YANMAR

PROJECT GUIDE

MARINE AUXILIARY DIESEL ENGINE

MODEL 6EY18 Series

6EY18LW
6EY18ALW

Project Guide	6EY18LW, 6EY18ALW Marine Auxiliary Diesel Engine	Code No.	0GEY1-G00300

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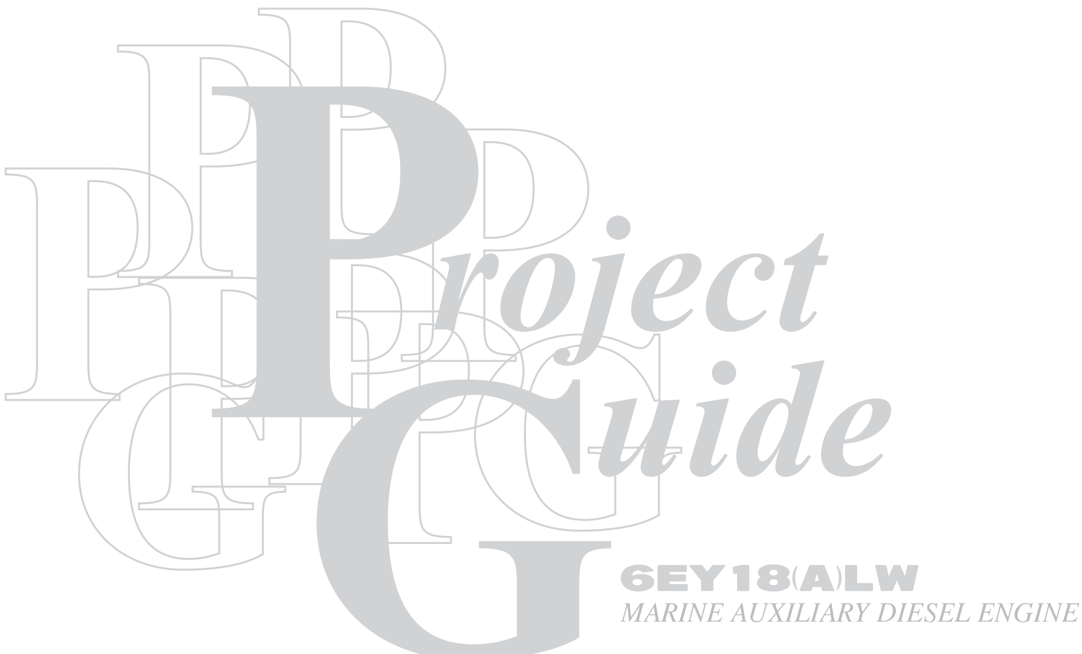
00 Introduction



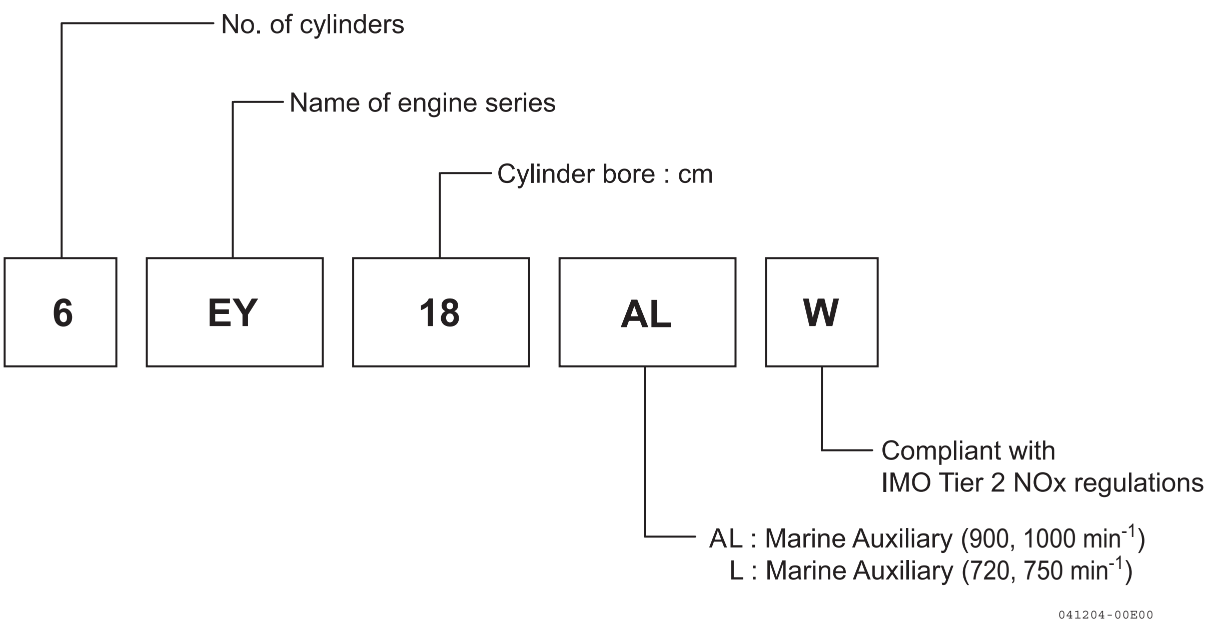
Project Guide

- This project guide was prepared as reference when planning the implementation of a Yanmar marine auxiliary diesel engine. Accordingly, no details of engine accessories are included; they are decided separately based on the subsequent consultations.
- The power of this engine is assured under the following atmospheric and standard operational conditions:

		Standard condition	Service condition
Ambient temperature	°C	25	0-45
Atmospheric pressure	kPa (mmHg)	100 (750)	–
Relative humidity	%	30	85 or below
Air cooler inlet water temp.	°C	25	38 or below

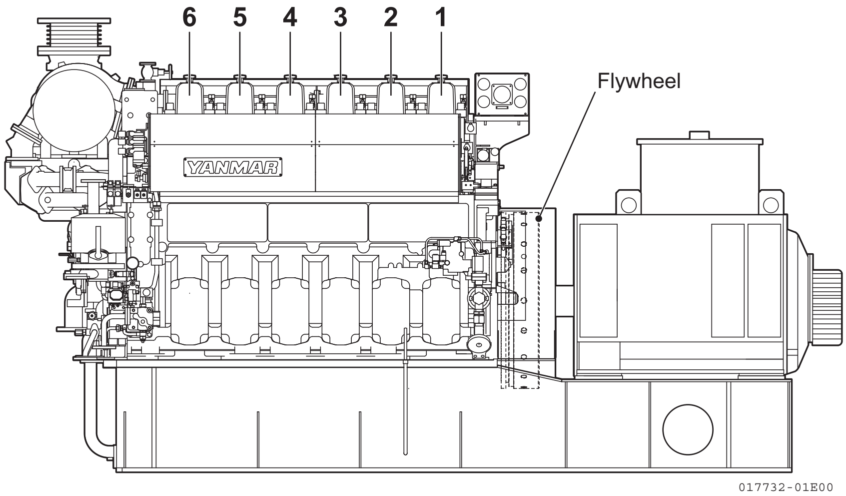
- The unit system used in this Project Guide is based on the international unit system (SI).
- Due to improvements to the product and other reasons, the descriptions in this Project Guide are subject to change without prior notice.
  Please check the specifications, performance, etc. of the product by the delivery specifications, drawings of finished product, operation manual and individual consultations.

Engine Model Name



Cylinder Layout and Operation Side

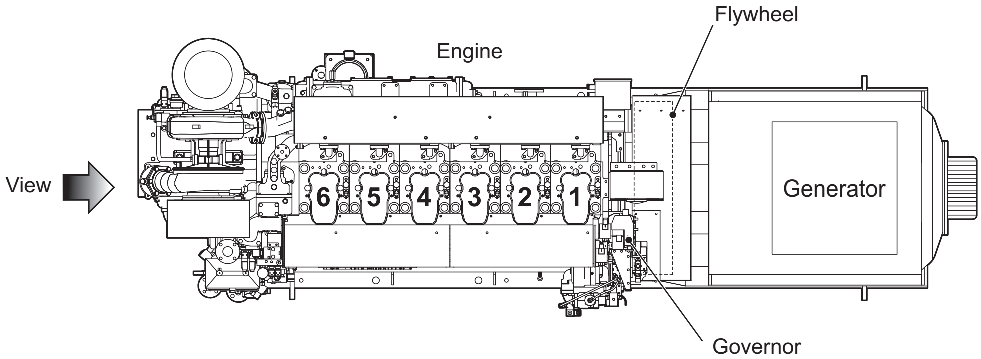
Cylinder Numbers: No.1,2,...counted from the flywheel side (main PTO side)



(Operation side)

Operation side: right side viewed from the opposite side of the flywheel

Non-operation side (Exhaust manifold side)

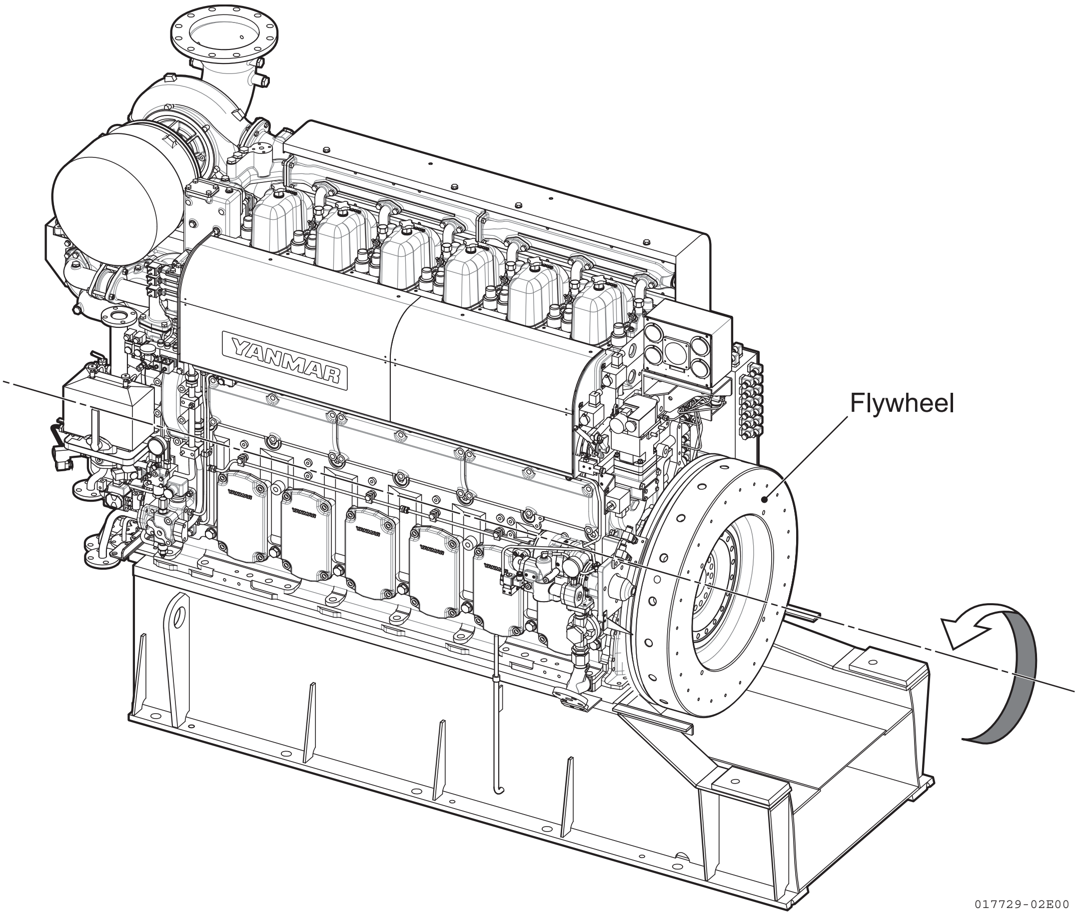


Operation side (Fuel injection pump case side)

(Viewed from top)

Direction of Rotation

Direction of Rotation: Counterclockwise viewed from flywheel side (Left Rotation).



Unit Conversion Table

Conversion values between the international unit system (SI) and the metric unit system are shown below:

Force

N	kgf
1	0.101972
9.80665	1

Conversion Examples
1 N = 0.101972 kgf
1 kgf = 9.80665 N

Moment of Force, Torque

N・m	kgf・m
1	0.101972
9.80665	1

Pressure

Pa	kgf/cm^2	mAq	mmHg
1	1.0197×10^{-5}	1.0197×10^{-4}	7.501×10^{-3}
9.80665×10^{4}	1	1.0000×10	7.356×10^{2}
9.80665×10^{3}	1.0000×10^{-1}	1	7.356×10
1.3332×10^{2}	1.3595×10^{-3}	1.3595×10^{-2}	1

Work, Energy

kW・h	J	kcal	kgf・m
1	3.600×10^{6}	8.600×10^{2}	3.671×10^{5}
2.778×10^{-7}	1	2.389×10^{-4}	1.0197×10^{-1}
1.163×10^{-3}	4.186×10^{3}	1	4.269×10^{2}
2.724×10^{-6}	9.80665	2.343×10^{-3}	1

Work Efficiency, Power

kW	PS
1	1.3596
0.7355	1

Piping Symbols

This Project Guide uses the following piping symbols.

Piping Diagram Codes

Equipment		Valves		Piping Parts	
	Pump		Globe valve		Flange fitting
	Plunger pump		Needle valve		Shut-off valve
	Hand pump		Angle valve		Spectacle flange
M	Motor		Butterfly valve		Joint
	Strainer		Sluice valve		Boss
	Centrifugal strainer		Screwed check valve		Orifice
AUTO	Automatic backwash strainer		Swing check valve		Expansion joint
	Porous plate strainer cylinder		Piston valve		Flexible pipe coupling
Meter & Sensors			Three-way piston valve		Seal pot
T	Thermometer		Cock		Loop seal
P	Pressure gauge		Three-way cock		Reducer
PD	Differential pressure gauge		Automatic pressure regulating valve		Air vent pipe
P	Oil signal		Automatic temp. regulating valve		Safety plate
	Grazed level gauge		Relief valve		Accumulator
PS	Pressure switch	S	Solenoid valve		Capillary tube
TS	Temperature switch		Pressure reducing valve	CUT	Copper pipe
FS	Float switch		Duplex check valve	STPG	Carbon steel pipe for pressure tube
DPS	Differential pressure SW		Velocity regulating valve	STKM	Carbon steel pipe for high pressure tube
PT	Pressure transmitter		Flow volume regulating valve	STS	Machine structural carbon steel pipe
RB	Resistance bulb			O.D.	Pipe outside diameter
TC	Thermocouple			I.D.	Pipe inner diameter

Remark:

- The black valve (globe valve, angle valve and needle valve) shows the constantly closed valve.

: Opened constantly
: Closed constantly

- Piping parts marked with an asterisk (*) are not included.

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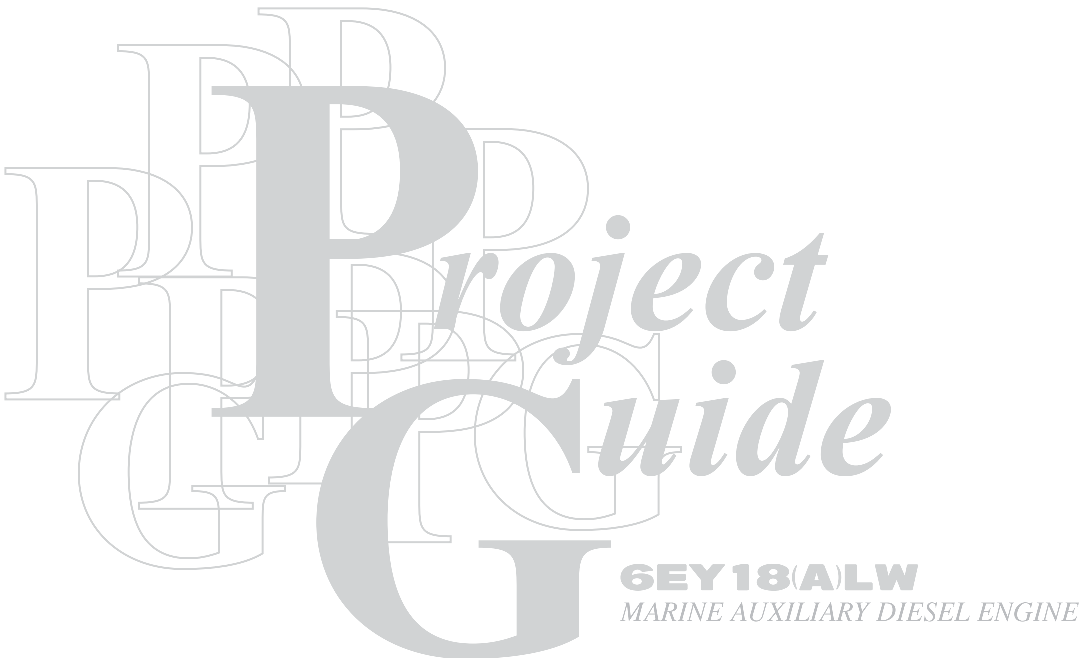
01 Outline



Major Specifications of Engine

1. Model 6EY18ALW (60 Hz, 900 min^{-1})

Model Name		6EY18ALW							
Type		Vertical water-cooled 4 cycle diesel engine							
No. of Cylinders		6							
Cylinder Bore×Stroke	mm	180×280							
Total Displacement	ℓ	42.75							
Continuous Rating	kW	800	745	680	660	615	550	500	455
Rated Speed	min^{-1}	900							
Brake Mean Effective Pressure	MPa	2.495	2.323	2.121	2.057	1.918	1.716	1.560	1.420
Mean Piston Velocity	m/s	8.40							
Power of Generating Equip. *	kWe	750	680	620	600	560	500	450	400
	kVA	937.5	850	775	750	700	625	562.5	500
Overload Rating		10% Overload: within 60 min (every 12 hours)							
Crankshaft Revolving Direction		Counterclockwise (viewed from the flywheel side)							
Firing Order		1-4-2-6-3-5-1							
Operation Side		Right side (viewed from the opposite side of the flywheel)							
Combustion System		Direct injection							
Lubrication System		Common bed incorporated sump							
Cooling System		Freshwater and freshwater mixing dual cooling system							
Turbocharging System		Exhaust gas turbine turbocharging with air cooler							
Starting System		Air starter							
Turning System		Turning bar							
Lubricating Oil		SAE30 or 40							
Specific Fuel Consumption	g/kW•h	190+5%	189+5%	188+5%	190+5%	188+5%	188+5%	189+5%	191+5%
Specific Lubricating Oil Consumption	g/kW•h	0.3-1.1							
Engine Dry Weight	kg	6600							
The specific fuel consumption shows the lower calorific value, 42.7 MJ/kg (10,200 kcal/kg), ISO3046/1, of a bare engine unit operated at 4/4 load and at rated speed and under the condition of complying with NOx emission regulation value (the tier 2 regulation) as required by IMO. When the engine-mounted lubricating oil pump is driven, 3 g/kW•h is added to the consumption and when the cooling water pump is driven, 1 g/kW•h is added to the consumption per one pump.									

* The above generator capacity varies depending on actual generator efficiency.

2. Model 6EY18LW (60 Hz, 720 min^{-1})

Model Name		6EY18LW				
Type		Vertical water-cooled 4 cycle diesel engine				
No. of Cylinders		6				
Cylinder Bore×Stroke	mm	180×280				
Total Displacement	ℓ	42.75				
Continuous Rating	kW	615	550	500	450	400
Rated Speed	min^{-1}	720				
Brake Mean Effective Pressure	MPa	2.397	2.144	1.949	1.754	1.560
Mean Piston Velocity	m/s	6.72				
Power of Generating Equip. *	kWe	560	500	450	400	360
	kVA	700	625	562.5	500	450
Overload Rating		10% Overload: within 60 min (every 12 hours)				
Crankshaft Revolving Direction		Counterclockwise (viewed from the flywheel side)				
Firing Order		1-4-2-6-3-5-1				
Operation Side		Right side (viewed from the opposite side of the flywheel)				
Combustion System		Direct injection				
Lubrication System		Common bed incorporated sump				
Cooling System		Freshwater and freshwater mixing dual cooling system				
Turbocharging System		Exhaust gas turbine turbocharging with air cooler				
Starting System		Air starter				
Turning System		Turning bar				
Lubricating Oil		SAE30 or 40				
Specific Fuel Consumption	g/kW•h	191+5%	190+5%	189+5%	189+5%	190+5%
Specific Lubricating Oil Consumption	g/kW•h	0.3-1.1				
Engine Dry Weight	kg	6600				
The specific fuel consumption shows the lower calorific value, 42.7 MJ/kg (10,200 kcal/kg), ISO3046/1, of a bare engine unit operated at 4/4 load and at rated speed and under the condition of complying with NOx emission regulation value (the tier 2 regulation) as required by IMO. When the engine-mounted lubricating oil pump is driven, 3 g/kW•h is added to the consumption and when the cooling water pump is driven, 1 g/kW•h is added to the consumption per one pump.						

* The above generator capacity varies depending on actual generator efficiency.

3. Model 6EY18ALW (50 Hz, 1000 min^{-1})

Model Name		6EY18ALW							
Type		Vertical water-cooled 4 cycle diesel engine							
No. of Cylinders		6							
Cylinder Bore×Stroke	mm	180×280							
Total Displacement	ℓ	42.75							
Continuous Rating	kW	800	745	680	660	615	550	500	455
Rated Speed	min^{-1}	1000							
Brake Mean Effective Pressure	MPa	2.246	2.091	1.909	1.851	1.726	1.544	1.403	1.277
Mean Piston Velocity	m/s	9.33							
Power of Generating Equip. *	kWe	750	680	620	600	560	500	450	400
	kVA	937.5	850	775	750	700	625	562.5	500
Overload Rating		10% Overload: within 60 min (every 12 hours)							
Crankshaft Revolving Direction		Counterclockwise (viewed from the flywheel side)							
Firing Order		1-4-2-6-3-5-1							
Operation Side		Right side (viewed from the opposite side of the flywheel)							
Combustion System		Direct injection							
Lubrication System		Common bed incorporated sump							
Cooling System		Freshwater and freshwater mixing dual cooling system							
Turbocharging System		Exhaust gas turbine turbocharging with air cooler							
Starting System		Air starter							
Turning System		Turning bar							
Lubricating Oil		SAE30 or 40							
Specific Fuel Consumption	g/kW•h	196+5%	195+5%	194+5%	193+5%	193+5%	197+5%	198+5%	198+5%
Specific Lubricating Oil Consumption	g/kW•h	0.3-1.1							
Engine Dry Weight	kg	6600							
The specific fuel consumption shows the lower calorific value, 42.7 MJ/kg (10,200 kcal/kg), ISO3046/1, of a bare engine unit operated at 4/4 load and at rated speed and under the condition of complying with NOx emission regulation value (the tier 2 regulation) as required by IMO. When the engine-mounted lubricating oil pump is driven, 3 g/kW•h is added to the consumption and when the cooling water pump is driven, 1 g/kW•h is added to the consumption per one pump.									

* The above generator capacity varies depending on actual generator efficiency.

4. Model 6EY18LW (50 Hz, 750 min^{-1})

Model Name		6EY18LW				
Type		Vertical water-cooled 4 cycle diesel engine				
No. of Cylinders		6				
Cylinder Bore×Stroke	mm	180×280				
Total Displacement	ℓ	42.75				
Continuous Rating	kW	615	550	500	450	400
Rated Speed	min^{-1}	750				
Brake Mean Effective Pressure	MPa	2.302	2.058	1.871	1.684	1.497
Mean Piston Velocity	m/s	7.00				
Power of Generating Equip. *	kWe	560	500	450	400	360
	kVA	700	625	562.5	500	450
Overload Rating		10% Overload: within 60 min (every 12 hours)				
Crankshaft Revolving Direction		Counterclockwise (viewed from the flywheel side)				
Firing Order		1-4-2-6-3-5-1				
Operation Side		Right side (viewed from the opposite side of the flywheel)				
Combustion System		Direct injection				
Lubrication System		Common bed incorporated sump				
Cooling System		Freshwater and freshwater mixing dual cooling system				
Turbocharging System		Exhaust gas turbine turbocharging with air cooler				
Starting System		Air starter				
Turning System		Turning bar				
Lubricating Oil		SAE30 or 40				
Specific Fuel Consumption	g/kW•h	192+5%	192+5%	191+5%	192+5%	194+5%
Specific Lubricating Oil Consumption	g/kW•h	0.3-1.1				
Engine Dry Weight	kg	6600				

The specific fuel consumption shows the lower calorific value, 42.7 MJ/kg (10,200 kcal/kg), ISO3046/1, of a bare engine unit operated at 4/4 load and at rated speed and under the condition of complying with NOx emission regulation value (the tier 2 regulation) as required by IMO. When the engine-mounted lubricating oil pump is driven, 3 g/kW•h is added to the consumption and when the cooling water pump is driven, 1 g/kW•h is added to the consumption per one pump.

* The above generator capacity varies depending on actual generator efficiency.

1. Model 6EY18ALW (900 min^{-1})

Pumps

Cooling Water Pump (High temp)	Centrifugal	27 m^3/h	20 m	Eng. mount
Cooling Water Pump (Low temp)	Centrifugal	27 m^3/h	20 m	Eng. mount
Fuel Feed Pump for M.D.O.	Gear type	0.623 m^3/h	Refer to 50-02	Eng. mount
Fuel Supply Pump for H.F.O.	Gear type	-	Refer to 50-02	Hull mount
Lubricating Oil Pump	Gear type	21.4 m^3/h	0.80 MPa	Eng. mount
Lubricating Oil Priming Pump	Gear type	4 m^3/h	0.15 MPa	Eng. mount

Strainers

Fuel Strainer (Eng. Inlet)	Duplex change over, notch wire	E.F. 35 μm	Eng. mount
Fuel Strainer (For H.F.O. Circulate)	Duplex change over, automatic backwashing	E.F. 10 μm	Hull mount
Fuel Strainer (For FCC)	(Recommend) Fine Strainer	E.F. 5 μm	Hull mount
Lubricating Oil Primary Strainer — Common Bed Incorporated Sump	Perforated Steel Plate	-	Assembled in common bed
Secondary Lubricating Oil Strainer	Automatic backwashing	35 μm (E.F. 30 μm)	Eng. mount

Coolers

Lubricating Oil Cooler	Multi-tubular with fins	8.7 m^2	Eng. mount
Air Cooler	Multi-tubular with plate fins	24.6 m^2	Eng. mount

Temperature Regulating Valves

Freshwater Regulating Valve for High Temperature	Direct-action, wax-pellet, regulating at outlet	• Engine power: 745/800 kW Load 65% or above: 60°C±4°C Load less than 65%: 85°C±4°C • Engine power: 660/680 kW Load 75% or above: 60°C±4°C Load less than 75%: 85°C±4°C • 445-615 kW 85°C±4°C	Eng. mount
Lubricating Oil Temp. Regulating Valve	Direct-action, wax-pellet	50-65 ℃	Eng. mount

Tanks

Lubricating Oil Tank Capacity	See 30-01-00
Engine Freshwater Holding Capacity	145 ℓ
Starting Air Sump	150 ℓ× 1 Bottle, 2.94 MPa

Other Data

Continuous Rating Power		kW	800	745	680	660	615	550	500	455
Heat Radiation	Heat Radiation to L.O. (at 100% Load)	MJ/h	350.4	337.9	323.2	318.7	292.7	275.5	262.3	250.4
	Heat Radiation to Low Temp. C.W. (at 100% Load)	MJ/h	203.4	178.6	149.2	140.1	216.4	187.6	167.5	150.9
	Heat Radiation to High Temp. C.W. (at 100% Load)	MJ/h	785.3	714.4	630.6	604.8	567.0	461.2	384.0	319.1
	Heat Radiation to Air (at 100% Load)	MJ/h	797.0	742.2	677.5	657.5	532.3	492.2	461.3	433.5
Combustion Air Volume at 100% Load [25°C]		m^3/h	4510	4320	4080	4060	3760	3600	3370	3100
Exh. Gas Volume at 100% Load [0°C]		m^3/h	4060	3880	3730	3720	3480	3320	3090	2860
Eng. Room Ventilation Air Volume			0.27-0.41 m^3/min・kW							
T/C Outlet Exh. Gas Temp. (at 100% Load, Ambient Temp. 25°C)		°C	370	360	350	350	350	340	335	330
Exh. Back Pressure at 100% Load			3.43 kPa or below							
Exhaust Pipe Diameter			250 A or 300 A							

2. Model 6EY18LW (720 min^{-1})

Pumps

Cooling Water Pump (High temp)	Centrifugal	21 m^3/h	16 m	Eng. mount
Cooling Water Pump (Low temp)	Centrifugal	21 m^3/h	16 m	Eng. mount
Fuel Feed Pump for M.D.O.	Gear type	0.499 m^3/h	Refer to 50-02	Eng. mount
Fuel Supply Pump for H.F.O.	Gear type	-	Refer to 50-02	Hull mount
Lubricating Oil Pump	Gear type	27.3 m^3/h	0.80 MPa	Eng. mount
Lubricating Oil Priming Pump	Gear type	4 m^3/h	0.15 MPa	Eng. mount

Strainers

Fuel Strainer (Eng. Inlet)		Duplex change over, notch wire	E.F. 35 μm	Eng. mount
Fuel Strainer (For H.F.O. Circulate)		Duplex change over, automatic backwashing	E.F. 10 μm	Hull mount
Fuel Strainer (For FCC)		(Recommend) Fine Strainer	E.F. 5 μm	Hull mount
Lubricating Oil Primary Strainer	Common Bed Incorporated Sump	Perforated Steel Plate	-	Assembled in common bed
Secondary Lubricating Oil Strainer		Automatic backwashing	35 μm (E.F. 30 μm)	Eng. mount

Coolers

Lubricating Oil Cooler	Multi-tubular with fins	8.7 m^2	Eng. mount
Air Cooler	Multi-tubular with plate fins	24.6 m^2	Eng. mount

Temperature Regulating Valves

Freshwater Regulating Valve for High Temperature	Direct-action, wax-pellet, regulating at outlet	• 550-615 kW Load 75%±5% or above: 60°C±4°C Load less than 75%±5%: 85°C±4°C • 400-500 kW 85°C±4°C	Eng. mount
Lubricating Oil Temp. Regulating Valve	Direct-action, wax-pellet	50-65°C	Eng. mount

Tanks

Lubricating Oil Tank Capacity	See 30-01-00
Engine Freshwater Holding Capacity	145 ℓ
Starting Air Sump	150 ℓ × 1 Bottle, 2.94 MPa

Other Data

Continuous Rating Power		kW	615	550	500	450	400
Heat Radiation	Heat Radiation to L.O. (at 100% Load)	MJ/h	280.3	266.3	229.0	224.4	224.4
	Heat Radiation to Low Temp. C.W. (at 100% Load)	MJ/h	184.6	162.3	141.4	129.4	129.4
	Heat Radiation to High Temp. C.W. (at 100% Load)	MJ/h	571.4	492.7	359.4	306.2	306.2
	Heat Radiation to Air (at 100% Load)	MJ/h	676.9	622.7	495.0	454.1	454.1
Combustion Air Volume at 100% Load [25°C]		m^3/h	4060	3760	3600	3370	3100
Exh. Gas Volume at 100% Load [0°C]		m^3/h	3720	3480	3320	3090	2860
Eng. Room Ventilation Air Volume			0.27-0.41 m^3/min・kW				
T/C Outlet Exh. Gas Temp. (at 100% Load, Ambient Temp. 25°C)		°C	335	335	300	300	300
Exh. Back Pressure at 100% Load			3.43 kPa or below				
Exhaust Pipe Diameter			250 A or 300 A				

3. Model 6EY18ALW (1000 min-1)

Pumps

Cooling Water Pump (High temp)	Centrifugal	29 m^3/h	23 m	Eng. mount
Cooling Water Pump (Low temp)	Centrifugal	29 m^3/h	23 m	Eng. mount
Fuel Feed Pump for M.D.O.	Gear type	0.692 m^3/h	Refer to 50-02	Eng. mount
Fuel Supply Pump for H.F.O.	Gear type	-	Refer to 50-02	Hull mount
Lubricating Oil Pump	Gear type	23.8 m^3/h	0.80 MPa	Eng. mount
Lubricating Oil Priming Pump	Gear type	4 m^3/h	0.15 MPa	Eng. mount

Strainers

Fuel Strainer (Eng. Inlet)	Duplex change over, notch wire	E.F. 35 μm	Eng. mount
Fuel Strainer (For H.F.O. Circulate)	Duplex change over, automatic backwashing	E.F. 10 μm	Hull mount
Fuel Strainer (For FCC)	(Recommend) Fine Strainer	E.F. 5 μm	Hull mount
Lubricating Oil Primary Strainer: Common Bed Incorporated Sump	Perforated Steel Plate	-	Assembled in common bed
Secondary Lubricating Oil Strainer	Automatic backwashing	35 μm (E.F. 30 μm)	Eng. mount

Coolers

Lubricating Oil Cooler	Multi-tubular with fins	8.7 m^2	Eng. mount
Air Cooler	Multi-tubular with plate fins	24.6 m^2	Eng. mount

Temperature Regulating Valves

Freshwater Regulating Valve for High Temperature	Direct-action, wax-pellet, regulating at outlet	• Engine power: 745/800 kW Load 65% or above: 60°C±4°C Load less than 65%: 85°C±4°C • Engine power: 660/680 kW Load 75% or above: 60°C±4°C Load less than 75%: 85°C±4°C • 445-615 kW 85°C±4°C	Eng. mount
Lubricating Oil Temp. Regulating Valve	Direct-action, wax-pellet	50-65°C	Eng. mount

Tanks

Lubricating Oil Tank Capacity	See 30-01-00
Engine Freshwater Holding Capacity	145 ℓ
Starting Air Sump	150 ℓ × 1 Bottle, 2.94 MPa

Other Data

Continuous Rating Power		kW	800	745	680	660	615	550	500	455
Heat Radiation	Heat Radiation to L.O. (at 100% Load)	MJ/h	350.4	337.9	323.2	318.7	292.7	275.5	262.3	250.4
Heat Radiation	Heat Radiation to LowTemp. C.W. (at 100% Load)	MJ/h	203.4	178.6	149.2	140.1	216.4	187.6	167.5	150.9
Heat Radiation	Heat Radiation to High Temp. C.W. (at 100% Load)	MJ/h	785.3	714.4	630.6	604.8	567.0	461.2	384.0	319.1
Heat Radiation	Heat Radiation to Air (at 100% Load)	MJ/h	797.0	742.2	677.5	657.5	532.3	492.2	461.3	433.5
Combustion Air Volume at 100% Load [25°C]		m^3/h	4510	4320	4080	4060	3760	3600	3370	3100
Exh. Gas Volume at 100% Load [0°C]		m^3/h	4060	3880	3730	3720	3480	3320	3090	2860
Eng. Room Ventilation Air Volume			0.27-0.41 m^3/min・kW							
T/C Outlet Exh. Gas Temp. (at 100% Load, Ambient Temp. 25°C)		°C	370	360	350	350	350	340	335	330
Exh. Back Pressure at 100% Load			3.43 kPa or below							
Exhaust Pipe Diameter			250 A or 300 A							

4. Model 6EY18LW (750 min^{-1})

Pumps

Cooling Water Pump (High temp)	Centrifugal	22 m^3/h	17 m	Eng. mount
Cooling Water Pump (Low temp)	Centrifugal	22 m^3/h	17 m	Eng. mount
Fuel Feed Pump for M.D.O.	Gear type	0.520 m^3/h	Refer to 50-02	Eng. mount
Fuel Supply Pump for H.F.O.	Gear type	-	Refer to 50-02	Hull mount
Lubricating Oil Pump	Gear type	21.2 m^3/h	0.80 MPa	Eng. mount
Lubricating Oil Priming Pump	Gear type	4 m^3/h	0.15 MPa	Eng. mount

Strainers

Fuel Strainer (Eng. Inlet)		Duplex change over, notch wire	E.F. 35 μm	Eng. mount
Fuel Strainer (For H.F.O. Circulate)		Duplex change over, automatic backwashing	E.F. 10 μm	Hull mount
Fuel Strainer (For FCC)		(Recommend) Fine Strainer	E.F. 5 μm	Hull mount
Lubricating Oil Primary Strainer	Common Bed Incorporated Sump	Perforated Steel Plate	-	Assembled in common bed
Secondary Lubricating Oil Strainer		Automatic backwashing	35 μm (E.F. 30 μm)	Eng. mount

Coolers

Lubricating Oil Cooler	Multi-tubular with fins	8.7 m^2	Eng. mount
Air Cooler	Multi-tubular with plate fins	24.6 m^2	Eng. mount

Temperature Regulating Valves

Freshwater Regulating Valve for High Temperature	Direct-action, wax-pellet, regulating at outlet	• 550-615 kW Load 75% ±5%or above: 60°C±4°C Load less than 75%±5%: 85°C±4°C • 400-500 kW 85°C±4°C	Eng. mount
Lubricating Oil Temp. Regulating Valve	Direct-action, wax-pellet	50-65°C	Eng. mount

Tanks

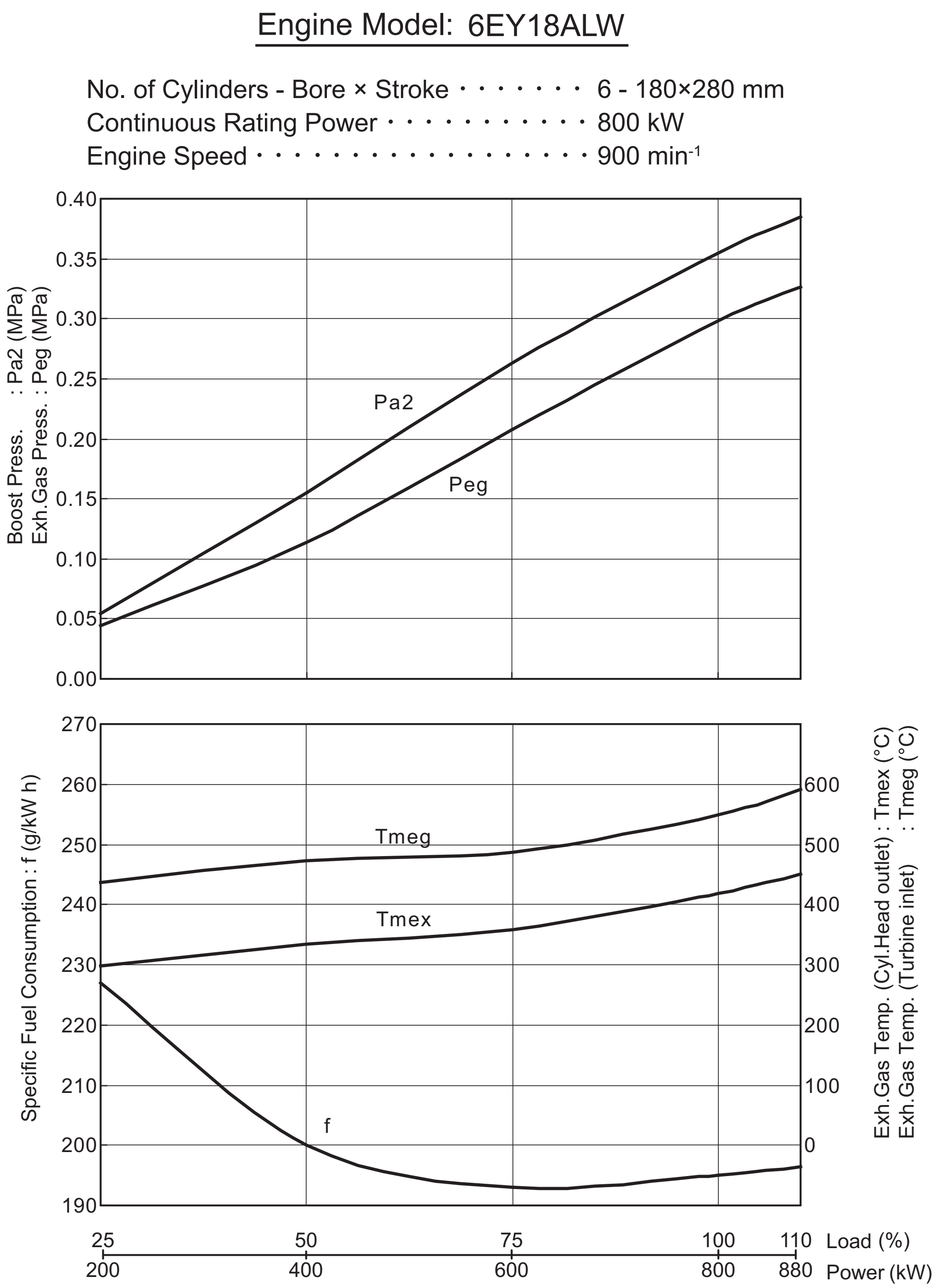
Lubricating Oil Tank Capacity	See 30-01-00
Engine Freshwater Holding Capacity	145 ℓ
Starting Air Sump	150 ℓ × 1 Bottle, 2.94 MPa

Other Data

Continuous Rating Power		kW	615	550	500	450	400
Heat Radiation	Heat Radiation to L.O. (at 100% Load)	MJ/h	280.3	266.3	229.0	224.4	224.4
Heat Radiation	Heat Radiation to Low Temp. C.W. (at 100% Load)	MJ/h	184.6	162.3	141.4	129.4	129.4
Heat Radiation	Heat Radiation to High Temp. C.W. (at 100% Load)	MJ/h	571.4	492.7	359.4	306.2	306.2
Heat Radiation	Heat Radiation to Air (at 100% Load)	MJ/h	676.9	622.7	495.0	454.1	454.1
Combustion Air Volume at 100% Load [25°C]		m^3/h	4060	3760	3600	3370	3100
Exh. Gas Volume at 100% Load [0°C]		m^3/h	3720	3480	3320	3090	2860
Eng. Room Ventilation Air Volume			0.27-0.41 m^3/min・kW				
T/C Outlet Exh. Gas Temp. (at 100% Load, Ambient Temp. 25°C)		°C	335	335	300	300	300
Exh. Back Pressure at 100% Load			3.43 kPa or below				
Exhaust Pipe Diameter			250 A or 300 A				

1. Model 6EY18ALW (for 60 Hz Generator)

1.1 800 kW/900 min^{-1}



Note:
- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1470

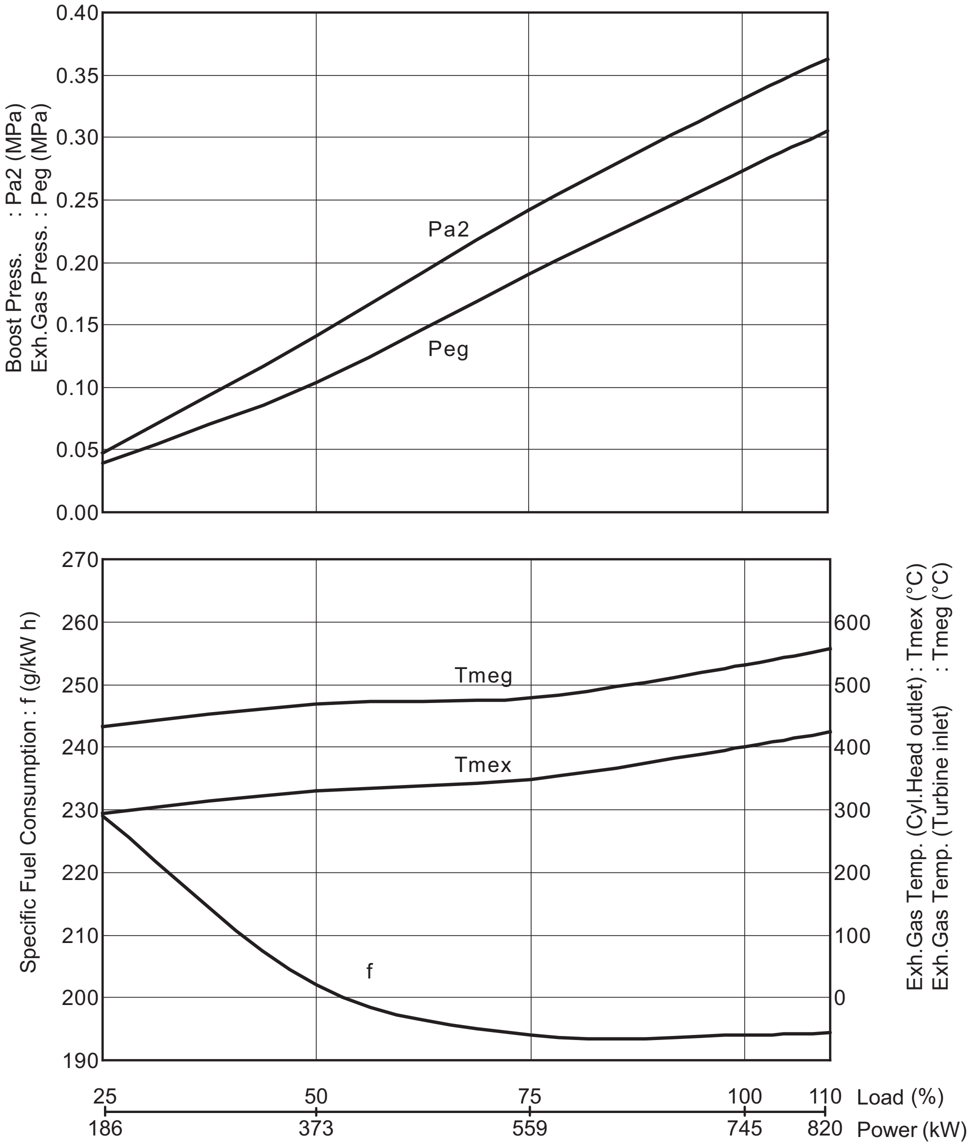
041285-00E00

Engine Performance

1.2 745 kW/900 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 745 kW
Engine Speed · · · · · · · · · · · · · · · · · · 900 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

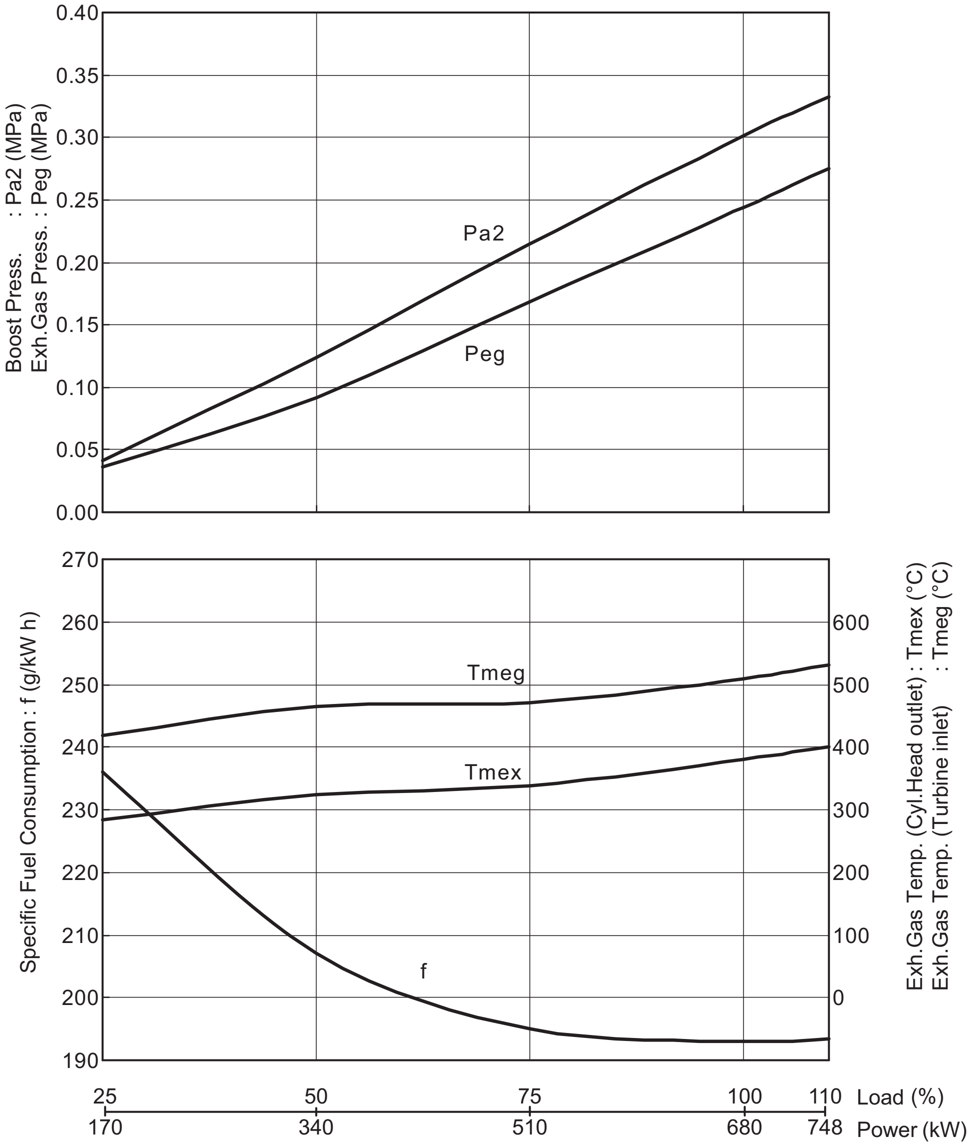
DWG. No.	G2-46623-1460

041284-00E00

1.3 680 kW/900 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 680 kW
Engine Speed · · · · · · · · · · · · · · · · · · · 900 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

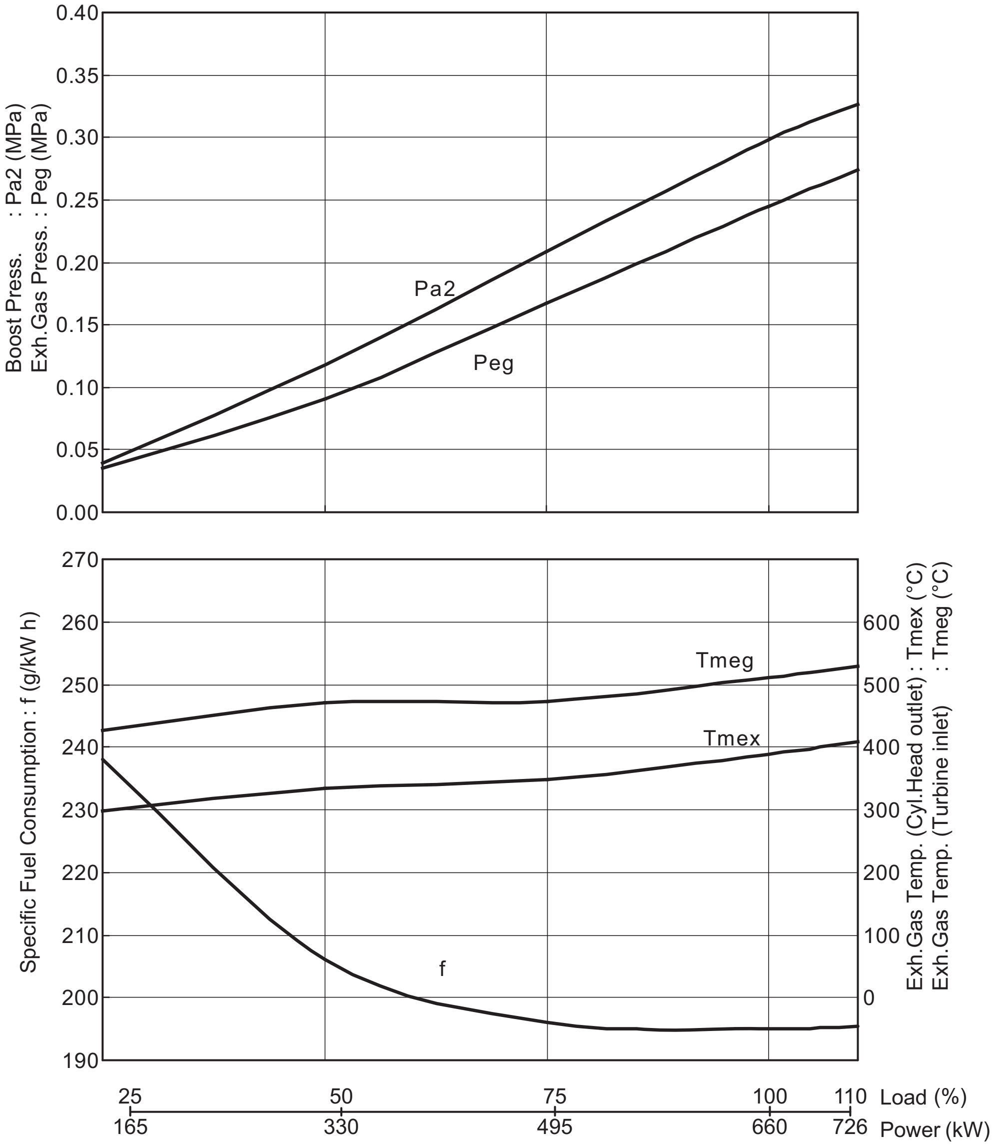
DWG. No.	G2-46623-1450

041283-00E00

1.4 660 kW/900 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · · 660 kW
Engine Speed · 900 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1440

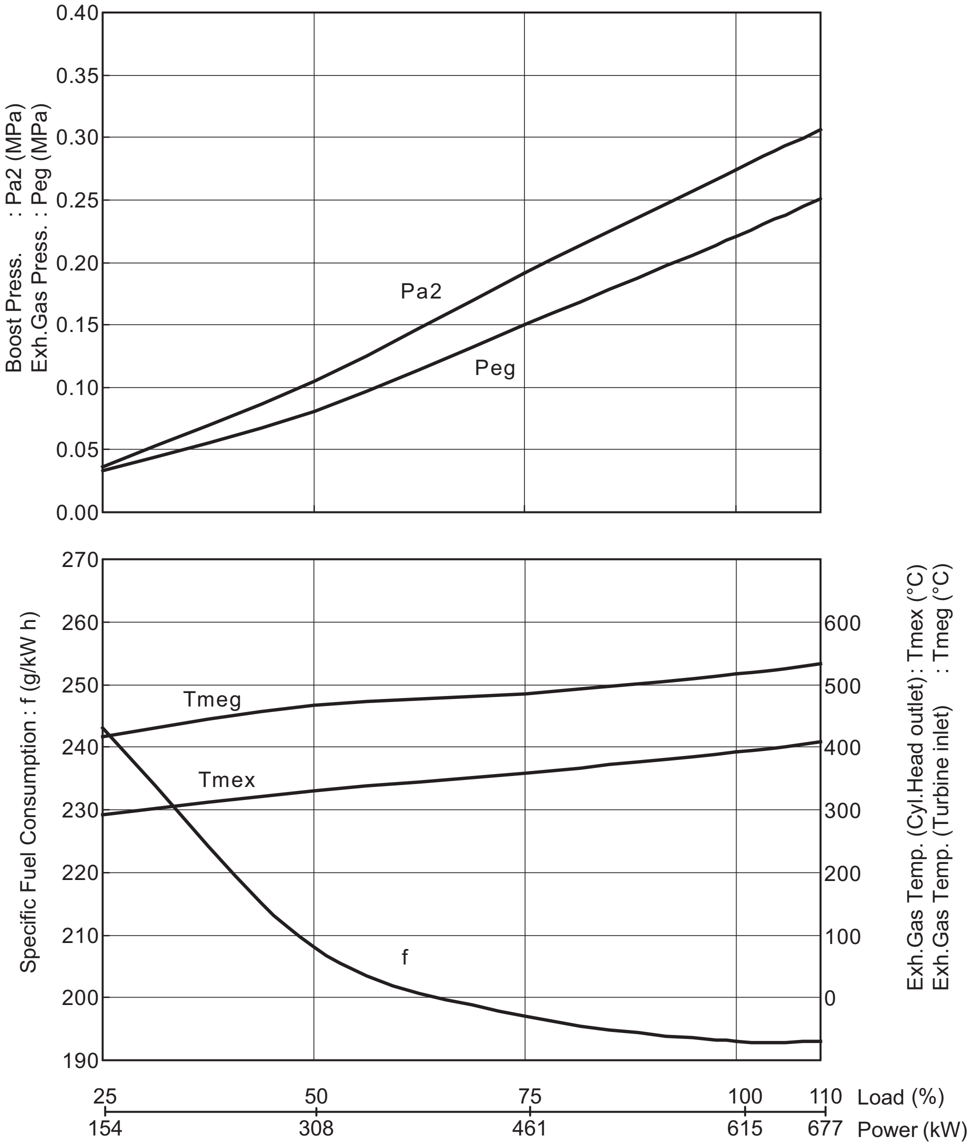
041282-00E00

Engine Performance

1.5 615 kW/900 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 615 kW
Engine Speed · · · · · · · · · · · · · · · · · · · 900 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

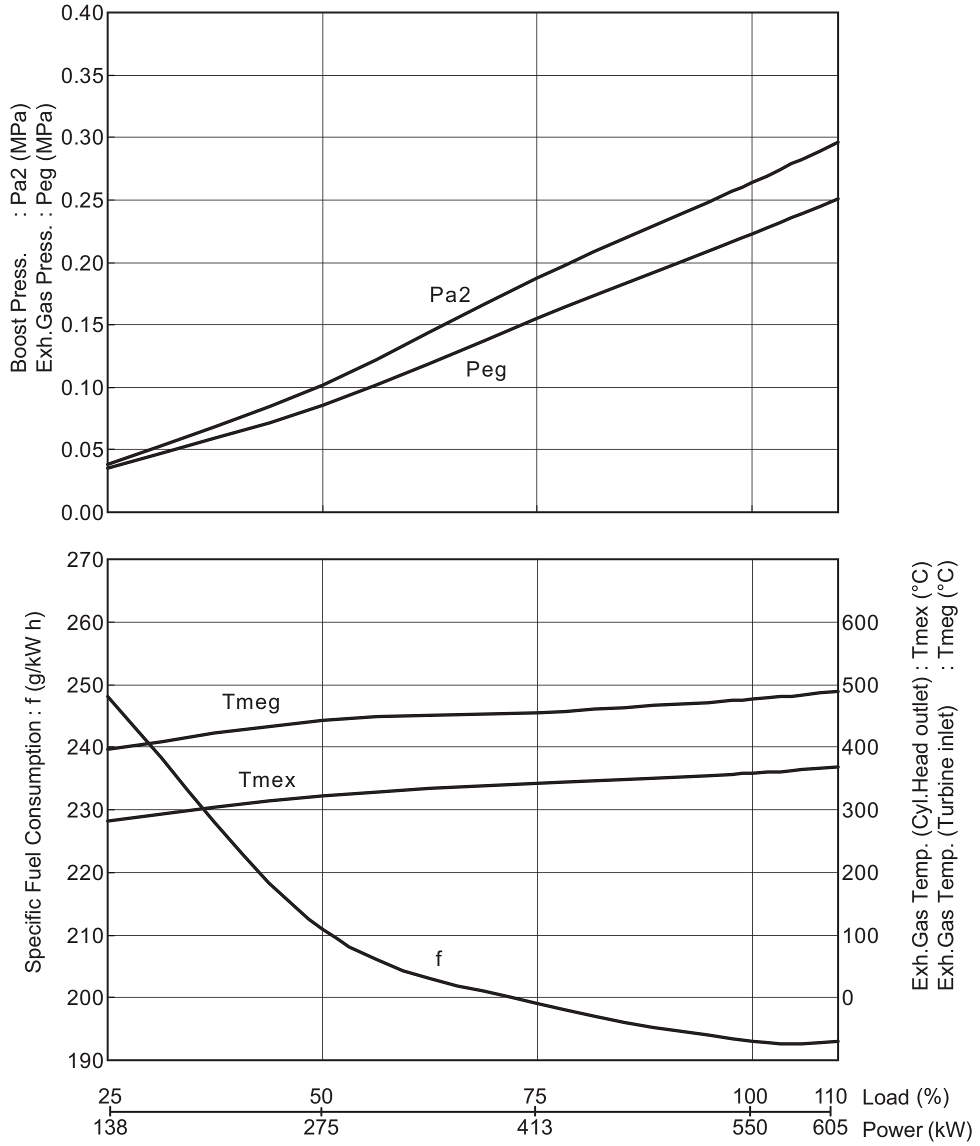
DWG. No.	G2-46623-1430

041281-00E00

1.6 550 kW/900 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 550 kW
Engine Speed · · · · · · · · · · · · · · · · · · · 900 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

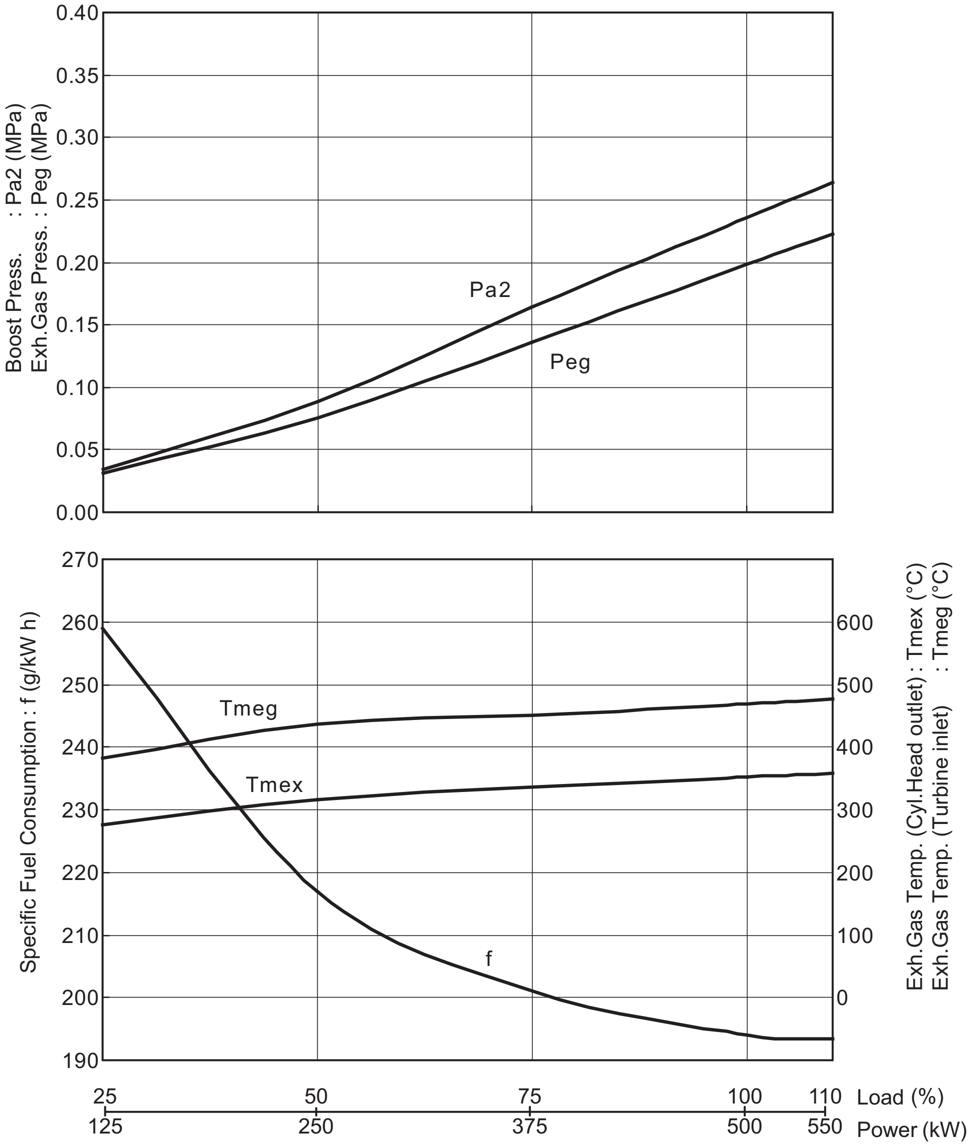
DWG. No.	G2-46623-1421

041280-00E00

1.7 500 kW/900 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 500 kW
Engine Speed · · · · · · · · · · · · · · · · · · · 900 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

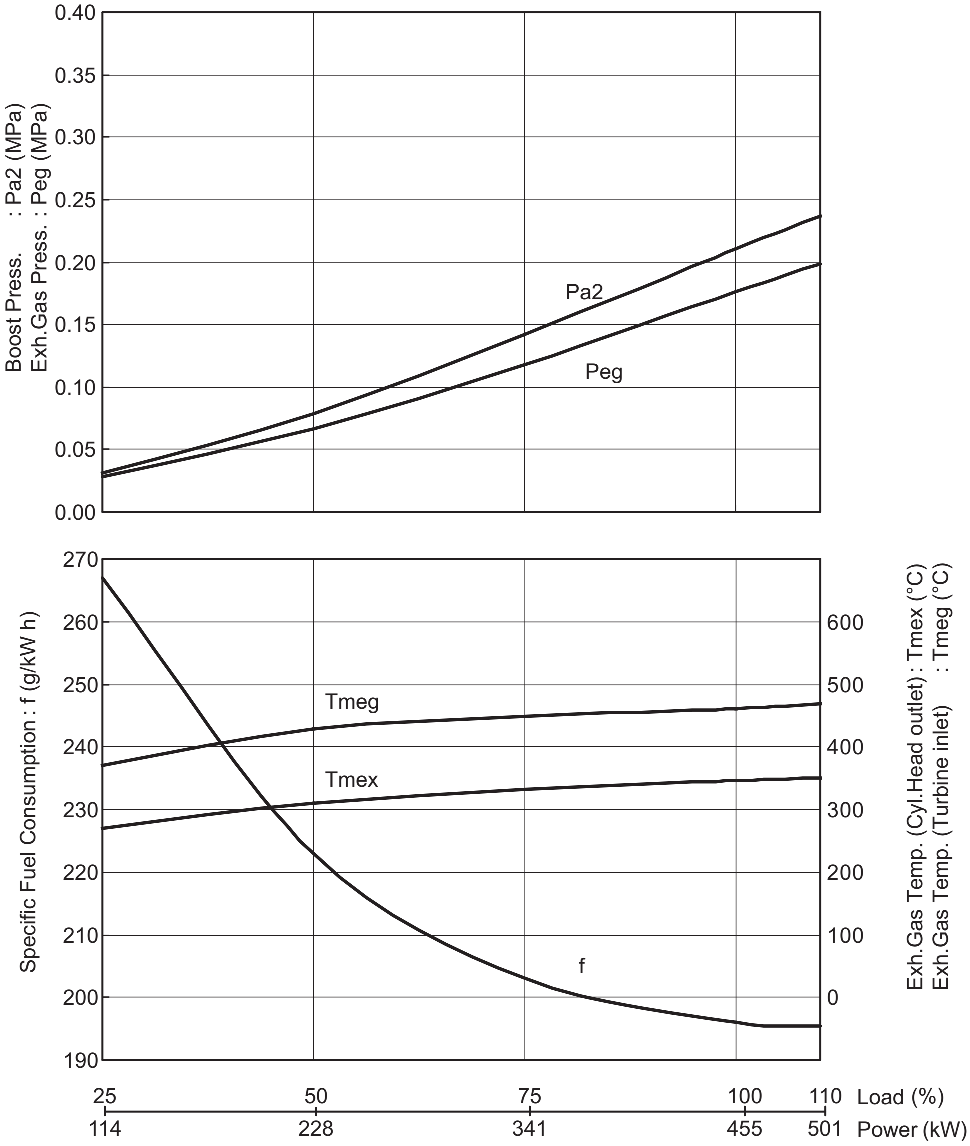
DWG. No.	G2-46623-1411

041279-00E00

1.8 455 kW/900 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 455 kW
Engine Speed · · · · · · · · · · · · · · · · · · · 900 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1401

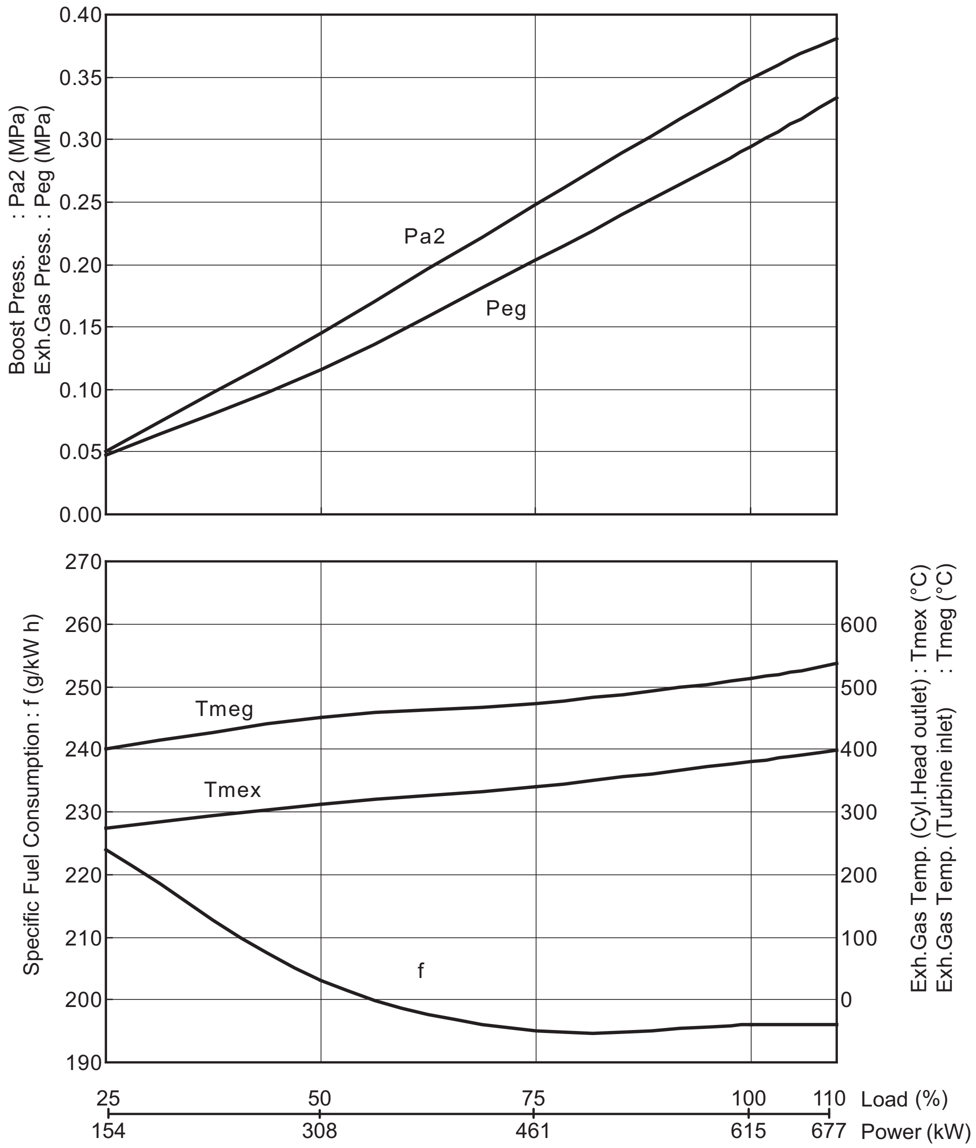
041278-00E00

2. Model 6EY18LW (for 60 Hz Generator)

2.1 615 kW/720 min^{-1}

Engine Model: 6EY18LW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 615 kW
Engine Speed · · · · · · · · · · · · · · · · · · 720 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1560

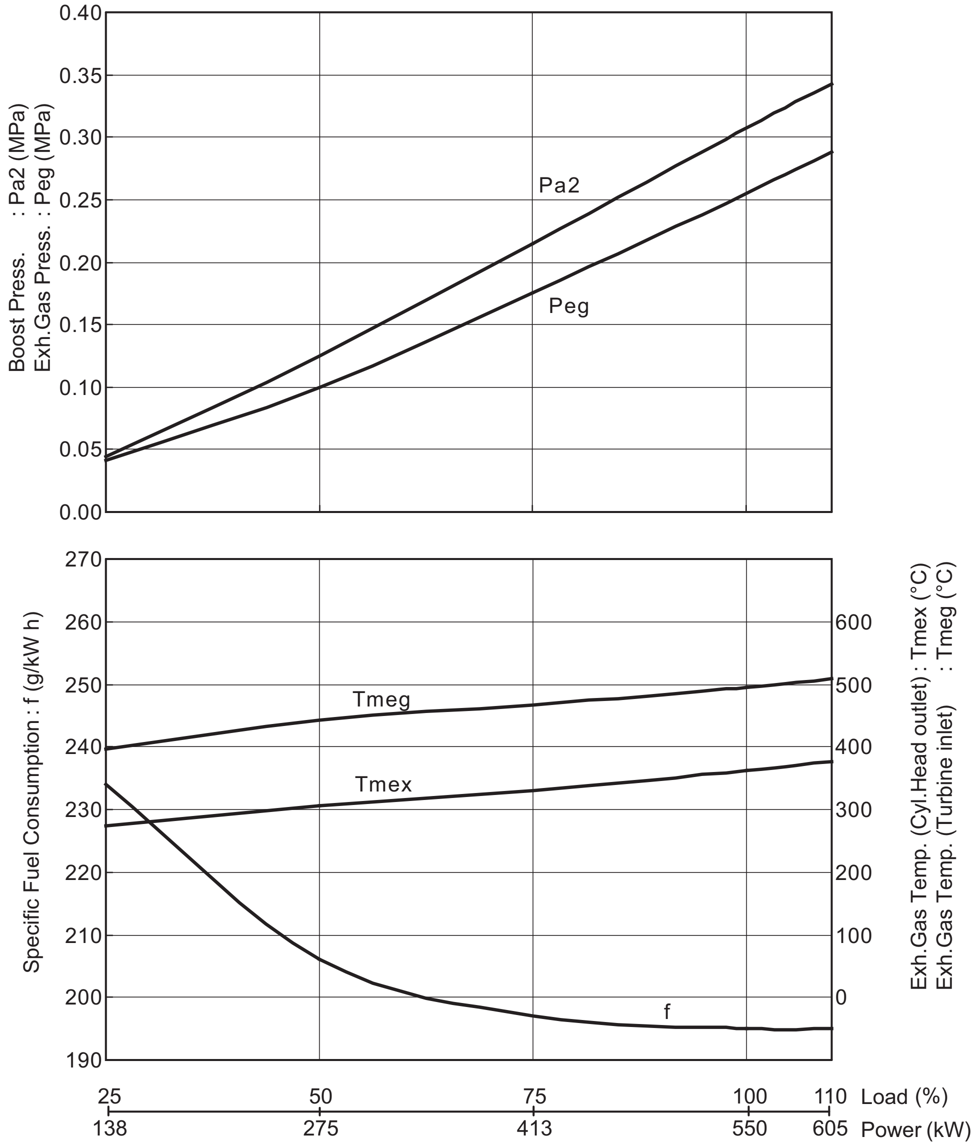
041349-00E00

Engine Performance

2.2 550 kW/720 min^{-1}

Engine Model: 6EY18LW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 550 kW
Engine Speed · · · · · · · · · · · · · · · · · · 720 min^{-1}



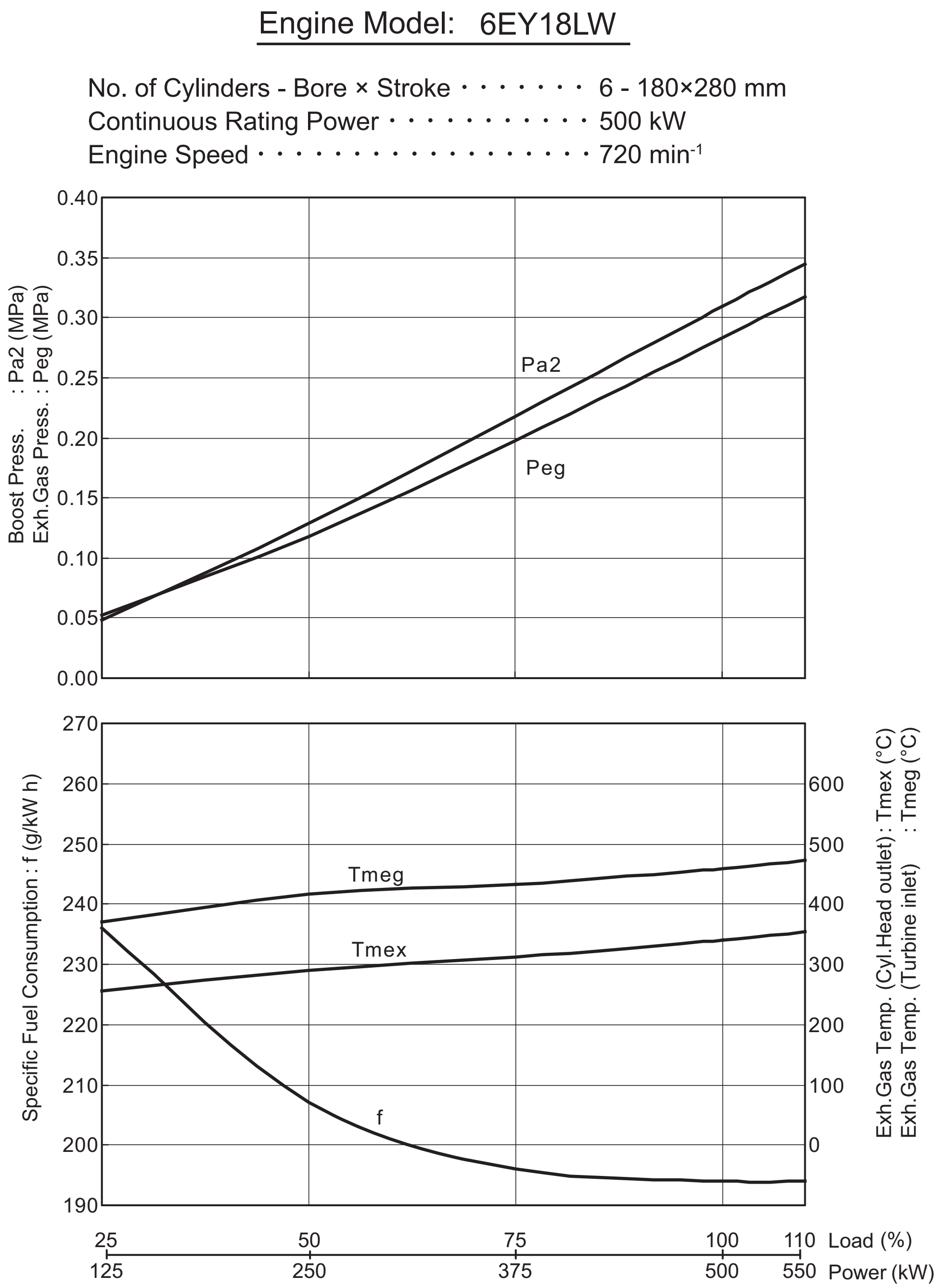
Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1390

041348-00E00

2.3 500 kW/720 min^{-1}



Note:
- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1550

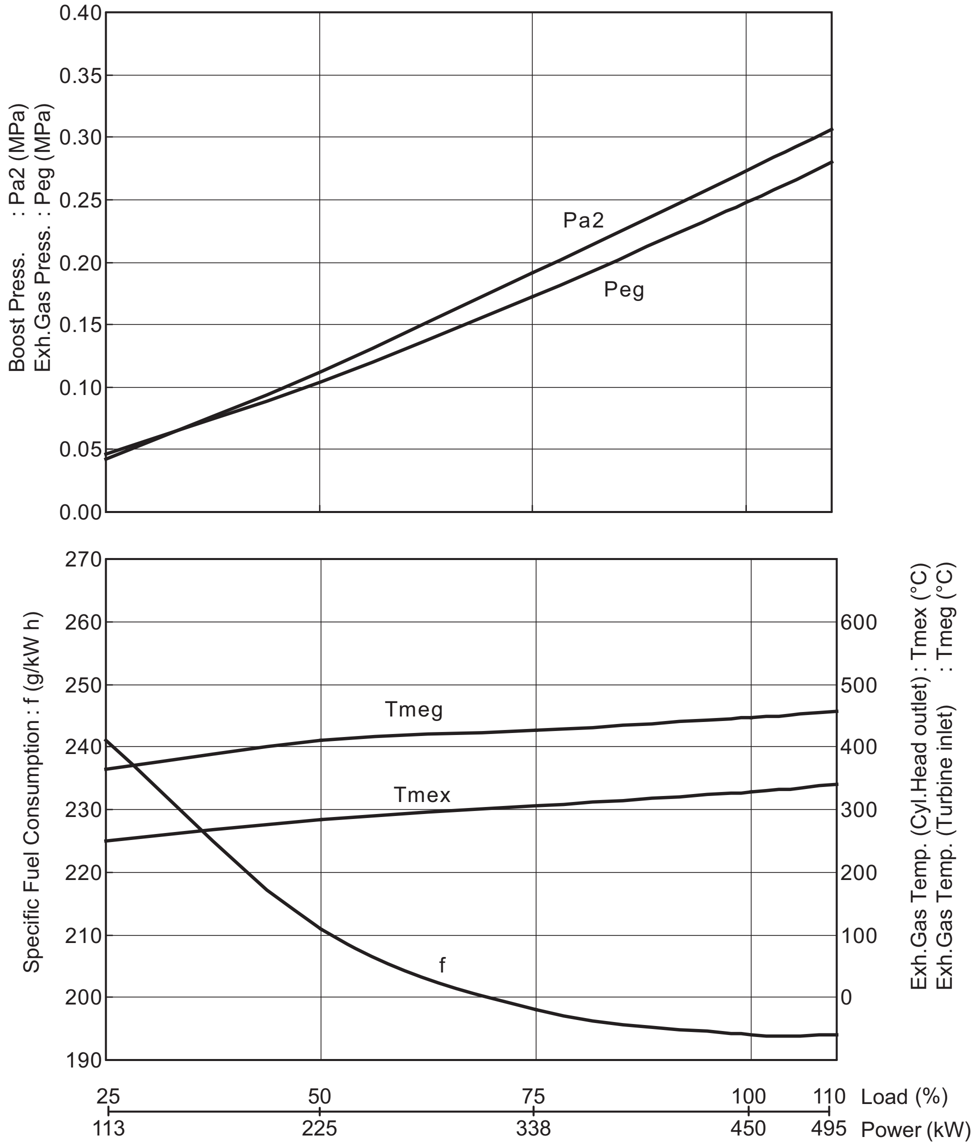
041347-00E00

Engine Performance

2.4 450 kW/720 min^{-1}

Engine Model: 6EY18LW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 450 kW
Engine Speed · · · · · · · · · · · · · · · · · · 720 min^{-1}



Note:
- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

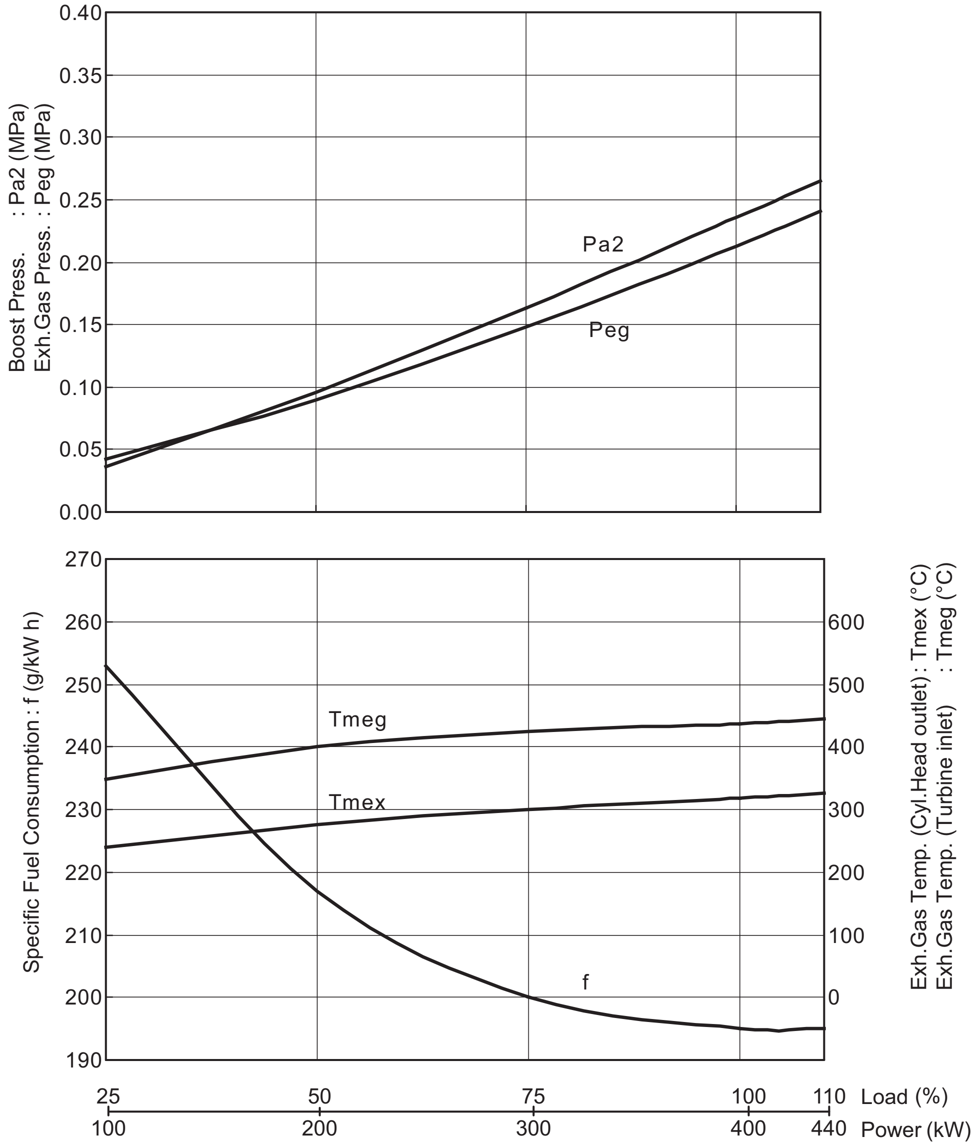
DWG. No.	G2-46623-1540

041346-00E00

2.5 400 kW/720 min^{-1}

Engine Model: 6EY18LW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 400 kW
Engine Speed · · · · · · · · · · · · · · · · · · 720 min^{-1}



Note:
- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1530

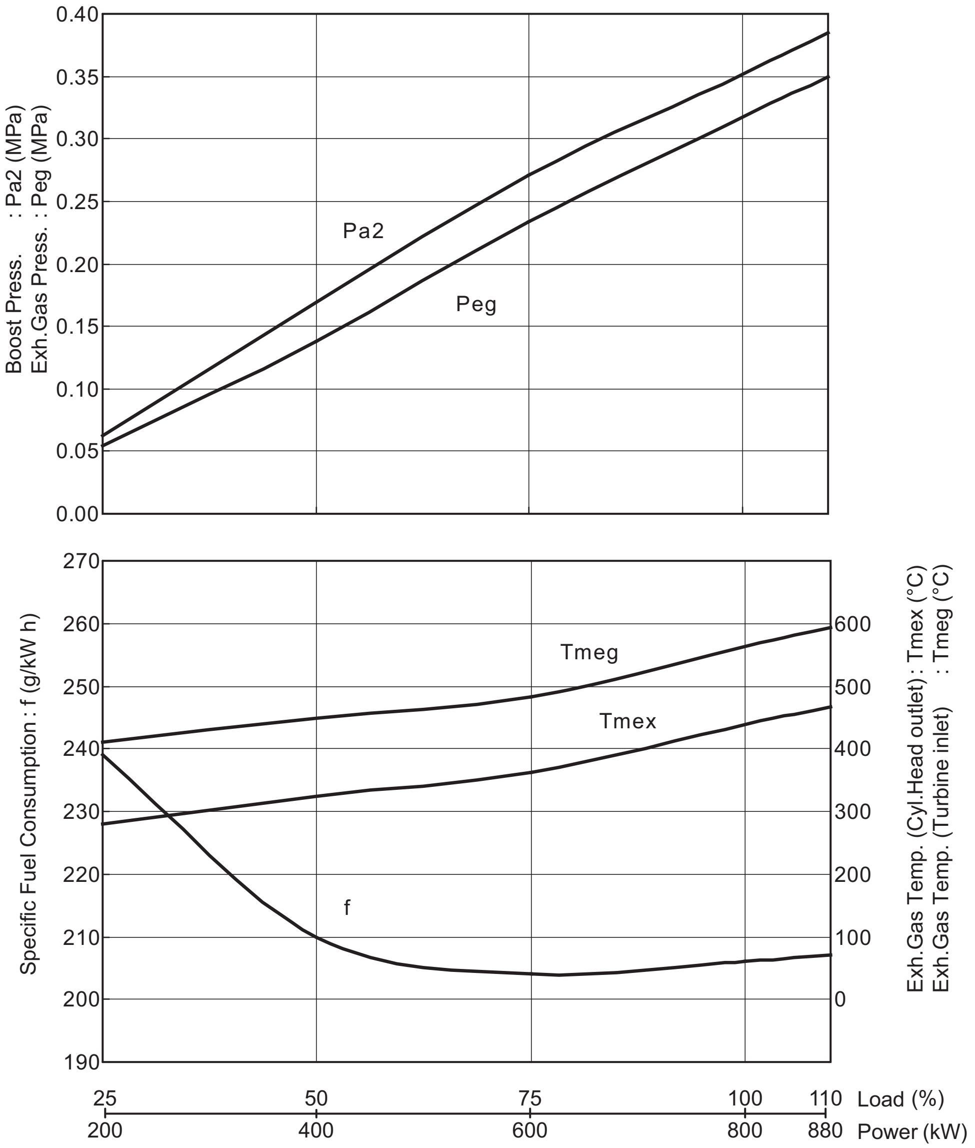
041345-00E00

3. Model 6EY18ALW (for 50 Hz Generator)

3.1 800 kW/1000 min-1

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 800 kW
Engine Speed · · · · · · · · · · · · · · · · · · 1000 min-1



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1690

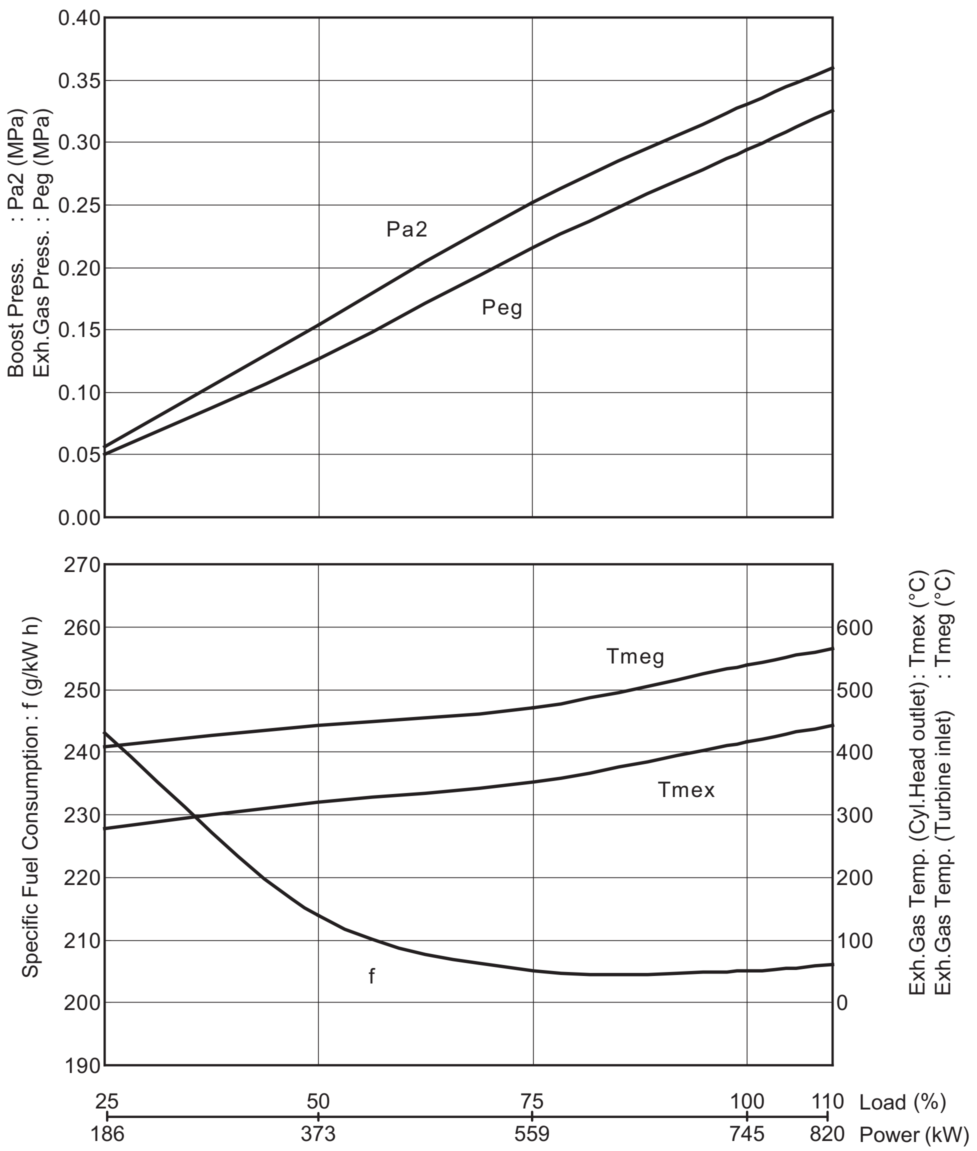
041293-00E00

Engine Performance

3.2 745 kW/1000 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 745 kW
Engine Speed · · · · · · · · · · · · · · · · · · 1000 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1680

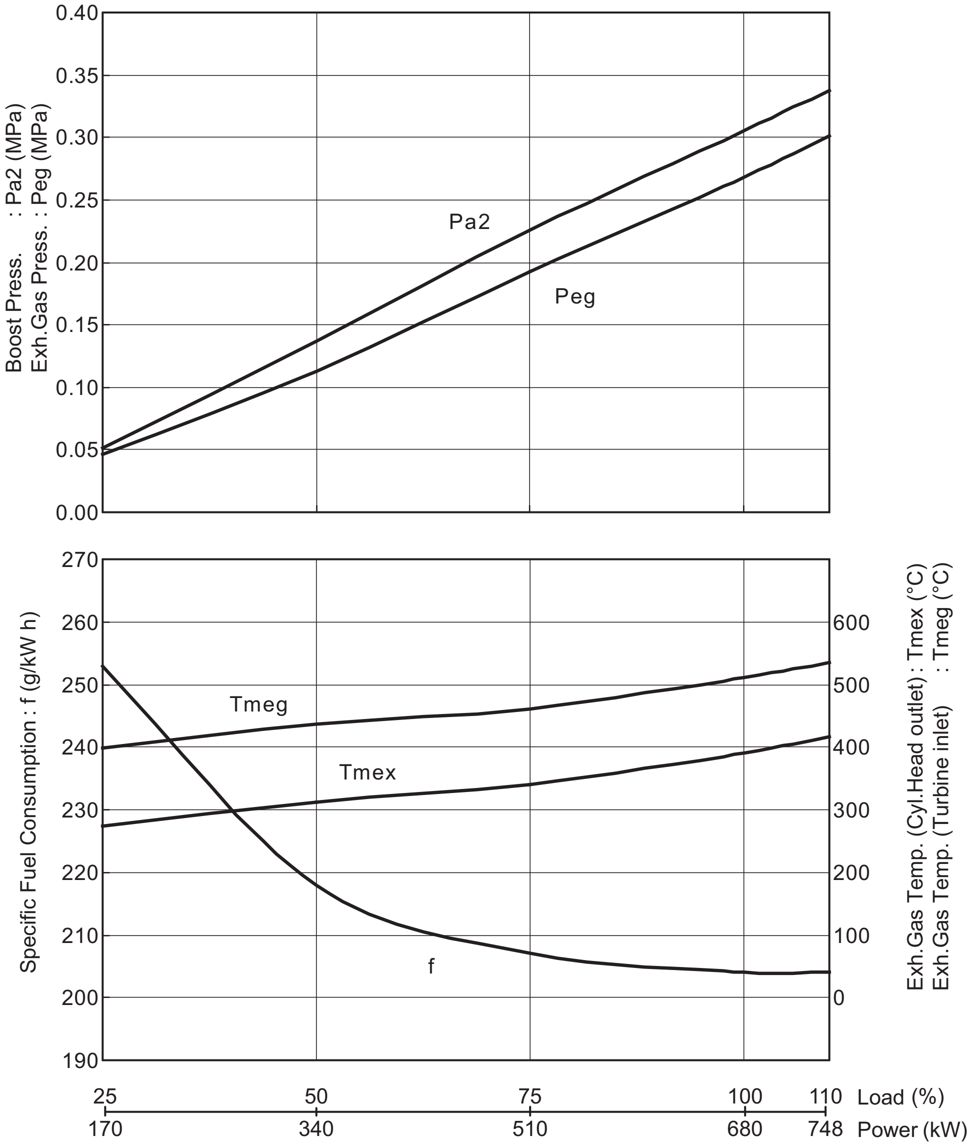
041292-00E00

Engine Performance

3.3 680 kW/1000 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 680 kW
Engine Speed · · · · · · · · · · · · · · · · · · · 1000 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1670

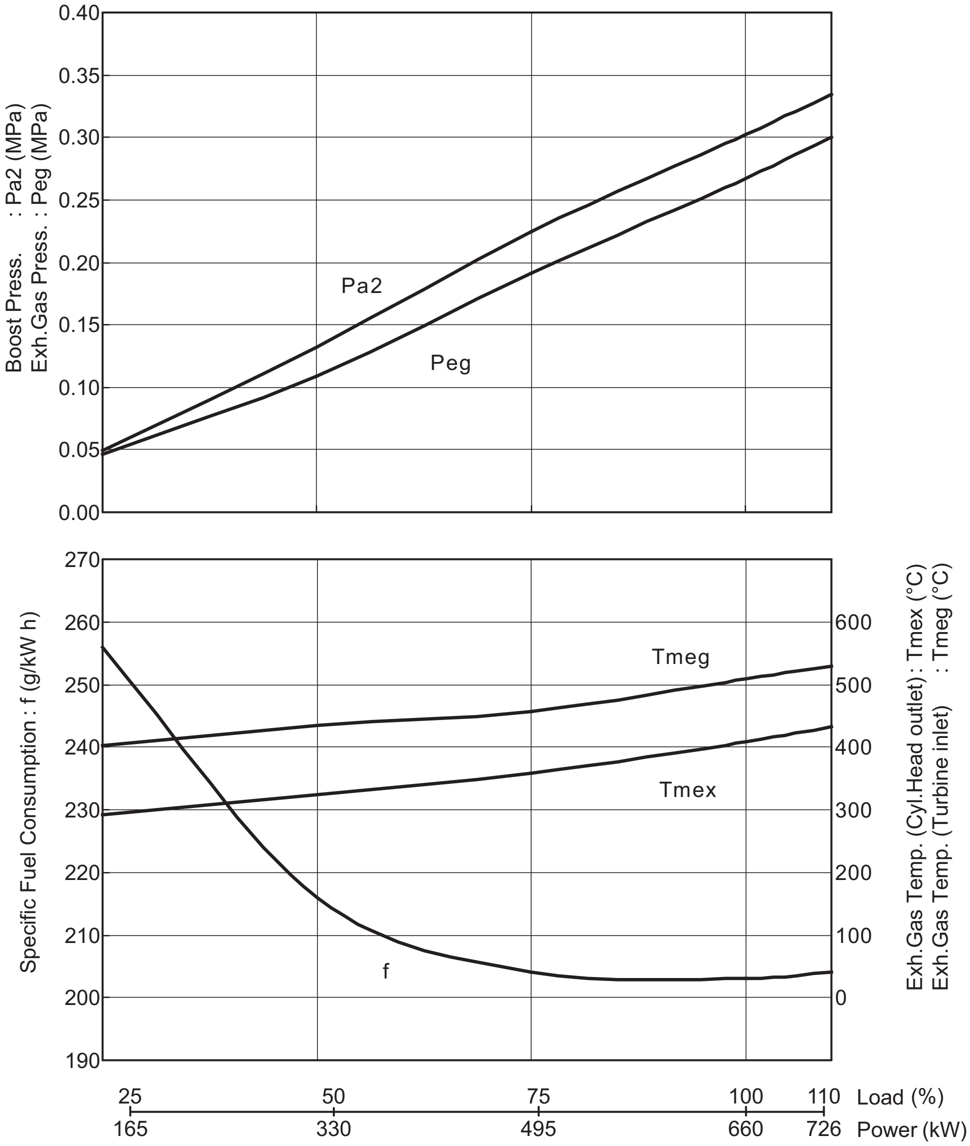
041291-00E00

Engine Performance

3.4 660 kW/1000 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 660 kW
Engine Speed · · · · · · · · · · · · · · · · · · 1000 min^{-1}



Note:

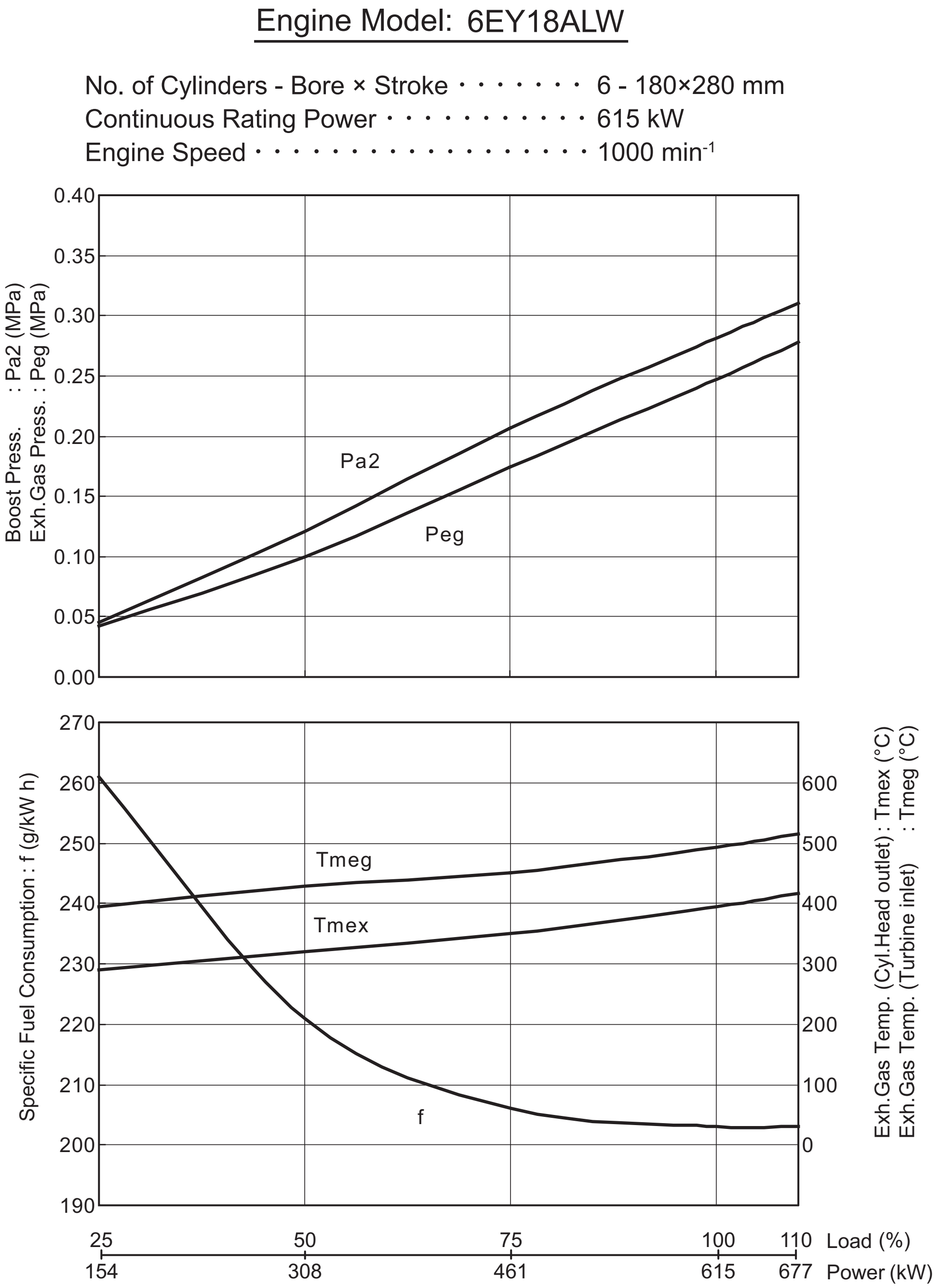
- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1660

041290-00E00

Engine Performance

3.5 615 kW/1000 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1650

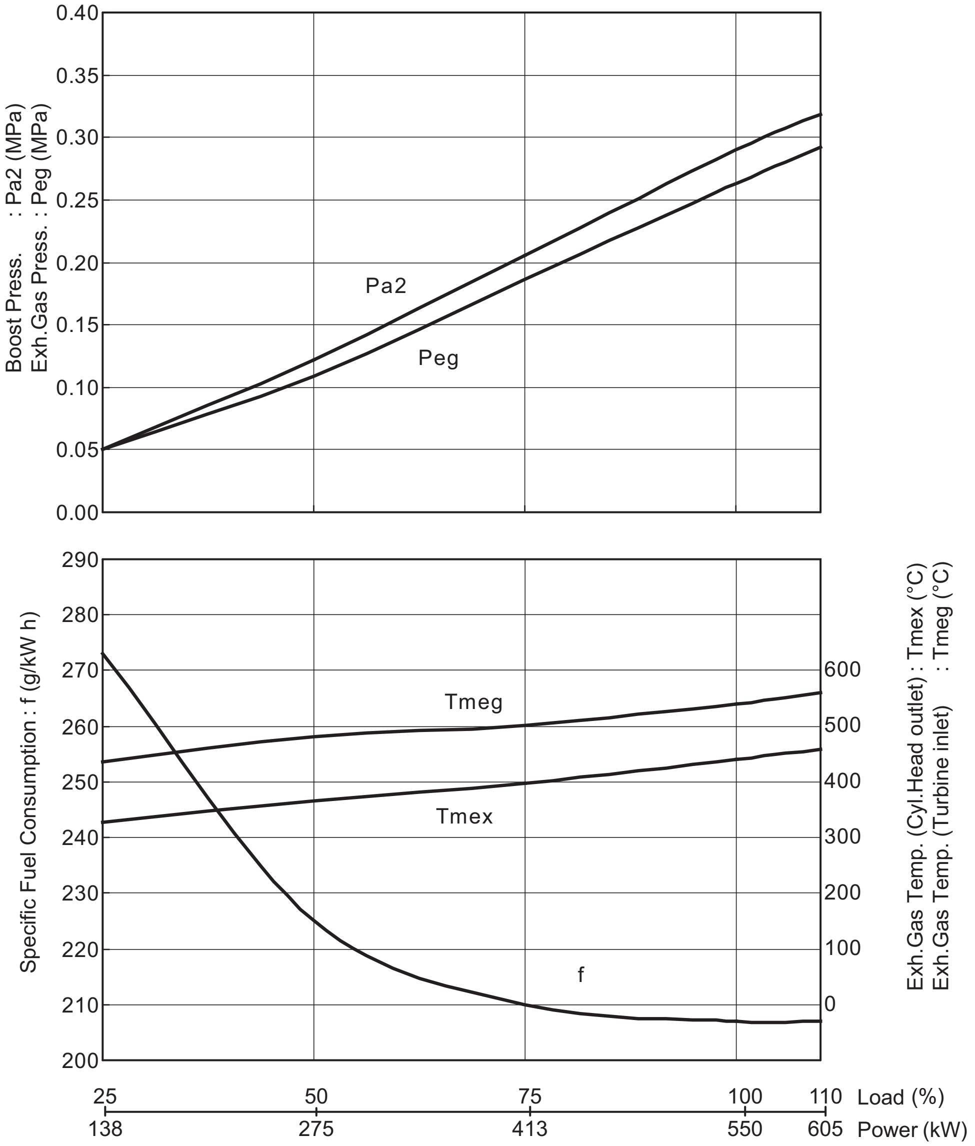
041289-00E00

Engine Performance

3.6 550 kW/1000 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 550 kW
Engine Speed · · · · · · · · · · · · · · · · · · 1000 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

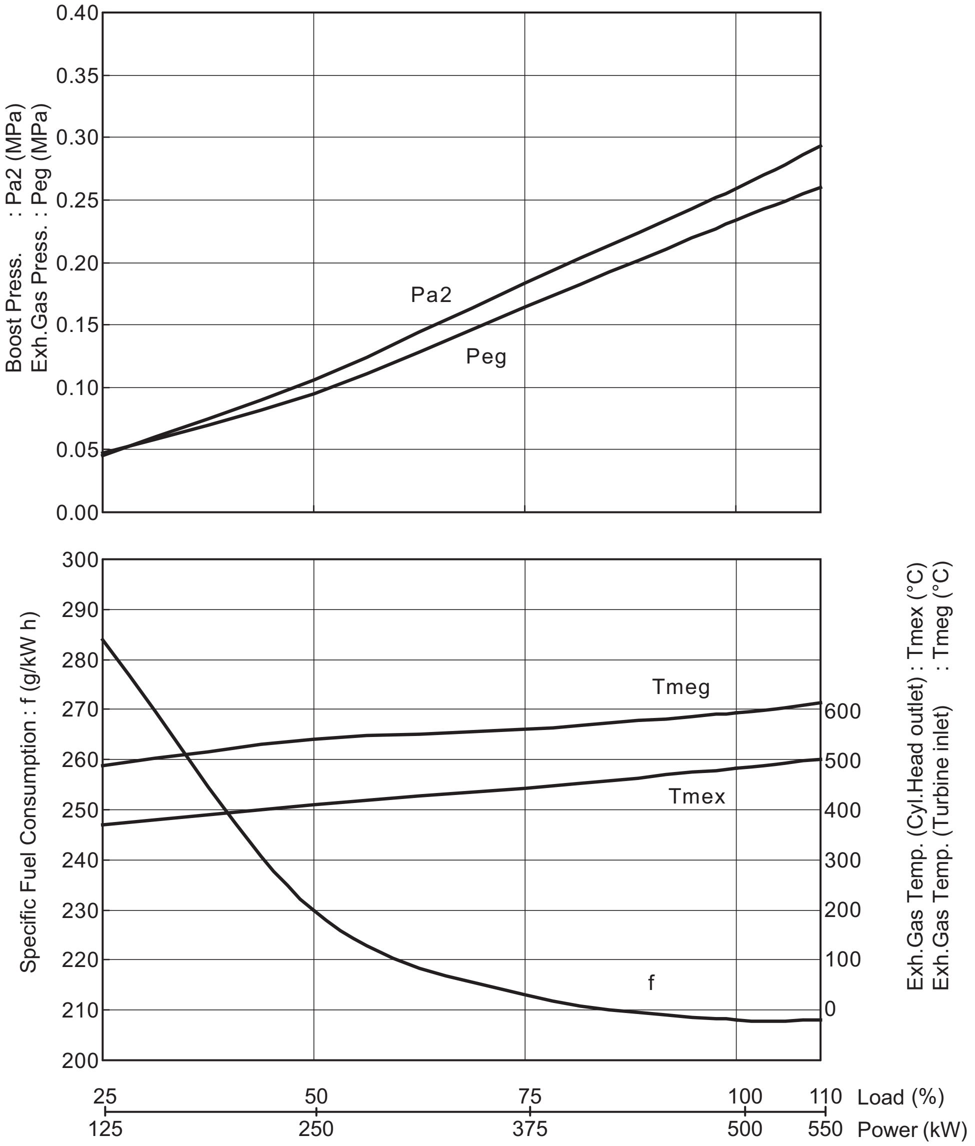
DWG. No.	G2-46623-1640

041288-00E00

3.7 500 kW/1000 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 500 kW
Engine Speed · · · · · · · · · · · · · · · · · · 1000 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1630

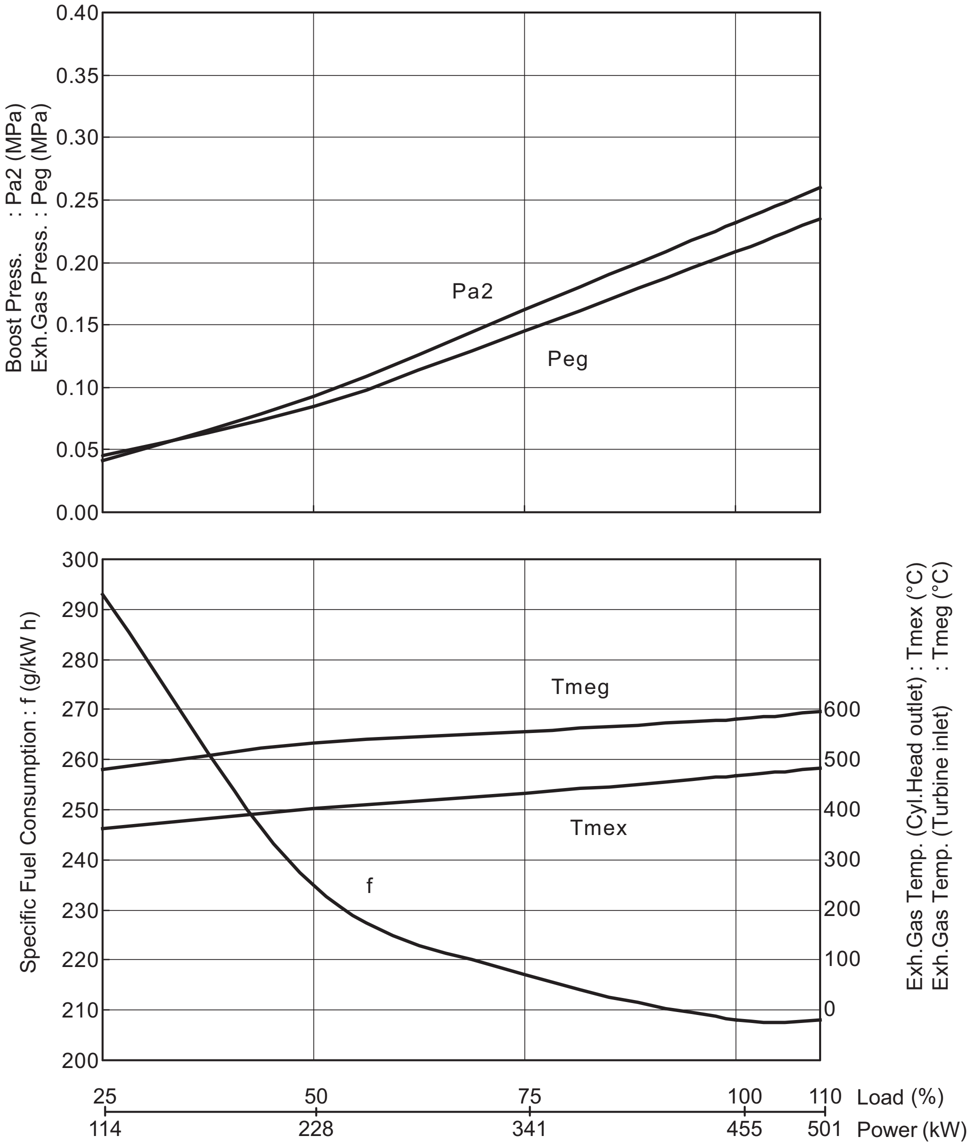
041287-00E00

Engine Performance

3.8 455 kW/1000 min^{-1}

Engine Model: 6EY18ALW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 455 kW
Engine Speed · · · · · · · · · · · · · · · · · · · 1000 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1620

041286-00E00

4. Model 6EY18LW (for 50 Hz Generator)

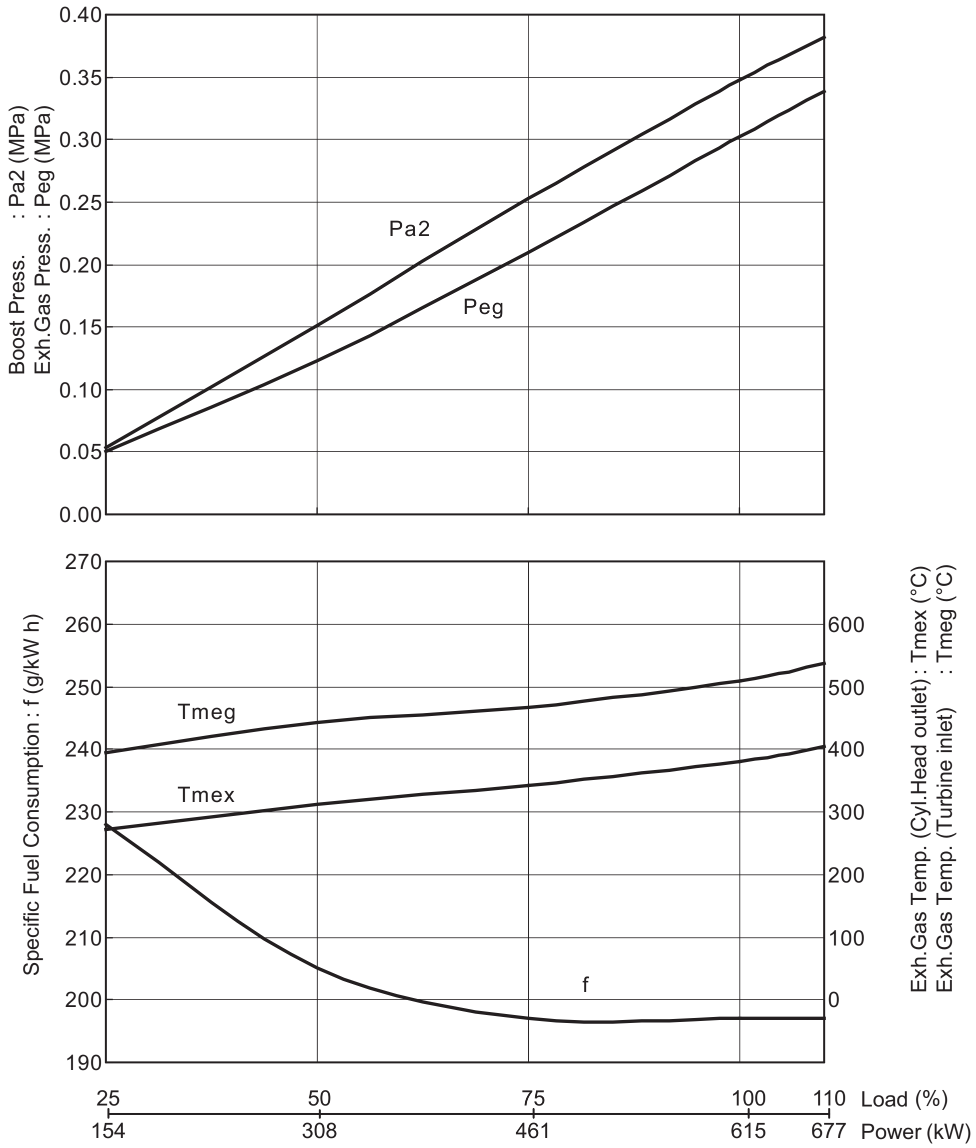
4.1 615 kW/750 min^{-1}

Engine Model: 6EY18LW

No. of Cylinders - Bore × Stroke · · · · · · · · 6 - 180×280 mm

Continuous Rating Power · · · · · · · · · · · · 615 kW

Engine Speed · 750 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1610

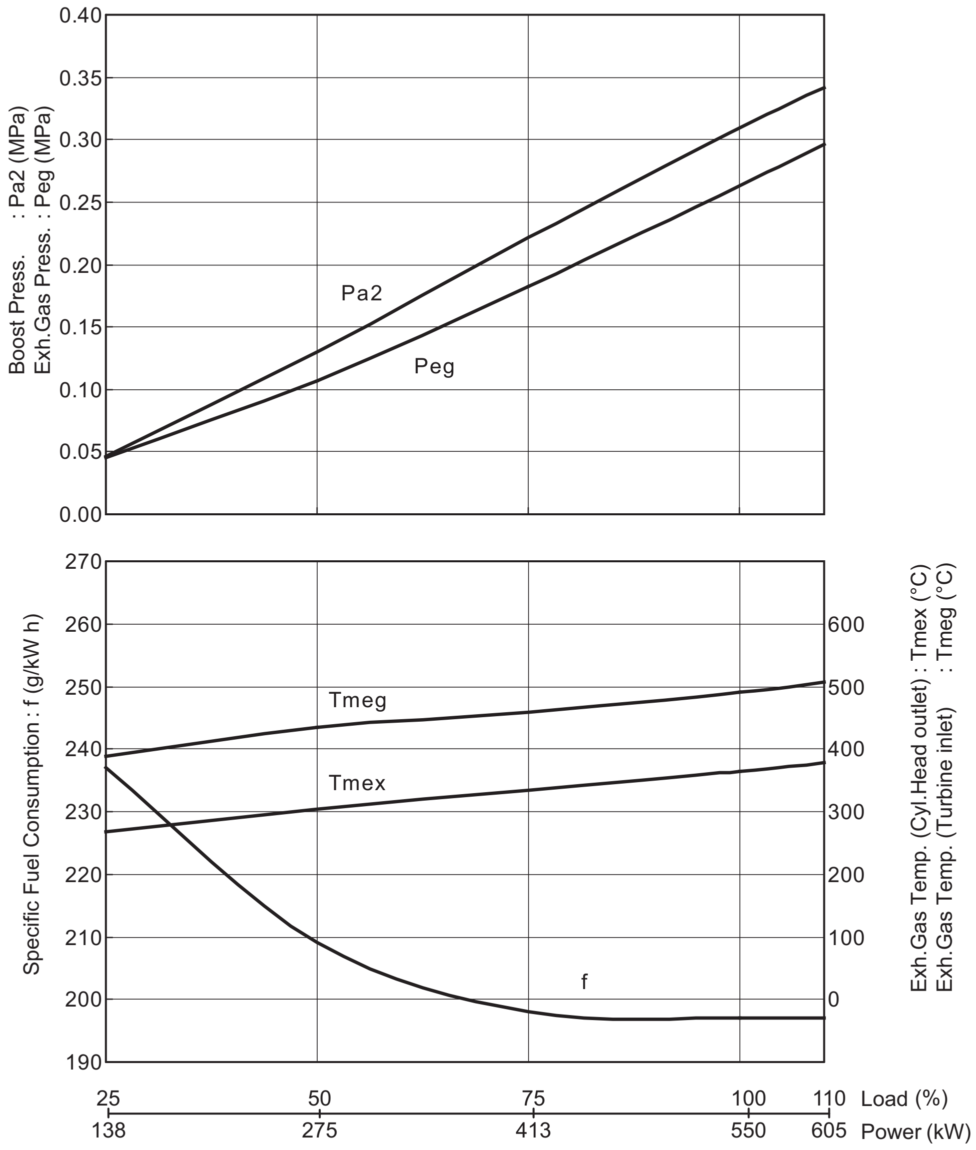
041354-00E00

Engine Performance

4.2 550 kW/750 min⁻¹

Engine Model: 6EY18LW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 550 kW
Engine Speed · · · · · · · · · · · · · · · · · · 750 min^{-1}



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

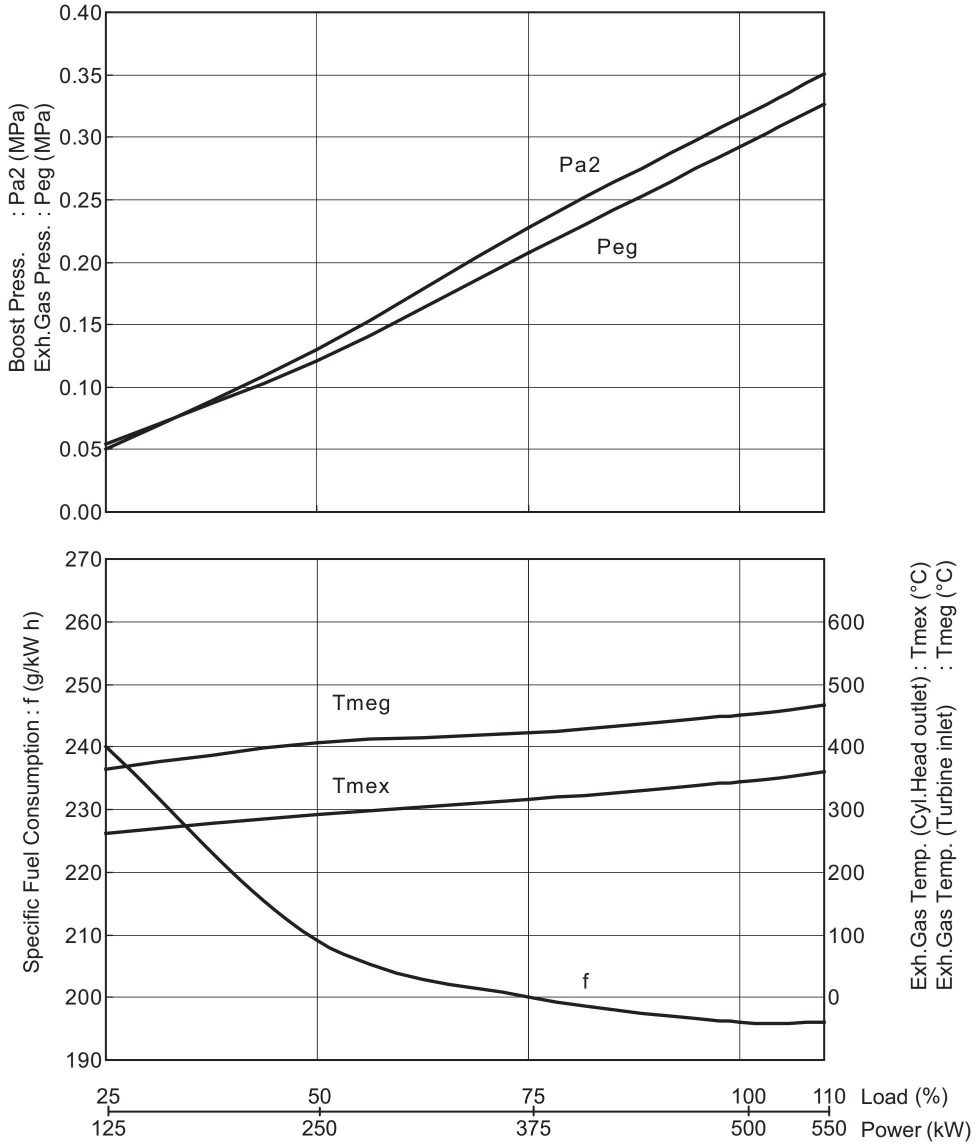
DWG. No.	G2-46623-1600

041353-00E00

4.3 500 kW/750 min^{-1}

Engine Model: 6EY18LW

No. of Cylinders - Bore × Stroke · · · · · · · 6 - 180×280 mm
Continuous Rating Power · · · · · · · · · · · 500 kW
Engine Speed · · · · · · · · · · · · · · · · · · 750 min^{-1}



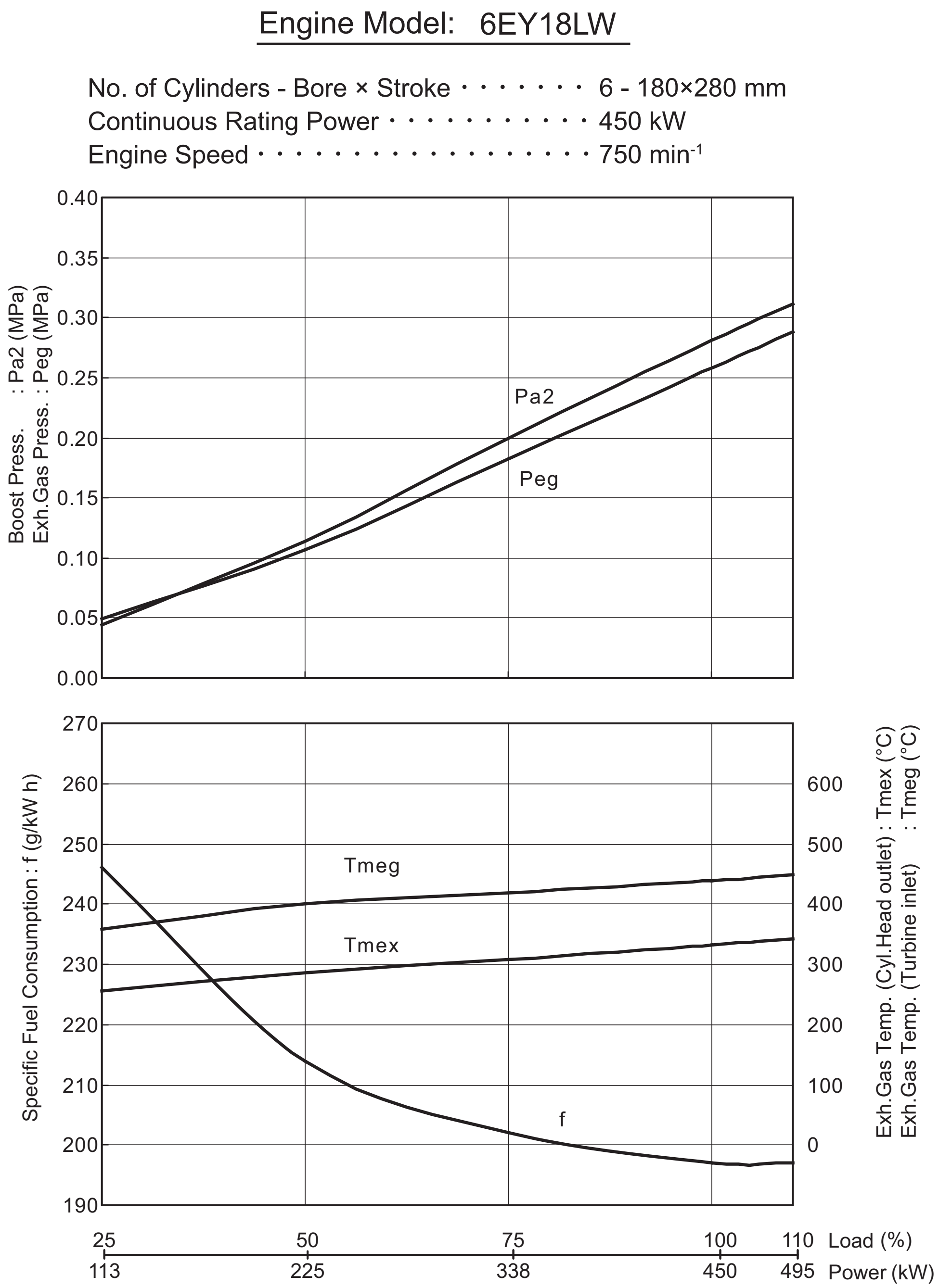
Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1590

041352-00E00

4.4 450 kW/750 min^{-1}



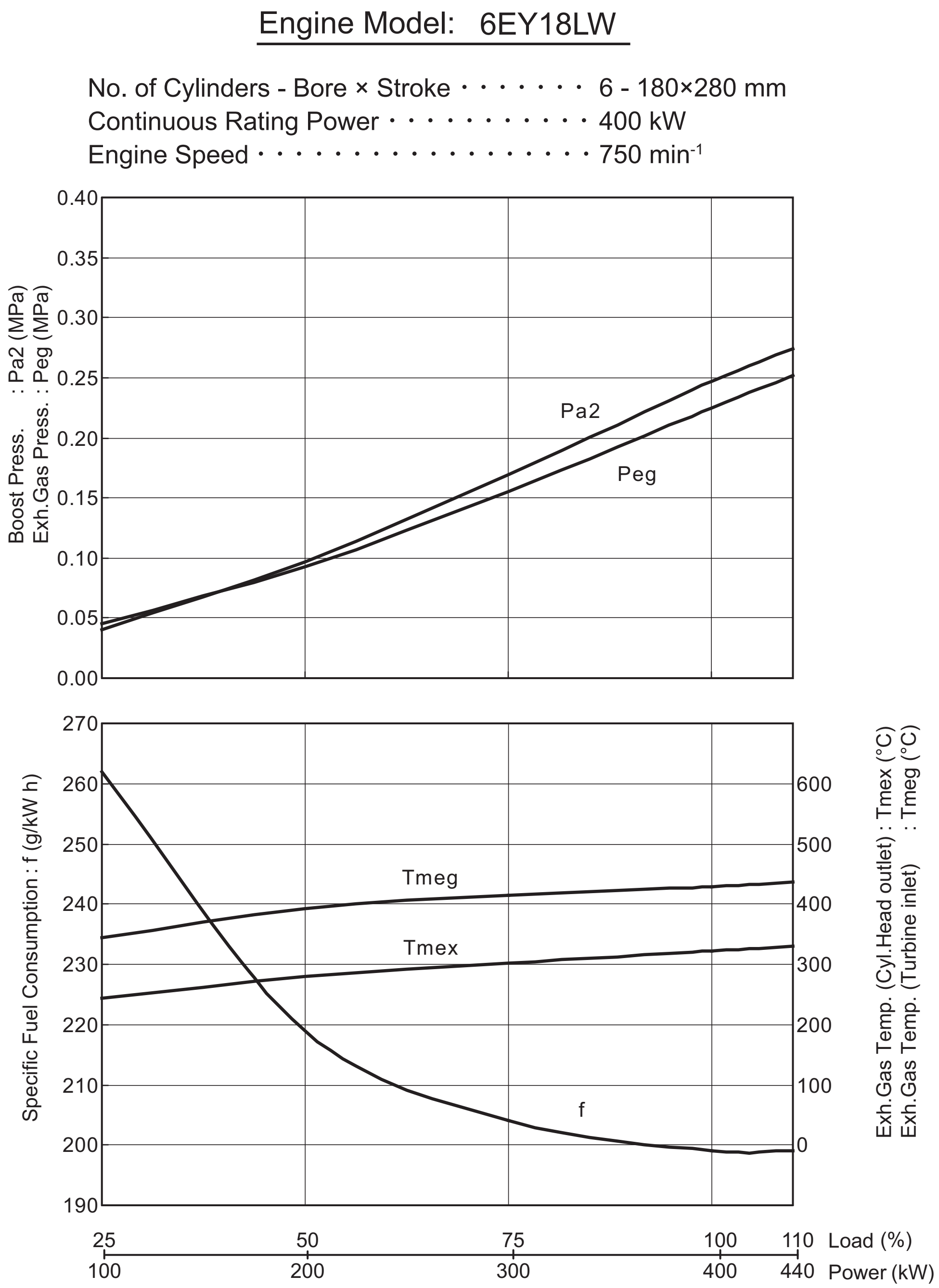
Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1580

041351-00E00

4.5 400 kW/750 min⁻¹



Note:

- Lower Calorific Value 42.7 MJ/kg
- Fuel Consumption at the Engine Shaft End (allowance +5%)
- With driven Pump (LOP×1,CWP×2)
- Conforming to IMO tier 2 regulations regarding NOx emissions

DWG. No.	G2-46623-1570

041350-00E00

Power and Specific Fuel Consumption

1. Definition of Engine Power and the Specific Fuel Consumption of 6EY18(A)LW Engine

Measure the engine power (output) at the shaft end. Do it when the engine is equipped with the auxiliary equipment, which represents the standard installation necessary for engine operation and is constantly driven by the engine's power (Auxiliary Equipment A under ISO 3046/1-1986 (E); in the case of this engine: the lubricating oil pump and the freshwater pump). If the use of other power sources is inevitable to drive this auxiliary equipment, the power required to drive such equipment is deducted from the engine output.

2. Measuring Conditions

Running in trial	: 30 h
Ambient temperature	: 25 ℃
Atmospheric pressure	: 100 kPa
Humidity	: 30 %
Water temp. at air cooler inlet	: 25 ℃
Exhaust gas back pressure	: 3.43 kPa or below
Fuel oil	: No.2, Class 1, JIS K2205 (M.D.O.), standard lower calorific value 42700 kJ/kg
Lubricating oil	: Viscosity 30 or 40 of SAE J300b, properties of API service category CD.

Power and Specific Fuel Consumption

3. Specific Fuel Consumption

The specific fuel consumption of the bare engine only, excluding the lubricating oil pump and the freshwater pump, is shown below. The tolerance is 5 %.

Engine Model		6EY18ALW															
Frequency (Hz)		60								50							
Engine Speed (min^{-1})		900								1000							
Continuous Rating Power (kW)		800	745	680	660	615	550	500	455	800	745	680	660	615	550	500	455
		Specific Fuel Consumption (g/kWh)															
Load	100%	190	189	188	190	188	188	189	191	196	195	194	193	193	197	198	198
	75%	188	189	190	191	192	194	196	198	194	195	197	194	196	200	203	207
	50%	195	197	202	201	203	206	212	218	200	204	208	206	211	215	220	225
	25%	222	224	231	233	238	243	254	262	229	233	243	246	251	263	274	283

Engine Model		6EY18LW									
Frequency (Hz)		60					50				
Engine Speed (min^{-1})		720					750				
Continuous Rating Power (kW)		615	550	500	450	400	615	550	500	450	400
		Specific Fuel Consumption (g/kWh)									
Load	100%	191	190	189	189	190	192	192	191	192	194
	75%	190	192	191	193	195	192	193	195	197	199
	50%	198	201	202	206	212	200	204	204	209	214
	25%	219	229	231	236	248	223	232	235	241	257

Note: Specific fuel consumption of partial loads (75 %, 50 %, 25 %) is for reference.

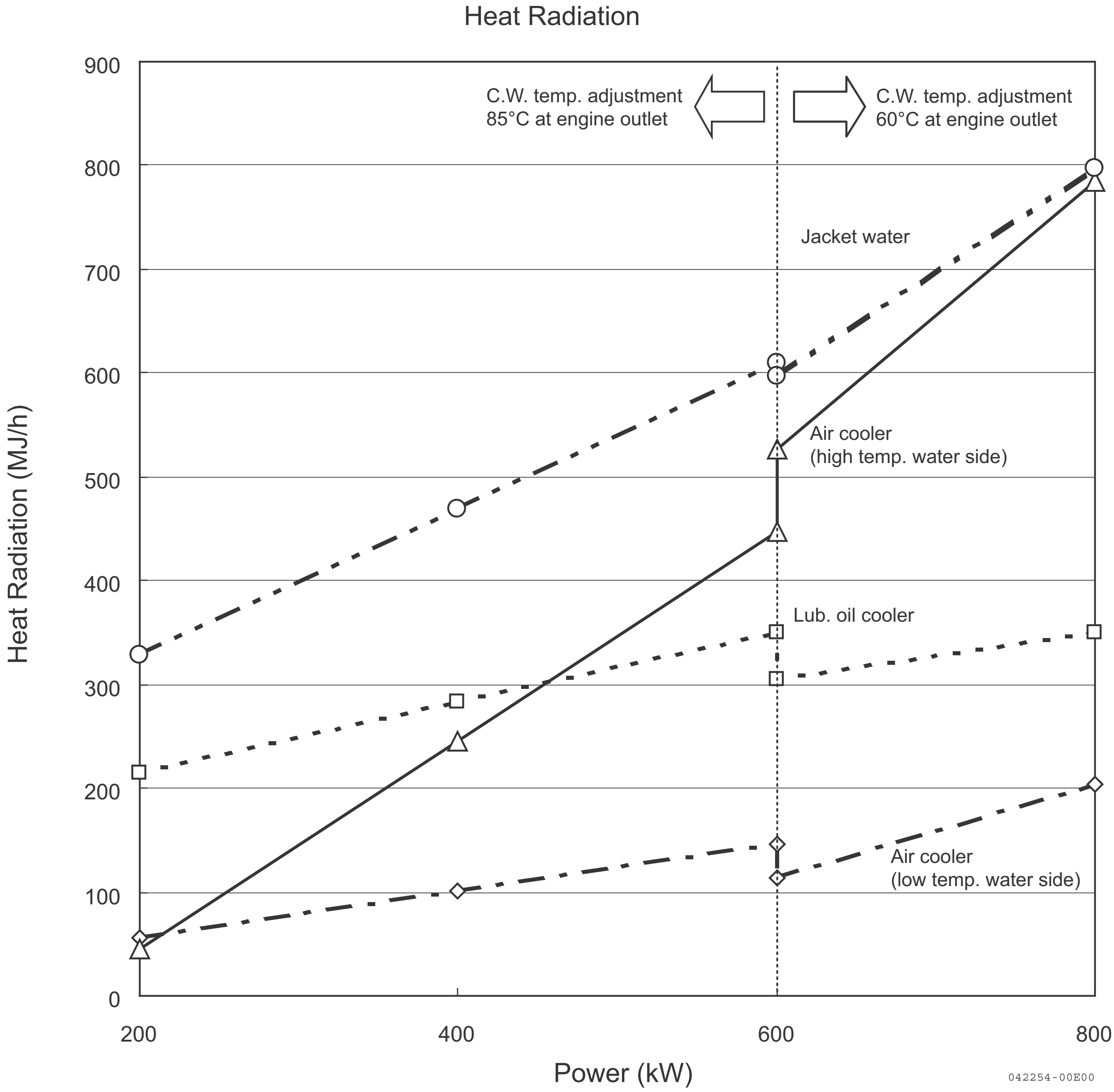
4. Correction of Specific Fuel Consumption

When the engine mounted lubricating oil pump is driven, 3 g/kWh is added to the above specific fuel consumption. When the cooling water pump is driven, 1 g/kWh is added to the specific fuel consumption per one pump.

Heat Balance

1. Model 6EY18ALW

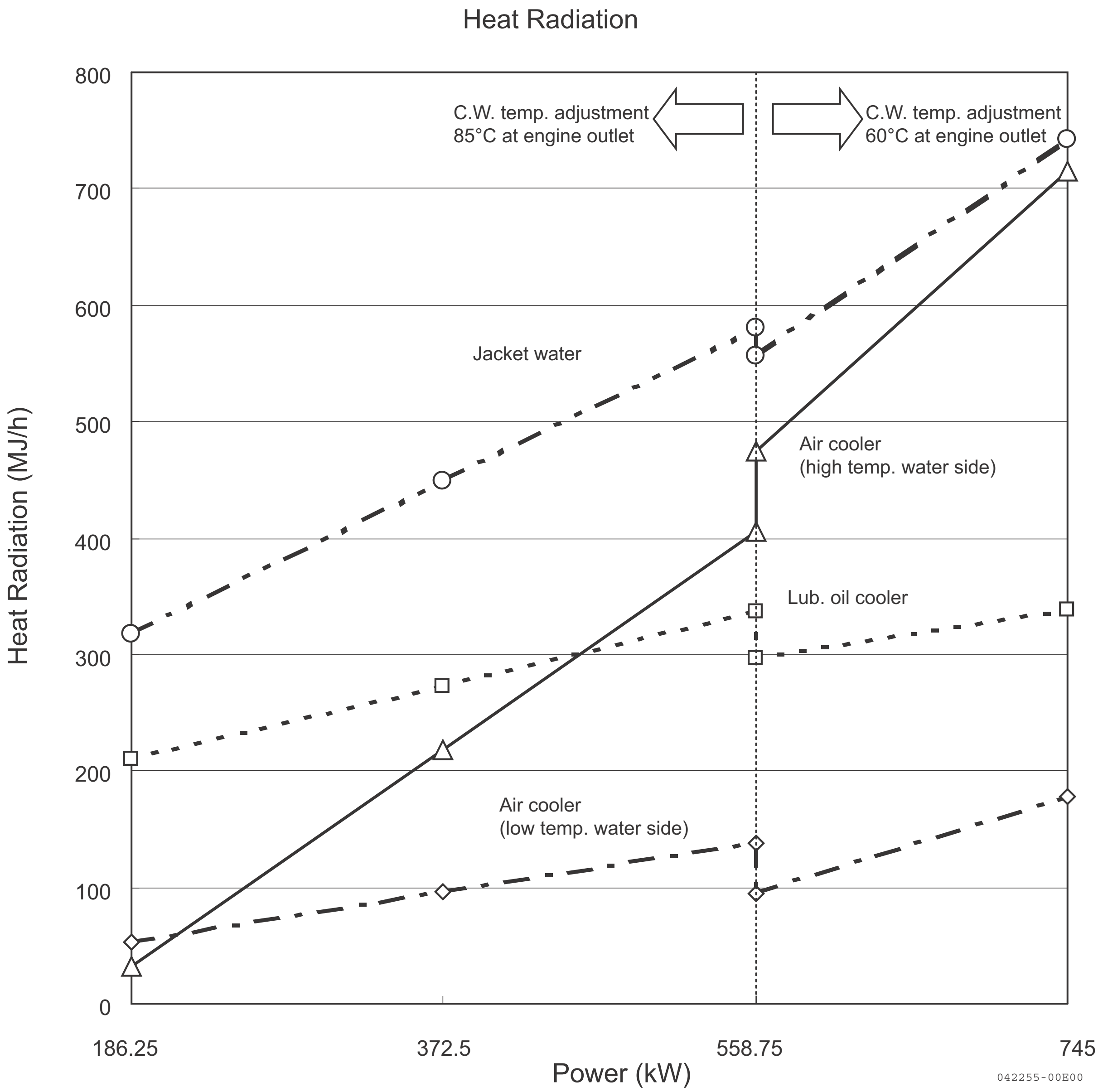
1.1 800 kW/900 min^{-1}, 1000 min^{-1}



	Quantity of Heat Exchange				
Load ratio (%)	25	50	75	75	100
Power (kW)	200	400	600	600	800
	MJ/h				
Lubricating oil cooler	214.8	282.6	350.4	305.2	350.4
Air cooler (low temp. water)	56.5	101.7	146.9	113.0	203.4
Air cooler (high temp. water)	45.2	246.1	447.0	527.4	785.3
Jacket water	327.8	468.8	609.9	597.8	797.0

Heat Balance

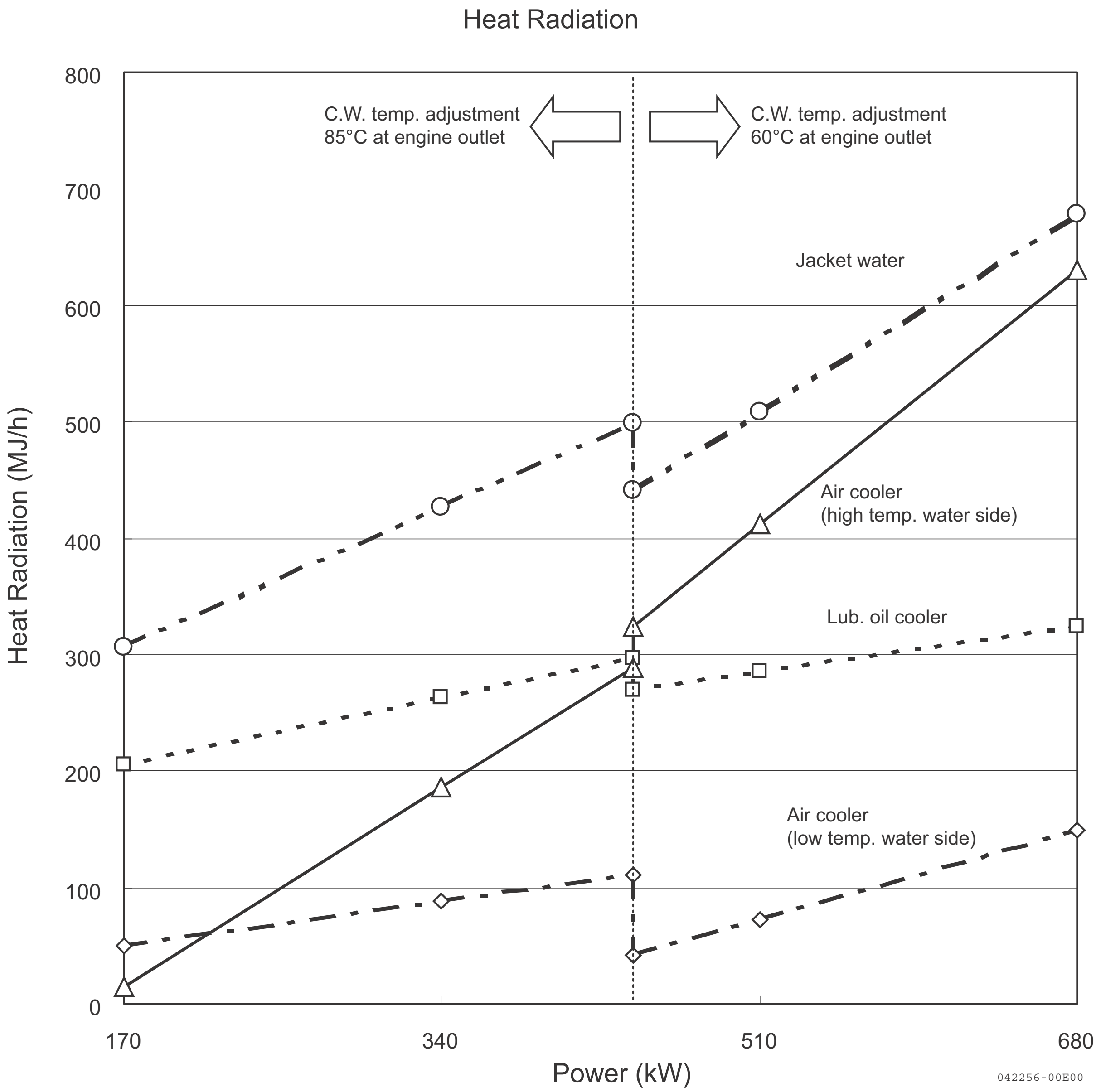
1.2 745 kW/900 min^{-1}, 1000 min^{-1}



	Quantity of Heat Exchange				
Load ratio (%)	25	50	75	75	100
Power (kW)	186.25	372.5	558.75	558.75	745
	MJ/h				
Lubricating oil cooler	210.1	273.2	336.4	295.8	337.9
Air cooler (low temp. water)	53.4	95.5	137.6	94.4	178.6
Air cooler (high temp. water)	31.4	218.5	405.6	474.3	714.4
Jacket water	318.1	449.4	580.8	556.7	742.2

Heat Balance

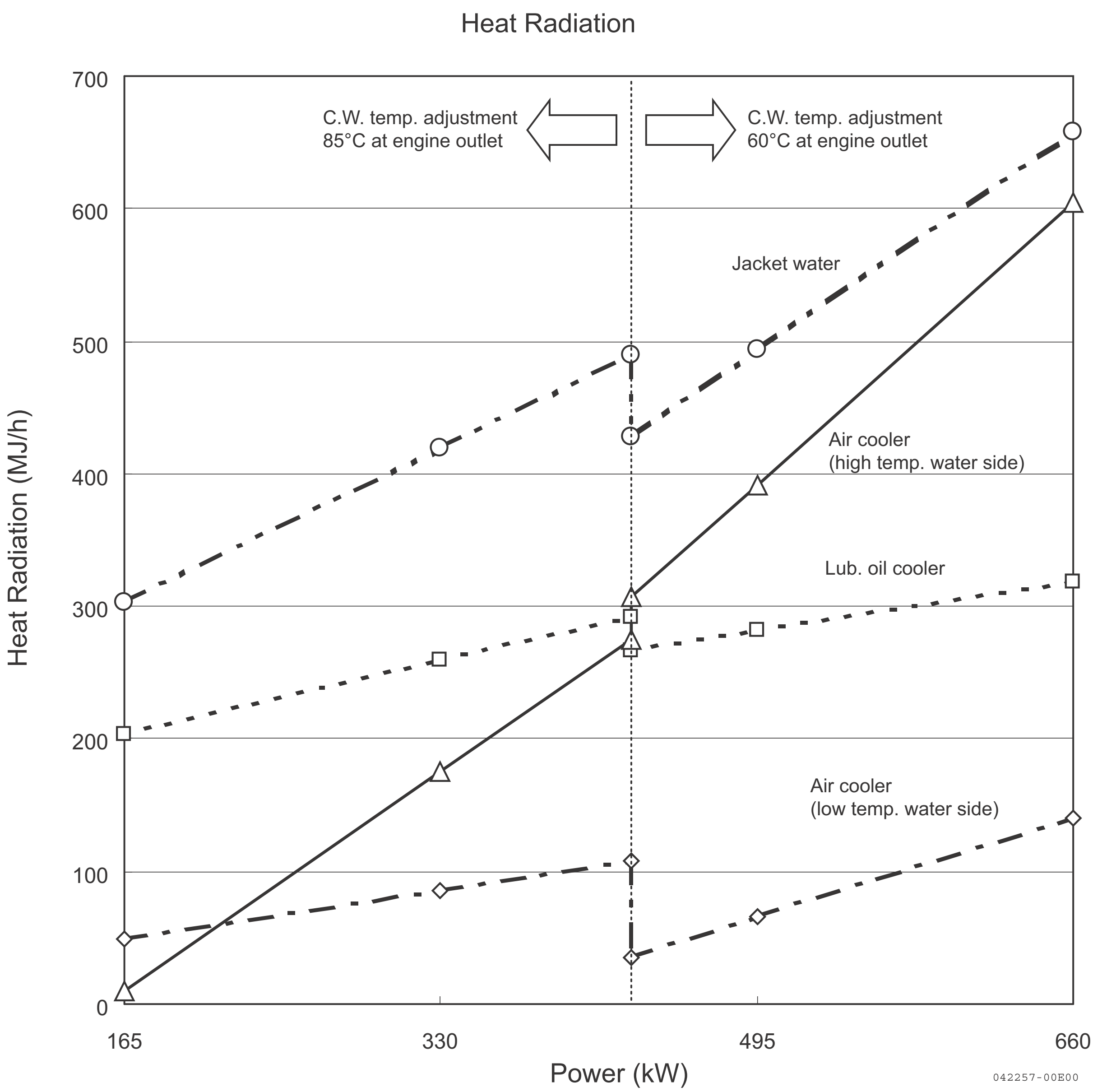
1.3 680 kW/900 min^{-1}, 1000 min^{-1}



	Quantity of Heat Exchange					
Load ratio (%)	25	50	65	65	75	100
Power (kW)	170	340	442	442	510	680
	MJ/h					
Lubricating oil cooler	204.6	262.2	296.8	269.4	284.8	323.2
Air cooler (low temp. water)	49.7	88.1	111.2	41.6	72.3	149.2
Air cooler (high temp. water)	15.1	185.8	288.3	323.7	411.4	630.6
Jacket water	306.6	426.5	498.4	440.4	508.1	677.5

Heat Balance

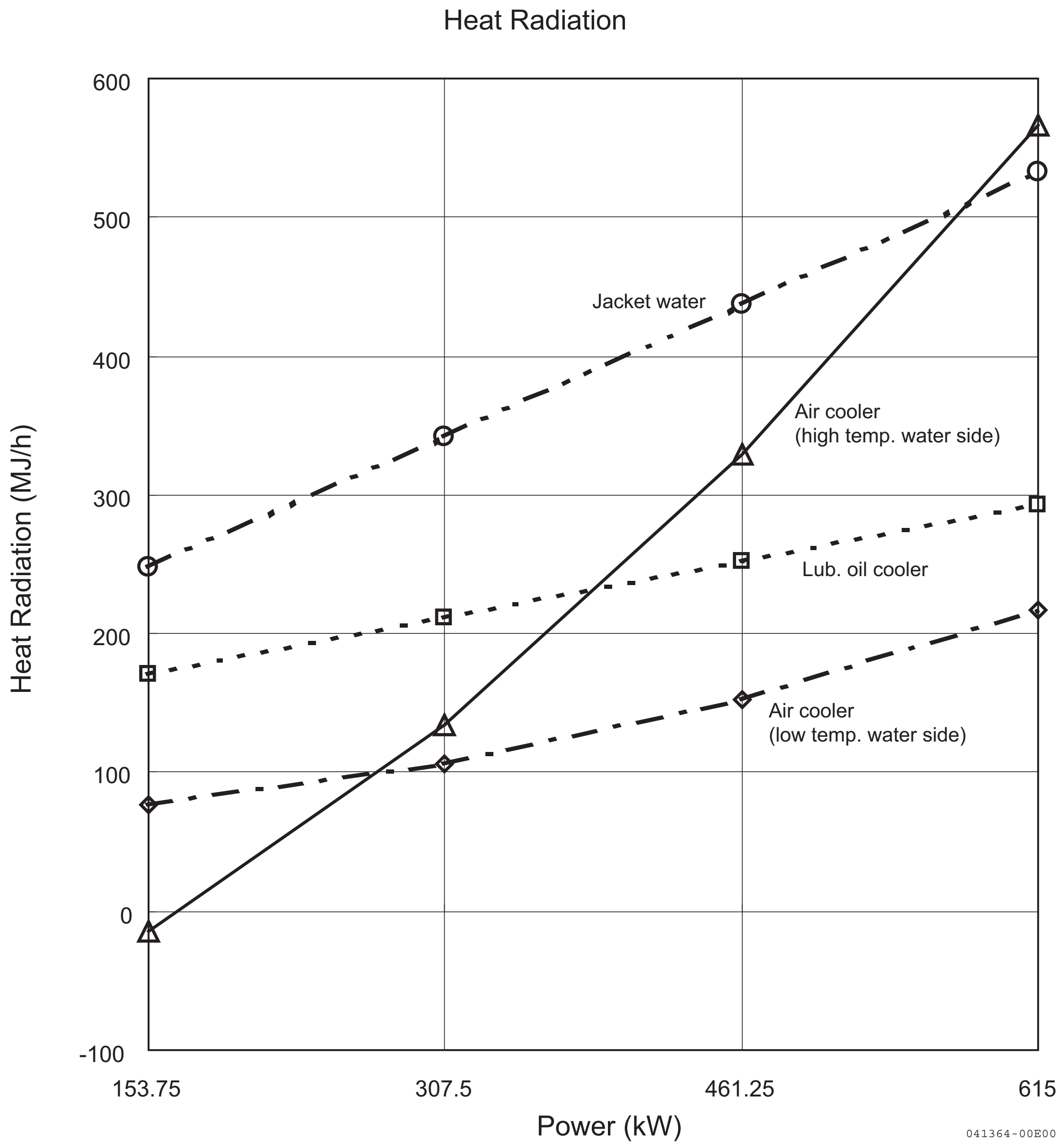
1.4 660 kW/900 min^{-1}, 1000 min^{-1}



	Quantity of Heat Exchange					
Load ratio (%)	25	50	65	65	75	100
Power (kW)	165	330	429	429	495	660
	MJ/h					
Lubricating oil cooler	202.9	258.8	292.4	266.5	281.4	318.7
Air cooler (low temp. water)	48.6	85.9	108.3	35.7	65.6	140.1
Air cooler (high temp. water)	10.0	175.8	275.3	307.0	392.1	604.8
Jacket water	303.1	419.4	489.3	427.4	493.2	657.5

Heat Balance

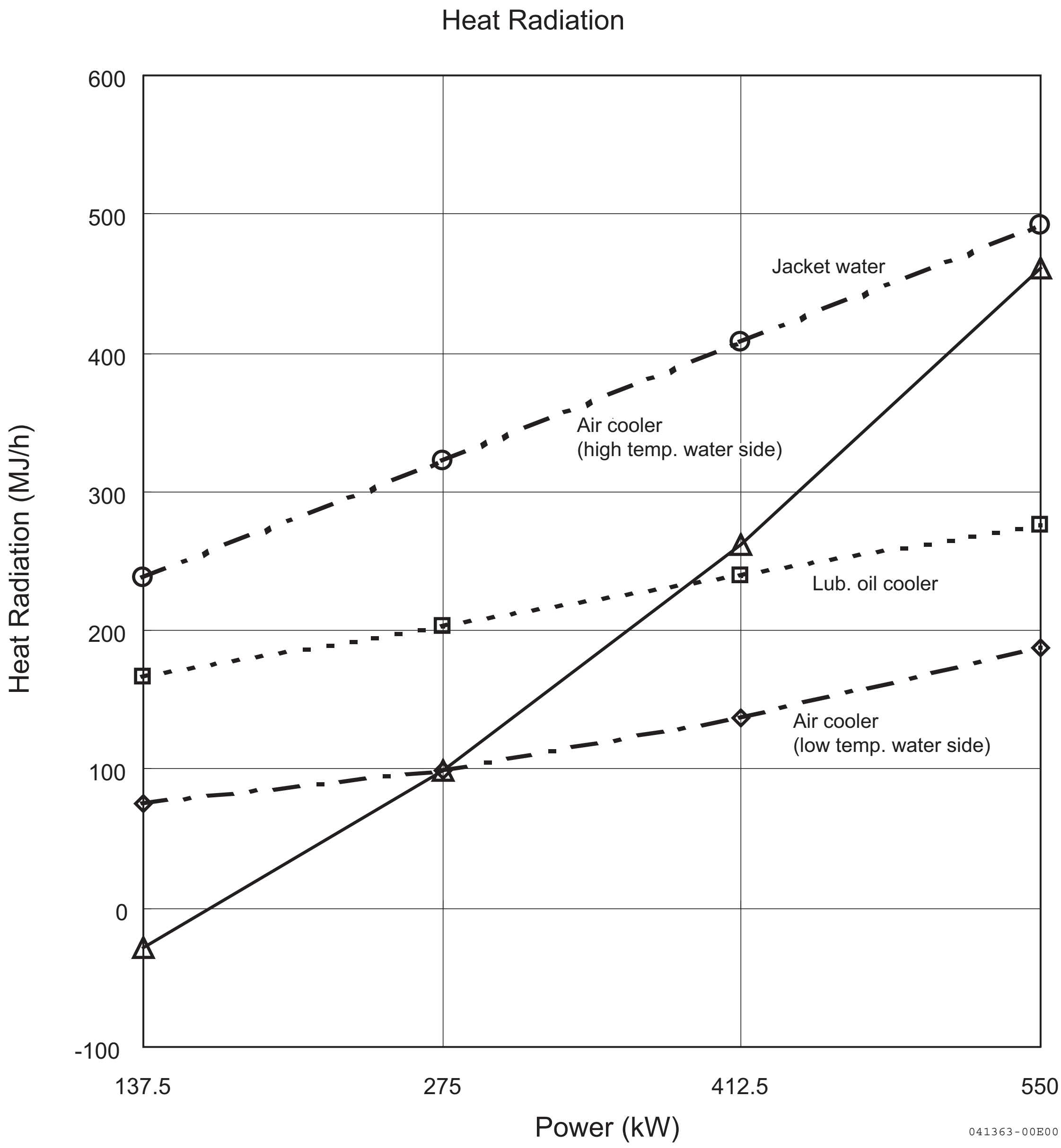
1.5 615 kW/900 min^{-1}, 1000 min^{-1}



	Quantity of Heat Exchange			
Load ratio (%)	25	50	75	100
Power (kW)	153.75	307.5	461.25	615
	MJ/h			
Lubricating oil cooler	170.7	211.3	252.0	292.7
Air cooler (low temp. water)	77.4	106.8	153.1	216.4
Air cooler (high temp. water)	-14.7	134.5	328.9	567.0
Jacket water	247.5	342.5	437.4	532.3

Heat Balance

1.6 550 kW/900 min^{-1}, 1000 min^{-1}

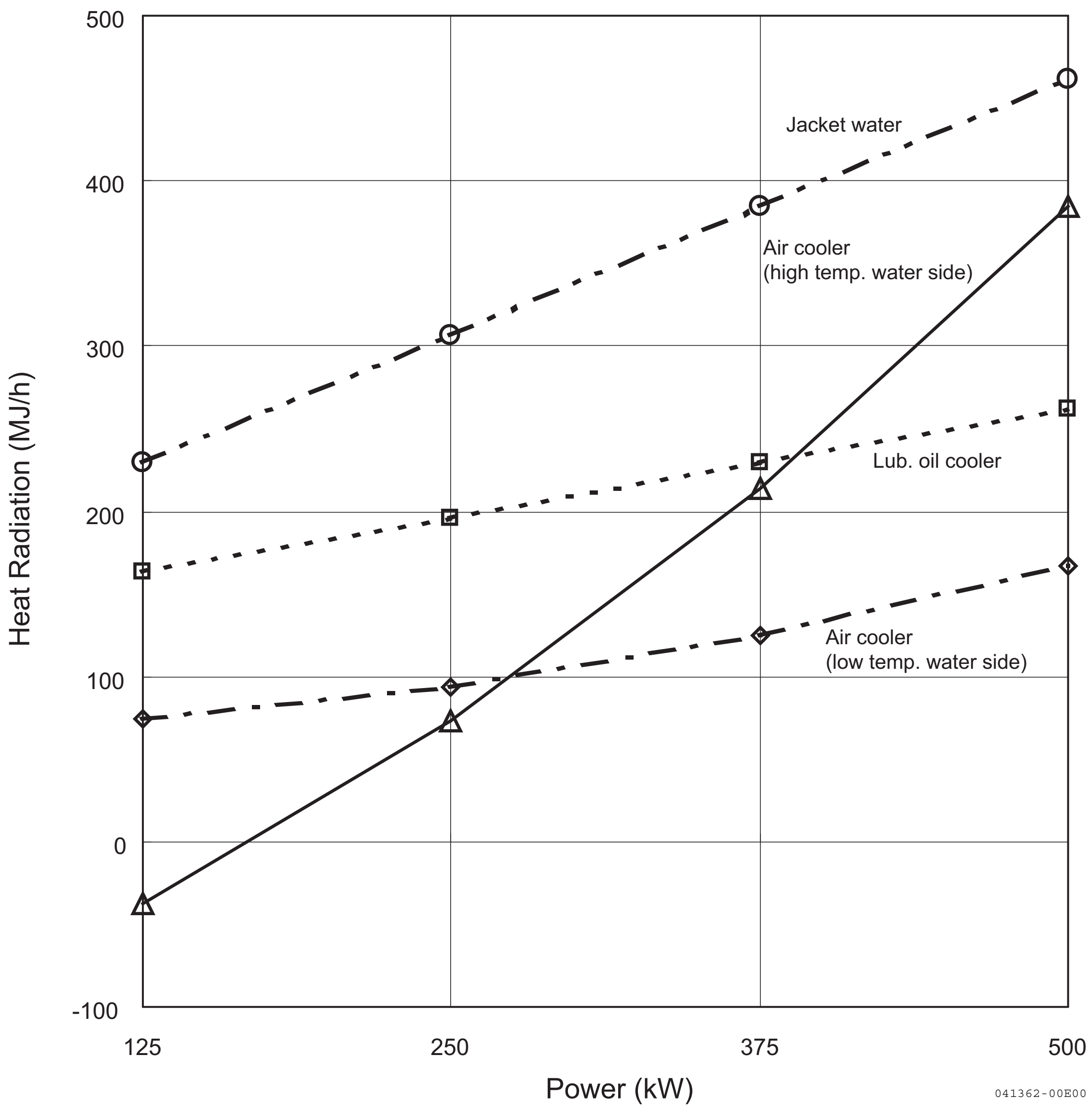


	Quantity of Heat Exchange			
Load ratio (%)	25	50	75	100
Power (kW)	137.5	275	412.5	550
	MJ/h			
Lubricating oil cooler	166.4	202.7	239.1	275.5
Air cooler (low temp. water)	75.3	99.2	136.6	187.6
Air cooler (high temp. water)	-27.8	99.2	262.4	461.2
Jacket water	237.5	322.4	407.3	492.2

Heat Balance

1.7 500 kW/900 min^{-1}, 1000 min^{-1}

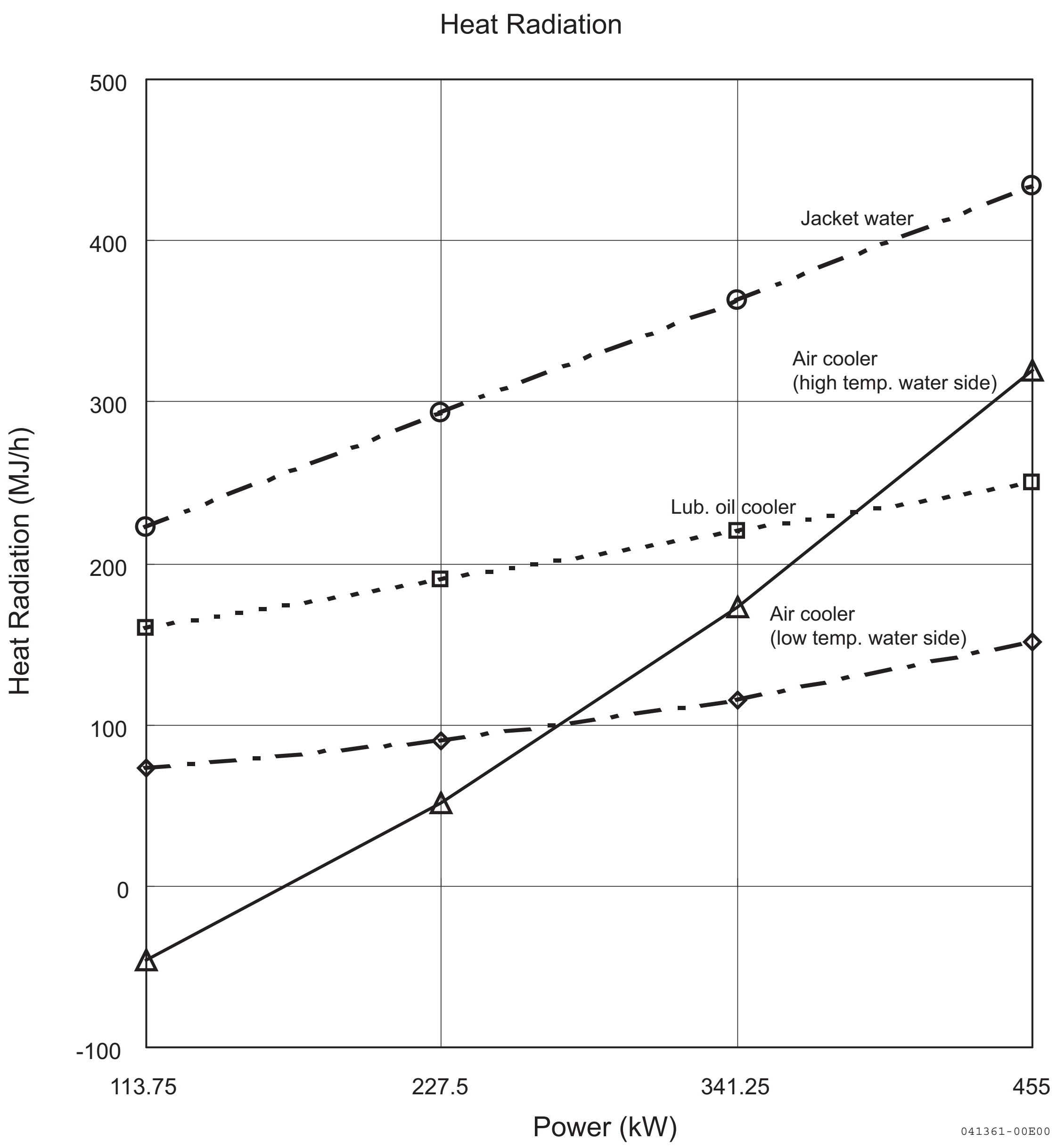
Heat Radiation



	Quantity of Heat Exchange			
Load ratio (%)	25	50	75	100
Power (kW)	125	250	375	500
	MJ/h			
Lubricating oil cooler	163.1	196.1	229.2	262.3
Air cooler (low temp. water)	73.8	93.8	125.1	167.5
Air cooler (high temp. water)	-37.6	73.4	214.3	384.0
Jacket water	229.8	307.0	384.1	461.3

Heat Balance

1.8 455 kW/900 min^{-1}, 1000 min^{-1}

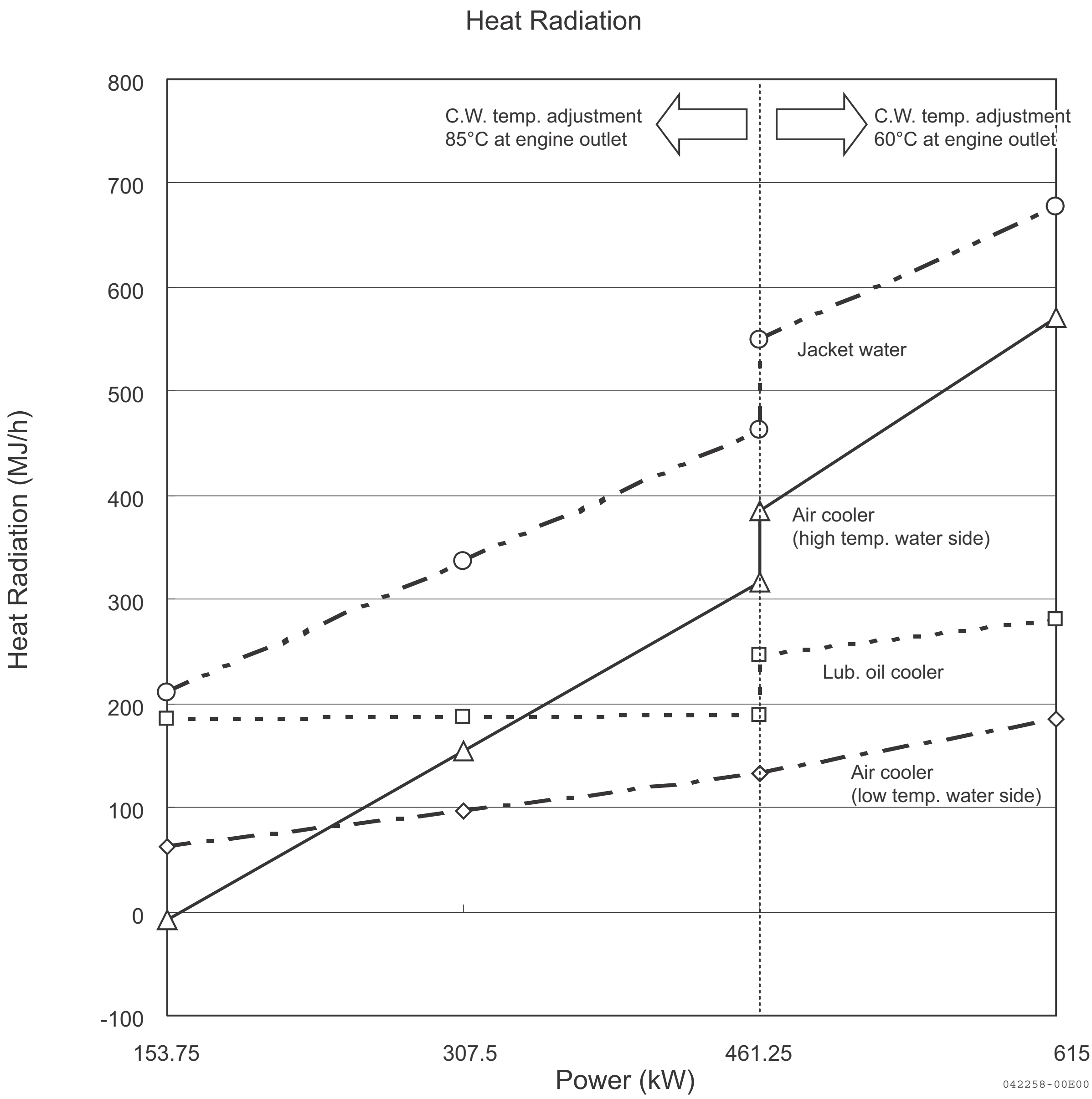


	Quantity of Heat Exchange			
Load ratio (%)	25	50	75	100
Power (kW)	113.75	227.5	341.25	455
	MJ/h			
Lubricating oil cooler	160.1	190.2	220.3	250.4
Air cooler (low temp. water)	72.6	89.4	115.5	150.9
Air cooler (high temp. water)	-46.1	51.2	173.3	319.1
Jacket water	222.8	293.1	363.3	433.5

Heat Balance

2. Model 6EY18LW

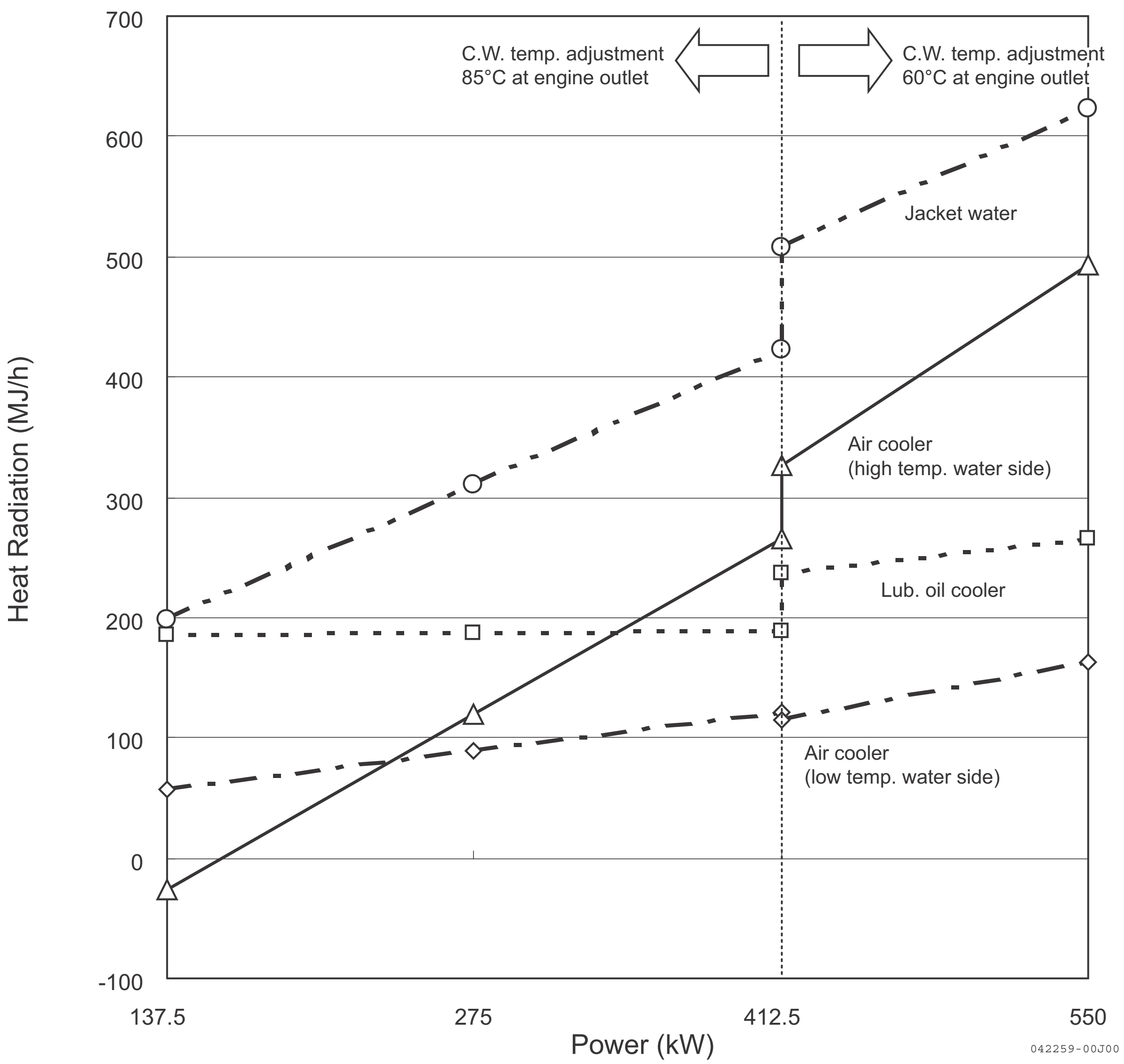
2.1 615 kW/720 min^{-1}, 750 min^{-1}



	Quantity of Heat Exchange				
Load ratio (%)	25	50	75	75	100
Power (kW)	153.75	307.5	461.3	461.25	615
	MJ/h				
Lubricating oil cooler	185.9	187.2	188.5	247.1	280.3
Air cooler (low temp. water)	61.5	96.7	131.9	131.8	184.6
Air cooler (high temp. water)	-8.8	154.0	316.9	385.1	571.4
Jacket water	211.0	337.0	463.0	548.8	676.9

2.2 550 kW/720 min^{-1}, 750 min^{-1}

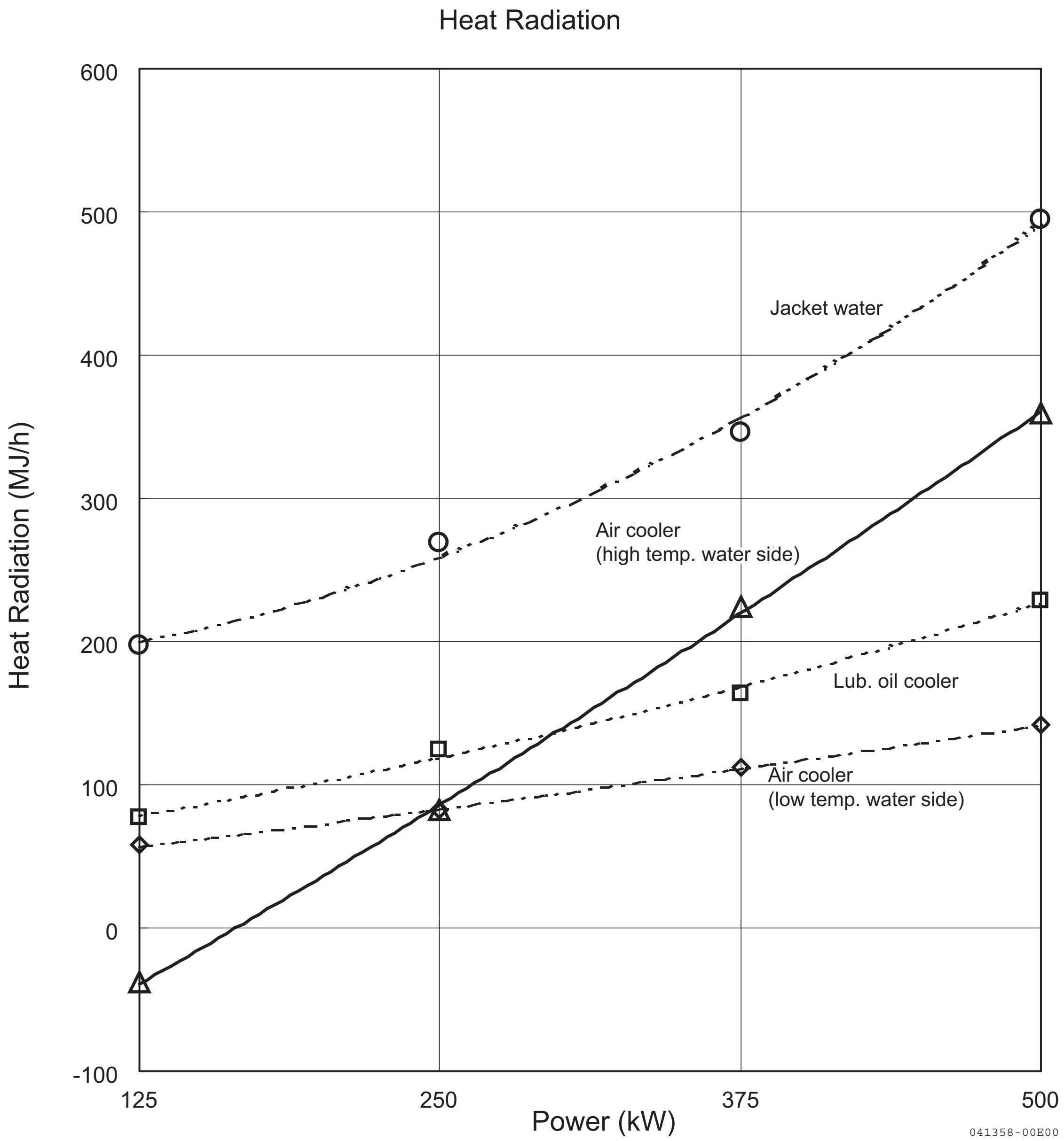
Heat Radiation



	Quantity of Heat Exchange				
Load ratio (%)	25	50	75	75	100
Power (kW)	137.5	275	412.5	412.5	550
	MJ/h				
Lubricating oil cooler	185.7	186.9	188.1	236.6	266.3
Air cooler (low temp. water)	57.8	89.3	120.7	115.1	162.3
Air cooler (high temp. water)	-26.0	119.6	265.2	326.1	492.7
Jacket water	197.7	310.3	423.0	508.2	622.7

Heat Balance

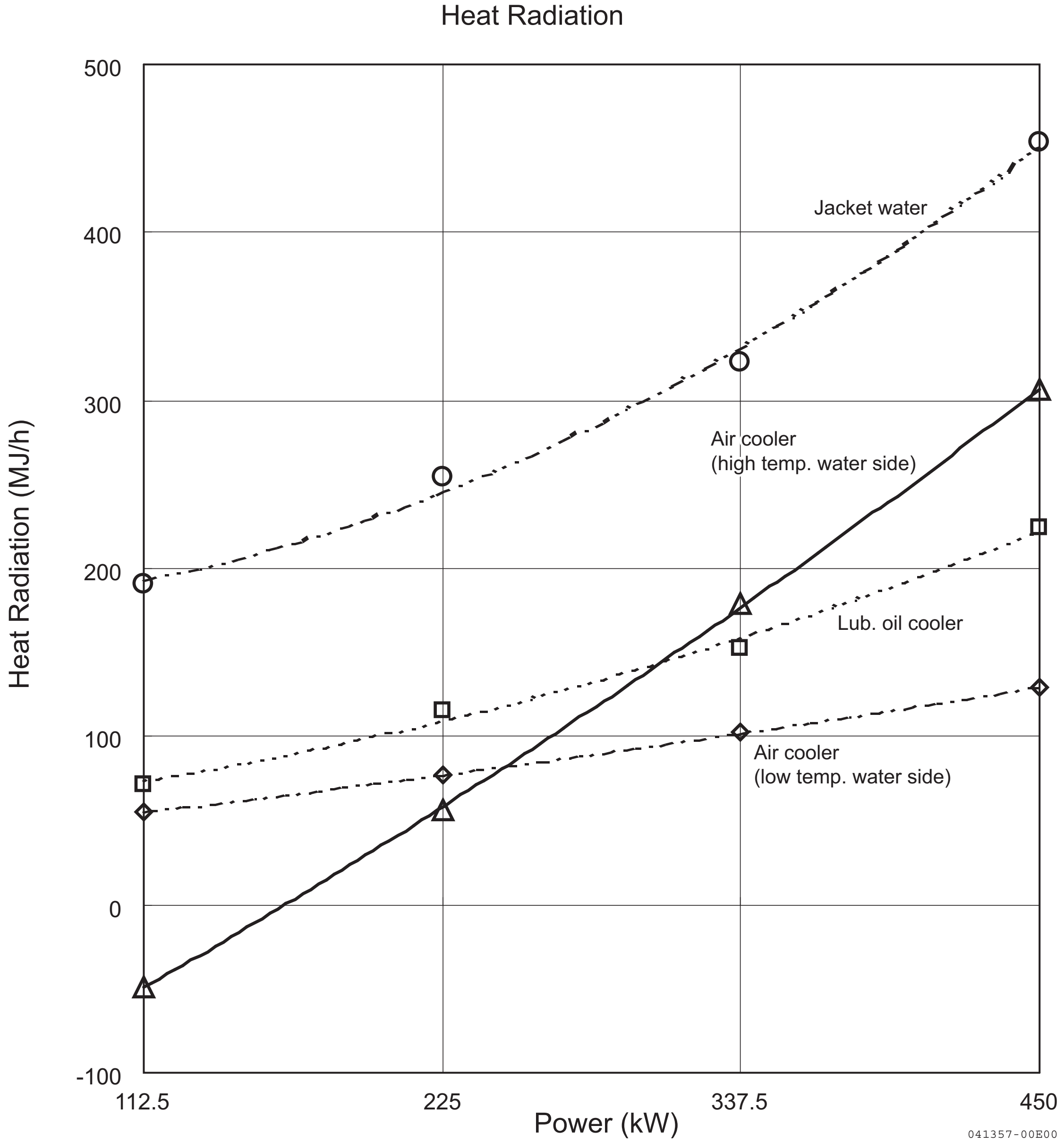
2.3 500 kW/720 min^{-1}, 750 min^{-1}



	Quantity of Heat Exchange			
Load ratio (%)	25	50	75	100
Power (kW)	125	250	375	500
	MJ/h			
Lubricating oil cooler	76.9	124.7	163.1	229.0
Air cooler (low temp. water)	57.7	82.1	112.7	141.4
Air cooler (high temp. water)	-38.1	81.9	223.8	359.4
Jacket water	197.2	268.7	346.5	495.0

Heat Balance

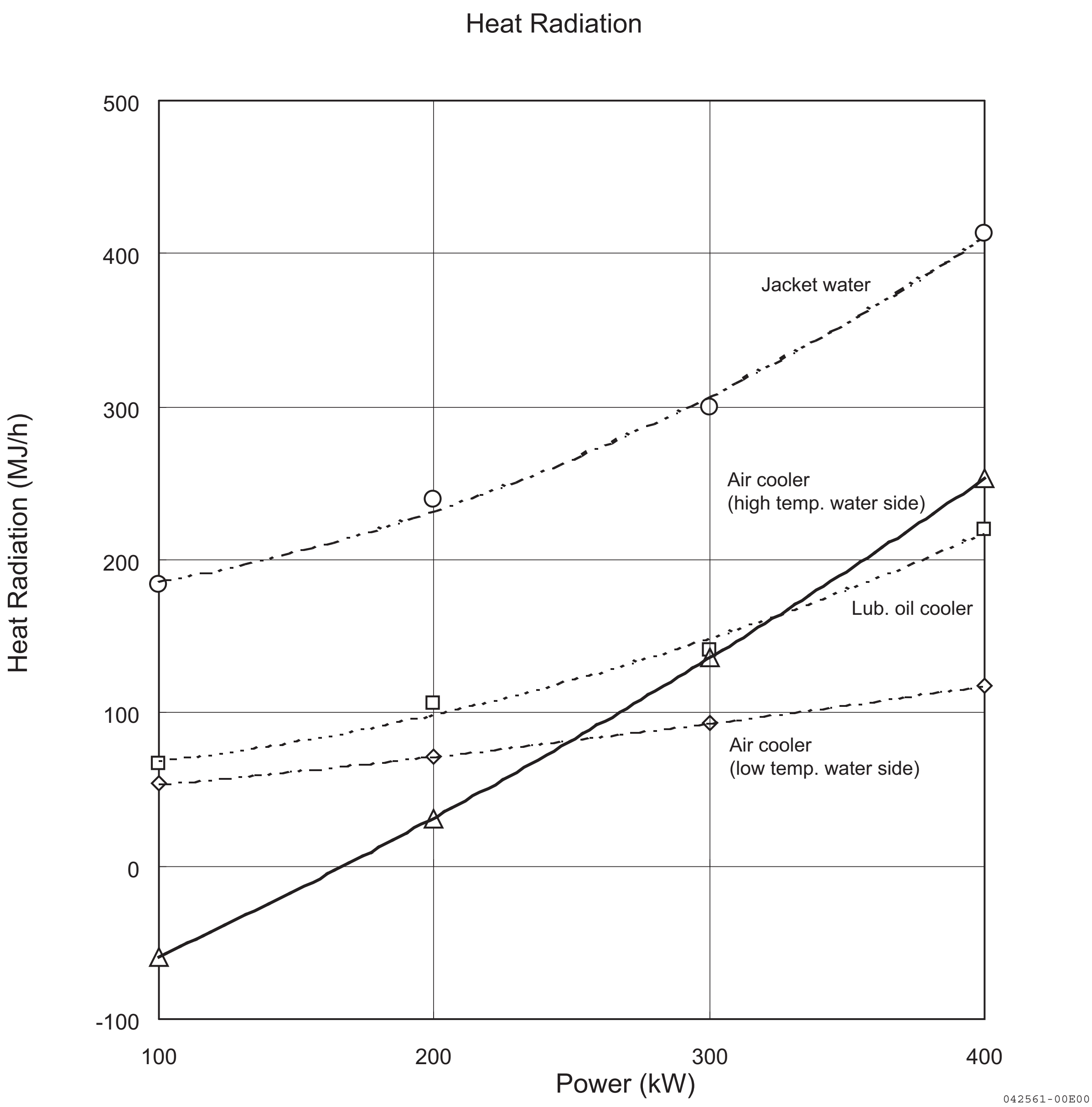
2.4 450 kW/720 min^{-1}, 750 min^{-1}



	Quantity of Heat Exchange			
Load ratio (%)	25	50	75	100
Power (kW)	112.5	225	337.5	450
	MJ/h			
Lubricating oil cooler	71.6	115.9	152.5	224.4
Air cooler (low temp. water)	55.6	76.7	102.9	129.4
Air cooler (high temp. water)	-48.9	56.1	178.9	306.2
Jacket water	190.3	253.9	322.5	454.1

Heat Balance

2.5 400 kW/720 min^{-1}, 750 min^{-1}



	Quantity of Heat Exchange			
Load ratio (%)	25	50	75	100
Power (kW)	100	200	300	400
	MJ/h			
Lubricating oil cooler	66.2	106.7	141.2	220.0
Air cooler (low temp. water)	53.6	71.6	93.6	118.0
Air cooler (high temp. water)	-59.5	31.3	136.0	253.0
Jacket water	183.6	239.3	299.1	413.0

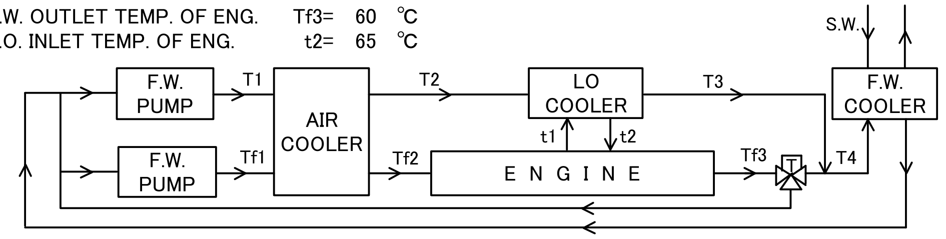
Heat Balance

(For reference) The calculation for heat balance

MODEL: 6EY18ALW DIESEL ENGINE (800 kW/900 min^{-1})

1. SYSTEM DIAGRAM FOR HEAT BALANCE (MIXED COOLING SYSTEM) (NOx LEVEL:IMO REG. TIER2)

F.W. LOW TEMP. T1= 38 ℃
F.W. OUTLET TEMP. OF ENG. Tf3= 60 ℃
L.O. INLET TEMP. OF ENG. t2= 65 ℃



2. CALCULATION

2-1. QUANTITY OF HEAT TRANSMISSION

TO L.O :	$Q1$	=	350	MJ/h
TO AIR :	$Q2_L$	=	203	MJ/h
:	$Q2_H$	=	785	MJ/h
TO F.W :	$Q3$	=	797	MJ/h

2-2. FRESHWATER SYSTEM (F.W.)

F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF AIR COOLER	$\Delta T1$	=	$\dfrac{Q2_L}{V * Rf * Cf}$	=	1.8 ℃
F.W. OUTLET TEMP. OF AIR COOLER	$T2$	=	$T1 + \Delta T1$	=	39.8 ℃
F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF L.O. COOLER	$\Delta T2$	=	$\dfrac{Q1}{V * Rf * Cf}$	=	3.1 ℃
F.W. OUTLET TEMP. OF L.O. COOLER	$T3$	=	$T2 + \Delta T2$	=	42.9 ℃
F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF ENGINE	$\Delta Tf2$	=	$\dfrac{Q3}{Vf * Rf * Cf}$	=	7.0 ℃
F.W. INLET TEMP. OF ENGINE	$Tf2$	=	$Tf3 - \Delta Tf2$	=	53.0 ℃
F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF AIR COOLER	$\Delta Tf1$	=	$\dfrac{Q2_H}{Vf * Rf * Cf}$	=	6.9 ℃
F.W. INLET TEMP. OF AIR COOLER	$Tf1$	=	$Tf2 - \Delta Tf1$	=	46.0 ℃
F.W. CAPA. TO F.W. COOLER	Vc	=	$V + \dfrac{Q3+Q2_H}{(Tf3 - T1) * Rf * Cf}$	=	44.2 m^3/h
F.W. INLET TEMP. OF F.W. COOLER	$T4$	=	$\dfrac{T3 * V + Tf3 * (Vc-V)}{Vc}$	=	49.5 ℃

2-3. LUBRICATING OIL SYSTEM (L.O.)

L.O. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF L.O. COOLER	Δt	=	$\dfrac{Q1}{Vl * Rl * Cl}$	=	9.7 ℃
L.O. INLET TEMP. OF L.O. COOLER	$t1$	=	$t2 + \Delta t$	=	74.7 ℃
L.O. & F.W. MEAN TEMP. DIFFERENCE OF L.O. COOLER	Δtm	=	$\dfrac{(t1-T2) - (t2-T3)}{2.3\mathrm{Log}((t1-T2)/(t2-T3))}$	=	28.0 ℃
COOLING AREA OF L.O. COOLER	A	=	$\dfrac{Q1}{\Delta tm * K}$	=	6.78 m^2 < 8.70 m^2

V	F.W. PUMP CAPA. FOR COOLER	27.0	m^3/h
Vf	F.W. PUMP CAPA. FOR ENGINE	27.0	m^3/h
Rf	DENSITY OF F.W.	1000	kg/m^3
Cf	SPECIFIC HEAT OF F.W.	4.19	kJ/(kg･℃)
Vl	L.O PUMP CAPACITY	21.4	m^3/h
Rl	DENSITY OF L.O.	900	kg/m^3
Cl	SPECIFIC HEAT OF L.O.	1.88	kJ/(kg･℃)
K	OVERALL HEAT TRANSFER COEFFICIENT OF L.O. COOLER	1.84	MJ/(m^2･℃･h)

DWG. NO. D2-46623-0571

041374-00E00

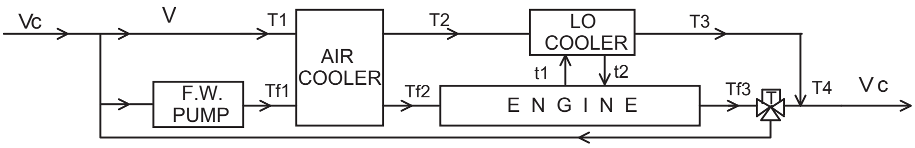
Heat Balance

(For reference) The calculation for heat balance

MODEL: 6EY18ALW DIESEL ENGINE (800 kW/900 min^{-1})

1. SYSTEM DIAGRAM FOR HEAT BALANCE (MIXED COOLING SYSTEM) (NOx LEVEL:IMO REG. TIER2)

F.W. LOW TEMP.	T1= 38	℃
F.W. OUTLET TEMP. OF ENG.	Tf3= 60	℃
L.O. INLET TEMP. OF ENG.	t2= 65	℃



2. CALCULATION

2-1. QUANTITY OF HEAT TRANSMISSION

TO L.O.	: Q1 =	350	MJ/h
TO AIR	: $Q2_L$ =	203	MJ/h
	: $Q2_H$ =	785	MJ/h
TO F.W.	: Q3 =	797	MJ/h

2-2. FRESHWATER SYSTEM (F.W.)

F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF AIR COOLER	$\Delta T1 = \dfrac{Q2_L}{V * Rf * Cf}$	= 1.8 ℃
F.W. OUTLET TEMP. OF AIR COOLER	$T2 = T1 + \Delta T1$	= 39.8 ℃
F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF L.O. COOLER	$\Delta T2 = \dfrac{Q1}{V * Rf * Cf}$	= 3.1 ℃
F.W. OUTLET TEMP. OF L.O. COOLER	$T3 = T2 + \Delta T2$	= 42.9 ℃
F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF ENGINE	$\Delta Tf2 = \dfrac{Q3}{Vf * Rf * Cf}$	= 7.0 ℃
F.W. INLET TEMP. OF ENGINE	$Tf2 = Tf3 - \Delta Tf2$	= 53.0 ℃
F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF AIR COOLER	$\Delta Tf1 = \dfrac{Q2_H}{Vf * Rf * Cf}$	= 6.9 ℃
F.W. INLET TEMP. OF AIR COOLER	$Tf1 = Tf2 - \Delta Tf1$	= 46.0 ℃
F.W. CAPA. TO F.W. COOLER	$Vc = V + \dfrac{Q3+Q2_H}{(Tf3 - T1) * Rf * Cf}$	= 44.2 m^3/h
F.W. INLET TEMP. OF F.W. COOLER	$T4 = \dfrac{T3 * V + Tf3 * (Vc-V)}{Vc}$	= 49.5 ℃

2-3. LUBRICATING OIL SYSTEM (L.O.)

L.O. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF L.O. COOLER	$\Delta t = \dfrac{Q1}{Vl * Rl * Cl}$	= 9.7 ℃
L.O. INLET TEMP. OF L.O. COOLER	$t1 = t2 + \Delta t$	= 74.7 ℃
L.O. & F.W. MEAN TEMP. DIFFERENCE OF L.O. COOLER	$\Delta tm = \dfrac{(t1-T2) - (t2-T3)}{2.3Log((t1-T2)/(t2-T3))}$	= 28.0 ℃
COOLING AREA OF L.O. COOLER	$A = \dfrac{Q1}{\Delta tm * K}$	= 6.78 m^2 < 8.70 m^2

V	F.W. FLOW CAPA. FOR COOLER	27.0 m^3/h
Vf	F.W. PUMP CAPA. FOR ENGINE	27.0 m^3/h
Rf	DENSITY OF F.W.	1000 kg/m^3
Cf	SPECIFIC HEAT OF F.W.	4.19 kJ/(kg・℃)
Vl	L.O PUMP CAPACITY	21.4 m^3/h
Rl	DENSITY OF L.O.	900 kg/m^3
Cl	SPECIFIC HEAT OF L.O.	1.88 kJ/(kg・℃)
K	OVERALL HEAT TRANSFER COEFFICIENT OF L.O. COOLER	1.84 MJ/(m^2・℃・h)

DWG. NO. D3-46623-1141

041375-00E00

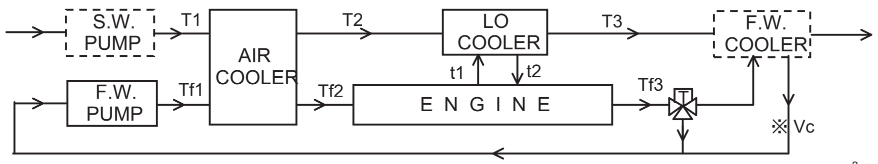
Heat Balance

(For reference) The calculation for heat balance

MODEL: 6EY18ALW DIESEL ENGINE (800 kW/900 min^{-1})

1. SYSTEM DIAGRAM FOR HEAT BALANCE (F.W.-S.W. COOLING SYSTEM)
(NOx LEVEL:IMO REG. TIER2)

S.W. LOW TEMP.	T1= 32	℃
F.W. OUTLET TEMP. OF ENG.	Tf3= 60	℃
L.O. INLET TEMP. OF ENG.	t2= 65	℃



※ Vc : Max. 27m^3/h

2. CALCULATION

2-1. QUANTITY OF HEAT TRANSMISSION

TO L.O.	: $Q1$ =	350	MJ/h
TO AIR	: $Q2_L$ =	203	MJ/h
	: $Q2_H$ =	785	MJ/h
TO F.W.	: $Q3$ =	797	MJ/h

2-2. SEAWATER SYSTEM (S.W.)

S.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF AIR COOLER $\Delta T1 = \dfrac{Q2_L}{V * R * C} = 1.9$ ℃

S.W. OUTLET TEMP. OF AIR COOLER $T2 = T1 + \Delta T1 = 33.9$ ℃

S.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF L.O. COOLER $\Delta T2 = \dfrac{Q1}{V * R * C} = 3.2$ ℃

S.W. OUTLET TEMP. OF L.O. COOLER $T3 = T2 + \Delta T2 = 37.1$ ℃

2-3. FRESHWATER SYSTEM (F.W.)

F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF ENGINE $\Delta Tf2 = \dfrac{Q3}{Vf * Rf * Cf} = 7.0$ ℃

F.W. INLET TEMP. OF ENGINE $Tf2 = Tf3 - \Delta Tf\ 2 = 53.0$ ℃

F.W. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF AIR COOLER $\Delta Tf1 = \dfrac{Q2_H}{Vf * Rf * Cf} = 6.9$ ℃

F.W. INLET TEMP. OF AIR COOLER $Tf1 = Tf2 - \Delta Tf\ 1 = 46.0$ ℃

Q3+Q2

2-4. LUBRICATING OIL SYSTEM (L.O.)

L.O. TEMP. DIFFERENCE BETWEEN INLET & OUTLET OF L.O. COOLER $\Delta t = \dfrac{Q1}{Vl * Rl * Cl} = 9.7$ ℃

L.O. INLET TEMP. OF L.O. COOLER $t1 = t2 + \Delta t = 74.7$ ℃

L.O. & F.W. MEAN TEMP. DIFFERENCE OF L.O. COOLER $\Delta tm = \dfrac{(t1-T2) - (t2-T3)}{2.3 Log((t1-T2)/(t2-T3))} = 34.0$ ℃

COOLING AREA OF L.O. COOLER $A = \dfrac{Q1}{\Delta tm * K} = 5.60\ m^2 < 7.10\ m^2$

V	S.W. PUMP CAPA. FOR COOLER	27.0	m^3/h
R	DENSITY OF S.W.	1025	kg/m^3
C	SPECIFIC HEAT OF S.W.	3.93	kJ/(kg・℃)
Vf	F.W. PUMP CAPA. FOR ENGINE	27.0	m^3/h
Rf	DENSITY OF F.W.	1000	kg/m^3
Cf	SPECIFIC HEAT OF F.W.	4.19	kJ/(kg・℃)
Vl	L.O PUMP CAPACITY	21.4	m^3/h
Rl	DENSITY OF L.O.	900	kg/m^3
Cl	SPECIFIC HEAT OF L.O.	1.88	kJ/(kg・℃)
K	OVERALL HEAT TRANSFER COEFFICIENT OF L.O. COOLER	1.84	MJ/(m^2・℃・h)

DWG. NO.	D3-46623-1401

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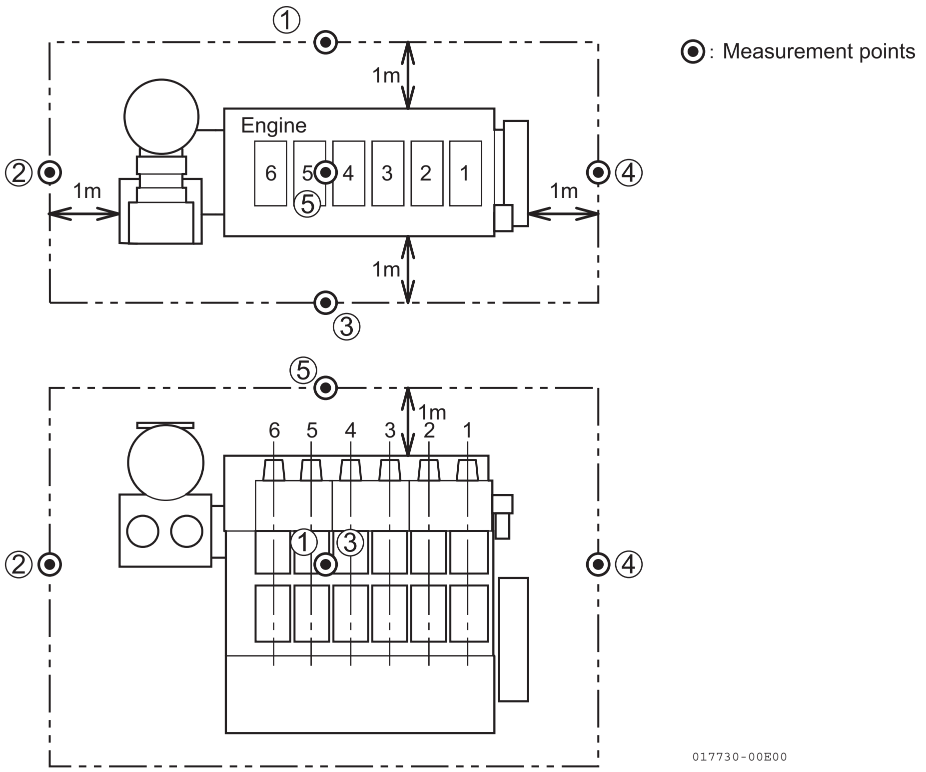
Measurement of Noise

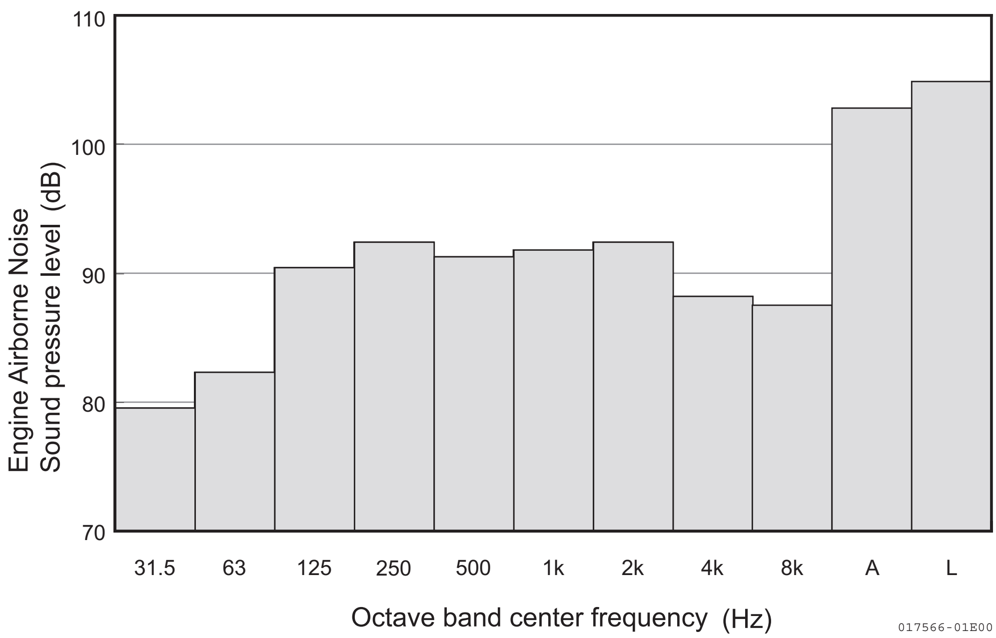
1. Measurement Positions and Noise Level

The measurement positions of noise are marked in the following diagram.
Noise must be 104 dB(A) or below (after correcting the background noise).



2. Spectrum Level (For Reference)

The noise spectrum level at the above ③ in 800 kW/900 min^{-1} is as follows (before correcting the environment).



Exhaust Gas Emissions

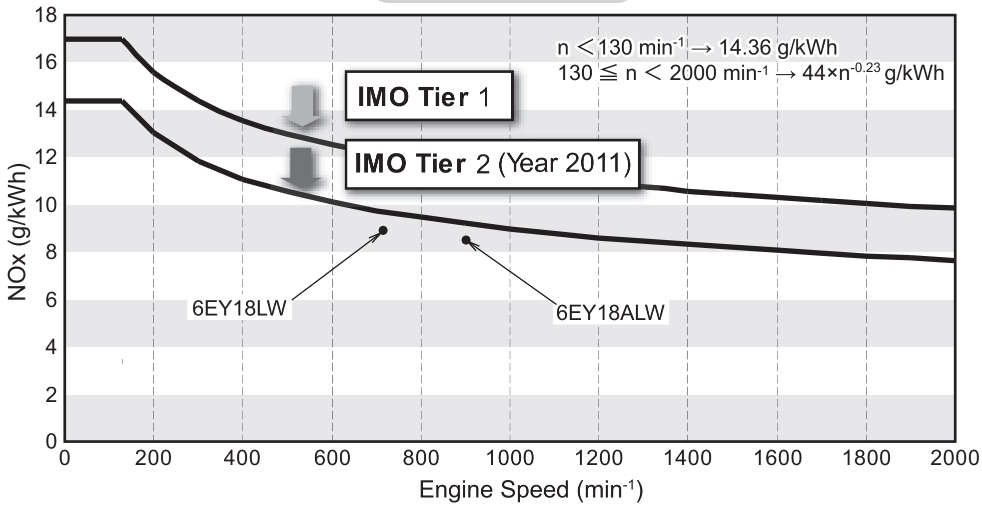
1. Exhaust Gas Emissions

The exhaust gas, although in extremely small quantities, contains CO_2, NOx, CO, SOx and HC. The exhaust emissions, ultimately, cause acid rains, photochemical smog, air pollutions and global warming. The reduction of exhaust gas emissions now represents an important theme for engine manufacturers.

Notably, the IMO in 1997 adopted a protocol supplementing the existing oceanic pollution prevention treaty with the annex "Regulations on Air Pollution Control Law from Marine Vessels" to prevent air pollution by ships. The regulation on NOx emissions went into effect in May 2005. In October 2008, the revision of the annex was adopted and the tier 2 regulation went into effect on January 1, 2011.

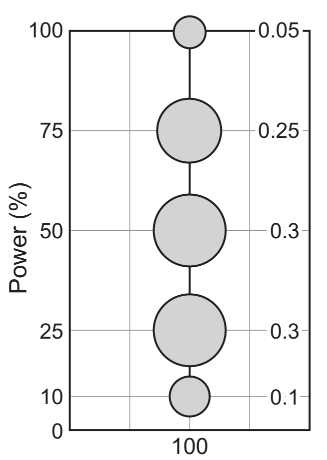
The 6EY18(A)LW is an environmentally-friendly engine and, as other conventional Yanmar engines, employs the ASSIGN combustion system. The 6EY18(A)LW, without the use of special equipment, passes the values set by the IMO NOx emission standards Tier 2. Fuel consumption and exhaust conditions are good.

IMO NOx Regulation



- NOx Regulation Applicable Vessels: Over 400 GRTs
- NOx Regulation Applicable Engines: Diesel engines of over 130 kW power
- NOx Regulation Allowable Limit: NOx limit tier 2 regulated by IMO

D2 Mode Marine Auxiliary



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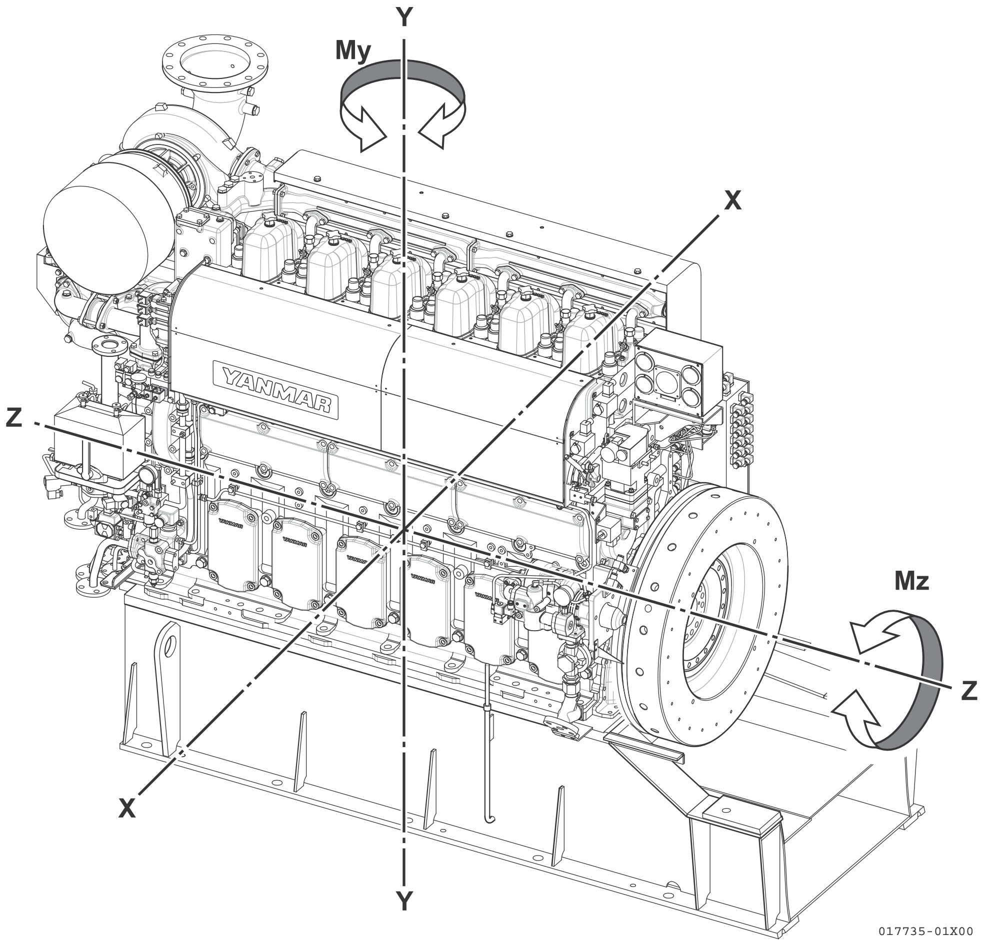
1. External Excitation Forces

The momentum produced by the engine's reciprocation and torque changes and the vibration frequencies are shown in the diagram below. Take care not to cause resonance with the vibration frequencies produced by the hull side.



Engine Model	Engine Speed min^{-1}	Unbalance Forces		Unbalance Momentums										
				Primary		Secondary		Third			Sixth		
		X kN	Y kN	Mz kNm	My kNm	Mz kNm	My kNm	Mz kNm	My kNm	No. of Cycles cpm	Mz kNm	My kNm	No. of Cycles cpm
6EY18 ALW	900	0	0	0	0	0	0	8.07	2.89	2700	2.79	0.56	5400
	1000	0	0	0	0	0	0	5.68	2.73	3000	3.07	0.63	6000
6EY18 LW	720	0	0	0	0	0	0	9.70	2.79	2160	2.92	0.60	4320
	750	0	0	0	0	0	0	9.06	2.74	2250	3.02	0.62	4500

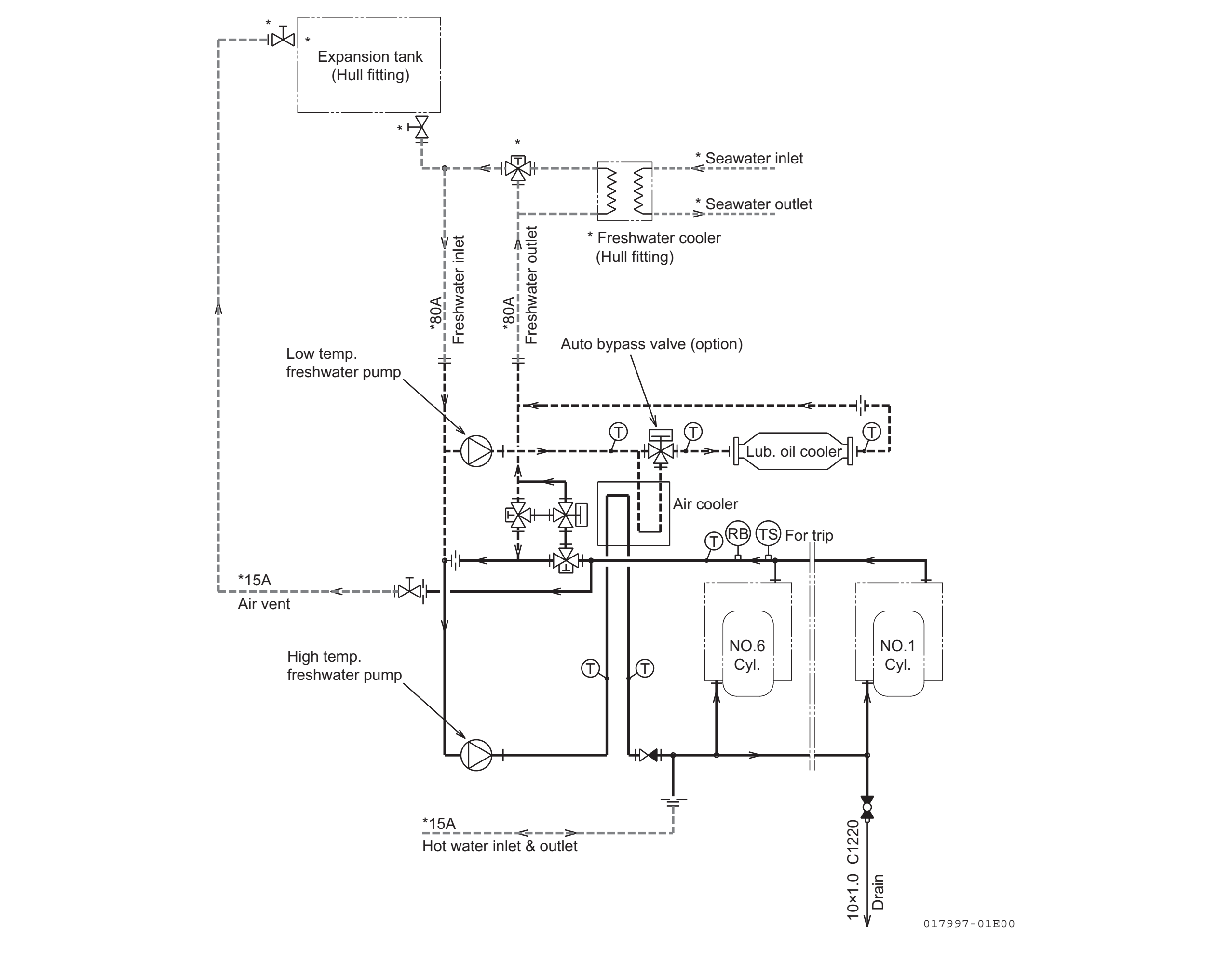
Outline

Equipment for Use with H.F.O. Low Load Operation

1. Freshwater/Freshwater Mixing Cooling System

The 6EY18(A)LW has a dual cooling system: the engine is cooled by high temperature freshwater and the auxiliary equipment is cooled by low temperature freshwater. The air cooler cools the air in two steps, with high temperature freshwater and low temperature freshwater.
As an option for low load operation, an automatic bypass valve can be equipped on the inlet of the low temperature freshwater side of the air cooler.
This valve bypasses the low temperature freshwater, so that the boost air can be heated at the air cooler for long continuous low load operation.

Diagram



2. Allowable Range of Low Load Continuous Operation

Freshwater/freshwater mixing cooling system with boost temp. control equipment	15%
Freshwater/freshwater mixing cooling system without boost temp. control equipment	20%
Freshwater/seawater dual cooling system	25%

Inspection and Maintenance Intervals

(Operation on M.D.O.)

No	Inspection Item		Inspection Interval (Operation Hrs.)	Remarks
1	Fuel injection pump	• Check fuel oil injection timing.	2000−3000	
		• Inspect and replace the deflector.	2000−3000	
		• Disassemble the plunger and barrel. Check the performance.	4000−6000	
2	Fuel injection valve	• Disassemble and clean.	1500−2000	
		• Adjust injection pressure and fuel spray.	1500−2000	
3	Engine system oil	• Check the oil level.	Everyday	
		• Analysis of lub. oil properties.	1000	
4	Lub. oil pump (engine system oil)	• Disassemble and inspect major parts.	8000−12000	
5	Lub. oil cooler	• Disassemble, clean and inspect.	8000−12000	
6	Lub. oil bypass filter (centrifugal)	• Disassemble, clean and inspect.	250−500	
7	Piston	• Overhaul; replace piston rings and oil ring; measure ring grooves and piston outside diameter.	8000−12000	
8	Connecting rod	• Check the crank pin bearing and piston pin bearing.	8000−12000	
9	Cylinder liner	• Remove carbon.	8000−12000	
		• Extract and check the jacket exterior.	16000−24000	
		• Check and measure the sliding surface.	8000−12000	
10	Main bearing	• Check the main bearing.	8000−12000	
11	Crankshaft	• Check the crank pin and journal.	8000−12000	
		• Check and adjust the crank deflection.	2000−3000	
12	Cooling water pump	• Disassemble and check major parts.	8000−12000	
13	Governor	• Disassemble and check the major parts of governor.	8000−12000	
		• Check the performance of fuel oil rack and fuel oil shut-off device.	Monthly	
		• Check the level of governor hydraulic oil.	Everyday	
14	Intake and exhaust valves and cylinder head	• Check and adjust valve head clearance.	1000−1500	
		• Check valve spring.	4000−6000	
		• Disassemble and check valve rotator.	As needed.	
		• Clean and lap intake valve seat.	8000−12000	
		• Check and lap exhaust valve seat.	8000−12000	
		• Check intake valve guide.	8000−12000	
		• Check exhaust valve guide.	8000−12000	
		• Clean the combustion chamber.	8000−12000	

Inspection and Maintenance Intervals

(Operation on M.D.O.)

No	Inspection Item		Inspection Interval (Operation Hrs.)	Remarks
15	Turbocharger	• Pour water to wash blower side.	150−200	
		• Disassemble and clean the blower.	8000−12000	
		• Disassemble and clean the turbine side.	8000−12000	
16	Air cooler	• Disassemble and clean; conduct water pressure test.	8000−12000	
17	Camshaft and tappet	• Disassemble and check fuel oil injection pump tappet and tappet guide.	8000−12000	
		• Check fuel oil cam and intake and exhaust cams.	4000−6000	
		• Check camshaft bearing.	16000−24000	

Inspection and Maintenance Intervals

(Operation on H.F.O.)

No	Inspection Item		Inspection Interval (Operation Hrs.)	Remarks
1	Fuel injection pump	• Check fuel oil injection timing.	2000–3000	
		• Inspect and replace the deflector.	2000–3000	
		• Disassemble the plunger and barrel. Check the performance.	4000–6000	
2	Fuel injection valve	• Disassemble and clean.	1500–2000	
		• Adjust injection pressure and fuel spray.	1500–2000	
3	Engine system oil	• Check the oil level.	Everyday	
		• Analysis of lub. oil properties.	1000	
4	Lub. oil pump (engine system oil)	• Disassemble and inspect major parts.	8000–12000	
5	Lub. oil cooler	• Disassemble, clean and inspect.	8000–12000	
6	Lub. oil bypass filter (centrifugal) (Option)	• Disassemble, clean and inspect.	250–500	
7	Piston	• Overhaul; replace piston rings and oil ring	8000–12000	
		• Measure ring grooves and piston outside diameter.	8000–12000	
8	Connecting rod	• Check the crank pin bearing and piston pin bearing.	16000–24000	
9	Cylinder liner	• Remove carbon.	8000–12000	
		• Extract and check the jacket exterior.	16000–24000	
		• Check and measure the moving face.	8000–12000	
10	Main bearing	• Check the main bearing.	8000–12000	
11	Crankshaft	• Check the crank pin and journal.	8000–12000	
		• Check and adjust the crank deflection.	2000–3000	
12	Cooling water pump	• Disassemble and check major parts.	8000–12000	
13	Governor	• Disassemble and check the major parts of governor.	8000–12000	
		• Check the performance of fuel oil rack and fuel oil shut-off device.	Monthly	
		• Check the level of governor hydraulic oil.	Everyday	
14	Intake and exhaust valves and cylinder head	• Check and adjust valve head clearance.	1000–1500	
		• Check valve spring.	8000–12000	
		• Disassemble and check valve rotator.	As needed.	
		• Clean and lap intake valve seat.	8000–12000	
		• Check and lap exhaust valve seat.	8000–12000	
		• Check intake valve guide.	8000–12000	
		• Check exhaust valve guide.	8000–12000	
		• Clean the combustion chamber.	8000–12000	

Inspection and Maintenance Intervals

(Operation on H.F.O.)

No	Inspection Item		Inspection Interval (Operation Hrs.)	Remarks
15	Turbocharger	• Pour water to wash blower side.	150–200	
		• Do a solid cleaning of the turbine side.	200–250	6EY18ALW
		• Do a water cleaning of the turbine side.	50–200	6EY18LW
		• Disassemble and clean the blower.	8000–12000	
		• Disassemble and clean the turbine side.	8000–12000	
16	Air cooler	• Disassemble and clean; conduct water pressure test.	8000–12000	
17	Camshaft and tappet	• Disassemble and check fuel oil injection pump tappet and tappet guide.	8000–12000	
		• Check fuel oil cam and intake and exhaust cams.	4000–6000	
		• Check camshaft bearing.	16000–24000	

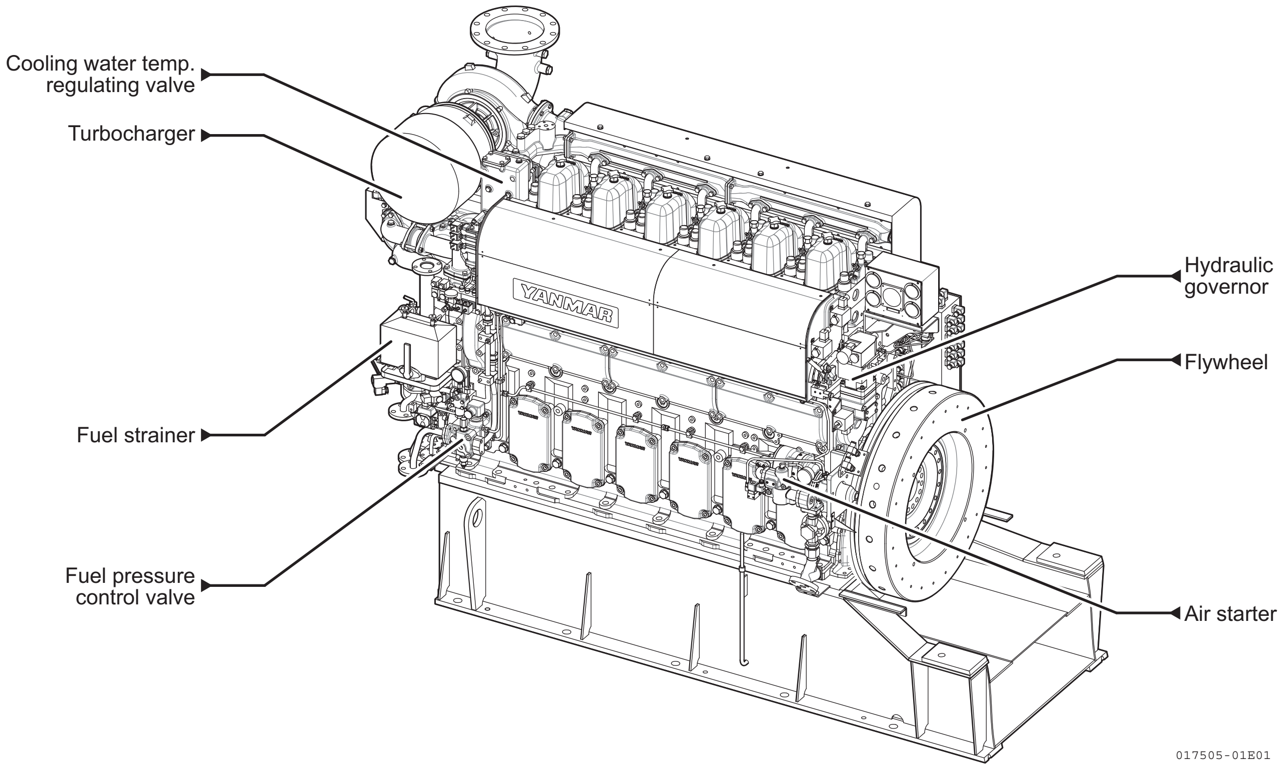
02 Engine Structure

Project Guide

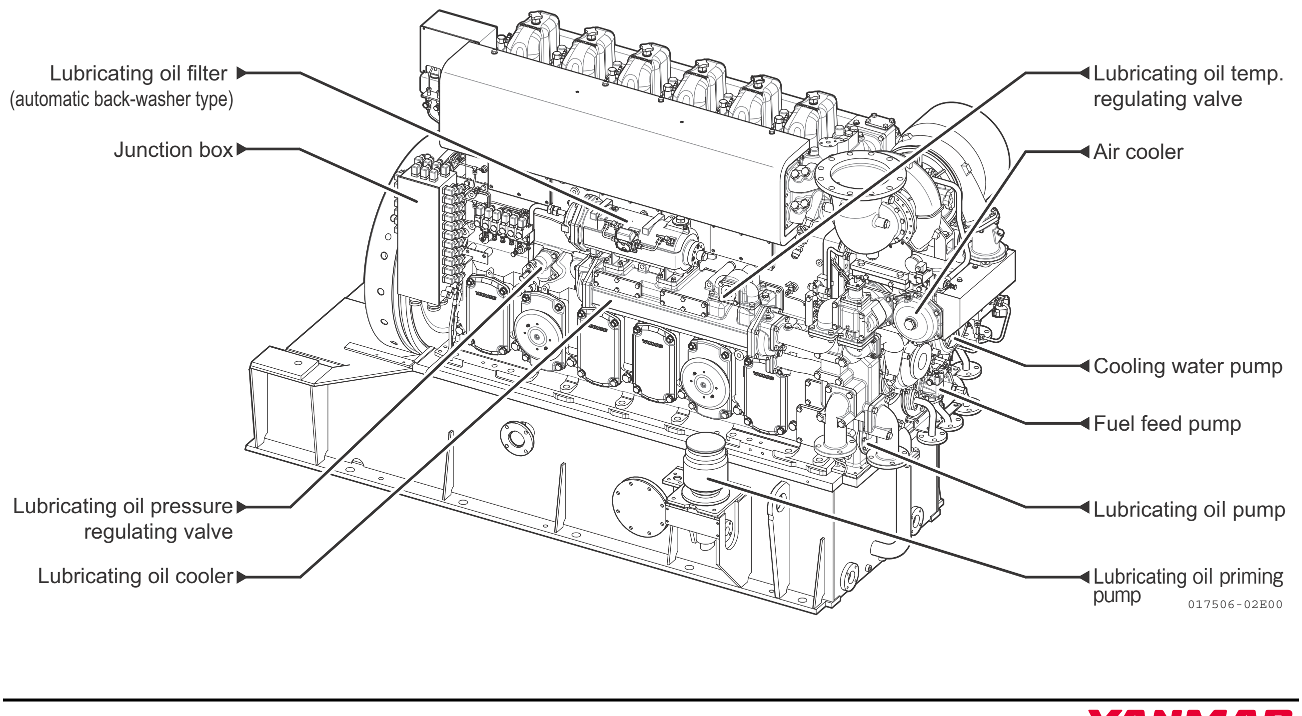
6EY18(A)LW
MARINE AUXILIARY DIESEL ENGINE

Engine External Appearance

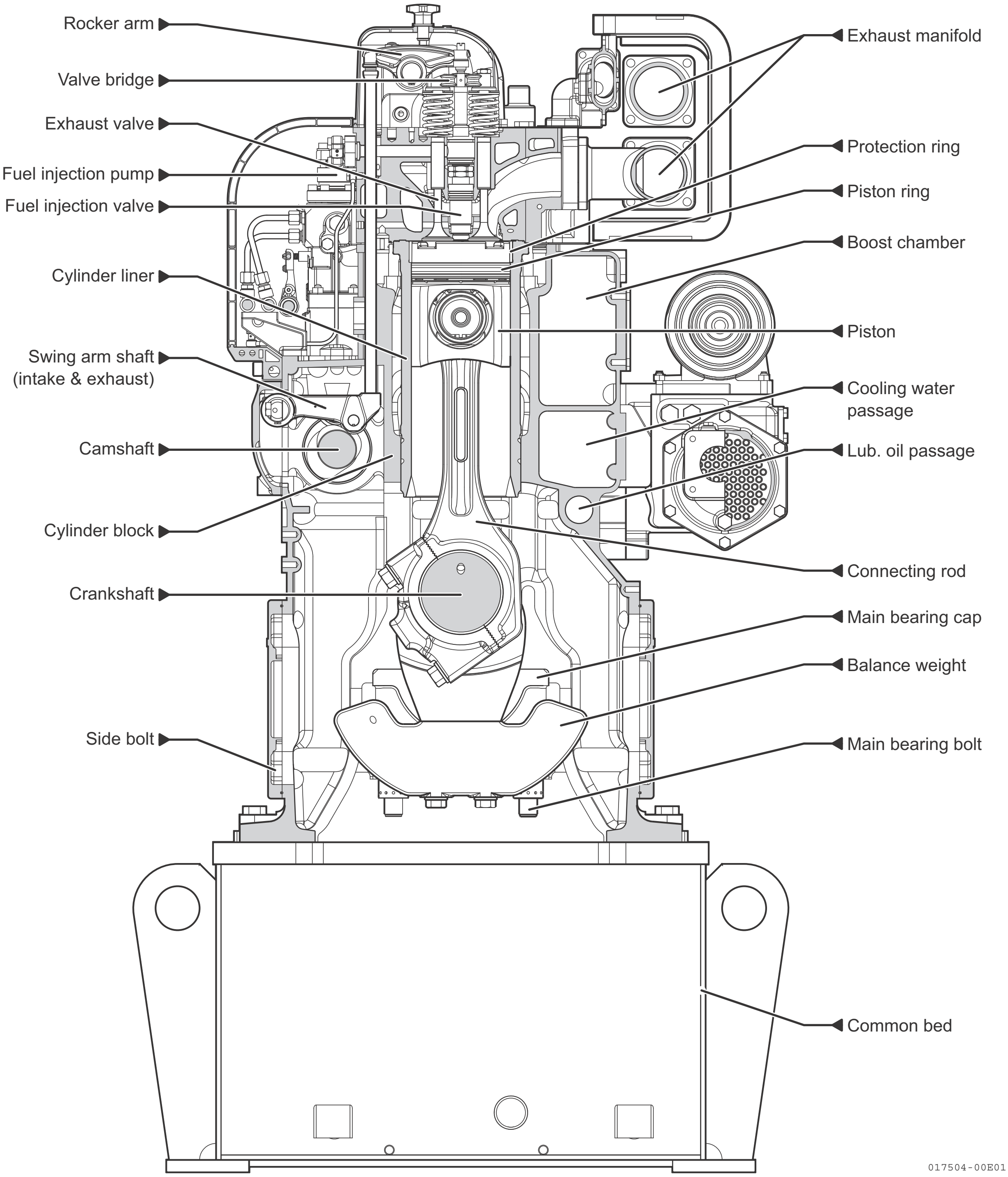
■ Operation Side (Fuel Injection Pump Side)



■ Non-Operation Side (Exhaust Manifold Side)



Engine Sectional Drawings

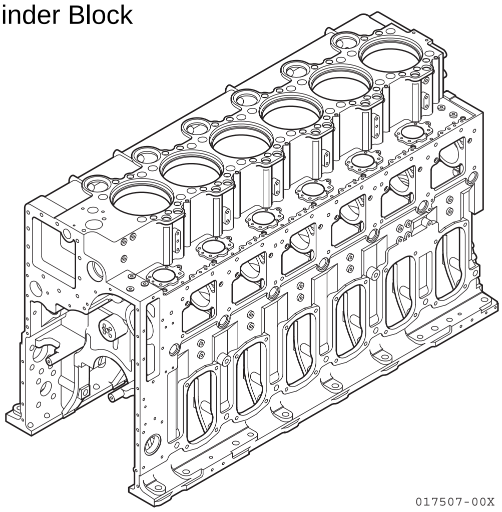


Structural Outline

■ Cylinder Block

The cylinder block is made of cast iron with hanging bearing in a dual box structure that can effectively withstand the high maximum combustion pressure. The wall thickness and rib shape are optimized through the structural and vibration analyses using 3D-FEM (3D Finite Element Method) for weight reduction and higher structural strength. The cylinder block houses the cam case, boost air chamber and cooling water and lubricating oil passages. This is instrumental not only in minimizing the external piping for simpler external appearance, but also in making the maintenance, inspection and handling easier.

Cylinder Block

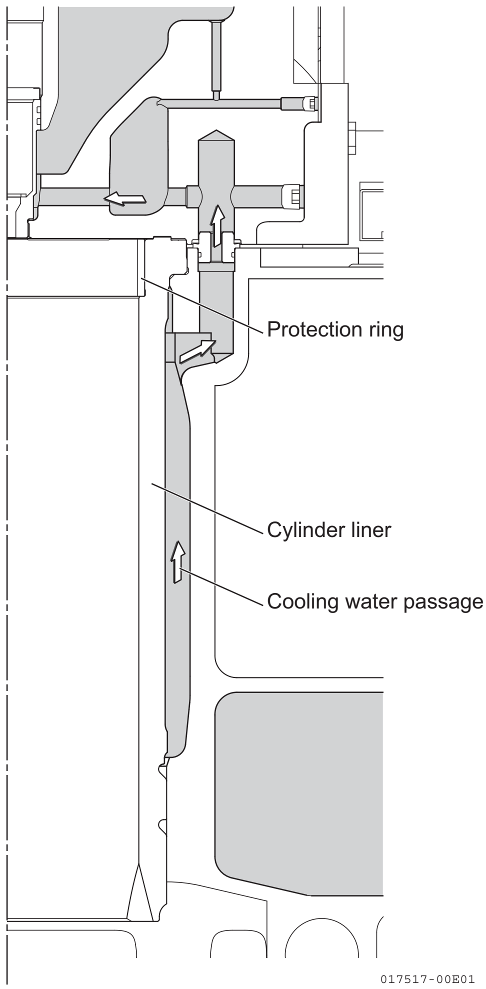


■ Cylinder Liner

The cylinder liner is made of special cast iron with superior wear-resistant characteristics. The upper fitting has a strong and thick wall structure to sufficiently withstand the high combustion pressure. The wall of the liner skirt is also thick, to prevent cavitations due to piston slapping. The inside surface of the liner is plateau honing processed.

The protection ring installation prevents carbon deposits on the outside circumference of the upper piston and wear of the cylinder liner due to carbon deposit. This is instrumental in controlling the lubricating oil consumption.

Cooling System of Cylinder Liner



■ Crankshaft and Main Bearing

The crankshaft is made of forged alloy steel. The pin and journal have large diameters. And also they are polish-finished after induction hardening. These result in sufficient strength and durability against strong combustion force.

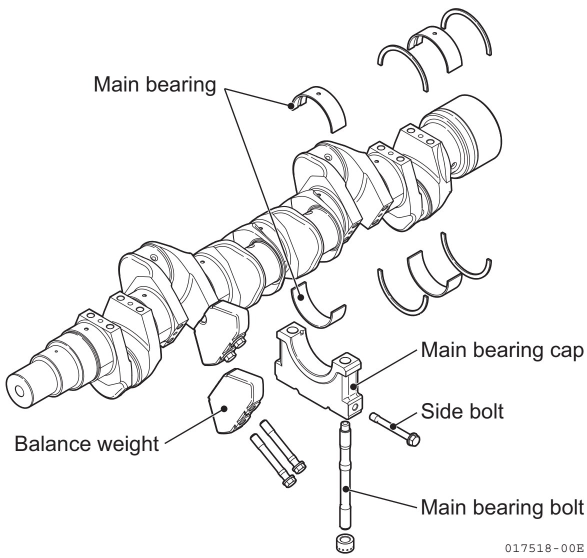
A large balance weight is installed to each cylinder to improve the balance ratio and ensuring an appropriate oil film thickness. The engine vibration is controlled to a low level through the assembly of the piston and connecting rod by mass class and by dynamic balance improvement.

The main bearing cap is firmly fastened to the cylinder block with two main bearing bolts and two side bolts, giving the main bearing high stiffness.

The main bearing bolt is tightened by hydraulic pressure by using special tools. So the inspection and replacement of the main bearing are easy and can be performed in a short time.

The main bearing is made of the aluminum bearing which is superior in wear- and fatigue-resistance, too.

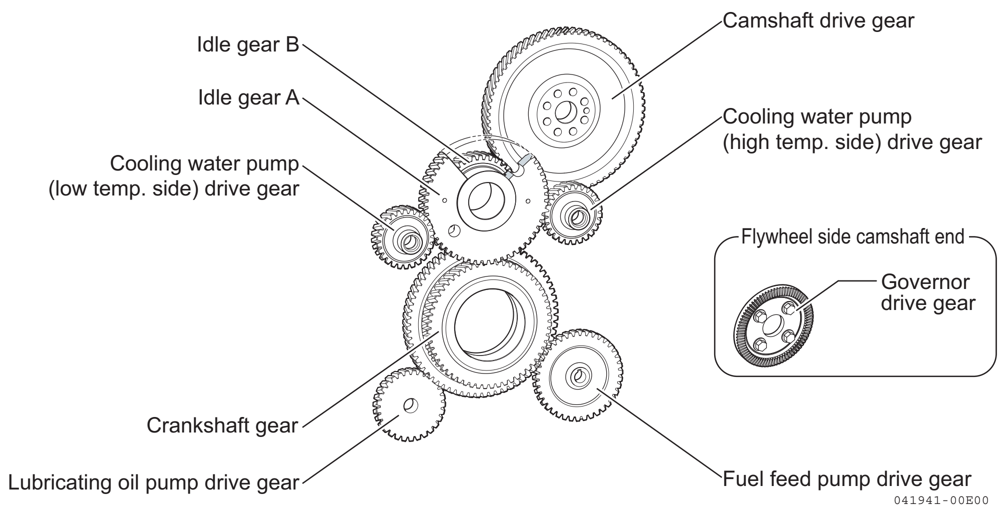
Crankshaft and Main Bearing



Structural Outline

■ Timing Gear and Gear Train

The timing gear is located at the front of the engine (the opposite side of the flywheel). The gear train is connected to the camshaft gear, governor drive gear and cooling water pump drive gear (for engine circulation) from the crankshaft gear via the idle gears. The lubricating oil pump drive gear is driven directly by the crankshaft gear. The gears are helical gears made of chrome molybdenum and wholly treated with carburizing hardening. They are extremely durable. The improved gear precision and reduced backlash further reduced the gear noise.

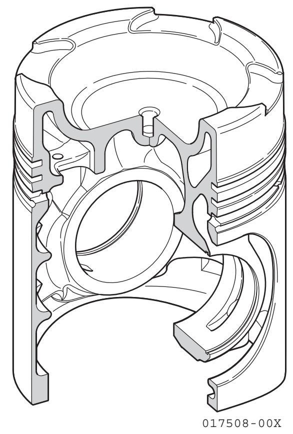


■ Piston

The piston is a mono-block structure with light and thin walls made of ductile cast iron. The piston employs the 'cocktail shaker' system where the cooling chamber at the rear of the combustion chamber is force-cooled by lubricating oil circulation. The wall thickness is optimized by 3D-FEM (3D Finite Element Method) to render it with sufficient strength and rigidity against the high combustion pressure and thermal load.

Since the ductile cast iron piston with small thermal expansion coefficient allow the piston skirt clearance to be small, it is possible to reduce the lubricating oil consumption.

The piston rings consist of two pressure rings and one oil ring. The moving face of the rings is chrome plated for improved ring durability.

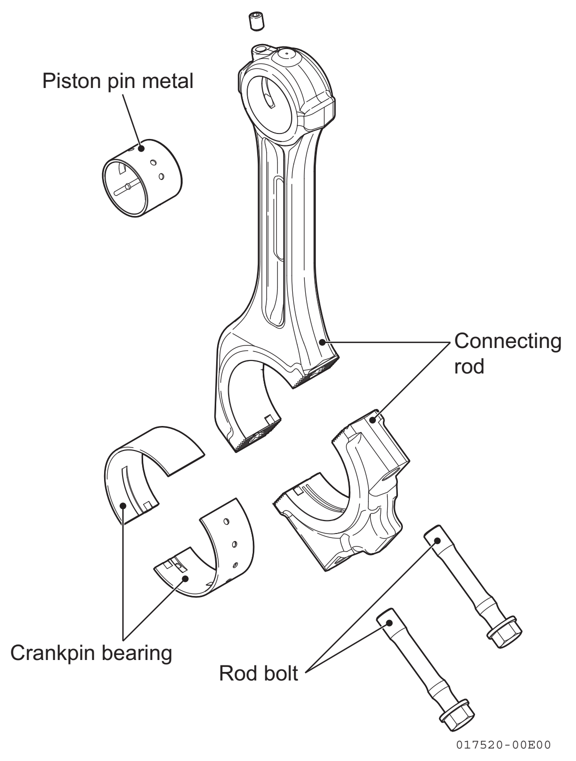


■ Connecting Rod

The connecting rod is made of forged carbon steel. The big end of the connecting rod is split aslant and the joint faces come in the serration joint.

The connecting rod bolts are angle tightened by machine bolts to obtain stable axial force.

The crankpin bearing of the big end is an aluminum bearing that can resist high surface pressure. The small end piston pin bush is made of the thin-walled lead bronze with backing metal. The bush is superior in break-in characteristics and durability.



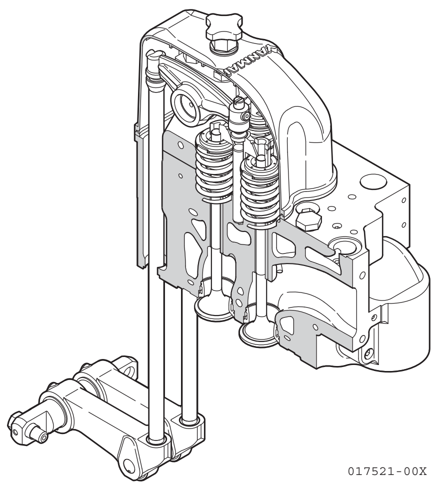
Structural Outline

■ Cylinder Head

The cylinder head is made of special cast iron with superior toughness. The upper and side walls are thick and the bottom wall is thin. They can withstand high combustion pressure and high thermal load that results from high power. The wall thickness is optimized by 3D-FEM. Also, effectively positioned diagonal ribs promote rigidity and cooling performance.

The intake and exhaust valves are arranged in tandem layout and the intake and exhaust ports are positioned on the same side (non-operation side). This facilitates good access for inspection and maintenance from the camshaft and fuel injection pump side and improves workability.

The four cylinder head bolts are tightened hydraulically to ensure stabilized axial force and uniform surface pressure of the cylinder head gasket. This is instrumental in preventing gas leakage. The disassembly and reassembly are easy with the hydraulic disassembly tools, an accessory to the engine.



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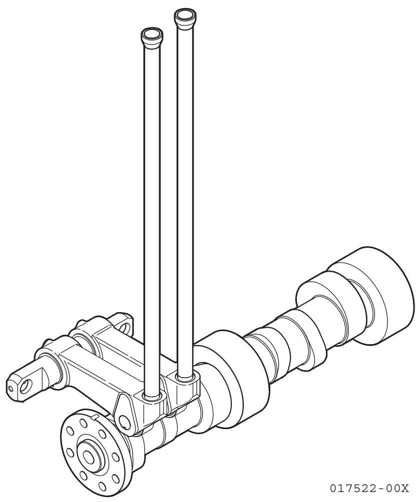
■ Valve Mechanism (Valve Train)

The valve mechanism uses the swing arm system.

The structure of the swing arm system is simple with no sliding surfaces of the tappet guides. This is instrumental in reducing the inertial mass of the valve train and in rendering superior dynamic characteristics.

The push rod is housed in the cylinder block and cylinder head to ensure safety and reduce noise.



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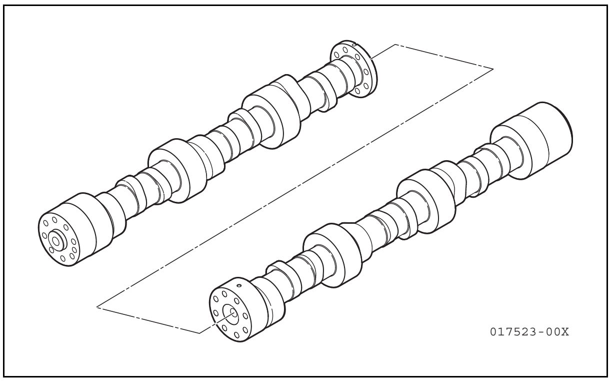
Structural Outline

■ Camshaft

The cam and camshaft are integrated and the shaft diameter is made large. This enables to render sufficient strength for the fuel cam against increased load due to high pressure injection. It is sufficiently rigid, too, against torsional vibrations. Besides these, the cam and bearing faces are induction hardened for higher wear resistance.

Since the camshaft is divided into two pieces, the short extraction distance makes disassembly and re-assembly work easy.



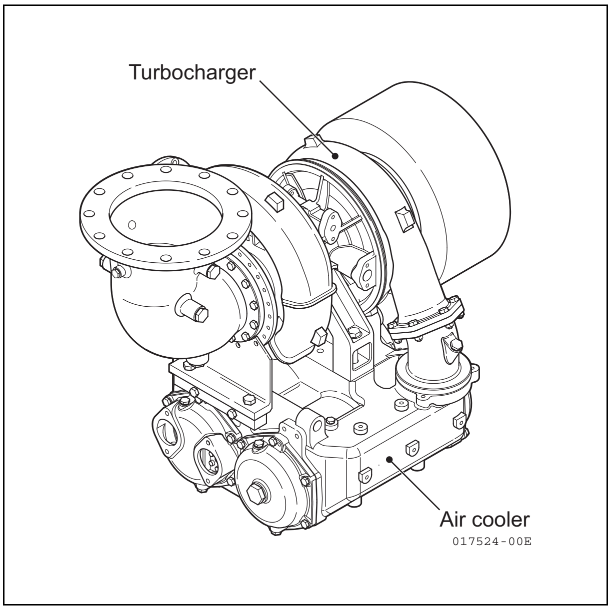
■ Air Charge and Exhaust Equipment

The air cooler unit serves as a turbocharger mount, too. This enabled both the turbocharger and air cooler to be arranged compactly at the opposite side of the flywheel in a unit. The structure is also effective in reducing the number of parts.

The air cooler has a plate fin box, double-core structure with good air-cooling performance.

The core can be extracted from the casing without removing the turbocharger. So, maintenance is easy.

High performance air-cooled radial turbochargers made by MHI (900, 1000 min^{-1} specification) and ABB-IHI (720, 750 min^{-1} specification) are used.



Structural Outline

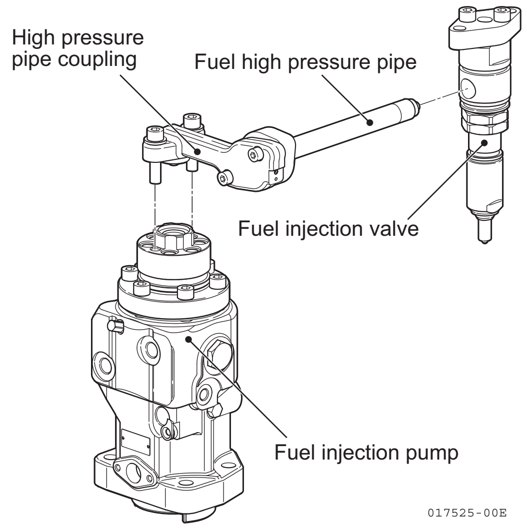
■ Fuel Injection Equipment

The fuel injection equipment consists of the fuel injection pumps, the fuel injection valves, the fuel high pressure pipes and the high pressure pipe couplings.

The high pressure pipe pierces through the cylinder head from the cylinder head side and connects with the fuel injection valve.

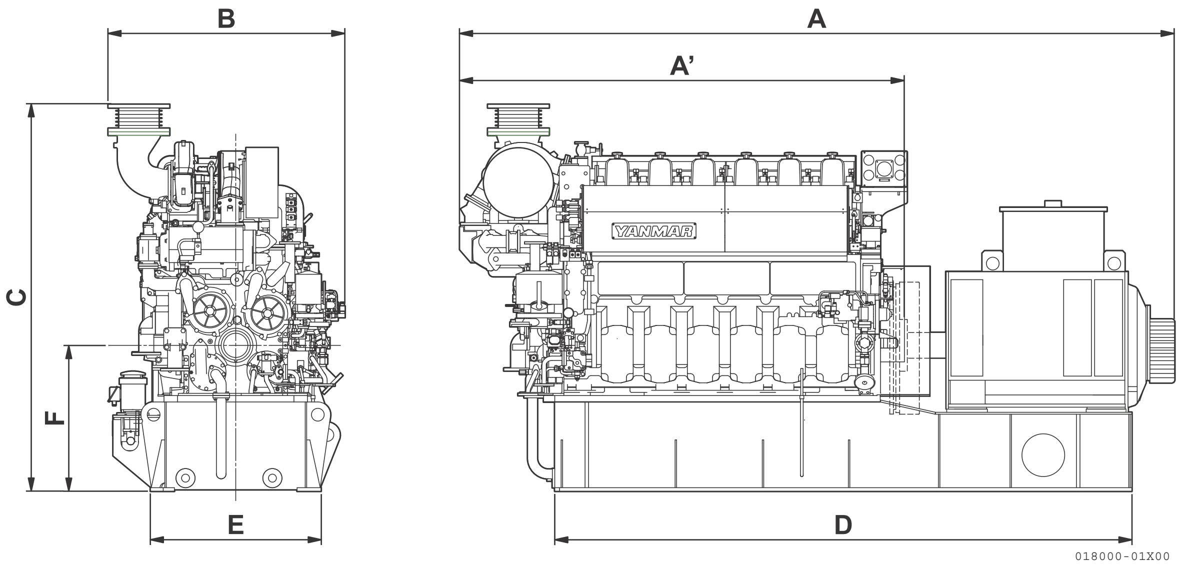
The high pressure pipe coupling system, instead of the conventional pipe system, is used to sufficiently withstand the high pressure injection. All joints are of the conical tight system for high sealing performance and easy assembly.

By employing the staggered layout nozzle for the fuel injection valve, the diameter of the injection holes is made small while the total area of injection holes is made large. This arrangement contributes to high combustion performance and low fuel consumption.



External Dimensions and Mass

■ Dimensions for Generator Set



■ Dimensions and Mass

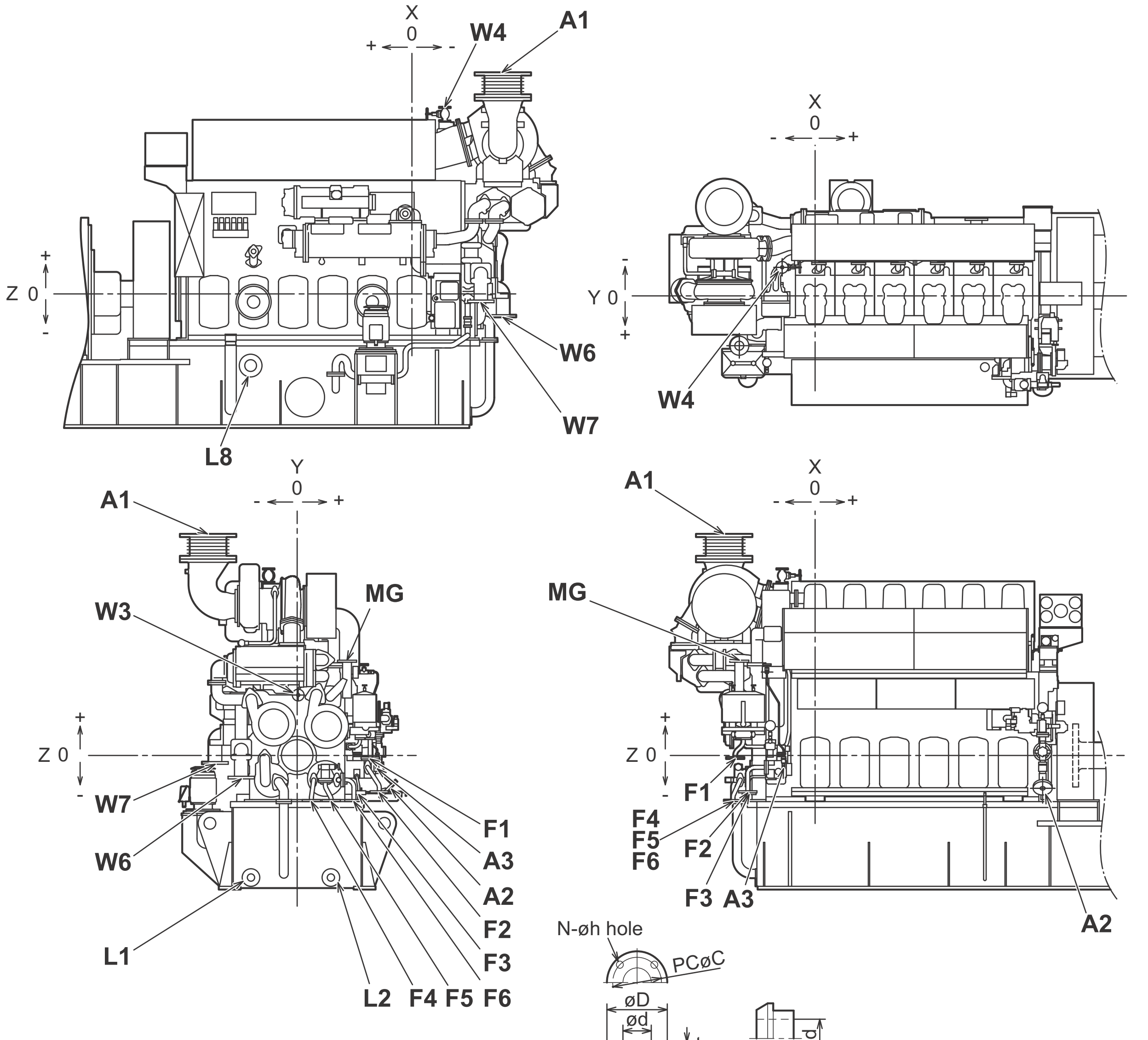
(mm)

Engine Model		6EY18ALW	6EY18LW
A (Total Length)		4680	4441
A'		2751	2751
B		1489	1493
C		2429	2429
D		3720	3620
E		1070	1070
F		915	915
Dry mass (kg)	Engine	6600	6600
	Generator Set	12100	11200

Note:

- Above data shows the case of engines with a common bed and built-in lubricating oil sump tank.
- Engine dry mass may differ depending on the specification and attached accessories.
- The dimensions and mass for the generator set are reference values, so the value may differ depending on the generator manufacturers.

Piping Connections



DWG. No.	B3-46623-154D

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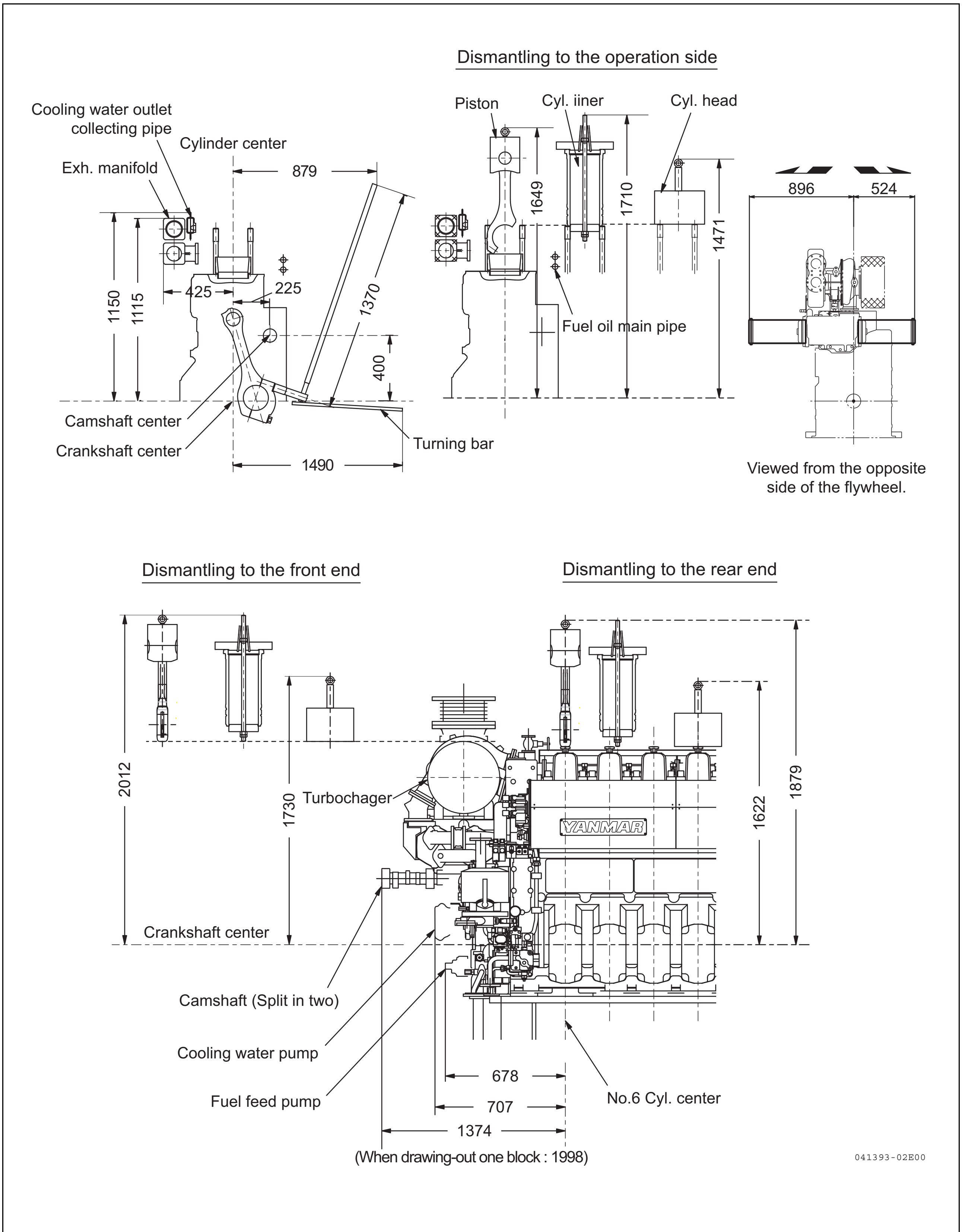
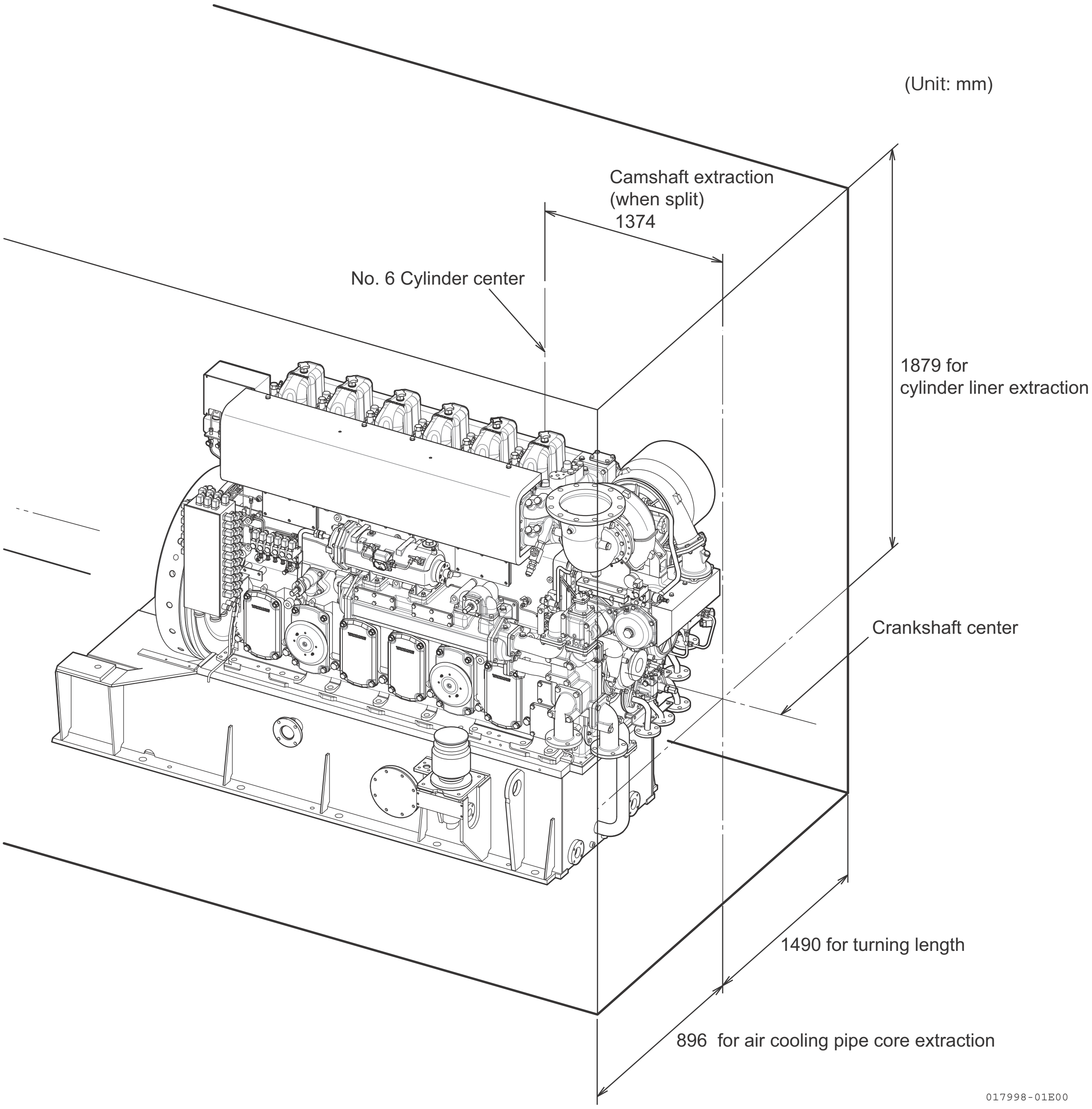
Symbol	Pipe connections	Size	Pipe	X	Y	Z	Flange	Symbol	Pipe connections	Size	Pipe	X	Y	Z	Flange
W3	Hot water inlet & outlet	5^{k}-15	15A	-585	7	412	1	F1	Fuel oil inlet (H.F.O.)	16^{k}-25	25A	-545	498	-24	1
W4	Freshwater air vent	5^{k}-15	15A	-225	-195	1277	1	F2	Fuel oil outlet (H.F.O.)	16^{k}-25	25A	-459	560	-255	1
W6	(Cooler) cooling water inlet	5^{k}-80	80A	-622	-382	-160	1	F3	Fuel oil drain	5^{k}-25	25A	-450	420	-267	1
W7	(Cooler) cooling water outlet	5^{k}-80	80A	-470	-560	-60	1	F4	M.D.O. feed pump inlet	16^{k}-25	25A	-560	97	-315	1
								F5	M.D.O. feed pump outlet	16^{k}-25	25A	-560	232	-315	1
								F6	M.D.O. feed return outlet	16^{k}-25	25A	-560	387	-315	1
								MG	Mist gas outlet	5^{k}-50	50A	-517	-340	650	1
L1	Lub. oil inlet	5^{k}-40	40A	-407	-315	-833	1								
L2	Lub. oil outlet	5^{k}-40	40A	-407	230	-833	1	A1	Exhaust outlet	5^{k}-250	250A	-620	-608	1512	1
L8	Lub. oil over flow	5^{k}-65	65A	1100	-529	-489	1	A2	Starting air inlet	40^{k}-25	25A	1552	638	-224	1
								A3	Control air inlet	-----	O.D.10	-215	548	-90	-

Disassembly and Maintenance Spaces

■ Principal Dimensions for Disassembly and Servicing



Disassembly and Maintenance Spaces

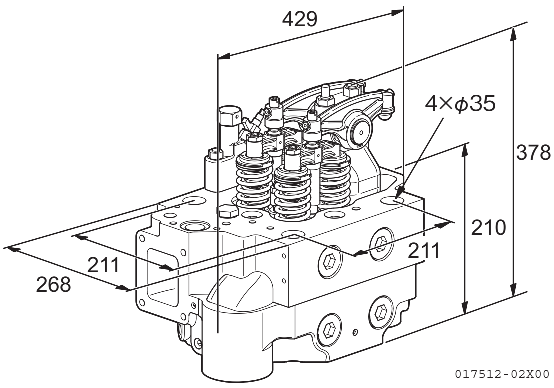


Mass and Dimensions of Major Parts

■ Dimensions of Major Parts

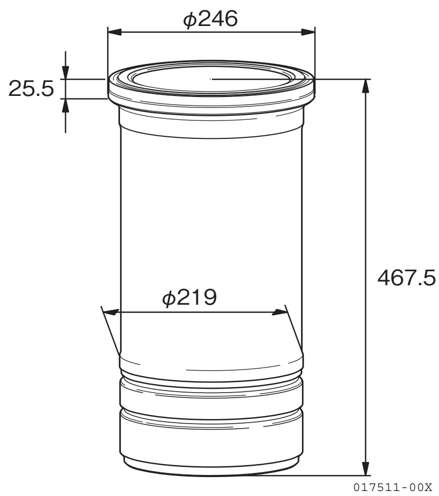
(mm)

Cylinder Head



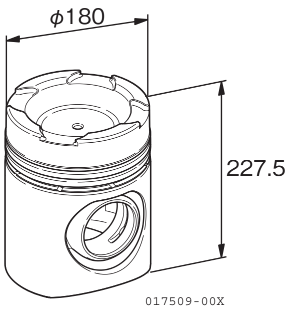
Cylinder head assembly mass: 105 kg

Cylinder Liner



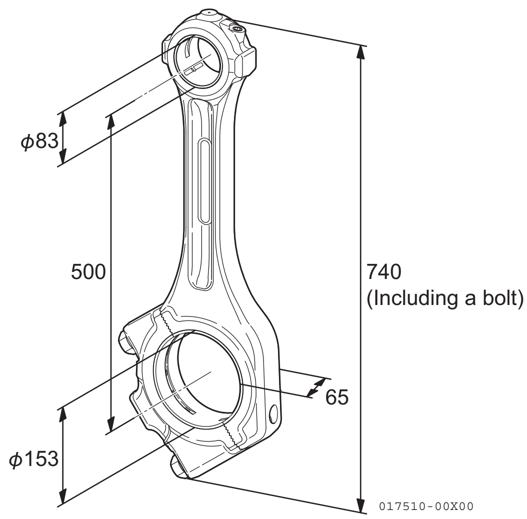
Cylinder liner mass: 39 kg

Piston



Piston mass: 12 kg

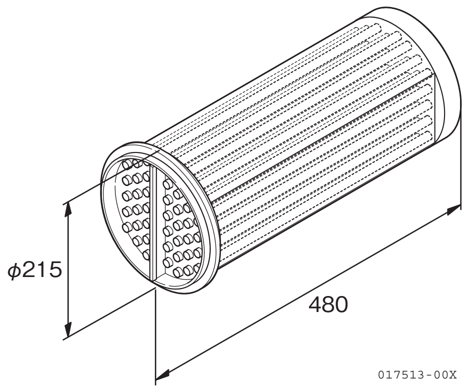
Connecting Rod



Connecting rod mass: 26 kg

Mass and Dimensions of Major Parts

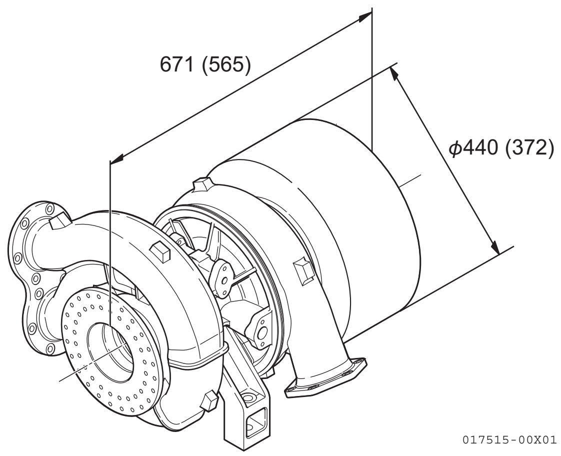
Air Cooler



Air cooler (core) mass: 18 kg

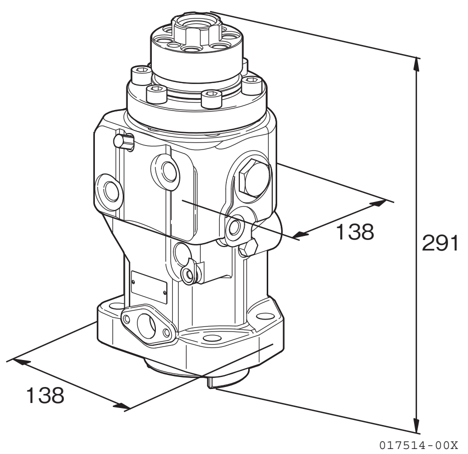
Turbocharger

The values in ( ) are for TPS.



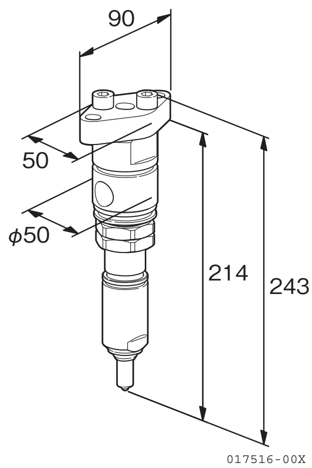
Turbocharger mass: MET 140 kg
TPS 96 kg

Fuel Injection Pump



Fuel injection pump assembly mass: 18 kg

Fuel Injection Valve



Fuel injection valve assembly mass: 1.3 kg

Material of Major Parts

Material and Manufacturers of Major Parts

Names of Parts		Material	Manufacturer
Cylinder block		Gray cast iron	
Crankshaft		Steel alloy (hardened & tempered)	
Connecting rod		Carbon steel (hardened & tempered)	
Piston		Nodular graphite cast iron	
Cylinder head		Gray cast iron	
Cylinder liner		High phosphorus gray cast iron	
Intake valve		Heat resisting steel	
Exhaust valve		Nimonic	
Fuel injection valve			Yanmar
Fuel injection pump			Yanmar
Turbocharger			MHI or ABB-IHI
Governor			Yanmar
Air cooler	Tube	Bronze for condenser	
	Body	Gray cast iron	
Lubricating oil cooler	Tube	Phosphorus deoxidized copper	
	Body	Nodular graphite cast iron	

Mass of Major Parts

Name of Part and Assembly	Mass (kg)	Remark
Cylinder head (assembly)	105	Per 1 cylinder
Piston and con. rod	33	Piston + Con. rod (excluding cap side)+ Piston pin
Cylinder liner	39	Per 1 cylinder
Main bearing cap	22	Per 1 cap
Air cooler (core)	18	Per 1 cap
Exhaust manifold cover	45	
Turbocharger	140	MHI (900, 1000 min^{-1} specification)
	96	ABB-IHI (720, 750 min^{-1} specification)
Camshaft	42	2-split type, per 1 piece
Camshaft gear	17	
Timing gear assembly	20	
Lubricating oil cooler (core)	47	
Lubricating oil pump	25	
Lubricating oil priming pump	37	Including motor
Lubricating oil strainer	65	
Cooling water pump	37 37	For high temperature cooling water For low temperature cooling water
Cooling water collecting pipe	12	2-split type, per 1 piece
Fuel feed pump	22	
Fuel strainer	22	
Fuel injection pump	18	
Pump case cover	6	2-split type, per 1 piece
Air starter	16	
Gear case cover	74	
Crankshaft	852	Including balance weight
Flywheel assembly	738	Including ring gear

03 Installation

Project Guide

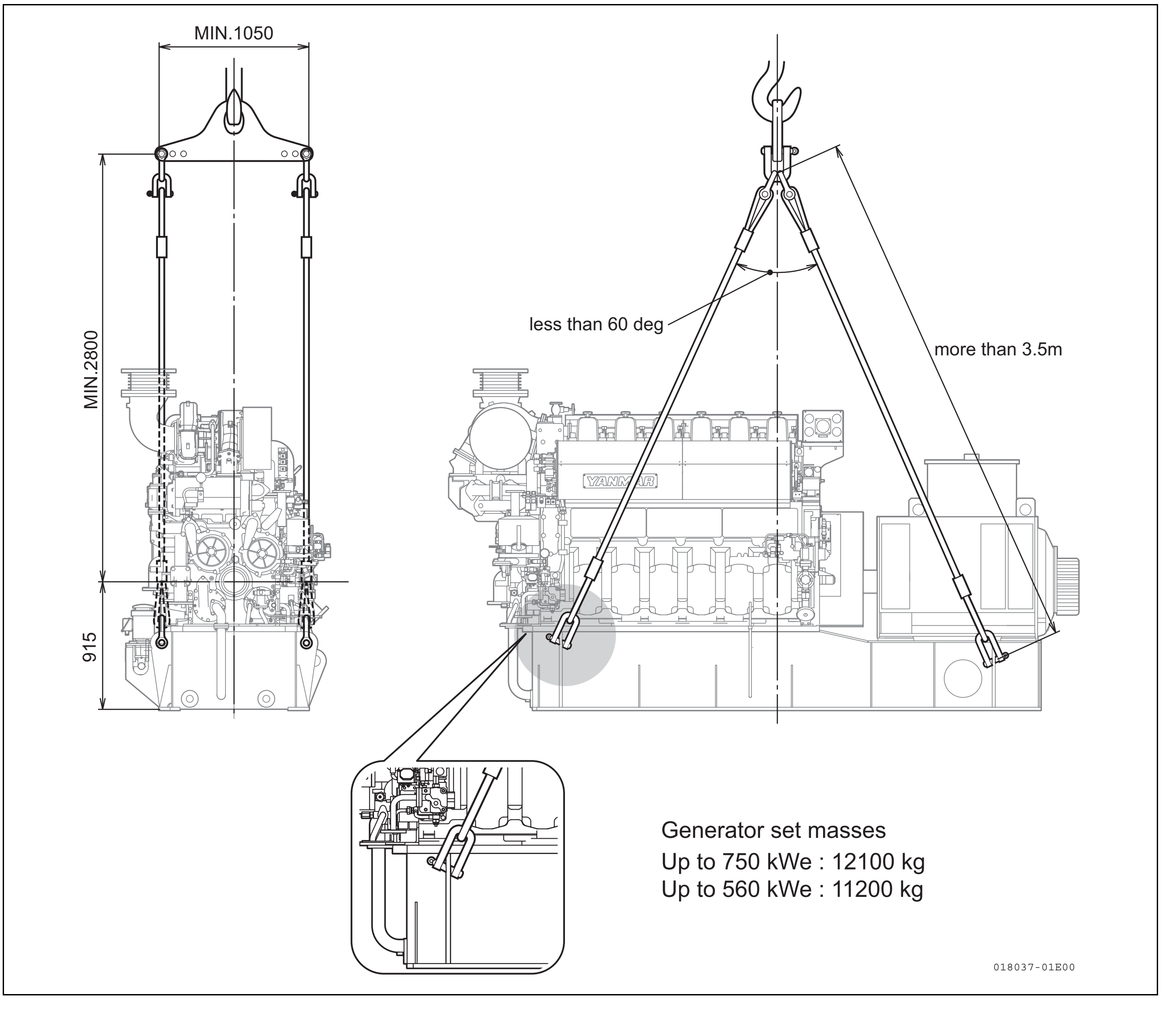
6EY18(A)LW

MARINE AUXILIARY DIESEL ENGINE

Lifting Procedures

1. Lifting Procedures

- When lifting the engine and generator, lift by the lifting fixtures installed to the common bed. (See the figure below.)
- In order not to cause the wire to touch the engine, use the lifting balance as shown below.



⚠ WARNING

In order to prevent an accident, be sure to comply with the following instructions when lifting the engine and generator set.

- **Select wires and shackles with sufficient capacities to lift the generator set.**
- **Adjust the wire length correctly so that the generator set will not tilt when lifted.**
- **Place wooden blocks or other protection in positions where the wire touches the generator set or driven equipment.**
- **Use a padding that does not break or fall during lifting. Attach it so that it does not cause damage to the engine or driven machine.**
- **Do not enter the space under the lifted generator set.**

Layout of Generator Set

1. Layout

Decide the engine layout in consideration of the following items:

■ Engine's lateral direction

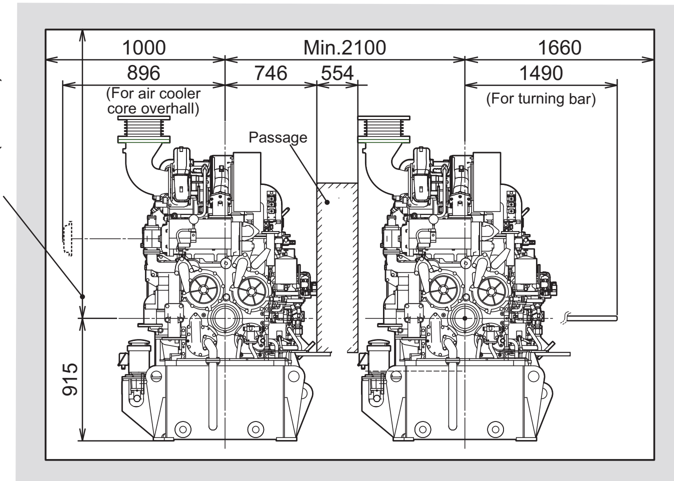
- Operation side: Ensure enough space for inspecting and servicing inside the crank case from the cylinder side cover in reference with the disassembly and maintenance dimensional drawing.
- Non-operation side: Ensure enough space for inspecting and servicing the lubricating oil cooler, lubricating oil strainer and air cooler.

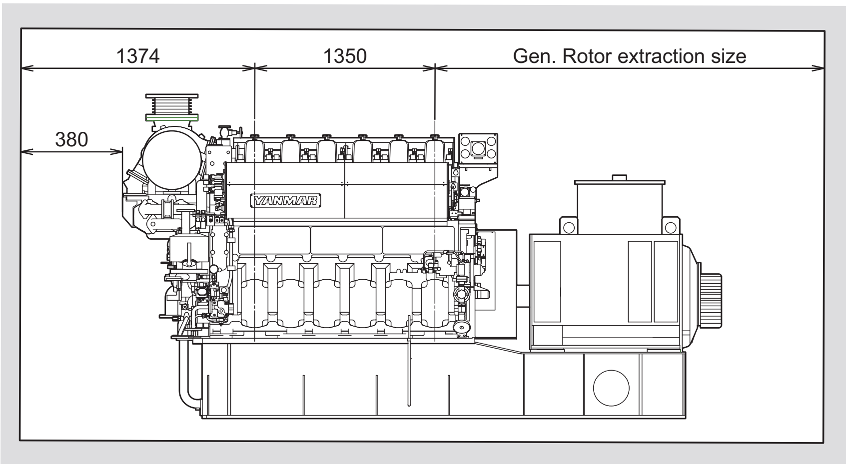
■ Engine's longitudinal direction

- Gear side: Ensure enough space for extracting the camshaft, cooling water pump and lubricating oil pump.
- Generator side: Ensure enough space for extracting the rotor in accordance with the drawing supplied by the generator manufacturer.
- Extend the I-beam of the longitudinal direction up to the distance either at the engine front or rear of the engine so that the service parts can be lifted or lowered.

■ Engine room height

Decide the height in consideration of the space for liner and piston extraction dimension in reference with the disassembly and maintenance dimensional drawing.





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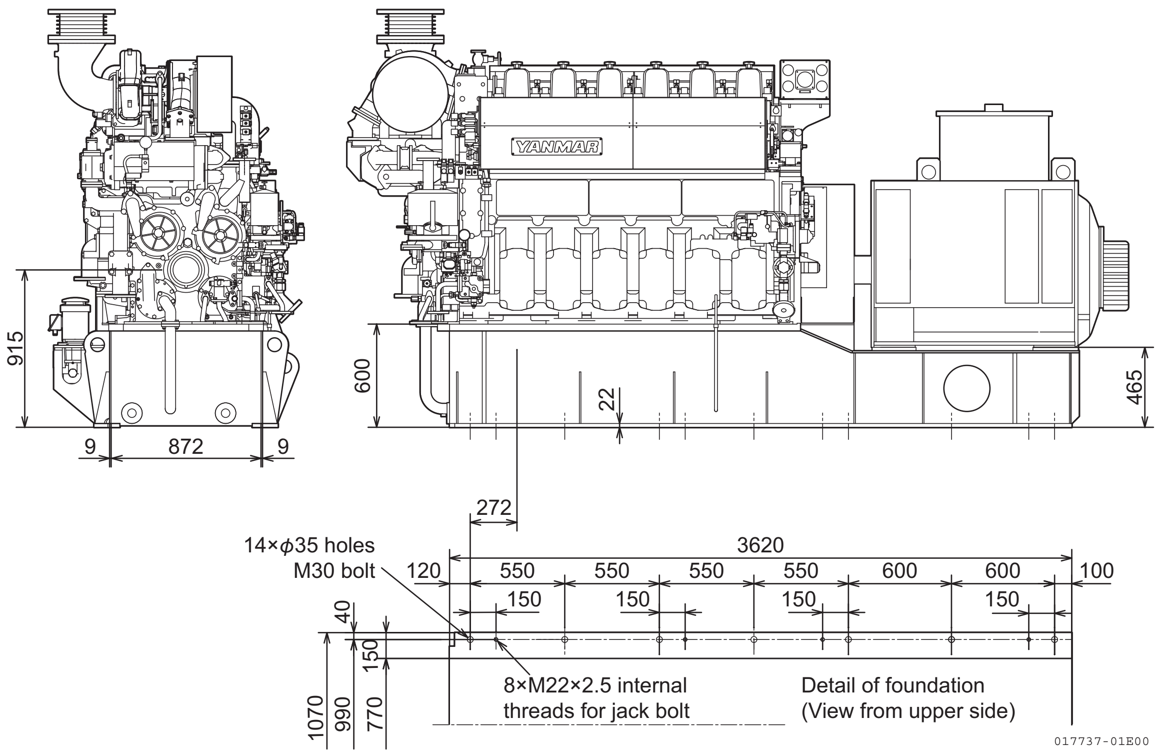
2. Disassembly and Maintenance Dimension

The spaces that are necessary for disassembling and servicing the engine are shown in No.02-06-00. Move the piston, liner, etc. towards the crankshaft and ensure enough space and height for servicing at the gear side or the generator side.

** When inspecting and servicing the cylinder cover, etc. between the engines, consider the use of the beam-running type chain block that can move across the engine room.

Installation of Generator Engine

1. Example of Fixed Installation



2. Engine Bed

2.1 Engine Bed

The engine bed should be of a structure with sufficient strength and rigidity so that any twisting, distortion, etc. of the hull side will not affect the generator engine side.

Arrange the engine bed side main girder and the common bed side main girder on the same line. Provide reinforcement ribs near each installation bolt.

Note:

The common bed installation seat width is fixed. Note that the longitudinal length can vary depending on the type of the generator.

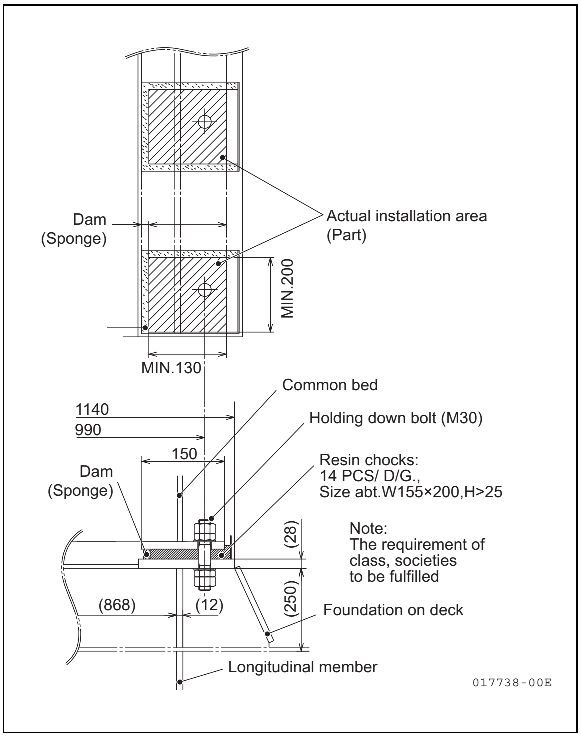
2.2 Resin Chock

The Shipping Classification Organization regulates the allowable surface pressure of resin. Accordingly, follow the values recommended by the respective resin manufacturer for the surface pressure and thickness of resin.

Shipping classification	Permitted surface pressure (MPa)	Temp.(°C)
NK, LR, ABS, BV, GL, NV, CR, KR	4.41	80
CCS	3.43	80

** Surface pressure at the set weight plus bolt tightening force.

The resign chock installation example is shown on the right hand.

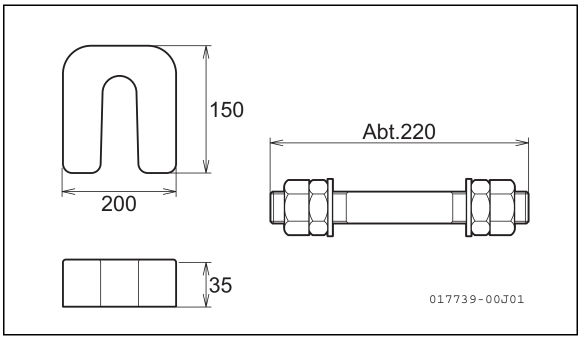


2.3 Installation Parts

The parts necessary for installation, including resin chock, belong to the procurement of the shipyard.

- Chock Liner

The reference figure of the cast iron foot liner is shown at the right. Check the surface pressure in the same way as in the resin chock, i.e., at set weight plus bolt tightening force. (Yanmar Standard: 4.9 MPa or below)



- Installation Bolt

Use the stud bolt for the installation bolt. The double-nut tightening system as shown at the right is recommended. The standard tightening torque is shown below:

Bolt size	Tightening torque (kN•m)
M30	0.42

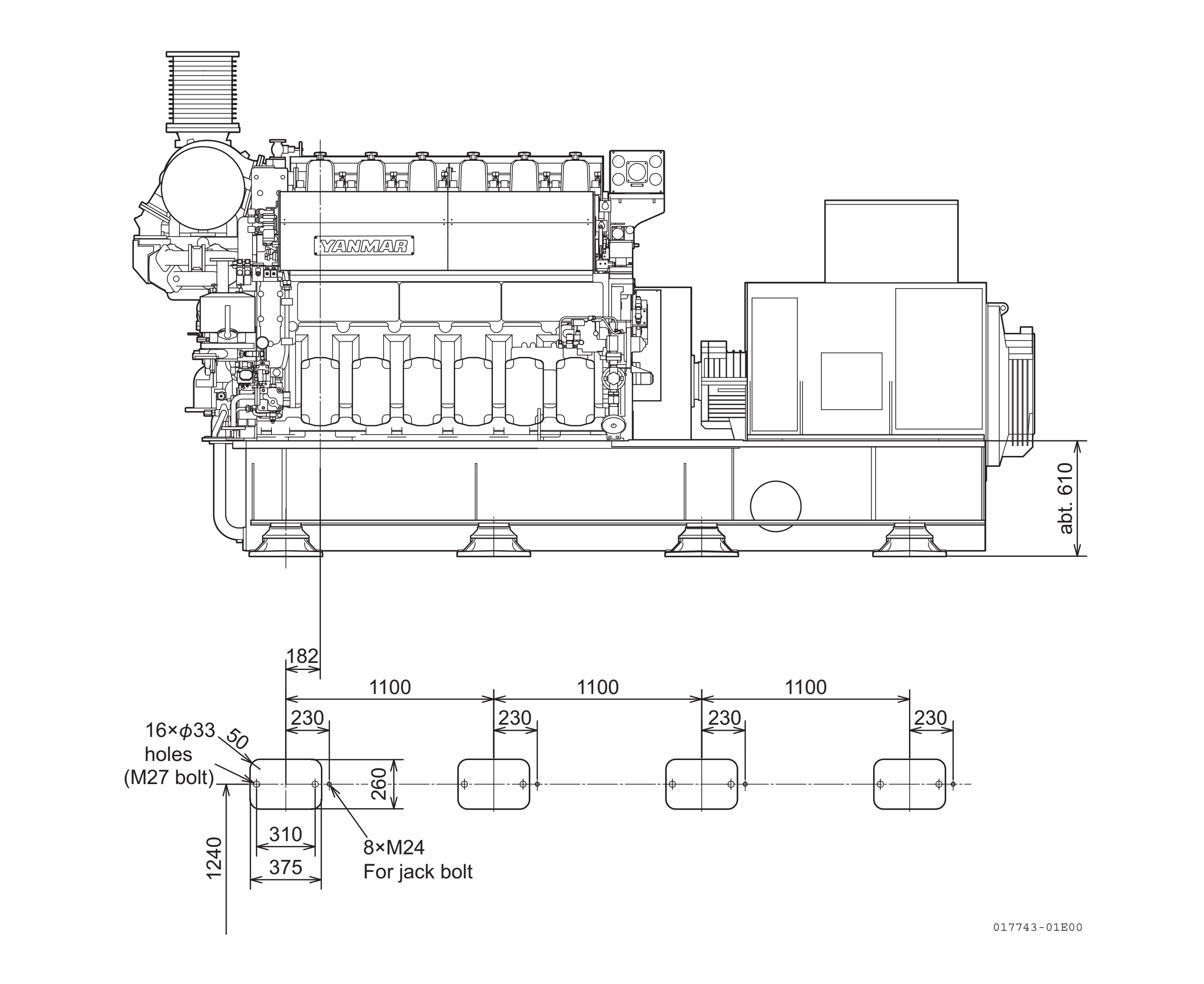
1. Outline

The vibration isolating installation of the generator set is instrumental in reducing engine vibrations transmitted to the hull and solid transmission noises and thereby improving the comfort of the living quarters (with reduced vibrations and quieter noise).

In addition, the vibrations of the auxiliary engine caused by the vibrations of the main engine, which give adverse effects to the auxiliary engines not being operated, can be reduced, too, by the vibration isolating installation.

The vibration isolating rubber is between the engine bed and common bed.

Example of Vibration Isolating Installation



Note:

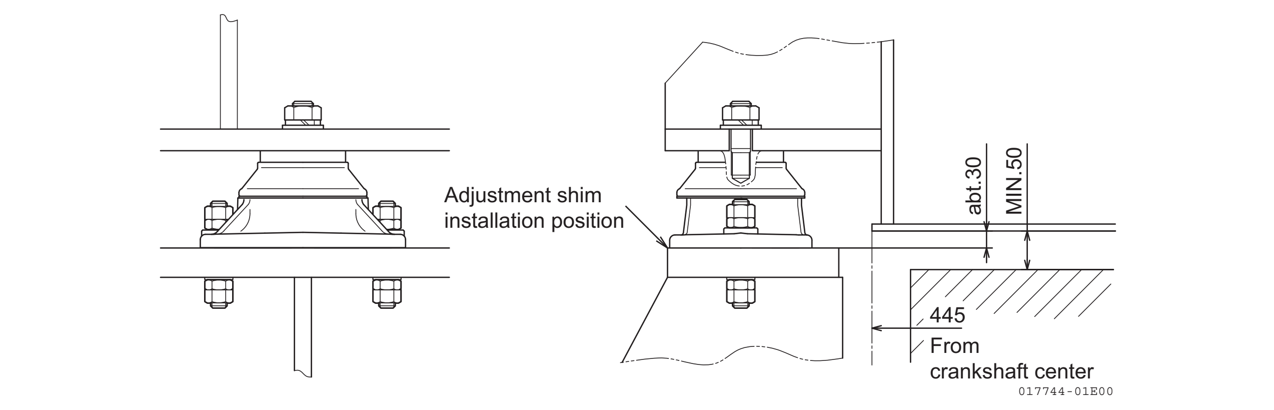
No. of vibration isolating installation rubbers and arrangement can vary depending on the generator type.

Vibration Isolating Installation of Generator Engine

2. Engine Bed

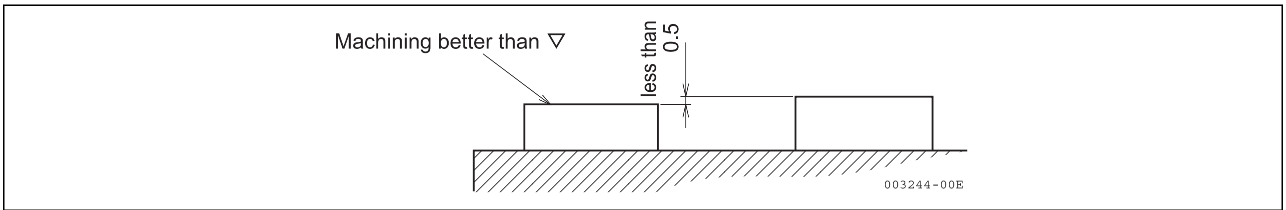
2.1 Engine Bed

- For the rigidity and rib arrangement of the engine bed, etc., apply the similar considerations as with the fixed installation mentioned previously.
- The vibration isolating installation rubber houses the stopper. There is no need to install another stopper.
- Ensure enough space between the engine side common bed and the hull side engine bed as shown in the figure below.

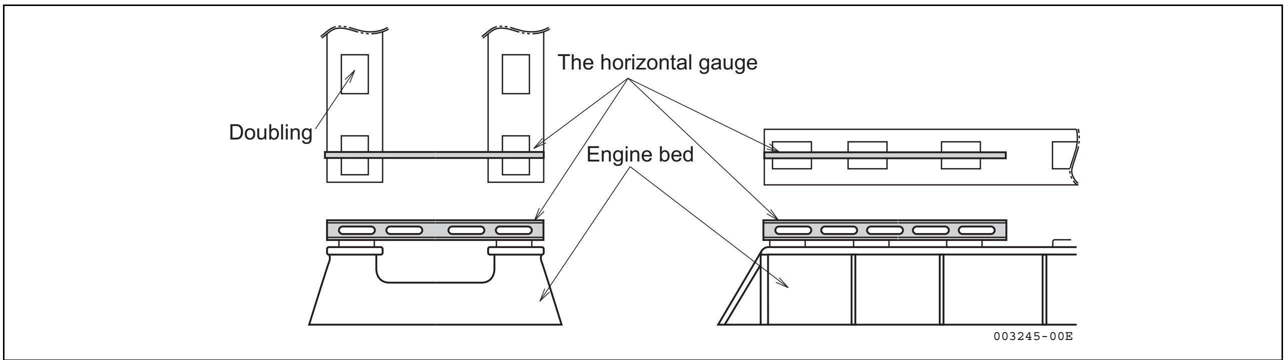


2.2 Dimensional Accuracy of Engine Bed

- Ensure the deviation from flatness of each vibration isolating rubber installation seat less than 1.5 mm. (Keep the gap between the neighboring heights less than 0.5 mm.)
- Do a doubling of the machined upper surface. Adjust the rubber installation face to the targeted value with the shim.



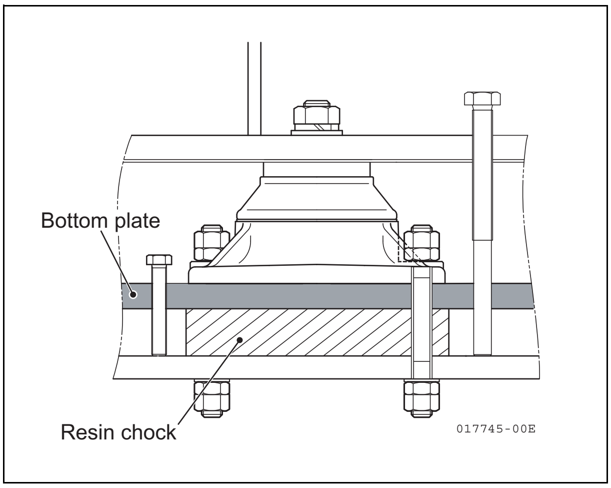
- Use the stainless steel shims. Prepare 0.5, 0.3 and 0.1 mm shims. Use one or two shims for each seat.



- When the installation is completed, measure and check the crankshaft deflection.
  If the deflection measurement value deviated from the standard value, change the shim thickness between the generator and common bed.

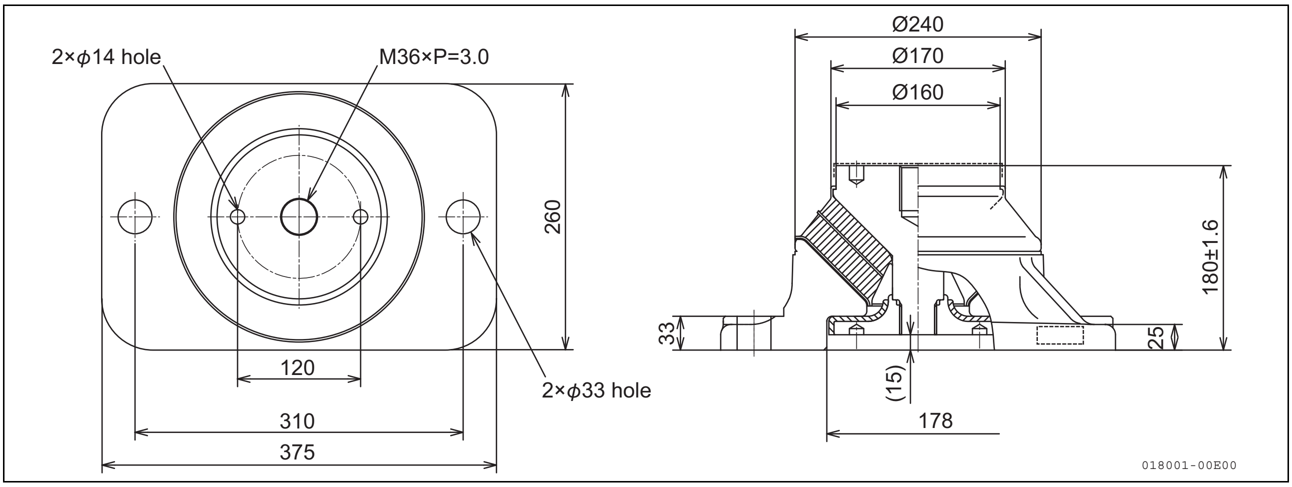
2.3 Resin Chock

- Install the bottom plate, equivalent to the engine bed doubling, to the engine bed with resin chock. (Make vibration isolating rubber installation bolt holes, bottom plate installation holes and jack holes in the bottom plate in advance. Make the surface roughness of the vibration isolating rubber installation face better than ∇ 25.)
- Make the deviation from flatness of the bottom plate vibration isolating rubber installation seat face, after fastening the resin chock, less than 1.5 mm (see 2.2).
- After checking that the resin has hardened, install the generator set (equipped with the vibration isolating rubbers in advance) on the bottom plate.



2.4 Rubber Mount

- Yanmar's rubber mount has a unique shape for highly effective vibration isolation. The external appearance and dimension of the rubber are shown below.
- 4 rubber mounts are applied on each side of the engine (10 rubbers in total on both sides). (The number of rubbers to be used differs depending on the generator set.)



2.5 Installation Bolts

Use the stud bolt for the installation bolt. The double nut tightening system is recommended.

Installation bolt	: M27 x 16 pcs.
Bolt material	: S25C
Recommended tightening torque	: 304 N•m (31 kgf•m)
(Reference) Bolt tightening force	: Approx. 56300 N (5740 kgf)

3. Connection to External Piping

Be sure to use flexible joints for the connection to the inlet and outlet pipe of the engine when installing the engine by rubber mounts.

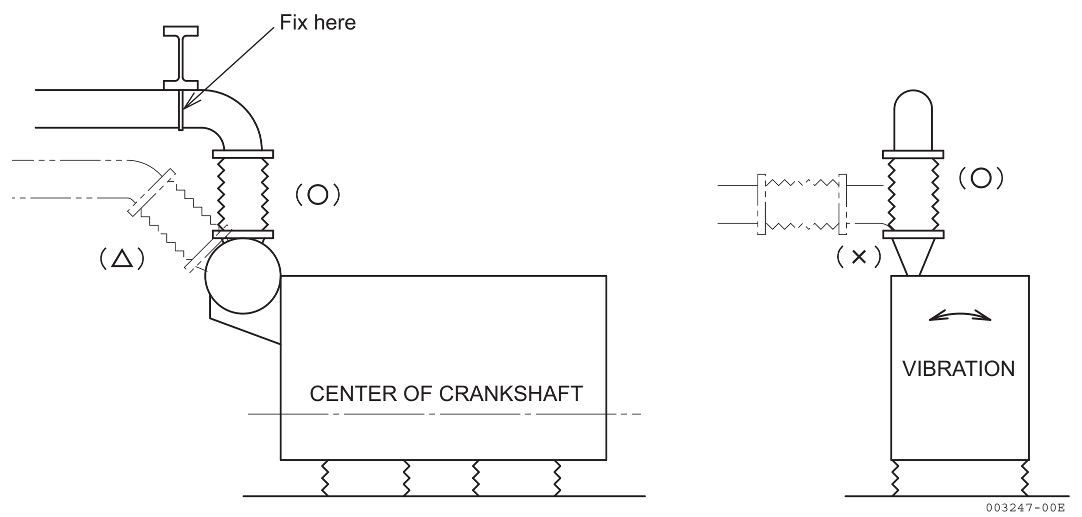
- Use a flexible exhaust pipe joint for use with the vibration isolation support at the exhaust outlet of the turbocharger.
- Select flexible pipes with appropriate pressure and thermal resistance capacities when connecting with the engine inlet pipe and outlet pipe. For details, refer to the following section.

3.1 Installation Guidance for the Flexible Pipes

The pipes should fit naturally to avoid initial stress such as elongation, excessive offset or twisting. In principle, flexible pipes should be installed perpendicular to the vibration. At the standard construction, the details are as following.

■ Flexible Pipe for Exhaust Gas

- Attach the pipe directly to the exhaust gas outlet of the turbocharger. Don't put a steel pipe or similar between the turbocharger and flexible pipe.
- When installing the flexible pipe, keep the pipe's specified length "L".
- Attach the flexible pipe vertically at the turbocharger outlet for protection of the flexible pipe. When the ceiling of the engine room is low and there is no space, the inclined installation of the flexible pipe to the crankshaft direction is permitted. Don't install a flexible pipe horizontally.
- The exhaust gas pipe undergoes significant thermal expansion.
  (Example: A temperature increase of 300°C causes a 10 m pipe to expand by 36 mm.)
  Consequently, you must retain the exhaust pipe close to the flexible pipe and leave the rest of the exhaust pipe free. Use expansion joint(s) for the exhaust pipe to absorb the thermal expansion.

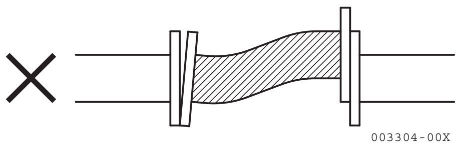


■ Installation of Flexible Pipe

Avoid excessive contraction, elongation, offset, bending, twisting or other forcible installation of the pipe that can cause initial stress when installing the flexible pipe.

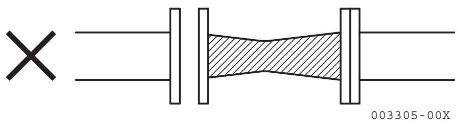
● Do not contract

Do not contract the pipe for installation. If contracted, stress will be produced in the bellows, wire blade loosened and premature breakage will result. If the pipe is too long, cut the surplus length for installation.



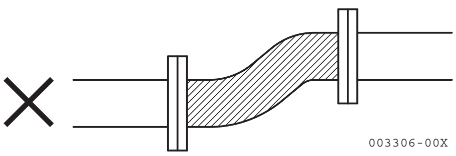
● Do not elongate

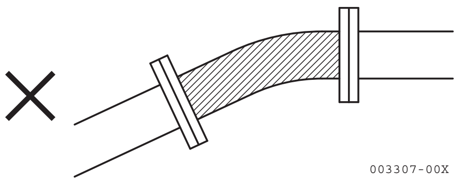
If the pipe is elongated forcibly for installation, excessive stress can work on the blade or joint and this can cause premature breakage of the pipe. Measure and cut the opponent piping to an accurate length.



● Do not offset or bend

If the pipe is installed deviated or distorted, the bellows will be distorted largely. This can cause initial stress. Avoid offset or distorted installation of the pipe.

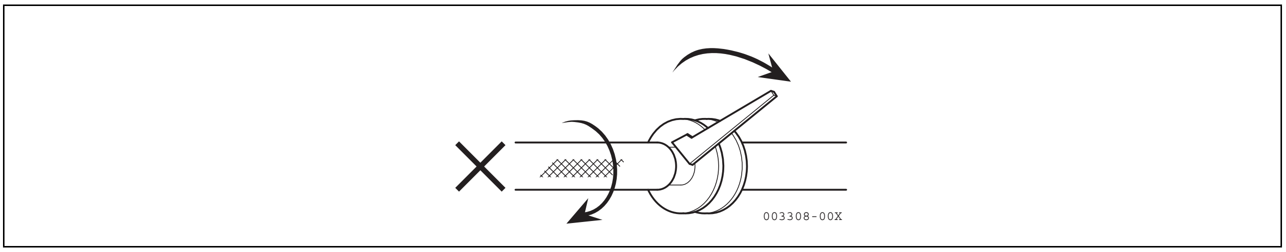




Vibration Isolating Installation of Generator Engine

● **Do not twist**

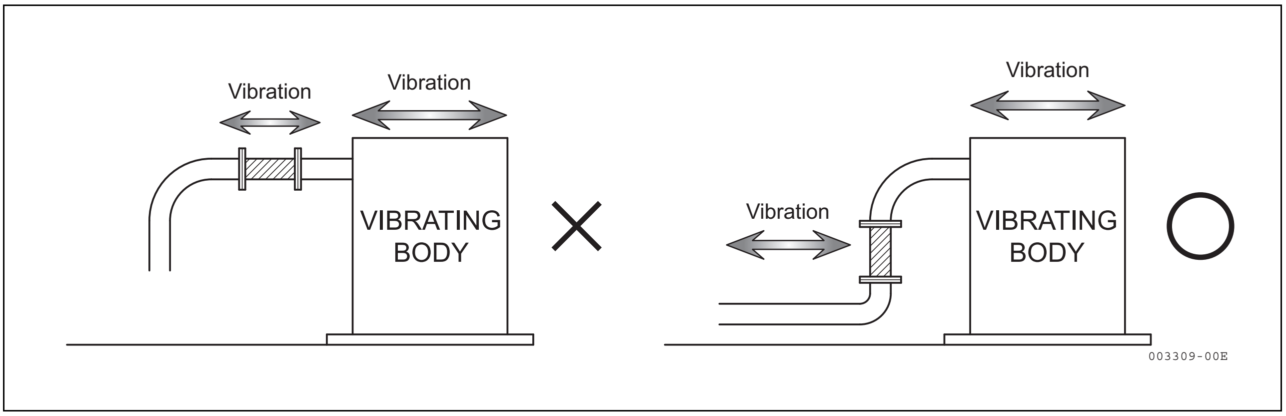
Twisting the pipe can cause residual shearing stress in the bellows. This can cause the bellows to crack. The pipe absorbs only small vibrations or vertical deviation. The pipe is not designed to withstand twisting. Accordingly, avoid the installation where the twisting of the pipe will be produced.



■ Installation Position

● **Install the pipe so that it makes a right angle to the direction of vibrations**

The pipe is designed to absorb primarily the movement in the vertical direction to the shaft. In addition, the spiral bellows, of which both ends are fixed, if contracted or expanded to the shaft direction, will be twisted and can cause premature breakage.



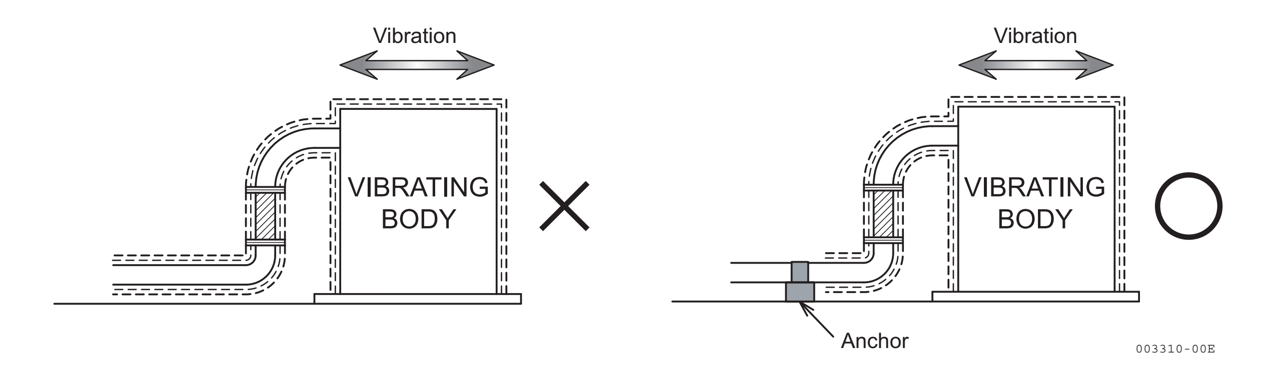
● **Install the pipe at a place with small pressure changes**

The bellows are sensitive to pressure changes. Install the pipe at a place apart from the valves in order to avoid pulsation or impact pressure as far as possible.

Vibration Isolating Installation of Generator Engine

● Be sure to install the anchor

If the opposite side of the vibrating body is not fixed, the pipe, instead of absorbing the vibrations, not only transmits vibrations but also amplifies vibrations with the pipe working as a spring and premature breakage can result. Accordingly, be sure to install the anchor as near as possible to the vibrating body.

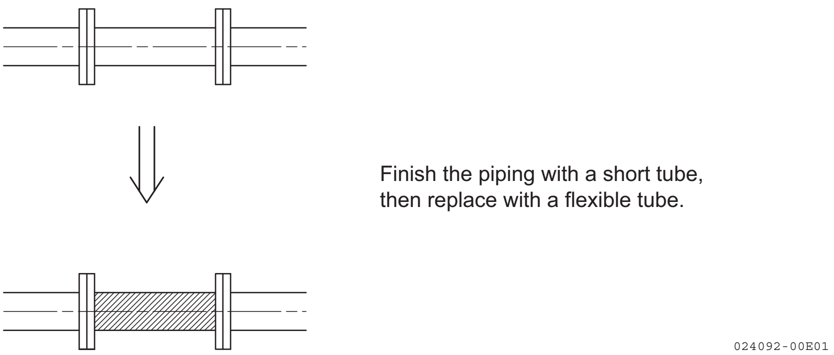


● Do not use the pipe to support heavy things

The pipe is designed to withstand the pressure inside the pipe, but it is not designed to support stationary or external force. Accordingly, install a hanger, etc. on the piping to support external forces.

■ Installation Dimensions

- Fitting of flexible tube for exhaust gas is to be set within 0 mm - +4.0 mm of length of axis, less than 1.0 mm offset of axis for drawing dimensions.
- Fitting of flexible tube for lubrication oil, cooling water, fuel oil and mist are to be set within -2.0 mm - +3.0 mm of length of axis, less than 2.0 mm offset of axis for drawing dimensions.
- If the above arrangements are difficult to keep, make a piece with the correct dimensions and then replace with a flexible tube.

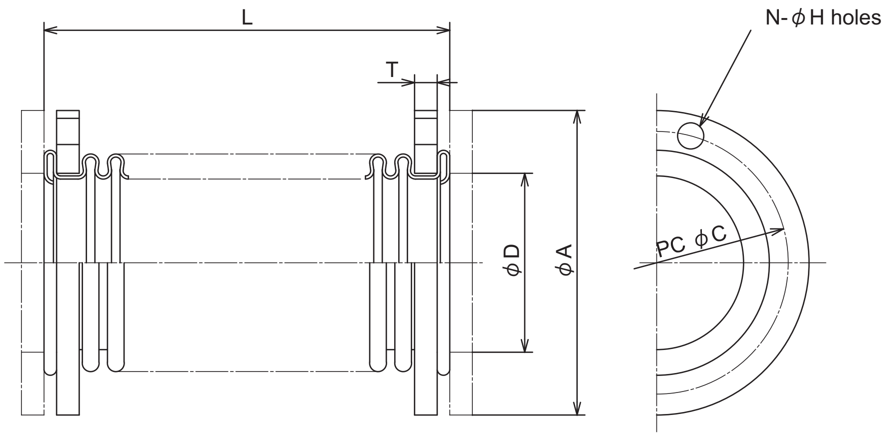


■ Splash Prevention

Cover a flexible tube for oil and flammable liquid with lagging material or the like to prevent leakage caused by looseness of the flange mounting bolt or damage to the tube.

Vibration Isolating Installation of Generator Engine

Exhaust Flexible Pipe (for Vibration Isolating Installation)



Pipe size (SGP)	Dimension (mm)						
	L	D	C	A	T	N	H
250A	400	268.5	345	385	22	12	23
300A	400	321.0	390	430	22	12	23

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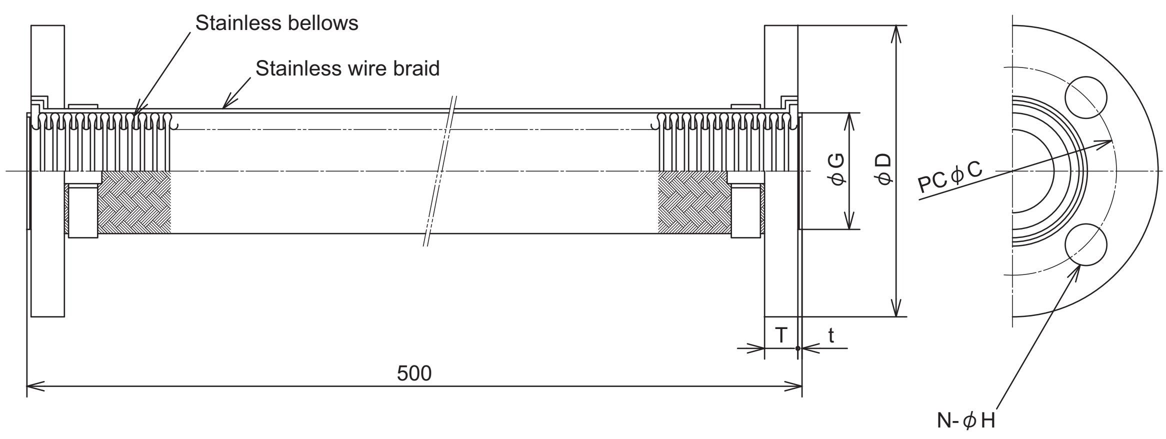
Flexible Hose



Pipe size	Dimension (mm)					
	D	G	C	N-ϕH	T	t
15A	80	44	60	4-12	9	4.0

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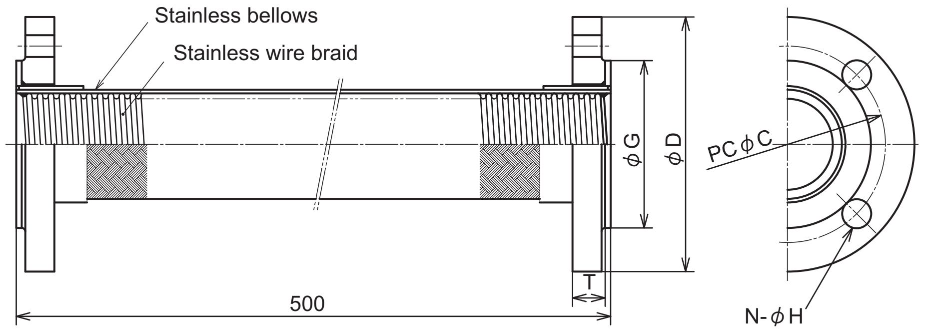
Flexible Hose



Pipe size	Dimension (mm)				
	D	G	C	N-φH	T
25A	95	48.5	75	4-12	10
40A	120	63.5	95	4-15	12
50A	130	73.5	105	4-15	14
65A	155	89.0	130	4-15	14
80A	180	103.5	145	4-19	14

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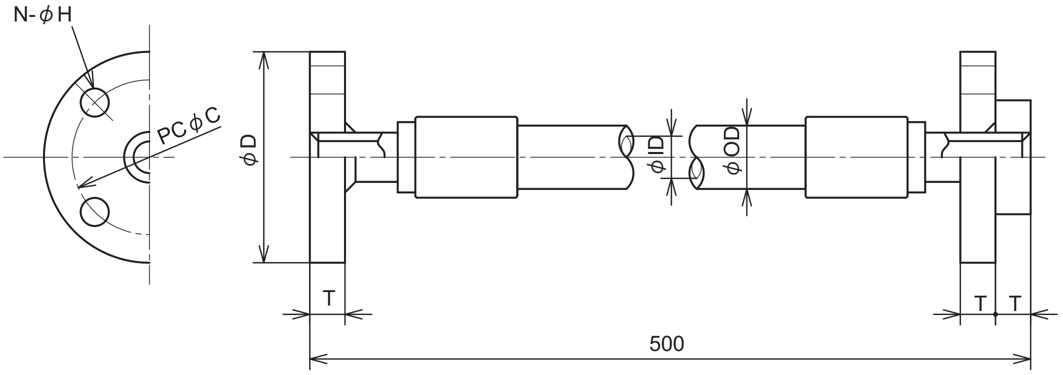
Flexible Hose (for M.D.O)



Pipe size	Dimension (mm)						
	ID	OD	D	C	T	N-H	Min. Bending R.
25A	25.4	35.0	125	90	14	4-19	270

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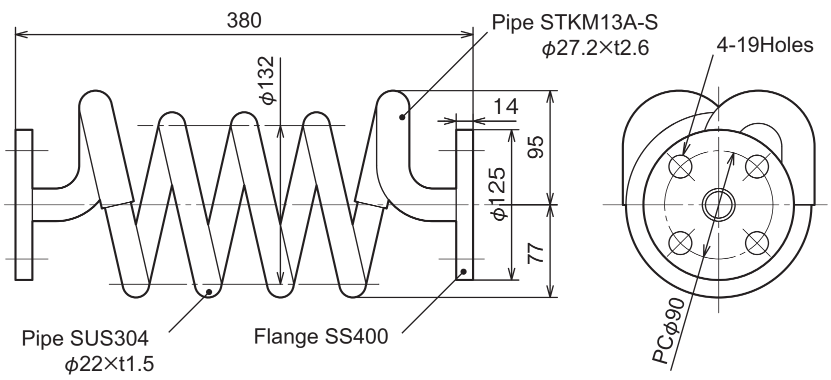
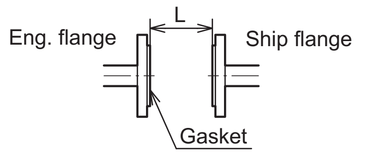
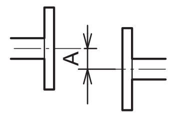
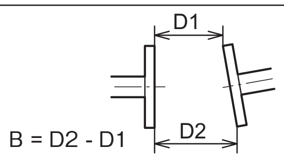
Flexible Hose (for H.F.O)



Specification			
Fluid	Fuel oil	Max. work. press	0.97 MPa
Service temp.	0℃～150℃	Mass	4.27 kg

Mounting tolerance			
Length	L	380^{+3}_{-2} mm	
Offset	A	≦ 2 mm	
Parallel	B	≦2 mm	

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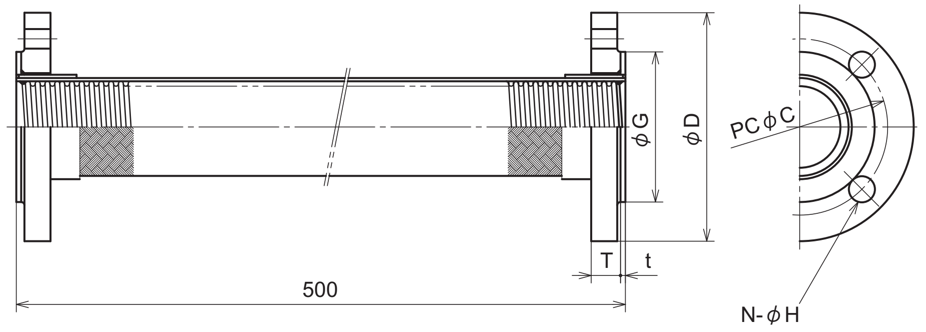
- Cover with a heat-resistant lagging sheet after completing your task. The fuel oil is hot.

Flexible Hose (for Starting Air)



Pipe size	Dimension (mm)					
	D	G	C	N-φH	T	t
25A	130	70	95	4-19	20	4.5

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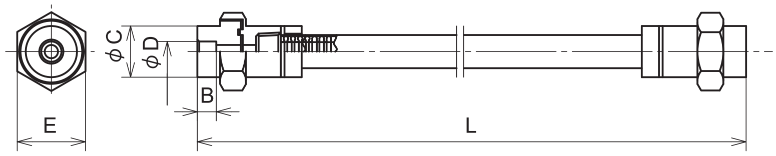
Flexible Hose (for Control Air)



Pipe size	Dimension (mm)				
	L	D	B	C	E
φ10	300	10.7	10	27	54

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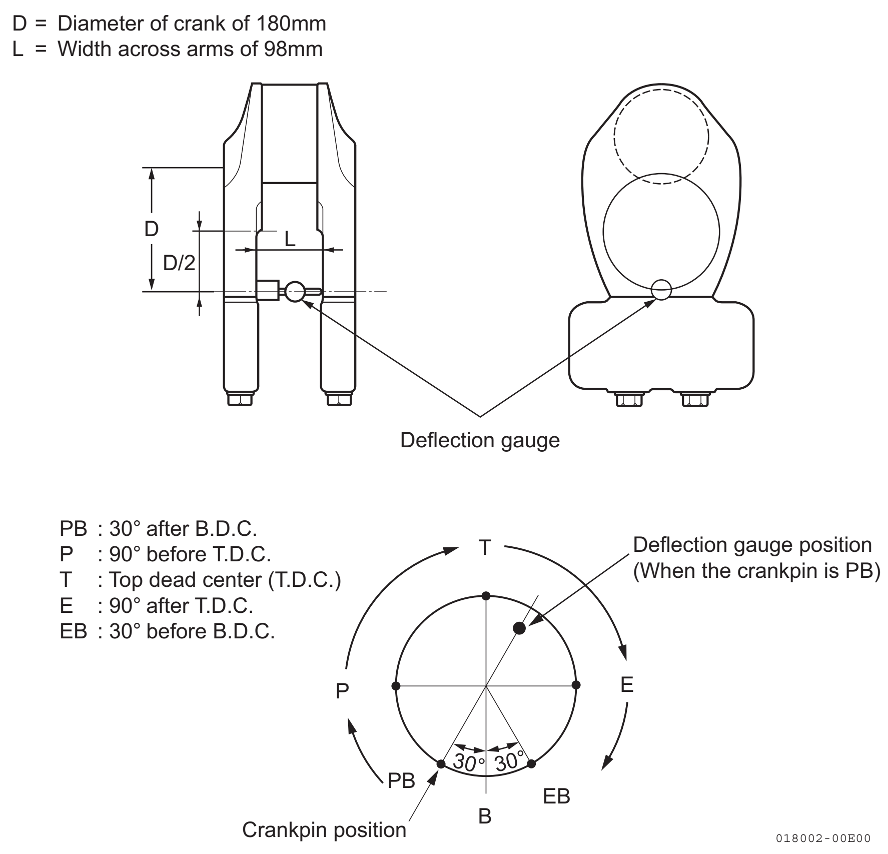
Crankshaft Deflection

1. Measurement of Crankshaft Deflection

- After installing the engine on board, measure the crankshaft deflection again to check that the deflection is within the specified value. (If the defection exceeds the specified value, adjust the crankshaft centering again.)
- Refer to the operation manual for the measurement procedures and the specified value



10 Air Charging and Exhaust System

Project Guide

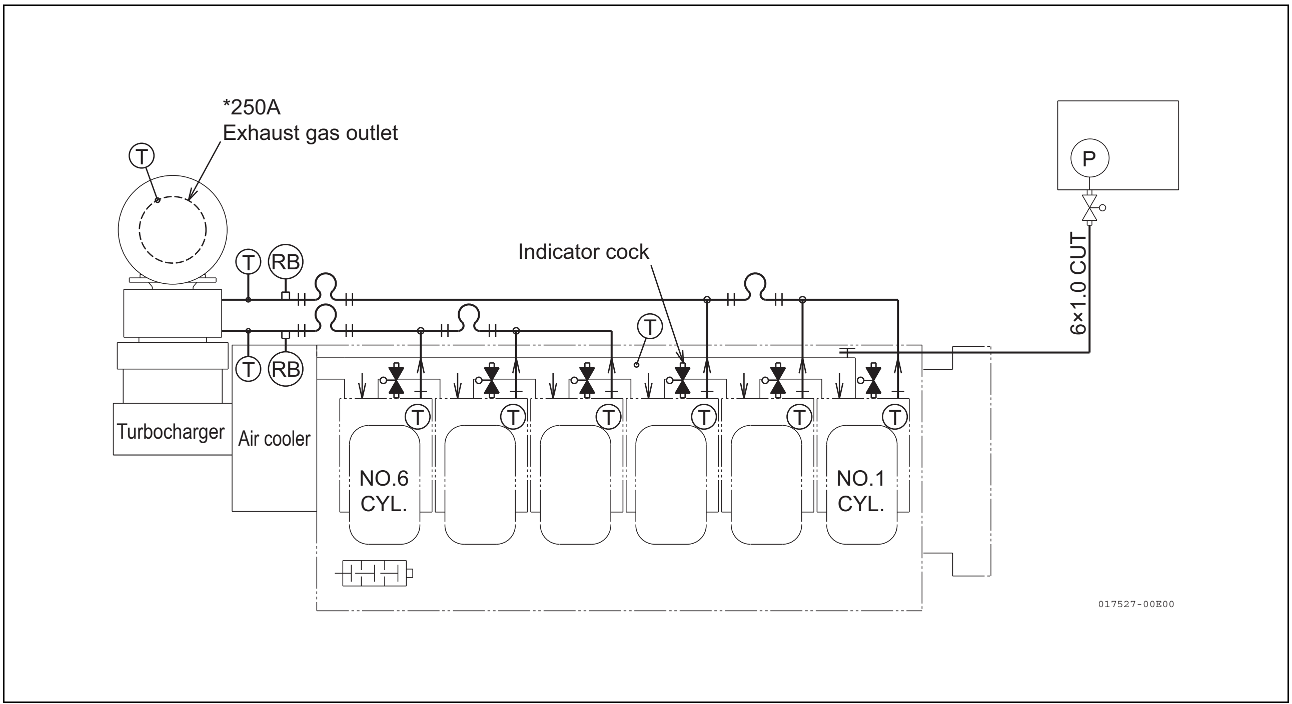
6EY18(A)LW
MARINE AUXILIARY DIESEL ENGINE

1. Outline

The air introduced from the silencer of the turbocharger is pressurized by the turbocharger's compressor, is cooled by the air cooler, passes through the charging air manifold built in the cylinder block and the suction port of the cylinder head and is sent to each combustion chamber.

It is recommended that the opening for ventilation be located near the turbocharger's air inlet at the upper part of the engine. Do not locate the opening for ventilation near the seawater or steam system. It is also recommended that the atmospheric pressure in the engine room be kept at positive pressure.

Air Charging and Exhaust System Diagram



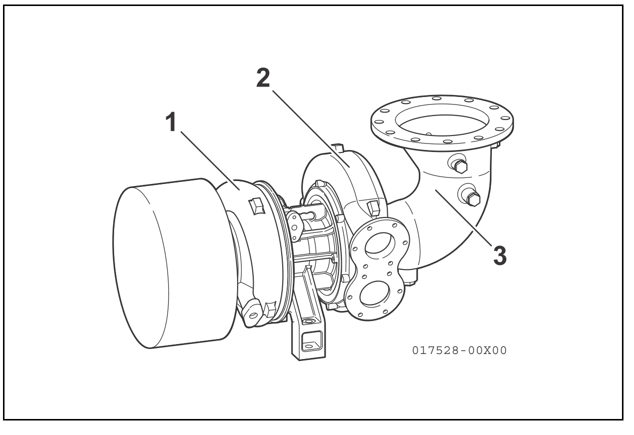
External Piping Diameter

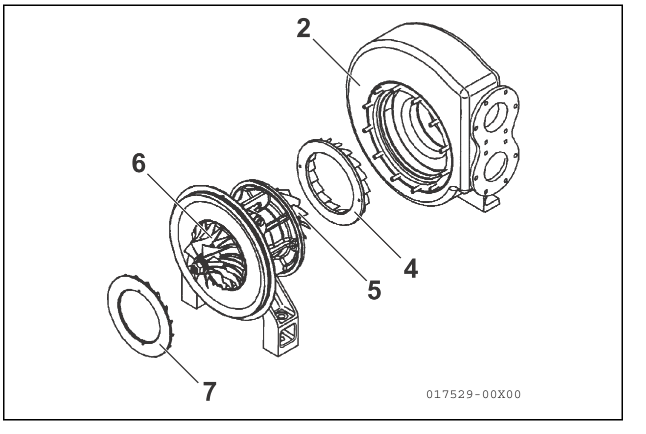
- Exhaust gas outlet diameter: 250A, 300A

2. Turbocharger

■ MET (900, 1000 min^{-1})

The air-cooled radial type turbocharger (model: MET18SRC) made by MHI with high-efficiency and high-pressureratio is installed on the opposite side of flywheel.
The exhaust gas passes to the turbine blade through the turbine housing and the turbine nozzle.
The turbocharger bearing is lubricated from the engine lubricating oil system.



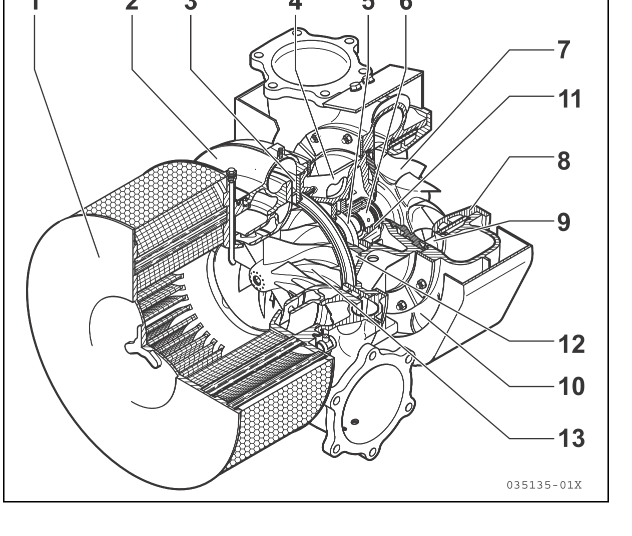


1 - Compressor housing
2 - Turbine housing
3 - Turbocharger outlet pipe
4 - Turbine nozzle
5 - Turbine blade
6 - Compressor blade
7 - Defuser

■ TPS (720, 750 min^{-1})

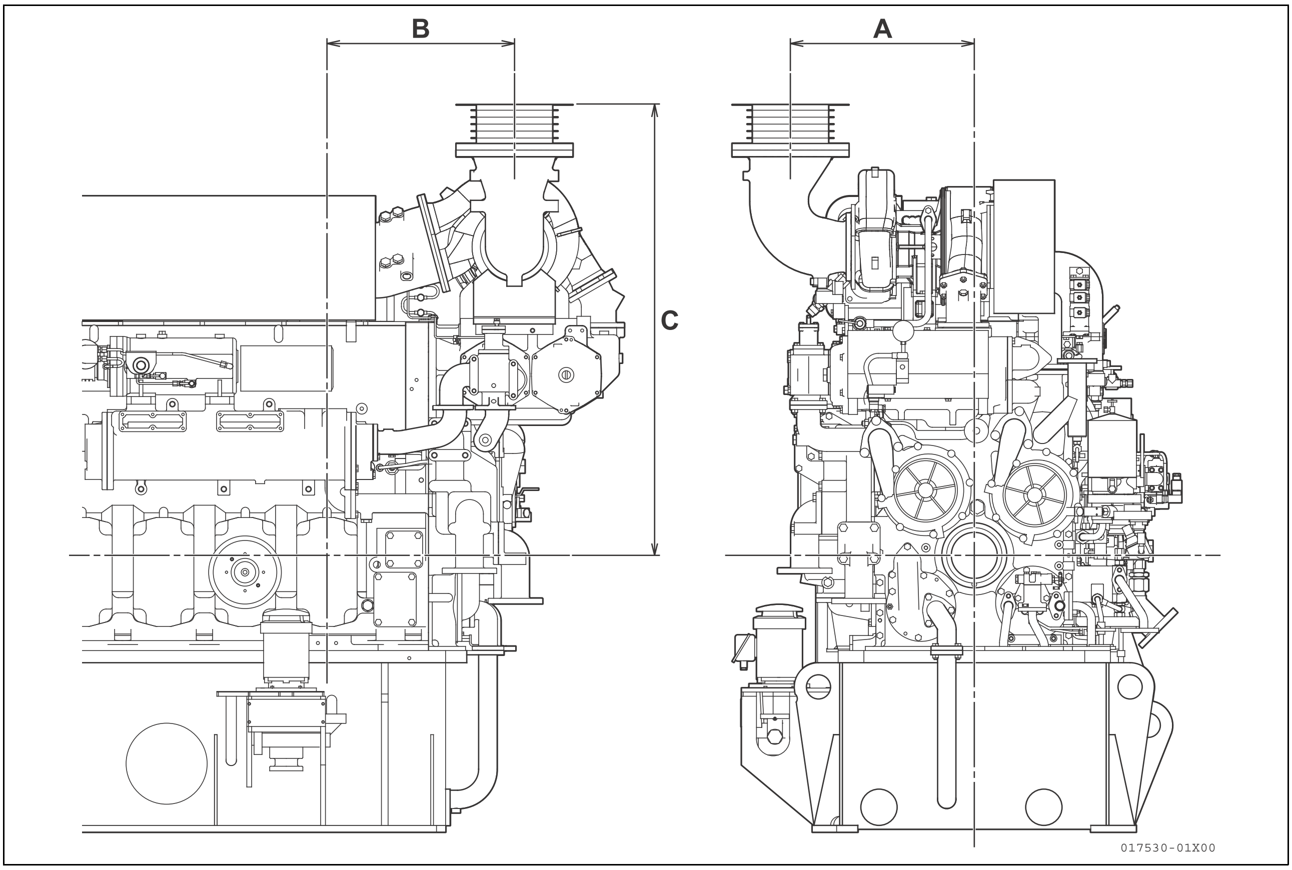
The air-cooled radial type turbocharger (model: TPS44) made by ABB-IHI with high-efficiency and high-pressure ratio is installed on the opposite side of flywheel.
The exhaust gas passes to the turbine blade through the turbine housing and the turbine nozzle.
The sliding bearing is lubricated from the engine lubricating oil system.

1 - Air suction enclosure/ noise muffler
2 - Compressor casing
3 - Diffuser
4 - Bearing casing
5 - Thrust bearing
6 - Radial bearing
7 - Turbine
8 - Gas outlet flange
9 - Nozzle link
10 - Turbine casing
11 - Turbineside bearing casing
12 - Compressorside bearing flange
13 - Compressor



3. Position of Turbocharger Outlet Pipe

Position of Turbocharger Exhaust Outlet

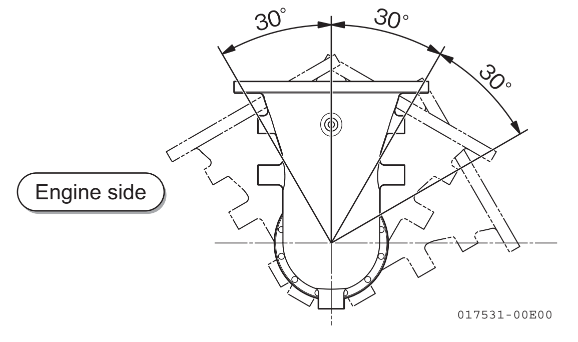


Exhaust Outlet and Flange Dimensions

	Exhaust outlet dimensions			Flange dimensions					
	A	B	C	Inside dia.	Outside dia.	Thick-ness	Pitch	Hole dia.	No. of holes
6EY18ALW 6EY18LW	608	620	1512	250A	385	22	345	23	12

The turbocharger outlet pipe is located at the non-operation side of the opposite side of the flywheel. The exhaust outlet pipe is directed upwards at a right angle as a standard. The direction can be changed in steps of 30 degrees.

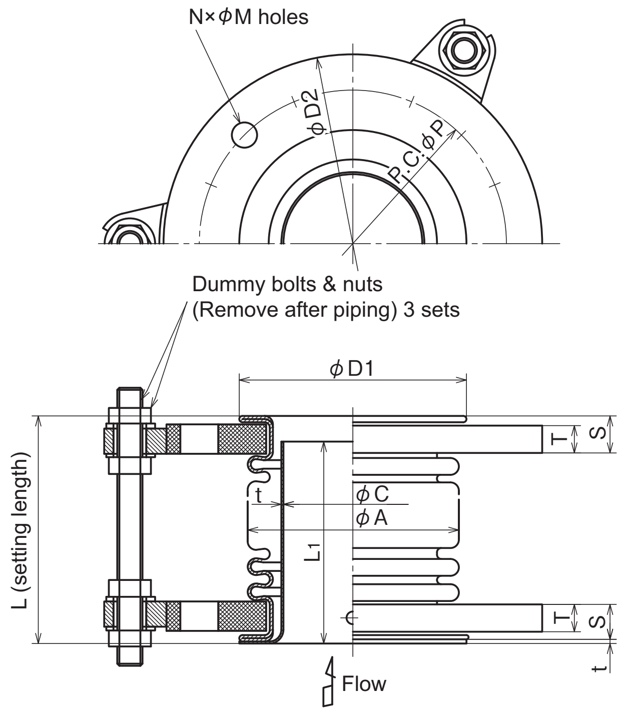
Position of Turbocharger Outlet Pipe



4. Exhaust Expansion Joint

The exhaust pipe expands due to the heat of the exhaust gas passing through it. The expansion applies load to the exhaust pipe and turbocharger and may cause cracks or damage. It is necessary to install the exhaust expansion joint in the exhaust pipe line to avoid it. The exhaust expansion joint must be directly joined to the turbocharger outlet pipe.

Turbocharger Outlet Exhaust Expansion Joint (for Fixed Installation)



Expansion length: extension 5 mm, contraction 27.3 mm (250A), 35.4 mm (300A) -------- setting length base

Pipe size	Dimension (mm)												Mass (kg)
	D1	D2	P	N	M	T	abt.S	A	C	t	L_1	L	
250A	295	385	345	12	23	22	24.2	285.5	235.5	1.5	128	171.5	22.6
300A	355	430	390	12	23	22	24.6	380.2	293	1.5	155	201.5	27

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Note:

- A gasket is not necessary on the flange face.
- The above-mentioned exhaust expansion joint is for use with engine fixed mounting.
  In the case of the vibration isolating installation, refer to the section of vibration isolating installation, 03-04.

1. Outline

Contamination may collect in the compressor of the turbocharger during engine operation.
With the turbocharger (model: MET18), it is possible to inject water and clean during operation.
This method is effective while the contamination is not so excessive, but when the contamination deposit has become hard and thick, this method cannot fully remove the contamination.
In that case, clean the compressor after removing.

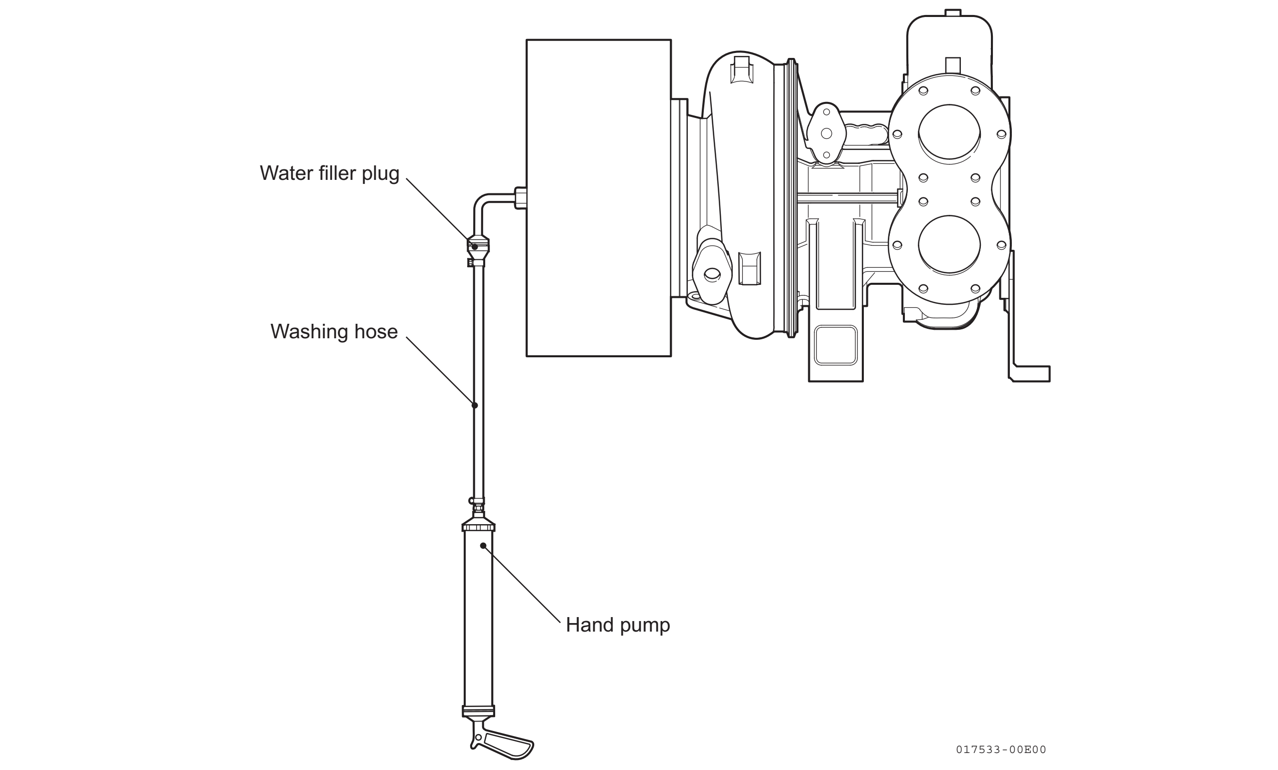
NOTICE

- If the intake air pressure does not go back to its normal value, disassemble the turbocharger and clean it.
- Use cleaning fluid.
- Do not clean the compressor immediately before you stop the engine. It can cause rust.

2. Cleaning Procedure

1. Operate the engine at 30 % to 40 % of the rated load.
2. Open the drain cock of the intake air chamber.
3. Fill cleaning fluid into a hand pump (approximately 0.25 ℓ).
4. Connect the cleaning hose to the filler of the turbocharger.
5. Slowly fill in the cleaning fluid (take 20 to 40 seconds).
6. Add the same amount of freshwater in the same way.
7. Repeat steps 3 to 5 three or four times.
8. If the intake air pressure does not come back, wait 10 minutes or more and do the cleaning again.
9. After cleaning the compressor, close the drain cock and the cap on the filler plug.
10. Run the engine under load for a minimum of 1 hour. This is to dry the engine.

* For details, refer to the operation manual of the turbocharger.



Turbocharger Compressor Water Cleaning Procedure (720, 750 min^{-1})

1. Outline

Contamination may collect in the compressor of the turbocharger during engine operation.
With the turbocharger (model: TPS44), it is possible to inject water and clean during operation.
This method is effective while the contamination is not so excessive, but when the contamination deposit has become hard and thick, this method cannot fully remove the contamination.
In that case, clean the compressor after removing.

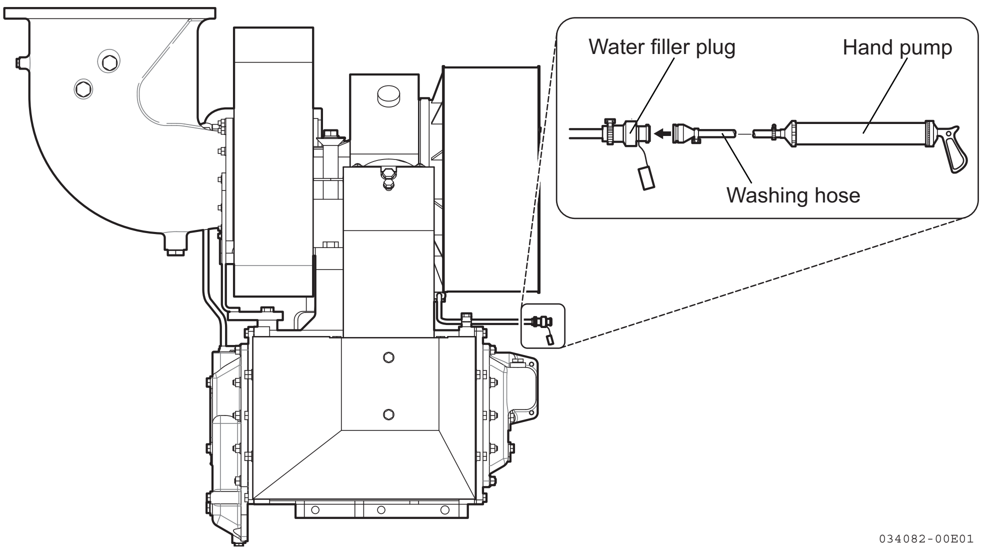
NOTICE

- If the intake air pressure does not go back to its normal value, disassemble the turbocharger and clean it.
- Always use freshwater. Never use seawater because it causes corrosion. Do not use cleaning water with coolant. The coolant particles can collect and contaminate the part.
- Do not clean the compressor immediately before you stop the engine. It can cause rust.

2. Cleaning Procedure

1. Operate the engine at 30 % to 40 % of the rated load.
2. Open the drain cock of the intake air chamber.
3. Fill cleaning fluid into a hand pump. (approximately 0.25 ℓ)
4. Connect the cleaning hose to the filler of the turbocharger.
5. Slowly fill in the cleaning fluid (take 20 to 40 seconds).
6. Wait 10 minutes or more and do the cleaning again. (Repeat a maximum of 3 times.)
7. After cleaning the compressor, close the drain cock and attach the cap on the filler plug.
8. Run the engine under load for at least 10 to 15 minutes. This makes the engine dry.

* For details, refer to the operation manual of the turbocharger.



Turbocharger Turbine Cleaning Procedure (900, 1000 min^{-1})

1. Outline

The use of heavy fuel oil can contaminate the nozzle ring. This results in the drop in the turbine efficiency, rise in the exhaust temperature, engine output drop, etc.

The turbocharger (model: MET18) introduces the system to wash by solid matter and remove the scale from the turbine parts every 200-250 hours.

This system, however, does not give such complete cleaning effect as can be achieved by disassembly servicing of the turbocharger on a periodic basis. Accordingly, the disassembly servicing on a periodic basis must be implemented separately.

Quantity of Cleaning Agent

Refer to the table below for the standard quantity of cleaning agent to be used in the initial stage. Excessive quantity can cause surging. Determine the optimum quantity in consideration of the operation condition of the engine.

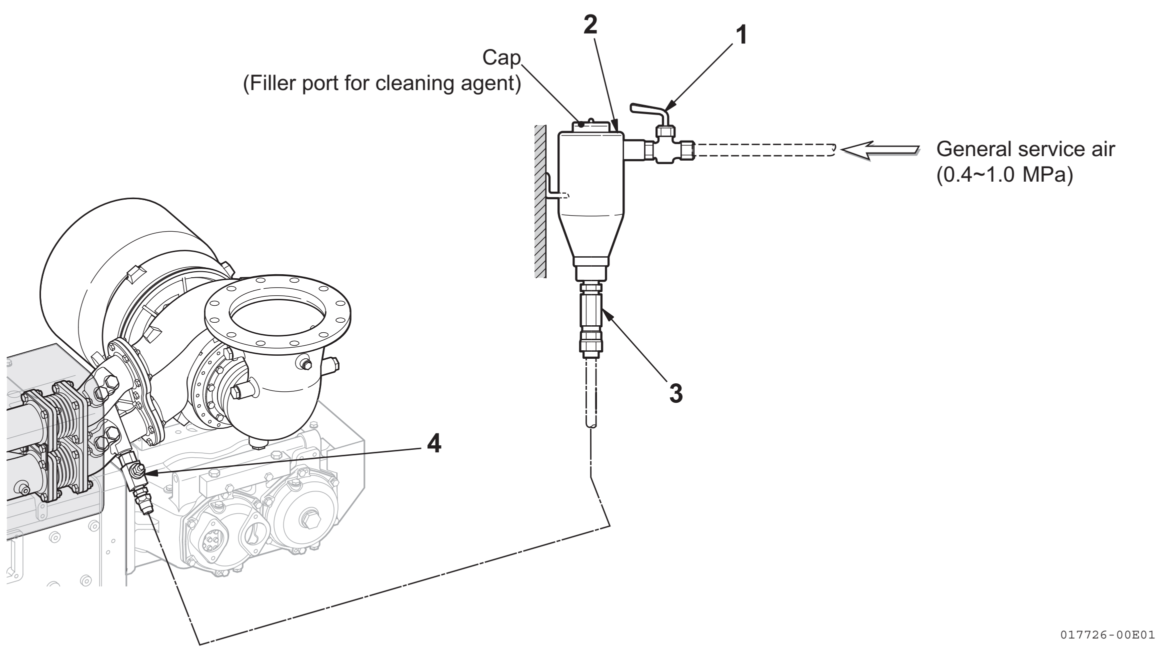
Use of Solid Cleaning Agent (ℓ / One Time)	0.05-0.1
Type of Solid Cleaning Agent	Marine grit #10 grain dia. 1.7-2.4 mm (Walnut-shell)

2. Washing Procedure

Adjust the engine output so that the engine load is about 75% and the temperature at turbocharger inlet is below 510 ℃ .

Clean the engine with the following procedure:

1. Open the valves in the following order and circulate air for 0.5-1 minute to cool the equipment:
   Valve (1) ⇒ Valve (3) ⇒ Valve (4)
2. Close the valves in the following order:
   Valve (4) ⇒ Valve (3) ⇒ Valve (1)
3. Fill the organic solid cleaning agent to the specified amount to tank (2).
   Close the cap of tank (2) firmly.
4. Open the valves in the following order, pass air and fill the cleaning agent:
   Valve (1) ⇒ Valve (3) ⇒ Valve (4)
5. Close the valves in the following order:
   Valve (4) ⇒ Valve (2) ⇒ Valve (1)



Turbocharger Turbine Cleaning Procedure (720, 750 min^{-1})

1. Outline

When the engine is operated on HFO, particles and sediments will deposit on the nozzle ring and turbine wheel.

As a result, the turbine efficiency will be lowered, the exhaust temperature increases and engine power decreases.

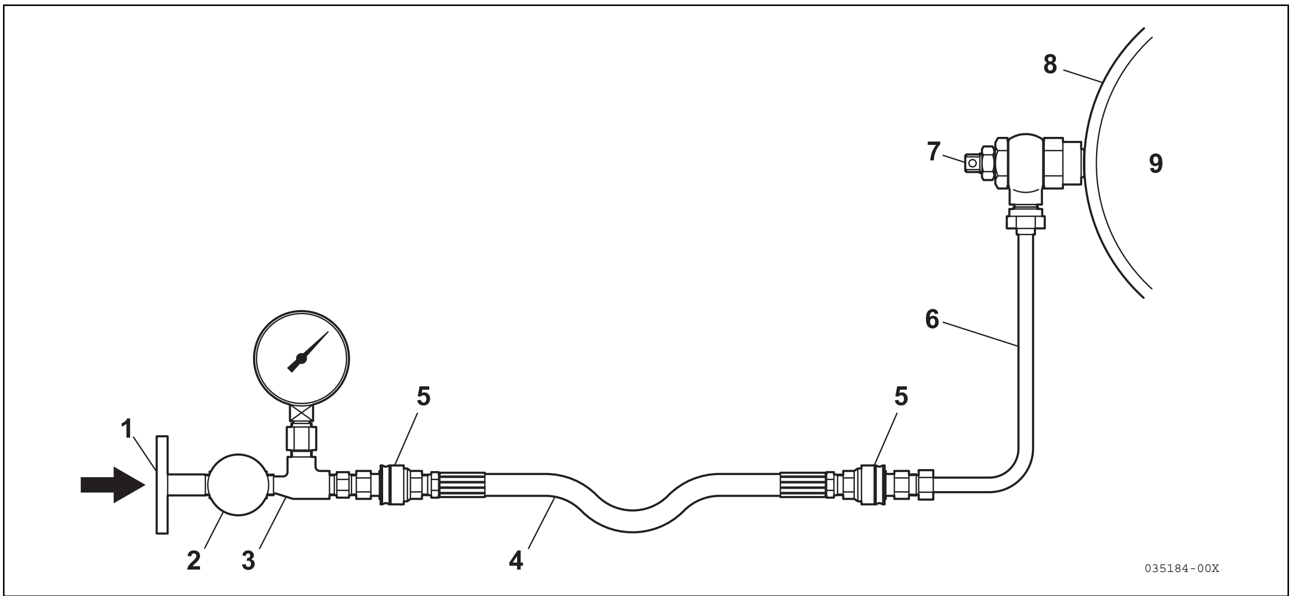
With the turbocharger (model: TPS44), it is possible to remove the scale of the turbine parts by cleaning the turbine with water every 50-200 hours to extend the overhaul interval.

This, however, does not mean that such cleaning is effective enough to substitute with the periodic assembly and servicing. Note that the periodic servicing is required separately.

2. Washing Procedure

1. Close the thermostat (2) and stop valve (7).
2. Connect the freshwater supply line (1).
3. Adjust the turbine between 400-450°C.
4. Wait for approx. 10 minutes.
5. Open the pressure thermostat (2) and set the water pressure (gauge pressure) to 0.25-0.45 MPa.
6. Open the stop valve (7) for 30 seconds and close it again.
7. Wait for approx. 3 minutes so that the injected water can evaporate.
8. Repeat steps 6 and 7 for two or three times.
9. Close the stop valve (7) and thermostat (2).
10. Run dry the exhaust gas turbocharger at constant load for approx. 10 minutes, and then increase engine load slowly.
11. Repeat the washing process if the exhaust gas turbocharger is affected by vibrations which did not occur before.
12. Remove the flexible hose (4).

* For details, refer to the operation manual of the turbocharger.



1 - Freshwater supply line
2 - Thermostat
3 - Union
4 - Removable flexible tube
5 - Snap joint
6 - Wash-water piping
7 - Stop valve
8 - Turbine casing
9 - Exh. gas

Selection of Exhaust Silencer

Select the silencer in the following steps:

[Selection Steps]

1. Checking whether spark arrester function is needed
   The regulations of Shipping Classification Organization require the installation of an exhaust silencer with the spark arrester function in a LNG tanker. The port regulations or the cargo owner may require the installation of such an exhaust silencer in other transport ships of hazardous materials.

2. Noise regulations for bridges, living quarters, and harbors
   As can be inferred from its damping characteristics, the optional exhaust silencer effectively muffles medium- and high-frequency noise, which sounds unpleasant to people. When the overall noise level of exhaust gas is regulated, more effective damping characteristics against low-frequency noise is needed. A special product (with greater capacity) can be supplied to meet this need.

3. Allowable pressure loss
   The allowable exhaust back pressure at the turbocharger outlet at 4/4 load is 3.43 kPa.
   Calculate the exhaust pipe resistance by using the exhaust gas data in section 01-02 Technical Data of this Project Guide and add the release pressure to the atmosphere, then select a silencer that matches the allowable range.

   Refer to section 10-06-00 Rigging of the Exhaust System for design details of the exhaust back pressure.

NOTICE

If the flow velocity inside the pipe exceeds 50 m/s, the internal absorption material may be removed and the noise reduction performance may decrease as a result.

Exhaust Silencer

Exhaust silencer with different noise attenuation and function are available.
The structure of all silencers is light weight and compact with a minimized body diameter.

1. Exhaust Silencer (without Spark Arrester) (Option)

Fig 1

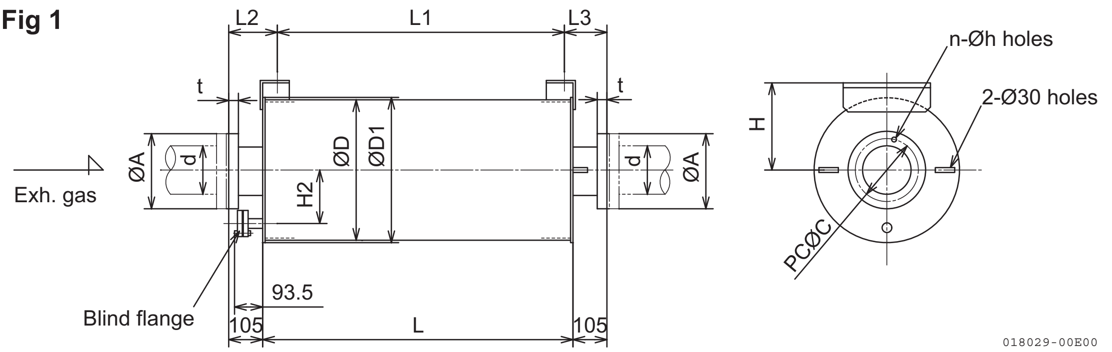
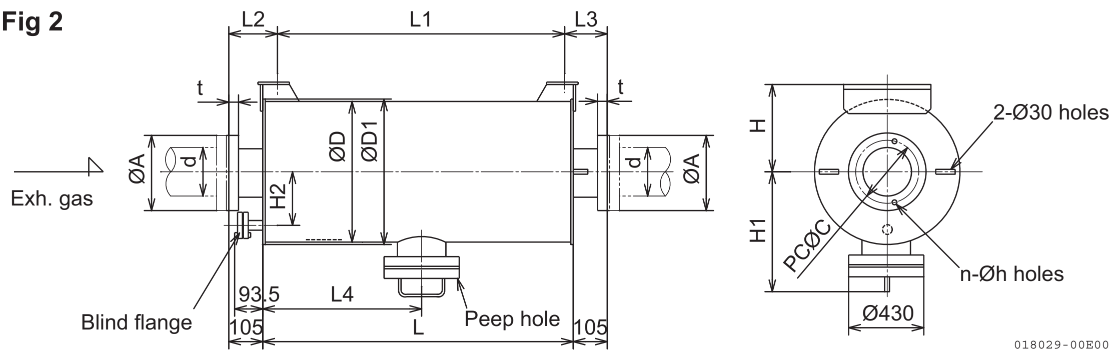


Fig 2



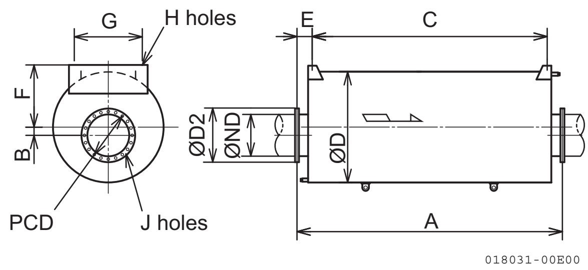
■ Dimensions

- Without Spark Arrester, Attenuation 3-5 dB (A)

Bore d	Fig	D	D1	L	L1	L2	L3	L4	H	H1	H2
250A	Fig 1	606.4	616.4	1390	1310	155	135	-	380	-	280
300A	Fig 2	756.4	766.4	1490	1395	163	142	746	460	518	355
350A	Fig 2	756.4	766.4	1490	1395	163	142	746	460	518	355

Bore d	Fig	A	C	t	n	h	Mass. kg
250A	Fig 1	385	345	22	12	23	150
300A	Fig 2	430	390	22	12	23	265
350A	Fig 2	480	435	24	12	25	285

2. Exhaust Silencer (without Spark Arrester) [Option]



■ Dimensions

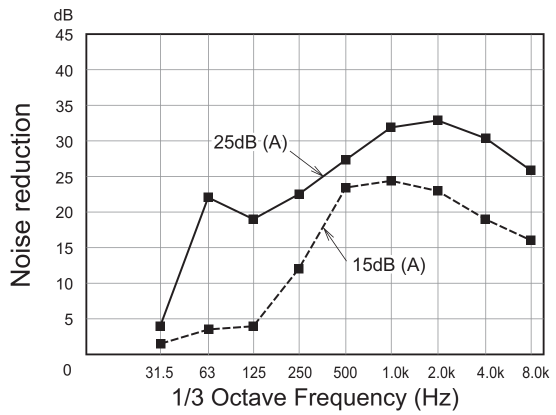
- Without Spark Arrester, Attenuation 15 dB (A)

Bore ND	A	B	C	D	E	F	G	H	D2	PCD	J	Mass. kg
250A	1440	0	950	480	245	320	240	4-19 × 20	385	345	12- ϕ 23	110
300A	1540	0	1050	530	245	350	260	4-19 × 20	430	390	12- ϕ 23	135
350A	1750	0	1190	560	280	365	320	4-19 × 20	480	435	12- ϕ 25	160

- Without Spark Arrester, Attenuation 25 dB (A)

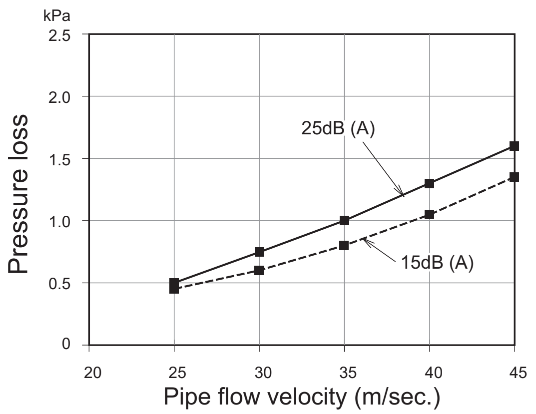
Bore ND	A	B	C	D	E	F	G	H	D2	PCD	J	Mass. kg
250A	1460	0	1140	670	160	385	350	4-19 × 20	385	345	12- ϕ 23	225
300A	1825	0	1445	770	190	435	500	4-19 × 20	430	390	12- ϕ 23	320
350A	1825	0	1445	900	190	500	500	4-19 × 20	480	435	12- ϕ 25	400

■ Attenuation Characteristics



∗ The data above is general characteristics.
Actual attenuation characteristics are influenced by the noise source (original sound, piping route, gas temperature and flow rate etc.).

■ Pressure Loss



∗ The data above is calculation value at the exhaust gas temperature 405℃

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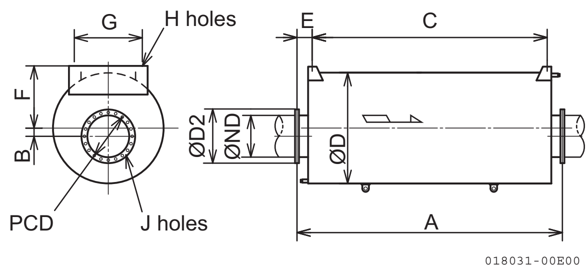
3. Exhaust Silencer (with Spark Arrester) [Option]

The exhaust silencer with spark arrester creates the swirl of the exhaust gas. The swirl makes the combustion particles in the exhaust gas touch the silencer inside wall. Then the particles are atomized and cooled. It thereby prevents sparks from being emitted.



■ Dimensions

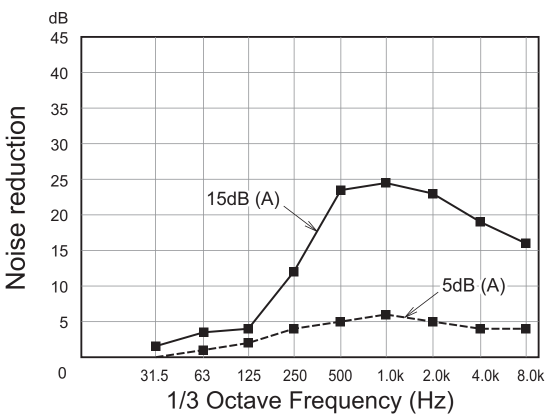
• With Spark Arrester, Attenuation 5 dB (A)

Bore ND	A	B	C	D	E	F	G	H	D2	PCD	J	Mass. kg
250A	990	0	670	590	160	345	350	4-19 × 20	385	345	12-ϕ23	125
300A	1150	0	770	670	190	385	350	4-19 × 20	430	390	12-ϕ23	165
350A	1280	0	900	770	190	435	500	4-19 × 20	480	435	12-ϕ25	215

• With Spark Arrester, Attenuation 15 dB (A)

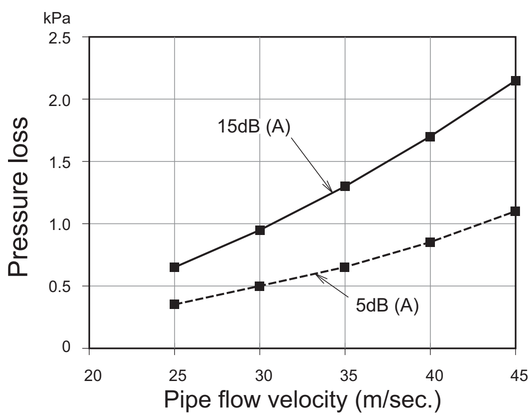
Bore ND	A	B	C	D	E	F	G	H	D2	PCD	J	Mass. kg
250A	1690	0	1370	590	160	345	350	4-19 × 20	385	345	12-ϕ23	190
300A	1900	0	1520	670	190	385	350	4-19 × 20	430	390	12-ϕ23	240
350A	2000	0	1620	770	190	435	500	4-19 × 20	480	435	12-ϕ25	300

■ Attenuation Characteristics



∗ The data above is general characteristics.
Actual attenuation characteristics are influenced by the noise source (original sound, piping route, gas temperature and flow rate etc.).

■ Pressure Loss



∗ The data above is calculation value at the exhaust gas temperature 405℃

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Rigging of Exhaust System

1. Exhaust Pipe

- Install the exhaust expansion joints in the exhaust system in the necessary quantity to absorb thermal expansion of the piping.
- The exhaust expansion joint accessory for the turbocharger outlet protects the turbocharger unit. Fasten the exhaust piping to the hull so that the outlet piping weight will not be applied to the exhaust expansion joint.
- In order not to cause exhaust gas to leak indoors, install a drain trap to prevent rainwater, exhaust drain, etc. to flow back to the engine.
- Provide thermal insulation on the exhaust piping and the silencer surface. If the insulation material used absorbs oil, cover the material with metallic sheet or equivalent material.

2. Allowable Exhaust Back Pressure

- The allowable exhaust back pressure at the turbocharger at 4/4 load is 3.43 kPa as shown below:

<u>Exhaust back pressure</u> = <u>Exhaust pipe resistance + Pressure loss of silencer + Discharging pressure to the open air (0.4 kPa) < 3.43 kPa</u>

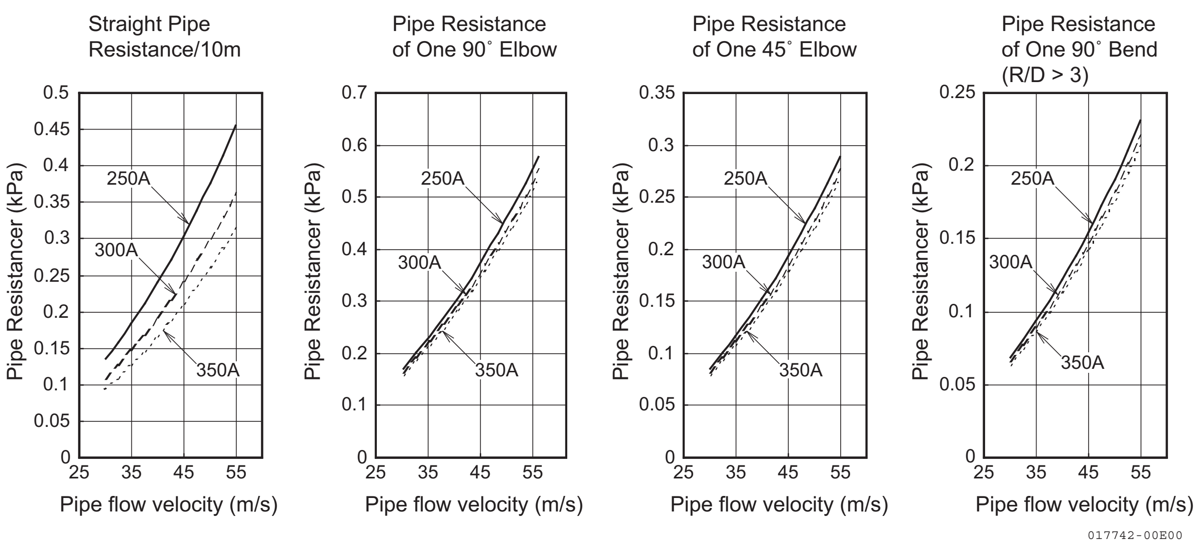
The standard bore of the exhaust pipe is 250A. If the allowable back pressure is exceeded, install a reducer at the outlet of the exhaust expansion joint to increase the bore of the exhaust pipe.

■ Calculation of Exhaust Back Pressure

The engine's exhaust gas flow rate (at 0°C) and the exhaust temperature at the turbocharger outlet are shown in section 01-02 Technical Data. Use these data to determine the exhaust gas flow rate and piping flow velocity at 100% load and calculate the exhaust gas pipe resistance and pressure loss of the silencer. (Refer to 10-05.)

■ Resistance of Exhaust Pipe

The approximate pipe resistance values of the exhaust pipe are shown in the diagrams below for both the straight and bent pipes. Calculate the pipe resistance based on the overall length of the straight pipe and number of bent pipes used. Avoid the use of small radius elbows as much as possible since these elbows will raise pipe resistance to a large value.



3. Cautions for Installing the Exhaust Expansion Joint

- Refer to the diagram below for installing the exhaust expansion joint.
- If the length (see “A” in the figure below) of the exhaust pipe is longer than 2 m, add an expansion joint.
- The expansion and construction of exhaust expansion joints are as follows.
  Expansion (Extension) : 5 mm
  Construction (Compression) : 40 mm
  After you finished setting the expansion joint, make sure to take off the set bolts.
- Set the turbocharger outlet piping so that it is not affected by the load caused by head elongation. Support “C” is to be fixed on the roof if “B” is over 1.5 m. The vertical piping should not be compressed more than 4 mm to the turbocharger side.
- During the operation, loosen the expansion joint bolts and retighten them to eliminate the strain on the exhaust gas pipe.

4. Installation of Silencer

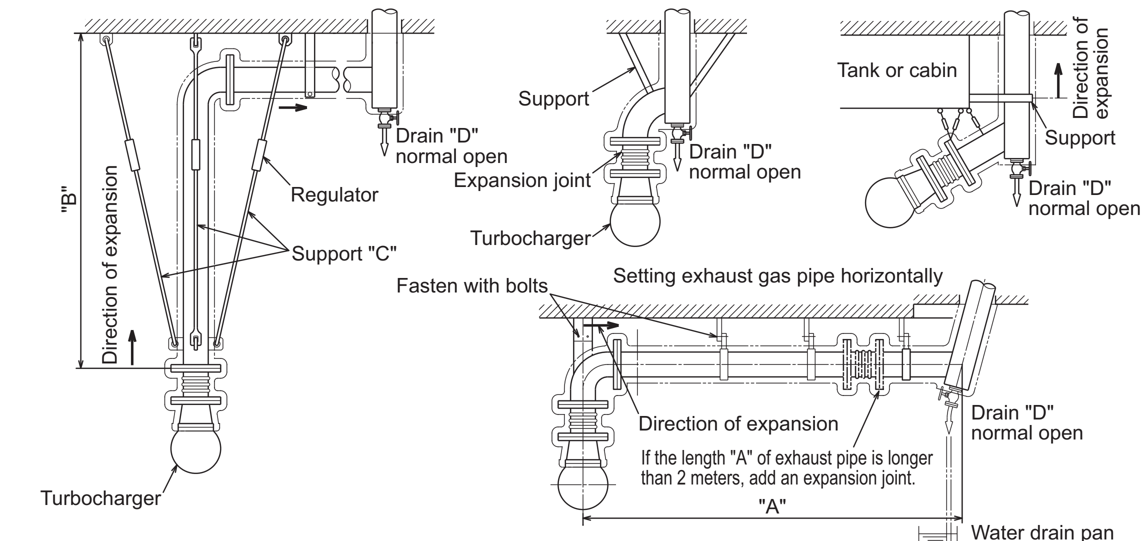
- The silencer can be installed horizontally or vertically with the accessory brackets.
- Install the silencer near the exhaust gas outlet as much as possible.
- Ensure the inspection and maintenance space near the inspection port.

5. Mist Vent Pipe

- As for the mist vent pipe from the crankcase, shorten the horizontal pipe and install it at an upward angle of 15° or more.
- Install the mist vent pipe independently without joining it with other air vent pipes.

6. Others

- Do not use the same pipe support fixture to fasten the mist pipe and exhaust gas pipe. Instead, use the respective fixtures to fasten them separately.
- Separate the mist pipe outlet and the exhaust gas outlet as much as possible from the engine room blowers so that they will not suck in the discharged gases.



Note:
Support "C" is to be fixed on the roof if "B" is over 1.5 m.

Note:
Design the system so that rain water and condensation water do not flow back to the engine.
・Drain valve should normally be open.
・Drain water should flow to the water drain pan or drain out.

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30 Lubricating Oil System

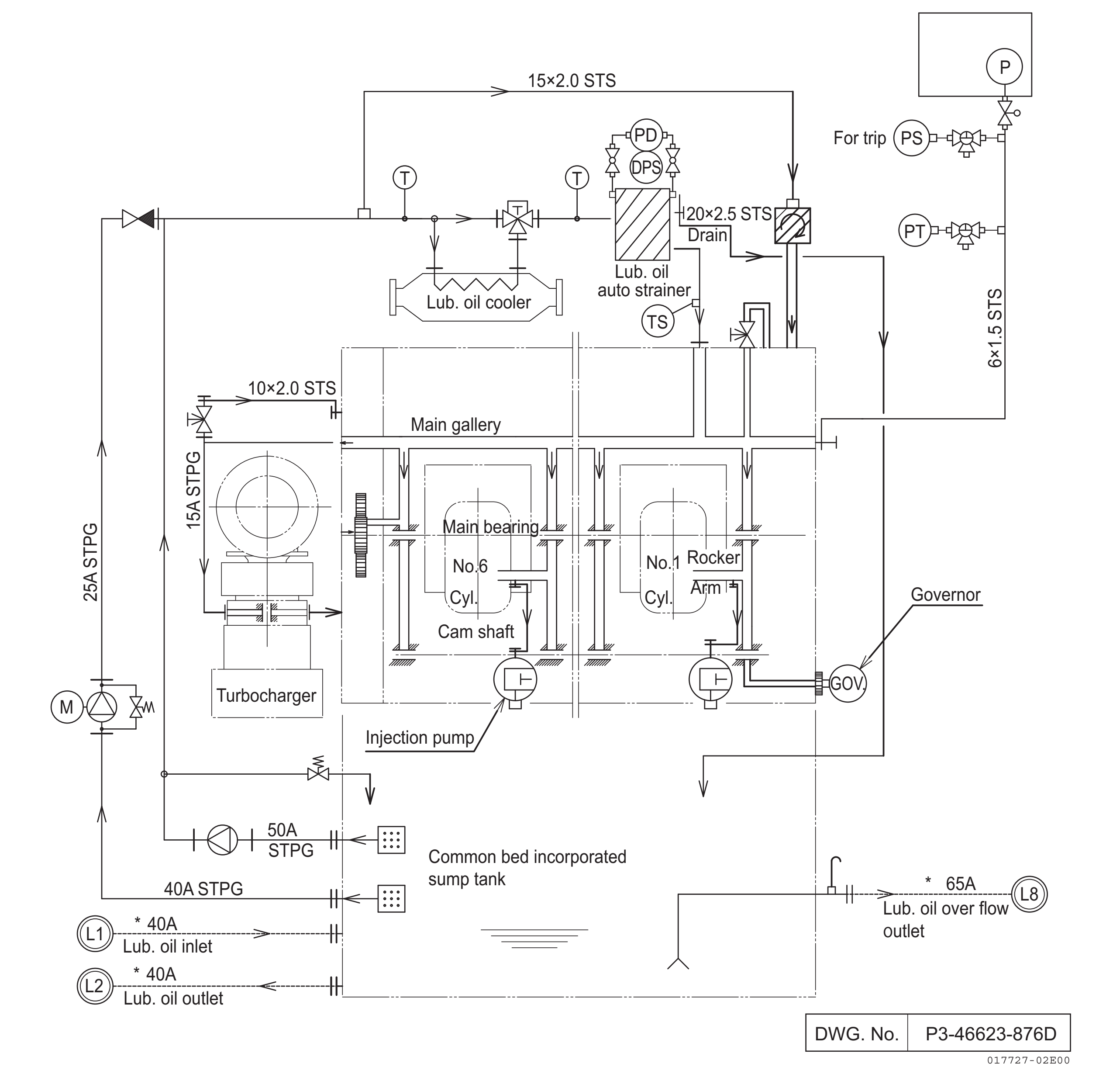
Project Guide
6EY18(A)LW
MARINE AUXILIARY DIESEL ENGINE

Engine Lubricating Oil System

1. Outline

The lubricating oil controlled by the lubricating oil pressure thermostat branches from the main gallery into three directions to main bearings and piston, to camshaft and rocker arm, and to turbocharger for lubricating and cooling.

Lubricating Oil System Diagram



External Piping Dia.

- L1 (Lubricating oil inlet) : 40A
- L2 (Lubricating oil outlet) : 40A
- L8 (Lubricating oil overflow) : 65A
- MG (Mist outlet) : 50A

Lubricating Oil Filling Capacity (ℓ)

Common Bed Incorporated Sump Tank		1000
Engine Piping (Including Lubricating Oil Cooler)		35
Governor	NZ61	1.3
	PSG	2.0

2. Lubricating Oil Consumption

Engine	Power (kW)	Lubricating oil consumption (ℓ/ h)
6EY18ALW	800	1.00
	745	0.94
	680	0.85
	660	0.83
	615	0.77
	550	0.69
	500	0.63
	455	0.57
6EY18LW	615	0.77
	550	0.69
	500	0.63
	450	0.57
	400	0.50
	360	0.45

3. Lubricating Oil System

- The lubricating oil lubricates the major moving parts: main bearings, crankshaft, connecting rods and piston pin bearings. The lubricating oil finally cools the piston.
- Lubricating oil from the main gallery passes through a drilled hole and lubricates the camshaft and bearings.
- Lubricating oil from the main gallery passes through the drilled hole and flows in the cylinder block and into each cylinder head and lubricates the rocker arm bearing and rocker arm, and then lubricates the valve head and valve stems.
- Lubricating oil flows to the turbocharger through the turbocharger lubricating oil pipe. It lubricates the turbocharger bearings and cools the casing.
- Lubricating oil for the governor gear passes through a drilled hole after lubricating the camshaft.

■ Lubricating Oil Pump

The lubricating oil pump is a gear pump. It is located at the opposite side of the flywheel.

■ Lubricating Oil Cooler

The lubricating oil cooler integrated with the bypass passage is of the fin tube type and is located at the non-operation side of the engine.

The lubricating oil strainer and the lubricating oil temperature thermostat are equipped directly on the top side.

■ Lubricating Oil Temperature Thermostat

Lubricating oil temperature thermostat: Direct-action, wax pellet type

Temperature regulating range: 50-65 °C

■ Lubricating Oil Strainer

Lubricating oil strainer: Continuous automatic back-wash type

Strainering capacity: E.F. 30 μm

■ Lubricating Oil Pressure Thermostat

Lubricating oil pressure thermostat: Piston valve type

Pressure regulation: 0.40-0.45 MPa

■ Lubricating Oil Pressure Regulating Valve for Turbocharger (if a MET turbocharger is installed)

Lubricating oil pressure regulating valve: Piston valve type

Pressure regulation: 0.1-0.2 MPa

■ Centrifugal Lubricating Oil Filter

The centrifugal lubricating oil filter is a bypass filter. One filter is installed on the non-operation side.

1. Lubricating Oil Priming Pump

The engine is equipped with the gear priming pump driven by the electric motor.
In order to prevent faulty lubrication on engine start and fretting wear, the pump provides continuous priming while the engine is being stopped.
When the priming is stopped for more than 2 hours, operate the pump first for at least 20 minutes before starting the engine.

The starting panel is to be procured separately by the user, however, it is possible for Yanmar to procure it in compliance with the request by the user.
Refer to the table below for the pump type, specifications and electric motor.

Priming Pump Major Specifications

Type	Vertical, gear pump driven by electric motor
Capacity	4 m^3/h
Discharge pressure	0.15 MPa
Speed	1750 min^{-1}
Motor	4P, 1.5 kW, AC 440 V, 60 Hz
Motor current	3.4 A
Protection	IP44
Grounding size	20b

Note: Other voltage and frequency motors are available.

1. Lubricating Oil Purification System

The lubricating oil purification system depends on the ship. Basic recommendations are given below.

1.1 General

When the engine is operated on Heavy Fuel Oil (H.F.O.), deterioration of lubricating oil is accelerated due to the entry of combustion residue in lubricating oil, which in turn accelerates the wear of major moving parts. Accordingly, it is important to select the appropriate type of lubricating oil and to purify lubricating oil appropriately to maintain its lubrication properties.

Basically, when using H.F.O. with a quality higher than 380 mm^2/s, we recommend a continuous purification by the centrifugal purifier as shown in 1.2 and 1.3. When using H.F.O. with a quality lower than 380 mm^2/s or Marine Diesel Oil (M.D.O.), the intermittent purification system as shown in 1.4 may be used.

1.2 Overflow Tank Purification System

In the case of parallel operation of multiple engines, we recommend the use of the continuous purification system with overflow tank as shown in Fig. 1. When using this system, consider the following points:

- Plan the overflow tank capacity so that the total of the lubricating oil sump tank capacity and the overflow tank capacity becomes about 2.0 liters/kW. (However, the lowest capacity is assumed to be 1200ℓ.)
- Plan the lubricating oil purifier capacity so that the number of purification times for the full amount of lubricating oil inside the system becomes about 4 times per day.
- Plan that the flow velocity in the overflow pipe will not exceed 0.25 m/s. In addition, use a bend to the overflow joint flange of the lubricating oil sump tank for downward piping. (If the piping extends long horizontally, the oil level in the sump tank will be raised when the engine is inclined.)

1.3 Continuous Purification for Each Engine Unit (Direct Purification System)

In the case of conducting parallel operation of multiple engines just for a temporary period, each engine unit may be purified continuously as shown in Fig. 2 instead of employing the overflow purification system. When using this direct purification system, consider the following points:

- Raise an appropriate caution plate or install a proper device so that lubricating oil will not be lost due to mis-operation of the sump tank outlet/inlet valve.
- Install the oil level alarm device (high, low) to detect the mis-operation of the sump tank inlet/outlet valve at an early stage.

1.4 Batch Purification System

When using the fuel oils with the quality of 380 mm^2/s or lower or M.D.O., a batch purification system as shown in Fig. 3 may be employed. When using this batch purification system, consider the following items:

- Watch the lubricating oil properties carefully and conduct purification on a periodic basis.
- The batch purification may be implemented during the ship's voyage when the standby unit is available, but we recommend to implement purification during anchorage to ensure safety.
- The centrifugal lubricating oil filter is mounted to the engine. In order to maintain the lubricating oil proprieties appropriately, it is recommended to install the fine filter to purify the by-pass flow.

Lubricating Oil Purification

Fig. 1 Overflow Purification System

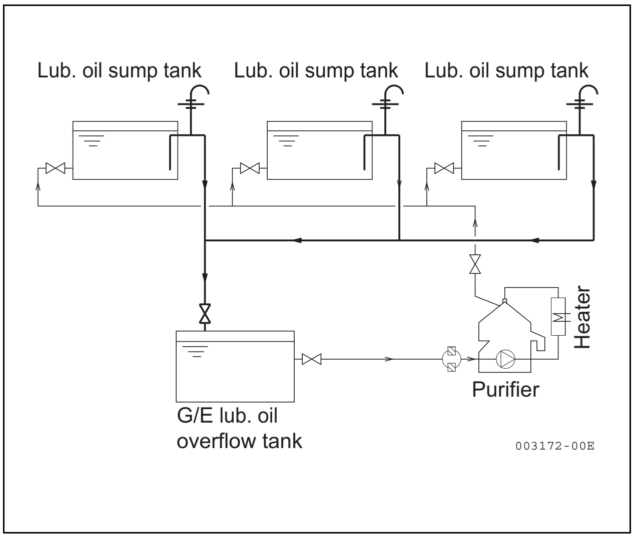


Fig. 2 Direct Purification System

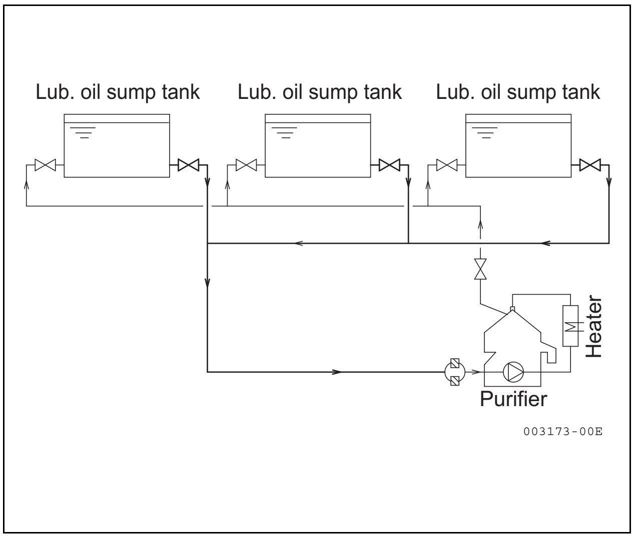
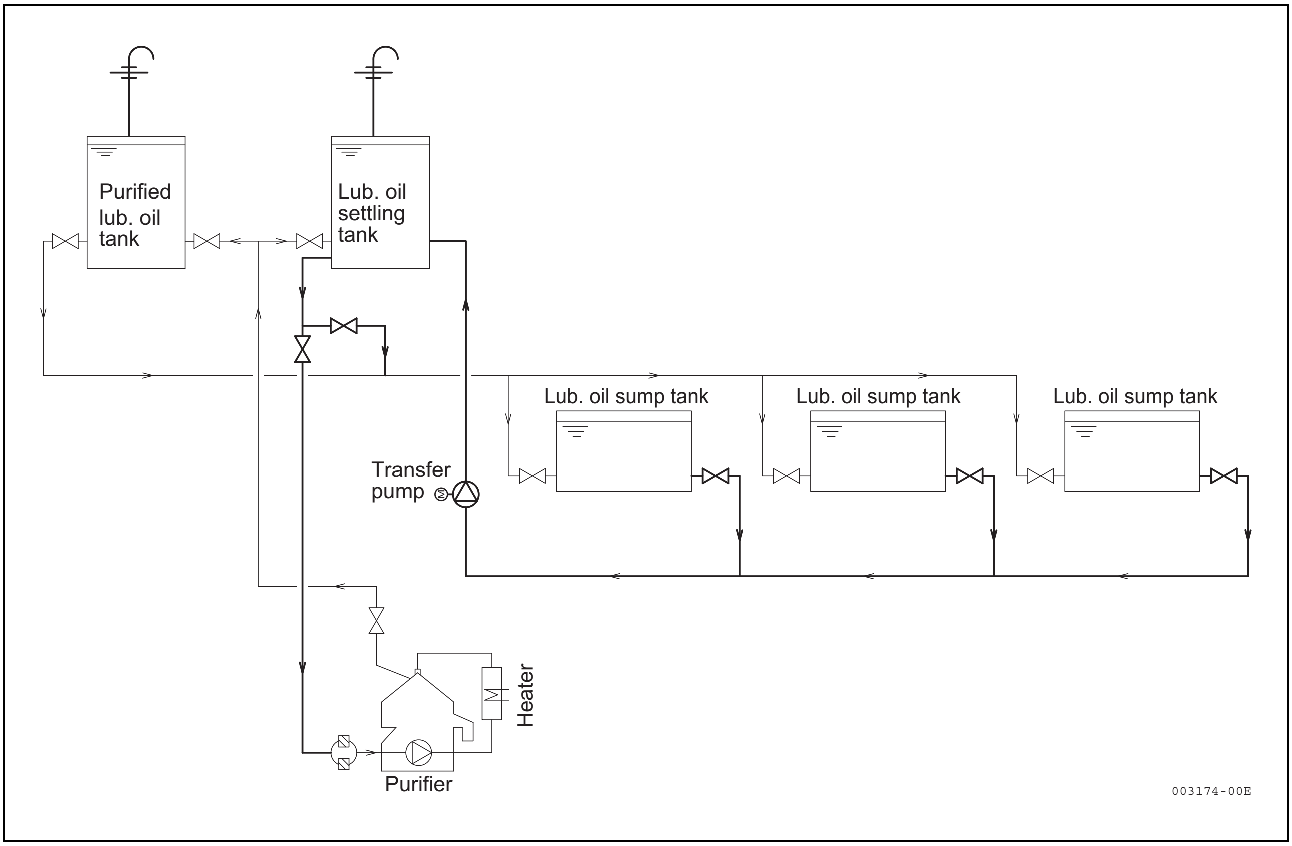


Fig. 3 Batch Purification System



Lubricating Oil Specifications

1. Outline

The selection of lubricating oil is extremely important with a diesel engine. Improper lubricating oil can cause the piston rings to stick and can cause the pistons, cylinder liners, and bearings to seize or prematurely wear. To avoid such problems, select lubricating oil in accordance with the standard shown below.

2. Selection of Lubricating Oil

The lubricating oil selection depends on the fuel oil properties and operation conditions of the engine. However, select a lubricating oil equivalent to API service grade CE or CD.

■ Viscosity

Use the values in the below table as a basis for your selection.

Viscosity (SAE)	Specific gravity	Flash point °C (open type)	Pour point °C	Viscosity mm^2/s		Viscosity index
				40°C	100°C	
30	0.89	230 or more	-10 or less	105-125	11-12.5	96-110
40	0.893	240 or more	-7.5 or less	140-155	14-15.5	96-110

■ Total base number for each fuel oil

Regarding the sulfur content in the used fuel oil, use the values in the below table as a basis for your selection. .

Fuel Oil Used	Sulfur Content (mass %)	TBN (mgKOH/g)
M.D.O./M.G.O.	1.0 or less	9-15
Low-sulfur fuel	1.5 or less	16-30
H.F.O.	more than 1.5 3.5 or less	30-42
	more than 3.5 4.5 or less	

3. Governor Oil

The engine employs a hydraulic governor. The hydraulic oil equivalent to engine's system oil can be used for the governor. However, do not use synthetic oil since this may deteriorate the oil seal and packing faster.

4. Lubricating Oil Control Standard

Analyze the lubricating oil properties every 500 hours of engine operation and replace or replenish the lubricating oil according to the control standard as shown in the table below.

Lubricating Oil Control Standard

<table>
<tr><td colspan="3">Item</td><td>Unit</td><td colspan="2">Control Standard</td><td colspan="2">Use Limit</td></tr>
<tr><td colspan="3">Flash point (PM method)</td><td>°C</td><td colspan="2">180 or above</td><td colspan="2">140</td></tr>
<tr><td colspan="3">Viscosity change</td><td>mm²/s (40°C)</td><td colspan="2">New Oil±15 %</td><td colspan="2">New Oil±25 %</td></tr>
<tr><td colspan="3">Water content</td><td>Vol.%</td><td colspan="2">0.1 or below</td><td colspan="2">0.2</td></tr>
<tr><td colspan="3">n-pentane insoluble content (A method)</td><td>mass %</td><td colspan="2">1.5 or below</td><td colspan="2">2.0</td></tr>
<tr><td colspan="3">Benzene insoluble content (A method)</td><td>mass %</td><td colspan="2">1.5 or below</td><td colspan="2">2.0</td></tr>
<tr><td colspan="3">Balance between n-pentane insoluble content and Benzene insoluble content</td><td>mass %</td><td colspan="2">–</td><td colspan="2">0.5</td></tr>
<tr><td rowspan="7">Total Base Number (T.B.N.)</td><td rowspan="2">Fuel oil</td><td rowspan="2">Sulfur content (mass %)</td><td rowspan="7">mgKOH/g</td><td colspan="4">Measurement</td></tr>
<tr><td>Hydrochloric acid method</td><td>Perchloric acid method</td><td>Hydrochloric acid method</td><td>Perchloric acid method</td></tr>
<tr><td>M.D.O./M.G.O.</td><td>1.0 or less</td><td rowspan="2">3.0</td><td rowspan="2">6.0</td><td rowspan="2">1.0</td><td rowspan="2">4.0</td></tr>
<tr><td>Low-sulfur fuel</td><td>1.5 or less</td></tr>
<tr><td rowspan="2">H.F.O.</td><td>more than 1.5
3.5 or less</td><td>5.0</td><td>10.0</td><td>3.0</td><td>7.0</td></tr>
<tr><td>more than 3.5
4.5 or less</td><td>12.0</td><td>18.0</td><td>10.0</td><td>15.0</td></tr>
</table>

Total Base Number (T.B.N.) of Fuel Oils

5. Table of Lubricating Oil Brands

Equivalent to API Service Grade CE or CD, SAE 30 & 40

Fuel Oil Used		M.D.O./M.G.O.	Low-sulfur fuel oil	H.F.O. (180, 380, 700 mm^2/s)	
Sulfur mass%		1.0 or less	1.5 or less	more than 1.5 3.5 or less	more than 3.5 4.5 or less
Total Base Number (T.B.N.)		9-15		16-30	30-42
	Supplier	Lubricating Oil Brand			
1	YANMAR	YANMAR MARINE SUPER OIL 30, 40		–	–
2	IDEMITSU KOSAN	DAPHNE MARINE OIL SX 30, 40		DAPHNE MARINE OIL MV30, MV40 SW30, SW40	DAPHNE MARINE OIL SA30, SA40, SH40
3	EXXON MOBIL	Mobilgard 312, 412		Mobilgard 312, 412 Mobilgard M330, M430	Mobilgard M330, M430 Mobilgard M340, M440
4	CASTROL	MCL 30, 40 Castrol MHP153,154 SEAMAX EXTRA 30, 40		Castrol TLX Plus 203, 204 Castrol TLX Plus 303, 304	Castrol TLX Plus 303, 304 Castrol TLX Plus 403, 404
5	CHEVRON (CALTEX, TEXACO)	DELO 1000 MARINE 30, 40 MARINE 30, 40 Taro 12 XD 30, 40		Taro 16 XD30,40 Taro 20 DP30, 40 Taro 30 DP30, 40	Taro 30 DP30, 40 Taro 40 XL30, 40
6	KYGNUS OIL	KYGNUS MARINE DX30, DX40		KYGNUS MARINE DX330, DX340	–
7	COSMO OIL	COSMO MARINE SUPER 30, 40		COSMO MARINE 3025, 4025	COSMO MARINE 3040, 4040
8	SHELL	GADINIA OIL 30, 40		ARGINA S OIL 30, 40 RIMURA FB OIL 30, 40	ARGINA T OIL 30, 40 ARGINA X OIL 30, 40
9	TOTAL Lubmarine	DISOLA M3015, 4015		AURELIA XL 3030, 4030 AURELIA TI 3030, 4030	AURELIA XL 3040, 4040 AURELIA TI 3040, 4040
10	BP	BP ENERGOL DS3-153, 154		BP ENERGOL IC-HFX 203, 204 IC-HFX 303, 304	BP ENERGOL IC-HFX 303, 304 IC-HFX 403, 404
11	JX Nippon Oil & Energy	MARINE T103, T104		MARINE T203, T204 MARINE T303,T304	MARINE T303, T304

40 Cooling Water System

Project Guide
6EY18(A)LW
MARINE AUXILIARY DIESEL ENGINE

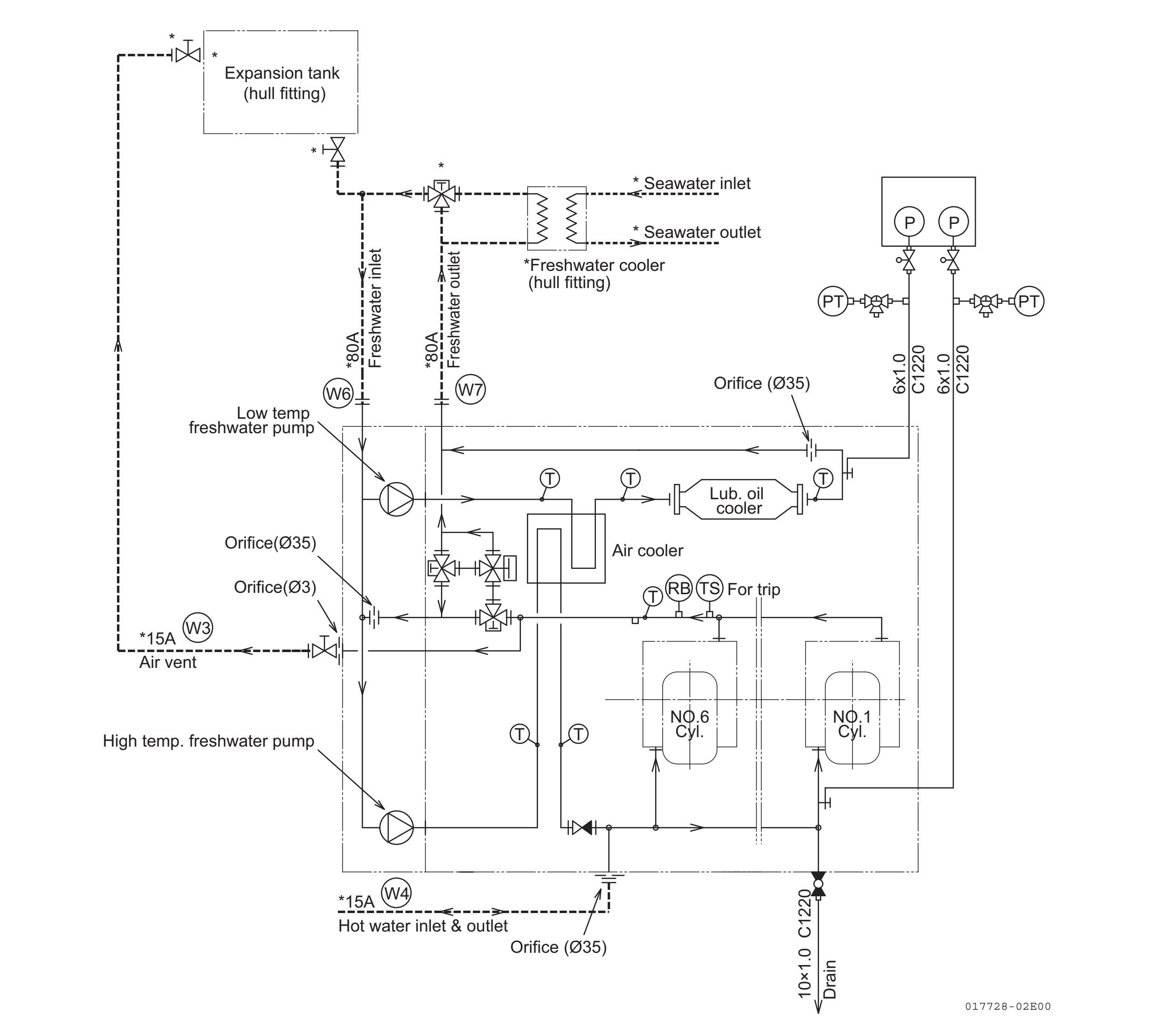
Engine Cooling Water System

1. Outline

The cooling water system of the Model 6EY18 engine is divided into two lines: a high temperature circuit for cooling the cylinder liners and cylinder head and a low temperature line for cooling the air cooler, lubricating oil cooler and other auxiliary equipment.

In addition, the cooling system of the air cooler consists of two stage cooling system: one is the high temperature circuit, the other is the low temperature circuit.

Engine Cooling Water System Diagram (Two-pump system)



External Piping Bore

- W1 (Freshwater inlet) : 80A
- W2 (Freshwater outlet) : 80A
- W3 (Freshwater system air vent pipe) : 15A
- W4 (Warming up freshwater inlet & outlet) : 15A

Freshwater Holding Capacity (liter)

Inside the engine	90
Lubricating oil cooler (Including air cooler)	55

2. Cooling Water Line

■ Low Temperature Side Cooling Water Line

In the low temperature side cooling water line, cooling water, fed from the low temperature cooling water pump, cools the air cooler and lubricating oil cooler.

In case of the freshwater/freshwater mixing circuit system, the cooling water returns to the freshwater cooler after joining with high temperature cooling water from the thermostat (temperature regulating valve). Other than the mixing circuit system, cooling water goes to the outside of the engine after cooling the oil cooler.

■ High Temperature Side Cooling Water Line

In the high temperature cooling water line, cooling water, fed from the high temperature cooling water pump, cools the air cooler, flows into the cylinder block and cools cylinder liners and cylinder heads. Then the flow is divided in two lines by a thermostat (temperature thermostat) located at the end of the collecting pipe-one to the cooling water pump, the other to the freshwater cooler.

● Cooling Water Pumps

The freshwater and seawater pumps are centrifugal pumps. Both are driven by the engine.

● Cooling Water Thermostat

The cooling water thermostat is a wax pellet type. The thermostat keeps the temperature at the engine outlet at a constant temperature. Furthermore, the dual stage temperature control equipment is employed depending on specifications (power, etc.), to reduce the thermal load that occurs under the engine high load range.

3. Engine Warm-Up

When the engine is under standby condition, supply hot water from the operating engine to warm up the standby engine.

This engine uses a cooling system that cools the fuel nozzles with jacket cooling water from outside the nozzle sleeves.

Accordingly, when the engine is operated, started and stopped on heavy fuel oils, it is essential to warm up the engine, under standby, with hot water of 65-70°C.

Depending on the load of the running engine or the piping layout, the hot water temperature may be lowered. In such a case, employ the pre-heating system.

Inboard Cooling Water System

1. Inboard Cooling Water System

The inboard cooling water system varies depending on the ship. The basic recommendations for the system are as follows:

1.1 Freshwater Cooling System for Marine Auxiliary Engines

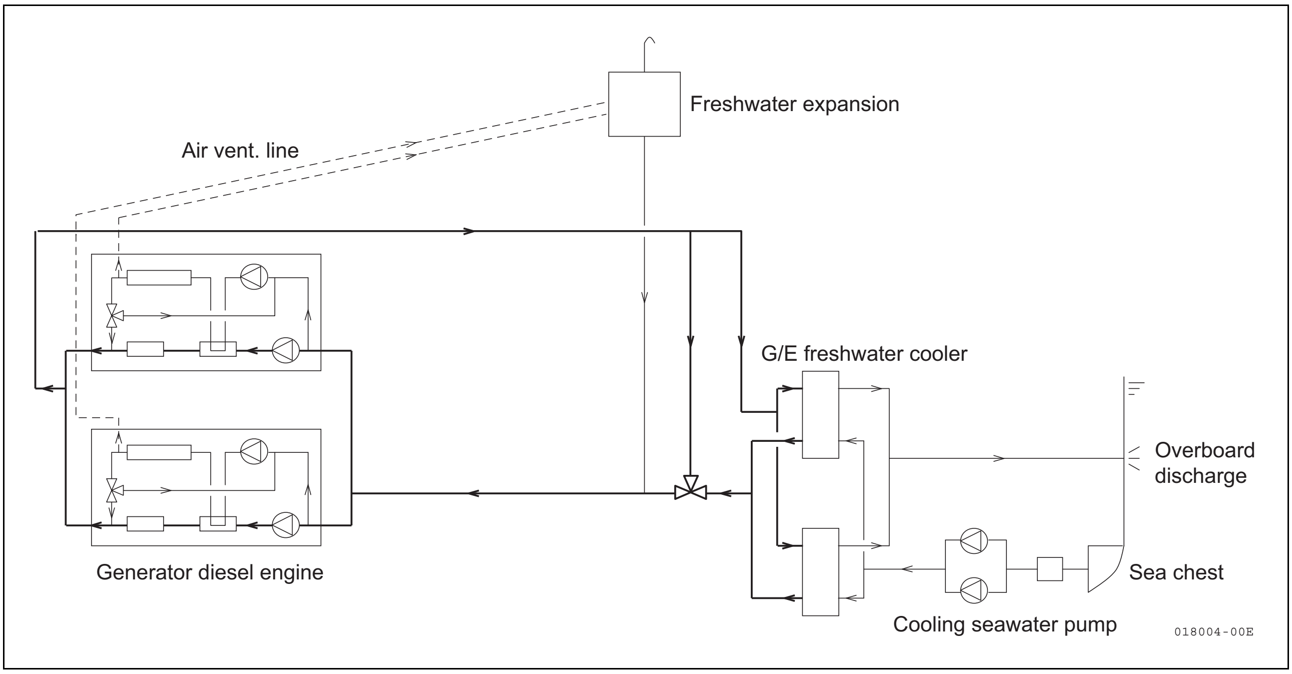
When providing the independent cooling water system for auxiliary engines, install the system as shown in the diagram below. Also take the following point into consideration when planning the cooling system:

- Design the freshwater cooler so that the low temperature side freshwater temperature is maintained at 38°C or below at the engine inlet. Design the freshwater cooler and inboard piping system so that its pressure loss is maintained below 0.1 MPa.
- If the freshwater cooler is used commonly for multiple engines, the pipe diameter shall be decided after considering the piping loss.
- Install the expansion tank about 4-15 m higher than the crankshaft center.
- Install the air vent piping on top of the engine's cooling water piping all the way to the expansion tank. Keep the air vent pipes open.
- The standard capacity of the expansion tank for an engine is 0.4 liters/kW. If the capacity of 0.4 liters/kW is not possible due to space limitation, minimum capacity of the expansion tank is 2 times the water holding capacity of an engine.

Minimum Expansion Tank Capacity

	6EY18ALW, 6EY18LW
Capacity(ℓ)	290

Cooling Water System for Marine Aux. Engines



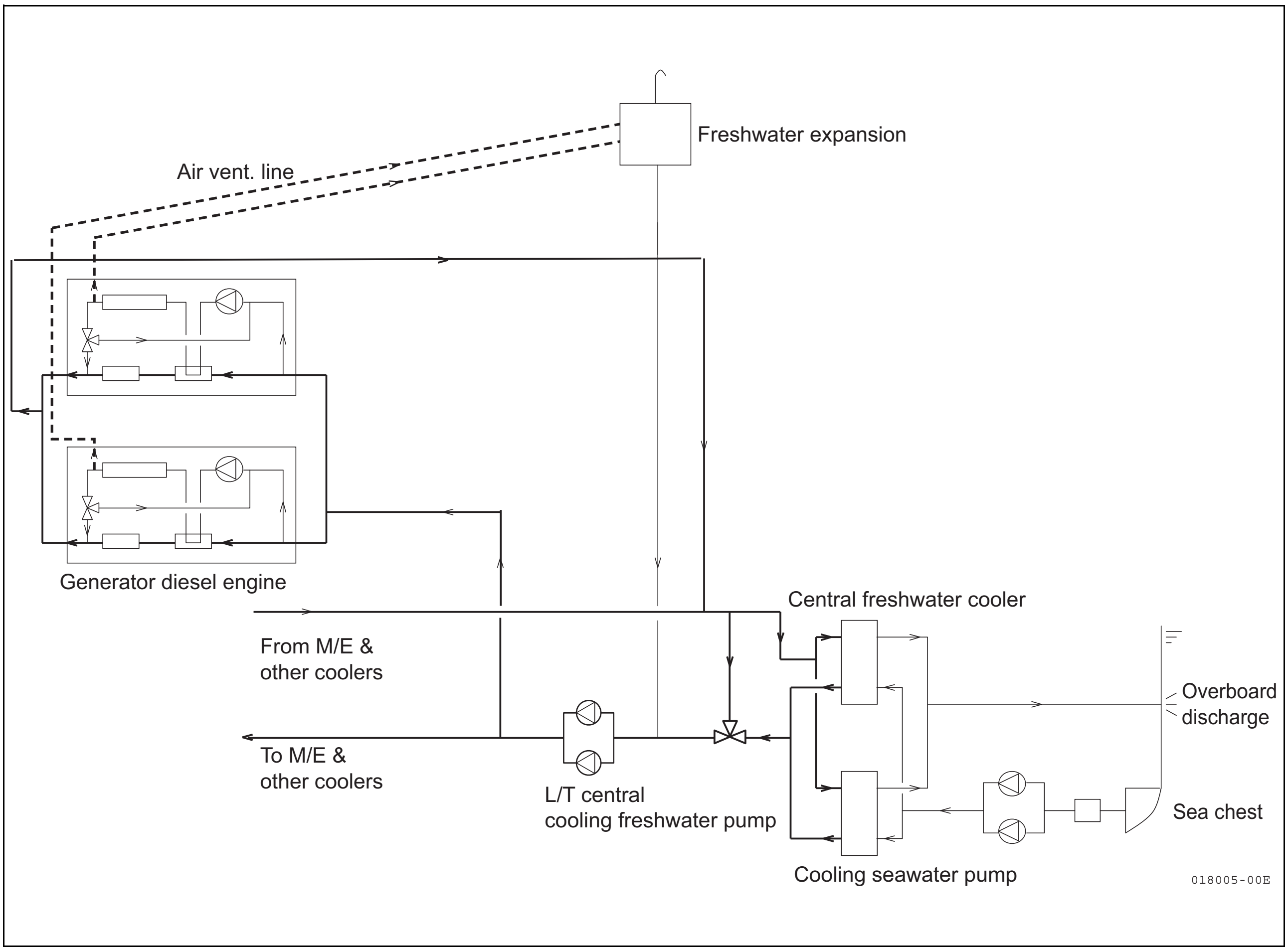
1.2 Central Freshwater Cooling System

When installing the common cooling water system for the main engine and other auxiliary equipment, refer to the example as shown in the following diagram.

- Design the freshwater cooler so that the low temperature side freshwater temperature is maintained below 38°C at the engine inlet. Design the low temperature side freshwater cooling pump so that the low temperature side freshwater pressure at engine inlet is maintained at 0.3 MPa or less.
- The allowable pressure of the cylinder jacket cooling water is 0.5 MPa. Design the central cooling system so that this pressure is not exceeded during engine operation.

  Low Temperature Side Engine Internal Pressure Loss: About 0.07 MPa
- Even when installing the central freshwater cooling system, take section 1-1 into consideration.

Central Freshwater Cooling System



Note:

If the cooling water pressure of the generator becomes high, consider installing the central pump on the inlet side of the central cooler.

1. Warming Up System

When the engine is under standby condition, supply hot water from the engine being operated to warm up the standby engine.

Fig. (a) below shows an example of the mutual engine warming up system.

The present engine employs the system where the fuel oil injection nozzle is cooled by the jacket cooling water from the outer circumference of the sleeve. Accordingly when the engine is operated, started and stopped on heavy fuel oils, it is essential to warm up the engine, under standby, with hot water of 65-70°C.

Depending on the load of the running engine or the piping layout, the hot water temperature may be lowered. In such a case, employ the pre-heating system.

For installing the pre-heating system, refer to the table and diagram (b).

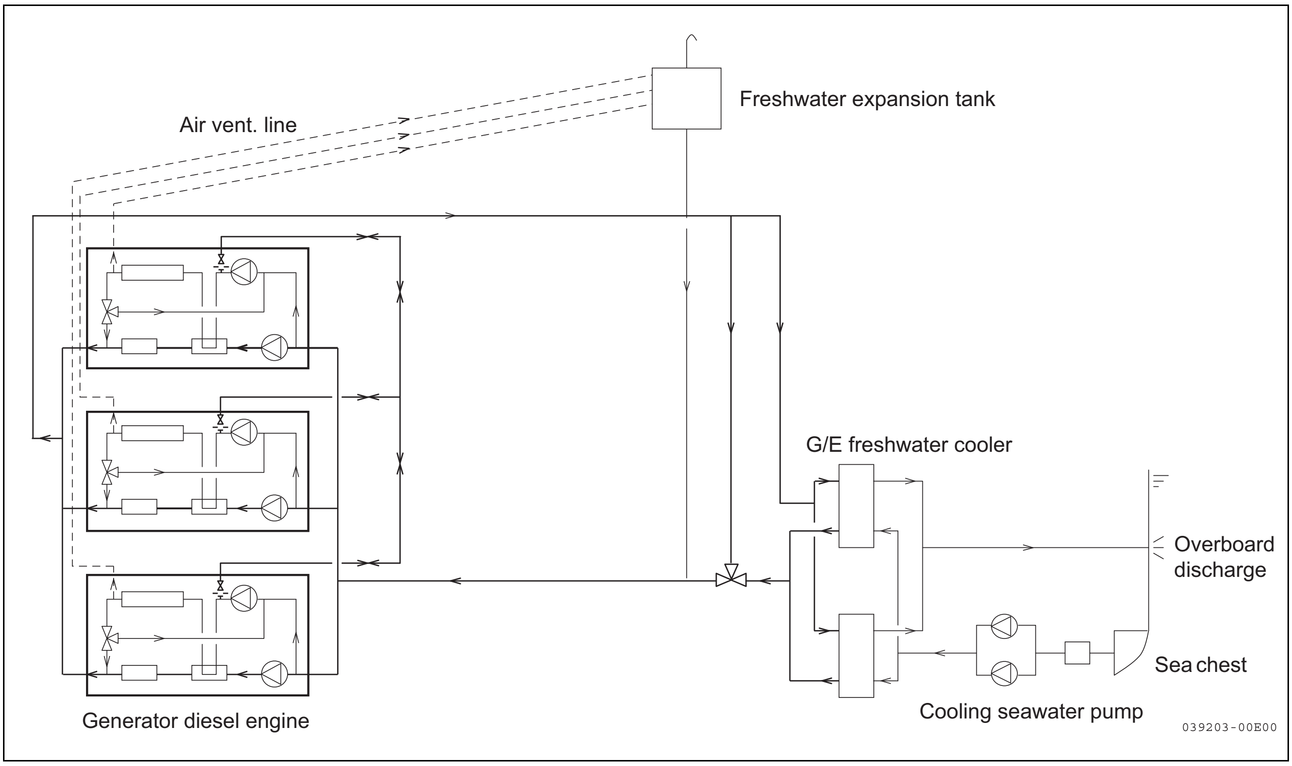
Engine Heat Radiation and Pre-Heating Circulation Pump Capacity

	Engine Heat Radiation (MJ/h)	Pump Capacity (m^3/h x m)
6EY18ALW, 6EY18LW	37	1.5 x 20

Note:

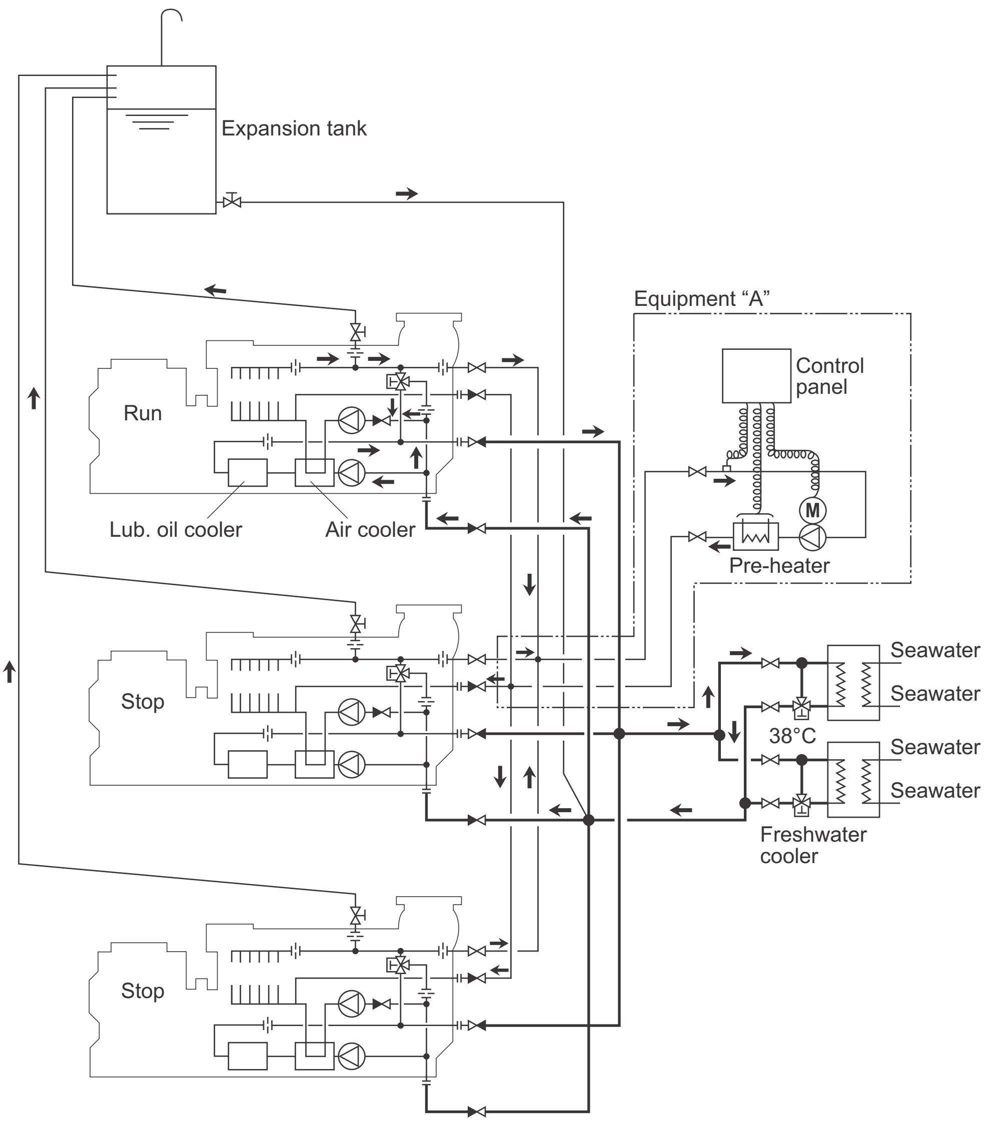
- Values above are for the capacity for one engine.
- The engine heat radiation above is the natural heat radiation calculated when the jacket cooling water temperature is 70°C and the engine room temperature 5°C. No natural heat radiation of the inboard piping surface is included.

Fig.(a) Mutual Engine Warming Up System



Warming Up System

Fig.(b) Pre-Heating System with Pre-Heater



Note : For direct starting, equipment "A" is required as the pre-heating system.

Note:

- The above diagram is a reference example with the pre-heater installed.
- When designing the pre-heating system, consider the system's pressure balance including the installed pre-heater, and adjust the orifice.
- Before handing over the vessel, make sure that there are no problems.

Handling of Cooling Freshwater

1. Outline

The use of freshwater causes water jacket corrosion and scale deposits that result in reducing the part strength and cooling effectiveness. Consequently, an anti-corrosion agent must be added to the freshwater. Since the engine's cooling water system contains parts made of cast iron, carbon steel, brass, and bronze, an anti-corrosion agent that is not harmful for these materials must be selected.

2. Standard of Cooling Freshwater

Recommended Water Quality	
pH (25°C)	6.5- 8.0
Total hardness ($CaCO_3$)	100 ppm or less
M alkaline content	30-100 ppm
Ammonium ion (NH_4^+)	0.05 ppm or less
Chlorine ion (Cl^-)	100 ppm or less
Sulfate ion (SO_4^{--}) concentration	100 ppm or less
Evaporation residuals	400 ppm or less

NOTICE

Do not use hard water.
Use of hard water can cause scale to accumulate on the water jacket wall of the cylinder heads and cylinder and overheating may result.

3. Corrosion-Proofing of Freshwater System

- When aluminum is used for the cooling water system, consult the supplier of the anti-corrosion agent since a different type of anti-corrosion agent must be used.
  Aluminum is not used in the cooling water system of this engine portion.
- With regard to the amount of anti-corrosion agent to be added, control of the concentration, addition of adjustment agent, and handling, comply with the standard recommended by the supplier of the anti-corrosion agent.
- If control of the concentration of anti-corrosion agent is not possible, replace the cooling water every year.

Handling of Cooling Freshwater

4. Cautions for Using Anti-Corrosion Agent

- Do not throw away cooling water containing anti-corrosion agent directly into the sea or rivers. This can cause environmental pollution. The disposal of waste fluid is regulated by the law. Dispose of the fluid in accordance with the handling manual of the anti-corrosion agent maker.
- Do not mix different brands of anti-corrosion agent. (If mixed use is inevitable, consult the anti-corrosion agent maker.)
- Anti-corrosion agent is a water treatment chemical for industrial application. Do not use this agent in the drinking water system.
- Wear rubber gloves and a mask when handling the agent. Do not touch it directly with your hands.
- If the agent touches your skin or gets in your eyes or mouth, thoroughly rinse it away with fresh water. If any abnormality remains, consult your doctor.

5. Recommended Anti-Corrosion Agent Brands

Brand	Supplier	Brand	Supplier
Royal Caviruston Antirust	Yanmar Sangyo Co., Ltd.	DIESEL GUARD NB	UNITOR & Taiho Industries Co., Ltd.
*Royal Freeze			
Polycrin I-109	Kurita Kogyo, Co., Ltd.	ROCOR NB LIQUID	
Polycrin I-175		NALCOOL 2000	NALCO Japan Co., Ltd.
*Kurilex L-501		NALFLET 9-108	
*Neos PN-106S	Neous Co., Ltd.	*NALFLET 9-111	
Neos PN-106		Yuniprot PC-200	Nippon Yuka Kogyo Co., Ltd.
Hi-mol L-10	Taiho Industries Co., Ltd.	Yuniprot PC-300	
Hi-mol AM-5		*Shadan K	Otsuka Chemical Co., Ltd.
*Olgard C-601	Organo Co., Ltd.	LIQUIDE WT	Ashland Japan Co., Ltd.

NOTICE

When the cooling water system is of an open circuit type, the concentration of the anti-corrosion agent can drop quickly. Consult the supplier of your anti-corrosion agent.
Some anti-corrosion and anti-freeze agents have only very low heat transmission characteristics. The use of any such agent can cause over heating during load operation.
When aluminum material is used in the cooling water system, use the anti-corrosion agents with an asterisk mark.
Aluminum is not used in the cooling water system of this engine portion.

50 Fuel Oil System

Project Guide

6EY18(A)LW

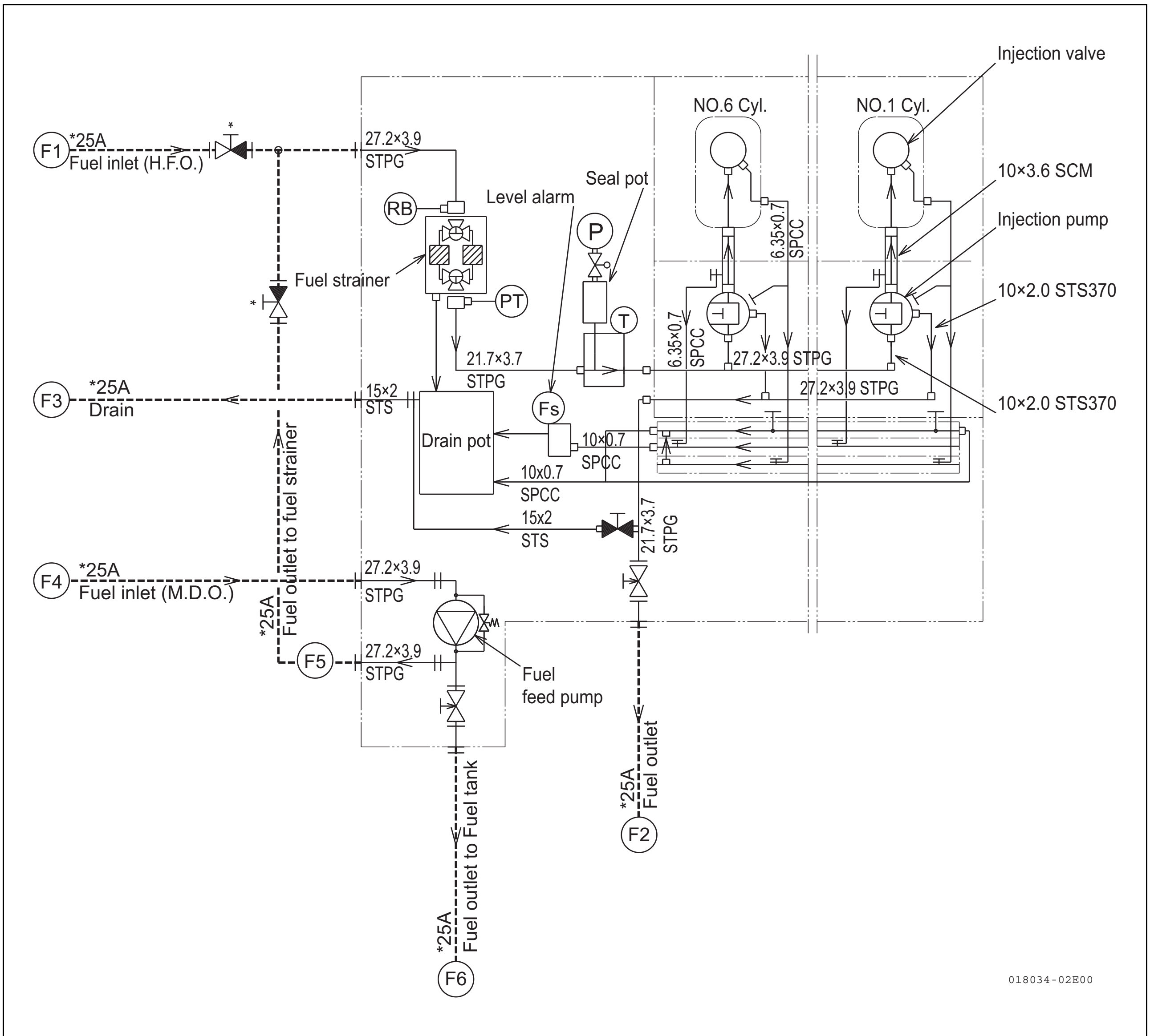
MARINE AUXILIARY DIESEL ENGINE

Engine Fuel System

1. Outline

The engine fuel system consists of the fuel feeding parts, high pressure injection parts, fuel discharging parts and their piping.

Engine Fuel System (H.F.O.) with Engine-Installed Feed Pump



External Piping Size

- F1 (Fuel inlet) :25A
- F2 (Fuel outlet) :25A
- F3 (Fuel oil drain outlet) :25A
- F4 (M.D.O. inlet) :25A
- F5 (M.D.O. outlet) :25A
- F6 (M.D.O. outlet) :25A

2. Fuel Injection Equipment

■ Fuel Injection Pump

In order to make high-pressure, short-period fuel injection possible, the fuel injection pump uses a high-pressure injection pump with an allowed pressure of 147 MPa.

To prevent deformation caused by high pressure, the plunger barrel has a closed top and is firmly attached to the fuel injection pump.

The discharge valve has a two-way delivery valve. This prevents cavitation inside the injection system.

The oil circuit returns oil that comes out of the plunger barrel. This prevents the fuel adjust rack from getting stuck and other negative effects on the plunger.

The system that lubricates the bottom sliding parts of the fuel injection pump by dropping oil on the pinion sleeve prevents the fuel adjust rack from getting stuck and malfunctions of the fuel pump.

■ Fuel Injection Valve

The fuel injection valve is a low-inertia build with very light moving parts. It has a needle valve that is responsive and improves the injection characteristics.

This engine has a zigzag nozzle. Compared with standard nozzles, the zigzag nozzle has smaller, but more injection holes. The holes are arranged so that fuel can be injected into the combustion chamber at 2 angles.

The small holes make the flow of air into the fuel spray easier and make the use of air more efficient. The result is better quality of emissions.The increase in the number of holes also decreases the fuel injection time.

■ Fuel High Pressure Pipe

The fuel injection pipe leads from the side of the cylinder head to the inside of the cylinder head. Then it leads to the fuel injection valve body. This pipe is made of forged high-carbon steel and a drilled hole in the pipe is used as the fuel oil passage. This design gives the pipe sufficient strength against high pressure. Both ends of the joint are conical-tight, improving the seal.

3. Pressure Adjustment

Refer to section 50-02.

Fuel Supplying System

1. Fuel Supply System

The fuel supply system varies depending on the ship, but we enumerate several basic recommendations as follows:

■ General

When the engine is operated on Heavy Fuel Oil (H.F.O.), we recommend the use of the pressurized circulation system for fuel supply as shown in the system diagram (a) below.
In the case of using H.F.O., it is necessary to heat fuel oil with the fuel heater to make the fuel viscosity at the engine inlet comply with the recommended value. However, depending on the heating temperature, the volatile content in the fuel oil will evaporate. To avoid this, the pressure in the fuel supply system must be kept higher than the pressure of the volatile content.
However, in the case of using Marine Diesel Oil (M.D.O.) the open tank system as shown in the diagram (d) may be used.

■ H.F.O. Supply Pump

The capacity of the fuel supply pump must be larger than the expected max. fuel consumption (max. consumption of the generator engine + fuel oil quantity discharged outside the system through fuel strainer, etc.).
Recommended capacity of the fuel supply pump is shown in Table 1.

Table 1 Fuel Supply Pump Capacity (Reference: max output base)

Model	1 Eng. set	2 Eng. sets	3 Eng. sets
6EY18ALW	0.25 m^3/h	0.45 m^3/h	0.65 m^3/h
6EY18LW	0.20 m^3/h	0.35 m^3/h	0.55 m^3/h

■ Fuel Heater

Design the heat capacity so that the recommended fuel oil viscosity at engine inlet can be maintained even during the max. fuel consumption. Consider the heat radiation of the system between the heater and the engine.

■ H.F.O. Circulating Pump

Design the fuel circulating pump capacity at 3 times or above the max. fuel consumption in order to prevent pressure drop in the circulating system at the time of sudden load change. In addition, when installing the self back-wash strainer in the circulating system, add the strainer's back wash capacity to the pump capacity. Recommended pump capacity is shown in Table 2.

Table 2 Fuel Circulating Pump Capacity (Reference: max output base)

Model	1 Eng. set	2 Eng. sets	3 Eng. sets
6EY18ALW	0.6 m^3/h	1.2 m^3/h	1.8 m^3/h
6EY18LW	0.5 m^3/h	1.0 m^3/h	1.5 m^3/h

Fuel Supplying System

■ H.F.O. Back-Wash Strainer

Install the back-wash strainer with the filtration performance of 10 μm (effective value) in the fuel circulating system (fuel heater outlet).
In the case of automated ships, it is recommended to install the automatic back-wash strainer.

■ Fine Strainer

In the case of using FCC fuel oil, it is recommended to install the fine strainer with the filtration capacity of about 5 μm in order to remove alumina, silica and other catalytic particles. This strainer does not need to be installed when an equivalent treatment system is provided.

■ H.F.O. Final Strainer

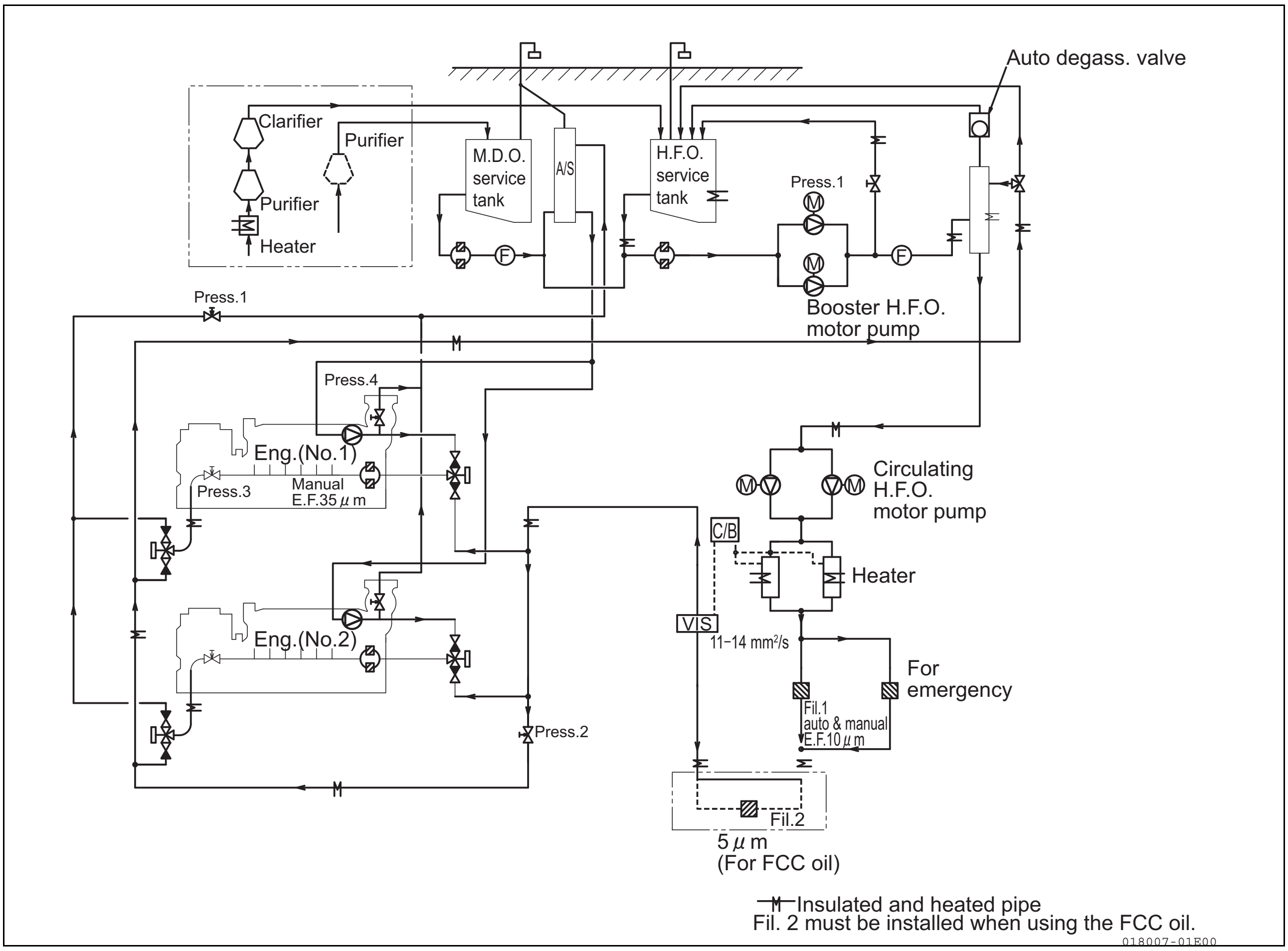
In order to protect the engine, install a duplex type strainer with a filtration performance of 35 μm (effective value) at the engine inlet.

■ Pressure Control Valve

In order to maintain the fuel pressure in the fuel system and inside the engine, install the pressure control valve as shown in the respective diagram.
For the pressure setting and adjustment of the pressure control valve, refer to the pressure specified in each system diagram.

Fuel Supplying System

2. Reference System Diagram (a) (Pressure Circulating System, w/Eng-Driven Fuel Pump)



Remark:

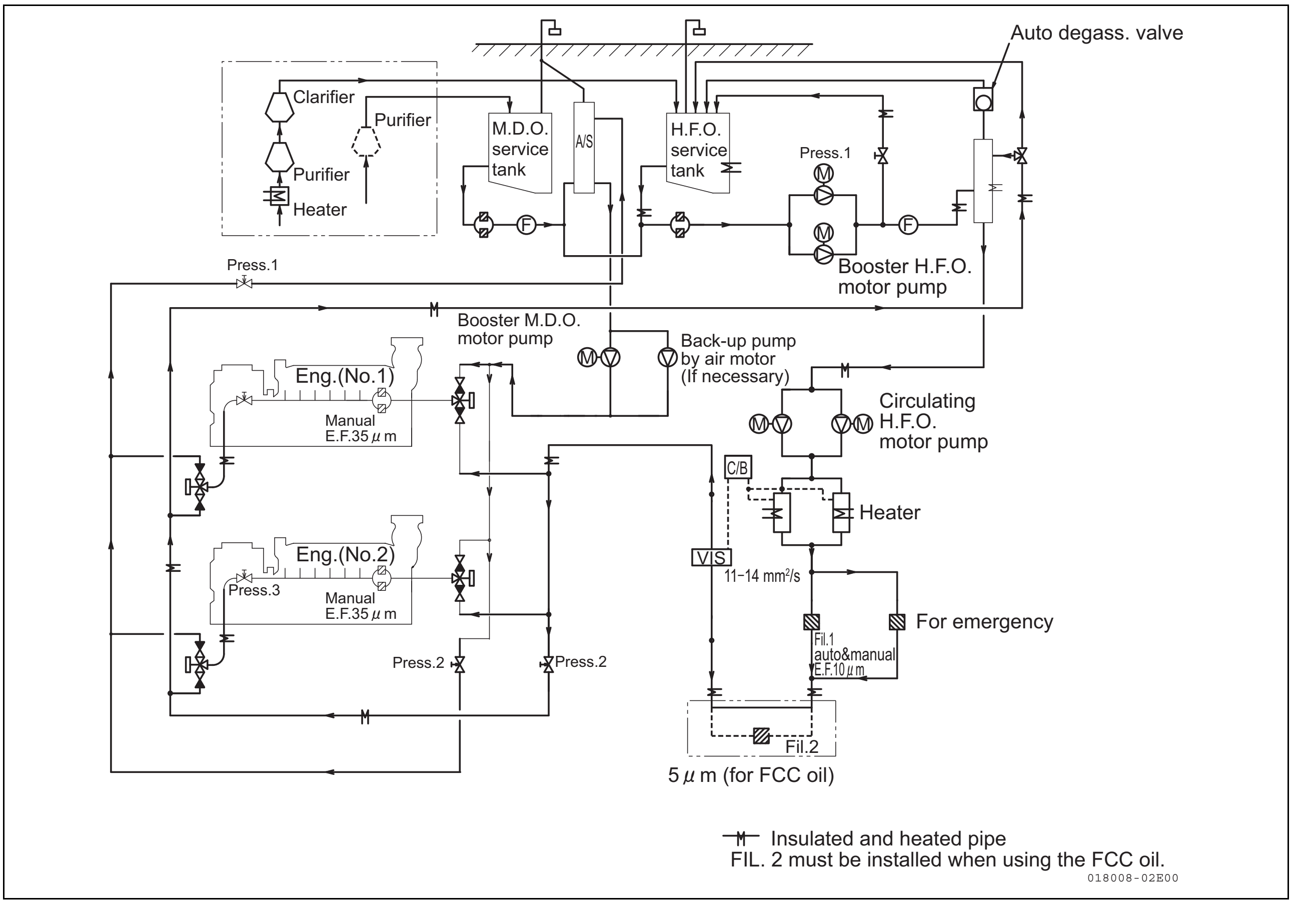
- The M.D.O. feed pump, driven by the engine, is installed. In order to facilitate the air venting of the fuel system of the engine, arrange that the lowest oil level of the M.D.O. tank is more than 2 m higher than the crankshaft center.
- When the engine is of the H.F.O. starting/stopping specifications, keep heated fuel oil (11-14 mm^2/s) always circulated during the standby period. If the temperature is not maintained above pour point of H.F.O., even a momentary suspension of circulation will cause problems when circulation starts again. Pay close attention to this point when designing the system.
- Settings of Pressure Control Valves

	Press.1	Press. 2	Press. 3	Press. 4
700 mm^2/s	0.40-0.45 MPa	0.65-0.70 MPa	0.55-0.60 MPa	
380 mm^2/s	0.25-0.30 MPa	0.45-0.50 MPa	0.40-0.45 MPa	0.70-0.75 MPa
180 mm^2/s	–	0.35-0.40 MPa	0.50-0.35 MPa	

1 mm^2/s = 1 cSt

Fuel Supplying System

3. Reference System Diagram (b) (Pressure Circulating System, w/o Engine-Driven Fuel pump)



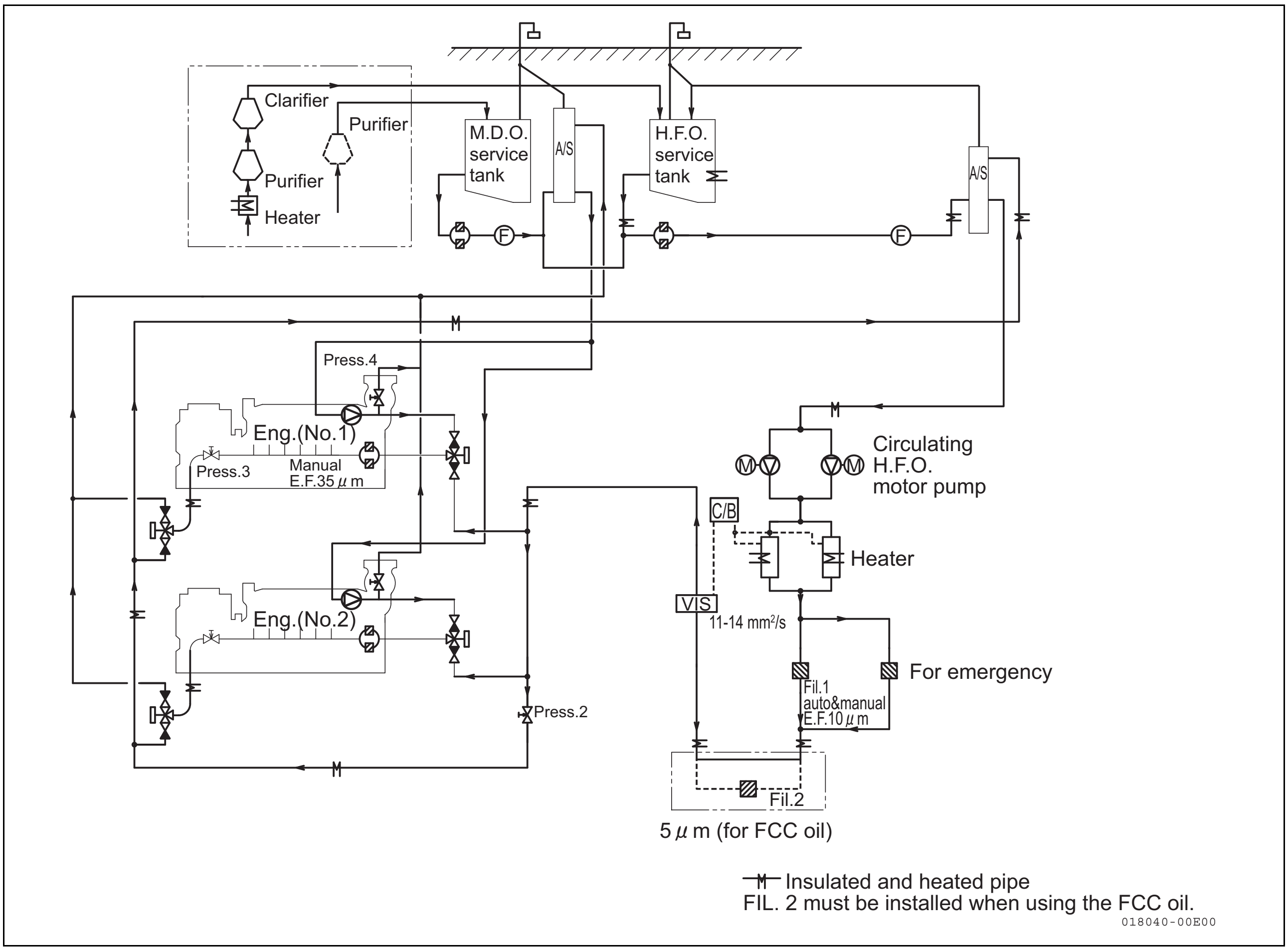
Remark:

- Since the engine is not equipped with a M.D.O. feed pump, arrange the system as follows to facilitate the emergency starting during black-out:
  - In case of starting and stopping with H.F.O.: Change the valves at the engine inlet and outlet to the M.D.O. side. Supply M.D.O. with the backup pump driven by an air motor and establish a system to enable pressurization.
  - In case of changing to M.D.O. at start and stop: Adjust the height of the M.D.O. gravity tank so that fuel oil can be fed at the engine inlet with more than 0.04 MPa. If this is not possible, install a backup pump driven by an air motor.
- When the engine is of the H.F.O. starting/stopping specifications, keep heated fuel oil circulated during standby with engine inlet viscosity (11-14 mm²/s). Even when the circulation has to be stopped temporarily, the fuel oil temperature needs to be kept over the fluid point since it is very hard to re-circulate the fuel oil upon restarting. Obey this point when designing the system.
- Settings of Pressure Control Valves

	Press.1	Press.2	Press.3
700 mm²/s	0.40-0.45 MPa	0.65-0.70 MPa	0.55-0.60 MPa
380 mm²/s	0.25-0.30 MPa	0.45-0.50 MPa	0.40-0.45 MPa
180 mm²/s	–	0.35-0.40 MPa	0.30-0.35 MPa

1 mm²/s = 1 cSt

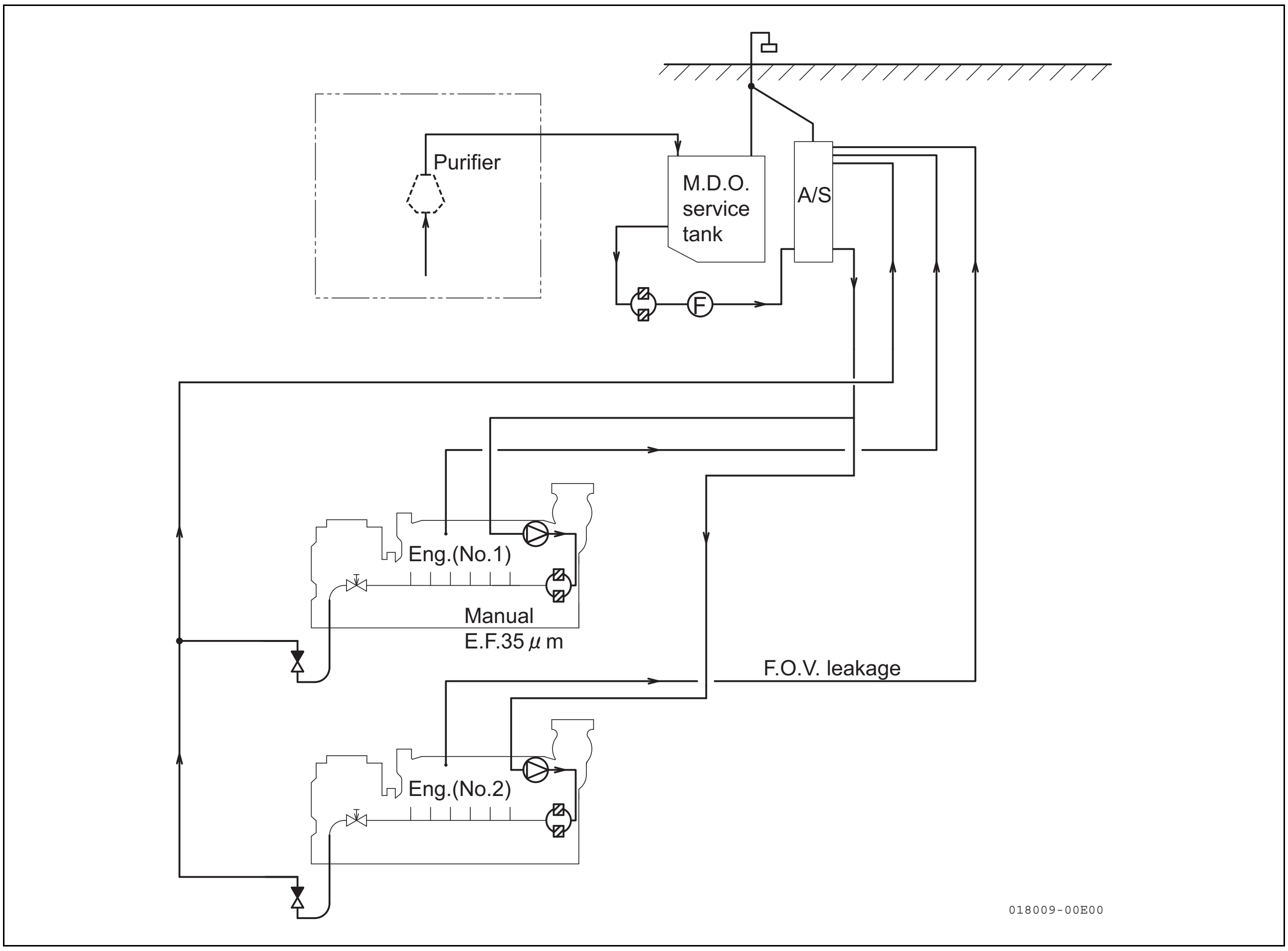
4. Reference System Diagram (c) (Open Tank System, w/Engine-Driven Fuel Pump)



Remark:

- In case of using the heavy fuel oil of less than 180 mm^2/s in kinematic velocity, if the oil replacement place is same every time and the volatile content is few, the open tank system in the above diagram may be used.
- The M.D.O. feed pump, driven by the engine, is installed. In order to facilitate the air venting of the fuel system of the engine, arrange that the lowest oil level of the M.D.O. tank is more than 2 m higher than the crankshaft center.

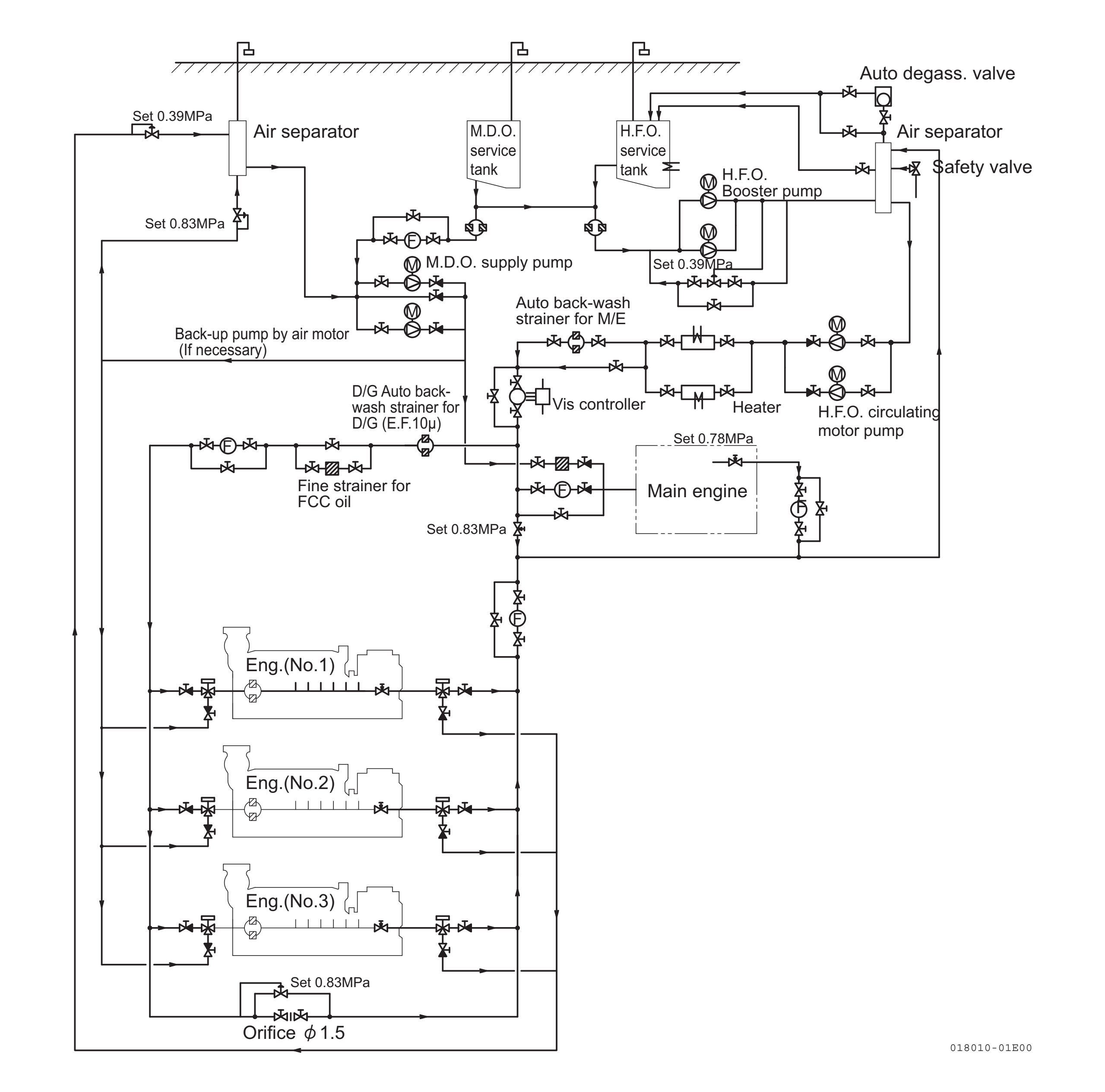
5. **Reference System Diagram (d)**
(Open Tank System (M.D.O.), w/Engine-Driven Fuel Pump)



Remark:

- In the case of using M.D.O., the open tank system as shown in the above diagram may be used.
- The M.D.O. feed pump, driven by the engine, is installed. In order to facilitate the air venting of the fuel system of the engine, arrange that the lowest oil level of the M.D.O. tank is more than 2 m higher than the crankshaft center.

6. Reference System Diagram (e) (Mono-Fuel System)



Remark:

- The necessary flow rate varies for main propulsion engines and generators. Make sure that you circulate the specified amount of heated fuel in generators.
- When designing the system, arrange that fuel oil viscosity at the generator engine inlet becomes 11-14 mm²/s.
- Make sure that the fuel pressure inside the generator does not exceed 0.78 MPa.

1. Fuel Pre-Treatment System

The fuel pre-treatment system may vary depending on the ship and is used together with the main engine. Below are the basic recommendations to be implemented.

■ General

The contaminants and water content included in low quality fuel oils can damage the fuel injection pump, fuel valve, etc. and cause the cylinder liner to wear abnormally and gives adverse effect to the combustion chamber parts. The contaminants can also cause faulty combustion.

In order to avoid these adverse effects, it is recommended to pre-treat the fuel oil supplied to the engine by the centrifugal purifier and other fuel oil pre-treatment equipment.

In the case of using M.D.O., pre-treatment equipment is basically not required, but if the fuel oil has a high water content, pre-treatment of fuel oil by a centrifugal purifier, etc. is necessary.

■ Settling Tank

The settling tank causes contaminants and water in fuel oils to precipitate for removal. The tank, thus, can mitigate the load of the pre-treatment system. It is recommended to install the settling tank.

In the case of using M.D.O., a settling tank is basically not required, but water content in the fuel oil can increase due to condensation inside the storage tank. Accordingly, it is recommended to install the settling tank when a fuel pre-treatment system is not provided.

■ Pre-Treatment Equipment

Various pre-treatment equipment is available, but it is generally recommended to install the centrifugal purifier.

Consult the manufacturer of the purifier for the purifier specifications.

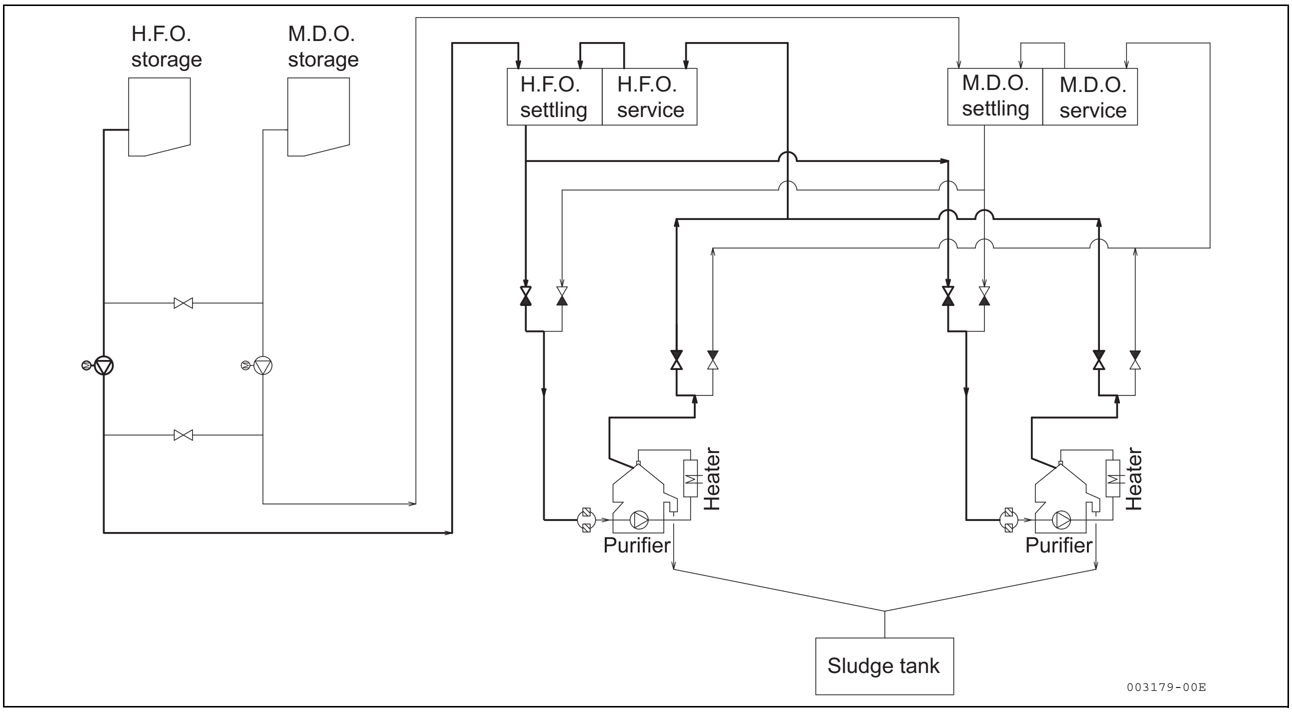
The pre-treatment amount should be large enough for the max. fuel consumption onboard and with some allowance to manage the increased consumption due to aging of the system.

■ Reference Diagram

The example on the next page is the system diagram of the typical fuel pre-treatment system.

Fuel Pre-Treatment System

Fuel Pre-Treatment System Diagram (Reference)



Fuel Quality Standard

1. Outline

In the case of ocean-going vessels, since different types of fuels with different refining processes are supplied in different parts of the world, combustion problems (rise of exhaust gas temperature, increase of soot, etc.) tend to occur. Most of these problems derive from the ignitability of fuel oil. Accordingly, ancillary equipment is necessary that processes the fuel oil, removes impurities in the fuel oil, and prevents gasification of the fuel oil.

2. Quality Standard of Loading Fuel Oil

1mm²/s = 1cSt

Applicable fuel quality standard			M.G.O.	M.D.O.	H.F.O.		
					180 mm²/s H.F.O.	380 mm²/s H.F.O.	700 mm²/s H.F.O.
Viscosity *1	at 50 °C	mm²/s	–	–	< 180	< 380	< 700
	at 40 °C		2-6	2-11	–	–	–
Limit values of properties	Density *2	kg/m³ at 15°C	< 890	< 900	< 991	< 1010	< 1010
	Flash point	°C	> 60	> 60	> 60	> 60	> 60
	Carbon residue	mass %	< 0.3	< 0.3	< 18	< 20	< 20
	Sulfur content *3	mass %	< 1.0	< 1.0	< 4.5	< 4.5	< 4.5
	Ash content	mass %	< 0.01	< 0.01	< 0.10	< 0.15	< 0.15
	Water content	vol. %	< 0.1	< 0.1	< 0.5	< 0.5	< 0.5
	Vanadium	mg/kg	–	–	< 350	< 450	< 450
	Sodium	mg/kg	–	–	< 100	< 100	< 100
	Alumina and silica	mg/kg	–	–	< 80	< 80	< 80
	Cetane index	–	> 45	> 45	–	–	–
	CCAI	–	–	–	< 870 *4 (< 850)	< 870 *4 (< 850)	< 870 *4 (< 850)
	Lubricity HFRR wear scar diameter	µm	< 520 *5 (< 460)	< 520 *5 (< 460)	–	–	–
Fuel equivalent to the quality standard fuel		ISO	DMA, DMZ *6	DMB	RMG180	RMK380	RMK700
		CIMAC	–	–	CIMAC E25	CIMAC G35	CIMAC H55
		BSI	–	–	(M6)	(M7)	(M9)
		JIS	Light oil *7	Heavy Fuel A	Heavy Fuel C		

Note:

*1: Maintain a value of 1.8 mm²/s or more at engine inlet.

*2: If you use fuel with a density higher than 991 kg/m³ at 15 °C, use a separable centrifuge.

*3: Use a fuel with a sulfur content that agrees with the laws and ordinances of the relevant harbors and waters.

*4: Use a fuel with a CCAI of less than 850 (see the next page).
If you must use fuel with a CCAI of more than the above values, incomplete combustion occurs and may lead to buildup of contamination in the combustion chamber and a bad color of the exhaust smoke. Take the necessary precautions.

*5: Use a fuel oil with a wear scar diameter correction value of 460 μm or less on the HFRR lubricity index. If the above specified value is exceeded, refer to the safety precautions at 50-05 3. Safety precautions when using low-sulfur, low-viscosity fuel oil.

*6: For safety reasons, you cannot use fuel oil that is equivalent to DMX of ISO 8217. This is because of the low minimum flash point of 43 °C.

*7: For safety reasons, you cannot use JIS K-2204 Number 3 or Number 3 Special light oil. This is because of the low minimum flash point of 45 °C.

3. Fuel Oil Properties at Engine Inlet

Impurities in heavy fuel oils can damage the fuel injection pump and fuel injection valve, cause abnormal wear of cylinder liners and degenerate exhaust valves and valve seats. Install a fuel oil pre-treatment system that can purify the fuel oil to the level shown in the table on the right.

Refer to section 50-04 Linear Diagrams of Fuel oil Temperature and Viscosity on Page 4/4.

H.F.O. Properties at Engine Inlet

Engine inlet viscosity	11-14 mm^2/s
Water content	0.2 vol% or below
Content of solid particles	20 ppm or below
Size of FCC catalytic particles	5 μm or below

FCC: Fluid catalytic cranking

4. CCAI (Calculated Carbon Aromaticity Index)

CCAI is an index for ignitability. A large CCAI value indicates a large delay in ignition and bad ignitability. In that case, the HFO direct starting is not possible or exhaust color is bad due to faulty combustion.

CCAI is the index to show the ignitability of fuel oils. The index is obtained by the following formula:

$$CCAI=D-141 \log \log (V + C) - 81$$

D: Density (15 ℃), kg/m^3

V: Viscosity (50 ℃), mm^2/s

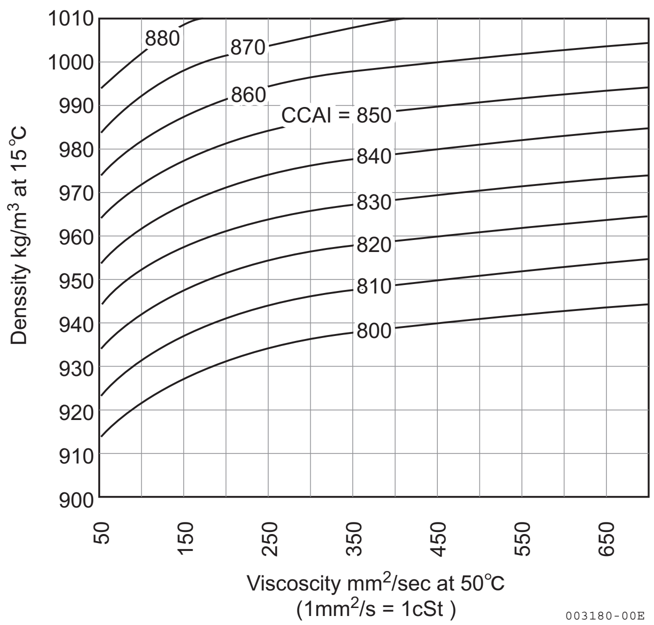
C: Constant

M.D.O. : 0.3

H.F.O. : 0.85

The relation between CCAI, density and viscosity of H.F.O. is shown on the diagram at the right. The smaller CCAI, the better ignitability.

When using H.F.O., select H.F.O. of which CCAI is 850 or below. When using the H.F.O. spec. engine and CCAI exceeds 850, start the engine on M.D.O.



5. Characteristics of H.F.O. and the Effects on the Engine (Reference)

■ Viscosity

The highly viscous H.F.O. varies largely in viscosity and viscosity index. In order to operate the engine regularly on H.F.O., it is essential to control the viscosity (11-14 mm^2/s) of fuel oil to the appropriate level that the engine requires.

■ Density, Asphaltene and CCAI

The higher the specific gravity, the larger the asphaltene content in the fuel oil. The CCAI is raised then due to the increase of the aromatic high polymer hydrocarbon. This causes the engine's ignitability to lower for abnormal combustion.

The quality fuel oil pre-treatment has a large effect on the specific gravity. Accordingly, it is important to make appropriate arrangement for the pre-treatment equipment and method.

■ Vanadium

The increase of vanadium content in fuel oil generally causes high temperature corrosion of the exhaust valve. Accordingly, the exhaust valve is provided with the measure to lower the face temperature and the use of corrosion-resistant material is required.

■ Alumina and Silica

The catalytic fine particles including alumina and silica contained in H.F.O. can cause abnormal wear of the engine's moving parts. Accordingly, it is important to install the appropriate fuel oil pre-treatment equipment and its proper control. The catalytic fine particles of 3-5 μm need to be removed by the pretreatment equipment.

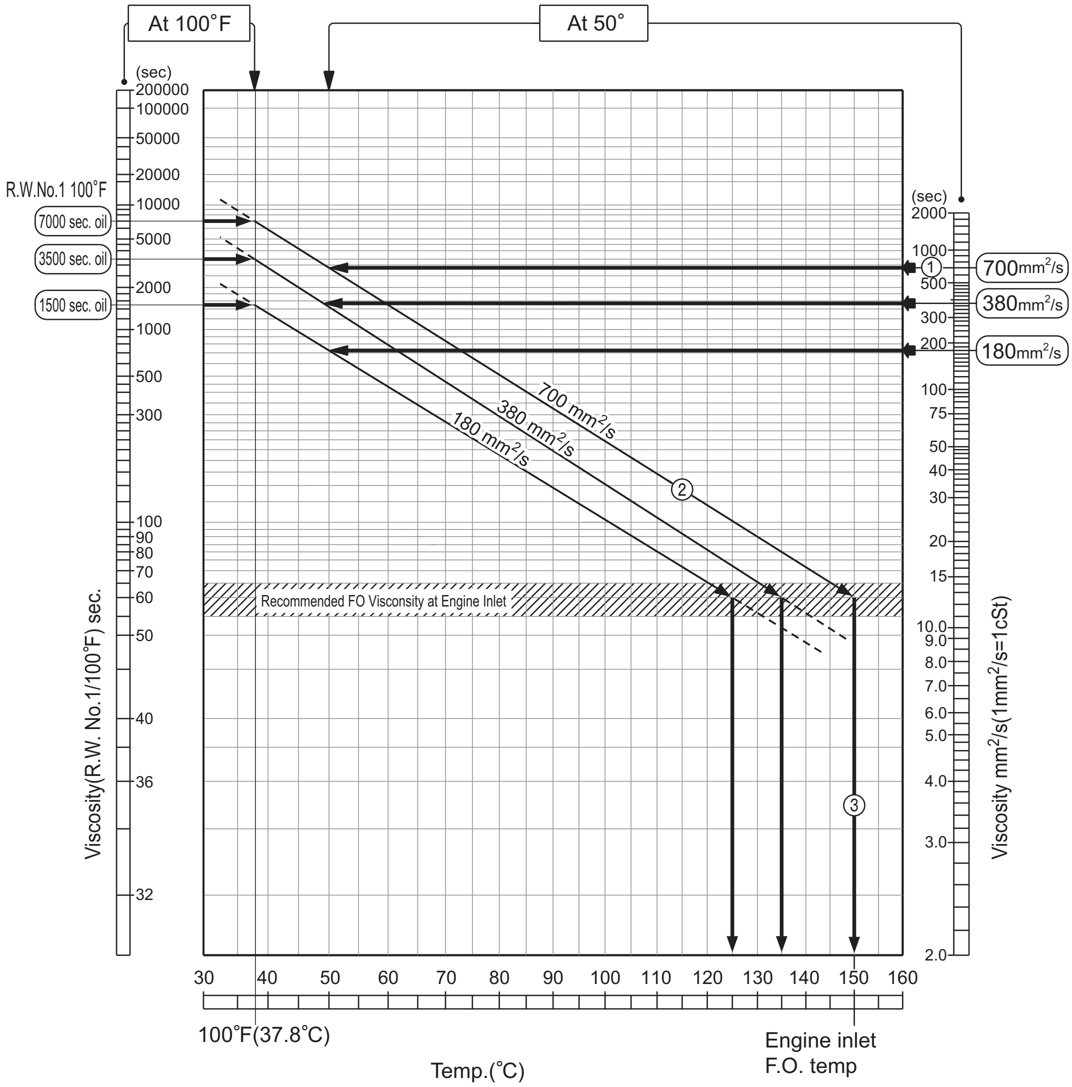
■ Residual Carbon

Large residual carbon content can cause combustion residue to deposit in the combustion chamber, especially during the low load operation. The combustion residues accumulated on the engine's moving parts accelerate wear and lubricating oil consumption.

■ Sulfur

The increase of sulfur content causes low temperature corrosion of the engine's combustion chamber parts. To prevent the corrosion, the combustion chamber parts need to be controlled to a proper level.

6. Fuel Temperature and Viscosity Diagram (Reference)



How to obtain the fuel heating temperature (reference)

Example: To obtain the heating temperature of the 700 mm^2/s (50℃) fuel oil:
Obtain Point ① at 700 mm^2/s (50℃) and obtain cross point of the 700 mm^2/s oil viscosity - temperature diagram ② with the recommended engine inlet F.O. viscosity.
Draw a perpendicular line ③ from this point.
The cross point of this line with the horizontal line (Engine Inlet F.O. temp.) shows the F.O. heating temperature (150℃ for this specific example).

003181-02E00

Low-Sulfur Fuel

1. Usage Standard for Low-Sulfur Fuel (1.5 %-0 %)

1.1 Effects of Low-Sulfur Fuel Oil on the Engine

Choose a lubricating oil with a total base number that conforms with the sulfur content of the fuel oil. This is necessary because it neutralizes the sulfur oxides that occur during operation (not only during low load operation).

Use the correct lubricating oil. If the fuel oil has low sulfur content and the lubricating oil has a high total base number, additives (calcium carbonate) in the lubricating oil and carbon residue will stick to hot engine parts and collect on the piston head and in the combustion chamber. The below conditions can occur when additives collect.

- A piston ring does not move well
- A cylinder liner has scuffing
- Bite-in and blowby on the exhaust valve

If combustion products (e.g. resin fraction, asphaltene) collect on the honing groove of the liner wall, they cause lacquering, which increases the consumption of lubricating oil, and scuffing.

1.2 Recommendations when Using Low-Sulfur Fuel Oil

When you use M.D.O., low-sulfur fuel oil (sulfur content 1.5 % to 0 %) and H.F.O., use lubricating oils that conform with the different values of sulfur content. The use of fuel with sulfur content is regulated in some areas because of environmental concerns. Outside regulated areas, you operate the engine on high-sulfur H.F.O. Inside such areas, you switch to low-sulfur fuel oil. Obey the below precautions when you use low-sulfur fuel oil.

- **If you only switch to low-sulfur fuel oil when you enter an area that regulates the use of high-sulfur fuel oil**

  In that case, operate the engine for less than 300 hours (approximately 2 weeks) with a high-alkali lubricating oil for high-sulfur content. Leave the regulated area within 300 weeks and switch back to high-sulfur fuel.
- **If you always use low-sulfur fuel oil (1.5 % to 0%)**

  Use a lubricating oil that is suitable for the sulfur content of the H.F.O. that you normally use.
- **If you use both low- and high-sulfur fuel oils alternately and operate the engine irregularly for more than 300 hours**

  Use different lubricating oils that are suitable for the different fuel oils. If the vessel does not allow holding 2 different kinds of lubricating oil, use a lubricating for high-sulfur fuel and leave the regulated area within 300 hours (approximately 2 weeks).

2. Precautions when Using Low-Viscosity Oils (e.g. marine gas oil)

The HFRR (High Frequency Reciprocating Rig) test evaluates the lubricity of fuel oil. The result is expressed in a wear scar diameter correction value. A large wear scar diameter correction value indicates bad lubricity of the fuel oil. Some parts (e.g. the plunger barrel of the fuel injection pump, the needle of the fuel injection valve) may not move freely.

3. Safety precautions when using low-sulfur, low-viscosity fuel oil

The sulfur content in the fuel oil has lubricity and serves as a lubricant. If the sulfur content becomes too small, lubricity may be insufficient. Obey the following instructions.

3.1 Fuel oil properties

Very low viscosity of the fuel oil causes seizure on the plunger barrel of the fuel injection pump. Make sure that you keep the fuel oil properties that are described below.

- Calculate the viscosity from the temperature of the supplied fuel. Keep a minimum viscosity at engine inlet at 1.8 mm^2/s or more.
- If it is not possible to keep the viscosity at the above value, install a fuel cooler or chill cooler.
- Use a fuel oil with a wear scar diameter correction value of 460 μm or less on the HFRR lubricity index.
- If you cannot keep the correct lubricity or the minimum viscosity, we recommend that you add a lubricity improver.

3.2 Sample lubricity improvers

Manufacturer	Infineum International Ltd.
Product name	F7458

If you use a lubricity improver (fuel additive), consult with the manufacturer of the lubricity improver.

4. About Switching Fuel Oils

Conduct the fuel switch-over as described in the operation manual.

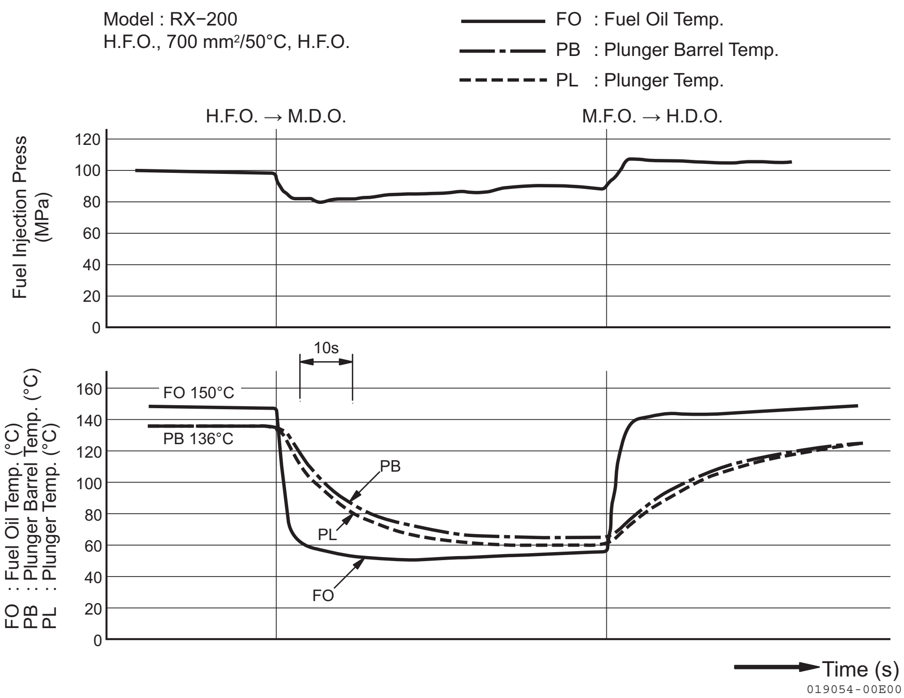
You can see in the below table that the plunger barrel does not get stuck etc. due to temperature change, even when you switch fuels during warm-up. This is the same for M.G.O.

Reference

Check if the plunger barrel is stuck when you switch from high-temperature H.F.O. to low-temperature M.D.O. during warm-up at the fuel injection pump inlet; or when you switch in the opposite direction. (Refer to the figure below.)

The fuel oil temperature inside the fuel injection pump changes rapidly, but the temperature of the plunger barrel changes slowly. Neither will result in sticking.

Switch-over test between H.F.O. and M.D.O.



5. About the Fuel Cooler

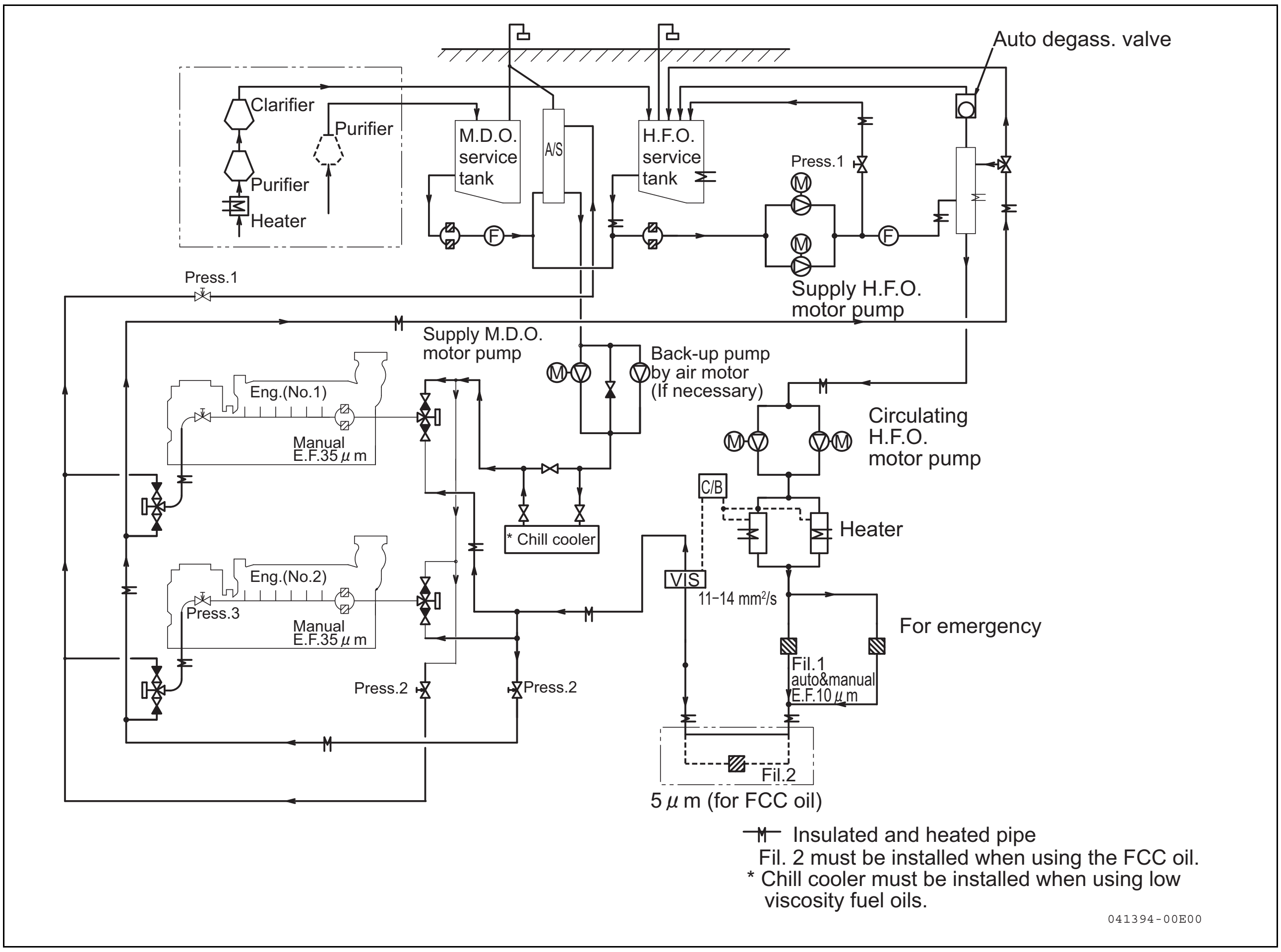
The following installation outline diagram for the fuel cooler and selection criteria are for your reference.

5.1 Installation outline example for a fuel cooler

Fuel oils with extremely low viscosity values (min. 1.5 mm²/s at 40 °C) are sometimes used as low sulfur fuel oil, such as MARINE GAS OIL (light oil, DMA (ISO8217: 2005)). But these low-viscosity fuel oils can cause seizure on the plunger barrel of the fuel injection pumps. In these cases, maintain the viscosity of the fuel oil at engine inlet at a minimum of 1.8 mm²/s.

Below is an example for an M.G.O., M.D.O. circulation line that has a fuel cooler installed to maintain a viscosity of 1.8 mm²/s or more at engine inlet.

Circulation line

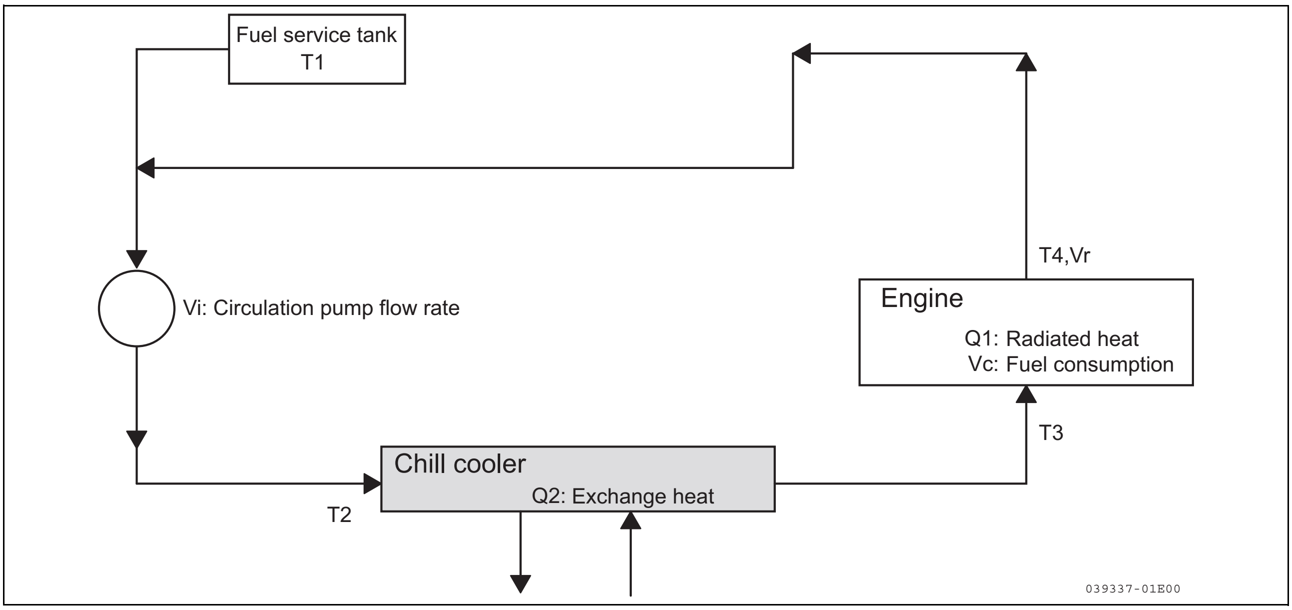


5.2 Capacity selection for the fuel cooler

The below table shows the design data for the fuel cooler.

[Design conditions]

- MARINE GAS OIL viscosity : (min. 1.5 mm^2/s at 40 °C) /ISO8217: 2005 DMA
- Temperature of the fuel service tank : 45 °C
- Electric circulation pump : 0.60 m^3/h
- Temperature to achieve 1.8 mm^2/s : Under 20 °C (min. 10 °C)
- This calculation is for 1 engine. (For multiple engines, multiply the values with the number of engines to get an approximate value.)



Item	Unit	Value	Remark
R : Fuel oil density	kg/m^3	890	According to property table
C : Fuel oil specific heat	kJ/kg °C	2	Constant
kW : Engine power	kW	800	According to the particular sheet of the Final Drawing.
FOC : Fuel consumption rate	g/k Wh	195	
Q1 : Radiated heat from engine to fuel oil	MJ/h	9.8	Radiated heat from the engine to the fuel oil. Refer to page 6/6
	kW	2.72	= MJ/h/3.6
T1 : Fuel service-tank temperature	°C	45	Assumed (max. engine room temperature)
T3 : Fuel oil engine inlet temperature	°C	20	DMA (1.5 mm^2/s at 40 °C) →1.8 mm^2/s
Vi : Fuel circulation pump flow rate	m^3/h	0.600	According to the particular sheet of the Final Drawing.
Vc : Fuel consumption	m^3/h	0.175	= kW × FOC/R
Vr : Fuel oil returned from engine	m^3/h	0.425	= Vi-Vc
ΔT : Fuel oil temperature difference between engine inlet and outlet	°C	13.0	= Q/(Vr*R*C)
T4 : Fuel oil engine outlet temperature	°C	33.0	= T3+ΔT
T2 : Temperature difference at fuel cooler inlet	°C	36.5	= ((Vr × ΔT)+(Vc × (T1 - T3))/Vi) + T3
Q2 : Radiated heat from fuel oil to fuel cooler	MJ/h	17.6	Vi × R × C × (T2 - T3)
	kW	4.89	= MJ/h/3.6

5.3 Selection criteria for the fuel cooler

- Decide the fuel temperature at engine inlet (fuel temperature at fuel cooler outlet) based on the actual properties of the used fuel.
- Fuel cooler capacity
  Radiated heat:
  Plan this with (heat value supplied from engine to fuel oil) plus (heat value of the fuel itself supplied from the service tank).
  Fuel circulation volume, return volume:
  The circulation volume is equal to the fuel circulation pump capacity. Plan the fuel oil return volume with (circulation pump capacity) minus (fuel consumption).
- Plan the radiated heat from the engine to the fuel oil with the table below.

Amount radiated from the engine to the fuel oil

Model	Engine power kW	Speed min^{-1}	Amount radiated from engine to fuel oil (Q1) MJ/h
6EY18LW	400-615	720	5.1
6EY18ALW	445-800	900	9.8

60 Speed Control

Project Guide

6EY18(A)LW
MARINE AUXILIARY DIESEL ENGINE

Starting and Stopping Time Schedule

1. Engine Starting

■ Ordinary Starting (Hot Engine, Warm State)

- When starting on M.D.O., do a warm-up run for at least 15 minutes before switching to H.F.O. operation.
- When switching to H.F.O. operation from M.D.O. operation or conducting H.F.O. direct starting, heat and circulate the H.F.O. so that the viscosity becomes 11-14 (mm^2/s) at the engine inlet.
- When conducting H.F.O. direct starting, check that the jacket cooling water temperature is kept at 65-70°C. (Refer to 40-03, Engine Heating System.)

■ Emergency Starting (Cold State)

- Operate the engine on M.D.O.
- Ensure that the ambient temperature is 0°C or more and that the lubricating oil and cooling water temperatures are 5°C or more.
  (When the lubricating oil priming pump was stopped for more than 2 hours, operate the pump for at least 20 minutes before starting the engine.)

2. Load Limit

■ Low Load Limit

- Freshwater/freshwater dual cooling system (in case the engine is equipped without the boost temp. control system)
  - Operation on M.D.O. : 15 %
  - Operation on H.F.O. : 20 %
- Freshwater/freshwater dual cooling system (in case the engine is equipped with the boost temp. control system)
  - Operation on M.D.O. : 15 %
  - Operation on H.F.O. : 15 %
- Freshwater/seawater dual cooling system
  - Operation on M.D.O. : 15 %
  - Operation on H.F.O. : 25 %

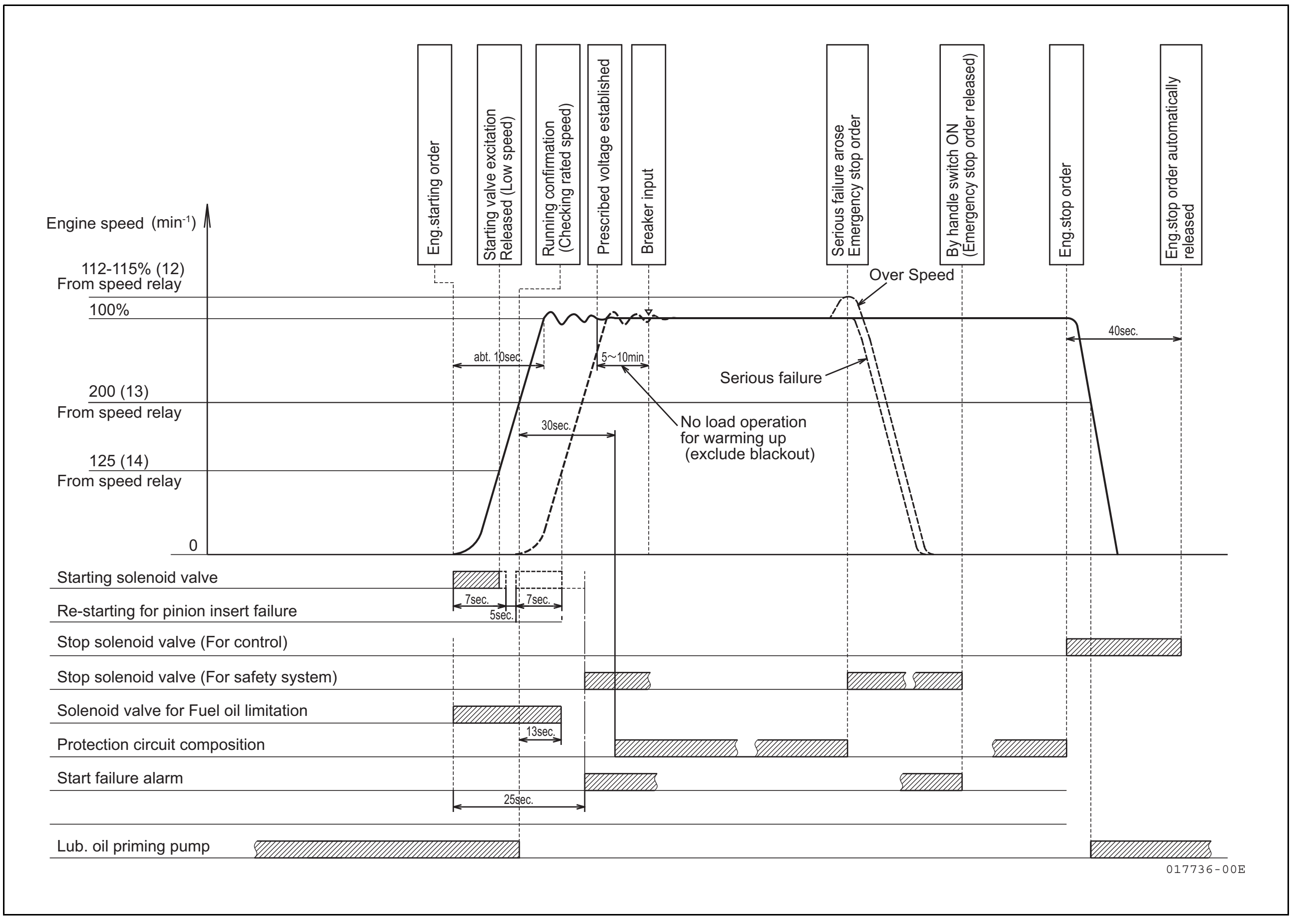
■ Caution

In general, when the engine was operated on H.F.O. at low load under the lower limit, combustion would be aggravated, which would cause the combustion chamber, exhaust pipe, turbocharger, etc. to be contaminated excessively. Accordingly, it is not recommended to operate the engine under the lower load limit for more than 3 hours.

Empirically, however, the combustion residues deposited during the low load operation for about 3 hours, will disappear when the engine is operated at more than 60 % load for approximately 30 minutes.

Starting and Stopping Time Schedule

Operation Load Schedule



1. Governor Specifications

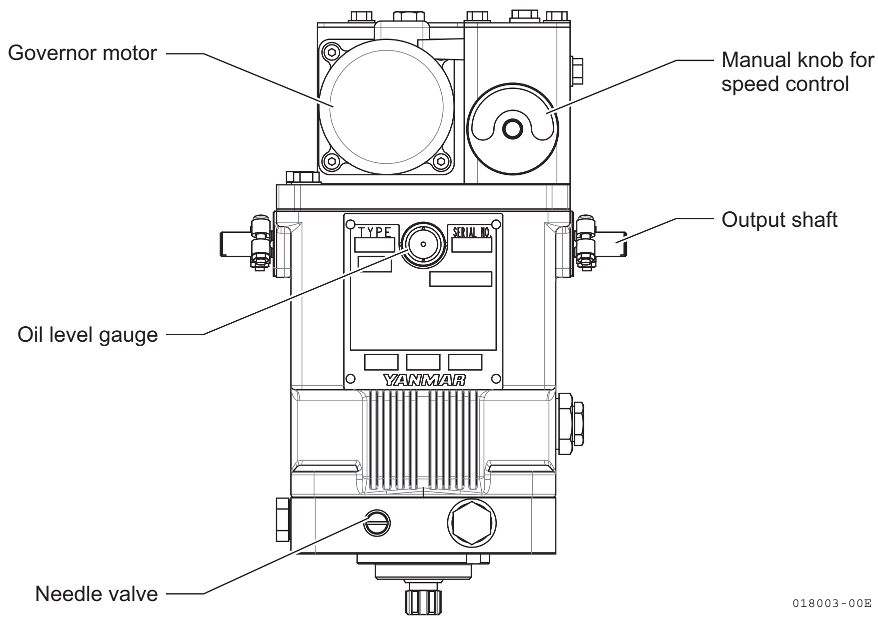
	Standard	Option
Type	NZ61 Hydraulic Governor with Governor Motor	PSG Hydraulic Governor with Governor Motor
Electric Source	AC 100-110V, 1ϕ, 20W AC 200-220V, 1ϕ, 28W (option)	DC 24V, 0.1A
Seconds/Frequency Change	8-12 sec/1 Hz	8-12 sec/1 Hz
Others	–	APM Motor Controller: Input-AC/DC 100-220V Output-DC 0-24V

2. Speed Setting

A motor-type governor is installed as a standard.

- Motor type: The speed is controlled by changing the phase. The upper and lower limit is controlled by the friction coupling.
- Speed Set Range
  Output 0-100 %: ± 10 % of rated speed.
- Droop: Speed regulation can be changed within the range of 3-10 % by controlling the droop-adjuster.

NZ61 Hydraulic Governor (with Governor Motor)

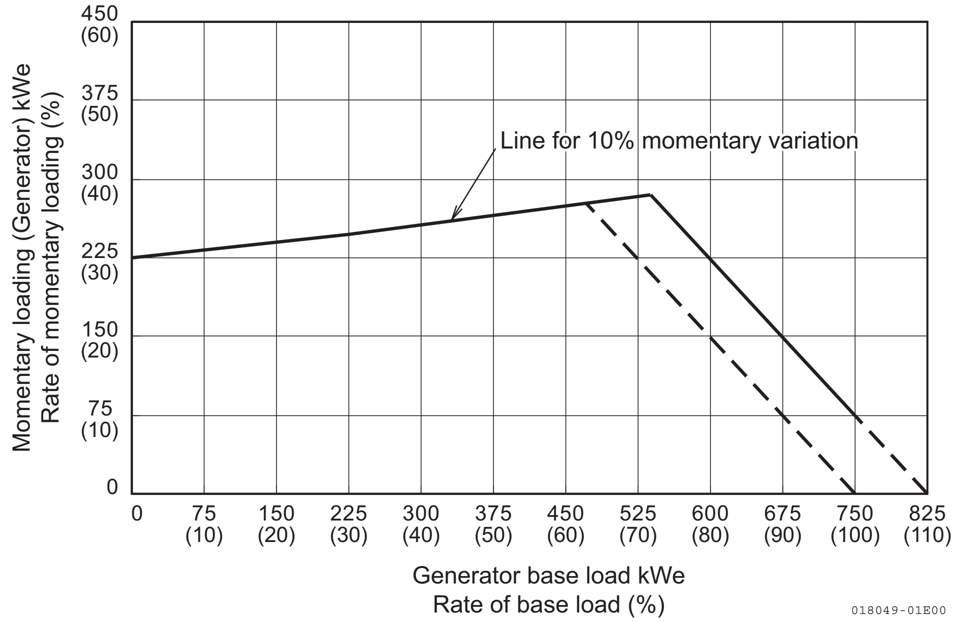


3. Load Input Characteristics

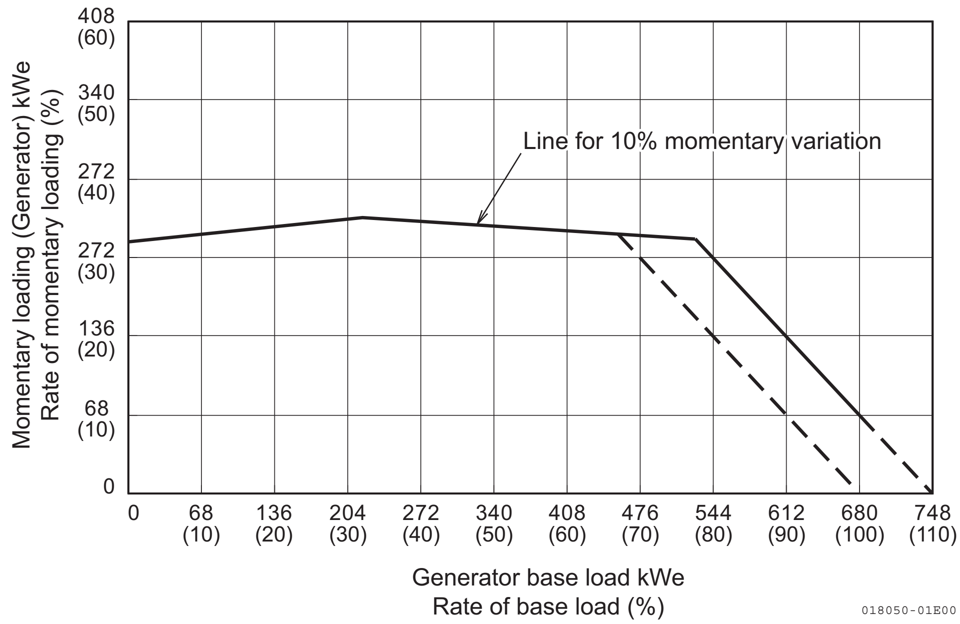
In relation to the brake mean effective pressure (BMEP) of this engine being at 2.5 MPa and the inertial mass including that of the generator, this engine has a three-stage instantaneous load input. Consider the load input characteristics as described below for planning the power scheme of the ship.

3.1 6EY18ALW

■ **800 kW/900, 1000 min^{-1} Load Input Characteristics (0→30%→63%→100%)**

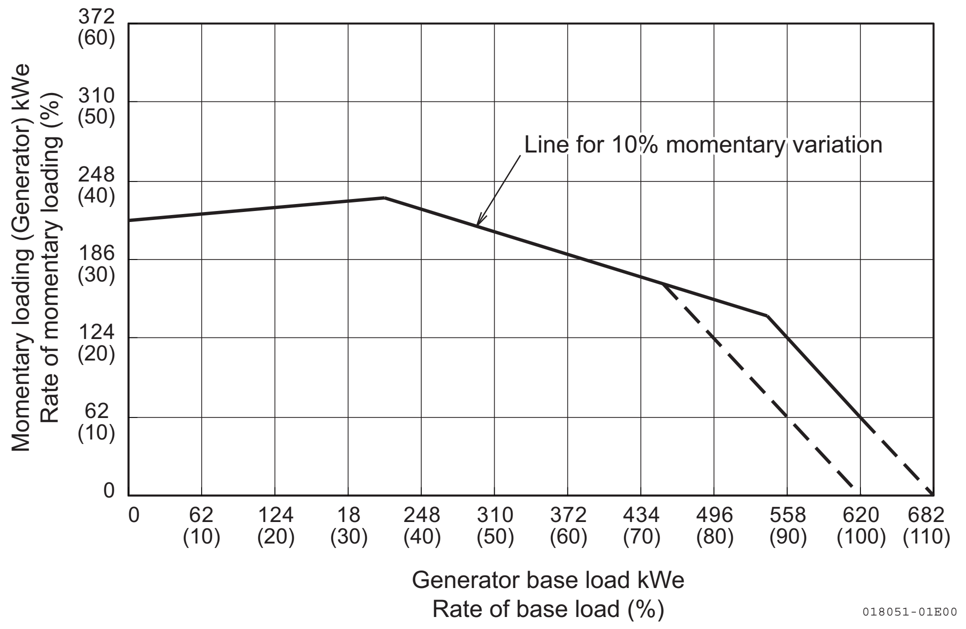


■ **745 kW/900, 1000 min^{-1} Load Input Characteristics (0→32%→67%→100%)**

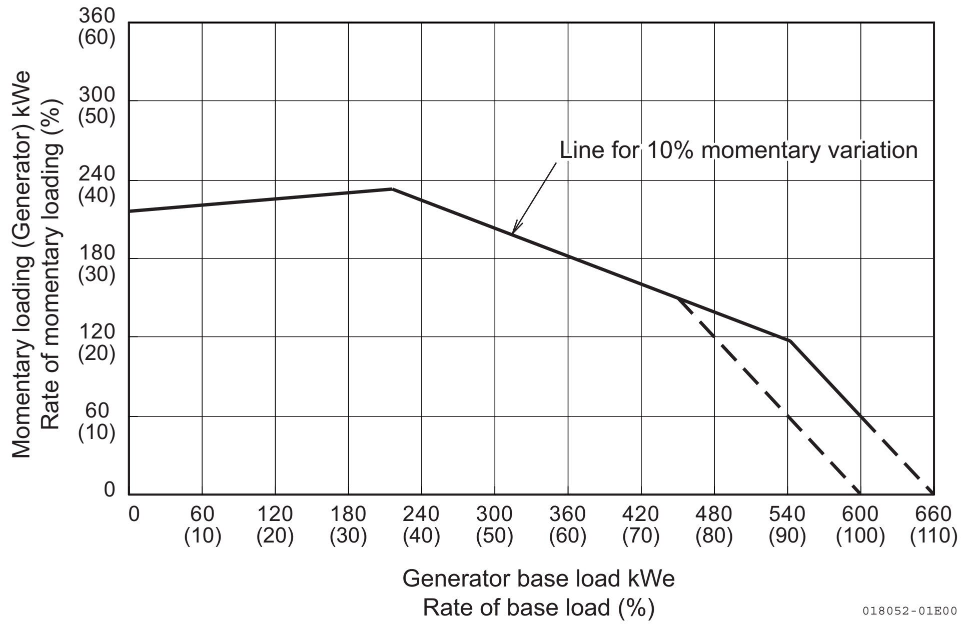


Governor

■ 680 kW/900, 1000 min^{-1} Load Input Characteristics (0→35%→73%→100%)

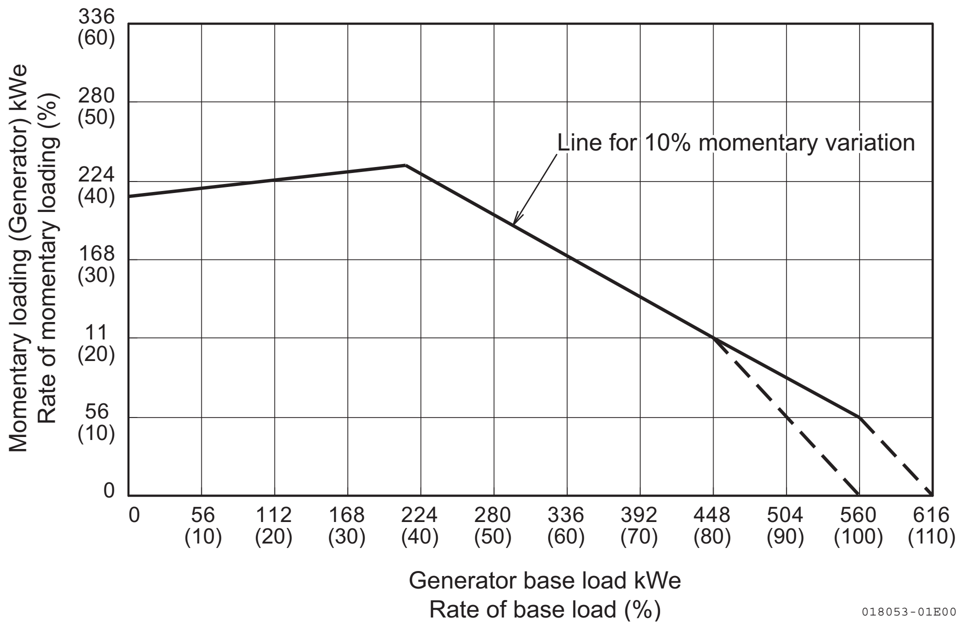


■ 660 kW/900, 1000 min^{-1} Load Input Characteristics (0→36%→75%→100%)

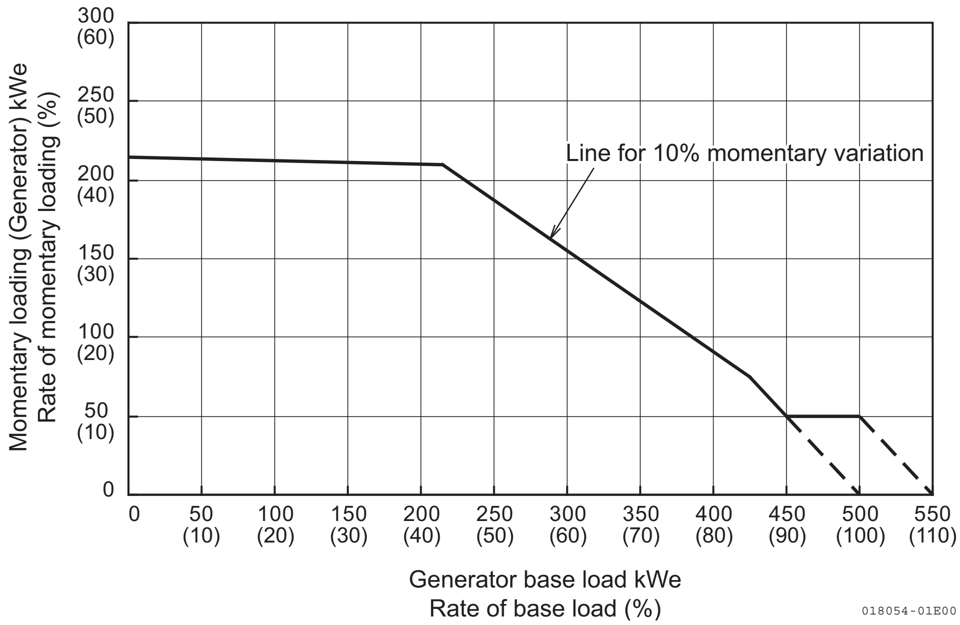


Governor

■ 615 kW/900, 1000 min^{-1} Load Input Characteristics (0→38%→80%→100%)

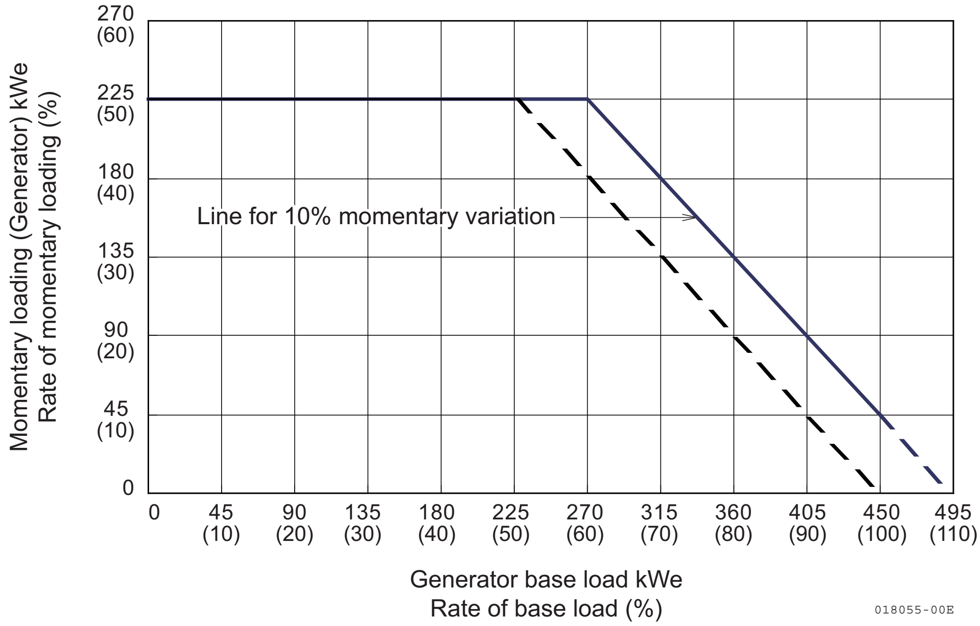


■ 550 kW/900, 1000 min^{-1} Load Input Characteristics (0→43%→85%→100%)

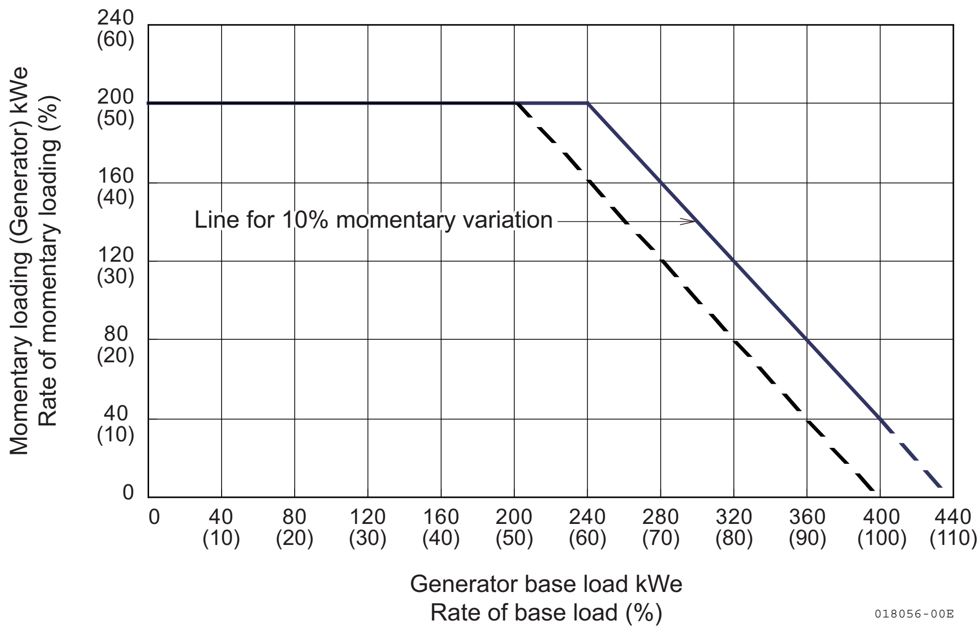


Governor

■ 500 kW/900, 1000 min^{-1} Load Input Characteristics (0→50%→100%)



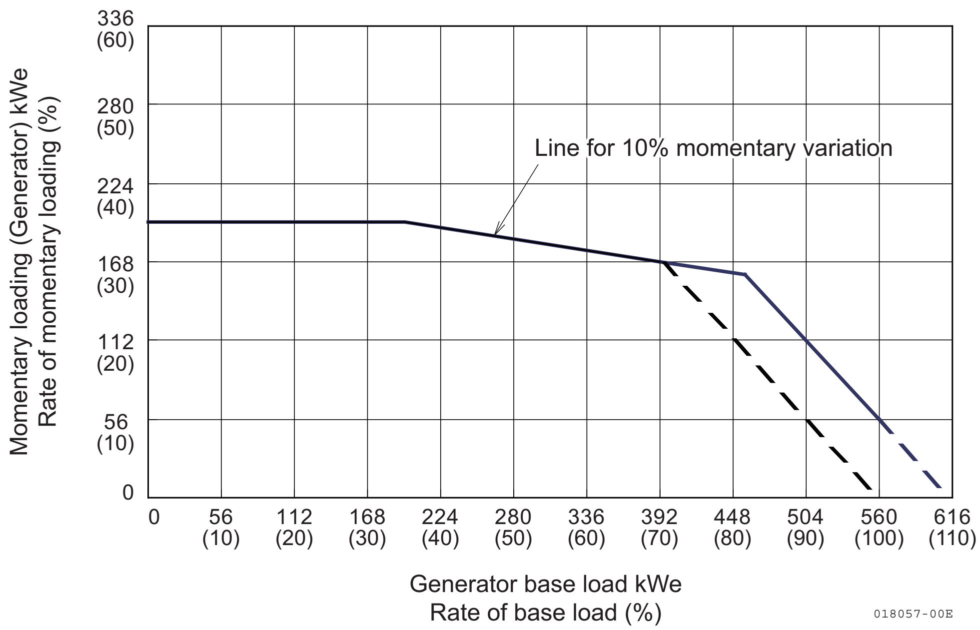
■ 455 kW/900, 1000 min^{-1} Load Input Characteristics (0→50%→100%)



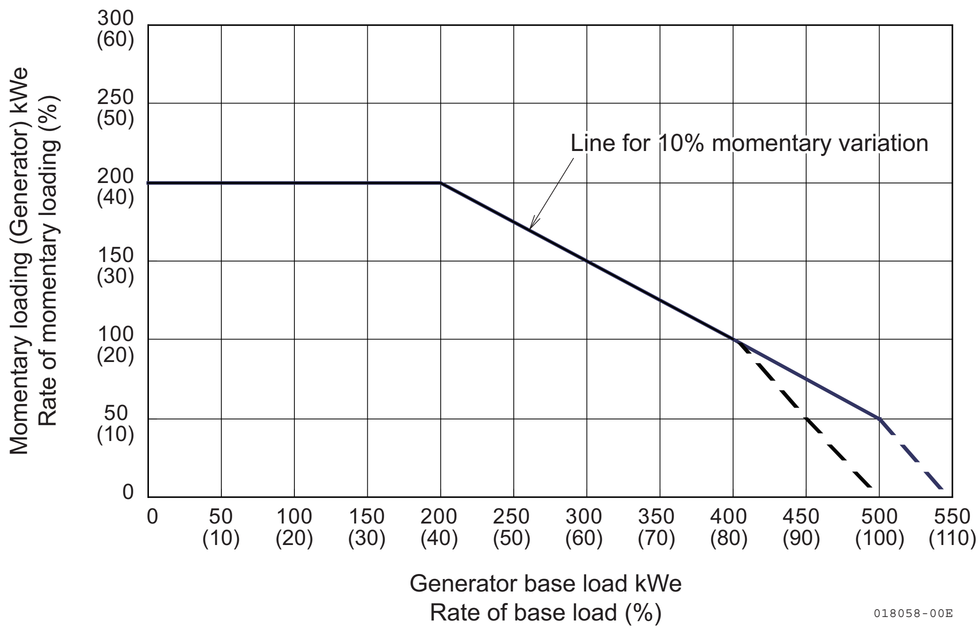
Governor

3.2 6EY18LW

■ 615 kW/720, 750 min^{-1} Load Input Characteristics (0→35%→70%→100%)

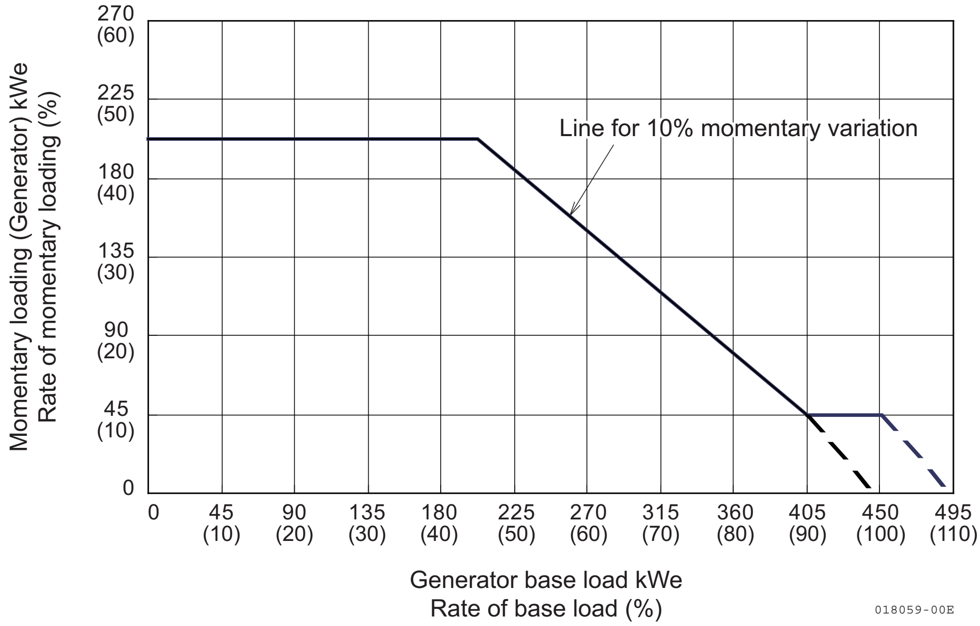


■ 550 kW/720, 750 min^{-1} Load Input Characteristics (0→40%→80%→100%)

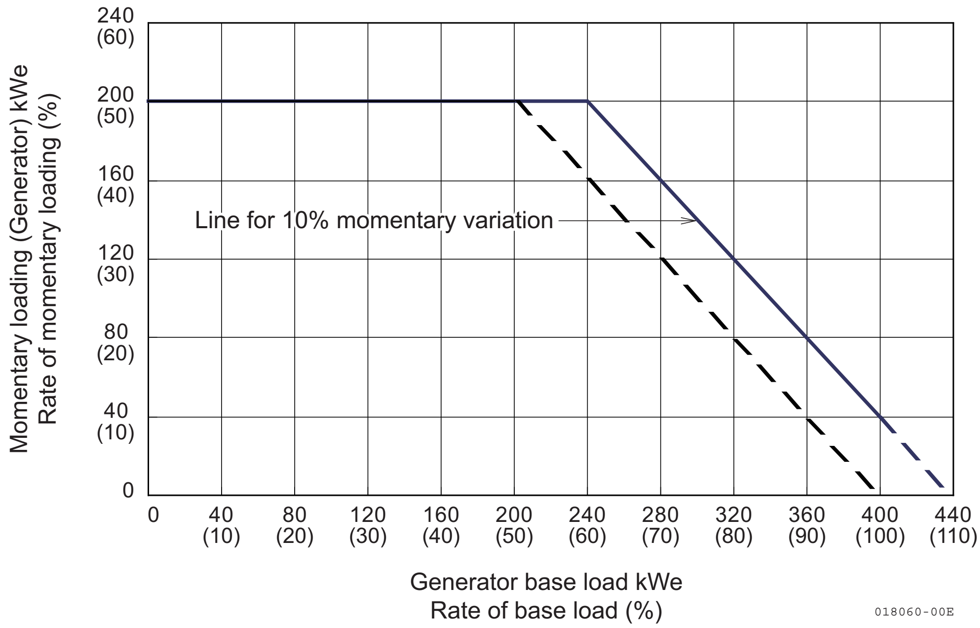


Governor

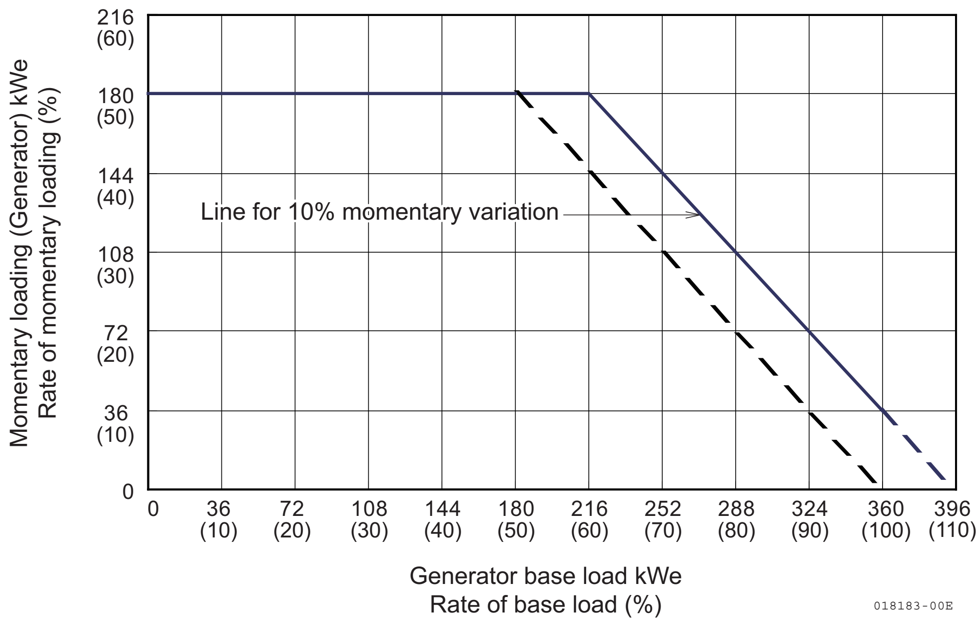
■ **500 kW/720, 750 min^{-1} Load Input Characteristics (0→45%→90%→100%)**



■ **450 kW/720, 750 min^{-1} Load Input Characteristics (0→50%→100%)**



■ **400 kW/720, 750 min^{-1} Load Input Characteristics (0→50%→100%)**



70 Starting and Control Air System

01 Starting and Control Air System

Project Guide

6EY18(A)LW

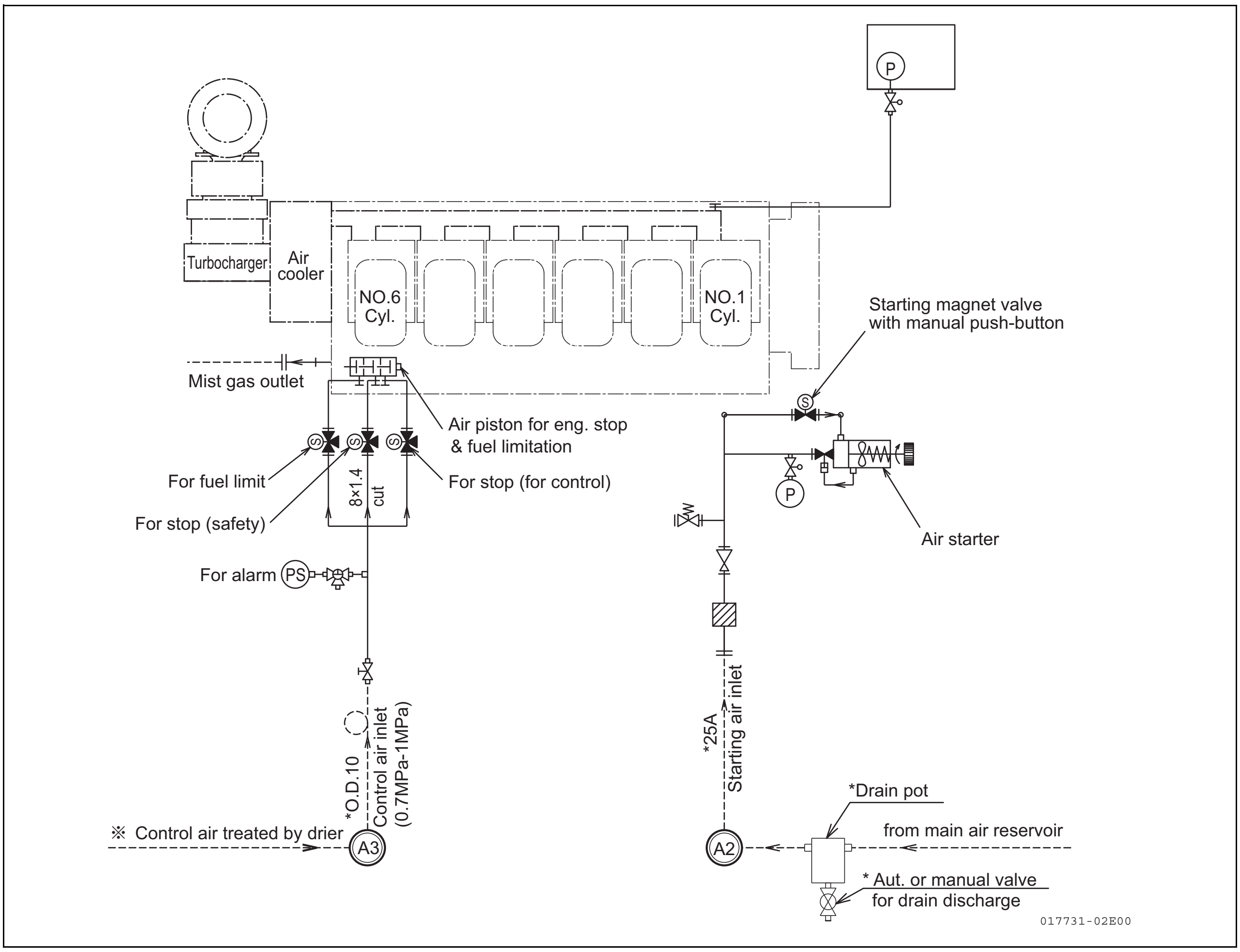
MARINE AUXILIARY DIESEL ENGINE

Starting and Control Air System

1. Outline

The engine's air system consists of the engine starting system, stopping system and the speed control system. The starting air system has a device called the air starter. The starting compressed air pressure (max. pressure 2.94 MPa) is reduced by the pressure reducing valve to 1.0 MPa and is sent to the air starter.
In the safety and control air system, the air sent under 0.7-1.0 MPa from the inboard line moves the air piston.

Starting and Control Air System Diagram



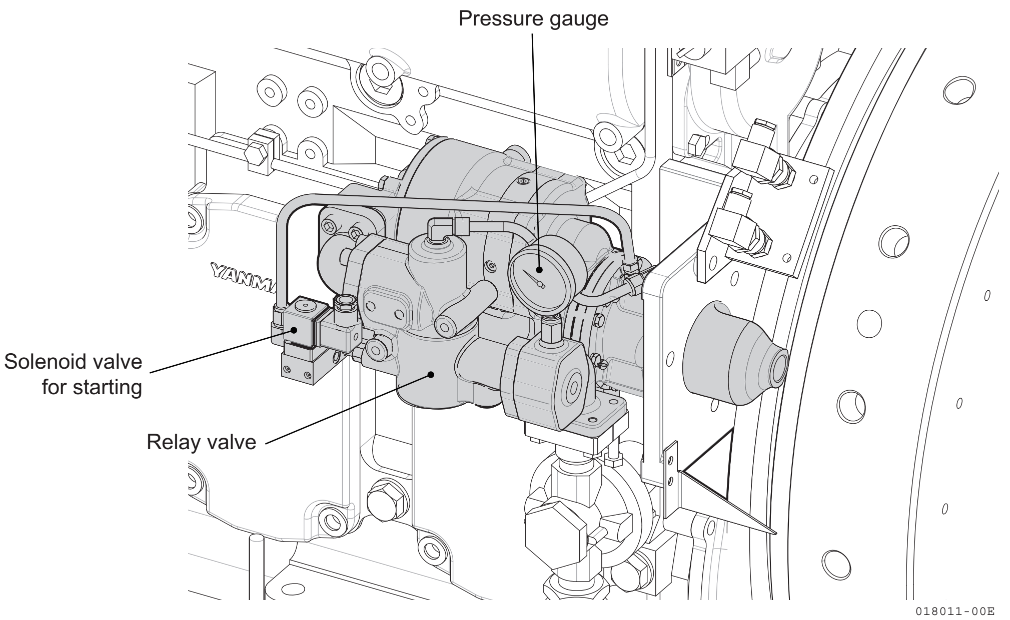
External pipe size
- A2 (Starting air inlet): 25 A
- A3 (Control air inlet): O.D.10 mm

Note:
- Install the drain plug at the lowest position of the hull air piping so drain will not enter the air starter.
- Supply dry air as control air.
- If the starting air pipes are longer than 30 m, it is recommended to use pipes with the next larger radius.
- Design the system so that control air can be supplied from the auxiliary air tank.
- During a blackout (i.e. in a deadship situation or loss of power), start by pressing the manual button that is installed on the start solenoid valve.

Starting and Control Air System

2. Starting Equipment

The starting equipment is a turbine type air motor, which drives a ring gear by means of a pinion gear to turn the engine.



Non-Operation Side

3. Safety and Control Equipment

The safety and control system consists of the governor, start and stop handle, fuel injection pump, and air piston, and the lever shaft to connect these parts.

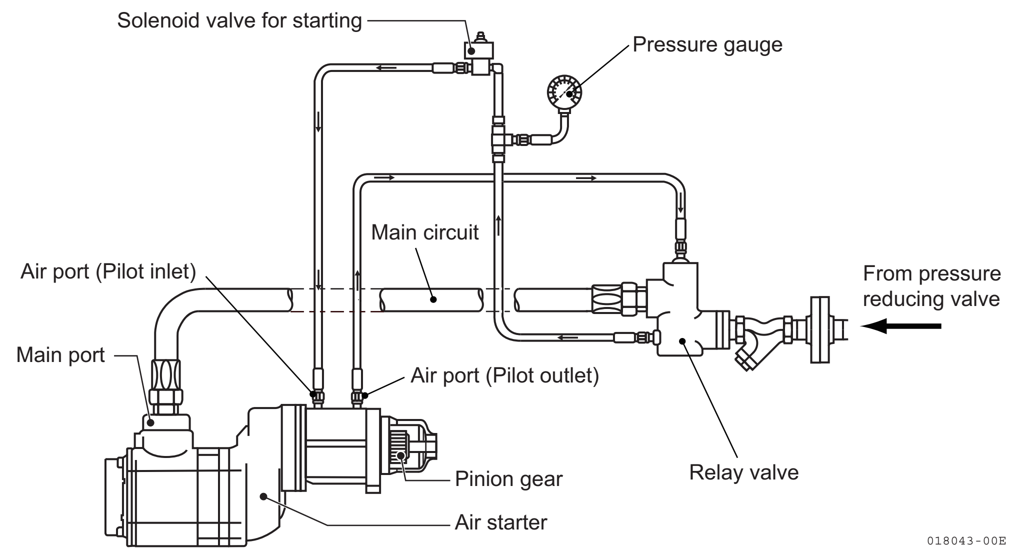
During engine startup, the air piston acts on the lever shaft that links the fuel oil injection pumps and controls the fuel injection amount. For engine shutdown, it stops fuel injection.

The engine is operated with the start and stop handle.

4. Engine Starting Sequence

Upon opening the starting valve, air is introduced into the pinion drive shaft housing. This causes the pinion gear to be pushed out for engagement with the ring gear.

When the pinion gear is fully engaged with the ring gear, air is introduced into the main circuit and the turbine is turned. The pinion gear thus turns the engine to start it. When reaching the specified engine speed (125 min^{-1}), the pinion gear disengages from the ring gear.



80 Safety and Control Systems

Project Guide

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MARINE AUXILIARY DIESEL ENGINE

Operation Data and Setting Values

6EY18(A)LW Alarm List

Fuel Oil, Lubricating Oil and Cooling Water Standard Settings for Engine Operation							
		Temperature (°C)			Pressure (MPa)		
		Service range	Alarm point	Trip point	Service range	Alarm point	Trip point
High Temp. Freshwater	Cylinder inlet	–	–	–	0.15–0.5	0.13	–
	Cylinder outlet	*Refer to 01-02	95	100	–	–	–
Low Temp. Cooling Water	Engine inlet	Up to 38	43	–	Up to 0.5	0.13 (w/eng.-mount pump)	–
	L.O. cooler outlet	Up to 55	–	–	–	–	–
Intake Air	A/C inlet	Load dependent	–	–	–	–	–
	A/C outlet	Up to 60	75	–	Up to 0.30	–	–
Lubricating Oil	Engine inlet	50–65	75	–	0.40–0.45	0.35	0.3
	Priming	–	–	–	0.02-0.25	–	0.02
	Strainer diff. press.	–	–	–	–	0.15	–
	Engine outlet	Up to 75	–		–	–	–
	T/C inlet	–	–	–	(0.1–0.2)	–	–
Fuel Oil (H.F.O.)	Engine inlet	$11–14 mm^2/s$	Low: $9.0 mm^2/s$ High: $17 mm^2/s$	–	0.55–0.60 ($700 mm^2/s$) 0.40–0.45 ($380 mm^2/s$) 0.30–0.35 ($180 mm^2/s$)		–
		–	–	–	–	(Service value minus 0.1)	–
	Strainer diff. press.	–	–	–	–	0.09	–
Starting Air	Engine inlet	–	–	–	0.85-1.0	0.80	–
				(Eng. supply pressure) 2.45–2.94			–
Control Air	Engine inlet	–	–	–	0.7–1.0	0.60	–
Exhaust Gas At 4/4 Load	Cylinder outlet	*Refer to 01-03	500 [Deviation Value 40°C]		–	–	–
	T/C inlet	*Refer to 01-03	610	–	–	–	–
	T/C outlet	*Refer to 01-02	500	–	Exhaust outlet allowable back pressure MAX. 3.43 kPa		
Over speed		Emergency trip 112–115%					
Remark: • Service settings are for engine rated power operation. • The alarm and emergency stop values are the standard values for reference.							

1. Outline

This engine is operated by the engine side control panel or the remote control equipment (built in the MSB) for starting/stopping and controlling.

The control circuits are constituted by the control system and the safety system, and they are necessary to satisfy the requirement of each Shipping Classification Organization. In addition, we can supply the engine side control panel, the starter of the lubricating oil priming pump and the intake air heating equipment for low load operation as the optional specification.

2. Control Equipment

■ Engine Starting (Remote, Engine Side)

The engine employs the air starter starting system. The air starter, which is started and stopped by the solenoid valve, employs the repeat starting control system in consideration of mis-meshing.

■ Engine Stop (Remote, Engine Side)

The engine is stopped by activating the fuel-cut air piston. The air piston is activated by the solenoid valve. The engine stop is released by the timer in normal stop and by the engine side handle switch in failure stop.

3. Safety Equipment

■ Starting Interlock

The following starting interlocks are installed in the engine control circuit:

- The position of the control position switch.
- Start/stop handle at operation position.
- Turning gear disengaged.
- No wire breakage of the engine speed pickup or speed relay defect.
- Stopping device not activated.
- Engine not being operated.

■ Emergency Stop

The following items actuate the engine control circuit for the engine emergency stop:

- Overspeed of the engine.
- LO pressure drop in the engine.
- Temp. rise of the engine cooling freshwater.

4. Operation

■ Engine-Mount

- Engine side/remote control site switching
- Engine starting (start button)
- Engine stop (handle)
- Reset (handle switch)

5. Measurement Items (Revolutions, Pressure, Temperature)

■ Engine Tachometer (Electric)

■ Bourdon Tube Pressure Gauge

- Lubricating oil
- Fuel oil
- High temp. freshwater (cyl. side)
- Low temp. freshwater (cooler side)
- Boost air
- Starting air

■ Bar Thermometer

Lubricating oil
- LO cooler inlet
- Engine inlet

High temp. freshwater (cyl. side)
- Air cooler inlet
- Engine inlet
- Main outlet

Low temp. freshwater (cooler side)
- Air cooler inlet
- Air cooler outlet
- LO cooler outlet

Fuel oil
- Engine inlet

Exhaust
- Outlet of each cylinder
- Turbocharger inlet
- Turbocharger outlet-Option

Boost air
- Air cooler inlet-Option
- Air cooler outlet

Communication with Generator Engine

1. Outline

When the engine side control panel is installed, input/output with MSB and ECC are required.

2. Input/Output with MSB

■ Input from MSB

- Remote/automatic starting
- Remote stopping

■ Output to MSB

- Governor motor connection
- Remote/automatic and engine side control switching
- Starting possible
- Engine operation signal
- Starting failure
- Failure stop (group)
- Engine stop activation

3. Input/Output with ECC (Controls)

■ Input from ECC

- Remote/manual emergency stop

■ Output to ECC

- Engine operation signal
- Starting failure
- Overspeed stop
- LO pressure drop stop
- Cooling freshwater temp. rise stop
- Failure stop (group)
- Power source loss
- Warning suspension (for monitoring)
- Safety stop system failure (group)
- Manual emergency stop

4. Output to ECC (for Monitoring)

■ Pressure

• Lub. oil (priming) pressure drop	(ON/OFF) - Option
• Fuel oil pressure drop	(ON/OFF) - Option
• Low temp. freshwater pressure drop	(ON/OFF) - Option
• Control air pressure drop	(ON/OFF)
• Lub. oil filter differential pressure rise	(ON/OFF)
• Fuel filter differential pressure rise	(ON/OFF) - Option

The following items are output from the junction box attached to engine:

• Lub. oil engine inlet pressure	(4-20 mA)
• High temp. freshwater engine inlet pressure	(4-20 mA)
• Boost engine inlet pressure	(4-20 mA) - Option
• Starting air engine inlet pressure	(4-20 mA) - Option

■ Temperature

• Lub. oil engine inlet temp.	(Pt100 Ω)
• High temp. freshwater engine main outlet temp.	(Pt100 Ω)
• Low temp. freshwater air cooler inlet temp.	(Pt100 Ω) - Option
• Exhaust each cylinder outlet temp.	(Pt100 Ω) - Option
• Exhaust turbocharger inlet temp.	(Pt100 Ω)
• Exhaust turbocharger outlet temp.	(Pt100 Ω) - Option
• Boost air-cooler outlet temp.	(Pt100 Ω) - Option
• H.F.O. engine inlet temp.	(Pt100 Ω) - Option

■ Others

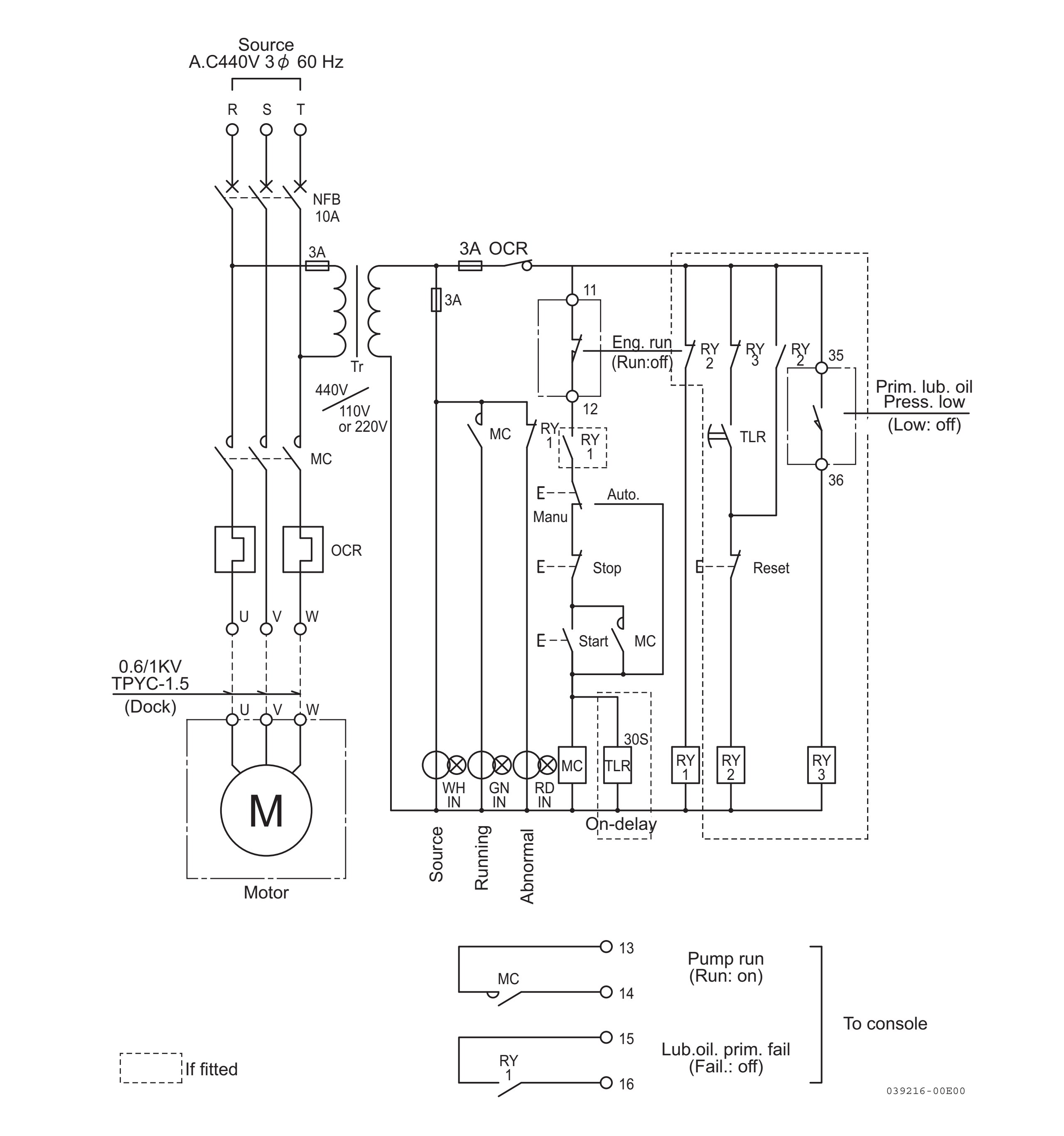
• Fuel high pressure pipe return oil level high	(ON/OFF)
• Lub. oil sump tank oil level low or high	(ON/OFF) - Option

* Optional specifications include the standard equipment by recommendation of Shipping Classification Organization Rules.

Lubricating Oil Priming Pump Starter

The lubricating oil priming pump switches to continuous operation while the engine is being stopped. Refer to the circuit diagram below in the case of procuring the starter for pump. This starter can be procured as an option.

Reference Circuit Diagram



81 Generator

Project Guide

6EY18(A)LW
MARINE AUXILIARY DIESEL ENGINE

Drawing and Data

1. Necessary Documents

The following drawings and documents are required for the direct coupling of the generator with the engine:

- Generator specifications (refer to 2 below)
- External drawing (refer to 2 below)
- Parts drawings (drawings for AVR and other supplied items)
- Drawing of shaft (for calculating torsional vibrations)
- Wiring diagram (for reference at shop test)

2. Generator Specifications and External Drawing

2.1 Generator Specifications

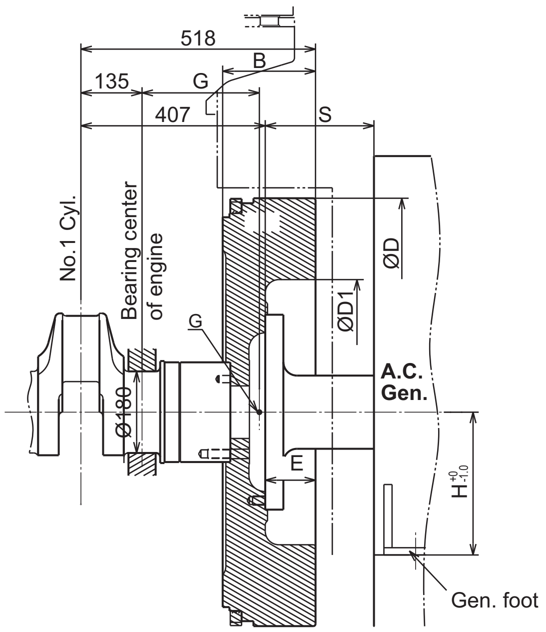
The generator specifications must include the following items:

- Output, voltage, current, no. of poles, revolutions, frequency, power factor and efficiency.
- With or without bearing lubrication, lubricating oil amount, pressure.
  (Lubricating oil: 65°C, Type: SAE30 or 40)
- Water cooling: quantity required, pressure, pressure loss, heat radiation, max. cooling water temperature.

2.2 External Drawing

Refer to the external dimensions below for direct coupling with the engine. Also, enter the following items:

- Weight, center of gravity, lifting method.
- Rotor extraction dimension, bearing disassembly/maintenance space.
- The position of bearing lubrication pipe inlet and outlet viewed from the direct coupling side towards the generator should be:
  Inlet-at the left side.
  Outlet-at the right side.
- The position of CW pipe's inlet and outlet should be at the left side when viewing the generator from the direct coupling side.
- Generator revolving direction should be clockwise when viewing the generator from the coupling side.



Data of flywheel		Others
Mass	708 kg	Direction of rotation
GD^2	381 kgm^2	: Counterclockwise
D	1030 mm	(Viewed from free end of generator)
B	134 mm	
D1	500 mm	H 315 mm
E	47 mm	S Min.193 mm
G (Center of gravity)	247 mm	

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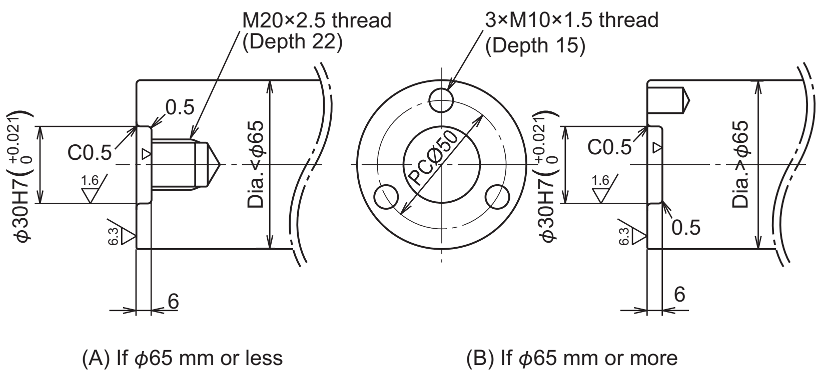
3. Data for Torsional Vibration Calculation

The generator shaft drawing should include the following items:

- Data for calculating the equivalent length (torsional stiffness).
- Inertia moment of fan, rotor, etc.
- The fitting tolerance between rotor boss and shaft.

*Install the seat for torsional vibration measurement at the shaft end of the generator bridge. (See the figure below.)

Detail of shaft free end (for measuring the torsional vibration)



Attach a cover during maintenance to protect yourself from moving parts.

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Coupling Type

1. Direct Coupling System

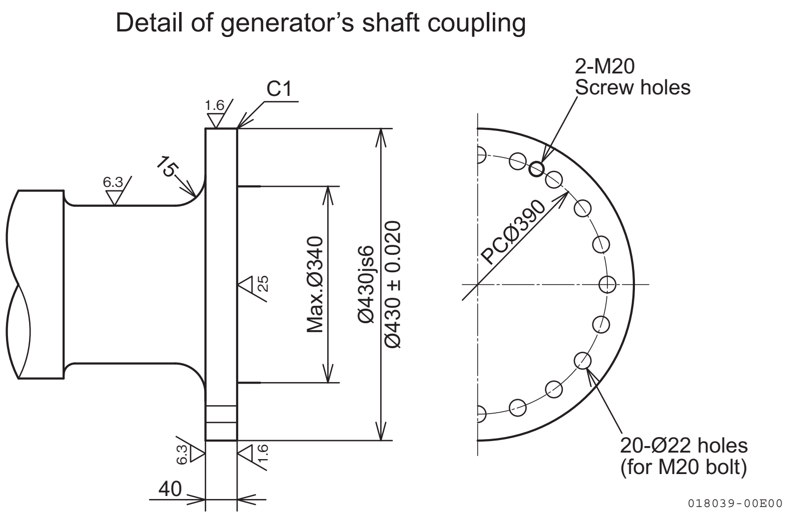
The direct coupling system is a rigid direct coupling (with fixed installation or vibration-proof mounting). It can couple both double bearing and single bearing type generators.

Flexible coupling by an elastic coupling is also possible for the double bearing type generators. In this case, a thrust bearing is required for the generator shaft (to counter pitching of the hull).

2. Direct Coupling Flange Size

The shaft end direct coupling flange sizes are shown below. In the case of the straight shaft end, procure the flange coupling with the following size from the generator manufacturer.

Rigid type flange size



Accessories

1. Accessories

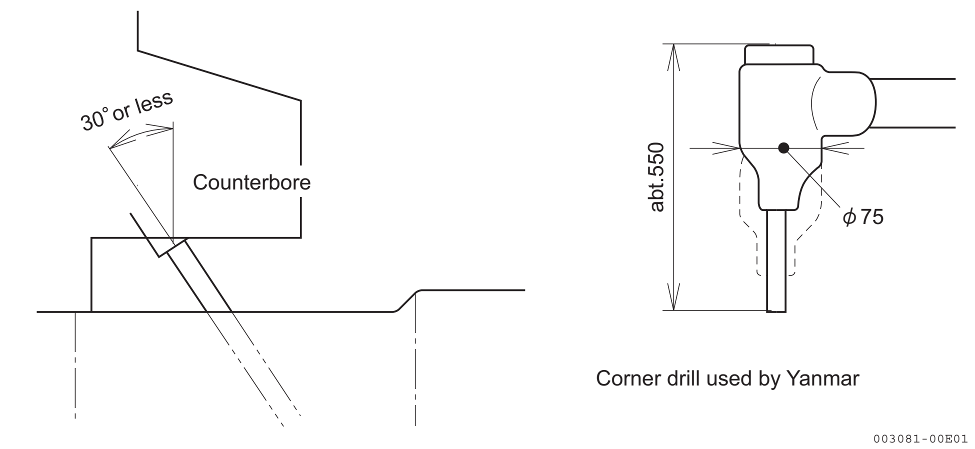
The following accessories should be procured from the generator manufacturer:

- Generator installation bolts and nuts with taper pin; jack bolts
- Bronze plate foot liner (shim)
- Magnetic center gauge
- Rotor fastening tool (for single bearing generator)
- Adapter for torsional vibration measurement

2. Others

- When there is no space for the corner drill to enter vertically for knock hole machining, machine the slant knock hole with an inclination less than 30 degrees to the vertical line as shown in the figure below.
- Diameter of knock hole should be less than 16 mm.

Knock hole machining procedure



90 Test

01 Shop Test Procedures of Generator Engine

Project Guide

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MARINE AUXILIARY DIESEL ENGINE

Shop Test Procedures of Generator Engine

1. Test Items

The following items are included in the shop test:

- Engine starting test
- Governor test (Including the momentary loading test)
- Engine load test (Refer to item 2 below for the test time at each load.)
- Measurement of bearing temperature
- Load test of generator
- Parallel running operation of generators
- Protection equipment test (Overspeed stop, emergency stop, and alarm switch activation are checked.)
- Measurement of crankshaft deflection (cold state)
- Measurement of torsional vibration

2. Engines to be certified under Shipping Classification Organizations and Japanese Government

The standard duration of the engine load operation test depends on the rules of each Shipping Classification Organization or other agency regulations. (Please refer to the table below.)

Table: Load and Duration for Test Operation on Land Unit: min.

		Shipping Classification Organization				Japanese Government Maritime Bureau
		NK, LRS, KR, CCS	ABS, CR	DNV, BV, RINA	GL	JG
0	Gen. Base	–	20	20	20	–
25	Gen. Base	20	20	20	20	20
50	Gen. Base	20	20	20	20	20
75	Gen. Base	20	20	20	20	20
100	Gen. Base	60	60	60	20	60
110	Gen. Base	20 (CCS-30)	30	45	–	20
100	Eng. Base	–	–	–	60	–
110	Eng. Base	–	–	–	45	–

91 Spare Parts

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Standard Spare Parts

Standard spare parts are the following and 1 set shall be attached per 1 vessel.

No.	Name of Parts	Quantity	Remark
1	Main bearing ass'y	1 set	
2	Thrust bearing	1 set	
3	Main bearing tightening bolts and nuts	2 pcs.	
4	Intake valve ass'y (including valve seat)	2 sets	
5	Exhaust valve ass'y (including valve seat)	4 sets	
6	Piston pin	1 set	
7	Piston ring (top, 2nd), oil control ring	1 each	
8	Piston pin bush	1 pc.	
9	Crankpin bearing	1 set	
10	Connecting rod bolt	2 pcs.	
11	Fuel injection valve ass'y	3 sets	
12	Plunger, plunger barrel and spring of the fuel injection pump	1 set	
13	Delivery valve, spring of the fuel injection pump	1 set	
14	Fuel injection high press. pipe	1 set	
15	Special packing (cylinder head, cylinder liner)	1 set	
16	Turbocharger standard spare parts	1 set	

Note:
The spare parts shown in the above table comply with the requirements of the Shipping Classification Organization Rules.

Recommended Replacement Interval for Consumable Items

Name of Assembly		Operation Hours and Required Quantities							
	Part Name	4000	8000	16000	20000	24000	32000	40000	50000
Fuel injection pump	Deflector	6							
	Plunger						6		
	Barrel						6		
Fuel injection valve	Nozzle	6							
Piston	Top ring		6						
	2nd ring		6						
	Oil ring		6						
Connecting rod	Crankpin bearing					6			
	Piston pin bearing					6			
	Rod bolt				12				
Main bearing	Main bearing						7		
Cooling water pump	Mechanical seal		2						
Cylinder head	Intake valve						12		
	Exhaust valve						12		
	Valve rotator		24						
	Exhaust valve seat						12		
	Intake valve guide						12		
	Exhaust valve guide						12		
Turbocharger	Compressor blade								1
	Turbine shaft with blade								1

Operation hours in the above table indicate a rough standard, because these hours vary depending on the quality of fuel oil, lubricating oil and engine usage.

92 Tools

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MARINE AUXILIARY DIESEL ENGINE

Standard Tools

No.	Names of Tools	Quantity	Remark
1	Cylinder head lifting tool	1 set	
2	Int./exh. valve attach/detach tool	1 set	
3	Main bearing insertion tool	1	
4	Hydraulic jack (cylinder head bolt)	1 set	
5	Spacer (bearing cap bolt)	1 set	Hydraulic jack is common with head bolt
6	Hydraulic pump	1	Including pressure gauge
7	Priming tool	1 set	Including two spacers
8	Plunger removal tool	1	
9	Nozzle sleeve disassembly tool	1	
10	Cylinder liner removal tool	1 set	
11	Protection ring removal tool	1	
12	Piston insertion tool	1	
13	Fuel valve removal tool	1 set	
14	Valve lapping tool	1	
15	Turning tool	1	
16	Double-headed wrench	1 set	10 × 13, 17 × 19, 22 × 24, 27 × 30 32 × 36, 41 × 46
17	Wrench	1 set	24, 41
18	Adjustable wrench	1	
19	T-handle	1	
20	Socket	1 set	
21	Sliding T-handle	1	19, 22, 30
22	Screwdriver	1 set	Phillips and flat head screwdrivers, one each
23	Hexagon rod wrench	1 set	4, 5, 6, 8
24	Thickness gauge	1 set	
25	Snap ring pliers	1	
26	Eye bolt	1 set	M10 × 2, M12 × 2
27	Turn handle	1	
28	Eye nut	1	M16
29	Box wrench	1	For tightening the fuel injection pump mount
30	Cleaning tool for the turbocharger blower	1	
31	Lubricating oil strainer pan	1	
32	Disassembly tool for the lubricating oil strainer element	1	
33	Nozzle tester assembly	1	
34	Max. pressure indicator	1	
35	Deflection gauge	1	

Standard Tools

No.	Names of Tools	Quantity	Remark
36	Deflection gauge mirror	1	
37	Inside micrometer	1	For cylinder bore measurement
38	Cyl. bore measurement positioning tool	1	
39	Turbine cleaning tool	1	Only on heavy fuel oil specifications

Special Tools

The special tools are prepared as optional parts.
It is recommended that the asterisked tools are always carried on board.

No.	Names of Tools	Remarks
1	Outside micrometer	
2	*Single ball micrometer	For measuring bearing thickness
3	Piston ring puller	
4	Lub. oil cooler pipe cleaning brush	
5	Lub. oil cooler pipe wooden plug	
6	Fuel injection valve cleaning needle	
7	Pressure switch tester	
8	750 N•m torque wrench and socket	24, 32
9	Extension bar for torque wrench	
10	Cylinder head turning mount	
11	Repair coating	1 kg, 2 kg or 4 kg cans

93 Painting Colors and Name Plates

01 Painting Colors and Name Plates

Project Guide

6EY18(A)LW

MARINE AUXILIARY DIESEL ENGINE

Painting Colors and Name Plates

1. Painting Colors

■ Painting Colors

Munsell 7.5BG 7/2

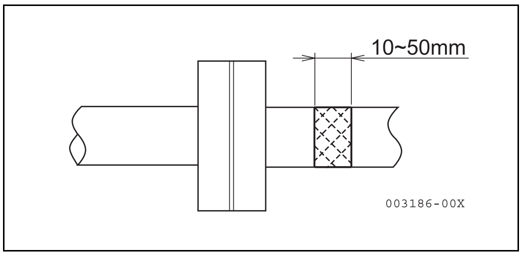
Yanmar Gold Silver (Option)

Other (The color is designated by Munsell code.) (Option)

■ Piping System ID Painting

Division		ID color	Munsell code	
Cooling water piping	Seawater	Green	5G	4/8
	Freshwater	Blue	10B	5/10
Fuel oil piping		Red	7.5R	4/14
Lubricating oil piping		Yellow	2.5Y	8/16
Air piping		White	N	9.5

- Paint the pipe as follows:



2. Name Plate

■ Operation and Name Plates

English and Japanese

■ Safety Labels

English and Japanese

99 Storage Procedures

Project Guide

6EY18(A)LW

MARINE AUXILIARY DIESEL ENGINE

Long Storage Procedures

1. Long Storage (Approx. 6 months - 1 year)

1.1 Storage Condition

- Provide sufficient ventilation and humidity prevention in the storage area.
  Keep the indoor temperature at 40 ℃ or below and humidity at 75% or below.
- Store the equipment indoors and do not expose the equipment to rainwater or briny air.
  If storage of the equipment outdoors is unavoidable, export packing pre-treatment and humidity prevention packing must be provided. (If outdoor storage is expected, contact us prior to your order.)
  In addition to the above, cover the packing with a water-proof sheet.
- The storage floor should be a concrete or steel plate. Place the equipment 300-500 mm above the floor surface.
- Cover the equipment with a dust-proof sheet.

1.2 Maintenance Inspection

- Once every month, check the exterior of the equipment and spray or brush anti-rust oil.
  <Parts to be Inspected>
  - Cylinder head top face and valve arm case interior
  - Governor link mechanism
  - Fuel injection pump rack
  - Generator shaft, crankshaft, flywheel and other exposed parts.
    (If the parts have moisture-proof packing, inspect once every three months.)
- Fill the common bed system oil. Conduct turning once a month while priming the lubricating oil.
  (Conduct priming until oil comes out from the piston pin and camshaft of each cylinder.)
- Once every three months, open the crank case side cover, turn the crankshaft for inspection and spray anti-rust oil.
  <Parts to be Inspected>
  - Crankshaft
  - Connecting rods
  - Cylinder liners and pistons
  - Cams and camshafts
  - Tappets and rollers

Recommended Anti-Rust Oil Brands

Maker Name	Brand
IDEMITSU KOSAN	NO RUST ENGINE OIL
SHELL	P-10 No.2
TONEN GENERAL OIL	P-103
JX Nippon Oil & Energy	ANTI-RUSTP-230
COSMO OILS	P-1000

Spray or brush the anti-rust oil.
The brands above can be used as the system oil. But stop the continuous engine operation with anti-rust oil within one week. Switch to the regular system oil as soon as possible.

Long Storage Procedures

- If the turbocharger is installed, maintain it as follows (every 3 months):
  - Remove the silencer from the turbocharger and spray anti-rust oil to the turbine wheel and inlet inducer.

1. Maintenance during and after Installation

1.1 Maintenance during Installation

- Whenever the equipment is disassembled, promptly re-assemble it or put a cover over it to protect it from dust.
- Apply anti-rust oil before re-assembly.
- Cover the whole engine if installation work is suspended before completion.
- Turn the crankshaft once every 10 days to prime the lubricating oil.

1.2 Maintenance after Installation

■ When the engine stops and it is impossible to maintain the engine

Preparation

1. Blow out cooling water from the engine, and close the water inlet and outlet valves.
2. Fill the fuel piping between the fuel oil strainer and the fuel injection pump with anti-rust oil, and perform priming sufficiently.
3. Turn the crankshaft to prime fuel injection pump and inject anti-rust oil inside the combustion chamber.
4. Spray anti-rust oil on the crankshaft inside the crankcase and on the cylinder liners, pistons, connecting rods, and camshafts.
5. Close the funnel cover to prevent rainwater from entering through the exhaust pipes and open the drain valve of the silencer or exhaust duct.
6. Spray anti-rust oil on the turbocharger bearings and oil feeding equipment.
7. Ventilate the engine room properly.
8. Cover the remote control equipment and each protection equipment with vinyl sheets, put in the drying agents and seal the sheets.
9. Turn off the engine control circuit.
10. Provide anti-rust treatment to the governor link mechanism.
11. If the engine has a hydraulic governor, fill the governor with anti-rust oil until it overflows.

Maintenance

1. Once a week, turn the crankshaft while priming the lubricating oil. Be sure to stop the crankshaft at a different position from the original position.
2. Once a month, check the engine exterior and spray anti-rust oil on the exposed areas.
   <Parts to be Inspected>
   - Cylinder head upper surface and rocker arm case interior
   - Governor link mechanism
   - Fuel injection pump rack
   - Crankshaft and other exposed areas
3. Spray anti-rust oil on the crankcase and governor link mechanism once every three months.
4. It is recommended that the drying agents sealed in the control panel of the remote control equipment, etc. be replaced every 6 months.
5. Analyze the lubricating oil properties every 6 months. Replace the lubricating oil if it is excessively oxidized.

Note:
When the engine has been stored for more than one year without engine operation for maintenance, be sure to disassemble and inspect the fuel injection pump and fuel strainer.

Maintenance after Installation

■ When maintenance personnel is present and the engine is operable

Conduct maintenance inspection in accordance with the instruction given in the engine's operation manual. When the driven machinery cannot be operated, disconnect it from the engine to enable engine operation for maintenance.

Preparation

1. Fill the cooling water lines with cooling water. (If the room temperature is expected to drop below 0℃, heat the engine room to prevent water from freezing or blow cooling water off each part.)
2. Cover the funnel to prevent rainwater from entering through the exhaust pipe.
3. Check that lubricating oil in each part is supplied to the specified quantity.
   (The anti-rust oil mentioned in 1-2 of 99-01 is sufficient.)
4. Fill the fuel oil tank with fuel oil and bleed air from the fuel oil line.
5. Fill the starting air tank with compressed air.

Maintenance

1. Start the engine manually every two weeks.
2. Before starting the engine, turn the crankshaft after priming the lubricating oil for 3-5 minutes.
3. Open each valve (closed before starting) and check that water and oil flows are normal.
4. After starting the engine, conduct an idling operation (at approx. 1/2 of the rated speed) for about 3 minutes, and check that each part is normal. Then raise the engine speed to the specified revolutions and operate the engine for about 5 minutes.
5. Check the pressure of the starting air tank and operate the compressor to charge the starting air tank when necessary.
6. When stopping the engine, open all of the indicator pressure valves and air running for discharging gas fully from the combustion chambers.
7. After stopping the engine, turn the crankshaft while priming the lubricating oil.
8. When the engine operation is finished, close the indicator pressure valve and other valves (fuel oil, cooling water, starting air, funnel, etc.)

1. Starting after Long Term Storage

1.1 If "Maintenance during installation" (1.1) in "Maintenance after installation" (99-02) was performed

1. Change the anti-rust oil of the engine, turbocharger, hydraulic governor to the regular system oil.
2. Open each valve and pass water or oil through it.
3. Measure the circuit resistance of the control circuit and generator to check the protection equipment.
4. Remove the drying agent from the generator, and inspect the inside of the generator.
5. Remove the silencer cover of the turbocharger.
6. Remove the funnel cover and the turbocharger exhaust outlet flange cover.
7. Inspect the inside of the engine.
8. Fill the fuel oil tank with fuel oil, vent air from the fuel oil line and prime the fuel oil.
9. Start the engine manually and check each part.
10. For operating the engine, follow the instructions given in the operation manual.
11. Connect the driven equipment with the engine.

1.2 If "When maintenance personnel is present and the engine is operable" of "Maintenance after installation" (1.2) in "Maintenance after installation" (99-02) was performed

1. Open the valves (closed previously).
2. Operate the engine manually. Check each part and control circuit.
3. Do a load run and check for defects.
4. Carefully read the engine's operation manual and follow the instructions in it.
5. Change the anti-rust oil in the engine, turbocharger and hydraulic governor to the regular system oil.

Storage Procedures for Spare Parts and Tools

1. Storage of Spare Parts and Tools

1.1 Spare Parts

- Store spare parts in the same conditions as the engine.
- O-rings, rubber pipes and other rubber spare parts will deteriorate during long term storage depending on the storage conditions. Be sure to check that there is no hardening or cracking on these parts before using them.

1.2 Tools

- The provided tools and special tools are pre-treated for protection against rust. Nevertheless, it is advisable to clean them with a rag and apply anti-rust oil after usage.

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