

KUBOTA ENGINES APPLICATION MANUAL

Fifth Edition

September, 2009

KUBOTA

PREFACE

1. This has been prepared so as to enable users to properly and efficiently utilize KUBOTA diesel engines.
2. This manual describes the features of the engines, the cautions and the check items for mounting the engines on various machines.
3. This manual is the revised version of "Application Manual" issued in November, 2005.
The following matters are included.
 - 1) Engine models are added or deleted by adjusting to the current models.
 - 2) Updates to the contents are intended based on various technical experiences.
 - 3) Various regulations and related matters, such as emission regulations, are included.
 - 4) The unit is replaced with SI units.
4. The contents of this manual are roughly divided into the following two items.
 - 1) General information
 - 2) Technical information
5. The specifications and features described in this manual are subject to change without advance notice for technical improvement.
6. If you have any question about this manual, please contact with nearest KUBOTA sales representatives or send e-mail to "k-iss@kubota.co.jp".

GENERAL INFORMATION (Diesel Engine)

0. GENERAL

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1. SPECIFICATIONS

Model		Z482	Z602	
Item				
Type		Vertical, water cooled 4-cycle diesel		
Number of Cylinders		2		
Bore × Stroke	mm (in.)	67.0 × 68.0 (2.64 × 2.68)	72.0 × 73.6 (2.83 × 2.90)	
Displacement	cm ³ (cu.in.)	479 (29.23)	599 (36.55)	
SAE J1995 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	9.9 (13.3/13.5) / 3600	10.8 (14.5/14.7) / 3200	12.5 (16.8/17.0) / 3600
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	9.3 (12.5/12.7) / 3600	10.3 (13.8/14.0) / 3200	11.6 (15.5/15.8) / 3600
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	8.1 (10.9/11.0) / 3600	8.8 (11.8/12.0) / 3200	10.1 (13.5/13.7) / 3600
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	9.9 (13.3/13.5) / 3600	10.8 (14.5/14.7) / 3200	12.5 (16.8/17.0) / 3600
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	9.3 (12.5/12.7) / 3600	10.3 (13.8/14.0) / 3200	11.6 (15.5/15.8) / 3600
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	8.1 (10.9/11.0) / 3600	8.8 (11.8/12.0) / 3200	10.1 (13.5/13.7) / 3600
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	9.3 (12.5/12.7) / 3600	10.3 (13.8/14.0) / 3200	11.6 (15.5/15.8) / 3600
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	8.1 (10.9/11.0) / 3600	8.8 (11.8/12.0) / 3200	10.1 (13.5/13.7) / 3600
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	29.7 (21.9) / 2600	38.0 (28.0) / 2400	37.8 (27.9) / 2600
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	28.6 (21.1) / 2600	36.6 (27.0) / 2400	36.3 (26.8) / 2600
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	3820	3470	3870
No Load Low Idling Speed	min ⁻¹ (rpm)	950		
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)		
Fuel Injection Pump Type		PFR		
Nozzle Type		Throttle Type		
Injection Timing (p : High pressure overflow method)		T.D.C-21° (T.D.C-22° p)	T.D.C-18° (T.D.C-19° p)	T.D.C-20° (T.D.C-21° p)
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)		
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)		
Compression Ratio		23.5	24.0	
Governor Type		Centrifugal ball mechanical type governor		
Cooling System		Radiator cooling		
Recommended Coolant Capacity	lit (USgal)	2.8 (0.74)		
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)		
Lubricating Oil Capacity	lit (USgal)	2.5 (0.66) [Std. oil pan]		
Starting System		Electric starter		
Starter Capacity	V-kW	12-0.8	12-0.95	
Alternator Capacity	V-A	12-14	12-40	
Direction of Revolution		Counter-clockwise (viewed from flywheel side)		
Dry Weight	kg (lbs)	53.1 (117.1)	57 (120.0)	

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		D722	D902	
Type		Vertical, water cooled 4-cycle diesel		
Number of Cylinders		3		
Bore × Stroke	mm (in.)	67.0 × 68.0 (2.64 × 2.68)	72.0 × 73.6 (2.83 × 2.90)	
Displacement	cm ³ (cu.in.)	719 (43.88)	898 (54.80)	
SAE J1995 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	14.9 (20.0/20.3) / 3600	16.1 (21.6/21.9) / 3200	18.5 (24.8/25.2) / 3600
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	14.0 (18.8/19.1) / 3600	15.4 (20.6/20.9) / 3200	17.5 (23.5/23.8) / 3600
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	12.2 (16.3/16.6) / 3600	13.4 (17.7/18.2) / 3200	15.2 (20.4/20.7) / 3600
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	14.9 (20.0/20.3) / 3600	16.1 (21.6/21.9) / 3200	18.5 (24.8/25.2) / 3600
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	14.0 (18.8/19.1) / 3600	15.4 (20.6/20.9) / 3200	17.5 (23.5/23.8) / 3600
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	12.2 (16.3/16.6) / 3600	13.4 (17.7/18.2) / 3200	15.2 (20.4/20.7) / 3600
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	14.0 (18.8/19.1) / 3600	15.4 (20.6/20.9) / 3200	17.5 (23.5/23.8) / 3600
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	12.2 (16.3/16.6) / 3600	13.4 (17.7/18.2) / 3200	15.2 (20.4/20.7) / 3600
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	45.8 (33.8) / 2600	56.1 (41.4) / 2600	56.1 (41.4) / 2400
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	44.1 (32.5) / 2600	54.3 (40.0) / 2600	54.4 (40.1) / 2400
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	3820	3470	3870
No Load Low Idling Speed	min ⁻¹ (rpm)	950		
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)		
Fuel Injection Pump Type		PFR		
Nozzle Type		Throttle Type		
Injection Timing (p : High pressure overflow method)		T.D.C-21° (T.D.C-22° p)	T.D.C-18° (T.D.C-19° p)	T.D.C-20° (T.D.C-21° p)
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)		
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)		
Compression Ratio		23.5	24.0	
Governor Type		Centrifugal ball mechanical type governor		
Cooling System		Radiator cooling		
Recommended Coolant Capacity	lit (USgal)	3.1 (0.82)		
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)		
Lubricating Oil Capacity	lit (USgal)	3.8 (1.00) [Std. oil pan]	3.7 (0.98) [Std. oil pan]	
Starting System		Electric starter		
Starter Capacity	V-kW	12-1.0	12-1.2	12-1.2
Alternator Capacity	V-A	12-12.5	12-40	12-40
Direction of Revolution		Counter-clockwise (viewed from flywheel side)		
Dry Weight	kg (lbs)	63.0 (139.1)	72.0 (158.8)	

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		D1005	
Item			
Type		Vertical, water cooled 4-cycle diesel	
Number of Cylinders		3	
Bore × Stroke	mm (in.)	76.0 × 73.6 (2.99 × 2.90)	
Displacement	cm ³ (cu.in.)	1001 (61.08)	
SAE J1349 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	17.5 (23.5/23.8) / 3000	18.5 (24.8/25.2) / 3600
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	16.8 (22.6/22.9) / 3000	17.5 (23.5/23.8) / 3600
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	14.6 (19.6/19.9) / 3000	15.2 (20.4/20.7) / 3600
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	17.5 (23.5/23.8) / 3000	18.5 (24.8/25.2) / 3600
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	16.8 (22.6/22.9) / 3000	17.5 (23.5/23.8) / 3600
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	14.6 (19.6/19.9) / 3000	15.2 (20.4/20.7) / 3600
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	16.8 (22.6/22.9) / 3000	17.5 (23.5/23.8) / 3600
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	14.6 (19.6/19.9) / 3000	15.2 (20.4/20.7) / 3600
Maximum Torque (Gross)	N·m (lbf·ft) / min ⁻¹ (rpm)	62.8 (46.3) / 2200	54.7 (40.3) / 2600
Maximum Torque (Overload)	N·m (lbf·ft) / min ⁻¹ (rpm)	61.2 (45.1) / 2200	52.9 (39.0) / 2600
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	3220	3820
No Load Low Idling Speed	min ⁻¹ (rpm)	900	
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Nozzle Type		Throttle Type	
Injection Timing (p : High pressure overflow method)		T.D.C-18° (T.D.C-19° p)	T.D.C-21° (T.D.C-22° p)
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)	
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)	
Compression Ratio		24.0	
Governor Type		Centrifugal flyweight mechanical type governor	
Cooling System		Radiator cooling	
Recommended Coolant Capacity	lit (USgal)	3.1 (0.82)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	lit (USgal)	5.1 (1.35) [Std. oil pan]	
Starting System		Electric starter	
Starter Capacity	V-kW	12-1.2 [KEA Std Spec.], 12-1.4 [EU Std Spec.]	
Alternator Capacity	V-A	12-40	
Direction of Revolution		Counter-clockwise (viewed from flywheel side)	
Dry Weight	kg (lbs)	93.0 (205.0)	

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		D1105	D1305
Item			
Type		Vertical, water cooled 4-cycle diesel	
Number of Cylinders		3	
Bore × Stroke	mm (in.)	78.0 × 78.4 (3.07 × 3.09)	78.0 × 88.0 (3.07 × 3.46)
Displacement	cm ³ (cu.in.)	1123 (68.53)	1261 (76.95)
SAE J1349 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	18.5 (24.8/25.2) / 3000	21.7 (29.1/29.5) / 3000
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	17.8 (23.9/24.2) / 3000	21.0 (28.1/28.5) / 3000
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	15.5 (20.7/21.2) / 3000	18.2 (24.4/24.8) / 3000
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	18.5 (24.8/25.2) / 3000	21.7 (29.1/29.5) / 3000
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	17.8 (23.9/24.2) / 3000	21.0 (28.1/28.5) / 3000
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	15.5 (20.7/21.0) / 3000	18.2 (24.4/24.8) / 3000
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	17.8 (23.9/24.2) / 3000	21.0 (28.0/28.5) / 3000
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	15.5 (20.8/21.0) / 3000	18.2 (24.2/24.8) / 3000
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	71.5 (52.7) / 2200	80.1 (59.1) / 2000
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	69.7 (51.4) / 2200	78.3 (57.8) / 2000
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	3220	3220
No Load Low Idling Speed	min ⁻¹ (rpm)	900	900
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Nozzle Type		Throttle Type	
Injection Timing (p : High pressure overflow method)		T.D.C-18° (T.D.C-19° p)	
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)	
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)	
Compression Ratio		24.0	
Governor Type		Centrifugal flyweight mechanical type governor	
Cooling System		Radiator cooling	
Recommended Coolant Capacity	lit (USgal)	3.1 (0.82)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	lit (USgal)	5.1 (1.35) [Std. oil pan]	5.7 (1.51) [Std. oil pan]
Starting System		Electric starter	
Starter Capacity	V-kW	12-1.2 [KEA Std Spec.], 12-1.4 [EU Std Spec.]	
Alternator Capacity	V-A	12-40	
Direction of Revolution		Counter-clockwise (viewed from flywheel side)	
Dry Weight	kg (lbs)	93.0 (205.0)	95.0 (209.0)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		D1105-T (Turbo)
Item		
Type		Vertical, water cooled 4-cycle diesel
Number of Cylinders		3
Bore × Stroke	mm (in.)	78.0 × 78.4 (3.07 × 3.09)
Displacement	cm ³ (cu.in.)	1123 (68.53)
SAE J1349 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	24.5 (32.8/33.3) / 3000
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	23.5 (32.5/31.9) / 3000
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	20.4 (27.4/27.7) / 3000
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	24.5 (32.8/33.3) / 3000
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	23.5 (31.5/31.9) / 3000
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	20.4 (27.4/27.7) / 3000
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	23.5 (31.5/31.9) / 3000
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	20.4 (27.4/27.7) / 3000
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	88.1 (65.0) / 2000
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	85.9 (63.4) / 2000
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	3220
No Load Low Idling Speed	min ⁻¹ (rpm)	1050
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)
Fuel Injection Pump Type		PFR
Nozzle Type		Throttle Type
Injection Timing (p : High pressure overflow method)		T.D.C-17° (T.D.C-18° p)
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)
Compression Ratio		23.0
Governor Type		Centrifugal flyweight mechanical type governor
Cooling System		Radiator cooling
Recommended Coolant Capacity	lit (USgal)	3.1 (0.82)
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)
Lubricating Oil Capacity	lit (USgal)	5.1 (1.35) [Std. oil pan]
Starting System		Electric starter
Starter Capacity	V-kW	12-1.2 [KEA Std Spec.], 12-1.4 [EU Std Spec.]
Alternator Capacity	V-A	12-40
Direction of Revolution		Counter-clockwise (viewed from flywheel side)
Dry Weight	kg (lbs)	97.0 (213.8)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V1505	V1505-T (Turbo)
Type		Vertical, water cooled 4-cycle diesel	
Number of Cylinders		4	
Bore × Stroke	mm (in.)	78.0 × 78.4 (3.07 × 3.09)	
Displacement	cm ³ (cu.in.)	1498 (91.41)	
SAE J1995 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	26.5 (35.5/36.0) / 3000	33.0 (44.2/44.9) / 3000
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	25.0 (33.5/34.0) / 3000	31.3 (42.0/42.6) / 3000
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	21.7 (29.1/29.5) / 3000	27.2 (36.4/37.0) / 3000
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	26.5 (35.5/36.0) / 3000	33.0 (44.2/44.9) / 3000
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	25.0 (33.5/34.0) / 3000	31.3 (42.0/42.6) / 3000
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	21.7 (29.1/29.5) / 3000	27.2 (36.4/37.0) / 3000
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	25.0 (33.5/34.0) / 3000	31.3 (42.0/42.6) / 3000
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	21.7 (29.1/29.5) / 3000	27.2 (36.4/37.0) / 3000
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	91.6 (67.6) / 2200	118.6 (87.5) / 2000
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	90.6 (66.8) / 2200	115.1 (84.9) / 2000
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	3220	
No Load Low Idling Speed	min ⁻¹ (rpm)	900	1050
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Nozzle Type		Throttle Type	
Injection Timing (p : High pressure overflow method)		T.D.C-17° (T.D.C-18° p)	
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)	
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)	
Compression Ratio		23.0	
Governor Type		Centrifugal flyweight mechanical type governor	
Cooling System		Radiator cooling	
Recommended Coolant Capacity	lit (USgal)	4.0 (1.07)	5.0 (1.32)
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	lit (USgal)	6.0 (1.59) [Std. oil pan]	6.7 (1.77) [Std. oil pan]
Starting System		Electric starter	
Starter Capacity	V-kW	12-1.2 [KEA Std Spec.], 12-1.4 [EU Std Spec.]	
Alternator Capacity	V-A	12-40	
Direction of Revolution		Counter-clockwise (viewed from flywheel side)	
Dry Weight	kg (lbs)	110.0 (242.5)	114.0 (251.3)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		D1005-BG	D1105-BG	D1305-BG	V1505-BG
Number of Cylinders		3			4
Type		Vertical, Water-cooled, 4 cycle diesel engine			
Bore × Stroke	mm (in.)	76.0 × 73.6 (2.99 × 2.90)	78.0 × 78.4 (3.07 × 3.09)	78.0 × 88.0 (3.07 × 3.46)	78.0 × 78.4 (3.07 × 3.09)
Total Displacement	cm ³ (cu.in.)	1001 (61.08)	1123 (68.53)	1261 (76.95)	1498 (91.41)
STANDBY					
ISO 3046	kW/min ⁻¹ (rpm)	9.8 / 1800	11.5 / 1800	13.1 / 1800	15.1 / 1800
SAE J-1349	HP/min ⁻¹ (rpm)	13.1 / 1800	15.4 / 1800	17.6 / 1800	20.2 / 1800
NET Continuous					
ISO 3046	kW/min ⁻¹ (rpm)	8.7 / 1800	10.1 / 1800	11.6 / 1800	13.4 / 1800
SAE J-1349	HP/min ⁻¹ (rpm)	11.7 / 1800	13.5 / 1800	15.6 / 1800	18.0 / 1800
Governor Regulation		Less than 5 %			
Combustion Chamber Type		Spherical type (E-T.V.C.S. : Three Vortex Combustion System)			
Fuel Injection Pump Type		PFR			
Governor		All speed mechanical governor			
Direction of Rotation		Counter-clockwise (viewed from flywheel side)			
Nozzle Type		Throttle Type			
Injection Timing		0.2705 rad (15.50 °) before T.D.C.		0.2618 rad (15.00 °) before T.D.C.	
Firing Order		1-2-3			1-3-4-2
Injection Pressure		13.73 MPa (140.0 kgf/cm ² , 1991 psi)			
Compression Ratio		24 : 1			
Lubricating System		Forced lubrication by trochoid pump			
Oil Pressure Indication		Electrical type switch			
Lubricating Filter		Full flow paper filter (Cartridge type)			
Cooling System		Pressurized radiator, forced circulation with water pump			
Starting System		Electric Starting with Starter			
Starting Motor		12 V, 1.0 kW			12 V, 1.2 kW
Starting Support Device		By glow plug in combustion chamber			
EGR		NONE			
Battery		12 V, 65 AH, equivalent		12 V, 75 AH, equivalent	
Charging Alternator		12 V, 360 W			
Fuel		Diesel Fuel No. 2-D (ASTM D975)			
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)			
Lubricating Oil Capacity		5.1 L (1.3 U.S.gals)		5.7 L (1.5 U.S.gals)	6.7 L (1.8 U.S.gals)
Weight (Dry)	kg (lbs)	110 (242)		112 (247)	127 (280)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		D1503-M	D1703-M	D1803-M
Item				
Type		Vertical, water cooled 4-cycle diesel		
Number of Cylinders		3		
Bore × Stroke	mm (in.)	83.0 × 92.4 (3.27 × 3.64)	87.0 × 92.4 (3.43 × 3.64)	87.0 × 102.4 (3.43 × 4.03)
Displacement	cm ³ (cu.in.)	1499 (91.47)	1647 (100.51)	1826 (111.43)
SAE J1349 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	23.8 (31.9/32.4) / 2800	26.1 (35.0/35.5) / 2800	27.9 (37.4/37.9) / 2700
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	21.7 (29.1/29.5) / 2800	24.3 (32.6/33.1) / 2800	26.5 (35.5/36.0) / 2700
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	18.9 (25.3/25.7) / 2800	21.1 (28.3/28.7) / 2800	23.0 (30.9/31.3) / 2700
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	23.8 (31.9/32.4) / 2800	26.1 (35.0/35.5) / 2800	27.9 (37.4/37.9) / 2700
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	21.7 (29.1/29.5) / 2800	24.3 (32.6/33.1) / 2800	26.5 (35.5/36.0) / 2700
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	18.9 (25.3/25.7) / 2800	21.1 (28.3/28.7) / 2800	23.0 (30.9/31.3) / 2700
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	21.7 (29.1/29.5) / 2800	24.3 (32.6/33.1) / 2800	26.5 (35.5/36.0) / 2700
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	18.9 (25.3/25.7) / 2800	21.1 (28.3/28.7) / 2800	23.0 (30.8/31.3) / 2700
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	94.9 (70.0) / 1600	104.3 (76.93) / 1600	115.6 (85.26) / 1600
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	91.6 (67.6) / 1600	101.3 (74.72) / 1600	112.7 (83.12) / 1600
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	3020		2920
No Load Low Idling Speed	min ⁻¹ (rpm)	800		
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)		
Fuel Injection Pump Type		PFR		
Nozzle Type		Throttle Type		
Injection Timing (p : High pressure overflow method)		T.D.C-18° (T.D.C-19° p)	T.D.C-16.25° (T.D.C-17.25° p)	
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)		
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)		
Compression Ratio		23.0	22.0	24.3
Governor Type		Centrifugal ball mechanical type governor		
Cooling System		Radiator cooling		
Recommended Coolant Capacity	lit (USgal)	5.5 (1.45)		5.8 (1.53)
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)		
Lubricating Oil Capacity	lit (USgal)	5.6 (1.48) [KEA std. oil pan] 7.0 (1.85) [EU std. oil pan]		7.0 (1.85) [Std. oil pan]
Starting System		Electric starter		
Starter Capacity	V-kW	12-1.4		12-2.0
Alternator Capacity	V-A	12-40		
Direction of Revolution		Counter-clockwise (viewed from flywheel side)		
Dry Weight	kg (lbs)	148.0 (326.3)		151.0 (332.9)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V2003-M	V2203-M
Item			
Type		Vertical, water cooled 4-cycle diesel	
Number of Cylinders		4	
Bore × Stroke	mm (in.)	83.0 × 92.4 (3.27 × 3.64)	87.0 × 92.4 (3.43 × 3.64)
Displacement	cm ³ (cu.in.)	1999 (121.99)	2197 (134.07)
SAE J1349 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	32.6 (43.7/44.3) / 2800	35.9 (48.1/48.8) / 2800
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	29.8 (39.9/40.5) / 2800	33.0 (44.3/44.9) / 2800
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	25.9 (34.7/35.2) / 2800	28.7 (38.5/39.0) / 2800
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	32.6 (43.7/44.3) / 2800	35.9 (48.1/48.8) / 2800
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	29.8 (39.9/40.5) / 2800	33.0 (44.3/44.9) / 2800
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	25.9 (34.7/35.2) / 2800	28.7 (38.5/39.0) / 2800
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	29.8 (40.0/40.5) / 2800	33.0 (44.0/44.9) / 2800
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	25.9 (34.7/35.2) / 2800	28.7 (38.5/39.0) / 2800
Maximum Torque (Gross)	N·m (lbf·ft) / min ⁻¹ (rpm)	130.3 (96.10) / 1600	143.2 (105.6) / 1600
Maximum Torque (Overload)	N·m (lbf·ft) / min ⁻¹ (rpm)	125.8 (92.79) / 1600	138.5 (102.2) / 1600
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	3020	
No Load Low Idling Speed	min ⁻¹ (rpm)	800	
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Nozzle Type		Throttle Type	
Injection Timing (p : High pressure overflow method)		T.D.C-16.25° (T.D.C-17.25° p)	
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)	
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)	
Compression Ratio		22.8	22.0
Governor Type		Centrifugal ball mechanical type governor	
Cooling System		Radiator cooling	
Recommended Coolant Capacity	lit (USgal)	8.1 (2.14)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	lit (USgal)	7.6 (2.01) [KEA std. oil pan] 9.5 (2.51) [EU std. oil pan]	
Starting System		Electric starter	
Starter Capacity	V-kW	12-1.4	
Alternator Capacity	V-A	12-40	
Direction of Revolution		Counter-clockwise (viewed from flywheel side)	
Dry Weight	kg (lbs)	180.0 (396.8)	220 (485.0)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V2403-M	V2403-M-T
Type		Vertical, water cooled 4-cycle diesel	
Number of Cylinders		4	
Bore × Stroke	mm (in.)	87.0 × 102.4 (3.43 × 4.03)	
Displacement	cm ³ (cu.in.)	2434 (148.53)	
SAE J1349 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	36.5 (48.9/49.6) / 2700	44.0 (59.0/59.8) / 2700
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	33.9 (45.4/46.0) / 2700	41.3 (55.3/56.1) / 2700
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	29.4 (39.4/40.0) / 2700	35.8 (48.0/48.7) / 2700
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	36.5 (48.9/49.6) / 2700	44.0 (59.0/59.8) / 2700
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	33.9 (45.4/46.0) / 2700	41.3 (55.3/56.1) / 2700
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	29.4 (39.4/40.0) / 2700	35.8 (48.0/48.7) / 2700
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	33.9 (45.5/46.0) / 2700	41.3 (55.3/56.1) / 2700
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	29.4 (39.4/40.0) / 2700	35.8 (48.0/48.7) / 2700
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	158.6 (117.0) / 1600	165.1 (122.0) / 1800
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	153.7 (113.4) / 1600	159.4 (117.6) / 1800
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	2920	2950
No Load Low Idling Speed	min ⁻¹ (rpm)	800	900
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Nozzle Type		Throttle Type	
Injection Timing (p : High pressure overflow method)		T.D.C-16.25° (T.D.C-17.25° p)	T.D.C-8.25° (T.D.C-9.25° p)
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)	
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)	
Compression Ratio		23.2	22.5
Governor Type		Centrifugal ball mechanical type governor	
Cooling System		Radiator cooling	
Recommended Coolant Capacity	lit (USgal)	8.4 (2.22)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	lit (USgal)	9.5 (2.51) [Std. oil pan]	
Starting System		Electric starter	
Starter Capacity	V-kW	12-2.0	12-2.0
Alternator Capacity	V-A	12-40	
Direction of Revolution		Counter-clockwise (viewed from flywheel side)	
Dry Weight	kg (lbs)	184.0 (405.6)	201.0 (443.0)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		D1803-M-DI	V2403-M-DI
Type		Vertical, water cooled 4-cycle diesel	
Number of Cylinders		3	4
Bore × Stroke	mm (in.)	87.0 × 102.4 (3.43 × 4.03)	
Displacement	cm ³ (cu.in.)	1826 (111.43)	2434 (148.53)
SAE J1995 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	27.9 (37.4/37.9) / 2700	36.5 (48.9/49.6) / 2700
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	26.5 (35.5/36.0) / 2700	35.0 (47.0/47.6) / 2700
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	23.0 (30.9/31.3) / 2700	30.4 (40.8/41.4) / 2700
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	27.9 (37.4/37.9) / 2700	36.5 (48.9/49.6) / 2700
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	26.5 (35.5/36.0) / 2700	35.0 (47.0/47.6) / 2700
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	23.0 (30.9/31.3) / 2700	30.4 (40.8/41.4) / 2700
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	26.5 (35.5/35.5) / 2700	35.0 (47.0/47.0) / 2700
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	23.0 (31.0/30.9) / 2700	30.4 (40.8/40.8) / 2700
Maximum Torque (Gross)	N·m (lbf·ft) / min ⁻¹ (rpm)	115.6 (85.26) / 1600	158.6 (117.0) / 1600
Maximum Torque (Overload)	N·m (lbf·ft) / min ⁻¹ (rpm)	112.9 (83.27) / 1600	155.2 (114.5) / 1600
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	2920	
No Load Low Idling Speed	min ⁻¹ (rpm)	900	
Combustion Chamber Type		Reentrant type (Direct Injection)	
Fuel Injection Pump Type		PFR	
Nozzle Type		Hole Type	
Injection Timing (p : High pressure overflow method)		T.D.C-5.0° (T.D.C-6.0° p)	
Fuel Injection Pressure	MPa (kgf/cm ²)	1st : 18.6 (190) 2nd : 22.6 (230)	
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)	
Compression Ratio		20.2	20.5
Governor Type		Centrifugal ball mechanical type governor	
Cooling System		Radiator cooling	
Recommended Coolant Capacity	lit (USgal)	5.8 (1.53)	8.4 (2.22)
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	lit (USgal)	7.0 (1.85) [Std. oil pan]	9.5 (2.51) [Std. oil pan]
Starting System		Electric starter	
Starter Capacity	V-kW	12-1.4	12-2.0
Alternator Capacity	V-A	12-30	12-40
Direction of Revolution		Counter-clockwise (viewed from flywheel side)	
Dry Weight	kg (lbs)	151.0 (332.9)	184.0 (405.6)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		D1703-M-BG	
Number of Cylinders		3	
Type		Vertical, Water-cooled, 4 cycle diesel engine	
Bore × Stroke mm (in.)		87.0 × 92.4 (3.43 × 3.64)	
Total Displacement cm ³ (cu.in.)		1647 (100.5)	
STANDBY ISO 3046 SAE J-1349		15.0 / 1500	18.1 / 1800
	kW/min ⁻¹ (rpm)	20.1 / 1500	24.3 / 1800
	HP/min ⁻¹ (rpm)		
NET Continuous ISO 3046 SAE J-1349		12.8 / 1500	15.1 / 1800
	kW/min ⁻¹ (rpm)	17.2 / 1500	20.2 / 1800
	HP/min ⁻¹ (rpm)		
Governor Regulation		Less than 5 %	
Combustion Chamber Type		Spherical type (E-T.V.C.S. : Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Governor		Mechanical all speed governor + Electronic Governor	
Direction of Rotation		Counter-clockwise (viewed from flywheel side)	
Nozzle Type		Throttle Type	
Injection Timing		0.2487 rad (14.25 °) before T.D.C.	
Firing Order		1-2-3	
Injection Pressure		13.73 MPa (140.0 kgf/cm ² , 1991 psi)	
Compression Ratio		22.0 : 1	
Lubricating System		Forced lubrication by trochoid pump	
Oil Pressure Indication		Electrical type switch	
Lubricating Filter		Full flow paper filter (Cartridge type)	
Cooling System		Pressurized radiator, forced circulation with water pump	
Starting System		Electric Starting with Starter	
Starting Motor		12 V, 1.4 kW	
Starting Support Device		By glow plug in combustion chamber	
EGR		NONE	
Battery		12 V, 60 AH, equivalent	
Charging Alternator		12 V, 480 W	
Fuel		Diesel Fuel No. 2-D (ASTM D975)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	Oil Pan Depth 90 mm (3.5 in.)	5.6 L (1.5 U.S.gals)	
	Oil Pan Depth 124 mm (4.88 in.)	7.0 L (1.8 U.S.gals)	
Weight (Dry) kg (lbs)		164 (362)	

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V2003-M-BG	
Number of Cylinders		4	
Type		Vertical, Water-cooled, 4 cycle diesel engine	
Bore × Stroke	mm (in.)	83.0 × 92.4 (3.27 × 3.64)	
Total Displacement	cm ³ (cu.in.)	1999 (122.0)	
STANDBY			
ISO 3046	kW/min ⁻¹ (rpm)	18.1 / 1500	21.8 / 1800
SAE J-1349	HP/min ⁻¹ (rpm)	24.3 / 1500	29.2 / 1800
NET Continuous			
ISO 3046	kW/min ⁻¹ (rpm)	15.5 / 1500	18.2 / 1800
SAE J-1349	HP/min ⁻¹ (rpm)	20.8 / 1500	24.4 / 1800
Governor Regulation		Less than 5 %	
Combustion Chamber Type		Spherical type (E-T.V.C.S. : Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Governor		Mechanical all speed governor + Electronic Governor	
Direction of Rotation		Counter-clockwise (viewed from flywheel side)	
Nozzle Type		Throttle Type	
Injection Timing		0.2487 rad (14.25 °) before T.D.C.	
Firing Order		1-3-4-2	
Injection Pressure		13.73 MPa (140.0 kgf/cm ² , 1991 psi)	
Compression Ratio		22.8 : 1	
Lubricating System		Forced lubrication by trochoid pump	
Oil Pressure Indication		Electrical type switch	
Lubricating Filter		Full flow paper filter (Cartridge type)	
Cooling System		Pressurized radiator, forced circulation with water pump	
Starting System		Electric Starting with Starter	
Starting Motor		12 V, 1.4 kW	
Starting Support Device		By glow plug in combustion chamber	
EGR		NONE	
Battery		12 V, 88 AH, equivalent	
Charging Alternator		12 V, 480 W	
Fuel		Diesel Fuel No. 2-D (ASTM D975)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	Oil Pan Depth 90 mm (3.5 in.)	7.6 L (2.0 U.S.gals)	
	Oil Pan Depth 124 mm (4.88 in.)	9.5 L (2.5 U.S.gals)	
Weight (Dry)		195 (430)	

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V2203-M-BG	
Number of Cylinders		4	
Type		Vertical, Water-cooled, 4 cycle diesel engine	
Bore × Stroke mm (in.)		87.0 × 92.4 (3.43 × 3.64)	
Total Displacement cm ³ (cu.in.)		2197 (134.1)	
STANDBY ISO 3046 SAE J-1349		20.1 / 1500	24.2 / 1800
	kW/min ⁻¹ (rpm)	27.0 / 1500	32.5 / 1800
	HP/min ⁻¹ (rpm)		
NET Continuous ISO 3046 SAE J-1349		17.2 / 1500	20.2 / 1800
	kW/min ⁻¹ (rpm)	23.1 / 1500	27.1 / 1800
	HP/min ⁻¹ (rpm)		
Governor Regulation		Less than 5 %	
Combustion Chamber Type		Spherical type (E-T.V.C.S. : Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Governor		Mechanical all speed governor + Electronic Governor	
Direction of Rotation		Counter-clockwise (viewed from flywheel side)	
Nozzle Type		Throttle Type	
Injection Timing		0.2487 rad (14.25 °) before T.D.C.	
Firing Order		1-3-4-2	
Injection Pressure		13.73 MPa (140.0 kgf/cm ² , 1991 psi)	
Compression Ratio		22.0 : 1	
Lubricating System		Forced lubrication by trochoid pump	
Oil Pressure Indication		Electrical type switch	
Lubricating Filter		Full flow paper filter (Cartridge type)	
Cooling System		Pressurized radiator, forced circulation with water pump	
Starting System		Electric Starting with Starter	
Starting Motor		12 V, 1.4 kW	
Starting Support Device		By glow plug in combustion chamber	
EGR		NONE	
Battery		12 V, 88 AH, equivalent	
Charging Alternator		12 V, 480 W	
Fuel		Diesel Fuel No. 2-D (ASTM D975)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	Oil Pan Depth 90 mm (3.5 in.)	7.6 L (2.0 U.S.gals)	
	Oil Pan Depth 124 mm (4.88 in.)	9.5 L (2.5 U.S.gals)	
Weight (Dry) kg (lbs)		195 (430)	

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V2403-M-BG	
Number of Cylinders		4	
Type		Vertical, Water-cooled, 4 cycle diesel engine	
Bore × Stroke	mm (in.)	87.0 × 102.4 (3.43 × 4.031)	
Total Displacement	cm ³ (cu.in.)	2434 (148.5)	
STANDBY			
ISO 3046	kW/min ⁻¹ (rpm)	22.0 / 1500	26.5 / 1800
SAE J-1349	HP/min ⁻¹ (rpm)	29.5 / 1500	35.5 / 1800
NET Continuous			
ISO 3046	kW/min ⁻¹ (rpm)	18.8 / 1500	22.1 / 1800
SAE J-1349	HP/min ⁻¹ (rpm)	25.2 / 1500	29.6 / 1800
Governor Regulation		Less than 5 %	
Combustion Chamber Type		Spherical type (E-T.V.C.S. : Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Governor		Mechanical all speed governor + Electronic Governor	
Direction of Rotation		Counter-clockwise (viewed from flywheel side)	
Nozzle Type		Throttle Type	
Injection Timing		0.2487 rad (14.25 °) before T.D.C.	
Firing Order		1-3-4-2	
Injection Pressure		13.73 MPa (140.0 kgf/cm ² , 1991 psi)	
Compression Ratio		23.2 : 1	
Lubricating System		Forced lubrication by trochoid pump	
Oil Pressure Indication		Electrical type switch	
Lubricating Filter		Full flow paper filter (Cartridge type)	
Cooling System		Pressurized radiator, forced circulation with water pump	
Starting System		Electric Starting with Starter	
Starting Motor		12 V, 2.0 kW	
Starting Support Device		By glow plug in combustion chamber	
EGR		NONE	
Battery		12 V, 88 AH, equivalent	
Charging Alternator		12 V, 480 W	
Fuel		Diesel Fuel No. 2-D (ASTM D975)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	Oil Pan Depth 90 mm (3.5 in.)	7.6 L (2.0 U.S.gals)	
	Oil Pan Depth 124 mm (4.88 in.)	9.5 L (2.5 U.S.gals)	
Weight (Dry)		190 (419)	

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V2003-M-T-BG	
Number of Cylinders		4	
Type		Vertical, Water-cooled, 4 cycle diesel engine	
Bore × Stroke mm (in.)		83.0 × 92.4 (3.27 × 3.64)	
Total Displacement cm ³ (cu.in.)		1999 (122.0)	
STANDBY			
	ISO 3046 kW/min ⁻¹ (rpm)	22.5 / 1500	27.1 / 1800
	SAE J-1349 HP/min ⁻¹ (rpm)	30.2 / 1500	36.3 / 1800
NET Continuous			
	ISO 3046 kW/min ⁻¹ (rpm)	20.4 / 1500	24.5 / 1800
	SAE J-1349 HP/min ⁻¹ (rpm)	27.4 / 1500	32.9 / 1800
Governor Regulation		Less than 5 %	
Combustion Chamber Type		Spherical type (E-T.V.C.S. : Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Governor		Mechanical all speed governor + Electronic Governor	
Direction of Rotation		Counter-clockwise (viewed from flywheel side)	
Nozzle Type		Throttle Type	
Injection Timing		0.2662 rad (15.25 °) before T.D.C.	
Firing Order		1-3-4-2	
Injection Pressure		13.73 MPa (140.0 kgf/cm ² , 1991 psi)	
Compression Ratio		21.7 : 1	
Lubricating System		Forced lubrication by trochoid pump	
Oil Pressure Indication		Electrical type switch	
Lubricating Filter		Full flow paper filter (Cartridge type)	
Cooling System		Pressurized radiator, forced circulation with water pump	
Starting System		Electric Starting with Starter	
Starting Motor		12 V, 1.4 kW	
Starting Support Device		By glow plug in combustion chamber	
EGR		NONE	
Battery		12 V, 88 AH, equivalent	
Charging Alternator		12 V, 480 W	
Fuel		Diesel Fuel No. 2-D (ASTM D975)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	Oil Pan Depth 90 mm (3.5 in.)	7.6 L (2.0 U.S.gals)	
	Oil Pan Depth 124 mm (4.88 in.)	9.5 L (2.5 U.S.gals)	
Weight (Dry) kg (lbs)		208 (459)	

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V2607-DI-T	V3307-DI-T
Item			
Type		Vertical, water cooled 4-cycle diesel	
Number of Cylinders		4	
Bore × Stroke	mm (in.)	87.0 × 110.0 (3.43 × 4.33)	94.0 × 120.0 (3.70 × 4.72)
Displacement	cm ³ (cu.in.)	2615 (159.6)	3331 (203.3)
SAE J1995 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	49.2 (66.0/66.9) / 2700	55.4 (74.3/75.3) / 2600
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	47.5 (63.7/64.6) / 2700	53.7 (72.2/73.0) / 2600
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	41.2 (55.3/56.1) / 2700	46.6 (62.5/63.4) / 2600
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	49.2 (66.0/66.9) / 2700	55.4 (74.3/75.3) / 2600
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	47.5 (63.7/64.6) / 2700	53.7 (72.0/73.0) / 2600
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	41.2 (55.3/56.1) / 2700	46.6 (62.5/63.4) / 2600
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	47.5 (63.7/64.6) / 2700	53.7 (72.0/73.0) / 2600
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	41.2 (55.2/56.1) / 2700	46.6 (62.5/63.4) / 2600
Maximum Torque (Gross)	N·m (lbf·ft) / min ⁻¹ (rpm)	220.3 (162.5) / 1600	265.0 (195.0) / 1600
Maximum Torque (Overload)	N·m (lbf·ft) / min ⁻¹ (rpm)	215.8 (159.2) / 1600	259.9 (191.7) / 1600
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	2920	2820
No Load Low Idling Speed	min ⁻¹ (rpm)	850	800
Combustion Chamber Type		Reentrant	
Fuel Injection Pump Type		PFR	
Nozzle Type		Hole Type	
Injection Timing (p : High pressure overflow method)		T.D.C-0.25° (T.D.C-1.25° p)	T.D.C+1.3° (T.D.C+0.3° p)
Fuel Injection Pressure	MPa (kgf/cm ²)	1st stage 18.63 MPa (190.0 kgf/cm ² , 2702 psi) 2nd stage 21.57 MPa (220.0 kgf/cm ² , 3129 psi)	1st stage 18.63 MPa (190.0 kgf/cm ² , 2702 psi) 2nd stage 22.56 MPa (230.0 kgf/cm ² , 3271 psi)
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)	
Compression Ratio		19.0	20.0
Governor Type		Centrifugal flyweight mechanical type governor	
Cooling System		Radiator cooling	
Recommended Coolant Capacity	lit (USgal)	6.0 (1.32)	6.3 (1.67)
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	lit (USgal)	10.2 (2.69) [Std. oil pan]	11.2 (2.96) [Std. oil pan]
Starting System		Electric starter	
Starter Capacity	V-kW	12-2.5	12-3.0
Alternator Capacity	V-A	12-60	
Direction of Revolution		Counter-clockwise (viewed from flywheel side)	
Dry Weight	kg (lbs)	235.0 (518.0)	275.0 (606.0)

- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V3600	V3600-T (Turbo)
Type		Vertical, water cooled 4-cycle diesel	
Number of Cylinders		4	
Bore × Stroke	mm (in.)	98.0 × 120.0 (3.86 × 4.72)	
Displacement	cm ³ (cu.in.)	3620 (220.9)	
SAE J1349 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	49.8 (66.8/67.7) / 2600	63.0 (84.5/85.7) / 2600
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	45.7 (61.3/62.2) / 2600	58.7 (78.7/79.8) / 2600
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	39.7 (53.2/54.0) / 2600	51.0 (68.4/69.3) / 2600
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	49.8 (66.8/67.7) / 2600	63.0 (84.5/85.7) / 2600
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	45.7 (61.3/62.2) / 2600	58.7 (78.7/79.8) / 2600
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	39.7 (53.2/54.0) / 2600	51.0 (68.4/69.3) / 2600
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	45.7 (61.3/62.2) / 2600	58.7 (78.7/79.8) / 2600
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	39.7 (53.2/54.0) / 2600	51.0 (68.0/69.3) / 2600
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	221.0 (163.0) / 1600	296.0 (218.0) / 1600
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	213.1 (157.2) / 1600	287.0 (212.0) / 1600
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	2820	
No Load Low Idling Speed	min ⁻¹ (rpm)	800	
Combustion Chamber Type		Spherical type (E-T.V.C.S.:Three Vortex Combustion System)	
Fuel Injection Pump Type		PFR	
Nozzle Type		Throttle Type	
Injection Timing (p : High pressure overflow method)		T.D.C-8° (T.D.C-9° p)	T.D.C-4° (T.D.C-5° p)
Fuel Injection Pressure	MPa (kgf/cm ²)	13.7 (140)	
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)	
Compression Ratio		22.6	21.8
Governor Type		Centrifugal flyweight mechanical type governor	
Cooling System		Radiator cooling	
Recommended Coolant Capacity	lit (USgal)	9.0 (2.38)	
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)	
Lubricating Oil Capacity	lit (USgal)	13.2 (3.49) [Std. oil pan]	
Starting System		Electric starter	
Starter Capacity	V-kW	12-3.0	
Alternator Capacity	V-A	12-90 (KEA Std) 12-60 (EU Std)	
Direction of Revolution		Counter-clockwise (viewed from flywheel side)	
Dry Weight	kg (lbs)	283.0 (624.0)	290.0 (639.0)

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When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V3800DI-T (Turbo)
Type		Vertical, water cooled 4-cycle diesel
Number of Cylinders		4
Bore × Stroke	mm (in.)	100.0 × 120.0 (3.94 × 4.72)
Displacement	cm ³ (cu.in.)	3769 (230.0)
SAE J1349 Gross Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	74.0 (99.2/100.6) / 2600
SAE J1349 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	71.4 (95.7/97.0) / 2600
SAE J1349 Net Continuous	kW (HP/PS) / min ⁻¹ (rpm)	62.0 (83.1/84.3) / 2600
ISO Gross	kW (HP/PS) / min ⁻¹ (rpm)	74.0 (99.2/100.6) / 2600
ISO Overload	kW (HP/PS) / min ⁻¹ (rpm)	71.4 (95.7/97.0) / 2600
ISO Continuous	kW (HP/PS) / min ⁻¹ (rpm)	62.0 (83.1/84.3) / 2600
JIS D1005 Net Intermittent	kW (HP/PS) / min ⁻¹ (rpm)	71.4 (95.7/97.0) / 2600
JIS B8014 Continuous	kW (HP/PS) / min ⁻¹ (rpm)	62.0 (83.0/84.3) / 2600
Maximum Torque (Gross)	N•m (lbf•ft) / min ⁻¹ (rpm)	325.0 (239.7) / 1600
Maximum Torque (Overload)	N•m (lbf•ft) / min ⁻¹ (rpm)	318.3 (234.8) / 1600
No Load High Idling Speed (Gross)	min ⁻¹ (rpm)	2820
No Load Low Idling Speed	min ⁻¹ (rpm)	800
Combustion Chamber Type		Center direct injection type (E-CDIS)
Fuel Injection Pump Type		PFR
Nozzle Type		Hole Type
Injection Timing (p : High pressure overflow method)		T.D.C-6° (T.D.C-7° p)
Fuel Injection Pressure	MPa (kgf/cm ²)	1st stage : 18.6 (190) 2nd stage : 23.5 (240)
Fuel		Diesel Fuel No. 2-D S500 or S15 (See page 4-19)
Compression Ratio		19.0
Governor Type		Centrifugal flyweight mechanical type governor
Cooling System		Radiator cooling
Recommended Coolant Capacity	lit (USgal)	9.0 (2.38)
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)
Lubricating Oil Capacity	lit (USgal)	13.2 (3.49) [Std. oil pan]
Starting System		Electric starter
Starter Capacity	V-kW	12-3.0
Alternator Capacity	V-A	12-90 (KEA Std.) 12-60 (EU Std.)
Direction of Revolution		Counter-clockwise (viewed from flywheel side)
Dry Weight	kg (lbs)	307.0 (677.0)

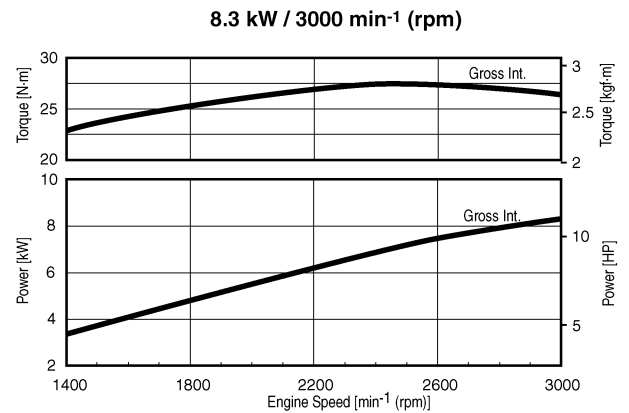
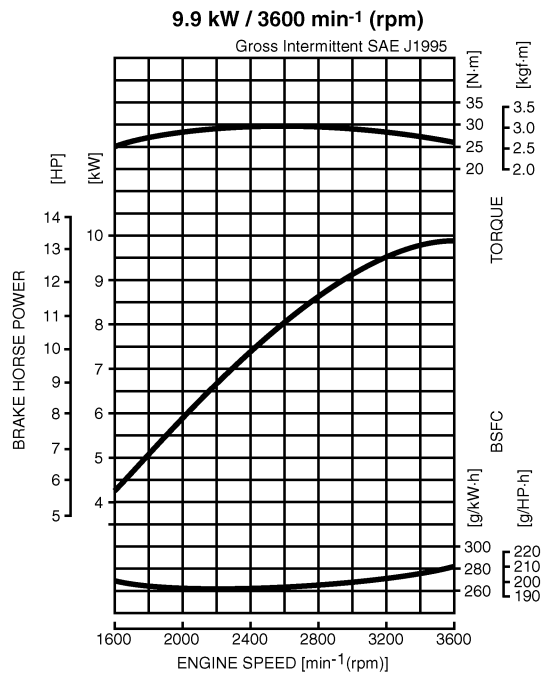
- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

Model		V3300-BG	V3600-T-BG	V3800DI-T-BG
Number of Cylinders		4		
Type		Vertical, Water-cooled, 4 cycle diesel engine		
Bore × Stroke	mm (in.)	98 × 110 (3.86 × 4.33)	98 × 120 (3.86 × 4.72)	100 × 120 (3.94 × 4.72)
Total Displacement	cm ³ (cu.in.)	3318 (202.48)	3620 (220.9)	3769 (230.0)
STANDBY				
ISO 3046	kW/min ⁻¹ (rpm)	27.5 / 1500	33.6 / 1800	52.8 / 1800
SAE J-1349	HP/min ⁻¹ (rpm)	36.9 / 1500	45.1 / 1800	70.8 / 1800
NET Continuous				
ISO 3046	kW/min ⁻¹ (rpm)	25.0 / 1500	30.6 / 1800	48.0 / 1800
SAE J-1349	HP/min ⁻¹ (rpm)	33.5 / 1500	41.0 / 1800	64.4 / 1800
Governor Regulation		Less than 5 %		
Combustion Chamber Type		Spherical type (E-T.V.C.S. : Three Vortex Combustion System)		
Fuel Injection Pump Type		PFR		
Governor		All speed mechanical governor		Mechanical + Electronic governor
Direction of Rotation		Counter-clockwise (viewed from flywheel side)		
Nozzle Type		Throttle Type		
Injection Timing		0.16 rad (9.0 °) before T.D.C.	0.070 rad (4.0 °) before T.D.C.	0.096 rad (5.5 °) before T.D.C.
Firing Order		1-3-4-2		
Injection Pressure		13.73 MPa (140.0 kgf/cm ² , 1991 psi)		1st stage 18.63 MPa (190.0 kgf/cm ² , 2702 psi) 2nd stage 23.54 MPa (240.0 kgf/cm ² , 3414 psi)
Compression Ratio		22.6	21.8	19.0
Lubricating System		Forced lubrication by trochoid pump		
Oil Pressure Indication		Electrical type switch		
Lubricating Filter		Full flow paper filter (Cartridge type)		
Cooling System		Pressurized radiator, forced circulation with water pump		
Starting System		Electric Starting with Starter		
Starting Motor		12 V, 3.0 kW		
Starting Support Device		By glow plug in combustion chamber		Intake Air Heater in Intake Manifold
EGR		NONE	Internal EGR (2 stage Exhaust Cam)	External EGR (EGR Cooler + Mechanical EGR Valve + Reed Valve)
Battery		12 V, 136 AH, equivalent		
Charging Alternator		12 V, 540 W		
Fuel		Diesel Fuel No. 2-D S500 or S15.		
Lubricating Oil (API Classification)		CF or other applicable grade (See page 5-3)		
Lubricating Oil Capacity		13.2 L (3.49 U.S.gals)		
Weight (Dry)	kg (lbs)	281 (619)	284 (626)	280 (617)

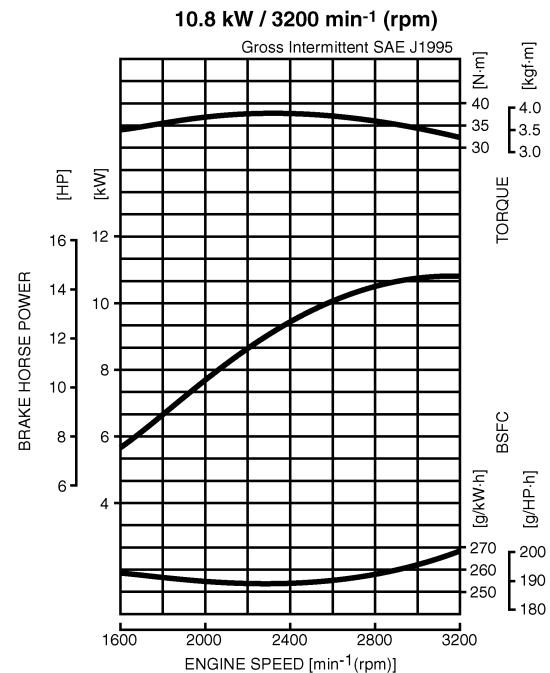
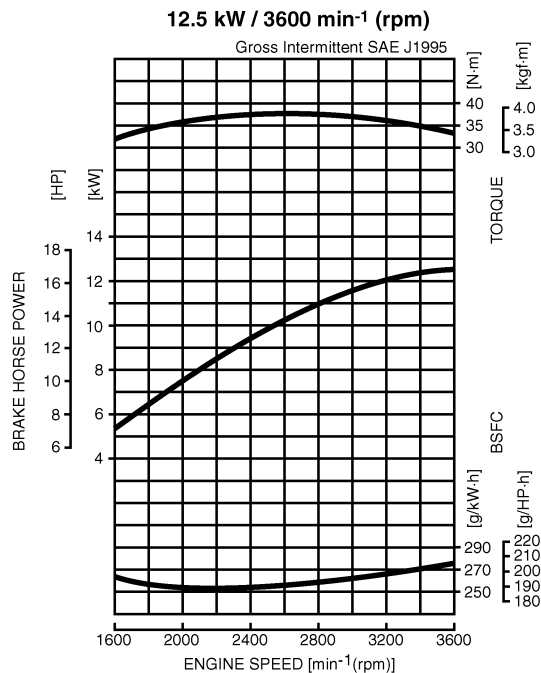
- 1) Specifications are subject to change without notice.
- 2) Dry weight is according to KUBOTA's standard specification.
When specification varies, the weight will vary accordingly.
- 3) Recommended Coolant Capacity : With radiator.
- 4) Lubricating oil capacity : With oil filter cartridge.

2. PERFORMANCE CURVES

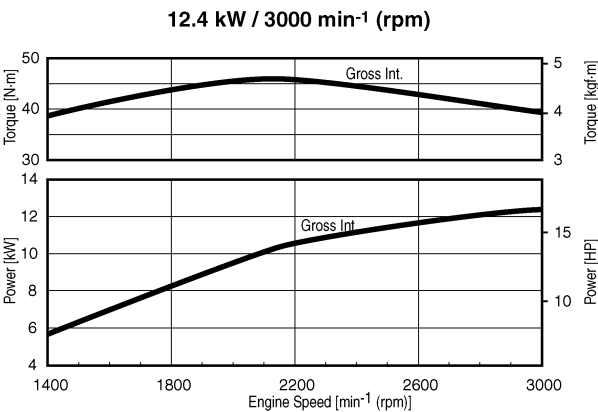
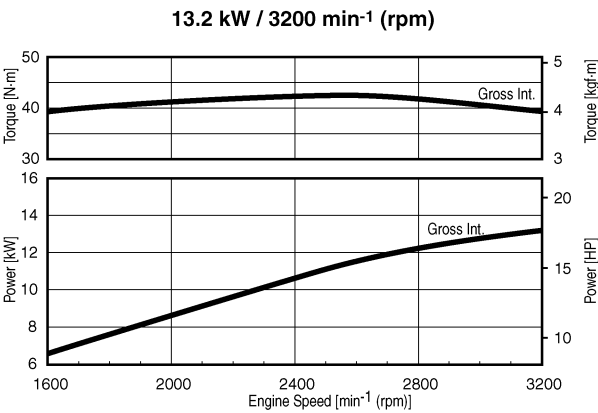
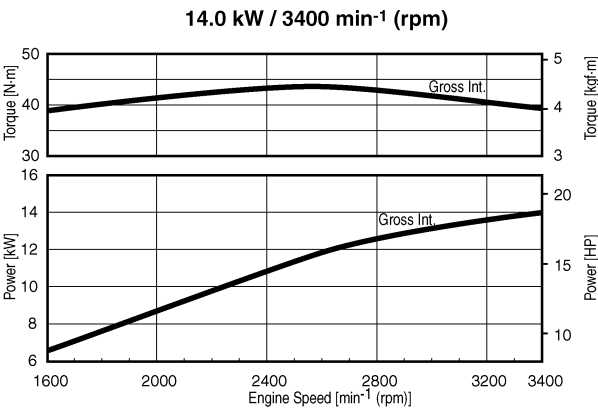
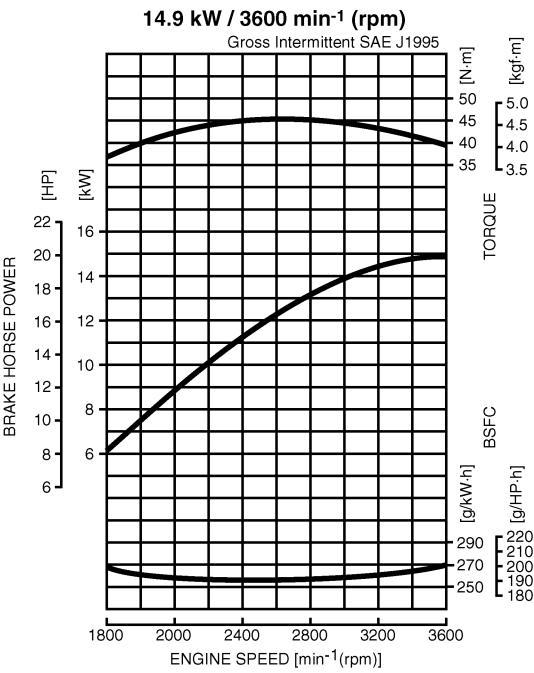
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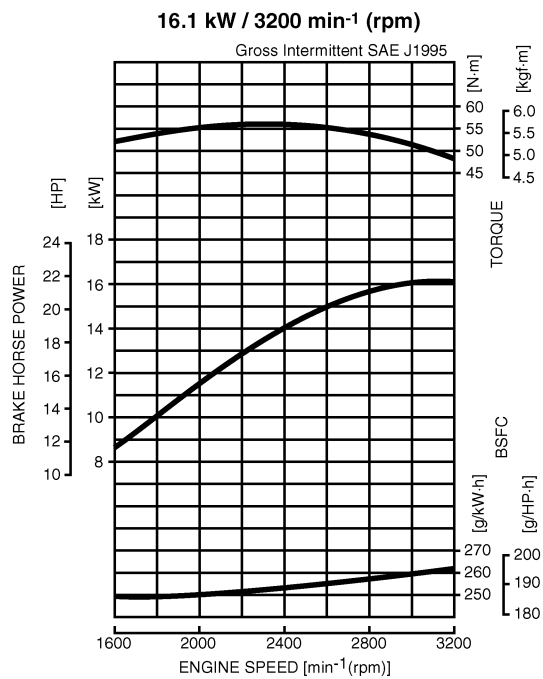
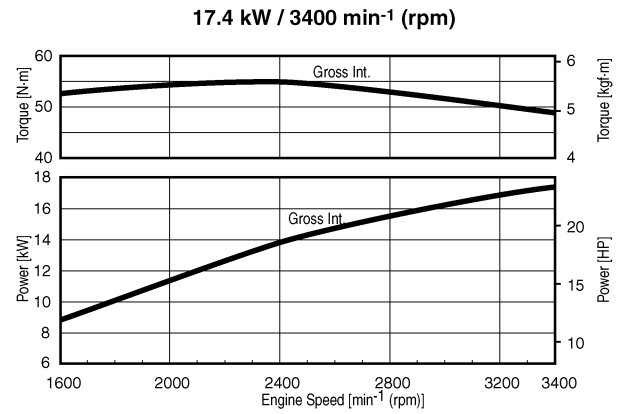
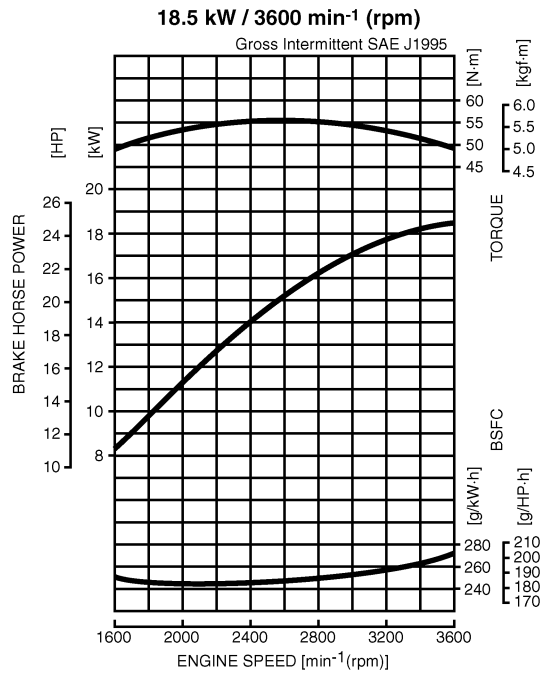
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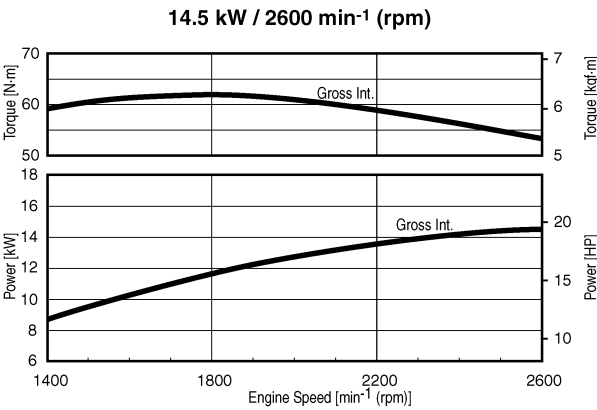
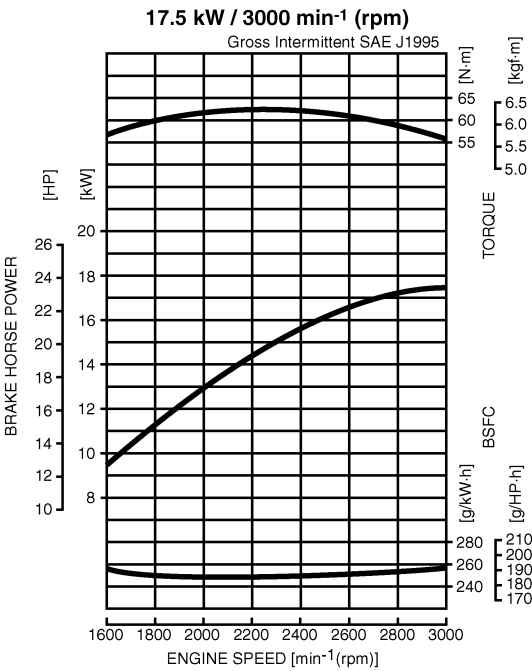
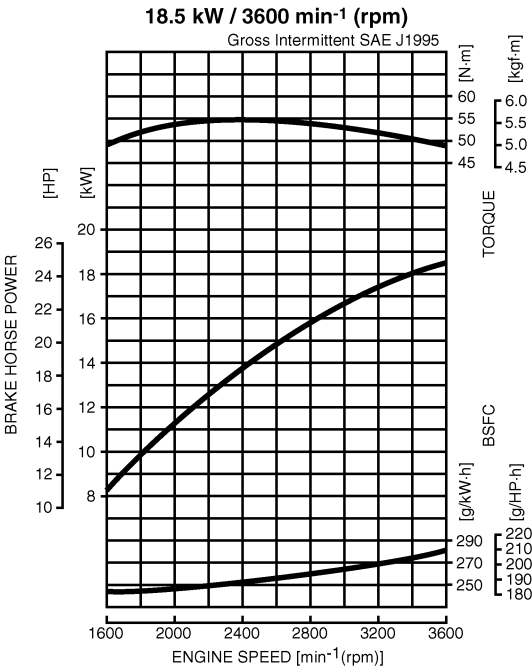
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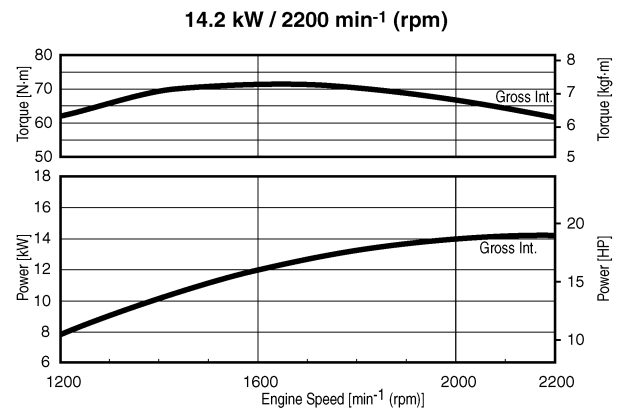
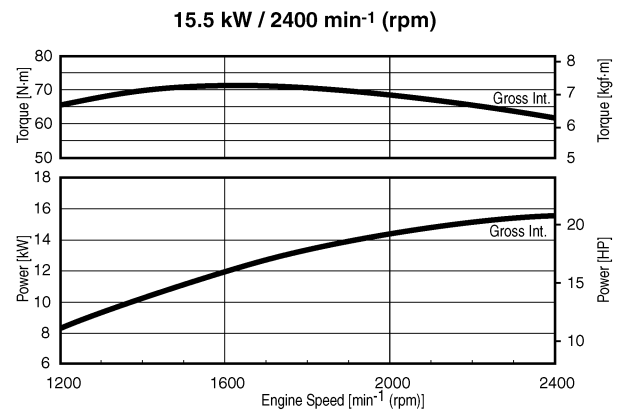
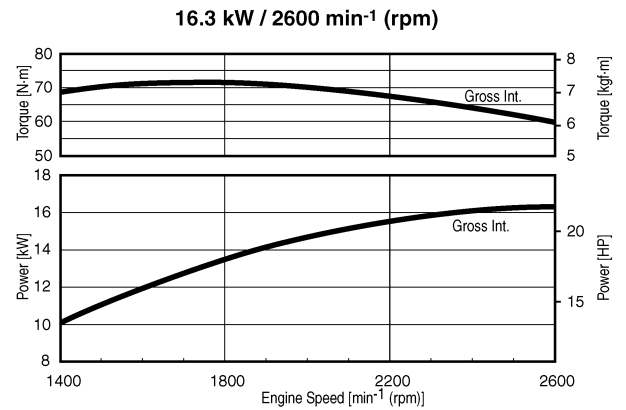
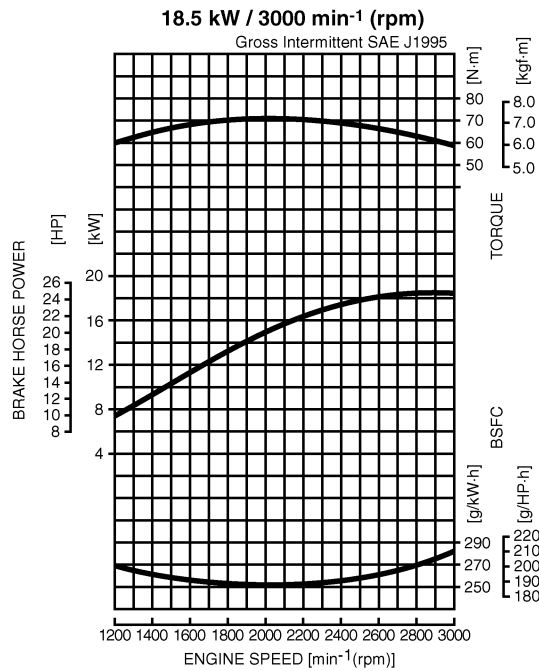
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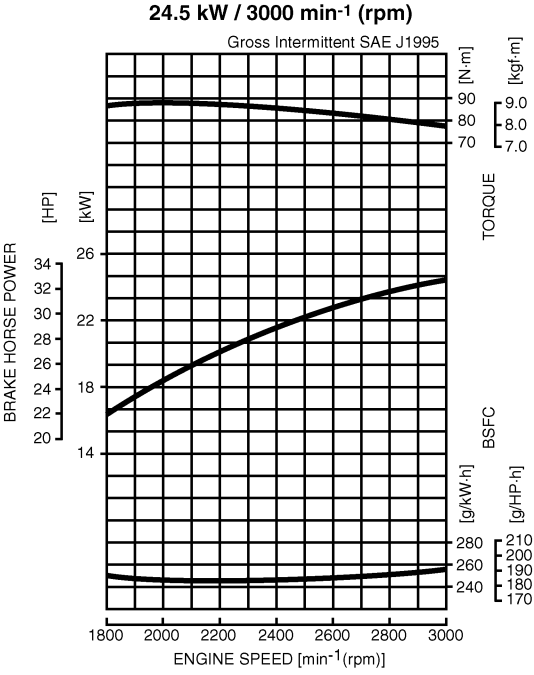
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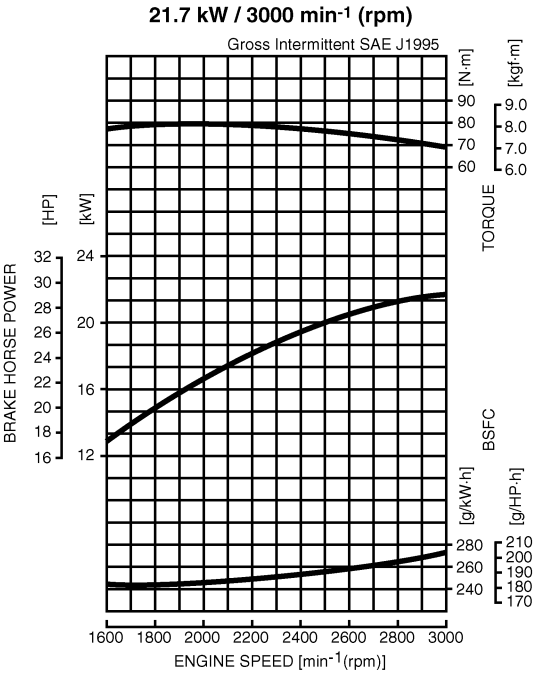
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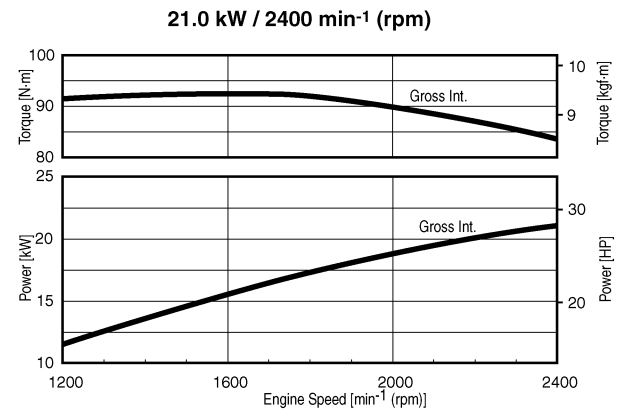
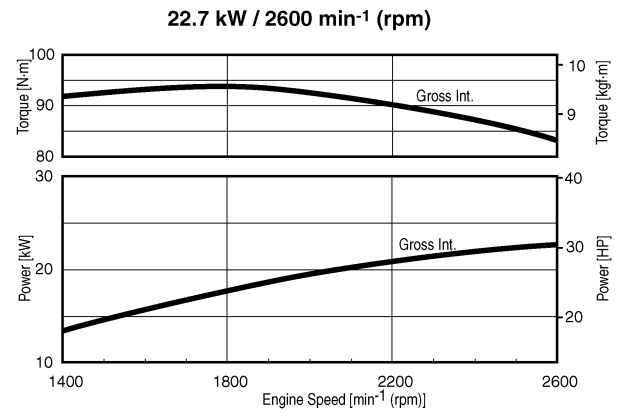
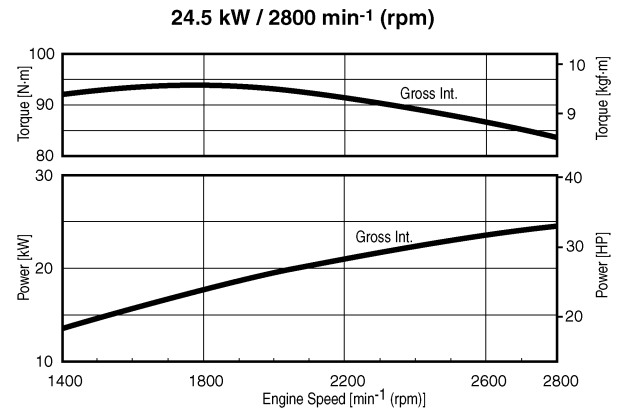
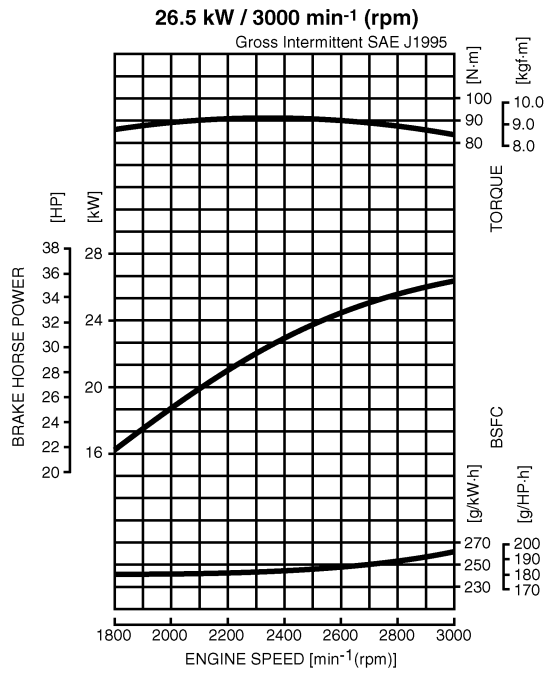
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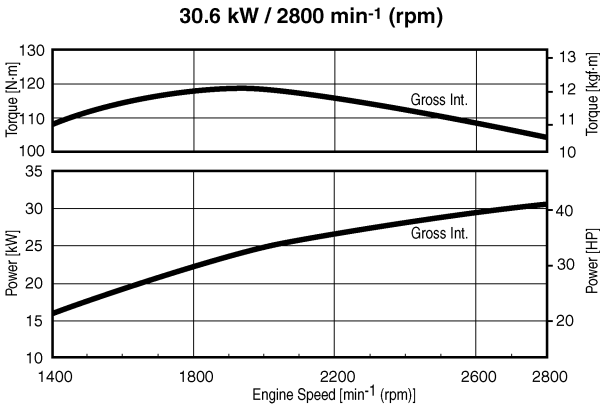
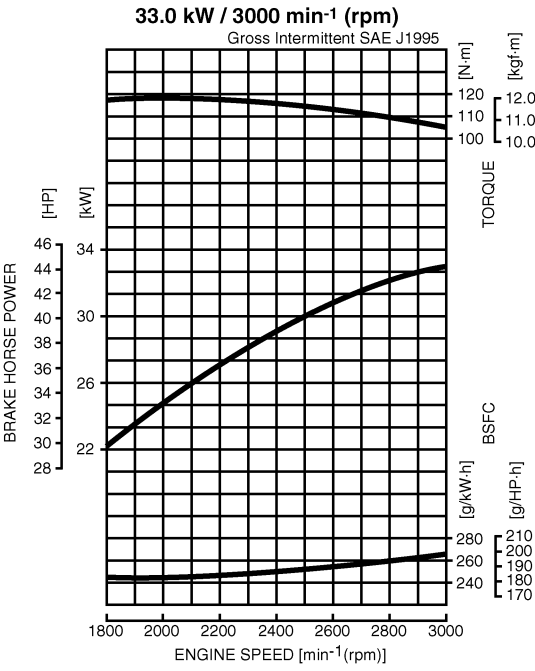
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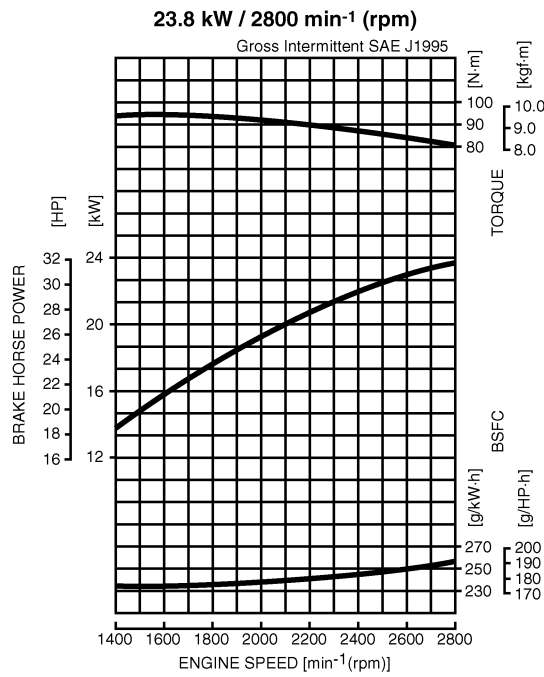
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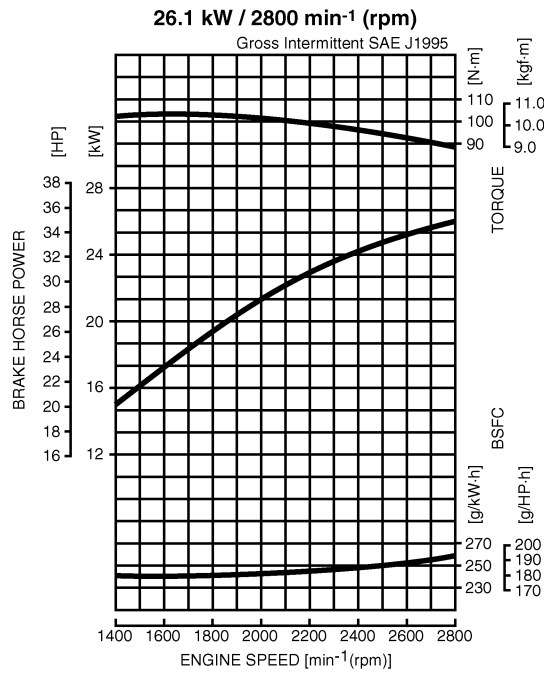
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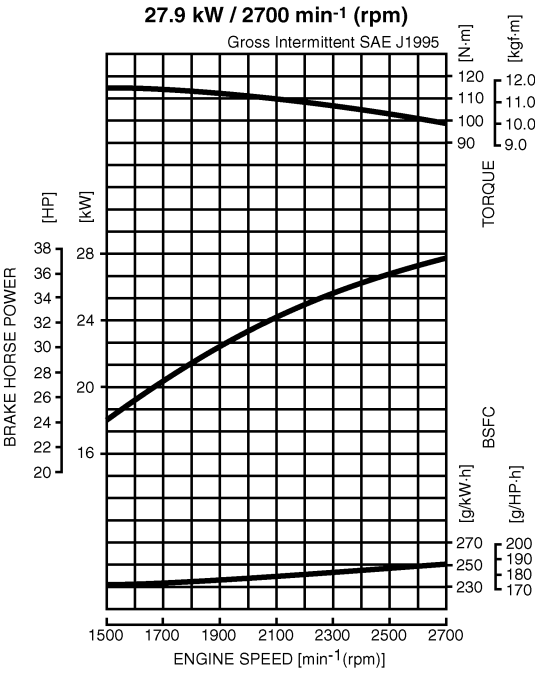
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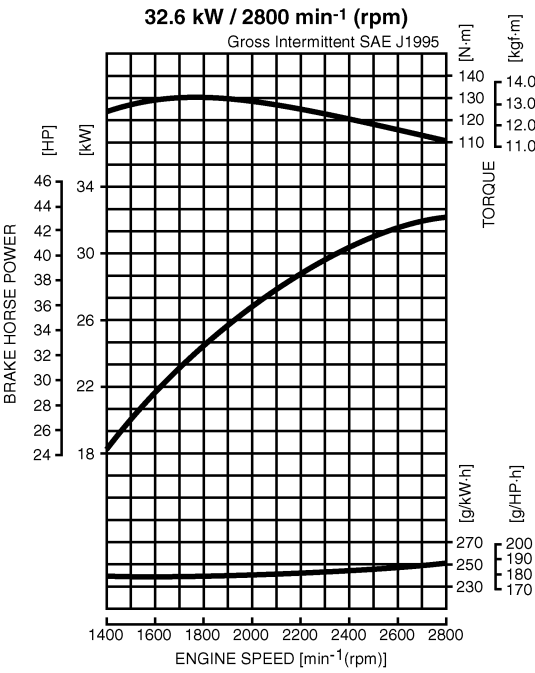
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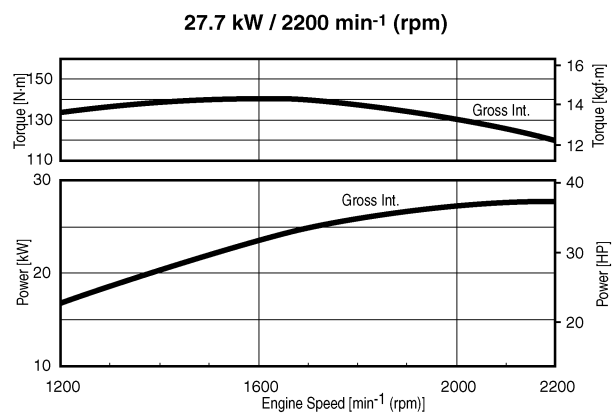
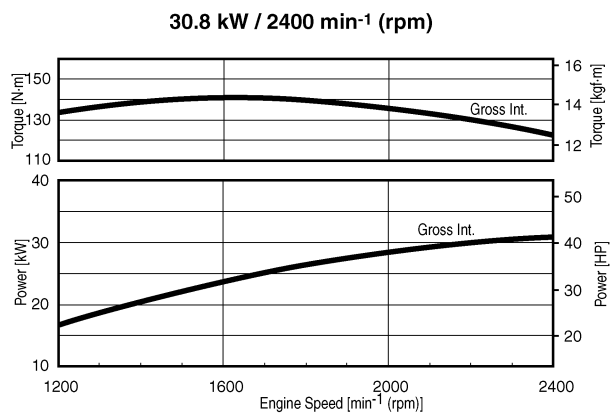
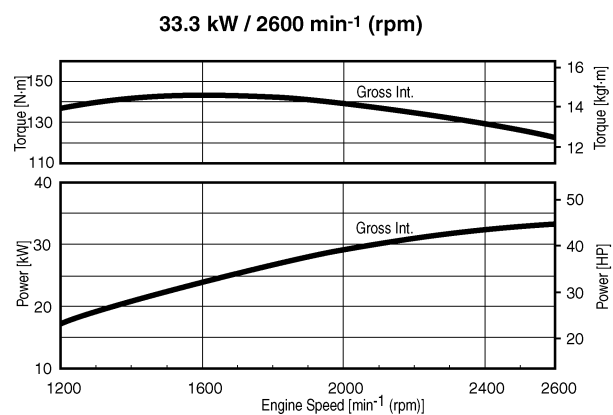
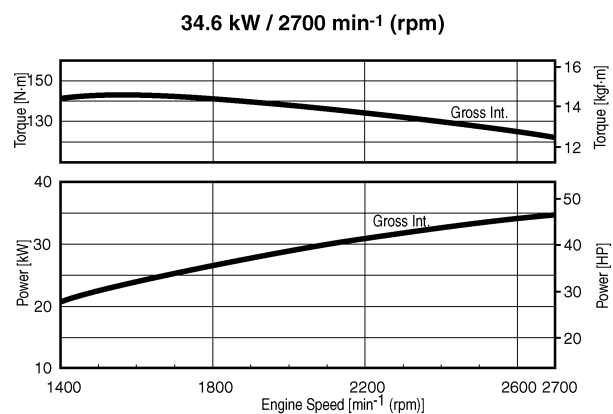
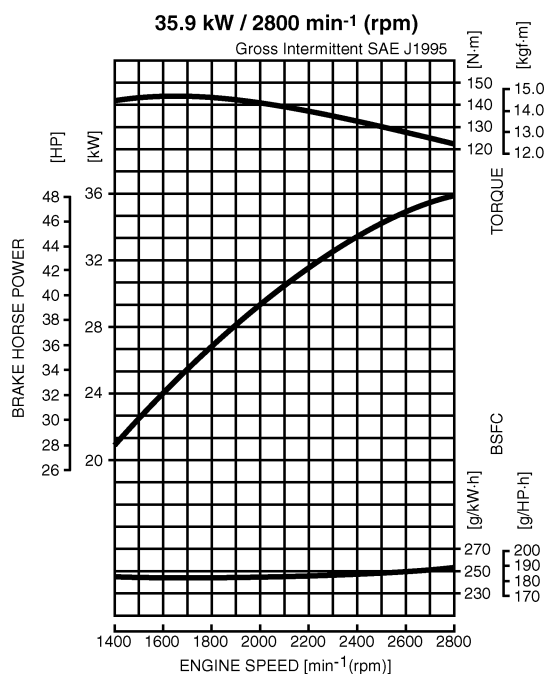
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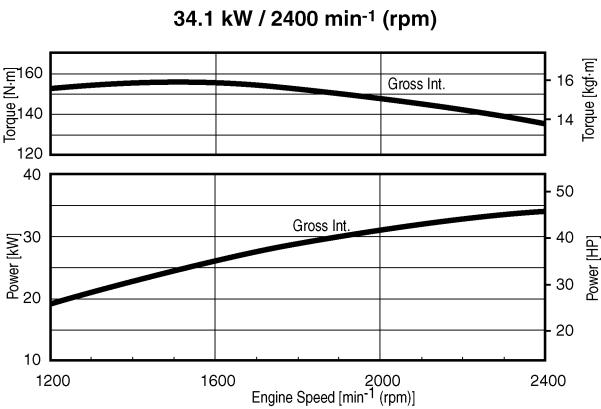
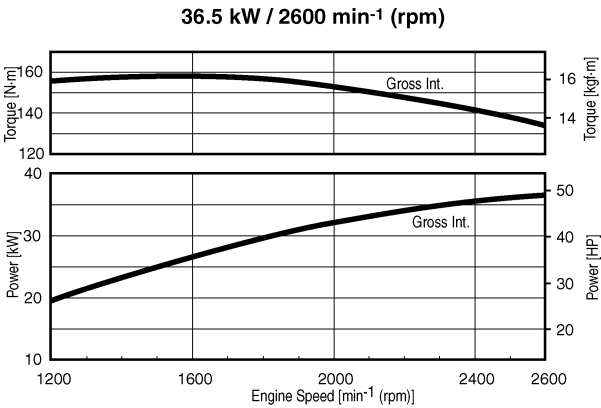
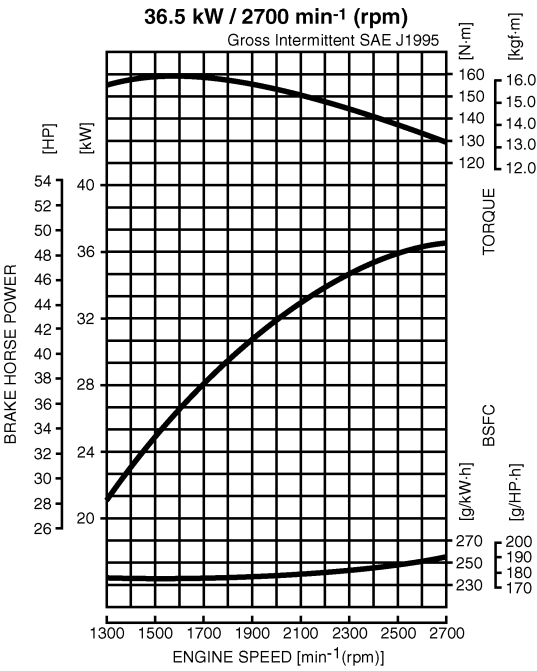
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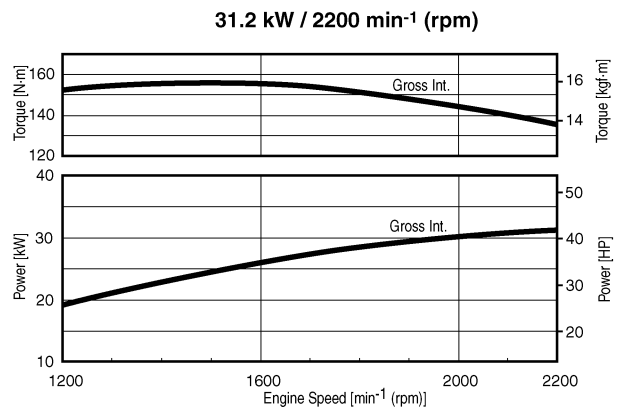
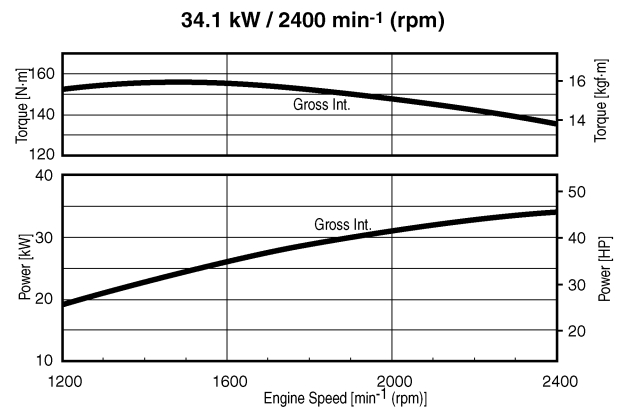
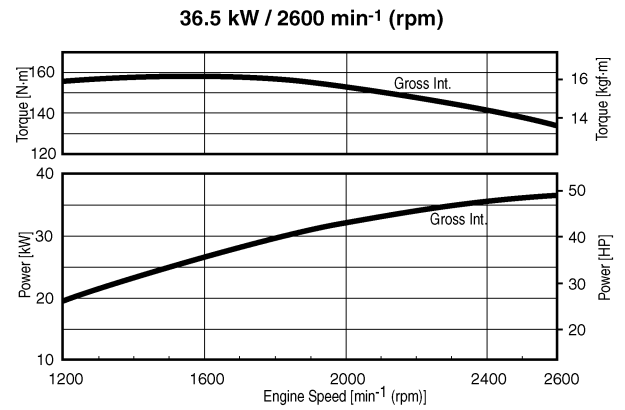
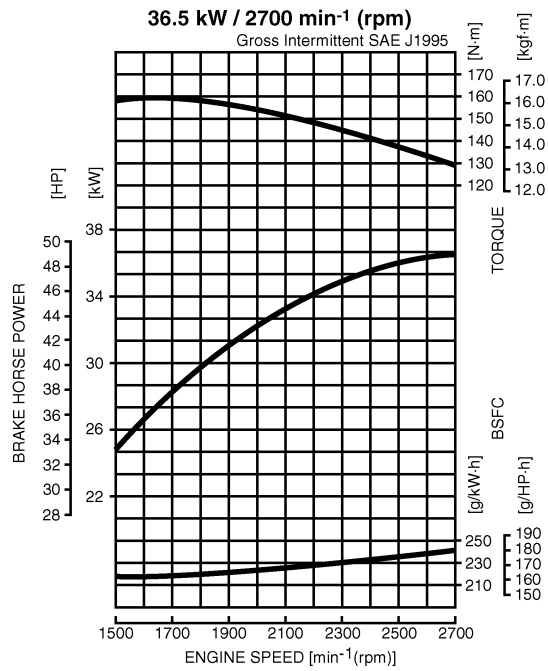
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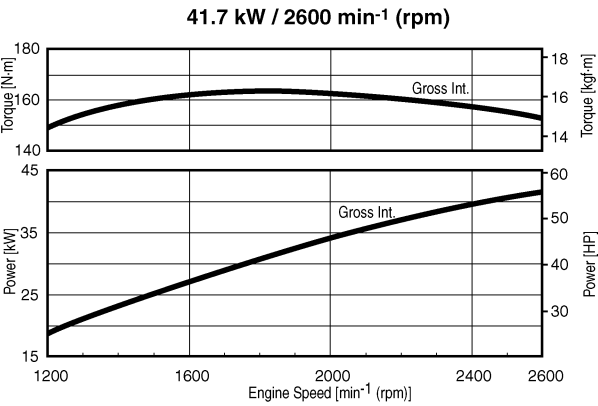
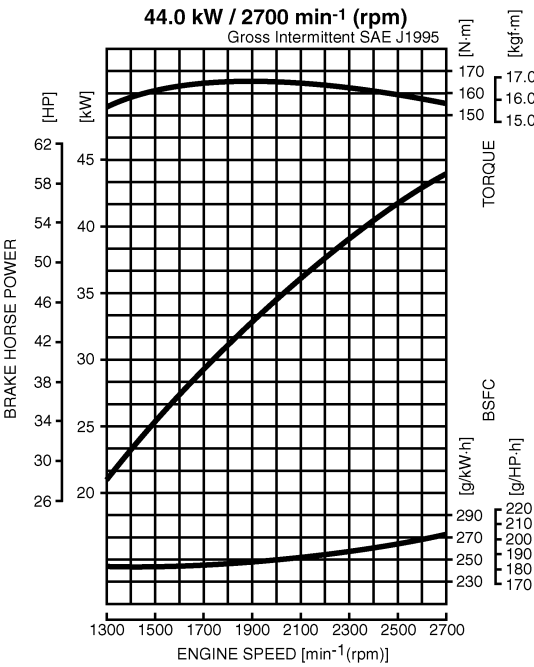
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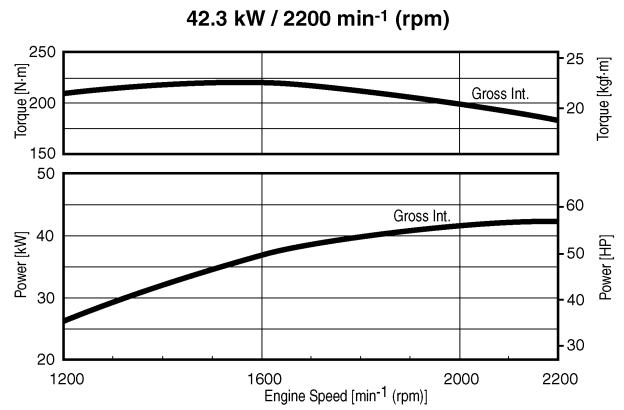
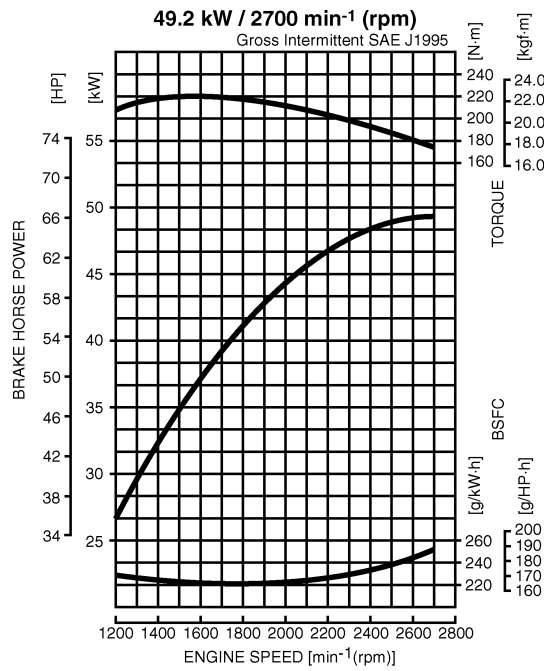
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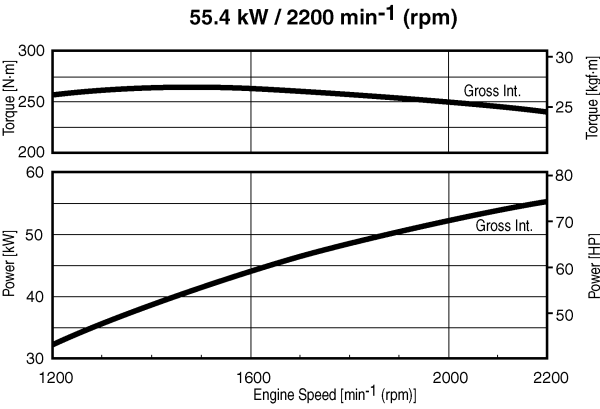
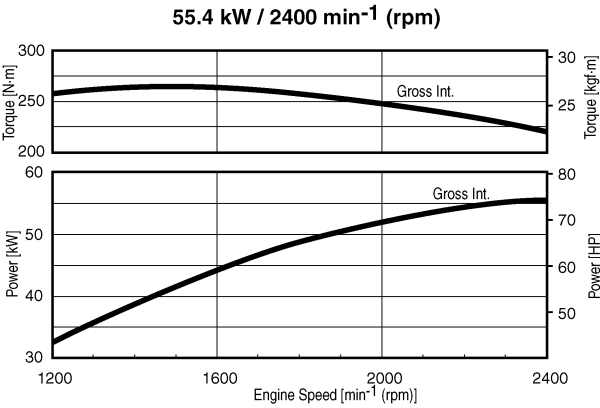
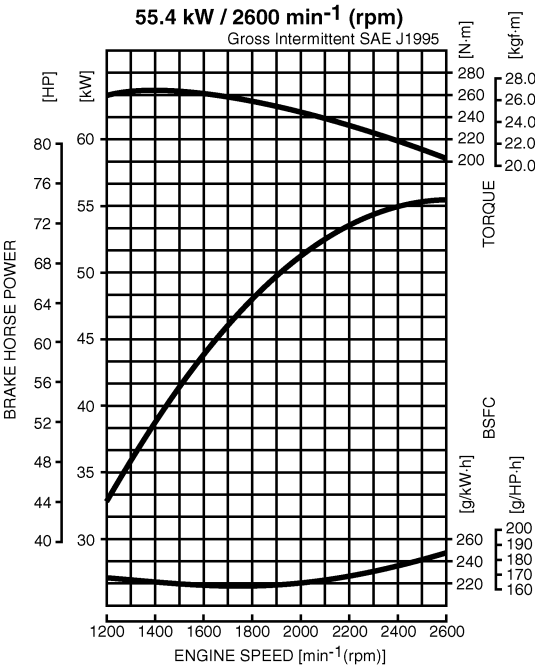
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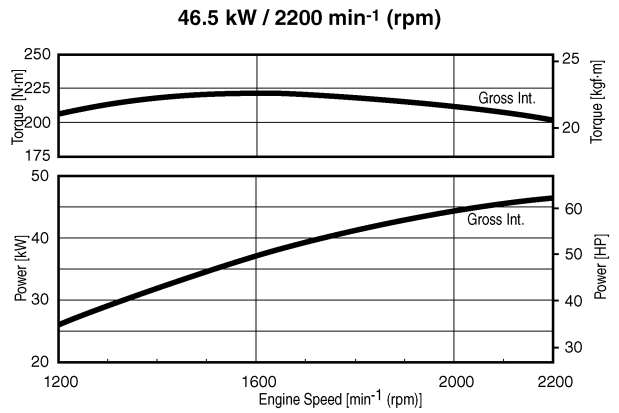
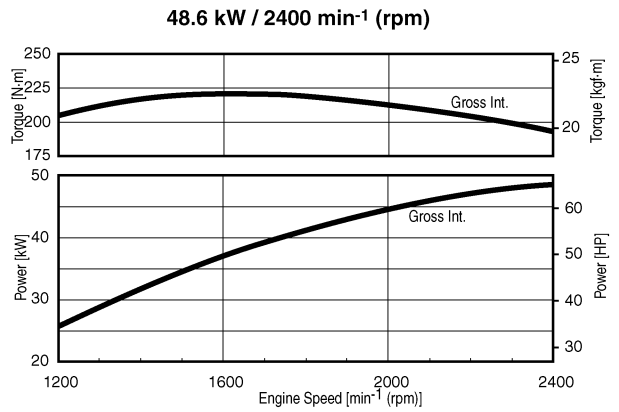
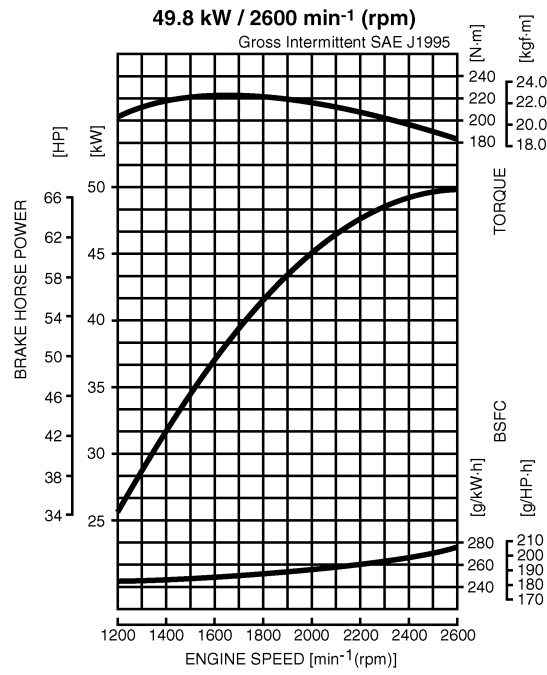
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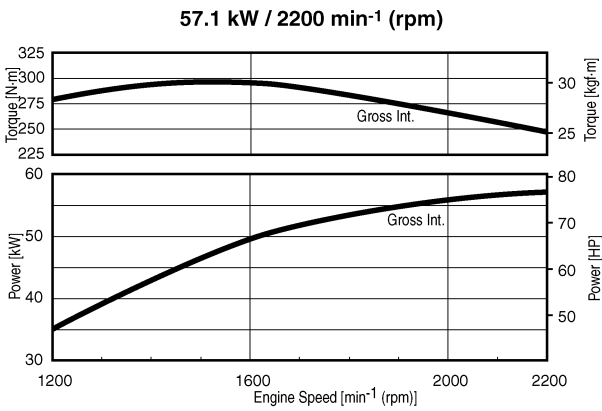
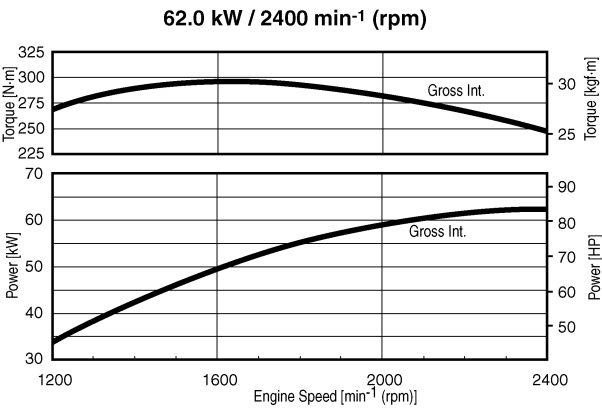
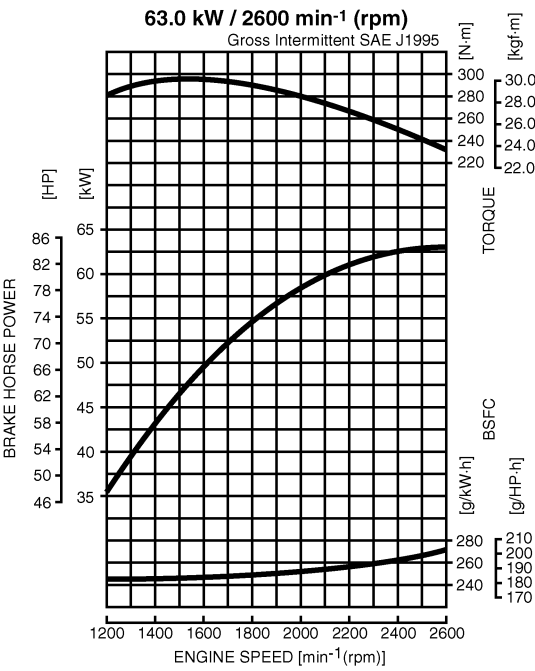
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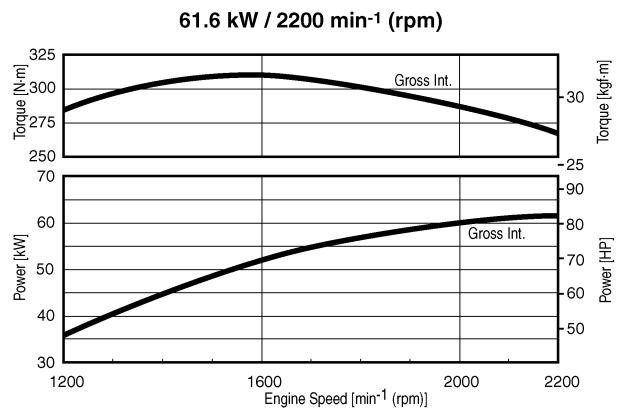
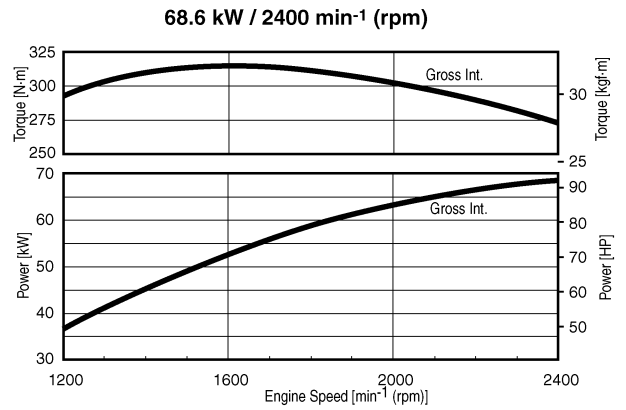
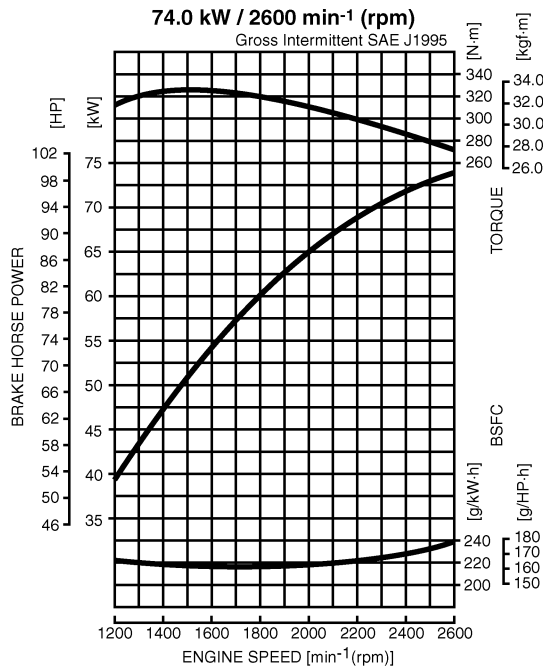
● V3600-E3



● V3600-T-E3

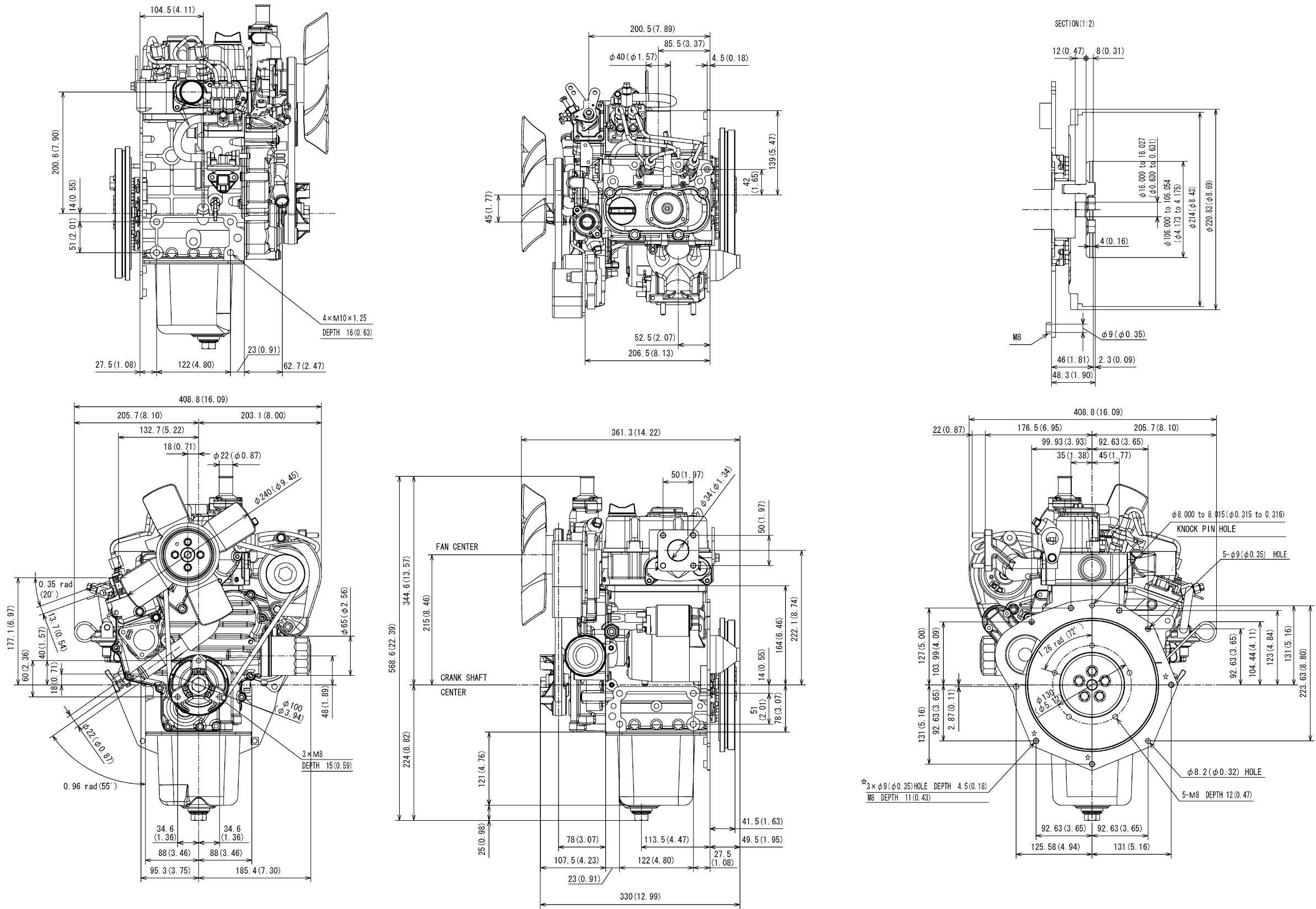


● V3800-DI-T-E3



3. DIMENSIONS
Z482-E3B-KEA-2 (1G689-00000)

Unit:mm(in.)



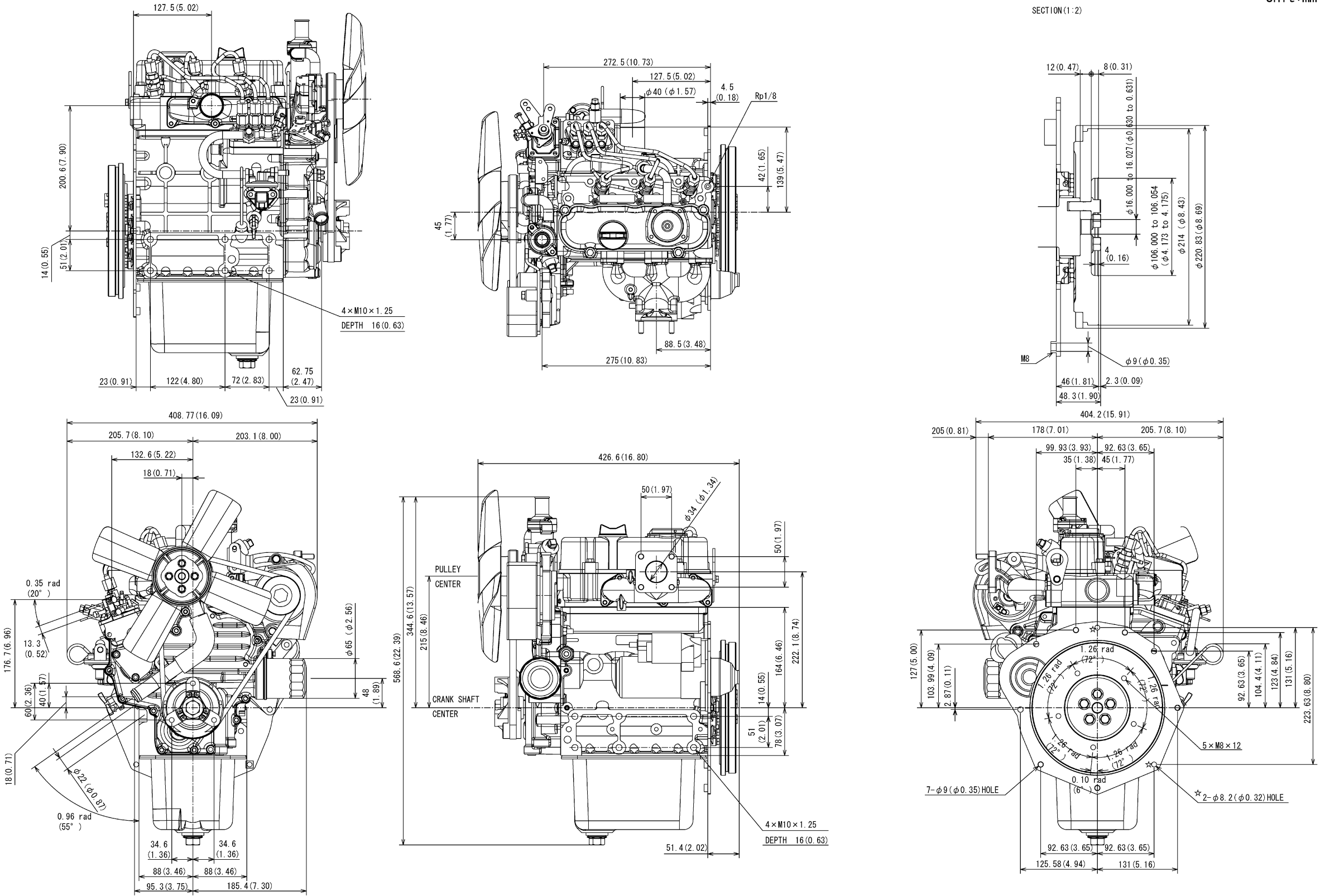
Above specifications may be changed without notice.

[illegible]

Above specifications may be changed without notice.

D722-E3B-KEA-2 (1G686-00000)

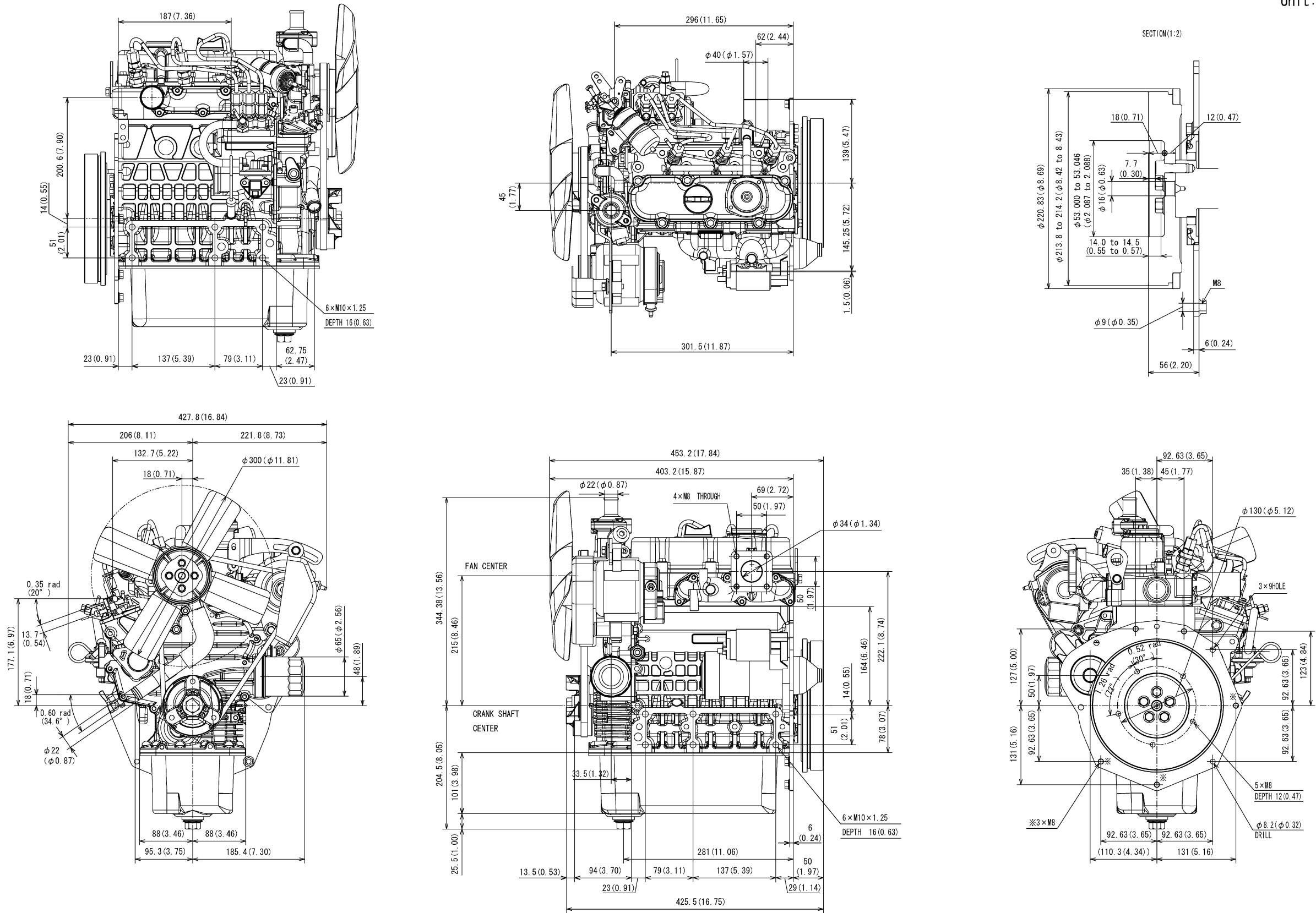
Unit:mm (in.)



Above specifications may be changed without notice.

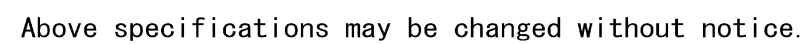
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Unit:mm (in.)

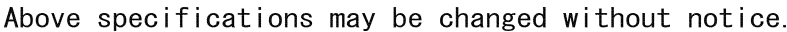


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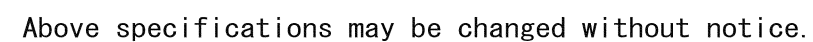
Unit:mm(in.)



Unit:mm(in.)

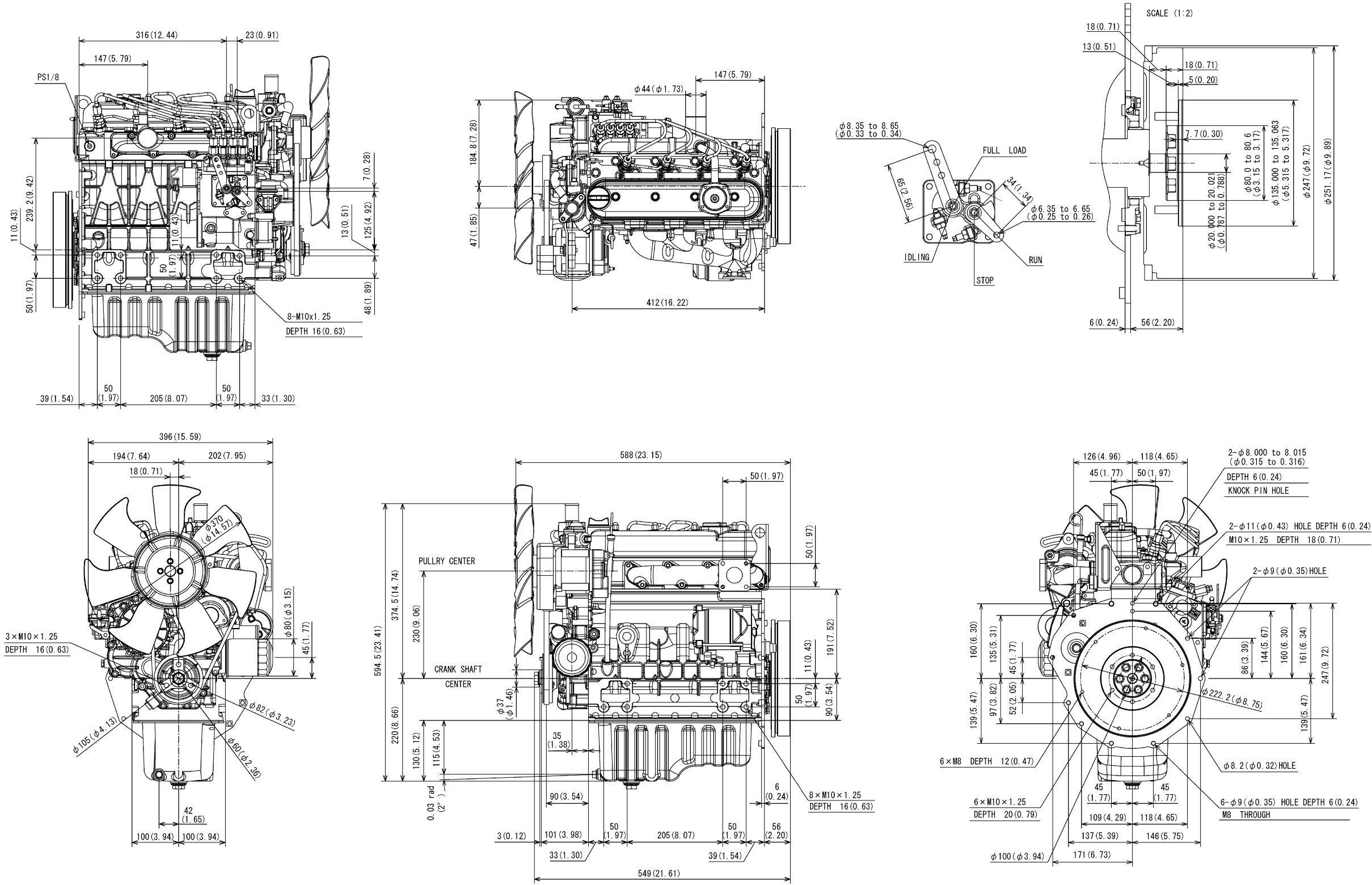


Unit:mm(in.)



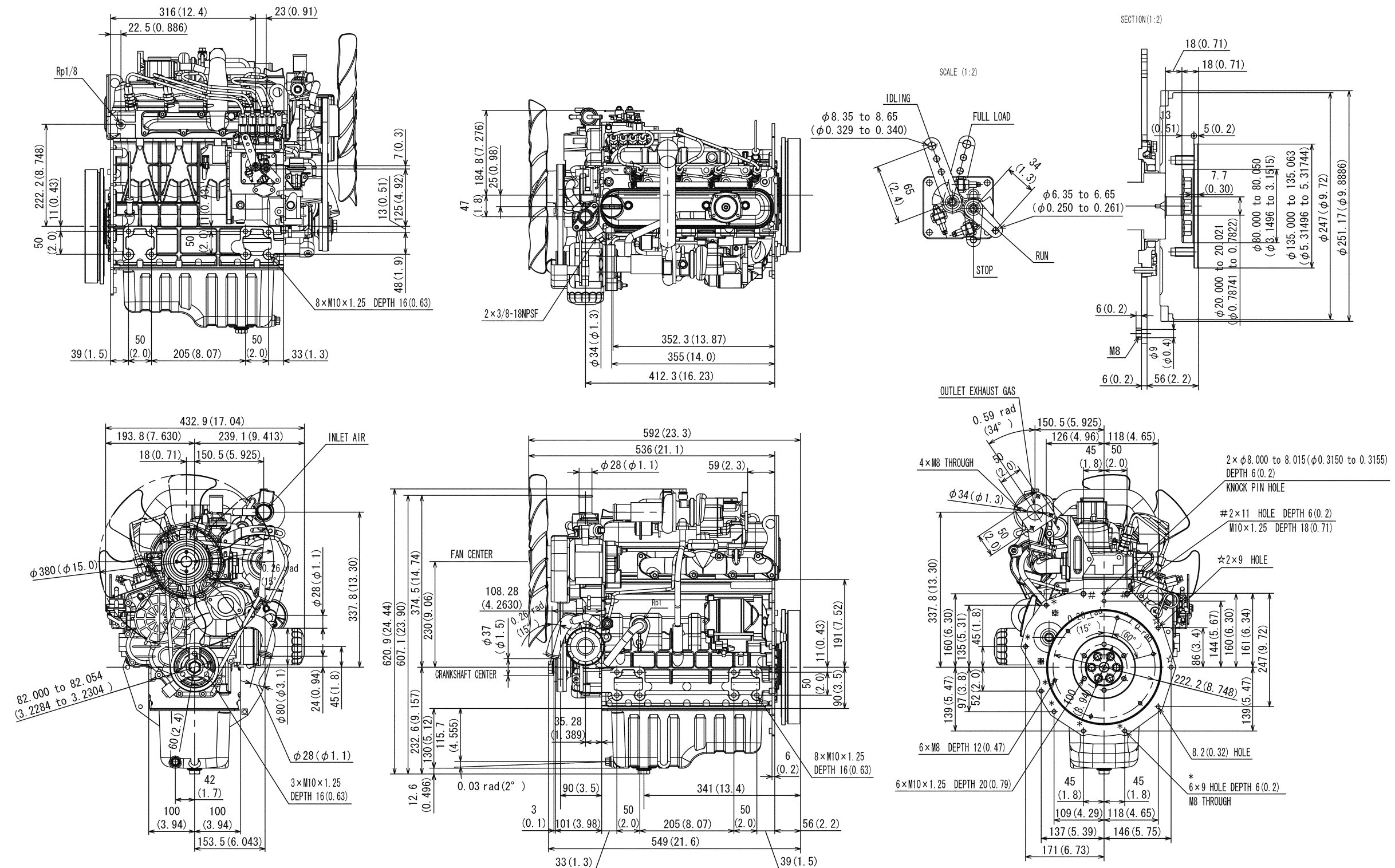
V1505-E3B-KEA-1 (1J994-00000)

Unit:mm(in.)



Above specifications may be changed without notice.

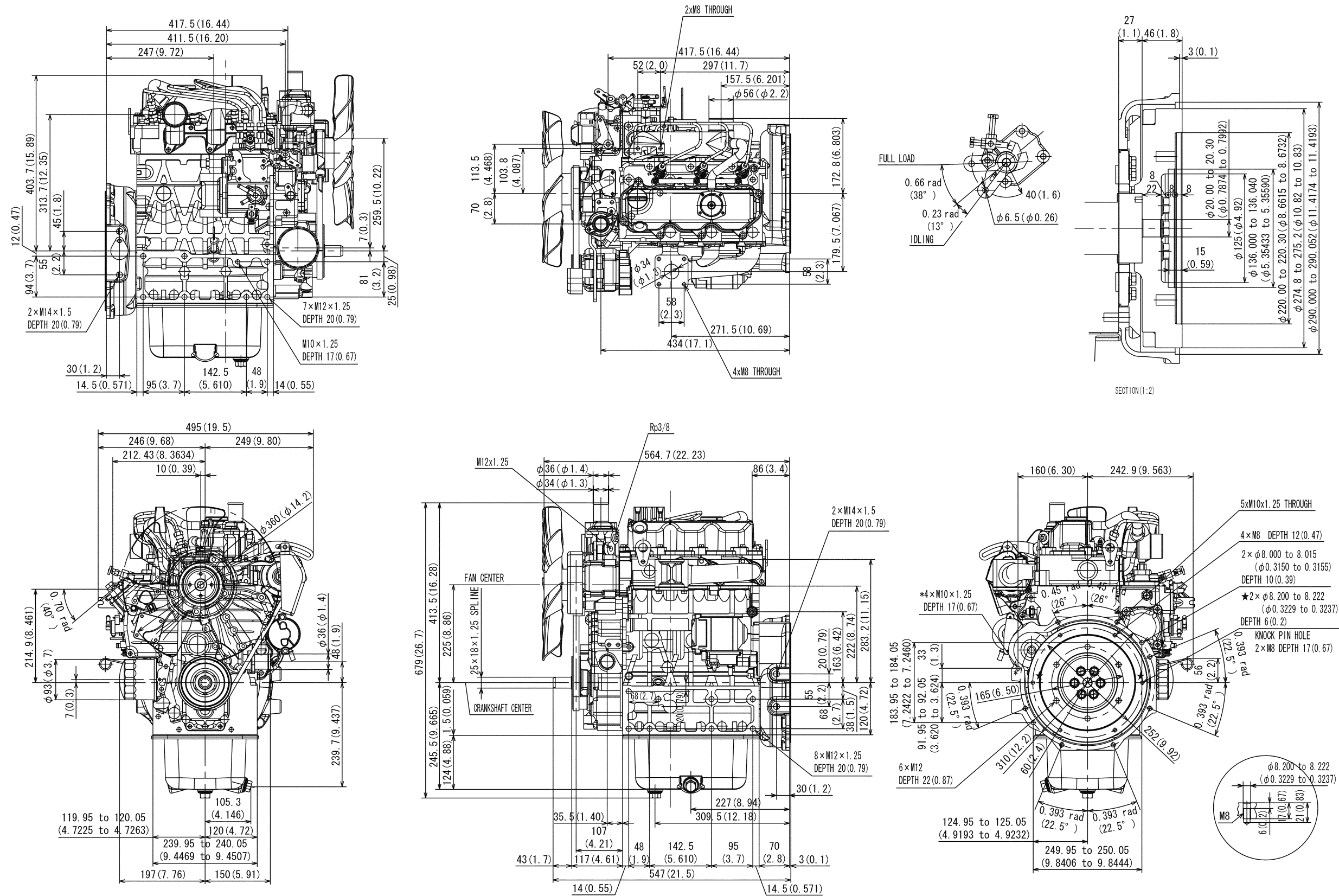
Unit:mm(in.)



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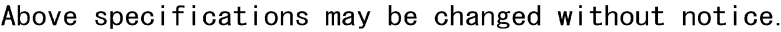
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Unit:mm(in.)

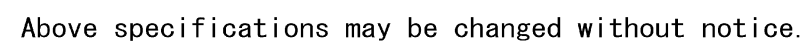


Above specifications may be changed without notice.

Unit:mm(in.)

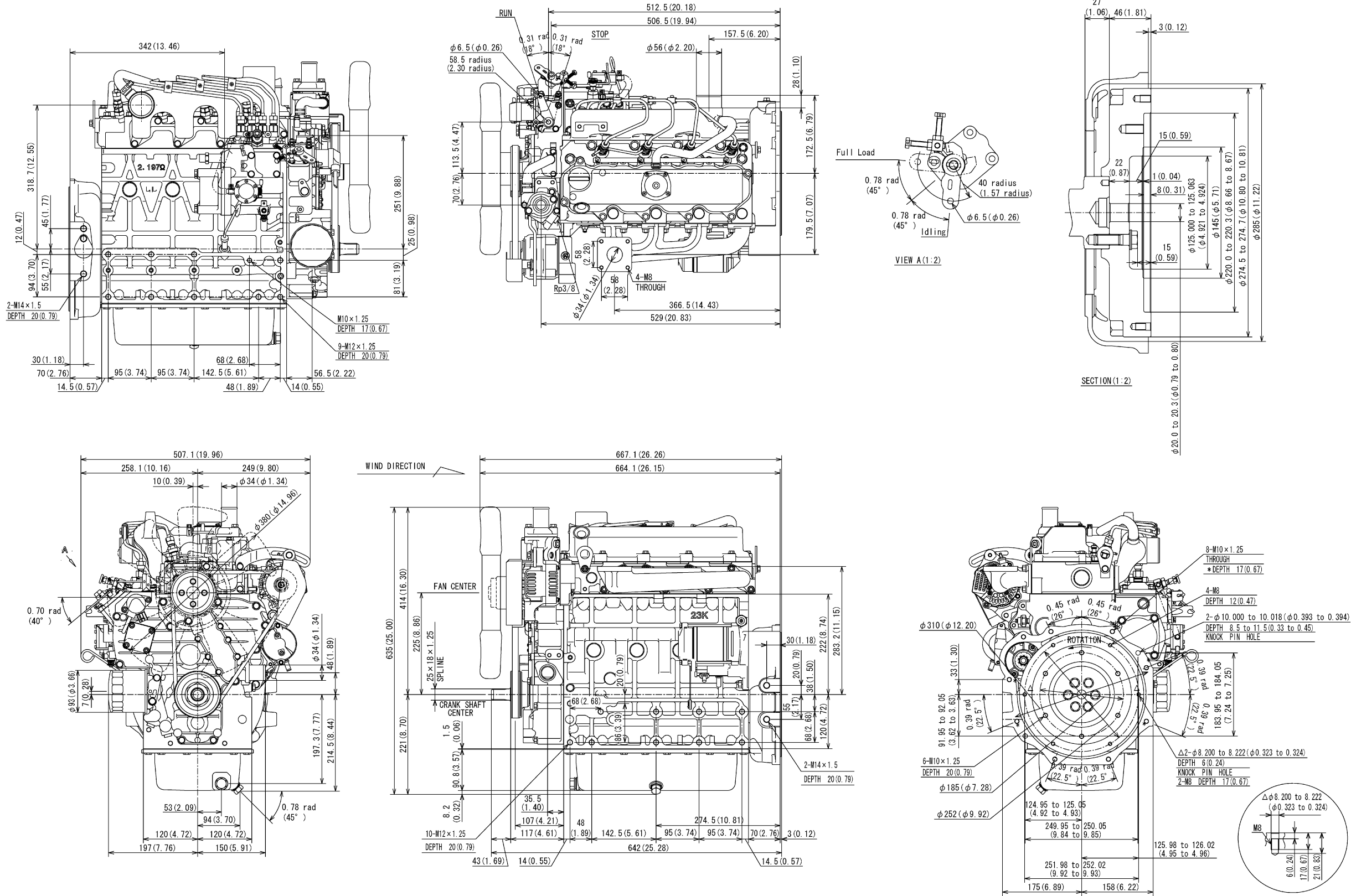


Unit:mm(in.)

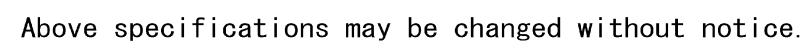


V2003-M-E3B-KEA-2 (1J464-00000), V2203-M-E3B-KEA-2 (1J465-00000)

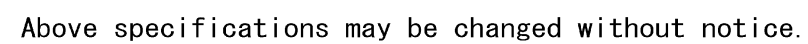
Unit:mm (in.)



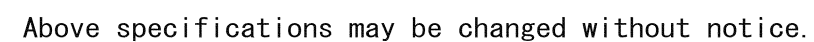
Unit:mm(in.)



Unit:mm(in.)

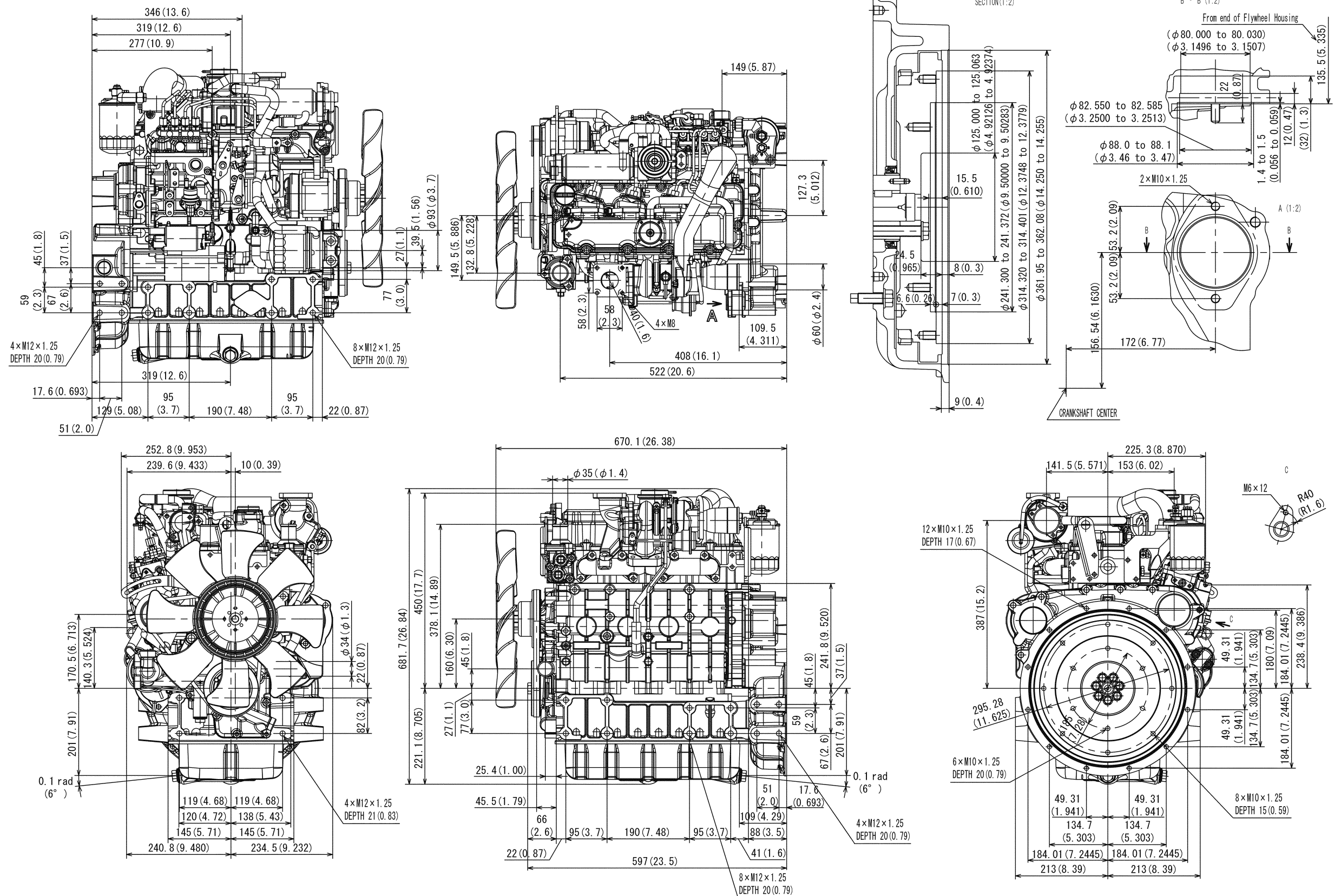


Unit:mm(in.)



V2607-DI-T-E3B-KEA-1 (1J700-10000)

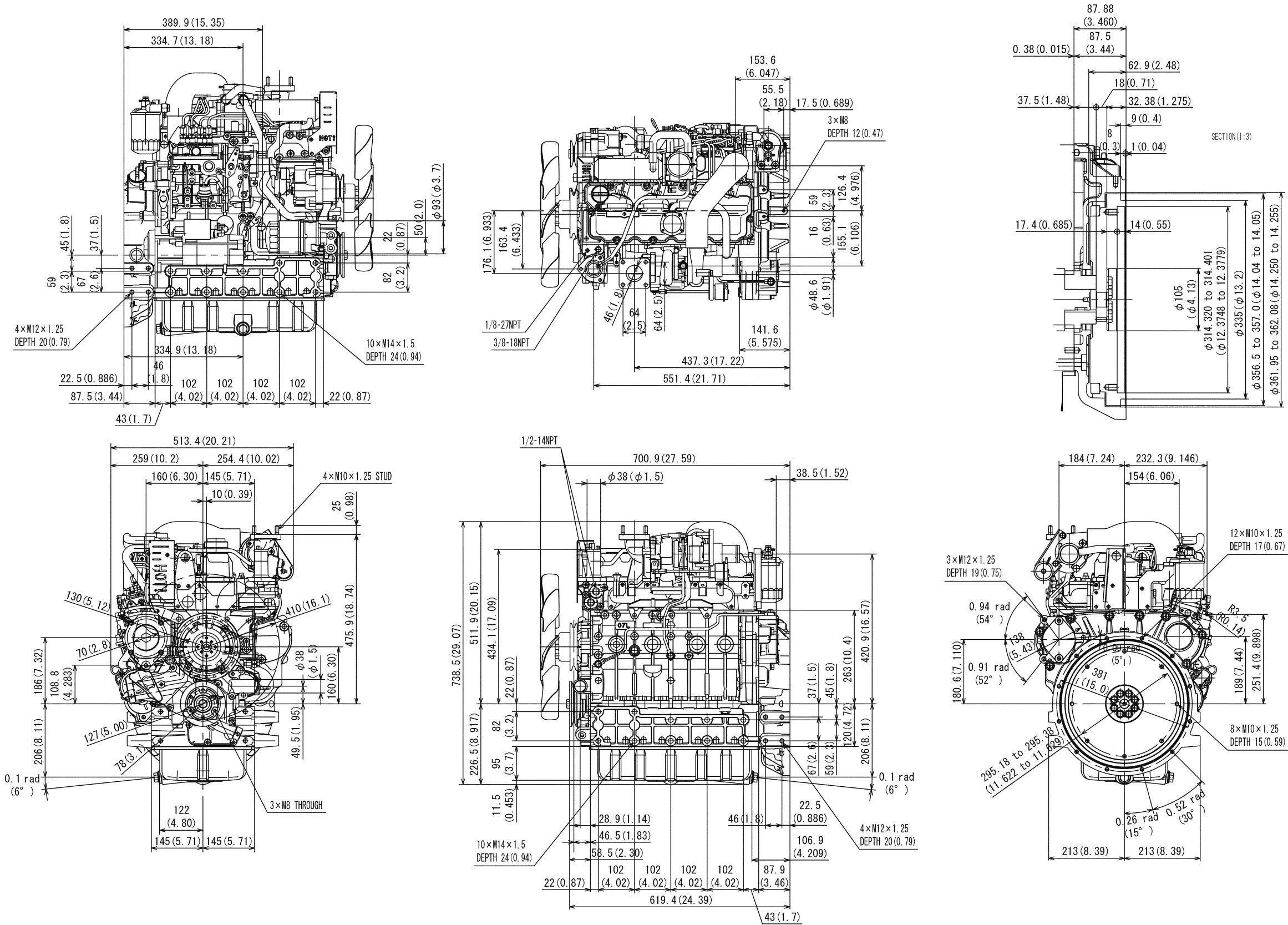
Unit:mm(in.)



Above specifications may be changed without notice.

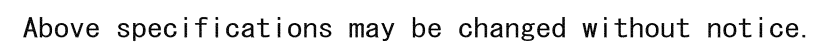
V3307-DI-T-E3B-KEA-1 (1J415-00000)

Unit:mm(in.)



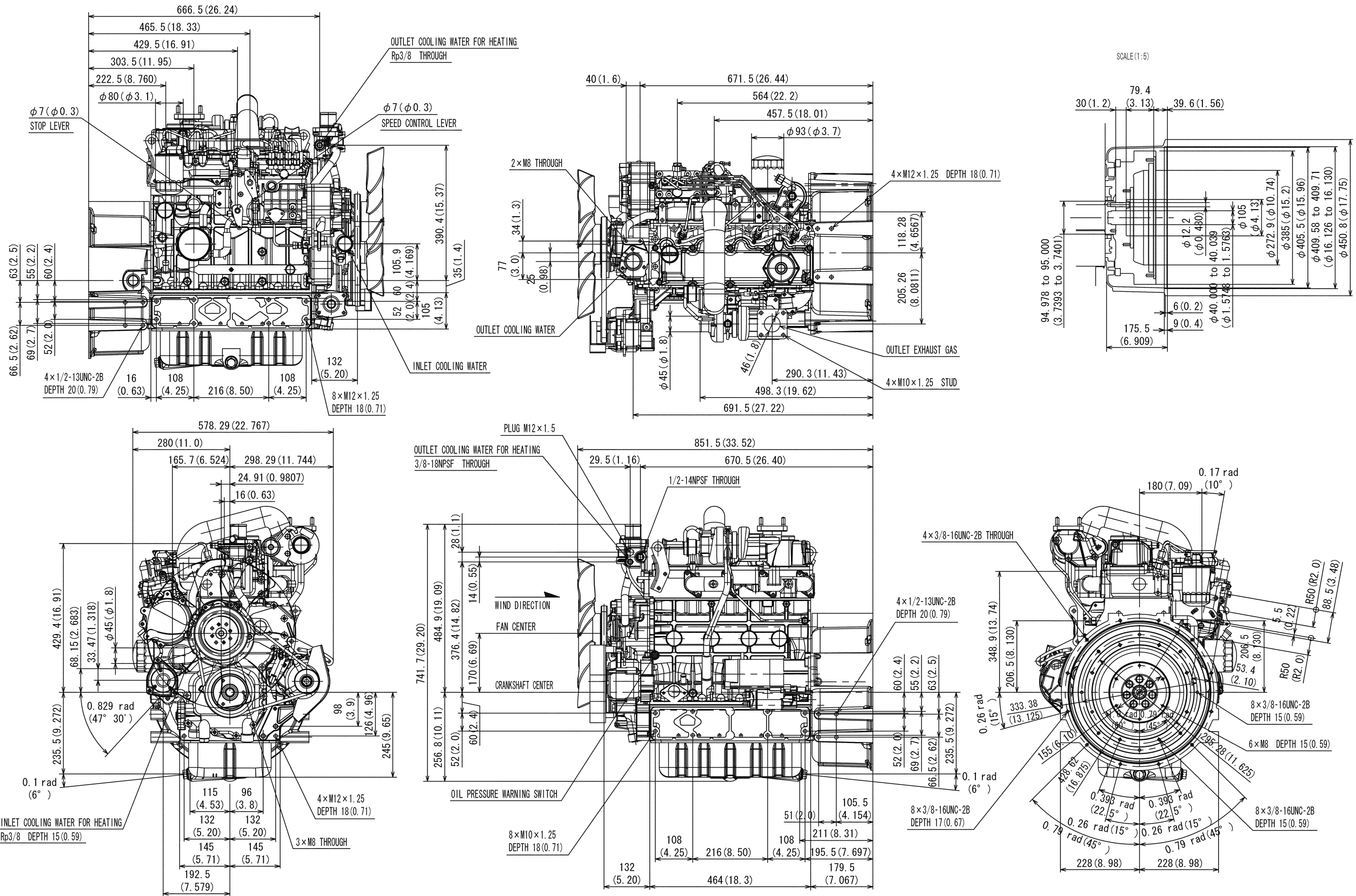
Above specifications may be changed without notice.

Unit:mm(in.)



V3600-T-E3B-KEA-2 (1J407-00000)

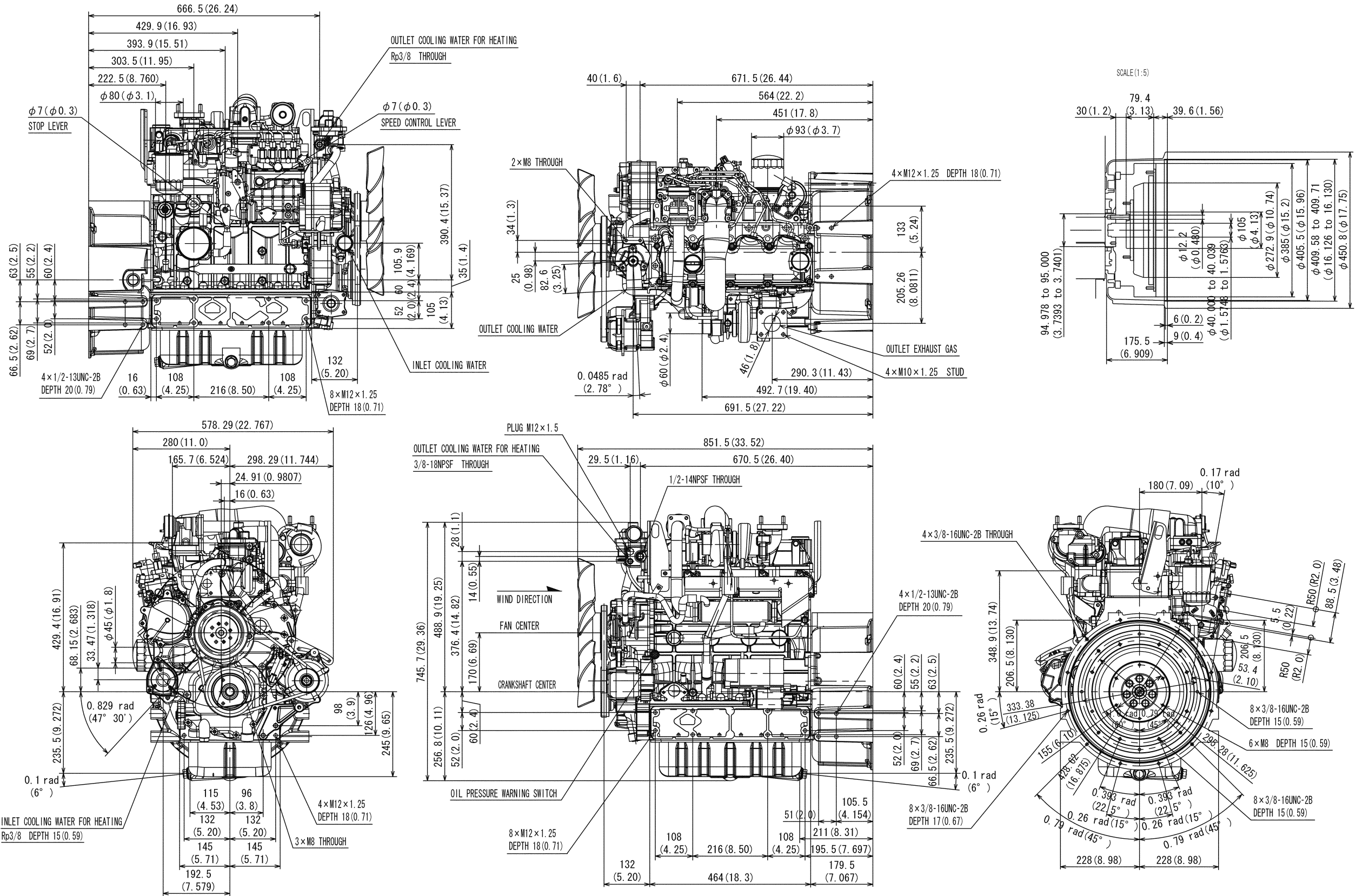
Unit:mm(in.)



Above specifications may be changed without notice.

V3800DI-T-E3B-KEA-2 (1J411-00000)

Unit:mm(in.)

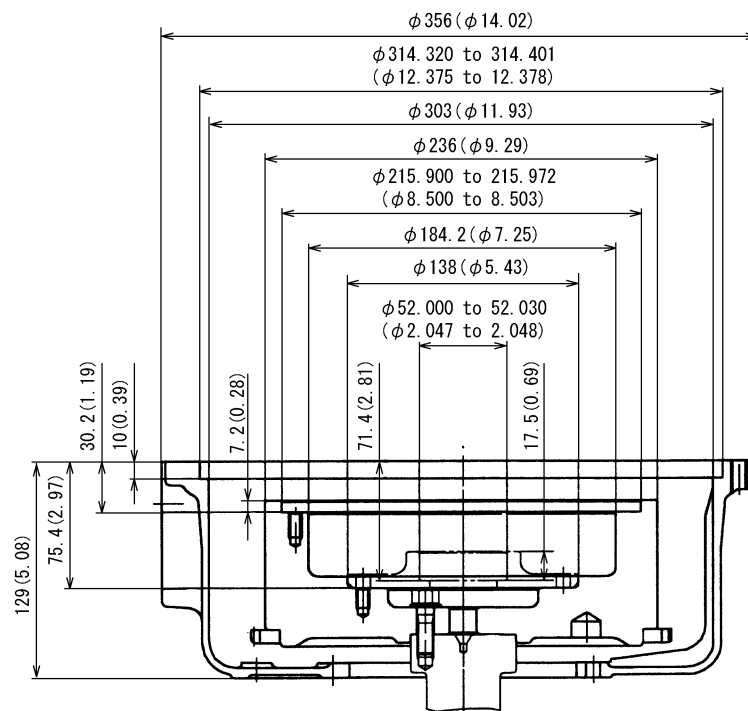


Above specifications may be changed without notice.

Flywheel Housing : Normal SAE No.5

Technical drawing of a circular mechanical part, likely a flange or end plate, showing a top view. The drawing includes concentric circles representing different diameters and radial dimensions. Key dimensions include:

- Outer diameter: 180 (7.09)
- Inner diameter: 120 (4.72)
- Intermediate diameters: $\phi 333.38$ ($\phi 13.13$), $\phi 200.02$ ($\phi 7.87$)
- Radial dimensions: 0.78 rad (45°), 0.39 rad (22.5°), 0.39 rad (22.5°)
- Thread specifications: 8-3/8-16UNC-2B DEPTH 17 (0.67), 6-5/16-18UNC-2B DEPTH 15 (0.59)
- Note: 4-M8 DEPTH 12 (0.47)



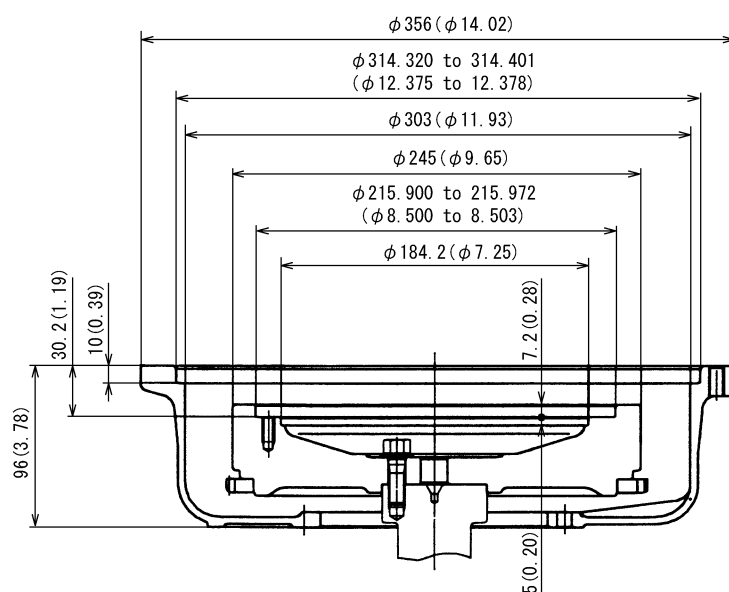
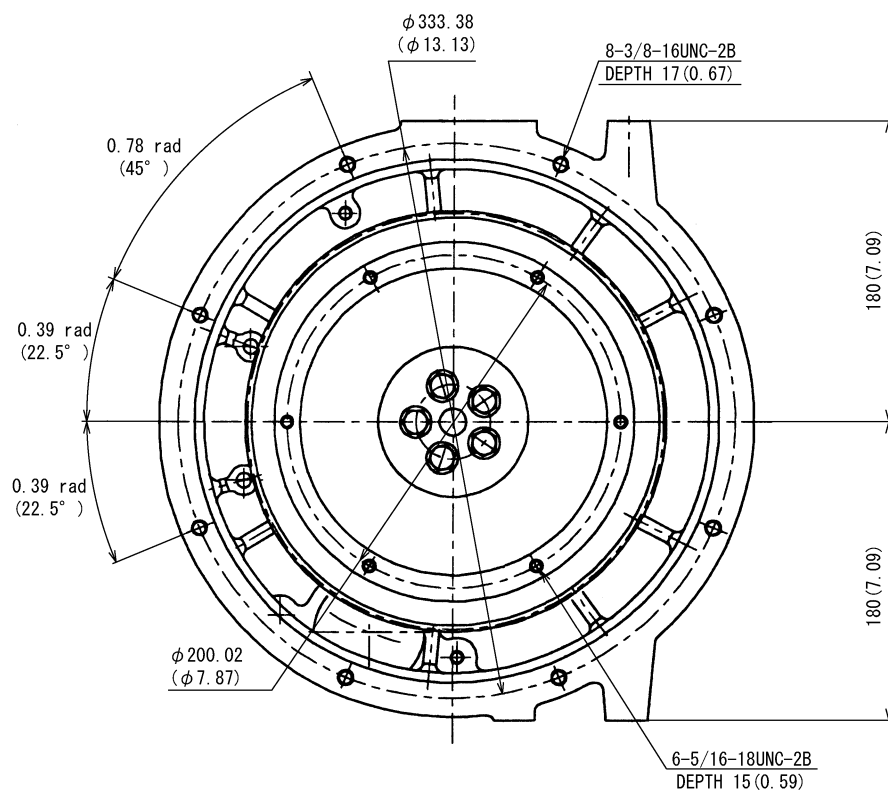
KiSS issued 09, 2009 A

S.M. Series

Flywheel : Short SAE for Clutch No.6-1/2

Flywheel Housing : Short SAE No.5

Unit:mm (in.)

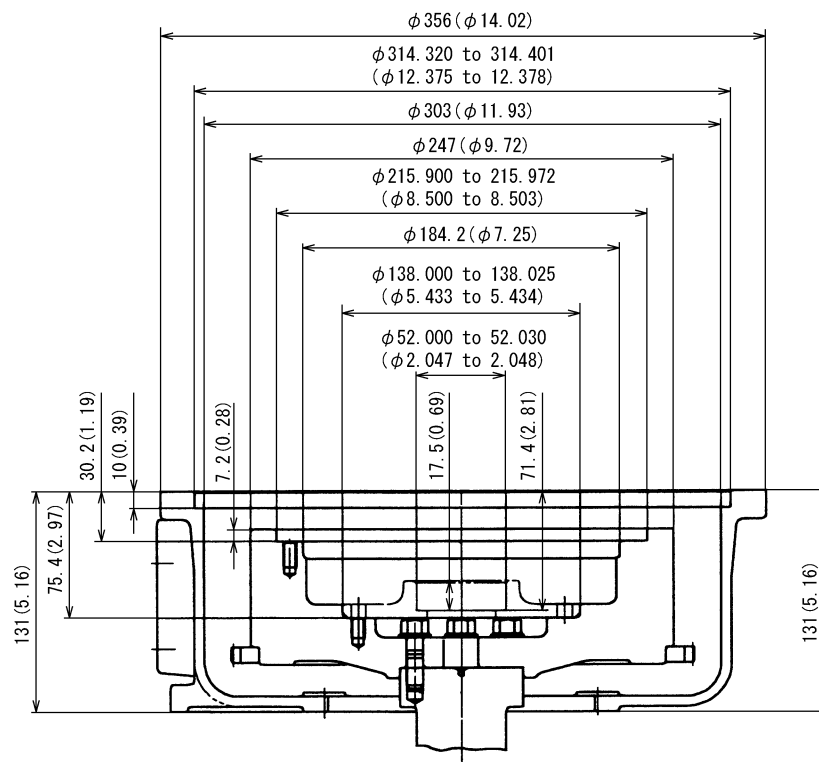
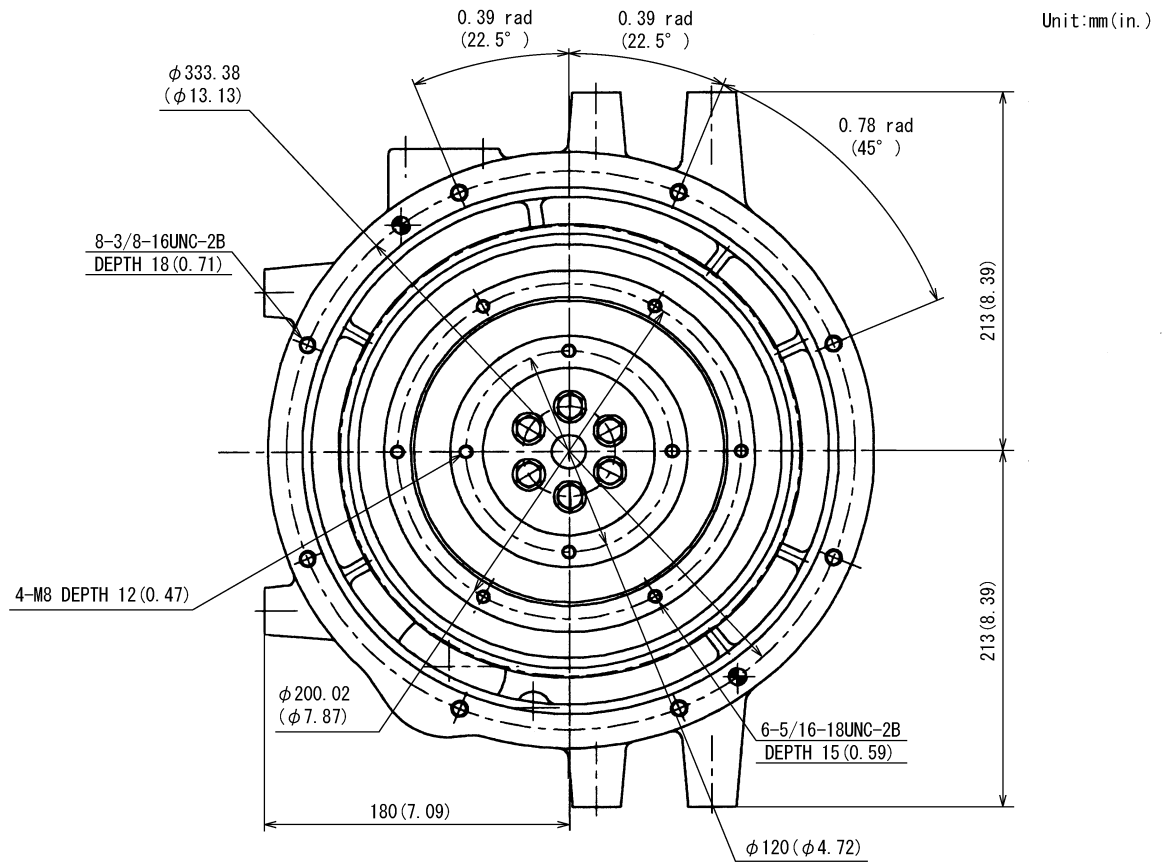


* Please refer to Kubota S.O.S Manual for further information.

05 Series

Flywheel : Normal SAE for Clutch No.6-1/2

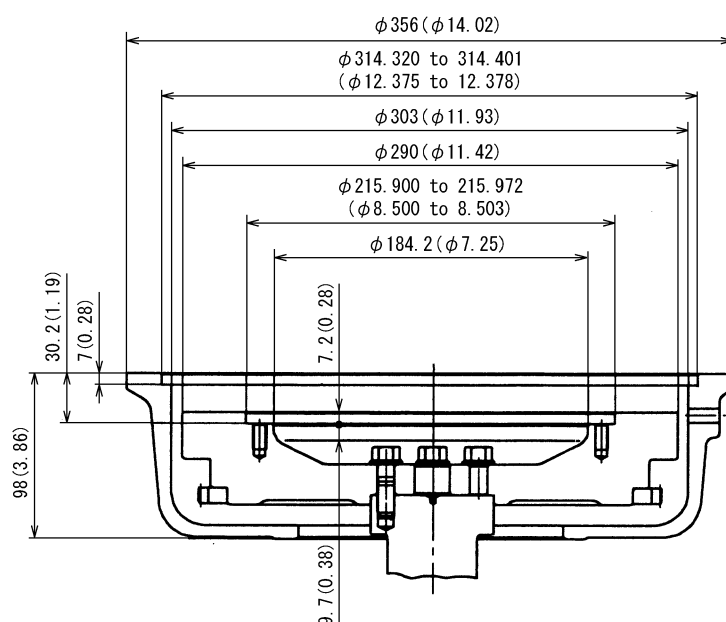
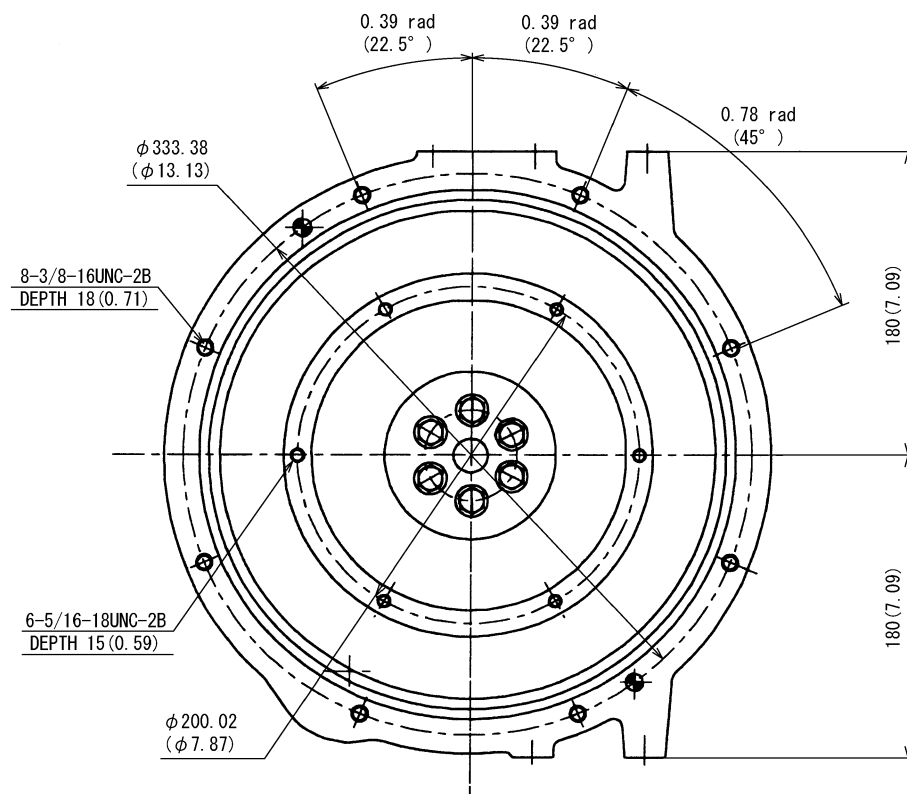
Flywheel Housing : Normal SAE No.5



* Please refer to Kubota S.O.S Manual for further information.

Flywheel Housing : Short SAE No.5

Unit:mm(in.)



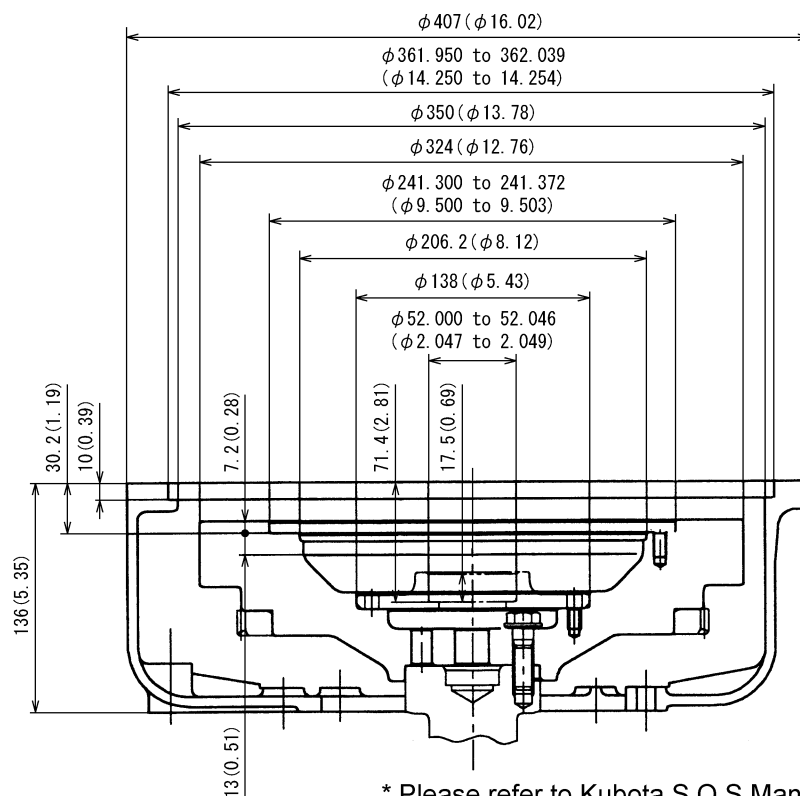
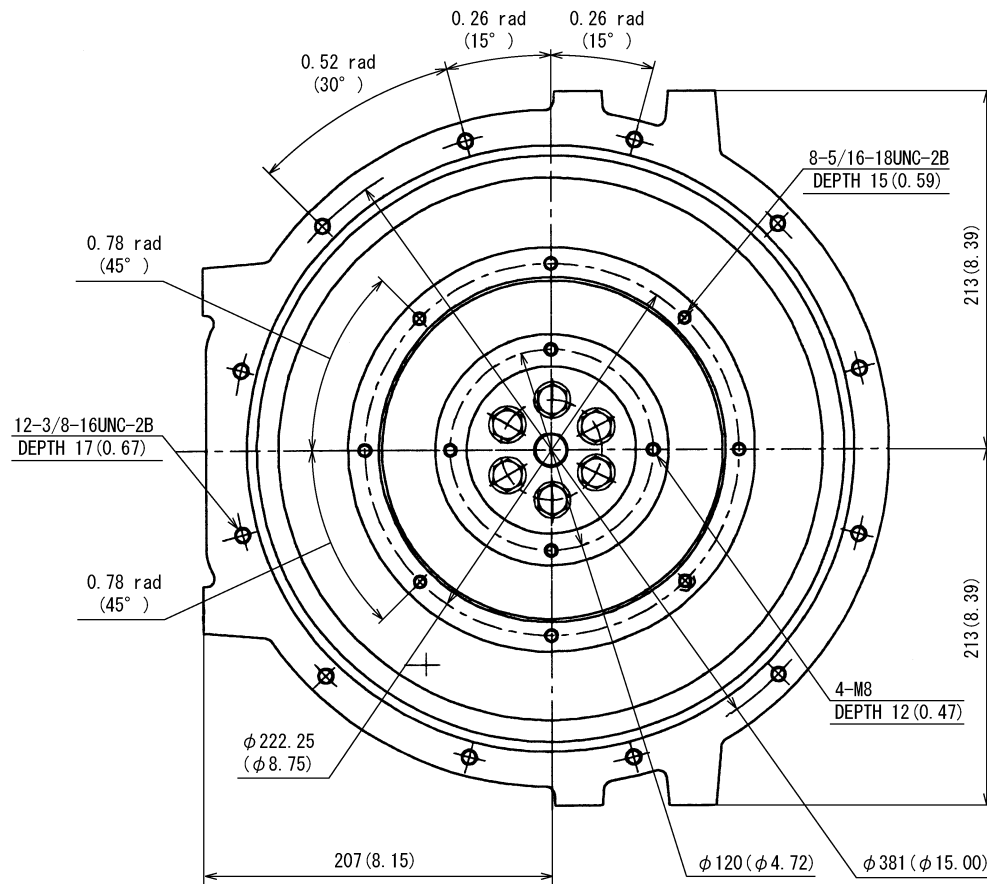
* Please refer to Kubota S.O.S Manual for further information.

03-M Series

Flywheel : Normal SAE for Clutch No.7-1/2

Flywheel Housing : Normal SAE No.4

Unit:mm(in.)



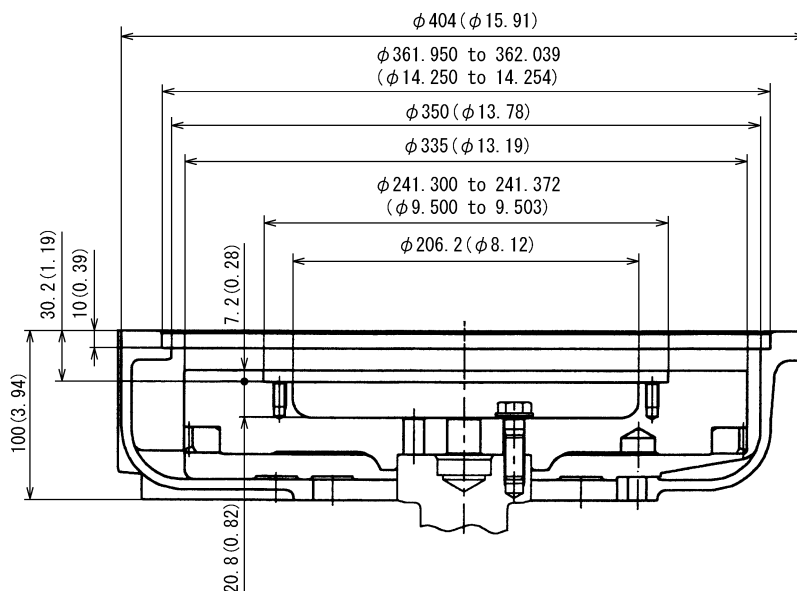
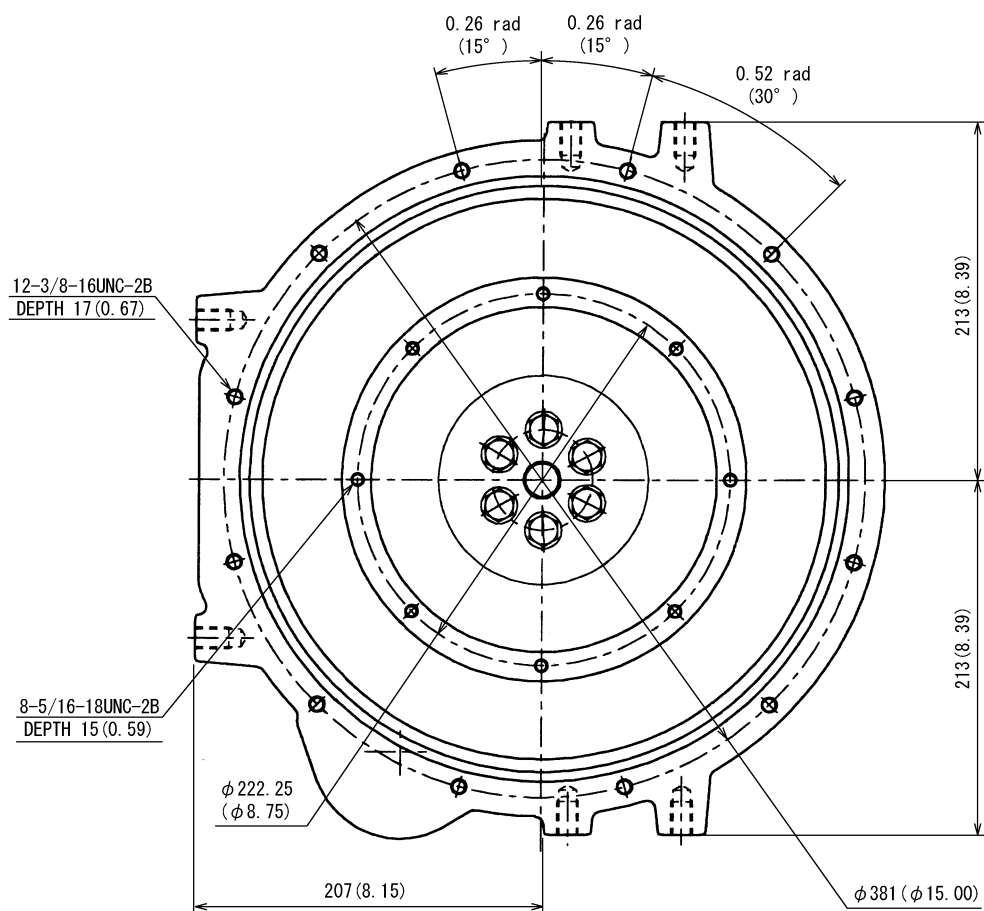
* Please refer to Kubota S.O.S Manual for further information.

03-M Series

Flywheel : Short SAE for Clutch No.7-1/2

Flywheel Housing : Short SAE No.4

Unit:mm(in.)



* Please refer to Kubota S.O.S Manual for further information.

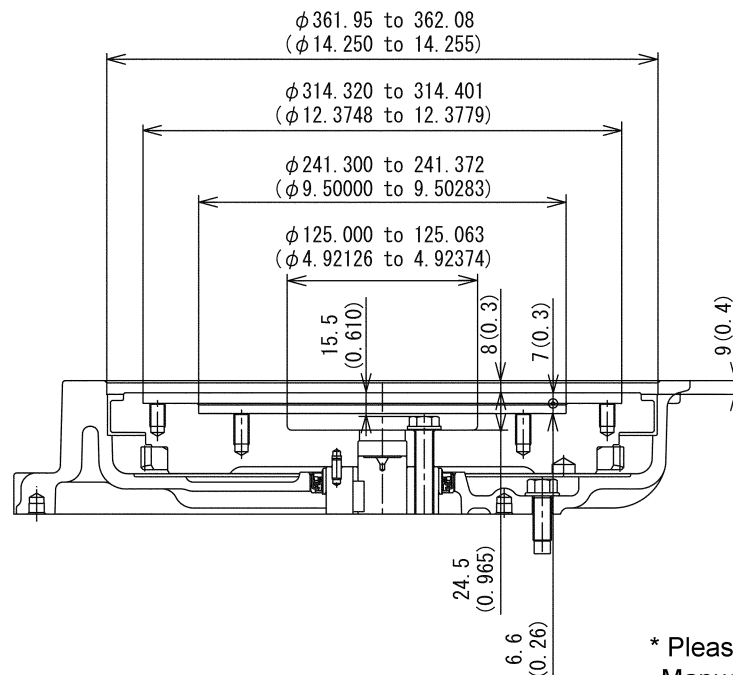
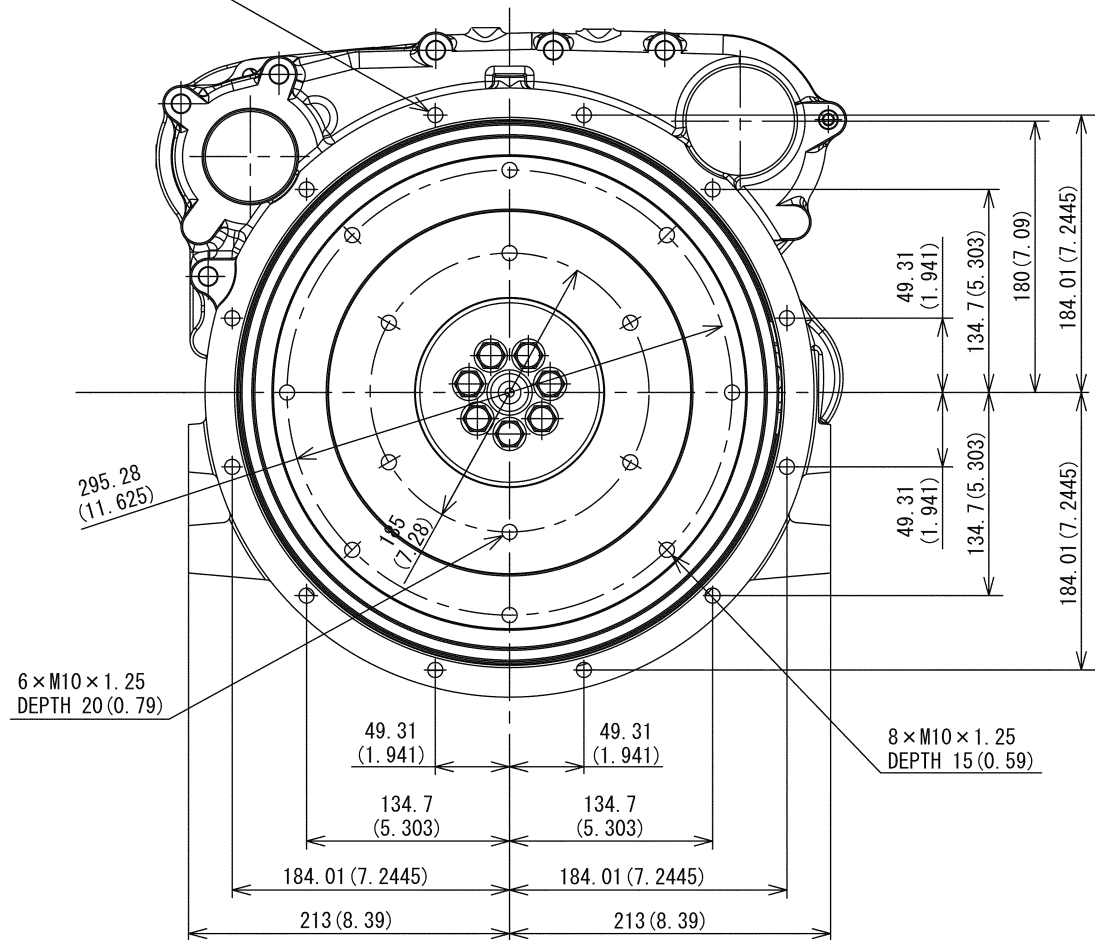
V2607-DI-T

Flywheel : Short SAE for Clutch No.10

Flywheel Housing : Short SAE No.4

12 × M10 × 1.25
DEPTH 17 (0.67)

Unit : mm (in.)



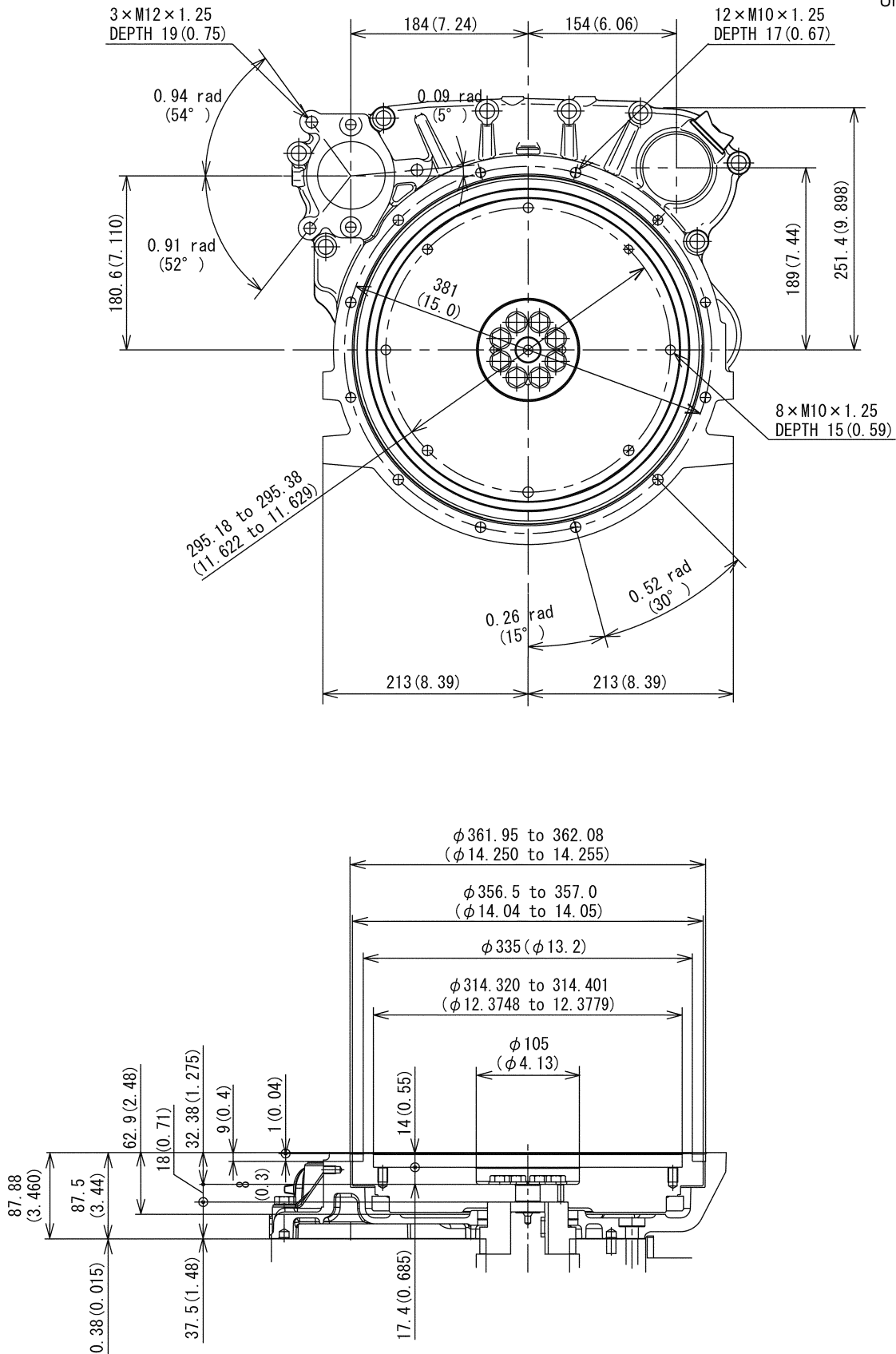
* Please refer to Kubota S.O.S
Manual for further information.

V3307-DI-T

Flywheel : Short SAE for Clutch No.10

Flywheel Housing : Short SAE No.4

Unit : mm (in.)



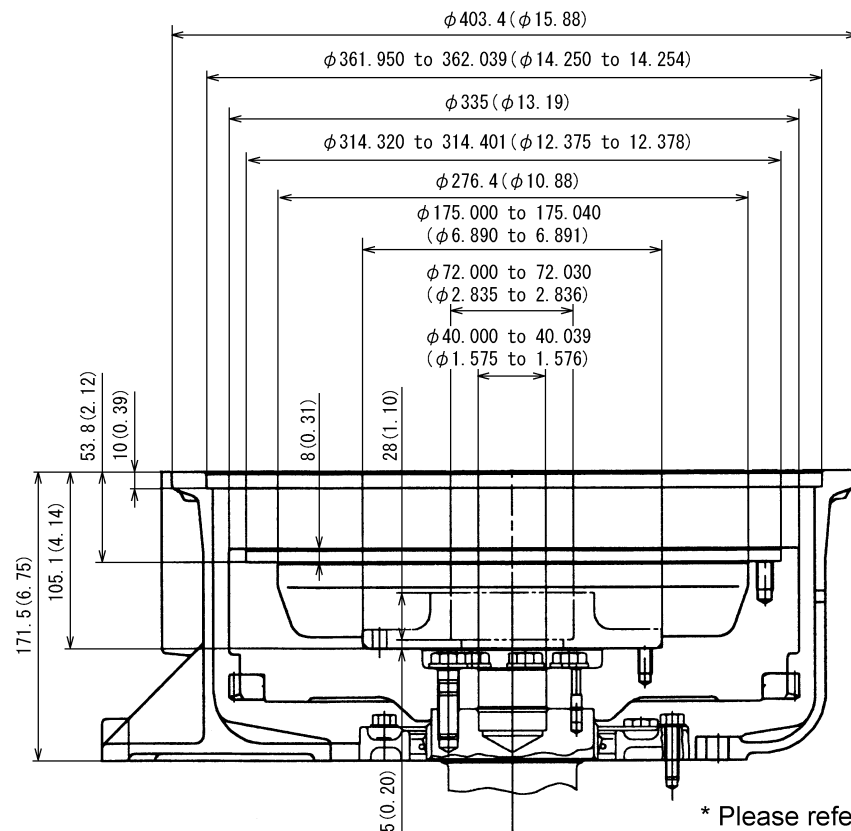
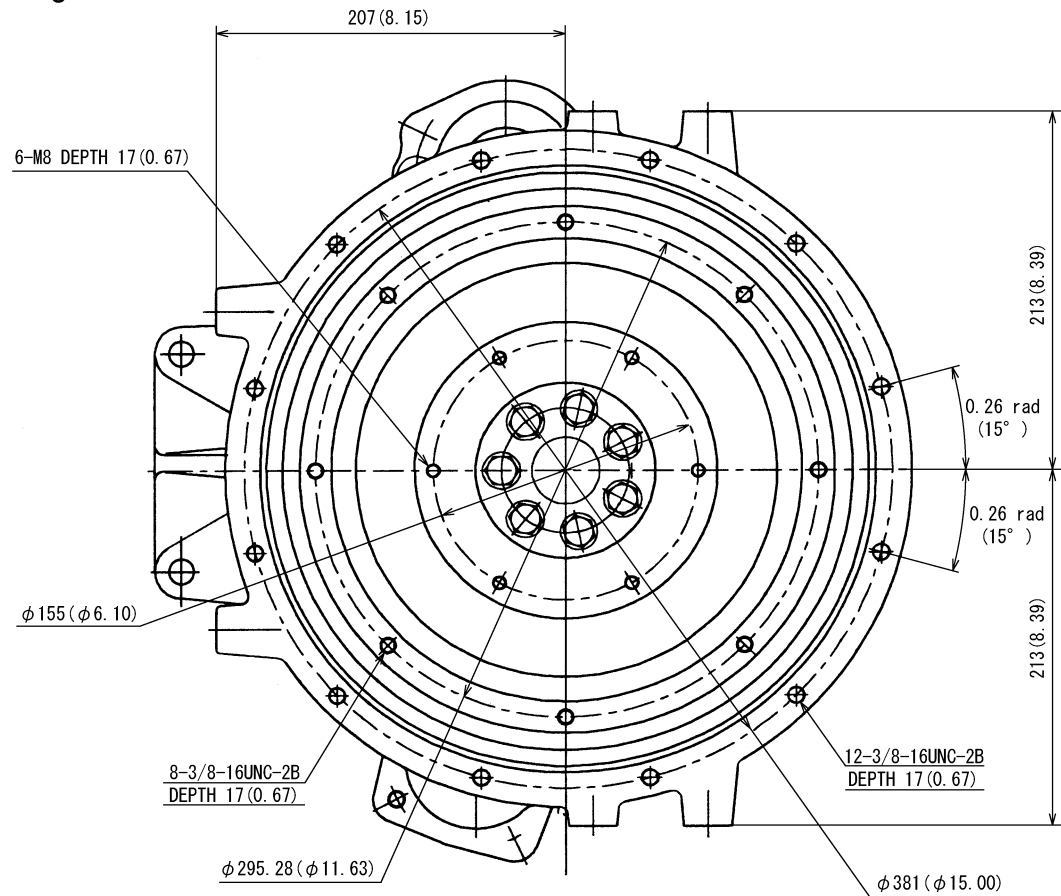
* Please refer to Kubota S.O.S Manual for further information.

V3 Series

Flywheel : Normal SAE for Clutch No.10

Flywheel Housing : Normal SAE No.4

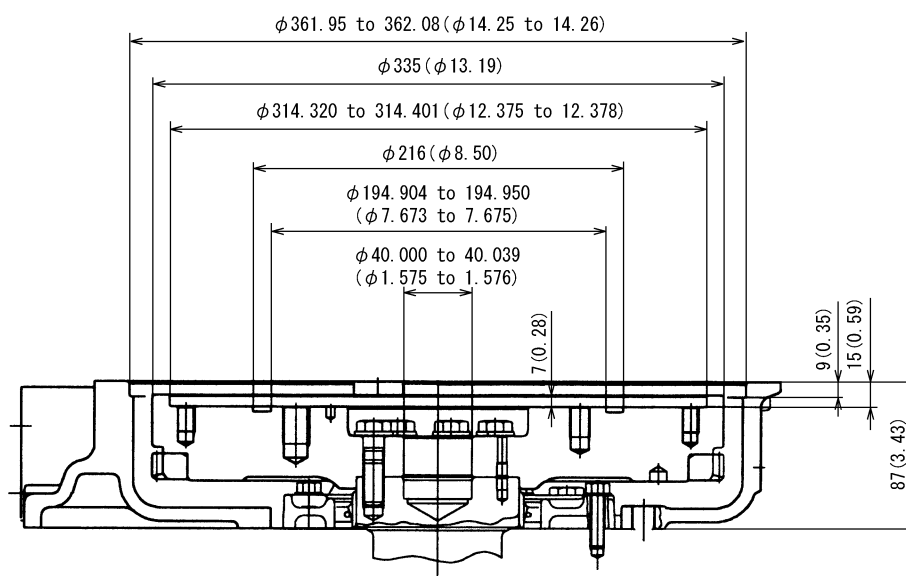
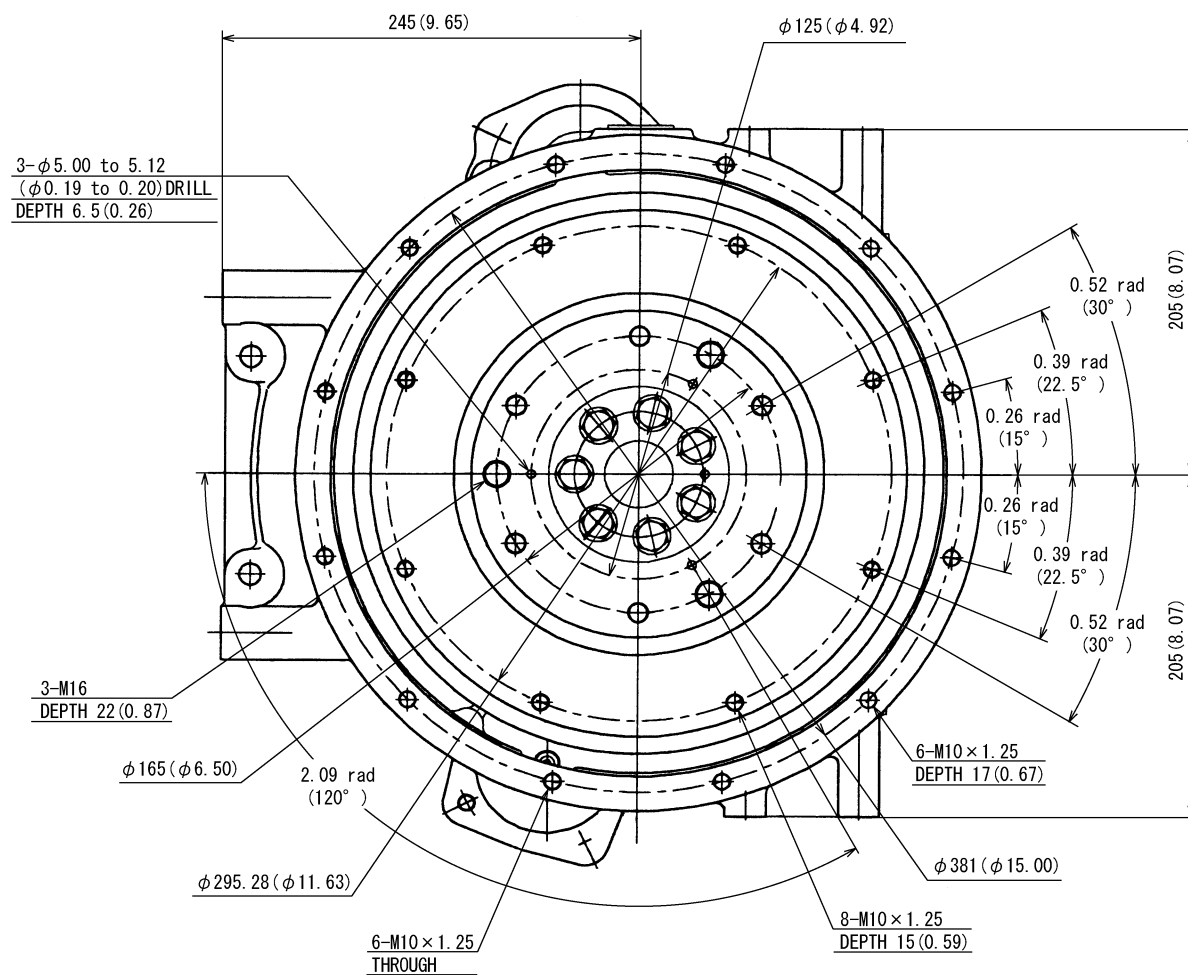
Unit:mm(in.)



* Please refer to Kubota S.O.S Manual for further information.

Flywheel Housing : Short SAE No.4

Unit:mm(in.)



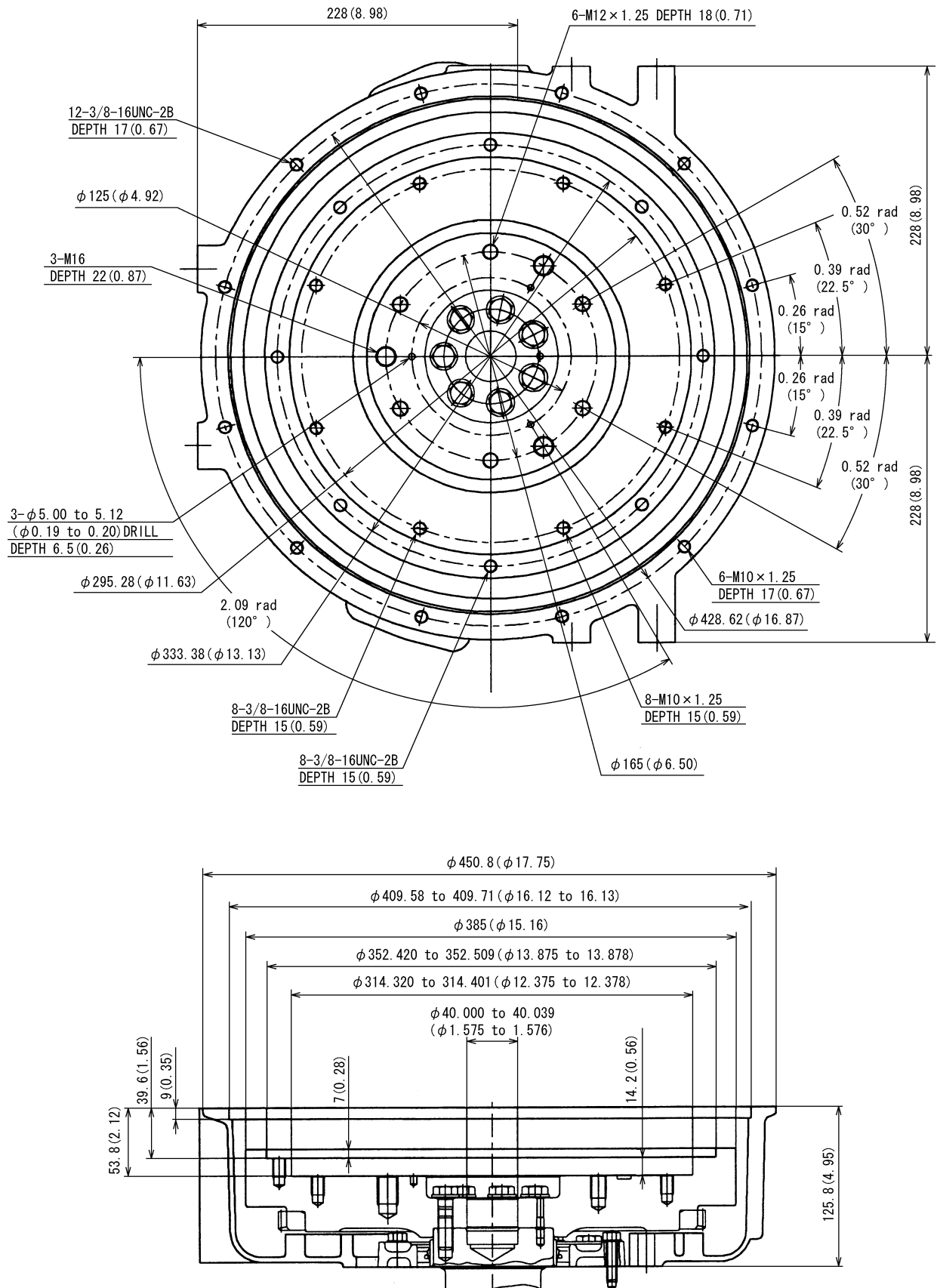
* Please refer to Kubota S.O.S Manual for further information.

V3 Series

Flywheel : Short SAE for Clutch No.10 and 11-1/2

Flywheel Housing : Short SAE No.3

Unit:mm(in.)



* Please refer to Kubota S.O.S Manual for further information.

4. ENGINE SELECTION

	Check Items	Detail of Check
1	Check the required horsepower.	1) Check whether continuous or intermittent horsepower is required. 2) Check that the engine horsepower is acceptable. (Check the engine speed at the same time.) 3) If an old engine is to be replaced. Compare the displacement (cc), horsepower (kW) and speed (rpm) with those of the new engine. If there is a substantial difference between the old and new engines, discussion will be required. 4) Remember that engine power loss is caused by high temperature or low atmospheric pressure.
2	Check the temperature requirement for cold starting. (Check that the cold start limit is acceptable.)	1) Check the minimum expected temperature. 2) Check the battery capacity and wire size. 3) Check whether or not the hydraulic pump and other devices apply a load when the engine starts.
3	Check the maximum required operating temperature. (Check the cooling capacity.)	1) Check the maximum expected temperature. 2) Check that the engine cooling capacity is adequate for the above temperature. (Request the customer to conduct a test under the most unfavorable operating conditions.) 3) Check the following engine installation condition; ☆Check that the engine is enclosed. ☆Check for heat sources (Such as the oil cooler and exhaust silencer) around the radiator. 4) If the cooling capacity is insufficient, correct the cooling air flow. Further, devise countermeasures, such as employment of large radiator or large fan, and increasing of fan speed. However, there is a case that changing the specification of the fan may not necessarily result in the improvement of cooling performance, since it will increase the load of the engine. Note : The cooling capacity checking methods are shown below. (1) Air-to-boil test (2) Temperature measuring test
4	Check the inclination	Check the maximum inclination.
5	Application check of emission regulations	1) Is it required to use the engine that has cleared the emission regulation? 2) In case that a conforming engine is required, confirm the kind of the applicable emission regulation, and that the relevant engine is the type that has complied with the applicable emission regulation.

1. EMISSION REGULATION

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EMISSION REGULATION

1. GENERAL

This version of Application Manual is edited for the purpose of performing the application with KUBOTA E3 Diesel Engines, which are designed for the compliance of the current emission regulations implemented in the North America and/or Europe. For the selection of Engines to comply with the emission regulation in the area other than North America or Europe, please refer the following information.

<The current Emission Regulation implemented in each region/country> P : Power

Region / Country	kW	Regulation
North America	$0 \leq P < 19$	Tier 4
	$19 \leq P < 56$	Interim Tier 4
	$56 \leq P < 75$	Tier 3
EU	$19 \leq P < 75$	Stage IIIA
JPN (MOT and MOE)	$19 \leq P < 75$	2007 / 2008 Regulation
JPN (MILT)	$8 \leq P < 75$	3rd Step
JPN (LEMA)	$0 \leq P < 19$	Tier 2
China	$0 \leq P < 75$	Tier 1
KOREA	$19 \leq P < 75$	Tier 3
INDIA (Gen Set)	$0 \leq P < 75$	Stage 2
INDIA (Construction)	$0 \leq P < 75$	Bharat Stage II

*As for the actual certification acquisition, please confirm with KUBOTA of the applicable Engine Model, especially in the area other than North America or EU.

Along with E3 models, E2 models are yet available to be used in the following countries per output category.

kW	Type	North America	Europe	Japan	China
$P < 19$	E3	Y	Y	Y	Y
	E2	N	Y	N	Y
$19 \leq P < 37$	E3	Y(-2012)	Y	Y(-2012)	Y
	E2	N	Y	N	Y
$37 \leq P < 56$	E3	Y(-2012)	Y(-2012)	Y(-2012)	Y/N
	E2	N	N	N	Y
$56 \leq P < 75$	E3	Y(-2011)	Y(-2011)	Y(-2011)	Y/N
	E2	N	N	N	Y

kW	Type	Korea	India	
			Gen Set	Construction
$P < 19$	E3	Y	(Y)	Y
	E2	Y	N	Y
$19 \leq P < 37$	E3	Y	Y	Y
	E2	N	N	Y
$37 \leq P < 56$	E3	Y	Y	Y
	E2	N	N	N
$56 \leq P < 75$	E3	Y	(Y)	Y
	E2	N	N	N

*As for the actual certification acquisition with E2 / E3 Models, again, please confirm with KUBOTA of the applicable Engine Model, especially in the area other than North America or EU.

*Y/N in China means that KUBOTA has acquired the certification for the limited E3 Models. Please consult with KUBOTA for more detailed information.

*(Y) in Gen Set of India means that the emission performance will be changes by output setting of this range. Please consult with KUBOTA for more detailed information.

2. CURRENT AND FUTURE EMISSION REGULATIONS

[1] CURRENT AND FUTURE EMISSION REGULATIONS ON USA

US EPA 40 CFR Part 1039 (June 29, 2004) Production Date

() Note : (NOx + NMHC / CO / PM) or (NOx / HC / CO / PM) Unit : g/kWh

Model Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0 kW < P < 8 kW						Tier 4 (7.5 / 8.0 / 0.40*)					
8 kW ≤ P < 19 kW						Tier 4 (7.5 / 6.6 / 0.40)					
19 kW ≤ P < 37 kW					Interim Tier 4 (7.5 / 5.5 / 0.30)			Tier 4 (4.7 / 5.5 / 0.03)			
37 kW ≤ P < 56 kW					Interim Tier 4 (4.7 / 5.0 / 0.30) (Option #1)			Tier 4 (4.7 / 5.0 / 0.03) (Option #2)			
					Tier 3 (4.7 / 5.0 / 0.40)						
56 kW ≤ P < 75 kW					Tier 3 (4.7 / 5.0 / 0.40)		Interim Tier 4 (0.40 / 0.19 / 5.0 / 0.02) Phase-in Option (4.7 / 5.0 / 0.02) < 50 %		Tier 4 (0.40 / 0.19 / 5.0 / 0.02)		
							Alt. NOx Phase-in Option (2.3 / 0.19 / 5.0 / 0.02)				
							Interim Tier 4 (0.40 / 0.19 / 5.0 / 0.02) Phase-in Option (4.7 / 5.0 / 0.02) < 75 %				
							Alt. NOx Phase-in Option (3.4 / 0.19 / 5.0 / 0.02)		Tier 4 (0.40 / 0.19 / 5.0 / 0.02)		
(Test Fuel Sulfur)											
P : Power											

* Optional Tier 4 PM = 0.8 g/kW-h (During model year 2008 and 2009)
= 0.6 g/kW-h (Starting with model year 2010)

Engine Condition : hand-startable, air-cooled, and direct injection

Note : 1. ☐ Entered into force

☐ Drafting or studying

☐ No limit / No regulation

2. **Bold red character shows the limit requires aftertreatment for PM.**

EU Directive 2004/26/EC (April 21, 2004)

Model Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Unit : g/kWh
0 kW < P < 8 kW												
8 kW ≤ P < 18 (19) kW												
18 (19) kW ≤ P < 37 kW												
For Constant Speed												
37 kW ≤ P < 56 kW												
For Constant Speed												
56 kW ≤ P < 75 kW												
For Constant Speed												
(Test Fuel Sulfur)												
P : Power												

() Note : (NO_x + NMHC / CO / PM) or (NO_x / HC / CO / PM)

Note : 1. Entered into force

2. Bold red character shows the limit requires after treatment for PM.

[3] CURRENT AND FUTURE EMISSION REGULATIONS ON JAPAN

JPN Ministry of the Environment (6/30/03 Report) Registration of Equipment (2006 Regulation covers off-road special motor vehicle also)

() Note : (NOx + NMHC / CO / PM / (smoke (%)) or (NOx / HC / CO / PM / (smoke (%)) Unit : g/kWh
 HC for 2010 Regulation is Non-Methane hydrocarbons (NMHC)

Model Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0 kW < P < 8 kW						No Regulation					
8 kW ≤ P < 19 kW						No Regulation					
19 kW ≤ P < 37 kW						2007 Regulation (6.00 / 1.00 / 5.00 / 0.40 / 40)	2013 Regulation (4.00 / 0.70 / 5.00 / 0.03 / 25)				
37 kW ≤ P < 56 kW						2008 Regulation (4.00 / 0.70 / 5.00 / 0.30 / 35)	2013 Regulation (4.00 / 0.70 / 5.00 / 0.025 / 25)				
56 kW ≤ P < 75 kW						2008 Regulation (4.00 / 0.70 / 5.00 / 0.25 / 30)	2012 Regulation (3.30 / 0.19 / 5.00 / 0.02 / 25)	2015 Regulation (0.40 / 0.19 / 5.00 / 0.02 / 25)			

Note : Mandatory implementation dates for 2011-2013 and 2014-2015 Regulations are to be determined later.

Ministry of Land, Infrastructure and Transportation / Recognition system for construction machinery

0 kW < P < 7.5 (8)kW						No Regulation					
8 kW ≤ P < 19 kW						3rd Step* (7.50 / 5.00 / 0.80 / 40)					
19 kW ≤ P < 37 kW						3rd Step* (6.00 / 1.00 / 5.00 / 0.40 / 40)					
37 kW ≤ P < 56 kW						3rd Step* (4.00 / 0.70 / 5.00 / 0.30 / 35)					
56 kW ≤ P < 75 kW						3rd Step* (4.00 / 0.70 / 5.00 / 0.25 / 30)					

Japan Land Engine Manufacturers Association (below 19 kW) Voluntary Regulation

0 kW < P < 8 kW						Tier 2 (7.5 / 8.0 / 0.40*)					
8 kW ≤ P < 19 kW						Tier 2 (7.5 / 6.6 / 0.40)					
P : Power	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

* Optional Tier 4 PM = 0.8 g/kWh (During model year 2008 and 2009)
 = 0.6 g/kWh (Starting with model year 2010)

Engine Condition : hand-startable, air-cooled, and direct injection

Note : 1. Entered into force

Drafting or studying

No limit / No regulation

2. Bold red character shows the limit requires aftertreatment for PM.

[4] CURRENT AND FUTURE EMISSION REGULATIONS ON CHINA

Chinese National Environment Protection Agency (April 3, 2007)											Sales Date	
Model Year											Unit : g/kWh	
2007											2017	
2008											2016	
2009											2015	
2010											2014	
2011											2013	
2012											2012	
2013											2011	
2014											2010	
2015											2009	
2016											2008	
2017											2007	
2018											2017	
2019											2016	
2020											2015	
2021											2014	
2022											2013	
2023											2012	
2024											2011	
2025											2010	
2026											2009	
2027											2008	
2028											2007	
2029											2017	
2030											2016	
2031											2015	
2032											2014	
2033											2013	
2034											2012	
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2038											2008	
2039											2007	
2040											2017	
2041											2016	
2042											2015	
2043											2014	
2044											2013	
2045											2012	
2046											2011	
2047											2010	
2048											2009	
2049											2008	
2050											2007	
2051											2017	
2052											2016	
2053											2015	
2054											2014	
2055											2013	
2056											2012	
2057											2011	
2058											2010	
2059											2009	
2060											2008	
2061											2007	
2062											2017	
2063											2016	
2064											2015	
2065											2014	
2066											2013	
2067											2012	
2068											2011	
2069											2010	
2070											2009	
2071											2008	
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2073											2017	
2074											2016	
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2079											2011	
2080											2010	
2081											2009	
2082											2008	
2083											2007	
2084											2017	
2085											2016	
2086											2015	
2087											2014	
2088											2013	
2089											2012	
2090											2011	
2091											2010	
2092											2009	
2093											2008	
2094											2007	
2095											2017	
2096											2016	

[5] CURRENT AND FUTURE EMISSION REGULATIONS ON KOREA

Korean Ministry of Environment (KMOE)
Equipment Production Date (Custom Clearance for Import) (Proposed Tier 3 to be regulation on engines)

() Note : (NOx + NMHC / CO / PM)

Unit : g/kWh

Model Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0 kW < P < 8 kW						No Regulation					
8 kW ≤ P < 19 kW						No Regulation					
19 kW ≤ P < 37 kW			Tier 2 (7.5 / 5.5 / 0.6)			Tier 3 (7.5 / 5.5 / 0.3)					
37 kW ≤ P < 75 kW			Tier 2 (7.5 / 5.0 / 0.4)			Tier 3 (4.7 / 5.0 / 0.4)					
P : Power	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

Note : 1.

Entered into force

2. **Bold red character shows the limit requires aftertreatment for PM.**

No limit / No regulation

[6] CURRENT AND FUTURE EMISSION REGULATIONS ON INDIA

India / Construction Equipment Vehicles (April 10, 2007)

() Note : (NOx / HC / CO / PM) or (NOx + NMHC / CO / PM) Unit : g/kWh

Model Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
0 kW < P < 8 kW											
8 kW ≤ P < 19 kW											
19 kW ≤ P < 37 kW											
37 kW ≤ P < 75 kW											

India / Gen Set Applications (May 17, 2002)

0 kW < P ≤ 19 kW											
19 kW < P ≤ 50 kW											
50 kW < P ≤ 250 kW											

P : Power

Note : 1.

Entered into force

Drafting or studying

No limit / No regulation

2. **Red character shows the limit requires after treatment for PM.**

2. RATING

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[3] METHOD OF POWER CORRECTION		2-3

RATING

Engine output indications are standardized in accordance with engine application and type in each country and test methods specified accordingly.

Indications for KUBOTA engine ratings conform to the Japan Industrial Standards (JIS), SAE and ISO.

1. ENGINE TESTING METHODS

Normally, testing methods for engine performance vary according to use. These methods also vary by countries, although in most major respects they are the same. Engine performance is determined by the following factors and the presence of accessories.

- 1) Fixed factors -
Piston displacement, compression ratio, cam timing and other factors that cannot be changed during operation.
- 2) Variable factors -
Revolution speed and other factors that can be changed during operation.
- 3) Environmental factors -
Atmospheric pressure, temperature, humidity and others.
- 4) Accessories -
Fan, muffler, air cleaner, speed change gears and other auxiliary equipment and accessories.

Therefore, engine performance can be determined only after taking into account the setting of variable factors, atmospheric conditions, and use of optional accessories. It is a common practice to select the annual mean value of the atmospheric conditions of the country in which the engine is used to minimize the error which must be corrected.

Engine performance is usually tested with the minimum number of accessories required for operation only.

Major standards for diesel engines are described below

2. STANDARD OF JAPAN, USA AND EUROPE

[1] PERFORMANCE TESTING METHODS

Country	Code number	Title
JAPAN	JIS B8002-1	Reciprocating internal combustion engines - Performance - Part 1 : Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods Part 3 : Test measurements Part 4 : Speed governing Part 5 : Torsional vibrations Part 6 : Overspeed protection Part 7 : Codes for engine power
	JIS B8014	Performance test method for constant revolution diesel engines
U.S.A.	SAE J1349	ENGINE POWER TEST CODE - SPARK IGNITION AND COMPRESSION IGNITION - NET POWER RATING
	SAE J1995	ENGINE POWER TEST CODE - SPARK IGNITION AND COMPRESSION IGNITION - GROSS POWER RATING
EUROPE	ISO 3046-1	Reciprocating internal combustion engines - Performance - Part 1 : Standard reference conditions, declarations of power, fuel and lubricating oil consumptions, and test methods Part 3 : Test measurements Part 4 : Speed governing Part 5 : Torsional vibrations Part 6 : Overspeed protection Part 7 : Codes for engine power

[2] SCOPE, DECLARATIONS OF POWER AND STANDARD REFERENCE CONDITIONS

	JIS B8002-1, ISO 3046-1	SAE J1995	SAE J1349
Scope	JIS B8002 : All reciprocating internal combustion (R.I.C.) engines excluding engines used to aircraft. ISO 3046 : R.I.C engines for land, rail - traction and marine use, excluding engines used to propel agricultural tractors, road vehicles and aircraft.	1) 4 or 2 cycle engine. 2) Spark ignition or compression ignition engine. 3) N/A engine or engine with T/C or S/C and I/C. 4) Excluding engines used to aircraft or marine.	
Declarations of power	1) Types of statement of power ISO power : The power determined under the operating conditions of the manufacturer's test bed and adjusted or corrected as determined by the manufacturer to the standard reference conditions. Service power : The power delivered under the ambient and operating conditions of an engine application. 2) Types of power application a) Continuous power b) Overload power c) Fuel stop power 3) Types of power • Indicated power • Brake power with a) essential dependent auxiliaries. b) essential independent auxiliaries. c) non - essential dependent auxiliaries.	Gross	Net
Standard reference conditions	Total barometric pressure : Pr=100 kPa	Inlet Air Supply Pressure (absolute) : Pr=100 kPa	
	Ambient air temperature : Tr=25 °C (77 °F)	Inlet Air Supply Temperature : Tr=25 °C (77 °F)	
	Relative humidity : $\phi_r=30\%$ Relative humidity of 30% at a temperature of 25 °C (77 °F) corresponds to a water vapour pressure of 1 kPa.	Dry Air Pressure (absolute) Pb dry=99 kPa	
	Charge air coolant temperature : Tcr=25 °C (77 °F)	REFERENCE CI FUEL SPECIFICATIONS Fuel Density at 15 °C (59 °F) =0.850 kg/L Fuel Kinematic Viscosity at 40 °C (104 °F) =2.6 mm ² /s Fuel Inlet Temperature=40 °C (104 °F)	

[3] METHOD OF POWER CORRECTION

	JIS B8002-1, ISO 3046-1	SAE J1995	SAE J1349
Formula of power correction	Standard power = $\alpha \times$ Text power $\doteq \alpha \times$ Test power	Standard power = (CA $\times$ CF) $\times$ Test power CA ; Air correction factor CF ; Fuel correction factor	
Correction factor	$\alpha = (fa)^{fm}$	CA = $(fa)^{fm}$ CF = $fd \times fv$	
Effective scope	$0.9 < \alpha < 1.1$ $10\text{ }^{\circ}\text{C (50 }^{\circ}\text{F)} \leq \text{Intake air temperature} \leq 40\text{ }^{\circ}\text{C (104 }^{\circ}\text{F)}$ $80\text{ kPa} \leq \text{Dry air pressure} \leq 110\text{ kPa}$	$15\text{ }^{\circ}\text{C (59 }^{\circ}\text{F)} \leq \text{Intake air temperature} \leq 40\text{ }^{\circ}\text{C (104 }^{\circ}\text{F)}$ $90\text{ kPa} \leq \text{Dry air pressure} \leq 105\text{ kPa}$	
Coefficient	Atmospheric factor : fa [For naturally aspirated engines mechanically pressure - charged engines and turbocharged engines with waste - gates operating] $fa = \left(\frac{99}{P_{bdry}} \right) \times \left(\frac{T_{ai} + 273}{298} \right)^{0.7}$ [For turbocharged engines without charge air cooling or with charge cooling by air/air cooler] $fa = \left(\frac{99}{P_{bdry}} \right)^{0.7} \times \left(\frac{T_{ai} + 273}{298} \right)^{1.2}$ [For turbocharged engines with charge air cooling by engine coolant] $fa = \left(\frac{99}{P_{bdry}} \right)^{0.7} \times \left(\frac{T_{ai} + 273}{298} \right)^{0.7}$	1. Calculation of CA Atmospheric factor : fa [For naturally aspirated engines mechanically pressure - charged engines.] $fa = \left(\frac{99}{P_{bdry}} \right) \times \left(\frac{T_{ai} + 273}{298} \right)^{0.7}$ [For turbocharged engines without charge air cooling or with charge cooling by air/air cooler] $fa = \left(\frac{99}{P_{bdry}} \right)^{0.7} \times \left(\frac{T_{ai} + 273}{298} \right)^{1.2}$ [For turbocharged engines with charge air cooling by engine coolant] $fa = \left(\frac{99}{P_{bdry}} \right)^{0.7} \times \left(\frac{T_{ai} + 273}{298} \right)^{0.7}$	
	Engine factor : fm $fm = 0.036 \times \frac{q}{R} - 1.14 \quad (37.2 < q/R < 65)$ $fm = 0.2 \quad (q/R \leq 37.2)$ $fm = 1.2 \quad (65 \leq q/R)$	Engine factor : fm $fm = 0.036 \times \frac{q}{R} - 1.14 \quad (37.2 < q/R < 65)$ $fm = 0.2 \quad (q/R \leq 37.2)$ $fm = 1.2 \quad (65 \leq q/R)$	
	Boost pressure ratio $R = \frac{PB + P_{bc}}{PB} \quad (NA ; R=1)$	Boost pressure ratio $R = \frac{PB + P_{bc}}{PB} \quad (NA ; R=1)$	
	Fuel mass per cycle per litre of engine swept volume $q = \frac{10^2 \times Be}{3 \times Ne \times Ve} \quad \text{mg/cyl.l}$	Fuel mass per cycle per litre of engine swept volume $q = \frac{10^2 \times Be}{3 \times Ne \times Ve} \quad \text{mg/cyl.l}$	
		2. Calculation of CF $fd = 1 + 0.70 \times \frac{0.850 - S_{go}}{S_{go}}$ $fv = \frac{1 + S/Vo}{1 + S/2.6} = \frac{1 + 0.15/Vo}{1 + 0.15/2.6}$ Sgo : Fuel density at testing (kg/L) Vo : Fuel viscosity at testing (mm ² /s)	

	JIS B8002-1, ISO 3046-1	SAE J1995	SAE J1349
Engine equipments	ISO standard power With essential dependent auxiliaries	Gross	Net
Intake air system	○	Option Minimum level restriction	○
Intake pipe	○		○
Air cleaner	○		○
Air heater			×
Charge air system	○	○	○
Boost control settings		○: In-use settings	○: In-use settings
Charge air cooling system	○	○	○
Charge air cooler	○	○	○
Fuel supply system	○	○	○
Fuel filter	○	Option	Option
Fuel feed pump	○	○	○
Fuel injection pump	○	○: In-use settings	○: In-use settings
Cooling system	○	○	○
Cooling water pump	○	○	○
Cooling fan	○	×	○
Thermostat		Option	Option
Lubricating system	○	○	○
Lubricating pump	○	○	○
Exhaust system	○	Option Minimum level restriction	○
Muffler	○		
			○
Emission control system	○	Option	○
Oil pump	×	×	×
Compressor for engine start	×	×	×
Ventilation fan	×	×	×

3. ENGINE PERFORMANCE

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ENGINE PERFORMANCE

1. OUTPUT

[1] GENERAL

The engine output depends upon the designed technical data (number of revolutions and displacement) and combustion efficiency (ups and downs of brake mean effective pressure, good and bad combustion performance) of engine.

It is calculated by the following formula.

$$\text{Output} = (\text{Bmep} \times N \times V) / 900$$

Bmep : Mean effective pressure (kg/cm²)

N : Number of revolutions (min⁻¹(rpm))

V : Displacement (liter)

The mean effective pressure depends upon various internal factors (combustion method, whether turbo charger is provided, type of nozzle and fuel pump, and adjustment of each section such as fuel injection timing).

Energy obtained by combusting fuel in the engine is not completely utilized for engine output.

Although diesel engines are more efficient than gasoline engines, only 30 to 35% of the energy generated by the diesel engines is effectively utilized (See Fig. 3-1). The residual 65 to 70% is not utilized (heat loss). Supposing that the gross heating value of combusted fuel is 100%, its distribution is called the "heat balance".

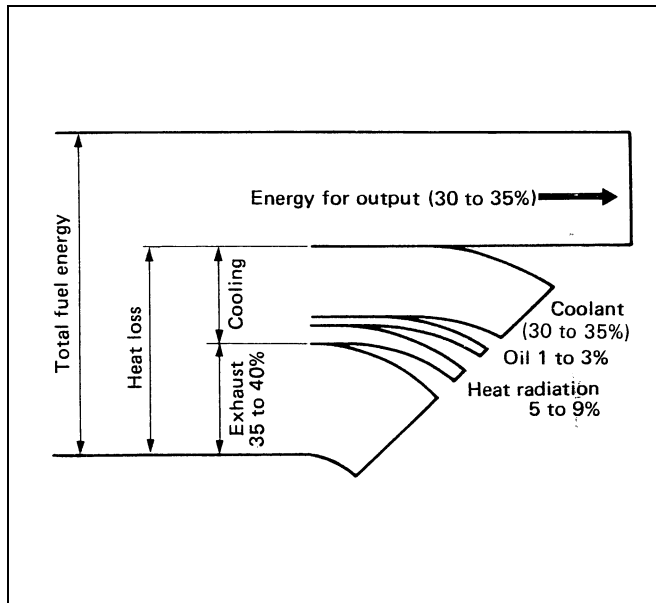


Fig. 3-1 Example of heat balance of diesel engine

In the above mentioned drawing, the ratio of the gross heating value (Qo) and the energy (heating value) (Qe) effectively utilized as the output is called the "thermal efficiency" (η_e) and calculated by the following formula.

$$\eta_e = Q_e / Q_o (\%)$$

$$= \text{Output (kW)} \times 3600 (\text{kJ/hr}) / 42700 \times B$$

42700 : Lower calorific value of fuel (kJ/kg)

B : Fuel consumption (kg/hr)

[2] ACTUAL EFFECTIVE OUTPUT

The final output (actual effective output) of engine varies with various external factors such as horsepower loss due to the power consumed for driving the cooling fan and water pump, resistance of muffler and air cleaner, environmental conditions such as temperature, humidity, and altitude, type of applied fuel, and horsepower loss and transmission efficiency of equipment driven by the engine.

Thus the final output mainly depends upon the horsepower loss. Also the output varies with the time factors such as "aging and wear" and "maintenance", which depend upon the operating time. (See Fig. 3-2).

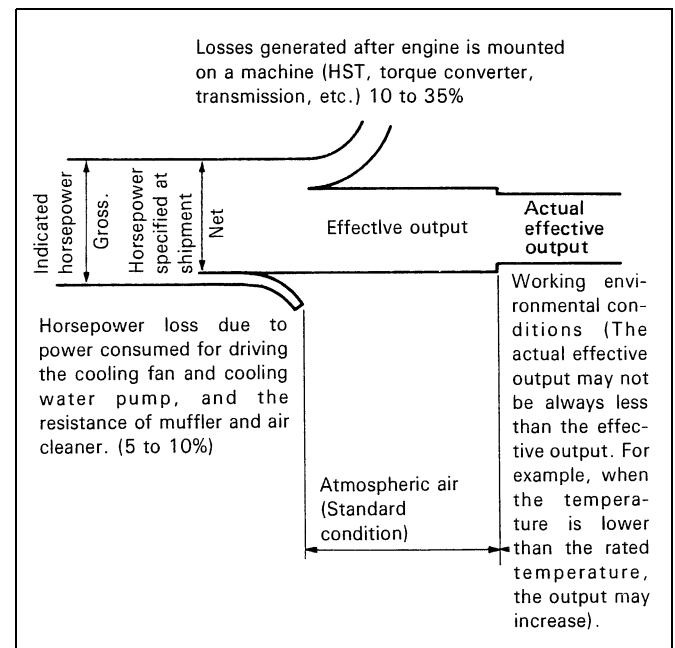


Fig. 3-2 Engine power loss

Fuel supply adjustment and governor setting are adjusted by KUBOTA according to each destination country in conformity with "JIS", "SAE" and "ISO" standards before shipment.

They may be adjusted to the output characteristic discussed with the Technical Department in case of special OEM requirements.

Engine performance is normally indicated by the output, torque and fuel consumption curves, which are closely related to each other.

[3] OUTPUT CHARACTERISTICS

When mounting an engine on a machine, it is risky to select an engine by its standard output alone (as shown in catalogue and other literatures) and comparing it with the required power of the machine. The following factors must be carefully considered when making a selection.

(1) For large load variations

Engines with large torque backup are suitable for frequent use with varying loads which require a broad torque range.

The amount of torque backup is indicated by torque rise (%).

Torque rise

$$= (\text{Max. torque} / \text{Torque at rated output}) \times 100 - 100 (\%)$$

As shown in the torque curve, KUBOTA engines have a high torque rise.

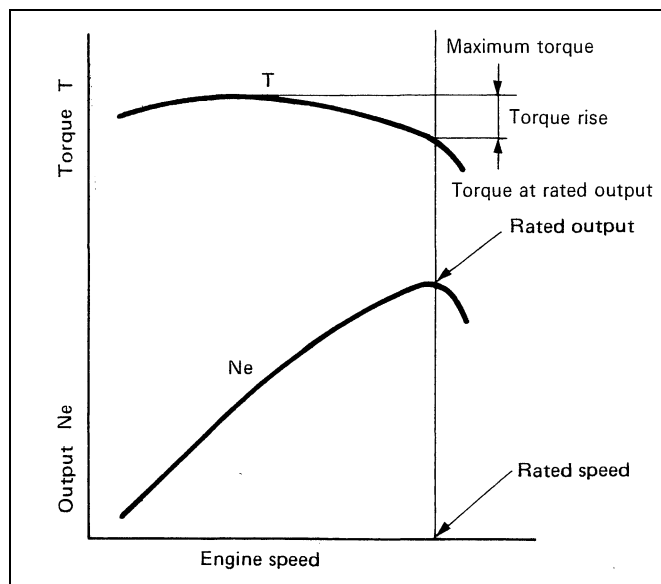


Fig. 3-3 Torque backup

(2) For constant speed applications

When an engine is to be used with a generator, for example, for which stable revolution characteristics are required, governor adjustment and inertia effect are needed to maintain the coefficient of revolution fluctuation at a minimum level. Unless these actions are taken, the generator voltage or frequency will vary largely with variation of engine revolution speed, preventing proper operation.

(3) For reduced engine speed applications

When an engine is to be operated slower than the rated speed in order to reduce the noise level below that of the rating, or due to the transmission unit to which the engine is connected, an optimum adjustment (including fan, pump and other equipment performance check) at that engine speed and output check is necessary.

Conditions for selection further vary with priority factors of the machine to which the engine is mounted. (e.g. emphasis on reduced fuel consumption, or larger output margin due to extremely long periods of operation.) There are many cases in which these factors are combined. It is suggested that careful review be given when determining the correct selection of an engine.

(4) Precautions for specifying engine output

When specifying the engine output characteristics it is necessary to consider the output decrease due to changes of ambient conditions, especially the temperature rise (rise of engine intake-air temperature as well as atmospheric temperature), power consumed by accessories and horsepower loss in the power transmission unit.

[4] FUEL CONSUMPTION

Whether the fuel consumption is efficient or not depends upon the specifications inherent to each engine such as combustion method (direct injection, swirl chamber, etc.), shape of combustion chamber, fuel injection timing, valve timing, type of nozzle, fuel pump, etc., and revolution speed.

The matching of engine and machine directly influences efficiency of fuel consumption.

Therefore sufficient consideration is required to select an engine to be mounted on each machine.

[5] GOVERNOR PERFORMANCE

In most machine including construction machines and industrial vehicles for cycle work involving starting -running -stop, -work, engine are used at varying loads. Therefore the engine governor must have a speed control function that allows fast fuel supply control over the entire range.

KUBOTA engine use an all speed governor with an automatic fuel control mechanism that detects even small changes in rpm.

This allows optimum fuel supply at all times under various conditions such as the maximum engines speed, maximum load, low speed load, idling, starting and acceleration.

KUBOTA engine uses two kinds of mechanical governor.

1. Steel Ball Type (SM Series, 03-M Series)
2. Weight Type (05 Series, 07 Series and V3 Series)

Steel Ball Type Governor

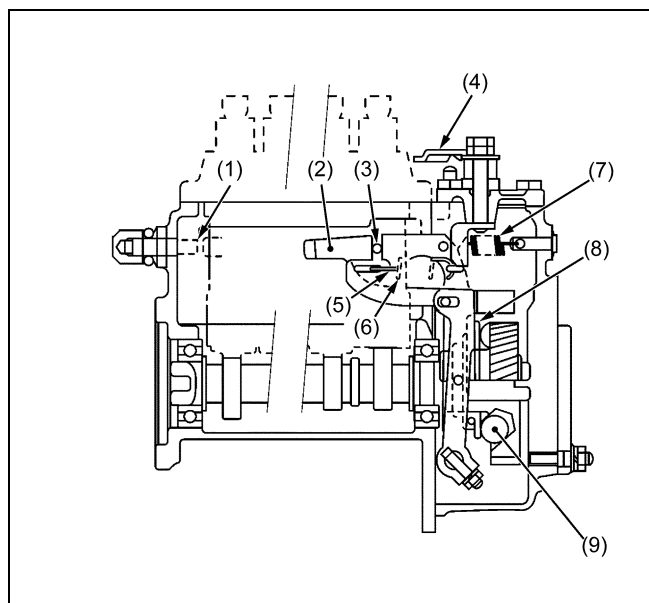
Several steel balls are incorporated into the fuel cam gear in such a way as it gives the steel balls centrifugal force in proportion to the revolving speed.

It has a structure in which the centrifugal force is transformed into thrust movement and controls the injection quantity of the fuel pump through the fork-lever, while being balanced with the tension of the governor spring, to keep the engine revolution constant.

Weight Type Governor

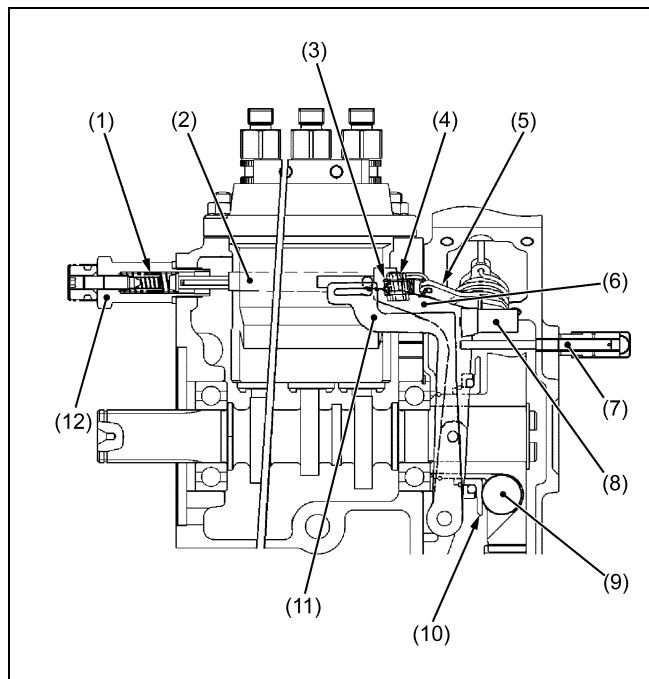
Two or three weights are incorporated into the fuel cam in such a way as it gives the weights centrifugal force in proportion to the revolving speed.

It has a structure in which the centrifugal force is transformed into thrust movement and controls the injection quantity of the fuel pump through the fork-lever, while being balanced with the tension of the governor spring, to keep the engine revolution constant.



(1) Idle limit spring	(6) Governor spring 1
(2) Fork lever 1	(7) Start spring
(3) Control rack pin	(8) Governor sleeve
(4) Speed control lever	(9) Governor ball
(5) Governor spring 2	

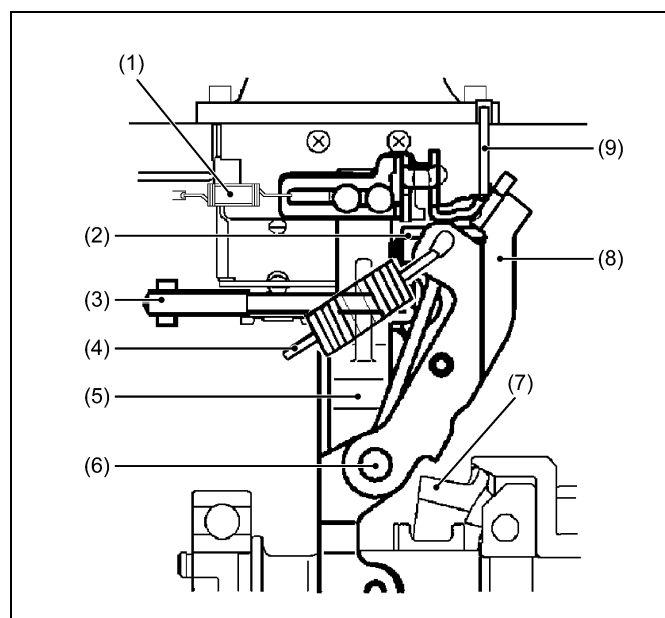
Fig. 3-4 Governor for S.M. series



(1) Start spring	(7) Adjusting screw
(2) Control rack	(8) Torque spring
(3) Governor spring 2	(9) Governor ball
(4) Governor spring 1	(10) Governor sleeve
(5) Governor lever	(11) Fork lever 2
(6) Fork lever 1	(12) Idling apparatus

Fig. 3-5 Governor for 03-M series

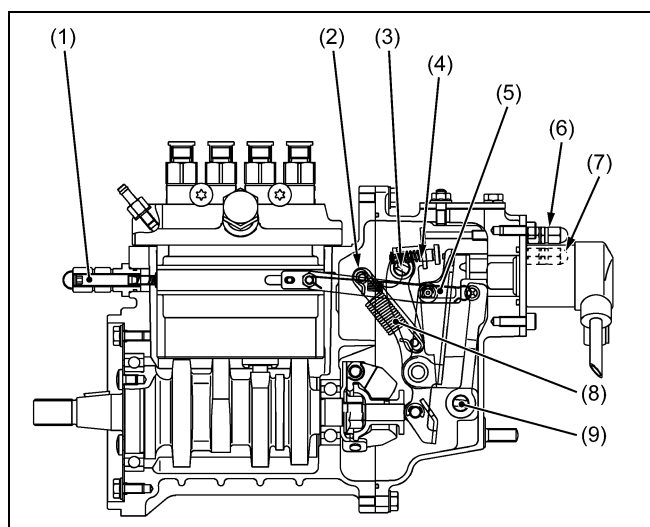
In the 05 series, the fuel cam shaft and the governor shaft are independent with each other and the governor weights are incorporated into the governor shaft. As the fork-lever, a three lever system with newly-employed floating levers (except BG type) has been employed to reduce the exhaust gas at the time of peak-torque.



(1) Start spring	(6) Fork lever shaft
(2) Floating lever	(7) Flyweight
(3) Max torque limiter	(8) Fork lever 2
(4) Governor spring	(9) Fuel limitation bolt
(5) Fork lever 1	

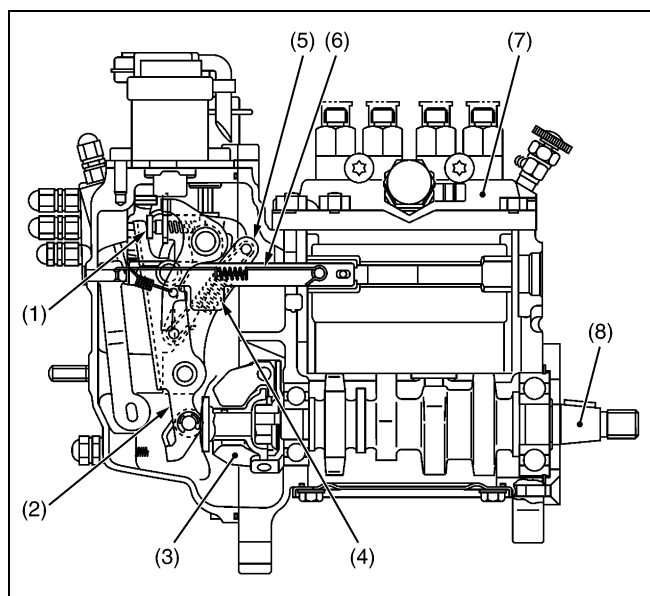
Fig. 3-6 Governor for 05 series

In the 07 and V3 series, the IPU (Injection Pump Unit) system is employed, where a PFR pump is mounted in the housing in which a torque-adjusting mechanism and a peak-torque adjusting mechanism along with a fuel cam, a governor mechanism, and others are incorporated.



(1) No-load maximum rotation	(5) Start spring
(2) Fork lever 2	(6) Output limiting bolt
(3) Speed control lever	(7) Torque limiting bolt
(4) Spring pin	(8) Governor spring
	(9) Fork lever 1

Fig. 3-7 Governor for 07 series



(1) Spring pin	(5) Fork lever 2
(2) Fork lever 1	(6) Start spring
(3) Flyweight	(7) Injection pump
(4) Governor spring	(8) Fuel camshaft

Fig. 3-8 Governor for V3 series

【Governor regulation】

Generator governor should be regulated as small as possible when load is changed, and recovered to normal level as quick as possible.

This is especially important when the engine is used for constant speed applications such as with generators.

Coefficient of regulation and stabilization period are defined as follow.

- Instant governor droop

$$= (N_1 - N_0) / N_0 \times 100\%$$

$$\text{or} = (N_3 - N_0) / N_0 \times 100\%$$

- Stabilized governor droop

$$= (N_2 - N_0) / N_0 \times 100\%$$

- Stabilization period

No load stabilization period = S_1 (sec)

Load stabilization period = S_2 (sec)

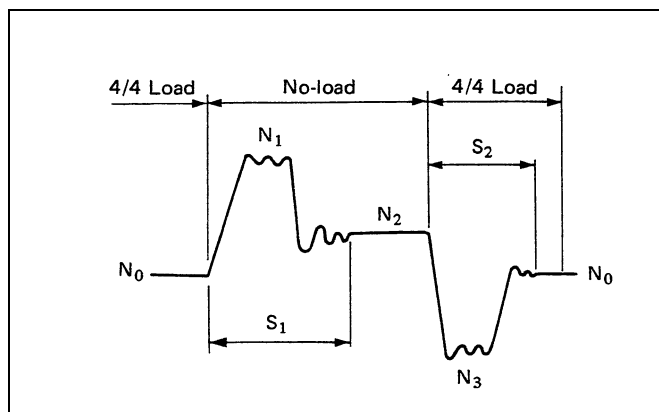


Fig. 3-9

1) For variable speed use ($2000 \sim 3000 \text{ min}^{-1} \text{ (rpm)}$)

Instant governor droop (%)	: 10
Stabilized governor droop (%)	: 6~10
Stabilization period (sec)	: 5
Low idling ($\text{min}^{-1} \text{ (rpm)}$)	: 800

2) For constant speed use

($1500, 1800, 3000, 3600 \text{ min}^{-1} \text{ (rpm)}$)

Instant governor droop (%)	: 10
Stabilized governor droop (%)	: 5
Stabilization period (sec)	: 5

※ Rate of governor regulation differ with the engine margin against load.

※ Consult when utmost precision is required.

[6] NOISE

Often they are subject to government regulation. One of the major development objectives for KUBOTA engines is a substantial reduction of noise and vibration.

(1) KUBOTA's E-T.V.C.S (Three Vortex Combustion System) originally developed.

By offsetting the direction of fuel injection into the swirl chamber and designing the throat of the swirl chamber to match the concave recess on the piston head, E-TVCS activates diffusive combustion in the main combustion chamber.

The injection pump and nozzle designs are optimized to match the combustion chamber.

The E-series is a well balanced engine series with improved power output, fuel economy, engine start ups, reduced noise and cleaner emission.

(2) Highly rigid crankcase

The cylinder block is the main housing of engine and supports the other main parts.

The cylinder block is usually of integrated cast iron construction, and includes complete passages for coolant and lubricating oil.

Three kinds (the tunnel type, the hanger type and ladder frame type) are adopted in Kubota engines.

【S.M., 05 and 03-M series】

The crankcase has tunnel-type integral structure. It is highly rigid and the injection pump is built into the case.

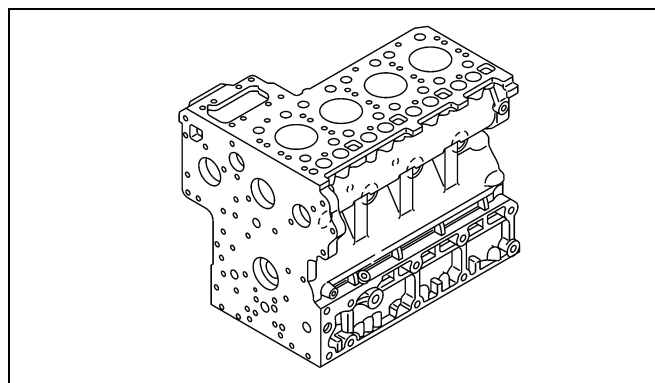


Fig. 3-10 Tunnel type cylinder block for S.M., 05 and 03-M series

【07 series】

The 07 series DI engine employs ladder frame structure type crankcases - the crankcase 1 with combustion part and the crankcase 2 which supports the crankcase 1.

The following benefits are in the ladder frame structure.

1. Minimizing parts.
2. Noise reduction.
3. Reduction of loss and dispersion on friction thanks to accuracy of axial concentricity.

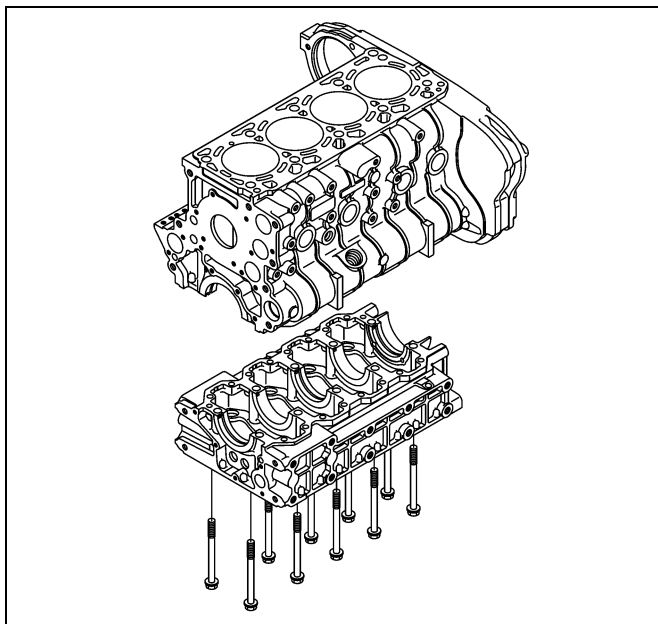


Fig. 3-11 Cylinder block for 07 series

【V3 series】

V3 series engine employs hanger type crankcase. The crankcase is divided into the two parts, i.e., the upper part and lower part. The upper part is combustion part and lower part support the upper part and reduces noise.

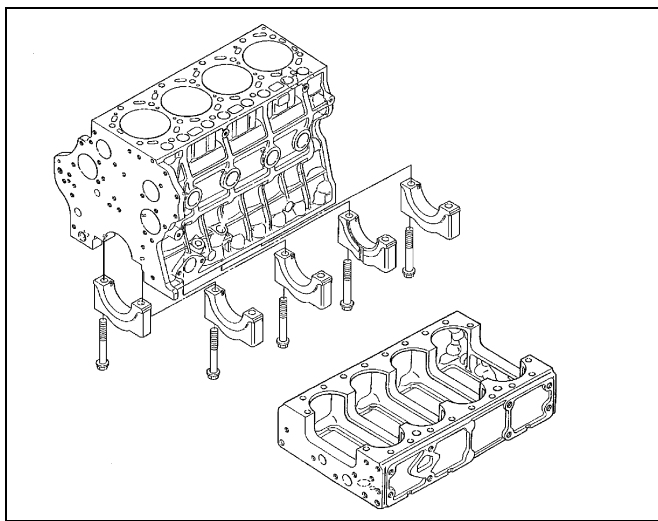


Fig. 3-12 Cylinder block for V3 series

(3) Consider to reduce mechanical noise**【SM, 05 and 03-M series】**

The E3 engines employ Molybdenum disulfide coated pistons to further reduce piston slap noise and Half floating head covers to reduce radiated noise, in addition to the conventional measures to reduce mechanical noise such as a tunnel-type cylinder block, off set pistons, and steel strut pistons.

【The 07 engines】

In addition to employing a Ladder frame structure type crankcase, the rear side gear train (a new concept of transferring the gear train from the conventional front-side to the rear-side (the flywheel side)) and the Half floating head cover have been employed to reduce radiated sound.

For the pistons, in addition to the conventional off set pistons and steel strut pistons, Molybdenum disulfide coated pistons have been employed to further reduce piston slap noise.

In addition, the micro groove metal has been employed to reduce sliding-surface noise by reducing the oil clearance between the crankshaft and metal.

【The V3 engines】

In addition to the conventional measures to reduce mechanical noise like a Hanger type crankcase, off set pistons, and steel strut pistons, the E3 engines employ Molybdenum disulfide coated pistons to further reduce piston slap noise, Half floating head covers to reduce radiated sound, and, also, the micro groove metal to reduce sliding surface noise by reducing the oil clearance between the crankshaft and the metal.

(4) Highly efficient governor

The installed high performance governor ensures stable revolution in the low speed range.

Therefore, it has become possible to set a lower value as the low idle speed. As a result, the noise has been reduced.

[7] VIBRATION

In order to reduce the vibration level as much as possible, special consideration has been taken in designing the crankshafts according to the number of cylinders and rotating parts such as the fan drive pulley, flywheel to minimize unbalanced inertia force and inertia couple of the reciprocating and rotating parts.

The crankshaft is made of a strong special steel alloy to reduce weight of the pin and arm sections. Alternating balance weights are used for each cylinder.

Other main parts are also made of special steel to reduce their weight and provide sufficient strength. The weight of the piston itself is reduced.

Thus, both the reciprocating mass and the rotating mass are reduced. The result is smaller inertia forces and smaller unbalanced inertia couple.

The table in TECHNICAL INFORMATION shows unbalanced forces of standard KUBOTA engines.

Unbalanced forces of engines

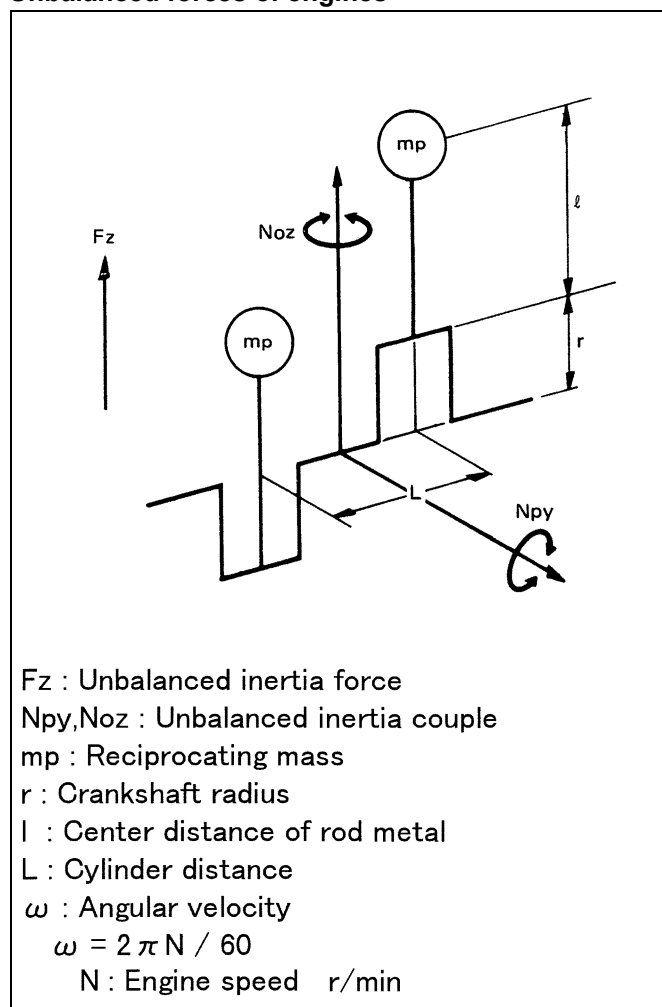


Fig. 3-13 Unbalanced forces of engines

F_z : Unbalanced inertia force

No. of cylinders	Order	F_z
2	1	0
	2	$2m_p \cdot r \cdot (r/l) \cdot \omega^2$
3	1	0
	2	0
4	1	0
	2	$4m_p \cdot r \cdot (r/l) \cdot \omega^2$

N_{py} : Unbalanced inertia couple

No. of cylinders	Order	F_z
2	1	$(m_p/2) \cdot r \cdot L \cdot \omega^2$
	2	0
3	1	$(3m_p/2) \cdot r \cdot L \cdot \omega^2$
	2	$3m_p \cdot r \cdot L \cdot (r/l) \cdot \omega^2$
4	1	0
	2	0

N_{oz} : Unbalanced inertia couple

No. of cylinders	Order	F_z
2	1	$(m_p/3) \cdot r \cdot L \cdot \omega^2$
	2	0
3	1	$(3m_p/2) \cdot r \cdot L \cdot \omega^2$
	2	0
4	1	0
	2	0

2. OPERATING ENVIRONMENT

[1] GENERAL

For the standard engine output performance, the values measured under the standard conditions specified by the world principle standards such as JIS, SAE and ISO are used as the standard. However since engines are used all over the world, their output performance varies with the operating conditions and ambient conditions (altitude, humidity and temperature). If the ambient temperature varies largely, the environment is dusty, or the engine is operated at an unusual installation altitude, the engine performance is directly or indirectly influenced.

It is necessary to consider the balance between the output compensation in accordance with the ambient conditions, and actions to adapt the engine to the operating conditions.

[2] COLD ENVIRONMENTS

In cold environments starting is a major problem. Once the engine is started, the air density becomes larger and the intake efficiency also becomes higher. More output can be expected in cold areas. When the temperature is very low, extra care must be taken regarding fuel and oil changes in their viscosity, freezing of water contained in the piping, or of water adhering on the filter.

At an extremely cold temperature, the viscosity of hydraulic fluid and lubrication oil may increase and the torque of starter may exceed its permissible value, hindering proper starting.

Requirements for cold starting

Cold intensity			Low temperatures more than 258 K {-15 °C (5 °F)}	Intense cold more than 253 K {-20 °C (-4 °F)}	Extreme cold more than 248 K {-25 °C (-13 °F)}
Item					
Combustion	Fuel	For cold weather	No.1-D (ASTM D975-94)	No.1-D (ASTM D975-94)	No.1-D (ASTM D975-94)
	Preheating	Combustion chamber	Glow 10 sec	Glow 10 sec	Glow 10 sec
		Intake air	-	-	Preheating
		Engine body	-	-	Preheating
Turning force	Starter		Standard	Size up from std.	Size up from std.
	Battery		Standard	Size up from std.	Size up from std.
Lubrication	Oil	For cold weather	SAE #10W or SAE #10W30	SAE #5W or SAE #10W30	SAE #5W or SAE #5W20
Cooling	Coolant		Antifreeze	Antifreeze	Antifreeze
			-	-	Preheating

1) Above table may be changed by application due to the drag torque of various machines.

2) Material of all pipes, resins and rubbers must be cold resistant material in extreme cold condition.

[3] HIGH TEMPERATURES

High compartment temperatures can be caused by high ambient temperatures, small engine room, soundproof cases and other reasons.

Among these the most important factor is the temperature of the intake and cooling air.

Even if the engine is contained in a soundproof case, its output is not affected as long as sufficient cold air is taken in from the outdoor atmosphere. In order to prevent overheating, it is necessary to measure and check the temperature of intake air and exhaust gas. At an extremely hot temperature it is necessary to control the

viscosity of fuel and lubrication oil, to maintain the cooling performance (prevent overheat) and to care about the temperature rise of electric equipment.

- ※ Output reduction
Output decreases as ambient temperature increases.
- ※ Radiation of cooling water
Care must be taken regarding the amount of radiation reduction, when an all seasons antifreeze is used for continuous operation at high temperature, or when a high density antifreeze is used.

Requirements for operation at high temperature

Temperature			High 30 to 40 °C (86 to 104 °F)	Extremely high 40 °C (104 °F) or higher
Item				
Combustion	Fuel	Type	No.2-D (ASTM D975-94)	No.2-D (ASTM D975-94)
		Temperature		
Lubrication	Oil	Type	SAE #30, 10W30,15W40	SAE #40 or 20W50
		Temperature	120 °C (248 °F) or lower	
Cooling	Reserve tank		Necessary to use	Necessary to use
	Radiator, fan		When necessary, use larger radiator and fan.	
Accessories	Permissible temperature		Starter, regulator, alternator, relay, timer : 80 °C (176 °F) or lower Emergency relay : 65 °C (149 °F) or lower	

[4] DUST

When the engine is to be used in extremely dusty areas or used continuously in a dusty environment, special care must be taken with air cleaner and radiator. The intake air must be cleaned with the air cleaner. Lowering of the radiator cooling capacity due to clogging dust must be prevented.

【Dust density】

A degree of dustiness is hard to express in numbers. Comparative indication of amount of dust contained per 1m^3 of air is one way to express dustiness.

Below are some examples :

- | |
|--|
| 1) Pavement : 0.0002 to 0.0004 g/m ³
2) Unpaved road : 0.005 to 0.01 g/m ³
3) Dusty road (after passing of a car on unpaved road 2) above) : 0.3 to 0.4 g/m ³
4) Construction site : 0.5 to 1.0 g/m ³
5) Extremely dusty operation : Over 1.0 g/m ³ |
|--|

【Air cleaner】

Air cleaner type and capacity must be chosen according to the dust level in the operating environment and conditions for maintenance.

If an improper selection is made, especially when the capacity is less than needed, intake air resistance becomes higher, resulting in reduced output.

In order to maintain air tight seals at the joining sections of intake system component parts and thus to prevent foreign matter from entering, it is necessary to ensure the security of the air intake system to prevent the component parts from being damaged.

[5] INCLINATION AND CENTER OF GRAVITY

Engine may be used inclined when it is used in a machine for working on slopes, during oscillation and when the engine is mounted at an angle. The tilted posture may be either momentary or continuous. Mounting the engine at an angle, even a small angle, should be avoided. When using an engine in a tilted posture continuously, the following points must be remembered.

- 1) If the engine is tilted to the front there is a possibility of an air pocket being created at the back of the cylinder head.
- 2) The effective volume of the oil pan becomes less, so air suction must be prevented.

Allowable angles for tilted operation are given below for engines with standard specifications.

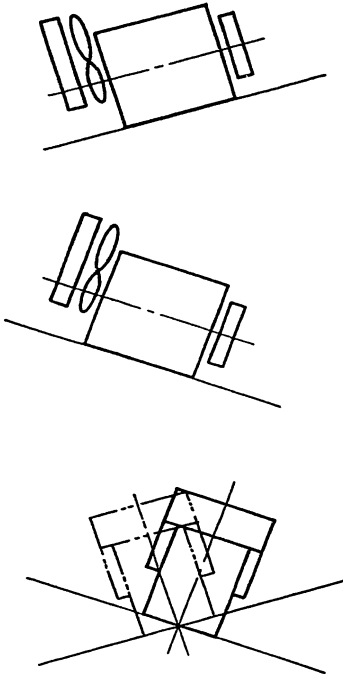
		Less than 10 minutes continuous operation	Continuous operation
	Front down	0.52 rad (30°)	0.35 rad (20°)
	Rear down	0.52 rad (30°)	0.35 rad (20°)
	Left or right side down	0.52 rad (30°)	0.35 rad (20°)

Fig. 3-14

Note : The engine for generator should be mounted level.

When the engine is mounted at an angle, the governor droop may worsen.

【Center of gravity】

With reference to tilted engines during operation, it is necessary to know the center of gravity position when checking for machine stability.

[6] DERATION OF ENGINE OUTPUT

Engine output is affected by atmospheric pressure, temperature and humidity.

An engine should be selected with sufficient power to meet the load demands under all operating conditions.

KUBOTA diesel engine performance curves are corrected to standard conditions explained in standards such as JIS, SAE an ISO.

Provided output should be corrected for various atmospheric conditions by above standards.

Deration coefficient table is shown in next page.

Deration of engine output is very important when selecting the proper engine model when using at high ambient temperature and in high altitude location.

Table of Factors Used to Convert Output Obtained under Standard Conditions to that under Specific Environmental Conditions.

Note 1. This table shows the factors used for modifying the output under the standard conditions (atmospheric pressure 100 kPa {750 mmHg} : atmospheric temperature 25 °C (77 °F) relative humidity 30% to that under specific environmental conditions.

The applicable standards are ISO 3046-1, JIS 8002. The factors are calculated according to the expressions specified in the standards.

2. This table is applicable to the naturally aspirated diesel engine.

3. The output under relative humidity other than 30% can be obtained by calculation.

Table 1 Conversion Factors under Relative Humidity of 30% and Mechanical Efficiency of 85% Naturally aspirated diesel engine

Altitude m	Atmospheric pressure		Upper : Intake air temperature (°C)												Lower : Saturation vapor pressure (kPa)															
	mmHg	kPa	0	5	10	15	20	25	30	35	40	45	50																	
0	760	101.3	0.61	0.87	1.23	1.71	2.34	3.17	4.25	5.63	7.38	9.59	12.34																	
100	751	100.1	1.087	1.070	1.053	1.036	1.019	1.001	0.984	0.966	0.947	0.927	0.906																	
200	741	98.8	1.072	1.055	1.038	1.021	1.004	0.987	0.970	0.952	0.933	0.914	0.893																	
300	732	97.6	1.057	1.040	1.023	1.007	0.990	0.973	0.956	0.938	0.920	0.900	0.880																	
400	723	96.4	1.042	1.026	1.009	0.993	0.976	0.959	0.942	0.925	0.906	0.887	0.867																	
500	714	95.2	1.028	1.011	0.995	0.979	0.962	0.946	0.929	0.912	0.893	0.874	0.854																	
600	705	94.0	1.013	0.997	0.981	0.965	0.949	0.932	0.916	0.898	0.880	0.861	0.841																	
700	696	92.8	0.999	0.983	0.967	0.951	0.935	0.919	0.903	0.886	0.868	0.849	0.829																	
800	688	91.7	0.985	0.969	0.954	0.938	0.922	0.906	0.890	0.873	0.855	0.836	0.816																	
900	679	90.5	0.972	0.956	0.940	0.925	0.909	0.893	0.877	0.860	0.843	0.824	0.804																	
1000	671	89.4	0.958	0.942	0.927	0.912	0.896	0.880	0.864	0.848	0.830	0.812	0.792																	
1100	662	88.3	0.944	0.929	0.914	0.899	0.883	0.868	0.852	0.835	0.818	0.800	0.780																	
1200	654	87.2	0.931	0.916	0.901	0.886	0.871	0.855	0.840	0.823	0.806	0.788	0.769																	
1300	646	86.1	0.918	0.903	0.888	0.873	0.858	0.843	0.827	0.811	0.794	0.776	0.757																	
1400	638	85.0	0.905	0.890	0.875	0.861	0.846	0.831	0.815	0.799	0.783	0.765	0.746																	
1500	630	84.0	0.892	0.878	0.863	0.848	0.834	0.819	0.804	0.788	0.771	0.753	0.734																	
1600	622	82.9	0.880	0.865	0.851	0.836	0.822	0.807	0.792	0.776	0.760	0.742	0.723																	
1700	614	81.9	0.867	0.853	0.839	0.824	0.810	0.795	0.780	0.765	0.748	0.731	0.712																	
1800	607	80.9	0.855	0.841	0.826	0.812	0.798	0.784	0.769	0.753	0.737	0.720	0.701																	
1900	599	79.9	0.843	0.829	0.815	0.801	0.787	0.772	0.758	0.742	0.726	0.709	0.690																	
2000	592	78.9	0.830	0.817	0.803	0.789	0.775	0.761	0.747	0.731	0.715	0.698	0.680																	
2100	584	77.9	0.819	0.805	0.791	0.778	0.764	0.750	0.736	0.720	0.705	0.688	0.669																	
2200	577	77.0	0.807	0.793	0.780	0.766	0.753	0.739	0.725	0.710	0.694	0.677	0.659																	
2300	570	76.0	0.795	0.782	0.769	0.755	0.742	0.728	0.714	0.699	0.684	0.667	0.649																	
2400	563	75.1	0.784	0.771	0.757	0.744	0.731	0.717	0.703	0.689	0.673	0.657	0.639																	
2500	556	74.1	0.773	0.759	0.746	0.733	0.720	0.707	0.693	0.678	0.663	0.647	0.629																	
2600	549	73.2	0.761	0.748	0.736	0.723	0.710	0.696	0.683	0.668	0.653	0.637	0.619																	
2700	542	72.3	0.750	0.738	0.725	0.712	0.699	0.686	0.672	0.658	0.643	0.627	0.609																	
2800	535	71.4	0.739	0.727	0.714	0.702	0.689	0.676	0.662	0.648	0.633	0.617	0.600																	
2900	529	70.5	0.729	0.716	0.704	0.691	0.679	0.666	0.652	0.638	0.623	0.607	0.590																	
3000	522	69.6	0.718	0.706	0.693	0.681	0.669	0.656	0.643	0.629	0.614	0.598	0.581																	
3100	516	68.8	0.708	0.695	0.683	0.671	0.659	0.646	0.633	0.619	0.604	0.589	0.571																	
3200	509	67.9	0.697	0.685	0.673	0.661	0.649	0.636	0.623	0.610	0.595	0.579	0.562																	
3300	503	67.1	0.687	0.675	0.663	0.651	0.639	0.627	0.614	0.600	0.586	0.570	0.553																	
3400	497	66.2	0.677	0.665	0.653	0.642	0.630	0.617	0.604	0.591	0.577	0.561	0.544																	
3500	491	65.4	0.667	0.655	0.644	0.632	0.620	0.608	0.595	0.582	0.568	0.552	0.536																	
3600	484	64.6	0.657	0.646	0.634	0.623	0.611	0.599	0.586	0.573	0.559	0.544	0.527																	

Note 1. This table shows the factors used for modifying the output under the standard conditions (atmospheric pressure 100 kPa {750 mmHg} : atmospheric temperature 25 °C (77 °F) relative humidity 30% to that under specific environmental conditions.
The applicable standards are ISO 3046-1, JIS 8002. The factors are calculated according to the expressions specified in the standards.

2. This table is applicable to the turbocharged diesel engine.

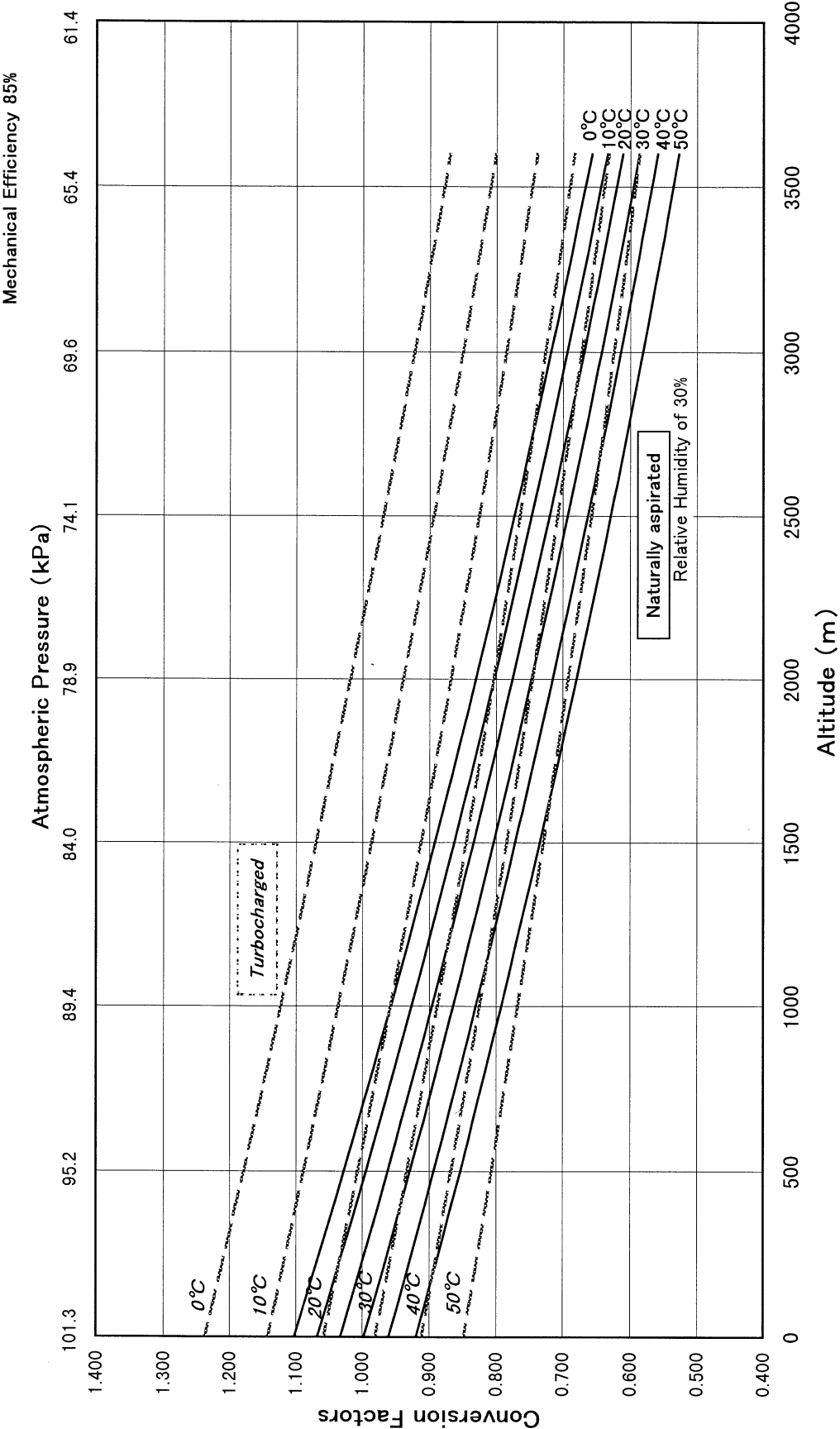
3. Relative humidity isn't taken into consideration.

Table 2 Conversion Factors under Mechanical Efficiency of 85%

Turbocharged diesel engine

Altitude	Atmospheric pressure		Intake air temperature (°C)														
m	mmHg	kPa	0	5	10	15	20	25	30	35	40	45	50				
0	760	101.3	1.237	1.189	1.143	1.099	1.058	1.018	0.981	0.945	0.912	0.879	0.848				
100	751	100.1	1.225	1.177	1.132	1.088	1.047	1.008	0.971	0.936	0.903	0.871	0.840				
200	741	98.8	1.214	1.166	1.121	1.078	1.037	0.999	0.962	0.927	0.894	0.862	0.832				
300	732	97.6	1.202	1.155	1.110	1.067	1.027	0.989	0.952	0.918	0.885	0.853	0.823				
400	723	96.4	1.190	1.143	1.099	1.057	1.017	0.979	0.943	0.909	0.876	0.845	0.815				
500	714	95.2	1.179	1.132	1.088	1.047	1.007	0.969	0.934	0.900	0.867	0.836	0.807				
600	705	94.0	1.167	1.121	1.078	1.037	0.997	0.960	0.925	0.891	0.859	0.828	0.799				
700	696	92.8	1.156	1.111	1.067	1.026	0.987	0.951	0.915	0.882	0.850	0.820	0.791				
800	688	91.7	1.145	1.100	1.057	1.016	0.978	0.941	0.906	0.873	0.842	0.811	0.783				
900	679	90.5	1.134	1.089	1.047	1.006	0.968	0.932	0.897	0.864	0.833	0.803	0.775				
1000	671	89.4	1.123	1.079	1.037	0.997	0.959	0.923	0.888	0.856	0.825	0.795	0.767				
1100	662	88.3	1.112	1.068	1.026	0.987	0.949	0.914	0.880	0.847	0.817	0.787	0.759				
1200	654	87.2	1.101	1.058	1.016	0.977	0.940	0.905	0.871	0.839	0.808	0.779	0.752				
1300	646	86.1	1.091	1.047	1.006	0.968	0.931	0.896	0.862	0.830	0.800	0.771	0.744				
1400	638	85.0	1.080	1.037	0.997	0.958	0.921	0.887	0.854	0.822	0.792	0.764	0.736				
1500	630	84.0	1.070	1.027	0.987	0.949	0.912	0.878	0.845	0.814	0.784	0.756	0.729				
1600	622	82.9	1.059	1.017	0.977	0.939	0.903	0.869	0.837	0.806	0.776	0.748	0.721				
1700	614	81.9	1.049	1.007	0.968	0.930	0.894	0.860	0.828	0.798	0.768	0.741	0.714				
1800	607	80.9	1.039	0.997	0.958	0.921	0.885	0.852	0.820	0.790	0.761	0.733	0.707				
1900	599	79.9	1.029	0.988	0.949	0.912	0.877	0.843	0.812	0.782	0.753	0.726	0.700				
2000	592	78.9	1.019	0.978	0.939	0.903	0.868	0.835	0.804	0.774	0.745	0.718	0.692				
2100	584	77.9	1.009	0.968	0.930	0.894	0.859	0.827	0.796	0.766	0.738	0.711	0.685				
2200	577	77.0	0.999	0.959	0.921	0.885	0.851	0.818	0.788	0.758	0.730	0.704	0.678				
2300	570	76.0	0.989	0.949	0.912	0.876	0.842	0.810	0.780	0.750	0.723	0.696	0.671				
2400	563	75.1	0.979	0.940	0.903	0.867	0.834	0.802	0.772	0.743	0.715	0.689	0.664				
2500	556	74.1	0.970	0.931	0.894	0.859	0.826	0.794	0.764	0.735	0.708	0.682	0.657				
2600	549	73.2	0.960	0.921	0.885	0.850	0.817	0.786	0.756	0.728	0.701	0.675	0.651				
2700	542	72.3	0.951	0.912	0.876	0.842	0.809	0.778	0.748	0.720	0.694	0.668	0.644				
2800	535	71.4	0.941	0.903	0.867	0.833	0.801	0.770	0.741	0.713	0.687	0.661	0.637				
2900	529	70.5	0.932	0.894	0.859	0.825	0.793	0.762	0.733	0.706	0.679	0.654	0.631				
3000	522	69.6	0.923	0.886	0.850	0.817	0.785	0.755	0.726	0.699	0.672	0.648	0.624				
3100	516	68.8	0.914	0.877	0.842	0.808	0.777	0.747	0.718	0.691	0.666	0.641	0.617				
3200	509	67.9	0.905	0.868	0.833	0.800	0.769	0.739	0.711	0.684	0.659	0.634	0.611				
3300	503	67.1	0.896	0.859	0.825	0.792	0.761	0.732	0.704	0.677	0.652	0.628	0.605				
3400	497	66.2	0.887	0.851	0.817	0.784	0.754	0.724	0.697	0.670	0.645	0.621	0.598				
3500	491	65.4	0.878	0.842	0.808	0.776	0.746	0.717	0.690	0.663	0.638	0.615	0.592				
3600	484	64.6	0.869	0.834	0.800	0.769	0.738	0.710	0.682	0.656	0.632	0.608	0.586				

Conversion Factors of Output



3. COLD STARTING AND OPERATION

[1] GENERAL

As explained in the preceding section regarding engines used in cold weather, a standard KUBOTA engine without external load can be started in temperatures as low as -15 °C (5 °F).

When the engine is mounted on a machine, cold starting performance is subject to various conditions, so very careful checks are necessary.

Points regarding fuel, lubricating oil, cooling water, starter, battery and glow plug are covered below.

[2] FUEL

The fuels of a high fluid point (viscosity) do not flow smoothly at an extremely cold temperature.

Such fuels should not be used. The table below shows the recommended fuels.

Standard Temp. range	JAPAN	U.S.A.
	JIS K2204	ASTM D975-94
-5 °C (23 °F) and over	Diesel Fuel No.2 (or its equivalent)	No.2-D
-5 °C to -15 °C (23 °F to 5 °F)	Diesel Fuel No.3 (or its equivalent) or Diesel Fuel Special No.3 (or its equivalent)	No.1-D
Under -15 °C (5 °F)	Diesel Fuel Special No.3 (or its equivalent)	

For the diesel fuels, each nation has used a standard specified by a nationally authorized organization. In accordance with such a standard, a diesel fuel suitable to each season or region is selected to use.

This is in addition to the standards of JAPAN and U.S.A. shown in the above table.

Note :

Do not allow water to be mixed with the fuel.

Water in the fuel may freeze and prevent fuel flow.

[3] LUBRICANT

Oil viscosity changes in cold temperature as crystallization of the wax element contained in oil proceeds, and fluidity is finally lost. Wrong selection of oil cannot only increase resistance for cold starting but also affect lubrication of each part. Oils for low temperature, containing additives for lowering the pour point, should be used.

Note :

The use of synthetic oil is not recommended.

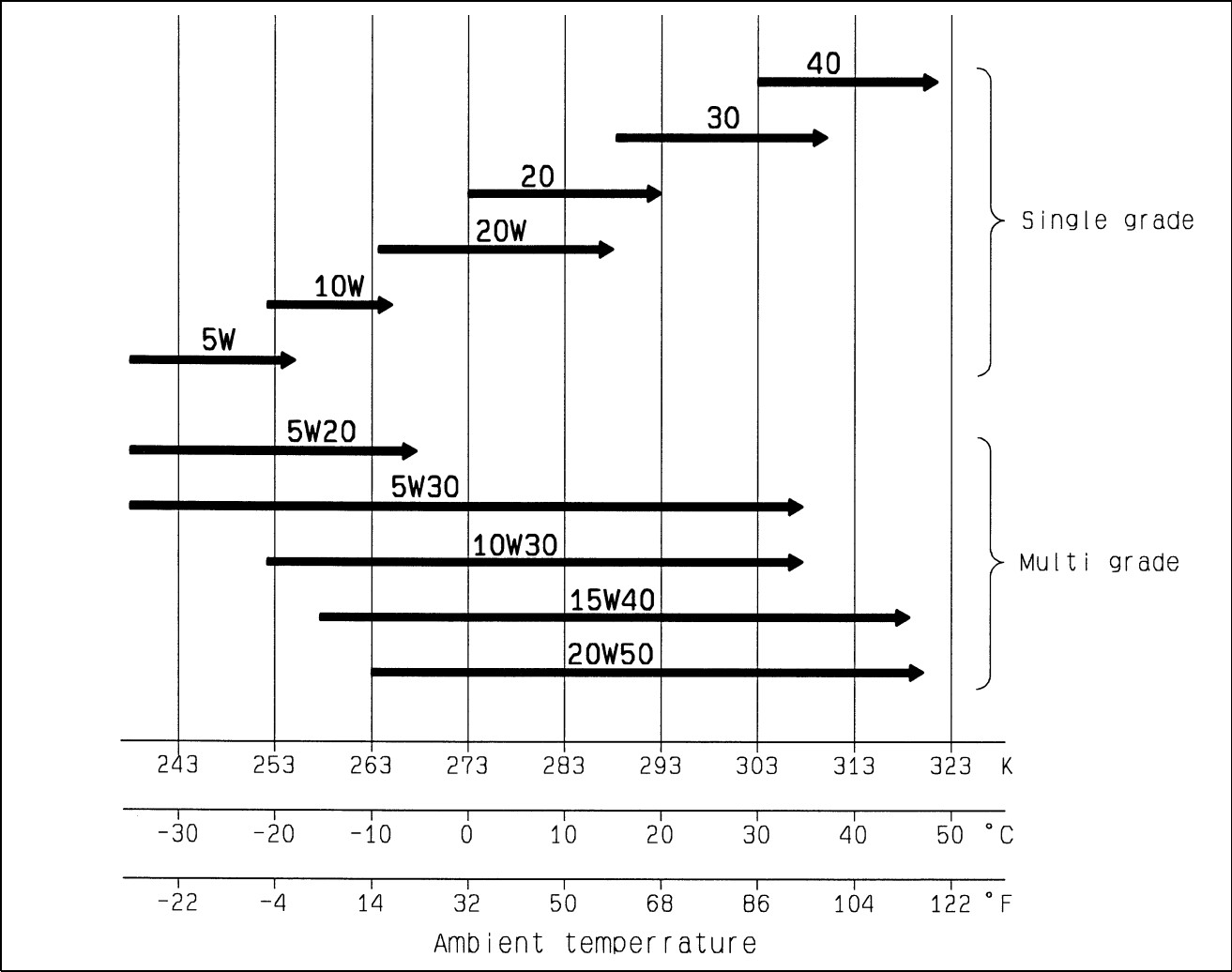


Fig. 3-15 Suitable oil viscosity chart

[4] COOLANT

High quality antifreeze must be used at all times.

- 1) Mix antifreeze with soft distilled water to use.
- 2) Premix the H₂O and antifreeze thoroughly before adding to the engine
- 3) Use only a 50/50 mix of H₂O and ethylene glycol (antifreeze) at all times.
- 4) Change antifreeze mix once a year.

[5] STARTER

Starters used in KUBOTA engines have the following standard capacities ;

Engine size Total displacement cc (cu.in.)	Starter capacity (kW) [More than -15 °C (5 °F)-BB Spec.]
Less than 700 (Less than 42.72)	0.8 to 1.0
700 to 1500 (42.72 to 91.54)	1.0 to 1.4
1500 to 3000 (91.54 to 183.06)	1.4 to 2.0
Over 3000 (Over 183.06)	2.0 to 2.5

Cold starting difficulty depends on the ambient temperature (intense cold or extreme cold) and resistance of transmission.

- 1) When an ON/OFF clutch is used between the engine and the power transmission, it can be set to OFF during starting and engine can be started as if starting an isolated engine.
- 2) Even though an ON/OFF clutch is not used, when resistance of the transmission is small, or when resistance is not small but the ambient temperature is not very cold, a standard starter may be sufficient.
- 3) On the contrary, as resistance increases, or as the ambient temperature becomes extremely cold, a large capacity starter and battery must be used.
- 4) As the displacement per cylinder increases, a larger capacity starter and battery must be used.

[6] BATTERY

From the viewpoint of startability, the battery capacity should be as high as possible. The capacity however is regulated by the assigned installation space and the balance between battery capacity and charging capacity. The table below is used as the standard in accordance with the description in the starter section.

Too much battery capacity imposes too much load on the starter. In the worst case, the starter may be burned up. Therefore, it is necessary to sufficiently examine and decide the battery capacity in accordance with the ambient conditions at starting.

As a principle, however, the battery is prepared and set by the manufacturer of machine to which the battery will be installed.

Battery capacity (AH)

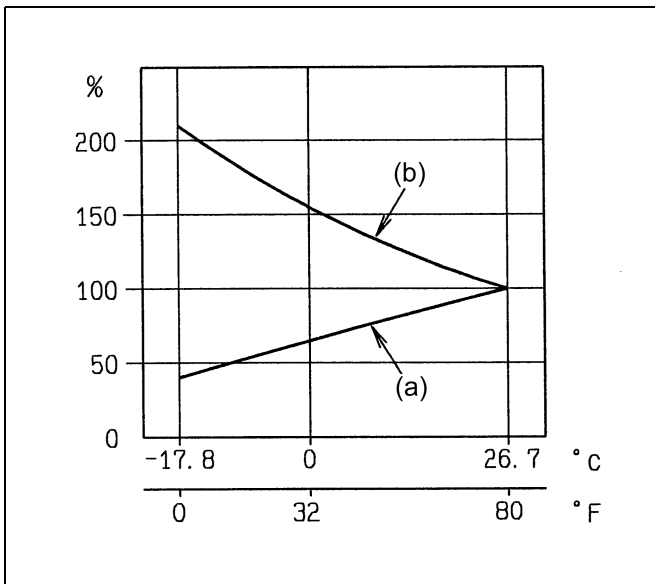
Engine size Total displacement cc (cu.in.)	Battery capacity (AH)	
	20hr Ratio	5hr Ratio
Less than 800 (Less than 48.82)	35 ~ 50	28~40
800 to 1900 (48.82 to 115.95)	65~75	53~62
1900 to 3000 (115.95 to 183.06)	100~120	80~96
Over 3000 (Over 183.06)	150~180	120~144

Cold Cranking Amperage

Engine size Total displacement cc (cu.in.)	Cold Cranking Amperage [C.C.A (A)]
Less than 800 (Less than 48.82)	350~400
800 to 1900 (48.82 to 115.95)	450~540
1900 to 3000 (115.95 to 183.06)	580~670
Over 3000 (Over 183.06)	1050~1200

Discharging capacity is reduced by temperature change. The battery discharging capacity varies with the ambient temperature change.

Especially at a low temperature, the decrease of discharging capacity poses a problem. As for the equipment used at an extremely cold temperature, if the load of its hydraulic pump, torque converter, etc. is estimated to increase, it is necessary to increase the battery capacity together with that of the starter. When further increase is required, use of 24 V specification starters and glow plugs should be considered.



(a) Comparison of cranking power available from fully charged battery at various temperature.

(b) Comparison of power required to crank engine with S.A.E. 10W-30 oil at various temperature.

Fig. 3-16

[7] BATTERY CABLE

The battery cable size (cross-sectional area) largely influences the starting performance of engine (especially at an extremely cold temperature).

It is necessary to select a cable of appropriate size. The following summarizes the procedures for specifying the battery cable size area.

Current (A)	Cable size (mm ²)	AWG size
380	15	6
440	20	4
550	30	2
630	40	1
710	50	0
800	60	2/0
960	85	3/0
1170	100	4/0

[Ambient temperature : 40 °C (104 °F)]

Procedures for specifying battery cable size

1. Obtain the rated current of starter.
To obtain the rated current (A), divide the rated output of starter (kW) by the battery voltage (V).

Ex.

When a 2.2 kW starter is driven by a
12 V battery : $2200 \text{ (W)} / 12 \text{ (V)} = 183.3 \text{ (A)}$

When a 2.2 kW starter is driven by a
24 V battery : $2200 \text{ (W)} / 24 \text{ (V)} = 91.7 \text{ (A)}$

2. Multiply the obtained rated current by three (since the current flow at starting is about three times the rated current).

Rated current $\times 3$

Ex. $183.3 \times 3 = 549.9 \text{ (A)}$

3. In accordance with the obtained starting current value and above table (Table of maximum current for each cable size in short time operation), select the minimum cable size to withstand the starting current value.

Ex.

The above table shows a cable of 30 or 40 mm² cross sectional area (low voltage cable for automobiles) must be used.

4. For 24 V special applications, the above guide-lines can also be used.

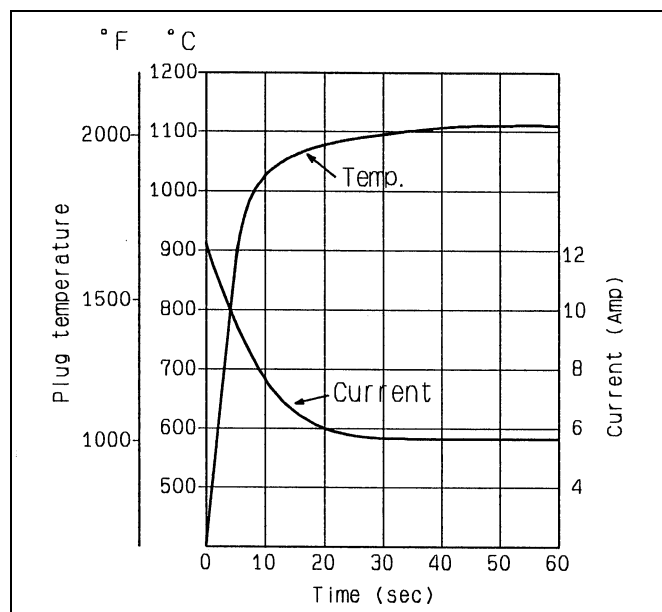
[8] GLOW PLUG

The temperature and current and period of time of glowing plug are as shown in Fig. 3-17.

With the S.M., 05, 03-M, 07 and V3 series, the Super Glow Plug (Quick Glow Plug) system is supplied as a standard component to reduce the preheating period. When preheating is too short, the combustion chamber does not become sufficiently warm and the operator must repeat starting operation.

In this case the battery is also discharged.

Note : Refer to 9-7, "[4] GLOW PLUG".



Glowing current time period and glow plug surface temperature and current.

Fig. 3-17

Atmospheric temperature °C (°F)	Time required * for red heat sec	Time required ** for preheating sec
Above 10 (50)	—	NO NEED
10 (50) to -5 (23)	Approx. 6	Approx. 5
Below -5 (23)		Approx. 10

* The above values are shown only as reference values and vary with engine types.

* Time required for red heat:

Time required for (raising the tube surface temperature to approx. 800 °C (1472 °F) at the glow terminal voltage of 12 V.

**Limit of continuous use is 20 seconds.

[9] AUXILIARY STARTING DEVICES

Auxiliary devices are required when the engine is started at extremely cold temperature, or when it must be started in a short period (in approx. 10 seconds) in severe cold temperatures.

1) Coolant heater

A coolant heater is installed in the coolant circuit to preheat coolant to 10 to 30 °C (50 to 86 °F).

2) Oil pan heater

Oil pan may be heated from the bottom with a heater, or oil in oil pans may be heated directly by sheathed heaters.

3) With stationary engines, engine room can be heated, or engine covered and heated with infrared heaters.

4) Regular pre-heating

About 50% of the rated voltage is applied to the glow plug to prepare for the emergency start. (Effective for reducing the starting time of emergency generator).

Time that a 50% of rated voltage could be applied. : Continuous

[WARNING]

Don't use starting aids such as ether.

4. FUEL SYSTEM

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FUEL SYSTEM

1. GENERAL

The fuel system feeds fuel from the fuel tank to the combustion chamber.

It contains a precision injection pump and injection system that greatly affects combustion performance.

A continuous supply of good quality filtered fuel is needed for these parts to function properly.

To make the exhaust gas emissions of engines meet regulations in each nation or region, the fuel injection system must be carefully controlled. Use of the poor fuel,

inadequate maintenance of the fuel injection system, and replacement of the injection system with any other one than those recommended by KUBOTA may significantly affect the emissions.

The engine may discharge excessive bad levels of controlled constituents exhaust gas, consequently resulting in non-conformance with applicable emission standards.

【Fuel System】

The general fuel system of KUBOTA diesel engines shown in the diagram below. Fuel from the tank flows in the passage and is injected from the nozzle via the fuel

injection pump. Overflow fuel returns to the tank. The system includes filters to protect it from entrance of air, water and dust.

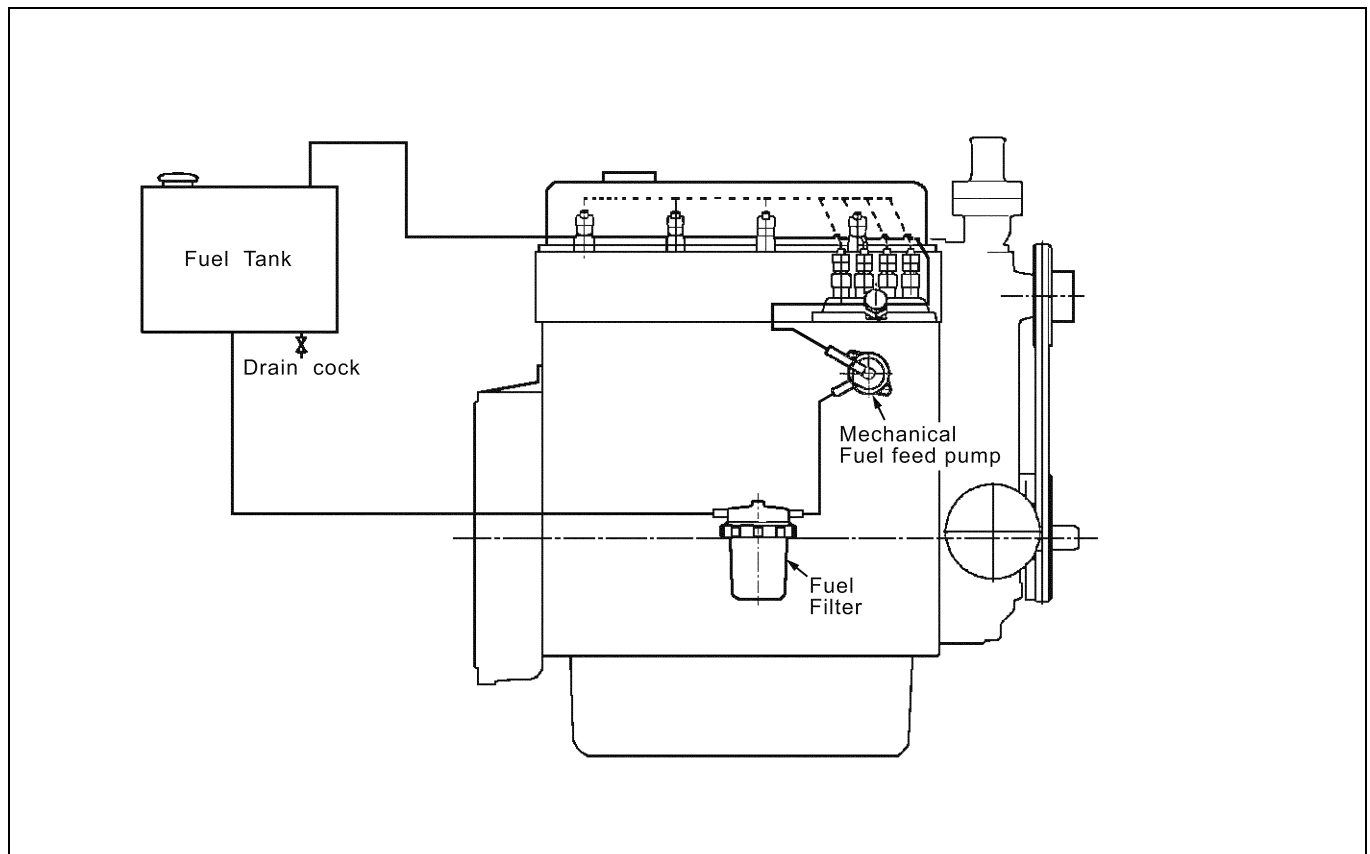


Fig. 4-1 Fuel system

While the engine is running, fuel is fed into the pump by the fuel feed pump after passing through the fuel filter where any foreign matter is removed. The fuel camshaft actuates the injection pump and force feeds fuel to the injection nozzle through the injection pipe.

Fuel is then sprayed through the nozzle into the combustion chamber. The fuel discharged after lubricating and cooling the injection nozzle is returned to the fuel tank automatically through the over-flow pipe.

2. FUEL INJECTION PUMP

The fuel injection pump is modified to fit KUBOTA engines.

The fuel injection pump is an extremely precise unit, so it must be handled very carefully. Water entering in the fuel system will cause seizure, rusting or early wear of the injection pump plunger, cylinder, nozzle, needle valve, etc. Normal fuel has an appropriate viscosity to maintain good lubrication.

In the fuel pump of 03-M, 07 and V3 engines, F.S.P(Fine Spill Port), which has such functions as timer and injection rate control, has been employed.

Also, in the 07 series engines, CPV(Constant Pressure Valve) has been employed in the fuel pump to prevent the secondary injection by keeping constant the residual pressure in the high-pressure pipes after fuel is injected. And in the E3 engines, the fuel injection timing, which most heavily influences the emission, is controlled to be within 0.5 degrees.

In SM, 05 series engine, a Bosch MD type mini pump is used for the injection pump, while in 03-M, 07 and V3 series engine, a Bosch KD type mini pump is used for the injection pump. These are small, lightweight and easy to handle,

【SM, 05 and 03-M series engine】

Injection timing can be adjusted by varying shim thickness.

Increasing or decreasing shim thickness by 0.025mm (0.00098") will delay or advance injection timing by approx. 0.25° (0.0044 rad).

【07 Series and V3 Series】

Injection timing can be adjusted by rotating the injection pump unit clockwise or anti-clockwise, this can be achieved once the high pressure injection pipes are removed and the unit injection pump mounting bolts are loosened.

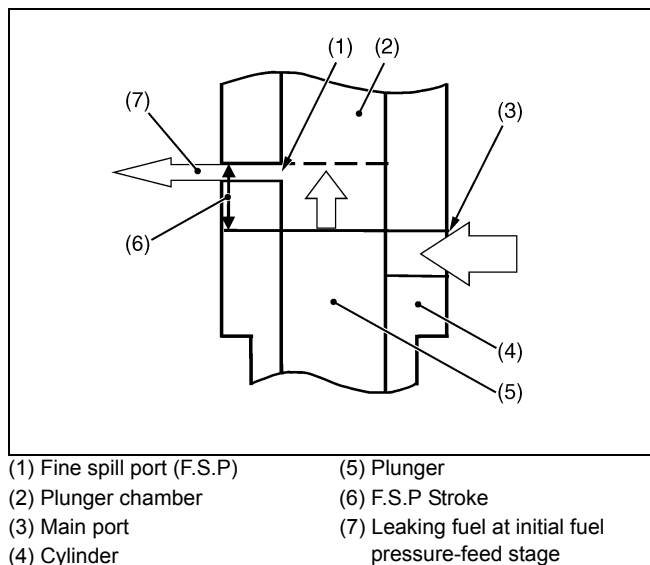


Fig. 4-2 F.S.P (Fine spill port)

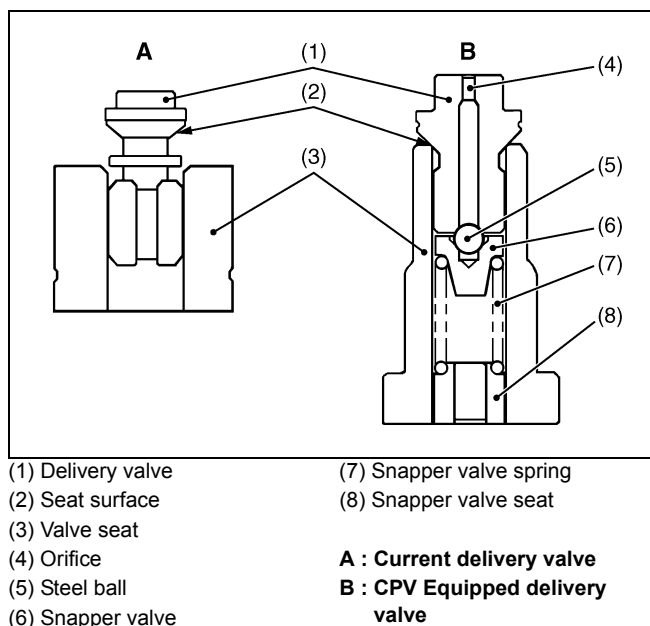
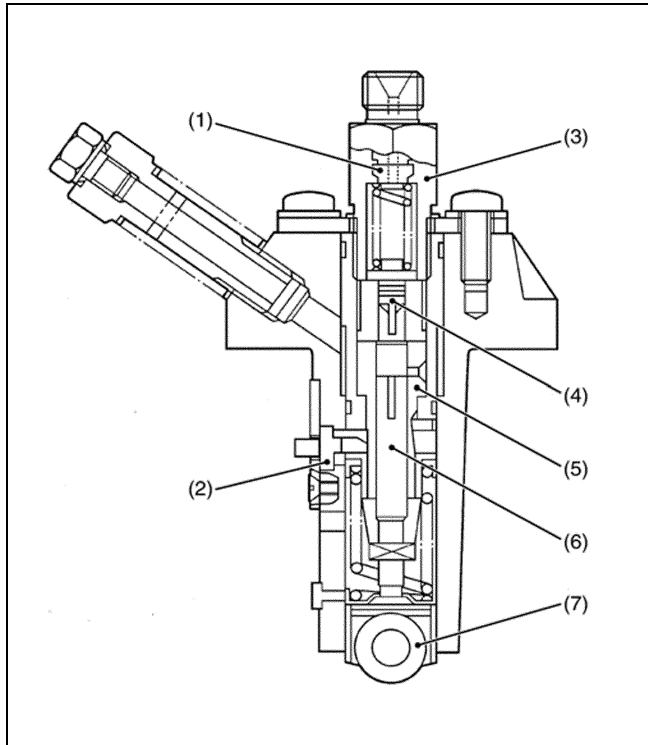


Fig. 4-3 CPV (Constant pressure valve)

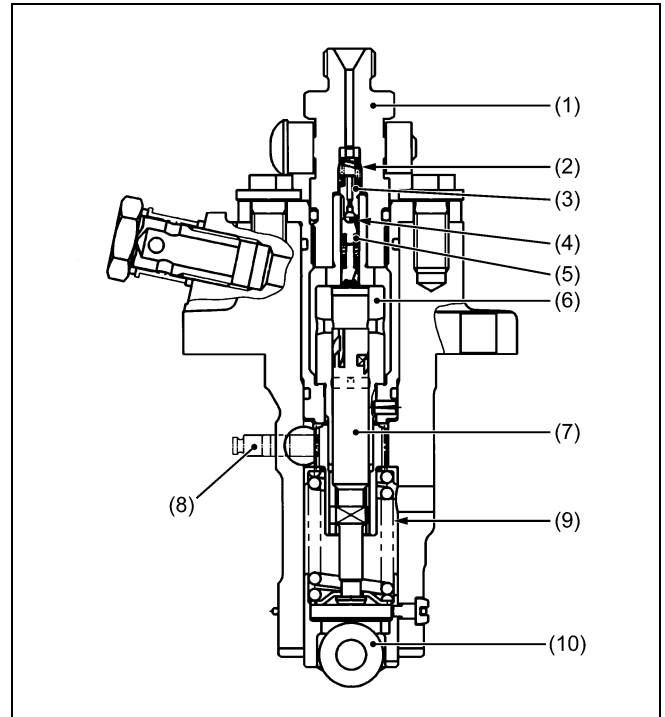
• S.M. series, 05 series



(1) Dumping valve	(5) Cylinder
(2) Control rack	(6) Plunger
(3) Delivery valve holder	(7) Tappet roller
(4) Delivery valve	

Fig. 4-4 Fuel injection pump

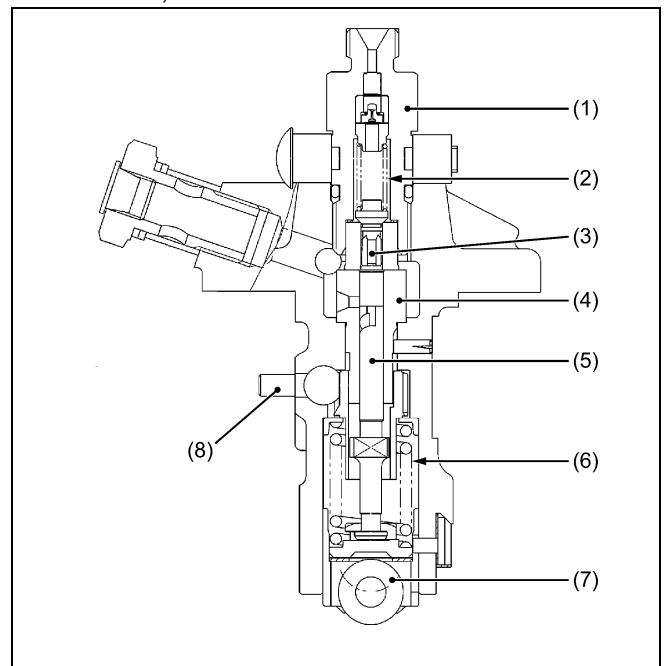
• 07 series



(1) Delivery valve holder	(6) Cylinder
(2) Delivery valve spring	(7) Plunger
(3) Delivery valve	(8) Control rack
(4) Steel ball	(9) Plunger spring
(5) Snapper valve	(10) Tappet roller

Fig. 4-5 Fuel injection pump

• 03-M series, V3 series



(1) Delivery valve holder	(5) Plunger
(2) Delivery valve spring	(6) Plunger spring
(3) Delivery valve	(7) Tappet roller
(4) Cylinder	(8) Control rack

Fig. 4-6 Fuel injection pump

3. FUEL INJECTION NOZZLE

Kubota's engines employ two types of nozzles, Pin type nozzles and Hole type nozzles, depending on the difference in their combustion chambers.

There are two types of the Pin type nozzle, Pintle type one and Throttle type one, among which Kubota employs the Throttle type.

Throttle type of nozzle is designed to control the injection quantity when the lift rate is low at start of the injection, and to cut down on the knocking sound caused by excessive fuel injection by giving the needle valve section more taper than before to prevent the rapid increase in the injection quantity when the initial injection turns into the full-force injection.

The injection pressure is adjusted in the range of 13.7 to 14.7MPa (140 to 150kgm², 1990 to 2133psi), in which the injection pressure can be adjusted by changing the shim thickness, if necessary.

The heat seal is employed to improve the durability and reliability of the nozzle.

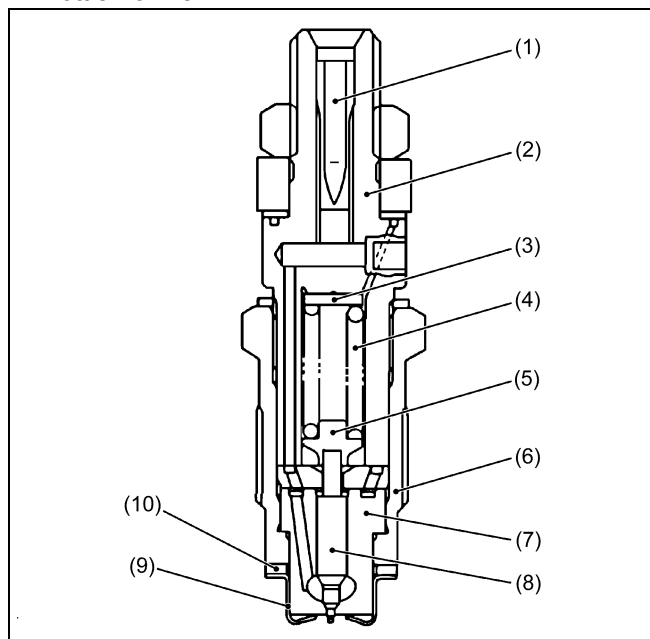
In the Hole type nozzles, the Two-stage type injection nozzles have been employed to respond to the emission and noise regulations, in addition to the conventional type nozzles.

The Two-stage type injection nozzle injects in two stages of the primary injection and the secondary injection, which is especially effective in reducing NOx (nitrogen oxides) and PM in emission.

As for the injection pressures, the primary injection pressure is set at 18.64 to 19.61Mpa (190.0 to 200.0 kgf/cm², 2703 to 2844psi.) and the secondary injection pressure is set at 23.54 to 24.52Mpa (240 to 250 kgf/cm², 3414 to 3556 psi.) depending on the models. Because the structure is so complicated that the injection pressure readjustment is not possible, it becomes necessary to change the nozzle as a nozzle main body assy, in the case of an occurrence of injection pressure drop or atomization failure.

(1) IDI

• Throttle nozzle

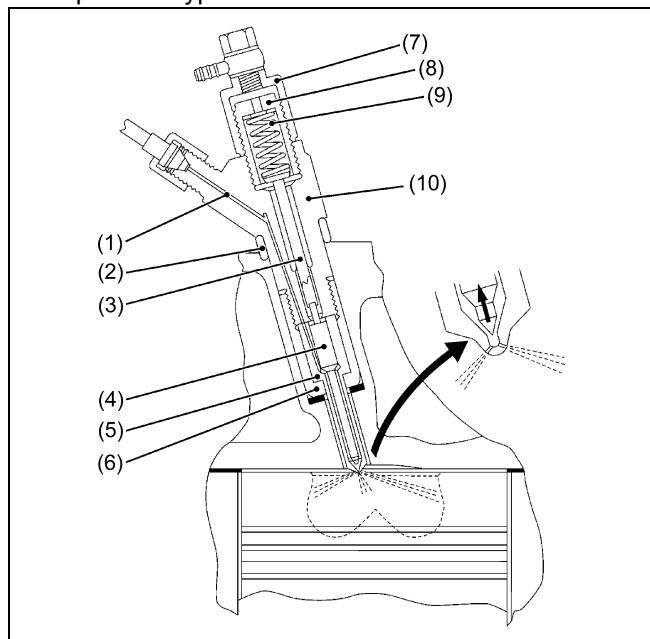


(1) Bar filter	(6) Retaining nut
(2) Nozzle holder body	(7) Nozzle piece
(3) Adjusting washer	(8) Needle valve
(4) Nozzle spring	(9) Heat seal
(5) Push rod	(10) Gasket

Fig. 4-7

(2) DI

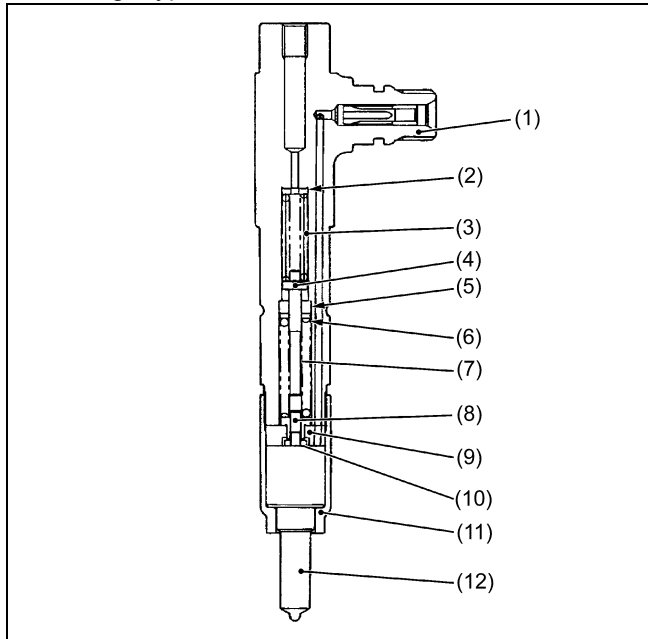
• Multiple hole type



(1) Fuel passage	(6) Nozzle nut
(2) Seal ring	(7) Nut
(3) Push rod	(8) Adjusting screw
(4) Needle valve	(9) Nozzle spring
(5) Nozzle body	(10) Nozzle holder

Fig. 4-8

• Two stage type



(1) Nozzle holder body	(7) Second spring
(2) 1st stage injection pressure adjusting shim	(8) Pre-lift adjusting spring seat
(3) First spring	(9) Chip-packing
(4) Pressure pin	(10) Max-lift adjusting washer
(5) Spring seat	(11) Retaining nut
(6) 2nd stage injection pressure adjusting shim	(12) Nozzle

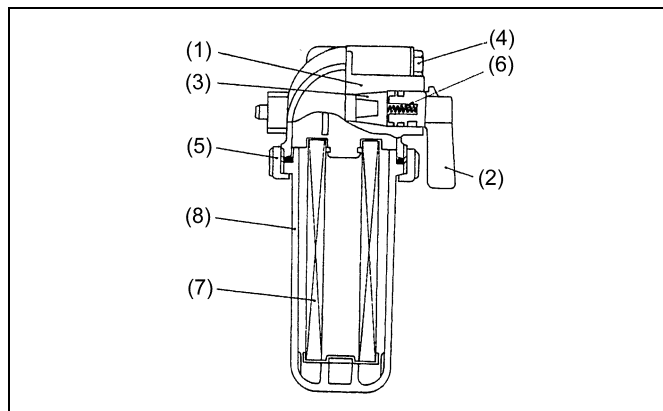
Fig. 4-9

4. FUEL FILTER

The fuel filter located between the tank and the injection pump prevents foreign matter from entering the injection pump. A standard KUBOTA filter uses a paper element (filtration diameter less than $15\ \mu$). Filtration surface areas available in KUBOTA filters are $250\ \text{cm}^2$ (38.75 sq.in.), $1100\ \text{cm}^2$ (170.5 sq.in.) and $1660\ \text{cm}^2$ (257.28 sq.in.), according to engine model.

Normally filter elements or cartridges must be changed every 400 hours. Three types of filters are shown.

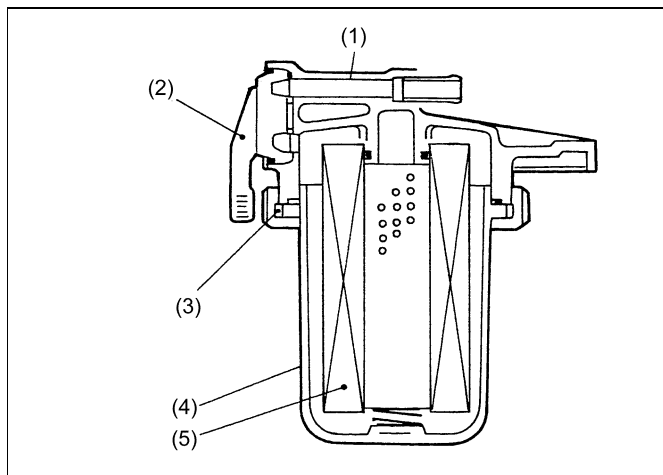
Fig 4-10 type filter is ordinary type. Air trapped in the filter is purged by the vent plug (4).



(1) Body (4) Vent plug (7) Filter element
(2) Lever (5) Ring nut (8) Cup
(3) Valve (6) Spring

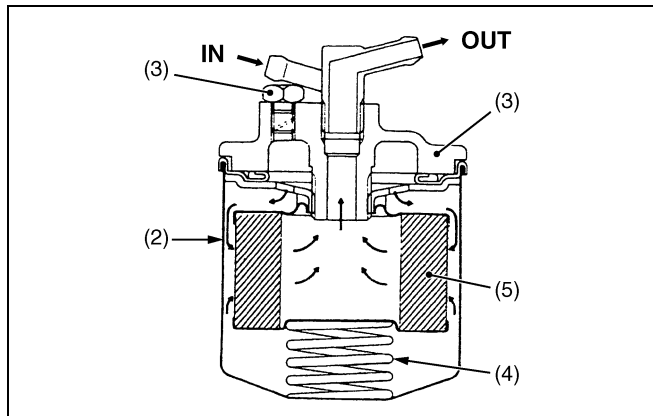
Fig. 4-10 Fuel filter

Fig. 4-11 type filter has an automatic venting mechanism that can complete venting in about one minute with the lever in the open position.



(1) Body (3) Retainer ring (5) Filter element
(2) Lever (4) Cup

Fig. 4-11 Fuel filter



(1) Body (3) Vent plug (5) Filter element
(2) Cup (4) Spring

Fig. 4-12 Fuel filter

Note :

Make sure the fuel IN/OUT pipings are properly connected. Otherwise, the performance of filter will deteriorate.

Proper location of the pre-filter, fuel pump and the main fuel filter is critical to provide adequate fuel supply. Electric fuel pump generally has less suction head capability. Therefore, it should be located as close to the fuel tank as possible. It is strongly recommended to evaluate and check the fuel pump suction and discharge head against fuel system restrictions. If the losses due to the restrictions are higher than the pump specification, the engine will have hard starting condition or will have low power complaint, especially when the filters will get plugged over time or when the fuel is at a low fuel level in the tank.

The pre-filter is necessary to protect an electric fuel pump. The pre-filter should have micron rating between 100-200 micron (see the electric fuel pump specifications for proper recommendations).

If the fuel has a high content of water or if water condensation condition may occur due to temperature fluctuations, it is recommended to use fuel water separator to prevent the fuel injection system and other problems.

Also, it is critical to mount the filter and the pump to avoid excessive vibration.

Fuel hoses, filters and pump should be located away from high heat surfaces such as exhaust system, hydraulic lines, etc. as high temperature will cause engine power loss due to lower viscosity of fuel at high temperature.

5. FUEL FEED PUMP

When a fuel tank is installed on higher than the fuel injection pump and low output engine is used, fuel fed to the fuel injection pump can be achieved by gravity. However, with a multi-cylinder, large displacement engine, fuel supply will be affected unless fuel is forced into the pump.

To avoid this problem, a fuel feed pump is used. Feed pumps come in two general types ; those powered mechanically by the engine, and those power electrically by the battery.

● Mechanical fuel feed pump

A diaphragm type feed pump can be installed under the fuel injection pump, this forces fuel into the injection pump by the pumping action of the diaphragm that reciprocates with the fuel camshaft, suction valve and pressure feed valve.

e.g. Specifications

At 1500 camshaft min^{-1} (rpm)

(engine min^{-1} (rpm) : 3000)

Fuel feed quantity : 225 cc/min. (13.73 cu.in.)

Suction head : 800 mm (31.5 in.)

Suction head is with pump in wet condition.

The diaphragm type feed pump is actuated by rotation of the camshaft.

This pump style will not provide quick priming.

● Electric fuel feed pump

An electric fuel feed pump is used when a fuel tank is positioned below the fuel pump of the engine. The pump starts when the starter switch is switched on. Fuel is supplied to the injection pump regardless of engine speed, even in cold conditions.

e.g. Specifications

Discharge 400 cc (2.44 cu.in.)/min. at 12 V voltage and 1.5 A current, suction head, 400 mm (15.7 in.)

This pump is driven by the battery. It can therefore be operated even with the engine stopped. The feed pump should be located near the fuel tank, to "PUSH" the fuel through the feed system.

Ensure that the electric pump is protected from dirt by using a strainer or sedimentor.

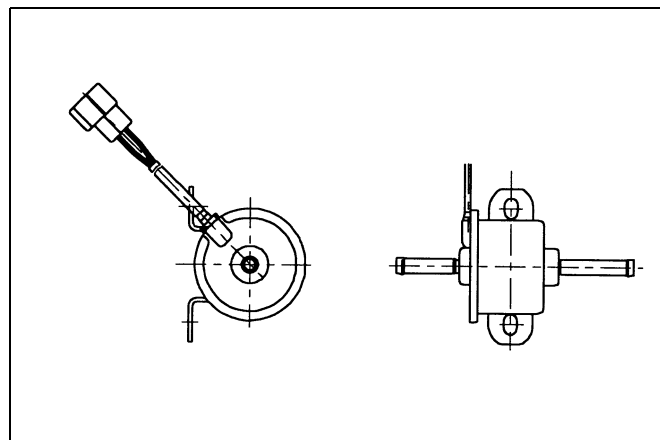


Fig. 4-14 Electric fuel feed pump

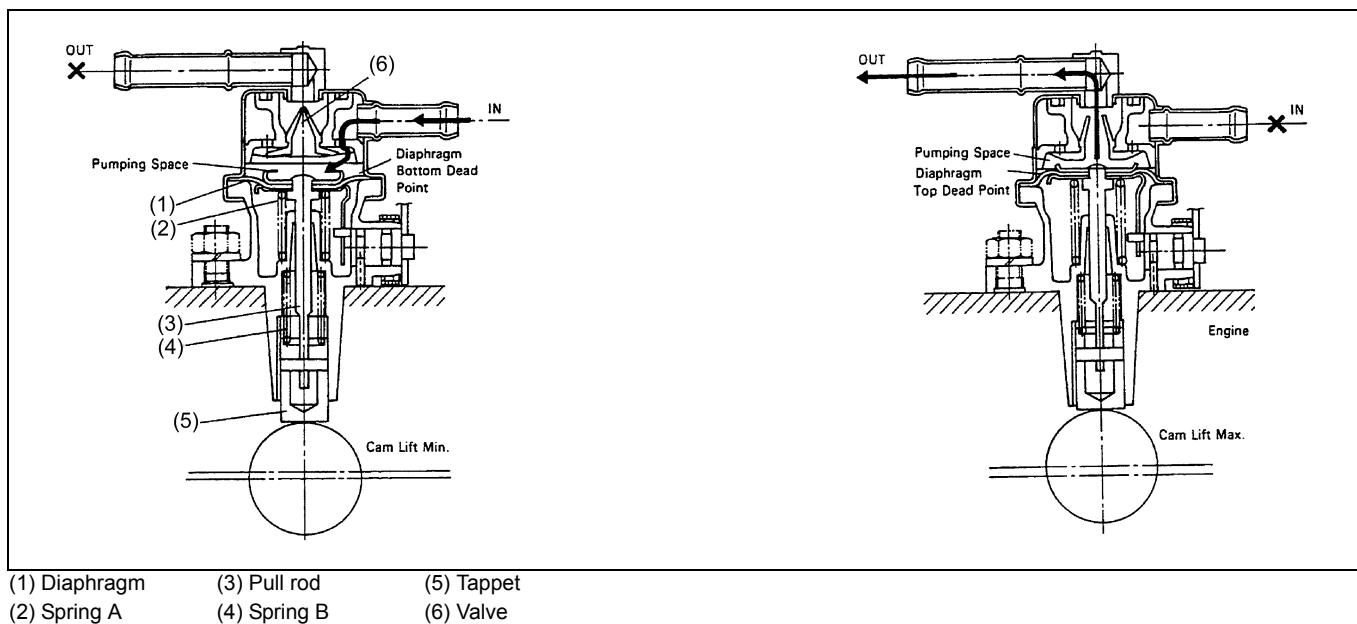


Fig. 4-13 Mechanical fuel feed pump action

6. FUEL TANK

The size, shape and position of fuel tank vary with the size and type of machine and application. Care should be taken with the following items.

(1) Capacity of fuel tank

The capacity of fuel tank varies with the application of machine to which the engine is installed. Generally the fuel tank capacity of mobile vehicles is small and that of stationary machines is large. To roughly estimate the required capacity, use the following formula.

Fuel tank sizing formula

$$Q_t = B_e \times P_r \times H_r$$

Q_t : Approximate tank capacity (liter)

B_e : Fuel consumption at the rated output
(liter/kW•hr)

$$B_e = b_e / (F_g \times 1000)$$

b_e : Fuel consumption (g/kW•hr)

F_g : Fuel specific gravity

P_r : Applicable power (rated output) (kW)

H_r : Running hours between fill-up (desired holding hours) (hr)

To obtain an approximate value, you may assume the fuel consumption per hour is 285 g/kW•hr and the fuel specific gravity is 0.84.

Fuel consumption by engine model is shown in TECHNICAL INFORMATION.

(2) Prevention of internal rusting

Since the tank is not always filled with fuel, its internal surface should be protected from rusting or for long term storage.

The surface should be treated by a reliable rust prevention method.

(3) Drain cock

It is very effective for maintenance of each equipment of the fuel system to provide a drain cock at the bottom of fuel tank for discharging water and substances other than fuel contents.

(4) Cap and filter of fuel tank

The fuel inlet port requires a filter (# 60 mesh) and a cap having a breather function. If a drum has been left outdoors, water or dirt may have entered it. A filter must be used for supplying fuel into the tank, and fuel at the bottom of drum must not be supplied to the tank. Fuel pickup should be above the tank bottom about 12 mm (1/2 in.). The cap must be sufficiently sealed so as to prevent fuel from leaking during operation. An air vent for maintaining the air pressure in the tank to atmospheric pressure must be provided.

(5) Position of fuel tank

The position of fuel tank varies with the distance from the engine, the inclination during operation of the engine, etc. When the gravity feed system is employed, the bottom of fuel tank must be at a 150 mm (6 in.) or more higher position than the top of fuel injection pump. Otherwise the fuel in the tank cannot be completely fed. If the bottom of fuel tank is extremely close to the top of fuel injection pump, the fuel feed pressure and amount of fuel may become insufficient, thus reducing or fluctuating output and rpm. Range of distance between the bottom of fuel tank and the top of fuel injection pump :

150 mm (6 in.) to 2000 mm (78 in.)

For further details of other fuel systems, refer to fuel piping item.

7. FUEL PIPE

Fuel pipe must be made of a material that will withstand the vibration expected during operation and remain durable for several years. Since it contains flammable oil, piping must be arranged carefully.

● Material

Since fuel pipe carries a flammable liquid, high quality oil resistant multi-layer rubber for fuel with a temperature resistance of 373 K {100 °C (212 °F)} or higher must be used. Low quality piping can expand or break which cause accidents.

● Piping precautions

- 1) Piping should not be positioned close to any rotating parts or intense vibration.
- 2) Piping should be routed to avoid extremely high and low temperature.
- 3) Sharp turning, tapers and unnecessary bending must be avoided, since they will increase flow resistance which may cause decrease in output or fluctuation of rpm.
- 4) The number of joints must be as small as possible to prevent leakage, and joints must be made as rigid as possible.
- 5) Flexible pipes must be used between parts that have different vibration sources.
- 6) Sags or dips in piping must be eliminated since water will collect in them.
- 7) Fuel pipe must not contact or cross with electric wire.

8. FUEL PIPING

The types of fuel piping used depends upon the application. The fuel tank and fuel injection pump, the position of fuel filter and feed pump and length of piping may make air bleeding difficult and also may cause air to be entrapped after long-term storage.

Before making the final decision, carry out sufficient checks by installing the piping on the actual machine.

KUBOTA recommends the following standard fuel piping. For further details, see page 4-9 to 4-18.

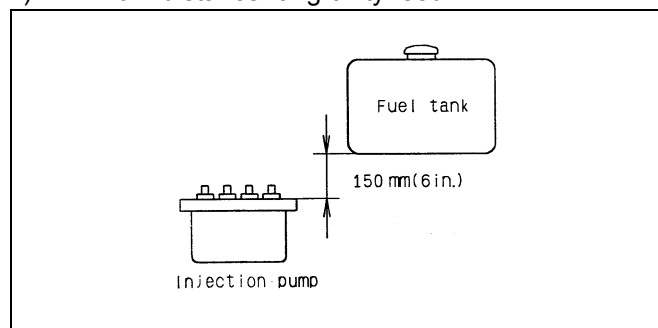
Even in case that the fuel piping recommended by KUBOTA is adopted, it is still required to check the system for the following points after installing the engine on the equipment. The location of the fuel tank, the specifications of the mounted equipment, the length of the pipes and the location of each component will affect the flow and the inclusion and bleeding of air.

- 1) Make sure that air bleeding can easily be done when the fuel tank is being replenished with fuel.
- 2) Make sure that the engine can be operated normally when the various dynamic inclined conditions (e.g., at a horizontal position, at a maximally inclined position, and at a maximally swinging condition) are combined with the fuel levels (the upper limit and lower limit levels) in the tank.

- 3) Check the restarting ability when a certain time has elapsed after the engine was stopped.
- 4) Check the temperature in the fuel tank when the engine is operating and check decrease of the engine output and the engine workability when the fuel temperature is rising.
- 5) Check the starting ability in cold condition.
- 6) Print the following cautionary points in the instruction manual.

- a) Use a high-quality fuel applicable to ambient and local conditions.
- b) In the cold weather, change the fuel to the one exclusively recommended for cold season so that the sedimentor and the filter can be prevented from being blocked by precipitated wax of the fuel.
- c) Periodically discharge the drain in the sedimentor.

7) Minimum distance for gravity feed.



A When the fuel tank is mounted above the injection pump

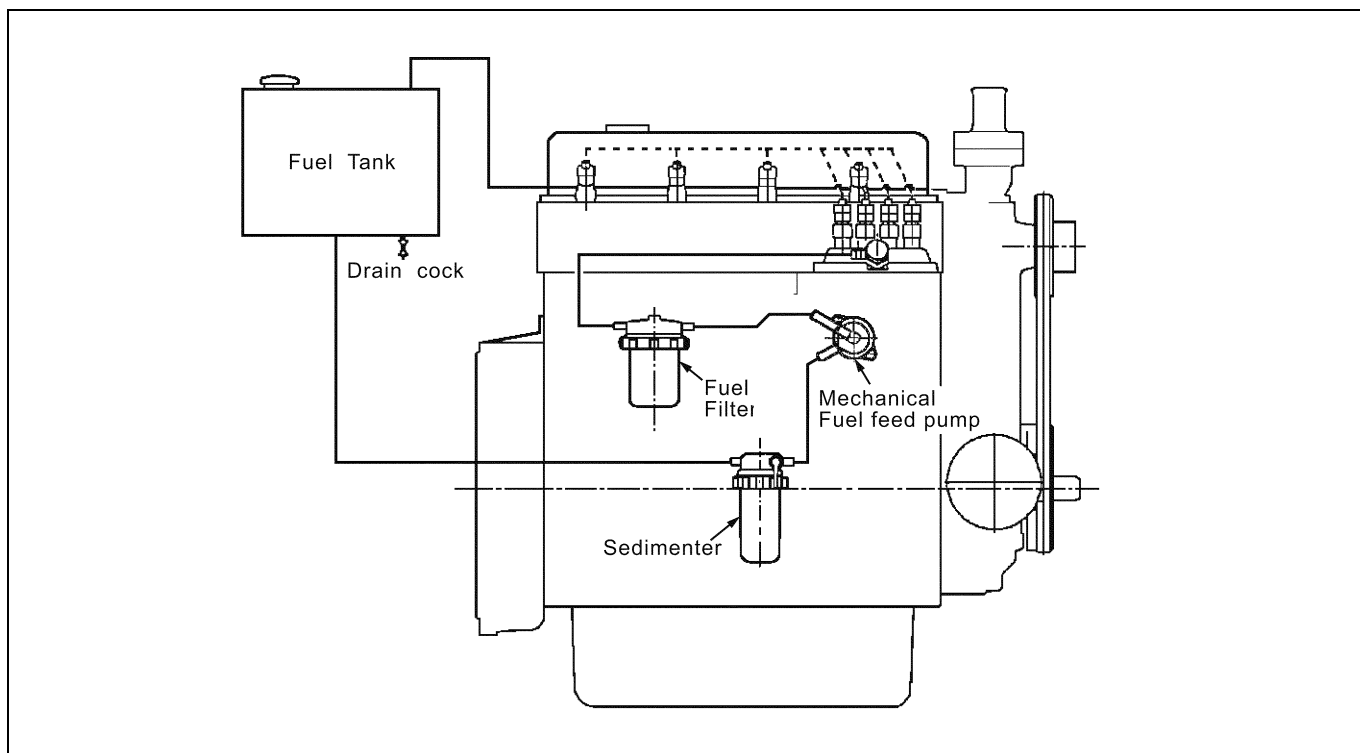


Fig. 4-15 Fuel piping

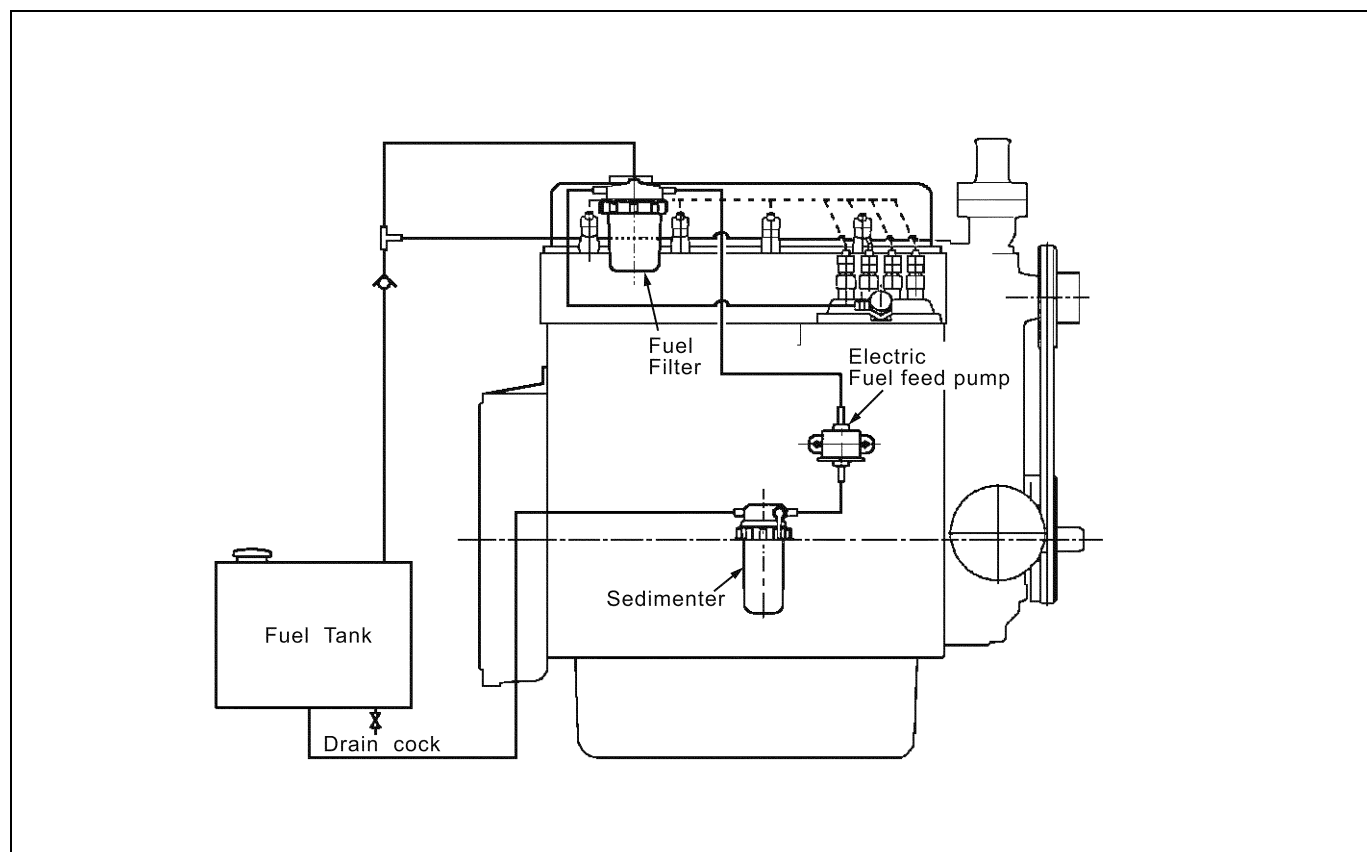
B When the fuel tank is mounted below or same level the injection pump

Fig. 4-16 Fuel piping

If the fuel tank is installed at a lower level than the injection pump or at the same level, the electric fuel feed pump should be used to improve air bleeding the fuel in the fuel system, starting failure, the output decrease and the fluctuation of rotation, all of which occur due to such installation positions can be prevented.

KUBOTA recommends the above piping.

It is desirable that the fuel filter is installed at higher position than the injection pump.

1) Standard piping for Super Mini and 05 series

- Upper tank with a Mechanical Fuel Feed Pump

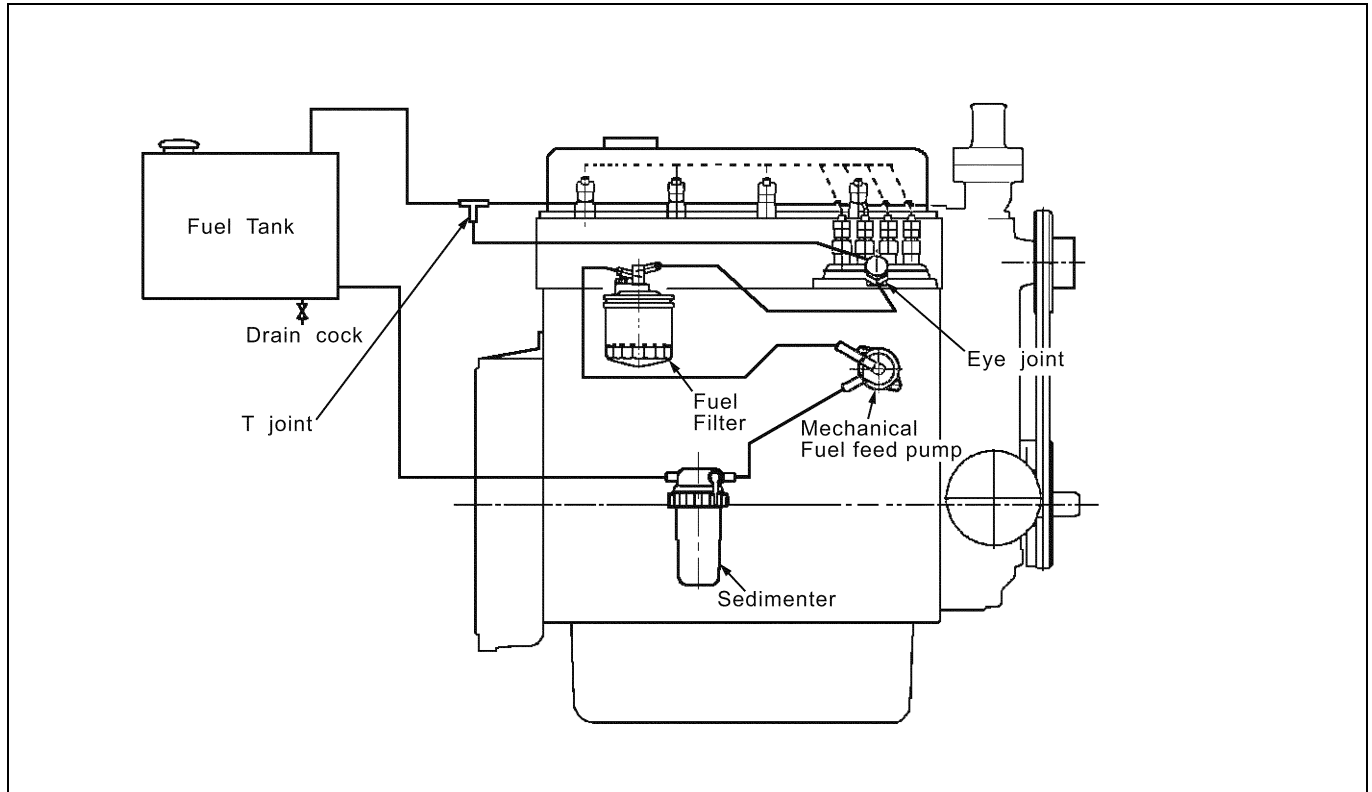


Fig. 4-17

A pre-filter must be installed with suction side of electric fuel pump to protect it.

- Upper tank with an Electric Fuel Feed Pump

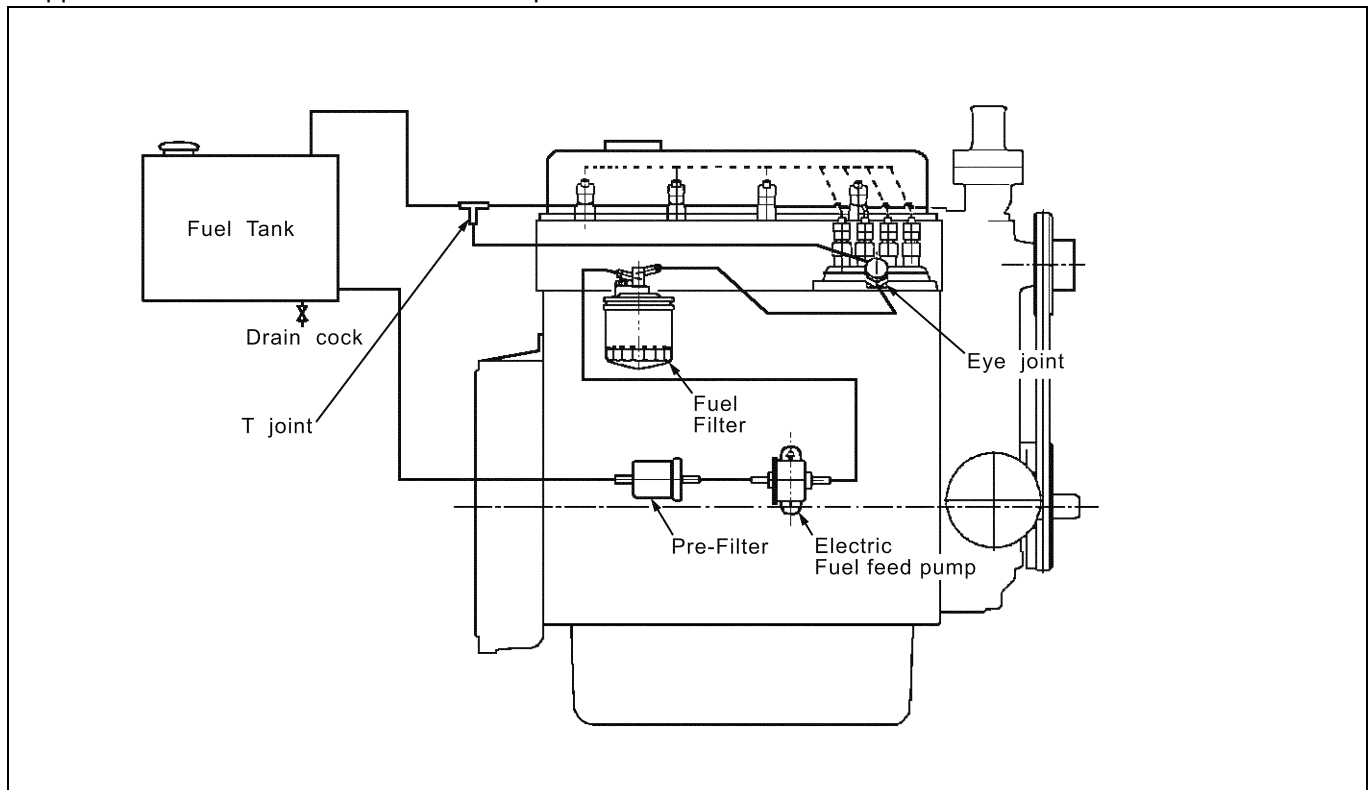


Fig. 4-18

2) Standard piping for Super Mini and 05 series

- Lower tank with a Mechanical Fuel Feed Pump

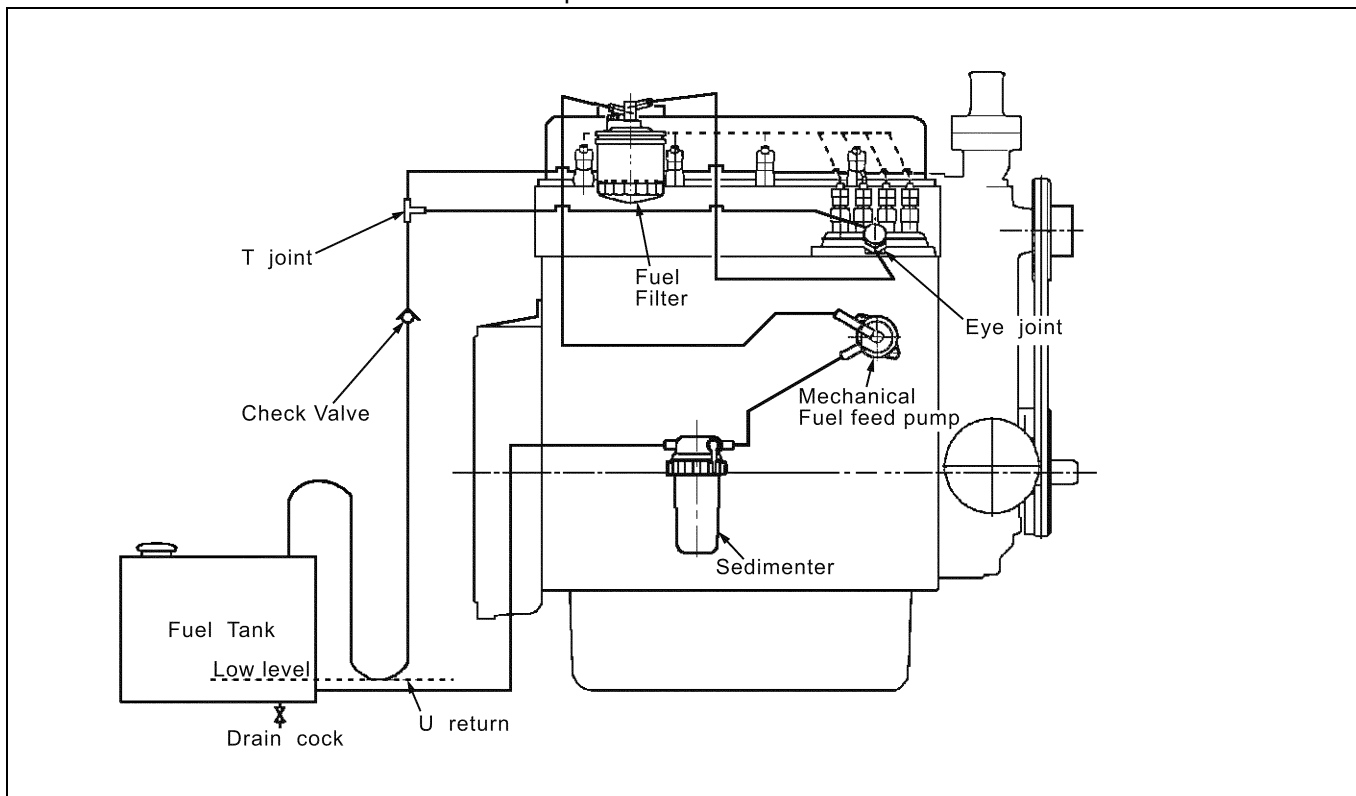


Fig. 4-19

A pre-filter must be installed with suction side of electric fuel pump to protect it.

- Lower tank with an Electric Fuel Feed Pump

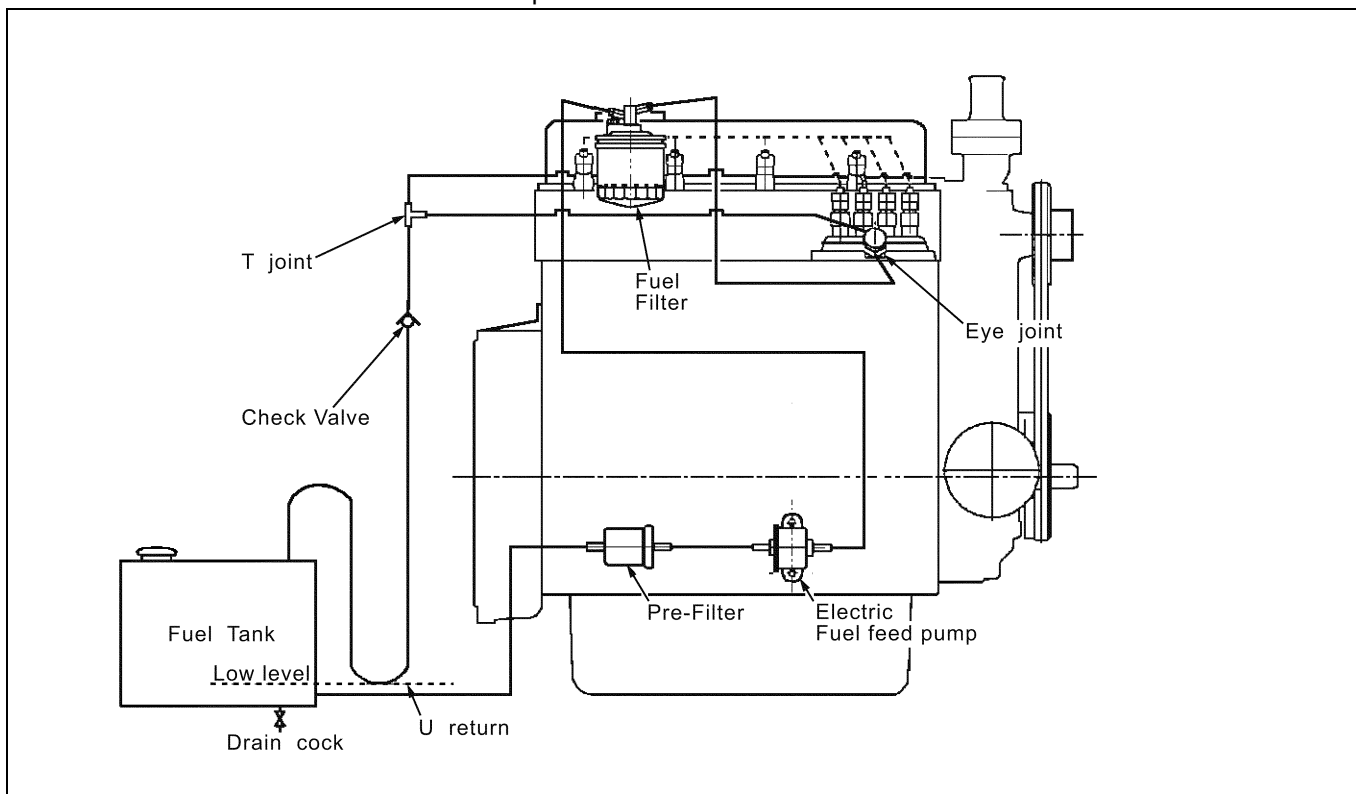


Fig. 4-20

3) Standard piping for 03-M series

- Upper tank with a Mechanical Fuel Feed Pump

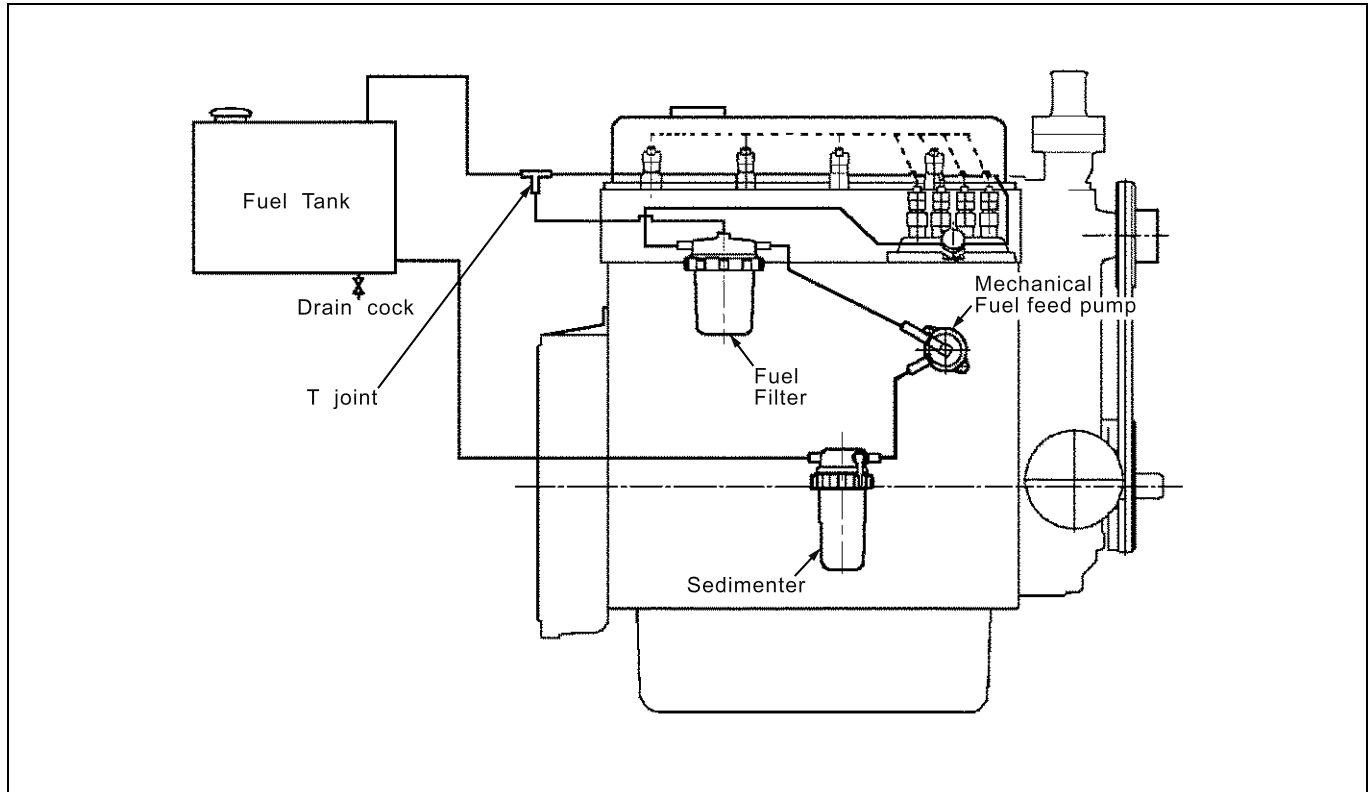


Fig. 4-21

A pre-filter must be installed with suction side of electric fuel pump to protect it.

- Upper tank with an Electric Fuel Feed Pump

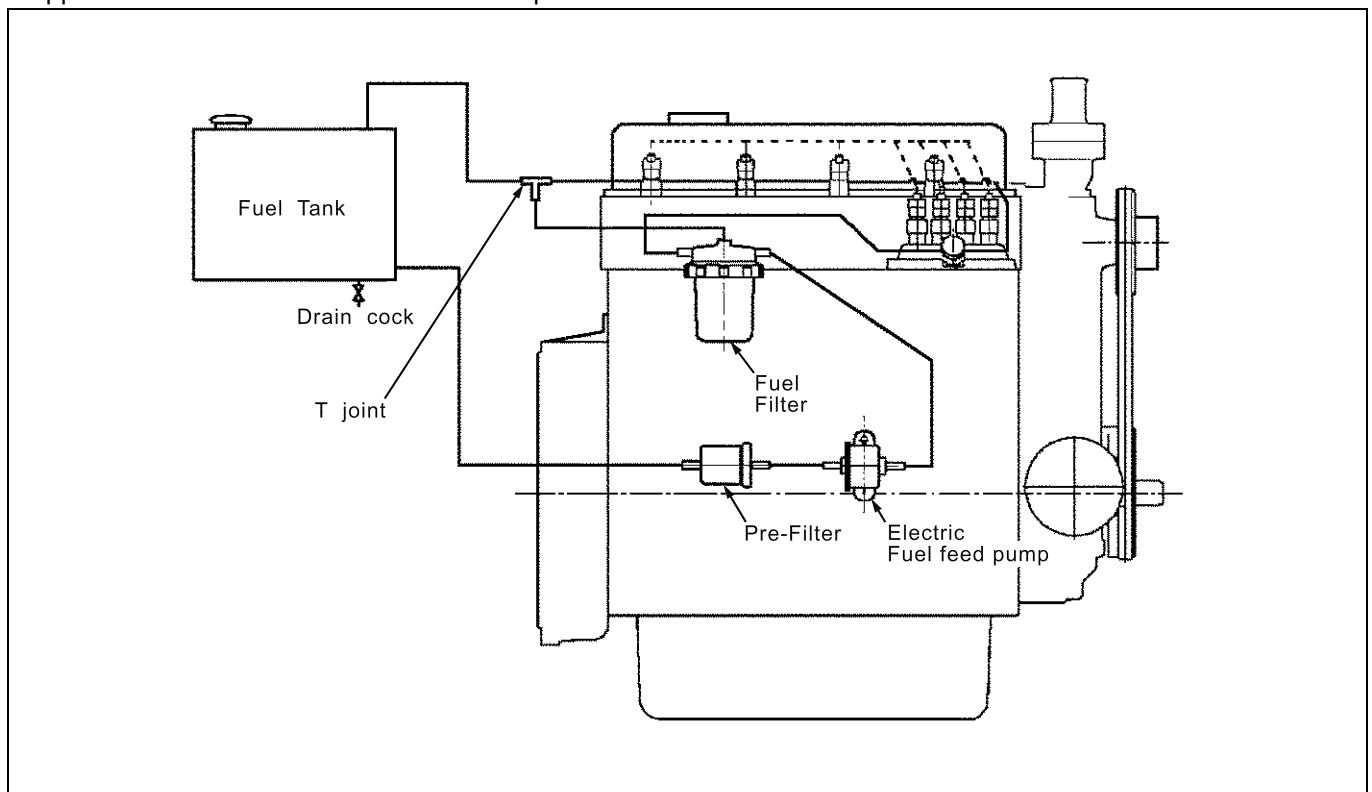


Fig. 4-22

4) Standard piping for 03-M series

- Lower tank with a Mechanical Fuel Feed Pump

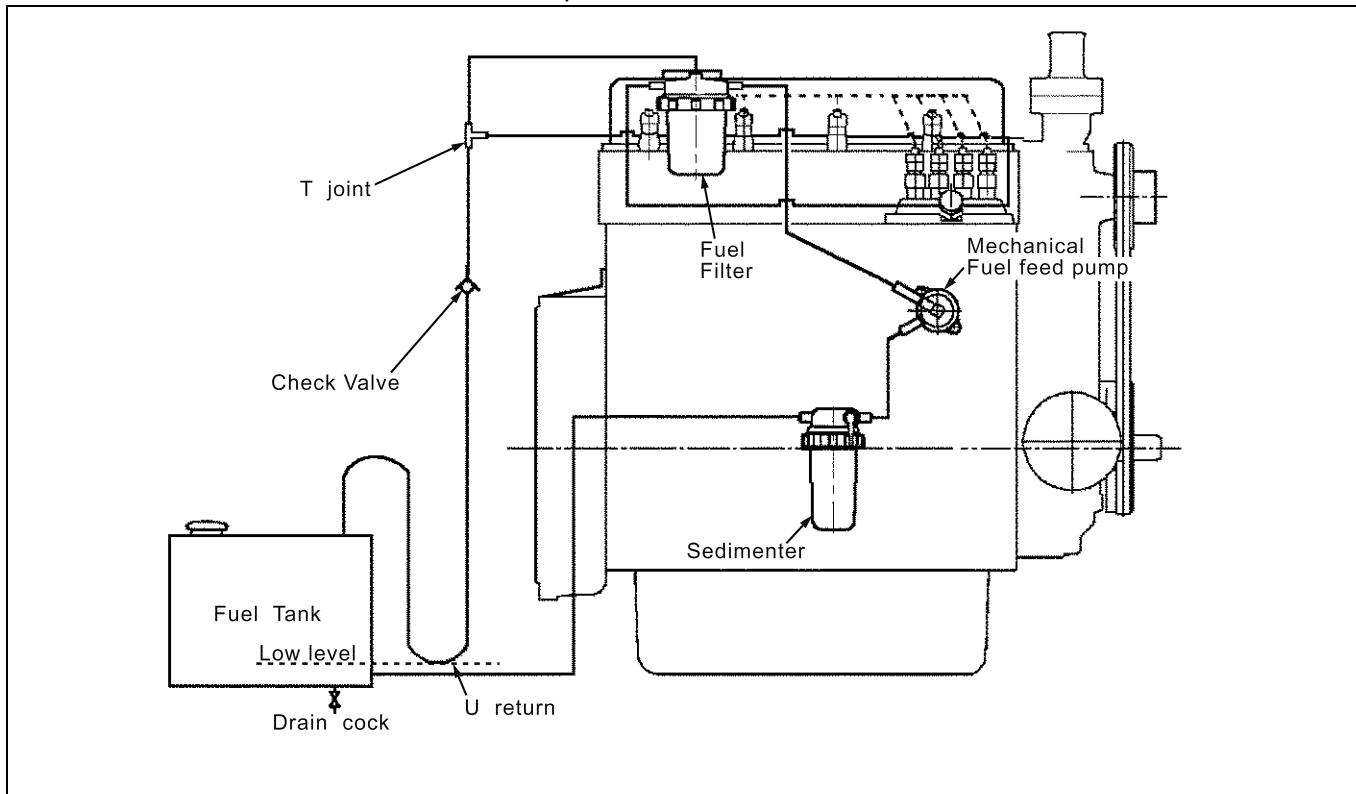


Fig. 4-23

A pre-filter must be installed with suction side of electric fuel pump to protect it.

- Lower tank with an Electric Fuel Feed Pump

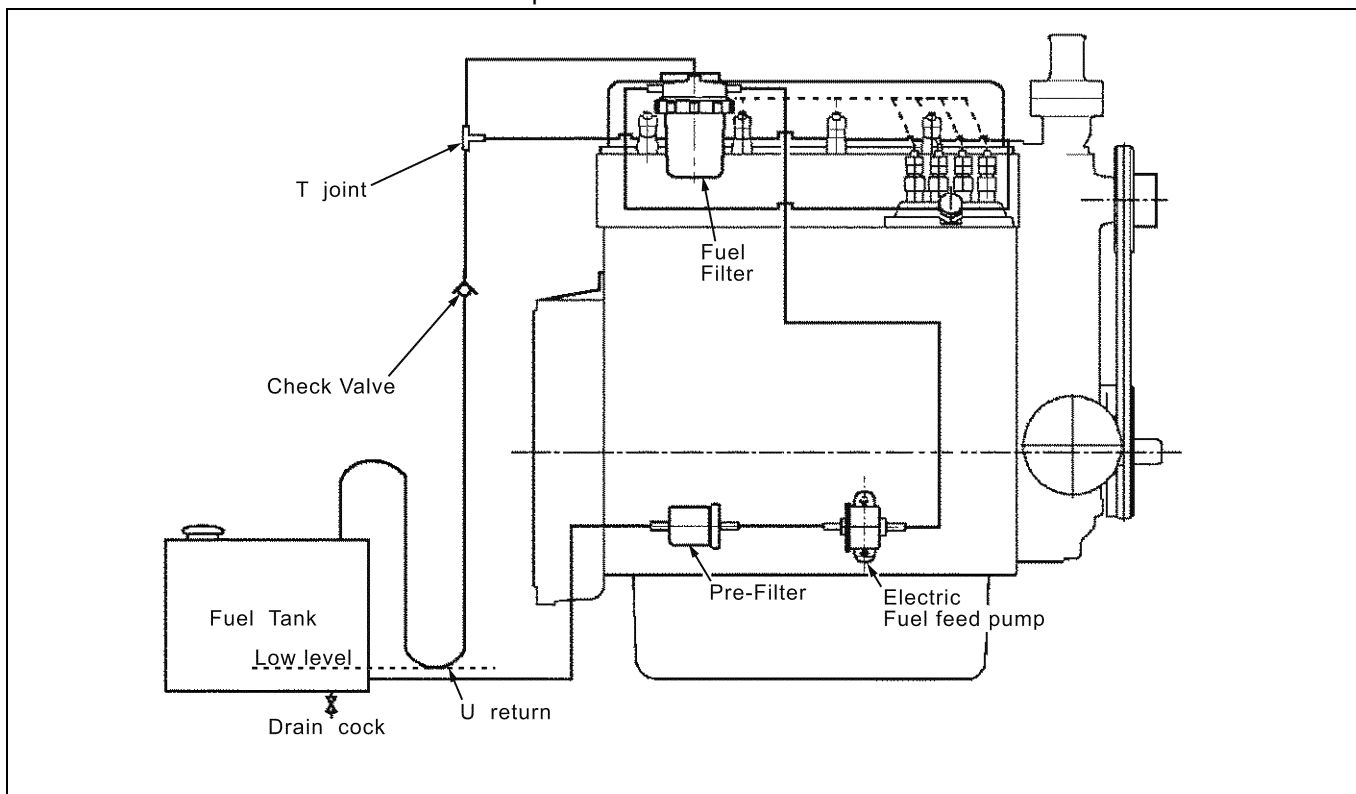


Fig. 4-24

5) Standard piping for 07 series

- Upper tank with a Mechanical Fuel Feed Pump

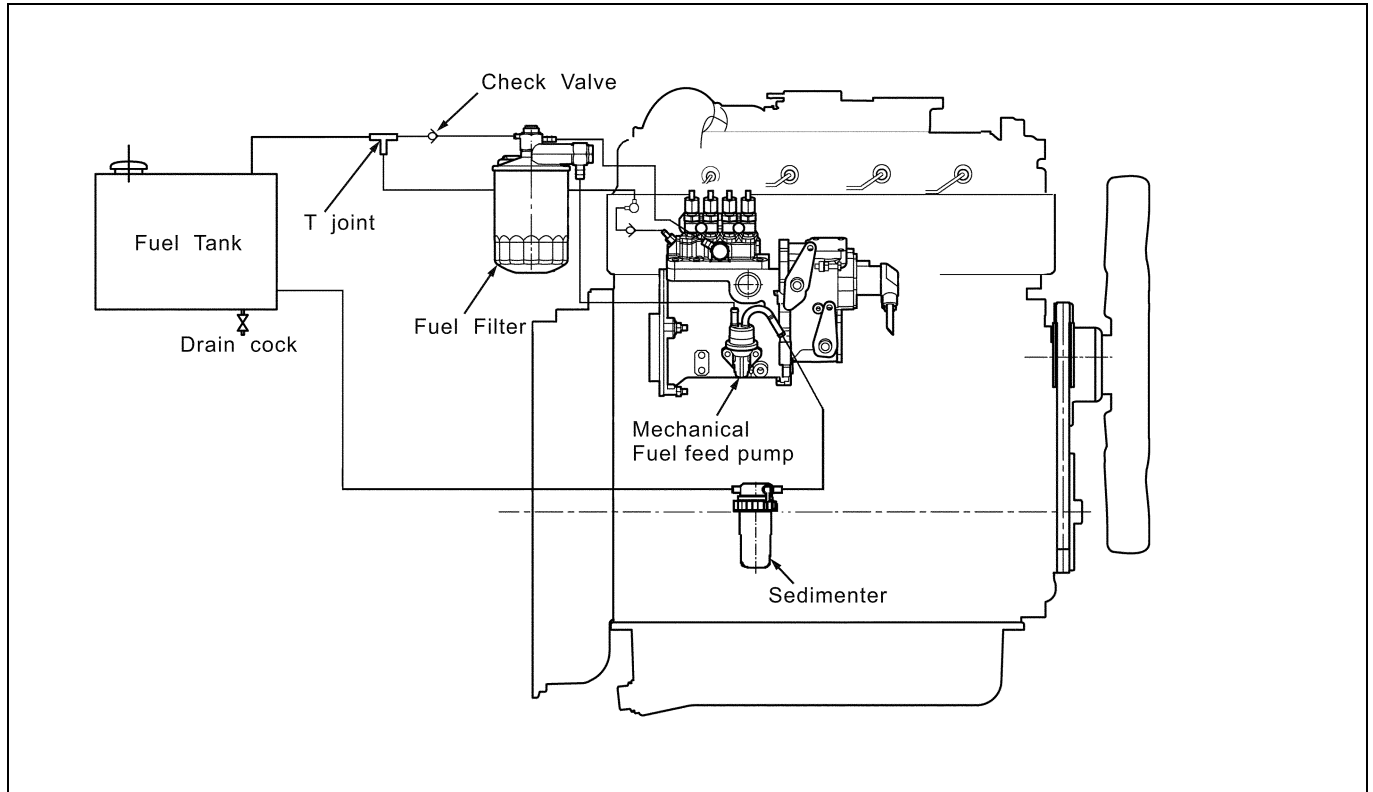


Fig. 4-25

A pre-filter must be installed with suction side of electric fuel pump to protect it.

- Upper tank with an Electric Fuel Feed Pump

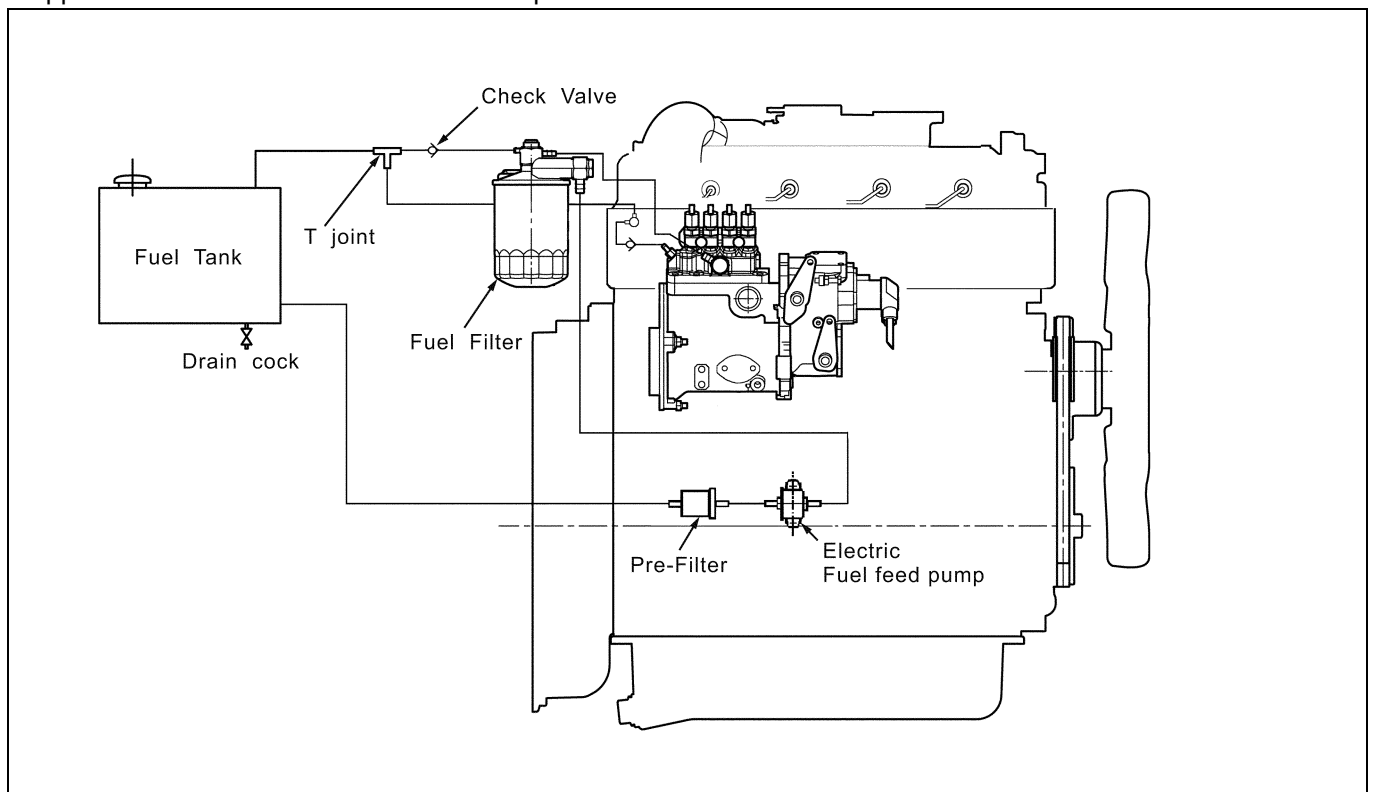


Fig. 4-26

6) Standard piping for 07 series

- Lower tank with a Mechanical Fuel Feed Pump

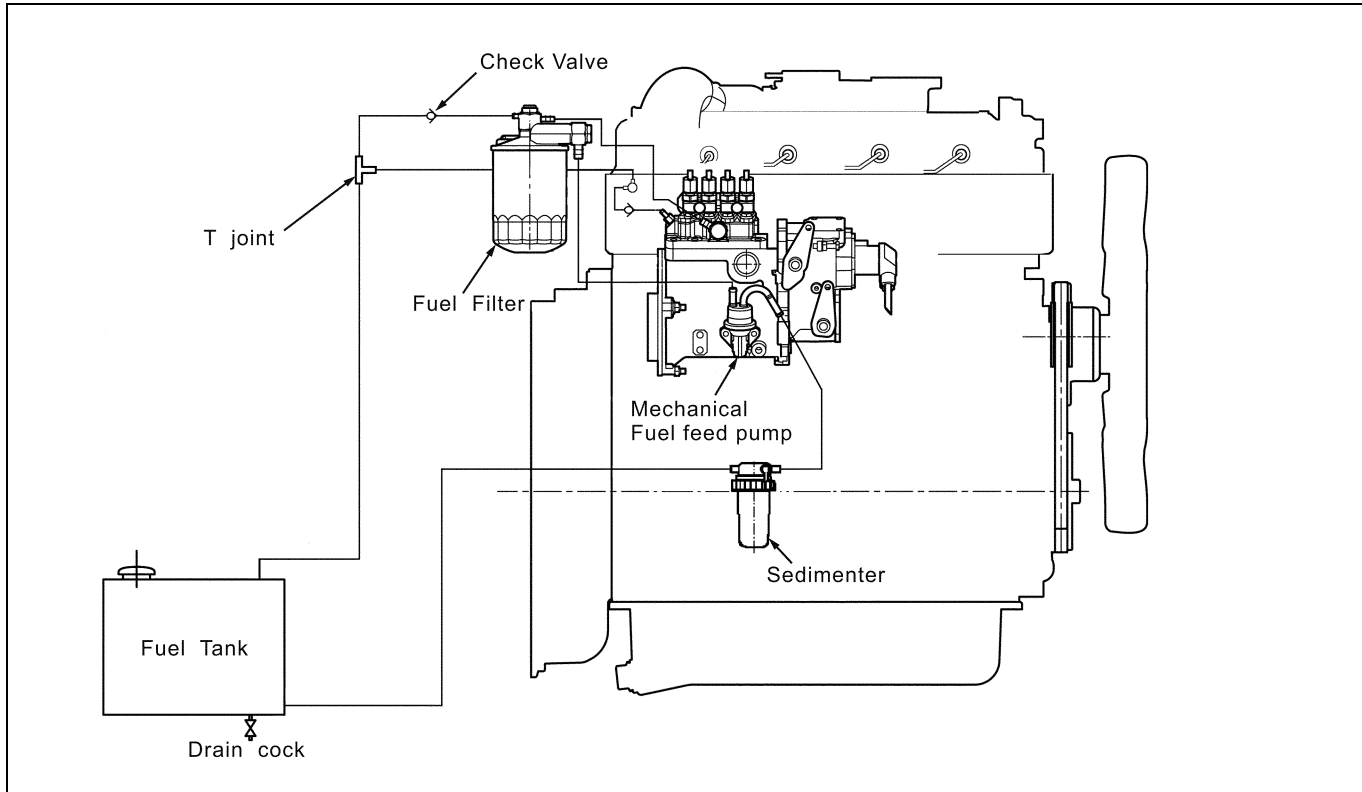


Fig. 4-27

A pre-filter must be installed with suction side of electric fuel pump to protect it.

- Lower tank with an Electric Fuel Feed Pump

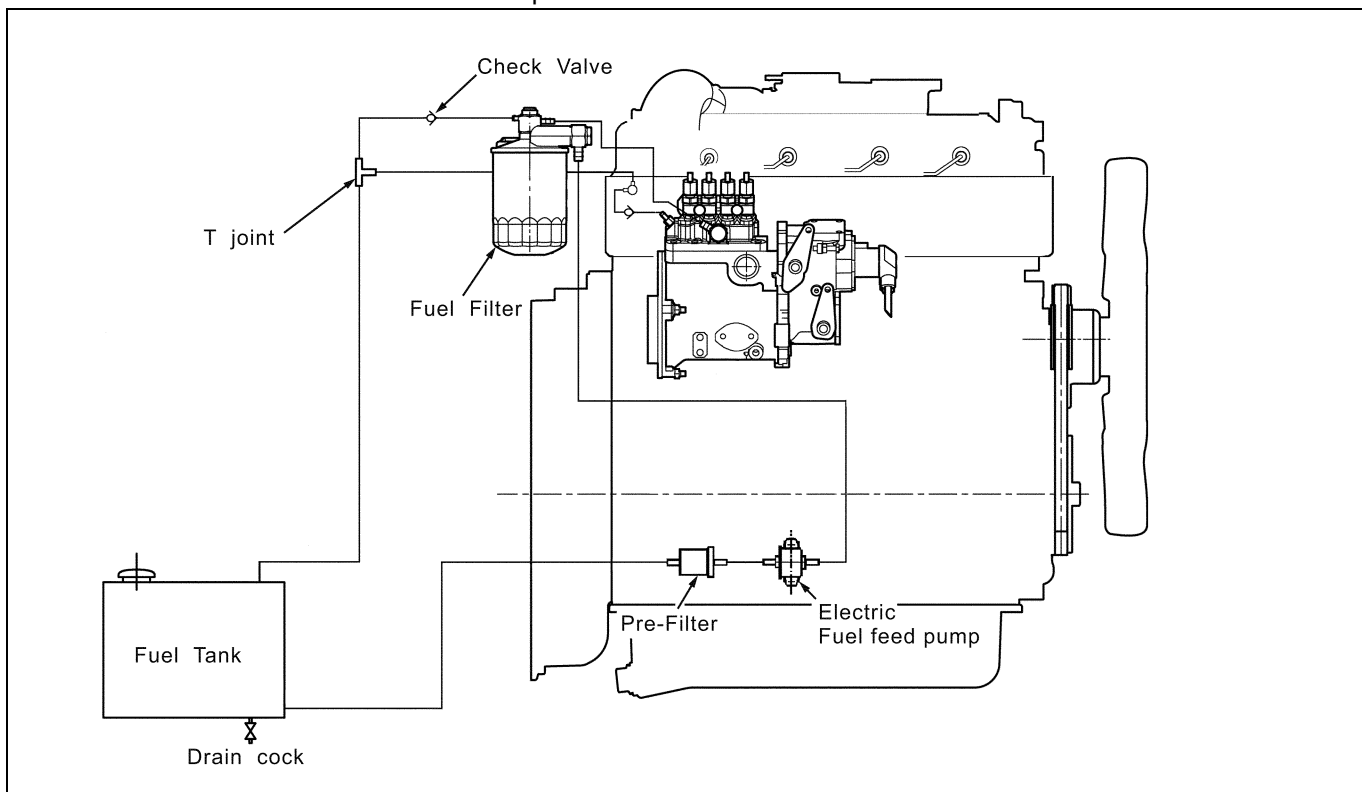


Fig. 4-28

7) Standard piping for V3 series

- Upper tank with a Mechanical Fuel Feed Pump

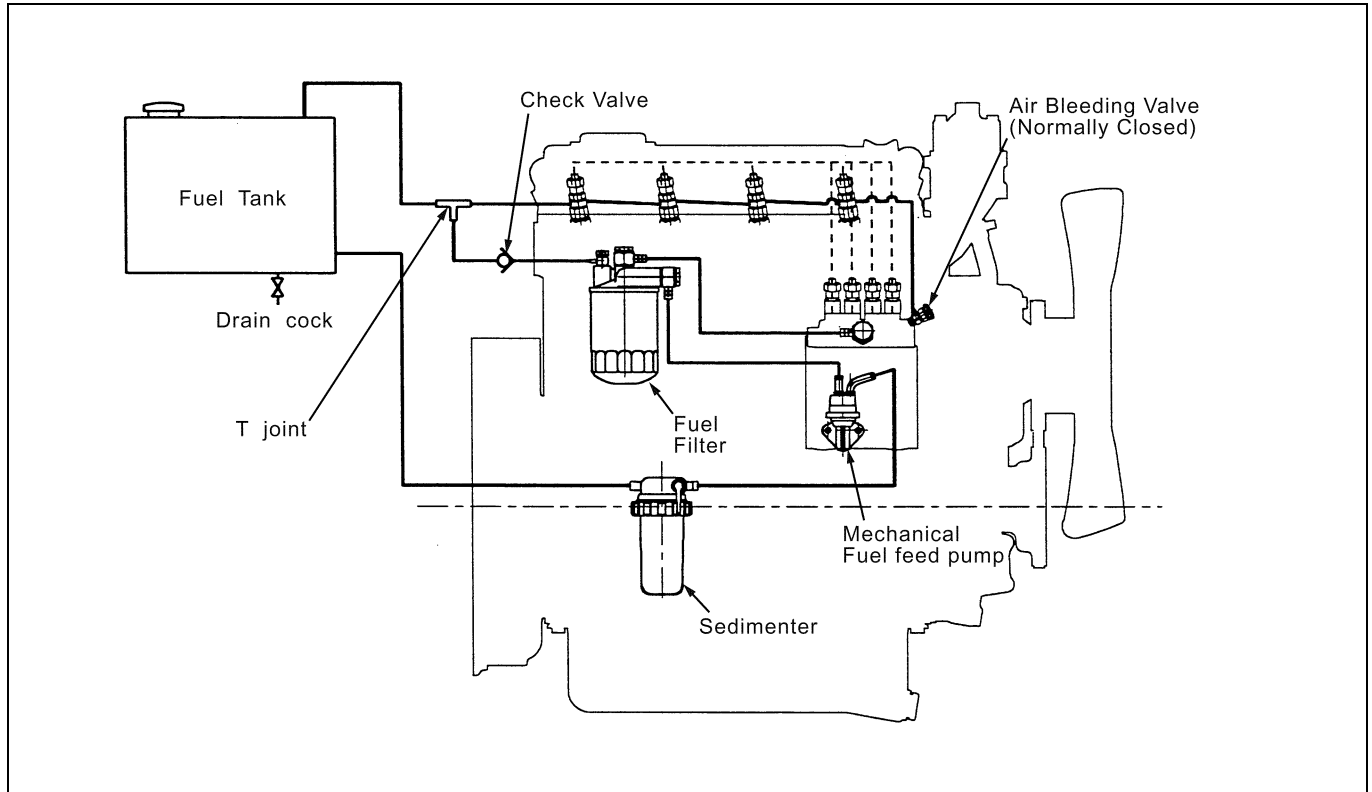


Fig. 4-29

A pre-filter must be installed with suction side of electric fuel pump to protect it.

- Upper tank with an Electric Fuel Feed Pump

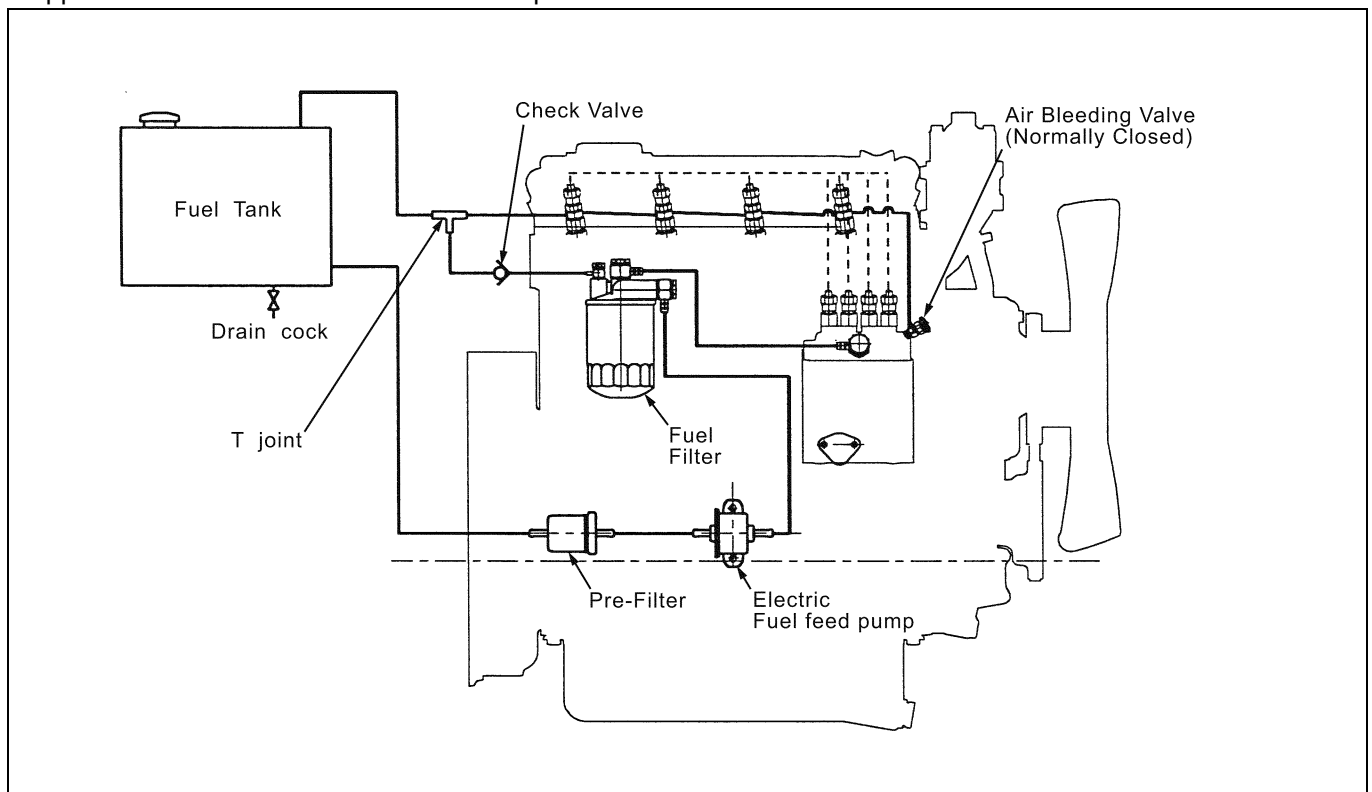


Fig. 4-30

8) Standard piping for V3 series

- Lower tank with a Mechanical Fuel Feed Pump

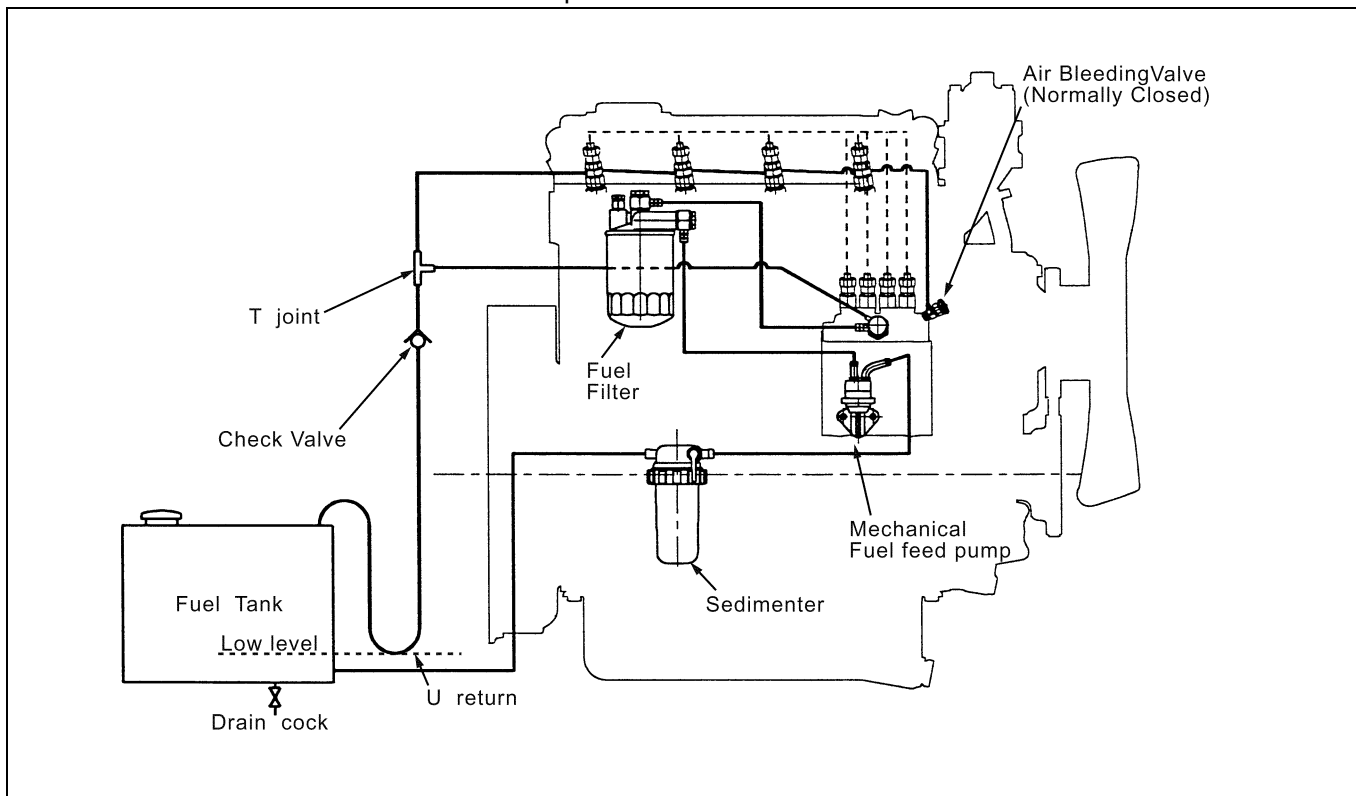


Fig. 4-31

A pre-filter must be installed with suction side of electric fuel pump to protect it.

- Lower tank with an Electric Fuel Feed Pump

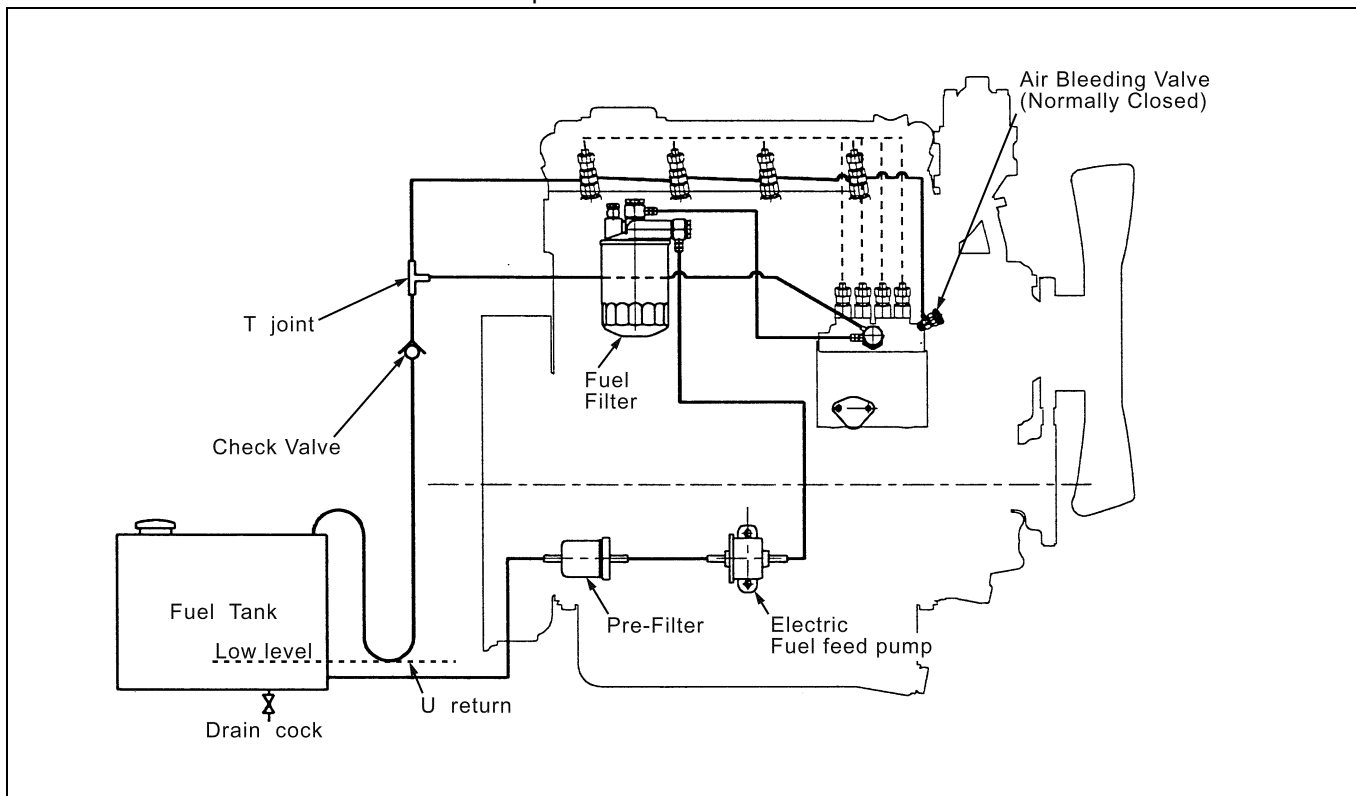


Fig. 4-32

9. FUEL

Fuel standards, grades and recommendations

Diesel fuels specified to EN590 or ASTM D975 are recommended.

- Since KUBOTA diesel engines of less than 56 kW (75 hp) utilize EPA Tier 4 and Interim Tier 4 standards, the use of low sulfur fuel or ultra low sulfur fuel is mandatory for these engines, when operated in US EPA regulated areas. Therefore, please use No.2-D S500 or S15 diesel fuel as an alternative to No.2-D, and use No.1-D S500 or S15 diesel fuel as an alternative to No.1-D for ambient temperatures below -10 °C (14 °F).
- No.2-D is a distillate fuel of lower volatility for engines in industrial and heavy mobile service. (SAE J313 JUN87)

Major fuel standards of the world

- 1) ASTM : American Society of Testing and Materials
- 2) US EPA : United States Environmental Protection Agency
- 3) ASTM : American Society of Testing and Materials
- 4) US EPA : United States Environmental Protection Agency

Note :

Don't use kerosen in KUBOTA diesel engines.

(1) Requirements for diesel fuel

The following properties are required of diesel fuel.

- 1) Good ignitability
- 2) Appropriate viscosity
- 3) Low sulfur content
- 4) Low pour point
- 5) Good volatility
- 6) Low residual carbon
- 7) Free of water and foreign matter

These are described in detail below :

- 1) Good ignitability

Fuel with good ignitability burns quickly as it is atomized into the combustion chamber, allowing easy starting and smooth running with a minimum of smoke and noise.

Therefore, fuel with good ignitability must be used. Ignitability is indicated by the cetane number.

Recommended fuel cetane rating

Cetane Rating : The minimum recommended Fuel Cetane Rating is 45. A cetane rating greater than 50 is preferred, especially for ambient temperatures below -20 °C (-4 °F) or elevations above 1500 m (5000 ft).

- 2) Appropriate viscosity

Combustion is the engine begins with atomization of fuel, which requires a low viscosity.

However, penetration of injection is required of the atomized fuel to distribute the atomized particles throughout the combustion chamber, this requires certain amount of viscosity.

Since fuel is also used to lubricate the plunger and nozzle sliding in the fuel injection subsystem, fuel must have a viscosity sufficient enough to prevent wear and seizure of parts.

It must not be too viscous, because volatility of the atomized fuel will be reduced and distribution throughout the combustion chamber will be uneven.

- 3) Low sulfur content

The sulfur content of fuel must be as low as possible since it contributes to wear of parts and deterioration of oil.

When a sulfuric compound is burned, it changes to sulfurous acid gas (SO₂) and sulfuric anhydride (SO₃).

A large amount of water is also generated in the form of condensation within the engine crankcase. All of these by-products turn into sulfuric acid, which is strongly corrosive. Corrosion in a diesel engine is the result.

Fuel sulfur content and notes on use

Diesel Fuel Specification Type and Sulfur Content % (ppm) used, must be compliant with all applicable emission regulations for the area in which the engine is operated.

- Use of diesel fuel with sulfur content less than 0.10 % (1000 ppm) is strongly recommended.
- If high-sulfur (sulfur content 0.50 % (5000 ppm) to 1.0 % (10000 ppm)) is used as a diesel fuel, change the engine oil and filter at shorter intervals. (approximately half)
- DO NOT USE Fuels that have sulfur content greater than 1.0 % (10000 ppm).

Note :

- **No.1-D or No.2-D, S500 : Low Sulfur (LSD) less than 500 ppm or 0.05 wt. %**
- **No.1-D or No.2-D, S15 : Ultra Low Sulfur Diesel (ULSD) 15 ppm or 0.0015 wt. %**
- **Use of high sulfur fuel in an external EGR system prohibited.**

4) Low pour point

Fuel must have a low pour point to run smoothly from the fuel tank to the filter and through the fuel pipe of the fuel pump in cold weather.

A low pour point and a good ignitability have contradicting effects since low pour point fuel generally has low cetane number.

5) Good volatility

Fuel is atomized, vaporized and mixed with air before ignition at the combustion of diesel engine. Fuel must have a good volatility to become vaporized and burn quickly.

Any unvaporized oil will cause soot and smoke, and eventually contaminate the oil. Fuel with good volatility burns more completely, minimizing fuel combustion, lowering the exhaust gas temperature and does not generate black smoke.

6) Low residual carbon

Residual carbon is the carbonic residue that is generated during vaporization and decomposition of oil.

Although residual carbon and carbon accumulation in the engine have no direct relationship, they should be minimized.

7) Free of water and foreign matter

The fuel pump in a diesel engine is extremely precise, even the smallest trace of foreign matter can critically affect the fuel injection mechanism. Dust or dirt in the air or a solid matter such as iron rust in the fuel must be eliminated. Water may become mixed with fuel during storage or transportation. Most of it is removed as it settles in storage. Colloidal water floating or dissolved in water (0.1 to 0.5%) can enter the combustion chamber. Diesel fuel containing water loses its ignitability, adversely affecting combustion performance. Water must also be eliminated since it will freeze in cold temperature and block filtration.

(2) Cetane number

Cetane numbers indicate the anti-diesel knocking characteristics of fuel. The cetane number is measured in a similar way as an octane number using standard CFR testing engines.

A standard fuel is a mixture of n-cetane and α -methylnaphthalene. The former indicates the lowest knocking point, its cetane number is defined as 100. The latter has the greatest knocking points, its cetane number is defined as 0. Knocking of the standard fuel and the sample fuel is compared on testing engines by changing

the mixing ratio of the two components in the standard fuel until both engines show equal knocking characteristics. The percentage of n-cetane at this point in a standard fuel is then taken as the cetane number of the sample fuel. Anti-knocking characteristics of fuel oil can also be indicated by diesel indexes and cetane indexes, which are derived from results of characteristics tests without using testing engines.

The cetane number for KUBOTA diesel engines must not be less than 45.

(3) Fuel ratings

Fuel ratings vary in different countries. Fuel must be chosen according to the operating temperature and emission regulations. Fuel feed will be adversely affected if a fuel is used in a temperature below its pour point.

Japan (JIS K2204)

- 1) Applicable range : This regulation specifies the diesel fuel to be used for diesel engines (mainly for automobiles).
- 2) Type : Diesel fuel is classified into five types, i.e., Special No.1, No.1, No.2, No.3, and Special No.3, according to each pour point.

3) Requirements**★ General matters**

Diesel fuel is mainly composed of refined mineral oil having proper quality as the fuel oil for diesel engines (mainly those for automobiles), and it shall not include water and sediments.

★ Required quality

The property of diesel fuel should be within the range specified in the table below.

Property Class of fuel	Flash point °C (°F)	Distillation (90% distillation temperature in °C (°F)	Pour point °C (°F)	Mass % of residual carbon in 10% residual oil	Cetane (2)	Kinematic viscosity 30 °C (86 °F) mm ² /s (cSt) (3)	Sulfuric mass %
Special No.1	Over 50 (122)	Below 360 (680)	Below +5 (41)	Below 0.1	Over 50	Over 2.7	Below 0.05
No.1	Over 50 (122)	Below 360 (680)	Below -2.5 (27.5)	Below 0.1	Over 50	Over 2.7	Below 0.05
No.2	Over 50 (122)	Below 350 (662)	Below -7.5 (18.5)	Below 0.1	Over 45	Over 2.5	Below 0.05
No.3	Over 45 (113)	Below 330 (626) (1)	Below -20 (-4)	Below 0.1	Over 45	Over 2.0	Below 0.05
Special No.3	Over 45 (113)	Below 330 (626)	Below -30 (-22)	Below 0.1	Over 45	Over 1.7	Below 0.05

Note :

(1) It is below 350 °C (662 °F) in case of Kinematic viscosity 30 °C (86 °F) is below 4.7 mm²/s (4.4 cSt).

(2) It is possible to use cetane number.

(3) 1 mm²/s = 1 cSt

U.S.A. (SAE J313)

Abstract :

Automotive and railroad diesel fuels, in general, are derived from petroleum refinery products which are commonly referred to as middle distillates. Middle distillates represent products which have a higher boiling range than gasoline and are obtained from fractional distillation of the crude oil or from streams from other refining processes. Finished diesel fuels represent blends of middle distillates. The properties of commercial distillate diesel fuels depend on the refinery practices employed and depend on the refinery practices

employed and the nature of the crude oils from which they are derived.

Thus, they may differ both with and within the region in which they are manufactured. Such fuels generally boil over a range between 163 and 371 °C (325 and 700 °F). Their makeup can represent various combinations of volatility, ignition quality, viscosity, sulfur level, gravity, and other characteristics.

Additives may be used to impart special properties to the finished diesel fuel.

Grade of Diesel fuel oil	Flash point °C (°F)	Distillation Temperatures °C (°F) 90% Point	Viscosity Kinematic cSt or mm²/s at 40 °C (104 °F)	Cetane Number
No.1-D	38 (100)	Below 288 (550)	1.3 to 2.4	Over 40
No.1-DLS	38 (100)	Below 288 (550)	1.3 to 2.4	Over 40
No.2-D	52 (125)	282 to 338 (540 to 640)	1.9 to 4.1	Over 40
No.2-DLS	52 (125)	282 to 338 (540 to 640)	1.9 to 4.1	Over 40

(4) Biodiesel fuel (B5)

Kubota only permits to use the biofuel (BDF) that satisfies the following conditions 1) - 4).

In using the biofuel (BDF), pay enough attention to the storing methods, using methods, and maintenance methods of the engine described in the following clauses of 5) to 14) while understanding the characteristics of the biofuel.

Conditions for the biofuel

- 1) Only the fuel that contains 5 % or lower volume mixing ratio of 100 % BDF (B100) in the mineral diesel fuel can be used. (B5)
- 2) The mineral diesel fuel shall be according to the newest edition of EN590 (Europe) or ASTM D975 (USA), while the B100 to be mixed shall be according to the newest edition of EN14214 (Europe) or ASTM D6751 (USA) standards. The final mixture fuel B5 shall, also, be according to the newest edition of E590 (Europe). Raw expressed vegetable oil cannot be used.
- 3) B100 or the mixed fuel B5 shall be purchased from the reliable manufacturers or dealers (in USA, the one accredited by BQ-9000). (Because on-the-site mixing tends to cause uneven mixing, it is recommendable to purchase the B5 that has been mixed at the manufacturer's factory in advance.)
- 4) Uses of Kubota Emission Certified Engines are responsible for obtaining any appropriate local, state and national exemptions required for the use of BDF.

Characteristics, storing procedures, and maintenance cautions of the biofuel

- 5) To prevent accumulation of moisture in the fuel tank, keep the fuel tank full as much as possible. Also, surely tighten the cap of the fuel tank to prevent moisture intrusion.
- 6) Confirm the engine oil level before starting the engine every day. Also, keep strictly the engine oil change interval because the delay in the engine oil change causes damages to the engine.
- 7) In the cold weather, take special care because clogging of the fuel lines can cause such problems as starting failures.
- 8) Be careful that BDF tends to aggravate multiplication of and contamination by microorganisms, which can cause such malfunctions like corrosion of the fuel Bsystem or too early clogging of the fuel filter.
- 9) Pay careful attention to the following cautions, because the fuel (BDF) during refueling and in the fuel tank tends to deteriorate by oxygen, water, heat, and foreign matters.
 - a) Do not store the fuel in the fuel tank or in drums for longer than 3 months.
 - b) In the case of the prolonged parking or storage of the vehicle, wash the engine by idling it using the conventional mineral diesel oil for at least 30 minutes.

- 10)BDF is hygroscopic and, therefore, tends to contain higher moisture content than the conventional diesel fuel. Accordingly, the intervals of the fuel filter cleaning and exchange, the fuel pipe check and exchange, the nozzle check and exchange, and the fuel system maintenance and check shall be shorter than those for the conventional mineral diesel fuel. In addition, use of a sedimenter is strongly recommended.
- 11)When the biodiesel fuel is spilled on a painted surface, immediately wipe it off because it can damage the painting.
- 12)If the biodiesel fuel of higher concentration than B5 is used, it is possible to deteriorate the output and fuel consumption. Also, the higher concentration biodiesel fuel than B5 can corrode the brass/zinc parts and rubber/resin products of the fuel system. Therefore, never use the higher concentration biodiesel fuel than B5.
- 13)The adjustment of the tamper parts (fuel confinement) of the engine under the use of the biodiesel fuel is deemed to be an illegal activity to the emission regulation and punished. Never execute such adjustments.
- 14)The BDF of palm-oil-base has lower low-temperature fluidity than the BDF of soybean/rape seed-oil-base. Therefore, pay special attention to the fact that it can cause the fuel filter clogging during the cold season.

5. LUBRICATION SYSTEM

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LUBRICATION SYSTEM

1. GENERAL

All moving parts of the engine must be lubricated to function properly. For this purpose, the lubricating oil circulating through the engine has a number of functions. In addition to reducing friction, the oil cools down the

engine, controls expansion and dispersion of bearing areas, provides a sealing action, prevents rusting, seals out dust, and purifies products generated in the cylinders by incomplete combustion.

[1] LUBRICATION SYSTEM

A typical lubrication system is shown in Fig. 5-1. Lubricating oil in the oil pan is circulated by a pump throughout the system as indicated by the arrows.

Oil pressure is controlled between 245 to 343 kPa (2.5 to 3.5 kgf/cm², 35.6 to 49.8 psi) and it is delivered to each section of the engine before returning to the oil pan. There are two main oil passages. One is through the

crankshaft to the crank pin metal and the other is in the wall of the crankcase to the rocker arm shaft of valve train. Should oil pressure fall for any reason, parts can become scored or other serious problems will arise. A warning lamp indicates oil pressure drop when it falls below 49.03 kPa (0.5 kgf/cm², 7.11 psi) or 98.06 kPa (1.0 kgf/cm², 14.22 psi) depending on engine type.

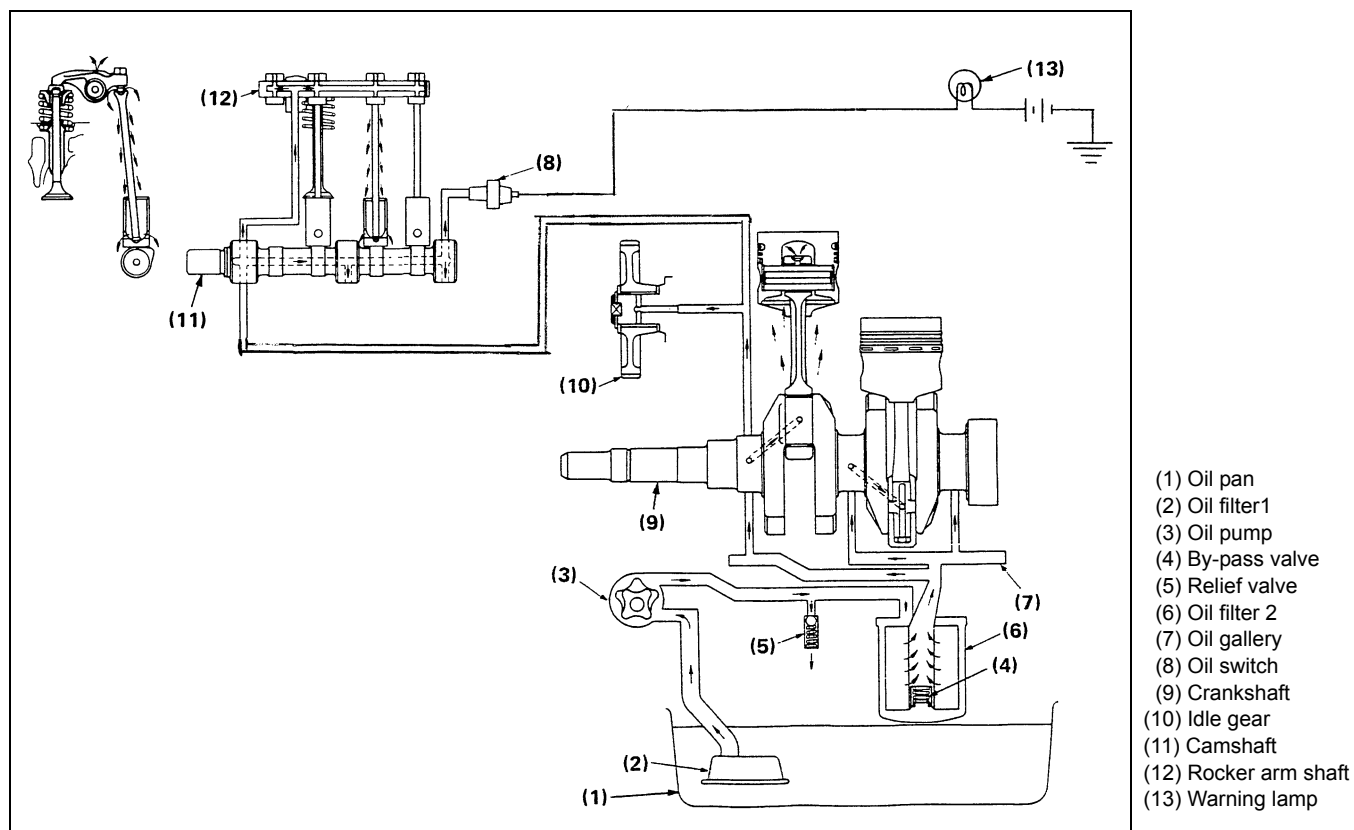


Fig. 5-1 Lubrication system

The lubrication system of this diesel engine comprises the oil pan (1), oil filter 1 (2), oil pump (3), valve (5), oil filter 2 (6), and oil switch (8).

Engine oil, after being cooled in the oil pan (1), passes through oil filter 1 (2) as it is drawn by the oil pump. Oil, pressurized by the trochoid type pump (3) is then filtered by oil filter 2 (6) to remove fine particles. Then it passed through oil gallery (7) (the oil passage in the crankcase)

to be forcibly supplied to crankshaft (9), connecting rod, idle gear (10), camshaft (11) and rocker arm shaft (12) to lubricate them.

Oil splashed by the crankshaft or oil dripping from the clearances between parts lubricates the pistons, cylinders connecting rod small ends, fuel camshaft, tappets, push rods, intake and exhaust valves and timing gear.

2. LUBRICATING OIL

Note :

- The use of synthetic oil is not recommended.
- Poor quality oil will shorten engine life.
- Use only the specified lubricating oils.

[1] FUNCTIONS OF ENGINE OIL

(1) Anti-wear action

The most important role of engine oil is prevention of seizures and to reduce frictional forces to minimize the wear between moving parts and contact surfaces depending on the reduction of friction force. (Such as cylinder walls and piston rings and both ends of connecting rods, crankshaft bearings, camshaft, tappets, etc.).

(2) Cooling action

The combustion chamber becomes extremely hot. Oil not only lubricates friction parts of piston but also cools the engine by acting as a heat exchange medium. This prevents seizures and high temperature oxidation of the oil itself. This cooling action is an extremely critical function. Extremely high viscosity or insufficient supply will result in seizures due to inadequate cooling.

(3) Sealing action

Cylinder walls and compression rings seal the combustion chamber to allow build-up of compression. Oil seals the clearance between the cylinder walls and rings to provide more complete sealing and prevent leakage of the compressed air to maintain the compression pressure. It also prevents combustion gas from blowing back into the crankcase.

The prevents reduction of engine output and contamination of oil by unburned fuel.

(4) Engine cleaning action

Oil removes deposits inside the engine to prevent wear due to build-up of deposits.

(5) Corrosion preventive action

Oil prevents acid corrosion of metal parts, such as bearing metals, etc.

(6) Rust prevention action

Engine oil prevents rusting caused by condensation of acidic gases.

[2] CLASSIFICATION OF ENGINE OIL

(1) Classification by viscosity

SAE (Society of Automotive Engineers) Standards are generally used to classify engine oil viscosities. Viscosity is a principal property of oil, the higher the viscosity, the thicker the oil film formed over the metal surface will be and the lower the viscosity, the thinner the film thickness becomes.

Viscosity varies with temperature. The higher the temperature, the lower the viscosity and vice versa. Engine oil should have the appropriate viscosity and have properties which are not affected by viscosity changes caused by temperature changes. In other words, engine oil must have a high viscosity index. Multi-grade oils having relatively low viscosity (SAE 10W-30) can provide superior lubrication at both low temperature and high temperatures. Such oils are available commercially for all-season use.

*"High viscosity index" means less viscosity change by temperature fluctuation.

SAE J-300

Vis- cosity No.	*Max. viscosity at each temp. (CP)	**Max.temp. expressing tolerable pump discharge performance °C (°F)	Viscosity at 100 °C (212 °F)	
			Min.	Max.
0W	3250 at -30 °C (-22 °F)	238 (-35)	3.8	
5W	3500 at -25 °C (-13 °F)	243 (-30)	3.8	
10W	3500 at -20 °C (-4 °F)	248 (-25)	4.1	
15W	3500 at -15 °C (5 °F)	253 (-20)	5.6	
20W	4500 at -10 °C (14 °F)	258 (-15)	5.6	
25W	6000 at -5 °C (23 °F)	263 (-10)	9.3	
20	—	—	5.6	< 9.3
30	—	—	9.3	< 12.5
40	—	—	12.5	< 16.3
50	—	—	16.3	< 21.9

* Measured by CCS viscometer (ASTM D-2602).

**Measured by mini rotary viscometer (ASTM D-3829).

When the viscosity is less than 30000 CP, the maximum temperature is measured.

(2) Recommended oil for E3 engine

- Refer to the following table for the suitable American Petroleum Institute (API) classification of engine oil according to the engine type (with internal EGR, external EGR or non-EGR) and the Fuel Type Used : (Low Sulfur, Ultra Low Sulfur or High Sulfur Fuels).

Fuel Type	Engine oil classification (API classification)	
	Engines with non-EGR Engines with internal EGR	Engines with external EGR
High Sulfur Fuel [0.05 % (500 ppm) ≤ Sulfur Content < 0.50 % (5000 ppm)]	CF (If the "CF-4, CG-4, CH-4, or CI-4" engine oil is used with a high-sulfur fuel, change the engine oil at shorter intervals. (approximately half))	—
Low Sulfur Fuel [Sulfur Content < 0.05 % (500 ppm)] or Ultra Low Sulfur Fuel [Sulfur Content < 0.0015 % (15 ppm)]	CF, CF-4, CG-4, CH-4 or CI-4	CF or CI-4 (Class CF-4, CG-4 and CH-4 engine oils cannot be used on EGR type engines.)

EGR : Exhaust Gas Re-circulation

- **CJ-4 classification oil is intended for use in engines equipped with DPF (Diesel Particulate Filter) and is Not Recommended for use in Kubota E3 specification engines.**
- **Oil used in the engine should have API classification and Proper SAE Engine Oil Viscosity according to the ambient temperatures where the engine is operated.**
- **With strict emission control regulations now in effect, the CF-4 and CG-4 engine oils have been developed for use with low sulfur fuels, for On-Highway vehicle engines. When a Non-Road engine runs on high sulfur fuel, it is advisable to use a "CF or better" classification engine oil with a high Total Base Number (a minimum TBN of 10 is recommended).**

[3] DEGRADATION OF ENGINE OIL

Engine oil is subjected to extremely harsh conditions. Since it is used at high temperatures and in situations where combustible compounds and soot become mixed, then degradation inevitably occurs. Cause and effect of oil degradation are described below.

(1) Effect of oxidation due to temperature changes

Oxidation of engine oil accelerates when oil is exposed to oxygen in the air at high temperatures. The speed of oxidation is faster with increase of temperature. Generally the speed of oxidation is doubled at each increase of 10 °C (50 °F) and the speed of oxidation accelerated further after the temperature reaches 150 °C (302 °F). The speed of oxidation is also affected by the metal which contacts engine oil and is the fastest when exposed copper-based metals.

Oil oxidation differs in low temperature sections, in the bearing system and in high temperature sections such as the ring grooves.

Specific oxidation conditions are described briefly below.

Oil temperature & oxidation process

★ Below 125 °C (257 °F)

Engine parts	Engine oil oxidation process
Main bearing, crank pin, oil pan, etc.	Gradual oil oxidation - peroxide generated - acid, (rich in extreme pressure) property) hydroxy acid-sludge generated Polymerization, Rate of wear

★ 125 to 200 °C (257 to 392 °F)

Engine parts	Engine oil oxidation process
Piston skirt, piston ring	Substantial oil oxidation - Gluey deposits generated Polymerization, Rate of wear

★ Above 200 °C (392 °F)

Engine parts	Engine oil oxidation process
Piston ring, piston head	Thermal cracking of oil and sludge light substance-combustion heavy substance-soot and hard carbon

(2) Effect of oxidation due to combustion

Oxidation of oil is not only affected by the oxidation of the oil itself but by entrance of aldehyde, peroxide, etc. which is produced by combustion. Gas with these substances blow back and is mixed with engine oil. Thus oxidation of oil is accelerated. With diesel engines, which used diesel fuel with higher sulfur content than gasoline, sulfur dioxide produced by combustion goes through the ring belt area as blow-by gas, changes into SO₃ after contacting the metal oxide. The absorbs water and becomes sulfuric acid it oxidizes the oil and accelerates cylinder wear.

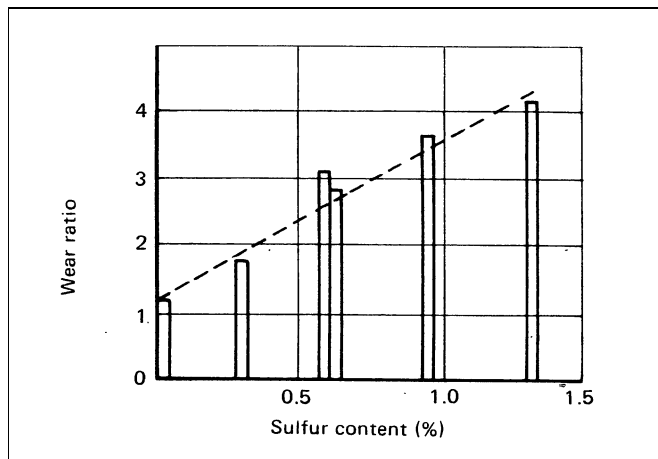


Fig. 5-2 Effect of sulfur on wear

[4] ANALYSIS RESULTS AND ENGINE OIL CHANGE INTERVALS

To determine proper engine oil change intervals, it is necessary to study the results of engine oil analysis and internal smear characteristics and wear of engine parts. It is not practical to over-haul an engine every time an inspection is necessary. Generally judgement of oil change is based on the result of oil analysis and experience.

(1) Viscosity

Viscosity of oil increases as the oil oxidizes and as it mixes with incompletely burnt fuel by-products (soot etc.). Since pressure loss is greater as oil volume decreases improper or insufficient lubrication can result. High viscosity of oil causes greater frictional resistance which generates more heat. This can eventually cause seizure of major parts such as cylinders, bearings etc. and lead to serious problems.

Oil must be changed before viscosity increase is too great.

(2) Total acid value

Oils in which additives are used have a certain acid value even when new. The acid value increases as the oil itself becomes oxidized and contaminated by combustion by-products. The acid value must be controlled to a 2 mg/KOH/g increase from the value when new.

Oil must be changed before acid number becomes too high.

(3) Alkalinity

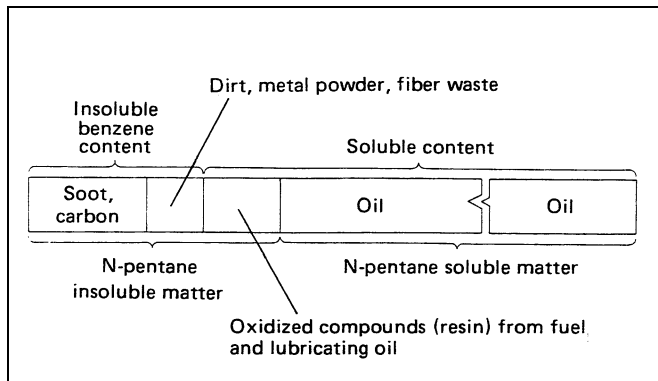
Detergent and dispersing agents contained in engine oil have a weak alkalinity to neutralize combustion by-products (especially sulfuric acid in diesel engines) and oil oxides. This alkalinity decreases gradually with use term. By checking this decrease of alkalinity, you can check the remaining level of detergent and dispersing agents in the oil, which in turn is an accurate indication of when to replace oil.

Generally certain allowances are made for exact replacement intervals but minimum alkalinity is usually considered to be approximately 1.0 mg/KOH/g.

(4) Insoluble matter of solvent

The amount of sludge in engine oil is measured by the percent of insoluble matter of solvent (weight %)

As shown in figure, N-pentane insoluble matter includes oxidized compounds of fuel or oil, inorganic matter such as dust and metal powder and soot. Oxidized compounds of fuel or oil are considered the remainder of N-pentane insoluble matter without insoluble benzene content, which is called the resin matter.



Generally the limit of N-pentane insoluble matter should be within 2.0% and insoluble benzene content within 1.5%.

Oil must be changed before sludge amount is too great. See "Operator's Manual" for oil change intervals.

3. LUBRICATING OIL PUMP

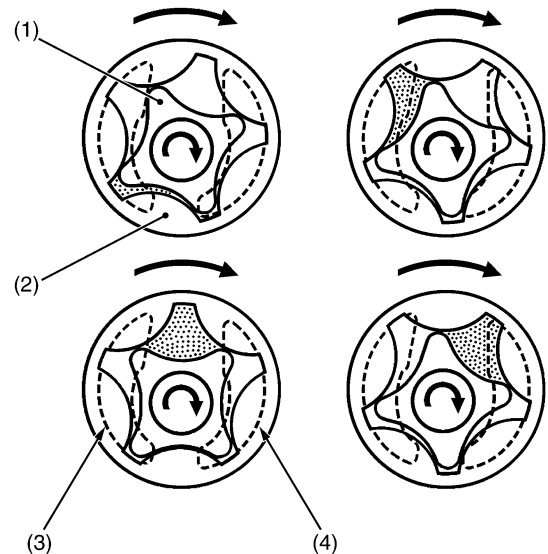
(1) Oil pump

A trochoid pump is used to pump oil. It is compact and driven by the crankshaft gear.

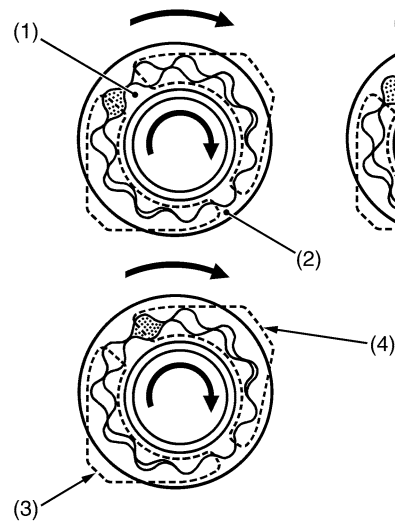
It also runs extremely smoothly and quietly.

The casing is made of an aluminum alloy and the rotor of a sintered steel alloy.

(A) 4 Lobes Inner Rotor



(B) 10 Lobes Inner Rotor



(1) Inner rotor
(2) Outer rotor

(3) Inlet port
(4) Outlet port

Fig. 5-3 Oil pump

The rotor has a precise clearance of 0.1 mm (0.0039 in.) which requires very careful attention. Make absolutely sure that no dirt or other foreign matter enters into oil pump through the oil filter.

Oil pump specifications

For S.M. and 03-M series

Type	Trochoid pump
Inner rotor	4 lobes
Delivery volume (2000 min ⁻¹ (rpm))	13.8 to 24.3 L/min 3.65 to 6.42 U.S gals/min (Varies according to model)
Delivery pressure (2000 min ⁻¹ (rpm)) (Regulator valve pressure)	200 to 440 kPa 2.0 to 4.5 kgf/cm ² 28.0 to 64.0 psi (Varies according to model)

For 05 series

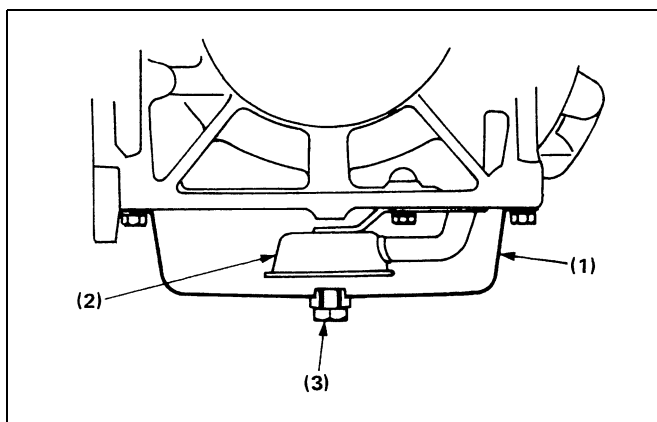
Type	Trochoid pump
Inner rotor	10 lobes
Delivery volume (3000 min ⁻¹ (rpm))	23.4 L/min 6.18 U.S gals/min
Delivery pressure (3000 min ⁻¹ (rpm)) (Regulator valve pressure)	343 to 440 kPa 3.5 to 4.5 kgf/cm ² 49.8 to 64.0 psi

For 07 series

Type	Trochoid pump	
	V2607	V3307
Inner rotor	10 lobes	10 lobes
Delivery volume (2000 min ⁻¹ (rpm))	36.48 L/min 9.63 U.S gals/min	45.6 L/min 12.05 U.S gals/min
Delivery pressure (2000 min ⁻¹ (rpm)) (Regulator valve pressure)	277 to 373 kPa 2.82 to 3.81 kgf/cm ² 40.1 to 54.1 psi	200 to 392 kPa 2.0 to 4.0 kgf/cm ² 28.4 to 56.9 psi

For V3 series

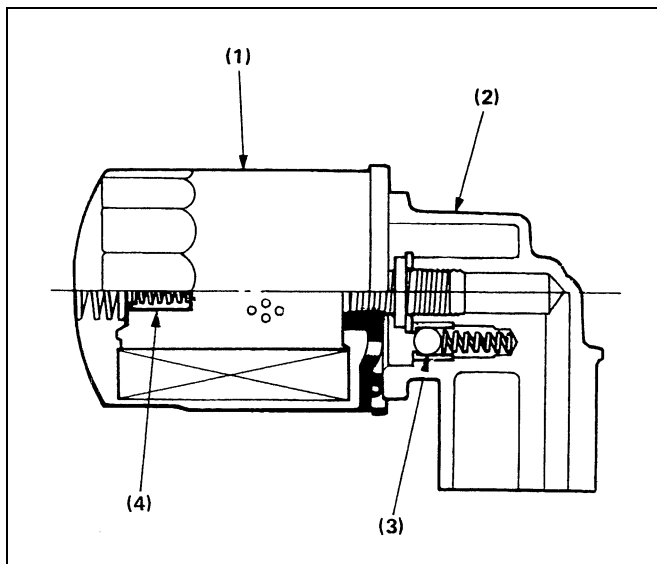
Type	Trochoid pump
Inner rotor	10 lobes
Delivery volume (2000 min ⁻¹ (rpm))	45.6 L/min 12.05 U.S gals/min
Delivery pressure (2000 min ⁻¹ (rpm)) (Regulator valve pressure)	200 to 392 kPa 2.0 to 4.0 kgf/cm ² 28.4 to 56.9 psi



(1) Oil pan
(2) Oil filter 1
(3) Drain plug

Fig. 5-4 Oil filter 1

Oil filter 2 is installed under the gear case on the side of gear case and is a standard full-flow type cartridge which requires minimum maintenance.



(1) Oil filter 2 (Oil filter cartridge)
(2) Gear case
(3) Relief valve
(4) By-pass valve

Fig. 5-5 Oil filter 2

● Function of valves and switches**Relief valve**

Maintains lubricating oil pressure at constant value adjusted to maintain pressure of 200 to 440 kPa (2.0 to 4.5 kgf/cm², 28.0 to 64.0 psi).

By-pass valve

By-pass valve is built into oil filter 2, if the filter becomes clogged, insufficient lubrication will result. To prevent this, the by-pass valve opens when the pressure difference before and after the filter exceeds 98.1 kPa (1.0 kgf/cm², 14.22 psi) to provide oil to engine parts.

4. LUBRICATING OIL FILTER

Oil in the oil pan first passes through filter 1 and is then suctioned by the oil pump. It then flows through filter 2 lubricating the various parts.

Oil filter 1 is installed near the bottom of the oil pan and removes dirt and foreign matter.

Oil switch

An oil switch is fitted at the camshaft bearing. If oil pressure drops below 49.0 to 98.1 kPa (0.5 to 1.0 kgf/cm², 7.11 to 14.22 psi) * a lamp connected to the switch lights up, advising the operator to stop engine and investigate the cause of the pressure drop.

* These will vary slightly according to model.

● Remote oil filter

When remote oil filter is used, the oil pressure at idling is as follows.

98 kPa (1.0 kgf/cm², 14 psi) or more

[Oil temperature : 90 to 95 °C (194 to 203 °F)]

5. OIL PAN

The oil pan holds a specified volume of oil, which is drawn up by the pump during operation and returns along the inside walls of the crankcase.

This flow cycle is repeated continuously as the engine runs.

The oil drain is located according to how the engine is installed and positioned for easy access for special drain requirements.

Oil gauge

The standard oil gauge is installed on the side of crankcase. The part which is inserted is made of rubber, which is grooved to release internal pressure during insertion. The oil gauge is stamped with lines indicating upper and lower limits. If oil is supplied far above the top limit, engine output will be reduced and oil temperature will be increased, so watch this point carefully.

Proper oil level is not indicated for a few minutes after the engine is stopped because of the time required for oil to return to the oil pan. Oil level must be measured in level position.

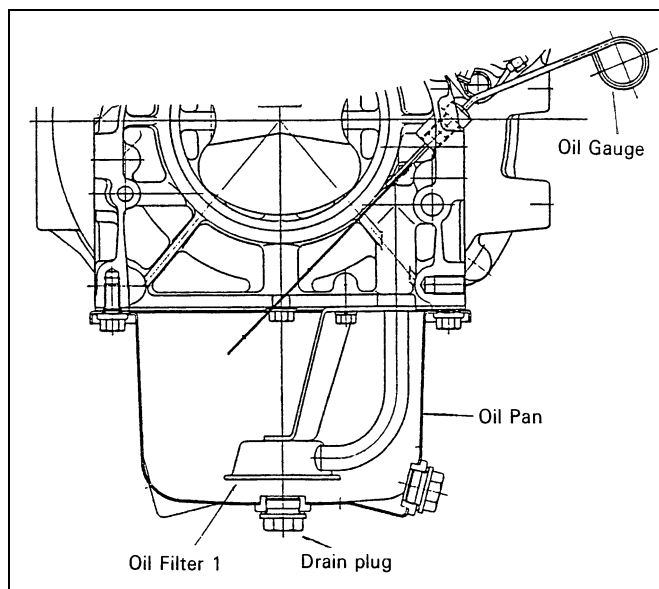


Fig. 5-6 Oil gauge

6. OIL SUPPLY PORT

Oil is supplied to the engine through the oil supply port located on top of the cylinder head cover or on the gear case or crankcase.

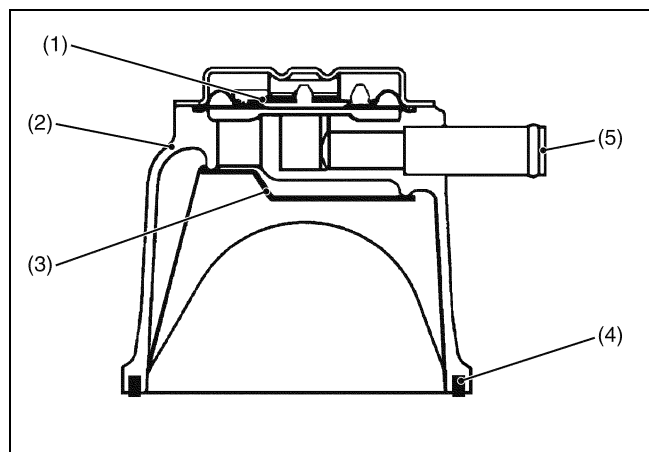
Oil flows through cylinder head and crankcase or gear case to the oil pan. This oil supply port should be easily accessible for servicing, even after the engine has been installed.

Care must be taken to decide the position of oil supply port so that the oil can be easily supplied to the piping installed on the machine.

7. CLOSED BREATHER

Closed breather system has been adopted to prevent the release of blow-by gas into the atmosphere.

After its oil content is filtered by oil shield (3), the blow-by gas is fed back to the intake manifold through breather valve (1) to be used for re-combustion.



(1) Breather valve	(4) Rubber packing
(2) Cylinder head cover	(5) Breather hose
(3) Oil shield	

Fig. 5-7 Closed breather system

6. AIR INTAKE SYSTEM

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2. AIR CLEANER		6-1
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[1] GENERAL		6-5
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AIR INTAKE SYSTEM

1. GENERAL

The intake and exhaust system is very important for engines.

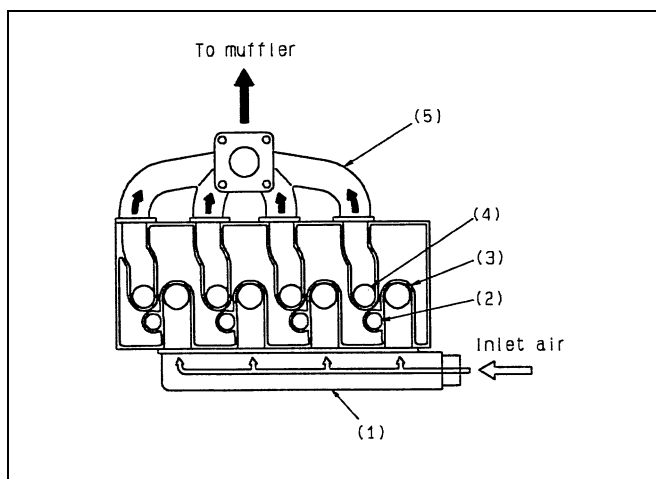
In order to operate an engine smoothly, the intake and exhaust system must be efficient enough for maximizing the functions of highly reliable valve mechanism. It is best to feed clean, low temperature (i.e. high density) air to the engine intake.

The intake system supplies the air required for combustion. Insufficient air intake decreases engine output. If air is not clean, wear increases on the piston, rings and cylinder and lubricating oil smear will tend to shorten engine life.

【Crossflow system】

Intake air temperature tends to rise if exhaust gas passages are near the intake passage ; this leads to decreased output. To prevent this, KUBOTA engines use a crossflow system.

As shown in the diagram, the KUBOTA engine employs the crossflow system which separates the intake and exhaust systems in opposite side of the cylinder head. This arrangement effectively prevents heating of intake air by exhaust heat which would result in decreased output. The crossflow type cylinder head provides better volumetric efficiency of the intake, alternately placed intake and exhaust ports minimize cylinder head distortion due to exhaust gas heat. The following sections cover important elements of the intake and exhaust systems.



(1) Inlet manifold	(4) Exhaust port
(2) Combustion chamber	(5) Exhaust manifold
(3) Intake port	

Fig. 6-1 Crossflow type cylinder head

2. AIR CLEANER

(1) General

The air cleaner, of which purpose is to purify intake air, has two types, ; the dry type and wet type. The dry-type air cleaner, which is generally used in most cases, uses a filter paper element and therefore dust removing efficiency is very high regardless of the engine speed. (99.5-99.8%)

In KUBOTA diesel engines, the dry-type air cleaner are employed as standard part for all models.

(2) Structure of dry type air cleaner

Dust or air containing moisture will infiltrate into air cleaner through the inlet installed perpendicularly on the bodies outer circumference and direct vortex flow along the guide is created inside the body.

After this, the air passes through the element and will further be purified.

The element is made of high-quality paper filter and can inhibit infiltration of very fine dust (20μ). Dust separated by the vortex flow will be collected into the rear-side and cover and then passed into the evacuator valve.

This evacuator valve will open and close automatically in accordance with pulsation of suction air and discharge the dust.

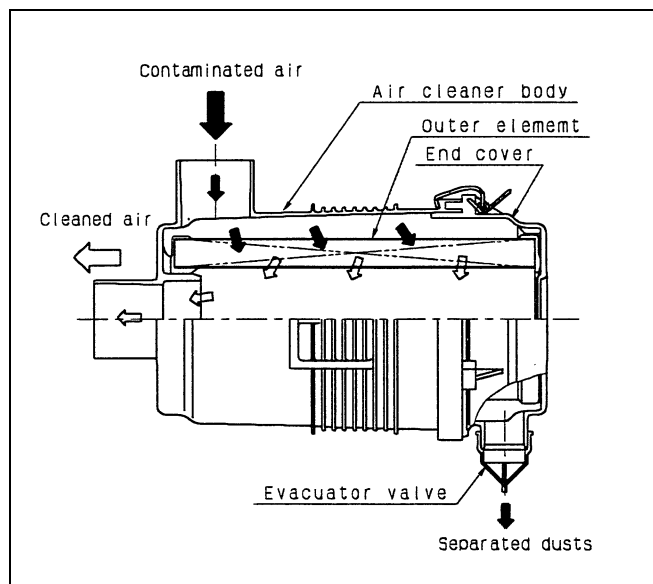


Fig. 6-2 Structure of air cleaner

1) Structure of single element air cleaner

This air cleaner is the most popularly used type for the small-size general purpose diesel engine and is composed of the air cleaner body, outer element, rear-side end cover, dust-evacuator valves, etc. The outline of the structure is shown in the Fig. 6-3.

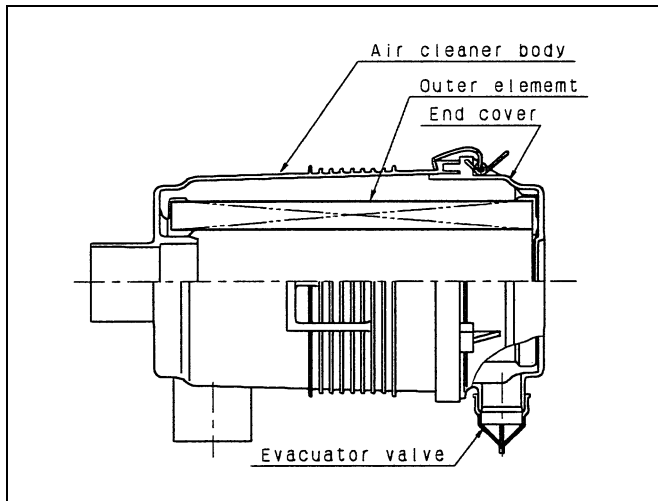


Fig. 6-3 Structure of singleelement air cleaner

2) Structure of doubleelement air cleaner

The air cleaner of doubleelement structure is used for the engine to be used in more severe environmental conditions such as the case of construction machinery and sweeper where the amount of dust is large. This type is made by adding the inner element to the previously-described singleelement air cleaner and the structure is shown in the following figure.

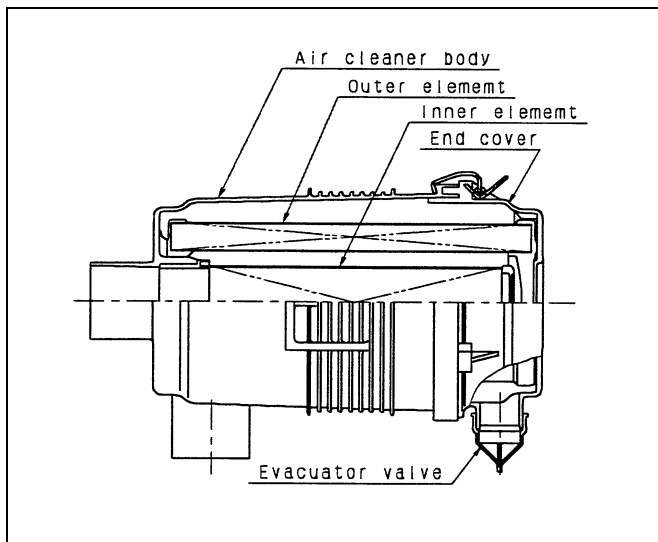


Fig. 6-4 Structure of doubleelement air cleaner

(3) Selection of air cleaner

1) Conditions for selection

- a) Amount of suction air
- b) Environmental conditions of dust
 - Small-amount dust conditions :
Generator, forklift, carrier, etc.
 - Large-amount dust conditions :
Agricultural machinery, construction machinery
- c) Mounting conditions
Mounting to engine, or mounting to machine
- d) Destination
Use in advanced countries, or to developing countries
- e) Use conditions
Operating hours and quality of maintenance
- f) Cost
Initial cost and maintenance cost

2) Selection of air cleaner and the cautionary items

- a) Cautionary items for environment
 - In case that an air cleaner is used in high dust concentration areas (high-temperature or high-humidity area), a model of sufficient capacity should be used. (It is required to use the air cleaner of one size higher capacity than those to be used in ordinary areas.)
The air cleaner should be the doubleelement type.
 - Reduction in the life of the air cleaner (clogging) is often caused by comparatively small-sized dust. However, in the case that there is a possibility that the suction port (air intake) of air cleaner may be clogged by large-size dust (such as fallen leaves and straw dust), it is required to move the suction port to a location with less dust or to install a pre-filter to remove such large-size dust.
 - In the case that there is a possibility that the air cleaner may suck in water, a water drain hole or water-separating device should be installed. Be very careful to prevent the water entering engine when washing the machine.
- b) Caution items when mounting to engines
 - Vibration of air cleaner should not exceed the rated value verified in the field operation of the actual machinery.
Large vibration will cause damage to various parts or allow dust leakage of the element (including the element gasket section).

- Be careful so that the suction port of air cleaner is not subjected to the detrimental conditions such as the followings :
 - a) Air cleaner should not inhale hot air, such as the hot side cooling air of radiator.
 - b) Air cleaner should not inhale exhaust gas. Particularly fine carbon will cause to early clogging.
 - c) Air cleaner should not inhale the material having viscosity such as mist of crankcase.
- Cautionary items when piping to the air cleaner
 - a) Is the inner diameter, length, or bending of pipe appropriate ?
Be careful so that the intake air resistance should not be too great.
 - b) Is the dust seal of piping system complete ?
If there is even the least gap in the suction air system, it will result in the early wear of the moving parts of engine.

Therefore, checking of the following items is required.

- 1) Is clamping force of the hose clamp sufficient, and will not the hose clamp be loosened by vibration ?
Are all hose connection "rubber to metal".
Are all rubber hose connections tight on metal connections.
- 2) Is strength of the hose sufficient ?
(Will not distortion or damage of the hose be incurred by negative suction pressure or positive suction air pressure ?)
- 3) Will dust infiltrate through the screw holes ?
- c) Cautionary items on maintenance
 - Maintain the air cleaner within the time specified in the operators manual. (In the case of the air cleaner provided with a dust indicator, maintenance should be performed after the warning of clogging is indicated.)
Unnecessary maintenance will be the cause of problems, such as the damage or deformed element.
 - Be careful so that dust adhered on the element should not infiltrate to the outlet side of air cleaner when removing the element.

- When cleaning the element, it should be done by blown air or water washing. (Depending on the kind of the element, water washing is allowed, or specified detergent can be used.) In case of blown air remember to blow air from the inside toward the outside.
- When removing the element, stop the engine.
- In case that there is a pin hole on the element, replace it with new one.

Installation example of air cleaners are shown :

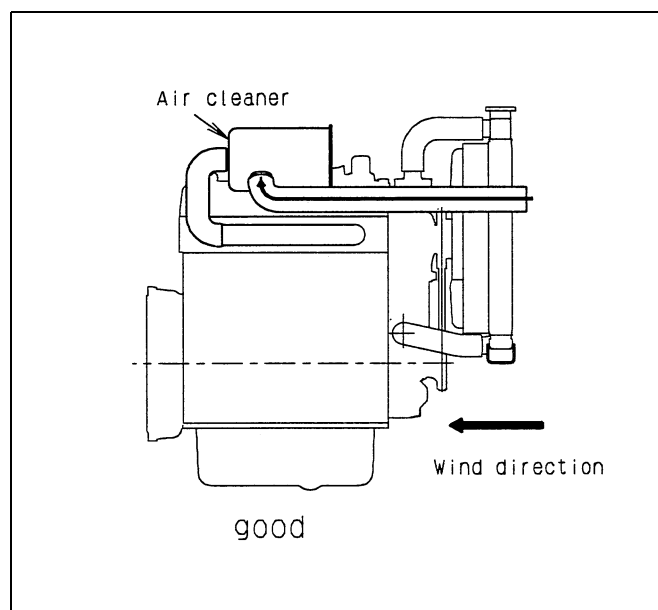


Fig. 6-5 Air cleaner installations

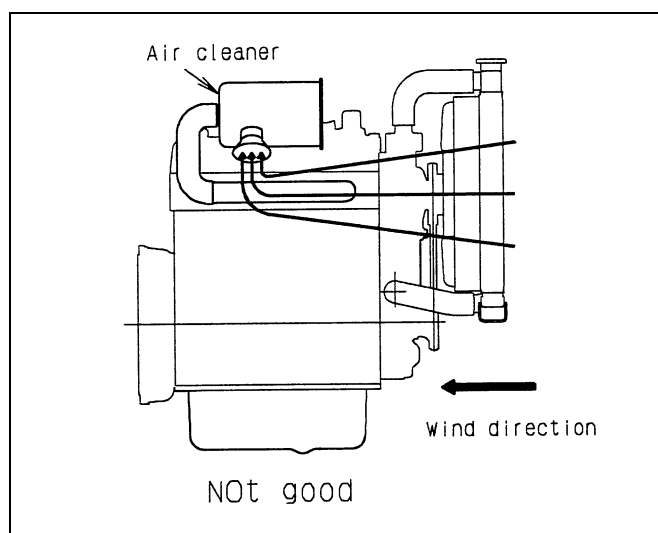


Fig. 6-6 Air cleaner installations

3. REQUIRED AIR VOLUME

The volume of air required during engine operation can be determined by the following formula.

$$Q_1 = V_h \times N \times C \times \eta \times k \times 10^{-3}$$

where as : Q_1 = Amount of intake air (m^3/min)

V_h = Total displacement (liter)

N = Engine speed (min^{-1} (rpm))

C = Coefficient 4 cycle ... 0.5

η = Intake efficiency 0.85 to 0.87

k = Coefficient

Natural aspirated engine : 1.0

Turbo charged engine : 1.5

The intake efficiency of KUBOTA diesel engines shall be as follows :

Natural aspirated engine

Engines of 3000 min^{-1} (rpm) or less : 0.87

Engines of 3600 min^{-1} (rpm) or less : 0.85

Turbo charged engine : 0.80

The air volume required for KUBOTA diesel engine is referred to in section. (TECHNICAL INFORMATION)

Example Calculation

[Engine model : V2203,

Engine speed : 2800 min^{-1} (rpm)]

$$Q_1 = V_h \times N \times C \times \eta \times k \times 10^{-3}$$

$V_h = 2.197 \text{ lit}$

$N = 2800 \text{ min}^{-1}$ (rpm)

$C = 0.5$

$\eta = 0.87$

$k = 1.0$

$$Q_1 = 2.197 \times 2800 \times 0.5 \times 0.87 \times 1.0 \times 10^{-3}$$

$$= 2.68 \text{ m}^3/\text{min}$$

4. INTAKE RESISTANCE

Resistance of the intake system is caused by the air cleaner and intake piping. This resistance must be kept below a certain point. To prevent decreases of engine output performance, this resistance must be held within the following reference sheet ;

Engine model series	Initial limit w/clean filter		Limit w/dirty filter	
	(mmAq)		(mmAq)	
	NA	TC	NA	TC
NSM	250	—	500	—
05	250	250	500	500
03M	250	250	500	500
07	—	400	—	630
V3	350	400	630	630
05-BG	200	—	500	—
03M-BG	200	200	500	500
V3-BG	250	250	500	500

Note :

- 1) The intake restriction is the total system limit.
- 2) The restriction must be measured as close to the intake manifold (or turbo inlet) as possible to properly measure the entire system restriction.
- 3) Intake restriction must be measured at the location that is not affected by pulsation.
- 4) For naturally aspirated (NA) engines, conduct the restriction test at full throttle, high Idle condition no load. For turbocharged engines conduct the restriction test at full throttle rated speed full load condition.
- 5) The application check must be performed at the Initial limit with clean filter condition.
- 6) If OEMs mention the restriction values on their operator manuals for service interval, refer to the above sheet (Limit w/dirty filter).

The intake piping should be made of a high quality compounded rubber with exceptional resistance to aging, oil and cold to reduce chances of cracking during operation.

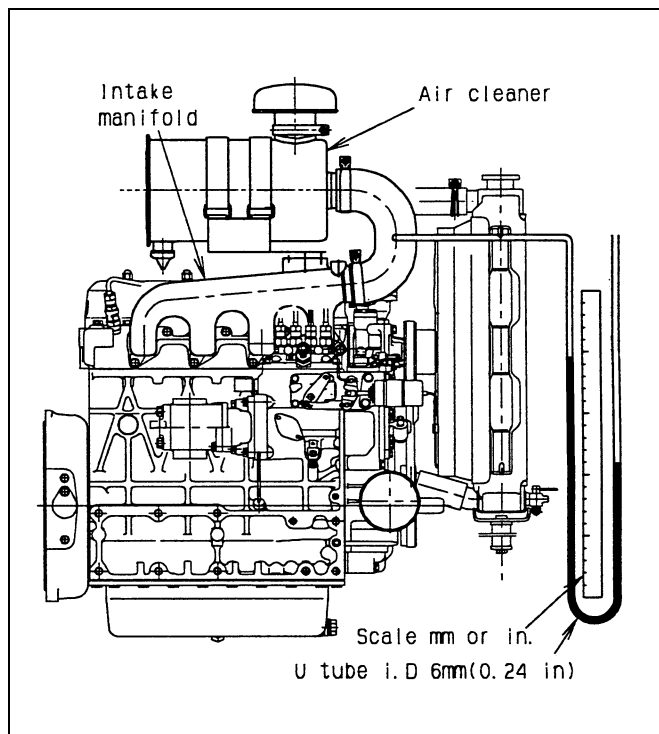


Fig. 6-7 Intake resistance measurement point

Note :

Intake resistance measurement point should be close to intake manifold.

5. TURBOCHARGER

[1] GENERAL

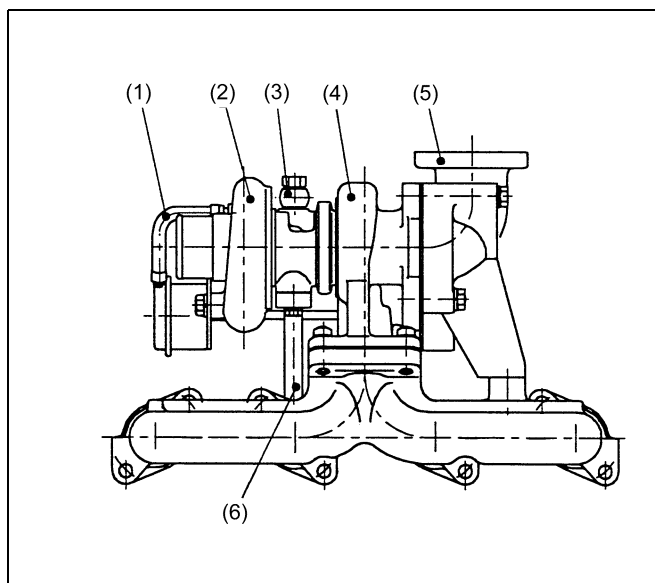
If air can be drawn in at a greater rate before it enters the cylinder more fuel can be burned and the output will be increased.

A turbocharger discharges the compressed air into the cylinders by a turbine using energy of the exhaust gas as power. Use of a turbocharger allows a small engine to have a high output.

[2] COMPONENTS OF TURBOCHARGER

The turbocharger is a compact unit mounted on the outlet of the exhaust manifold.

It consists of a turbine portion to convert exhaust gas energy into a rotating force, a compressor to compress intake air, a waste gate valve to prevent excessive pressures at high speed operation, a lubricator to supply engine oil to bearings and a boost compensator to adjust the fuel injection amount at low speed and during acceleration.



(1) Waste gate piping	(4) Turbine
(2) Compressor	(5) Exhaust port
(3) Lubricating piping	(6) Lubricating oil return pipe

Fig. 6-8 Example of turbocharger

7. EXHAUST SYSTEM

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[3] EXTERNAL / MECHANICAL EGR		7-6

EXHAUST SYSTEM

1. GENERAL

An engine's exhaust system must be able to freely discharge all high temperature exhaust gas after combustion to the outside air.

Exhaust resistance must be as low as possible in order to prevent a decrease in power, however exhaust noise must be kept at an acceptable level. Careful design is required to reconcile these two conflicting factors.

Exhaust gas from the exhaust manifold can either be directly fed into the muffler or routed to a place which will not interfere with the operator by exhaust pipe. The most important point in all cases is to reduce back pressure to a minimum.

2. LIMITATION OF PERMISSIBLE BACK PRESSURE

Limitation of permissible back pressure for KUBOTA engines :

Refer to the table below.

Position to measure back pressure is at the outlet of exhaust manifold. Use a manometer to measure it. Refer to Fig. 7-2.

Unit : kPa (mmHg)

Back Pressure		
S.M. series		9.3 (70) or less
05 series		10.7 (80) or less
03-M series		
07 series	V2607DI-T	9.3 (70) - 13.3 (100)
	V3307DI-T	11.3 (85) - 15.3 (115)
V3 series	V3600	12.0 (90) or less
	V3600-T	13.3 (100) or less
	V3800DI-T	11.3 (85) - 15.3 (115)
All BG series		7.07 (53) or less

Note :

Back pressure to be measured at rated rpm and load.

Fig. 7-1

Generally speaking,

- Back pressure increases as engine speed increases. Increase in back pressure varies with muffler construction.
- Mufflers with higher back pressures have larger output loss. (approximately 5%)
- Back pressure increases as exhaust piping has many bends, longer length, many restrictions and smaller muffler volume.

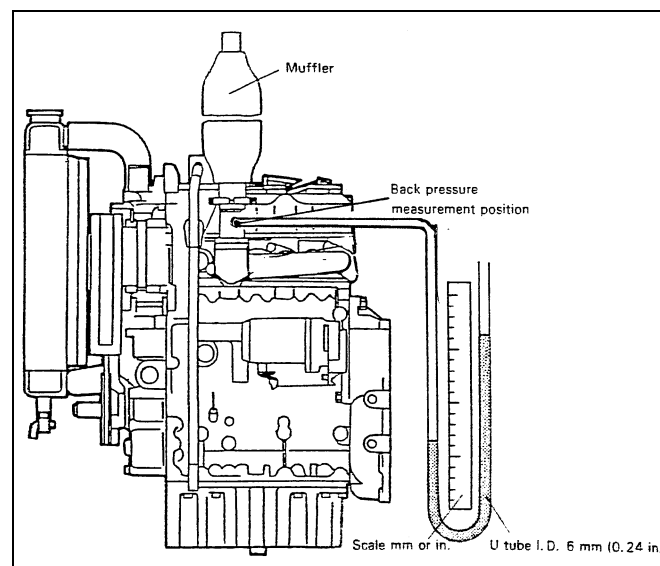


Fig. 7-2 Back pressure measurement point

3. CALCULATION OF BACK PRESSURE

Back pressure is decided in accordance with resistance of muffler and exhaust pipe (length, pipe diameter, number of bend and bending radius) and gas volume. Back pressure can be determined by the following formula.

1) Gas volume and resistance

a) Gas volume and speed

$$\nu = [VE / (\pi \times D^2/4)] \div 3600$$

VE : Gas volume (m³/hr)
(See attached TECHNICAL DATA)

ν : Gas speed (m/s)

D : Internal diameter of exhaust pipe (m)

b) Resistance

- Straight pipe (resistance per one meter) ΔP (mmAq)

$$\Delta P = \lambda \times (L / D) \times (\gamma \times v^2) / (2 \cdot g)$$

L : Pipe length = 1m

D : Inside diameter of pipe (m)

γ : Specific gravity of gas at 673 K { 400 °C (752 °F) }
0.5 (kg/m³)

v : Gas speed (m/sec)

g : 9.8

λ : Friction coefficient = 0.030

- Elbow (resistance per one elbow) $\Delta P'$ (mmAq)

$$\Delta P' = \zeta \times \gamma \times v^2 / 2 \cdot g$$

ζ : Short elbow = 0.51

Long elbow = 0.36

Result of calculations by the above formula are on next page (Fig. 7-3)

2) Resistance of mufflers (PM)

3) Total resistance (P)

$$P = \Delta P \times L + \Delta P' \times N + PM$$

L : Pipe length (m)

N : Number of elbow

4. MUFFLER

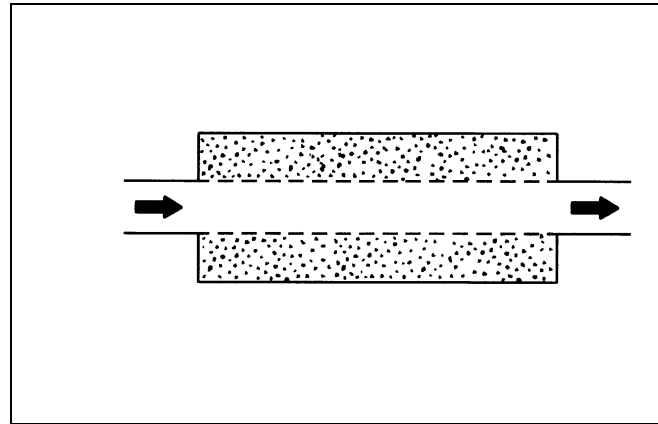
High temperature and high pressure exhaust gas is intermittently discharged by fuel combustion, generating pressure waves inside the exhaust pipe which results in noise.

Mufflers are used to reduce this noise. There are three major types of mufflers described.

Muffler types :

- Absorption type

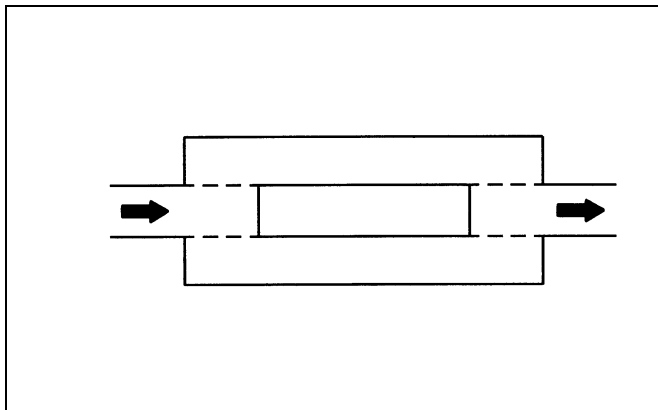
A perforated pipe is surrounded by glass fiber and other noise absorbing materials.



- Expansion type

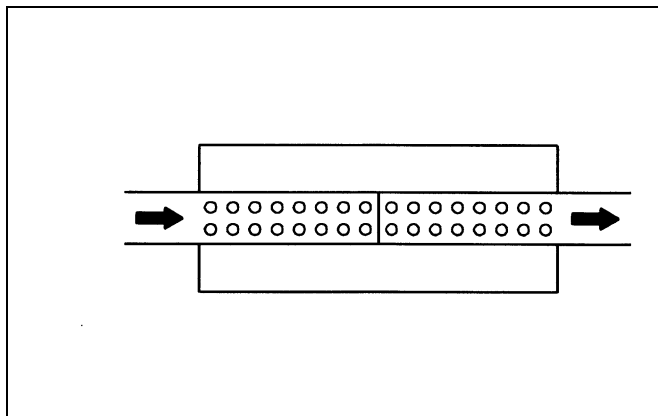
Exhaust gas is discharged into an expansion chamber from the exhaust pipe to diffuse the noise.

This type comes with either a single or multiple expansion chambers.

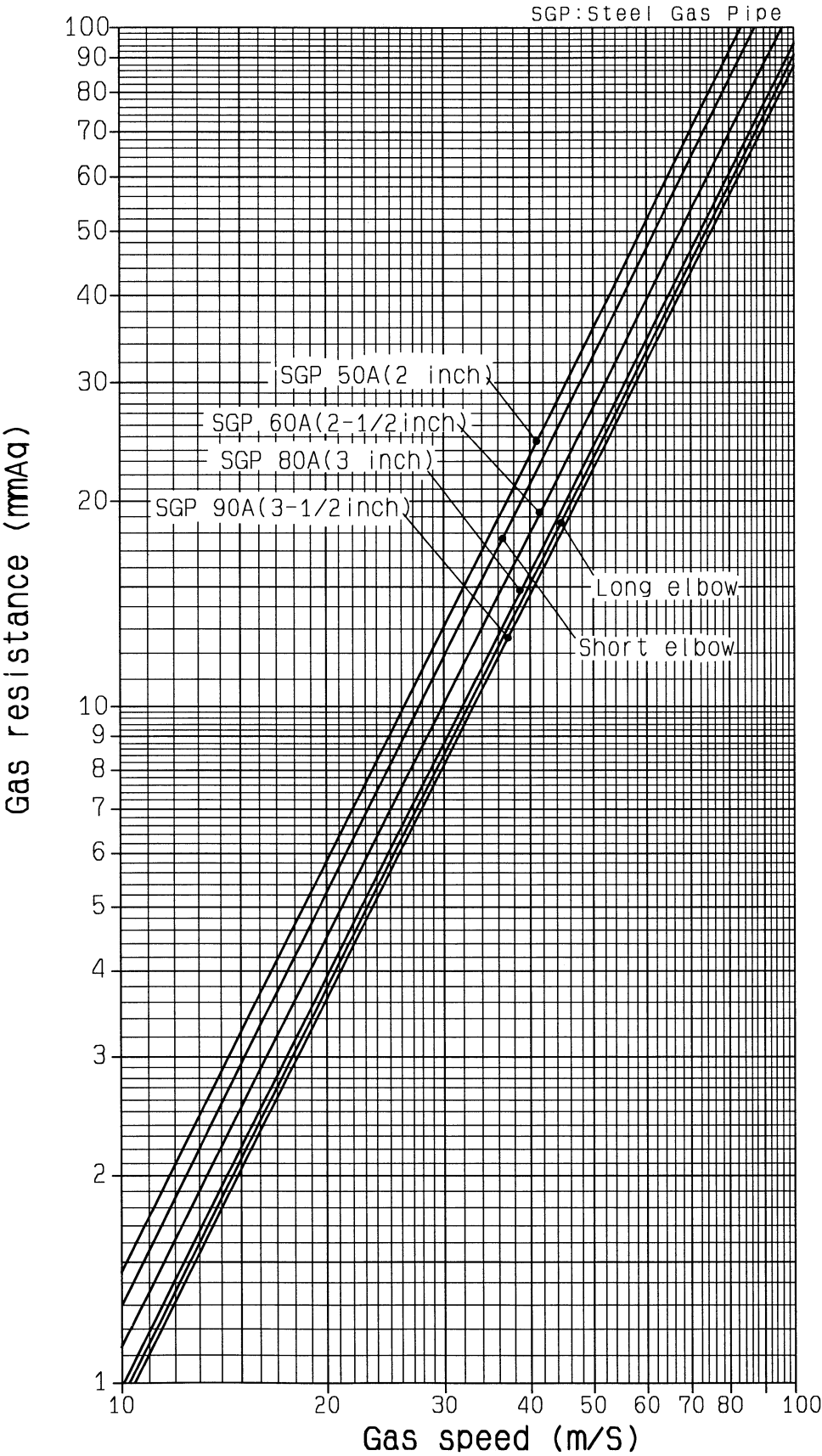


- Dispersion type

Noise is muffled by changing the direction of the gas flow.



Rough estimate chart of exhaust gas resistance on straight pipe and elbow



Elbow dimensions

	Short elbow	Long elbow	
	ϕD	A	ϕD
2 inch	52.9	50.8	52.9
2-1/2 inch	67.9	63.5	67.9
3 inch	80.7	76.2	80.7
3-1/2 inch	93.2	88.9	93.2

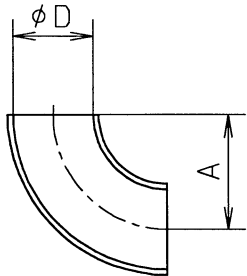


Fig. 7-3

There are many cases when combinations of these three kinds are used. The size of a muffler should generally be four or six times more than engine total displacement. This will vary according to length of exhaust pipe, type of muffler and purpose. Tests are required to determine the optimum arrangement.

When designing an exhaust system, exhaust direction and the high temperature of the pipes must be carefully considered for safety avoiding key engine parts, such as fuel piping and wiring are necessary when enclosing a muffler in an engine room or soundproof case. Air flow must be taken into consideration to keep the temperature inside as low as possible.

Other precautions

- 1) When directing the exhaust port upwards, rain will enter. Therefore, a snap-open cap at the top or a small drainage hole on the bottom of manifold must be provided.
- 2) If the muffler and exhaust piping are mounted on the machine body itself, a heatproof flexible pipe must be installed between the engine and the muffler. External piping must be isolated from vibration. Muffler must be held by additional stay from the engine in order to prevent a crack or break in the exhaust manifold or muffler itself.
- 3) Refer to the list of optional parts to arrange exhaust manifold outlets and directions of discharge.

5. EXHAUST GAS RECIRCULATION (EGR) SYSTEM

[1] GENERAL

In order to meet with the strict emission regulations, Kubota has adopted the EGR on the V3-E3B series and 07-E3B series. The nitrogen oxide (NO_x) which is a hazardous component in exhaust gas is generated by oxidation of nitrogen in the air, due to rise of the combustion temperature in cylinders. The EGR is a

system in which the exhaust gas with lean oxygen is cooled and returned to cylinders again in order to lower the combustion temperature. As a result, NO_x can be decreased.

And EGR has 2 types. One is an internal EGR, the other is an external EGR.

[2] INTERNAL EGR (V3600-T-E3B)

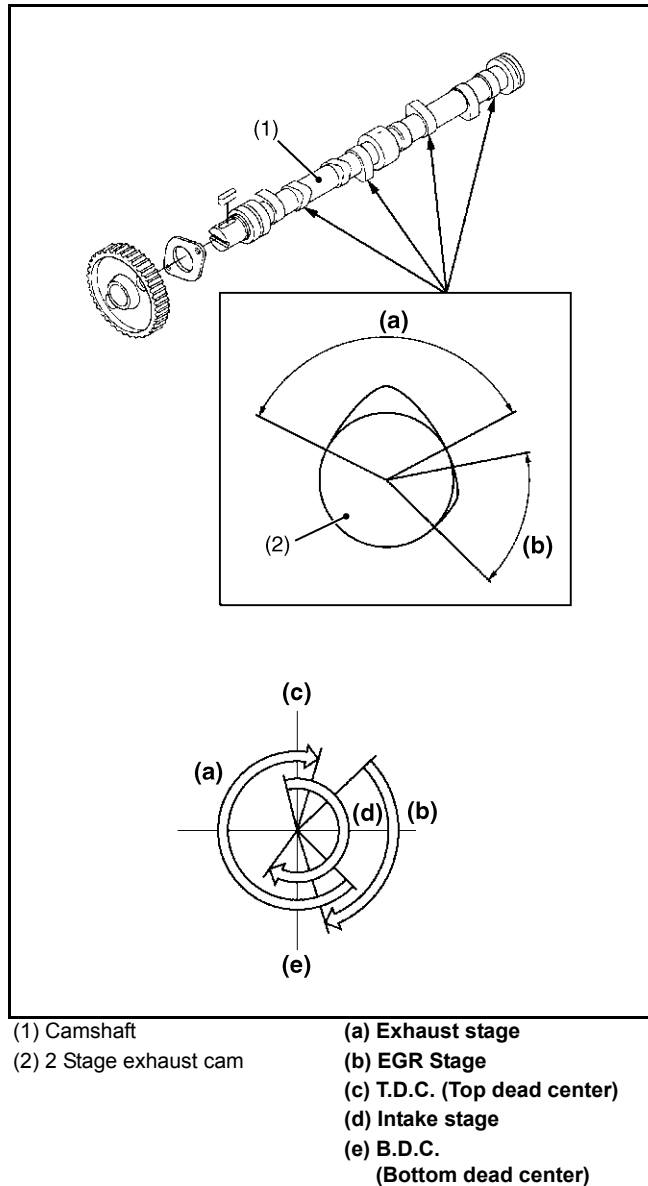


Fig. 7-4 Closed breather system

Internal EGR consists of 2 stage exhaust camshaft. At the exhaust stroke, 1st stage exhaust cam opens the exhaust valve, and exhaust gas flows into the exhaust manifold. At the suction stroke, intake valve is open and fresh air flows into the cylinder, and also, 2nd stage exhaust cam opens the exhaust valve, and exhaust gas in the exhaust manifold is sucked back into the cylinder.

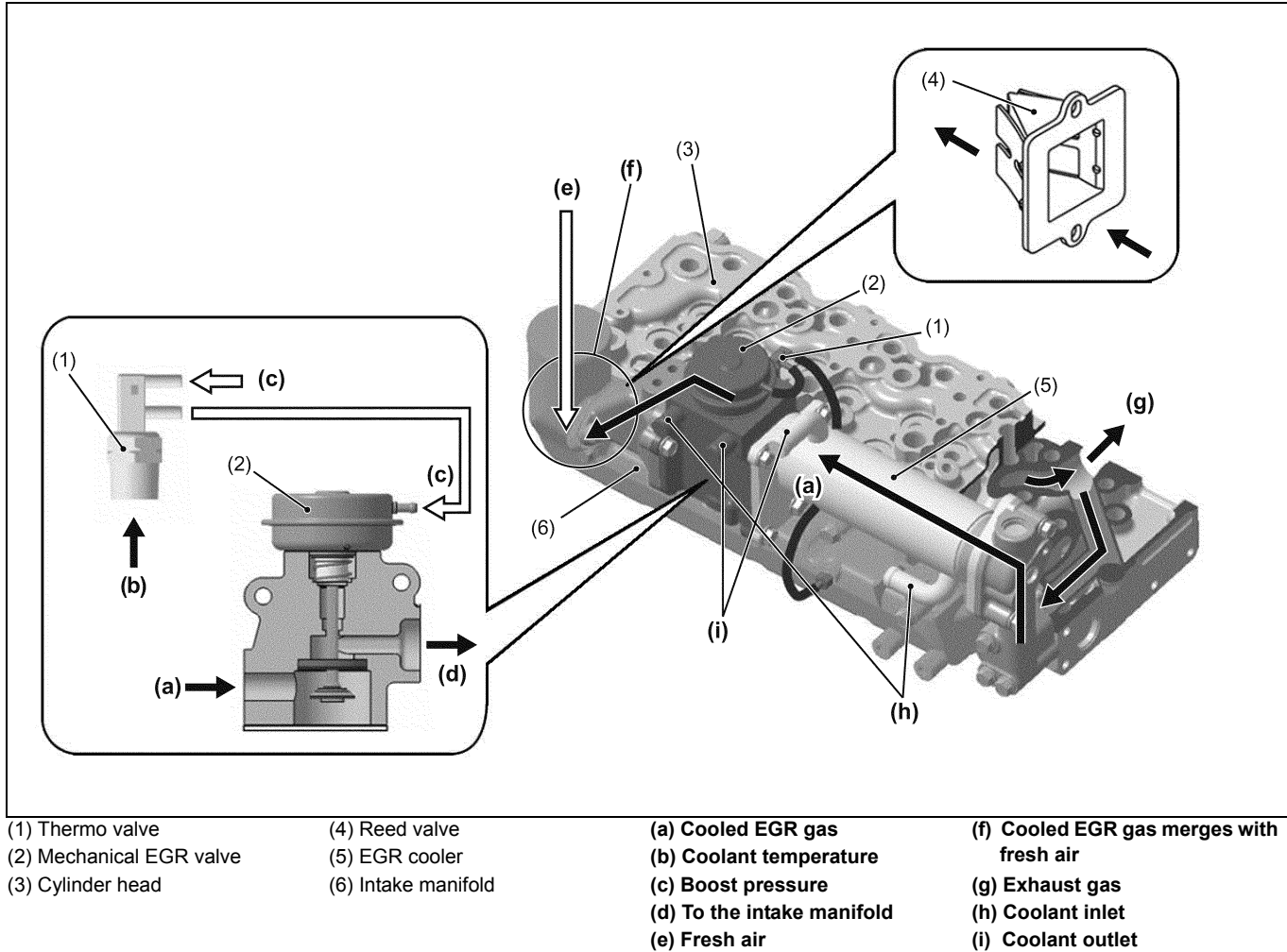
[3] EXTERNAL / MECHANICAL EGR**(1) V2607-DI-T-E3B / V3307-DI-T-E3B**

Fig. 7-5

External mechanical EGR consists of water cooled EGR cooler (5), mechanical EGR valve (2), reed valve (4) and thermo valve (1).

When the coolant temperature **(b)** is getting higher, thermo valve (1) is open and the boost pressure of intake manifold (6) gets to reach the diaphragm of mechanical EGR valve (2).

If the coolant temperature **(b)** is high, but the boost pressure is low, the EGR valve (2) does not open. If coolant temperature **(b)** is high, boost pressure is also high, EGR valve (2) is open and cooled EGR gas **(a)** through the water cooled EGR cooler (5) flows into the intake manifold (6). And the reed valve (4) between EGR valve (2) and intake manifold (6) prevents the fresh air flowing into EGR system.

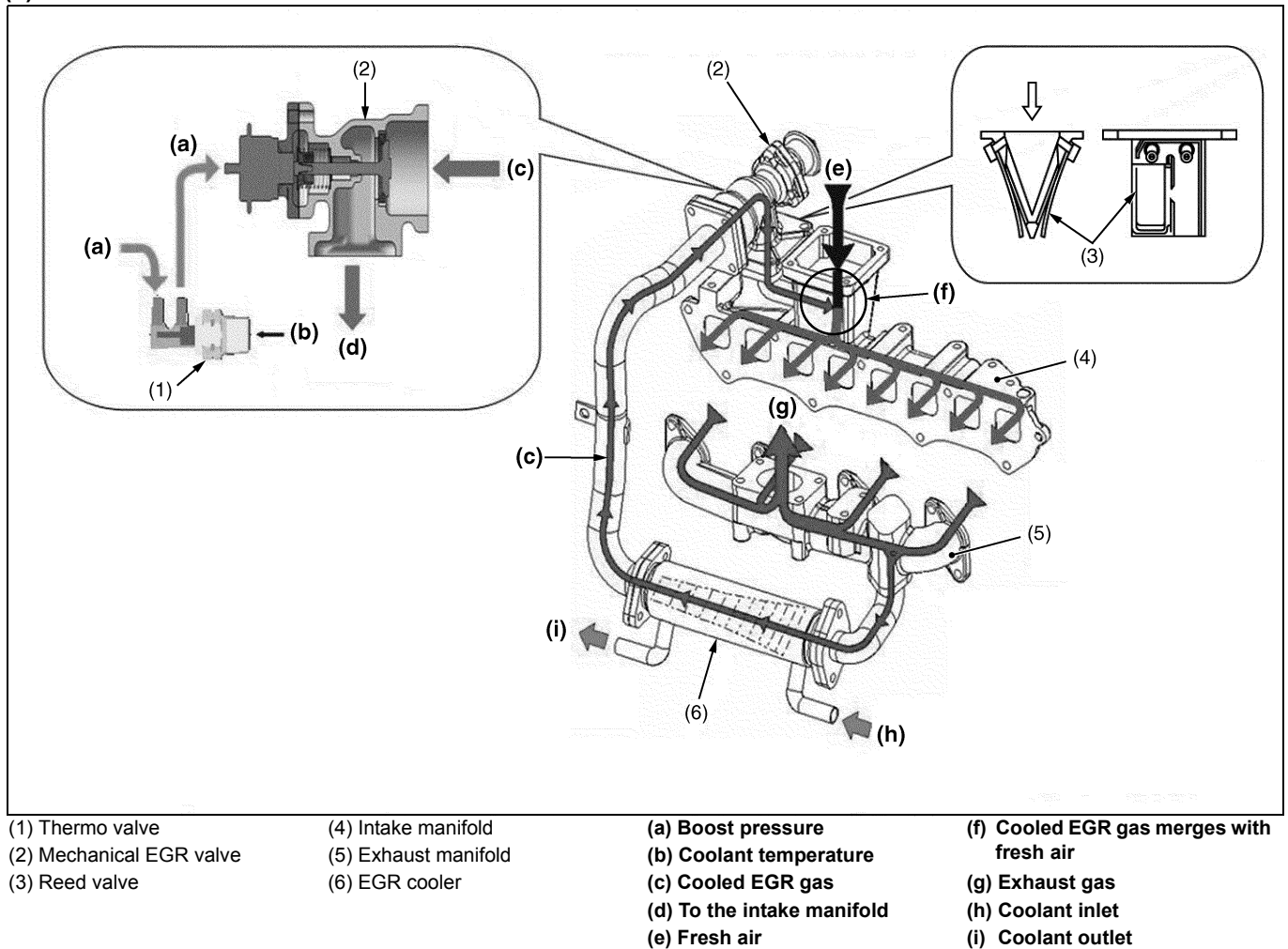
(2) V3800DI-T-E3B

Fig. 7-6

External / Mechanical EGR consists of water cooled EGR cooler, mechanical EGR valve, reed valve and thermo valve.

When the coolant temperature is getting higher, thermo valve is open and the boost pressure of intake manifold gets to reach the diaphragm of mechanical EGR valve.

If the coolant temperature is high, but the boost pressure is low, the EGR valve does not open. If coolant temperature is high, boost pressure is also high, EGR valve is open and cooled EGR gas through the water cooled EGR cooler flows into the intake manifold. And the reed valve between EGR valve and intake manifold prevents the fresh air flowing into EGR system.

8. COOLING SYSTEM

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COOLING SYSTEM

1. GENERAL

Heat generated inside the combustion chamber during combustion and heat generated by friction of moving

parts is removed by the cooling system to allow continuous operation in the proper range.

【Coolant flow】

The cooling system cools the engine while it is running to prevent overheating and maintain a proper operating temperature.

Kubota engines are used pressurized forced-circulation type.

This system consists of a radiator (1), water pump (2), cooling fan (3), thermostat (4) and coolant temperature sensor (some models).

The coolant is cooled through the radiator core, and the fan set behind the radiator pulls cooling air through the core to improve cooling.

When the coolant in the engine is at a low temperature, the thermostat valve is closed so that the coolant is circulated in the engine through the bypass pipe.

When the temperature of the coolant becomes the valve opening temperature of thermostat (4), the thermostat (4) opens the valve to return the heated coolant to the radiator (1).

The water pump (2) sucks the cooled coolant, forces it into the cylinder block (6) and draws out the hot coolant. 03-M, 07, V3, series engines employ the bottom bypass system to improve the cooling performance of radiator and the three step valve opening type thermostat to reduce thermal shock radically.

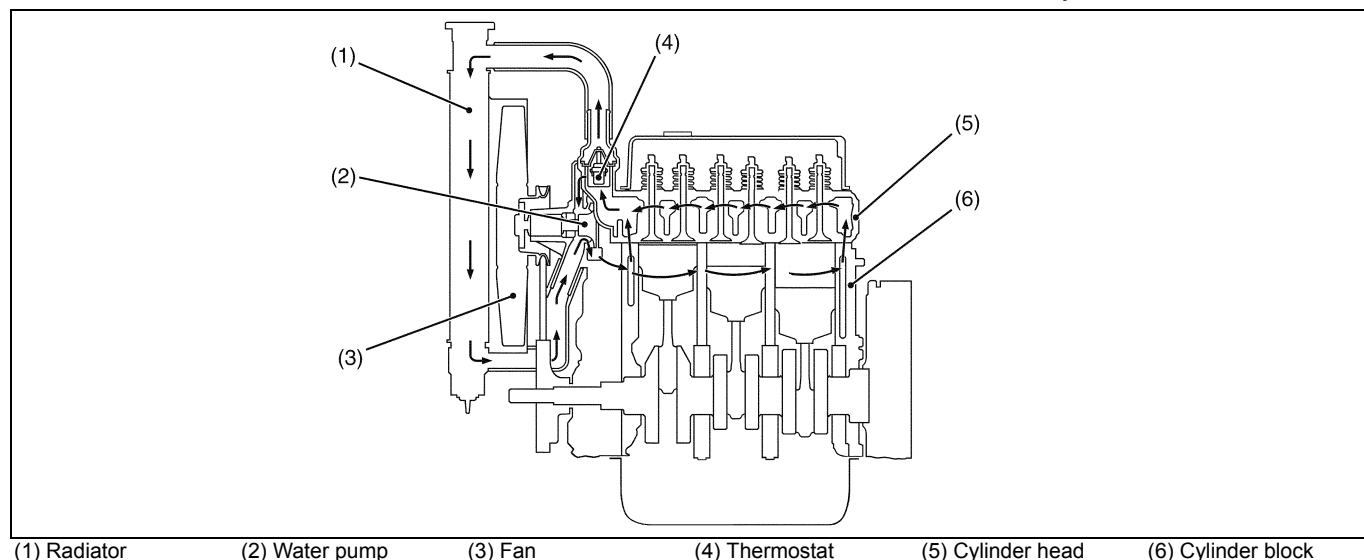


Fig. 8-1 Cooling system

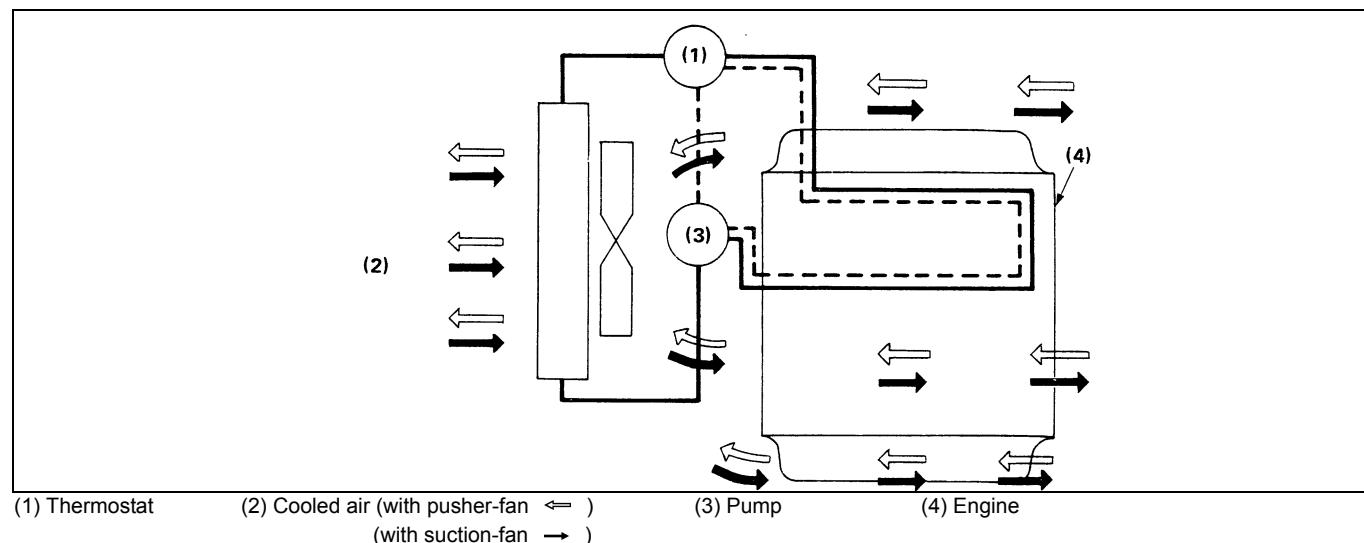


Fig. 8-2 Cooling air flow

2. RADIATOR

[1] GENERAL

Heated cooling water, passing through the radiator is cooled when the fan causes air to pass through the radiator and disperse the heat. The standard radiator mounted on KUBOTA engine is a tube-and-corrugated-fin type with a superior cooling effect. Radiator capacity is selected according to rated output (at standard condition) of an engine to prevent overheating extended operation.

Pressurized cooling water inside the radiator is kept less than 88 kPa (0.9 kgf/cm², 12.8 psi) by the radiator cap to prevent deformation of radiator due to excessive pressure. Generally, corrugated-fin types come with louver or without louver and with various fin pitches. When selecting a radiator, dust conditions, ambient temperature, load etc. must be considered carefully.

A radiator has many thin copper, brass or aluminium components and requires special care and handling. Radiators should be installed where they are not subjected to impacts and vibration. Measures should also be taken to prevent engine parts or other objects from contacting radiator.

A coolant recovery tank should be installed for all applications.

This helps prevent loss of coolant and overheating resulting from coolant level.

[2] TYPE

In general, there are two kinds of radiators. One is a down flow radiator. The other is a cross flow radiator.

★ Down flow radiator (Conventional)

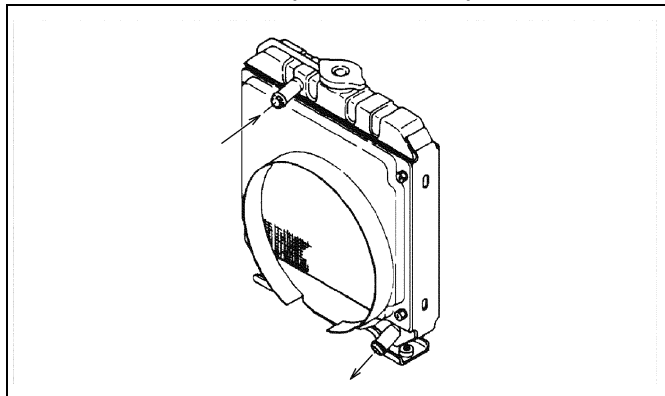


Fig. 8-3

★ Cross-flow radiator

In a cross-flow radiator the coolant passageways travel horizontally rather than vertically. Another feature of the cross-flow radiator is that the inlet and outlet tanks are located on the sides of the radiator, rather than on top and bottom. This allows for a "low profile" cooling system.

These radiators offer a compact cooling system, but special attention must be given to key issues associated with a cross-flow radiator.

1) Cooling system fill

- a) A cooling system should be designed to provide complete filling of the engine, piping, and radiator without air pockets in the system. Due to the nature of the cross-flow radiator design, this can be very difficult.
- b) Even with a standard coolant recovery bottle, removing this air can require several warm-up and cool-down cycles.
- c) Only cooling system with a pressurized recovery tank will allow proper and quick de-aeration.

2) De-aeration capability

- a) De-aeration capability is the ability of a cooling system to get rid of air and gasses entrapped in the cooling system. Air can be introduced into the system during fill or during normal operation.
 - b) A properly designed down-flow radiator has a top tank with a baffle. The area above the baffle serves as space to isolate entrapped air from the coolant.
 - c) A cross-flow radiator has no method of separating the entrapped air from the coolant causing the air to constantly be drawn back into the system. Constant splashing as coolant enters the tank causes air and coolant to mix, allowing the cooling system to draw the air in.
- * Air retained in the cooling system can cause "hot spots" in the engine, particularly the cylinder head. It can also reduce cooling capacity and possibly cause cavitations of the water pump.

3) Drawdown capability

- a) Drawdown capability is the ability of a cooling system to correctly function with a given amount of coolant loss.
- b) Cross-flow radiators do not provide drawdown capability during operation, Even With A Standard Coolant Recovery Bottle.
- * Only at cool-down will coolant from the recovery bottle be allowed back into the radiator.

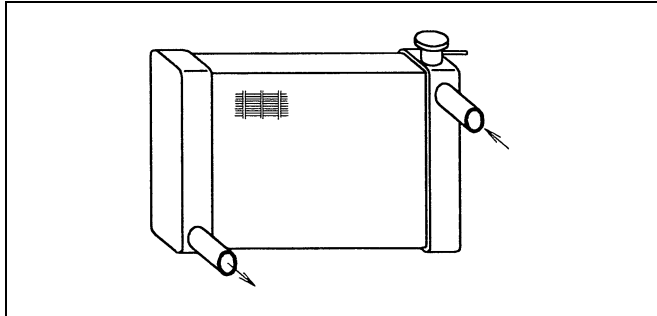


Fig. 8-4

[3] RADIATOR POSITION

In case of mounting a radiator parallel to the crankshaft, positioning of other components, such as the fan belt drive system, becomes complicated. Non-standard positioning should be avoided as much as possible.

(1) Basic arrangement

Basically a fan is installed on the water pump shaft, and a radiator position is shown below.

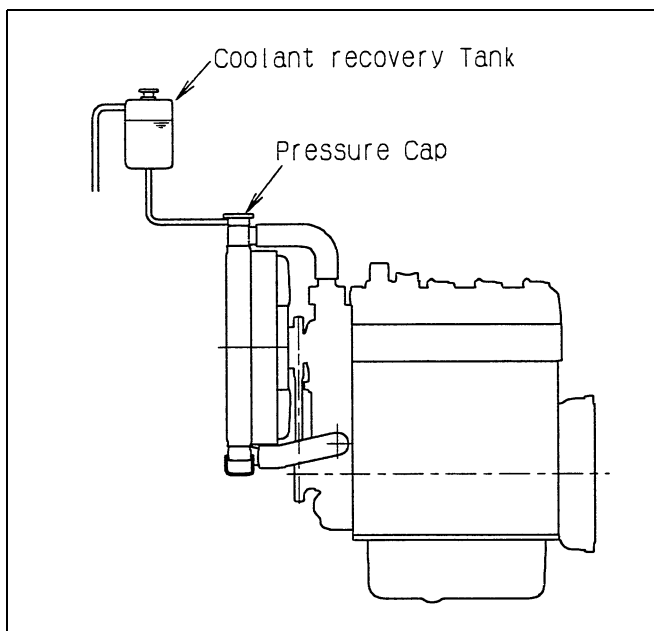


Fig. 8-5

(2) Top of radiator below engine water outlet

Sometimes a radiator is positioned at a lower level and the pressure cap may be positioned at a lower level than the rest of system. In this case, a special venting/bleed line arrangement is required. Below are examples.

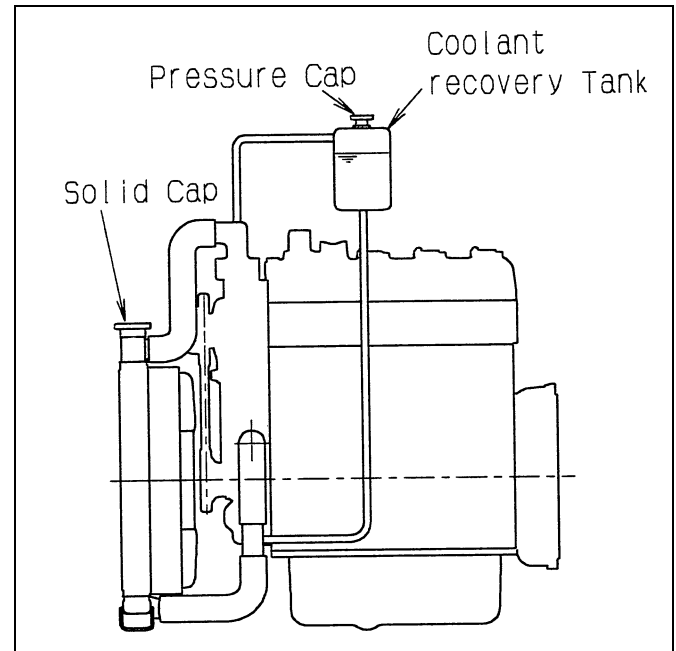


Fig. 8-6

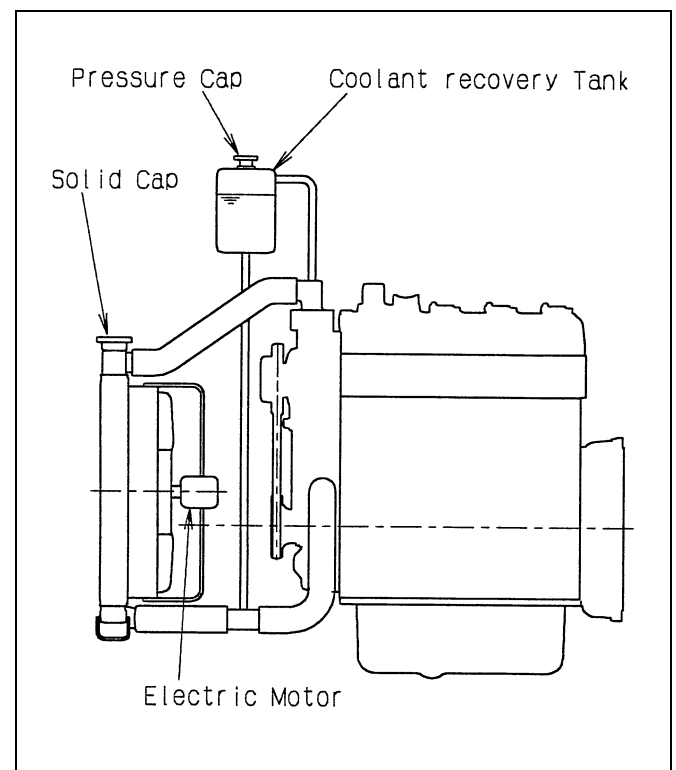


Fig. 8-7

(3) Distance between fan and radiator core

Clearance between fan and radiator core should be kept as far as possible, within the space limitation in radiator mounting.

If the clearance between fan and radiator core cannot be maximized due to lack of space, it should be more than 25 mm (1 in.).

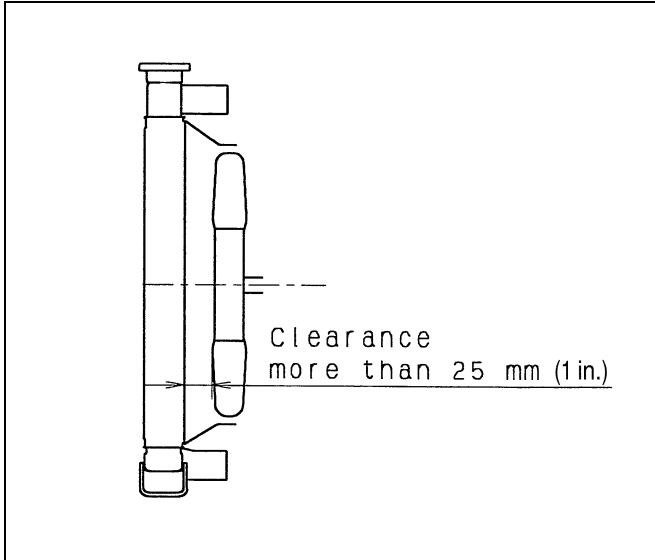
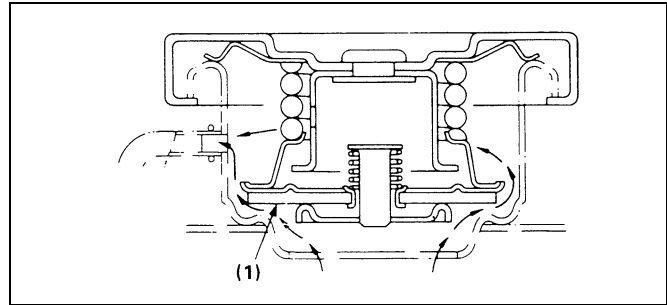


Fig. 8-8

[4] RADIATOR CAP

Pressure inside a radiator is slightly higher than atmospheric pressure and is regulated by the radiator cap.

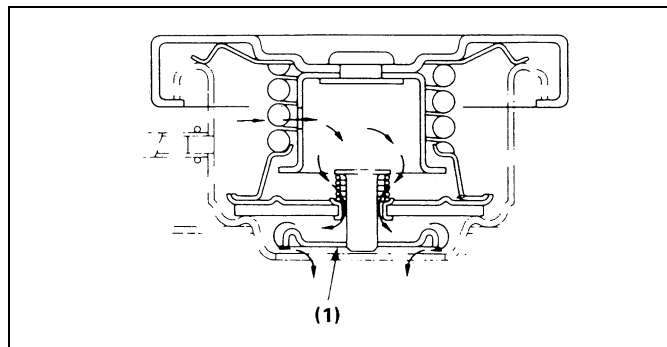
[less than 88 kPa (0.9 kgf/cm², 12.8 psi)]

【Function of Radiator Cap】**(1) When internal pressure is high**

(1) Pressure valve

Fig. 8-9 When radiator internal pressure is greater than 88 kPa (0.9 kgf/cm², 12.8 psi)

When temperature in the radiator increases, the coolant volume increases proportionally. This, combined with steam generation, may cause the internal pressure to rise up to 88 kPa (0.9 kgf/cm², 12.8 psi). The pressure valve opens, allowing coolant to escape and preventing rise in pressure. This protects the radiator.

(2) When radiator internal pressure is lower than atmospheric pressure

(1) Vacuum valve

Fig. 8-10 When radiator internal pressure is lower than atmospheric pressure

When coolant temperature drops, coolant volume decreases, reducing internal radiator pressure to below atmospheric pressure.

The vacuum valve opens, equalizing radiator internal pressure and atmospheric pressure, protecting the deformation of radiator.

3. COOLING FAN

A cooling fan moves the air required to disperse radiator heat. The exact type is generally selected after considering the following factors.

(1) Air direction (Suction/Pusher fan)

- ★ A suction type cooling fan is generally used on moving vehicles since air is taken in from the direction in which the vehicle is running.
- ★ When enclosing an engine in a noise-proof case, a suction type fan is used to prevent noise from being discharged.
- ★ A pusher type cooling fan is used for machines working in dusty places to prevent radiator clogging as cooling air passes through machine before entering the radiator.

(2) Cooling fan diameter

Generally, large diameter cooling fans provide sufficient cooling air at low rpm. However, the same cooling effect can be obtained with a smaller diameter fan by providing higher fan speed or fan blades with a steep-blade angle. This allows a more compact installation. Standard cooling fans on KUBOTA engines have a 240 to 430 mm (9.4 to 16.9 in.) out side diameter.

(3) Cooling fan speed

Standard KUBOTA cooling fans are driven by the crankshaft via a V-belt and pulley to rotate approx. 0.9 to 1.4 times faster than engine speed.

(4) Shroud

A shroud is provided around the cooling fan on the radiator side to increase air flow efficiency. The relative position of the shroud and fan are closely related to suction efficiency of air flow, but available positions are limited by the surrounding space. Standard positioning is shown at Fig. 8-11.

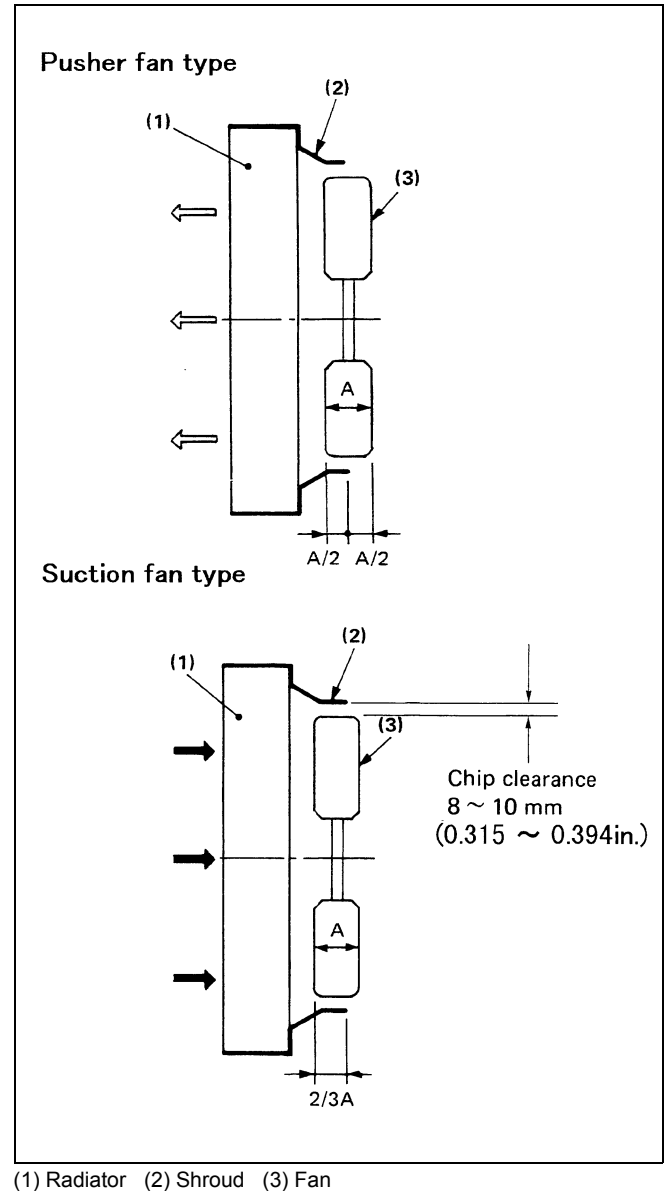


Fig. 8-11

(5) Air discharge

Generally, a 15 to 20% additional air discharge capacity is provided based on heat dispersion as a margin to ensure efficient cooling under most conditions.

(6) Power requirements

Power consumed for fan drive is in proportion to air discharge and radiator core air flow resistance. The calculation expressions are as follows.

$$L_s = L_{ad} / \eta_{ad}$$

L_s : Horsepower requirements (PS)

L_{ad} : Adiabatic compression horsepower (PS)

$$L_{ad} = P_{df} \cdot Q / 4500$$

η_{ad} : Adiabatic efficiency of fan (%)

(Generally 50 - 70%)

Q : Suction capacity (m³/min.)

P_{df} : Compression difference between the push side and the suction side (mmAq)

(The performance curves of cooling fans used for KUBOTA diesel engine are shown in attached TECHNICAL INFORMATION.)

(7) Fan spacer

Various thickness spacers, which are installed between a fan and a water pump, are available. These are used to properly position the fan in the shroud. If thicker spacers than 21 mm (0.83 in.) on the S.M., 05 or 03-M, 07 series and 27 mm (1.06 in.) on the V3 series are installed, details of the installation should be sent and reviewed with the KUBOTA Engineering Department, in order to avoid excessive loading on the water pump bearings. If larger diameter and heavier fans than the KUBOTA standards are installed, the spacers are not recommended.

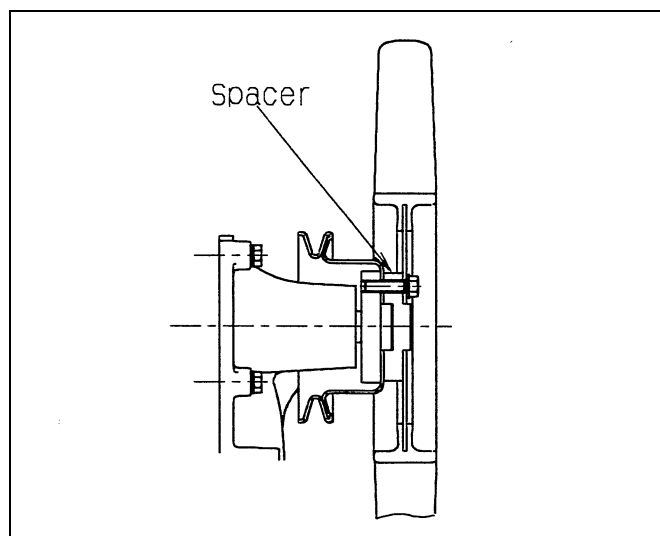


Fig. 8-12

(8) Electric fan

Use of electric fans on vehicles for radiator cooling has been increasing recently.

These fans turn at a constant speed regardless of engine speed.

However, in cases where cooling air is not enough due to insufficient vehicle velocity, the cooling effect on engine body, oil pan, etc is sometimes less than that of a direct-driving fan.

For this reason, cooling capacity and air flow around the engine must be examined and thorough tests conducted after the engine is installed.

Also, care must be taken to the capacity of alternator since the DC motor drives the fan.

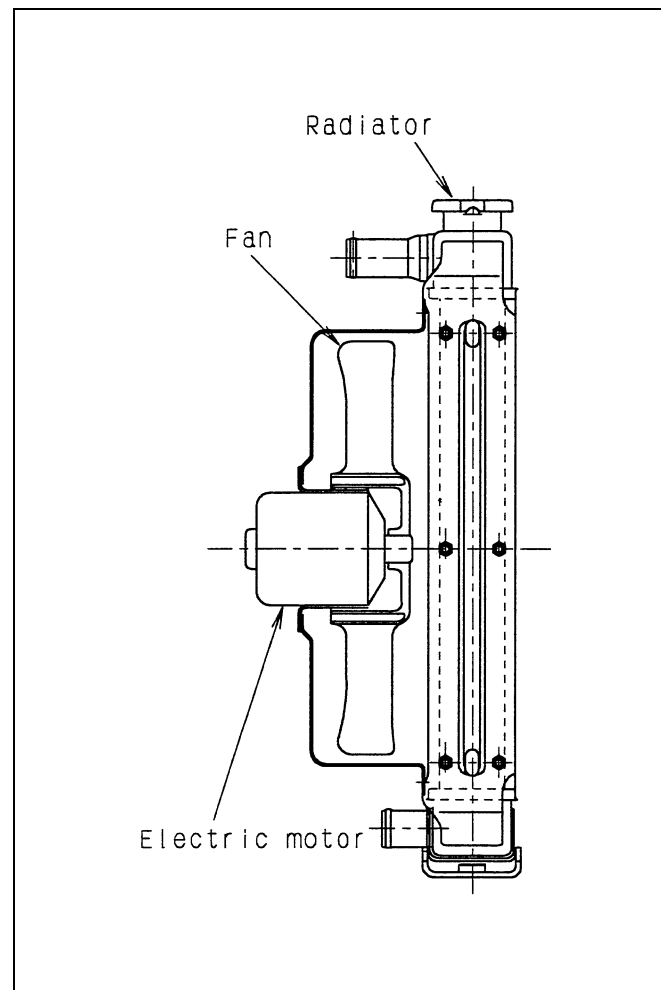


Fig. 8-13

Great care should be taken in the selection of temperature switches and the use of fan relay switches to ensure positive switch relay function.

4. COVERING

Most engines are covered to some extent. Additional design importance is given to system compactness and noise reduction.

Covering encases the engine. The most important factor to be considered in covering the engine is heat radiation.

(1) Air cleaner must be positioned where fresh, clean air is available. Care must also be used to avoid adverse effect on engine output.

(2) Radiator fan

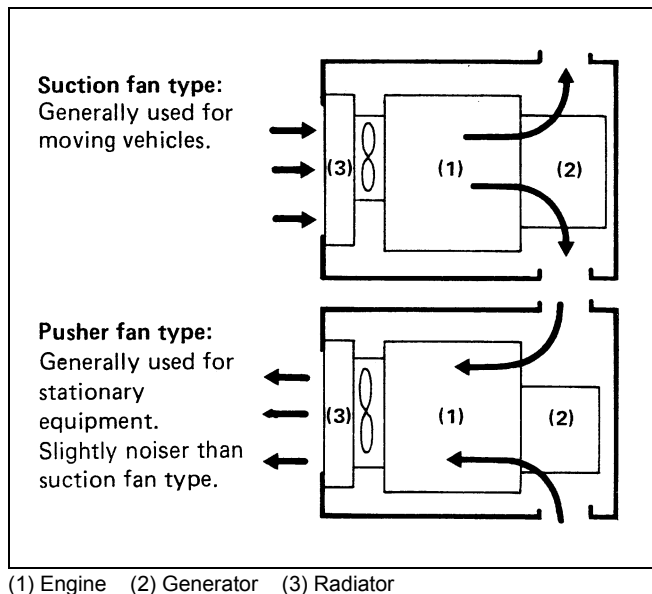


Fig. 8-14 Encloser type

(3) Heat balance

When the engine is covered for noise reduction, check carefully cooling system on running to avoid over heat. It is very important.

(4) Maintenance

Machines must also be designed for easy check, supply or replacement of fuel, lubricating oil, coolant and filter elements.

5. WATER PUMP

A centrifugal water pump with an impeller is mounted on top of the gear case at the front of the engine (radiator side). It pumps heated coolant from the cylinder head to the radiator. A seal is used to prevent leakage from around the pump shaft. The fan driving pulley is connected to the end of the pump shaft and both water pump and fan are driven by the crankshaft via the V-belt.

★ The performance curves of water pump are in accordance with attached technical information.

6. THERMOSTAT

Coolant is adjusted to the proper temperature by the thermostat located at the upper part of the cylinder head before being fed to the radiator. With thermostat control the coolant does not enter the radiator when engine temperature is low and only circulates inside the engine until it reaches a certain temperature.

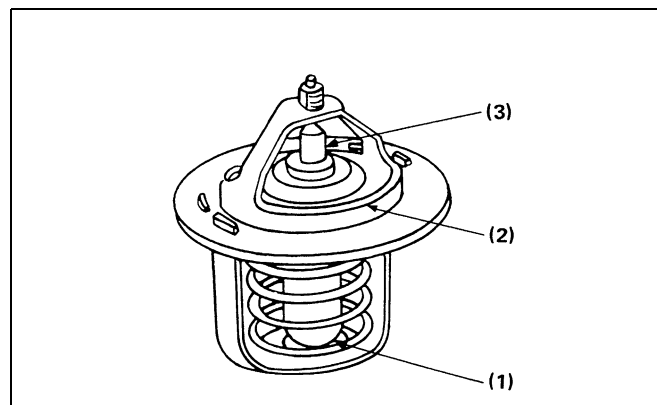
★ Typical specification

For Super Mini series	
Valve opening temperature :	71 °C (159.8 °F)
Valve full open temperature :	85 °C (185 °F)
Valve lift :	6 mm (0.236 in.)

For 05 series and 03-M series	
Valve opening temperature :	71 °C (159.8 °F)
Valve full open temperature :	85 °C (185 °F)
Valve lift :	8 mm (0.315 in.)

For 07 series	
V2607 Engine	
Valve opening temperature :	82 °C (180 °F)
Valve full open temperature :	95 °C (203 °F)
Valve lift :	8 mm (0.315 in.)
V3307 Engine	
Valve opening temperature :	76.5 °C (169.7 °F)
Valve full open temperature :	90 °C (194 °F)
Valve lift :	8 mm (0.315 in.)

For V3 series	
Valve opening temperature :	76.5 °C (169.7 °F)
Valve full open temperature :	90 °C (194 °F)
Valve lift :	8 mm (0.315 in.)

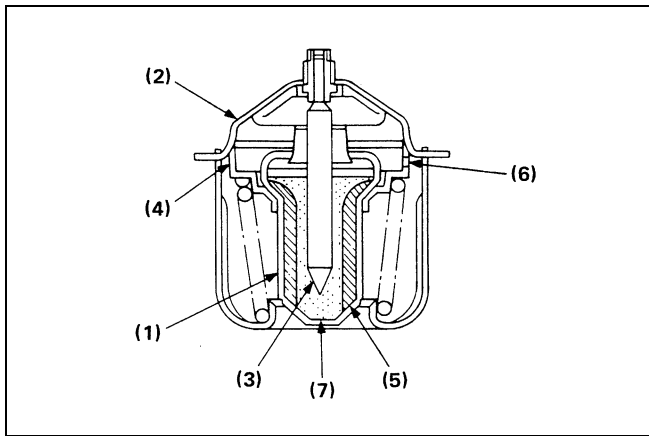


(1) Pellet (2) Seat (3) Spindle

Fig. 8-15 Thermostat

A wax pellet-type thermostat is controlled by waxed sealed in a pellet. The wax is solid at low temperature but liquefies and expands when heated to open the thermostat valve.

(1) At low temperature [below 71 °C (159.8 °F) or below 76.5 °C (169.7 °F)]

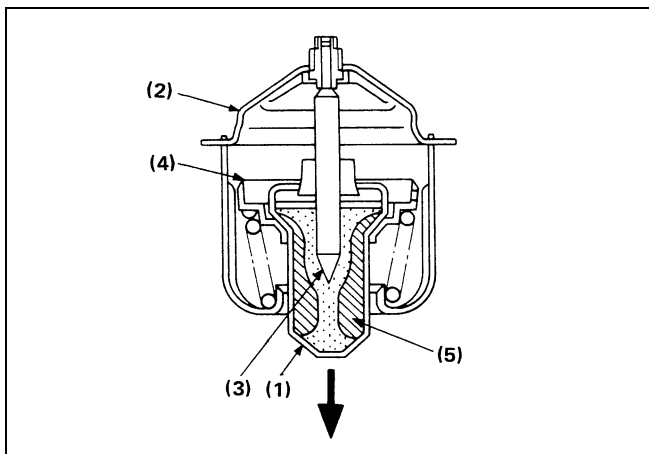


(1) Pellet	(4) Valve	(7) Synthetic rubber
(2) Seat	(5) Wax(solid)	
(3) Spindle	(6) Leak hole	

Fig. 8-16 At low temperature

When the thermostat is closed, cooling water does not enter the radiator but only circulates inside the engine through the water return pipe. Any air remaining in the engine's water jacket escapes to radiator side through the leak hole (6) in the thermostat.

(2) At high temperature [above 71 °C (159.8 °F) or above 76.5 °C (169.7 °F)]



(1) Pellet	(3) Spindle	(5) Wax (liquid)
(2) Seat	(4) Valve	

Fig. 8-17 At high temperature

When the coolant temperature exceeds 71 °C (159.8 °F) or 76.5 °C (169.7 °F), wax turns from a solid into a liquid (5) and expands.

Since the spindle (3) is fixed, the pellet (1) pushes the valve (4) from its seat (2), and coolant flows from the cylinder head to the radiator.

• Thermostat for 03-M, 07, V3 series engines

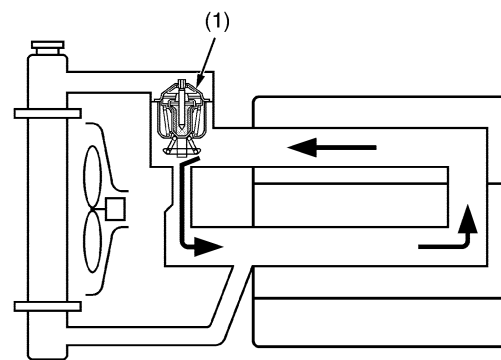
Bottom bypass system is introduced in 03-M, 07, V3 series for improving the cooling performance of the radiator.

While the temperature of coolant in the engine is low, the thermostat is held closed and the coolant is allowed to flow through the bypass pipe and to circulate in the engine.

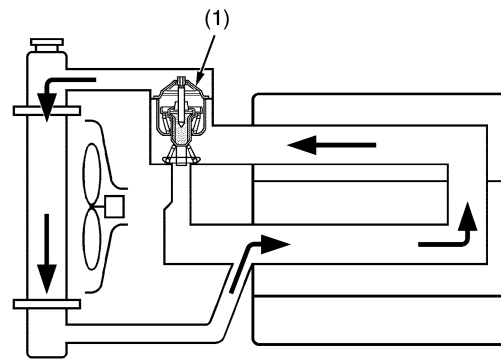
When the temperature exceeds the thermostat valve opening level, the thermostat fully opens itself to prevent the hot coolant from flowing through the bypass into the engine.

In this way, the radiator can boost its cooling performance.

(A) Thermostat Closed



(B) Thermostat Open



(1) Thermostat

Fig. 8-18 Thermostat for 03-M, 07, V3 series

● Thermostat for 07 and V3 series engines

07 and V3 series engine employ the three step valve opening type thermostat to reduces thermal shock radically.

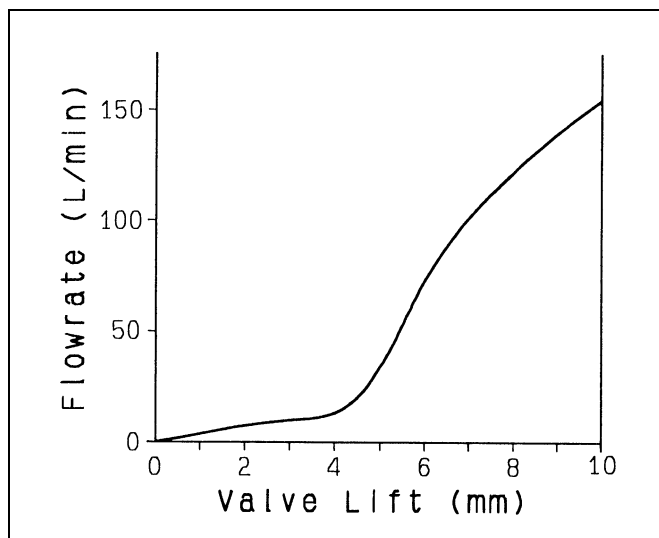


Fig. 8-19 Valve lift versus flow rate

The 07 and V3 series engine are equipped with the flow control thermostat. The valve has a notch to control the coolant flow rate smoothly in small steps.

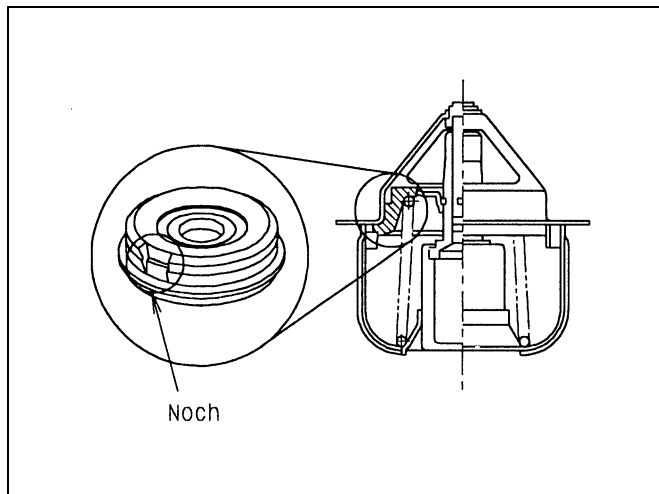


Fig. 8-20 Thermostat for V3 series

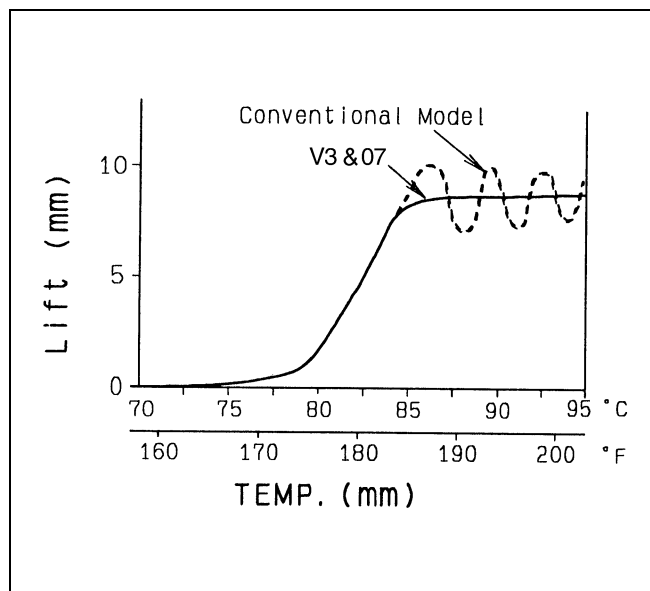


Fig. 8-21 Comparison of temperature rise form

(3) Coolant temperature for KUBOTA diesel engines

The coolant temperature is under the control of load, engine speed, cooling fan, radiator, water pump, thermostat, type of enclosure, pressure of radiator cap, ambient temperature and so on.

In case that the coolant is the mixture of 50% water and 50% ethylene glycol, the allowable water temperature is as follows :

Allowable coolant temperature	110 °C (230 °F)
Pressure of radiator cap	82 to 96 kPa
	0.84 to 0.98 kgf/cm ²
	12 to 14 psi

Note :

When a local radiator is procured by customers and pressure of the radiator cap is 48 kPa (0.49 kgf/cm², 7 psi), the allowable coolant temperature is 104.4 °C (220 °F).

The coolant temperature must be under the above temperature at maximum ambient temperature condition [51.7 °C to 54.4 °C (125 °F to 130 °F)].

If an emergency shut down system is used, the temperature switch must be set at the allowable temperature listed in the above table.

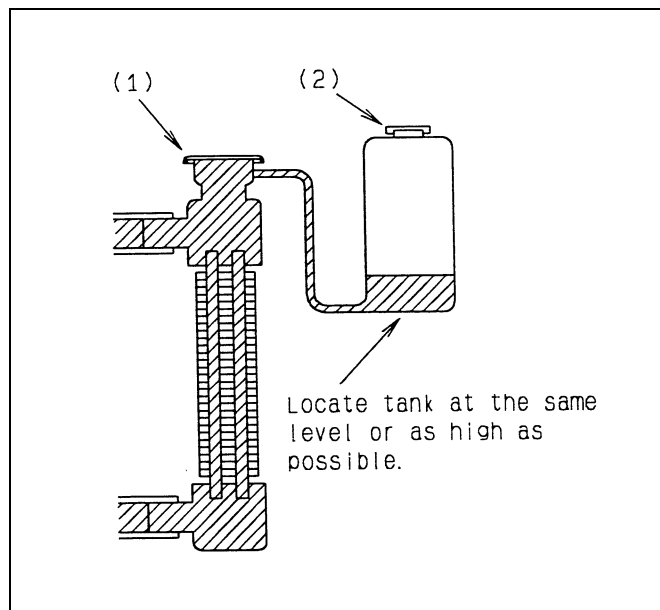
7. COOLANT RECOVERY TANK

The following benefits are provided by installing a coolant recovery tank independently to the radiator.

- 1) The radiator is always completely full which prevents entrance of air into the cooling system.
- 2) Any coolant overflow due to heat expansion is transferred to the coolant recovery tank and returns to the radiator when the temperature lowers. This eliminates coolant waste and the need to add coolant periodically.
- 3) Coolant is replenished to the coolant recovery tank only. Maintenance can be done easily if coolant level is visible.

【Types of coolant recovery tanks】

- 1) Semi-sealed type : An open-air type with slight natural evaporation of coolant, but low cost.
- 2) Actual capacity of a coolant recovery tank should be sized more than about 10% of total cooling system capacity.



(1) Cap with pressure valve (2) Cap with air bleed

Fig. 8-22 Semi-sealed type

8. OIL COOLER

Oil in a separate hydraulic implement (e.g. HST) linked to the engine is cooled either by the same radiator for the engine, or by an oil cooler installed in front or rear of the radiator. Capacity and wind resistance factors must be carefully examined.

The fig below shows an example of oil cooler located in front of the radiator. In this case, the oil cooler should be considered to position as uniform restriction as possible.

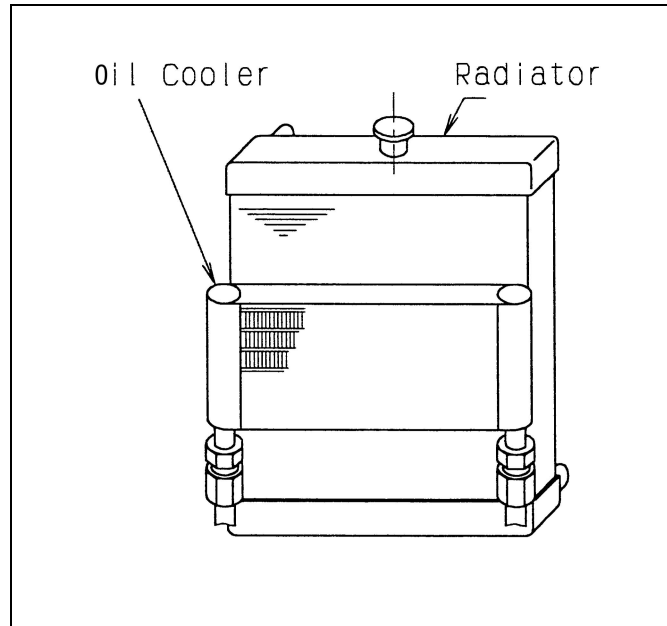


Fig. 8-23

An oil cooling system is available using the coolant circuit of the engine. This also requires careful study of air resistance and heat exchange factors. Please contact the KUBOTA for details.

9. COOLING SYSTEM PRECAUTIONS

(1) Prevention of air entrapment

If air should enter the cooling system at point of connection, it can result in abnormal boiling, reduced pump performance, and overheating locally. This can cause loss of coolant due to air expansion and other problems.

Connections must be carefully checked. The same applies to exhaust gas entering due to faulty cylinder head gaskets.

(2) Radiator surface cleaning

The surface of the radiator is important to overall cooling performance. If the surface becomes dirty, overheating will result. A dust net is sometimes provided at the front and a wiper is installed to automatically clean the surface according to circumstances.

(3) Radiator support

A radiator must be properly supported to prevent vibration and impact if the engine is installed in a moving vehicle.

The Fig. 8-24 shows typical radiator installation.

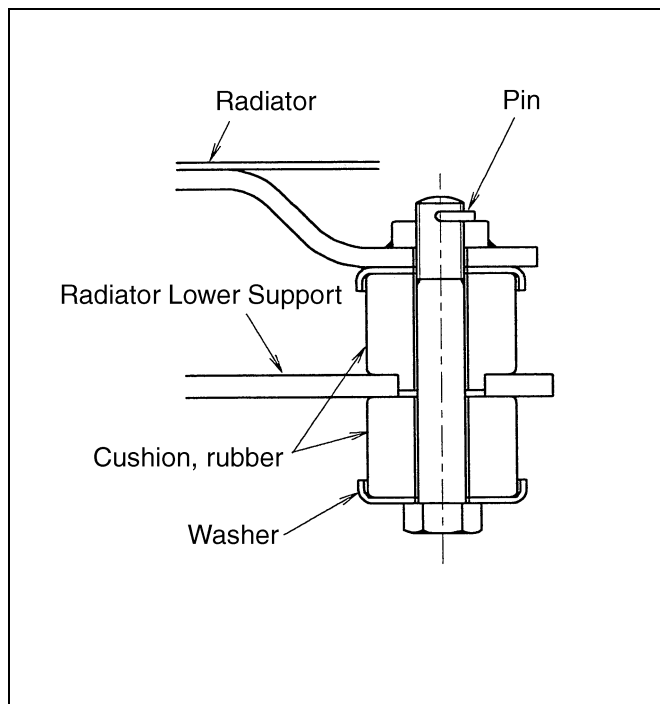


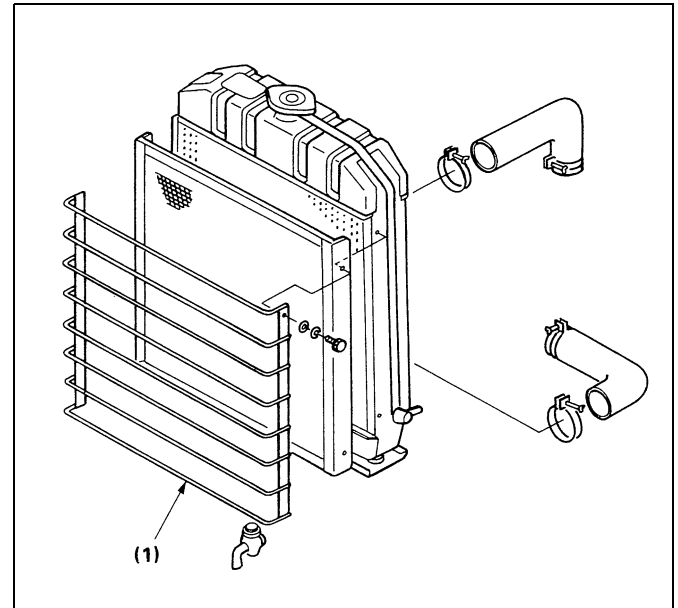
Fig. 8-24 An example of installation of KUBOTA radiator

Note :

Use upper support depending on the vibration level.

(4) Protection of radiator

If the radiator surface is directly exposed to outside, a protective frame should be installed around it. A typical example is shown Fig. 8-25.



(1) Protector

Fig. 8-25

(5) Prevention of air recirculation

It is important to take cool air into the radiator in order to get the best cooling effect.

Therefore when engine compartment is designed, suitable barriers and ducting arrangements around the radiator must be considered to prevent hot air recirculation.

Below show examples of compartment designs.

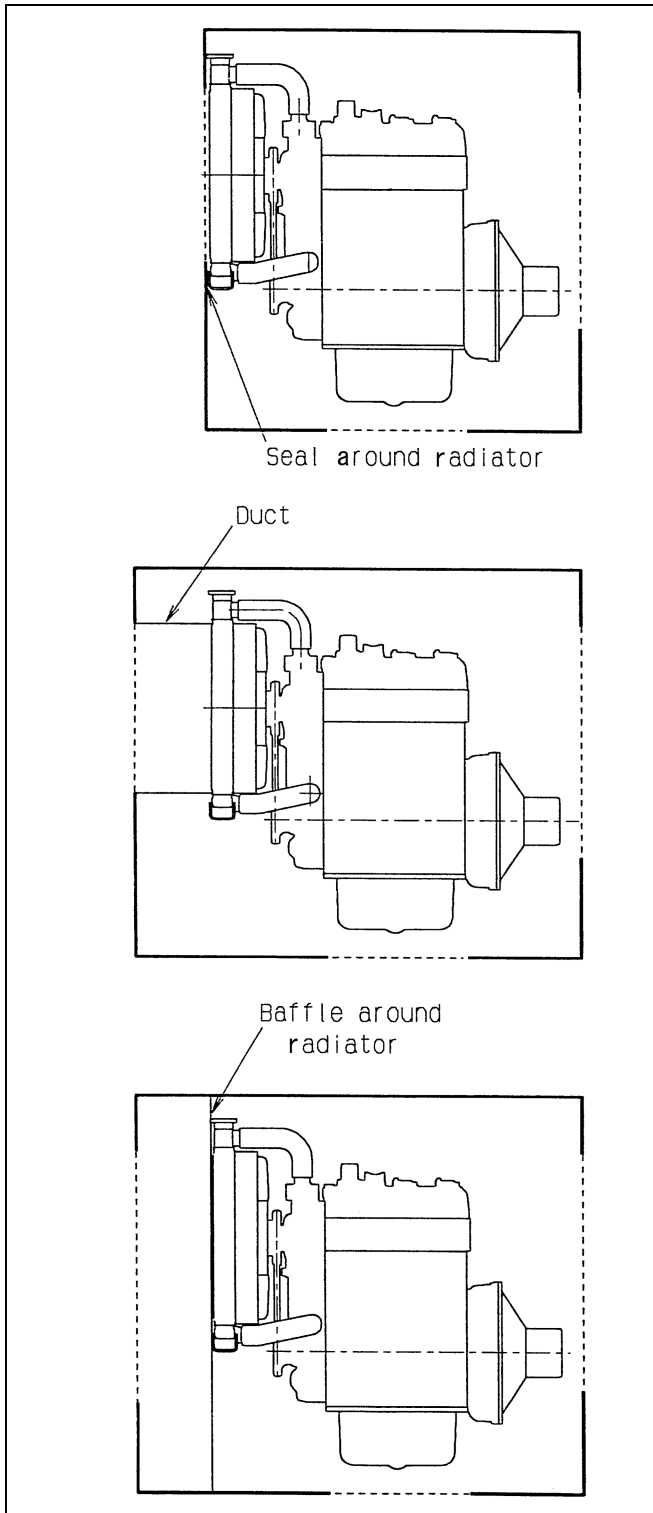


Fig. 8-26

(6) Entrance and exit of air blow

Open area of entrance and exit of air flow should be enough to prevent air flow reduction.

The open area should be at least, the same as radiator core area or more.

Opening the bottom of engine compartment is an effective way to make engine oil temperature lower.

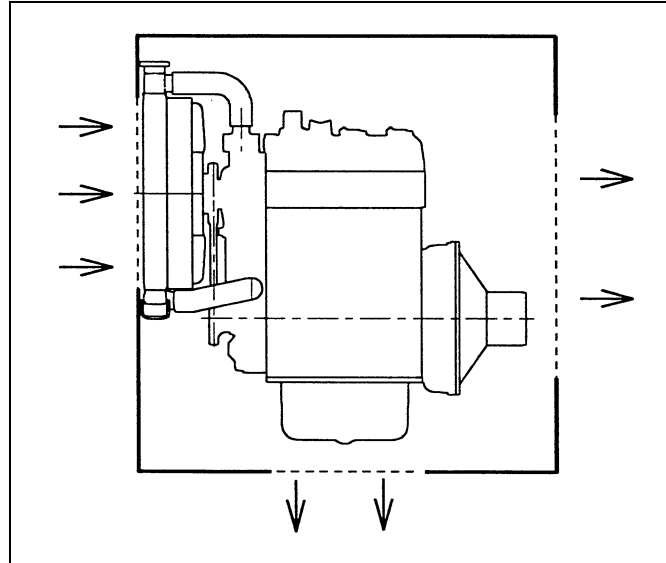


Fig. 8-27

10. HEAT REJECTION TO COOLANT

The amount of cooling loss, which can be dispersed by coolant in an engine is expressed as follows :

$H_o = H_u \times N_e \times b_e \times i / 1000$
The amount of heat dispersion by coolant of each engine is in accordance with attached TECHNICAL INFORMATON.
where as ;
H_o : Amount of heat dispersion by cooling water (cooling loss) kJ/hr (kcal/hr)
b_e : Specific fuel consumption (gr/kW•hr)
i : Dispersion ratio to cooling water (%)
H_u : Diesel fuel low caloric value 43074 kJ/kg (10290 kcal/kg)
N_e : Engine output (kW)

11. RADIATOR CAPACITY

(1) General

Generally, water at atmospheric pressure boils at 100 °C (212 °F).

As the pressure inside the radiator is raised higher than the atmospheric pressure, the boiling point is also raised, and thereby the coolant temperature in the radiator can be kept lower than the boiling point, thus preventing eventual cavitation inside the pump.

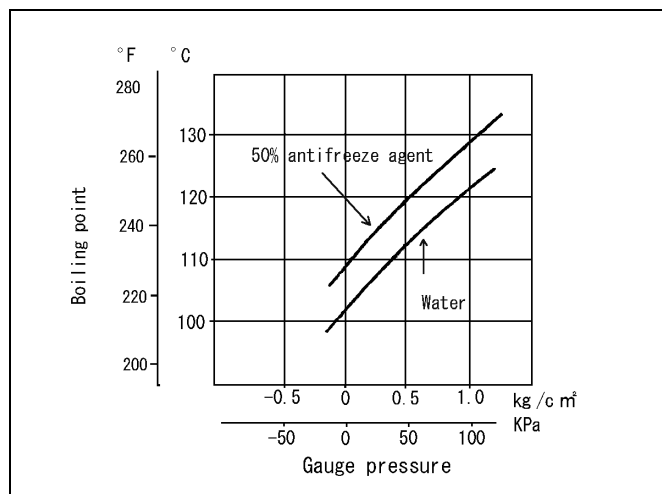


Fig. 8-28 A boiling point of water at different pressures

Boiling point of coolant

Rad. cap pressure	% of water /antifreeze	Boiling point	
		°C	°F
0 kPa {0 kgf/cm ² (0 psi) }	100% water	100	212
	50/50	108	226
88.2 kPa {0.9 kgf/cm ² (13 psi) }	100% water	118	244
	50/50	126	259

(2) Determination of a radiator size

The final determination of a radiator size is dependent on the load, ambient temperature and whether the engine is in a compartment or not, always select a larger radiator if a severe condition exists.

1) Factors of radiator size determination

[Operating condition]

Ambient temperature ⇒ Will the engine be open to the air or enclosed ?
Ambient pressure ⇒ Will the engine be used at high altitudes ?
Ambient humidity ⇒ Will the engine be used in extremely dry areas ?
Dust conditions ⇒ Will dust adhere to radiator surface ?
Movement of vehicle ⇒ Will the engine be installed in a moving vehicle ?
Load pattern ⇒ Will overloads be applied frequently ?
Cooling ⇒ Will the oil and/or hydraulic system also be cooled ?

[Construction]

Cooling water ⇒ How is it sufficient ?
Air flow ⇒ Is surrounding air nomally still ?
Type of radiator ⇒ Is it readily available ?
Space ⇒ How much space is available for radiator installation ?

2) Step of radiator specification determination

1) Determine heat load.
2) Determine overheating limit
3) Determine specifications of cooling system.

(3) Cooling capacity checking methods

1) Air-to-boil (ATB) test

ATB is a quick and easy method to determine a machine's present cooling efficiency and help predict the cooling performance at elevated ambient temperatures.

[Test equipment]

- Temperature meter or data collector and at least 6-thermocouple probes and 4-optional probes
- A 50/50 mixture of Ethylene Glycol anti-freeze must be used in the engine
- 88.2 kPa {0.9 kgf/cm² (12.8 psi)} rated radiator cap installed
- Blocked open thermostat
- Engine tachometer

[Test conditions]

- (a) Ambient temperature of at least 24 °C (75 °F) is required for accurate testing.
If outside temperature is below 24 °C (75 °F) testing must be completed in a heated room.
 - Testing in temperatures below 24 °C (75 °F) or in high winds might produce inaccurate results.
 - Ambient temperature readings should be taken approximately 3 m (10 ft) from the machine.
- (b) Machine must be tested at a duty cycle that represents the worst case scenario that the machine will be used in the field.
- (c) All machine enclosure panels, screens and fan shrouding must be in place.

[Test setup]

1. Install blocked open thermostat.
2. Install thermocouples to record the following data.
 - a. Radiator coolant in (Top tank)
 - b. Radiator coolant out (Optional but recommended)
 - c. Air cleaner inlet air
 - d. Engine oil
 - e. Exhaust gas
 - f. Engine speed
 - g. Ambient
 - h. Radiator air in (Optional)
 - i. Compartment air (Optional)
 - j. Radiator air out (Optional)
 - k. Hydraulic oil (Optional)

Note :

- Engine speed and exhaust temperature is required to estimate the engine loading.
- Radiator coolant temperature readings must be taken in the coolant stream.
- Ambient temperature readings should be taken 3 m (10 ft) from the unit.
- Oil temperature should be taken in the oil sump as close to the center as possible.

3. Operate the unit at its most severe operating condition until the coolant temperature is stabilized (does not change more than 2 °C (36 °F) in 15 minutes). Stabilization usually takes place after operating the engine for 45 minutes to 1.5 hours under loaded condition.
4. Record data in **Temperature Measuring Sheet** in small time increments until stabilization temperature is reached.
5. To calculate ATB
88.2 kPa {0.9 kgf/cm² (12.8 psi)} radiator cap

ATB (Air-To-Boil) = (A-B) + C

A=Theoretical coolant boiling temperature or maximum allowable coolant temperature

- 110 °C (230 °F) is Kubota's maximum allowable coolant temperature with a 88.2 kPa {0.9 kgf/cm² (12.8 psi)} radiator cap.

If a 48.3 kPa {0.5 kgf/cm² (7 psi)} cap is used, substitute 104 °C (220 °F) in place of 110 °C (230 °F).

B=Top tank or engine coolant out line temperature (Thermostat fully open)

C=Actual ambient temperature recorded during test

Example: A D722 using a 88.2 kPa {0.9 kgf/cm² (12.8 psi)} radiator cap running in a turf tractor under severe operating conditions.

The top tank coolant temperature was measured at 90 °C (195 °F). The ambient was recorded at 29 °C (85 °F). Therefore;

$$\text{ATB} = \{110\text{ °C (230 °F)} - 90\text{ °C (195 °F)}\} + 29\text{ °C (85 °F)}$$

$$\text{ATB} = 20\text{ °C (35 °F)} + 29\text{ °C (85 °F)}$$

$$\text{ATB} = 49\text{ °C (120 °F)}$$

[To evaluate ATB]

Kubota's minimum allowable ATB is 49 °C (120 °F).

An ATB below 49 °C (120 °F) indicates limited cooling reserve.

Using the above example, the ATB of 49 °C (120 °F) means that if the ambient temperature would rise from 29 °C (85 °F) to 49 °C (120 °F) then the top tank coolant temperature would rise to the maximum allowable of 110 °C (230 °F).

- The ATB is the maximum ambient temperature which the machine can operate in and not exceed Kubota's maximum coolant temperature.

The equipment manufacturer should determine the unit's anticipated operating ambient and design the cooling system to provide for proper cooling under all potential operating conditions.

Since it is not always possible to test the application at the highest anticipated ambient, a higher than 49 °C (120 °F) ambient should be the target.

[Summation]

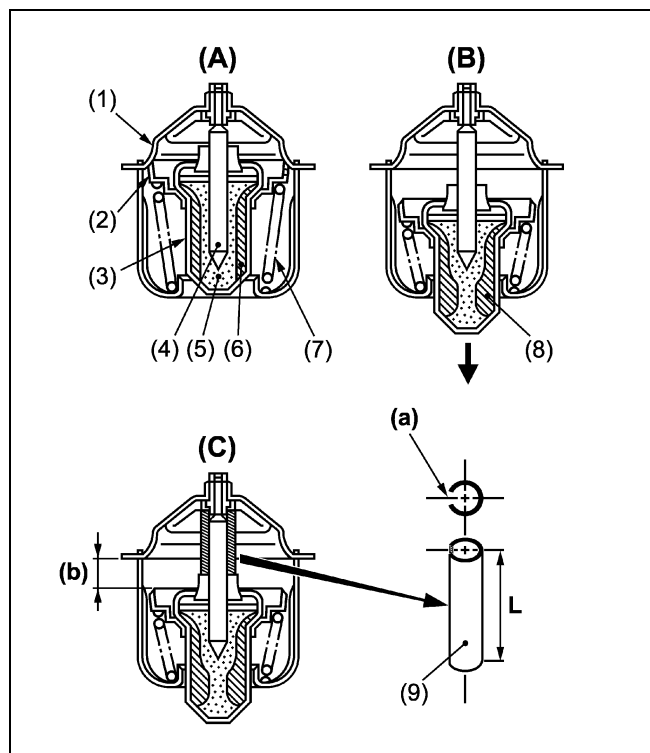
1. ATB test can be used for engineering evaluations and is a part of a standard Application Review.
2. ATB should be **49 °C (120 °F) or higher.**
3. ATB figures higher than 49 °C (120 °F) will provide the greatest cooling reserve and maximum engine life.
4. The radiator inlet air temperature must not be more than -12 °C (10 °F) above ambient temperature, recorded 3 m (10 ft) from the machine.
Higher than -12 °C (10 °F) indicates poor air recirculation.
5. The difference between the top tank temperature and bottom tank coolant temperature should be approximately -5 °C (10 °F).
A greater differential might indicate too much restriction in the cooling circuit.
6. If the machine is operated at altitude, the air density and the cooling fan airflow across the radiator will decrease.
Therefore, the higher the ATB the more reserve is available.
7. The use of 50/50 mixture of anti-freeze and water only adds about -15 °C (5 °F) to the top tank temperature over pure water.
However, the boiling point under cap pressure of 88.2 kPa {0.9 kgf/cm² (12.8 psi)} increases from 118 °C (244 °F) to 126 °C (259 °F) using a 50/50 mixture.
8. Air filter inlet should be positioned to take in air at or near ambient temperature.
High inlet temperatures can have a negative effect on ATB and oil temperature.
9. **Oil temperature must be below 120 °C (248 °F) Intermittent Duty {110 °C (230 °F) Continuous Duty}.**
Elevated temperatures can increase oil oxidation and must be corrected.
 - Elevated oil temperatures can be a result of high air intake temperatures, high engine compartment temperatures, poor air recirculation or inadequate cooling system capacity.

[Sleeve used to hold thermostat open]

Sleeve length

Series	Length (L)
S.M. series	12.0 to 12.5 mm (0.47 to 0.49 in.)
05 series	14.0 to 14.5 mm (0.55 to 0.57 in.)
03-M series	14.0 to 14.5 mm (0.55 to 0.57 in.)
07 series	14.0 to 14.5 mm (0.55 to 0.57 in.)
V3 series	14.0 to 14.5 mm (0.55 to 0.57 in.)

Above sleeve lengths will provide valve openings of :
 6 mm (0.24 in.) for S.M. series
 8 mm (0.31 in.) for 05, 03-M, 07, V3 series



(1) Seat	(6) Wax (Solid)
(2) Valve	(7) Spring
(3) Pellet	(8) Wax (Liquid)
(4) Spindle	(9) Copper tubing
(5) Synthetic rubber	6.35 mm dia. (0.25 in. dia.)

(A) Thermostat closed**(B) Thermostat fully open****(C) Thermostat fully open (Sleeve installed)****(a) Split with hacksaw blade****(b) 6 mm (0.24 in.) or 8 mm (0.31 in.)**

Fig. 8-29 Thermostat

2) Normal heat test

This method can be used instead of the air-to-boil test. Apply the maximum horsepower and torque to the engine at the maximum required operating temperature, and measure the engine water temperature to check for overheating.

12. COOLANT

Quality of coolant is an important factor.

Cooling is adversely affected by corrosion of engine parts. This can reduce engine output and shorten engine life.

(1) Nature of water

Water is used for cooling since it absorbs heat well and is readily available. Coolant boils at 100 °C (212 °F) freezes at 0 °C (32 °F) and has other disadvantages such as a tendency to leave deposits and corrode metal parts.

These disadvantages can cause cooling system problems. Special measures, such as those listed below, are required :

- a) Raising of the boiling point by pressurizing the cooling system (Radiator cap) and using antifreeze.
- b) Lowering the freezing point by using antifreeze.
- c) Selecting water carefully and using a rust preventive.
- d) Don't use hard water.

(2) Deposits and rust

Deposits (scale) can be generated wherever water exists and can accumulate easily in the cylinder block and cylinder head where temperature is consistently high and where the radiator temperature varies greatly. Deposits will take the form of brown and sticky tar, and have very poor thermal conductivity. Accumulated deposits restrict water circulation and reduce the overall cooling effect.

Rust, on the other hand, is gathered on metal parts and restricts water circulation if left untreated.

Rust also lowers the overall cooling effect (like deposits), because it has poor thermal conductivity. Rusted metal surfaces become rough and pitted. Metal pieces can become scaled and thick and lose their strength, causing cracks or fatigue failure.

(3) Grade of water

Clean soft water should be used for the cooling system. Distilled water, tap water, and pure rain are especially recommended. Natural water generally contains minerals and sometimes salt, which can oxidize metal and accelerate corrosion. On the other hand, hard water is liable to create deposits more quickly. If impure water has to be used for cooling, completely flush the cooling system and add a rust preventive.

13. FREEZING AND ANTIFREEZE COOLANT

(1) Freezing of coolant

Water freezes at 0 °C (32 °F), and its volume expands approximately 9%. This expansion force is so great that water loses its fluidity. When the cooling water freezes in the cooling system, expansion can crack the engine and radiator or lead to other damage.

(2) Major components of antifreeze coolant

Freezing temperature is lowered to prevent the freezing of coolant by adding ethylene glycol, etc..

★ Ethylene glycol

Ethylene glycol has no odor, will not evaporate and will not affect paints and coatings. It has a high boiling point, and can be used along with an anti-corrosive agent in the summer.

(3) Types and characteristics of antifreeze coolant

KUBOTA recommends the use of ethylene glycol base antifreeze coolant of permanent type which is most commonly used.

★ Characteristics of permanent type antifreeze coolant

【Characteristics of antifreeze】

Main components	Ethylene glycol
Specific gravity 20 °C (68 °F)	Above 1.12
Boiling point	145 °C (293 °F)
Flash point	Flame retardant but burns
Hygroscopicity	Very easily absorbs humidity
Freezing of undiluted solution or mixture	Freezes sometimes below -20 °C (-4 °F)

【Characteristics during use】

Boiling point	100 to 113 °C (212 to 235.4 °F)
Evaporation of main components	Small evaporation
Boiling of during operation	No

(4) Caution in using antifreeze coolant

1) Never use poor quality antifreeze coolant

The main components of the antifreeze coolant can corrode metal, gathering rust in the cooling system over an extended period. Corrosion is caused by acids and various kinds of additives which are used to neutralize them. Some additives give the cooling water alkaline properties that can rapidly corrode light metal. Poor quality antifreeze has poor content of corrosion preventive. The content further becomes less potent with the dilution of water.

For this reason, poor quality antifreeze accelerates metal corrosion.

2) Do not use antifreeze for extended periods

Except for quality permanent antifreeze coolant which does not require replacement for a long time. Drain the antifreeze coolant mixture when it is not in use and flush the cooling system.

Use of antifreeze coolant for an extended time can result in increased corrosion within the cooling system.

3) Use permanent type ethylene glycol antifreeze coolant when temperature of coolant exceeds 100 °C (212 °F).

4) Completely cover the container since the undiluted solution is hygroscopic.

5) Undiluted solutions of permanent type can freeze below -20 °C (-4 °F) in some cases, so watch the temperature carefully.

6) Never drink antifreeze coolant, because they are poisonous.

7) Do not spill antifreeze coolant over painted surfaces since they may dissolve paint.

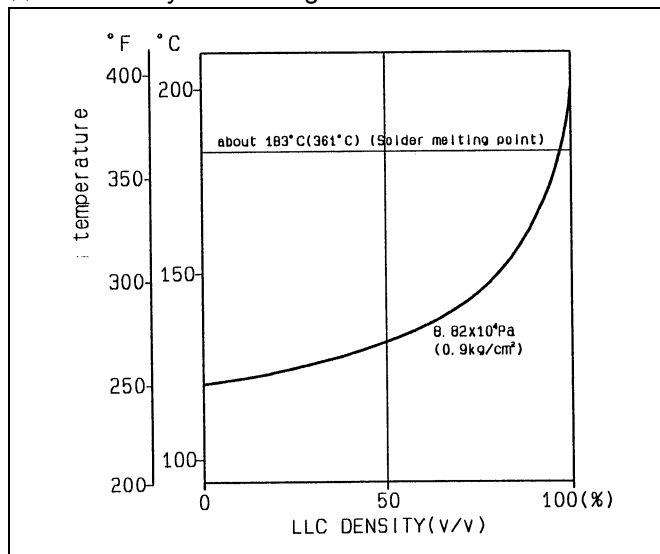
(5) Dilution ratios

Always use a 50/50 mix of ethylene glycol coolant in KUBOTA engines.

Contact KUBOTA concerning coolant for extreme conditions.

When the density becomes too high, the boiling point rises and the solder strength lowers, resulting in a dangerous situation. The following drawing shows the relation between the boiling point and density.

★LLC Density and Boiling Point



L.L.C : Long Life Coolant

(6) Adding antifreeze coolant

1) Completely drain the cooling water and flush the cooling system.

2) Check for leaks or loose connections at the radiator, cylinder head gasket, drain cock, etc..

3) Mix antifreeze coolant and water at the specified ratio before pouring into engine.

4) For replenishment, add 50/50 mix to cooling system for permanent types.

Note :

If antifreeze and water are not mixed thoroughly, before putting into the engine, hot spots may develop leading to engine overheating.

9. ELECTRICAL SYSTEM

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ELECTRICAL SYSTEM

1. GENERAL

A typical electrical system is shown in Fig.9-1.

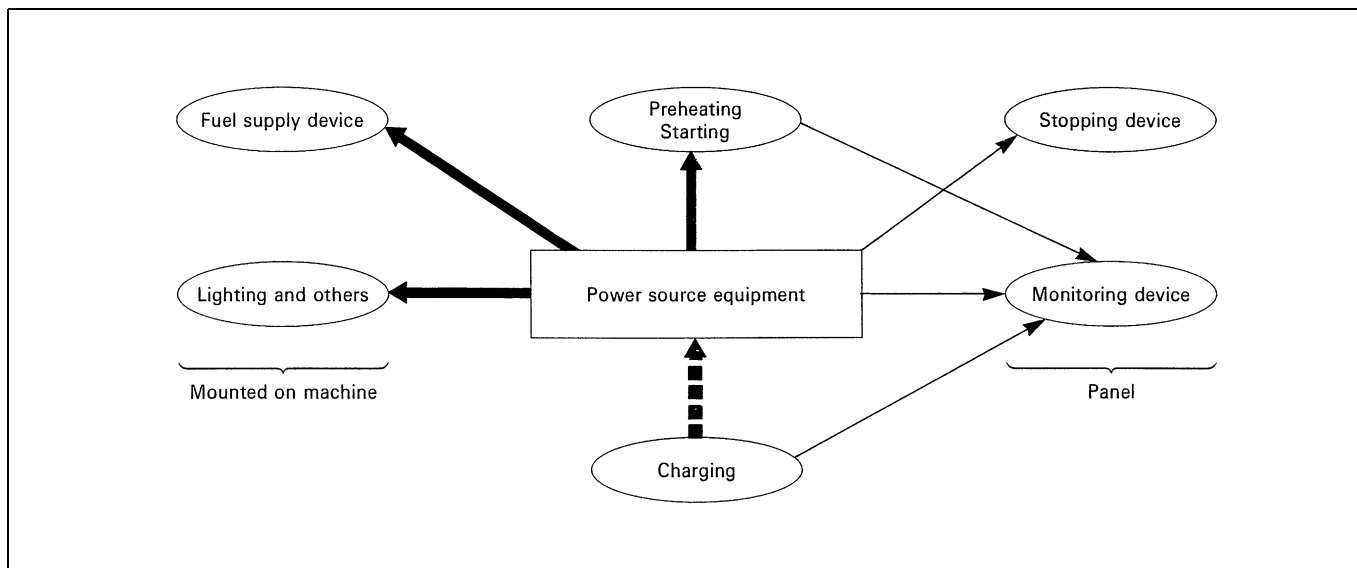


Fig. 9-1

An electrical system consists of starting equipment, such as a starter and glow plug ; charging devices, such as an alternator, regulator, and battery ; and indication and

control equipment, such as an oil switch, water temperature switch, glow plug indicator, timer and starter switch.

2. STARTING DEVICE

[1] GENERAL

The starting device is composed of the starter, starter switch, glow plug, slow blow fuse, battery, glow lamp timer, safety relay for starter, etc., and the outline of the basic operation is as the followings ;

- 1) Voltage from battery is added to the B terminal of starter switch through the slow blow fuse.
- 2) If the starter switch is turned on, B terminal will be connected to AC, and the electrical current will flow to each load.
- 3) If the starter switch is turned to preheating, B terminal will be connected to AC and 19, making the glow plug heat, and at the same time lighting the glow lamp, and the lamp will be turned off by activation of the lamp timer after 5 seconds.
Even if glow lamp is turned off, when the starter switch is either in the preheating position or starting position, the glow plugs will remain heating.
- 4) If the starter switch is turned to the starting position, B terminal will be connected to AC, 19, and 50 will be connected to the ST terminal of starter (in case of the type with safety relay, it shall be connected via relay) to start the engine.
- 5) After the engine is started, if you have let your hand off the starter switch, it automatically returns to ON position.

[2] STARTER

The function of starter is to rotate the engine with the speed higher than the minimum rotation speed required to start the engine.

Particularly in the diesel engine of which compression ratio is high, small-sized and powerful starters are required, and for this purpose, the direct-current / direct-winding type, which can produce powerful rotation force when the rotation speed is still low, is suitable.

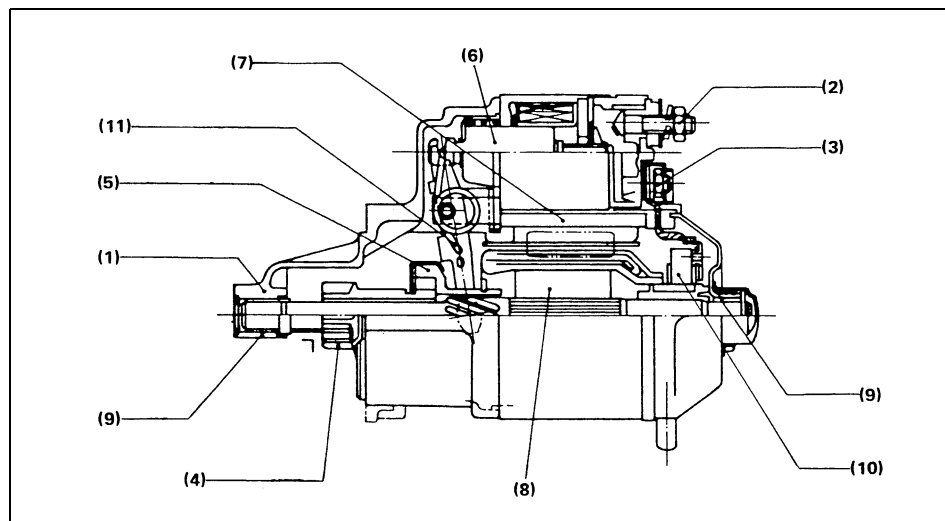
However, compared with other electric motors the size of this type is small and the weight is light, in proportion to its large output resulting in a short usage time (rated time : 31 sec.).

(1) Types of starter

1) Conventional type

This type is provided with the magnet switch with terminal, and the pinion made of carburized materials

and the overrunning clutch (roller clutch) to prevent overrun of the armature after starting.



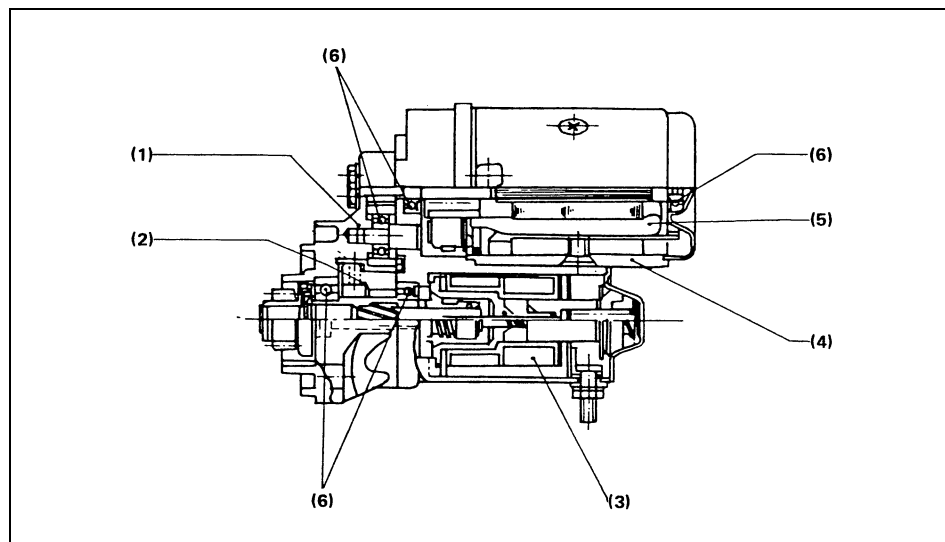
- (1) Drive side housing
- (2) B terminal
- (3) S terminal
- (4) Pinion
- (5) Overrunning clutch
- (6) Solenoid
- (7) Yoke
- (8) Armature
- (9) Bearing
- (10) Brush
- (11) Drive lever

Fig. 9-2 Conventional type

2) Reduction type

This type drives the pinion reducing the speed of the small-sized high-speed large-output motor by 1/3 to 1/5, so that the motor can be made smaller and lighter.

The starter is made lighter by using aluminum die cast metal, and in addition, there is no exposure of the pinion sliding surface and waterproofing is improved.



- (1) Drive side housing
- (2) Overrunning clutch
- (3) Solenoid
- (4) Yoke
- (5) Armature
- (6) Bearing

Fig. 9-3 Reduction type

(2) Circuit of the starter

1) When the starter switch is turned to start position:

a) If the starter switch is turned to start position, electrical current will flow to holding coil (H.C) and pulling coil (P.C), and it will excite the 3 coils, and suck the plunger.

Consequently, the pinion gear will move out to the fly wheel side, and the ring gear and pinion gear will be intermeshed.

b) Electrical current will also flow to the armature from P.C, and it will remove the load in the initial stage of armature rotation.

(If the armature is slightly rotated, it will facilitate intermesh of the pinion gear and ring gear.)

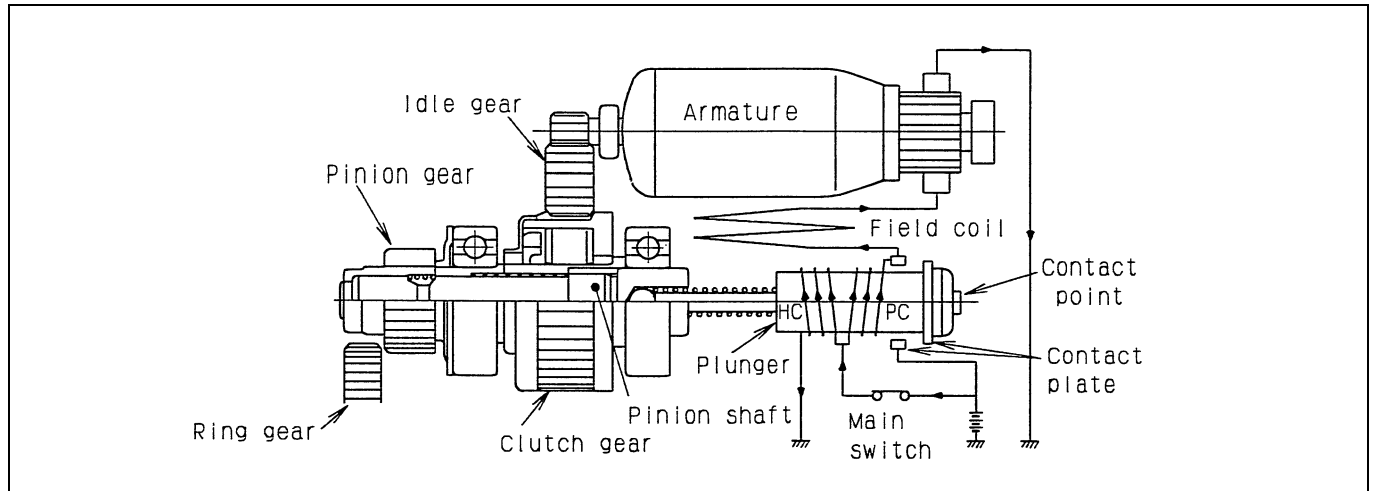


Fig. 9-4

2) During cranking of the engine :

a) If the pinion gear and ring gear are fully intermeshed, the main contact point will be closed, and the field coil and armature coil will be directly connected from the battery so that a large amount of electrical current flows and the pinion gear rotates.

b) Potential difference of P.C will become zero by the voltage from the main switch and the voltage from the main contact point, making the magnetic force nonexistent.

c) Therefore, the plunger is supported by H.C alone while the pinion is intermeshed with the ring gear.

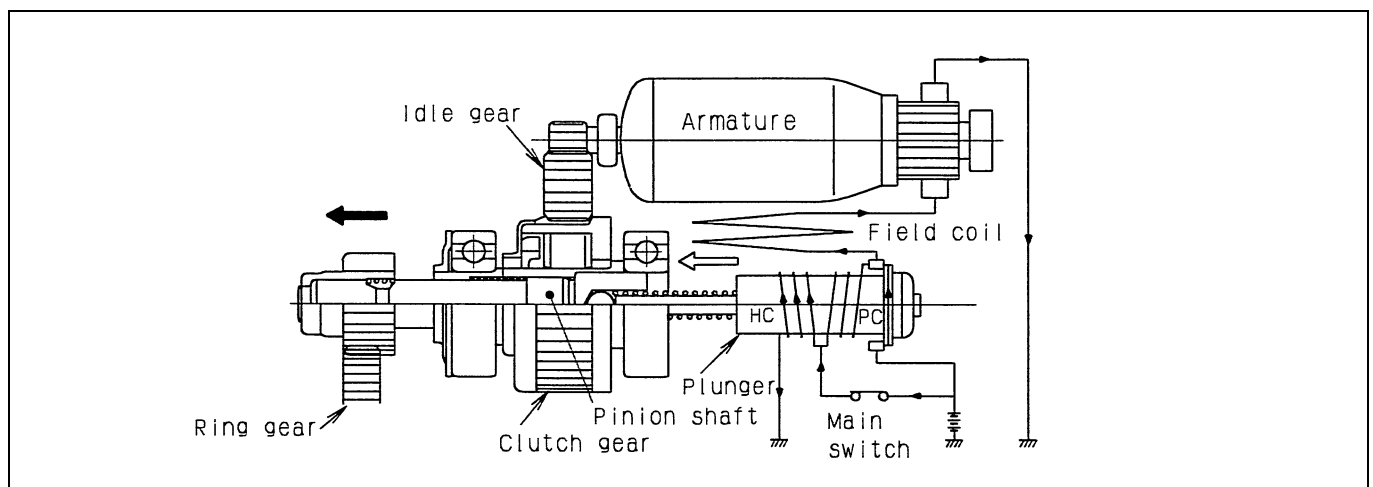


Fig. 9-5

3) When the engine is started :

a) When the engine is started, rotation of the gear will become faster than rotation of the pinion gear. (If such a state is left as it is, rotation of the engine will be driven directly into the armature, and may damage it.)

b) In case that rotation faster than that of the armature is transmitted to the pinion gear, the overrunning clutch will begin to race, and will protect the armature from abnormal rotation.

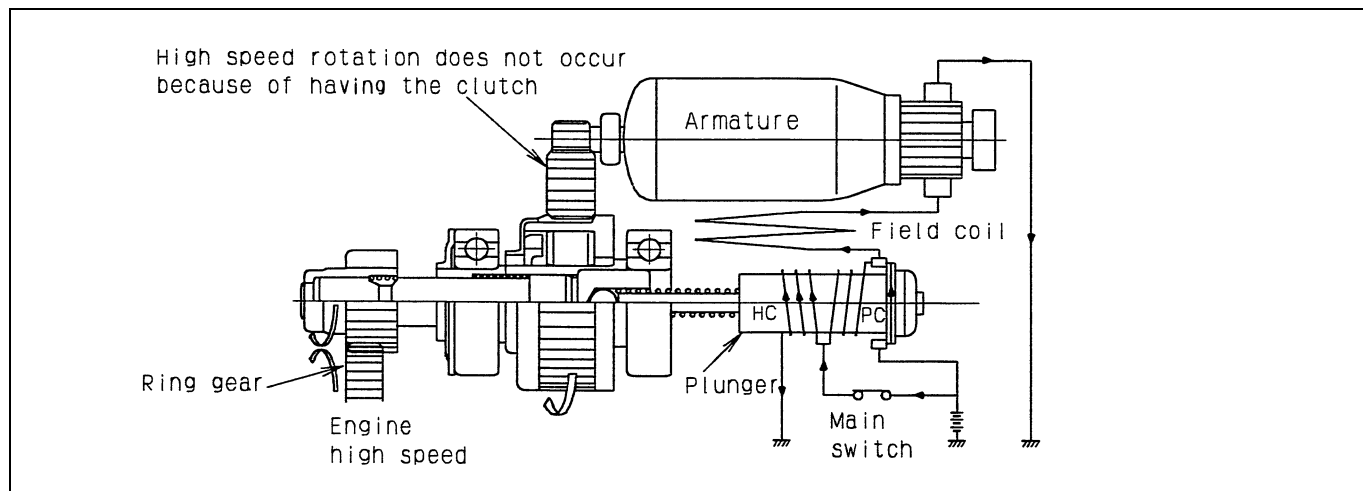


Fig. 9-6

4) When the starter switch is returned to AC :

a) If the starter switch is returned to AC, energizing to H.C will be shut off.

b) The force on the plunger will cease and the pinion gear will be returned by the return spring. At the same time, the main contact point will be opened as well, and rotation of the armature will be stopped. Braking of the armature is performed by abrasion force of the brush and commutator.

* For an instance, potential difference of the C terminal becomes higher than that of the S terminal, and electrical current flows from the main contact point to the direction of P.C and H.C so that engaging force of the plunger will be offset each other, and the plunger will be returned quickly.

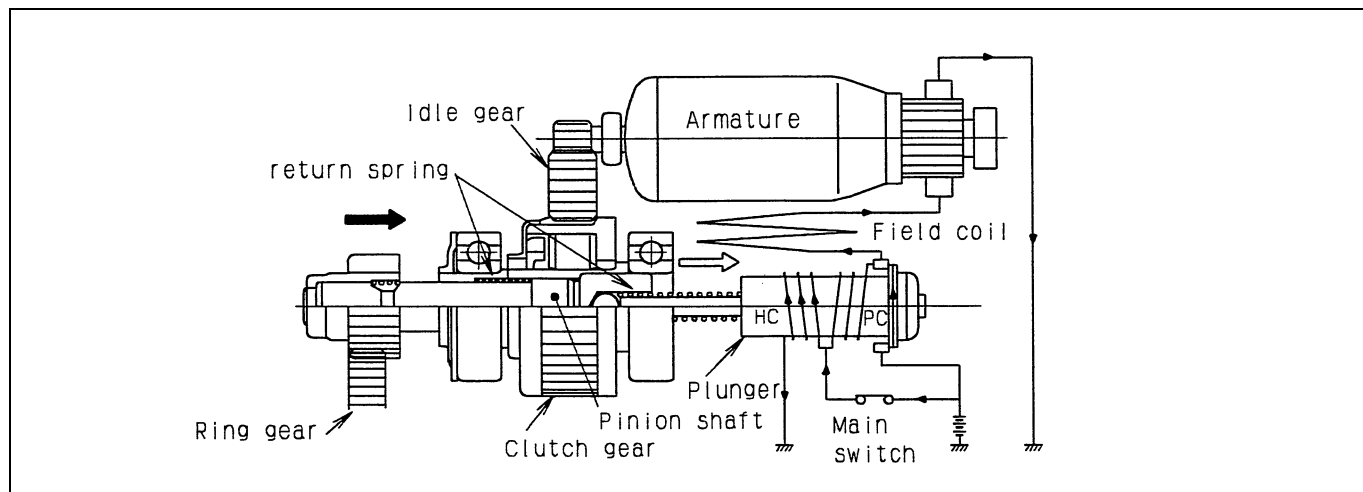


Fig. 9-7

5) The check method for the starter wiring connection

Terminal	The measuring method	The judging standard and countermeasure
S terminal	1. Remove the wiring to the starter B terminal and connect the S terminal wiring alone. 2. Remove the wiring connection of other parts connected to the battery (+) terminal. 3. Connect a voltmeter to the battery (+) terminal and starter S terminal. 4. Connect an ammeter to the S terminal wiring. 5. Connect a voltmeter to the battery (-) terminal and the starter body. 6. Turn the key switch to the starting position, wait 3 seconds, and measure each value of the ammeter and voltmeters. 7. Calculate the wiring resistances from the measured current and voltages and sum up them.	The total sum of resistance shall satisfy the following standard. KBT Standard Starter for; NSM, 07, V3 : 50 to 70 mΩ or lower 05, 03M : 90 mΩ or lower When the above standard is not satisfied, the wiring diameter shall be increased.
B terminal	1. By the stop solenoid and stop lever, keep the engine in the condition where start up is not possible. 2. Connect the S terminal wiring. 3. Connect the starter B terminal wiring. 4. Remove the wiring connection of other parts connected to the battery (+) terminal. 5. Connect a voltmeter to the battery (+) terminal and starter B terminal. 6. Connect a voltmeter to the battery (-) terminal and starter body. 7. Connect a clamp-on ammeter to the starter B terminal wiring. 8. Turn the key switch to the starting position, wait 3 seconds, and measure each value of the ammeter and voltmeters. 9. Calculate the wiring resistances from the measured current and voltages and sum up them.	The total sum of resistance shall satisfy the following standard. KBT Standard Starter for; NSM, 07, V3 : 50 to 70 mΩ or lower 05, 03M : 90 mΩ or lower When the above standard is not satisfied, the wiring diameter shall be increased.

Note :

The starter type must be checked before application review.

(3) Overrunning clutch

1) Function

In case that the pinion gear and ring gear are still intermeshed even when the engine is started, the motor will be forced to run in abnormal rotation, and the armature, brush, etc. will be damaged.

In order to prevent such an error, the overrunning clutch will function as the device to let the pinion race against the armature shaft when the engine is started, and to shut off transmission of rotation of the engine to the motor.

2) Action

a) When starting :

If the outer is rotated in the arrow mark direction receiving rotation of the armature, the clutch roller will be pushed toward the narrower side of clearance between the outer concave side and the inner so that the outer and inner will be locked. The roller will function as a wedge between the inner and outer, and will transmit the rotation of the outer to the inner, and both will rotate in the same speed.

b) After the engine is started :

When the pinion is forced to rotate by the ring gear, rotation of the inner (rotation of engine $\times$ gear ratio) will become faster than that of the outer (a number of rotation of armature), and the clutch roller will move toward the direction that compresses the spring. Consequently, clearance between the outer concave side and the inner becomes wide to prevent overrunning of the armature.

(It is required to decrease the contact pressure of the pinion gear and ring gear to realize smooth separation of the pinion gear, and for the sake of this, the pinion gear must be in the state of racing.)

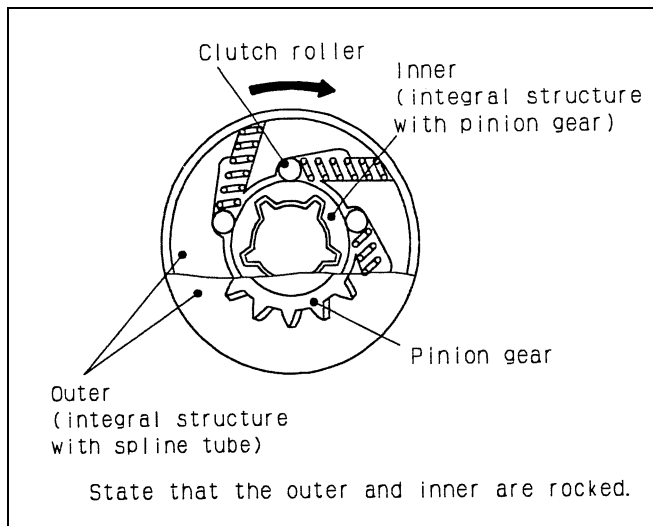


Fig. 9-8

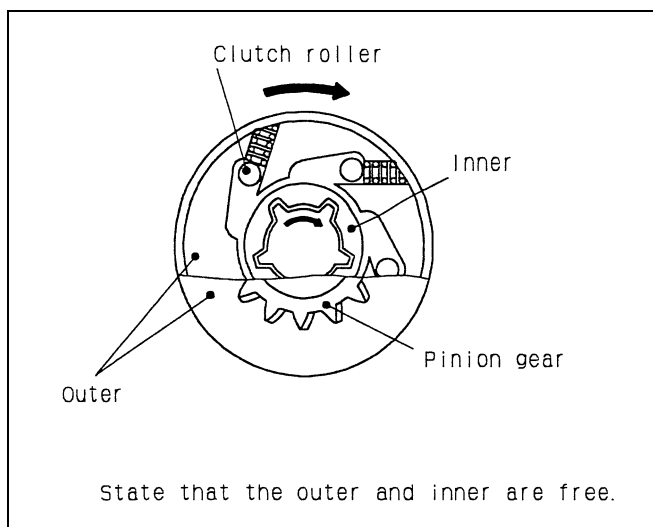


Fig. 9-9

[3] STARTER SWITCH

Starter switch is an important part comprising of the starting device of engine. Particularly, as seizing of the starter and solenoid may be incurred due to failure of the starter switch, careful consideration is required for the installation position, place, and direction, so that rain or cleaning water should not directly splash on the starter switch.

As the standard part of KUBOTA engine, the starter switch in below figure is recommended.

(Part No. : 15248 - 63593) or (Part No. : 1E013 - 63592)

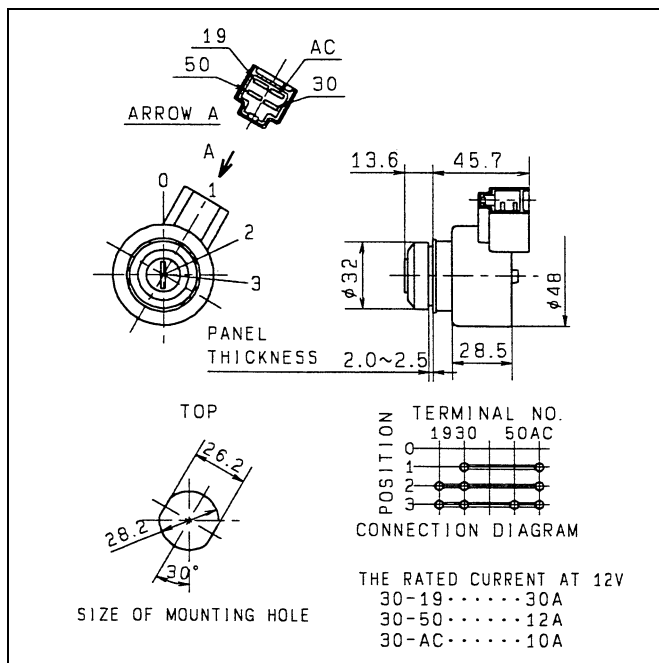


Fig. 9-10 - (1) Starter switch (15248 - 63593)

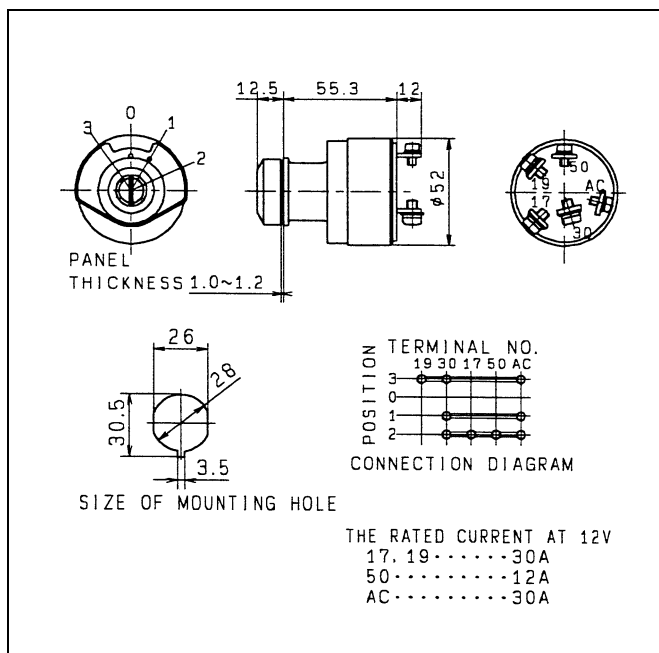


Fig. 9-10 - (2) Starter switch (1E013 - 63592)

[4] GLOW PLUG

(1) General

Pressed heat of air, and if the cylinder and head is cold when the engine is to be started, the glow plug will be used to supplement this compressed heat.

On the S.M., 05, 03-M, 07 and V3 series of KUBOTA diesel engine, the QGS type plug of double-material type

(2) Structure and function

In case of the conventional sheathed-type glow plug, the heating element is only incorporated in the sheathed tube, however, in case of this quick glow type, the heating element that combines a heating element and resistive element is connected in series.

As for the temperature increase property, when the temperature at the initial stage of power supply is low due to activation of the resistive element, resistance is small and enough electrical current flows into the heating element so that the temperature will increase quickly.

If power supply is continued, the amount of electrical current decreases and overheating is prevented, this is because temperature of the resistive element will increase and the resistance will become large (about 10 times).

and high reliability, of which temperature is increase is fast, is employed. The outline specifications are as shown in the next page. (Q.G.S : Quick Glow System)

Further, the heat point is at 2 to 3 mm (0.08 to 0.12 in.) from the tip, and protrusion into the combustion chamber is short.

KUBOTA's standard starter switch has the function that the glow plug will be energized as well when energizing the starter.

In case that starter switch is prepared by an OEM, it should also be designed so that the glow plug will also be energized when energizing to the starter.

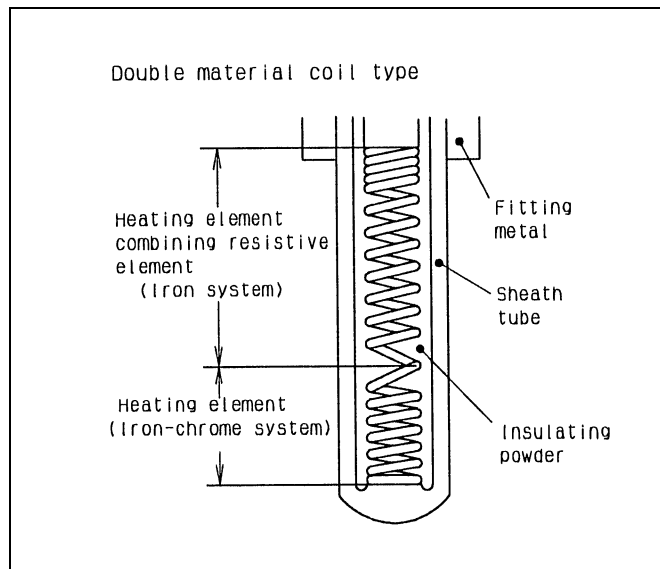


Fig. 9-11 Structure of glow plug

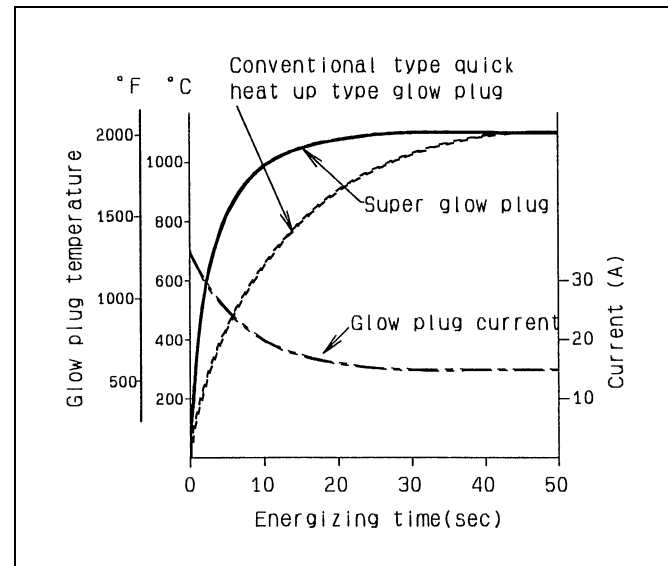


Fig. 9-12 Comparison of the temperature increase

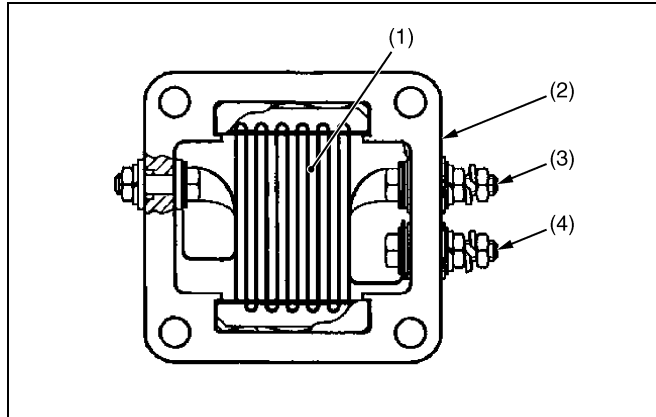
[5] INTAKE AIR HEATER

(1) General

The intake air heater is introduced in order to further improve the starting performance and to reduce the white smoke at cold starting.

The intake air heater is mounted on the intake manifold. In this new construction, there is no need to arrange any glow plug on the cylinder head.

This means that a multi-valve design can be implemented and that the starting performance and serviceability are enhanced.



(1) Heater element (3) +Terminal 1
(2) Intake air heater body (4) +Terminal 2

Fig. 9-13 Heater element type

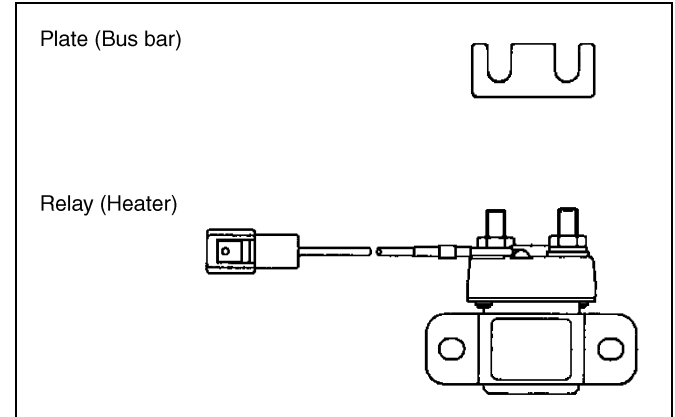


Fig. 9-14 Option parts

[6] GLOW LAMP AND LAMP TIMER

(1) General

The purpose of glow lamp is to time the activating conditions of the glow plug located in the combustion chamber of engine.

When the starter switch is turned to preheating position, the lamp timer will activate the glow plug lamp, and when the timer has activated after 5 seconds, the lamp will be turned off.

Even if the lamp is turned off by the lamp timer, the glow plug will still be kept turned ON, if the starter switch is in preheating position, or the starter is in the state of being turned ON.

(2) Activation circuit

- a) If the starter switch is turned to preheating, energizing will be made to No.6 terminal of the lamp timer from No.19 terminal through the glow lamp.

Then, the lamp timer is grounded, and it will light the glow lamp for 5 seconds.

At the same time, energizing will also be made to the glow plug directly from No.19 terminal, and the glow plug will be heated.

- b) If the starter switch is turned to starting, energizing will be made to No.5 terminal of the lamp timer so that electrical power of the glow lamp cannot be grounded, and the glow lamp will not be on. Energizing will be made to the glow plug directly from No.19 terminal of the starter switch, and the glow plug will be heated.

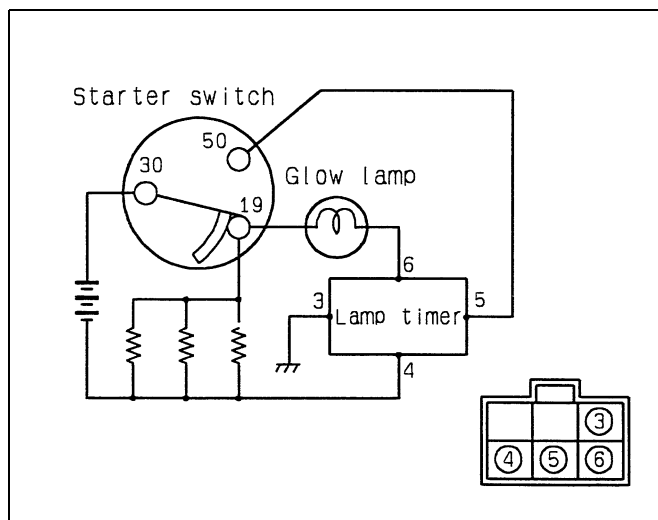


Fig. 9-16

[7] GLOW SYSTEM WITH THE SENSOR

(1) General

The purpose of this system is to control energizing time to the glow plug by means of water temperature of the engine, and this system makes it easy for the operator to start the engine even when it is in cold season, because starting preparation can be completed if it is confirmed that the glow lamp is turned off.

This system consist of starter switch, glow lamp, glow relay, glow controller, water temperature sensor and glow plug.

(2) Glow controller

If the starter switch is turned on, water temperature will be detected by water temperature sensor of engine, and energizing time to the glow plug and glow lamp will be controlled by rise and fall of the water temperature.

When the glow plug has reached start-temperature, the controller will turn off the glow lamp.

When the starter switch is the starting position, the glow plug will be energized directly from the starter switch so that starting ability is improved. When the starter switch is in this position, the glow lamp will be turned off.

☆ When the atmospheric temperature is more than +5 °C (41 °F), the engine can be started without heating of glow plug.

Water temperature	Energizing time to the timer
20 °C (68 °F)	3.3 sec
0 °C (32 °F)	5.0 sec
-15 °C (5 °F)	10 sec

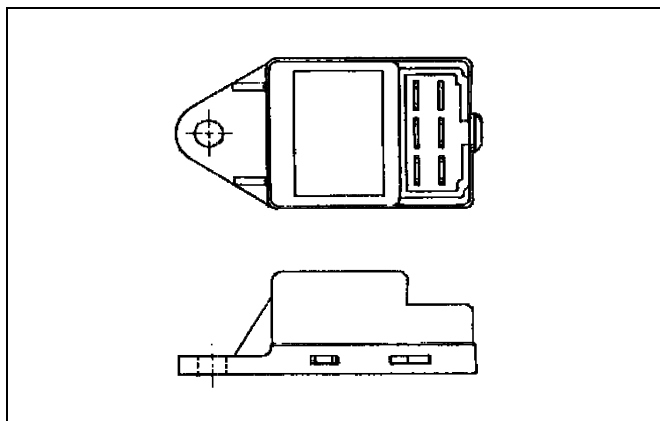


Fig. 9-15 Glow lamp timer

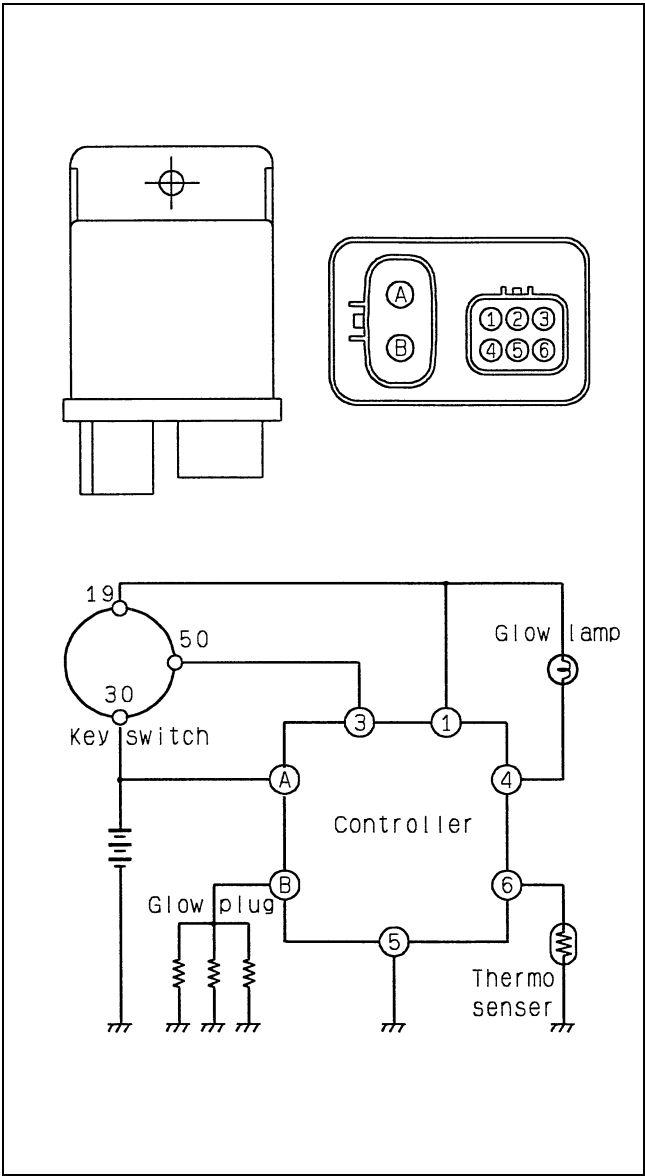


Fig. 9-17 Glow controller

(3) Water temperature sensor
(Only use for glow plug)

The water temperature sensor for glow plug is installed to near the thermostat.

When the water temperature is decreased, the electrical resistance will become small, and when the water temperature is increased, will become large.

Temperature	Resistance value (Ω)
-20 °C (-4 °F)	16.2
0 °C (32 °F)	3.88
20 °C (68 °F)	2.45
40 °C (104 °F)	1.14
60 °C (140 °F)	0.58
80 °C (176 °F)	0.32

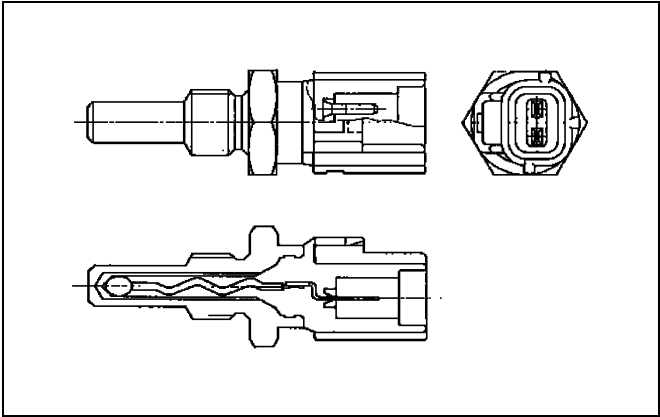


Fig. 9-18 Sensor (water temperature)

[8] HEATER SYSTEM

(1) General

This system is intended for the prevention of burnout caused by oversupply of current to the intake heater.

(2) Heater controller

Turn the key switch on to make conduction between terminals A and B for 25 seconds.

The output is cut off when 25 seconds have passed.

Turn the key switch to the start position (50) to make conduction between terminals A and B for the duration while the position of the switch is maintained.

The timer period after the key switch is turned off from on and turned on again varies based on the following re-energization characteristics.

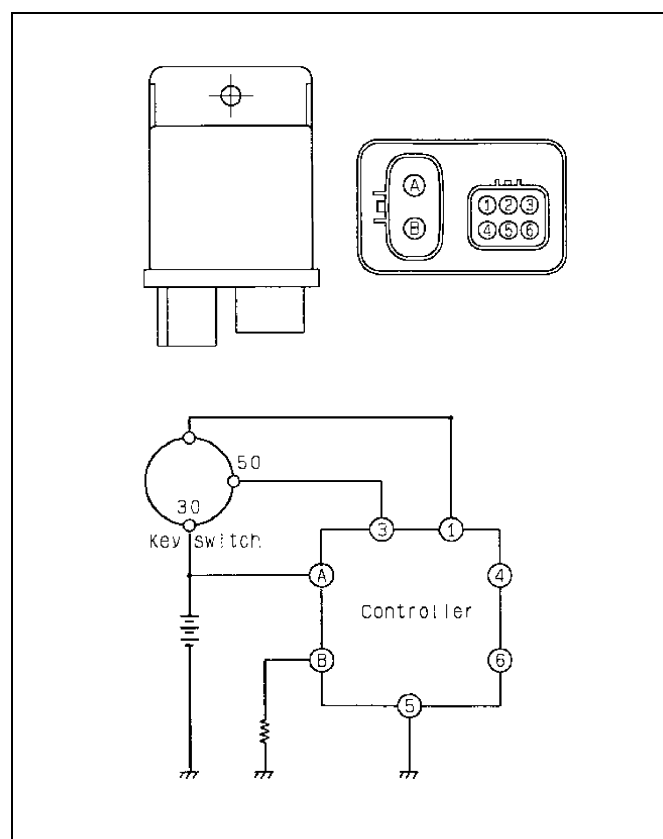


Fig. 9-19 Controller

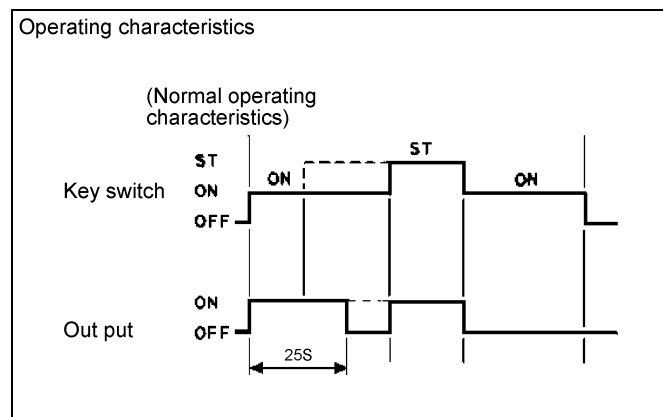


Fig. 9-20 Operating characteristic

Re-energization characteristics

The preheat timer period as the key switch is turned off from on and turned on again depends on the period of key switch deactivation.

Refer Ref. 1 and Ref. 2.

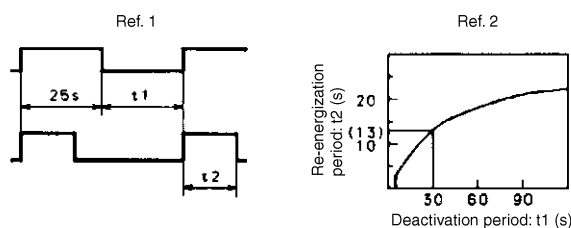


Fig. 9-21 Re-energization characteristics

[9] STARTER SAFETY SYSTEM

The purpose of this system is to prevent accidental starting of the starter during rotating of the engine.

The No.50 terminal of the starter switch will be connected to the ST terminal of the starter through the safety relay, and when the engine is started and the alternator begins charging, this relay will automatically shut off the starting circuit by detecting the generated voltage of the alternator.

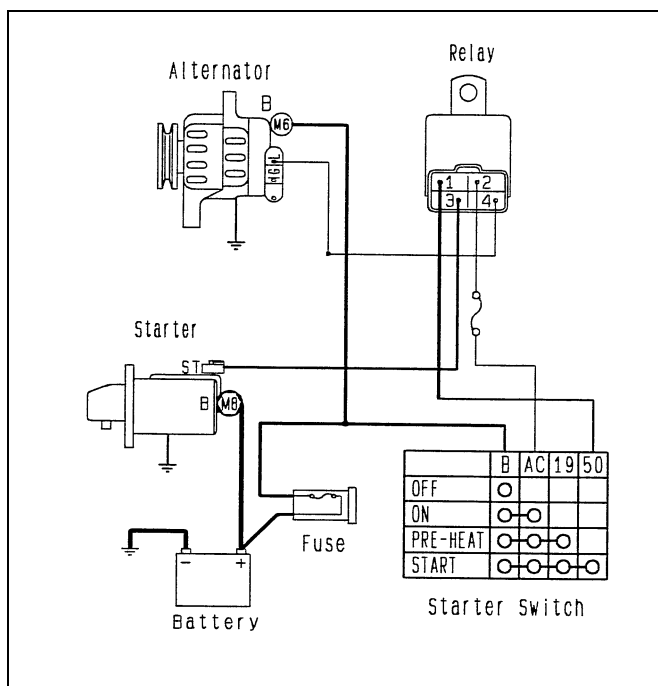


Fig. 9-22 Safety system circuit

Note :

The above is only available when the combination of the alternator and fan driving pulley is either of the following :

- (1) 1K574-64010(40A) : fan driving pulley diameter 112 mm
- (2) 1G882-64010(40A) : fan driving pulley diameter 122 mm

3. CHARGING DEVICE

[1] GENERAL

The function of the charging device is to charge batteries. There are various types depending on the size of the engine, and in case of KUBOTA engines, it can be

broadly divided into the two types, i.e., the separate regulator type and the built-in type.

[2] IC REGULATOR BUILT-IN TYPE ALTERNATOR

The alternator is incorporated with an IC regulator, this has been made small size and light weight by the semiconductor technique of the IC regulator.

The cooling property and safety is improved by incorporating the cooling fan and roller that is an integral structure.

Further, the serviceability is also improved by facilitating mounting and removal of the rectifier and IC regulator.

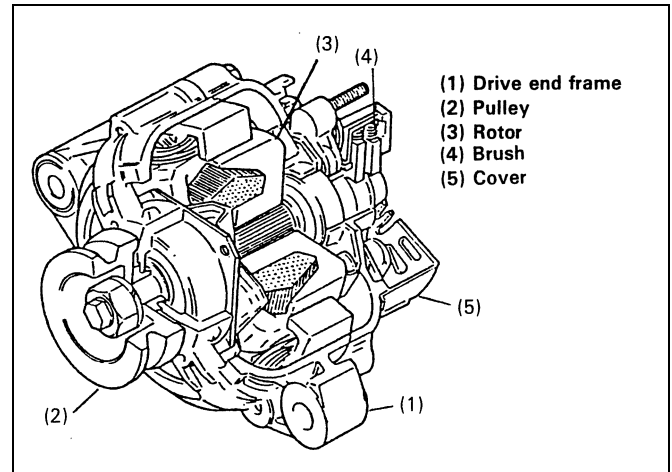


Fig. 9-23 IC regulator built-in type alternator

(1) D2 Type regulator

IC regulator has a special feature that makes it possible to interrupt field current by using the transistor or IC instead of the contact-point-type regulator.

IC regulator has the special features as follows :

- 1) Readjustment for this regulator is unnecessary because the control voltage does not change over time. Further, vibration-proof property and durability is excellent because IC regulator has no moving parts.
- 2) Since IC regulator has over-temperature compensation property, which makes the control voltage low if the temperature is increased, it makes it possible to properly charge the batteries.

The circuit inside IC regulator is as shown in the following figure.

It is composed of the monolithic IC-incorporated hybrid IC. (Since the inside circuit of the monolithic IC is extremely complex, it is described as M.IC circuit.)

Tr1 has the function as the contact point to control field electrical current, and as the charging lamp relay to light the charging lamp.

M.IC controls Tr1 and Tr2 by detecting decrease of the output voltage of alternator, decrease of the L-terminal voltage, disconnection of the rotor coil, etc.

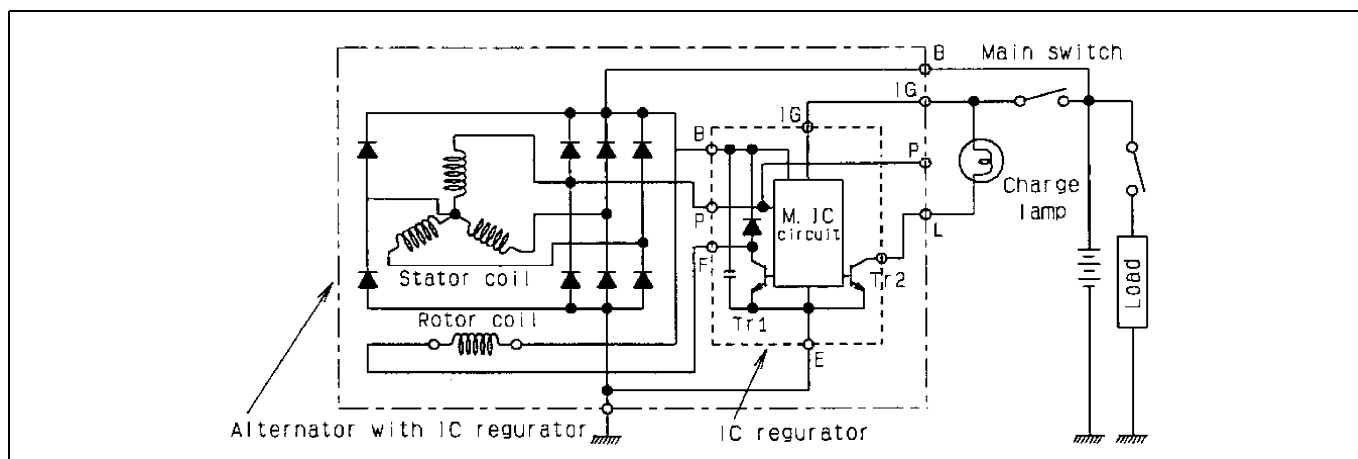


Fig. 9-24 D2 Type regulator circuit

Application example (1)

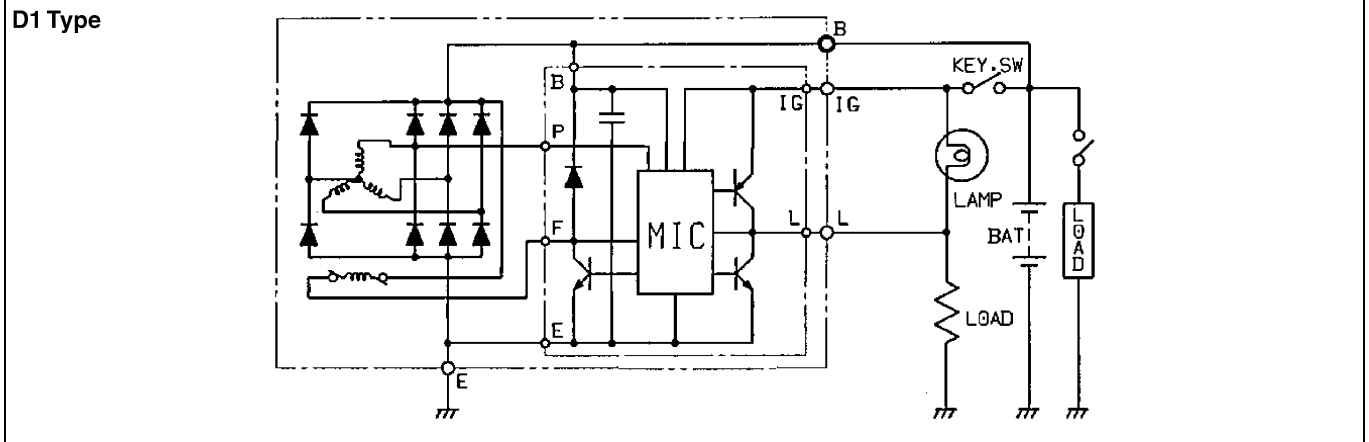


Fig. 9-25 D1 Type regulator circuit

Application example (2)

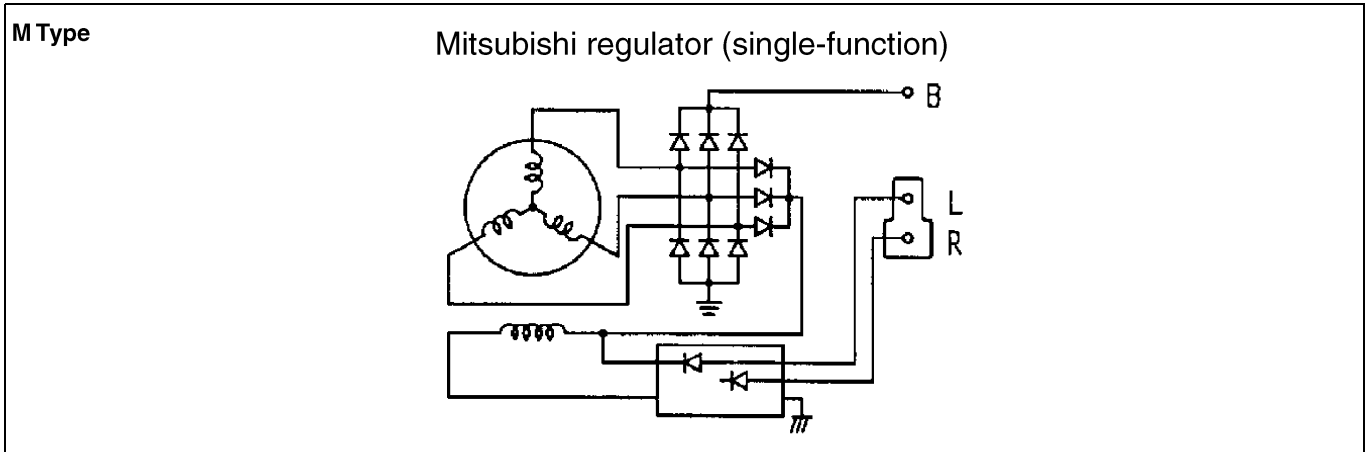


Fig. 9-26 M Type regulator circuit

● **Specification of alternator with IC (incorporated with) regulator**

Normal voltage	12 V	
Maximum output	S.M.	20 A, 40 A
	05	20 A, 30 A, 40 A, 60 A
	03-M	20 A, 30 A, 40 A, 45 A, 70 A
	07	60 A
	V3	45 A, 60 A, 90A
Rotational direction	Right as seen from pulley side	
Armature wiring	3 phase, Y wiring	
Rectifying system	Total wave rectification ☆	
min ⁻¹ (rpm) at no load (when cold)	14 V at 0 A 1050 ~ 1350 min ⁻¹ (rpm)	
min ⁻¹ (rpm) at max. output (when cold)	14 V at maximum output below 4000 min ⁻¹ (rpm)	

Generating capacity will be determined by rpm of engine and pulley ratio.

● **Standard pulley dimensions**

Engine	Pulley	Crank pulley mm (in.)	Alternator pulley mm (in.)
S.M. series		100 (3.94)	58.5 (2.30)
05 series		105 (4.13)	58.5 (2.30)
03-M series		130 (5.12)	65 (2.56)
07 series		131 (5.16)	65 (2.56)
V3 series		143 (5.63)	70 (2.76)

The variation of generating capacity according to the min⁻¹ (rpm) of engine is shown as the figure in next page.

☆ **Total wave rectification**

In case of the generator for mobile equipment of which purpose is to charge the batteries, alternating current cannot be used as it is. Because of this, it is required to conduct the action called rectification so that the alternating current can be changed to direct current. Alternator conducts rectification by means of diode.

If the voltage is applied to diode in the normal direction, enough electrical current can flow even by small voltage, however if applied in the reverse direction, it inhibits the reverse flow of electrical current.

Using this property, alternate current generated in the stator coil is changed to the direct current.

As for the rectification using diode, there are two methods, i.e., 'half-wave rectification' that takes out only positive portion of alternate current, and 'total-wave rectification' that rectifies both positive and negative current and change to the direct current.

【Half-wave rectification】

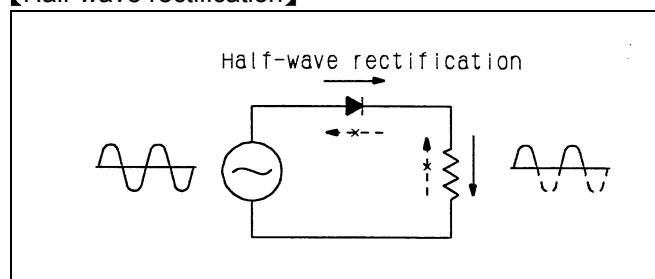


Fig. 9-27

【Total-wave rectification】

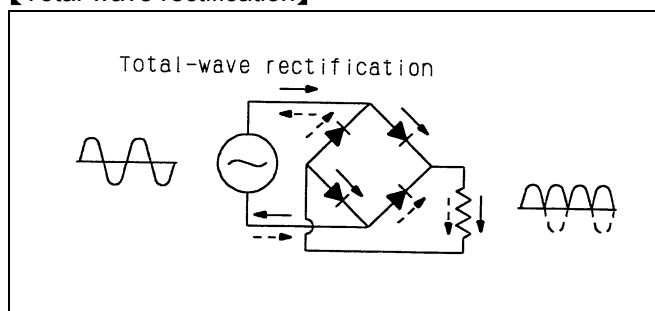


Fig. 9-28

● Alternator P Terminal

(1) P terminal waveform: The alternator P terminal outputs rotation signals required by a tachometer, etc.

The P terminal corresponds with one phase of the alternator stator and the output waveform during power generation is a waveform equivalent to the rectangular wave with a frequency in proportion to the number of revolutions of the alternator.

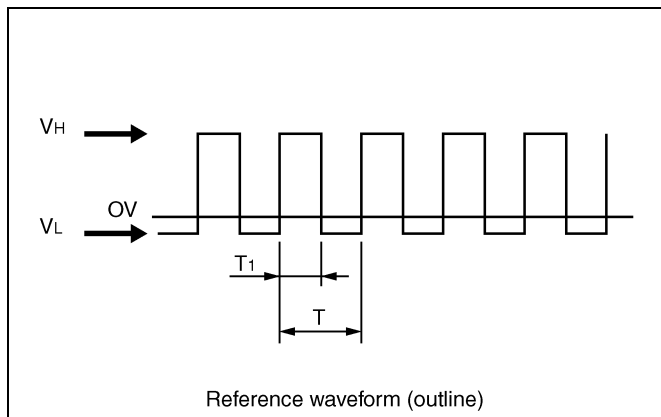


Fig. 9-29

Frequency ($1/T$): Number of revolutions of alternator [rpm] / 10 [Hz]

Duty (T_1/T): approx. 50%

V_H (average): about +0 to 2 V with reference to the alternator B terminal voltage (average)

V_L : about -2 to 0 V

Note :

- 1) As with the B terminal waveform, the P terminal waveform includes noise, which varies depending on the number of revolutions, output and wiring (see the waveform in a separate material).
- 2) Surge voltage may be generated by any charging cable disconnection (especially with high number of revolutions/high output), etc.

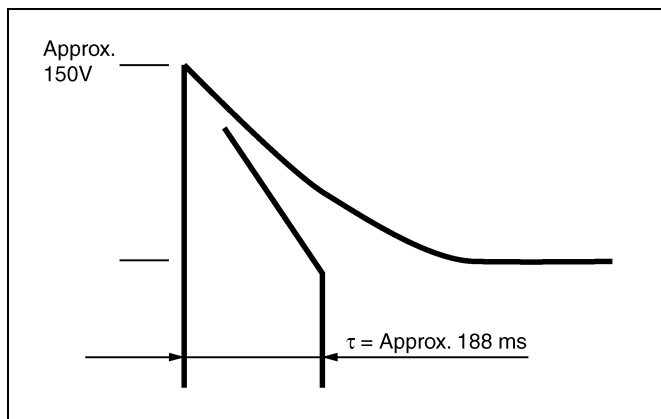


Fig. 9-30

Surge voltage waveform with any charging cable disconnection. (Alternator : F3A-H, 40 A 15000 rpm, max output)

- 3) May be $V_{Hmin} = 6.5$ V in high electric load shedding or unloaded condition with the battery fully charged.

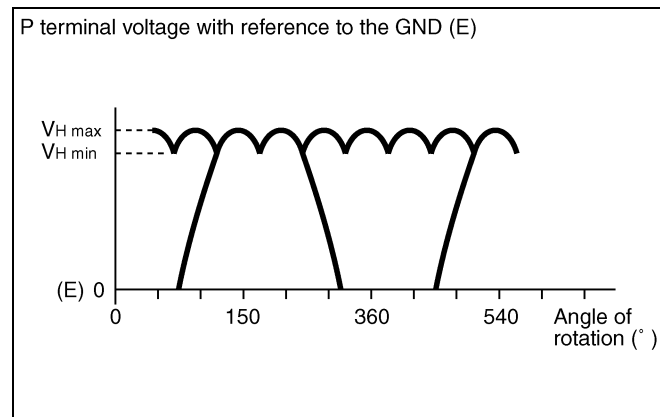


Fig. 9-31

- (2) Load connected to the P terminal

P terminal output current: 0.5 A max (average current)

Note :

- 1) Ensure that there is no load short circuit or wrong wiring.
- 2) Do not connect inductive or capacitive load (connection of such load subject to discussion of the specification).
- 3) When detecting a waveform, take the noise and V_{Hmin} into consideration.
- 4) Take the surge voltage into consideration for the input of the load.
- 5) Use the actual equipment for sufficient check of the operation of the load.

Generating Current

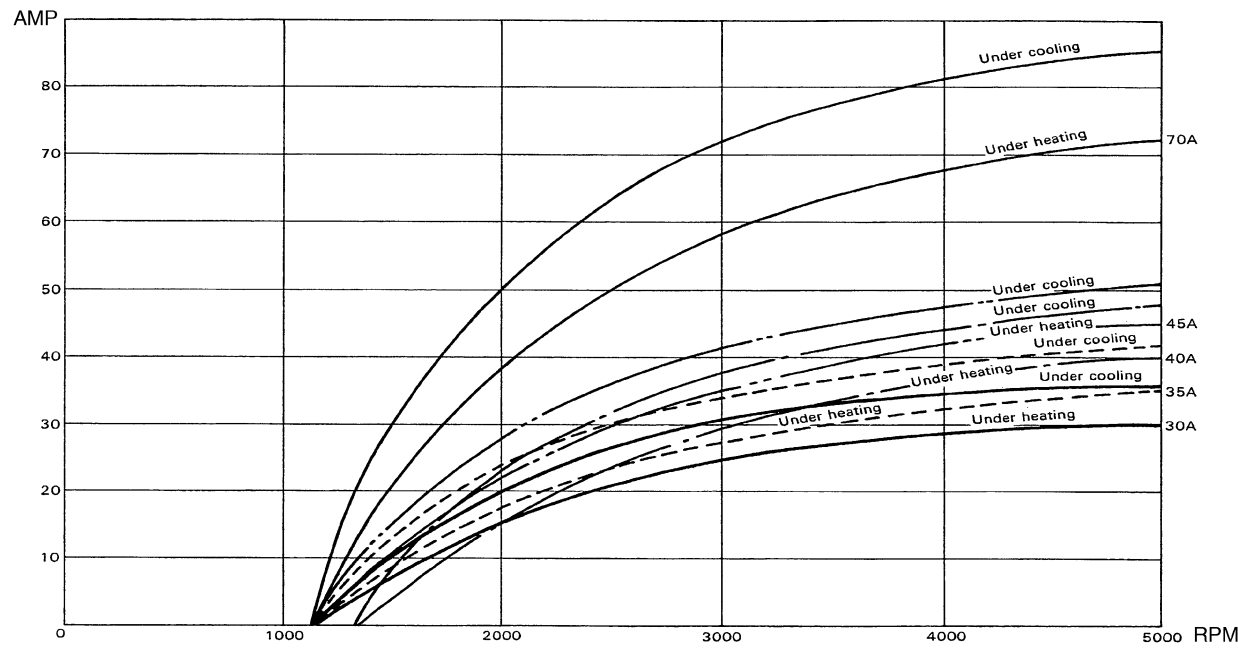


Fig. 9-32 Alternator output characteristics (at 14V constant)

[3] AC DYNAMO AND REGULATOR

(1) AC dynamo

The structure of AC dynamo is simple, and it is composed of the stator and rotor as its main component parts. As for the stator, 6 generating coils are wound, and the rotor has 6 permanent magnets around the circumference, and it rotates on the center of the stator coil.

Specification of AC dynamo

Normal voltage	12 V
Normal output	150 W
Rotational direction	Right as seen from the pulley side
Output min ⁻¹ (rpm)	4250 min ⁻¹ (rpm)
Charge starting min ⁻¹ (rpm)	1800 min ⁻¹ (rpm)

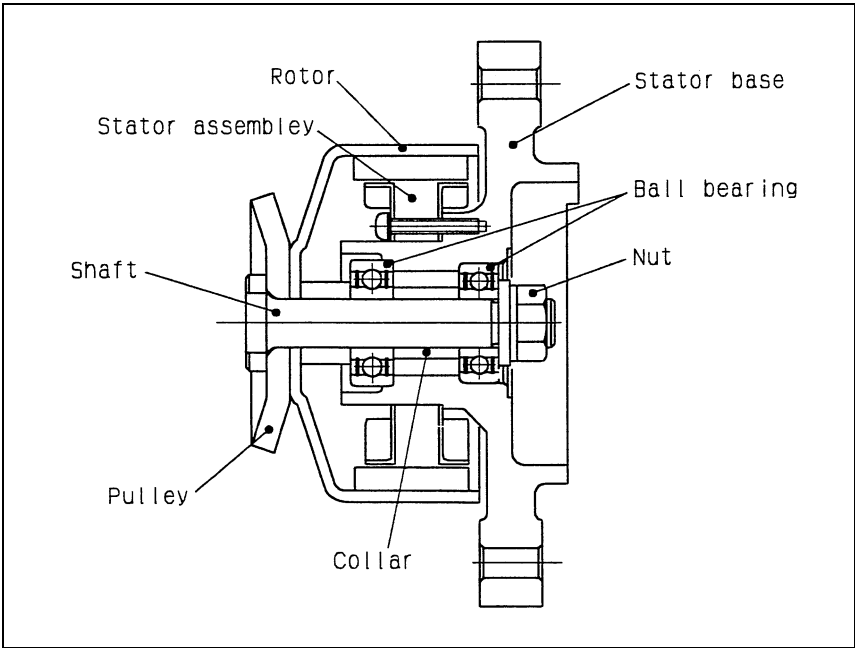


Fig. 9-33 AC dynamo

(2) Thyristor type regulator

Thyristor-type regulator is composed of the diode, resistor, thyristor, zener diode, and transistor.

When the battery voltage is low, the thyristor will be turned on, and complete the charging circuit to the battery.

Further, if the battery voltage is increased to be more than the specified value of the zener diode ($14.5 \pm 0.5 \text{ V}$), thyristor will be turned off, and the charging circuit to battery is shut off.

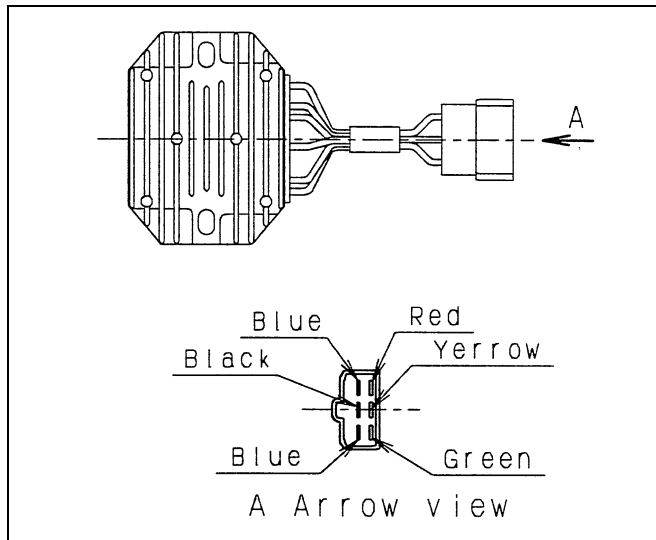


Fig. 9-34 Regulator (Kubota Standard Type)

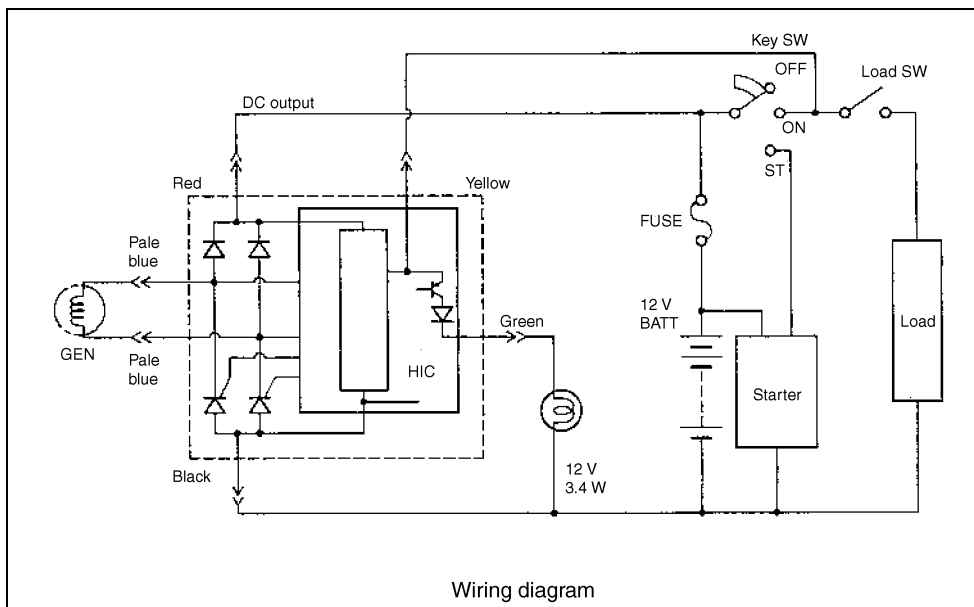


Fig. 9-35 Inside circuit of regulator

4. STOPPING DEVICE

[1] GENERAL

To stop diesel engine, normally, the operator will operate the stop lever, and reduce the injection amount of fuel to zero.

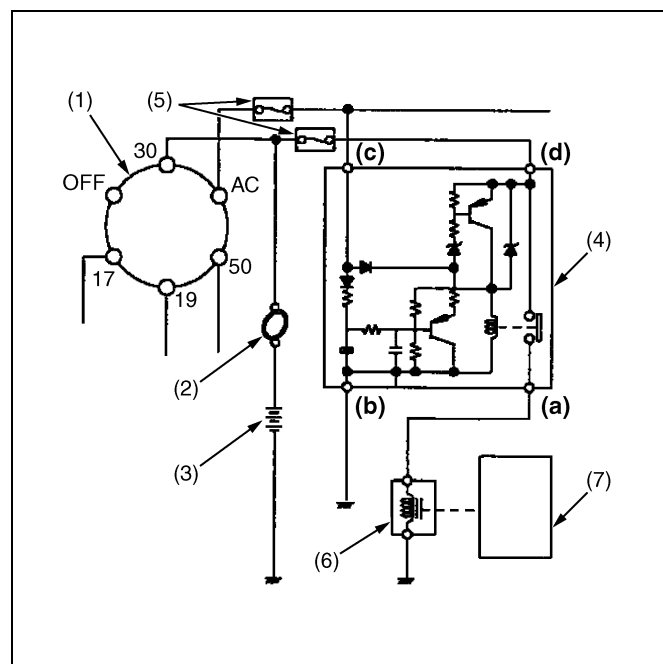
However, this operation of stopping the engine can be performed in such a way that the engine solenoid is excited by turning starter switch to the off position, and the stop solenoid plunger is pulled in to stop the fuel and the engine.

This system uses the engine key to operate the stop device, and facilitates easy operation, in addition, manual operation is also possible.

[2] SOLENOID

(1) Energize to stop type solenoid

This stopping device is composed of the solenoid and timer relay, and will keep activating the solenoid for about 10 seconds after the starter switch is turned to off position so that the control rack is pushed to the non-injection position, and the engine is stopped.



(1) Starter switch	(5) Fuse
(2) Fusible ring	(6) Solenoid
(3) Battery	(7) Injection pump
(4) Timer relay	

Fig. 9-36 Energize to stop device

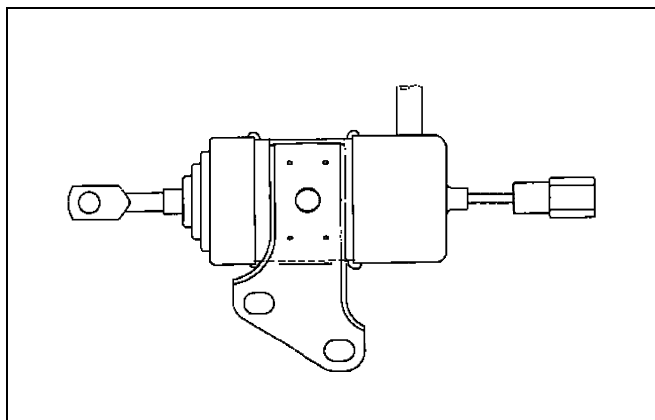


Fig. 9-37 Energize to stop device

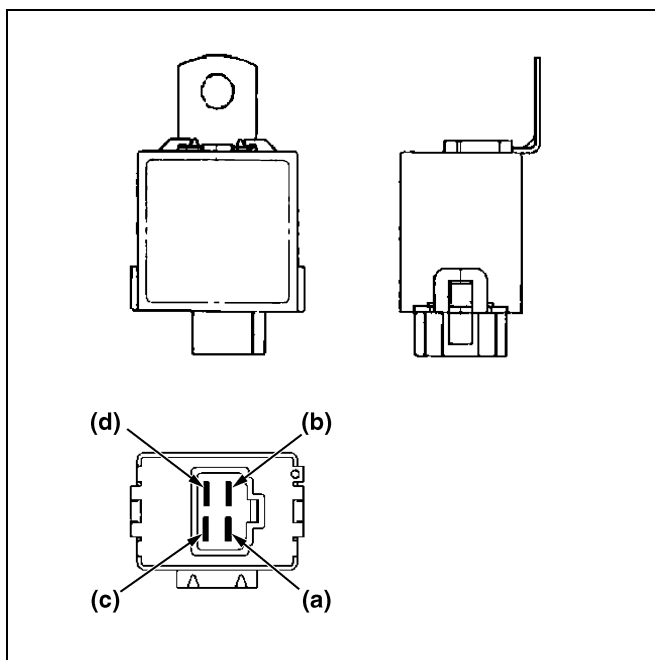


Fig. 9-38 Timer relay

(2) Energize to run type solenoid

In case that electrical trouble (equipment damage, disconnection of wire, and short circuiting) has occurred, the energized to stop type solenoid can stop the engine only by manual operation, and on the other hand, in case of energize to run type, engine can be stopped forcibly (automatically).

The energize to run type is an effective system in view of safety, however the engine cannot be started if electrical trouble has occurred.

1) Activation circuit

a) When the starter switch is turned to 'start' :

If the starter switch is turned on, electrical current will flow from AC of the starter switch to Hold Coil (H.C), and excite H.C.

If the main contact point of the starter is closed, electrical current will flow from C terminal of the starter to Pull Coil (P.C), and excite P.C.

With above procedure, the plunger will then be pulled in.

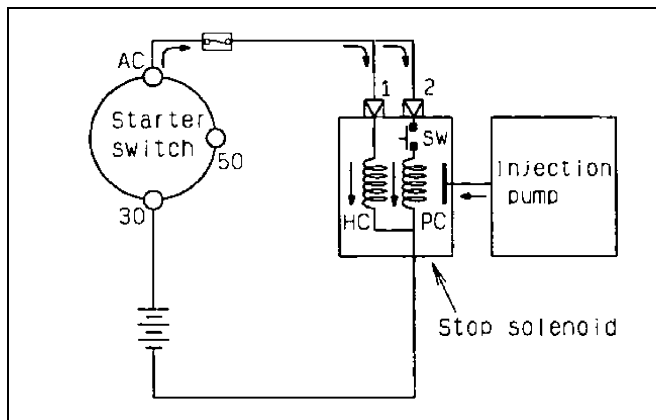


Fig. 9-39

b) When the starter switch is turned on :

The plunger is attracted by the magnetic force of the attraction coil and completely drawn, when the solenoid internal contact is opened to cut off the current to the attraction coil. However, the holding coil maintains the plunger at the drawn position.

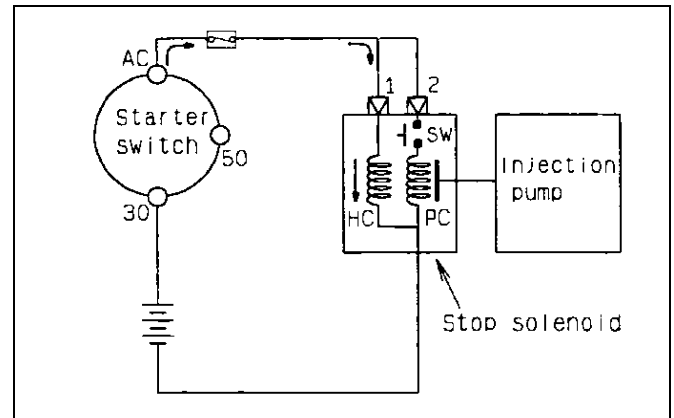


Fig. 9-40

c) When the starter switch is turned off :

When the key switch is turned off, the current to the holding coil is cut off and the plunger returns to the initial position by the return ring in the solenoid, which brings the injection pump fuel injection quantity to 0.

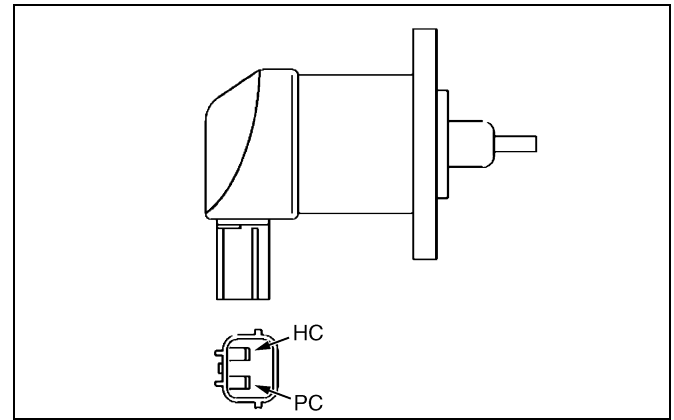


Fig. 9-41 Energize to run solenoid

5. MONITORING AND CONTROLLING DEVICE

[1] MONITORING DEVICE

(1) General

Minimum limit monitoring is required to maintain the normal operation of the engine.

Operating and monitoring devices include parts and instruments as follows

- a) Glow lamp
- b) Oil pressure lamp
- c) Water temperature lamp
- d) Charging lamp
- e) Water temperature meter
- f) Hour meter

- g) Oil pressure gauge
- h) Fuel gauge
- i) Pilot lamp

Which equipment is employed shall be determined by taking into consideration the factors such as the types of engines, use condition (temperature, time, load, etc.), and design.

(2) Lamps

There are lamps which indicate abnormality of oil pressure, coolant temperature, and one which indicates heated condition of the glow plug.

The pilot lamp combines the four lamps, i.e., glow lamp, oil pressure lamp, coolant temperature lamp, and charging lamp into one unit, and is convenient when planning the control box and when operating.

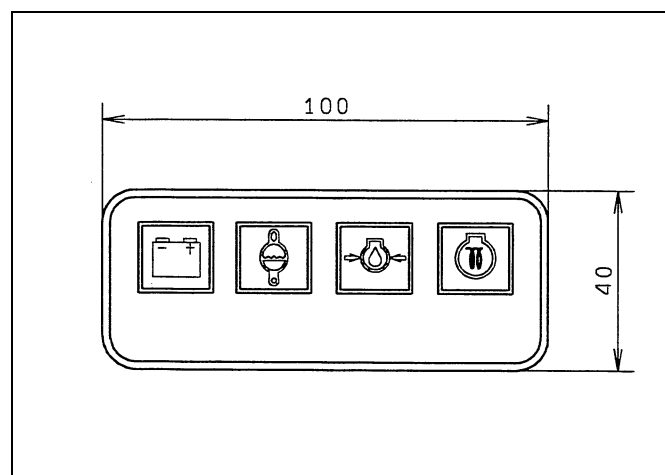


Fig. 9-42 Pilot lamp (Kubota option)

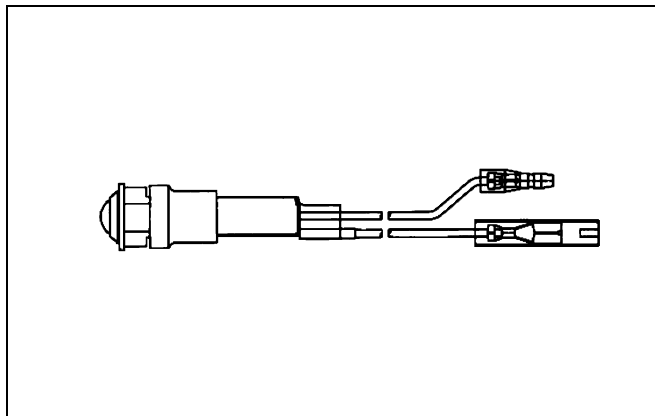


Fig. 9-43 Indicator lamp (Kubota standard)

(3) Water temperature and oil pressure gauge (Kubota option)

The gauge indicates cooling water temperature and lubricating oil pressure during the operation of the engine.

Generally, the lamp-indication type is often employed, however other indication types are also available depending on the request, and several types are available as optional parts from KUBOTA.

When employing these gauges, it is required to install the relevant sensors on the engine.

(4) Hour meter (Kubota option)

There are two types, i.e., the mechanical type and electrical type.

In case of the mechanical type, the cable length is predetermined since the engine and the hour meter are connected by cable, and the maximum length is restricted depending on the drive resistance. Installation of mechanical type is comparatively easy. However, in case of the electrical type, design and preparation of the parts, as well as adjustment for installation are necessary for the sake of installing the sensor.

[2] CONTROLLING DEVICE

(1) General

This section describes the electronic governor system, which is mounted mainly on the BG type.

(2) ECU (Engine Control Unit)

ECU also has an actuator function that is necessary for the control of electronic governors; therefore, it is used in such engines like the BG-type engines of generator specification.

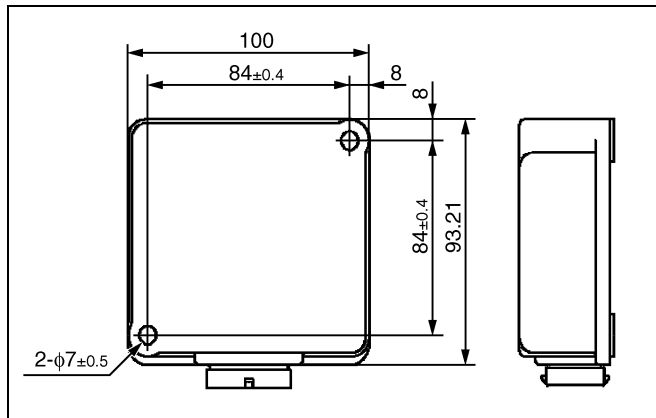


Fig. 9-44

(4) Engine speed sensor

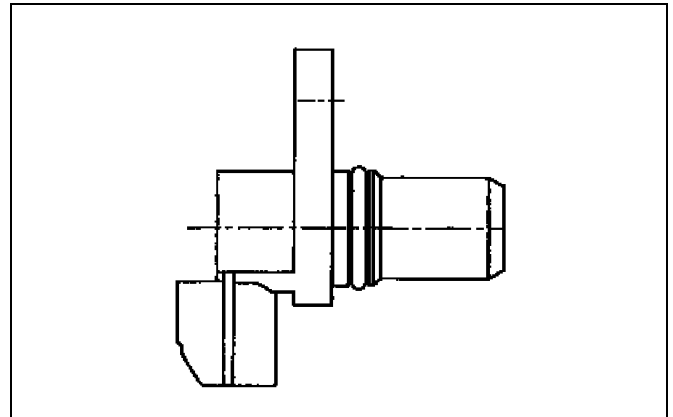


Fig. 9-46

(3) Proportional solenoids

The proportional solenoid is able to control the plunger position instantaneously by changing the driving current of the solenoid in addition to the functions of the conventional Stop solenoid.

The proportional solenoid is used in the electronic governors to reduce the revolution fluctuation by linearly controlling the control rack of the fuel pump of the engine. Such electronic governors are widely used for various applications including power generators and refrigerators.

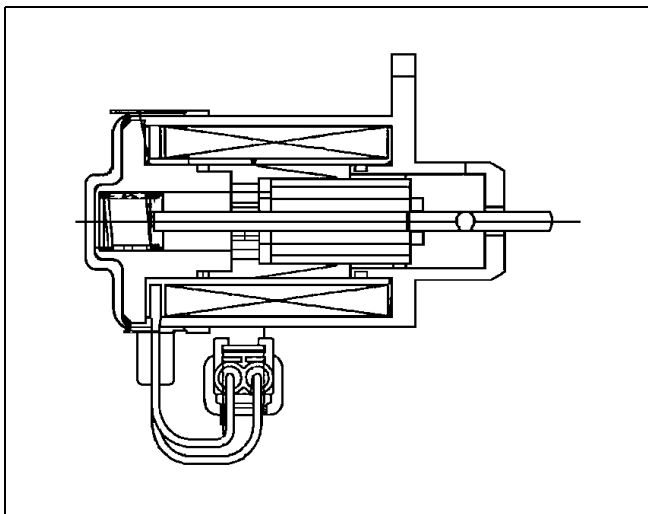


Fig. 9-45

6. ELECTRONIC GOVERNOR

[1] GENERAL

BG series uses an electronic governor in conjunction with a mechanical governor. The function of the electronic governor is, by isochronous control, to maintain constant engine speed the prescribed level, even if the load changes, by controlling the fuel.

[2] SOFTWARE BLOCK DIAGRAM

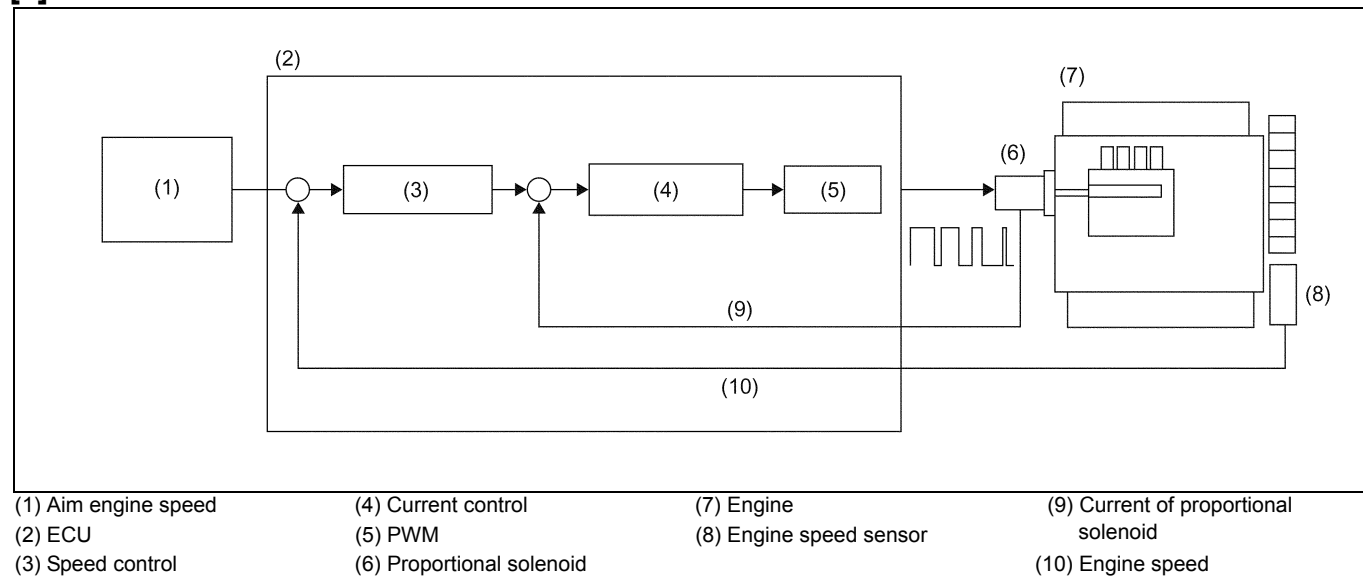


Fig. 9-47

Note :

Feedback Signal : Equivalent fuel injection quantity substituted from the current of engine speed and proportional solenoid.

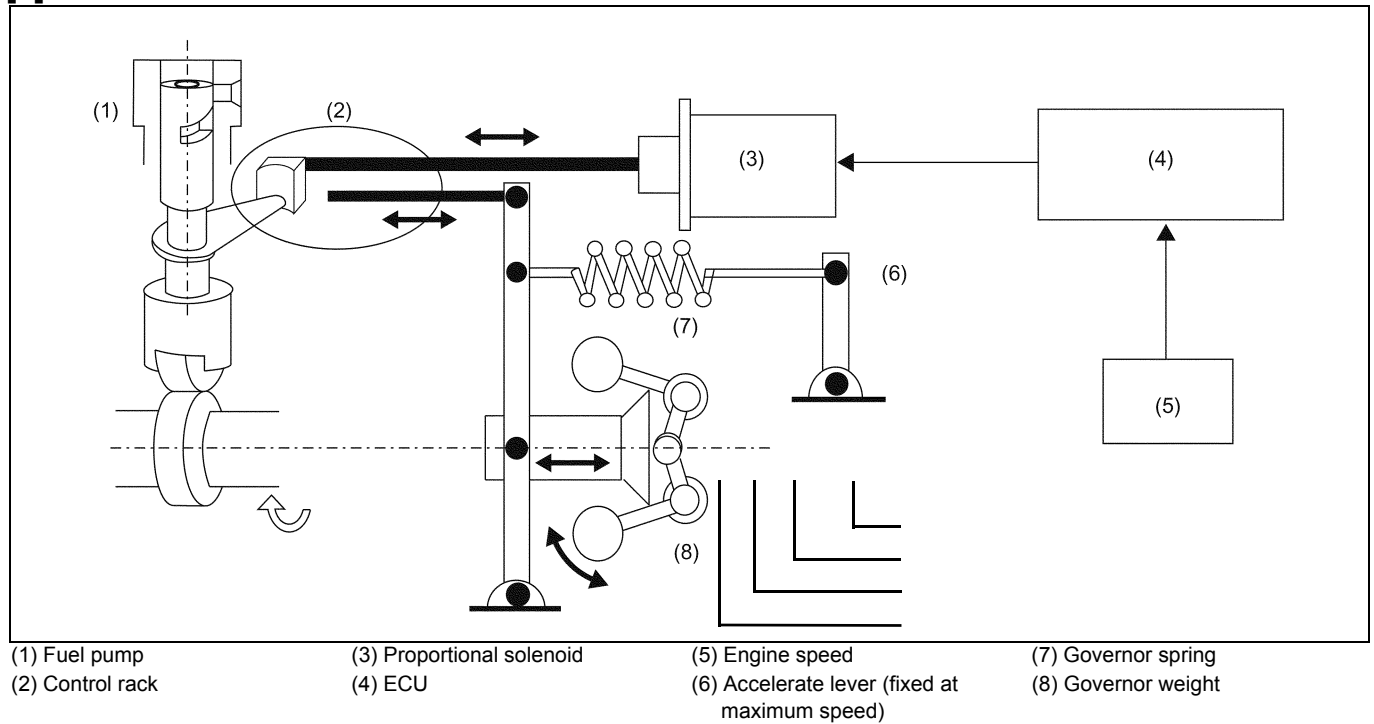
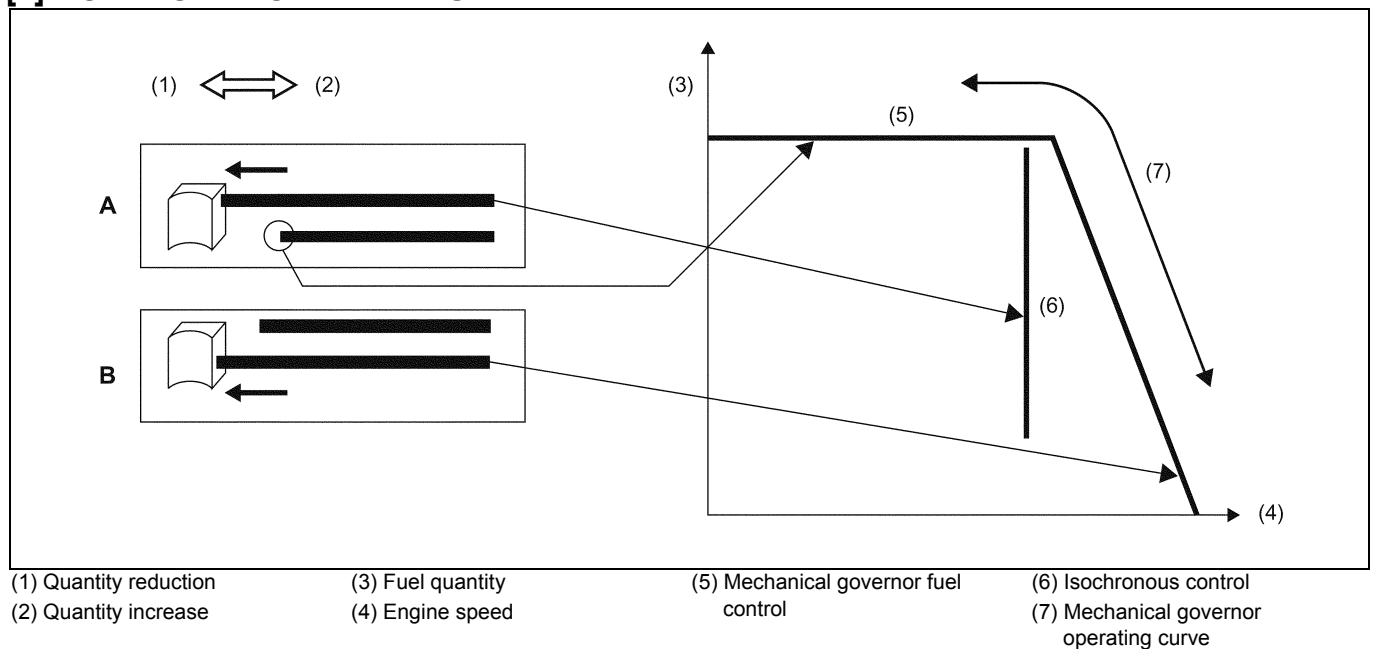
[3] CONSTRUCTION

Fig. 9-48

[4] CONTROLLING MECHANISM

A : Within the range of the mechanical governor free speed control occurs.

B : If the engine rotational speed increases priority is given to the mechanical governor control function.

Fig. 9-49

7. WIRING

[1] STANDARD WIRING (KUBOTA Recommendation)

The two types of the wiring, i.e.,
Starter with safety device / Energize to stop type solenoid for S.M., 05, 03-M series
and Starter with safety device / Energize to run type solenoid for S.M., 05, 03-M, 07, V3 series, respectively, as follows.

In case that a particular request is not presented, the KUBOTA standard specification or similar wiring to the specifications are recommended.

[2] CAUTIONARY ITEMS FOR WIRING

1) Equipment should be grounded securely.

When the grounding is not properly done, necessary amount of electrical current will not flow, and function of electrical equipment will not be exhibited fully. For example, it is possible that insufficient grounding of the starter will cause failure to start, and in addition, after repeating the starting many times, the starter will seize. Therefore, select a clean metal surface for the grounding wire attachment (on the main machine side as well as engine side), and completely remove the paint to make the contact resistance as low as possible.

2) The wire diameter of wiring and the electrical current capacity of each fuse are shown in the wiring diagram. However, these are only recommended values, and therefore when applying to the actual case, be careful to use the correct sites taking into consideration the length of wiring and the connection form.
Note that the wire diameters not specified in the wiring diagram shall be 0.8 to 1.25 mm².

3) Wiring should be routed and secured, be careful so that the insulation will not be worn off due to contact with other parts during operation, and short circuiting will not occur.

Further, it is recommended to protect wiring with corrugated protective covers.

4) In case that wiring is made mistaking the polarity, wiring materials may be burned and damaged, or it may result in personal injury.

It is important that any mistaken wiring never be made, and in addition, attention and care (by changing the colors and length of wire) should be taken not to let workers perform incorrect wiring.

5) Use low-voltage wires for automobile (AV SS wire, etc.) for wiring. However, in case that the ambient temperature is more than 75 °C (167 °F), use heat-resistant wires (AVX wire, etc.).

Example :

A V 0.5 RW

Color code

Sectional area

Insulation material : Vinyl

Low-voltage wire for automobile

6) To protect wiring, use a fuse or slow-blow fuse. Note that slow-blow fuses should be located near to the battery, and fuse box to the starter switch.

7) As for the load that may incur when unexpected current comes into the circuit, such as the case of motors, be careful not to directly connect to ACC and any wires connected directly to battery '+'.

8) Attach covers to the terminal on the terminal on the positive side of the battery to prevent sparks due to accidental contact.

[3] SIZE OF WIRING

(1) General

- a) The size of wiring shall be determined taking into consideration the various factors such as the length of cable, electrical current value, allowable voltage drop, etc.
- b) When electrical current 'A' (Amperes) flows in the circuit, the resistance 'ohms' always exists as the result of electrical power loss in the cable, and the voltage will be decreased.
The difference between the voltage of electrical power source and the voltage at the connection end of the cable of each equipment is the voltage drop leading to poor performance.
- c) Excessive electrical power loss in the cable will cause overheating of the cable and drastic voltage drop.
To resolve such a problem, it is important to take into consideration that the cable resistance is the accumulated value of complete circuit and to correctly use the specified cables.
- d) The rated value of the cable shall be determined according to the allowable electrical current value.
Electrical resistance depends on the total sectional area of the conductive material (wire).
It is possible to minimize the electrical power loss and voltage drop by using correct cables.
It is important to restrain the temperature increase of the cable for the cables that are used together in a harness.
- e) All of the voltage drop in the circuit should not exceed 10% of the regular voltage. (For example, 1.2 V in case of 12 V circuit.)
The voltage drop expected to occur in the circuit can be measured by using the simple formula as shown below :

$$\text{Voltage drop} = \text{Current value} \times \text{Total cable resistance}$$

- f) For the cables in which electrical current will flow continuously for a long period of time, attention and care must be taken for both the temperature increase and voltage drop, and on the other hand, as for the circuit to be used for a short time (for example, preheating circuit), care must be taken for the voltage drop.
Voltage drop of the glow plug circuit, is should be minimized so that necessary level to heat the glow plug can be maintained.

(2) Connector and terminal

After selecting the correct cables, it is required to select the connectors and terminals that can match each electrical part.

The connectors and terminals of major electrical parts that are employed in KUBOTA engines are shown in the SOS.

(3) Battery cable

The battery cable is the first 'connection' in the electric system of engine. Attention and care should be taken so that this cable should be of the sufficient size matching the electrical current required, and the length should be as short as possible.

Take care to securely install the battery terminals, and tightly clamp the cables.

Voltage drop against each battery cable should not exceed 0.6 V DC – 0.8 V DC.

Recommended minimum battery cable :

Engine	Cable size (mm ²)	AWG size
S.M. series	20	4
05 series	20	4
03-M series	30	3
07 series	60	2/0
V3 series	60	2/0

8. BATTERY

The battery makes it possible to store electric energy as chemical energy, and to take it out as electric energy as needed.

Further, a battery is the device that can repeatedly charge and discharge.

(1) Formula of discharging amount

Discharging amount (Ah) = Rated capacity (Ah) × (S.G. when fully charged - S.G. when measuring) / (S.G. when fully charged - S.G. when fully discharged)

In general case :

S.G. when fully charged : 1.26 {20 °C (68 °F)}

S.G. when fully discharged : 1.06 {20 °C (68 °F)}

S.G. : Specific Gravity

Battery capacity is indicated by the electricity amount that can be taken out before the voltage reaches the discharging end voltage, after the fully charged battery is continuously discharged with a electrical current.

Capacity (Ah) = Discharging current (A) × Time until discharging end voltage (Hr)

[Meaning of 45 Ah / 20 Hr]

45 Ah / 20 Hr = 2.25 A ... 20 hour rate current

Capacity is determined when the battery voltage becomes the discharging end voltage, when the battery is discharged for 20 hours at 2.25 A.

(2) Temperature rectification

Temperature compensation should be made for the specific gravity measured by a gravimeter.

This specific gravity value will indicate that "it is low when the temperature is high", and "it becomes high when the temperature becomes low".

Generally, the specific gravity of the electrolyte of battery shall be taken using the temperature of 20 °C (68 °F) as the standard, and as for the rate of the change, the specific gravity decreases by 0.0007 against a temperature increase of 1 °C (34 °F), and the specific gravity increases by 0.0007 against the temperature of 1 °C (34 °F).

It is convenient to use the following formula to convert the specific gravity measured at a certain temperature into the standard temperature of 20 °C (68 °F).

$$S_{20} = S_t + 0.0007 (t - 20)$$

S_{20} : S.G. at the temperature of 20 °C (68 °F)

S_t : S.G. at the temperature of t °C

[Example : In case of electrolyte temperature of 40 °C (104 °F)]

Reading of gravimeter : 1.240

$$S_{20} = 1.240 + 0.0007 (40 - 20) = 1.254$$

Consequently, the S.G. converted into 20 °C (68 °F) is 1.254. If looked at on the gravimeter, it appears that it is discharged by about 10%, however, if converted into the standard temperature, it is practically near to the state of full charge.

The charged or discharged state of battery can be known by measuring the S.G. of the electrolyte.

When measuring S.G., it can easily be performed comparatively by using a suction gravimeter.

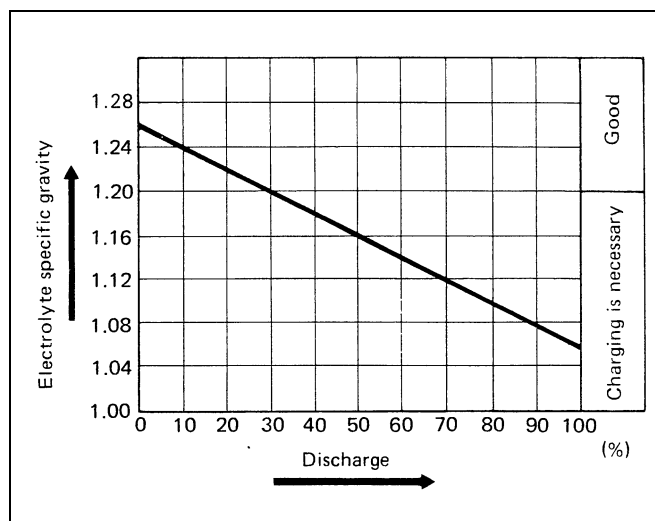


Fig. 9-50 Relation between specific gravity of electrolyte and discharging amount

Gravity of electrolyte 20 °C (68 °F)	State of discharging
1.260	100
1.210	75
1.160	50
1.110	25
1.060	Totally discharged

Fig. 9-51 Specific gravity indication varies with discharging amount

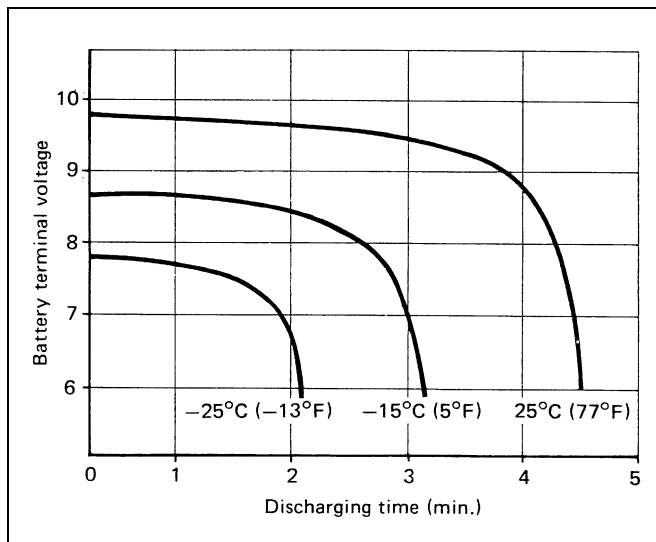
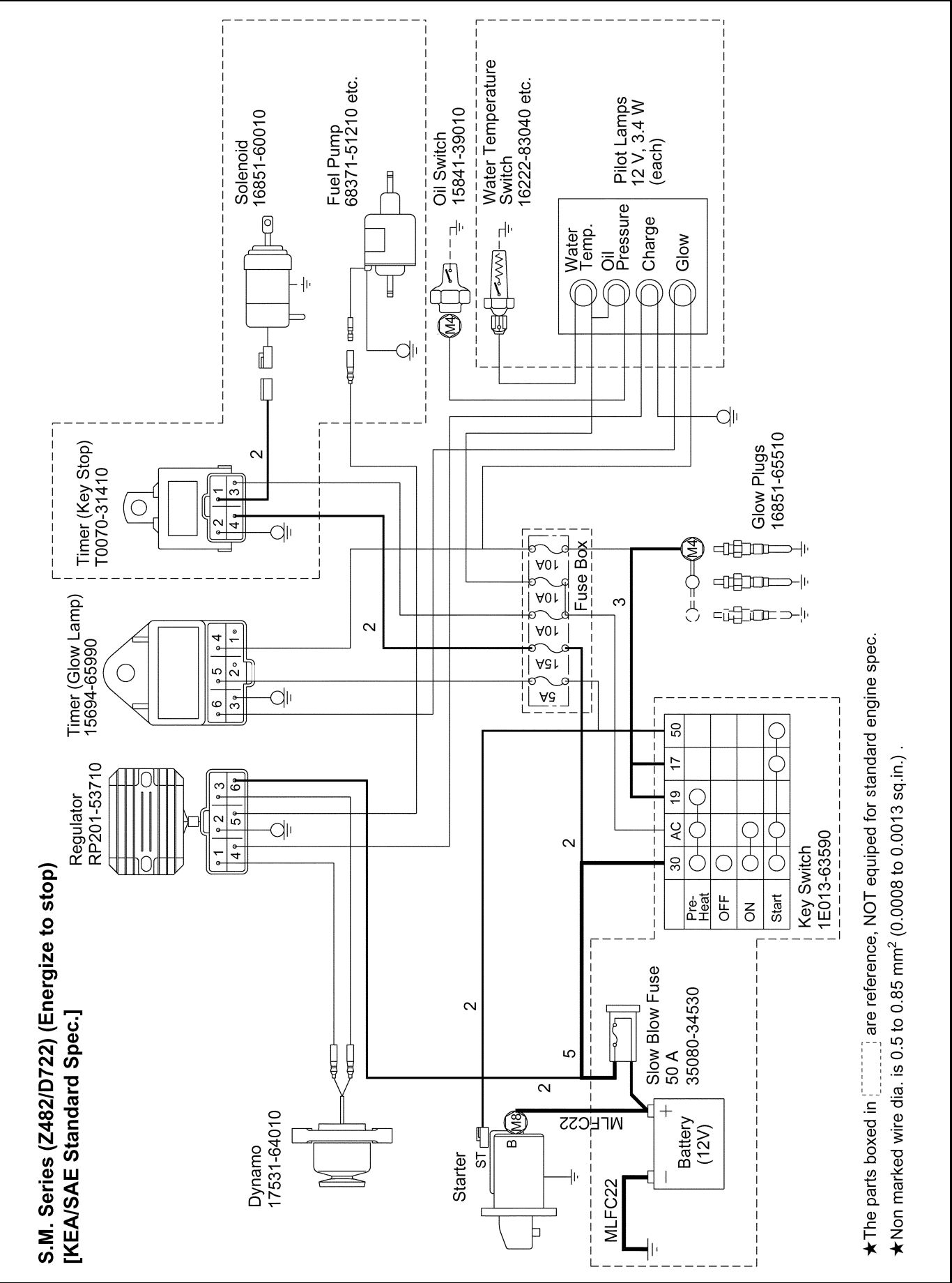
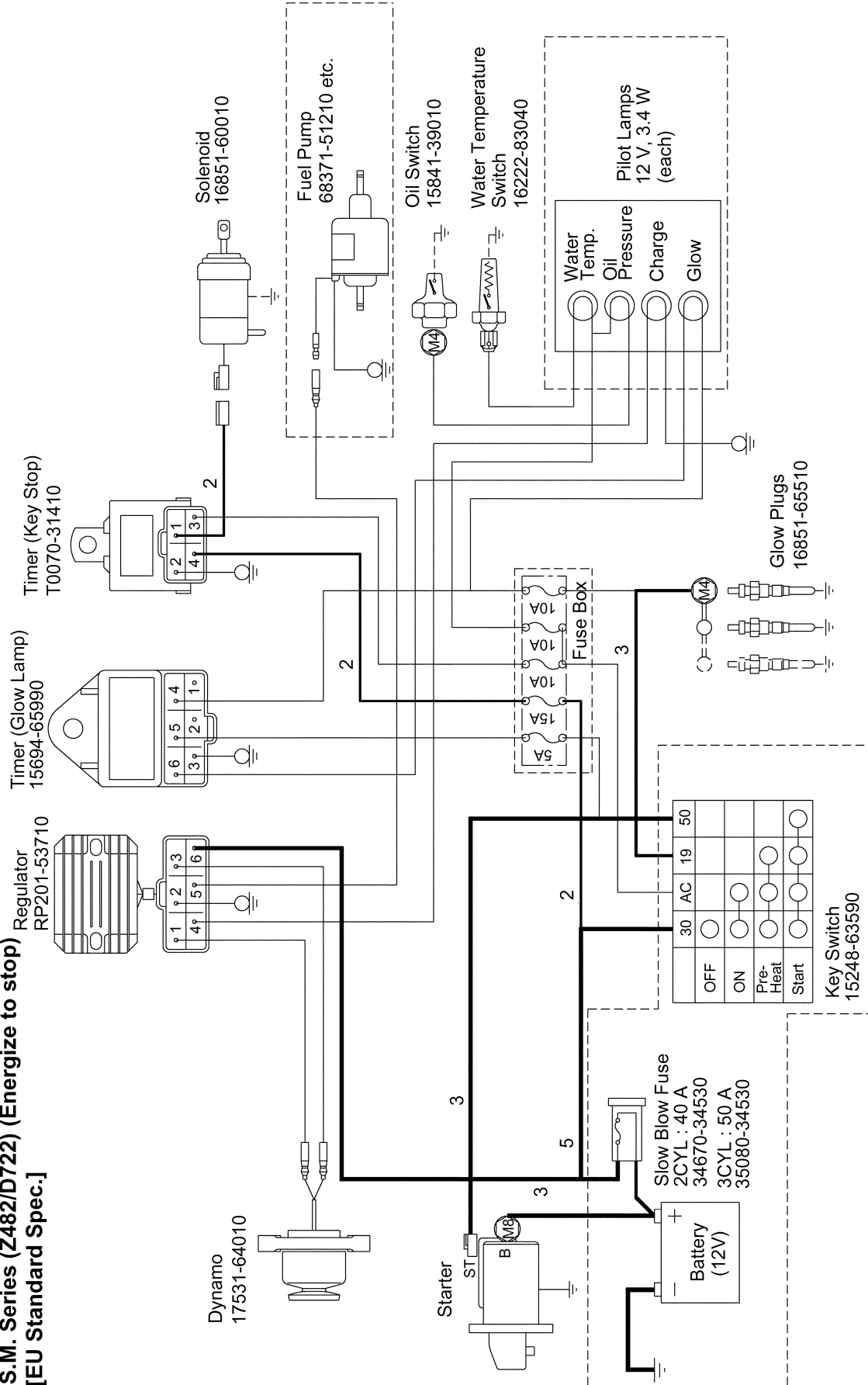


Fig. 9-52 Battery temperature and discharge ability
(Example of N70 : 12 V, 70 A)

9. WIRING DIAGRAM

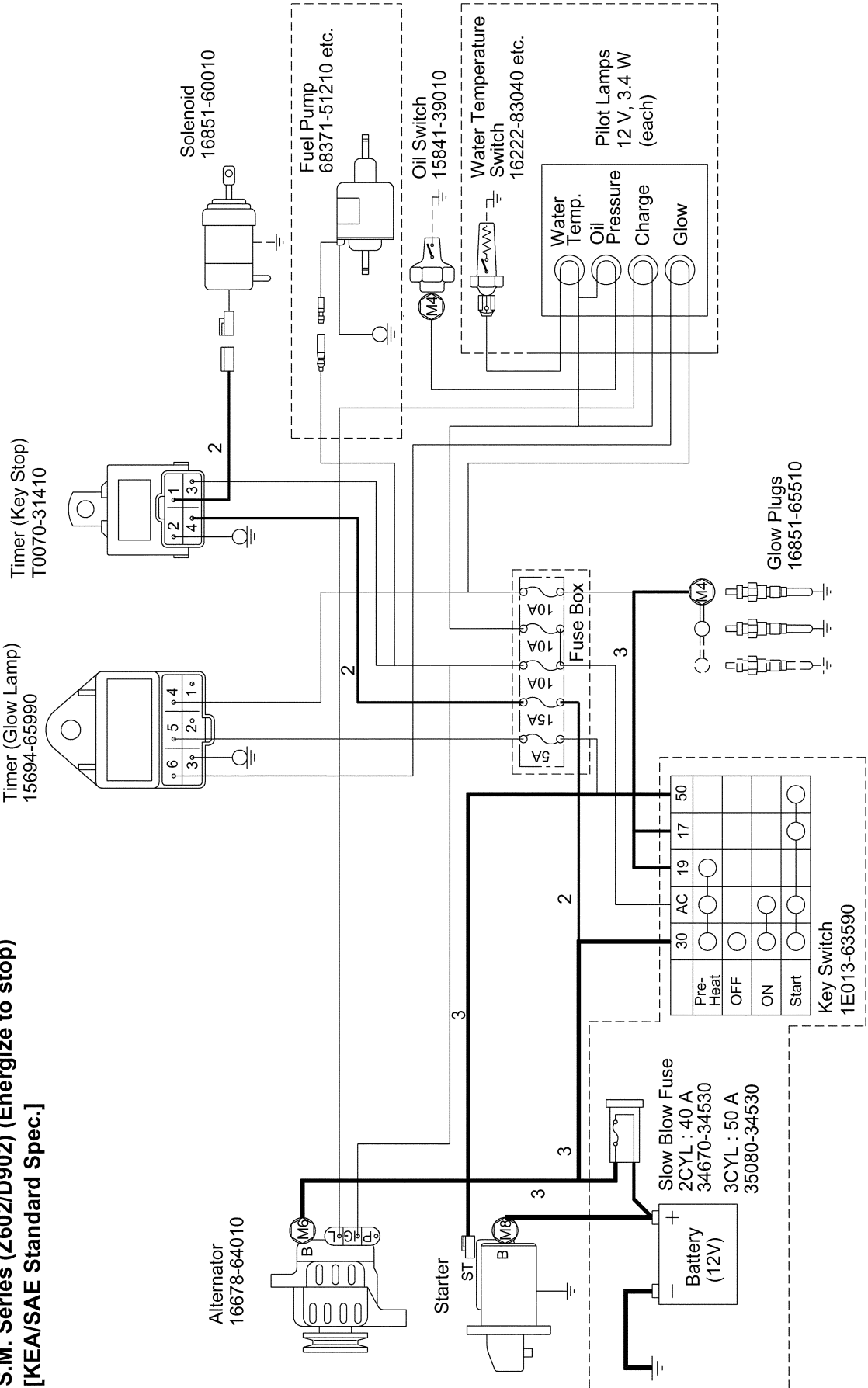


S.M. Series (Z482/D722) (Energize to stop)
[EU Standard Spec.]



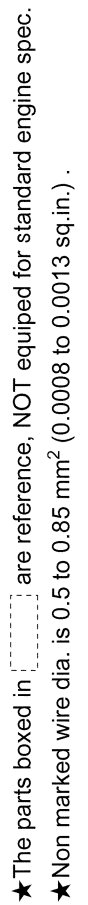
- ★ The parts boxed in [] are reference, NOT equipped for standard engine spec.
- ★ Non marked wire dia. is 0.5 to 0.85 mm² (0.0008 to 0.0013 sq.in.) .

S.M. Series (Z602/D902) (Energize to stop)
[KEA/SAE Standard Spec.]

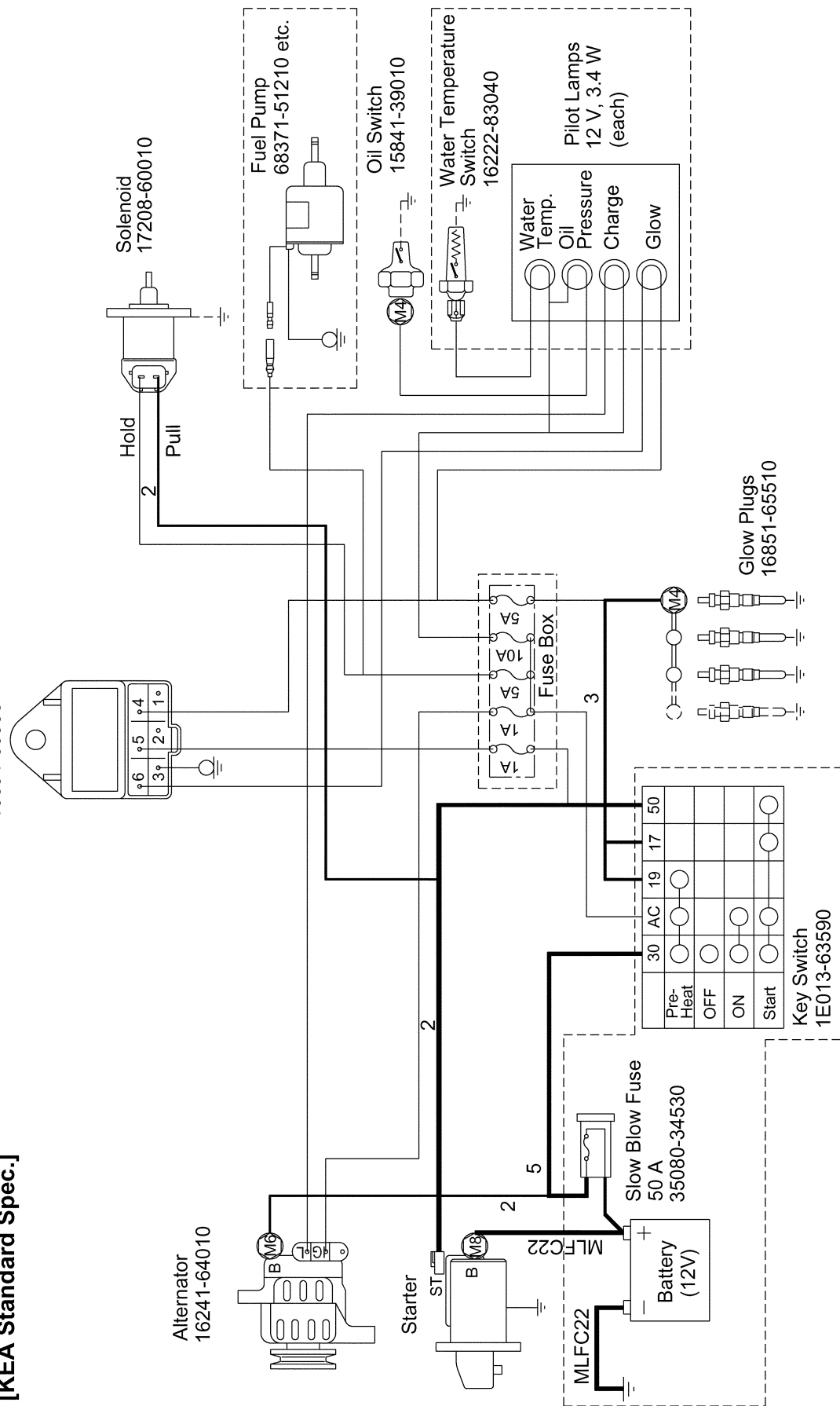


★The parts boxed in [] are reference, NOT equipped for standard engine spec.
★Non marked wire dia. is 0.5 to 0.85 mm² (0.0008 to 0.0013 sq.in.) .

Timer (Key Stop)
T0070-31410



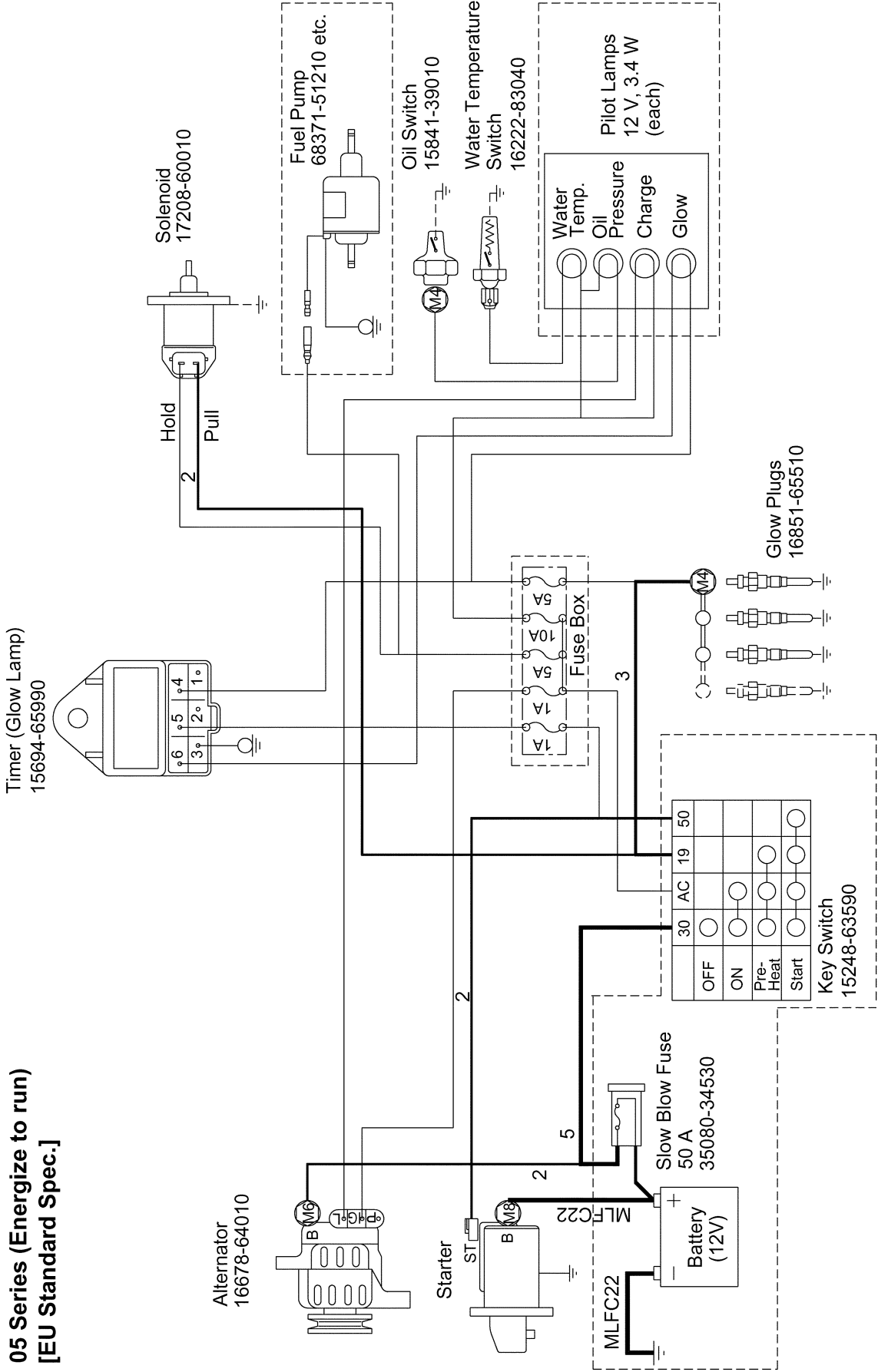
Timer (Glow Lamp)
15694-65990



★The parts boxed in are reference, NOT equipped for standard engine spec.

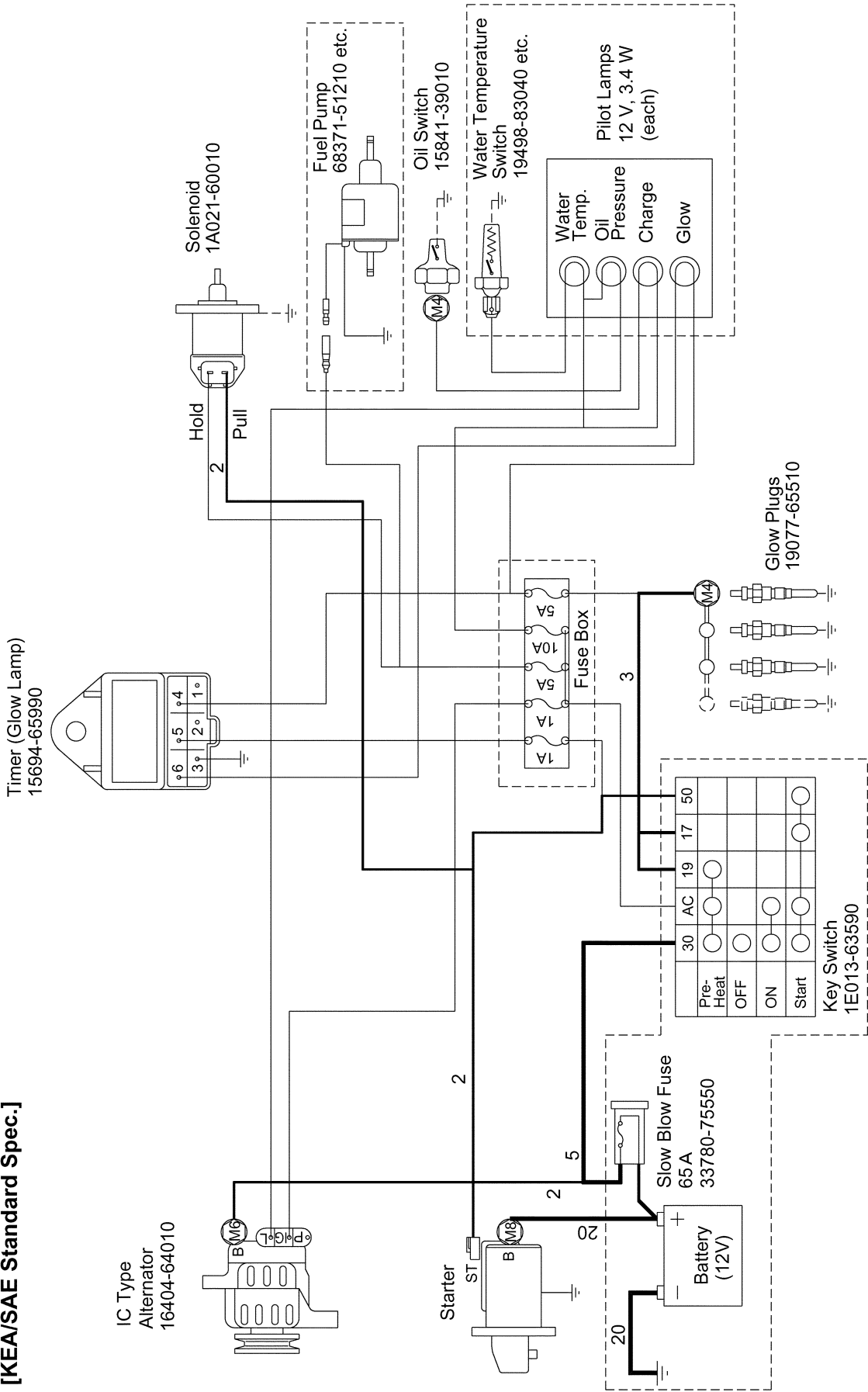
★Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.).

05 Series (Energize to run)
[EU Standard Spec.]



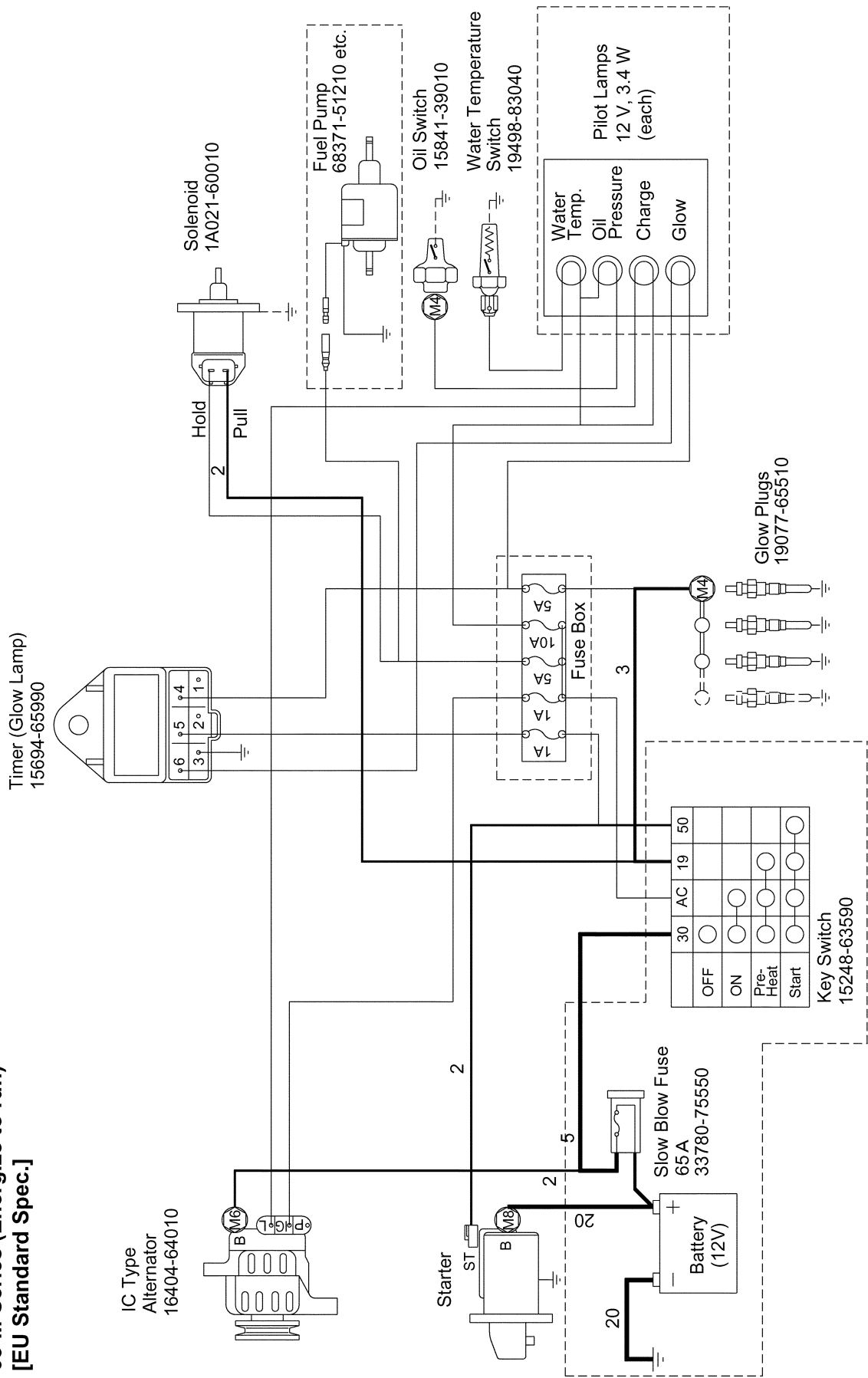
★ The parts boxed in [] are reference, NOT equipped for standard engine spec.
★ Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .

03-M Series (Energize to run)
[KEA/SAE Standard Spec.]



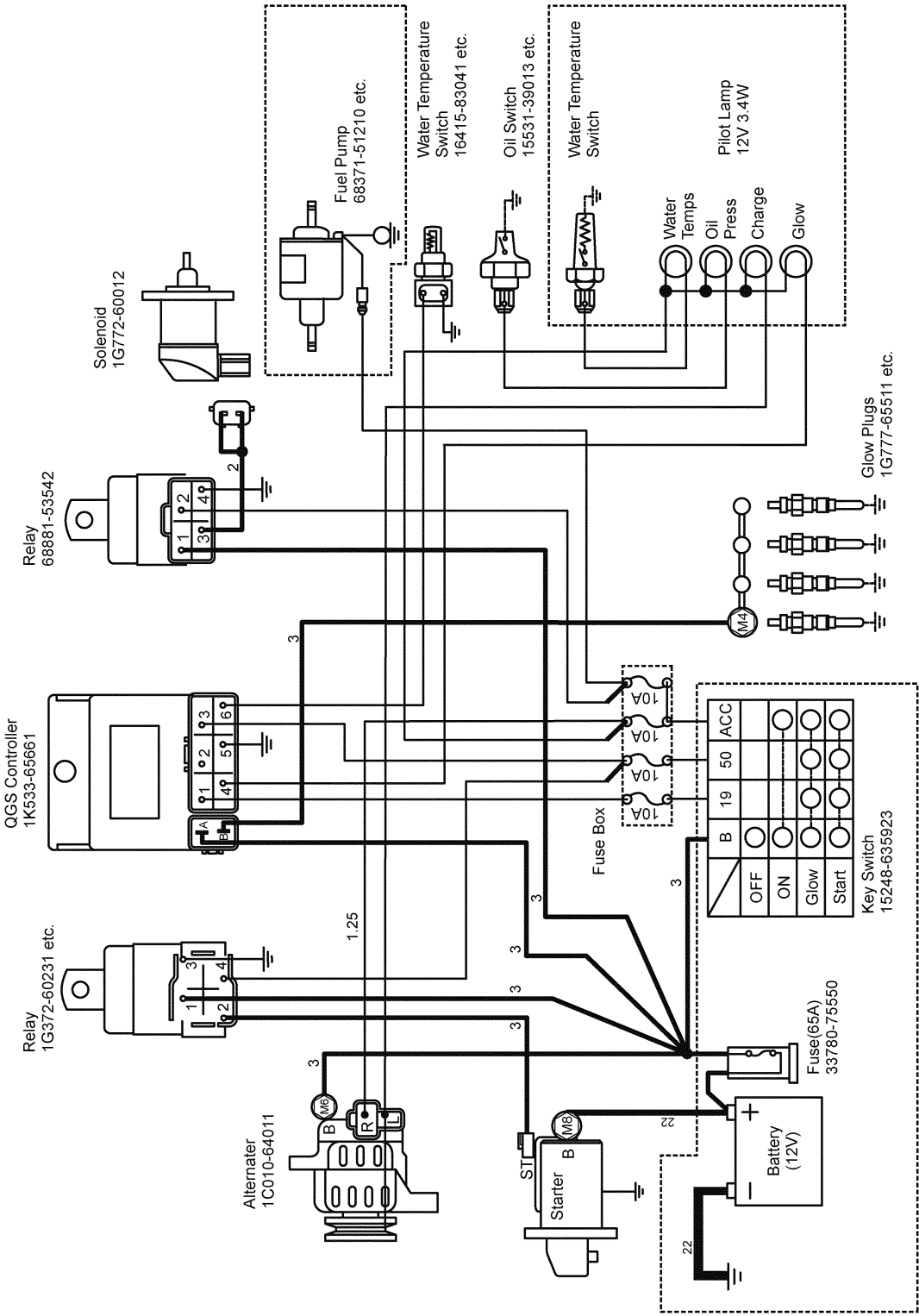
★ The parts boxed in [] are reference, NOT equipped for standard engine spec.
★ Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .

03-M Series (Energize to run)
[EU Standard Spec.]

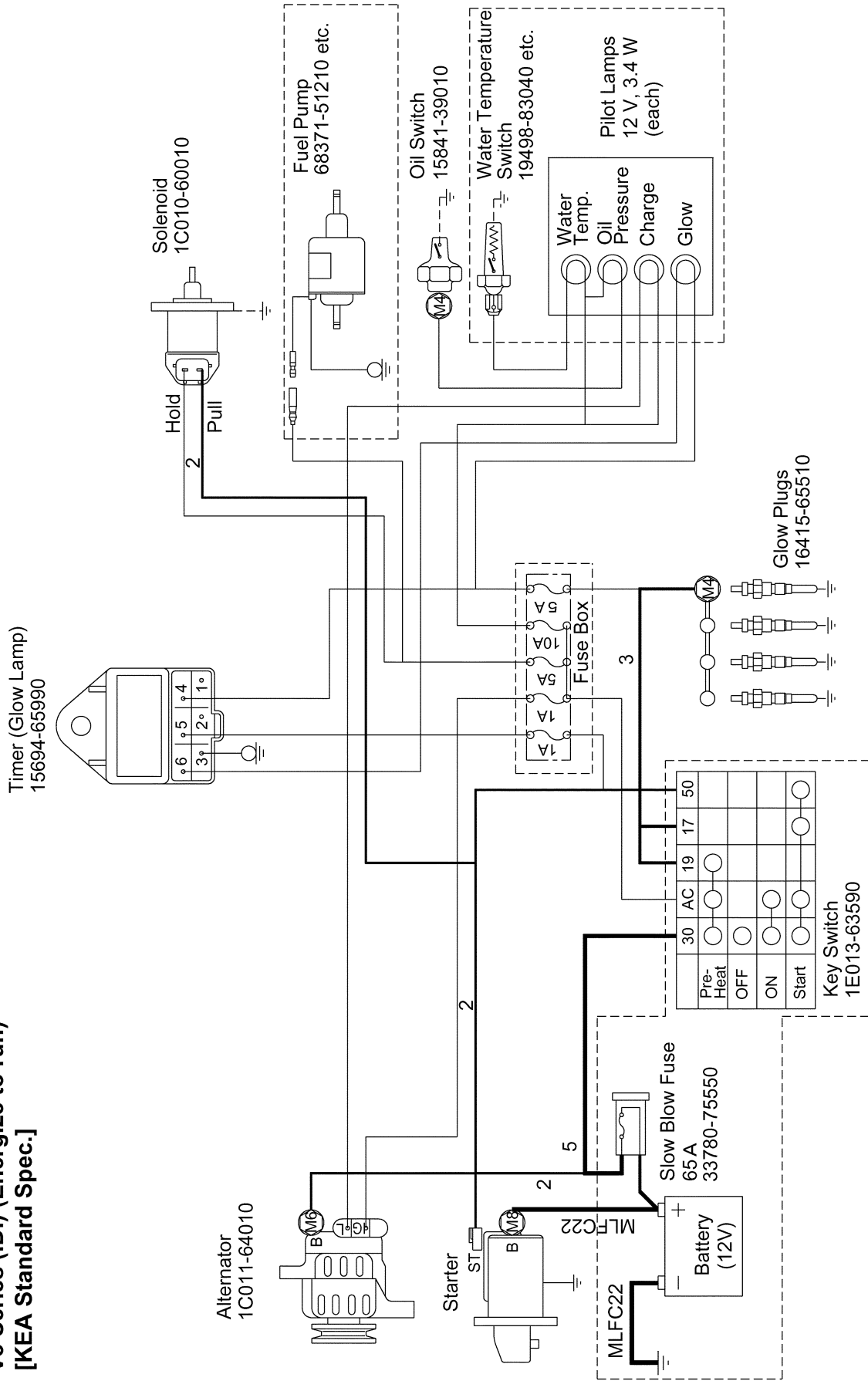


★ The parts boxed in [] are reference, NOT equipped for standard engine spec.
★ Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .

07 Series (V2607/V3307) (Energize to run)
[Standard Spec.]

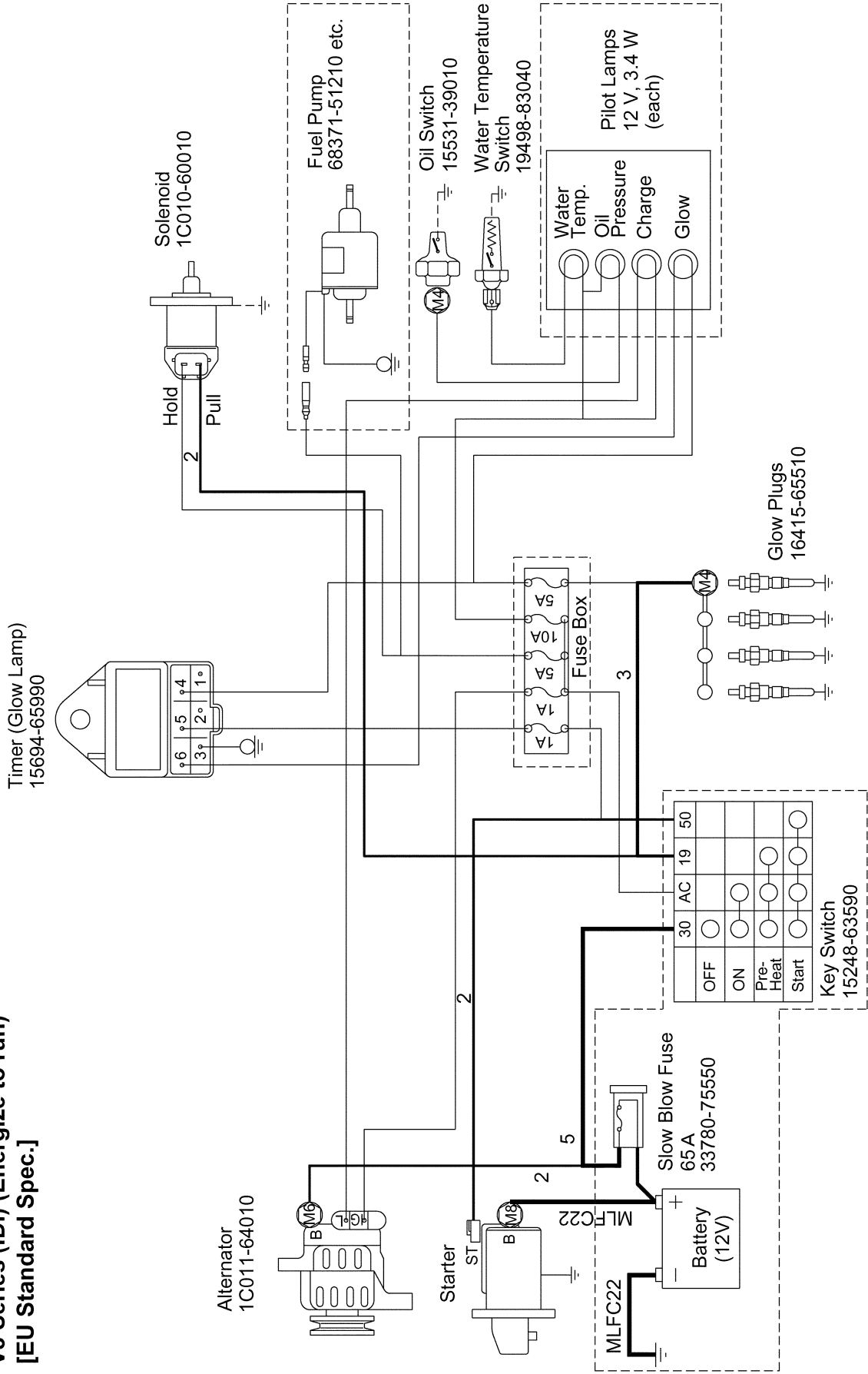


V3 Series (IDI) (Energize to run)
[KEA Standard Spec.]



★ The parts boxed in [] are reference, NOT equipped for standard engine spec.
★ Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .

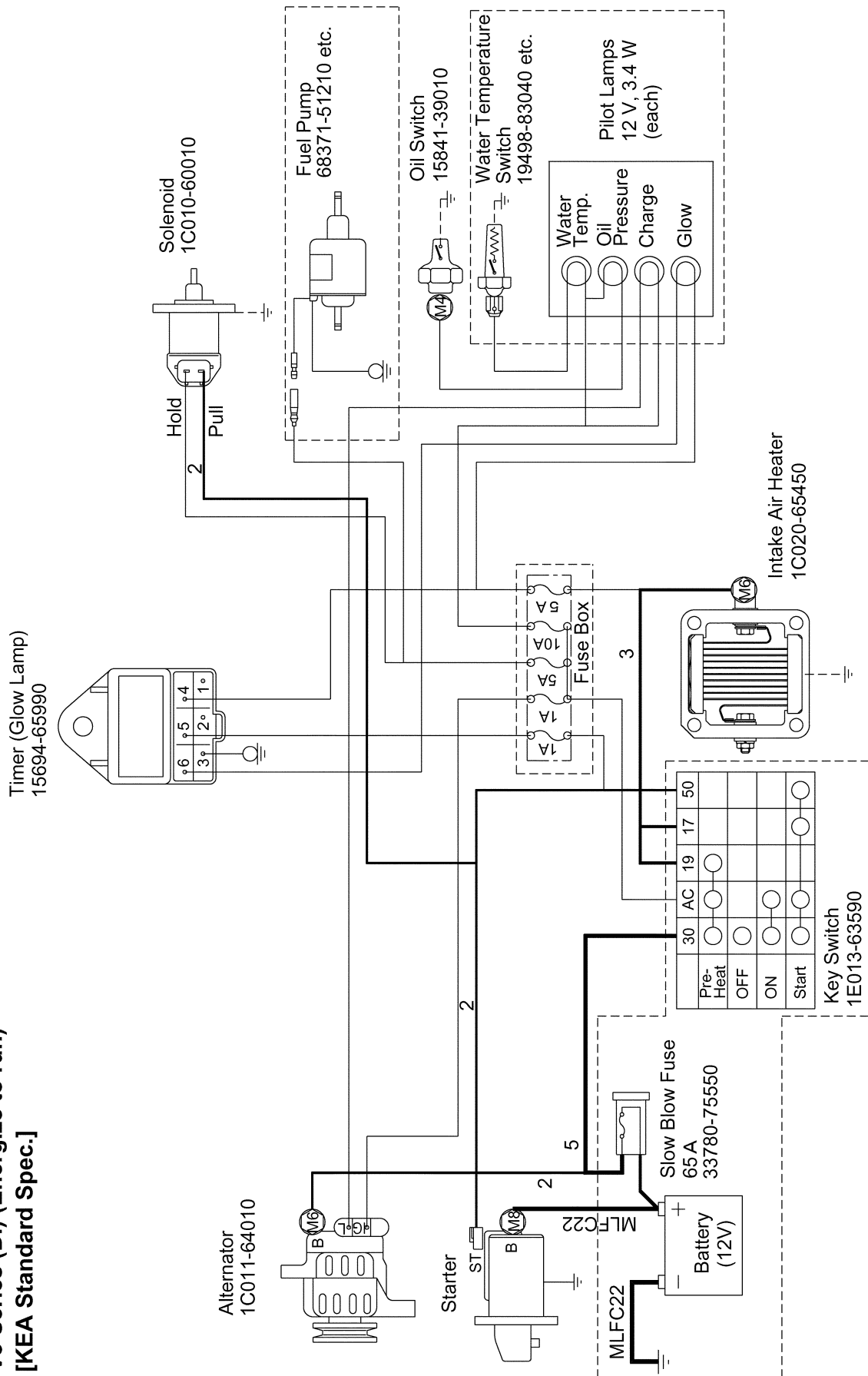
V3 Series (IDI) (Energize to run)
[EU Standard Spec.]



★ The parts boxed in [] are reference, NOT equipped for standard engine spec.

★ Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .

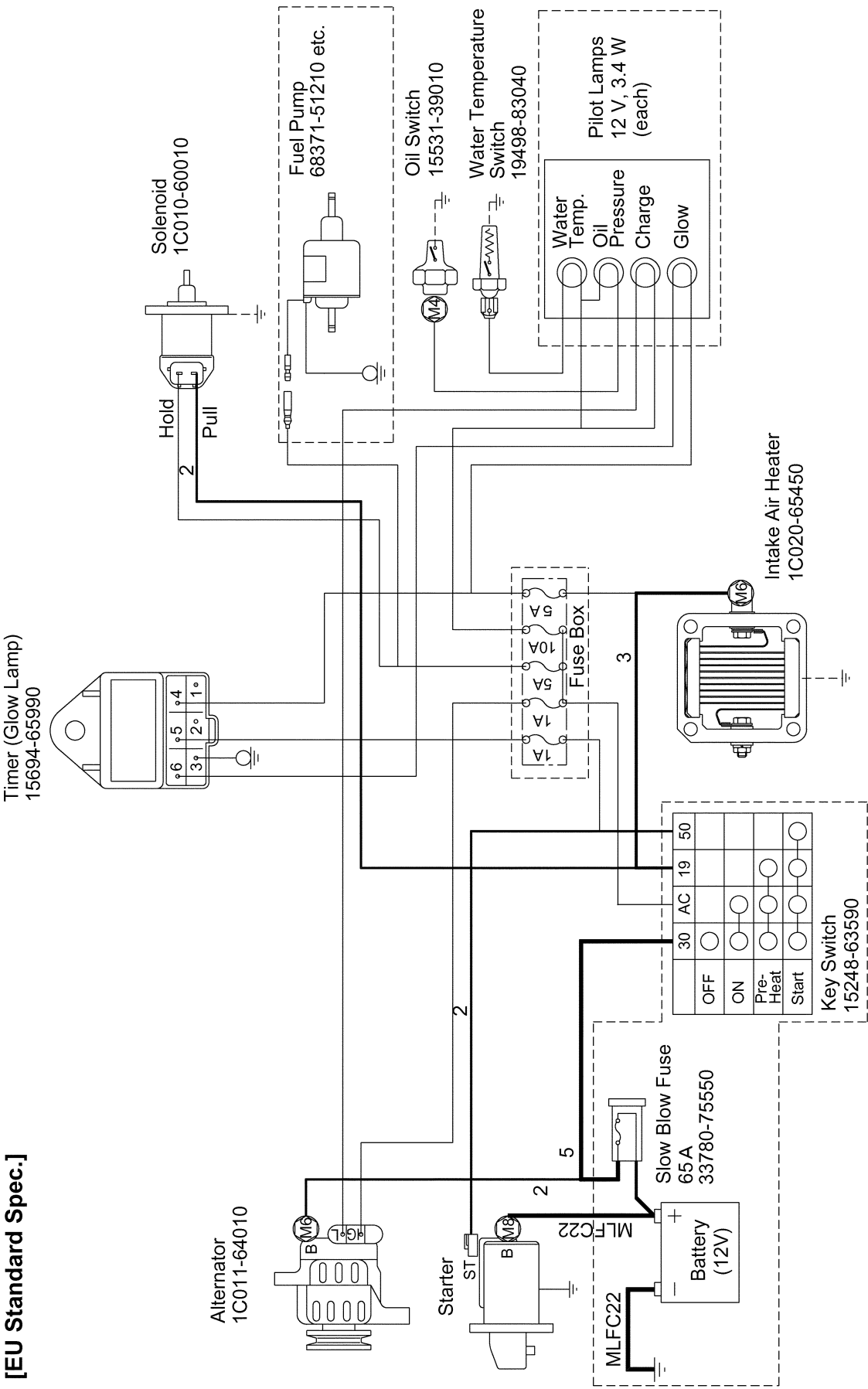
V3 Series (DI) (Energize to run) [KEA Standard Spec.]



★ The parts boxed in [] are reference, NOT equipped for standard engine spec.

★ Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.).

V3 Series (DI) (Energize to run)
[EU Standard Spec.]



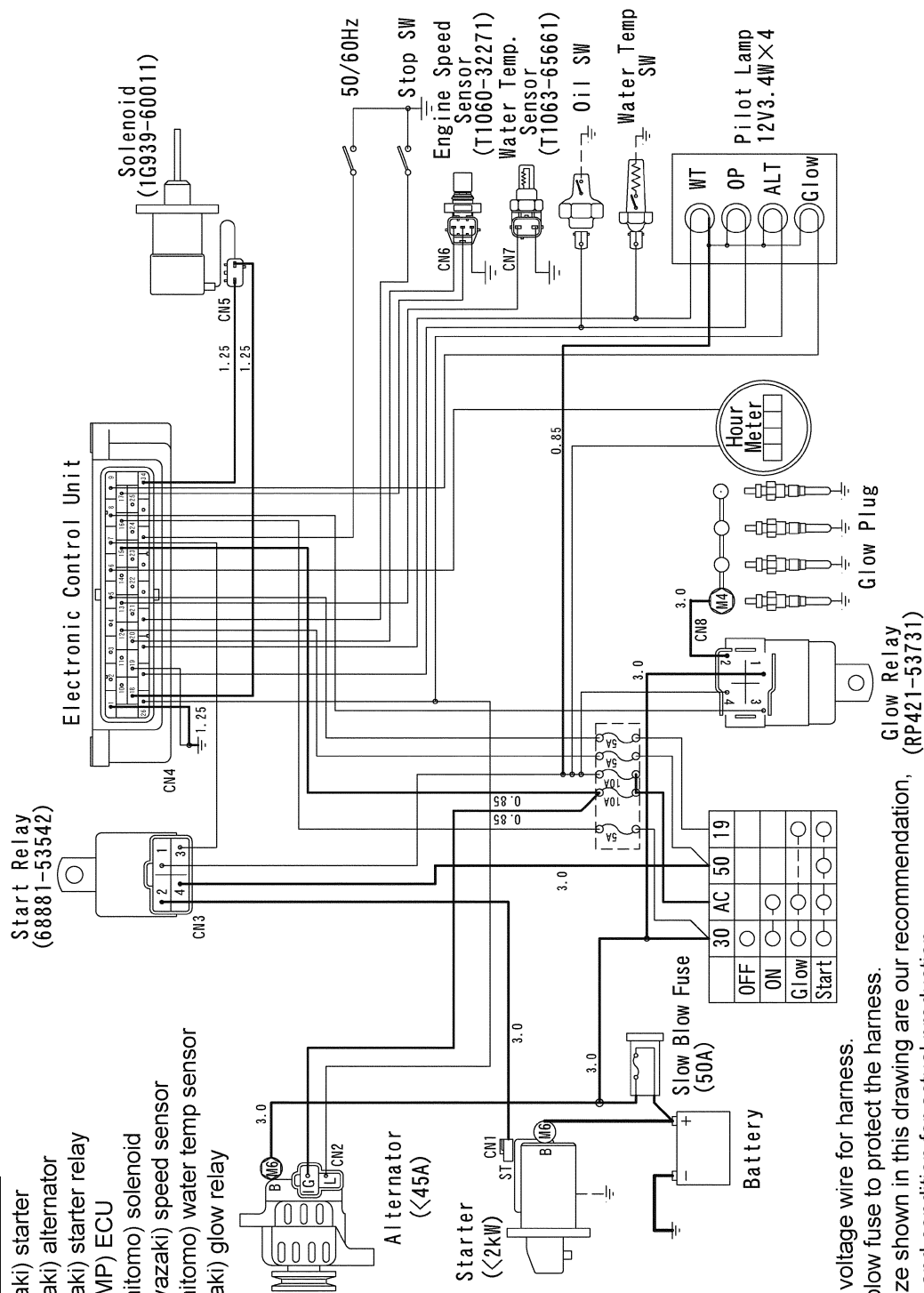
★ The parts boxed in [] are reference, NOT equipped for standard engine spec.

★ Non marked wire dia. is 0.8 to 1.25 mm² (0.0012 to 0.0019 sq.in.) .

03-M Series (Electric governor)

Harness Side Connector Number

- CN1 : 7123-2115 (yazaki) starter
 CN2 : 7123-2128 (yazaki) alternator
 CN3 : 7123-2249 (yazaki) starter relay
 CN4 : 3-1437290-9 (AMP) ECU
 CN5 : 6189-0249 (sumitomo) solenoid
 CN6 : 7283-8732-40 (yazaki) speed sensor
 CN7 : 6189-0552 (sumitomo) water temp sensor
 CN8 : 7123-9246 (yazaki) glow relay



1. Use automotive low voltage wire for harness.
2. Use fuse and slow-blow fuse to protect the harness.
3. The wire and fuse size shown in this drawing are our recommendation, consider wire length and condition for actual production.
4. Allocate slow-blow fuse close to battery, fuse box close to key switch.
5. Do not directly connect induction device, such as motor, to AC line.
6. Use more than 0.5 mm² wire for unspecified wires in this drawing.

10. PTO SYSTEM

CONTENTS

1. GENERAL		10-1
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3. FRONT OF CRANKSHAFT (Radiator side)		10-3
4. FRONT AND REAR OF FUEL CAMSHAFT		10-8
5. GOVERNOR SHAFT FOR 05 SERIES		10-9
6. SIDE PTO FOR 07 SERIES (Option)		10-9
7. GEAR CASE DRIVE KIT FOR V3 SERIES		10-10

PTO SYSTEM

1. GENERAL

Power can be taken off a KUBOTA engine from the following points within a certain range dictated by total engine output.

Power can be taken from the engine at several points. The amount of power that can be taken at a position may be 100% (Full engine horse power) or less than that. This depends on strength of engine components (Example : At fuel camshaft parts are smaller), type of drive component and direction of power take - off.

To ensure proper engine performance and long life the drive system must be carefully designed. A review by KUBOTA is recommended.

PTO Usage						
PTO Position	Notes	S.M.	05	03-M	07	V3
Crank Front	Auxiliary Power	Yes	Yes	Yes	Yes	Yes
Crank Rear	Main Power	Yes	Yes	Yes	Yes	Yes
Governor Shaft	Hydraulic Pump		Yes		No	
Rear of Fuel Camshaft	Hydraulic Pump	Yes	No	Yes	No	
Front of Fuel Camshaft	Tachometer	Yes	Yes	Yes	No	Yes
Gear case	Hydraulic Pump	No	No	Option	Yes	Yes

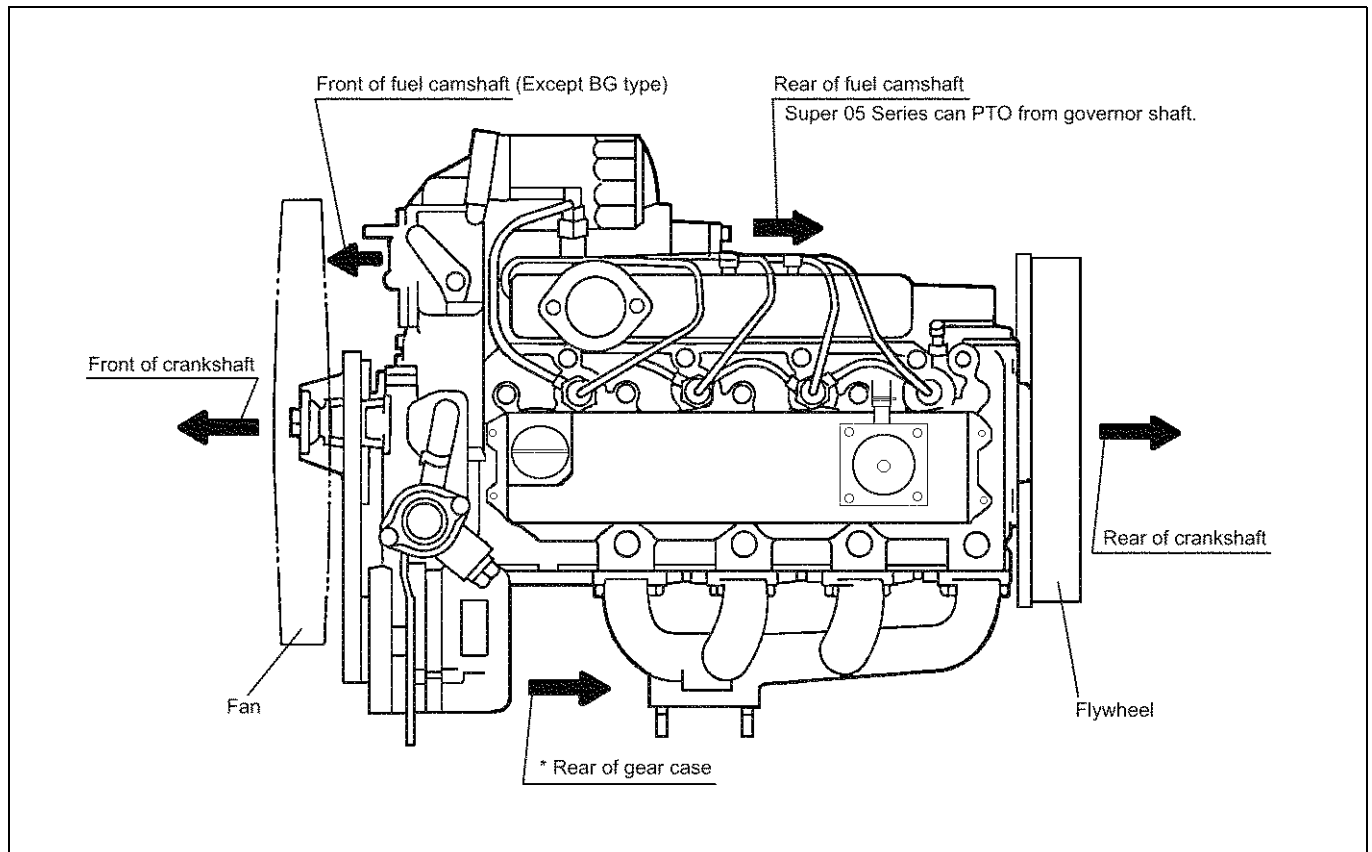


Fig. 10-1

Table of PTO

	Location		Application	Connecting method	Remarks
1	Rear of crankshaft		Main power	Flange direct-coupling	
				Belt drive by pulley	
2	Front of crankshaft		Auxiliary power drive	Rotation transmission by concentric shaft	Ex. Air Conditioning
				Belt drive by pulley	
3	Fuel camshaft	Front	Tachometer	Oldham	Contact KUBOTA for available power
		Rear	Hydraulic pump	Spline or oldham	
4	*Side PTO		Hydraulic pump	Spline	
5	*Governor shaft		Hydraulic pump	Oldham	Only 05 series

Note : 1. Rear : Flywheel side

2. *marked location : Available model is limited.

3. The transmissible power slightly varies with models and positions.

2. REAR OF CRANKSHAFT (Flywheel side)

(1) For direct connection with housing

1) Housing

Join flange faces and tighten bolts (by pilot dia or knock pin).

2) Rotating body

Join flywheel mounting face with flange face and tighten bolts (by dowel).

3) Precision of case and rotating body

Rigid connection of the PTO, marine gear or transmission to the engine flywheel housing can make the system compact. Special attention should be paid to the assembly precision for this type of connection.

Improper assembly will result in excessive power loss premature parts failure.

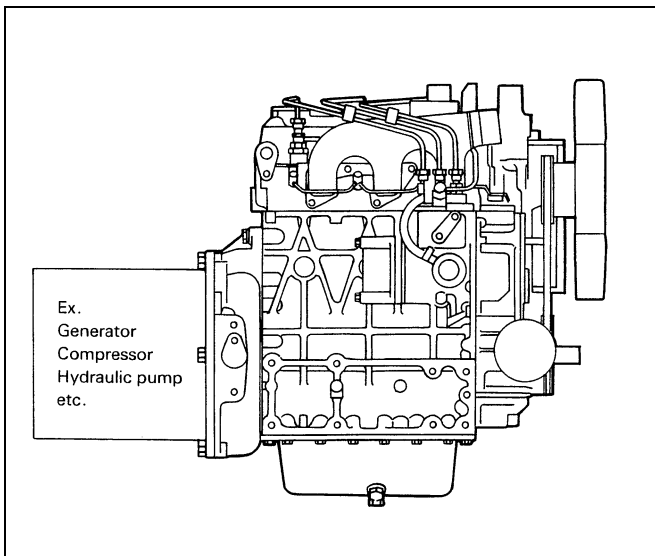


Fig. 10-2

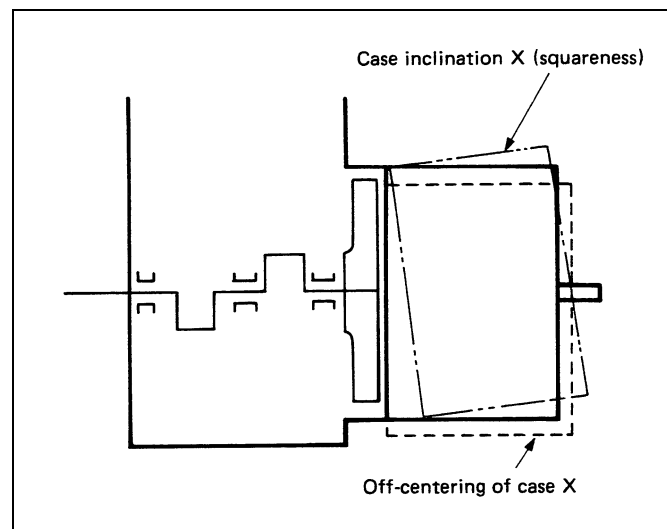


Fig. 10-3

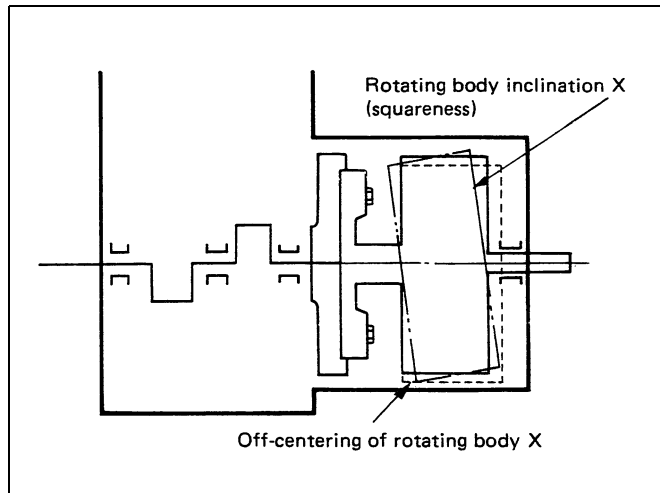


Fig. 10-4 Precision of rotating body

(2) For using belt**1) Direction**

- a) When taking power off in two directions, arrange so that tension is offset.
- b) When taking motive power off in one direction, take it off downward. Ensure that side load is within KUBOTA's specs.

2) Available load

Determine by referring to "Table of PTO" in page 10-2 and Fig. 10-5.

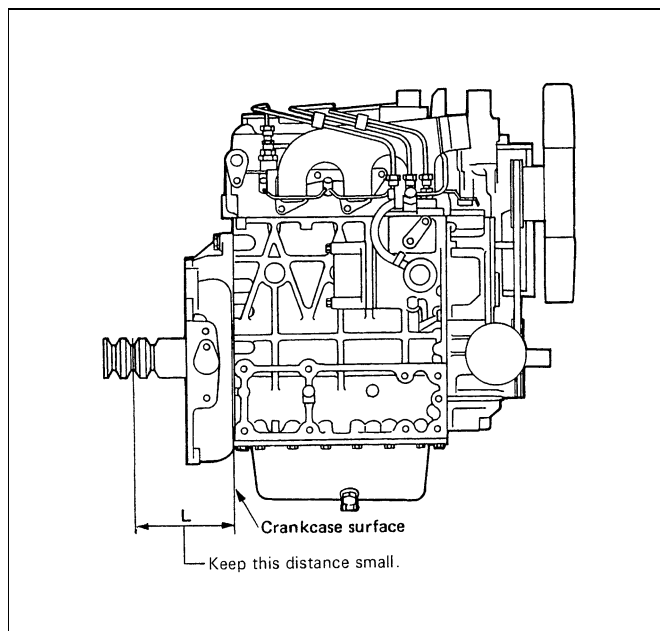


Fig. 10-5

3) When using belt

When belt driving is used, careful consideration must be given to the amount of overhang and size of load, allowable load must be strictly observed, belt tension also greatly influences load. Belt must be tightened as specified.

3. FRONT OF CRANKSHAFT (Radiator side)

(1) Taking off in axial direction

- a) Take off from the same shaft center via a flange coupling (concentric).

Note :

- 1. PTO should be able to be dismantled easily when replacing the fan belt.
- 2. Since spline is formed at the crankshaft end, an adapter suitable to the spline required.

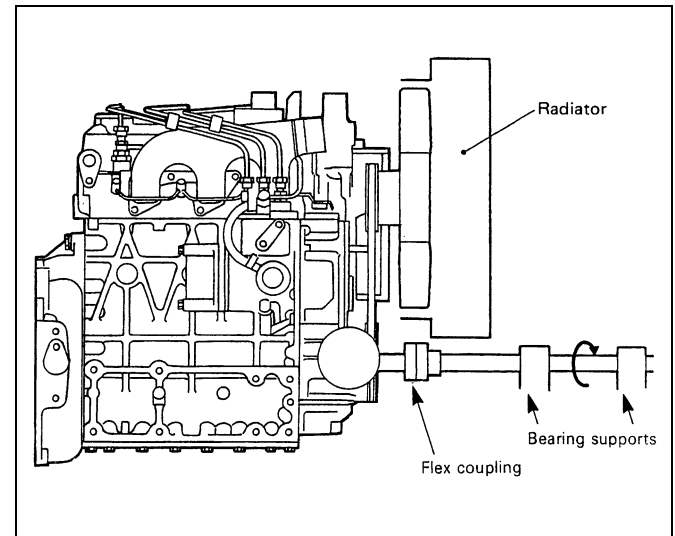


Fig. 10-6

- b) An example of front PTO for 03-M series.

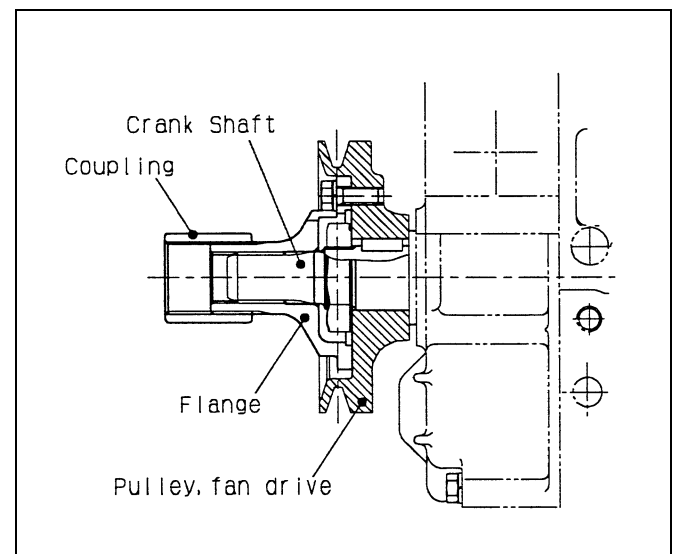


Fig. 10-7

(2) For using belt**1) Direction**

- When taking power off in two directions, arrange so that the tension is offset.
- When taking power off in one directions, take it off downward. Ensure that side load is within KUBOTA's specs.

2) Available load

Determine by referring to "Table of PTO" in page 10-2 and Fig. 10-8.

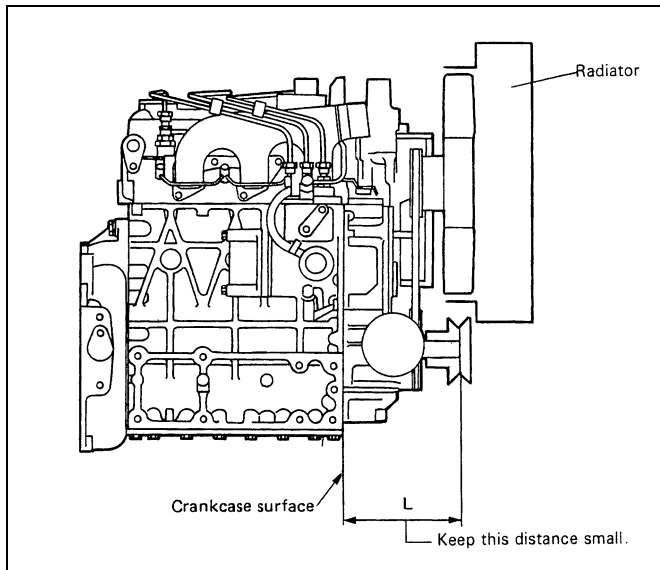


Fig. 10-8

[Power Take-off Recommendations]

- If PTO shaft length are too long, an outboard bearing must be added.
- Flexible couplings allow a little miss alignment between engine and drive device.
They also dampen inertial loads, they must be used, along with outboard bearing, for front PTO drives.
- Power disconnects (Clutches, Hydraulic unloader valve, etc.) reduce the load on the engine when being started.
Using them may eliminate the cost of adding a heavy duty starter.
- SAE housings allow direct coupling of industry standard generators, clutches and pumps.
- To minimize the possibility of excessive overhang when driving two separate loads through two separate belts, it is best to place the two loads as directly opposite each other as possible.
- To reduce overhang, belt drive pulleys must be as close to the engine as possible.

(1) Side load calculation for V-belt drive application

When V-belt pulley is used for PTO according to the following procedure, confirm that the position of the pulley is within the allowable limit.

Even if it is located within the limit, minimize the overhang as much as possible to avoid any side load problems.

Also, tension of the belt is very important for the life of the bearing of the engine and the belt.

Follow the recommendation of the belt manufacture for tensioning the belt.

The following calculation method is only a reference for designing. Therefore, it is important to eventually carry out the actual operation test or the endurance test using the actual machine to check for problems.

(2) Procedure to determine the allowable side load**1) Find the design horsepower Pd**

- Select the service factor Ks from Table No.1 depending on the type of the driven machine and the service cycle.

If can not find you machine on Table No.1 use 1.3 as the service factor.

- Calculate the Design Horsepower according to Formula No.1.

$$Pd = Ks \times Pr \dots (\text{Formula No.1})$$

Pd : Design Horsepower (HP)

Pr : Required Horsepower for the machine (HP)

Ks : Service Factor

2) Find the shaft load

- Calculate Ψ or $(D-d) / c$

$$\Psi = 180 - 57 (D-d) / c \dots (\text{Formula No.2})$$

Ψ : Arc of contact on small sheave (deg)

D : Diameter of large sheave (mm or in.)

d : Diameter of small sheave (mm or in.)

c : Center distance between both sheave (mm or in.)

b) Find the Arc correction factor $K \Psi$ from Fig. 10-9.

c) Calculate the belt speed.

$$V = (d \times N) / 3.82 \dots (\text{Formula No.3})$$

V : Belt speed (ft/min)

d : Diameter of small (large) sheave (in.)

N : Small (large) sheave speed (rpm)

or

$$V = (d \times N) / 318.3 \dots (\text{Formula No.3})$$

V : Belt speed (m/min)

d : Diameter of small (large) sheave (mm)

d) Calculate the shaft load F_d .

$$F_d = 33000 \times [(2.5 - K \Psi) / K \Psi] \times (P_d / V) \dots (\text{Formula No.4})$$

F_d : Shaft load (lbs)

or

$$F_d = 4500 \times [(2.5 - K \Psi) / K \Psi] \times (P_d / V) \dots (\text{Formula No.4})$$

F_d : Shaft load (kg)

(3) Find the allowable overhang from the engine according to Fig. 10-10 and design the position within the allowable limit.

For reference, attached the information about the dimension from the crankcase to the flywheel and the fan drive pulley. (Table No.2)

ARC CORRECTION FACTOR $K \Psi$

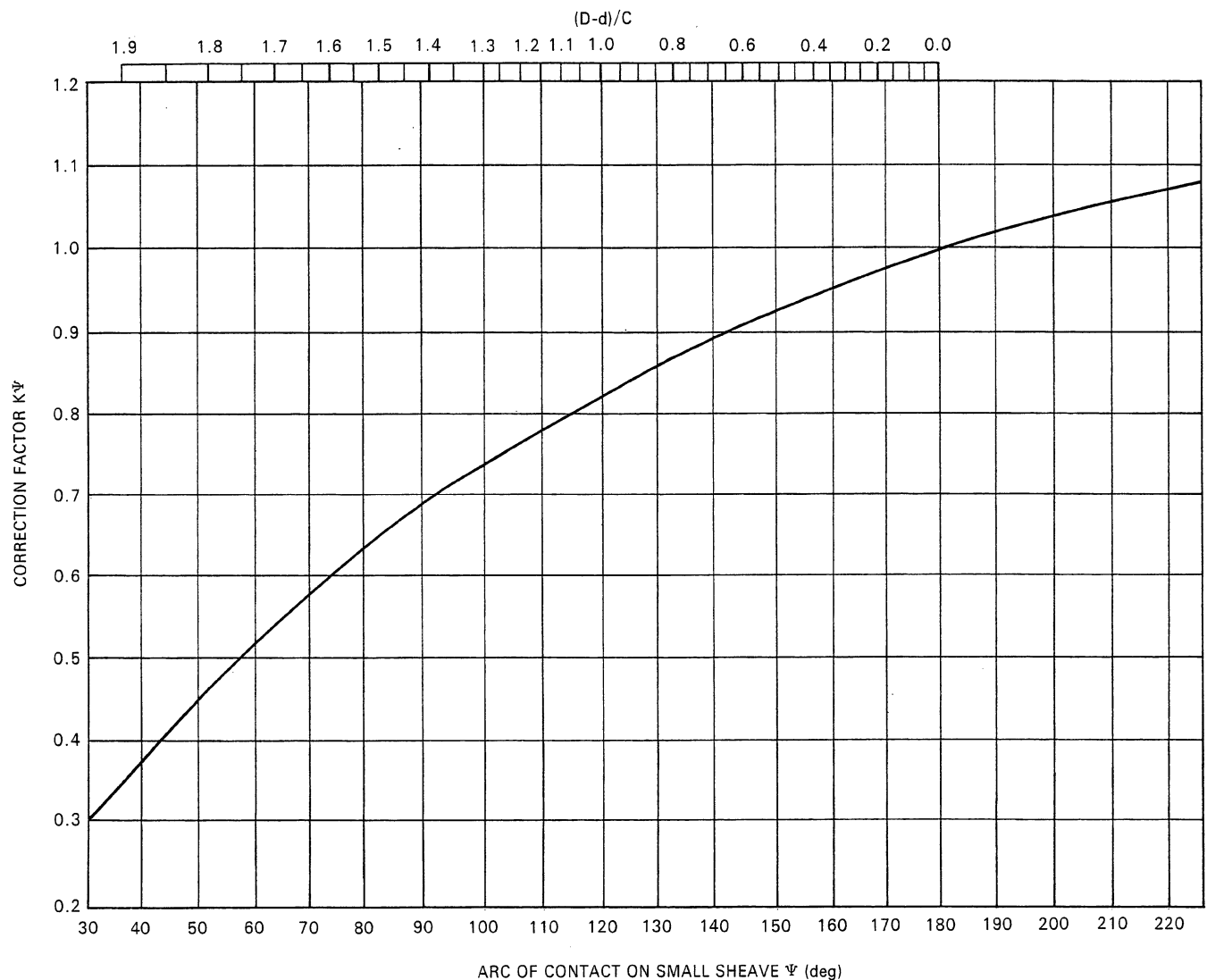


Fig. 10-9

TABLE NO.1 SERVICE FACTORS

Driven Machine	Type of Service		
	I	II	III
Agitators for Liquids	1.0	1.1	1.2
Blowers and Exhausters			
Centrifugal Pumps & Compressors			
Fans up to 10 Horsepower			
Light Duty Conveyors			
Belt Conveyors for Sand, Grain, etc	1.1	1.2	1.3
Dough Mixers			
Fan Over 10 Horsepower			
Generators			
Line Shafts			
Laundry Machinery			
Machine Tools			
Punches - Presses - Shears			
Printing Machinery			
Positive Displacement Rotary Pumps			
Removing and Vibrating Screens	1.2	1.3	1.4
Brick Machinery			
Bucket Elevators			
Exciters			
Piston Compressors			
Conveyors (Drag - Pan - Screw)			
Hammer Mills			
Paper Mill Beaters			
Piston Rumps			
Positive Displacement Blowers			
Pulverizers			
Saw Mill and Woodworking Machinery			
Textile Machinery			
Crushers (Syratory - Jaw - Roll)	1.3	1.4	1.5
Mills (Ball - Rod - Tube)			
Hoists			
Rubber - Extruders - Mills			

TYPE OF SERVICE

I : Intermittent Service	3-5 Hours Daily or Seasonal
II : Normal Service	8-10 Hours Daily
III : Continuous Service	16-24 Hours Daily

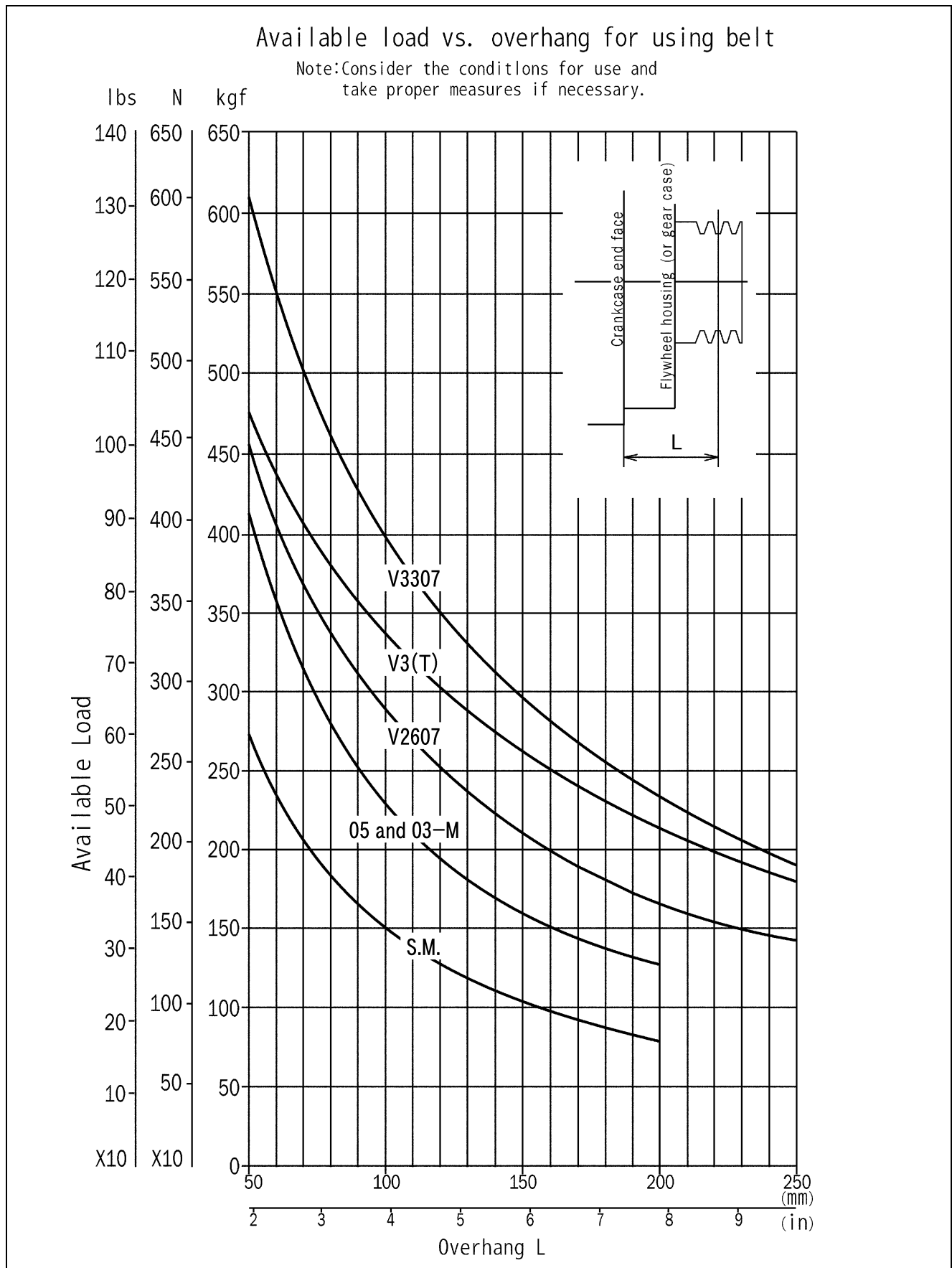


Fig. 10-10

4. FRONT AND REAR OF FUEL CAMSHAFT

(1) Front of fuel camshaft or camshaft

Driving a tachometer or small pump, the small amount of power required can be taken off by making a connection with slot fitting of camshaft's end face.

Connect with bolts at the flange joint face.

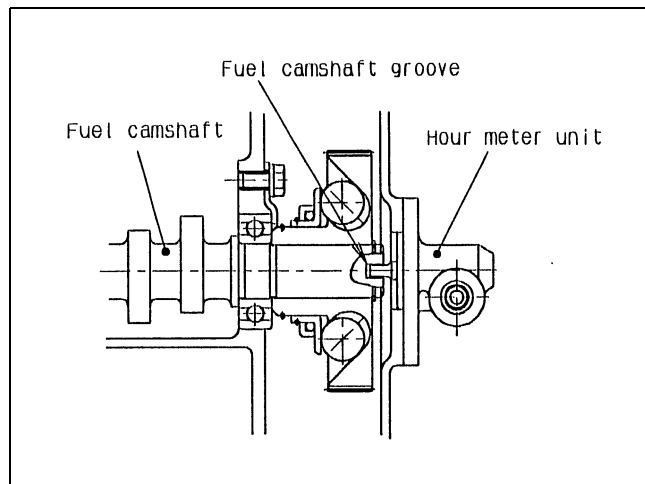


Fig. 10-11

(2) Rear of fuel camshaft

The hydraulic pump is mounted here by a holder and driven by an arrangement of gears.

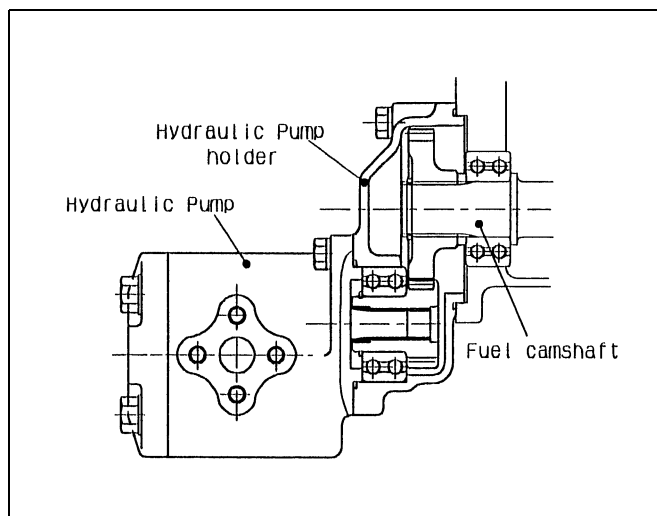
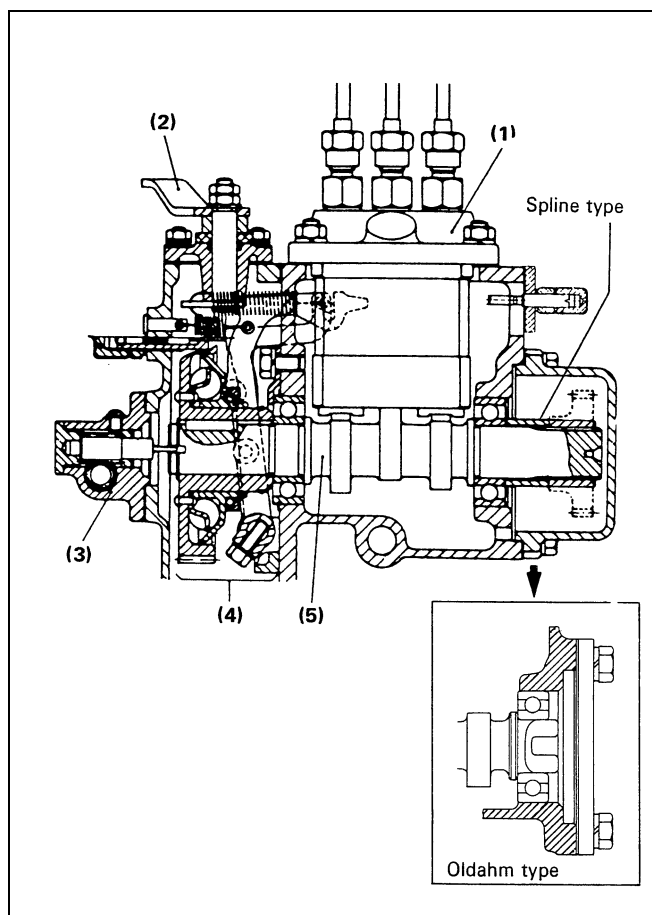


Fig. 10-12



(1) Injection pump	(4) Governor system
(2) Speed control lever	(5) Fuel camshaft
(3) Hour meter unit	

Fig. 10-13

5. GOVERNOR SHAFT FOR 05 SERIES

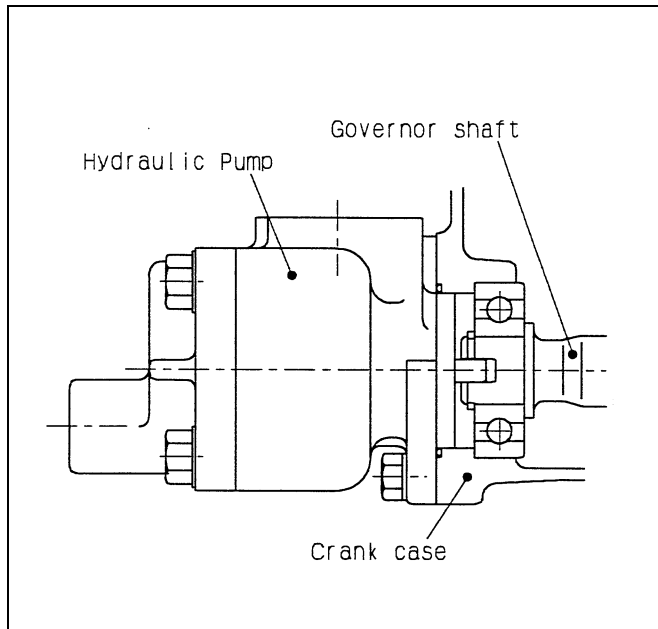


Fig. 10-14

6. SIDE PTO FOR 07 SERIES (Option)

1) V2607

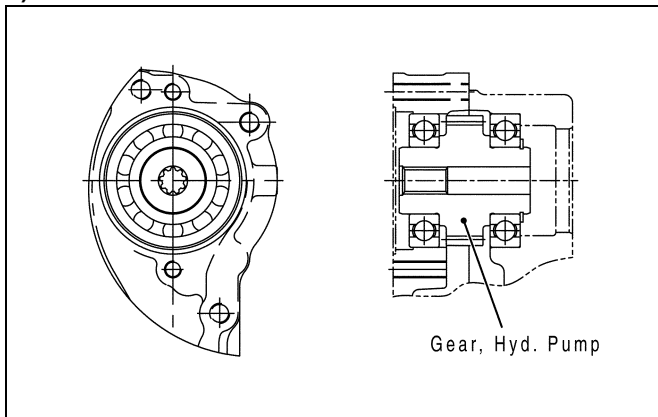


Fig. 10-15

2) V3307

A Type PTO

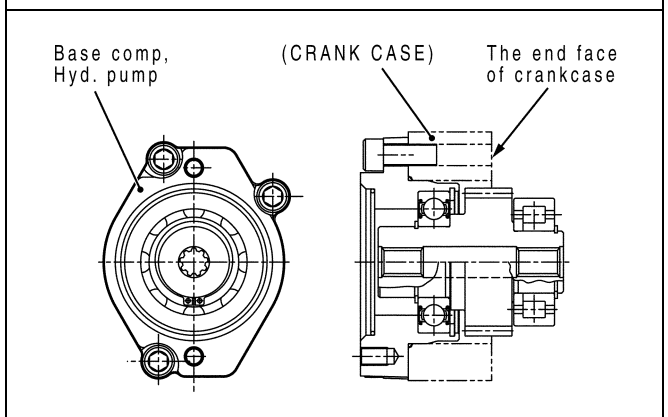


Fig. 10-16

B Type PTO

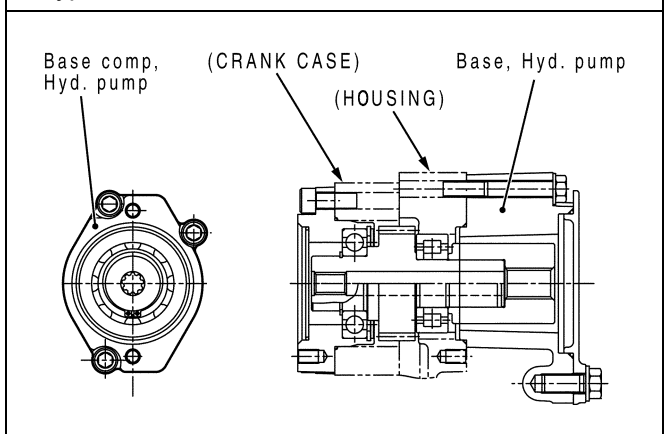


Fig. 10-17

7. GEAR CASE DRIVE KIT FOR V3 SERIES

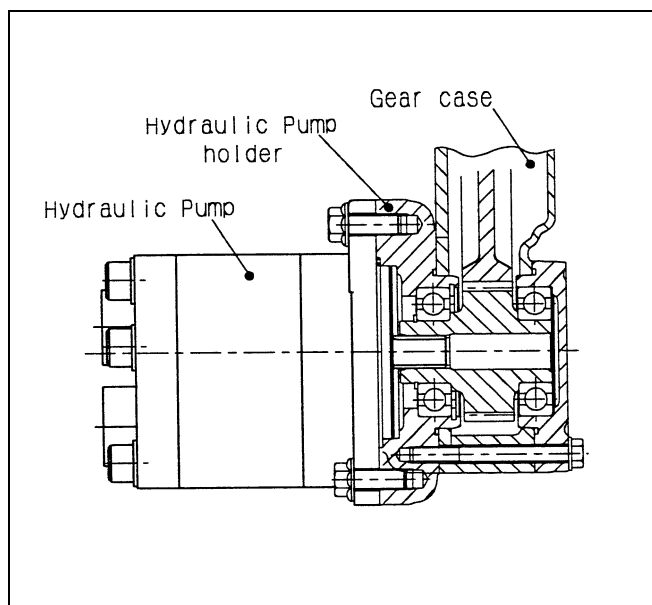


Fig. 10-18

11. MOUNTING SYSTEM

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MOUNTING SYSTEM

1. GENERAL

When setting an engine on a machine, major importance should be given to assembling with precision the parts connected to flywheels, and crank shafts which rotate at high speeds.

The following points must be carefully observed.

- 1) Do not apply excessive force to the engine during assembly. (For prevention of off-centering surface deflection, excessive, clearance and thrust)
- 2) Minimize bending moment to rotating shaft. (For extended life of shafts and bearings)
- 3) Avoid resonance around the engine mounting frame. (Use of appropriate supporting method and rigid mounting frame).
- 4) Avoid torsional vibration between the engine and driven components. (Connection with a rotating body)
- 5) Take air flow into consideration when enclosed cover is used. (for proper cooling)
- 6) Provide access for easy maintenance when covering engine or parts. (for easy maintenance)
- 7) Take maintenance and reliability into consideration for remote control. (for positive operation)

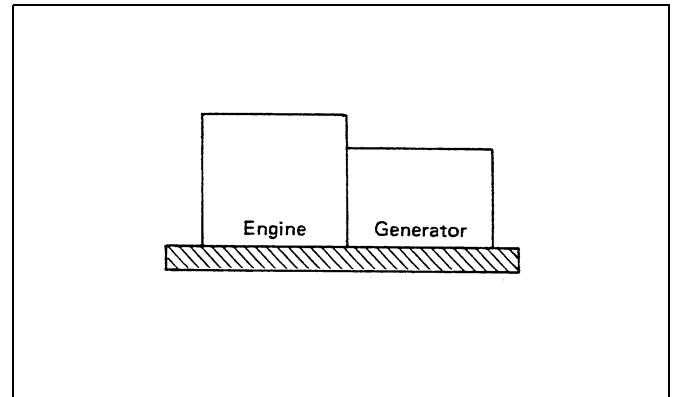
2. SUPPORTING METHOD

Vibrations from a machine mounted with an engine depend on the vibration of the engine itself, rigidity of the mounting frame, weight of engine with equipment connected, vibromotive force and the supporting method between the engine and equipment.

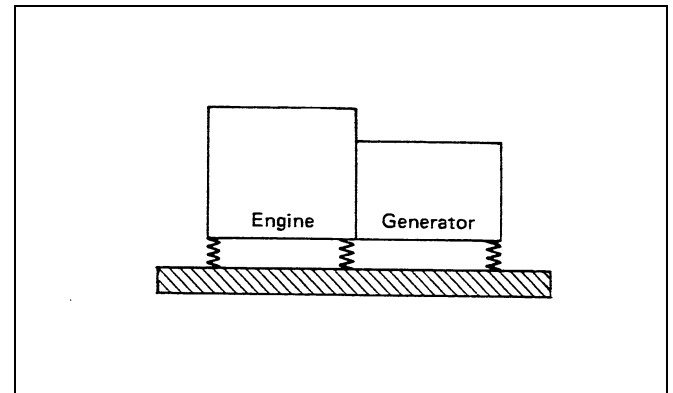
Improper mounting and support will create resonant vibration in the engine system, which will cause noise and can result in major problems. The supporting method must be carefully designed.

Typical connection and supporting methods

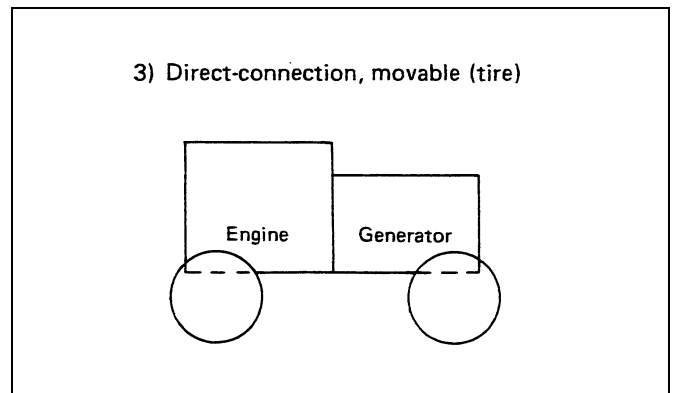
1) Direct-connection, stationary



2) Direct-connection, anti-vibration support



3) Direct-connection, movable (tire)



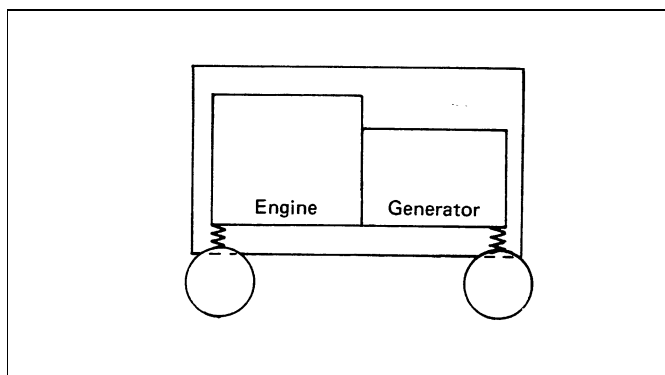
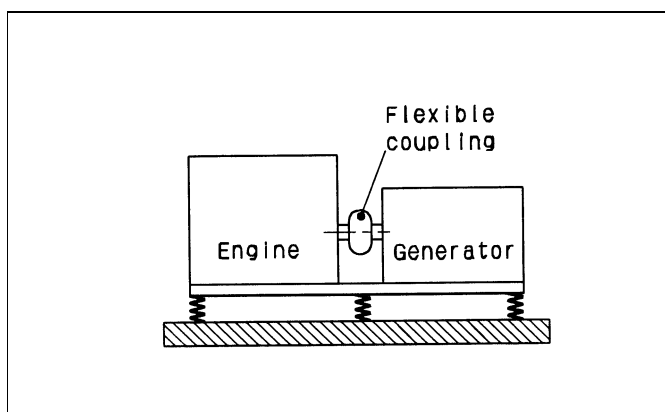
4) Direct-connection, anti-vibration support, movable**5) Separate transmission, anti-vibration engine support**

Fig. 11-1

Determine the best supporting method considering the above vibration conditions and the characteristics of the machine on which the engine is to be mounted.

Vibration acceleration and amplitude should be below the allowable levels.

Many types of anti-vibration support are being adopted recently.

Explain the determination method of anti-vibration support specifications next.

What is the goal for engine mounting ?

a) If machine has an operator and noise / vibration reduction are very important, then maximum vibration isolation is required.

However, this usually means that the isolators are very "soft" and have larger movement, so any accessory attached to the engine should have their "mass" as closely centralized to the engines / transmissions natural "roll center" as possible or very high displacement, acceleration type vibration can occur.

e.g. : The further away from engine / transmissions natural "roll" center the end of the muffler gets, the worse the movement.

b) If no operator, (e.g. : water pump) then isolation importance is not as great and "hard" mounts with less movement can be used.

This will make it much easier to mount the engines accessories to the engine (less "wobble").

However a high frequency, high acceleration, low displacement vibration can occur.

c) Is machine subjected to heavy bouncing ?

Either moving by itself or when being carried by another vehicle.

Mounts that may have to withstand up to 6G (6X) engine transmission weight may be required with strong overload in the vertical +/- and lateral movements.

d) Is mounting base rigid enough ?

That the base does not have an interfering natural frequency / displacement that coincides with the engine / attachment / transmission isolators and engine rotational frequency.

This is when a vibration reading on the machines chassis is important and may require the use of a strobe to point to the problem area.

[REQUIREMENTS IN MOUNTING THE ENGINE]

- Keep the chassis isolated from engine vibration as much as possible.
- Support the engine with the operating condition safely.

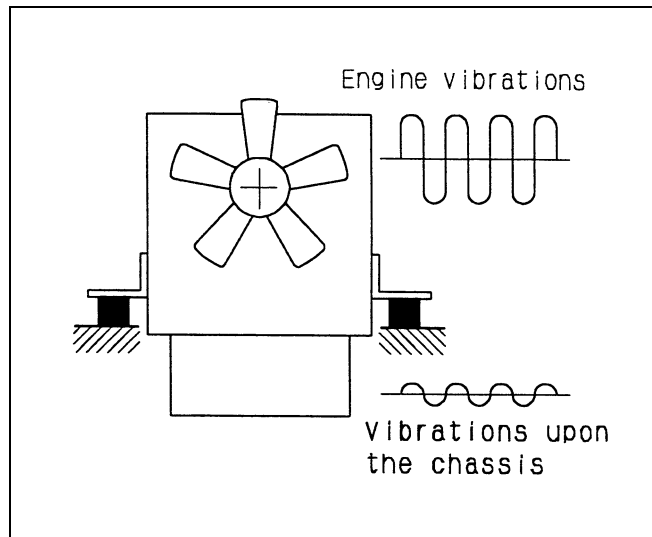


Fig. 11-2 Engine mount

(1) How to isolate the chassis from engine vibration

Elastic materials such as vibration-insulating rubber products (VIRP) are used to support an engine mount to isolate the chassis from engine vibration as much as possible.

A flexible supported engine mount has its specific natural frequency. When the engine runs near or at rpm that corresponds to that frequency, resonance occurs, which adversely amplifies the vibrations. To cope with this problem, the following points are important. :

First, support the engine with an elastic material such as VIRP.

Second, keep the engine mount's natural frequency away enough from the engine's operating speed range. (See Fig. 11-2)

Vibration-insulating rubber products (VIRP), commonly used for engine mounts, are discussed.

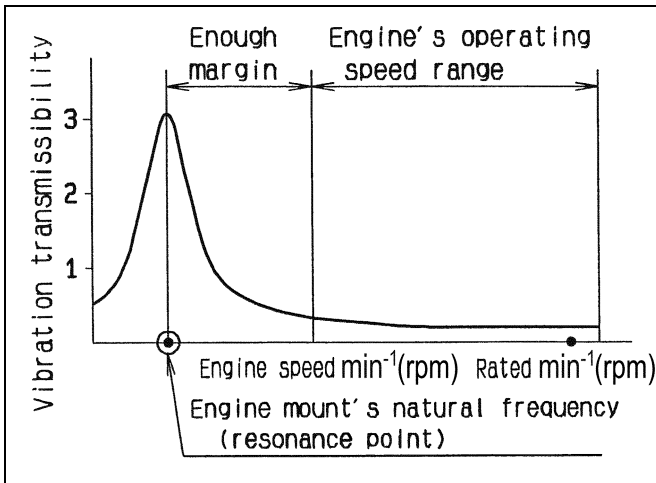


Fig. 11-3 Engine's operating speed range versus engine mount's natural frequency

(2) Conditions for safety supporting with vibration-insulating rubber products (VIRP)

Unlike rigid support with metallic stays, stiffness is a key factor in supporting an engine with VIRP in an elastic way. The VIRP helps reduce the effect of vibration upon the chassis, but the engine tends to shake more.

The softer the rubber is, the smaller the vibration transmissibility becomes, and the lower the resonance point drops. If a strong external force comes from the chassis, however, the engine will move, possibly causing an interference around the radiator or damaging the engine-related equipment. Keep engine mounting base very rigid. If the VIRP, with the rubber's deflection too large, easily gets cracked. For reliable engine mounting, therefore, keep the following point in mind :

Select VIRP that has small deflection with respect to various loads and that is durable enough.

Here are major loads that are exerted on an engine-mounting VIRP.

- Engine's own weight
- Engine's vibromotive force
- External force coming from the chassis

A VIRP to be applied must have a spring constant appropriate to support all these loads.

Now let's discuss some precautions on the loads in mounting an engine.

1) Engine's own weight

An engine's own weight cannot be avoided. Suppose that a load is equally applied on each piece of VIRP. Divide the engine's weight by the number of the VIRP pieces. The result must be below the permissible load of each VIRP piece. When the deflection of the VIRP is

high, it is advisable to have a somewhat higher spring constant even within the permissible load. The permissible load P and the deflection H of VIRP are expressed as follow :

Permissible load of VIRP : $P > W/n$ Deflection of VIRP : $H = W / (K \times n)$

Where W : Engine weight

K : Spring constant of VIRP

n : Number of VIRP pieces

It is clear that the engine weight divided by the VIRP pieces must be smaller than the permissible load and that the deflection H must be kept low.

2) Engine's vibromotive force

The VIRP is exposed to the vibromotive force of an engine while it is running. An appropriately selected spring constant does not give the VIRP much deflection due to the vibromotive force. It should be noted, however, that generally there is a resonance point in the operating speed range of a rubber-mounted engine.

By resonance, the vibromotive force becomes multiplied by several times, which deflects the VIRP greatly. To allow no resonance point in the engine's operating speed range, the natural frequency must be kept out of this range.

Often, the engines low idle speed will have to be increased.

But when the engine STARTS and STOPS, the resonance point is experienced along the way of speeding up and slowing down.

The VIRP must withstand such vibrations that occur during the start and stop the engine.

These vibrations generally roll the engine. To reduce the deflection in such direction, increase the spring constant in the rolling direction or modify the support structure.

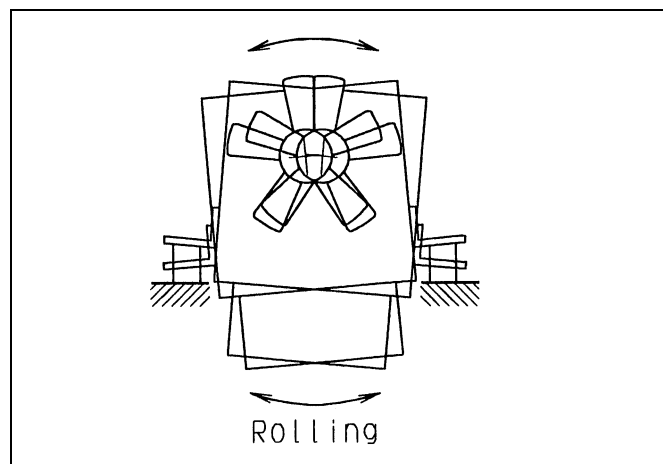


Fig. 11-4 Vibration at engine start and stop

3) External force coming from the chassis

On general purpose engines, an external force coming from the chassis is imposed mostly on the external force varies from machine to machine.

The VIRP must be strong and durable against the external force of the type of machine in question.

But the VIRP is not designed to withstand an impact load or other momentary force.

To deal with such force, it is absolutely necessary to add safety stoppers.

The stoppers can limit the VIRP's maximum deflection that is caused by the external force.

Any external forces beyond the limit are received by the stoppers, which protects the VIRP and ensures safeness.

If by any chance the VIRP breaks down, the stoppers work to hold the engine in place.

It is preferable to install the stoppers in 3 directions (vertical, crosswise and lengthwise).

Fig. 11-5 shows a typical stopper and Table 1 lists external forces that are transmitted from the chassis of various type machines.

Types of machines	External force
Stationary type	1 ~ 2G
Power unit type	2 ~ 3G
Offroad, frame and construction machinery	2 ~ 4G

Impact loads are not included in the above external forces.

Table 1 External forces that are transmitted the chassis of various types of machines

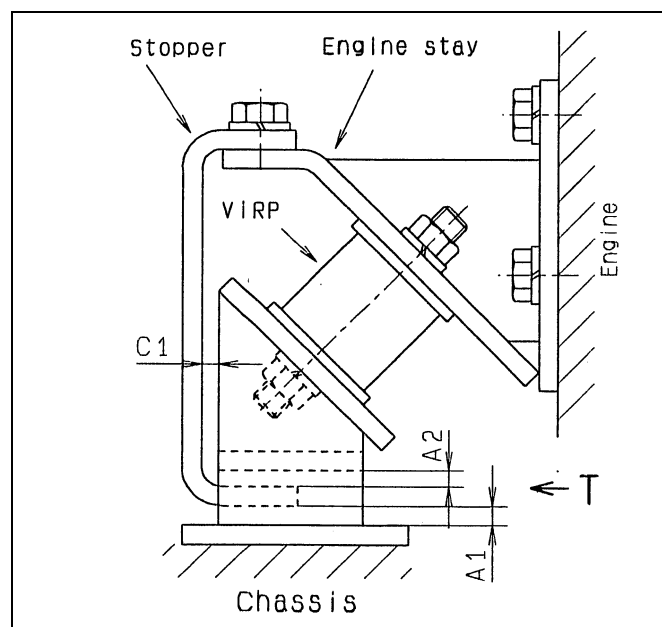
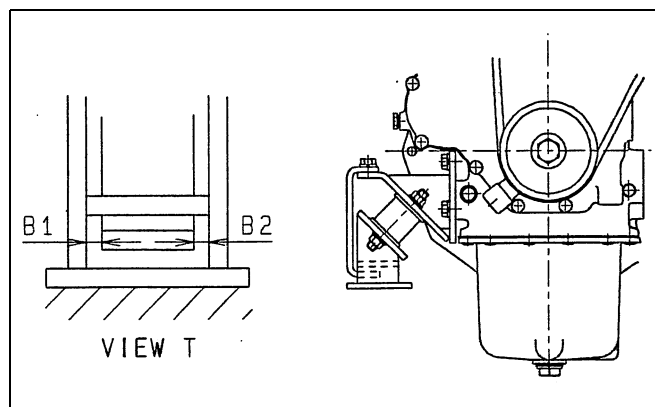


Fig. 11-5 Typical stopper



VIRP's vertical maximum deflection is limited by the clearance A1 and A2.

VIRP's lengthwise maximum deflection is limited by the clearance B1 and B2.

VIRP's crosswise maximum deflection is limited by the clearance C1 and C2.

(Clearance C2 is opposite clearance C1 with respect to the crankshaft center.)

[ENGINE'S VIBRATION CHARACTERISTICS]

Reciprocating engine structurally have their source of vibration inside (reciprocating movements of the piston and connecting rod, torque variations, etc.) Their frequency characteristics depend on the number of cylinders, cylinder arrangement and other factors. An engine's motion can be divided into 6 types : 3 translational motions (vertical, crosswise and lengthwise) and 3 rotary motions (rolling, yawing and pitching.) (See Fig. 11-6)

Below discussed are the relations between these 6 types of vibrating motions and the vibration characteristics of 4-cycle in-line 3 cylinders as well 4 cylinders engines.

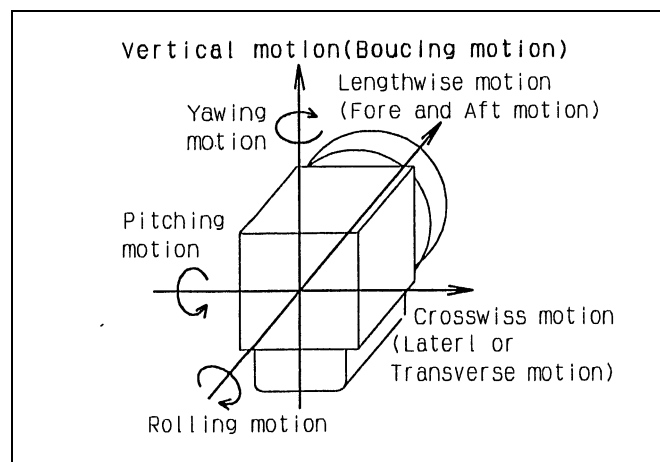


Fig. 11-6 Engine's 6 types of vibrating motions

(1) Three-cylinder engine's vibration characteristics

Engine's motion	Pitching and yawing
Rotational degree	1st order
Remarks	Caused by inertial couple of force. Aggravated with increasing rpm.
Engine's motion	Rolling
Rotational degree	One and a half order
Remarks	Caused by torque variations.

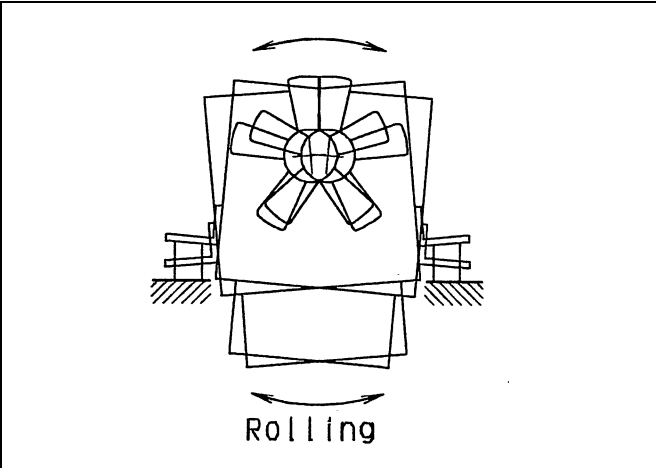
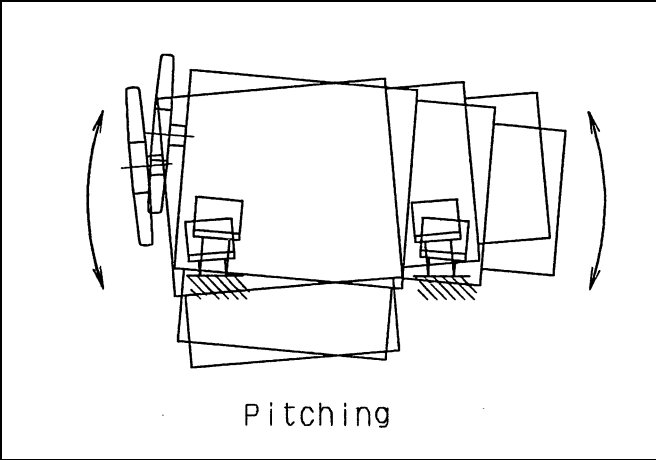


Fig. 11-7 Vibration characteristics of 3 cylinder engine

(2) Four-cylinder engine's vibration characteristics

Engine's motion	Vertical
Rotational degree	2nd order
Remarks	Caused by reciprocating secondary inertial force. Aggravated with increasing rpm.
Engine's motion	Rolling
Rotational degree	2nd order
Remarks	Caused by torque variations.

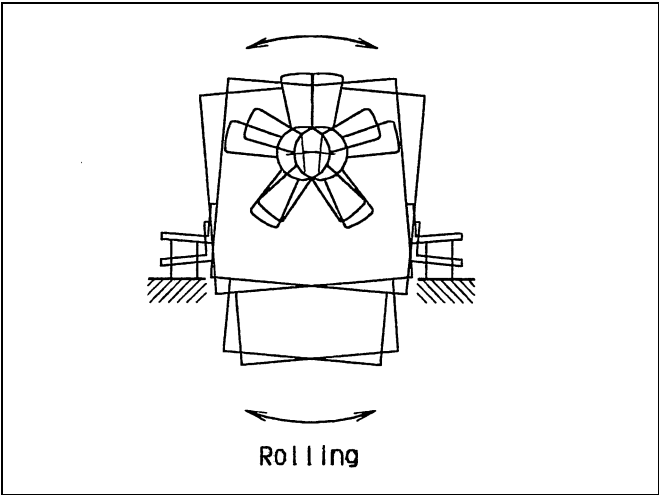
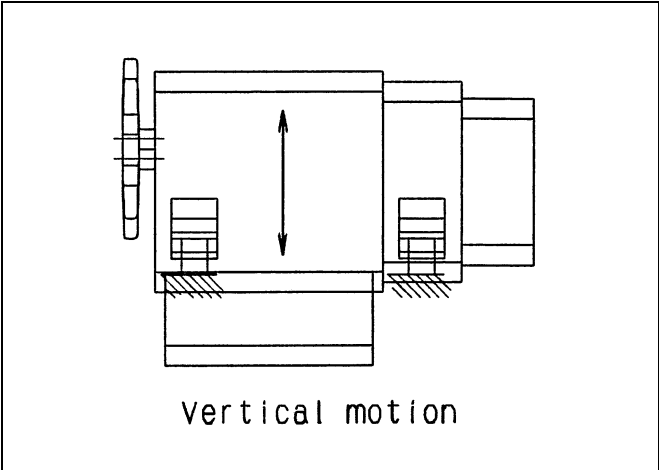


Fig. 11-8 Vibration characteristics of 4 cylinder engine

A particular type of vibration to be noted is the one that occurs near the resonance point at low engine rpm. The natural frequency of a rubber engine mount is somewhere between 5 and 25 Hz. At too low an idling engine rpm, for example, the rolling vibration of an idling engine may be (amplified) by resonance. It is therefore important to make sure that the vibromotive force of an engine idling at low speed does not resonate.

[DECIDING THE ENGINE MOUNT SPECIFICATIONS]

Fig. 11-9 shows the procedural flow of determining the engine mount specifications. First of all, measure an engine's and attachments physical properties.

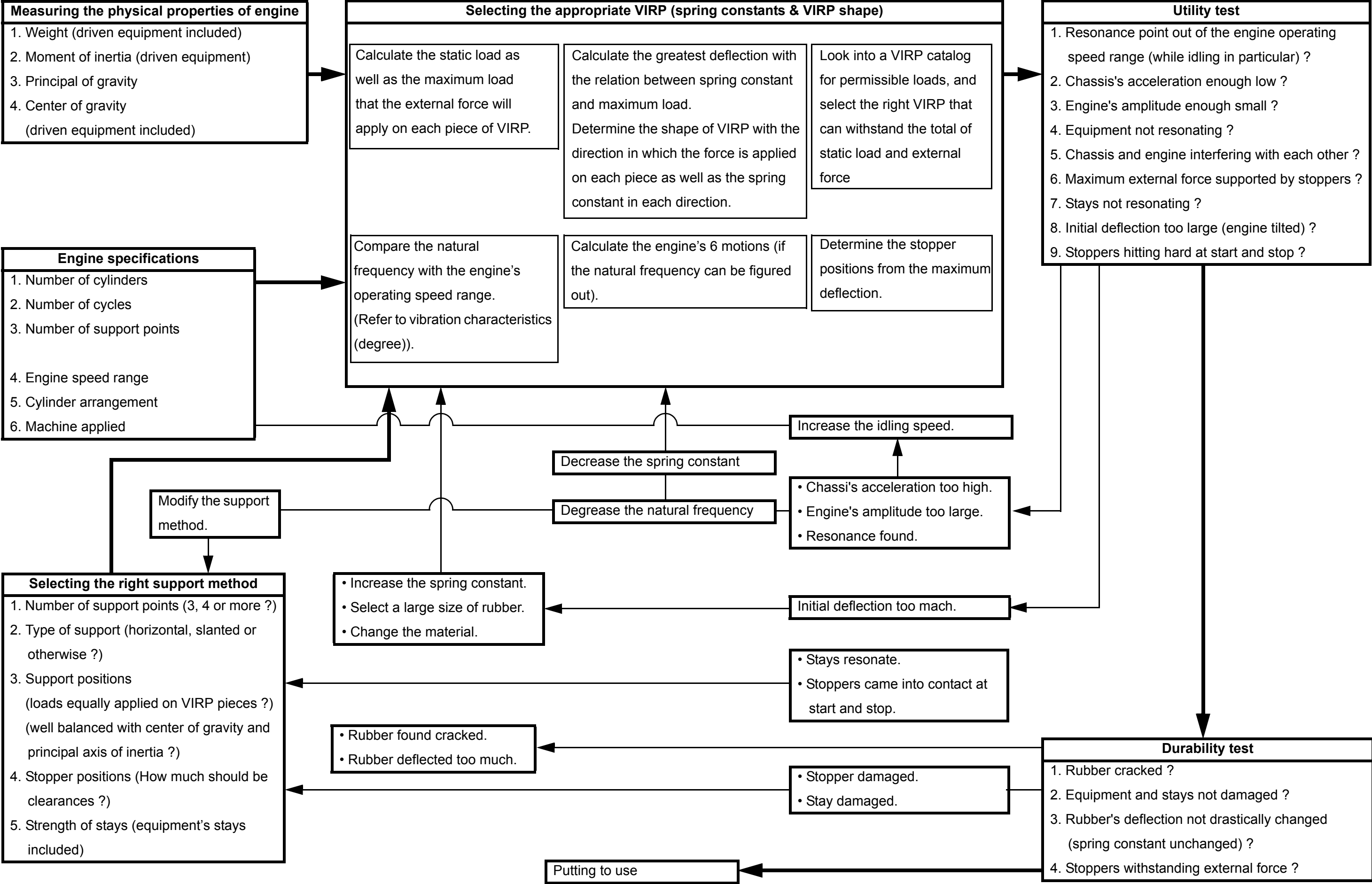


Fig. 11-9 Deciding the engine mount specifications

Considering the engine mounting position and space and other factors, determine the number of support points, support positions, and support method. Then with the engine's physical properties, support method and specifications in mind, select the right type of VIRP.

At this stage, mount the engine on the machine with the VIRP and carry out the utility test and durability test.

Make sure, there is no problem and introduce this type of VIRP.

The next page chapters cover engine support methods, selection of VIRP, possible problems and other related matters.

[VIBRATION INSULATING RUBBER PRODUCTS (VIRP)]

(1) Selecting VIRP

Please consult KUBOTA Engineering or VIRP manufacturer for proper selection of VIRP.

(2) VIRP characteristics

VIRP have the following main features.

- Damping force available
- Spring constants presettable in three axes
- VIRP shaped in a relatively flexible way

For use of VIRP, the following points must be kept in mind.

- Creep phenomenon
- Temperature characteristic
- Oil resistance

1) Creep phenomenon

Since the VIRP has been applied, it gradually suffers from permanent deformation.

Initial deflection comes after the first 2 weeks, and slight, gradual deformation continues thereafter.

This problem must be considered in advance.

2) Temperature characteristics

The VIRP is greatly affected by temperature fluctuations. The higher the temperature, the smaller the spring constant, and vice versa.

The temperature characteristics depend on the types of rubber, but their spring constants suddenly get higher. This means that temperature changes must be understood well. It is also important to adjust test-run temperatures to the practical application.

3) Oil resistance

Some VIRP materials are not resistant to oil and grease. Pick up the appropriate VIRP material that sufficiently withstands oil and grease for engine-supporting applications.

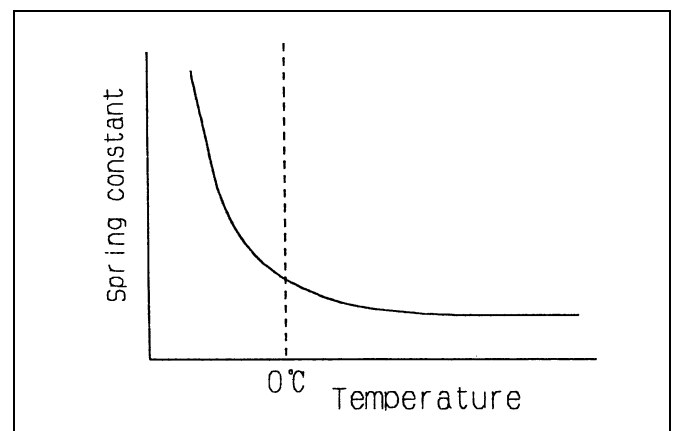


Fig. 11-9 VIRP spring constants versus temperatures

[SUPPORTING PROCEDURE]

(1) Supporting points

In most cases, engines are supported at 3 or 4 points. Whether in a 3-point or 4-point support design, all the VIRP points must be arranged to be equally loaded. If any of the VIRP pieces is under unequally heavy load, not just its durability is affected, but also unusual vibrations may occur. The load upon each of the VIRP pieces is determined by its center of gravity and supporting position. If the support positions cannot be changed and the load cannot be equally distributed, preferably modify the spring constant of each VIRP piece and allow the same level of deflection to all the pieces.

This helps keep the engine at a level.

1) Three-point support positions

A typical 3-point support is shown in Fig. 11-10. In this design, both sides of the crankcase toward the fan as well as the bottom of the flywheel housing are supported.

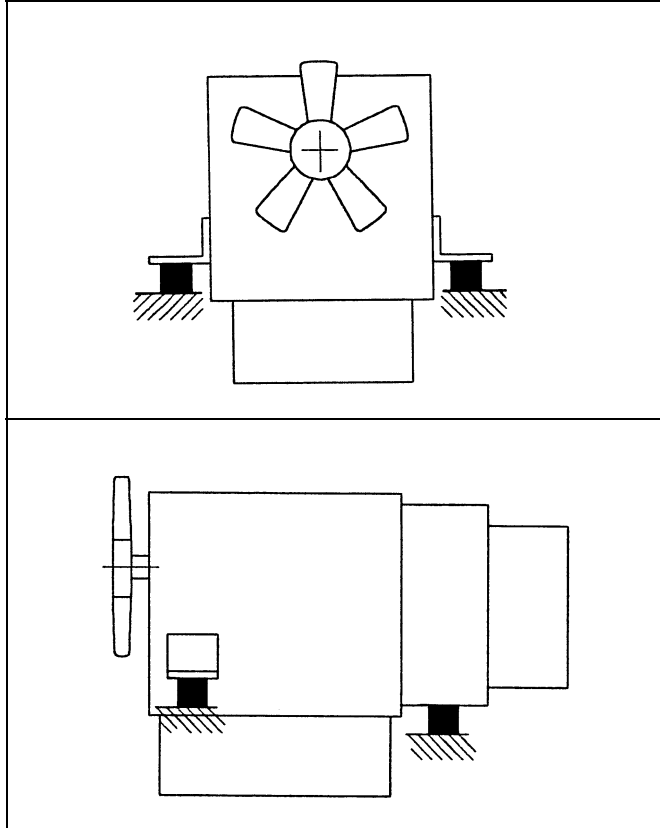


Fig. 11-10 Typical 3-point support arrangement

2) Four-point support positions

A typical 4-point support is shown in Fig. 11-11 and Fig. 11-12.

In this design, both sides of the crankcase toward the fan as well as both sides of the flywheel housing are supported.

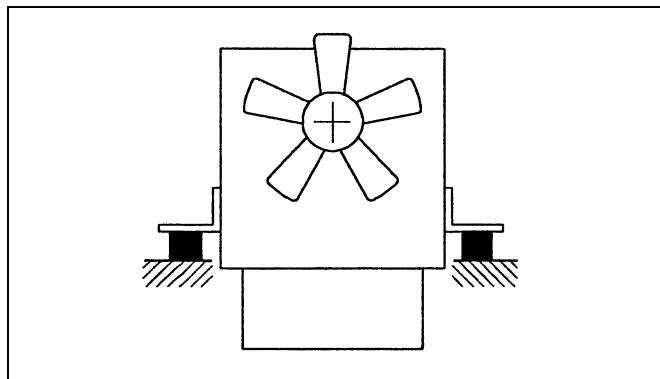


Fig. 11-11 Typical 4-point support arrangement

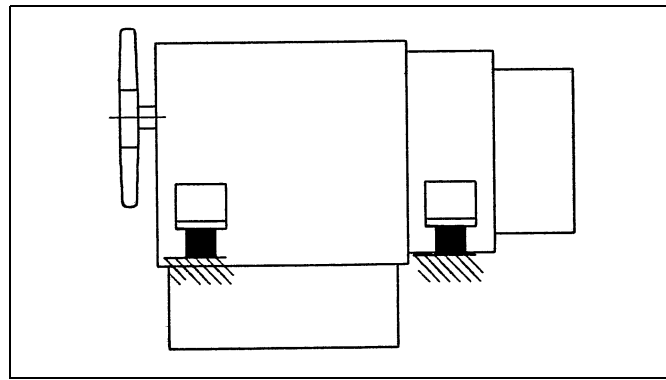


Fig. 11-12 Typical 4-point support arrangement

(2) Support stay configurations

Most general-purpose engines are supported at 4 points. There are two common ways to support them : horizontal stays and slanted stays.

1) Horizontal stays

The horizontal stays are shown in Fig. 11-13. This is the simplest method in a compact way. To keep the natural frequency low in this arrangement, have the stays as close to the center of gravity of the engine as possible. Because the vibrations occur vertically or horizontally depending on the support positions, it is equally important to find the best support positions.

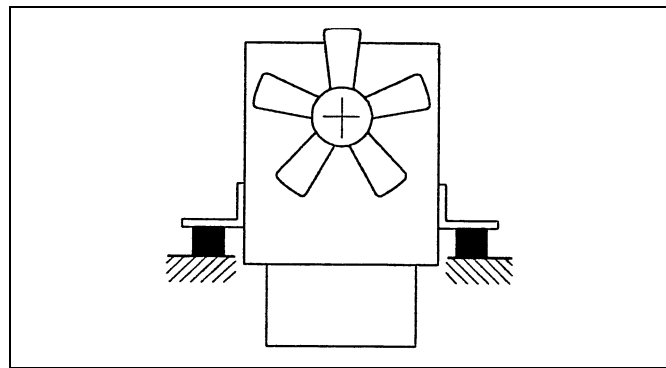


Fig. 11-13 Horizontal stays

2) Slanted (angled) stays

The slanted stays are shown in Fig. 11-14. This method is commonly used when the rolling vibration's natural frequency needs to be lower. Such natural frequency is kept smaller by aligning the shearing direction (softest portion) of VIRP with the rolling direction. The tilt angle θ is determined by the following factors among others.

- Principal axis of inertia
- Direction of external force
- Durability of VIRP

The above factors are discussed one by one next.

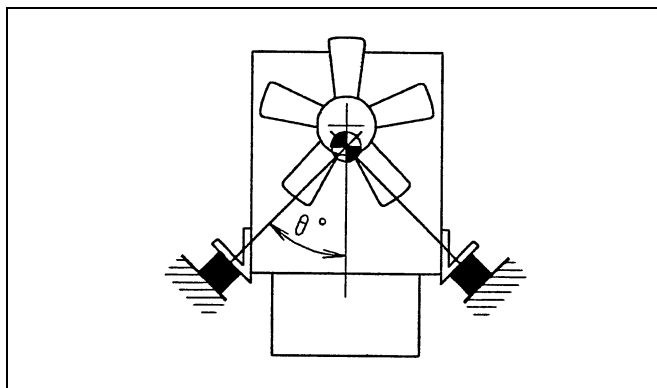


Fig. 11-14 Slanted stays (A)

a) Principal axis of inertia

With the support positions fixed, the natural frequency can be lowered by setting the tilt angle θ along the principal axis of inertia (see Fig. 11-15). Tilt angles of $30\sim 60^\circ$ are commonly adopted.

b) Direction of external force

The slanted support system is weak against the vertical external force coming from the chassis.

The tilt angle therefore must be determined by the type of machine. If the vertical external force is applied, narrow the tilt angle θ or raise the spring constant. It should also be noted that the slanted support has a smaller spring constant in the rolling direction and that the vibrations become noticeable at start and stop of the engine.

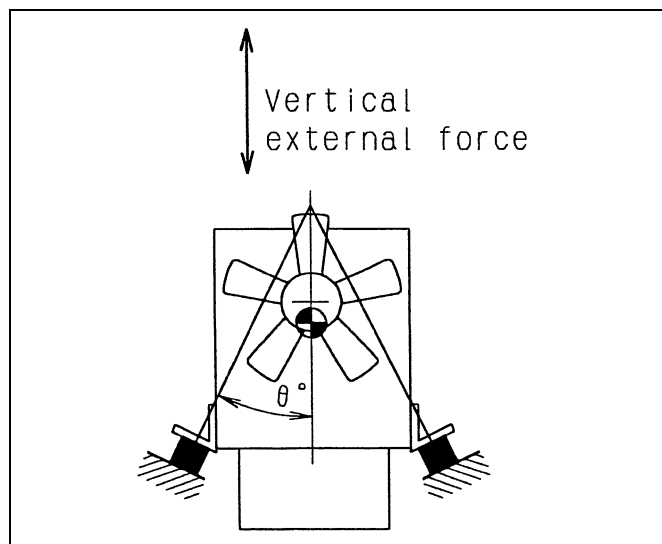


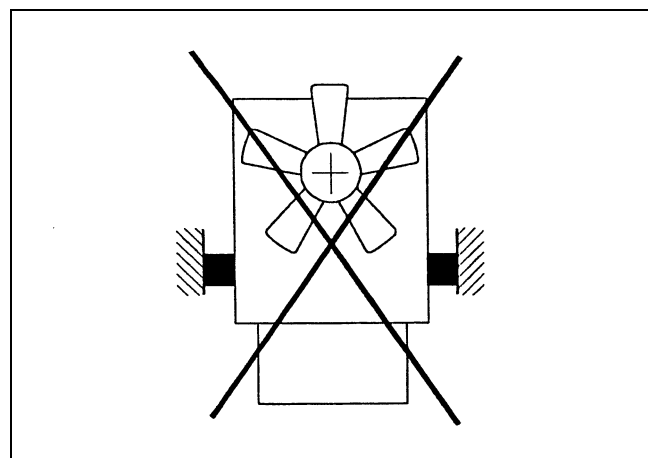
Fig. 11-15 Slanted stays (B)

c) Durability of VIRP

The slanted stays support the engine in the shearing direction, in which the VIRP is most affected, and help reduce the natural frequency.

An extreme tilt angle of $\theta = 90^\circ$ must be avoided.

The permissible load of VIRP is generally small in the shearing direction, which may affect its durability. The tilt angle θ must therefore be determined to keep the shearing load low.

Fig. 11-16 Tilt angle $\theta = 90^\circ$

3) Support stays

The support stays should be designed with a sufficient strength margin. The support stays must also be free from resonance with the engine's vibrations because the stays themselves have their own natural frequency. The thickness of the stays vary from machine to machine. To cope with a great external force as construction machinery, the stays must be designed to be stiff. It is advisable to have the stays relatively short and place them near the engine.

[ATTACHING EQUIPMENT ON THE ENGINE]

Generally speaking, it is better to place a silencer, air cleaner and other equipment separate from the engine. In many cases, stays for air cleaner, silencer, fuel filter and others are affected much by vibrations, and such equipment is set up easy to resonate. Resonance may damage the equipment and their stays much earlier than expected.

Preferably place those equipment on the chassis and connect them with the engine using flexible pipes or the like. When placed directly on the engine, proper measures must be taken against vibrations. And carry out a durability test with the equipment on the engine to make sure there is no problem. It is important to check related water, fuel and other pipes that are vulnerable to vibrations.

[INSTALLING DRIVEN EQUIPMENT]

Suppose that a hydraulic pump, for example, is to be connected overhanging on the flywheel side of the engine. In this layout, keep in mind the pump's weight and length.

Too heavy a pump changes the center of gravity of the engine mount too much, which gets the flywheel side VIRP overloaded. Also when an external force is transmitted, the engine may move unusually. Too long a pump, increases the amplitude of the pump's end vibration. With this in mind, it is advisable to employ a pump as short as possible.

If a driven unit is too big, preferably adopt a 4-point support method : 2 points for the engine and 2 points for the driven unit. If a driven unit is not just big but also heavy, a 5- or 6-point support way could be better : 4 points for the engine and 1 or 2 points for the driven unit.

Fig. 11-17 shows a typical side-by-side layout of an engine and a driven unit. As shown here, place the VIRP under the entire system including the engine.

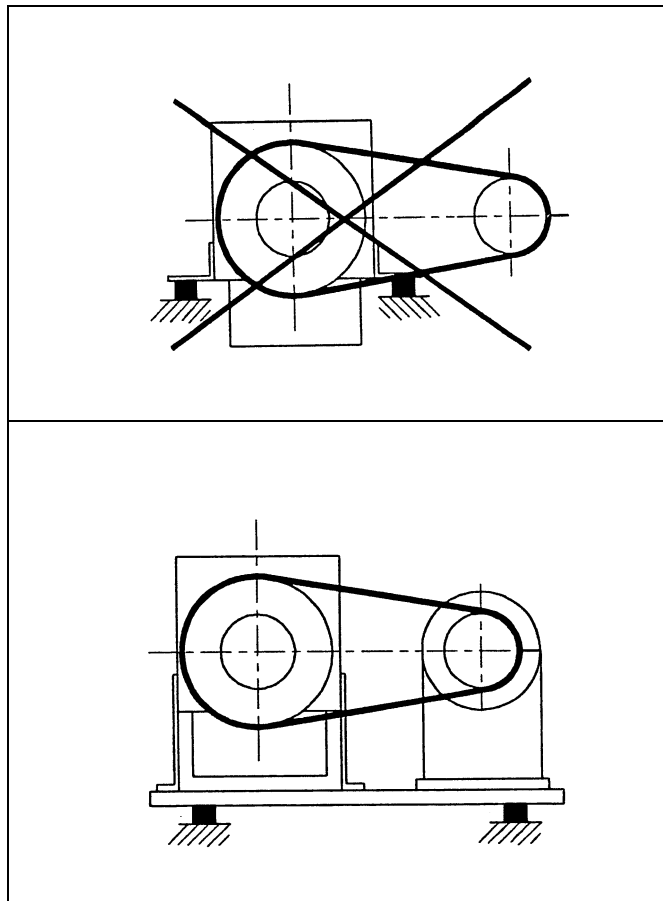


Fig. 11-17 Engine mount in side-by-side setup

[NATURAL FREQUENCY VERSUS RESONANCE]

When an engine is mounted, there surely is a natural frequency. The natural frequency depends on the following factors :

Weight, moment of inertia, center of gravity, support positions, spring constant of VIRP, and principal axis inertia.

In using rubber for the engine mount, the natural frequency must be strictly considered. If the engine runs around the natural-frequency rpm, resonance occurs and the vibromotive force gets amplified up to several times. This may damage the equipment, stays or VIRP pieces, or invite an interference with the chassis.

The natural frequency can be calculated. In a practical test, however, run the engine in its entire speed range and find an rpm at which the vibration reaches a peak (resonance point) : the natural frequency stands at this rpm. If the natural frequency is within the engine's operating speed range, it is necessary to keep the natural frequency below the operating speed range or the lowest operating speed above the natural frequency. The following measures could be taken in order to reduce the natural frequency.

- Lowering the spring constant of VIRP
- Increasing the moment of inertia (for rotary motion)
- Decreasing the distance from the center of gravity to the support positions (for translational motion)
- Increasing the weight (for translational motion)
- Reducing the number of supporting points (VIRP pieces)

The above ways help reduce the natural frequency and keep the resonance point away from the engine's operating speed range. But the entire amplitude and acceleration may remain the same.

When the spring constant of VIRP is made smaller, for example, the natural frequency becomes lower too. The smaller the spring constant, however, the less the VIRP can withstand the vibromotive force.

This means that the VIRP may be affected much more by the same level of vibromotive force.

The durability is also degraded accordingly.

The same is true with a smaller number of VIRP pieces. Just lowering the natural frequency is not sufficient.

Other points that would be adversely affected must be kept. In mind, too.

The engine mount may also resonate by an external force. This is called engine shake.

If the resonance point lies at low frequencies of 5~20 Hz, the external force from the chassis gets the engine resonating. In such case, VIRP with great damping force must be used.

[PRECAUTIONS IN SWITCHING TO DIFFERENT-TYPE ENGINE]

Suppose the VIRP is used for an engine of different type from the previous one.

It is essential to consider a quite different design of engine mount.

This is because a different-type engine requires a different set of VIRP factors. Here are the points to remember in selecting the appropriate VIRP.

- Physical properties of the engine (weight, moment of inertia, center of gravity, etc.)
- Specifications of the engine (number of cylinders, speed range, etc.)
- Supporting method of the engine (support positions, number of supporting points, etc.)

According to these data, the following factors will be different, also, causing a different mode of vibration.

- Natural frequency
- Vibration characteristics of the engine

Take an example of an engine that has nearly the same specifications, except the weight, as those of the previously mounted engine.

The smaller the weight, the greater the natural frequency. This causes the resonance-point rpm to go higher and adversely affects the vibration in the low rpm range. There may be cases in which the engine mount must be redesigned or the idling speed must be changed.

Now we have another example of an engine.

The engine is almost identical in physical properties, supporting positions and piston displacement, but has three cylinders instead of four.

In this case, the vibration characteristics will be different. With the same engine mount design, the three-cylinder engine produces generally proper vibration characteristics in the low speed range. On a four-cylinder engine, the idling vibration happens at the 2nd order engine vibration ; on a three-cylinder engine, it occurs at the one-and-a half order. Let's say, a four cylinder engine resonates at $600 \text{ min}^{-1} (\text{rpm})$.

Resonance occurs at $800 \text{ min}^{-1} (\text{rpm})$ on a three-cylinder engine. In such cases too, the engine mount must be redesigned or the idling speed must be changed.

In other words, even though the chassis remains the same and the engine is almost identical to the previous one, the engine mount design may have to be redesigned in order to keep the vibrations low.

[PRECAUTIONS IN PIPING WHEN USE RUBBER MOUNT]

If engine and related equipment are supported on different frames, flexible piping must be used.

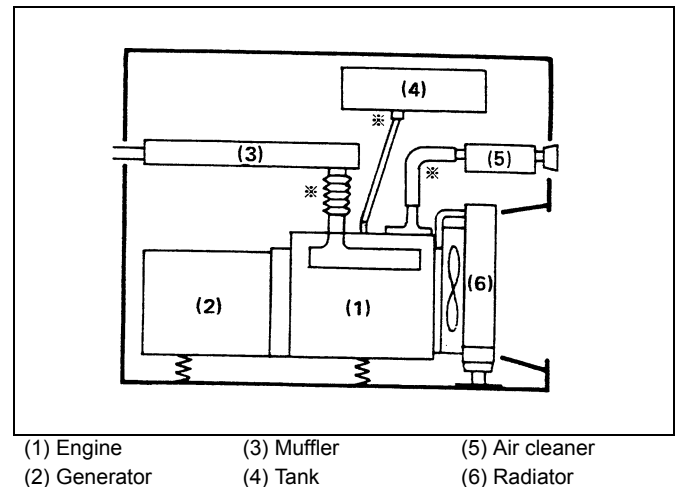


Fig. 11-18 Example

3. POWER TRANSMISSION DEVICE

[FLEXIBLE COUPLING]

Torsional vibration and impact of the drive shaft can be absorbed by a flexible coupling which prevents them from being transmitted to the driven shaft. Installation of such a coupling between the engine and driven shaft is limited by available space. A flexible coupling also prevents torsional vibrations and impacts generated at driven shaft from being transmitted to the engine. There are many types available, such as rubber types, resin types, chain types, tire types and fluid types.

Select according to specific load and use condition.

[POWER CUTOFF DEVICE (Clutches / Disconnects)]

Power cutoff devices (clutches) allow engines to be warmed-up at no load. It is a general practice to install clutches on such as products vehicles, tractors, pump sets ; etc. which can encounter sudden loads.

The following kinds of clutches are available.

Mechanical type	Dry type	● Engagement ● Friction plate loaded type (spring) ... *1 ● Centrifugal clutch
	Wet type	● Friction plate loaded type (spring) ... *2
Electric type		● Electromagnetic clutch ... *3

Note 1 :

The spring loaded type clutches (*1, 2) are always “IN” and a clutch pedal or lever is used to cut off power against spring force. For this reason, thrust force is applied to the crankshaft and care must be given to prevent use at a load exceeding the allowable limit.

Note 2 :

The electromagnetic clutch (*3), must be grounded to prevent an electric current from flowing to the crankshaft. Otherwise, bearing metals will be electrically corroded, resulting in possible bearing and crankshaft failure.

Detailed consultations should be held with the engine maker to determine the most appropriate clutch for a particular engine and purpose.

[TORSIONAL VIBRATION]

When an output shaft is directly connected to the crankshaft, it is necessary to examine stresses caused by torsional vibration of the shaft system depending on rigidity and inertia force of connecting shaft system. When connecting the engine directly to generator, compressor, pump, air blower, etc., contact KUBOTA.

4. SPEED CHANGE DEVICES

The following kinds of speed change devices are available.

- 1) Mechanical type : Gear speed change devices
- 2) Fluid type : Torque converter
- 3) Fluid type : Hydrostatic transmission (HST)

Efficiency is a common factor of an engine regarding load characteristics against engine characteristics and adaptability to using conditions and its frequency.

Fluid types allow stepless variation of torque and speed. Efficiency is lower than a mechanical type and varies greatly depending on speed range, so that matching should be done carefully.

Fluid types also require special maintenance since oil is used as the transmission a medium.

Various factors, including oil temperature, heat dispersion, rising of starting temperature limit due to resistance increase at cold starting must be considered, along with oil viscosity for use in cold weather.

Oil viscosity, and increased viscosities due to low ambients are important considerations.

5. OPERATING MECHANISM

If an engine is covered ; starting, speed changing, and stopping must be controlled remotely via a mechanical (rod or wire) or an electrical system.

In this case, consider clearances of link mechanism, wear and aging factors carefully. Improper installation will adversely affect engine performance.

Provide special attention to frequency of use and force applied to levers.

6. OTHER PRECAUTIONS

- 1) When both the engine and transmission machine are directly connected and fixed, rigidity and strength of the mounting base must be considered carefully.
i.e. Material, plate thickness, flatness, roughness, etc.
- 2) Engine mounting stands and fixing bolts must have sufficient rigidity and strength.

1) Purpose :

One of the policies of KUBOTA Corporation Engine Division (hereinafter referred as "KUBOTA") is to assist equipment manufacturers in the application of KUBOTA engines with the objective of improving the overall equipment quality. One of the methods used to achieve this objective is the review, testing and documentation (Installation Review) of an engine installation with the equipment manufacturer.

Customer satisfaction is directly related to the proper engine application in the end equipment. It is important to obtain the best possible installation in all equipment / applications to insure repeat sales, optimum equipment reputation and reduced warranty claims.

KUBOTA is responsible for performing Engine Application Review for KUBOTA direct OEM and KUBOTA Distributors are responsible for Distributor OEM and retail applications respectively. In case KUBOTA Distributors request KUBOTA the supply of OEM Specified Engine, completed Engine Application Review forms should be sent to KUBOTA Engine Engineering Dept. via KUBOTA Engine Export Dept.. KUBOTA Engine Engineering Department will review and inform the registration number with comments to KUBOTA Distributors via KUBOTA Engine Export Dept.

Improper application or installation without a registered Application Review can result in denial of warranty.

2) Application Review Forms :

Following forms are used for KUBOTA to review its Direct OEM product. KUBOTA Distributors are recommended to use the same forms for the review.

·Review Form - (a) :

- Engine Application Sheet 1/3 : required technical factors and environmental conditions in installation (A-1)
- Engine Application Sheet 2/3 : power requirement as per each PTO system and engine model recommendation (A-2)
- Engine Application Sheet 3/3 : product type, engine mounting system and other technical informations (A-3)
- Engine Performance, Maintenance and Safety Check Sheet (B-1)
- Engine Specification Sheet (B-2---1/2, 2/2)

Review Form - (b) :

- All of the "Review Form - (a)" sheets and
- Engine Operation Measuring Data Sheet (b-1)
- Temperature Measuring Sheet (b-2)
- Vibration Measuring Sheet (b-3)

New part of Modification Request and Part Change Information & Agreement Sheet (C-1), (C-2)

3) Supplement :

The purpose of this application review is, as mentioned in the paragraph 1), to assist equipment manufactures in the application of Kubota engines with the objective of improving overall equipment quality. In this object, Kubota and the Kubota distributors assume no and hereby disclaim any additional liability in undertaking this review, including but not limited to, any liability under any express or implied warranties, applicable national, state or local laws, regulations or ordinances, or otherwise. The customer is responsible for accurately and fully completing this engine application review and returning it to Kubota or the Kubota distributors, as the case maybe.

The customer is further responsible for confirming the suitability for different operating conditions or legal regulations and requirements at each delivery destination.

A -1 Engine Application Sheet (1/3)

Date: / / 200 .

(technical factors and environmental conditions in installation)

Customer :		Product Name :		Model Name :	
Address :					
a person in charge :		Tel :		Fax :	
start of production : -200 . units/1 st lot		Production quantity : units/year			
(☐ new product ☐ minor change product)		(at commercial base)			
Distributor :		a person in charge :			
Address :		Tel :		Fax :	
1. Requirements for engine		* ☐ points to be marked by "x"			
*Applicable output standard : ☐ ISO-3046, ☐ SAE-J1349,					
(1)-1 Gross {Gross intermittent} :		(1)-2 Overload {New intermittent} :		(1)-3 Continuous {Net continuous} :	
(. HP)		(. HP)		(. HP)	
. kW (. ps) / min ⁻¹ (rpm)		. kW (. ps) / min ⁻¹ (rpm)		. kW (. ps) / min ⁻¹ (rpm)	
(2) Displacement :		(3) Max. torque :			
L		. N-m (. kg-m) / min ⁻¹ (rpm)			
(4) Dimensions :		[Total length]		[Total width]	
Max. mm (inch)		Max. mm (inch)		[Total height]	
				Max. mm (inch)	
(5) Idling speed :		(6) Max. speed :		(7) Operating speed :	
(without load) min ⁻¹ (rpm)		(without load) min ⁻¹ (rpm)		min ⁻¹ (rpm)	
(8) Loading pattern :		(9) Regulation & standard requirements (emission, dimension, materials, others) :			
% 125 100 75 50 25 0 (min⁻¹ (rpm)) time (☐ sec., ☐ min.,)		☐ EPA ☐ 97/68/EC ☐ Others (10) Others : 			
→					
2. Operating condition		* ☐ points to be marked by "x"			
(1) Operating hours : Countermeasure to be considered for such applications like generator and refrigeration unit, etc. which is operated for specially long hour (e.g., big oil sump, to select engine to have surplus output.)					
*annual estimated usage :		*seasonal characteristics :			
hr.		☐ No. ☐ Yes (from : to :)			
(2) Operator : Easier maintenance to be considered for applications to be used at least or rental market. ☐ private use ☐ rental use ☐ professional operator					
(3) Atmosphere : Special countermeasure to be taken for special condition.					
a) Cold starting temp. :		b) Max. (or Highest) operating temp. :			
°C (° F)		°C (° F)			
c) Max. (Highest) operating altitude :		d) Highest operating humidity :			
m (ft)		%			
(4) Dust : Special consideration to be applied to air cleaner and radiator for dusty conditions. ☐ straw, grass, dry leaf, ash ☐ dust, sand (particle size : about μ) *dust prevention : ☐ No ☐ Yes ()					
(5) Rust prevention : Special countermeasure is necessary depending on the condition. ☐ Not necessary ☐ Necessary (for ☐ salt ☐ chemical :)					
(6) Inclined angle : Consideration like draining air from fuel line is necessary in case of continuous operation in inclined area. ☐ No ☐ Yes (Max. inclined angle : about degrees, Max. continuous operation : about minutes)					

* If there are specification or structural changes at Customer's product, application must be rechecked and reported.

confirmed

Customer : Distributor : KUBOTA :

A-2 Engine Application Sheet (2/3)

(technical factors and environmental conditions in installation)

3. Power requirement					* ☐ points to be marked by "x"
*Applicable output standard : ☐ ISO-3046, ☐ SAE-J1349.					
SYSTEM (unit)	Engine drive	Power take off system	Load	concurrent drive : *mark	
1 (1 st drive)	A : 1. system ☐ mechanical ☐ hydraulic 2. PTO position ☐ H side (rear) ☐ G side (front) ☐ C side (cam.s)	1) clutch : ☐ Yes ☐ No (Type :)	1. rated output (. HP) . kW (. ps) / min ⁻¹ (rpm)		
		2) coupling : ☐ Yes ☐ No (Type :)	2. max. output (. HP) . kW (. ps) / min ⁻¹ (rpm)		
		3) belt or chain drive : ☐ Yes ☐ No (Type : , no. of :)	3. load pattern		
		*overhang : mm			
2 (2 nd drive)	B : 1. system ☐ mechanical ☐ hydraulic 2. PTO position ☐ H side (rear) ☐ G side (front) ☐ C side (cam.s)	1) clutch : ☐ Yes ☐ No (Type :)	1. rated output (. HP) . kW (. ps) / min ⁻¹ (rpm)		
		2) coupling : ☐ Yes ☐ No (Type :)	2. max. output (. HP) . kW (. ps) / min ⁻¹ (rpm)		
		3) belt or chain drive : ☐ Yes ☐ No (Type : , no. of :)	3. load pattern		
		*overhang : mm			
3 (3 rd drive)	C : 1. system ☐ mechanical ☐ hydraulic 2. PTO position ☐ H side (rear) ☐ G side (front) ☐ C side (cam.s)	1) clutch : ☐ Yes ☐ No (Type :)	1. rated output (. HP) . kW (. ps) / min ⁻¹ (rpm)		
		2) coupling : ☐ Yes ☐ No (Type :)	2. max. output (. HP) . kW (. ps) / min ⁻¹ (rpm)		
		3) belt or chain drive : ☐ Yes ☐ No (Type : , no. of :)	3. load pattern		
		*overhang : mm			
4 (4 th drive)	D : 1. system ☐ mechanical ☐ hydraulic 2. PTO position ☐ H side (rear) ☐ G side (front) ☐ C side (cam.s)	1) clutch : ☐ Yes ☐ No (Type :)	1. rated output (. HP) . kW (. ps) / min ⁻¹ (rpm)		
		2) coupling : ☐ Yes ☐ No (Type :)	2. max. output (. HP) . kW (. ps) / min ⁻¹ (rpm)		
		3) belt or chain drive : ☐ Yes ☐ No (Type : , no. of :)	3. load pattern		
		*overhang : mm			
5	possible max. concurrent load to engine	(SYS. A) + (SYS. B) + (SYS. C) + (SYS. D) = (total) (. HP) + + + = . kW (. ps) / min ⁻¹ (rpm)			
6	frequency of max. load	☐ intermittent max. load	☐ continuous rated load	☐ stand-by load (Generator etc.)	
7	starting resistance (load)	cold starting temperature : °C (°F)	instant load at cold starting (dragged torque : . N-m or kg-m) (surplus output is necessary in case of larger fluid resistance.) ☐ no load		
8	(1) power requirement	(max. power requirement) (surplus output ratio) --- Atmosphere and others (. HP) . x = . kW (. ps) / min ⁻¹ (rpm)			
	(2) torque requirement (peak torque)	. x = . N-m or kg-m / ~ min ⁻¹ (rpm)			
4. Recommended KUBOTA standard engine					* ☐ points to be marked by "x"
*Applicable output standard : ☐ ISO-3046, ☐ SAE-J1349.					
KUBOTA standard engine model		- - - 1 (cord no. -) (. HP) . kW (. ps) / min ⁻¹ (rpm)			

* If there are specification or structural changes at Customer's product, application must be rechecked and reported.

A -3 Engine Application Sheet (3/3)

(technical factors and environmental conditions in installation)

5. Mounting & matching

* ☐ points to be marked by "x"

(1) product type :

☐ vehicle ☐ transportable ☐ stationary

(2) Engine mount position : from whole product (body)

☐ front ☐ center ☐ rear

Engine mount direction :

(gear case direction for product forward direction)

☐ front ☐ rear ☐ left ☐ Right

(3) Speed control lever

Operation : ☐ manual ☐ foot pedal ☐ others

Connection : ☐ rod ☐ wire (electric)

[Engine mounting position---sketch]

(4) Engine mounting system

A. mount base :

(material : , plate thickness : , flatness :)

B. rubber cushion :

☐ No ☐ Yes (material : , spring constant :)

C. mounting feet :

☐ No ☐ Yes (plate thickness : , no. of holding points :)

D. flywheel housing direct mounting :

☐ No ☐ Yes (☐ knock pin ☐ centering location)

E. engine support or common mount base :

☐ No ☐ Yes (material : , plate thickness :)

[Engine mounting system---sketch or photo]

* frontal view

* side view

* top view

* crankshaft center

6. Other technical information

* ☐ points to be marked by "x"

(1) engine rpm at centrifugal clutch engagement : min⁻¹ (rpm)

(2) **belt drive** : tension force / direction of rotation, overhung, belt type / no. of belt, diameter or pulley. etc.

(3) **thrust force on crankshaft** : ☐ No ☐ Yes

(4) in case it is necessary to check torsional vibration : loaded weight on flywheel / loaded position on crankshaft.
GD² and crankshaft diameter.

(5) **fuel tank position** : height difference between the bottom of fuel tank and the upper surface of injection pump.

* note : fuel feed pump, fuel filter and fuel piping must be checked and sketched in details.

(6) **Safety shut down, warning system** : ☐ No ☐ Yes

☐ water temp. ☐ oil temp. ☐ oil pressure
☐ over running

(7) **accessory parts supply**

* radiator : ☐ KBT ☐ local

* muffler : ☐ KBT ☐ local

* air cleaner : ☐ KBT ☐ local

* fuel filter : ☐ KBT ☐ local

etc.

(8) other unique specifications or technical information :

☐ No ☐ Yes

[fuel line system - - - sketch]

* fuel injection pump
fitting face

(unit = mm/inch)

* If there are specification or structural changes at Customer's product, application must be rechecked and reported.

Unit model / serial no. :	Product Name :
Engine Model :	Engine serial no. :
Checked place at :	Loadng condition :

checking items		judged	checking items		judged
1. Engine oil :					
- Oil temp. (below 110° C. or 230° F. at continuous operation)			- fuel draining from tank bottom		
- oil level checking			- air bleeding from fuel line		
- oil supply			- check, cleaning, replacement of fuel filter		
- oil draining			- fuel pipe's contact with hot part		
- oil filter replacement			- fuel pipe's contact with engine or machine		
			- caution label on fuel type and fire		
			- temperature of fuel system must not beyond 60°C or 140° F		
2. Cooling system					
- obstacles, radiator front and rear			5. Electric parts		
- clearance, fan and radiator core / shroud			- temp. (to be below 80°C or 176° F)		
- prevention of re-circulation cooling air			- fixing direction		
- prevention dust of radiator			- protection from rain, vibration		
- checking, closed by dust on radiator			- key switch, prevented from rain, washing		
- capacity (radiator locally supplied)			- earth (two earth connections necessary for rubber cushion mount)---Battery ⇔ Engine / Battery ⇔ Chassis		
- antifreeze coolant			- battery capacity		
- reserve tank			- battery check, cleaning, replacement		
air to boil (ATB = above 55° C or 131° F, at continuous operation)			- battery cord has a structure not connected conversely		
- water supply and level checking			- battery cord not bundled other cords		
- water draining			- contact parts, covered by corrugate tube		
- fan belt adjustment			- wiring clipping, suitable for vibration		
- fan best replacement			- engine stop at shut down of electric circuit (e.g. Battery dropped out)		
- danger of scald by overblown hot water			- alternator L-terminal load > 5mA, when short circuit protector is adopted.		
- danger of scald by damages of radiator cap, Hoses			- Do NOT connect relay with alternator L-terminal when short circuit is not adopted		
3. Inlet and Exhaust			6. Others		
- entrance of rain, dust and hot air from air cleaner			- no excessive force on engine speed control lever		
- capacity (locally supplied air cleaner)			- no resonance point between low and high engine Operation		
- back pressure of muffler (locally supplied muffler)			- engine oil, specified oil is used		
- check, cleaning and replacement of air cleaner Element			- cold starting ability, satisfactory for customer Requirement		
- objects, easy burn, on or over muffler			- PTO system, proper		
- exhaust direction (not toward human being, battery, fuel system)			- side PTO, correct		
- cover to prevent a burn			- belt tension drive, durable		
			- engine serial number, can be read		
			- engine maintenance interval, clarified		
			- guard for rotating		
			- cover at high temp. Parts / area for burn prevention		
			- safety label		
4. Fuel system					
- filter at fuel tank, supply port					
- waved fuel piping, fuel drop to fuel tank					
- air bleeding, after fitter change or fuel empty					
- electric fuel feed pump for low positioned tank					
- fuel supply to fuel tank					

note : judgment (evaluation) : O = good, OK, E = to be examined, X = No good, need modification.

* If there are specification or structural changes at Customer's product, application must be rechecked and reported.

confirmed

Customer : _____ Distributor : _____ KUBOTA : _____

B -2 Engine Specification Sheet (1/2)

Engine model :

ITEM	UNIT	SPECIFICATION
Type		Vertical, Water cooled, 4-stroke Diesel
Number of cylinder - Bore×Stroke	mm	-Φ ×L
Total Displacement	L	
Power (Continuous)	kW [HP] (ps) / min ⁻¹ (rpm)	
Power (Overload)	kW [HP] (ps) / min ⁻¹ (rpm)	
High idling speed	min ⁻¹ (rpm)	
Low idling speed	min ⁻¹ (rpm)	
Combustion chamber type		Spherical type (E-TVCS Three Vortex Combustion System)
Fuel injection pump type		BOSCH PFR-MD type "mini" pump
Type of Governor		Centrifugal mechanical type (Flyweight, Ball)
Injection nozzle type		BOSCH "Throttle" type
Fuel injection timing	deg.	- ° Before Top Dead Center
Fuel injection pressure	MPa	13.7 (140 kgf/cm ² or 1191.5 psi)
Fuel		Diesel fuel No.2-D S500 or S15
Compression ratio	ε	
Cooling system		Pressurized {88.3 kPa (0.9 kgf/cm ² or 12.8 psi)} radiation and forced circulation with water pump
Starting system		Electric self-starter with glow plug
Lubricating oil quality		Class CF lubricating oil as per API classification is recommended. 10W-30 (SAE)
Lubricating oil capacity	L	
Direction of rotation		Counter-clockwise (from Flywheel side view)
Dry weight	kg	
Injection (Fire) order		
Fuel tank capacity	L	
Fuel consumption	gr/kW [HP], (ps)/h	
Coolant capacity	L	
Regulator		IC type. Built in regulator on alternator
Starter	V-kW	-
Starting aid device		
Dynamo / Alternator	V-W	- (A at min ⁻¹ (rpm))
Dimension (L×W×H)	mm	
Recommended battery capacity	V-Ah	-
Application		

B-2 Engine Specification Sheet (2/2)

Basic Engine model : _____

Cord number : _____

	Compose no.	Parts name	STD Part NR of basic E/G	Request P/N of OEM customer	Remarks, Reason of change part.
A	Basic engine component parts			***note	
	010	Crank case	-	-	
	012	Oil pan	-	-	
	030	Cylinder head	-	-	
		Water temperature sender	-	-	
	040	Gear case	-	-	
	114	Inlet manifold	-	-	
	125	Exhaust manifold	-	-	
	250	Flywheel	-	-	
	251	Rear end plate	-	-	
		Flywheel housing	-	-	
		Pump housing	-	-	
	320	Inner oil filter	-	-	
		Oil filter cartridge	-	-	
		Oil filter flange or oil cooler	-	-	
	360	Oil gauge (dipstick)	-	-	
		Oil gauge guide (dipstick guide)	-	-	
	520	Fuel pump (feed)-mechanical	-	-	
	630	Starter	-	-	
	640	Dynamo or Alternator	-	-	
		Dynamo stay	-	-	
	650	Glow plug	-	-	
		Stop solenoid	-	-	
	723	Water flange	-	-	
		Thermo-switch	-	-	
	731	Thermostat	-	-	
		Thermostat cover	-	-	
	740	Fan (cooling)	-	-	
		Fan pulley	-	-	
	741	Fan drive pulley	-	-	
	742	Fan belt	-	-	
	839	Oil switch	-	-	
	860	Operator's manual	-	-	
B	Accessories parts			***note	
	(110)	Air cleaner	-	-	
	(111)	Air cleaner stay	-	-	
		Air cleaner band	-	-	
	(113)	Inlet pipe	-	-	
	(120)	Muffler	-	-	
		Muffler flange	-	-	
	(430)	Fuel filter	-	-	
		Fuel filter holder	-	-	
	(520)	Fuel pump (feed)-electrical	-	-	
		Pre-filter	-	-	
	(630)	Starter key switch	-	-	
	(720)	Radiator	-	-	
		Water pipe upper	-	-	
		Water pipe lower	-	-	
		Reserve tank	-	-	
		Radiator support	-	-	
	(741)	Fan cover	-	-	
		Timer	-	-	
		Coupler	-	-	
C	Optional parts			***note	
	(069)	Cushion (rubber)	-	-	
	(830)	Hour meter, drive unit, cable	-	-	
		Water temperature gauge	-	-	
		Hydraulic pump	-	-	
		PTO shaft	-	-	
		Engine stand	-	-	

***note : 1) It is requested specify the exact parts NR. If possible please attach the contents of the Kit, or Comp. Parts.

2) When you have to ask KBT to adopt "New parts" you should be required to apply "Sheet C-1".

b-1 Engine Operation Measuring Data Sheet

Date : / / 200 .

[flat condition or inclined condition]

Unit model : _____	Product Name : _____	Engine oil API classification : _____	Type of machine oil : _____
Unit serial no. : _____	Engine Model : _____	Engine oil SAE viscosity : _____	Machine oil viscosity : _____
Measuring place at : _____	Engine serial no. : _____	weather : _____, dry temp. : _____ atmospheric pressure : _____ mmHg	dry temp. : _____ Battery : V, AH

		Engine (pulley diameter = ϕ)										machine (pulley diameter = ϕ)				
		load	rotation (with load) min ⁻¹ (rpm)	estimated output kW [HP](ps)	Exhaust temp. (together) °C/°F	exhaust color *** Bosch	oil temp. °C/°F	cooling temperature		intake air temp. °C/°F	evaluation	radiator cooling air		Engine room temp. °C/°F	Hydra. oil temp. °C/°F	evaluation
							°C/°F	inlet °C/°F	outlet °C/°F			inlet °C/°F	outlet °C/°F			
		standard value:														
		normal start : glow = " , starter = "														
		cold start : glow = " , starter = "														
		low idling speed	0/4													
		high idling speed	0/4													
		at lower loaded 1	1/4													
		at lower loaded 2	1/4													
		at medium loaded 3	1/2													
at medium loaded 4	1/2															
at continues loaded 5	4/4															
at maximum loaded 6	13/10															

* cooling water consumption : cc (LLC %)	note:
* overflow volume of cooling water at engine stop : cc	1 .
*	2 .
*	3 .

note : 1) *Measuring is to be carried by KUBOTA experienced engineer or KUBOTA's approved engineer.*
*** Exhaust color (eye observation) : A=(Bosch : 0-15%), AB=(15-25%), B=(25-35%), BC=(35-45%), C=(45-55%), CD=(55-65%), D=(65-75%), DE=(75-85%), E=(85-100%).

***If there are specification or structural changes at Customer's product, application must be rechecked and reported.**

confirmed

Customer : _____ Distributor : _____ KUBOTA : _____

00/jan/14

Кубота

reported by : _____ / KBT Engineer.

b-2 Temperature Measuring Sheet

Unit model / serial no. :	Product Name :	checked place at :
Engine model :	Engine serial no. :	Loading condition :

measuring		before	1st	2nd	3rd	4th	5th	6th	7th	8th	standard value of evaluation °C/°F	remarks
* measuring started time :		E/G	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F		
* measuring stopped time :		start	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F		
(unit = degrees .°C/°F)			°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	°C/°F	
1. Atmosphere	AT											
2. Engine room	RT										<75/167	
3. Exhaust gas (together)	EXT											
4. Engine oil	LOT										<110/230 <120/248	(at Continuous) (at Overload)
	ΔT											
5. Air intake	IAT										<45/113	
	ΔT										<5/9	(IAT)-(AT)
6. Cooling air inlet	CAIT										<40/104	
7. Cooling air outlet	CAOT											
	ΔT										<30/54	(CAOT)-(CAIT)
8. Cooling water inlet ®	CWIT										<110/230	**radiator cap = 0.9 kgf/cm ²
9. Cooling water outlet ®	CWOT											
10. Air To Boil												
***ATB=(x)-(CWIT)+(AT)	ATB										>55/131	(at Max.load)
11. Overflow volume of cooling water	OFQ											
12. Fuel	FOT										<60/140	
	ΔT										<20/36	(FOT)-(AT)
13. Battery surface	BRT										<55/131	
14. surface of starter, alternator, regulator, etc.	STT ALT RET										<80/176	
15. Engine rotation (min ⁻¹ (rpm))	N										Low Idling High Idling	

note : 1) **Operating conditions : Engine oil / Class CF lubricating oil as per API classification is recommended, Cooling water / LLC 50%, Thermostat / fully open by force.**

2) The above judgment (evaluation) standards is to be applied in the max. ambient condition of 40°C (140°F), in case that the ambient temperature is over 40°C (140°F), it must be judged adding the balance between the actual temperature and 40°C (140°F) to the judgment standard.

3) **Do not run a cooling test if the ambient temperature is below 24°C (27°F) because the large change in air density and radiation from non cooling system parts give false results.**

***Air To Boil (ATB) value must be calculated by using below max. temperature :

(1) LLC 50% with 88.3 kPa (0.9 kgf/cm² or 12.8 psi) pressure cap : (x) = 128°C (262°F),

(2) Fresh water 100% with 88.3 kPa (0.9 kgf/cm² or 12.8 psi) pressure cap : (x) = 118°C (244°F)

special note :

1) The judgment standard > 55 °C (131°F) in the above formula { ***ATB = (x) - (CWIT) + (AT) } is KUBOTA's standard. It may change depending on applications, countries, locations, etc., therefore, it is better to judge under the discussion with OEM's referring their own experienced values.

Agreement :

* If there are specification or structural changes at Customer's product, application must be rechecked and reported.

confirmed

Customer : _____

Distributor : _____

KUBOTA : _____

b-3 Vibration Measuring Sheet

Unit model / serial no. :	Product Name :	checked place at :
Engine model :	Engine serial no. :	Loading condition :

(unit)		vibrating acceleration RMS*** (G)				total amplitude (mm)				result	
	direction (rotation)→	standard value of evaluation	4/4 full load min ⁻¹ (rpm)	0/4 No load min ⁻¹ (rpm)	(resonance point) min ⁻¹ (rpm)	standard value of evaluation	4/4 full load min ⁻¹ (rpm)	0/4 No load min ⁻¹ (rpm)	(resonance point) min ⁻¹ (rpm)	good OK	No good to be modified
1. Crank case											
	up / down	8(10)				0.7(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					
2. Radiator											
	up / down	2(3)				0.5(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					
3. Muffler											
	up / down	5(10)				0.7(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					
4. Air cleaner											
	up / down	5(10)				0.7(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					
5. Fuel filter											
	up / down	5(6)				0.7(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					
6. Fuel tank											
	up / down	7(10)				0.7(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					
7. Starter											
	up / down	5(10)				0.7(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					
8. Alternator											
	up / down	5(10)				0.7(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					
9. Electric parts like Regulator, Lamp timer etc. and others											
	up / down	2(3)				0.5(1)					
	forward / rear	↑				↑					
	left / right	↑				↑					

note : 1) "forward / rear" is crankshaft direction and "left / right" is a right angle direction for crankshaft.
 2) Figure () in the judgment column shows max. value of resonance point where passed by temporally.
 3) RMS*** : root mean square value.

special note :

* If there are specification or structural changes at Customer's product, application must be rechecked and reported.

confirmed

Customer : _____ Distributor : _____ KUBOTA : _____

C-1 ☐ Modification Request of Engine specification

Equipment model : _____	
Engine model name :	Code number :
Contents of modification :	
Reason of modification :	
Attached documents :	
Requirement of effective production : From, ... month year.	

If anything, your comment will be highly appreciated.

☐ Agreed	☐ Disagree
Comments :	Comments :
* Expected effective production :	
Engine : month year.	
(Related engine order number :)	

The diagram illustrates the relationship between three entities: KUBOTA Corporation, KUBOTA (Engine) Distributor, and Equipment Maker (Customer). KUBOTA Corporation is divided into two departments: Engine Engineering dept. and Engine Export Dept. KUBOTA (Engine) Distributor is shown with a date field. Equipment Maker (Customer) is also shown with a date field. Arrows indicate interactions: a double-headed arrow between KUBOTA Corporation and KUBOTA (Engine) Distributor, and single-headed arrows pointing from KUBOTA (Engine) Distributor to Equipment Maker (Customer).

```
graph LR
    subgraph KC [KUBOTA Corporation]
        EED[Engine Engineering dept.]
        EED <--> EED2[Engine Export Dept.]
    end
    subgraph KD [KUBOTA (Engine) Distributor]
        D1[Date : / / 200 .]
    end
    subgraph EM [Equipment Maker (Customer)]
        D2[Date : / / 200 .]
    end
    KD --> KC
    KD --> EM
```

Attn. : _____
Equipment Maker (Customer)

Ref. No. : KEED.OS-_____
Date : ____ / ____ / 200 ____

C-2 Part Change Information & Agreement Sheet

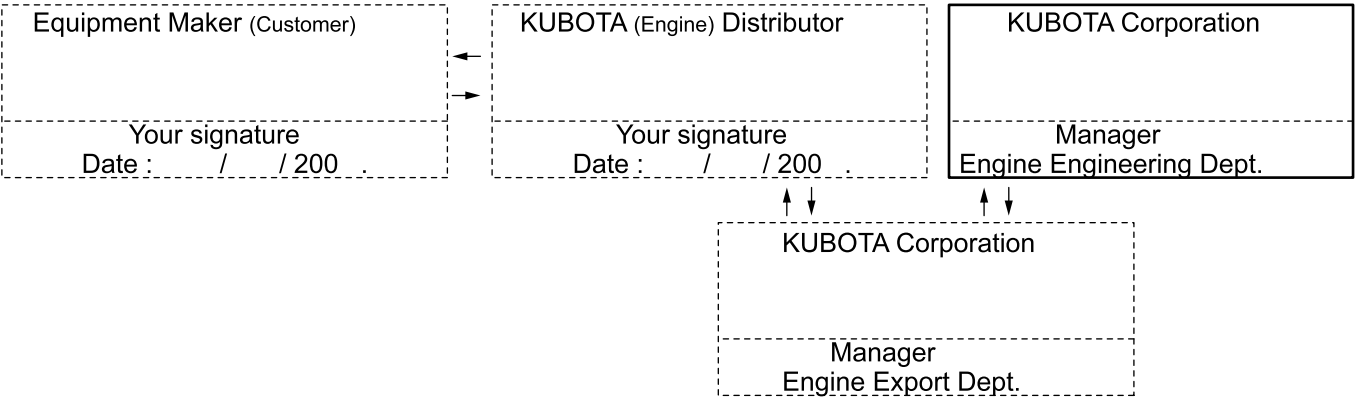
We would like to receive your agreement with following modification of engine components.

Engine model name :	Code number :
Contents of modification :	
Reason of modification :	
Attached documents :	
Effective production planned Engine production from : month year.	

We notify the above modification plan through KUBOTA Engine Distributor (_____).
You are requested to return with your agreement in soonest possible.
If anything, your comment will be highly appreciated.

☐ Agreed	☐ Disagree
Comments :	

confirmed



TECHNICAL INFORMATION (Diesel Engine)

1. S.M. SERIES

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1. BRAKE HORSE POWER

a) ISO 3046, 2534

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	Gross	kW	6.0	6.6	7.1	7.7	8.3	-	9.9
		PS	8.2	8.9	9.7	10.5	11.3	-	13.5
	Overload	kW	5.8	6.3	6.9	7.4	7.9	-	9.3
		PS	7.9	8.6	9.3	10.0	10.8	-	12.7
	Continuous	kW	5.1	5.5	6.0	6.4	6.9	-	8.1
		PS	6.9	7.5	8.1	8.7	9.3	-	11.0
Z602	Gross	kW	7.4	8.1	8.8	9.4	10.1	10.8	12.5
		PS	10.1	11.0	11.9	12.8	13.7	14.7	17.0
	Overload	kW	7.1	7.8	8.4	9.0	9.6	10.1	11.6
		PS	9.7	10.6	11.4	12.2	13.0	13.8	15.8
	Continuous	kW	6.2	6.7	7.3	7.8	8.3	8.8	10.1
		PS	8.4	9.2	9.9	10.6	11.3	12.0	13.7
D722	Gross	kW	9.0	9.9	10.7	11.5	12.4	-	14.9
		PS	12.3	13.5	14.6	15.7	16.9	-	20.3
	Overload	kW	8.7	9.5	10.3	11.0	11.9	-	14.0
		PS	11.9	13.0	14.0	15.0	16.1	-	19.1
	Continuous	kW	7.6	8.3	8.9	9.6	10.3	-	12.2
		PS	10.3	11.3	12.1	13.1	14.0	-	16.6
D902	Gross	kW	11.1	12.1	13.1	14.1	15.1	16.1	18.5
		PS	15.0	16.4	17.8	19.2	20.5	21.9	25.2
	Overload	kW	10.8	11.7	12.6	13.6	14.5	15.4	17.5
		PS	14.6	15.9	17.2	18.4	19.7	20.9	23.9
	Continuous	kW	9.3	10.2	11.0	11.8	12.6	13.4	15.2
		PS	12.7	13.8	14.9	16.0	17.1	18.2	20.7

b) SAE J1349

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	Gross Intermittent	kW	6.0	6.6	7.1	7.7	8.3	-	9.9
		HP	8.1	8.8	9.6	10.3	11.1	-	13.3
	Net Intermittent	kW	5.8	6.3	6.9	7.4	7.9	-	9.3
		HP	7.8	8.5	9.2	9.9	10.6	-	12.5
	Net Continuous	kW	5.1	5.5	6.0	6.4	6.9	-	8.1
		HP	6.8	7.4	8.0	8.6	9.2	-	10.9
Z602	Gross Intermittent	kW	7.4	8.1	8.8	9.4	10.1	10.8	12.5
		HP	9.9	10.8	11.7	12.6	13.6	14.5	16.8
	Net Intermittent	kW	7.1	7.8	8.4	9.0	9.6	10.1	11.6
		HP	9.6	10.4	11.2	12.0	12.8	13.6	15.6
	Net Continuous	kW	6.2	6.7	7.3	7.8	8.3	8.8	10.1
		HP	8.3	9.0	9.8	10.5	11.1	11.8	13.6
D722	Gross Intermittent	kW	9.0	9.9	10.7	11.5	12.4	-	14.9
		HP	12.1	13.3	14.4	15.5	16.6	-	20.0
	Net Intermittent	kW	8.7	9.5	10.3	11.0	11.9	-	14.0
		HP	11.7	12.8	13.8	14.8	15.9	-	18.8
	Net Continuous	kW	7.6	8.3	8.9	9.6	10.3	-	12.2
		HP	10.2	11.1	11.9	12.9	13.8	-	16.4
D902	Gross Intermittent	kW	11.1	12.1	13.1	14.1	15.1	16.1	18.5
		HP	14.8	16.2	17.5	18.9	20.2	21.6	24.8
	Net Intermittent	kW	10.8	11.7	12.6	13.6	14.5	15.4	17.5
		HP	14.4	15.7	16.9	18.2	19.4	20.6	23.5
	Net Continuous	kW	9.3	10.2	11.0	11.8	12.6	13.4	15.2
		HP	12.5	13.6	14.7	15.8	16.9	17.9	20.4

c) JIS D1005, B8014

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	Net Intermittent (D1005)	kW	5.8	6.3	6.9	7.4	7.9	-	9.3
		PS	7.9	8.6	9.3	10.0	10.8	-	12.7
	Continuous (B8014)	kW	5.1	5.5	6.0	6.4	6.9	-	8.1
		PS	6.9	7.5	8.1	8.7	9.3	-	11.0
Z602	Net Intermittent (D1005)	kW	7.1	7.8	8.4	9.0	9.6	10.1	11.6
		PS	9.7	10.6	11.4	12.2	13.0	13.8	15.8
	Continuous (B8014)	kW	6.2	6.7	7.3	7.8	8.3	8.8	10.1
		PS	8.4	9.2	9.9	10.6	11.3	12.0	13.7
D722	Net Intermittent (D1005)	kW	8.7	9.5	10.3	11.0	11.9	-	14.0
		PS	11.9	13.0	14.0	15.0	16.1	-	19.1
	Continuous (B8014)	kW	7.6	8.3	8.9	9.6	10.3	-	12.2
		PS	10.3	11.3	12.1	13.1	14.0	-	16.6
D902	Net Intermittent (D1005)	kW	10.8	11.7	12.6	13.6	14.5	15.4	17.5
		PS	14.6	15.9	17.2	18.4	19.7	20.9	23.9
	Continuous (B8014)	kW	9.3	10.2	11.0	11.8	12.6	13.4	15.2
		PS	12.7	13.8	14.9	16.0	17.1	18.2	20.7

Note :**1. Above powers may be changed by emission regulations applied.****2. Conversion rates**

☆ 1 kW = 1.35962 PS = 1.34048 HP

☆ 1 PS = 0.7355 kW = 0.985925 HP

☆ 1 HP = 0.7457 kW = 1.01428 PS

2. FUEL CONSUMPTION

a) ISO 3046 (Value at Overload) - Subject to $\pm 5\%$ tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	Brake Horse Power	kW	5.8	6.3	6.9	7.4	7.9	-	9.3
		PS	7.9	8.6	9.3	10.0	10.8	-	12.7
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	-	0.285
		kg/PS•hr	0.188	0.188	0.188	0.191	0.195	-	0.210
	Fuel Consumption	lit/hr	1.76	1.91	2.09	2.29	2.49	-	3.16
Z602	Brake Horse Power	kW	7.1	7.8	8.4	9.0	9.6	10.1	11.6
		PS	9.7	10.6	11.4	12.2	13.0	13.8	15.8
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	0.270	0.285
		kg/PS•hr	0.188	0.188	0.188	0.191	0.195	0.199	0.210
	Fuel Consumption	lit/hr	2.17	2.36	2.54	2.78	3.02	3.26	3.95
D722	Brake Horse Power	kW	8.7	9.5	10.3	11.0	11.9	-	14.0
		PS	11.9	13.0	14.0	15.0	16.1	-	19.1
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	-	0.285
		kg/PS•hr	0.188	0.188	0.188	0.191	0.195	-	0.210
	Fuel Consumption	lit/hr	2.64	2.88	3.13	3.40	3.75	-	4.75
D902	Brake Horse Power	kW	10.8	11.7	12.6	13.6	14.5	15.4	17.5
		PS	14.6	15.9	17.2	18.4	19.7	20.9	23.9
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	0.270	0.285
		kg/PS•hr	0.188	0.188	0.188	0.191	0.195	0.199	0.210
	Fuel Consumption	lit/hr	3.26	3.55	3.84	4.20	4.57	4.95	5.95

Note :

Fuel Consumption Calculating Formula

$$\text{Fuel Consumption (lit/hr)} = \frac{\text{Fuel Consumption (kg/kW•hr)} \times \text{Brake Horse Power (kW)}}{0.84}$$

0.84 (g/cc) : Gravity of Diesel Fuel

b) SAE J1349 (Value at Net Intermittent) - Subject to $\pm 5\%$ tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	Brake Horse Power	kW	5.8	6.3	6.9	7.4	7.9	-	9.3
		HP	7.8	8.5	9.2	9.9	10.6	-	12.5
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	-	0.285
		kg/HP•hr	0.190	0.190	0.190	0.194	0.198	-	0.213
		lb/HP•hr	0.419	0.419	0.419	0.428	0.436	-	0.469
	Fuel Consumption	Gal/hr	0.47	0.51	0.55	0.60	0.66	-	0.84
Z602	Brake Horse Power	kW	7.1	7.8	8.4	9.0	9.6	10.1	11.6
		HP	9.6	10.4	11.2	12.0	12.8	13.6	15.6
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	0.270	0.285
		kg/HP•hr	0.190	0.190	0.190	0.194	0.198	0.201	0.213
		lb/HP•hr	0.419	0.419	0.419	0.427	0.436	0.444	0.469
	Fuel Consumption	Gal/hr	0.57	0.61	0.66	0.72	0.79	0.85	1.03
D722	Brake Horse Power	kW	8.7	9.5	10.3	11.0	11.9	-	14.0
		HP	11.7	12.8	13.8	14.8	15.9	-	18.8
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	-	0.285
		kg/HP•hr	0.190	0.190	0.190	0.194	0.198	-	0.213
		lb/HP•hr	0.419	0.419	0.419	0.428	0.436	-	0.469
	Fuel Consumption	Gal/hr	0.70	0.77	0.83	0.90	0.99	-	1.26
D902	Brake Horse Power	kW	10.8	11.7	12.6	13.6	14.5	15.4	17.5
		HP	14.4	15.7	16.9	18.2	19.4	20.6	23.5
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	0.270	0.285
		kg/HP•hr	0.190	0.190	0.190	0.194	0.198	0.201	0.213
		lb/HP•hr	0.419	0.419	0.419	0.427	0.436	0.444	0.469
	Fuel Consumption	Gal/hr	0.85	0.93	1.00	1.09	1.19	1.29	1.55

Note :
Fuel Consumption Calculating Formula

$$\text{Fuel Consumption (Gal/hr)} = \frac{\text{Fuel Consumption (lb/HP•hr)} \times \text{Brake Horse Power (HP)}}{7.1}$$

7.1 (lb/Gal) : Gravity of Diesel Fuel

3. NOISE LEVEL

Model	Engine Speed min ⁻¹ (rpm)	Unit	Sound Pressure at 1 m (3.3 ft)	
			at Full Load	at No Load
Z482	1500	dB (A)	77.2	75.7
	1800		78.8	77.2
	2000		80.0	78.2
	2500		82.8	80.8
	3000		85.6	83.5
	3200		-	-
	3600		88.7	86.5
Z602	1500	dB (A)	76.8	74.6
	1800		78.8	76.6
	2000		80.1	77.9
	2500		83.5	81.3
	3000		86.8	84.6
	3200		88.2	86.0
	3600		90.8	88.6
D722	1500	dB (A)	78.4	76.9
	1800		80.1	78.5
	2000		81.3	79.6
	2500		84.1	82.3
	3000		87.0	85.0
	3200		-	-
	3600		90.3	88.0
D902	1500	dB (A)	77.9	75.7
	1800		79.9	77.7
	2000		81.3	79.1
	2500		84.6	82.4
	3000		88.0	85.8
	3200		89.3	87.1
	3600		92.0	89.8

These data show the average noise level at four points.

Note :

[Measurement conditions]

☆ With radiator, cooling fan, air cleaner and muffler.

4. AIR REQUIREMENTS

(1) Combustion Air Requirements

{Refer to 25 °C (77 °F) and 750 mmHg}

Engine Speed Model	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	m ³ /hr	27.5	30.0	32.5	35.0	37.5	-	44.0
	m ³ /min	0.46	0.50	0.54	0.58	0.63	-	0.73
	lit/sec	7.64	8.33	9.30	9.72	10.42	-	12.21
	in ³ /sec	466	509	551	593	636	-	745
	ft ³ /min	16.2	17.7	19.1	20.6	22.1	-	25.9
Z602	m ³ /hr	34.4	37.5	40.6	43.8	46.9	48.9	55.0
	m ³ /min	0.57	0.63	0.68	0.73	0.78	0.81	0.92
	lit/sec	9.55	10.42	11.29	12.16	13.03	13.58	15.27
	in ³ /sec	583	636	689	742	795	829	932
	ft ³ /min	20.2	22.1	23.9	25.8	27.6	28.8	32.4
D722	m ³ /hr	41.3	45.0	48.8	52.5	56.3	-	66.0
	m ³ /min	0.69	0.75	0.81	0.88	0.94	-	1.10
	lit/sec	11.47	12.51	13.55	14.60	15.64	-	18.33
	in ³ /sec	700	763	827	891	954	-	1119
	ft ³ /min	24.3	26.5	28.7	30.9	33.1	-	38.9
D902	m ³ /hr	51.6	56.3	60.9	65.6	70.3	73.3	82.4
	m ³ /min	0.86	0.94	1.02	1.09	1.17	1.22	1.37
	lit/sec	14.32	15.63	16.93	18.23	19.53	20.35	22.90
	in ³ /sec	874	954	1033	1112	1192	1242	1397
	ft ³ /min	30.3	33.1	35.9	38.6	41.4	43.1	48.5

Note :

☆ Combustion Air Requirements Calculating Formula

$$Q_1 = V_h \cdot N \cdot C \cdot \eta \cdot k \cdot 10^{-3}$$

Q₁ : Amount of intake air (m³/min)

V_h : Total displacement (lit)

N : Engine speed (min⁻¹(rpm))

C : Coefficient = 0.5

η : Intake efficiency

3000 min⁻¹(rpm) or less : 0.87

3600 min⁻¹(rpm) or less : 0.85

k : Coefficient : 1.0

(2) Cooling Air Requirements

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	m ³ /hr		756	821	900	984	1070	-	1355
	m ³ /min		12.6	13.7	15.0	16.4	17.8	-	22.6
	lit/sec		210	228	250	273	297	-	376
	in ³ /sec		12817	13922	15248	16673	18142	-	22969
	ft ³ /min		445	483	529	579	630	-	798
Z602	m ³ /hr		939	1021	1101	1203	1307	1412	1710
	m ³ /min		15.6	17.0	18.3	20.0	21.8	23.5	28.5
	lit/sec		261	284	306	334	363	392	475
	in ³ /sec		15913	17302	18660	20390	22150	23936	28985
	ft ³ /min		553	601	648	708	769	831	1006
D722	m ³ /hr		1134	1238	1343	1462	1612	-	2040
	m ³ /min		18.9	20.6	22.4	24.4	26.9	-	34.0
	lit/sec		315	344	373	406	448	-	567
	in ³ /sec		19225	20993	22761	24784	27328	-	34577
	ft ³ /min		668	729	790	861	949	-	1201
D902	m ³ /hr		1413	1537	1661	1818	1978	2142	2578
	m ³ /min		23.6	25.6	27.7	30.3	33.0	35.7	43.0
	lit/sec		393	427	461	505	549	595	716
	in ³ /sec		23955	26062	28149	30810	33528	36302	43706
	ft ³ /min		832	905	977	1070	1164	1260	1518

Note :

Above data is decided by following conditions.

(a) Using the standard radiator recommended in SOS.

(b) Engine is run as open unit.

(3) Combustion and Cooling Air Requirements

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	m ³ /hr		784	851	932	1019	1108	-	1399
	m ³ /min		13.1	14.2	15.5	17.0	18.5	-	23.3
	lit/sec		218	236	259	283	308	-	389
	in ³ /sec		13283	14430	15799	17266	16778	-	23714
	ft ³ /min		461	501	549	600	652	-	823
Z602	m ³ /hr		973	1058	1141	1247	1354	1461	1765
	m ³ /min		16.2	17.6	19.0	20.8	22.6	24.3	29.4
	lit/sec		270	294	317	346	376	406	490
	in ³ /sec		16496	17938	19349	21132	22945	24765	29917
	ft ³ /min		573	623	672	734	797	860	1039
D722	m ³ /hr		1175	1283	1392	1515	1668	-	2106
	m ³ /min		19.6	21.4	23.2	25.2	27.8	-	35.1
	lit/sec		327	357	387	421	463	-	585
	in ³ /sec		19925	21756	23588	25675	28282	-	35696
	ft ³ /min		692	755	819	892	982	-	1240
D902	m ³ /hr		1465	1594	1722	1883	2048	2215	2661
	m ³ /min		24.4	26.6	28.7	31.4	34.1	36.9	44.3
	lit/sec		407	443	478	523	569	615	739
	in ³ /sec		24829	27015	29182	31922	34720	37544	45103
	ft ³ /min		862	938	1013	1108	1206	1304	1566

Note :**1. Cooling Air Fan and Pulley Specification**

Model		Z482	Z602	D722	D902
Item					
Fan Diameter	mm	φ 240	φ 260	φ 260	φ 260
	in.	φ 9.45	φ 10.24	φ 10.24	φ 10.24
No. of Blade and Type of Shape		4, S type	4, S type	4, S type	5, F type
Diameter of Fan Driving Pulley	mm	φ 100	φ 100	φ 100	φ 100
	in.	φ 3.94	φ 3.94	φ 3.94	φ 3.94
Diameter of Fan Pulley	mm	φ 84	φ 84	φ 84	φ 84
	in.	φ 3.31	φ 3.31	φ 3.31	φ 3.31

2. Conversion Rates☆ 1 lit = 61.0237 in³ = 0.035315 ft³☆ 1 ft³ = 28.3168 lit☆ 1 lit/sec = 3.6 m³/hr = 2.1189 ft³/min

5. EXHAUST GAS VOLUME

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	Combustion Air Requirements	m ³ /min	0.46	0.50	0.54	0.58	0.63	-	0.73
	Brake Horse Power	kW	5.8	6.3	6.9	7.4	7.9	-	9.3
	Fuel Consumption	lit/hr	1.76	1.91	2.09	2.29	2.49	-	3.16
		g/hr	1478	1604	1756	1924	2092	-	2654
	Exhaust Gas Volume	m ³ /hr	75.2	81.8	88.4	95.0	103.2	-	120.0
		m ³ /min	1.25	1.36	1.47	1.58	1.72	-	2.00
		lit/sec	20.9	22.7	24.5	26.4	28.7	-	33.3
		in ³ /sec	1275	1386	1498	1610	1749	-	2034
		ft ³ /min	44.3	48.1	52.0	55.9	60.7	-	70.6
Z602	Combustion Air Requirements	m ³ /min	0.57	0.63	0.68	0.73	0.78	0.81	0.92
	Brake Horse Power	kW	7.1	7.8	8.4	9.0	9.6	10.1	11.6
	Fuel Consumption	lit/hr	2.17	2.36	2.54	2.78	3.02	3.26	3.95
		g/hr	1823	1980	2135	2333	2535	2739	3317
	Exhaust Gas Volume	m ³ /hr	80.7	90.6	101.2	110.6	120.2	130.3	147.0
		m ³ /min	1.34	1.51	1.69	1.84	2.00	2.17	2.45
		lit/sec	22.4	25.2	28.1	30.7	33.4	36.2	40.8
		in ³ /sec	1368	1535	1715	1874	2038	2208	2491
		ft ³ /min	47.5	53.3	59.5	65.1	70.8	76.7	86.5
D722	Combustion Air Requirements	m ³ /min	0.69	0.75	0.81	0.88	0.94	-	1.10
	Brake Horse Power	kW	8.7	9.5	10.3	11.0	11.9	-	14.0
	Fuel Consumption	lit/hr	2.64	2.88	3.13	3.40	3.75	-	4.75
		g/hr	2.22	2.42	2.63	2.86	3.15	-	3.99
	Exhaust Gas Volume	m ³ /hr	108.4	118.3	128.1	138.0	147.8	-	173.3
		m ³ /min	1.81	1.97	2.14	2.30	2.46	-	2.89
		lit/sec	30.1	32.9	35.6	38.3	41.1	-	48.1
		in ³ /sec	1838	2005	2172	2339	2506	-	2938
		ft ³ /min	63.8	69.6	75.4	81.2	87.0	-	102.0

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
D902	Combustion Air Requirements	m ³ /min	0.86	0.94	1.02	1.09	1.17	1.22	1.37
	Brake Horse Power	kW	10.8	11.7	12.6	13.6	14.5	15.4	17.5
	Fuel Consumption	lit/hr	3.26	3.55	3.84	4.20	4.57	4.95	5.95
		g/hr	2741	2982	3221	3526	3837	4154	5002
	Exhaust Gas Volume	m ³ /hr	120.3	135.6	150.3	167.3	184.0	193.9	218.8
		m ³ /min	2.00	2.26	2.50	2.79	3.07	3.23	3.65
		lit/sec	33.4	37.7	41.7	46.5	51.1	53.9	60.8
		in ³ /sec	2039	2299	2548	2836	3118	3287	3708
		ft ³ /min	70.8	79.8	88.5	98.5	108.3	114.1	128.8

Note :

☆ Exhaust Gas Volume Calculating Formula

$$GL = (AL + 7.1 \times Be/10000) \times (298 + t) \times 760 / 298 / (760 + Ps) \text{ (m}^3\text{/hr)}$$

AL : Combustion Air Requirements (m³/hr)

Be : Fuel Consumption (g/hr)

t : Exhaust Gas Temperature (°C)

Ps : Exhaust Gas Back Pressure (mmHg)

[Conversion Rates]

$$\star 1 \text{ lit} = 61.0237 \text{ in}^3 = 0.035315 \text{ ft}^3$$

$$\star 1 \text{ ft}^3 = 28.3168 \text{ lit}$$

$$\star 1 \text{ lit/sec} = 3.6 \text{ m}^3\text{/hr} = 127.133 \text{ ft}^3\text{/hr}$$

6. HEAT REJECTION TO COOLANT

a) ISO 3046 (Value at Overload)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	Brake Horse Power	kW	5.8	6.3	6.9	7.4	7.9	-	9.3
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	-	0.285
	Heat Rejection To Coolant	kJ/hr	22297	24220	26526	29006	31562	-	39959
		kcal/hr	5327	5786	6337	6929	7540	-	9546
Z602	Brake Horse Power	kW	7.1	7.8	8.4	9.0	9.6	10.1	11.6
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	0.270	0.285
	Heat Rejection To Coolant	kJ/hr	27472	29846	32188	35172	38207	41289	49997
		kcal/hr	6620	7192	7757	8476	9207	9950	12048
D722	Brake Horse Power	kW	8.7	9.5	10.3	11.0	11.9	-	14.0
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	-	0.285
	Heat Rejection To Coolant	kJ/hr	33446	36522	39597	43117	47542	-	60153
		kcal/hr	7990	8725	9459	10300	11357	-	14370
D902	Brake Horse Power	kW	10.8	11.7	12.6	13.6	14.5	15.4	17.5
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	0.270	0.285
	Heat Rejection To Coolant	kJ/hr	41322	44955	48557	53145	57835	62620	75391
		kcal/hr	9958	10833	11701	12807	13937	15090	18168

b) SAE J1349 (Value at Net Intermittent)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
Z482	Brake Horse Power	kW	5.8	6.3	6.9	7.4	7.9	-	9.3
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	-	0.285
	Heat Rejection To Coolant	kJ/hr	22297	24220	26526	29006	31562	-	39959
		Btu/hr	21140	22962	25149	27500	29923	-	37885
Z602	Brake Horse Power	kW	7.1	7.8	8.4	9.0	9.6	10.1	11.6
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	0.270	0.285
	Heat Rejection To Coolant	kJ/hr	27472	29846	32188	35172	38207	41289	49997
		Btu/hr	26247	28539	30778	33631	36534	39480	47807
D722	Brake Horse Power	kW	8.7	9.5	10.3	11.0	11.9	-	14.0
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	-	0.285
	Heat Rejection To Coolant	kJ/hr	33446	36522	39597	43117	47542	-	60153
		Btu/hr	31710	34626	37542	40879	45074	-	57031

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2800	3000	3200	3600
D902	Brake Horse Power	kW	10.8	11.7	12.6	13.6	14.5	15.4	17.5
	Specific Fuel Consumption	kg/kW•hr	0.255	0.255	0.255	0.260	0.265	0.270	0.285
	Heat Rejection	kJ/hr	41322	44955	48557	53145	57835	62620	75391
	To Coolant	Btu/hr	39512	42986	46430	50817	55301	59877	72089

Note :☆ **Heat Rejection to Coolant Calculating Formula**

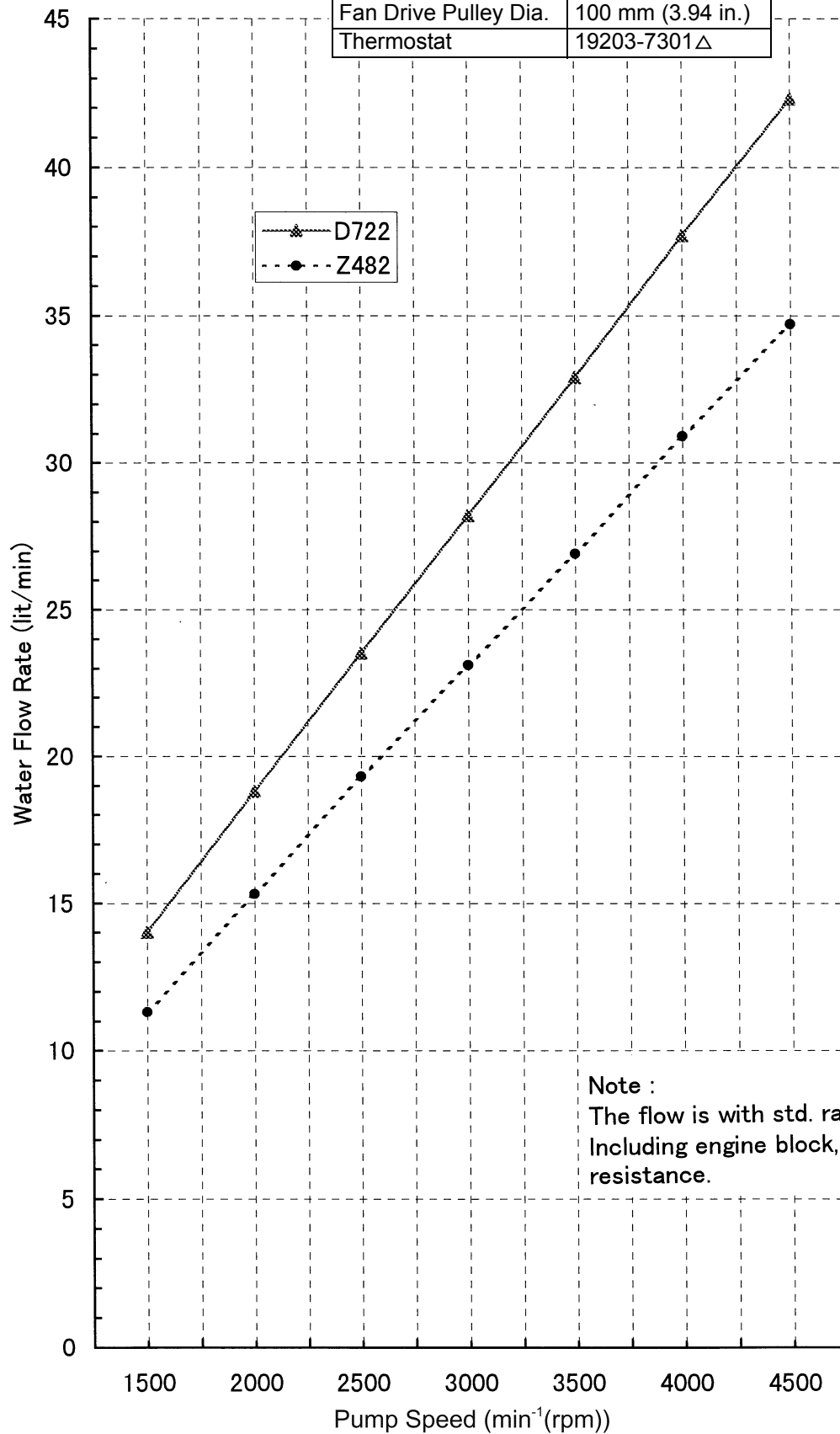
$$H_o = H_u \times N_e \times b_e \times i$$

H_o : Heat rejection to coolant
H_u : Diesel fuel low caloric value
 (42700 kJ/kg, 10290 kcal/kg
 or 18520 Btu/lb)
N_e : Brake horse power (kW)
b_e : Specific fuel consumption (g/kW•hr)
i : Dispersion ratio to coolant (%)

7. WATER FLOW RATE

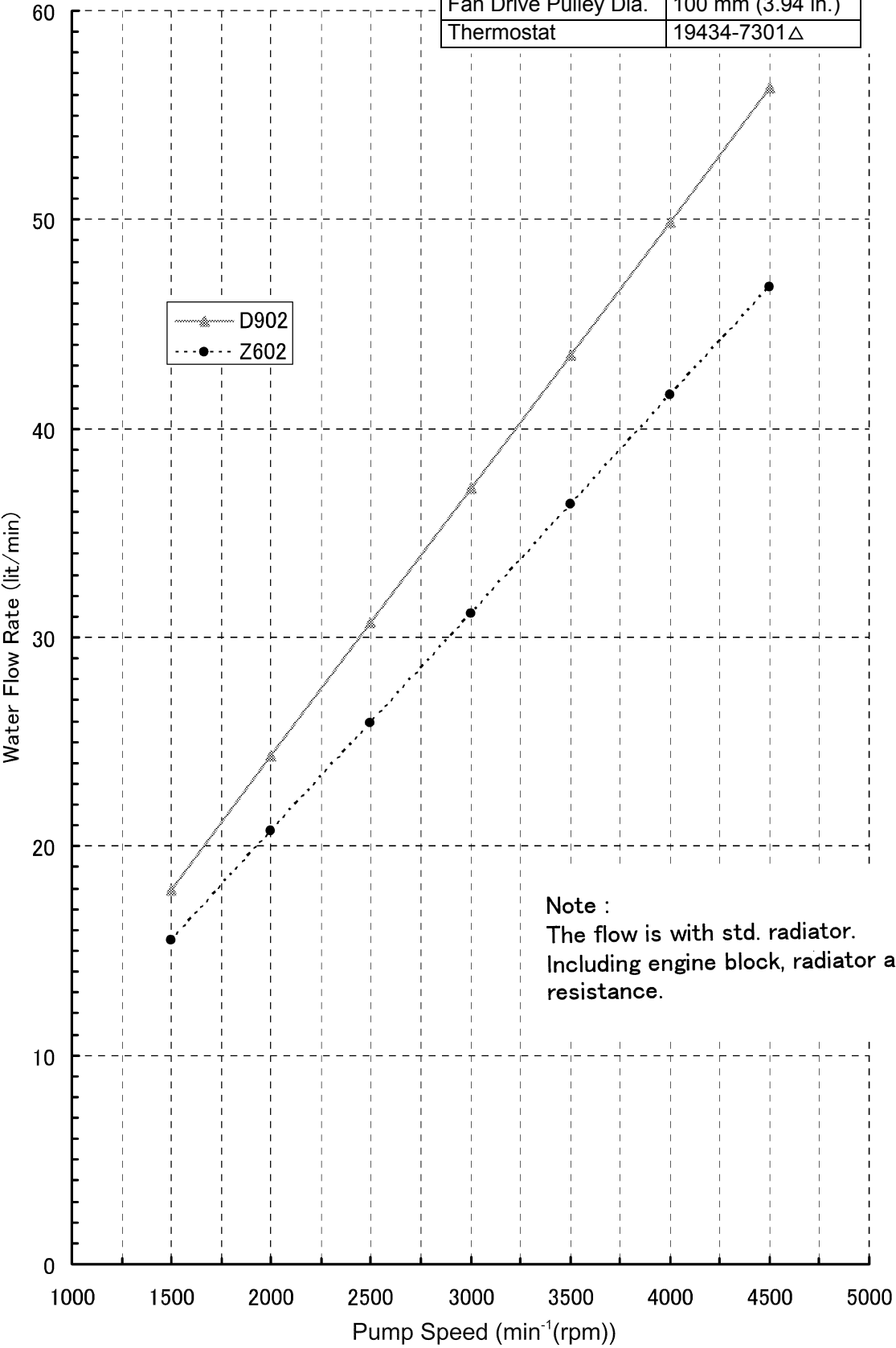
(1) Water Flow Rate of Z482/D722

Water Pump	1E051-7303△
Fan Pulley Dia.	84 mm (3.31 in.)
Fan Drive Pulley Dia.	100 mm (3.94 in.)
Thermostat	19203-7301△



(2) Water Flow Rate of Z602/D902

Water Pump	1E051-7303Δ
Fan Pulley Dia	84 mm (3.31 in.)
Fan Drive Pulley Dia.	100 mm (3.94 in.)
Thermostat	19434-7301Δ



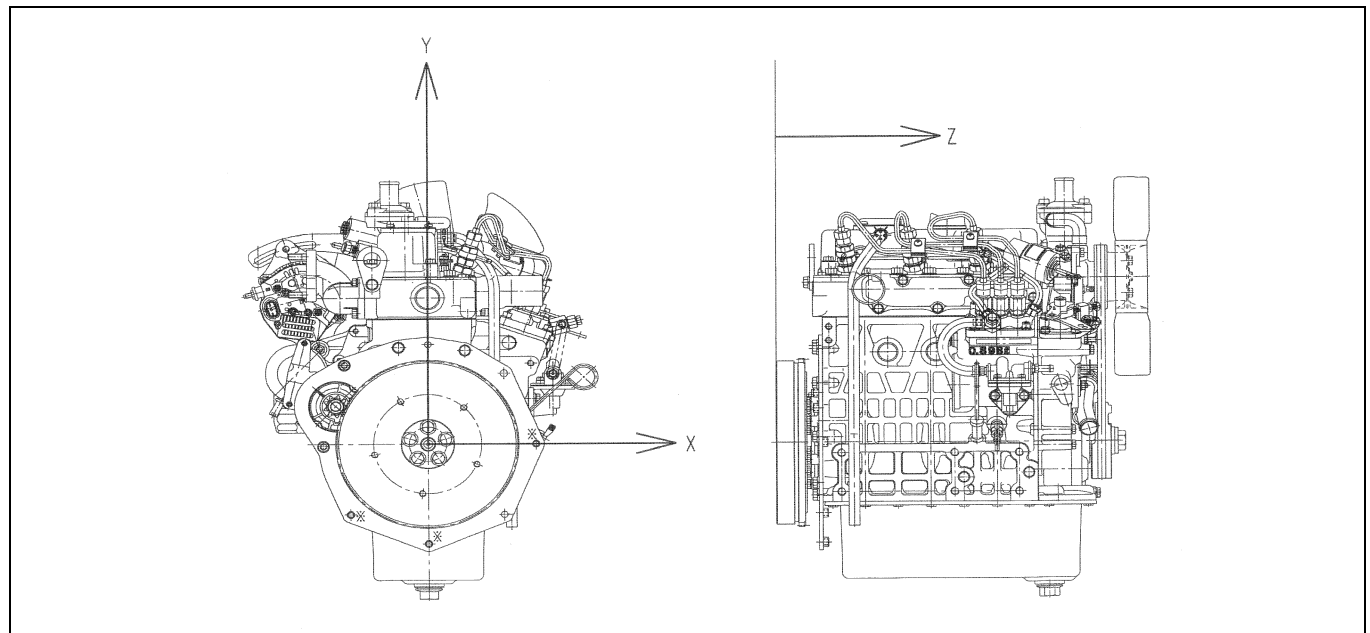
8. CENTER OF GRAVITY

1. With Standard Flywheel and Flywheel Housing

Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
Z482	53.1 (117.1)	3.0 (0.12)	62.0 (2.44)	135.0 (5.32)
Z602	63.5 (140.0)	-14.5 (-0.57)	70.3 (2.77)	145.6 (5.73)
D722	63.1 (139.1)	2.0 (0.08)	64.0 (2.52)	171.0 (6.73)
D902	74.7 (164.7)	-25.5 (-1.00)	73.3 (2.89)	179.5 (7.07)

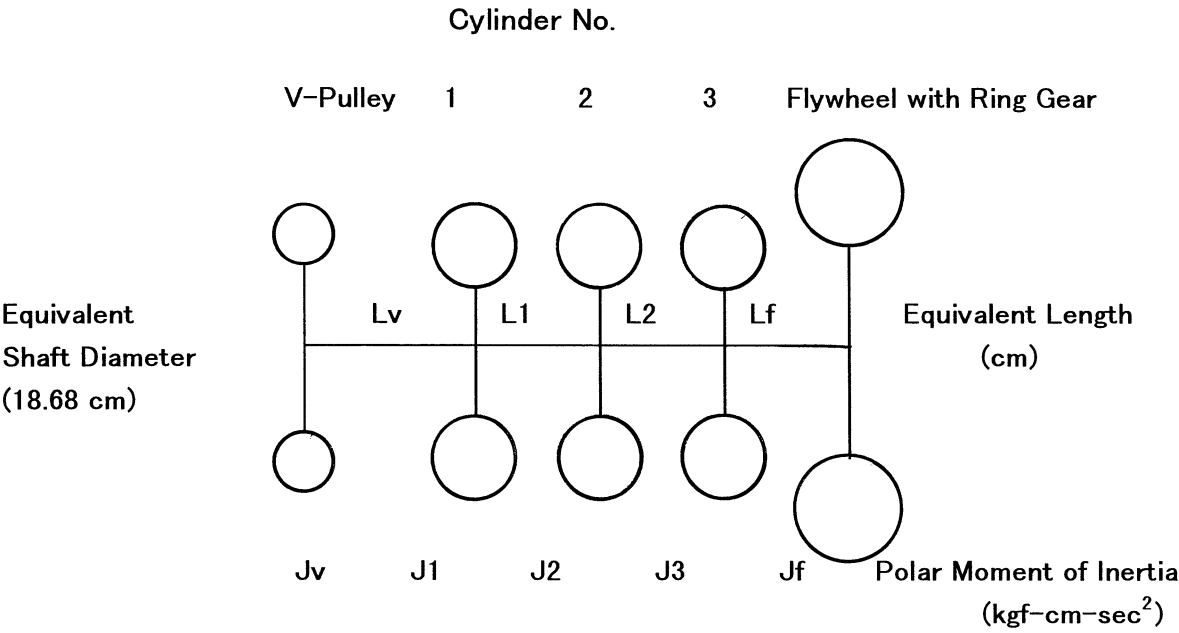
2. With SAE Flywheel and Flywheel Housing

Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
Z482	81.0 (178.6)	1.0 (0.04)	42.0 (1.65)	156.0 (6.14)
D722	90.4 (199.3)	1.0 (0.04)	47.0 (1.85)	188.0 (7.40)



9. MASS ELASTIC SYSTEMS

(A) With Standard Flywheel



Model	Equivalent Length (cm)				Polar Moment of Inertia (kgf-cm-sec ²)				
	Lv	L1	L2	Lf	Jv	J1	J2	J3	Jf
Z482	30670	5136	-	3673	0.012	0.013	0.014	-	0.392
Z602	34992	4348	-	2734	0.012	0.026	0.026	-	0.390
D722	30670	5136	5136	3673	0.013	0.017	0.011	0.018	0.392
D902	35082	4528	4528	2824	0.013	0.026	0.026	0.026	0.523

Note :

Model		Z482	Z602	D722	D902
Flywheel & V-pulley					
KEA spec.	Flywheel	16851-2511△	16851-2511△	16861-2511△	1G962-2511△
	V-pulley	16851-7428△	16851-7428△	16861-7428△	1G952-7428△
EU spec.	Flywheel	16851-2511△	16851-2511△	16861-2511△	1G962-2511△
	V-pulley	16851-7428△	16852-7428△	16861-7428△	1G962-7428△

10. UNBALANCED FORCES

1. Base Data

F_z = Unbalanced inertia force

$$= 4m_p * r * \omega^2 * (r/l) \cos 2\theta \text{ (kgf)}$$

N_{py} , No_z = Unbalanced inertia couple (kgf-m)

m_p = Reciprocating mass = W_p/G (kg)

W_p = Reciprocating weight = (kgf)

G = Gravitational Acceleration = $9.80665 \text{ (m/sec}^2\text{)}$

r = Crank radius (m)

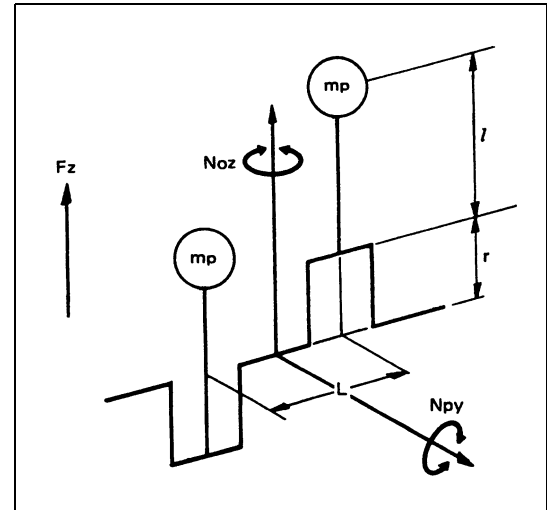
l = Center distance of connecting rod (m)

L = Cylinder distance (m)

ω = Angular velocity

$$= 2\pi n/60 \text{ (rad/sec)}$$

n = Engine speed ($\text{min}^{-1}(\text{rpm})$)



Model	l (m)	r (m)	L (m)	Wp (kgf)	Bore (mm)	Stroke (mm)
Z482	0.0980	0.0340	0.0720	0.4210	67.0	68.0
Z602	0.0980	0.0368	0.0800	0.4510	72.0	73.6
D722	0.0980	0.0340	0.0720	0.4210	67.0	68.0
D902	0.0980	0.0368	0.0800	0.4510	72.0	73.6

2. Unbalanced inertia force and couple

($\times \omega^2$)

Model	No. of Cylinder	Cylinder Bore (mm)	Order	F_z	N_{py}	No_z
Z482	2	67.0	1	0	0.000053	0.000053
			2	0.001013	0	0
Z602	2	72.0	1	0	0.000068	0.000068
			2	0.001271	0	0
D722	3	67.0	1	0	0.000091	0.000091
			2	0	0.000063	0
D902	3	72.0	1	0	0.000117	0.000117
			2	0	0.000088	0

3. An example of calculation

Calculation Condition	ω^2	F_z , N_{py} , No_z		
			Order	Calculation
Engine model : Z482 Engine speed : $3600 \text{ min}^{-1}(\text{rpm})$	$(2 \times \pi \times 3600/60)^2 = 142122$	F_z (kgf)	1	0
			2	$0.001027 \times 142122 = 146.0 \text{ kg}$
		N_{py} (kgf-m)	1	$0.000053 \times 142122 = 7.5 \text{ kg}$
			2	0
		No_z (kgf-m)	1	$0.000053 \times 142122 = 7.5 \text{ kg}$
			2	0
Engine model : Z602 Engine speed : $3600 \text{ min}^{-1}(\text{rpm})$	$(2 \times \pi \times 3600/60)^2 = 142122$	F_z (kgf)	1	0
			2	$0.001023 \times 142122 = 180.6 \text{ kg}$
		N_{py} (kgf-m)	1	$0.000068 \times 142122 = 9.6 \text{ kg}$
			2	0
		No_z (kgf-m)	1	$0.000068 \times 142111 = 9.6 \text{ kg}$
			2	0

2. 05 SERIES

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1. BRAKE HORSE POWER

a) ISO 3046, 2534

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Gross	kW	-	-	-	14.2	14.5	14.8	16.1	17.5	18.5
		PS	-	-	-	19.3	19.7	20.1	21.9	23.8	25.2
	Overload	kW	-	-	-	13.7	14.0	14.3	15.5	16.8	17.5
		PS	-	-	-	18.7	19.1	19.4	21.1	22.9	23.8
	Continuous	kW	-	-	-	11.9	12.2	12.4	13.5	14.6	15.2
		PS	-	-	-	16.2	16.5	16.9	18.3	19.9	20.7
D1105	Gross	kW	-	-	15.5	15.9	16.3	16.8	18.1	18.5	-
		PS	-	-	21.1	21.6	22.2	22.8	24.6	25.2	-
	Overload	kW	-	-	15.1	15.4	15.8	16.2	17.5	17.8	-
		PS	-	-	20.5	21.0	21.5	22.1	23.8	24.2	-
	Continuous	kW	-	-	13.1	13.4	13.7	14.1	15.2	15.5	-
		PS	-	-	17.8	18.2	18.6	19.2	20.7	21.0	-
D1305	Gross	kW	-	-	-	-	18.8	-	20.2	21.7	-
		PS	-	-	-	-	25.6	-	27.5	29.5	-
	Overload	kW	-	-	-	-	18.2	-	19.6	21.0	-
		PS	-	-	-	-	24.8	-	26.6	28.5	-
	Continuous	kW	-	-	-	-	15.8	-	17.0	18.2	-
		PS	-	-	-	-	21.5	-	23.1	24.8	-
D1105-T	Gross	kW	-	-	-	-	-	-	-	24.5	-
		PS	-	-	-	-	-	-	-	33.3	-
	Overload	kW	-	-	-	-	-	-	-	23.5	-
		PS	-	-	-	-	-	-	-	31.9	-
	Continuous	kW	-	-	-	-	-	-	-	20.4	-
		PS	-	-	-	-	-	-	-	27.7	-
V1505	Gross	kW	19.4	20.1	21.2	21.8	22.7	23.6	24.5	26.5	-
		PS	26.4	27.3	28.8	29.6	30.9	32.1	33.3	36.0	-
	Overload	kW	18.7	19.3	20.3	20.8	21.6	22.4	23.2	25.0	-
		PS	25.4	26.2	27.6	28.3	29.4	30.5	31.6	34.0	-
	Continuous	kW	16.2	16.8	17.6	18.1	18.8	19.5	20.2	21.7	-
		PS	22.0	22.8	24.0	24.6	25.5	26.5	27.4	29.5	-
V1505-T	Gross	kW	-	-	-	-	-	-	30.6	33.0	-
		PS	-	-	-	-	-	-	41.6	44.9	-
	Overload	kW	-	-	-	-	-	-	29.2	31.3	-
		PS	-	-	-	-	-	-	39.6	42.6	-
	Continuous	kW	-	-	-	-	-	-	25.3	27.2	-
		PS	-	-	-	-	-	-	34.4	37.0	-

b) SAE J1349

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Gross Intermittent	kW	-	-	-	14.2	14.5	14.8	16.1	17.5	18.5
		HP	-	-	-	19.0	19.4	19.8	21.6	23.5	24.8
	Net Intermittent	kW	-	-	-	13.7	14.0	14.3	15.5	16.8	17.5
		HP	-	-	-	18.4	18.8	19.1	20.8	22.6	23.5
	Net Continuous	kW	-	-	-	11.9	12.2	12.4	13.5	14.6	15.2
		HP	-	-	-	16.0	16.3	16.6	18.1	19.6	20.4
D1105	Gross Intermittent	kW	-	-	15.5	15.9	16.3	16.8	18.1	18.5	-
		HP	-	-	20.8	21.3	21.8	22.5	24.3	24.8	-
	Net Intermittent	kW	-	-	15.1	15.4	15.8	16.2	17.5	17.8	-
		HP	-	-	20.2	20.7	21.2	21.8	23.4	23.9	-
	Net Continuous	kW	-	-	13.1	13.4	13.7	14.1	15.2	15.5	-
		HP	-	-	17.5	18.0	18.4	18.9	20.4	20.7	-
D1305	Gross Intermittent	kW	-	-	-	-	18.8	-	20.2	21.7	-
		HP	-	-	-	-	25.2	-	27.1	29.1	-
	Net Intermittent	kW	-	-	-	-	18.2	-	19.6	21.0	-
		HP	-	-	-	-	24.5	-	26.2	28.1	-
	Net Continuous	kW	-	-	-	-	15.8	-	17.0	18.2	-
		HP	-	-	-	-	21.2	-	22.8	24.4	-
D1105-T	Gross Intermittent	kW	-	-	-	-	-	-	-	24.5	-
		HP	-	-	-	-	-	-	-	32.8	-
	Net Intermittent	kW	-	-	-	-	-	-	-	23.5	-
		HP	-	-	-	-	-	-	-	31.5	-
	Net Continuous	kW	-	-	-	-	-	-	-	20.4	-
		HP	-	-	-	-	-	-	-	27.4	-
V1505	Gross Intermittent	kW	19.4	20.1	21.2	21.8	22.7	23.6	24.5	26.5	-
		HP	26.0	26.9	28.4	29.2	30.4	31.6	32.8	35.5	-
	Net Intermittent	kW	18.7	19.3	20.3	20.8	21.6	22.4	23.2	25.0	-
		HP	25.0	25.9	27.2	27.9	29.0	30.1	31.1	33.5	-
	Net Continuous	kW	16.2	16.8	17.6	18.1	18.8	19.5	20.2	21.7	-
		HP	21.7	22.5	23.6	24.2	25.2	26.1	27.0	29.1	-
V1505-T	Gross Intermittent	kW	-	-	-	-	-	-	30.6	33.0	-
		HP	-	-	-	-	-	-	41.0	44.2	-
	Net Intermittent	kW	-	-	-	-	-	-	29.2	31.3	-
		HP	-	-	-	-	-	-	39.1	42.0	-
	Net Continuous	kW	-	-	-	-	-	-	25.3	27.2	-
		HP	-	-	-	-	-	-	34.0	36.4	-

c) JIS D1005, B8014

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	建設機械用 定格出力 (D1005)	kW	-	-	-	13.7	14.0	14.3	15.5	16.8	17.5
		PS	-	-	-	18.7	19.1	19.4	21.1	22.9	23.8
	定回転用 定格出力 (B8014)	kW	-	-	-	11.9	12.2	12.4	13.5	14.6	15.2
		PS	-	-	-	16.2	16.5	16.9	18.3	19.9	20.7
D1105	建設機械用 定格出力 (D1005)	kW	-	-	15.1	15.4	15.8	16.2	17.5	17.8	-
		PS	-	-	20.5	21.0	21.5	22.1	23.8	24.2	-
	定回転用 定格出力 (B8014)	kW	-	-	13.1	13.4	13.7	14.1	15.2	15.5	-
		PS	-	-	17.8	18.2	18.6	19.2	20.7	21.0	-
D1305	建設機械用 定格出力 (D1005)	kW	-	-	-	-	18.2	-	19.6	21.0	-
		PS	-	-	-	-	24.8	-	26.6	28.5	-
	定回転用 定格出力 (B8014)	kW	-	-	-	-	15.8	-	17.0	18.2	-
		PS	-	-	-	-	21.5	-	23.1	24.8	-
D1105-T	建設機械用 定格出力 (D1005)	kW	-	-	-	-	-	-	-	23.5	-
		PS	-	-	-	-	-	-	-	31.9	-
	定回転用 定格出力 (B8014)	kW	-	-	-	-	-	-	-	20.4	-
		PS	-	-	-	-	-	-	-	27.7	-
V1505	建設機械用 定格出力 (D1005)	kW	18.7	19.3	20.3	20.8	21.6	22.4	23.2	25.0	-
		PS	25.4	26.2	27.6	28.3	29.4	30.5	31.6	34.0	-
	定回転用 定格出力 (B8014)	kW	16.2	16.8	17.6	18.1	18.8	19.5	20.2	21.7	-
		PS	22.0	22.8	24.0	24.6	25.5	26.5	27.4	29.5	-
V1505-T	建設機械用 定格出力 (D1005)	kW	-	-	-	-	-	-	29.2	31.3	-
		PS	-	-	-	-	-	-	39.6	42.6	-
	定回転用 定格出力 (B8014)	kW	-	-	-	-	-	-	25.3	27.2	-
		PS	-	-	-	-	-	-	34.4	37.0	-

Note :

1. Above powers may be changed by emission regulations applied.

2. There are some data of engine for generator in another section of this materials.

3. Conversion rates

☆ 1 kW = 1.35962 PS = 1.34048 HP

☆ 1 PS = 0.7355 kW = 0.985925 HP

☆ 1 HP = 0.7457 kW = 1.01428 PS

2. FUEL CONSUMPTION

a) ISO 3046 (Value at Overload) - Subject to $\pm 5\%$ Tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Brake Horse Power	kW	-	-	-	13.7	14.0	14.3	15.5	16.8	17.5
		PS	-	-	-	18.7	19.1	19.4	21.1	22.9	23.8
	Specific Fuel Consumption	kg/kWh	-	-	-	0.272	0.271	0.276	0.277	0.279	0.292
		kg/PSH	-	-	-	0.200	0.199	0.203	0.204	0.205	0.215
	Fuel Consumption	lit/hr	-	-	-	4.46	4.52	4.69	5.12	5.59	6.09
D1105	Brake Horse Power	kW	-	-	15.1	15.4	15.8	16.2	17.5	17.8	-
		PS	-	-	20.5	21.0	21.5	22.1	23.8	24.2	-
	Specific Fuel Consumption	kg/kWh	-	-	0.266	0.268	0.270	0.275	0.277	0.284	-
		kg/PSH	-	-	0.196	0.197	0.199	0.202	0.204	0.209	-
	Fuel Consumption	lit/hr	-	-	4.77	4.93	5.08	5.32	5.77	6.02	-
D1305	Brake Horse Power	kW	-	-	-	-	18.2	-	19.6	21.0	-
		PS	-	-	-	-	24.8	-	26.6	28.5	-
	Specific Fuel Consumption	kg/kWh	-	-	-	-	0.274	-	0.283	0.284	-
		kg/PSH	-	-	-	-	0.201	-	0.208	0.209	-
	Fuel Consumption	lit/hr	-	-	-	-	5.94	-	6.60	7.09	-
D1105-T	Brake Horse Power	kW	-	-	-	-	-	-	-	23.5	-
		PS	-	-	-	-	-	-	-	31.9	-
	Specific Fuel Consumption	kg/kWh	-	-	-	-	-	-	-	0.272	-
		kg/PSH	-	-	-	-	-	-	-	0.200	-
	Fuel Consumption	lit/hr	-	-	-	-	-	-	-	7.61	-
V1505	Brake Horse Power	kW	18.7	19.3	20.3	20.8	21.6	22.4	23.2	25.0	-
		PS	25.4	26.2	27.6	28.3	29.4	30.5	31.6	34.0	-
	Specific Fuel Consumption	kg/kWh	0.264	0.266	0.267	0.270	0.271	0.268	0.276	0.283	-
		kg/PSH	0.194	0.195	0.196	0.199	0.200	0.197	0.203	0.208	-
	Fuel Consumption	lit/hr	5.86	6.10	6.45	6.69	6.99	7.16	7.63	8.42	-
V1505-T	Brake Horse Power	kW	-	-	-	-	-	-	29.2	31.3	-
		PS	-	-	-	-	-	-	39.6	42.6	-
	Specific Fuel Consumption	kg/kWh	-	-	-	-	-	-	0.269	0.273	-
		kg/PSH	-	-	-	-	-	-	0.198	0.201	-
	Fuel Consumption	lit/hr	-	-	-	-	-	-	9.34	10.19	-

Note :

Fuel Consumption Calculating Formula

$$\text{Fuel Consumption (lit/hr)} = \frac{\text{Fuel Consumption (kg/kW·hr)} \times \text{Brake Horse Power (kW)}}{0.84}$$

0.84 (g/cc) : Gravity of Diesel Fuel

b) SAE J1349 (Value at Net Intermittent) - Subject to $\pm 5\%$ Tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Brake Horse Power	kW	-	-	-	13.7	14.0	14.3	15.5	16.8	17.5
		HP	-	-	-	18.4	18.8	19.1	20.8	22.6	23.5
	Specific Fuel Consumption	kg/kWh	-	-	-	0.272	0.271	0.276	0.277	0.279	0.292
		lb/HPh	-	-	-	0.448	0.445	0.454	0.455	0.459	0.481
	Fuel Consumption	Gal/hr	-	-	-	1.16	1.18	1.22	1.33	1.46	1.59
D1105	Brake Horse Power	kW	-	-	15.1	15.4	15.8	16.2	17.5	17.8	-
		HP	-	-	20.2	20.7	21.2	21.8	23.4	23.9	-
	Specific Fuel Consumption	kg/kWh	-	-	0.266	0.268	0.270	0.275	0.277	0.284	-
		lb/HPh	-	-	0.438	0.441	0.444	0.453	0.456	0.467	-
	Fuel Consumption	Gal/hr	-	-	1.25	1.29	1.32	1.39	1.51	1.57	-
D1305	Brake Horse Power	kW	-	-	-	-	18.2	-	19.6	21.0	-
		HP	-	-	-	-	24.5	-	26.2	28.1	-
	Specific Fuel Consumption	kg/kWh	-	-	-	-	0.274	-	0.283	0.284	-
		lb/HPh	-	-	-	-	0.450	-	0.466	0.467	-
	Fuel Consumption	Gal/hr	-	-	-	-	1.55	-	1.72	1.85	-
D1105-T	Brake Horse Power	kW	-	-	-	-	-	-	-	23.5	-
		HP	-	-	-	-	-	-	-	31.5	-
	Specific Fuel Consumption	kg/kWh	-	-	-	-	-	-	-	0.272	-
		lb/HPh	-	-	-	-	-	-	-	0.448	-
	Fuel Consumption	Gal/hr	-	-	-	-	-	-	-	1.99	-
V1505	Brake Horse Power	kW	18.7	19.3	20.3	20.8	21.6	22.4	23.2	25.0	-
		HP	25.0	25.9	27.2	27.9	29.0	30.1	31.1	33.5	-
	Specific Fuel Consumption	kg/kWh	0.264	0.266	0.267	0.270	0.271	0.268	0.276	0.283	-
		lb/HPh	0.434	0.437	0.439	0.444	0.447	0.441	0.454	0.466	-
	Fuel Consumption	Gal/hr	1.53	1.59	1.68	1.74	1.82	1.87	1.99	2.20	-
V1505-T	Brake Horse Power	kW	-	-	-	-	-	-	29.2	31.3	-
		HP	-	-	-	-	-	-	39.1	42.0	-
	Specific Fuel Consumption	kg/kWh	-	-	-	-	-	-	0.269	0.273	-
		lb/HPh	-	-	-	-	-	-	0.443	0.450	-
	Fuel Consumption	Gal/hr	-	-	-	-	-	-	2.44	2.66	-

Note :**Fuel Consumption Calculating Formula**

$$\text{Fuel Consumption (Gal/hr)} = \frac{\text{Fuel Consumption (lb/HP}\cdot\text{hr)} \times \text{Brake Horse Power (HP)}}{7.1}$$

7.1 (lb/Gal) : Gravity of Diesel Fuel

3. NOISE LEVEL

Model	Engine Speed min ⁻¹ (rpm)	Unit	Sound Pressure at 1 m (3.3 ft)	
			at Full Load	at No Load
D1005	1500	dB (A)	79.8	78.3
	1800		82.1	80.7
	2000		83.8	82.3
	2500		87.5	85.9
	3000		90.5	89.0
	3600		93.0	92.0
D1105	1500	dB (A)	80.0	78.6
	1800		82.5	81.0
	2000		84.2	82.6
	2500		87.8	86.4
	3000		92.0	89.5
D1305	1500	dB (A)	80.6	77.3
	1800		82.8	80.0
	2000		84.3	81.8
	2500		88.1	85.9
	3000		91.8	89.5
D1105-T	1500	dB (A)	80.5	79.0
	1800		83.1	81.5
	2000		84.9	83.2
	2500		88.6	87.1
	3000		93.0	90.3
V1505	1500	dB (A)	81.5	80.0
	1800		84.0	82.5
	2000		85.8	83.0
	2500		89.5	84.2
	3000		92.0	91.2
V1505-T	1500	dB (A)	82.2	80.6
	1800		84.8	83.2
	2000		86.6	84.9
	2500		90.4	88.8
	3000		93.0	92.1

These data show the average noise level at four points.

Note :

[Measurement conditions]

☆ With radiator, cooling fan, air cleaner and muffler.

4. AIR REQUIREMENTS

(1) Combustion Air Requirements

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Combustion Air Requirements	m ³ /hr	-	-	-	65.3	67.9	70.5	73.2	78.4	94.1
		m ³ /min	-	-	-	1.09	1.13	1.18	1.22	1.31	1.57
		lit/sec	-	-	-	18.14	18.87	19.59	20.32	21.77	26.13
		in ³ /sec	-	-	-	1107	1151	1196	1240	1329	1594
		ft ³ /min	-	-	-	38.4	40.0	41.5	43.1	46.1	55.4
D1105	Combustion Air Requirements	m ³ /hr	-	-	70.3	73.3	76.2	79.1	82.1	87.9	-
		m ³ /min	-	-	1.17	1.22	1.27	1.32	1.37	1.47	-
		lit/sec	-	-	19.54	20.35	21.17	21.98	22.80	24.43	-
		in ³ /sec	-	-	1192	1242	1292	1341	1391	1491	-
		ft ³ /min	-	-	41.4	43.1	44.9	46.6	48.3	51.8	-
D1305	Combustion Air Requirements	m ³ /hr	-	-	-	-	85.6	-	92.2	98.7	-
		m ³ /min	-	-	-	-	1.43	-	1.54	1.65	-
		lit/sec	-	-	-	-	23.77	-	25.60	27.43	-
		in ³ /sec	-	-	-	-	1451	-	1562	1674	-
		ft ³ /min	-	-	-	-	50.4	-	54.2	58.1	-
D1105-T	Combustion Air Requirements	m ³ /hr	-	-	-	-	-	-	-	121.3	-
		m ³ /min	-	-	-	-	-	-	-	2.02	-
		lit/sec	-	-	-	-	-	-	-	33.69	-
		in ³ /sec	-	-	-	-	-	-	-	2056	-
		ft ³ /min	-	-	-	-	-	-	-	71.4	-
V1505	Combustion Air Requirements	m ³ /hr	86.0	89.9	93.8	97.7	101.7	105.6	109.5	117.3	-
		m ³ /min	1.43	1.50	1.56	1.63	1.69	1.76	1.82	1.95	-
		lit/sec	23.89	24.98	26.07	27.15	28.24	29.32	30.41	32.58	-
		in ³ /sec	1458	1524	1591	1657	1723	1789	1856	1988	-
		ft ³ /min	50.6	52.9	55.2	57.5	59.8	62.1	64.4	69.0	-
V1505-T	Combustion Air Requirements	m ³ /hr	-	-	-	-	-	-	151.0	161.8	-
		m ³ /min	-	-	-	-	-	-	2.52	2.70	-
		lit/sec	-	-	-	-	-	-	41.94	44.94	-
		in ³ /sec	-	-	-	-	-	-	2560	2742	-
		ft ³ /min	-	-	-	-	-	-	88.9	95.2	-

Note :

☆ **Combustion Air Requirements Calculating Formula**

$$Q_1 = V_h \cdot N \cdot C \cdot \eta \cdot k \cdot 10^{-3}$$

Q₁ : Amount of intake air (m³/min)

V_h : Total displacement (lit)

N : Engine speed (min⁻¹(rpm))

C : Coefficient = 0.5

η : Intake efficiency

Natural aspirated engine

3000 min⁻¹(rpm) or less : 0.87

3600 min⁻¹(rpm) or less : 0.85

Turbo charged engine : 0.80

k : Coefficient : 1.0

Natural aspirated engine : 1.0

Turbo charged engine : 1.5

(2) Cooling Air Requirements**{Refer to 25 °C (77 °F) and 750 mmHg}**

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Cooling Air Requirements	m ³ /hr	-	-	-	1913	1939	2014	2196	2400	2615
		m ³ /min	-	-	-	31.9	32.3	33.6	36.6	40.0	43.6
		lit/sec	-	-	-	531	539	559	610	667	726
		in ³ /sec	-	-	-	32423	32868	34133	37231	40676	44331
		ft ³ /min	-	-	-	1126	1141	1185	1293	1412	1539
D1105	Cooling Air Requirements	m ³ /hr	-	-	2050	2116	2180	2285	2478	2585	-
		m ³ /min	-	-	34.2	35.3	36.3	38.1	41.3	43.1	-
		lit/sec	-	-	569	588	606	635	688	718	-
		in ³ /sec	-	-	34742	35862	36956	38731	41999	43820	-
		ft ³ /min	-	-	1206	1245	1283	1345	1458	1522	-
D1305	Cooling Air Requirements	m ³ /hr	-	-	-	-	2552	-	2631	2828	-
		m ³ /min	-	-	-	-	42.5	-	43.9	47.1	-
		lit/sec	-	-	-	-	709	-	731	786	-
		in ³ /sec	-	-	-	-	43257	-	44604	47944	-
		ft ³ /min	-	-	-	-	1502	-	1549	1665	-
D1105-T	Cooling Air Requirements	m ³ /hr	-	-	-	-	-	-	-	3269	-
		m ³ /min	-	-	-	-	-	-	-	54.5	-
		lit/sec	-	-	-	-	-	-	-	908	-
		in ³ /sec	-	-	-	-	-	-	-	55414	-
		ft ³ /min	-	-	-	-	-	-	-	1924	-
V1505	Cooling Air Requirements	m ³ /hr	2516	2619	2770	2872	3001	3074	3275	3617	-
		m ³ /min	41.9	43.6	46.2	47.9	50.0	51.2	54.6	60.3	-
		lit/sec	699	727	769	798	834	854	910	1005	-
		in ³ /sec	42654	44392	46951	48689	50864	52113	55510	61309	-
		ft ³ /min	1481	1541	1630	1691	1766	1809	1927	2129	-
V1505-T	Cooling Air Requirements	m ³ /hr	-	-	-	-	-	-	4010	4374	-
		m ³ /min	-	-	-	-	-	-	66.8	72.9	-
		lit/sec	-	-	-	-	-	-	1114	1215	-
		in ³ /sec	-	-	-	-	-	-	67981	74147	-
		ft ³ /min	-	-	-	-	-	-	2360	2575	-

Note :**Above data is decided by following conditions.****(a) Using the standard radiator recommended in SOS.****(b) Engine is run as open unit.**

(3) Combustion and Cooling Air Requirements
{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Combustion and Cooling Air Requirements	m ³ /hr	-	-	-	1978	2007	2084	2270	2478	2709
		m ³ /min	-	-	-	33.0	33.4	34.7	37.8	41.3	45.2
		lit/sec	-	-	-	549	557	579	630	688	753
		in ³ /sec	-	-	-	33530	34020	35328	38471	42005	45925
		ft ³ /min	-	-	-	1164	1181	1227	1336	1458	1595
D1105	Combustion and Cooling Air Requirements	m ³ /hr	-	-	2120	2189	2256	2364	2560	2673	-
		m ³ /min	-	-	35.3	36.5	37.6	39.4	42.7	44.6	-
		lit/sec	-	-	589	608	627	657	711	743	-
		in ³ /sec	-	-	35934	37104	38247	40072	43390	45311	-
		ft ³ /min	-	-	1248	1288	1328	1391	1507	1573	-
D1305	Combustion and Cooling Air Requirements	m ³ /hr	-	-	-	-	2637	-	2724	2927	-
		m ³ /min	-	-	-	-	44.0	-	45.4	48.8	-
		lit/sec	-	-	-	-	733	-	757	813	-
		in ³ /sec	-	-	-	-	44707	-	46167	49618	-
		ft ³ /min	-	-	-	-	1552	-	1603	1723	-
D1105-T	Combustion and Cooling Air Requirements	m ³ /hr	-	-	-	-	-	-	-	3390	-
		m ³ /min	-	-	-	-	-	-	-	56.5	-
		lit/sec	-	-	-	-	-	-	-	942	-
		in ³ /sec	-	-	-	-	-	-	-	57470	-
		ft ³ /min	-	-	-	-	-	-	-	1995	-
V1505	Combustion and Cooling Air Requirements	m ³ /hr	2602	2709	2864	2970	3102	3180	3384	3734	-
		m ³ /min	43.4	45.1	47.7	49.5	51.7	53.0	56.4	62.2	-
		lit/sec	723	752	795	825	862	883	940	1037	-
		in ³ /sec	44112	45917	48542	50346	52587	53902	57366	63297	-
		ft ³ /min	1532	1594	1685	1748	1826	1872	1992	2198	-
V1505-T	Combustion and Cooling Air Requirements	m ³ /hr	-	-	-	-	-	-	4161	4536	-
		m ³ /min	-	-	-	-	-	-	69.4	75.6	-
		lit/sec	-	-	-	-	-	-	1156	1260	-
		in ³ /sec	-	-	-	-	-	-	70541	76890	-
		ft ³ /min	-	-	-	-	-	-	2449	2670	-

Note :**1. Cooling Air Fan and Pulley Specifications**

Model		D1005	D1105	D1305	D1105-T	V1505	V1505-T
Item							
Fan Diameter	mm	ϕ 330			ϕ 340	ϕ 370	ϕ 380
	in.	ϕ 13			ϕ 13.4	ϕ 14.6	ϕ 15
No. of Blade and type of shape		4,S type			5,F type	7,F type	
Diameter of Fan	mm	ϕ 105					
Driving Pulley	in.	ϕ 4.1					
Diameter of Fan Pulley	mm	ϕ 96					
	in.	ϕ 3.8					

2. Conversion Rates☆ 1 lit = 61.0237 in³ = 0.035315 ft³☆ 1 ft³ = 28.3168 lit☆ 1 lit/sec = 3.6 m³/hr = 2.1189 ft³/min

5. EXHAUST GAS VOLUME

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Combustion Air Requirements	m ³ /min	-	-	-	1.09	1.13	1.18	1.22	1.31	1.57
	Brake Horse Power	kW	-	-	-	13.7	14.0	14.3	15.5	16.8	17.5
	Fuel Consumption	lit/hr	-	-	-	4.46	4.52	4.69	5.12	5.59	6.09
		g/hr	-	-	-	3742	3794	3940	4297	4695	5117
	Exhaust Gas Volume	m ³ /hr	-	-	-	163.4	170.9	178.1	186.7	200.9	242.6
		m ³ /min	-	-	-	2.72	2.85	2.97	3.11	3.35	4.04
		lit/sec	-	-	-	45.4	47.5	49.5	51.9	55.8	67.4
		in ³ /sec	-	-	-	2771	2897	3019	3165	3405	4112
		ft ³ /min	-	-	-	96.2	100.6	104.8	109.9	118.2	142.8
D1105	Combustion Air Requirements	m ³ /min	-	-	1.17	1.22	1.27	1.32	1.37	1.47	-
	Brake Horse Power	kW	-	-	15.1	15.4	15.8	16.2	17.5	17.8	-
	Fuel Consumption	lit/hr	-	-	4.77	4.93	5.08	5.32	5.77	6.02	-
		g/hr	-	-	4010	4139	4265	4470	4847	5058	-
	Exhaust Gas Volume	m ³ /hr	-	-	168.4	179.6	191.7	204.9	216.8	249.2	-
		m ³ /min	-	-	2.81	2.99	3.20	3.42	3.61	4.15	-
		lit/sec	-	-	46.8	49.9	53.3	56.9	60.2	69.2	-
		in ³ /sec	-	-	2855	3044	3250	3474	3675	4225	-
		ft ³ /min	-	-	99.1	105.7	112.8	120.6	127.6	146.7	-
D1305	Combustion Air Requirements	m ³ /min	-	-	-	-	1.43	-	1.54	1.65	-
	Brake Horse Power	kW	-	-	-	-	18.2	-	19.6	21.0	-
	Fuel Consumption	lit/hr	-	-	-	-	5.94	-	6.60	7.09	-
		g/hr	-	-	-	-	4993	-	5544	5956	-
	Exhaust Gas Volume	m ³ /hr	-	-	-	-	227.1	-	240.1	257.3	-
		m ³ /min	-	-	-	-	3.79	-	4.00	4.29	-
		lit/sec	-	-	-	-	63.1	-	66.7	71.5	-
		in ³ /sec	-	-	-	-	3850	-	4071	4362	-
		ft ³ /min	-	-	-	-	133.7	-	141.3	151.4	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1105-T	Combustion Air Requirements	m ³ /min	-	-	-	-	-	-	-	2.02	-
	Brake Horse Power	kW	-	-	-	-	-	-	-	23.5	-
	Fuel Consumption	lit/hr	-	-	-	-	-	-	-	7.61	-
		g/hr	-	-	-	-	-	-	-	6396	-
	Exhaust Gas Volume	m ³ /hr	-	-	-	-	-	-	-	301.0	-
		m ³ /min	-	-	-	-	-	-	-	5.02	-
		lit/sec	-	-	-	-	-	-	-	83.6	-
		in ³ /sec	-	-	-	-	-	-	-	5103	-
		ft ³ /min	-	-	-	-	-	-	-	177.2	-
V1505	Combustion Air Requirements	m ³ /min	1.43	1.50	1.56	1.63	1.69	1.76	1.82	1.95	-
	Brake Horse Power	kW	18.7	19.3	20.3	20.8	21.6	22.4	23.2	25.0	-
	Fuel Consumption	lit/hr	5.86	6.10	6.45	6.69	6.99	7.16	7.63	8.42	-
		g/hr	4923	5124	5419	5620	5871	6015	6407	7076	-
	Exhaust Gas Volume	m ³ /hr	203.3	213.0	222.7	232.0	243.2	258.0	273.5	298.7	-
		m ³ /min	3.39	3.55	3.71	3.87	4.05	4.30	4.56	4.98	-
		lit/sec	56.5	59.2	61.9	64.4	67.6	71.7	76.0	83.0	-
		in ³ /sec	3446	3611	3775	3933	4123	4373	4636	5063	-
		ft ³ /min	119.6	125.4	131.1	136.5	143.2	151.8	161.0	175.8	-
V1505-T	Combustion Air Requirements	m ³ /min	-	-	-	-	-	-	2.52	2.70	-
	Brake Horse Power	kW	-	-	-	-	-	-	29.2	31.3	-
	Fuel Consumption	lit/hr	-	-	-	-	-	-	9.34	10.19	-
		g/hr	-	-	-	-	-	-	7846	8558	-
	Exhaust Gas Volume	m ³ /hr	-	-	-	-	-	-	374.4	411.4	-
		m ³ /min	-	-	-	-	-	-	6.24	6.86	-
		lit/sec	-	-	-	-	-	-	104.0	114.3	-
		in ³ /sec	-	-	-	-	-	-	6347	6974	-
		ft ³ /min	-	-	-	-	-	-	220.4	242.2	-

Note :☆ **Exhaust Gas Volume Calculating Formula**

$$GL = (AL + 7.1 \times Be/10000) \times (298 + t) \times 760 / 298 / (760 + Ps) \text{ (m}^3\text{/hr)}$$

AL: Combustion Air Requirements (m³/hr)

Be: Fuel Consumption (g/hr)

t : Exhaust Gas Temperature (°C)

Ps : Exhaust Gas Pressure (mmHg)

[Conversion Rates]

$$\star 1 \text{ lit} = 61.0237 \text{ in}^3 = 0.035315 \text{ ft}^3$$

$$\star 1 \text{ ft}^3 = 28.3168 \text{ lit}$$

$$\star 1 \text{ lit/sec} = 3.6 \text{ m}^3\text{/hr} = 127.133 \text{ ft}^3\text{/hr}$$

6. HEAT REJECTION TO COOLANT

a) ISO 3046 (Value at Overload)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Brake Horse Power	kW	-	-	-	13.7	14.0	14.3	15.5	16.8	17.5
	Specific Fuel Consumption	kg/kW•h	-	-	-	0.272	0.271	0.276	0.277	0.279	0.292
	Heat Rejection To Coolant	kJ/h	-	-	-	56407	57181	59381	64771	70765	77123
		kcal/h	-	-	-	13593	13780	14310	15609	17053	18585
D1105	Brake Horse Power	kW	-	-	15.1	15.4	15.8	16.2	17.5	17.8	-
	Specific Fuel Consumption	kg/kW•h	-	-	0.266	0.268	0.270	0.275	0.277	0.284	-
	Heat Rejection To Coolant	kJ/h	-	-	60440	62389	64292	67380	73066	76234	-
		kcal/h	-	-	14565	15035	15493	16238	17608	18371	-
D1305	Brake Horse Power	kW	-	-	-	-	18.2	-	19.6	21.0	-
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	0.274	-	0.283	0.284	-
	Heat Rejection To Coolant	kJ/h	-	-	-	-	75254	-	77599	83408	-
		kcal/h	-	-	-	-	18135	-	18700	20100	-
D1105-T	Brake Horse Power	kW	-	-	-	-	-	-	-	23.5	-
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	-	-	-	0.272	-
	Heat Rejection To Coolant	kJ/h	-	-	-	-	-	-	-	96404	-
		kcal/h	-	-	-	-	-	-	-	23232	-
V1505	Brake Horse Power	kW	18.7	19.3	20.3	20.8	21.6	22.4	23.2	25.0	-
	Specific Fuel Consumption	kg/kW•h	0.264	0.266	0.267	0.270	0.271	0.268	0.276	0.283	-
	Heat Rejection To Coolant	kJ/h	74206	77229	81681	84705	88488	90661	96571	106660	-
		kcal/h	17882	18611	19684	20412	21324	21848	23272	25703	-
V1505-T	Brake Horse Power	kW	-	-	-	-	-	-	29.2	31.3	-
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	-	-	0.269	0.273	-
	Heat Rejection To Coolant	kJ/h	-	-	-	-	-	-	118268	128994	-
		kcal/h	-	-	-	-	-	-	28501	31086	-

Note :

☆ Heat Rejection to Coolant Calculating Formula

$$H_o = H_u \times N_e \times b_e \times i$$

H_o : Heat rejection to coolant
H_u : Diesel fuel low caloric value
 (42700 kJ/kg, 10290 kcal/kg
 or 18520 Btu/lb)
N_e : Brake horse power (kW)
b_e : Specific fuel consumption (g/kW•hr)
i : Dispersion ratio to coolant (%)

b) SAE J1349 (Value at Net Intermittent)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800	3000	3600
D1005	Brake Horse Power	kW	-	-	-	13.7	14.0	14.3	15.5	16.8	17.5
	Specific Fuel Consumption	kg/kW•h	-	-	-	0.272	0.271	0.276	0.277	0.279	0.292
	Heat Rejection To Coolant	kJ/h	-	-	-	56407	57181	59381	64771	70765	77123
		Btu/h	-	-	-	53466	54201	56285	61394	67076	73103
D1105	Brake Horse Power	kW	-	-	15.1	15.4	15.8	16.2	17.5	17.8	-
	Specific Fuel Consumption	kg/kW•h	-	-	0.266	0.268	0.270	0.275	0.277	0.284	-
	Heat Rejection To Coolant	kJ/h	-	-	60440	62389	64292	67380	73066	76234	-
		Btu/h	-	-	57290	59137	60941	63868	69257	72260	-
D1305	Brake Horse Power	kW	-	-	-	-	18.2	-	19.6	21.0	-
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	0.274	-	0.283	0.284	-
	Heat Rejection To Coolant	kJ/h	-	-	-	-	75254	-	77599	83408	-
		Btu/h	-	-	-	-	71331	-	73553	79060	-
D1105-T	Brake Horse Power	kW	-	-	-	-	-	-	-	23.5	-
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	-	-	-	0.272	-
	Heat Rejection To Coolant	kJ/h	-	-	-	-	-	-	-	96404	-
		Btu/h	-	-	-	-	-	-	-	91378	-
V1505	Brake Horse Power	kW	18.7	19.3	20.3	20.8	21.6	22.4	23.2	25.0	-
	Specific Fuel Consumption	kg/kW•h	0.264	0.266	0.267	0.270	0.271	0.268	0.276	0.283	-
	Heat Rejection To Coolant	kJ/h	74206	77229	81681	84705	88488	90661	96571	106660	-
		Btu/h	70338	73204	77423	80289	83875	85935	91537	101099	-
V1505-T	Brake Horse Power	kW	-	-	-	-	-	-	29.2	31.3	-
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	-	-	0.269	0.273	-
	Heat Rejection To Coolant	kJ/h	-	-	-	-	-	-	118268	128994	-
		Btu/h	-	-	-	-	-	-	112102	122270	-

Note :

☆ Heat Rejection to Coolant Calculating Formula

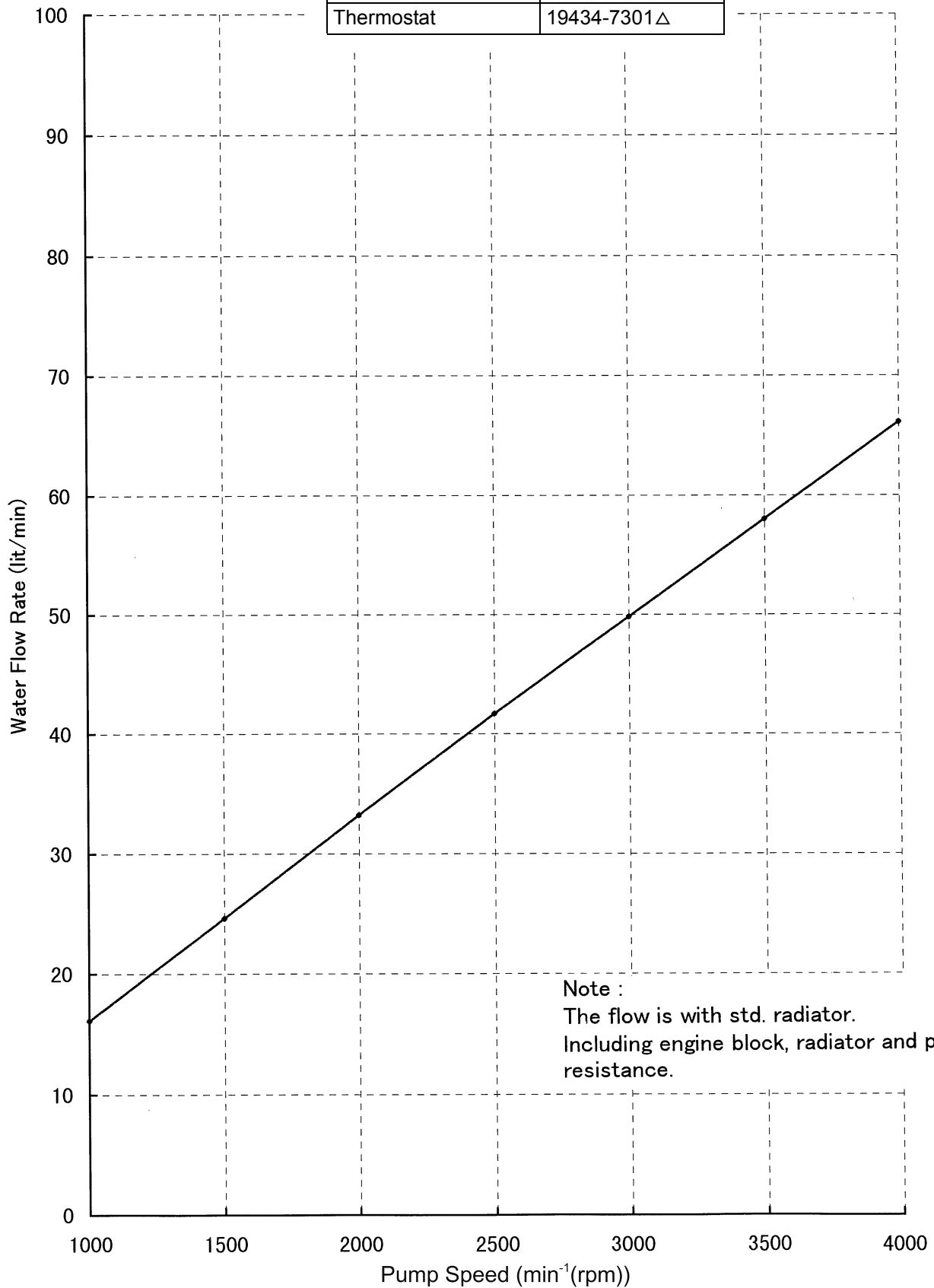
$$H_o = H_u \times N_e \times b_e \times i$$

H_o:Heat rejection to coolant
H_u : Diesel fuel low caloric value
 (42700 kJ/kg, 10290 kcal/kg
 or 18520 Btu/lb)
N_e : Brake horse power (kW)
b_e : Specific fuel consumption (g/kW•hr)
i : Dispersion ratio to coolant (%)

7. WATER FLOW RATE

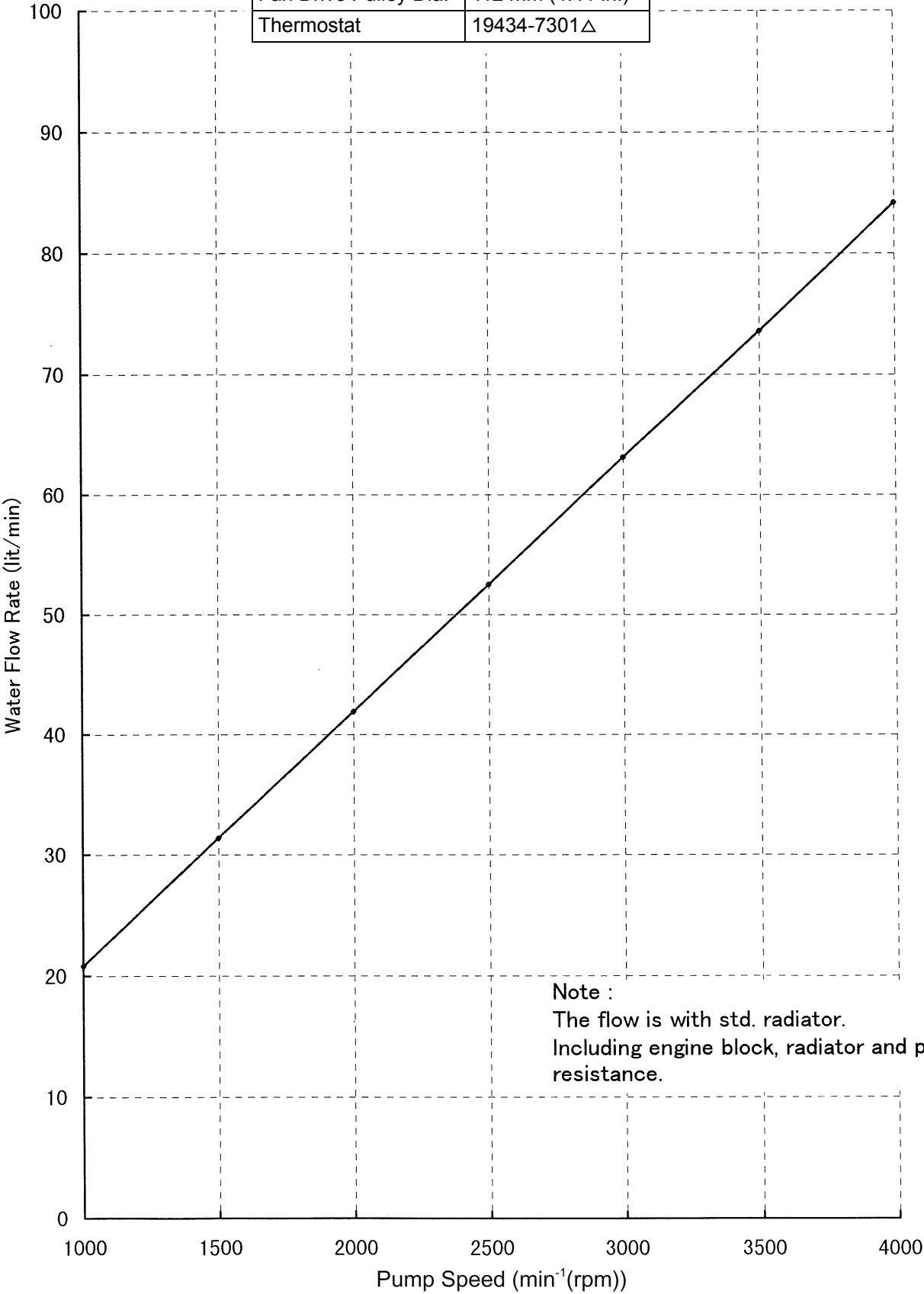
(1) Industrial Use

Water Pump	16251-7303△
Fan Pulley Dia.	98 mm (3.86 in.)
Fan Drive Pulley Dia.	105 mm (4.13 in.)
Thermostat	19434-7301△



(2) Geneset (BG) Use

Water Pump	16251-7303Δ
Fan Pulley Dia.	98 mm (3.86 in.)
Fan Drive Pulley Dia.	112 mm (4.41 in.)
Thermostat	19434-7301Δ



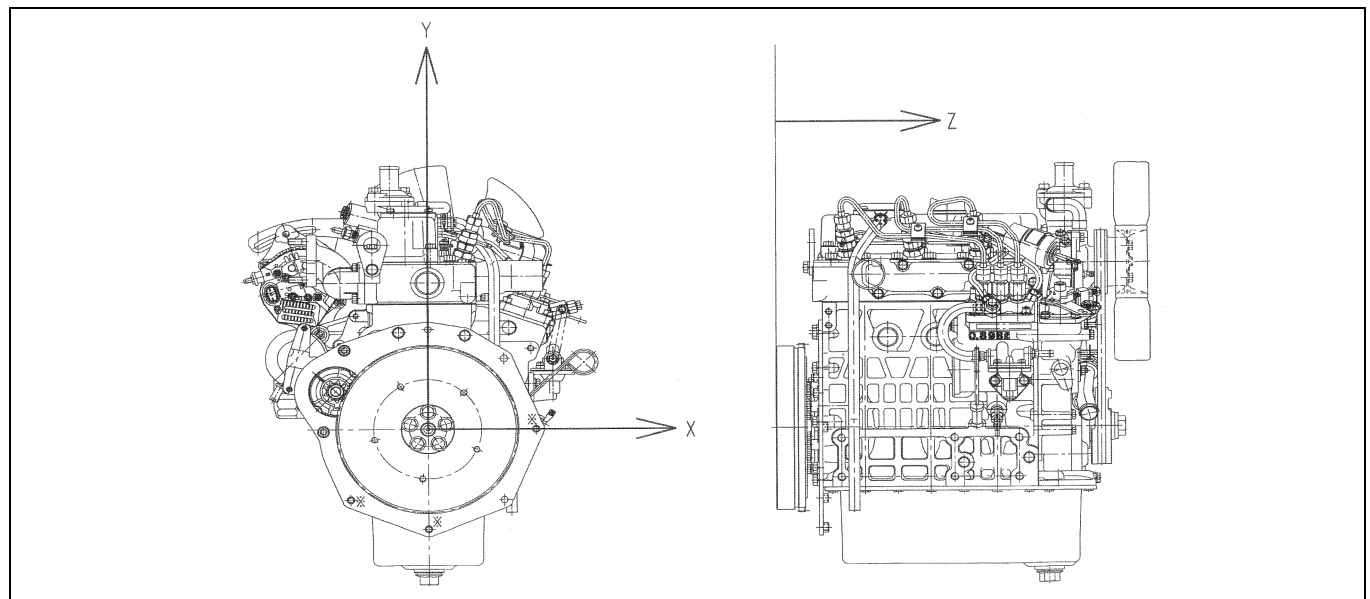
8. CENTER OF GRAVITY

1. With Standard Flywheel and Flywheel Housing

Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
D1005	93.0 (205.0)	-6.2 (-0.24)	76.7 (3.02)	208.8 (8.22)
D1105	93.0 (205.0)	-6.3 (-0.25)	75.6 (2.98)	208.3 (8.20)
D1305	95.0 (209.0)	-6.4 (-0.25)	76.9 (3.03)	208.3 (8.20)
D1105-T	97.0 (213.8)	-14.9 (-0.59)	91.2 (3.59)	212.1 (8.35)
V1505	110.0 (242.5)	-4.7 (-0.19)	70.2 (2.76)	252.3 (9.93)
V1505-T	114.0 (251.3)	-10.5 (-0.41)	80.9 (3.19)	251.5 (9.90)

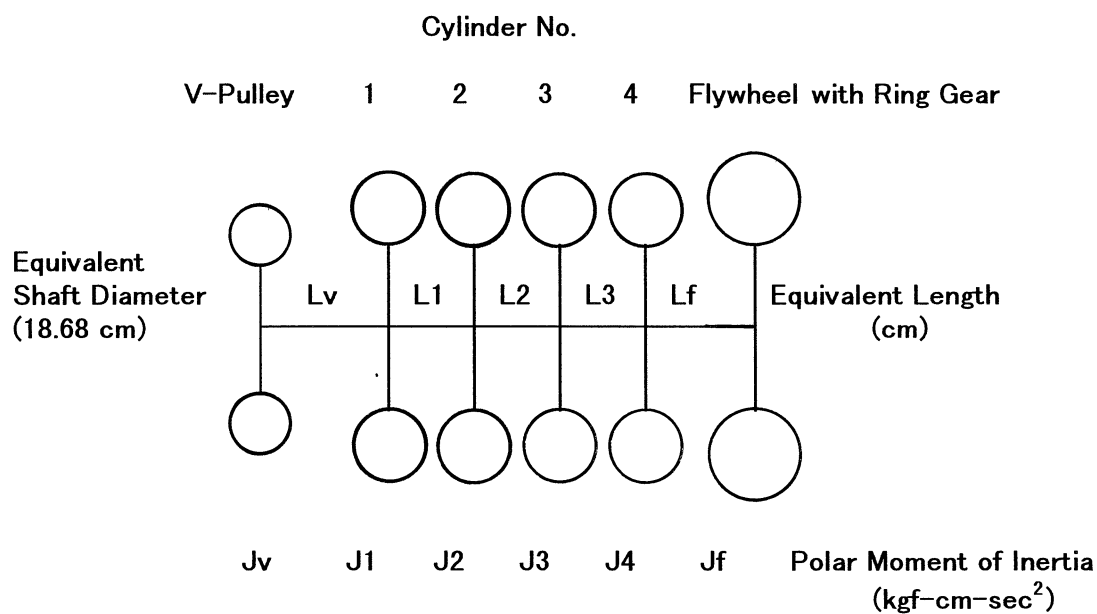
2. With SAE Flywheel and Flywheel Housing

Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
D1005	110.0 (242.5)	-4.8 (-0.19)	59.5 (2.34)	227.0 (8.94)
D1105	110.0 (242.5)	-4.9 (-0.19)	58.5 (2.30)	226.2 (8.91)
D1305	112.0 (246.9)	-5.0 (-0.20)	59.8 (2.35)	226.2 (8.91)
D1105-T	114.0 (251.3)	-12.0 (-0.47)	73.2 (2.88)	236.1 (9.30)
V1505	127.0 (280.0)	-3.8 (-0.15)	56.3 (2.22)	267.8 (10.54)
V1505-T	137.0 (302.2)	-8.5 (-0.33)	65.6 (2.58)	269.9 (10.63)



9. MASS ELASTIC SYSTEMS

(A) With Standard Flywheel

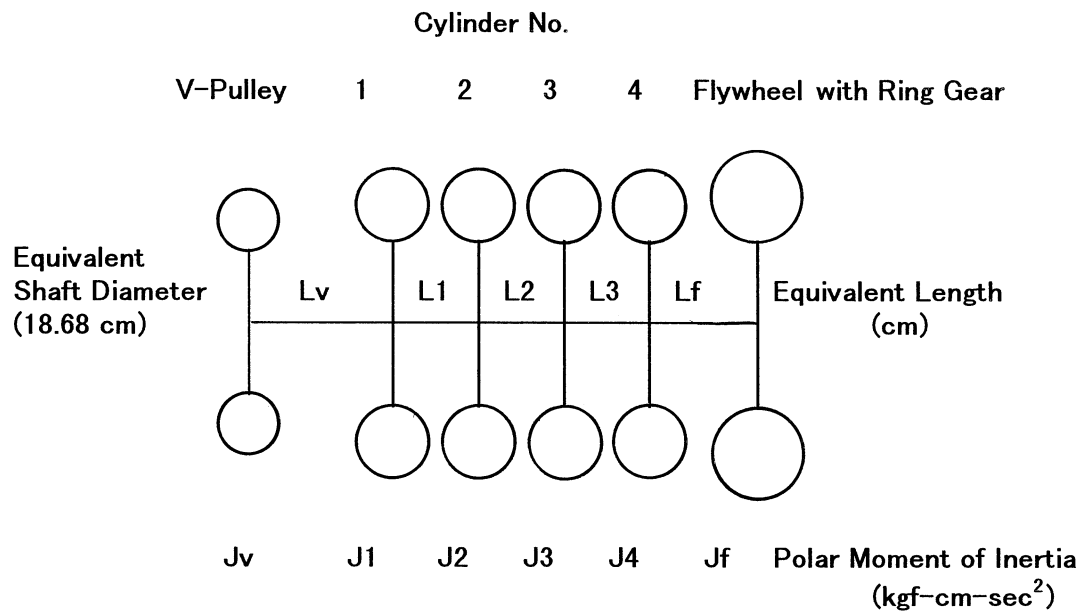


Model	Equivalent Length (cm)					Polar Moment of Inertia (kgf-cm-sec ²)					
	Lv	L1	L2	L3	Lf	Jv	J1	J2	J3	J4	Jf
D1005	20200	2520	2520	-	1863	0.013	0.049	0.029	0.049	-	1.062
D1105	20200	2520	2520	-	1863	0.013	0.051	0.031	0.051	-	1.062
D1305	20200	2520	2520	-	1863	0.013	0.057	0.056	0.058	-	1.810
D1105-T	20200	2520	2520	-	1863	0.013	0.051	0.031	0.051	-	1.062
V1505	20200	2520	2520	2520	1863	0.012	0.041	0.041	0.041	0.041	1.062
V1505-T	20200	2520	2520	2520	1863	0.012	0.041	0.041	0.041	0.041	1.062

Note :

3 Cylinder Models	D1005/D1105/ D1105-T	Flywheel	16239-2511△
		V-pulley	16229-7428△
	D1305	Flywheel	1G900-2511△
		V-pulley	1G900-7428△
4 Cylinder Models		Flywheel	16259-2511△
		V-pulley	16249-7428△

(B) With SAE Flywheel



Model	Equivalent Length (cm)					Polar Moment of Inertia (kgf-cm-sec ²)					
	Lv	L1	L2	L3	Lf	Jv	J1	J2	J3	J4	Jf
D1005	20200	2520	2520	-	1863	0.013	0.049	0.029	0.049	-	1.810
D1105	20200	2520	2520	-	1863	0.013	0.051	0.031	0.051	-	1.810
D1305	-	-	-	-	-	-	-	-	-	-	-
D1105-T	20200	2520	2520	-	1863	0.013	0.051	0.031	0.051	-	1.810
V1505	20200	2520	2520	2520	1863	0.012	0.041	0.041	0.041	0.041	1.810
V1505-T	20200	2520	2520	2520	1863	0.012	0.041	0.041	0.041	0.041	1.810

Note :

3 Cylinder Models	Flywheel	16239-2511Δ
	V-pulley	16229-7428Δ
4 Cylinder Models	Flywheel	16259-2511Δ
	V-pulley	16249-7428Δ

10. UNBALANCED FORCES

1. Base Data

F_z = Unbalanced inertia force

$$= 4m_p * r * \omega^2 * (r/l) \cos 2\theta \text{ (kgf)}$$

N_{py} , N_{oz} = Unbalanced inertia couple (kgf-m)

m_p = Reciprocating mass = W_p/G (kg)

W_p = Reciprocating weight (kgf)

G = Gravitational Acceleration = 9.80665 (m/sec²)

r = Crank radius (m)

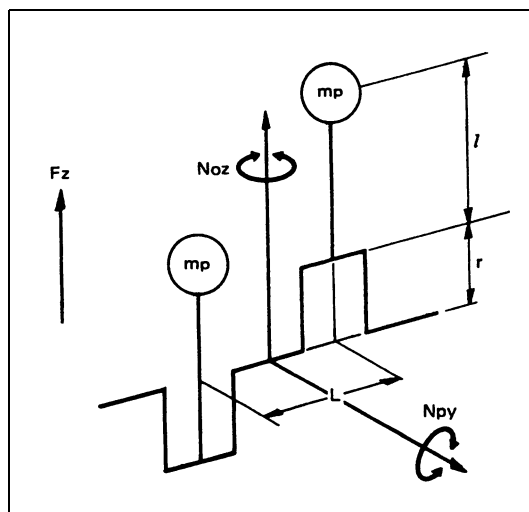
l = Center distance of connecting rod (m)

L = Cylinder distance (m)

ω = Angular velocity

$$= 2\pi n/60 \text{ (rad/sec)}$$

n = Engine speed (min⁻¹(rpm))



Model	l (m)	r (m)	L (m)	Wp (kgf)	Bore (mm)	Stroke (mm)
D1005	0.116	0.0368	0.085	0.67	76.0	73.6
D1105	0.116	0.0392	0.085	0.69	78.0	78.4
D1305	0.116	0.0440	0.085	0.69	78.0	88.0
D1105-T	0.116	0.0392	0.085	0.69	78.0	78.4
V1505	0.116	0.0392	0.085	0.69	78.0	78.4
V1505-T	0.116	0.0392	0.085	0.69	78.0	78.4

2. Unbalanced inertia force and couple

($\times \omega^2$)

Model	No. of Cylinder	Cylinder Bore (mm)	Order	Fz	Npy	Noz
D1005	3	76.0	1	0	0.0001851	0.0001851
			2	0	0.0001174	0
D1105 D1105-T	3	78.0	1	0	0.0002030	0.0002030
			2	0	0.0001372	0
D1305	3	78.0	1	0	0.0002279	0.0002279
			2	0	0.0001729	0
V1505	4	78.0	1	0	0	0
V1505-T			2	0.003728	0	0

3. An example of calculation

Calculation Condition	ω^2	Fz, Npy, Noz		
			Order	Calculation
Engine model : D1305 Engine speed : 3000 min ⁻¹ (rpm)	$(2 \times \pi \times 3000/60)^2 = 98696$	Fz (kgf)	1	0
			2	0
		Npy (kgf-m)	1	$0.0002279 \times 98696 = 22.5$
			2	$0.0001729 \times 98696 = 17.1$
		Noz (kgf-m)	1	$0.0002279 \times 98696 = 22.5$
			2	0

11. TECHNICAL INFORMATION OF ENGINE FOR GENERATOR

1. Brake Horse Power

Model	Engine Speed [r/min]		1800	
			kW	HP/PS
D1005-BG	ISO 3046 [kW,PS]	Stand-by	9.8	13.3
		Continuous	8.7	11.8
	SAE J1349 [kW,HP]	Stand-by	9.8	13.1
		Continuous	8.7	11.7
D1105-BG	ISO 3046 [kW,PS]	Stand-by	11.5	15.6
		Continuous	10.1	13.7
	SAE J1349 [kW,HP]	Stand-by	11.5	15.4
		Continuous	10.1	13.5
D1305-BG	ISO 3046 [kW,PS]	Stand-by	13.1	17.8
		Continuous	11.6	15.8
	SAE J1349 [kW,HP]	Stand-by	13.1	17.6
		Continuous	11.6	15.6
V1505-BG	ISO 3046 [kW,PS]	Stand-by	15.1	20.5
		Continuous	13.4	18.2
	SAE J1349 [kW,HP]	Stand-by	15.1	20.2
		Continuous	13.4	18.0

2. Noise Level [at 1m (3.3 ft) dB (A)]

Model	Engine Speed [r/min]	1800
D1005-BG	4/4 Load (Continuous)	81.4
	No Load	80.2
	Stand-by	81.6
D1105-BG	4/4 Load (Continuous)	81.8
	No Load	80.5
	Stand-by	82.0
D1305-BG	4/4 Load (Continuous)	82.6
	No Load	81.3
	Stand-by	82.8
V1505-BG	4/4 Load (Continuous)	83.3
	No Load	82.0
	Stand-by	83.5

3. Heat Rejection Coolant

ISO 3046 (Value Output for Stand-by)

Model	Engine Speed	r/min	1800
D1005-BG	Brake Horse Power	kW	9.8
	Specific Fuel Consumption	kg/kWhr	0.247
	Heat Rejection To Coolant	kJ/hr	41300
		kcal/hr	10000
D1105-BG	Brake Horse Power	kW	11.5
	Specific Fuel Consumption	kg/kWhr	0.247
	Heat Rejection To Coolant	kJ/hr	48500
		kcal/hr	11700
D1305-BG	Brake Horse Power	kW	13.1
	Specific Fuel Consumption	kg/kWhr	0.254
	Heat Rejection To Coolant	kJ/hr	56800
		kcal/hr	13700
V1505-BG	Brake Horse Power	kW	15.1
	Specific Fuel Consumption	kg/kWhr	0.247
	Heat Rejection To Coolant	kJ/hr	63700
		kcal/hr	15400

SAE J1349 (Value Output for Stand-by)

Model	Engine Speed	r/min	1800
D1005-BG	Brake Horse Power	HP	13.1
	Specific Fuel Consumption	lb/HPhr	0.406
	Heat Rejection To Coolant	kJ/hr	41300
		Btu/hr	39500
D1105-BG	Brake Horse Power	HP	15.4
	Specific Fuel Consumption	lb/HPhr	0.406
	Heat Rejection To Coolant	kJ/hr	48500
		Btu/hr	46400
D1305-BG	Brake Horse Power	HP	17.6
	Specific Fuel Consumption	lb/HPhr	0.418
	Heat Rejection To Coolant	kJ/hr	56800
		Btu/hr	54300
V1505-BG	Brake Horse Power	HP	20.2
	Specific Fuel Consumption	lb/HPhr	0.406
	Heat Rejection To Coolant	kJ/hr	63700
		Btu/hr	60900

3. 03-M SERIES

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1. BRAKE HORSE POWER

a) ISO 3046, 2534

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Gross	kW	-	-	-	-	22.1	22.9	23.8
		PS	-	-	-	-	30.0	31.1	32.4
	Overload	kW	-	-	-	-	20.4	21.0	21.7
		PS	-	-	-	-	27.7	28.6	29.5
	Continuous	kW	-	-	-	-	17.7	18.3	18.9
		PS	-	-	-	-	24.1	24.8	25.7
D1703-M	Gross	kW	20.5	21.5	22.4	23.3	24.3	25.2	26.1
		PS	27.9	29.2	30.5	31.7	33.0	34.3	35.5
	Overload	kW	19.5	20.4	21.2	22.0	22.8	23.6	24.3
		PS	26.5	27.7	28.8	29.9	31.0	32.0	33.1
	Continuous	kW	16.9	17.7	18.4	19.1	19.8	20.5	21.1
		PS	23.0	24.1	25.0	25.9	26.9	27.8	28.7
D1803-M	Gross	kW	22.8	23.8	24.8	25.9	26.9	27.9	-
		PS	31.0	32.4	33.7	35.2	36.6	37.9	-
	Overload	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		PS	29.8	31.1	32.3	33.6	34.8	36.0	-
	Continuous	kW	19.0	19.8	20.6	21.5	22.3	23.0	-
		PS	25.9	27.0	28.0	29.2	30.3	31.3	-
V2003-M	Gross	kW	25.7	26.8	28.0	29.2	30.3	31.5	32.6
		PS	34.9	36.4	38.1	39.7	41.2	42.8	44.3
	Overload	kW	24.2	25.1	26.1	27.1	28.0	28.9	29.8
		PS	32.9	34.1	35.5	36.9	38.0	39.3	40.5
	Continuous	kW	21.0	21.8	22.7	23.5	24.3	25.1	25.9
		PS	28.6	29.6	30.8	32.0	33.0	34.2	35.2
V2203-M	Gross	kW	28.2	29.5	30.8	32.0	33.3	34.6	35.9
		PS	38.3	40.1	41.9	43.5	45.3	47.0	48.8
	Overload	kW	26.6	27.8	28.9	29.9	30.9	32.0	33.0
		PS	36.2	37.8	39.3	40.6	42.1	43.5	44.9
	Continuous	kW	23.1	24.1	25.1	25.9	26.9	27.8	28.7
		PS	31.5	32.8	34.1	35.3	36.5	37.8	39.0
V2403-M	Gross	kW	31.2	32.7	34.1	35.5	36.5	36.5	-
		PS	42.4	44.5	46.4	48.3	49.6	49.6	-
	Overload	kW	29.6	30.9	32.1	33.3	34.1	33.9	-
		PS	40.2	42.0	43.7	45.3	46.3	46.0	-
	Continuous	kW	25.7	26.9	27.9	28.9	29.6	29.4	-
		PS	35.0	36.5	37.9	39.3	40.3	40.0	-
V2403-M-T	Gross	kW	-	-	-	-	41.7	44.0	-
		PS	-	-	-	-	56.7	59.8	-
	Overload	kW	-	-	-	-	39.2	41.3	-
		PS	-	-	-	-	53.3	56.1	-
	Continuous	kW	-	-	-	-	34.1	35.8	-
		PS	-	-	-	-	46.3	48.7	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1803-M-DI	Gross	kW	22.8	23.8	24.8	25.9	26.9	27.9	-
		PS	31.0	32.4	33.7	35.2	36.6	37.9	-
	Overload	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		PS	29.8	31.1	32.3	33.6	34.8	36.0	-
	Continuous	kW	19.0	19.8	20.6	21.5	22.3	23.0	-
		PS	25.9	27.0	28.0	29.2	30.3	31.3	-
V2403-M-DI	Gross	kW	31.2	32.7	34.1	35.5	36.5	36.5	-
		PS	42.4	44.5	46.4	48.3	49.6	49.6	-
	Overload	kW	30.2	31.6	32.9	34.2	35.1	35.0	-
		PS	41.1	43.0	44.8	46.5	47.8	47.6	-
	Continuous	kW	26.3	27.5	28.6	29.7	30.5	30.4	-
		PS	35.7	37.4	38.9	40.4	41.5	41.4	-

b) SAE J1349

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Gross Intermittent	kW	-	-	-	-	22.1	22.9	23.8
		HP	-	-	-	-	29.6	30.7	31.9
	Net Intermittent	kW	-	-	-	-	20.4	21.0	21.7
		HP	-	-	-	-	27.3	28.2	29.1
	Net Continuous	kW	-	-	-	-	17.7	18.3	18.9
		HP	-	-	-	-	23.7	24.5	25.3
D1703-M	Gross Intermittent	kW	20.5	21.5	22.4	23.3	24.3	25.2	26.1
		HP	27.5	28.8	30.0	31.2	32.6	33.8	35.0
	Net Intermittent	kW	19.5	20.4	21.2	22.0	22.8	23.6	24.3
		HP	26.2	27.3	28.4	29.4	30.6	31.6	32.6
	Net Continuous	kW	16.9	17.7	18.4	19.1	19.8	20.5	21.1
		HP	22.7	23.8	24.7	25.6	26.6	27.4	28.3
D1803-M	Gross Intermittent	kW	22.8	23.8	24.8	25.9	26.9	27.9	-
		HP	30.6	31.9	33.2	34.7	36.1	37.4	-
	Net Intermittent	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		HP	29.4	30.6	31.8	33.2	34.4	35.5	-
	Net Continuous	kW	19.0	19.8	20.6	21.5	22.3	23.0	-
		HP	25.5	26.6	27.6	28.8	29.8	30.9	-
V2003-M	Gross Intermittent	kW	25.7	26.8	28.0	29.2	30.3	31.5	32.6
		HP	34.5	35.9	37.5	39.1	40.6	42.2	43.7
	Net Intermittent	kW	24.2	25.1	26.1	27.1	28.0	28.9	29.8
		HP	32.4	33.7	35.0	36.3	37.5	38.8	39.9
	Net Continuous	kW	21.0	21.8	22.7	23.5	24.3	25.1	25.9
		HP	28.2	29.2	30.4	31.6	32.6	33.7	34.7
V2203-M	Gross Intermittent	kW	28.2	29.5	30.8	32.0	33.3	34.6	35.9
		HP	37.8	39.5	41.3	42.9	44.6	46.4	48.1
	Net Intermittent	kW	26.6	27.8	28.9	29.9	30.9	32.0	33.0
		HP	35.7	37.2	38.7	40.0	41.5	42.9	44.3
	Net Continuous	kW	23.1	24.1	25.1	25.9	26.9	27.8	28.7
		HP	31.0	32.3	33.6	34.8	36.0	37.2	38.5
V2403-M	Gross Intermittent	kW	31.2	32.7	34.1	35.5	36.5	36.5	-
		HP	41.8	43.8	45.7	47.6	48.9	48.9	-
	Net Intermittent	kW	29.6	30.9	32.1	33.3	34.1	33.9	-
		HP	39.7	41.4	43.1	44.7	45.7	45.4	-
	Net Continuous	kW	25.7	26.9	27.9	28.9	29.6	29.4	-
		HP	34.5	36.0	37.4	38.8	39.7	39.4	-
V2403-M-T	Gross Intermittent	kW	-	-	-	-	41.7	44.0	-
		HP	-	-	-	-	55.9	59.0	-
	Net Intermittent	kW	-	-	-	-	39.2	41.3	-
		HP	-	-	-	-	52.6	55.3	-
	Net Continuous	kW	-	-	-	-	34.1	35.8	-
		HP	-	-	-	-	45.6	48.0	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1803-M-DI	Gross Intermittent	kW	22.8	23.8	24.8	25.9	26.9	27.9	-
		HP	30.6	31.9	33.2	34.7	36.1	37.4	-
	Net Intermittent	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		HP	29.4	30.6	31.8	33.2	34.4	35.5	-
	Net Continuous	kW	19.0	19.8	20.6	21.5	22.3	23.0	-
		HP	25.5	26.6	27.6	28.8	29.8	30.9	-
V2403-M-DI	Gross Intermittent	kW	31.2	32.7	34.1	35.5	36.5	36.5	-
		HP	41.8	43.8	45.7	47.6	48.9	48.9	-
	Net Intermittent	kW	30.2	31.6	32.9	34.2	35.1	35.0	-
		HP	40.5	42.4	44.2	45.9	47.1	47.0	-
	Net Continuous	kW	26.3	27.5	28.6	29.7	30.5	30.4	-
		HP	35.2	36.8	38.3	39.9	40.9	40.8	-

c) JIS D1005, B8014

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	建設機械用 定格出力 (D1005)	kW	-	-	-	-	20.4	21.0	21.7
		PS	-	-	-	-	27.7	28.6	29.5
	定回転用 定格出力 (B8014)	kW	-	-	-	-	17.7	18.3	18.9
		PS	-	-	-	-	24.1	24.8	25.7
D1703-M	建設機械用 定格出力 (D1005)	kW	19.5	20.4	21.2	22.0	22.8	23.6	24.3
		PS	26.5	27.7	28.8	29.9	31.0	32.0	33.1
	定回転用 定格出力 (B8014)	kW	16.9	17.7	18.4	19.1	19.8	20.5	21.1
		PS	23.0	24.1	25.0	25.9	26.9	27.8	28.7
D1803-M	建設機械用 定格出力 (D1005)	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		PS	29.8	31.1	32.3	33.6	34.8	36.0	-
	定回転用 定格出力 (B8014)	kW	19.0	19.8	20.6	21.5	22.3	23.0	-
		PS	25.9	27.0	28.0	29.2	30.3	31.3	-
V2003-M	建設機械用 定格出力 (D1005)	kW	24.2	25.1	26.1	27.1	28.0	28.9	29.8
		PS	32.9	34.1	35.5	36.9	38.0	39.3	40.5
	定回転用 定格出力 (B8014)	kW	21.0	21.8	22.7	23.5	24.3	25.1	25.9
		PS	28.6	29.6	30.8	32.0	33.0	34.2	35.2
V2203-M	建設機械用 定格出力 (D1005)	kW	26.6	27.8	28.9	29.9	30.9	32.0	33.0
		PS	36.2	37.8	39.3	40.6	42.1	43.5	44.9
	定回転用 定格出力 (B8014)	kW	23.1	24.1	25.1	25.9	26.9	27.8	28.7
		PS	31.5	32.8	34.1	35.3	36.5	37.8	39.0
V2403-M	建設機械用 定格出力 (D1005)	kW	29.6	30.9	32.1	33.3	34.1	33.9	-
		PS	40.2	42.0	43.7	45.3	46.3	46.0	-
	定回転用 定格出力 (B8014)	kW	25.7	26.9	27.9	28.9	29.6	29.4	-
		PS	35.0	36.5	37.9	39.3	40.3	40.0	-
V2403-M-T	建設機械用 定格出力 (D1005)	kW	-	-	-	-	39.2	41.3	-
		PS	-	-	-	-	53.3	56.1	-
	定回転用 定格出力 (B8014)	kW	-	-	-	-	34.1	35.8	-
		PS	-	-	-	-	46.3	48.7	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1803-M-DI	建設機械用 定格出力 (D1005)	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		PS	29.4	30.6	31.8	33.2	34.4	35.5	-
	定回転用 定格出力 (B8014)	kW	19.0	19.8	20.6	21.5	22.3	23.0	-
		PS	25.5	26.6	27.6	28.8	29.8	30.9	-
V2403-M-DI	建設機械用 定格出力 (D1005)	kW	30.2	31.6	32.9	34.2	35.1	35.0	-
		PS	40.5	42.4	44.2	45.9	47.1	47.0	-
	定回転用 定格出力 (B8014)	kW	26.3	27.5	28.6	29.7	30.5	30.4	-
		PS	35.2	36.8	38.3	39.9	40.9	40.8	-

Note :

1. Above powers may be changed by emission regulations applied.

2. Conversion rates

☆ 1 kW = 1.35962 PS = 1.34048 HP

☆ 1 PS = 0.7355 kW = 0.985925 HP

☆ 1 HP = 0.7457 kW = 1.01428 PS

2. FUEL CONSUMPTION

a) ISO 3046 (Value at Overload) - Subject to $\pm 5\%$ Tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Brake Horse Power	kW	-	-	-	-	20.4	21.0	21.7
		PS	-	-	-	-	27.7	28.6	29.5
	Specific Fuel Consumption	kg/kWh	-	-	-	-	0.261	0.268	0.286
		kg/PSh	-	-	-	-	0.192	0.197	0.211
	Fuel Consumption	lit/hr	-	-	-	-	6.34	6.71	7.41
D1703-M	Brake Horse Power	kW	19.5	20.4	21.2	22.0	22.8	23.6	24.3
		PS	26.5	27.7	28.8	29.9	31.0	32.0	33.1
	Specific Fuel Consumption	kg/kWh	0.263	0.265	0.268	0.270	0.272	0.275	0.279
		kg/PSh	0.194	0.195	0.197	0.199	0.200	0.203	0.205
	Fuel Consumption	lit/hr	6.12	6.44	6.76	7.07	7.39	7.73	8.06
D1803-M	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		PS	29.8	31.1	32.3	33.6	34.8	36.0	-
	Specific Fuel Consumption	kg/kWh	0.253	0.255	0.258	0.265	0.267	0.271	-
		kg/PSh	0.186	0.188	0.190	0.195	0.196	0.199	-
	Fuel Consumption	lit/hr	6.59	6.93	7.30	7.81	8.14	8.55	-
V2003-M	Brake Horse Power	kW	24.2	25.1	26.1	27.1	28.0	28.9	29.8
		PS	32.9	34.1	35.5	36.9	38.0	39.3	40.5
	Specific Fuel Consumption	kg/kWh	0.255	0.259	0.262	0.265	0.269	0.275	0.281
		kg/PSh	0.187	0.191	0.193	0.195	0.198	0.202	0.206
	Fuel Consumption	lit/hr	7.34	7.76	8.15	8.55	8.95	9.46	9.95
V2203-M	Brake Horse Power	kW	26.6	27.8	28.9	29.9	30.9	32.0	33.0
		PS	36.2	37.8	39.3	40.6	42.1	43.5	44.9
	Specific Fuel Consumption	kg/kWh	0.256	0.259	0.261	0.268	0.270	0.273	0.276
		kg/PSh	0.189	0.190	0.192	0.197	0.199	0.201	0.203
	Fuel Consumption	lit/hr	8.13	8.56	8.99	9.51	9.95	10.40	10.85
V2403-M	Brake Horse Power	kW	29.6	30.9	32.1	33.3	34.1	33.9	-
		PS	40.2	42.0	43.7	45.3	46.3	46.0	-
	Specific Fuel Consumption	kg/kWh	0.258	0.260	0.264	0.269	0.275	0.276	-
		kg/PSh	0.190	0.191	0.194	0.198	0.202	0.203	-
	Fuel Consumption	lit/hr	9.08	9.58	10.11	10.68	11.17	11.15	-
V2403-M-T	Brake Horse Power	kW	-	-	-	-	39.2	41.3	-
		PS	-	-	-	-	53.3	56.1	-
	Specific Fuel Consumption	kg/kWh	-	-	-	-	0.282	0.288	-
		kg/PSh	-	-	-	-	0.207	0.212	-
	Fuel Consumption	lit/hr	-	-	-	-	13.16	14.13	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1803-M-DI	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		PS	29.8	31.1	32.3	33.6	34.8	36.0	-
	Specific Fuel Consumption	kg/kWh	0.251	0.249	0.258	0.249	0.252	0.257	-
		kg/PSh	0.185	0.183	0.190	0.183	0.186	0.189	-
	Fuel Consumption	lit/hr	6.55	6.77	7.30	7.34	7.70	8.12	-
V2403-M-DI	Brake Horse Power	kW	30.2	31.6	32.9	34.2	35.1	35.0	-
		PS	41.1	43.0	44.8	46.5	47.8	47.6	-
	Specific Fuel Consumption	kg/kWh	0.237	0.245	0.250	0.244	0.247	0.251	-
		kg/PSh	0.174	0.181	0.184	0.180	0.182	0.185	-
	Fuel Consumption	lit/hr	8.53	9.25	9.82	9.96	10.33	10.47	-

Note :**Fuel Consumption Calculating Formula**

$$\text{Fuel Consumption (lit/hr)} = \frac{\text{Fuel Consumption (kg/kW}\cdot\text{hr)} \times \text{Brake Horse Power (kW)}}{0.84}$$

0.84 (g/cc) : Gravity of Diesel Fuel

b) SAE J1349 (Value at Net Intermittent) - Subject to $\pm 5\%$ Tolerance

Model	Engine Speed	min ¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Brake Horse Power	kW	-	-	-	-	20.4	21.0	21.7
		HP	-	-	-	-	27.3	28.2	29.1
	Specific Fuel Consumption	kg/kWh	-	-	-	-	0.261	0.268	0.286
		lb/HPh	-	-	-	-	0.430	0.441	0.471
	Fuel Consumption	Gal/hr	-	-	-	-	1.65	1.75	1.93
D1703-M	Brake Horse Power	kW	19.5	20.4	21.2	22.0	22.8	23.6	24.3
		HP	26.2	27.3	28.4	29.4	30.6	31.6	32.6
	Specific Fuel Consumption	kg/kWh	0.263	0.265	0.268	0.270	0.272	0.275	0.279
		lb/HPh	0.433	0.436	0.441	0.445	0.448	0.453	0.458
	Fuel Consumption	Gal/hr	1.60	1.68	1.76	1.84	1.93	2.02	2.10
D1803-M	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		HP	29.4	30.6	31.8	33.2	34.4	35.5	-
	Specific Fuel Consumption	kg/kWh	0.253	0.255	0.258	0.265	0.267	0.271	-
		lb/HPh	0.415	0.419	0.425	0.436	0.439	0.446	-
	Fuel Consumption	Gal/hr	1.72	1.81	1.90	2.04	2.12	2.23	-
V2003-M	Brake Horse Power	kW	24.2	25.1	26.1	27.1	28.0	28.9	29.8
		HP	32.4	33.7	35.0	36.3	37.5	38.8	39.9
	Specific Fuel Consumption	kg/kWh	0.255	0.259	0.262	0.265	0.269	0.275	0.281
		lb/HPh	0.419	0.427	0.431	0.436	0.442	0.452	0.461
	Fuel Consumption	Gal/hr	1.91	2.02	2.13	2.23	2.34	2.47	2.59
V2203-M	Brake Horse Power	kW	26.6	27.8	28.9	29.9	30.9	32.0	33.0
		HP	35.7	37.2	38.7	40.0	41.5	42.9	44.3
	Specific Fuel Consumption	kg/kWh	0.256	0.259	0.261	0.268	0.270	0.273	0.276
		lb/HPh	0.422	0.426	0.430	0.440	0.444	0.449	0.454
	Fuel Consumption	Gal/hr	2.12	2.23	2.34	2.48	2.60	2.71	2.83
V2403-M	Brake Horse Power	kW	29.6	30.9	32.1	33.3	34.1	33.9	-
		HP	39.7	41.4	43.1	44.7	45.7	45.4	-
	Specific Fuel Consumption	kg/kWh	0.258	0.260	0.264	0.269	0.275	0.276	-
		lb/HPh	0.424	0.428	0.435	0.443	0.453	0.455	-
	Fuel Consumption	Gal/hr	2.37	2.50	2.64	2.79	2.91	2.91	-
V2403-M-T	Brake Horse Power	kW	-	-	-	-	39.2	41.3	-
		HP	-	-	-	-	52.6	55.3	-
	Specific Fuel Consumption	kg/kWh	-	-	-	-	0.282	0.288	-
		lb/HPh	-	-	-	-	0.464	0.473	-
	Fuel Consumption	Gal/hr	-	-	-	-	3.43	3.68	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1803-M-DI	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
		HP	29.4	30.6	31.8	33.2	34.4	35.5	-
	Specific Fuel Consumption	kg/kWh	0.251	0.249	0.258	0.249	0.252	0.257	-
		lb/HPh	0.413	0.409	0.425	0.410	0.415	0.423	-
	Fuel Consumption	Gal/hr	1.71	1.77	1.90	1.91	2.01	2.12	-
V2403-M-DI	Brake Horse Power	kW	30.2	31.6	32.9	34.2	35.1	35.0	-
		HP	40.5	42.4	44.2	45.9	47.1	47.0	-
	Specific Fuel Consumption	kg/kWh	0.237	0.245	0.250	0.244	0.247	0.251	-
		lb/HPh	0.390	0.404	0.412	0.402	0.406	0.413	-
	Fuel Consumption	Gal/hr	2.22	2.41	2.56	2.60	2.69	2.73	-

Note :**Fuel Consumption Calculating Formula**

$$\text{Fuel Consumption (Gal/hr)} = \frac{\text{Fuel Consumption (lb/HP}\cdot\text{hr)} \times \text{Brake Horse Power (HP)}}{7.1}$$

7.1 (lb/Gal) : Gravity of Diesel Fuel

3. NOISE LEVEL

Model	Engine Speed min ⁻¹ (rpm)	Unit	Sound Pressure at 1 m (3.3 ft)	
			at Full Load	at No Load
D1503-M	1500	dB (A)	84.2	80.3
	1800		85.8	82.5
	2200		87.9	85.4
	2600		89.9	88.2
	2800		91.0	89.7
D1703-M	1500	dB (A)	85.2	81.3
	1800		86.8	83.5
	2200		88.9	86.4
	2600		90.9	89.2
	2800		92.0	90.7
D1803-M	1500	dB (A)	86.2	82.3
	1800		87.8	84.5
	2200		89.9	87.4
	2600		91.9	90.2
	2700		92.5	92.2
V2003-M	1500	dB (A)	83.7	79.8
	1800		85.5	82.2
	2200		87.9	85.4
	2600		90.3	88.6
	2800		91.5	90.2
V2203-M	1500	dB (A)	84.7	80.8
	1800		86.5	83.2
	2200		88.9	86.4
	2600		91.3	89.6
	2800		92.5	91.2
V2403-M	1500	dB (A)	85.7	81.8
	1800		87.5	84.2
	2200		89.9	87.4
	2600		92.3	90.6
	2700		93.0	92.7
V2403-M-T	1500	dB (A)	84.2	81.0
	1800		86.3	84.8
	2200		89.5	88.3
	2600		93.4	92.3
	2700		93.5	93.0
D1803-M-DI	1500	dB (A)	88.3	83.1
	1800		89.9	85.3
	2200		92.2	88.4
	2600		94.4	91.4
	2700		94.6	92.4

Model	Engine Speed min ⁻¹ (rpm)	Unit	Sound Pressure at 1 m (3.3 ft)	
			at Full Load	at No Load
V2403-M-DI	1500	dB (A)	87.8	82.6
	1800		89.7	85.1
	2200		92.2	88.4
	2600		94.7	91.7
	2700		94.9	92.7

These data show the average noise level at four points.

Note :

[Measurement conditions]

☆ With radiator, cooling fan, air cleaner and muffler.

4. AIR REQUIREMENTS

(1) Combustion Air Requirements

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Combustion Air Requirements	m ³ /hr	-	-	-	-	98.3	102.1	105.9
		m ³ /min	-	-	-	-	1.64	1.70	1.76
		lit/sec	-	-	-	-	27.31	28.36	29.41
		in ³ /sec	-	-	-	-	1667	1731	1795
		ft ³ /min	-	-	-	-	57.9	60.1	62.3
D1703-M	Combustion Air Requirements	m ³ /hr	94.6	98.9	103.2	107.5	111.8	116.1	120.4
		m ³ /min	1.58	1.65	1.72	1.79	1.86	1.93	2.01
		lit/sec	26.27	27.46	28.66	29.85	31.05	32.24	33.43
		in ³ /sec	1603	1676	1749	1822	1895	1967	2040
		ft ³ /min	55.7	58.2	60.7	63.3	65.8	68.3	70.8
D1803-M	Combustion Air Requirements	m ³ /hr	104.8	109.6	114.4	119.1	123.9	128.7	-
		m ³ /min	1.75	1.83	1.91	1.99	2.07	2.14	-
		lit/sec	29.12	30.45	31.77	33.10	34.42	35.74	-
		in ³ /sec	1777	1858	1939	2020	2100	2181	-
		ft ³ /min	61.7	64.5	67.3	70.1	72.9	75.7	-
V2003-M	Combustion Air Requirements	m ³ /hr	114.8	120.0	125.2	130.4	135.7	140.9	146.1
		m ³ /min	1.91	2.00	2.09	2.17	2.26	2.35	2.43
		lit/sec	31.88	33.33	34.78	36.23	37.68	39.13	40.58
		in ³ /sec	1946	2034	2123	2211	2299	2388	2476
		ft ³ /min	67.6	70.6	73.7	76.8	79.8	82.9	86.0
V2203-M	Combustion Air Requirements	m ³ /hr	126.2	131.9	137.6	143.4	149.1	154.8	160.6
		m ³ /min	2.10	2.20	2.29	2.39	2.48	2.58	2.68
		lit/sec	35.04	36.63	38.23	39.82	41.41	43.01	44.60
		in ³ /sec	2138	2236	2333	2430	2527	2624	2722
		ft ³ /min	74.3	77.6	81.0	84.4	87.8	91.1	94.5
V2403-M	Combustion Air Requirements	m ³ /hr	139.8	146.1	152.5	158.8	165.2	171.5	-
		m ³ /min	2.33	2.44	2.54	2.65	2.75	2.86	-
		lit/sec	38.82	40.59	42.35	44.12	45.88	47.65	-
		in ³ /sec	2369	2477	2584	2692	2800	2907	-
		ft ³ /min	82.3	86.0	89.7	93.5	97.2	101.0	-
V2403-M-T	Combustion Air Requirements	m ³ /hr	-	-	-	-	198.8	206.4	-
		m ³ /min	-	-	-	-	3.31	3.44	-
		lit/sec	-	-	-	-	55.22	57.34	-
		in ³ /sec	-	-	-	-	3370	3499	-
		ft ³ /min	-	-	-	-	117.0	121.5	-
D1803-M-DI	Combustion Air Requirements	m ³ /hr	104.8	109.6	114.4	119.1	123.9	128.7	-
		m ³ /min	1.75	1.83	1.91	1.99	2.07	2.14	-
		lit/sec	29.12	30.45	31.77	33.10	34.42	35.74	-
		in ³ /sec	1777	1858	1939	2020	2100	2181	-
		ft ³ /min	61.7	64.5	67.3	70.1	72.9	75.7	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
V2403-M-DI	Combustion Air Requirements	m ³ /hr	139.8	146.1	152.5	158.8	165.2	171.5	-
		m ³ /min	2.33	2.44	2.54	2.65	2.75	2.86	-
		lit/sec	38.82	40.59	42.35	44.12	45.88	47.65	-
		in ³ /sec	2369	2477	2584	2692	2800	2907	-
		ft ³ /min	82.3	86.0	89.7	93.5	97.2	101.0	-

Note :☆ **Combustion Air Requirements Calculating Formula**

$$Q_1 = V_h \cdot N \cdot C \cdot \eta \cdot k \cdot 10^{-3}$$

Q₁ : Amount of intake air (m³/min)

V_h : Total displacement (lit)

N : Engine speed (min⁻¹(rpm))

C : Coefficient = 0.5

η : Intake efficiency

Natural aspirated engine : 0.87

Turbo charged engine : 0.80

k : Coefficient : 1.0

Natural aspirated engine : 1.0

Turbo charged engine : 1.5

(2) Cooling Air Requirements**{Refer to 25 °C (77 °F) and 750 mmHg}**

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Cooling Air Requirements	m ³ /hr	-	-	-	-	2490	2633	2909
		m ³ /min	-	-	-	-	41.5	43.9	48.5
		lit/sec	-	-	-	-	692	731	808
		in ³ /sec	-	-	-	-	42204	44636	49308
		ft ³ /min	-	-	-	-	1465	1550	1712
D1703-M	Cooling Air Requirements	m ³ /hr	2402	2528	2654	2774	2903	3034	3166
		m ³ /min	40.0	42.1	44.2	46.2	48.4	50.6	52.8
		lit/sec	667	702	737	771	806	843	879
		in ³ /sec	40719	42845	44996	47020	49212	51429	53669
		ft ³ /min	1414	1488	1562	1633	1709	1786	1864
D1803-M	Cooling Air Requirements	m ³ /hr	2589	2723	2866	3065	3197	3358	-
		m ³ /min	43.1	45.4	47.8	51.1	53.3	56.0	-
		lit/sec	719	756	796	852	888	933	-
		in ³ /sec	43882	46152	48590	51962	54196	56927	-
		ft ³ /min	1524	1602	1687	1804	1882	1977	-
V2003-M	Cooling Air Requirements	m ³ /hr	2882	3045	3200	3357	3516	3715	3905
		m ³ /min	48.0	50.8	53.3	55.9	58.6	61.9	65.1
		lit/sec	800	846	889	932	977	1032	1085
		in ³ /sec	48845	51616	54244	56903	59595	62965	66192
		ft ³ /min	1696	1792	1883	1976	2069	2186	2298
V2203-M	Cooling Air Requirements	m ³ /hr	3192	3359	3528	3734	3908	4083	4261
		m ³ /min	53.2	56.0	58.8	62.2	65.1	68.1	71.0
		lit/sec	887	933	980	1037	1085	1134	1184
		in ³ /sec	54116	56943	59802	63293	66240	69219	72229
		ft ³ /min	1879	1977	2076	2198	2300	2403	2508
V2403-M	Cooling Air Requirements	m ³ /hr	3566	3760	3969	4193	4385	4376	-
		m ³ /min	59.4	62.7	66.1	69.9	73.1	72.9	-
		lit/sec	990	1045	1102	1165	1218	1216	-
		in ³ /sec	60441	63740	67278	71079	74338	74178	-
		ft ³ /min	2099	2213	2336	2468	2581	2576	-
V2403-M-T	Cooling Air Requirements	m ³ /hr	-	-	-	-	5123	5496	-
		m ³ /min	-	-	-	-	85.4	91.6	-
		lit/sec	-	-	-	-	1423	1527	-
		in ³ /sec	-	-	-	-	86847	93157	-
		ft ³ /min	-	-	-	-	3016	3235	-
D1803-M-DI	Cooling Air Requirements	m ³ /hr	1993	2058	2220	2230	2341	2468	-
		m ³ /min	33.2	34.3	37.0	37.2	39.0	41.1	-
		lit/sec	554	572	617	620	650	686	-
		in ³ /sec	33780	34889	37631	37807	39681	41833	-
		ft ³ /min	1173	1211	1307	1313	1378	1453	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
V2403-M-DI	Cooling Air Requirements	m ³ /hr	2593	2811	2986	3029	3140	3182	-
		m ³ /min	43.2	46.9	49.8	50.5	52.3	53.0	-
		lit/sec	720	781	830	841	872	884	-
		in ³ /sec	43952	47657	50620	51337	53230	53941	-
		ft ³ /min	1526	1655	1758	1783	1848	1873	-

Note :

Above data is decided by following conditions.

(a) Using the standard radiator recommended in SOS.

(b) Engine is run as open unit.

(3) Combustion and Cooling Air Requirements
{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Combustion and Cooling Air Requirements	m ³ /hr	-	-	-	-	2588	2735	3015
		m ³ /min	-	-	-	-	43.1	45.6	50.2
		lit/sec	-	-	-	-	719	760	837
		in ³ /sec	-	-	-	-	43871	46367	51103
		ft ³ /min	-	-	-	-	1523	1610	1774
D1703-M	Combustion and Cooling Air Requirements	m ³ /hr	2497	2626	2758	2881	3015	3150	3286
		m ³ /min	41.6	43.8	46.0	48.0	50.2	52.5	54.8
		lit/sec	694	730	766	800	837	875	913
		in ³ /sec	42322	44521	46744	48842	51107	53396	55709
		ft ³ /min	1470	1546	1623	1696	1775	1854	1934
D1803-M	Combustion and Cooling Air Requirements	m ³ /hr	2694	2832	2981	3185	3321	3487	-
		m ³ /min	44.9	47.2	49.7	53.1	55.4	58.1	-
		lit/sec	748	787	828	885	923	969	-
		in ³ /sec	45659	48010	50528	53981	56296	59109	-
		ft ³ /min	1585	1667	1754	1874	1955	2052	-
V2003-M	Combustion and Cooling Air Requirements	m ³ /hr	2996	3165	3325	3487	3651	3855	4051
		m ³ /min	49.9	52.8	55.4	58.1	60.9	64.3	67.5
		lit/sec	832	879	924	969	1014	1071	1125
		in ³ /sec	50791	53651	56366	59114	61894	65353	68668
		ft ³ /min	1764	1863	1957	2053	2149	2269	2384
V2203-M	Combustion and Cooling Air Requirements	m ³ /hr	3319	3491	3666	3877	4057	4238	4422
		m ³ /min	55.3	58.2	61.1	64.6	67.6	70.6	73.7
		lit/sec	922	970	1018	1077	1127	1177	1228
		in ³ /sec	56255	59179	62135	65723	68767	71843	74951
		ft ³ /min	1953	2055	2157	2282	2388	2495	2602
V2403-M	Combustion and Cooling Air Requirements	m ³ /hr	3705	3906	4121	4352	4551	4548	-
		m ³ /min	61.8	65.1	68.7	72.5	75.8	75.8	-
		lit/sec	1029	1085	1145	1209	1264	1263	-
		in ³ /sec	62810	66217	69862	73771	77138	77086	-
		ft ³ /min	2181	2299	2426	2562	2678	2677	-
V2403-M-T	Combustion and Cooling Air Requirements	m ³ /hr	-	-	-	-	5322	5702	-
		m ³ /min	-	-	-	-	88.7	95.0	-
		lit/sec	-	-	-	-	1478	1584	-
		in ³ /sec	-	-	-	-	90217	96656	-
		ft ³ /min	-	-	-	-	3133	3356	-
D1803-M-DI	Combustion and Cooling Air Requirements	m ³ /hr	2098	2168	2334	2350	2465	2597	-
		m ³ /min	35.0	36.1	38.9	39.2	41.1	43.3	-
		lit/sec	583	602	648	653	685	721	-
		in ³ /sec	35558	36747	39570	39827	41781	44015	-
		ft ³ /min	1235	1276	1374	1383	1451	1528	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
V2403-M-DI	Combustion and Cooling Air Requirements	m ³ /hr	2733	2958	3139	3187	3305	3354	-
		m ³ /min	45.5	49.3	52.3	53.1	55.1	55.9	-
		lit/sec	759	822	872	885	918	932	-
		in ³ /sec	46321	50134	53204	54029	56030	56848	-
		ft ³ /min	1608	1741	1847	1876	1945	1974	-

Note :**1. Cooling Air Fan and Pulley Specifications**

Model		D1703-M	D1803-M	V2003-M	V2203-M	V2403-M	V2403-M-T
Item							
Fan Diameter	mm	φ 380					
	in.	φ 15					
No. of Blade and type of shape		7,S type	7,F type				
Diameter of Fan Driving Pulley	mm	φ 122	φ 104	φ 125			
	in.	φ 4.8	φ 4.1	φ 4.9			
Diameter of Fan Pulley	mm	φ 97	φ 104	φ 97			
	in.	φ 3.8	φ 4.1	φ 3.8			

Model		D1803-M-DI	V2403-M-DI
Item			
Fan Diameter	mm	φ 380	φ 375
	in.	φ 15	φ 14.8
No. of Blade and type of shape		7,F type	
Diameter of Fan Driving Pulley	mm	φ 104	φ 104
	in.	φ 4.1	φ 4.1
Diameter of Fan Pulley	mm	φ 104	φ 104
	in.	φ 4.1	φ 4.1

2. Conversion Rates☆ 1 lit = 61.0237 in³ = 0.035315 ft³☆ 1 ft³ = 28.3168 lit☆ 1 lit/sec = 3.6 m³/hr = 2.1189 ft³/min

5. EXHAUST GAS VOLUME

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Combustion Air Requirements	m ³ /min	-	-	-	-	1.64	1.70	1.76
	Brake Horse Power	kW	-	-	-	-	20.4	21.0	21.7
	Fuel Consumption	lit/hr	-	-	-	-	6.34	6.71	7.41
		g/hr	-	-	-	-	5327	5634	6223
	Exhaust Gas Volume	m ³ /hr	-	-	-	-	276.0	289.9	304.7
		m ³ /min	-	-	-	-	4.60	4.83	5.08
		lit/sec	-	-	-	-	76.7	80.5	84.6
		in ³ /sec	-	-	-	-	4679	4915	5164
		ft ³ /min	-	-	-	-	162.5	170.6	179.3
D1703-M	Combustion Air Requirements	m ³ /min	1.58	1.65	1.72	1.79	1.86	1.93	2.01
	Brake Horse Power	kW	19.5	20.4	21.2	22.0	22.8	23.6	24.3
	Fuel Consumption	lit/hr	6.12	6.44	6.76	7.07	7.39	7.73	8.06
		g/hr	5139	5408	5679	5935	6211	6491	6774
	Exhaust Gas Volume	m ³ /hr	254.0	268.6	283.5	298.6	314.0	329.7	345.7
		m ³ /min	4.23	4.48	4.72	4.98	5.23	5.50	5.76
		lit/sec	70.5	74.6	78.7	82.9	87.2	91.6	96.0
		in ³ /sec	4305	4553	4805	5061	5323	5589	5860
		ft ³ /min	149.5	158.1	166.8	175.7	184.8	194.1	203.5
D1803-M	Combustion Air Requirements	m ³ /min	1.75	1.83	1.91	1.99	2.07	2.14	-
	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
	Fuel Consumption	lit/hr	6.59	6.93	7.30	7.81	8.14	8.55	-
		g/hr	5538	5825	6133	6558	6840	7185	-
	Exhaust Gas Volume	m ³ /hr	281.3	297.4	314.0	331.0	348.1	365.5	-
		m ³ /min	4.69	4.96	5.23	5.52	5.80	6.09	-
		lit/sec	78.1	82.6	87.2	91.9	96.7	101.5	-
		in ³ /sec	4768	5042	5322	5611	5900	6196	-
		ft ³ /min	165.5	175.1	184.8	194.8	204.9	215.1	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
V2003-M	Combustion Air Requirements	m ³ /min	1.91	2.00	2.09	2.17	2.26	2.35	2.43
	Brake Horse Power	kW	24.2	25.1	26.1	27.1	28.0	28.9	29.8
	Fuel Consumption	lit/hr	7.34	7.76	8.15	8.55	8.95	9.46	9.95
		g/hr	6165	6515	6846	7182	7522	7947	8354
	Exhaust Gas Volume	m ³ /hr	328.1	346.8	365.8	385.1	404.8	424.9	445.3
		m ³ /min	5.47	5.78	6.10	6.42	6.75	7.08	7.42
		lit/sec	91.1	96.3	101.6	107.0	112.4	118.0	123.7
		in ³ /sec	5561	5879	6201	6528	6861	7203	7549
		ft ³ /min	193.1	204.1	215.3	226.7	238.2	250.1	262.1
V2203-M	Combustion Air Requirements	m ³ /min	2.10	2.20	2.29	2.39	2.48	2.58	2.68
	Brake Horse Power	kW	26.6	27.8	28.9	29.9	30.9	32.0	33.0
	Fuel Consumption	lit/hr	8.13	8.56	8.99	9.51	9.95	10.40	10.85
		g/hr	6830	7187	7548	7988	8360	8736	9116
	Exhaust Gas Volume	m ³ /hr	360.7	381.2	402.1	423.4	445.0	467.0	489.3
		m ³ /min	6.01	6.35	6.70	7.06	7.42	7.78	8.16
		lit/sec	100.2	105.9	111.7	117.6	123.6	129.7	135.9
		in ³ /sec	6114	6462	6815	7178	7544	7916	8294
		ft ³ /min	212.3	224.4	236.6	249.2	261.9	274.9	288.0
V2403-M	Combustion Air Requirements	m ³ /min	2.33	2.44	2.54	2.65	2.75	2.86	-
	Brake Horse Power	kW	29.6	30.9	32.1	33.3	34.1	33.9	-
	Fuel Consumption	lit/hr	8.13	8.56	8.99	9.51	9.95	10.40	-
		g/hr	6830	7187	7548	7988	8360	8736	-
	Exhaust Gas Volume	m ³ /hr	398.2	420.8	443.8	467.4	491.2	515.4	-
		m ³ /min	6.64	7.01	7.40	7.79	8.19	8.59	-
		lit/sec	110.6	116.9	123.3	129.8	136.4	143.2	-
		in ³ /sec	6749	7133	7523	7923	8327	8737	-
		ft ³ /min	234.3	247.7	261.2	275.1	289.1	303.4	-
V2403-M-T	Combustion Air Requirements	m ³ /min	-	-	-	-	3.31	3.44	-
	Brake Horse Power	kW	-	-	-	-	39.2	41.3	-
	Fuel Consumption	lit/hr	-	-	-	-	13.16	14.13	-
		g/hr	-	-	-	-	11054	11866	-
	Exhaust Gas Volume	m ³ /hr	-	-	-	-	535.1	556.4	-
		m ³ /min	-	-	-	-	8.92	9.27	-
		lit/sec	-	-	-	-	148.6	154.6	-
		in ³ /sec	-	-	-	-	9071	9432	-
		ft ³ /min	-	-	-	-	315.0	327.5	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1803-M-DI	Combustion Air Requirements	m ³ /min	1.75	1.83	1.91	1.99	2.07	2.14	-
	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
	Fuel Consumption	lit/hr	6.55	6.77	7.30	7.34	7.70	8.12	-
		g/hr	5505	5686	6133	6161	6467	6818	-
	Exhaust Gas Volume	m ³ /hr	281.2	297.2	314.0	330.3	347.3	364.8	-
		m ³ /min	4.69	4.95	5.23	5.50	5.79	6.08	-
		lit/sec	78.1	82.6	87.2	91.7	96.5	101.3	-
		in ³ /sec	4767	5038	5322	5598	5888	6184	-
		ft ³ /min	165.5	174.9	184.8	194.4	204.4	214.7	-
V2403-M-DI	Combustion Air Requirements	m ³ /min	2.33	2.44	2.54	2.65	2.75	2.86	-
	Brake Horse Power	kW	30.2	31.6	32.9	34.2	35.1	35.0	-
	Fuel Consumption	lit/hr	8.53	9.25	9.82	9.96	10.33	10.47	-
		g/hr	7163	7767	8249	8366	8675	8791	-
	Exhaust Gas Volume	m ³ /hr	398.8	421.9	445.2	468.2	491.9	515.5	-
		m ³ /min	6.65	7.03	7.42	7.80	8.20	8.59	-
		lit/sec	110.8	117.2	123.7	130.0	136.6	143.2	-
		in ³ /sec	6760	7152	7547	7936	8337	8739	-
		ft ³ /min	234.7	248.3	262.0	275.5	289.5	303.4	-

Note :☆ **Exhaust Gas Volume Calculating Formula**

$$GL = (AL + 7.1 \times Be/10000) \times (298 + t) \times 760 / 298 / (760 + Ps) \text{ (m}^3\text{/hr)}$$

AL : Combustion Air Requirements (m³/hr)

Be : Fuel Consumption (g/hr)

t : Exhaust Gas Temperature (°C)

Ps : Exhaust Gas Pressure (mmHg)

[Conversion Rates]

$$\star 1 \text{ lit} = 61.0237 \text{ in}^3 = 0.035315 \text{ ft}^3$$

$$\star 1 \text{ ft}^3 = 28.3168 \text{ lit}$$

$$\star 1 \text{ lit/sec} = 3.6 \text{ m}^3\text{/hr} = 127.133 \text{ ft}^3\text{/hr}$$

6. HEAT REJECTION TO COOLANT

a) ISO 3046 (Value at Overload)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Brake Horse Power	kW	-	-	-	-	20.4	21.0	21.7
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	0.261	0.268	0.286
	Heat Rejection To Coolant	kJ/h	-	-	-	-	73423	77654	85782
		kcal/h	-	-	-	-	17694	18713	20672
D1703-M	Brake Horse Power	kW	19.5	20.4	21.2	22.0	22.8	23.6	24.3
	Specific Fuel Consumption	kg/kW•h	0.263	0.265	0.268	0.270	0.272	0.275	0.279
	Heat Rejection To Coolant	kJ/h	70839	74538	78279	81801	85615	89471	93368
		kcal/h	17071	17962	18864	19713	20632	21561	22500
D1803-M	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
	Specific Fuel Consumption	kg/kW•h	0.253	0.255	0.258	0.265	0.267	0.271	-
	Heat Rejection To Coolant	kJ/h	76341	80290	84531	90398	94285	99037	-
		kcal/h	18397	19349	20371	21784	22721	23866	-
V2003-M	Brake Horse Power	kW	24.2	25.1	26.1	27.1	28.0	28.9	29.8
	Specific Fuel Consumption	kg/kW•h	0.255	0.259	0.262	0.265	0.269	0.275	0.281
	Heat Rejection To Coolant	kJ/h	84976	89797	94368	98995	103678	109541	115154
		kcal/h	20478	21640	22741	23856	24985	26398	27750
V2203-M	Brake Horse Power	kW	26.6	27.8	28.9	29.9	30.9	32.0	33.0
	Specific Fuel Consumption	kg/kW•h	0.256	0.259	0.261	0.268	0.270	0.273	0.276
	Heat Rejection To Coolant	kJ/h	94146	99065	104039	110110	115237	120420	125658
		kcal/h	22688	23873	25072	26535	27770	29019	30282
V2403-M	Brake Horse Power	kW	29.6	30.9	32.1	33.3	34.1	33.9	-
	Specific Fuel Consumption	kg/kW•h	0.258	0.260	0.264	0.269	0.275	0.276	-
	Heat Rejection To Coolant	kJ/h	105150	110889	117044	123657	129326	129048	-
		kcal/h	25339	26722	28206	29799	31165	31098	-
V2403-M-T	Brake Horse Power	kW	-	-	-	-	39.2	41.3	-
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	0.282	0.288	-
	Heat Rejection To Coolant	kJ/h	-	-	-	-	151089	162066	-
		kcal/h	-	-	-	-	36410	39055	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1803-M-DI	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
	Specific Fuel Consumption	kg/kW•h	0.251	0.249	0.258	0.249	0.252	0.257	-
	Heat Rejection To Coolant	kJ/h	58768	60697	65466	65773	69033	72778	-
		kcal/h	14162	14627	15776	15850	16636	17538	-
V2403-M-DI	Brake Horse Power	kW	30.2	31.6	32.9	34.2	35.1	35.0	-
	Specific Fuel Consumption	kg/kW•h	0.237	0.245	0.250	0.244	0.247	0.251	-
	Heat Rejection To Coolant	kJ/h	76463	82909	88063	89311	92604	93841	-
		kcal/h	18426	19980	21222	21523	22316	22614	-

Note :

☆ **Heat Rejection to Coolant Calculating Formula**

$$H_o = H_u \times N_e \times b_e \times i$$

H_o : Heat rejection to coolant
H_u : Diesel fuel low caloric value
 (42700 kJ/kg, 10290 kcal/kg
 or 18520 Btu/lb)
N_e : Brake horse power (kW)
b_e : Specific fuel consumption (g/kW•hr)
i : Dispersion ratio to coolant (%)

b) SAE J1349 (Value at Net Intermittent)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
D1503-M	Brake Horse Power	kW	-	-	-	-	20.4	21.0	21.7
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	0.261	0.268	0.286
	Heat Rejection To Coolant	kJ/h	-	-	-	-	73423	77654	85782
		Btu/h	-	-	-	-	69596	73606	81310
D1703-M	Brake Horse Power	kW	19.5	20.4	21.2	22.0	22.8	23.6	24.3
	Specific Fuel Consumption	kg/kW•h	0.263	0.265	0.268	0.270	0.272	0.275	0.279
	Heat Rejection To Coolant	kJ/h	70839	74538	78279	81801	85615	89471	93368
		Btu/h	67146	70653	74198	77537	81152	84807	88501
D1803-M	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
	Specific Fuel Consumption	kg/kW•h	0.253	0.255	0.258	0.265	0.267	0.271	-
	Heat Rejection To Coolant	kJ/h	76341	80290	84531	90398	94285	99037	-
		Btu/h	72361	76105	80125	85686	89370	93874	-
V2003-M	Brake Horse Power	kW	24.2	25.1	26.1	27.1	28.0	28.9	29.8
	Specific Fuel Consumption	kg/kW•h	0.255	0.259	0.262	0.265	0.269	0.275	0.281
	Heat Rejection To Coolant	kJ/h	84976	89797	94368	98995	103678	109541	115154
		Btu/h	80546	85116	89449	93835	98273	103830	109151
V2203-M	Brake Horse Power	kW	26.6	27.8	28.9	29.9	30.9	32.0	33.0
	Specific Fuel Consumption	kg/kW•h	0.256	0.259	0.261	0.268	0.270	0.273	0.276
	Heat Rejection To Coolant	kJ/h	94146	99065	104039	110110	115237	120420	125658
		Btu/h	89238	93900	98615	104370	109230	114142	119107
V2403-M	Brake Horse Power	kW	29.6	30.9	32.1	33.3	34.1	33.9	-
	Specific Fuel Consumption	kg/kW•h	0.258	0.260	0.264	0.269	0.275	0.276	-
	Heat Rejection To Coolant	kJ/h	105150	110889	117044	123657	129326	129048	-
		Btu/h	99669	105108	110942	117211	122584	122321	-
V2403-M-T	Brake Horse Power	kW	-	-	-	-	39.2	41.3	-
	Specific Fuel Consumption	kg/kW•h	-	-	-	-	0.282	0.288	-
	Heat Rejection To Coolant	kJ/h	-	-	-	-	151089	162066	-
		Btu/h	-	-	-	-	143213	153618	-
D1803-M-DI	Brake Horse Power	kW	21.9	22.8	23.7	24.7	25.6	26.5	-
	Specific Fuel Consumption	kg/kW•h	0.251	0.249	0.258	0.249	0.252	0.257	-
	Heat Rejection To Coolant	kJ/h	58768	60697	65466	65773	69033	72778	-
		Btu/h	55704	57533	62054	62344	65435	68984	-

Model	Engine Speed	min ⁻¹ (rpm)	2200	2300	2400	2500	2600	2700	2800
V2403-M-DI	Brake Horse Power	kW	30.2	31.6	32.9	34.2	35.1	35.0	-
	Specific Fuel Consumption	kg/kW•h	0.237	0.245	0.250	0.244	0.247	0.251	-
	Heat Rejection To Coolant	kJ/h	76463	82909	88063	89311	92604	93841	-
		Btu/h	72477	78587	83472	84656	87777	88949	-

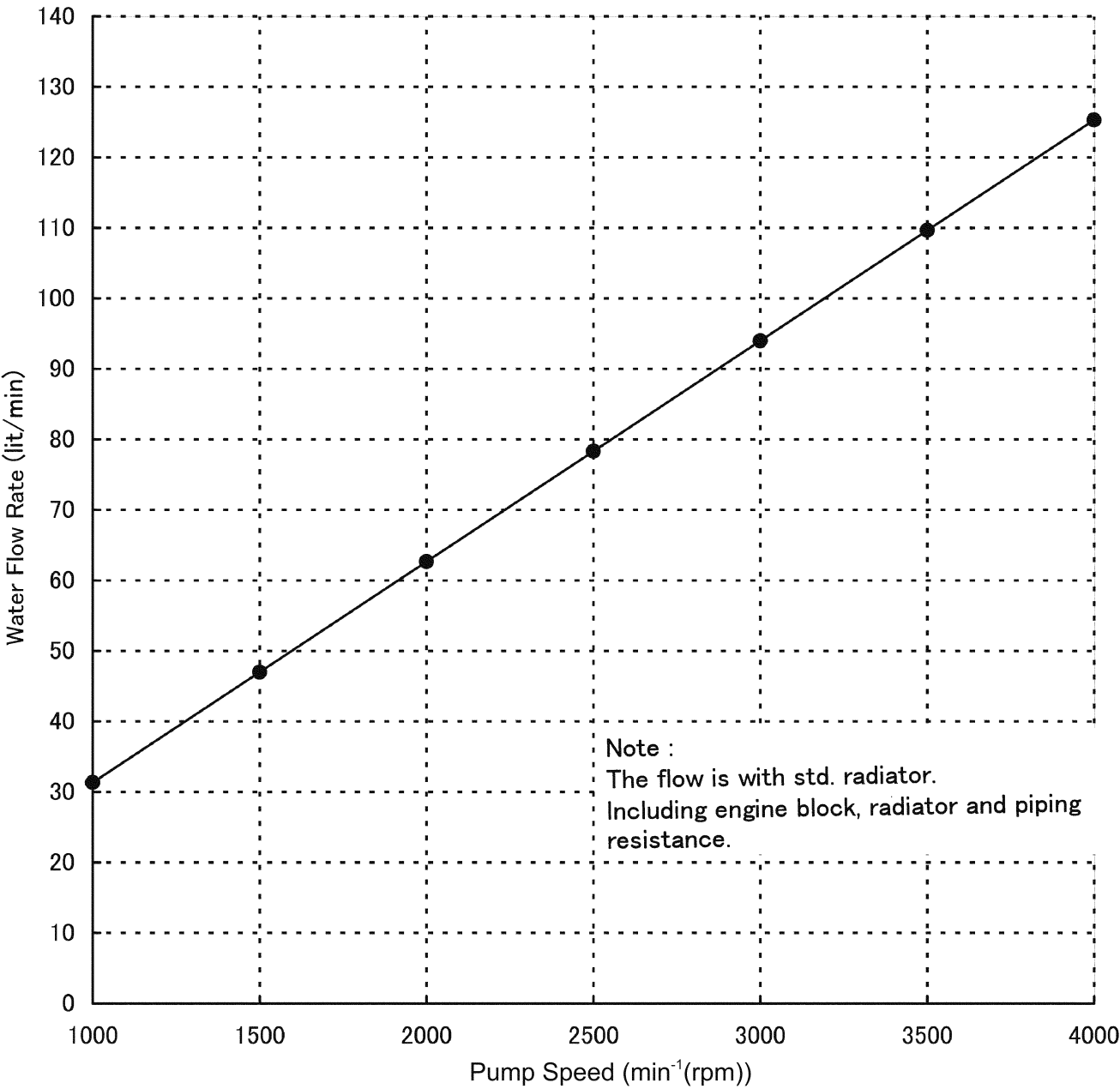
Note :☆ **Heat Rejection to Coolant Calculating Formula**

$$H_o = H_u \times N_e \times b_e \times i$$

H_o : Heat rejection to coolant
H_u : Diesel fuel low caloric value
 (42700 kJ/kg, 10290 kcal/kg
 or 18520 Btu/lb)
N_e : Brake horse power (kW)
b_e : Specific fuel consumption (g/kW•hr)
i : Dispersion ratio to coolant (%)

7. WATER FLOW RATE

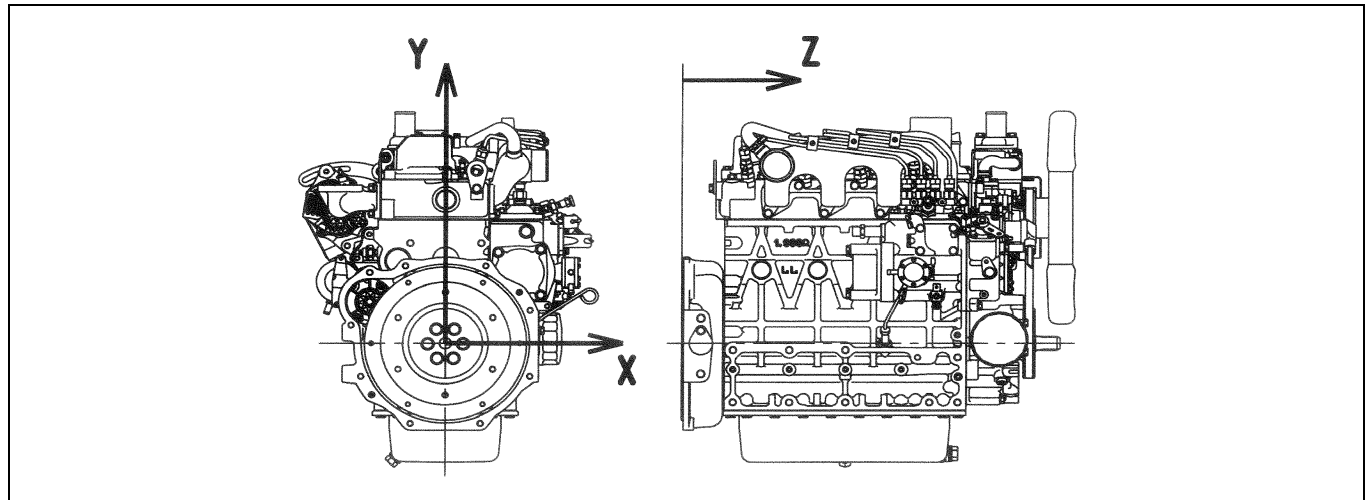
Water Pump	1A051-7303Δ 1G730-7303Δ
Fan Pulley Dia.	104 mm (4.09 in.)
Fan Drive Pulley Dia.	130 mm (5.12 in.)
Thermostat	1A021-7301Δ



8. CENTER OF GRAVITY

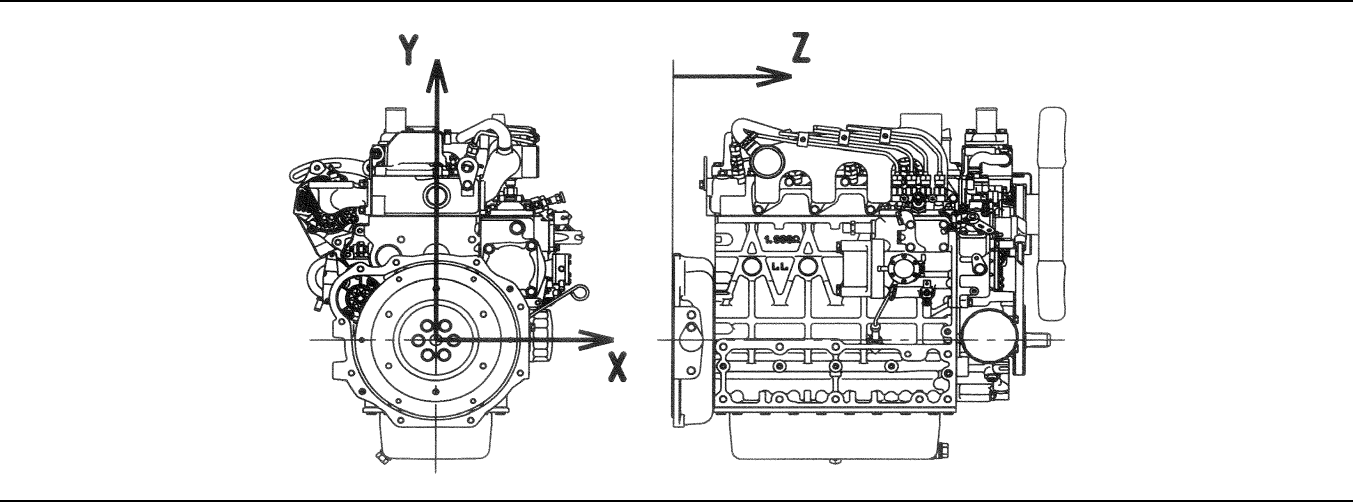
1. With Standard Flywheel and Flywheel Housing

Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
D1503-M	148.0 (326.3)	3.0 (0.12)	78.0 (3.07)	261.0 (10.28)
D1703-M	148.0 (326.3)	3.0 (0.12)	78.0 (3.07)	261.0 (10.28)
D1803-M	151.0 (332.9)	3.0 (0.12)	79.0 (3.11)	261.0 (10.28)
V2003-M	180.0 (396.8)	3.0 (0.12)	78.0 (3.07)	317.0 (12.48)
V2203-M	180.0 (396.8)	3.0 (0.12)	78.0 (3.07)	317.0 (12.48)
V2403-M	184.0 (405.7)	3.0 (0.12)	79.0 (3.11)	317.0 (12.48)
V2403-M-T	201.0 (443.1)	-1.0 (-0.04)	86.0 (3.39)	315.0 (12.40)
D1803-M-DI	151.0 (332.9)	3.0 (0.12)	79.0 (3.11)	261.0 (10.28)
V2403-M-DI	184.0 (405.7)	3.0 (0.12)	79.0 (3.11)	317.0 (12.48)



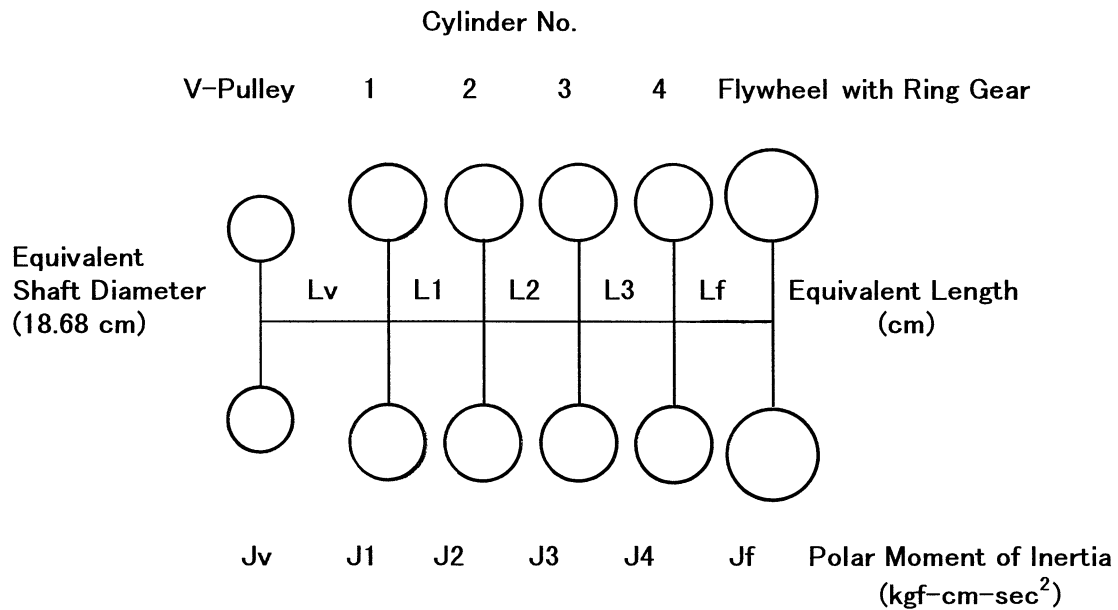
2. With Short SAE Flywheel and Flywheel Housing (Normal type is an option)

Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
D1503-M	168.8 (372.1)	2.0 (0.08)	68.0 (2.68)	291.0 (11.46)
D1703-M	168.8 (372.1)	2.0 (0.08)	68.0 (2.68)	291.0 (11.46)
D1803-M	171.8 (379.0)	2.0 (0.08)	69.0 (2.72)	291.0 (11.46)
V2003-M	200.8 (443.0)	3.0 (0.12)	70.0 (2.76)	347.0 (13.66)
V2203-M	200.8 (443.0)	3.0 (0.12)	70.0 (2.76)	347.0 (13.66)
V2403-M	204.8 (452.0)	3.0 (0.12)	71.0 (2.80)	347.0 (13.66)
V2403-M-T	221.8 (489.0)	-1.0 (-0.04)	78.0 (3.07)	346.0 (13.62)
D1803-M-DI	171.8 (378.8)	2.0 (0.08)	69.0 (2.72)	291.0 (11.46)
V2403-M-DI	204.8 (451.5)	3.0 (0.12)	71.0 (2.80)	347.0 (13.66)



9. MASS ELASTIC SYSTEMS

(A) With Standard Flywheel



Model	Equivalent Length (cm)					Polar Moment of Inertia (kgf-cm-sec ²)					
	Lv	L1	L2	L3	Lf	Jv	J1	J2	J3	J4	Jf
D1503-M	9710	1896	1896	-	1255	0.046	0.095	0.060	0.095	-	1.701
D1703-M	9710	1896	1896	-	1255	0.046	0.096	0.061	0.096	-	1.701
D1803-M	10272	1653	1653	-	1038	0.041	0.095	0.095	0.095	-	3.084
V2003-M	9710	1896	1896	1896	1255	0.032	0.085	0.085	0.085	0.085	1.701
V2203-M	9710	1896	1896	1896	1255	0.032	0.086	0.086	0.086	0.086	1.701
V2403-M	10272	1653	1653	1653	1038	0.014	0.095	0.095	0.095	0.095	3.050
V2403-M-T	10272	1653	1653	1653	1038	0.014	0.095	0.095	0.095	0.095	3.050
D1803-M-DI	10272	1653	1653	-	1038	0.041	0.095	0.095	0.095	-	3.084
V2403-M-DI	10272	1653	1653	1653	1038	0.014	0.095	0.095	0.095	0.095	3.050

Note :

Model	Flywheel Comp	Fan Drive Pulley
D1503-M	16414-2501△	1A053-7428△
D1703-M	↑	↑
D1803-M	1G840-2501△	1G840-7428△
V2003-M	19629-2501△	1A085-7428△
V2203-M	↑	↑
V2403-M	1G850-2501△	↑
V2403-M-T	1G850-2501△	1A085-7428△
D1803-M-DI	1G840-2501△	1G840-7428△
V2403-M-DI	1G850-2501△	↑

10. UNBALANCED FORCES

1. Base Data

F_z = Unbalanced inertia force

$$= 4m_p \cdot r \cdot \omega^2 \cdot (r/l) \cos 2\theta \text{ (kgf)}$$

N_{py} , N_{oz} = Unbalanced inertia couple (kgf-m)

m_p = Reciprocating mass = W_p/G (kg)

W_p = Reciprocating weight (kgf)

G = Gravitational Acceleration = 9.80665 (m/sec²)

r = Crank radius (m)

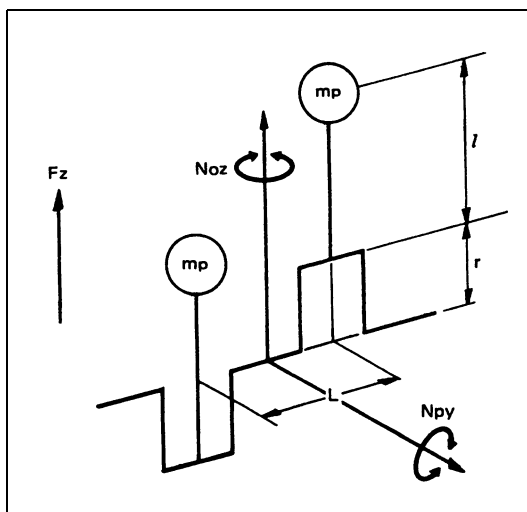
l = Center distance of connecting rod (m)

L = Cylinder distance (m)

ω = Angular velocity

$$= 2\pi n/60 \text{ (rad/sec)}$$

n = Engine speed (min⁻¹(rpm))



Model	l (m)	r (m)	L (m)	Wp (kgf)	Bore (mm)	Stroke (mm)
D1503-M	0.1330	0.0462	0.0950	0.928	83.0	92.4
D1703-M	0.1330	0.0462	0.0950	0.979	87.0	92.4
D1803-M	0.1330	0.0512	0.0950	0.979	87.0	102.4
V2003-M	0.1330	0.0462	0.0950	0.928	83.0	92.4
V2203-M	0.1330	0.0462	0.0950	0.979	87.0	102.4
V2403-M	0.1330	0.0512	0.0950	0.979	87.0	102.4
V2403-M-T	0.1330	0.0512	0.0950	0.979	87.0	102.4
D1803-M-DI	0.1330	0.0462	0.0950	0.979	87.0	102.4
V2403-M-DI	0.1330	0.0512	0.0950	0.979	87.0	102.4

2. Unbalanced inertia force and couple

($\times \omega^2$)

Model	No. of Cylinder	Cylinder Bore (mm)	Order	Fz	Npy	Noz
D1503-M	3	83.0	1	0	0.000360	0.000360
			2	0	0.000250	0
D1703-M	3	87.0	1	0	0.000379	0.000379
			2	0	0.000264	0
D1803-M	3	87.0	1	0	0.000421	0.000421
			2	0	0.000324	0
V2003-M	4	83.0	1	0	0	0
			2	0.00607	0	0
V2203-M	4	87.0	1	0	0	0
			2	0.00641	0	0
V2403-M	4	87.0	1	0	0	0
			2	0.00787	0	0
V2403-M-T	4	83.0	1	0	0	0
			2	0.00787	0	0
D1803-M-DI	3	87.0	1	0	0.000379	0.000379
			2	0	0.000264	0
V2403-M-DI	4	87.0	1	0	0	0
			2	0.00787	0	0

3. An example of calculation

Calculation Condition	ω^2	Fz, Npy, Noz		
			Order	Calculation
Engine model : V2403-M-T Engine speed : 2800 min ⁻¹ (rpm)	$(2 \times \pi \times 2800/60)^2$ = 85975	Fz (kgf)	1	0
			2	$0.00787 \times 85975 = 677$
		Npy (kgf-m)	1	0
			2	0
		Noz (kgf-m)	1	0
			2	0

11. TECHNICAL INFORMATION OF ENGINE FOR GENERATOR

1. Brake Horse Power

Model	Engine Speed [r/min]		1500		1800	
			kW	HP/PS	kW	HP/PS
D1703-M-BG	ISO 3046 [kW,PS]	Stand-by	15.0	20.5	18.1	24.6
		Continuous	12.8	17.4	15.1	20.5
	SAE J1349 [kW,HP]	Stand-by	15.0	20.1	18.1	24.3
		Continuous	12.8	17.2	15.1	20.2
V2003-M-BG	ISO 3046 [kW,PS]	Stand-by	18.1	24.6	21.8	29.6
		Continuous	15.5	21.1	18.2	24.7
	SAE J1349 [kW,HP]	Stand-by	18.1	24.3	21.8	29.2
		Continuous	15.5	20.8	18.2	24.4
V2203-M-BG	ISO 3046 [kW,PS]	Stand-by	20.1	27.3	24.2	32.9
		Continuous	17.2	23.4	20.2	27.5
	SAE J1349 [kW,HP]	Stand-by	20.1	27.0	24.2	32.5
		Continuous	17.2	23.1	20.2	27.1
V2403-M-BG	ISO 3046 [kW,PS]	Stand-by	22.0	29.9	26.5	36.0
		Continuous	18.8	25.6	22.1	30.0
	SAE J1349 [kW,HP]	Stand-by	22.0	29.5	26.5	35.5
		Continuous	18.8	25.2	22.1	29.6
V2003-M-T-BG	ISO 3046 [kW,PS]	Stand-by	22.5	30.6	27.1	36.8
		Continuous	20.4	27.7	24.5	33.3
	SAE J1349 [kW,HP]	Stand-by	22.5	30.2	27.1	36.3
		Continuous	20.4	27.4	24.5	32.9

2. Noise Level [at 1m (3.3 ft) dB (A)]

Model	Engine Speed [r/min]	1500	1800
D1703-M-BG	4/4 Load (Continuous)	84.7	86.3
	No Load	81.0	83.2
	Stand-by	84.9	86.5
V2003-M-BG	4/4 Load (Continuous)	83.2	85.0
	No Load	79.5	81.9
	Stand-by	83.4	85.2
V2203-M-BG	4/4 Load (Continuous)	84.2	86.0
	No Load	80.5	82.9
	Stand-by	84.4	86.2
V2403-M-BG	4/4 Load (Continuous)	85.2	87.0
	No Load	81.5	83.9
	Stand-by	85.4	87.2
V2003-M-T-BG	4/4 Load (Continuous)	82.5	84.6
	No Load	78.8	81.5
	Stand-by	82.7	84.8

3. Heat Rejection Coolant

ISO 3046 (Value Output for Stand-by)

Model	Engine Speed	r/min	1500	1800
D1703-M-BG	Brake Horse Power	kW	15.0	18.1
	Specific Fuel Consumption	kg/kWhr	0.233	0.235
	Heat Rejection To Coolant	kJ/hr	60100	69000
		kcal/hr	14500	16600
V2003-M-BG	Brake Horse Power	kW	18.1	21.8
	Specific Fuel Consumption	kg/kWhr	0.233	0.235
	Heat Rejection To Coolant	kJ/hr	75600	89700
		kcal/hr	18200	21600
V2203-M-BG	Brake Horse Power	kW	20.1	24.2
	Specific Fuel Consumption	kg/kWhr	0.233	0.235
	Heat Rejection To Coolant	kJ/hr	84000	99600
		kcal/hr	20200	24000
V2403-M-BG	Brake Horse Power	kW	22.0	26.5
	Specific Fuel Consumption	kg/kWhr	0.233	0.235
	Heat Rejection To Coolant	kJ/hr	91900	109000
		kcal/hr	22200	26300
V2003-M-T-BG	Brake Horse Power	kW	22.5	27.1
	Specific Fuel Consumption	kg/kWhr	0.233	0.233
	Heat Rejection To Coolant	kJ/hr	94000	11100
		kcal/hr	22700	26600

SAE J1349 (Value Output for Stand-by)

Model	Engine Speed	r/min	1500	1800
D1703-M-BG	Brake Horse Power	HP	20.1	24.3
	Specific Fuel Consumption	lb/HP-hr	0.383	0.386
	Heat Rejection To Coolant	kJ/hr	60100	69000
		Btu/hr	57100	66000
V2003-M-BG	Brake Horse Power	HP	24.3	29.2
	Specific Fuel Consumption	lb/HP-hr	0.383	0.386
	Heat Rejection To Coolant	kJ/hr	75600	89700
		Btu/hr	72300	85800
V2203-M-BG	Brake Horse Power	HP	27.0	32.5
	Specific Fuel Consumption	lb/HP-hr	0.383	0.386
	Heat Rejection To Coolant	kJ/hr	84000	99600
		Btu/hr	80300	95200
V2403-M-BG	Brake Horse Power	HP	29.5	35.5
	Specific Fuel Consumption	lb/HP-hr	0.383	0.386
	Heat Rejection To Coolant	kJ/hr	91900	109000
		Btu/hr	87900	104300
V2003-M-T-BG	Brake Horse Power	HP	30.2	36.3
	Specific Fuel Consumption	lb/HP-hr	0.383	0.383
	Heat Rejection To Coolant	kJ/hr	94000	110500
		Btu/hr	89900	105700

4. 07 SERIES

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1. BRAKE HORSE POWER

a) ISO 3046, 2534

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Gross	kW	42.3	-	-	49.2
		PS	57.5	-	-	66.9
	Overload	kW	41.1	-	-	47.5
		PS	55.9	-	-	64.6
	Continuous	kW	35.7	-	-	41.2
		PS	48.6	-	-	56.1
V3307-DI-T	Gross	kW	55.4	55.4	55.4	-
		PS	75.3	75.3	75.3	-
	Overload	kW	54.0	53.9	53.7	-
		PS	73.5	73.3	73.0	-
	Continuous	kW	46.9	46.8	46.6	-
		PS	63.8	63.6	63.4	-

b) SAE J1349

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Gross Intermittent	kW	42.3	-	-	49.2
		HP	56.7	-	-	66.0
	Net Intermittent	kW	41.1	-	-	47.5
		HP	55.1	-	-	63.7
	Net Continuous	kW	35.7	-	-	41.2
		HP	47.9	-	-	55.3
V3307-DI-T	Gross Intermittent	kW	55.4	55.4	55.4	-
		HP	74.3	74.3	74.3	-
	Net Intermittent	kW	54.0	53.9	53.7	-
		HP	72.4	72.2	72.0	-
	Net Continuous	kW	46.9	46.8	46.6	-
		HP	62.9	62.7	62.5	-

c) JIS D1005, B8014

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	建設機械用 定格出力 (D1005)	kW	41.1	-	-	47.5
		PS	55.9	-	-	64.6
	定回転用 定格出力 (B8014)	kW	35.7	-	-	41.2
		PS	48.6	-	-	56.1
V3307-DI-T	建設機械用 定格出力 (D1005)	kW	54.0	53.9	53.7	-
		PS	73.5	73.3	73.0	-
	定回転用 定格出力 (B8014)	kW	46.9	46.8	46.6	-
		PS	63.8	63.6	63.4	-

Note :**1. Above powers may be changed by emission regulations applied.****2. Conversion rates**

☆ 1 kW = 1.35962 PS = 1.34048 HP

☆ 1 PS = 0.7355 kW = 0.985925 HP

☆ 1 HP = 0.7457 kW = 1.01428 PS

2. FUEL CONSUMPTION

a) ISO 3046(Value at Overload) - Subject to $\pm 5\%$ Tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Brake Horse Power	kW	41.1	-	-	47.5
		PS	55.9	-	-	64.6
	Specific Fuel Consumption	kg/kWh	0.236	-	-	0.251
		kg/PS _h	0.174	-	-	0.184
	Fuel Consumption	lit/hr	11.58	-	-	14.17
V3307-DI-T	Brake Horse Power	kW	54.0	53.9	53.7	-
		PS	73.5	73.3	73.0	-
	Specific Fuel Consumption	kg/kWh	0.251	0.254	0.257	-
		kg/PS _h	0.185	0.187	0.189	-
	Fuel Consumption	lit/hr	16.16	16.29	16.42	-

Note :

Fuel Consumption Calculating Formula

$$\text{Fuel Consumption (lit/hr)} = \frac{\text{Fuel Consumption (kg/kW}\cdot\text{hr)} \times \text{Brake Horse Power (kW)}}{0.84}$$

0.84 (g/cc) : Gravity of Diesel Fuel

b) SAE J1349 (Value at Net Intermittent) - Subject to $\pm 5\%$ Tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Brake Horse Power	kW	41.1	-	-	47.5
		HP	55.1	-	-	63.7
	Specific Fuel Consumption	kg/kWh	0.236	-	-	0.251
		lb/HP _h	0.389	-	-	0.412
	Fuel Consumption	Gal/hr	3.02	-	-	3.70
V3307-DI-T	Brake Horse Power	kW	54.0	53.9	53.7	-
		HP	72.4	72.2	72.0	-
	Specific Fuel Consumption	kg/kWh	0.251	0.254	0.257	-
		lb/HP _h	0.413	0.418	0.422	-
	Fuel Consumption	Gal/hr	4.21	4.25	4.28	-

Note :

Fuel Consumption Calculating Formula

$$\text{Fuel Consumption (Gal/hr)} = \frac{\text{Fuel Consumption (lb/HP}\cdot\text{hr)} \times \text{Brake Horse Power (HP)}}{7.1}$$

7.1 (lb/Gal) : Gravity of Diesel Fuel

3. NOISE LEVEL

Model	Engine Speed min ⁻¹ (rpm)	Unit	Sound Pressure at 1 m (3.3 ft)	
			at Full Load	at No Load
V2607-DI-T	1500	dB (A)	88.8	82.8
	1800		90.3	85.3
	2200		92.3	88.6
	2400		93.3	90.2
	2600		94.3	91.9
	2700		94.8	92.7
V3307-DI-T	1500	dB (A)	89.0	83.9
	1800		90.6	86.2
	2200		92.7	89.3
	2400		93.7	90.9
	2600		94.8	92.5

These data show the average noise level at four points.

Note :

[Measurement conditions]

☆ With radiator, cooling fan, air cleaner and muffler.

4. AIR REQUIREMENTS

(1) Combustion Air Requirements

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Combustion Air Requirements	m ³ /hr	196.8	-	-	255.6
		m ³ /min	3.28	-	-	4.26
		lit/sec	54.67	-	-	71.00
		in ³ /sec	3336	-	-	4333
		ft ³ /min	115.8	-	-	150.5
V3307-DI-T	Combustion Air Requirements	m ³ /hr	255.8	280.3	308.0	-
		m ³ /min	4.26	4.67	5.13	-
		lit/sec	71.06	77.85	85.55	-
		in ³ /sec	4336	4751	5220	-
		ft ³ /min	150.6	165.0	181.3	-

Note :

☆ **Combustion Air Requirements Calculating Formula**

$$Q_1 = V_h \cdot N \cdot C \cdot \eta \cdot k \cdot 10^{-3}$$

Q₁ : Amount of intake air (m³/min)

V_h : Total displacement (lit)

N : Engine speed (min⁻¹(rpm))

C : Coefficient = 0.5

η : Intake efficiency

Natural aspirated engine : 0.87

Turbo charged engine : 0.80

k : Coefficient : 1.0

Natural aspirated engine : 1.0

Turbo charged engine : 1.5

(2) Cooling Air Requirements

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Cooling Air Requirements	m ³ /hr	3799	-	-	5517
		m ³ /min	63.3	-	-	91.9
		lit/sec	1055	-	-	1532
		in ³ /sec	64402	-	-	93515
		ft ³ /min	2236	-	-	3247
V3307-DI-T	Cooling Air Requirements	m ³ /hr	5305	5347	5389	-
		m ³ /min	88.4	89.1	89.8	-
		lit/sec	1474	1485	1497	-
		in ³ /sec	89924	90640	91355	-
		ft ³ /min	3123	3147	3172	-

Note :

Above data is decided by following conditions.

(a) Using the standard radiator recommended in SOS.

(b) Engine is run as open unit.

(3) Combustion and Cooling Air Requirements**{Refer to 25 °C (77 °F) and 750 mmHg}**

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Combustion and Cooling Air Requirements	m ³ /hr	3996	-	-	5772
		m ³ /min	66.6	-	-	96.2
		lit/sec	1110	-	-	1603
		in ³ /sec	67738	-	-	97848
		ft ³ /min	2352	-	-	3398
V3307-DI-T	Combustion and Cooling Air Requirements	m ³ /hr	5561	5627	5697	-
		m ³ /min	92.7	93.8	95.0	-
		lit/sec	1545	1563	1583	-
		in ³ /sec	94261	95391	96576	-
		ft ³ /min	3273	3312	3354	-

Note :**1. Cooling Air Fan and Pulley Specifications**

Model		V2607-DI-T	V3307-DI-T
Item			
Fan Diameter	mm	φ 410	
	in.	φ 16.1	
No. of Blade and type of shape		8,F type	
Diameter of Fan Driving Pulley	mm	φ 127	
	in.	φ 5	
Diameter of Fan Pulley	mm	φ 130	
	in.	φ 5.1	

2. Conversion Rates☆ 1 lit = 61.0237 in³ = 0.035315 ft³☆ 1 ft³ = 28.3168 lit☆ 1 lit/sec = 3.6 m³/hr = 2.1189 ft³/min

5. EXHAUST GAS VOLUME

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Combustion Air Requirements	m ³ /min	3.28	-	-	4.26
	Brake Horse Power	kW	41.1	-	-	47.5
	Fuel Consumption	lit/hr	11.58	-	-	14.17
		g/hr	9729	-	-	11906
	Exhaust Gas Volume	m ³ /hr	442.9	-	-	615.2
		m ³ /min	7.38	-	-	10.25
		lit/sec	123.0	-	-	170.9
		in ³ /sec	7507	-	-	10427
		ft ³ /min	260.7	-	-	362.1
V3307-DI-T	Combustion Air Requirements	m ³ /min	4.26	4.67	5.13	-
	Brake Horse Power	kW	54.0	53.9	53.7	-
	Fuel Consumption	lit/hr	16.16	16.29	16.42	-
		g/hr	13573	13684	13795	-
	Exhaust Gas Volume	m ³ /hr	588.8	643.2	704.8	-
		m ³ /min	9.81	10.72	11.75	-
		lit/sec	163.6	178.7	195.8	-
		in ³ /sec	9981	10903	11948	-
		ft ³ /min	346.5	378.6	414.9	-

Note :

☆ Exhaust Gas Volume Calculating Formula

$$GL = (AL + 7.1 \times Be/10000) \times (298 + t) \times 760 / 298 / (760 + Ps) \text{ (m}^3\text{/hr)}$$

AL : Combustion Air Requirements (m³/hr)

Be : Fuel Consumption (g/hr)

t : Exhaust Gas Temperature (°C)

Ps : Exhaust Gas Pressure (mmHg)

[Conversion Rates]

$$\star 1 \text{ lit} = 61.0237 \text{ in}^3 = 0.035315 \text{ ft}^3$$

$$\star 1 \text{ ft}^3 = 28.3168 \text{ lit}$$

$$\star 1 \text{ lit/sec} = 3.6 \text{ m}^3\text{/hr} = 127.133 \text{ ft}^3\text{/hr}$$

6. HEAT REJECTION TO COOLANT

a) ISO 3046 (Value at Overload)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Brake Horse Power	kW	41.1	-	-	47.5
	Specific Fuel Consumption	kg/kW•h	0.236	-	-	0.251
	Heat Rejection To Coolant	kJ/h	112041	-	-	162689
		kcal/h	27000	-	-	33100
V3307-DI-T	Brake Horse Power	kW	54.0	53.9	53.7	-
	Specific Fuel Consumption	kg/kW•h	0.251	0.254	0.257	-
	Heat Rejection To Coolant	kJ/h	156442	157687	158932	-
		kcal/h	37700	38000	38300	-

Note :

☆ Heat Rejection to Coolant Calculating Formula

$$Ho = Hu \times Ne \times be \times i$$

Ho: Heat rejection to coolant
 Hu: Diesel fuel low caloric value
 (42700 kJ/kg, 10290 kcal/kg
 or 18520 Btu/lb)
 Ne: Brake horse power (kW)
 be: Specific fuel consumption (g/kW•hr)
 i : Dispersion ratio to coolant (%)

b) SAE J1349 (Value at Net Intermittent)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600	2700
V2607-DI-T	Brake Horse Power	kW	41.1	-	-	47.5
	Specific Fuel Consumption	kg/kW•h	0.236	-	-	0.251
	Heat Rejection To Coolant	kJ/h	112041	-	-	162689
		Btu/h	106200	-	-	154208
V3307-DI-T	Brake Horse Power	kW	54.0	53.9	53.7	-
	Specific Fuel Consumption	kg/kW•h	0.251	0.254	0.257	-
	Heat Rejection To Coolant	kJ/h	156442	157687	158932	-
		Btu/h	148287	149467	150647	-

Note :

☆ Heat Rejection to Coolant Calculating Formula

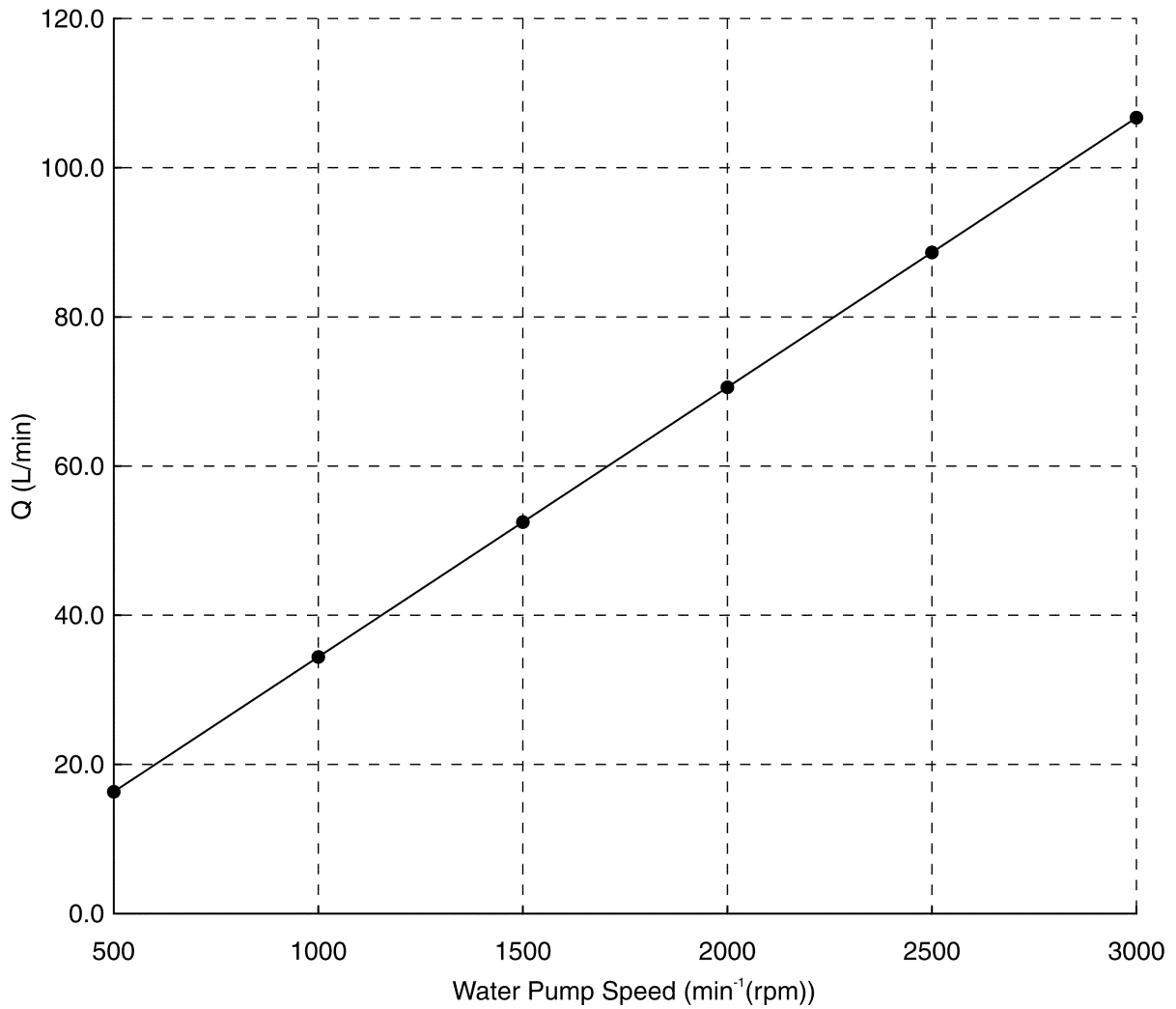
$$Ho = Hu \times Ne \times be \times i$$

Ho: Heat rejection to coolant
 Hu: Diesel fuel low caloric value
 (42700 kJ/kg, 10290 kcal/kg
 or 18520 Btu/lb)
 Ne: Brake horse power (kW)
 be: Specific fuel consumption (g/kW•hr)
 i : Dispersion ratio to coolant (%)

7. WATER FLOW RATE

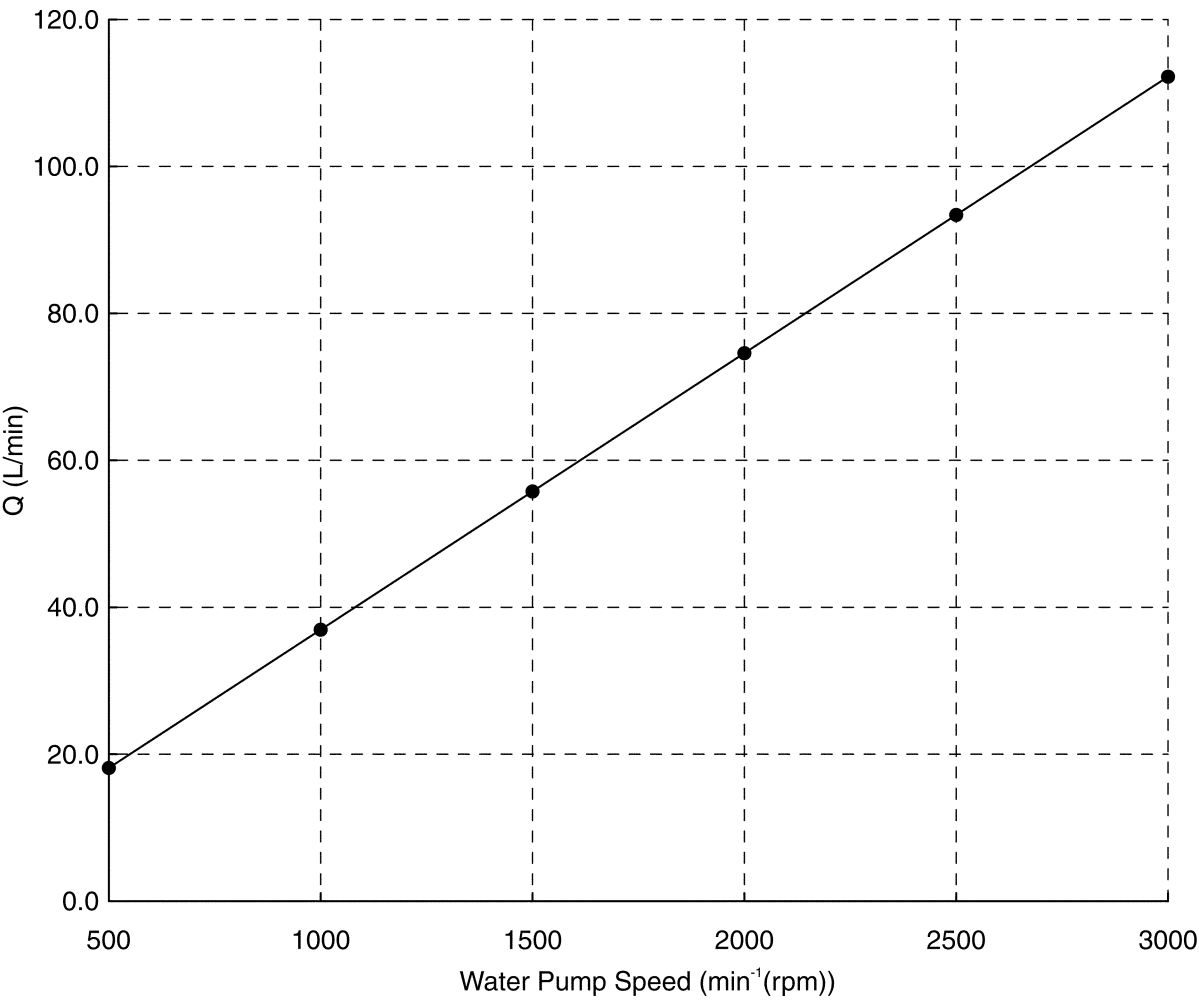
(1) Water Flow Rate of V2607-DI-T

Water Pump	1G770-7303Δ
Fan Pulley Dia.	130 mm (5.12 in.)
Fan Drive Pulley Dia.	127 mm (5.00 in.)
Thermostat	1G772-7301Δ



(2) Water Flow Rate of V3307-DI-T

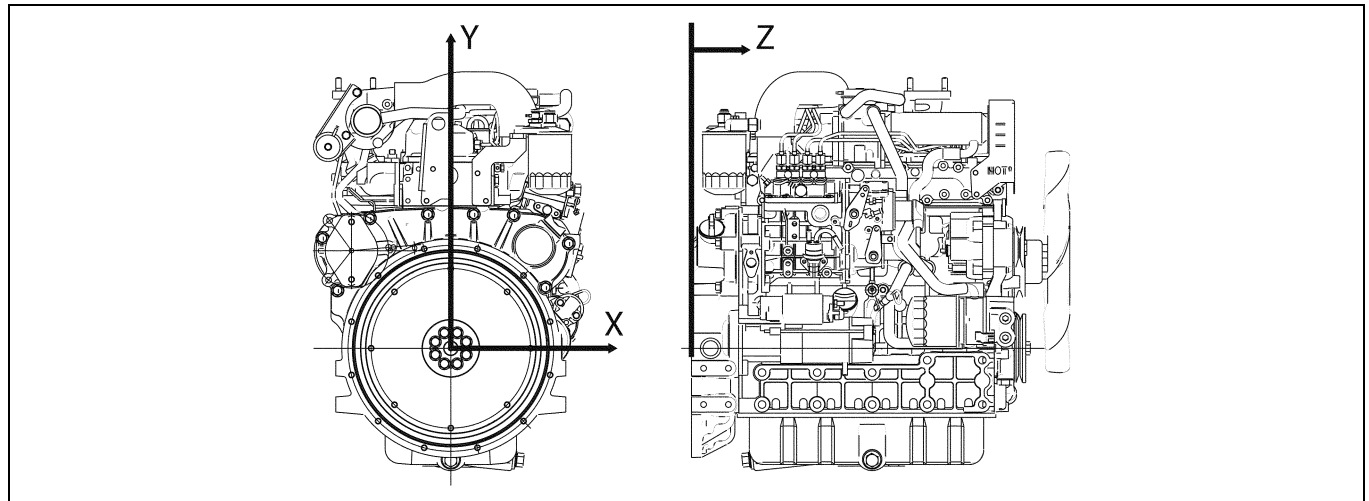
Water Pump	1G772-7303Δ
Fan Pulley Dia.	130 mm (5.12 in.)
Fan Drive Pulley Dia.	127 mm (5.00 in.)
Thermostat	1C011-7301Δ



8. CENTER OF GRAVITY

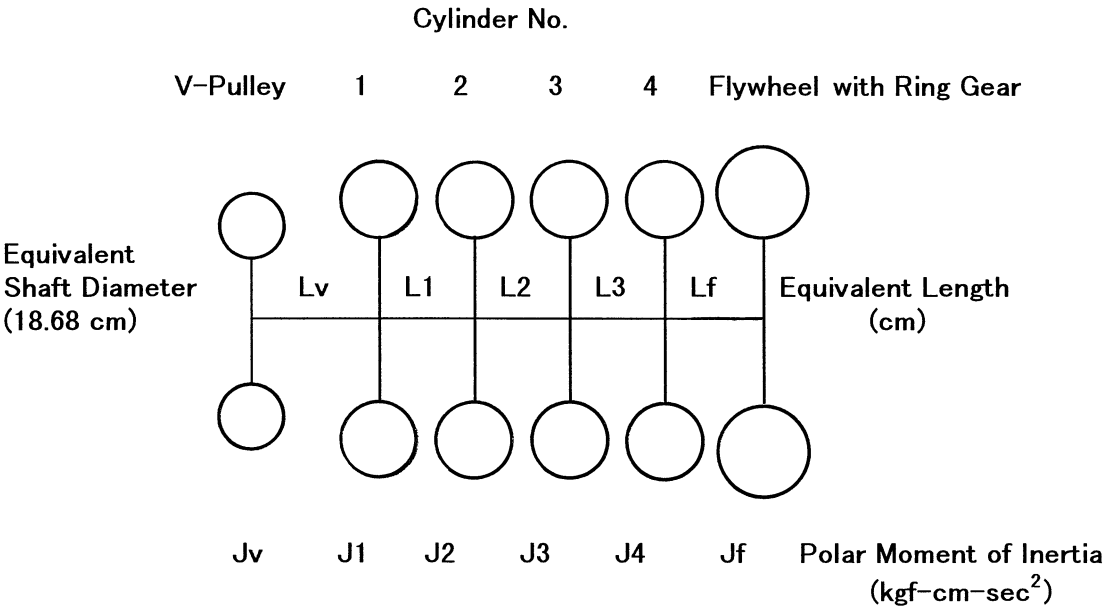
1. With SAE Flywheel and Flywheel Housing

Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
V2607-DI-T	235.0 (518.1)	8.0 (0.31)	98.0 (3.86)	262.0 (10.31)
V3307-DI-T	268.0 (590.8)	14.0 (0.55)	116.0 (4.57)	272.9 (10.74)



9. MASS ELASTIC SYSTEMS

(A) With Standard Flywheel



Model	Equivalent Length (cm)					Polar Moment of Inertia (kgf-cm-sec ²)					
	Lv	L1	L2	L3	Lf	Jv	J1	J2	J3	J4	Jf
V2607-DI-T	3931	992	992	992	1313	0.022	0.128	0.128	0.128	0.128	4.028
V3307-DI-T	3964	1206	1206	1206	1192	0.022	0.156	0.156	0.156	0.156	4.466

Note :

Model	Flywheel Comp	Fan Drive Pulley
V2607-DI-T	1J700-2511△	1J777-7428△
V3307-DI-T	1J415-2511△	1G777-7428△

10. UNBALANCED FORCES

1. Base Data

F_z = Unbalanced inertia force

$$= 4m_p * r * \omega^2 * (r/l) \cos 2\theta \text{ (kgf)}$$

N_{py} , N_{oz} = Unbalanced inertia couple (kgf-m)

m_p = Reciprocating mass = W_p/G (kg)

W_p = Reciprocating weight (kgf)

G = Gravitational Acceleration = $9.80665 \text{ (m/sec}^2\text{)}$

r = Crank radius (m)

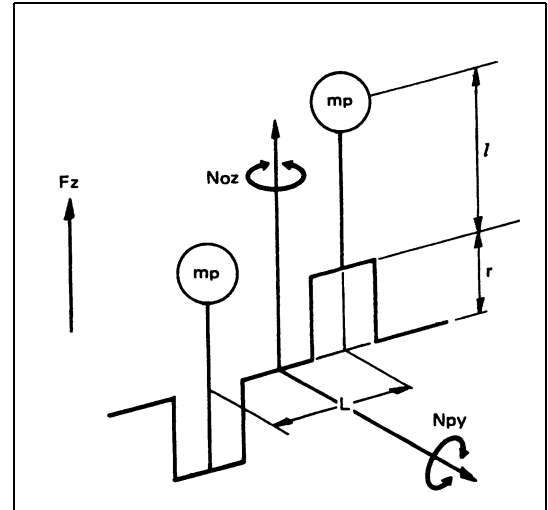
l = Center distance of connecting rod (m)

L = Cylinder distance (m)

ω = Angular velocity

$$= 2\pi n/60 \text{ (rad/sec)}$$

n = Engine speed ($\text{min}^{-1}(\text{rpm})$)



Model	l (m)	r (m)	L (m)	Wp (kgf)	Bore (mm)	Stroke (mm)
V2607-DI-T	0.148	0.055	0.095	0.9921	87.0	110.0
V3307-DI-T	0.1620	0.0600	0.1020	1.2190	94.0	120.0

2. Unbalanced inertia force and couple ($\times \omega^2$)

Model	No. of Cylinder	Cylinder Bore (mm)	Order	F_z	N_{py}	N_{oz}
V2607-DI-T	4	87.0	1	0	0	0
			2	0.008271	0	0
V3307-DI-T	4	94.0	1	0	0	0
			2	0.011049	0	0

3. An example of calculation

Calculation Condition	ω^2	F_z, N_{py}, N_{oz}		
			Order	Calculation
Engine model : V3307-DI-T Engine speed : $2700 \text{ min}^{-1}(\text{rpm})$	$(2 \times \pi \times 2700/60)^2 = 79944$	F_z (kgf)	1	0
			2	$0.011049 \times 79944 = 883.3\text{kg}$
		N_{py} (kgf-m)	1	0
			2	0
		N_{oz} (kgf-m)	1	0
			2	0

5. V3 SERIES

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1. BRAKE HORSE POWER

a) ISO 3046, 2534

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Gross	kW	46.5	48.6	49.8
		PS	63.2	66.1	67.7
	Overload	kW	43.8	45.3	45.7
		PS	59.5	61.5	62.2
	Continuous	kW	38.0	39.3	39.7
		PS	51.7	53.4	54.0
V3600-T	Gross	kW	57.1	62.3	63.0
		PS	77.6	84.7	85.7
	Overload	kW	54.2	58.7	58.7
		PS	73.7	79.9	79.8
	Continuous	kW	47.1	51.0	51.0
		PS	64.0	69.4	69.3
V3800 DI-T	Gross	kW	61.6	68.6	74.0
		PS	83.8	93.3	100.6
	Overload	kW	59.8	66.4	71.4
		PS	81.2	90.2	97.0
	Continuous	kW	51.9	57.6	62.0
		PS	70.6	78.4	84.3

b) SAE J1349

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Gross Intermittent	kW	46.5	48.6	49.8
		HP	62.3	65.1	66.8
	Net Intermittent	kW	43.8	45.3	45.7
		HP	58.7	60.7	61.3
	Net Continuous	kW	38.0	39.3	39.7
		HP	51.0	52.7	53.2
V3600-T	Gross Intermittent	kW	57.1	62.3	63.0
		HP	76.5	83.5	84.5
	Net Intermittent	kW	54.2	58.7	58.7
		HP	72.7	78.8	78.7
	Net Continuous	kW	47.1	51.0	51.0
		HP	63.1	68.4	68.4
V3800 DI-T	Gross Intermittent	kW	61.6	68.6	74.0
		HP	82.6	92.0	99.2
	Net Intermittent	kW	59.8	66.4	71.4
		HP	80.1	89.0	95.7
	Net Continuous	kW	51.9	57.6	62.0
		HP	69.6	77.3	83.1

c) JIS D1005, B8014

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	建設機械用 定格出力 (D1005)	kW	43.8	45.3	45.7
		PS	59.5	61.5	62.2
	定回転用 定格出力 (B8014)	kW	38.0	39.3	39.7
		PS	51.7	53.4	54.0
V3600- T	建設機械用 定格出力 (D1005)	kW	54.2	58.7	58.7
		PS	73.7	79.9	79.8
	定回転用 定格出力 (B8014)	kW	47.1	51.0	51.0
		PS	64.0	69.4	69.3
V3800 DI-T	建設機械用 定格出力 (D1005)	kW	59.8	66.4	71.4
		PS	81.2	90.2	97.0
	定回転用 定格出力 (B8014)	kW	51.9	57.6	62.0
		PS	70.6	78.4	84.3

Note :**1. Above powers may be changed by emission regulations applied.****2. There are some data of engine for generator in another section of this materials.****3. Conversion rates**

☆ 1 kW = 1.35962 PS = 1.34048 HP

☆ 1 PS = 0.7355 kW = 0.985925 HP

☆ 1 HP = 0.7457 kW = 1.01428 PS

2. FUEL CONSUMPTION

a) ISO 3046 (Value at Overload) - Subject to $\pm 5\%$ Tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Brake Horse Power	kW	43.8	45.3	45.7
		PS	59.5	61.5	62.2
	Specific Fuel Consumption	kg/kWh	0.279	0.292	0.302
		kg/PSh	0.205	0.215	0.222
	Fuel Consumption	lit/hr	14.56	15.74	16.42
V3600-T	Brake Horse Power	kW	54.2	58.7	58.7
		PS	73.7	79.9	79.8
	Specific Fuel Consumption	kg/kWh	0.265	0.279	0.292
		kg/PSh	0.195	0.205	0.215
	Fuel Consumption	lit/hr	17.13	19.51	20.40
V3800 DI-T	Brake Horse Power	kW	59.8	66.4	71.4
		PS	81.2	90.2	97.0
	Specific Fuel Consumption	kg/kWh	0.232	0.239	0.245
		kg/PSh	0.171	0.176	0.180
	Fuel Consumption	lit/hr	16.50	18.87	20.79

Note :

Fuel Consumption Calculating Formula

$$\text{Fuel Consumption (lit/hr)} = \frac{\text{Fuel Consumption (kg/kW}\cdot\text{hr)} \times \text{Brake Horse Power (kW)}}{0.84}$$

0.84 (g/cc) : Gravity of Diesel Fuel

b) SAE J1349 (Value at Net Intermittent) - Subject to $\pm 5\%$ Tolerance

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Brake Horse Power	kW	43.8	45.3	45.7
		HP	58.7	60.7	61.3
	Specific Fuel Consumption	kg/kWh	0.279	0.292	0.302
		lb/HPh	0.459	0.480	0.496
	Fuel Consumption	Gal/hr	3.80	4.10	4.28
V3600-T	Brake Horse Power	kW	54.2	58.7	58.7
		HP	72.7	78.8	78.7
	Specific Fuel Consumption	kg/kWh	0.265	0.279	0.292
		lb/HPh	0.436	0.459	0.480
	Fuel Consumption	Gal/hr	4.47	5.09	5.32
V3800 DI-T	Brake Horse Power	kW	59.8	66.4	71.4
		HP	80.1	89.0	95.7
	Specific Fuel Consumption	kg/kWh	0.232	0.239	0.245
		lb/HPh	0.381	0.393	0.402
	Fuel Consumption	Gal/hr	4.30	4.92	5.42

Note :

Fuel Consumption Calculating Formula

$$\text{Fuel Consumption (Gal/hr)} = \frac{\text{Fuel Consumption (lb/HP·hr)} \times \text{Brake Horse Power (HP)}}{7.1}$$

7.1 (lb/Gal) : Gravity of Diesel Fuel)

3. NOISE LEVEL

Model	Engine Speed min ⁻¹ (rpm)	Unit	Sound Pressure at 1 m (3.3 ft)	
			at Full Load	at No Load
V3600	1500	dB (A)	91.3	86.9
	1800		92.0	88.7
	2200		93.0	90.5
	2400		93.5	91.6
	2600		94.0	93.0
V3600-T	1500	dB (A)	91.3	87.1
	1800		92.0	90.0
	2200		93.0	92.5
	2400		93.5	93.5
	2600		94.0	94.4
V3800-DI-T	1500	dB (A)	91.6	85.9
	1800		91.2	88.3
	2200		92.5	90.8
	2400		94.0	91.8
	2600		96.0	92.7

These data show the average noise level at four points.

Note :

[Measurement conditions]

☆ With radiator, cooling fan, air cleaner and muffler. without balancer.

4. AIR REQUIREMENTS

(1) Combustion Air Requirements

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Combustion Air Requirements	m ³ /hr	207.9	226.8	245.7
		m ³ /min	3.46	3.78	4.09
		lit/sec	57.74	62.99	68.24
		in ³ /sec	3523	3844	4164
		ft ³ /min	122.4	133.5	144.6
V3600-T	Combustion Air Requirements	m ³ /hr	281.9	308.4	335.1
		m ³ /min	4.70	5.14	5.59
		lit/sec	78.29	85.68	93.09
		in ³ /sec	4778	5228	5680
		ft ³ /min	165.9	181.6	197.3
V3800 DI-T	Combustion Air Requirements	m ³ /hr	264.9	299.5	334.4
		m ³ /min	4.42	4.99	5.57
		lit/sec	73.59	83.20	92.90
		in ³ /sec	4491	5077	5669
		ft ³ /min	155.9	176.3	196.9

Note :

☆ **Combustion Air Requirements Calculating Formula**

$$Q_1 = Vh \cdot N \cdot C \cdot \eta \cdot k \cdot 10^{-3}$$

Q₁ : Amount of intake air (m³/min)

Vh : Total displacement (lit)

N : Engine speed (min⁻¹(rpm))

C : Coefficient = 0.5

η : Intake efficiency

Natural aspirated engine : 0.87

Turbo charged engine : 0.80

k : Coefficient : 1.0

Natural aspirated engine : 1.0

Turbo charged engine : 1.5

(2) Cooling Air Requirements**{Refer to 25 °C (77 °F) and 750 mmHg}**

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Cooling Air Requirements	m ³ /hr	5671	6121	6388
		m ³ /min	94.5	102.0	106.5
		lit/sec	1575	1700	1775
		in ³ /sec	96126	103758	108290
		ft ³ /min	3338	3603	3760
V3600-T	Cooling Air Requirements	m ³ /hr	6670	7658	8010
		m ³ /min	111.2	127.6	133.5
		lit/sec	1853	2127	2225
		in ³ /sec	113061	129818	135769
		ft ³ /min	3926	4508	4715
V3800 DI-T	Cooling Air Requirements	m ³ /hr	5418	7407	8163
		m ³ /min	90.3	123.4	136.0
		lit/sec	1505	2057	2267
		in ³ /sec	91832	125553	138367
		ft ³ /min	3189	4360	4805

Note :**Above data is decided by following conditions.****(a) Using the standard radiator recommended in SOS.****(b) Engine is run as open unit.**

(3) Combustion and Cooling Air Requirements**{Refer to 25 °C (77 °F) and 750 mmHg}**

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Combustion and Cooling Air Requirements	m ³ /hr	5879	6348	6634
		m ³ /min	98.0	105.8	110.6
		lit/sec	1633	1763	1843
		in ³ /sec	99649	107602	112454
		ft ³ /min	3460	3736	3905
V3600-T	Combustion and Cooling Air Requirements	m ³ /hr	6952	7967	8345
		m ³ /min	115.9	132.8	139.1
		lit/sec	1931	2213	2318
		in ³ /sec	117839	135046	141449
		ft ³ /min	4092	4689	4912
V3800 DI-T	Combustion and Cooling Air Requirements	m ³ /hr	5682	7706	8497
		m ³ /min	94.7	128.4	141.6
		lit/sec	1578	2141	2360
		in ³ /sec	96323	130630	144037
		ft ³ /min	3345	4536	5002

Note :**1. Cooling Air Fan and Pulley Specifications**

Model		V3600	V3600-T	V3800DI-T
Item				
Fan Diameter	mm	φ 430		
	in.	φ 16.9		
No. of Blade and type of shape		7,F type		8,F type
Diameter of Fan Driving Pulley	mm	φ 143		
	in.	φ 5.6		
Diameter of Fan Pulley	mm	φ 157		φ 154
	in.	φ 6.2		φ 6.1

2. Conversion Rates☆ 1 lit = 61.0237 in³ = 0.035315 ft³☆ 1 ft³ = 28.3168 lit☆ 1 lit/sec = 3.6 m³/hr = 2.1189 ft³/min

5. EXHAUST GAS VOLUME

{Refer to 25 °C (77 °F) and 750 mmHg}

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Combustion Air Requirements	m ³ /min	3.46	3.78	4.09
	Brake Horse Power	kW	43.8	45.3	45.7
	Fuel Consumption	lit/hr	14.56	15.74	16.42
		g/hr	12230	13219	13795
	Exhaust Gas Volume	m ³ /hr	528.5	576.3	623.4
		m ³ /min	8.81	9.61	10.39
		lit/sec	146.8	160.1	173.2
		in ³ /sec	8959	9769	10568
		ft ³ /min	311.1	339.2	366.9
V3600-T	Combustion Air Requirements	m ³ /min	4.70	5.14	5.59
	Brake Horse Power	kW	54.2	58.7	58.7
	Fuel Consumption	lit/hr	17.13	19.51	20.40
		g/hr	14389	16385	17136
	Exhaust Gas Volume	m ³ /hr	738.8	809.7	878.5
		m ³ /min	12.31	13.49	14.64
		lit/sec	205.2	224.9	244.0
		in ³ /sec	12524	13725	14891
		ft ³ /min	434.9	476.6	517.0
V3800 DI-T	Combustion Air Requirements	m ³ /min	4.42	4.99	5.57
	Brake Horse Power	kW	59.8	66.4	71.4
	Fuel Consumption	lit/hr	16.50	18.87	20.79
		g/hr	13860	15847	17464
	Exhaust Gas Volume	m ³ /hr	582.1	738.7	850.4
		m ³ /min	9.70	12.31	14.17
		lit/sec	161.7	205.2	236.2
		in ³ /sec	9867	12522	14415
		ft ³ /min	342.6	434.8	500.5

Note :

☆ Exhaust Gas Volume Calculating Formula

$GL = (AL + 7.1 \times Be/10000) \times (298 + t) \times 760 / 298 / (760 + Ps) \text{ (m}^3/\text{hr)}$

AL: Combustion Air Requirements (m³/hr)

Be: Fuel Consumption (g/hr)

t : Exhaust Gas Temperature (°C)

Ps : Exhaust Gas Pressure (mmHg)

[Conversion Rates]

☆ 1 lit = 61.0237 in³ = 0.035315 ft³

☆ 1 ft³ = 28.3168 lit

☆ 1 lit/sec = 3.6 m³/hr = 127.133 ft³/hr

6. HEAT REJECTION TO COOLANT

a) ISO 3046 (Value at Overload)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Brake Horse Power	kW	43.8	45.3	45.7
	Specific Fuel Consumption	kg/kW•h	0.279	0.292	0.302
	Heat Rejection To Coolant	kJ/h	167231	180510	188395
		kcal/h	40300	43500	45400
V3600-T	Brake Horse Power	kW	54.2	58.7	58.7
	Specific Fuel Consumption	kg/kW•h	0.265	0.279	0.292
	Heat Rejection To Coolant	kJ/h	196694	225846	236199
		kcal/h	47400	53900	56400
V3800 DI-T	Brake Horse Power	kW	59.8	66.4	71.4
	Specific Fuel Consumption	kg/kW•h	0.232	0.239	0.245
	Heat Rejection To Coolant	kJ/h	159762	218426	240720
		kcal/h	38500	44000	48500

b) SAE J1349 (Value at Net Intermittent)

Model	Engine Speed	min ⁻¹ (rpm)	2200	2400	2600
V3600	Brake Horse Power	kW	43.8	45.3	45.7
	Specific Fuel Consumption	kg/kW•h	0.279	0.292	0.302
	Heat Rejection To Coolant	kJ/h	167231	180510	188395
		Btu/h	158514	171100	178574
V3600-T	Brake Horse Power	kW	54.2	58.7	58.7
	Specific Fuel Consumption	kg/kW•h	0.265	0.279	0.292
	Heat Rejection To Coolant	kJ/h	196694	225846	236199
		Btu/h	186440	214073	223886
V3800 DI-T	Brake Horse Power	kW	59.8	66.4	71.4
	Specific Fuel Consumption	kg/kW•h	0.232	0.239	0.245
	Heat Rejection To Coolant	kJ/h	159762	218426	240720
		Btu/h	151434	207040	228171

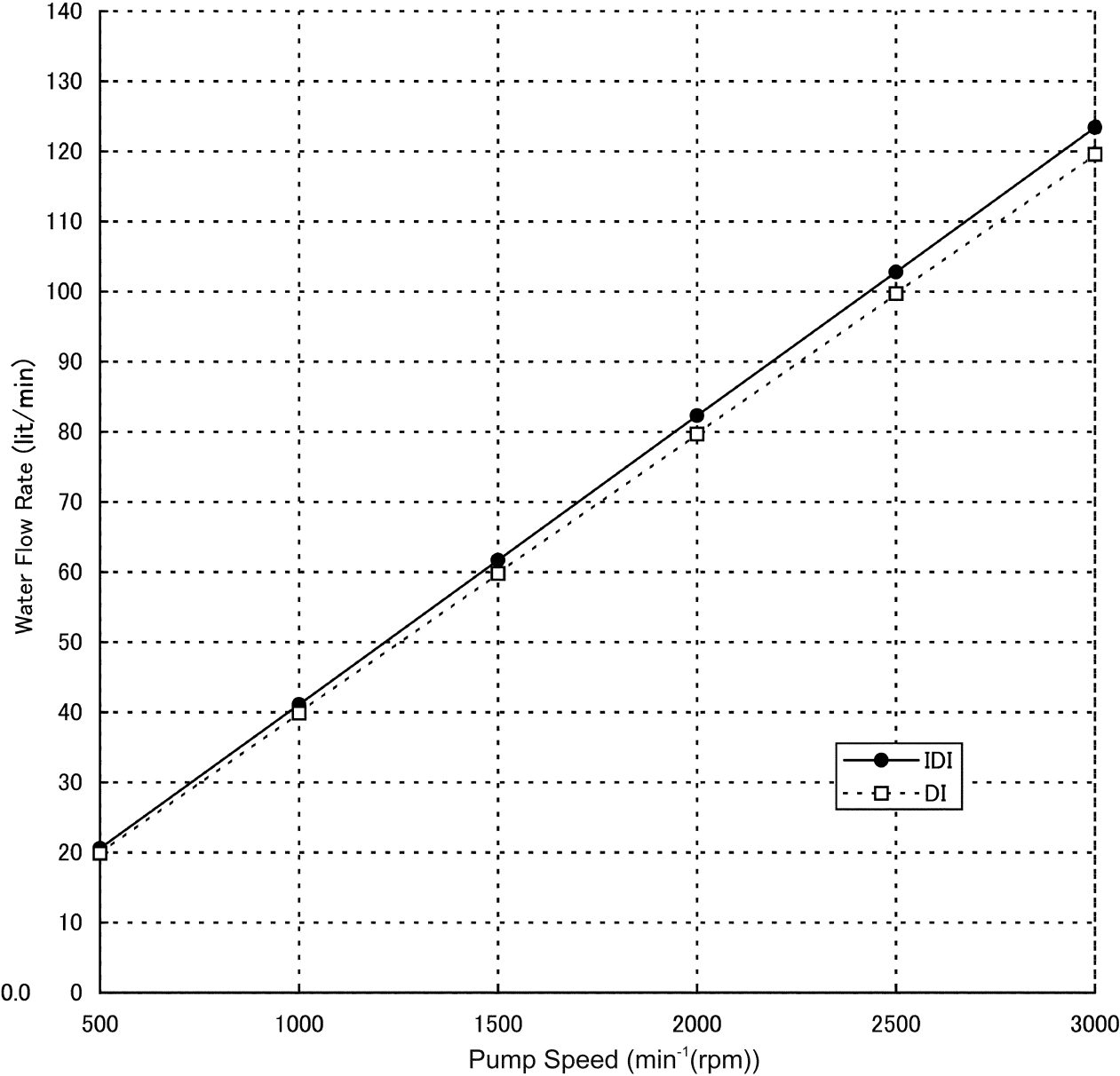
Note :☆ **Heat Rejection to Coolant Calculating Formula**

$$H_o = H_u \times N_e \times b_e \times i$$

H_o : Heat rejection to coolant
H_u : Diesel fuel low caloric value
 (42700 kJ/kg, 10290 kcal/kg
 or 18520 Btu/lb)
N_e : Brake horse power (kW)
b_e : Specific fuel consumption (g/kW•hr)
i : Dispersion ratio to coolant (%)

7. WATER FLOW RATE

Water Pump	1K011-7303△
Fan Pulley Dia.	154 mm (6.06 in.)
Fan Drive Pulley Dia.	143 mm (5.63 in.)
Thermostat	1C011-7301△



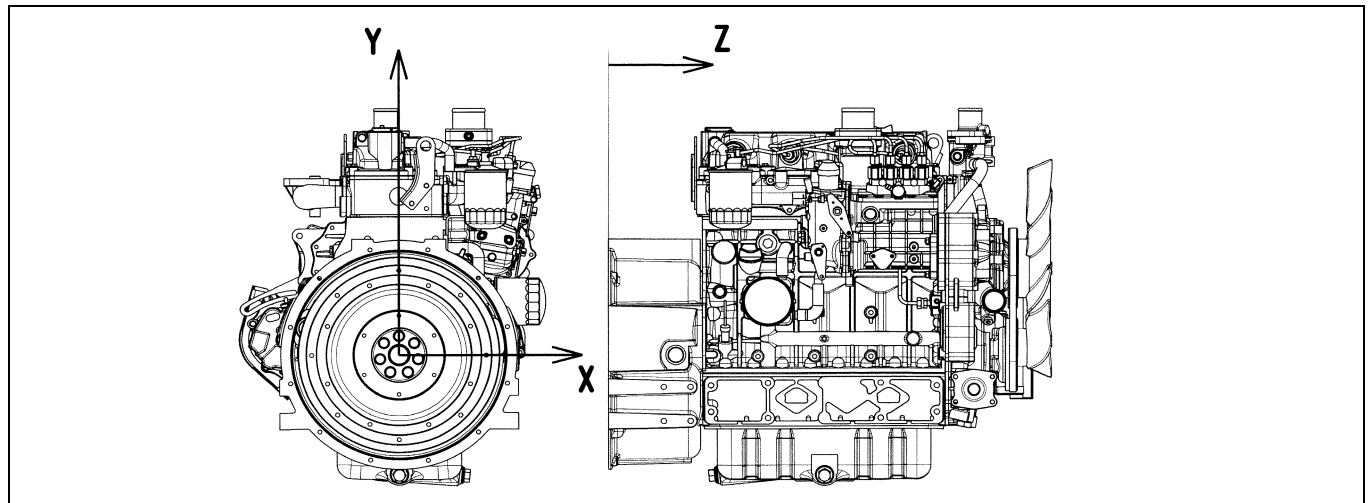
8. CENTER OF GRAVITY

1. With Short SAE Flywheel and Flywheel Housing (#4) EU spec

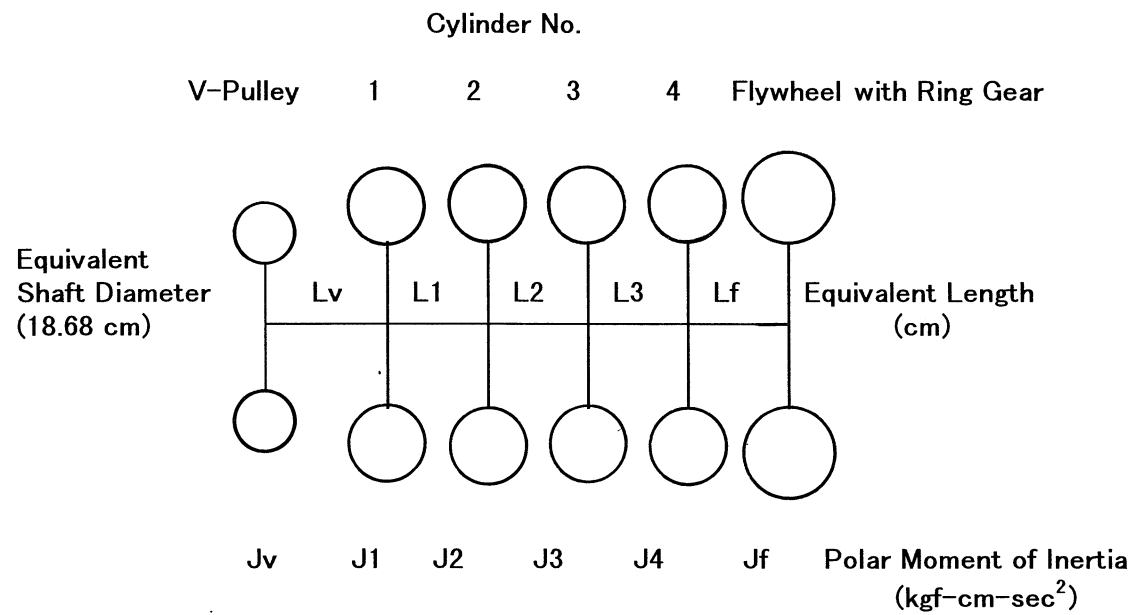
Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
V3600	252.0 (555.6)	4.0 (0.16)	107.0 (4.21)	315.0 (12.40)
V3600-T	261.0 (575.4)	1.0 (0.04)	110.0 (4.33)	319.0 (12.56)
V3800-DI-T	267.0 (588.6)	1.0 (0.04)	109.0 (4.29)	320.0 (12.60)

2. With Normal SAE Flywheel and Flywheel Housing (#3) KEA spec

Model	Dry Weight kg (lb)	Center of Gravity		
		X mm (in.)	Y mm (in.)	Z mm (in.)
V3600	297.0 (654.8)	4.0 (0.16)	100.0 (3.94)	354.0 (13.94)
V3600-T	306.0 (674.6)	1.0 (0.04)	103.0 (4.06)	358.0 (14.09)
V3800-DI-T	312.0 (687.8)	1.0 (0.04)	102.0 (4.02)	359.0 (14.13)



9. MASS ELASTIC SYSTEMS



Model	Equivalent Length (cm)					Polar Moment of Inertia (kgf-cm-sec ²)					
	Lv	L1	L2	L3	Lf	Jv	J1	J2	J3	J4	Jf
V3600	5772	1213	1213	1213	713	0.028	0.183	0.183	0.183	0.183	10.88
V3600-T	5772	1213	1213	1213	713	0.028	0.183	0.183	0.183	0.183	10.88
V3800-DI-T	5772	1213	1213	1213	713	0.028	0.183	0.183	0.183	0.183	10.88

Note :

Model	Flywheel Comp	Fan Drive Pulley
V3600	1G521-2501△	1K011-7428△
V3600-T	↑	↑
V3800-DI-T	1G539-2501△	1K011-7428△

10. UNBALANCED FORCES

1. Base Data

F_z = Unbalanced inertia force

$$= 4m_p * r * \omega^2 * (r/l) \cos 2\theta \text{ (kgf)}$$

N_{py} , No_z = Unbalanced inertia couple (kgf-m)

m_p = Reciprocating mass = W_p/G (kg)

W_p = Reciprocating weight (kgf)

G = Gravitational Acceleration = $9.80665 \text{ (m/sec}^2\text{)}$

r = Crank radius (m)

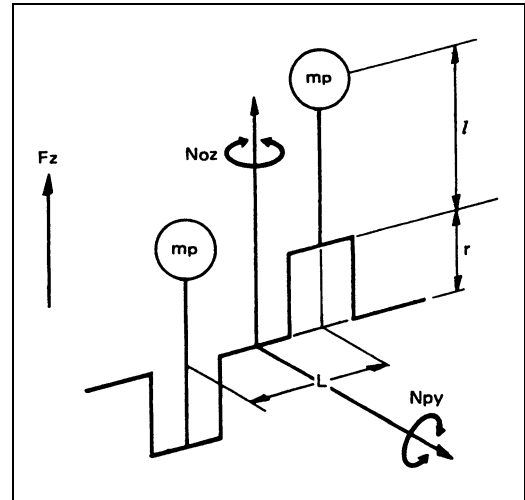
l = Center distance of connecting rod (m)

L = Cylinder distance (m)

ω = Angular velocity

$$= 2\pi n/60 \text{ (rad/sec)}$$

n = Engine speed (min^{-1} (rpm))



Model	l (m)	r (m)	L (m)	Wp (kgf)	Bore (mm)	Stroke (mm)
V3600	0.170	0.055	0.108	1.45	98.0	120.0
V3600-T	0.170	0.055	0.108	1.45	98.0	120.0
V3800-DI-T	0.170	0.055	0.108	1.41	100.0	120.0

2. Unbalanced inertia force and couple

($\times \omega^2$)

Model	No. of Cylinder	Cylinder Bore (mm)	Order	F_z	N_{py}	No_z
V3600	4	98.0	1	0	0	0
			2	0.0105	0	0
V3600-T	4	98.0	1	0	0	0
			2	0.0105	0	0
V3800-DI-T	4	100.0	1	0	0	0
			2	0.0102	0	0

3. An example of calculation

Calculation Condition	ω^2	F_z, N_{py}, No_z		
			Order	Calculation
Engine model : V3600 Engine speed : 2600 min^{-1} (rpm)	$(2 \times \pi \times 2600/60)^2 = 74132$	F_z (kgf)	1	0
			2	$0.0105 \times 74132 = 778$
		N_{py} (kgf-m)	1	0
			2	0
		No_z (kgf-m)	1	0
			2	0

11. TECHNICAL INFORMATION OF ENGINE FOR GENERATOR

1. Brake Horse Power

Model	Engine Speed [r/min]		1500		1800	
			kW	HP/PS	kW	HP/PS
V3300-BG	ISO 3046 [kW,PS]	Stand-by	27.5	37.4	33.6	45.7
		Continuous	25.0	34.0	30.6	41.6
	SAE J1349 [kW,HP]	Stand-by	27.5	36.9	33.6	45.1
		Continuous	25.0	33.5	30.6	41.0
V3600-T-BG	ISO 3046 [kW,PS]	Stand-by	35.3	48.0	43.1	58.6
		Continuous	32.1	43.6	39.2	53.3
	SAE J1349 [kW,HP]	Stand-by	35.3	47.3	43.1	57.8
		Continuous	32.1	43.0	39.2	52.6
V3800DI-T-BG	ISO 3046 [kW,PS]	Stand-by	—	—	52.8	71.8
		Continuous	—	—	48.0	65.3
	SAE J1349 [kW,HP]	Stand-by	—	—	52.8	70.8
		Continuous	—	—	48.0	64.4

2. Noise Level [at 1m (3.3 ft) dB (A)]

Model	Engine Speed [r/min]	1500	1800
V3300-BG	4/4 Load (Continuous)	85.1	87.7
	No Load	84.2	86.9
	Stand-by	85.3	87.9
V3600-T-BG	4/4 Load (Continuous)	90.8	92.5
	No Load	86.8	89.7
	Stand-by	91.0	92.7
V3800DI-T-BG	4/4 Load (Continuous)	—	90.7
	No Load	—	88.3
	Stand-by	—	90.9

3. Heat Rejection Coolant

ISO 3046 (Value Output for Stand-by)

Model	Engine Speed	r/min	1500	1800
V3300-BG	Brake Horse Power	kW	27.5	33.6
	Specific Fuel Consumption	kg/kWhr	0.243	0.244
	Heat Rejection To Coolant	kJ/hr	91310	112000
		kcal/hr	22004	27000
V3600-T-BG	Brake Horse Power	kW	35.3	43.1
	Specific Fuel Consumption	kg/kWhr	0.243	0.246
	Heat Rejection To Coolant	kJ/hr	117208	144900
		kcal/hr	28245	34900
V3800DI-T-BG	Brake Horse Power	kW	—	52.8
	Specific Fuel Consumption	kg/kWhr	—	0.230
	Heat Rejection To Coolant	kJ/hr	—	141500
		kcal/hr	—	33800

SAE J1349 (Value Output for Stand-by)

Model	Engine Speed	r/min	1500	1800
V3300-BG	Brake Horse Power	HP	36.9	45.1
	Specific Fuel Consumption	lb/HPhr	0.399	0.401
	Heat Rejection To Coolant	kJ/hr	91310	112000
		Btu/hr	87310	107100
V3600-T-BG	Brake Horse Power	HP	47.3	57.8
	Specific Fuel Consumption	lb/HPhr	0.399	0.404
	Heat Rejection To Coolant	kJ/hr	117208	144900
		Btu/hr	112074	138500
V3800DI-T-BG	Brake Horse Power	HP	—	70.8
	Specific Fuel Consumption	lb/HPhr	—	0.378
	Heat Rejection To Coolant	kJ/hr	—	141500
		Btu/hr	—	134100