

PROJECT GUIDE

HIMSEN H21/32 FOR STATIONARY



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General Information**P.00.000*****Structural Design and Installation*** **P.01.000*****Performance Data*** **P.02.000*****Dynamic Characteristics and Noise*** **P.03.000*****Operation and Control System*** **P.04.000*****Fuel System*** **P.05.000*****Lubricating Oil System*** **P.06.000*****Cooling Water System*** **P.07.000*****Air and Exhaust Gas System*** **P.08.000*****Delivery and Maintenance*** **P.09.000****Appendix**

General Information	Introduction	Sheet No. P.00.100	Page 1 / 1
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General

This project guide provides necessary information and recommendations for the application of HYUNDAI's HiMSEN H21/32 generating sets(gen-set).

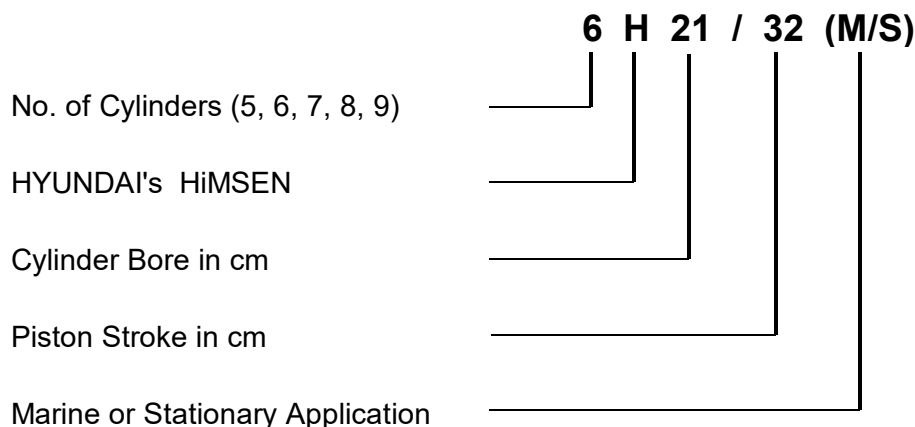
'HiMSEN'® is the registered brand name of HYUNDAI's own design engine and the abbreviation of '**Hi-Touch Marine & Stationary Engine**'.

HiMSEN H21/32 generating sets are delivered as complete packages, an engine and a generator are mounted on a common base frame together with related auxiliary equipments.

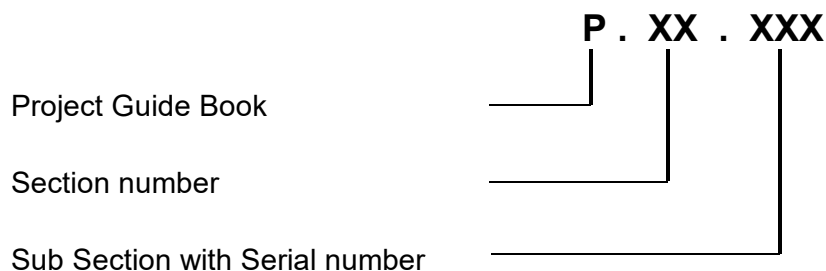
Please note that all data and information prepared in this project guide are for guidance only and subject to revision without notice. Therefore, please contact Hyundai Heavy Industries Co., Ltd. before actual applications of the data. Hyundai Heavy Industries Co., Ltd.(HHI) will always provide the data for the installation of the specific project.

Each sheet is identified by the engine type and own 'Sheet Number'. Therefore, please use engine type 'H21/32' and 'Sheet No.' for easier communications.

ENGINE MODEL DESIGNATION



SHEET NUMBER



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Nov. 2023

Sheet No.

Description

P.00.000
General Information

P.00.100

Introduction

P.00.200

Contents

P.00.300

Engine Nomenclature

P.01.000
Structural Design and Installation

P.01.100

Principal Data

P.01.200

Engine Cross Section

P.01.300

Engine Design Outline

P.01.400

Genset Dimension and Weight

P.01.500

Mounting

P.01.600

Overhaul Dimension

P.02.000
Performance Data

P.02.100

Rated Power for Genset

P.02.200

Engine Capacity Data

P.02.300

Engine Performance - 720 rpm

P.02.310

Engine Performance - 750 rpm

P.02.320

Engine Performance - 900 rpm

P.02.330

Engine Performance - 1000 rpm

P.02.400

Exhaust Gas Emission

P.02.500

Correction of Fuel Consumption

P.02.600

Correction of Exh. Gas Temp.

P.02.700

Power Derating Diagram

P.03.000
Dynamic Characteristics and Noise

P.03.100

External Forces and Couples

P.03.200

Moment of Inertia

P.03.300

Noise Measurement

P.04.000
Operation and Control System

P.04.100

Engine Operation

P.04.200

Start & Load up of Engine

P.04.400

Engine Control System

P.04.600

Outline of Engine Automation

P.04.700

Operation Data & Alarm Points

P.04.800

Local Instrumentation

P.04.900

HiEMS

P.05.000
Fuel Oil System

P.05.100

Internal Fuel Oil System

P.05.200

External Fuel Oil System

P.05.300

Fuel Oil Specification

P.05.310

Fuel Oil Viscosity Diagram

P.05.320

Fuel Oil Quality

Sheet No.

Description

P.06.000
Lubricating Oil System

P.06.100

Internal Lubricating Oil System

P.06.200

External Lubricating Oil System

P.06.300

Lubricating Oil Specification

P.06.310

List of Lubricants

P.07.000
Cooling Water System

P.07.100

Internal Cooling Water System

P.07.110

Internal Cooling Water System-1

P.07.120

Internal Cooling Water System-2

P.07.200

External Cooling Water System

P.07.210

External Cooling Water System-1

P.07.220

External Cooling Water System-2

P.07.300

Cooling Water Treatment

P.08.000
Air and Exhaust Gas System

P.08.100

Internal Compressed Air System

P.08.200

External Compressed Air System

P.08.300

Internal Combustion Air System

P.08.400

External Combustion Air System

P.08.500

External Exhaust Gas System

P.08.510

External Exh. Gas Pipe Connection

P.08.600

Exh. Gas Silencer with Spark Arrestor

P.08.610

Exh. Gas Silencer without Spark Arrestor

P.08.700

Generator Information

P.09.000
Engine Maintenance

P.09.100

Maintenance Schedule

P.09.200

Recommended Wearing Parts

P.09.300

List of Recommended Spare Parts

P.09.400

Heavy Parts for Maintenance

P.09.500

Commissioning Spare Parts

P.09.600

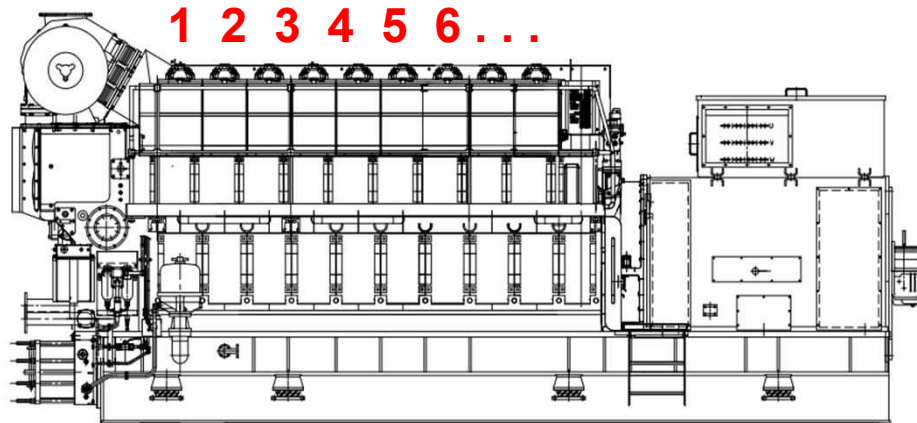
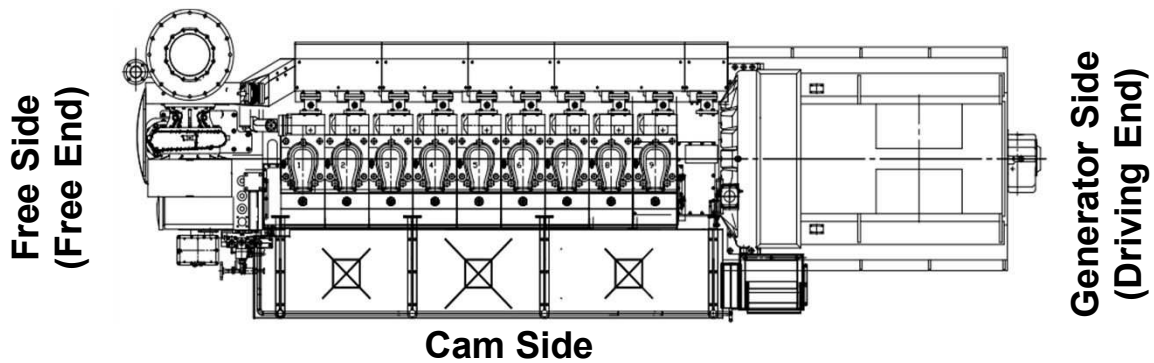
List of Standard Tools

P.09.700

List of General Tools

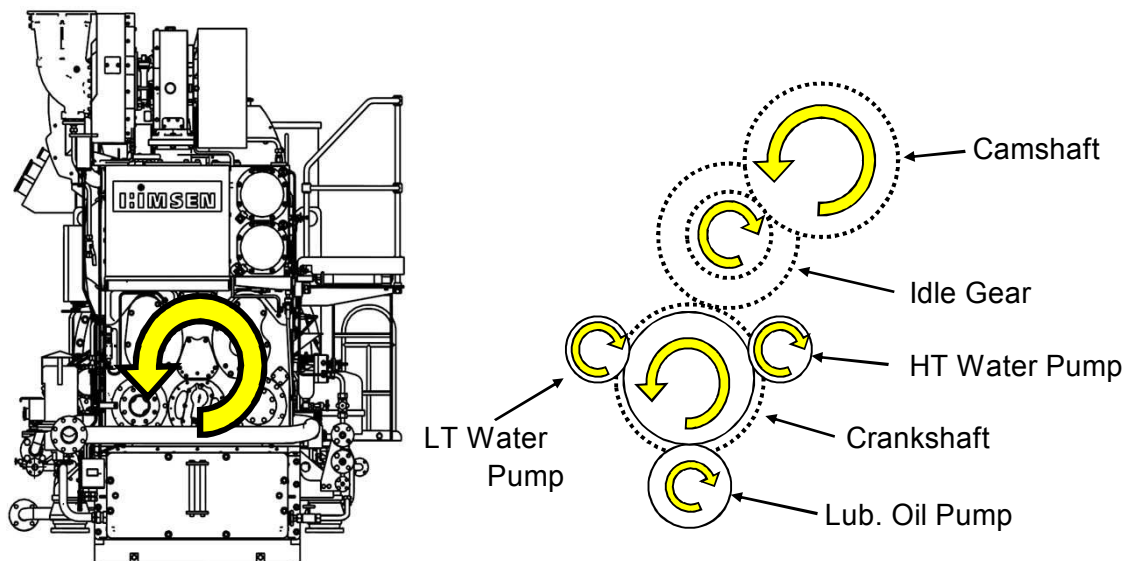
Appendix 1
Piping Symbols
Appendix 2
Instrumentation Code

Cylinder Numbering


Exh. Side


Direction of Engine Rotation

Counterclockwise viewed from Free End.


Viewed from Free End

General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

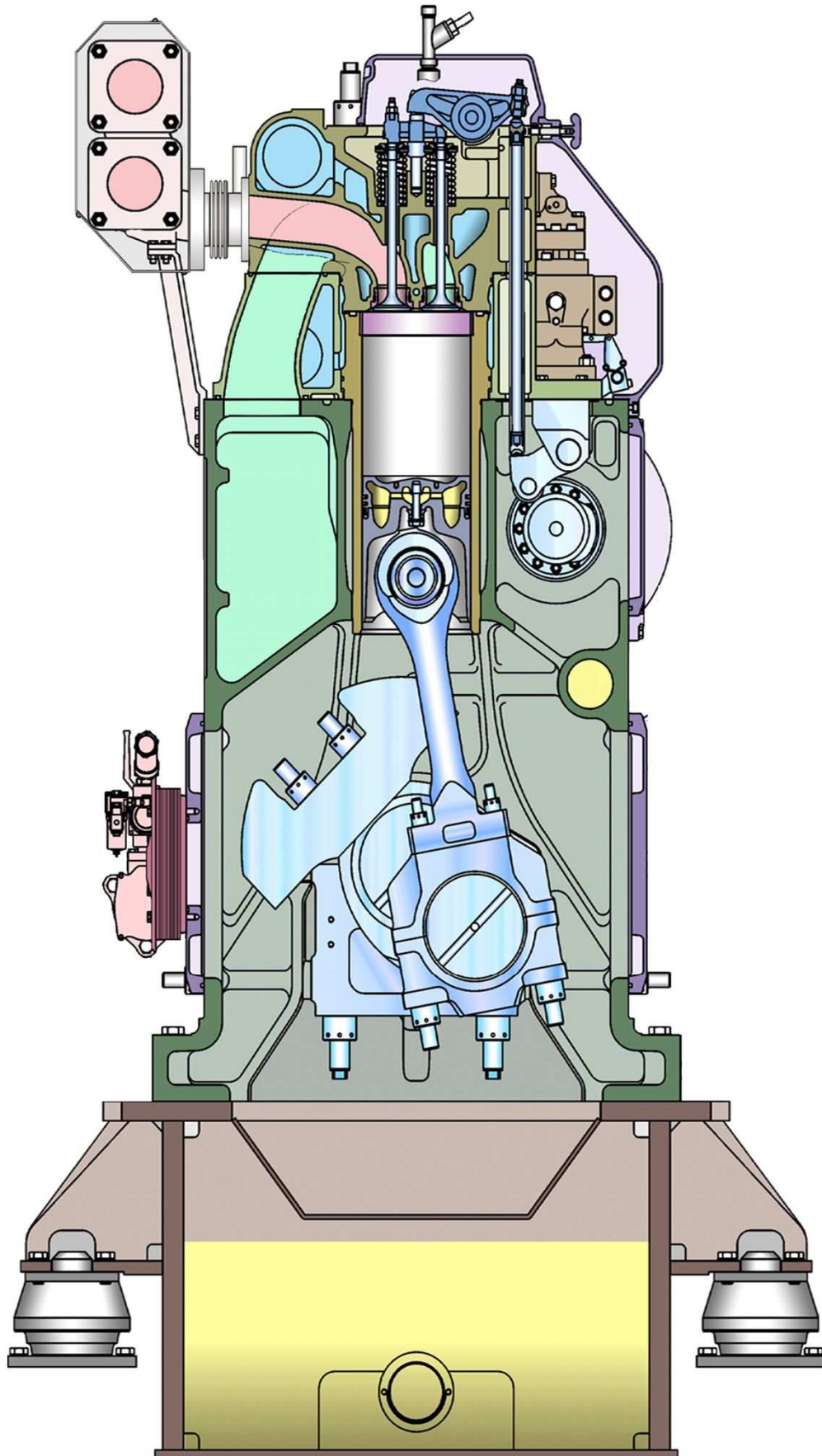
Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

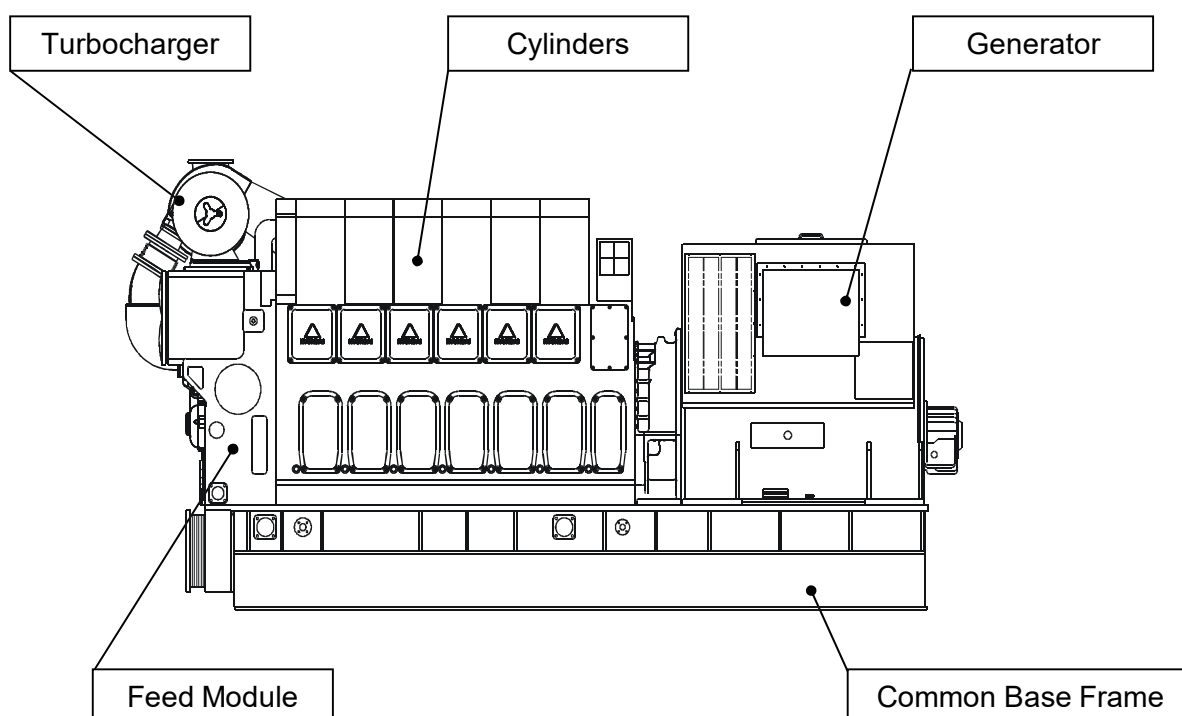
Type of Engine		4-stroke, vertical, direct injection, single acting and trunk piston type with turbocharger and inter-cooler			
Cylinder Configuration		In-line			
Number of Cylinder		5 - 6 - 7 - 8 - 9			
Rated Speed	rpm	720	750	900	1000
Power per Cylinder	kW	160	160	200	200
Cylinder Bore	mm	210			
Piston Stroke	mm	320			
Swept Volume per Cylinder	d m³	11.1			
Mean Piston Speed	m/s	7.7	8.0	9.6	10.7
Mean Effective Pressure	bar	24.1	23.1	24.1	21.7
Compression Ratio		17 : 1			
Direction of Engine Rotation		Clockwise viewed from Generator Side (Non-Reversible)			
Cylinder Firing Order	5H21/32S	1 - 2 - 4 - 5 - 3			
	6H21/32S	1 - 4 - 2 - 6 - 3 - 5			
	7H21/32S	1 - 2 - 4 - 6 - 7 - 5 - 3			
	8H21/32S	1 - 3 - 5 - 7 - 8 - 6 - 4 - 2			
	9H21/32S	1 - 3 - 5 - 7 - 9 - 8 - 6 - 4 - 2			



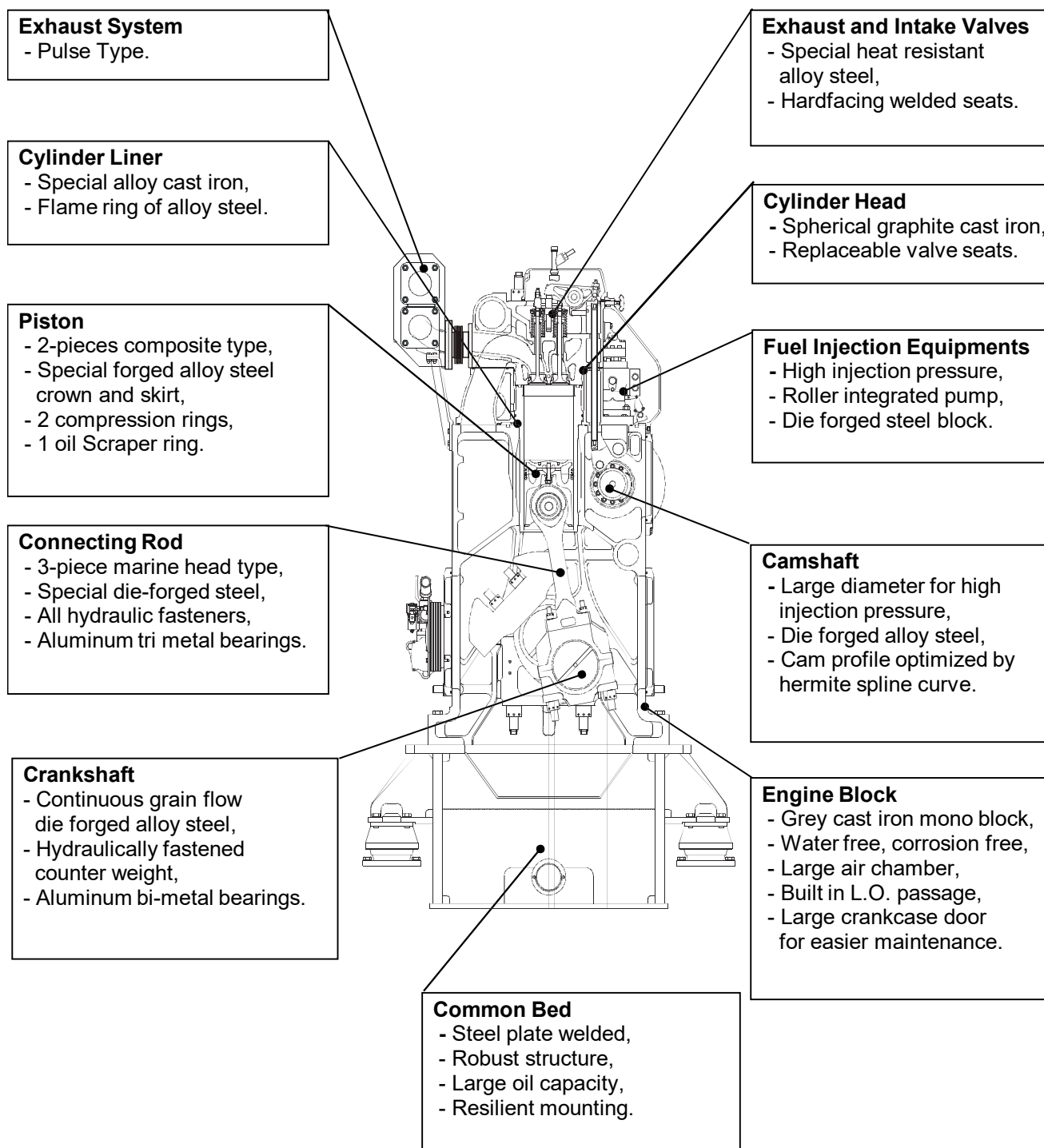
1. General

Hyundai's Marine Genset 'HiMSEN H21/32' Family have simple and smart design suitable for marine application with high reliability and performance. The key features are summarized as follows:

1. **Heavy Fuel Engine** with same fuel of main engine(Uni-Fuel concept).
Hence, the viscosity of the Diesel Fuel and Heavy Fuel is acceptable up to 700 cSt at 50 °C.
2. **Economical and Ecological Engine** with low fuel consumption, NOx emission and Smoke, etc. , which is based on the following specific designs;
 - High stroke to bore ratio,
 - High compression ratio,
 - Optimized supercharging with miller cycle,
 - High fuel injection pressure.
3. **Reliable and Practical Engine** with simple, smart and robust structure.
 - A number of engine components are minimized with pipe-free design
 - Most of the components are directly accessible for easy maintenance
 - Maintenance concept for each parts is to be provided
 - Feed system is fully modularized with direct accessibility
 - Highly integrated control system
 - Raven components are applied
 - Up-to-date technology is adopted



2. Design of Main Components



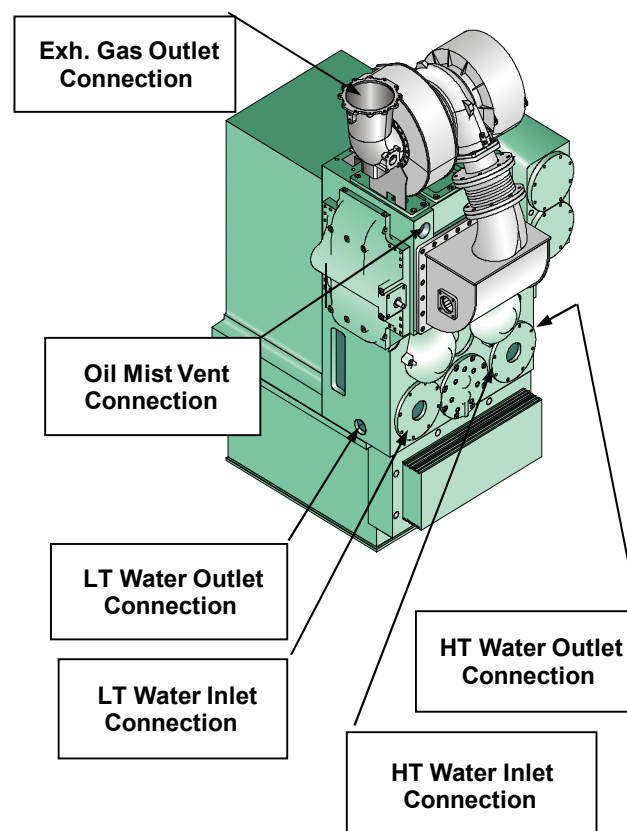
4. Description of Feed Module

HiMSEN has a unique design of Feed Module for better reliability and easier maintenance, that is, the feed system of the engine, such as cooling water and lubricating oil system, are fully modularized into the Feed Module with the following key features;

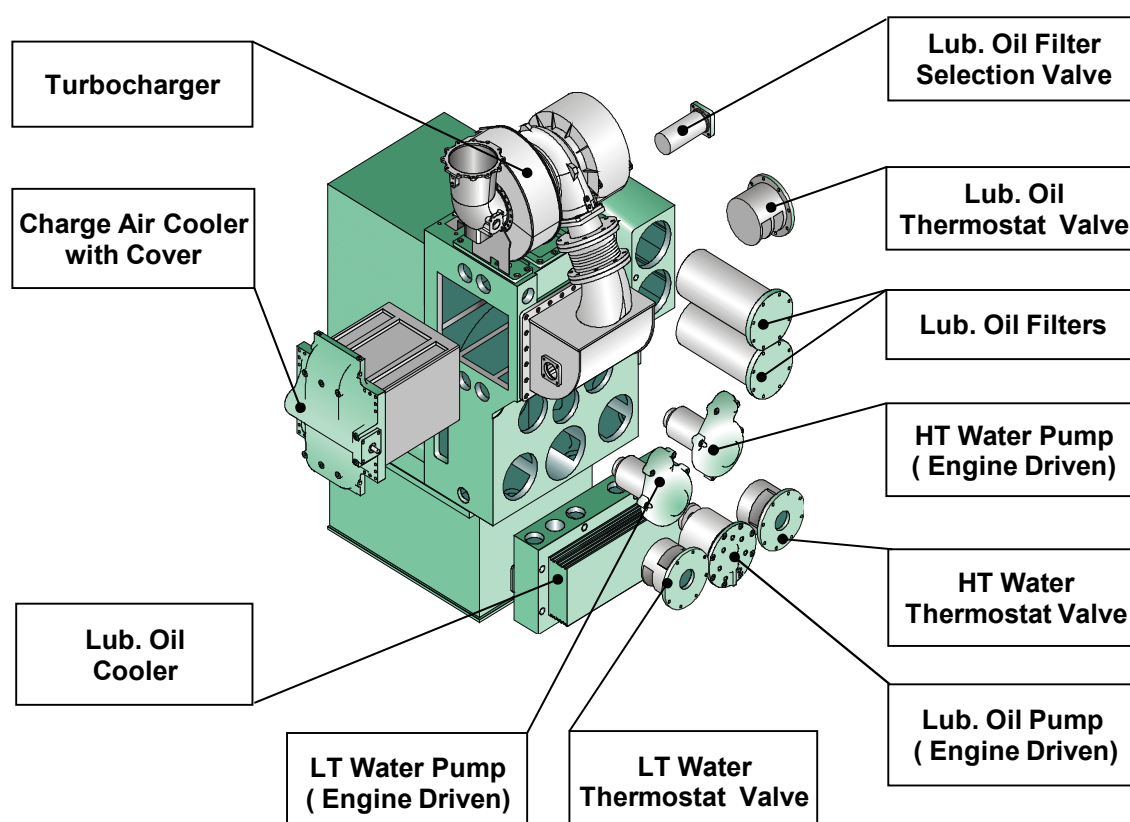
1. All the components of the system, for example, pumps, valves, filters and coolers are mounted on feed block without any pipe connection, which provides direct accessibility with fewer parts for easy maintenance as shown below.

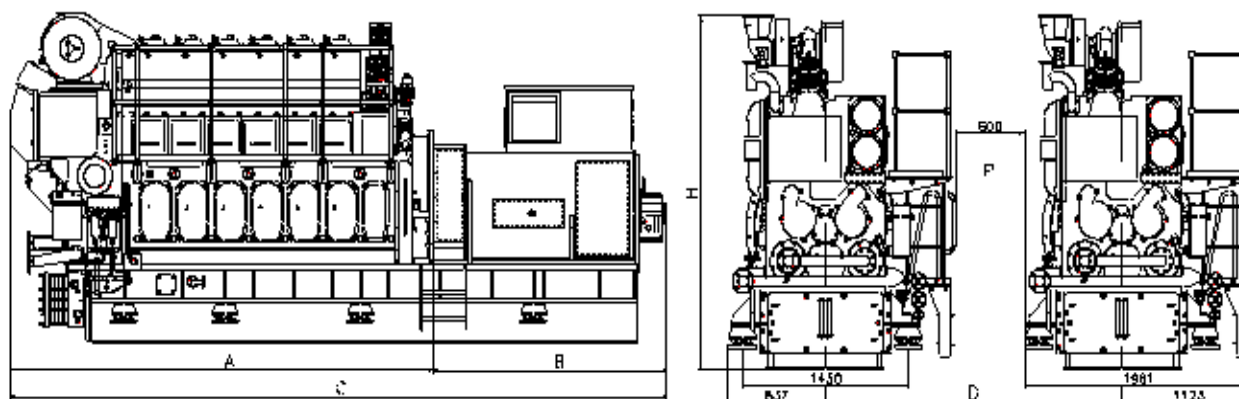
2. Feed Block has cast-in flow channels for Cooling Water and Lub Oil circuits, which are arranged to secure water-tight to oil space and simplified in combination with pumps and valve housings for better flow characteristics to avoid any risk of corrosion due to cavitation.

Outline of Feed Module



Components of Feed Module





Genset for 720/750 rpm

Engine type	Dimension (mm)					Dry Weight (ton) ²⁾	
	A	B ¹⁾	C ¹⁾	D	H	Engine ³⁾	Genset ^{1),4)}
5H21/32	3,405	1,926	5,331	2,613	2,712	14.0	22.4
6H21/32	3,781	2,093	5,874	2,613	2,712	15.6	23.5
7H21/32	4,111	1,923	6,034	2,613	2,781	17.1	26.5
8H21/32	4,453	2,175	6,628	2,613	2,781	18.5	29.1
9H21/32	4,783	2,265	7,048	2,613	2,911	19.9	31.7

Genset for 900/1000 rpm

Engine type	Dimension (mm)					Dry Weight (ton) ²⁾	
	A	B ¹⁾	C ¹⁾	D	H	Engine ³⁾	Genset ^{1),4)}
5H21/32	3,411	2,097	5,508	2,613	2,712	13.4	22.9
6H21/32	3,781	1,896	5,677	2,613	2,781	15.1	26.1
7H21/32	4,235	1,900	6,135	2,613	2,781	16.7	28.6
8H21/32	4,453	2,175	6,628	2,613	2,911	18.4	29.1
9H21/32	4,783	2,265	7,048	2,613	2,911	19.8	31.7

1) : Depending on alternator.

2) : Weight included a standard alternator (Maker : HHI-EES)

3) : Without Common base frame

4) : With Common base frame & Generator

D : Min. distance between engines

P : Free passage between the engines, width 600mm and height 2,000mm.

Note) All dimensions and weight are approximate value and subject to change without prior notice.

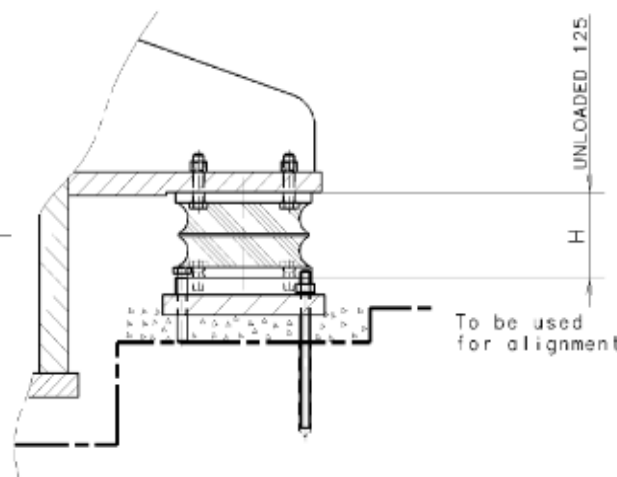
General

A HiMSEN Generating-set consists of Diesel engine and Generator mounted on Common Base Frame. The Common Base Frame is installed on resilient mounts on the steel structure of the concrete foundation.

Design of Resilient Mounting

A resilient mounting of the generating-set is made with a number of rubber elements to isolate vibrations between generator set and hull structure. These rubber elements are bolted to brackets of the Common Bed as shown on right figure.

The number and position of the rubber elements depend on the dynamic characteristics of the plant. Therefore, the final specification of the rubber elements shall be decided based on the information from the plant contractor case by case.



< Resilient mounting >

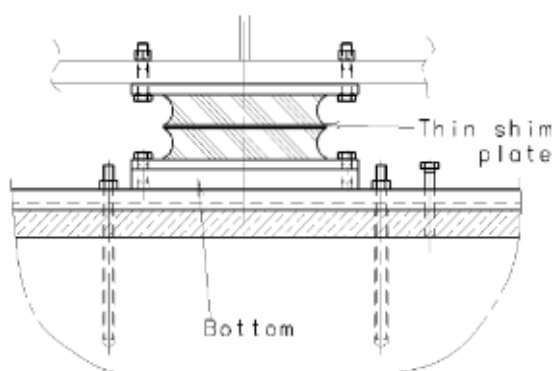
Connections to the Generating-set (for resilient mounting)

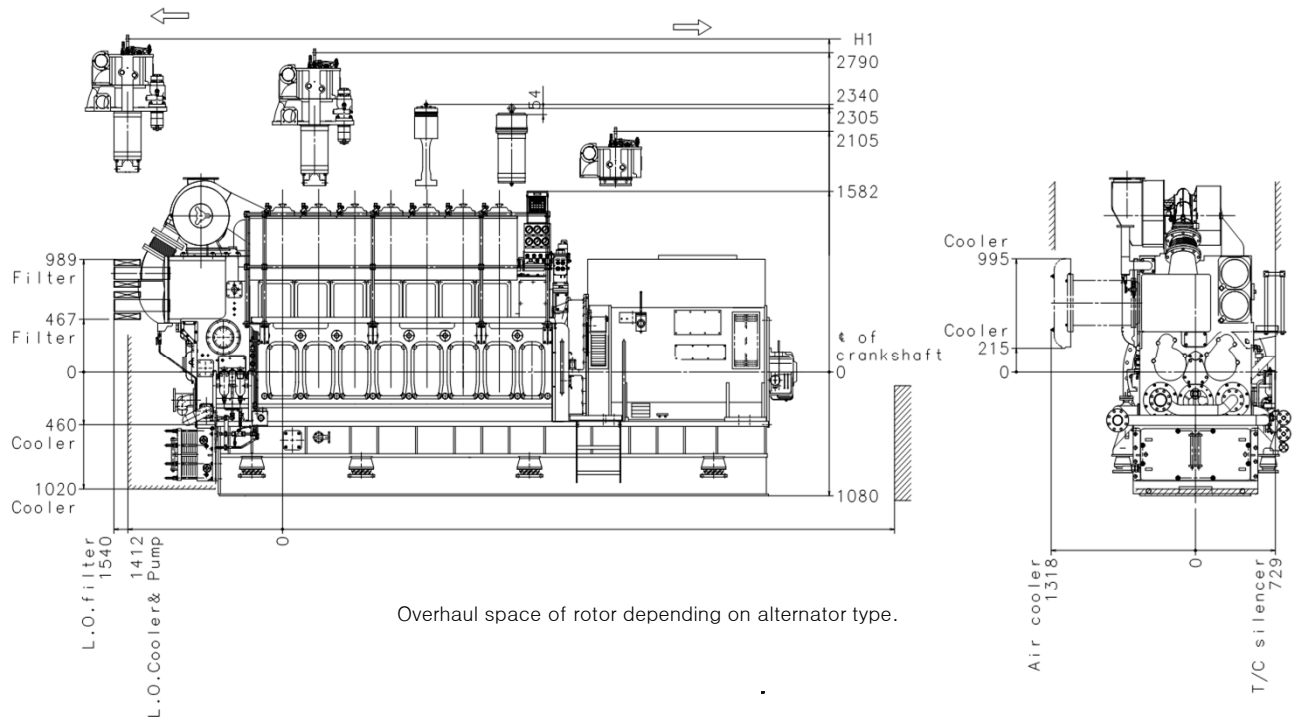
Generating-set mounted on the resilient mounts usually has some relative motions to the foundation structure(of concrete block). Any rigid fixing between generator set and foundation structure cause damages of generator set. Therefore, all connections, for example, pipes, gratings, ladders, electric wires, etc., should be flexible enough to absorb the relative movements.

Recommendations for Seating Design and Adjustment (for resilient mounting)

The foundation for Common Base Frame mounting should be rigid enough to support the load from Generator Set. The thin shim plate can be used between bottom of mounting and Top of filling piece are required to adjust leveling of each mount.as shown below.

It is also recommended to check the crankshaft deflection before starting up the plant to secure the correct adjustments of the shim plate and leveling of the generator set.





Remark) H1 is overhaul height of the cylinder unit passing through the turbocharger.

H1=2,790mm, for 5H21/32, 6H21/32-720rpm

H1=2,836mm, for 6H21/32-900rpm, 7H21/32, 8H21/32-720rpm

H1=2,949mm, for 8H21/32-900rpm, 9H21/32

General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

Engine Type	Rated Output at							
	720 rpm/60Hz		750 rpm/50Hz		900 rpm/60Hz		1000 rpm/50Hz	
	Engine (kW _m)	Generator (kW _e)	Engine (kW _m)	Generator (kW _e)	Engine (kW _m)	Generator (kW _e)	Engine (kW _m)	Generator (kW _e)
5H21/32S	800	752	800	752	-	-	-	-
6H21/32S	960	902	960	902	1,200	1,128	1,200	1,128
7H21/32S	1,120	1,064	1,120	1,064	1,400	1,323	1,400	1,323
8H21/32S	1,280	1,216	1,280	1,216	1,600	1,512	1,600	1,512
9H21/32S	1,440	1,368	1,440	1,368	1,800	1,710	1,800	1,710

Remark : 1) According to ISO 3046-1:2002, overload > 100%, it is allowed to use overload > 100% for governing purpose only such as transient load conditions and suddenly applied load.
The overload engine power shall not be used for the supply of electrical consumers.
2) The alternator outputs are calculated for an efficiency of 94~95% and a power factor of 0.8 lagging.

Reference Condition

General definition of diesel engine rating is specified in accordance with ISO 3046/1.
However, the engine outputs are available within tropical condition without derating.

ISO Conditions

Turbocharger air inlet pressure : 1,000 mbar
Turbocharger air inlet temperature : 298 K (25 °C)
Charge air coolant temperature : 298 K (25 °C)

Tropical Conditions

Turbocharger air inlet pressure : 1,000 mbar
Turbocharger air inlet temperature : 318 K (45 °C)
Charge air coolant temperature : 309 K (36 °C)

Performance Data	Engine Capacity Data	Sheet No. P.02.200	Page 1 / 4
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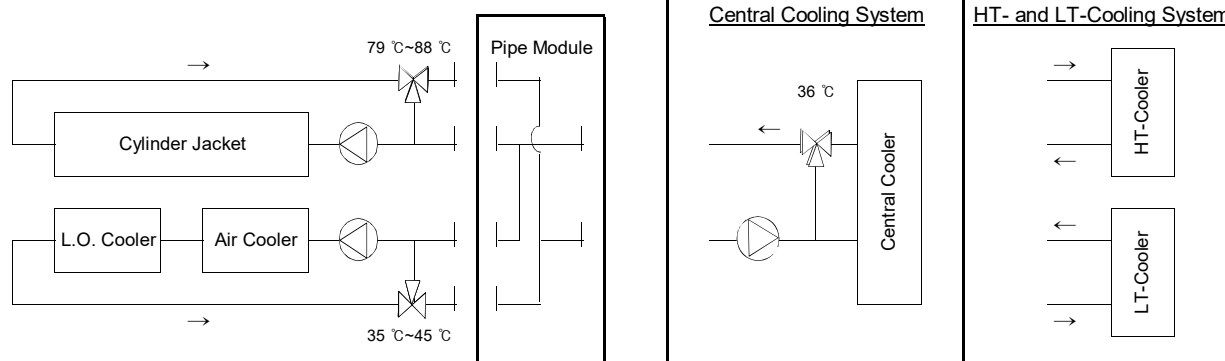
720 rpm/60 Hz (160 kW/cyl.)

Engine MCR	Cyl. kW	5 800	6 960	7 1120	8 1280	9 1440
COOLING CAPACITIES						
Charge Air						
Heat dissipation 1)	kW	319	383	447	511	574
LT-cooling water flow	m³/h	35	35	45	45	50
LT-cooling water temperature, cooler in / out	°C	36 / 44	36 / 45	36 / 45	36 / 46	36 / 46
Lubricating Oil						
Heat dissipation 1),3)	kW	135	162	189	215	242
LT-cooling water flow	m³/h	35	35	45	45	50
LT-cooling water temperature, cooler in / out	°C	44 / 47	45 / 49	45 / 48	46 / 50	46 / 50
Cylinder Jacket						
Heat dissipation 1)	kW	136	163	190	217	244
HT-cooling water flow	m³/h	35	35	45	45	50
HT-cooling water temperature, engine in / out	°C	79 / 82	78 / 82	78 / 82	78 / 82	78 / 82
GAS DATA 2)						
Combustion air consumption	kg/h	5760	6912	8064	9216	10368
Exhaust gas flow	kg/h	5909	7091	8272	9454	10636
Exhaust gas temperature	°C	280	280	280	280	280
Allowable exhaust gas back pressure max.	mbar	30	30	30	30	30
HEAT RADIATION						
Engine radiation 1)	kW	18	21	25	29	32
Alternator radiation	kW	(See separate data from alternator maker)				
STARTING AIR						
Air consumption per start(Incl. jet air) 6)	Nm³	1.90	2.00	2.10	2.20	2.30
Jet air consumption at sudden load up	Nm³	1.00	1.00	1.00	1.00	1.00
Starting air source, pressure max. / min.	bar	30 / 15	30 / 15	30 / 15	30 / 15	30 / 15
PUMP CAPACITIES						
Engine Driven Pumps 5)						
Lubricating oil pump (6 bar)	m³/h	41	51	51	65	65
HT-cooling water pump (1~2.5 bar)	m³/h	35	35	45	45	50
LT-cooling water pump (1~2.5 bar)	m³/h	35	35	45	45	50
External Pumps 4)						
MDO supply pump(head) (8 bar)	m³/h	0.59	0.71	0.82	0.94	1.06
HFO supply pump(head) (4 bar)	m³/h	0.29	0.35	0.41	0.47	0.53
HFO booster pump (8 bar at F.O inlet, F1 7))	m³/h	0.59	0.71	0.82	0.94	1.06

Remark :

- 1) under tropical condition with tolerance 10%
- 2) under ISO reference condition with flow tolerance +/-5% and exhaust gas temperature +/-25 °C
- 3) including additional heat for purification (30 kJ/kWh)
- 4) to be added flushing oil quantity of automatic filter

- 5) the flow capacity to be within a tolerance of 0% to +10%.
- 6) on condition of applying low pressure air starter.
- 7) HFO booster pump head to be designed by external system designer considering pressure loss of external system.
- 8) Engine performance data depends on LCV (Low Calorific Value) of used fuel oil respectively, which influences fuel rack index of fuel injection pump.

Cooling System Arrangement


Performance Data	Engine Capacity Data	Sheet No. P.02.200	Page 2 / 4
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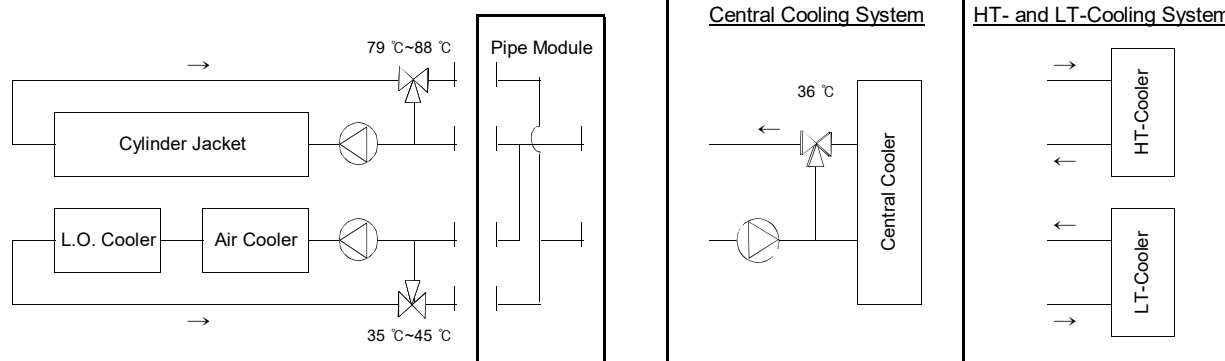
750 rpm/50 Hz (160 kW/cyl.)

Engine MCR		Cyl. kW	5 800	6 960	7 1120	8 1280	9 1440
COOLING CAPACITIES							
Charge Air							
Heat dissipation 1)		kW	319	383	447	511	574
LT-cooling water flow		m³/h	35	35	45	45	50
LT-cooling water temperature, cooler	in / out	°C	36 / 44	36 / 45	36 / 45	36 / 46	36 / 46
Lubricating Oil							
Heat dissipation 1),3)		kW	135	162	189	215	242
LT-cooling water flow		m³/h	35	35	45	45	50
LT-cooling water temperature, cooler	in / out	°C	44 / 47	45 / 49	45 / 48	46 / 50	46 / 50
Cylinder Jacket							
Heat dissipation 1)		kW	136	163	190	217	244
HT-cooling water flow		m³/h	35	35	45	45	50
HT-cooling water temperature, engine	in / out	°C	79 / 82	78 / 82	78 / 82	78 / 82	78 / 82
GAS DATA 2)							
Combustion air consumption		kg/h	5760	6912	8064	9216	10368
Exhaust gas flow		kg/h	5909	7091	8272	9454	10636
Exhaust gas temperature		°C	280	280	280	280	280
Allowable exhaust gas back pressure	max.	mbar	30	30	30	30	30
HEAT RADIATION							
Engine radiation 1)		kW	18	21	25	29	32
Alternator radiation		kW	(See separate data from alternator maker)				
STARTING AIR							
Air consumption per start(Incl. jet air) 6)		Nm³	1.90	2.00	2.10	2.20	2.30
Jet air consumption at sudden load up		Nm³	1.00	1.00	1.00	1.00	1.00
Starting air source, pressure	max. / min.	bar	30 / 15	30 / 15	30 / 15	30 / 15	30 / 15
PUMP CAPACITIES							
Engine Driven Pumps 5)							
Lubricating oil pump	(6 bar)	m³/h	43	53	53	68	68
HT-cooling water pump	(1~2.5 bar)	m³/h	35	35	45	45	50
LT-cooling water pump	(1~2.5 bar)	m³/h	35	35	45	45	50
External Pumps 4)							
MDO supply pump(head)	(8 bar)	m³/h	0.59	0.71	0.82	0.94	1.06
HFO supply pump(head)	(4 bar)	m³/h	0.29	0.35	0.41	0.47	0.53
HFO booster pump	(8 bar at F.O inlet, F.1 7))	m³/h	0.59	0.71	0.82	0.94	1.06

Remark :

- 1) under tropical condition with tolerance 10%
- 2) under ISO reference condition with flow tolerance +/-5% and exhaust gas temperature +/-25 °C
- 3) including additional heat for purification (30 kJ/kWh)
- 4) to be added flushing oil quantity of automatic filter

- 5) the flow capacity to be within a tolerance of 0% to +10%.
- 6) on condition of applying low pressure air starter.
- 7) HFO booster pump head to be designed by external system designer considering pressure loss of external system.
- 8) Engine performance data depends on LCV (Low Calorific Value) of used fuel oil respectively, which influences fuel rack index of fuel injection pump.

Cooling System Arrangement


Performance Data	Engine Capacity Data	Sheet No. P.02.200	Page 3 / 4
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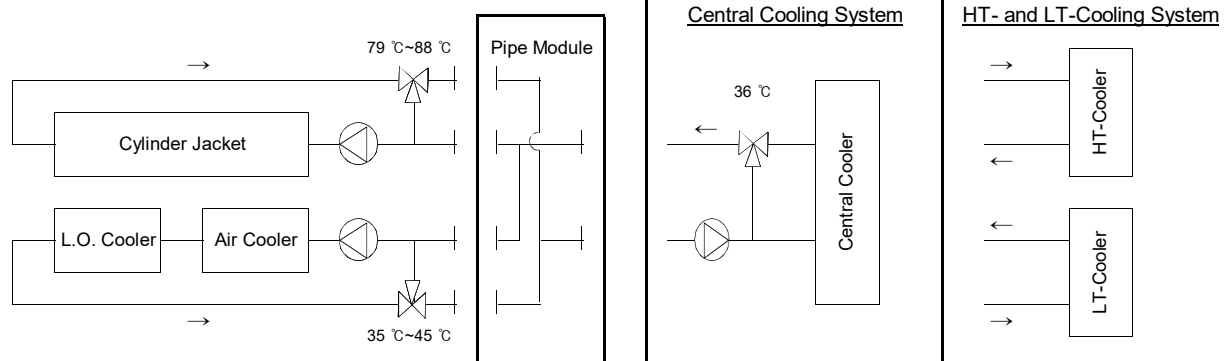
900 rpm/60 Hz (200 kW/cyl.)

Engine MCR	Cyl. kW	6 1200	7 1400	8 1600	9 1800
COOLING CAPACITIES					
Charge Air					
Heat dissipation 1)	kW	479	559	638	718
LT-cooling water flow	m³/h	35	45	45	50
LT-cooling water temperature, cooler in / out	°C	36 / 48	36 / 47	36 / 48	36 / 48
Lubricating Oil					
Heat dissipation 1),3)	kW	203	237	271	305
LT-cooling water flow	m³/h	35	45	45	50
LT-cooling water temperature, cooler in / out	°C	45 / 53	47 / 51	48 / 53	48 / 54
Cylinder Jacket					
Heat dissipation 1)	kW	204	239	273	307
HT-cooling water flow	m³/h	35	45	45	50
HT-cooling water temperature, engine in / out	°C	77 / 82	77 / 82	77 / 82	77 / 82
GAS DATA 2)					
Combustion air consumption	kg/h	8640	10080	11520	12960
Exhaust gas flow	kg/h	8864	10342	11819	13297
Exhaust gas temperature	°C	280	280	280	280
Allowable exhaust gas back pressure max.	mbar	30	30	30	30
HEAT RADIATION					
Engine radiation 1)	kW	27	31	36	40
Alternator radiation	kW	(See separate data from alternator maker)			
STARTING AIR					
Air consumption per start(Incl. jet air) 6)	Nm³	2.00	2.10	2.20	2.30
Jet air consumption at sudden load up	Nm³	1.00	1.00	1.00	1.00
Starting air source, pressure max. / min.	bar	30 / 15	30 / 15	30 / 15	30 / 15
PUMP CAPACITIES					
Engine Driven Pumps 6)					
Lubricating oil pump (6 bar)	m³/h	51	51	65	65
HT-cooling water pump (1~2.5 bar)	m³/h	35	45	45	50
LT-cooling water pump (1~2.5 bar)	m³/h	35	45	45	50
External Pumps 4)					
MDO supply pump(head) (8 bar)	m³/h	0.89	1.04	1.18	1.33
HFO supply pump(head) (4 bar)	m³/h	0.44	0.52	0.59	0.67
HFO booster pump (8 bar at F.O inlet, F1 7))	m³/h	0.89	1.04	1.18	1.33

Remark :

- 1) under tropical condition with tolerance 10%
- 2) under ISO reference condition with flow tolerance +/-5% and exhaust gas temperature +/-25 °C
- 3) including additional heat for purification (30 kJ/kWh)
- 4) to be added flushing oil quantity of automatic filter

- 5) the flow capacity to be within a tolerance of 0% to +10%.
- 6) on condition of applying low pressure air starter.
- 7) HFO booster pump head to be designed by external system designer considering pressure loss of external system.
- 8) Engine performance data depends on LCV (Low Calorific Value) of used fuel oil respectively, which influences fuel rack index of fuel injection pump.

Cooling System Arrangement


1000 rpm/50 Hz (200 kW/cyl.)

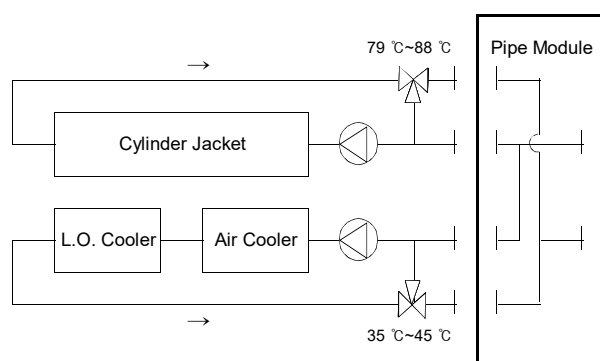
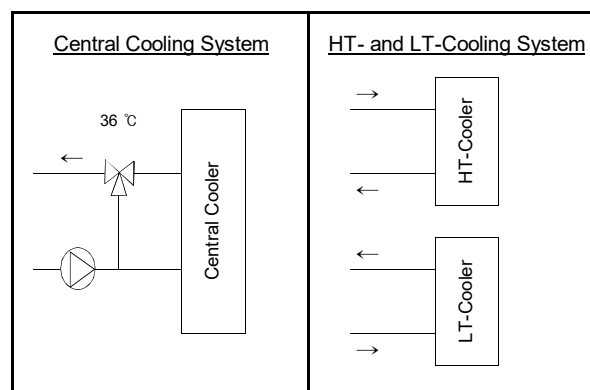
Engine MCR		Cyl. kW	6 1200	7 1400	8 1600	9 1800
COOLING CAPACITIES						
Charge Air						
Heat dissipation 1)		kW	479	559	638	718
LT-cooling water flow		m³/h	35	45	45	50
LT-cooling water temperature, cooler	in / out	°C	36 / 48	36 / 47	36 / 48	36 / 48
Lubricating Oil						
Heat dissipation 1),3)		kW	205	239	274	308
LT-cooling water flow		m³/h	35	45	45	50
LT-cooling water temperature, cooler	in / out	°C	48 / 53	47 / 51	48 / 53	48 / 54
Cylinder Jacket						
Heat dissipation 1)		kW	207	241	275	310
HT-cooling water flow		m³/h	35	45	45	50
HT-cooling water temperature, engine	in / out	°C	77 / 82	77 / 82	77 / 82	77 / 82
GAS DATA 2)						
Combustion air consumption		kg/h	8640	10080	11520	12960
Exhaust gas flow		kg/h	8864	10342	11819	13297
Exhaust gas temperature		°C	290	290	290	290
Allowable exhaust gas back pressure	max.	mbar	30	30	30	30
HEAT RADIATION						
Engine radiation 1)		kW	27	32	36	41
Alternator radiation		kW	(See separate data from alternator maker)			
STARTING AIR						
Air consumption per start(Incl. jet air) 6)		Nm³	2.00	2.10	2.20	2.30
Jet air consumption at sudden load up		Nm³	1.00	1.00	1.00	1.00
Starting air source, pressure	max. / min.	bar	30 / 15	30 / 15	30 / 15	30 / 15
PUMP CAPACITIES						
Engine Driven Pumps 6)						
Lubricating oil pump	(6 bar)	m³/h	51	51	65	65
HT-cooling water pump	(1~2.5 bar)	m³/h	35	45	45	50
LT-cooling water pump	(1~2.5 bar)	m³/h	35	45	45	50
External Pumps 4)						
MDO supply pump(head)	(8 bar)	m³/h	0.90	1.05	1.20	1.35
HFO supply pump(head)	(4 bar)	m³/h	0.45	0.52	0.60	0.67
HFO booster pump	(8 bar at F.O inlet, F.1 7))	m³/h	0.90	1.05	1.20	1.35

Remark :

- 1) under tropical condition with tolerance 10%
- 2) under ISO reference condition with flow tolerance $\pm 5\%$ and exhaust gas temperature $\pm 25^\circ\text{C}$
- 3) including additional heat for purification (30 kJ/kWh)
- 4) to be added flushing oil quantity of automatic filter

- 5) the flow capacity to be within a tolerance of 0% to +10%.
- 6) on condition of applying low pressure air starter.
- 7) HFO booster pump head to be designed by external system designer considering pressure loss of external system.
- 8) Engine performance data depends on LCV (Low Calorific Value) of used fuel oil respectively, which influences fuel rack index of fuel injection pump.

Cooling System Arrangement



Engine Performance Data

Normal rating (Tier-II & Tier-III with SCR) Rated Power : 160 kW/cyl. at 720 rpm

Performance Data		Engine Load (%)					
		110	100	85	75	50	25
CYLINDER DATA							
Cylinder Output	kW	176	160	136	120	80	40
Mean Effective Pressure	bar	26.5	24.1	20.5	18.1	12.1	6.1
COMBUSTION AIR DATA ¹⁾							
Mass Flow	kg/kWh	6.1	6.3	6.5	6.8	7.1	8.6
Air Temperature after Cooler	°C	45	45	45	45	45	45
EXHAUST GAS DATA ¹⁾							
Mass Flow	kg/kWh	6.3	6.5	6.7	7.0	7.3	8.8
Gas Temperature after Turbine	°C	319	309	305	303	324	334
HEAT BALANCE DATA ²⁾							
Charge Air	kJ/kWh	1447	1366	1189	1080	811	505
Lubricating Oil	kJ/kWh	616	606	606	693	891	1249
Jacket Cooling Water	kJ/kWh	606	610	613	628	786	1399
Radiation	kJ/kWh	89	80	84	101	134	337
FUEL OIL CONSUMPTION ³⁾							
Specific Fuel Oil Consumption	g/kWh	183	182	182	184	197	226

Remarks

Reference condition based on ISO 3046-1:2002 (turbocharger inlet air pressure 1 bar, intake air temperature 25°C, LT-cooling water temperature 25°C) except heat balance data. For heat balance data, please see Remark 2)

The above values are based on IMO Tier 2 emission level without SCR operation.

- 1) Mass flow rate tolerance $\pm 5\%$, Temperature Tolerance $\pm 25^\circ\text{C}$ ($50\% < \text{Load} \leq 110\%$)

Mass flow rate tolerance $\pm 10\%$, Temperature Tolerance $\pm 35^\circ\text{C}$ ($\text{Load} \leq 50\%$)

- For heat recovery, additional temperature tolerance -10°C should be accounted.

- When calculating heat dissipation for heat recovery based on the mass flow & temperature, the mass flow & temperature's tolerances should be considered.

These data are indicative values. For each project, please contact to HHI-EMD.

- 2) Reference condition based on tropical condition (turbocharger inlet air pressure 1 bar, intake air temperature 45°C ,

LT-cooling water temperature 36°C)

Heat dissipation tolerance $+10\%$ for coolers, -15% for heat recovery.

Additional heat for lube oil purification should be included (30 kJ/kWh)

- 3) Engine driven pumps Detached : Lube oil pump, HT-pump, LT-pump

SFOC tolerance $+5\%$ at 100% load.

SFOC excludes clean leakage fuel oil.

Fuel oil based on MDO, LCV 42,700 kJ/kg

Warranted SFOC at 100% load at non-SCR operation condition only.

Note) The values are only for reference, it would be changed for each project. For each project, please contact to HHI-EMD.

Note) In case of performance data for 5H21/32, please see the 5H21's Engine Performance Sheet

Performance Data	Engine Performance - 750 rpm	Sheet No. P.02.310	Page 1 / 1
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Engine Performance Data

Normal rating (Tier-II & Tier-III with SCR) Rated Power : 160 kW/cyl. at 750 rpm

Performance Data		Engine Load (%)					
		110	100	85	75	50	25
CYLINDER DATA							
Cylinder Output	kW	176	160	136	120	80	40
Mean Effective Pressure	bar	25.4	23.1	20.8	19.6	11.5	5.8
COMBUSTION AIR DATA ¹⁾							
Mass Flow	kg/kWh	6.6	6.7	6.7	6.8	7.2	8.5
Air Temperature after Cooler	°C	45	45	45	45	45	45
EXHAUST GAS DATA ¹⁾							
Mass Flow	kg/kWh	6.8	6.9	6.9	7.0	7.4	8.7
Gas Temperature after Turbine	°C	315	320	320	330	350	370
HEAT BALANCE DATA ²⁾							
Charge Air	kJ/kWh	1498	1417	1232	1122	860	538
Lubricating Oil	kJ/kWh	617	606	606	693	891	1249
Jacket Cooling Water	kJ/kWh	606	610	613	628	786	1399
Radiation	kJ/kWh	89	80	84	101	134	337
FUEL OIL CONSUMPTION ³⁾							
Specific Fuel Oil Consumption	g/kWh	183	182	182	184	197	226

Remarks

Reference condition based on ISO 3046-1:2002 (turbocharger inlet air pressure 1 bar, intake air temperature 25°C, LT-cooling water temperature 25°C) except heat balance data. For heat balance data, please see Remark 2)

The above values are based on IMO Tier 2 emission level without SCR operation.

1) Mass flow rate tolerance $\pm 5\%$, Temperature Tolerance $\pm 25^\circ\text{C}$ ($50\% < \text{Load} \leq 110\%$)

Mass flow rate tolerance $\pm 10\%$, Temperature Tolerance $\pm 35^\circ\text{C}$ ($\text{Load} \leq 50\%$)

- For heat recovery, additional temperature tolerance -10°C should be accounted.

- When calculating heat dissipation for heat recovery based on the mass flow & temperature, the mass flow & temperature's tolerances should be considered.

These data are indicative values. For each project, please contact to HHI-EMD.

2) Reference condition based on tropical condition (turbocharger inlet air pressure 1 bar, intake air temperature 45°C ,

LT-cooling water temperature 36°C)

Heat dissipation tolerance $+10\%$ for coolers, -15% for heat recovery.

Additional heat for lube oil purification should be included (30 kJ/kWh)

3) Engine driven pumps Detached : Lube oil pump, HT-pump, LT-pump

SFOC tolerance $+5\%$ at 100% load.

SFOC excludes clean leakage fuel oil.

Fuel oil based on MDO, LCV 42,700 kJ/kg

Warranted SFOC at 100% load at non-SCR operation condition only.

Note) The values are only for reference, it would be changed for each project. For each project, please contact to HHI-EMD.

Note) In case of performance data for 5H21/32, contact to HHI-EMD separately.

Performance Data	Engine Performance- 900 rpm	Sheet No. P.02.320	Page 1 / 1
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Engine Performance Data

Normal rating (Tier-II & Tier-III with SCR) Rated Power : 200 kW/cyl. at 900 rpm

Performance Data - 900 rpm		Engine Load (%)					
		110	100	85	75	50	25
CYLINDER DATA							
Cylinder Output	kW	220	200	180	150	100	50
Mean Effective Pressure	bar	26.5	24.1	20.5	18.0	12.0	6.0
COMBUSTION AIR DATA ¹⁾							
Mass Flow	kg/kWh	6.1	6.2	6.4	6.6	7.0	8.6
Air Temperature after Cooler	°C	45	45	45	45	45	45
EXHAUST GAS DATA ¹⁾							
Mass Flow	kg/kWh	6.3	6.4	6.6	6.8	7.2	8.8
Gas Temperature after Turbine	°C	318	315	316	321	344	348
HEAT BALANCE DATA ²⁾							
Charge Air	kJ/kWh	1380	1295	1082	964	685	437
Lubricating Oil	kJ/kWh	620	609	609	697	882	1260
Jacket Cooling Water	kJ/kWh	609	613	616	631	778	1411
Radiation	kJ/kWh	89	81	85	102	133	340
FUEL OIL CONSUMPTION ³⁾							
Specific Fuel Oil Consumption	g/kWh	184	183	183	185	195	228

Remarks

Reference condition based on ISO 3046-1:2002 (ambient air pressure 1 bar, intake air temperature 25°C, LT-cooling water temperature 25°C) except heat balance data. For heat balance data, please see Remark 2)

The above values are based on IMO Tier 2 emission level without SCR operation.

1) Mass flow rate tolerance $\pm 5\%$, Temperature Tolerance $\pm 25^\circ\text{C}$ ($50\% < \text{Load} \leq 110\%$)

Mass flow rate tolerance $\pm 10\%$, Temperature Tolerance $\pm 35^\circ\text{C}$ ($\text{Load} \leq 50\%$)

- For heat recovery, additional temperature tolerance -10°C should be accounted.

- When calculating heat dissipation for heat recovery based on the mass flow & temperature, the mass flow & temperature's tolerances should be considered.

These data are indicative values. For each project, please contact to HHI-EMD.

2) Reference condition based on tropical condition (ambient air pressure 1 bar, intake air temperature 45°C , LT-cooling water temperature 36°C)

Heat dissipation tolerance $+10\%$ for coolers, -15% for heat recovery.

Additional heat for lube oil purification should be included (30 kJ/kWh)

3) Engine driven pumps Detached : Lube oil pump, HT-pump, LT-pump

SFOC tolerance $+5\%$ at 100% load.

SFOC excludes clean leakage fuel oil.

Fuel oil based on MDO, LCV 42,700 kJ/kg

Warranted SFOC at 100% load at non-SCR operation condition only.

Note) The values are only for reference, it would be changed for each project. For each project, please contact to HHI-EMD.

Note) In case of performance data for 5H21/32, please see the 5H21's Engine Performance Sheet

Performance Data	Engine Performance - 1000 rpm	Sheet No. P.02.330	Page 1 / 1
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Engine Performance Data

Normal rating (Tier-II & Tier-III with SCR) Rated Power : 200 kW/cyl. at 1000 rpm

Performance Data - 900 rpm		Engine Load (%)					
		110	100	85	75	50	25
CYLINDER DATA							
Cylinder Output	kW	220	200	170	150	100	50
Mean Effective Pressure	bar	23.8	21.7	18.4	16.2	10.8	5.4
COMBUSTION AIR DATA ¹⁾							
Mass Flow	kg/kWh	6.6	6.7	6.8	7.1	8.8	7.8
Air Temperature after Cooler	°C	45	45	45	45	45	45
EXHAUST GAS DATA ¹⁾							
Mass Flow	kg/kWh	6.8	6.9	7.0	7.3	9.0	8.0
Gas Temperature after Turbine	°C	315	320	320	330	350	370
HEAT BALANCE DATA ²⁾							
Charge Air	kJ/kWh	1420	1355	1170	1050	765	511
Lubricating Oil	kJ/kWh	627	616	616	704	891	1270
Jacket Cooling Water	kJ/kWh	615	620	622	638	786	1423
Radiation	kJ/kWh	90	82	86	103	134	342
FUEL OIL CONSUMPTION ³⁾							
Specific Fuel Oil Consumption	g/kWh	186	185	185	187	197	230

Remarks

Reference condition based on ISO 3046-1:2002 (ambient air pressure 1 bar, intake air temperature 25°C, LT-cooling water temperature 25°C) except heat balance data. For heat balance data, please see Remark 2)

The above values are based on IMO Tier 2 emission level without SCR operation.

- 1) Mass flow rate tolerance $\pm 5\%$, Temperature Tolerance $\pm 25^\circ\text{C}$ ($50\% < \text{Load} \leq 110\%$)

Mass flow rate tolerance $\pm 10\%$, Temperature Tolerance $\pm 35^\circ\text{C}$ ($\text{Load} \leq 50\%$)

- For heat recovery, additional temperature tolerance -10°C should be accounted.

- When calculating heat dissipation for heat recovery based on the mass flow & temperature, the mass flow & temperature's tolerances should be considered.

These data are indicative values. For each project, please contact to HHI-EMD.

- 2) Reference condition based on tropical condition (ambient air pressure 1 bar, intake air temperature 45°C , LT-cooling water temperature 36°C)

Heat dissipation tolerance $+10\%$ for coolers, -15% for heat recovery.

Additional heat for lube oil purification should be included (30 kJ/kWh)

- 3) Engine driven pumps Detached : Lube oil pump, HT-pump, LT-pump

SFOC tolerance $+5\%$ at 100% load.

SFOC excludes clean leakage fuel oil.

Fuel oil based on MDO, LCV 42,700 kJ/kg

Warranted SFOC at 100% load at non-SCR operation condition only.

Note) The values are only for reference, it would be changed for each project. For each project, please contact to HHI-EMD.

General

HiMSEN H21/32 is designed for environment-friendly engine and satisfies IMO NO_x emission limit with low fuel consumption and nearly smokeless operation even at idle load.

Typical exhaust compositions in volume ratio at full load are as follows:

Nitrogen N ₂	approx. 75%
Oxygen O ₂	approx. 13%
Carbon Dioxide CO ₂	approx. 5%
Water (Vapour) H ₂ O	approx. 6%
Argon Ar	approx. 1%
Soot, Ash, NO _x , CO, HC, etc residue	

Residue is little in amount but ecologically critical. Therefore, a careful attention is required for the treatment of fuel oil and engine operating conditions.

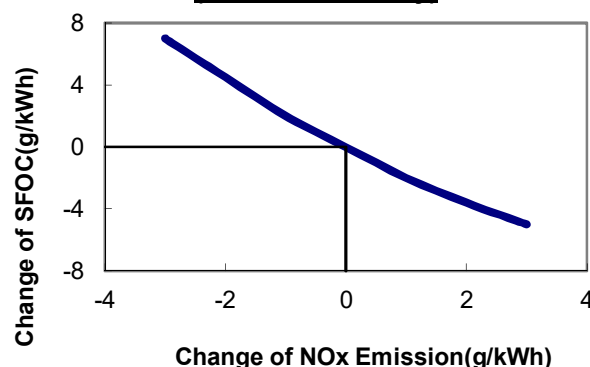
If there is no special requirements from customer regarding the exhaust gas emission, HiMSEN Genset shall be delivered with optimized performance conditions fulfilling the IMO limit value of NO_x emission.

Therefore, it is strongly requested to contact the engine maker if there is any further requirements regarding exhaust gas emission or special operating conditions.

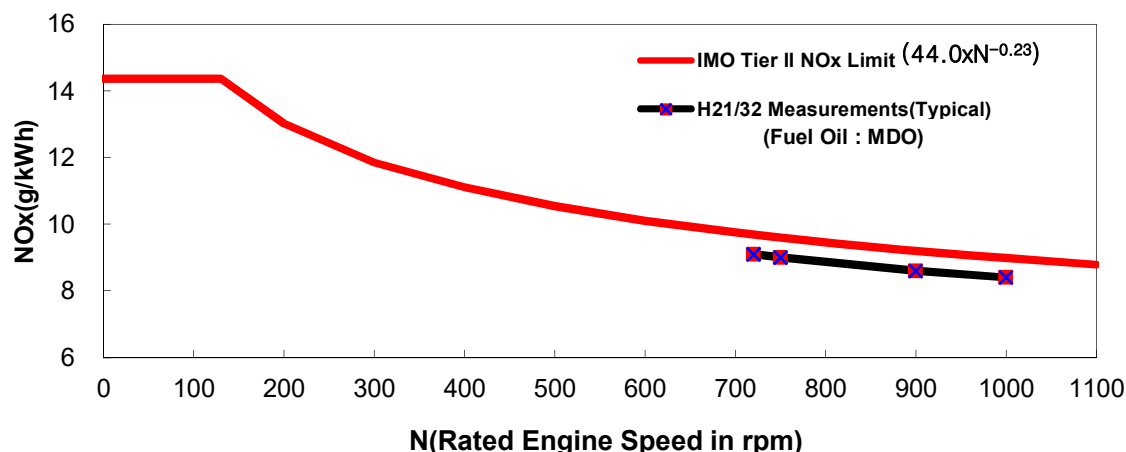
NO_x Emission

The amount of NO_x Emission depends on the engine operating condition, typically high combustion temperature and specific fuel oil consumption. A new engine shall be optimized to meet the customer's specific requirements. However, an engine in service also can be optimized further regarding NO_x emission, if needed. In this case, trade off with SFOC might be considered as follows:

**Trade off of NO_x-SFOC
(for reference only)**



Measurements of NO_x Emission



NO_x Emission from Marine Generator Engine Test Cycle D2
in accordance with ISO 8718-4 and IMO NO_x Technical Code

Performance Data	Correction of Fuel Consumption	Sheet No. P.02.500	Page 1 / 2
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Correction for ambient condition

Specific Fuel Oil Consumption(SFOC) is referred to the ISO 3046/1 reference condition normally.

However, for the condition other than ISO 3046-1:2002 reference condition, the SFOC at MCR can be estimated according to the below mentioned formula.

$$\text{SFOC}_{\text{amb}} = \text{SFOC}_{\text{ISO}} * \text{dSFOC}$$

$$\text{dSFOC} = [100 + (\text{T}_{\text{intake}} - 25) * 0.05 - (\text{P}_{\text{amb}} - 1000) * 0.007 + (\text{T}_{\text{cw}} - 25) * 0.07] / 100 * (42700 / \text{LCV})$$

SFOC_{amb} : Specific Fuel Oil Consumption at actual operating condition [g/kWh]

SFOC_{ISO} : Specific Fuel Oil Consumption at ISO 3046/1 reference condition [g/kWh]

dSFOC : Deviation of the SFOC

T_{intake} : Intake air temperature at actual operating condition [°C]

P_{amb} : Ambient air pressure at actual operating condition [mbar]

T_{cw} : Cooling water temperature before Charge Air Cooler(CAC) at actual operating condition [°C]

LCV : Lower Calorific Value of the fuel oil [kJ/kg]

Example,

Intake air temperature(T_{intake}) : 30 [°C]

P_{amb} : 1000 [mbar]

Cooling water temperature(T_{cw}) : 30 [°C]

Lower Calorific Value(LCV) : 42700 [kJ/kg]

SFOC_{ISO} : 183 [g/kWh] at 720[rpm], MCR

then, dSFOC = 1.006 and the SFOC at site condtion will be increased to 184.1[g/kWh].

Clean leak fuel oil

Clean leak fuel oil (recycling fuel oil) during engine operation is subtracted from measured fuel oil consumpti (Refer to P.05.100 Internal fuel oil system)

$$\text{FOC}_{\text{amb}} = \text{FOC} - \text{clean leak fuel oil} *$$

*) The FOC and clean leak fuel oil (kg/h) are measured over minimum 10 mins.

Performance Data	Correction of Fuel Consumption	Sheet No. P.02.500	Page 2 / 2
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Correction of additional fuel consumption

If additional devices are attached on the engine or operation fuel is changed, the SFOC for MCR will be increased approximately as follows:

Item	Additional SFOC [g/kWh]
Lub. Oil pump	+ 2
L.T Cooling water pump.	+ 1
H.T. Cooling water pump	+ 1
F.O. Feed pump	Please discuss with HHI-EMD
Charge air pressure control device	Please discuss with HHI-EMD
Operation with MGO	+ 2
500mmWC > Exhaust gas back pressure after turbine > 300 mmWC	+ 0.5 / 100 mmWC

LT & HT Pump attached engine(Genset & Propulsion)

Additional SFOC by water pump =

Additional SFOC at 100% load * (100/Load)^x * (actual rpm/nominal rpm)³ [g/kWh]

LO Pump attached engine(Genset & Propulsion)

Additional SFOC by LO pump =

Additional SFOC at 100% load * (100/Load)^x * (actual rpm/nominal rpm) [g/kWh]

Load	100 ~ 25%	Under 25%
x	1.15	1.28

1. General

Correction for ambient condition

Exhaust gas temperature after turbine is referred to ISO 3046/1 standard condition normally.

However, for the condition other than ISO 3046/1 standard condition, the exhaust gas temperature after turbine could be estimated according to the below mentioned formula :

$$T_{\text{exh.amb}} = T_{\text{exh.ISO}} + dT_{\text{exh}}$$

$$dT_{\text{exh}} = (T_{\text{intake}} - 25) \times 1.5 + (T_{\text{cw}} - 25) \times 0.7$$

$T_{\text{exh.amb}}$: Exhaust gas temperature after turbine at actual operating condition [°C]

$T_{\text{exh.ISO}}$: Exhaust gas temperature after turbine at ISO 3046/1 standard condition [°C]

dT_{exh} : Deviation of the exhaust gas temperature after turbine [°C]

T_{intake} : Intake air temperature at actual operating condition [°C]

T_{cw} : Cooling water temperature before charge air cooler(CAC) at actual operating condition [°C]

Example,

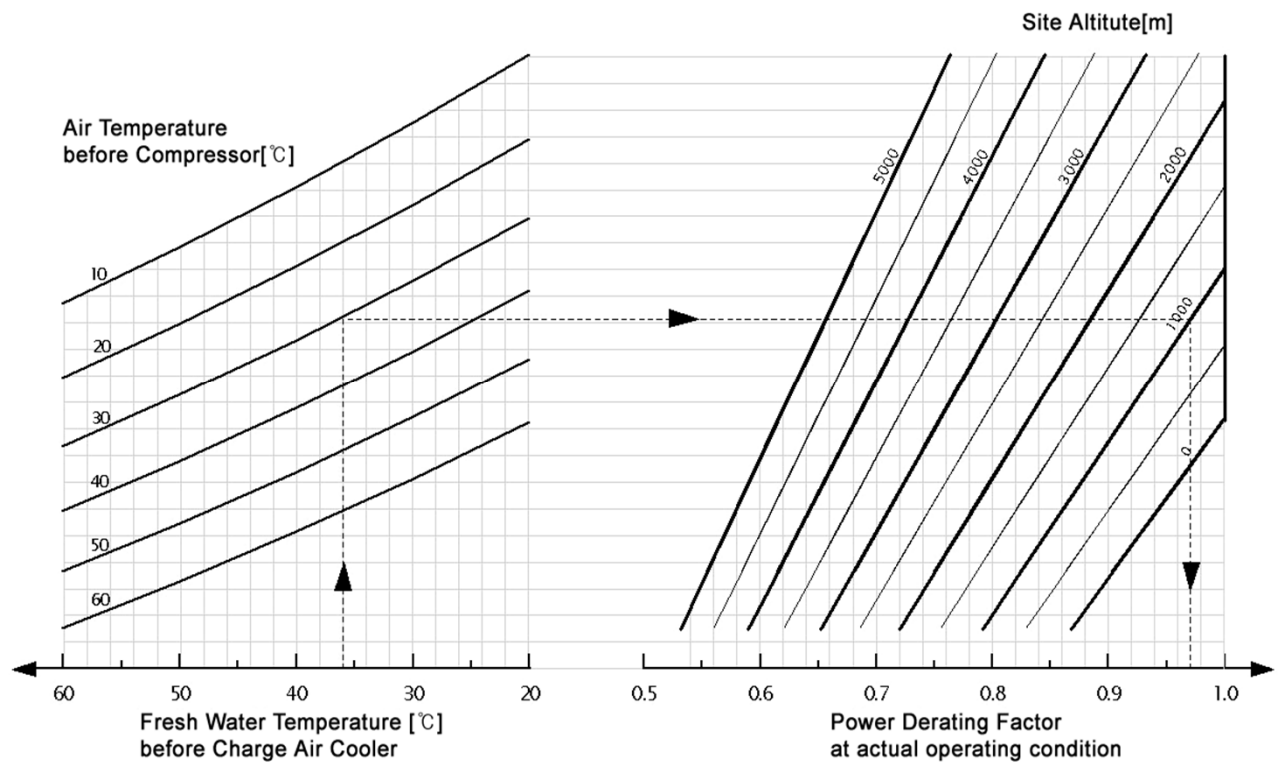
Intake air temperature(T_{intake}) : 35 [°C]

Cooling water temperature(T_{cw}) : 35 [°C]

$T_{\text{exh.ISO}}$: 290 [°C] at 720 [rpm], MCR

then, $dT_{\text{exg}} = 22$ [°C] and the $T_{\text{exh.amb}}$ at actual operating condition will be increased to 312 [°C].

Engine output power at MCR shall be reduced depending on the intake air temperature, cooling water temperature and site altitude.



Example

Cooling water temperature before charge air cooler : 36[°C]

Intake air temperature : 30[°C]

Site altitude : 1000[m]

From the power derating diagram, the power derating factor at actual operating condition is 0.97. Therefore the engine output power at actual operating condition should be derated to the 97% of the standard engine power.

General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

Engine Type	Speed	External Forces and Moments				Guide Force Moments		
		Order		Moment		Order		Moment
				Horizontal	Vertical			
	rpm	No.	Hz	kNm	kNm	No.	Hz	kNm
5H21/32	720	1	12.0	0.0	6.0	2.5	30.0	26.3
		2	24.0	0.0	16.8	5	60.0	9.7
	750	1	12.5	0.0	6.5	2.5	31.3	26.3
		2	25.0	0.0	18.2	5	62.5	9.7
	900	1	15.0	0.0	10.6	2.5	37.5	25.9
		2	30.0	0.0	29.7	5	75.0	9.6
	1000	1	16.7	0.0	13.1	2.5	41.7	25.9
		2	33.3	0.0	36.6	5	83.3	9.6
6H21/32	720	1	12.0	0.0	0.0	3	36.0	19.7
		2	24.0	0.0	0.0	6	72.0	7.2
	750	1	12.5	0.0	0.0	3	37.5	19.1
		2	25.0	0.0	0.0	6	75.0	7.2
	900	1	15.0	0.0	0.0	3	45.0	13.9
		2	30.0	0.0	0.0	6	90.0	6.4
	1000	1	16.7	0.0	0.0	3	50.0	11.4
		2	33.3	0.0	0.0	6	100.0	6.4
7H21/32	720	1	12.0	0.0	3.6	3.5	42.0	26.1
		2	24.0	0.0	3.4	7	84.0	4.7
	750	1	12.5	0.0	3.9	3.5	43.8	26.1
		2	25.0	0.0	3.7	7	87.5	4.7
	900	1	15.0	0.0	5.6	3.5	52.5	23.7
		2	30.0	0.0	5.3	7	105.0	4.4
	1000	1	16.7	0.0	6.9	3.5	58.3	23.7
		2	33.3	0.0	6.5	7	116.7	4.4
8H21/32	720	1	12.0	0.0	0.0	4	48.0	23.5
		2	24.0	0.0	0.0	8	96.0	3.0
	750	1	12.5	0.0	0.0	4	50.0	23.5
		2	25.0	0.0	0.0	8	100.0	3.0
	900	1	15.0	0.0	0.0	4	60.0	20.8
		2	30.0	0.0	0.0	8	120.0	3.0
	1000	1	16.7	0.0	0.0	4	66.7	20.6
		2	33.3	0.0	0.0	8	133.3	3.0
9H21/32	720	1	12.0	0.0	2.6	4.5	54.0	21.8
		2	24.0	0.0	1.8	9	108.0	1.7
	750	1	12.5	0.0	2.8	4.5	56.3	21.8
		2	25.0	0.0	2.0	9	112.5	1.7
	900	1	15.0	0.0	4.0	4.5	67.5	19.3
		2	30.0	0.0	2.9	9	135.0	2.1
	1000	1	16.7	0.0	5.0	4.5	75.0	19.3
		2	33.3	0.0	3.6	9	150.0	2.1

Engine Type	Speed	Rating	Moments of Inertia ; J ¹⁾				
			Engine MOI	Flywheel		Alternator MOI ²⁾	Total MOI
				MOI	Mass		
	1/min	kW	kg m ²	kg m ²	kg	kg m ²	kg m ²
5H21/32	720	800	68.3	244.0	1255.6	89.1	401.4
	750	800	68.3	154.2	1024.9	89.1	311.6
6H21/32	720	960	77.0	244.0	1255.6	99.0	420.0
	750	960	77.0	244.0	1255.6	99.0	420.0
	900	1200	77.0	154.2	1024.9	141.4	372.6
	1000	1200	77.0	154.2	1024.9	141.4	372.6
7H21/32	720	1120	85.6	270.0	1340.1	95.4	451.0
	750	1120	85.6	270.0	1340.1	95.4	451.0
	900	1400	85.6	154.2	1024.9	152.8	392.6
	1000	1400	85.6	154.2	1024.9	152.8	392.6
8H21/32	720	1280	94.2	270.0	1340.1	147.7	511.9
	750	1280	94.2	270.0	1340.1	147.7	511.9
	900	1600	94.2	244.0	1255.6	169.0	507.2
	1000	1600	94.2	154.2	1024.9	169.0	417.4
9H21/32	720	1440	106.8	270.0	1340.1	185.0	561.8
	750	1440	106.8	270.0	1340.1	185.0	561.8
	900	1800	106.8	244.0	1255.6	171.0	521.8
	1000	1800	106.8	154.2	1024.9	171.0	432.0

1) Moment of Inertia : $GD^2 = 4 \times J$ (kg m²)

2) Recommended values, in case of different MOI, should be confirmed by a torsional vibration analysis.

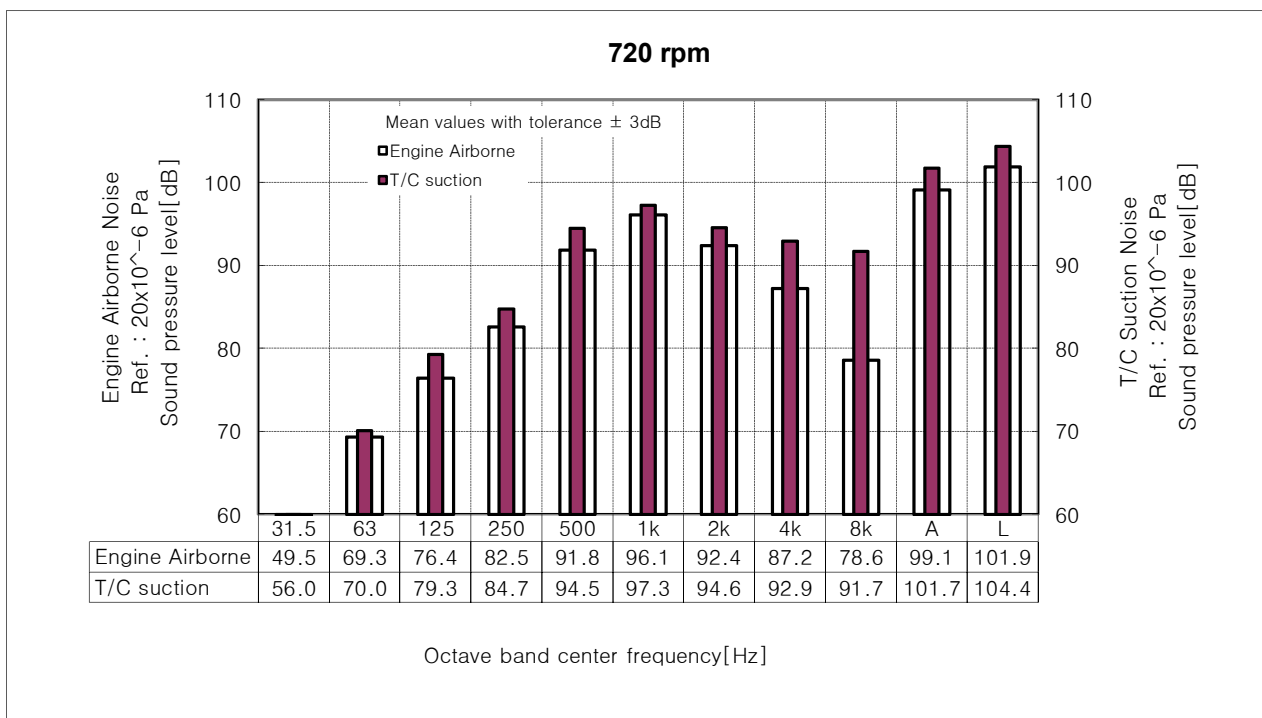
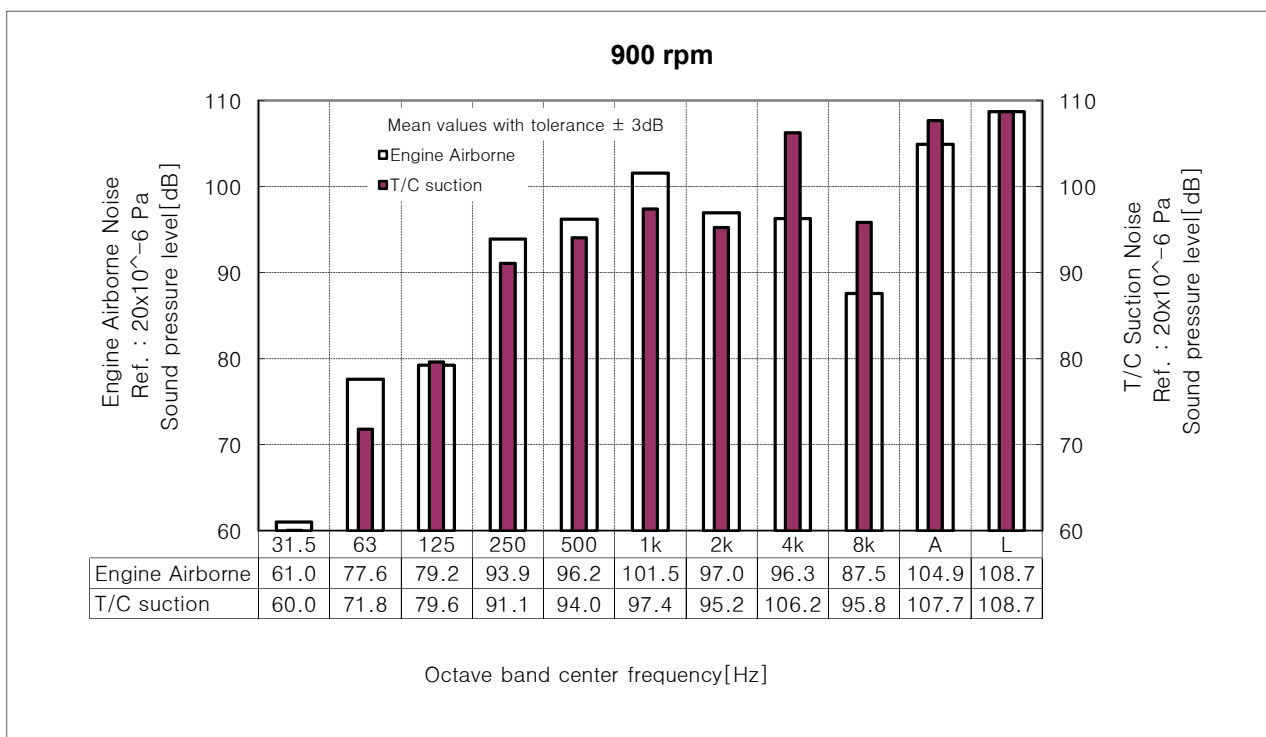
General

The airborne noise and air intake noise of the engine are defined as a sound pressure level according to ISO 6798 and ISO 8528-10, and measured at a distance of 1 m away from the engine surface at full load.

A typical measured result of each rated speed is as shown below.

The values are average with Linear and A-weighting in one octave band.

The measured value for specific project, if required, could be a little different from the below.



General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

Operation and Control System	Engine Operation	Sheet No. P.04.100	Page 1 / 2
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1. General

HiMSEN is a heavy fuel engine and it is not necessary to change over to diesel fuel at any operating condition, for example, engine start, stop, low load running, etc. However, there are some recommendations to maintain good performance and reliability consistently.

HFO

- Over 20 % load operation : no restriction
- Below 20 % load operation : load up over 70 % load at every limited time at corresponding load in "Low Load Operation Criteria"

2. Normal Starting Condition

Lub. Oil

- Continuous prelubrication is required,
- Temperature : over 40 °C (Preheated).

Cylinder Cooling Water

- Start on MDO/MGO : over 40 °C (Preheated),
- Start on HFO : over 60 °C (Preheated).

Intake Air

- Air temperature : between 0 °C and 45 °C.

Fuel Oil (MDO/MGO or HFO)

- Precirculation is required.
- Engine inlet viscosity :
12 ~ 18 cSt (HFO).
2 ~ 14 cSt (MDO/MGO).

3. Emergency Cold Starting

- Fuel Oil : only MDO/MGO acceptable,
- Cylinder Cooling Water : minimum 5 °C,
- Lube Oil : minimum 10 °C, prelubricated, (approx.1500 cSt based on SAE 40)
- Intake air temperature : minimum 0 °C.

4. Restrictions for Low Load Operation

Idle Running

- Less than 5 minutes of idle running is permitted if the engine is going to stop.
- Maximum 30 minutes of idle running is permitted if the engine is loaded after idle running.

Long Term Low Load operation

MDO/MGO

- Over 15 % load operation : no restriction
- Below 15 % load operation : load up over 70 % load at every limited time at corresponding load in "Low Load Operation Criteria"

5. Engine Load-Up

HiMSEN generating sets fulfill all requirements regarding the load application of all major classification societies and IACS.

Load-Up with Cold Engine

It is required to warm up the engine by loading up gradually upto about 50% load for a few minutes with MDO/MGO only.

After 50% load, the cylinder cooling water temperature should be minimum 60 °C to load-up from 50% to 100% load.

Load-Up with Warm Engine

A warm engine or stand-by engine with cooling water temperature over 60 °C can be loaded up from starting to 100% load immediately without any restriction. However, sudden load-up will take a few seconds to achieve stable frequency.

Continuous Load-Up

The quickest way to load-up from 0% to 100% load can be achieved by increasing the load continuously and gradually.

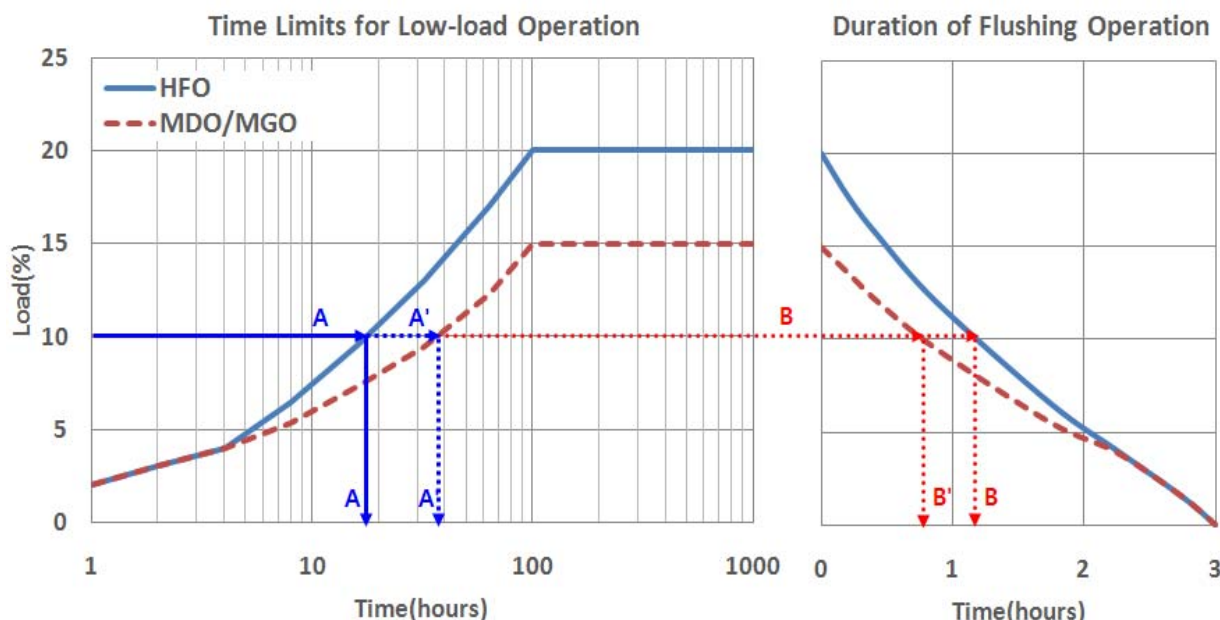
Step by Step Load-Up

Considering the time required for stabilizing the frequency deviation due to sudden load-up, it is recommended to load up from idle to full load by more than three steps under approval of classification society.

HiMSEN gen-sets fulfill the requirements of classification societies concerning the frequency deviation and recovery time when loading up by 3 steps from 0% to 100%.

It is recommended to have 3 steps according to IACS (especially for gen-sets due to higher BMEP).

<Low Load Operation Criteria>



A no-load operation is recommended for a minute, not exceed 5 minutes.

'Time Limits for Low Load Operation'(Left) shows admissible operation time at certain load, and 'Duration of Flushing Operation' shows the time duration that operates at not less than 70% of full load in order to have deposits burnt away.

<Example>

1. Time Limits for Low Load Operation(Line A, A')

At 10% of full load, HFO operation is permissible for about 17 hours(Line A), whereas MDO/MGO operation for 37 hours(Line A').

2. Duration of Flushing Operation(Line B, B')

Engine should be operated for roughly 1.15hours(HFO) and 0.75 hours(MDO/MGO) at not less than 70% of full load.

Engine load-up

HiMSEN engines fulfill all requirements regarding the load application of all major classification societies and IACS.

The engine has to be in warm condition for normal or emergency load up. When the engine is in cold condition, the continuous load up should be slower than normal and high step load should be prohibited.

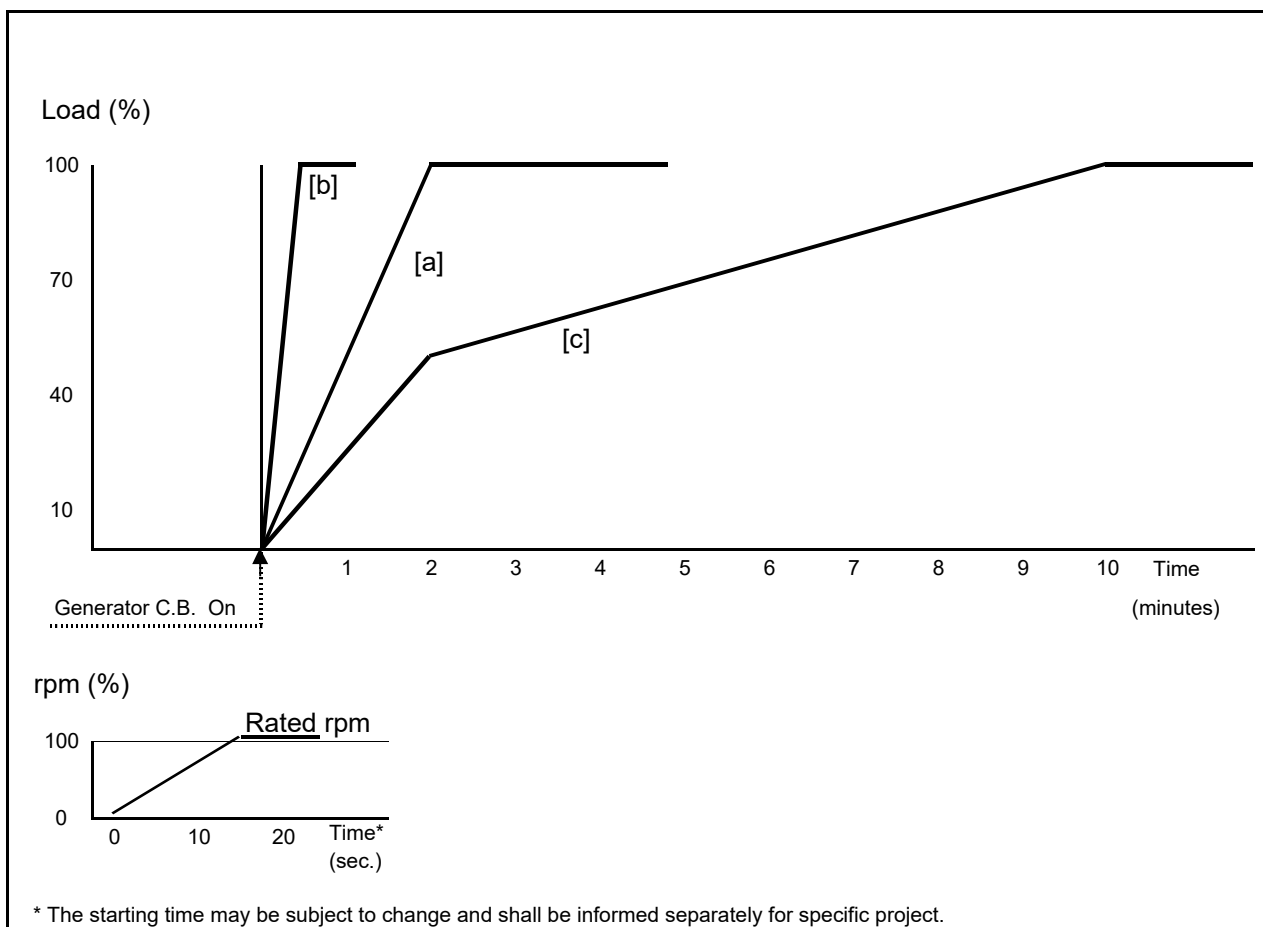
Continuous load-up

The continuous load up capacity in engine condition is referred in "Engine load up capacity in ramp".

At warm condition, the 100 % load can be achieved in 2 min. by continuous ramping up at normal condition. At emergency condition, the load can be more quickly increased to 100 % in 30 sec.

Step by step load-up

Considering the time and safety required for stabilizing the frequency due to sudden load up, it is recommended to load up from idle to full load by more than three steps under approval of classification society. HiMSEN generating-sets fulfill the requirements of classification societies concerning the frequency deviation and recovery time when loading up 3 steps from 0 % to 100 %.



Engine load up capacity in ramp

Curve [a] : Starting condition & load-up with warm(stand by) engine

- . Continuous prelubrication is required
- . Lubricating oil Temperature : over 40 °C
- . Jacket cooling water temperature : over 40 °C on MDO start.
- . Jacket cooling water temperature : over 60 °C on HFO start.
- . Intake air(Compressor air inlet) temperature : between 0 °C and 45 °C
- . Starting air pressure: Refer to Sheet No. P.02.200.
- . Fuel oil : MDO or HFO
 - Temperature controlled fuel oil should be circulated continuously before engine start.

Curve [b] : Max. capacity for quick starting & load-up with warm(stand by) engine

- . Required same condition as [a].

Curve [c] : Starting condition & load-up with cold engine

- . Continuous prelubrication is required
- . Lubricating Oil Temperature : minimum 10 °C
- . Jacket cooling water temperature : minimum 15 °C
- . Intake air(Compressor air inlet) temperature : minimum 0 °C
- . Starting air pressure: Starting condition with warm engine + Min. 5 bar
- . Fuel oil : only MDO acceptable

Operation and Control System	Engine Control System	Sheet No. P.04.400	Page 1 / 1
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Engine Stop

Two stop functions are applied to engine for safety reason.

Emergency Stop

Emergency stop valve activates stop air cylinder at each fuel injection pump and governor stops the engine via fuel regulating shaft by stop solenoid valve simultaneously.

Normal Stop

Governor stops the engine via fuel regulating shaft.

Stop Signals

Both stoppers are activated by normal stop order by Stop Button or Shut-Down signals as below;

- Lub. Oil Pressure Switch 'Low',
- High Temp Cooling Water Temp. Switch 'High',
- Engine Over Speed RPM 'High',
- Emergency Stop Switch 'Operation',
- Bearing Temp. Switch 'High' (OPTION).
- Oil Mist Density 'HIGH' (OPTION).
- Both Engine speed sensors 'Fail'

Prelubrication System

Pre lub. Oil Pump

The Pump Unit is installed in engine side and supplies Prelub. Oil to engine during either the engine stops or the engine's rpm level is below RUN State during engine starting.

General

HiMSEN generating-sets provide automation system for engine safety, control and indicating based on programmable logic controller.

The system is independently installed in each engine and also can be connected to the remote system, for example main switch board of engine control room via hard wired communication cables.

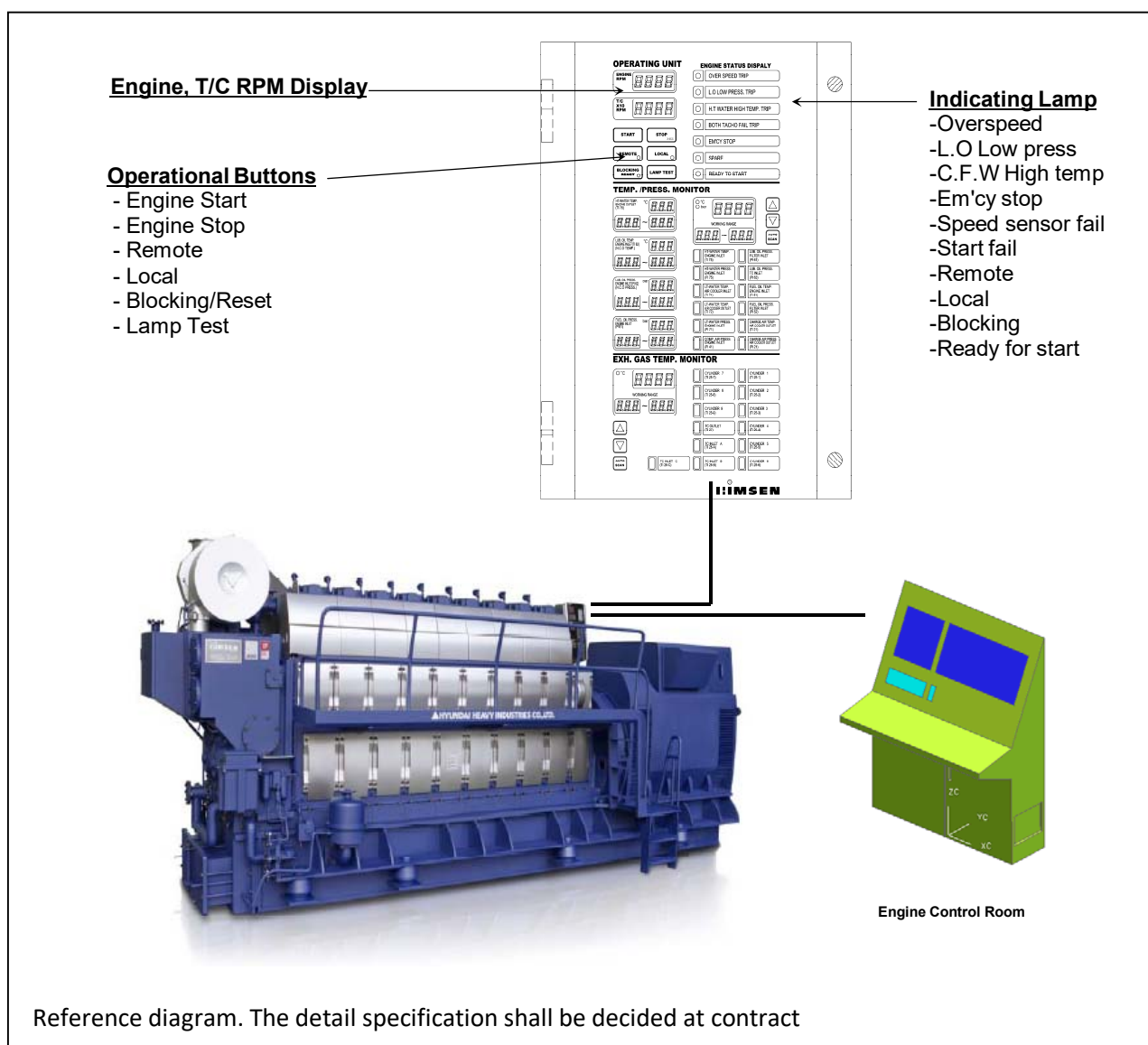
In addition to fulfilling the requirements of all classification societies and IACS, the system provides more friendly features to customers. For example,

- Compact size and easy installation,
- Digital display,(Engine & T/C rpm)

System Configuration

The system consists of the following sub systems.

- Control(Start/Stop) and Safety system,
- Digital Tachometer Unit(Engine & T/C rpm),
- Indicating & Switch Unit
- Electronic Instrumentation,
- Local gauges,
- Provision for external signal interface of Yard's requirement.



Operation and Control System	Operation Data & Alarm Points	Sheet No. P.04.700	Page 1 / 1
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Operation data of the engine is generally listed as below table.

Some data may be subjected to change and shall be informed separately for specific project.

System	Descriptions	Normal Operation Range at Rated power		Alarm & Sensor		Autostop of Engine	
Speed control	Engine speed	SI47	720/750/900 /1000 rpm			SD High	113% (1st) 115% (2nd)
	TC speed	SI42		AL High	(A)		
Fuel oil system	Fuel oil filter differential pressure	PI51~52		AL High	1.5 bar		
	Fuel oil pressure engine inlet	PI51					
	For continuous HFO operation	(MDO)	4.0 ~ 8.0 bar	AL Low	1 bar		
		(HFO)	7.0 ~ 10.0 bar	AL Low	6 bar		
	For continuous MDO operation	(MDO)	7.0 ~ 8.0 bar	AL Low	6 bar		
	Fuel oil temperature engine inlet	TI51					
		(MDO)	30~45 °C				
		(HFO)	110~150 °C	AL High	155 °C		
	Clean fuel oil leakage tank level	LS54		AL High	High level		
Lubricating oil system	Lubricating oil filter differential pressure (D)		0.1 ~ 1.0 bar	AL High	1.5 bar		
	Lubricating oil pressure engine inlet	PI62	4.0 ~ 5.0 bar	AL Low	3.5 bar	SD Low	3 bar
	Lubricating oil priming pressure			AL Low	0.1 bar		
	Lubricating oil temperature engine inlet	TI62	60 ~ 70 °C	AL High	80 °C		
	Lubricating oil pressure TC inlet	PI63	(A)	AL Low	(A)		
	Lubricating oil temperature main bearing★)	TI69		AL High	95 °C	SD High	100 °C
	Lubricating oil mist detector★)			AL High	High level	SD High	High level
	Lubricating oil sump tank level			AL Low	Low level		
Cooling water system	High temperature water pressure engine inlet	PI75	2.5 ~ 5.0 bar	AL Low	0.4+(B) bar		
	High temperature water temperature	TI75	70 ~ 80 °C				
	High temperature water temperature	TI76	75 ~ 85 °C	AL High	90 °C	SD High	95 °C
	Low temperature water pressure engine inlet	PT71	1.0 ~ 5.0 bar	AL Low	0.4+(B) bar		
	Low temperature water temperature engine inlet	TI71	30 ~ 40 °C	AL High	45 °C		
	Low temperature water temperature air cooler outlet	TI72	35 ~ 50 °C				
Combustion gas / air system	Cylinder pressure (C)	Max. 210 bar					
	Cylinder pressure deviation from average of cylinders	Max. ±5 bar					
	Charge air pressure after cooler	PI21	3.3 ~ 5.1 bar				
	Charge air temperature after cooler	TI21	35 ~ 55 °C				
	Exhaust gas temperature deviation from average of	TI25	±50 °C	AL High	±70 °C		
	Exhaust gas temperature TC inlet		420 ~ 580 °C	AL High	620 °C		
	Exhaust gas temperature TC outlet	TI27	230 ~ 410 °C	AL High	450 °C		
Compressed air system	Compressed air inlet pressure (After reducing valve)	PI41	5.0 ~ 7.0 bar	AL Low	4.5 bar	For 5, 6, 7 cylinder	
			8.0 ~ 10.0 bar	AL Low	7.5 bar	For 8, 9 cylinder	

(A) Depending on cylinder No. and T/C maker

(B) Depend on the height of expansion tank

(C) Measured at indicator cock

(D) Based on standard cartridge type filter

★) Can be applied as an option.

Operation and Control System	Local Instrumentations	Sheet No. P.04.800	Page 1 / 1
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Definition of code

Code	Description	Code	Description
AL	Alarm	SD	Shutdown

Operation data for each T/C maker

T/C maker	T/C type	T/C lubricating inlet pressure	
		Pressure range	Alarm
		Bar	Bar
KBB	ST - series	2.0 ~ 4.0	1.5
ABB	TPS - series	2.0 ~ 3.0	1.5
	A130 ~ A145	3.2 ~ 4.5	3
	A150 ~ A155	1.5 ~ 2.5	1.3
	TPL - series	1.5 ~ 2.5	1.3
MHI	MET30SRC	0.6 ~ 1.5	0.6
	MET37SRC	0.6 ~ 1.5	0.6
Napier	Na - series	1.5 ~ 2.5	1.3

The symbol number and measuring range for local instrument

	Description	Symbol No.	Measuring range
Pressure	Fuel oil pressure at engine inlet	PI 52	0 ~ 16 bar
	Lubricating oil pressure at engine inlet	PI 62	0 ~ 10 bar
Temperature	Fuel oil temperature at engine inlet	TI 52	0 ~ 200 °C
	Low temperature water temperature at air cooler inlet	TI 71	0 ~ 120 °C
	Low temperature water temperature at air cooler outlet	TI 72	0 ~ 120 °C

1. All measurement can be monitored on local operating panel.

1. Introduction

Hyundai intelligent equipment management Solution

HiEMS, offers a real-time engine status monitoring, troubleshooting guidance to marine engineers and provides connectivity between engines and on shore monitoring center. With HiEMS, HiMSEN customers can get our experts of engine and service close to you. With intuitive UI, engine operators can figure out the root cause of a certain alarm and get the technical advice and troubleshooting guide. When detecting the abnormalities in engine, HiEMS transfers alarm/fault information and sensor data to onshore for the detail analysis. Also, HiEMS keeps long term data for fleet and engine managements.

2. Benefits

2.1. On Ship

HiEMS provides guidance for the engine operator, maintenance function with engineering based instruction guide and integrated trouble shooting guide, which enables engine operators to run and maintain HiMSEN Engine at optimal condition.

2.2. On Shore

Ship managers can manage the fleet of HiMSEN engines with HiEMS, accessible 24*7 through the Digital Innovation (DI) center of HGS (Hyundai Global Service).

Ship managers can get real-time remote diagnostics, qualified advices and services from our engineers and service experts. (On reporting service version)

3. Main features

3.1. On Ship

Real-time status monitoring of the HiMSEN engine

- Status of the engine, indicator of sub systems, trend and surveillance with FAT.

Analysis tools for engine data

- Performance, deviation, correlation analysis and Statistics.

Maintenance and guidance based on the instruction guide

- Alarm manager, maintenance manager, wearing parts manager.

3.2. On Shore

Status monitoring of the fleet of HiMSEN engines

- Overall status of alarm and running hour.
- Long term data management and reporting service.

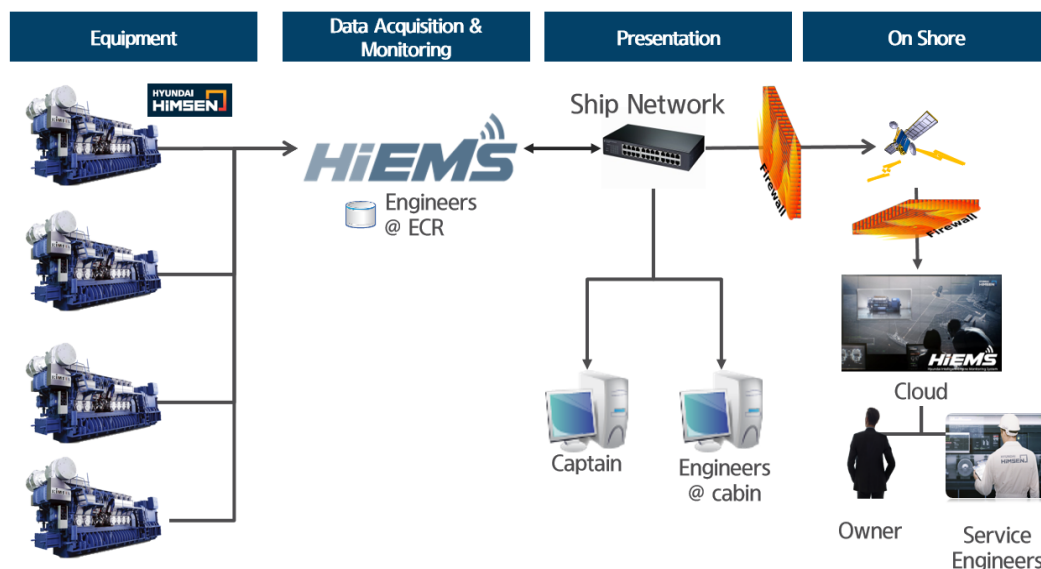
4. License policy

4.1. Standard Version

- All main features for "On ship" is available, data of a specific time interval is sent to on shore, such as alarm, statistics and operational data.

4.2 Reporting service version

- Including "Standard version" features, regular reporting service is available through Hyundai Global Service (HGS).
- Contact Hyundai Global Service (HGS) for reporting service.



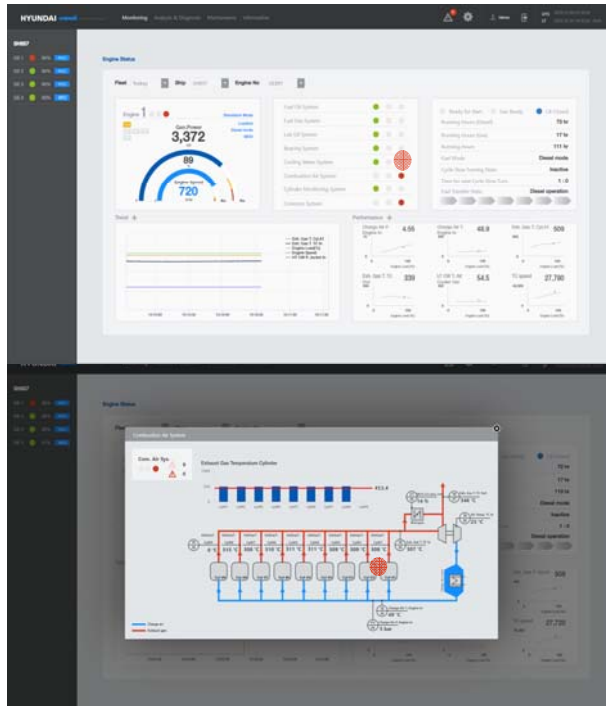
HiEMS configuration and network

5. Key Functions

5.1 Monitoring

Real-time status monitoring of the HiMSEN engine

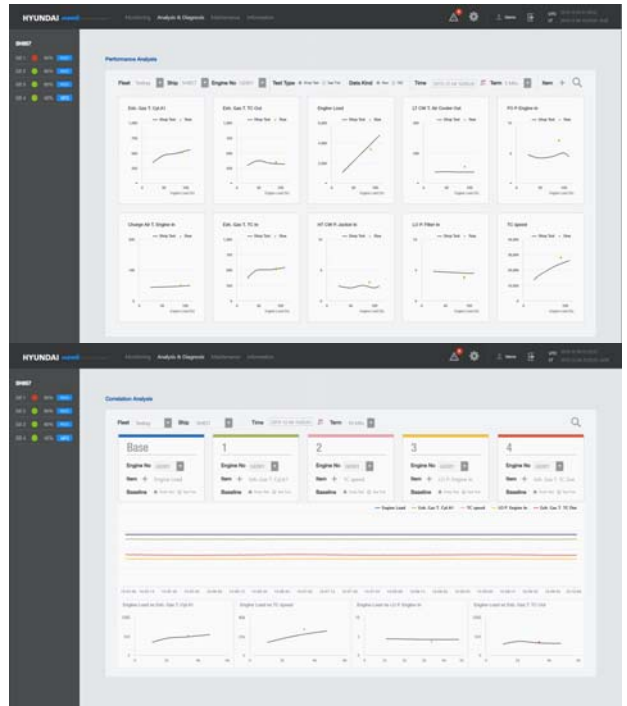
- Indicators of sub systems, running information.
- Status information by location through P&ID.(DF only)



5.3 Analysis & Diagnosis

Analysis tools for engine data

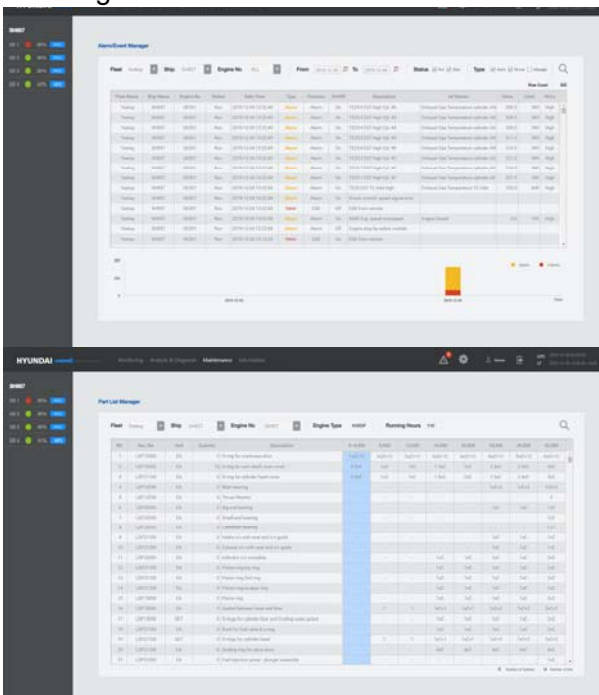
- Performance, deviation, correlation analysis and statistics.
- Compare FAT data with current state.



5.2 Maintenance

Maintenance and guidance based on the Instruction guide

- Alarm/Event, maintenance, wearing parts manager.



5.4 Fleet Management(Optional)

On shore, status monitoring of the fleet of HiMSEN engines

- Overall status of alarm, running hour and reporting service.



Digital innovation center

General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

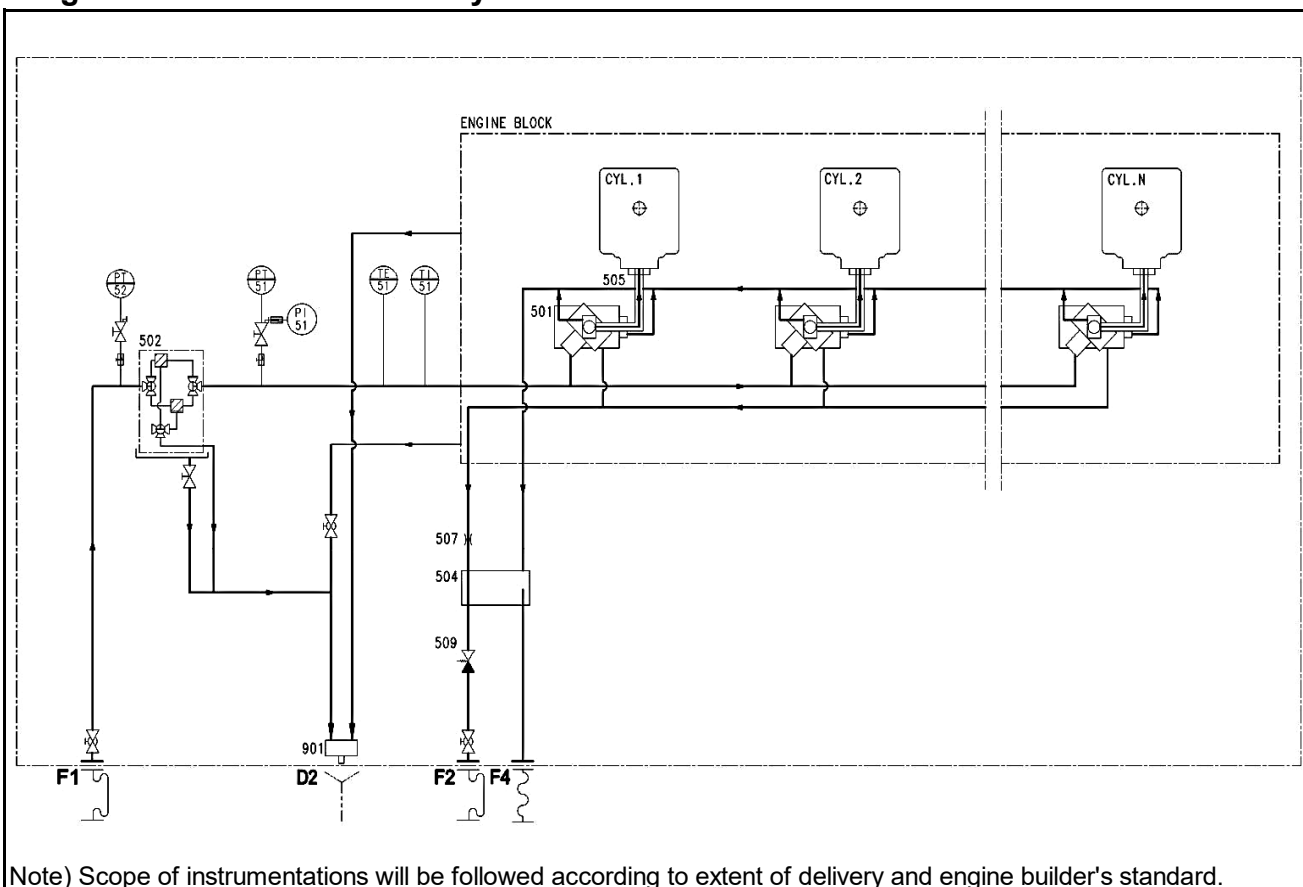
Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

Diagram for Internal Fuel Oil System



General Description

Fuel system for the diesel engine is designed for a reliable combustion of heavy fuel oil as well as diesel fuel oil. Therefore, it is not recommended to change over the fuels except for the cold starting, flushing of the system, maintenance or long term stand still.

Fuel Injection Equipment comprises an injection pump, connection block, injection pipe and injection valve, which are installed on each cylinder in line. The system is designed for operating high fuel injection pressure for better combustion.

The amount of fuel injection is controlled by governor via the common regulating shaft and spring loaded linkage, which maintains the engine speed at the preset-value by continuous positioning of the fuel pump rack.

The clean leak oil from each injection pump, high pressure connection block, etc. is drained and collected to the recycling fuel oil leakage alarm tank. It can be recycled without additional separation process. Recycling fuel oil leakage alarm tank is a modularized box for the external connections, which provides :

- Connections for fuel oil return pipes 25A
- Connection for a recycling drain pipe 15A
- Alarm switch and tank for excessive leakage

The dirty leak oil is collected to the common drain pipe led to the sludge tank. The total leak rate of fuel oil is $0.23 \times C_f^{(1)}$ liter / cylinder hour (Tolerance $\pm 50\%$). The recycling fuel oil can be led to external tank to be reused.

1) C_f : HFO = 0.5, MDO = 1.0, MGO = 2.0

Option

Fuel oil safety filter can be mounted on request as an option.

Fuel Oil System	Internal Fuel Oil System	Sheet No. P.05.100	Page 2 / 2
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Size of External Pipe Connections

Code	Description	Size
F1	Fuel Oil Inlet	25A
F2	Fuel Oil Outlet	25A
F4	Leaked Fuel Oil Drain (clean oil)	15A
D2	Waste Oil Drain (dirty oil)	Φ25

Size of Connections is standard according to JIS B 2220.

Fuel Oil System	External Fuel Oil System	Sheet No. P.05.200	Page 1 / 4
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1. General Requirements

The external fuel system for the auxiliary engines can be a common with main engine system or an independent system depending on the shipbuilder's choice.

In any cases, the condition of fuel oil, especially heavy fuel oil, is critical for the reliable operation of the engine. The most important conditions and requirements of the external fuel oil system are described as follows :

Well Cleaned Fuel

Solid particles and water in the fuel cause over wearing and frequent maintenance for the engine itself as well as external fuel system. Therefore, the proper and reliable separation equipment should be included in the external fuel oil system not only for heavy fuel oil but also for distillate fuel.

Proper Viscosity, Temperature and Pressure

are necessary. Therefore, preheating, insulation with heat tracing, and pressurizing equipment should be included in the external fuel oil system. Especially if the fuel is at low viscosity, fuel temperature should be controlled to meet the required viscosity by fuel cooling device such as cooler unit.

In order to prevent excessive pressure losses and also to minimize possible pressure pulses in the piping system, the fuel oil velocity should not exceed :

MDO Suction Pipe	
MDO Pressure Pipe	: 0.5 ~ 1.0 m/s
HFO Suction Pipe	: 1.5 ~ 2.0 m/s
HFO Pressure Pipe	: 0.3 ~ 0.8 m/s
	: 0.5 ~ 1.2 m/s

Marine diesel fuel oil

Diesel fuel oil system is necessary to back up (especially for emergency situations) and, it is also used for flushing before engine stop for long period standstill and in the event of major overhaul.

External fuel system

comprises the fuel treatment system and fuel feed system. General requirements described on next section and more detailed information can be provided if needed for specific vessel or plant.

2. Fuel Oil Treatment System

The fuel treatment system should be designed for proper cleaning of heavy fuel oil considering total fuel consumption of the plant.

Centrifugal Separators should be an automatic type with the same additional stand-by unit.

The separator should be capable of purifying the worst grade of fuel oil.

Normally, fuel oil grade of H380 to H700 require the capability of up to 1010 kg/m³.

For distillate fuel, an independent purifier system is required.

It is necessary to ensure a proper cleaning of the HFO as follows:

- Selection and operation of the fuel oil centrifuges according to suppliers recommendation
- Correct HFO temperature at inlet to the centrifuges
(The centrifuges should be always be operated with an inlet temperature of 98 °C for HFO)
- Correct throughput of fuel through the centrifuges

$$Q = P \times b \times 24(h) / p \times t$$

P = maximum continuous output of the engine(s) [kW]

b = specific fuel consumption + safety margin (15 %) [g/kWh]

p = density of the fuel [kg/m³]

t = daily separating time(h) (usually = 23 h or 23.5 h)

- Proper density of HFO in conformance with the centrifuge specification
- Proper maintenance of the centrifuges

The centrifuges should be operated in parallel, unless the centrifuge installation comprises manually operated centrifuges, with purifier followed by clarifier. To achieve the maximum separation efficiency, it is recommended to always use all available HFO centrifuges whenever possible, and to operate them in parallel with an adjusted feed rate lowering the throughput in the centrifuges. This will ensure the longest possible retention time in the centrifuges and optimal efficiency for removal of catalytic fines.

Fuel Oil System	External Fuel Oil System	Sheet No. P.05.200	Page 2 / 4
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It is important that maintenance and operation of the centrifuge is done according to the recommendations of the manufacturer.

The required capacity of the daily (service) tank and the settling tank for heavy fuel oil is minimum 24 operating hours feed for continuous full load operation. Each tank should be heated to have stable temperature between 50-70°C. Each tank should be equipped with effective sludge and water drain system.

3. Fuel Feed System

The fuel feed system can be common with other engines. The one of the most important is the proper control of the fuel viscosity. So the fuel feed system should have appropriated heating equipment and insulation accordingly. In addition, the fuel oil should be pressurized to avoid the gas separation due to high temperature.

Day tank for heavy fuel oil

The heavy fuel day tank should be filled with cleaned fuel by continuous fuel separation.

- Tank capacity : minimum 24 operating hours feed for full load operation.
- Tank heating : approx. 75 °C, as stable as possible.
- Sludge / water space and drain provided.

HFO / MDO changeover valve

The heavy fuel oil and marine diesel oil changeover valves should be installed before the supply pump and the cooler for fuel oil outlet respectively. The valve can be a manual type or an electro-pneumatic remote control type for the flexible fuel mode selection at any load conditions.

Suction strainer

To protect the supply pump, a suction strainer with a fineness of approx. 0.5 mm with magnet should be installed on the pump suction side.

Supply pump

- Capacity : min. 1.5 x total fuel consumption at maximum continuous rating + back flushing quantity
- Pump head : 4 bar
- Operating temperature : 100 °C
- Viscosity (for electric motor) : 1000 cSt

Flow meter

If a measuring device for fuel oil consumption is required, it has to be fitted between the supply pump and the mixing tank.

A by-pass line has to be installed in parallel with the flow meter to ensure the fuel oil supply free from possible clogging.

Mixing tank

The major purpose of mixing tank is to ensure the ventilation of the gas from the hot fuel oil and a gradual temperature balance by mixing the hot returned oil from the engine with the oil from the day tank.

The volume of mixing is tank is required not less than 100 liters.

Pressure control valve

The pressure control valves maintain constant system pressure. The surplus oil return to the supply pump suction side or to the fuel oil return line.

Booster pump

Since the heated fuel oil has to be continuously recirculated, the booster pump should ensure the fuel circulation with the required pressure in the system.

- Capacity : min. 3.0 x total fuel consumption at maximum continuous rating + back flushing quantity
- Pump head : 8 bar at Fuel oil inlet, F1
- Operating temperature : 150 °C
- Viscosity (for electric motor) : 500 cSt

Heater and viscosity controller

In order to ensure the correct injection viscosity at 12 ~ 18 cSt (HFO), the dual heaters are controlled by the viscosity controller.

Each heater should have sufficient capacity for heating the fuel oil for all engines at full load, one heater can therefore be overhauled while the other one is in service.

Fuel Oil System	External Fuel Oil System	Sheet No. P.05.200	Page 3 / 4
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Auto back flushing filter

In the circulating lines, absolute 10 μm automatic back-flushing filter must be installed before the branch pipe for each engine to ensure the cleanness of the fuel oil. If the cleaning cycles of the automatic back-flushing filter are increased, the fuel oil treatment system must be optimized in order to protect the engine.

Safety filter

Fuel oil safety filter, duplex type of absolute 50 μm , to be built in the fuel oil supply line of each engine.

Drain tank for dirty oil

The dirty leak oil from the engine is drained by gravity and collected to the drain tank for dirty oil, where heating coils are required. The drain tank should be transferred to the sludge tank.

Marine diesel oil feed system

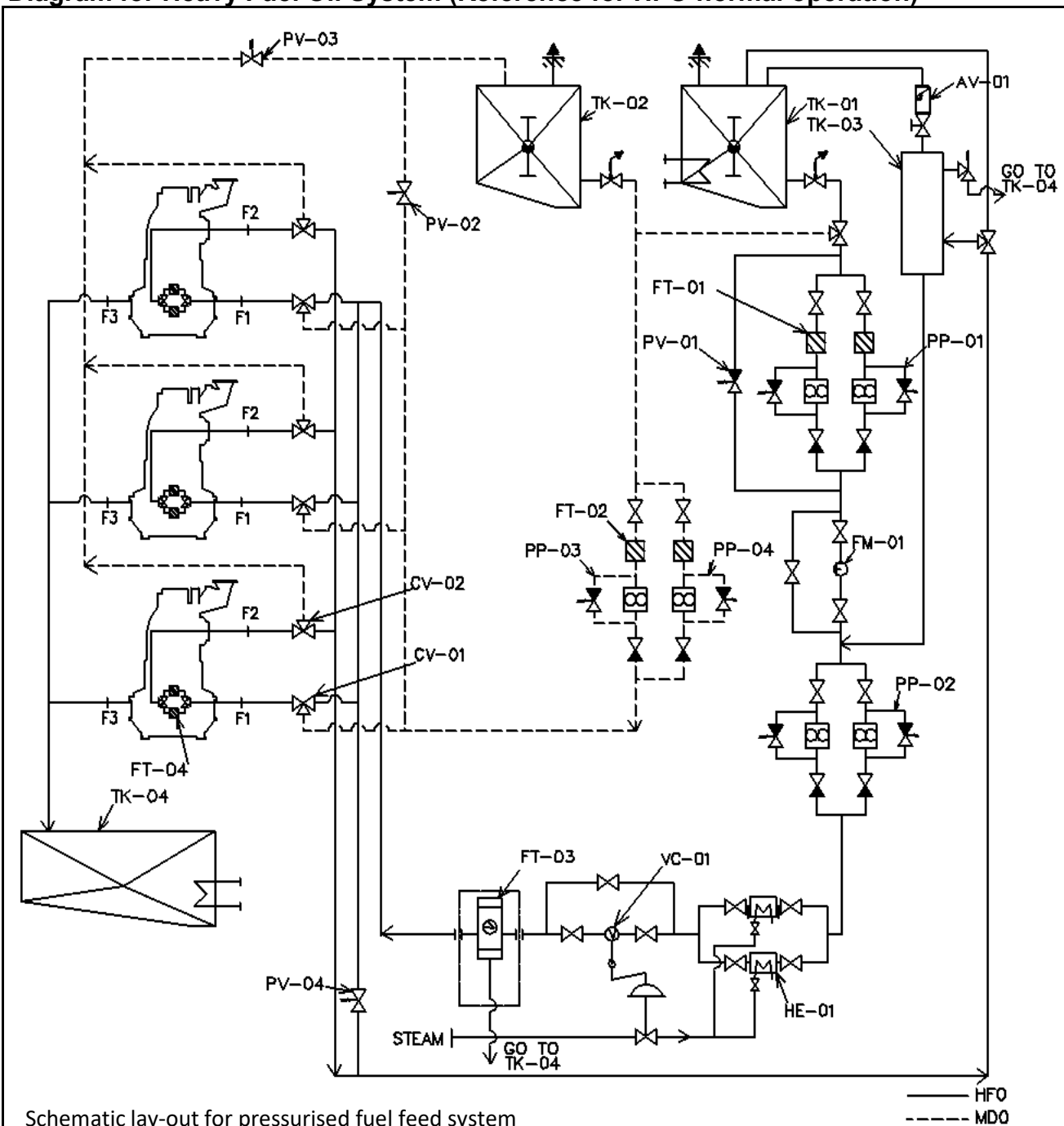
Even for the heavy fuel oil engine, an independent marine diesel oil feed system is required for the cases as below;

- Long time low load operation or stop
- Maintenance of heavy fuel oil system
- Emergency situation such as a black-out.

Emergency start

In emergency situation such as black out, marine diesel oil must be supplied to start up stand-by engines with a sufficient fuel oil pressure, which can be supplied by emergency booster pump or a gravity tank which is located minimum 8 m above the engine.

Diagram for Heavy Fuel Oil System (Reference for HFO normal operation)



System components

TK-01 DAY TANK, HFO

TK-02 DAY TANK, MDO

TK-03 MIXING TANK

TK-04 DRAIN TANK

FT-01 SUCTION STRAINER, HFO

FT-02 SUCTION STRAINER, MDO

FT-03 AUTOMATIC FILTER(10 μ m)

CV-01/CV-02 HFO/MDO CHANGE OVER VALVE (LOCAL OR REMOTE CONTROL)

FM-01 FLOWMETER

HE-01 HEATER

VC-01 VISCOSITY CONTROLLER

AV-01 AUTO DEAERATING VALVE

FT-04 SAFETY FILTER(50 μ m)

PP-03 MDO PUMP(8 bar)

PP-04 EMCY MDO PUMP(6 bar)

PV-01 HFO PRESSURE CONTROL VALVE

PV-02 MDO INLET PRESSURE CONTROL VALVE(6 bar)

PV-03 MDO OUTLET PRESSURE CONTROL VALVE(2 bar)

PV-04 HFO INLET PRESSURE CONTROL VALVE(9 bar)

PP-01 HFO SUPPLY PUMP(4 bar)

PP-02 HFO BOOSTER PUMP(8 bar at F.O. inlet,F1)

*) In case of continuous MDO operation, contact to HHI-EMD.

(Note: Additional day tanks for low sulfur HFO and/or MDO may be required due to IMO MARPOL Annex VI, a special notation of classification societies, a local regulation, or other reasons.)

Fuel System	Fuel Oil Specification	Sheet No. P.05.300	Page 1 / 9
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General

The fuel specifications are based on ISO 8217:2017. The fuels are largely classified into two categories as distillate fuels and residual fuels. Distillate fuels are divided into DMX, DMA, DFA, DMZ, DFZ, DMB, and DFB. Residual fuels are divided into RMA 10, RMB 30, RMD 80, RME 180, RMG 180 to 700, RMK 380 to 700. The usage of DMX is restricted by SOLAS requirement due to its low flash point.

The consensus of the marine market is a simplified terminology for fuels used in the market after 1st January 2020, in accordance with the most relevant characteristics.

HiMSEN is able to operate with all fuels specified in the below table. And, using the simplified terminology as listed Table 5-3-1 allows easy determination if a fuel is fit for the purpose near in time.

HiMSEN designates the fuel grades as the following table:

Fuel grade		Sulfur content(%)	Typical viscosity(cSt) (at 50°C for residual fuels & 40°C for distillate fuels)		ISO 8217:2017
			Minimum	Maximum	
HFO (Heavy Fuel Oil)	HSFO (High Sulfur Fuel Oil)	1.0 < S ≤ 3.5 (or even higher)	10	700	Residual marine fuels (RMB,RMD,RME,RMG, RMK)
	LSFO (Low Sulfur Fuel Oil)	0.5 < S ≤ 1.0			
	VLSFO (Very Low Sulfur Fuel Oil)	0.1 < S ≤ 0.5	2 ~ 380 (Not decided yet)		Not defined
	ULSFO (Ultra Low Sulfur Fuel Oil)	S ≤ 0.1	9 ~ 67 (Not decided yet)		
MGO (Marine Gas Oil)		S ≤ 1.0	2	6	Distillate marine fuels (DMA,DFA,DMZ,DFZ)
MDO (Marine Diesel Oil)		S ≤ 1.5	2	11	Distillate marine fuels (DMB,DFB) Residual marine fuels (RMA10)

Table 5-3-1: Designation of fuel grades

Fuel System	Fuel Oil Specification	Sheet No. P.05.300	Page 2 / 9
--------------------	-------------------------------	------------------------------	---------------

Distillate fuels

Characteristics		Unit	Limit	Category ISO-F-						Test Method		
				DMX	DMA	DFA	DMZ	DFZ	DMB	DFB	Reference	
Kinematic viscosity at 40°C		mm ² /s ^{a)}	max.	5.5	6.0		6.0		11.0		ISO 3104	
			min.	1.4	2.0		3.0		2.0			
Density at 15°C		kg/m ³	max.	-	890.0		890.0		900.0		ISO 3675 or ISO 12185	
Cetane index		-	min.	45	40		40		35		ISO 4264	
Sulfur ^{b)}		mass %	max.	1.0	1.0		1.0		1.5		ISO 8754 ISO 14596 ASTM D4294	
Flash point		°C	min.	43.0	60.0		60.0		60.0		ISO 2719	
Hydrogen sulfide		mg/kg	max.	2.0	2.0		2.0		2.0		IP 570	
Acid number		mg KOH/g	max.	0.5	0.5		0.5		0.5		ASTM D664	
Total sediment by hot filtration		mass %	max.	-	-		-		0.10 ^{c)}		ISO 10307-1	
Oxidation stability		g/m ³	max.	25	25		25		25 ^{d)}		ISO 12205	
Fatty acid methyl ester(FAME) ^{e)}		volume %	max	-	-	7.0	-	7.0	-	7.0	ASTM D7963 or IP579	
Carbon residue: micro method on the 10% volume distillation residue		mass %	max.	0.3	0.30		0.30		-		ISO 10370	
Carbon residue: micro method		mass %	max.	-	-		-		0.30		ISO 10370	
Cloud point ^{f)}	Winter	°C	max.	-16	report		report		-		ISO 3015	
	summer	°C	min	-16	-		-		-			
Cold filter plugging point ^{f)}	Winter	°C	max.	-	report		report		-		IP 309 OR IP 612	
	summer	°C	min	-	-		-		-			
Pour point (upper) ^{f)}	Winter	°C	max.	-	-6		-6		0		ISO 3016	
	summer	°C	max.	-	0		0		6			
Appearance		-	-	Clear and bright ^{g)}						^{c)}		
Water		volume %	max.	-	-		-		0.30 ^{c)}		ISO 3733	
Ash		mass %	max.	0.01	0.01		0.01		0.01		ISO 6245	
Lubricity, corrected wear scar diameter (WSD 1,4) at 60°C ^{h)}		µm	max.	520	520		520		520 ^{d)}		ISO 12156-1	

^{a)} 1 mm²/s = 1 cSt

^{b)} Notwithstanding the limits given, a purchaser shall define the maximum sulfur content in accordance with relevant statutory limitations. See Introduction of ISO 8217:2017.

^{c)} If the sample is not clear and bright, the total sediment by hot filtration and water tests shall be required. See 6.8 and 6.12 of ISO 8217:2017.

^{d)} If the sample is not clear and bright, the test cannot be undertaken and therefore, compliance with this limit cannot be shown.

Fuel System	Fuel Oil Specification	Sheet No. P.05.300	Page 3 / 9
-------------	------------------------	------------------------------	---------------

- e) See 5.1 and Annex A ISO 8217:2017.
- f) Pour point cannot guarantee operability for all ships in all climates. The purchaser should confirm that the cold flow characteristics (pour point, cloud point, cold filter plugging point) are suitable for the ship's design and intended voyage. See 6.11 ISO 8217:2017.
- g) If the sample is dyed and not transparent, then the water limit and test method as given in 6.12. ISO 8217:2017 shall apply.
- h) This requirement is applicable to fuels with a sulfur content below 500 mg/kg (0.050 mass %).

Table 5-3-2: Specifications of distillate fuels

Fuel System	Fuel Oil Specification	Sheet No. P.05.300	Page 4 / 9
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Residual fuels

Characteristics	Unit	Limit	Category ISO-F-											Test method reference	
			RMA	RMB	RMD	RME	RMG				RMK				
			10	30	80	180	180	380	500	700	380	500	700		
Kinematic viscosity at 50°C	mm ² /s ^{a)}	max.	10.0	30.0	80.0	180.0	180.0	380.0	500.0	700.0	380.0	500.0	700.0	ISO 3104	
Density at 15°C	kg/m ³	max.	920.0	960.0	975.0	991.0	991.0				1,010.0			ISO 3675 or ISO 12185	
CCAI	-	max.	850	860	860	860	870				870				
Sulfur ^{b)}	mass %	max.	Statutory requirements ^{*)}											ISO 8754 ISO 14596 ASTM D4294	
Flash point	°C	min.	60.0	60.0	60.0	60.0	60.0				60.0			ISO 2719	
Hydrogen sulfide	mg/kg	max.	2.0	2.0	2.0	2.0	2.0				2.0			IP 570	
Acid number ^{c)}	mg KOH/g	max.	2.5	2.5	2.5	2.5	2.5				2.5			ASTM D664	
Total sediment aged	mass %	max.	0.1	0.1	0.1	0.1	0.1				0.1			ISO 10307-2	
Carbon residue: micro method	mass %	max.	2.5	10.0	14.0	15.0	18.0				20.0			ISO 10370	
Pour point (upper) ^{d)}	winter	°C	max.	0	0	30	30	30				30			ISO 3016
	Summer	°C	max.	6	6	30	30	30				30			
Water	volume %	max.	0.30	0.50	0.50	0.50	0.50				0.50			ISO 3733	
Ash	mass %	max.	0.04	0.07	0.07	0.07	0.10				0.15			ISO 6245	
Vanadium	mg/kg	max.	50	150	150	150	350				450			IP 501, IP 470 or ISO 14597	
Sodium	mg/kg	max.	50	100	100	50	100				100			IP 501, IP 470	
Aluminum plus silicon	mg/kg	max.	25	40	40	50	60				60			IP501, IP 470 or ISO 10478	
Used lubricating oils (ULO) calcium and zinc; or calcium and phosphorus	mg/kg	-	Do not use if : calcium > 30 and zinc > 15 or calcium > 30 and phosphorus > 15											IP 501 or IP 470 IP 500	

^{a)} 1 mm²/s=1 cSt

^{b)} The purchaser shall define the maximum sulfur content in accordance with relevant statutory limitations.

^{c)} See Annex H of ISO 8217:2017.

^{d)} The purchaser should confirm that this pour point is suitable for the ship's intended area of operation.

^{*)} International statutory requirements

Fuel System	Fuel Oil Specification	Sheet No. P.05.300	Page 5 / 9
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This document specifies allowable minimum flash point limits following the provisions given in the SOLAS convention. MARPOL Annex VI, which controls air pollution from ships, includes a requirement that either the fuel shall not exceed a specified maximum sulfur content or an approved equivalent alternative means be used. During the lifetime of this document, regional and/or national bodies may introduce their own local emission requirements, which can impact the allowable sulfur content, for example, the EU Sulfur Directive. It is the purchaser's and the user's responsibility to establish which statutory requirements are to be met and specify on that basis the corresponding maximum fuel sulfur content to the supplier.

Table 5-3-3: Specifications of residual fuels

Biofuels

Biofuels are largely classified into 3 categories as transesterified biofuels(biodiesel), bio-blends and others. (Classify biofuels with or without International standard)

- Transesterified Biofuels (International standards EN 14214 or ASTM D 6751-19)
ex) Biodiesel (Fatty Acid Methyl Ester – FAME)
- HVO (Hydrotreated Vegetable Oil) (International standards EN 15940,
Paraffinic Diesel Fuel from Hydrotreatment)
- Bio-blends (Mixture of Biofuels and Fossil fuels)
- Other biofuels
ex) Crude biofuels (Palm oils, Vegetable oil, Animal fat), Refined biofuels, etc.

HiMSEN is able to operate continuously with biofuels specified in the below Table 5-3-4 and Table 5-3-5

- When using biofuels included in quality standards Table 5-3-4 and Table 5-3-5,
you need to get confirmation from HiMSEN.

Biodiesel / Fatty Acid Methyl Ester (FAME)

Biodiesel (FAME) is derived from Crude biofuels by using transesterification processes.
It can be used alone or blended with petro-diesel in any proportions.

International standards EN 14214 or ASTM D 6751-19 are commonly used to specify the quality of biodiesel. (See the Table 5-3-4)

Fuel System	Fuel Oil Specification	Sheet No. P.05.300	Page 6 / 9
--------------------	-------------------------------	------------------------------	---------------

Table 5-3-4 Specifications of biodiesel(FAME)

Characteristics b)	Unit	Min. limit	Max. limit	Test method reference
FAME content	% (m/m)	96.5	-	EN 14103
Density at 15°C	kg/m ³	860	900	EN ISO 3675 / EN ISO 12185
Viscosity at 40°C	mm ² /s	3.5	5.0	EN ISO 3104 / EN 14105
Cold filter plugging point(CFPP)	°C	-	a)	EN 116
Flash point	°C	101	-	EN ISO 2719 / EN ISO 3679
Sulfur content	mg/kg	-	10	EN ISO 20846 / EN ISO 20884
Cetane number	-	51.0	-	EN ISO 5165
Sulfated ash content	% (m/m)	-	0.02	ISO 3987
Water content	mg/kg	-	500	EN ISO 12937
Total contamination	mg/kg	-	24	EN 12662
Copper strip corrosion (3 hours at 50 °C)	rating	1b(Class1)	1a	EN ISO 2160
Oxidation stability, 110°C	hours	8	-	EN 14112
Total Acid Number (TAN)	mg KOH/g	-	0.5	EN 14104
Iodine value	-	-	120	EN 14111
Linolenic Acid Methylester	% (m/m)	-	12	EN 14103
Polyunsaturated (≥ 4 Double bonds) Methylester	% (m/m)	-	1	EN 14103
Methanol content	% (m/m)	-	0.2	EN 14110
Monoglyceride content	% (m/m)	-	0.7	EN 14105
Diglyceride content	% (m/m)	-	0.2	EN 14105
Triglyceride content	% (m/m)	-	0.2	EN 14105
Free Glycerine	% (m/m)	-	0.02	EN 14105 / EN 14106
Total Glycerine	% (m/m)	-	0.25	EN 14105
Group I metals (Na+K)	mg/kg	-	5	EN 14108 / EN 14109 / EN 14538
Group II metals (Ca+Mg)	mg/kg	-	5	EN 14538
Phosphorus content	mg/kg	-	4	EN14107

a) The temperatures related to filterability have to be at least 10~15 °C above the minimum fuel oil temperature (maximum temperature among cloud point, pour point, CFPP, and LTFT) in the whole fuel treatment process, even during engine stop unless flushing using pure diesel oil were performed before engine stop.

b) The information of storage and deterioration of Biodiesel regarding EN14214 should be discussed/ checked by fuel oil supplier before biodiesel is applied to engine.

Fuel System	Fuel Oil Specification	Sheet No. P.05.300	Page 7 / 9
--------------------	-------------------------------	------------------------------	---------------

Hydrotreated Vegetable Oil (HVO)

The EN 15940:2016 + A1:2018 + AC:2019 standard covers hydrotreated paraffinic renewable diesel fuel and synthetic Fischer-Tropsch products GTL, BTL and Coal-to-Liquid (CTL).

Since HVO consists of paraffinic hydrocarbons, it cannot meet the requirements set by EN 14214:2013+ A2:2019, which is a standard developed and valid only for methyl ester chemistry type biodiesel, namely FAME. As a matter of fact, HVO meets EN 590, except the requirement for minimum density. International standards EN 15940 are commonly used to specify the quality of HVO. (See the Table 5-3-5)

Table 5-3-5 Specifications of HVO(EN15940)

Characteristics b)	Unit	Min. limit	Max. limit	Test method reference
FAME content	% (v/v)	-	7.0	EN 14103
Density at 15°C	kg/m³	765	800	ISO 3675 / ISO 12185
Total aromatics	% (m/m)	-	1.1	EN 12916
Kinematic viscosity at 40°C	mm²/s	2.0	4.5	ISO 3104 / EN 14105
Cold filter plugging point(CFPP)	°C	-	a)	EN 116
Flash point	°C	55.0	-	ISO 2719
Sulfur content	mg/kg	-	5	ISO 20846 / ISO 20884
Cetane number	-	70	-	ISO 5165 / EN 15195
Sulfated ash content	% (m/m)	-	0.01	ISO 3987
Water content	% (m/m)	-	0.020	ISO 12937
Total contamination	mg/kg	-	24	EN 12662
Copper strip corrosion (3 hours at 50 °C)	rating	-	Class 1	ISO 2160
Oxidation stability	hours	20	-	EN 14112
Oxidation stability	g/m3	-	25	EN 14112
Carbon residue : on the 10% volume distillation residue	mass %	-	0.30	ISO 10370
Ash	% (m/m)	-	0.010	ISO 6245
Lubricity HFRR at 60°C	µm	-	460	EN 12156-1
Evaporated at 250°C	% (v/v)	-	65	ISO 3405
Evaporated at 350°C	% (v/v)	-	85	ISO 3405
Distillation 95% (v/v)	°C	-	360.0	ISO 3924

a) The temperatures related to filterability have to be at least 10~15 °C above the minimum fuel oil temperature (maximum temperature among cloud point, pour point, CFPP, and LTFT) in the whole fuel treatment process even during engine stop unless flushing using pure diesel oil were performed before engine stop.

Fuel System	Fuel Oil Specification	Sheet No. P.05.300	Page 8 / 9
--------------------	-------------------------------	------------------------------	---------------

Bio-blends

Bio-blends are mixture of biofuels and fossil fuels.

The volume ratio of the biofuel in the bio-blends are referred to as follows.

- B##, BD## (## : the volume ratio of the biofuel in the bio-blends)

ex) BD20 = Biodiesel 20% + Distillate marine fuels 80%

(In the case of Biodiesel mixture, it is specially referred to as BD##)

B20 = Biofuel 20% + Fossil fuel 80%

(Except for Biodiesel mixture, the other bio-blends are referred to as B##)

The quality standards of biodiesel-blends(BD##) are referred to the Table 5-3-4 and the bio-blends(B##) except for biodiesel-blends(BD##) are referred to the Table 5-3-6.

General biofuels

The quality standards of general liquid biofuels except biodiesel(FAME) are as shown below

Table 5-3-6.(General biofuels include a wide range of specifications. In order to reduce confusion when applying biofuel standards, HiMSEN set the integrated standard with the Table 5-3-6.)

Only biofuels that meet EN14214 or EN15940 can be applied to Micro-Pilot (MP) injector.

The information of storage and deterioration of biofuels should be discussed/checked by fuel oil supplier before the biofuel is applied to engine.

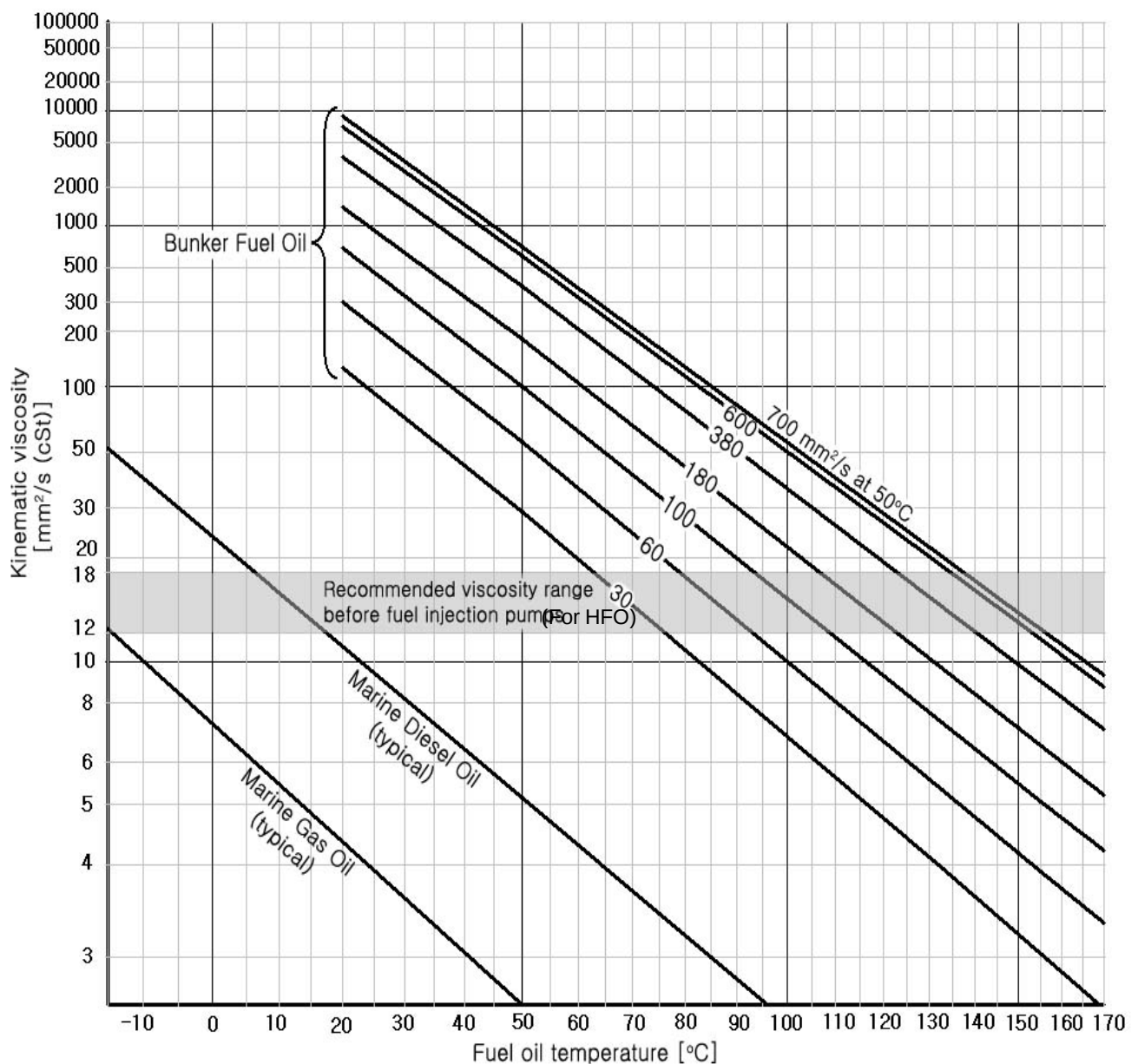
Table 5-3-6 Specifications of general biofuel, bio-blends.

Characteristics b)	Unit	Min. limit	Max. limit	Test method reference
Viscosity before injection pumps	cSt	2	18	ISO 3104
Kinematic viscosity at 50 °C	mm ² /s	-	700	
Density at 15°C	kg/m ³	-	1010	ISO 3675 / ISO 12185
Sulfur	mass %	Statutory requirements		ISO 8754 / ISO 14596 / ASTM D4294
Flash point	°C	60	-	ISO 2719
Cloud point	°C	-	a)	ISO 3015
Cold filter plugging point (CFPP)	°C	-	a)	IP 309
Pour point	°C	-	a)	ISO 3016
Total sediment by hot filtration	mass %	-	0.1	ISO 10307-1
Total sediment aged	mass %	-	0.1	ISO 10307-2
Ash	mass %	-	0.15	ISO 6245
Carbon residue (a) : micro method on the 10% volume distillation residue	mass %	-	0.3	ISO 10370
Carbon residue (b) : micro method	mass %	-	20	ISO 10370
Asphaltenes	mass %	-	8	-
Water	vol %	-	0.5	ISO 3733
Total Acid number (TAN)	mg KOH/g	-	2.5 b)	ASTM D664
Strong acid number	mg KOH/g	-	0	ASTM D664
Oxidation stability	g/m ³	-	25	ISO 12205
Hydrogen sulfide	mg/kg	-	2	IP 570
Copper strip corrosion (3h at 50 °C)	Rating	1b	1a	ASTM D130

Characteristics b)	Unit	Min. limit	Max. limit	Test method reference
Lubricity, corrected wear scar diameter	µm	-	520	ISO 12156-1
Vanadium	mg/kg	-	450	IP 501 / IP 470 / ISO 14597
Sodium	mg/kg	-	100	IP 501 / IP 470
Aluminium + Silicon	mg/kg	-	60 c)	IP 501 / IP 470 / ISO 10478
Used lubricating oils (ULO):	-	-	-	IP 501 / IP 470 / IP 500
- Calcium (Ca)	mg/kg	30	-	
- Zinc (Zn)	mg/kg	15	-	
- Phosphorus (P)	mg/kg	15 d)	-	
Cetane number	-	51	-	ISO 4264
Alkali content (Na+K)	mg/kg	-	100	EN 14108 / EN 14109 / 14538
Alkali content (Ca+Mg)	mg/kg	-	30	EN 14538
Lead (Pb) content	mg/kg	-	10	ASTM D 5059
Steel corrosion (24/72h at 20, 60, 120degC)	rating	No signs of corrosion		LP 2902
Iodine number	g l/100g	-	120	ISO 3961
Oxidation stability	h	5	-	EN 14112
Synthetic polymers	%m	-	0	LP 2501
Lower calorific value	MJ/kg	35	-	DIN 51900-3

- a) The temperatures related to filterability have to be at least 10~15 °C above the minimum fuel oil temperature (maximum temperature among cloud point, pour point, CFPP, and LTFT) in the whole fuel treatment process, even during engine stop unless flushing using pure diesel oil were performed before engine stop.
- b) It is required the agreement of FIP maker and HHI if the total acid number is more than 2.5 mg KOH/g.
- c) Aluminium and Silicon contents shall be less than 10 ppm at engine inlet although those contents is required less than 60 mg/kg in fuel oil.
- d) It is required the agreement of SCR maker if the project is required the SCR with engine.

The viscosity of HFO to the engine should be kept within the value of 12-18 cSt. However, the viscosity varies depending on the properties and the temperature of the fuel oil. Maximum preheating temperature of HFO is limited up to 155 °C to avoid vaporizing in fuel system. A typical fuel oil viscosity diagram regarding temperature is as follows :



Note : The viscosity of MDO/MGO to the engine should be kept within the value of 2 ~ 14 cSt in order to avoid possible sticking of fuel injection pump due to low lubricity of MDO/MGO.

Fuel Oil System	Fuel Oil Quality	Sheet No. P.05.320	Page 1 / 2
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1. Fuel Characteristics

Viscosity

The viscosity of fuel oil to the engine should be kept within the value of 12 ~ 18 cSt for heavy fuel oil and 3 ~ 14 cSt for marine diesel oil / marine gas oil, which could be achieved by proper heating recommended by fuel supplier as the viscosity varies depending on the properties of the fuel oil.

Density

If the density of the fuel oil is over the maximum density (991 kg/m³ at 15 °C), the fuel oil is hard to be used because it is highly expected to be contaminated by water or solid unfiltered from system. The special centrifuging system should be installed for the fuel oil with the maximum density (1010 kg/m³ at 15 °C).

Sulfur

It is important to keep proper sulfur contents in the fuel oil. The high sulfur content in the fuel may increase the risk of low temperature corrosion in the combustion chamber and contribute to the formation of high temperature deposit. It is also recommended to keep the proper alkalinity of the lubricating oil for neutralizing.

Ash

The ash content comes from natural crude oil and also from contamination during treatment of the fuel. The solid ingredients can be removed mostly by centrifuging of the fuel. However there are soluble compounds such as vanadium and sodium, which can be transformed as ash after combustion. As the ash in any form promotes mechanical wear of engine parts and harmful deposits in the combustion chamber, the ash components should be carefully analyzed and removed in advance.

Vanadium and Sodium

Vanadium is oil – soluble and comes from crude oil mostly. However sodium is water-soluble and comes from crude oil as well as contaminated fuel by salt water.

As vanadium and sodium become corrosive ash after combustion, these should be removed as possible. A sodium compound contributes to lower the melting point of vanadium ash, which is very corrosive and harmful to exhaust valves and turbocharger. Therefore, compounds should be less than 1/3 of vanadium contents in weight.

Conradson Carbon

Including much conradson carbon may impair combustion properties of the fuel and cause deposit formation in combustion chamber and exhaust system particularly at low engine output.

Asphaltenes

High asphaltene contents shall contribute to forming of deposit in combustion chamber as well as exhaust system at low loads and stick the fuel injection pump. It also causes excessive centrifuge sludge and deposits in the fuel system.

Water

The water content can be measured by a standardized distillation test. The water causes corrosion and cavitations of the fuel injection pump and fouling of the exhaust system and turbochargers. The water content should be reduced to maximum 0.2% by centrifuging.

Abrasive Particles

Fuel oil can be contaminated by abrasive particles composed of aluminium and silicon. If the efficient fuel treatment is not applied, these fine catalysts can cause abnormal wear on injection system and cylinder liners / piston rings. The aluminium plus silicon should be reduced to maximum 15 mg/kg before engine inlet.

Fuel Oil System	Fuel Oil Quality	Sheet No. P.05.320	Page 2 / 2
-----------------	------------------	------------------------------	---------------

2. Ignition Quality

The ignition quality is related to the ignition delay to the intervals between fuel injection and combustion. If the engine is operated at low load or in the condition of low temperature or pressure in the combustion chamber, the ignition delay is lengthened. During the initial operation, the engine can be damaged by the low ignition quality without sufficient preheating. The equation of CCAI (Calculated Carbon Aromaticity Index) developed by Shell can be used to get the ignition quality of the heavy fuel oil.

Calculated Carbon Aromaticity Index

$$CCAI = D - 81 - 141 \log [\log (V_k + 0.85)]$$

D = Density (kg/m³ at 15 °C)

V_k = Viscosity (cSt at 50 °C)

Note

If the value of CCAI is increased, the ignition quality has decreased value. The Fuel oil with high CCAI value may be happened a combustion problem.

To prevent any troubles about poor ignition quality, engine should be preheated sufficiently before start and has proper functions of cooling system and injection system.

From light distillates to residual fuels, net & gross specific energy can be tested or calculated according to various international standards. Basically, the specific energy value provided by fuel supplier is adapted for the determination of the heat of combustion. If it is not supplied from fuel supplier, it can be calculated by the specification of other properties as the equations given below.

For residual fuels,

$$N = (46.704 - 8.802\rho^2 10^{-6} + 3.167\rho 10^{-3}) \times [1 - 0.01(w + a + s)] + 0.0942s - 0.02449w$$

$$G = (52.190 - 8.802\rho^2 10^{-6}) \times [1 - 0.01(w + a + s)] + 0.0942s$$

For marine distillate fuels,

$$N = (46.423 - 8.792\rho^2 10^{-6} + 3.170\rho 10^{-3}) \times [1 - 0.01(w + a + s)] + 0.0942s - 0.02449w$$

$$G = (51.916 - 8.792\rho^2 10^{-6}) \times [1 - 0.01(w + a + s)] + 0.0942s$$

where

N = Net specific energy [MJ/kg]

G = Gross specific energy [MJ/kg]

ρ = Density at 15°C [kg/m³]

w = Water content [mass %]

a = Ash content [mass %]

s = Sulfur content [mass %]

Ref. ISO 8217:2017(E)

* Refer to that the actual specific energy test method (for example ASTM D 240) takes priority over the specific energy calculation method as above.

General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

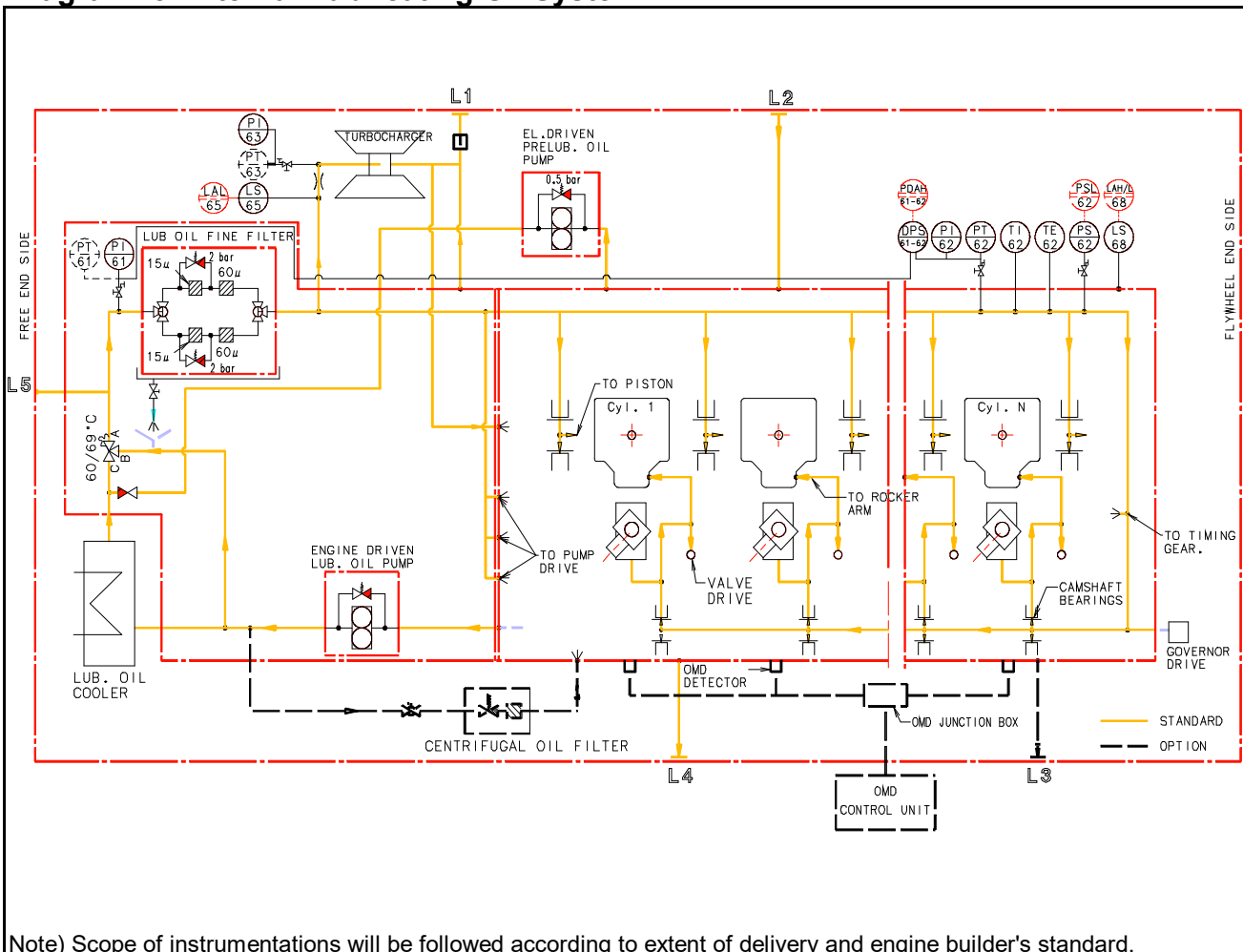
Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

Diagram for Internal Lubricating Oil System



Note) Scope of instrumentations will be followed according to extent of delivery and engine builder's standard.

1. General Description

The engine has its own internal lubricating oil system with the wet type oil sump, which supplies lubricating oil to all moving parts for lubricating as well as cooling.

Most of the oil passages are incorporated into the engine components and the equipments of the system are mounted directly on Feed Module without pipe connections.

The system comprises following equipments;

1. Lubricating oil cooler
2. Engine driven Lubricating oil pump (with pressure regulating valve)
3. El. motor driven prelubricating pump
4. Lubricating oil thermostatic valve

5. Lubricating oil filter

6. Wet sump tank

7. Centrifugal oil filter

8. Oil mist detector(Optional)

2. Sizes of External Pipe Connections

Code	Description	Pipe size
L1	Oil vapor discharge	65A
L2	Lub. oil from separator / Supply	25A
L3	Lub. oil over flow	40A
L4	Lub. oil to separator	25A
L5	C.W. auto shut-off valve	PF1/4

Size of Connections are standard according to JIS B 2220.

3. Quantity of Lubricating Oil

Total quantity of lubricating oil inside the engine is as follows;

Engine type	Oil quantities in liter			
	720/750 rpm		900/1000 rpm	
	min.	max.	min.	max.
5H21/32	630	820	750	930
6H21/32	740	950	840	1040
7H21/32	830	1070	940	1170
8H21/32	910	1180	1080	1350
9H21/32	980	1270	1140	1420

4. Specific Lubricating Oil Consumption

SLOC : 0.6 g/kWh

- Tolerance : +25% depending on the operating conditions
- Only MCR should be used to evaluate the lubricating oil consumption.

5. Engine Driven Lubricating Oil Pump

The engine driven lubricating oil pump is a gear type, mounted on the feed module of the engine. The pump is designed to provide sufficient flow even at low speed.

6. Prelubricating Oil Pump

The pre-lubricating pump is gear type, and electric motor driven. The pre-lubricating pump is automatically started to operate when engine is stopped. And the pre-lubricating is required during the engine stop period if the fuel oil is circulating. In case that the automatic pre-lubrication has been switched off, the engine must be pre-lubricated sufficiently before starting up.

7. Lubricating Oil Cooler

The lubricating oil cooler is of the plate type, mounted on the feed module of the engine.

8. Thermostatic Valve

The thermostatic valve is of the wax element mixing type, working at fixed temperature range of 60 ~ 69 °C for engine inlet, and is mounted on the feed module of the engine.

9. Lubricating Oil Filter

The lubricating oil filter is of the duplex paper cartridge type, mounted on the feed module of the engine. Each filter has a safety cartridge of stainless steel.

- Paper cartridge fineness : 15 μ m,
- Safety cartridge fineness : 60 μ m.

10. Pressure Regulating Valve

The pressure regulating valve adjusts inlet pressure lub. oil filter at 4~5 bar and is mounted on engine driven lubricating oil pump.

11. Centrifugal Oil Filter

Centrifugal oil filter can be mounted on engine. A centrifugal force is taken from the oil pressure.

12. Lubricating Oil Sump Drain

It is recommended to use the separator suction pipe for draining of the lubricating oil sump.

1. General

The external lubricating oil system is required for not only cleaning but also heating the oil to start the engine quickly. The system shall be used commonly for all auxiliary engines.

Though filtering equipment built on engine shall be sufficient for the engine operating only MDO, the centrifugal purification is commonly required for MDO and HFO operation.

2. Lubricating Oil Separator

Self cleaning type or manual cleaning type separator can be used.

Separator Capacity

The separators should be dimensioned for continuous operation and following formula can be used, as a guidance, for estimating the required flow for the separator capacity:

$$F = p \times 1.4 \times n / t$$

F = required flow (l/h),
p = total engine output (kW),
n = number of oil circulation per day,
(4 for MDO/MGO, 6 for HFO)
t = actual separation time per day,
(Normally 23 hour)

As simple estimation, above formula can be expressed as follows:

$$F = 0.3 \times p \text{ (l/h)}$$

The below formular is used to find the rated capacity for the separator:

$$V = F / B \text{ (l/h)}$$

V = rated capacity for the separator (l/h)
F = required flow (l/h)
B = throughput factor (0.2 ~ 0.25)

Throughput factor(B) shall be in accordance with the separator maker's recommendations.

3. Separator installation

The separator should be in continuous operation while the engine is on running in order to ensure removal of contaminants as quick as possible. If possible, the separator should be in operation also when the engine on shut-down for the reducing of the contamination level. In the latter case, oil temperature for efficiencies of separation needs to be maintained through heaters. Those installations with their separation plant shut down during engine stop, should consider re-starting the separator prior to engine start-up because contamination (engine leaks, condensation) could occur during engine stop.

With multi-engine plants, it would be the best to install one separator per each engine (Fig. 1). The cleaning systems of auxiliary engines are often designed such that the separator intermittently serves on engine at a time. If only one separator is in operation, the following layouts can be used (Fig. 2).

Oil cleaning, the discharge depending upon the operating time between two periods of oil cleaning the discharge interval may have to be shortened during the first couple of hours. In this way the separator will be able to cope with the high level of contaminants at the beginning of the cleaning phase. The appropriate discharge interval has to be found by trial and error.

It is important that maintenance and operation of the separator should be performed according to the manufacturer's recommendations.

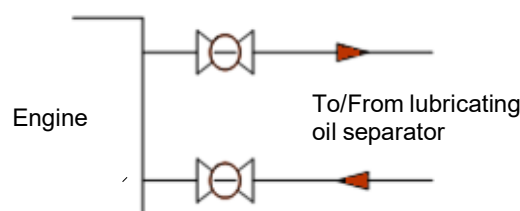


Fig. 1 Principle lay-out for direct separating on a single plant

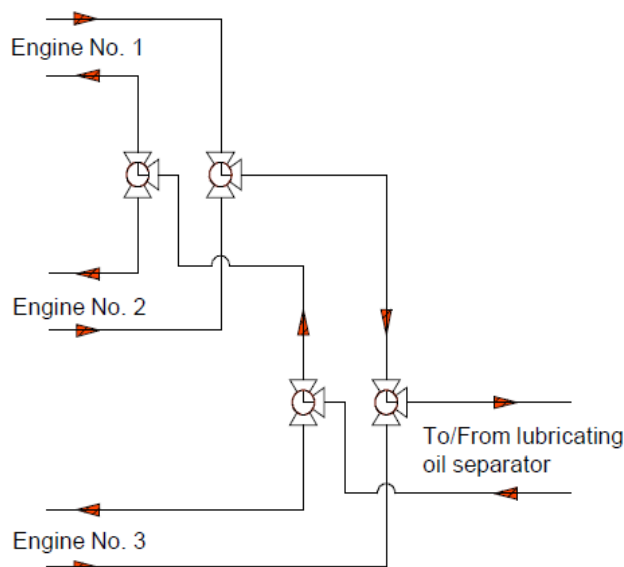


Fig. 2 Principle lay-out for direct separating on a multi plant

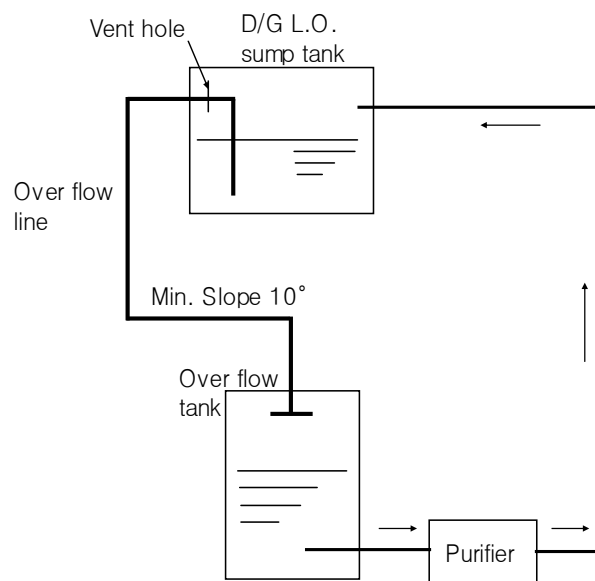


Fig. 3 Principle lay-out for overflow system

It should be ensured that the separator is only connected with one engine at a time in order to ensure that there is no suction and discharging from one engine to another.

With only one engine in operation there are no problems with separating, but if multi engines are in operation for some time it is recommended to spilt up the time so that there is separation on all engines, which are operating in turns.

4. Overflow system

In some cases, overflow system can be applied as an alternative for continuous purification (Fig. 3).

In order to have a better siphon effect, the overflow pipe from sump to overflow tank should have a continuous downward gradient of minimum 10 degrees without high and low point.

5. Suction Strainer

0.8 ~ 1.0 mm mesh size of suction filter should be inserted before the separator pump.

6. Pump for separator

The pump can be either directly driven by the separator or driven by an independent motor as recommended from a separator

7. Heater for separator

The lubricating oil in wet sump tank and in the system is to be warm-up to 40 °C from the separator heater prior to engine starting. Sump tank is to be heated-up to approx 65 °C in engine service.

Heater for separator should be designed to heat the lubricating oil from 65 °C up to 95 ~ 98°C according to separator maker's recommendation.

If the separation temperature is lowered from 95 °C to 90 °C the separator throughput has to be reduced by 22% to maintain the same separation efficiency.

8. Velocities and Pressure Losses

In order to prevent excessive pressure losses in the piping system, we recommend that the lubricating oil velocity should not exceed:

Suction Pipe : 0.5 ~ 1.5 m/s

Pressure Pipe : 1.0 ~ 2.5 m/s

9. Crank Case Ventilation

Where two or more engines are installed, vent pipes, if fitted, and lubrication oil drain pipes should be independent to avoid inter circulation between crankcases.

- The crankcase vent pipes from each engine shall be led independently to the top of the funnel. The pipes should not be connected to any other branch such as a tank vent, etc.
- The outlet of vent pipe is to be fitted with corrosion resistant flame screen separately for each engine.
- The vent pipe should have a continuous upward gradient of minimum 10 degrees without high point or low point.
- The vent pipe should be equipped with a condensate trap and drain near the engine.
- The connection between the engine and yard vent pipe is to be flexible, if resilient mounting is applied.
- The dimension of the flexible connection is 65A, and the vent pipe size after the flexible connection must be min. 65A.
- The oil mist should not be go into suction side of intake duct located outside (for outdoor type) or engine room (for indoor type).
- Criteria for high back pressure of crank case ventilation is that the maximum crank case inner pressure should not exceed 30 mmWC at maximum continuous rating.

Diagram for the external lubricating oil system(wet oil sump), multi engine

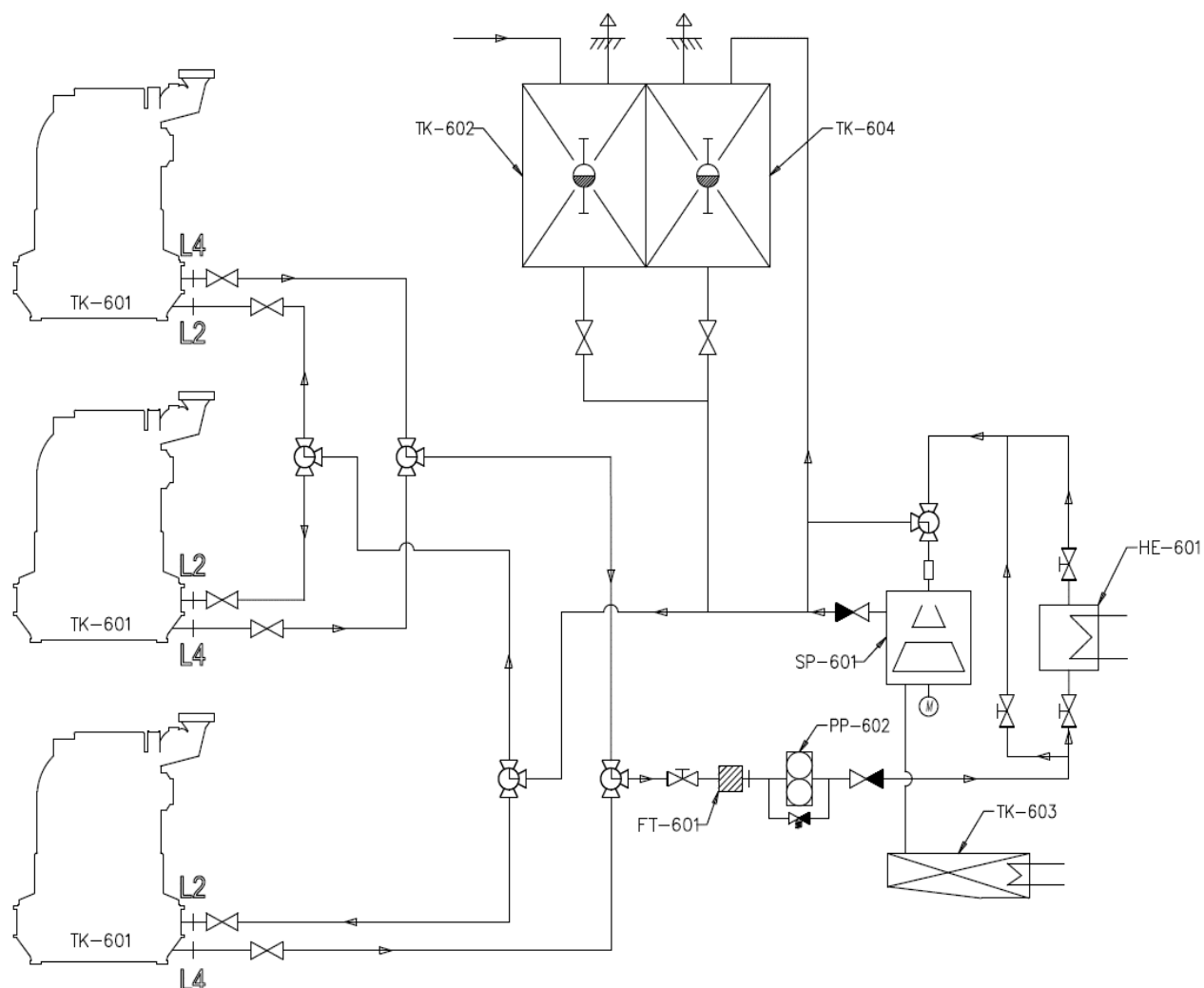


Fig. 4 External lubricating oil system (Wet Sump) for multi-engine installation (B91-314112-7.1)

System components			
Code	Descriponents	Code	Descriponents
TK-601	System oil tank	HE-601	Pre-heater for the separator
TK-602	Storage tank	SP-601	Separator
TK-603	Sludge tank	PP-602	Feed pump for the separator
TK-604	Separated oil tank	FT-601	Suction strainer

1. Oil Grade

A medium-alkaline, heavy duty (HD) oils in API-CD class has to be used for HiMSEN engine including turbocharger lubrication.

Please refer to the table 'List of Lubricants'.

2. Oil Viscosity

The oil viscosity is based on SAE 40 oil and recommended to be 145 mm²/sec. at 40 °C.

The lubricating oil should be heated to 40 °C prior to engine start.

3. Governor Oil Grade

In case of the hydraulic governor, an independent oil system is required. For further information, please refer to the sheet 'List of Lubricants'.

BN - Value

BN (Base Number) is a measure of the alkalinity or basicity of the oil. It is expressed in milligrams of potassium hydroxide per gram of the oil (mg KOH/g).

Alkalinity in lubricating oil is necessary to neutralize the acidic combustion products coming from the sulfur in fuel. Therefore, lubricating oil with suitable BN should be selected to maintain proper balance between alkalinity in lubricating oil and the sulfur level in fuel after consulting with lubricating oil supplier or specialist.

- High sulfur fuel + Low BN lube oil
→ Excessive corrosive wear

- Low sulfur fuel + High BN lube oil
→ Excessive top land deposit formation
→ Lacquering formation on cylinder liner surface

4. Lubricating oil selection

The general lubricating oil BN selection strategy is to match the lubricating oil with the fuel sulfur contents (%). Because BN decreases at various rates in each engine and condition, lubricating oil consumption also should be considered to have sufficient equilibrium during operation.

When the marine diesel oil / marine gas oil is to be used only for temporary engine operation, higher BN lubricating oil used for residual fuel (heavy fuel oil) would not present any problems. The acceptable period of temporary operation is less than 200 hours.

It is necessary to use proper lubricating oil based on sulfur content of fuel as per the lubricating oil list for HiMSEN engine described on the instruction manual in order to avoid excessive deposits in the combustion chamber, exhaust gas line and turbochargers.

Residual fuel

Sulfur contents (%)	BN
3.5 -	40 - 55
0.5 - 3.5	30 - 40
0.1 - 0.5	20 - 30
- 0.1	20

Distillated fuel (MGO/MDO)

: BN 10~20

* Refer to the Sheet No.P.05.300 for specification of residual and distillated fuel.

Oil brand	Engine system lubricating oil			Governor oil
Oil company	Brand name	SAE	BN ^{*)}	
Shell	Mysella S3 N40	40	5	1) Same as Engine system L.O 2) Refer to the governor manual for detailed L.O specification, volume of governor. 3) Initial filling: Oil filled 4) Electrical (Digital) Governor: Not applied
	Mysella S5 N40		4.5	
	Shell Gadinia S3 40		12	
	Shell Argina S2 40		20	
	Shell Argina S3 40		30	
	Shell Argina S4 40		40	
	Shell Argina S5 40		50	
TOTAL (Lubmarine)	Aurelia LNG	40	5	
	Nateria X 405		5.2	
	DISOLA M 4012		12	
	DISOLA M 4015		14	
	AURELIA TI 4020		20	
	AURELIA TI 4030		30	
	AURELIA TI 4040		40	
Chevron (Taxaco, Caltex)	AURELIA TI 4055		55	
	HDAX 9700	40	5.8	
	DELO SHP 40		12	
	DELO 1000 Marine 40		12	
	TARO 20 DP 40(X)		20	
	TARO 30 DP 40(X)		30	
	TARO 40 XL 40(X)		40	
ExxonMobil	TARO 50 XL 40(X)		50	
	Pegasus 805 Ultra	40	5.4	
	Pegasus 805		6.2	
	Pegasus 1005		5.4	
	Pegasus 1105		6.2	
	Pegasus 1107		7.3	
	Pegasus 1		6.5	
	Mobilgard ADL 40, Mobil Delvac 1640		12	
	Mobilgard 412		15	
	Mobilgard M420		20	
	Mobilgard M430		30	
	Mobilgard M440		40	
BP (Castrol)	CASTROL Duratex L	40	4.5	
	CASTROL MLC 40		12	
	CASTROL MHP 154		15	
	CASTROL TLX Xtra 204		20	
	CASTROL TLX Xtra 304		30	
	CASTROL TLX Xtra 404		40	
	CASTROL TLX Xtra 504		50	
	CASTROL TLX Xtra 554		55	
SK Lubricants	SUPERMAR 13TP 40	40	13	
	SUPERMAR 24TP 40		24	
	SUPERMAR 30TP 40		30	
	SUPERMAR 40TP 40		40	
LUKOIL	Navigo TPEO 12/40	40	12	
	Navigo TPEO 15/40		15	
	Navigo TPEO 20/40		20	
	Navigo TPEO 30/40		30	
	Navigo TPEO 40/40		40	
	Navigo TPEO 50/40		50	
	Navigo TPEO 55/40		55	

Oil brand	Engine system lubricating oil			Governor oil
Oil company	Brand name	SAE	BN ^{*)}	
Gulf Oil Marine	GulfSea Power MDO 4012, SeaLub Power MDO 4012	40	12	1) Same as Engine system L.O 2) Refer to the governor manual for detailed L.O specification, volume of governor. 3) Initial filling: Oil filled 4) Electrical (Digital) Governor: Not applied
	GulfSea Power MDO 4015, SeaLub Power MDO 4015		15	
	GulfSea Power MDO 4020, SeaLub Power MDO 4020		20	
	GulfSea Power 4030, SeaLub Power 4030		30	
	GulfSea Power 4040, SeaLub Power 4040		40	
	GulfSea Power 4055, SeaLub Power 4055		55	
ENI S.p.A.	AGIP CLADIUM 120	40	12	
	AGIP CLADIUM 300		30	
	AGIP CLADIUM 400		40	
	AGIP CLADIUM 500S		50	
Petronas	PETRONAS Disrol 50	40	6	
	PETRONAS Disrol 120		12	
	PETRONAS Disrol 300		32	
	PETRONAS Disrol 400		42	
	PETRONAS Disrol 500		51	
AEGEAN	ALFAMAR 430	40	30	
	ALFAMAR 440		40	
	ALFAMAR 450		50	
	ALFAMAR 455		55	
SINOPEC TPEO	SINOPEC TPEO 4012	40	12	
	SINOPEC TPEO 4015		15	
	SINOPEC TPEO 4020		20	
	SINOPEC TPEO 4030		30	
	SINOPEC TPEO 4040		40	
	SINOPEC TPEO 4050		50	
Hyundai Oilbank	Hyundai XTeer HGSL 40	40	4.5	
	Hyundai XTeer TPEO 4012		12	
	Hyundai XTeer TPEO 4015		15	
	Hyundai XTeer TPEO 4020		20	
	Hyundai XTeer TPEO 4030		30	
	Hyundai XTeer TPEO 4040		40	
	Hyundai XTeer TPEO 4050		50	
Gazpromneft Lubricants	Gazpromneft Ocen TPL 1240	40	12	
	Gazpromneft Ocen TPL 1540		15	
	Gazpromneft Ocen TPL 2040		20	
	Gazpromneft Ocen TPL 3040		30	
Petro-Canada	Sentinel 445	40	4.7	
Oil volume	See the separate data for sump volume as per each engine type.			UG-25+: 2.1 Liter Europa : 1.5 Liter

This list is given as guidance only.

***) Refer to Sheet No. P.06.300 when selecting BN value.**

General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

Cooling Water System	Internal Cooling Water System	Sheet No. P.07.100	Page 1 / 1
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1. General

The engine has two cooling water circuits internally, which are low temperature(LT) and high temperature(HT) water circuits. Most of the element of the circuits are modularized and directly mounted on the feed block (See Sheet No. P.01.300 'Engine Design Outline').

Low temperature water circuit comprises;

- Engine driven pump(option)
- Charge air cooler
- Lubricating oil cooler
- Wax type thermostat valve(option)
(Dividing type)
(Temp. range 35 - 45 °C fixed)

High temperature water circuit comprises;

- Engine driven pump
- Engine water jackets and Cylinder Heads
- Wax type thermostat valve (dividing type)
(Temp. range 79 - 88 °C fixed)

2. Scope of supply

The internal cooling system consists of the following built-in equipment. Marked (*) equipment can be supplied as option on request.

- * Engine driven low temperature cooling water pump (option)
- Engine driven high temperature cooling water pump
- One stage charge air cooler
- High temperature cooling water control thermostatic valve
- * Low temperature cooling water control thermostatic valve (option)
- * Electric pre-heater unit or electric preheat element on engine (option)

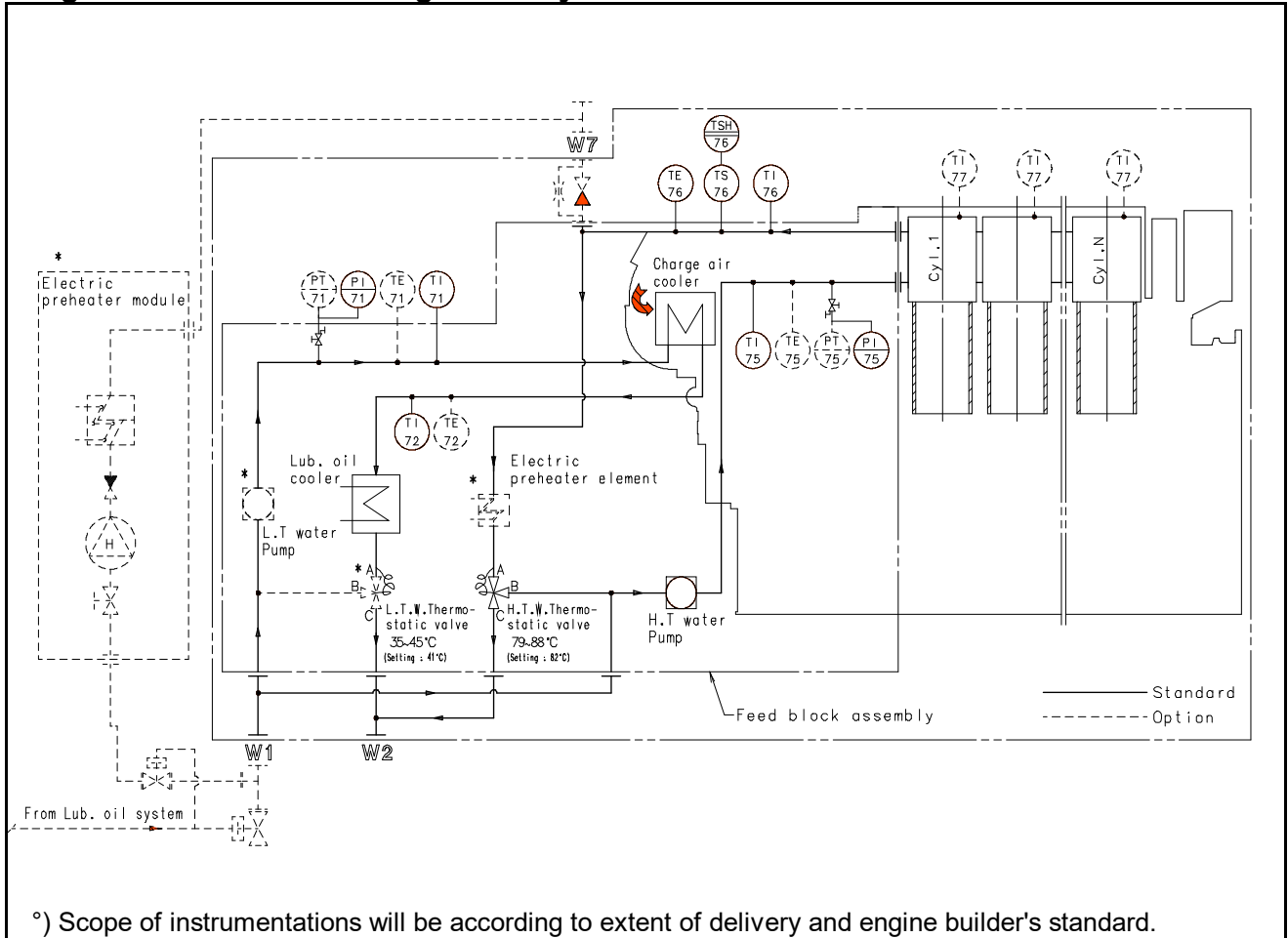
3. External Connections

Two kinds of external connections are provided for the engine room conditions as follows(Refer to system diagrams.);

System-1 : Combined connection for only L.T water supply and return.

System-2 : Separated system for L.T and H.T water system.

Diagram for Internal Cooling Water System-1

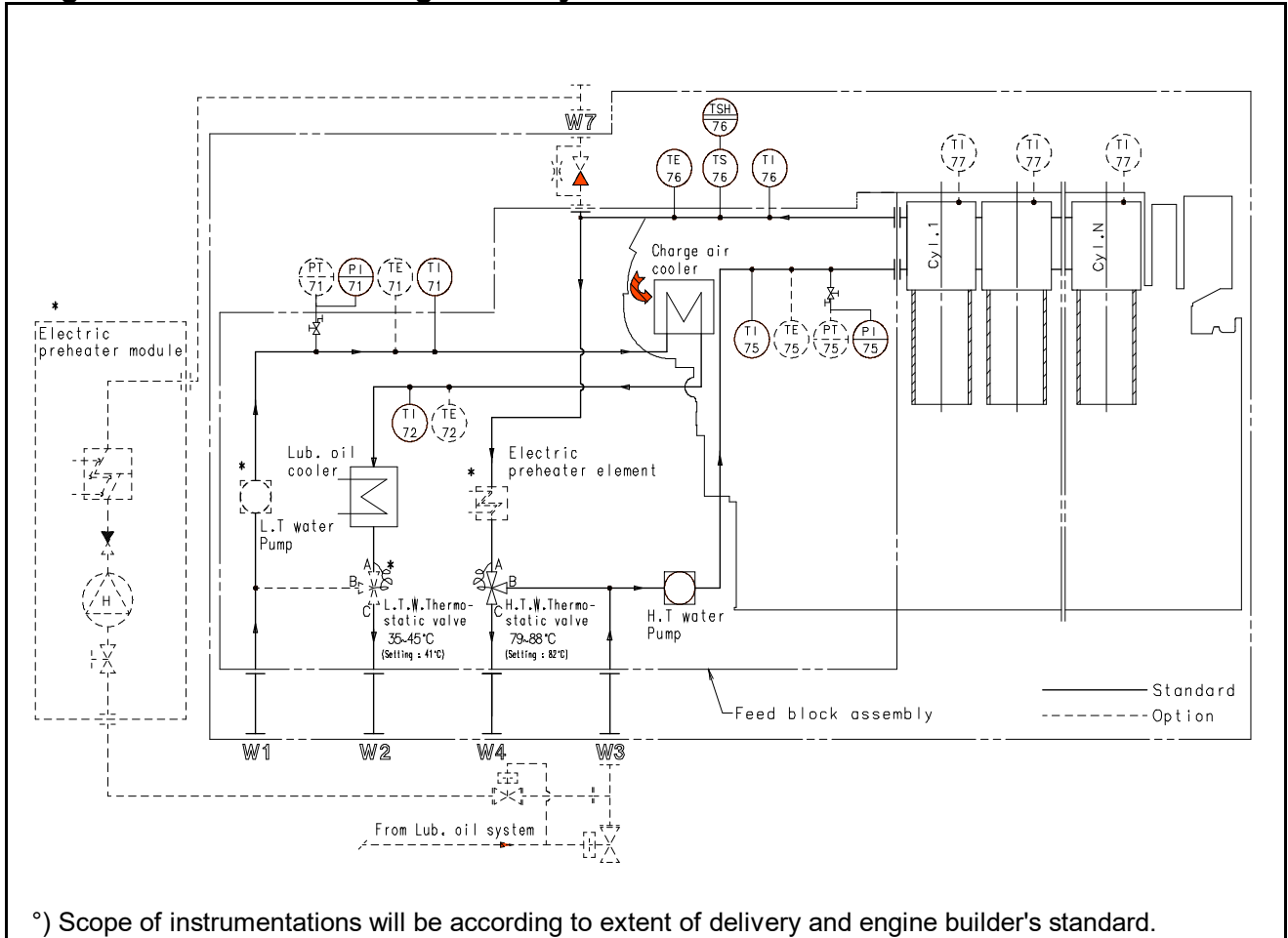


Size of External Pipe Connections

Code	Description	Pipe size
W1	L.T. Cooling Water Inlet	80A/100A
W2	L.T. Cooling Water Outlet	80A/100A
W7	Venting to Expansion Tank	25A

Size of Connections is standard according to JIS B 2220.

Diagram for Internal Cooling Water System-2



Size of External Pipe Connections

Code	Description	Pipe size
W1	L.T. Cooling Water Inlet	80A/100A
W2	L.T. Cooling Water Outlet	80A/100A
W3	H.T. Cooling Water Inlet	80A/100A
W4	H.T. Cooling Water Outlet	80A/100A
W7	Venting to Expansion Tank	25A

Size of Connections is standard according to JIS B 2220.

1. General

The engine has two cooling circuits of LT and HT internally. However, the external connections can be provided for one (System1) or two string (System2) cooling circuits.

2. Design Data for External Cooling Water System

Pressure drop

Engine HT system : approx. 0.5 bar
 Charge Air Cooler : approx. 0.5 bar
 Lub Oil Cooler : approx. 0.2 bar
 Thermostatic Valve : approx. 0.5 bar
 (These values may be different depending on the actual design of each plant.)

Fresh Water Velocity

Max. 2.5 m/s

Sea Water Velocity

Suction Pipe : 1.0 - 1.5 m/s
 Delivery Pipe : 1.5 - 2.5 m/s

Expansion tank

To avoid cavitation in cooling water system, a certain suction head for engine driven cooling water pump is required as follow:

- Minimum head : 0.5 bar
 (5 meters above the crank shaft level)

- Tank volume : 100 liter + (*)

(*) : Min. 10 % of the HT & LT water volume of additional engine(s).

The cooling water volume of the engines:

Engine type	HT & LT Water Volume
5H21/32	302 liter
6H21/32	315 liter
7H21/32	328 liter
8H21/32	341 liter
9H21/32	354 liter

Central Cooling

The central cooler for fresh water can be of the tube or plate type, which may be a common cooler for several engines or an independent cooler for each engine.

Fresh Water Side

Flow Quantity and Heat Dissipation :
 Please refer to
 'Engine Capacity Data'.

Pressure drop : Max. 0.5 bar.

Pump : centrifugal type (El. motor driven)

Water Temp. before Engine : Nor. 36 °C

Sea Water Side

Flow Quantity : typically 1.5 times of
 Fresh Water flow.

Pressure drop : typically 1.0-1.5 bar.

Engine Inlet Cooling Water Pressure

Engine inlet cooling water pressure should be kept under 2.5bar.

Cooling water

The cooling water system is designed for using normal fresh water with dosing corrosion inhibitor.

If sea water or other coolant system should be applied, please contact the engine maker separately in advance.

Preheating

In order to ensure start of engine and quick load up, pre-heating facility must be installed on the internal or external cooling water circuit. Pre-heating for all engines are required.

Pre-heating temperature :

- Marine diesel oil operation : minimum 40 °C

- Heavy fuel oil operation : minimum 60 °C

Electric pre-heating element (Option)

The mount type on the cooling water preheating arrangement consists of a thermostat-controlled electric-heating element which is built in high temperature cooling water circuit located on the engine's Feed Module. The pre-heater is activated by thermostat at 60 °C which provides water (60 °C) to jacket water outlet.

Recommended capacity of pre-heater

Cyl.	Electric pre-heater(kW)
5	15
6	15
7	15
8	15
9	15

The baggiest capacity is applied for all cylinder for better heating effect.

Operation

Before the engine starts on heavy fuel oil / marine diesel oil, the engine jacket must be pre-heated by pre-heater.

It is recommended that the pre-heater is arranged for automatic operation, so that the pre-heater shall be disconnected while the engine is running and connected while the engine is stand-by condition.

When the engine is in standstill, an external valve for pre-heater must be shut off the cooling water inlet.

Preheating unit (Option)

External pre-heating unit comprising with the follows can be supplied as option :

- Electric or steam heater
- Circulating water pump
- Control panel and circulating pump starter
- Switch on-off of heating media

The capacity of external pre-heater should be 2.0 kW per cylinder. The flow through the engine for each cylinder should be approx. 2.5 liter / min. with flow top and downwards.

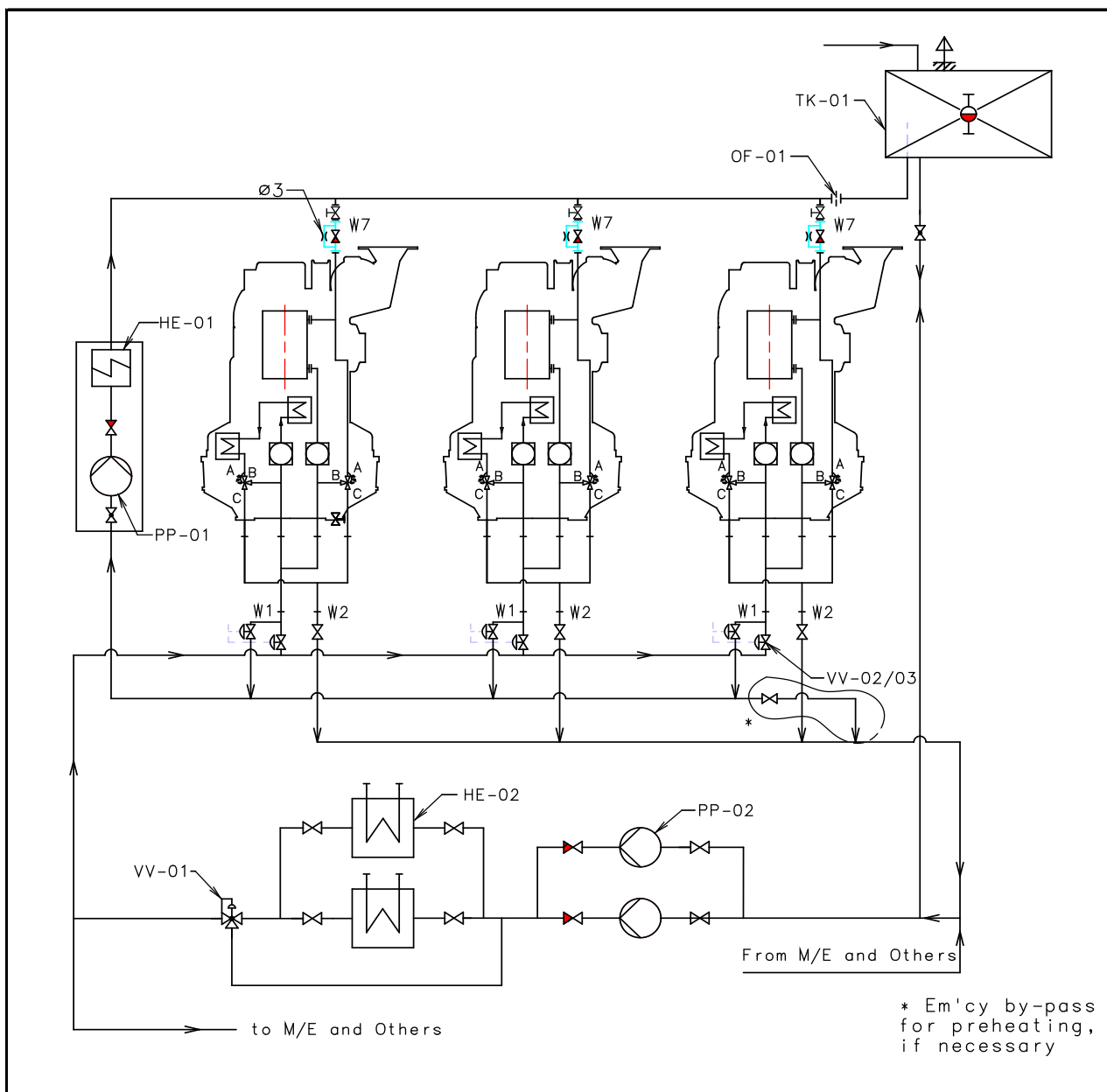
Auto shut off valve must be installed on the external cooling water system to ensure preheating, which prevents cooling water from flowing into the engine during preheating.

Preheating of stand-by engine

When only one engine sets are in service and others in stand-by, cold cooling water should not be passed into the cooling jackets on stand-by engines, which will cause cold corrosion in cooling system.

Stand-by engines should be kept warm condition through heating source such as thermal heating through venting pipe from a running engine or pre-heater.

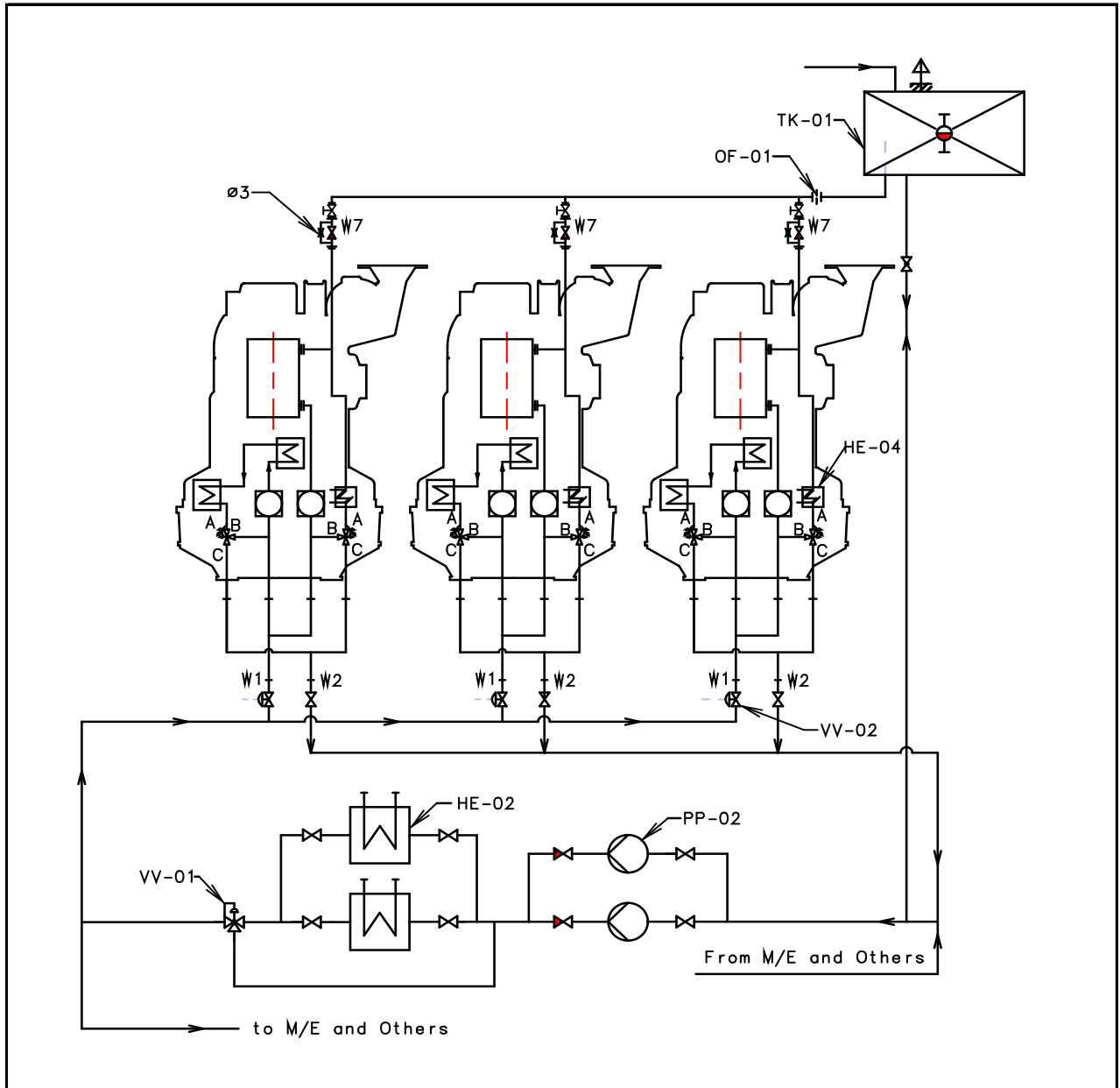
External Cooling Water System-1 with jacket preheating unit (for reference)



System components

TK - 01	Expansion tank	PP - 02	Central cooling water pump
HE - 01	Preheater	VV - 02/03	Auto shut-off v/v
PP - 01	Preheating pump	OF - 01	Orifice (ø3)
HE - 02	Central cooler	VV - 01	Thermostatic v/v

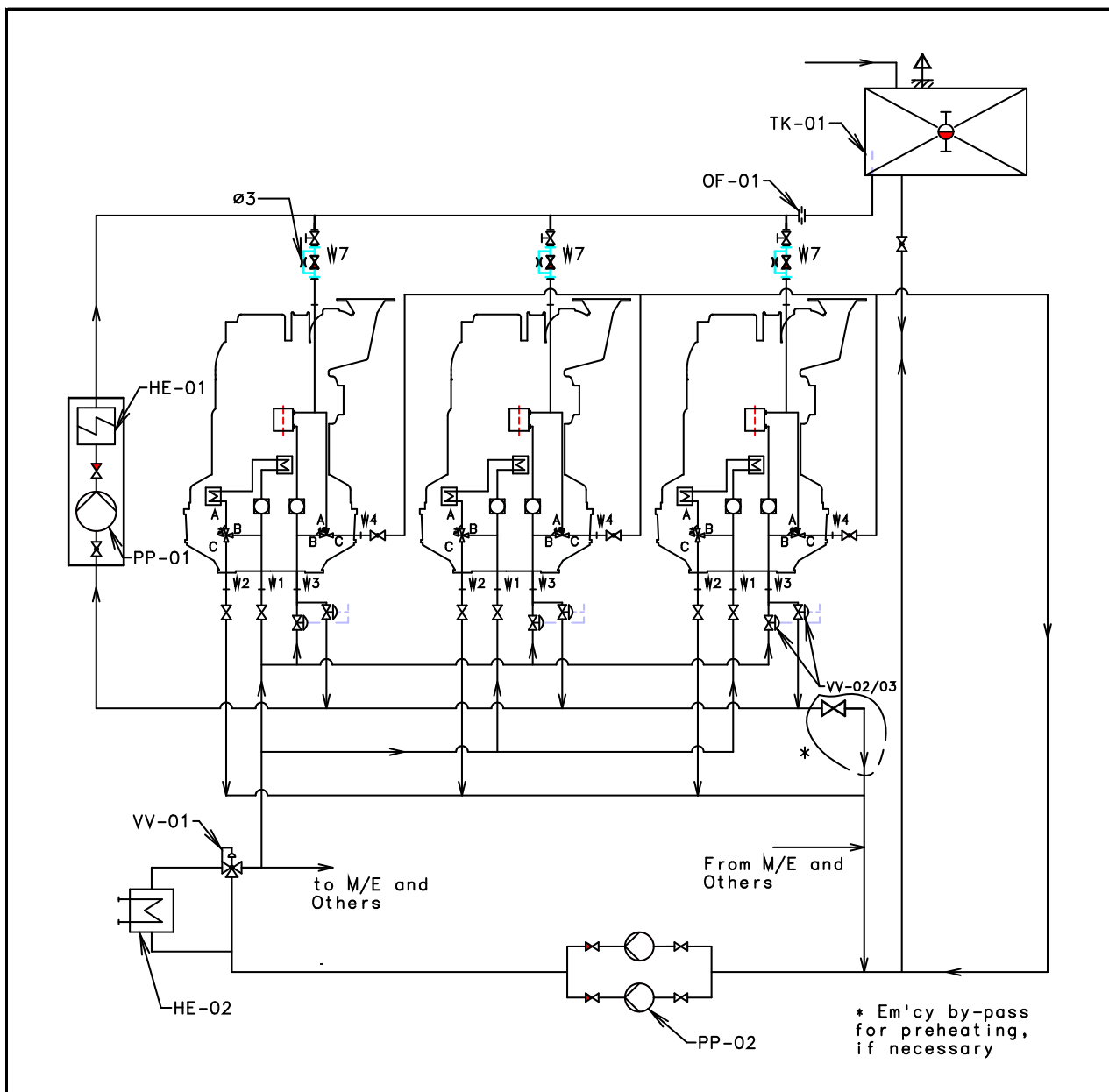
External Cooling Water System-1 with jacket preheating element (for reference)



System components

TK - 01	Expansion tank	PP - 02	Central cooling water pump
HE - 04	Electric preheating element	VV - 02	Auto shut-off v/v
HE - 02	Central cooler	OF - 01	Orifice (ø3)
VV - 01	Thermostatic v/v		

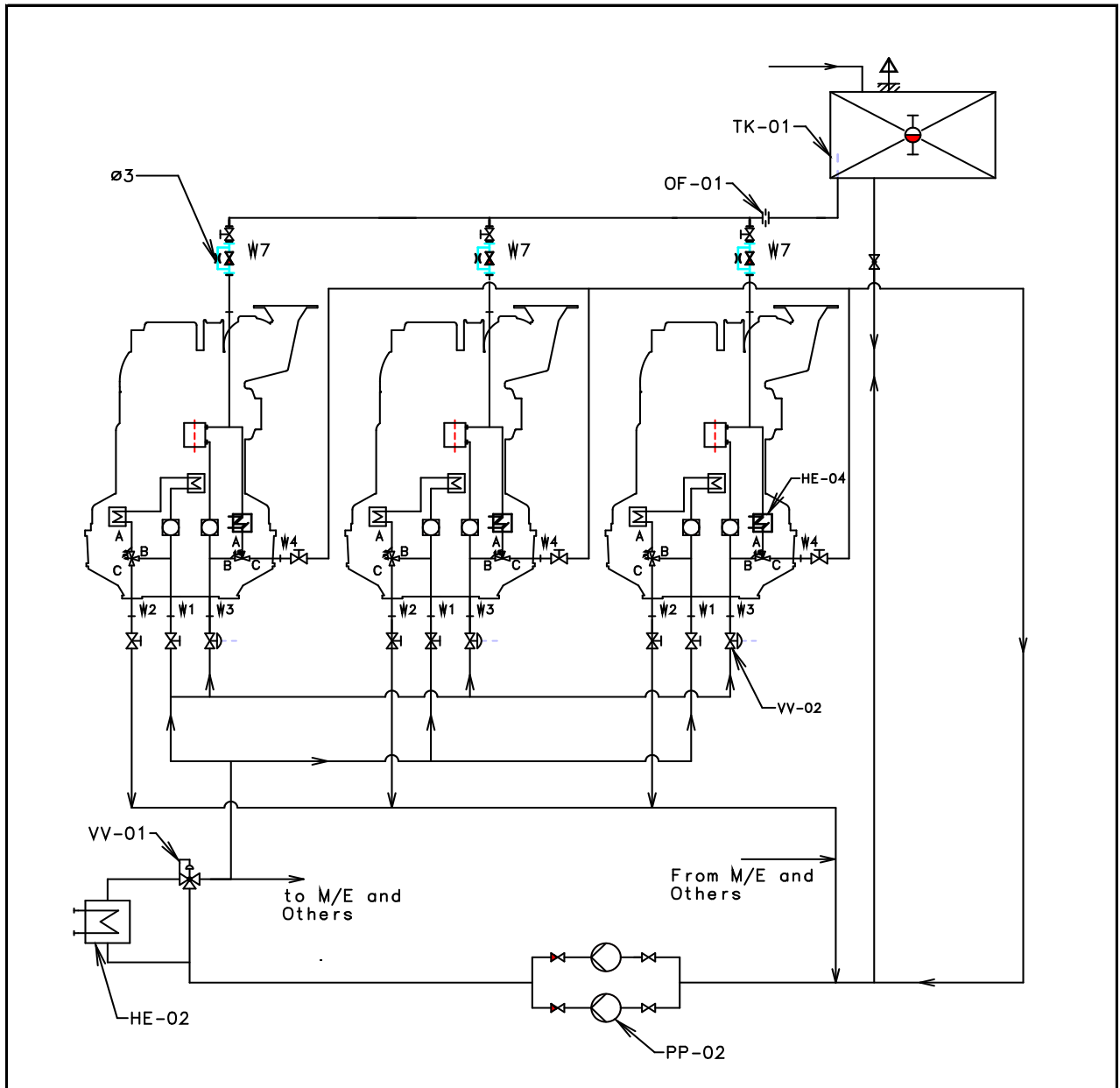
External Cooling Water System-2 with jacket preheating unit (for reference)



System components

TK - 01	Expansion tank	PP - 02	Central cooling water pump
HE - 01	Preheater	VV - 02/03	Auto shut-off v/v
PP - 01	Preheating pump	OF - 01	Orifice (ø3)
HE - 02	Central cooler	VV - 01	Thermostatic v/v

External Cooling Water System-2 with jacket preheating element (for reference)



System components

TK - 01	Expansion tank	PP - 02	Central cooling water pump
HE - 04	Electric preheating element	VV - 02	Auto shut-off v/v
HE - 02	Central cooler	OF - 01	Orifice (ø3)
VV - 01	Thermostatic v/v		

1. Quality of Cooling Water

The cooling of the engine should be only distilled (demineralized) or fresh water, which should be checked and treated to satisfy following requirements below table before adding corrosion inhibitor. It is necessary for keeping effective cooling and preventing corrosion of the system. Though the distilled water fully satisfy to the requirements for cooling water, it is necessary to add corrosion inhibitor before applying cooling water to engine cooling water system because untreated cooling water absorbs carbon dioxide from the air and then becomes corrosive.

pH	7 to 9
Total Hardness as CaCO ₃	max. 75 ppm(mg/l)
Chlorides Cl ⁻	max. 80 ppm(mg/l)
Sulphates as SO ₄ ²⁻	max. 100 ppm(mg/l)
Silica as SiO ₂	max. 60 ppm(mg/l)
Residue after evaporation	max. 400 ppm(mg/l)

Sea water or fresh water contaminated by sea water even in small amount is not allowed to be used as cooling water of the engine due to high risk of severe corrosion and deposits formation in the system.

Rainwater is heavily contaminated and highly corrosive in general, which is also not recommended as cooling water.

Tap water (drinking water) is not recommended as cooling water due to risk of chalk deposit formation inside the cooling system. However, if the distilled water, for example from fresh water generator, is not available, tap water may be used as cooling water after softening and some other treatments according to the ingredients.

Note

Chloride and Sulphate are corrosive even in the presence of an inhibitor.

2. Treatment of Cooling Water

Cooling water should be treated properly and corrosion inhibitor should be added.

The analysis and treatment of cooling water are recommended to be carried out by experts. Otherwise, comply the treatment procedures strictly according to the instructions from the supplier.

The recommended products are listed in following table.

Manufacturer	Brand Name	Constituent	Delivery Form	Recommended
				Dosage
Chevron (FAMM)	DELO XLI(Havoline XLI)	Carboxylates	Liquid	75 liter / 1,000 liter
VECOM	Cooltreat NCLT	Nitrite	Liquid	48 liter / 1,000 liter
Wilhelmsen Chemicals	Rocor NB	Nitrite, Borate	Liquid	63 liter / 1,000 liter
NALCO	NALCOOL2000, TRAC102	Nitrite, Borate	Liquid	128 liter / 1,000 liter
	TRAC100	Molybdate, silicate	Liquid	17.5 liter / 1,000 liter
	TRAC115, TRAC108	Nitrite, Borate	Liquid	28 liter / 1,000 liter
GE Water & Process Technologies	CorrShield NT4200	Nitrite	Liquid	30 liter / 1,000 liter
Shell	Shipcare Cooling Water Treat	Nitrite, Borate	Liquid	128 liter / 1,000 liter
Drew marine	LIQUIDEWT	Nitrite	Liquid	24 liter / 1,000 liter
	MAXIGARD	Nitrite	Liquid	64 liter / 1,000 liter

Note

Follow the guidelines of corrosion inhibitor manufacturer for cooling water treatment.

Note

Oily inhibitors adhere to cooling surface and influence cooling efficiency, which are not recommended for cooling water. Only nitrite-borate based inhibitors are recommended.

Note

Some inhibitors may be toxic and hazardous. Strict control is required when handling inhibitors.

General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

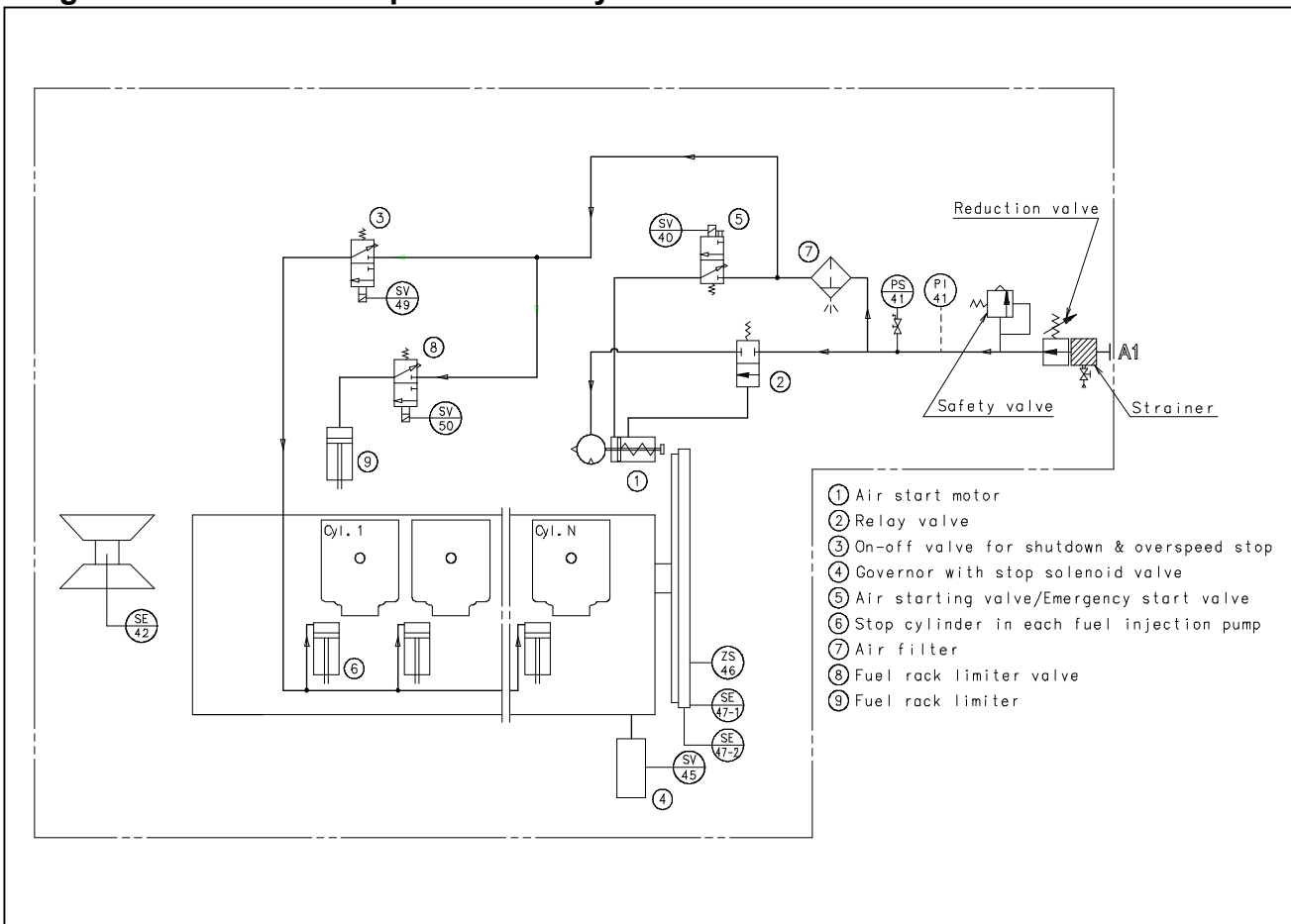
Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

Diagram for Internal Compressed Air System



1. General Description

Compressed air of max. 30 bar is supplied for engine start, emergency stop and safety system as for the control air. The detail information of engine operation is explained in Operation and control system.

Air Starter Complete comprises relay valve, air starting valve and starting air motor unit for starting the engine by turning Flywheel with gears. The compressed air is directly delivered to the air start motor through reduction valve.

Engine Stopper comprises Stop Solenoid Valve for Stop Cylinder incorporated in Fuel Injection Pump and Governor Stop. It is for immediate engine stop.

Fuel Limiter Unit is provided for Governor of Woodward UG type, which limits the amount of fuel during engine starting.

2. Size of External Pipe Connection

Code	Description	Pipe size
A1	Compressed air inlet	40A

Size of Connection is standard according to JIS B 2220.

3. Scope of Supply

The compressed air system consists of the following built-in equipments.

1. Engine Starter Complete
2. Stop Sol. Valve and Stop Cylinders
3. Fuel Limiter Unit for Governor

1. General Requirements

The maximum 30 bar for the compressed air system is required for engine operation. Therefore, all external supply system should be properly designed for this nominal pressure and also should satisfy the rules of corresponding classification society.

Dry and Clean Air is essential for the reliable function of the engine starting and control system. Therefore, the compressed air supply system should include Oil and Water Separating equipments. The air supply pipe to engine should also be arranged with slope and the water trap is to be positioned at the lowest points.

2. Starting Air Vessels

Air consumption per one start is specified in 'Engine Capacity Data'. The capacity of starting air vessel varies as per Classification Societies or Customer's requirement.

Volumes for three starts of one auxiliary engine are as follows;

Engine Type	Volume (liter)
5H21/32	380
6H21/32	400
7H21/32	420
8H21/32	440
9H21/32	460

A typical Diagram for External Compressed Air System

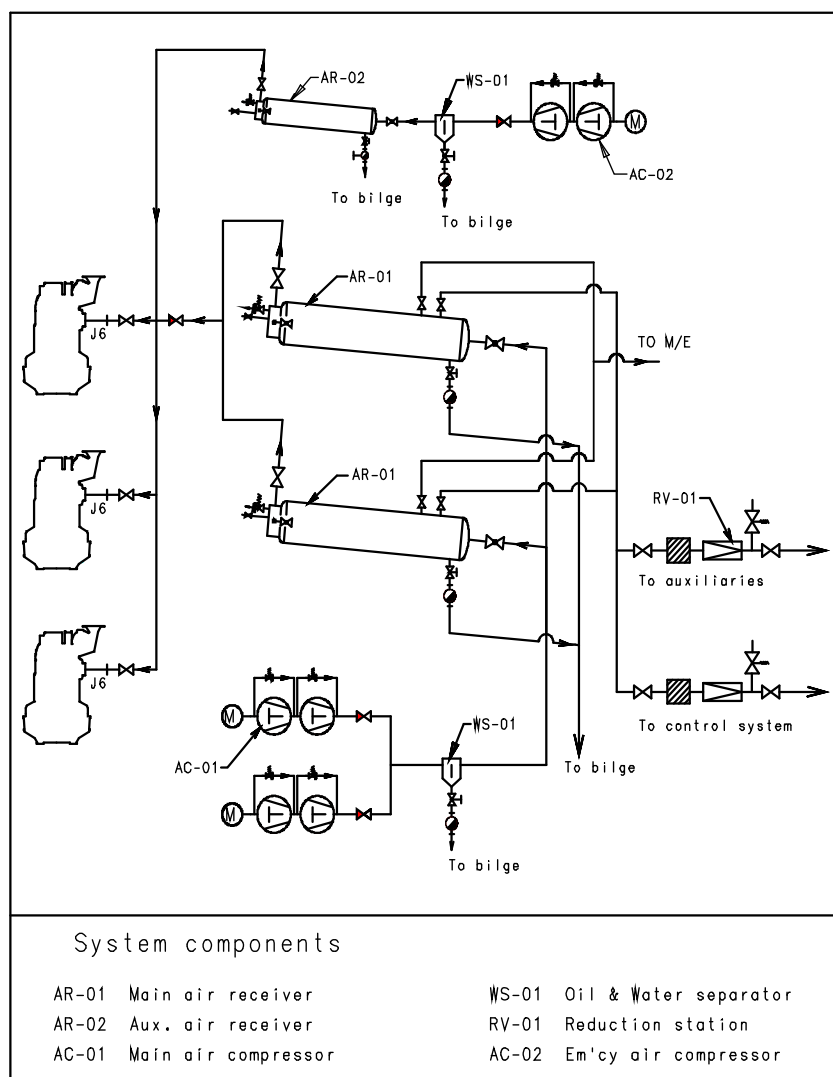
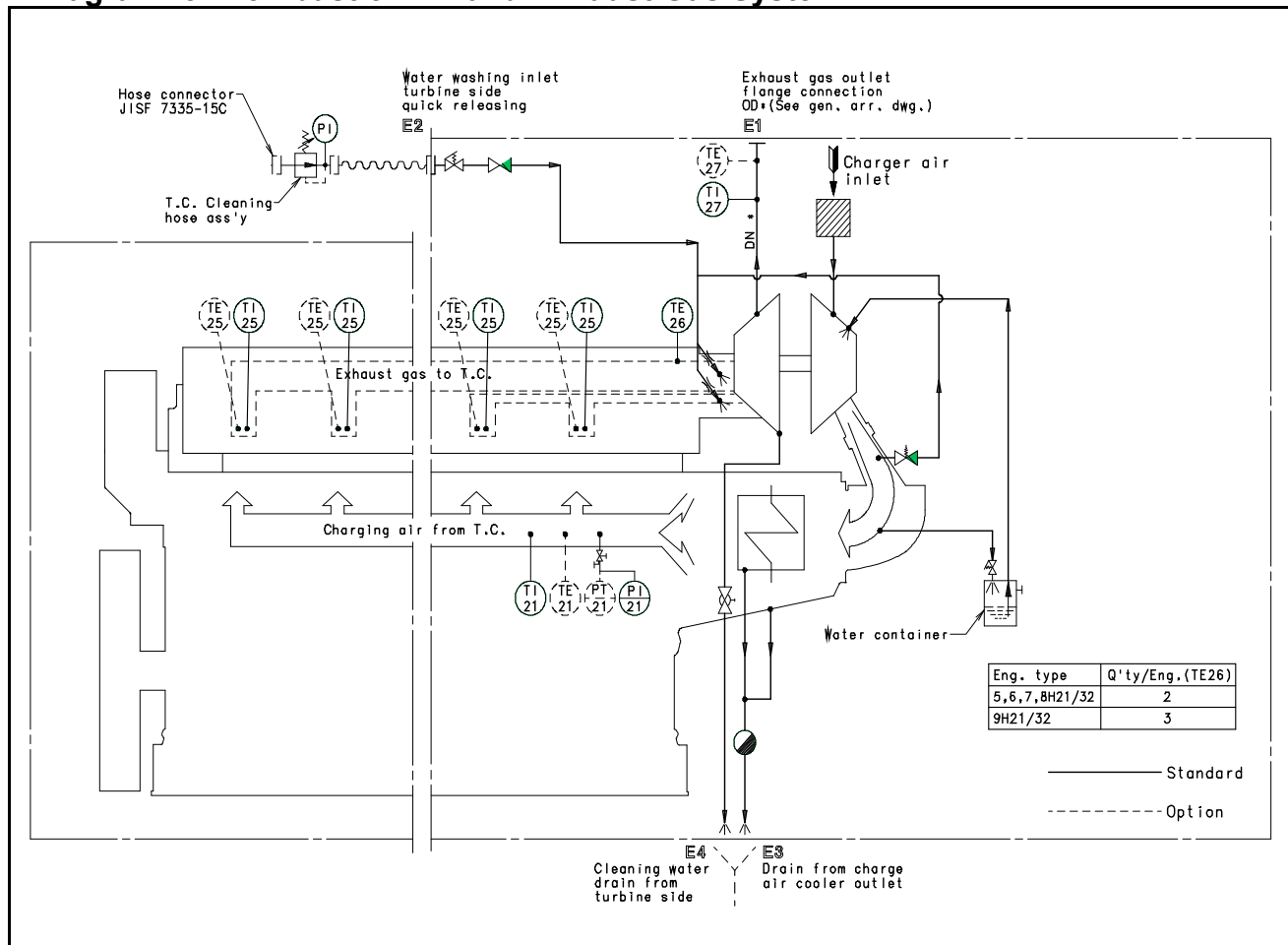


Diagram for Combustion Air and Exhaust Gas System



General Description

The air required for combustion is taken from the engine room through a filter fitted on the turbocharger. It is imperative that the combustion air be free from sea water, dust and fumes etc.

Turbocharger is a radial uncooled type with high efficiency and mounted on the feed module of the engine. The water washing systems for the compressor and turbine are supplied as standard.

Charge Air Cooler is a one stage fresh water cooled type. A sea water cooled type charge air cooler is not recommended in general.

Charge air waste gate valve can be installed as optional for increasing exhaust gas temperature (for active SCR) or operating of arctic condition.

Water Mist Catcher is installed between Charge Air Cooler and Air Chamber of Engine Block.

Air Chamber is incorporated into the Engine Block with large volume for even distribution of induced air to each cylinder.

Exhaust Pipe System is a Pulse type, which has better performance at low load with good acceleration. In this case, a Jet Air system may be required to improve acceleration.

Water Drain Pipes are installed for the Air Chamber, and Water Mist Catcher.

1. General

As the engines are consuming considerable amount of air in the engine room directly or the outdoor intake system is required, the design of combustion air is important not only for man-working but also for engine running. Various requirements are applicable depending on the ambient condition but the minimum requirements and recommendations for the engines are described as follows.

2. Combustion Air

Arrangement of air intake pipes should be made to supply fresh air for engine combustion, which should be free from any risk of water spray, exhaust gas, dust, oil mist and electric equipment, etc.

In case of the engine room intake air system, the intake air temperature of the engine room would be increased by the radiation heat from the engines and generators. Therefore intake air ducts should be installed to face the air intake silencer for each turbocharger as close as possible.

In case of the outdoor direct intake air system, the independent intake air system should be applied for each turbocharger even for the case of engine with two or more turbochargers. A different intake air design for the engine of each project, please contact to HHI-EMD. The piping system of intake air should be considered to allow thermal expansion and harmful vibration to avoid stress of pipe. The end of deep slope position of intake air pipe, cleanable waste trap and water drain should be prepared.

Combustion air intake pipe system, the air velocity must not exceed 15 m/s during engine running.

Prior to commissioning, the pressure loss must be checked nearby compressor side whether the depression of compressor air inlet must not exceed 200 mm WC maximum. The measuring point is approx. 1~2m before from the turbocharger air inlet casing.

Air consumption volume should be designed in accordance with " Engine Capacity Data " (P.02.200).

Air filtration should be prevented from the outdoor's sand, cement, dust, and other particles, all particles size are not to be entered Max. 5 μm and above.

Oil bath type filter are generally used for the industrial area, cement plants, and sand winded area. Recommendable pressure loss of oil bath intake filter is 50~70 mm WC and even of fouled condition, must be kept within 110 mm WC.

Environmental Condition of Max. particle size of dust is typically applied depending on site.

- . Non-industrial area in rain/dry condition
: 0.8 / 2 μm
- . Area of emissions, chimneys, work area
: 60 μm
- . Metropolitan area , residential/Industrial area
: 7 / 20 μm
- . Desert area, during sand storms
: 500 μm

3. Ventilation of Engine Room

To determine the amount of air ventilation for an engine room, all heat sources of the engine room should be considered.

[Total amount of ventilation of auxiliary engine]

$$= Q_c + Q_r + Q_v \text{ (m}^3/\text{h)}$$

where,

$Q_c \text{ (m}^3/\text{h)}$: Air required for engine combustion,

$Q_r \text{ (m}^3/\text{h)}$: Air required for engine radiation,

$$Q_r = \frac{\text{Engine radiation heat (kJ / h)}}{\text{Air conditioning factor (} Q_a = 12 \text{)}}$$

$Q_v \text{ (m}^3/\text{h)}$: Air required for other heat sources such as alternator and exhaust gas pipe , etc.

Note

Should outdoor intake air system, and shut-off of air intake be necessary, a special provision is required as option.

Air and Exhaust Gas System	External Exhaust Gas System	All Type	
		Sheet No. P.08.500	Page 1 / 2

1. General Requirements

Exhaust gas of the engine flows out from turbocharger to atmosphere via an external exhaust gas system, which may be comprised of expansion bellows, exhaust gas pipe, exhaust gas boiler (possibly) and silencer, exhaust gas ventilation unit, relief valve (or rupture disc), etc.

Independent exhaust gas system should be prepared for each engine even for the case of common boiler system with other engines. In case of applied two or more turbochargers on a single engine, the exhaust gas pipes are recommended to be combined into a Y-type forked pipe. And each exhaust gas pipe have to be symmetric and each exhaust gas flow should be no interference.

Back pressure of the exhaust system in total is recommended to be less than 300 mmWC at maximum countious rating. The maximum back pressure should not exceed 500 mmWC at maximum countious rating. Please see the 'correction of fuel oil consumption' for the fuel consumption correction in case of exceeding 300 mmWC at maximum countious rating. The measuring position is approx. 1 ~ 2 m after the turbocharger gas outlet casing.

Recommended velocity external exhaust gas piping is recommended to be designed that velocity of exhaust gas through pipes should not exceed approximately 40 m/sec at maximum continuous rating.

Insulation of the whole exhaust system is required for the safety and to reduce noise and loss of thermal energy, which, of course, should comply with requirements of classification society and other related authorities.

2. Piping Design for Exhaust Gas System

In order to have lower back pressure and thermal loss, following design consideration is required;

- Pipe should be as short and straight as possible. Pipe bendings are minimized and the bending radius should be as large as possible.
- A water separating pocket and drain should be provided on the pipe.
- Rigid (fixed) supports and movable supports must be provided considering the thermal expansion and vibration of pipes.

- The exhaust gas outlet of Turbocharger can be turned on request.

For more information, please refer to the sheet 'External Exh. Gas Pipe Connection (P.08.510)'.

3. Expansion Bellows

The expansion bellows has to be mounted between the turbocharger outlet and external exhaust gas pipe in order to compensate thermal expansion and mechanical vibration.

The expansion bellows are supplied separately as standard. However, an additional expansion bellows may be required depending on the actual length of exhaust pipe in total.

Note

1. The external exhaust pipe must not exert any force against the gas outlet on the engine.
2. The external exhaust pipe just on expansion bellows should be fixed rigidly so that turbocharger can be free from any forces from the external exhaust pipe.
3. The sturdy fixed-point support must be provided for the expansion bellows on the turbocharger. It should be positioned, immediately above the expansion bellows in order to prevent the transmission of forces, resulting from the weight, thermal expansion or lateral displacement of the exhaust piping, to the turbocharger.
4. The exhaust piping should be mounted with a slope towards the gas outlet on the engine. It is recommended to have drain facilities in order to be able to remove condensate or rainwater.

4. Installation Procedure for Exp. Bellows

- 1) The generating set (or engine) should be installed in its final position before any external pipes are connected.

- 2) Remove the counter flange from the engine connection, if fitted.

Air and Exhaust Gas System	External Exhaust Gas System	Sheet No. P.08.500	Page 2 / 2
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3) Fasten the counter flange temporarily to the outlet side of the bellows.

For the correct orientation of the bellows (flow direction), see the dimensional drawing.

4) Fasten the bellows to the engine temporarily.

5) Align the external pipe to the counter flange.

No axial, lateral or angular deflection of the bellows is allowed.

Anchor the external pipe to the steel structure within 1 m from flange.

Observe that the pipe clamping with bracket must be very rigid in order to prevent vibration and movement of the exhaust gas pipe.

Most problems with bursting and vibration originate from poor clamping and support.

Especially the support in the axial direction must be rigid.

6) Put some temporary protection cover between the flanges in order to prevent debris from falling into the turbocharger.

7) Tack weld the counter flange to the external pipe.

8) Remove the bellows and weld the flange finally to the external pipe.

9) Remove the protection cover.

Place the bellows with gaskets between the flanges.

10) Lubricate the threads of the connection screw with heat resistant grease and tighten first until finger tight. Finally tighten the screw in a diagonal sequence.

11) Remove the guide bar between the flanges of the bellows.

5. Exhaust Gas Boiler

Thermal energy of exhaust gas can be utilized by boiler. Please refer to the sheets 'Engine Capacity Data (P.02.200)' for the exhaust gas data.

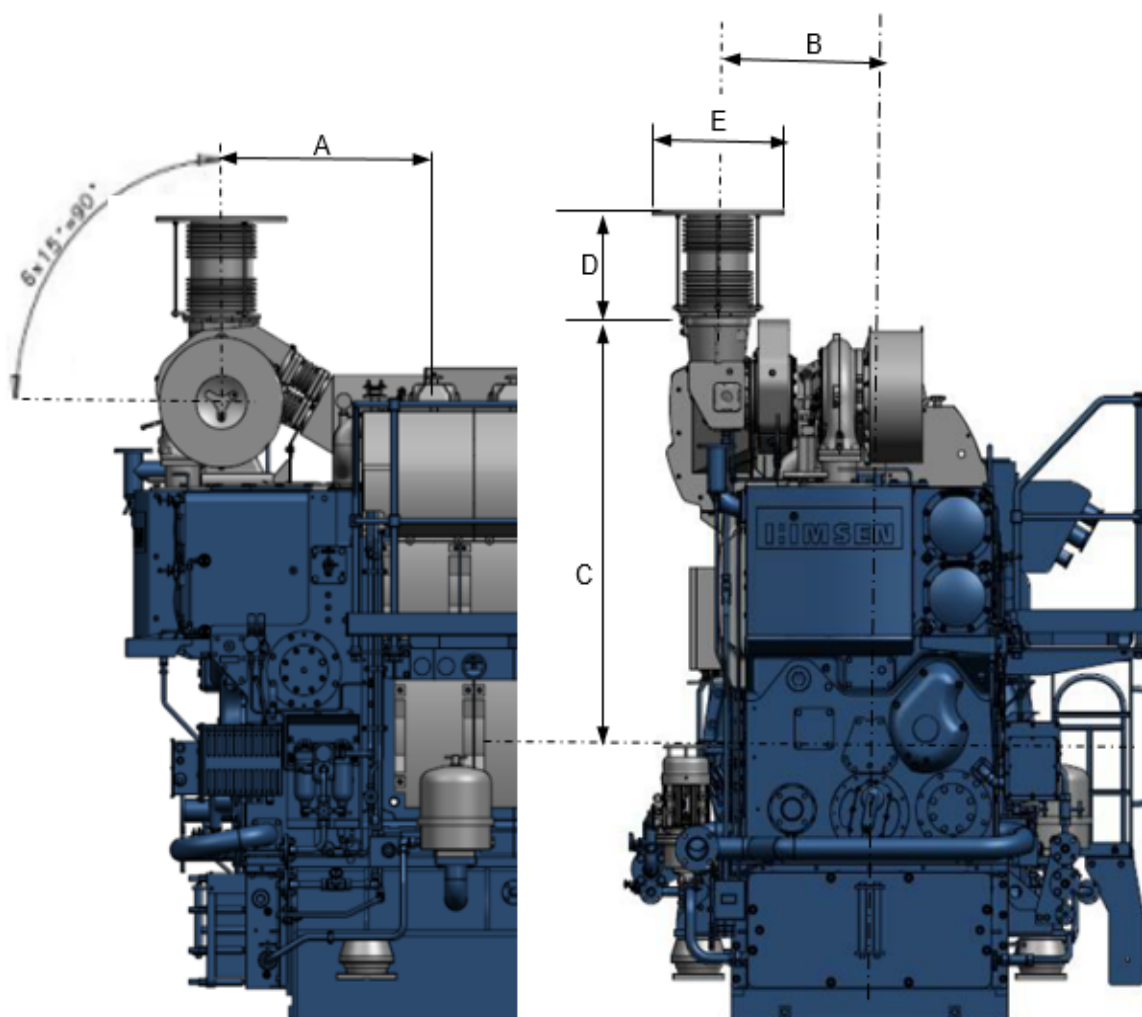
A boiler may be a separate unit for each engine or a common unit with other engines.

In any cases, however, the exhaust gas line for each engine should be separated from other engine's exhaust gas lines.

The back-pressure through boiler should be minimized to be within limited level for total exhaust gas system.

6. Exhaust Gas Silencer

Exhaust Gas Silencer can be supplied as option on request. The noise attenuation of silencer shall be either 25 dB(A) or 35 dB(A). For more information, please refer to the sheets for 'Exh. Gas Silencer (P.08.610/620)'.


Genset for 720 rpm (160 kW / cyl.)

Engine Type	Exh. Outlet Position(mm)				E	
	A	B	C	D	Size	Standard
5H21/32	909	579	1,632	372	350A	JIS F 7805
6H21/32	909	579	1,632	372	350A	JIS F 7805
7H21/32	745	625	1,700	402	400A	JIS F 7805
8H21/32	883	625	1,700	402	400A	JIS F 7805
9H21/32	847	748	1,831	482	450A	JIS F 7805

Genset for 900 rpm (200 kW / cyl.)

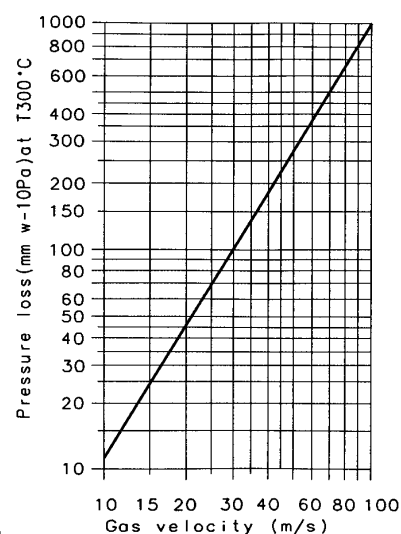
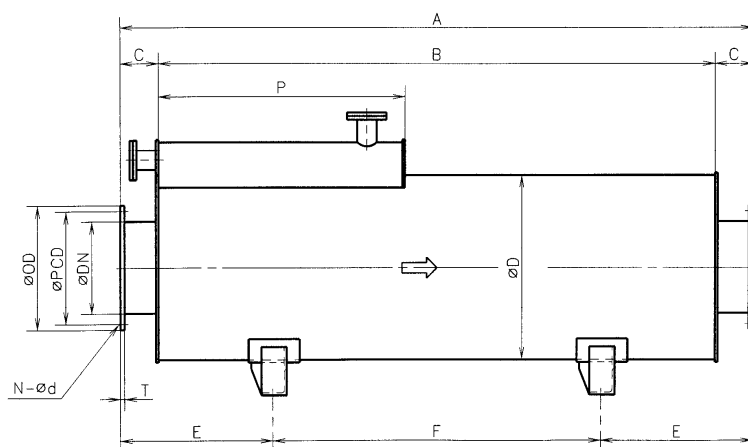
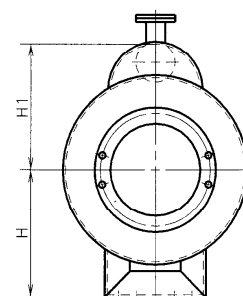
Engine Type	Exh. Outlet Position(mm)				E	
	A	B	C	D	Size	Standard
6H21/32	883	625	1,700	402	400A	JIS F 7805
7H21/32	883	625	1,700	402	450A	JIS F 7805
8H21/32	847	748	1,831	482	450A	JIS F 7805
9H21/32	847	748	1,831	482	500A	JIS F 7805

The silencer is of an absorption type delivered with spark arrestor and mounting bracket, excluding insulation.

The silencer can be mounted horizontally or vertically.

The gas flow passes through a straight perforated tube, surrounded with a efficient sound absorbing material. The silencer gives whereby an excellent sound attenuation suitable for even a wide operating range.

The gas pressure will be dropped into an approximate value shown on the graph, pressure loss vs. gas velocity.



25dB Type Silencer

Unit : mm

Cylinder type	DN	A	B	C	D	E	F	H	H1	P	PCD	OD	T	N-d	Weight (kg)
5-6 (720rpm)	350	2850	2550	150	710	600	1650	500	485	970	435	480	16	12-25	510
6 (900rpm) 7-8 (720rpm)	400	3100	2800	150	760	700	1700	520	514	1040	495	540	20	16-25	580
7-8 (900rpm) 9 (720rpm)	450	3400	3100	150	810	800	1800	550	554	1100	555	605	16	16-23	810
9 (900rpm)	500	3700	3400	150	860	850	2000	600	582	1180	605	655	16	20-23	920

35dB Type Silencer

Unit : mm

Cylinder type	DN	A	B	C	D	E	F	H	H1	P	PCD	OD	T	N-d	Weight (kg)
5-6 (720rpm)	350	4000	3700	150	710	1000	2000	500	485	970	435	480	16	12-25	545
6 (900rpm) 7-8 (720rpm)	400	4500	4200	150	760	1200	2100	520	514	1040	495	540	20	16-25	650
7-8 (900rpm) 9 (720rpm)	450	4900	4600	150	810	1250	2400	550	554	1100	555	605	16	16-23	900
9 (900rpm)	500	5400	5100	150	860	1350	2700	600	582	1180	605	655	16	20-23	1070

**Air and Exhaust
Gas System**
Exh. Silencer without Spark Arrestor

Sheet No.

P.08.610

Page

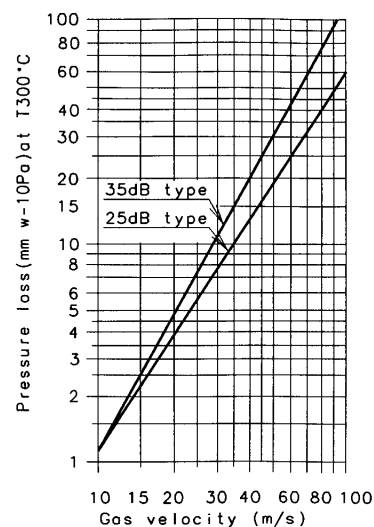
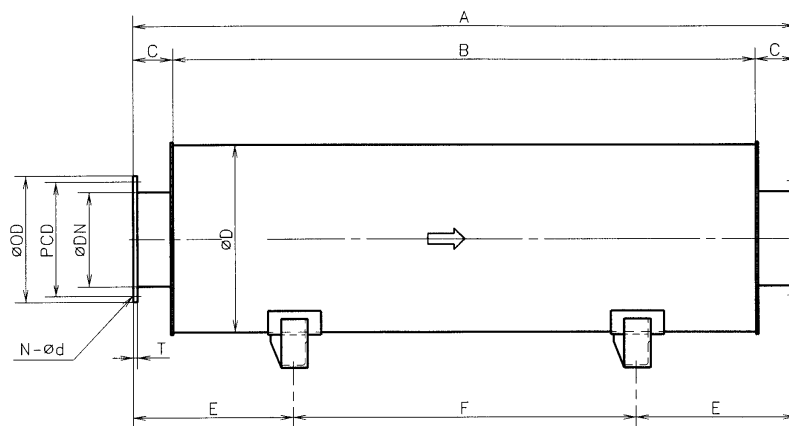
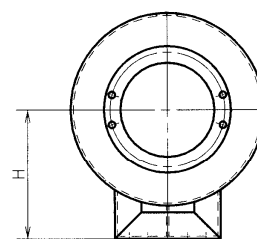
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Silencer is of an absorption type delivered with mounting bracket, excluding the spark arrestor and insulation.

The silencer can be mounted horizontally or vertically.

The gas flow passes through a straight perforated tube, surrounded with a efficient sound absorbing material. The silencer gives whereby an excellent sound attenuation suitable for even a wide operating range.

The gas pressure will be dropped into an approximate value shown on the graph, pressure loss vs. gas velocity.


25dB Type Silencer

Unit : mm

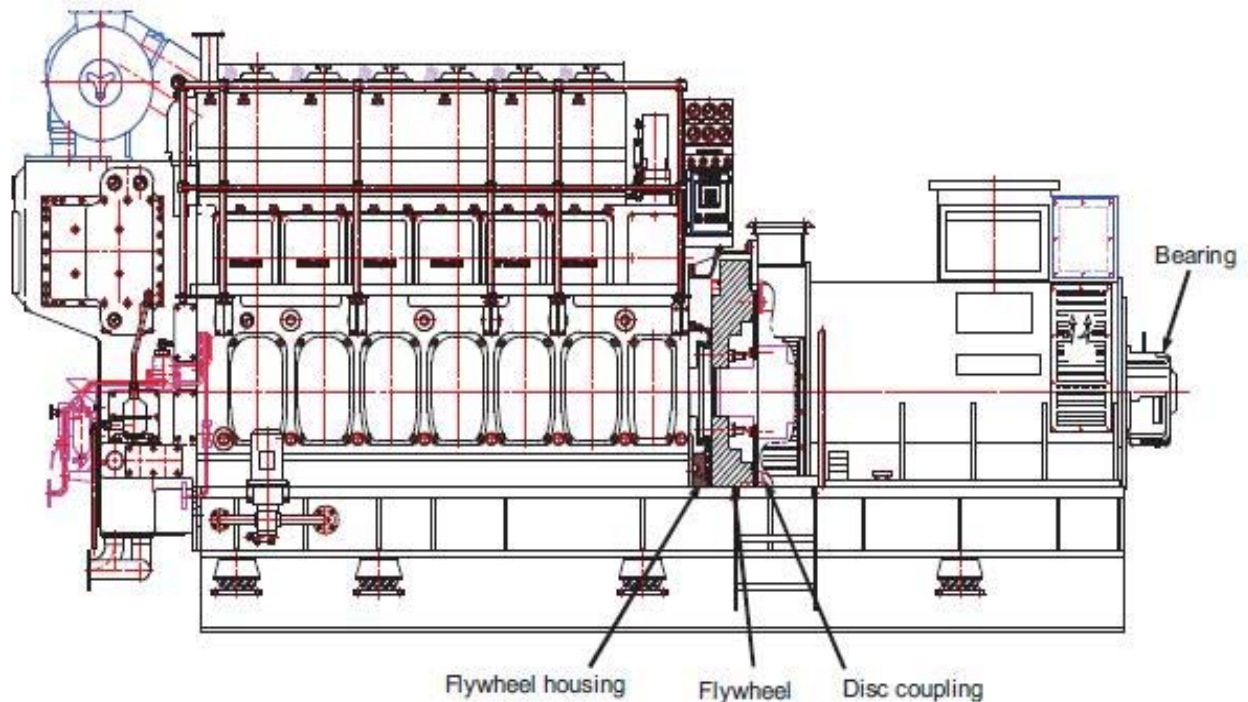
Cylinder type	DN	A	B	C	D	E	F	H	PCD	OD	T	N-d	Weight (kg)
5-6 (720rpm)	350	2600	2300	150	710	600	1400	500	435	480	16	12-25	430
6 (900rpm) 7-8 (720rpm)	400	2900	2600	150	760	700	1500	520	495	540	20	16-25	510
7-8 (900rpm) 9 (720rpm)	450	3200	2900	150	810	800	1600	550	555	605	16	16-23	710
9 (900rpm)	500	3500	3200	150	860	850	1800	600	605	655	16	20-23	830

35dB Type Silencer

Unit : mm

Cylinder type	DN	A	B	C	D	E	F	H	PCD	OD	T	N-d	Weight (kg)
5-6 (720rpm)	350	3500	3200	150	710	850	1800	500	435	480	16	12-25	490
6 (900rpm) 7-8 (720rpm)	400	4000	3700	150	760	1000	2000	520	495	540	20	16-25	585
7-8 (900rpm) 9 (720rpm)	450	4400	4100	150	810	1100	2200	550	555	605	16	16-23	865
9 (900rpm)	500	4900	4600	150	860	1200	2500	600	605	655	16	20-23	1035

Generator	Generator Information	Sheet No. P.08.700	Page 1 / 1
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Mounting of Generator

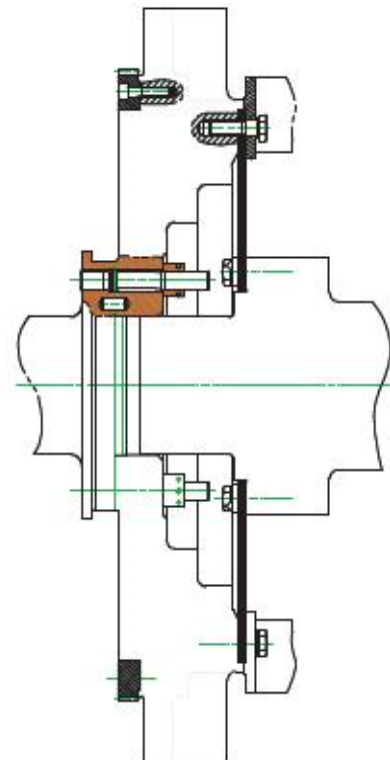
As a standard design of H21/32 engine, the engine and generator shall be rigidly mounted and disc coupled on common base frame .

Generator Bearing

Type of generator bearing is of single sleeve, self-lubricating type and mounted end of generator.

Optional Design

As special arrangement, double sleeve bearing, forced lubricating of generator bearing, cooler and flexible coupling can be applied as an optional design on request.



General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

Delivery and Maintenance **P.09.000**

Appendix

for Stationary Gen-Set

Major Overhaul Guidance

Section No.		Description	Overhaul Interval (hours)											Remark	
			Others	500 *)	1,500	3,000	6,000	9,000	12,000	15,000	18,000	21,000	24,000		
Major Fasteners - Confirmation															
M11100	A11100	Bolt for Base Frame and Resilient Mount		▲			◆								
G11100	-	Nut for Resilient Mount and Foundation		▲			◆								
	A13000	Bolt for Engine Block and Base Frame		◆			◆								
M13250	A13000	Hyd. Nut for Main Bearing Cap		◆			◆								
M21100	A13000	Hyd. Nut for Cylinder Head		◆			◆								
M25000	A25000	Bolt and Nut for Camshaft		▲			◆								
M31000	A32000	Hyd. Nut for Con-Rod (Shaft)		◆			◆								
M31000	A32000	Hyd. Nut for Con-Rod (Big-end)		◆			◆								
M33200	A33100	Hyd. Nut for Counter Weight		◆			◆								
M35300	A35000	Bolt and Nut for Timing Gear		▲			◆								
-	A81000	Bolt and Nut for Turbocharger Mounting		▲			◆								
Major Bearing															
M13250	A13250	Main Bearing					√				■				
M13250	A13250	Thrust Washer : Axial Clearance					◎						■		
M25000/M25300	A25300	Camshaft Bearing : Clearance					√		◎				■		
M32120	A32000	Con-Rod Bearing (Big-end)					√		■		■				
M32130	A32000	Con-Rod Bearing (Small-end)					√		■				■		
M35300	A35000	Bearing Bush for Idle Gear : Clearance											■		
Resilient Mount															
M11100	A11100	Resilient Mount		●			●							**)	
Cylinder Unit and Con. Rod															
M15100	A15000	Cylinder Liner					√		■						
M15100	A15000	Flame Ring					√		■						
M21100	A15000/A21100	Cylinder Head & Water Jacket Cooling Water Space					√		■						
M21120/M21130 /M21200	A21100/A21200	Intake/Exhaust v/v Spindle, Seat Ring and v/v Guide: Overhaul and Reconditioning					√		■		■				
M21210	A21200	Intake/Exhaust v/v : Clearance		●	●										**)
M21210	A21200	Rocker Arm Shaft and Bush					√		■						
M21220	A21200	Rotocap			○				■						
-	A22000	Indicator Valve							■						
M31100	A31100	Piston Rings					√		■						
M31100	A31100	Piston and Piston Pin					√		■						
M31100/M31101	A32000	Con-Rod Bore (Big-end)					√		■						
M31100/M32130	A32000	Piston Pin & Con-Rod (Small-end) : Clearance					√		■						
-	A32000	Shim Plate for Con-Rod					√		■						
-	A32000	Stud for Con-Rod Shaft											■		
<div>■ Expected life time</div> <div>■ Overhaul inspection</div> <div>● Check & adjustment</div> <div>○ Function test</div> <div>√ 1 Cylinder overhaul. If not good, check all cylinders.</div> <div>◆ Confirm tightening: Tighten with specified torque or hyd.pressure. Do not loosen!</div> <div>◎ Measuring or sampling without dismantling</div> <div>▲ Visual Inspection</div>															
*) These are not parts of normal maintenance interval, but, the confirmation or visual inspection of the specified ones to be carried out after Overhaul/New.															
**) During on board (site) commissioning, inspection is carried out by HHI-EMD service engineer.															
When doing maintenance and overhaul work, seals (o-rings & gaskets, etc.) should be renewed.															
The overhaul intervals and expected life time stated above are only for guidance as these depend on the actual service condition, the quality of used fuel or lubricating oil, the treatment of cooling water and so on.															

Delivery and Maintenance	Maintenance Schedule	Sheet No. P.09.100	Page 2 / 3
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for Stationary Gen-Set

Major Overhaul Guidance

Section No.		Description	Overhaul Interval (hours)											Remark
			Others	500 *)	1,500	3,000	6,000	9,000	12,000	15,000	18,000	21,000	24,000	
Crankshaft and Gears														
M33100	A33100	Crankshaft : Deflection					◎							***)
-	A33300/A42300	Gear Teeth on Flywheel & Turning Gear					▲							
-	A33400	Torsional Vibration Damper : Fluid sampling (Only for Viscous Damper)						◎						
-	A33500	Flexible Coupling (If applied)	▲											
M35300	A35000	Timing Gear and Pump Driving Gear : Clearance and Backlash						◎						
Valve Operating Mechanism														
M23000	A23000	Swing Arm Roller Shaft and Bush						■					■	
M25000	A23000/A25000	Contact Faces of Cam and Swing Arm Roller Camshaft Bearing		▲			▲							
Control System														
G40000	A41000	Fuel Control Linkage : Movement Check	○											Weekly
G40001	-	Safety Device : Function Check	○											Monthly
-	A41000	Governor Oil Level (Only for Mechanical Hydraulic Governor)	▲											*** Daily
M45200	A45200	Engine RPM Pick-up Sensor : Clearance					●							In case of necessity
M45200	A45200	Temperature / Pressure Sensor	○											
Fuel System														
G05100	-	Analyze Fuel Oil Properties : Sampling	◎											Every Bunkering
M51100	A51000	Fuel Injection Pump												
		- Deflector : Erosion			◎	■								
		- Plunger Assembly					■						■	
		- Delivery Valve Assembly (except case)					■		■					
		- Delivery Valve Case					■						■	
		- Roller Bush for Tappet							■				■	
M52000/M52002 /M52003	A52000	Fuel Injection Valve : Opening Pressure		●	●		■							****) ■ : Atomizer life time
M98380	A98380	Fuel Oil Shock Absorber (If applied)				■								If pressure drop reaches limit (See G01400)
M56000	A56000	Fuel Oil Filter	■											
Lubricating Oil System														
G06200	-	Analyze Lub. Oil Properties : Sampling	◎											Every 3 month
M61000	A61000	Lubricating Oil Pump						■						***)
M62000	A62000	Lubricating Oil Cooler	■											
M63000	A63000	Lubricating Oil Filter (Cartridge Type)	■		■									If pressure drop reaches limit (See G01400)
-	A63000	Auto Backwashing Filter (If applied)	■											***)
-	A64000	Thermostatic Valve : Clean & Check Elements						■						***)
M67000	A67000	Lubricating Oil Centrifugal Filter	■											***)
<div>■ Expected life time ■ Overhaul inspection ● Check & adjustment ○ Function test</div> <div>√ 1 Cylinder overhaul. If not good, check all cylinders. ◆ Confirm tightening: Tighten with specified torque or hyd.pressure. Do not loosen! ◎ Measuring or sampling without dismantling ▲ Visual Inspection</div> <p>*) These are not parts of normal maintenance interval, but, the confirmation or visual inspection of the specified ones to be carried out after Overhaul/New.</p> <p>***) See maker manual recommendation.</p> <p>****) Regardless of the normal check and adjustment interval, if the exhaust gas temperature deviation alarm occurs, individual cylinders should be inspected according to M52000.</p> <p>When doing maintenance and overhaul work, seals (o-rings & gaskets, etc.) should be renewed.</p> <p>The overhaul intervals and expected life time stated above are only for guidance as these depend on the actual service condition, the quality of used fuel or lubricating oil, the treatment of cooling water and so on.</p>														

Delivery and Maintenance	Maintenance Schedule	Sheet No. P.09.100	Page 3 / 3
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for Stationary Gen-Set

Major Overhaul Guidance

Section No.		Description	Overhaul Interval (hours)												Remark
			Others	500 *)	1,500	3,000	6,000	9,000	12,000	15,000	18,000	21,000	24,000		
Cooling Water System															
G07100	-	Analyze Cooling Water Properties : Sampling	☉											Weekly : Test Kit Every 3 month : Lab. Test	
M71000	A71000	Cooling Water Pump							■						
-	A74000	Thermostatic Valve : Clean & Check Elements							■					***)	
M75000	A75000	Water Drain Line : Cleaning	●											Weekly (Depend on condition)	
Compressed Air System															
O02300	-	Air Running	○											Monthly	
G40000	-	Check Starting & Stop Syatem	○											Weekly (Over a Week Stand-still Condition)	
-	A42100	Starting Air Motor	■											***)	
Combustion air system															
G81000	A75000	Charge air condensate drain pipe	●											Weekly	
M80000	A83000	Turbocharger	■											***)	
		- Clean Air Filter (Only for Filter Silencer type)	■		■									Every 500hrs running	
		- Turbine : Water-washing	●											Every 200hrs running	
		- Compressor : Water-washing	●											Every 24~50hrs running	
M84000	A84000	Charge Air Cooler							■						

- Expected life time
- Overhaul inspection
- Check & adjustment
- Function test

- √ 1 Cylinder overhaul. If not good, check all cylinders.
- ◆ Confirm tightening: Tighten with specified torque or hyd.pressure. Do not loosen!
- ☉ Measuring or sampling without dismantling
- ▲ Visual Inspection

*) These are not parts of normal maintenance interval, but, the confirmation or visual inspection of the specified ones to be carried out after Overhaul/New.
 ***) See maker manual recommendation.

When doing maintenance and overhaul work, seals (o-rings & gaskets, etc.) should be renewed.

The overhaul intervals and expected life time stated above are only for guidance as these depend on the actual service condition, the quality of used fuel or lubricating oil, the treatment of cooling water and so on.

Delivery and Maintenance	Recommended Wearing Parts	Sheet No. P.09.200	Page 1 / 2
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for Stationary Gen-Set

List of Consumable Parts for one engine
(C=Number of cylinder / U=Number of unit)

Section No.	Parts Description	Quantity for the operating hours								
		set/ea	0-3000	0-6000	0-9000	0-12000	0-15000	0-18000	0-21000	0-24000
	Covers for Engine Block									
A17000	Gaskets for gear case cover	set	-	1	1	2	2	3	3	4
A19300	O-ring for crankcase cover	ea	-	2 x C	2 x C	4 x C	4 x C	6 x C	6 x C	8 x C
A19300	O-ring for camshaft cover	set	-	1 x C	1 x C	2 x C	2 x C	3 x C	3 x C	4 x C
A21100	O-rings for cylinder head cover	ea	0.5 x C	1 x C	1.5 x C	2 x C	2.5 x C	3 x C	3.5 x C	4 x C
	Bearings									
A13250	Main bearing (upper & lower)	set	-	-	-	-	-	1xC+2	1xC+2	1xC+2
A13250	Thrust washer	ea	-	-	-	-	-	-	-	2
A25300	Camshaft bearing	ea	-	-	-	-	-	-	-	1xC+1
A32000	Big-end bearing (upper & lower)	set	-	-	-	-	-	1 x C	1 x C	1 x C
A32000	Small-end bearing	ea	-	-	-	-	-	-	-	1 x C
A35000	Bearing bush for idle gear	ea	-	-	-	-	-	-	-	1
	Cylinder Unit and Con-Rod									
A15000	Flame ring	ea	-	-	-	1 x C	1 x C	1 x C	1 x C	2 x C
A15000	O-rings & gasket for cylinder liner / cooling water jacket	set	-	1	1	1xC+1	1xC+1	2xC+1	2xC+1	3xC+1
A21100	O-ring for cylinder head	ea	-	1	1	1xC+1	1xC+1	2xC+1	2xC+1	3xC+1
A21100	Bush & O-ring for fuel valve	set	-	-	-	1 x C	1 x C	1 x C	1 x C	2 x C
A21100	O-rings for valve guide & exh. valve seat ring	set	-	-	-	1 x C	1 x C	2 x C	2 x C	3 x C
A21100	Intake v/v spindle, seat ring and v/v guide	set	-	-	-	-	-	1 x C	1 x C	1 x C
A21100	Exhaust v/v spindle, seat ring and v/v guide	set	-	-	-	-	-	1 x C	1 x C	1 x C
A22000	Indicator v/v complete	set	-	-	-	1 x C	1 x C	1 x C	1 x C	2 x C
A23000	Roller bush for swing arm	ea	-	-	-	-	-	-	-	1 x C
A31100	Piston top ring / 2nd ring / scraper ring	set	-	-	-	1 x C	1 x C	1 x C	1 x C	2 x C
A32000	Shim plate for con-rod	ea	-	-	-	1 x C	1 x C	1 x C	1 x C	2 x C
A32000	Stud for con-rod shaft	ea	-	-	-	-	-	-	-	4 x C
	Fuel System									
A51000	Plunger assembly for fuel pump	ea	-	-	-	-	-	-	-	1 x C
A51000	O-rings & seal ring for plunger ass'y	set	-	1 x C	1 x C	2 x C	2 x C	3 x C	3 x C	4 x C
A51000	Gaskets & seal ring for fuel pump	set	-	-	-	-	-	-	-	1 x C
A51000	Deflector & gasket for fuel pump	set	1 x C	2 x C	3 x C	4 x C	5 x C	6 x C	7 x C	8 x C
A51000	Delivery valve assembly (except case)	set	-	-	-	1 x C	1 x C	1 x C	1 x C	2 x C
A51000	Delivery valve case	ea	-	-	-	-	-	-	-	1 x C
A51000	O-ring for fuel pump	set	-	1 x C	1 x C	2 x C	2 x C	3 x C	3 x C	4 x C
A51000	O-ring for fuel pump drive	ea	-	-	-	-	-	-	-	1 x C
A52000	Fuel injection nozzle with dowel pin	set	-	1 x C	1 x C	2 x C	2 x C	3 x C	3 x C	4 x C
A52000	O-rings & gasket for fuel injection valve	set	2 x C	4 x C	6 x C	8 x C	10 x C	12 x C	14 x C	16 x C
A52300	O-rings for fuel injection pipe block	set	2 x C	4 x C	6 x C	8 x C	10 x C	12 x C	14 x C	16 x C
A53000	O-rings for fuel feed pipe connection	set	-	1	1	2	2	3	3	4

Delivery and Maintenance	Recommended Wearing Parts	Sheet No. P.09.200	Page 2 / 2
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for Stationary Gen-Set

Section No.	Parts Description	Quantity for the operating hours								
		set/ea	0-3000	0-6000	0-9000	0-12000	0-15000	0-18000	0-21000	0-24000
	Lubricating Oil System									
A61000	Bushes for lub. oil pump	set	-	-	-	1 x U	1 x U	1 x U	1 x U	2 x U
A61000	O-rings for lub. oil pump	set	-	-	-	1 x U	1 x U	1 x U	1 x U	2 x U
A62000	O-ring for lub. oil cooler connection (Installation on engine side)	set	-	-	-	10	10	10	10	20
A63000	Lub. oil filter cartridge (Paper cartridge type)	ea	2 x U	4 x U	6 x U	8 x U	10 x U	12 x U	14 x U	16 x U
A63000	O-rings for lub. oil filter assembly (Paper cartridge type)	set	1 x U	2 x U	3 x U	4 x U	5 x U	6 x U	7 x U	8 x U
A64000	O-ring for lub. oil thermostat valve	ea	-	-	-	1 x U	1 x U	1 x U	1 x U	2 x U
A64000	Gasket for thermostatic valve cover	ea	-	-	-	1	1	1	1	2
A67000	Spare parts for centrifugal filter (See manual for centrifugal filter)	set	-	-	-	-	-	-	-	-
	Cooling Water System									
A71000	Oil seal, mechanical seal & O-ring for HT and LT-pump	set	-	-	-	1 x U	1 x U	1 x U	1 x U	2 x U
A74000	O-ring for C.W thermostat valve (Wax type installed on engine)	ea	-	-	-	1 x U	1 x U	1 x U	1 x U	2 x U
A74000	O-ring for thermostatic valve housing (Wax type installed on engine)	ea	-	-	-	1 x U	1 x U	1 x U	1 x U	2 x U
A77000	O-ring for cooling water connection	ea	-	3	3	6	6	9	9	12
A78000	O-ring for cyl.head cooling water connection	ea	-	8	8	4xC+6	4xC+6	4xC+14	4xC+14	8xC+12
	Supercharging System									
A81000	Gaskets and O-ring for compressor out	set	-	-	-	1	1	1	1	2
A82000	Gasket for connection flange	ea	-	1	1	1xC+1	1xC+1	2xC+1	2xC+1	3xC+1
A83000	O-rings and gaskets for T/C connection	set	-	-	-	1	1	1	1	2
	Charge Air Cooler									
A84000	O-rings and gaskets for air cooler	set	-	-	-	1	1	1	1	2
	Turbocharger									
	Turbine nozzle ring (See manual for turbocharger)	ea	-	-	-	1	1	1	1	2
	Spare parts for turbocharger (See manual for turbocharger)	set	-	-	-	-	-	-	-	-
	Air filter mat (Engine room air suction)	ea	2	4	6	8	10	12	14	16

Delivery and Maintenance	List of Recommended Spare Parts	Sheet No. P.09.300	Page 1 / 2
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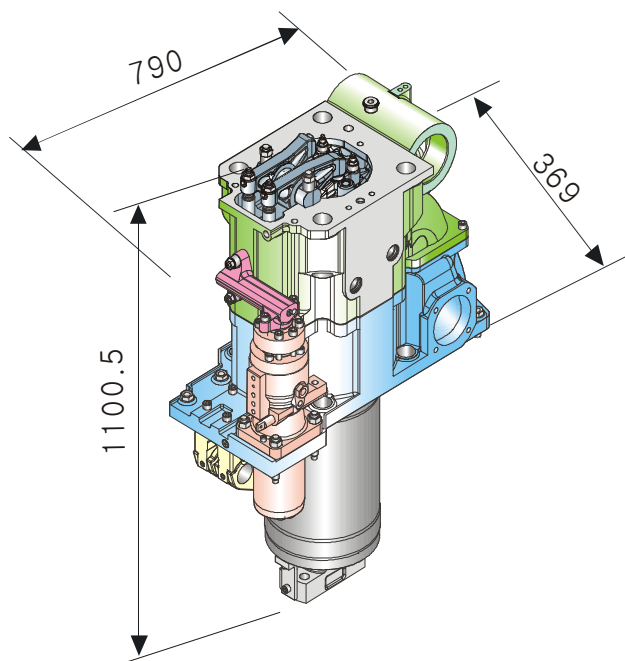
List of minimum Spare Parts for each plant

Parts Description	Q'ty	Sec. No.	Item No.	Remark
Engine Block and Covers				
Main bearing, upper	1	A13250	251	
Main bearing, lower	1	A13250	251	
Thrust washer	2	A13250	252	
Main bearing stud	2	A13000	231	
Nut for main bearing stud	2	A13000	232	
O-ring for crankcase door	1	A19300	384	
Cylinder Head				
Valve spindle, intake	2	A21200	201	
Valve spindle, exhaust	4	A21200	202	
Conical piece	6	A21200	206	
Valve spring	6	A21200	203	
Intake valve seat ring	2	A21100	111	
Exhaust valve seat ring	4	A21100	112	
Valve guide	6	A21100	113	
Roto cap	6	A21200	204	
O-ring for cylinder head	2	A21100	903	
O-ring for Exhaust valve seat ring	4	A21100	118	
O-ring for valve guide	6	A21100	291	
Sealing for cylinder head cover	1	A21100	805	
O-ring for cooling water connection	1	A15000	923	
O-ring for cooling water connection	1	A15000	922	
O-ring for cooling water connection	2	A15000	932	
O-ring for cooling water connection	4	A78000	712	
O-ring for cooling water jacket	1	A15000	901	
O-ring for cooling water jacket	1	A15000	902	
O-ring for cooling water jacket	2	A15000	903	
Piston, Connecting Rod and Cyl. Liner				
Piston pin	1	A31100	120	
Piston ring, top	1	A31100	151	
Piston ring, 2nd	1	A31100	152	
Piston ring, scraper	1	A31100	153	
Connecting rod big end bearing	1	A32000	120	
Small end bearing bush	1	A32000	130	
Stud for connecting rod big-end, M30	2	A32000	191	
Stud for connecting rod shaft, M20	4	A32000	194	
Nut for connecting rod big-end stud, M30	2	A32000	192	
Nut for connecting rod shaft stud, M20	4	A32000	195	
Shim plate	1	A32000	196	
Cylindrical pin	4	A32000	193	
Metal gasket for cylinder liner	1	A15000	191	
O-ring for cylinder liner	1	A15000	192	
O-ring for cylinder liner	1	A15000	193	

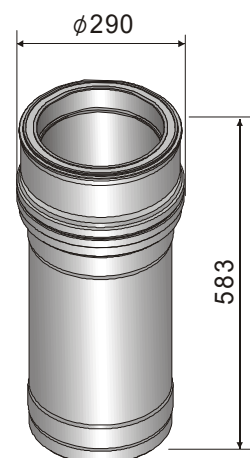
Delivery and Maintenance	List of Recommended Spare Parts	Sheet No. P.09.300	Page 2 / 2
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List of minimum Spare Parts for each plant

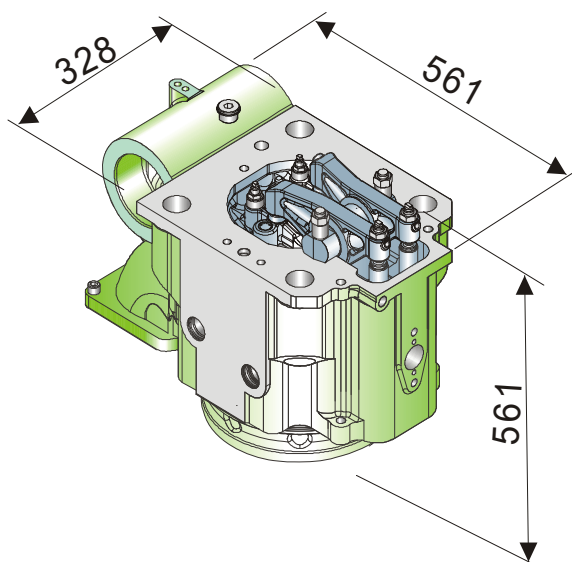
Parts Description	Q'ty	Sec. No.	Item No.	Remark
Fuel Injection Equipment				
Fuel injection pump	1	A51000	100	N:Half of max. cyl.no.
Fuel injection valve	N	A52000	100	
Fuel high pressure block	1	A52300	200	
Piping System				
Flexible connecting pipe, each type	1 set	A98370	–	
Paper insert for centrifugal filter(If applied)	1 set	A67000	701	
Lube oil filter, 1st filter	1 set	A63000	702	
Air & Exhaust Gas System				
Gasket for air cooler cover	1	A84000	111	
Gasket for air cooler cover	1	A84000	122	
Supercharging System				
Air cooler spare	1 set	–	–	Maker Standard



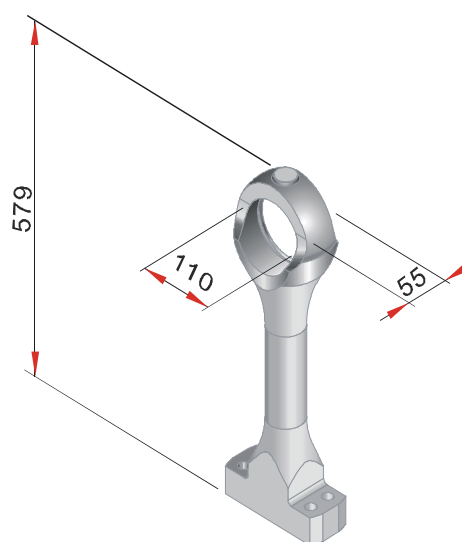
Cylinder unit
Approx. 404 kg



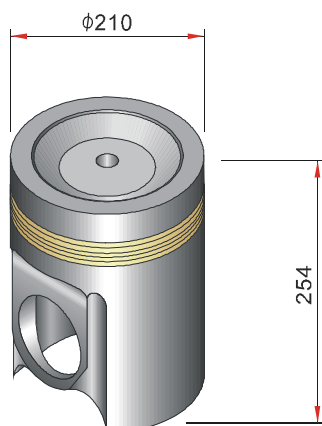
Cylinder liner
Approx. 70 kg



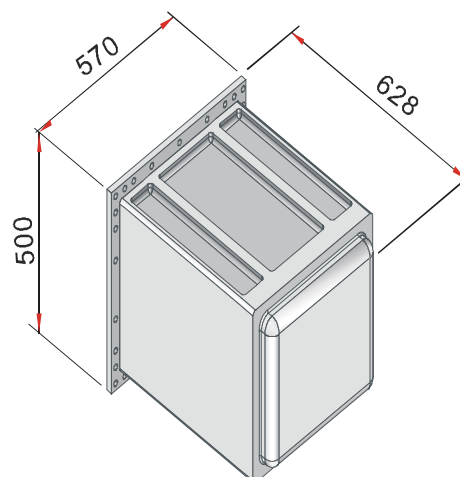
Cylinder head and rocker arms assembly
Approx. 165 kg



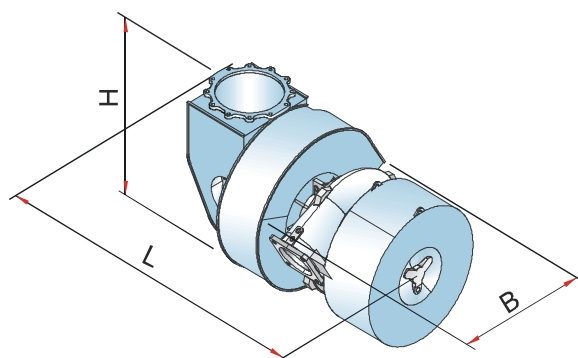
Connecting rod shaft
Approx. 22.5 kg



Piston
Approx. 24.4 kg



Air Cooler
Approx. 252 kg



Turbocharger

Turbocharger type	B	H	L	Weight(kg)
HPR3000, ST3	425	449	930	135
HPR4000, ST4	516	527	1080	190
HPR5000, ST5	610	690	1320	335
TPS48, A130	448	511	926	129
TPS52, A135	518	589	1074	187
TPS57, A140	631	720	1311	300

Delivery and Maintenance	Commissioning Spare Parts	Sheet No. P.09.500	Page 1 / 2
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for Stationary Gen-Set

List of minimum Spare Parts for each plant

Parts Description	Q'ty	Sec. No.	Item No.	Remark
Cylinder Head				
Intake valve seat ring	2	A21100	111	
Exhaust valve seat ring	2	A21100	112	
Intake valve spindle	2	A21200	201	
Exhaust valve spindle	2	A21200	202	
Fuel Injection Equipment				
Fuel injection pump complete	1	A51000	100	
Thrust washer	-	A51000	-	
Fuel injection valve complete	1	A52000	100	
Atomizer for fuel injection nozzle	2	A52000	012	
Dowel pin for fuel injection nozzle	4	A52000	005	
Fuel high press block	1	A52300	100	
Sealing & O-ring				
Metal gasket for cylinder liner	1	A15000	191	
O-ring for cylinder liner	1	A15000	192	
O-ring for cylinder liner	1	A15000	193	
O-ring for cooling water jacket	1	A15000	901	
O-ring for cooling water jacket	1	A15000	902	
O-ring for cooling water jacket	2	A15000	903	
O-ring for cooling water jacket fuel oil pump side	1	A15000	907	
O-ring for cooling water connection	1	A15000	922	
O-ring for cooling water connection	1	A15000	923	
O-ring for cooling water connection	2	A15000	932	
O-ring for connection piece	1	A15000	942	
O-ring for connection piece	1	A15000	943	
Oil sealing ring for crankcase cover	1	A19300	384	
Oil sealing ring for camshaft cover	2	A19300	388	
O-ring for exhaust valve seat ring	2	A21100	118	
O-ring for fuel valve bush	1	A21100	119	
Sealing ring for cylinder head cover	1	A21100	805	
O-ring for cylinder head	1	A21100	903	
O-ring for fuel injection valve	4	A52000	004	
O-ring for fuel high pressure block	2	A52300	116	
O-ring for fuel high pressure block	4	A52300	117	
O-ring for fuel feed pipe connection	2	A53000	117	
O-ring for fuel feed pipe connection	2	A53000	118	
Mechanical seal for cooling water pump	1	A71000	211	
Oil seal for cooling water pump	1	A71000	212	
O-ring for cooling water connection	4	A78000	712	
Bellows				
Gasket for exhaust pipe	4	A82000	284	
Gasket for exhaust pipe	9	A82000	287	
Axial compensator for T/C inlet	2	A82000	340	

Delivery and Maintenance	Commissioning Spare Parts	Sheet No. P.09.500	Page 2 / 2
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for Stationary Gen-Set

List of minimum Spare Parts for each plant

Parts Description	Q'ty	Sec. No.	Item No.	Remark
Sensors & Solenoid valves				
F.O leakage level switch	1	A45220	540	
Level switch with L.O sump tank	1	A45215	680	
Temp. switch (70~120°C)	1	A45230	761	
Press switch (1~10bar)	1	A45260	—	
Engine rpm pick-up sensor	1	A45210	—	
Press. transmitter (0~6bar)	1	A45260	—	
Press. transmitter (0~6bar)	1	A45260	—	
Press. transmitter (0~10bar)	1	A45260	—	
Press. transmitter (0~10bar)	1	A45260	—	
Press. transmitter (0~16bar)	1	A45260	—	Option
Press. transmitter (0~40bar)	1	A45260	—	Option
Press. transmitter (PT51, 52)	1	A45260	510	
Press. transmitter PT71	1	A45260	710	
Diff. pressure switch	1	A45200	—	Option
Temp. transmitter (PT100, L:60)	1	A45230	—	
Temp. transmitter (PT100, L:80)	1	A45230	—	
Temp. transmitter for T/C inlet with plug	1	A45236	260	
Temp. transmitter for T/C outlet with plug	1	A45237	270	
Temp. transmitter for Exh. gas cyl. outlet	1	A45235	250	
Signal converter	1	A45200	—	Option
Oil mist detector	1	A45225	—	Option
Solenoid valve SV49	1	A42003	201	
Amplifier	1	A46002	—	
Pressure gauge & Thermometer				
Pressure gauge [0-6 bar]	1	A45100	203	
Pressure gauge [0-10 bar]	1	A45100	205	
Pressure gauge [0-16 bar]	1	A45100	208	
H-Thermometer [120°Cx100L]	1	A45101	001	
H-Thermometer [200°Cx60L]	1	A45101	002	
H-Thermometer [120°Cx120L]	1	A45101	003	
V-Thermometer [PF3/4x650°Cx100L]	1	A45101	004	
H-Thermometer [PF3/4x650°Cx200L]	1	A45101	005	

Delivery and Maintenance	List of Standard Tools	Sheet No. P.09.600	Page 1 / 2
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Tool Description	Q'ty	Tool.No.	Remark
Cylinder Head and Liner Lifting tool for cylinder head Fit/Removal device for valve conical clamping piece Grinding tool for cylinder head/liner/block Extract/Suspension device for cylinder liner Cylinder bore gauge Removing device for flame ring Feeler gauge for in/exhaust valve Air gun Plier for locking ring	1 1 1 1 1 1 1 1 1	91.110 91.120 91.140 91.150 91.260 91.270 91.280 91.620 91.940	
Piston and Connecting Rod Guide bush for piston Lifting tool (eye bolt M10) for piston Holding piece for crank pin bearing Suspension device for con-rod Guide support for con-rod Turning bracket for con-rod Clamping support for con-rod Support for con-rod & piston Plier 85 for piston pin locking ring Plier for piston ring opener Lapping device for intake/exhaust valve seat Removal device for exhaust valve seat	1 1 1 1 1 1 2 2 1 1 1 1	91.160 91.170 91.180 91.190 91.200 91.210 91.220 91.230 91.240 91.250 91.360 91.580	
Crankshaft and Main Bearing Lifting device for main bearing cap Fitting device for main bearing Deflection gauge for crankshaft	4 1 1	91.290 91.300 91.310	
Fuel Injection Valve Removal device for fuel injection valve Test tool for fuel valve nozzle Lapping device for injection valve bush Cleaning tool for fuel injection valve nozzle Removal tool for atomizer nut Long socket for nozzle nut Removal device for fuel valve bush	1 1 1 1 1 1 1	91.130 91.340 91.350 91.370 91.390 91.630 91.720	
General Tools Max. pressure indicator Spanner 3/4 for turning gear Extension bar 24 for turning gear T/V damper tool Extension bar 20 Removal device for cooling water connection Turbocharger cleaning hose valve Cleaning hose for turbocharger	1 1 1 1 1 1 1 Set 1	91.100 91.320 91.330 91.930 91.931 91.380 91.934 98.100	

Delivery and Maintenance	List of Standard Tools	Sheet No. P.09.600	Page 2 / 2
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Tool Description	Q'ty	Tool.No.	Remark
Hydraulic Tools Hydraulic jack (M39x2) for cylinder head/main bearing cap Hydraulic jack (M30x2) for side stud/con-rod big end/counter weight/flywheel Hydraulic jack (M20x1.5) for Con-rod shaft Angle piece Set of spare parts for Hyd. jack M39 Set of spare parts for Hyd. jack M30 Set of spare parts for Hyd. jack M20 Support (Hyd. jack M39) for main bearing cap Support (Hyd. jack M30) for side stud/con-rod big end Long support (Hyd. jack M30) for counter weight/flywheel Long support (Hyd. jack M39) for cylinder head Long support (Hyd. jack M20) for con-rod shaft Extension screw (Hyd. jack M39) for cylinder head Extension screw (Hyd. jack M30) for flywheel/counter weight Extension screw (Hyd. jack M20) for con-rod shaft Distributing piece (2-port) Distributing piece (4-port) High pressure hose (L=550) High pressure hose (L=3000) Turning pin (Ø10) Turning pin (Ø8) Pneumatic hydraulic pump Flexible air hose for pneumatic hydraulic pump	4 2 2 2 1 1 1 2 2 2 4 1 4 2 2 1 1 4 2 2 1 1 2 1	91.400 91.410 91.420 91.421 91.430 91.440 91.450 91.460 91.470 91.480 91.490 91.500 91.510 91.520 91.530 91.541 91.542 91.551 91.552 91.600 91.610 91.850 91.851	
Standard Tool Box Spare & Tool box	4	91.640	
Supercharging System Air cooler tool	1 Set	-	Maker supply

Delivery and Maintenance	List of General Tools	Sheet No. P.09.700	Page 1 / 1
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for Stationary Gen-Set

List of General Tools for Each Plant

Tool Description	Q'ty	Tool No.	Remark
Toque wrench(20-120NM)	1	91.820	
Toque wrench(50-300NM)	1	91.825	
Toque wrench(140-760NM)	1	91.830	
Wrench 100	1	99.100	
Wrench 200	1	99.110	
Wrench 300	1	99.120	
Plier 250	1	99.130	
Converter(from 1/2" to 3/4")	1	99.140	
Reducer(from 3/4" to 1/2")	1	99.150	
Tee handle 12.5	1	99.170	
Extension bar 06	1	99.180	
Extension bar 17	1	99.190	
Extension bar 19	1	99.200	
Extension bar 24	1	99.210	
Extension bar 36	1	99.220	
Extension bar 46	1	99.230	
Extension bar 60	1	99.240	
Eye bolt M16	4	99.250	
Eye bolt M20	4	99.260	
Spanner 10	1	99.270	
Spanner 12	1	99.280	
Spanner 13	1	99.290	
Spanner 14	1	99.300	
Spanner 17	1	99.310	
Spanner 19	1	99.320	
Spanner 22	1	99.330	
Spanner 24	1	99.340	
Spanner 27	1	99.350	
Spanner 30	1	99.360	
Spanner 32	1	99.370	
Spanner 36	1	99.380	
Spanner 41	1	99.390	
Spanner 46	1	99.400	
Spanner 50	1	99.410	
Box and key set	1	99.420	
Extension bar 24-long	1	99.460	
Socket wrench	1	99.470	

General Information **P.00.000**

Structural Design and Installation **P.01.000**

Performance Data **P.02.000**

Dynamic Characteristics and Noise **P.03.000**

Operation and Control System **P.04.000**

Fuel System **P.05.000**

Lubricating Oil System **P.06.000**

Cooling Water System **P.07.000**

Air and Exhaust Gas System **P.08.000**

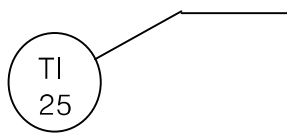
Delivery and Maintenance **P.09.000**

NO.	SYMBOL	SYMBOL DESIGNATION	NO.	SYMBOL	SYMBOL DESIGNATION
1. GENERAL CONVENTIONAL SYMBOLS					
1.1		PIPE	1.6		HIGH PRESSURED PIPE
1.2		PIPE WITH INDICATION OF DIRECTION OF FLOW	1.7		TRACING
1.3		VALVES, GATE VALVES, COCKS AND FLAPS	1.8		ENCLOSURE FOR SEVERAL COMPONENTS ASSEMBLED IN ONE UNIT
1.4		APPLIANCES			
1.5		INDICATING AND MEASURING INSTRUMENTS			
2. PIPES AND PIPE JOINT					
2.1		CROSSING PIPES, NOT CONNECTED	2.13		BLANK FLANGE
2.2		CROSSING PIPES, CONNECTED	2.14		SPECTACLE FLANGE
2.3		TEE PIPE	2.15		BULKHEAD FITTING WATER TIGHT, FLANGED
2.4		FLEXIBLE PIPE	2.16		BULKHEAD CROSSING, NON-WATERTIGHT
2.5		EXPANSION PIPE (CORRUGATED) GENERAL	2.17		TEST PIECE WITH PLUG
2.6		JOINT, SCREWED	2.18		ORIFICE
2.7		JOINT, FLANGED	2.19		REDUCER
2.8		JOINT, SLEEVE	2.20		OPEN DRAIN & AIR VENT
2.9		JOINT, HOSE COUPLING	2.21		ORIFICE
2.10		EXPANSION JOINT WITH GLAND	2.22		LOOP EXPANSION JOINT
2.11		EXPANSION PIPE	2.23		SNAP-COUPLING
2.12		CAP NUT			
3. VALVES, GATE VALVES, COCKS AND FLAPS					
3.1		VALVE, STRAIGHT THROUGH	3.10		FLAP, ANGLE
3.2		VALVE, ANGLE	3.11		REDUCING VALVE
3.3		STOP VALVE (SCREW ENDED)	3.12		SAFETY VALVE
3.4		VALVE, THREE-WAY	3.13		ANGLE SAFETY VALVE
3.5		NON-RETURN VALVE (FLAP) STRAIGHT	3.14		SELF-CLOSING VALVE
3.6		NON-RETURN VALVE (FLAP) ANGLE	3.15		QUICK-OPENING VALVE
3.7		NON-RETURN VALVE (FLAP) STRAIGHT, SCREW DOWN	3.16		QUICK-CLOSING VALVE
3.8		NON-RETURN VALVE (FLAP) ANGLE, SCREW DOWN	3.17		REGULATING VALVE
3.9		FLAP, STRAIGHT THROUGH	3.18		ANGLE VALVE

NO.	SYMBOL	SYMBOL DESIGNATION	NO.	SYMBOL	SYMBOL DESIGNATION
3.19		BALL VALVE(-COCK)	3.34		COCK,ANGLE,WITH BOTTOM CONNECTION
3.20		BUTTERFLY VALVE	3.35		COCK,THREE-WAY,WITH BOTTOM CONNECTION
3.21		GATE VALVE	3.36		SOLENOID VALVE
3.22		DOUBLE-SEATED CHANGEOVER VALVE	3.37		3-WAY TEST VALVE
3.23		SUCTION VALVE CHEST	3.38		THERMOSTATIC VALVE
3.24		SUCTION VALVE CHEST WITH NON RETURN VALVES	3.39		VALVE WITH TEST FLANGE
3.25		DOUBLE-SEATED CHANGEOVER VALVE,STRAIGHT	3.40		3-WAY VALVE WITH REMOTE CONTROL(ACTUATOR)
3.26		DOUBLE-SEATED CHANGEOVER VALVE,ANGLE	3.41		NON-RETURN VALVE(AIR)
3.27		COCK,STRAIGHT THROUGH	3.42		3/2 SPRING RETURN VALVE, NORMALLY CLOSED
3.28		COCK,ANGLE	3.43		2/2 SPRING RETURN VALVE, NORMALLY CLOSED
3.29		COCK,THREE-WAY,L-PORT IN PLUG	3.44		3/2 SPRING RETURN VALVE CONTR. BY SOLENOID
3.30		COCK,THREE-WAY,T-PORT IN PLUG	3.45		ON/OFF VALVE CONTROLLED BY SOLENOID AND PILOT DIRECTIONAL VALVE AND WITH SPRING RETURN
3.31		COCK,FOUR-WAY,STRAIGHT THROUGH IN PLUG			
3.32		COCK,WITH BOTTOM CONNECTION			
3.33		COCK,STRAIGHT THROUGH WITH BOTTOM CONNECTION			
4. CONTROL AND REGULATION PART					
4.1		HAND-OPERATED	4.11		AIR MOTOR DRIVEN
4.2		REMOTE CONTROL	4.12		MANUAL(AT PNEUMATIC VALVE)
4.3		SPRING	4.13		PUSH BUTTON
4.4		MASS	4.14		SPRING
4.5		FLOAT	4.15		SOLENOID
4.6		PISTON	4.16		SOLENOID AND PILOT DIRECTIONAL VALVE
4.7		MEMBRANE	4.17		BY PLUNGER OR TRACER
4.8		ELECTRO-MAGNETIC			
4.9		FLAME TRAP			
4.10		ELECTRIC MOTOR DRIVEN			
5. APPLIANCES					
5.1		MUDBOX	5.3		DUPLEX STRAINER
5.2		SIMPLEX STRAINER	5.4		MAGNETIC FILTER

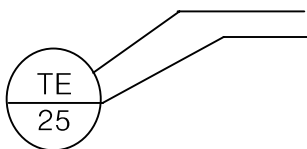
List of Symbols	Piping Symbols	Sheet No. Appendix 1	Page 3 / 3
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NO.	SYMBOL	SYMBOL DESIGNATION	NO.	SYMBOL	SYMBOL DESIGNATION
5.5		SEPARATOR	5.16		AIR FILTER WITH MANUAL CONTROL
5.6		STEAM TRAP	5.17		AIR FILTER WITH AUTOMATIC DRAIN
5.7		CENTRIFUGAL PUMP	5.18		WATER TRAP WITH MANUAL CONTROL
5.8		GEAR-OR SCREW PUMP	5.19		AIR LUBRICATOR
5.9		HAND PUMP (BUCKET)	5.20		SILENCER
5.10		EJECTOR	5.21		FIXED CAPACITY PNEUMATIC MOTOR WITH DIRECTION OF FLOW
5.11		VARIOUS ACCESSORIES (TEXT TO BE ADDED)	5.22		SINGLE ACTING CYLINDER WITH SPRING RETURNED
5.12		PISTON PUMP	5.23		DOUBLE ACTING CYLINDER WITH SPRING RETURNED
5.13		HEAT EXCHANGER	5.24		AUTO DRAIN TRAP
5.14		ELECTRIC PRE-HEATER			
5.15		AIR FILTER			
6. FITTINGS					
6.1		FUNNEL	6.10		SHORT SOUNDING PIPE WITH SELF-CLOSING COCK
6.2		BELL-MOUTHED PIPE END	6.11		STOP FOR SOUNDING ROD
6.3		AIR PIPE	6.12		OIL TRAY COAMING
6.4		AIR PIPE WITH NET	6.13		BEARING
6.5		AIR PIPE WITH COVER	6.14		WATER JACKET
6.6		AIR PIPE WITH COVER AND NET			
6.7		AIR PIPE WITH PRESSURE-VACUUM VALVE			
6.8		AIR PIPE WITH PRESSURE-VACUUM VALVE			
6.9		DECK FITTINGS FOR SOUNDING OR FILLING PIPE			
7. READING INSTRUMENTS WITH ORDINARY SYMBOL DESIGNATIONS					
7.1		SIGHT FLOW INDICATOR	7.5		COUNTER (INDICATE FUNCTION)
7.2		OBSERVATION GLASS	7.6		RECORDER
7.3		LEVEL INDICATOR			
7.4		DISTANCE LEVEL INDICATOR			

Symbol explanation


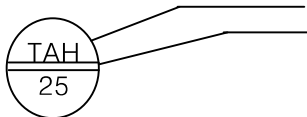
Measuring device
Locally reading

Temperature Indicator
No. 25*



Measuring device
Sensor mounted on engine/unit
Reading/identification mounted in a panel on the engine/unit

Temperature element
No. 25*



Measuring device
Sensor mounted on engine/unit
Reading/identification outside the engine/unit

Temperature Alarm High
No. 25*

*Refer to standard location and text for instruments on the following page

Specification of letter code for measuring devices	
1st letter	Following letters
F Flow	A Alarm
L Level	D Differential
P Pressure	E Element
S Speed, Solenoid	H High
T Temperature	I Indicating
U Voltage	L Low
V Viscosity	S Switching, Stop
Z Position	T Transmitting
	X Failure
	V Valve

General

Standard text for instruments

Diesel engine / generator

1. Combustion gas system

- | | | | |
|------|-----------------------------|------|--------------------------------|
| 21 | Charge air at cooler outlet | 25 | Exhaust gas at cylinder outlet |
| 26 | Exhaust gas at TC inlet | 27 | Exhaust gas at TC outlet |
| 49-1 | Alternator winding 1 | 49-2 | Alternator winding 2 |
| 49-3 | Alternator winding 3 | | |

2. Compressed air system

- | | | | |
|----|---|----|----------------------------------|
| 40 | Air starting valve / emergency stop valve | 41 | Compressed air at engine inlet |
| 42 | Turbocharger speed | 43 | Charge air condition valve |
| 45 | Stop solenoid on governor | 46 | Micro switch for turning gear |
| 47 | Engine speed | 48 | Overspeed |
| 49 | On-off v/v for shut down and overspeed stop | 50 | Fuel rack limiter solenoid valve |

3. Fuel oil system

- | | | | |
|----|--------------------------|----|-----------------------|
| 51 | Fuel oil at engine inlet | 52 | Fuel oil filter inlet |
| 54 | Leakage alarm tank | | |

4. Lub. oil system

- | | | | |
|----|--------------------------|----|--------------------------|
| 61 | Lub. oil at filter inlet | 62 | Lub. oil at engine inlet |
| 63 | Lub. oil at TC inlet | 65 | Prelubricating |
| 68 | Level in base frame | 92 | Oil mist detector |

5. Cooling water system

- | | | | |
|----|----------------------------|----|--------------------------------|
| 19 | Preheater | 71 | L.T. water at air cooler inlet |
| 75 | H.T. water at engine inlet | 76 | H.T. water at engine outlet |

NOTES

[illegible]

Global Leader

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