	Project Guides	Index

L21/31

L21/31

Introduction

I 00

General

Introduction

With this Project Guide we hope that we have provided you with a "tool" covering all necessary information required for project planning of the GenSet installation and making your daily work easier. Further, our Project Department is available with advices on more specific questions concerning the projecting.

All figures, values, measurements or information about performance stated in the project guide are for guidance only and shall not be used for detailed design purposes or as a substitute for specific drawings and instructions prepared for such purposes.

Our product range is constantly reviewed, developed and improved according to needs and conditions dectated. Therefore, we reserve the right to make changes in the technical specification and data without prior notice.

Concerning the alternator, the specific data depend on the alternator type.

Project related drawings and installation instructions will be forwarded in a Installation Manual, when the contract documentation has been completed.

The Installation Manual will comprise all necessary drawings, piping diagrams, cable plans and specifi-cations of our supply.

Code numbers

MAN B&W Holeby Diesel Identification No. **X XX XX X**

- **Code letter** — X
- **Function/system** — XX
- **Sub-function** — XX
- **Choice number** — X

Code letter: The code letter indicates the contents of the documents:

B	:	Basic Diesel engine / built-on engine
D	:	Designation of plant
E	:	Extra parts per engine
G	:	Generator
I	:	Introduction
P	:	Extra parts per plant

08028-0D/H5250/94.08.12

Function/system number: A distinction is made between the various chapters and systems, e.g.: Fuel oil system, monitoring equipment, foundation, test running, etc.

Sub-function: This figure varies from 0-99.

Choice number: This figure varies from 0-9:

0	:	General information	1	:	Standard
2-8	:	Standard optionals	9	:	Optionals

Key for Engine Designation

General

Engine Type Identification

The engine types of the MAN B&W programme are identified by the following figures:

6 L 28/32 H MCR

No of cylinders

5, 6, 7, 8, 9
12, 16, 18

Engine Type

L : In-line
V : V-built

Cyl. diam/stroke

16/24 : 160/240
21/31 : 210/310
23/30 : 225/300
27/38 : 270/380
28/32 : 280/320
32/40 : 320/400

Design Variant

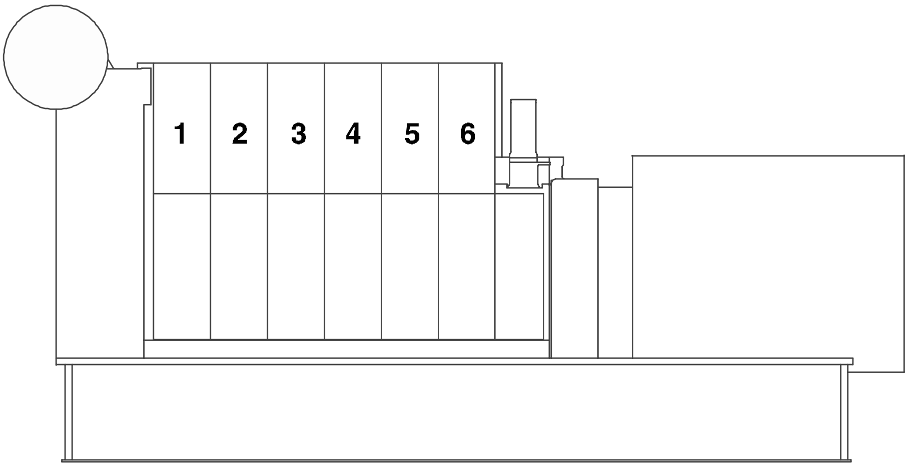
Rating

MCR : Maximum continuous rating
ECR : Economy continuous rating

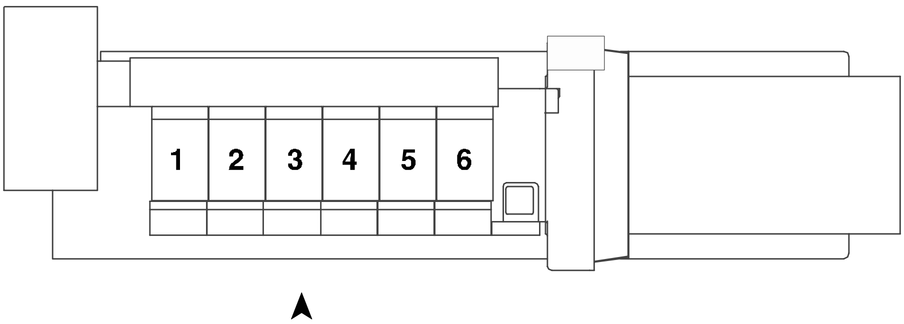
08028-0D/H5250/94.08.12

In-Line

Front end **Flywheel end**



Exhaust side / Right side

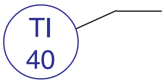


Service side / Fuel Pump side / Left side

08028-0D/H5250/94.08.12

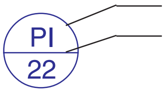
General

Explanation of Symbols



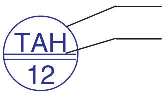
Measuring device
Local reading

Temperature **I**ndicator
No. 40 *



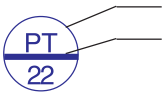
Measuring device
Sensor mounted on engine/unit
Reading/identification mounted in a panel on the engine/unit

Pressure **I**ndicator
No. 22 *



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

Temperature **A**larm **H**igh
No. 12 *



Measureing device
Sensor mounted on engine/unit
Reading/identification in a panel on the engine/unit and reading/indication outside the engine/unit

Pressure **T**ransmitting
No. 22 *

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

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, System	H	High
T	Temperature	I	Indicating
U	Voltage	L	Low
V	Viscosity	S	Switching, Stop
X	Sound	T	Transmitting
Z	Position	X	Failure
		V	Valve, Atuator

General

Standard Text for Instruments

Diesel Engine/Alternator

LT Water System

01	inlet to air cooler	04	inlet to alternator	07	inlet to lub. oil cooler
02	outlet from air cooler	05	outlet from alternator	08	inlet to fresh water cooler (SW)
03	outlet from lub. oil cooler	06	outlet from fresh water cooler (SW)	09	

HT Water System

10	inlet to engine	14	inlet to HT air cooler	17	outlet from fresh water cooler
10A	FW inlet to engine	14A	FW inlet to air cooler	18	inlet to fresh water cooler
11	outlet from each cylinder	14B	FW outlet from air cooler	19	preheater
12	outlet from engine	15	outlet from HT system	19A	inlet to prechamber
13	inlet to HT pump	16	outlet from turbocharger	19B	outlet from prechamber

Lubricating Oil System

20	inlet to cooler	24	sealing oil - inlet engine	28	level in base frame
21	outlet from cooler / inlet to filter	25	prelubricating	29	main bearings
22	outlet from filter / inlet to engine	26	inlet rocker arms and roller guides		
23	inlet to turbocharger	27	intermediate bearing / alternator bearing		

Charging Air System

30	inlet to cooler	34	charge air conditioning	38	
31	outlet from cooler	35	surplus air inlet	39	
32	jet assist system	36	inlet to turbocharger		
33	outlet from TC filter / inlet to TC compr.	37	charge air from mixer		

Fuel Oil System

40	inlet to engine	44	outlet from sealing oil pump	48	
41	outlet from engine	45	fuel-rack position	49	
42	leakage	46	inlet to prechamber		
43	inlet to filter	47			

Nozzle Cooling System

50	inlet to fuel valves	54		58	oil splash
51	outlet from fuel valves	55	valve timing	59	alternator load
52		56	injection timing		
53		57	earth/diff. protection		

Exhaust Gas System

60	outlet from cylinder	64		68	
61	outlet from turbocharger	65		69	
62	inlet to turbocharger	66			
63	compustion chamber	67			

Compressed Air System

70	inlet to engine	74	inlet to reduction valve	78	inlet to sealing oil system
71	inlet to stop cylinder	75	microswitch for turning gear	79	
72	inlet to balance arm unit	76	inlet to turning gear		
73	control air	77	waste gate pressure		

Load Speed

80	overspeed air	84	engine stop	88	index - fuel injection pump
81	overspeed	85	microswitch for overload	89	turbocharger speed
82	emergency stop	86	shutdown	90	engine speed
83	engine start	87	ready to start		

Miscellaneous

91	natural gas - inlet to engine	94	cylinder lubricating	97	remote
92	oil mist detector	95	voltage	98	alternator winding
93	knocking sensor	96	switch for operating location	99	common alarm

08028-0D/H5250/94.08.12

General

No	Symbol	Symbol designation
1.		GENERAL CONVENTIONAL SYMBOLS
1.1		Pipe
1.2		Pipe with indication of direction of flow
1.3		Valves, gate valves, cocks and flaps
1.4		Appliances
1.5		Indicating and measuring instruments
1.6		High-pressure pipe
1.7		Tracing
1.8		Enclosure for several components assembled in one unit
2.		PIPES AND PIPE JOINTS
2.1		Crossing pipes, not connected
2.2		Crossing pipes, connected
2.3		Tee pipe
2.4		Flexible pipe
2.5		Expansion pipe (corrugated) general
2.6		Joint, screwed
2.7		Joint, flanged
2.8		Joint, sleeve
2.9		Joint, quick-releasing
2.10		Expansion joint with gland
2.11		Expansion pipe
2.12		Cap nut
2.13		Blank flange

No	Symbol	Symbol designation
2.14		Spectacle flange
2.15		Orifice
2.16		Orifice
2.17		Loop expansion joint
2.18.		Snap coupling
2.19		Pneumatic flow or exhaust to atmosphere
3.		VALVES, GATE VALVES, COCKS AND FLAPS
		Valve, straight through
		Valve, angle
		Valve, three-way
		Non-return valve (flap), straight
		Non-return valve (flap), angle
		Non-return valve (flap), straight screw down
		Non-return valve (flap), angle, screw down
		Safety valve
		Angle safety valve
		Self-closing valve
		Quick-opening valve
		Quick-closing valve
		Regulating valve
		Ball valve (cock)
		Butterfly valve
		Gate valve

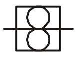
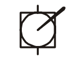
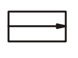
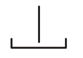
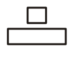
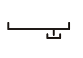
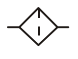
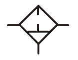
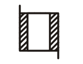
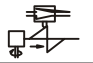
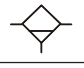
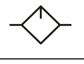
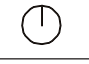
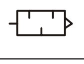
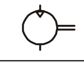
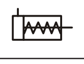
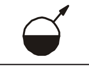
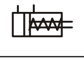
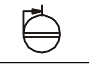
08028-0D\H5250\94.08.12

General

No	Symbol	Symbol designation	No	Symbol	Symbol designation
3.17		Double-seated changeover valve	4.		CONTROL AND REGULATION PARTS
3.18		Suction valve chest	4.1		Fan-operated
3.19		Suction valve chest with non-return valves	4.2		Remote control
3.20		Double-seated changeover valve, straight	4.3		Spring
3.21		Double-seated changeover valve, angle	4.4		Mass
3.22		Cock, straight through	4.5		Float
3.23		Cock, angle	4.6		Piston
3.24		Cock, three-way, L-port in plug	4.7		Membrane
3.25		Cock, three-way, T-port in plug	4.8		Electric motor
3.26		Cock, four-way, straight through in plug	4.9		Electromagnetic
3.27		Cock with bottom connection	4.10		Manual (at pneumatic valves)
3.28		Cock, straight through, with bottom conn.	4.11		Push button
3.29		Cock, angle, with bottom connection	4.12		Spring
3.30		Cock, three-way, with bottom connection	4.13		Solenoid
3.31		Thermostatic valve	4.14		Solenoid and pilot directional valve
3.32		Valve with test flange	4.15		By plunger or tracer
3.33		3-way valve with remote control (actuator)	5.		APPLIANCES
3.34		Non-return valve (air)	5.1		Mudbox
3.35		3/2 spring return valve, normally closed	5.2		Filter or strainer
3.36		2/2 spring return valve, normally closed	5.3		Magnetic filter
3.37		3/2 spring return valve contr. by solenoid	5.4		Separator
3.38		Reducing valve (adjustable)	5.5		Steam trap
3.39		On/off valve controlled by solenoid and pilot directional valve and with spring return	5.6		Centrifugal pump

08028-0D\H5250\94.08.12

General

No.	Symbol	Symbol designation	No.	Symbol	Symbol designation
5.7		Gear or screw pump	6. FITTINGS		
5.8		Hand pump (bucket)	6.1		Funnel / waste tray
5.9		Ejector	6.2		Drain
5.10		Various accessories (text to be added)	6.3		Waste tray
5.11		Piston pump	6.4		Waste tray with plug
5.12		Heat exchanger	6.5		Turbocharger
5.13		Electric preheater	6.6		Fuel oil pump
5.14		Air filter	6.7		Bearing
5.15		Air filter with manual control	6.8		Water jacket
5.16		Air filter with automatic drain	6.9		Overspeed device
5.17		Water trap with manual control	7. READING INSTR. WITH ORDINARY DESIGNATIONS		
5.18		Air lubricator	7.1		Sight flow indicator
5.19		Silencer	7.2		Observation glass
5.20		Fixed capacity pneumatic motor with direction of flow	7.3		Level indicator
5.21		Single acting cylinder with spring returned	7.4		Distance level indicator
5.22		Double acting cylinder with spring returned	7.5		Recorder
5.23		Steam trap			

08028-0D\H5250\94.08.12

General information

D 10

List of Capacities

L21/31

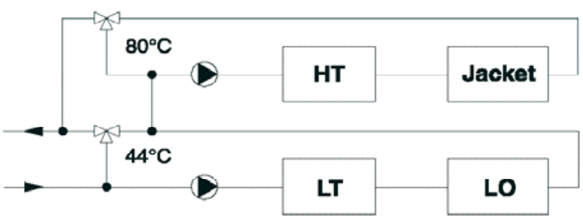
Maximum continuous rating at 900 Rpm.		Cyl. kW	5 950	6 1320	7 1540	8 1760	9 1980
Engine-driven pumps :							
LT cooling water pump	(1-2.5 bar)	m³/h	55	55	55	55	55
HT cooling water pump	(1-2.5 bar)	m³/h	55	55	55	55	55
Lubricating oil pump	(3-5 bar)	m³/h	31	31	41	41	41
External pumps :							
Max. delivery pressure of cooling water pumps		bar	2.5	2.5	2.5	2.5	2.5
Diesel oil pump	(5 bar at fuel oil inlet A1)	m³/h	0.65	0.91	1.06	1.21	1.36
Fuel oil supply pump	(4 bar discharge pressure)	m³/h	0.32	0.44	0.52	0.59	0.67
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	0.66	0.92	1.07	1.23	1.38
Cooling capacities :							
Lubricating oil		kW	195	158	189	218	247
LT charge air		kW	118	313	366	418	468
Total LT system		kW	313	471	555	636	715
* LT flow at 36°C inlet and 44°C outlet		m³/h	27.0	44.0	48.1	51.9	54.0
Jacket cooling		kW	154	274	326	376	427
HT charge air		kW	201	337	383	429	475
Total HT system		kW	355	611	709	805	902
* HT flow at 44°C inlet and 80°C outlet		m³/h	8.5	19.8	22.6	25.3	27.9
Total from engine		kW	668	1082	1264	1441	1617
LT flow from engine at 36°C inlet		m³/h	27.0	43.5	47.6	51.3	53.5
LT outlet temperature from engine at 36°C inlet		°C	55	58	59	61	63
(1-string cooling water system)							
Gas data :							
Exhaust gas flow		kg/h	6679	9600	11200	12800	14400
Exhaust gas temperature at turbine outlet		°C	335	348	348	348	348
Maximum allowable back pressure		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/h	6489	9330	10900	12400	14000
Starting air system :							
Air consumption per start incl. air for jet assist		Nm³	1.0	1.2	1.4	1.6	1.8
Heat radiation :							
Engine		kW		49	50	54	58
Alternator		kW	(See separate data from alternator maker)				

The stated heat balances are based on 100% load and tropical condition.

The mass flows and exhaust gas temperature are based on ISO ambient condition.

* The outlet temperature of the HT water is fixed to 80°C,
and 44°C for the LT water.
At different inlet temperature the flow will change accordingly.

Example: If the inlet temperature is 25°C then the LT flow will change to (44-36)/(44-25)*100 = 42% of the original flow.
The HT flow will not change.



08028-0D/H5250/94.08.12

List of Capacities

L21/31

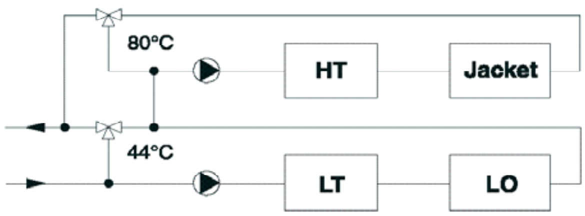
		Cyl.	5	6	7	8	9
Maximum continuous rating at 1000 Rpm.		kW	1000	1320	1540	1760	1980
Engine-driven pumps :							
LT cooling water pump	(1-2.5 bar)	m³/h	61	61	61	61	61
HT cooling water pump	(1-2.5 bar)	m³/h	61	61	61	61	61
Lubricating oil pump	(3-5 bar)	m³/h	34	34	46	46	46
External pumps :							
Max. delivery pressure of cooling water pumps		bar	2.5	2.5	2.5	2.5	2.5
Diesel oil pump	(5 bar at fuel oil inlet A1)	m³/h	0.69	0.92	1.08	1.23	1.38
Fuel oil supply pump	(4 bar discharge pressure)	m³/h	0.34	0.45	0.53	0.60	0.68
Fuel oil circulating pump	(8 bar at fuel oil inlet A1)	m³/h	0.70	0.93	1.09	1.25	1.40
Cooling capacities :							
Lubricating oil		kW	206	162	192	222	252
LT charge air		kW	125	333	388	443	499
Total LT system		kW	331	495	580	665	751
* LT flow at 36°C inlet and 44°C outlet		m³/h	35.5	47.8	52.1	56.2	60.5
Jacket cooling		kW	163	280	332	383	435
HT charge air		kW	212	361	411	460	509
Total HT system		kW	374	641	743	843	944
* HT flow at 44°C inlet and 80°C outlet		m³/h	8.9	20.9	23.9	26.7	29.5
Total from engine		kW	705	1136	1323	1508	1695
LT flow from engine at 36°C inlet		m³/h	35.5	47.2	51.5	55.6	59.9
LT outlet temperature from engine at 36°C inlet (1-string cooling water system)		°C	53	57	59	60	61
Gas data :							
Exhaust gas flow		kg/h	6920	10200	11900	13600	15300
Exhaust gas temperature at turbine outlet		°C	335	333	333	333	333
Maximum allowable back pressure		bar	0.025	0.025	0.025	0.025	0.025
Air consumption		kg/h	6720	9940	11600	13200	14900
Starting air system :							
Air consumption per start incl. air for jet assist		Nm³	1.0	1.2	1.4	1.6	1.8
Heat radiation :							
Engine		kW	21	47	50	54	56
Alternator		kW	(See separate data from alternator maker)				

The stated heat balances are based on 100% load and tropical condition.

The mass flows and exhaust gas temperature are based on ISO ambient condition.

* The outlet temperature of the HT water is fixed to 80°C, and 44°C for the LT water. At different inlet temperature the flow will change accordingly.

Example: If the inlet temperature is 25°C then the LT flow will change to (44-36)/(44-25)*100 = 42% of the original flow. The HT flow will not change.

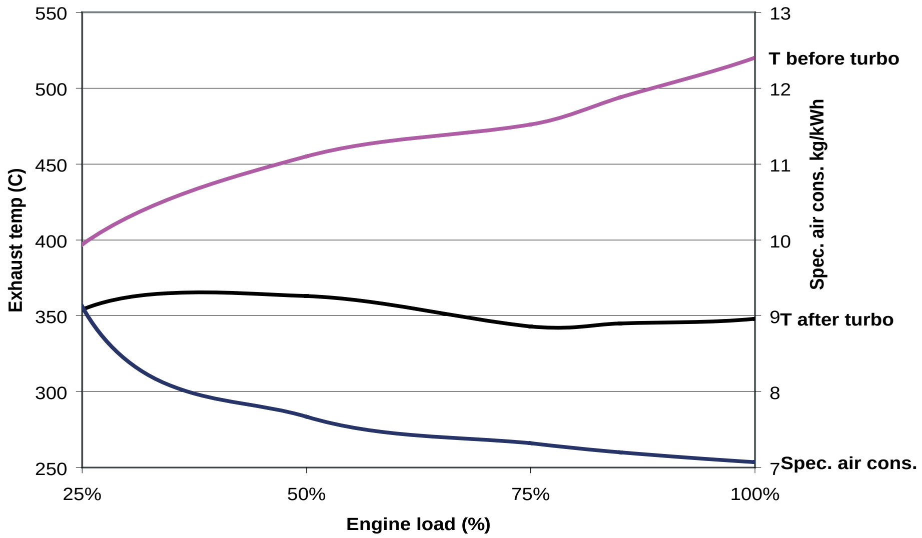


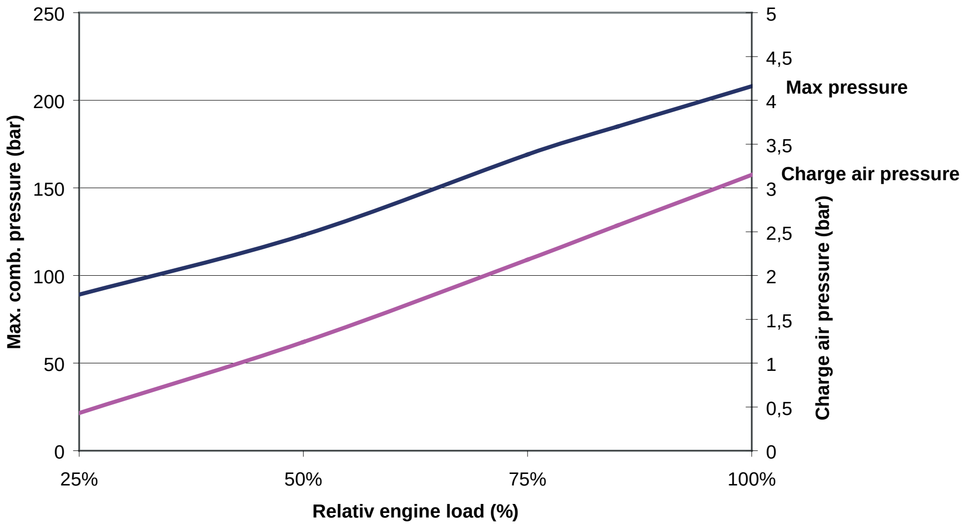
L21/31

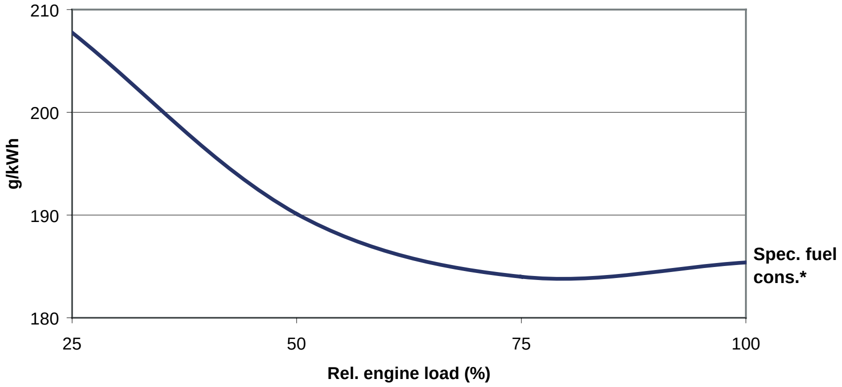
P = 220 kW/cyl. at 900 rpm Pme = 27.3 bar

Ambient cond. 25.0 C - 1.00 bar - Cool W 35.3 C

MDO calorific value 42700 kJ/kg
(Generator load, const.rpm)







* tolerance +5%

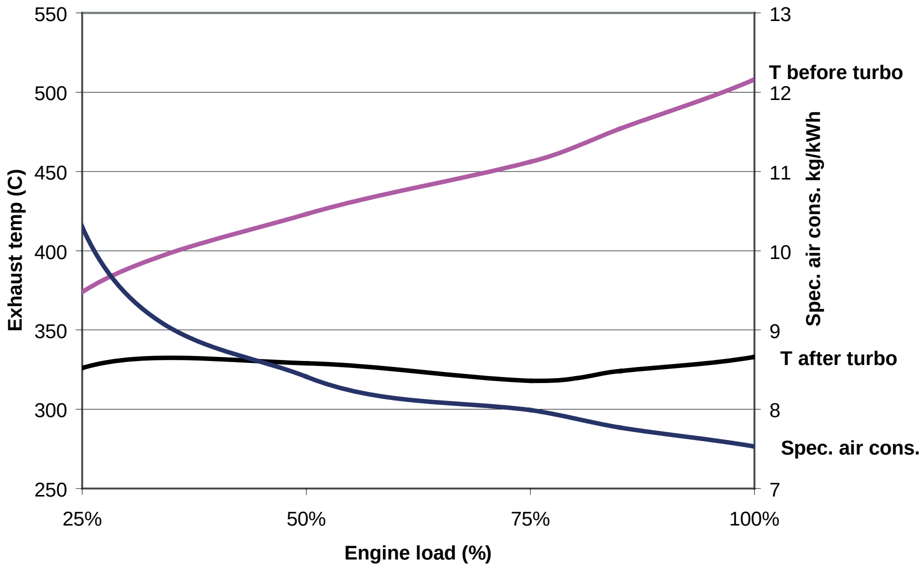
08028-0D/H5250/94.08.12

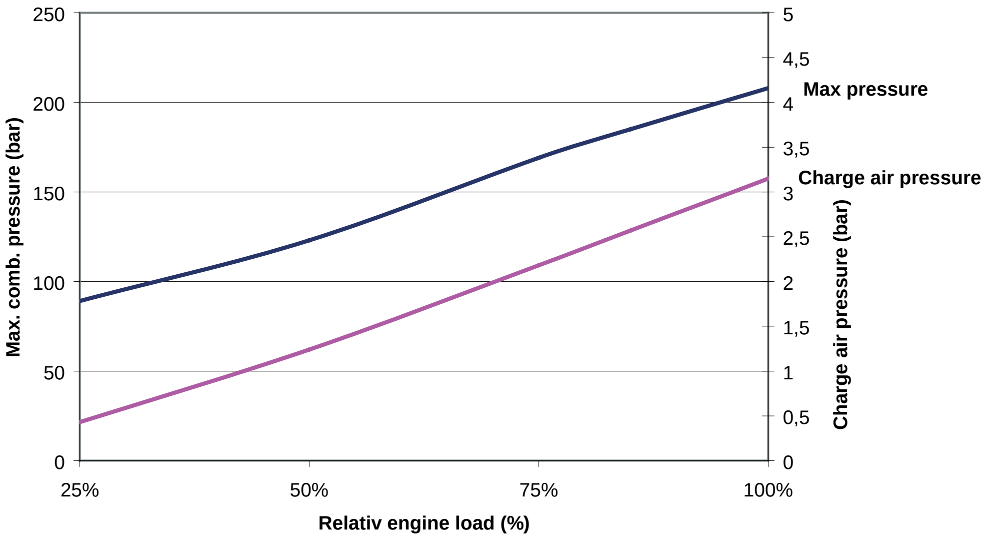
L21/31

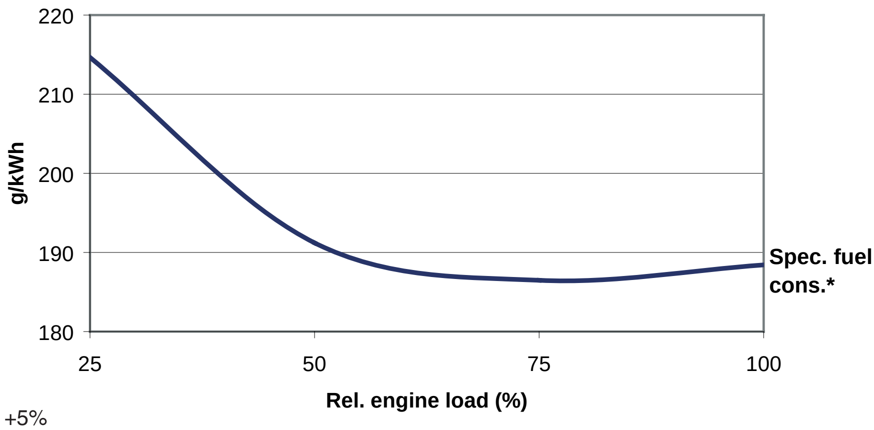
P = 220 kW/cyl. at 1000 rpm Pme = 24.6 bar

Ambient cond. 25.0 C - 1.00 bar - Cool W 35.3 C

MDO calorific value 42700 kJ/kg
(Generator load, const.rpm)







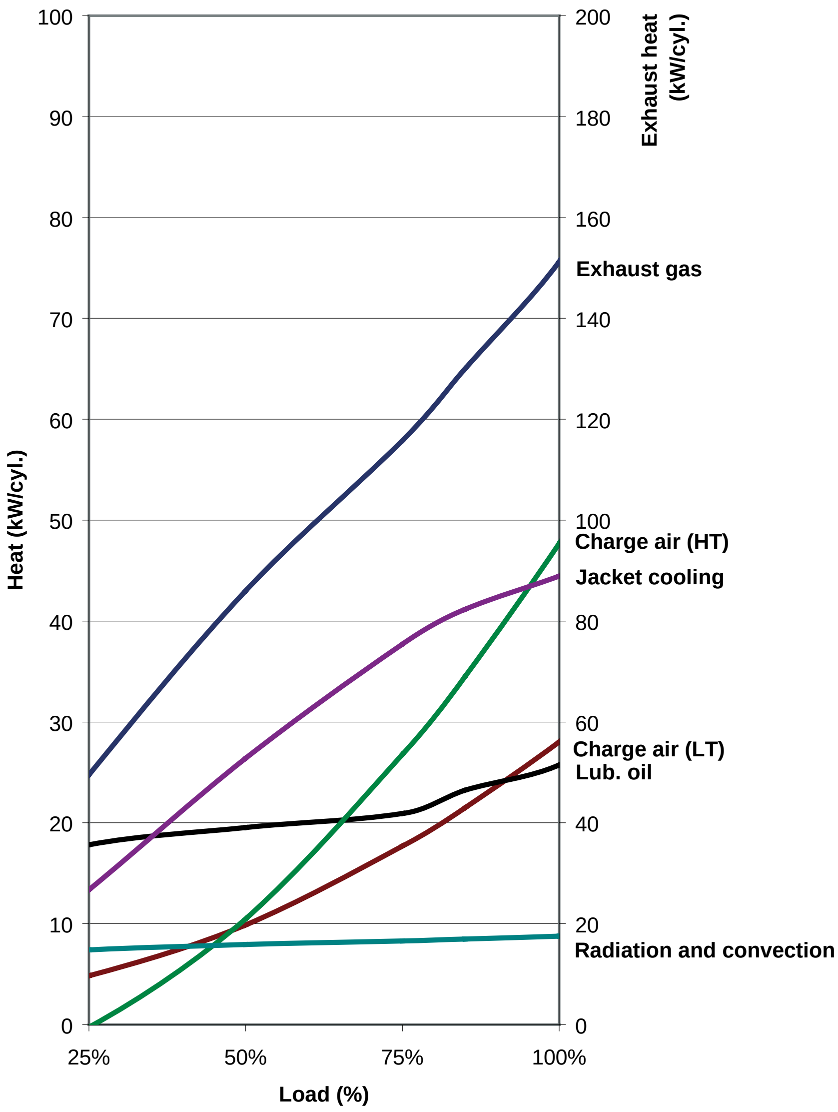
* tolerance +5%

08028-0D/H5250/94.08.12

Heat Balance

L21/31

P = 220 kW/cyl. at 900 RPM. Pme = 27.3 bar
ISO Condition (Generator load, const. RPM)

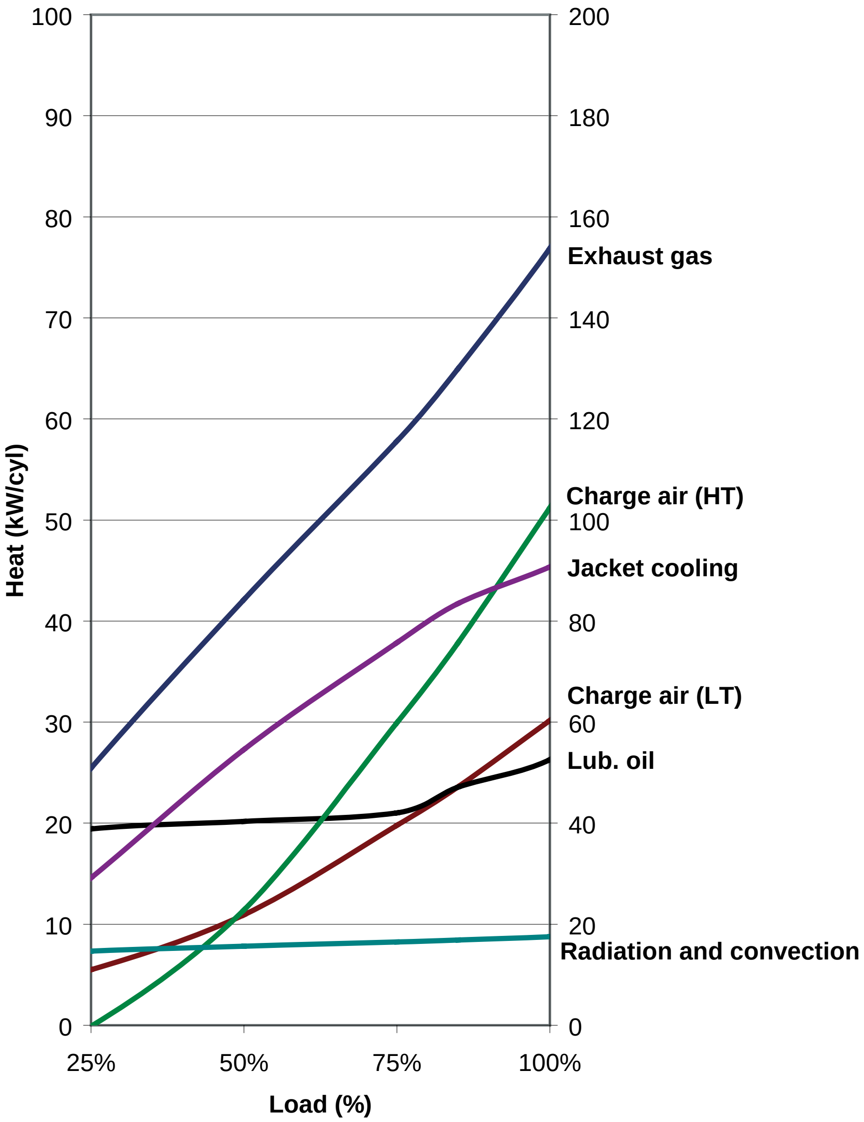


08028-0D/H5250/94.08.12

* tolerance ±10%

L21/31

P = 220 kW/cyl. at 1000 RPM. Pme = 24.6 bar
ISO Condition (Generator load, const. RPM)



08028-0D/H5250/94.08.12

* tolerance ±10%

Purpose

This should be seen as an easily comprehensible sound analysis of MAN Diesel GenSets. These measurements can be used in the project phase as a basis for decisions concerning damping and isolation in buildings, engine rooms and around exhaust systems.

Measuring Equipment

All measurements have been made with Precision Sound Level Meters according to standard IEC Publication 651or 804, type 1 - with 1/1 or 1/3 octave filters according to standard IEC Publication 225. Used sound calibrators are according to standard IEC Publication 942, class 1.

Definitions

Sound Pressure Level: $L_P = 20 \times \log P/P_0$ [dB]

where P is the RMS value of sound pressure in pascals, and P_0 is 20 µPa for measurement in air.

Sound Power Level: $L_W = 10 \times \log P/P_0$ [dB]

where P is the RMS value of sound power in watts, and P_0 is 1 pW.

Measuring Conditions

All measurements are carried out in one of MAN Diesel's test bed facilities.

During measurements, the exhaust gas is led outside the test bed through a silencer. The GenSet is placed on a resilient bed with generator and engine on a common base frame.

Sound Power are normally determined from Sound Pressure measurements.

New measurement of exhaust sound is carried out at the test bed, unsilenced, directly after turbocharger, with a probe microphone inside the exhaust pipe.

Previously used method for measuring exhaust sound are DS/ISO 2923 and DIN 45635, here is measured on unsilenced exhaust sound, one meter from the opening of the exhaust pipe, see Fig. no 1.

Sound Measuring "on-site"

The Sound Power Level can be directly applied to on-site conditions. It does not, however, necessarily result in the same Sound Pressure Level as measured on test bed.

Normally the Sound Pressure Level on-site is 3-5 dB higher than the given surface Sound Pressure Level (L_{pf}) measured at test bed. However, it depends strongly on the acoustical properties of the actual engine room.

Standards

Determination of Sound Power from Sound Pressure measurements will normally be carried out according to:

ISO 3744 (Measuring method, instruments, background noise, no of microphone positions etc) and ISO 3746 (Accuracy due to criterion for suitability of test environment, K2>2 dB)

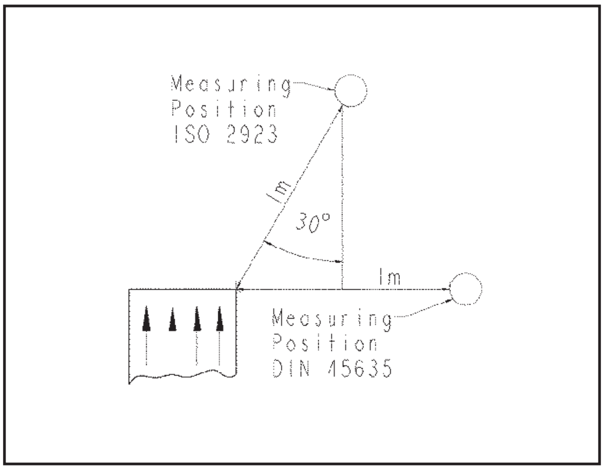


Fig. no 1.

08028-0D/H5250/94.08.12

Sound Measurements

L21/31

Engine and Exhaust Sound

Number of cylinders	5		6		7		8		9	
RPM	900	1000	900	1000	900	1000	900	1000	900	1000
Engine sound:										
Mean sound pressure L_{pfA} [dB]	99.0	100.1	100.2	105.2	-	-	-	105.5	-	105.7
Power [kW]	950	1000	1320	1200	-	-	-	1720	-	1935
Number of cylinders	5		6		7		8		9	
RPM	900	1000	900	1000	900	1000	900	1000	900	1000
Exhaust sound: **										
Sound pressure L_{pA} [dB]	126.4	126.4	-	-	133.6	-	-	133	-	-
Power kW	950	1000	-	-	1400	-	-	1720	-	-

For further information see: "Description of sound measurements" D 10 25 0.

** Measured in exhaust pipe with probe.

The stated values are calculated and actual measurements on specified plant may be different.

Exhaust Gas Emission

General

The composition of the exhaust gases emitted by our medium-speed four-stroke diesel engines during full load operation, and depending on the air/fuel ratio, is as follows:

		% Volume
Nitrogen N_2	approx.	76
Oxygen O_2	approx.	13
Carbon dioxide CO_2	approx.	4
Water (vapour) H_2O	approx.	6
Argon Ar	approx.	1
Ash, soot, NO_x, CO, HC, etc.		the remaining

However, as regards the environmental impact attributable to diesel exhaust gases, only the components listed under "the remaining" are of interest. Among the above the various proportion of carbon monoxide, CO, nitrogen oxides, NO_x, sulphur dioxide SO_2 and of hydrocarbons, HC, are known as noxious materials on account of their toxicity.

The ash and SO_2 content of the exhaust gas is solely determined by the composition of the fuel and not by the combustion in the engine.

SO_2 can be determined by the empirical relationship: SO_2 * = (21.9 x S) - 2.1 (kg/tonne fuel). Where S is the sulphur content of fuel in % of the weight.

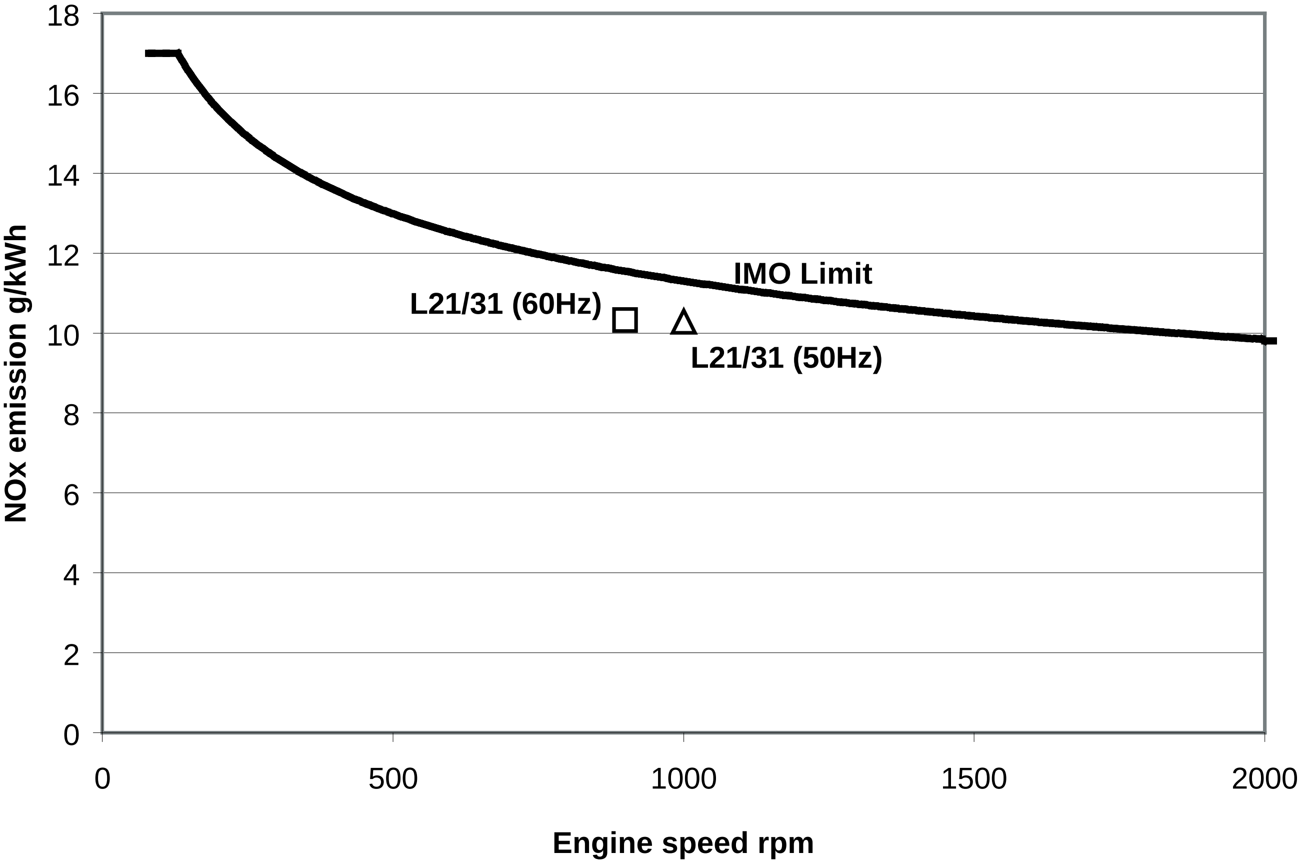
The soot emission, though it does play a role, causes no problem in case of super-charged engines due to the large amount of excess air compared with naturally aspirated engines.

As the NO_x emission is also considerably influenced by the site and operating conditions of the engine (e.g. charge air temperature), the MAN B&W Diesel A/S, Holeby works should be consulted and advised of any existing local ordinances before any statements regarding emissions are made in case of concrete projects.

* Reference: Lloyds Register Marine Exhaust Emissions Research.

General

The NOx measurements are made after Annex VI of MARPOL 73/78, The Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines. The NOx emission is measured at worst case conditions during the IMO certification and surveyed by the major classifications societies. The emissions are measured at five load points and calculated as a weighted average after the D2 cycle. The D2 cycle is used for marine auxiliary engines where the 75% and 50% load points have the biggest contribution the average value.



08028-0D/H5250/94.08.12

L21/31

No. of cyl.	Generator type	Max. cont. rating kW	Speed r/min.	Moment of inertia (J)		
				Engine kgm²	Flywheel ** kgm²	Generator ** kgm²
5	TNC6 564-8*	1000	900	63.5	166.3	95.4
	TNC6 564-6*	1075	1000	103.7	251	78
6	TNC6 566-8*	1200	900	79.5	166.3	96.6
	TNC6 567-6*	1290	1000	79.5	166.3	90.4
7	TNC6 634-6*	1505	1000	88.8		116
8	TNC6 636-6*	1720	1000	112.3	166.3	138.9

* Generator, make ULJANIK

** If other generator is chosen the values will change.

Component	Overhaul Recommendations	Hours Between Overhauls
Turbocharger	Dry cleaning of turbine side	every week
	Water washing of compressor side	25-75
	Air filter cleaning : Based on observations.	
	Inspection: Check all mounting screws, casing screws and pipe line connections for tight fit by tapping, retighten if necessary	with new or overhauled turbocharger once aft 1000
	Compressor cleaning in dismantled condition: compressor inner components, final diffusor, compressor wheel	8,000
	Silencer cleaning in dismantled condition: silencer felt linings .	8,000
	Major overhaul: Dismantling, cleaning, inspection, checking and cleaning cartridge, checking bearing clearances, checking gaps and clearances on reassembly	16,000
Regulating system	Function check of overspeed and shutdown devices. Check that the control rod of each individual fuel pump can easily go to "stop" position	monthly
Compressed air system	Check of compressed air system	16,000
Main bearings	Inspection according to classification survey, normally after 32.000 running hours or 4 years of service	32,000
	Retightening of main bearing cap. 200 hours after new or overhaul and every	8,000
	Retightening of screws for counterweights. 200 hours after new or overhaul and every and after overspeed	8,000
Flexible mountings	Check anti-vibration mountings	8,000
Autolog reading	Only after request from class or dismounting og alternator	
Fuel pump	Fuel pump barrel/plunger assembly. Overhaul based on operational observations	
Lub. oil filter cartridge	Replacement based on observations of pressure drop	
Cylinder unit:		
Cylinder head	Checking and adjustment of valve clearance	2,000
– Fuel injection valve	Checking, cleaning and adjustment of opening pressure	4,000
Exhaust valve	Overhaul and regrinding of spindle and valve seat	16,000
	Function check of rotocap	quarterly
– Air inlet valve	Overhaul in connection with exhaust valve overhaul	16,000
Valve guide	Measuring of inside diameter in connection with valve overhaul ...	16,000
– Cylinder head nuts	Retightening 200 hours after new or overhaul	
Big-end bearing	Retightening; 200 hours after new or overhaul and every	8,000
	Inspection:In connection with unit overhaul	16,000
Piston	Overhaul, replacement of compression rings, scraper rings and measuring of ring grooves:In connection with unit overhaul	16,000
Cylinder liner	Inspection, measuring and reconditioning of running surface condition; In connection with unit overhaul	16,000

Overhaul Recommendations

L21/31

Component	Overhaul Recommendations	Hours Between Overhauls
Turbocharger	Dry cleaning of turbine side... Water washing of compressor side	every week 25-75
	Air filter cleaning : Based on observations.	
	Inspection: Check all mounting screws, casing screws and pipe line connections for tight fit by tapping, retighten if necessary	with new or overhauled turbo-charger once aft 1000
	Compressor cleaning in dismantled condition: compressor inner components, final diffusor, compressor wheel......................	8,000
	Silencer cleaning in dismantled condition: silencer felt linings .	8,000
	Major overhaul: Dismantling, cleaning, inspection, checking and cleaning cartridge, checking bearing clearances, checking gaps and clearances on reassembly	15,000
Regulating system	Function check of overspeed and shutdown devices. Check that the control rod of each individual fuel pump can easily go to "stop" position	monthly
Compressed air system	Check of compressed air system	16,000
Main bearings	Inspection according to classification survey, normally after 32.000 running hours or 4 years of service	32,000
	Retightening of main bearing cap. 200 hours after new or overhaul and every	8,000
	Retightening of screws for counterweights. 200 hours after new or overhaul and every and after overspeed	8,000
Flexible mountings	Check anti-vibration mountings	8,000
Autolog reading	Only after request from class or dismounting og alternator	
Fuel pump	Fuel pump barrel/plunger assembly. Overhaul based on operational observations	
Lub. oil filter cartridge	Replacement based on observations of pressure drop	
Cylinder unit:		
Cylinder head	Checking and adjustment of valve clearance	2,000
– Fuel injection valve	Checking, cleaning and adjustment of opening pressure	3,000
Exhaust valve	Overhaul and regrinding of spindle and valve seat	16,000
	Function check of rotocap	quarterly
– Air inlet valve	Overhaul in connection with exhaust valve overhaul	16,000
Valve guide	Measuring of inside diameter in connection with valve overhaul ...	16,000
– Cylinder head nuts	Retightening 200 hours after new or overhaul	
Big-end bearing	Retightening; 200 hours after new or overhaul and every .... Inspection:In connection with unit overhaul	8,000 16,000
Piston	Overhaul, replacement of compression rings, scraper rings and measuring of ring grooves:In connection with unit overhaul	16,000
Cylinder liner	Inspection, measuring and reconditioning of running surface condition; In connection with unit overhaul....................................	16,000

08028-0D/H5250/94.08.12

Basic Diesel Engine

B 10

General

The engine is a turbocharged, single-acting four-stroke diesel engine of the trunk type with a cylinder bore of 210 mm and a stroke of 310 mm. The crankshaft speed is 900 or 1000 rpm.

The engine can be delivered as an in-line engine with 5 to 9 cylinders.

For easy maintenance the cylinder unit consists of: the cylinder head, water jacket, cylinder liner, piston and connecting rod which can be removed as complete assemblies with possibility for maintenance by recycling. This allows shoreside reconditioning work which normally yields a longer time between major overhauls.

The engine is designed for an unrestricted load profile on HFO, low emission, high reliability and simple installation.

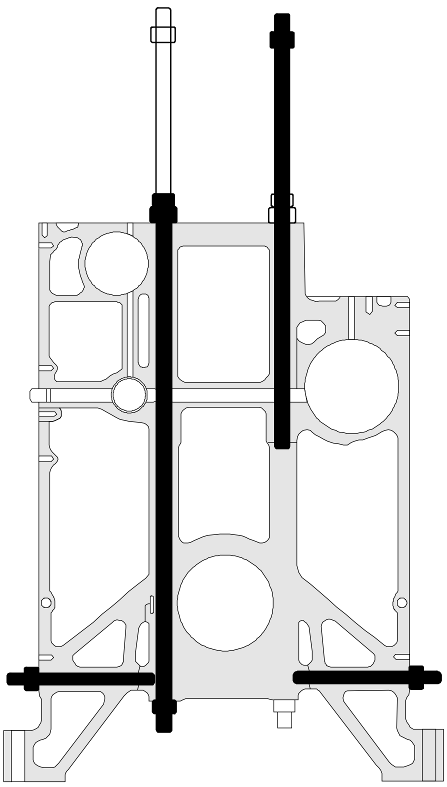


Fig 1 Engine frame.

08028-0D/H5250/94.08.12

Engine Frame

The monobloc cast iron engine frame is designed to be very rigid. All the components of the engine frame are held under compression stress. The frame is designed for an ideal flow of forces from the cylinder head down to the crankshaft and gives the outer shell low surface vibrations.

Two camshafts are located in the engine frame. The valve camshaft is located on the exhaust side in a very high position and the injection camshaft is located on the service side of the engine.

The main bearings for the underslung crankshaft are carried in heavy supports by tierods from the intermediate frame floor, and are secured with the bearing caps. These are provided with side guides and held in place by means of studs with hydraulically tightened nuts. The main bearing is equipped with replaceable shells which are fitted without scraping.

On the sides of the frame there are covers for access to the camshafts and crankcase. Some covers are fitted with relief valves which will operate if oil vapours in the crankcase are ignited (for instance in the case of a hot bearing).

Base Frame

The engine and alternator are mounted on a rigid base frame. The alternator is considered as an integral part during engine design. The base frame, which is flexibly mounted, acts as a lubricating oil reservoir for the engine.

Cylinder Liner

The cylinder liner is made of special centrifugal cast iron and fitted in a bore in the engine frame. The liner is clamped by the cylinder head and rests by its flange on the water jacket.

L21/31

The liner can thus expand freely downwards when heated during the running of the engine.

The liner is of the flange type and the height of the flange is identical with the water cooled area which gives a uniform temperature pattern over the entire liner surface.

The lower part of the liner is uncooled to secure a sufficient margin for cold corrosion in the bottom end. There is no water in the crankcase area.

Fig 2 Cylinder liner.

The gas sealing between liner and cylinder head consists of an iron ring.

To reduce bore polishing and lub. oil consumption a slip-fit-type flame ring is arranged on the top side of the liner.

Cylinder Head

The cylinder head is of cast iron with an integrated charge air receiver, made in one piece. It has a bore-cooled thick walled bottom. It has a central bore for the fuel injection valve and 4 valve cross flow design, with high flow coefficient. Intensive water cooling of the nozzle tip area made it possible to omit direct nozzle cooling. The valve pattern is turned about 20° to the axis and achieves a certain intake swirl.

The cylinder head is tightened by means of 4 nuts and 4 studs which are screwed into the engine frame. The nuts are tightened by means of hydraulic jacks.

The cylinder head has a screwed-on top cover. It has two basic functions: oil sealing of the rocker chamber and covering of the complete head top face.

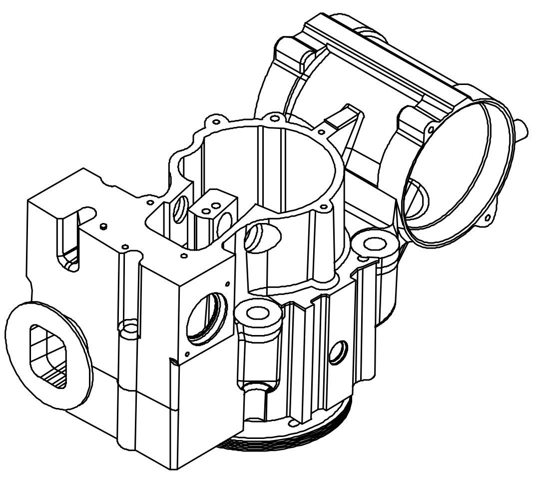


Fig 3 Cylinder head.

08028-0D/H5250/94.08.12

Air Inlet and Exhaust Valves

The valve spindles are made of heat-resistant material and the spindle seats are armoured with welded-on hard metal.

All valve spindles are fitted with valve rotators which turn the spindles each time the valves are activated. The turning of the spindles ensures even temperature levels on the valve discs and prevents deposits on the seating surfaces.

The cylinder head is equipped with replaceable valve seat rings. The exhaust valve seat rings are water cooled in order to ensure low valve temperatures.

Valve Actuating Gear

The rocker arms are actuated through rollers, roller guides and push rods. The roller guides for inlet and exhaust valves are mounted in the water jacket part.

Each rocker arm activates two valve spindles through a valve bridge with thrust screws and adjusting screws for valve clearance.

The valve actuating gear is pressure-feed lubricated from the centralized lubricating system, through the water jacket and cylinder head and from there into the rocker arm shaft to the rocker bearing.

Fuel Injection System

The engine is provided with one fuel injection pump unit, an injection valve, and a high pressure pipe for each cylinder.

The injection pump unit is mounted on the engine frame. The pump unit consists of a pump housing embracing a roller guide, a centrally placed pump barrel and a plunger. The pump is activated by the fuel cam, and the volume injected is controlled by turning the plunger.

The fuel injection valve is located in a valve sleeve in the centre of the cylinder head. The opening of the valve is controlled by the fuel oil pressure, and the valve is closed by a spring.

The high pressure pipe which is led through a bore in the cylinder head is surrounded by a shielding tube.

The shielding tube also acts as a drain channel in order to ensure any leakage from the fuel valve and the high pressure pipe will be drained off.

The complete injection equipment including injection pumps and high pressure pipes is well enclosed behind removable covers.

Piston

The piston, which is oil-cooled and of the composite type, has a body made of nodular cast iron and a crown made of forged deformation resistant steel. It is fitted with 2 compression rings and 1 oil scraper ring in hardened ring grooves.

By the use of compression rings with different barrel-shaped profiles and chrome-plated running surfaces, the piston ring pack is optimized for maximum sealing effect and minimum wear rate.

The piston has a cooling oil space close to the piston crown and the piston ring zone. The heat transfer, and thus the cooling effect, is based on the shaker effect arising during the piston movement. The cooling medium is oil from the engine's lubricating oil system.

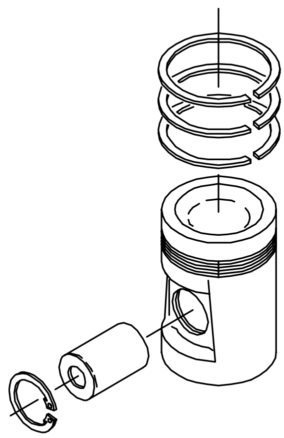


Fig 4 Piston.

L21/31

Oil is supplied to the cooling oil space through a bore in the connecting rod. Oil is drained from the cooling oil space through ducts situated diametrically to the inlet channels.

The piston pin is fully floating and kept in position in the axial direction by two circlips.

Connecting Rod

The connecting rod is of the marine head type.

The joint is above the connecting rod bearing. This means that the big-end bearing need not to be opened when pulling the piston. This is of advantage for the operational safety (no positional changes/no new adaption), and this solution also reduces the height dimension required for piston assembly / removal.

Connecting rod and bearing body consist of die-forged CrMo steel.

The material of the bearing shells are identical to those of the crankshaft bearing. Thin-walled bearing shells having an AlSn running layer are used.

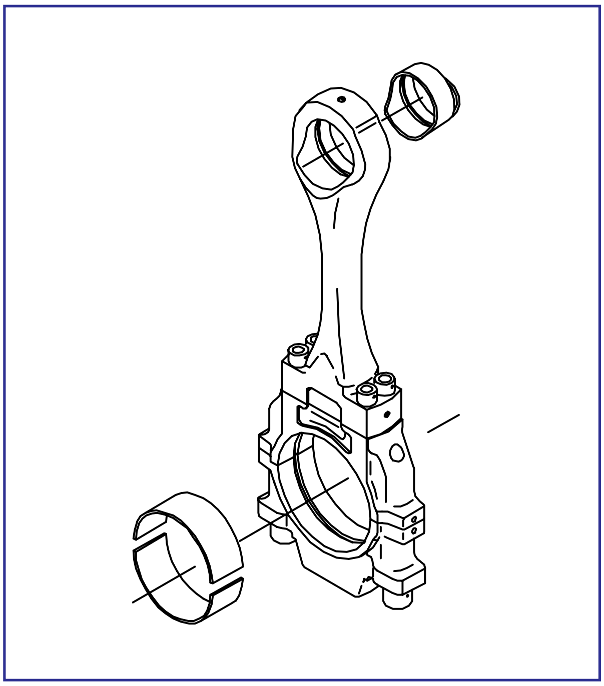


Fig 5 Connecting rod.

The bearing shells are of the precision type and are therefore to be fitted without scraping or any other kind of adaption.

The small-end bearing is of the trimetal type and is pressed into the connecting rod. The bush is equipped with an inner circumferential groove, and a pocket for distribution of oil in the bush itself and for the supply of oil to the pin bosses.

Crankshaft and Main Bearings

The crankshaft, which is a one-piece forging, is suspended in underslung bearings. The main bearings are of the trimetal type, which are coated with a running layer. To attain a suitable bearing pressure and vibration level the crankshaft is provided with counterweights, which are attached to the crankshaft by means of two hydraulic screws.

At the flywheel end the crankshaft is fitted with a gear wheel which, through two intermediate wheels, drives the camshafts.

Also fitted here is a flexible disc for the connection of an alternator. At the opposite end (front end) there is a gear wheel connection for lub. oil and water pumps.

Lubricating oil for the main bearings is supplied through holes drilled in the engine frame. From the main bearings the oil passes through bores in the crankshaft to the big-end bearings and then through channels in the connecting rods to lubricate the piston pins and cool the pistons.

Camshaft and Camshaft Drive

The inlet and exhaust valves as well as the fuel pumps of the engine are actuated by two camshafts.

Due to the two-camshaft design an optimal adjustment of the gas exchange is possible without interrupting the fuel injection timing. It is also possible to adjust the fuel injection without interrupting the gas exchange.

The two camshafts are located in the engine frame. On the exhaust side, in a very high position, the valve camshaft is located to allow a short and stiff valve train and to reduce moving masses.

The injection camshaft is located at the service side of the engine.

Both camshafts are designed as cylinder sections and bearing sections in such a way that disassembly of single cylinder sections is possible through the side openings in the crankcase.

The two camshafts and the governor are driven by the main gear train which is located at the flywheel end of the engine. They rotate with a speed which is half that of the crankshaft.

The camshafts are located in bearing bushes which are fitted in bores in the engine frame; each bearing is replaceable.

Front-End Box

The front-end box is fastened to the front end of the engine. It contains all pipes for cooling water and lubricating oil systems and also components such as pumps, filters, coolers and valves.

The components can be exchanged by means of the clip on/clip off concept without removing any pipes. This also means that all connections for the engine, such as cooling water and fuel oil, are to be connected at the front end of the engine to ensure simple installation.

Governor

The engine speed is controlled by a hydraulic or electronic governor with hydraulic actuators.

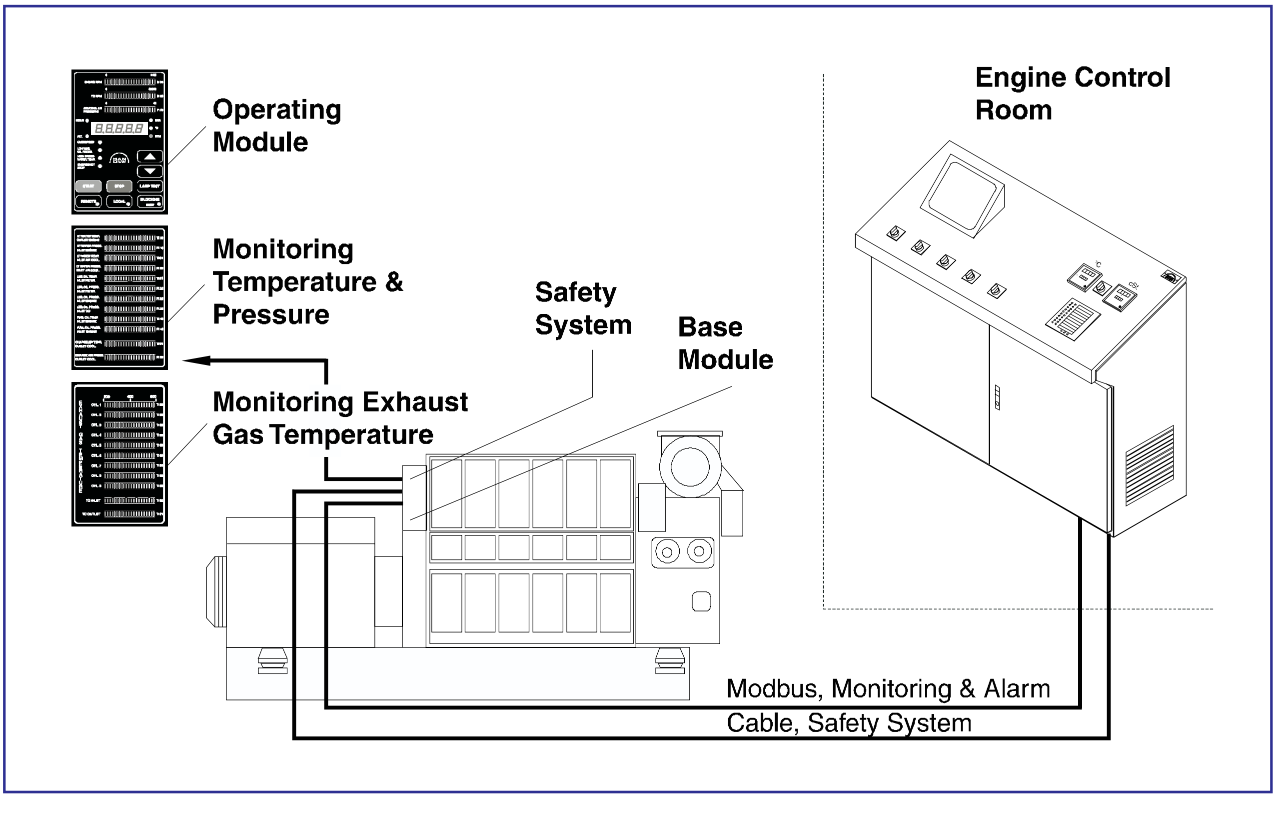


Fig 6 Monitoring and safety system.

08028-0D/H5250/94.08.12

L21/31

Monitoring and Control System

All media systems are equipped with temperature sensors and pressure sensors for local and remote reading. Connecting to the alarm system in control room is made by modbus communication

On the local monitoring module, the pressure, temperature and rpm are illustrated by means of a bar graph. On the display will be indicated whether it is the working hours, load in per cent, pressure, temperature or rpm which is measured.

To ensure precise monitoring, the static indications will appear by means of a lighting diode placed in the middle of the bar graph and dynamic indications will appear by means of a normal bar graph on the display.

The number and type of parameters to have indications and alarm functions are chosen in accordance with - but not limited to the requirements of the classification societies.

The engine has as standard shutdown functions for low lubricating oil pressure and high cooling water temperature, and for overspeed and emergency stop. The system is arranged for compatibility with the CoCoS (Computer Controlled Surveillance) system for remote controlled engine diagnosis.

Turbocharger System

The turbocharger system of the engine, which is a constant pressure system, consists of an exhaust gas receiver, a turbocharger, a charge air cooler and a charge air receiver.

The turbine wheel of the turbocharger is driven by the engine exhaust gas, and the turbine wheel drives the turbocharger compressor, which is mounted on the common shaft. The compressor draws air from the engine room through the air filters.

The turbocharger forces the air through the charge air cooler to the charge air receiver. From the charge air receiver the air flows to each cylinder through the inlet valves.

The charge air cooler is a compact two-stage tube-type cooler with a large cooling surface. The high temperature water is passed through the first stage of the charging air cooler and the low temperature water is passed through the second stage. At each stage of the cooler the water is passed two times through the cooler, the end covers being designed with partitions which cause the cooling water to turn.

From the exhaust valves, the exhaust gas is led through to the exhaust gas receiver where the pulsatory pressure from the individual cylinders is equalized and passed on to the turbocharger as a constant pressure, and further to the exhaust outlet and silencer arrangement.

The exhaust gas receiver is made of pipe sections, one for each cylinder, connected to each other by means of compensators to prevent excessive stress in the pipes due to heat expansion.

To avoid excessive thermal loss and to ensure a reasonably low surface temperature the exhaust gas receiver is insulated.

Compressed Air System

The engine is started by means of a built-on air driven starter.

The compressed air system comprises a dirt strainer, main starting valve and a pilot valve which also acts as an emergency valve, making it possible to start the engine in case of a power failure.

Fuel Oil System

The built-on fuel oil system consists of inlet pipes for fuel oil, mechanical fuel pump units, high pressure pipes as well as return pipes for fuel oil.

Fuel oil leakages are led to a leakage alarm which is heated by means of the inlet fuel oil.

Lubricating Oil System

All moving parts of the engine are lubricated with oil circulating under pressure.

The lubricating oil pump is of the helical gear type. A pressure control valve is built into the system. The pressure control valve reduces the pressure before the filter with a signal taken after the filter to ensure constant oil pressure with dirty filters.

The pump draws the oil from the sump in the base frame, and on the pressure side the oil passes through the lubricating oil cooler and the full-flow depth filter with a nominel fineness of 15 microns. Both the oil pump, oil cooler and the oil filter are placed in the front-end box. The system can also be equipped with a centrifugal filter.

Cooling is carried out by the low temperature cooling water system and temperature regulation effected by a thermostatic three-way valve on the oil side.

The engine is as standard equipped with an electrically-driven prelubricating pump.

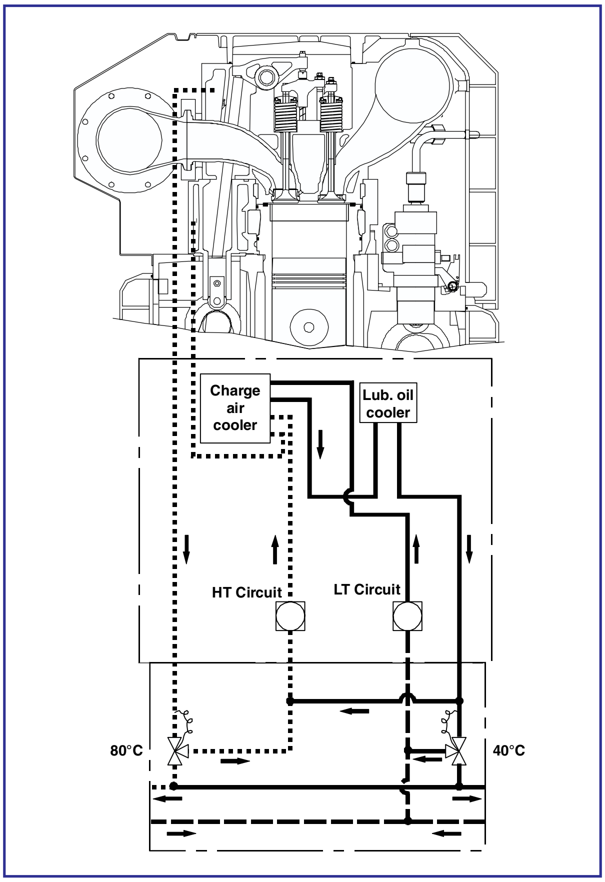


Fig 7 Internal cooling water system.

Cooling Water System

The cooling water system consists of a low temperature system and a high temperature system.

Both the low and the high temperature systems are cooled by treated freshwater.

Only a one string cooling water system to the engine is required.

The water in the low temperature system passes through the low temperature circulating pump which drives the water through the second stage of the charge air cooler and then through the lubricating oil cooler before it leaves the engine together with the high temperature water.

The high temperature cooling water system passes through the high temperature circulating pump and then through the first stage of the charge air cooler before it enters the cooling water jacket and the cylinder head. Then the water leaves the engine with the low temperature water.

Both the low and high temperature water leaves the engine through separate three-way thermostatic valves which control the water temperature.

The low temperature system (LT) is separately bleeded. The HT system is automatically bleeded to expansion tank.

It should be noted that there is no water in the engine frame.

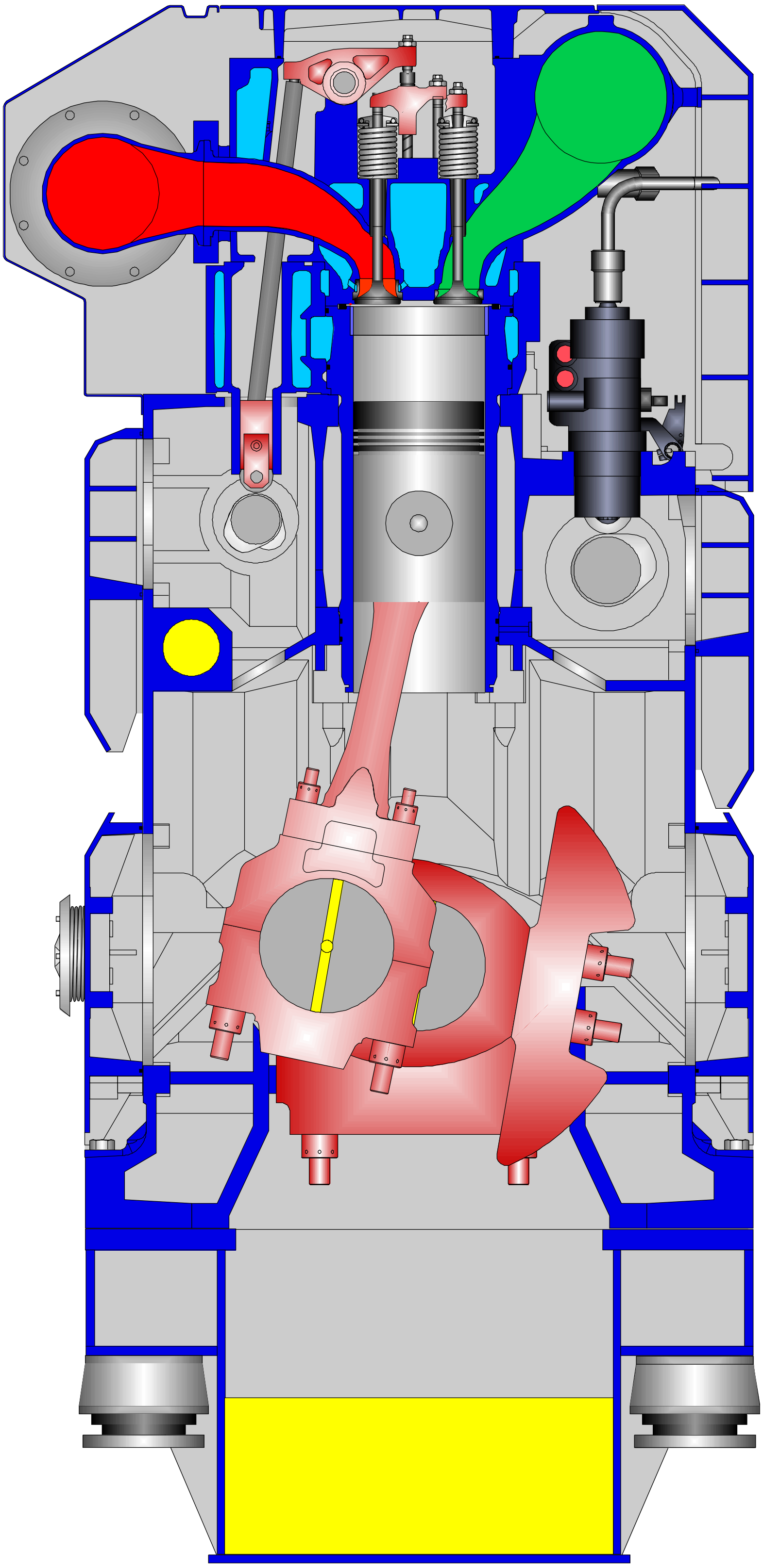
Tools

The engine can optionally be delivered with all necessary tools for the overhaul of each specific plant. Most of the tools can be arranged on steel plate panels.

Turning

The engine is equipped with a manual turning device.

08028-0D/H5250/94.08.12

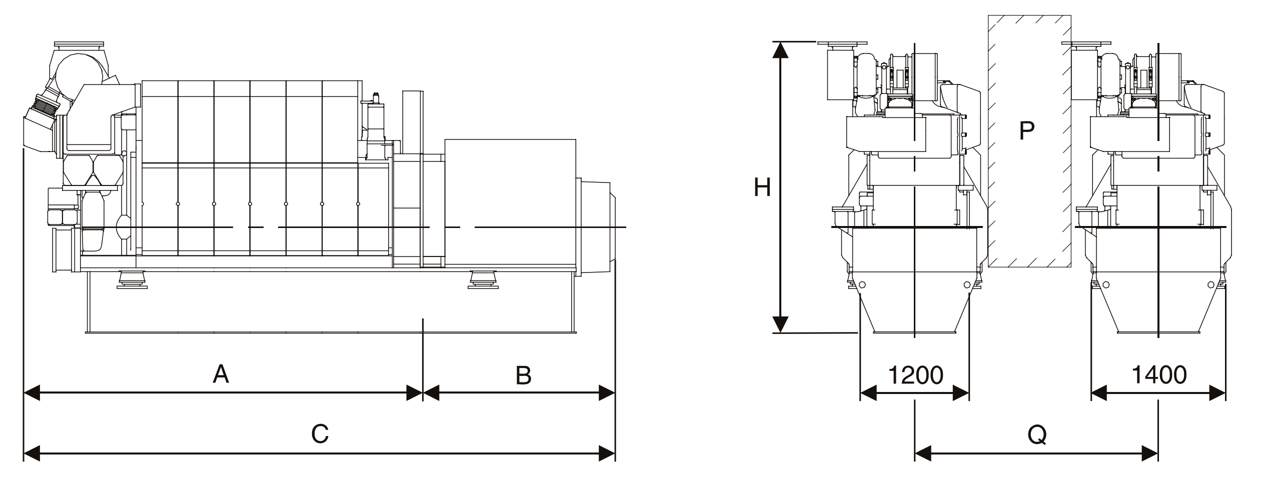


L21/31

Cycle	**:**	**4-stroke**
Configuration	**:**	**In-line**
Cyl. Nos. available	**:**	**5-6-7-8-9**
Power range	**:**	**950-1980 kW**
Speed	**:**	**900/1000 rpm**
Bore	**:**	**210 mm**
Stroke	**:**	**310 mm**
Stroke/bore ratio	**:**	**1.48:1**
Piston area per cyl.	**:**	**346 cm^2**
Swept volume per cyl.	**:**	**10.7 ltr.**
Compression ratio	**:**	**15.5:1**
Max. combustion pressure	**:**	**200 bar (in combustion chamber)**
Turbocharging principle	**:**	**Constant pressure system and intercooling**
Fuel quality acceptance	**:**	**HFO up to 700 cSt/50° C (BSMA 100-M9)**

Power lay-out		MCR version	
Speed	rpm	900	1000
Mean piston speed	m/sec.	9.3	10.3
Mean effective pressure:			
5 cylinder engine	bar	23.6	22.4
6, 7, 8, 9 cylinder engine	bar	27.3	24.6
Power per cylinder:			
5 cylinder engine	kW/cyl.	190	200
6, 7, 8, 9 cylinder engine	kW/cyl.	220	220

08028-0D/H5250/94.08.12



Cyl. no	A (mm)	* B (mm)	* C (mm)	H (mm)	**Dry weight GenSet (t)
5 (900 rpm)	3959	1820	5680	3180	21.5
5 (1000 rpm)	3959	1870	5730	3180	21.5
6 (900 rpm)	4314	1870	6086	3180	23.7
6 (1000 rpm)	4314	2000	6216	3180	23.7
7 (900 rpm)	4669	1970	6760	3180	25.9
7 (1000 rpm)	4669	1970	6537	3180	25.9
8 (900 rpm)	5024	2250	7210	3287	28.5
8 (1000 rpm)	5024	2250	7176	3287	28.5
9 (900 rpm)	5379	2400	7660	3287	30.9
9 (1000 rpm)	5379	2400	7660	3287	30.9

08028-0D/H5250/94.08.12

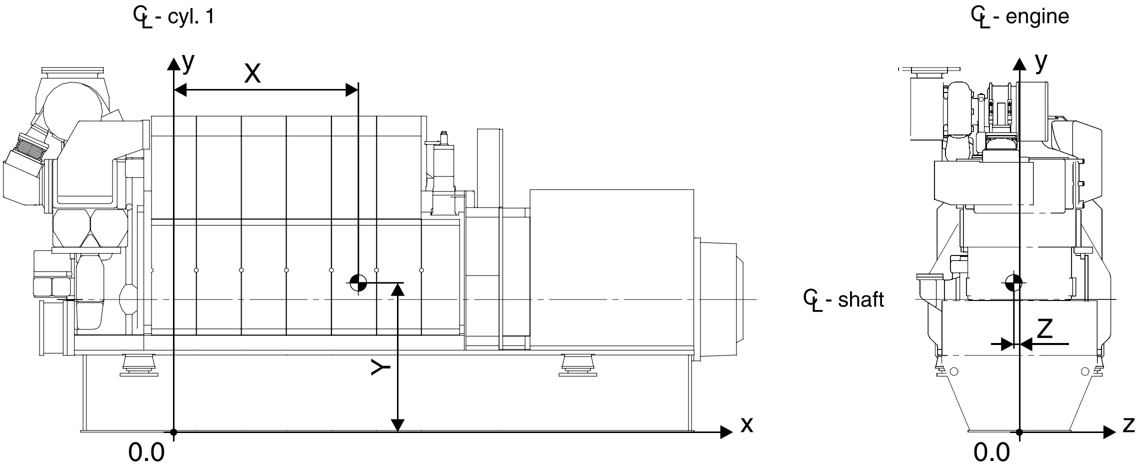
P Free passage between the engines, width 600 mm and height 2000 mm.
Q Min. distance between engines: 2400 mm (without gallery) and 2600 mm (with galley)

* Depending on alternator
** Weight incl. standard alternator (based on a Uljanik alternator)

All dimensions and masses are approximate, and subject to changes without prior notice.

Centre of Gravity

L21/31



Engine Type	X - mm	Y - mm	Z - mm
5L21/31	1205	1235	0
6L21/31	1470	1235	0
7L21/31	1730	1235	0
8L21/31	1925	1235	0
9L21/31	2315	1235	0

The values are expected values based on alternator, make Uljanik. If an other alternator is chosen, the values will change.

Actual values is stated on General Arrangement.

Centre of gravity is stated for dry GenSet.

Material Specification

L21/31

Components	Material
Frame	Nodular cast iron
Front end box	Grey cast iron
Crankshaft	Forged and tempered chromium-molybdenum steel
Connecting rod	Forged and tempered chromium-molybdenum steel
Piston	Composite piston: Skirt : nodular cast iron Crown : forged, hardned and tempered chronium molydenum steel
Cylinder head	Nodular cast iron
Cylinder liner	Centrifugally cast iron copper-vanadium alloyed
Exhaust and inlet valves	Hardened and tempered chromium-silicon steel Coating nickel base alloy
Fuel injection equipment	L'Orange
Turbocharger	MAN B&W
Governor	Regulateurs Europa
Charge air cooler	
Tubes	Arsenical aluminium bras
Tubeplates	Steel
Covers	Grey cast iron
Lubricating oil cooler	
Plates	Stainless steel
Thrust plates	Steel, coated

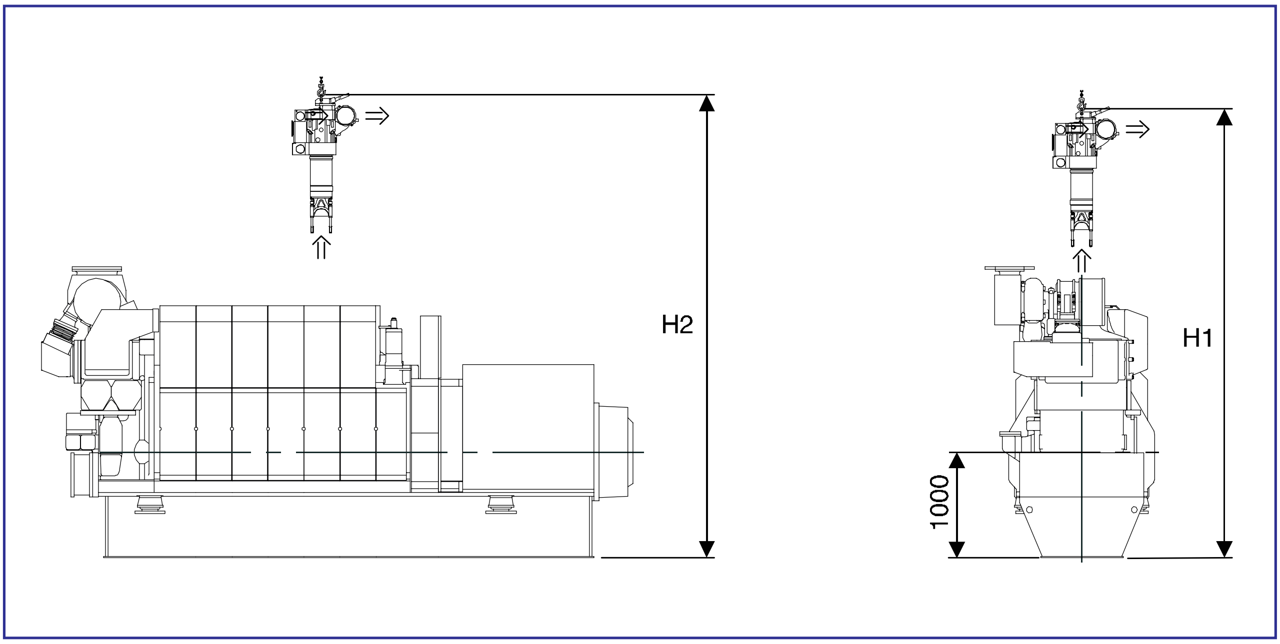


Fig 1 Dismantling height.

Engine Type	H1 (mm)	H2 (mm)
Cylinder Unit, complete:	3705	3965
Unit dismantled: Cylinder liner, water jacket, connecting rod and piston:	3245	3505

Dismantling Height

H1 : For dismantling at the service side.

H2 : For dismantling passing the alternator.
(Remaining cover not removed).

L21/31

Dismantling Space

It must be considered that there is sufficient space for pulling the charge air cooler element, lubricating oil cooler, lubricating oil filter cartridge, lubricating pump and water pumps.

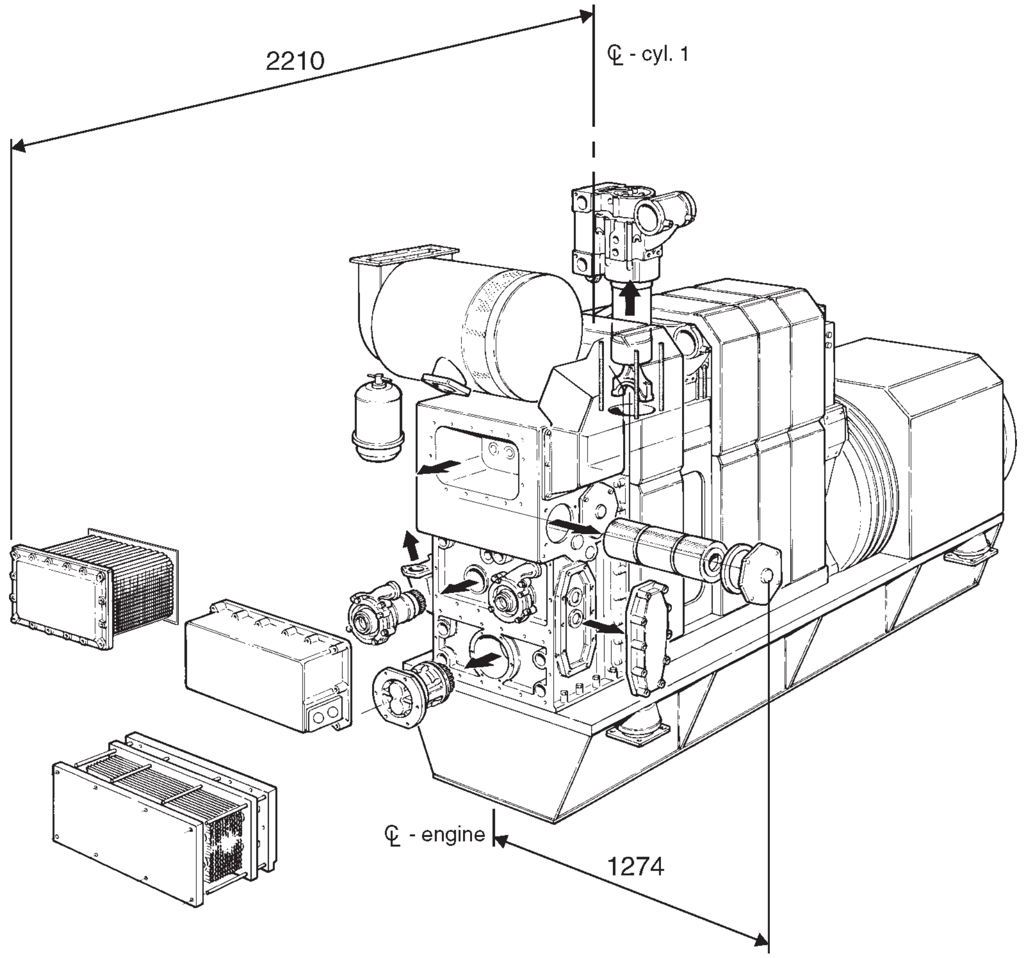
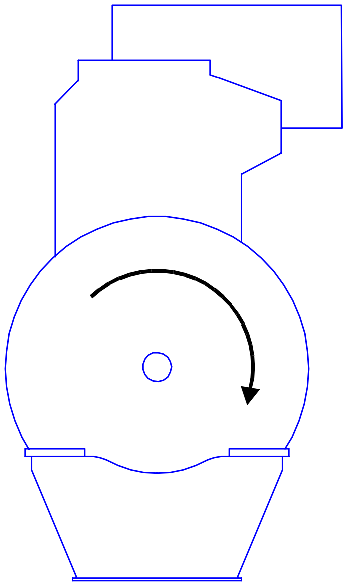


Fig 2 Overhaul areas for charge air cooler element, lub. oil cooler and lub. oil filter cartridge.

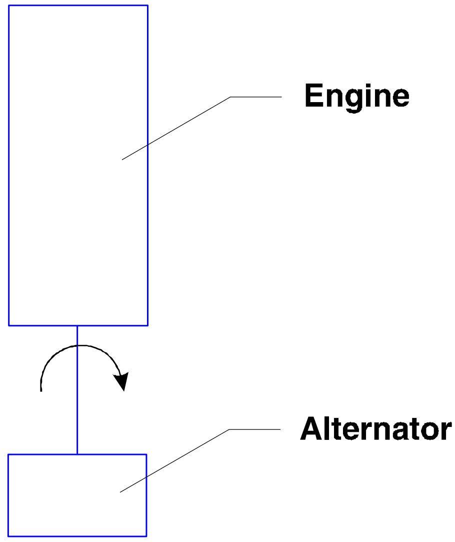
08028-0D/H5250/94.08.12

1607566-7.1 Page 1 (1)	Engine Rotation Clockwise	B 10 11 1

General



Direction "Clockwise" of diesel engine seen from flywheel end



08028-0D/H5250/94.08.12

Fuel Oil System

B 11

Internal Fuel Oil System

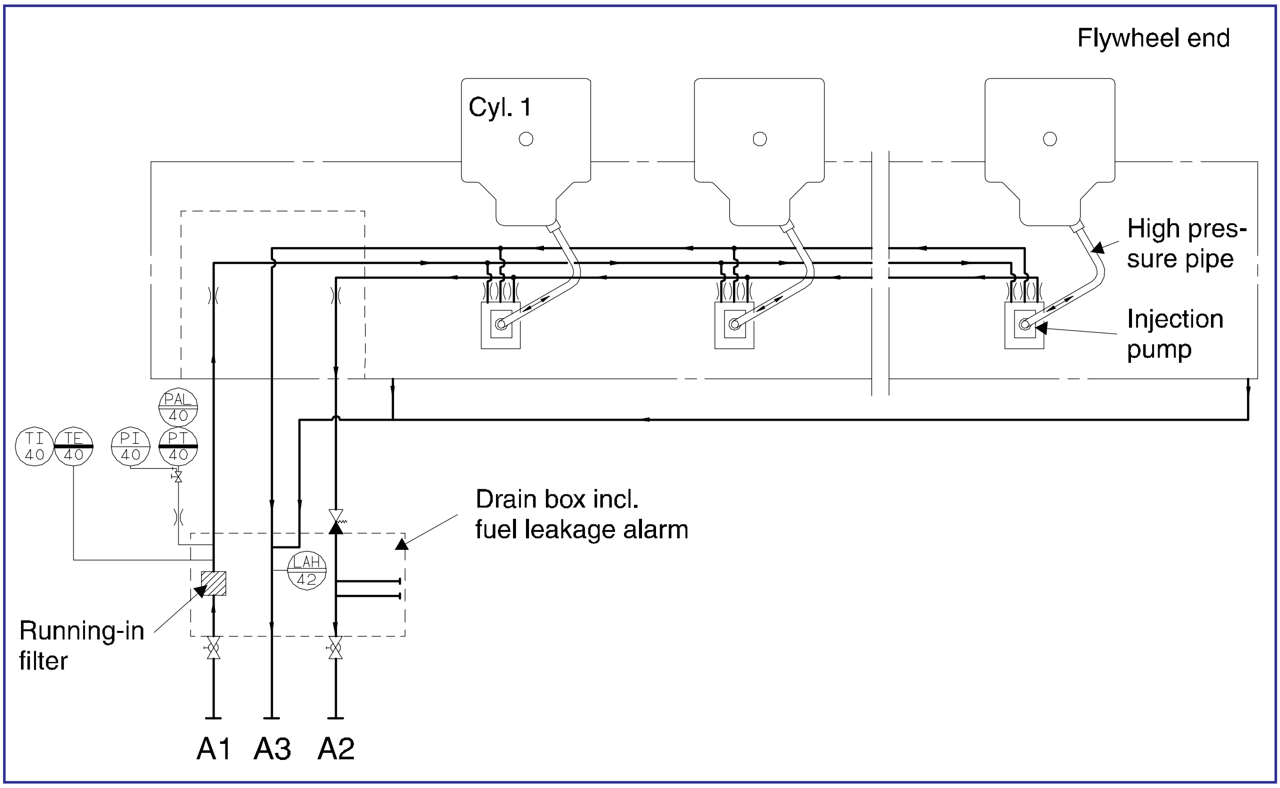


Fig 1 Diagram for fuel oil system.

Pipe description		
A1	Fuel oil inlet	DN20
A2	Fuel oil outlet	DN20
A3	Waste oil outlet to drain tank	DN15

Flange connections are standard according to DIN 2501

General

The internal built-on fuel oil system as shown in fig. 1 consists of the following parts:

- the running-in filter
- the high-pressure injection equipment
- the waste oil system

Running-in Filter

The running-in filter has a fineness of 50 μ and is placed in the fuel inlet pipe. Its function is to remove impurities in the fuel pipe between safety filter and the engine in the running-in period.

Note: The filter must be removed before ship delivery or before handling over to the customer.

*It is adviced to install the filter every time the external fuel pipe system has been dismantled, but it is **important to remove** the filter again when the extern fuel oil system is considered to be clean for any impurities.*

Fuel Injection Equipment

Each cylinder unit has its own set of injection equipment comprising injection pump unit, high-pressure pipe and injection valve.

08028-0D/H5250/94.08.12

L21/31

The injection equipment and the distribution pipes are housed in a fully enclosed compartment thus minimizing heat losses from the preheated fuel. This arrangement reduces external surface temperatures and the risk of fire caused by fuel leakage.

The injection pump unit are with integrated roller guide directly above the camshaft.

The fuel quantity injected into each cylinder unit is adjusted by means of the governor, which maintains the engine speed at the preset value by a continuous positioning of the fuel pump racks, via a common regulating shaft and spring-loaded linkages for each pump.

The injection valve is build into the centre of the cylinder head.

The injection oil is supplied from the injection pump to the injection valve via a double-walled pressure pipe and an insert piece in the cylinder head.

Waste Oil System

Waste and leak oil from the fuel pump compartment, fuel valves and fuel pumps is led to a fuel leakage alarm unit.

The alarm unit consists of a box with a float switch for level monitoring. In case of a larger than normal leakage, the float switch will initiate an alarm. The supply fuel oil to the engine is led through the unit in order to keep this heated up, thereby ensuring free drainage passage even for high-viscous waste/leak oil.

Data

For pump capacities, see D 10 05 0 "List of Capacities".

Specific fuel oil consumption is stated in B 10 01 1.

Set points and operating levels for temperature and pressure are stated in B 19 00 0 "Operating Data and Set Points".

08028-0D/H5250/94.08.12

L21/31

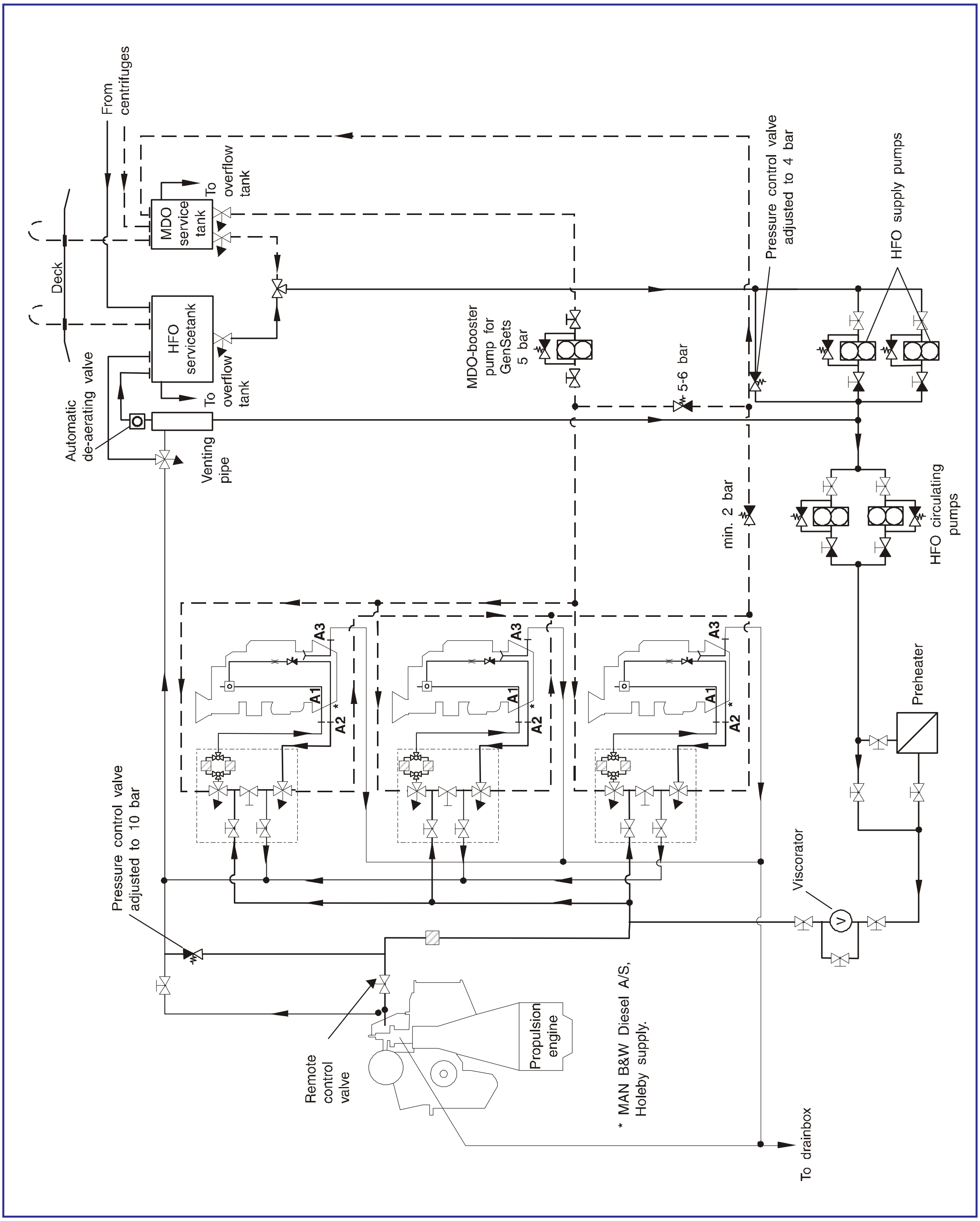


Fig 1 Fuel oil diagram.

08028-0D/H5250/94.08.12

L21/31

Uni-Fuel

The fuel system on page 1 is designed as a uni-fuel system, which means that the propulsion engine and the GenSets are running on the same fuel oil and are fed from the common fuel feed system. The uni-fuel concept is a unique foundation for substantial savings in operating costs and it is also the simplest fuel system, resulting in lower maintenance and easier operation.

The diagram on page 1 is a guidance. It has to be adapted in each case to the actual engine and pipe lay-out.

Fuel Feed System

The common fuel feed system is a pressurized system, consisting of HFO supply pumps, HFO circulating pumps, preheater and equipment for controlling the viscosity, (e.g. a viscorator as shown).

From the service tank, the oil is led to one of the electrically driven supply pumps, which deliver the oil with a pressure of approximately 4 bar to the low pressure side of the fuel oil system, thus avoiding boiling of the fuel in the venting tank in the temperature range applied.

From the low pressure part of the fuel system, the fuel oil is led to an electrically driven circulating pump, which pumps the fuel through a preheater to the engines. For the propulsion engine please see the specific plant specifications. The internal fuel system for the GenSets is shown in B 11 00 0 "Internal Fuel Oil System".

It is recommended to place a safety duplex filter with a fineness of max. 50 µm as close as possible to each engine as shown at the fuel oil diagram. It is possible, however not our standard/recommendations, to place a common fuel oil safety duplex filter and a common MDO filter for the entire GenSet installation. In this case it must be ensured that the fuel oil system fullfil the classification rules and protect the engines from impurities.

Note: a filter surface load of 1 l/cm^2. hour must not be exceeded.

The venting tank is connected to the service tank via an automatic de-aerating valve, which will release any gases present.

To ensure ample filling of the fuel injection pumps, the capacity of the electrically driven circulating pumps must be 3 times higher than the amount of fuel, consumed by the diesel engine at 100% load. The surplus amount of fuel oil is re-circulated through the engine and back through the venting tank.

To ensure a constant fuel pressure to the fuel injection pumps during all engine loads, a spring-loaded overflow is inserted in the fuel system.

The circulating pump pressure should be as specified in "*B 19 00 0, Operating Data & Set Points*" which provides a pressure margin against gasification and cavitation in the fuel system even at a temperature of 150°C.

The circulating pumps will always be running, even if the propulsion engine and one or several of the GenSets are stopped. This is in order to circulate heated heavy fuel oil through the fuel system on the engine(s), thereby keeping them ready to start with preheated fuel injection pumps and the fuel valves de-aerated.

MDO Operation

The MDO to the GenSets is delivered from a separate pipeline from the service tank by means of a booster pump.

The pump capacity of the MDO pump must be 3 times higher than the amount of MDO, consumed by the diesel engines at 100% load.

The system is designed in such a way that the fuel type for the GenSets can be changed independent of the fuel supply to the propulsion engine.

As an optional, the GenSet plant can be delivered with the fuel changing system, consisting of a set of remotely controlled, pneumatically actuated 3-way fuel changing valves for each GenSet and a fuel changing valve control box common for all GenSets. A separate fuel changing system for each GenSet gives the advantage of individually choosing MDO or HFO mode.

Such a change-over may become necessary, for instance, if the engine(s) has to be:

- stopped for a prolonged period.
- stopped for major repairs of the fuel system, etc.

If the fuel type for the propulsion engine has to be changed from HFO to MDO, then the 3-way valves immediately after the service tanks have to be changed.

Emergency Start

Further, the MDO must be available as a fuel in emergency situations.

If a black-out occurs, starting up the auxiliary engines on MDO can be seen in two ways:

- The MDO is supplied from the MDO booster pump which can be driven pneumatically or electrically. If the pump is driven electrically it must be connected to the emergency switchboard.

- A gravity tank (100 - 200 l) may be arranged above the engine.

If no pumps are available, it is possible to start up the engine if a tank - as mentioned above - is placed minimum 8 meters above the engine. However, only if the change-over valve is placed as near as possible to the engine.

Fuel Oil Specification

General

Marine Gas Oil (MGO)

MGO is a medium class distillate oil which therefore must not contain any residual components.

The key property ratings refer to CIMAC #21 /2003.

Property		Units	Value
Density at 15°C	min.	kg/m^3	820.0
	max.	kg/m^3	890.0
Kinematic Viscosity at 40°C		mm^2/s	>1.5
		mm^2/s	<6.0
Flash Point		°C	>60
Water content		% by volume	<0.05
Sulphur content		% by weight	<1.5
Ash		% by weight	<0.01
Carbon residue (10% v/v)		% by weight	<0.30

Minimum injection viscosity at entering the engine >1.5 cSt.

Marine Diesel Oil (MDO)

MDO is offered as heavy distillate (CIMAC) or as a blend of distillate and small amounts of residual oil (CIMAC) exclusively for marine applications. The commonly used term for the blend, which is of dark brown to black colour, is Blended MDO. MDO is produced from crude oil and must be free from organic acids.

The key properties are based on the test methods specified.

Property	Units	Value	
CIMAC #21 /2003		DB	DC
Density at 15°C	kg/m^3	$\leq$ 900	$\leq$ 920
Kinematic Viscosity at 40°C	cSt (mm^2/s)	<11	<14
Flash Point	°C	>60	>60
Water content	% by volume	<0.3	<0.3
Sulphur content	% by weight	<2.0	<2.0
Ash content	% by weight	<0.01	<0.05
Carbon residue	% by weight	<0.30	<2.5
Vanadium	mg/kg	-	<100
Aluminium + Silicium	mg/kg	-	<25

Minimum injection viscosity at entering the engine >1.5 cSt.

08028-0D/H5250/94.08.12

General

Heavy Fuel Oil (HFO)

Commercially available fuel oils with a viscosity up to 700 cSt at 50° C corresponding to 55 cSt at 100° C can be used for MAN B&W four-stroke medium speed diesel engines.

For guidance on purchase, reference is made to ISO 8216/17, BS 6843 and to CIMAC recommendations regarding requirements for heavy fuel for diesel engines, #21 /2003. From these maximum accepted grades are RMH 55 and K55.

It means that engines can be operated on the same fuel oils as MAN B&W two-stroke low-speed diesel engines.

The data in the HFO standards and specifications refer to the same fuel type as delivered to the ship, i.e. before on-board cleaning.

In order to ensure effective and sufficient cleaning of the HFO, i.e. removal of water and solid contaminants, the fuel oil specific gravity at 15° C (60° F) should be below 991 kg/m³. Higher densities can be allowed if special treatment systems are installed.

Current analysis information is not sufficient for estimating the ignition and combustion properties of the oil. This means that service results depend on oil properties which cannot be known beforehand. This especially applies to the tendency of the oil to form deposits in combustion chambers, gas passages and turbines.

Guiding Heavy Fuel Oil Specification

Based on our general service experience we have, as a supplement to the above-mentioned standards, drawn up the guiding HFO-specification shown below.

Heavy fuel oils limited by this specification have, to the extent of the commercial availability, been used with satisfactory results on MAN B&W four-stroke medium speed diesel engines.

The data refer to the fuel as supplied, i.e. before any on-board cleaning.

Property	Units	Value
Density at 15°C	kg/m³	≤ 991*
Kinematic Viscosity at 100°C at 50 °C	 cSt cSt	 ≤ 55 ≤ 700
Flash Point	°C	> 60
Pour Point	°C	≤ 30
Conradsen Carbon Residue	% (m/m)	≤ 22
Micro Carbon Residue		≤ 22
Ash	% (m/m)	≤ 0.15
Total Sediment after Ageing	% (m/m)	≤ 0.10
Water	% (v/v)	≤ 1.0
Sulphur	% (m/m)	≤ 4.5
Vanadium	mg/kg	≤ 600
Aluminium + Silicium	mg/kg	≤ 80
CCAI		**
Asphaltenes		≤ 2/3 of carbon residue
FIA Cetane Number		***

m/m = mass V/V = volume

*) May be increased to 1.010 (kg/m³) provided adequate cleaning equipment is installed, and modern type of centrifuges.

**) If the CCAI value exceeds 840 it is recommended to have the FIA index measured revealing if ignition and combustion problems may arise.

If the CCAI value exceeds 840 ignition and combustion problems can occur.

***) If the FIA value is below 20 increasing ignition and combustion problems may be foreseen at low load operation.

If heavy fuel oils, with analysis data exceeding the besides figures, are to be used, especially with regard to viscosity and specific gravity, the engine builder should be contacted for advice regarding possible changes in the fuel oil system.

Blends

Fuel oil containing used lubricating oil (ULO) has to comply with the CIMAC #21/2003 fuel oil specification.

The admixing of used engine oil to the fuel involves a substantial danger because the lubricating oil additives have an emulsifying effect and keep dirt, water and catfines finely suspended. Therefore, they impede or preclude the necessary cleaning of the fuel. We ourselves and others have made the experience that severe damage included by wear may occur to the engine and turbocharger components as a result.

The admixing of non-mineral oil constituents (such as coal oil) and of residual products from refining or other processes (such as solvents) is harmfull to the engine! The reasons are, for example: the abrasive and corrosive effects, the adverse combustion properties, a poor compatibility with mineral oils and, last but not least, the negative environmental effects. The order letter for the fuel should expressly mention what is prohibited, as this constraint has not yet been incorporated in the commonly applied fuel specifications.

The admixing of chemical waste materials (such as solvents) to the fuel is for reasons of environmental protection prohibited by resolution of the IMO Marine Environmental Protection Committee of 1 Jan. 92.

Vanadium / Sodium

Should the vanadium/sodium ratio be unfavourable, the melting temperature of the heavy fuel oil ash may drop into the range of the exhaust valve temperature which will result in high-temperature corrosion and deposits build up. By precleaning the heavy fuel oil in the settling tank and in the centrifugal separators, the water, and with it the water-soluble sodium compounds can be largely removed.

If the sodium content is lower than 30% of the vanadium content, the risk of high-temperature corrosion will be small. It must also be prevented that sodium in the form of sea water enters the engine together with the intake air.

If sodium content is higher than 100 mg/kg, an increase of salt deposits is to be expected in the combustion space and in the exhaust system. This condition will have an adverse effect on engine operation (among others, due to surging of the turbocharger).

Under certain conditions, high-temperature corrosion may be prevented by a fuel additive that raises the melting temperature of the heavy fuel oil ash.

Ash

Heavy fuel oils with a high ash content in the form of foreign particles such as sand, corrosion elements and catalyst fines (catfines) in heavy fuel oils coming from catalytic cracking processes. In most cases, these catfines will be aluminium oxides, silicium oxides, which causes high wear in the injection system and in the engine.

Sulphuric Acid Corrosion

The engine should be operated at the cooling water temperatures specified in the operating manual for the respective load. If the temperature of the component surface exposed to the acidic combustion gases is below the acid dew point, acid corrosion can occour.

Fuel Oil Condition, when entering the Engine

As practically all fuel oil specifications including the above standards refer to the same fuel type as supplied, the fuel supplied to a ship has to be treated on board before use. For running on the oil quality mentioned above it is necessary that equipment exists on board, which can treat, respectively clean and preheat, the fuel oil with optimum efficiency.

General

In B 11 00 0 "**Cleaning Recommendations**" our recommendations are outlined.

For economical HFO operation the fuel oil condition at engine inlet should be as recommended below.

Property	Units	Value
Water	% by volume	max. 0.2
Solid particles	ppm (mg/kg)	max. 20
Particle size	Micron	max. 5
Viscosity	cSt	Range 12-18

For fuels above 180 cSt/50° C a pressurerized fuel oil system is necessary to avoid boiling and foaming of the fuel.

The preheating chart on page 5 illustrates the expected preheating temperature as function of the specific fuel oil viscosity.

The viscosity leaving the heaters should be 10-15 cSt and approx. 12-18 cSt entering the engine.

Viscosity Adjustment

To enable a proper injection viscosity and a to prevent overloading of the fuel equipment it is essential to maintain a constant viscosity within the limits stipulated, see preheating chart on page 5.

A vessel heated either by steam or electricity adjusts the viscosity of the fuel. There are two means of adjusting the power supply to the vessel:

– Either by measuring the temperature of the media, or
– by measuring the viscosity of the media

Temperature controller

If this method is chosen it demands a laboratory apparatus enabling the staff to test the fuel oil samples on a regular basis and set the temperature controller accordingly. The frequency is dependent on the homogenity of the fuel ie. how often charges are received and how well these are blended in the tanking system.

The reason being that the charges of the fuel oils may vary considerably in properties eg. fractions, viscosity indexes, etc.

Viscosity regulator (Viscorator)

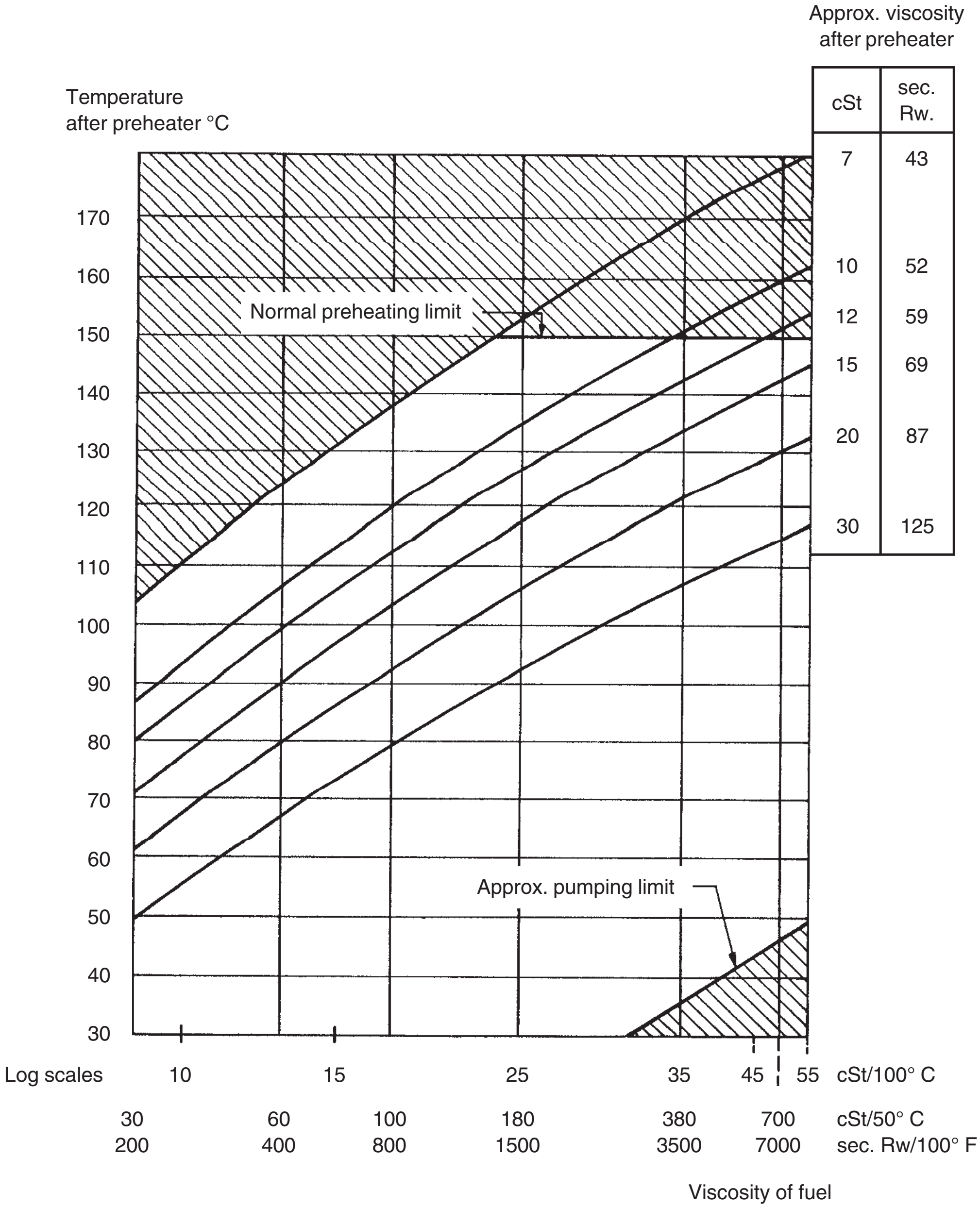
If this method is chosen the viscosity of the fuel oil is monitored continuously and the temperature is adjusted at the set value depending of the quality of heating elements and the controls of these.

There are in the principle two different methods of monitoring the viscosity of the fuel:

– True measurement (pressure drop in a calibrated tube)*
– Ultrasonic vibration

*) The difficulty of this method is that the equipment has to be maintained and calibrated regularly. However this method is by far to be preferred.

Fuel oil - preheating chart



08028-0D/H5250/94.08.12

This chart is based on information from oil suppliers regarding typical marine fuels with viscosity index 70-80. Since the viscosity after the preheater is the controlling parameter, the preheating temperature may vary, dependent on the viscosity and viscosity index of the fuel.

General

General Considerations

The quality of a fuel oil is stated, in analysis data, in terms of physical and chemical properties, which are decisive to the suitability of the fuel oil for different applications. For diesel engine fuels the combustion quality, the content of impurities and the handling properties are the main quality criteria.

Since residual fuels are traded and designated according to viscosity, it has become common practice to associate viscosity with quality. This practice can be very misleading, especially with modern residual fuels, as a fuel oil of low viscosity can often be just as bad, or even worse, than other fuel oils of very high viscosity.

The quality of refinery residues is dependent on the origin of the crude oil, the grade of utilization when refining the crude oil, and the refinery technique used.

Some of the residues used in fuel oil production are of a viscosity requiring visbreaking, a process which will reduce the viscosity without improving the quality at all.

When producing residual fuels from visbreaked, cracked residues and from "straight run" residues, the final adjustment of viscosity to fulfil the requirements of the different grades of intermediate fuels is achieved by adding gas oil.

However, it must be noted that considerable reduction of the viscosity is achieved by adding a relatively small amount of gas oil, which will give only a minor improvement of the quality of the blend. This means that the quality to a major extent depends on residues present in the blend. Therefore the quality also depends on the density.

As a consequence of the possible variations in the quality of residues and the influence of adding gas oil, the quality of blended fuels can vary, even for fuel oils of equal nominal viscosity.

Combustion Quality

Combustion quality is the ability of the fuel oil to ignite and burn in a proper way. The ignition quality, combustion intensity, and length and completeness of combustion are properties influenced by the chemical composition and structure of the fuel oil.

Ignition quality relates to ignition delay, i.e. the time elapsed between the start of injection and the start of combustion.

Ignition quality is expressed by the cetane number, diesel index or cetane index. In all cases the higher the value, the better the ignition quality. For diesel oil the ignition quality is expressed by the cetane number determined by a specified method in a standard engine running under standard conditions.

For distillate fuels the ignition quality can be expressed by the diesel index or cetane index, both to be calculated from physical properties such as the aniline point, specific gravity and mid-distillation temperature. The cetane number, diesel index or cetane index of a certain fuel oil will show reasonable correlation between the numerical values.

For residual fuels ignition quality is an even more important parameter. The reason why it does not appear in the international specifications is that a standardized testing method is non-existent. Therefore, parameters such as the Calculated Carbon Aromaticity Index (CCAI) are resorted to as an aid which is derived from determinable fuel parameters. According to our experience, only a rough assessment of the ignition quality of the heavy fuel oil is possible with the help of this method.

However, the CCAI has become so well-known in widespread publications that, in spite of the reservations mentioned above, we were compelled to classify the respective MAN B&W Diesel A/S, four-stroke engines according to CCAI-rating, too, see also B 11 01 0 "**Nomogram for Determination of CCAI**".

A FIA cetane number test is also good for evaluation of the combustion quality.

General

Fuel ignition analyser FIA 100/4 measurements

In the FIA 100 instrument, the ignition delay is defined as a time delay (in millisenconds, msec.) from the start of injection, until the pressure has increased to 0.2 bar above the initial chamber pressure.

The start of the main combustion phase is defined as being the time (in msec.) from when the pressure has increased to 3 bar above the intial chamber pressure.

The start of the combustion is used to establish the ignition quality of a tested fuel expressed as a FIA CN (Cetane Number). The basis for FIA CN is a reference curve for the instrument in question showing the ignition properties of mixtures of the reference fuels U15 and T22 from Phillips Petr. Int. This reference curve establishes the relationship between ignition quality, recorded in milliseconds, and Cetane Number of the different mixtures of the reference fuels. For heavy fuels, the ignition properties range from CN =18.7 to above CN = 40.

The rate of heat release (ROHR) is used to evaluate the combustion properties of the oil.

FIA compared with CCAI

Comparing the FIA test and CCAI, the FIA gives a relative picture of ignition qualities of fuels, which may be of use for the ship operator before buying the fuel. The CCAI does not provide sufficient information and has in some tests shown very inconsistent indications, i.e. the FIA test should be carried out when the CCAI value is higher than 840.

Conversion of FIA 100/4 test result to actual engine performance

When using the FIA 100/4 test conditions for temperature and pressure, the differences between the different fuels are more pronounced than what would actually be seen in the engine, and the results must be seen in this context and in relation to the engine types in question.

However, the information about the differences in the fuel behaviour makes it possible to see the effects of the fuel in composition on the ignition and the heat release pattern which may or may not have any impact on the particular engine.

The engine load also influences the performance of the fuel. At low load operation, ignition must take place at lower temperature. This will increase the demand for ignition quality and if the lighter fuel fractions are highly aromatic, low load combustion problems may be found.

As mentioned above, the longer time the engine has for ignition, the less sensitive the engine is to the ignition delay quality of the fuel.

This consideration has been proved lately in a small number of ships with auxiliary engines and main engine operating on the same fuel. Ignition problems have been observed on the auxiliary engines during low load operation only, having no effect on the two-stroke low-speed engine.

The combustion condition of the fuel oils is normally evaluated from Conradson Carbon residue and the asphaltene contents.

Content of Impurities

The content of impurities of diesel engine fuels should be kept as low as possible. Harmful and unwanted impurities should, be removed in the pre-treatment system in order to minimize wear and corrosion of engine components. Impurities derive from the crude oil itself, from refinery processes and from handling and storage of oils. The amount of water and solid impurities can be reduced by centrifuging and filtration.

Sand, rust, metal oxides and catalyst particles can be found as solid particles in fuel oil.

Fuel-related wear and corrosion in diesel engines take the form of mechanical wear and chemically induced corrosion, the latter in the form of high and low temperature corrosion.

The solid impurities and particles produced during combustion, collectively known as ash, cause mechanical wear of engine components.

Especially catalyst particles, silicone and aluminium oxides and silicates in the form of sand are very abrasive. From sulphur, vanadium and sodium corrosive ash in the form of oxides, carbonates and sulphates, is created during combustion.

Further the sulphur content of a fuel oil may lead to low temperature corrosion of combustion chamber components and the formation of deposits on these. The corrosive effect is due to the formation of sulphuric acid.

Sea water in the fuel oil may lead to several detrimental effects to the fuel system and to the diesel engine in general by giving rise to mechanical and corrosive wear, as well as fouling.

Handling Properties

Handling of the fuel, i.e. storage, pumping and treatment, is affected mainly by physical properties such as viscosity, density, flash point and pour point, but other fuel oil properties such as stability, emulsification tendency, viscosity index and the nature and amount of water and solid impurities will also influence the handling system.

The nominal viscosity is decisive for the preheating temperature necessary to achieve adequate viscosity for pumping, settling, centrifuging and injection.

The density influences the gravitational settling of water and solid contaminants in settling tanks. Specific gravity is also an important parameter in the centrifuging process. The flash point is, for safety reasons, limited to a minimum of 60°C (140°F) by classification societies and other authorities.

The flash point is related to the volatility of the amount and nature of lighter fractions in the fuel oil, and might thus be used to estimate the propensity of gasification in non-pressurized parts of the fuel system.

The pour point defines the temperature at which wax crystallization will take place and prevent the fuel oil from flowing and from being pumped.

Therefore, the pour point must be taken into account when deciding the presence and capacity of heating coils in bunker tanks.

Quality Criteria	Fuel Oil Characteristics	Main Effects
Combustion quality	Conradson carbon asphaltenes + FIA test	Ignition ability. Combustion condition. Fouling of gasways.
Content of impurities	Sulphur	Corrosive wear. Cold corrosion.
	Vanadium Sodium	Formation of deposits on exhaust valves and turbo-chargers. High temperature corrosion.
	Sea water	Disturbance of combustion process. Increased heat-load of combustion chamber components, fouling of gas ways, mechanical wear and cavitation of fuel injection system.
	Ash Catalyst fines	Mechanical and corrosive wear of combustion chamber components. Formation of deposits. Mechanical wear of fuel injection system, cylinder liners and piston rings.
Handling properties	Viscosity Density Pour point	Temperatures, pressures, and capacities of fuel oil systems for storage, pumping and pre-treatment.
	Flash point	Safety requirements.

Table 1. Fuel properties affecting diesel engine and fuel systems.

Fuel Oil Cleaning Recommendations

General

Centrifuging

Fuel oils should always be considered as contaminated upon delivery and should therefore be thoroughly cleaned to remove solids as well as liquid contaminants before use.

The solid contaminants in the fuel oil are mainly rust, sand, dust and refinery catalysts. Liquid contaminants are mainly water, i.e. either fresh water or salt water.

Impurities in the fuel can cause damage to fuel pumps and fuel valves, and can lead to increased cylinder liner wear and deterioration of the exhaust valve seats. Also increased fouling of gas ways and turbocharger blades may result from the use of inadequately cleaned fuel oil. Effective cleaning can only be ensured by using a centrifuge.

We recommend that the capacity of the installed centrifuge should, at least, be according to the centrifuge maker's instructions.

Cleaning of distillate fuel such as ISO 8217 classes DMX to DMB is generally not necessary. But handling of a liquid fuel on board ships gives a risk of contamination with sea water. Therefore it is a good idea to centrifuge all fuel on board ships.

Fuel classes DMC to RMH55 require a treatment with centrifuge in all cases.

Automatic centrifuges must be used. Fuel types RMK35 to RMK55 require centrifuges capable to handle up to 1010 kg/m^3 density.

To obtain optimum cleaning it is of the utmost importance that the centrifuge is operated with a fuel oil viscosity as low as possible, i.e. that the highest possible temperature is maintained in the centrifuge oil preheater.

Supplementary Equipment

Experience proves that if the centrifugal installation is dimensioned and installed correctly – and operated correctly according to the supplier's instructions – this is a sufficient way of cleaning the fuel.

All supplementary equipment, such as the 10 mμ nominal filter, will have a positive effect and may contribute to longer intervals between overhauls. Also, supplementary equipment will reduce the operation costs.

This equipment can give difficulties if incorrectly installed, However if correctly installed and operated can with some fuels give benefits in lower wear and sludge formation.

Specific Fuel Oil Consumption SFOC

L21/31

Constant Speed Engines

Engine type	L21/31 MCR	
Speed r/min	900	1000
kW/cyl.		
5 cyl. engine	190	200
6, 7, 8, 9 cyl. engine	220	220

Load	SFOC (g/kWh)	
25 %	219	219
50 %	192	192
75 %	186	187
100 %	186	189

All values based on ISO 3046/1 conditions.

Ambient air temperature 25° C
Ambient air pressure 1000 mbar
Cooling water for air cooler 25° C

Marine diesel oil (MDO). Lower calorific value: 42,700 kJ/kg

Tolerance: +5%

With built-on pumps, the SFOC will be increased by:

Lub. oil main pump $1.2 \times \left(\frac{110}{\text{load \%} + 10} \right) \%$

LT Cooling water pump $0.7 \times \left(\frac{110}{\text{load \%} + 10} \right) \%$

HT Cooling water pump $0.7 \times \left(\frac{110}{\text{load \%} + 10} \right) \%$

For other reference conditions, the SFOC is to be corrected by:

Ambient air temperature	rise	10°	C	0.6	%
Ambient air pressure	rise	10 mbar	- 0.07%		
Cooling water to air cooler	rise	10°	C	0.7	%
Lower calorific value	rise	427 kJ/kg	- 1.0 %		

08028-0D/H5250/94.08.12

General

Fuel Oil Safety Filter

The duplex fuel oil safety filter is with Star pleated filter elements, the fineness of the filter is 25-37 µ Abs.

The filter is supplied loose, and is to be built in the fuel oil supply line before each engine.

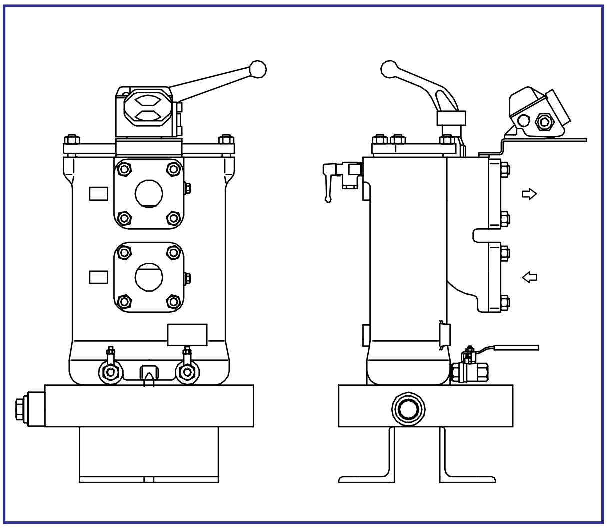


Fig 1 Fuel oil safety filter.

Lubrication Oil System

B 12

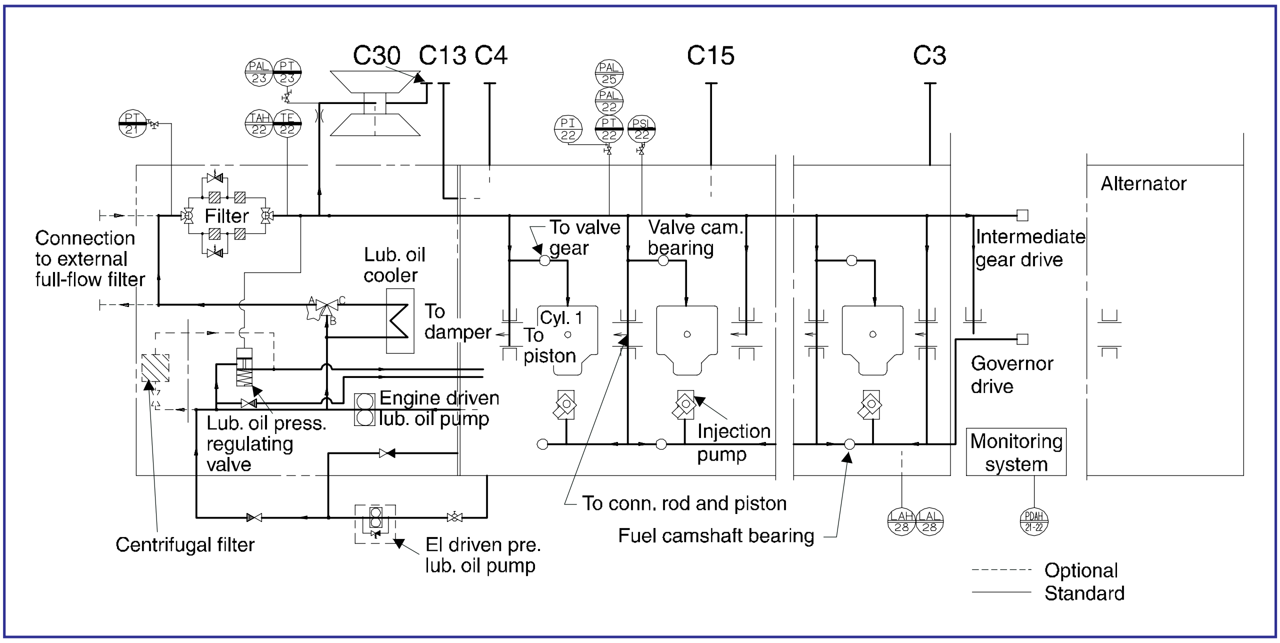


Fig 1 Diagram for internal lubricating oil system.

Pipe description for connection at the engine		
C3	Lubricating oil from separator	DN25
C4	Lubricating oil to separator	DN25
C13	Oil vapour discharge*	DN65
C15	Lubricating oil overflow	DN50
C30	Venting pipe turbocharger bearings	DN40

Flange connections are standard according to DIN 2501

* For external pipe connection, please see section for crankcase ventilation.

General

As standard the lubricating oil system is based on wet sump lubrication.

All moving parts of the engine are lubricated with oil circulating under pressure in a closed system.

The lubricating oil is also used for the purpose of cooling the pistons and turbocharger.

The standard engine is equipped with:

- Engine driven lubricating oil pump.
- Lubricating oil cooler.
- Lubricating oil thermostatic valve.
- Duplex full-flow depth filter.
- Pre-lubricating oil pump.

Oil Quantities

The approximate quantities of oil necessary for a new engine, before starting up are given in the table, see "B 12 01 1 Lubricating Oil in Base Frame" (max. litre H3)

When engine or pre-lubricating oil pump is running approx. 200 litres of lubricating oil is accumulated in the front-end box and the lubricating oil system of the engine.

This oil will return to the oil sump when the engine and the pre-lubricating oil pump are stopped.

This oil return may cause level alarm HIGH.

The level alarm will disappear when the pre-lubricating oil pump is started again.

L21/31

Lubricating Oil Consumption

The lubricating oil consumption is 0.4 - 0.8 g/kWh, see "Specific Lubricating Oil Consumption - SLOC, B 12 15 0 / 504.07"

It should, however, be observed that during the running-in period the lubricating oil consumption may exceed the values stated.

Quality of Oil

Only HD lubricating oil (Detergent Lubricating Oil) should be used, characteristics are stated in "Lubricating Oil Specification B 12 15 0".

System Flow

The lubricating oil pump draws oil from the oil sump and pumps the oil through the cooler and filter to the main lubricating oil bore, from where the oil is distributed throughout the engine. Subsequently the oil returns by gravity to the oil sump.The oil pressure is controlled by an adjustable spring-loaded relief valve built in the system.

The main groups of components to be lubricated are:

1 – Turbocharger
2 – Main bearings, big-end bearing pistons etc.
3 – Camshaft drive
4 – Governor drive
5 – Rocker arms
6 – Camshaft

ad 1) The turbocharger is an integrated part of the lubricating oil system, thus allowing continuous priming and lubrication when engine is running. For priming and during operation the turbocharger is connected to the lubricating oil circuit of the engine. The oil serves for bearing lubrication and also for dissipation of heat.

The inlet line to the turbocharger is equipped with an orifice in order to adjust the oil flow.

ad 2) Lubricating oil for the main bearings is supplied through holes in the engine frame. From the main bearings it passes through bores in the crankshaft to the connecting rod big-end bearings.

The connecting rods have bored channels for supply of oil from the big-end bearings to the small-end bearings, which has an inner circumferential groove, and a bore for distribution of oil to the piston.

From the front main bearing channels are bored in the crankshaft for lubricating of the damper.

ad 3) The lubricating oil pipes for the camshaft drive gear wheels are equipped with nozzles which are adjusted to apply the oil at the points where the gearwheels are in mesh.

ad 4) The lubricating oil pipe for the gear wheels are adjusted to apply the oil at the points where the gear wheels are in mesh.

ad 5) The lubricating oil to the rocker arms is led through bores in the engine frame to each cylinder head. The oil continuous through bores in the cylinder head and rocker arm to the movable parts to be lubricated at the rocker arm and valve bridge.

ad 6) Through a bores in the frame lubricating oil is led to camshafts bearings.

Lubricating Oil Pump

The lubricating oil pump, which is of the gear wheel type, is mounted in the front-end box of the engine and is driven by the crankshaft.

Lubricating Oil Cooler

As standard the lubricating oil cooler is of the plate type. The cooler is mounted on the front-end box.

Thermostatic Valve

The thermostatic valve is a fully automatic 3-way valve with thermostatic elements set at fixed temperature.

Built-on Full-flow Depth Filter

The lubricating oil filter is of the duplex paper cartridge type. It is a depth filter with a nominel fineness of 10-15 microns, and a safety filter with a fineness of 60 microns.

Pre-lubrication

As standard the engine is equipped with an electric-driven pre-lubricating oil pump mounted parallel to the main pump. The pump is arranged for automatic operation, ensuring standstill of the pre-lubricating oil pump when the engine is running, and running during engine standstill in stand-by position by the engine control system.

Draining of the Oil Sump

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

Crankcase Ventilation

The crankcase ventilation is not to be directly connected with any other piping system. It is preferable that the crankcase ventilation pipe from each engine is led independently to the open air. The outlet is to be fitted with corrosion resistant flame screen separately for each engine.

However, if a manifold arrangements is used, its arrangements are to be as follows:

1) The vent pipe from each engine is to run indepently to the manifold, and be fitted with corrosion resistant flame screen within the manifold.

2) The manifold is to be located as high as practicable so as to allow substantial length of piping separating the crankcase.

3) The manifold is to be vented to the open air, such that the vent outlet is fitted with corrosion resistant flame screen, and the clear open area of the vent outlet is not less than the aggregate area of the individual crankcase vent pipes entering the manifold.

4) The manifold is to be provided with drainage arrangement.

The ventilation pipe should be designed to eliminate the risk of water condensation in the pipe flowing back into the engine and should end in the open air:

- The connection between engine (C13) and the ventilation pipe must be flexible.
- The ventilation pipe should be continuously inclined (min. 5 degrees).
- A continuous drain has to be installed near the engine. The drain must not be lead back to the engine.
- Dimension of the flexible connection DN65.
- Dimension of the ventilation pipe after the flexible connection min. DN80.

Oil Level Switches

The oil level is automatically monitored by level switches giving alarm if the level is out of range.

Optionals

Centrifugal bypass filter can be built-on.

Data

For heat dissipation and pump capacities, see D 10 05 0 "List of Capacities".

Operation levels for temperature and pressure are stated in B 19 00 0 "Operating Data and Set Points".

08028-0D/H5250/94.08.12

General

The engine is as standard equipped with an electric driven pump for prelubricating before starting.

The pump is self-priming.

The engine must always be prelubricated 2 minutes prior to start if the automatic continuous prelubricating has been switched off.

The automatic control of prelubricating must be made by the customer or can be ordered from MAN B&W, Holeby.

The voltage for the automatic control must be supplied from the emergency switchboard in order to secure post- and prelubrication in case of a critical situation. The engines can be restarted within 20 min. after prelubrication have failed.

Engine type	No of cyl.	Pump type	m³/h	rpm	Electric motor 3x380 V, 50 Hz		
					kW	Start current Amp.	Full-load current Amp.
L16/24	5-6-7-8-9	Make: IMO Type: ACD025N6 IRBP	2.2	2820	0.55	6.8	1.5
L21/31	5-6-7-8-9	Make: Type: R35/40 FL-Z-DB-SO	6.82	2900	3.0	47.0	6.3
L27/38	5-6-7-8-9	Make: WP Type: R35/40 FL-Z-DB-SO	6.82	2900	3.0	47.0	6.3

Engine type	No of cyl.	Pump type	m³/h	rpm	Electric motor 3x440 V, 60 Hz		
					kW	Start current Amp.	Full-load current Amp.
L16/24	5-6-7-8-9	Make: IMO Type: ACD025N6 IRBP	2.6	3360	0.75	7.2	1.6
L21/31	5-6-7-8-9	Make: Type: R35/40 FL-Z-DB-SO	8.19	3480	3.45	46.0	5.9
L27/38	5-6-7-8-9	Make: WP Type: R35/40 FL-Z-DB-SO	8.19	3480	3.45	46.0	5.9

08028-0D/H5250/94.08.12

General

Requirement

This document is valid for the following engine types: L16/24, L21/31, L23/30H, L27/38, L28/32H, V28/32H, V28/32S and L32/40.

Heavy Duty lubricating oil (HD-Lubricating oil) has to be used coresponding to at least type CF after API service system (http://api-ep.api.org/filelibrary/ACF1E1.pdf). Further the lubricating oil should be rust and oxidation inhibited.

Viscosity

Marine
Engine SAE class
L23/30H, L+V28/32H
30* 105 cSt @ 40° C

L16/24, L21/31, L27/38, L32/40
40 145 cSt @ 40° C

Stationary
L16/24, L21/31, L27/38, L23/30H, L+V28/32H, V28/32S
40 145 cSt @ 40° C

* At cooling water temperatures above 32° C SAE 40 oil can be used. In this case, please contact MAN Diesel, Holeby.

Guiding Values for BN

When selecting lubricating oil, attention must be paid to the fuel oil sulphur content.

Marine GenSet engines are normally running at low load compared to propulsion engines, therefore the absolute fuel consumption is lower and consequently the lubricating oil is exposed to a smaller amount of sulphur. Therefore the BN-value (Base Number) of the lubricating oil has to be lower in order to neutralise the sulphur input from the fuel.

The lubricating oil consumption has an influence on the recommended initial BN value. When the lubricating oil consumption is high, low BN values is recommended, and opposite. How to evaluate the lubricating oil consumption, please see section B 12 15 0 "Specific Lubricating Oil Consumption".

The BN selection is based on typical load profiles for marine GenSet (50-60% of rated power) and for stationary GenSet (50-100% of rated power)

For all engines except L32/40

Oil type	**BN** (mg KOH/g)
Gas oil	8-12
Marine diesel	10-15
Heavy fuel oil (S<1.5%)	15-20
Heavy fuel oil (S>1.5%)	20-40

For engines L32/40

Oil type	**BN** (mg KOH/g)
Gas oil	12-15
Marine diesel	15-25
Heavy fuel oil (S<1.5%)	25-35
Heavy fuel oil (S>1.5%)	30-40

For low loaded marine GenSet engines the lowest BN values are recommended and for high loaded stationary engines the highest BN values are recommended. If the load profile is different, this should be taken in consideration. However, the operation results are the criteria that prove which BN is the most economical one for efficient engine operation.

In order to meet the emission regulations, more often fuel oils with different sulphur content are in operation. At habour/coastal operation a low sulphur fuel oil will be used and at sea operation a high sulphur fuel oil will be used. The lubricating oil BN value will have to be evaluated from engine running hours operating on the two different fuel oils. Normally the BN value should be evaluated from the fuel oil with the highest sulphur content, please see section B 11 00 0 "Guidelines Regarding MAN Diesel GenSets Operating on Low Sulphur Fuel Oil".

Operation on Marine Diesel Oil (MDO)

At engine operation on MDO we recommend to install a build on centrifugal by-pass filter as an additionally filter to the build on full flow depth filter and the lubricating oil separator.

Operation on Heavy Fuel Oil (HFO)

HFO operating engines requires effective lubricating oil cleaning. In order to secure a safe operation it is necessary to use a supplement cleaning equipment together with the built on full flow depth filter. For this purpose a centifugal unit, a decanter unit or an automatic by-pass filter can be used.

Continuous lubricating oil cleaning during engine operation is necessary.

The centrifugal unit, decanter unit and the automatic by-pass filter capacity to be adjusted according to makers resommendations.

The capacity is evaluated below.

Cleaning Capacity

Normally, it is recommended to use a self-cleaning filtration unit in order to optimize the cleaning period and thus also optimize the size of the filtration unit.

Separators for manual cleaning can be used when the reduced effective cleaning time is taken into consideration by dimensioning the separator capacity.

The required Flow

In order to evaluate the required lubricating oil flow through the separator, the separator suppliers recommendation should be followed.

As a guidance, the following formula should form the basis for choosing the required flow for the separator capacity:

$$Q = \frac{P \times 1.36 \times n}{t}$$

Q = required flow (l/h)
P = engine output (kW).
t = actual effective separator operating time per day (hour)
n = number of turnovers per day of the theoretical oil volume corresponding to 1.36 l/kW or 1 l/HP.

The following values for "n" are recommended:

n = 5 for HFO operating (residual)
n = 4 for MDO operating
n = 3 for distillate fuel

Example: for 1000 kW engine operating on HFO, self-cleaning separator with a daily effective separating period of 23 hours:

$$Q = \frac{1000 \times 1.36 \times 5}{23} = \mathbf{295\ l/h}$$

Separator Installation

It is recommended to carry out continuous lubricating oil cleaning during engine operation at a lubricating oil temperature between 95°C till 98°C at entering the separator.

With multi-engine plants, one separator per engine in operation is recommended, but if only one separator is in operation, the following lay-outs can be used.

A common separator can be installed, possibly with one in reserve for operation of all engines through a pipe system, which can be carried out in various ways. Fig. 1 and 2 show a principle lay-out for a single plant and a multi-plant.

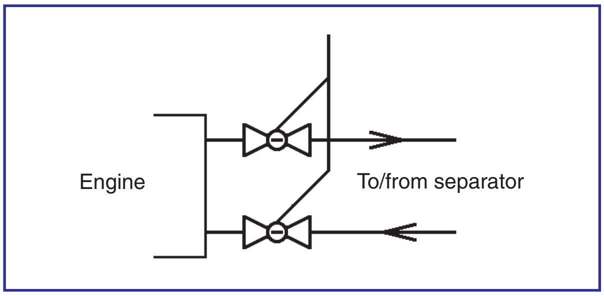


Fig 1 Principle lay-out for direct separating on a single plant.

08028-0D/H5250/94.08.12

General

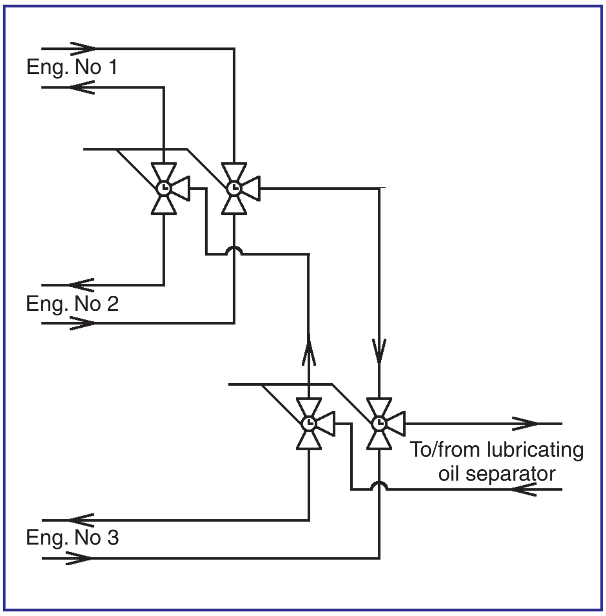


Fig 2 Principle lay-out for direct separating on a multi plant.

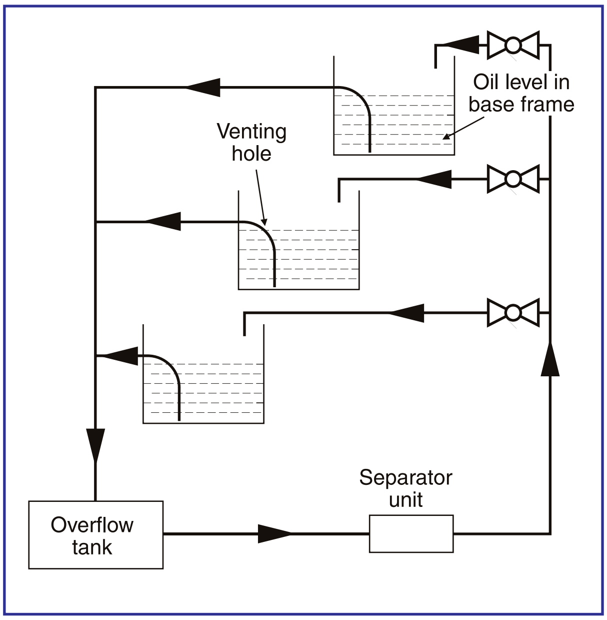


Fig 3 Principle lay-out for overflow system.

The aim is to ensure that the separator is only connected with one engine at a time. This to ensure that there is no suction and discharging from one engine to another.

To provide the above-mentioned it is recommended that inlet and outlet valves are connected, so that they can only be changed-over simultaneously.

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

The capacity of the separator has to correspond with the separating of oil on the single engine n times during the available time, every 24 hours. (see page 1)

Overflow System

As an alternative to the direct separating an overflow system can be used (see fig. 3).

By-pass Centrifugal Filter

The Holeby GenSets can be delivered with built-on by-pass centrifugal filters.

By-pass Depth Filter

When dimensioning the by-pass depth filter the supplier’s recommendations are to be followed.

Cooling Water System

B 13

General

Protection against Corrosion in Freshwater Cooling System

The engine fresh water ***must*** be carefully treated, maintained and monitored so as to avoid corrosion or the formation of deposits which can result in insufficient heat transfer, it is necessary to treat the cooling water. MAN B&W recommend that this treatment is carried out according to the following procedure:

- Clean the cooling water system.
- Fill up with deionized or distilled cooling water (for example from the freshwater generator) with corrosion inhibitor added.
- Carry out regular checks of the cooling water system and the condition of the cooling water.

Observance of these precautions, and correct venting of the system, will reduce service difficulties caused by the cooling water to a minimum.

Cleaning of the Cooling Water System

Before starting the inhibition process, any existing deposits of lime or rust, or any oil sludge, should be removed in order to improve the heat transfer and to ensure uniform protection of the surface by means of the inhibitor.

The cleaning should comprise degreasing to remove oil sludge, and descaling with acid afterwards to remove rust and lime deposits.

Ready-mixed cleaning agents, specially made for cleaning the cooling water system, can be obtained from companies specializing in cooling water treatment. These companies offer assistance and control of the treatment in all major ports. A number of these companies are mentioned on the enclosed list. We point out that the directions given by them should be closely followed. It is of particular importance to flush the system completely after cleaning.

Cleaning agents emulsified in water as well as slightly alkaline cleaning agents can be used for the degreasing process, whereas ready-mixed cleaning agents which involve the risk of fire must obviously not be used. For descaling with acid, especially products based on amino-sulphonic acid, citric acid, and tartaric acid are recommendable, as these acids are usually obtainable as solid substances, easily soluble in water, and do not emit poisonous vapours.

The cleaning agents should not be directly admixed, but should be dissolved in water and then added to the cooling water system.

Normally, cleaning can be executed without any dismantling of the engine. We point out that the water should be circulated in the engine to achieve the best possible result.

As cleaning can cause leaks to become apparent in poorly assembled joints or partly defective gaskets, inspection should be carried out during the cleaning process. The acid content of the system oil should also be checked immediately after cleaning, and 24 hours afterwards.

Cooling Water - Inhibitors

The filling-up with cooling water and the admixture of the inhibitor is to be carried out directly after the cleaning in order to prevent formation of rust on the cleaned surfaces.

Raw Water

The formation of lime stone on cylinder liners and in cylinder heads may reduce the heat transfer, which will result in unacceptably high temperatures in the material.

Therefore, it is recommended that deionized or distilled water (for example from the freshwater generator) is used as cooling water. However, on account of its lack of hardness, this water will be relatively corrosive, and a corrosion inhibitor should therefore always be added.

08028-0D/H5250/94.08.12

General

If deionized or distilled water cannot be obtained, normal drinking water can be used in exceptional cases. If so, the total hardness of the water must not exceed 9° dH (German hardness degrees). The chloride, chlorine, sulphate, and silicate contents are also to be checked. These contents should not exceed the following values:

Chloride	50 ppm	(50 mg/litre)
Chlorine	10 ppm	(10 mg/litre)
Sulphate	100 ppm	(100 mg/litre)
Silicate	150 ppm	(150 mg/litre)

There should be no sulphide and ammonia content. Rain water must not be used, as it may be heavily contaminated.

It should be noted that softening of water does not reduce its sulphate and chloride contents.

Corrosion Inhibitors

To protect freshwater cooling systems in marine diesel engines against corrosion, various types of inhibitors are available.

Generally, only nitrite-borate based inhibitors are recommended.

A number of the products marketed by major companies are specified on the enclosed list, together with the necessary dosages and admixing procedures. We recommend that these directions are strictly observed.

Treatment of the cooling water with inhibting oils is not recommended, as such treatment involves the risk of oil adhering to the heat transmitting surfaces.

Chromate inhibitors must not be used in plants connected to a freshwater generator.

Evaporated cooling water is to be replaced with noninhibited water, whereas a loss of water through leakage must be replaced with inhibited water.

When overhauling individual cylinders, a new dosage of inhibitor must, if necessary, be added immediately after completing the job.

Checking of the Cooling Water System and the Cooling Water during Service

If the cooling water is contaminated during service, sludge or deposits may form. The condition of the cooling water system should therefore be regularly checked, especially if deionized or distilled water is not used. If deposits are found in the cooling spaces, these spaces or, if necessary, the entire system should be cleaned.

According to experience, a zinc galvanized coating in the freshwater cooling system is often very susceptible to corrosion, which results in heavy formation of sludge, even if the cooling water is correctly inhibited. The initial descaling with acid will, to a great extent, remove the galvanized coating. Generally, therefore, we advise against the use of galvanized piping in the freshwater cooling system.

The quality of the cooling water is to be checked regularly, if possible once a week. Basically the inhibitor concentration, the pH value and the chloride concentration should be in accordance with limits stated by inhibitor manufacturer. For this purpose the inhibitor manifactures normally supply simple test kits.

As a general guidance values the pH value should be 7-10 measured at 20° C and the chloride concentration should not exceed 50 ppm (50 mg/litre).

The water sample for these tests is to be taken from the circulating system, and not from the expansion tank or the pipe leading to it.

The concentration of inhibitor must under no circumstances be allowed to fall below that recommended by the producer, as this would increase the risk of corrosion.

A clear record of all measuring results should be kept, so that the actual condition and trend of the system may be currently ascertained and evaluated.

A sudden or gradual increase in the chloride content of the cooling water may be indicative of salt water leakages. Such leakages are to be traced and repaired at the first opportunity.

08028-0D/H5250/94.08.12

A chloride content in the cooling water higher than the 50 ppm specified might, in exceptional cases be tolerated. However, in that case the upper limit specified by the individual inhibitor supplier must not be exceed.

A clear record of all measuring results should be kept, so that the actual condition and trend of the system may be currently ascertained and evaluated.

A sudden or gradual degrease in pH value, or an increase of the sulphate content, may indicate exhaust gas leakage. The pH value can be increased by adding inhibtor; however, if major quantities are necessary, the water should be replaced.

Every third month a cooling water sample should be sent ashore for laboratory analysis, in particular to ascertain the contents of inhibtor, sulphate, and iron, as well as the total salinity of the water.

Cleaning and Inhibiting Procedure

The engine must not be running during the cleaning procedure, as this may involve the risk of overheating when draining.

Degreasing

Use clean tap water for filling-up. The cooling water in the system can be used, if it does not contain inhibitors.

Heat the water to 60° C and circulate the water continuously.

Drain to lowest water level in expansion tank.

Add the amount of degreasing chemical specified by the supplier, preferably from the suction side of the freshwater pump.

Drain to lowest water level in the expansion tank directly afterwards.

Circulate the cleaning chemical for the period specified by the supplier.

The cooling water system must not be kept under pressure.

Check, and repair any leaks.

Drain the system and fill up completely with clean tap water, in order to flush out any oil or grease from the tank.

Circulate the water for 2 hours, and drain again.

Descaling with Acid Solution

Fill up with clean tap water and heat to 70-75° C.

Dissolve the necessary dosage of acid compound in a clean iron drum with hot water.

Fill the drum half up with water and slowly add the acid compound, while stirring vigorously. Then fill the drum up completely with hot water while continuing to stir (e.g. using a steam hose).

Be careful - use protective spectacles and gloves.

For engines which have been treated before the trial trip, the lowest concentration recommended by the supplier will normally be sufficient.

For untreated engines, a higher concentration - depending on the condition of the cooling system - will normally be necessary.

Drain some water from the system and add the acid solution via the expansion tank.

The cooling water system must not be put under pressure.

Keep the temperature of the water between 70° C and 75° C, and circulate it constantly. The duration of the treatment will depend on the degree of fouling. Normally, the shortest time recommended by the supplier will be sufficient for engines which are treated before the trial trip. For untreated engines, a longer time must be reckoned with. Check every hour, for example with pH-paper, that the acid in the solution has not been used up.

General

A number of descaling preparations contain colour indicators which show the state of the acid solution. If the acid content is exhausted, a new acid solution can be added, in which case, the weakest recommended concentration should be used.

The solubility of acids in water is often limited. Therefore if, in exceptional cases, a large amount is required, descaling can be carried out in two stages with a new solution of compound and clean water. Normally the supplier will specify the maximum solubility.

After completing the descaling, drain the system and flush with water. Acid residues can be neutralized with clean tap water containing 10 kg soda per ton of water. Circulate the mixture for 30 minutes, then drain and flush the system.

The cooling water system must not be put under pressure.

Continue to flush until water used is neutral (pH approx. 7).

Adding of Inhibitors

Fill up the cooling water system with water from the evaporator to the lowest water level in the expansion tank.

Weight out the quantity of inhibitors specified by the supplier and dissolve in a **clean** iron drum with hot water from the evaporator.

Add the solution via the expansion tank to the system. Then fill up to normal water level with water from the evaporator.

Allow the engine to run for not less than 24 hours to ensure that a stable protection of the cooling surfaces is formed.

Subsequently, test the cooling water with a test kit (available from the inhibitor supplier) to ensure that an adequate inhibitor concentration has been obtained.

This should be checked every week.

The acid content of the system oil is to be checked directly after the descaling with acid, and again 24 hours afterwards.

General

Nitrite-borate corrosion inhibitors for cooling water treatment

Company	Name of Inhibitor	Delivery Form	Maker's minimum Recommended Dosage*
Castrol Limited Swindon Wiltshire, England	Castrol Solvex WT4 Castrol Solvex WT2	Powder Liquid	3 kg/1000 l 20 l/1000 l
Drew Ameriod Marine Boonton, N.J./U.S.A	DEWT-NC Liquidewt Maxiguard	Powder Liquid Liquid	3.2 kg/1000 l 8 l/1000 l 16 l/1000 l
Houseman Scandinavia 3660 Stenløse Denmark	Cooltreat 651 Cooltreat 652	Liquid Liquid	5 l/1000 l 5 l/1000 l
Nalfleet Marine Chemicals Northwich, Cheshire CW8DX, England	Nalfleet EWT Liq (9-108) Nalfleet EWT 9-131C Nalfleet EWT 9-111 Nalcool 2000	 Liquid Liquid Liquid Liquid	 3 l/1000 l 10 l/1000 l 10 l/1000 l 10 l/1000 l
Rohm & Haas (ex Duolite) Paris, France	RD11 DIA PROSIM RD25 DIA PROSIM	Powder Liquid	3 kg/1000 l 50 l/1000 l
Unitor Rochem Marine Chemicals Oslo, Norway	Dieselguard NB Rocor NB Liquid	Powder Liquid	3 kg/1000 l 10 l/1000 l

* Initial dosage may be larger

The list is for guidance only and must not be considered complete. We undertake no responsibility for difficulties that might be caused by these or other water inhibitos/chemicals.

The suppliers are listed in alpabetical order.

Suitable cleaners can normally be supplied by these firms.

08028-0D/H5250/94.08.12

Internal Cooling Water System

General

Internal Cooling Water System

The engine's cooling water system comprises a low temperature (LT) circuit and a high temperature (HT) circuit. The systems are designed only for treated fresh water.

Low Temperature Cooling Water System

The LT cooling water system includes charge air cooling and lubricating oil cooling.

High Temperature Cooling Water System

The high temperature cooling water is used for the cooling of cylinder liners and cylinder heads.

The engine outlet temperature ensures an optimal combustion in the entire load area when running on Heavy Fuel Oil (HFO), i.e. this temperature limits the thermal loads in the high-load area, and hot corrosion in the combustion area is avoided.

In the low-load area the temperature is sufficiently high to secure a perfect combustion and at the same time cold corrosion is avoided; the latter is also the reason why the engine, in stand-by position and when starting on HFO, should be preheated with a cooling water temperature of at least 60°C - either by means of cooling water from running engines or by means of a separate preheating system.

System Layout

MAN B&W Holeby's standard for the internal cooling water system is shown on our Basic Diagram.

Temperature regulation in the HT and LT systems takes place in the internal system where also the pumps are situated. This means that it is only nessesary with two main pipes for cooling of the engine. The only demand is that the FW inlet temperature is between 10 and 40° C

To be able to match every kind of external systems, the internal system can as optional be arranged with a FW cooler for an external SW system.

HT-circulating and LT-circulating Pumps

The circulating pumps which are of the centrifugal type are mounted in the front-end box of the engine and are driven by the crankshaft through gear transmissions.

Technical data: See "list of capacities" D 10 05 0

Thermostatic Valves

The thermostatic valves are fully automatic three-way valves with thermostatic elements set at fixed temperatures.

Preheating Arrangement

In connection with plants where all engines are stopped for a certain period of time it is possible to install an electric heat exchanger in the external system.

In connection with plants with more than one engine the stand-by engines can be automatically preheated by the operating engines by means of the pipe connections leading to the expansion system and the HT-circulation pumps.

08028-0D/H5250/94.08.12

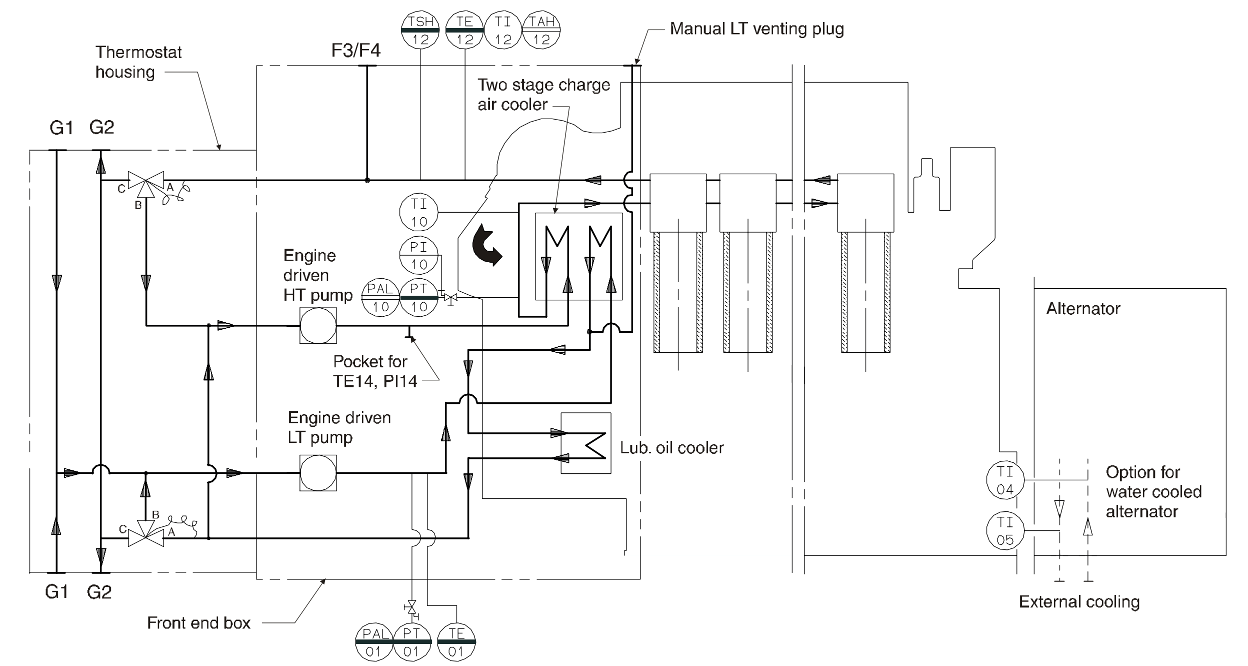


Fig. 1 Diagram for internal cooling water system.

Pipe description		
F3	Venting to expansion tank	DN 25
F4	HT fresh water from preheater	DN 25
G1	LT fresh water inlet	DN 80
G2	LT fresh water outlet	DN 80

Flange connections are standard according to DIN 2501

Description

The system is designed as a single circuit with two flange connections on both sides of the engine to the external centralized cooling water system.

The engine is equipped with a self-controlling temperature water circuit.

Thus, the engine on the cooling water side only requires fresh water between 10 and 40° C and so the engine can be integrated in the ship's cooling water system as a stand-alone unit. This is a simple solution with low installation costs, which also can be interesting in case of repowering, where the engine power is increased, and the distance to the other engines is larger.

Low Temperature Circuit

The components for circulation and temperature regulation are placed in the internal system.

The charge air cooler and the lubricating oil cooler are situated in serial order. After the LT water has passed the lubricating oil cooler, it is let to the thermostatic valves and depending on the water temperature, the water will either be re-circulated or led to the external system.

L21/31

High Temperature Circuit

The built-on engine-driven HT-circulating pump of the centrifugal type pumps water through the first stage of the charge air cooler and then through the distributing bore to the bottom of the cooling water jacket. The water is led out through bores at the top of the cooling water jacket to the bore in the cylinder head for cooling of this, the exhaust valve seats and the injector valve.

From the cylinder heads the water is led through to the thermostatic valve, and depending on the engine load, a smaller or larger amount of the water will be led to the external system or will be re-circulated.

Data

For heat dissipation and pump capacities, See D 10 05 0, "List of Capacities".

Set points and operating levels for temperature and pressure are stated in B 19 00 0, "Operating Data and Set Points".

Other design data are stated in B 13 00 0, "Design Data for the External Cooling Water System".

08028-0D/H5250/94.08.12

Design Data for the External Cooling Water System

General

This data sheet contains data regarding the necessary information for dimensioning of auxiliary machinery in the external cooling water system for the L21/31 type engine(s). The stated data are for one engine only and are specified at MCR.

The cooling water inlet pipe line has the function as preheating line during standstill.

Note: *make sure that this pipe line always is open for this function.*

For heat dissipation and pump capacities see D 10 05 0 "List of Capacities". Set points and operating levels for temperature and pressure are stated in B 19 00 0 "Operating Data and Set points".

External Pipe Velocities

For external pipe connections we prescribe the following maximum water velocities:

Fresh water : 3.0 m/s

Pressure Drop

The engines have an attached pump for both LT and HT cooling water. The external pressure shall be ≤ 1.0 bar.

Expansion Tank

To provide against volume changes in the closed jacket water cooling system, caused by changes in temperature or leakage, an expansion tank must be installed.

As the expansion tank also provides a certain suction head for the fresh water pump to prevent cavitation, the lowest water level in the tank should be minimum 5 m above the center line of the crankshaft.

Minimum recommended tank volume: 0.1 m³.
For multi plants the tank volume should be min.:

V = 0.1 + (exp. vol. per extra eng.) [m³]

As the LT system is vented to the HT system, both systems must be connected to the same expansion tank.

Data for External Preheating System

The capacity of the external preheater should be 2.5-3.0 kW/cyl. The flow through the engine should for each cylinder be approx. 4.0 l/min with flow from top and downwards and 25 l/min with flow from bottom and upwards. See also table 1 below.

Cyl. No	5	6	7	8	9
Quantity of water in eng: HT and LT system (litre)	245	260	275	290	305
Expansion vol. (litre)	4	5	5	5	6

Table 1 Showing cooling water data which are depending on the number of cylinders.

External Cooling Water System

General

Design of External Cooling Water System

It is not difficult to make a system fulfil the requirements, but to make the system both simple and cheap and still fulfil the requirements of both the engine builder and other parties involved can be very difficult. A simple version cannot be made without involving the engine builder.

The diagrams are principal diagrams, and are MAN B&W's recommendation for the design of external cooling water systems.

The systems are designed on the basis of the following criteria:

1. Simplicity.
2. Preheating with surplus heat.
3. Preheating in engine top, downwards.
4. As few change-over valves as possible.

Ad 1)
Cooling water systems have a tendency to be unnecessarily complicated and thus uneconomic in installation and operation. Therfore, we have attached great importance to simple diagram design with optimal cooling of the engines and at the same time installation- and operation- friendly systems resulting in economic advantages.

Ad 2)
It has been stressed on the diagrams that the alternator engines in stand-by position as well as the propulsion engine in stop position are preheated, optimally and simply, with surplus heat from the running engines.

Ad 3)
If the engines are preheated with reverse cooling water direction, i.e. from the top and downwards, an optimal heat distribution is reached in the engine. This method is at the same time more economic since the need for heating is less and the water flow is reduced.

Ad 4)
The systems have been designed in such a way that the change-over from sea operation to harbour operation/stand-by with preheating can be made with a minimum of manual or automatic interference.

Fresh Water Treatment

The engine cooling water is, like fuel oil and lubricating oil, a medium which must be carefully selected, treated, maintained and monitored.

Otherwise, corrosion, corrosion fatigue and cavitation may occur on the surfaces of the cooling system which are in contact with the water, and deposits may form.

Corrosion and cavitation may reduce the life time and safety factors of parts concerned, and deposits will impair the heat transfer and may result in thermal overload of the components to be cooled.

The treatment process of the cooling water has to be effected before the first commission of the plant, i.e. immediately after installation at the shipyard or at the power plant.

08028-0D/H5250/94.08.12

General

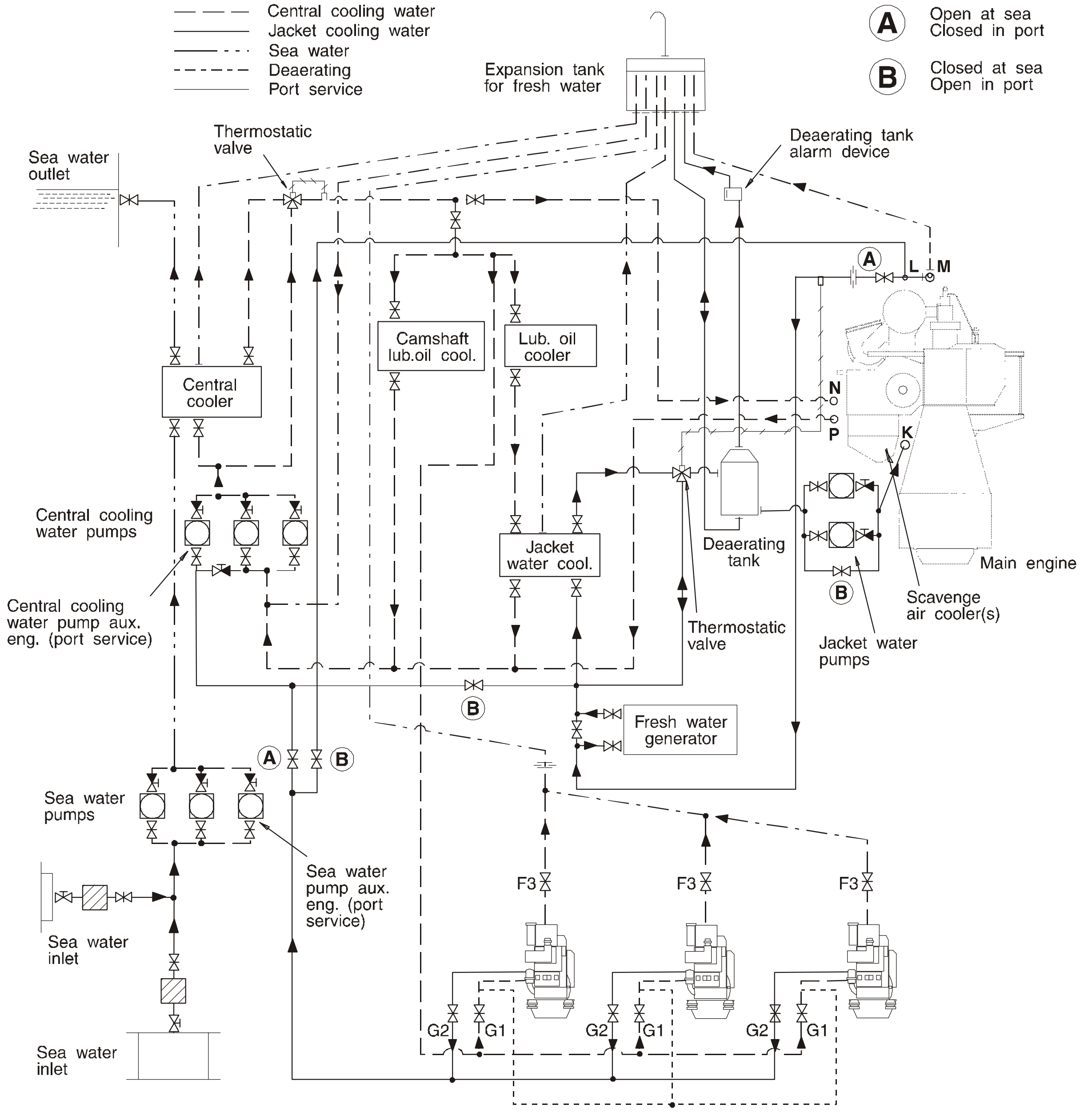


Fig 1 Central cooling system.

08028-0D/H5250/94.08.12

General

System Design

The system is a central cooling water system of simple design with only one central cooler. In order to minimize the power consumption the FW pump installation consists of 3 pumps, two for sea operation and a smaller one for harbour operation.

The GenSets are connected as a one-string plant, with only one inlet- and one outlet cooling water connection and with internal HT and LT-circuit, see also B 13 00 0 “Internal Cooling Water System 1”, describing this system.

The propulsion engines HT-circuit temperature is adjusted with LT-water mixing by means of the thermostatic valve.

Preheating

Engines starting on HFO and engines in stand-by position **must** be preheated. It is also recommended to preheat engines operating on MDO due to the prolonged life time of the engines' wearing parts. Therefore it is recommended that the preheating is arranged for automatic operation, so that the preheating is disconnected when the engine is running and connected when the engine is in stand-by position. The preheating is adjusted so that the temperature is 60 ± 5°C at the top cover (see thermometer TI11), and approximately 25 to 45°C at outlet of the cylinders (see thermometer TI10).

When working out the external cooling water system it must be ensured, that no cold cooling water is pressed through the engine and thus spoiling the preheating during stand-by. The diesel engine has no built-in shut-off valve in the cooling water system. Therefore the designer of the external cooling water system must make sure that the preheating of the GenSets is not disturbed.

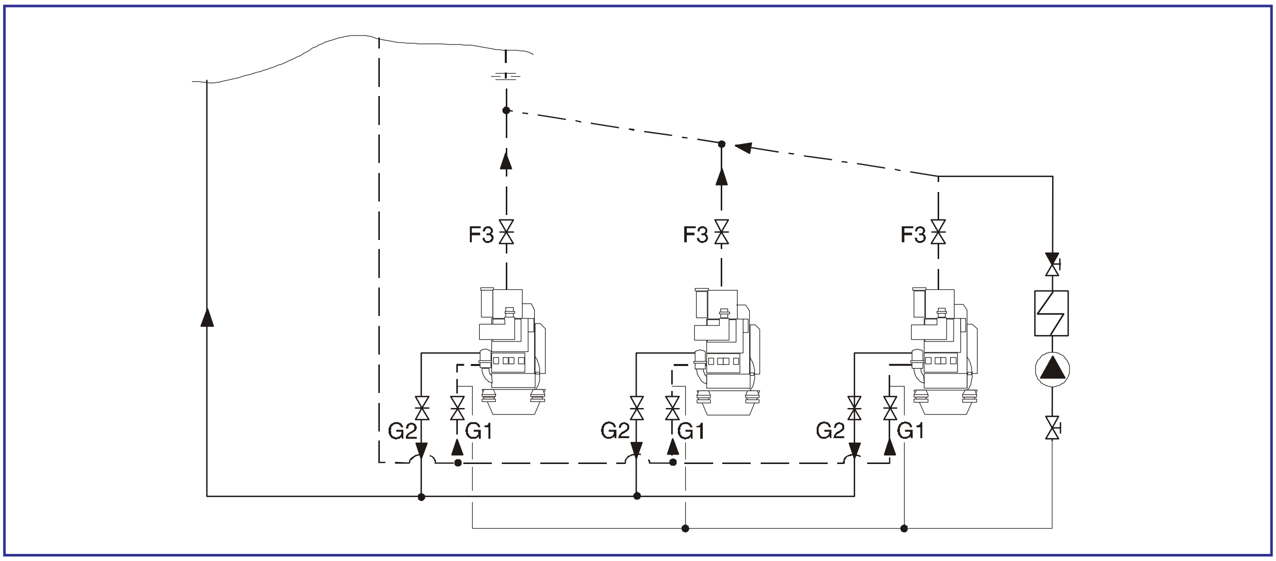
Preheating of Stand-by GenSets during Sea Operation

GenSets in stand-by position are preheated automatically via the venting pipe with water from the running engines. This is possible due to the interconnection of the GenSet's HT-pumps which force the water downwards in the stand-by engines.

It is to be stated that the interconnection between the GenSet L.T. inlets is not to be disturbed. If an on/off valve is built in, a bypass has to be installed. It is then possible to preheat the GenSet automatically in standby position with the running GenSets.

Preheating of Stand-by GenSets and Propulsion Engines during Harbour Operation

During harbour stay the propulsion and GenSets are also preheated in stand-by position by the running GenSets. Valve (B) is open and valve (A) is closed. Thus, the propulsion engine is heated from top and downwards, which is the most economical solution.



08028-0D/H5250/94.08.12

Fig 2 Preheating.

Compressed Air System

B 14

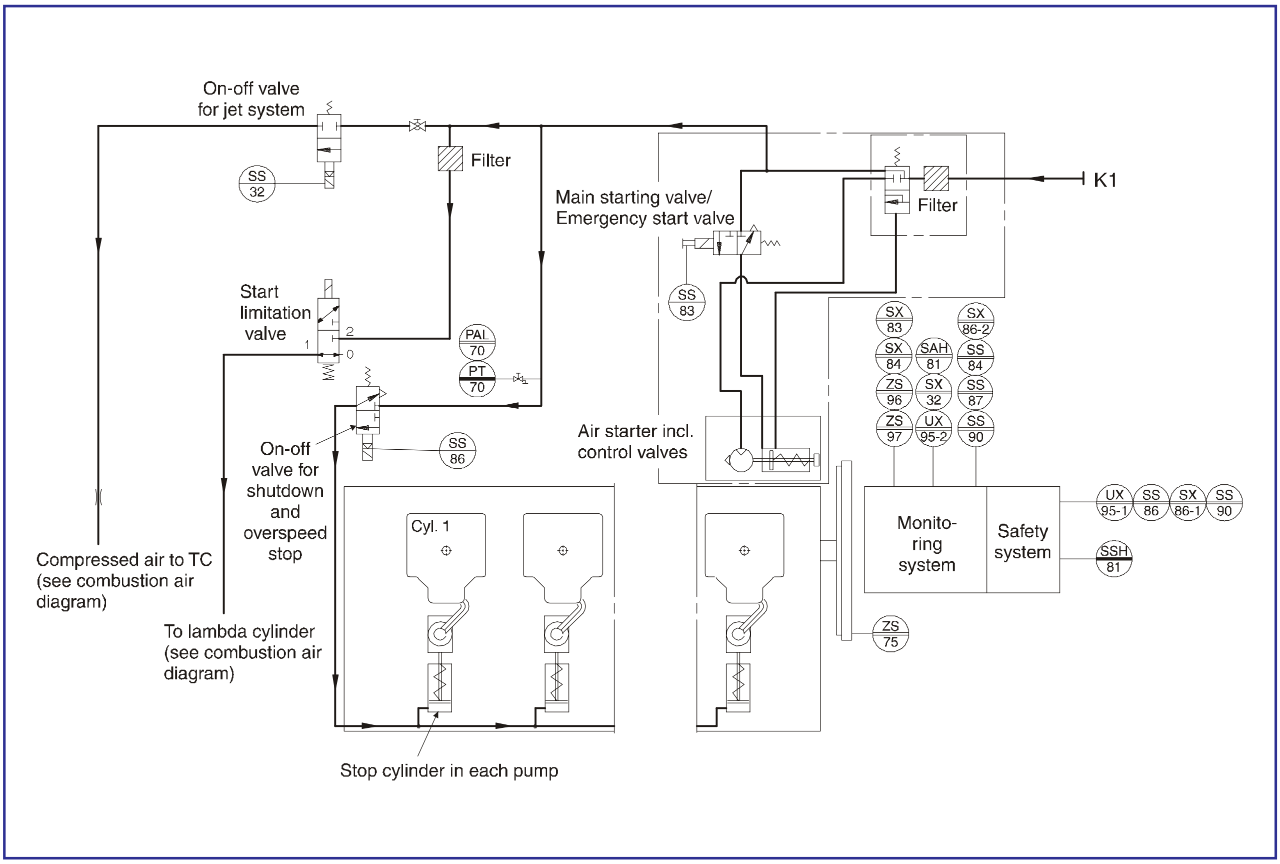


Fig. 1 Diagram for compressed air system.

Pipe description		
K1	Compressed air inlet	DN 40

Flange connections are standard according to DIN 2501

General

The compressed air system on the engine consists of a starting system, starting control system and safety system. Further, the system supplies air to the jet system and the stop cylinders on each fuel injection pump.

The compressed air is supplied from the starting air receivers max. inlet pressure at starter unit is 8.3 bar to the engine.

To avoid dirt particles in the internal system, a strainer is mounted in the inlet line to the engine.

Starting System

The engine is started by means of a built-on air starter, safety clutch and drive shaft with pinion. Further, there is a main starting valve.

Control System

The air starter is activated electrically with a pneumatic 3/2-way solenoid valve. The valve can be activated manually from the starting box on the engine, and it can be arranged for remote control, manual or automatic.

L21/31

For remote activation the starting coil is connected so that every starting signal to the starting coil goes through the safe start function which is connected to the basemodule mounted on the engine.

Further, the starting valve also acts as an emergency starting valve which makes it possible to activate the air starter manually in case of power failure.

Safety System

Air supply must not be interrupted when the engine is running.

As standard the engine is equipped with a pneumatically/mechanically stop cylinder, which starts to operate if the safety system is activated. The system is activated electrically. One stop cylinder for each cylinder is intergrated in each fuel injection pump.

Pneumatic Start Sequence

When the starting valve is opened, air will be supplied to the drive shaft housing of the air starter.

The air supply will - by activating a piston - bring the drive pinion into engagement with the gear rim on the engine flywheel.

When the pinion is fully engaged, the pilot air will flow to, and open the main starting valve, whereby air will be led to the air starter, which will start to turn the engine.

When the rpm exceeds approx. 158, at which firing has taken place, the starting valve is closed whereby the air starter is disengaged.

Optionals

Besides the standard components, the following standard optional can be built-on:

- Main valve, inlet engine.

General

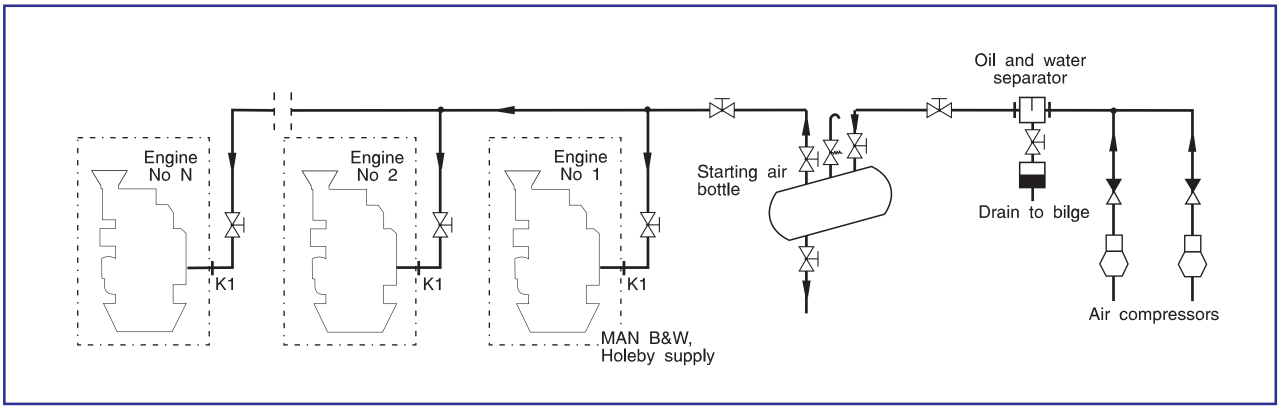


Fig 1. Diagram for Compressed Air System

Design of External System

The external compressed air system should be common for both propulsion engines and GenSet engines.

Separate tanks shall only be installed in turbine vessels, or if GenSets in engined vessels are installed far away from the propulsion plant.

The design of the air system for the plant in question should be according to the rules of the relevant classification society.

As regards the engine's internal compressed air system, please see B 14 00 0 "Internal Compressed Air System".

An oil and water separator should be mounted between the compressor and the air receivers, and the separator should be equipped with automatic drain facilities.

Each engine needs only one connection for compressed air, please see diagram for the compressed air system.

Installation

In order to protect the engine's starting and control equipment against condensation water, the following should be observed:

- The air receiver(s) should always be installed with good drainage facilities. Receiver(s) arranged in horizontal position must be installed with a slope downwards of min. 3° - 5° deg.
- Pipes and components should always be treated with rust inhibitors.
- The starting air pipes should be mounted with a slope towards the receivers, preventing possible condensed water from running into the compressors.
- Drain valves should be mounted at the lowest position on the starting air pipes.

Combustion Air System

B 15

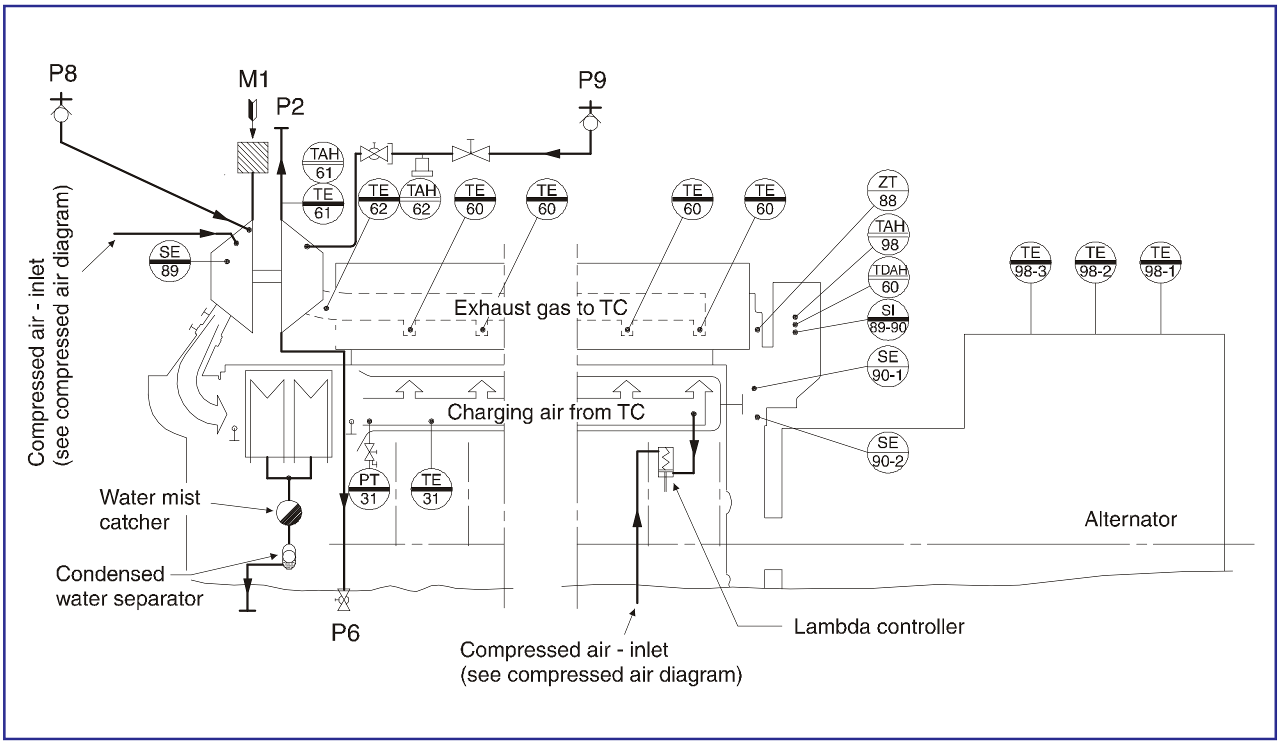


Fig 1 Diagram for combustion air system.

Pipe Description		
M1	Charge air inlet	
P2	Exhaust gas outlet: 5 cyl. engine 6 + 7 cyl. engine 8 + 9 cyl. engine	 DN 350 DN 450 DN 500
P6	Drain from turbocharger - outlet	
P8	Water washing compressor side with quick coupling - inlet	
P9	Working air, dry cleaning turbine side with quick coupling - inlet	

Flange connections are standard according to DIN 2501.

General

The air intake to the turbochargers takes place directly from the engine room through the intake silencer on the turbocharger.

From the turbocharger the air is led via the charge air cooler and charge air receiver to the inlet valves of each cylinder.

The charge air cooler is a compact two-stage tube-type cooler with a large cooling surface.

The charge air receiver is mounted in the engine's front end box.

It is recommended to blow ventilation air in the level of the top of the engine(s) close to the air inlet of the turbocharger, but not so close that sea water or vapour may be drawn-in. It is further recommended that there always should be a positive air pressure in the engine room.

L21/31

Cleaning of Turbocharger

The turbocharger is fitted with an arrangement for dry cleaning of the turbine side, and water washing of the compressor side.

Lambda Controller

The purpose of the lambda controller is to prevent injection of more fuel in the combustion chamber than can be burned during a momentary load increase. This is carried out by controlling the relation between the fuel index and the charge air pressure.

The lambda controller has the following advantages:

- Reduction of visible smoke in case of sudden momentary load increases.
- Improved load ability.
- Less fouling of the engine's exhaust gas ways.
- Limitation of fuel oil index during starting procedure.

The above states that the working conditions are improved under difficult circumstances and that the maintenance costs for an engine, working with many and major load changes, will be reduced.

Data

For charge air heat dissipation and exhaust gas data, see D 10 05 0 "List of Capacities".

Set points and operating levels for temperature and pressure are stated in B 19 00 0 "Operating Data and Set Points".

08028-0D/H5250/94.08.12

General

Combustion Air Requirements

- The combustion air must be free from water spray, dust, oil mist and exhaust gases.

- The air ventilation fans shoud be designed to maintain a positive air pressure of 50 Pa (5 mmWC) in the auxiliary engine room in all running conditions.

The combustion air is normally taken from the engine room through a filter fitted on the turbocharger.

In ***tropical service*** a sufficient volume of air must be supplied to the turbocharger(s) at outside air temperature. For this purpose there must be an air duct installed for each turbocharger, with the outlet of the duct facing the respective intake air silencer. No water of condensation from the air duct must be allowed to be drawn in by the turbocharger.

In ***arctic service*** the air must be heated to at least 0°C. If necessary air preheaters must be provided.

Ventilator Capacity

The capacity of the air ventilators must be large enough to cover:

- The combustion air requirements of all consumers.

- The air required for carrying off the heat emission.

See "List of Capacities" section D 10 05 0 for information about required combustion air quantity and heat emission.

For minimum requirements concerning engine room ventilation see applicable standards such as ISO 8861.

General

During operation the compressor will gradually be fouled due to the presence of oil mist and dust in the inlet air.

The fouling reduces the efficiency of the turbocharger which will result in reduced engine performance.

Therefore manual cleaning of the compressor components is necessary in connection with overhauls. This situation requires dismantling of the turbocharger.

However, regular cleaning by injecting water into the compressor during normal operation of the engine has proved to reduce the fouling rate to such an extent that good performance can be maintained in the period between major overhauls of the turbochar-ger.

The cleaning effect of injecting pure fresh water is mainly based upon the mechanical effect arising, when the water droplets impinge the deposit layer on the compressor components.

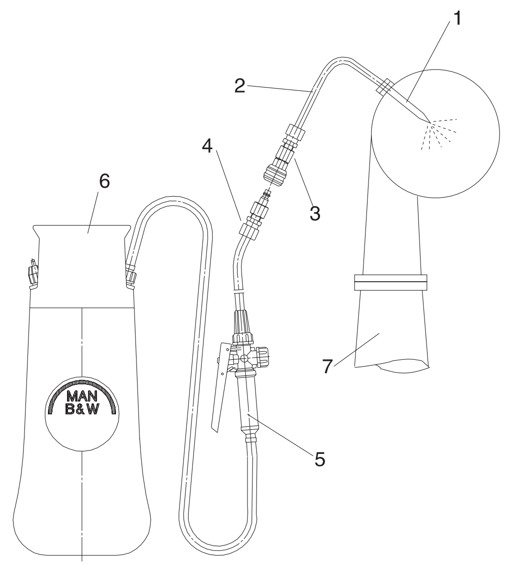
The water is injected in a measured amount and within a measured period of time by means of the water washing equipment.

The water washing equipment, see fig 1, comprises two major parts. The transportable container (6) including a hand valve with handle (5) and a plug-in coupling (4) at the end of a lance.

Installed on the engine there is the injection tube (1), connected to a pipe (2) and a snap coupling (3).

The cleaning procedure is:

1. Fill the container (6) with a measured amount of fresh water. Blow air into the container by means of a blow gun, until the prescribed operation pressure is reached.



1	Injection tube	5	Hand valve with handle
2	Pipe	6	Container
3	Snap coupling	7	Charge air line
4	Plug-in coupling		

Fig 1 Water washing equipment

2. Connect the plug-in coupling of the lance to the snap coupling on the pipe, and depress the handle on the hand valve.

3. The water is then injected into the compressor.

The washing procedure is executed with the engine running at normal operating temperature and with the engine load as high as possible, i.e. at a high compressor speed.

The frequency of water washing should be matched to the degree of fouling in each individual plant.

08028-0D/H5250/94.08.12

Lambda Controller

Purpose

The purpose of the lambda controller is to prevent injection of more fuel in the combustion chamber than can be burned during a momentary load increase. This is carried out by controlling the relation between the fuel index and the charge air pressure.

Advantages

The lambda controller has the following advantages:

- Reduction of visible smoke in case of sudden momentary load increases.
- Improved load ability.
- Less fouling of the engine's exhaust gas ways.
- Limitation of fuel oil index during starting procedure.

The above states that the working conditions are improved under difficult circumstances and that the maintenance costs for an engine, working with many and major load changes, will be reduced.

Principles of Functioning

Fig. 1. illustrates the controller's operation mode. In case of a momentary load increase, the regulating device will increase the index on the injection pumps and hereby the regulator arm (1) is turned, the switch (2) will touch the piston arm (3), whereby the electrical circuit will be closed.

Thus the solenoid valve (4) opens. The jet system is activated, the turbocharger accelerates and increases the charge air pressure, thereby pressing the piston (3) backwards in the lambda cylinder (5). When the lambda ratio is satisfactory the jet system will be deactivated.

At 50% load change the system will be activated for about 3-8 seconds.

If the system is activated for more than 10 seconds the air supply will be shutoff and a "Jet system failure" signal will be generated.

Shutdown Function

The controller also have a stop function. In case of a shutdown situation (e.g. overspeed, low lubricating oil pressure or high temperature for H.T. water), the safety system will activate the shutdown valve (6) and thereby compressed air will press the piston in the Lambda controller downwards and force the index at the fuel pumps to zero.

The shutdown stop is independent of the governor due to the spring loaded pull rod connection.

Fuel Oil Limitation during Start Procedure

During the start procedure the controller is activated as an index limiter.

Hereby, heavy smoke formation is avoided during start, and the regulating device cannot overreact. The fuel limiter function stops when the engine reaches the nominal RPM.

The jet system is released at 50 RPM during the starting procedure.

Air Consumption

Jet air consumption at sudden step loads:

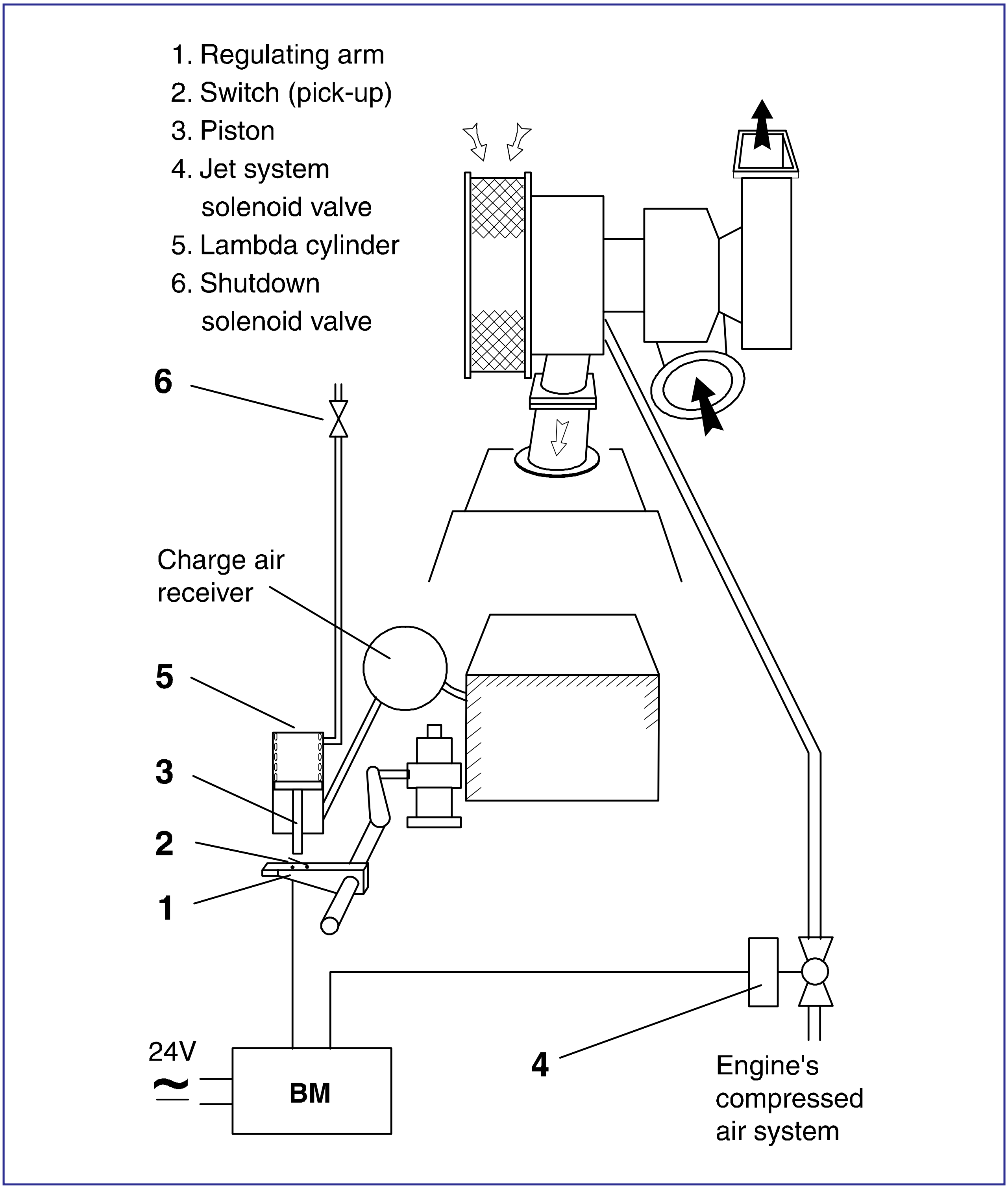
$$\text{Air cons.} = \frac{(\text{step load \%} - 25) \times N}{111} \quad (\text{Nm}^3)$$

N = Number of cylinders.

Example:
At 50% stepload for a 6L21/31 the air consumption will be :

$$\frac{(50\,\% - 25) \times 6}{111} = 1{,}35 \quad (\text{Nm}^3)$$

L21/31



08028-0D/H5250/94.08.12

Fig. 1 Lambda Controller

Exhaust Gas System

B 16

General

Internal Exhaust Gas System

From the exhaust valves, the gas is led to the exhaust gas receiver where the fluctuating pressure from the individual cylinders is equalized and the total volume of gas led further on to the turbocharger, at a constant pressure. After the turbocharger, the gas is led to the exhaust pipe system.

The exhaust gas receiver is cast sections, one for each cylinder, connected to each other, by means of compensators, to prevent excessive stress due to heat expansion.

After each cylinder thermosensor for reading the exhaust gas temperature is fitted. The value is indicated by means of the MEG-module (Monitor exhaust Gas Temperature).

To avoid excessive thermal loss and to ensure a reasonably low surface temperature the exhaust gas receiver is insulated.

External Exhaust Gas System

The exhaust back-pressure should be kept as low as possible.

It is therefore of the utmost importance that the exhaust piping is made as short as possible and with few and soft bends.

Long, curved, and narrow exhaust pipes result in higher back-pressure which will affect the engine combustion. Exhaust back-pressure is a loss of energy and will cause higher fuel consumption.

The exhaust back-pressure should not exceed 25 mbar at MCR. An exhaust gas velocity through the pipe of maximum 35 m/sec is often suitable, but depends on the actual piping.

Holeby will be pleased to assist in making a calculation of the exhaust back-pressure.

The gas outlet of turbocharger, the expansion bellows, the exhaust pipe, and silencer, (in case of silencer with spark arrestor care must be taken that the cleaning parts are accessible), must be insulated with a suitable material.

The insulation should be shielded by a thin plating, and should comply with the requirements of the classification society and/or the local authorities.

Exhaust Pipe Dimensions

It should be noted that concerning the maximum exhaust gas velocity the pipe dimension after the expansion bellow should be increased for some of the engines.

The wall thickness of the external exhaust pipe should be min. 3 mm.

Exhaust Pipe Mounting

When the exhaust piping is mounted, the radiation of noise and heat must be taken into consideration.

Because of thermal fluctuations in the exhaust pipe, it is necessary to use flexible as well as rigid suspension points.

In order to compensate for thermal expansion in the longitudinal direction, expansion bellows must be inserted. The expansion bellows should preferably be placed at the rigid suspension points.

Note: The exhaust pipe must not exert any force against the gas outlet on the engine.

One sturdy fixed-point support must be provided for the expansion bellows on the turbocharger. It should be positioned, immediately above the expansion bellow in order to prevent the transmission of forces, resulting from the weight, thermal expansion or lateral displacement of the exhaust piping, to the turbocharger.

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.

General

Position of Gas Outlet on Turbocharger

B 16 02 0 shows turning alternatives positions of the exhaust gas outlet. Before dispatch of the engine from Holeby exhaust gas outlet will be turned to the wanted position.

The turbocharger is, as standard, mounted in the front end.

Exhaust Gas Boiler

To utilize the thermal energy from the exhaust, an exhaust gas boiler producing steam or hot water can be installed.

Each engine should have a separate exhaust gas boiler or, alternatively, a common boiler with separate gas ducts. Concerning exhaust gas quantities and temperature, see list of capacities D 10 05 0, and engine performance D 10 10 0.

The discharge temperature from the exhaust gas boiler should not be lower than 180° C (in order to avoid sulphuric acid formation in the funnel).

The exhaust gas boilers should be installed with by-pass entering in function at low load operation.

The back-pressure over the boiler must be included in the back-pressure calculation.

Expansion Bellow

The expansion bellow, which is supplied separately, must be mounted directly on the exhaust gas outlet, see also E 16 01 1-2.

Exhaust Silencer

The position of the silencer in the exhaust gas piping is not decisive for the silencing effect. It would be useful, however, to fit the silencer as high as possible to reduce fouling. The necessary silencing depends on the loudness of the exhaust sound and the discharge from the gas outlet to the bridge wing.

The exhaust silencer, see E 16 04 2-3-5-6 is supplied loose with counterflange, gaskets and bolts.

08028-0D/H5250/94.08.12

Description

The tendency to fouling on the gas side of turbochargers depends on the combustion conditions, which are a result of the load and the maintenance condition of the engine as well as the quality of the fuel oil used.

Fouling of the gas ways will cause higher exhaust gas temperatures and higher wall temperatures of the combustion chamber components and will also lead to a higher fuel consumption rate.

Tests and practical experience have shown that radial-flow turbines can be successfully cleaned by the dry cleaning method.

This cleaning method employs cleaning agents consisting of dry solid bodies in the form of granules. A certain amount of these granules, depending on the turbocharger size, is, by means of compressed air, blown into the exhaust gas line before the gas inlet casing of the turbocharger.

The injection of granules is done by means of working air with a pressure of 5-7 bar.

On account of their hardness, particularly suited blasting agents such as nut-shells, broken or artificially shaped activated charcoal with a grain size of 1.0 mm to max. 1.5 mm should be used as cleaning agents.

The solid bodies have a mechanical cleaning effect which removes any deposits on nozzle vanes and turbine blades.

Dry cleaning can be executed at full engine load and does not require any subsequent operating period of the engine in order to dry out the exhaust system.

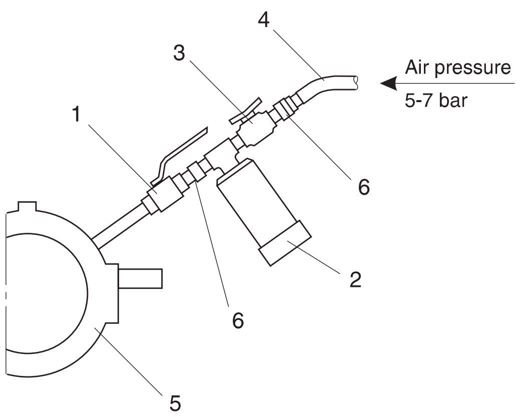
Experience has shown that regular cleaning intervals are essential to successful cleaning, as ex-cessive fouling is thus avoided. For cleaning intervals see the instruction book.

The cleaning intervals can be shorter or longer based on operational experience.

Cleaning System

The cleaning system consists of a cleaning agent container (**2**) with a capacity of approx. 0.5 liters and a removable cover. Furthermore the system consists of an air valve (**3**), a closing valve (**1**) and two snap on connectors.

The position numbers (**2**) and (**3**) indicate the system's "blow-gun". Only one "blow-gun" is used for each engine plant. The blow-gun is working according to the ejector principle with pressure air (working air) at 5-7 bar as driven medium. Injection time approx. 2 min. Air consumption approx. 5 Nm^3/2 min.



1	Closing valve	2	Container
3	Air valve	4	working air inlet
5	Exhaust pipe	6	Snap coupling

Fig 1 Arrangement of dry cleaning of turbocharger - Turbine.

08028-0D/H5250/94.08.12

General

Dry cleaning of turbochargers

Suppliers of cleaning agents:

1. "Solf Blast Grit, Grade 14/25"

TURCO Products B.V.
Verl. Blokkenweg 12, 617 AD EDE - Holland
Tel.:08380 - 31380, Fax.: 08380 - 37069

2. Designation unknown

Neptunes Vinke B.V.
Schuttevaerweg 24, 3044 BB Rotterdam
Potbus 11032, 3004 E.A. Rotterdam, Holland
Tel.: 010 - 4373166 Fax.: 4623466

3. "Grade 16/10"

FA. Poul Auer GmbH
Strahltechnik
D-6800 Mainheim 31, Germany

4. "Granulated Nut Shells"

Eisenwerke Würth GmbH + Co.
4107 Bad Friederichshall, Germany
Tel.: 0 71 36-60 01

5. "Soft Blasting Grade 12/3a"

H.S. Hansen Eftf. Kattegatvej 2
2100 Copenhagen Ø, Denmark
Tel.:(31) 29 97 00 Telex: 19038

6. "Crushed Nutshells"

Brigantine, Hong Kong

7. "Turbine Wash"

Ishikawajima-Harima Heavy Industries Co.
Ishiko Bldg., 2-9-7 Yassu, Chuo-Ku
Tokyo 104, Japan
Tel.: 03-2 77-42 91

General

8. "A-C Cleaner" (Activated Coal)

Mitsui Kozan Co. Ltd. (Fuel Dept.)
Yamaguchi Bldg., 2-1-1 Nihonbashi
Muromachi, Chuo-Ku
Tokyo 103, Japan

9. "OMT-701"

Marix KK
Kimura Bldg., 6-2-1 Shinbashi
Minato-Ku, Tokyo 105, Japan
Tel.: 03-4 36-63 71, Telex: 242-7232 MAIX J

10. "OMT-701"

OMT Incorporated
4F, Kiji Bldg., 2-8 Hatchobori,
4-chome, Chuo-Ku, Tokyo 104, Japan
Tel.: 03-5 53-50 77, Telex: 252-2747 OMTINC J

11. "Marine Grid No. 14" (Walnut)

Hikawa Marine
Kaigan-Dori 1-1-1, Kobe 650, Japan
Tel.: 0 78-3 21-66 56

12. "Marine Grid No. 14"

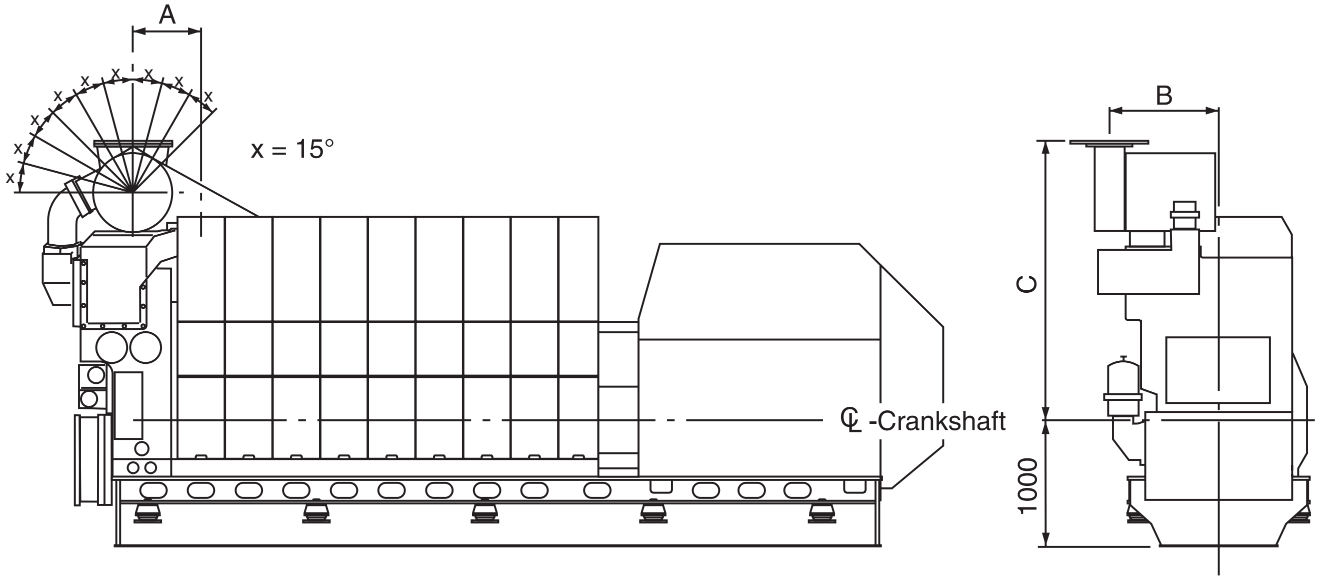
Mashin Shokai
Irie-Dori, 3-1-13, Hyogo-Ku
Kobe 652, Japan
Tel.: 0 78-6 51-15 81

13. Granulate

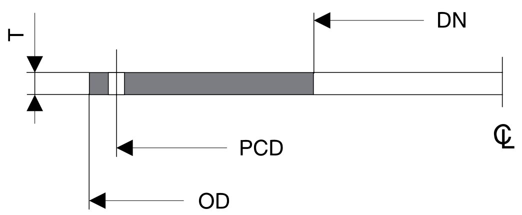
MAN B&W Diesel A/S
Teglholmsgade 41 2450 København SV, Danmark
Tel.: +45 33 851100 Fax.: +45 33 851030

The list is for guidance only and must not be considered complete. We undertake no responsibility that might be caused by these or other products.

L21/31



Flange



Dimensions			
Engine type	A	B	C
5-7L21/31	792	740	2182.5
8-9L21/31	792	790	2289

Exhaust flange D. mating dimensions						
Engine type	DN (mm)	OD (mm)	T (mm)	PCD (mm)	Hole size (mm)	No of holes
5L21/31 (TCR 16)	350	490	20	445	22	12
6-7L21/31 (TCR 16)	450	595	20	550	22	16
8-9L21/31 (TCR 18)	500	695	20	600	22	20

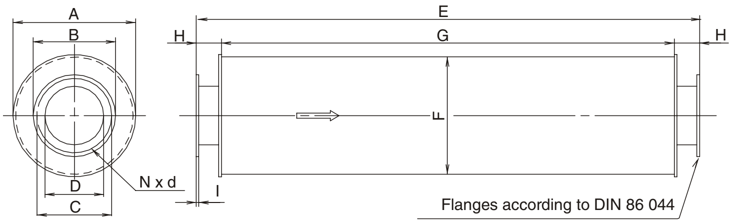
Design

The operating of the silencer is based on the absorption system. The Gasflow passes straight-through a perforated tube, surrounded by highly effecient sound absorbing material, thus giving an excellent attenuation over a wide frequency range.

The silencer is delivered without insulation and fastening fittings.

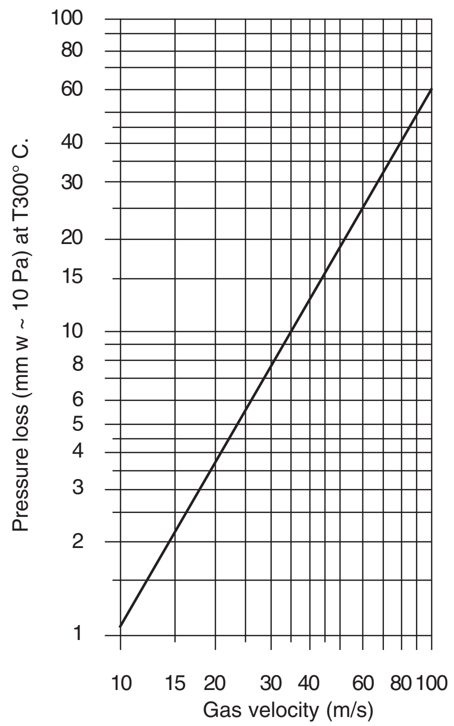
Pressure Loss

The pressure loss will not be more then in a straight tube having the same lenght and bore as the silencer. Graphic shows pressure loss in relation to velocity.



Installation

The silencer may be installed, vertically, horizontally or in any position close to the end of the piping.



Silencer type (A)

Damping dB(A)	Engine type	DN	A	B	C	D	E	F	G	H	I	N x d	Weight kg
25	5L21/31	350	890	490	445	359	2500	850	2200	150	16	12xø22	400
25	6L21/31 7L21/31	450	1040	595	550	461	3300	1000	3000	150	16	16xø22	700
25	8L21/31 9L21/31	500	1140	645	600	512	3500	1100	3250	125	16	20xø22	900

Silencer type (B)

Damping dB(A)	Engine type	DN	A	B	C	D	E	F	G	H	I	N x d	Weight kg
25	5L21/31	350	730	490	445	359	3000	700	2750	125	16	12xø22	347
25	6L21/31 7L21/31	450	830	595	550	461	3400	800	3050	175	16	16xø22	473
25	8L21/31 9L21/31	500	930	645	600	512	3600	900	3300	150	16	20xø22	597

Dimension for flanges for exhaust pipes is according to DIN 86 044

08028-0D/H5250/94.08.12

Silencer without Spark Arrestor, Damping 35 dB (A)

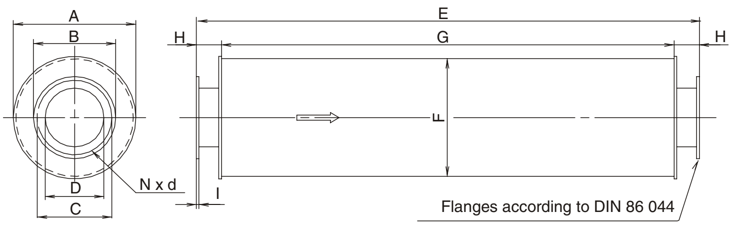
Design

The operating of the silencer is based on the absorption system. The Gasflow passes straight-through a perforated tube, surrounded by highly effecient sound absorbing material, thus giving an excellent attenuation over a wide frequency range.

The silencer is delivered without insulation and fastening fittings.

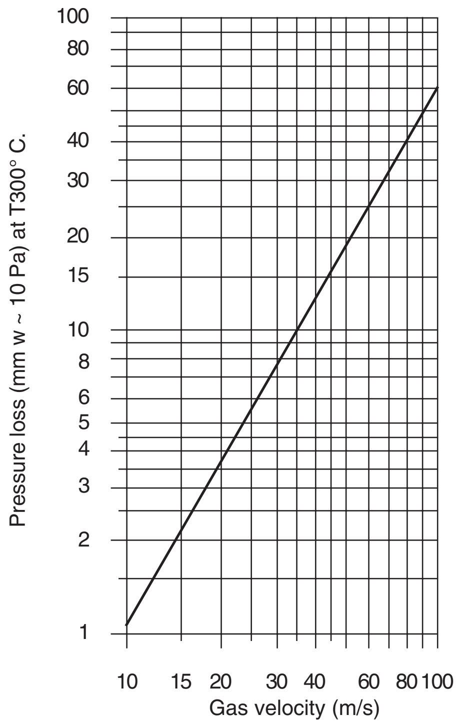
Pressure Loss

The pressure loss will not be more then in a straight tube having the same lenght and bore as the silencer. Graphic shows pressure loss in relation to velocity.



Installation

The silencer may be installed, vertically, horizontally or in any position close to the end of the piping.



Silencer type (A)

Damping dB(A)	Engine type	DN	A	B	C	D	E	F	G	H	I	N x d	Weight kg
35	5L21/31	350	890	490	445	359	3500	850	3300	100	16	12xø22	550
35	6L21/31 7L21/31	450	1040	595	550	461	4300	1000	4000	150	16	16xø22	900
35	8L21/31 9L21/31	500	1140	645	600	512	4500	1100	4200	150	16	20xø22	1100

Silencer type (B)

Damping dB(A)	Engine type	DN	A	B	C	D	E	F	G	H	I	N x d	Weight kg
35	5L21/31	350	880	490	445	359	3400	850	3200	100	16	12xø22	528
35	6L21/31 7L21/31	450	1080	595	550	461	4000	1050	4000	100	16	16xø22	1015
35	8L21/31 9L21/31	500	1130	645	600	512	4000	1100	4000	100	16	20xø22	1093

Dimension for flanges for exhaust pipes is according to DIN 86 044

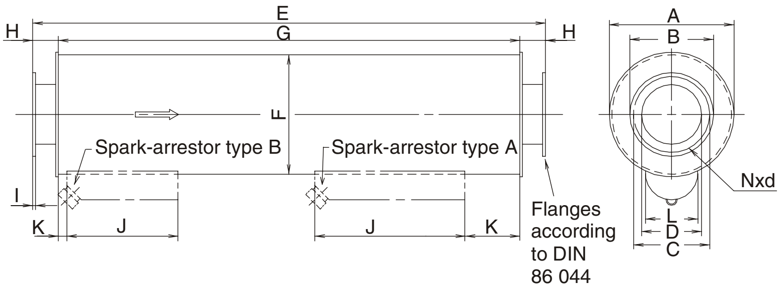
Silencer with Spark Arrestor, Damping 25 dB (A)

Design

The operating of the silencer is based on the absorption system. The Gasflow passes straight-through a perforated tube, surrounded by highly effecient sound absorbing material, thus giving an excellent attenuation over a wide frequency range.

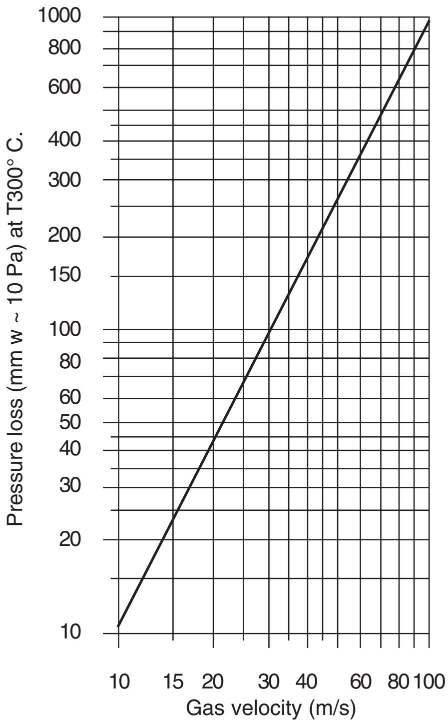
The operation of the spark arrestor is based on the centrifugal system. The gases are forced into a rotary movement by means of a number of fixed blades. The solid particles in the gases are thrown against the wall of the spark arrestor and collected in the soot box. (Pressure loss, see graphic)

The silencer is delivered without insulation and fastening fittings.



Installation

The silencer/spark arrestor has to be installed as close to the end of the exhaust pipe as possible.



Silencer type (A)

Damping dB(A)	Engine type	DN	A	B	C	D	E	F	G	H	I	J	K	L	N x d	Weight kg
25	5L21/31	350	890	490	445	359	2900	850	2600	150	16	500	80	270	12xø22	450
25	6L21/31 7L21/31	450	1040	595	550	461	3700	1000	3500	100	16	1000	100	300	16xø22	800
25	8L21/31 9L21/31	500	1140	645	600	512	4000	1100	3800	100	16	1000	150	310	20xø22	1000

Silencer type (B)

Damping dB(A)	Engine type	DN	A	B	C	D	E	F	G	H	I	J	K	L	N x d	Weight kg
25	5L21/31	350	730	490	445	359	3000	700	2750	125	16	650	50	300	12xø22	377
25	6L21/31 7L21/31	450	830	595	550	461	3400	800	3050	175	16	800	100	350	16xø22	526
25	8L21/31 9L21/31	500	930	645	600	512	3600	900	3300	150	16	900	100	350	20xø22	643

Dimension for flanges for exhaust pipes is according to DIN 86 044

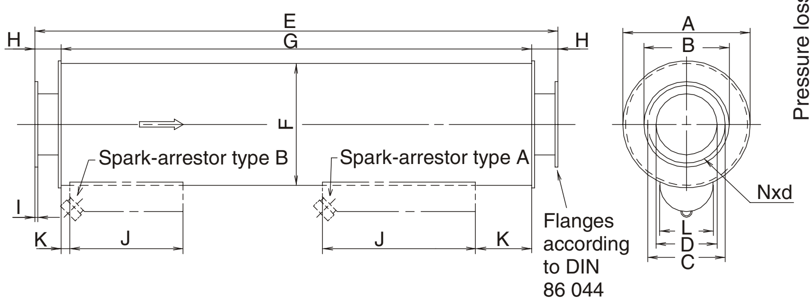
08028-0D/H5250/94.08.12

Design

The operating of the silencer is based on the absorption system. The Gasflow passes straight-through a perforated tube, surrounded by highly effecient sound absorbing material, thus giving an excellent attenuation over a wide frequency range.

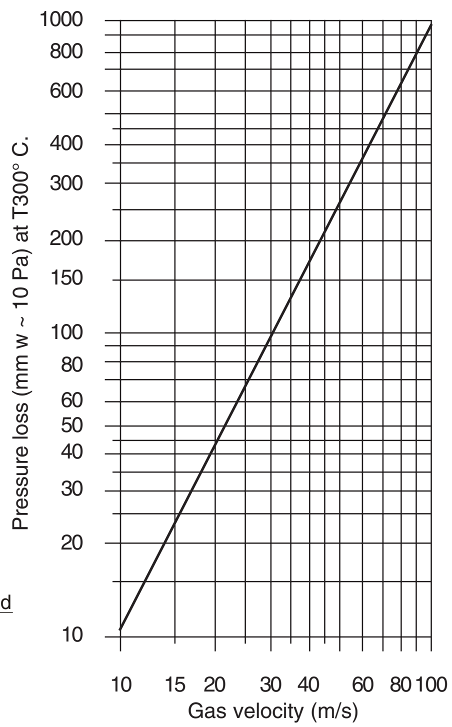
The operation of the spark arrestor is based on the centrifugal system. The gases are forced into a rotary movement by means of a number of fixed blades. The solid particles in the gases are thrown against the wall of the spark arrestor and collected in the soot box. (Pressure loss, see graphic)

The silencer is delivered without insulation and fastening fittings.



Installation

The silencer/spark arrestor has to be installed as close to the end of the exhaust pipe as possible.



Silencer type (A)

Damping dB(A)	Engine type	DN	A	B	C	D	E	F	G	H	I	J	K	L	Nxd	Weight kg
35	5L21/31	350	890	490	445	359	3700	850	3500	100	16	450	80	270	12xø22	550
35	6L21/31 7L21/31	450	1040	595	550	461	4700	1000	4500	100	16	1000	100	300	16xø22	1000
35	8L21/31 9L21/31	500	1140	645	600	512	5000	1100	4750	125	16	1000	150	310	20xø22	1250

Silencer type (B)

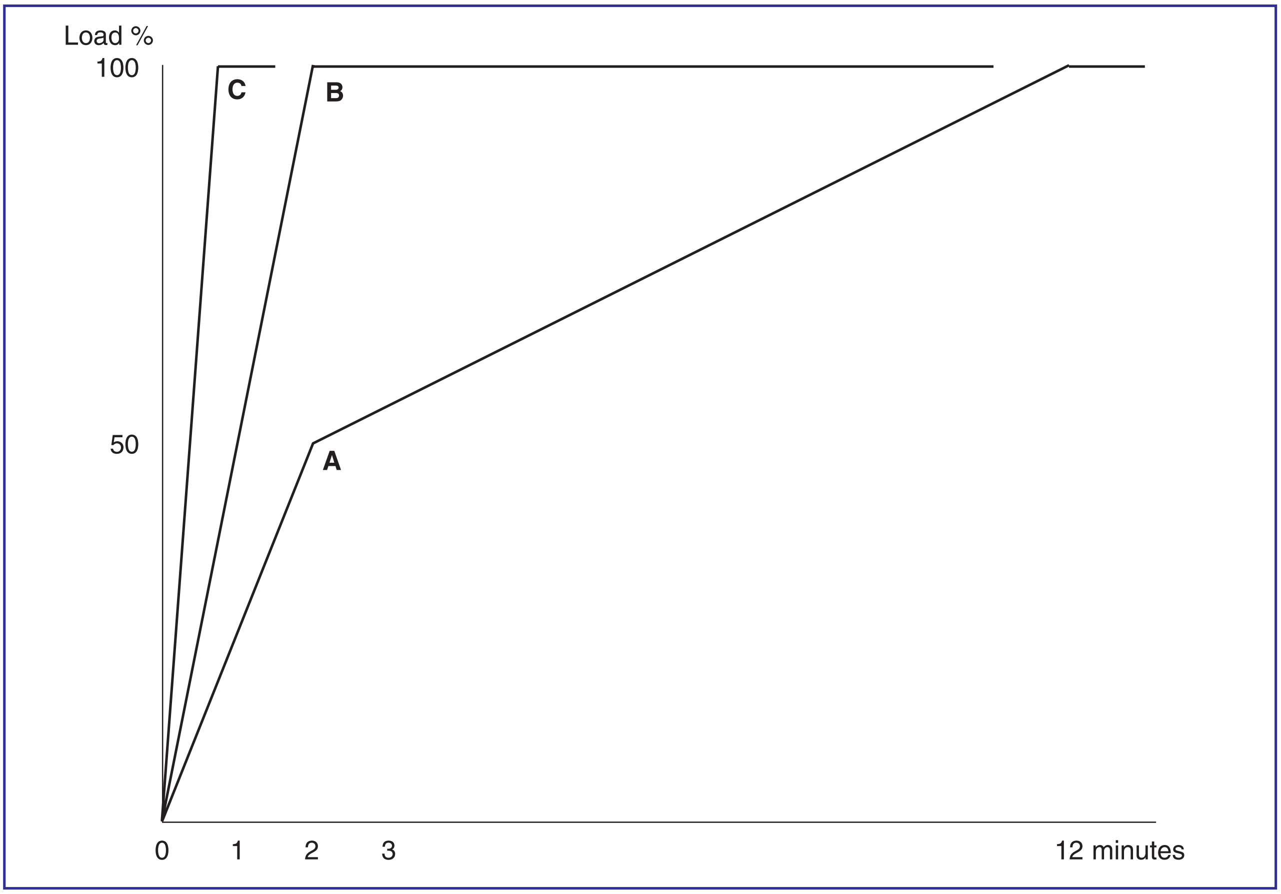
Damping dB(A)	Engine type	DN	A	B	C	D	E	F	G	H	I	J	K	L	Nxd	Weight kg
35	5L21/31	350	880	490	445	359	3750	850	3500	125	16	650	50	300	12xø22	627
35	6L21/31 7L21/31	450	1080	595	550	461	4650	1050	4350	150	16	800	100	350	16xø22	1140
35	8L21/31 9L21/31	500	1130	645	600	512	4700	1100	4500	100	16	900	100	350	20xø22	1204

Dimension for flanges for exhaust pipes is according to DIN 86 044

Speed Control System

B 17

General



The engine can be started and loaded according to the following procedure:

A) Normal start without preheated cooling water. Only on MDO. Continuous lubricating.

B) Normal start with preheated cooling water. On MDO or HFO. Continuous lubricating.

C) Stand-by engine. Emergency start, with preheated cooling water, continuous prelubricating. On MDO or HFO.

Above curves indicates the absolute shortes time and we advise that loading to 100% takes some more minutes.

Starting on HFO

During shorter stops or if the engine is in a stand-by position on HFO, the engine must be preheated and HFO viscosity must be in the range 12-18 cSt.

If the engine normally runs on HFO, preheated fuel must be circulated through the engine while preheating, although the engine has run or has been flushed on MDO for a short period.

Starting on MDO

For starting on MDO there are no restrictions except for the lub. oil viscosity which may not be higher than 1500 cSt (10° C SAE 40).

Initial ignition may be difficult if the engine and the ambient temperature are lower than 0° C and the cooling water temperature is lower than 15° C.

Prelubricating

Continuous prelubricating is standard. Intermittent prelubricating is not allowed for stand-by engines.

If the prelubrication has been switch-off for more than 20 minutes the start valve will be blocked.

General

Governor Type

As standard, the engines are equipped with a hydraulic - mechanical governor, make Regulateurs Europa, type 1102.

Speed Adjustment

Manual and electric.

Manual operated : speed setting controlled by handwheel.

Electric motor : series wound: 24V AC/DC for raise and lower the speed.

Speed Adjustment Range

Between -5% and +10% of the nominal speed at idle running.

Droop

Adjustable by dial type lockable control from 0-10% droop.

Load Distribution

By the droop setting.

Shutdown/Stop

Solenoid energised to "stop".

Manually operated shut-down knob fitted on governor energised to "stop" only.

Stop Solenoid voltages: 24V DC.

08028-0D/H5250/94.08.12

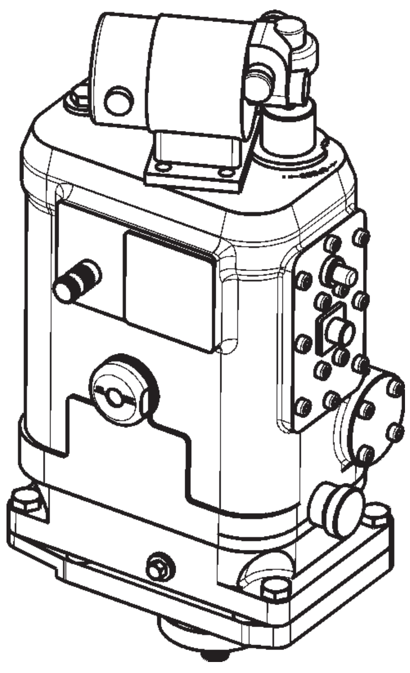


Fig 1 Regulateurs Europa governor.

General

Description

The **Co**mputer **Co**ntrolled **S**urveillance system is the family name of the software application products from the MAN B&W Diesel group.

CoCoS comprises four individual software application products:

- CoCoS-EDS, **E**ngine **D**iagnostics **S**ystem
- CoCoS-MPS, **M**aintenance **P**lanning **S**ystem
- CoCoS-SPC, **S**pare **P**art **C**atalogue
- CoCoS-SPO, **S**tock Handling and Spare **P**art **O**rdering

CoCoS MPS, SPC, and SPO can communicate with one another, or they can be used as separate stand-alone system. These three applications can also handle non-MAN B&W Diesel technical equipment; for instance pumps and separators.

The objectives of the CoCos software products are to provide:

- Increased availability and reliability of engines.
- Efficient reduction of operating costs and losses.
- Efficient planning of engine maintenance.
- Easy and unambiguous identification of spare parts.
- Integrated stock handling and spare part ordering.

CoCoS-EDS *(P 17 50 1, P 17 50 2)*

Engine **D**iagnostics **S**ystem, CoCoS-EDS assists in the performance evaluation through diagnostics. Key features are: on-line data logging, monitoring, diagnostics and trends.

The main objectives of CoCoS-EDS are:

- To assist in decision making onboard, at the office, or at the power plant.
- To improve availability and reliability of engines.
- To reduce operating costs and losses due to engine failure.

These objectives are achieved through:

- Logging, monitoring and storage of operating data.
- Unambiguous diagnostics of operating states.
- Timely detection of irregularities.

To obtain the full benefits of the principal features of CoCoS-EDS, it should have on-line connections to the alarm system and other data acquisition systems. However, manual input facilities make it possible to utilise CoCoS-EDS for off-line equipment, too.

CoCoS-MPS *(P 17 60 1, P 17 60 2)*

Maintenance **P**lanning **S**ystem, CoCoS-MPS assists in the planning and initiating of preventive maintenance. Key features are: scheduling of inspections and overhaul, forecasting and budgeting of spare part requirements, estimating of the amount of work hours needed, work procedures, and logging of maintenance history.

The main objectives of CoCoS-MPS are:

- To assist in decision making onboard or at the power plant.
- To improve availability and reliability of engines.
- To reduce maintenance costs and losses.

08028-0D/H5250/94.08.12

General

These objectives are achieved through:

- Comprehensive maintenance programmes.
- Dedicated tools for extensive planning of engine performance.
- Forecasting of the consumption of spare parts and work hours.
- Logging of maintenance history and experience.

CoCoS-MPS can be used as a stand-alone system. However, to obtain the full benefits of the principal features of CoCoS-MPS, it should have direct access to CoCoS-SPC and CoCoS-SPO.

CoCoS-SPC *(P 17 70 1, P 17 70 2)*

Spare **P**art **C**atalogue, CoCoS-SPC assists in the identification of spare part. Key features are: multi-level part lists, spare part information, and graphics.

The main objectives of CoCoS-MPS are:

- To assist in the identification of spare parts for engines and other technical equipment, on-board or at the power plant.
- To give easy access to spare part information.

These objectives are achieved through:

- Multilevel part lists.
- Graphics.
- Spare part information.
- Extended search.

CoCoS-SPC can be used as a stand-alone system. However, to obtain the full benefits of the features of CoCoS-SPC, it should have direct access to CoCoS-MPS and CoCoS-SPO.

CoCoS-SPO *(P 17 80 1, P 17 80 2)*

Stock Handling and Spare **P**art **O**rdering, CoCoS-SPO assists in managing the procurement and control of the spare part stock. Key features are: available stock, store location, planned receipts and issues, minimum stock, safety stock, suppliers, prices and statistics.

The main objectives of CoCoS-SPO are:

- To assist in the handling of the spare part stock.
- To give up-to-date information on current stock.
- To forecast spare part availability.
- To assist in the procurement of spare parts.

These objectives are achieved through:

- Stock administration.
- Automatic generation of ordering proposals.
- Easy preparation of - and follow-up on - orders.
- Extensive reporting.

CoCoS-SPO can be used as a stand-alone system. However, to obtain the full benefits of the integrated stock handling and spare part ordering, and of the other principal features of CoCoS-SPO, it should have direct access to CoCoS-MPS and CoCoS-SPC.

CoCoS Suite *(P 17 90 1)*

CoCoS Suite includes the four above-mentioned system;
P 17 50 1 (2), P 17 60 1 (2), P 17 70 1 (2) and P 17 80 1 (2).

Safety and Control System

B 19

Operation Data & Set Points

L21/31

	Normal Value at Full load		Acceptable value at shop test or after repair	Alarm Set point		Autostop of engine	
Lubricating Oil System							
Temp. after cooler (inlet filter) SAE 40	TI 21	68-73° C	<73° C	TAH 21	80° C		
Pressure after filter(inlet engine)	PI 22	4.2-5.0 bar	>4.5 bar	PAL 22	3.5 bar	PSL 22 (PSL 22) (D)	3.0 bar (2.5 bar)
Pressure drop across filter	PDAH 21-22	0.1-1 bar	<0.5 bar	PDAH 21-22	1.5 bar		
Prelubricating pressure	(PI 22)	0.13-1.5 bar	<1.0 bar	PAL 25	0.12 bar (H)		
Pressure inlet turbocharger	PI 23	1.5 ± 0.2 bar (C)	>1.5 bar	PAL 23	0.9 bar		
Lub. oil level in base frame				LAL 28/LAH 28	low/high level		
Pressure before filter	PI 21	4.5-5.5 bar					
Fuel Oil System							
Pressure after filter MDO HFO	PI 40 PI 40	3.5-6 bar 4-16 bar (A)		PAL 40 PAL 40	3 bar 3-6 bar (E)		
Leaking oil				LAH 42	High leakage level		
Temperature inlet engine MDO HFO	TI 40 TI 40	30-40°C 110-140°C					
Cooling Water System							
Press. LT system, inlet engine	PI 01	2.5-4.5 bar	>1.8 bar	PAL 01	0.4 + (B) bar		
Press. HT system, inlet engine	PI 10	2.0-4.0 bar	>1.8-<6 bar	PAL 10	0.4 + (B) bar		
Temp. HT system, outlet engine	TI 12	75-85°C	<85° C	TAH 12 TAH 12-2	90° C 93° C	TSH 12 (TSH 12) (D)	95° C (100° C)
Temp. LT system, inlet engine	TI 01	30-40°C					
Exhaust Gas and Charge Air							
Exh. gas temp. before TC	TI 62	480-530° C		TAH 62 TAH 62-2	570° C 620° C		
Exh. gas temp. outlet cyl.	TI 60	350-450° C		TAH 60	465° C		
Diff. between individual cyl.			average ±25° C	TAD 60	average ± 50° C		
Exh. gas temp. after TC	TI 61	250-350° C		TAH 61	450° C		
Ch. air press. after cooler	PI 31	2.8-3.1 bar					
Ch. air temp. after cooler	TI 31	40-55° C	<55° C				
Compressed Air System							
Press. inlet engine	PI 70	7-9 bar	>7.5-<9 bar	PAL 70	6.5 bar		
Speed Control System							
Engine speed elec.	SI 90	1000 rpm		SAH 81	1150 rpm	SSH 81 (SSH 81) (D)	1130 rpm (1150 rpm)
	SI 90	900 rpm		SAH 81	1035 rpm	SSH 81 (SSH 81) (D)	1017 rpm (1035 rpm)

08028-0D/H5250/94.08.12

L21/31

	Normal Value at Full load		Acceptable value at shop test or after repair	Alarm Set point		Autostop of engine	
Turbocharger speed	SI 89	30000-47000 rpm		SAH 89	(J)		
Alternator							
Winding temperature	TI 98	100° C		TAH 98	130° C		
Miscellaneous							
Jet system failure				SX32	switch		
Monitoring system failure		24 VDC ± 15%		UX 95-1	switch		
Safety system failure		24 VDC ± 15%		UX 95-2	switch		
Turning engaged				ZS75	Engaged (F)		
Local indication				ZS 96	switch		
Remote indication				ZS 97	switch		
Common shutdown				SS 86	switch (F)		
Monitoring sensor cable failure				SX 86-1	switch		
Safety sensor cable failure				SX 86-2	switch		
Start failure				SX 83	switch (G)		
Stop signal				SS 84	switch (F)		
Stop failure	SI 90			SX 84	switch		
Engine run		900/1000 rpm		SS 90	880 rpm (I)		
Ready to start				SS 87	switch		

Remarks to Individual Parameters

A. Fuel Oil Pressure, HFO-operation.

When operating on HFO, the system pressure must be sufficient to depress any tendency to gasification of the hot fuel.

The system pressure has to be adjusted according to the fuel oil preheating temperature.

B. Cooling Water Pressure, Alarm Set Points.

As the system pressure in case of pump failure will depend on the height of the expansion tank above the engine, the alarm set point has to be adjusted to 0.4 bar plus the static pressure. The static pressure set point can be adjusted on the base module SW3.

C. Lub. Oil Pressure, Offset Adjustment.

The read outs of lub. oil pressure has an offset adjustment because of the transmitter placement. This has to be taken into account in case of test and calibration of the transmitter.

D. Software Created Signal.

Software created signal from PI 22, TI 12, SI 90.

08028-0D/H5250/94.08.12

E. Set Points depending on Fuel Temperature.

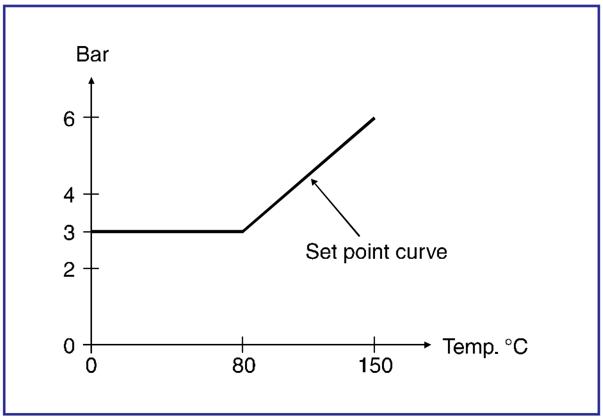


Fig 1 Set point curve.

F. Start Interlock.

The following signals are used for start interlock/ blocking:

1) Turning must not be engaged
2) Engine must not be running
3) "Remote" must be activated
4) No shutdowns must be activated.
5) The prelub. oil pressure must be OK, 20 min. after stop.
6) "Stop" signal must not be activated

G. Start Failure.

If remote start is activated and the engine is in blocking or local mode or turning is engaged the alarm time delay is 2 sec.
Start failure will be activated if revulutions are below 50 rpm within 5 sec. from start or revulutions are below 210 rpm 10 sec. from start.
Start failure alarm will automatically be re-leased after 30 sec. of activation.

H. Alarm Hysterese.

On all alarm points (except prelub. oil pressure) a hysterese of 0.5% of full scale are present. On prelub. oil pressure alarm the hysterese is 0.2%.

I. Engine Run Signal.

The engine run signal is activated when engine rpm >880 or lube oil pressure >3.0 bar or TC rpm >5000 rpm.
If engine rpm is above 210 rpm but below 880 rpm within 30 sec. the engine run signal will be activated.

J. Limits for Turbocharger Overspeed Alarm (SAH 89)

Engine type	900 rpm	1000 rpm
5L21/31 / TCR 16	47,630	47,630
6L21/31 / TCR 16	47,630	47,630
7L21/31 / TCR 16	47,630	47,630
8L21/31 / TCR 18	39,280	39,280
9L21/31 / TCR 18	39,280	39,280

General

General Description

Monitoring and instrumentation on the engine represents a tailor-made system. The system is designed to fulfil the following requirements:

- Continuous analogue monitoring
- Independent safety system
- Easy installation
- Simple operation
- Instrumentation complete
- No maintenance
- Prepared for CoCoS
- Redundant safety system

In order to fulfil all classification society requirements the engine is equipped with monitoring sensors for all medias as standard. If just one classification society require one specific measuring point it is standard on the engine. Also a built-on safety system is standard.

The engine is equipped with the following main safety, control and monitoring components:

- Safety system
- Governor
- Monitoring modules
  - base module (BM)
  - operation box (OB)
  - monitoring of temperatures/pressures panel (MTP)
  - monitoring of exhaust gas temperature panel (MEG)
  - monitoring of bearing temperature panel (MBT), option
  - bearing temperature display (BTD), option
  - oil mist detector, option
- Instrumentation (sensors, wiring, junction boxes)
- Manometers and thermometers
- Output module (OM), option
- Alarm panel (AP), option

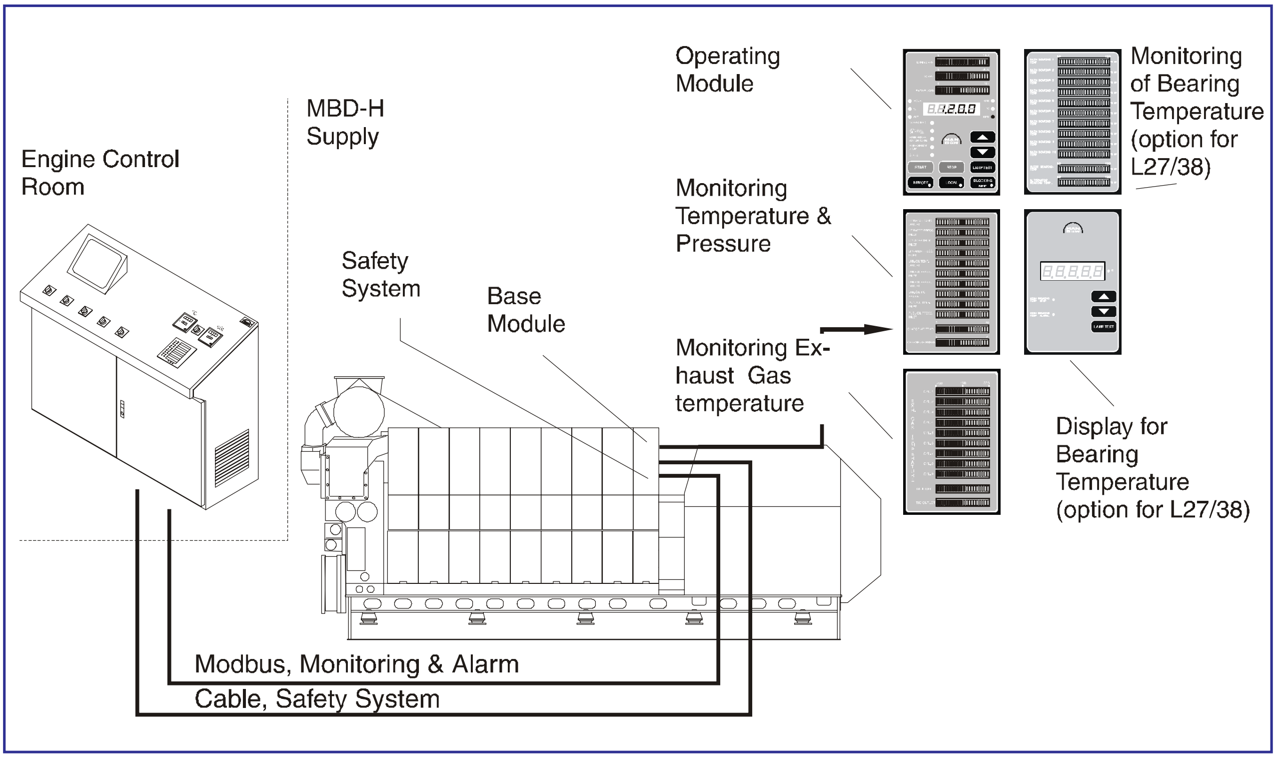


Fig 1 Monitoring and safety system.

08028-0D/H5250/94.08.12

General

Safety System

The safety system is an independent system for monitoring and controlling the GenSet's shutdown functions.

The safety system is based on a programme logic controller (PLC) which automatically controls the automatically stop (shutdown) in case of:

Shutdown

1) Overspeed
2) Low lube oil pressure
3) High HT water temp.
4) Emergency stop
5) High bearing temp. (option)
6) Oil mist stop (option)
7) Differential protection / earth connection (option)

Set points and special conditions can be found in the "Operation Data & Set Points, B 19 00 0"

Connection to and from the power management system is hard wire connection.

Indication of each shutdown can be found on the operation box and directly on the safety system module inside the terminal box.

Governor

The engine speed is controlled by a hydraulic governor or electronic controller with hydraulic actuator.

Information about the design, function and operation of the governor is found in the special governor instruction book.

The governor is mounted on the flywheel end of the engine and is driven from the camshaft via a cylindrical gear wheel and a set of bevel gears.

Regulating Shaft

The governor's movements are transmitted through a spring-loaded pull rod to the fuel injection pump regulating shaft which is fitted along the engine.

The spring-loaded pull rod permits the governor to give full deflection even if the stop cylinder of the manoeuvering system keeps the fuel injection pump at "no fuel" position.

Each fuel injection pump is connected to the common, longitudinal regulating shaft by means of a spring-loaded arm.

Should a fuel plunger seize in its barrel, thus blocking the regulating guide, governing of the remaining fuel injection pumps may continue unaffected owing to the spring-loaded linkage between the blocked pump and the regulating shaft.

Monitoring System

All media systems are equipped with temperature sensors and pressure sensors for local and remote reading.

The sensors for monitoring and alarming are connected to the base module.

Base Module

The base module is the centre of the monitoring system.

The base module, the OB-module, the MTP-module and the MEG-module are designed by MAN B&W Diesel A/S, Holeby specifically for this engine type.

Apart from the electrical main connection to the alternator the ship yard only has to perform the following electrical connection:

– 24 VDC supply to the safety system.
– Cable connection to/from power management system.
– 24 VDC supply to the base module.
– Modbus communication or interlink to output module.

The vessel's alarm and monitoring system in the main switch board can be connected to the base module by means of a 3-wire MODBUS communication link. For further information, please see the description "Communication from the GenSet".

In situations where the vessel's system cannot operate a MODBUS communication unit, MBD-H offers an output module (OM) to be installed in the vessel's control room.

By means of the OM it is possible to connect all digital and analogue signals to the vessel's monitoring system in a conventional manner.

Communication between the base module (BM) and the output module (OM) takes place via a 3-wire interlink bus (RS485).

In the base module all the alarms are generated and delay and cut-off at standstill is done. Set points and special conditions can be found in "Operation Data & Set Points, B 19 00 0".

The Base Module do also include redundant safety stop function for:

1) Overspeed
2) Low lube oil pressure
3) High cooling water temperature

The set points for above redundant safety stop are adjusted to a higher/lower point as the safety system. This will secure that the safety system will normally stop the engine in a critical situation. Only in case that the safety system is out of order the redundant safety stop will be needed.

Operating Box Module (OB)

This module includes the following possibilities:

- Operation of:
  - engine start
  - engine stop
  - remote mode
  - local mode
  - blocking/reset mode
  - lamp test
  - arrow up - shift upwards through measurements for display
  - arrow down - shift downwards through measurements for display
- Indication of:
  - Engine rpm
  - TC rpm
  - Starting air pressure
  - Display for digital read out
  - Indication of software version
- Shutdowns indication:
  - overspeed
  - low lub. oil pressure
  - high fresh water temp.
  - emergency stop / oil mist

Please note that the local stop push button must be activated at least 3 sec. before the engine will stop.

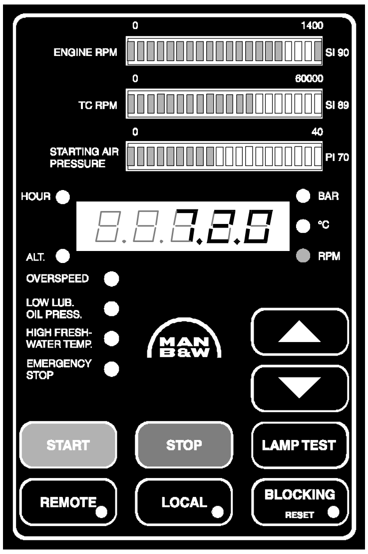


Fig 2 Operation box module (OB).

The manual start button must be activated until ignition, takes place. If the engine have been without prelubrication in more than 20 minutes the engine can not be electrical started.

The push buttons REMOTE - LOCAL - BLOCKING is only related to the start function. In case of BLOCKING the engine can not be started from local or from remote (switchboard).

General

The stop function is not depended of the REMOTE - LOCAL - BLOCKING position.

On the local operating box module the pressure, temperature and rpm are illustrated by means of a display: an LED indicates whether it is the working hours, alternator, pressure, temperature or rpm which is measured.

The display of the operation box module is used to read each individual measurement chosen by using "arrow up" or "arrow down" incl. MTP and MEG measurements. All rpm, pressures and temperatures are indicated in full values. The value displayed is indicated by flashing of the last segment of the bargraph on the OB, MTP or MEG module.

If the lamp test button is activated for more than 3 sec. the software version will be displayed.

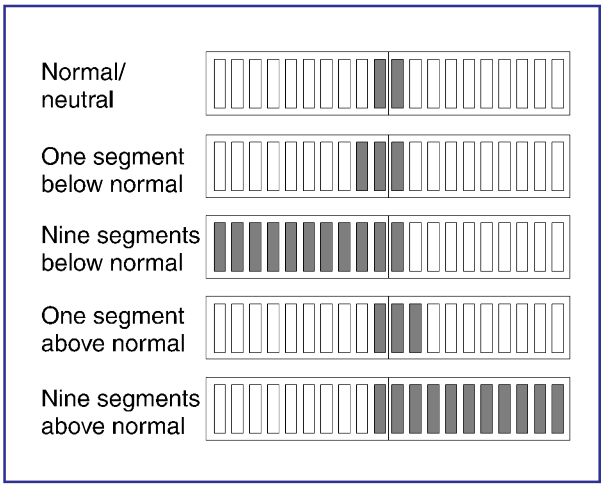


Fig 3 Monitoring of temperature/pressure module (MTP).

Monitoring of Temp./Pressure Panel (MTP)

All temperatures and pressures shown on the MTP module's bargraph are indicated with illuminated segments. When the temperatures and pressures are within the stated limits, two segments are illuminated in the middle forming a straight line. This means that it is easy to check the engines' systems, even at distance.

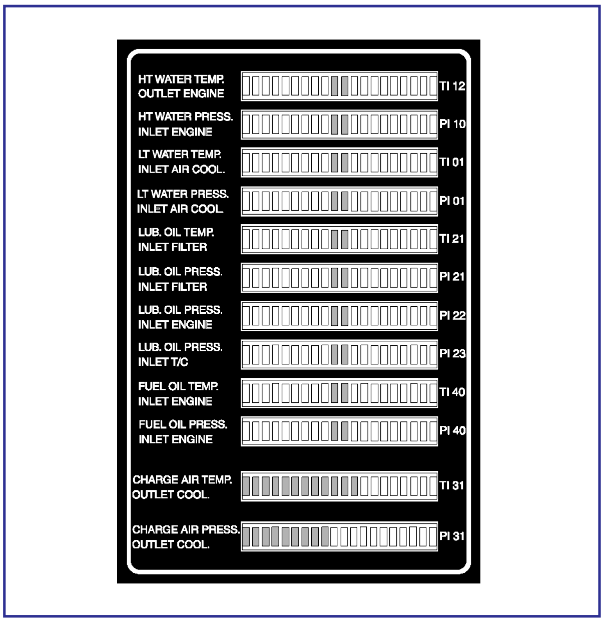


Fig 4 Monitor temp./press. (MTP)

If there is a deviation, the bargraph in question will start to illuminate the segments upwards or downwards, depending on rising or falling measurements, see fig 4.

It must be mentioned that the latter does not apply to the charge air temperature and charge air pressure, because they will vary with the engine load.

Monitoring of Exhaust Gas Temperature Panel (MEG)

The temperature shown on the MEG module is indicated with segments illuminated from the left to the right. The number of segments illuminated depends on the actual temperature of the exhaust gas.

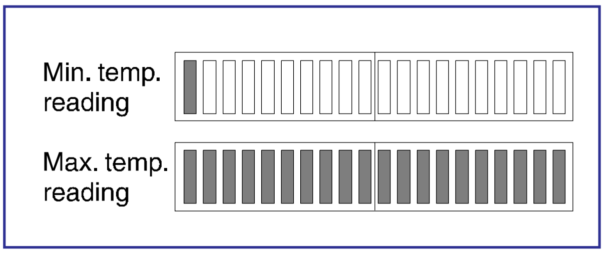


Fig 5 Monitoring of exhaust gas temperature module (MEG).

For emergency operation in case of totally black-out on the 24 V DC supply the engine is equipped with manometers for:

- Lub. oil pressure
- Cooling water pressure
- Fuel oil pressure

and thermometers for:

- Cooling water temp.
- Fuel oil temp.

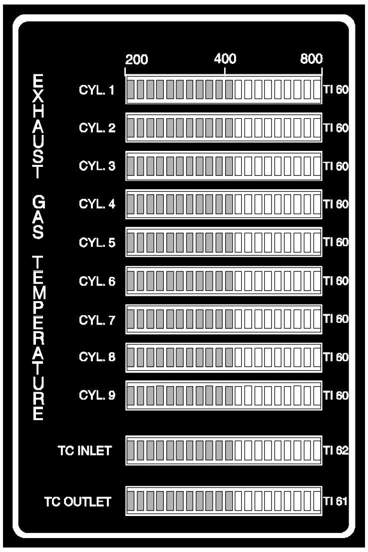


Fig 6 Monitor exh. gas temperature (MEG).

Equaliser Function for Exhaust Gas Temperature

An equaliser function has been introduced to take into consideration the old learning that the exhaust temperature values must be identical on a four-stroke diesel engine.

On the engine type L16/24, L27/38 and especially L21/31 it is observed that the temperature are not identical althrough the engine combustion is adjusted correctly. This fact may involve that the ship's crew will adjust the fuel pumps improperly to obtain identical exhaust temperature values for each cylinder and this is of course not desirable.

By performing an offset adjustment equalisation of the temperature when the engine is adjusted correctly the operator will get the impression that the temperatures then are identical when the pumps etc are adjusted correctly. If a deviation of the temperatures occurs, it is because of problems with the combustion or the fuel pumps just as the operator is used to.

The equaliser function is activated by pressing the arrow push buttons on the OB panel for minimum three seconds. A menu occurs and by pressing arrow push buttons up/down the following options are available:

- "NO" (Nothing happens and you return to normal mode)
- "YES" (Equalisation is completed if possible. New offsets are calculated)
- "RESET" (All offset values are re-zeroed)

The chosen option is accepted by pressing "BLOCKING" or "lamp test". If equalisation cannot be completed, "Err-2" will show up for two seconds and afterwards it returns to normal mode again. In case that a temperature deviation is above 40° C it will not be possible to complete an equalisation and "Err-2" will be indicated. The 40° C deviation is from the "real" readings, and not from the "manipulated" readings.

If the equaliser is activated on the OB panel without choosing an option, it will automatically return to normal OB display again after 15 seconds.

Monitoring of Bearing Temperature, MBT (option)

The temperature shown on the MBT module is indicated with segments illuminated from the left to the right. The number of segments illuminated depends on the actual temperature of the bearing temperature.

General

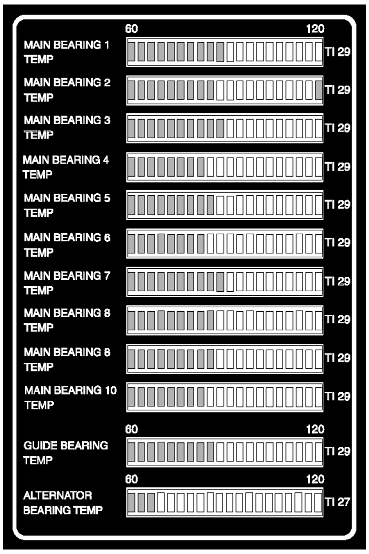


Fig 7 Monitoring of bearing temperature (MBT), option.

Display for Bearing Temperature Display, BTD (option)

On the bearing temperature display the excact measuring value for each individual bearing temperautre can be read. Furthermore an indication of high bearing temperature alarm and very high bearing temperature shutdown are indicated.

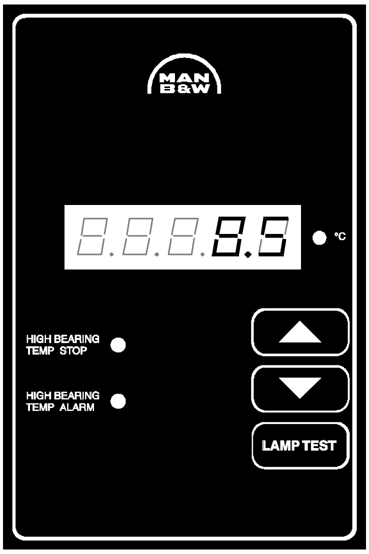


Fig 8 Display for bearing temperature (BTD), option.

Output Module (option)

For alarm systems which cannot be communicated through the MODBUS protocol, an output module has been designed. This module includes conventional output signals (4-20 mA) for all analogue measuring values, signals for limit values, and information signals from the safety system.

The output module will be delivered in a separate box (IP56) with the dimensions (H/L/W): 380 x 380 x 155 mm.

Alarm Panel (option)

An alarm panel with 24 alarm points can be connected to the system. The alarm panel can be installed on the engine or in the engine control room, see fig 7. The dimensions for the panel are (H/L/W): 144 x 96 x 35 mm.

It is important that all alarms leads to prompt investigation and remedy of the error. No alarm is insignificant. It is therefore important that all engine crew members are familiar with and well trained in the use and importance of the alarm system.The most serious alarms are equipped with slowdown and/or shutdown functions.

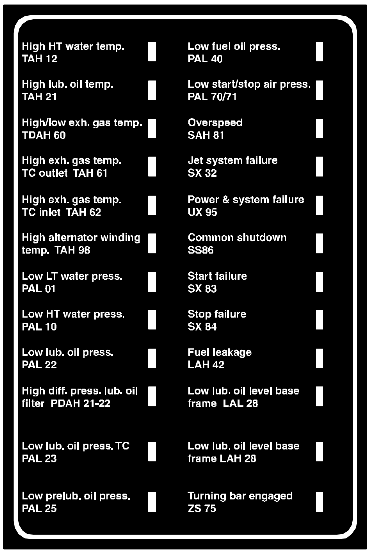


Fig 9 Alarm panel.

08028-0D/H5250/94.08.12

Instrumentation

Pressure measurements are generated from the pressure transmitters.

The exhaust gas temperatures are generated by NiCr/Ni thermo sensors.

Temperatures are generated by PT100 sensors.

The above transmitters and sensors are specially designed for installation on diesel engines.

The pressure sensors are placed centrally at the front of the engine, facilitating easy access for maintenance and overhauls, and minimizing wire connections.

The temperature sensors are placed at the measuring point.

Data

Power supply	:	24 VDC -20 to +30%, max ripple 10%
Power consumption	:	< 2 amp
Ambient temp.	:	-20°C to 70°C
External communication links	:	MODBUS ASCII / RTU or interlink (RS422 / RS485)

General

System Layout

Fig 1 shows the system layout. The modules BM, OB, MTP, MEG and safety system are all placed on the engine. More detailed information on each module and sensors can be read in the description "Safety, Control and Monitoring System".

Communication

Communication from the BM-module to the ship's alarm & monitoring system can be done in three ways:

1) In the BM-module there is a MODBUS ASCII or RTU interface communication.

2) An output module (OM) can be placed in the control room switchboard or alarm disk. Communication from the BM-module to the OM-module is made via the 3 wire module interlink bus.

In the OM-module all the signals are converted into 4-20 mA signals and digital outputs.

All signals can be wired up from the OM-module to the ship's alarm & monitoring system.

3) A simple alarm panel (AP) with 24 LED channels can be installed in the control room. This solution only serves digital alarms.

If the alarm system can communicate with MODBUS ASCII or RTU, there is no need for the OM-module or AP. All signals can be communicated by the MODBUS.

In the following please find a description of the MODBUS protocol and addressing of the signals.

MODBUS Protocol (BM)

The BM has a standard MODBUS ASCII and RTU interface which may be selected, by means of a DIP switch on the BM, to be either:

- RS422 5 wire (Rx+, Rx-, Tx+, Tx-, GND) or
- RS485 3 wire (Rx+/Tx+, Rx-/Tx-, GND)

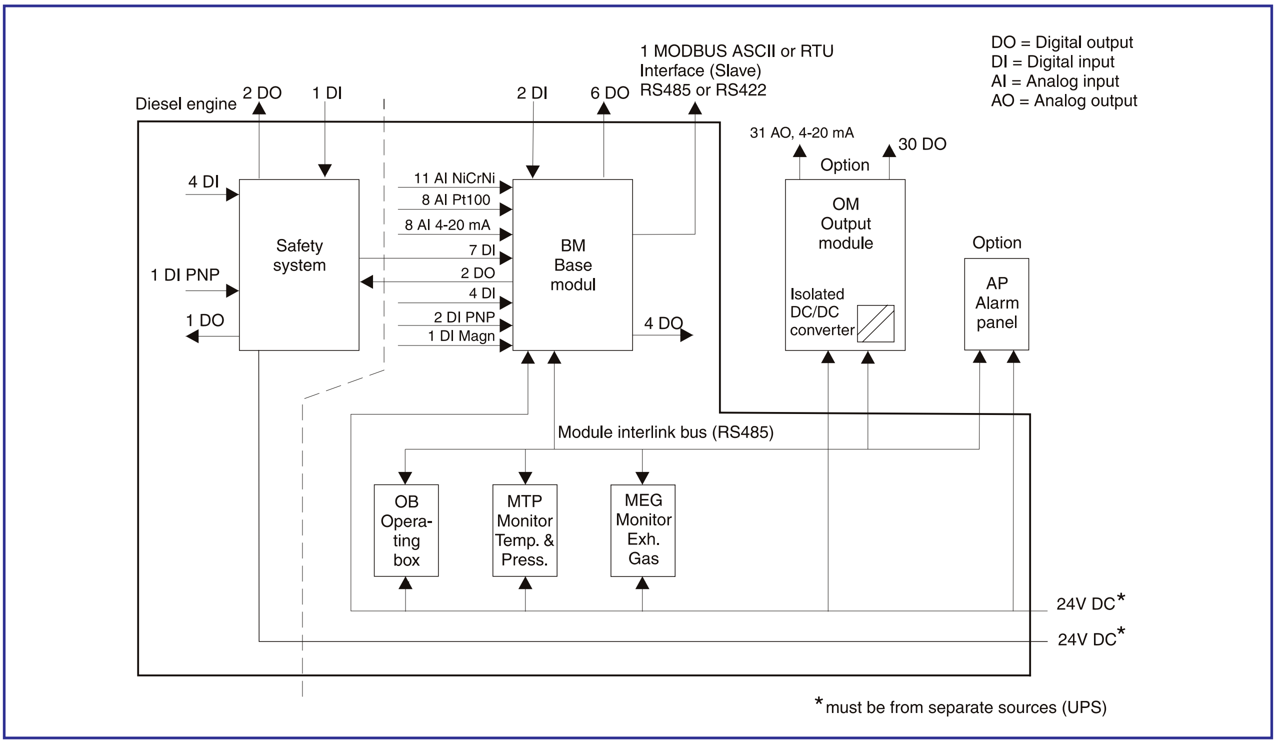


Fig 1 System overview: "monitoring system & safety system"

08028-0D/H5250/94.08.12

General

The communication setup is: 9600 baud, 8 databits, 1 stopbit, no parity.

The BM MODBUS protocol accept one command (Function Code 03) for reading analog and digital input values one at a time, or as a block of up to 32 inputs.

MODBUS is defined by the company AEG Modicon and the implementated protocol in the BM is designed to observe the relevant demands in the latest protocol description from AEG Modicon:

MODBUS was originally defined by EAG Modicon, but is now adminstered by the MODBUS-IDA group. The MODBUS protocol implemented for the BM is defined in the document "MODBUS over serial line specification and implementation V1.0", available at http://www.modbus.org/

The following chapter describes the commands in the MODBUS protocol, which are implementated, and how they work.

Protocol Description

The ASCII and RTU version of the MODBUS protocol is used, where the BM works as MODBUS slave. All data bytes will be converted to 2-ASCII characters (hex-values). Thus, when below is referred to „bytes“ or „words“, these will fill out 2 or 4 characters, respectively in the protocol.

The general „message frame format“ has the following outlook:

[:] [SLAVE] [FCT] [DATA] [CHECKSUM] [CR] [LF]

- [:] 1 char. Begin of frame
- [SLAVE] 2 char. Modbus slave address Selected on DIP-switch at BM print
- [FCT] 2 char. Function code
- [DATA] n X 2 chars data.
- [CHECKSUM] 2 char checksum (LRC)
- [CR] 1 char CR
- [LF] 1 char LF (end of frame)

Notice: The MODBUS address [SLAVE] should be adjusted on the DIP-switch (SW 1) on the BM. Allowed addresses are 1..63 (address 0 is not allowed). Broadcast packages will not be accepted (to be ignored), see fig 2.

The following function codes (FCT) is accepted:

- 03H: Read n words at specific address.
- 10H: Write n words at specific address.

In response to the message frame, the slave (BM) must answer with appropriate data. If this is not possible, a package with the most important bit in FCT set to 1 will be returned, followed by an exception code, where the following is supported:

- 01: Illegal function
- 02: Illegal data address
- 03: Illegal data value
- 06: BUSY. Message rejected

SW 1: MODBUS address

Switch no	1	2	3	4	5	6	
Address:							
0	OFF	OFF	OFF	OFF	OFF	OFF	**Not allowed**
1	ON	OFF	OFF	OFF	OFF	OFF	
2	OFF	ON	OFF	OFF	OFF	OFF	
63	ON	ON	ON	ON	ON	ON	**Not allowed**

Fig 2 Modbus address

08028-0D/H5250/94.08.12

FCT = 03H: Read n words

The master transmits an inquiry to the slave (BM) to read a number (n) of datawords from a given address. The slave (BM) replies with the required number (n) of datawords. To read a single register (n) must be set to 1. To read block type register (n) must be in the range 1...32.

Request (master):
[DATA] = [ADR][n]
[ADR]=Word stating the address in HEX.
[n]=Word stating the number of words to be read.

Answer (slave-BM):
[DATA] = [bb][1. word][2. word]....[n. word]
[bb]=Byte, stating number of subsequent bytes.
[1. word]=1. dataword
[2. word]=2. dataword
[n. word]=No n. dataword

FCT = 10H: Write n words

The master sends data to the slave (BM) starting from a particular address. The slave (BM) returns the written number of bytes, plus echoes the address.

Write data (master):
[DATA] = [ADR][n] [bb][1. word][2. word]....[n word]
[ADR] = Word that gives the address in HEX.
[n] = Word indicating number of words to be written.
[bb] = Byte that gives the number of bytes to follow (2*n)
Please note that 8bb9 is byte size!
[1. word]=1. dataword
[2. word]=2. dataword
[n. word]=No n. dataword

Answer (slave-BM):
[DATA] = [ADR][bb*2]
[ADR]= Word HEX that gives the address in HEX
[bb*2]=Number of words written.
[1. word]=1. dataword
[2. word]=2. dataword
[n. word]=No n. dataword

MODBUS addressing

In order to be able to read from the different I/O and data areas, they have to be supplied with an „address".

In the MODBUS protocol each address refers to a word or „register". For the GenSet there are following I/O registers:

– Block (multiple) I/O registers occupying up to 32 word of registers (see table 3, 4, 5 and 6).

Block I/O registers hold up to 32 discrete I/O's placed at adjacent addresses, so it is possible to request any number of I/O's up to 32 in a single MODBUS command. Please refer to table 3, 4, 5 and 6 which specifies the block I/Os registers addresses and how the individual I/O's are situated within the „block".

Data Format

The following types of data format have been chosen:

Digital: Consists of 1 word (register):
1 word: [0000H]=OFF
[FFFFH]=ON

Integer: Consists of 1 word (register):
1 word: 12 bit signed data
(second complement):
[0000H]=0
[0FFFH]=100% of range
[F000H]=-100% of range

Notice: 12 bit data format must be used no matter what dissolution a signal is sampled with. All measuring values will be scaled to 12 bit signed.

Example 1:

PI10, range 0-6 bar
The value 2.3 bar will be represented as 38.33% of 6 bar = 0621H

General

MODBUS Timeout

To prevent lock up of the protocol, ie. a breakdown on the connection, a number of timeouts are to be built in, as specified in the MODBUS protocol specification:

MODBUS specification max. time between characters in a frame: 10 ms

MODBUS specification max. time between receipt of frame and answer: 1 second

However the implementation of the protocol in the GenSet Base Module is able to handle much smaller timeouts (response times), which may be required in order to obtain an acceptable worst-case I/O scan time:

Base Module, max. time between characters in a frame:5 ms

Base Module, max. time between receipt of frame and answer: 100 ms

General

In the tables below each signal has a importance statement with following meaning:

Required by the classification society or MAN B&W.
Recommended by MAN B&W.
"Nice to have".

In the tables below some signals have a remark with following meaning:

a) Required by American Bureau of Shipping, ABS.
b) Required by Bureau Veritas, BV.
c) Required by Jugoslavenski Register & DnV.
d) Required by Registro Italiano Navale, RINA.
e) Required by Nippon Kaiji Kyokai, NKK & DnV.
f) Bureau Veritas, Lloyds Register of Shipping and ABS demand alarm point for low/high heavy fuel oil temp. Normally this is placed at yard side as an common alarm for all aux. engines. The signal can also be generated from iTI40.
g) "Common shutdown" consists of following signals: PSL22, TSH12, SSH81 and ZS82 (as option TSH29/27 for L27/38 or LSH92 for L27/38 and L32/40). Furthermore it consist also of the redundant shutdowns performed in the Base Module.
h) "Safety system failure" consists of following signals: Power supply failure and internal watch dog alarm.
i) "Safety sensor cable failure" means cable failure on one or more of following sensors: lub. oil pressostate PSL22, cool. water ther-mostate TSH12, speed pick-up SE90-2 or emergency stop switch ZS82 (as option TSH29/27 for L27/38 or LSH92 for L27/38 and L32/40)
j) "Local shutdown" only consists of the shutdowns (PSL22, TSH, SSH81, and ZS82) in the safety system.
k) For L27/38, L21/31 and L32/40 the signal ZS82, also includes high oil mist shutdown, LSH92 if it is installed (option).
l) Oil mist (LSH/LAH92) is standard for 7, 8, 9 cyl. L27/38 (for marine application) and L32/40. For 5, 6 cyl. L27/38 and L21/31 it is an option.
m) Required by Det Norske Veritas, DnV.
n) For L16/24 engine type TC rpm range is 0-80000.
o) Not accepted by all classification societies.
p) For GenSets with high voltage alternators.

General) All alarm signals are already performed with necessary time delay. F.ex. lub. oil level alarms (LAL/LAH28) includes 30 sec. alarm delay. Start air alarm (PAL70) includes 15 sec. alarm delay. No further delay are needed.

Table 3 (Block scanning)

Signal	Name/description	Address	Data format	Importance	Remark	Meas. range
oLAH42	Drain box high level	4002	Digital	Required		
oPAL25	Prelub. oil low press.	4003	Digital	Required		
oSX32	Jet system failure	4004	Digital	Required		
oUX95-2	Safety system failure	4005	Digital	Required	h)	
oSS86	Common shutdown	4006	Digital	Required	g)	
oTAH98	Alternator winding temp. high	4007	Digital	Required		
oPAL10	HT water press. inlet low	4008	Digital	Required		
oPAL70	Starting air press. low	4009	Digital	Required		
oPDAH21-22	Diff. press. high, lub. oil filter	400A	Digital	Required		
oPAL 22	Lub. oil press. inlet low	400B	Digital	Required		
oPAL40	Fuel press. low	400C	Digital	Required		
oTAH12	HT water temp. high	400D	Digital	Required		
oTAH21	Lub. oil temp. inlet high	400E	Digital	Required		
oLAL28	Low oil level base frame	400F	Digital	Recommended	b)	
oLAH28	High oil level base frame	4010	Digital	Recommended		
iZS75	Microswitch, turning gear engaged	4011	Digital	Recommended	b)	
oSAH81	Overspeed alarm	4012	Digital	Recommended		
oTAD60	Exh. gas temp. high or low	4013	Digital	Recommended	m)	
oTAH61	TC temp. outlet, high	4014	Digital	Recommended		
oTAH62	TC temp. inlet, high	4015	Digital	Recommended	m)	

Cont.

General

Cont. of table 3

Signal	Name/description	Address	Data format	Importance	Remark	Meas. range
iTI12	HT water temp. outlet	4016	Integeter 12 Bit	Recommended	m)	0-200° C
iTI21/22	Lub. oil temp. inlet	4017	Integeter 12 Bit	Recommended	a) + m)	0-200° C
iTI40	Fuel oil temp. inlet	4018	Integeter 12 Bit	Recommended	f)	0-200° C
iTI98-1	Alternator winding temp. 1	4019	Integeter 12 Bit	Recommended	a)	0-200° C
iTI98-2	Alternator winding temp. 2	401A	Integeter 12 Bit	Recommended	a)	0-200° C
iTI98-3	Alternator winding temp. 3	401B	Integeter 12 Bit	Recommended	a)	0-200° C
iPI10	HT water press. inlet	401C	Integeter 12 Bit	Recommended	a) + m)	0-6 bar
iPI22	Lub. oil press inlet engine	401D	Integeter 12 Bit	Recommended	a) + m)	0-10 bar
iPI40	Fuel oil press. inlet	401E	Integeter 12 Bit	Recommended		0-16 bar
iPI70	Starting air pressure	401F	Integeter 12 Bit	Recommended	a)	0-40 bar
oSX86-2	Safety sensor cable failure	4020	Digital	Recommended	i)	
oSX83	Start failure	4021	Digital	Recommended		

Table 3 MODBUS block 1 (multiple i/o) register addressing.

Table 4 (Block scanning)

Signal	Name/description	Address	Data format	Importance	Remark	Meas. range
iPSL22	Lub. oil inlet low pressure, stop	4042	Digital	Nice to have		
iTSH12	HT water outlet high temp., stop	4043	Digital	Nice to have		
iZS82 (LSH92)	Emergency shutdown (oil mist)	4044	Digital	Nice to have	k)+l)	
iSSH81	Overspeed stop	4045	Digital	Nice to have		
oZS96	Local indication	4046	Digital	Nice to have		
oZS97	Remote indication	4047	Digital	Nice to have		
oSA99	(Spare)	4048	Digital			
oSS90A	Engine running	4049	Digital	Nice to have		
iTE60-1	Exh. gas temp., cylinder 1	404A	Integer 12 Bit	Nice to have	c)	0-800° C
iTE60-2	Exh. gas temp., cylinder 2	404B	Integer 12 Bit	Nice to have	c)	0-800° C
iTE60-3	Exh. gas temp., cylinder 3	404C	Integer 12 Bit	Nice to have	c)	0-800° C
iTE60-4	Exh. gas temp., cylinder 4	404D	Integer 12 Bit	Nice to have	c)	0-800° C
iTE60-5	Exh. gas temp., cylinder 5	404E	Integer 12 Bit	Nice to have	c)	0-800° C
iTE60-6	Exh. gas temp., cylinder 6	404F	Integer 12 Bit	Nice to have	c)	0-800° C
iTE60-7	Exh. gas temp., cylinder 7	4050	Integer 12 Bit	Nice to have	c)	0-800° C
iTE60-8	Exh. gas temp., cylinder 8	4051	Integer 12 Bit	Nice to have	c)	0-800° C
iTE60-9	Exh. gas temp., cylinder 9	4052	Integer 12 Bit	Nice to have	c)	0-800° C
iTE61	Exh. gas temp. outlet TC	4053	Integer 12 Bit	Nice to have	d)	0-800° C
iTE62	Exhaust gas temp. inlet TC	4054	Integer 12 Bit	Nice to have	e)	0-800° C
iTI01	LT water temp. inlet	4055	Integer 12 Bit	Nice to have		0-200° C
iTI31	Charge air temp.	4056	Integer 12 Bit	Nice to have		0-200° C
iPI01	LT water press. inlet	4057	Integer 12 Bit	Nice to have		0-6 bar
iPI21	Lub. oil press. inlet filter	4058	Integer 12 Bit	Nice to have		0-10 bar
iPI23	Lub. oil TC press.	4059	Integer 12 Bit	Nice to have		0-4 bar
iPI31	Charge air press.	405A	Integer 12 Bit	Nice to have		0-4 bar
oSE90	Engine RPM pickup	405B	Integer 12 Bit	Nice to have		0-1600 rpm
oSE89	TC RPM pickup	405C	Integer 12 Bit	Nice to have	n)	0-60000 rpm
oUX95-2_Dly	(Spare)	405D	Digital			
oSX84	Stop failure	405E	Digital	Nice to have		
iSS86-3	Shutdown from safety system	405F	Digital	Nice to have	j)	
oPAL01	LT water press. inlet	4060	Digital	Nice to have		
oPAL23	Lub. oil press. TC, low	4061	Digital	Nice to have		

Table 4 MODBUS block 2 (multiple i/o) register addressing.

08028-0D/H5250/94.08.12

Table 5 (Block scanning)

Signal	Name/description	Address	Data format	Importance	Remark	Meas. range
oSAH89	High TC rpm	40C2	Digital	Nice to have	m)	
oTAH62-2	High exh. gas temp. before TC	40C3	Digital	Nice to have	m)	
oTAH12-2	High cooling water temp.	40C4	Digital	Nice to have	m)	
oTAH60-1	High exh. gas temp cyl. 1	40C5	Digital	Nice to have	m)	
oTAH60-2	High exh. gas temp cyl. 2	40C6	Digital	Nice to have	m)	
oTAH60-3	High exh. gas temp cyl. 3	40C7	Digital	Nice to have	m)	
oTAH60-4	High exh. gas temp cyl. 4	40C8	Digital	Nice to have	m)	
oTAH60-5	High exh. gas temp cyl. 5	40C9	Digital	Nice to have	m)	
oTAH60-6	High exh. gas temp cyl. 6	40CA	Digital	Nice to have	m)	
oTAH60-7	High exh. gas temp cyl. 7	40CB	Digital	Nice to have	m)	
oTAH60-8	High exh. gas temp cyl. 8	40CC	Digital	Nice to have	m)	
oTAH60-9	High exh. gas temp cyl. 9	40CD	Digital	Nice to have	m)	
oUX95-1	Monitoring system failure	40CE	Digital	Recommended		
oSX86-1	Monitoring sensor failure	40CF	Digital	Recommended		
iLAH92	High oil mist alarm (oil splash)	40D0	Digital	Nice to have	l)	

Table 5 MODBUS block 3 (mutiple i/o) register addressing.

Individual scanning

Signal	Name/description	Address	Data format	Importance	Remark	Meas. range
oZS57	Earth connector & diff. protection	4090	Digital	Nice to have	p)	

General

Table 6 (Block scanning)

Signal	Name/description	Address	Data format	Importance	Remark	Meas. range
Following signals are only available as option for engine type L27/38.						
iTI29-1	Main bearing temp.	4005H	Integer 12 Bit	Nice to have		0-800° C
iTI29-2	Main bearing temp.	4004H	Integer 12 Bit	Nice to have		0-800° C
iTI29-3	Main bearing temp.	4003H	Integer 12 Bit	Nice to have		0-800° C
iTI29-4	Main bearing temp.	4002H	Integer 12 Bit	Nice to have		0-800° C
iTI29-5	Main bearing temp.	4006H	Integer 12 Bit	Nice to have		0-800° C
iTI29-6	Main bearing temp.	4007H	Integer 12 Bit	Nice to have		0-800° C
iTI29-7	Main bearing temp.	4008H	Integer 12 Bit	Nice to have		0-800° C
iTI29-8	Main bearing temp.	4009H	Integer 12 Bit	Nice to have		0-800° C
iTI29-9	Main bearing temp.	400AH	Integer 12 Bit	Nice to have		0-800° C
iTI29-10	Main bearing temp.	400BC	Integer 12 Bit	Nice to have		0-800° C
iTI29-11	Guide bearing temp.	400CH	Integer 12 Bit	Nice to have		0-800° C
oTI29-1	Cable break	400DH	Digital	Nice to have		
oTI29-2	Cable break	400EH	Digital	Nice to have		
oTI29-3	Cable break	400FH	Digital	Nice to have		
oTI29-4	Cable break	4010H	Digital	Nice to have		
oTI29-5	Cable break	4011H	Digital	Nice to have		
oTI29-6	Cable break	4012H	Digital	Nice to have		
oTI29-7	Cable break	4013H	Digital	Nice to have		
oTI29-8	Cable break	4014H	Digital	Nice to have		
oTI29-9	Cable break	4015H	Digital	Nice to have		
oTI29-10	Cable break	4016H	Digital	Nice to have		
oTI29-11	Cable break	4017H	Digital	Nice to have		
iTI27-1	Alternator bearing temp.	4018H	Integer 12 Bit	Nice to have		0-200° C
iTI27-2	Alternator bearing temp.	4019H	Integer 12 Bit	Nice to have		0-200° C
iTI INTERNT.	Compensation resistor	401AH	Integer 12 Bit	Nice to have		0-200° C
oTSH29/27	High bearing temp. shutdown	401BH	Digital	Nice to have		
oTSH29/27	High bearing temp. shutdown	401CH	Digital	Nice to have		
oTSH29/27A	Common alarm main bearing temp.	401DH	Digital	Nice to have		
oTSH29/27B	Common alarm main bearing temp.	401EH	Digital	Nice to have		
oUX29/27	Common cable failure	401FH	Digital	Nice to have		

Table 6 MODBUS block 4 (mutiple i/o) register addressing.

Table 7 (Individual scanning of control signals)

Signal	Name/description	Address	Data format	Importance	Remark	Meas. range
	Running hours	C141	32 bit word			2 registers
	Start via MODBUS	C1C1	Digital		o)	
	Stop via MODBUS	C201	Digital		o)	
	Start counter	C241	32 bit word			2 registers

Table 7 MODBUS block 5 (multiple i/o) register addressing.

In fig 8 and 9 some examples of wiring are illustrated. See also description "Guidelines for cable and wiring" for further information.

General

Engine type L16/24, L21/31, L27/38 or L32/40

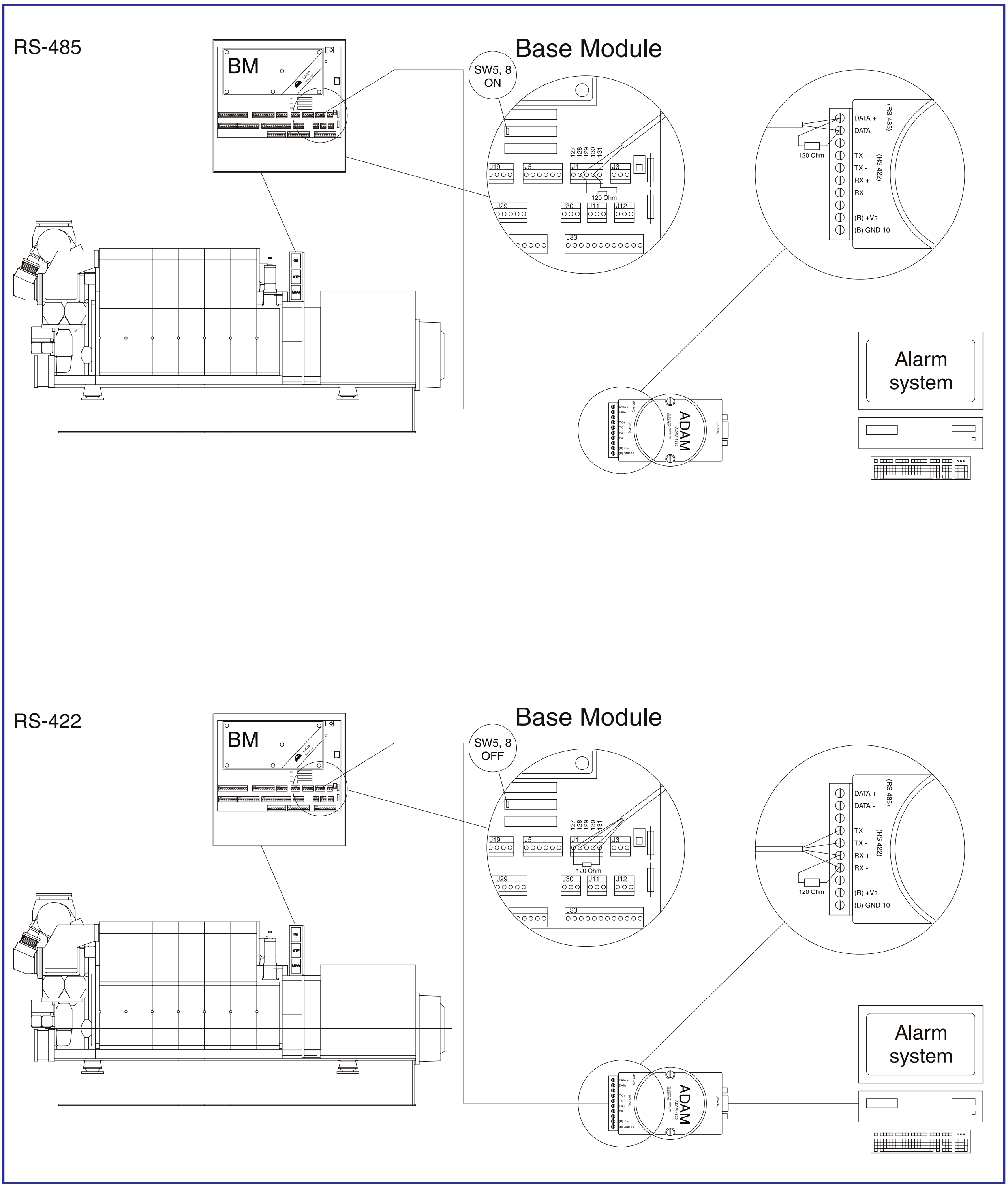


Fig 8 MODBUS communication (RS 485 and RS 422).

08028-0D/H5250/94.08.12

General

Engine type L27/38 incl. bearing surveillance module

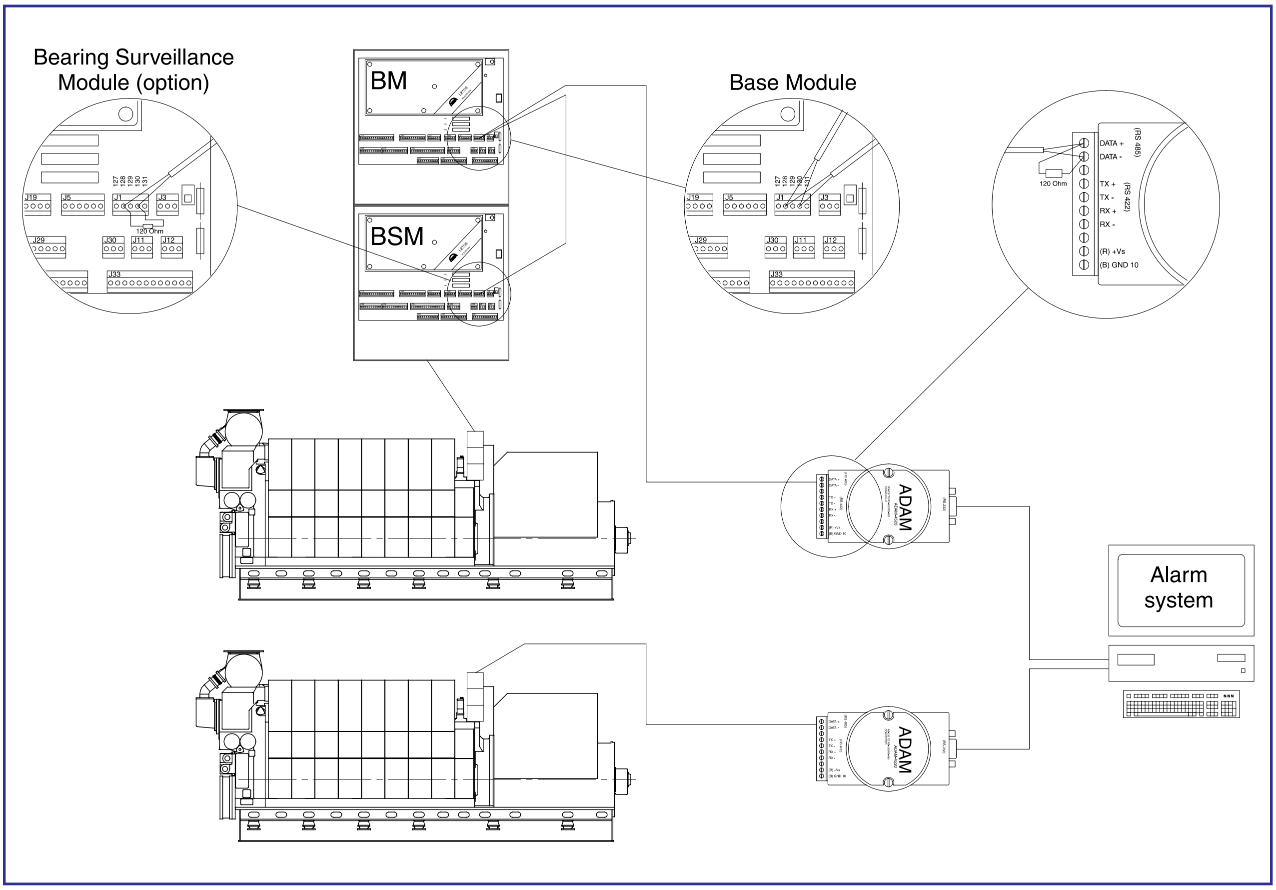


Fig 9 MODBUS communication (RS 485).

Comment: Always connect each engine with separate serial cable to the alarm system. Do not connect all auxiliary engines on one serial cable connection.

08028-0D/H5250/94.08.12

Description

The oil mist detector type Tufmon from company Dr. Horn is standard on the 7, 8 and 9L27/38 engine types and option for all other engine types.

The oil mist detector is based on direct measurement of the oil mist concentration in the natural flow from the crankcase to the atmosphere.

The detector is developed in close cooperation between the manufacturer Dr. Horn and us and it has have been tested under realistic conditions at our testbed.

The oil mist sensor is mounted on the venting pipe together with the electronic board. At first the sensor will activate an alarm, and secondly the engine will be stopped, in case of critical oil mist concentration. Furthermore there is an alarm in case of sensor failure. To avoid false alarms direct heating of the optical sensor is implemented. The installation is integrated on the engine. No extra piping/cabling is required.

Fig 1 Oil mist detector.

Tecnical Data

Power supply : 24 V DC +30% / -25%
Power consumption : 1 A
Operating temperature : 0° C....+70° C

Enclosure according to DIN 40050:
- Analyzer : IP54
- Speed fuel rack and optical sensors : IP67
- Supply box and connectors : IP65

08028-0D/H5250/94.08.12

General

Description

The prelubricating oil pump box is for controlling the prelubricating oil pump built onto the engine.

The control box consists of a cabinet with starter, overload protection and control system. On the front of the cabinet there is a lamp for "pump on", a change-over switch for manual start and automatic start of the pump, furthermore there is a main switch.

The pump can be arranged for continuous or intermittent running. (For L16/24, L21/31 & L27/38 only continuous running is accepted).

Depending on the number of engines in the plant, the control box can be for one or several engines.

The prelubricating oil pump starting box can be combined with the high temperature preheater control box.

See also B 12 07 0, Prelubricating Pump.

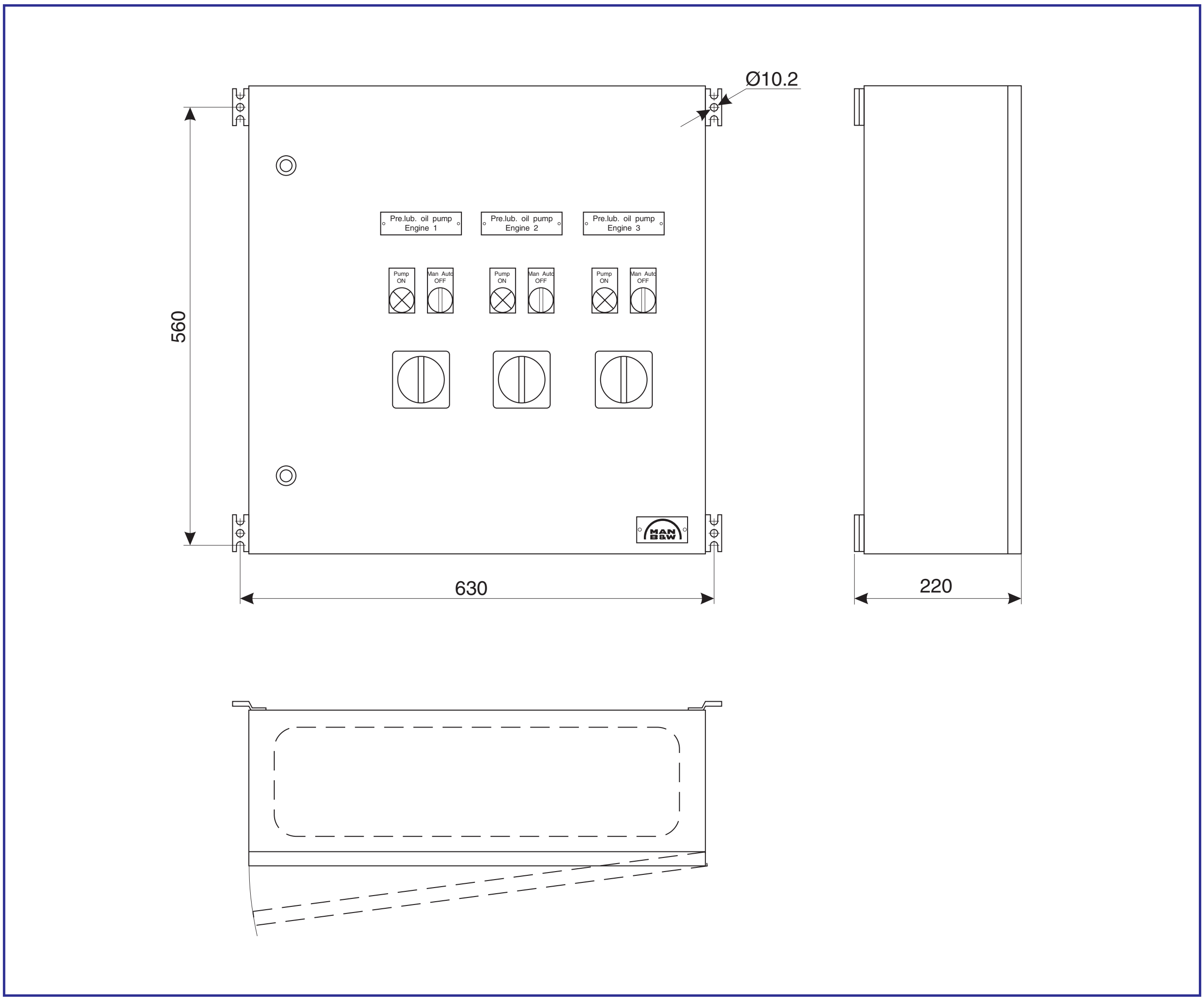


Fig 1 Dimensions.

08028-0D/H5250/94.08.12

E 19 11 0	Prelubricating Oil Pump Starting Box	1631477-3.3 Page 2 (2)

General

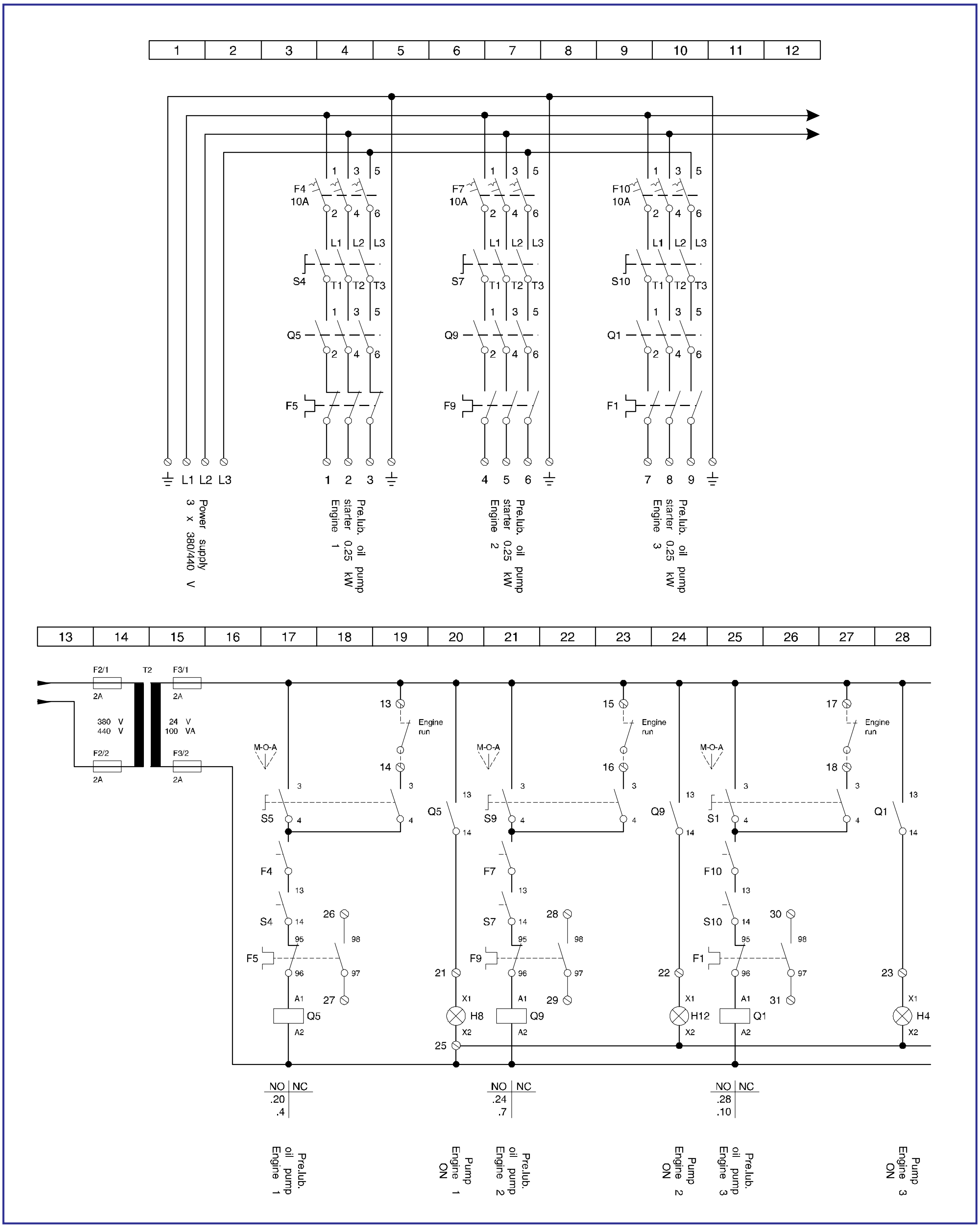


Fig 2 Wiring diagram.

08028-0D/H5250/94.08.12

Foundation

B 20

Foundation Recommendations

When the generating sets are installed on a transverse stiffened deck structure, it is generally recommended to strengthen the deck by a longitudinal stiffener inline with the resilient supports, see fig 2.

For longitudinal stiffened decks it is recommended to add transverse stiffening below the resilient supports.

It is a general recommendation that the steel foundations is in line with both the supporting transverse and longitudinal deck structure , fig 1, in order to obtain sufficient stiffness in the support of the resilient mounted generating sets.

The strength and the stiffness of the deck structure has to be based on the actual deck load, i.e. weight of machinery, tanks etc. and furthermore, resonance with the free forces and moments from especially the propulsion system have to be avoided.

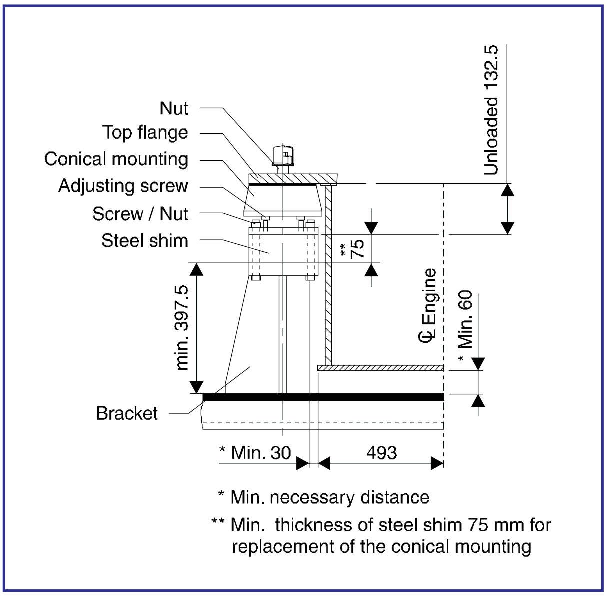


Fig 1 Transverse stiff deck structure.

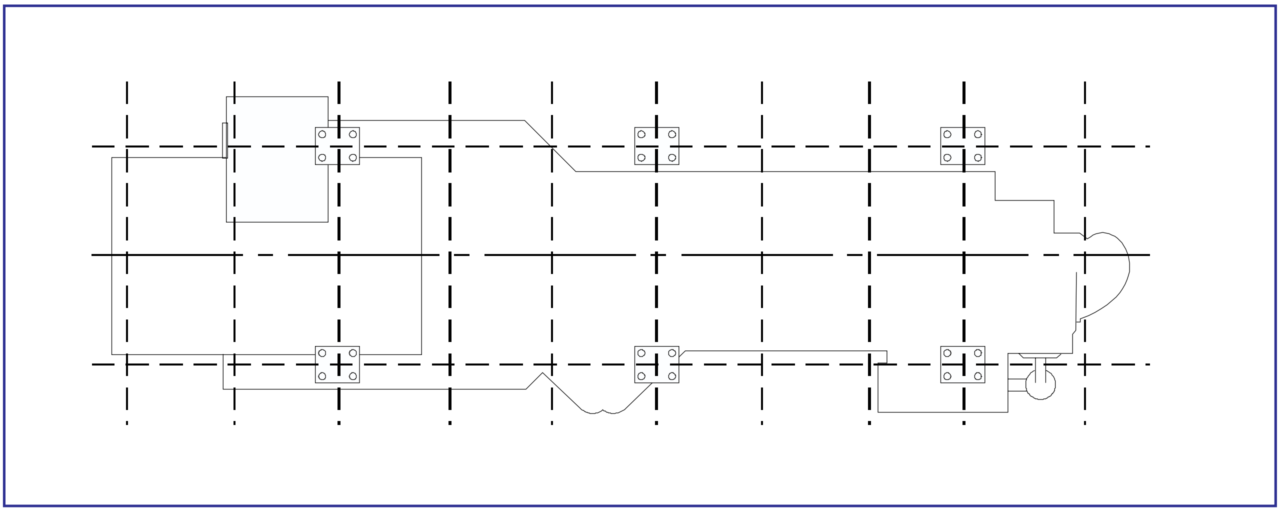


Fig 2 Resilient supports.

08028-0D/H5250/94.08.12

Resilient Mounting of Generating Sets

On resiliently mounted generating sets, the diesel engine and the alternator are placed on a common rigid base frame mounted on the ship's/machine house's foundation by means of resilient supports, Conical type.

All connections from the generating set to the external systems should be equipped with flexible connections and pipes. Gangway etc. must not be welded to the external part of the installation.

Resilient Support

A resilient mounting of the generating set is made with a number of conical mountings. The number and the distance between them depend on the size of the plant. These conical mountings are bolted to the top flange of the base frame *(see fig 1).*

The setting from unloaded to loaded condition is normally between 5-11 mm for the conical mounting.

The support of the individual conical mounting can be made in one of the following three ways:

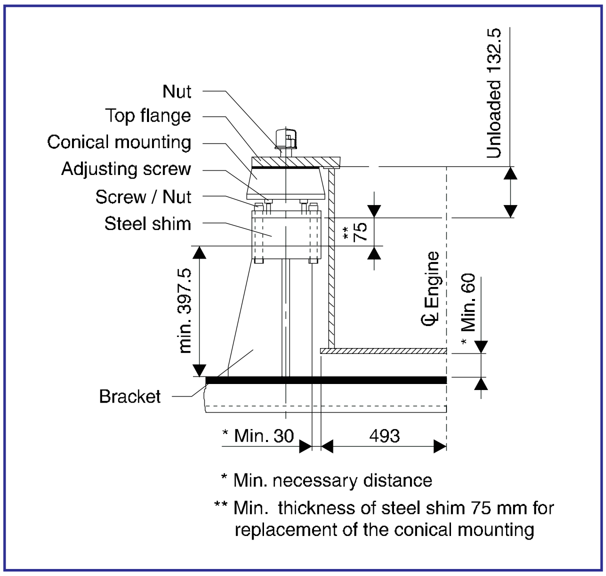


Fig 1 Resilient mounting of generating sets.

1) The support between the bottom flange of the conical mounting and the foundation is made with a loose steel shim. This steel shim is adjusted to an exact measurement (min. 75 mm) for each conical mounting.

2) The support can also be made by means of two steel shims, at the top a loose steel shim of at least 75 mm and below a steel shim of at least 10 mm which are adjusted for each conical mounting and then welded to the foundation.

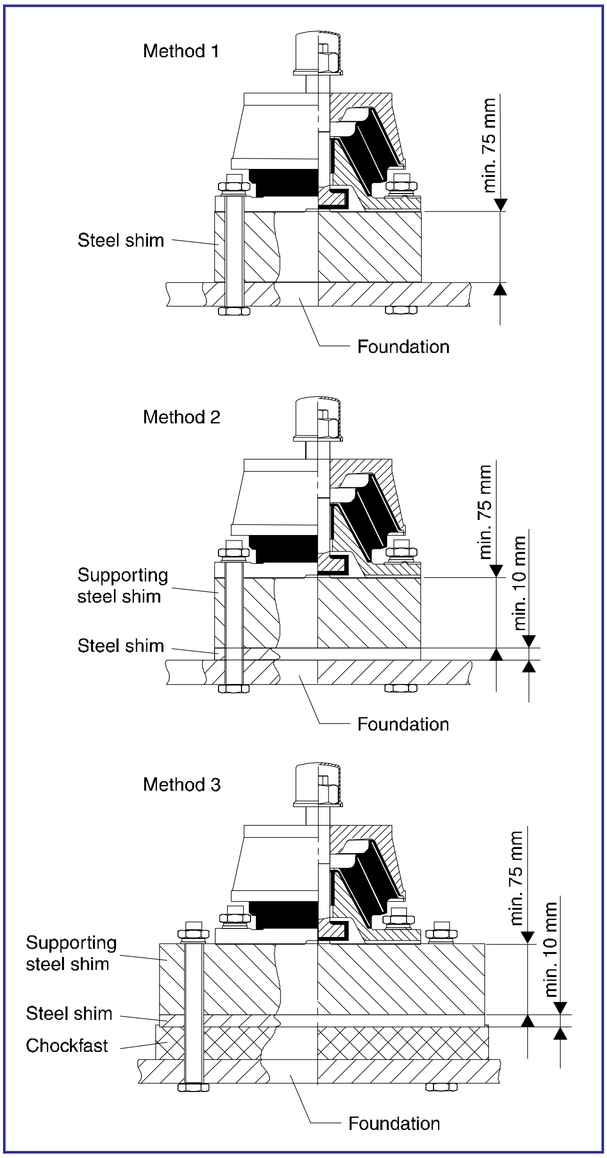


Fig 2 Support of conicals.

08028-0D/H5250/94.08.12

3) Finally, the support can be made by means of chockfast. It is necessary to use two steel shims, the top steel shim should be loose and have a minimum thickness of 75 mm and the bottom steel shim should be cast in chockfast with a thickness of at least 10 mm.

Irrespective of the method of support, the 75 mm steel shim is necessary to facilitate a possible future replacement of the conical mountings, which are always replaced in pairs.

Adjustment of Engine and Alternator on Base Frame

The resiliently mounted generating set is normally delivered from the factory with engine and alternator mounted on the common base frame. Eventhough the engine and alternator have been adjusted by the factory with the alternator rotor placed correctly in the stator and the crankshaft bend of the engine is within the prescribed tolerances.

Test running

B 21

General

1) Warming up of GenSets.

2) Load test in hours: (at 750 / 1000 rpm for 50 Hz or 720 / 900 / 1200 rpm for 60 Hz)

Load (%)	25	50	75	100	110
American Bureau of Shipping	1	1	1	1	1
Bureau Veritas	1	1	1	1	1
Chinese Corp. Register of Shipping	1	1	1	1	1
Det Norske Veritas	1	1	1	1	1
Germanischer Lloyd	1	1	1	1	1
Lloyd's Register of Shipping	1	1	1	1	1
Registro Italiano Navale	1	1	1	1	1
USSR Register of Shipping	3/4	3/4	3/4	4	3/4
Register of Shipping of Peoples Republic of China	1	3/4	3/4	2	3/4
Nippon Kaiji Kyokai	3/4	3/4	3/4	2	3/4

3) Governor test: Measurement of momentaneous speed variation
Measurement of permanent speed variation,

from	100 %	load to	0%	load
–	0 %	– –	50%	–
–	50 %	– –	100%	–

4) Overspeed test.

5) Parallel running of GenSets.

6) Test of remote start/stop and emergency functions.

7) Test of alarm functions according to the actual list for the specific plant.

8) Crankshaft deflection with warm engine (not 16/24).

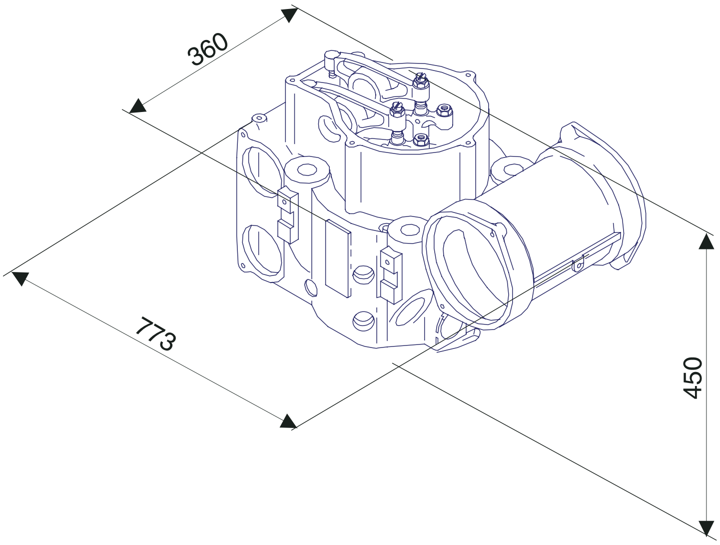
9) General inspection.

10) Inspection of lub. oil filter cartridges of each engine.

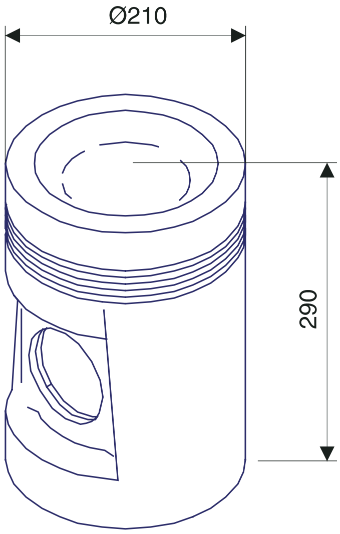
Spare Parts

E 23

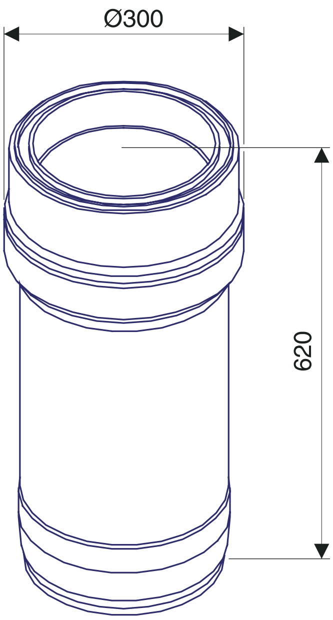
L21/31



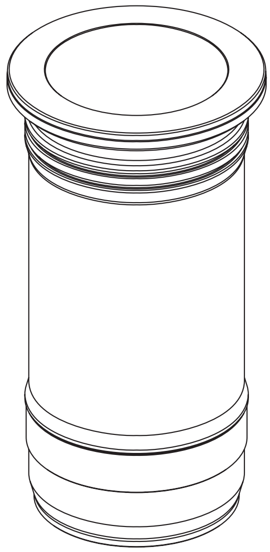
Cylinder head incl. rocker arms approx. 225 kg



Piston approx. 40 kg



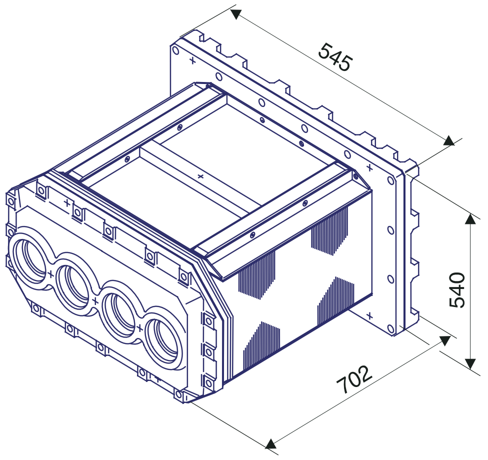
Cylinder liner approx. 80 kg
only for 5 cyl.



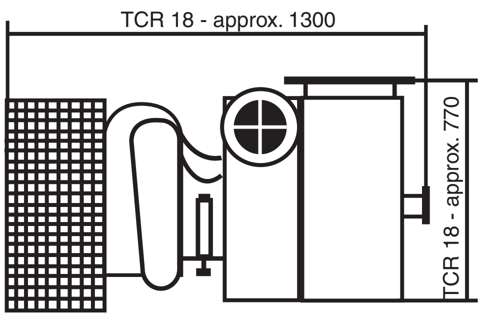
Cylinder liner
only for 6-7-8-9 cyl.

08028-0D/H5250/94.08.12

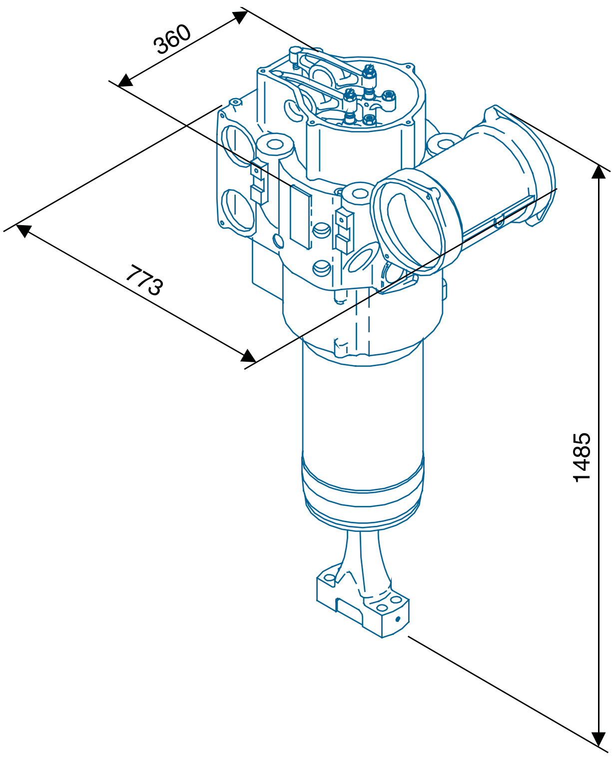
L21/31



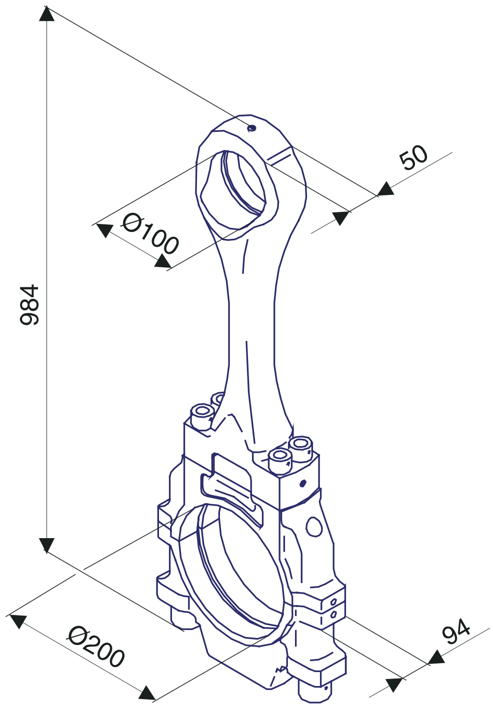
Charge air cooler approx. 267 kg



Turbocharger - TCR16 approx. kg
Turbocharger - TCR18 approx. 440 kg



Cylinder unit approx. 485 kg



Connecting rod approx. 62 kg

08028-0D/H5250/94.08.12

Recommended Wearing Parts

L21/31

08028-0D/H5250/94.08.12

L21/31 Consumption for one engine excl. cylinder unit	0-4000 hours	0-8000 hours	0-12000 hours	0-16000 hours	0-20000 hour	0-24000 hour	0-28000 hour	0-32000 hour
Number of cylinder	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**
Inlet and exhaust valves, inc. valve guide and valve seats. cyl. sets	none	none	none	none	none	5 6 7 8 9	5 6 7 8 9	5 6 7 8 9
O-ring, sleeve for fuel injection valve cyl. sets	none	none	none	5 6 7 8 9	5 6 7 8 9	5 6 7 8 9	10 12 14 16 18	10 12 14 16 18
O-rings for mounting of cyl.units. cyl. sets	none	none	none	5 6 7 8 9	5 6 7 8 9	5 6 7 8 9	10 12 14 16 18	10 12 14 16 18
O-rings for injection valve mounting. cyl. sets	10 12 14 16 18	20 24 28 32 36	30 36 42 48 54	40 48 56 64 72	50 60 70 80 90	60 72 84 96 108	70 84 96 112 126	80 96 112 128 144
Injection nozzle cyl. sets	none	5 6 7 8 9	5 6 7 8 9	10 12 14 16 18	10 12 14 16 18	15 18 21 24 27	15 18 21 24 27	20 24 28 32 36
O-rings for air cooler sets	none	none	none	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	2 2 2 2 2
O-ring for camshaft gear wheel inspection. sets	none	none	none	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	2 2 2 2 2
Lub.oil filter cartridges. sets	2 2 2 2 2	4 4 4 4 4	6 6 6 6 6	8 8 8 8 8	10 10 10 10 10	12 12 12 12 12	14 14 14 14 14	16 16 16 16 16
O-rings for lub. oil filter cartridge sets	none	none	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	2 2 2 2 2	2 2 2 2 2	2 2 2 2 2
O-ring for cyl.head top shield. cyl.sets	2 2 3 3 3	4 4 5 6 6	6 7 8 10 10	8 10 11 13 14	10 12 14 16 18	12 14 17 19 21	14 17 20 22 24	16 19 22 26 30
O-ring for relief valve, crankcase doors. sets	none	none	none	2 2 2 2 2	2 2 2 2 2	2 2 2 2 2	2 2 2 2 2	4 4 4 4 4
Plunger/barrel for injection pump sets	none	none	none	none	none	none	none	5 6 7 8 9
Turbine nozzle ring for TC	none	none	none	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	2 2 2 2 2
Kits for water pumps L.T. + H.T. sets	none	none	none	2 2 2 2 2	2 2 2 2 2	2 2 2 2 2	2 2 2 2 2	4 4 4 4 4
Kits for lubricating oil pump sets	none	none	none	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	2 2 2 2 2
Kits for prelubricating oil pump sets	none	none	none	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	1 1 1 1 1	2 2 2 2 2
Kits for turbine and main starting valve sets	observation	observation	observation	observation	observation	observation	observation	observation
Consumption for cylinder unit	**0-4000 hours**	**0-8000 hours**	**0-12000 hours**	**0-16000 hours**	**0-20000 hours**	**0-24000 hours**	**0-28000 hours**	**0-32000 hours**
Number of cylinder	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**	**5 6 7 8 9**
O-rings for cylinder head mountingcyl. sets	none	none	none	5 6 7 8 9	5 6 7 8 9	5 6 7 8 9	5 6 7 8 9	10 12 14 16 18
Piston, scraper rings, flame rings and sealing rings cyl. sets	none	none	none	5 6 7 8 9	5 6 7 8 9	5 6 7 8 9	5 6 7 8 9	10 12 14 16 18
Big-end bearings sets	none	none	none	none	none	none	none	5 6 7 8 9

Extent according to the requirements of *(Marine engines only)*:

For guidance
American Bureau of Shipping.
Bureau Veritas.
Lloyd's Register of Shipping.
Det Norske Veritas.

Demands
Germanischer Lloyd.
USSR Register of Shipping.
Chinese Register.
Nippon Kaiji Kyokai
Korean Register of Shipping
Registro Italiano Navale

Description	Qty.	Plate	Item
Cylinder Head			
Valve spindle, inlet	2	50502	274
Valve spindle, exhaust	2	50502	274
Spring	4	50502	201
Valve seat ring, inlet	2	50501	123
Valve seat ring, exhaust	2	50502	184
Valve rotators	4	50502	191
Kit for cylinder unit consisting of following items	1	50500	021
O-ring		50501	064
O-ring		50501	135
O-ring		50501	172
O-ring		50501	196
O-ring		50501	231
O-ring		50501	243
O-ring		50501	363
Circlip		50502	095
Conical ring 2/2		50502	178
O-ring		50502	237
O-ring		50502	250
O-ring		50502	536
O-ring		50510	014
Piston ring		50601	093
Piston ring		50601	103
Oil scraper ring		50601	127
Sealing ring		50610	031
O-ring		50610	055
O-ring		51230	027
O-ring		51402	033
O-ring		51402	104
O-ring		51404	022
O-ring		51404	046
Seal ring		51630	033

L21/31

Description	Qty.	Plate	Item
Piston and Connecting Rod, Cylinder Liner			
Screw for connecting rod	2	50601	152
Screw for connecting rod	4	50601	211
Bush for connecting rod	1	50601	056
Piston pin	1	50601	019
Retaining ring	2	50601	032
Connecting rod bearing 2/2	1	50601	139
Engine Frame and Base Frame			
Main bearing shells	1	51101	241
Stud	2	51101	216
Nut	2	51101	228
Turbocharger System			
Gasket	1	51202	024
Fuel Oil System and Injection Equipment			
Fuel oil injector	*	51402	116
Fuel oil injection pump	1	51401	565
Fuel oil high-pressure pipe in cylinder head			
- Pressure pipe, complete	1	51404	117
- Delivery socket, complete	1	51404	129

* No of spare parts = $\frac{C}{2}$ (add up to equal number)

C = Number of cylinders for engine with **max. cyl.** no in plant.

ex. A plant consists of 2x5L21/31 and 2x**7**L21/31.

Then the number of spare parts must be $\frac{\mathbf{7}}{2}$ = 3.5

Plate No. and Item No. refer to the spare parts plates in the instruction book.

08028-0D/H5250/94.08.12

Tools

P 24

Description	Qty.	Plate	Item
Cylinder head			
Valve spring tightening device	1	52000	014
Lifting tool for cylinder unit	1	52000	038
Grinding tool for cylinder head/liner	1	52000	087
Max. pressure indicator	1	52000	134
Handle for indicator valve	1	52000	146
Piston, connecting rod and cylinder liner			
Removing device for flame ring	1	52000	021
Guide bush for piston	1	52000	045
Fit and removal device for connecting rod bearing	1	52000	069
Lifting device for cylinder liner	1	52000	082
Lifting device for piston and connecting rod	1	52000	104
Testing mandrel for piston ring grooves, 6.43 mm	1	52000	153
Testing mandrel for piston ring grooves, 5.43 mm	1	52000	165
Piston ring opener	1	52000	190
Supporting device for connecting rod and piston in the cylinder liner (2 pieces), incl. fork	1	52000	212
Fork		52000	221
Honing brush	1	52000	224
Operating gear for inlet and exhaust valves			
Feeler gauge	1	52000	010
Crankshaft and main bearings			
Dismantling tool for main bearing upper shell	1	52000	035
Tool for fixing of marine head for counterweight	1	52000	060
Turbocharger System			
Eye screw for lifting	1	52000	036
Container complete for water washing of compressor side	1	51205	318
Blowgun for dry cleaning of turbocharger	1	51210	136
Fuel oil system and injection equipment			
Cleaning tool for fuel injector	1	52000	013
Extractor device for injector valve	1	52000	407
Grinding device for nozzle seat, incl. plier for piston pin lock ring	1	52000	074
Plier for piston pin lock ring		52000	177
Pressure testing tool	1	52000	050
Lubricating oil system			
Fitting device for lube. oil cooler	1	52000	044
Eye screw for lifting	1	52000	032

P 24 01 1	Standard Tools for Normal Maintenance	1683314-1.1 Page 2 (2)

L21/31

Description	Qty.	Plate	Item
Hydraulic tools			
Hydraulic tools box 1, incl. pressure pump	1	52000	633
consisting of:			
Pressure pump complete		52000	011
Hose with unions		52000	202
Force-off device		52000	424
Storage tank		52000	520
Set of spare parts		52000	532
Hydraulic tools box 2	1	52000	544
consisting of:			
Hydraulic tightening cylinder M33 x 2		52000	275
Pressure part M33 x 2		52000	371
Set of spare parts		52000	238
Hydraulictightening cylinder M30 x 2		52000	287
Pressure part, short M22 x 2		52000	383
Pressure part, long M22 x 2		52000	096
Tension screw M22 x 2		52000	131
Set of spare parts		52000	251
Turn pin		52000	556
Turn pin		52000	568
Turn pin		52000	334
Angle piece		52000	358
Measuring device		52000	448
Hydraulic tools box 3	1	52000	581
consisting of:			
Hydraulic tightening cylinder M30 x 2		52000	263
Pressure part, short M30 x 2		52000	072
Pressure part, long M30 x 2		52000	059
Tension screw		52000	118
Set of spare part		52000	226
Turn pin		52000	593
Turn pin		52000	603
Turn pin		52000	334
Resetting device for hydraulic cylinder	1	52000	436
Broad chissel	1	52000	473
Broad chissel	1	52000	485

08028-0D/H5250/94.08.12

L21/31

Description	Qty.	Plate	Item
Fit and removal device for main bearing cap	1	52001	036
Fit and removing device for connecting rod bearing	1	52001	073
Turning device for cylinder unit	1	52001	107
Grinding machine for valve seat rings	1	52001	119
Fit and removing device for valve guides	1	52001	120
Touching bow for inlet valve	1	52001	132
Fitting device for valve seat rings	1	52001	156
Plate (used with item 181)	1	52001	168
Extractor for valve seat rings	1	52001	181
Fit and removing device for fuel injection pump	1	52001	203
Setting device for fuel injection pump	1	52001	215
Fit and removing device for cooler insert	1	52001	239
Micrometer screw	1	52001	252

08028-0D/H5250/94.08.12

B 25 Preservation and Packing

B 98

Preservation of diesel engine before dispatch

Preservation of Diesel Engine:

1) Lubricating oil system.

Lub. oil is drained from base frame, lub. oil filter and cooler.

After cleaning of the engine and the base frame, a rust-preventing lubricating oil is added, and the entire lub. oil system is primed.

The oil is just covering the bottom of the base frame.

The following types of oils are suitable:

Mobilarma 524.

Esso Rustban 335.

Chevron EP Industrial Oil 68.

Shells Ensis Oil SAE 30 / SAE 10 W.

BP Protective Oil 30/40.

2) Fuel oil system.

The fuel oil is drained. The fuel valves are cleaned and pressure tested with Mobil White-Terex 309 or similar, and the entire fuel oil system is filled with this type of oil.

3) Bright components internal or external on the diesel engine such as crankshaft, camshaft and gear wheels are covered with Mobilux EP004.

4) Bags with a hygroscopic product are suspended inside the diesel engine in the crankcase. The bags are equipped with a humidity indicator.

SilicaGel or a similar product can be used in a quantity of 3000 grams/m^3.

The bags must not touch any surfaces, and if necessary the surface is covered with a plastic sheet.

5) All external surfaces are sprayed with a protective layer of Valvoline tectyl 511M.

6) All openings and flange connections are carefully closed.

7) Electric boxes are protected inside by volatile corrosion inhibitor tape.

General

Spare parts and tools.

Preservation of supplied spare parts and tools are made as follows:

Dinitrol 25B or Dinitrol 3850

special tools in boxes are protected by a volatile corrosion inhibitor tape

Storage conditions

The boxes must **always** be stored under roof, protected from direct rain, sea-fog and dust. The boxes must be covered with tarpaulin.

Maintenance of preservation

Immediately upon arrival the boxes are to be opened and the parts examined for damage to the preservation, and if necessary repaired.

This procedure must be repeated every 2-4 months depending on the storage conditions.

Smaller boxes containing special tools such as:

grinding machine for valve seats

indicator

test equipment for fuel valves

measuring equipment

etc.

must be removed from the shipment, inspected for corrosion and stored in a dry place.

After inspection the boxes with the spare parts must be closed and covered with tarpaulin.

Cleaning of parts can be made with petroleum, turpentine or similar solvents.

Notice:Special preservation can be made on request.

08028-0D/H5250/94.08.12

Removal of preservation before starting of a new engine

General

Starting of a New Engine

1) Clean the outside of the engine, Valvoline tectyl 511M, can be removed with hot water.

2) Remove the hygroscopic bags from the interior of the engine.

The bags are placed in the crankcase.

3) Fill the lub. oil system with oil according to our specification.

The rust-preventing oil does not need draining, it is fully mixable with the lub. oil.

4) The fuel oil system does not need draining as the engine can be started on diesel oil, mixed with the preservation oil.

5) The internal and external protection with grease Mobilux EP004 does not need cleaning before starting, it is fully mixable with the

Lifting of Complete Generating Sets.

The generating sets should only be lifted in the two wire straps. Normally, the lifting tools and the wire straps are mounted by the factory. If not, it must be observed that the fixing points for the lifting tools are placed differently depending on the number of cylinders.

The lifting tools are to be removed after the installation, and the protective caps should be fitted.

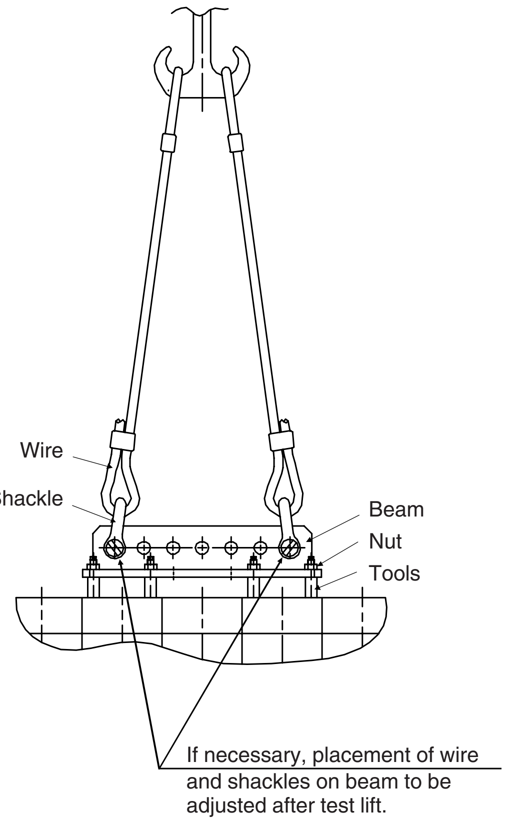
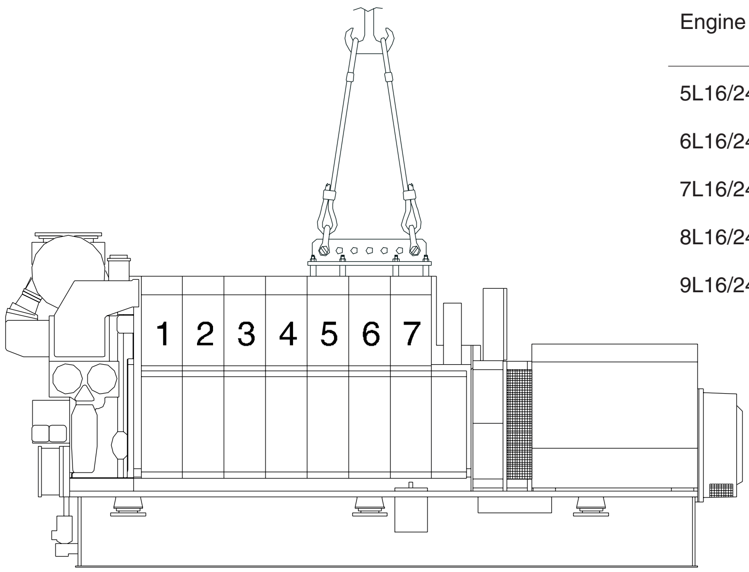


Fig. 1. Lifting tools



Engine Type	2x4 bolt to be mounted over cover of Cyl. no.	
5L16/24, 5L21/31	3 cyl.	5 cyl.
6L16/24, 6L21/31	4 cyl.	6 cyl.
7L16/24, 7L21/31	5 cyl.	7 cyl.
8L16/24, 8L21/31	5 cyl.	7 cyl.
9L16/24, 9L21/31	6 cyl.	8 cyl.

Note: Based on MBD-H standard generator

Fig. 2. Lifting tools' and wires placing on engine.

Variant

V 00

General

The overhaul intervals are based on operation on a specified fuel oil quality at normal service output, which means 70-100% of MCR.

In the long run it is not possible to achieve safe and optimum economical running without an effective maintenance system.

The structure and amount of information in the maintenance programme mean that it can be integrated in the entire ship's/power station's maintenance system or it can be used separately.

The core of the maintenance system is the key diagram, indicating the inspection intervals for the components/systems, so that the crew can make the necessary overhauls based on the engines' condition and/or the time criteria.

The maintenance system is divided into 2 main groups:

a. Major overhaul / inspection: These works are to be carried out during major overhauls and inspections of the engine.

b. Duty during operation: indicated the works to be carried out by the personnel during the daily operation of the engine.

The stated recommended intervals are only for guidance as different service conditions, the quality of the fuel oil and the lubricating oil, treatment of the cooling water, etc., will decisively influence the actual service results and thus the intervals between necessary overhauls.

Experience with the specific plant/personnel should be used to adjust the time between overhauls. It should also be used to adjust the timetable stated for guidance in the working cards.

Working Cards

Each of the working cards can be divided into two: a front page and one or several pages describing and illustrating the maintenance work (instruction book).

The front page indicates the following:

1) Safety regulations, which MUST be carried out before the maintenance work can start.

2) A brief description of the work.

3) Reference to any work which must be carried out before the maintenance work can start.

4) Related procedures - indicates other works, depending on the present work - or works which it would be expedient to carry out.

5) Indicates x number of men in x number of hours to accomplish the work.

The stated consumption of hours is only intended as a guide.

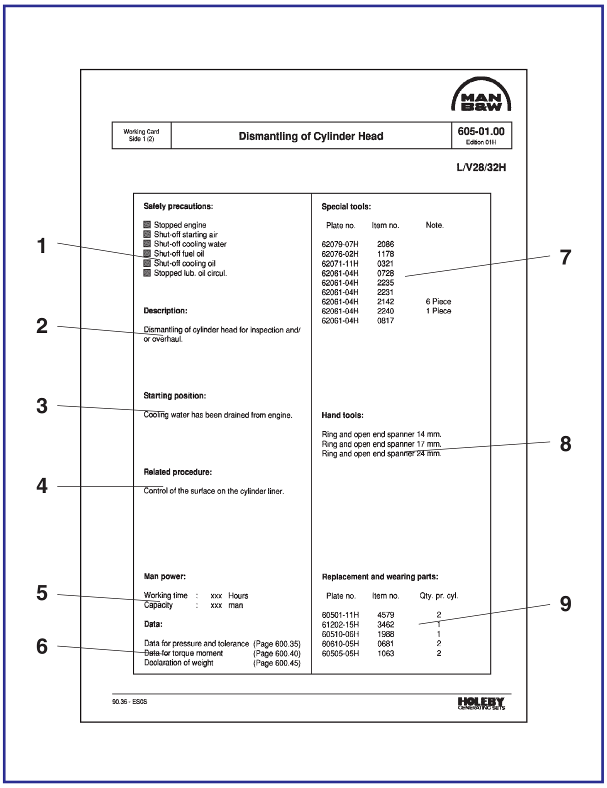


Fig. 1 Instruction guide for working cards.

L21/31

Experience with the specific station/personnel may lead to updating.

6) Refers to data required to carry out the work.

7) Special tools which must be used. Please note that not all tools are standard equipment.

8) Various requisite hand tools.

9) Indicates the components/parts which it is advisible to replace during the maintenance work. Please note that this is a condition for the intervals stated.

L21/31

Major overhaul/inspection

● = Overhaul to be carried out
■ = Check the condition

Description	Check new/ overhauled parts after - hours	50	200	2000	10000	20000	40000	Daily	Weekly	Monthly	3rd month	Observations	Working Card No
		Time Between Overhauls											
Cylinder Unit:													
Dismantling of cylinder unit .... Dismantling of cylinder head, water jacket and cyl. liner.						●							505-01.55
Cylinder Head and Water Jacket													
Inspection of inlet, exhaust valves and valve guide						●							505-01.05
Valve rotator						■							505-01.15
Safety valve - overhaul and adjustment of opening pressure						■							505-01.25
Indicator valve						■							505-01.26
Cylinder head cooling water space - Inspection						■							505-01.45
Cylinder head nut - Retightening	200												505-01.40
Piston, Connecting Rod and Cylinder Liner													
Inspection of piston						■							506-01.10
Piston ring and scraper ring						●							506-01.10
Piston pin and bush for connecting rod - Check of clearance						■							506-01.15
Connecting rod - Measuring of big-end bore						■							506-01.15
Inspection of big-end bearing shells						■							506-01.16
Connecting rod - Retightening	200				■								506-01.25
Cylinder liner - Cleaning, honing and measuring						●							506-01.35
Camshaft and Camshaft Drive													
Camshaft - Inspection of gear wheels, bolt, connections etc.	200					■							507-01.00
Camshaft bearing - Inspection of clearance						■							507-01.05
Camshaft adjustment - check the condition						■							507-01.20
Lubrication of camshaft bearing - Check						■							507-01.00

L21/31

Major overhaul/inspection

● = Overhaul to be carried out
■ = Check the condition

Description	Check new/ overhauled parts after - hours	50	200	2000	10000	20000	40000	Daily	Weekly	Monthly	3rd month	Observations	Working Card No
Operating Gear for Inlet Valves and Exhaust Valves													
Roller guide for valve gear						■							508-01.00
Valve gear - Valve bridge, spring, push rod, etc						■							508-01.10
Lubricating of operating gear - Check						■							508-01.00
Crankshaft and Main Bearing													
Inspection of main bearing							■						510-01.05
Inspection of guide bearing							■						510-01.05
Vibration viscodamper, see working card													510-04.00
Counterweight - Retightening, see page 500.40	200				■								
Main and guide bearing cap - Retightening	200				■								510-01.05
Engine Frame and Base Frame													
Bolts between engine frame and base frame - Retightening, see page 500.40	200				■								
Turbocharger System													
Charging air cooler - Cleaning and inspection												■	512-01.00
Retightening of all bolts and connections	200				■								512-30.00
For turbocharger, see special instruction book													
Compressed Air System													
Air starter motor - Dismantling and inspection												■	513-01.30

08028-0D/H5250/94.08.12

L21/31

Major overhaul/inspection

● = Overhaul to be carried out
■ = Check the condition

Description	Check new/ overhauled parts after - hours	Time Between Overhauls 50	200	2000	10000	20000	40000	Daily	Weekly	Monthly	3rd month	Observations	Working Card No
Fuel Oil System and Injection Equipment													
Fuel oil injection pump - Check of condition												●	514-01.06
Fuel injection valve - Adjustment of opening pressure				■									514-01.10
Lubricating Oil System													
Lubricating oil pump - Engine driven						■							515-01.00
Lubricating oil cooler												●	515-06.00
Prelubricating pump - El. driven						■							515-01.05
Thermostatic valve												■	515-01.20
Cooling Water System													
Cooling water pump - Engine driven (HT / LT water)						■							
Thermostatic valve												■	516-04.00

Alternator - see special instruction book

Planned maintenance programme during operation, see 500.26.

08028-0D/H5250/94.08.12

L21/31

Remarks:

Duties during Operation

● = Overhaul to be carried out
■ = Check the condition

Description	Check new/ overhauled parts after - hours	50	200	2000	10000	20000	40000	Daily	Weekly	Monthly	3rd month	Observations	Working Card No
		Time Between Overhauls											
Operating of Engine													
Readings of data for Engine and Generator, with reference to "Engine Performance Data", section 502-1									■				502-01.00
Check for leakages		■											502-05.00
Specification - Cooling water													
Cooling water system - Water samples, see section 504									■				505-01.15
Cylinder Head													
Inlet and exhaust valve - check and adjustment of valve clearance				■									
Lubricating of operating gear - Check						■							
Check of valve rotators' rotation during engine rotation .				■									505-01.15
Control and Safety System, Automatics and Instruments													
Safety, alarm and monitoring equipment											■		509-01.00
Lambda controller - Adjustment											■		509-10.00
Governor - Check oil level, see governor instruction book, section 509											■		section 509
Turbocharger System													
Cleaning of air filter - Compressor side												●	512-35.00
Dry cleaning of turbine side			●										512-10.00
Water washing of compressor side			●										512-05.00
Exhaust pipe compensator...									■				512-01.10
Retightening of all bolts and connections.......................			■										512-30.00

08028-0D/H5250/94.08.12

L21/31

Duties during Operation

● = Overhaul to be carried out
■ = Check the condition

Description	Check new/ Overhauled parts after -hours	50	200	2000	10000	20000	40000	Daily	Weekly	Montly	3th month	Observations	Working Card No
Compressed Air System													
Function test - Main and emergency starting valve.........											■		513-01.40
Air filter, draining of bowl (filter element to be replaced when pressure drop exceeds 0,7 bar)								●					513-01.21
Compressed air system - Check of the system..............									■				513-01.90
Fuel Oil System and Injection Equipment													
Fuel oil system - Check the system................................									■				514-01.90
Fuel oil - Oil samples after every bunkering, see sec.504													section 504
Fuel injection valve - Adjustment of opening pressure				■									514-01.10
Lubricating Oil System													
Lubricating oil filter - Cleaning and replacement				●									515-01.10
Centrifugal filter - Cleaning and replacement paper filter			●										515-15.00
Lubricating oil - Oil samples											■		
Lubricating oil system - Check the system									■				515-01.90
Cooling Water System													
Cooling water system - Water samples									■				
Cooling water system - Check the system									■				516-01.90
Engine Frame and Bedplate													
Flexible mounting - Check anti-vibration mountings........				■									519-03.00
Safety cover - Function test..													
Alternator - see special instruction book													
Major overhaul/inspection, see 500.25													

08028-0D/H5250/94.08.12