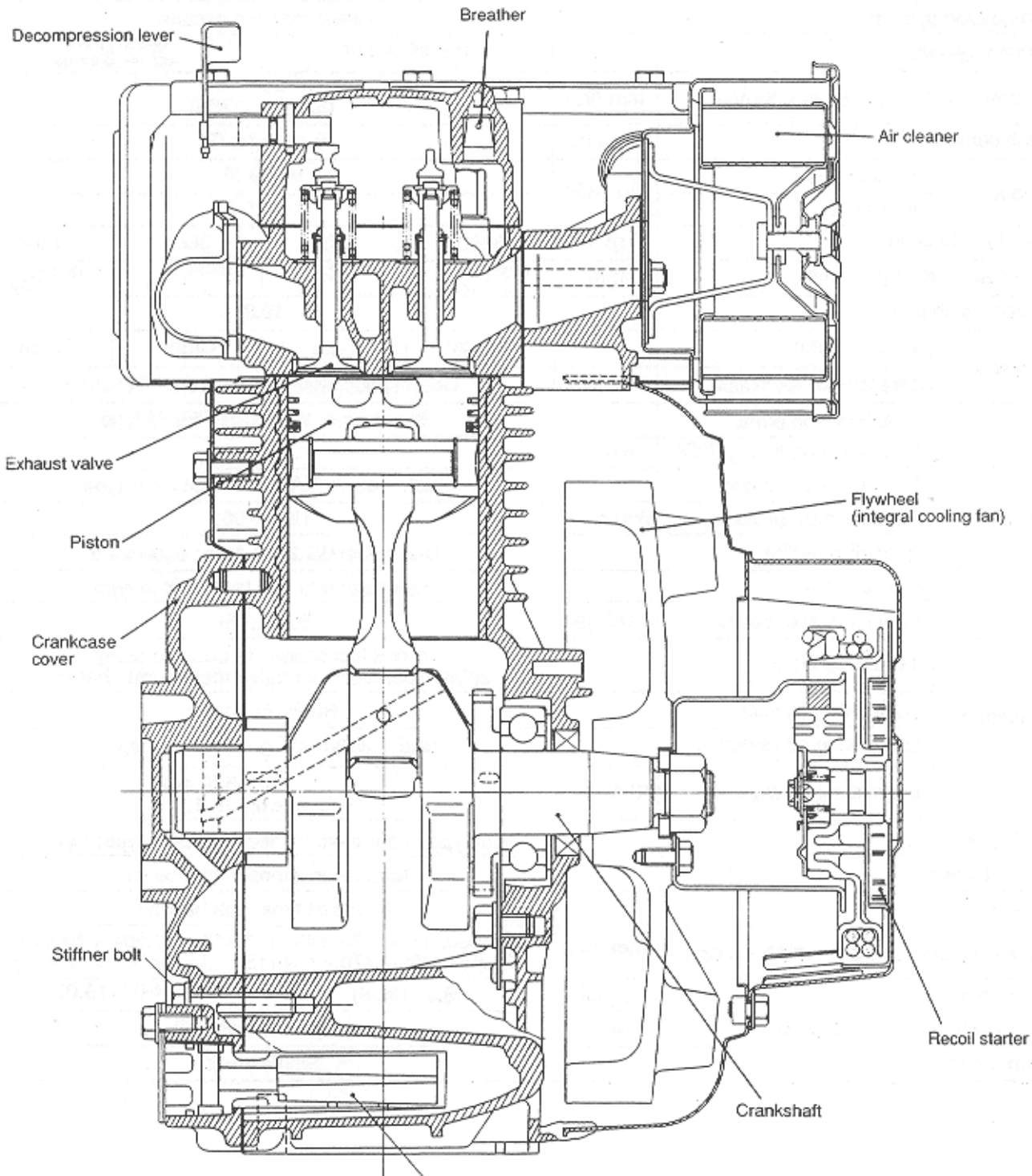
Item \ Model			L60AE				L70AE			
			D	S	DE	SE	D	S	DE	SE
Type			Single-cylinder, vertical-4 cycle air-cooled diesel							
Cooling system			Forced air cooling by flywheel fan							
Combustion system			Direct injection system							
Starting system			Recoil starter		Starting motor with recoil starter		Recoil starter		Starting motor with recoil starter	
Number of cylinders - Bore × Stroke		mm (in.)	1-75 × 62 (2.953 × 2.441)				1-78 × 62 (3.071 × 2.441)			
Displacement		ℓ (cu.in.)	0.273 (16.66)				0.296 (18.06)			
Output	Continuous	kW (HP)	4.0 (5.5)				4.4 (6.0)			
	Maximum		4.4 (6.0)				4.9 (6.7)			
Speed (PTO shaft)		rpm	3600	1800	3600	1800	3600	1800	3600	1800
Speed at no-load, max/min		rpm	$3800^{\pm 30}$ / 1200	$1900^{\pm 15}$ / 600	$3800^{\pm 30}$ / 1200	$1900^{\pm 15}$ / 600	$3800^{\pm 30}$ / 1200	$1900^{\pm 15}$ / 600	$3800^{\pm 30}$ / 1200	$1900^{\pm 15}$ / 600
Compression ratio			19.5							
PTO shaft	PTO position		Crank	Cam	Crank	Cam	Crank	Cam	Crank	Cam
	Direction of revolution		Counterclockwise viewed from PTO shaft							
Fuel oil	Fuel injection pump		Bosch type, YANMAR PFE-M type							
	Fuel injection timing (FID)	bTDC	$14^{\pm 1}$							
	Fuel injection nozzle		Hole nozzle, YANMAR YDLLA-P type							
	Fuel injection pressure	Mpa (kgf/cm²)	19.6 (200)							
	Fuel oil selection		Diesel fuel BS 2869 A1 or equivalent							
	Fuel oil filter		Paper element, FO tank built-in type							
	Fuel oil tank capacity	ℓ (US gal.)	3.5 (0.92)							
Lubicating oil	Type of lubrication		Forced lubrication via trochoid pump; splash lubrication for valve rocker arm chamber							
	Lubricating oil filter		Resin, 60 mesh							
	Lubricating oil selection		SAE 10W30, API grade CC or higher							
	Lubricating oil capacity	ℓ (US gal.)	1.1 (0.29) effective 0.4 (0.11)							
Air cleaner			Wet type paper element filter (Oil-bath type: Option)							
Exhaust silencer			Expansion silencer with cover							
Governor			All speed type, mechanical							
Engine dimensions (Length × Width × Height)		mm (in.)	D-spec. 383 × 421 × 450 (15.079 × 16.575 × 17.717) S-spec. 358 × 421 × 450 (14.094 × 16.575 × 17.717)							
Dry weight		kg (lb)	33.5 (73.9)		39.0 (86.0)		33.5 (73.9)		39.0 (86.0)	
Permissible angle of inclination		deg.	20 (momentary 30)							
Balancer shaft			Single shaft							

Specifications

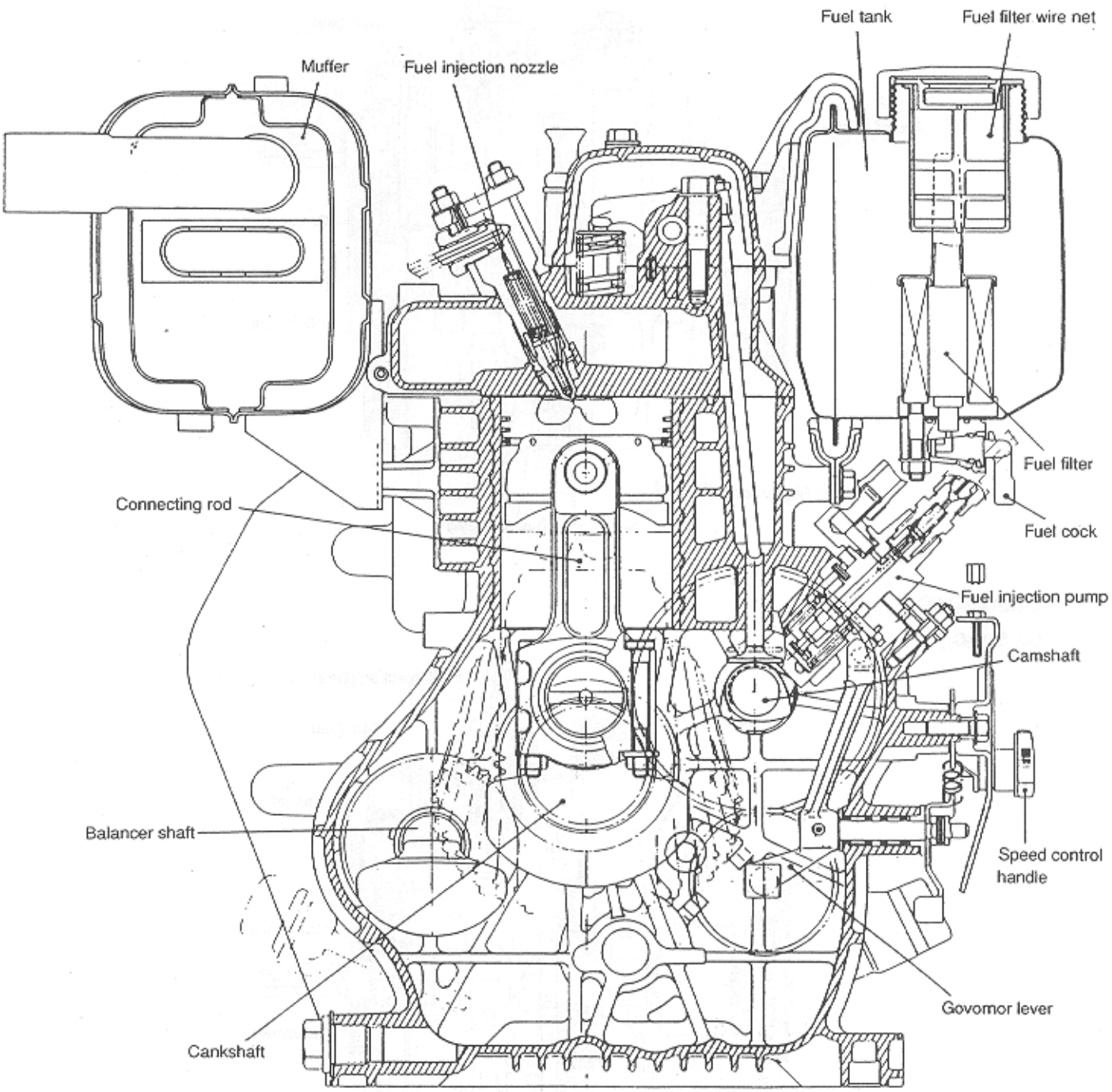
Item \ Model			L75AE–				L90AE–			
			D	S	DE	SE	D	S	DE	SE
Type			Single-cylinder, vertical-4 cycle air-cooled diesel							
Cooling system			Forced air cooling by flywheel fan							
Combustion system			Direct injection system							
Starting system			Recoil starter		Starting motor with recoil starter		Recoil starter		Starting motor with recoil starter	
Number of cylinders - Bore × Stroke		mm (in.)	1–80 × 70 (3.150 × 2.756)				1–84 × 70 (3.307 × 2.756)			
Displacement		ℓ (cu.in.)	0.351 (21.42)				0.387 (23.62)			
Output	Continuous	kW (HP)	4.8 (6.5)				5.9 (8.0)			
	Maximum		5.5 (7.5)				6.6 (9.0)			
Speed (PTO shaft)		rpm	3600	1800	3600	1800	3600	1800	3600	1800
Speed at no-load, max/min		rpm	3800±30 / 1200	1900±15 / 600	3800±30 / 1200	1900±15 / 600	3800±30 / 1200	1900±15 / 600	3800±30 / 1200	1900±15 / 600
Compression ratio			20.2				18.9			
PTO shaft	PTO position		Crank	Cam	Crank	Cam	Crank	Cam	Crank	Cam
	Direction of revolution		Counterclockwise viewed from PTO shaft							
Fuel oil	Fuel injection pump		Bosch type, YANMAR PFE-M type							
	Fuel injection timing (FID)	bTDC	13±1							
	Fuel injection nozzle		Hole nozzle, YANMAR YDLLA-P type							
	Fuel injection pressure	Mpa (kgf/cm²)	19.6 (200)							
	Fuel oil selection		Diesel fuel BS 2869 A1 or equivalent							
	Fuel oil filter		Paper element, FO tank built-in type							
	Fuel oil tank capacity	ℓ (US gal.)	5.5 (1.45)							
Lubicating oil	Type of lubrication		Forced lubrication via trochoid pump; splash lubrication for valve rocker arm chamber							
	Lubricating oil filter		Resin, 60 mesh							
	Lubricating oil selection		SAE 10W30, API grade CC or higher							
	Lubricating oil capacity	ℓ (US gal.)	1.65 (0.44) effective 0.6 (0.16)							
Air cleaner			Wet type paper element filter (Oil-bath type: Option)							
Exhaust silencer			Expansion silencer with cover							
Governor			All speed type, mechanical							
Engine dimensions (Length × Width × Height)		mm (in.)	D-spec. 417 × 470 × 494 (16.417 × 18.503 × 19.449) S-spec. 392 × 470 × 494 (15.433 × 18.503 × 19.449)							
Dry weight		kg (lb)	48.5 (106.9)		54.0 (119.0)		48.5 (106.9)		54.0 (119.0)	
Permissible angle of inclination		deg.	20 (momentary 30)							
Balancer shaft			Single shaft							

Item \ Model			L100AE–			
			D	S	DE	SE
Type			Single-cylinder, vertical-4 cycle air-cooled diesel			
Cooling system			Forced air cooling by flywheel fan			
Combustion system			Direct injection system			
Starting system			Recoil starter		Starting motor with recoil starter	
Number of cylinders - Bore × Stroke		mm (in.)	1–86 × 70 (3.386 × 2.756)			
Displacement		ℓ (cu.in.)	0.406 (24.78)			
Output	Continuous	kW (HP)	6.6 (9.0)			
	Maximum		7.4 (10.0)			
Speed (PTO shaft)		rpm	3600	1800	3600	1800
Speed at no-load, max/min		rpm	$3800^{\pm 50}/1200$	$1900^{\pm 15}/600$	$3800^{\pm 50}/1200$	$1900^{\pm 15}/600$
Compression ratio			19.3			
PTO shaft	PTO position		Crank	Cam	Crank	Cam
	Direction of revolution		Counterclockwise viewed from PTO shaft			
Fuel oil	Fuel injection pump		Bosch type, YANMAR PFE-M type			
	Fuel injection timing (FID)	bTDC	$13^{\pm 1}$			
	Fuel injection nozzle		Hole nozzle, YANMAR YDLLA-P type			
	Fuel injection pressure	Mpa (kgf/cm²)	19.6 (200)			
	Fuel oil selection		Diesel fuel BS 2869 A1 or equivalent			
	Fuel oil filter		Paper element, FO tank built-in type			
	Fuel oil tank capacity	ℓ (US gal.)	5.5 (1.45)			
Lubicating oil	Type of lubrication		Forced lubrication via trochoid pump; splash lubrication for valve rocker arm chamber			
	Lubricating oil filter		Resin, 60 mesh			
	Lubricating oil selection		SAE 10W30, API grade CC or higher			
	Lubricating oil capacity	ℓ (US gal.)	1.65 (0.44) effective 0.6 (0.16)			
Air cleaner			Wet type paper element filter (Oil-bath type: Option)			
Exhaust silencer			Expansion silencer with cover			
Governor			All speed type, mechanical			
Engine dimensions (Length × Width × Height)		mm (in.)	D-spec. 417 × 470 × 494 (16.417 × 18.504 × 19.449) S-spec. 392 × 470 × 494 (15.433 × 18.503 × 19.449)			
Dry weight		kg (lb)	48.5 (106.9)		54.0 (119.0)	
Permissible angle of inclination		deg.	20 (momentary 30)			
Balancer shaft			Single shaft			

1.2 Cross Sectional Views

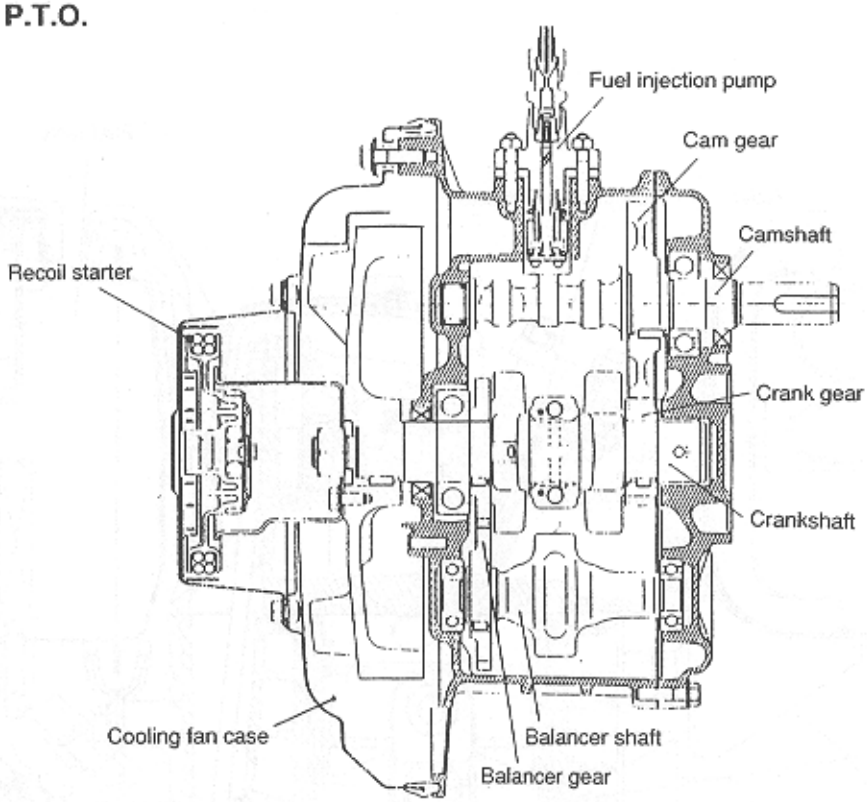


Longitudinal sectional view

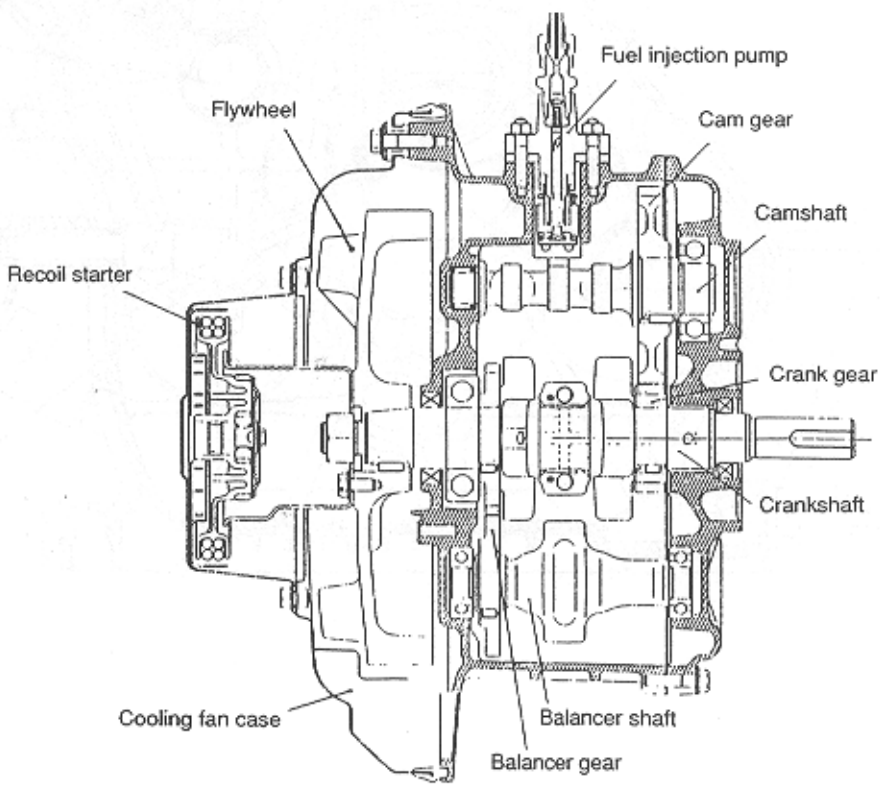


Plan view

Camshaft P.T.O. (S spec.)



Crankshaft P.T.O. (D spec.)



2. Service Standards

Unit: mm (in.)

Parts		Model	Standard	Service limit	Remarks
Intake/exhaust valve seats					
Seat angle		L40AE~ L100AE	60°–90°	—	
Seat width		L40AE~ L100AE	1.5–3.0 (0.059–0.118)	—	
Intake/exhaust valves & valve guides					
Valve sinkage		L40AE~ L100AE	0.3–0.7 (0.012–0.028)	1.1 (0.043)	
Valve guide I.D.	Intake/ Exhaust	L40AE, L48AE	5.500–5.515 (0.2165–0.2171)	5.58 (0.2197)	
		L60AE, L70AE	6.0–6.015 (0.2362–0.2368)	6.08 (0.2394)	
		L75AE~ L100AE	7.0–7.015 (0.2756–0.2762)	7.08 (0.2787)	
Valve stem O.D.	Intake	L40AE, L48AE	5.465–5.475 (0.2152–0.2156)	5.40 (0.2126)	
		L60AE, L70AE	5.960–5.975 (0.2346–0.2352)	5.90 (0.2323)	
		L75AE~ L100AE	6.960–6.975 (0.2740–0.2745)	6.90 (0.2717)	
	Exhaust	L40AE, L48AE	5.450–5.460 (0.2146–0.2150)	5.40 (0.2126)	
		L60AE, L70AE	5.945–5.960 (0.2341–0.2346)	5.90 (0.2323)	
		L75AE~ L100AE	6.945–6.960 (2.734–2.740)	6.90 (0.2717)	
Valve spring					
Free length		L40AE, L48AE	28 (1.102)	26.5 (1.043)	
		L60AE, L70AE	33 (1.299)	31.5 (1.240)	
		L75AE~ L100AE	40 (1.575)	39.5 (1.555)	

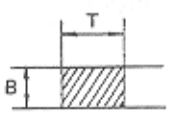
Unit: mm (in.)

Parts	Model	Standard	Service limit	Remarks
Valve spring				
Inclination	L40AE, L48AE	<0.75 (0.030)	—	
	L60AE, L70AE	<0.6 (0.024)	—	
	L75AE~ L100AE	<1.0 (0.039)	—	
Spring constant (kg/mm)	L40AE, L48AE	1.14~1.4kg (2.51~3.09 lb)	—	
	L60AE, L70AE	1.27~1.55kg (2.80~3.42 lb)	—	
	L75AE~ L100AE	1.80~2.51kg (3.97~5.51 lb)	—	
Intake/exhaust valve rocker-arm, rocker shaft and push rods				
IN/EX valve rocker arm shaft O.D.	L40AE~ L70AE	11.989–12.000 (0.4720–0.4724)	11.90 (0.4685)	
	L75AE~ L100AE	14.989–15.000 (0.5901–0.5906)	14.90 (0.5866)	
IN/EX valve rocker arm I.D.	L40AE~ L70AE	12.016–12.034 (0.4731–0.4738)	12.10 (0.4764)	
	L75AE~ L100AE	15.016–15.034 (0.5912–0.5919)	15.10 (0.5945)	
Push rod length	L40AE~ L48AE	129.8–130.2 (5.110–5.126)	—	
	L60AE~ L70AE	162.3–162.7 (6.390–6.406)	—	
	L75AE~ L100AE	196.8–197.2 (7.748–7.764)	—	
Push rod distortion	L40AE~ L100AE	< 0.05 (0.0020)	0.3 (0.0118)	
Valve clearance				
Intake and exhaust	L40AE~ L100AE	0.15 (0.0059)	—	

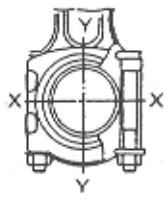
Unit: mm (in.)

Parts		Model	Standard	Service limit	Remarks
Valve opening/closing timing					
Intake	Open	L40AE~ L70AE	25° b T.D.C.	—	
		L75AE~ L100AE	20° b T.D.C.	—	
	Closed	L40AE~ L70AE	59° a B.D.C.	—	
		L75AE~ L100AE	53° a B.D.C.	—	
Exhaust	Open	L40AE~ L70AE	59° b B.D.C.	—	
		L75AE~ L100AE	53° b. B.D.C	—	
	Closed	L40AE~ L70AE	25° a T.D.C.	—	
		L75AE~ L100AE	20° a T.D.C.	—	
Piston					
Piston O.D.		L40AE	67.965 (2.6758)	67.68 (2.6646)	Refer to Page 31 for measuring position. Oversize: 0.25 mm 0.50 mm
		L48AE	69.965 (2.7545)	69.70 (2.7441)	
		L60AE	74.965 (2.9514)	74.70 (2.9410)	
		L70AE	79.965 (3.1482)	77.70 (3.0590)	
		L75AE	7.9965 (3.1482)	79.70 (3.1378)	
		L90AE	83.965 (3.3057)	83.70 (3.2953)	
		L100AE	85.965 (3.3844)	85.70 (3.3740)	
Clearance between piston and sleeve		L40AE~ L90AE	0.04–0.06 (0.00157–0.00236)	—	
		L100AE	0.05–0.07 (0.00197–0.00276)	—	
Piston pin hole ID		L40AE/ L48AE	18.985–18.996 (0.7474–0.7479)	19.07 (0.7508)	
		L60AE/ L70AE	20.983–20.996 (0.8261–0.8266)	21.07 (0.8295)	
		L75AE~ L100AE	22.983–22.996 (0.9048–0.9054)	23.07 (0.9083)	
Clearance between piston pin hole and piston pin		L40AE	L 0.004–0.015 T (0.0002–0.0006)	—	L: Loose fit T: Tight fit
		L48AE~ L100AE	L 0.005–0.017 T (0.0002–0.0007)	—	

Unit: mm (in.)

Parts		Model	Standard	Service limit	Remarks
Piston pin					
Piston pin O.D.		L40AE, L48AE	18.992–19.000 (0.7477–0.7480)	18.92 (0.7449)	
		L60AE, L70AE	20.991–21.000 (0.8264–0.8268)	20.91 (0.8232)	
		L75AE~ L100AE	22.991–23.000 (0.9052–0.9055)	22.91 (0.9020)	
Piston and rings					
1st ring side clearance (ring width and ring groove)		L40AE~ L100AE	0.065–0.095 (0.0026–0.0037)	0.15 (0.0059)	
2nd ring side clearance (ring width and ring groove)		L40AE~ L100AE	0.03–0.065 (0.0012–0.0026)	0.15 (0.0059)	
Oil ring side clearance (ring width and ring groove)		L40AE~ L100AE	0.02–0.055 (0.0008–0.0022)	0.15 (0.0059)	
Piston ring					
1st ring	T dimensions	L40AE	2.7–2.9 (0.1063–0.1141)	2.52 (0.0992)	
		L48AE	3.0–3.2 (0.1181–0.1260)	2.77 (0.1091)	
		L60AE~ L70AE	3.2–3.4 (0.1260–0.1339)	2.97 (0.1169)	
		L75AE	3.3–3.5 (0.1299–0.1378)	3.07 (0.1209)	
		L90AE	3.4–3.6 (0.1339–0.1417)	3.17 (0.1248)	
		L100AE	3.6–3.8 (0.1417–0.1496)	3.37 (0.1327)	
	B dimensions	L40AE~ L100AE	1.470–1.485 (0.0579–0.0585)	1.36 (0.0535)	
2nd ring	T dimensions	L40AE	2.75–2.95 (0.1083–0.1161)	2.75 (0.1083)	
		L48AE	3.0–3.2 (0.1181–0.1260)	2.77 (0.1091)	
		L60AE/ L70AE	3.2–3.4 (0.1260–0.1339)	2.97 (0.1169)	
		L75AE	3.3–3.5 (0.1300–0.1378)	3.07 (0.1209)	
		L90AE	3.4–3.6 (0.1339–0.1417)	3.17 (0.1248)	
		L100AE	3.6–3.8 (0.1417–0.1496)	3.37 (0.1327)	
	B dimensions	L40AE~ L70AE	1.470–1.490 (0.0579–0.0587)	1.36 (0.0535)	
		L75AE~ L100AE	1.970–1.990 (0.0776–0.0783)	1.86 (0.0732)	

Unit: mm (in.)

Parts		Model	Standard	Service limit	Remarks
Piston ring					
Oil ring	T dimensions	L40AE	2.6–2.8 (0.1024–0.1102)	2.49 (0.0980)	
		L48AE	2.0–2.4 (0.0787–0.0945)	1.99 (0.0783)	
		L60AE/ L70AE	2.1–2.5 (0.0827–0.0984)	2.07 (0.0815)	
		L75AE	2.4–2.8 (0.0945–0.1102)	2.37 (0.0933)	
		L90AE/ L100AE	2.5–2.9 (0.0984–0.1141)	2.47 (0.0972)	
	B dimensions	L40AE~ L70AE	3.470–3.490 (0.1366–0.1374)	3.36 (0.1323)	
		L75AE~ L100AE	3.970–3.990 (0.1563–0.1571)	3.86 (0.1520)	
End gap	1st ring	L40AE~ L100AE	0.20–0.35 (0.0078–0.0138)	1.0 (0.0394)	
	2nd ring	L40AE~ L100AE	0.30–0.45 (0.0118–0.0177)	1.0 (0.0394)	
	Oil ring	L40AE~ L100AE	0.15 – 0.35 (0.0059 – 0.0138)	1.0 (0.0394)	
Connecting rod					
Small end hole (piston pin)	ID	L40AE, L48AE	19.012–19.024 (0.7485–0.7490)	19.10 (0.7520)	
		L60AE, L70AE	21.014–21.028 (0.8273–0.8279)	21.10 (0.8307)	
		L75AE~ L100AE	23.025–23.038 (0.9065–0.9070)	23.10 (0.9094)	
	Oil clearance	L40AE, L48AE	0.015–0.030 (0.0006–0.0012)	—	
		L60AE, L70AE	0.017–0.034 (0.0007–0.0013)	—	
		L75AE~ L100AE	0.028–0.044 (0.0011–0.0017)	—	
Large end hole (Crank pin)	ID (Y-Y direction)	L40AE, L48AE	30.007–30.015 (1.1814–1.1817)	30.09 (1.1846)	
		L60AE, L70AE	36.007–36.015 (1.4176–1.4179)	36.09 (1.4209)	
		L75AE~ L100AE	40.000–40.042 (1.5748–1.5765)	40.08 (1.5780)	
	Oil clearance	L40AE~ L70AE	0.025–0.050 (0.0010–0.0020)	—	
		L75AE~ L100AE	0.033–0.062 (0.0013–0.0024)	—	

Unit: mm (in.)

Parts			Model	Standard	Service limit	Remarks
Crankshaft and Main bearing						
Crank pin		Pin O.D.	L40AE, L48AE	29.965–29.982 (1.1797–1.1804)	29.90 (1.1772)	
			L60AE, L70AE	35.965–35.982 (1.4159–1.4166)	35.90 (1.4134)	
			L75AE~ L100AE	39.965–39.982 (1.5734–1.5741)	39.90 (1.5709)	
		Oil clearance	L40AE~ L70AE	0.025–0.055 (0.0010–0.0022)	—	
			L75AE~ L100AE	0.033–0.062 (0.0013–0.0024)		
Crank jouranl part	Gear cover side	Journal O.D.	L40AE, L48AE	30.002–30.015 (1.1812–1.1817)	29.91 (1.1776)	
			L60AE, L70AE	35.002–35.018 (13780–1.3787)	34.91 (1.3744)	
			L75AE~ L100AE	40.002–40.018 (1.5749–1.5755)	39.91 (1.5713)	
		Oil clearance	L40AE, L48AE	0.025–0.058 (0.0010–0.0023)	0.17 (0.0067)	
			L60AE~ L100AE	0.025–0.061 (0.0010–0.0024)		
	Flywheel side	Journal O.D.	L40AE, L48AE	30.002–30.015 (1.1812–1.1817)	—	
			L60AE, L70AE	35.007–35.018 (1.3782–1.3787)	—	
			L75AE~ L100AE	40.007–40.018 (1.5751–1.5755)	—	
Journal part	Flywheel side	Bearing I.D.	L40AE, L48AE	29.990–30.000 (1.1807–1.1811)	—	
			L60AE, L70AE	34.988–35.000 (1.3775–1.3780)	—	
			L75AE~ L100AE	39.988–40.000 (1.5743–1.5748)	—	
		Fitting	L40AE, L48AE	0.002–0.025 (0.00008–0.0010)	—	Tight fit
			L60AE, L70AE	0.007–0.030 (0.0003–0.0012)	—	
			L75AE~ L100AE			

Unit: mm (in.)

Parts		Model	Standard	Service limit	Remarks
Camshaft					
Needle bearing on cylinder block side	Shaft O.D.	L40AE~ L100AE	14.989–15.000 (0.5901–0.5906)	14.92 (0.5874)	
	Bearing I.D.	L40AE~ L100AE	15.016–15.034 (0.5912–0.5919)	—	
	Oil clearance	L40AE~ L100AE	0.016–0.045 (0.0006–0.0018)	—	
Ball bearing on crankcase cover side	Stem O.D.	L40AE, L48AE	24.980–24.993 (0.9835–0.9840)	24.90 (0.9803)	
		L60AE, L70AE	29.980–29.993 (1.1803–1.1808)	29.90 (1.1772)	
		L75AE~ L100AE	34.980–34.993 (1.3772–1.3777)	34.90 (1.3740)	
Ball bearing on crankcase cover side	Bearing I.D.	L40AE, L48AE	24.990–25.000 (0.9839–0.9843)	25.02 (0.9850)	
		L60AE, L70AE	29.990–30.000 (1.1807–1.1811)	30.02 (1.1819)	
		L75AE~ L100AE	34.990–35.000 (1.3776–1.3780)	35.02 (1.3787)	
	Oil clearance	L40AE, L48AE	L 0.020–0.030 T (0.0008–0.0012)	0.08–0.10 (0.0031–0.0039)	L: Loose fit T: Tight fit
		L60AE, L70AE			
		L75AE~ L100AE			
Thrust clearance (Gap of axial direction)		L40AE~ L100AE	0.040–0.280 (0.0016–0.0110)	0.45 (0.0177)	
Tappet					
Tappets for IN/ EX. valves	Stem O.D.	L40AE~ L100AE	6.960–6.980 (0.2740–0.2748)	6.87 (0.2705)	
	Hole dia. (Cylinder block)	L40AE~ L100AE	7.000–7.015 (0.2756–0.2762)	7.06 (0.2780)	
	Oil clearance	L40AE~ L100AE	0.020–0.055 (0.0008–0.0022)	—	
Tappets for fuel injection pump	O.D.	L40AE~ L100AE	23.972–23.993 (0.9438–0.9446)	23.89 (0.9405)	
	Hole dia. (Cylinder block)	L40AE~ L100AE	24.000–24.033 (0.9449–0.9462)	24.06 (0.9472)	
	Oil clearance	L40AE~ L100AE	0.007–0.061 (0.0003–0.0024)	—	

Unit: mm (in.)

Parts		Model	Standard	Service limit	Remarks
Crankcase cover					
Crankshaft bearing part	I.D.	L40AE, L48AE	34.000–34.025 (1.3386–1.3396)	—	
		L60AE, L70AE	39.000–39.025 (1.5354–1.5364)	—	
		L75AE~ L100AE	44.000–44.025 (1.7323–1.7333)	—	
	Bearing O.D (Plain)	L40AE, L48AE	34.070–34.105 (1.3413–1.3427)	—	
		L60AE, L70AE	39.070–39.105 (1.5382–1.5396)	—	
		L75AE L100AE	44.085–44.120 (1.7356–1.7370)	—	
	Fitting	L40AE~ L70AE	0.045–0.105 (0.0018–0.0041)	—	Tight fit
		L75AE~ L100AE	0.060–0.120 (0.0024–0.0047)	—	
	Bearing metal I.D. (Plain metal)	L40AE, L48AE	30 (1.1811)	30.13 (1.1862)	
		L60AE, L70AE	35 (1.3780)	35.13 (1.3831)	
		L75AE~ L100AE	40 (1.5748)	40.13 (1.5800)	
Camshaft bearing part	I.D.	L40AE~ L48AE	51.945–51.965 (2.0451–2.0455)	—	
		L60AE, L70AE	61.940–61.960 (2.4386–2.4394)	—	
		L75AE~ L100AE	71.935–71.955 (2.8321–2.8329)	—	
	Ball bearing O.D.	L40AE, L48AE	51.987–52.000 (2.0467–2.0472)	—	Tight fit
		L60AE~ L70AE	61.987–62.000 (2.4404–2.4409)	—	
		L75AE~ L100AE	71.987–72.000 (2.8341–2.8346)	—	
	Fitting	L40AE, L48AE	0.022–0.055 (0.0009–0.0022)	—	
		L60AE, L70AE	0.027–0.060 (0.0011–0.0024)	—	
		L75AE~ L100AE	0.032–0.065 (0.0013–0.0026)	—	

Unit: mm (in.)

Parts		Model	Standard	Service limit	Remarks
Cylinder block					
Crankshaft bearing part	I.D.	L40AE, L48AE	71.9905–72.0095 (2.8343–2.8350)	—	
		L60AE, L70AE	79.980–79.996 (3.1488–3.1494)	—	
		L75AE~ L100AE	89.984–90.000 (3.5427–3.5433)	—	
	Ball bearing O.D.	L40AE, L48AE	71.987–72.000 (2.8341–2.8346)	—	
		L60AE, L70AE	79.987–80.000 (3.1491–3.1496)	—	
		L75AE~ L100AE	89.985–90.000 (3.5427–3.5433)	—	
	Fitting	L40AE, L48AE	0.0225–0.0095 (0.00089–0.00037)	—	
		L60AE, L70AE	0.009–0.020 (0.00035–0.00079)	—	
		L75AE, L100AE	0.015–0.016 (0.00059–0.00063)	—	
Camshaft bearing part	I.D.	L40AE, L100AE	20.957–20.978 (0.8251–0.8259)	—	
Cylinder sleeve I.D.		L40AE	68.000–68.030 (2.6771–2.6783)	68.16 (2.6835)	
		L48AE	70.000–70.030 (2.7559–2.7571)	70.16 (2.7622)	
		L60AE	75.000–75.030 (2.9528–2.9539)	75.18 (2.9598)	
		L70AE	78.000–78.030 (3.0709–3.0720)	78.18 (3.0779)	
		L75AE	80.000–80.030 (3.1496–3.1509)	80.18 (3.1567)	
		L90AE	84.000–84.030 (3.3071–3.3083)	84.18 (3.3142)	
		L100AE	86.000–86.030 (3.3858–3.3870)	86.18 (3.3929)	

Unit: mm (in.)

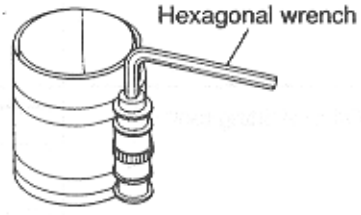
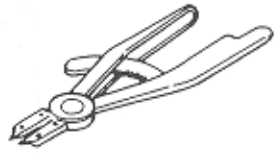
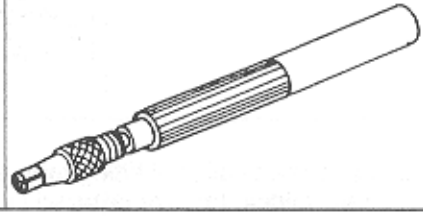
Parts		Model	Standard	Service limit	Remarks
Oil pump (Trochoid pump)					
Outer	Outer rotor O.D.	L40AE~ L100AE	28.96–28.98 (1.1402–1.1409)	28.90 (1.1378)	
	Housing I.D. (Crankcase over)	L40AE~ L100AE	29.100–29.121 (1.1457–1.1465)	29.18 (1.1488)	
	Clearance between housing ID and outer rotor O.D.	L40AE~ L100AE	0.120–0.161 (0.0047–0.0063)	—	
Width	Outer and Inner rotor width	L40AE~ L100AE	7.97–8.00 (0.3138–0.3150)	7.90 (0.3110)	
	Housing depth	L40AE~ L100AE	8.02–8.05 (0.3157–0.3169)	8.10 (0.3189)	
	Clearance between housing and inner/outer rotors	L40AE~ L100AE	0.02–0.08 (0.0008–0.0031)	—	
Clearance between the inner and outer rotor		L40AE~ L100AE	<0.14 (0.0055)	0.25 (0.0098)	
Cylinder compression pressure at 3000 rpm engine speed (turn the starter motor)		L40AE~ L100AE	2942 kPa (30 kgf/cm²) [427 psi]	2452 kPa (25 kgf/cm²) [356 psi]	
Cylinder compression pressure at 500 rpm engine speed (pull the recoil starter)		L40AE~ L100AE	2452 kPa (25 kgf/cm²) [356 psi]	1961 kPa (20 kgf/cm²) [284 psi]	

3. Disassembly and Reaseembly

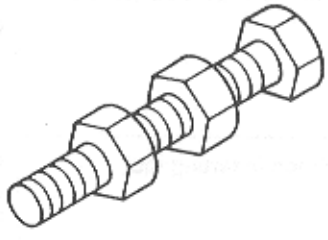
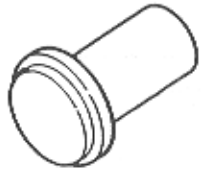
3.1 TOOLS, METERS AND INSTRUMENTS

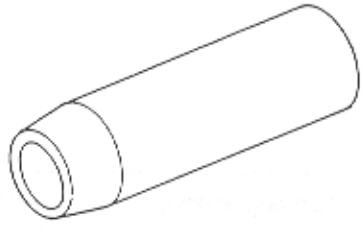
Keep the following tools, jigs, and other service items on hand to ensure accurate measurement and diagnosis and efficient servicing.

1. Tools

Name of tool	Description (YANMAR Code No.)	Illustration
YANMAR service tool set	Type A (including 65 tools) (955000-00001) Type B (including 46 tools) (955000-00002)	
Piston inserting tool	Commercially available (955500-02476) For ϕ 60 – 125	
Bore Pliers	(28190-000130) (included in YANMAR service tool set)	
Shaft pliers	(28190-000020) (included in YANMAR service tool set)	
Piston ring remover	(135410-92140)	
Cleaning needle for fuel injection valve	Wire (use ϕ 0.19) Commercially available	———
	Pinvise Commercially available (28210-000010)	

<table>
<tr><th>Name of tool</th><th>Description (YANMAR Code No.)</th><th>Illustration</th></tr>
<tr><td>Flywheel end nut wrench*</td><td>Special-purpose tool for tightening the crankshaft end nut.

(114250-92101)</td><td>  </td></tr>
<tr><td>Flywheel extractor*</td><td>(114250-92121)
<table><tr><th>Model</th><th>Bolt</th><th>pcs</th><th>Nut</th><th>pcs</th></tr><tr><td>L40AE – L70AE</td><td>26116-060454</td><td>3</td><td>26716-060002</td><td>6</td></tr><tr><td>L75AE – L100AE</td><td>"</td><td>4</td><td>"</td><td>8</td></tr></table></td><td> 
  </td></tr>
<tr><td>Oil seal fitting tool*</td><td><table><tr><th rowspan="2">Code</th><th colspan="2">Applicable part</th></tr><tr><th>Cylinder block (Crankshaft)</th><th>Sidecover (Crank & Cam shaft)</th></tr><tr><td>114250-92311</td><td>—</td><td>L40AE, L48AE</td></tr><tr><td>114350-92311</td><td>L40AE ~ L70AE</td><td>L60AE, L70AE</td></tr><tr><td>114650-92310</td><td colspan="2">L75AE ~ L100AE</td></tr></table></td><td>  </td></tr>
<tr><td>Oil seal fitting guide*</td><td>After insertion of seal into crankcase cover, use this tool to install crankcase cover on cylinder block.

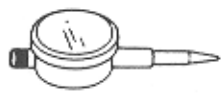
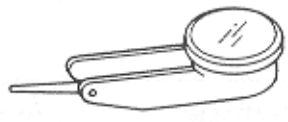
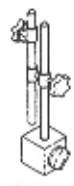
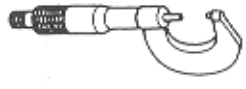
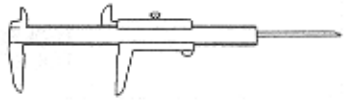
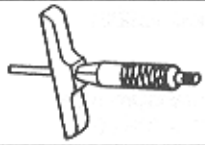
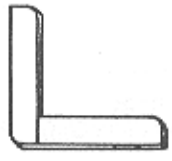
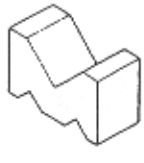
Jig for inserting crankshaft and camshaft oil seals
<table><tr><th>Code</th><th>Applicable Model</th></tr><tr><td>114250-92301</td><td>L40AE-S, L48AE-S, L40AE-D, L48AE-D</td></tr><tr><td>114268-92300</td><td>L40AE-DE, L48AE-DE</td></tr><tr><td>114350-92301</td><td>L60AE-S, L70AE-S, L60AE-D, L70AE-D</td></tr><tr><td>114368-92300</td><td>L60AE-DE, L70AE-DE</td></tr><tr><td>114650-92300</td><td>L75AE-S, L90AE-S, L100AE-S</td></tr><tr><td>114668-92300</td><td>L75AE-DE, L90AE-DE, L100AE-DE</td></tr></table></td><td>  </td></tr>
<tr><td>Valve stem seal fitting tool*</td><td><table><tr><th>Model</th><th>Code</th></tr><tr><td>L40AE, L48AE</td><td>114250-92350</td></tr><tr><td>L60AE, L70AE</td><td>114350-92350</td></tr><tr><td>L75AE–100AE</td><td>114650-92350</td></tr></table></td><td>  </td></tr>
</table>

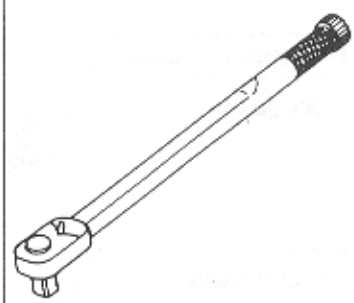
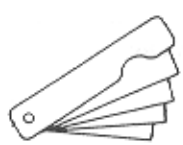
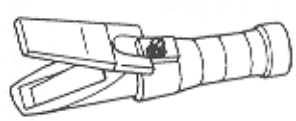
*Dimensions of oil seal fitting tool, oil seal fitting guide, flywheel tightening handle, flywheel extractor and valve stem seal fitting tool are detailed in Appendix 2.

2. Meters, Instruments, and Service Accessories

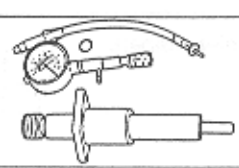
(Necessary for middle- and small-size engine service shops)

– Typical sizes –

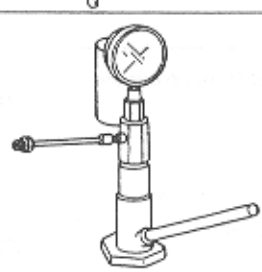
Instrument Name	Description	Illustration
Dial gauge	mm (in.) 1 div.: 0.01 (0.0004) Range: 0–5 (0–0.197); 0–10 (0–0.394) To measure bending and gap of the shaft, surface distortion, etc.	
Test indicator	mm (in.) 1 div.: 0.01 (0.0004) Range: 0–0.8 (0–0.031) To measure positions too narrow and too deep for normal dial indicators.	
Magnet stand	mm (in.) Main bar (dia. × length): 12 × 176 (0.472 × 6.929); 14 × 183 (0.551 × 7.205) Sub bar (dia. × length): 10 × 165 (0.394 × 6.496); 12 × 165 (0.472 × 6.496) To attach dial indicators to various positions for easy accurate viewing.	
Micrometer	Range mm (in.) 0–25 (0–0.984) 25–50 (0.984–1.969) 50–75 (1.969–2.953) 75–100 (2.953–3.937) To measure the O.D. of the crankshaft, piston, piston pin, etc.	
Cylinder gauge	Range mm (in.) 10–18 (0.394–0.709) 18–35 (0.709–1.378) 35–60 (1.378–2.362) 50–100 (1.969–3.937) To measure the I.D. of the cylinder liners and beaings.	
Vernier calipers	mm (in.) 1 div.: 0.05 (0.002) Range: 0–150 (0–5.906) To measure outside diameter, depth, thickness, width, etc.	
Depth micrometer	mm (in.) Range: 0–25 (0–0.984) To measure value sinkage and liner projection.	
Square	mm (in.) Size: 100 (3.937) To measure the inclination of valve springs and squareness of various parts.	
V-block	mm (in.) Size: 100 × 50 × 55 (3.937 × 1.9685 × 2.165 in.) Use when measuring the bending of a shaft.	

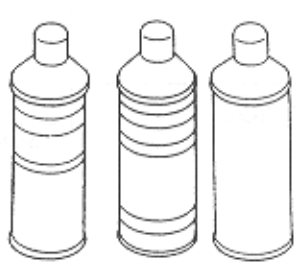
<table>
<tr><th>Instrument Name
(Yanmar code No.)</th><th>Description</th><th>Illustration</th></tr>
<tr><td>Torque wrench</td><td>
<table>
<tr><th>Size
mm (in.)</th><th>Range
kg-cm (lb-ft)</th></tr>
<tr><td>6–14
(0.236–0.551)</td><td>40–300
(2.9–21.7)
300–800
(21.7–57.8)</td></tr>
<tr><td>15 (0.591)
17 (0.669)
19 (0.748)
21 (0.827)</td><td>300–1,600
(21.7–115.7)</td></tr>
</table>
Use when tightening bolts and nuts with specified torques.
</td><td>  </td></tr>
<tr><td>Plastigage</td><td>To measure oil clearance between crankpin and main bearing.
<table>
<tr><th>Type</th><th>Applicable clearance mm (in.)</th></tr>
<tr><td>PG-1 (Green)</td><td>0.025–0.076 (0.001–0.003)</td></tr>
<tr><td>PR-1 (Red)</td><td>0.051–0.152 (0.002–0.006)</td></tr>
<tr><td>PB-1 (Gray)</td><td>0.102–0.229 (0.004–0.009)</td></tr>
</table>
</td><td>Plastigage
 
Measuring scale</td></tr>
<tr><td>Thickness gauge</td><td>To measure clearances between piston rings and piston grooves or between shaft couplings during installation.</td><td>  </td></tr>
<tr><td>Battery electrolyte tester
(955000-00013)</td><td>To inspect antifreeze solution and electrolyte for specific gravity, and charging condition.</td><td>  </td></tr>
<tr><td>Compression gauge</td><td>L40AE – L100AE

Tool set
TOL-97190060

To measure compressive pressure in the cylinder.</td><td>  </td></tr>
<tr><td>Nozzle tester
(737600-93502)

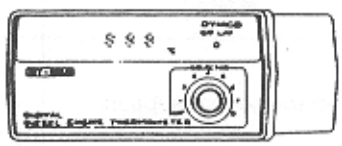
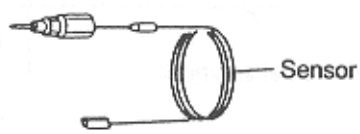
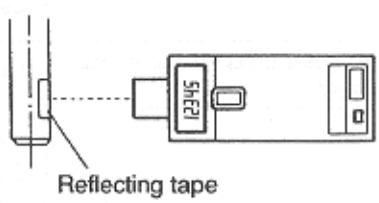
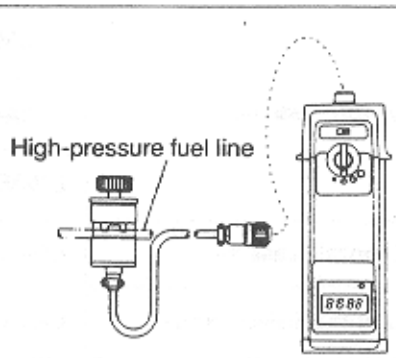
High pressure pipe
(124233–93400)</td><td>Pressure gauge: 0–500 kg/cm^2

To inspect spray condition and the injection pressure of the fuel injection valve.</td><td>  </td></tr>
<tr><td>Color check
(for flaw detection)

Set product
(6 bottles)
(975500-004560)</td><td>
<table>
<tr><td>Penetrant
(97550-00451)</td><td>450 cc (27.5 cu. in.)</td></tr>
<tr><td>Developer
(97550-004520)</td><td>450 cc (27.5 cu. in.)</td></tr>
<tr><td>Cleaning agent
(97550-004530)</td><td>450 cc (27.5 cu. in.)</td></tr>
</table>
Use in detecting flaws.
</td><td>  </td></tr>
</table>

3. Instruments

(Select the appropriate thermometer and tachometer from among the following types.)

Instrument Name (Yanmar code No.)		Description	Illustration
Thermometer	Digital type Model: BT-800 (955000-08000)	Instantaneously measures temperature in each cylinder using a select switch.	
	Sensor (955000-08640)	CA 64	
Tachometer	Photoelectric type (non-contacting) Model HT-441 (95500H-T4410)	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 
	Reflecting Tape (10 pieces) (955000-01041)		
	High-pressure fuel pipe clamping type Model: GE-450 (955000-01045)	Measures engine RPM's using pulse system.	
Circuit tester		To measure resistance, DC voltage, AC voltage, DC current, and for continuity testing.	

3.2 TIGHTENING TORQUES

Standard bolts and nuts tightening torque:
M6 70–100 kg-cm (5.1–7.2 lb-ft)
M8 180–200 kg-cm (13–14.5 lb-ft)

Where specified torque be applied	Model	Thread No. dia. × pitch	Tightening torque kg-cm (lb-ft)	Remarks
Valve rocker arm support	L40AE–L70AE	M8 × 1.25	200–230 (14.5–16.6)	Hexagonal dimension: 12
	L75AE–L100AE	M10 × 1.5	430–470 (31.1–34.0)	Hexagonal dimension: 14
Flywheel end nuts*	L40AE–L70AE	M16 × 1.5	1200–1300 (86.8–94.0)	Hexagonal dimension: 24
	L75AE–L100AE	M18 × 1.5	2200–2300 (159.1–166.3)	
Crankcase cover bolts	L40AE, L48AE	14-M6 × 1.0	100–120 (7.2–8.7)	Hexagonal dimension: 10
	L60AE–L100AE	13-M8 × 1.25	200–230 (14.5–16.7)	Hexagonal dimension: 12
Stiffener bolts on crankcase cover	L40AE–L100AE	M8 × 1.25	200–230 (14.5–16.6)	
Head stud bolts (stud side)•	L40AE, L48AE	4-M8 × 1.25	130–150 (9.4–10.8)	Apply "screw locking agent"
	L60AE, L70AE	4-M9 × 1.25	130–150 (9.4–10.8)	
	L75AE–L100AE	4-M10 × 1.5	130–150 (9.4–10.8)	
Cylinder head nuts*	L40AE, L48AE	4-M8 × 1.25	280–320 (20.3–23.1)	Apply oil to the face of the threaded part. Hexagonal dimension: 12
	L60AE, L70AE	4-M9 × 1.25	420–460 (30.4–33.3)	Hexagonal dimension: 14
	L75AE–L100AE	4-M10 × 1.5	540–580 (39.0–42.0)	Hexagonal dimension: 17
FO nozzle case nut	L40AE–L100AE	1-0.605-40UNS-2B	400–450 (28.9–32.5)	Hexagonal dimension: 15
FO pump delivery holder	L40AE–L100AE	M14 × 1.5	300–350 (21.7–25.3)	Hexagonal dimension: 17
FO pump stud bolts (stud side)•	L40AE–L100AE	3-M6 × 1.0	70–100 (5.1–7.2)	Apply "screw locking agent"
FO pump nuts	L40AE–L100AE	3-M6 × 1.0	100–120 (7.2–8.7)	Hexagonal dimension: 10
FO nozzle bolts (stud side)•	L40AE–L100AE	2-M6 × 1.0	70–100 (5.1–7.2)	Apply "screw locking agent"
FO injection nozzle nuts	L40AE–L100AE	2-M6 × 1.0	100–120 (7.2–8.7)	Hexagonal dimension: 10
Connecting rod bolts & nuts*	L40AE–L70AE	2-M7 × 1.0	180–210 (13–15.2)	Apply oil to the face of the threaded part. Hexagonal dimension: 10
	L75AE –L100AE	2-M8 × 1.0	375–425 (27.1–30.7)	Hexagonal dimension: 13

Notes:

1. *For bolts and nuts marked *, apply engine oil to the thread and seat.*
2. *For bolts and nuts marked •, apply screw locking agent to the thread before threading them.*

3.3 MAINTENANCE SCHEDULE

Periodical maintenance is the key to a smooth-running, long-lasting engine. The table below shows when checks should be carried out.

○ Check, Add ● Replace

Item \ Operating hours	Every day	Every 20 – 50 hrs	Every 100 hrs	Every 200 hrs	Every 500 hrs	Every 1000 hrs
Check and retighten all bolts and nuts	○				(Head bolt retightening) ○	
Check and add engine oil	○					
Change engine oil		(1st) ●	(2nd and subsequent) ●			
Check and add fuel oil	○					
Clean and replace oil filter						Replace as requierd. ●
Air cleaner element (Type) Paper	(In dusty conditions, the element should be replaced more frequently). ● every 500 hours					
Air cleaner element (Type) Oil bath					●	
Clean fuel filter					○	(replace-ment) ●
Check for oil leakage (engine oil, fuel oil)	○					
Check injection nozzle					○	
Check injection pump					○	
Adjust valve clearance of intake and exhaust valves		(1st) ○			○	
Inspection and refacing of intake and exhaust valve seats						○
Replace piston ring						●
Check the surfaces of brush and slip ring					○	(for YDG generator)
Check battery electrolyte level	Check the battery once a month and add electrolyte if necessary.					
Drain fuel from F.O. tank	Monthly					
Check fuel piping					(Replace if necessary) ○	
Clean spark arrester (option)			○			

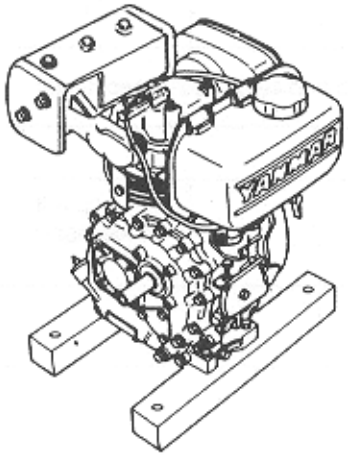
3.4 DISASSEMBLY PROCEDURES

Basic procedures

- Gather the required tools, jigs and meters.
- Have a notebook, etc. ready for recording service information.
- Fill containers with cleaning solution for cleaning parts.
- Prepare a special place for parts and containers.
- Drain old lubricating oil from engine.
- Arrange disassembled parts.
- Keep all bolts and nuts with their relative parts to make sure they are not reassembled incorrectly.
- Determine exactly what the problem is before disassembly. Never remove unnecessary parts.

1. Fuel tank

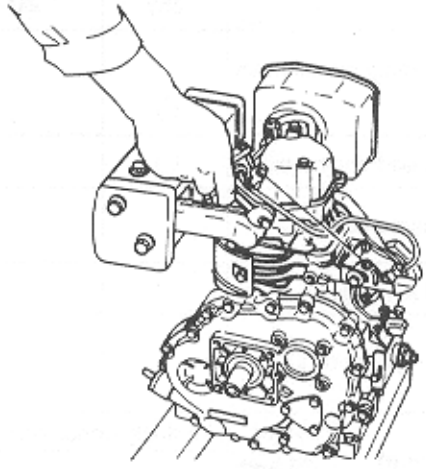
1) Pull the overflow pipe out toward the tank.
2) Release the hose clamp on the pump side of the fuel pipe.
3) Remove the fuel tank stay (upper part).
4) Remove the fuel tank. (Pull the oil pipe on the pump side up and out.)
   - Release the hose clamp on the pump side.



Removing the fuel tank

2. Exhaust silencer

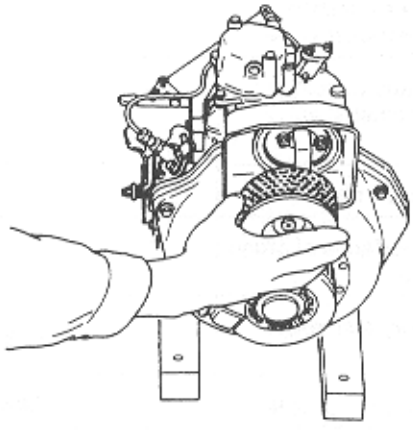
1) Remove the flange nuts.
2) Remove the stay bolt.



Removing the exhaust silencer

3. Air clearner

1) Remove the air cleaner cover.
2) Pull out the filter element.
3) Remove the cleaner case.



Removing the air cleaner

4. Recoil starter

The recoil starter does not have to be removed every time. Remove only when necessary.

5. Cooling fan case

Remove the cooling fan case.