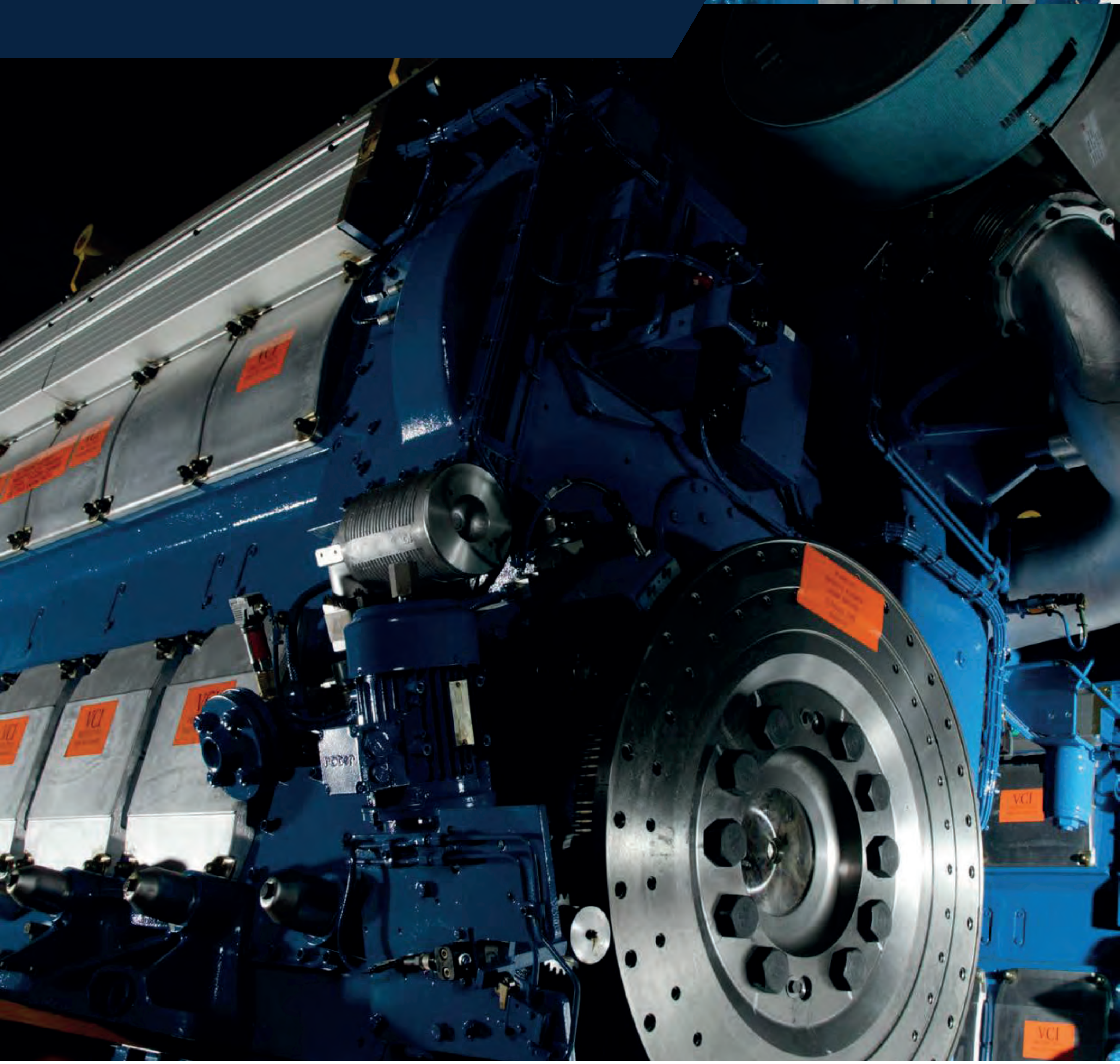
WÄRTSILÄ Engines

Wärtsilä 26

PRODUCT GUIDE



Introduction

This Product Guide provides data and system proposals for the early design phase of marine engine installations. For contracted projects specific instructions for planning the installation are always delivered. Any data and information herein is subject to revision without notice. This 1/2018 issue replaces all previous issues of the Wärtsilä 26 Project Guides.

Issue	Published	Updates
1/2018	19.09.2018	Technical data updated. Other updates throughout the Product Guide
1/2017	30.11.2017	Technical data updated. Other updates throughout the Product Guide.
2/2016	27.09.2016	Technical data updated
1/2016	07.09.2016	Technical data section updated
1/2015	18.06.2015	Updates throughout the product guide

Wärtsilä, Marine Solutions

Vaasa, September 2018

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1. Main Data and Outputs

The Wärtsilä 26 is a 4-stroke, non-reversible, turbocharged and intercooled diesel engine with direct fuel injection.

Cylinder bore	260 mm
Stroke	320 mm
Piston displacement	17,0 l/cyl
Number of valves	2 inlet valves and 2 exhaust valves
Cylinder configuration	6, 8 and 9 in-line; 12 and 16 in V-form
V angle	55°
Direction of rotation	clockwise, counter-clockwise on request
Speed	900, 1000 rpm
Mean piston speed	9.6, 10.7 m/s

1.1 Maximum continuous output

Table 1-1 Rating table for Wärtsilä 26

Cylinder configuration	Main engines		Generating sets			
	900 rpm	1000 rpm	900 rpm		1000 rpm	
	[kW]	[kW]	[KVA]	[kWe]	[KVA]	[kWe]
6L26	1950	2040	2352	1882	2461	1969
8L26	2600	2720	3136	2509	3281	2625
9L26	2925	3060	3528	2823	3691	2953
12V26	3900	4080	4704	3764	4922	3937
16V26	5200	5440	6273	5018	6562	5250

The generator outputs are calculated for an efficiency of 96.5% and a power factor of 0.8. The maximum fuel rack position is mechanically limited to 110% of the continuous output for engines driving generators.

The mean effective pressure p_e can be calculated as follows:

$$P_e = \frac{P \times c \times 1.2 \times 10^9}{D^2 \times L \times n \times \pi}$$

where:

P_e = mean effective pressure [bar]

P = output per cylinder [kW]

n = engine speed [rpm]

D = Cylinder diameter [mm]

L = length of piston stroke [mm]

c = operating cycle (4)

1.2 Reference conditions

The output is available up to an air temperature of max. 45°C. For higher temperatures, the output has to be reduced according to the formula stated in ISO 3046-1:2002 (E).

The specific fuel oil consumption is stated in the chapter *Technical data*. The stated specific fuel oil consumption applies to engines with engine driven pumps, operating in ambient conditions according to ISO 15550:2002 (E). The ISO standard reference conditions are:

total barometric pressure	100 kPa
air temperature	25 °C
relative humidity	30 %
charge air coolant temperature	25 °C

Correction factors for the fuel oil consumption in other ambient conditions are given in standard ISO 15550:2002 (E).

1.3 Operation in inclined position

Max. inclination angles at which the engine will operate satisfactorily.

- Permanent athwart ship inclinations 15.0°
- Temporary athwart ship inclinations 22.5°
- Permanent fore-and-after inclinations 5.0°
- Temporary fore-and-after inclinations 7.5°

Larger angles are possible with special arrangements.

1.4 Dimensions and weights

1.4.1 Main engines

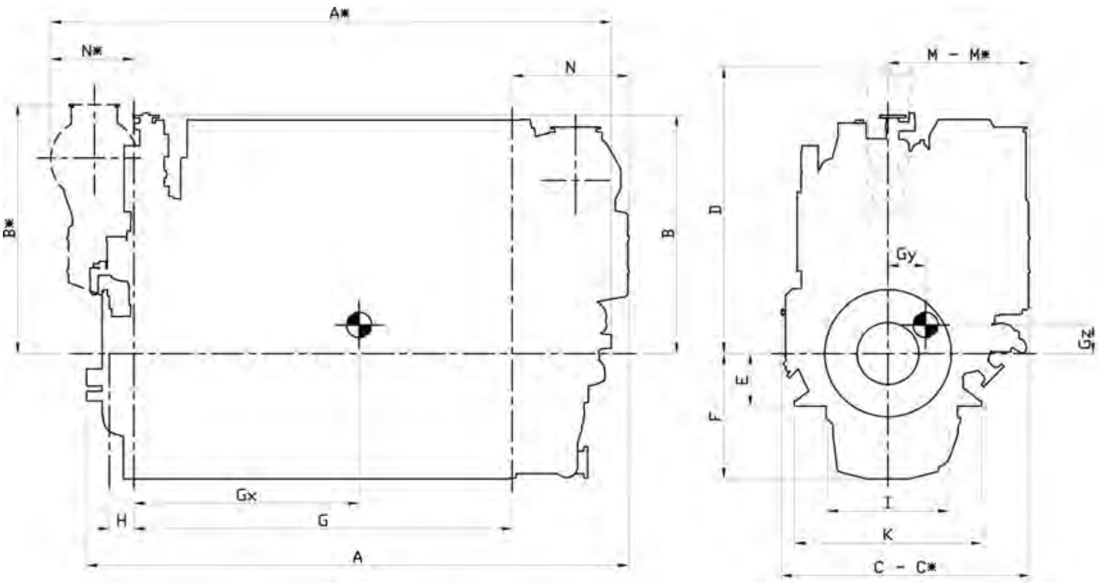

Fig 1-1 In-line engines (DAAE034755b)

Engine	A*	A	B*	B	C*	C	D	E	F_{wet}	F_{dry}	G
W 6L26	4387	4130	1882	1833	1960	2020	2430	400	950	818	2866
W 8L26	5302	5059	2023	1868	2010	2107	2430	400	950	818	3646
W 9L26	5691	5449	2023	1868	2016	2107	2430	400	950	818	4036

Engine	H	I	K	M*	M	N*	N	Weight	
								dry sump	wet sump
W 6L26	186	920	1420	1103	1171	669	904	17.0	17.2
W 8L26	186	920	1420	1167	1258	794	1054	21.6	21.9
W 9L26	186	920	1420	1167	1258	794	1054	23.3	23.6

Engine	Wet sump						Dry sump					
	Gx *	Gy *	Gz *	Gx	Gy	Gz	Gx *	Gy *	Gz *	Gx	Gy	Gz
W 6L26	1551	90	450	1300	90	450	1551	90	458	1300	90	458
W 8L26	2002	78	457	1704	78	457	2002	78	465	1704	78	465
W 9L26	2204	74	454	1921	74	454	2204	74	462	1921	74	462

* Turbocharger at flywheel end.

All dimensions in mm. Weight in metric tons with liquids (wet sump) but without flywheel.

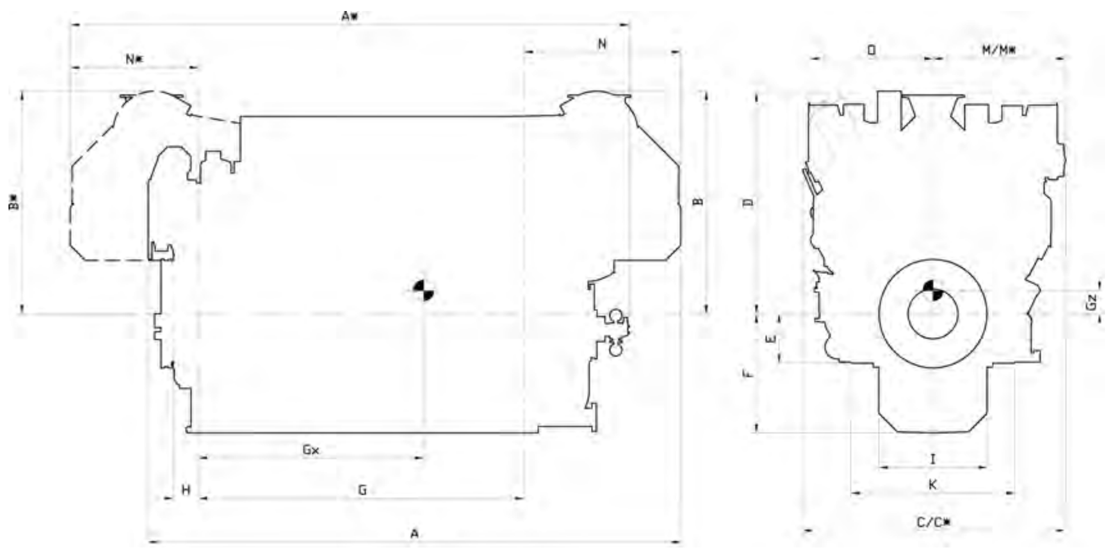

Fig 1-2 V-engines (DAAE034757b)

Engine	A*	A	B*	B	C*	C	D	E	F_{wet}	F_{dry}	G
W 12V26	5442	5314	2034	2034	2552	2602	2060	460	1110	800	3035
W 16V26	6223	6025	2151	2190	2489	2763	2060	460	1110	800	3875

Engine	H	I	K	M *	M	N *	N	O	Weight	
									dry sump	wet sump
W 12V26	235	1010	1530	1364	1238	1433	1698	1148	28.7	29.0
W 16V26	235	1010	1530	1248	1248	1363	1626	1160	36.1	37.9

Engine	Wet sump				Dry sump			
	Gx *	Gz *	Gx	Gz	Gx *	Gz *	Gx	Gz
W 12V26	1224	413	1811	413	1224	470	1811	470
W 16V26	1852	548	2258	548	1852	568	2258	568

* Turbocharger at flywheel end.

All dimensions in mm. Weight in metric tons with liquids (wet sump) but without flywheel.

1.4.2 Generating sets

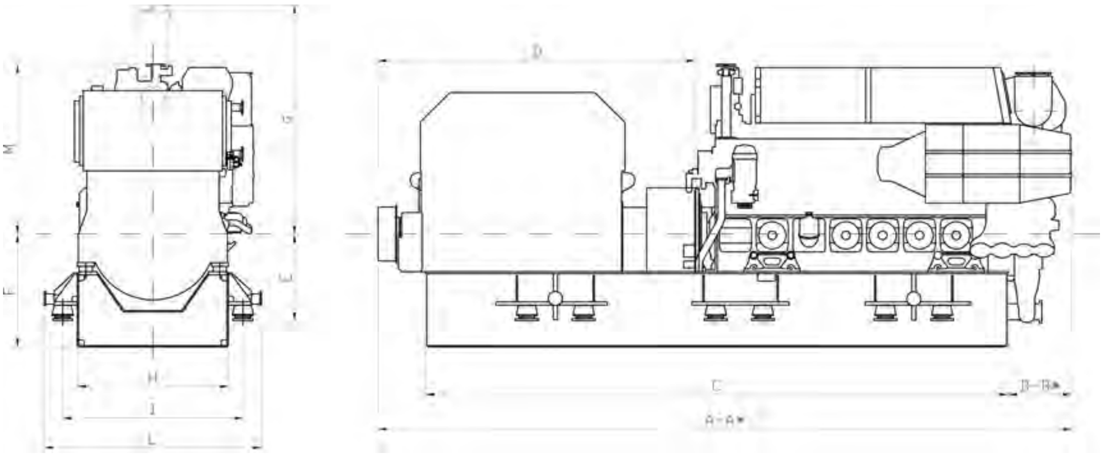

Fig 1-3 Generating sets (DAAE034758b)

Engine	A	A*	B	B*	C	D	E	F	G	H	I	L	M	Weight
W 6L26	7500	7500	835	702	6000	3200	921	1200	2430	1600	1910	2300	1833	35
W 8L26	8000	8000	835	702	7000	3300	921	1200	2430	1600	1910	2300	1868	45
W 9L26	8500	8500	835	702	7500	3400	921	1300	2430	1600	1910	2300	1868	50
W 12V26	8400	-	1263	-	6700	3600	981	1560	2765	2000	2310	2700	2126**	60
W 16V26	9700	-	1400	-	7730	4000	981	1560	2765	2000	2310	2700	2156**	70

* Turbocharger at flywheel end. ** TC inclination 30°

All dimensions in mm. Weight in metric tons with liquids (wet sump) but without flywheel.

NOTE

Generating set dimensions are for indication only, based on low voltage generators. Final generating set dimensions and weights depend on selection of generator and flexible coupling.

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2. Operating Ranges

2.1 Engine operating range

Running below nominal speed the load must be limited according to the diagrams in this chapter in order to maintain engine operating parameters within acceptable limits. Operation in the shaded area is permitted only temporarily during transients. Minimum speed is indicated in the diagram, but project specific limitations may apply.

2.1.1 Controllable pitch propellers

An automatic load control system is required to protect the engine from overload. The load control reduces the propeller pitch automatically, when a pre-programmed load versus speed curve (“engine limit curve”) is exceeded, overriding the combinator curve if necessary. The engine load is derived from fuel rack position and actual engine speed (not speed demand).

The propeller efficiency is highest at design pitch. It is common practice to dimension the propeller so that the specified ship speed is attained with design pitch, nominal engine speed and 85% output in the specified loading condition. The power demand from a possible shaft generator or PTO must be taken into account. The 15% margin is a provision for weather conditions and fouling of hull and propeller. An additional engine margin can be applied for most economical operation of the engine, or to have reserve power.

The propulsion control must also include automatic limitation of the load increase rate. Maximum loading rates can be found later in this chapter.

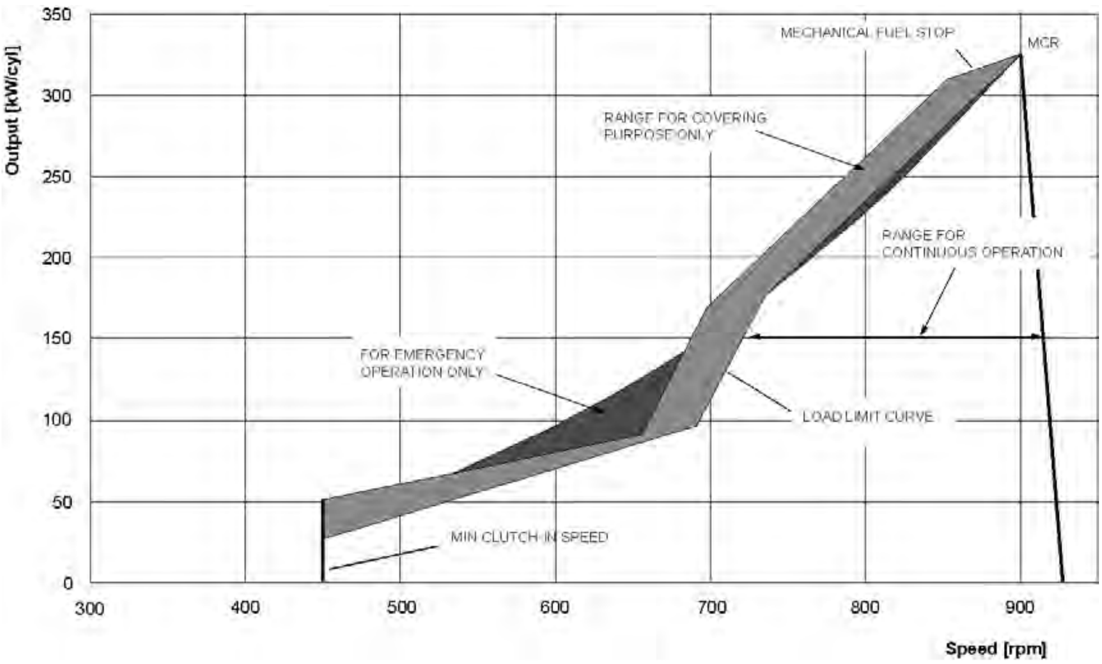


Fig 2-1 **Operating field for CP propeller 900rpm**

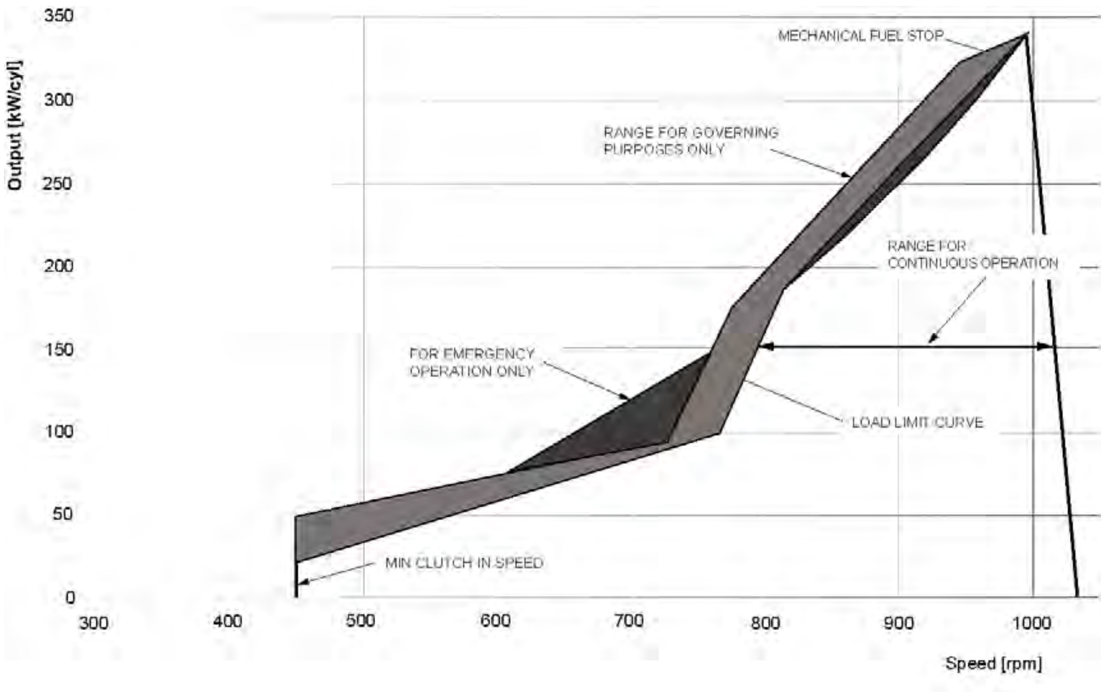


Fig 2-2 **Operating field for CP propeller 1000rpm**

2.1.2 Fixed pitch propellers

The thrust and power absorption of a given fixed pitch propeller is determined by the relation between ship speed and propeller revolution speed. The power absorption during acceleration, manoeuvring or towing is considerably higher than during free sailing for the same revolution speed. Increased ship resistance, for reason or another, reduces the ship speed, which increases the power absorption of the propeller over the whole operating range.

Loading conditions, weather conditions, ice conditions, fouling of hull, shallow water, and manoeuvring requirements must be carefully considered, when matching a fixed pitch propeller to the engine. The nominal propeller curve shown in the diagram must not be exceeded in service, except temporarily during acceleration and manoeuvring. A fixed pitch propeller for a free sailing ship is therefore dimensioned so that it absorbs max. 85% of the engine output at nominal engine speed during trial with loaded ship. Typically this corresponds to about 82% for the propeller itself.

If the vessel is intended for towing, the propeller is dimensioned to absorb 95% of the engine power at nominal engine speed in bollard pull or towing condition. It is allowed to increase the engine speed to 101.7% in order to reach 100% MCR during bollard pull.

A shaft brake should be used to enable faster reversing and shorter stopping distance (crash stop). The ship speed at which the propeller can be engaged in reverse direction is still limited by the windmilling torque of the propeller and the torque capability of the engine at low revolution speed.

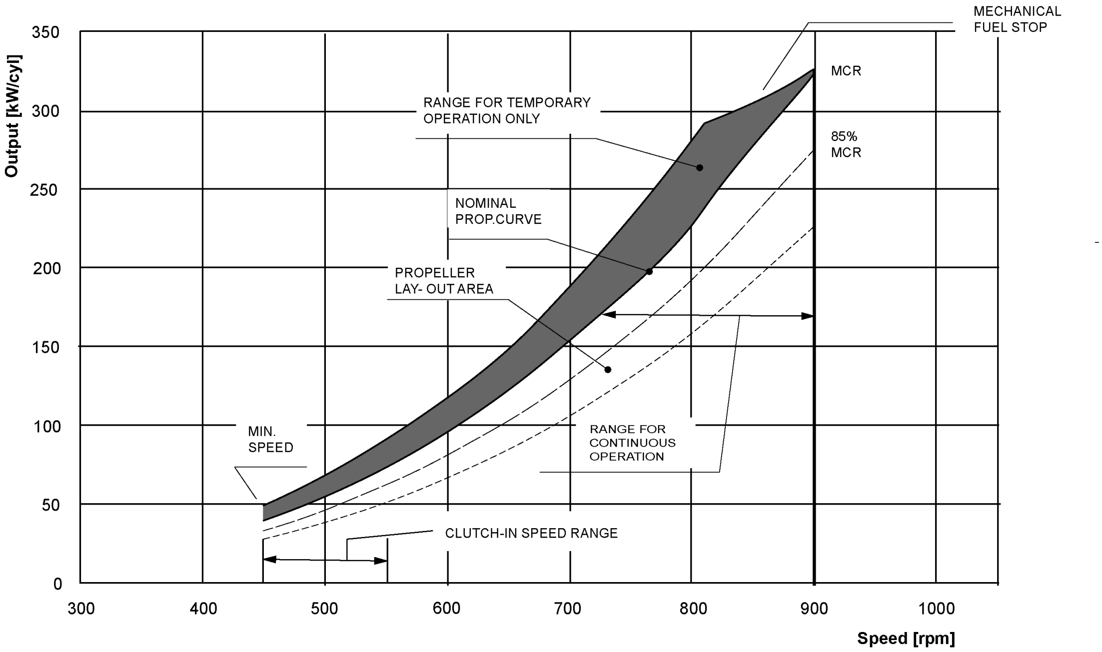


Fig 2-3 **Operating field for FP Propeller 900rpm**

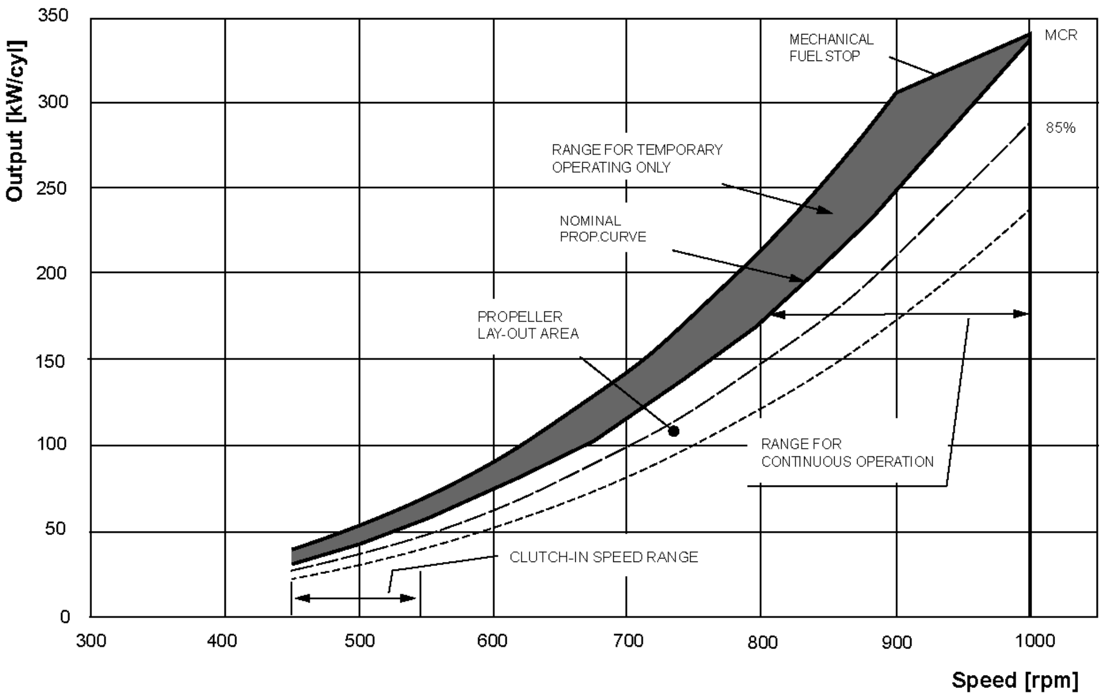


Fig 2-4 **Operating field for FP Propeller 1000rpm**

2.1.2.1 FP propellers in twin screw vessels

Requirements regarding manoeuvring response and acceleration, as well as overload with one engine out of operation must be very carefully evaluated if the vessel is designed for free sailing, in particular if open propellers are applied. If the bollard pull curve significantly exceeds the maximum overload limit, acceleration and manoeuvring response can be very slow. Nozzle propellers are less problematic in this respect.

2.1.3 Dredgers

Mechanically driven dredging pumps typically require a capability to operate with full torque down to 80% of nominal engine speed. This requirement results in significant de-rating of the engine.

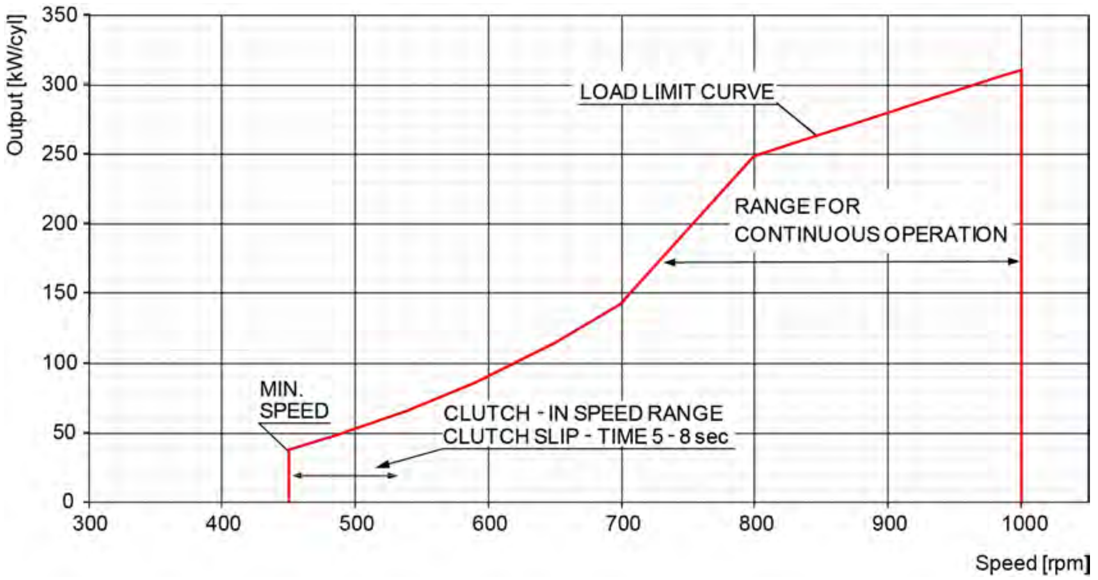


Fig 2-5 Operating field for Dredgers

2.2 Loading capacity

Controlled load increase is essential for highly supercharged diesel engines, because the turbocharger needs time to accelerate before it can deliver the required amount of air. A slower loading ramp than the maximum capability of the engine permits a more even temperature distribution in engine components during transients.

The engine can be loaded immediately after start, provided that the engine is pre-heated to a HT-water temperature of 60…70ºC, and the lubricating oil temperature is min. 40 ºC.

The ramp for normal loading applies to engines that have reached normal operating temperature.

2.2.1 Mechanical propulsion

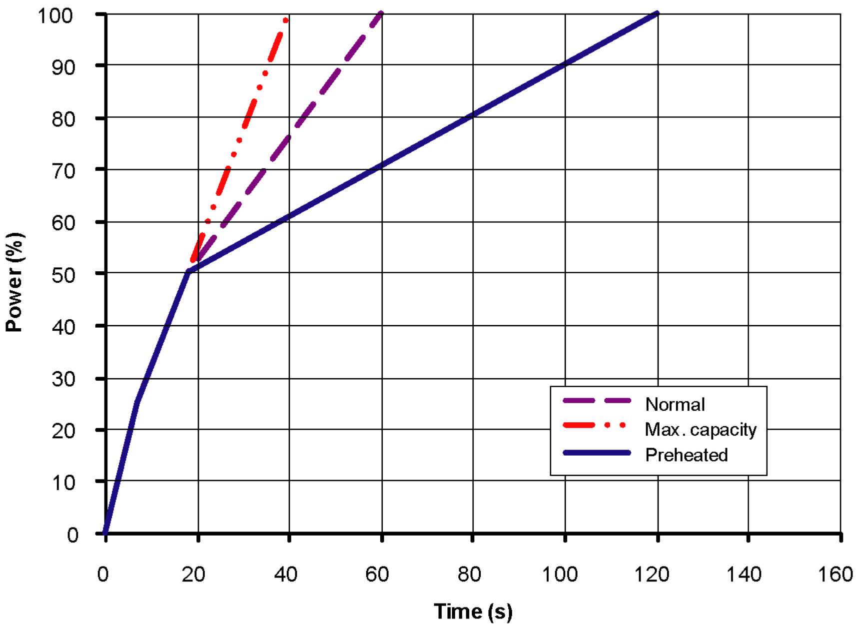


Fig 2-6 Maximum recommended load increase rates for variable speed engines

The propulsion control must include automatic limitation of the load increase rate. If the control system has only one load increase ramp, then the ramp for a preheated engine should be used. In tug applications the engines have usually reached normal operating temperature before the tug starts assisting. The “emergency” curve is close to the maximum capability of the engine.

If minimum smoke during load increase is a major priority, slower loading rate than in the diagram can be necessary below 50% load.

Large load reductions from high load should also be performed gradually. In normal operation the load should not be reduced from 100% to 0% in less than 15 seconds. When absolutely necessary, the load can be reduced as fast as the pitch setting system can react (overspeed due to windmilling must be considered for high speed ships).

2.2.2 Diesel electric propulsion and auxiliary engines

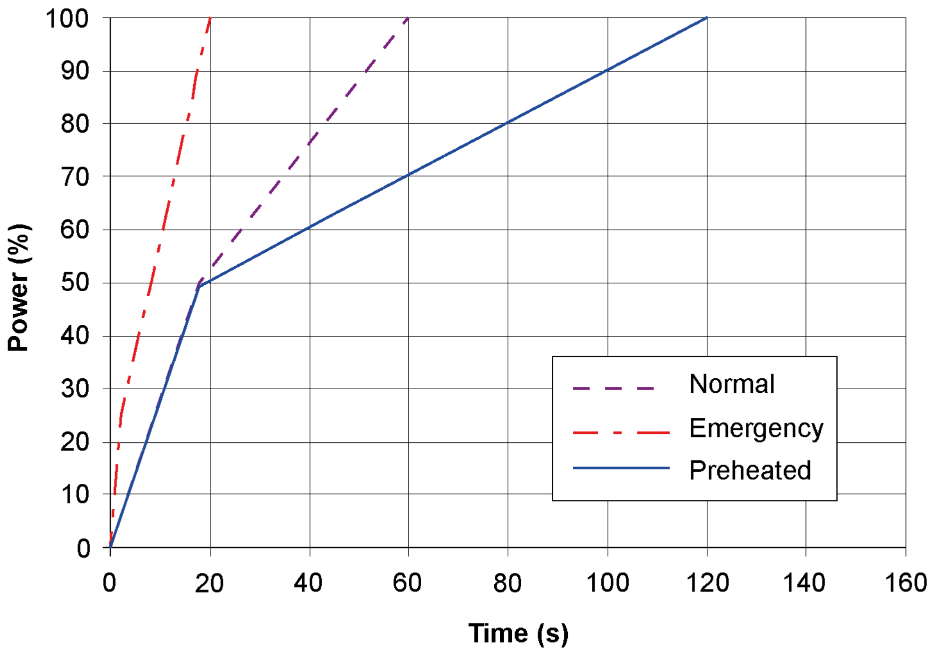


Fig 2-7 Maximum recommended load increase rates for engines operating at nominal speed

In diesel electric installations loading ramps are implemented both in the propulsion control and in the power management system, or in the engine speed control in case isochronous load sharing is applied. If a ramp without knee-point is used, it should not achieve 100% load in shorter time than the ramp in the figure. When the load sharing is based on speed droop, the load increase rate of a recently connected generator is the sum of the load transfer performed by the power management system and the load increase performed by the propulsion control.

The “emergency” curve is close to the maximum capability of the engine and it shall not be used as the normal limit. In dynamic positioning applications loading ramps corresponding to 20-30 seconds from zero to full load are however normal. If the vessel has also other operating modes, a slower loading ramp is recommended for these operating modes.

In typical auxiliary engine applications there is usually no single consumer being decisive for the loading rate. It is recommended to group electrical equipment so that the load is increased in small increments, and the resulting loading rate roughly corresponds to the “normal” curve.

In normal operation the load should not be reduced from 100% to 0% in less than 15 seconds. If the application requires frequent unloading at a significantly faster rate, special arrangements can be necessary on the engine. In an emergency situation the full load can be thrown off instantly.

2.2.2.1 Maximum instant load steps

The electrical system must be designed so that tripping of breakers can be safely handled. This requires that the engines are protected from load steps exceeding their maximum load acceptance capability. The maximum permissible load step is 33% MCR. The resulting speed drop is less than 10% and the recovery time to within 1% of the steady state speed at the new load level is max. 5 seconds.

When electrical power is restored after a black-out, consumers are reconnected in groups, which may cause significant load steps. The engine can be loaded in three steps up to 100% load, provided that the steps are 0-33-66-100. The engine must be allowed to recover for at least 7 seconds before applying the following load step, if the load is applied in maximum steps.

2.2.2.2 Start-up time

A diesel generator typically reaches nominal speed in about 20...25 seconds after the start signal. The acceleration is limited by the speed control to minimise smoke during start-up.

2.3 Low load operation

The engine can be started, stopped and operated on gas, heavy and light fuel oil with the following limits for low load operations:

Absolute idling (declutched main engine, disconnected generator)

- Maximum 10 minutes if the engine is to be stopped after the idling.

- Maximum 8 hours if the engine is to be loaded after the idling.

Operation below 20 % load

- Maximum 100 hours continuous operation. At intervals of 100 operating hours the engine must be loaded to minimum 70 % of the rated output.

Operation above 20% load

- No restrictions.

2.4 Low air temperature

In standard conditions the following minimum inlet air temperatures apply:

- Starting + 5°C
- Idling - 5°C *)
- High load - 10°C *)
- Artic package -10°C / -30°C

Depending on the setup down to -45°C.

If the engine is equipped with a two-stage charge air cooler, sustained operation between 0 and 40% load can require special provisions in cold conditions to prevent too low engine temperature.

For further guidelines, see chapter *Combustion air system design*.

3. Technical Data

3.1 Introduction

This chapter contains technical data of the engine (heat balance, flows, pressures etc.) for design of auxiliary systems. Further design criteria for external equipment and system layouts are presented in the respective chapter.

3.1.1 Engine driven pumps

The fuel consumption stated in the technical data tables is with engine driven pumps. The increase in fuel consumption with engine driven pumps is given in the table below; correction in g/kWh.

Table 3-1 Constant speed engines

Application	Engine driven pumps	Engine load [%]				
		100	85	75	50	25
Inline	Lube oil	-2.3	-2.7	-3.1	-4.8	-10.8
	LT Water	-0.6	-0.7	-0.8	-1.2	-2.7
	HT Water	-0.6	-0.7	-0.8	-1.2	-2.8
	Fuel Water	-0.1	-0.1	-0.1	-0.2	-0.5
V-engine	Lube oil	-1.4	-1.6	-1.8	-2.8	-6.5
	LT Water	-0.4	-0.5	-0.6	-0.9	-2.1
	HT Water	-0.4	-0.5	-0.6	-0.9	-2.1
	Fuel Water	-0.1	-0.1	-0.1	-0.1	-0.3

Table 3-2 Variable speed engines

Application	Engine driven pumps	Engine load [%]				
		100	85	75	50	25
Inline	Lube oil	-2.3	-2.5	-2.8	-3.7	-6.2
	LT Water	-0.6	-0.6	-0.6	-0.6	-0.6
	HT Water	-0.6	-0.6	-0.6	-0.6	-0.6
	Fuel Water	-0.1	-0.1	-0.1	-0.2	-0.3
V-engine	Lube oil	-1.4	-1.5	-1.6	-2.2	-3.7
	LT Water	-0.4	-0.4	-0.4	-0.4	-0.5
	HT Water	-0.4	-0.4	-0.4	-0.4	-0.5
	Fuel Water	-0.1	-0.1	-0.1	-0.1	-0.2

3.2 IMO Tier 2

3.2.1 Wärtsilä 6L26

Table 3-3

Wärtsilä 6L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	1950	2040	1950	2040
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	3.7	4.1	3.9	4.1
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	3.8	4.2	4.0	4.2
Flow at 85% load	kg/s	3.3	3.7	3.4	3.5
Flow 75% load	kg/s	3.0	3.4	3.0	3.1
Flow 50% load	kg/s	2.1	2.3	1.9	2.2
Temp. after turbo, 100% load (TE517)	°C	343	324	318	324
Temp. after turbo, 85% load (TE517)	°C	343	319	327	328
Temp. after turbo, 75% load (TE517)	°C	349	321	339	341
Temp. after turbo, 50% load (TE517)	°C	367	344	402	388
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	500	500	500	500
Calculated exhaust diameter for 35 m/s	mm	492	507	493	507
Heat balance (Note 3)					
Jacket water, HT circuit	kW	348	372	336	372
Charge air, LT-circuit	kW	611	723	689	723
Lubricating oil, LT-circuit	kW	288	306	282	306
Radiation	kW	92	97	92	97
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	2.9	3.2	2.9	3.2
Fuel flow to engine (without engine driven pump), approx.	m³/h	1.6	1.8	1.7	1.8
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	190.6	194.4	191.5	194.4
Fuel consumption at 85% load	g/kWh	189.6	193.4	188.7	191.5
Fuel consumption at 75% load	g/kWh	192.0	195.3	190.6	193.4
Fuel consumption at 50% load	g/kWh	202.3	207.0	196.6	201.3

Wärtsilä 6L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Clean leak fuel quantity, MDF at 100% load	kg/h	7.7	8.2	7.8	8.2
Clean leak fuel quantity, HFO at 100% load	kg/h	1.5	1.6	1.6	1.6
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	60	66	60	66
Pump capacity (main), stand-by	m³/h	55	55	55	55
Priming pump capacity, 50Hz/60Hz	m³/h	11 / 13	11 / 13	11 / 13	11 / 13
Oil volume, wet sump, nom.	m³	1.3	1.3	1.3	1.3
Oil volume in separate system oil tank, nom.	m³	2.6	2.8	2.6	2.8
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	350 + static	350 + static	350 + static	350 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	35	35	35	35
Pressure drop over engine	kPa	210	210	210	210
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.3	0.3	0.3	0.3
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	260 + static	280 + static	260 + static	280 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	42	47	42	47
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	16	16	16	16
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	80	80	80	80

Wärtsilä 6L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800
Starting air consumption, start (successful)	Nm^3	1.4	1.4	1.4	1.4

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42 700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.2.2 Wärtsilä 8L26

Wärtsilä 8L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	2600	2720	2600	2720
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	5.0	5.6	5.2	5.4
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	5.1	5.6	5.4	5.6
Flow at 85% load	kg/s	4.4	4.9	4.6	4.7
Flow 75% load	kg/s	4.0	4.5	4.0	4.2
Flow 50% load	kg/s	2.8	3.1	2.5	2.9
Temp. after turbo, 100% load (TE517)	°C	343	324	318	324
Temp. after turbo, 85% load (TE517)	°C	343	319	327	328
Temp. after turbo, 75% load (TE517)	°C	349	321	339	341
Temp. after turbo, 50% load (TE517)	°C	367	344	402	388
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	550	550	550	550
Calculated exhaust diameter for 35 m/s	mm	569	585	570	585
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	464	496	448	496
Charge air, LT-circuit	kW	814	964	918	964
Lubricating oil, LT-circuit	kW	384	408	376	408
Radiation	kW	122	130	123	130
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	3.7	4.1	3.7	4.1
Fuel flow to engine (without engine driven pump), approx.	m³/h	2.2	2.3	2.2	2.3
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	190.6	194.4	191.5	194.4
Fuel consumption at 85% load	g/kWh	189.6	193.4	188.7	191.5
Fuel consumption at 75% load	g/kWh	192.0	195.3	190.6	193.4
Fuel consumption at 50% load	g/kWh	202.3	207.0	196.6	201.3
Clean leak fuel quantity, MDF at 100% load	kg/h	10.3	10.9	10.3	10.9
Clean leak fuel quantity, HFO at 100% load	kg/h	2.1	2.2	2.1	2.2
Lubricating oil system (Note 5)					

Wärtsilä 8L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	81	90	81	90
Pump capacity (main), stand-by	m³/h	75	75	75	75
Priming pump capacity, 50Hz/60Hz	m³/h	16 / 19	16 / 19	16 / 19	16 / 19
Oil volume, wet sump, nom.	m³	1.6	1.6	1.6	1.6
Oil volume in separate system oil tank, nom.	m³	3.5	3.7	3.5	3.7
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	360 + static	370 + static	360 + static	370 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	45	45	45	45
Pressure drop over engine	kPa	220	220	220	220
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.4	0.4	0.4	0.4
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	270 + static	250 + static	270 + static	250 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	56	62	56	62
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	18	18	18	18
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	120	120	120	120
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300

Wärtsilä 8L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Low pressure limit in air vessels	kPa	1800	1800	1800	1800
Starting air consumption, start (successful)	Nm^3	1.8	1.8	1.8	1.8

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42 700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.2.3 Wärtsilä 9L26

Wärtsilä 9L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	2925	3060	2925	3060
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	5.6	6.1	5.9	6.1
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	5.8	6.3	6.0	6.3
Flow at 85% load	kg/s	5.0	5.5	5.1	5.3
Flow 75% load	kg/s	4.5	5.0	4.5	4.7
Flow 50% load	kg/s	3.2	3.5	2.8	3.2
Temp. after turbo, 100% load (TE517)	°C	343	324	318	324
Temp. after turbo, 85% load (TE517)	°C	343	319	327	328
Temp. after turbo, 75% load (TE517)	°C	349	321	339	341
Temp. after turbo, 50% load (TE517)	°C	367	344	402	388
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	600	600	600	600
Calculated exhaust diameter for 35 m/s	mm	603	621	604	621
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	522	558	504	558
Charge air, LT-circuit	kW	916	1085	1033	1085
Lubricating oil, LT-circuit	kW	432	459	423	459
Radiation	kW	138	146	139	146
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	3.7	4.1	3.7	4.1
Fuel flow to engine (without engine driven pump), approx.	m³/h	2.5	2.6	2.5	2.6
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	190.6	194.4	191.5	194.4
Fuel consumption at 85% load	g/kWh	189.6	193.4	188.7	191.5
Fuel consumption at 75% load	g/kWh	192.0	195.3	190.6	193.4
Fuel consumption at 50% load	g/kWh	202.3	207.0	196.6	201.3
Clean leak fuel quantity, MDF at 100% load	kg/h	11.6	12.3	11.6	12.3
Clean leak fuel quantity, HFO at 100% load	kg/h	2.3	2.5	2.3	2.5
Lubricating oil system (Note 5)					

Wärtsilä 9L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	81	90	81	90
Pump capacity (main), stand-by	m³/h	75	75	75	75
Priming pump capacity, 50Hz/60Hz	m³/h	16 / 19	16 / 19	16 / 19	16 / 19
Oil volume, wet sump, nom.	m³	1.7	1.7	1.7	1.7
Oil volume in separate system oil tank, nom.	m³	3.9	4.1	3.9	4.1
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	360 + static	350 + static	360 + static	350 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	50	50	50	50
Pressure drop over engine	kPa	220	220	220	220
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.45	0.45	0.45	0.45
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	250 + static	260 + static	250 + static	260 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	63	70	63	70
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	21	21	21	21
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	120	120	120	120
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300

Wärtsilä 9L26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Low pressure limit in air vessels	kPa	1800	1800	1800	1800
Starting air consumption, start (successful)	Nm^3	2.0	2.0	2.0	2.0

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42 700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.2.4 Wärtsilä 12V26

Wärtsilä 12V26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	3900	4080	3900	4080
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	7.4	8.1	7.8	8.2
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	50	50	50	50
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	7.7	8.4	8.0	8.4
Flow at 85% load	kg/s	6.6	7.3	6.8	7.1
Flow 75% load	kg/s	6.0	6.7	6.0	6.2
Flow 50% load	kg/s	4.2	4.7	3.7	4.3
Temp. after turbo, 100% load (TE517)	°C	343	324	318	324
Temp. after turbo, 85% load (TE517)	°C	343	319	327	328
Temp. after turbo, 75% load (TE517)	°C	349	321	339	341
Temp. after turbo, 50% load (TE517)	°C	367	344	402	388
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	700	700	700	700
Calculated exhaust diameter for 35 m/s	mm	696	717	698	717
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	696	744	672	744
Charge air, HT-circuit	kW	884	1048	997	1048
Charge air, LT-circuit	kW	336	398	380	398
Lubricating oil, LT-circuit	kW	576	612	564	612
Radiation	kW	184	194	185	194
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	4.6	5.2	4.6	5.2
Fuel flow to engine (without engine driven pump), approx.	m³/h	3.3	3.5	3.3	3.5
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	189.6	193.4	190.6	193.4
Fuel consumption at 85% load	g/kWh	188.7	192.5	187.7	190.6
Fuel consumption at 75% load	g/kWh	191.0	194.4	189.6	192.5
Fuel consumption at 50% load	g/kWh	201.3	206.1	195.6	200.4
Clean leak fuel quantity, MDF at 100% load	kg/h	15.4	16.4	15.5	16.4
Clean leak fuel quantity, HFO at 100% load	kg/h	3.1	3.3	3.1	3.3

Wärtsilä 12V26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	63	63	63	63
Temperature after engine, approx.	°C	79	79	79	79
Pump capacity (main), engine driven	m³/h	99	110	99	110
Pump capacity (main), stand-by	m³/h	83	83	83	83
Priming pump capacity, 50Hz/60Hz	m³/h	20 / 25	20 / 25	20 / 25	20 / 25
Oil volume, wet sump, nom.	m³	2.4	2.4	2.4	2.4
Oil volume in separate system oil tank, nom.	m³	5.3	5.5	5.3	5.5
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	280 + static	350 + static	280 + static	350 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	73	73	73	73
HT-water out from the engine, nom (TE402)	°C	93	93	93	93
Capacity of engine driven pump, nom.	m³/h	60	67	60	67
Pressure drop over engine	kPa	160	160	160	160
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.55	0.55	0.55	0.55
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	280 + static	350 + static	280 + static	350 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	60	67	60	67
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	71	71	71	71
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300

Wärtsilä 12V26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Low pressure limit in air vessels	kPa	1800	1800	1800	1800
Starting air consumption, start (successful)	Nm^3	3.0	3.0	3.0	3.0

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps(two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.2.5 Wärtsilä 16V26

Wärtsilä 16V26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	5200	5440	5200	5440
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	9.9	10.8	10.4	10.8
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	50	50	50	50
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	10.2	11.2	10.7	11.2
Flow at 85% load	kg/s	8.8	9.8	9.1	9.4
Flow 75% load	kg/s	8.0	9.0	8.0	8.3
Flow 50% load	kg/s	5.6	6.2	5.0	5.8
Temp. after turbo, 100% load (TE517)	°C	343	324	318	324
Temp. after turbo, 85% load (TE517)	°C	343	319	327	328
Temp. after turbo, 75% load (TE517)	°C	349	321	339	341
Temp. after turbo, 50% load (TE517)	°C	367	344	402	388
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	800	800	800	800
Calculated exhaust diameter for 35 m/s	mm	804	828	806	828
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	928	992	896	992
Charge air, HT-circuit	kW	1179	1397	1330	1397
Charge air, LT-circuit	kW	448	531	507	531
Lubricating oil, LT-circuit	kW	768	816	752	816
Radiation	kW	245	259	246	259
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	7.0	7.8	7.0	7.8
Fuel flow to engine (without engine driven pump), approx.	m³/h	4.4	4.7	4.4	4.7
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	189.6	193.4	190.6	193.4
Fuel consumption at 85% load	g/kWh	188.7	192.5	187.7	190.6
Fuel consumption at 75% load	g/kWh	191.0	194.4	189.6	192.5
Fuel consumption at 50% load	g/kWh	201.3	206.1	195.6	200.4
Clean leak fuel quantity, MDF at 100% load	kg/h	20.6	21.9	20.7	21.9
Clean leak fuel quantity, HFO at 100% load	kg/h	4.1	4.4	4.1	4.4

Wärtsilä 16V26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	63	63	63	63
Temperature after engine, approx.	°C	79	79	79	79
Pump capacity (main), engine driven	m³/h	117	130	117	130
Pump capacity (main), stand-by	m³/h	98	98	98	98
Priming pump capacity, 50Hz/60Hz	m³/h	20 / 25	20 / 25	20 / 25	20 / 25
Oil volume, wet sump, nom.	m³	3.0	3.0	3.0	3.0
Oil volume in separate system oil tank, nom.	m³	7.0	7.3	7.0	7.3
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	350 + static	440 + static	350 + static	440 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	73	73	73	73
HT-water out from the engine, nom (TE402)	°C	93	93	93	93
Capacity of engine driven pump, nom.	m³/h	80	89	80	89
Pressure drop over engine	kPa	200	200	200	200
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.68	0.68	0.68	0.68
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	350 + static	440 + static	350 + static	440 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	80	89	80	89
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	71	83	71	83
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300

Wärtsilä 16V26		AE/DE IMO Tier 2	AE/DE IMO Tier 2	ME IMO Tier 2	ME IMO Tier 2
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Low pressure limit in air vessels	kPa	1800	1800	1800	1800
Starting air consumption, start (successful)	Nm^3	3.9	3.9	3.9	3.9

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps(two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.3 IMO Tier 2 optimization (high P6, T6)

3.3.1 Wärtsilä 6L26

Table 3-4

Wärtsilä 6L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	1950	2040	1950	2040
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	3.8	4.0	3.8	4.0
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	3.9	4.1	3.9	4.1
Flow at 85% load	kg/s	3.4	3.6	3.3	3.5
Flow 75% load	kg/s	3.1	3.3	2.9	3.1
Flow 50% load	kg/s	2.2	2.4	1.9	2.2
Temp. after turbo, 100% load (TE517)	°C	340	340	340	340
Temp. after turbo, 85% load (TE517)	°C	340	340	340	344
Temp. after turbo, 75% load (TE517)	°C	340	340	357	357

Wärtsilä 6L26		**AE/DE**	**AE/DE**	**ME**	**ME**
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Temp. after turbo, 50% load (TE517)	°C	353	344	390	378
Backpressure, max.	kPa	5.0	5.0	5.0	5.0
Exhaust gas pipe diameter, min	mm	500	500	500	500
Calculated exhaust diameter for 35 m/s	mm	495	510	495	510
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	366	384	366	384
Charge air, LT-circuit	kW	630	678	630	678
Lubricating oil, LT-circuit	kW	300	324	300	324
Radiation	kW	90	96	90	96
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	2.9	3.2	2.9	3.2
Fuel flow to engine (without engine driven pump), approx.	m³/h	1.6	1.8	1.6	1.8
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	191.0	194.9	191.0	194.9
Fuel consumption at 85% load	g/kWh	190.6	194.4	188.7	191.5
Fuel consumption at 75% load	g/kWh	193.9	196.3	190.1	193.4
Fuel consumption at 50% load	g/kWh	203.2	207.0	193.7	198.5
Clean leak fuel quantity, MDF at 100% load	kg/h	7.7	8.2	7.8	8.2
Clean leak fuel quantity, HFO at 100% load	kg/h	1.5	1.6	1.6	1.6
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	60	66	60	66
Pump capacity (main), stand-by	m³/h	55	55	55	55
Priming pump capacity, 50Hz/60Hz	m³/h	11 / 13	11 / 13	11 / 13	11 / 13
Oil volume, wet sump, nom.	m³	1.3	1.3	1.3	1.3
Oil volume in separate system oil tank, nom.	m³	2.6	2.8	2.6	2.8
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0

Wärtsilä 6L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	350 + static	350 + static	350 + static	350 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	35	35	35	35
Pressure drop over engine	kPa	210	210	210	210
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.3	0.3	0.3	0.3
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	260 + static	280 + static	260 + static	280 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	42	47	42	47
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	16	16	16	16
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	80	80	80	80
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800
Starting air consumption, start (successful)	Nm³	1.4	1.4	1.4	1.4

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.3.2 Wärtsilä 8L26

Wärtsilä 8L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	2600	2720	2600	2720
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	5.1	5.4	5.1	5.4
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	5.2	5.5	5.2	5.5
Flow at 85% load	kg/s	4.6	4.8	4.4	4.6
Flow 75% load	kg/s	4.2	4.4	3.9	4.2
Flow 50% load	kg/s	3.0	3.2	2.6	3.0
Temp. after turbo, 100% load (TE517)	°C	340	340	340	340
Temp. after turbo, 85% load (TE517)	°C	340	340	340	344
Temp. after turbo, 75% load (TE517)	°C	340	340	357	357
Temp. after turbo, 50% load (TE517)	°C	353	344	390	378
Backpressure, max.	kPa	5.0	5.0	5.0	5.0
Exhaust gas pipe diameter, min	mm	550	550	550	550
Calculated exhaust diameter for 35 m/s	mm	572	589	572	589
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	488	512	488	512
Charge air, LT-circuit	kW	840	904	840	904
Lubricating oil, LT-circuit	kW	400	432	400	432
Radiation	kW	120	128	120	128
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	3.7	4.1	3.7	4.1
Fuel flow to engine (without engine driven pump), approx.	m³/h	2.2	2.3	2.2	2.3
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	191.0	194.9	191.0	194.9
Fuel consumption at 85% load	g/kWh	190.6	194.4	188.7	191.5
Fuel consumption at 75% load	g/kWh	193.9	196.3	190.1	193.4
Fuel consumption at 50% load	g/kWh	203.2	207.0	193.7	198.5
Clean leak fuel quantity, MDF at 100% load	kg/h	10.3	10.9	10.3	10.9
Clean leak fuel quantity, HFO at 100% load	kg/h	2.1	2.2	2.1	2.2
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450

Wärtsilä 8L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	81	90	81	90
Pump capacity (main), stand-by	m³/h	75	75	75	75
Priming pump capacity, 50Hz/60Hz	m³/h	16 / 19	16 / 19	16 / 19	16 / 19
Oil volume, wet sump, nom.	m³	1.6	1.6	1.6	1.6
Oil volume in separate system oil tank, nom.	m³	3.5	3.7	3.5	3.7
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	360 + static	370 + static	360 + static	370 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	45	45	45	45
Pressure drop over engine	kPa	220	220	220	220
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.4	0.4	0.4	0.4
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	270 + static	250 + static	270 + static	250 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	56	62	56	62
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	18	18	18	18
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	120	120	120	120
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800

Wärtsilä 8L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Starting air consumption, start (successful)	Nm^3	1.8	1.8	1.8	1.8

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.3.3 Wärtsilä 9L26

Wärtsilä 9L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	2925	3060	2925	3060
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	5.7	6.0	5.7	6.0
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	5.9	6.2	5.9	6.2
Flow at 85% load	kg/s	5.1	5.4	5.0	5.2
Flow 75% load	kg/s	4.7	5.0	4.4	4.7
Flow 50% load	kg/s	3.3	3.6	2.9	3.3
Temp. after turbo, 100% load (TE517)	°C	340	340	340	340
Temp. after turbo, 85% load (TE517)	°C	340	340	340	344
Temp. after turbo, 75% load (TE517)	°C	340	340	357	357
Temp. after turbo, 50% load (TE517)	°C	353	344	390	378
Backpressure, max.	kPa	5.0	5.0	5.0	5.0
Exhaust gas pipe diameter, min	mm	600	600	600	600
Calculated exhaust diameter for 35 m/s	mm	606	625	606	625
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	549	576	549	576
Charge air, LT-circuit	kW	945	1017	945	1017
Lubricating oil, LT-circuit	kW	450	486	450	486
Radiation	kW	135	144	135	144
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	3.7	4.1	3.7	4.1
Fuel flow to engine (without engine driven pump), approx.	m³/h	2.5	2.6	2.5	2.6
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	191.0	194.9	191.0	194.9
Fuel consumption at 85% load	g/kWh	190.6	194.4	188.7	191.5
Fuel consumption at 75% load	g/kWh	193.9	196.3	190.1	193.4
Fuel consumption at 50% load	g/kWh	203.2	207.0	193.7	198.5
Clean leak fuel quantity, MDF at 100% load	kg/h	11.6	12.3	11.6	12.3
Clean leak fuel quantity, HFO at 100% load	kg/h	2.3	2.5	2.3	2.5
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450

Wärtsilä 9L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	81	90	81	90
Pump capacity (main), stand-by	m³/h	75	75	75	75
Priming pump capacity, 50Hz/60Hz	m³/h	16 / 19	16 / 19	16 / 19	16 / 19
Oil volume, wet sump, nom.	m³	1.7	1.7	1.7	1.7
Oil volume in separate system oil tank, nom.	m³	3.9	4.1	3.9	4.1
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	360 + static	350 + static	360 + static	350 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	50	50	50	50
Pressure drop over engine	kPa	220	220	220	220
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.45	0.45	0.45	0.45
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	250 + static	260 + static	250 + static	260 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	63	70	63	70
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	21	21	21	21
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	120	120	120	120
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800

Wärtsilä 9L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Starting air consumption, start (successful)	Nm^3	2.0	2.0	2.0	2.0

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.3.4 Wärtsilä 12V26

Wärtsilä 12V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	3900	4080	3900	4080
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	7.7	8.2	7.7	8.2
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	50	50	50	50
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	7.8	8.3	7.8	8.3
Flow at 85% load	kg/s	6.8	7.2	6.6	7.0
Flow 75% load	kg/s	6.2	6.6	5.9	6.2
Flow 50% load	kg/s	4.4	4.8	3.8	4.4
Temp. after turbo, 100% load (TE517)	°C	340	340	340	340
Temp. after turbo, 85% load (TE517)	°C	340	340	340	344
Temp. after turbo, 75% load (TE517)	°C	340	340	357	357
Temp. after turbo, 50% load (TE517)	°C	353	344	390	378
Backpressure, max.	kPa	5.0	5.0	5.0	5.0
Exhaust gas pipe diameter, min	mm	700	700	700	700
Calculated exhaust diameter for 35 m/s	mm	700	721	700	721
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	732	768	732	768
Charge air, HT-circuit	kW	840	912	840	912
Charge air, LT-circuit	kW	432	444	432	444
Lubricating oil, LT-circuit	kW	600	648	600	648
Radiation	kW	180	192	180	192
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	4.6	5.2	4.6	5.2
Fuel flow to engine (without engine driven pump), approx.	m³/h	3.3	3.5	3.3	3.5
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	190.1	193.9	190.1	193.9
Fuel consumption at 85% load	g/kWh	189.6	193.4	187.7	190.6
Fuel consumption at 75% load	g/kWh	193.0	195.3	189.1	192.5
Fuel consumption at 50% load	g/kWh	202.3	206.1	192.8	197.5
Clean leak fuel quantity, MDF at 100% load	kg/h	15.4	16.4	15.5	16.4
Clean leak fuel quantity, HFO at 100% load	kg/h	3.1	3.3	3.1	3.3

Wärtsilä 12V26		AE/DE	AE/DE	ME	ME
Cylinder output	kW/cyl	325	340	325	340
Engine speed	rpm	900	1000	900	1000
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	63	63	63	63
Temperature after engine, approx.	°C	79	79	79	79
Pump capacity (main), engine driven	m³/h	99	110	99	110
Pump capacity (main), stand-by	m³/h	83	83	83	83
Priming pump capacity, 50Hz/60Hz	m³/h	20 / 25	20 / 25	20 / 25	20 / 25
Oil volume, wet sump, nom.	m³	2.4	2.4	2.4	2.4
Oil volume in separate system oil tank, nom.	m³	5.3	5.5	5.3	5.5
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	280 + static	350 + static	280 + static	350 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	73	73	73	73
HT-water out from the engine, nom (TE402)	°C	93	93	93	93
Capacity of engine driven pump, nom.	m³/h	60	67	60	67
Pressure drop over engine	kPa	160	160	160	160
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.55	0.55	0.55	0.55
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	280 + static	350 + static	280 + static	350 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	60	67	60	67
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	71	71	71	71
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800

Wärtsilä 12V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Starting air consumption, start (successful)	Nm^3	3.0	3.0	3.0	3.0

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.3.5 Wärtsilä 16V26

Wärtsilä 16V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	5200	5440	5200	5440
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	10.2	10.9	10.2	10.9
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	50	50	50	50
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	10.4	11.0	10.4	11.0
Flow at 85% load	kg/s	9.1	9.6	8.8	9.3
Flow 75% load	kg/s	8.3	8.8	7.8	8.3
Flow 50% load	kg/s	5.9	6.4	5.1	5.9
Temp. after turbo, 100% load (TE517)	°C	340	340	340	340
Temp. after turbo, 85% load (TE517)	°C	340	340	340	344
Temp. after turbo, 75% load (TE517)	°C	340	340	357	357
Temp. after turbo, 50% load (TE517)	°C	353	344	390	378
Backpressure, max.	kPa	5.0	5.0	5.0	5.0
Exhaust gas pipe diameter, min	mm	800	800	800	800
Calculated exhaust diameter for 35 m/s	mm	808	833	808	833
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	976	1024	976	1024
Charge air, HT-circuit	kW	1120	1216	1120	1216
Charge air, LT-circuit	kW	576	592	576	592
Lubricating oil, LT-circuit	kW	800	864	800	864
Radiation	kW	240	256	240	256
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	7.0	7.8	7.0	7.8
Fuel flow to engine (without engine driven pump), approx.	m³/h	4.4	4.7	4.4	4.7
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	190.1	193.9	190.1	193.9
Fuel consumption at 85% load	g/kWh	189.6	193.4	187.7	190.6
Fuel consumption at 75% load	g/kWh	193.0	195.3	189.1	192.5
Fuel consumption at 50% load	g/kWh	202.3	206.1	192.8	197.5
Clean leak fuel quantity, MDF at 100% load	kg/h	20.6	21.9	20.7	21.9
Clean leak fuel quantity, HFO at 100% load	kg/h	4.1	4.4	4.1	4.4

Wärtsilä 16V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	63	63	63	63
Temperature after engine, approx.	°C	79	79	79	79
Pump capacity (main), engine driven	m³/h	117	130	117	130
Pump capacity (main), stand-by	m³/h	98	98	98	98
Priming pump capacity, 50Hz/60Hz	m³/h	20 / 25	20 / 25	20 / 25	20 / 25
Oil volume, wet sump, nom.	m³	3.0	3.0	3.0	3.0
Oil volume in separate system oil tank, nom.	m³	7.0	7.3	7.0	7.3
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	350 + static	440 + static	350 + static	440 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	73	73	73	73
HT-water out from the engine, nom (TE402)	°C	93	93	93	93
Capacity of engine driven pump, nom.	m³/h	80	89	80	89
Pressure drop over engine	kPa	200	200	200	200
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.68	0.68	0.68	0.68
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	350 + static	440 + static	350 + static	440 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	80	89	80	89
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	71	83	71	83
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800

Wärtsilä 16V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Starting air consumption, start (successful)	Nm^3	3.9	3.9	3.9	3.9

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.4 IMO Tier 2 with SFOC reduction

3.4.1 Wärtsilä 6L26

Table 3-5

Wärtsilä 6L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	1950	2040	1950	2040
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	3.7	4.1	3.9	4.1
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	3.8	4.1	4.2	4.2
Flow at 85% load	kg/s	3.3	3.7	3.6	3.6
Flow 75% load	kg/s	3.0	3.4	3.0	3.0
Flow 50% load	kg/s	2.6	2.9	1.8	2.4
Temp. after turbo, 100% load (TE517)	°C	329	312	306	312
Temp. after turbo, 85% load (TE517)	°C	326	304	311	313
Temp. after turbo, 75% load (TE517)	°C	337	311	326	327
Temp. after turbo, 50% load (TE517)	°C	271	252	327	322
Backpressure, max.	kPa	3.0	3.0	3.0	3.0

Wärtsilä 6L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Exhaust gas pipe diameter, min	mm	500	500	500	500
Calculated exhaust diameter for 35 m/s	mm	487	498	499	502
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	330	354	318	354
Charge air, LT-circuit	kW	636	750	720	750
Lubricating oil, LT-circuit	kW	282	300	276	300
Radiation	kW	90	96	90	96
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	2.9	3.2	2.9	3.2
Fuel flow to engine (without engine driven pump), approx.	m³/h	1.6	1.7	1.6	1.7
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	188.2	192.0	189.1	192.0
Fuel consumption at 85% load	g/kWh	186.8	190.6	186.8	189.6
Fuel consumption at 75% load	g/kWh	190.6	193.9	189.1	192.0
Fuel consumption at 50% load	g/kWh	197.0	201.8	190.4	195.1
Clean leak fuel quantity, MDF at 100% load	kg/h	7.7	8.2	7.8	8.2
Clean leak fuel quantity, HFO at 100% load	kg/h	1.5	1.6	1.6	1.6
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	60	66	60	66
Pump capacity (main), stand-by	m³/h	55	55	55	55
Priming pump capacity, 50Hz/60Hz	m³/h	11 / 13	11 / 13	11 / 13	11 / 13
Oil volume, wet sump, nom.	m³	1.3	1.3	1.3	1.3
Oil volume in separate system oil tank, nom.	m³	2.6	2.8	2.6	2.8
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	350 + static	350 + static	350 + static	350 + static

Wärtsilä 6L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	35	35	35	35
Pressure drop over engine	kPa	210	210	210	210
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.3	0.3	0.3	0.3
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	260 + static	280 + static	260 + static	280 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	42	47	42	47
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	16	16	16	16
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	80	80	80	80
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800
Starting air consumption, start (successful)	Nm³	1.4	1.4	1.4	1.4

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.4.2 Wärtsilä 8L26

Wärtsilä 8L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	2600	2720	2600	2720
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	5.0	5.4	5.2	5.4
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	5.1	5.5	5.6	5.6
Flow at 85% load	kg/s	4.4	4.9	4.8	4.8
Flow 75% load	kg/s	4.0	4.5	4.0	4.0
Flow 50% load	kg/s	3.4	3.9	2.4	3.2
Temp. after turbo, 100% load (TE517)	°C	329	312	306	312
Temp. after turbo, 85% load (TE517)	°C	326	304	311	313
Temp. after turbo, 75% load (TE517)	°C	337	311	326	327
Temp. after turbo, 50% load (TE517)	°C	342	252	327	322
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	550	550	550	550
Calculated exhaust diameter for 35 m/s	mm	562	575	577	579
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	440	472	424	472
Charge air, LT-circuit	kW	848	1000	960	1000
Lubricating oil, LT-circuit	kW	376	400	368	400
Radiation	kW	120	128	120	128
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	3.7	4.1	3.7	4.1
Fuel flow to engine (without engine driven pump), approx.	m³/h	2.2	2.3	2.2	2.3
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	188.2	192.0	189.1	192.0
Fuel consumption at 85% load	g/kWh	186.8	190.6	186.8	189.6
Fuel consumption at 75% load	g/kWh	190.6	193.9	189.1	192.0
Fuel consumption at 50% load	g/kWh	197.0	201.8	190.4	195.1
Clean leak fuel quantity, MDF at 100% load	kg/h	10.3	10.9	10.3	10.9
Clean leak fuel quantity, HFO at 100% load	kg/h	2.1	2.2	2.1	2.2
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450

Wärtsilä 8L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	81	90	81	90
Pump capacity (main), stand-by	m³/h	75	75	75	75
Priming pump capacity, 50Hz/60Hz	m³/h	16 / 19	16 / 19	16 / 19	16 / 19
Oil volume, wet sump, nom.	m³	1.6	1.6	1.6	1.6
Oil volume in separate system oil tank, nom.	m³	3.5	3.7	3.5	3.7
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	360 + static	370 + static	360 + static	370 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	45	45	45	45
Pressure drop over engine	kPa	220	220	220	220
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.4	0.4	0.4	0.4
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	270 + static	250 + static	270 + static	250 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	56	62	56	62
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	18	18	18	18
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	120	120	120	120
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800

Wärtsilä 8L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Starting air consumption, start (successful)	Nm^3	1.8	1.8	1.8	1.8

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.4.3 Wärtsilä 9L26

Wärtsilä 9L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	2925	3060	2925	3060
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	5.6	6.1	5.8	6.0
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	55	55	55	55
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	5.8	6.2	6.3	6.3
Flow at 85% load	kg/s	5.0	5.5	5.4	5.4
Flow 75% load	kg/s	4.5	5.0	4.5	4.5
Flow 50% load	kg/s	3.9	4.4	2.7	3.6
Temp. after turbo, 100% load (TE517)	°C	329	312	306	312
Temp. after turbo, 85% load (TE517)	°C	326	304	311	313
Temp. after turbo, 75% load (TE517)	°C	337	311	326	327
Temp. after turbo, 50% load (TE517)	°C	342	252	327	322
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	600	600	600	600
Calculated exhaust diameter for 35 m/s	mm	596	610	611	615
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	495	531	477	531
Charge air, LT-circuit	kW	954	1125	1080	1125
Lubricating oil, LT-circuit	kW	423	450	414	450
Radiation	kW	135	144	135	144
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	3.7	4.1	3.7	4.1
Fuel flow to engine (without engine driven pump), approx.	m³/h	2.4	2.6	2.4	2.6
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	188.2	192.0	189.1	192.0
Fuel consumption at 85% load	g/kWh	186.8	190.6	186.8	189.6
Fuel consumption at 75% load	g/kWh	190.6	193.9	189.1	192.0
Fuel consumption at 50% load	g/kWh	197.0	201.8	190.4	195.1
Clean leak fuel quantity, MDF at 100% load	kg/h	11.6	12.3	11.6	12.3
Clean leak fuel quantity, HFO at 100% load	kg/h	2.3	2.5	2.3	2.5
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450

Wärtsilä 9L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	68	68	68	68
Temperature after engine, approx.	°C	78	78	78	78
Pump capacity (main), engine driven	m³/h	81	90	81	90
Pump capacity (main), stand-by	m³/h	75	75	75	75
Priming pump capacity, 50Hz/60Hz	m³/h	16 / 19	16 / 19	16 / 19	16 / 19
Oil volume, wet sump, nom.	m³	1.7	1.7	1.7	1.7
Oil volume in separate system oil tank, nom.	m³	3.9	4.1	3.9	4.1
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	360 + static	350 + static	360 + static	350 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	81	81	81	81
HT-water out from the engine, nom (TE402)	°C	91	91	91	91
Capacity of engine driven pump, nom.	m³/h	50	50	50	50
Pressure drop over engine	kPa	220	220	220	220
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.45	0.45	0.45	0.45
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	250 + static	260 + static	250 + static	260 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	63	70	63	70
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	21	21	21	21
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Capacity engine driven seawater pump, max.	m³/h	120	120	120	120
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800

Wärtsilä 9L26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Starting air consumption, start (successful)	Nm^3	2.0	2.0	2.0	2.0

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.4.4 Wärtsilä 12V26

Wärtsilä 12V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	3900	4080	3900	4080
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	7.5	8.1	8.0	8.2
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	50	50	50	50
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	7.7	8.3	8.4	8.4
Flow at 85% load	kg/s	6.6	7.3	7.2	7.2
Flow 75% load	kg/s	6.0	6.7	6.0	6.0
Flow 50% load	kg/s	5.2	5.9	3.6	4.8
Temp. after turbo, 100% load (TE517)	°C	329	312	306	312
Temp. after turbo, 85% load (TE517)	°C	326	304	311	313
Temp. after turbo, 75% load (TE517)	°C	337	311	326	327
Temp. after turbo, 50% load (TE517)	°C	271	252	327	322
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	700	700	700	700
Calculated exhaust diameter for 35 m/s	mm	688	705	706	710
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	660	708	636	708
Charge air, HT-circuit	kW	864	1068	984	1032
Charge air, LT-circuit	kW	408	432	456	480
Lubricating oil, LT-circuit	kW	564	600	552	600
Radiation	kW	180	192	180	192
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	4.6	5.2	4.6	5.2
Fuel flow to engine (without engine driven pump), approx.	m³/h	3.2	3.4	3.2	3.4
HFO viscosity before engine	cSt	16...24	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt	2.0	2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	45
Fuel consumption at 100% load	g/kWh	187.2	191.0	188.2	191.0
Fuel consumption at 85% load	g/kWh	185.8	189.6	185.8	188.7
Fuel consumption at 75% load	g/kWh	189.6	193.0	188.2	191.0
Fuel consumption at 50% load	g/kWh	196.1	200.9	189.4	194.2
Clean leak fuel quantity, MDF at 100% load	kg/h	15.4	16.4	15.5	16.4
Clean leak fuel quantity, HFO at 100% load	kg/h	3.1	3.3	3.1	3.3

Wärtsilä 12V26		AE/DE	AE/DE	ME	ME
Cylinder output	kW/cyl	325	340	325	340
Engine speed	rpm	900	1000	900	1000
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	63	63	63	63
Temperature after engine, approx.	°C	79	79	79	79
Pump capacity (main), engine driven	m³/h	99	110	99	110
Pump capacity (main), stand-by	m³/h	83	83	83	83
Priming pump capacity, 50Hz/60Hz	m³/h	20 / 25	20 / 25	20 / 25	20 / 25
Oil volume, wet sump, nom.	m³	2.4	2.4	2.4	2.4
Oil volume in separate system oil tank, nom.	m³	5.3	5.5	5.3	5.5
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	280 + static	350 + static	280 + static	350 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	73	73	73	73
HT-water out from the engine, nom (TE402)	°C	93	93	93	93
Capacity of engine driven pump, nom.	m³/h	60	67	60	67
Pressure drop over engine	kPa	160	160	160	160
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.55	0.55	0.55	0.55
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	280 + static	350 + static	280 + static	350 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	60	67	60	67
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	71	71	71	71
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800

Wärtsilä 12V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Starting air consumption, start (successful)	Nm^3	3.0	3.0	3.0	3.0

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

3.4.5 Wärtsilä 16V26

Wärtsilä 16V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Engine output	kW	5200	5440	5200	5440
Mean effective pressure	MPa	2.55	2.4	2.55	2.4
Combustion air system (Note 1)					
Flow of air at 100% load	kg/s	10.0	10.9	10.5	10.9
Temperature at turbocharger intake, max.	°C	45	45	45	45
Air temperature after air cooler, nom. (TE601)	°C	50	50	50	50
Exhaust gas system (Note 2)					
Flow at 100% load	kg/s	10.2	11.0	11.2	11.2
Flow at 85% load	kg/s	8.8	9.8	9.6	9.6
Flow 75% load	kg/s	8.0	9.0	8.0	8.0
Flow 50% load	kg/s	6.9	7.8	4.8	6.4
Temp. after turbo, 100% load (TE517)	°C	329	312	306	312
Temp. after turbo, 85% load (TE517)	°C	326	304	311	313
Temp. after turbo, 75% load (TE517)	°C	337	311	326	327
Temp. after turbo, 50% load (TE517)	°C	271	252	327	322
Backpressure, max.	kPa	3.0	3.0	3.0	3.0
Exhaust gas pipe diameter, min	mm	800	800	800	800
Calculated exhaust diameter for 35 m/s	mm	795	814	815	820
Heat balance (Note 3)					
Jacket water, HT-circuit	kW	880	944	848	944
Charge air, HT-circuit	kW	1152	1424	1312	1376
Charge air, LT-circuit	kW	544	576	608	640
Lubricating oil, LT-circuit	kW	752	800	736	800
Radiation	kW	240	256	240	256
Fuel system (Note 4)					
Pressure before injection pumps (PT101)	kPa	700±50	700±50	700±50	700±50
Engine driven pump capacity at 12 cSt (MDF only)	m³/h	7.0	7.8	7.0	7.8
Fuel flow to engine (without engine driven pump), approx.	m³/h	4.3	4.6	4.3	4.6
HFO viscosity before engine	cSt	0...0	16...24	16...24	16...24
HFO temperature before engine, max. (TE 101)	°C	140	140	140	140
MDF viscosity, min	cSt		2.0	2.0	2.0
MDF temperature before engine, max. (TE 101)	°C	45	45	45	50
Fuel consumption at 100% load	g/kWh	187.2	191.0	188.2	191.0
Fuel consumption at 85% load	g/kWh	185.8	189.6	185.8	188.7
Fuel consumption at 75% load	g/kWh	189.6	193.0	188.2	191.0
Fuel consumption at 50% load	g/kWh	196.1	200.9	189.4	194.2
Clean leak fuel quantity, MDF at 100% load	kg/h	20.5	21.9	20.7	21.9
Clean leak fuel quantity, HFO at 100% load	kg/h	4.1	4.4	4.1	4.4

Wärtsilä 16V26		AE/DE	AE/DE	ME	ME
Cylinder output	**kW/cyl**	**325**	**340**	**325**	**340**
Engine speed	**rpm**	**900**	**1000**	**900**	**1000**
Lubricating oil system (Note 5)					
Pressure before bearings, nom. (PT201)	kPa	450	450	450	450
Pressure after pump, max.	kPa	800	800	800	800
Suction ability including pipe loss, max.	kPa	30	30	30	30
Priming pressure, nom. (PT201)	kPa	80	80	80	80
Temperature before bearings, nom. (TE201)	°C	63	63	63	63
Temperature after engine, approx.	°C	79	79	79	79
Pump capacity (main), engine driven	m³/h	117	130	117	130
Pump capacity (main), stand-by	m³/h	98	98	98	98
Priming pump capacity, 50Hz/60Hz	m³/h	20 / 25	20 / 25	20 / 25	20 / 25
Oil volume, wet sump, nom.	m³	3.0	3.0	3.0	3.0
Oil volume in separate system oil tank, nom.	m³	7.0	7.3	7.0	7.3
Oil consumption (100% load), approx.	g/kWh	0.5	0.5	0.5	0.5
Crankcase ventilation flow rate	l/min/cyl	150	150	150	150
Crankcase backpressure (max)	kPa	0.3	0.3	0.3	0.3
Oil volume in speed governor	l	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0	1.4 / 2.0
High temperature cooling water system					
Pressure at engine, after pump, nom. (PT401)	kPa	350 + static	440 + static	350 + static	440 + static
Pressure at engine, after pump, max. (PT401)	kPa	500	500	500	500
Temperature before cylinders, approx. (TE401)	°C	73	73	73	73
HT-water out from the engine, nom (TE402)	°C	93	93	93	93
Capacity of engine driven pump, nom.	m³/h	80	89	80	89
Pressure drop over engine	kPa	200	200	200	200
Pressure drop in external system, max	kPa	60	60	60	60
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Water volume in engine	m³	0.68	0.68	0.68	0.68
Low temperature cooling water system					
Pressure at engine, after pump, nom. (PT471)	kPa	350 + static	440 + static	350 + static	440 + static
Pressure at engine, after pump, max. (PT471)	kPa	500	500	500	500
Temperature before engine (TE471)	°C	25...38	25...38	25...38	25...38
Capacity of engine driven pump, nom.	m³/h	80	89	80	89
Pressure drop in external system, max.	kPa	60	60	60	60
Pressure drop over charge air cooler	kPa	50	50	50	50
Pressure drop over oil cooler	kPa	71	83	71	83
Pressure from expansion tank	kPa	70...150	70...150	70...150	70...150
Starting air system (Note 6)					
Pressure, nom.	kPa	3000	3000	3000	3000
Pressure, max.	kPa	3300	3300	3300	3300
Low pressure limit in air vessels	kPa	1800	1800	1800	1800

Wärtsilä 16V26		AE/DE	AE/DE	ME	ME
Cylinder output	kW/cyl	325	340	325	340
Engine speed	rpm	900	1000	900	1000
Starting air consumption, start (successful)	Nm^3	3.9	3.9	3.9	3.9

Notes:

Note 1 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C) and 100% load. Flow tolerance 5%.

Note 2 At ISO 15550 conditions (ambient air temperature 25°C, LT-water 25°C). Flow tolerance 5% and temperature tolerance 20°C.

Note 3 The heat balances are made for ISO 15550 standard reference conditions. The heat balances include engine driven pumps (two water pumps and one lube oil pump).

Note 4 According to ISO 15550, lower calorific value 42700 kJ/kg at constant engine speed, with engine driven pumps (two cooling water + one lubricating oil pumps). Tolerance 5%.The fuel consumption at 85 % load is guaranteed and the values at other loads are given for indication only.

Note 5 Speed governor oil volume depends on the speed governor type.

Note 6 At manual starting the consumption may be 2...3 times lower.

ME = Engine driving propeller, variable speed

AE = Auxiliary engine driving generator

DE = Diesel-Electric engine driving generator

Subject to revision without notice.

4. Description of the Engine

4.1 Definitions

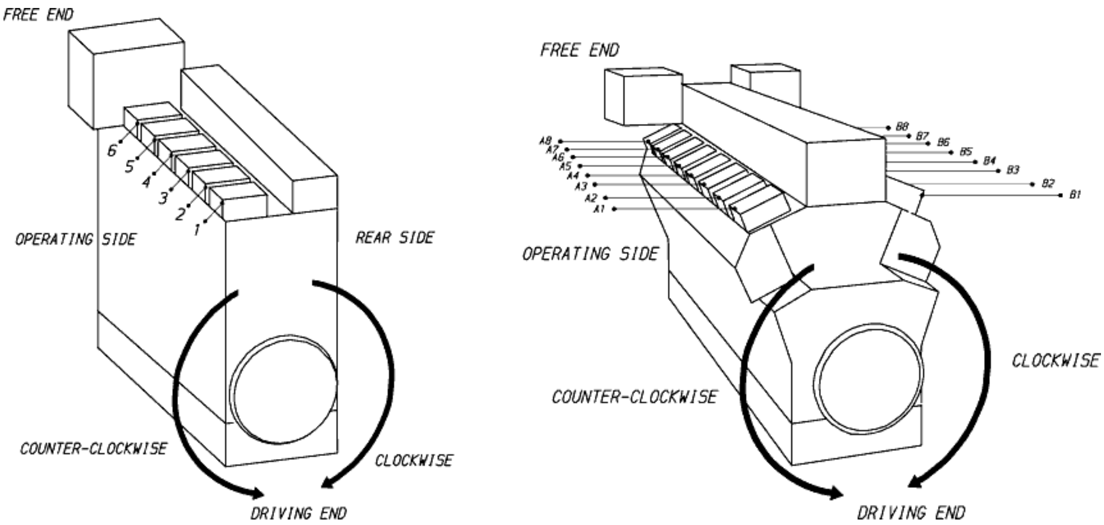


Fig 4-1 In-line engine and V-engine definitions (1V93C0029 / 1V93C0028)

4.2 Main engine components

Main dimensions and weights are presented in chapter *Main Data and Outputs*.

4.2.1 Engine block

The engine block is a one piece nodular cast iron component. The engine block is of stiff and durable design to absorb internal forces. The engine can be resiliently mounted without requiring any intermediate foundations.

The engine block carries the under-slung crankshaft.

The main bearing caps, made of nodular cast iron, are fixed from below by two hydraulically tensioned studs. They are guided sideways by the engine block at the top as well as at the bottom. Hydraulically tightened horizontal side studs provide a very rigid crankshaft bearing.

For ease of mounting the engine feet (nodular cast iron) can be mounted in a number of positions along the engine block. This minimises modifications to existing foundation and makes various mounting configurations easy to implement.

Engine–driven cooling water pumps and a lubricating oil pump are mounted on a multi functional cast iron housing (pump module) which is fitted at the free end of the engine.

4.2.2 Crankshaft

The crankshaft is forged in one piece and is underslung in the engine block. The crankshaft design satisfies the requirements of all classification societies.

The crankshaft design features a very short cylinder distance with a maximum bearing length resulting in a short engine. The crankshaft is forged from one piece of high tensile steel.

Counterweights are fitted on the crankshaft webs. The high degree of balancing results in an even and thick oil film for all bearings. The gear on the crankshaft is fitted by a flange connection.

Depending on the outcome of the torsional vibration calculation, vibration dampers will be fit at the free end of the engine. If required full output can be taken from either end of the engine.

4.2.3 Connecting rod

The connecting rod is of forged alloy steel. All connecting rod studs are hydraulically tightened.

The connecting rod has a horizontal split at the crankpin bearing. The advantages of this type of connecting rod are:

- Shorter length
- High rigidity (stiffness)
- Low mass (results in smaller bearing load)

For overhaul the piston and connecting rod are removed together with the cylinder liner as one unit. The oil supply for the piston cooling, gudgeon pin bush and piston skirt lubrication takes place through a single drilling in the connecting rod.

4.2.4 Main bearings and big end bearings

The main bearings and the crankpin bearings are of the bi–metal type with a steel backing and a soft running layer with excellent corrosion resistance.

4.2.5 Cylinder liner

The cylinder liners are centrifugally cast of a special grey cast iron alloy developed for good wear resistance and high strength. They are of wet type, sealed against the engine block by means of a gasket at the upper part and by O-rings at the lower part. To eliminate the risk of bore polishing the liner is equipped with an anti-polishing ring.

Cooling around the liner is divided into two parts: the greater volume in the lower part for uniform cooling water distribution and a smaller volume at the top of the jacket to facilitate an efficient cooling due to a high flow velocity.

4.2.6 Piston

The piston is of composite design with nodular cast iron skirt and steel crown. The piston skirt and cylinder liner are lubricated by a unique lubricating system utilizing lubricating nozzles in the piston skirt. This system ensures excellent running behaviour and constant low lubrication oil consumption during all operating conditions. Oil is fed through the connecting rod to the cooling spaces of the piston. The piston cooling operates according to the cocktail shaker principle. The piston ring grooves in the piston top are hardened for better wear resistance.

4.2.7 Piston rings

The piston ring set consists of two directional compression rings and one spring-loaded conformable oil scraper ring. All rings are chromium-plated and located in the piston crown. The two compression rings are asymmetrically profiled.

4.2.8 Cylinder head

The cylinder head is made of spheroidal or grey lamellar cast iron. The thermally loaded flame plate is cooled efficiently by cooling water led from the periphery radially towards the centre of the head. Cooling channels are drilled in the bridges between valves, to provide the best possible heat transfer.

The mechanical load is absorbed by a strong intermediate deck, which together with the upper deck and the side walls form a box section in the four corners of which the hydraulically tightened cylinder head bolts are situated. The exhaust valve seats are directly water-cooled.

All valves are equipped with valve rotators.

A “multi-duct” casting is fitted to the cylinder head. It connects the following media with the cylinder head:

- charge air from the receiver
- exhaust gas to exhaust system
- cooling water from cylinder head to the return pipe

4.2.9 Camshaft and valve mechanism

The cams are integrated in the drop forged completely hardened camshaft material. To provide the required rigidity to deal with the high transmission forces involved, the fuel cam is located very close to the bearing.

The bearing journals are made in separate pieces which are fitted to the camshaft sections by means of flanged connections. This design allows lateral dismantling of the camshaft sections.

The camshaft bearings are located in integrated bores in the engine block casting. The built–on valve tappet unit bolted to the engine block makes maintenance easy.

The valve tappets are of piston type with self-adjustment of roller against cam to give an even distribution of the contact pressure. The valve springs make the valve mechanism dynamically stable.

Variable Inlet valve Closure (VIC), which is available on IMO Tier 2 engines, offers flexibility to apply early inlet valve closure at high load for lowest NOx levels, while good part-load performance is ensured by adjusting the advance to zero at low load. The inlet valve closure can be adjusted up to 30° crank angle.

4.2.10 Camshaft drive

The camshaft is driven from the crankshaft through a fully integrated gear train.

Camshaft gear is shrunk on camshaft. Adjusting of timing is possible by means of oil pressure on the gear wheel.

4.2.11 Turbocharging and charge air cooling

The charge air module for the V–engine is a casting in which the charge air cooler is accommodated and which supports the turbochargers.

For the in–line engine the turbocharger support and the charge air housing are different modules. Connections between turbocharger, charge air cooler and scavenging air duct as well as the connections to the cooling water systems and turbocharger housing(s) are integrated. This construction eliminates the conventional piping outside the engine.

The selected turbocharger offers the ideal combination of high-pressure ratios and good efficiency at full and part load.

The turbocharger is supplied with inboard plain bearings, which offers easy maintenance of the cartridge from the compressor side. The turbocharger is lubricated by engine lubricating oil with integrated connections.

The turbocharger(s) is (are) as standard located at the driving end, but can also be mounted on the free end.

The charge air cooler is of the one-stage type for in-line engines and of the two–stage type, consisting of HT and LT cooling water sections, for V-engines. Treated fresh water is used in both sections. The charge air cooler is an insert type element and can easily be removed for cleaning the air side.

The water side is accessible through removal of the cooler end covers.

4.2.12 Fuel injection equipment

The high injection pressure and bore to stroke ratio ensure low NOx emission and low fuel oil consumption. The fuel injection equipment and system piping are located in a hot box, providing maximum reliability and safety when using pre-heated heavy fuel oils. The fuel oil circulation lines are mounted directly in the fuel injection pump tappet housing. Particular design attention has been made to significantly reduce pressure pulses in the system.

The HP fuel pumps are individual per cylinder with shielded high pressure pipes. The HP fuel pumps are of the flow through type to ensure good performance with all fuel oil types. The pumps are completely isolated from the camshaft compartment preventing fuel contamination of the lubricating oil.

The nozzles of the fuel injector are cooled with lubricating oil.

The HP fuel pump is a reliable mono–element type designed for injection pressures up to 1500 bar. The engine is stopped through activation of the individual stop cylinders on each HP fuel pump.

4.2.13 Lubricating oil system

The engine internal lubricating oil system include the engine driven lubricating oil pump, the electrically driven prelubricating oil pump, thermostatic valve, filters and lubricating oil cooler. The lubricating oil pumps are located in the free end of the engine, while the automatic filter, cooler and thermostatic valve are integrated into one module.

4.2.14 Cooling water system

The fresh water cooling system is divided into a high temperature (HT) and a low temperature (LT) circuit.

The HT-water cools cylinder liners, cylinder heads and the first stage of the charge air cooler on V engines. The LT-water cools the second stage of the charge air cooler and the lubricating oil.

4.2.15 Exhaust pipes

The complete exhaust gas system is enclosed in an insulated box consisting of easily removable panels. Mineral wool is used as insulating material.

4.2.16 Pump module

The pump module is a cast iron housing fitted at the free end of the engine which supports the cooling water pumps, the lubricating oil pump(s) and the fuel oil circulating pump (for distillate fuel oil only). The module contains the liquid channels between the pumps and the corresponding channels in the engine block, the charge air module, the lubricating oil module and the engine sump. Also the thermostatic valves of the cooling water systems for V engines are mounted in the pump module.

4.2.17 Automation system

Wärtsilä 26 is equipped with a modular embedded automation system, Wärtsilä Unified Controls - UNIC C2 which has a hardwired interface for control functions and a bus communication interface for alarm and monitoring.

UNIC C2 has an engine safety module and a local control panel mounted on the engine. The engine safety module handles fundamental safety, for example overspeed and low lubricating oil pressure shutdown.

The safety module also performs fault detection on critical signals and alerts the alarm system about detected failures. The local control panel has push buttons for local start/stop and shutdown reset, as well as a display showing the most important operating parameters. Speed control is included in the automation system on the engine.

Conventional heavy duty cables are used on the engine and the number of connectors are minimised. Power supply, bus communication and safety-critical functions are doubled on the engine. All cables to/from external systems are connected to terminals in the main cabinet on the engine.

4.3 Cross section of the engine

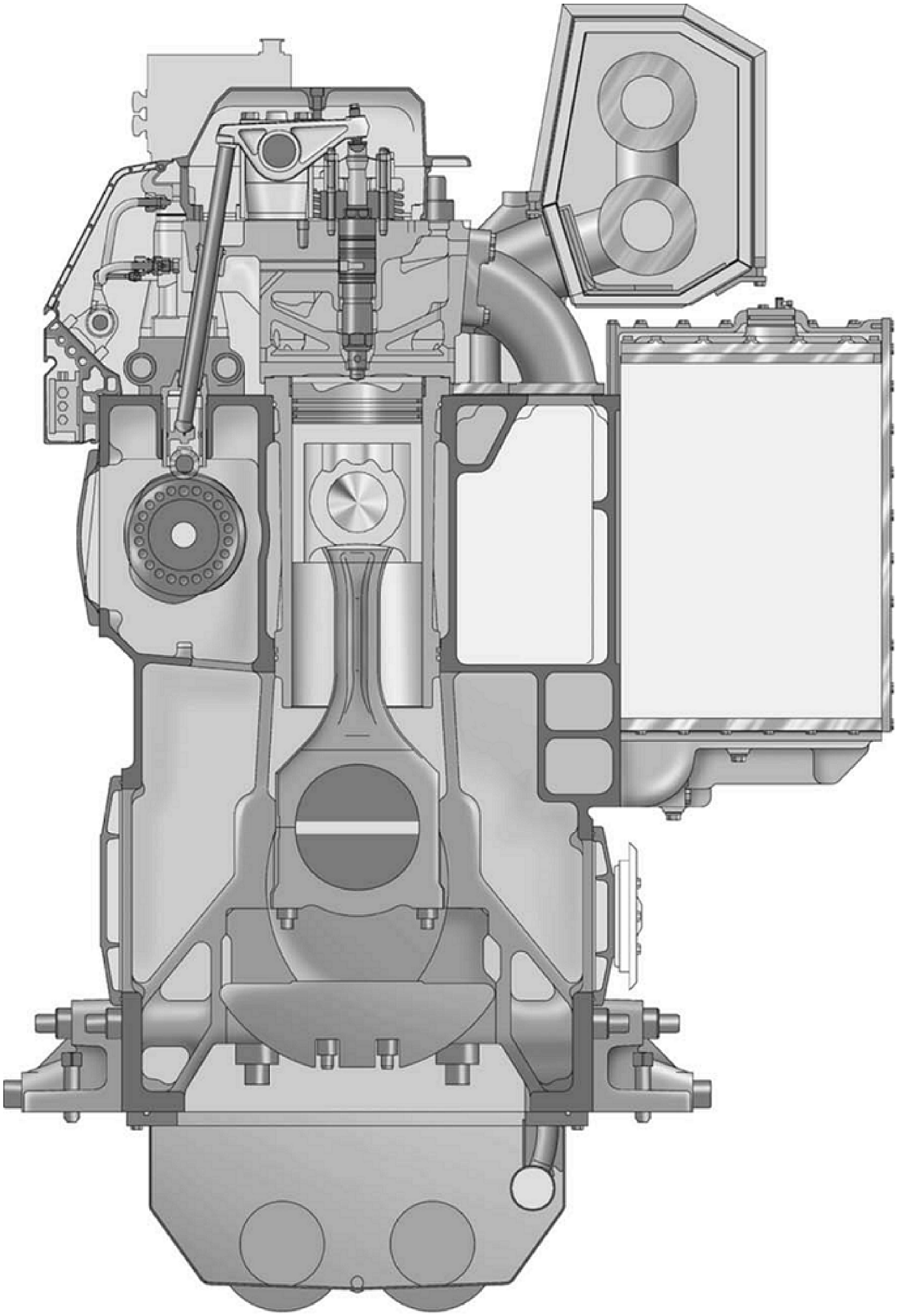


Fig 4-2 Cross section of in-line engine

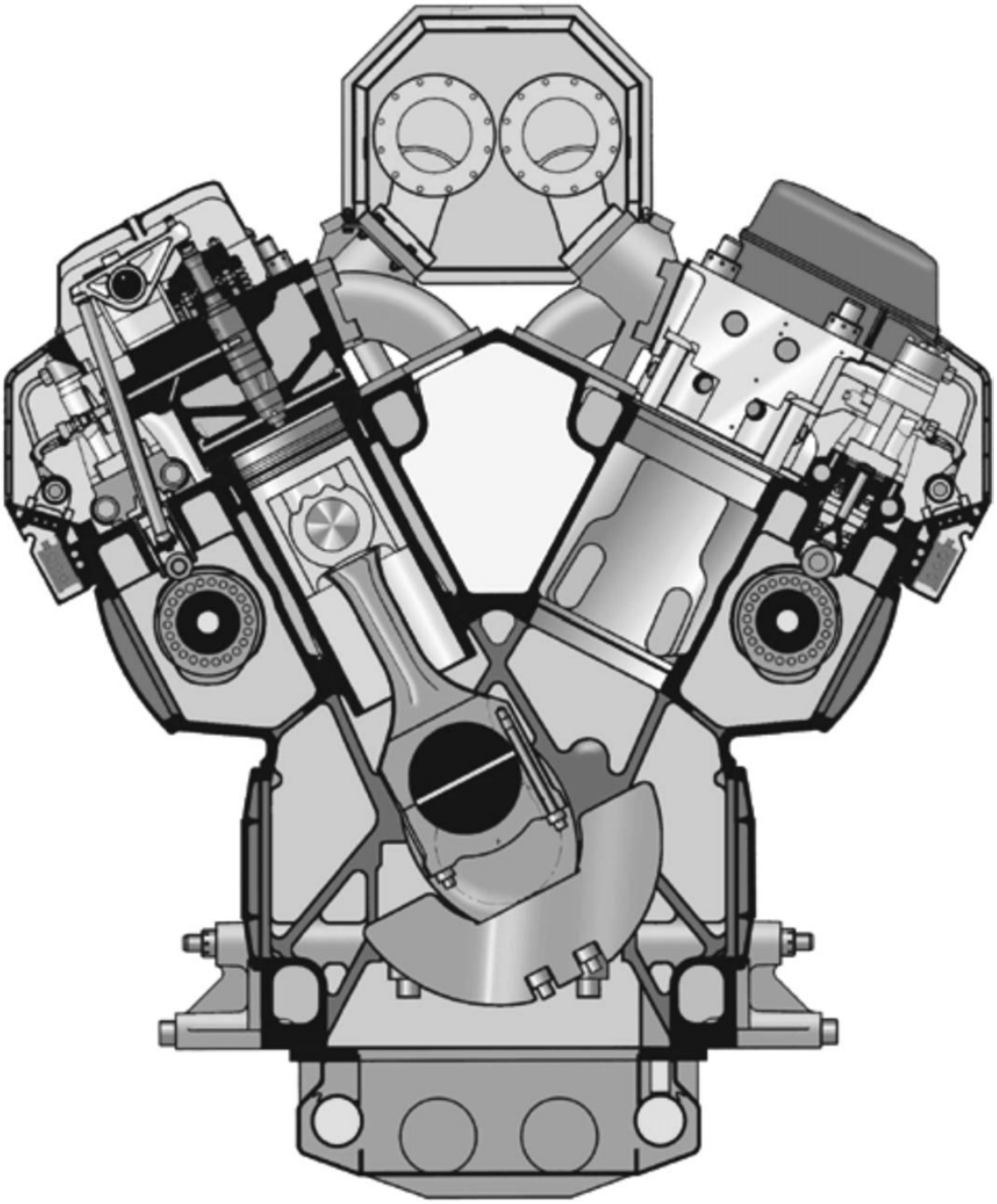


Fig 4-3 **Cross section of V-engine**

4.4 Overhaul intervals and expected life times

The following overhaul intervals and lifetimes are for guidance only. Actual figures will be different depending on service conditions. Expected component lifetimes have been adjusted to match overhaul intervals.

Achieved life times very much depend on the operating conditions, average loading of the engine, fuel quality used, fuel handling systems, performance of maintenance etc.

Table 4-1 Time between overhauls and expected lifetimes

Component	MDF	HFO	MDF	HFO
	Time between overhauls [h]		Expected component lifetimes [h]	
Piston	24 000	12 000	72 000	48 000
Piston rings	-	-	24 000	12 000
Cylinder liner	24 000	12 000	72 000	36 000
Cylinder head	24 000	12 000	-	-
Inlet valve	24 000	12 000	48 000	36 000
Exhaust valve	24 000	12 000	24 000	24 000
Injection valve	4000	4 000	-	-
Injection valve nozzle	-	-	4 000	4 000
Injection pump	24 000	24 000	-	-
Injection pump element	-	-	24 000	24 000
Main bearing	-	-	36 000	24 000
Turbocharger	-	-	12 000	24 000
	8 000	8 000	48 000[1)]	48 000
Intermediate bearing	-	-	48 000	36 000

NOTE

Lifetime for rotating parts.

4.5 Engine storage

At delivery the engine is provided with VCI coating and a tarpaulin. For storage longer than 3 months please contact Wärtsilä Finland Oy.

5. Piping Design, Treatment and Installation

This chapter provides general guidelines for the design, construction and installation of piping systems, however, not excluding other solutions of at least equal standard.

Fuel, lubricating oil, fresh water and compressed air piping is usually made in seamless carbon steel (DIN 2448) and seamless precision tubes in carbon or stainless steel (DIN 2391), exhaust gas piping in welded pipes of corten or carbon steel (DIN 2458). Pipes on the freshwater side of the cooling water system must not be galvanized. Sea-water piping should be made in hot dip galvanised steel, aluminium brass, cunifer or with rubber lined pipes.

Attention must be paid to fire risk aspects. Fuel supply and return lines shall be designed so that they can be fitted without tension. Flexible hoses must have an approval from the classification society. If flexible hoses are used in the compressed air system, a purge valve shall be fitted in front of the hose(s).

The following aspects shall be taken into consideration:

- Pockets shall be avoided. When not possible, drain plugs and air vents shall be installed
- Leak fuel drain pipes shall have continuous slope
- Vent pipes shall be continuously rising
- Flanged connections shall be used, cutting ring joints for precision tubes

Maintenance access and dismounting space of valves, coolers and other devices shall be taken into consideration. Flange connections and other joints shall be located so that dismounting of the equipment can be made with reasonable effort.

5.1 Pipe dimensions

When selecting the pipe dimensions, take into account:

- The pipe material and its resistance to corrosion/erosion.
- Allowed pressure loss in the circuit vs delivery head of the pump.
- Required net positive suction head (NPSH) for pumps (suction lines).
- In small pipe sizes the max acceptable velocity is usually somewhat lower than in large pipes of equal length.
- The flow velocity should not be below 1 m/s in sea water piping due to increased risk of fouling and pitting.
- In open circuits the velocity in the suction pipe is typically about 2/3 of the velocity in the delivery pipe.

Recommended maximum fluid velocities on the delivery side of pumps are given as guidance in table *5-1*.

Table 5-1 Recommended maximum velocities on pump delivery side for guidance

Piping	Pipe material	Max velocity [m/s]
Fuel piping (MDF and HFO)	Black steel	1.0
Lubricating oil piping	Black steel	1.5
Fresh water piping	Black steel	2.5

Piping	Pipe material	Max velocity [m/s]
Sea water piping	Galvanized steel	2.5
	Aluminium brass	2.5
	10/90 copper-nickel-iron	3.0
	70/30 copper-nickel	4.5
	Rubber lined pipes	4.5

NOTE

The diameter of gas fuel piping depends only on the allowed pressure loss in the piping, which has to be calculated project specifically.

Compressed air pipe sizing has to be calculated project specifically. The pipe sizes may be chosen on the basis of air velocity or pressure drop. In each pipeline case it is advised to check the pipe sizes using both methods, this to ensure that the alternative limits are not being exceeded.

Pipeline sizing on air velocity: For dry air, practical experience shows that reasonable velocities are 25...30 m/s, but these should be regarded as the maximum above which noise and erosion will take place, particularly if air is not dry. Even these velocities can be high in terms of their effect on pressure drop. In longer supply lines, it is often necessary to restrict velocities to 15 m/s to limit the pressure drop.

Pipeline sizing on pressure drop: As a rule of thumb the pressure drop from the starting air vessel to the inlet of the engine should be max. 0.1 MPa (1 bar) when the bottle pressure is 3 MPa (30 bar).

It is essential that the instrument air pressure, feeding to some critical control instrumentation, is not allowed to fall below the nominal pressure stated in chapter "*Compressed air system*" due to pressure drop in the pipeline.

5.2 Trace heating

The following pipes shall be equipped with trace heating (steam, thermal oil or electrical). It shall be possible to shut off the trace heating.

- All heavy fuel pipes
- All leak fuel and filter flushing pipes carrying heavy fuel

5.3 Operating and design pressure

The pressure class of the piping shall be equal to or higher than the maximum operating pressure, which can be significantly higher than the normal operating pressure.

A design pressure is defined for components that are not categorized according to pressure class, and this pressure is also used to determine test pressure. The design pressure shall also be equal to or higher than the maximum pressure.

The pressure in the system can:

- Originate from a positive displacement pump
- Be a combination of the static pressure and the pressure on the highest point of the pump curve for a centrifugal pump
- Rise in an isolated system if the liquid is heated

Within this Product Guide there are tables attached to drawings, which specify pressure classes of connections. The pressure class of a connection can be higher than the pressure class required for the pipe.

Example 1:

The fuel pressure before the engine should be 1.0 MPa (10 bar). The safety filter in dirty condition may cause a pressure loss of 0.1 MPa (1 bar). The viscosimeter, heater and piping may cause a pressure loss of 0.2 MPa (2 bar). Consequently the discharge pressure of the circulating pumps may rise to 1.3 MPa (13 bar), and the safety valve of the pump shall thus be adjusted e.g. to 1.4 MPa (14 bar).

- The minimum design pressure is 1.4 MPa (14 bar).
- The nearest pipe class to be selected is PN16.
- Piping test pressure is normally 1.5 x the design pressure = 2.1 MPa (21 bar).

Example 2:

The pressure on the suction side of the cooling water pump is 0.1 MPa (1 bar). The delivery head of the pump is 0.3 MPa (3 bar), leading to a discharge pressure of 0.4 MPa (4 bar). The highest point of the pump curve (at or near zero flow) is 0.1 MPa (1 bar) higher than the nominal point, and consequently the discharge pressure may rise to 0.5 MPa (5 bar) (with closed or throttled valves).

- The minimum design pressure is 0.5 MPa (5 bar).
- The nearest pressure class to be selected is PN6.
- Piping test pressure is normally 1.5 x the design pressure = 0.75 MPa (7.5 bar).

Standard pressure classes are PN4, PN6, PN10, PN16, PN25, PN40, etc.

5.4 Pipe class

Classification societies categorize piping systems in different classes (DNV) or groups (ABS) depending on pressure, temperature and media. The pipe class can determine:

- Type of connections to be used
- Heat treatment
- Welding procedure
- Test method

Systems with high design pressures and temperatures and hazardous media belong to class I (or group I), others to II or III as applicable. Quality requirements are highest in class I.

Examples of classes of piping systems as per DNV rules are presented in the table below.

Table 5-2 Classes of piping systems as per DNV rules

Media	Class I		Class II		Class III	
	MPa (bar)	°C	MPa (bar)	°C	MPa (bar)	°C
Steam	> 1.6 (16)	or > 300	< 1.6 (16)	and < 300	< 0.7 (7)	and < 170
Flammable fluid	> 1.6 (16)	or > 150	< 1.6 (16)	and < 150	< 0.7 (7)	and < 60
Other media	> 4 (40)	or > 300	< 4 (40)	and < 300	< 1.6 (16)	and < 200

5.5 Insulation

The following pipes shall be insulated:

- All trace heated pipes
- Exhaust gas pipes
- Exposed parts of pipes with temperature > 60°C

Insulation is also recommended for:

- Pipes between engine or system oil tank and lubricating oil separator
- Pipes between engine and jacket water preheater

5.6 Local gauges

Local thermometers should be installed wherever a new temperature occurs, i.e. before and after heat exchangers, etc.

Pressure gauges should be installed on the suction and discharge side of each pump.

5.7 Cleaning procedures

Instructions shall be given to manufacturers and fitters of how different piping systems shall be treated, cleaned and protected before delivery and installation. All piping must be checked and cleaned from debris before installation. Before taking into service all piping must be cleaned according to the methods listed below.

Table 5-3 Pipe cleaning

System	Methods
Fuel oil	A,B,C,D,F
Lubricating oil	A,B,C,D,F
Starting air	A,B,C
Cooling water	A,B,C
Exhaust gas	A,B,C
Charge air	A,B,C

A = Washing with alkaline solution in hot water at 80°C for degreasing (only if pipes have been greased)

B = Removal of rust and scale with steel brush (not required for seamless precision tubes)

C = Purging with compressed air

D = Pickling

F = Flushing

5.7.1 Pickling

Pipes are pickled in an acid solution of 10% hydrochloric acid and 10% formaline inhibitor for 4-5 hours, rinsed with hot water and blown dry with compressed air.

After the acid treatment the pipes are treated with a neutralizing solution of 10% caustic soda and 50 grams of trisodiumphosphate per litre of water for 20 minutes at 40...50°C, rinsed with hot water and blown dry with compressed air.

5.7.2 Flushing

More detailed recommendations on flushing procedures are when necessary described under the relevant chapters concerning the fuel oil system and the lubricating oil system. Provisions are to be made to ensure that necessary temporary bypasses can be arranged and that flushing hoses, filters and pumps will be available when required.

5.8 Flexible pipe connections

Pressurized flexible connections carrying flammable fluids or compressed air have to be type approved.

Great care must be taken to ensure proper installation of flexible pipe connections between resiliently mounted engines and ship's piping.

- Flexible pipe connections must not be twisted
- Installation length of flexible pipe connections must be correct
- Minimum bending radius must respected
- Piping must be concentrically aligned
- When specified the flow direction must be observed
- Mating flanges shall be clean from rust, burrs and anticorrosion coatings
- Bolts are to be tightened crosswise in several stages
- Flexible elements must not be painted
- Rubber bellows must be kept clean from oil and fuel
- The piping must be rigidly supported close to the flexible piping connections.

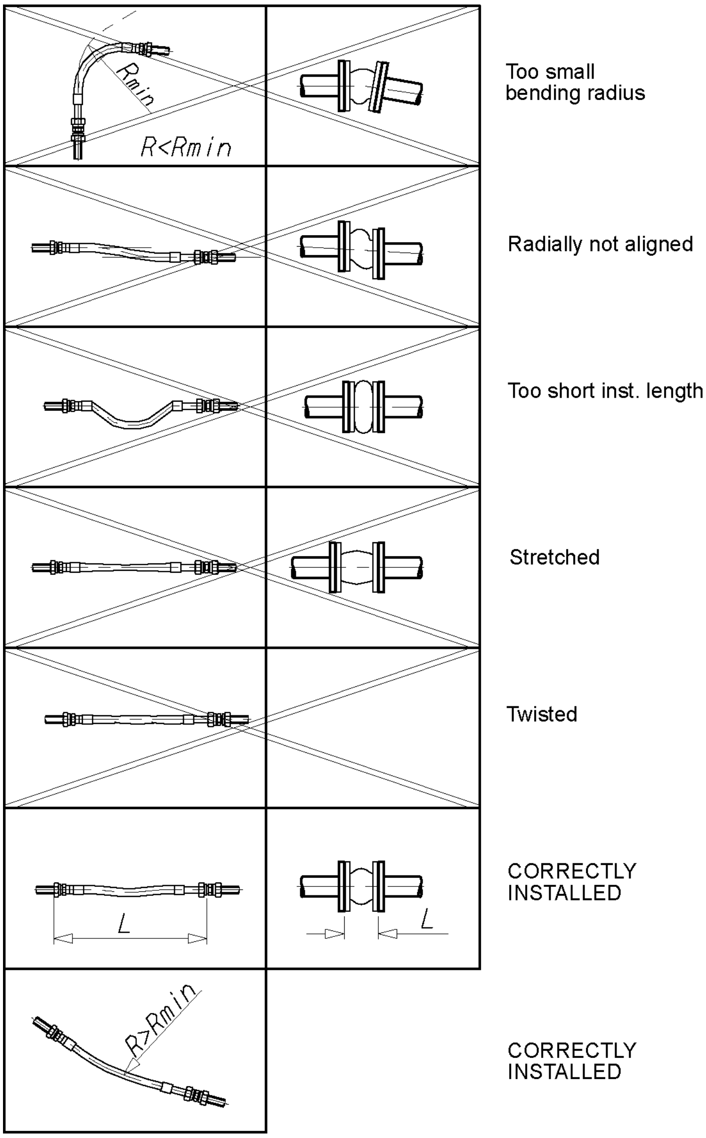


Fig 5-1 Flexible hoses (4V60B0100a)

5.9 Clamping of pipes

It is very important to fix the pipes to rigid structures next to flexible pipe connections in order to prevent damage caused by vibration. The following guidelines should be applied:

- Pipe clamps and supports next to the engine must be very rigid and welded to the steel structure of the foundation.
- The first support should be located as close as possible to the flexible connection. Next support should be 0.3-0.5 m from the first support.
- First three supports closest to the engine or generating set should be fixed supports. Where necessary, sliding supports can be used after these three fixed supports to allow thermal expansion of the pipe.
- Supports should never be welded directly to the pipe. Either pipe clamps or flange supports should be used for flexible connection.

Examples of flange support structures are shown in Figure *5-2*. A typical pipe clamp for a fixed support is shown in Figure *5-3*. Pipe clamps must be made of steel; plastic clamps or similar may not be used.

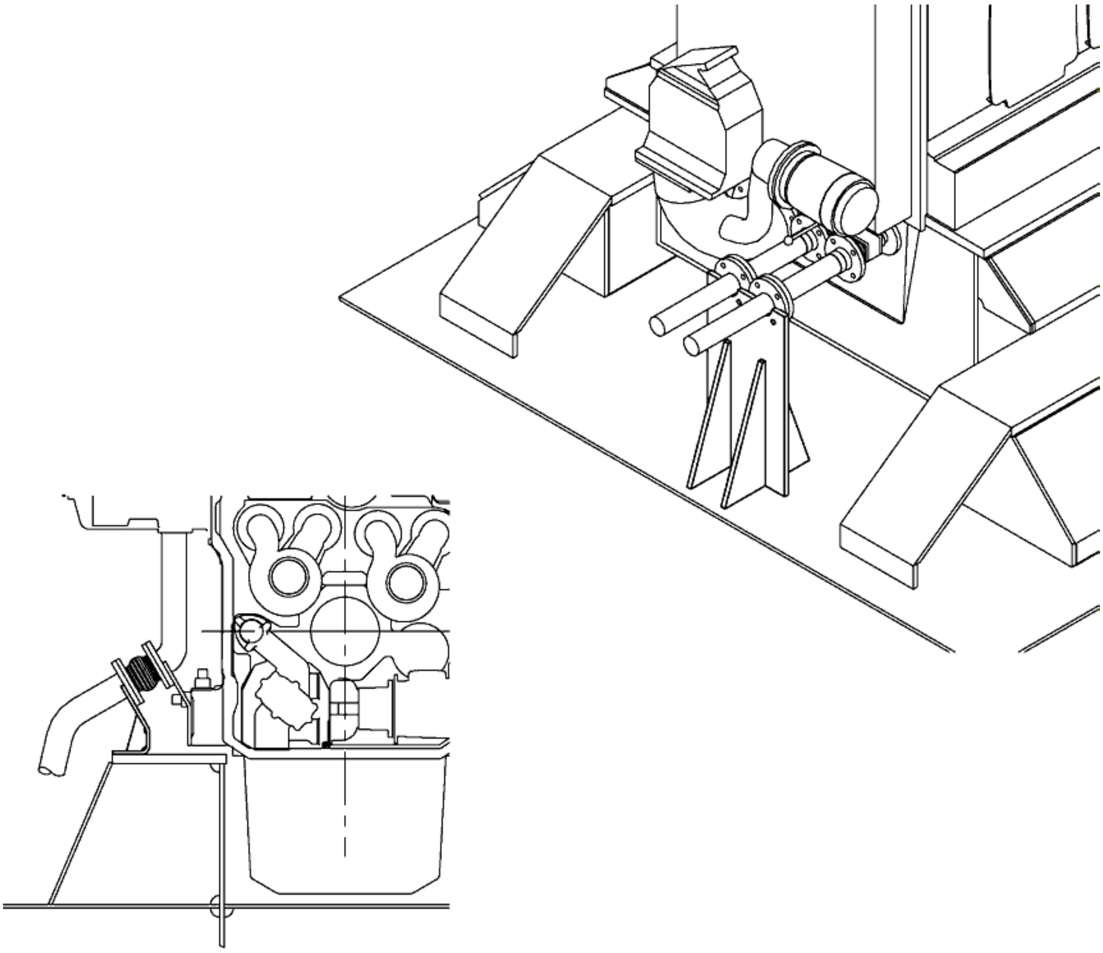
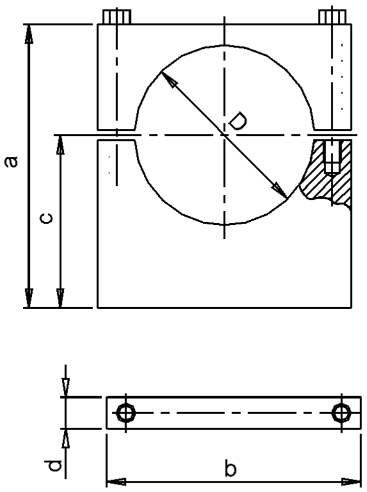


Fig 5-2 Flange supports of flexible pipe connections (4V60L0796)



DN	d_u [mm]	D [mm]	a [mm]	b [mm]	c [mm]	d [mm]	BOLTS
25	33.7	35	150	80	120	25	M10x50
32	42.4	43	150	75	120	25	M10x50
40	48.3	48	154.5	100	115	25	M12x60
50	60.3	61	185	100	145	25	M12x60
65	76.1	76.5	191	115	145	25	M12x70
80	88.9	90	220	140	150	30	M12x90
100	114.3	114.5	196	170	121	25	M12x100
125	139.7	140	217	200	132	30	M16x120
150	168.3	170	237	240	132	30	M16x140
200	219.1	220	295	290	160	30	M16x160
250	273.0	274	355	350	190	30	M16x200

d_u = Pipe outer diameter

Fig 5-3 Pipe clamp for fixed support (4V61H0842)

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6. Fuel Oil System

6.1 Acceptable fuel characteristics

The fuel specifications are based on the ISO 8217:2017 (E) standard. Observe that a few additional properties not included in the standard are listed in the tables. For maximum fuel temperature before the engine, see chapter "*Technical Data*".

The fuel shall not contain any added substances or chemical waste, which jeopardizes the safety of installations or adversely affects the performance of the engines or is harmful to personnel or contributes overall to air pollution.

6.1.1 Marine Diesel Fuel (MDF)

The fuel specification is based on the ISO 8217:2017(E) standard and covers the fuel grades ISO-F-DMX, DMA, DFA, DMZ, DFZ, DMB and DFB. These fuel grades are referred to as MDF (Marine Diesel Fuel).

The distillate grades mentioned above can be described as follows:

- DMX: A fuel quality which is suitable for use at ambient temperatures down to –15 °C without heating the fuel. Especially in merchant marine applications its use is restricted to lifeboat engines and certain emergency equipment due to reduced flash point. The low flash point which is not meeting the SOLAS requirement can also prevent the use in other marine applications, unless the fuel system is built according to special requirements. Also the low viscosity (min. 1.4 cSt) can prevent the use in engines unless the fuel can be cooled down enough to meet the min. injection viscosity limit of the engine.
- DMA: A high quality distillate, generally designated MGO (Marine Gas Oil) in the marine field.
- DFA: A similar quality distillate fuel compared to DMA category fuels but a presence of max. 7,0% v/v of Fatty acid methyl ester (FAME) is allowed.
- DMZ: A high quality distillate, generally designated MGO (Marine Gas Oil) in the marine field. An alternative fuel grade for engines requiring a higher fuel viscosity than specified for DMA grade fuel.
- DFZ: A similar quality distillate fuel compared to DMZ category fuels but a presence of max. 7,0% v/v of Fatty acid methyl ester (FAME) is allowed.
- DMB: A general purpose fuel which may contain trace amounts of residual fuel and is intended for engines not specifically designed to burn residual fuels. It is generally designated MDO (Marine Diesel Oil) in the marine field.
- DFB: A similar quality distillate fuel compared to DMB category fuels but a presence of max. 7,0% v/v of Fatty acid methyl ester (FAME) is allowed.

6.1.1.1 Table Light fuel oils

Table 6-1 Distillate fuel specifications

Characteristics	Unit	Limit	Category ISO-F							Test method(s) and references
			DMX	DMA	DFA	DMZ	DFZ	DMB	DFB	
Kinematic viscosity at 40 °C j)	mm^2/s a)	Max	5,500	6,000		6,000		11,00		ISO 3104
		Min	1,400 i)	2,000		3,000		2,000		

Characteristics		Unit	Limit	Category ISO-F							Test method(s) and references
				DMX	DMA	DFA	DMZ	DFZ	DMB	DFB	
Density at 15 °C		kg/m³	Max	-	890,0		890,0		900,0		ISO 3675 or ISO 12185
Cetane index			Min	45	40		40		35		ISO 4264
Sulphur b, k)		% m/m	Max	1,00	1,00		1,00		1,50		ISO 8754 or ISO 14596, ASTM D4294
Flash point		°C	Min	43,0 l)	60,0		60,0		60,0		ISO 2719
Hydrogen sulfide		mg/kg	Max	2,00	2,00		2,00		2,00		IP 570
Acid number		mg KOH/g	Max	0,5	0,5		0,5		0,5		ASTM D664
Total sediment by hot filtration		% m/m	Max	-	-		-		0,10 c)		ISO 10307-1
Oxidation stability		g/m³	Max	25	25		25		25 d)		ISO 12205
Fatty acid methyl ester (FAME) e)		% v/v	Max	-	-	7,0	-	7,0	-	7,0	ASTM D7963 or IP 579
Carbon residue – Micro method on 10% distillation residue		% m/m	Max	0,30	0,30		0,30		-		ISO 10370
Carbon residue – Micro method		% m/m	Max	-	-		-		0,30		ISO 10370
Cloud point f)	winter	°C	Max	-16	Report		Report		-		ISO 3015
	summer			-16	-		-		-		
Cold filter plugging point f)	winter	°C	Max	-	Report		Report		-		IP 309 or IP 612
	summer			-	-		-		-		
Pour point f)	winter	°C	Max	-	-6		-6		0		ISO 3016
	summer			-	0		0		6		
Appearance			-	Clear and bright g)					c)		-
Water		% v/v	Max	-	-		-		0,30 c)		ISO 3733
Ash		% m/m	Max	0,010	0,010		0,010		0,010		ISO 6245
Lubricity, corr. wear scar diam. h)		µm	Max	520	520		520		520 d)		ISO 12156-1

NOTE

a) 1 mm^2/s = 1 cSt.

b) Notwithstanding the limits given, the purchaser shall define the maximum sulphur content in accordance with relevant statutory limitations.

c) If the sample is not clear and bright, the total sediment by hot filtration and water tests shall be required.

d) If the sample is not clear and bright, the Oxidation stability and Lubricity tests cannot be undertaken and therefore, compliance with this limit cannot be shown.

e) See ISO 8217:2017(E) standard for details.

f) Pour point cannot guarantee operability for all ships in all climates. The purchaser should confirm that the cold flow characteristics (pour point, cloud point, cold filter clogging point) are suitable for ship's design and intended voyage.

g) If the sample is dyed and not transparent, see ISO 8217:2017(E) standard for details related to water analysis limits and test methods.

h) The requirement is applicable to fuels with a sulphur content below 500 mg/kg (0,050 % m/m).

Additional notes not included in the ISO 8217:2017(E) standard:

i) Low min. viscosity of 1,400 mm^2/s can prevent the use ISO-F-DMX category fuels in Wärtsilä® 4-stroke engines unless a fuel can be cooled down enough to meet the specified min. injection viscosity limit.

j) Allowed kinematic viscosity before the injection pumps for Wärtsilä 26 engine type is 2,0 - 24 mm^2/s.

k) There doesn't exist any minimum sulphur content limit for Wärtsilä® 4-stroke diesel engines and also the use of Ultra Low Sulphur Diesel (ULSD) is allowed provided that the fuel quality fulfils other specified properties.

l) Low flash point of min. 43 °C can prevent the use ISO-F-DMX category fuels in Wärtsilä® engines in marine applications unless the ship's fuel system is built according to special requirements allowing the use or that the fuel supplier is able to guarantee that flash point of the delivered fuel batch is above 60 °C being a requirement of SOLAS and classification societies.

6.1.2 Heavy Fuel Oil (HFO)

Residual fuel grades are referred to as HFO (Heavy Fuel Oil). The fuel specification HFO 2 is based on the ISO 8217:2017(E) standard and covers the categories ISO-F-RMA 10 to RMK 700. Fuels fulfilling the specification HFO 1 permit longer overhaul intervals of specific engine components than HFO 2.

6.1.2.1 Table Heavy fuel oils

Table 6-2 Residual fuel specifications

Characteristics	Unit	Limit HFO 1	Limit HFO 2	Test method reference
Kinematic viscosity bef. inj. pumps [d)]	mm^2/s [b)]	20 ± 4	20 ± 4	-
Kinematic viscosity at 50 °C, max.	mm^2/s [b)]	700,0	700,0	ISO 3104
Density at 15 °C, max.	kg/m^3	991,0 / 1010,0 [a)]	991,0 / 1010,0 [a)]	ISO 3675 or ISO 12185
CCAI, max. [f)]	-	850	870	ISO 8217, Annex F
Sulphur, max. [c, g)]	%m/m	Statutory requirements		ISO 8754 or ISO 14596
Flash point, min.	°C	60,0	60,0	ISO 2719
Hydrogen sulfide, max.	mg/kg	2,00	2,00	IP 570
Acid number, max.	mg KOH/g	2,5	2,5	ASTM D664
Total sediment aged, max.	%m/m	0,10	0,10	ISO 10307-2
Carbon residue, micro method, max.	%m/m	15,00	20,00	ISO 10370
Asphaltenes, max. [d)]	%m/m	8,0	14,0	ASTM D3279
Pour point (upper), max. [e)]	°C	30	30	ISO 3016
Water, max. [d)]	%V/V	0,50	0,50	ISO 3733 or ASTM D6304-C [d)]
Water before engine, max. [d)]	%V/V	0,30	0,30	ISO 3733 or ASTM D6304-C [d)]
Ash, max.	%m/m	0,050	0,150	ISO 6245 or LP1001 [d, i)]
Vanadium, max. [g)]	mg/kg	100	450	IP 501, IP 470 or ISO 14597
Sodium, max. [g)]	mg/kg	50	100	IP 501 or IP 470
Sodium before engine, max. [d, g)]	mg/kg	30	30	IP 501 or IP 470
Aluminium + Silicon, max. [d)]	mg/kg	30	60	IP 501, IP 470 or ISO 10478
Aluminium + Silicon before engine, max. [d)]	mg/kg	15	15	IP 501, IP 470 or ISO 10478
Used lubricating oil [h)] - Calcium, max. - Zinc, max. - Phosphorus, max.	 mg/kg mg/kg mg/kg	 30 15 15	 30 15 15	 IP 501 or IP 470 IP 501 or IP 470 IP 501 or IP 500

NOTE

a) Max. 1010 kg/m³ at 15 °C, provided the fuel treatment system can reduce water and solids (sediment, sodium, aluminium, silicon) before engine to the specified levels.

b) 1 mm²/s = 1 cSt.

c) The purchaser shall define the maximum sulphur content in accordance with relevant statutory limitations.

d) Additional properties specified by the engine manufacturer, which are not included in the ISO 8217:2017(E) standard.

e) Purchasers shall ensure that this pour point is suitable for the equipment on board / at the plant, especially if the ship operates / plant is located in cold climates.

f) Straight run residues show CCAI values in the 770 to 840 range and are very good ignitors. Cracked residues delivered as bunkers may range from 840 to – in exceptional cases – above 900. Most bunkers remain in the max. 850 to 870 range at the moment. CCAI value cannot always be considered as an accurate tool to determine fuels' ignition properties, especially concerning fuels originating from modern and more complex refinery processes.

g) Sodium contributes to hot corrosion on exhaust valves when combined with high sulphur and vanadium contents. Sodium also strongly contributes to fouling of the exhaust gas turbine blading at high loads. The aggressiveness of the fuel depends on its proportions of sodium and vanadium, but also on the total amount of ash. Hot corrosion and deposit formation are, however, also influenced by other ash constituents. It is therefore difficult to set strict limits based only on the sodium and vanadium content of the fuel. Also a fuel with lower sodium and vanadium contents than specified above, can cause hot corrosion on engine components.

h) The fuel shall be free from used lubricating oil (ULO). A fuel shall be considered to contain ULO when either one of the following conditions is met:

- Calcium > 30 mg/kg and zinc > 15 mg/kg OR
- Calcium > 30 mg/kg and phosphorus > 15 mg/kg

i) The ashing temperatures can vary when different test methods are used having an influence on the test result.

6.2 Internal fuel oil system

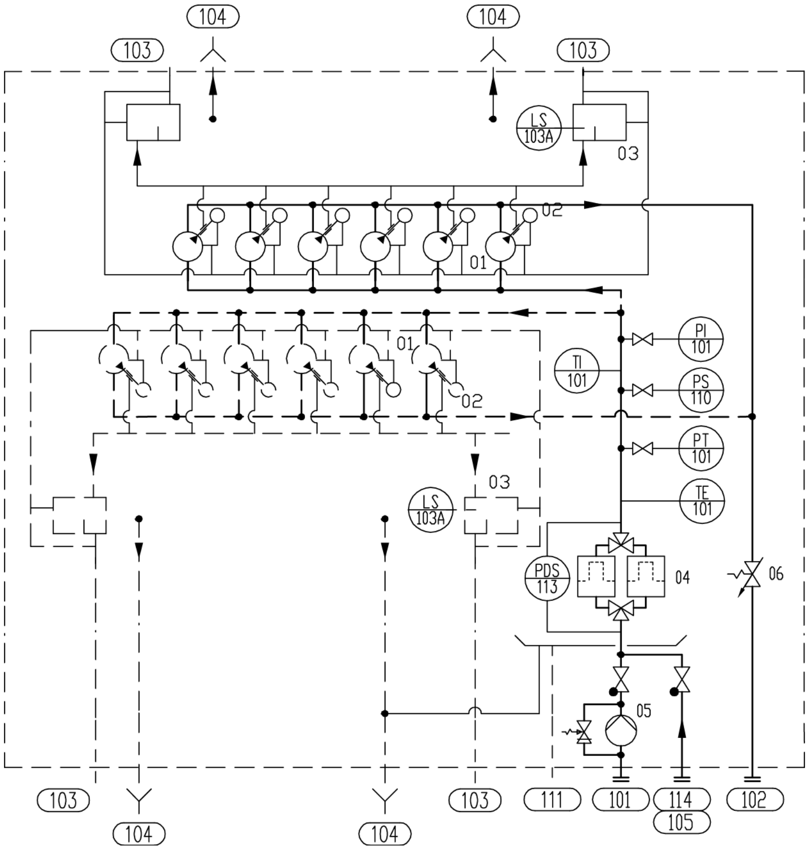


Fig 6-1 Internal fuel oil system, MDF (DAAE031815b)

System components					
01	Injection pump	03	Fuel oil leakage collector	05	Engine driven fuel feed pump
02	Injection valve	04	Duplex fine filter	06	Pressure regulating valve

Sensors and indicators			
PT101	Fuel oil pressure, engine inlet	TI101	Fuel oil temperature, engine inlet
TE101	Fuel oil temperature, engine inlet	PI101	Fuel oil pressure, engine inlet (if GL)
LS103A/B	Fuel oil leakage, injection pipe	PS110	Fuel oil stand-by pump start (if stand-by pump)
PDS113	Fuel oil filter, pressure difference		

Pipe connections		Size	Pressure class	Standard
101	Fuel inlet	DN32	PN16	DIN2633/DIN2513 R13
101	Fuel inlet, 16V	DN40	PN16	DIN2633/DIN2513 R13
102	Fuel outlet	L26: DN32 V26: DN25	PN16	DIN2633/DIN2513 V13
103	Leak fuel drain, clean fuel	OD22	PN250	DIN2353
104	Leak fuel drain, dirty fuel	OD22	PN250	DIN2353
105	Fuel stand-by connection, in-line engines	L26: DN32 V26: DN25	PN16	DIN2633
111	Drain from fuel filter drip tray, V-engines only	OD22	PN250	DIN2353
114	Fuel from starting/day tank, in-line engines	L26: DN32 V26: DN25	PN16	DIN2633

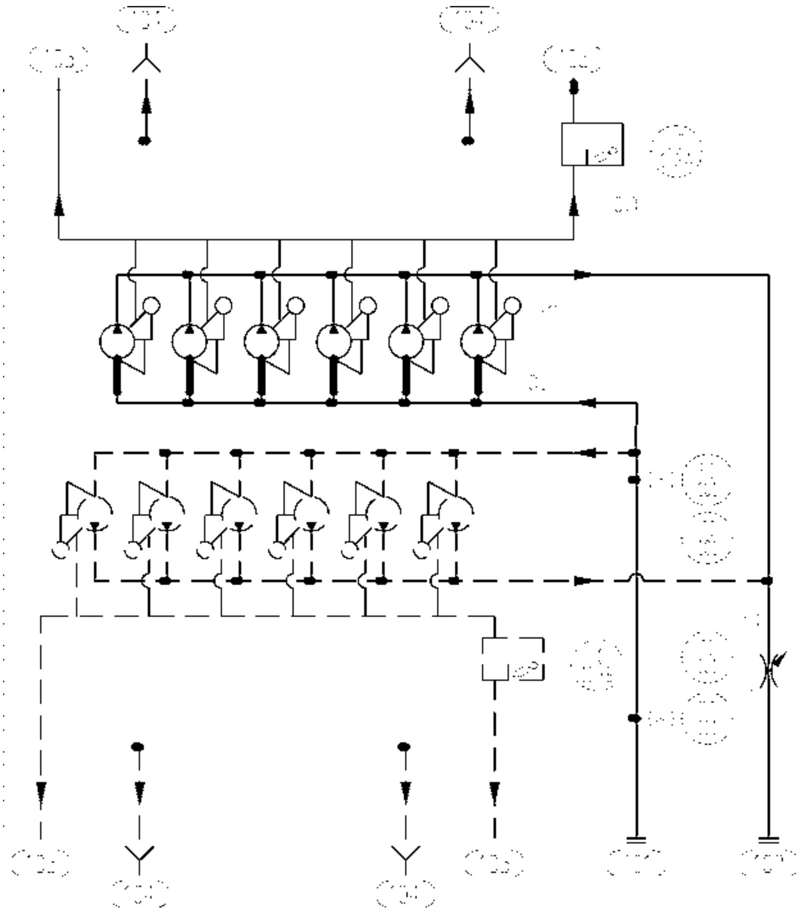


Fig 6-2 Internal fuel oil system, HFO (DAAE031861B)

System components			
01	Injection pump	03	Fuel oil leakage collector
02	Injection valve	04	Adjustable orifice

Sensors and indicators			
PT101	Fuel oil pressure, engine inlet	TI101	Fuel oil temperature, engine inlet
TE101	Fuel oil temperature, engine inlet	PI101	Fuel oil pressure, engine inlet (if GL)
LS103A/B	Fuel oil leakage, injection pipe A/B bank		

Pipe connections		Size	Pressure class	Standard
101	Fuel inlet, in-line engines	DN32	PN16	DIN2633/DIN2513 R13
101	Fuel inlet, V-engines	DN25	PN16	DIN2633/DIN2513 V13
102	Fuel outlet, in-line engines	DN32	PN16	DIN2633/DIN2513 R13
102	Fuel outlet, V-engines	DN25	PN16	DIN2633/DIN2513 V13
103	Leak fuel drain, clean fuel	OD22	PN250	DIN2353
104	Leak fuel drain, dirty fuel	OD22	PN250	DIN2353

The engine can be specified to either operate on heavy fuel oil (HFO) or on marine diesel fuel (MDF). The engine is designed for continuous operation on HFO. It is however possible to operate HFO engines on MDF intermittently without alternations. If the operation of the engine is changed from HFO to continuous operation on MDF, then a change of exhaust valves from Nimonic to Stellite is recommended.

A pressure control valve in the fuel return line on the engine maintains desired pressure before the injection pumps.

6.2.1 Leak fuel system

Clean leak fuel from the injection valves and the injection pumps is collected on the engine and drained by gravity through a clean leak fuel connection. The clean leak fuel can be re-used without separation. The quantity of clean leak fuel is given in chapter *Technical data*.

Other possible leak fuel and spilled water and oil is separately drained from the hot-box through dirty fuel oil connections and it shall be led to a sludge tank.

6.3 External fuel oil system

The design of the external fuel system may vary from ship to ship, but every system should provide well cleaned fuel of correct viscosity and pressure to each engine. Temperature control is required to maintain stable and correct viscosity of the fuel before the injection pumps (see *Technical data*). Sufficient circulation through every engine connected to the same circuit must be ensured in all operating conditions.

The fuel treatment system should comprise at least one settling tank and two separators. Correct dimensioning of HFO separators is of greatest importance, and therefore the recommendations of the separator manufacturer must be closely followed. Poorly centrifuged fuel is harmful to the engine and a high content of water may also damage the fuel feed system.

Injection pumps generate pressure pulses into the fuel feed and return piping.

The fuel pipes between the feed unit and the engine must be properly clamped to rigid structures. The distance between the fixing points should be at close distance next to the engine. See chapter *Piping design, treatment and installation*.

A connection for compressed air should be provided before the engine, together with a drain from the fuel return line to the clean leakage fuel or overflow tank. With this arrangement it is possible to blow out fuel from the engine prior to maintenance work, to avoid spilling.

NOTE

In multiple engine installations, where several engines are connected to the same fuel feed circuit, it must be possible to close the fuel supply and return lines connected to the engine individually. This is a SOLAS requirement. It is further stipulated that the means of isolation shall not affect the operation of the other engines, and it shall be possible to close the fuel lines from a position that is not rendered inaccessible due to fire on any of the engines.

6.3.1 Fuel heating requirements HFO

Heating is required for:

- Bunker tanks, settling tanks, day tanks
- Pipes (trace heating)
- Separators
- Fuel feeder/booster units

To enable pumping the temperature of bunker tanks must always be maintained 5...10°C above the pour point, typically at 40...50°C. The heating coils can be designed for a temperature of 60°C.

The tank heating capacity is determined by the heat loss from the bunker tank and the desired temperature increase rate.

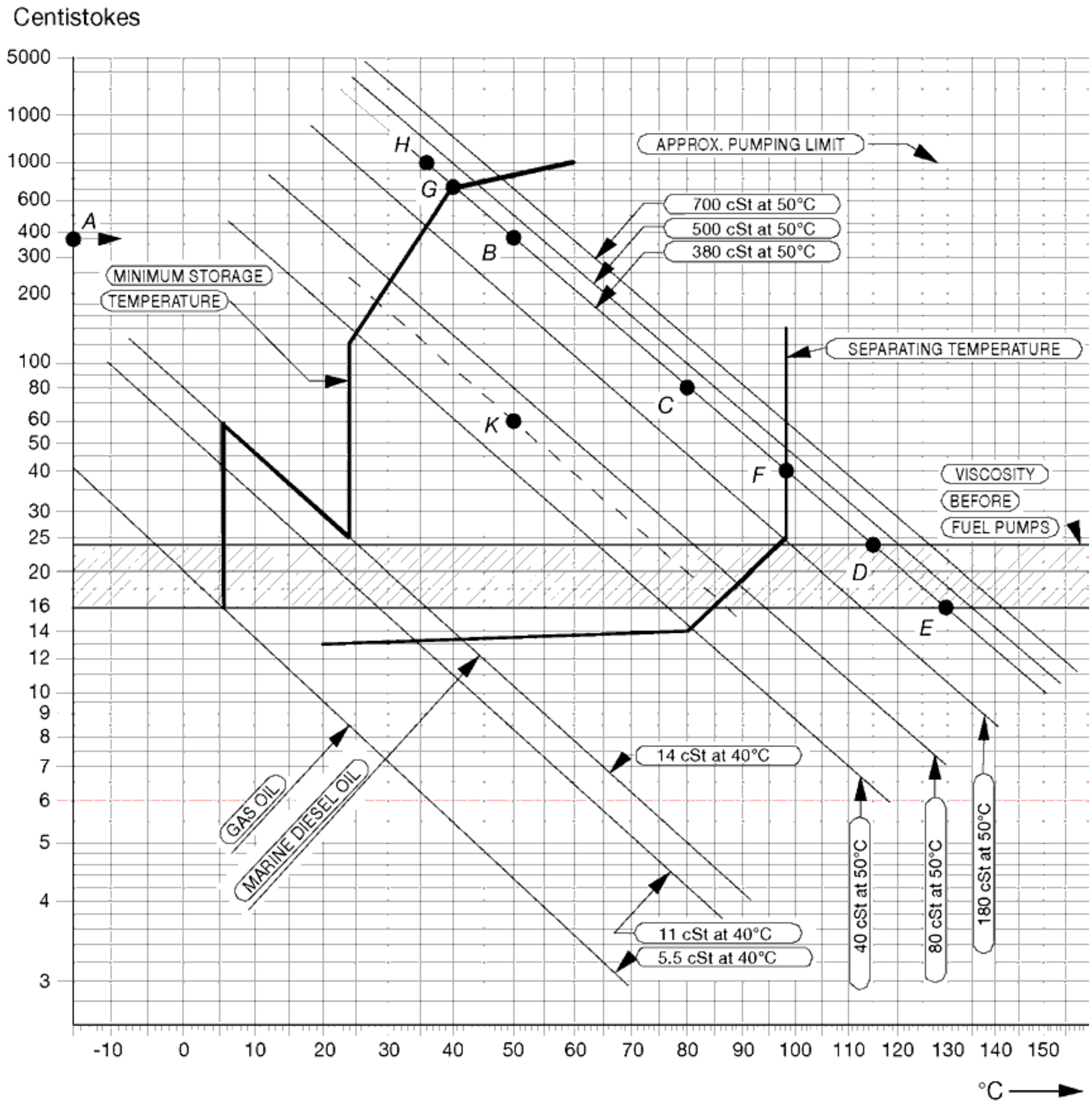


Fig 6-3 **Fuel oil viscosity-temperature diagram for determining the pre-heating temperatures of fuel oils (4V92G0071b)**

Example 1: A fuel oil with a viscosity of 380 cSt (A) at 50°C (B) or 80 cSt at 80°C (C) must be pre-heated to 115 - 130°C (D-E) before the fuel injection pumps, to 98°C (F) at the separator and to minimum 40°C (G) in the bunker tanks. The fuel oil may not be pumpable below 36°C (H).

To obtain temperatures for intermediate viscosities, draw a line from the known viscosity/temperature point in parallel to the nearest viscosity/temperature line in the diagram.

Example 2: Known viscosity 60 cSt at 50°C (K). The following can be read along the dotted line: viscosity at 80°C = 20 cSt, temperature at fuel injection pumps 74 - 87°C, separating temperature 86°C, minimum bunker tank temperature 28°C.

6.3.2 Fuel tanks

The fuel oil is first transferred from the bunker tanks to settling tanks for initial separation of sludge and water. After centrifuging the fuel oil is transferred to day tanks, from which fuel is supplied to the engines.

6.3.2.1 Settling tank, HFO (1T02) and MDF (1T10)

Separate settling tanks for HFO and MDF are recommended.

To ensure sufficient time for settling (water and sediment separation), the capacity of each tank should be sufficient for min. 24 hours operation at maximum fuel consumption. The tanks should be provided with internal baffles to achieve efficient settling and have a sloped bottom for proper draining. The temperature in HFO settling tanks should be maintained between 50°C and 70°C, which requires heating coils and insulation of the tank. Usually MDF settling tanks do not need heating or insulation, but the tank temperature should be in the range 20...40°C.

6.3.2.2 Day tank, HFO (1T03) and MDF (1T06)

Two day tanks for HFO are to be provided, each with a capacity sufficient for at least 8 hours operation at maximum fuel consumption. A separate tank is to be provided for MDF. The capacity of the MDF tank should ensure fuel supply for 8 hours. Settling tanks may not be used instead of day tanks.

The day tank must be designed so that accumulation of sludge near the suction pipe is prevented and the bottom of the tank should be sloped to ensure efficient draining. HFO day tanks shall be provided with heating coils and insulation. It is recommended that the viscosity is kept below 140 cSt in the day tanks. Due to risk of wax formation, fuels with a viscosity lower than 50 cSt at 50°C must be kept at a temperature higher than the viscosity would require. Continuous separation is nowadays common practice, which means that the HFO day tank temperature normally remains above 90°C. The temperature in the MDF day tank should be in the range 20...40°C. The level of the tank must ensure a positive static pressure on the suction side of the fuel feed pumps.

If black-out starting with MDF from a gravity tank is foreseen, then the tank must be located at least 15 m above the engine crankshaft.

6.3.2.3 Starting tank, MDF (1T09)

The starting tank is needed when the engine is equipped with the engine driven fuel feed pump and when the MDF day tank (1T06) cannot be located high enough, i.e. less than 2 meters above the engine crankshaft.

The purpose of the starting tank is to ensure that fuel oil is supplied to the engine during starting. The starting tank shall be located at least 2 meters above the engine crankshaft. The volume of the starting tank should be approx. 60 l.

6.3.2.4 Leak fuel tank, clean fuel (1T04)

Clean leak fuel is drained by gravity from the engine. The fuel should be collected in a separate clean leak fuel tank, from where it can be pumped to the day tank and reused without separation. The pipes from the engine to the clean leak fuel tank should be arranged continuosly sloping. The tank and the pipes must be heated and insulated, unless the installation is designed for operation on MDF only.

The leak fuel piping should be fully closed to prevent dirt from entering the system.

6.3.2.5 Leak fuel tank, dirty fuel (1T07)

In normal operation no fuel should leak out from the components of the fuel system. In connection with maintenance, or due to unforeseen leaks, fuel or water may spill in the hot box of the engine. The spilled liquids are collected and drained by gravity from the engine through the dirty fuel connection.

Dirty leak fuel shall be led to a sludge tank. The tank and the pipes must be heated and insulated, unless the installation is designed for operation exclusively on MDF.

6.3.3 Fuel treatment

6.3.3.1 Separation

Heavy fuel (residual, and mixtures of residuals and distillates) must be cleaned in an efficient centrifugal separator before it is transferred to the day tank.

Classification rules require the separator arrangement to be redundant so that required capacity is maintained with any one unit out of operation.

All recommendations from the separator manufacturer must be closely followed.

Centrifugal disc stack separators are recommended also for installations operating on MDF only, to remove water and possible contaminants. The capacity of MDF separators should be sufficient to ensure the fuel supply at maximum fuel consumption. Would a centrifugal separator be considered too expensive for a MDF installation, then it can be accepted to use coalescing type filters instead. A coalescing filter is usually installed on the suction side of the circulation pump in the fuel feed system. The filter must have a low pressure drop to avoid pump cavitation.

Separator mode of operation

The best separation efficiency is achieved when also the stand-by separator is in operation all the time, and the throughput is reduced according to actual consumption.

Separators with monitoring of cleaned fuel (without gravity disc) operating on a continuous basis can handle fuels with densities exceeding 991 kg/m3 at 15°C. In this case the main and stand-by separators should be run in parallel.

When separators with gravity disc are used, then each stand-by separator should be operated in series with another separator, so that the first separator acts as a purifier and the second as clarifier. This arrangement can be used for fuels with a density of max. 991 kg/m3 at 15°C. The separators must be of the same size.

Separation efficiency

The term Certified Flow Rate (CFR) has been introduced to express the performance of separators according to a common standard. CFR is defined as the flow rate in l/h, 30 minutes after sludge discharge, at which the separation efficiency of the separator is 85%, when using defined test oils and test particles. CFR is defined for equivalent fuel oil viscosities of 380 cSt and 700 cSt at 50°C. More information can be found in the CEN (European Committee for Standardisation) document CWA 15375:2005 (E).

The separation efficiency is measure of the separator's capability to remove specified test particles. The separation efficiency is defined as follows:

$$n = 100 \times \left(1 - \frac{C_{out}}{C_{in}}\right)$$

where:

n = separation efficiency [%]

C_{out} = number of test particles in cleaned test oil

C_{in} = number of test particles in test oil before separator

6.3.3.2 Separator unit (1N02/1N05)

Separators are usually supplied as pre-assembled units designed by the separator manufacturer.

Typically separator modules are equipped with:

- Suction strainer (1F02)
- Feed pump (1P02)
- Pre-heater (1E01)
- Sludge tank (1T05)
- Separator (1S01/1S02)
- Sludge pump
- Control cabinets including motor starters and monitoring

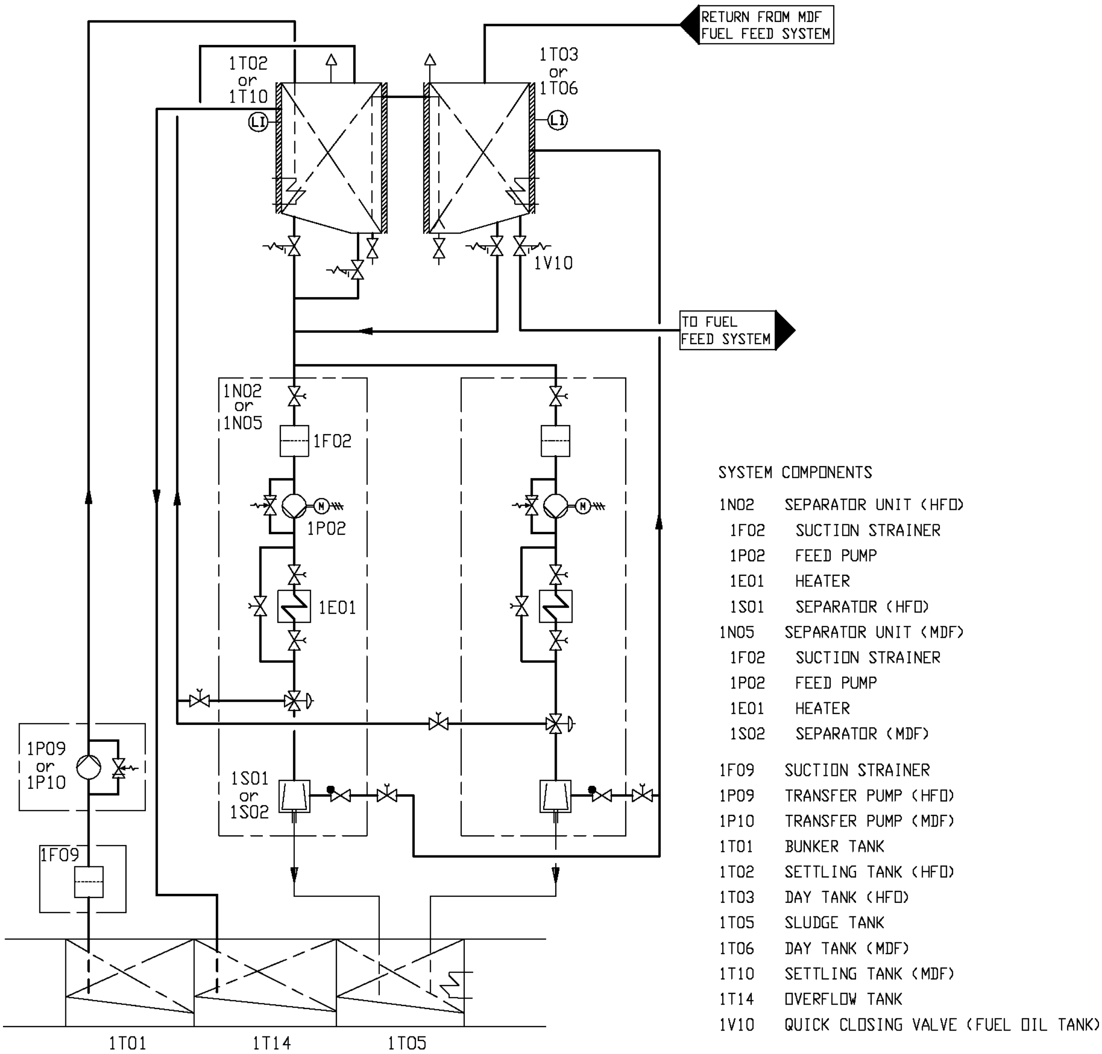


Fig 6-4 Fuel transfer and separating system (V76F6626F)

6.3.3.3 Separator feed pumps (1P02)

Feed pumps should be dimensioned for the actual fuel quality and recommended throughput of the separator. The pump should be protected by a suction strainer (mesh size about 0.5 mm)

An approved system for control of the fuel feed rate to the separator is required.

Design data:	HFO	MDF
Design pressure	0.5 MPa (5 bar)	0.5 MPa (5 bar)
Design temperature	100°C	50°C
Viscosity for dimensioning electric motor	1000 cSt	100 cSt

6.3.3.4 Separator pre-heater (1E01)

The pre-heater is dimensioned according to the feed pump capacity and a given settling tank temperature.

The surface temperature in the heater must not be too high in order to avoid cracking of the fuel. The temperature control must be able to maintain the fuel temperature within ± 2°C.

Recommended fuel temperature after the heater depends on the viscosity, but it is typically 98°C for HFO and 20...40°C for MDF. The optimum operating temperature is defined by the sperarator manufacturer.

The required minimum capacity of the heater is:

$$P = \frac{Q \times \Delta T}{1700}$$

where:

P = heater capacity [kW]

Q = capacity of the separator feed pump [l/h]

ΔT = temperature rise in heater [°C]

For heavy fuels ΔT = 48°C can be used, i.e. a settling tank temperature of 50°C. Fuels having a viscosity higher than 5 cSt at 50°C require pre-heating before the separator.

The heaters to be provided with safety valves and drain pipes to a leakage tank (so that the possible leakage can be detected).

6.3.3.5 Separator (1S01/1S02)

Based on a separation time of 23 or 23.5 h/day, the service throughput Q [l/h] of the separator can be estimated with the formula:

$$Q = \frac{P \times b \times 24[h]}{\rho \times t}$$

where:

P = max. continuous rating of the diesel engine(s) [kW]

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

ρ = density of the fuel [kg/m^3]

t = daily separating time for self cleaning separator [h] (usually = 23 h or 23.5 h)

The flow rates recommended for the separator and the grade of fuel must not be exceeded. The lower the flow rate the better the separation efficiency.

Sample valves must be placed before and after the separator.

6.3.3.6 MDF separator in HFO installations (1S02)

A separator for MDF is recommended also for installations operating primarily on HFO. The MDF separator can be a smaller size dedicated MDF separator, or a stand-by HFO separator used for MDF.

6.3.3.7 Sludge tank (1T05)

The sludge tank should be located directly beneath the separators, or as close as possible below the separators, unless it is integrated in the separator unit. The sludge pipe must be continuously falling.

6.3.4 Fuel feed system - MDF installations

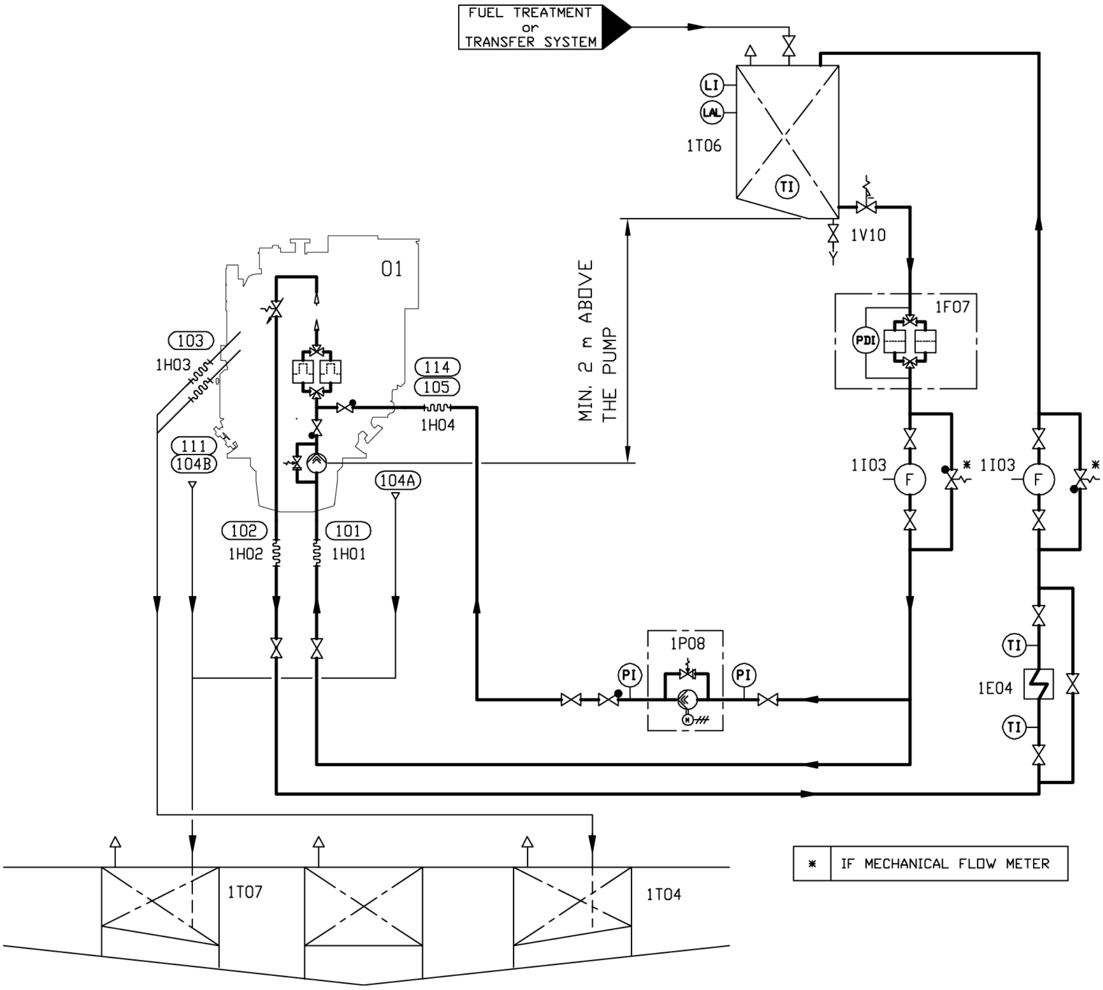


Fig 6-5 Fuel feed system for inline engine (DAAF078369a)

System components			
01	Diesel engine Wärtsilä L26	1P08	Stand-by pump, MDF
1E04	Cooler (MDF)	1T04	Leak fuel tank, clean fuel
1F07	Suction strainer, MDF	1T06	Day tank, MDF
1H0X	Flexible pipe connection	1T07	Leak fuel tank, dirty fuel
1I03	Flow meter	1V10	Quick closing valve (fuel oil tank)

Pos	Pipe connections	Size
101	Fuel inlet	DN32
102	Fuel outlet	DN32
103	Leak fuel drain, clean fuel	2 * OD22
104A	Leak fuel drain, dirty fuel	OD22
104B	Leak fuel drain, dirty fuel	OD22
105	Fuel stand-by connection	DN32
111	Drain fuel from fuel filter drip tray	OD22
114	Fuel from starting/day tank	DN32

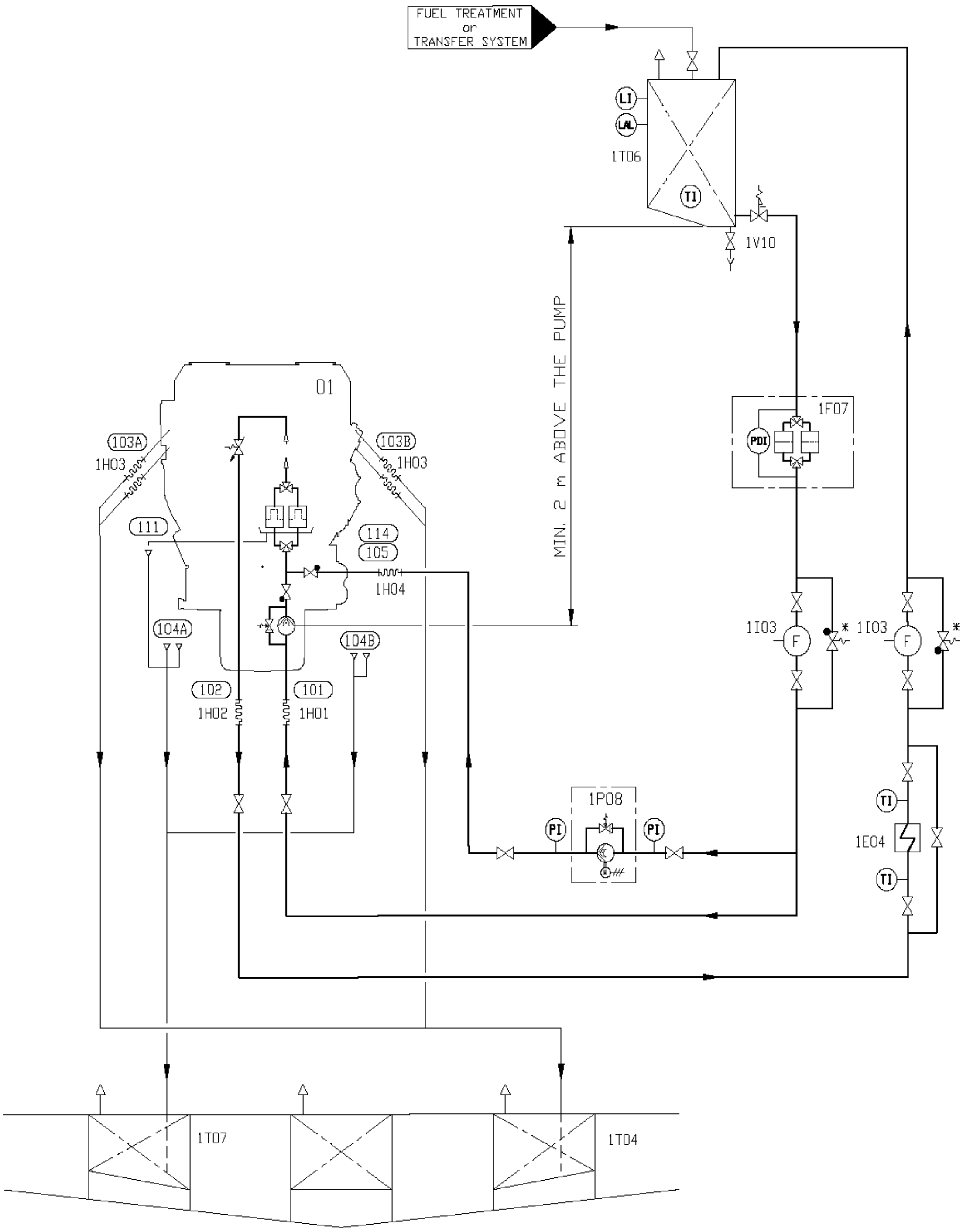


Fig 6-6 Fuel feed system for V-engine (DAAF078370 a)

System components			
01	Diesel engine Wärtsilä V26	1P08	Stand-by pump, MDF
1E04	Cooler (MDF)	1T04	Leak fuel tank, clean fuel
1F07	Suction strainer, MDF	1T06	Day tank, MDF
1H0X	Flexible pipe connection	1T07	Leak fuel tank, dirty fuel
1I03	Flow meter	1V10	Quick closing valve (fuel oil tank)

Pos	Pipe connections	Size
101	Fuel inlet	DN32

Pos	Pipe connections	Size
102	Fuel outlet	DN25
103	Leak fuel drain, clean fuel	4 * OD22
104	Leak fuel drain, dirty fuel	4 * OD22
105	Fuel stand-by connection	DN25
111	Drain fuel from fuel filter drip tray	OD22
114	Fuel from starting/day tank	DN25

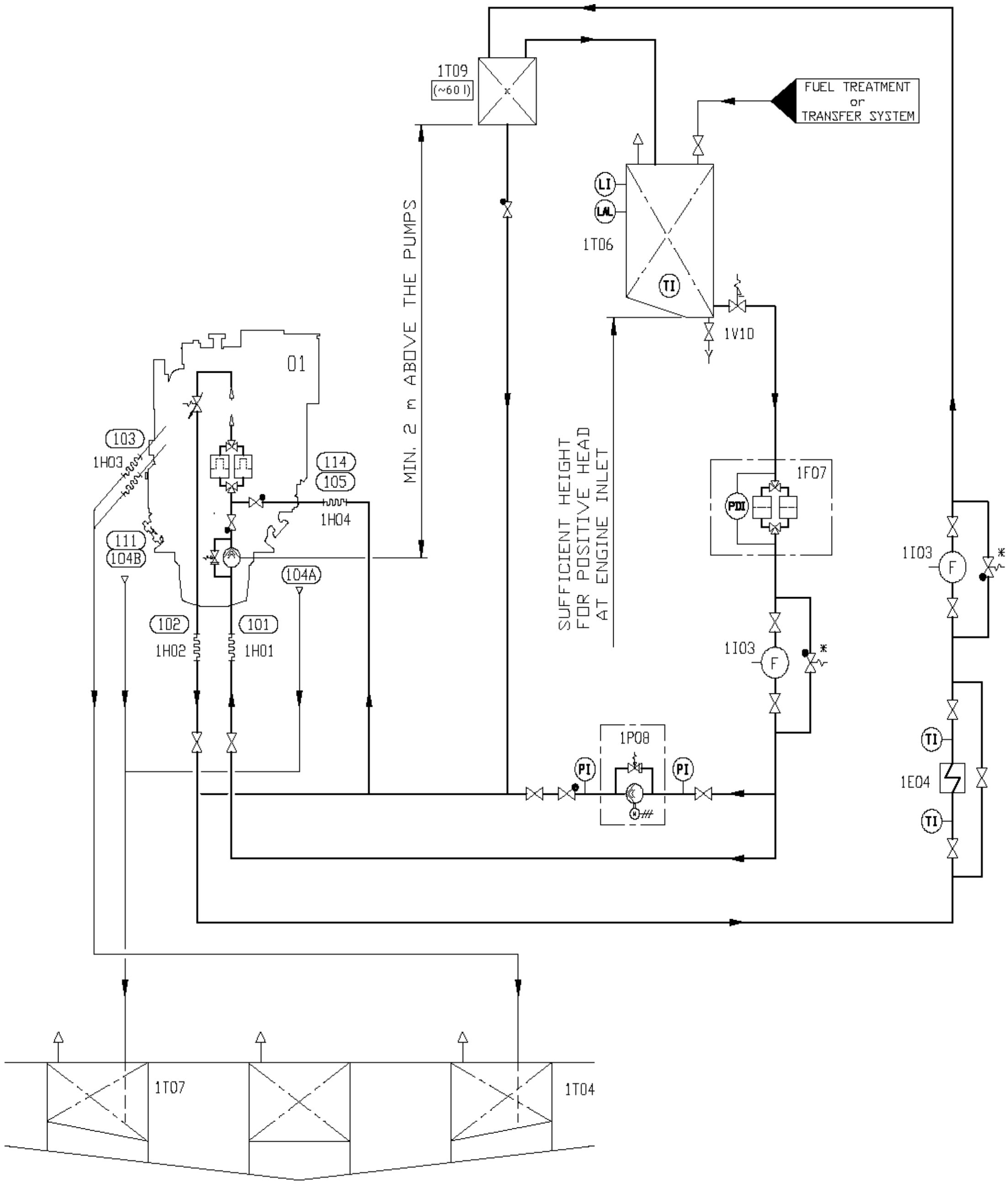


Fig 6-7 Typical example of external fuel system for multiple inline engine installation (DAAF078371 a)

System components			
01	Diesel engine Wärtsilä L26	1T04	Leak fuel tank, clean fuel
1E04	Cooler (MDF)	1T06	Day tank, MDF
1F07	Suction strainer, MDF	1T07	Leak fuel tank, dirty fuel
1H0X	Flexible pipe connection	1T09	Starting tank (MDF)
1I03	Flow meter	1V10	Quick closing valve (fuel oil tank)
1P08	Stand-by pump, MDF		

Pos	Pipe connections	Size
101	Fuel inlet	DN32
102	Fuel outlet	DN32

Pos	Pipe connections	Size
103	Leak fuel drain, clean fuel	2 * OD22
104A	Leak fuel drain, dirty fuel	OD22
104B	Leak fuel drain, dirty fuel	OD22
105	Fuel stand-by connection	DN32
111	Drain fuel from fuel filter drip tray	OD22
114	Fuel from starting/day tank	DN32

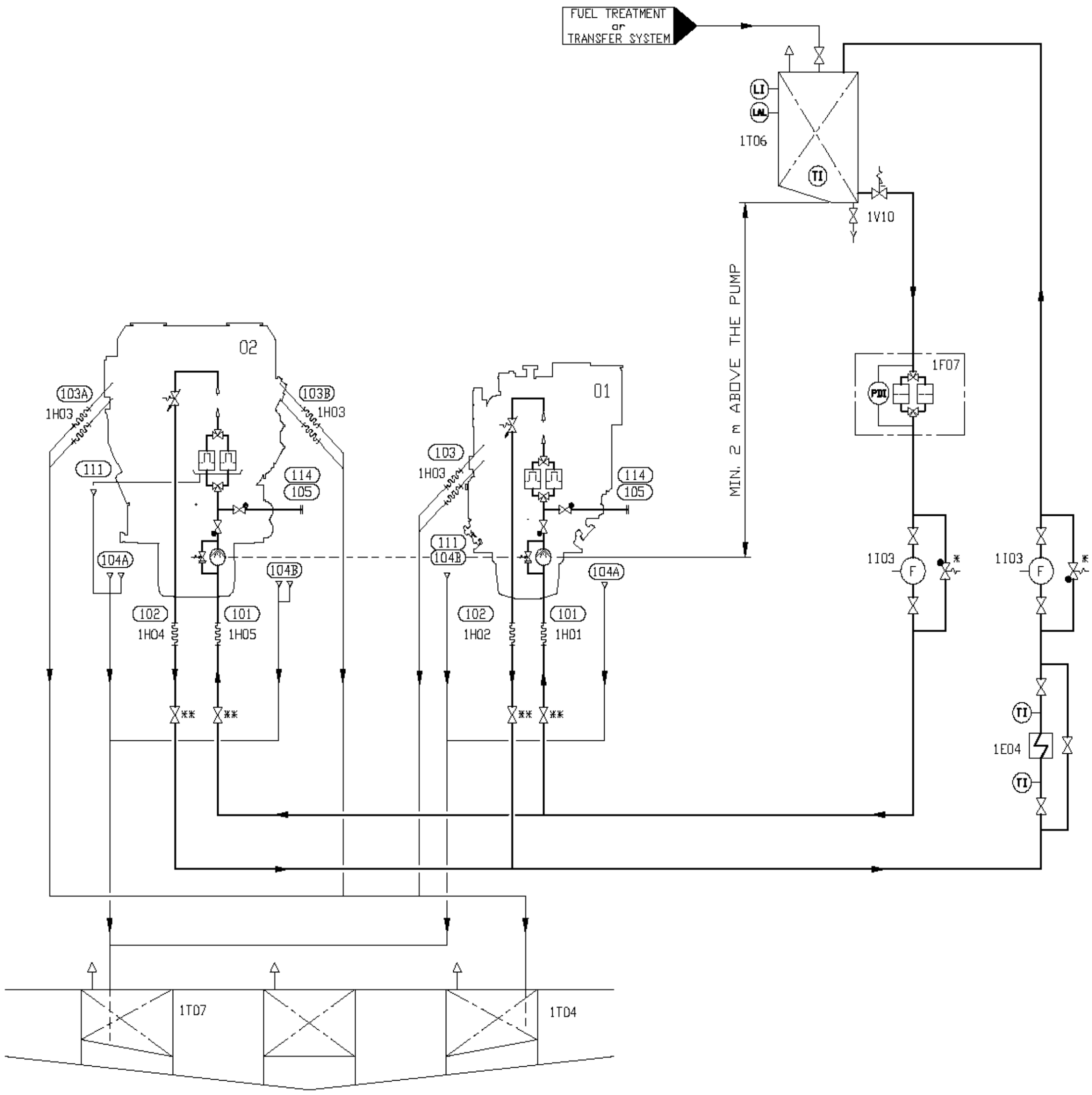


Fig 6-8 **Typical example of external fuel system for multiple engine installation (DAAF078372 a)**

System components			
01	Diesel engine Wärtsilä L26	1T04	Leak fuel tank, clean fuel
02	Diesel engine Wärtsilä V26	1T06	Day tank, MDF
1E04	Cooler (MDF)	1T07	Leak fuel tank, dirty fuel
1F07	Suction strainer, MDF	1V10	Quick closing valve (fuel oil tank)
1H0X	Flexible pipe connection		
1I03	Flow meter (MDF)		

Pos	Pipe connections	L26	V26
101	Fuel inlet	DN32	
102	Fuel outlet	DN32	DN25
103	Leak fuel drain, clean fuel	2 * OD22	4 * OD22
104A	Leak fuel drain, dirty fuel	OD22	2 * OD22
104B	Leak fuel drain, dirty fuel	OD22	2 * OD22
105	Fuel stand-by connection	DN32	DN25
111	Drain fuel from fuel filter drip tray	OD22	

Pos	Pipe connections	L26	V26
114	Fuel from starting/day tank	DN32	DN35

If the engines are to be operated on MDF only, heating of the fuel is normally not necessary. In such case it is sufficient to install the equipment listed below. Some of the equipment listed below is also to be installed in the MDF part of a HFO fuel oil system.

6.3.4.1 Circulation pump, MDF (1P03)

The circulation pump maintains the pressure at the injection pumps and circulates the fuel in the system. It is recommended to use a screw pump as circulation pump. A suction strainer with a fineness of 0.5 mm should be installed before each pump. There must be a positive static pressure of about 30 kPa on the suction side of the pump.

Design data:	
Capacity	6 x the total consumption of the connected engines
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	1.0 MPa (10 bar)
Nominal pressure	see chapter "*Technical Data*"
Design temperature	50°C
Viscosity for dimensioning of electric motor	90 cSt

6.3.4.2 Stand-by pump, MDF (1P08)

The stand-by pump is required in case of a single main engine equipped with an engine driven pump. It is recommended to use a screw pump as stand-by pump. The pump should be placed so that a positive static pressure of about 30 kPa is obtained on the suction side of the pump.

Design data:	
Capacity	6 x the total consumption of the connected engine
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	1.2 MPa (12 bar)
Design temperature	50°C
Viscosity for dimensioning of electric motor	90 cSt

6.3.4.3 Flow meter, MDF (1I03)

If the return fuel from the engine is conducted to a return fuel tank instead of the day tank, one consumption meter is sufficient for monitoring of the fuel consumption, provided that the meter is installed in the feed line from the day tank (before the return fuel tank). A fuel oil cooler is usually required with a return fuel tank.

The total resistance of the flow meter and the suction strainer must be small enough to ensure a positive static pressure of about 30 kPa on the suction side of the circulation pump.

There should be a by-pass line around the consumption meter, which opens automatically in case of excessive pressure drop.

6.3.4.4 Fine filter, MDF (1F05)

The fuel oil fine filter is a full flow duplex type filter with steel net. This filter must be installed as near the engine as possible.

The diameter of the pipe between the fine filter and the engine should be the same as the diameter before the filters.

Design data:	
Fuel viscosity	according to fuel specifications
Design temperature	50°C
Design flow	Larger than feed/circulation pump capacity
Design pressure	1.6 MPa (16 bar)
Fineness	25 μm (absolute mesh size)

Maximum permitted pressure drops at 14 cSt:	
- clean filter	20 kPa (0.2 bar)
- alarm	80 kPa (0.8 bar)

6.3.4.5 Pressure control valve, MDF (1V02)

The pressure control valve is installed when the installation includes a feeder/booster unit for HFO and there is a return line from the engine to the MDF day tank. The purpose of the valve is to increase the pressure in the return line so that the required pressure at the engine is achieved.

Design data:	
Capacity	Equal to circulation pump
Design temperature	50°C
Design pressure	1.6 MPa (16 bar)
Set point	0.4...0.7 MPa (4...7 bar)

6.3.4.6 MDF cooler (1E04)

The fuel viscosity may not drop below the minimum value stated in *Technical data*. When operating on MDF, the practical consequence is that the fuel oil inlet temperature must be kept below 45°C. Very light fuel grades may require even lower temperature.

Sustained operation on MDF usually requires a fuel oil cooler. The cooler is to be installed in the return line after the engine(s). LT-water is normally used as cooling medium.

If MDF viscosity in day tank drops below stated minimum viscosity limit then it is recommended to install an MDF cooler into the engine fuel supply line in order to have reliable viscosity control.

Design data:	
Heat to be dissipated	2 kW/cyl
Max. pressure drop, fuel oil	80 kPa (0.8 bar)
Max. pressure drop, water	60 kPa (0.6 bar)
Margin (heat rate, fouling)	min. 15%
Design temperature MDF/HFO installation	50/150°C

6.3.4.7 Return fuel tank (1T13)

The return fuel tank shall be equipped with a vent valve needed for the vent pipe to the MDF day tank. The volume of the return fuel tank should be at least 100 l.

6.3.4.8 Black out start

Diesel generators serving as the main source of electrical power must be able to resume their operation in a black out situation by means of stored energy. Depending on system design and classification regulations, it may in some cases be permissible to use the emergency generator. HFO engines without engine driven fuel feed pump can reach sufficient fuel pressure to enable black out start by means of:

- A gravity tank located min. 15 m above the crankshaft
- A pneumatically driven fuel feed pump (1P11)
- An electrically driven fuel feed pump (1P11) powered by an emergency power source

6.3.5 Fuel feed system - HFO installations

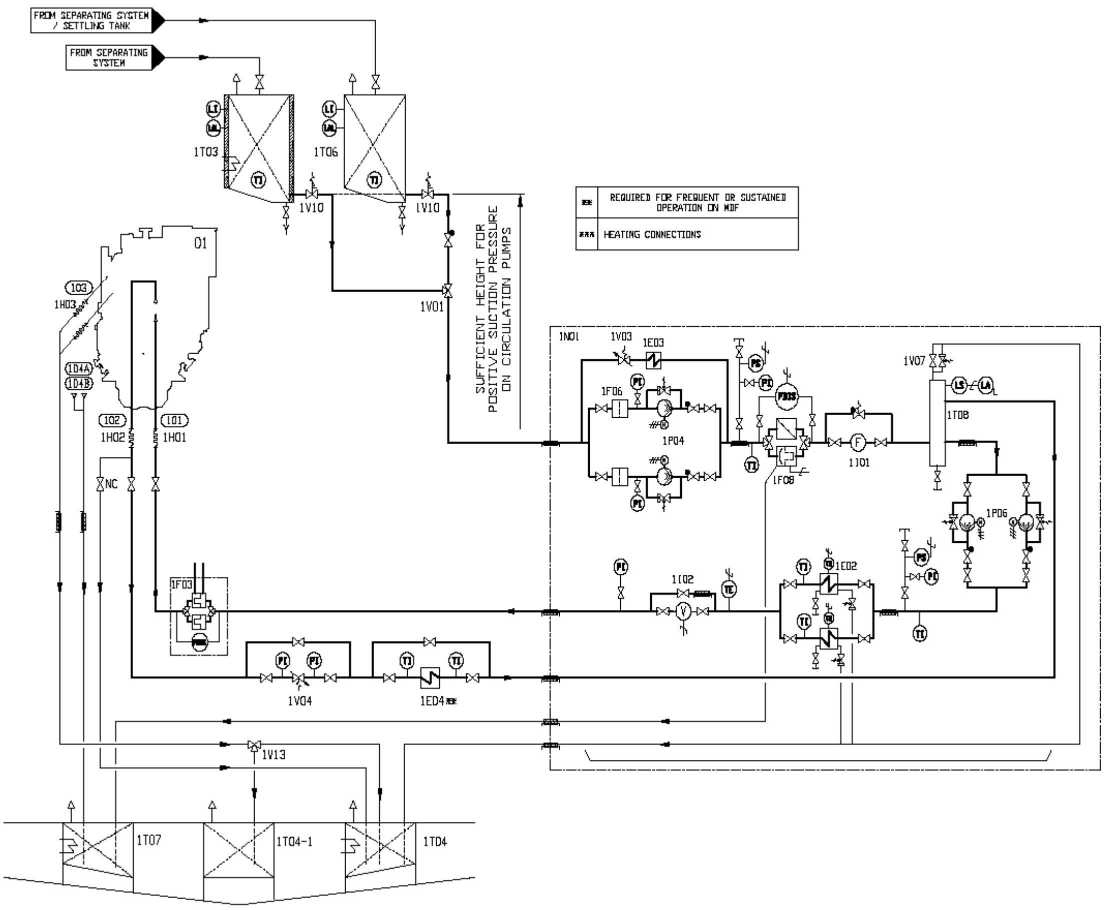


Fig 6-9 **Example of fuel oil system (HFO), (DAAF078373 a)**

System components:			
01	Diesel engine Wärtsilä 26	1T03	Day tank (HFO)
1E02	Heater (booster unit)	1T04	Leak fuel tank (clean fuel) - HFO
1E03	Cooler (booster unit)	1T04-1	Leak fuel tank (clean fuel) - MDF
1E04	Cooler (MDF)	1T06	Day tank (MDF)
1F03	Safety filter (HFO)	1T07	Leak fuel tank (dirty fuel)
1F06	Suction filter (booster unit)	1T08	De-aeration tank (booster unit)
1F08	Automatic filter (booster unit)	1V01	Change over valve
1H0X	Flexible pipe connections	1V03	Pressure control valve (booster unit)
1I01	Flow meter (booster unit)	1V04	Pressure control valve (HFO)
1I02	Viscosity meter (booster unit)	1V07	Venting valve (booster unit)
1N01	Feeder/booster unit	1V10	Quick closing valve (fuel oil tank)
1P04	Fuel feed pump (booster unit)	1V13	Change over valve for leak fuel
1P06	Circulation pump (booster unit)		

Pos.	Pipe connections	L26	V26
101	Fuel inlet	DN32	DN25
102	Fuel outlet	DN32	DN25
103	Leak fuel drain, clean fuel	2 * OD22	4 * OD22
104A	Leak fuel drain, dirty fuel	OD22	2 * OD22

Pos.	Pipe connections	L26	V26
104B	Leak fuel drain, dirty fuel	OD22	2 * OD22

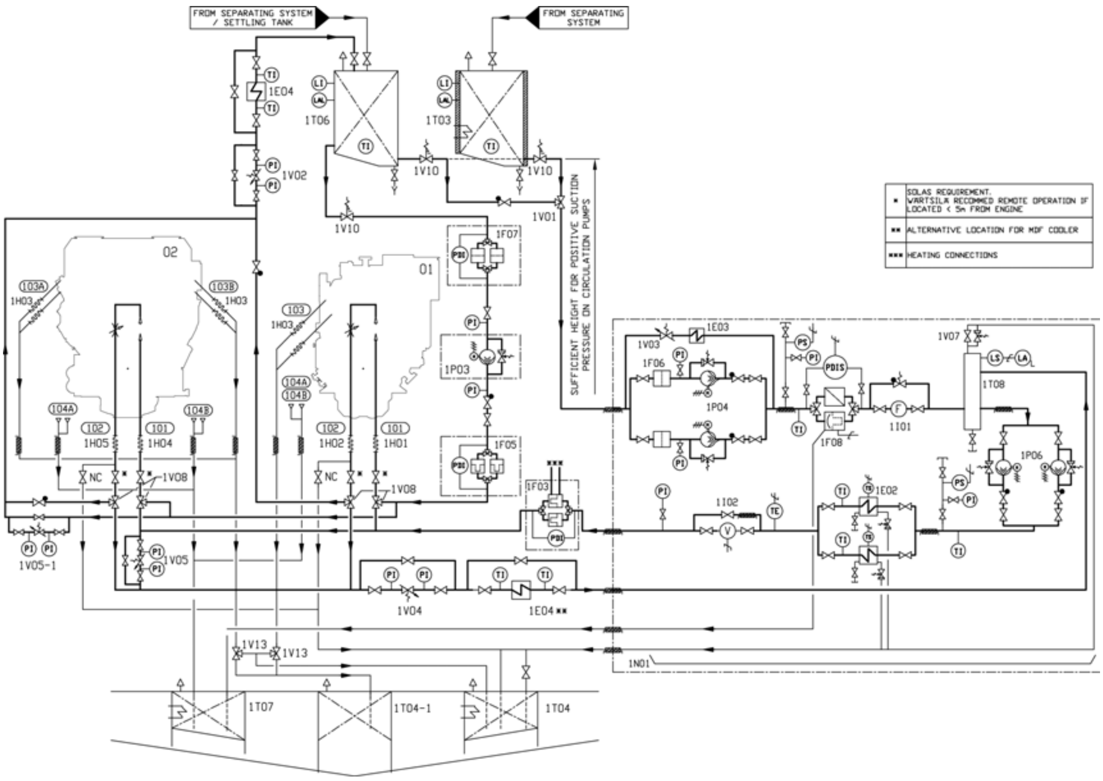


Fig 6-10 **Example of fuel oil system (HFO), multiple engine installation, (DAAF078374 a)**

System components:			
01	Diesel engine Wärtsilä L26	1T03	Day tank (HFO)
02	Diesel engine Wärtsilä V26	1T04	Leak fuel tank (clean fuel) - HFO
1E02	Heater (booster unit)	1T04-1	Leak fuel tank (clean fuel) - MDF
1E03	Cooler (booster unit)	1T06	Day tank (MDF)
1E04	Cooler (MDF)	1T07	Leak fuel tank (dirty fuel)
1F03	Safety filter (HFO)	1T08	De-aeration tank (booster unit)
1F05	Fine filter (MDF)	1V01	Change over valve
1F06	Suction filter (booster unit)	1V02	Pressure control valve (MDF)
1F07	Suction strainer (MDF)	1V03	Pressure control valve (booster unit)
1F08	Automatic filter (booster unit)	1V04	Pressure control valve (HFO)
1H0X	Flexible pipe connections	1V05	Overflow valve (HFO/MDF)
1I01	Flow meter (booster unit)	1V05-1	Overflow valve (HFO/MDF)
1I02	Viscocity meter (booster unit)	1V07	Venting valve (booster unit)
1N01	Feeder / booster unit	1V08	Changeover valve
1P03	Circulation pump (MDF)	1V10	Quick closing valve (fuel oil tank)
1P04	Fuel feed pump (booster unit)	1V13	Change over valve for leak fuel
1P06	Circulation pump (booster unit)		

Pos.	Pipe connections	L26	V26
101	Fuel inlet	DN32	DN25
102	Fuel outlet	DN32	DN25
103	Leak fuel drain, clean fuel	2 * OD22	4 * OD22
104A	Leak fuel drain, dirty fuel	OD22	2 * OD22
104B	Leak fuel drain, dirty fuel	OD22	2 * OD22

HFO pipes shall be properly insulated. If the viscosity of the fuel is 180 cSt/50°C or higher, the pipes must be equipped with trace heating. It sha ll be possible to shut off the heating of the pipes when operating on MDF (trace heating to be grouped logically).

6.3.5.1 Starting and stopping

The engine can be started and stopped on HFO provided that the engine and the fuel system are pre-heated to operating temperature. The fuel must be continuously circulated also through a stopped engine in order to maintain the operating temperature. Changeover to MDF for start and stop is not required.

Prior to overhaul or shutdown of the external system the engine fuel system shall be flushed and filled with MDF.

6.3.5.2 Changeover from HFO to MDF

The control sequence and the equipment for changing fuel during operation must ensure a smooth change in fuel temperature and viscosity. When MDF is fed through the HFO feeder/booster unit, the volume in the system is sufficient to ensure a reasonably smooth transfer.

When there are separate circulating pumps for MDF, then the fuel change should be performed with the HFO feeder/booster unit before switching over to the MDF circulating pumps. As mentioned earlier, sustained operation on MDF usually requires a fuel oil cooler. The viscosity at the engine shall not drop below the minimum limit stated in chapter *Technical data*.

6.3.5.3 Number of engines in the same system

When the fuel feed unit serves Wärtsilä 26 engines only, maximum two engines should be connected to the same fuel feed circuit, unless individual circulating pumps before each engine are installed.

Main engines and auxiliary engines should preferably have separate fuel feed units. Individual circulating pumps or other special arrangements are often required to have main engines and auxiliary engines in the same fuel feed circuit. Regardless of special arrangements it is not recommended to supply more than maximum two main engines and two auxiliary engines, or one main engine and three auxiliary engines from the same fuel feed unit.

In addition the following guidelines apply:

- Twin screw vessels with two engines should have a separate fuel feed circuit for each propeller shaft.
- Twin screw vessels with four engines should have the engines on the same shaft connected to different fuel feed circuits. One engine from each shaft can be connected to the same circuit.

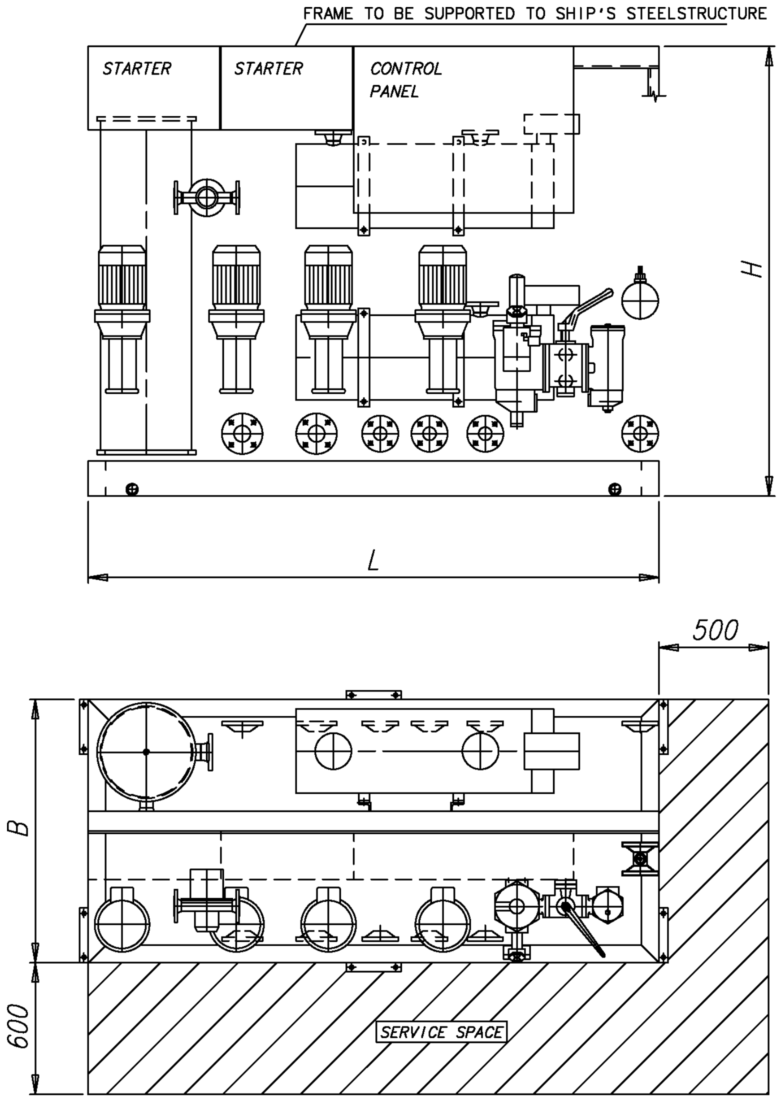
6.3.5.4 Feeder/booster unit (1N01)

A completely assembled feeder/booster unit can be supplied. This unit comprises the following equipment:

- Two suction strainers
- Two fuel feed pumps of screw type, equipped with built-on safety valves and electric motors
- One pressure control/overflow valve
- One pressurized de-aeration tank, equipped with a level switch operated vent valve
- Two circulating pumps, same type as the fuel feed pumps
- Two heaters, steam, electric or thermal oil (one heater in operation, the other as spare)
- One automatic back-flushing filter with by-pass filter
- One viscosimeter for control of the heaters

- One control valve for steam or thermal oil heaters, a control cabinet for electric heaters
- One temperature sensor for emergency control of the heaters
- One control cabinet including starters for pumps
- One alarm panel

The above equipment is built on a steel frame, which can be welded or bolted to its foundation in the ship. The unit has all internal wiring and piping fully assembled. All HFO pipes are insulated and provided with trace heating.



	H	L	B
STEAM	1800	2500	1100
ELECTRICAL	2050	2600	1200

All dimensions in mm.

Fig 6-11 Feeder/booster unit, example (DAAE006659)

Fuel feed pump, booster unit (1P04)

The feed pump maintains the pressure in the fuel feed system. It is recommended to use a screw pump as feed pump. The capacity of the feed pump must be sufficient to prevent pressure drop during flushing of the automatic filter.

A suction strainer with a fineness of 0.5 mm should be installed before each pump. There must be a positive static pressure of about 30 kPa on the suction side of the pump.

Design data:

Capacity	Total consumption of the connected engines added with the flush quantity of the automatic filter (1F08) and 15% margin.
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	0.7 MPa (7 bar)
Design temperature	100°C
Viscosity for dimensioning of electric motor	1000 cSt

Pressure control valve, booster unit (1V03)

The pressure control valve in the feeder/booster unit maintains the pressure in the de-aeration tank by directing the surplus flow to the suction side of the feed pump.

Design data:	
Capacity	Equal to feed pump
Design pressure	1.6 MPa (16 bar)
Design temperature	100°C
Set-point	0.3...0.5 MPa (3...5 bar)

Automatic filter, booster unit (1F08)

It is recommended to select an automatic filter with a manually cleaned filter in the bypass line. The automatic filter must be installed before the heater, between the feed pump and the de-aeration tank, and it should be equipped with a heating jacket. Overheating (temperature exceeding 100°C) is however to be prevented, and it must be possible to switch off the heating for operation on MDF.

Design data:	
Fuel viscosity	According to fuel specification
Design temperature	100°C
Preheating	If fuel viscosity is higher than 25 cSt/100°C
Design flow	Equal to feed pump capacity
Design pressure	1.6 MPa (16 bar)
Fineness:	
- automatic filter	35 µm (absolute mesh size)
- by-pass filter	35 µm (absolute mesh size)
Maximum permitted pressure drops at 14 cSt:	
- clean filter	20 kPa (0.2 bar)
- alarm	80 kPa (0.8 bar)

Flow meter, booster unit (1I01)

If a fuel consumption meter is required, it should be fitted between the feed pumps and the de-aeration tank. When it is desired to monitor the fuel consumption of individual engines in a multiple engine installation, two flow meters per engine are to be installed: one in the feed line and one in the return line of each engine.

There should be a by-pass line around the consumption meter, which opens automatically in case of excessive pressure drop.

If the consumption meter is provided with a prefilter, an alarm for high pressure difference across the filter is recommended.

De-aeration tank, booster unit (1T08)

It shall be equipped with a low level alarm switch and a vent valve. The vent pipe should, if possible, be led downwards, e.g. to the overflow tank. The tank must be insulated and equipped with a heating coil. The volume of the tank should be at least 100 l.

Circulation pump, booster unit (1P06)

The purpose of this pump is to circulate the fuel in the system and to maintain the required pressure at the injection pumps, which is stated in the chapter *Technical data*. By circulating the fuel in the system it also maintains correct viscosity, and keeps the piping and the injection pumps at operating temperature.

When more than two engines are connected to the same feeder/booster unit, individual circulation pumps (1P12) must be installed before each engine.

Design data:	
Capacity:	
- without circulation pumps (1P12)	6 x the total consumption of the connected engine
- with circulation pumps (1P12)	15% more than total capacity of all circulation pumps
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	1.0 MPa (10 bar)
Design temperature	150°C
Viscosity for dimensioning of electric motor	500 cSt

Heater, booster unit (1E02)

The heater must be able to maintain a fuel viscosity of 14 cSt at maximum fuel consumption, with fuel of the specified grade and a given day tank temperature (required viscosity at injection pumps stated in *Technical data*). When operating on high viscosity fuels, the fuel temperature at the engine inlet may not exceed 135°C however.

The power of the heater is to be controlled by a viscosimeter. The set-point of the viscosimeter shall be somewhat lower than the required viscosity at the injection pumps to compensate for heat losses in the pipes. A thermostat should be fitted as a backup to the viscosity control.

To avoid cracking of the fuel the surface temperature in the heater must not be too high. The heat transfer rate in relation to the surface area must not exceed 1.5 W/cm^2.

The required heater capacity can be estimated with the following formula:

$$P = \frac{Q \times \Delta T}{1700}$$

where:

P = heater capacity (kW)

Q = total fuel consumption at full output + 15% margin [l/h]

ΔT = temperature rise in heater [°C]

Viscosimeter, booster unit (1I02)

The heater is to be controlled by a viscosimeter. The viscosimeter should be of a design that can withstand the pressure peaks caused by the injection pumps of the diesel engine.

Design data:	
Operating range	0...50 cSt
Design temperature	180°C
Design pressure	4 MPa (40 bar)

6.3.5.5 Pump and filter unit (1N03)

When more than two engines are connected to the same feeder/booster unit, a circulation pump (1P12) must be installed before each engine. The circulation pump (1P12) and the safety filter (1F03) can be combined in a pump and filter unit (1N03). A safety filter is always required.

There must be a by-pass line over the pump to permit circulation of fuel through the engine also in case the pump is stopped. The diameter of the pipe between the filter and the engine should be the same size as between the feeder/booster unit and the pump and filter unit.

Circulation pump (1P12)

The purpose of the circulation pump is to ensure equal circulation through all engines. With a common circulation pump for several engines, the fuel flow will be divided according to the pressure distribution in the system (which also tends to change over time) and the control valve on the engine has a very flat pressure versus flow curve.

In installations where MDF is fed directly from the MDF tank (1T06) to the circulation pump, a suction strainer (1F07) with a fineness of 0.5 mm shall be installed to protect the circulation pump. The suction strainer can be common for all circulation pumps.

Design data:	
Capacity	6 x the fuel consumption of the engine
Design pressure	1.6 MPa (16 bar)
Max. total pressure (safety valve)	1.0 MPa (10 bar)
Design temperature	150°C
Pressure for dimensioning of electric motor (ΔP):	
- if MDF is fed directly from day tank	0.7 MPa (7 bar)
- if all fuel is fed through feeder/booster unit	0.3 MPa (3 bar)
Viscosity for dimensioning of electric motor	500 cSt

Safety filter (1F03)

The safety filter is a full flow duplex type filter with steel net. The filter should be equipped with a heating jacket. The safety filter or pump and filter unit shall be installed as close as possible to the engine.

Design data:

Fuel viscosity	according to fuel specification
Design temperature	150°C
Design flow	Equal to circulation pump capacity
Design pressure	1.6 MPa (16 bar)
Filter fineness	37 µm (absolute mesh size)
Maximum permitted pressure drops at 14 cSt:	
- clean filter	20 kPa (0.2 bar)
- alarm	80 kPa (0.8 bar)

6.3.5.6 Overflow valve, HFO (1V05)

When several engines are connected to the same feeder/booster unit an overflow valve is needed between the feed line and the return line. The overflow valve limits the maximum pressure in the feed line, when the fuel lines to a parallel engine are closed for maintenance purposes.

The overflow valve should be dimensioned to secure a stable pressure over the whole operating range.

Design data:	
Capacity	Equal to circulation pump (1P06)
Design pressure	1.6 MPa (16 bar)
Design temperature	150°C
Set-point (Δp)	0.2...0.7 MPa (2...7 bar)

6.3.6 Flushing

The external piping system must be thoroughly flushed before the engines are connected and fuel is circulated through the engines. The piping system must have provisions for installation of a temporary flushing filter.

The fuel pipes at the engine (connections 101 and 102) are disconnected and the supply and return lines are connected with a temporary pipe or hose on the installation side. All filter inserts are removed, except in the flushing filter of course. The automatic filter and the viscosimeter should be bypassed to prevent damage. The fineness of the flushing filter should be 35 µm or finer.

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7. Lubricating Oil System

7.1 Lubricating oil requirements

7.1.1 Engine lubricating oil

The lubricating oil must be of viscosity class SAE 40 and have a viscosity index (VI) of minimum 95. The lubricating oil alkalinity (BN) is tied to the fuel grade, as shown in the table below. BN is an abbreviation of Base Number. The value indicates milligrams KOH per gram of oil.

Table 7-1 Fuel standards and lubricating oil requirements

Category	Fuel standard		Lubricating oil BN
A	ASTM D 975-01, BS MA 100: 1996 CIMAC 2003 ISO 8217:2017(E)	GRADE NO. 1-D, 2-D, 4-D DMX, DMA, DMB DX, DA, DB ISO-F-DMX, DMB	10...30
B	ASTM D 975-01 BS MA 100: 1996 CIMAC 2003 ISO 8217:2017(E)	GRADE NO. 1-D, 2-D, 4-D DMX, DMA, DMB DX, DA, DB ISO-F-DMX - DMB	15...30
C	ASTM D 975-01, ASTM D 396-04, BS MA 100: 1996 CIMAC 2003 ISO 8217:2017(E)	GRADE NO. 4-D GRADE NO. 5-6 DMC, RMA10-RMK55 DC, A30-K700 RMA10-RMK 700	30...55

BN 50-55 lubricants are to be selected in the first place for operation on HFO. BN 40 lubricants can also be used with HFO provided that the sulphur content of the fuel is relatively low, and the BN remains above the condemning limit for acceptable oil change intervals. BN 30 lubricating oils should be used together with HFO only in special cases; for example in SCR (Selective Catalyctic Reduction) installations, if better total economy can be achieved despite shorter oil change intervals. Lower BN may have a positive influence on the lifetime of the SCR catalyst.

It is not harmful to the engine to use a higher BN than recommended for the fuel grade.

Different oil brands may not be blended, unless it is approved by the oil suppliers. Blending of different oils must also be validated by Wärtsilä, if the engine still under warranty.

An updated list of validated lubricating oils is supplied for every installation.

7.1.2 Oil in speed governor or actuator

An oil of viscosity class SAE 30 or SAE 40 is acceptable in normal operating conditions. Usually the same oil as in the engine can be used. At low ambient temperatures it may be necessary to use a multigrade oil (e.g. SAE 5W-40) to ensure proper operation during start-up with cold oil.

7.1.3 Oil in turning device

It is recommended to use EP-gear oils, viscosity 400-500 cSt at 40°C = ISO VG 460.

An updated list of approved oils is supplied for every installation.

7.2 Internal lubricating oil system

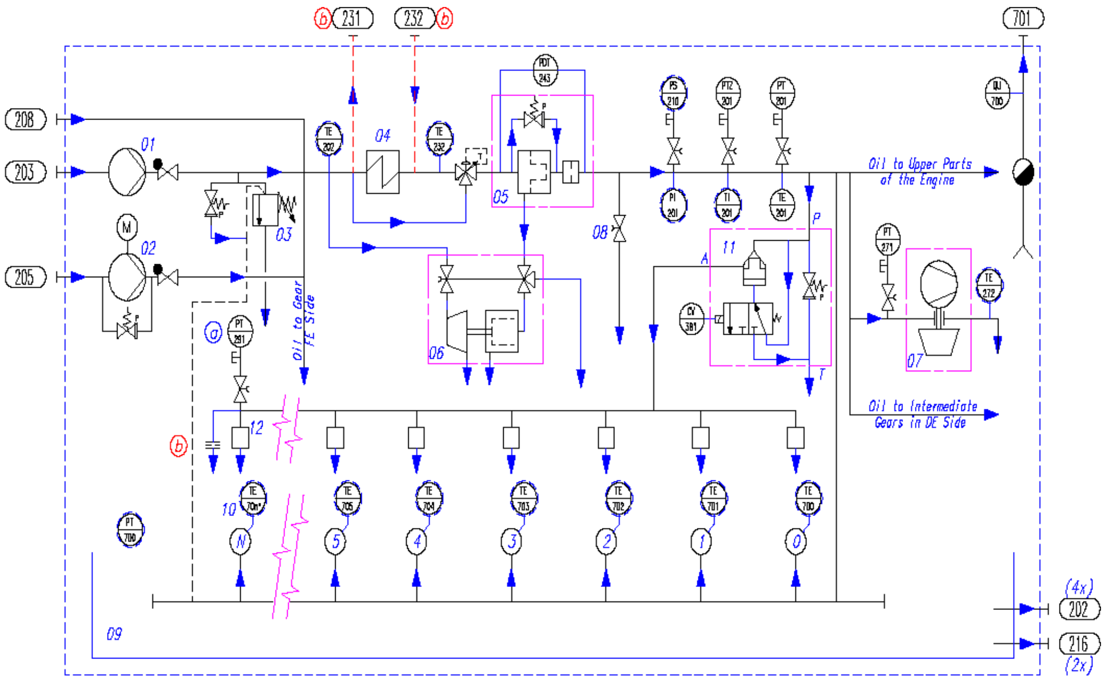

Fig 7-1 Internal lubricating oil system, dry sump engines(DAAR007321b)

System components, dry sump					
01	Main lubricating oil pump	05	Automatic filter	09	Dry sump
02	Pre-lubricating oil pump	06	Centrifugal filter	10	Cylinder line
03	Pressure control valve	07	Turbocharger	11	Vic control valve
04	Lubricating oil cooler	08	Sample valve	12	Vic valve tappet

Sensors and indicators, dry sump			
PT201	Lubricating oil pressure, engine inlet	TE272	Lubricating oil temp. TC outlet
PT271	Lubricating oil pressure TC inlet	TE70n	Main bearing temperature
PTZ201	Lubricating oil pressure, engine inlet	PI201	Lubricating oil pressure, engine inlet
PDT243	Lubricating oil filter pressure difference	PS210	Lubricating oil stand-by pump switch
TE201	Lubricating oil temp. engine inlet	PT700	Crankcase pressure
TI201	Lubricating oil temp. engine inlet	TE202	Lubricating oil temp. engine outlet
QU700	Oil mist detector (optional)	TE232	Lubricating oil temp. LOC outlet
PT291	Control oil pressure after vic valve	CV381	Vic control valve

Pipe connections, dry sump	
202	Lubricating oil outlet
203	Lubricating oil to engine driven pump
205	Lubricating oil to priming pump
208	Lubricating oil from el. driven pump
216	Lubricating oil drain
231	Lube oil to ext system
232	Lube oil from ext system
701	Crankcase ventilation

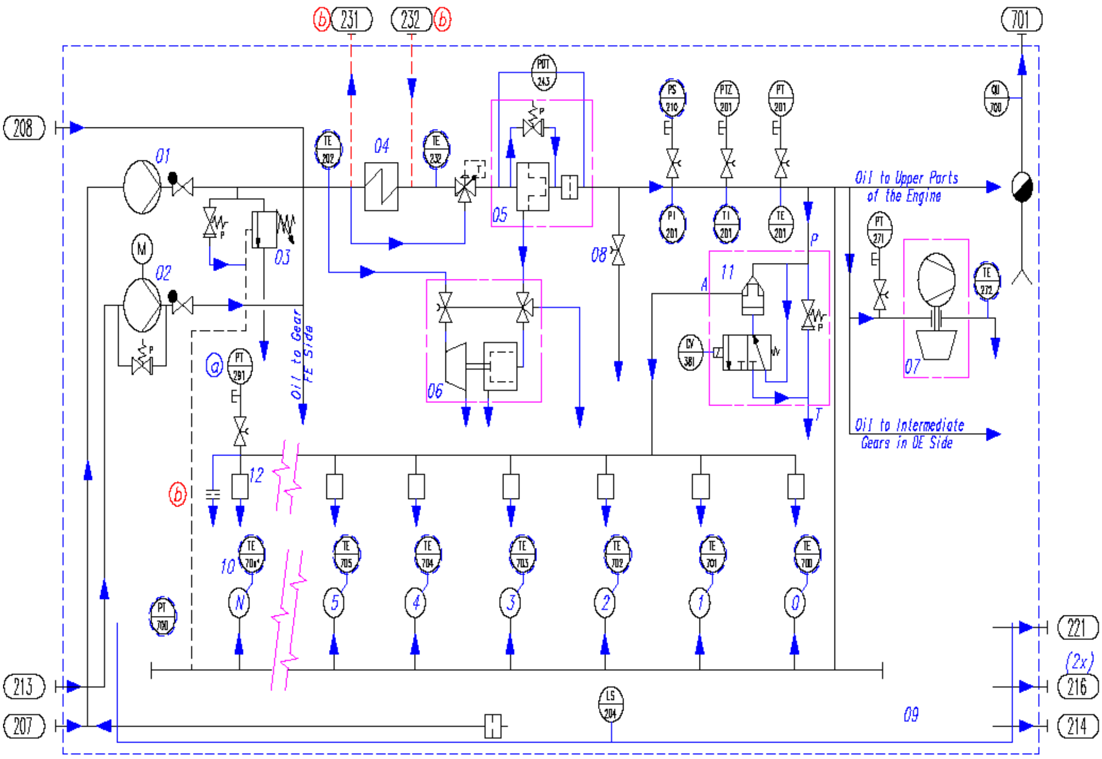

Fig 7-2 Internal lubricating oil system, wet sump engines (DAAR007318b)

System components, wet sump			
01	Main lubricating oil pump	07	Turbocharger
02	Pre-lubricating oil pump	08	Sample valve
03	Pressure control valve	09	Wet sump
04	Lubricating oil cooler	10	Cylinder line
05	Automatic filter	11	Vic control valve
06	Centrifugal filter	12	Vic valve tappet

Sensors and indicators, wet sump			
TE201	Lubricating oil temp. engine inlet	TE272	Lubricating oil temp. TC outlet
TI201	Lubricating oil temp. engine inlet	TE202	Lubr.oil temp. engine outlet
PT201	Lubricating oil pressure, engine inlet	QU700	Oil mist detector
PT271	Lubricating oil pressure TC inlet	PT700	Crankcase pressure
PTZ201	Lubricating oil pressure, engine inlet	TE232	Lubricating oil temp. LOC outlet
PDT243	Differential pressure lubricating oil filter	PI201	Lubricating oil pressure, engine inlet
LS204	Lubricating oil level	PS210	Lubricating oil stand-by pump switch
TE70n	Main bearing temp. (optional), cyl. n	PT291	Control oil pressure, after vic valve
CV381	Vic control valve		

Pipe connections, wet sump	
207	Lubricating oil to el.driven pump
208	Lubricating oil from el. driven pump
213	Lubricating oil from separator and filling
214	Lubricating oil to separator and drain
216	Lubricating oil drain (wet sump)
221	Lubricating oil overflow

Pipe connections, wet sump	
231	Lube oil to ext system
232	Lube oil from ext system
701	Crankcase ventilation

The lubricating oil sump is of wet sump type for auxiliary and diesel-electric engines. Dry sump is recommended for main engines operating on HFO. The dry sump type has two oil outlets at each end of the engine. Two of the outlets shall be connected to the system oil tank.

The direct driven lubricating oil pump is of gear type and is equipped with a combined pressure control and safety relief valve. The pump is dimensioned to provide sufficient flow even at low speeds. A stand-by pump connection is available as option. Concerning suction height, flow rate and pressure of the engine driven pump, *see Technical data.*

The pre-lubricating oil pump is an electric motor driven gear pump equipped with a safety valve. The pump should always be running, when the engine is stopped. Concerning suction height, flow rate and pressure of the pre-lubricating oil pump, *see Technical data.*

The lubricating oil module built on the engine consists of the lubricating oil cooler, thermostatic valve and automatic filter.

The centrifugal filter is installed to clean the back-flushing oil from the automatic filter.

All dry sump engines are delivered with a running-in filter in oil supply line to the main bearings. This filter is to be removed after commissioning.

7.3 External lubricating oil system

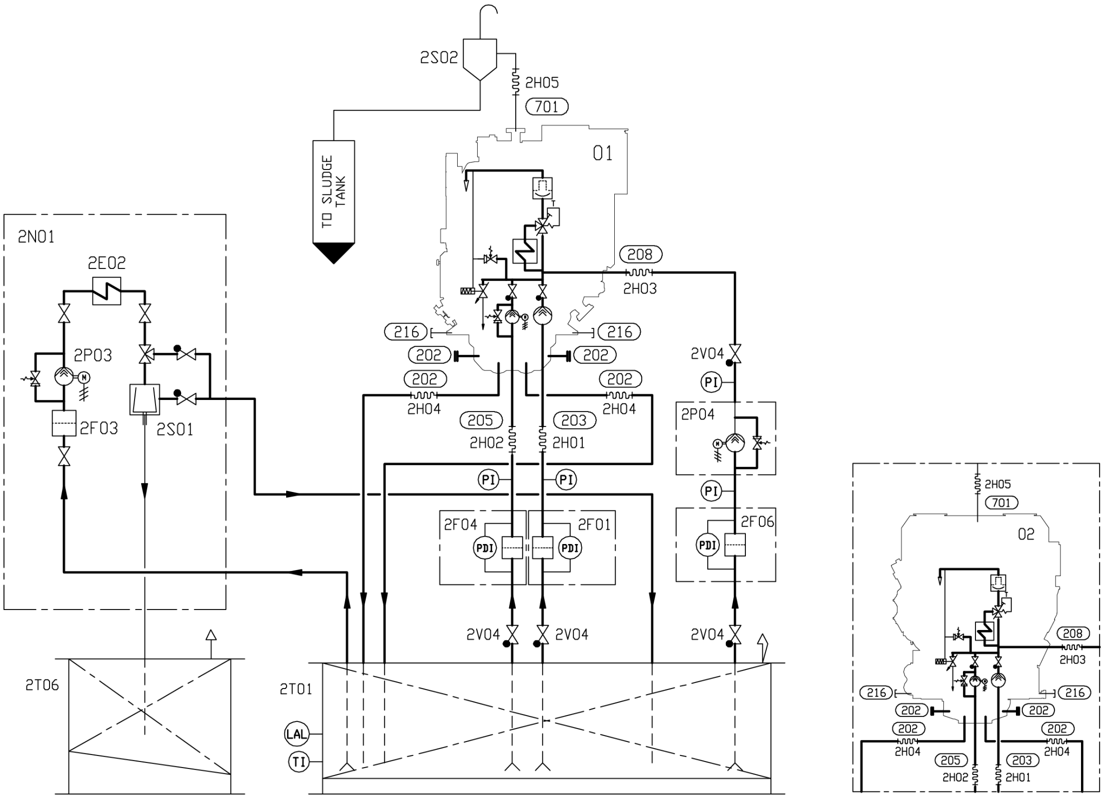

Fig 7-3 **Typical example of an external lubricating oil system for a single main engine with a dry sump (DAAF078375 a)**

System components:			
01	Diesel engine Wärtsilä L26	2N01	Separator unit
02	Diesel engine Wärtsilä V26	2P03	Separator pump (separator unit)
2E02	Heater (separator unit)	2P04	Stand-by pump
2F01	Suction strainer (main LO pump)	2S01	Separator (separator unit)
2F03	Suction filter (separator unit)	2S02	Condensate trap
2F04	Suction strainer (pre lubricating oil pump)	2T01	System oil tank
2F06	Suction strainer (stand-by pump)	2T06	Sludge tank
2H0X	Flexible pipe connections	2V04	Non-return valve

Pos	Pipe connections	L26	V26
202	Lube oil outlet (from oil sump)	4 * DN150	
203	Lube oil to engine driven pump	DN200	DN150
205	Lube oil to priming pump	DN65	
208	Lube oil from el. driven pump	DN80	DN100
216	Lube oil drain	2 * plug G 3/4"	
701	Crankcase air vent	DN80	DN100

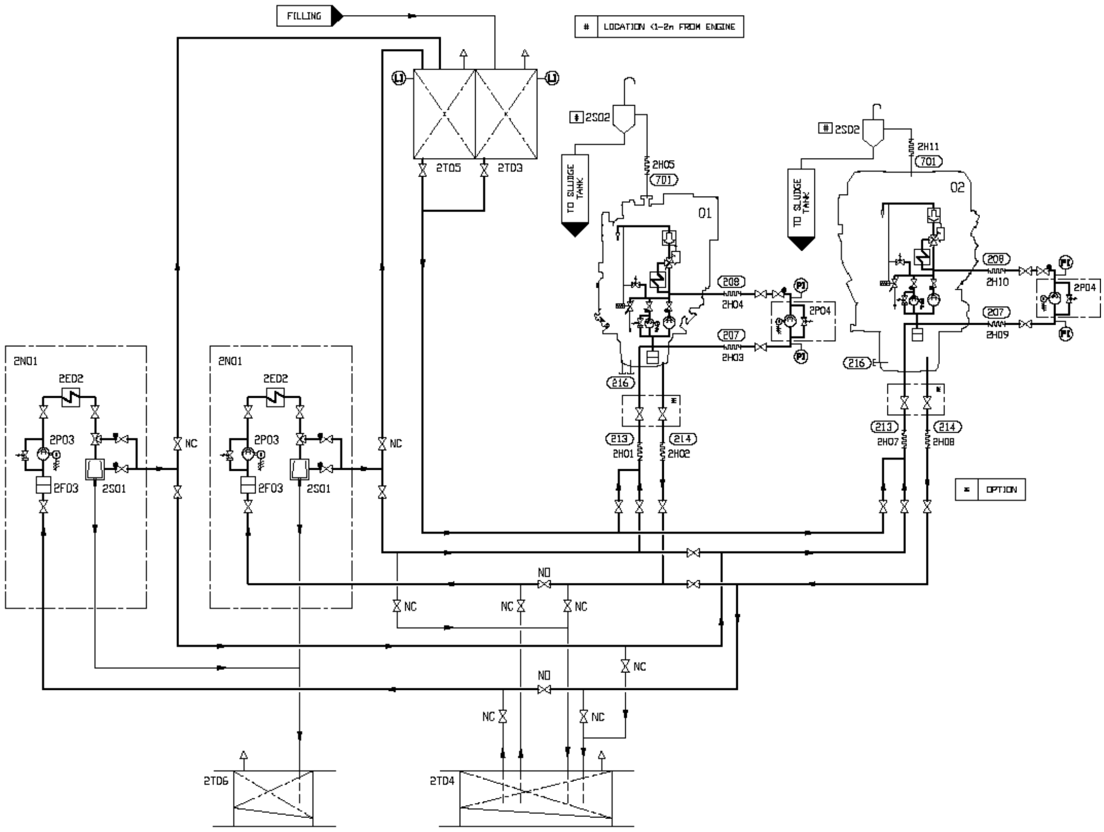

Fig 7-4 **Typical example of an external lubricating oil system for a single main engine with a wet sump (DAAF078378 a)**

System components:			
01	Diesel engine Wärtsilä L26	2P04	Stand-by pump
02	Diesel engine Wärtsilä V26	2S01	Separator (separator unit)
2E02	Heater (separator unit)	2S02	Condensate trap
2F03	Suction filter (separator unit)	2T03	New oil tank
2H0X	Flexible pipe connections	2T04	Renovating oil tank
2N01	Separator unit	2T05	Renovated oil tank
2P03	Separator pump (separator unit)	2T06	Sludge tank

Pos	Pipe connections	L26	V26
207	Lube oil to el. driven pump	DN125	DN150
208	Lube oil from el. driven pump	DN80	DN100
213	Lube oil from separator and filling	DN40(*) or plug G1 1/2"	
214	Lube oil to separator and drain	DN40(*) or plug G1 1/2"	
216	Lube oil drain	2 * plug G1 1/2"	
701	Crankcase air vent	DN80	DN100

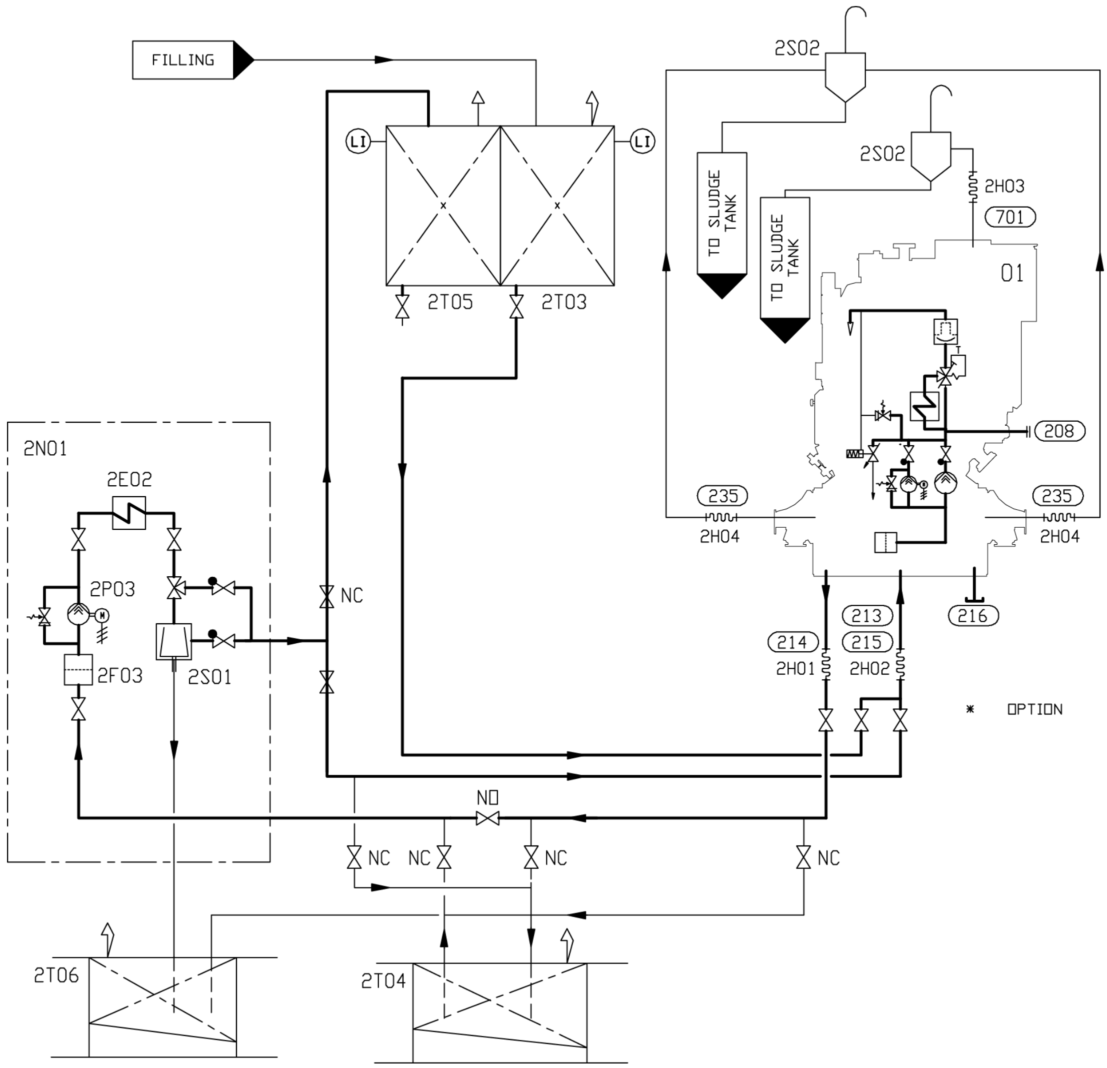

Fig 7-5 **Typical example of an external lubricating oil system for a genset with wet CBF (DAAF078377 a)**

System components:			
01	Diesel engine Wärtsilä 26	2S01	Separator (separator unit)
2E02	Heater (separator unit)	2S02	Condensate trap
2F03	Suction filter (separator unit)	2T03	New oil tank
2H0X	Flexible pipe connections	2T04	Renovating oil tank
2N01	Separator unit	2T05	Renovated oil tank
2P03	Separator pump (separator unit)	2T06	Sludge tank

Pos	Pipe connections	L26	V26
208	Lube oil from el. driven pump	DN80	DN100
213	Lube oil from separator and filling	DN40	
214	Lube oil to separator and drain	DN40(*) or plug G 2"	
215	Lube oil filling	DN40	
216	Lube oil drain	2 * plug G 2"	
235	Lube oil tank air vent	2 * DN80	
701	Crankcase air vent	DN80	DN100

7.3.1 Separation system

7.3.1.1 Separator unit (2N01)

Each engine must have a dedicated lubricating oil separator and the separators shall be dimensioned for continuous separating. If the installation is designed to operate on MDF only, then intermittent separating might be sufficient.

Auxiliary engines operating on a fuel having a viscosity of max. 380 cSt / 50°C may have a common lubricating oil separator unit. Three in-line engines may have a common lubricating oil separator unit. In installation with V engines as auxiliary engines, two engines may have a common lubricating oil separator unit. In installations with four or more engines two lubricating oil separator units should be installed.

Separators are usually supplied as pre-assembled units.

Typically lubricating oil separator units are equipped with:

- Feed pump with suction strainer and safety valve
- Preheater
- Separator
- Control cabinet

The lubricating oil separator unit may also be equipped with an intermediate sludge tank and a sludge pump, which offers flexibility in placement of the separator since it is not necessary to have a sludge tank directly beneath the separator.

Separator feed pump (2P03)

The feed pump must be selected to match the recommended throughput of the separator. Normally the pump is supplied and matched to the separator by the separator manufacturer.

The lowest foreseen temperature in the system oil tank (after a long stop) must be taken into account when dimensioning the electric motor.

Separator preheater (2E02)

The preheater is to be dimensioned according to the feed pump capacity and the temperature in the system oil tank. When the engine is running, the temperature in the system oil tank located in the ship's bottom is normally 65...75°C. To enable separation with a stopped engine the heater capacity must be sufficient to maintain the required temperature without heat supply from the engine.

Recommended oil temperature after the heater is 95°C.

It shall be considered that, while the engine is stopped in stand-by mode without LT water circulation, the separator unit may be heating up the total amount of lubricating oil in the oil tank to a value higher than the nominal one required at engine inlet, after lube oil cooler (see Technical Data chapter). Higher oil temperatures at engine inlet than the nominal, may be creating higher component wear and in worst conditions damages to the equipment and generate alarm signal at engine start, or even a load reduction request to PMS.

The surface temperature of the heater must not exceed 150°C in order to avoid cooking of the oil.

The heaters should be provided with safety valves and drain pipes to a leakage tank (so that possible leakage can be detected).

Separator (2S01)

The separators should preferably be of a type with controlled discharge of the bowl to minimize the lubricating oil losses.

The service throughput *Q* [*l/h*] of the separator can be estimated with the formula:

$$Q = \frac{1.35 \times P \times n}{t}$$

where:

Q = volume flow [l/h]

P = engine output [kW]

n = 5 for HFO, 4 for MDF

t = operating time [h/day]: 24 for continuous separator operation, 23 for normal dimensioning

Sludge tank (2T06)

The sludge tank should be located directly beneath the separators, or as close as possible below the separators, unless it is integrated in the separator unit. The sludge pipe must be continuously falling.

7.3.1.2 Renovating oil tank (2T04)

In case of wet sump engines the oil sump content can be drained to this tank prior to separation.

7.3.1.3 Renovated oil tank (2T05)

This tank contains renovated oil ready to be used as a replacement of the oil drained for separation.

7.3.2 System oil tank (2T01)

Recommended oil tank volume is stated in chapter *Technical data.*

The system oil tank is usually located beneath the engine foundation. The tank may not protrude under the reduction gear or generator, and it must also be symmetrical in transverse direction under the engine. The location must further be such that the lubricating oil is not cooled down below normal operating temperature. Suction height is especially important with engine driven lubricating oil pump. Losses in strainers etc. add to the geometric suction height. Maximum suction ability of the pump is stated in chapter *Technical data.*

The pipe connection between the engine oil sump and the system oil tank must be flexible to prevent damages due to thermal expansion. The return pipes from the engine oil sump must end beneath the minimum oil level in the tank. Further on the return pipes must not be located in the same corner of the tank as the suction pipe of the pump.

The suction pipe of the pump should have a trumpet shaped or conical inlet to minimise the pressure loss. For the same reason the suction pipe shall be as short and straight as possible and have a sufficient diameter. A pressure gauge shall be installed close to the inlet of the lubricating oil pump. The suction pipe shall further be equipped with a non-return valve of flap type without spring. The non-return valve is particularly important with engine driven pump and it must be installed in such a position that self-closing is ensured.

Suction and return pipes of the separator must not be located close to each other in the tank.

The ventilation pipe from the system oil tank may not be combined with crankcase ventilation pipes.

It must be possible to raise the oil temperature in the tank after a long stop. In cold conditions it can be necessary to have heating coils in the oil tank in order to ensure pumpability. The separator heater can normally be used to raise the oil temperature once the oil is pumpable. Further heat can be transferred to the oil from the preheated engine, provided that the oil viscosity and thus the power consumption of the pre-lubricating oil pump does not exceed the capacity of the electric motor.

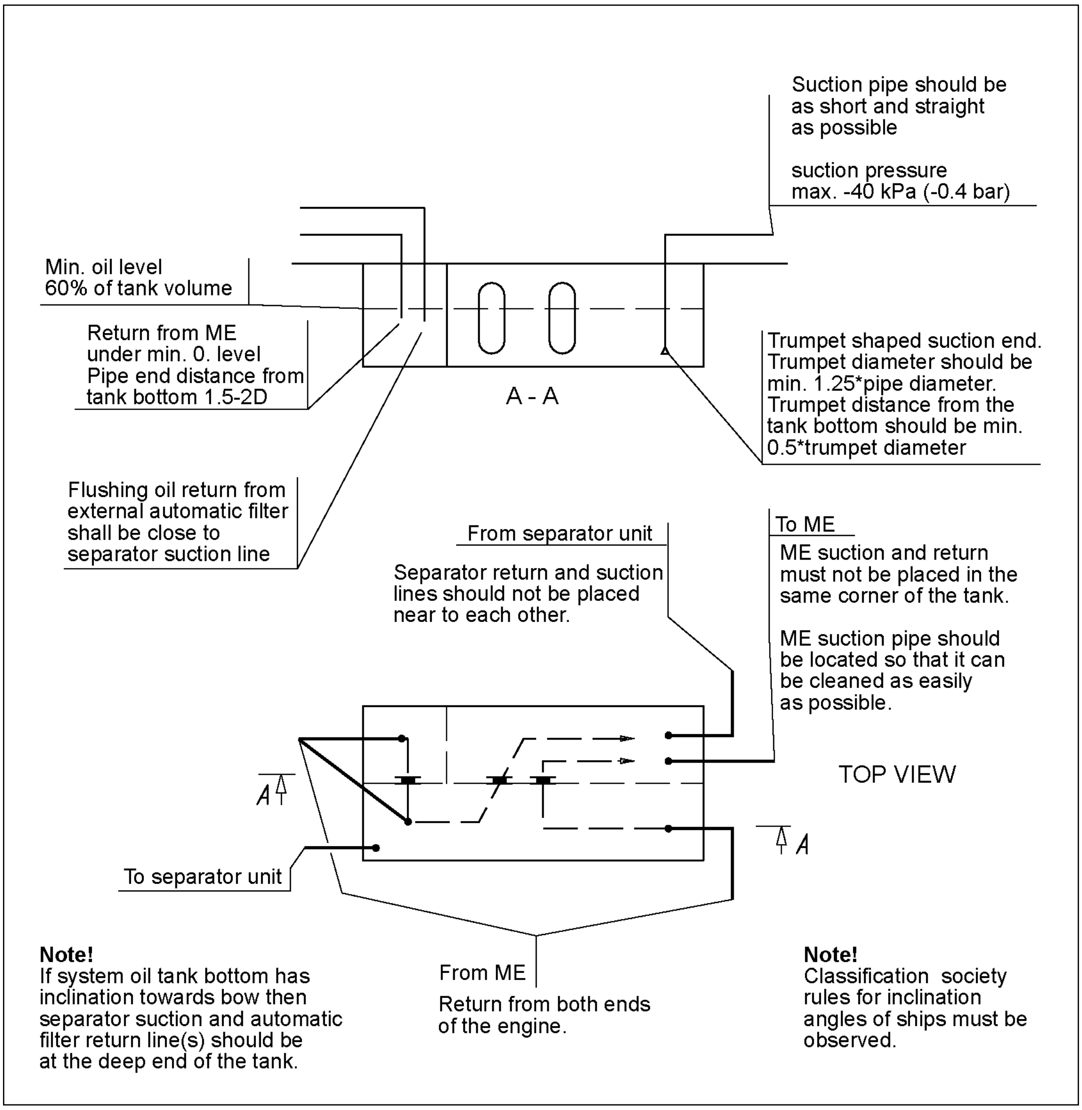

Fig 7-6 **Example of system oil tank arrangement (DAAE007020e)**

Design data:

Oil tank volume	1.2...1.5 l/kW, see also *Technical data*
Oil level at service	75...80% of tank volume
Oil level alarm	60% of tank volume

7.3.3 New oil tank (2T03)

In engines with wet sump, the lubricating oil may be filled into the engine, using a hose or an oil can, through the crankcase cover or through the separator pipe. The system should be arranged so that it is possible to measure the filled oil volume.

7.3.4 Suction strainers (2F01, 2F04, 2F06)

It is recommended to install a suction strainer before each pump to protect the pump from damage. The suction strainer and the suction pipe must be amply dimensioned to minimize pressure losses. The suction strainer should always be provided with alarm for high differential pressure.

Design data:	
Fineness	0.5...1.0 mm

7.3.5 Lubricating oil pump, stand-by (2P04)

The stand-by lubricating oil pump is normally of screw type and should be provided with an safety valve.

Design data:	
Capacity	see *Technical data*
Design pressure, max	0.8 MPa (8 bar)
Design temperature, max.	100°C
Lubricating oil viscosity	SAE 40
Viscosity for dimensioning the electric motor	500 mm^2/s (cSt)

7.4 Crankcase ventilation system

The purpose of the crankcase ventilation is to evacuate gases from the crankcase in order to keep the pressure in the crankcase within acceptable limits.

Each engine must have its own vent pipe into open air. The crankcase ventilation pipes may not be combined with other ventilation pipes, e.g. vent pipes from the system oil tank.

The diameter of the pipe shall be large enough to avoid excessive back pressure. Other possible equipment in the piping must also be designed and dimensioned to avoid excessive flow resistance.

A condensate trap must be fitted on the vent pipe near the engine.

The connection between engine and pipe is to be flexible.

Design data:	
Flow	see *Technical data*
Backpressure, max.	see *Technical data*
Temperature	80°C

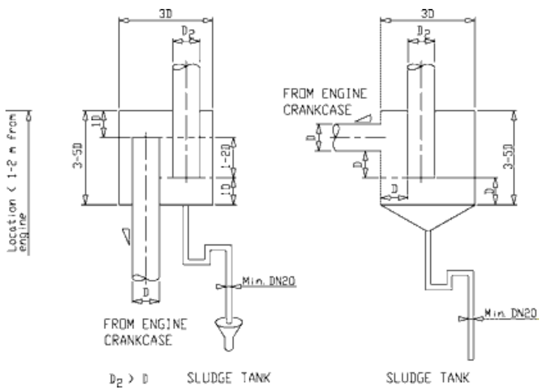

Fig 7-7 **Condensate trap (DAAE032780B)**

The size of the ventilation pipe (D2) out from the condensate trap should be equal or bigger than the ventilation pipe (D) coming from the engine.
For more information about ventilation pipe (D) size, see the external lubricating oil system drawing.

The max. back-pressure must also be considered when selecting the ventilation pipe size.

7.5 Flushing instructions

Flushing instructions in this Product Guide are for guidance only. For contracted projects, read the specific instructions included in the installation planning instructions (IPI). The fineness of the flushing filter and further instructions are found from installation planning instructions (IPI).

7.5.1 Piping and equipment built on the engine

Flushing of the piping and equipment built on the engine is not required and flushing oil shall not be pumped through the engine oil system (which is flushed and clean from the factory). It is however acceptable to circulate the flushing oil via the engine sump if this is advantageous. Cleanliness of the oil sump shall be verified after completed flushing.

7.5.2 External oil system

Refer to the system diagram(s) in section *External lubricating oil system* for location/description of the components mentioned below.

If the engine is equipped with a wet oil sump the external oil tanks, new oil tank (2T03), renovating oil tank (2T04) and renovated oil tank (2T05) shall be verified to be clean before bunkering oil. Especially pipes leading from the separator unit (2N01) directly to the engine shall be ensured to be clean for instance by disconnecting from engine and blowing with compressed air.

If the engine is equipped with a dry oil sump the external oil tanks, new oil tank and the system oil tank (2T01) shall be verified to be clean before bunkering oil.

Operate the separator unit continuously during the flushing (not less than 24 hours). Leave the separator running also after the flushing procedure, this to ensure that any remaining contaminants are removed.

If an electric motor driven stand-by pump (2P04) is installed then piping shall be flushed running the pump circulating engine oil through a temporary external oil filter (recommended mesh 34 microns) into the engine oil sump through a hose and a crankcase door. The pump shall be protected by a suction strainer (2F06).

Whenever possible the separator unit shall be in operation during the flushing to remove dirt. The separator unit is to be left running also after the flushing procedure, this to ensure that any remaining contaminants are removed.

7.5.3 Type of flushing oil

7.5.3.1 Viscosity

In order for the flushing oil to be able to remove dirt and transport it with the flow, ideal viscosity is 10...50 cSt. The correct viscosity can be achieved by heating engine oil to about 65°C or by using a separate flushing oil which has an ideal viscosity in ambient temperature.

7.5.3.2 Flushing with engine oil

The ideal is to use engine oil for flushing. This requires however that the separator unit is in operation to heat the oil. Engine oil used for flushing can be reused as engine oil provided that no debris or other contamination is present in the oil at the end of flushing.

7.5.3.3 Flushing with low viscosity flushing oil

If no separator heating is available during the flushing procedure it is possible to use a low viscosity flushing oil instead of engine oil. In such a case the low viscosity flushing oil must be disposed of after completed flushing. Great care must be taken to drain all flushing oil from pockets and bottom of tanks so that flushing oil remaining in the system will not compromise the viscosity of the actual engine oil.

7.5.3.4 Lubricating oil sample

To verify the cleanliness a LO sample shall be taken by the shipyard after the flushing is completed. The properties to be analyzed are Viscosity, BN, AN, Insolubles, Fe and Particle Count.

Commissioning procedures shall in the meantime be continued without interruption unless the commissioning engineer believes the oil is contaminated.

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8. Compressed Air System

Compressed air is used to start engines and to provide actuating energy for safety and control devices. The use of starting air for other purposes is limited by the classification regulations.

To ensure the functionality of the components in the compressed air system, the compressed air has to be free from solid particles and oil.

8.1 Internal compressed air system

The engine is started with a pneumatic starting motor operating at a nominal pressure of 3 MPa (30 bar). The starting motor drives a pinion that turns the gear mounted on the flywheel. Over 100 rpm the master starter valve closes, and the pinion is drawn back by spring force. If the electric system fails, the pinion will be pushed back by the driving force of the diesel engine.

The engine can not be started when the turning gear is engaged.

Each HP fuel pump is provided with a pneumatic stop cylinder which pushes the fuel injection pumps to zero-delivery when activated. The stop solenoid valve which admits air to the pneumatic stop cylinders will be activated by the engine stop and safety system, also in case of an overspeed or an emergency stop command.

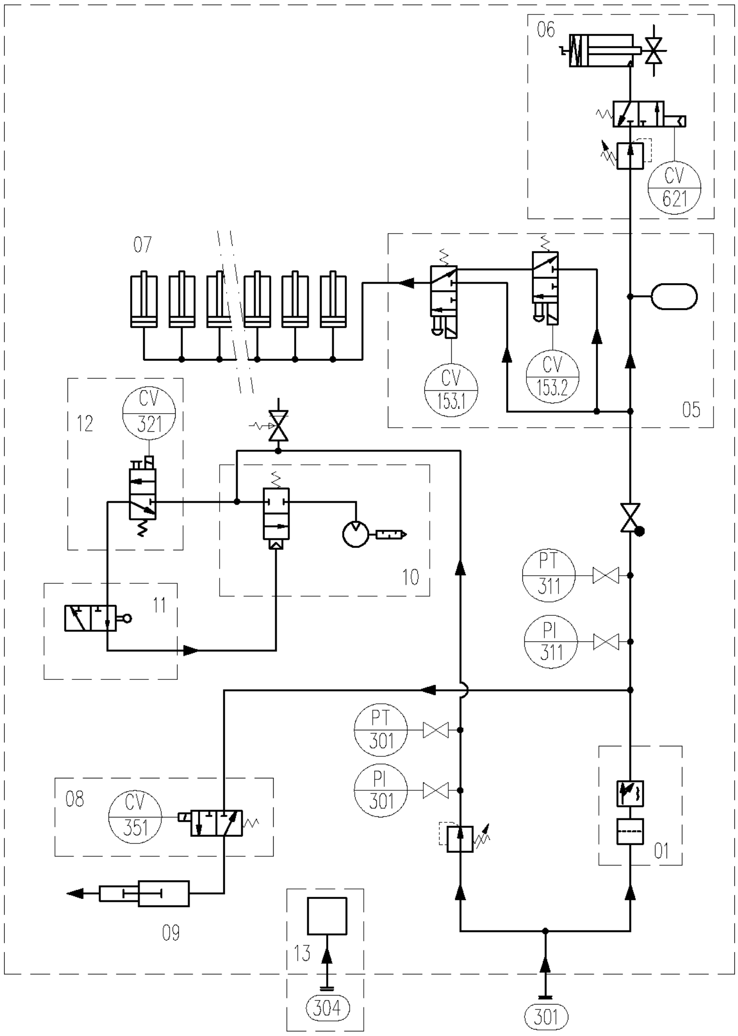


Fig 8-1 **Internal compressed air system, in-line engines (DAAE038893a)**

System components			
01	Air filter with water separator	09	Booster for governor
05	Stop unit	10	Starting air motor
06	Emergency shut off valve	11	Blocking valve, turning gear engaged
07	Pneumatic stop cylinder at each injection pump	12	Start solenoid valve (with manual switch)
08	Booster solenoid valve	13	Pneumatic speed setting governor

Sensors and indicators			
PT301	Starting air pressure, engine inlet	CV351	Booster valve for governor
PT311	Control air pressure	CV621	Charge air shut off valve
CV153.1	Stop/shutdown solenoid valve	PI301	Starting air pressure, engine inlet
CV153.2	Stop/shutdown solenoid valve 2	PI311	Control air pressure
CV321	Instrument air valve control		

Pipe connections		Size	Pressure class	Standard
301	Starting air inlet, 3 MPa	DN40	PN40	ISO 7005-1
304	Control air to speed governor	OD6	PN250	DIN2353

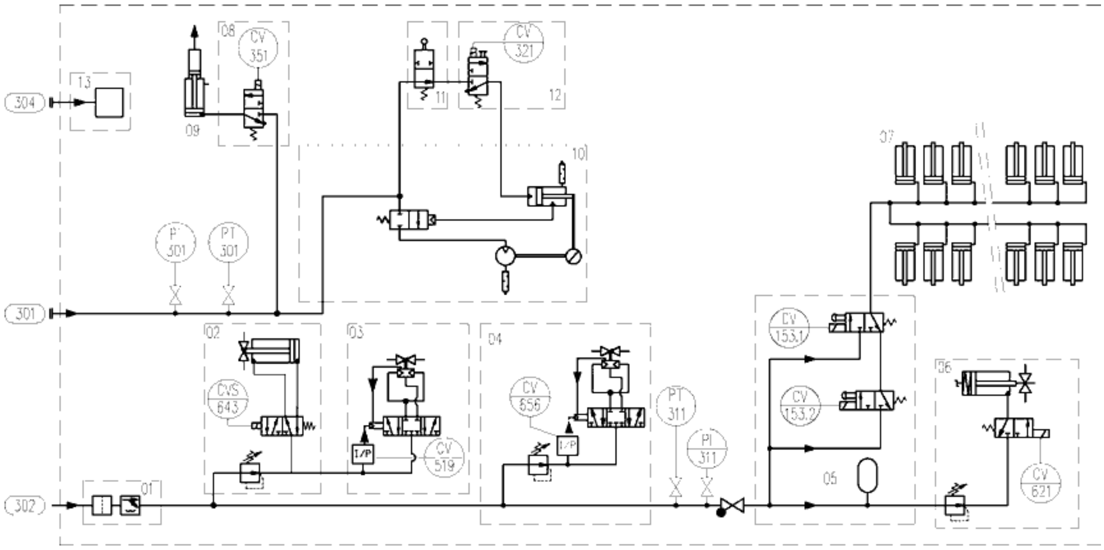


Fig 8-2 **Internal compressed air system, V-engines (DAAE034771b)**

System components			
01	Air filter with water separator	08	Booster solenoid valve
02	By-pass valve	09	Booster for governor
03	Exhaust waste gate	10	Starting air motor
04	Air waste gate	11	Blocking valve, turning gear engaged
05	Stop unit	12	Start solenoid valve (with manual switch)
06	Emergency shut off valve	13	Pneumatic speed setting governor
07	Pneumatic stop cylinder at each injection pump		

Sensors and indicators			
PT301	Starting air pressure, engine inlet	CV519	Exhaust waste gate control valve
PT311	Control air pressure	CV621	Charge air shut off valve
CV153.1	Stop/shutdown solenoid valve	CVS643	By-pass control valve
CV153.2	Stop/shutdown solenoid valve 2	CV656	Air waste gate control
CV321	Instrument air valve control	PI301	Starting air pressure, engine inlet
CV351	Booster valve for governor	PI311	Control air pressure

Pipe connections		Size	Pressure class	Standard
301	Starting air inlet	DN40	PN40	DIN2635
302	Control air inlet	OD8	PN400	DIN2353
304	Control air to speed governor (in case of mechanical governor with pneumatic speed setting)	OD6	PN250	DIN2353

8.2 External compressed air system

The design of the starting air system is partly determined by classification regulations. Most classification societies require that the total capacity is divided into two equally sized starting air receivers and starting air compressors. The requirements concerning multiple engine installations can be subject to special consideration by the classification society.

The starting air pipes should always be slightly inclined and equipped with manual or automatic draining at the lowest points.

Instrument air to safety and control devices must be treated in an air dryer.

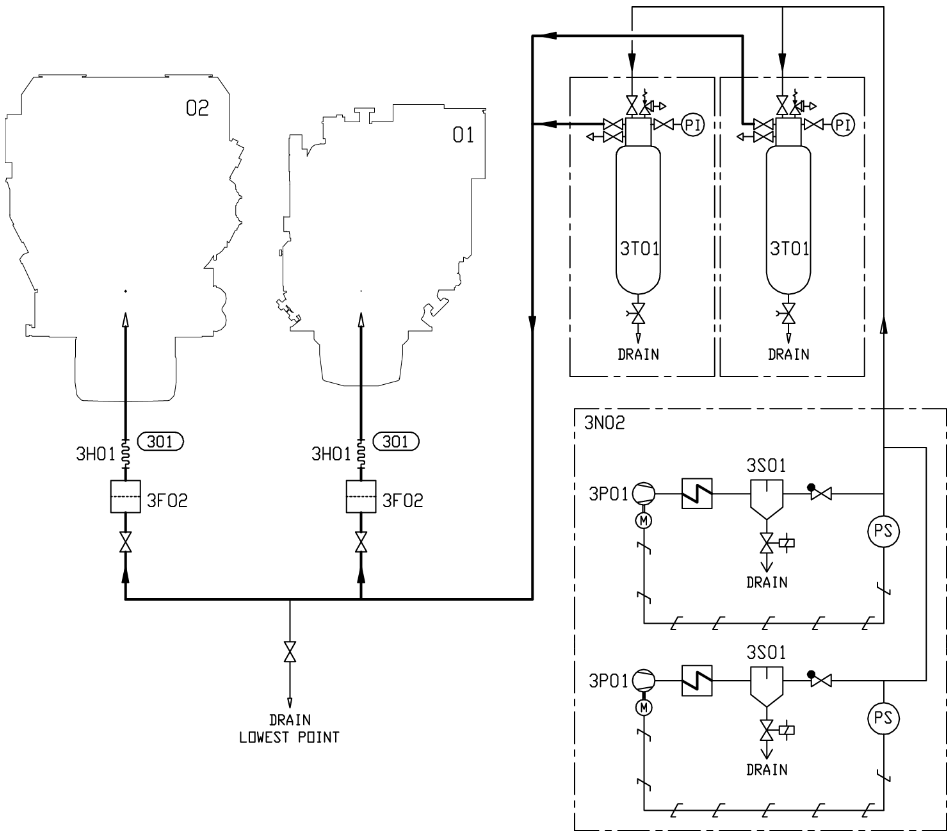


Fig 8-3 **Example of external compressed air system (DAAF078379 a)**

System components			
01	Diesel engine Wärtsilä L26	3N02	Starting air compressor unit
02	Diesel engine Wärtsilä V26	3P01	Compressor (starting air compressor unit)
3H01	Flexible pipe connection	3S01	Separator (starting air compressor unit)
3F02	Air filter (starting air inlet)	3T01	Staring air vessel

Pos	Pipe connections	Size
301	Staring air inlet	DN40

8.2.1 Starting air compressor unit (3N02)

At least two starting air compressors must be installed. It is recommended that the compressors are capable of filling the starting air vessel from minimum (1.8 MPa) to maximum pressure in 15...30 minutes. For exact determination of the minimum capacity, the rules of the classification societies must be followed.

8.2.2 Oil and water separator (3S01)

An oil and water separator should always be installed in the pipe between the compressor and the air vessel. Depending on the operation conditions of the installation, an oil and water separator may be needed in the pipe between the air vessel and the engine.

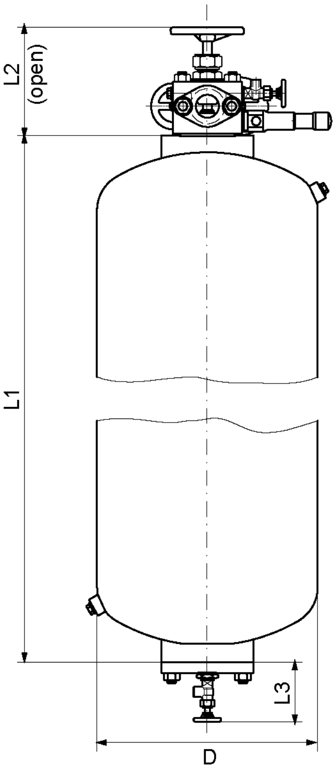
8.2.3 Starting air vessel (3T01)

The starting air vessels should be dimensioned for a nominal pressure of 3 MPa.

The number and the capacity of the air vessels for propulsion engines depend on the requirements of the classification societies and the type of installation.

It is recommended to use a minimum air pressure of 1.8 MPa, when calculating the required volume of the vessels.

The starting air vessels are to be equipped with at least a manual valve for condensate drain. If the air vessels are mounted horizontally, there must be an inclination of 3...5° towards the drain valve to ensure efficient draining.



Size [Litres]	Dimensions [mm]				Weight [kg]
	L1	L2 [1)]	L3 [1)]	D	
125	1807	243	110	324	170
180	1217	243	110	480	200
250	1767	243	110	480	274
500	3204	243	133	480	450
710	2740	255	133	650	625
1000	3560	255	133	650	810

[1)] Dimensions are approximate.

Fig 8-4 Starting air vessel

The starting air consumption stated in technical data is for a successful start. During start the main starting valve is kept open until the engine starts, or until the max. time for the starting attempt has elapsed. A failed start can consume two times the air volume stated in technical data. If the ship has a class notation for unattended machinery spaces, then the starts are to be demonstrated.

The required total starting air vessel volume can be calculated using the formula:

$$V_R = \frac{p_E \times V_E \times n}{p_{R\,max} - p_{R\,min}}$$

where:

V_R = total starting air vessel volume [m^3]

p_E = normal barometric pressure (NTP condition) = 0.1 MPa

V_E = air consumption per start [Nm^3] See *Technical data*

n = required number of starts according to the classification society

p_{Rmax} = maximum starting air pressure = 3 MPa

p_{Rmin} = minimum starting air pressure = See *Technical data*

NOTE

The total vessel volume shall be divided into at least two equally sized starting air vessels.

8.2.4 Air filter, starting air inlet (3F02)

Condense formation after the water separator (between starting air compressor and starting air vessels) create and loosen abrasive rust from the piping, fittings and receivers. Therefore it is recommended to install a filter before the starting air inlet on the engine to prevent particles to enter the starting air equipment.

An Y-type strainer can be used with a stainless steel screen and mesh size 400 µm. The pressure drop should not exceed 20 kPa (0.2 bar) for the engine specific starting air consumption under a time span of 4 seconds.

9. Cooling Water System

9.1 Water quality

The fresh water in the cooling water system of the engine must fulfil the following requirements:

pH	min. 6.5...8.5
Hardness	max. 10 °dH
Chlorides	max. 80 mg/l
Sulphates	max. 150 mg/l

Good quality tap water can be used, but shore water is not always suitable. It is recommended to use water produced by an onboard evaporator. Fresh water produced by reverse osmosis plants often has higher chloride content than permitted. Rain water is unsuitable as cooling water due to the high content of oxygen and carbon dioxide.

Only treated fresh water containing approved corrosion inhibitors may be circulated through the engines. It is important that water of acceptable quality and approved corrosion inhibitors are used directly when the system is filled after completed installation.

9.1.1 Corrosion inhibitors

The use of an approved cooling water additive is mandatory. An updated list of approved products is supplied for every installation and it can also be found in the Instruction manual of the engine, together with dosage and further instructions.

9.1.2 Glycol

Use of glycol in the cooling water is not recommended unless it is absolutely necessary. Starting from 20% glycol the engine is to be de-rated 0.23 % per 1% glycol in the water. Max. 60% glycol is permitted.

Corrosion inhibitors shall be used regardless of glycol in the cooling water.

9.2 Internal cooling water system

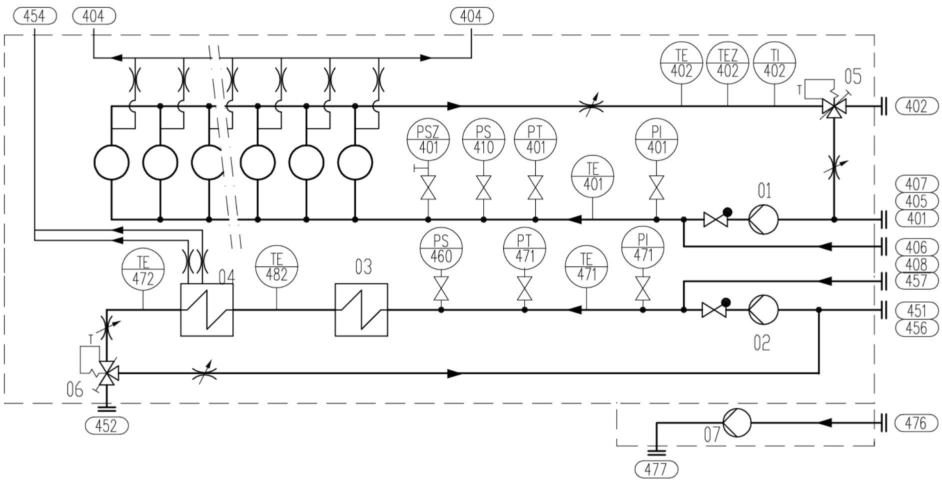


Fig 9-1 **Internal cooling water system, in-line engines (DAAE038904C)**

System components					
01	HT cooling water pump	04	Charge air cooler	06	LT thermostatic valve
02	LT cooling water pump	05	HT thermostatic valve	07	Sea water pump
03	Lubricating oil cooler				

Sensors and indicators			
PI401	HT water pressure before cylinder jackets (if GL)	TI402	HT water temp. after cylinder jackets
TE401	HT water temp. before cylinder jackets	PI471	LT water pressure before cylinder jackets (if GL)
PT401	HT water pressure before cylinder jackets	TE471	LT water temp. engine inlet (if GL)
PS410	HT water stand-by pump start (if stand-by pump)	PT471	LT water pressure, engine inlet
PSZ401	HT water pressure before cylinder jackets (if GL)	PS460	LT water stand-by pump start (if stand-by pump)
TE402	HT water temp. after cylinder jackets	TE482	LT water temp. after lube oil cooler (if FAKS)
TEZ402	HT water temp. after cylinder jackets	TE472	LT water temp. after CAC

Pipe connections (in-line engines)		Size	Pressure class	Standard
401	HT water inlet	DN80	PN10	DIN2576
402	HT water outlet	DN80	PN10	DIN2576
404	HT water air vent	OD12	PN250	DIN2353
405	HT water to preheater	DN80	PN10	DIN2576
406	Water from preheater	DN80	PN10	DIN2576
407	HT water to stand-by pump	DN80	PN10	DIN2576
408	HT water from stand-by pump	DN80	PN10	DIN2576
451	LT water inlet	DN80	PN10	DIN2576
452	LT water outlet	DN80	PN10	DIN2576
454	LT water air vent	OD10	PN10	DIN2353
456	LT water to stand-by pump	DN80	PN10	DIN2576
457	LT water from stand-by pump	DN80	PN10	DIN2576
476	Sea water to engine driven pump	DN80	PN10	DIN2576
477	Sea water from engine driven pump	DN80	PN10	DIN2576

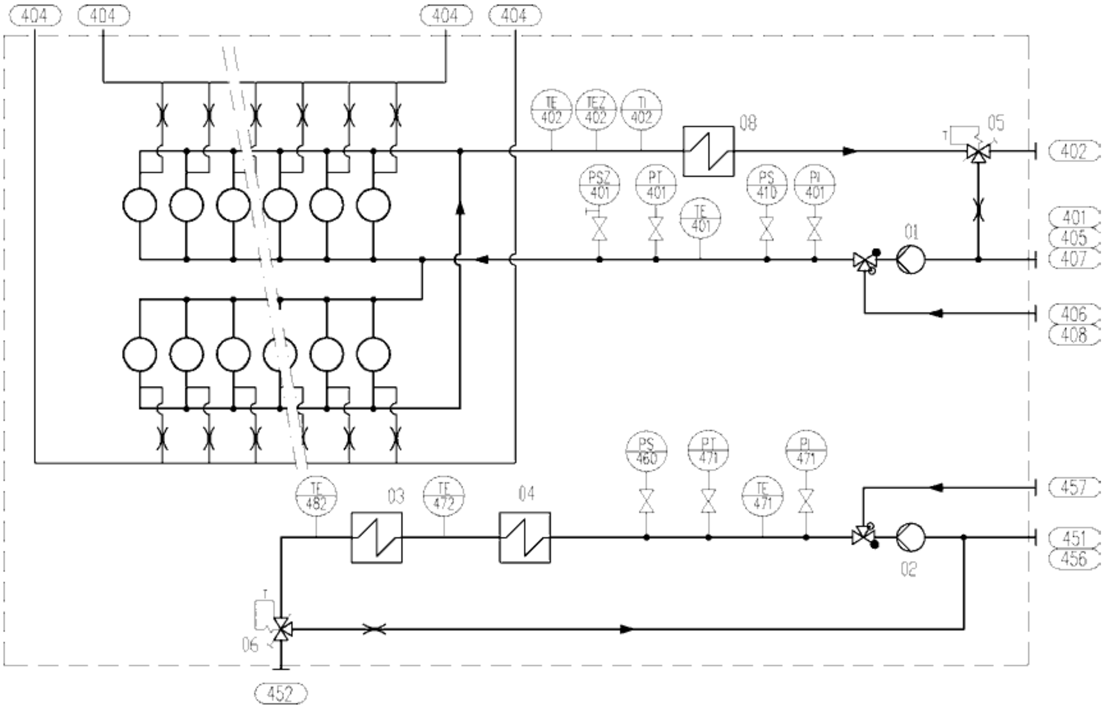


Fig 9-2 Internal cooling water system, V-engines (DAAE038906b)

System components			
01	HT cooling water pump	05	HT thermostatic valve
02	LT cooling water pump	06	LT thermostatic valve
03	Lubricating oil cooler	08	Charge air cooler (HT)
04	Charge air cooler (LT)		

Sensors and indicators			
PI401	HT water pressure before cylinder jackets (if GL)	TI402	HT water temp. after cylinder jackets
PS410	HT water stand-by pump start (if stand-by pump)	PI471	LT water pressure before cylinder jackets (if GL)
TE401	HT water temp. before cylinder jackets	TE471	LT water temp. engine inlet
PT401	HT water pressure before cylinder jackets	PT471	LT water pressure, engine inlet
PSZ401	HT water pressure before cylinder jackets (if GL)	PS460	LT water stand-by pump start (if stand-by pump)
TE402	HT water temp. after cylinder jackets	TE472	LT water temp after CAC (if FAKS)
TEZ402	HT water temp. after cylinder jackets	TE482	LT water temp. after lube oil cooler

Pipe connection		Size	Pressure class	Standard
401	HT water inlet	DN100	PN10	DIN2576
402	HT water outlet	DN100	PN10	DIN2576
404	HT water air vent	OD12		DIN2353
405	HT water to pre-heater	DN100	PN10	DIN2576
406	HT water from pre-heater	DN100	PN10	DIN2576
407	HT water to stand-by pump	DN100	PN10	DIN2576
408	HT water from stand-by pump	DN100	PN10	DIN2576
451	LT water inlet	DN100	PN10	DIN2576
452	LT water outlet	DN100	PN10	DIN2576
456	LT water to stand-by pump	DN100	PN10	DIN2576
457	LT water from stand-by pump	DN100	PN10	DIN2576

The fresh water cooling system is divided into a high temperature (HT) and a low temperature (LT) circuit. The HT water circulates through cylinder jackets, cylinder heads and the 1st stage of the charge air cooler, if the engine is equipped with a two-stage charge air cooler. V-engines are equipped with a two-stage charge air cooler, while in-line engines have a single-stage charge air cooler.

The LT water circulates through the charge air cooler and the lubricating oil cooler, which is built on the engine.

Temperature control valves regulate the temperature of the water out from the engine, by circulating some water back to the cooling water pump inlet. The HT temperature control valve is always mounted on the engine, while the LT temperature control valve can be either on the engine or separate. In installations where the engines operate on MDF only it is possible to install the LT temperature control valve in the external system and thus control the LT water temperature before the engine.

9.2.1 Engine driven circulating pumps

The LT and HT cooling water pumps are engine driven. The engine driven pumps are located at the free end of the engine.

Pump curves for engine driven pumps are shown in the diagrams. The nominal pressure and capacity can be found in the chapter *Technical data*.

Table 9-1 Impeller diameters of engine driven HT & LT pumps

Engine	Engine speed [rpm]	HT		LT		LT + gearbox cooling (optional)	
		impeller Ø [mm]	Non return valve orifice* Ø [mm]	impeller Ø [mm]	Non return valve orifice* Ø [mm]	impeller Ø [mm]	Non return valve orifice* Ø [mm]
6L26	900 1000	216 196	40 40	204 196	40 40	204 196	47 47
8L26	900 1000	216 196	47 54	204 196	54 47	216 204	54 59
9L26	900 1000	216 196	54 54	204 196	59 59	216 216	59 54
12V26	900 1000	178 178	-	178 178	-	-	-
16V26	900 1000	199 199	-	199 199	-	-	-

*) Only for in-line engines.

Table 9-2 Nominal flows and heads of engine driven HT & LT pumps

Engine	Engine speed [rpm]	HT		LT		LT + gearbox cooling (optional)	
		Flow [m³/h]	Head [m H_2O]	Flow [m³/h]	Head [m H_2O]	Flow [m³/h]	Head [m H_2O]
6L26	900 1000	35 35	35 35	42 47	26 27	52 57	26 27
8L26	900 1000	45 45	36 36	56 62	27 25	70 76	25 27
9L26	900 1000	50 50	36 34	63 70	25 26	78 85	27 27
12V26	900 1000	60 67	28 35	60 67	28 35	-	-
16V26	900 1000	80 89	35 44	80 89	35 44	-	-

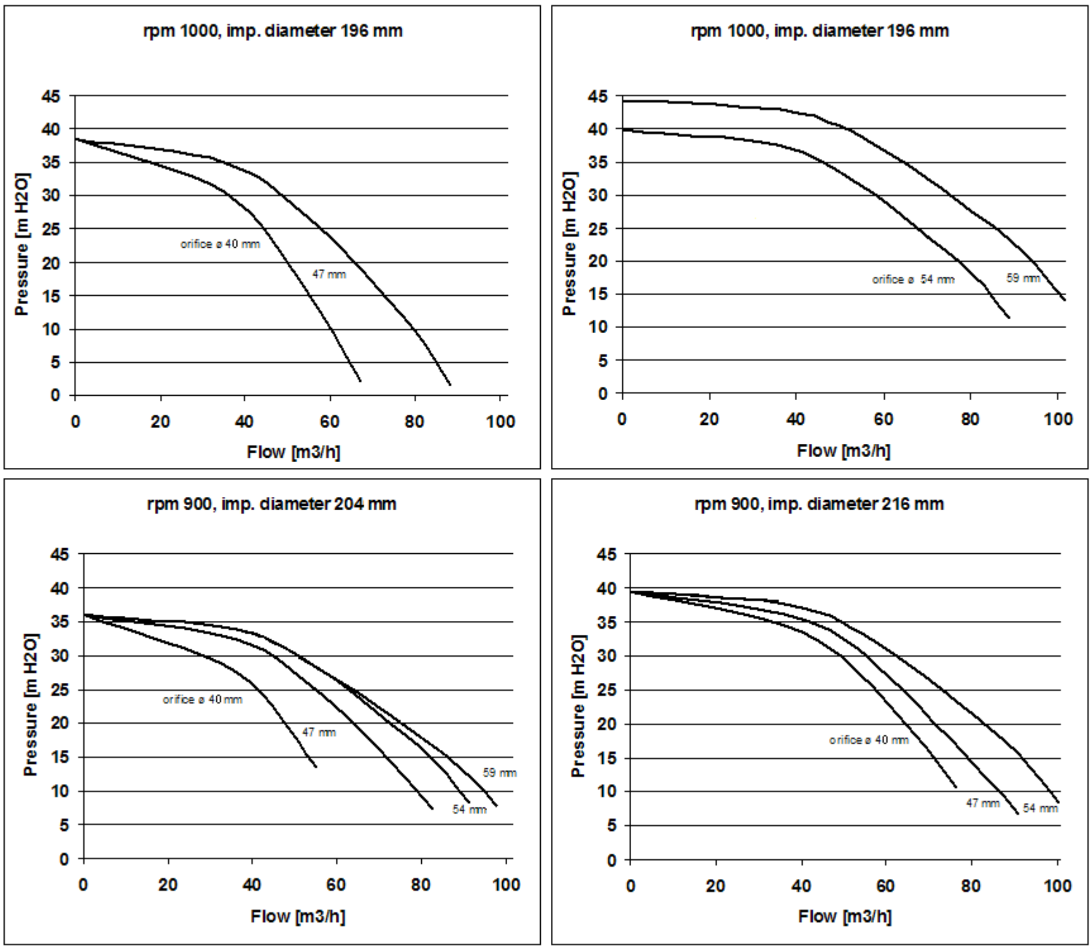


Fig 9-3 Pump curves W26 in-line

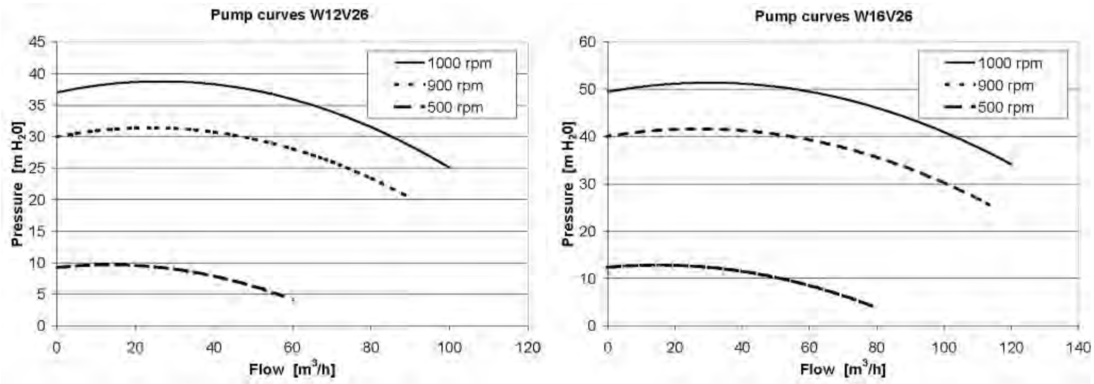


Fig 9-4 **Pump curves W26 V engines (9910ZT141A)**

9.2.2 Engine driven sea water pump

An engine drive sea-water pump is available for in-line main engines:

Engine	Capacity [m³/h]	Head [mwc]
W 6L26	80	25
W 8L26	120	25
W 9L26	120	25

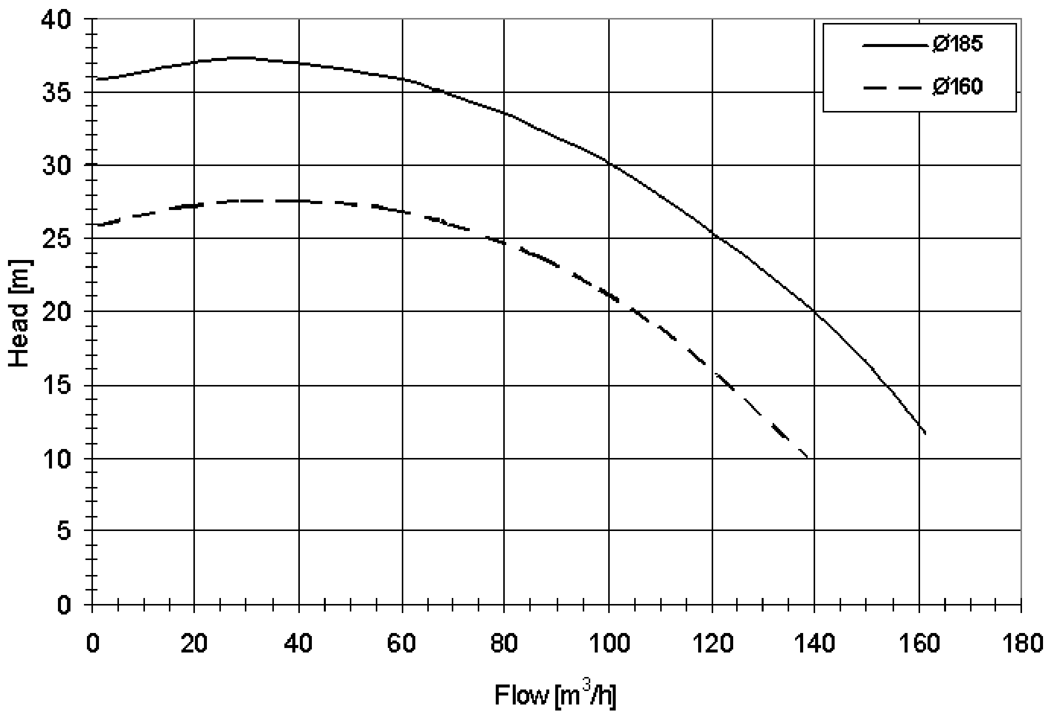


Fig 9-5 **Engine driven sea water pump at 1000 rpm**

9.3 External cooling water system

It is recommended to divide the engines into several circuits in multi-engine installations. One reason is of course redundancy, but it is also easier to tune the individual flows in a smaller system. Malfunction due to entrained gases, or loss of cooling water in case of large leaks can also be limited. In some installations it can be desirable to separate the HT circuit from the LT circuit with a heat exchanger.

The external system shall be designed so that flows, pressures and temperatures are close to the nominal values in *Technical data* and the cooling water is properly de-aerated.

Pipes with galvanized inner surfaces are not allowed in the fresh water cooling system. Some cooling water additives react with zinc, forming harmful sludge. Zinc also becomes nobler than iron at elevated temperatures, which causes severe corrosion of engine components.

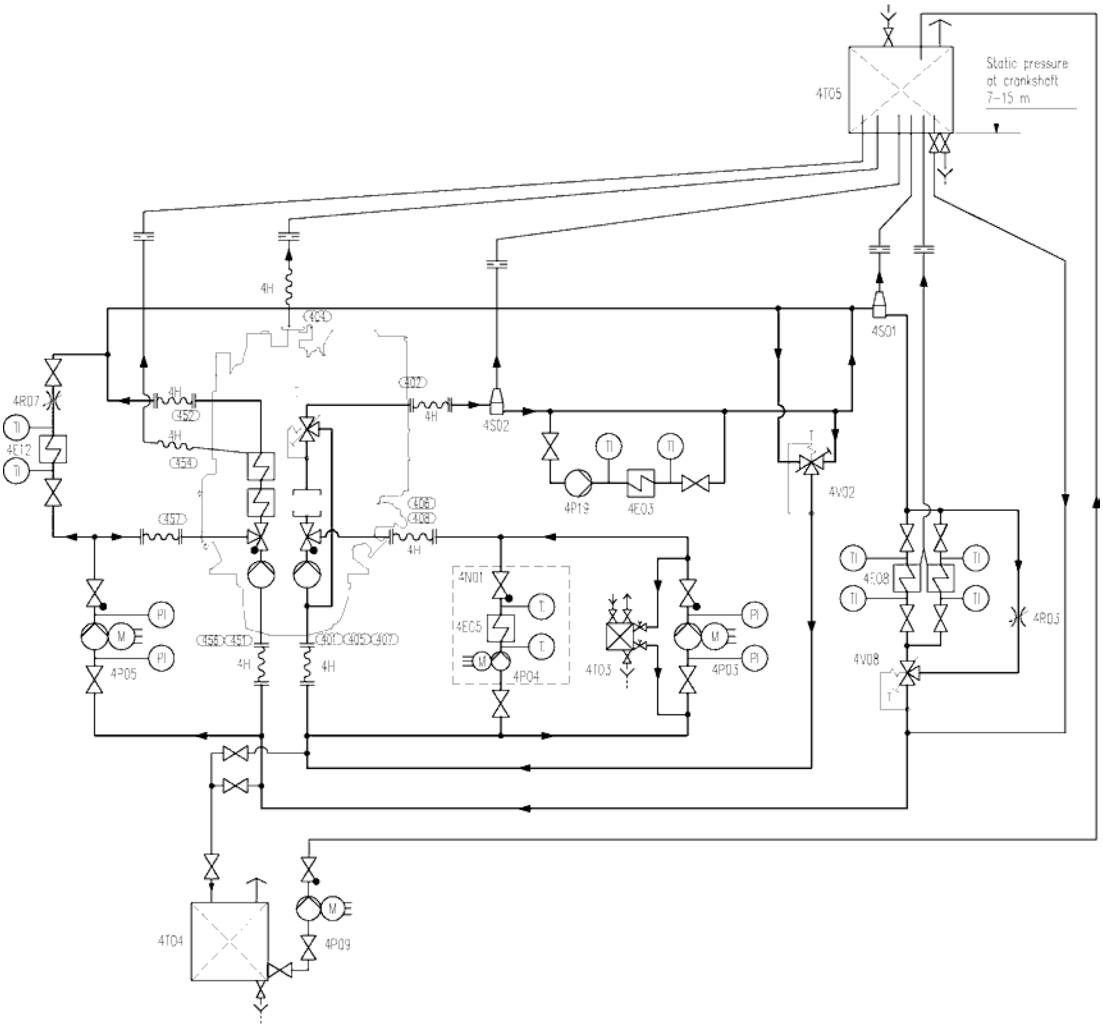


Fig 9-6 External cooling water system example, only for MDF (DAAE038900c)

System components:			
4E03	Heat recovery (evaporator)	4P19	Circulating pump (evaporator)
4E05	Heater (preheater)	4R03	Adjustable throttle valve (LT cooler)
4E08	Central cooler	4R07	Adjustable throttle valve (LT water)
4E12	Cooler (installation parts)	4S02	Air deaerator (HT)
4N01	Preheating unit	4T03	Additive dosing tank
4P03	Stand-by pump (HT)	4T04	Drain tank

System components:			
4P04	Circulating pump (preheater)	4T05	Expansion tank
4P05	Stand-by pump (LT)	4V02	Temperature control valve (heat recovery)
4P09	Transfer pump	4V08	Temperature control valve (central cooler)
Pipe connections are listed below the internal cooling water system diagrams			

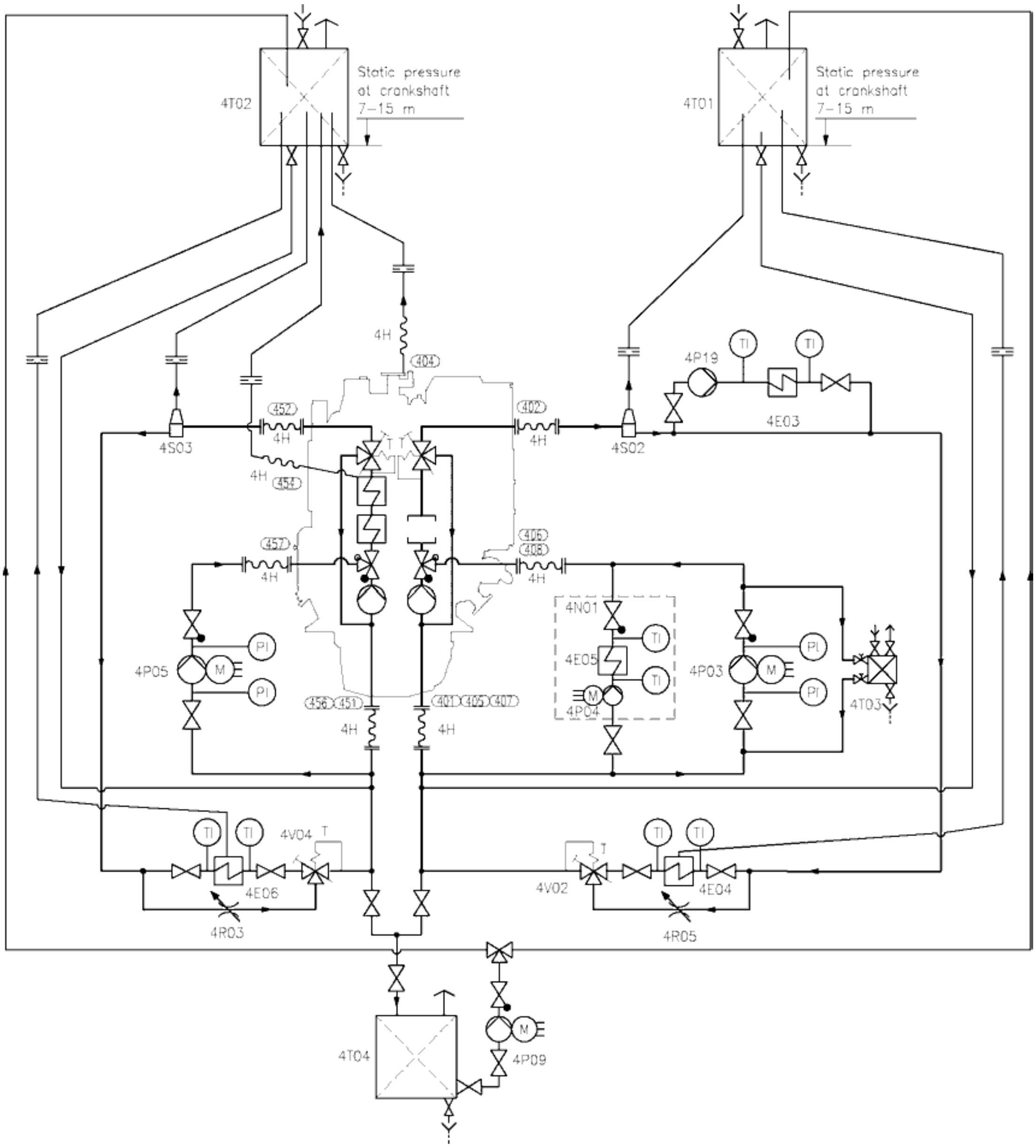


Fig 9-7 External cooling water system example (DAAE038901c)

System components:			
4E03	Heat recovery (evaporator)	4R03	Adjustable throttle valve (LT cooler)
4E04	Raw water cooler (HT)	4R05	Adjustable throttle valve (HT valve)
4E05	Heater (preheater)	4S02	Air deaerator (HT)
4E06	Raw water cooler (LT)	4S03	Air deaerator (LT)
4N01	Preheating unit	4T03	Additive dosing tank
4P03	Stand-by pump (HT)	4T04	Drain tank
4P04	Circulating pump (preheater)	4T05	Expansion tank
4P05	Stand-by pump (LT)	4V02	Temperature control valve (heat recovery)
4P19	Circulating pump (evaporator)	4V08	Temperature control valve (central cooler)
4P09	Transfer pump		
*Pipe connections are listed below the internal cooling water system diagram*s			

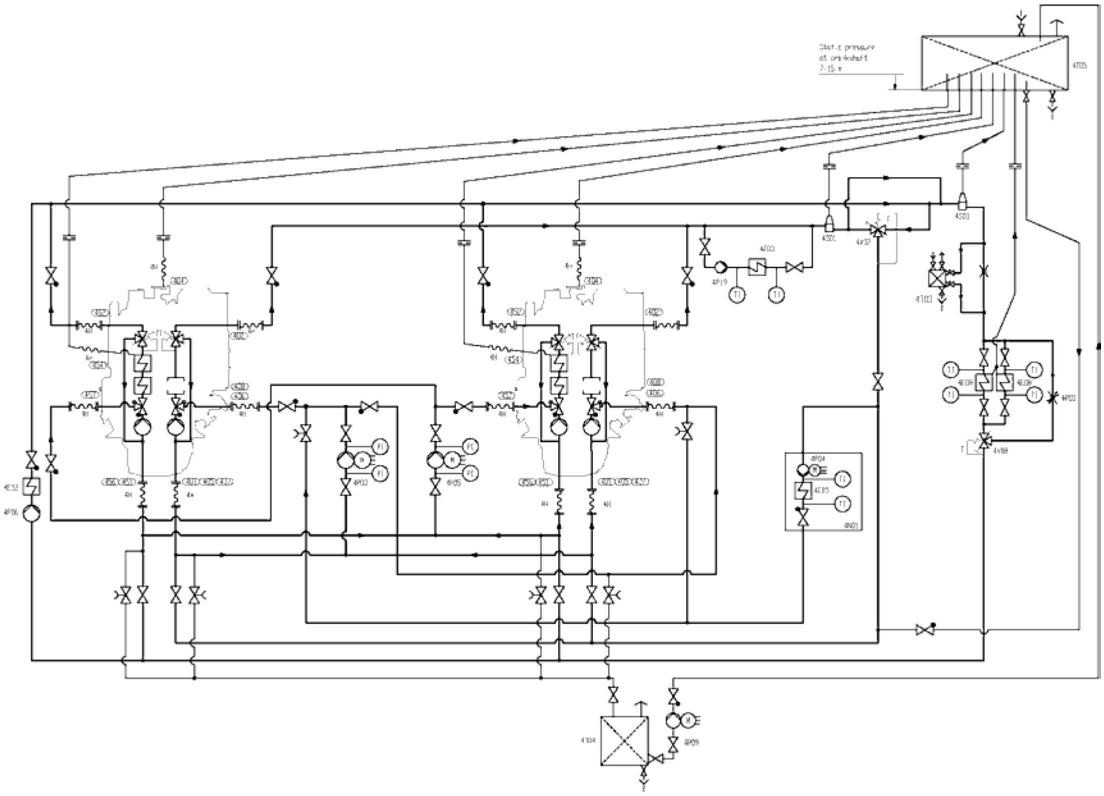


Fig 9-8 External cooling water system example (DAAE038902c)

System components:			
4E03	Heat recovery (evaporator)	4P09	Transfer pump
4E05	Heater (preheater)	4P19	Circulating pump (evaporator)
4E08	Central cooler	4R03	Adjustable throttle valve (LT cooler)
4E12	Cooler (installation parts)	4S01	Air venting
4N01	Preheating unit	4T03	Additive dosing tank
4P03	Stand-by pump (HT)	4T04	Drain tank
4P04	Circulating pump (preheater)	4T05	Expansion tank
4P05	Stand-by pump (LT)	4V02	Temperature control valve (heat recovery)
4P06	Circulating pump	4V08	Temperature control valve (central cooler)
*Pipe connections are listed below the internal cooling water system diagram*s			

Ships (with ice class) designed for cold sea-water should have provisions for recirculation back to the sea chest from the central cooler:

- For melting of ice and slush, to avoid clogging of the sea water strainer
- To enhance the temperature control of the LT water, by increasing the seawater temperature

9.3.1 Stand-by circulation pumps (4P03, 4P05)

Stand-by pumps should be of centrifugal type and electrically driven. Required capacities and delivery pressures are stated in *Technical data*.

NOTE

Some classification societies require that spare pumps are carried onboard even though the ship has multiple engines. Stand-by pumps can in such case be worth considering also for this type of application.

9.3.2 Sea water pump (4P11)

The capacity of electrically driven sea water pumps is determined by the type of coolers and the amount of heat to be dissipated.

Significant energy savings can be achieved in most installations with frequency control of electrically driven sea water pumps. Minimum flow velocity (fouling) and maximum sea water temperature (salt deposits) are however issues to consider.

9.3.3 Temperature control valve for central cooler (4V08)

When it is desired to utilize the engine driven LT-pump for cooling of external equipment, e.g. a reduction or a generator, there must be a common LT temperature control valve in the external system, instead of an individual valve for each engine. The common LT temperature control valve is installed after the central cooler and controls the temperature of the water before the engine and the external equipment, by partly bypassing the central cooler. The valve can be either direct acting or electrically actuated.

The set-point of the temperature control valve 4V08 is 38 °C in the type of system described above.

Engines operating on HFO must have individual LT temperature control valves. A separate pump is required for the external equipment in such case, and the set-point of 4V08 can be lower than 38 °C if necessary.

When there is no temperature control valve in the seawater system (4V07, see figure 9.16), it is advised to install a temperature control valve over the central cooler(s) in order to maintain the temperature before engine at a constant value.

9.3.4 Temperature control valve for heat recovery (4V02)

The temperature control valve after the heat recovery controls the maximum temperature of the water that is mixed with HT water from the engine outlet before the HT pump. The control valve can be either self-actuated or electrically actuated.

The set-point is usually somewhere close to 75 °C.

The arrangement shown in the example system diagrams also results in a smaller flow through the central cooler, compared to a system where the HT and LT circuits are connected in parallel to the cooler.

9.3.5 Coolers for other equipment and MDF coolers

The engine driven LT circulating pump can supply cooling water to one or two small coolers installed in parallel to the engine, for example a MDF cooler or a reduction gear cooler. This is only possible for engines operating on MDF, because the LT temperature control valve cannot be built on the engine to control the temperature after the engine. Separate circulating pumps are required for larger flows.

Design guidelines for the MDF cooler are given in chapter *Fuel system*.

9.3.6 Fresh water central cooler (4E08)

The fresh water cooler can be of either plate, tube or box cooler type. Plate coolers are most common. Several engines can share the same cooler.

It can be necessary to compensate a high flow resistance in the circuit with a smaller pressure drop over the central cooler.

The flow to the fresh water cooler must be calculated case by case based on how the circuit is designed.

As an alternative for the central coolers of the plate or of the tube type a box cooler can be installed. The principle of box cooling is very simple. Cooling water is forced through a U-tube-bundle, which is placed in a sea-chest having inlet- and outlet-grids. Cooling effect is reached by natural circulation of the surrounding water. The outboard water is warmed up and rises by its lower density, thus causing a natural upward circulation flow which removes the heat.

Box cooling has the advantage that no raw water system is needed, and box coolers are less sensitive for fouling and therefor well suited for shallow or muddy waters.

9.3.7 Waste heat recovery

The waste heat in the HT cooling water can be used for fresh water production, central heating, tank heating etc. The system should in such case be provided with a temperature control valve to avoid unnecessary cooling, as shown in the example diagrams. With this arrangement the HT water flow through the heat recovery can be increased.

The heat available from HT cooling water is affected by ambient conditions. It should also be taken into account that the recoverable heat is reduced by circulation to the expansion tank, radiation from piping and leakages in temperature control valves.

9.3.8 Air venting

Air may be entrained in the system after an overhaul, or a leak may continuously add air or gas into the system. The engine is equipped with vent pipes to evacuate air from the cooling water circuits. The vent pipes should be drawn separately to the expansion tank from each connection on the engine, except for the vent pipes from the charge air cooler on V-engines, which may be connected to the corresponding line on the opposite cylinder bank.

Venting pipes to the expansion tank are to be installed at all high points in the piping system, where air or gas can accumulate.

The vent pipes must be continuously rising.

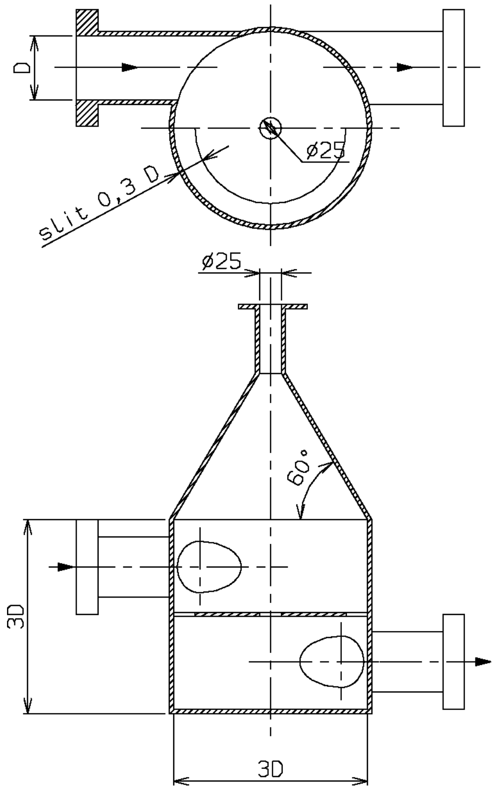


Fig 9-9 **Automatic de-aerator (9811MR102).**

The water flow is forced in a circular movement in the air separator. Air and gas collect in the centre of the separator due to the higher centrifugal force on water.

9.3.9 Expansion tank (4T05)

The expansion tank compensates for thermal expansion of the coolant, serves for venting of the circuits and provides a sufficient static pressure for the circulating pumps.

Design data:

Pressure from the expansion tank at pump inlet	70 - 150 kPa (0.7...1.5 bar)
Volume	min. 10% of the total system volume

NOTE

The maximum pressure at the engine must not be exceeded in case an electrically driven pump is installed significantly higher than the engine.

Concerning the water volume in the engine, see chapter *Technical data*.

The expansion tank should be equipped with an inspection hatch, a level gauge, a low level alarm and necessary means for dosing of cooling water additives.

The vent pipes should enter the tank below the water level. The vent pipes must be drawn separately to the tank (see air venting) and the pipes should be provided with labels at the expansion tank.

The balance pipe down from the expansion tank must be dimensioned for a flow velocity not exceeding 1.0...1.5 m/s in order to ensure the required pressure at the pump inlet with engines running. The flow through the pipe depends on the number of vent pipes to the tank and the size of the orifices in the vent pipes. The table below can be used for guidance.

Table 9-3 Minimum diameter of balance pipe

Nominal pipe size	Max. flow velocity (m/s)	Max. number of vent pipes with ø 5 mm orifice
DN 32	1.1	3
DN 40	1.2	6
DN 50	1.3	10
DN 65	1.4	17

9.3.10 Drain tank (4T04)

It is recommended to collect the cooling water with additives in a drain tank, when the system has to be drained for maintenance work. A pump should be provided so that the cooling water can be pumped back into the system and reused.

Concerning the water volume in the engine, see chapter *Technical data*. The water volume in the LT circuit of the engine is small.

9.3.11 Additive dosing tank (4T03)

It is also recommended to provide a separate additive dosing tank, especially when water treatment products are added in solid form. The design must be such that the major part of the water flow is circulating through the engine when treatment products are added.

The tank should be connected to the HT cooling water circuit as shown in the example system diagrams.

9.3.12 Preheating

The cooling water circulating through the cylinders must be preheated to at least 60 °C, preferably 70 °C. Presence of preheating is is an absolute requirement for installations that are designed to operate on heavy fuel and marine diesel fuel.

The energy required for preheating of the HT cooling water can be supplied by a separate source or by a running engine, often a combination of both. In all cases a separate circulating pump must be used. It is common to use the heat from running auxiliary engines for preheating of main engines. In installations with several main engines the capacity of the separate heat source can be dimensioned for preheating of two engines, provided that this is acceptable for the operation of the ship. If the cooling water circuits are separated from each other, the energy is transferred over a heat exchanger.

9.3.12.1 Heater (4E05)

The energy source of the heater can be electric power, steam or thermal oil.

It is recommended to heat the HT water to a temperature near the normal operating temperature. The heating power determines the required time to heat up the engine from cold condition.

The minimum required heating power is 3 kW/cyl, which makes it possible to warm up the engine from 20 °C to 60...70 °C in 10-15 hours. The required heating power for shorter heating time can be estimated with the formula below. About 1.5 kW/cyl is required to keep a hot engine warm.

Desig data:

Preheating temperature	min. 60°C

Required heating power	3 kW/cyl
Heating power to keep hot engine warm	1.5 kW/cyl

Required heating power to heat up the engine, see formula below:

$$P = \frac{(T_1 - T_0)(m_{eng} \times 0.14 + V_{LO} \times 0.48 + V_{FW} \times 1.16)}{t} + k_{eng} \times n_{cyl}$$

where:

P =	Preheater output [kW]
T_1 =	Preheating temperature = 60...70 °C
T_0 =	Ambient temperature [°C]
m_{eng} =	Engine weight [ton]
V_{LO} =	Lubricating oil volume [m^3] (wet sump engines only)
V_{FW} =	HT water volume [m^3]
t =	Preheating time [h]
k_{eng} =	Engine specific coefficient = 0.75 kW
n_{cyl} =	Number of cylinders

The formula above should not be used for $P < 2.5$ kW/cyl

9.3.12.2 Circulation pump for preheater (4P04)

Design data:

Capacity	0.45 m^3/h per cylinder
Delivery pressure	80...100 kPa (0.8...1.0 bar)

9.3.12.3 Preheating unit (4N01)

A complete preheating unit can be supplied. The unit comprises:

- Electric or steam heaters
- Circulating pump
- Control cabinet for heaters and pump
- Set of thermometers
- Non-return valve
- Safety valve

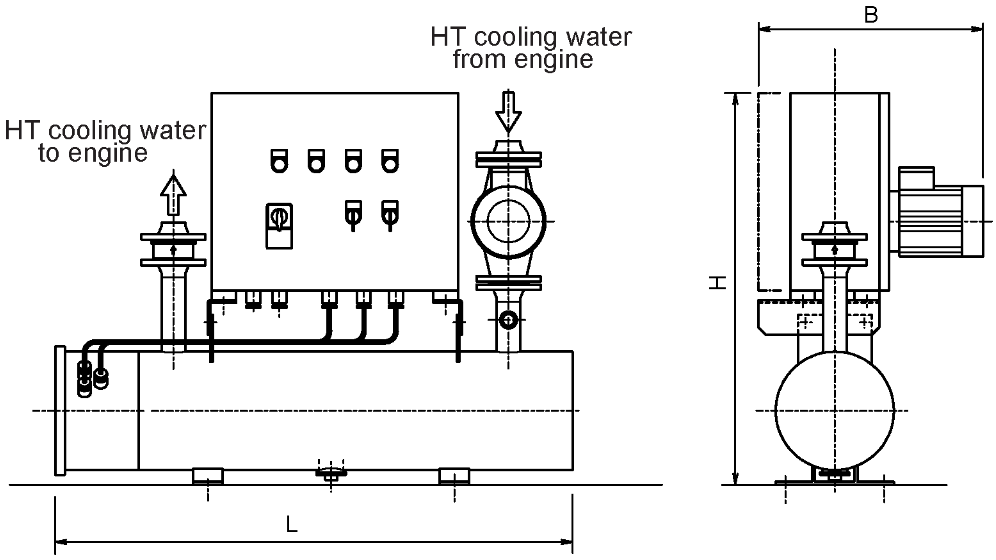


Fig 9-10 Electric pre-heating unit, main dimensions

Heating power [kW]*	L [mm]	H [mm]	B [mm]	Mass [kg] (wet)
12 (16)	1050	800	460	93
16 (21)	1250	800	460	95
18 (24)	1250	800	460	95
24 (32)	1250	840	480	103
32 (42)	1250	840	480	125

9.3.13 Throttles

Throttles (orifices) are to be installed in all by-pass lines to ensure balanced operating conditions for temperature control valves. Throttles must also be installed wherever it is necessary to balance the waterflow between alternate flow paths.

9.3.14 Thermometers and pressure gauges

Local thermometers should be installed wherever there is a temperature change, i.e. before and after heat exchangers etc. in external system.

Local pressure gauges should be installed on the suction and discharge side of each pump.

10. Combustion Air System

10.1 Engine room ventilation

To maintain acceptable operating conditions for the engines and to ensure trouble free operation of all equipment, attention shall be paid to the engine room ventilation and the supply of combustion air.

The air intakes to the engine room must be located and designed so that water spray, rain water, dust and exhaust gases cannot enter the ventilation ducts and the engine room.

The dimensioning of blowers and extractors should ensure that an overpressure of about 50 Pa is maintained in the engine room in all running conditions.

For the minimum requirements concerning the engine room ventilation and more details, see applicable standards, such as ISO 8861.

The amount of air required for ventilation is calculated from the total heat emission Φ to evacuate. To determine Φ, all heat sources shall be considered, e.g.:

- Main and auxiliary diesel engines
- Exhaust gas piping
- Generators
- Electric appliances and lighting
- Boilers
- Steam and condensate piping
- Tanks

It is recommended to consider an outside air temperature of no less than 35°C and a temperature rise of 11°C for the ventilation air.

The amount of air required for ventilation is then calculated using the formula:

$$q_V = \frac{\Phi}{\rho \times c \times \Delta T}$$

where:

q_v = air flow [m³/s]

Φ = total heat emission to be evacuated [kW]

ρ = air density 1.13 kg/m³

c = specific heat capacity of the ventilation air 1.01 kJ/kgK

ΔT = temperature rise in the engine room [°C]

The heat emitted by the engine is listed in chapter *Technical data*.

The engine room ventilation air has to be provided by separate ventilation fans. These fans should preferably have two-speed electric motors (or variable speed). The ventilation can then be reduced according to outside air temperature and heat generation in the engine room, for example during overhaul of the main engine when it is not preheated (and therefore not heating the room).

The ventilation air is to be equally distributed in the engine room considering air flows from points of delivery towards the exits. This is usually done so that the funnel serves as exit for most of the air. To avoid stagnant air, extractors can be used.

It is good practice to provide areas with significant heat sources, such as separator rooms with their own air supply and extractors.

Under-cooling of the engine room should be avoided during all conditions (service conditions, slow steaming and in port). Cold draft in the engine room should also be avoided, especially in areas of frequent maintenance activities. For very cold conditions a pre-heater in the system should be considered. Suitable media could be thermal oil or water/glycol to avoid the risk for freezing. If steam is specified as heating medium for the ship, the pre-heater should be in a secondary circuit.

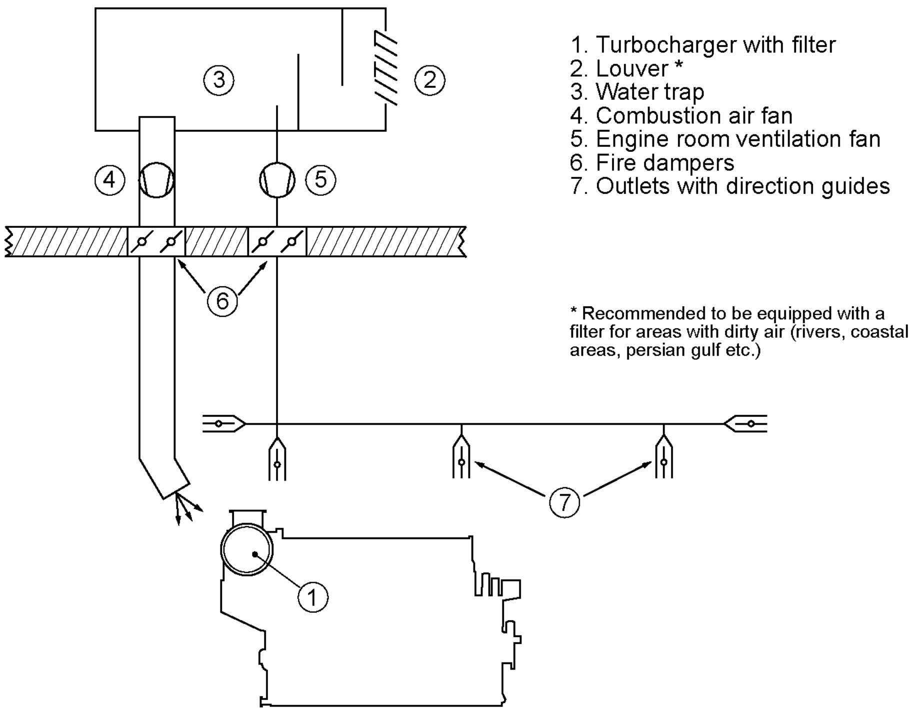


Fig 10-1 Engine room ventilation, turbocharger with air filter (DAAE092651)

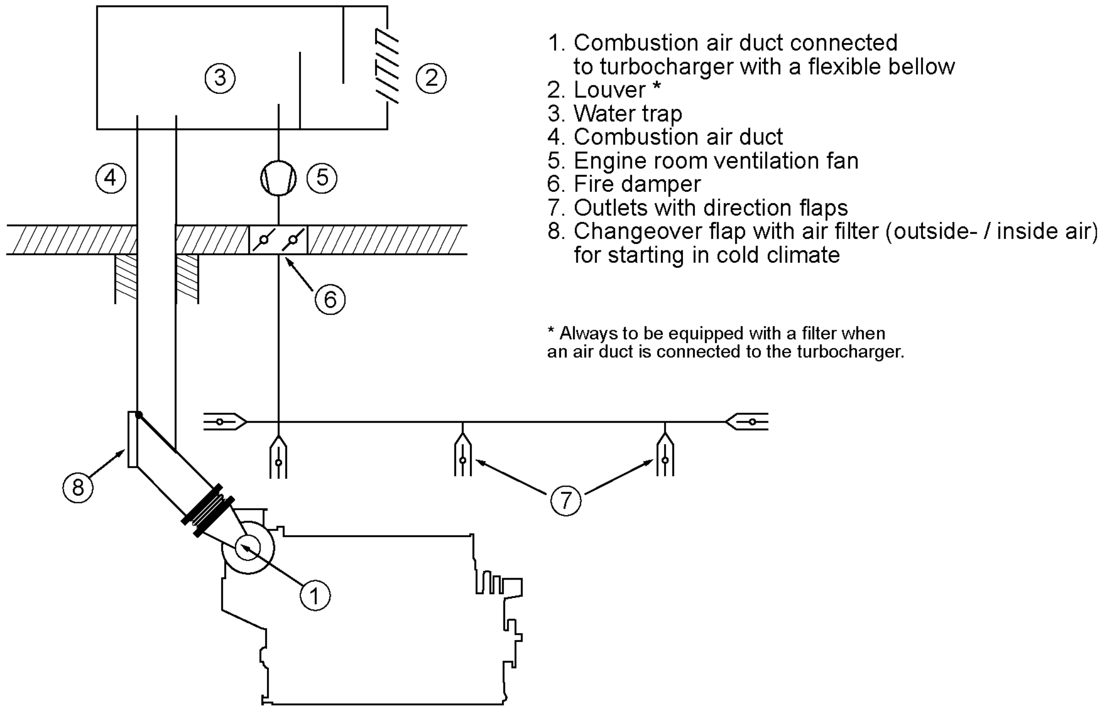


Fig 10-2 Engine room ventilation, air duct connected to the turbocharger (DAAE092652A)

10.2 Combustion air system design

Usually, the combustion air is taken from the engine room through a filter on the turbocharger. This reduces the risk for too low temperatures and contamination of the combustion air. It is important that the combustion air is free from sea water, dust, fumes, etc.

For the required amount of combustion air, see section *Technical data*.

The combustion air shall be supplied by separate combustion air fans, with a capacity slightly higher than the maximum air consumption. The combustion air mass flow stated in technical data is defined for an ambient air temperature of 25°C. Calculate with an air density corresponding to 30°C or more when translating the mass flow into volume flow. The expression below can be used to calculate the volume flow.

$$q_c = \frac{m'}{\rho}$$

where:

q_c = combustion air volume flow [m³/s]

m' = combustion air mass flow [kg/s]

ρ = air density 1.15 kg/m³

The fans should preferably have two-speed electric motors (or variable speed) for enhanced flexibility. In addition to manual control, the fan speed can be controlled by engine load.

In multi-engine installations each main engine should preferably have its own combustion air fan. Thus the air flow can be adapted to the number of engines in operation.

The combustion air should be delivered through a dedicated duct close to the turbocharger, directed towards the turbocharger air intake. The outlet of the duct should be equipped with a flap for controlling the direction and amount of air. Also other combustion air consumers, for example other engines, gas turbines and boilers shall be served by dedicated combustion air ducts.

If necessary, the combustion air duct can be connected directly to the turbocharger with a flexible connection piece. With this arrangement an external filter must be installed in the duct to protect the turbocharger and prevent fouling of the charge air cooler. The permissible total pressure drop in the duct is max. 1.5 kPa. The duct should be provided with a step-less change-over flap to take the air from the engine room or from outside depending on engine load and air temperature.

For very cold conditions arctic setup is to be used. The combustion air fan is stopped during start of the engine and the necessary combustion air is drawn from the engine room. After start either the ventilation air supply, or the combustion air supply, or both in combination must be able to maintain the minimum required combustion air temperature. The air supply from the combustion air fan is to be directed away from the engine, when the intake air is cold, so that the air is allowed to heat up in the engine room.

10.2.1 Charge air shut-off valve (optional)

In installations where it is possible that the combustion air includes combustible gas or vapour the engines can be equipped with charge air shut-off valve. This is regulated mandatory where ingestion of flammable gas or fume is possible.

10.2.2 Condensation in charge air coolers

Air humidity may condense in the charge air cooler, especially in tropical conditions. The engine equipped with a small drain pipe from the charge air cooler for condensed water.

The amount of condensed water can be estimated with the diagram below.

Example, according to the diagram:

At an ambient air temperature of 35°C and a relative humidity of 80%, the content of water in the air is 0.029 kg water/ kg dry air. If the air manifold pressure (receiver pressure) under these conditions is 2.5 bar (= 3.5 bar absolute), the dew point will be 55°C. If the air temperature in the air manifold is only 45°C, the air can only contain 0.018 kg/kg. The difference, 0.011 kg/kg (0.029 - 0.018) will appear as condensed water.

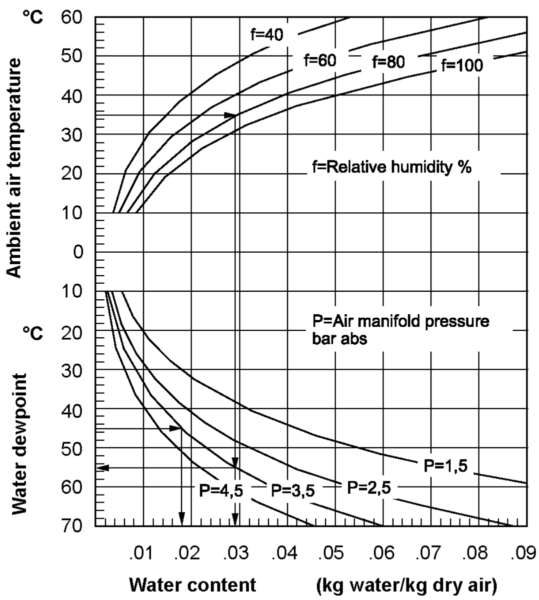


Fig 10-3 Condensation in charge air coolers

11. Exhaust Gas System

11.1 Internal exhaust gas system

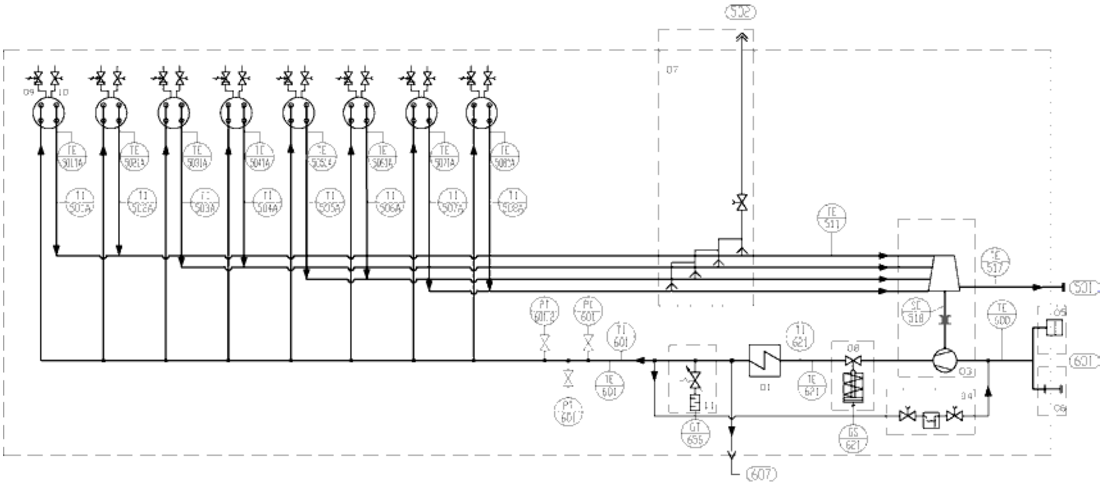


Fig 11-1 Charge air and exhaust gas system 8L, 2-pulse system (DAAE047964a)

System components, in-line engines			
01	Charge air cooler	07	Turbine cleaning device
03	Turbocharger	08	Charge air shut-off valve (optional)
04	Compressor cleaning device	09	Safety valve
05	Air filter and silencer	10	Indicator valve
06	Suction branch (alternative for 05)	11	Air waste gate

Sensors and indicators, in-line engines			
TE5xx1A	Exhaust gas temp. after cylinder	TI5xxA	Exhaust gas temp. after cylinder (if GL)
TE511	Exhaust gas temp. TC inlet	TI601	Charge air temp. engine inlet
TE517	Exhaust gas temp. TC outlet	TI621	Charge air temp. CAC inlet
SE518	TC speed	TE600	Charge air temp. TC inlet (if FAKS)
PI601	Charge air pressure, engine inlet (if GL)	TE621	Charge air temp. CAC inlet (if FAKS)
PT601	Charge air pressure, engine inlet	GS621	Charge air shut-off valve position (optional)
PT601.2	Charge air pressure, engine inlet	GT656	Air waste gate position
TE601	Charge air temp. engine inlet		

Pipe connections, in-line engines		Size	Pressure class	Standard
501	Exhaust gas outlet	6L: DN300 8L, 9L: DN350	PN6	
502	Cleaning water to turbine	Quick coupling		
601	Air inlet to turbocharger (if suction branch)	6L: Øint 280; Øpc 340; 12XØ14 8L, 9L: Øint 333; Øpc 405; 12XØ14		
607	Condensate after air cooler	OD8	PN400	DIN2535

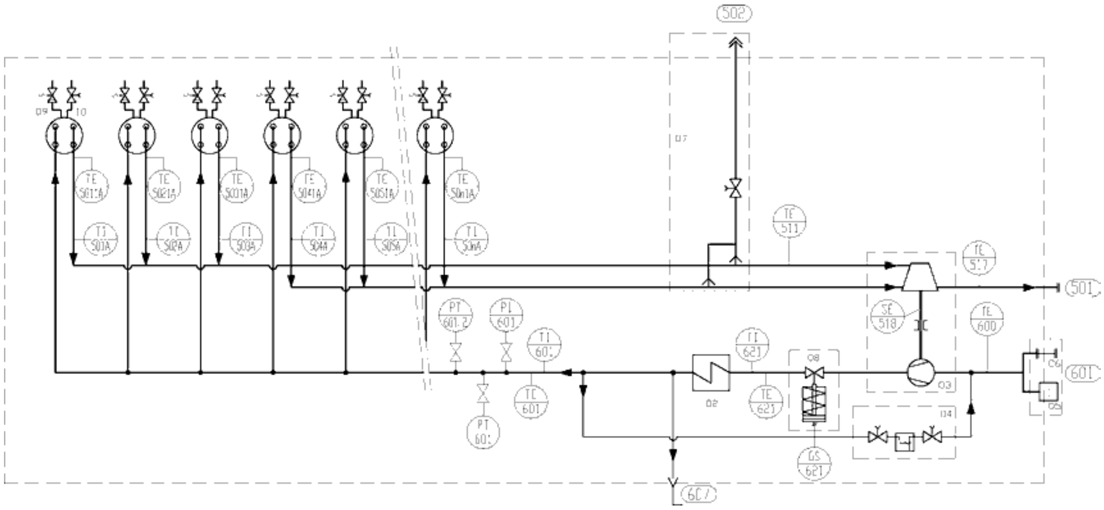


Fig 11-2 Charge air and exhaust gas system 6L & 9L, 3-pulse system (DAAE038908a)

System components, in-line engines			
01	Charge air cooler	07	Turbine cleaning device
03	Turbocharger	08	Charge air shut-off valve (optional)
04	Compressor cleaning device	09	Safety valve
05	Air filter and silencer	10	Indicator valve
06	Suction branch (alternative for 05)	11	Air waste gate

Sensors and indicators, in-line engines			
TE5xx1A	Exhaust gas temp. after cylinder	TI5xxA	Exhaust gas temp. after cylinder (if GL)
TE511	Exhaust gas temp. TC inlet	TI601	Charge air temp. engine inlet
TE517	Exhaust gas temp. TC outlet	TI621	Charge air temp. CAC inlet
SE518	TC speed	TE600	Charge air temp. TC inlet (if FAKS)
PI601	Charge air pressure, engine inlet (if GL)	TE621	Charge air temp. CAC inlet (if FAKS)
PT601	Charge air pressure, engine inlet	GS621	Charge air shut-off valve position (optional)
PT601.2	Charge air pressure, engine inlet	GT656	Air waste gate position
TE601	Charge air temp. engine inlet		

Pipe connections, in-line engines		Size	Pressure class	Standard
501	Exhaust gas outlet	6L: DN300 8L, 9L: DN350	PN6	
502	Cleaning water to turbine	Quick coupling		
601	Air inlet to turbocharger (if suction branch)	6L: Øint 280; Øpc 340; 12XØ14 8L, 9L: Øint 333; Øpc 405; 12XØ14		
607	Condensate after air cooler	OD8	PN400	DIN2535

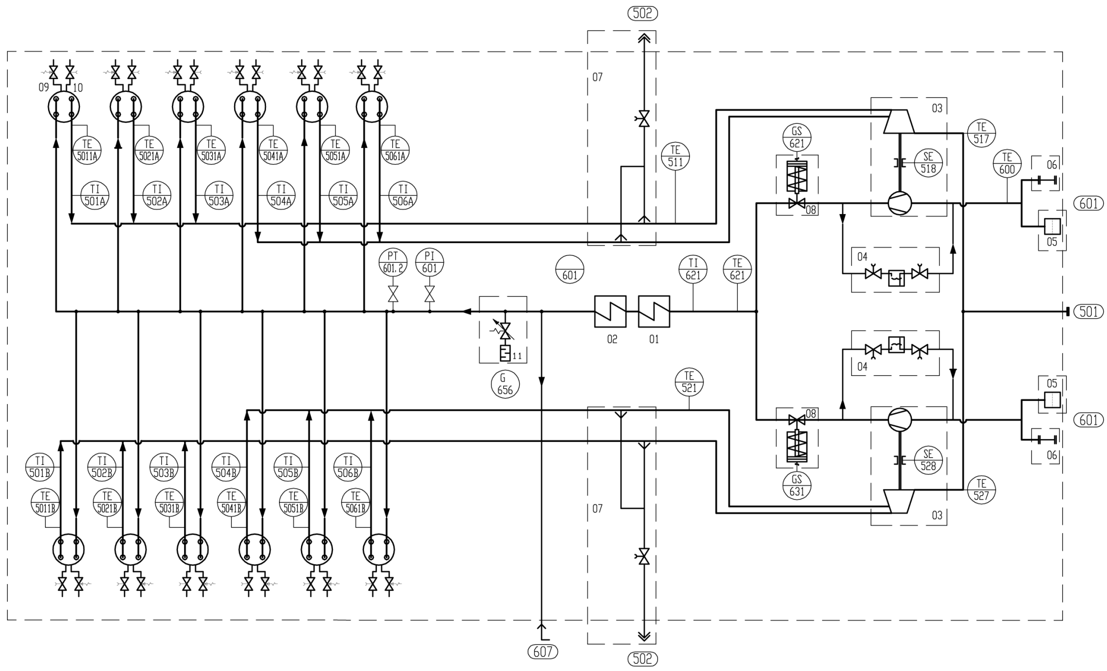


Fig 11-3 Charge air and exhaust gas system 12V, pulse system (DAAE042959a)

System components, 12V-engine			
01	Charge air cooler (HT)	07	Turbine cleaning device
02	Charge air cooler (LT)	08	Charge air shut-off valve (optional)
03	Turbocharger	09	Safety valve
04	Compressor cleaning device	10	Indicator valve
05	Air filter and silencer	11	Air waste gate
06	Suction branch (alternative for 05)		

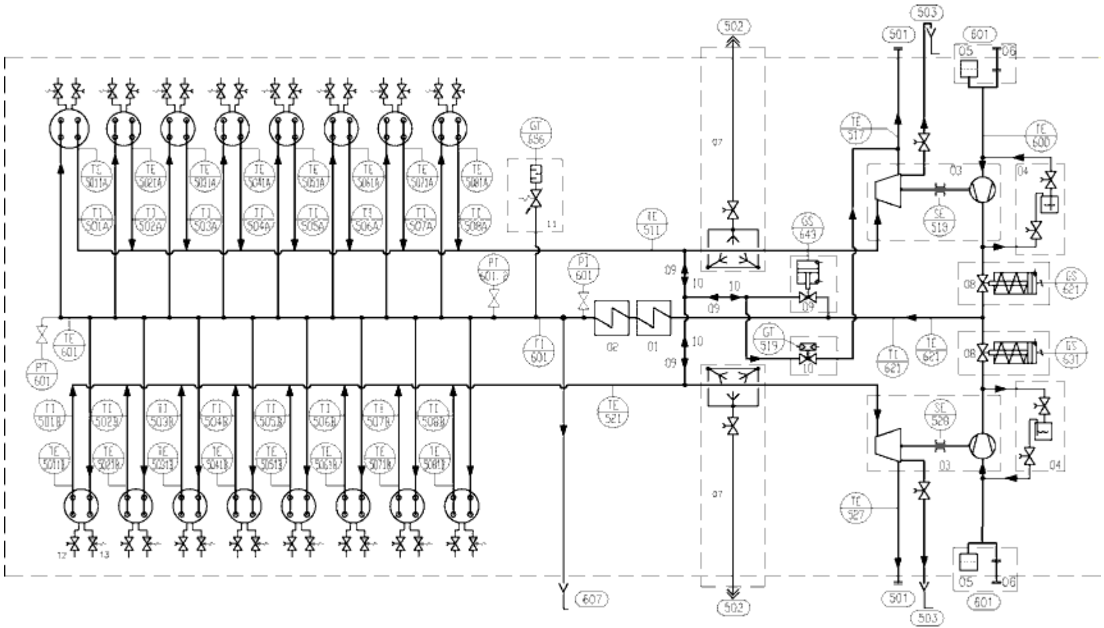


Fig 11-4 **Charge air and exhaust gas system 16V, with SPEX, by-pass and waste gate (DAAE038909A)**

System components, 16V-engine					
01	Charge air cooler (HT)	06	Suction branch (alternative for 05)	11	Air waste gate
02	Charge air cooler (LT)	07	Turbine cleaning device	12	Indicator valve
03	Turbocharger	08	Charge air shut-off valve (option-al)	13	Safety valve
04	Compressor cleaning device	09	Charge air by-pass valve		
05	Air filter and silencer	10	Exhaust waste gate valve		

Sensors and indicators, V-engines			
TE5xx1A	Exhaust gas temp. after cylinder, A-bank	TI621	Charge air temp. CAC inlet
TE5xx1B	Exhaust gas temp. after cylinder, B-bank	PI601	Charge air pressure, engine inlet (if GL)
TE511	Exhaust gas temp. TC inlet, A-bank	TI5xxA	Exhaust gas temp. after cylinder, A-bank (if GL)
TE521	Exhaust gas temp. TC inlet, B-bank	TI5xxB	Exhaust gas temp. after cylinder, B-bank (if GL)
TE517	Exhaust gas temp. TC outlet, A-bank	PT601.2	Charge air pressure, engine inlet
TE527	Exhaust gas temp. TC outlet, B-bank	TE600	Charge air temp. TC inlet (if FAKS)
SE518	TC speed, A-bank	TE621	Charge air temp. CAC inlet (if FAKS)
SE528	TC speed, B-bank	GS621	Charge air shut-off valve position, A-bank
PT601	Charge air pressure, engine inlet	GS631	Charge air shut-off valve position, B-bank
TE601	Charge air temp. engine inlet	GT656	Air waste gate position
TI601	Charge air temp. engine inlet		

Pipe connections, V-engines		Size	Pressure class	Standard
501	Exhaust gas outlet	12V: DN450 16V: DN400	PN6	
502	Cleaning water to turbine	Quick coupling		
503	Cleaning water from turbine	16V: DN25		
601	Air inlet to turbocharger (if suction branch)	12V: Øint 280; Øpc 340; 12XØ14 16V: Øint 378; Øpc 495; 16XØ22		
607	Condensate after air cooler	OD8	PN400	DIN2535

11.2 Exhaust gas outlet

The exhaust gas outlet from the turbocharger can be inclined into several positions. The possibilities depend on the cylinder configuration as shown in figures of this section. The turbocharger can be located at both ends, the figure shows only free end solutions. A flexible bellow has to be mounted directly on the turbine outlet to protect the turbocharger from external forces.

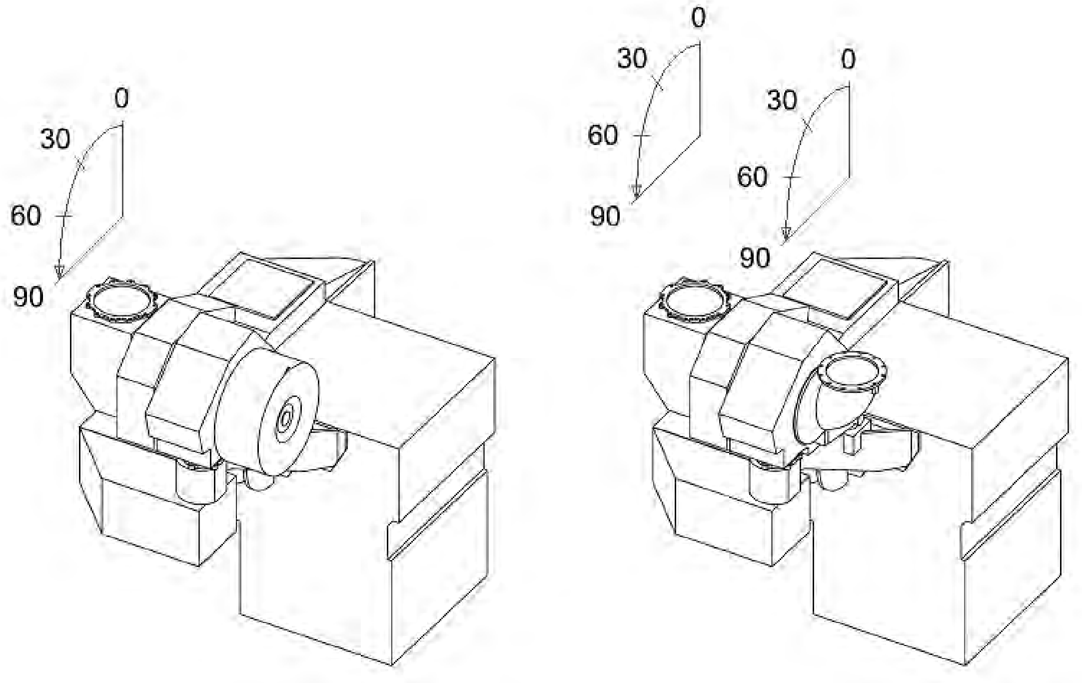


Fig 11-5 Exhaust outlet possibilities, in-line engines

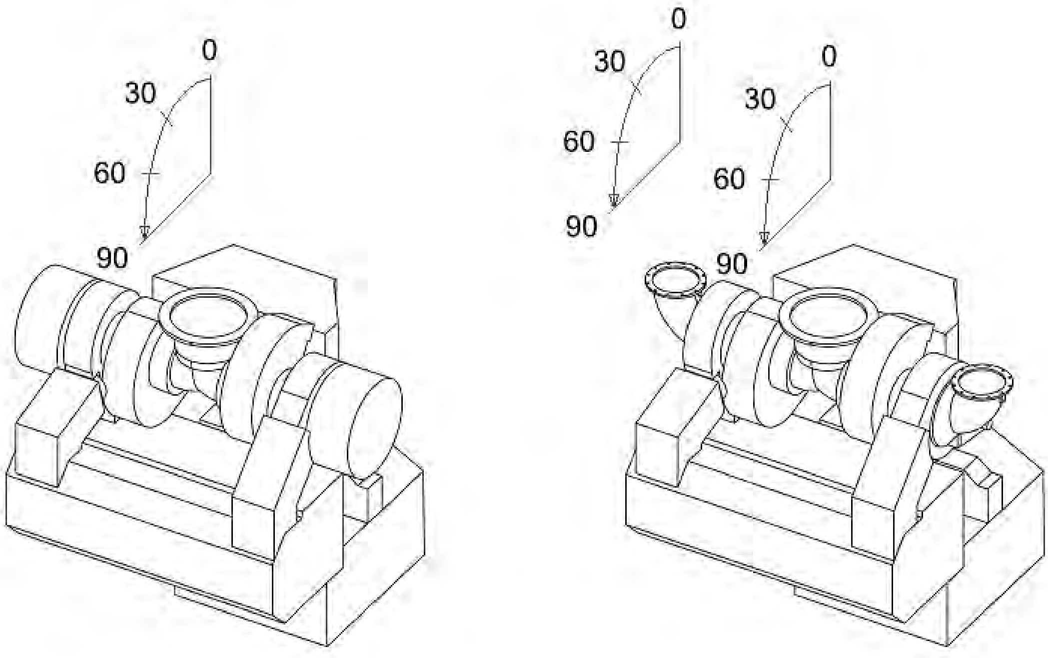


Fig 11-6 Exhaust outlet possibilities, 12V-engine

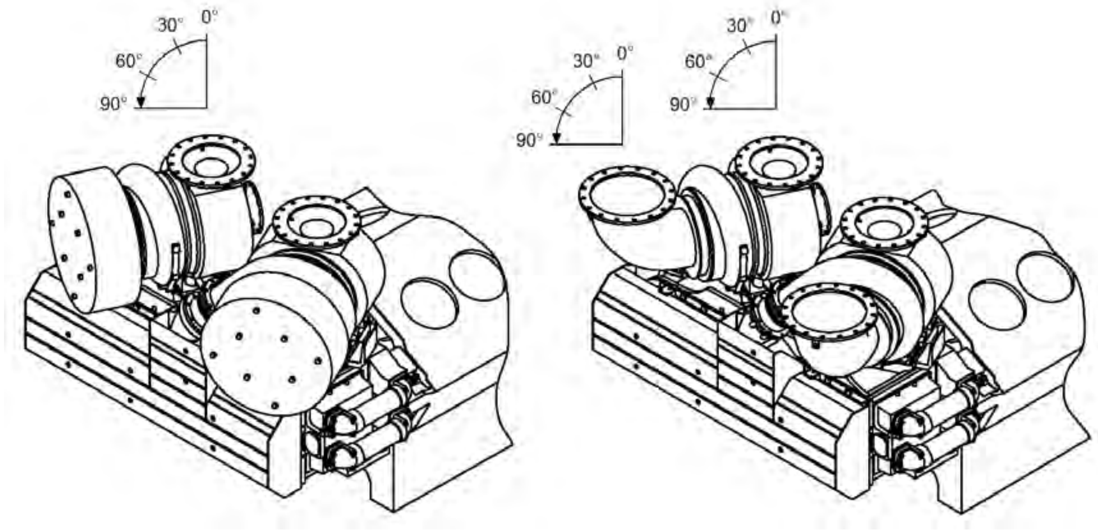


Fig 11-7 **Exhaust outlet possibilities, 16V-engine**

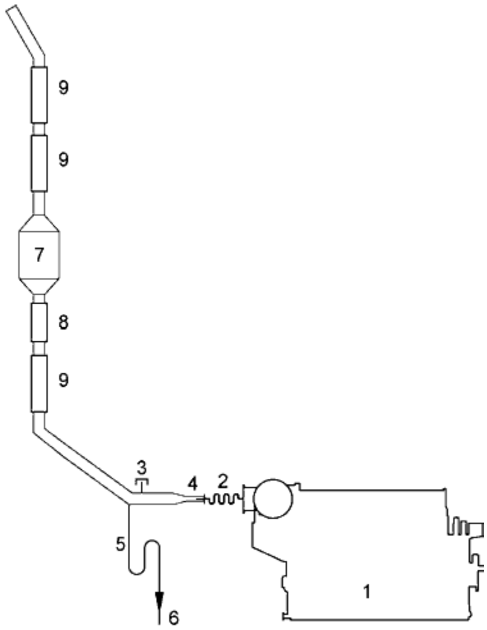
Engine	TC in free end	TC in driving end
W 6L26	0°,30°,45°,60°,90°	0°,30°,45°,60°,90°
W 8/9L26	0°,30°,45°,60°,90°	0°,30°,45°,60°,90°
W 12V26	0°,30°,60°	0°,30°,60°
W 16V26*	0°	0°

*ABB,KBB

11.3 External exhaust gas system

Each engine should have its own exhaust pipe into open air. Backpressure, thermal expansion and supporting are some of the decisive design factors.

Flexible bellows must be installed directly on the turbocharger outlet, to compensate for thermal expansion and prevent damages to the turbocharger due to vibrations.



1 Diesel engine
2 Exhaust gas bellows
3 Connection for measurement of back pressure
4 Transition piece
5 Drain with water trap, continuously open
6 Bilge
7 SCR
8 Urea injection unit (SCR)
9 CSS silencer element

Fig 11-8 External exhaust gas system

11.3.1 Piping

The piping should be as short and straight as possible. Pipe bends and expansions should be smooth to minimise the backpressure. The diameter of the exhaust pipe should be increased directly after the bellows on the turbocharger. Pipe bends should be made with the largest possible bending radius; the bending radius should not be smaller than 1.5 x D.

The recommended flow velocity in the pipe is maximum 35…40 m/s at full output. If there are many resistance factors in the piping, or the pipe is very long, then the flow velocity needs to be lower. The exhaust gas mass flow given in chapter *Technical data* can be translated to velocity using the formula:

$$v = \frac{4 \times m'}{1.3 \times \left(\frac{273}{273 + T}\right) \times \pi \times D^2}$$

where:

v = gas velocity [m/s]

m' = exhaust gas mass flow [kg/s]

T = exhaust gas temperature [°C]

D = exhaust gas pipe diameter [m]

The exhaust pipe must be insulated with insulation material approved for concerned operation conditions, minimum thickness 30 mm considering the shape of engine mounted insulation. Insulation has to be continuous and protected by a covering plate or similar to keep the insulation intact.

Closest to the turbocharger the insulation should consist of a hook on padding to facilitate maintenance. It is especially important to prevent the airstream to the turbocharger from detaching insulation, which will clog the filters.

After the insulation work has been finished, it has to be verified that it fulfils SOLAS-regulations. Surface temperatures must be below 220°C on whole engine operating range.

11.3.2 Supporting

It is very important that the exhaust pipe is properly fixed to a support that is rigid in all directions directly after the bellows on the turbocharger. There should be a fixing point on both sides of the pipe at the support. The bellows on the turbocharger may not be used to absorb thermal expansion from the exhaust pipe. The first fixing point must direct the thermal expansion away from the engine. The following support must prevent the pipe from pivoting around the first fixing point.

Absolutely rigid mounting between the pipe and the support is recommended at the first fixing point after the turbocharger. Resilient mounts can be accepted for resiliently mounted engines with “double” variant bellows (bellow capable of handling the additional movement), provided that the mounts are self-captive; maximum deflection at total failure being less than 2 mm radial and 4 mm axial with regards to the bellows. The natural frequencies of the mounting should be on a safe distance from the running speed, the firing frequency of the engine and the blade passing frequency of the propeller. The resilient mounts can be rubber mounts of conical type, or high damping stainless steel wire pads. Adequate thermal insulation must be provided to protect rubber mounts from high temperatures. When using resilient mounting, the alignment of the exhaust bellows must be checked on a regular basis and corrected when necessary.

After the first fixing point resilient mounts are recommended. The mounting supports should be positioned at stiffened locations within the ship’s structure, e.g. deck levels, frame webs or specially constructed supports.

The supporting must allow thermal expansion and ship’s structural deflections.

11.3.3 Back pressure

The maximum permissible exhaust gas back pressure is stated in chapter *Technical Data*. The back pressure in the system must be calculated by the shipyard based on the actual piping design and the resistance of the components in the exhaust system. The exhaust gas mass flow and temperature given in chapter *Technical Data* may be used for the calculation.

Each exhaust pipe should be provided with a connection for measurement of the back pressure. The back pressure must be measured by the shipyard during the sea trial.

11.3.4 Exhaust gas bellows (5H01, 5H03)

Bellows must be used in the exhaust gas piping where thermal expansion or ship’s structural deflections have to be segregated. The flexible bellows mounted directly on the turbocharger outlet serves to minimise the external forces on the turbocharger and thus prevent excessive vibrations and possible damage. All exhaust gas bellows must be of an approved type.

11.3.5 SCR-unit (11N14)

The SCR-unit requires special arrangement on the engine in order to keep the exhaust gas temperature and backpressure into SCR-unit working range. The exhaust gas piping must be straight at least 3...5 meters in front of the SCR unit. If both an exhaust gas boiler and a SCR unit will be installed, then the exhaust gas boiler shall be installed after the SCR. Arrangements must be made to ensure that water cannot spill down into the SCR, when the exhaust boiler is cleaned with water.

More information about the SCR-unit can be found in the *Wärtsilä Environmental Product Guide.*

11.3.6 Exhaust gas boiler

If exhaust gas boilers are installed, each engine should have a separate exhaust gas boiler. Alternatively, a common boiler with separate gas sections for each engine is acceptable.

For dimensioning the boiler, the exhaust gas quantities and temperatures given in chapter *Technical data* may be used.

11.3.7 Exhaust gas silencers

The exhaust gas silencing can be accomplished either by the patented Compact Silencer System (CSS) technology or by the conventional exhaust gas silencer.

11.3.7.1 Exhaust noise

The unattenuated exhaust noise is typically measured in the exhaust duct. The in-duct measurement is transformed into free field sound power through a number of correction factors.

The spectrum of the required attenuation in the exhaust system is achieved when the free field sound power (A) is transferred into sound pressure (B) at a certain point and compared with the allowable sound pressure level (C).

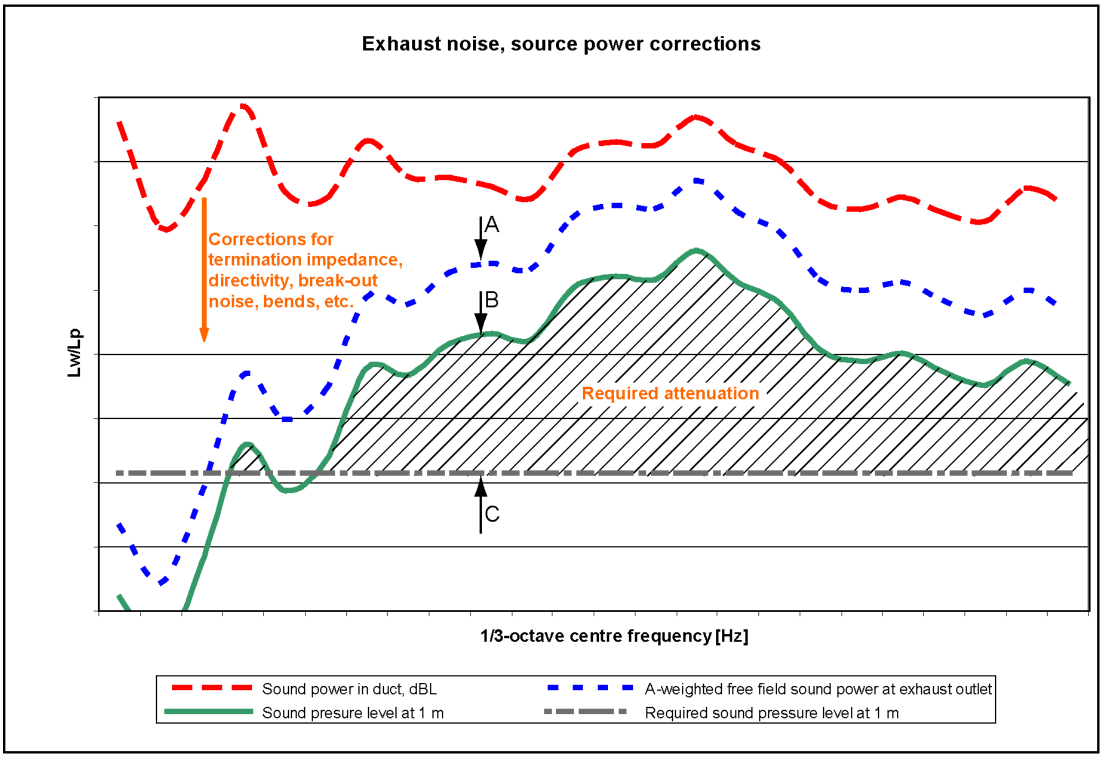


Fig 11-9 Exhaust noise, source power corrections

The conventional silencer is able to reduce the sound level in a certain area of the frequency spectrum. CSS is designed to cover the whole frequency spectrum.

11.3.7.2 Silencer system comparison

With a conventional silencer system, the design of the noise reduction system usually starts from the engine. With the CSS, the design is reversed, meaning that the noise level acceptability at a certain distance from the ship's exhaust gas pipe outlet, is used to dimension the noise reduction system.

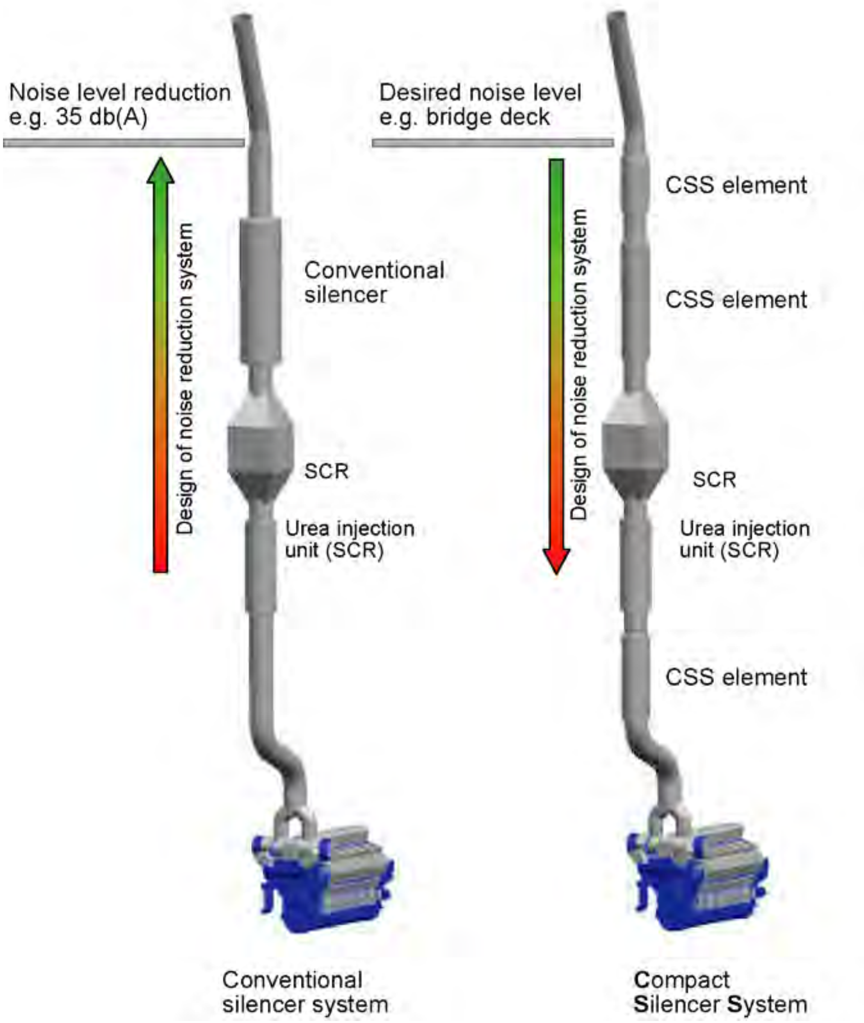


Fig 11-10 Silencer system comparison

11.3.7.3 Compact silencer system (5N02)

The CSS system is optimized for each installation as a complete exhaust gas system. The optimization is made according to the engine characteristics, to the sound level requirements and to other equipment installed in the exhaust gas system, like SCR, exhaust gas boiler or scrubbers.

The CSS system is built up of three different CSS elements; resistive, reactive and composite elements. The combination-, amount- and length of the elements are always installation specific. The diameter of the CSS element is 1.4 times the exhaust gas pipe diameter.

The noise attenuation is valid up to a exhaust gas flow velocity of max 40 m/s. The pressure drop of a CSS element is lower compared to a conventional exhaust gas silencer (5R02).

11.3.7.4 Conventional exhaust gas silencer (5R02)

Yard/designer should take into account that unfavourable layout of the exhaust system (length of straight parts in the exhaust system) might cause amplification of the exhaust noise between engine outlet and the silencer. Hence the attenuation of the silencer does not give any absolute guarantee for the noise level after the silencer.

When included in the scope of supply, the standard silencer is of the absorption type, equipped with a spark arrester. It is also provided with a soot collector and a condense drain, but it comes without mounting brackets and insulation. The silencer can be mounted either horizontally or vertically.

The noise attenuation of the standard silencer is either 25 or 35 dB(A). This attenuation is valid up to a flow velocity of max. 40 m/s.

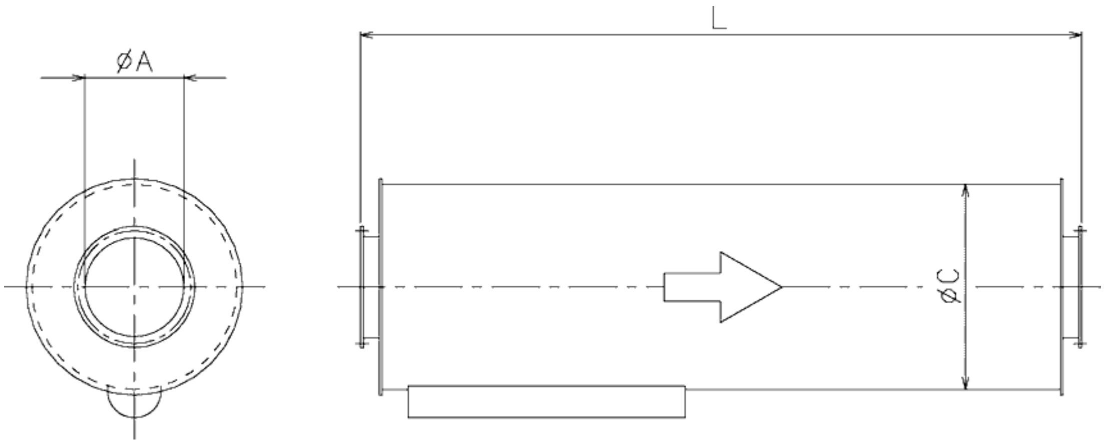


Fig 11-11 Exhaust gas silencer (9855MR366)

Table 11-1 Typical dimensions of the exhaust gas silencer

Engine type	A [mm]	C [mm]	Attenuation: 25 dB(A)		Attenuation: 35 dB(A)	
			L [mm]	Weight [kg]	L [mm]	Weight [kg]
6L26	500	1200	3430	690	4280	860
8L26	600	1300	4010	980	5260	1310
9L26	600	1300	4010	980	5260	1310
12V26	700	1500	4550	1470	6050	1910
16V26	800	1700	4840	1930	6340	2490
Flanges: DIN 2501						

12. Turbocharger Cleaning

Regular water cleaning of the turbine and the compressor reduces the formation of deposits and extends the time between overhauls. Fresh water is injected into the turbocharger during operation. Additives, solvents or salt water must not be used and the cleaning instructions in the operation manual must be carefully followed.

12.1 Turbine cleaning system

A dosing unit consisting of a flow meter and an adjustable throttle valve is delivered for each installation. The dosing unit is installed in the engine room and connected to the engine with a detachable rubber hose. The rubber hose is connected with quick couplings and the length of the hose is normally 10 m. One dosing unit can be used for several engines.

Water supply:	
Fresh water	
Min. pressure	0.3 MPa (3 bar)
Max. pressure	2 MPa (20 bar)
Max. temperature	80 °C
Flow	15-30 l/min (depending on cylinder configuration)

The turbocharges are cleaned one at a time on V-engines.

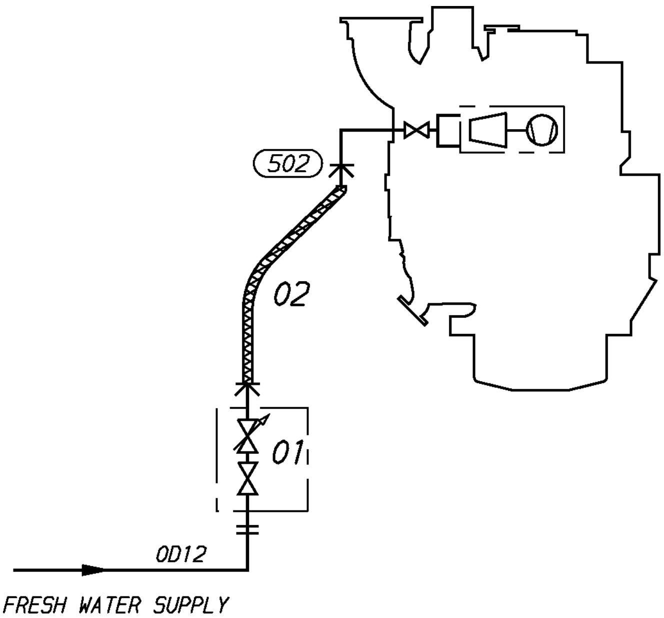


Fig 12-1 Turbine cleaning system (DAAE003884)

System components		Pipe connections		Size
01	Dosing unit with shut-off valve	502	Cleaning water to turbine	Quick coupling
02	Rubber hose			

12.2 Compressor cleaning system

The compressor side of the turbocharger is cleaned using a separate dosing vessel mounted on the engine.

13. Exhaust Emissions

Exhaust emissions from the diesel engine mainly consist of nitrogen, oxygen and combustion products like carbon dioxide (CO_2), water vapour and minor quantities of carbon monoxide (CO), sulphur oxides (SO_x), nitrogen oxides (NO_x), partially reacted and non-combusted hydrocarbons (HC) and particulate matter (PM).

There are different emission control methods depending on the aimed pollutant. These are mainly divided in two categories; primary methods that are applied on the engine itself and secondary methods that are applied on the exhaust gas stream.

13.1 Diesel engine exhaust components

The nitrogen and oxygen in the exhaust gas are the main components of the intake air which don't take part in the combustion process.

CO_2 and water are the main combustion products. Secondary combustion products are carbon monoxide, hydrocarbons, nitrogen oxides, sulphur oxides, soot and particulate matters.

In a diesel engine the emission of carbon monoxide and hydrocarbons are low compared to other internal combustion engines, thanks to the high air/fuel ratio in the combustion process. The air excess allows an almost complete combustion of the HC and oxidation of the CO to CO_2, hence their quantity in the exhaust gas stream are very low.

13.1.1 Nitrogen oxides (NO_x)

The combustion process gives secondary products as Nitrogen oxides. At high temperature the nitrogen, usually inert, react with oxygen to form Nitric oxide (NO) and Nitrogen dioxide (NO_2), which are usually grouped together as NO_x emissions. Their amount is strictly related to the combustion temperature.

NO can also be formed through oxidation of the nitrogen in fuel and through chemical reactions with fuel radicals. NO in the exhaust gas flow is in a high temperature and high oxygen concentration environment, hence oxidizes rapidly to NO_2. The amount of NO_2 emissions is approximately 5 % of total NOx emissions.

13.1.2 Sulphur Oxides (SO_x)

Sulphur oxides (SO_x) are direct result of the sulphur content of the fuel oil. During the combustion process the fuel bound sulphur is rapidly oxidized to sulphur dioxide (SO_2). A small fraction of SO_2 may be further oxidized to sulphur trioxide (SO_3).

13.1.3 Particulate Matter (PM)

The particulate fraction of the exhaust emissions represents a complex mixture of inorganic and organic substances mainly comprising soot (elemental carbon), fuel oil ash (together with sulphates and associated water), nitrates, carbonates and a variety of non or partially combusted hydrocarbon components of the fuel and lubricating oil.

13.1.4 Smoke

Although smoke is usually the visible indication of particulates in the exhaust, the correlations between particulate emissions and smoke is not fixed. The lighter and more volatile hydrocarbons will not be visible nor will the particulates emitted from a well maintained and operated diesel engine.

Smoke can be black, blue, white, yellow or brown in appearance. Black smoke is mainly comprised of carbon particulates (soot). Blue smoke indicates the presence of the products of the incomplete combustion of the fuel or lubricating oil. White smoke is usually condensed water vapour. Yellow smoke is caused by NO_x emissions. When the exhaust gas is cooled significantly prior to discharge to the atmosphere, the condensed NO_2 component can have a brown appearance.

13.2 Marine exhaust emissions legislation

13.2.1 International Maritime Organization (IMO)

The increasing concern over the air pollution has resulted in the introduction of exhaust emission controls to the marine industry. To avoid the growth of uncoordinated regulations, the IMO (International Maritime Organization) has developed the Annex VI of MARPOL 73/78, which represents the first set of regulations on the marine exhaust emissions.

The IMO Tier 3 NOx emission standard will enter into force from year 2016. It will by then apply for new marine diesel engines that:

- Are > 130 kW
- Installed in ships which keel laying date is 1.1.2016 or later
- Operating inside the North American ECA and the US Caribbean Sea ECA

From 1.1.2021 onwards Baltic sea and North sea will be included in to IMO Tier 3 NOx requirements.

13.2.2 Other Legislations

There are also other local legislations in force in particular regions.

13.3 Methods to reduce exhaust emissions

All standard Wärtsilä engines meet the NOx emission level set by the IMO (International Maritime Organisation) and most of the local emission levels without any modifications. Wärtsilä has also developed solutions to significantly reduce NOx emissions when this is required.

Diesel engine exhaust emissions can be reduced either with primary or secondary methods. The primary methods limit the formation of specific emissions during the combustion process. The secondary methods reduce emission components after formation as they pass through the exhaust gas system.

Refer to the "*Wärtsilä Environmental Product Guide*" for information about exhaust gas emission control systems.

14. Automation System

Wärtsilä Unified Controls – UNIC is a modular embedded automation system. UNIC C2 has a hardwired interface for control functions and a bus communication interface for alarm and monitoring.

14.1 UNIC C2

UNIC C2 is a fully embedded and distributed engine management system, which handles all control functions on the engine; for example start sequencing, start blocking, speed control, load sharing, normal stops and safety shutdowns.

The distributed modules communicate over a CAN-bus. CAN is a communication bus specifically developed for compact local networks, where high speed data transfer and safety are of utmost importance.

The CAN-bus and the power supply to each module are both physically doubled on the engine for full redundancy.

Control signals to/from external systems are hardwired to the terminals in the main cabinet on the engine. Process data for alarm and monitoring are communicated over a Modbus TCP connection to external systems.

Alternatively modbus RTU serial line RS-485 is also available.

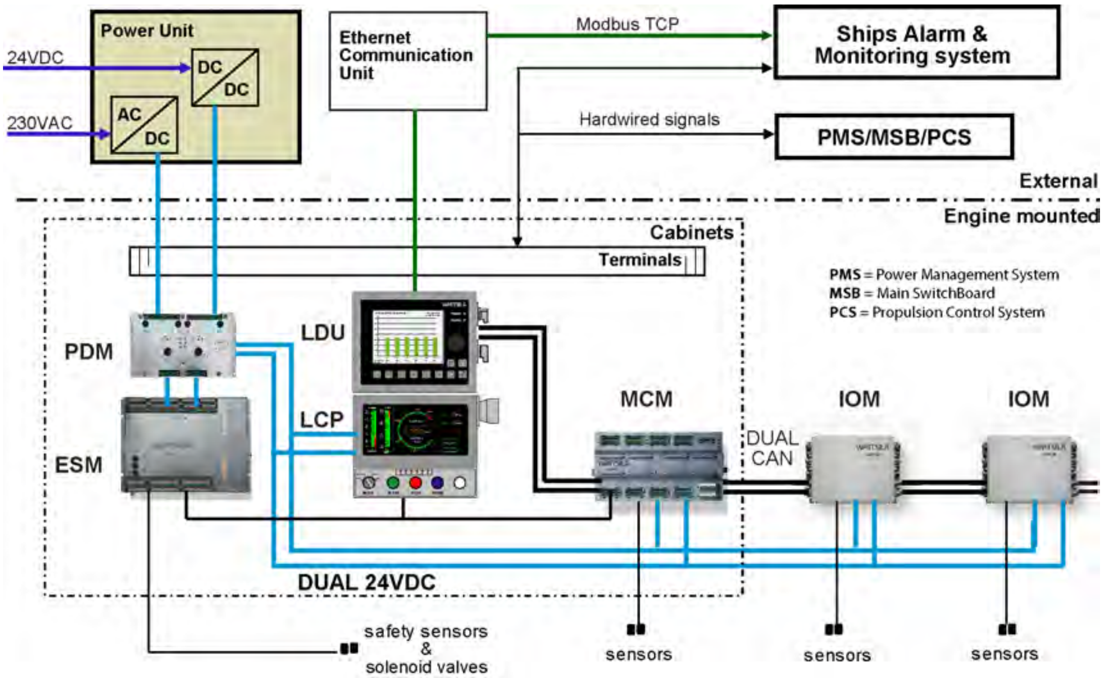


Fig 14-1 Architecture of UNIC C2

Short explanation of the modules used in the system:

MCM Main Control Module. Handles all strategic control functions (such as start/stop sequencing and speed/load control) of the engine.

ESM Engine Safety Module handles fundamental engine safety, for example shutdown due to overspeed or low lubricating oil pressure.

LCP	Local Control Panel is equipped with push buttons and switches for local engine control, as well as indication of running hours and safety-critical operating parameters.
LDU	Local Display Unit offers a set of menus for retrieval and graphical display of operating data, calculated data and event history. The module also handles communication with external systems over Modbus TCP.
PDM	Power Distribution Module handles fusing, power distribution, earth fault monitoring and EMC filtration in the system. It provides two fully redundant supplies to all modules.
IOM	Input/Output Module handles measurements and limited control functions in a specific area on the engine.
CCM	Cylinder Control Module handles fuel injection control and local measurements for the cylinders.

The above equipment and instrumentation are prewired on the engine. The ingress protection class is IP54.

14.1.1 Local control panel and local display unit

Operational functions available at the LCP:

- Local start
- Local stop
- Local emergency speed setting selectors (mechanical propulsion):
  - Normal / emergency mode
  - Decrease / Increase speed
- Local emergency stop
- Local shutdown reset

  Local mode selector switch with the following positions:
  - Local: Engine start and stop can be done only at the local control panel
  - Remote: Engine can be started and stopped only remotely
  - Blow: In this position it is possible to perform a “blow” (an engine rotation check with indicator valves open and disabled fuel injection) by the start button
  - Blocked: Normal start of the engine is not possible

The LCP has back-up indication of the following parameters:

- Engine speed
- Turbocharger speed
- Running hours
- Lubricating oil pressure
- HT cooling water temperature

The local display unit has a set of menus for retrieval and graphical display of operating data, calculated data and event history.

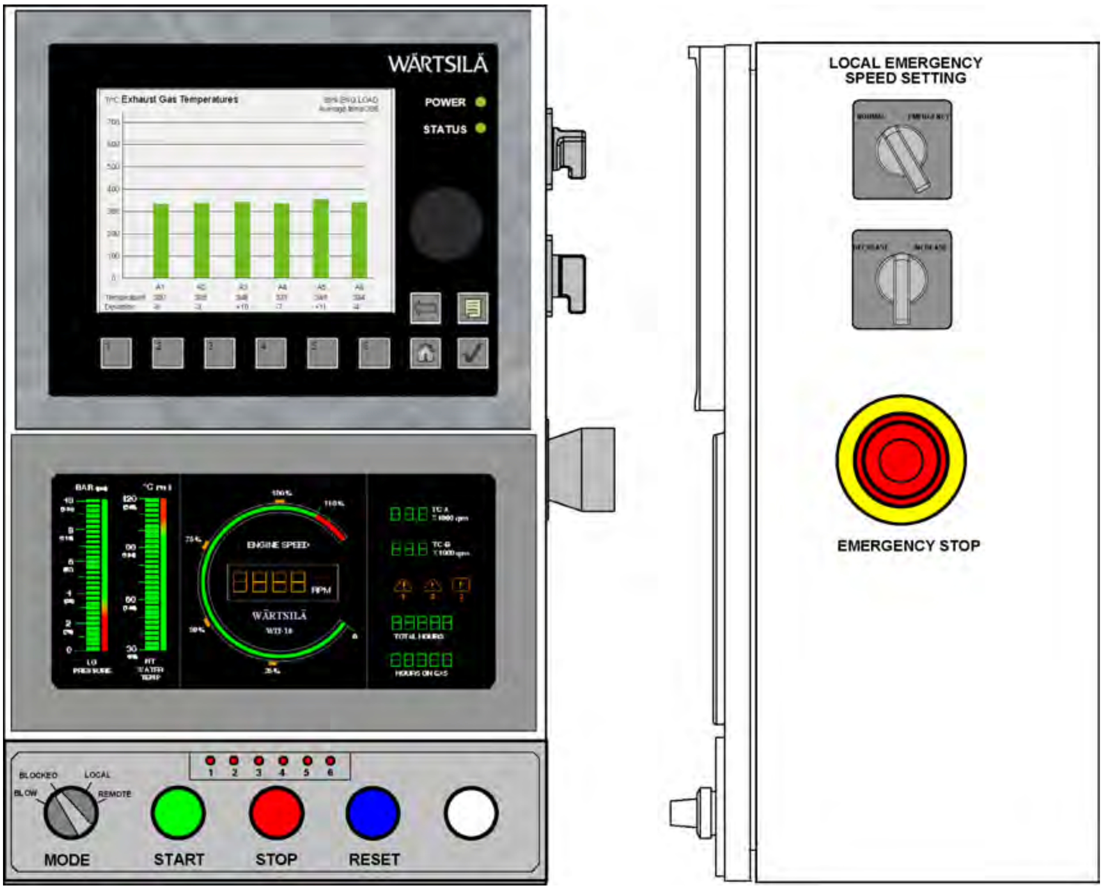


Fig 14-2 Local control panel and local display unit

14.1.2 Engine safety system

The engine safety module handles fundamental safety functions, for example overspeed protection. It is also the interface to the shutdown devices on the engine for all other parts of the control system.

Main features:

- Redundant design for power supply, speed inputs and stop solenoid control
- Fault detection on sensors, solenoids and wires
- Led indication of status and detected faults
- Digital status outputs
- Shutdown latching and reset
- Shutdown pre-warning
- Shutdown override (configuration depending on application)
- Analogue output for engine speed
- Adjustable speed switches

14.1.3 Power unit

A power unit is delivered with each engine. The power unit supplies DC power to the automation system on the engine and provides isolation from other DC systems onboard. The cabinet is designed for bulkhead mounting, protection degree IP44, max. ambient temperature 50°C.

The power unit contains redundant power converters, each converter dimensioned for 100% load. At least one of the two incoming supplies must be connected to a UPS. The power unit supplies the equipment on the engine with 2 x 24 VDC.

Power supply from ship's system:

- Supply 1: 230 VAC / abt. 250 W
- Supply 2: 24 VDC / abt. 250 W

14.1.4 Ethernet communication unit

Ethernet switch and firewall/router are installed in a steel sheet cabinet for bulkhead mounting, protection class IP44.

14.1.5 Cabling and system overview

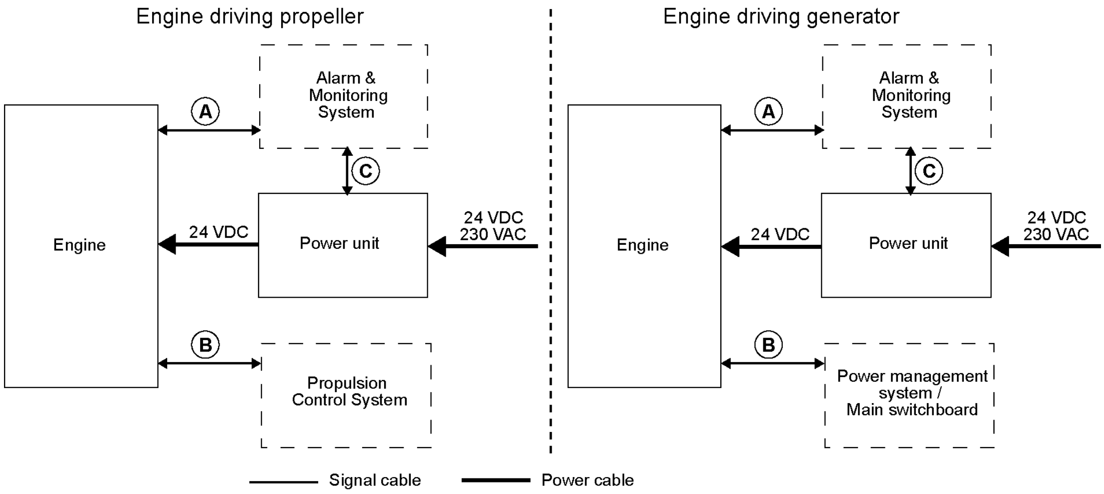


Fig 14-3 UNIC C2 overview

Table 14-1 Typical amount of cables

Cable	From <=> To	Cable types (typical)
A	Engine <=> Power Unit	2 x 2.5 mm^2 (power supply) * 2 x 2.5 mm^2 (power supply) *
B	Power unit => Communication interface unit	2 x 2.5 mm^2 (power supply) *
C	Engine <=> Propulsion Control System Engine <=> Power Management System / Main Switch-board	1 x 2 x 0.75 mm^2 1 x 2 x 0.75 mm^2 1 x 2 x 0.75 mm^2 24 x 0.75 mm^2 24 x 0.75 mm^2
D	Power unit <=> Integrated Automation System	2 x 0.75 mm^2
E	Engine <=> Integrated Automation System	3 x 2 x 0.75 mm^2
F	Engine => Communication interface unit	1 x Ethernet CAT 5
G	Communication interface unit => Integrated automation system	1 x Ethernet CAT 5
H	Gas valve unit => Communication interface unit	1 x Ethernet CAT 5

NOTE

Cable types and grouping of signals in different cables will differ depending on installation.

* Dimension of the power supply cables depends on the cable length.

Power supply requirements are specified in section *Power unit*.

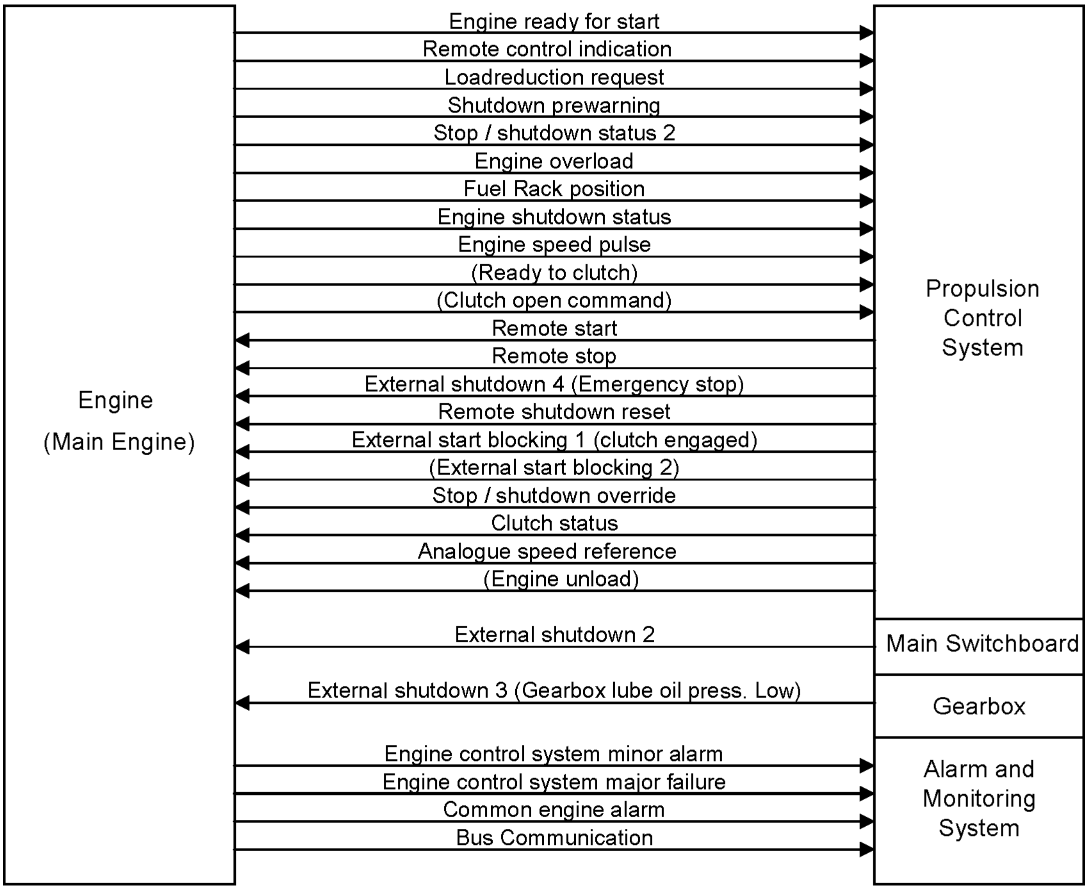


Fig 14-4 **Signal overview (Main engine)**

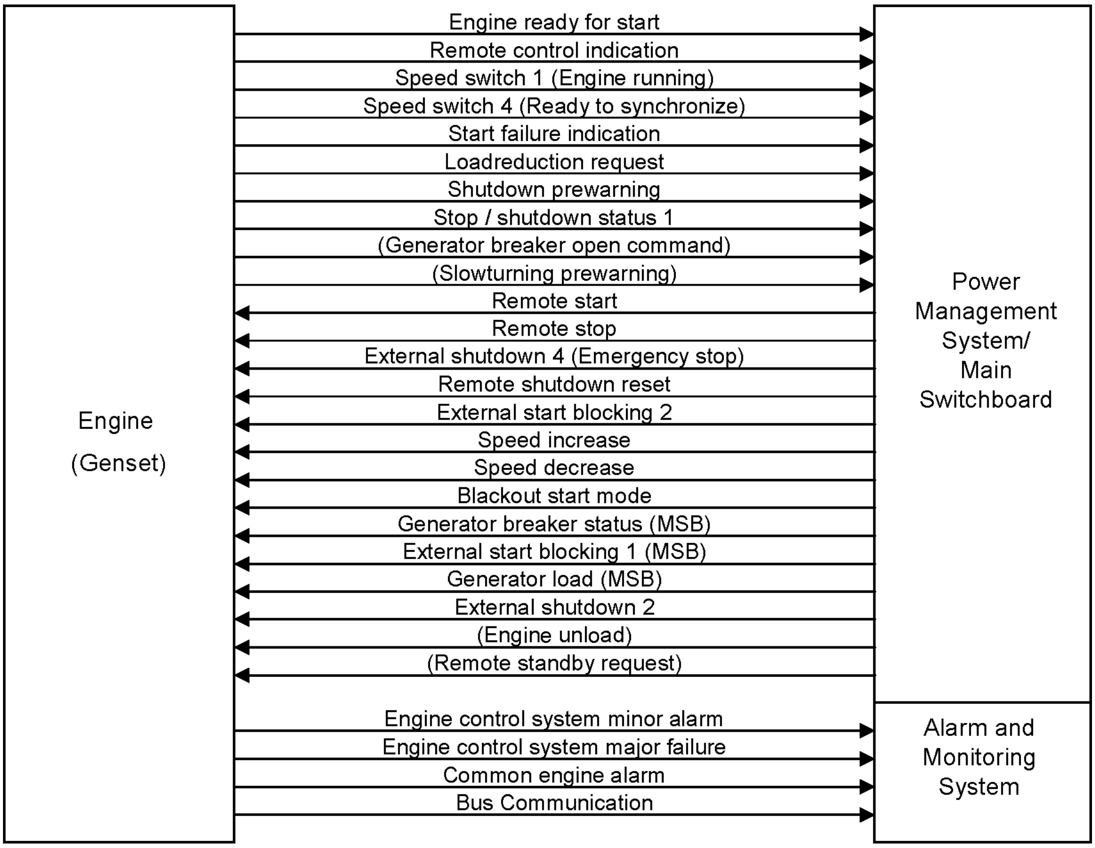


Fig 14-5 **Signal overview (Generating set)**

14.2 Functions

14.2.1 Start

The engine has a pneumatic starting motor controlled by a solenoid valve. The solenoid valve can be energized either locally with the start button, or from a remote control station. In an emergency situation it is also possible to operate the valve manually.

Starting is blocked both pneumatically and electrically when the turning gear is engaged. Fuel injection is blocked when the stop lever is in stop position (conventional fuel injection).

Startblockings are handled by the system on the engine (main control module).

14.2.1.1 Startblockings

Starting is inhibited by the following functions:

- Turning gear engaged
- Stop lever in stop position
- Pre-lubricating pressure low
- Local engine selector switch in blocked position
- Stop or shutdown active
- External start blocking 1 (e.g. reduction gear oil pressure)
- External start blocking 2 (e.g. clutch position)
- Engine running

For restarting of a diesel generator in a blackout situation, start blocking due to low pre-lubricating oil pressure can be suppressed for 30 min.

14.2.2 Stop and shutdown

Normal stop is initiated either locally with the stop button, or from a remote control station. The control devices on the engine are held in stop position for a preset time until the engine has come to a complete stop. Thereafter the system automatically returns to “ready for start” state, provided that no start block functions are active, i.e. there is no need for manually resetting a normal stop.

Manual emergency shutdown is activated with the local emergency stop button, or with a remote emergency stop located in the engine control room for example.

The engine safety module handles safety shutdowns. Safety shutdowns can be initiated either independently by the safety module, or executed by the safety module upon a shutdown request from some other part of the automation system.

Typical shutdown functions are:

- Lubricating oil pressure low
- Overspeed
- Oil mist in crankcase
- Lubricating oil pressure low in reduction gear

Depending on the application it can be possible for the operator to override a shutdown. It is never possible to override a shutdown due to overspeed or an emergency stop.

Before restart the reason for the shutdown must be thoroughly investigated and rectified.

14.2.3 Speed control

14.2.3.1 Main engines (mechanical propulsion)

The electronic speed control is integrated in the engine automation system.

The remote speed setting from the propulsion control is an analogue 4-20 mA signal. It is also possible to select an operating mode in which the speed reference can be adjusted with increase/decrease signals.

The electronic speed control handles load sharing between parallel engines, fuel limiters, and various other control functions (e.g. ready to open/close clutch, speed filtering). Overload protection and control of the load increase rate must however be included in the propulsion control as described in the chapter "*Operating ranges*".

For single main engines a fuel rack actuator with a mechanical-hydraulic backup governor is specified. Mechanical back-up can also be specified for twin screw vessels with one engine per propeller shaft. Mechanical back-up is not an option in installations with two engines connected to the same reduction gear.

14.2.3.2 Generating sets

The electronic speed control is integrated in the engine automation system.

The load sharing can be based on traditional speed droop, or handled independently by the speed control units without speed droop. The later load sharing principle is commonly referred to as isochronous load sharing. With isochronous load sharing there is no need for load balancing, frequency adjustment, or generator loading/unloading control in the external control system.

In a speed droop system each individual speed control unit decreases its internal speed reference when it senses increased load on the generator. Decreased network frequency with higher system load causes all generators to take on a proportional share of the increased total load. Engines with the same speed droop and speed reference will share load equally. Loading and unloading of a generator is accomplished by adjusting the speed reference of the individual speed control unit. The speed droop is normally 4%, which means that the difference in frequency between zero load and maximum load is 4%.

In isochronous mode the speed reference remains constant regardless of load level. Both isochronous load sharing and traditional speed droop are standard features in the speed control and either mode can be easily selected. If the ship has several switchboard sections with tie breakers between the different sections, then the status of each tie breaker is required for control of the load sharing in isochronous mode.

14.3 Alarm and monitoring signals

Regarding sensors on the engine, please see the internal P&I diagrams in this product guide. The actual configuration of signals and the alarm levels are found in the project specific documentation supplied for all contracted projects.

14.4 Electrical consumers

14.4.1 Motor starters and operation of electrically driven pumps

Separators, preheaters, compressors and fuel feed units are normally supplied as pre-assembled units with the necessary motor starters included. The engine turning device and various electrically driven pumps require separate motor starters. Motor starters for electrically driven pumps are to be dimensioned according to the selected pump and electric motor.

Motor starters are not part of the control system supplied with the engine, but available as optional delivery items.

14.4.1.1 Engine turning device (9N15)

The crankshaft can be slowly rotated with the turning device for maintenance purposes. The motor starter must be designed for reversible control of the motor. The electric motor ratings are listed in the table below.

Table 14-2 Electric motor ratings for engine turning device

Engine	Voltage [V]	Frequency [Hz]	Power [kW]	Current [A]
L26	3 x 400 / 440	50 / 60	0.75 / 0.9	2.0 / 2.1
V26	3 x 400 / 440	50 / 60	1.1 / 1.3	2.6 / 2.8

14.4.1.2 Pre-lubricating oil pump

The pre-lubricating oil pump must always be running when the engine is stopped. The pump shall start when the engine stops, and stop when the engine starts. The engine control system handles start/stop of the pump automatically via a motor starter.

It is recommended to arrange a back-up power supply from an emergency power source. Diesel generators serving as the main source of electrical power must be able to resume their operation in a black out situation by means of stored energy. Depending on system design and classification regulations, it may be permissible to use the emergency generator.

For dimensioning of the pre-lubricating oil pump starter, the values indicated below can be used. For different voltages, the values may differ slightly.

Table 14-3 Electric motor ratings for pre-lubricating pump

Engine type	Voltage [V]	Frequency [Hz]	Power [kW]	Current [A]
W 6L26	3 x 400	50	4.0	8.2
	3 x 440	60	4.6	8.2
W 8L, 9L26	3 x 400	50	5.5	12.5
	3 x 440	60	6.3	12.0
W 12V26	3 x 400	50	7.5	14.0
	3 x 440	60	5.5	10.5
W 16V26	3 x 400	50	9.2	17.6
	3 x 440	60	10.6	17.7

14.4.1.3 Stand-by pump, lubricating oil (if installed) (2P04)

The engine control system starts the pump automatically via a motor starter, if the lubricating oil pressure drops below a preset level when the engine is running. There is a dedicated sensor on the engine for this purpose.

The pump must not be running when the engine is stopped, nor may it be used for pre-lubricating purposes. Neither should it be operated in parallel with the main pump, when the main pump is in order.

14.4.1.4 Stand-by pump, HT cooling water (if installed) (4P03)

The engine control system starts the pump automatically via a motor starter, if the cooling water pressure drops below a preset level when the engine is running. There is a dedicated sensor on the engine for this purpose.

14.4.1.5 Stand-by pump, LT cooling water (if installed) (4P05)

The engine control system starts the pump automatically via a motor starter, if the cooling water pressure drops below a preset level when the engine is running. There is a dedicated sensor on the engine for this purpose.

14.4.1.6 Circulating pump for preheater (4P04)

The preheater pump shall start when the engine stops (to ensure water circulation through the hot engine) and stop when the engine starts. The engine control system handles start/stop of the pump automatically via a motor starter.

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15. Foundation

Engines can be either rigidly mounted on chocks, or resiliently mounted on rubber elements. If resilient mounting is considered, Wärtsilä should be informed about existing excitations such as propeller blade passing frequency. Dynamic forces caused by the engine are listed in the chapter *Vibration and noise*.

15.1 Steel structure design

The system oil tank may not extend under the reduction gear, if the engine is of dry sump type and the oil tank is located beneath the engine foundation. Neither should the tank extend under the support bearing, in case there is a PTO arrangement in the free end. The oil tank must also be symmetrically located in transverse direction under the engine.

The foundation and the double bottom should be as stiff as possible in all directions to absorb the dynamic forces caused by the engine, reduction gear and thrust bearing. The foundation should be dimensioned and designed so that harmful deformations are avoided.

The foundation of the driven equipment must be integrated with the engine foundation.

15.2 Mounting of main engines

15.2.1 Rigid mounting

When main engines are rigid mounted normally either adjustable steel chocks or resin chocks are used. The chocking arrangement shall be sent to the classification society and Wärtsilä for approval.

The bolt closest to the flywheel at either side of the engine shall be made as a Ø34H7/m6 fitted bolt. All other bolts are clearance bolts.

The clearance bolts shall be through bolts with lock nuts. Ø33 holes can be drilled into the seating through the holes in the mounting brackets.

The design of the foundation bolts is shown in the foundation drawings. When these dimensions are followed, standard bolts can be used for the clearance bolts in order to fulfill the requirements of the classification societies. For the fitting bolts is recommended to use a high strength steel, e.g. 42CrMo4 TQ+T or similar. A high strength material makes it possible to use a higher bolt tension, which results in a larger bolt elongation (strain). A large bolt elongation improves the safety against loosening of the nuts.

To ensure sufficient elongation distance sleeves according to the bolt drawings shall be used.

In order to avoid bending stresses in the foundation bolts the nuts underneath the top-plate must be provided with spherical washers which can compensate for an inclined surface. Alternatively the contact face of the nut/bolthead underneath the top plate should be counter bored perpendicular to the orientation of the bolt.

When tightening the bolts with a torque wrench, the equivalent stress in the bolts is allowed to be max. 90% of the material yield strength.

Side supports should be fitted to all engine feet where no fitting bolts are used. In addition end supports should be fitted at the free end of the engines in case fitting bolts are omitted. Side supports are to be welded to the top plate before aligning the engine and fitting the chocks. If resin shocks are used an additional pair of lateral supports shall be fitted at the flywheel end of the engine. The clearance hole in the chock and top plate should have a diameter about 2 mm larger than the bolt diameter for all clearance bolts.

15.2.1.1 Resin chocks

Installation of main engines on resin chocks is possible provided that the requirements of the classification societies are fulfilled.

During normal conditions, the support face of the engine feet has a maximum temperature of about 75°C, which should be considered when selecting the type of resin.

The total surface pressure on the resin must not exceed the maximum value, which is determined by the type of resin and the requirements of the classification society. It is recommended to select a resin type, which has a type approval from the relevant classification society for a total surface pressure of 5 N/mm² (typical conservative value is $p_{tot} < 3.5$ N/mm²).

When installing an engine on resin chocks the following issues are important:

- Sufficient elongation of the foundation bolts
- Maximum allowed surface pressure on the resin $p_{tot} = p_{static} + p_{bolt}$
- Correct tightening torque of the foundation bolts

15.2.1.2 Adjustable steel chocks

As an alternative to resin chocks or conventional steel chocks it is also permitted to install the engine on adjustable steel chocks. The chock height is adjustable between 45 mm and 65 mm for the approved type of chock. There must be a chock of adequate size at the position of each holding down bolt.

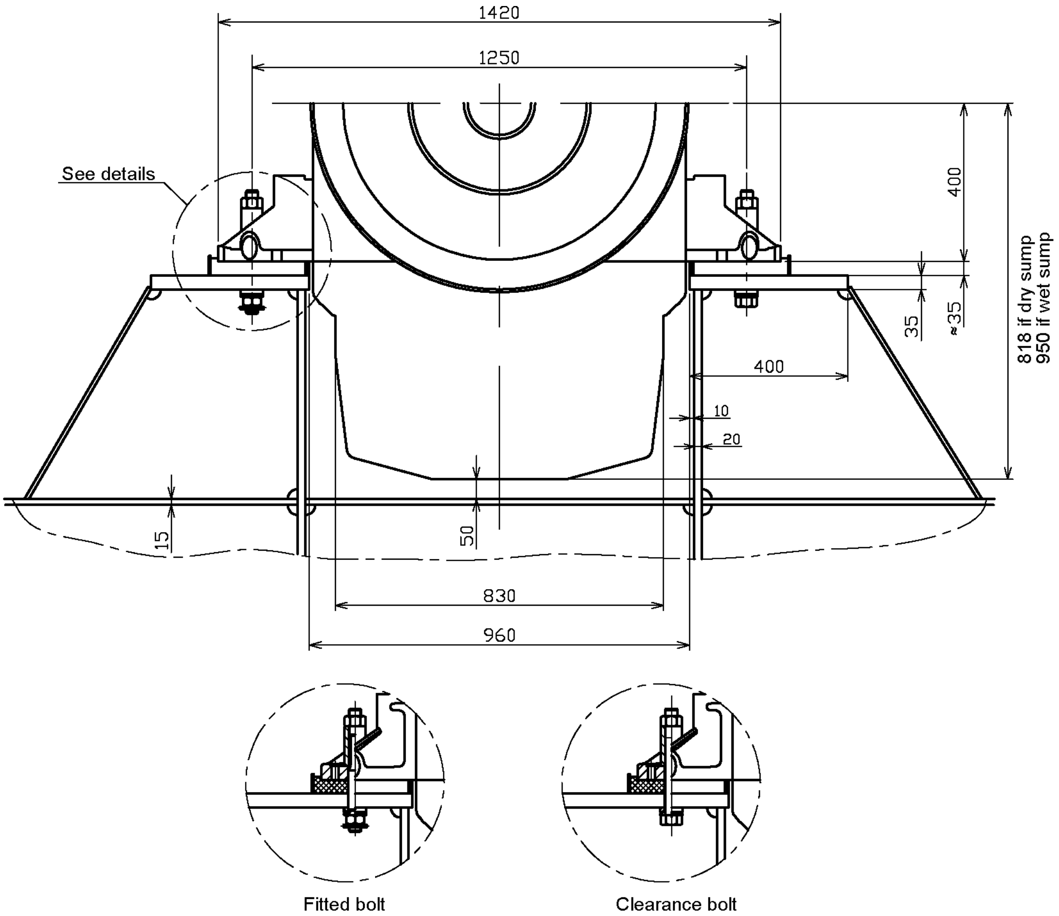


Fig 15-1 **Seating and fastening, rigidly mounted in-line engine on resin chocks (DAAE077678a/DAAE077679a)**

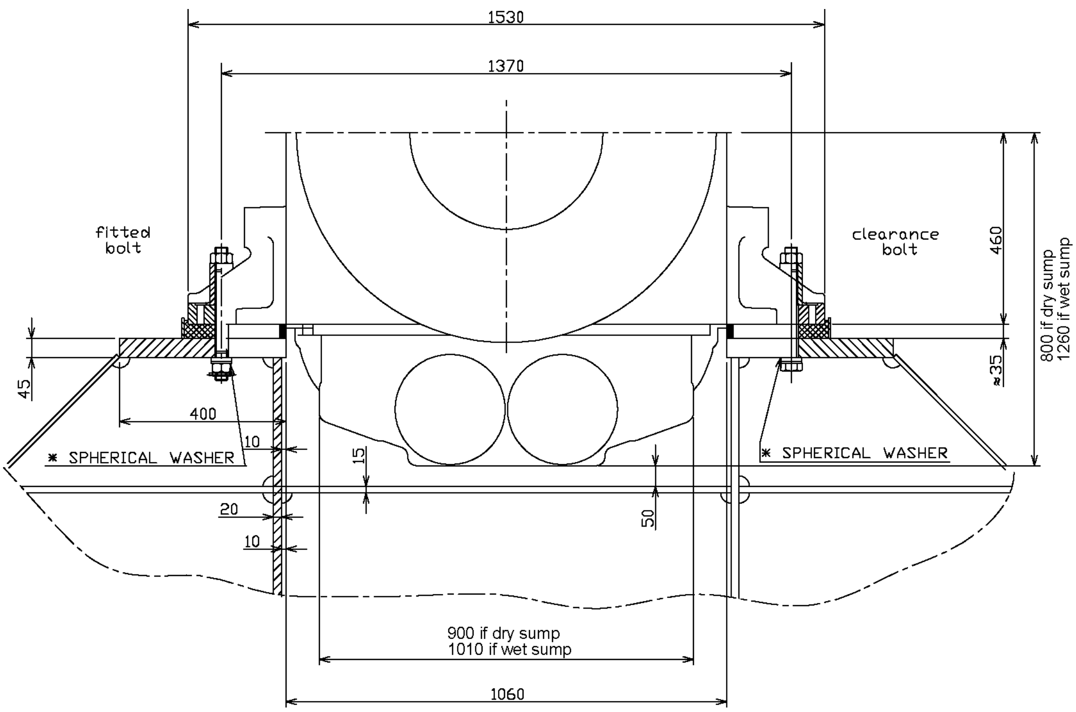
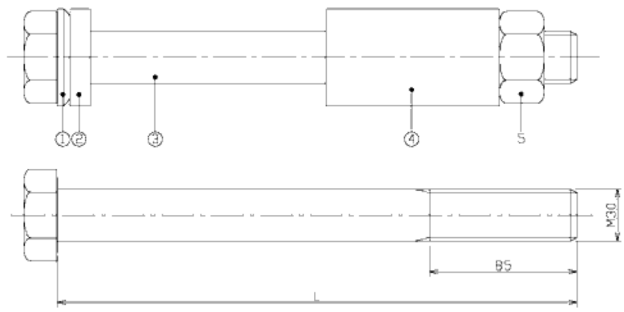


Fig 15-2 **Seating and fastening, rigidly mounted V-engines on resin chocks (9813ZT114/9813ZT117)**

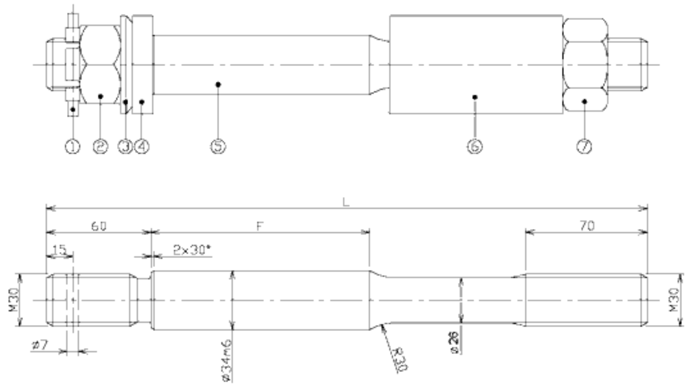
Clearance bolt



1. Spherical washer
2. Concial seat
3. Clearance bolt
4. Distance bush
5. Hexagon nut

L: W L26 = top plate + filling + 210 mm
W V26 = top plate + filling + 220 mm

Fitted bolt



1. Split pen
2. Castle nut
3. Spherical washer
4. Conical seat
5. Fitted bolt
6. Distance bush
7. Hexagon nut

L: W L26 = top plate + filling + 245 mm
W V26 = top plate + filling + 255 mm

F: W L26 = top plate + filling + 25 mm
W V26 = top plate + filling + 35 mm

Distance bush

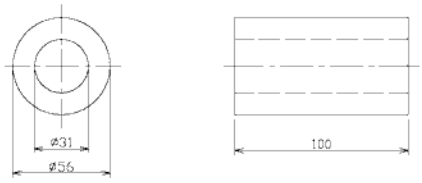


Fig 15-3 **Clearance bolt (9813ZT122) / Fitted bolt (9813ZT121)**

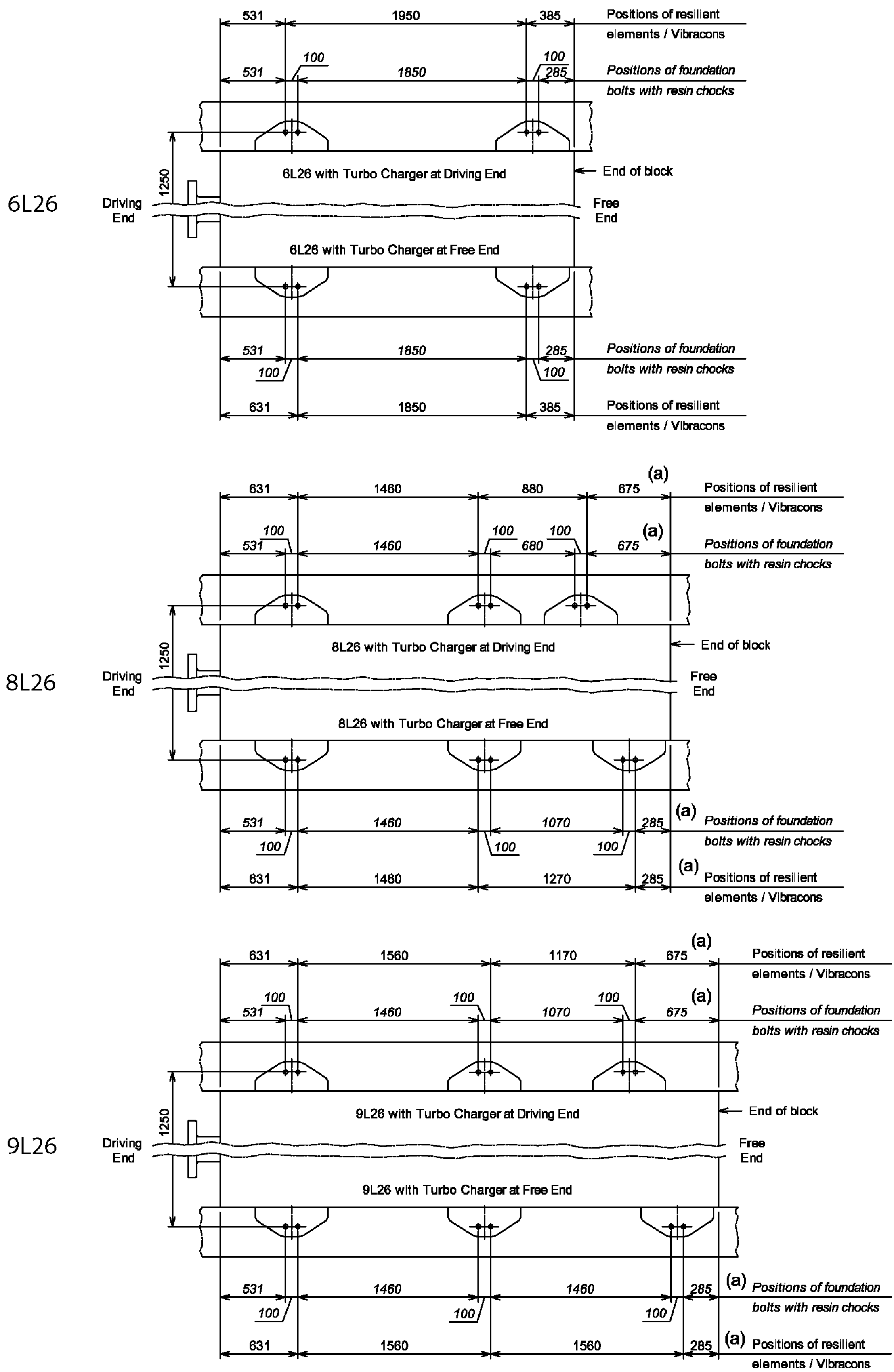


Fig 15-4 **Foundation top-view and drilling plan, in-line engines (9813ZT110a)**

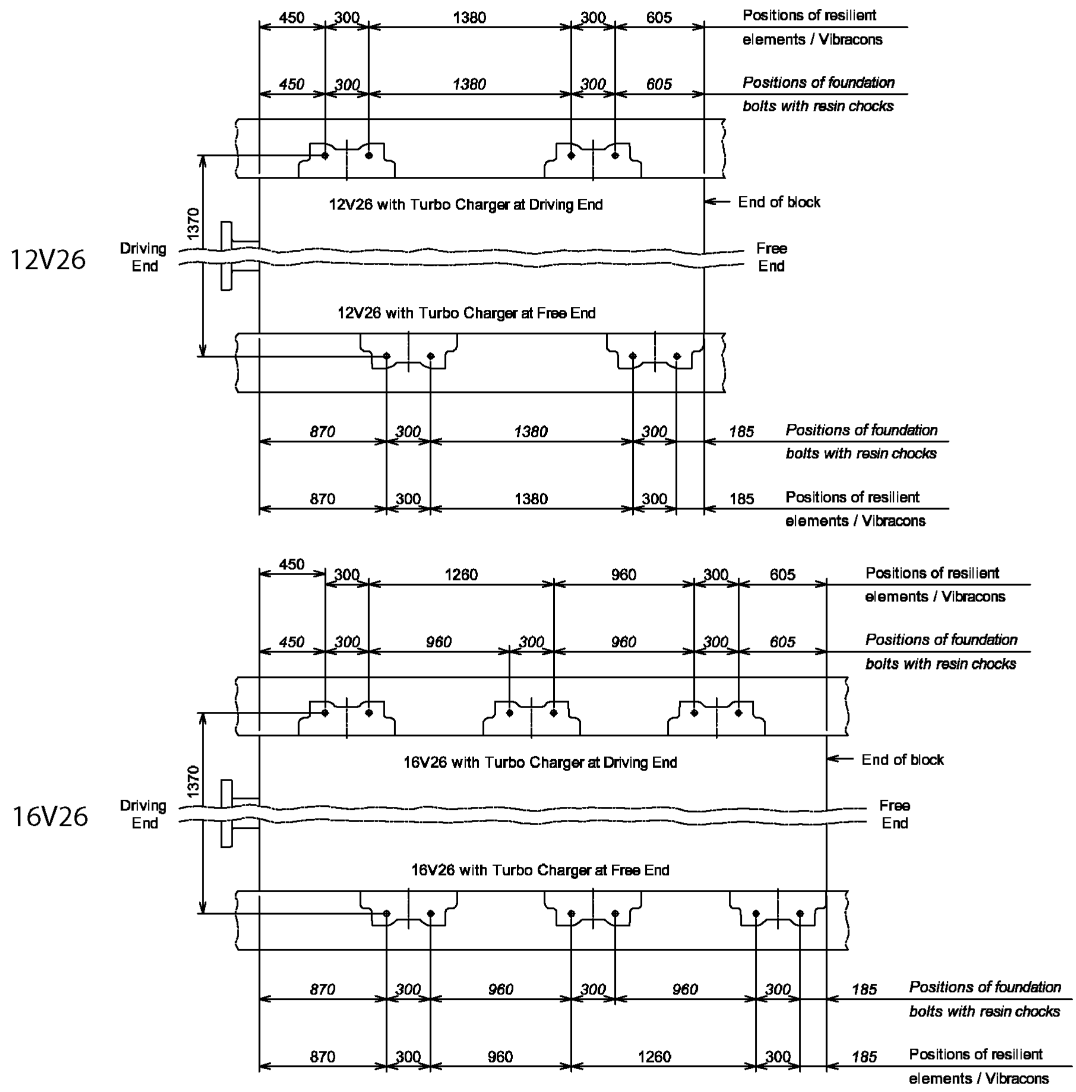


Fig 15-5 Foundation top-view and drilling plan, V-engines (9813ZT112a)

15.2.2 Resilient mounting

Engines driving gearboxes, generators, pumps etc. can be resiliently mounted in order to reduce vibrations and structure borne noise, while the driven equipment is fixed to a solid foundation. The engine block is rigid, therefore no intermediate base-frame is necessary. The resiliently elements are bolted to the engine feet directly.

The transmission of forces emitted by the engine is 10...30% when comparing resiliently mounting with rigid mounting.

Note! For resiliently mounted 9L engines the available speed range is limited. Please contact Wärtsilä for further information.

The standard engine mountings are of conical type. With conical mounting the rubber rubber element is loaded by both compression and shear. The mounts are equipped with an internal central buffer. Hence no additional side or end supports are required to limit the movements of the engine due to ships motions. The material of the mountings is rubber, which has superior vibration technical properties. Unfortunately natural rubber is prone to damage by mineral oil, therefore such elements should not be installed directly on the tank top, where they might come into contact with oily water. The rubber elements are protected against dripping and splashing from above by means of covers.

The number of resilient elements and their location is calculated to avoid resonance with excitations from the engine and the propeller.

When installing and aligning the engine on resilient elements it should be aimed at getting the same force on each rubber element. This means that the compression of all elements is equal. Due to creep of the resilient elements the alignment needs to be checked at regular intervals and corrected when necessary. To facilitate the alignment and re-alignment resilient elements of the height adjustable type are used for resiliently mounted engines.

Due to the soft mounting the engine will move when passing resonance speeds at start and stop. Also due to heavy seas engines will move. Typical amplitudes are ±3.5 mm at the crankshaft centre and ± 17 mm at top of the engine (the figures are calculated for a 22.5° roll angle). The torque reaction (at 1000 rpm and 100% load) will cause a displacement of the engine of up to 1 mm at the crankshaft centre and 5 mm at the turbocharger outlet. The coupling between engine and driven equipment should be flexible enough to be able to cope with these displacements.

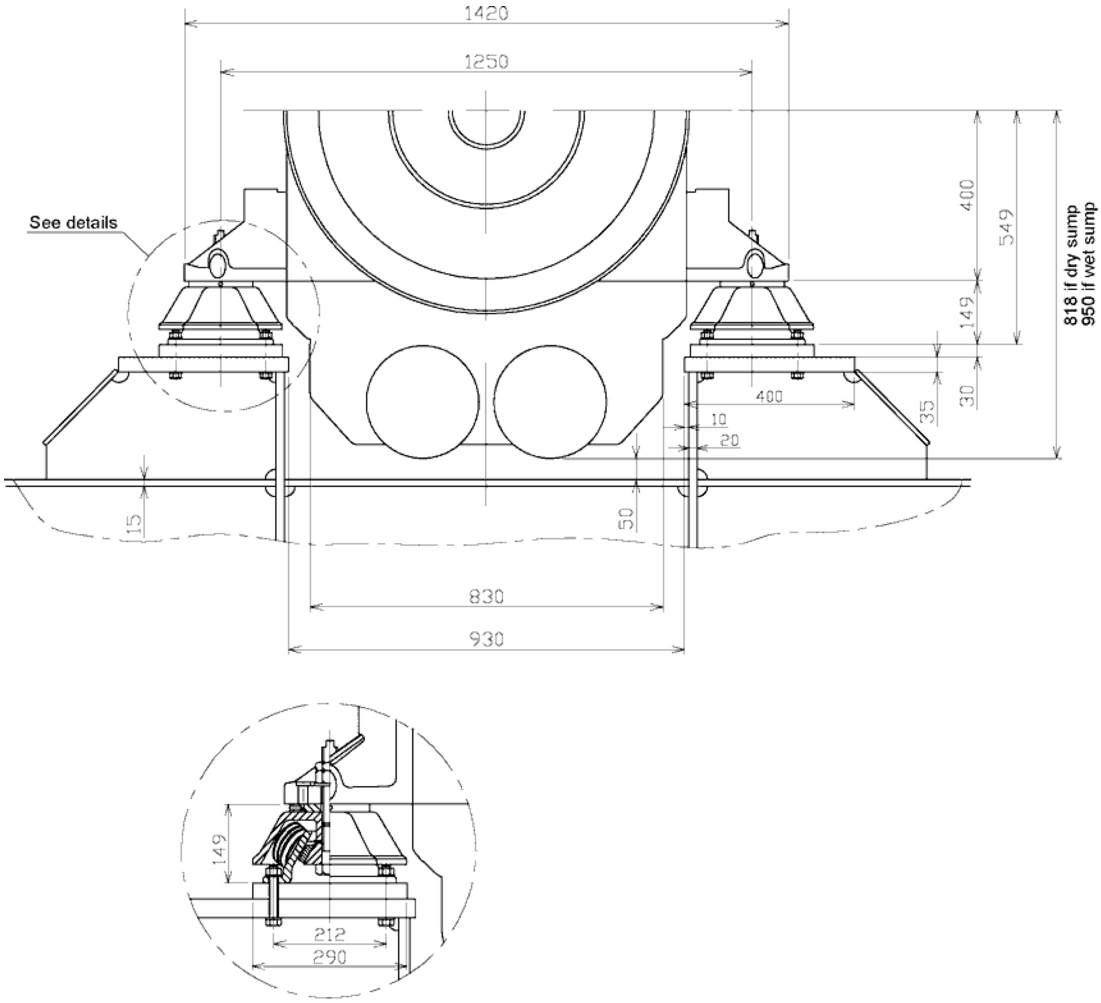


Fig 15-6 **Principle of resilient mounting, in-line engines (DAAE077680 / DAAE077681)**

15.3 Mounting of generating sets

15.3.1 Generator feet design

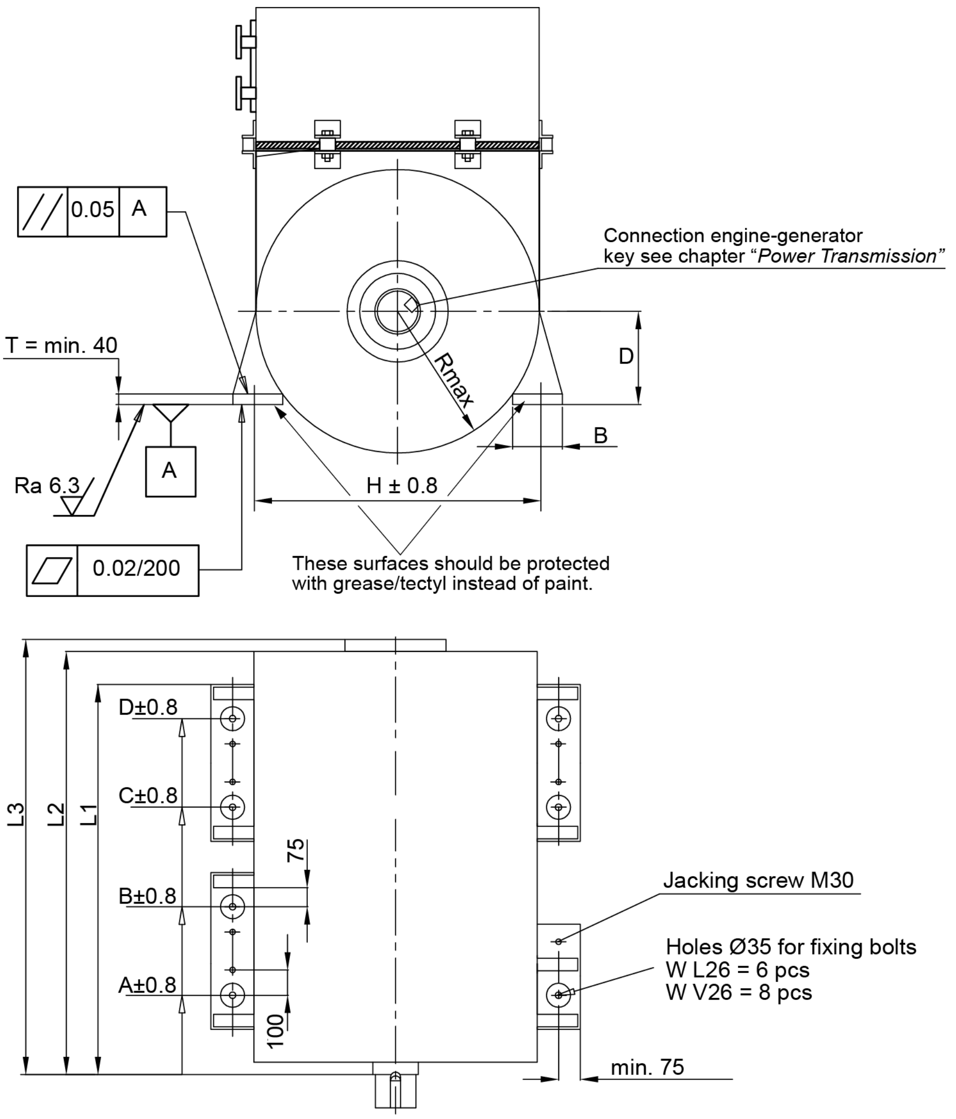


Fig 15-7 Distance between fixing bolts on generator (9506ZT733B)

H [mm]	Rmax [mm]
1250	560
1340	650
1420	700
1540	750
1620	780
1800	850
1950	925
2200	1000

15.3.2 Resilient mounting

Generating sets, comprising engine and generator mounted on a common base frame, are usually installed on resilient mounts on the foundation in the ship.

The resilient mounts reduce the structure borne noise transmitted to the ship and also serve to protect the generating set bearings from possible fretting caused by hull vibrations.

The number of mounts and their location is calculated to avoid resonance with excitations from the generating set engine, the main engine and the propeller.

NOTE

To avoid induced oscillation of the generating set, the following data must be sent by the shipyard to Wärtsilä at the design stage:

- Main engine speed and number of cylinders
- Propeller shaft speed and number of propeller blades

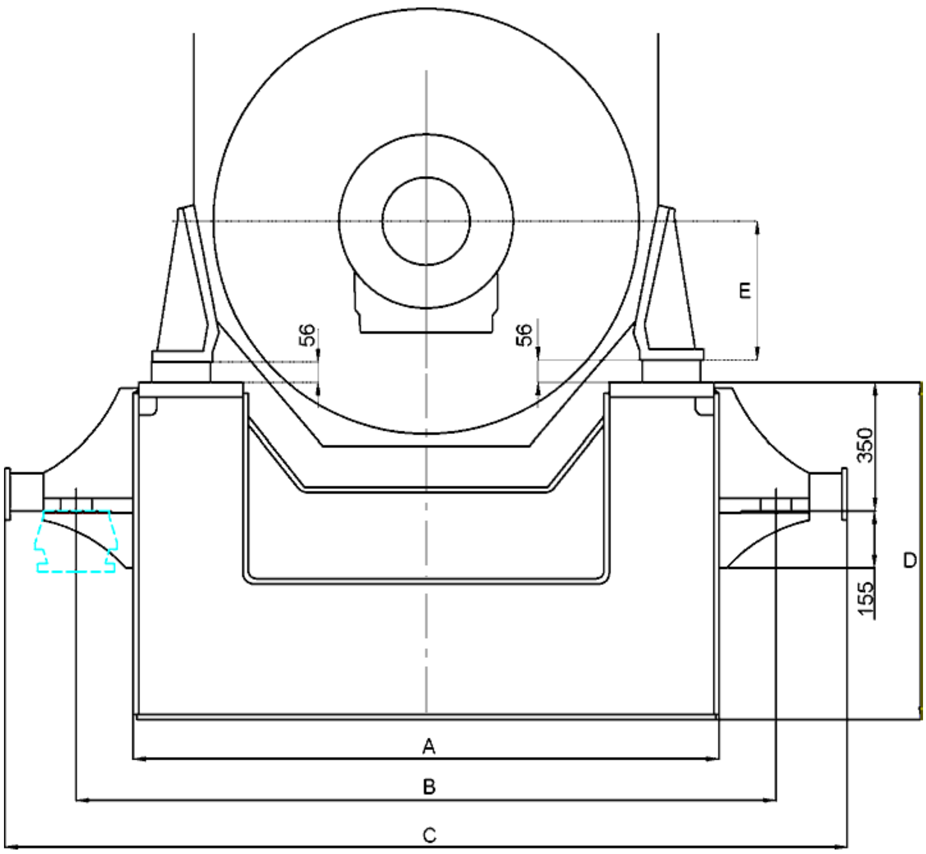


Fig 15-8 Standard generator dimensions and common base frame arrangement (9506ZT732)

Engine	Dimensions [mm]				
	A	B	C	D	E
W 6L26	1600	1910	2300	800	344
W 8L26	1600	1910	2300	800	344
W 9L26	1600	1910	2300	900	344
W 12V26	2000	2310	2700	1100	404
W 16V26	2000	2310	2700	1100	404

15.4 Flexible pipe connections

When the engine or generating set is resiliently installed, all connections must be flexible and no grating nor ladders may be fixed to the engine or generating set. When installing the flexible pipe connections, unnecessary bending or stretching should be avoided. The external pipe must be precisely aligned to the fitting or flange on the engine. It is very important that the pipe clamps for the pipe outside the flexible connection must be very rigid and welded to the steel structure of the foundation to prevent vibrations, which could damage the flexible connection.

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16. Vibration and Noise

Wärtsilä 26 generating sets comply with vibration levels according to ISO 8528-9. Main engines comply with vibration levels according to ISO 10816-6 Class 5.

16.1 External forces and couples

Some cylinder configurations produce external forces and couples. These are listed in the tables below.

The ship designer should avoid natural frequencies of decks, bulkheads and superstructures close to the excitation frequencies. The double bottom should be stiff enough to avoid resonances especially with the rolling frequencies.

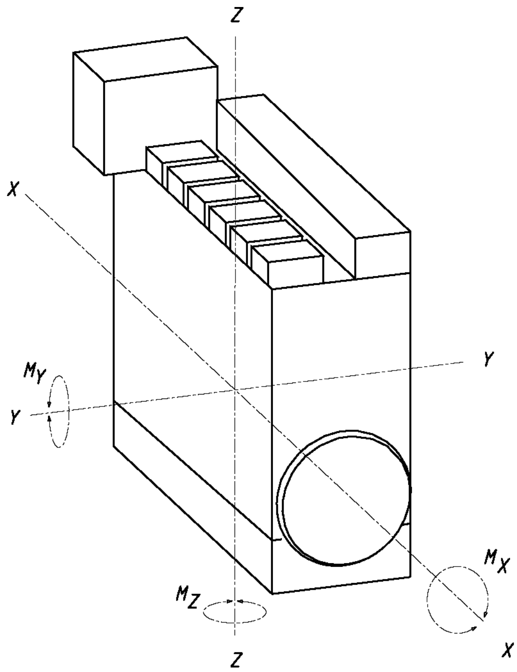

Fig 16-1 Coordinate system

Table 16-1 External forces and couples

Engine	Speed [rpm]	Frequency [hz]	F_Y [kN]	F_Z [kN]	Frequency [hz]	M_Y [kNm]	M_Z [kNm]	Frequency [hz]	M_Y [kNm]	M_Z [kNm]
W 6L26	900 1000	15 16.7	5.0 6.1	5.0 6.1	15 16.7	3.5 4.3	3.5 4.3	30 33.3	0.5 0.6	- -
W 8L26	900 1000	15 16.7	5.0 6.1	5.0 6.1	15 16.7	4.5 5.5	4.5 5.5	30 33.3	0.5 0.6	- -
W 9L26	900 1000	15 16.7	3.1 3.8	3.1 3.8	15 16.7	29 35	21 25	30 33.3	15 19	- -
W 12V26	900 1000	15 16.7	5.0 6.1	5.0 6.1	15 16.7	4.0 5.0	4.0 5.0	30 33.3	0.2 0.3	0.2 0.3
W 16V26	900 1000	15 16.7	5.0 6.1	5.0 6.1	15 16.7	6.0 7.4	6.0 7.4	30 33.3	0.3 0.4	0.4 0.5

- couples are zero or insignificant

16.2 Torque variations

Table 16-2 Torque variation at 100% load

Engine	Speed [rpm]	Frequency [hz]	M_X [kNm]	Frequency [hz]	M_X [kNm]
W 6L26	900 1000	45 50	15.4 12.0	90 100	10.2 10.2
W 8L26	900 1000	60 66.7	31.4 31.8	120 133.3	4.7 4.3
W 9L26	900 1000	67.5 75	30.7 31.6	135 150	3.0 2.6
W 12V26	900 1000	45 50	4.0 3.1	90 100	19.6 19.6
W 16V26	900 1000	60 66.7	21.5 21.8	120 133.3	7.2 6.7

16.3 Mass moments of inertia

The mass-moments of inertia of the main engines (including flywheel) are typically as follows:

Engine	Inertia [kgm²]
W 6L26	121
W 8L26	136
W 9L26	183
W 12V26	236
W 16V26	279

16.4 Air borne noise

The airborne noise of the engine is measured as a sound power level according to ISO 9614-2. The results are presented with A-weighing in octave bands, reference level 1 pW. Two values are given; a minimum value and a 90% value. The minimum value is the lowest measured noise level. The 90% value indicates that 90% of all measured noise levels are below this value.

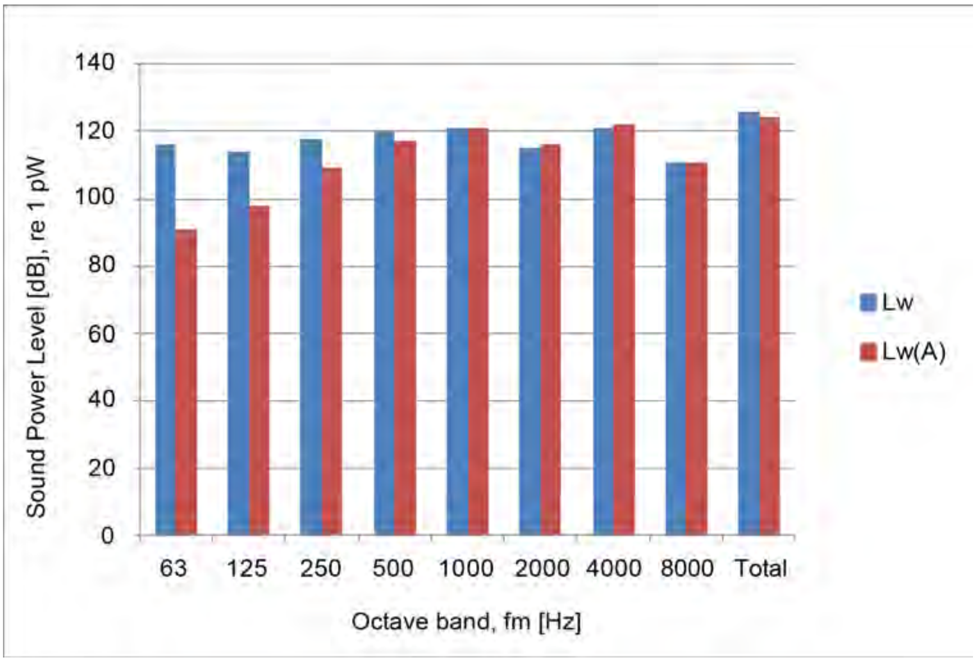

Fig 16-2 Typical sound power level for engine noise, W L26

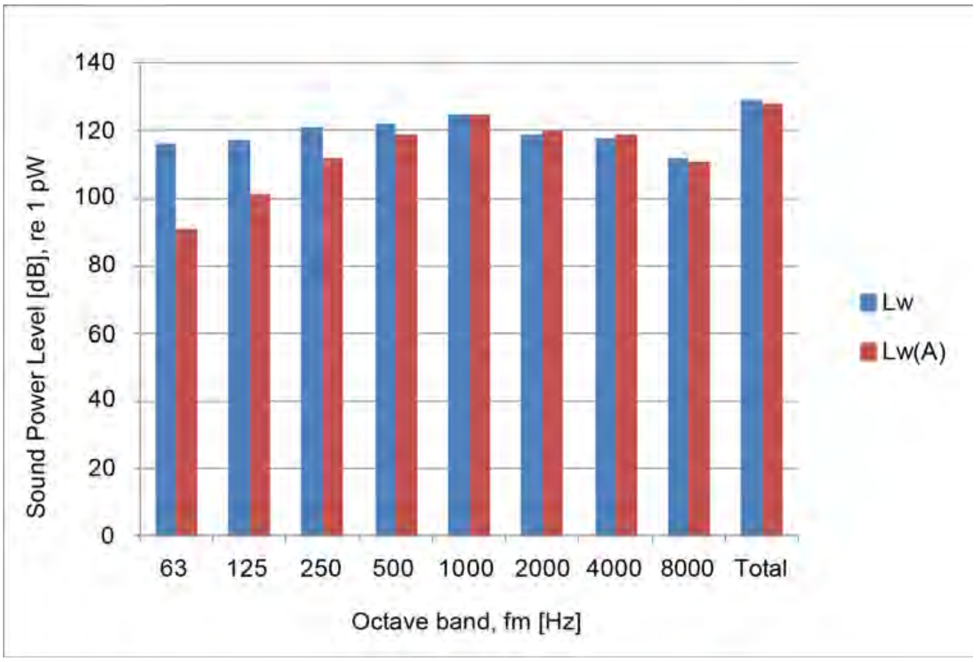

Fig 16-3 Typical sound power level for engine noise, W V26

16.5 Exhaust noise

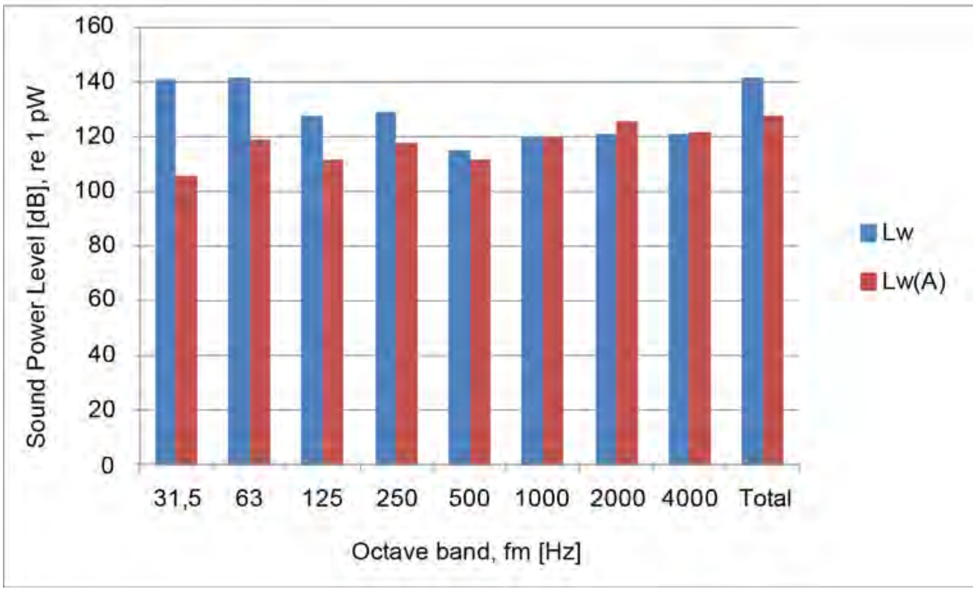

Fig 16-4 **Typical sound power level for exhaust noise, W L26**

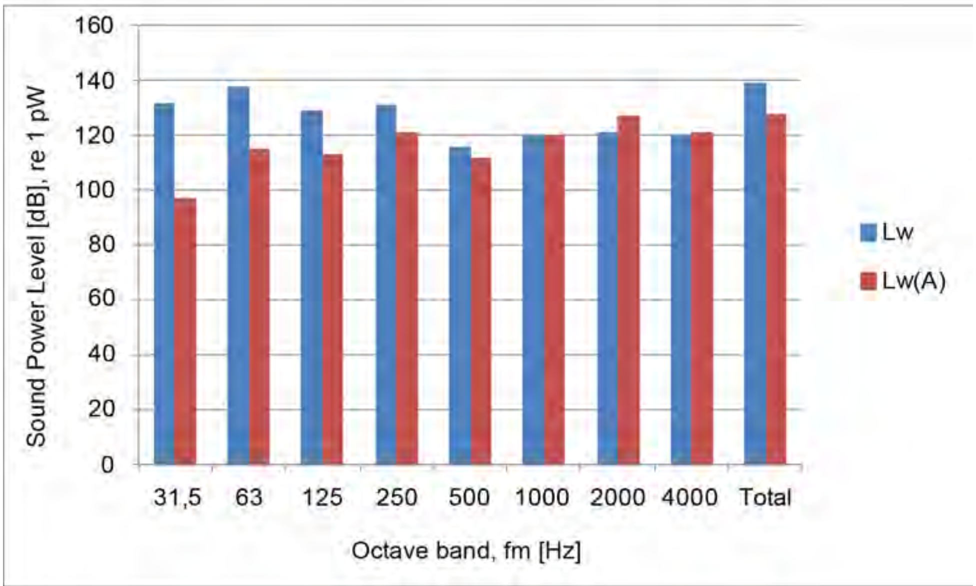

Fig 16-5 **Typical sound power level for exhaust noise, W V26**

17. Power Transmission

17.1 Flexible coupling

The power transmission of propulsion engines is accomplished through a flexible coupling or a combined flexible coupling and clutch mounted on the flywheel. The crankshaft is equipped with an additional shield bearing at the flywheel end. Therefore also a rather heavy coupling can be mounted on the flywheel without intermediate bearings.

The type of flexible coupling to be used has to be decided separately in each case on the basis of the torsional vibration calculations.

In case of two bearing type generator installations a flexible coupling between the engine and the generator is required.

The following figure gives an indication of flywheel-coupling length based on engine nominal torque. Changes are possible due to constant development.

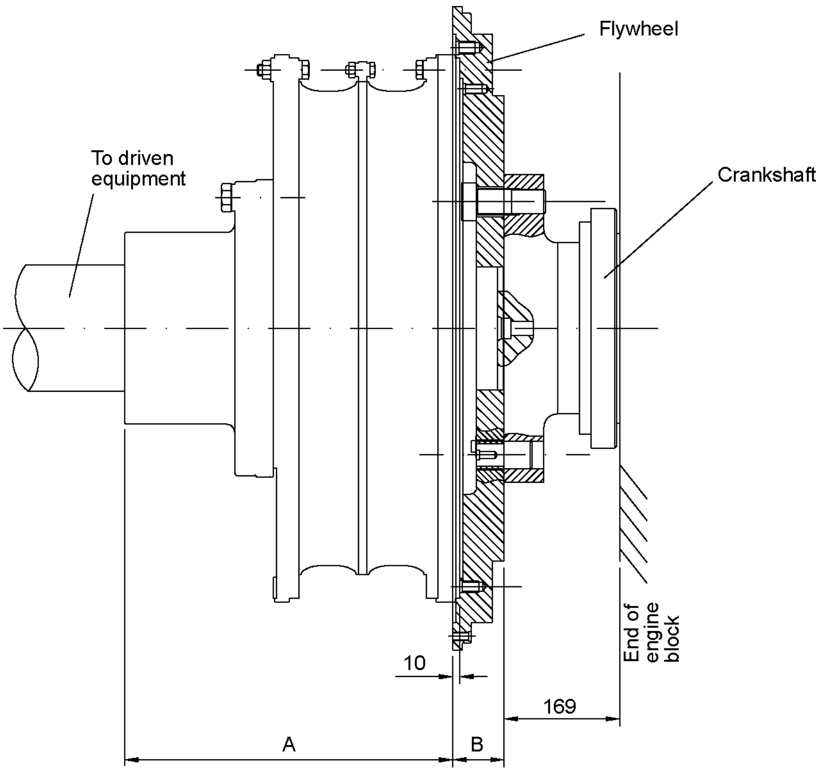

Fig 17-1 Connection engine/driven equipment (DAAE026899c)

Engine	A [mm]			B [mm]
	Main engine rigid mounting 1)	Main engine resilient mounting 2)	Generating set	
W 6L26	440	470	355	75
W 8L26	475	500	355	75
W 9L26	475	530	370	75

1) single row coupling

2) two row coupling

Classification rules usually require a fail safe device for single main engines. The fail safe device permits restricted operation in case the flexible parts of the coupling would fail.

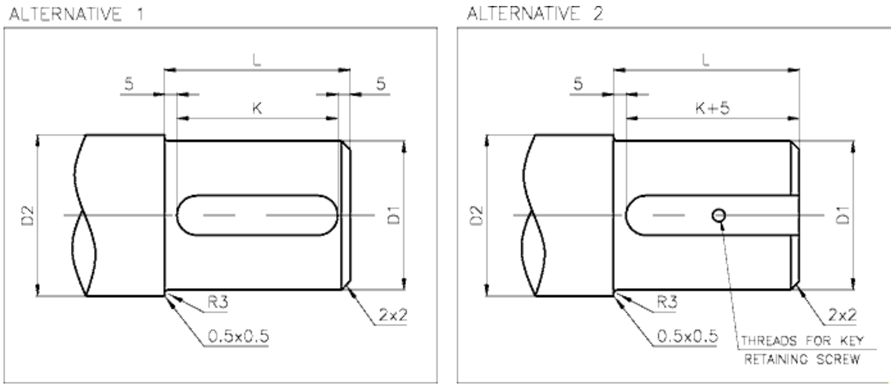

Fig 17-2 Directives for generator end design (9506ZT734)

Alternative 1: Permitted keys are according to DIN 6685, Part 1: Type A, B, C or D.

Alternative 2: Permitted keys are according to DIN 6685, Part 1: Type C or D.

Engine	D1 [mm]	L [mm]	K [mm]	min. D2 [mm]
W 6L26	160	250	240	175
W 8L26	160	250	240	175
W 9L26	160	250	240	175
W 12V26	210	250	240	225
W 16V26	220	280	270	235

17.2 Clutch

In many installations the propeller shaft can be separated from the diesel engine using a clutch. The use of multiple plate hydraulically actuated clutches built into the reduction gear is recommended.

A clutch is required when two or more engines are connected to the same driven machinery such as a reduction gear.

To permit maintenance of a stopped engine clutches must be installed in twin screw vessels which can operate on one shaft line only.

17.3 Shaft locking device

A shaft locking device should also be fitted to be able to secure the propeller shaft in position so that wind milling is avoided. This is necessary because even an open hydraulic clutch can transmit some torque. Wind milling at a low propeller speed (<10 rpm) can due to poor lubrication cause excessive wear of the bearings.

The shaft locking device can be either a bracket and key or an easier to use brake disc with calipers. In both cases a stiff and strong support to the ship's construction must be provided.

To permit maintenance of a stopped engine clutches must be installed in twin screw vessels which can operate on one shaft line only. A shaft locking device should also be fitted to be able to secure the propeller shaft in position so that wind milling is avoided. This is necessary because even an open hydraulic clutch can transmit some torque. Wind milling at a low propeller speed (<10 rpm) can due to poor lubrication cause excessive wear of the bearings.

The shaft locking device can be either a bracket and key or an easier to use brake disc with calipers. In both cases a stiff and strong support to the ship's construction must be provided.

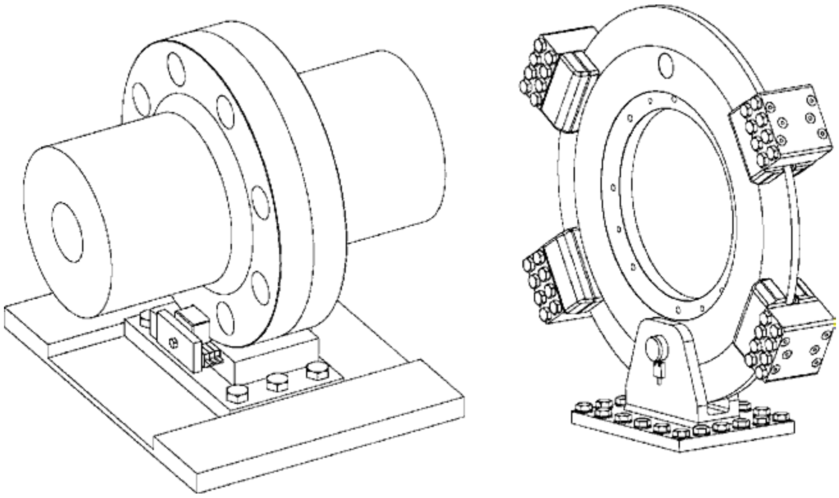

Fig 17-3 **Shaft locking device and brake disc with calipers**

17.4 Power-take-off from the free end

At the free end a shaft connection as a power take off can be provided. If required full output can be taken from the PTO shaft.

The arrangement of the standard PTO shaft is shown in this section. The maximum allowable bending moments on the PTO shaft depend on several criteria. As a guidance the values as mentioned in table below can be used for the maximum allowed bending moments and radial forces. When these values are exceeded, an extra support bearing is needed.

In the figures an indication is given how an extra support bearing could be arranged externally. Such a support bearing is only possible when engine and support bearing are rigidly mounted on the same base. This can be the ship's foundation but this can also be a flexible mounted common base frame.

Table 17-1 **Maximum allowable loading crankshaft flanges (can be applied simultaneously) (9910ZT161f)**

	Radial Force [kN]	Moments [kNm]		Axial Force [kN]
		L	V	
Driving end	100	13	9	10
Free end (PTO)	100	6.5	4.5	7

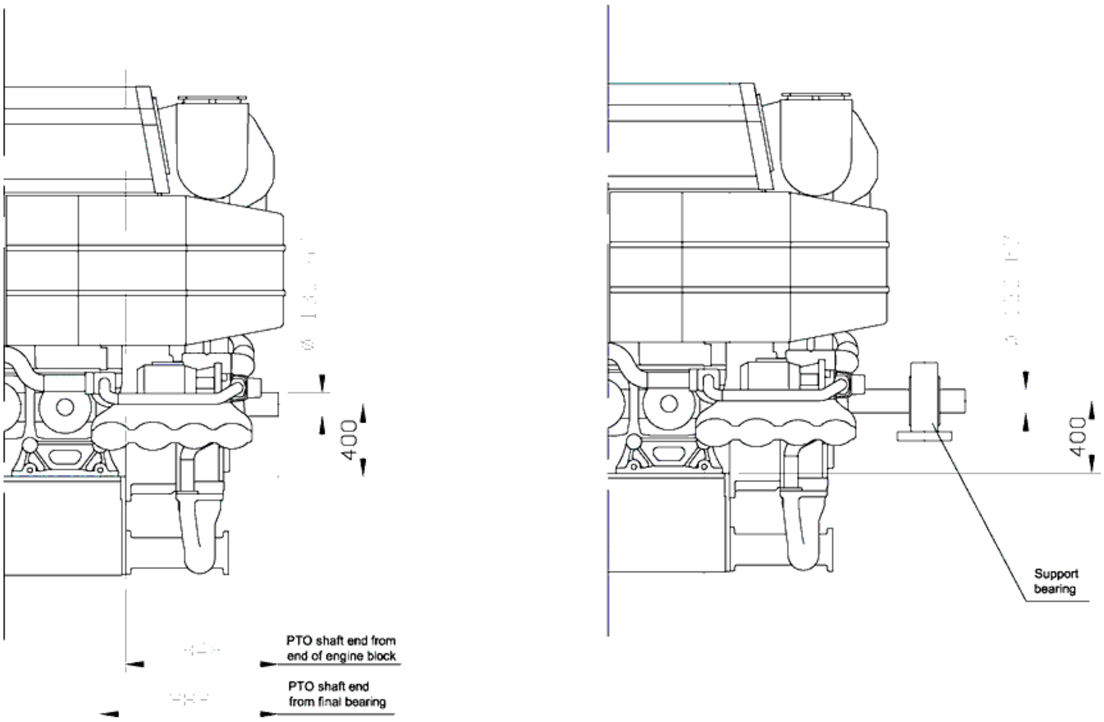

Fig 17-4 **PTO-shaft arrangement of standard PTO shaft and with external support bearing for in-line engines**

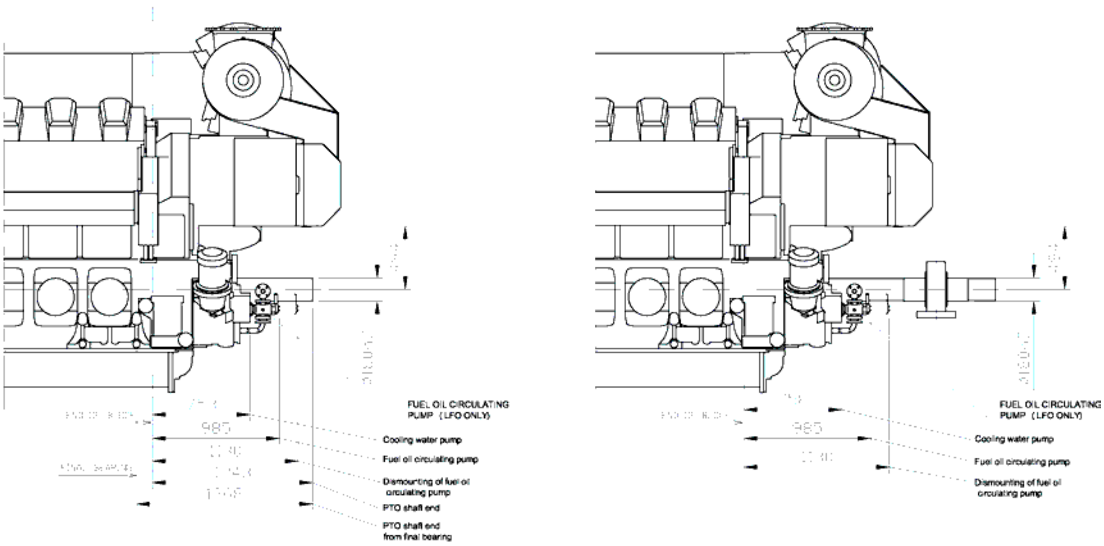

Fig 17-5 **PTO-shaft arrangement of standard PTO shaft and with external support bearing for V engines**

17.5 Input data for torsional vibration calculations

A torsional vibration calculation is made for each installation. For this purpose exact data of all components included in the shaft system are required. See list below.

Installation

- Classification
- Ice class
- Operating modes

Reduction gear

A mass elastic diagram showing:

- All clutching possibilities
- Sense of rotation of all shafts
- Dimensions of all shafts
- Mass moment of inertia of all rotating parts including shafts and flanges
- Torsional stiffness of shafts between rotating masses
- Material of shafts including tensile strength and modulus of rigidity
- Gear ratios
- Drawing number of the diagram

Propeller and shafting

A mass-elastic diagram or propeller shaft drawing showing:

- Mass moment of inertia of all rotating parts including the rotating part of the OD-box, SKF couplings and rotating parts of the bearings
- Mass moment of inertia of the propeller at full/zero pitch in water
- Torsional stiffness or dimensions of the shaft
- Material of the shaft including tensile strength and modulus of rigidity
- Drawing number of the diagram or drawing

Main generator or shaft generator

A mass-elastic diagram or an generator shaft drawing showing:

- Generator output, speed and sense of rotation
- Mass moment of inertia of all rotating parts or a total inertia value of the rotor, including the shaft
- Torsional stiffness or dimensions of the shaft
- Material of the shaft including tensile strength and modulus of rigidity
- Drawing number of the diagram or drawing

Flexible coupling/clutch

If a certain make of flexible coupling has to be used, the following data of it must be informed:

- Mass moment of inertia of all parts of the coupling
- Number of flexible elements
- Linear, progressive or degressive torsional stiffness per element
- Dynamic magnification or relative damping
- Nominal torque, permissible vibratory torque and permissible power loss

- Drawing of the coupling showing make, type and drawing number

Operational data

- Operational profile (load distribution over time)
- Clutch-in speed
- Power distribution between the different users
- Power speed curve of the load

17.6 Turning gear

The engine is equipped with an electrical driven turning gear for turning the engine. The electrical motor is equipped with a hand wheel for manual turning.

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18. Engine Room Layout

18.1 Crankshaft distances

Minimum crankshaft distances have to be followed in order to provide sufficient space between engines for maintenance and operation.

18.1.1 In-line engines

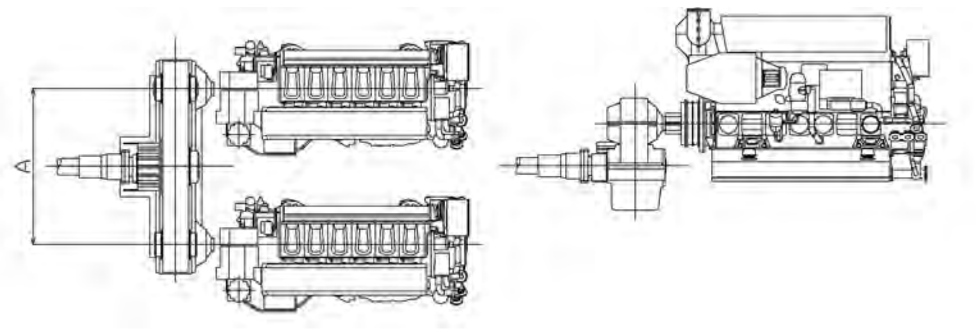

Fig 18-1 Crankshaft centre distances, in-line engines (DAAE026895a)

Engine type	A[1] [mm]	A[2] [mm]
W 6L26	2500	2300
W 8L26	2500	2400
W 9L26	2500	2400

1) Maintenance charge air cooler with standard service tool

2) Maintenance charge air cooler without standard service tool

18.1.2 V-engines

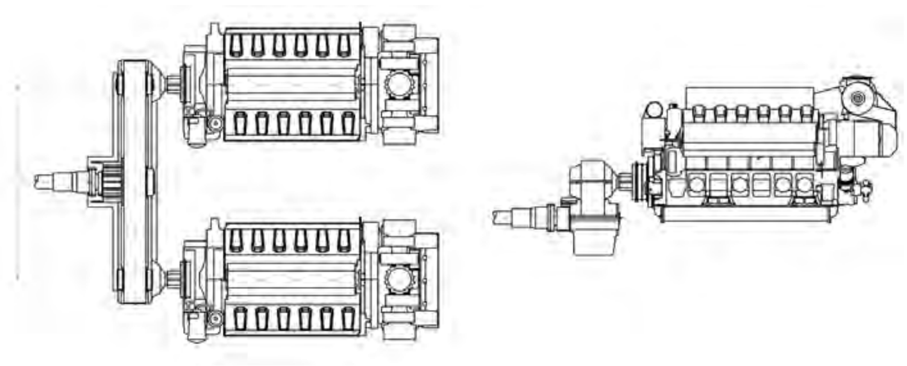

Fig 18-2 Crankshaft centre distances, V-engines (DAAE034187b)

Engine type	A [mm]
W 12V26	3150
W 16V26	3150

18.1.3 Father-and-son arrangement

When connecting two engines of different type and/or size to the same reduction gear the minimum crankshaft distance has to be evaluated case by case. However, some general guidelines can be given:

- It is essential to check that all engine components can be dismounted. The most critical are usually turbochargers and charge air coolers
- When using a combination of in-line and V-engine, the operating side of in-line engine should face the v-engine in order to minimise the distance between crankshafts
- Special care has to be taken checking the maintenance platform elevation between the engines to avoid structures that obstruct maintenance

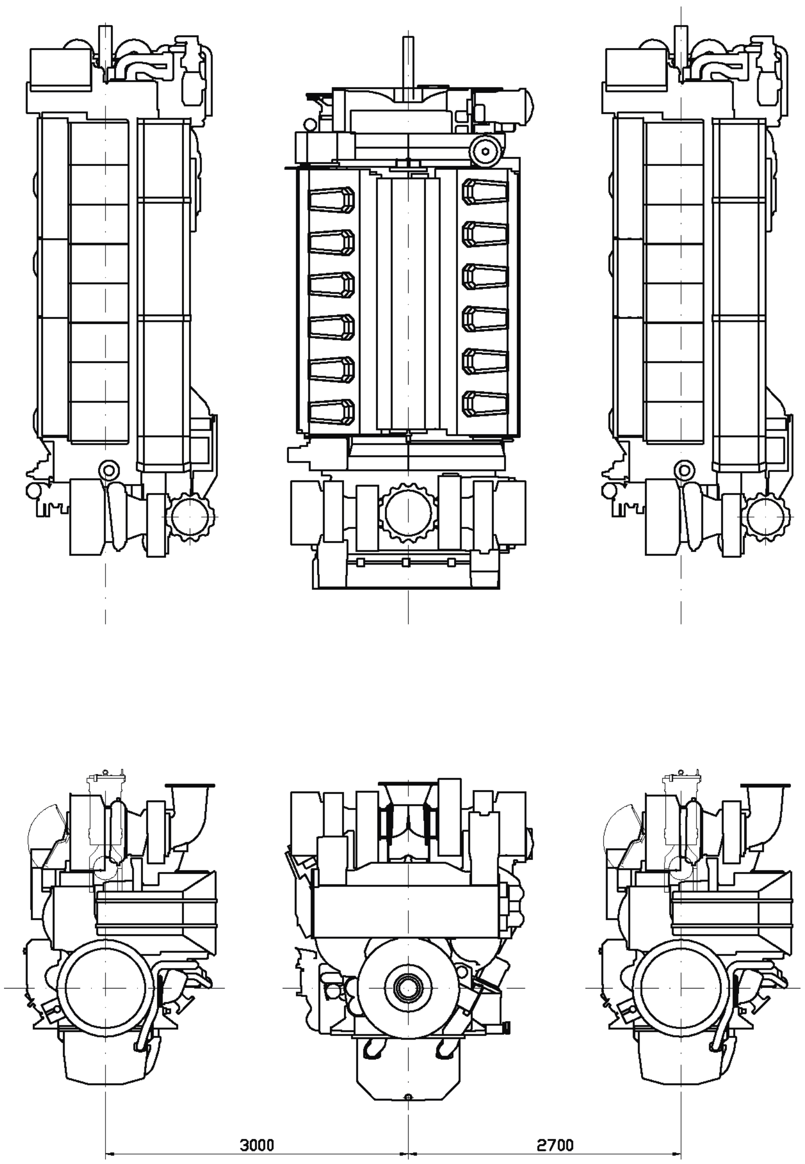

Fig 18-3 **Main engine arrangement with two in-line engine and one V-engine (DAAE033711)**

18.1.4 Distance from adjacent intermediate/propeller shaft

Some machinery arrangements feature an intermediate shaft or propeller shaft running adjacent to engine. To allow adequate space for engine inspections and maintenance there has to be sufficient free space between the intermediate/propeller shaft and the engine. To enable safe working conditions the shaft has to be covered. It must be noticed that also dimensions of this cover have to be taken into account when determining the shaft distances in order to fulfil the requirement for minimum free space between the shaft and the engine.

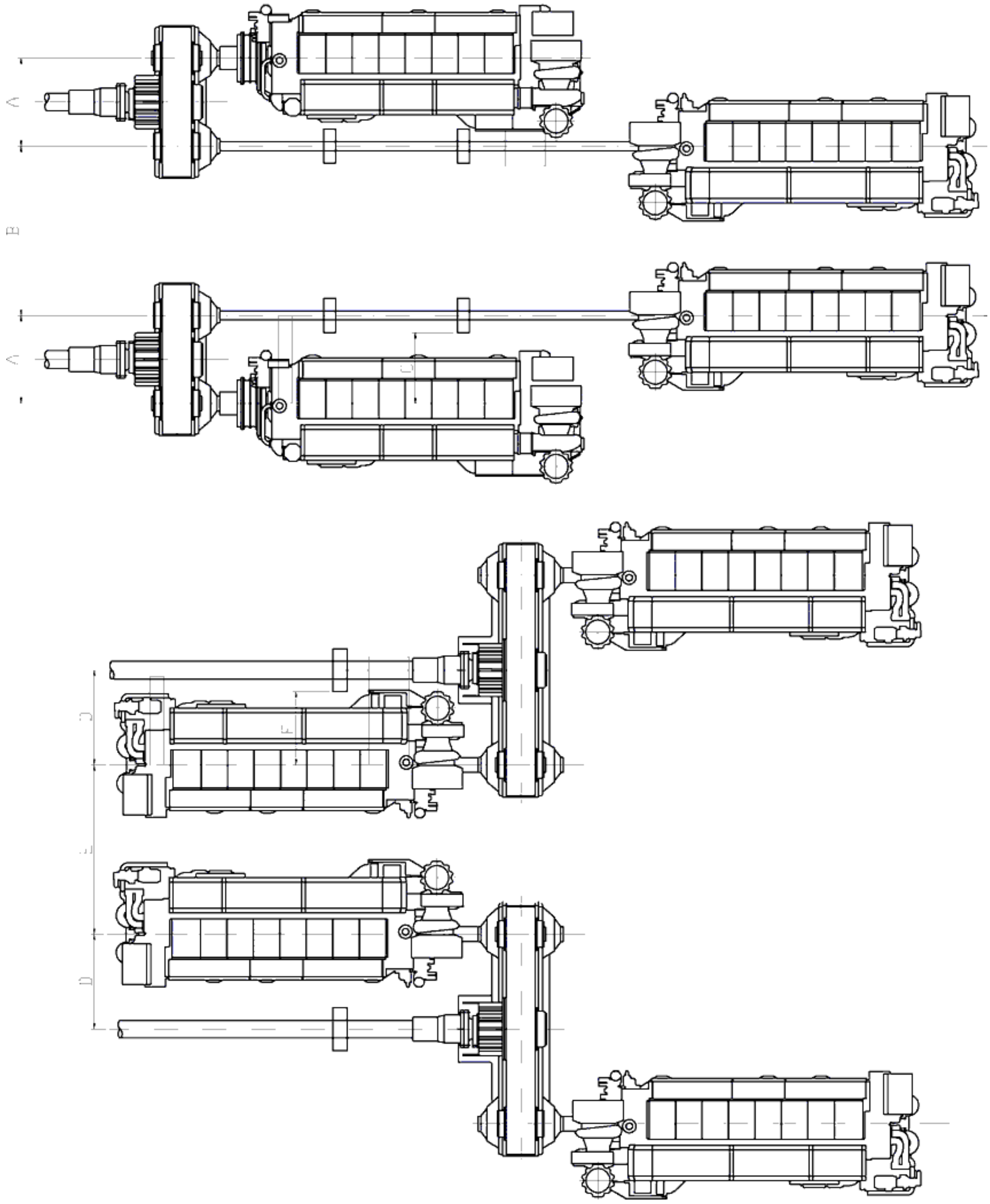

Fig 18-4 Main engines arrangement, 4 engines (DAAE033712)

Engine	A	B	C	D	E	F
W L26	1500	2500	1172	1500	2500	1172
W V26	1900	3000	1633	2100	3000	1782

18.2 Space requirements for maintenance

18.2.1 Working space around the engine

The required working space around the engine is mainly determined by the dismounting dimensions of some engine components, as well as space requirement of some special tools. It is especially important that no obstructive structures are built next to engine driven pumps, as well as camshaft and crankcase doors.

However, also at locations where no space is required for any engine part dismounting, a minimum of 1000 mm free space everywhere around the engine is recommended to be reserved for maintenance operations.

18.2.2 Engine room height and lifting equipment

The required engine room height is determined by the transportation routes for engine parts. If there is sufficient space in transverse and longitudinal direction, there is no need to transport engine parts over the rocker arm covers or over the exhaust pipe and in such case the necessary height is minimized.

Separate lifting arrangements are usually required for overhaul of the turbocharger since the crane travel is limited by the exhaust pipe. A chain block on a rail located over the turbocharger axis is recommended.

18.2.3 Maintenance platforms

In order to enable efficient maintenance work on the engine, it is advised to build the maintenance platforms on recommended elevations. The width of the platforms should be at minimum 800 mm to allow adequate working space. The surface of maintenance platforms should be of non-slippery material (grating or chequer plate).

NOTE

Working Platforms should be designed and positioned to prevent personnel slipping, tripping or falling on or between the walkways and the engine

18.3 Transportation and storage of spare parts and tools

Transportation arrangement from engine room to storage and workshop has to be prepared for heavy engine components. This can be done with several chain blocks on rails or alternatively utilising pallet truck or trolley. If transportation must be carried out using several lifting equipment, coverage areas of adjacent cranes should be as close as possible to each other.

Engine room maintenance hatch has to be large enough to allow transportation of main components to/from engine room.

It is recommended to store heavy engine components on slightly elevated adaptable surface e.g. wooden pallets. All engine spare parts should be protected from corrosion and excessive vibration.

On single main engine installations it is important to store heavy engine parts close to the engine to make overhaul as quick as possible in an emergency situation.

18.4 Required deck area for service work

During engine overhaul some deck area is required for cleaning and storing dismantled components. Size of the service area is dependent of the overhauling strategy chosen, e.g. one cylinder at time, one bank at time or the whole engine at time. Service area should be plain steel deck dimensioned to carry the weight of engine parts.

18.4.1 Service space requirement for the in-line engine

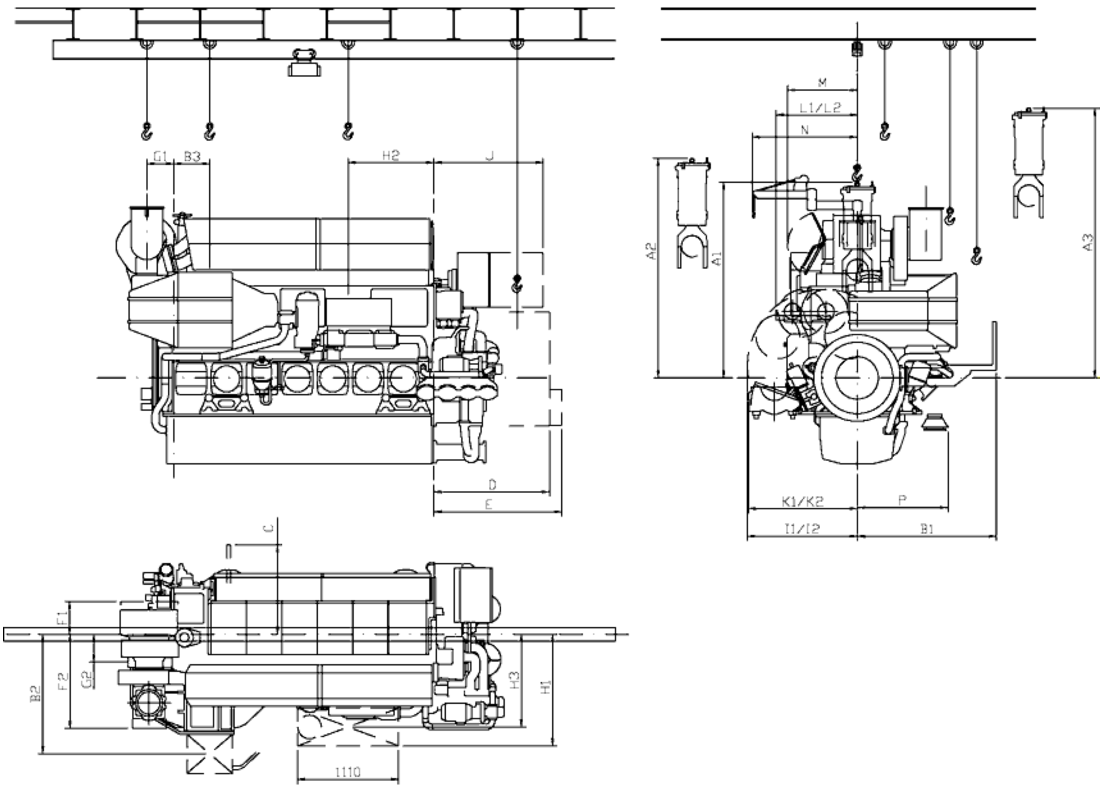

Fig 18-5 Service space requirements for in-line engines, turbocharger in driving end (DAAE026452c)

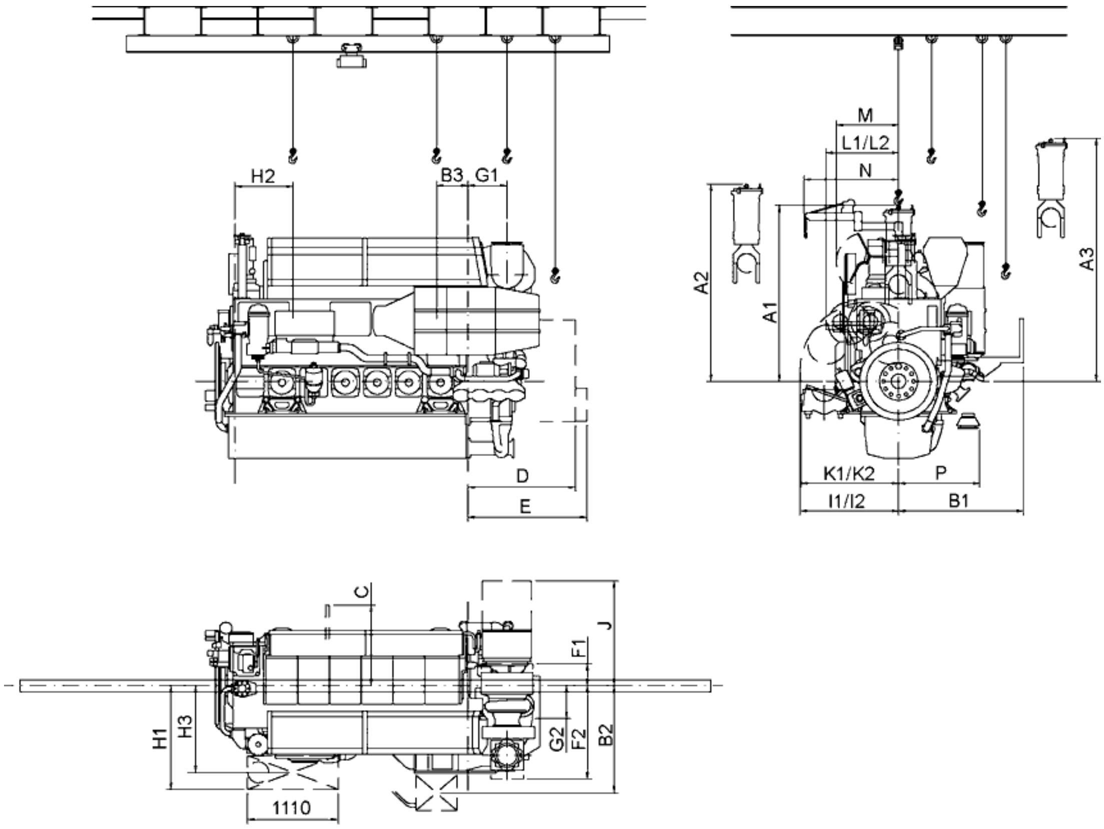

Fig 18-6 **Service space requirements for in-line engines, turbocharger in free end (DAAE030871B)**

Description		TC at driving end			TC at free end		
		6L	8L	9L	6L	8L	9L
A1	Height to lift the power unit out of cylinder head studs		2164			2164	
A2	Height for transporting the power unit sidewards over hotbox profile		2430			2430	
A3	Height for transporting the power unit sidewards over isolating box		3000			3000	
B1	Length for dismantling charge air cooler insert		1600			1600	
B2	Recommended lifting point for charge air cooler insert		1318			1318	
B3	Recommended lifting point for charge air cooler insert		395			395	
C	Removal of main bearing side screw (to both side)		987			987	
D	Distance for dismantling of engine driven pumps		1100			1100	
E	Distance for dismantling and lifting pump cover with fitted pumps (min)		1250			1510	
F1	Minimum axial clearance for dismantling and assembly of silencers	364	450	450	264	361	361
F2	Minimum axial clearance for dismantling and assembly of exhaust gas outlet elbow (recommended +400 mm)	1038	1178	1178	1146	1270	1270
G1	Lifting point for turbocharger	275	369	369	481	526	526
G2	Lifting point for turbocharger	305	298	298	405	390	390
H1	Width for dismantling lubricating oil module and/or plate cooler		1300			1300	
H2	Recommended lifting point for dismantling lubricating oil module and/or plate cooler		969			715	
H3	Recommended lifting point for dismantling lubricating oil module and/or plate cooler		1003			1027	
I1	Dismounting space camshaft gearwheel		1300			1300	
I2	Dismounting space intermediate gearwheel		1250			1250	
J	Space necessary for access to the connection box		1350			1350	
K1	Dismounting space main bearing caps (to either side)		1200			1200	
K2	Dismounting space big end bearing caps (to either side)		1172			1172	
L1	Dismounting space camshaft journal		808			808	
L2	Dismounting space camshaft section		895			895	
M	Hotbox opening space		850			850	
N	Dismounting space for high pressure fuel pumps with standard tool		1160			1160	
P	Dismounting space for resilient element (metalastic)		1000			1000	

18.4.2 Service space requirement for the V-engine

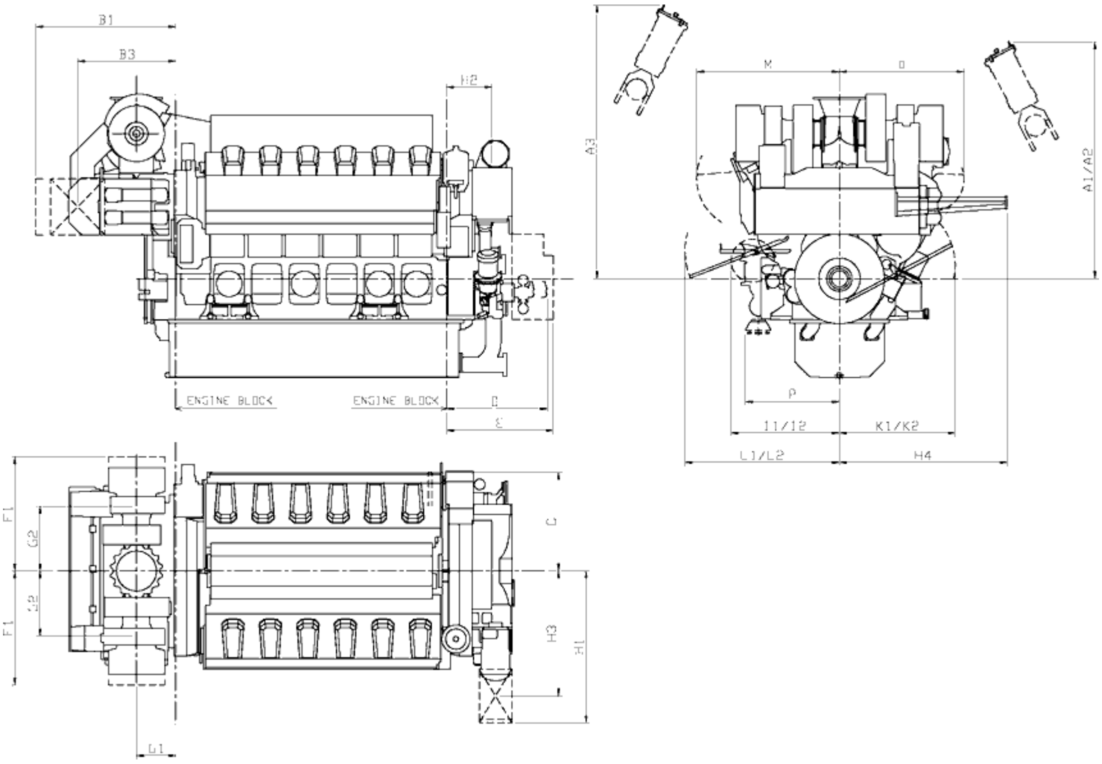

Fig 18-7 **Service space requirements for V-engines, turbocharger in driving end (DAAE033190a)**

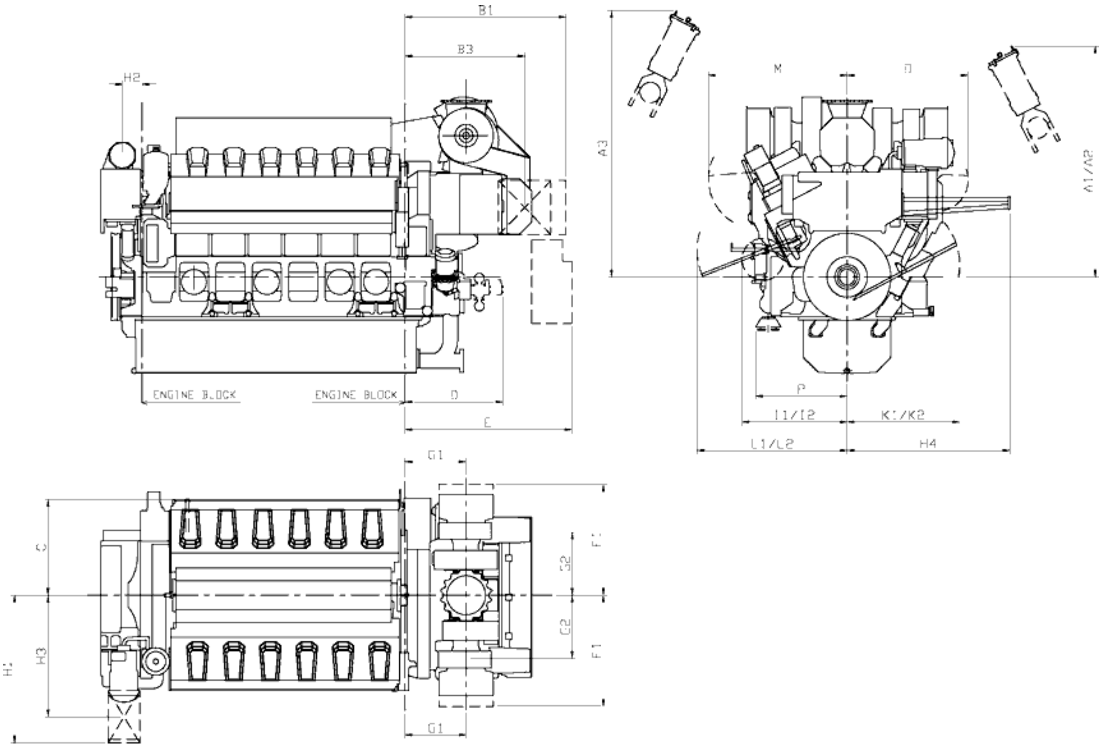

Fig 18-8 **Service space requirements for V-engines, turbocharger in free end (DAAE033191a)**

Description		TC in flywheel end		TC in free end	
		12V	16V	12V	16V
A1	Height to lift the power unit out of cylinder head studs	2220		2220	
A2	Height for transporting the power unit sidewards over hotbox profile	2765		2765	
A3	Height for transporting the power unit sidewards over isolating box	3170		3170	
B1	Length for dismantling charge air cooler insert	1670		1955	
B3	Recommended lifting point for charge air cooler insert	1100		1382	
C	Removal of main bearing side screw (to both side)	1210		1210	
D	Distance for dismantling and lifting of engine driven pumps	1230		1230	
E	Distance for dismantling pump cover with fitted pumps (min)	1295		2025	2170
F1	Minimum axial clearance for dismantling and assembly of silencers (recommended +400)	1380		1380	
G1	Lifting point for turbocharger	440	576	705	842
G2	Lifting point for turbocharger	730	573	730	573
H1	Width for dismantling lubricating oil cooler	1800		1800	
H2	Recommended lifting point for dismantling lubricating oil cooler	509		225	
H3	Recommended lifting point for dismantling lubricating oil cooler	1400		1400	
H4	Dismounting tool for lubricating oil cooler	1900		1900	
I1	Dismounting space camshaft gearwheel	1315		1315	
I2	Dismounting space intermediate gearwheel	1350		1350	
K1	Dismounting space main bearing caps (to either sides)	1045		1045	
K2	Dismounting space big end bearing caps (to either sides)	1400		1400	
L1	Dismounting space camshaft journal	1210		1210	
L2	Dismounting space camshaft section	1830		1830	
M	WECS opening space	1700		1700	
O	Hotbox opening space	1500		1500	
P	Dismounting space for resilient element (metalastic)	1155		1155	

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19. Transport Dimensions and Weights

19.1 Lifting of main engines

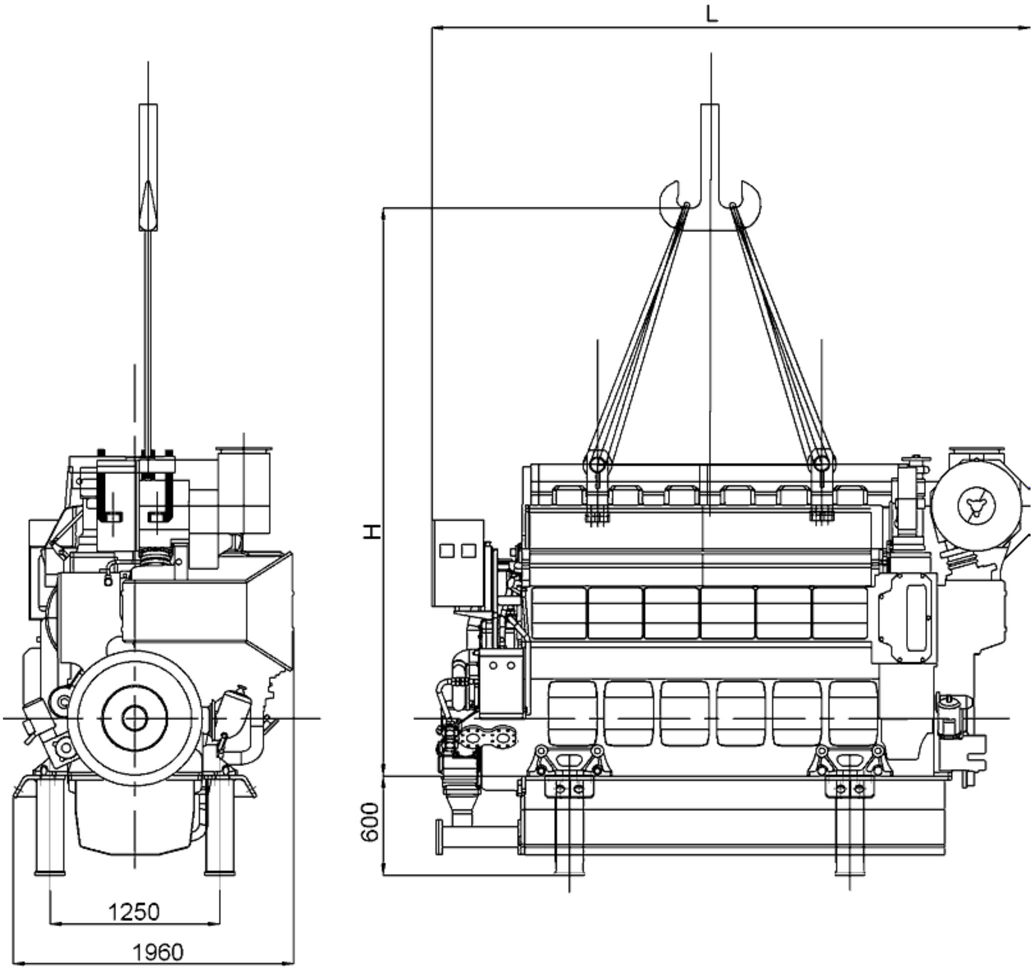

Fig 19-1 Lifting of main engines, in-line engines (DAAE026602a)

Engine	L	H
W 6L26	4387	3435
W 8L26	5302	3494
W 9L26	5691	3494

All dimensions in mm.

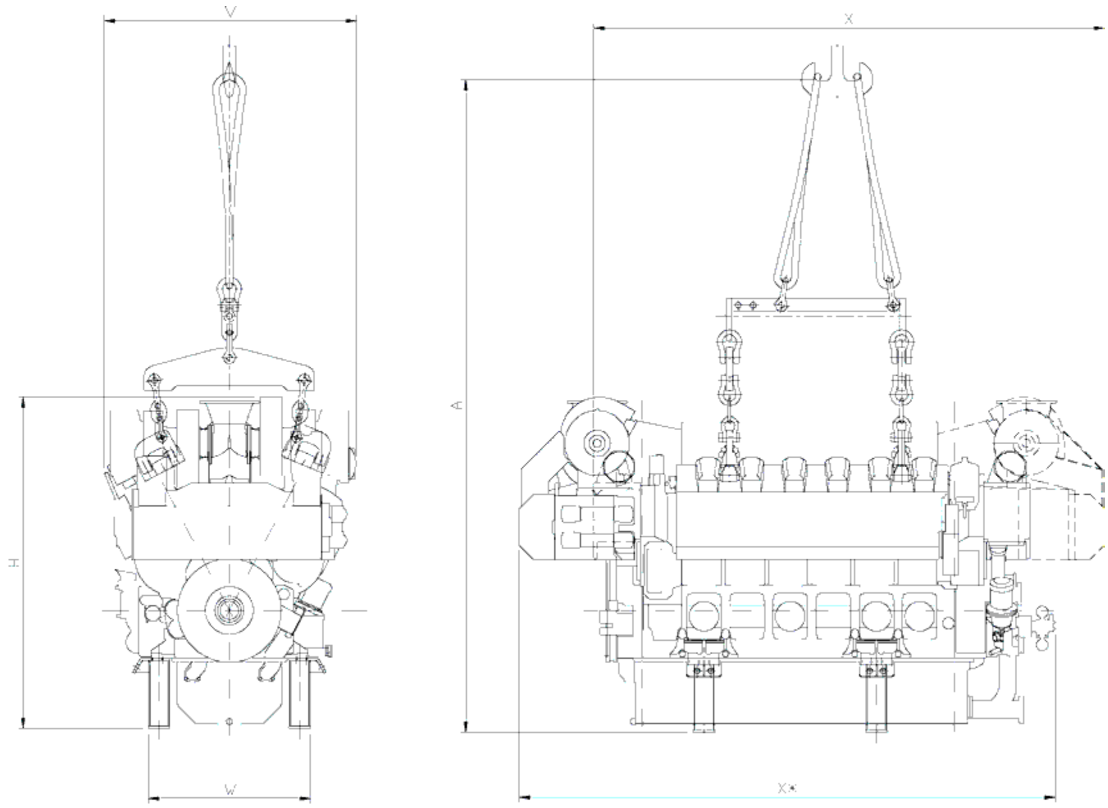

Fig 19-2 Lifting of main engines, V-engines (9610ZT128c)

Engine	A	V	W	X*	H*	X	H	Weight **
W 12V26	6355	2453	1580	5218	3224	4968	3224	31.2
W 16V26	6355	2473	1580	6220	3224	5981	3224	37.4

*) Turbocharger in driving end

**) Weight [ton] for wet sump engines including hoisting tool and transport support

All dimensions in mm.

19.2 Lifting of generating sets

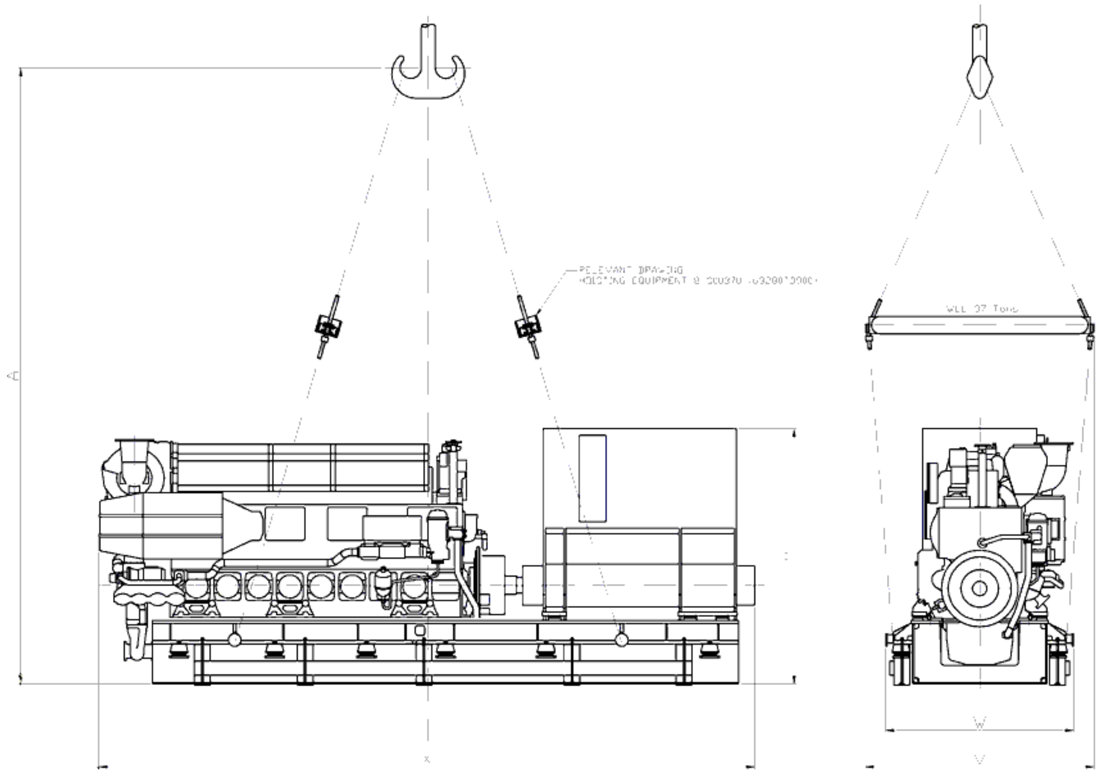

Fig 19-3 Lifting of generating sets (9610ZT129a)

Engine	Dimensions [mm]							Weights [ton]		
	A	X*	H*	X	H	V	W	Generating set	Hoisting tool	Transport support
W 6L26	6546	7100	3100	7345	3100	2780	2300	37.7	1.7	0.5
W 8L26	8167	8180	3160	8243	3160	2780	2300	42.9	1.7	0.5
W 9L26	8731	8570	3160	8853	3160	2780	2300	47.5	1.7	0.5
W 12V26	-	-	-	8353	3660	2780	2700	59.3	1.7	0.5
W 16V26	-	-	-	9772	3660	2780	2700	68.8	1.7	0.5

*) Turbocharger in driving end

The dimensions X, H and the weight of the generating set depends on the generator.

19.3 Engine components

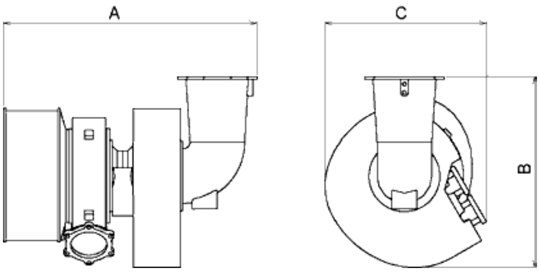

Fig 19-4 Turbocharger

Engine	A [mm]	B [mm]	C [mm]	Weight [kg]
W 6L26	1217	804	660	335
W 8L26	1428	879	831	570
W 9L26	1428	879	831	570
W 12V26	1217	804	660	2*335
W 16V26	1185	830	978	2*775

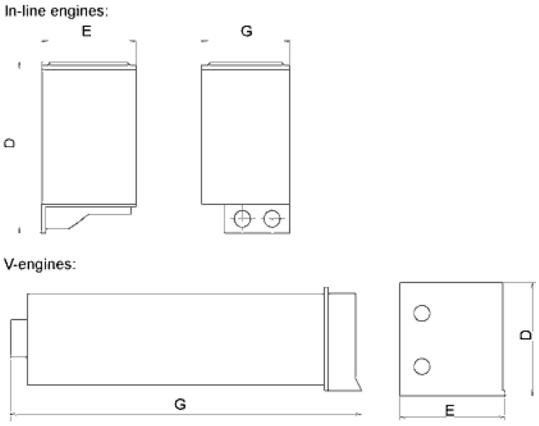

Fig 19-5 Charge Air Cooler

Engine	D [mm]	E [mm]	G [mm]	Weight [kg]
W 6L26	965	534	500	440
W 8L26	965	534	500	530
W 9L26	965	534	500	530
W 12V26	625	590	1900	680
W 16V26	625	590	1900	725

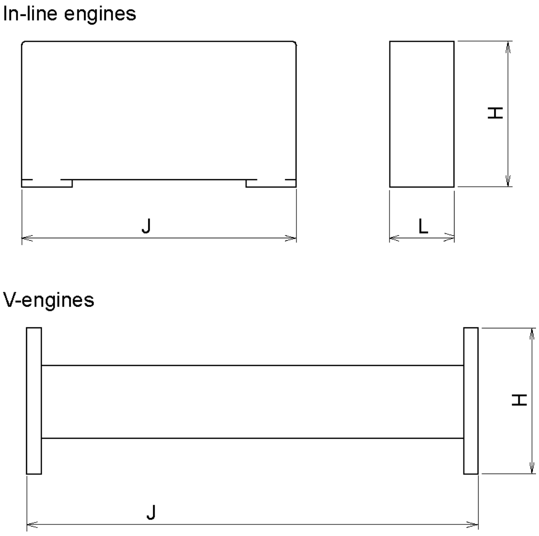

Fig 19-6 Lubricating oil cooler

Engine	H [mm]	J [mm]	L [mm]	Weight [kg]
W 6L26	291	694	304	100
W 8L26	379	694	304	120
W 9L26	412	694	304	128
W 12V26	370	1300	-	145/165*
W 16V26	370	1300	-	145/165*

*) in case of increased cooler capacity

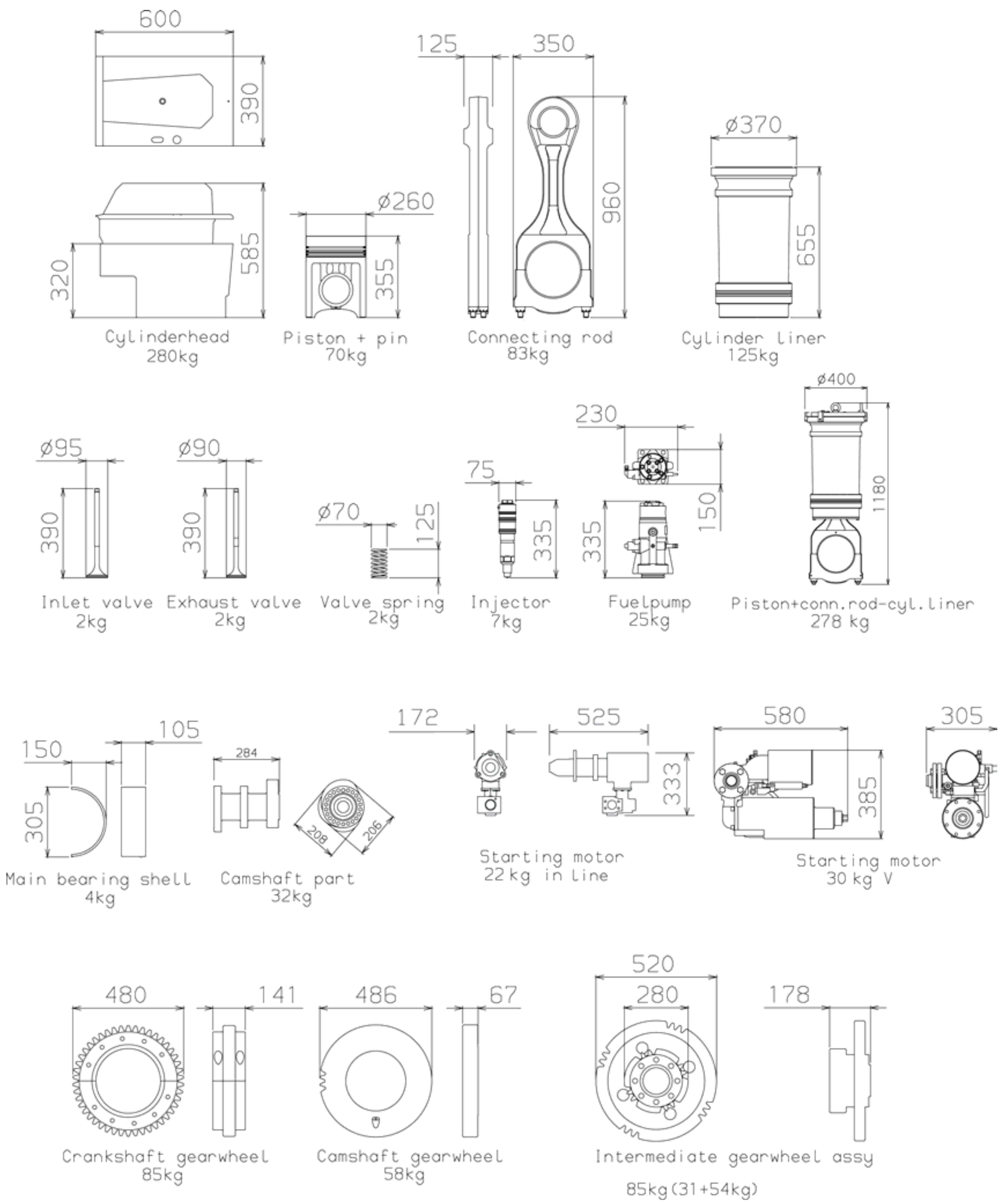

Fig 19-7 **Major spare parts**

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20. Product Guide Attachments

This and all other product guides can be accessed on the internet, at www.wartsila.com. Product guides are available both in web and PDF format. Engine outline drawings are available not only in 2D drawings (in PDF, DXF format), but also in 3D models in near future. Please consult your sales contact at Wärtsilä for more information.

Engine outline drawings are not available in the printed version of this product guide.

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21. ANNEX

21.1 Unit conversion tables

The tables below will help you to convert units used in this product guide to other units. Where the conversion factor is not accurate a suitable number of decimals have been used.

Length conversion factors

Convert from	To	Multiply by
mm	in	0.0394
mm	ft	0.00328

Mass conversion factors

Convert from	To	Multiply by
kg	lb	2.205
kg	oz	35.274

Pressure conversion factors

Convert from	To	Multiply by
kPa	psi (lbf/in^2)	0.145
kPa	lbf/ft^2	20.885
kPa	inch H_2O	4.015
kPa	foot H_2O	0.335
kPa	mm H_2O	101.972
kPa	bar	0.01

Volume conversion factors

Convert from	To	Multiply by
m^3	in^3	61023.744
m^3	ft^3	35.315
m^3	Imperial gallon	219.969
m^3	US gallon	264.172
m^3	l (litre)	1000

Power conversion

Convert from	To	Multiply by
kW	hp (metric)	1.360
kW	US hp	1.341

Moment of inertia and torque conversion factors

Convert from	To	Multiply by
kgm^2	lbft^2	23.730
kNm	lbf ft	737.562

Fuel consumption conversion factors

Convert from	To	Multiply by
g/kWh	g/hph	0.736
g/kWh	lb/hph	0.00162

Flow conversion factors

Convert from	To	Multiply by
m^3/h (liquid)	US gallon/min	4.403
m^3/h (gas)	ft^3/min	0.586

Temperature conversion factors

Convert from	To	Multiply by
°C	F	F = 9/5 *C + 32
°C	K	K = C + 273.15

Density conversion factors

Convert from	To	Multiply by
kg/m^3	lb/US gallon	0.00834
kg/m^3	lb/Imperial gallon	0.01002
kg/m^3	lb/ft^3	0.0624

21.1.1 Prefix

Table 21-1 The most common prefix multipliers

Name	Symbol	Factor	Name	Symbol	Factor	Name	Symbol	Factor
tera	T	10^{12}	kilo	k	10^3	nano	n	10^{-9}
giga	G	10^9	milli	m	10^{-3}			
mega	M	10^6	micro	μ	10^{-6}			

21.2 Collection of drawing symbols used in drawings

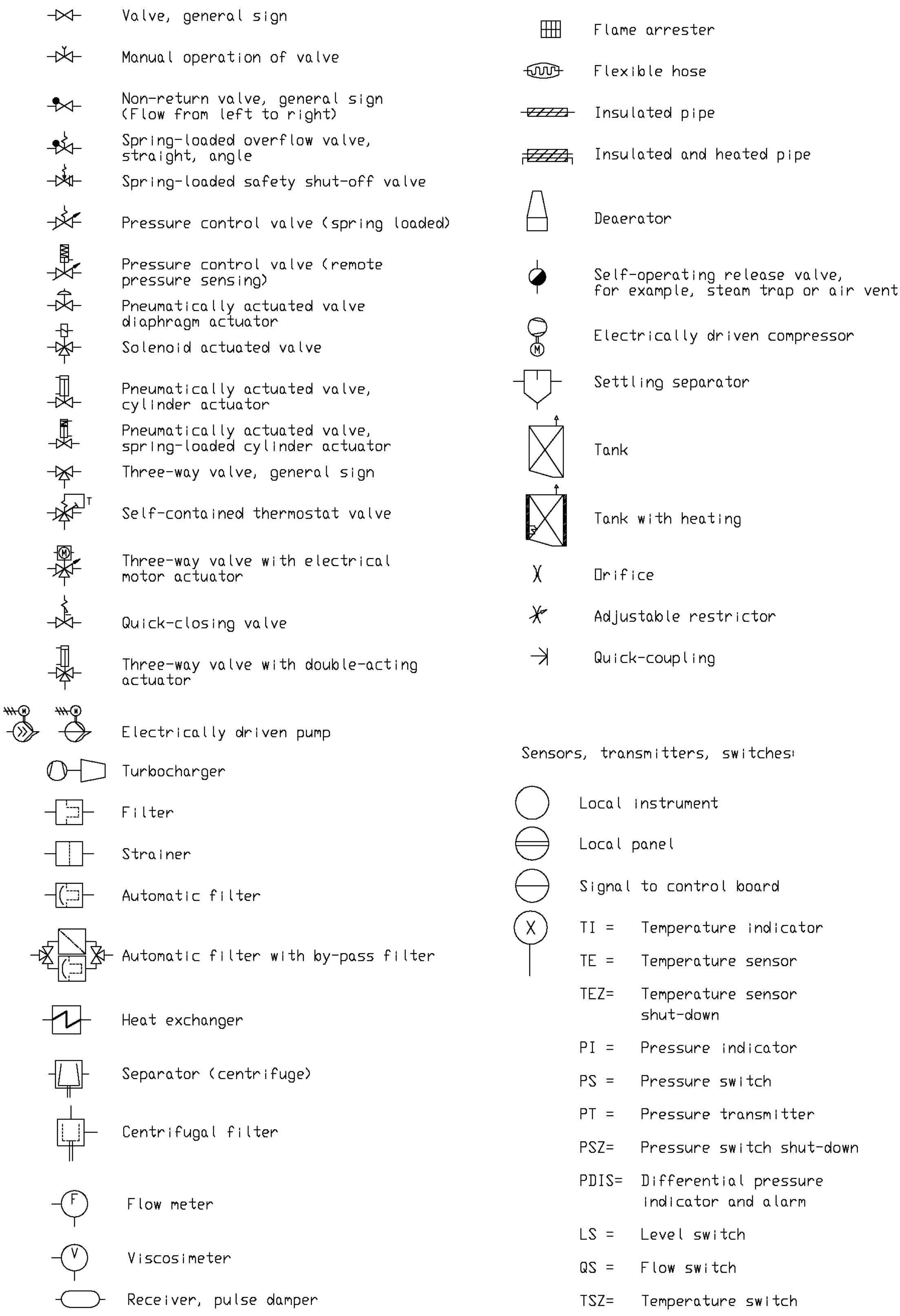

Fig 21-1 List of symbols (DAAE000806D)

Wärtsilä is a global leader in complete lifecycle power solutions for the marine and energy markets. By emphasising technological innovation and total efficiency, Wärtsilä maximises the environmental and economic performance of the vessels and power plants of its customers.

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