E0	04/09/09	Emissione per approvazione WBE1 – Copia conforme a rev. C0	DL	DL	LM
C0	02/07/09	Emissione per approvazione	DL	DL	LM
RE	VISIONE	DESCRIZIONE	EL,	CON	APP.

#### MINISTERO DELLE INFRASTRUTTURE E DEI TRASPORTI

# MAGISTRATO ALLE ACQUE

# NUOVI INTERVENTI PER LA SALVAGUARDIA DI VENEZIA

LEGGE N.798 DEL 29-11-1984

CONVENZIONE REP. N° 7191 DEL 04-10-1991

ATTO ATTUATIVO REP. 8100 DEL 19-12-2005 (PROGETTAZIONE)

ATTO ATTUATIVO A VALERE SU 6<sup>^</sup> ASSEGNAZIONE CIPE PER IL "SISTEMA MOSE" (OPERA)

# INTERVENTI ALLE BOCCHE LAGUNARI PER LA REGOLAZIONE DEI FLUSSI DI MAREA

CUP: D51B02000050001

#### PROGETTO ESECUTIVO

WBS: CO.Q1.68

WBE: CO.O1.68.PE.01

MEZZI PER LA SOSTITUZIONE DELLE PARATOIE

#### SPECIFICA TECNICA – IMPIANTO DI GENERAZIONE, DISTRIBUZIONE E UTILIZZO ENERGIA ELETTRICA

#### APPENDICI 2 E 3

ELABORATO  D. Lazzarin	CONTROLLATO D. Lesina	APPROVATO L. Mazza
N. ELABORATO	CODICE FILE	DATA
MV055P-PE-GES-1124-E0	MV055P-PE-GES-1124-E0.doc	04 Settembre 2009

#### CONSORZIO "VENEZIA NUOVA"

COORDINAMENTO PROGETTAZIONE

VERIFICATO:

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M. T. Brotto

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#### **APPENDICI**

Appendice 2 – Generatore Wartsila 9L 20

 $Appendice \ 3-Connettori\ elettrici\ MC$ 

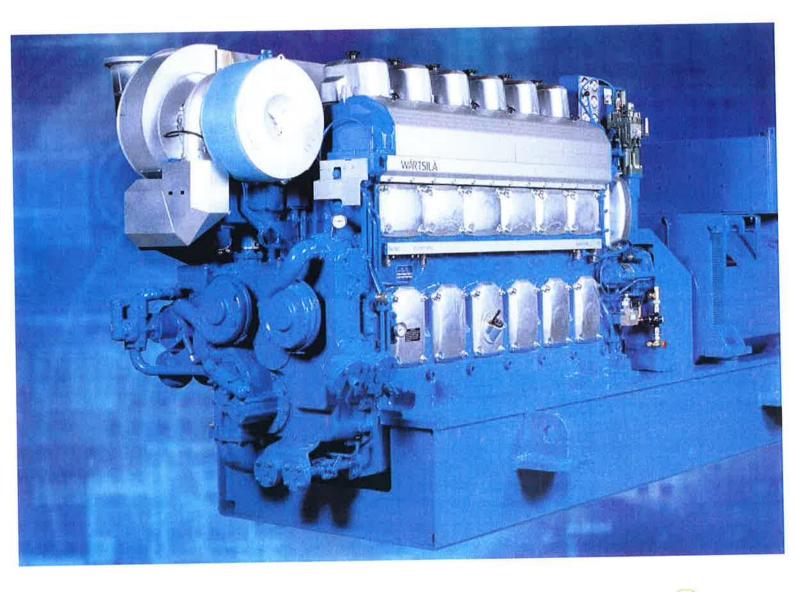
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### IMPIANTO DI GENERAZIONE, DISTRIBUZIONE E UTILIZZO ENERGIA ELETTRICA

#### **APPENDICI 2 E 3**

APPENDICE 2	GENERATORE WARSTILA 9L 20	X
APPENDICE 3	CONNETTORI ELETTRICI MC	

# Project guide





## Introduction

This Project Guide provides engine 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 1/2003 issue replaces all previous issues of the Wärtsilä 20 Project Guides. This revision contains minor technical updates and modifications on texts.

Wärtsilä Finland Oy Marine Application Technology

Vaasa, November 2003

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# General data and outputs

#### 1.1. Technical main data

The Wärtsilä 20 is a 4-stroke, non-reversible, turbocharged and intercooled diesel engine with direct injection of fuel.

Cylinder bore 200 mm
Stroke 280 mm
Piston displacement 8.8 l/cyl

Number of valves 2 inlet valves and 2 exhaust valves

Cylinder configuration 4, 5, 6, 8, 9, in-line

Direction of rotation Clockwise, counter-

clockwise on request

# 1.2. Maximum continuous output

The mean effective pressure Pe can be calculated as follows:

$$P_e [bar] = \frac{P \cdot c \cdot 1.2 \cdot 10^9}{D^2 \cdot L \cdot p \cdot \pi}$$

where

 $P_e$  = mean effective pressure [bar]

P = output per cylinder [kW]

n = engine speed [r/min]

D = cylinder diameter [mm]

L = length of piston stroke [mm]

c = operating cycle (4)

#### Note!

The minimum nominal speed is 1000 RPM both for installations with controllable pitch and fixed pitch propellers.

Table 1.1. Rating table for main engines

Engine	Output in kW (BHP) at 1000 RPM						
	kW	(BHP)					
4L20	720	980					
5L20	825	1120					
6L20	1080	1470					
8L20	1440	1960					
9L20	1620	2200					

The maximum fuel rack position is mechanically limited to 100% of the continuous output for main engines.

The permissible overload is 10% for one hour every twelve hours. The maximum fuel rack position is mechanically limited to 110% continuous output for auxiliary engine.

The alternator outputs are calculated for an efficiency of 0.95 and a power factor of 0.8.

#### 1.3. Reference conditions

The output is available up to a charge air coolant temperature of max. 38°C and 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).

Table 1.2. Rating table for auxiliary engines

Engine	Output at											
21.8	720 RPN	1/60 Hz	750 RPM	1/50 Hz	900 RPM	1/60 Hz	1000 RPM/50 Hz					
	Engine (kW)	Generator (kVA)	Engine (kW)	Generator (kVA)	Engine (kW)	Generator (kVA)	Engine (kW)	Generator (kVA)				
4L20	520	620	540	640	680	810	720	855				
5L20					775	920	825	980				
6L20	780	930	810	960	1020	1210	1080	1280				
8L20	1040	1240	1080	1280	1360	1615	1440	1710				
9L.20	1170	1390	1215	1440	1530	1815	1620	1925				

The specific fuel consumption is stated in the chapter for Technical data with the reference for the engine driven equipment and the effect they have on the specific fuel consumption. The statement applies to engines operating in ambient conditions according to ISO.

• total barometric pressure

100 kPa

• air temperature

25°C

• relative humidity

30%

• charge air coolant temperature 25°C

For other than ISO 3046-1 conditions the same standard gives correction factors on the fuel oil consumption.

#### **Fuel characteristics** 1.3.1

Table 1.3. MDF Specifications

Property	Unit	ISO-F-DMX	ISO-F-DMA	ISO-F-DMB	ISO-F-DMC 1)	Test method ref.
Viscosity, min., before injection pumps 2)	cSt	1.8	1.8	1.8	1.8	ISO 3104
	cSt at 40°C	5,5	6	11	14	ISO 3104
Viscosity, max, before injection pumps 2)		24	24	24	24	ISO 3104
Density, max.	kg/m³ at 15°C	3)	890	900	920	ISO 3675 or 12185
Cetane number		45	40	35	-	ISO 5165 or 4264
Water, max.	% volume	_	_	0.3	0.3	ISO 3733
Sulphur, max.	% mass	1	1.5	2	2	ISO 8574
Ash, max.	% mass	0.01	0.01	0.01	0.05	ISO 6245
Vanadium, max.	mg/kg			-	100	ISO 14597
Sodium before engine, max. 2)	mg/kg	_		1-1	30	ISO 10478
Aluminium + Silicon, max.	mg/kg	_		_	25	ISO 10478
Aluminium + Silicon before engine, max. 2)	mg/kg		==	1-1	15	ISO 10478
Carbon residue (micro method, 10 % vol dist.bottoms), max.	% mass	0,30	0.30	_	_	ISO 10370
Carbon residue (micro method), max.	% mass		====	0.30	2.50	ISO 10370
Flash point (PMCC), min. 2)	°C	60	60	60	60	ISO 2719
Pour point, max. 4)	°C		-6 - 0	0–6	0–6	ISO 3016
Sediment	% mass		-	0.07	_	ISO 3735

- 1) Use of ISO-F-DMC category fuel is allowed provided that the fuel treatment system is equipped with a fuel centrifuge.
- 2) Additional properties specified by the engine manufacturer, which are not included in the ISO specification or differ from the ISO specification.
- 3) In some geographical areas there may be a maximum limit.
- 4) Different limits specified for winter and summer qualities.

The fuel specification "HFO 2" is based on the ISO 8217:1996(E) standard and covers the fuel categories IS-F-RMA10 - RMK55. Additionally "HFO 1" has been defined. This tighter specification is an alternative and by

using this specification, longer overhaul intervals of specific engine components are possible. See table in the chapter for Description of the engine.

Table 1.4. HFO Specifications

Property	Unit	Limit HFO 1	Limit HFO 2	Test method ref.
Viscosity, max.	cSt at 100°C cSt at 50°C Redwood No. 1 s at 100°F	55 730 7200	55 730 7200	ISO 3104
Viscosity, min/max. Before engine 4)	cSt	16/24	16/24	
Density, max.	kg/m³ at 15°C	991 1)/1010	991 1)/1010	ISO 3675 or 12185
CCAI, max. <sup>4)</sup>		850	870 <sup>2)</sup>	ISO 8217
Water, max.	% volume	1.0	1.0	ISO 3733
Water before engine, max.4)	% volume	0.3	0.3	ISO 3733
Sulphur, max.	% mass	2,0	5.0	ISO 8754
Ash, max.	% mass	0.05	0.20	ISO 6245
Vanadium, max.	mg/kg	100	600 3)	ISO 14597
Sodium, max. <sup>4)</sup>	mg/kg	50	100 3)	ISO 10478
Sodium before engine, max.4)	mg/kg	30	30	ISO 10478
Aluminium + Silicon, max.	mg/kg	30	80	ISO 10478
Aluminium + Silicon before engine, max.4)	mg/kg	15	15	ISO 10478
Conradson carbon residue, max.	% mass	15	22	ISO 10370
Asphaltenes, max. <sup>4)</sup>	% mass	8	14	ASTM D 3279
Flash point (PMCC), min.	°C	60	60	ISO 2719
Pour point, max.	°C	30	30	ISO 3016
Total sediment potential, max.	% mass	0.10	0.10	ISO 10307-2

- 1) Max. 1010 kg/m³ at 15°C provided the fuel treatment system can remove water and solids.
- 2) 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.
- 3) Sodium contributes to hot corrosion on exhaust valves when combined with high sulphur and vanadium contents. Sodium also contributes strongly to fouling of the exhaust gas turbine blading at high loads. The aggressiveness of the fuel depends not only on its proportions of sodium and vanadium but also on the total amount of ash constituents. 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 that specified above, can cause hot corrosion on engine components.
- 4) Additional properties specified by the engine manufacturer, which are not included in the ISO specification.

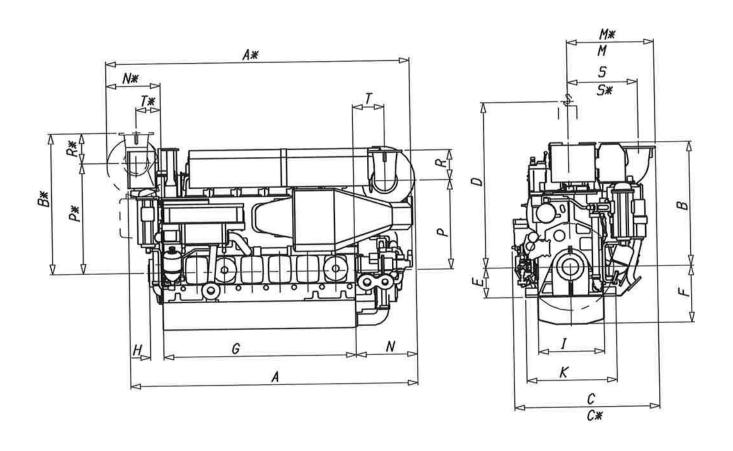
Lubricating oil, foreign substances or chemical waste, hazardous to the safety of the installation or detrimental to the performance of the engines, should not be contained in the fuel.

The limits above also correspond to the demands of the following standards. The properties marked with 4) are not specifically mentioned in the standards but should also be fulfilled.

- BS MA 100: 1996, RMH 55 and RMK 55
- CIMAC 1990, Class H55 and K55
- ISO 8217: 1996(E), ISO-F-RMH 55 and RMK 55

### 1.4. Principal dimensions and weights

Main engines (3V92E0068b)



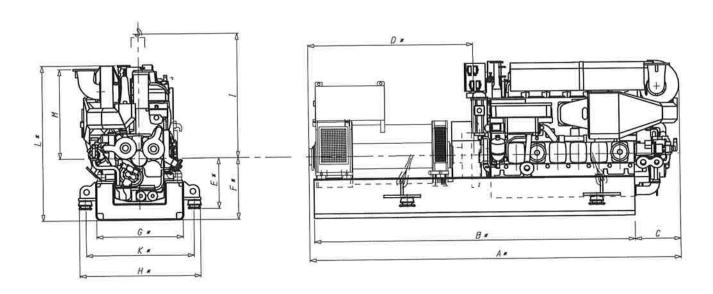
Engine	A*	A	В*	В	C*	С	D	E	F	G	Н	I	K
4L20		2510		1348		1483	1800	325	725	1480	155	718	980
5L20		2833		1423		1567	1800	325	725	1780	155	718	980
6L20	3254	3108	1528	1348	1580	1579	1800	325	624	2080	155	718	980
8L20	3973	3783	1614	1465	1756	1713	1800	325	624	2680	155	718	980
9L20	4261	4076	1614	1449	1756	1713	1800	325	624	2980	155	718	980

Engine	M*	М	N*	N	P*	P	R*	R	S*	s	T*	Т	Weight
4L20		854		665		920		248		694		349	7.2
5L20		938		688		1001		328		750		370	7.8
6L20	951	950	589	663	1200	971	328	328	762	763	273	343	9.3
8L20	1127	1084	708	738	1224	1000	390	390	907	863	325	339	11
9L20	1127	1084	696	731	1224	1000	390	390	907	863	325	339	11.6

\* Turbocharger at flywheel end

<sup>\*\*</sup> Weights (in Metric tons) with liquids (wet sump) but without flywheel (range 450 - 850 average 600 kg)

#### Auxiliary engines (3V58E0576b)



ENGINE	<b>A</b> *	В*	C	D*	E*	F*	G*	Н*	I	K*	L*	M	Weight [ton]
4L20	4910	4050	665	2460	725	990	1270	1770	1800	1580	2338	1168	14.0
5L20	5220	3975	688	2430	725	1075	1420	1920	1800	1730	2458	1329	15.1
6L20	5325	4575	663	2300	725	895/ 975	1270/ 1420	1770/ 1920	1800	1580/ 1730	2243/ 2323	1299	16.8
8L20	6030	5100	731	2310	725	1025	1420 / 1570	1920/ 2070	1800	1730/ 1880	2474	1390	20.7
9L20	6535	5400	731	2580	725	1075/ 1125	1570/ 1800	2070/ 2300	1800	1880/ 2110	2524/ 2574	1390	23.8

<sup>\*</sup> Values are based on standard alternator, whose type (water or air cooled) and size affects to width, length, height and weight. Weight is based on wet sump engine with engine liquids.

# 2. Operating ranges

#### 2.1. General

The operating field of the engine depends on the required output, and these should therefore be determined together. This applies to both FPP and CPP applications. Concerning FPP applications also the propeller matching must be clarified.

A diesel engine can deliver its full output only at full engine speed. At lower speeds the available output and also the available torque are limited to avoid thermal overload and turbocharger surging. This is because the turbocharger is less efficient and the amount of scavenge air supplied to the engine is low. Often e.g. the exhaust valve temperature can be higher at low load (when running according to the propeller law) than at full load. Furthermore, the smallest distance to the so-called surge limit of the compressor typically occurs at part load. Margin is required to permit reasonable wear and fouling of the turbocharging system and different ambient conditions (e.g. suction air temperature).

As a rule, the higher the specified mean effective pressure the narrower is the permitted engine operating range. This is the reason why separate operating fields may be specified for different output stages, and the available output for FP-propellers may be lower than for CP-propellers. To-day's development towards lower emis-

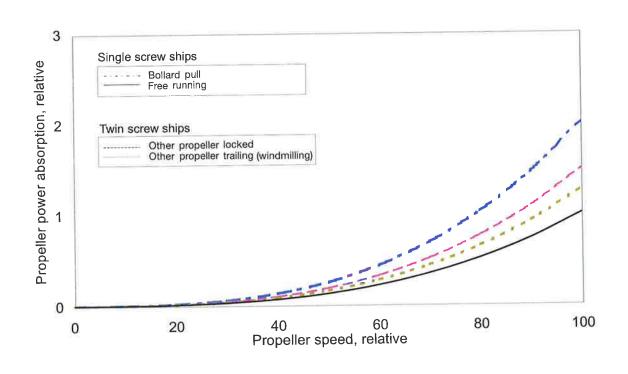
Figure 2.1. Propeller power absorption in different conditions - example

sions, lower fuel consumption and SCR compatibility also contribute to the restriction of the operating field.

A matter of high importance is the matching of the propeller and the engine. Weather conditions, acceleration, the loading condition of the ship, draught and trim, the age and fouling of the hull, and ice conditions all play an important role.

With a FP propeller these factors all contribute to moving the power absorption curve towards higher thermal loading of the engine. There is a risk for surging of the turbocharger (when moving to the left in the power-rpm diagram). On the other hand, with a new and clean hull in ballast draft the power absorption is lighter and full power will not be absorbed as the maximum engine speed limits the speed range upwards. These drawbacks are avoided by specifying CP-propellers.

A similar problem is encountered on twin-screw (or multi-screw) ships with fixed-pitch propellers running with only one propeller. If one propeller is wind-milling (rotating freely), the other propeller will feel an increased power absorption, and even more so, if the other propeller is blocked. The phenomenon is more pronounced on ships with a small block coefficient. The issue is illustrated in the diagram below.



The figure also indicates the magnitude of the so-called bollard pull curve, which means the propeller power absorption curve at zero ship speed. It is a relevant condition for some ship types, such as tugs, trawlers and icebreakers. This diagram is valid for open propellers. Propellers running in nozzles are less sensitive to the speed of advance of the ship.

The bollard pull curve is also relevant for all FPP applications since the power absorption during acceleration is always somewhere between the free running curve and the bollard pull curve! If the free sailing curve is very close to the 100% engine power curve and the bollard pull curve at the same time is considerably higher than the 100% engine power curve, then the acceleration from zero ship speed will be very difficult. This is because the propeller will require such a high torque at low speed that the engine is not capable of increasing the speed. As a consequence the propeller will not develop enough thrust to accelerate the ship.

Heavy overload will also occur on a twin-screw vessel with FP propellers during manoeuvring, when one propeller is reversed and the other one is operating forward. When dimensioning FP propellers for a twin screw vessel, the power absorption with only one propeller in operation should be max. 90% of the engine power curve, or alternatively the bollard pull curve should be max 120% of the engine power curve. Otherwise the engine must be de-rated 20-30% from the normal output for FPP applications. This will involve extra costs for non-standard design and separate EIAPP certification. For this reason it is recommended to select CP-propellers for twin-screw ships with mechanical propulsion.

FP-propeller should never be specified for a twin-in/single-out reduction gear as one engine is not capable of driving a propeller designed for the power of two engines.

For ships intended for operation in heavy ice, the additional torque of the ice should furthermore be considered.

For selecting the machinery, typically a sea margin of 10...15 % is applied, sometimes even 25...30 %. This means the relative increase in shaft power from trial conditions to typical service conditions (a margin covering increase in ships resistance due to fouling of hull and propeller, rough seas, wind, shallow water depth etc). Furthermore, an engine margin of 10...15 % is often applied, meaning that the ship's specified service speed should be achieved with 85...90 % of the MCR. These two independent parameters should be selected on a project specific basis.

The minimum speed of the engine is a project specific issue, involving torsional vibrations, elastic mounting, built-on pumps etc.

In projects where the standard operating field, standard output, or standard nominal speed do not satisfy all project specific demands, the engine maker should be contacted.

#### Matching the engines with 2.2. driven equipment

#### 2.2.1 **CP-propeller**

Controllable pitch propellers are normally dimensioned and classified to match the Maximum Continuous Rating of the prime mover(s). In case two (or several) engines are connected to the same propeller it is normally dimensioned corresponding to the total power of all connected prime movers. This is also the case if the propeller is driven by prime movers of different types, as e.g. one diesel engine and one electric motor (which may work as a shaft generator in some operating modes). In case the total power of all connected prime movers will never be utilised, classification societies can approve a dimensioning for a lower power in case the plant is equipped with an automatic overload protection system. The rated power of the propeller will affect the blade thickness, hub size and shafting dimensions.

Designing a CP-propeller is a complex issue, requiring compromises between efficiency, cavitation, pressure pulses, and limitations imposed by the engine and a possible shaft generator, all factors affecting the blade geometry. Generally speaking the point of optimisation (an optimum pitch distribution) should correspond to the service speed and service power of the ship, but the issue may be complicated in case the ship is intended to sail with various ship speeds, and even with different operating modes. Shaft generators or generators (or any other equipment) connected to the free end of the engine should be considered in case these will be used at sea.

The propeller efficiency is typically highest when running along the propeller curve defined by the design pitch, in other word requiring the engine at part load to run slowly and heavily. Typically also the efficiency of a diesel engine running at part load is somewhat higher when running at a lower speed than the nominal.

Pressure side cavitation may easily occur when running at high propeller speed and low pitch. This is a noisy type of cavitation and it may also be erosive. However the pressure side cavitation behaviour can be improved a lot by a suitable propeller blade design. Also cavitation at high power may cause increased pressure pulses, which can be reduced by increased skew angle and optimized blade geometry.

It is of outmost importance that the propeller designer has information about all the actual operation conditions for the vessel. Often the main objective is to minimise the extent and fluctuation of the suction side cavitation to reduce propeller-induced hull vibrations and noise at high power, while simultaneously avoiding noisy pressure side cavitation and a large drop in efficiency at reduced propeller pitch and power.

20

The propeller may enter the pressure side cavitation area already when reducing the power to less than half, maintaining nominal speed. In twin-in/single-out installations the plant cannot be operated continuously with one engine and a shaft generator connected, if the shaft generator requires operation at nominal propeller speed.

Many solutions are possible to solve this problem:

- The shaft generator (connected to the secondary side of the clutch) is used only when sailing with high power.
- The shaft generator (connected to the secondary side of the clutch) is used only when manoeuvring with low or moderate power, the transmission ratio being selected to give nominal frequency at reduced propeller speed.
- The shaft generator is connected to the primary side of the clutch of one of the engines, and can be used independently from the propeller, e.g. to produce power for thrusters during manoeuvring.
- No shaft generator is installed.

This type of issues are not only operational of nature, they have to be considered at an early stage when selecting the machinery configuration. For all these reasons it is essential to know the ship's operating profile when designing the propeller and defining the operating modes.

In normal applications no more than two engines should be connected to the same propeller.

CP-propellers typically have the option of being operated at variable speed. To avoid the above mentioned pressure side cavitation the propeller speed should be kept sufficiently below the cavitation limit, but not lower than necessary. On the other hand, there are also limitations on the engine's side, such as avoiding thermal overload at lower speeds.

To optimise the operating performance considering these limitations CP-propellers are typically operating along a preset combinator curve, combining optimum speed and pitch throughout the whole power range, controlled by one single control lever on the bridge. Applications with two engines connected to the same propeller must have separate combinator curves for one engine operation and twin engine operation. This applies similarly to twin-screw vessels. Two or several combinator curves may be foreseen in complicated installations for different operating modes (one-engine, two-engines, manoeuvring, free running etc).

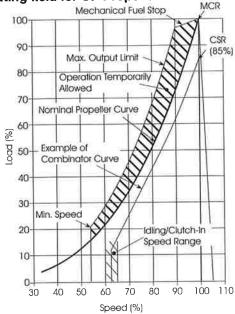
At a given propeller speed and pitch, the ship's speed affects the power absorption of the propeller. This effect is to some extent ship-type specific, being more pronounced on ships with a small block coefficient. The power absorption of the propeller can sometimes be almost twice as high during acceleration than during free steady-state running. Navigation in ice can also add to the torque absorption of the propeller.

An engine can deliver power also to other equipment like a pump, which can overload the engine if used without prior load reduction of the propeller.

For the above mentioned reasons an automatic load control system is required in all installations running at variable speed. The purpose of this system is to protect the engine from thermal load and surging of the turbocharger. With this system the propeller pitch is automatically reduced when a pre-programmed load versus speed curve (the "load curve") is exceeded, overriding the combinator curve if necessary. The load information must be derived from the actual fuel rack position and the speed should be the actual speed (and not the demand). A so-called overload protection, which is active only at full fuel pump settings, is not sufficient in variable speed applications.

The diagrams below show the operating ranges for CP-propeller installations. The design range for the combinator curve should be on the right hand side of the nominal propeller curve. Operation in the shaded area is permitted only temporarily during transients.

#### Operating field for CP Propeller



The clutch-in speed is a project specific issue. From the engine point of view, the clutch-in speed should be high enough to have a sufficient torque available, but not too high. The slip time on the other hand should be as long as possible. In practise longer slip times than 5 seconds are exceptions, but the clutch should typically be dimensioned so that it allows a slip time of at least 3 seconds. From the clutch point of view, a high clutch-in speed causes a high thermal load on the clutch itself, which has to be taken into account when specifying the clutch. A reasonable compromise is to select the idle speed as clutch-in speed. In applications with two engines connected to the same propeller (CP), it might be necessary to select a slightly higher clutch-in speed. In case the engine has to continue driving e.g. a pump or a generator (connected on the primary side of the clutch) during the clutch-in process a higher clutch-in speed may be necessary, but then also some speed drop has to be permitted.

CP-propellers in single-screw ships typically rotate counter-clockwise, requiring a clockwise sense of rotation of the engine with a typically single-stage reduction gear. The sense of rotation of propellers in twin-screw ships is a project specific issue.

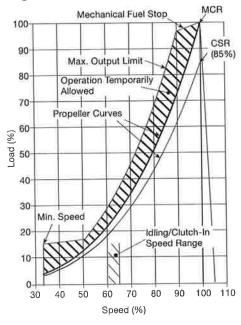
#### 2.2.2 FP-propeller

The fixed pitch propeller needs a very careful matching, as explained above. The operational profile of the ship is very important (acceleration requirements, loading conditions, sea conditions, manocuvring, fouling of hull and propeller etc).

The FP-propeller should normally be designed to absorb maximum 85% of the maximum continuous output of the main engine (power transmission losses included) at nominal speed when the ship is on trial. Typically this corresponds to 81-82% for the propeller itself (excluding power transmission losses). This is typically referred to as the "light running margin", a compensation for expected future drop in revolutions for a constant given power, typically 5-6%.

For ships intended for towing, the bollard pull condition needs to be considered as explained earlier. The propeller should be designed to absorb not more than 95 % of the maximum continuous output of the main engine at nominal speed when operating in towing or bollard pull conditions, whichever service condition is relevant. In order to reach 100 % MCR it is allowed to increase the engine speed to 101.7 %. The speed does not need to be restricted to 100 % after bollard pull tests have been carried out. The absorbed power in free running and nominal speed is then relatively low, e.g. 50 – 65 % of the output at service conditions.

#### **Operating field for FP Propeller**



The engine is non-reversible, so the reduction gear has to be of the reversible type. A shaft brake should also be installed.

A Robinson diagram (= four-quadrant diagram) showing the propeller torque ahead and astern for both senses of rotation is needed to determine the parameters of the crash stop.

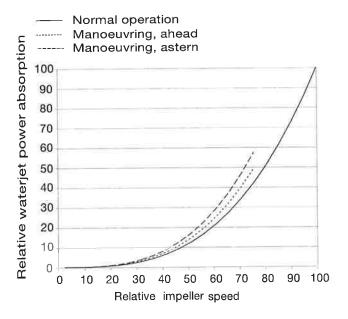
FP-propellers in single-screw ships typically rotate clockwise, requiring a counter clockwise sense of rotation of the engine with a typically single-stage (in the ahead mode) reverse reduction gear.

#### 2.2.3 Water jets

Water jets also require a careful matching with the engine, similar to that of the fixed pitched propeller. However, there are some distinctive differences between the dimensioning of a water jet compared to that of a fixed pitch propeller.

Water jets operate at variable speed depending on the thrust demand. The power absorption vs. rpm of a water jet follows a cubic curve under normal operation. The power absorption vs. rpm is higher when the ship speed is reduced, with the maximum torque demand occurring when manoeuvring astern. The power absorption vs. revolution speed for a typical water jet is illustrated in the diagram below.

#### Water jet power absorption



The reversal of the thrust from the water jet is achieved by a reversing bucket. Moving the bucket into the jet stream and thereby deflecting it forward, towards the bow, reverses the thrust from the jet. The bucket can be gradually inserted in the water jet, so that only part of the jet is deflected. This way the thrust can be controlled continuously from full ahead to full astern just by adjusting the position of the bucket. The reversing bucket is typically operated at part speed only.

The speed of the ship has only a small influence on the revolution speed of water jet, unlike the case for a fixed pitched propeller. This means that there will only be a very small change in water jet speed when the ship speed drops. Increased resistance, due to fouling of the hull, rough seas, wind or shallow water depth, will therefore not affect the torque demand on an engine coupled to a water jet in the same degree as on an engine coupled to a fixed pitched propeller. This means that the water jet can be matched closer to the MCR than a fixed pitched propeller. In fact, the wa-

ter jet power absorption should be dimensioned close to 100% MCR to get out as much power as possible. However, some margin should be left, due to tolerances in the power estimates of the jet and the small, but still present, increase in torque demand due to a possible increase in ship resistance.

The torque demand at lower speeds should also be carefully compared to the operating field of the engine. Engines with highly optimised turbo chargers can have an operating field that does not cover the water jet power demand over the entire speed range. Also the lower efficiency of the transmission and the reduction gear at part load should be accounted for in the estimation of the power absorption. The time spent at manoeuvring should be considered as well, if the power absorption in manoeuvring mode exceeds the operating field for continuous operation for the engine. In projects where the standard operating field does not satisfy all project specific demands, the engine maker should be contacted.

#### 2.2.4 Other propulsors

#### **Azimuth thrusters**

Azimuth thrusters can be equipped with fixed-pitch or controllable-pitch propellers. Most of the above given instructions for CP- and FP-propellers are valid also in case of azimuth thrusters, however with some specific features. The azimuth thrusters offer a good manoeuvrability by turning the propulsor. During slow manoeuvring in harbour the propeller works close to the bollard pull curve, which therefore has to be properly considered especially when matching azimuth thrusters with FP-propeller with the engine. Reversing and crash stop are also performed by turning the FP-thrusters (rather than changing the sense of rotation), causing a heavy propeller curve but in a different way than with an ordinary shaft line.

#### **Tunnel thrusters**

Tunnel thrusters are typically driven by electric motors, but can also be driven by diesel engines. Tunnel thrusters can be equipped with fixed-pitch or controllable-pitch propellers. Tunnel thrusters with CP-propellers can be operated at constant speed, which may be feasible to get the quickest possible response, or according to a combinator curve. A load control system is required. A non-reversible diesel engine driving a tunnel thruster with FP-propeller is typically not a feasible solution, as an extra reversible gear box would be needed.

#### Voith-Schneider propellers

This type of propulsor is operated at variable speed and pitch. It is important to have some kind of load control system to prevent overload over the whole speed range, as described in previous chapters.

#### 2.2.5 Dredgers

The power generation plant of a dredger can be of different configurations:

- Diesel-electric. Propulsors and dredging pumps are electrically driven. This is a good and flexible solution, but also the most expensive.
- Mechanically driven main propellers, and electrically driven dredging pumps and thrusters. The main engines and generators driven e.g. from the free end of the crankshaft are running at constant speed, and the dredging pumps can be operated at variable speed with a frequency converter. This is a good, flexible and cost-effective solution.

The configuration with the main engine running at constant speed has proved to be a good solution, also capable of taking the typical load transients coming from the dredging pumps.

 Mechanically driven main propellers and dredging pumps. The main engines have to operate at variable speed. This may appear to be the cheapest solution, but it has operational limitations.

In this configuration, when the dredging pumps are mechanically driven, dredging requires a capability to run a constant torque down to 70 or 80 % of the nominal speed. This kind of torque requirement results in normally significant de-rating of the main engines.

#### 2.2.6 Generators

Generators are typically operated at nominal speed. Modern generators are synchronous AC machines, producing a frequency equalling the number of pole pairs times the rotational speed. The synchronous speed of such generators is listed below.

Table 2.1. Synchronous speed of generators

Number	Number _	Synchr. speed, rpm					
of pole pairs	of poles	50 Hz	60 Hz				
1	2	3000	3600				
2	4	1500	1800				
3	6	1000	1200				
4	8	750	900				
5	10	600	720				
6	12	500	600				
7	14	428.6	514.3				
8	16	375	450				
9	18	333.3	400				
10	20	300	360				
11	22	272.7	327.3				

In some rare installations, shaft generators or diesel-generators may be operated at variable frequency, sometimes referred to as floating frequency. This may be the case with a shaft generator supplying the ship's service electricity, when it may be clearly feasible to operate the propulsion plant at variable speed for reasons of propeller efficiency or cavitation.

Desired transmission ratios between main engines and shaft generators cannot always be exactly found, as the number of teeth in the reduction gear has to be selected in steps of complete teeth.

This is also the case when the generator nominal speed is a multiple of the nominal speed of the engine. The number of teeth is selected to permit all teeth being in contact with all teeth of the other gear wheel, to avoid uneven wear. To achieve this target, gear wheels with a multiple number of teeth compared with its smaller pair should be avoided. This is valid for the main power transmission from the engine to the propeller, as well as for PTOs for shaft generators. In other words cases where a combination of tooth numbers giving exactly the desired transmission ratio can be found, it is not feasible to use them.

The maximum output of diesel engines driving auxiliary generators and diesel engines driving generators for propulsion is 110 % of the MCR.

#### 2.3. Loading capacity

The loading rate of a highly supercharged diesel engine must be controlled, because the turbocharger needs time to accelerate before it can deliver the required amount of air. However in normal operation the load should always be applied gradually.

#### 2.3.1 Diesel-mechanical propulsion

The loading is to be controlled by a load increase programme, which is included in the propeller control system.

#### 2.3.2 Diesel-electric propulsion

Class rules regarding load acceptance capability should not be interpreted as guidelines on how to apply load on the engine in normal operation. The class rules only determine what the engine must be capable of, if an emergency situation occurs.

The electrical system onboard the ship must be designed so that the diesel generators are protected from load steps that exceed the limit. Normally system specifications must be sent to the classification society for approval and the functionality of the system is to be demonstrated during the ship's trial.

The loading performance is affected by the rotational inertia of the whole generating set, the speed governor adjustment and behaviour, generator design, alternator excitation system, voltage regulator behaviour and nominal output.

Loading capacity and overload specifications are to be developed in co-operation between the plant designer, engine manufacturer and classification society at an early stage of the project. Features to be incorporated in the power management systems are presented in the Chapter for electrical power generation.

#### 2.3.3 Auxiliary engines driving generators

The load should always be applied gradually in normal operation. This will prolong the lifetime of engine components. The class rules only determine what the engine must be capable of, if an emergency situation occurs. Provided that the engine is preheated to a HT-water temperature of 60...70 °C the engine can be loaded immediately after start.

The fastest loading is achieved with a successive gradual increase in load from 0 to 100 %. It is recommended that the switchboards and the power management system are designed to increase the load as smoothly as possible.

The electrical system onboard the ship must be designed so that the diesel generators are protected from load steps that exceed the limit. Normally system specifications must be sent to the classification society for approval and the functionality of the system is to be demonstrated during the ship's trial.

#### 2.4. Ambient conditions

#### 2.4.1 High air temperature

The maximum inlet air temperature is +45°C. Higher temperatures would cause an excessive thermal load on the engine, and can be permitted only by de-rating the engine (permanently lowering the MCR) 0.35 % for each 1°C above + 45°C.

#### 2.4.2 Low air temperature

When designing ships for low temperatures the following minimum inlet air temperature shall be taken into consid-

- For starting + 5°C.
- For idling: 5°C.
- At high load: 10°C.

At high load, cold suction air with a high density causes high firing pressures. The given limit is valid for a standard engine.

For temperatures below 0°C special provisions may be necessary on the engine or ventilation arrangement.

Other guidelines for low suction air temperatures are given in the chapter for Combustion air system.

#### 2.4.3 High water temperature

The maximum inlet LT-water temperature is + 38°C. Higher temperatures would cause an excessive thermal load on the engine, and can be permitted only if de-rating the engine (permanently lowering the MCR) 0.3 % for each 1°C above + 38°C.

#### 2.4.4 Operation at low load and idling

The engine can be started, stopped and operated on heavy fuel under all operating conditions. Continuous operation on heavy fuel is preferred rather than changing over to diesel fuel at low load operation and manoeuvring. The following recommendations apply:

# Absolute idling (declutched main engine, disconnected generator)

Maximum 5 minutes (recommended about 1 min for post cooling), if the engine is to be stopped after the idling.

# Operation at < 20 % load on HFO or < 10 % on MDF

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

# Operation at > 20 % load on HFO or > 10 % on MDF

No restrictions.

# 3. Technical data tables

Fingine speed	Diesel engine Wärtsilä 4L20			ME	AE	AE	AE	AE
Figure output	_		*****					
Page	0 -		_					
Cylinder bore	9							
Stroke   mm			-	700	710		720	700
Swept volume	·							
Compression ratio								
Description   Pressure, max.   Bar   167   150   150   167	-		am					
Priming pressure, max.	-		1	1/7	150		167	167
Charge air pressure at 100% load   MPa   24,6   2	•							
Mean effective pressure         bar m/s         24,6         24,6         24,6         25,8         24,6           Mean piston speed         m/s         9,3         6,7         7         8,4         9,3           Mean piston speed         m/s         bp         35.5         ************************************				190	180		190	190
Mean piston speed         m/s         9,3         6,7         7         8,4         9,3           Minimum speed (FPP installations)         lp         350         Section of the post of th	_			24.6	24.6		25.0	04.6
Minimum speed (FPP installations)	-							
Flow of air at 100% load	• -				6,7	7	8,4	9,3
Flow of air at 100% load			hp	350				
Ambient air temperature, max.  Air temperature after air cooler  Air temperature after air cooler, alarm  Exhaust gas system  Exhaust gas flow (100% load)  Exhaust gas flow (85% load)  Exhaust gas flow (75% load)  Exhaust gas flow (75% load)  Exhaust gas flow (75% load)  Exhaust gas temp. after turbocharger (100% load)  Exhaust gas temp. after turbocharger (100% load)  Exhaust gas temp. after turbocharger (100% load)  Exhaust gas temp. after turbocharger (55% load)  Exhaust gas back pressure drop, max.  Diameter of turbocharger connection  mm  Calculated dia for 35 m/s  mm  300  250  Exhaust gas temp. after turbocharger (55% load)  Exhaust gas pipe diameter, min.  Exhaust gas temp. after turbocharger (55% load)  Exhaust gas temp. after turbocharger (55% load)  Exhaust gas temp. after turbocharger (55% load)  Exhaust gas back pressure drop, max.  Diameter of turbocharger connection  mm  300  Exhaust gas flow (250  Exhaust gas flow (250  Exhaust gas back pressure drop, max.  Exhaust gas back pressure drop, max.  Exhaust gas back pressure drop, max.  Exhaust gas flow (250  Exhaust gas flow (250	Combustion air system							
Air temperature after air cooler Air temperature after air cooler, alarm  **C*** C*** C*** C*** C*** C*** C***	Flow of air at 100% load		-	1,42	0,94	-	1,25	1,42
Air temperature after air cooler, alarm	Ambient air temperature, max.							
Exhaust gas system           Exhaust gas flow (100% load)         3)         kg/s         1,46         0,97         1,02         1,39         1,48           Exhaust gas flow (85% load)         3)         kg/s         1,25         0,84         0,89         1,21         1,28           Exhaust gas flow (75% load)         3)         kg/s         0,73         0,55         0,59         0,77         0,84           Exhaust gas flow (25% load)         3)         kg/s         0,73         0,55         0,59         0,77         0,84           Exhaust gas temp, after turbocharger (100% load)         1)         3)         kg/s         0,73         0,55         0,59         0,77         0,84           Exhaust gas temp, after turbocharger (75% load)         1)         3)         °C         350         360         360         340         350           Exhaust gas temp, after turbocharger (75% load)         1)         3)         °C         370         360         365         340         350           Exhaust gas temp, after turbocharger (50% load)         1)         3)         °C         370         360         365         340         350           Exhaust gas temp, after turbocharger (50% load)         1)         3)	Air temperature after air cooler					4560		
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Exhaust gas temp. after turbocharger (50% load)         1) 3) °C         390         370         370         350         360           Exhaust gas back pressure drop, max.         kPa         3         3         3         3         300 <t< td=""><td></td><td>1) 3)</td><td>°C</td><td>370</td><td>360</td><td>365</td><td>340</td><td>350</td></t<>		1) 3)	°C	370	360	365	340	350
Exhaust gas back pressure drop, max.         kPa         3           Diameter of turbocharger connection         mm         200           Exhaust gas pipe diameter, min.         mm         300         250         250         300         300           Calculated dia for 35 m/s         mm         305         251         257         295         305           Heat balance         2) 3)         *** <td< td=""><td></td><td>1) 3)</td><td>°C</td><td>390</td><td>370</td><td>370</td><td>350</td><td>360</td></td<>		1) 3)	°C	390	370	370	350	360
Diameter of turbocharger connection         mm         300         250         250         300         300           Exhaust gas pipe diameter, min.         mm         305         251         257         295         305           Heat balance         2) 3)         ****         ****         *****         *****         ****		, ,	kPa			3		
Exhaust gas pipe diameter, min.         mm         300         250         250         300         300           Calculated dia for 35 m/s         mm         305         251         257         295         305           Heat balance         2) 3)           Jacket water         kW         161         127         132         149         161           Charge air         kW         220         157         161         206         220           Lubricating oil         kW         85         67         69         78         85           Exhaust gases         kW         523         356         374         490         523           Radiation         kW         42         31         31         37         42           Fuel system           Pressure before injection pumps         kPa (bar)         500(6)	-		mm			200		
Calculated dia for 35 m/s         mm         305         251         257         295         305           Heat balance         2) 3)           Jacket water         kW         161         127         132         149         161           Charge air         kW         220         157         161         206         220           Lubricating oil         kW         85         67         69         78         85           Exhaust gases         kW         523         356         374         490         523           Radiation         kW         42         31         31         37         42           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)         78         85           Fuel system         Pressure before injection pumps         kPa (bar)         600(6)         78         42           Pump capacity, MDF, engine driven         m²/h         0,41         0,87         0,9         0,41         0,41           Fuel consumption (100% load)         3) g/kWh         196         195         195         194         196           Fuel consumption (50% load)         3) g/kWh         194         198	<u> </u>		mm	300	250	250	300	300
Heat balance         2) 3)           Jacket water         kW         161         127         132         149         161           Charge air         kW         220         157         161         206         220           Lubricating oil         kW         85         67         69         78         85           Exhaust gases         kW         523         356         374         490         523           Radiation         kW         42         31         31         37         42           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)         523         560(6)			mm	305	251	257	295	305
Jacket water         kW         161         127         132         149         161           Charge air         kW         220         157         161         206         220           Lubricating oil         kW         85         67         69         78         85           Exhaust gases         kW         523         356         374         490         523           Radiation         kW         42         31         31         37         42           Fuel system           Pressure before injection pumps         kPa (bar)         523         600(6)         523         42         523         36         374         490         523         523         523         374         490         523         523         326         374         490         523         523         326         374         490         523         324         420 <t< td=""><td></td><td>2) 3)</td><td></td><td></td><td></td><td></td><td></td><td></td></t<>		2) 3)						
Charge air  Lubricating oil  Lubricating oil  kW  85  67  69  78  85  Exhaust gases  kW  523  356  374  490  523  Radiation  kW  42  31  31  37  42  Fuel system  Pressure before injection pumps  kPa (bar)  Pump capacity, MDF, engine driven  m³/h  0,41  0,87  0,9  0,41  0,41  Fuel consumption (100% load)  3) g/kWh  196  Fuel consumption (85% load)  Fuel consumption (75% load)  Fuel consumption (50% load)  3) g/kWh  194  195  Fuel consumption (50% load)  3) g/kWh  201  204  204  201  201  Leak fuel quantity, clean MDF fuel (100% load)  kg/h  0,5  600(6)  194  196  196  197  196  197  196  196  197  Fuel consumption (75% load)  3) g/kWh  197  Fuel consumption (50% load)  3) g/kWh  201  204  204  201  201  Leak fuel quantity, clean MDF fuel (100% load)  kg/h  0,5  0,4  4:1  Lubricating oil system  Pressure before engine, nom.		-/ -/	kW	161	127	132	149	161
Lubricating oil       kW       85       67       69       78       85         Exhaust gases       kW       523       356       374       490       523         Radiation       kW       42       31       31       37       42         Fuel system         Pressure before injection pumps       kPa (bar)       600(6)       500(6)	5							
Exhaust gases         kW         523         356         374         490         523           Radiation         kW         42         31         31         37         42           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)         500(6) <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>85</td>								85
Radiation         kW         42         31         31         37         42           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)         5           Pump capacity, MDF, engine driven         m³/h         0,41         0,87         0,9         0,41         0,41           Fuel consumption (100% load)         3) g/kWh         196         195         195         194         196           Fuel consumption (85% load)         3) g/kWh         193         196         196         194         196           Fuel consumption (75% load)         3) g/kWh         194         198         198         195         197           Fuel consumption (50% load)         3) g/kWh         201         204         204         201         201           Leak fuel quantity, clean MDF fuel (100% load)         kg/h         0,5         0,4         0,4         0,5         0,5           Fuel flow/consumption ratio         4:1         450 (4,5)         450 (4,5)         450 (4,5)         450 (4,5)								523
Fuel system           Pressure before injection pumps         kPa (bar)         600(6)           Pump capacity, MDF, engine driven         m³/h         0,41         0,87         0,9         0,41         0,41           Fuel consumption (100% load)         3) g/kWh         196         195         195         194         196           Fuel consumption (85% load)         3) g/kWh         193         196         196         194         196           Fuel consumption (75% load)         3) g/kWh         194         198         198         195         197           Fuel consumption (50% load)         3) g/kWh         201         204         204         201         201           Leak fuel quantity, clean MDF fuel (100% load)         kg/h         0,5         0,4         0,4         0,5         0,5           Fuel flow/consumption ratio         4:1         4:1         4:1         4:1         4:1         4:1           Lubricating oil system         kPa (bar)         450 (4,5)         450 (4,5)         450 (4,5)         450 (4,5)								42
Pressure before injection pumps       kPa (bar)       600(6)         Pump capacity, MDF, engine driven       m³/h       0,41       0,87       0,9       0,41       0,41         Fuel consumption (100% load)       3) g/kWh       196       195       195       194       196         Fuel consumption (85% load)       3) g/kWh       193       196       196       194       196         Fuel consumption (75% load)       3) g/kWh       194       198       198       195       197         Fuel consumption (50% load)       3) g/kWh       201       204       204       201       201         Leak fuel quantity, clean MDF fuel (100% load)       kg/h       0,5       0,4       0,4       0,5       0,5         Fuel flow/consumption ratio       4:1       4:1       450 (4,5)       450 (4,5)       450 (4,5)								
Pump capacity, MDF, engine driven       m³/h       0,41       0,87       0,9       0,41       0,41         Fuel consumption (100% load)       3) g/kWh       196       195       195       194       196         Fuel consumption (85% load)       3) g/kWh       193       196       196       194       196         Fuel consumption (75% load)       3) g/kWh       194       198       198       195       197         Fuel consumption (50% load)       3) g/kWh       201       204       204       201       201         Leak fuel quantity, clean MDF fuel (100% load)       kg/h       0,5       0,4       0,4       0,5       0,5         Fuel flow/consumption ratio       4:1       4:1       4.1	-	l <sub>2</sub> D <sub>2</sub>	(bar)			600(6)		
Fuel consumption (100% load) 3) g/kWh 196 195 195 194 196 Fuel consumption (85% load) 3) g/kWh 193 196 196 194 196 Fuel consumption (75% load) 3) g/kWh 194 198 198 195 197 Fuel consumption (50% load) 3) g/kWh 201 204 204 201 201 Leak fuel quantity, clean MDF fuel (100% load) kg/h 0,5 0,4 0,4 0,5 0,5 Fuel flow/consumption ratio 4:1  Lubricating oil system  Pressure before engine, nom. kPa (bar) 450 (4,5)	,		, ,	0.41	0.87	` '	0.41	0.41
Fuel consumption (85% load) 3) g/kWh 193 196 196 194 196 Fuel consumption (75% load) 3) g/kWh 194 198 198 195 197 Fuel consumption (50% load) 3) g/kWh 201 204 204 201 201 Leak fuel quantity, clean MDF fuel (100% load) kg/h 0,5 0,4 0,4 0,5 0,5 Fuel flow/consumption ratio 4:1  Lubricating oil system  Pressure before engine, nom. kPa (bar) 450 (4,5)						-		
Fuel consumption (75% load) 3) g/kWh 194 198 198 195 197 Fuel consumption (50% load) 3) g/kWh 201 204 204 201 201 Leak fuel quantity, clean MDF fuel (100% load) kg/h 0,5 0,4 0,4 0,5 0,5 Fuel flow/consumption ratio 4:1  Lubricating oil system  Pressure before engine, nom. kPa (bar) 450 (4,5)	± '	, .						
Fuel consumption ( 50% load) 3) g/kWh 201 204 204 201 201 Leak fuel quantity, clean MDF fuel (100% load) kg/h 0,5 0,4 0,4 0,5 0,5 Fuel flow/consumption ratio 4:1  Lubricating oil system  Pressure before engine, nom. kPa (bar) 450 (4,5)								
Leak fuel quantity, clean MDF fuel (100% load) kg/h 0,5 0,4 0,4 0,5 0,5  Fuel flow/consumption ratio 4:1  Lubricating oil system  Pressure before engine, nom. kPa (bar) 450 (4,5)	± '	, .						
Fuel flow/consumption ratio  Lubricating oil system  Pressure before engine, nom.  kPa (bar)  4:1  450 (4,5)		<i>5</i> ) g						
Lubricating oil system  Pressure before engine, nom. kPa (bar) 450 (4,5)	* *		kg/n	0,5	0,4		0,5	0,5
Pressure before engine, nom. kPa (bar) 450 (4,5)	-					4:1		
*	-		4			450 (4.5)		
Pressure before engine, alarm kPa (bar) 300 (3)	9							
	Pressure before engine, alarm	kPa	a (bar)			300 (3)		

		_				
Pressure before engine, stop	kPa (bar)			200 (2)		
Priming pressure, nom.	kPa (bar)			80 (0,8)		
Priming pressure, alarm	kPa (bar)			50 (0,5)		
Temperature before engine, nom.	°C			63		
Temperature before engine, alarm	°C			80		
Temperature after engine, abt.	°C			78		
Pump capacity (main), engine driven	$m^3/h$			28		
Pump capacity (main), separate	m³/h			18		
Pump capacity (priming)	$4)$ $m^3/h$			6,9/8,4		
Oil volume, wet sump, nom.	$m^3$			0,27		
Oil volume in separate system oil tank, nom.	m³	1	0,7	0,7	0,9	1
Filter fineness, nom.	microns/60%			15		
Filter difference pressure, alarm	kPa (bar)			150 (1,5)		
Oil consumption (100% load), abt.	5) g/kWh			0,6		
Cooling water system						
High temperature cooling water syste	m					
Pressure before engine, nom.	kPa (bar)		200 (2	,0) + static		
Pressure before engine, alarm	kPa (bar)		100 (1	,0) + static		
Pressure before engine, max.	kPa (bar)			350 (3,5)		
Temperature before engine, abt.	°C			83		
Temperature after engine, nom.	°C			91		
Temperature after engine, alarm	°C			105		
Temperature after engine, stop	°C			110		
Pump capacity, nom.	$m^3/h$	20	18	18,5	19,5	20
Pressure drop over engine	kPa (bar)			50 (0,5)		
Water volume in engine	$m^3$			0,09		
Pressure from expansion tank	kPa (bar)		70150	(0,71,5)		
Pressure drop over central cooler, max.	kPa (bar)			60 (0,6)		
Delivery head of stand-by pump	kPa (bar)			200 (2)		
Low temperature cooling water syste	m					
Pressure before charge air cooler, nom.	kPa (bar)		200	(2) + static		
Pressure before charge air cooler, alarm	kPa (bar)		100	(1) + static		
Pressure before charge air cooler, max.	kPa (bar)			350 (3,5)		
Temperature before charge air cooler, max.	°C			38		
Temperature before charge air cooler, min.	°C			25		
Pump capacity, nom.	m³/h	24	19	20	22,5	24
Pressure drop over charge air cooler	kPa (bar)			30 (0,3)		
Pressure drop over oil cooler	kPa (bar)			30 (0,3)		
Pressure drop over central cooler, max.	kPa (bar)			60 (0,6)		
Pressure from expansion tank	kPa (bar)		70150	0,71,5)		
Delivery head of stand-by pump	kPa (bar)			200 (2)		
Starting air system	,			-		
Air supply pressure before engine (max.)	MPa (bar)			3 (30)		
Air supply pressure alarm	MPa (bar)			1,8 (18)		
Air consumption per start (20°C)	6) Nm <sup>3</sup>			0,4		
1) At an ambient temperature of 25°C	-/			,		

- At an ambient temperature of 25°C. 1)
- The figures are at 100% load and include the 5% tolerance on sfoc and engine driven pumps.
- According to ISO 3046/1, lower calorific value 42 700 kJ/kg, with engine driven pumps. Tolerance 5%. Constant speed applications are Auxiliary and DE. Mechanical propulsion variable speed applications according to propeller law.
- Capacities at 50 and 60 Hz respectively.
- 5) Tolerance + 0.3 g/kWh
- At remote and automatic starting, the consumption is 1.2 Nm³

Subject to revision without notice.

Page			ME	AE	AE
Engine output	Diesel engine Wärtsilä 5L20				
Engine output					
Engine output					
Stroke	8 -	_	1120		
Stroke   S	·				
Swept volume					
Compression ratio Compression pressure, max.  Firing pressure, max.  Firing pressure, max.  Firing pressure, max.  Mean effective pressure Mean piston speed	*	din			
Compression pressure, max.   bar   bar   0.3		bar			
Firing pressure, max.   Max					
Mean effective pressure  Mean effective pressure  Mean offective pressure  Flow of air at 100% load  Ablication air system  Flow of air at 100% load  Ablication air emperature, max.  Active mean of a color of					
Mean piston speed         m/s         9,3         8,4         9,3           Minimum speed (FPP installations)         rpm         350           Combustion air system           How of air at 100% load         kg/s         1,5         1,42         1,5           Ambient air temperature, max.         °C         45         45           Air temperature after air cooler, alarm         °C         75           Exhaust gas flow (100% load)         3)         kg/s         1,33         1,37         1,37           Exhaust gas flow (85% load)         3)         kg/s         1,33         1,37         1,37           Exhaust gas flow (25% load)         3)         kg/s         1,14         1,25         1,25           Exhaust gas flow (25% load)         3)         kg/s         1,33         1,37         1,37           Exhaust gas temp. after turbocharger (100% load)         1)         3)         kg/s         0,24         0,94           Exhaust gas temp. after turbocharger (50% load)         1)         3)         °C         355         350         360           Exhaust gas back pressure drop, max.         kpa         3         360         360         360           Exhaust gas temp. after turbocharger (50% load)	-		22.5		22,5
Mainimum speed (FPP installations) rpm 350  Combustion air system  Flow of air at 100% load Ambient air temperature, max. Air temperature after air cooler, alarm  Exhaust gas temp after air cooler, alarm  Exhaust gas flow (100% load) 3) kg/s 1,55 1,55 1,55 Exhaust gas flow (85% load) 3) kg/s 1,33 1,37 1,37  Exhaust gas flow (85% load) 3) kg/s 1,19 1,25 1,25  Exhaust gas flow (25% load) 3) kg/s 0,82 0,94 0,94  Exhaust gas flow (25% load) 1) 3) °C 360 360 360  Exhaust gas temp, after turbocharger (100% load) 1) 3) °C 365 350 350  Exhaust gas temp, after turbocharger (55% load) 1) 3) °C 365 350 360  Exhaust gas temp, after turbocharger (55% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (55% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (55% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (55% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 305 360 360  Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 305 360 360  Exhaust gas pipe diameter, min.  Calculated dia for 35 m/s 42  Jacket water  Fleat balance  Jacket water  Jacket water  Jacket water  Jacket water  Jacket water  Jacket water  Jac	-				9,3
Combustion air system   Flow of air at 100% load   kg/s   1,5   1,42   1,5				-	
Flow of air at 100% load					
Ambient air temperature, max. Air temperature after air cooler C		ka/s	1.5	1,42	1,5
Air temperature after air cooler, alarm  Exhaust gas System  Exhaust gas flow (100% load)  Exhaust gas flow (55% load)  Exhaust gas temp. after turbocharger (100% load)  Exhaust gas temp. after turbocharger (85% load)  Exhaust gas temp. after turbocharger (50% load)  Exhaust gas back pressure drop, max.  In many specified to the company of the com			1,0		
Name					
Exhaust gas system  Exhaust gas flow (100% load) 3) kg/s 1,55 1,55 1,55 Exhaust gas flow (85% load) 3) kg/s 1,33 1,37 1,37 Exhaust gas flow (85% load) 3) kg/s 1,133 1,37 1,37 Exhaust gas flow (25% load) 3) kg/s 1,19 1,25 1,25 Exhaust gas flow (25% load) 3) kg/s 0,82 0,94 0,94 Exhaust gas temp. after turbocharger (100% load) 1) 3) °C 360 360 360 Exhaust gas temp. after turbocharger (85% load) 1) 3) °C 365 350 350 Exhaust gas temp. after turbocharger (75% load) 1) 3) °C 365 350 360 Exhaust gas temp. after turbocharger (75% load) 1) 3) °C 365 350 360 Exhaust gas temp. after turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas temp. after turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas pack pressure drop, max. Par 3 Diameter of turbocharger connection mm 250 Exhaust gas pipe diameter, min. 350 Exhaust gas pipe diameter, min. 350 Exhaust gas pipe diameter, min. 317 317  Heat balance				75	
Exhaust gas flow (100% load) 3) kg/s 1,55 1,55 1,55 Exhaust gas flow (85% load) 3) kg/s 1,33 1,37 1,37 Exhaust gas flow (75% load) 3) kg/s 1,19 1,25 1,25 Exhaust gas flow (75% load) 3) kg/s 0,82 0,94 0,94 Exhaust gas flow (25% load) 1) 3) °C 360 360 360 360 Exhaust gas temp, after turbocharger (85% load) 1) 3) °C 365 350 350 Exhaust gas temp, after turbocharger (75% load) 1) 3) °C 365 350 360 360 Exhaust gas temp, after turbocharger (75% load) 1) 3) °C 365 350 360 360 Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 385 360 360 Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas temp, after turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 395 360 360 Exhaust gas been paffer turbocharger (50% load) 1) 3) °C 305 395 360 360 Exhaust gas been paffer		J			
Exhaust gas flow (100% load)  Exhaust gas flow (25% load)  Exhaust gas flow (25% load)  Exhaust gas flow (25% load)  Exhaust gas temp. after turbocharger (100% load)  Exhaust gas temp. after turbocharger (85% load)  Exhaust gas temp. after turbocharger (85% load)  Exhaust gas temp. after turbocharger (85% load)  Exhaust gas temp. after turbocharger (75% load)  Exhaust gas temp. after turbocharger (50% load)  Exhaust gas back pressure drop, max.  Diameter of turbocharger connection  Exhaust gas pipe diameter, min.  Calculated dia for 35 m/s  Heat balance  2) 3)  Back water  Charge air  Lubricating oil  Exhaust gases  Radiation  Pressure before injection pumps  Pressure before injection pumps  Fuel consumption (100% load)  Fuel consumption (55% load)  Expansing oil  Leak fuel quantity, clean MDF fuel (100% load)  Pressure before engine, nom.  Pressure before engine, alarm  Pressure before engine, alarm  Pressure before engine, alarm  Pressure before engine, etop  Priming pressure, nom.  Pressure before engine, stop  Priming pressure, nom.	-	3) kg/s	1.55	1,55	1,55
Exhaust gas flow (75% load)  Exhaust gas flow (75% load)  Exhaust gas flow (25% load)  Exhaust gas flow (25% load)  Exhaust gas temp. after turbocharger (100% load)  Exhaust gas temp. after turbocharger (85% load)  Exhaust gas temp. after turbocharger (75% load)  Exhaust gas temp. after turbocharger (50% load)  Exhaust gas temp. after turbocharger (50% load)  Exhaust gas back pressure drop, max.  Diameter of turbocharger connection  Exhaust gas pipe diameter, min.  Calculated dia for 35 m/s  Heat balance  2) 3)  Jacket water  Charge air  kW 189 173 189  Charge air  kW 240 226 240  Lubricating oil  Exhaust gases  kW 101 91 101  Exhaust gases  Radiation  Fuel system  Pressure before injection pumps  RPa (bar)  Fuel consumption (100% load)  Fuel consumption (100% load)  Fuel consumption (75% load)  Leak fuel quantity, clean MDF fuel (100% load)  Fuel flow/consumption ratio  Lubricating oil system  Pressure before engine, nom.  kPa (bar)  RPa (bar)					1,37
Exhaust gas flow (25% load)  Exhaust gas temp. after turbocharger (100% load)  Exhaust gas temp. after turbocharger (85% load)  Exhaust gas temp. after turbocharger (75% load)  Exhaust gas temp. after turbocharger (75% load)  Exhaust gas temp. after turbocharger (75% load)  Exhaust gas temp. after turbocharger (50% load)  Exhaust gas back pressure drop, max.  Diameter of turbocharger connection  Exhaust gas pipe diameter, min.  Calculated dia for 35 m/s  Meat balance  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Lubricating oil  Exhaust gas gas pipe diameter, min.  Exhaust gas pipe diameter, min.  Mm  317  317  Heat balance  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Exhaust gas gas pipe diameter, min.  Lubricating oil  Exhaust gas gas pipe diameter, min.  Exhaust gas gas pipe diameter, min.  Mm  317  317  318  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Exhaust gas gas pipe diameter, min.  Bay  Lubricating oil  Exhaust gas gas pipe diameter, min.  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Lubricating oil  Exhaust gas gas pipe diameter, min.  Bay  Jacket water  Authoricating oil  Bay  Jacket water  Authoricating oil  Bay  Jacket water  Authoricating oil  Bay  Jacket water  Jacket water  Jacket water  Jacket water  Jacket water					1,25
Exhaust gas temp. after turbocharger (100% load) 1) 3) °C 360 360 360 Exhaust gas temp. after turbocharger (85% load) 1) 3) °C 365 350 350 350 Exhaust gas temp. after turbocharger (75% load) 1) 3) °C 385 360 360 360 Exhaust gas temp. after turbocharger (75% load) 1) 3) °C 385 360 360 360 Exhaust gas temp. after turbocharger (75% load) 1) 3) °C 395 360 360 360 Exhaust gas back pressure drop, max. kPa 3 3 Diameter of turbocharger connection mm 250 Exhaust gas pipe diameter, min. mm 317 317 317 317				0,94	0,94
Exhaust gas temp. after turbocharger (85% load) 1) 3) °C 365 350 350  Exhaust gas temp. after turbocharger (75% load) 1) 3) °C 385 360 360  Exhaust gas temp. after turbocharger (50% load) 1) 3) °C 395 360 360  Exhaust gas temp. after turbocharger (50% load) 1) 3) °C 395 360  Exhaust gas back pressure drop, max. kPa 3  Diameter of turbocharger connection mm 250  Exhaust gas pipe diameter, min. mm 350  Calculated dia for 35 m/s mm 317 317  Heat balance 2) 3)  Jacket water kW 189 173 189  Jacket water kW 240 226 240  Lubricating oil kW 101 91 101  Exhaust gases kW 602 558 602  Radiation kW 49 43 43 49  Fuel system  Pressure before injection pumps kPa (bar) 600(6)  Fuel consumption (100% load) 3) g/kWh 196 196 196  Fuel consumption (85% load) 3) g/kWh 195 195  Fuel consumption (50% load) 3) g/kWh 196 197 197  Fuel consumption (50% load) 3) g/kWh 202 208 208  Leak fuel quantity, clean MDF fuel (100% load) kg/h 0,7 0,7 0,7  Fuel flow/consumption ratio  Lubricating oil system  Pressure before engine, nom. kPa (bar) 450 (4,5) 450 (4,5) 450 (4,5)  Pressure before engine, nom. kPa (bar) 80 (0,8) 80 (0,8) Priming pressure, nom.	Exhaust gas flow (25/6 load)	, –		360	360
Exhaust gas temp. after turbocharger (75% load) 1) 3) °C 385 360 360  Exhaust gas temp. after turbocharger (50% load) 1) 3) °C 395 360 360  Exhaust gas back pressure drop, max.  Diameter of turbocharger connection mm 250  Exhaust gas pipe diameter, min.  Calculated dia for 35 m/s mm 317 317 317  Heat balance 2) 3)  Jacket water kW 189 173 189  Charge air kW 240 226 240  Lubricating oil kW 101 91 101  Exhaust gases kW 602 558 602  Radiation kW 49 43 49  Fuel system  Pressure before injection pumps kPa (bar) 450 (45) 195  Fuel consumption (100% load) 3) g/kWh 196 196 196  Fuel consumption (50% load) 3) g/kWh 196 197 197  Fuel consumption (50% load) 3) g/kWh 196 197 197  Fuel consumption (50% load) 3) g/kWh 202 208 208  Leak fuel quantity, clean MDF fuel (100% load) kg/h 0,7 0,7 0,7  Fuel flow/consumption ratio  Lubricating oil system  Pressure before engine, nom. kPa (bar) 450 (4,5) 450 (4,5) 450 (4,5)  Pressure before engine, stop kPa (bar) 80 (0.8) 80 (0.8)  Priming pressure, nom.	Exhaust gas temp, after turbocharger (85% load)	, ,		350	350
Exhaust gas temp. after turbocharger (50% load) 1) 3) °C 395 360 360   Exhaust gas back pressure drop, max.	Exhaust gas temp, after turbocharger (75% load)	, ,		360	360
Exhaust gas back pressure drop, max.   KPa   250	Exhaust gas temp, after turbocharger (50% load)	, ,	395	360	360
Diameter of turbocharger connection         mm         250           Exhaust gas pipe diameter, min.         mm         350           Calculated dia for 35 m/s         mm         317         317           Heat balance         2) 3)         ***         ***           Jacket water         kW         189         173         189           Jacket water         kW         240         226         240           Lubricating oil         kW         101         91         101           Exhaust gases         kW         602         558         602           Radiation         kW         49         43         49           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)           Pump capacity, MDF, engine driven         m³/h         0,57         0,57         0,57           Fuel consumption (100% load)         3) g/kWh         196         196         196           Fuel consumption (85% load)         3) g/kWh         195         195         195           Fuel consumption (75% load)         3) g/kWh         196         197         197           Fuel consumption (50% load)         3) g/kWh         202         208	Exhaust gas temp, after temporary			3	
Exhaust gas pipe diameter, min.         mm         350           Calculated dia for 35 m/s         mm         317         317           Heat balance         2) 3)           Jacket water         kW         189         173         189           Charge air         kW         240         226         240           Lubricating oil         kW         101         91         101           Exhaust gases         kW         602         558         602           Radiation         kW         49         43         49           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)         50           Pump capacity, MDF, engine driven         m³/h         0,57         0,57         0,57           Fuel consumption (100% load)         3) g/kWh         196         196         196           Fuel consumption (85% load)         3) g/kWh         195         195         195           Fuel consumption (75% load)         3) g/kWh         196         197         197           Fuel consumption (50% load)         3) g/kWh         202         208         208           Leak fuel quantity, clean MDF fuel (100% load)         kg/h         0,7 <td></td> <td>mm</td> <td></td> <td>250</td> <td></td>		mm		250	
Calculated dia for 35 m/s         mm         317         317           Heat balance         2) 3)           Jacket water         kW         189         173         189           Charge air         kW         240         226         240           Lubricating oil         kW         101         91         101           Exhaust gases         kW         602         558         602           Radiation         kW         49         43         49           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)           Pump capacity, MDF, engine driven         m³/h         0,57         0,57         0,57           Fuel consumption (100% load)         3) g/kWh         196         196         196           Fuel consumption (85% load)         3) g/kWh         195         195         195           Fuel consumption (75% load)         3) g/kWh         196         197         197           Fuel consumption (50% load)         3) g/kWh         202         208         208           Leak fuel quantity, clean MDF fuel (100% load)         kg/h         0,7         0,7         0,7           Fuel flow/consumption ratio         Lubricati		mm		350	
Heat balance		mm	317	317	317
Jacket water		2) 3)			
Charge air         kW         240         226         240           Lubricating oil         kW         101         91         101           Exhaust gases         kW         602         558         602           Radiation         kW         49         43         49           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)           Pump capacity, MDF, engine driven         m³/h         0,57         0,57         0,57           Fuel consumption (100% load)         3) g/kWh         196         196         196         196           Fuel consumption (85% load)         3) g/kWh         195         195         195         195           Fuel consumption (75% load)         3) g/kWh         196         197		kW	189	173	
Lubricating oil         kW         101         91         101           Exhaust gases         kW         602         558         602           Radiation         kW         49         43         49           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)         600(6)           Pump capacity, MDF, engine driven         m³/h         0,57         0,57         0,57           Fuel consumption (100% load)         3) g/kWh         196         196         196           Fuel consumption (85% load)         3) g/kWh         195         195         195           Fuel consumption (75% load)         3) g/kWh         196         197         197           Fuel consumption (50% load)         3) g/kWh         202         208         208           Leak fuel quantity, clean MDF fuel (100% load)         kg/h         0,7         0,7         0,7           Fuel flow/consumption ratio         Lubricating oil system           Pressure before engine, nom.         kPa (bar)         450 (4,5)         450 (4,5)         450 (4,5)           Pressure before engine, stop         kPa (bar)         200 (2)         200 (2)         200 (2)           Priming pressure, nom.	2	kW	240	226	
Exhaust gases         kW         602         558         602           Radiation         kW         49         43         49           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)           Pump capacity, MDF, engine driven         m³/h         0,57         0,57           Pump capacity, MDF, engine driven         m³/h         0,57         0,57         0,57           Fuel consumption (100% load)         3) g/kWh         196         196         196           Fuel consumption (85% load)         3) g/kWh         195         195         195           Fuel consumption (75% load)         3) g/kWh         196         197         197           Fuel consumption (50% load)         3) g/kWh         202         208         208           Leak fuel quantity, clean MDF fuel (100% load)         kg/h         0,7         0,7         0,7           Fuel flow/consumption ratio         Lubricating oil system         kPa (bar)         450 (4,5)         450 (4,5)         450 (4,5)           Pressure before engine, nom.         kPa (bar)         300 (3)         300 (3)         300 (3)         300 (3)           Pressure before engine, stop         kPa (bar)         200 (2)         200 (2)<		kW	101		
Radiation         kW         49         43         49           Fuel system           Pressure before injection pumps         kPa (bar)         600(6)           Pump capacity, MDF, engine driven         m³/h         0,57         0,57           Fuel consumption (100% load)         3) g/kWh         196         196         196           Fuel consumption (85% load)         3) g/kWh         195         195         195           Fuel consumption (75% load)         3) g/kWh         196         197         197           Fuel consumption (50% load)         3) g/kWh         202         208         208           Leak fuel quantity, clean MDF fuel (100% load)         kg/h         0,7         0,7         0,7           Fuel flow/consumption ratio         4:1         4:1         4:1         4:1           Lubricating oil system         Pressure before engine, nom.         kPa (bar)         450 (4,5)         450 (4,5)         450 (4,5)           Pressure before engine, alarm         kPa (bar)         300 (3)         300 (3)         300 (3)           Pressure before engine, stop         kPa (bar)         80 (0,8)         80 (0,8)         80 (0,8)           Priming pressure, nom.         kPa (bar)         80 (0,8)         80 (0,8)<	9	kW	602		
Fuel system         Pressure before injection pumps       kPa (bar)       600(6)         Pump capacity, MDF, engine driven       m³/h       0,57       0,57         Fuel consumption (100% load)       3) g/kWh       196       196         Fuel consumption (85% load)       3) g/kWh       195       195         Fuel consumption (75% load)       3) g/kWh       196       197       197         Fuel consumption (50% load)       3) g/kWh       202       208       208         Leak fuel quantity, clean MDF fuel (100% load)       kg/h       0,7       0,7       0,7         Fuel flow/consumption ratio       4:1       4:1       4:1         Lubricating oil system       Pressure before engine, nom.       kPa (bar)       450 (4,5)       450 (4,5)       450 (4,5)         Pressure before engine, alarm       kPa (bar)       300 (3)       300 (3)       300 (3)         Pressure before engine, stop       kPa (bar)       200 (2)       200 (2)       200 (2)         Priming pressure, nom.       kPa (bar)       80 (0,8)       80 (0,8)       80 (0,8)	•	kW	49	43	49
Pressure before injection pumps         kPa (bar)         600(6)           Pump capacity, MDF, engine driven         m³/h         0,57         0,57           Fuel consumption (100% load)         3) g/kWh         196         196           Fuel consumption (85% load)         3) g/kWh         195         195           Fuel consumption (75% load)         3) g/kWh         196         197         197           Fuel consumption (50% load)         3) g/kWh         202         208         208           Leak fuel quantity, clean MDF fuel (100% load)         kg/h         0,7         0,7         0,7           Fuel flow/consumption ratio         4:1         4:1         4:1           Lubricating oil system         Pressure before engine, nom.         kPa (bar)         450 (4,5)         450 (4,5)         450 (4,5)           Pressure before engine, stop         kPa (bar)         200 (2)         200 (2)         200 (2)           Priming pressure, nom.         kPa (bar)         80 (0,8)         80 (0,8)         80 (0,8)					
Pump capacity, MDF, engine driven       m³/h       0,57       0,57       0,57         Fuel consumption (100% load)       3) g/kWh       196       196       196         Fuel consumption (85% load)       3) g/kWh       195       195       195         Fuel consumption (75% load)       3) g/kWh       196       197       197         Fuel consumption (50% load)       3) g/kWh       202       208       208         Leak fuel quantity, clean MDF fuel (100% load)       kg/h       0,7       0,7       0,7         Fuel flow/consumption ratio       4:1       4:1         Lubricating oil system       Pressure before engine, nom.       kPa (bar)       450 (4,5)       450 (4,5)       450 (4,5)         Pressure before engine, alarm       kPa (bar)       300 (3)       300 (3)       300 (3)       300 (3)         Pressure before engine, stop       kPa (bar)       200 (2)       200 (2)       200 (2)         Priming pressure, nom.       kPa (bar)       80 (0,8)       80 (0,8)       80 (0,8)		kPa (bar)			0.55
Fuel consumption (100% load)  Fuel consumption (85% load)  Fuel consumption (75% load)  Fuel consumption (75% load)  Fuel consumption (50% load)  Leak fuel quantity, clean MDF fuel (100% load)  Fuel flow/consumption ratio  Lubricating oil system  Pressure before engine, nom.  Pressure before engine, alarm  Pressure before engine, stop  Priming pressure, nom.  Rea (bar) 196  196  197  197  197  197  197  197		m³/h	0,57		
Fuel consumption ( 85% load)  Fuel consumption ( 75% load)  Fuel consumption ( 75% load)  Fuel consumption ( 50% load)  Leak fuel quantity, clean MDF fuel (100% load)  Leak fuel quantity, clean MDF fuel (100% load)  Fuel flow/consumption ratio  Lubricating oil system  Pressure before engine, nom.  Pressure before engine, alarm  Pressure before engine, alarm  Pressure before engine, stop  RPa (bar) 450 (4,5)  RPa (bar) 300 (3)  RPa (bar) 200 (2)  RPa (bar) 80 (0,8)		3) g/kWh			
Fuel consumption ( 75% load)  Fuel consumption ( 50% load)  Leak fuel quantity, clean MDF fuel (100% load)  Leak fuel quantity, clean MDF fuel (100% load)  Fuel flow/consumption ratio  Lubricating oil system  Pressure before engine, nom.  Pressure before engine, alarm  Pressure before engine, stop  Priming pressure, nom.  KPa (bar) 450 (4,5)  KPa (bar) 300 (3)  KPa (bar) 300 (3)  KPa (bar) 200 (2)  KPa (bar) 80 (0,8)  Resource before engine, stop  KPa (bar) 80 (0,8)  KPa (bar) 80 (0,8)  Fuel flow/consumption ( 75% load)  KPa (bar) 80 (0,8)  Fuel flow/consumption ( 75% load)  KPa (bar) 80 (0,8)  Fuel flow/consumption ( 50% load)  Resource before engine, stop  KPa (bar) 80 (0,8)  Fuel flow/consumption ( 50% load)  Fuel flow/consumption ( 50% load)  KPa (bar) 80 (0,8)  Fuel flow/consumption ( 50% load)  Fuel flow/consumption ( 50% load)  KPa (bar) 80 (0,8)  Fuel flow/consumption ( 50% load)  Fuel flow/consumption ( 50% load)  KPa (bar) 80 (0,8)  Fuel flow/consumption ( 50% load)  Fuel flow/consumption ( 50% load)  KPa (bar) 80 (0,8)  Fuel flow/consumption ( 50% load)  Fuel flow/consumpti	-	3) g/kWh			
Fuel consumption ( 50% load)  Leak fuel quantity, clean MDF fuel (100% load)  Fuel flow/consumption ratio  Lubricating oil system  Pressure before engine, nom.  Pressure before engine, alarm  Pressure before engine, stop  Priming pressure, nom.  System  kPa (bar) 450 (4,5) 450 (4,5) 450 (4,5) 450 (4,5) 300 (3	Fuel consumption (75% load)	, .			
Leak fuel quantity, clean MDF fuel (100% load)       kg/ft       4:1         Fuel flow/consumption ratio       4:1         Lubricating oil system       kPa (bar)       450 (4,5)       450 (4,5)         Pressure before engine, nom.       kPa (bar)       300 (3)       300 (3)       300 (3)         Pressure before engine, stop       kPa (bar)       200 (2)       200 (2)       200 (2)         Priming pressure, nom.       kPa (bar)       80 (0,8)       80 (0,8)       80 (0,8)	Fuel consumption (50% load)	, 0			
Fuel flow/ consumption ratio         Lubricating oil system       Image: Line flow consumption ratio         Pressure before engine, nom.       kPa (bar)       450 (4,5)       450 (4,5)       450 (4,5)         Pressure before engine, alarm       kPa (bar)       300 (3)       300 (3)       300 (3)         Pressure before engine, stop       kPa (bar)       200 (2)       200 (2)       200 (2)         Priming pressure, nom.       kPa (bar)       80 (0,8)       80 (0,8)       80 (0,8)	Leak fuel quantity, clean MDF fuel (100% load)	kg/h	0,7		0,7
Pressure before engine, nom.       kPa (bar)       450 (4,5)       450 (4,5)       450 (4,5)         Pressure before engine, alarm       kPa (bar)       300 (3)       300 (3)       300 (3)         Pressure before engine, stop       kPa (bar)       200 (2)       200 (2)       200 (2)         Priming pressure, nom.       kPa (bar)       80 (0,8)       80 (0,8)       80 (0,8)	Fuel flow/consumption ratio			4:1	
Pressure before engine, nom.  Pressure before engine, alarm  Pressure before engine, stop  Priming pressure, nom.  RYa (bar) 300 (3) 300 (3) 300 (3)  RPa (bar) 200 (2) 200 (2) 200 (2)  RPa (bar) 80 (0,8) 80 (0,8) 80 (0,8)  Priming pressure, nom.	Lubricating oil system				450 (4.5)
Pressure before engine, aiami  Pressure before engine, stop  Pressure before engine, stop  Priming pressure, nom.    Pressure before engine, stop   kPa (bar)   200 (2)   200 (2)   200 (2)	Pressure before engine, nom.		,		
Pressure before engine, stop  Priming pressure, nom.  kPa (bat) 80 (0,8) 80 (0,8) 80 (0,8)  50 (0,5) 50 (0,5)	Pressure before engine, alarm	, ,			
Priming pressure, nom. 50.005	4				
Priming pressure, alarm kPa (bar) 50 (0,5)	* -			·	
	Priming pressure, alarm	kPa (bar)	50 (0,5)	ou (u,o)	50 (0,5)

Temperature before engine, nom.	°C		63	
Temperature before engine, alarm	°C		80	
Temperature after engine, abt.	°C		78	
Pump capacity (main), engine driven	m³/h		28	
Pump capacity (main), separate	m³/h		19,5	
Pump capacity (priming)	4)   m <sup>3</sup> /h		6,9/8,4	
Oil volume, wet sump, nom.	$m^3$		0,32	
Oil volume in separate system oil tank, nom.	$m^3$	1,1	1	1,1
Filter fineness, nom.	microns/60%		15	
Filter difference pressure, alarm	kPa (bar)	150 (1,5)	150 (1,5)	150 (1,5)
Oil consumption (100% load), abt.	5) g/kWh		0,6	
Cooling water system	, 0			
High temperature cooling water system	m			
Pressure before engine, nom.	kPa (bar)		200 (2,0) + static	
Pressure before engine, alarm	kPa (bar)		100 (1,0) + static	
Pressure before engine, max.	kPa (bar)		350 (3,5)	
Temperature before engine, abt.	°C		83	
Temperature after engine, nom.	°C		91	
Temperature after engine, nom.  Temperature after engine, alarm	°C		105	
Temperature after engine, stop	°C		110	
Pump capacity, nom.	m³/h	25	24	25
Pressure drop over engine	kPa (bar)		50 (0,5)	
Water volume in engine	$m^3$	0,105	0,09	0,09
Pressure from expansion tank	kPa (bar)		70150 (0,71,5)	
Pressure drop over central cooler, max.	kPa (bar)		60 (0,6)	
Delivery head of stand-by pump	kPa (bar)		200 (2)	
Low temperature cooling water system				
Pressure before charge air cooler, nom.	kPa (bar)		200 (2) + static	
Pressure before charge air cooler, alarm	kPa (bar)		100 (1) + static	
Pressure before charge air cooler, max.	kPa (bar)		350 (3,5)	
Temperature before charge air cooler, max.	°C		38	
Temperature before charge air cooler, min.	°C		25	
Pump capacity, nom.	m³/h	30	28	30
Pressure drop over charge air cooler	kPa (bar)		30 (0,3)	
Pressure drop over oil cooler	kPa (bar)		30 (0,3)	
	kPa (bar)		60 (0,6)	
<del>-</del>			70150 (0,71,5)	
_	, ,		200 (2)	
•	,			
	MPa (bar)		3 (30)	
* * * *	, ,		0,4	
Pressure drop over central cooler, max. Pressure from expansion tank Delivery head of stand-by pump <b>Starting air system</b> Air supply pressure before engine (max.) Air supply pressure, alarm Air consumption per start (20°C)	kPa (bar) kPa (bar) MPa (bar) MPa (bar) MPa (bar) MPa (bar)		70150 (0,71,5) 200 (2) 3 (30) 1,8 (18)	

<sup>1)</sup> At an ambient temperature of 25°C.

Subject to revision without notice.

<sup>2)</sup> The figures are at 100% load and include the 5% tolerance on sfoc and engine driven pumps.

According to ISO 3046/1, lower calorific value 42 700 kJ/kg, with engine driven pumps. Tolerance 5%. Constant speed applications are Auxiliary and DE. Mechanical propulsion variable speed applications according to propeller law.

<sup>4)</sup> Capacities at 50 and 60 Hz respectively.

<sup>5)</sup> Tolerance + 0.3 g/kWh

<sup>6)</sup> At remote and automatic starting, the consumption is 1.2 Nm<sup>3</sup>

ΑE

1000

1080

1470

167

190

24,6

9,3

2,2

2,26

1,97

1,78

1,29

330

330

330

330

350

374

226

327

143

727

59

1,48

191

190

190

198

0,9

kPa (bar)

kPa (bar)

kPa (bar)

0,5	0,0	0,7	0,1	٠,>
		4:1		
		450 (4,5)		
		300 (3)		
		200 (2)		
		80 (0,8)		
		50 (0,5)		
		, ,		
	Marin	e Project G	uide W20	- 1/2003

Pressure before engine, alarm

Pressure before engine, stop

Priming pressure, nom.

Priming pressure, alarm

Air consumption per start (20°C)

 $Nm^3$ 

- <u>&</u>

0,4

At an ambient temperature of 25°C.

<sup>2)</sup> The figures are at 100% load and include the 5% tolerance on sfoc and engine driven pumps.

<sup>3)</sup> According to ISO 3046/1, lower calorific value 42 700 kJ/kg, with engine driven pumps. Tolerance 5%. Constant speed applications are Auxiliary and DE. Mechanical propulsion variable speed applications according to propeller law.

<sup>4)</sup> Capacities at 50 and 60 Hz respectively.

<sup>5)</sup> Tolerance + 0.3 g/kWh

<sup>6)</sup> At remote and automatic starting, the consumption is 1.2 Nm<sup>3</sup> Subject to revision without notice.

Diocol ongine Wärtsilä 81 20		ME	AE	AE	AE	AE
Diesel engine Wärtsilä 8L20	ethem.	1000	720	750	900	1000
Engine speed	rpm kW	1440	1040	1080	1360	1440
Engine output	hp	1960	1410	1470	1850	1960
Engine output	mm	1700	1110	200		
Cylinder bore	mm			280		
Stroke	dm³			70,4		
Swept volume Compression ratio	(IIII			15		
Compression pressure, max.	bar	167	150	150	167	167
Firing pressure, max.	bar	190	180	180	190	190
Charge air pressure at 100% load	MPa			0,3		
Mean effective pressure	bar	24,6	24,6	24,6	25,8	24,6
Mean piston speed	m/s	9,3	6,7	7	8,4	9,3
Minimum speed (FPP installations)	rpm	350				
Combustion air system	-1					
Flow of air at 100% load	kg/s	2,85	1,96	2,04	2,79	2,85
Ambient air temperature, max.	°C	-,	,	45		
Air temperature after air cooler	°C			4560		
Air temperature after air cooler, alarm	°C			75		
Exhaust gas system						
Exhaust gas flow (100% load)	3) kg/s	2,94	2,02	2,1	2,87	2,93
Exhaust gas flow (85% load)	3) kg/s	2,5	1,74	1,81	2,48	2,53
Exhaust gas flow (75% load)	3) kg/s	2,18	1,57	1,62	2,24	2,29
Exhaust gas flow (25% load)	3) kg/s	1,44	1,11	1,15	1,61	1,64
Exhaust gas temp. after turbocharger (100% load)	1) 3) °C	350	360	360	350	340
Exhaust gas temp. after turbocharger (85% load)	1) 3) °C	355	360	360	340	340
Exhaust gas temp. after turbocharger (75% load)	1) 3) °C	360	360	360	340	340
Exhaust gas temp. after turbocharger (50% load)	1) 3) °C	390	370	370	350	350
Exhaust gas back pressure drop, max.	kPa			3		
Diameter of turbocharger connection	mm			300		
Exhaust gas pipe diameter, min.	mm	400	350	350	400	400
Calculated dia for 35 m/s	mm	433	362	369	428	429
Heat balance	2) 3)					
Jacket water	kW	330	244	254	307	330
Charge air	kW	434	306	322	407	442
Lubricating oil	kW	219	162	167	204	219
Exhaust gases	kW	1003	684	708	890	969
Radiation	kW	76	55	57	74	76
Fuel system						
Pressure before injection pumps	kPa (bar)			600(6)		
Pump capacity, MDF, engine driven	m³/h	1,91	1,47	1,53	1,72	1,91
Fuel consumption (100% load)	3) g/kWh	196	193	193	192	193
Fuel consumption (85% load)	3) g/kWh	195	194	194	191	192
Fuel consumption (75% load)	3) g/kWh	195	195	195	191	193
Fuel consumption (50% load)	3) g/kWh	201	202	202	200	200
Leak fuel quantity, clean MDF fuel (100% load)	kg/h	1,2	0,8	0,9	1,1	1,2
Fuel flow/consumption ratio				4:1		
Lubricating oil system						
Pressure before engine, nom.	kPa (bar)			450 (4,5)		
Pressure before engine, alarm	kPa (bar)			300 (3)		
Pressure before engine, stop	kPa (bar)			200 (2)		
Priming pressure, nom.	kPa (bar)			80 (0,8)		
Priming pressure, alarm	kPa (bar)			50 (0,5)		

At an ambient temperature of 25°C.

<sup>2)</sup> The figures are at 100% load and include the 5% tolerance on sfoc and engine driven pumps.

According to ISO 3046/1, lower calorific value 42 700 kJ/kg, with engine driven pumps. Tolerance 5%. Constant speed applications are Auxiliary and DE. Mechanical propulsion variable speed applications according to propeller law.

<sup>4)</sup> Capacities at 50 and 60 Hz respectively.

<sup>5)</sup> Tolerance + 0.3 g/kWh

<sup>6)</sup> At remote and automatic starting, the consumption is 1.2 Nm<sup>3</sup>

Subject to revision without notice.

Diesel engine Wärtsilä 9L20			ME	AE	AE	AE	AE
Engine speed	rc	om	1000	720	750	900	1000
Engine output	_	:W	1620	1170	1215	1530	1620
Engine output		hp	2200	1590	1650	2080	2200
Cylinder bore		nm			200		
Stroke		nm			280		
Swept volume		$m^3$			79,2		
Compression ratio					15		
Compression pressure, max.	1	bar	167	150	150	167	167
Firing pressure, max.		bar	190	180	180	190	190
Charge air pressure at 100% load		[Pa	.,,		0,3		
Mean effective pressure		bar	24,6	24,6	24,6	25,8	24,6
-		n/s	9,3	6,7	7	8,4	9,3
Mean piston speed  Minimum aroud (EPP installations)		pm	350	٠,٠		,	
Minimum speed (FPP installations)	-1	PIII	330				
Combustion air system	1	-/-	3,19	1,98	2,11	3,09	3,19
Flow of air at 100% load		g/s °C	3,19	1,90	45	5,07	5,17
Ambient air temperature, max.		°C			4560		
Air temperature after air cooler					75		
Air temperature after air cooler, alarm		°C			73		
Exhaust gas system		,		0.05	0.10	2.17	2 20
Exhaust gas flow (100% load)		g/s	3,28	2,05	2,18	3,17	3,28
Exhaust gas flow (85% load)		g/s	2,85	1,79	1,91	2,76	2,89
Exhaust gas flow (75% load)		g/s	2,54	1,62	1,73	2,47	2,59
Exhaust gas flow (25% load)		g/s	1,65	1,18	1,27	1,76	1,86
Exhaust gas temp. after turbocharger (100% load)	1) 3)	°C	340	360	360	340	340
Exhaust gas temp. after turbocharger (85% load)	1) 3)	°C	340	360	360	340	340
Exhaust gas temp. after turbocharger (75% load)	1) 3)	°C	350	370	370	340	340
Exhaust gas temp. after turbocharger (50% load)	1) 3)	°C	380	380	380	350	330
Exhaust gas back pressure drop, max.	1	kPa			3		
Diameter of turbocharger connection	1	mm			300	450	450
Exhaust gas pipe diameter, min.	1	mm	450	350	350	450	450
Calculated dia for 35 m/s	1	mm	470	365	376	446	470
Heat balance	2) 3)						
Jacket water		kW	380	280	291	353	380
Charge air		kW	495	342	355	458	495
Lubricating oil		kW	244	177	183	229	244
Exhaust gases		kW	1085	771	800	985	1085
Radiation		kW	79	63	66	75	79
Fuel system							
Pressure before injection pumps	kPa (	bar)			600(6)		
Pump capacity, MDF, engine driven	m	n³/h	1,91	1,47	1,53	1,72	1,91
Fuel consumption (100% load)	3) g/k	:Wh	192	193	193	191	192
Fuel consumption (85% load)	3) g/k	.Wh	189	193	193	190	191
Fuel consumption (75% load)	3) g/k	cWh	190	194	194	191	192
Fuel consumption (50% load)	3) g/k	«Wh	196	202	202	199	200
Leak fuel quantity, clean MDF fuel (100% load)	k	g/h	1,3	0,9	1	1,2	1,3
Fuel flow/consumption ratio					4:1		
Lubricating oil system							
Pressure before engine, nom.	kPa (	(bar)			450 (4,5)		
Pressure before engine, alarm	kPa (				300 (3)		
Pressure before engine, stop	kPa (				200 (2)		
Priming pressure, nom.	kPa (				80 (0,8)		
Priming pressure, alarm	kPa (				50 (0,5)		
z							

Air consumption per start (20°C)

Nm<sup>3</sup>

0,4

<sup>1)</sup> At an ambient temperature of 25°C.

<sup>2)</sup> The figures are at 100% load and include the 5% tolerance on sfoc and engine driven pumps.

<sup>3)</sup> According to ISO 3046/1, lower calorific value 42 700 kJ/kg, with engine driven pumps. Tolerance 5%. Constant speed applications are Auxiliary and DE. Mechanical propulsion variable speed applications according to propeller law.

<sup>4)</sup> Capacities at 50 and 60 Hz respectively.

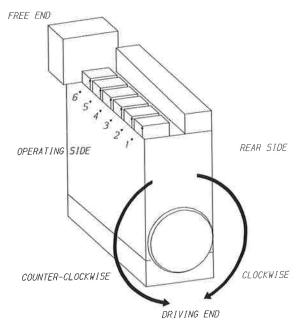
<sup>5)</sup> Tolerance + 0.3 g/kWh

<sup>6)</sup> At remote and automatic starting, the consumption is 1.2 Nm<sup>3</sup> Subject to revision without notice.

# 4. Description of the engine

#### 4.1. Definitions

#### In-line engine (1V93C0029)



#### 4.2. Main components

The dimensions and weights of engine parts are shown in the chapter for dimensions and weights.

#### 4.2.1 Engine block

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

#### 4.2.2 Crankshaft

The crankshaft is forged in one piece and mounted on the engine block in an under-slung way.

#### 4.2.3 Connecting rod

The connecting rod is of forged alloy steel. All connecting rod studs are hydraulically tightened. Oil is led to the gudgeon pin bearing and piston through a bore in the connecting rod.

#### 4.2.4 Main bearings and big end bearings

The main bearings and the big end bearings are of the Al based bi-metal type with steel back.

#### 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 metallically 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.

#### 4.2.6 Piston

The piston is of composite design with nodular cast iron skirt and steel crown. The piston skirt is pressure lubricated, which ensures a well-controlled oil flow to the cylinder liner 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.

#### 4.2.8 Cylinder head

The cylinder head is made of grey cast iron. The thermally loaded flame plate is cooled efficiently by cooling water led from the periphery radially towards the centre of the head. The bridges between the valves cooling channels are drilled 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.

#### 4.2.9 Camshaft and valve mechanism

The camshaft is built of one piece for each cylinder cam piece with separate bearing pieces in between. The cam and bearing pieces are held together with two hydraulically tightened centre screws. The drop forged completely hardened camshaft pieces have fixed cams. The camshaft bearing housings are integrated in the engine block casting and are thus completely closed. The bearings are installed and removed by means of a hydraulic tool. The original installation in the factory is done with cooling of the bearing. The

camshaft covers, one for each cylinder, seal against the engine block with a closed O-ring profile.

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.

#### 4,2.10 Camshaft drive

The camshafts are driven by the crankshaft through a gear train.

# 4.2.11 Turbocharging and charge air cooling

The charge air cooler is single stage type and cooled by LT-water.

#### 4.2.12 Injection equipment

The injection pumps are one-cylinder pumps located in the "multi-housing", which has the following functions:

- · housing for the injection pump element
- · fuel supply channel along the whole engine
- fuel return channel from each injection pump
- lubricating oil supply to the valve mechanism
- guiding for the valve tappets

The injection pumps have built-in roller tappets and are through-flow type to enable heavy fuel operation. They are also equipped with a stop cylinder, which is connected to the electro-pneumatic overspeed protection system.

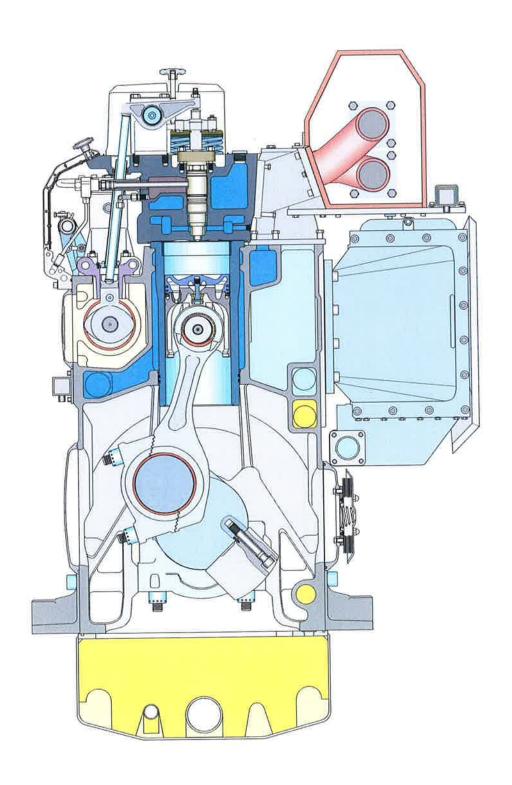
The injection valve is centrally located in the cylinder head and the fuel is admitted sideways through a high pressure connection screwed in the nozzle holder. The injection pipe between the injection pump and the high pressure connection is well protected inside the hot box. The high pressure side of the injection system is completely separated from the hot parts of the exhaust gas components.

#### 4.2.13 Exhaust pipes

The exhaust manifold pipes are made of special heat resistant nodular cast iron alloy.

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

# 4.3. Cross sections of the 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.

In this list HFO is based on HFO2 specification stated in the chapter for general data and outputs.

Table 4.1. Time between overhauls and expected component lifetimes

	нго	MDF	HFO	MDF
	Time between overhauls (h)	Time between overhauls (h)	Expected comp. lifetimes (h)	Expected comp lifetimes (h)
Main bearing	12000	16000	36000	48000
Big end bearing	12000	16000	24000	32000
Gudgeon pin bearing	12000	16000	48000	48000
Camshaft bearing bush	16000	16000	32000	32000
Camshaft intermed. gear bearing	16000	16000	32000	32000
Balancing shaft bearing, 4L20	12000	16000	24000	32000
Cylinder head	12000	16000		
Inlet valve	12000	16000	36000	32000
Inlet valve seat	12000	16000	36000	32000
Exhaust valve	12000	16000	24000	32000
Exhaust valve seat	12000	16000	36000	32000
Valve guide, EX	12000	16000	24000	32000
Valve guide, IN	12000	16000	36000	48000
Piston crown	12000	16000	24000	48000
Piston rings	12000	16000	12000	16000
Cylinder liner	12000	16000	48000	64000
Antipolishing ring	12000	16000	24000	32000
Connecting rod	12000	16000		
Connecting rod screws	12000	16000	24000	32000
Valve tappet and roller			24000	32000
Injection pump tappet and roller			24000	32000
Injection element	12000	16000	24000	32000
Injection valve	6000	8000		
Injection nozzle	6000	8000	6000	8000
Water pump shaft seal	12000	12000	12000	12000
Water pump bearing			24000	24000
Turbocharger	24000	24000		
Governor	12000	12000		
Vibration damper	Acc. to manuf.	Acc. to manuf.		

# Piping design, treatment and installation

#### 5.1. General

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). The pipes in the freshwater side of the cooling water system must not be galvanized. Sea-water piping should be in Cunifer or hot dip galvanized steel.

Attention shall be given to the fire risk aspects. The fuel supply and return lines shall be designed so that they can be fitted without tension. When flexible hoses are used, they shall be of class approved type. If flexible hoses are used in the compressed air system an outlet valve shall be fitted in front of the hose(s).

It is recommended to make a fitting order plan prior to construction. The following aspects shall be taken into consideration:

- in the tank top sections (blocks) larger pipes shall be installed prior to smaller and if/when the deck sections are upside down the large pipes comes closer to the underside of the deck.
- the main lines shall be installed before the branches
- · technically more difficult systems to be built before simpler systems
- the plan shall include the time schedule and manpower needed
- pockets shall be avoided and when not possible equipped with drain plugs and air vents
- · 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 equipments can be made with reasonable effort.

#### 5.2. Pipe dimensions

Table 5.1. Recommended maximum fluid velocities and flow rates for pipework\*

Nominal pipe diameter					Flow rate				ľ	
(Media —>	Sea-v	water	Fresh	water	Lubrica	iting oil	Marine	diesel oil	Heavy	fuel oil
Pipe material —>	Steel ga	lvanized	Mild	steel	Mild	steel	Mild	steel	Mild	steel
Pump side ->)	suction	delivery								
32	1 2.9	1.4 4.1	1.5 4.3	1.5 4.3	0.6 1.7	1 2.9	0.9 2.6	1.1 3.2	0.5 1.4	0.6 1.7
40	1,2 5.4	1.6 7.2	1.7 7.7	1.7 7.7	0.7 3.2	1.2 5.4	1 4.5	1.2 5.4	0.5 2.3	0.7 3.2
50	1.3 9.2	1.8 12.7	1.9 13.4	1.9 13.4	0.8 5.7	1.4 9.9	1.1 7.8	1.3 9.2	0.5 3.5	0.8 5.7
65	1.5 17.9	2 23.9	2.1 25.1	2.1 25.1	0.8 9.6	1.5 17.9	1.2 14.3	1.4 16.7	0.6 7.2	0.9 10.8
80	1.6 29	2.1 38	2.2 39.8	2.2 39.8	0.9 16.3	1.6 29	1.3 23.5	1.5 27.1	0.6 10.9	1 18.1
100	1.8 50.9	2.2 62.2	2.3 65	2.3 65	0.9 25.5	1.6 45.2	1.4 39.6	1.6 45.2	0.7 19.8	1.2 33.9
125	2 88.4	2.3 102	2.4 106	2.4 110	1.1 48.6	1.7 75.1	1.5 66.3	1.7 75.1	0.8 35.3	1.4 61.9
150	2.2 140	2.4 153	2.5 159	2.6 165	1.3 82.7	1.8 115	1.5 95.4	1.8 115	0.9 57.3	1.6 108
200	2.3 260	2.5 283	2.6 294	2.7 305	1.3 147	1.8 204	_		_	_
Aluminium brass		2.6 294							P	
250	2.5 442	2.6 460	2.7 477	2.7 477	1.3 230	1.9 336	_	_		
Aluminium brass		2.7 147				1	1			
300	2.6 662	2.6 662	2.7 687	2.7 687	1.3 331	1.9 484			_	_
Aluminium brass		2.8 713								
350	2.6 901	2.6 901	2.7 935	2.7 935	1.4 485	693	_			_
Aluminium brass		2.8 970			1					
400	2.6 1180	2.7 1220	2.7 1220	2.7 1220	1.4 633	905	_	_	_	_
Aluminium brass		2.8								
450	2.6 1490	2.7 1550	2.7 1550	2.7 1550	1.4 802	2 1150				
Aluminium brass		2.9 1660								
500	2.6 1840	2.7 1910	2.7 1910	2.7 1910	1.5 1060	2.1 1480	_	_	_	_
Aluminium brass		2.9 2050								

<sup>\*</sup> The velocities given in the above table are guidance figures only. National standards can also be applied.

#### 5.3. 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

#### 5.4. Pressure class

The pressure class of the piping should be higher than or equal to the design pressure, which should be higher than or equal to the highest operating (working) pressure. The highest operating (working) pressure is equal to the setting of the safety valve in a system. The pressure in the system

- 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
- rise in an isolated system if the liquid is heated e.g. preheating of a system

Within this Project 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 7 bar. The safety filter in dirty condition may cause a pressure loss of 1.0 bar. The viscosimeter, automatic filter, preheater and piping may cause a pressure loss of 2.5 bar. Consequently the discharge pressure of the circulating pumps may rise to 10.5 bar, and the safety valve of the pump shall thus be adjusted e.g. to 12 bar.

- A design pressure of not less than 12 bar has to be se-
- The nearest pipe class to be selected is PN16.
- Piping test pressure is normally 1.5 x the design pressure = 18 bar.

#### Example 2:

The pressure on the suction side of the cooling water pump is 1.0 bar. The delivery head of the pump is 3.0 bar, leading to a discharge pressure of 4.0 bar. The highest point of the pump curve (at or near zero flow) is 1.0 bar higher than the nominal point, and consequently the discharge pressure may rise to 5.0 bar (with closed or throttled valves).

- Consequently a design pressure of not less than 5.0 bar shall be selected.
- The nearest pipe class to be selected is PN6.
- Piping test pressure is normally 1.5 x the design pressure = 7.5 bar.

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

#### 5.5. Pipe class

The principle of categorisation of piping systems in classes (e.g. DNV) or groups (e.g. ABS) by the classification societies can be used for choosing of:

- type of joint 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 on 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	Cl	ass I	Cl	ass II	Cla	ss III		
	bar	°C	bar	°C	bar	°C		
Steam	> 16	or > 300	< 16	and < 300	< 7	and < 170		
Flammable fluid	> 16	or > 150	< 16	and < 150	< 7	and < 60		
Other media	> 40	or > 300	< 40	and < 300	< 16	and < 200		

#### Insulation 5.6.

The following pipes shall be insulated

- All trace heated pipes
- Exhaust gas pipes

Insulation is also recommended for:

- Pipes between engine or system oil tank and lubricating oil separator
- Pipes between engine and jacket water preheater
- For personnel protection work safety any exposed parts of pipes at walkways, etc., to be insulated to avoid excessive temperatures and risks for personnel injury.

In addition to the operational aspects of the different piping systems requiring insulation the risks of fire and personnel injury due to hot surfaces shall be given attention by insulating and/or shielding of hot surfaces.

#### **5.7**. 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.

#### Cleaning procedures 5.8.

Instructions shall be given to manufacturers and/or fitters of how different piping systems shall be treated, cleaned and protected before and during transportation and before block assembly or assembly in the hull. All piping should be checked to be clean from debris before installation and joining. All piping should be cleaned according to the procedures 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

#### 5.8.1 **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.

#### **Flushing** 5.8.2

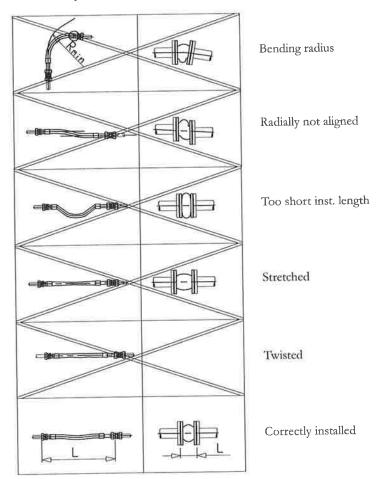
More detailed recommendations on flushing procedures are when necessary described under the relevant chapters concerning the fuel oil system and the lubricating oil system. Provisions are to be made to ensure that necessary temporary bypasses can be arranged and that flushing hoses, filters and pumps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

#### Flexible pipe connections 5.9.

Great care must be taken to ensure the 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.

## Flexible hoses (4V60B0100)



## Fuel oil system

#### 6.1. General

Fuel characteristics of the fuels are presented under heading Fuel characteristics in the Chapter for General data and outputs.

#### 6.1.1 Operating principals

The engine needs regulated fuel system before and after the engine to control viscosity and temperature of the fuel. Fuel systems are recommended to be closed due to better control of viscosity and temperature and conservation of the heating energy.

#### Fuel heating and cooling

The fuel temperature has to be controlled so that the viscosity of the fuel before injection pumps is stable and according to the limits specified in chapter General data and outputs.

#### 6.1.2 Black out starting

For stand-by generating set engines sufficient fuel pressure for a safe start must be ensured in a case of a black out. This can be done with:

- a gravity tank min. 15 m above the engine centerline
- a pneumatic emergency pump (1P11)
- an electric motor driven pump (1P11) fed from an emergency supply

If the engines are equipped with engine driven fuel feed pumps, see heading for MDF installations.

## 6.1.3 Number of engines

In multi-engine installations, the following main principles should be followed when dimensioning the fuel system:

 A separate fuel feed circuit is recommended for each propeller shaft (two-engine installations); in four-engine installations so that one engine from each shaft is fed from the same circuit. Main and auxiliary engines are recommended to be connected to separate fuel feed circuits.

## 6.2. MDF installations

#### 6.2.1 General

When running on MDF the fuel oil inlet temperature should be kept at maximum of +45°C. When running long periods with low load this requires an external MDF cooler (1E04) to be installed.

#### 6.2.2 Internal fuel system

The standard system comprises the following built-on equipment:

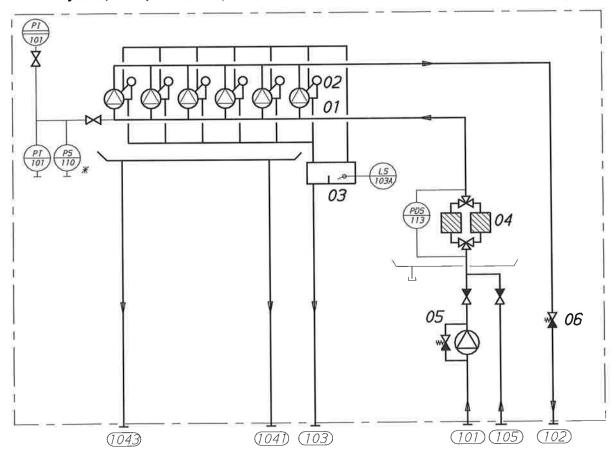
- · fuel injection pumps
- injection valves
- pressure control valve in the outlet pipe

Controlled leak fuel from the injection valves and the injection pumps is drained to atmospheric pressure (Clean leak fuel system). The clean leak fuel can be reconducted to the system without treatment. The quantity of leak fuel is given in chapter for Technical data. Possible uncontrolled leak fuel and spilled water and oil is separately drained from the hot-box and shall be led to a sludge tank ("Dirty" leak fuel system).

#### Dimensions of fuel pipe connections on the engine

Code	Description	Size	Pressure class	Standard
101	Fuel inlet, HFO	OD18	PN160	DIN 2353
101	Fuel inlet, MDF	OD28	PN100	DIN 2353
102	Fuel outlet, HFO	OD18	PN160	DIN 2353
102	Fuel outlet, MDF	OD28	PN100	DIN 2353
103	Leak fuel drain, clean fuel	OD18	Ē	ISO 3304
1041	Leak fuel drain, dirty fuel	OD22	2	ISO 3304
1043	Leak fuel drain, dirty fuel	OD18	¥	ISO 3304
105	Fuel stand-by connection	OD22	PN160	DIN 2353

#### Internal fuel system, MDF (4V76F5881b)

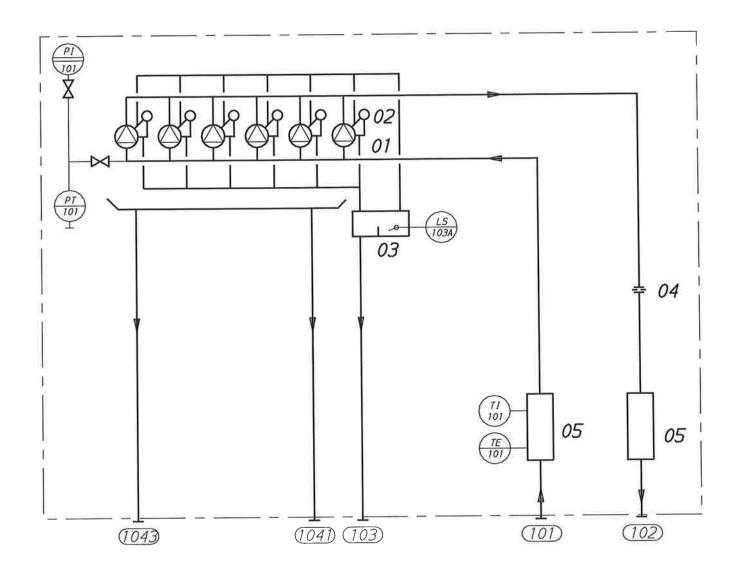


\* IF STAND-BY PUMP

#### System components

- Injection pump 01
- 02 Injection valve
- Level alarm for leak fuel oil from injection 03 pipes
- Duplex fine filter 04
- Engine driven fuel feed pump 05
- Pressure regulating valve 06

## Internal fuel system, HFO (4V76F5880a)



System components		Pipe connections	
01	Injection pump	101	Fuel inlet
02	Injection valve	102	Fuel outlet
03	Level alarm for leak fuel oil from injection pipes	103	Leak fuel drain, clean fuel
04	Adjustable orifice	1041	Leak fuel drain, dirty fuel free end
05	Pulse damper	1043	Leak fuel drain, dirty fuel fw-end

### Engine driven fuel feed pump

20

If the engine is equipped with an engine driven gear type fuel feed pump, the day tank shall be arranged so that the minimum level always remains above the top of the engine. This arrangement enables deaeration of the circuit and minimizes the risk of sucking air into the system, if there is a leakage e.g. in a pipe joint. Special measures for black-out start are not required.

### 6.2.3 External fuel system

#### General

The design of the external fuel system may vary from ship to ship but every system should provide well cleaned fuel with the correct temperature and pressure to each engine.

### Filling, transfer and storage

The ship must have means to transfer the fuel from bunker tanks to settling tanks and between the bunker tanks in order to balance the ship.

The amount of fuel in the bunker tanks depends on the total fuel consumption of all consumers onboard, maximum time between bunkering and the decided margin.

#### Separation

Even if the fuel to be used is marine diesel fuel or gas oil only, it is recommended to install a separator as there should be some means of separating water from the fuel.

## Settling tank, MDF (1T10)

In case where MDF is the only fuel onboard the settling tank should normally be dimensioned to ensure fuel supply for min. 24 operating hours when filled to maximum. The tank should be designed to provide the most efficient sludge and condensed water rejecting effect. The bottom of the tank should have slope to ensure good drainage. The MDF settling tank does not need heating coils or insulation.

The temperature in the MDF settling tank should be between 20 - 40°C.

### Separator unit, MDF (1N05)

Suction strainer for separator feed pump (1F02)

A suction filter shall be fitted to protect the feed pump.

• fineness 0.5 mm

#### Feed pump, separator (1P02)

The use of a screw pump is recommended. The pump should be separate from the separator and electrically driven.

#### Design data:

The pump should be dimensioned for the actual fuel quality and recommended throughput through the separator. The flow rate through the separator should not exceed the maximum fuel consumption by more than 10%. No control valve should be used to reduce the flow of the pump.

Operating pressure, max.

0.5 MPa (5 bar)

Operating temperature

40°C

#### Preheater, separator (1E01)

Fuels having a viscosity higher than 5 mm<sup>2</sup>/s (cSt) at 50°C need preheating before the separator. For MDF the preheating temperature should be according to the separator supplier.

#### MDF separator (1S02)

The fuel oil separator should be sized according to the recommendations of the separator supplier.

#### Sludge tank, separator (1T05)

The sludge tank should be placed below the separators and as close as possible. The sludge pipe should be continuously falling without any horizontal parts.

#### Fuel feed system

#### General

For marine diesel fuel (MDF) and fuels having a viscosity of less than 11.5 mm<sup>2</sup>/s(cSt)/50°C and if the tanks can be located high enough to prevent cavitation in the fuel feed pump, a system with an open de-aeration tank may be installed.

#### Day tank, MDF (1T06)

The diesel fuel day tank is dimensioned to ensure fuel supply for 12...14 operating hours when filled to maximum\*.

\*Note that according to SOLAS 1974 Chapter II-1 Part C Regulation 26.11 (as amended in 1981 and 1996), ships are to be fitted with two separate service tanks for fuel to propulsion and vital systems such as main engines (ME), auxiliary engines (AE) and auxiliary boilers (AB). Settling tanks must not be considered en lieu of service tanks.

Acceptable arrangements acc. to SOLAS are:

For MDO operation:		For HFO operation:	
TANK	CAPACITY FOR	TANK	<u>CAPACITY FOR</u>
MDO 1 service	ME+AE+AB 8 hours	HFO 1 service	ME+AE+AB 8 hours
MDO 2 service	ME+AE+AB 8 hours	HFO 2 service	ME+AE+AB 8 hours
		MDO service	cold start and repairs
		or	
		HFO service	ME+AE+AB 8 hours
		MDO service	ME+AE+AB 8 hours

For ME and AB or	perating on HFO and AE operating on MDO:	
TANK	CAPACITY FOR	
HFO 1 service	ME+AB 8 hours	
HFO 2 service	ME+AB 8 hours	
MDO 1 service	AE 8 hours	
MDO 2 service	AE 8 hours	
or		
HFO service	ME+AB 8 hours	
MDO 1 service	The greater of ME+AE+AB 4 hours or ME+AB 8 hours	
MDO 2 service	The greater of ME+AE+AB 4 hours or ME+AB 8 hours	

#### Suction strainer, MDF (1F07)

A suction strainer with a fineness of 0.5 mm should be installed for protecting the feed pumps.

#### Circulation pump, MDF (1P03)

The circulation pump maintains the pressure before the engine. It is recommended to use a screw pump as circulation pump.

#### Design data:

- capacity to cover the total consumption of the engines and the flush quantity of a possible automatic filter
- the pumps should be placed so that a positive static pressure of about 30 kPa is obtained on the suction side of the pumps.

## Pressure control (overflow) valve, MDF (1V02)

The pressure control valve maintains the pressure in the feed line directing the surplus flow to the suction side of the feed pump.

set point 0.4 MPa (4 bar)

#### Fuel consumption meter

If a totalizer fuel consumption meter is required, it should be fitted in the day tank feed line. In case of a continous engine fuel consumption indication is required, two meters per engine need to be installed.

#### Cooler/Heater

Since the viscosity before the engine must stay between the allowed limits stated in the Chapter for General data and outputs, a heater might be necessary in case the day tank temperature is low. Cooler is needed where long periods of low load operation is expected since fuel gets heated in the engine during the circulation. The cooler is located in the return line after the engine(s). LT-water is normally used as cooling medium.

#### Leak fuel tank, clean fuel (1T04)

Clean leak fuel drained from the injection pumps can be reused without repeated treatment. The fuel should be collected in a separate clean leak fuel tank and, from there, be pumped to the settling tank. The pipes from the engine to the drain tank should be arranged continuously sloping.

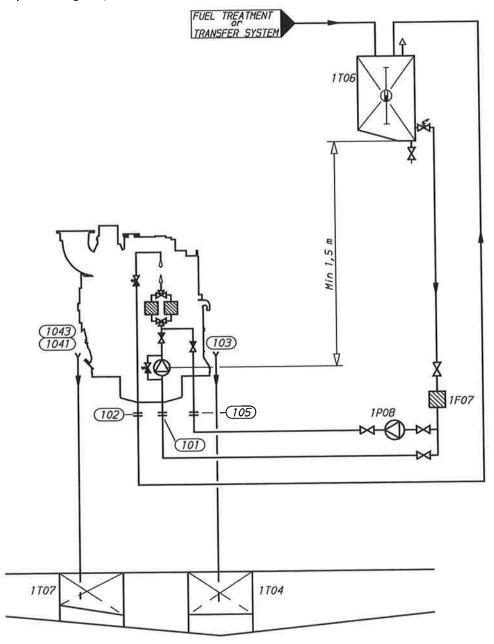
#### Leak fuel tank, dirty fuel (1T07)

Under normal operation no fuel should leak out of the dirty system. Fuel, water and oil is drained only in the event of unattended leaks or during maintenance. Dirty leak fuel pipes shall be led to a sludge tank.

#### Fuel feed unit

Fuel feed equipment can also be combined to form a unit.

## Fuel feed system, main engine (3V76F5884)



System components		Pipe connections		
1F07	Suction strainer, MDF	101	Fuel inlet	
1P08	MDF stand by pump	102	Fuel outlet	
1T04	Leak fuel tank, clean fuel	103	Leak fuel drain, clean fuel	
1T06	Day tank, MDF	1041	Leak fuel drain, dirty fuel free end	
1T07	Leak fuel tank, dirty fuel	1043	Leak fuel drain, dirty fuel flywheel end	
		105	Fuel stand-by connection	

#### 6.3. HFO installations

#### 6.3.1 General

For pumping, the temperature of fuel storage 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 design of the external fuel system may vary from ship to ship, but every system should provide well cleaned fuel with the correct temperature and pressure to each engine. When using heavy fuel it is most important that the fuel is properly cleaned from solid particles and water. In addition to the harm poorly centrifuged fuel will do to the engine, a high content of water may cause damage to the heavy fuel feed system. For the feed system, well-proven components should be used.

The fuel treatment system should comprise at least one settling tank and two (or several) separators to supply the engine(s) with sufficiently clean fuel. Dimensioning of HFO separators is of greatest importance and therefore the recommendations of the separator designer should be closely followed.

The vent pipes of all tanks containing heavy fuel oil must be continuously upward sloping.

#### Remarks:

When dimensioning the pipes of the fuel oil system common known rules for recommended fluid velocities must be followed.

The fuel oil pipe connections on the engine can be smaller than the pipe diameter on the installation side.

#### **Fuel heating**

In ships intended for operation on heavy fuel, steam or thermal oil heating coils must be installed in all tanks.

All heat consumers should be considered:

- bunker tanks
- day and settling tanks
- trace heating
- · fuel separators
- fuel booster modules

The heating requirement of tanks is calculated from the maximum heat losses from the tank and from the requirement of raising the temperature by typically 1°C/h. The heat loss can be assumed to be 15 W/m²°C between tanks and shell plating against the sea and 3 W/m²°C between tanks and cofferdams. The heat capacity of fuel oil can be taken as 2 kJ/kg°C.

The day and settling tank temperatures are usually in the range 50 - 80°C. A typical heating capacity is 12 kW each.

Trace heating of insulated fuel pipes requires about 1.5  $\rm W/m^{20}C$ . The area to be used is the total external area of the fuel steel pipe.

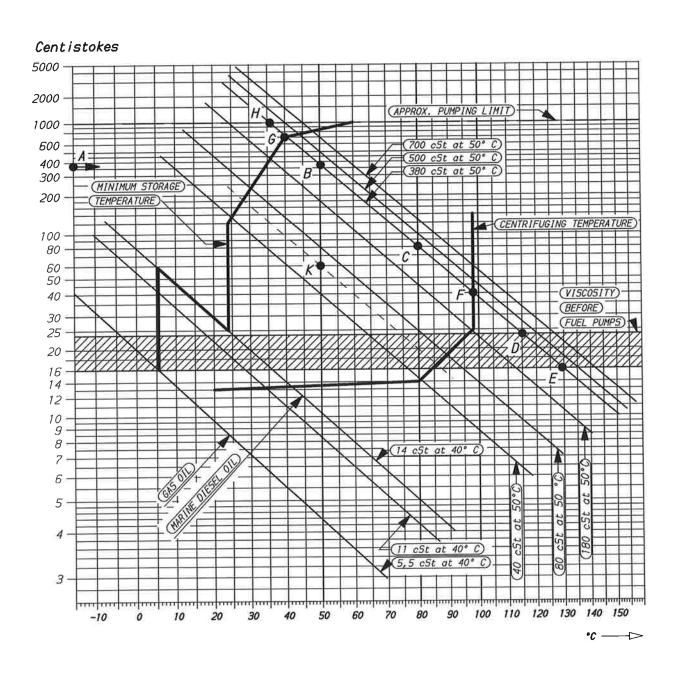
Fuel separators require typically 7 kW/installed engine MW and booster units 30 kW/installed engine MW. See also formulas presented later in this chapter.

Example: A fuel oil with a viscosity of 380 mm<sup>2</sup>/s (cSt) (A) at 50°C (B) or 80 mm<sup>2</sup>/s (cSt) at 80°C (C) must be preheated to 115 - 130°C (D-E) before the fuel injection pumps, to 98°C (F) at the centrifuge and to minimum 40°C (G) in the storage 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: Known viscosity 60 mm²/s (cSt) at 50°C (K). The following can be read along the dotted line: viscosity at 80°C = 20 mm²/s (cSt), temperature at fuel injection pumps 74 - 87°C, centrifuging temperature 86°C, minimum storage tank temperature 28°C.

Fuel oil viscosity-temperature diagram for determining the preheating temperatures of fuel oils (4V92G0071a)



#### 6.3.2 Internal fuel system

The standard system comprises the following built-on equipment:

- heavy fuel injection pumps
- injection valves
- inlet and outlet fuel damper with pressure control valve on the outlet damper

Leak fuel from the injection valves and the injection pumps is drained to atmospheric pressure (Clean leak fuel system). The clean leak fuel can be reconducted to the system without treatment. The quantity of leak fuel is given in chapter for Technical data. Possible uncontrolled leak fuel and spilled water and oil is separately drained from the hot-box and shall be led to a sludge tank ("Dirty" leak fuel system).

### Pressure control valve adjustment

For auxiliary engines installed in parallel, the pressure drop differences around engines shall be compensated with the control valve on the outlet pulse damper. It is recommended to install pressure gauges at suitable places to be able to verify the pressure drop. If pressures can not be measured onboard, the temperatures can be used for a rough estimation.

The adjustment on the control valves should be carried out after the pressure regulating valve in the fuel system has been adjusted to approximately 6-7 bar with all control valves fully open. The adjustment must be tested in different loading situations including the cases with one or more of the engines being in stand by mode. If the main engine is connected to the same fuel booster unit the circulation/temperatures must also be checked with and without the main engine being in operation.

Matters other than piping geometry that can influence on the circulation/temperatures are:

- overflow valve adjustment
- fuel pipe insulation
- trace heating efficiency
- booster pump and/or heater sizing
- set point on the feeder and/or booster pump safety valve

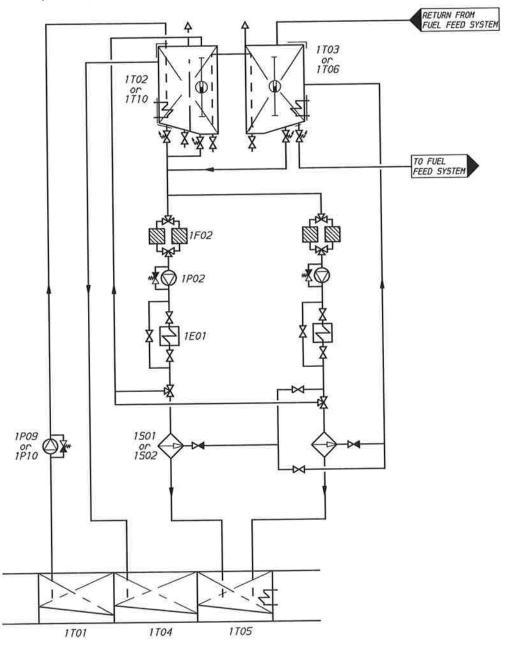
#### 6.3.3 External fuel system

#### General

The engine is designed for continuous heavy fuel operation. It is, however, possible to operate the engine on diesel fuel without making any alterations.

The engine can be started and stopped on heavy fuel provided that the engine and the fuel system are preheated to operating temperature. Switch-over from HFO to MDF for start and stop is not recommended.

## Fuel transfer and separating system (3V76F5882)



#### System components

1E01	Heater	1T01	Bunker tank
1F02	Suction filter	1T02	Settling tank, HFO
1P02	Feed pump	1T03	Day tank, HFO
1P09	Transfer pump, HFO	1T04	Overflow tank
1P10	Transfer pump, MDF	1T05	Sludge tank
1S01	Separator, HFO	1T06	Day tank, MDF
1S02	Separator, MDF	1T10	Settling tank, MDF

Note that settling and day tanks have been drawn separate in order to show overflow pipe. They normally have common intermediate wall and insulation.

#### Filling, transfer and storage

The ship must have means to transfer the fuel from bunker tanks to settling tanks and between the bunker tanks in order to balance the ship.

The amount of fuel in the bunker tanks depends on the total fuel consumption of all consumers onboard, maximum time between bunkering and the decided margin.

#### Separation

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

#### Separator mode of operation

Two separators, both of the same size, should be installed. The capacity of one separator to be sufficient for the total fuel consumption. The other (stand-by) separator should also be in operation all the time.

It is recommended that conventional separators with gravity disc are arranged for operation in series, the first as a purifier and the second as a clarifier. This arrangement can be used for fuels with a density up to max. abt. 991 kg/m³ at 15°C.

Separators with controlled discharge of sludge (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.

#### Settling tank, HFO (1T02)

The settling tank should normally be dimensioned to ensure fuel supply for min. 24 operating hours when filled to maximum. The tank should be designed to provide the most efficient sludge and water rejecting effect. The bottom of the tank should have slope to ensure good drainage. The tank is to be provided with a heating coil and should be well insulated.

To ensure constant fuel temperature at the separator, the settling tank temperature should be kept stable. The temperature in the settling tank should be between 50...70°C.

The min. level in the settling tank should be kept as high as possible. In this way the temperature will not decrease too much when filling up with cold bunker.

#### Separator unit (1N02)

### Suction strainer for separator feed pump (1F02)

A suction strainer shall be fitted to protect the feed pump. The strainer should be equipped with a heating jacket in case the installation place is cold.

• fineness 0.5 mm

#### Feed pump, separator (1P02)

The pump should be dimensioned for the actual fuel quality and recommended throughput through the separator. The flow rate through the separator should not exceed the maximum fuel consumption by more than 10%. No control valve should be used to reduce the flow of the pump.

Design data:

delivery pressure (max.)

0.2 MPa (2 bar)

• operating temperature

100°C

viscosity for dimensioning electric motor

 $1000 \text{ mm}^2/\text{s} \text{ (cSt)}$ 

#### Preheater, separator (1E01)

The preheater is normally dimensioned according to the feed pump capacity and a given settling tank temperature. The heater surface temperature must not be too high in order to avoid cracking of the fuel.

The heater should be controlled to maintain the fuel temperature within  $\pm$  2°C. The recommended preheating temperature for heavy fuel is 98°C.

Design data:

The required minimum capacity of the heater is:

 $P(kW) = m(1/h) \Delta t(^{\circ}C) / 1700$ 

P(kW) = heater capacity

m = capacity of the separator feed pump

 $\Delta t = \text{temperature rise in heater}$ 

For heavy fuels  $\Delta t = 48$ °C can be used, i.e. a settling tank temperature of 50°C.

Fuels having a viscosity higher than 5 mm<sup>2</sup>/s (cSt) at 50°C need preheating before the separator.

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

## HFO separator (1S01)

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The fuel oil separator should be sized according to the recommendations of the separator supplier.

Based on a separation time of 23 or 23.5 h/day, the nominal capacity of the separator can be estimated acc. to the following formula:

$$Q[l/h] = \frac{P[kW] \cdot b \cdot 24[h]}{\rho \cdot t[h]}$$

where:

P = max. continuous rating of the diesel engine

b = specific fuel consumption + 15% safety margin

 $\rho$  = density of the fuel

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

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

### Sludge tank, separator (1T05)

The sludge tank should be placed below the separators and as close as possible. The sludge pipe should be continuously falling without any horizontal parts.

#### Fuel feed system

#### General

The fuel feed system for HFO shall be of the pressurized type in order to prevent foaming in the return lines and cavitation in the circulation pumps.

The heavy fuel pipes shall be properly insulated and equipped with trace heating, if the viscosity of the fuel is 180 mm²/s (cSt)/50°C or higher. It shall be possible to shut-off the heating of the pipes when running MDF (the tracing pipes to be grouped together according to their use).

Any provision to change the type of fuel during operation should be designed to obtain a smooth change in fuel temperature and viscosity, e.g. via a mixing tank. When changing from HFO to MDF, the viscosity at the engine should be above 2.8 mm²/s(cSt) and not drop below 2.0 mm²/s(cSt) even during short transient conditions. In certain applications a cooler may be necessary.

#### Day tank, HFO (1T03)

The heavy fuel day tank is usually dimensioned to ensure fuel supply for about 24 operating hours when filled to maximum (see note for MDF day tanks). The design of the tank should be such that water and dirt particles do not accumulate in the suction pipe. The tank has to be provided with a heating coil and should be well insulated.

Maximum recommended viscosity in the day tank is 140 mm<sup>2</sup>/s (cSt). Due to the risk of wax formation, fuels with a viscosity lower than 50 mm<sup>2</sup>/s (cSt)/50°C must be kept at higher temperatures than what the viscosity would require.

Fuel viscosity	Minimum day tank
(mm <sup>2</sup> /s (cSt) at 100°C)	temperature (°C)
55	80
35	70
25	60

#### Feeder/booster unit (1N01)

A completely assembled fuel feed unit can be supplied as an option.

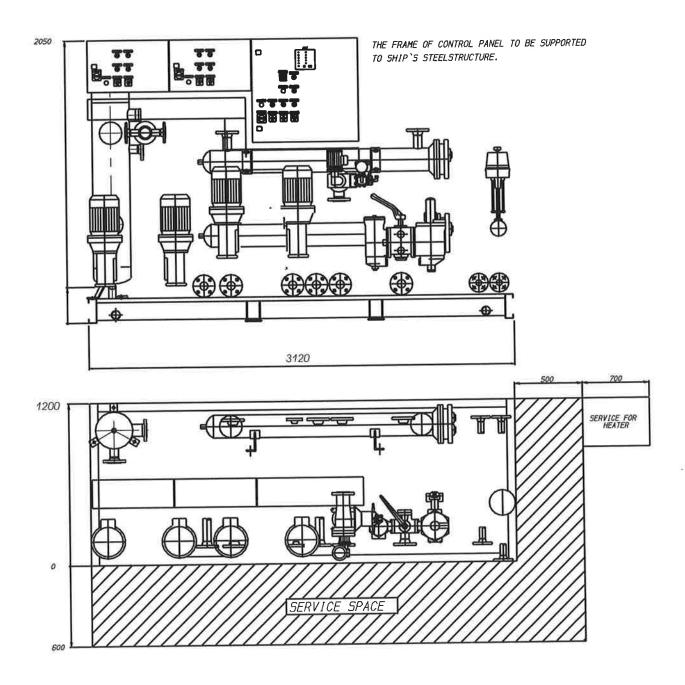
This unit normally comprises the following equipment:

- two suction strainers
- two booster 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 circulation pumps, same type as above
- two heaters, steam, electric or thermal oil (one in operation, the other as spare)
- one automatic back-flushing filter with by-pass filter
- one viscosimeter for the control of the heaters
- one steam or thermal oil control valve or control cabinet for electric heaters
- one thermostat for emergency control of the heaters
- one control cabinet with starters for pumps, automatic filter and viscosimeter
- one alarm panel

The above equipment is built on a steel frame, which can be welded or bolted to its foundation in the ship. All heavy fuel pipes are insulated and provided with trace heating.

When installing the unit, only power supply, group alarms and fuel, steam and air pipes have to be connected.

#### Fuel feed unit, example (4V76F5613)



## Suction strainer HFO (1F06)

A suction strainer with a fineness of 0.5 mm should be installed for protecting the feed pumps. The strainer should be equipped with a heating jacket.

### Feed pump, HFO (1P04)

The feed pump maintains the pressure in the fuel feed system. It is recommended to use a high temperature resistant screw pump as feed pump.

#### Design data:

- capacity to cover the total consumption of the engines and the flush quantity of a possible automatic filter
- The pumps should be placed so that a positive static pressure of about 30 kPa is obtained on the suction side of the pumps.

- delivery pressure

0.6 MPa (6 bar)

- operating temperature

100°C

- viscosity for dimensioning electric motor

1000 mm<sup>2</sup>/s (cSt)

### Pressure control (overflow) valve HFO

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

set point

0.3...0.5 MPa (3...5 bar)

## Automatically cleaned fine filter, HFO (1F08)

The use of automatic back-flushing filters is recommended, installed between the feeder pumps and the deaeration tank in parallel with an insert filter as the stand-by half.

For back-flushing filters the feed pump capacity should be sufficient to prevent pressure drop during the flushing operation.

#### Design data:

• fuel oil according to spec.

• operating temperature 0...100°C

• preheating from 25 mm<sup>2</sup>/s

(cSt)/100°C

• flow feed pump capacity

• operating pressure 1 MPa (10 bar)

• design pressure 1.6 MPa (16 bar)

• test pressure fuel side 2 MPa(20 bar)

heating jacket 1 Mpa

(10 bar)

• fineness:

= back-flushing filter  $35 \,\mu\text{m}$  (absolute mesh

size)

= insert filter  $35 \,\mu\mathrm{m}$  (absolute mesh

size)

• Maximum recommended pressure drop for normal filters at 14 mm<sup>2</sup>/s (cSt):

- clean filter 20 kPa (0.2 bar) - dirty filter 60 kPa (0.6 bar) - alarm

80 kPa (0.8 bar)

#### Fuel consumption meter (1101)

If a fuel consumption meter is required, it should be fitted between the feed pumps and the de-aeration tank. An automatically opening by-pass line around the consumption meter is recommended in case of possible clogging.

#### De-aeration tank (1T08)

The volume of the tank should be about 50 l. It shall be equipped with a vent valve, controlled by a level switch. It shall also be insulated and equipped with a heating coil. The vent pipe should, if possible, be led downwards, e.g. to the overflow tank.

#### Circulation pump, HFO (1P06)

The purpose of this pump is to circulate the fuel in the system and to maintain the pressure stated in the chapter for Technical data at the injection pumps. It also circulates the fuel in the system to maintain the viscosity, and keeps the piping and injection pumps at operating temperature.

The feed pump capacity should be sufficient to prevent pressure drop during the flushing of the automatic filter if installed on the pressure side of this pump.

Design data:

- capacity constant (see below) times the total consumption of the engines and the flushing of the automatic filter
- capacity constant

- pressure 1 MPa (10 bar)

- temperature 150°C

- viscosity (for dimensioning

the el. motor) 500 mm<sup>2</sup>/s (cSt)

#### Heater (1E02)

The heater(s) is normally dimensioned to maintain an injection viscosity of 14 mm<sup>2</sup>/s (cSt) according to the maximum fuel consumption and a given day tank temperature.

To avoid cracking of the fuel the surface temperature in the heater must not be too high. The surface power of electric heaters must not be higher than 1.5 W/cm2. The output of the heater shall be controlled by a viscosimeter. As a reserve a thermostat control may be fitted.

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.

Design data:

The required minimum capacity of the heater is:

 $P(kW) = m(l/h) \Delta t(^{\circ}C) / 1700$ 

P(kW) = heater capacity

m = evaluated by multiplying the specific fuel consumption of the engines by the total max. output of the engines

 $\Delta t$  = temperature rise, higher with increased fuel viscosity To compensate for heat losses due to radiation the above power should be increased with 10% + 5 kW.

The following values can be used:

Fuel viscosity	Temperature rise
(mm <sup>2</sup> /s (cSt) at 100°C)	in heater (°C)
55	65 (80 in day tank)
35	65 (70 in day tank)
25	60 (60 in day tank)

#### Viscosimeter (1102)

For the control of the heater(s) a viscosimeter has to be installed. A thermostatic control shall be fitted, to be used as safety when the viscosimeter is out of order. The viscosimeter should be of a design, which stands the pressure peaks caused by the injection pumps of the diesel engine.

Design data:

•	operation range	$050 \text{ mm}^2/\text{s (cSt)}$
•	temperature	180°C
•	pressure	4 MPa (40 bar)

#### Safety filter (1F03)

Since no fuel filters are built on the engine, one duplex type safety filter with an alarm contact for high differential pressure is installed between the booster module and the engine. The filter should be located as close to the engine as possible. A common filter can be used for all engines after each booster module.

• min. fineness  $50 \,\mu\text{m}$ 

#### Overflow valve (1V05)

This valve limits the maximum pressure in fuel line to the engine by relieving the pressure to the return line.

# Pressure control valve on the return line (1V04)

This valve controls the pressure in the return line from the engine.

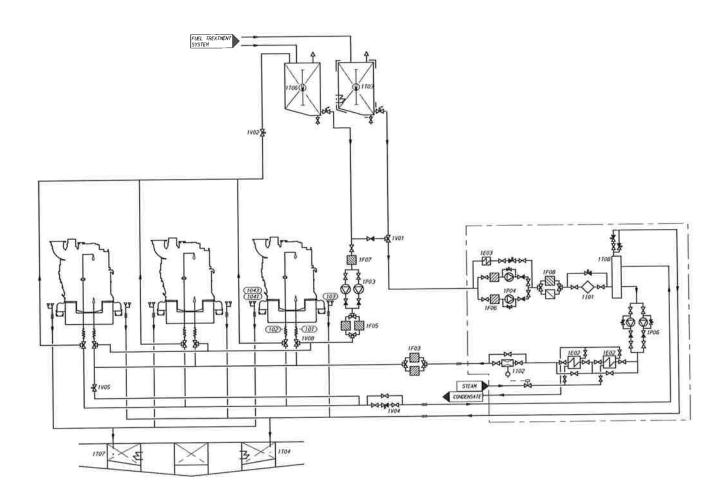
#### Leak fuel tank, clean fuel (1T04)

Clean leak fuel drained from the injection pumps can be reused without repeated treatment. The fuel should be collected in a separate clean leak fuel tank and, from there, be pumped to the settling tank. The pipes from the engine to the drain tank should be arranged continuously sloping and should be provided with heating and insulation.

### Leak fuel tank, dirty fuel (1T07)

Under normal operation no fuel should leak out of the dirty system. Fuel, water and oil is drained only in the event of unattended leaks or during maintenance. Dirty leak fuel pipes shall be led to a sludge tank and be trace heated and insulated.

## Fuel feed system, auxiliary engines (3V76F5883a)



Creaton	components
SVSICILI	COHIDOHICHES

System co	omponents		
1E02	Heater	1V01	Change over valve
1E03	Cooler	1V02	MDF pressure control valve
1F03	Safety filter, HFO	1V04	Pressure control valve
1F05	Safety filter, MDF	1V05	Overflow valve
1F06	Suction strainer, HFO	1V08	3-way change over valve
1F07	Suction strainer, MDF		
1F08	Automatic filter		
1101	Flowmeter		
1102	Viscosimeter	Pipe connecti	ons
1P03	MDF pump	101	Fuel inlet
1P04	Fuel feed pump, HFO	102	Fuel outlet
1P06	Circulation pump	103	Leak fuel drain, clean fuel
1T03	Day tank, HFO	1041	Leak fuel drain, dirty fuel free end
1T04	Leak fuel tank, clean fuel	1043	Leak fuel drain, dirty fuel flywheel end
1T06	Day tank, MDF		
1T07	Leak fuel tank, dirty fuel		
1T08	De-aeration tank		

## 7. Lubricating oil system

#### 7.1. General

Each engine should have a lubricating oil system of its own. Engines operating on heavy fuel should have continuous centrifuging of the lubricating oil.

The following equipment is built on the engine as standard:

- Engine driven lubricating oil pump
- Prelubricating oil pump
- Lubricating oil cooler
- Thermostatic valve
- Automatic filter
- Centrifugal filter
- Pressure control valve

The following equipment can be mounted on the engine as optional:

• Stand by pump connections

The engine sump is normally: Wet

Dry sump is available upon request.

## 7.2. Lubricating oil quality

#### **Engine lubricating oil**

The system oil should be of viscosity class SAE 40 (ISO VG 150).

The alkalinity, BN, of the system oil should be 30 - 55 mg/KOH/g in heavy fuel use; higher at higher sulphur content of the fuel. It is recommended to use BN 40 lubricants with category C fuels. The use of high BN (50 - 55) lubricants in heavy fuel installations is recommended, if the use of BN 40 lubricants causes short oil change intervals.

Modern trunk piston diesel engines are stressing the lubricating oils due to low specific lubricating oil consumption. Also the ingress of residual fuel combustion products into the lubricating oil can cause deposit formation on the surface of certain engine components. Due to this many lubricating oil suppliers have developed new lubricating oil formulations with better fuel and lubricating oil compatibility.

If MDF is used as fuel, a lubricating oil with a BN of 10 - 22 is recommended. However, an approved lubricating oil with a BN of 24 - 30 can also be used, if the desired lower BN lubricating oil brand is not included in table below.

Table 7.1. Approved system oils - recommended in the first place, in gas oil (A) or marine diesel oil (B) installations

Supplier	Brand name	Viscosity	BN	Fuel category
BP	Energol HPDX40	SAE 40	12	A
	Energol IC-HFX 204	SAE 40	20	A, B
Castrol	MHP 154	SAE 40	15	A, B
	Seamax Extra 40	SAE 40	15	A, B
	TLX 204	SAE 40	20	A, B
Chevron Texaco	Delo 1000 Marine 40	SAE 40	12	A
(Caltex + FAMM)	Delo 2000 Marine 40	SAE 40	20	A, B
	Taro 20 DP 40	SAE 40	20	A, B
ExxonMobil	Mobilgard ADL 40	SAE 40	15	A, B
	Mobilgard 412	SAE 40	15	A, B
	Mobilgard 1 SHC	SAE 40	15	A, B
Petrobras	Marbrax CCD-410-AP	SAE 40	12	A
	Marbrax CCD-415	SAE 40	15	A, B
	Marbrax CCD-420	SAE 40	20	A, B
Shell	Gadinia Oil 40	SAE 40	12	A
	Sirius FB Oil 40	SAE 40	13	A
Statoil	MarWay SP40	SAE 40	12	A
TotalFina Elf/	Disola M 4015	SAE 40	14	Λ
Lubmarine	Aurelia 4020	SAE 40	20	A, B
	Caprano S 412	SAE 40	12	A
	Stellano S 420	SAE 40	20	A, B

The lubricating oils mentioned in the table below are representing a new detergent/dispersant additive chemistry and have shown good performance in HFO operation. These lubricating oils are recommended in the first place in order to reach full service intervals.

Table 7.2. Approved system oils: lubricating oils with improved detergent/dispersant additive chemistry - heavy fuel (C), recommended in the first place

Supplier	Brand name	Viscosity	BN	Fuel category
ВР	Energol IC-HFX 404	SAE 40	40	С
/ <u>1</u>	Energol IC-HFX 504	SAE 40	50	С
Castrol	TLX 404	SAE 40	40	С
Castroi	TLX 504	SAE 40	50	С
	TLX 554	SAE 40	55	С
 Cepsa	Troncoil 4040 PLUS	SAE 40	40	C
Sepsa	Troncoil 4050 PLUS	SAE 40	50	С
	Ertoil Koral 4040 SHF	SAE 40	40	С
	Ertoil Koral 4050 SHF	SAE 40	50	С
ChevronTexaco	Taro 40 XL 40	SAE 40	40	C
(Caltex + FAMM)	Taro 50 XL 40	SAE 40	50	С
Conton . A Little,	Delo 3400 Marine 40	SAE 40	40	С
	Delo 3550 Marine 40	SAE 40	55	С
ExxonMobil	Exxmar 40 TP 40	SAE 40	40	С
- AROHITIODA	Exxmar 50 TP 40	SAE 40	50	С
	Mobilgard M 440	SAE 40	40	С
	Mobilgard M50	SAE 40	50	С
	Mobilgard 440	SAE 40	40	С
	Mobilgard 50 M	SAE 40	50	C
	Mobilgard SP 55	SAE 40	55	С
Pertamina	Martron 440	SAE 40	40	С
	Martron 450	SAE 40	50	С
Petrobras	Marbrax CCD-440	SAE 40	40	С
	Marbrax CCD-450	SAE 40	50	С
Petron	Petromar XC 4040	SAE 40	40	С
	Petromar XC 5540	SAE 40	55	С
Repsol YPF	Neptuno W NT 4000 SAE 40	SAE 40	40	С
	Neptuno W NT 5500 SAE 40	SAE 40	55	С
Shell	Argina X 40	SAE 40	40	С
	Argina XL 40	SAE 40	50	С
Statoil	MarWay 4040	SAE 40	40	С
	MarWay 5040	SAE 40	50	С
TotalFinaElf/	Aurelia XL 4055	SAE 40	55	С
Lubmarine	Aurelia XT 4040	SAE 40	40	C
	Aurelia XT 4055	SAE 40	55	C
	Stellano S 440	SAE 40	40	С
	Stellano S 450	SAE 40	50	C

The lubricating oils in table below, representing conventional additive technology, are also approved for use. However, with these lubricating oils, the service intervals will most likely be shorter.

NB! Different oil brands must not be blended unless approved by oil supplier and, during guarantee time, by engine manufacturer.

Table 7.3. Approved system oils: lubricating oils with conventional detergent/dispersant additive chemistry

Supplier	Brand name	Viscosity	BN	Fuel category
ВР	Energol IC-HFX 304	SAE 39	30	A, B, C
Castrol	TLX 304	SAE 40	30	A, B, C
Cepsa	Troncoil 3040 PLUS	SAE 40	30	A, B, C
	Ertoil Koral 3040 SHF	SAE 40	30	A, B, C
ChevronTexaco	Taro 30 DP 40	SAE 40	30	A, B, C
(Caltex + FAMM)	Delo 3000 Marine 40	SAE 40	30	A, B, C
ExxonMobil	Exxmar 30 TP 40	SAE 40	30	A, B, C
	Mobilgard M 430	SAE 40	30	A, B, C
	Mobilgard 430	SAE 40	30	A, B, C
Pertamina	Martron 430	SAE 40	30	A, B, C
Petrobras	Marbrax CCD-430	SAE 40	30	A, B, C
Petron	Petromar XC 3040	SAE 40	30	A, B, C
Shell	Argina T 40	SAE 40	30	A, B, C
Statoil	MarWay 3040	SAE 40	30	A, B, C
TotalFinaElf/	Aurelia 4030	SAE 40	30	A, B, C
Lubmarine	Stellano S 430	SAE 40	30	A, B, C

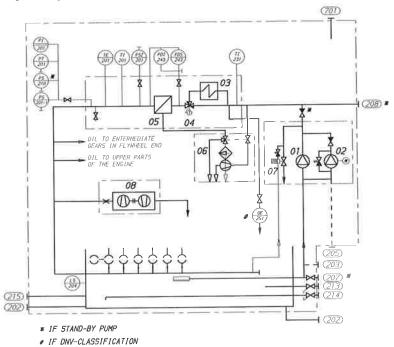
# 7.3. Internal lubricating oil system

Depending on the type of application the lubricating oil system built on the engine can vary somewhat in design.

Dimensions of lubricating oil pipe connections on the engine

Pipe c	onnections	Size	Pressure class	Standard
202	Lubrication oil outlet (if dry sump)	DN100	see 4V32A0506	
203	Lubrication oil to engine driven pump (if dry sump)	DN100	see 4V32A0506	
205	Lubrication oil to priming pump (if dry sump)	DN32	PN40	ISO 7005-1
207	Lubrication oil to electric driven pump	DN100	PN16	ISO 7005-1
208	Lubrication oil from electric driven pump	DN80	PN16	ISO 7005-1
213	Lubrication oil from separator and filling	DN32	PN40	ISO 7005-1
214	Lubricating oil to separator and drain	DN32		
215	Lubricating oil filling	M48*2		
701	Crankcase air vent	DN65		

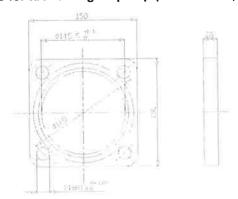
### Internal lubricating oil system (4V76E3854b)



#### System components

01	Lubricating oil main pump
02	Prelubricating oil pump
03	Lubricating oil cooler
04	Thermostatic valve
05	Automatic filter
06	Centrifugal filter
07	Pressure control valve
08	Turbocharger

Flange for lubricating oil pump (4V32A0506a)



### 7.3.1 Lubricating oil pump

The direct driven lubricating oil pump is of the gear type. The pump is dimensioned to provide sufficient flow even at low speeds and is equipped with an overflow valve which is controlled from the oil inlet pipe. If necessary, the engine is provided with pipe connections for a separate, electric motor driven stand-by pump.

Concerning flow rates and pressures, see Technical Data. The suction height of the pump should not exceed 4 m.

#### 7.3.2 Prelubricating pump

The prelubricating pump is an electric motor driven constant volume pump equipped with a safety valve.

The pump is of screw type.

The pump is used for:

- Filling of the engine lubricating oil system before starting, e.g. when the engine has been out of operation for a long time
- Continuous prelubrication of a stopped engine through which heated heavy fuel is circulating
- Continuous prelubrication of a stopped engine(s) in a multi-engine installation always when any one engine is running

Concerning flow and pressures, see Technical Data. The suction height of the built-on prelubricating pump should not exceed 3.5 m.

### 7.3.3 Lubricating oil cooler

The lubricating oil cooler is a brazed plate cooler and it is integrated in the lubricating oil module.

#### 7.3.4 Thermostatic valve

The thermostatic valve is integrated in the lubricating oil module.

## 7.3.5 Lubricating oil automatic filter

The lubricating oil fine filter is a back flushing automatic filter with sludge discharge to the centrifugal filter.

Design data:

• Fine filter (full flow)  $25 \mu m$ • Safety net (full flow)  $100 \mu m$ 

#### 7.3.6 Centrifugal filter

The centrifugal filter is powered by oil flow and filters the back flush of fine filter.

#### 7.3.7 Lubricating oil module

The lubricating oil module, consisting of filters, thermostatic valve and oil cooler, is supported directly on the engine block.

# 7.4. External lubricating oil system

When designing the piping diagram, the procedure to flush the system should be clarified and presented in the diagram.

#### 7.4.1 System oil tank (2T01)

The dry engine sump has two drain outlets at the flywheel end and two at the free end. Two of the drains shall be connected. The pipe connection between the sump and the system oil tank should be arranged flexible enough to allow thermal expansion.

Recommendations for the tank design are given in the drawing of the engine room arrangement. The tank must not be placed so that the oil is cooled so much that the recommended lubricating oil temperature cannot be obtained. If there is space enough a cofferdam below the tank is recommended.

Design data:

- Oil volume 1.2...1.5 l/kW
- Tank filling 75...80%

#### 7.4.2 Suction strainer (2F06)

A suction strainer complemented with magnetic rods can be fitted in the suction pipe to protect the lubricating oil pump.

The suction strainer as well as the suction pipe diameter should be amply dimensioned to minimize the pressure loss. The suction strainer should always be provided with alarm for high differential pressure.

• Fineness 0.5...1.0 mm

# 7.4.3 Lubricating oil pump, stand-by (2P04)

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

Design data:

Capacity see Technical data

Operating pressure, max 8 bar
Operating temperature, max. 100°C
Lubricating oil viscosity SAE 40

## 7.5. Separation system

#### Separator (2N01)

For HFO operation the lubrication oil separator should be dimensioned for continuous centrifuging. For MDF intermittent centrifuging might be sufficient. Each lubricating oil system should have a separator unit of its own.

Each main engine operating on heavy fuel shall have a dedicated separator.

Auxiliary engines operating on a fuel having a viscosity of max.  $35 \,\mathrm{mm^2/s}$  (cSt) /  $100^{\circ}\mathrm{C}$  may have a common separator. In installations with four or more auxiliary engines two separators should be installed.

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

The separators should be dimensioned for continuous operation.

Design data:

90 - 95°C · Centrifuging temperature

Capacity:

Q = 1.36 P n / t

Where:

Q = volume flow [1 / h]

P = total engine output

n = number of through-flows of dry sump system oil tank volume n/day: 5 for HFO, 4 for MDF

t = operating time [h / day]: 24 for continuos separatoroperation, 23 for normal dimensioning

Note!

Det Norske Veritas states in their class rules of July 2001 that come into force 1.1.2002 the following:

(Pt.4 Ch.6 Sec.5 C 203) "For diesel engines burning residual oil fuel, cleaning of the lubrication oil by means of purifiers are to be arranged. These means are additional to filters."

## 7.5.2 Separator pump (2P03)

The separator pump can be directly driven by the separator or separately driven by an electric motor. The flow should be adapted to achieve the above mentioned optimal flow.

## 7.5.3 Separator preheater (2E02)

The preheater can be a steam, thermal oil or an electric heater. The surface temperature of the heater must not exceed 150°C in order to avoid coking of the oil.

Design data

- · For engines with centrifuging during operation, the heater should be dimensioned for this operating condition. The temperature in the separate system oil tank in the ship's bottom is normally 65 - 75°C.
- For engines with centrifuging stopped engine, the heater should be large enough to allow centrifuging at optimal rate of the separator without heat supply from the diesel engine.

Note!

The heaters are to be provided with safety valves with escape pipes to a leakage tank so that the possible leakage can

#### 7.5.4 Renovating oil tank (2T04)

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

#### 7.5.5 Renovated oil tank (2T05)

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

## 7.6. Filling, transfer and storage

## 7.6.1 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.

## 7.7. Crankcase ventilation system

A crankcase vent pipe shall be provided for each engine. If the engine has a dry sump and there is a system oil tank, this tank shall have its own vent pipe. Vent pipes of several engines and vent pipes of engine crankcases and tanks should not be joined together.

The connection between the engine and the vent pipe is to be flexible.

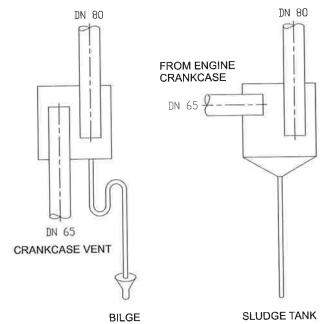
A condensate trap shall be fitted on all vent pipes within 1 -2 meters of the engine, see drawing 4V76E2522.

Recommended size of the vent pipe after the condensate trap is DN 80

Pipe connection engine:

Crankcase air vent DN65, ISO 7005-1, NP16

#### Crankcase ventilation (4V76E2522)



## 7.8. Flushing instructions

If the engine is equipped with a wet oil sump and the complete lubricating oil system is built on the engine, flushing is not required. The system oil tank should be carefully cleaned and the oil separated to remove dirt and welding slag.

If the engine is equipped with a dry sump and parts of the lubricating oil system are off the engine, these must be flushed in order to remove any foreign particles before start up.

If an electric motor driven stand-by pump is installed, this should be used for the flushing. In case only an engine driven main pump is installed, the ideal is to use for flushing a temporary pump of equal capacity as the main pump.

The circuit is to be flushed drawing the oil from the sump tank pumping it through the off-engine lubricating oil system and a flushing oil filter with a mesh size of 34 microns or finer and returning the oil through a hose and a crankcase door to the engine sump.

The flushing pump should be protected by a suction strainer. Automatic lubricating oil filters, if installed, must be bypassed during the first hours of flushing.

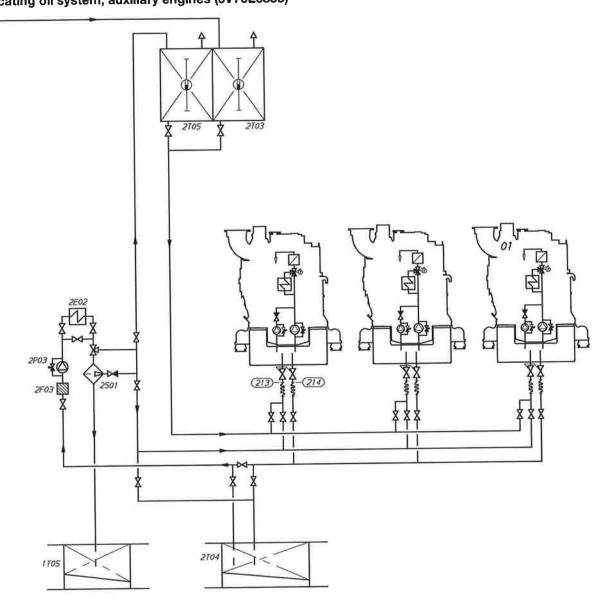
The flushing is more effective if a dedicated heated low viscosity flushing oil is used or if the engine oil is heated. Furthermore, lubricating oil separators should be in operation prior to and during the flushing.

The minimum recommended flushing time is 24 hours. During this time the welds in the lubricating oil piping should be gently knocked at with a hammer to release slag and the flushing filter inspected and cleaned at regular intervals.

Either a separate flushing oil or the approved engine oil can be used for flushing. Even if an approved engine oil is used, it cannot further be used as engine oil.

## 7.9. System diagrams

Lubricating oil system, auxiliary engines (3V76E3855)



System components

Sludge tank 1T05

2E02 Heater

Suction strainer 2F03

2P03 Separator pump

2S01 Separator

2T03 New oil tank

2T04 Renovating oil tank

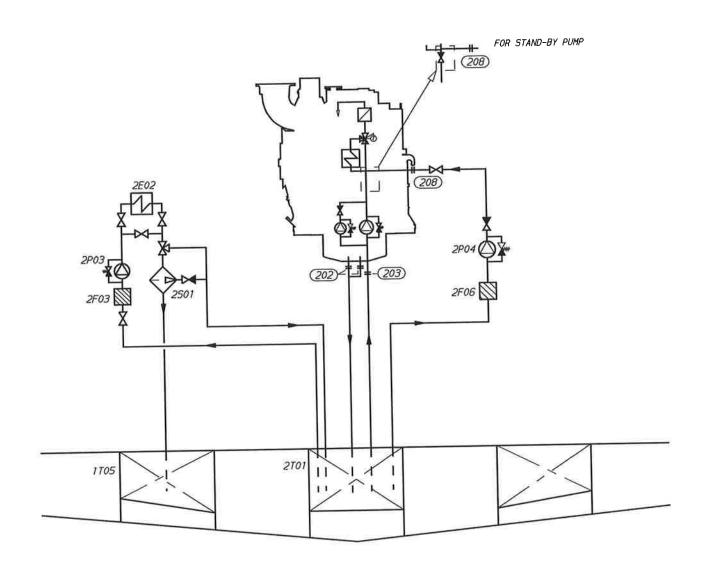
Renovated oil tank 2T05

Pipe connections

Lubrication oil from separator and filling 213

Lubrication oil to separator and drain 214

## Lubricating oil system, main engine (3V76E3856b)



#### System components

1T05	Sludge tank
2E02	Heater
2F03	Suction strainer
2F06	Suction strainer
2P03	Separator pump
2P04	Stand-by lubrication oil pump
2S01	Separator
2T01	System oil tank

#### Pipe connections

202	Lubrication oil outlet (from oil sump)
203	Lubrication oil to engine driven pump
208	Lubrication oil from electric driven pump

# Compressed air system

#### 8.1. General

Compressed air is used to start engines and to provide actuating energy for safety and control devices. Compressed air is used onboard also for other purposes with different pressures. The use of starting air supply for these other purposes is limited in the classication regulations.

## 8.2. Compressed air quality

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

## 8.3. Internal starting air system

The engine is equipped with a pneumatic starting motor driving the engine through a gear rim on the flywheel.

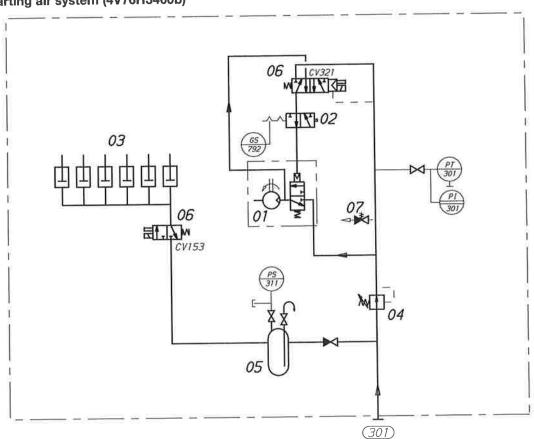
Table 8.1. Dimensions of starting air pipe connections

Code	Description	Size	Pressure class	Standard
301	Starting air inlet	OD28	PN100	DIN 2353

#### on the engine

The nominal starting air pressure of 30 bar is reduced to 10 bar with a pressure regulator mounted on the engine.

#### Internal starting air system (4V76H3460b)



#### System components

Turbine starter with pneumatic actuator 01 Blocking valve, turning gear engaged 02

Pneumatic cylinder at each injection pump 03

04 Pressure regulator

Air container 05

06 Solenoid valve

Safety valve 07

## Pipe connections

Starting air inlet

Pipe dimensions OD28

The compressed air system of the electro-pneumatic overspeed trip is connected to the starting air system. For this reason, the air supply to the engine must not be closed during operation.

## 8.4. External starting air system

The design of the starting air system is partly determined by the rules of the classification societies. Most classification societies require the total capacity to be divided over two roughly equally sized starting air receivers and starting air compressors.

If the inertia of the directly coupled equipment is much larger than the normal reference equipment used on test-bed the starting air consumption per start value has to be increased in relation to total (engine included) inertial masses involved.

External starting air system (3V76H3461)

It should be noted that the minimum pressures stated in the chapter for technical data assume that this pressure is available at engine inlet.

The rule requirements of some classification societies are not precise for multiple engine installations.

#### Starting air filter

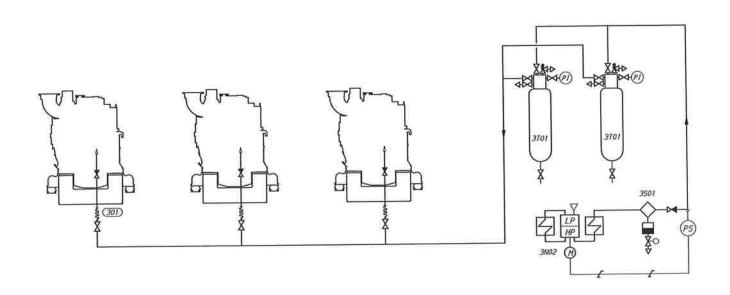
Condense formation after the water separator (between starting air compressor and starting air receivers) has been experienced in tropical areas. This can, depending of the materials and surface treatments used, create and loosen abbrasive rust from the piping, fittings and receivers.

Therefore it might be needed to install a filter in the external starting air system just before the engine to prevent particles to enter the starting air equipment if a high condense formation is expected.

#### Starting air receiver (3T01)

The starting air receiver should be dimensioned for a nominal pressure of 30 bar.

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



System components

3T01 Starting air vessel

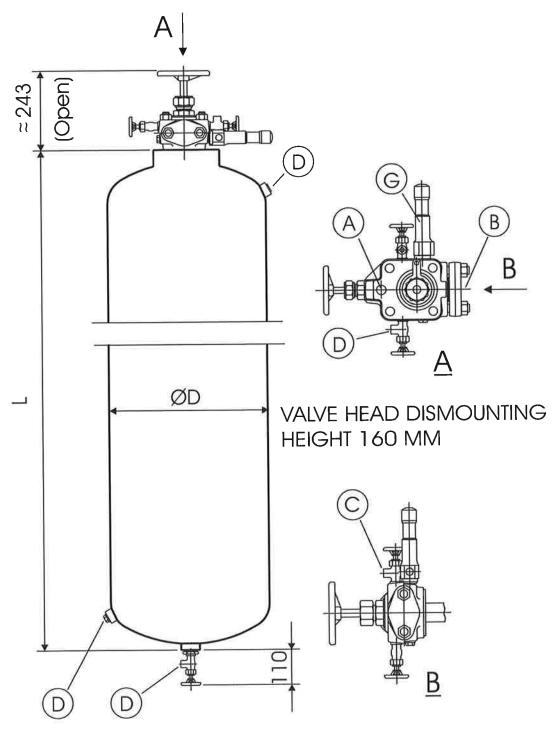
3S01 Oil and water separator

3N02 Starting air compressor

Pipe connections

301 Starting air inlet

## Starting air receiver (3V49A0133)



Connection	ons		Size [litres]	L	D	Weight [kg]
A	Inlet	G 3/4 in	125	1807	324	170
В	Outlet	To be bored max 48.3 or G 1 $\frac{1}{2}$	250	1767	480	274
С	Pressure gauge	G 1/4 in				
D	Drain	G 1/4 in				
G	Safety valve	G ½ in				

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

Recommended min. volumes of starting air vessels are:

Single main engine	2 x 125 l
Multiple main engines	2 x 250 l
• 1 - 3 auxiliary engines	2 x 125 l
• > 3 auxiliary engines	2 x 250 1

## Oil and water separator (3S01)

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

The starting air pipes should always be drawn with slope and be arranged with manual or automatic draining at the lowest points.

## Starting air compressor (3N02)

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

## **Cooling water system**

#### 9.1. General

Only treated fresh water may be used for cooling the engines.

To allow start on heavy fuel, the cooling water system has to be preheated to a temperature as near to the operating temperature as possible.

#### 9.1.1 Water quality

The cylinder, turbocharger, charge air and oil are all cooled with fresh water. The pH-value and hardness of the water should be within normal values (hardness < 10°dH, pH > 6.5). The chloride and sulphate contents should be as low as possible (chlorides < 80 mg/l). To prevent rust formation in the cooling water system, the use of corrosion inhibitors is mandatory. See the instructions in the Instruction Manual.

Shore water is not always suitable. The hardness of shore water may be too low, which can be compensated by additives, or too high, causing scale deposits even with additives.

Fresh water generated by a reverse osmosis plant onboard often has a high chloride content (higher than the permitted 80 mg/l) causing corrosion.

For ships with a wide sailing area a safe solution is to use fresh water produced by an evaporator (onboard), using additives according to the Instruction Manual (important).

Sea-water will cause severe corrosion and deposits formation even in small amounts.

Rain water is unsuitable as cooling water due to a high oxygen and carbon dioxide content, causing a great risk for corrosion.

## 9.1.2 Approved cooling water treatment products

Product	Supplier
Drewgard 4109	Drew Ameroid Marine
Maxigard	Division, Ashland
DEWT-NC powder	Chemical Company
Liquidewt	Boonton, USA
Vecom CWT Diesel QC-2	
CorrShield NT 4293	GE Betz Europe, Belgium
CorrShield NT 4200	GE Betz, Trevose, USA
Q8 Corrosion Inhibitor Long-Life	Kuwait Petroleum (Danmark) AS
Cooltreat 651	Houseman Ltd. Burnham,
	Slough, U.K.
Marisol CW	Maritech AB,
	Kristianstad, Sweden
Nalco 39 L	Nalco Chemical Company
Nalcool 2000	Naperville, Illinois, USA
Nalfleet EWT 9-108	Nalfleet Marine Chemicals
Nalfleet CWT 9-131C	Nortwich, Cheshire, U.K.
Nalcool 2000	
RD11	Rohm & Haas
RD11M	Paris, France
RD25	
Havoline XLi	S.A. Arteco N.V. Belgium
Havoline Xli	Texaco Global Products, LLC Houston, USA
Korrostop KV	RRS-Yhtiöt, Jäppilä, Finland
Ruostop XM	Tampereen Prosessi- Insinöörit
	Pirkkala, Finland
Dieselguard NB	Unitor ASA, Oslo
Rocor NB liquid	Norway
Cooltreat AL	
Vecom CWT Diesel QC-2	Vecom Holding B.V.
	Maassluis, Holland
W T Supra	TotalFinaElf, Paris, France

#### **Glycol**

Use of glycol in the cooling water is not recommended. It is however possible to use up to 10% glycol without engine derating. For higher concentrations the engine shall be derated 0.67% for each percentage unit exceeding 10.

# 9.2. Internal cooling water system

#### 9.2.1 Charge air cooler

The charge air cooler built on the engine is of the insert type with removable cooler insert.

Design data:

• See Technical data

# 9.2.2 Engine driven circulating cooling water pumps

The LT and HT circuit circulating pumps are always engine driven. The pumps are centrifugal pumps driven by the engine crankshaft through a gear transmission.

The HT and LT water pump impeller diameters and corresponding pump curves are presented in the following tables.

On request, connections for electric motor driven stand-by pumps can be provided.

Pump materials:

housing cast iron

• impeller bronze

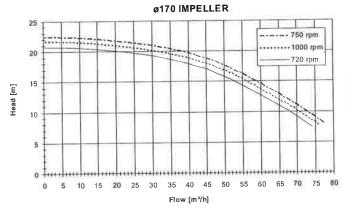
• shaft stainless steel

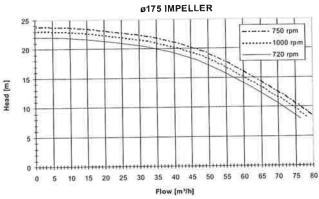
• sealing mechanical

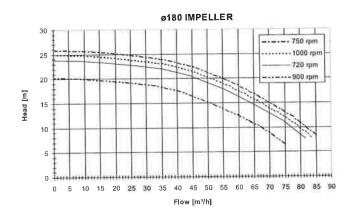
Capacities are according to Chapter for Technical data and the pump curves below.

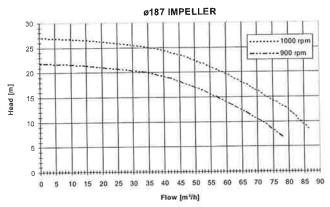
Table 9.1. Impeller diameters and nominal flows of engine driven HT & LT pumps

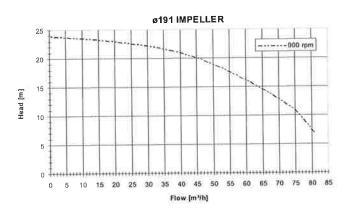
Engine	Engine speed [RPM]	HT impeller [Ø mm]	LT impeller [Ø mm]
4L20	720	170	170
	750	170	170
	900	180	187
	1000	170	170
5L20	900	187	187
	1000	170	170
6L20	720	175	175
	750	175	175
	900	187	187
	1000	175	175
8L20	720	180	180
	750	180	180
	900	191	197
	1000	180	187
9L20	720	180	180
	750	180	180
	900	191	197
	1000	180	187

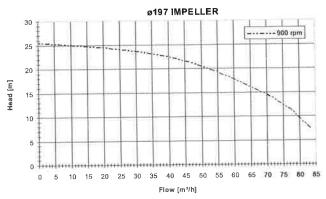












#### 9.2.3 Engine driven sea water pump

For main engines (only) an engine driven sea-water pump is available:

Capacity [m³/h]:

4L20:	40
5L20:	60
6L20:	60
8L20:	104
9L20:	104

Head

about 20 meters water column

#### Thermostatic valve LT-circuit 9.2.4

The thermostatic valve for the LT-circuit is arranged to control the outlet temperature of the water on engines. The thermostatic valve has one fixed set point of 49°C with 38°C as fully closed and 50°C as fully open and it is of the direct acting type.

## 9.2.5 Thermostatic valve HT-circuit

The thermostatic valve for the HT-circuit is arranged to control the outlet temperature of the water. It is of the direct acting type.

• set point of the 91°C HT-thermostatic valve

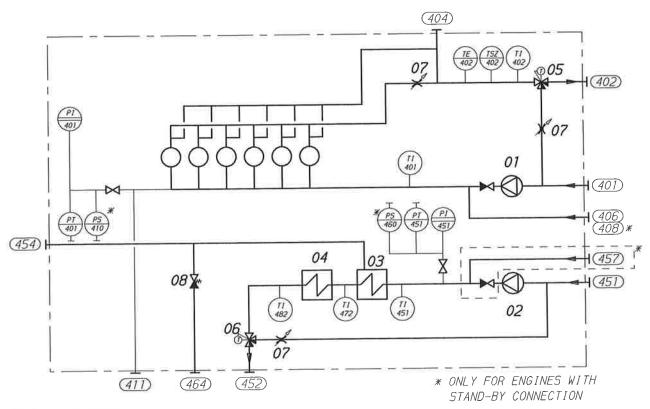
## 9.2.6 Lubricating oil cooler

The lubricating oil cooler is cooled by fresh water and connected in series with the charge air cooler.

## Dimensions of water pipe connections on the engine

Pipe ce	onnections	Size	Pressure class	Standard
401	HT-water inlet	DN65	PN16	ISO 7005-1
402	HT-water outlet	DN65	PN16	ISO 7005-1
404	HT-water air vent	OD12	PN250	DIN 2353
406	Water from preheater to HT-circuit	OD28	PN100	DIN 2353
408	HT-water from stand-by pump	DN65	PN16	ISO 7005-1
411	HT-water drain	M10x1		Plug
451	LT-water inlet	DN80	PN16	ISO 7005-1
452	LT-water outlet	DN80	PN16	ISO 7005-1
454	LT-water air vent from air cooler	OD12	PN250	DIN 2353
457	LT-water from stand-by pump	DN80	PN16	ISO 7005-1
464	LT-water drain	M18x1.5	<b>3</b> 1	Plug

## Internal cooling water system (4V76C5048b)



#### System components

01	HT-cooling water pump
02	LT-cooling water pump
03	Charge air cooler
04	Lubrication oil cooler
05	HT-thermostatic valve
06	LT-thermostatic valve
07	Adjustable orifice
08	Safety valve

## 9.3. External cooling water system

The fresh water pipes should be designed to minimize the flow resistance in the external piping. Galvanized pipes should not be used for fresh water.

Ships (with ice class) designed for cold sea-water should have temperature regulation with a recirculation back to the sea chest:

- for heating of the sea chest to meltice and slush, to avoid clogging the sea-water strainer
- to increase the sea-water temperature to enhance the temperature regulation of the LT-water

## 9.3.1 Sea water pump (4P11)

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

## 9.3.2 Fresh water central cooler (4E08)

The fresh water cooler can be of either tube or plate type. Due to the smaller dimensions the plate cooler is normally used. The fresh water cooler can be common for several engines, also one independent cooler per engine is used.

Design data:

• Fresh water flow

see Technical Data

In case of fresh water central cooler is used for combined LT and HT water flows in a parallel system the total flow can be calculated with the following formula:

$$q = \ q_{\text{LT}} + \frac{3.6 \ \cdot \Phi}{4.19 \ \cdot \left(T_{\text{out}} - T_{\text{ir}}\right)} \label{eq:q}$$

where:

total fresh water flow  $q[m^3/h]=$ 

nominal LT pump capacity  $q_{LT}[m^3/h]=$ 

heat dissipated to HT water  $\Phi [kW] =$ 

HT water temperature after engine (91°C) T<sub>out</sub>= HT water temperature after cooler (38°C)  $T_{in}=$ 

Pressure drop on fresh water side, max.

60 kPa (0.6 bar)

If the flow resistance in the external pipes is high it should be observed when designing the cooler.

· Sea-water flow

acc. to cooler manufacturer, normally 1.2 - 1.5

x the fresh water flow

• Pressure drop on sea-water side, norm.

80-140 kPa (0.8 - 1.4

bar)

• Fresh water temperature after cooler (before engine), 38°C.

see Technical Data

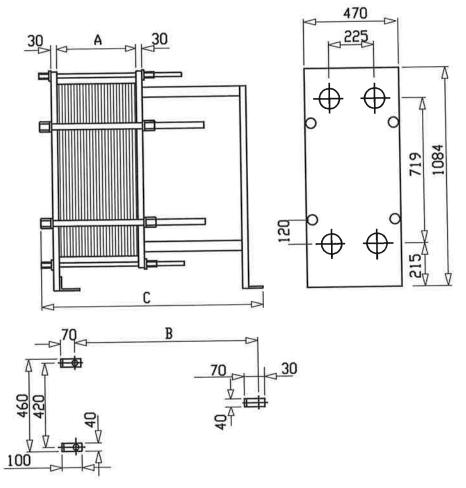
Safety margin to be added

15% + margin for

fouling

See also the table showing example coolers with calculation data.

# Central cooler, main dimensions (4V47E0188b)



Engine		Cooling water		Sea-water		Measures			Weight			
Туре	Eng. speed [rpm]	Flow [m³/h]	Tcw, in [°C]	Tcw, out	Flow [m³/h]	Tsw, in [°C]	Tsw, out [°C]	A [mm]	B [mm]	C [mm]	Dry [kg]	Wet [kg]
	750	22	52.1	38	30	32	42.6	80	505	695	270	287
4L20	1000	27	54.3	38	36	32	44.3	106	505	695	275	298
5L20	1000	33	52.9	38	44	32	43.2	121	655	845	280	306
	750	33	52	38	44	32	42.6	121	655	845	280	306
6L20	1000	40	53.3	38	53	32	43.5	150	655	845	288	321
	750	44	52	38	59	32	42.6	156	655	845	289	323
8L20	1000	53	53.6	38	71	32	43.8	198	655	845	298	341
	750	49	52.1	38	67	32	42.7	186	655	845	293	336
9L20	1000	59	53.7	38	80	32	43.8	221	905	1095	305	354

## Stand-by circulating cooling water pumps

The pumps should be centrifugal pumps driven by an electric motor. Capacities according to Chapter for Technical

#### **Expansion tank (4T05)** 9.3.4

The expansion tank should compensate for volume changes in the cooling water system, serve as venting arrangement and provide sufficient static pressure for the cooling water circulating pumps.

Design data:

pressure from the expansion tank

0.7...1.5 bar

volume

min. 10% of the system

Concerning engine water volumes, see Chapter for Technical data.

The tank should be equipped so that it is possible to dose water treatment agents.

The vent pipe of each engine should be drawn to the tank separately, continuously rising, and so that mixing of air into the water cannot occur (the outlet should be below the water level).

The expansion tank is to be provided with inspection devices.

#### 9.3.5 Drain tank (4T04)

It is recommended to provide a drain tank to which the engines and coolers can be drained for maintenance so that the water and cooling water treatment can be collected and reused. For the water volume in the engine, see Technical data (HT-circuit).

Most of the cooling water in the engine can be recovered from the HT-circuit, whereas the amount of water in the LT circuit is small.

#### 9.3.6 Preheating

Engines started and stopped on heavy fuel and all engines on which high load will be applied immediately after start (stand-by generating sets) have to be preheated as close to the actual operating temperature as possible, or minimum 60°C. Preheating is however, recommended for all engines, also main engines running on MDF only.

The energy required for heating of the HT-cooling water in the main and auxiliary engines can be taken from a running engine or a separate source. In both cases a separate circulating pump should be used to ensure the circulation. If the cooling water systems of the main and auxiliary engines are separated from each other in other respects, the energy is recommended to be transmitted through heat exchangers.

For installations with several engines the preheater unit can be chosen for heating up two engines. The heat from a running engine can be used and therefore the power consumption of the heater will be less than the nominal capac-

#### Heater (4E05)

Steam, electrical or thermal oil heaters can be used.

Design data:

preheating temperature

min. 60°C

required heating power

2 kW/cyl.

## Preheating pump (4P04)

Design data of the pump:

capacity

 $0.3 \text{ m}^3/\text{h} \text{ x cyl}$ .

pressure

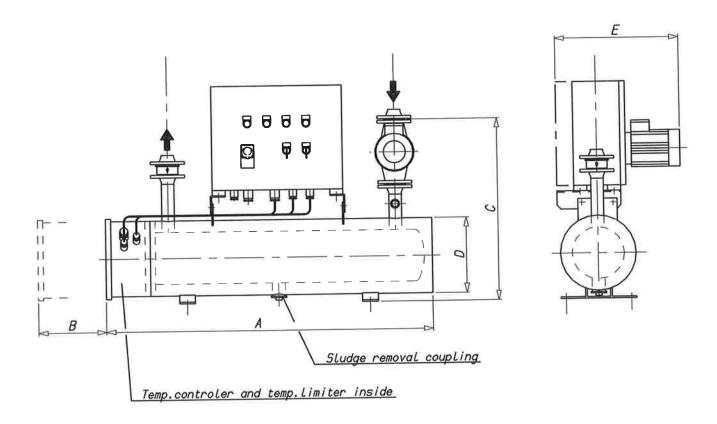
abt. 80 kPa (0.8 bar)

#### Preheating unit (4N01)

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

- electric or steam heaters
- circulating pump
- control cabinet for heaters and pump
- one set of thermometers

# Preheating unit, electric (3V60L0653a)



Heater capacity	Pump capacity	Weight	Pipe conn.		D	imensions		
kW	m3/h	kg	In / Outlet	A	В	С	D	E
7.5	3	75	DN40	1050	720	610	790	425
12	3	93	DN40	1050	550	660	240	450
15	3	93	DN40	1050	720	660	240	450
18	3	95	DN40	1250	900	660	240	450
22.5	8	100	DN40	1050	720	700	290	475
27	8	103	DN40	1250	900	700	290	475
30	8	105	DN40	1050	720	700	290	475
36	8	125	DN40	1250	900	700	290	475
45	8	145	DN40	1250	720	755	350	50
54	8	150	DN40	1250	900	755	350	50:

## 9.3.7 Air venting (4S01)

Air and gas may be entrained in the piping after overhaul, centrifugal pump seals may leak, or air or gas may leak from in any equipment connected the HT- or LT-circuit, such as diesel engine, water cooled starting air compressor etc.

As presented in the external cooling diagrams, it is recommended that either of the following air venting equipment is installed:.

1. At the HT-outlet from the engine. This is necessary for a quick venting after starting the engine, especially after overhaul when entrained air may remain in the system, and especially at departures at low load, when the HT thermostatic valve recirculates all water. At higher load when a part of the HT-water goes to the cooler, any possible air or gas bubbles may still be recirculated depending on the geometry and position of the HT thermostatic valve. If the branch to the cooler is vertically down the bubbles may be conducted to the by-pass line and back into circulation.

2. One in the LT system line for venting of any entrained air.

#### 9.3.8 Orifices

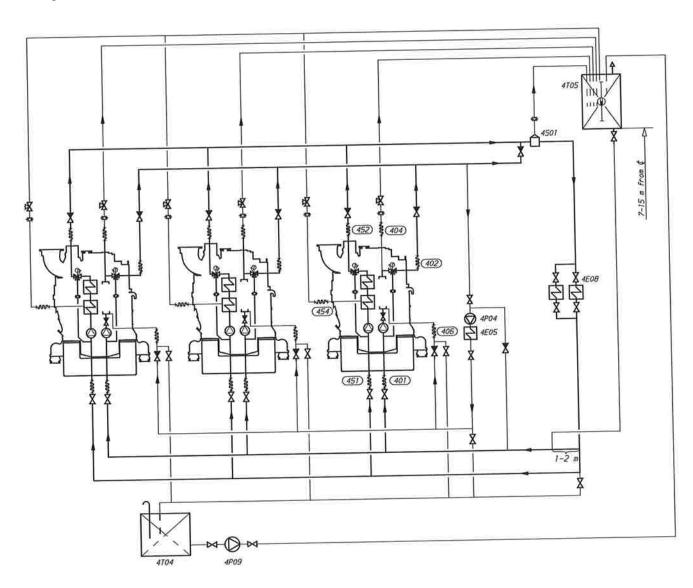
Orifices must be mounted after the HT outlet, after lubricating oil cooler and in all by-pass lines in order to adjust the circulations pumps and to balance the pressure drop when the water is not flowing through the cooler.

#### 9.3.9 Waste heat recovery

The waste heat of the HT-circuit may be used for fresh water production, central heating, tank heating etc. In such cases the piping system should permit by-passing of the central cooler. With this arrangement the HT-water flow through the heat recovery can be increased.

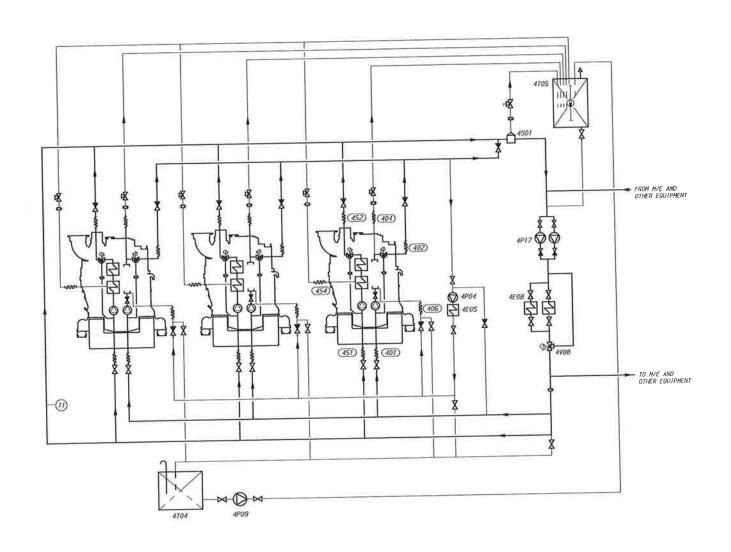
#### **Example system diagrams** 9.4.

Cooling water system, auxiliary engines (3V76C5049)



System components		Pipe connections		
4E05	Preheater	401	HT-water inlet	
4E08	Central cooler	402	HT-water outlet	
4P04	Preheating pump	404	HT-air vent	
4P09	Transfer pump	406	Water from preheater to HT circuit	
4S01	Air venting	451	LT-water inlet	
4T04	Drain tank	452	LT-water outlet	
4T05	Expansion tank	454	LT-water air vent from air cooler	
4103	Expansion carri			

# Cooling water system, auxiliary engines and main engine (3V76C5050)



System	components
4E05	Preheater

4E08 Central cooler Preheating pump 4P04

Transfer pump 4P09

LP-pump 4P17

Air venting 4S01

Drain tank 4T04

Expansion tank 4T05 Thermostatic valve 4V08

## Pipe connections

HT-water inlet 401 HT-water outlet 402

HT-air vent 404

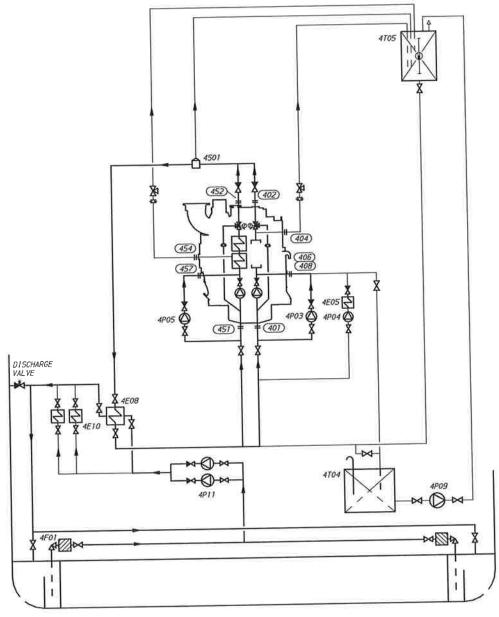
Water from preheater to HT circuit 406

LT-water inlet 451

452 LT-water outlet

LT-water air vent from air cooler 454

# Cooling water system, main engine (3V76C5051)



System	components

4T05

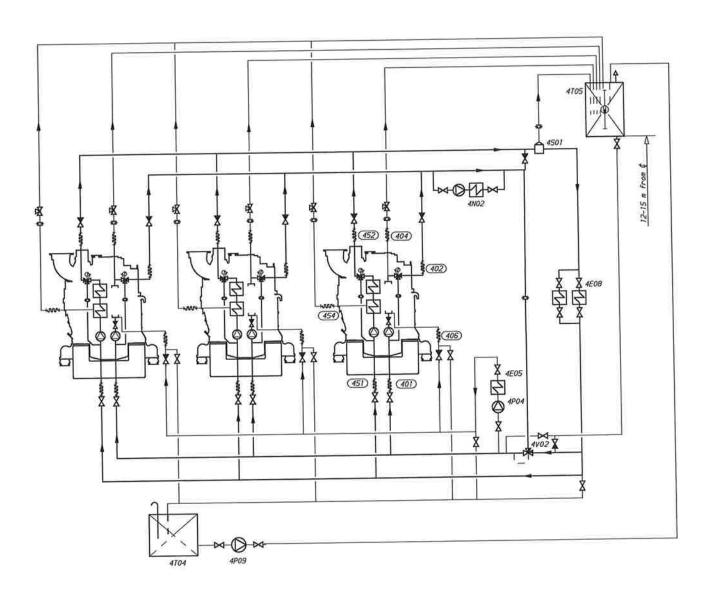
System Co	mponents
4E05	Preheater
4E08	Central cooler
4E10	Gear cooler
4F01	Sea water filter
4P03	HT-stand-by pump
4P04	Preheating pump
4P05	LT-stand-by pump
4P09	Transfer pump
4P11	Sea-water pump
4S01	Air venting
4T04	Drain tank

#### Pipe connections

_	
401	HT-water inlet
402	HT-water outlet
404	HT-air vent
406	Water from preheater to HT circuit
408	HT-water from stand-by pump
451	LT-water inlet
452	LT-water outlet
454	LT-water air vent from air cooler

Expansion tank

# Cooling water system, HFO engines with evaporator (3V76C5052b)



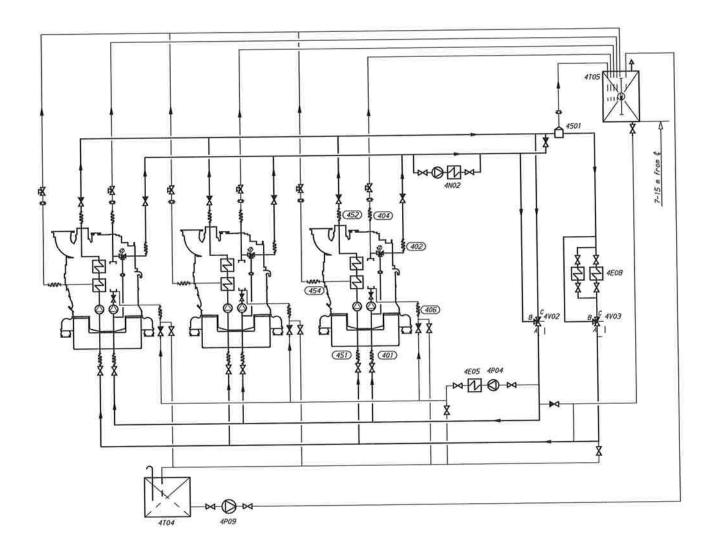
Swetem	components

4E05	Preheater
4E08	Central cooler
4N02	Evaporator
4P04	Preheating pump
4P09	Transfer pump
4801	Air venting
4T04	Drain tank
4T05	Expansion tank
4V02	Thermostatic valve

## Pipe connections

r	
401	HT-water inlet
402	HT-water outlet
404	HT-air vent
406	Water from preheater to HT circuit
451	LT-water inlet
452	LT-water outlet
454	LT-water air vent from air cooler

# Cooling water system, MDO engines with evaporator (3V76C5053)



Swetom	components
DASICIII	COMPONENTS

4E05	Preheater
4E08	Central cooler
4N02	Evaporator
4P04	Preheating pump
4P09	Transfer pump
4S01	Air venting
4T04	Drain tank
4T05	Expansion tank
4V02	Thermostatic valve
4V03	LT-thermostatic valve

## Pipe connections

401

402	H'T-water outlet
404	HT-air vent
406	Water from preheater to HT circuit
451	LT-water inlet
452	LT-water outlet
454	LT-water air vent from air cooler

HT-water inlet

# 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 so located 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 5 mmWC 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.

#### Ventilation

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

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

It is recommended to consider an outside air temperature of not 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 from the formula:

$$Q_{v} = \frac{\Phi}{\rho \cdot \Delta t \cdot c}$$

where:

 $Q_v = \text{ amount of ventilation air } [m^3/s]$ 

total heat emission to be evacuated [kW]

density of ventilation air 1.15 kg/m<sup>3</sup>

 $\Delta t = \text{temperature rise in the engine room } [^{\circ}C]$ 

specific heat capacity of the ventilation air 1.01

The heat emitted by the engine is listed in the chapter for

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 an exit for the majority 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.

# 10.2. Combustion air system design

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

The combustion air should be delivered through a dedicated duct close to the turbocharger, directed towards the turbocharger air intake. Also other combustion air comsumers like other engines, gas turbines and boilers shall be served by dedicated combustion air ducts.

For the required amount of combustion air, see the chapter for Technical data.

If necessary, the combustion air duct can be directly connected to the turbocharger with a flexible connection piece. To protect the turbocharger a filter must be built into the air duct. The permissible pressure drop in the duct is max. 100 mmWC.

# Charge air shut-off valve

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.

# Combustion air for engines

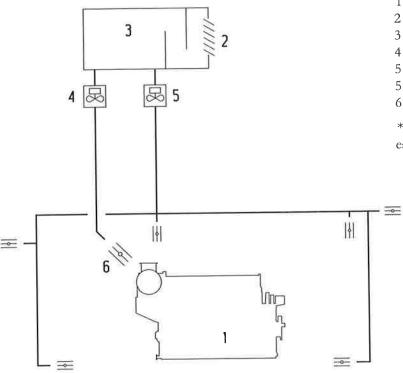
· Each engine has its own combustion air fan, with a capacity slightly higher than the maximum air consumption. The fan should have a two-speed electric motor (or variable speed) for enhanced flexibility. In addition to manual control, the fan speed can be controlled by the engine load.

 The combustion air is conducted close to the turbocharger, the outlet being equipped with a flap for controlling the direction and amount of air.

With these arrangements the normally required minimum air temperature to the main engine, see Chapter for Operation ranges, can typically be maintained. For lower temperatures special provisions are necessary.

In special cases the duct can be connected directly to the turbocharger, with a stepless change-over flap to take the air from the engine room or from outside depending on engine load.

## Engine room ventilation (4V69E8169)



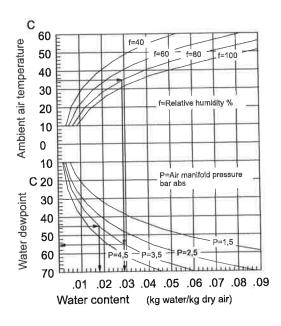
# Condensation in charge air coolers

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.

# Engine room ventilation

- The rest of the engine room ventilation is provided by separate ventilation fans. These fans should preferably have two-speed electric motors (or variable speed) for enhanced flexibility.
- For very cold conditions a preheater 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 a heating system for the ship the preheater should be in a secondary circuit.
- This system permits flexible operation, e.g. in port the capacity can be reduced during overhaul of the main engine when it is not preheated (and therefore not heating the room)...
  - 1 Diesel engine
  - 2 Suction louver \*
  - 3 Water trap
  - 4 Combustion air fan
  - 5 Engine room ventilation fan
  - 5 Flap
  - 6 Outlets with flaps
  - \* Recommended to be equipped with a filter for areas with dirty air (rivers, coastal areas, etc.)

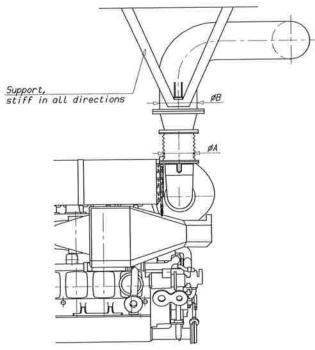


# 11. Exhaust gas system

# 11.1.Internal exhaust gas system

## 11.1.1 Exhaust gas outlet

Exhaust gas outlet (4V76A2679)



Engine	Bellows A (inner dia)	Piping B (inner dia)
4L20	200	250-300
5L20	250	300-350
6L20	250	300-350
8,9L20	300	350-450

The exhaust gas outlet from the turbocharger can be rotated to several positions, the positions depending on the number of cylinders. Other directions can be arranged by means of the adapter at the turbocharger outlet.

# 11.2.External exhaust gas system

Each engine should have its own exhaust pipe into open air. Flexible bellows have to be mounted directly to the turbocharger outlet, to compensate for thermal expansion and prevent damages on the turbocharger due to vibrations.

It is very important that the exhaust pipe is properly fixed to a rigid support directly after the bellows. Resilient mounts are acceptable at the fixing points between the exhaust pipe and the rigid support. The mounts must however be stiff enough to prevent dynamic deflections in excess of 1 mm peak to peak. Conical rubber mounts similar to the mounts that are installed under generating sets can be used. Adequate thermal insulation must be provided to protect the rubber mounts from high exhaust gas temperatures.

The piping should be as short and straight as possible.

The bends should be made with the largest possible bending radius, minimum radius used should be 1.5 D. The exhaust pipe must be insulated all the way from the turbocharger and the insulation is to be 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 detaching insulation, which will then clog the filters.

The exhaust gas pipes and/or silencers should be provided with water separating pockets and drainage.

Recommended flow velocity is 35...40 m/s. Lower velocities might be needed with long piping or if there are many resistance factors in the piping.

The exhaust gas mass flow given in the Chapter for Technical data can be translated to velocity using the formula: Where:

$$v [m/s] = \frac{4 \cdot m}{1.3 \cdot \left(\frac{273}{273 + t}\right) \cdot \pi \cdot D^2}$$

v [m/s] = gas velocity

m [kg/s] = exhaust gas mass flow

t [°C] = exhaust gas temperature

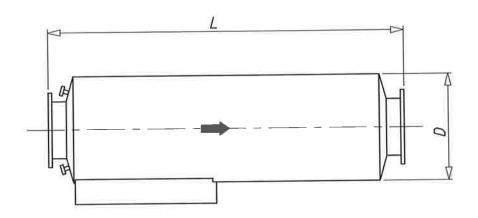
D [m] = exhaust gas pipe diameter

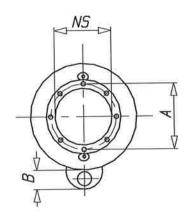
# 11.2.1 Exhaust gas silencer (5R01)

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 water drain, but is 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).

## Exhaust silencer (4V49E0137a)





_					Attenu	ation	
				25 d	B (A)	35 dI	3 (A)
DN	D	A	В	L	Weight (kg)	L	Weight (kg)
250	700	335	120	2070	230	2870	340
300	700	395	150	2600	280	3600	400
350	850	445	180	2640	340	3640	490
400	950	495	205	3180	500	4180	670
450	1100	550	230	3440	600	4440	780

#### 11.2.2 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 the Chapter for Technical data may be used.

# 11.2.3 Exhaust gas bellows (5H01)

Bellows must be used in exhaust gas piping where thermal expansion or ship's structural deflections have to be segregated in order to limit stress levels.

#### 11.2.4 Supporting

The number of mounting supports should always be kept to a minimum and positioned at stiffened locations within the ship's structure, e.g. decklevels, webframes or specially constructed supports.

The supporting must allow thermal expansion and ship's structural deflections during construction and operation.

#### 11.2.5 Back pressure

The maximum permissible exhaust gas back pressure is 3 kPa (300 mm WC) at full load, which should be verified by a calculation, made by the shipyard. The back pressure should also be measured on the sea trial. A measuring connection should be provided on each exhaust piping system during the construction.

# 12. Turbocharger cleaning

# 12.1.Turbine cleaning system (5Z03)

Periodic water cleaning of the turbine reduces the formation of deposits and extends the interval between overhauls. Only fresh water should be used and the cleaning instructions in the operation manual must be carefully followed.

For washing of the turbine side of the turbocharger, fresh water with a pressure of not less than 300 kPa (3.0 bar) is required.

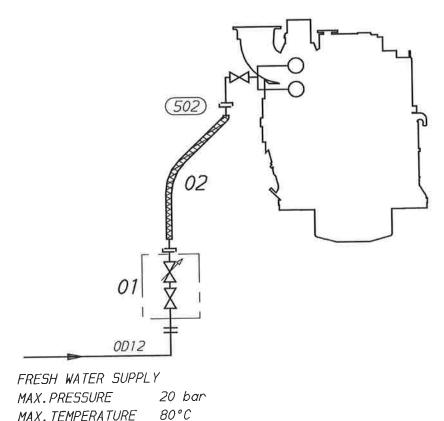
The washing is carried out during operation at regular intervals, depending on the quality of the heavy fuel, 100 – 500 h.

The water flow required for each turbine washing depends on the final turbocharger selection. The following typical values can be given (for guidance) for engines with a nominal speed of 900 or 1000 rpm:

4L20: 6 l/min
5L20, 6L20: 8 l/min
8L20, 9L20: 10 l/min

The washing time is three times 30 seconds with 10 minutes between washings.

# Turbocharger cleaning system (4V76A2709)



System components

01 Shut of and flow adjusting unit, bulkhead mounted

02 Rubber hose about 10 m

Pipe connections

502 Cleaning water to turbine

Quick coupling

# 13. Exhaust emissions

#### 13.1. General

Exhaust emissions from the diesel engine mainly consist of nitrogen, carbon dioxide (CO<sub>2</sub>) and water vapour with smaller quantities of carbon monoxide (CO), sulphur oxides (SOx) and nitrogen oxides (NOx), partially reacted and non-combusted hydrocarbons and particulates. Emission control of large diesel engines means primarily the control of the NOx emissions.

# 13.2. Diesel engine exhaust components

Due to the high efficiency of the diesel engines, the emissions of carbon dioxide (CO<sub>2</sub>), carbon monoxide (CO) and hydrocarbons (HC) are low. The same high combustion temperatures that give thermal efficiency in the diesel engine also cause high emissions of nitrogen oxides (NOx). The emissions of sulphur oxides (SOx) and particulates are formed in the combustion process out of the sulphur, ash and asphaltenes that are always present in heavy fuel oil.

# 13.2.1 Nitrogen oxides (NOx)

Nitric oxide (NO) and Nitrogen dioxide (NO<sub>2</sub>) are usually grouped together as NOx emissions. Predominant oxide of nitrogen found inside the diesel engine cylinder is NO, which forms mainly in the oxidation of atmospheric (molecular) nitrogen in the high temperature gas regions. NO can also be formed through oxidation of the nitrogen in fuel and through chemical reactions with fuel radicals. The amount of NO<sub>2</sub> emissions is approximately 5 %.

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 it is required. For Wärtsilä 20, the Selective Catalytic Reduction (SCR) is an optional NOx reduction method.

## 13.2.2 Sulphur Oxides (SOx)

Sulphur oxides (SOx) are direct result of the sulphur content of the fuel oil. During the combustion process the fuel bound sulphur is rapidly oxidised to sulphur dioxide (SO<sub>2</sub>). A small fraction of SO<sub>2</sub> may be further oxidised to sulphur trioxide (SO<sub>3</sub>). The SOx emission controls are directed mainly at limiting the sulphur content of the fuel.

#### 13.2.3 Particulates

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.

The main parameters affecting the particulate emissions are the fuel oil injection and fuel oil parameters. The use of fuel oil with good ignition and combustion properties and low content of ash and sulphur will reduce the formation of particulates. For marine diesel engines the particulate removal systems, because of their size and high cost, are not for the time being economically or practically potential solutions.

#### 13.2.4 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 NOx emissions. When the exhaust gas is cooled significantly prior to discharge to the atmosphere, the condensed NO<sub>2</sub> component can have a brown appearance.

# 13.3. Marine exhaust emissions legislation

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 Organisation) has developed the Annex VI of MARPOL 73/78, which represents the first set of regulations on the marine exhaust emissions.

There is yet no legislation concerning the particulate emissions from the marine diesel engines, although the authorities are planning to set strict limits to the particulates in the near future. Smoke is regulated in some countries or regions based on its visibility.

## 13.3.1 MARPOL Annex VI

MARPOL 73/78 Annex VI includes regulations for example on such emissions as nitrogen oxides, sulphur oxides, volatile organic compounds and ozone depleting substances. The Annex VI has yet to be ratified. The regulations will enter into force 12 months after the date on which at least 15 states, constituting not less than 50 % of the gross tonnage of the world's merchant shipping, have signed the protocol. The most important regulation of the MARPOL Annex VI is the control of NOx emissions.

The engines comply with the proposed NOx levels set by the IMO in the MARPOL Annex VI. The NOx controls apply to diesel engines over 130 kW installed on ships built (defined as date of keel laying or similar stage of construction) on or after January 1, 2000 along with engines which have undergone a major conversion on or after January 1, 2000.

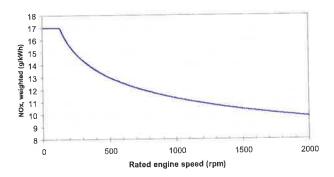
For Wärtsilä 20 with a rated speed of 720 rpm, the NOx level is below 12.1 g/kWh and with 750 rpm the level is below 12.0 g/kWh. With a rated speed of 900 rpm the NOx level is below 11.5 g/kWh and with 1000 rpm the level is below 11.3 g/kWh. The tests are done according to IMO regulations (NOx Technical Code).

The IMO NOx limit is defined as follows:

NOx [g/kWh]

$$= 17$$
 rpm  $< 130$   
 $= 45 \text{ x rpm}^{-0.2}$   $130 < \text{rpm} < 2000$   
 $= 9.8$  rpm  $> 2000$ 

#### IMO NOx emission limit



#### 13.3.2 EIAPP Statement of Compliance

An EIAPP (Engine International Air Pollution Prevention) Statement of Compliance will be issued for each engine showing that the engine complies with the NOx regulations set by the IMO. For the time being only a Statement of Compliance can be issued, because the regulation is not yet in force.

When testing the engine for NOx emissions, the reference fuel is Marine Diesel Fuel (distillate) and the test is performed according to ISO 8178 test cycles. Subsequently, the NOx value has to be calculated using different weighting factors for different loads that have been corrected to ISO 8178 conditions. The most commonly used ISO 8178 test cycles are presented in following table.

Table 13.1. ISO 8178 test cyc
-------------------------------

able forming the series						
E2: Diesel electric propulsion,	Speed (%)	100	100	100	100	
variable pitch	Power (%)	100	75	50	25	
1	Weighting factor	0.2	0.5	0.15	0.15	
E3: Propeller law	Speed (%)	100	91	80	63	
k	Power (%)	100	75	50	25	
	Weighting factor	0.2	0.5	0.15	0.15	
D2: Auxiliary engine	Speed (%)	100	100	100	100	100
	Power (%)	100	50	50	25	10
	Weighting factor	0.05	0.3	0.3	0.3	0.1

For EIAPP certification, the "engine family" or the "engine group" concepts may be applied. This has been done for the Wärtsilä 20 diesel engine. The engine families are represented by their parent engines and the certification emission testing is only necessary for these parent engines. Further engines can be certified by checking documents, components, settings etc., which have to show correspondence with those of the parent engine.

All non-standard engines, for instance over-rated engines, non-standard-speed engines etc. have to be certified individually, i.e. "engine family" or "engine group" concepts do not apply.

According to the IMO regulations, a Technical File shall be made for each engine. This Technical File contains information about the components affecting NOx emissions, and each critical component is marked with a special IMO number. Such critical components are injection nozzle, injection pump, camshaft, cylinder head, piston, connecting rod, charge air cooler and turbocharger. The allowable setting values and parameters for running the engine are also specified in the Technical File.

The marked components can later, on-board the ship, be identified by the surveyor and thus an IAPP (International Air Pollution Prevention) Statement of Compliance for the ship can be issued on basis of the EIAPP Statement of Compliance and the on-board inspection.

# 13.4. Methods to reduce exhaust emissions

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.

## 13.4.1 Selective Catalytic Reduction (SCR)

Selective Catalytic Reduction (SCR) is the only way to reach a NOx reduction level of 85-95%.

#### General system description

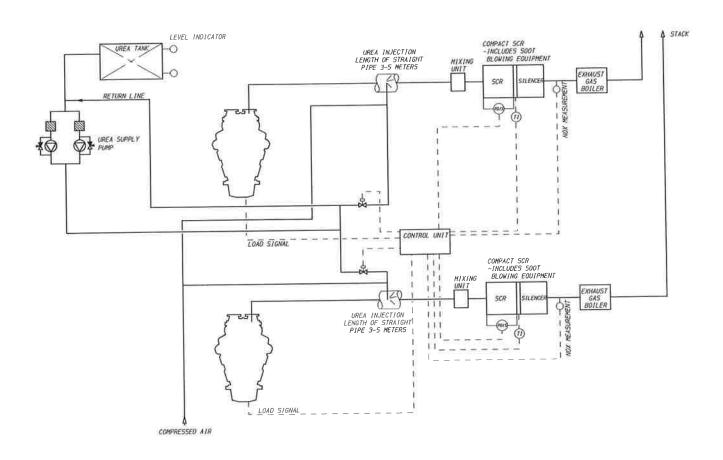
The reducing agent, aqueous solution of urea (40 wt-%), is injected into the exhaust gas directly after the turbocharger. Urea decays immediately to ammonia (NH<sub>3</sub>) and carbon dioxide. The mixture is passed through the catalyst where NOx is converted to harmless nitrogen and water, which are normally found in the air that we breathe. The catalyst elements are of honeycomb type and are typically of a ceramic structure with the active catalytic material spread over the catalyst surface.

The injection of urea is controlled by feedback from a NOx measuring device after the catalyst. The rate of NOx reduction depends on the amount of urea added, which can be expressed as NH<sub>3</sub>/NOx ratio. The increase of the catalyst volume can also increase the reduction rate.

When operating on HFO, the exhaust gas temperature before the SCR must be at least 330°C, depending on the sulphur content of the fuel. When operating on MDF, the exhaust gas temperature can be lower. If an exhaust gas boiler is specified, it should be installed after the SCR.

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## Typical P&ID for Compact SCR (3V28A0006a)



The disadvantages of the SCR are the large size and the relatively high installation and operation costs. To reduce the size, Wärtsilä has together with subsuppliers developed the Compact SCR, which is a combined silencer and SCR. The Compact SCR will require only a little more space than an ordinary silencer.

The lifetime of the catalyst is mainly dependent on the fuel oil quality and also to some extent on the lubricating oil quality. The lifetime of a catalyst is typically 3-5 years for liquid fuels and slightly longer if the engine is operating on gas. The total catalyst volume is usually divided into three layers of catalyst, and thus one layer at time can be replaced, and remaining activity in the older layers can be utilised.

Urea consumption and replacement of catalyst layers are generating the main running costs of the catalyst. The urea consumption is about 15 g/kWh of 40 wt-% urea. The urea solution can be prepared mixing urea granulates with water or the urea can be purchased as a 40 wt-% solution. The urea tank should be big enough for the ship to achieve the required autonomy.

# 14. Automation system

#### 14.1. General

The engine automation system consists of local and remote control of the running parameters, local and remote monitoring of the sensors and automatic safety operations.

# 14.2. Power supply

The power requirement of the automation system is about  $150~\mathrm{W}~(24~\mathrm{V}~\mathrm{DC})$ .

# 14.3. Safety System

#### 14.3.1 General

The safety system can be split into five major parts: starting, stopping, start blocking, shutdowns and load reduction requests.

#### 14.3.2 Starting (8N08)

## Start of an auxiliary engine

The principle diagram of a start/stop system is shown in drawing 4V50G3472.

The described relay automation is usually not included in the scope of supply, but can as an option be supplied in a separate cabinet. The control, safety and sequencing functions of this system can also be incorporated in the power management or automation system of the vessel.

#### Start sequence

The engine is equipped with a pneumatic starting motor, which drives the engine through a gear rim on the flywheel. The starting motor is controlled by a solenoid valve. The engine can be started by activating the solenoid valve, locally by a start button on the engine or remotely e.g. from the diesel automation system.

A generating set reaches the nominal speed in 6...8 seconds after the starting solenoid has been activated.

#### Start blocking (8N08)

Starting shall be inhibited by the following functions:

- Turning device engaged
- Prelubricating pressure low. In case of black-out, starting is allowed within 5 minutes after the pressure has dropped below the set point of 0.5 bar.
- Engine start blocking selector switch turned into "Blocked" position
- Engine running (300 rpm)

- Stop signal to engine activated (safety shut-down, emergency stop, normal stop)
- Stop lever on stop position

In an emergency case, the engine can always be started by manually operating the main starting valve. This by-passes start blocking due to low prelubricating pressure.

#### Starting air cut off

The start signal to be cut off by:

- Speed switch in SPEMOS (115 RPM)
- A time relay function, which allows the start signal to be activated about 5 seconds. The time between consecutive starting attempts shall be about 30 seconds.
- Stop signal to engine activated.

#### Start fuel limiter

The speed governor is provided with a start fuel limiter function in order to optimize the fuel injection during the acceleration period. This is controlled by a speed switch in the speed measuring system.

#### Override of lubricating oil pressure shut-down

To enable start of the engine, the automatic shut-down for low lubricating oil pressure must be disabled during the starting sequence. This is most conveniently done using the "engine running" contact. Further, a time delay of about 10 seconds is to be arranged in order to allow the engine driven lubricating oil pump to establish sufficient pressure.

#### Start of a main engine

The principle diagram of a start/stop system is shown in drawing 4V50G3619.

A main engine can be started and stopped in the same way as an auxiliary engine. Some minor differences should, however, be noted:

- The 5 min. time delay of prelubricating pressure described for black-out start is not recommended.
- For some installations start blocking may be required from clutch position, pitch NOT zero and reduction gear lubricating oil pressure. Autostop of the engine can also be required for low lubricating oil pressure in the reduction gear.

## 14.3.3 Stopping (8N08)

#### Normal stop of the engine

The engine is stopped remotely via the 'remote stop' input or in local control by the stop button on the engine.

Manual stop can also be done by turning the stop lever into the stop position.

There are two stop solenoids on the engine. One is built into the speed governor. The other one is controlling compressed air, which is fed to pneumatic cylinders at each fuel injection pump, forcing the pumps to no-fuel when activated. This system is independent of the governor. The engine can be stopped by activating one or both of the solenoids for at least 60 seconds. Emergency and safety shut-down should activate both.

When two engines are connected to a common reduction gear it is recommended that the clutches are blocked in the "OUT" position when the engine is not running. When an engine is stopped, the clutch should open to prevent the engine from being driven through the gear. At an overspeed shutdown signal the clutch should remain

'Engine stop/shutdown' output contact is always closed when the stop signal is active.

# 14.3.4 Shutdowns (8N08)

The engine shall be automatically shut down in the following cases:

- Lubricating oil pressure low (pressure switch)
- Cooling water temperature high (temperature switch)
- Overspeed (speed switch in SPEMOS)

The shutdown is latching, and a shutdown reset has to be given before it is possible to re-start. Naturally, before this the reason of the shutdown must be investigated.

For a single main engine installation it might be necessary to arrange a 5 sec delay on the autostop functions (except for overspeed) to give the possibility of overriding the autostop signal from the bridge and prevent the engine from stopping in a critical manoeuvring situation.

# Overspeed protection

A main engine is equipped with two independently adjustable switches for overspeed.

- The speed switch with the lower set point (nom. RPM + 15%) can be connected for momentary activation of the electro-pneumatic stop solenoid. The speed switch is activated and the stop solenoid is energized only as long as the speed is above the set point. When the speed has decreased, the stop solenoid is de-energized and the speed is again controlled by the governor.
- The speed switch with the higher set point (nom. RPM+ 18%) shall be connected with latching function in order to ensure shut-down of the engine.

# 14.3.5 Charge air shut-off valve

If gas detector senses combustible gas or vapour in the engine room the charge air shut-off valve must be automatically closed and engine shutdown activated. Also overspeed of the engine should automatically close this valve and activate shutdown. Since this is optional equipment most commonly used in offshore installations the construction varies with engine type and installation and the instructions in manuals must be followed.

# 14.4.Speed Measuring (8N03)

An electronic speed measuring and monitoring system (SPEMOS) is built into the engine junction box.

The system monitors the engine speed with two pick-ups and the turbocharger speed with a single pick-up. A 24 V DC power supply is required for the SPEMOS.

Table 14.1. Speed measuring & monitoring system signals

Function	Signal	Usage	Remark
Start fuel limiter	contact	internal	100 RPM below idling speed
Starting air cut off	contact	internal	115 RPM
Engine running	volt. free contact	external	300 RPM
Overspeed	volt. free contact	external	nominal + 15% speed
Engine speed	0 - 10 V DC	internal & external	0 - 1500 RPM
Turbocharger speed	0 - 10 V DC	internal & external	0 - 60000 RPM
Power/tacho failure	volt. free contact	external	

# 14.5. Sensors & signals

Drawing 4V50L5692 shows a typical engine wiring diagram with a standard set of sensors for monitoring, alarm and safety.

Table 14.2. Standard sensors for remote monitoring and alarm

Sensor	Code	Signal	Alarm	Remark
Fuel oil pressure	PT101	4 - 20 mA	0.4 MPa (4 bar)	HFO
Lubricating oil pressure	PT201	4 - 20 mA	0.3 MPa (3 bar)	
Starting air pressure	РТ301	4 - 20 mA	0.8 MPa (8 bar)	
HT water pressure	РТ401	4 - 20 mA	0.2 MPa (2 bar)	installation specific
LT water pressure	PT451	4 - 20 mA	0.2 MPa (2 bar)	installation specific
Exhaust gas temperature after each cylinder and turbocharger	TE501	4 - 20 mA	500°C	NiCrNi + amplifier
Lubricating oil temperature	TE201	Pt 100	80°C	
HT water temperature	TE402	Pt 100	105°C	
Charge air temperature	TE622	Pt 100	75°C	
Injection pipe leakage	LS103A	volt. free contact		
Lubricating oil level in wet oil sump low	LS204	volt. free contact	_	
Lubricating oil filter pressure drop	PDS243	volt. free contact	0.15 MPa (1.5 bar)	
Pneumatic overspeed trip pressure low	PS311	volt, free contact	1.8 MPa (18 bar)	
Overload	GS166	volt. free contact		main engines only

Table 14.3. Standard sensors for engine safety

Sensor	Code	Signal	Set point	Remark
Lubricating oil pressure	PSZ201	volt. free contact	0.2 MPa (2 bar)	shut-down
Cooling water temperature high	TSZ402	volt. free contact	110°C	shut-down
Overspeed	SSZ173	volt. free contact	nom. RPM + 15%	shut-down
Turning gear enganged	GS792	volt. free contact		start block
Prelubricating pressure low	PS201-1	volt. free contact	50 kPa (0.5 bar)	start block
Selector switch blocked, local, remote	HS724	volt. free contact		start block

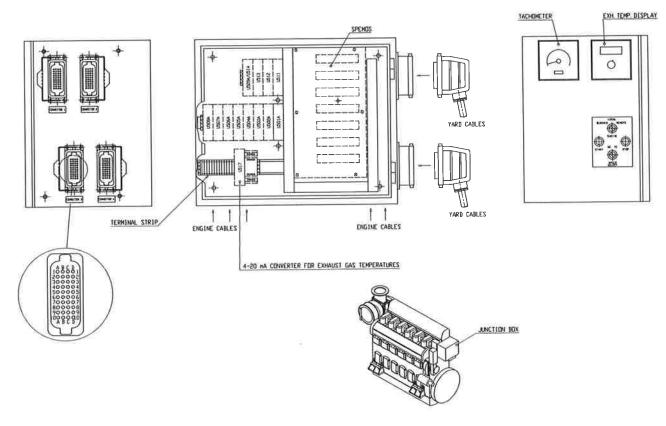
The analogue temperature sensors are of type Pt-100. (100  $\Omega$  at 0°C).

The exhaust gas temperature sensors (NiCr/Ni thermocouples) are connected to converters with an output signal of 4 - 20 mA, two wire connection.

The analogue pressure transmitters have an output signal of 4 - 20 mA, two wire connection.

All sensors are wired to a common junction box, see drawing 1V50L5433, on the engine. Most sensor cables plug into connection rails located on either side of the engine. Multicore cables connect the rails to the junction box. Cables furnished by the yard for monitoring, alarm and control shall be connected to the junction box with multi pin connectors.

## Junction box with multi pin connectors (1V50L5433c)



## 14.6. Local instrumentation

The engine is equipped with the following set of instruments for local reading of pressures, temperatures and other parameters.

#### Pressure gauges in panel on engine

- Lubricating oil pressure
- Fuel oil pressure
- Cooling water pressure (HT)
- Cooling water pressure (LT)
- Charge air pressure
- · Starting air pressure

#### **Thermometers**

- Fuel oil before engine
- Lubricating oil before lubricating oil cooler
- Lubricating oil after lubricating oil cooler
- · Cooling water (HT) before engine
- · Cooling water (HT) after engine
- Cooling water (LT) before charge air cooler
- Cooling water (LT) after charge air cooler
- Cooling water (LT) after lubricating oil cooler
- Charge air after charge air cooler

#### **Electrical instruments**

- Tachometer for engine speed and turbocharger speed
- · Running hour counter
- Digital display for exhaust gas temperature with selector switch for temperature after each cylinder and after turbocharger

# 14.7. Control of auxiliary equipment

#### 14.7.1 Stand-by pumps

Stand-by pumps are required for single main engine.

If the pressure drops below a pre-set level when the engine is running, the stand-by pump should be started. The stand-by pump starter shall include an interposing relay controlling the main contactor.

Latching must be done in the standby starter and alarm system respectively. The reason for the pressure drop should be investigated as soon as possible. Stop of the standby pump should always be a manual operation. Before stopping the standby pump, the reason for the pressure drop must have been investigated and rectified

Monitoring signals can be used to initiate the start of stand-by pumps.

# 14.7.2 Pre-lubricating oil pump (9N03)

The engine is equipped with an electric pre-lubricating pump.

The pre-lubricating pump is used for filling of the lubricating oil system, pre-lubricate a stopped engine before start and for preheating by circulating warm lubricating oil. The colder the engine is, the earlier the pump should be started before the engine is started.

The pump may also be run continuously when the engine is stopped and must run in multiple engine installations when other engines are running.

For continuous prelubrication of a stopped engine, through which heavy fuel is circulating.

To ensure continuous prelubrication of a stopped engine, automatic starting and stopping of the prelubricating pump is recommended. This can be achieved using the 300 RPM speed switch.

For dimensioning the pre-lubricating pump starter, the values indicated below can be used. For different voltages, the values may differ slightly. The starter is not included in the standard delivery of the engine.

- 400V / 50Hz 2.2kW, In=4.7A
- 440V / 60Hz 2.5kW In=4.7A

# 14.7.3 Cooling water pre-heater & circulation pump

In order to get the engine up to and maintain a cooling water temperature >70°C, preheating has to be arranged for the engine. Preheating is preferably done by an electric preheater with a required heating power depending of the engine type. The preheater is not included in the standard delivery of the engine.

The temperature control should be automatic.

For automatic starting and stopping of the circulating pump to circulate cooling water through the stopped engine(s), the 'Engine running' signal can be used as reference.

In some main engine installations the circulating pump needs to be running at prolonged idling. For these cases special instructions are given.

# 14.8. Speed control (8103)

## 14.8.1 Main engine speed control

#### Mechanical-hydraulic governors

The engines have hydraulic-mechanical governors with pneumatic speed setting. These governors are usually provided with a shut-down solenoid as the only electrical equipment.

The idling speed is selected for each installation based on calculations, for CP-propeller installations at 55 - 65% of the nominal speed and for FP-propeller installations at about 35%.

The standard control air pressure for pneumatically controlled governors is:

p = 0.514 \* n - 14.3

p = control air pressure [kPa]

n = engine speed [RPM]

Governors for engines in FP-propeller installations are provided with a smoke limiting function, which limits the fuel injection as a function of the charge air pressure.

Governors for engines connected to a common reduction gear are specially adapted and adjusted for the same speed droop, normally about 4%, to obtain basic load sharing. In addition, it is recommended to arrange external load sharing based on the fuel rack position transducer.

Governors are, as standard, equipped with a built-in delay of the speed change rate so that the time for speed acceleration from idle to rated speed and vice versa is preset.

In special cases speed governors of the electronic type can be used.

# 14.8.2 Generating set speed control Mechanical-hydraulic governors

Auxiliary generator sets are normally provided with mechanical-hydraulic governors for remote electric speed setting from e.g. a Power Management System (PMS).

The governor is equipped with a speed setting motor for synchronizing, load sharing and frequency control.

The governor is also equipped with a shutdown solenoid and an electrically controlled start fuel limiter. The synchronizing is operated by ON/OFF control as "increase" or "decrease" by polarity switching. Normal speed change rate is about 0.3 Hz/s.

Engines, which are to be run in parallel have governors specially adapted for the same speed droop, about 4%, to obtain basic load sharing. During load sharing and frequency control, the external load sharing system (PMS) must have a control deadband implemented, allowing for an uneven load or frequency drift of 1 - 2%.

## 14.8.3 Electronic speed governor

An Electronic speed control, comprising a separately mounted electronic speed control unit and a built-on actuator, offers efficient tools for filtering speed and load signals. This is often required in order to achieve good stability without sacrificing the transient response. Further the dynamic response can be adjusted and optimised for the particular installation, or even for different operating modes of the same engine. An electronic speed control is also capable of isochronous load sharing. In isochronous mode, there is no need for external load sharing, frequency adjustment, or engine loading/unloading control in the external control system. Both isochronous load sharing and traditional speed droop are standard features in all electronic speed controllers and either mode can be selected.

Speed droop means that the governor speed reference automatically decreases as the engine load increases. The speed droop is normally adjusted to about 4%. This is to ensure proper load sharing between parallelling units. To compensate for the speed decrease of the plant when the load increases, and vice versa when the load decreases, the PMS must in an outer (cascade) loop correct for the frequency drift.

Isochronous load sharing means that the governor speed reference stays the same, regardless of the load level. A shielded twisted pair cable between the speed controllers is necessary for isochronous load sharing. If the ship has two or more switchboard sections, which can be either connected or separated, there must be a breaker also for the load sharing lines between each speed control.

# **Electronic speed control for Main Engines**

An electronic speed control is recommended for more demanding installations, e.g. main engine installations with two engines connected to the same reduction gear, in particular if there is a shaft generator on the reduction gear.

The remote speed setting can be either an increase/decrease signal, or an analog 4-20mA speed reference, both from e.g. a propulsion control system. The rate at which the speed changes is adjustable in the speed controller.

Actuators with mechanical backup are only recommended for single main engines. The actuator should in case of a single main engine be reverse acting, so that the change over to the mechanical backup takes place automatically.

# **Electronic speed control for Diesel** electric/Generator set

An electronic speed control is always recommended for diesel electric installations due to the sometimes strongly fluctuating power demand from the dominant consumer (propulsion).

For an auxiliary generating set, an electronic speed control can be specified as an option.

Actuators with mechanical backup are not recommended for multi-engine installations.

# 14.9. Microprocessor based engine control system (WECS) (8N01)

As an alternative to the conventional way of cabling the sensor signals wire by wire from the engine to the external alarm, monitoring and control systems, an Engine Control System (WECS) can be provided. The WECS is a microprocessor based monitoring and control system.

## 14.9.1 Components

The system for one engine consists of one main control unit (MCU) and several distributed control units (DCU) or sensor multiplexer units (SMU) depending on the amount of sensors which are connected to the DCU:s and SMU:s. The SMU is used only to collect sensor data, while the DCU also is used for distributing processing power from the MCU.

## 14.9.2 Functions of the MCU

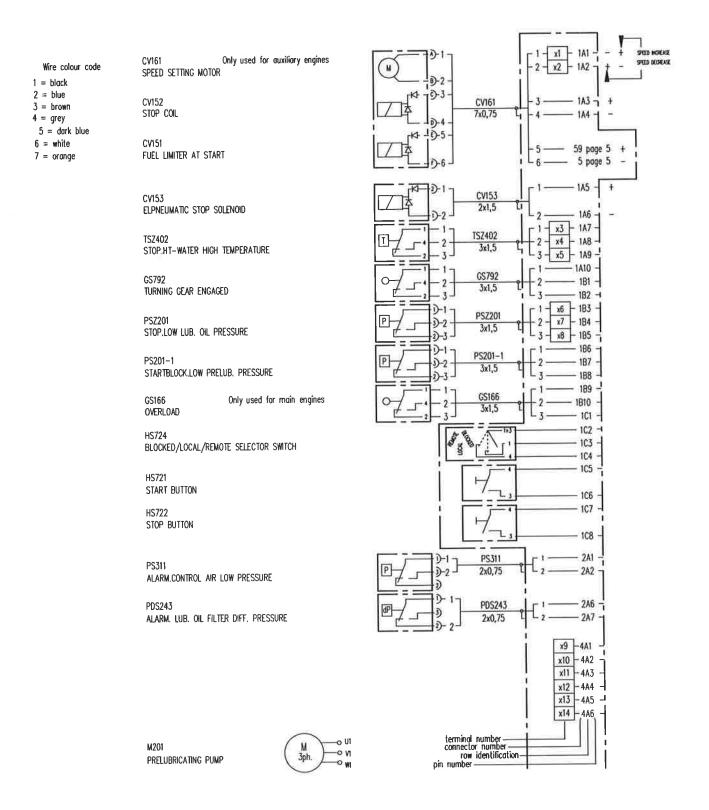
The MCU collects measuring data from the sensors on the engine, converts the information into digital form and communicates by serial link with the external monitoring, alarm and control systems. The MCU also handles the functions described in the previous paragraphs, i.e. speed measuring, start/stop sequences and automatic shut-downs. Vital functions, such as lubricating oil pressure and overspeed shut-down, are also handled by external switches independent of the MCU.

#### 14.9.3 Communications

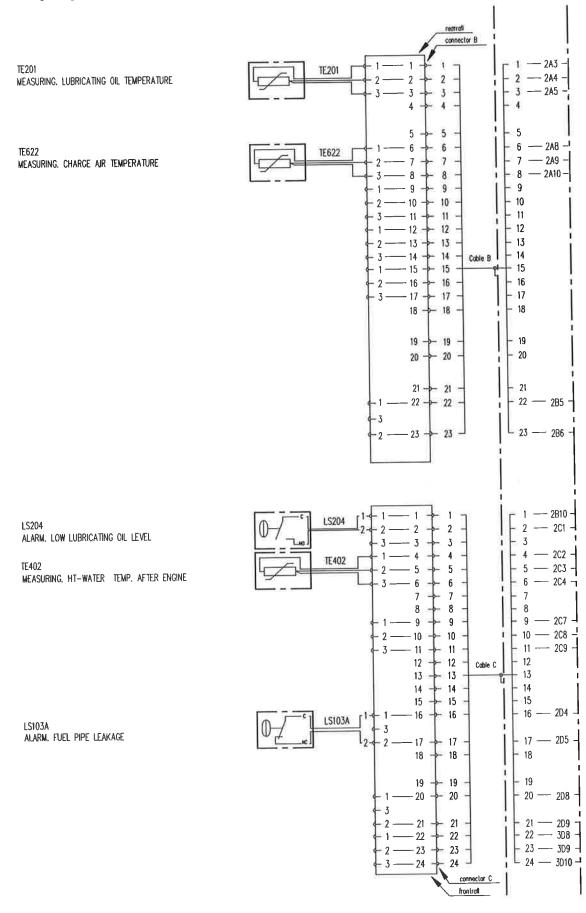
By having field bus connection via multi-standard RS-ports for communication with external systems, cabling work furnished by the yard will be minimized. In addition, installation work, service and maintenance will be easier.

The RS-interface is 4-wire RS485. The communication follows the Modbus RTU protocol specifications with the MCU as a slave in the Modbus network. A typical setup is a monitoring and alarm system functioning as a master and each MCU (one per engine) functioning as slaves.

## Typical wiring diagram (4V50L5692-1a)



#### Typical wiring diagram (4V50L5692-2a)



# Typical wiring diagram (4V50L5692-3a)

PT201

MEASURING, LUBRICATING OIL PRESSURE

PT451

MEASURING, LT-WATER PRESSURE

PT101

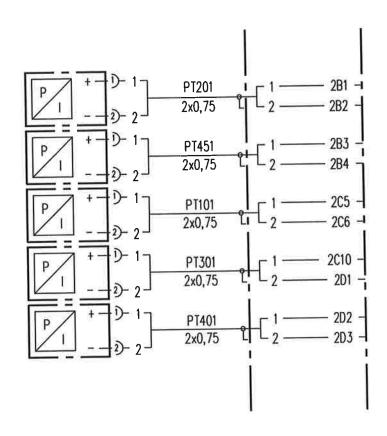
MEASURING, FUEL OIL PRESSURE

PT301

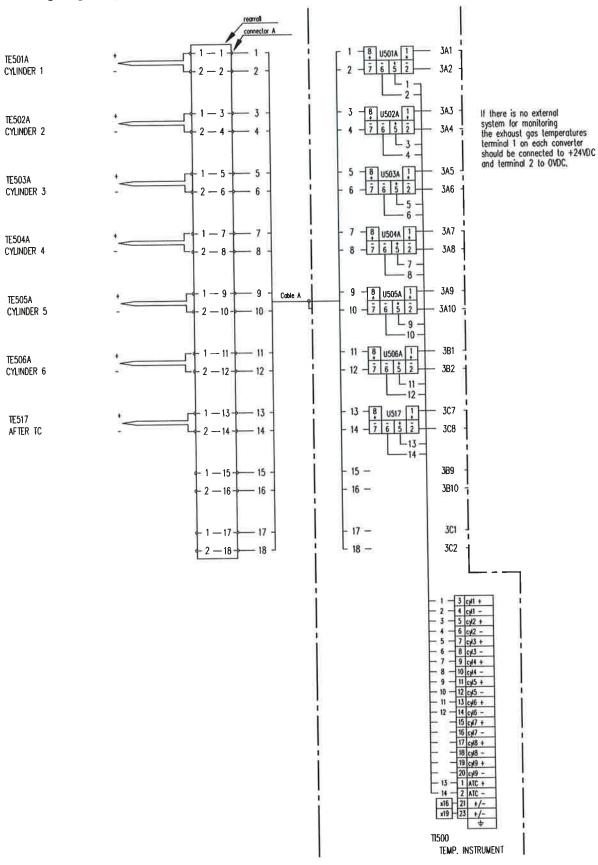
MEASURING. STARTING AIR PRESSURE

PT401

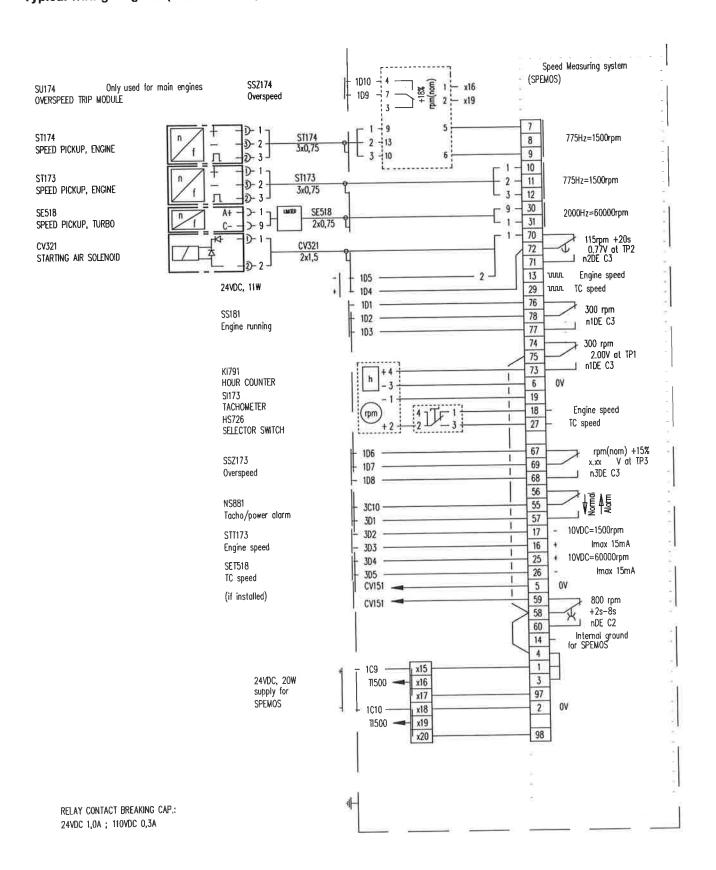
MEASURING. HT-WATER PRESSURE



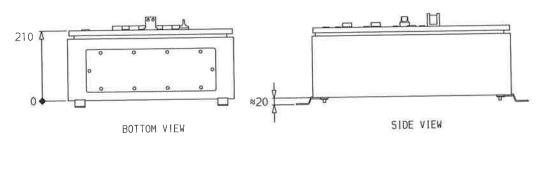
## Typical wiring diagram (4V50L5692-4a)

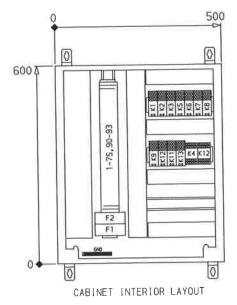


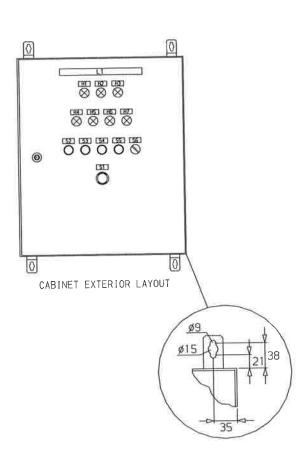
## Typical wiring diagram (4V50L5692-5a)



# Start stop system for an auxiliary engine (4V50G3472-1d)







#### Indication lamps

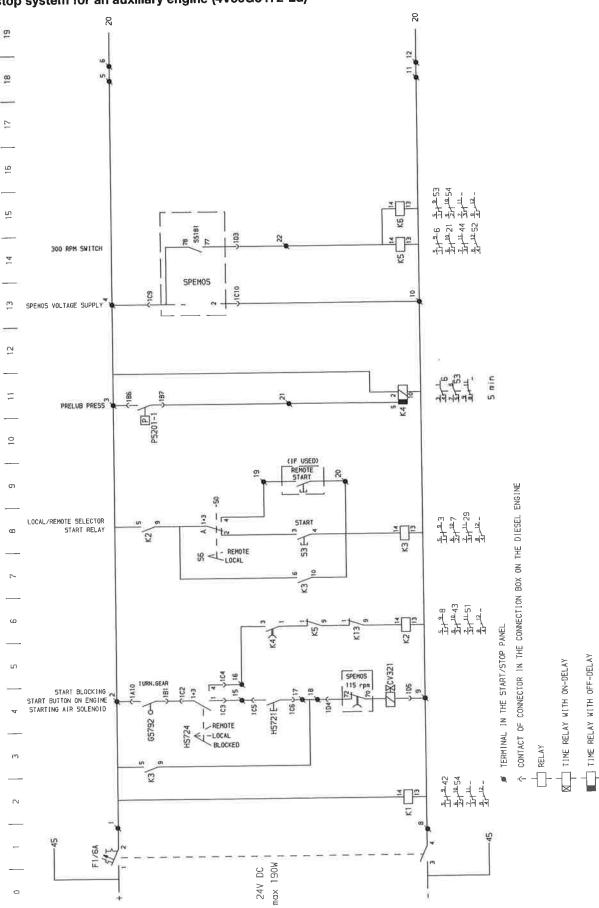
H1	Power on
H2	Ready for start
Н3	Engine running
H4	Cooling water temperature high
H5	Lubrication oil pressure low

H6 OverspeedH7 Start failure

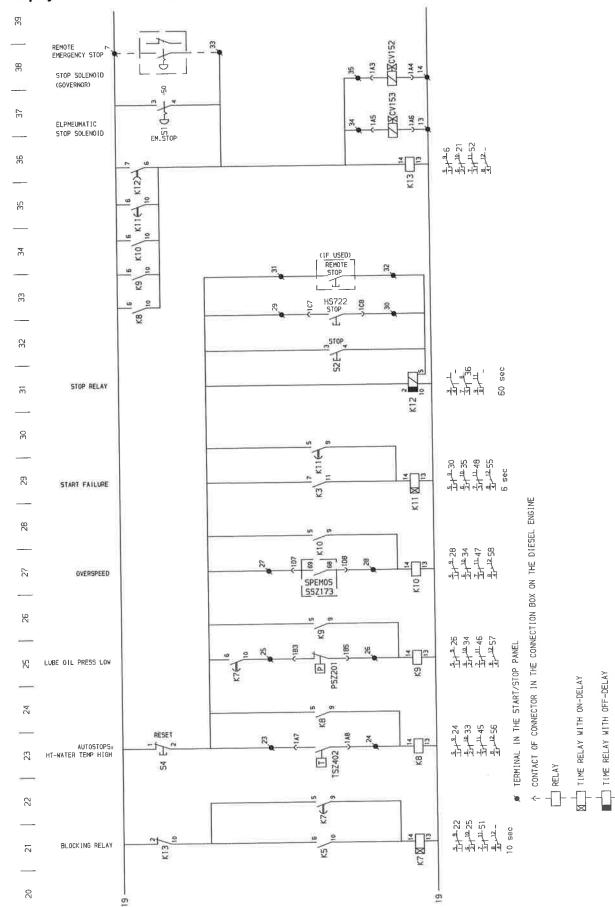
#### Pushbuttons and selectors

S1	Emergency stop
S2	Stop
S3	Start
S4	Reset
S5	Lamp test
S6	Local / Remote mode of start

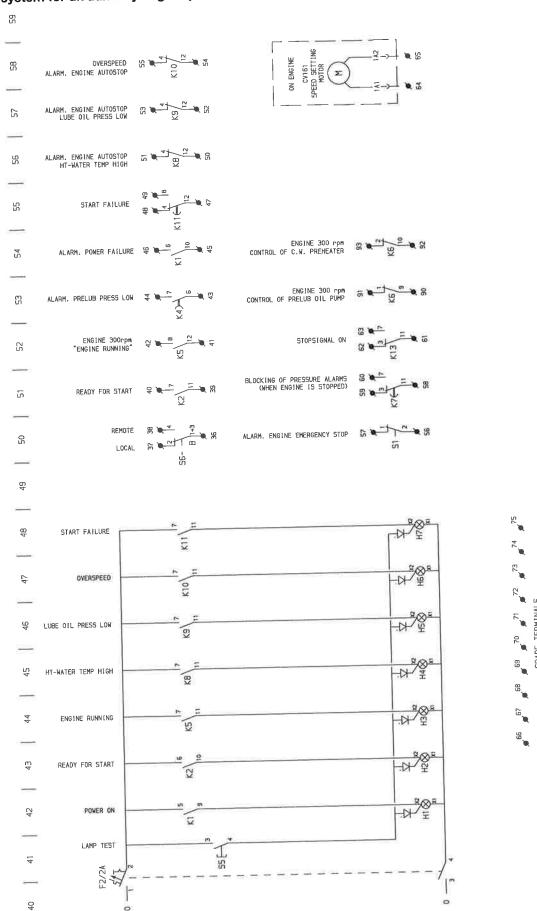
# Start stop system for an auxiliary engine (4V50G3472-2d)



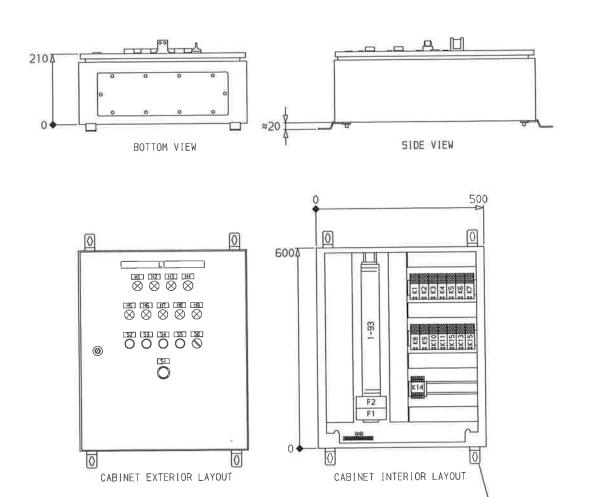
# Start stop system for an auxiliary engine (4V50G3472-3d)



# Start stop system for an auxiliary engine (4V50G3472-4d)



# Start/stop system for a main engine (4V50G3619-1a)



#### Indication lamps

H1	Power on			
	-	,	_	

H2 Ready for start

H3 Engine running

H4 Overload

H5 Cooling water temperature high

H6 Lubrication oil pressure low

H7 Overspeed

H8 Reduction gear lubrication pressure low

H9 Start failure

#### Pushbuttons and selectors

Emerger	icy stop
Emerger	ıcy stop

S2 Stop

S3 Start

S4 Reset

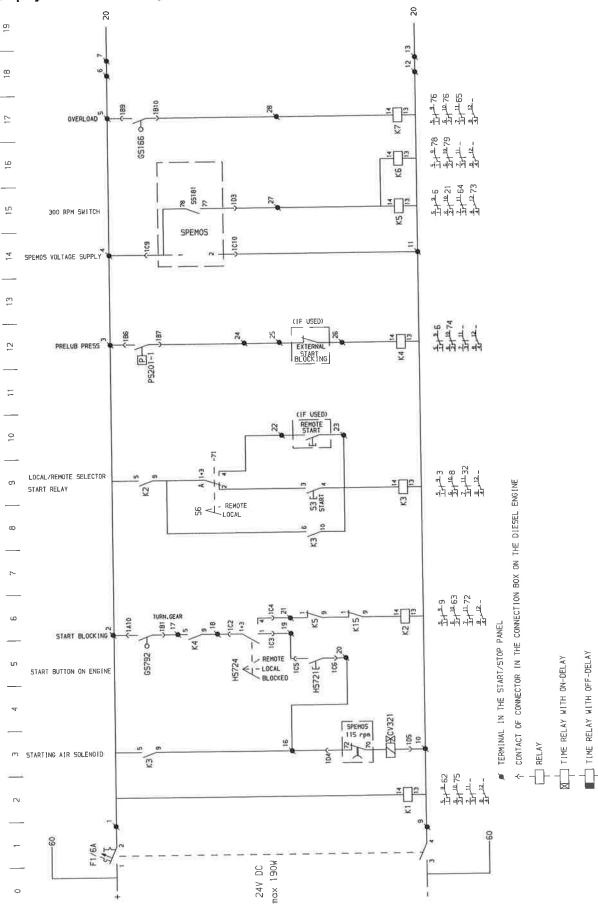
S5 Lamp test

S6 Local / Remote mode of start

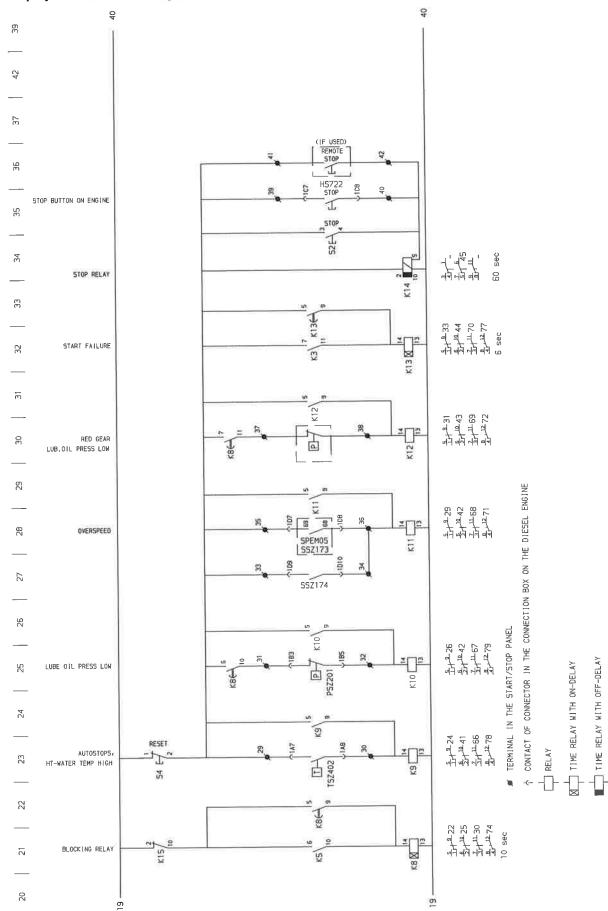
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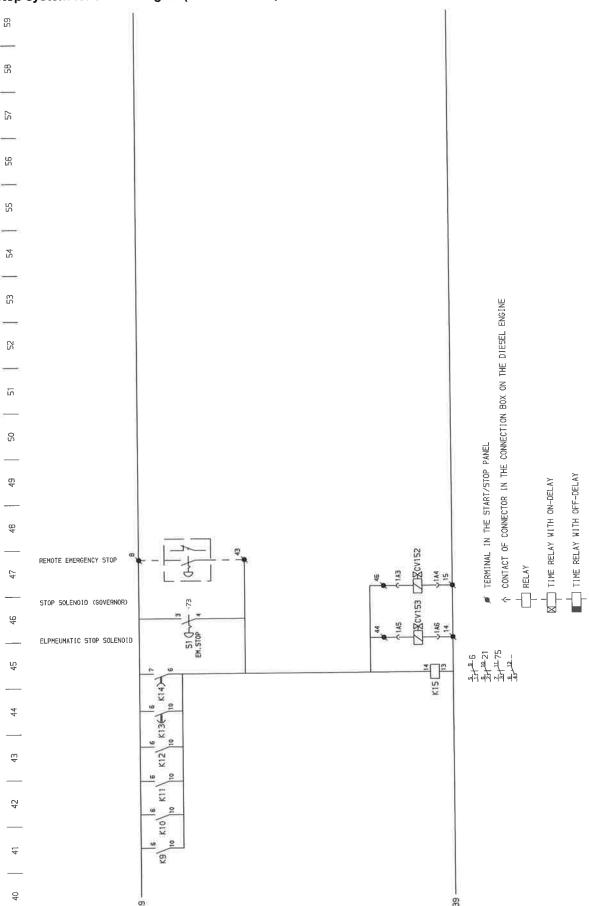
# Start/stop system for a main engine (4V50G3619-2a)



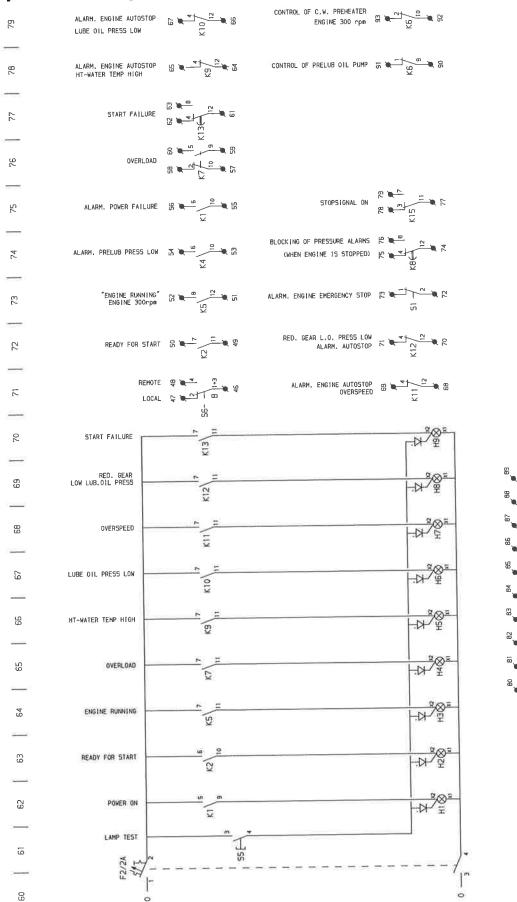
#### Start/stop system for a main engine (4V50G3619-3a)



## Start/stop system for a main engine (4V50G3619-4a)



#### Start/stop system for a main engine (4V50G3619-5a)



## 15. Electrical power generation and management

#### 15.1.General

The electrical concept design, either performed by the Ship Owner, Consultant, Yard or Wärtsilä as 'The Ship Power Supplier', is the basis for a co-ordination and optimisation of the electric power generation and management being supplemented by these general guidelines.

#### 15.1.1 Definitions

The marine vessel's electric supply system is an alternating current (a.c.) three-phase, three-wire insulated. The engine produced mechanical energy is converted into electrical energy by a generator, which usually is of the synchronous type and intended for continuous operation.

The voltage of the network and generator is low voltage (LV) up to 1000 V and medium voltage (MV) from 1 kV. Ordinary low voltages are 400 V (50 Hz), 450 V (60 Hz) and 690 V (50 or 60 Hz).

Nominal medium system voltages are 3 kV, 3,3 kV, 6 kV, 6,6 kV, 10 kV and 11 kV for 50 Hz or 60 Hz.

Low voltage is normally used in installations with total power up to about 10 MVA due to short circuit current restrictions in the switchgear.

The common network frequency (f) is 50 Hz or 60 Hz and the generator synchronous rated speed nrG [rpm] is calculated from:

nrG = 60 \* f/p

where p = pole pairs, and subsequently the number of poles = 2 \* p

Generator power definitions:

Sr = rated output, rated apparent power in kilovolt-amperes kVA

 $Sr = Pr/\cos \varphi r$ 

Pr = rated active power in kilowatts kW

 $\cos \varphi r = \text{rated power factor}$ 

 $\cos \varphi r = Pr/Sr$ 

The generator rated active power limit Pr should match with the diesel rated output power PDIESEL taking into account the efficiency  $\eta_{\text{GEN}}$  of the generator.

 $Pr = \eta_{GEN} * P_{DIESEL}$ 

Generator  $\eta_{GEN}$  is typically 95...97 % at full load and  $\cos\phi$ 0,8

#### 15.1.2 Electric load demand at consumers and generators

The load demand analysis (electric load balance) listing the various loads and modes onboard ship is usually evaluated in the concept design phase and made available to the generator set supplier as the basis for dimensioning the genera-

The generator feeds power to the consumers in the network including all electrical transmission losses. If only the consumer power consumption is advised, the total required power supplied by the generator shall be increased with the network losses, which typically could be 5...9 % depending on type, size and quality of electrical components.

#### 15.1.3 Operation modes

The generators shall be capable of operating in parallel.

The operation modes of the vessel have different demands of electric power and number of generating sets in operation. Important factors are:

- operation profile
- actual operation mode and maximum expected load
- operational practice (e.g. at least 2 generating sets running)
- redundancy requirements
- accepted loading practice of the generating sets (e.g. 90 % of Pr)

#### 15.1.4 Basic requirements

For a.c. generating sets used onboard ships and offshore installations which have to comply with rules of classification society (Class), the specific requirements of the Class shall be observed.

The main source of electrical power consists of at least two generating sets, and a shaft generator may be considered to be one of the required generators if capable of operating in parallel. The capacity of the generating sets shall be such that in the event of any one set being stopped it will still be possible to supply those services necessary to provide normal operational conditions of propulsion, safety and minimum comfortable conditions of habitability.

In the following there are some common basic requirements of the generating set performance.

Frequency and voltage variations in a.c. installations:

Table 15.1.

Load condition:	Steady state	Transient state		
Freq./speed regulation	95 – 105 %	90 – 110 %		
A.c. voltage regulation	97,5 – 102,5 %	85 – 120 %		

Although the Class sets requirements for sudden load changes, the general recommendation is to apply electrical loads in a ramp function rather than in sudden load steps. Reference is also made to Chapter for Operating Ranges.

## 15.2. Electric power generation

#### 15.2.1 General dimensioning criteria

The generator voltage, capacity and number of units are basically defined from the operation mode with the highest expected electric load. The most demanding operation mode is usually manoeuvring or cargo handling, while max speed at sea in a diesel-electric ship may require more power.

It should be considered that at least one generating set should be stand-by offering flexibility to perform maintenance work on any other generating set.

For example, in an uncomplicated vessel the generator capacity could be selected in a way that one unit is suitable for port and sea conditions, and two units for manoeuvring conditions having a 3rd unit as a stand-by.

General dimensioning criteria with respect to power, among others:

- type of vessel
- operation mode and application
- · requirements of the connected load
- load power factor cos φ
- cost efficient loading level, optimum specific fuel consumption
- redundancy requirements
- starting characteristics of high power motors

Due consideration is to be given to the transient frequency and voltage characteristics of the generating set during and after a sudden load change. Any particular requirement of the load acceptance shall be subject to agreement between the customer and Wärtsilä.

#### 15.2.2 Power factor

Rated power factor  $\cos \varphi r$  of the generator shall be selected in accordance with the network load  $\cos \varphi$ , which usually is 0,8 ... 0,85.

In a diesel electric drive vessel e.g.: with cyclo converters and/or low loading of propulsors, the power factor is usually 0,7...0,8 and the generators are to be dimensioned accordingly.

The most common power factor for generators is 0,8.

#### 15.2.3 Generator reactances

An important issue with regard to short circuit figures and starting capacity in the network is the generators' subtransient reactance xd". The xd" is typically 15...20 (up to 25) %.

Generally a high xd" causes a lower short circuit current but reduces the starting capacity of high power motors in the network due to an excessive voltage drop.

A very low xd" increases the generator size in comparison to a high xd", but the possibility to choose a specific xd" is somewhat restricted.

A compromise between high starting capacity and low short circuit level of the network, and low distortion level of the distorted voltage waveform in a 'polluted' vessel, is to be done when deciding the generator reactances.

# 15.2.4 Generator protection and switchgear

Generator set switchgear, control gear and monitoring equipment is usually mounted off the generating set. All components incorporated in the switchgear shall be adequately rated to suit the generating set and the specified mains operation, including the prospective fault current.

The generator is basically protected by the generator breaker and protection devices, usually being tripped by the following protection functions:

- short circuit
- overload
- time delayed over-current
- reverse-power
- differential-current
- voltage protections (over and under voltage release)
- earth fault
- stator RTD temperature HI/HI

Generating set protection systems mainly related to the engine are set in the chapter for Automation System, and comprise among others:

load shedding

- overspeed
- engine shutdown
- emergency stop
- major alarm from the speed governor.

#### 15.2.5 Motor starting capacity of the network

The starting capacity of the electrical network depends mainly on the connected spare generator capacity, generator xd", xd' and allowed voltage drop. The maximum allowed transient voltage drop is 15 %, which in some cases is too much for sensitive equipment.

The starting characteristics of the most power consuming motor or consumer is to be carefully checked. The generator manufacturer is to be informed (preferably at the offering stage) on the motor characteristics, operation and starting method in order to evaluate the expected voltage drop.

An excessive voltage drop causes generator dimensioning adjustments and/or means of alternative motor starting methods, e.g. soft starting device.

#### 15.2.6 Speed Governor

The speed governor is a device, which senses the speed of the engine and controls the fuel flow to the engine to maintain the speed at the desired level to meet changes in load output. Governor types are mainly hydraulic/mechanical or electronic, which are used in more complex projects.

In electrical terms, the speed governor controls the generator's and network's frequency and the active load sharing by speed droop feedback or an 'isochronous' (zero droop)

The steady state frequency characteristics depend mainly on the performance of the engine speed governor, while the transient frequency characteristics depend on the combined behaviour of all engine system components.

Basic definition of speed droop:

A decrease in speed reference for an increase in load, i.e. the % of the current speed reference by which the speed reference is drooped (decreased) from zero to full load.

An external speed setting from the power management system compensates the speed droop effect keeping the frequency stable in long term steady state conditions.

Speed droop based load sharing is possible with both a hydraulic/mechanical and an electronic governor. For most applications a droop of 3...5 % is recommended. The droop setting, as well as the dynamical performances of the governor, shall be equal for all parallelling generators in order to have a proportional load sharing.

An isochronous load sharing for parallelling generators is possible with an electronic governor. All parallelling generators are to have the same maker and type of electronic governor. The isochronous mode governor will maintain a constant speed up to 100 % load.

### 15.2.7 Automatic Voltage Regulator (AVR)

The AVR controls the generator voltage and the reactive load sharing. The brushless exciter-AVR system is to detect changes in terminal voltage (e.g. caused by a sudden load change) and to vary the field excitation as required to restore the terminal voltage of the generator.

The AVR, including the spare AVR where applicable, shall be tested and approved by the Class together with the generator forming a unit.

The exciter and AVR are normally supplied from the generator (shunt excitation) or sometimes from a shaft-mounted external Permanent Magnet Generator (PMG), which is used on generators, e.g. in a network with notable voltage distortion.

In order to maintain a possible network short-circuit current, high enough (at least 3 \* IN) to trip the generator or achieve selectivity in the distribution, a booster (short-circuit excitation) circuit is provided for the shunt excitation.

The reactive load sharing of parallelling generators is provided by the AVR using parallelling compensation circuits called:

- voltage droop compensation
- crosscurrent compensation

The droop compensation is the most commonly used circuit for reactive load sharing and is possible with an analogue or a digital AVR. The voltage droop depends on the reactive load, i.e. a decrease in voltage for an increase in reactive load.

The crosscurrent compensation is a more complex method for reactive load sharing. The voltage is maintained constant without 'droop', and the reactive load is balanced.

Manual voltage control in the main switchboard as a back-up is generally provided only on the request of the customer.

#### 15.2.8 Shaft generators

A shaft generator (SG) is driven by a main propulsion unit, which usually is intended to operate at constant speed in a CPP installation.

Shaft generators are normally connected to:

 a secondary PTO from a step-up gear (generator runs parallel to the propeller shaft)

- a primary PTO from a step-up gear (generator runs parallel to the engine)
- an engine free end

A constant frequency shaft generator may be an alternative in a vessel with a diesel driving a FPP.

It is recommended to provide the main engines with electronic speed governors when shaft generator installations are applied in multi engine installations (twin-in/single-out).

The SG is dimensioned with regard to the operating mode, electric load at sea and thruster (or other high power consumer) sizes.

In the case with secondary PTO the shaft generator speed nrG and the gear ratio is to correspond to a suitable high speed of the main engine, in order to have power enough to run both shaft generator and CPP at a constant speed at sea. In the manoeuvring mode the propeller cavitation can be reduced, by selecting a 2-stage (speed) PTO gear enabling a lower main engine and propeller speed.

#### 15.2.9 Earthed neutral

The vessels' generation and distribution systems are ordinarily insulated in low voltage installations as well as for tankers.

The network in medium voltage installations is mostly earthed via a high resistance connected to the generators' neutral. The rating of the earthed neutral system shall be defined taking into account the ratings of all components of electrical equipment in the generation circuit.

Earthed neutral options are e.g. a separate earthing transformer with a resistance, a low resistance earthed neutral or a direct earthed neutral.

The earthed neutral cabinet is normally delivered by the switchgear supplier and co-ordinated with the generator supplier.

#### 15.2.10 Emergency diesel generator

The emergency source of electrical power shall be self-contained independently from engine room systems with more stringent requirements as to operability when heeling and listing as well as location, starting arrangements and load acceptance.

The emergency diesel generator (EDG), supplying the emergency consumers required by statutory requirements, is basically dimensioned according to worst loading case of fire fighting, flooding and blackout start.

The starting capacity of the emergency network shall be specially considered, as the most power consuming emergency electrical consumer (motor) often determines the size of EDG. Allowance is also recommended for possible future additional emergency loads.

The emergency consumers comprises e.g.: emergency lighting, navigational and communication equipment, fire alarm systems, fire and sprinkler pumps, bilge pump, water-tight doors, person lifts, steering gear.

Many shipowners have additional requirements with regard to EDG-supplied services as precautionary measures against blackout, e.g.: essential (non-emergency) auxiliaries for electric power generation and propulsion. This further loading of EDG shall of course be reflected in the EDG size, and a shedding system for non-emergency consumers to be provided and trip, in case the EDG should be overloaded.

It is not recommended to use the EDG as a harbour generator, ref. Solas Ch. II-1 Part D Reg. 42. 1.4 and Reg. 43. 1.4.

# 15.3. Electric power management system (PMS)

#### 15.3.1 General

The main task of an electric power management (PMS) is to control the generation plant and to ensure the availability of electrical power in the network as well as to avoid blackout situations.

The PMS controls the starting/stopping and synchronising of a generator to the network, frequency monitoring, steady state load sharing between on-line generators, blackout starting, shaft generator, gear clutches and executes load tripping when the power plant is overloaded (load shedding).

The main busbar is normally subdivided into at least two parts connected by bus tie breakers, and the connection of generating sets and other duplicated equipment shall be equally divided between the parts.

#### 15.3.2 Control modes

The PMS is to have redundant hierarchy of control modes, the following provisions being typical:

- automatic, independently derived signals without manual intervention
- · remote control, manually initiated
- · local control, e.g. hand or electric

The automatic mode is the normal operation mode. It is recommended that means are provided to start an engine locally and to synchronise manually at the main switchboard in case of PMS failure. The back-up system is recommended to be an independent operating system, hard wired and with galvanic isolation to the main system.

Monitoring of the generating set operation to verify correct functioning by measurement or protection and supervisory control parameters in accordance to Class and requirements are set in the chapter for Automation System.

#### 15.3.3 Main breaker control

20

The following main breakers in the main switchboard are typically controlled from the PMS:

- diesel generator
- shaft generator
- bus tie breaker
- shore connection
- high power consumers, e.g.: bow thruster, AC-compressor,
- emergency switchboard connection

## 15.3.4 Blackout start and precautionary measures

In case of blackout in the main switchboard (MSB) the related generating sets get a starting order and the first available generating set to 'run up' will connect to the MSB. The following units are to be automatically synchronised.

Precautions against failing blackout start are:

- booster and fuel supply pumps connected to emergency switchboard (ES)
- pre lubricating pump connected to ES
- sequential re-start of essential pumps, fans and heavy consumers to achieve a loading ramp rather than big loading steps

Precautions against total loss of propulsion (diesel mechanical concepts) in a blackout situation could be following measures:

- essential ME pumps are engine driven
- essential propulsion train pumps are gear driven
- essential electrical pumps and fans for propulsion are connected to ES
- operate with split network

# 15.3.5 Parallelling of generators, load sharing

The PMS provides automatic synchronising of auxiliary diesel generators i.e. frequency adjustment to bring the incoming set into synchronism and phase with the existing system, considering possible restrictions (e.g.: short circuit level) regarding max number of generators allowed to be connected to the MSB.

The PMS controls the active (kW) load sharing over the speed governor:

• droop control, characteristics about 4 %

isochronous load sharing, possible by means of an electronic speed governor taking care of ramping up, load sharing and ramping down; PMS only connects the set and after allowance by the governor disconnects the set.

Active load sharing between diesel generators is normally proportional (balanced). The droop setting shall be equal for all parallelling generators in order to have a proportional load sharing.

Some feature mode options could promote an economical and environment-friendly operation of the engines, e.g.:

- master-topping up, i.e. master(s) with constant optimal load and a topping up set taking care of the load variations
- sequencing of the master-topping up units

### 15.3.6 Shaft generator load transfer

The PMS controls the main engine in shaft generator (SG) applications giving priority to the electric generation, including possible propulsion load reduction where applicable.

Operating with SG supplying the main switchboard (MSB) in parallel with the connected propulsion line, the frequency may be unstable in rough sea, etc. It is recommended to use the SG independently supplying the MSB or part of it. If 2 SG are available e.g. in a twin-screw vessel, the MSB should be split into 2 parts, each part being supplied by a dedicated SG.

The load transfer from/to the auxiliary diesel generator(s) should normally be on a short time basis, i.e. parallelling only for the time of unloading the generator(s) followed by generator breaker opening.

The shaft generator is typically supplying thruster(s) in a separate network during the manoeuvring mode.

In the following a typical example of load transfer at sea to a running shaft generator when the thrusters have been disconnected:

- assure that the main engine load is stable and that the constant speed mode is selected
- synchronise the SG-section and the MSB (i.e. the auxiliary diesel engine(s) are usually synchronised to the main engine) and close the SG-section bustic breaker
- transfer load to SG by unloading the auxiliary diesel generator(s) according to unloading rate
- open the auxiliary diesel generator's breaker(s) when unloading trip level is reached
- stop the auxiliary diesel engine(s)

### 15.3.7 Load dependent start/stop

The PMS includes functions for automatic load dependent start/stop of diesel generation sets.

The start/stop limits and start order in an installation with several parallelling generating sets are set to achieve an optimal loading of the engines in the specific operation mode of the vessel. The PMS calculates the network's nominal power and total generator load over a defined period of time and compares that against the load dependent autostart/autostop limits. The objective is to ensure that the actual load is supplied by an appropriate number of generating sets to achieve best possible energy efficiency and fuel economy.

## 15.3.8 Power reservation for heavy consumers

Heavy consumers may be connected to a power reservation system in the PMS, which checks if there is enough reserve power capacity in the network upon a start request from the heavy consumer. If necessary the PMS will start and synchronise the next standby unit, and gives the start permission to the heavy consumer when the needed starting capacity is available.

# 15.3.9 Load shedding (preference tripping)

Auto start function is not fast enough as blackout prevention after rapid and large loss of power generating capacity, e.g. after tripping of a generator.

In order to protect the generator(s) against sustained overload, and to ensure the integrity of supplies to services required for propulsion and steering as well as the safety of the ship, suitable load shedding arrangements shall be arranged.

Typical consumers that may be tripped are:

- galley consumers
- AC-compressors
- accommodation ventilation
- reduction of propulsion power

# 15.3.10 Special applications, e.g.: Auxiliary Propulsion Drive (APD)

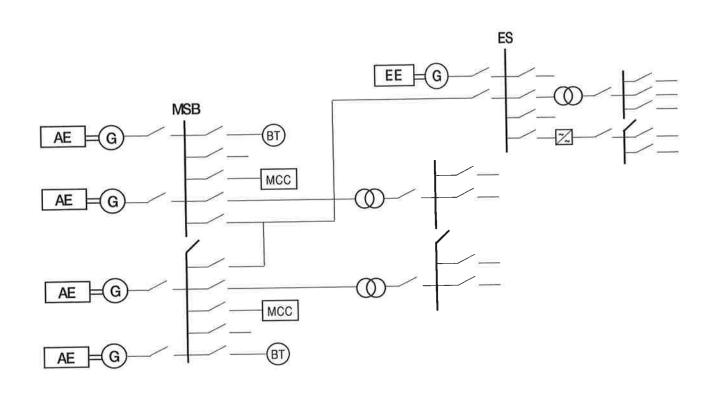
A special application providing limited redundancy with respect to increased availability of the vessel's propulsion system is the so-called Auxiliary Propulsion Drive (APD). The principle idea of this solution is that the ship can be propelled by the auxiliary generating sets, by using the shaft generator as an electric motor, in case the main engine (ME) is not available.

The benefit of the combined shaft generator and APD is an increase of safety when it is used as back-up propulsion in e. g. following operating modes:

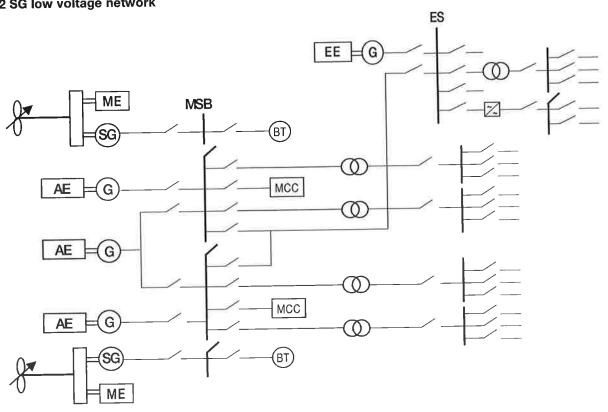
- booster mode, both ME and PTO are driving the propeller
- standby mode, ME disconnected for maintenance and APD is connected if manoeuvring is required
- emergency mode (take me home), APD is used to propel the ship if ME fails

## 15.4. Typical one line main diagrams

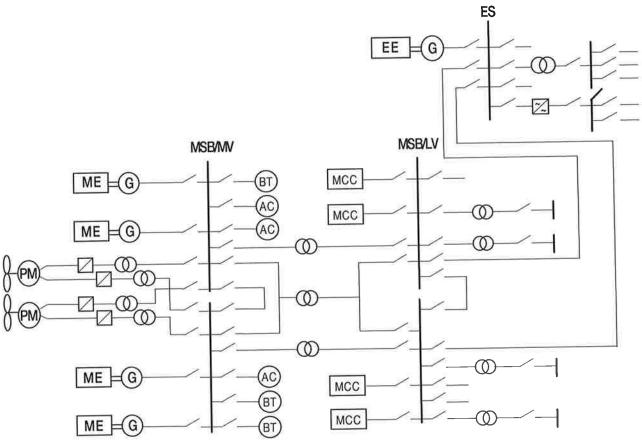
#### 4 ADG low voltage network



### 3 ADG + 2 SG low voltage network



## Diesel electric ship, medium voltage network



AC Air conditioning

AE Auxiliary engine

**BT** Bow thruster

EE Emergency engine

Emergency switch

ES board

G Generator

LV Low voltage

MCC Motor control center

ME Main Engine

MSB Main switch board

MV Medium voltage

PM Propulsion motor

SG Shaft generator

## 16. Foundation

#### 16.1.General

Engines can be either rigidly mounted on chocks, or resiliently mounted on rubber elements.

Wärtsilä should be informed about existing excitations (other than Wärtsilä supplied engine excitations) and natural hull frequencies, especially if resilient mounting is considered.

Dynamic forces caused by the engine are shown in the Chapter for Vibration and noise.

## 16.2.Steel structure design

The system oil tank should 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.

## 16.3. Mounting of main engines

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.

## 16.3.1 Rigid mounting

Main engines are normally rigidly mounted on the seating, either on steel or resin chocks.

The engine has 4 mounting brackets cast to the engine block. Each bracket has a threaded hole for an M16 jacking screw and two Ø22 holes for M20 holding down bolts.

The bolt closest to the flywheel at either side of the engine shall be made as a Ø23H7/m6 fitted bolt. All other bolts are clearance bolts.

The clearance bolts shall be through bolts with lock nuts at both the lower and upper ends. Ø22 holes can be drilled into the seating through the holes in the mounting brack-

In order to avoid bending stress in the bolts and ensure that the bolts remain tight the contact face of the nut under the seating top plate shall be counterbored.

The elongation of holding down bolts can be calculated from the formula:

$$\Delta L = 6.18 \cdot 10^{-6} F \sum_{i}^{n} \frac{L_{i}}{D_{i}^{2}}$$

 $\Delta L = bolt elongation [mm]$ 

F = tensile force in bolt [N]

 $L_i$ = part length of bolt with diameter  $D_i$  [mm]

 $D_i$  = part diameter of bolt with length  $L_i$  [mm]

Lateral supports as shown in 2V69A0236 shall be fitted against the engine block. The wedge type supports shall be lightly knocked into position when the engine is hot and secured with a tack weld. Minimum bearing surface on the wedges is 80%.

The chocking arrangement shall be sent to the classification society and Wärtsilä for approval.

#### Steel chocks

The top plates of the engine girders are normally inclined outwards with regard to the centre line of the engine. The inclination of the supporting surface should be 1/100. The seating top plate should be designed so that the wedge-type steel chocks can easily be fitted into their positions. The wedge-type chocks also have an inclination of 1/100 to match the inclination of the seating. If the top plate of the engine girder is fully horizontal, a chock is welded to each point of support. The chocks should be welded around the periphery as well as through holes drilled for this purpose at regular intervals to avoid possible relative movement in the surface layer. The welded chocks are then face-milled to an inclination of 1/100. The surfaces of the welded chocks should be large enough to fully cover the wedge-type chocks.

The supporting surface of the seating top plate should be machined so that a bearing surface of at least 75% is obtained.

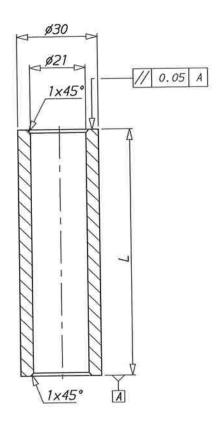
The cutout in the chocks for the clearance bolts should be about 2 mm larger than the bolt diameter. The maximum cut out area is 20%. Holes are to be drilled and reamed to the correct tolerance for the fitted bolts after the coupling alignment has been checked and the chocks have been lightly knocked into position.

In order to assure proper fastening and to avoid bending stress in the bolts, the contact face of the nut underneath the seating top plate should be counterbored.

Holding down bolts shall be long enough to ensure sufficient elongation when tightened.

An effective bolt length of 160 mm (between the nuts) will ensure a sufficient elongation. It is recommended to fit distance sleeves with L  $\geq$  95 according to drawing 4V33F0214 under the seating top plate. M20 8.8 bolts can be used. Tightening torque 390 - 430 Nm.

#### Distance sleeve (4V33F0214)



#### Table 16.1. Total load on resin chocks

#### Total load Ptotal [MPa] Bolt tension load Pbolt [MPa] Dwt load Pstatic [MPa] Engine 3.23 2.9 0.33 4L20 3.27 2.9 0.37 5L20 3.30 2.9 0.40 6L20 3.40 2.9 0.50 8L20 3.48 2.9 0.58 9L20

Wet engine with wet sump with standard equipment and flywheel.

#### **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 required to select a resin type, which has a type approval from the relevant classification society.

In order to assure proper fastening and to avoid bending stress in the bolts, the contact face of the nut underneath the seating top plate should be counterbored.

If the engine is installed on resin chocks, the seating shall be as shown in 2V69A0236, except that the 1:100 inclination is not necessary.

When installing an engine on resin chocks the following issues are important:

- Sufficient elongation of the holding down bolts
- Maximum allowed surface pressure on the resin p<sub>tot</sub> = p<sub>static</sub> + p<sub>bolt</sub>
- Correct tightening torque of the holding down bolts The elongation  $\Delta L$  of the holding down bolts should be:  $\Delta L$  [mm]  $\geq 0.12$  for a surface presure on the resin  $p_{tot} \leq 3.5$  MPa

 $\Delta$ L [mm]  $\geq 0.0343$  x p<sub>tot</sub> [MPa] for p<sub>tot</sub> > 3.5 MPa

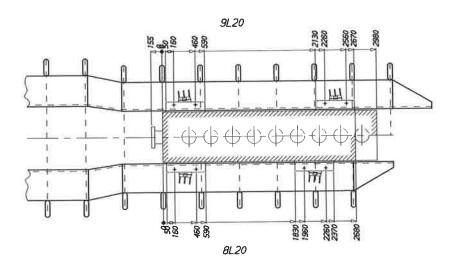
The recommended dimensions of resin chocks are 140 x 410 mm. This gives gives a deadweight loading  $p_{\text{static}}$  on the resin which is presented in the table below.

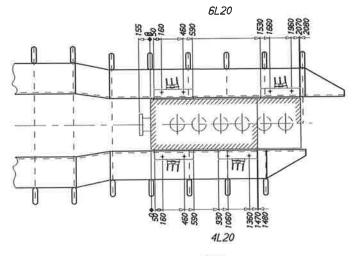
Most resin types can take at least 3.5 MPa and the bolt holding down force ( $p_{bolt}$ ) can be chosen to produce 3 MPa on the resin. This corresponds to a bolt tension of 83 000 N (with recommended chock dimensions) and a tightening torque of about 305 Nm tightening the bolts to 53% of yield, assuming M20 8.8 bolts.

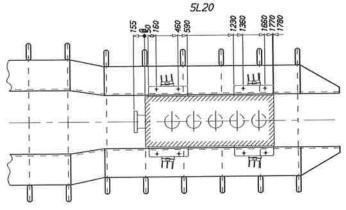
To ensure sufficient elongation a distance sleeve according to drawing 4V33F0214 with  $L \ge 45$  mm shall be fitted under the seating top plate

#### Main engine seating (2V69A0236a)

View from above

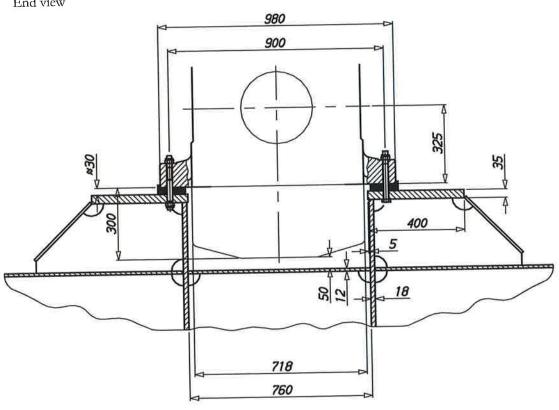




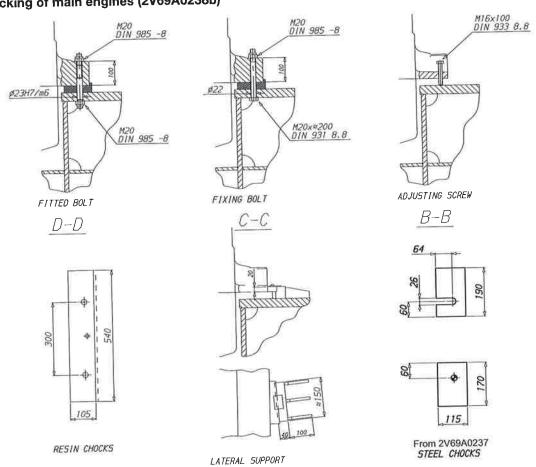


## Main engine seating (2V69A0236a)

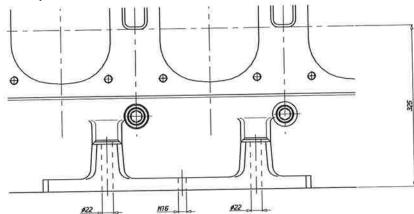
End view

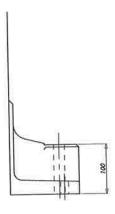


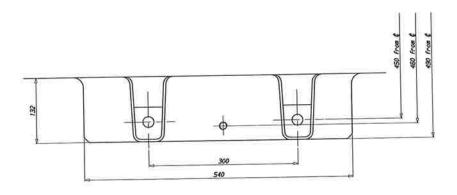
## Chocking of main engines (2V69A0238b)



## Mounting bracket (2V10A1836)



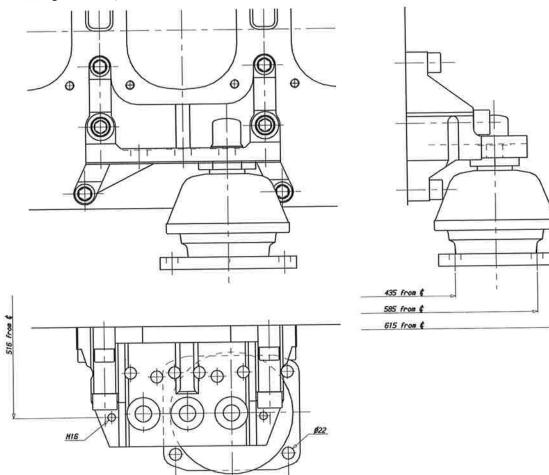




### 16.3.2 Resilient mounting

In order to reduce vibrations and structure borne noise, main engines may be resiliently mounted on rubber elements.

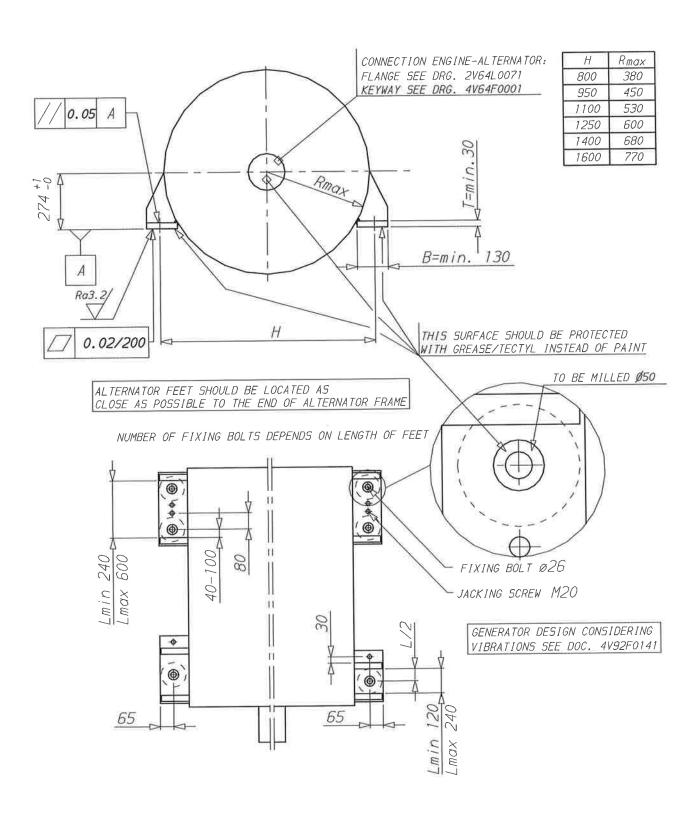
#### Mounting bracket (2V10A1837)



## 16.4. Mounting of generating sets

#### 16.4.1 Alternator feet design

Instructions for designing the feet of the alternator and the distance between its holding down bolts (4V92F0134c)



#### 16.4.2 Resilient mounting

Generating sets, comprising engine and generator mounted on a common base plate, 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 vibration.

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:

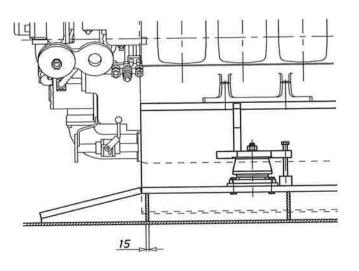
- Main engine speed [RPM] and number of cylinders
- Propeller shaft speed [RPM] and number of propeller blades

The selected number of mounts and their final position is shown in the generating set drawing.

#### Seating

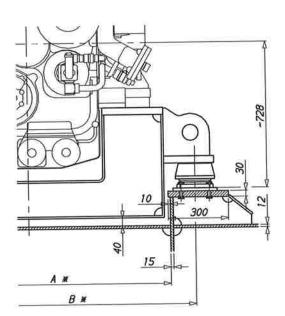
The seating for the common base plate must be rigid enough to carry the load from the generating set. The recommended seating design is shown in the drawing below.

## Recommended design of the generating set seating (3V46L0720c)



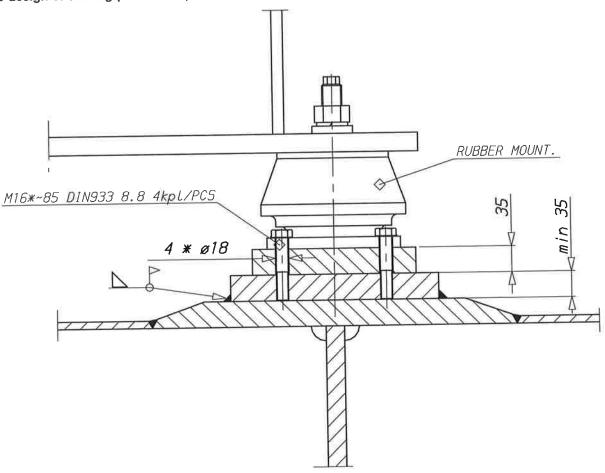
ENGINE	A *	B *
4L20	1330	1580
5L20	1330	1580
6L20	1330-1480	1580-1730
8L20	1480-1630	1730-1880
9L20	1630-1860	1880-2110





If the generating set will be installed directly on a deck or on the tank top, the alternative design shown in drawing 4V46L0296 can be permitted.

#### Alternative design of seating (4V46L0296)



The lateral distance between the mounts varies between 1340 mm and 1640 mm depending on the number of cylinders of the engine and the type of generator.

#### **Rubber mounts**

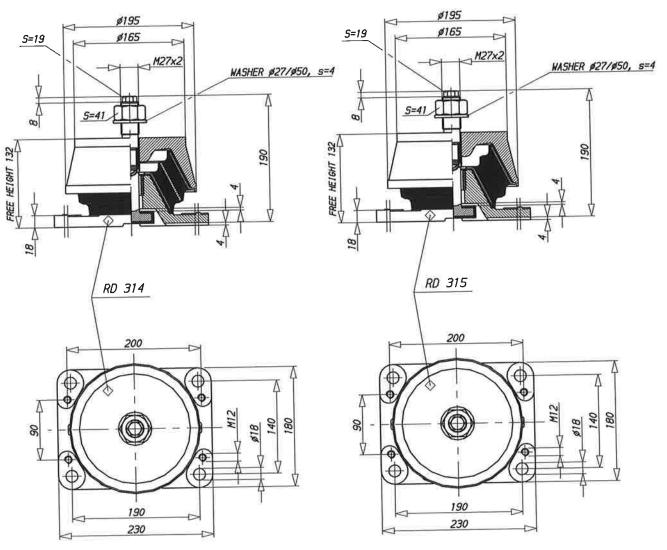
Conical mounts in natural rubber are used.

The mounts are equipped with an internal adjustable central buffer. Hence, no additional side or end buffers are required to limit the movements due to ship motions

Particularly with the alternative foundation design (see drawing 4V46L0296), care must be taken that the mounts will not come in contact with oil, oily water or fuel.

The mating surfaces of the common base plate is delivered machined, with holes for attaching the mounts which are delivered separate.

#### Rubber mounts (3V46L0706)



Туре	Rubber hardness	Load capacity
RD 314	45	2600 kg
RD 314	50	3200 kg
RD 314	55	3700 kg
RD 314	60	4300 kg
RD 314	65	4900 kg
RD 315	45	1400 kg
RD 315	50	1900 kg
RD 315	55	2300 kg
RD 315	60	2700 kg
RD 315	65	3100 kg

#### Installation of the generating set

A correct mounting of the generating set requires that all rubber elements are equally compressed, i.e. the load on each mount is equal. The installation procedure is:

- $\bullet\,$  Remove the M27x2 nut and the washer from the mount.
- Attach each mount to the common base plate by fitting the washer on the central buffer and tighten the nut by hand (see drawing 3V46L0706).
- Lower the installation load onto the mounts, loosen the nut.
- Jacking screws are used for levelling the installation.
   Holes for the jacking screws are pre-drilled before delivery. M20 x 160 DIN933 8.8 jacking screws can be used.
   Jacking screws are supplied by the shipyard.
- Would the screw turn out to be too short, temporary chocks can be used to increase the lift.
- To avoid that the generating set weight is resting on the internal buffer instead of on the rubber it is important to check that all internal buffers can easily be turned by ap-

plying a spanner to the top hexagon (S = 19). If this is not possible, remove the installation load progressively until all buffers can be turned freely. Turn the internal buffer counter clockwise (upwards) and re-lower the installation onto the mounts. Repeat the above procedure until all buffers can be rotated freely with the full installation load applied.

- The correct deflection of the mounts is between 4 and 10 mm depending on the weight of the generating set and the selected quality of the rubber. The calculated compressed height of the mounts is shown in the generating set drawing.
- Check that the mounts are evenly compressed. The
  compressed height of all mounts must be within 2.0 mm.
  Adjustments in height shall be made using machined
  chocks. If shims are used the minimum thickness of a
  shim is 0.5 mm and only one shim per mount is permitted.
- Check that the seating of each mount is horizontal. This
  is done by measuring the compressed height of each
  mount on all sides. The difference must not exceed 0.5
  mm.

Adjustments are made with wedge type chocks.

- Set the internal buffer working clearance for each mount:
- Turn the internal buffer counter clockwise (upwards) to the maximum upper position.
- Turn the internal buffer two full turns clockwise (downwards).
- Finally, tighten the nut with a torque of 300 Nm. While doing this the top hexagon must be secured with a spanner

The mounts should preferably be allowed to settle for a minimum of 48 hours, due to initial creeping, before lining up pipework, etc.

The transmission of forces emitted by the engine is 10...30% when using rubber mountings compared to rigid mounting.

## 16.5. Reduction gear foundations

The engine and the reduction gear must have common foundation girders.

# 16.6.Free end PTO driven equipment foundations

The foundation of the driven equipment must be integrated with the engine foundation.

## 16.7. Flexible pipe connections

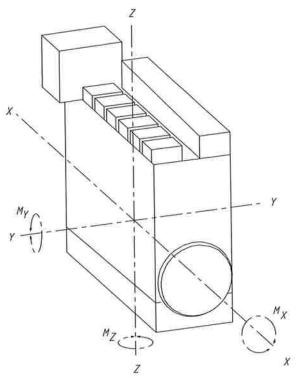
When the engine or generating set is resiliently installed, all connections must be flexible and no grating nor ladders may be fixed to the engine or generating set. When installing the flexible pipe connections, unnecessary bending or stretching should be avoided. The external pipe must be precisely 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.

## 17. Vibration and noise

#### 17.1. General

Dynamic forces and moments caused by the engine appear from the table. Due to manufacturing tolerances some variation of these values may occur.

#### Coordinate system of the external torques



## 17.2. External forces and couples

Table 17.1. External forces

FZ = 0 FV = 0 and FX = 0 for 5, 6 and 9 cylinder engines

FZ = 0, $FY = 0$ and $FX = 0$ for 5, 6 and 9 cylinder engines						
Engine	Speed	Frequency	Fz			
	[rpm]	[Hz]	[kN]			
	720	48	0.7			
4L20	750	50	0.8			
	900	60	1.1			
	1000	66.7	1.4			
	720	48	1.4			
8L20	750	50	1.5			
	900	60	2.2			
	1000	66.7	2.7			

Table 17.2. External couples

MZ = 0, MY = 0 for 4, 6 and 8 cylinder engines

Engine	Speed	Frequency	MY	MZ
	[RPM]	[Hz]	[kNm]	[kNm]
	900	15	3.4	3.4
5L20		30	21	-
	1000	16.7	4.2	4.2
		33.3	26	_
	720	12	4.5	4.5
		24	3.1	_
	750	12.5	4.9	4.9
9L20		25	3.3	
	900	15	7	7
		30	4.8	_
	1000	16.7	8.6	8.6
		33.3	5.9	

Table 17.3. Rolling moments

Engine	Speed	Frequency	Full load (M <sub>X</sub> )	Zero load (M <sub>X</sub> )	Frequency	Full load (Mx)	Zero load (M <sub>X</sub> )
	[RPM]	[Hz]	[kNm]	[kNm]	[Hz]	[kNm]	[kNm]
4L20	720	24	10	4.8	48	7.5	1.6
T Agreement	750	25	9.4	5.6	50	7.5	1.5
	900	30	4.8	10	60	7.4	1.4
	1000	33.3	1.5	13	66.7	7.4	1.3
5L.20	900	37.5	18	4.3	75	6.2	1.7
J120	1000	41.7	18	4.3	83.3	6.3	1.8
6L20	720	36	13	1.4	72	4.2	1.2
Marine C.	750	37.5	12	1.9	75	4.2	1.2
	900	45	9.8	4.7	90	4.7	1.3
	1000	50	7.8	6.8	100	4.7	1.3
8L20	720	48	15	3.1	96	1.7	0.7
OL.	750	50	15	3.1	100	1.7	0.7
	900	60	15	2.8	120	2.2	0.7
	1000	66.7	15	2.6	133.3	2.2	0.7
9L20	720	54	13	3.5	108	1.1	0.5
an exercise SE	750	56.3	13	3.5	112.5	1.1	0.5
	900	67.5	14	3.6	135	1.6	0.5
	1000	75	14	3.6	150	1.6	0.5

## 17.3. Mass moments of inertia

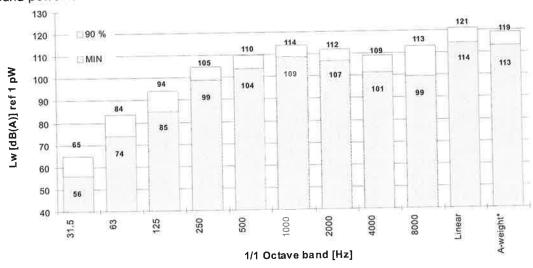
The mass-moments of inertia of the propulsion engines (including flywheel, coupling outer part and damper) Are typically as follows:

Engine	J[kgm²]
4L20	90 - 120
5L20	130 - 150
6L20	90 - 150
8L20	110 - 160
9L20	100 - 170

Figure 17.1. Sound power levels

## 17.4. 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 smallest sound power level found in the measurements. The 90% level is such that 90% of all measured values are below this figure.



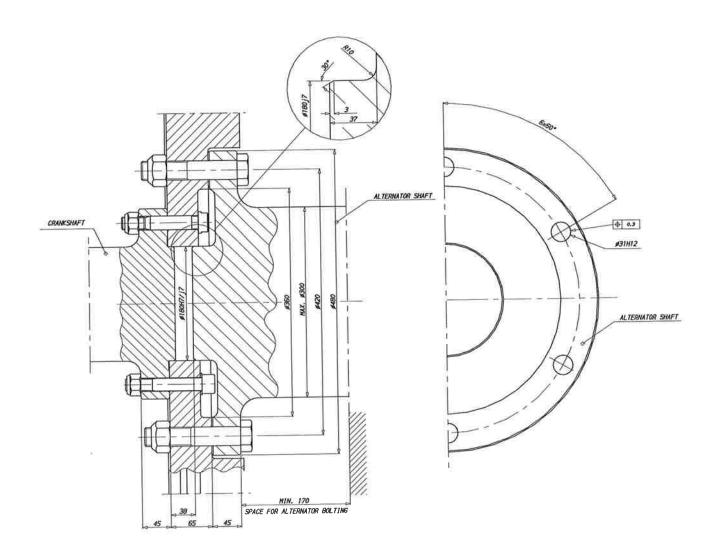
## 18. Power transmission

### 18.1. General

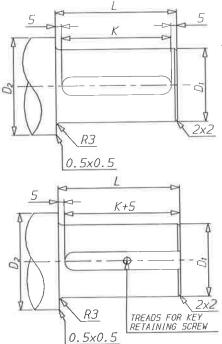
The full engine power can be taken from both ends of the engine. At the flywheel end there is always a flywheel for the management of the torsional vibration characteristics of the system and to facilitate manual turning of the engine. The flywheel creates a natural flange connection. At the free end a shaft connection as a power take off can be provided.

## 18.2. Connection to alternator

Connection engine/single bearing alternator (2V64L0071)



#### Connection engine/two-bearing alternator (4V64F0001a)



ALTERNATIVE 1

ALTERNATOR MANUFACTURER SUPPLIES KEY

Engine	$D_{l}$	L	K	min $D_2$
4L20	120	150	140	130
5L20	120	150	140	130
6L20	150	190	180	160
8L20	150	190	180	160
9L20	150	190	180	160

KEYWAY: DIN6885

ALTERNATIVE 2

### 18.3. 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 alternator installations a flexible coupling between the engine and the generator is required.

### 18.4.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

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 line locking device should also be fitted to be able to secure a propeller shaft in position so that windmilling is avoided as also an open hydraulic clutch can transmit a small torque.

### 18.5. Shaftline locking device and brake

### 18.5.1 Locking device

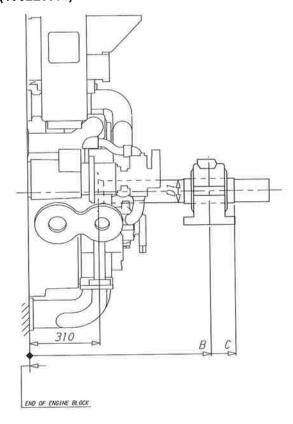
• A shaftline locking device is needed when the operation of the ship makes it possible to turn the shafting by the water flow in the propeller.

#### 18.5.2 Brake

 A shaftline brake is needed when the shaftline needs to be actively stopped. This is the case when the direction of rotation needs to be reversed.

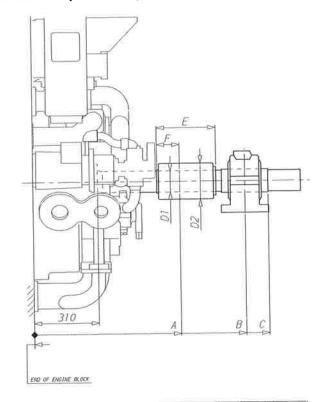
## 18.6. Power-take-off from the free end

#### Power take off at free end alternative 1 (4V62L0931)



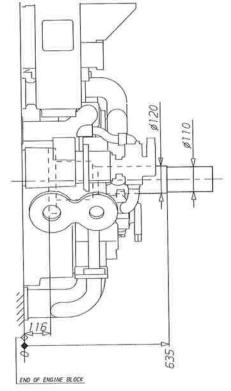
D1	В	С
100	800	910

#### alternative 2 (4V62L0932)



D1	D2	A	В	C	Ε	F
100	170	700	1010	1120	280	108
110	185	750	1070	1180	300	118

#### alternative 3 (4V62L1158)



NOTE! Max output maybe restricted due to max coupling weight 135kg. 1320kW always accepted

# 18.7.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 the list below.

#### General

- Classification
- Ice class
- Operating modes

#### Data of 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

#### Data of 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

#### Data of main alternator or shaft alternator

A mass-elastic diagram or an alternator shaft drawing showing:

- alternator 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

#### Data of 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

## 18.8. Turning gear

• A manual turning tool is provided with the engine.

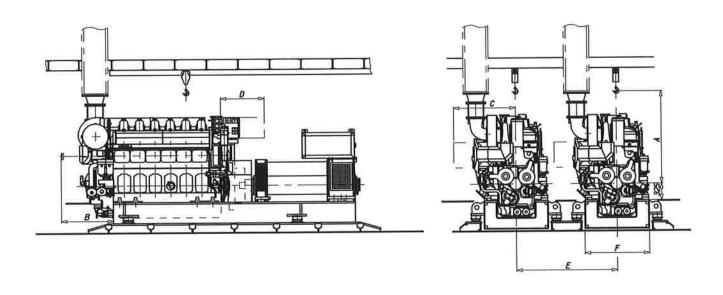
## 19. Engine room layout

#### 19.1. Crankshaft distances

Minimum crankshaft distances have to be followed in order to provide sufficient space between engines for maintenance and operation.

#### 19.1.1 In-line engines

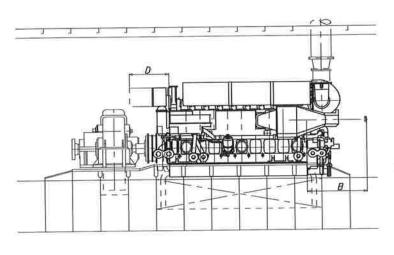
Engine room arrangement, generating sets (2V69C0278d)

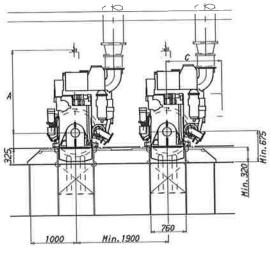


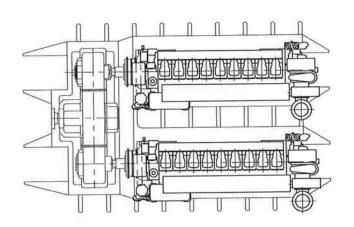
ENGINE	A	В	C	D	E	F
4L20	1800	700	1200	845	1970	1270
5L20	1800	700	1200	845	1970	1270
6L20	1800	1000	1200	845	1970 / 2020	1270 / 1420
8L20	1800	1300	1200	845	2020 / 2170	1420 / 1570
9L20	1800	1300	1200	845	2170/2400	1570/1800

- A = Minimum height when removing a piston
- B = Camshaft overhaul distance
- C = Charge air cooler overhaul distance
- D = Length for the door in the connecting box, from engine block
- E = Min. distance of engines dependent on common base plate
- F = Width of the common base plate dependent on width of the alternator

## Engine room arrangement, main engines TC in free end (2V69C0275b)







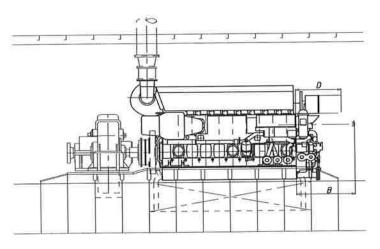
Engine	A	В	С	D
4L20	1800	700	1200	845
5L20	1800	700	1200	845
6L20	1800	1000	1200	845
8L20	1800	1300	1200	845
9L.20	1800	1300	1200	845

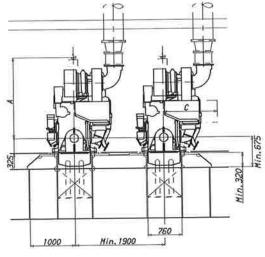
A = Minimum height when removing a piston B = Camshaft overhaul distance

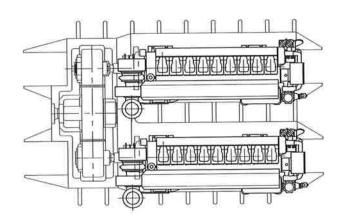
C = Charge air cooler overhaul distance

 $D = \underset{\mbox{\ensuremath{\text{Length}}}}{\text{\ensuremath{\text{connecting}}}}$  box, from engine block

## Engine room arrangement, main engines TC in driving end (2V69C0276)







Engine	A	В	С	D
6L20	1800	1000	1200	1010
8L20	1800	1300	1200	1010
9L.20	1800	1300	1200	1010

- A = Minimum height when removing a piston
- B = Camshaft overhaul distance
- C = Charge air cooler overhaul distance
  D = Length for the door on the connecting box, from engine block

# 19.2.Space requirements for maintenance

### 19.2.1 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.

# 19.2.2 Engine room height and lifting equipment

It is essential for efficient and safe working conditions that the lifting equipment are applicable for the job and they are correctly dimensioned and located.

The required engine room height depends on space reservation of the lifting equipment and also on the lifting and transportation arrangement. The minimum engine room height can be achieved if there is enough transversal and longitudinal space, so that there is no need to transport parts over insulation box or rocker covers.

Separate lifting arrangement for overhauling turbocharger is required (unless overhead travelling crane, which also covers the turbocharger is used). Turbocharger lifting arrangement is usually best handled with a chain block on a rail located above the turbocharger axis.

See Chapter for General data and outputs for the necessary hook heights.

# 19.3. Handling 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.

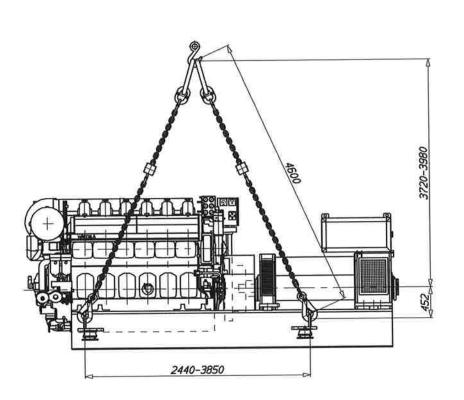
# 19.4.Required deck area for service work

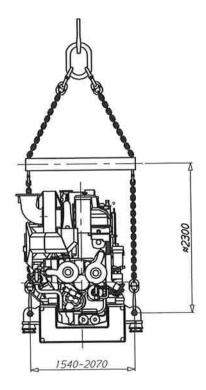
During engine overhaul some deck area is required for cleaning and storing dismantled components. Size of the service area is dependent of the overhauling strategy chosen, e.g. one cylinder at time, one bank at time or the whole engine at time. Service area should be plain steel deck dimensioned to carry the weight of engine parts.

## 20. Transport dimensions and weights

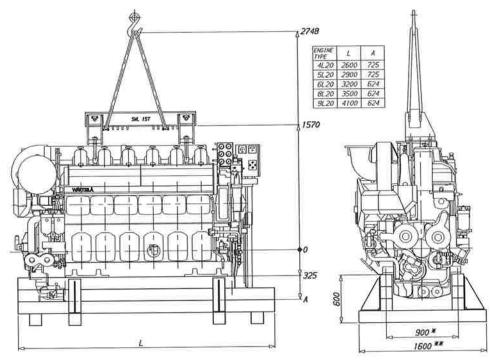
## 20.1. Lifting of engines

Lifting of generating sets (3V83D0300c)





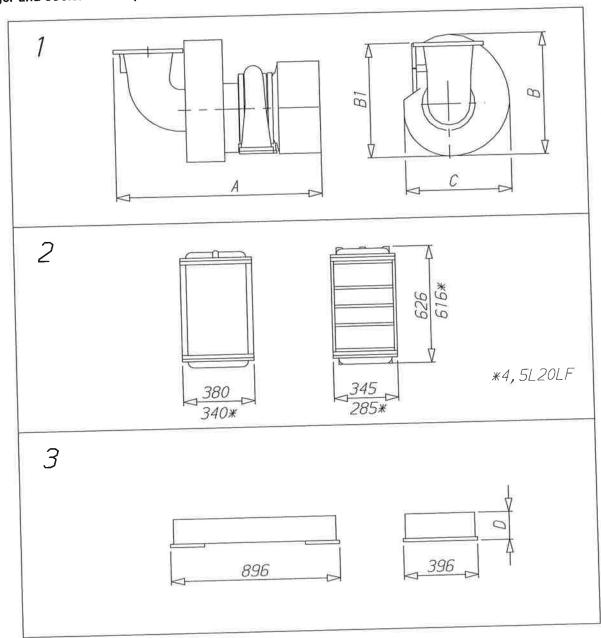
Lifting of main engines (3V83D0285b)



#) 1020 FOR FLEXIBLE HOUNTED ENGINE

## 20.2. Engine components

## Turbocharger and cooler inserts (4V92L1282)



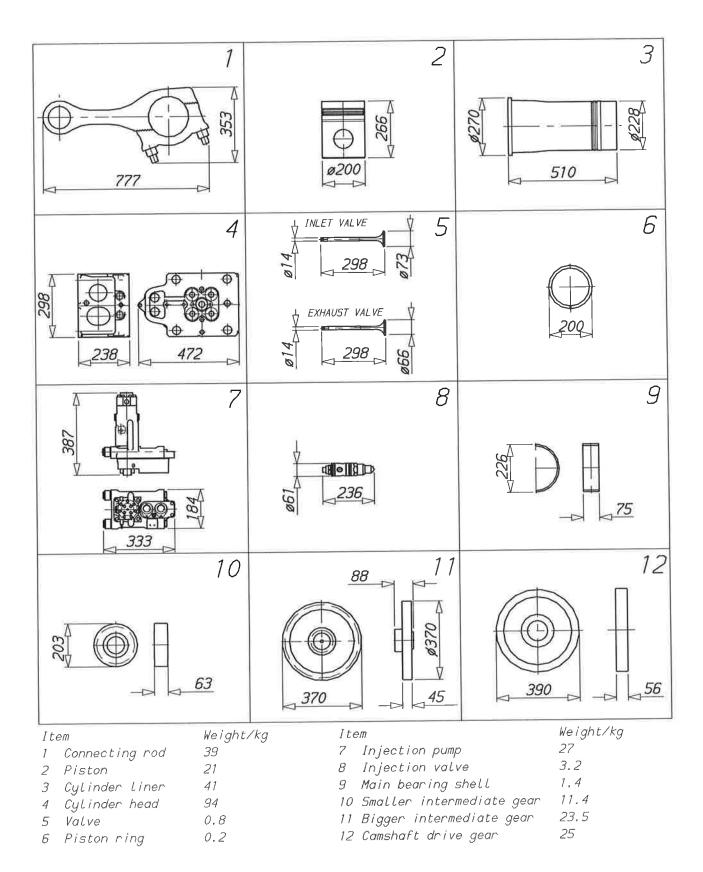
Engine	Weights (kg)				Dimensions (mm)				
	1 (LF)	1 (LD)	2	3	А	B(LF)	B1 (LD)	C	D
	147	I (LD)	120	78	945	576		480	150
4L			120	87	1097	648		554	168
5L	212	212	160	101	1097	636	692	568	196
6L	212	212	160	123	1339	785		673	247
8LPC	340	340	160	123	1339	760	797	675	247
<u>8L2P</u> 9L	340	340	160	137	1339	773	813	667	275

- 1. Turbocharger
- 2. Charge air cooler
- 3. Lubricating oil cooler insert

#### Abbreviations used:

- LD TC in driving end
- TC in free end
- PC Pulse-converter
- 2P Pulse charging

#### Major spare parts (4V92L1283)



## 21. Dimensional drawings

Dimensional drawings can be found in the CD-ROM included in the back cover pocket of this project guide. The drawing formats are Adobe portable document file (.pdf) and AutoCAD (.dxf).

#### List of the drawings:

3V58E0584a	4L20 Diesel alternator set LF
3V58E0580b	5L20 Diesel alternator set LF
3V58E0553c	6L20 Diesel alternator set LF
3V58E0552c	8L20 Diesel alternator set LF
3V58E0549c	9L20 Diesel alternator set LF
4V58E0541e	6L20 Diesel engine LD
4V58E0533c	8L20 Diesel engine LD
4V58E0534d	9L20 Diesel engine LD
4V58E0564	4L20 Diesel engine LF
4V58E0568a	5L20 Diesel engine LF
4V58E0560b	6L20 Diesel engine LF
4V58E0559Ъ	8L20 Diesel engine LF
4V58E0561a	9L20 Diesel engine LF

## 21.1.Notes for the CD-ROM

Hardware requirements:

• CD-ROM drive

Software requirements:

- Adobe Acrobat Reader 4.0 or later or other application capable of reading the files
- AutoCAD 13 or later or other application capable of reading the files.

The files are organized in folders according to the engine types.

### **22. ANNEX**

### 22.1. Ship inclination angles

Inclination angles at which main and essential auxiliary machinery is to operate satisfactorily

Classification society	Lloyd's Register	Det Norske	American	Germanischer	Bureau Veritas
	of Shipping	Veritas	Bureau	Lloyd	
			of Shipping		
Rules referred	2002	2003	2003	2003	2003
Paragraphs	Pt.5 Ch.1 Sec.3	Pt.4 Ch.1 Sec.3	Pt.4 Ch.1 Sec.1	Pt.1 Ch.2 Sec.1	Pt.C Ch.1 Sec.1
where referenced	Par.3.6	Par.B200	Par.7.9	Par.C 1.1	Par.2.4.1
	Pt.6 Ch.2 Sec.1	Pt.4 Ch.4 Sec.2		Pt.1 Ch.3 Sec.1	Pt.C Ch.2 Sec.2
	Par.1.9	Par.A101		Par.E 1.1	Par.1.6.1
Classification society	Russian Maritime	Registro Italiano	China	Indian Register	
នាំ	Reg. of Shipping	Navale	Classification	of Shipping	
			Society		
	2000	2001	2002	1999	
Paragraph	VII-2.3	Pt.C Ch.2	Pt.III Ch.1	Pt.4 Ch.1.7.1	
where referenced		Sec.2.1.6.1	Sec.1.1.3.1		

Main and aux. engines

Heel to each side 15

Rolling to each 22.5 \*\*\*\*

Ship length, L

500/L Trim

7.5 \*\*\*\* Pitching

L < 100 L > 100 | Ship length is used for LR, DNV and CCS

Other Classes have constant trim of 5 degrees

### Emergency sets

Heel to each side 22.5\*

Rolling to each 22.5

side

Trim

Pitching

10

Electrical installation\*\*

Heel to each side 15

Rolling to each

side

22.5\*\*\*

7.5

Ship length, L

L < 100L > 100

5

Pitching

500/L

Ship length is used for LR, DNV and CCS Other Classes have constant trim of 5 degrees

Athwartships and fore-and-aft inclinations may occur simultaneously.

<sup>\*</sup> In ships for the carriage of liquefied gases and of chemicals the emergency power supply must also remain operable to a final inclination up to a maximum of 30 degrees.

<sup>\*\*</sup> Not emergency equipment.

<sup>\*\*\*</sup> DNV, ABS, RINA, GL and BV stipulate that up to an angle of 45 degrees no undesired switching or functional operations may occur. IRS stipulates that no undesired switching or functional operations may occur without angle statement.

<sup>\*\*\*\*</sup>RINA states the period for rolling peroid of 10 s and pitching period of 5 s.

### 22.2.Unit conversion tables

### Length

Length	m	in	ft	mile	nautical mile
m	11	39.370	3,2808	6.2137e-04	5.3996e-04
in	0.0254	1	8.3333e-02	1.5783e-05	1.37149e-05
ft	0.3048	12	1	1.8939e-04	1.6458e-04
mile	1609.3	63360	5280	1	0.86898
nautical mile	1852	72913	6076.1	1.1508	1

Values are rounded to five meaning digits where not accurate.

Length	m	in	ft	mile	nautical mile
m	1	1/0.0254	1/(12*0.0254)	1/(0.0254*63360)	1/1852
in	0.0254	1	1/12	1/(63360)	0.0254/1852
ft	0.0254*12	12	1	1/(5280)	12*0.0254/1852
mile	0.0254*63360	63360	5280	1	63360*0.0254/1852
nautical mile	1852	1852/0.0254	1852/(12*0.0254)	1852/(63360*0.0254)	1

Equations are accurate.

### **Area**

Area	square m	square inch	square foot
square m	1	1550.0	10.764
square inch	6.4516e-04	1	6.9444e-03
square foot	9.2903e-02	144	1

Values are rounded to five meaning digits where not accurate.

Area	square m	square inch	square foot
square m	1	1/0.0254^2	1/(12*0.0254)^2
square inch	0.0254^2	1	1/144
square foot	(12*0.0254)^2	144	1

Equations are accurate.

### **Volume**

Volume	cubic m	1 (liter)	cubic inch	cubic foot	Imperial gallon	US gallon
cubic m	1	1000	61024	35.315	219.97	264.17
l (liter)	0.001	1	61.024	3.5315e-02	0.21997	0.26417
cubic inch	1.6387e-05	1.6387e-02	1	5.7870e-04	3.6047e-03	4.3290e-03
cubic foot	2.8317e-02	28.317	1728	1	6.2288	7.4805
Imperial gallon	4.5461e-03	4.5461	277.42	0.16054	1	1.2009
US gallon	3.7854e-03	3.7854	231	0.13368	0.83267	1

Values are rounded to five meaning digits where not accurate.

Volume	cubic m	l (liter)	cubic inch	cubic foot	Imperial gallon	US gallon
cubic m	1	1000	1/0.0254^3	1/(12*0.0254)^3	1/0.00454609	1/(231*0.0254^3)
l (liter)	0.001	1	1/0.254^3	1/(12*0.254)^3	1/4.54609	1/(231*0.254^3)
cubic inch	0.0254^3	0.254^3	1	1/12^3	0.254^3/4.54609	1/231
cubic foot	(12*0.0254)^3	(12*0.254)^3	12^3	1,	(12*0.254)^3/4.54609	12^3/231
Imperial gallon	0.00454609		4.54609/0.254^3	4.54609/(12*0.0254)^3	1	4.54609/(231*0.254^3)
	231*0.0254^3	231*0.254^3	231	231/12^3	231*0.254^3/4.54609	1

Equations are accurate but some of them are reduced in order to limit the number of decimals.

### **Energy**

Energy	J	BTU	cal	lbf ft
I	1	9.4781e-04	0.23885	0.73756
BTU	1055.06	1	252.00	778.17
cal	4.1868	3.9683e-03	1	0.32383
lbf ft	1.35582	1.2851e-03	3.0880	1

Values are rounded to five meaning digits where not accurate.

### Mass

Mass	kg	lb	OZ
kg	1	2.2046	35.274
lb	0.45359	1	16
oz	0.028350	0.0625	1

Values are rounded to five meaning digits where not accurate.

### **Density**

Density	kg / cubic m	lb / US gallon	lb / Imperial gallon	lb / cubic ft
kg / cubic m	1	0.0083454	0.010022	0.062428
lb / US gallon	119.83	1	0.83267	0.13368
lb / Imperial gallon	99.776	1.2009	1	0.16054
lb / cubic ft	16.018	7.4805	6.2288	1

Values are rounded to five meaning digits where not accurate.

### **Power**

Power	W	hp	US hp
W	1	0.0013596	0.0013410
hp	735.499	1	1.0136
US hp	745.7	0.98659	1

Values are rounded to five meaning digits where not accurate.

### **Pressure**

Pressure	Pa	bar	mmWG	psi
Pa	1	0.00001	0.10197	0.00014504
bar	100000	1	10197	14.504
mmWG	9.80665	9.80665e-05	1	0.0014223
psi	6894.76	0.0689476	703.07	11

Values are rounded to five meaning digits where not accurate.

### **Massflow**

Massflow	ka / s	1h / s
kg / s	1	2.2046
lb/s	0.45359	1

Values are rounded to five meaning digits where not accurate.

### **Volumeflow**

Volumeflow	cubic m / s	1 / min	cubic m / h	cubic in / s	cubic ft / s	cubic ft / h	USG / s	USG / h
cubic m / s	1	60000	3600	61024	35.315	127133	264.17	951019
1 / min	1.6667e-05	1	0.06	0.98322	1699.0	0.47195	227.12	0.063090
cubic m / h	0.00027778	16.667	1	0.058993	101.94	0.028317	13.627	0.0037854
cubic in / s	1.6387e-05	1.0171	16.951	1	1728	0.48	231	0.064167
cubic ft / s	0.028317	0.00058858	0.0098096	0.00057870	1	0.00027778	0.13368	3.7133e-05
cubic ft / h	7.8658e-06	2.1189	35.315	2.0833	3600	1	481.25	0.13368
USG / s	0.0037854	0.0044029	0.073381	0.0043290	7.4805	0.0020779	1	0.00027778
USG / h	1.0515e-06	15.850	264.17	15.584	26930	7.4805	3600	111

Values are rounded to five meaning digits where not accurate.

### **Temperature**

Below are the most common temperature conversion formulas:

 $^{\circ}C = value[K] - 273.15$ 

 $^{\circ}C = 5 / 9 * (value[F] - 32)$ 

 $K = value[^{\circ}C] + 273.15$ 

K = 5 / 9 \* (value[F] - 32) + 273.15

F = 9 / 5 \* value[°C] + 32

F = 9 / 5 \* (value[K] - 273.15) + 32

### **Prefix**

Below are the most common prefix multipliers:

T = Tera = 1 000 000 000 000 times

 $G = Giga = 1\ 000\ 000\ 000\ times$ 

M = Mega = 1 000 000 times

k = kilo = 1000 times

m = milli = divided by 1 000

 $\mu = \text{micro} = \text{divided by 1 000 000}$ 

n = nano = divided by 1 000 000 000

### 22.3. Collection of drawing symbols used in drawings

→ Valve, general design

►► Non-return valve, general design

Spring-loaded overflow valve, straight, angle

Remote-controlled valve

Three-way valve, general design

D Self-contained thermostat valve

-Solenoid valve

· Pump, general design

Electrically driven pump

-O Compressor

**D+□**! Turbocharger

Filter or strainer

Automatic filter with by-pass filter

1 Heat exchanger

Separator Separator

> Flow meter

Viscosimeter

+W+ Flexible hose

<del>= =</del> Insulated pipe

Insulated and heated pipe



Water, oil and condensate separator, general design



Electrically driven compressor



Tank

**¦⊢** Orifice

**—** Quick-coupling

LOCAL INSTRUMENTS

TI Thermometer

PI Pressure gauge

Differential pressure indicator

SENSORS

(TE) 201

(L5) Level switch

Pressure switch

(PDS) Differential pressure switch

 $\frac{(15\overline{Z})}{(201)}$  Temperature switch for control

Pressure switch for control

Pressure transmitter

Temperature sensor (analogue)

(65) 792) Limit switch

Inductive transducer

Magnetic transducer

## ALLEGATI AL DOCUMENTO MV055P-PE-GES-1124 MEZZI PER LA SOSTITUZIONE DELLE PARATOIE SPECIFICA TECNICA

### IMPIANTO DI GENERAZIONE, DISTRIBUZIONE E UTILIZZO ENERGIA ELETTRICA

### **APPENDICI 2 E 3**

APPENDICE 2	GENERATORE WARSTILA 9L 20	
APPENDICE 3	CONETTORI ELETTRICI MC	X





Jusqu'à 1000V jusqu'à 1000A

up to 1000A

bis 1000V bis 1000A

Rundsteckverbinder einpolig, isoliert, mit Bajonettverriegelung Ø 12mm, Ø 16mm, Ø 30mm

Ø 12mm, Ø 16mm, Ø 30mm Round Connectors single-pole, insulated, with bayonet locking up to 1000V

Connecteurs cylindriques unipolaires, isolés, avec verrouillage baïonnette Ø 12mm, Ø 16mm, Ø 30mm

**Multi-Contact** 

Inhaltsverzeichnis	Contents	Tables d	Tables des matières
Ø 16 mm	Baureine NS berüngsschutzt in unge- stackten Zustand	NS Series touch protected in unmated condition	Série NS avec protection au toucher à l'état débroche
PA	Einbaudosen mit Gewinde anschubs und Bajonettverriegelung	Panel receptacles with threaded stud and bayonet locking	Prisos à encastrer avec embout filete et verouliage baronnette
98	Buchsen und Stecker inf. Gewinde anschluss und Bajonettverriegelung	Sockets and plugs with threaded stud and beyonet locking	Douilles et broches wer embout flete et verrouilige barornette
	Kupplungen mit Grinpanschuss und Bajonettverriegelung	Couplers with crimp sieeve and bayonet locking	Raccords avec fut a sertir et verrouilage baionnette
	13.2	14-21	12. #1

Série Standard	Prises a encestrer avec embout flete et vercoullage basonnetto	Douilles et broches avec embout fileté et verouillage bajonnette	Raccords avec fut à settr et verrouiliage baionnette
Standard Series	Panel receptacles with threaded stud and beyonel locking	Speckets and plugs with threaded stud and bayonet locking	Couplers with crimp sleeve and bayonet focking
Baureihe Standard	Einbaudosen mit Gewinds- anschluss und Bajonettverriegelung	Buchsen und Stecker mit Gewinde. anschluss und Bajonettverniegelung	Kupplungen mit Crimparschluss und Bajonetiverriegelung
Ø 12 mm Ø 30 mm			

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**Power** line

Industrie-Steckverbinder Industrial Connectors Connecteurs Industriels

Inhaltsverzeichnis

Tables des matières

5	Introduction Principe du verrouillage baionnette	Presentation des modèles	oires:	Outils de montage	100
Generalités	Introduction Principe du v baionnette	Présenta	Accessoires:	Outils de	
General Information	Introduction Bayoner locking system	Overview of models	Acressories:	Assembly tools	64
Aligemeine Angaben	Enführung Prinzip der Bajonetiverriegelung © \$	Typenubersicht	Zubehör	Montagewerkzeuge	0.0
(INFOS)				1	And Andreas

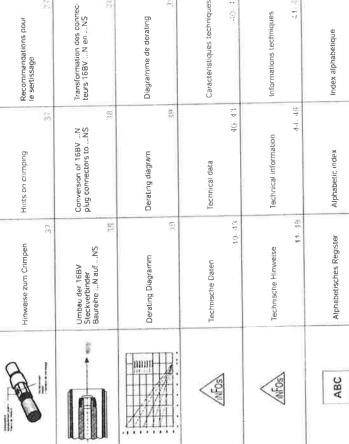
F3 2 Couvercle de protection Bouchons de protection Micro-rupteur Futs à sertir 7 177 Protective covers Protective caps Microswitch 10 E (5) Schutzkappen Schutzdeckei Mikroschalter

## **Multi-Contact**

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Applications

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Crimp sleeves

Crimphülsen

h

## Généralités General Information Allgemeine Angaben

## Farbcodierung

ist bei Einbaudgsen line Farbcodicrung durch einen Farbrin and Frontplatte Die Kupplungen

crhatten die Farbo Farbband auf der

			)		
ang ist bei Einbaudgsen	ndosen	Panel receptacles can be colour-coded	ptacles ca	in be color.	ricoded
aring zwischen Flansch	lansch	with a coloured nng installed between	ured nng	installed b	etween
moglich.		flange and panel.	panel.		
mit Crimpanschluss	iuss	Couplers w	vith crimp	Couplers with crimp sleeves are coded	re coded
acodierung durch ein	nein .	with a coloured marking tape on the	ured mar	king tape c	on the
r Isolation.		insulation		1	
Furthereda	20	21	22	23	24
	grun-geib	Schwarz	101	Diau	desp

Colour coding

## Code couleurs vert jame none 0 0 0 0 0 0 0

## When ordering, always specify the desired colour by adding the respective code after the Order No. If no colour is specified in the order, black insulation is always. Ordering information Bestellhinweis

Bei jeder Bestellung ist die gewunschte Farbe durch Anfugen des entsprechenden Codes nach der Artikel-Nt. anzugeben Ohne Angabe der Farbe in der Bestellung werden grundsatzlich schwarze Isola-Immer auf dem neuesten Stand Auf unsprer Webseite tionen geliefen.

www.putterporter; gents sind immer die neuesten Kataloge. Montageanleitungen und Neugkeiten abrohaa: Besuchen Sie uns regelmassig, dann sind Sie auf dem neuesten Stand.

Änderungen / Vorbehalte
Alte Daten, Abbildungen und Zeichnungen in diesem Kalalog sind das Resultat
sorgfaltige Prüfungen. Sie entsprechen
dem Stand unserer Erfahnungen, Irrum sicherheitstechnischen Grunden. Es ist alleine auf die Katalogdaten abzusteilen vorbehalten, Ebenfalls vorbehalten sind deshalb ratsam, bei Konstruktionen, in nehmen, um sicherzustellen, dass die neuesten Daten zur Anwendung die unsere Bauteile einfliessen, nicht Anderungen aus konstruktions- bzw. sondern mit uns Rücksprache zu kommen. Wir beraten Sie gerne.

and news are always accessible. Visit us regularly, and you will always be Changes / Provisos excepted up to date

All data, illustrations and drawings in this catalogue are the result of careful examination. They are in accordance with our experience to date, Errors

therefore advisable not to rely solely on the data in the catalogue but to consult to be make sure this information is up to date. We shall be pleased to advise reasons. When designing equipment incorporating our components, it is modifications for design and safety We also reserve the right to make

you.

### Pictograms

Piktogramme

These parts have assembly instructions with an ID-Number e.g. MA001. The assembly instructions can be downloaded from our home-

Fur diese Teile besteht eine Montageanleitung mit einer ID-Nummer, z.B. MAOOT (Die Montageanleitungen können ab unserer Horne-

contact com herun

page www.multiligo tergeladen werden.



Bitte Farbcode angeben

Live parts are touch protected in the unmated condition according to: IEC 61984, IEC, DIN EN 60529, VDE 0470, part 1 1



Die aktiven Teile, sind in nicht, gestecktern Zustand berührungssicher gemass. IEC 61984.

(1)

IEC, DIN EN 60529, VDE 0470, Teil 1

l'état debroché d'après: CEI 61984, CEI, DIN EN 60529, VDE 0470, partie 1

Les parties conductrices sont protègees au toucher à

www.nittll.comtast.com nos catalogues, instructions de montage et dernières nouveautés sont accessibles. Consulteznous régulièrement et vous disposerez Toujours & jour Sur notre site Web

the latest catalogs, assembly instructions

ayya multi-contast com

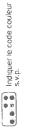
Afways up to date On our WebiSite

toujours d'informations réactualisées Modifications / Reserves

### composants, de ne pas seulement se réferer aux données du catalogue, mais de faire appel à nos services pour vous assurer de la validité des données et pour des raisons constructives ou techniques. Il est donc conseille, pour les conceptions faisant appel a nos également de modifications apportées nous tenons volontiers à votre service pour vous permettre de disposer des lations les plus récentes. Nous Les données, illustrations et dessins figurant dans ce catalogue ont fait informations correspondent à l'état 'objet de contrôles rigoureux. Ces et vous sont communiquées sous réserve d'erreurs et sous réserve actuel de notre expérience

### Pictogrammes

montage identifiee par un code, par ex. MA001, Ces notice de montage peuvent être télechargées sous. Ces articles ont une notice de



Single-pole round connectors, insulated, Ø 12 mm. Einpolige Rundsteckverbinder,

couplers in industrial installations, switchgast, less stands, standby power units, etc. All fully and socket inserts are equipped with a bayoner lock to prevent inadvertent disconnection (see below). On request the 20 16 mm are made of brass (chimp connectors of Cu) and are plated with approx. 6 microns of silver. Contact supports are made of plastic. These plug connectors are used as equipment connectors and nominal contact diameters of 12 mm, 15 mm and 30 mm are single-pole plug connectors equipped with tried and tested MC\*-Multilams. Contact inserts Panel receptacles and couplers with connectors can be equiped with a

Kontaktemsatze sind aus Messing (Cimpanschusse aus Cu) mit ca. 6 pm Silberauflage geferfigt. Die Kontakt-träger bestehen aus Kunststoff. Diese Steckverbinder werden in Industrie- und Schallsanlagen sowne in Pruffelderin

Notstromversorgungsanlagen etc., als

correspondant après le no de l'article Sauf contre-indication lors de la commande, nous livrons des isolants de

couleur noire

Indiquer fors de chaque commande la couleur désirée en ajoutant le code

Pour vos commandes

Einbaudosen und Kupplungen mit den Kortaktnenndurchmessem Ø 12 mm. Ø 16 mm und Ø 30 mm sind einpolige Steckverbinder, ausgerüstet mit den bewahrten MC\*-Kontaktjameilen. Die

werss white blanc

braun brown brown

26 violett violet

grun Green Green

getb yellow

Z3 blau blue bieu

72 701 700 700 700 700

einsatze besitzen als Abzugssicherung eine Bagionetiverriegelung (siehe unten). Auf Anfrage können die Ø 16 Steckverbinder mit einer Steckkodie-Gerateanschluss und Kupplung eingesetzt. Alle Stecker und Buchsen-

rung versehen werden

### Ø 16 mm and Ø 30 mm. with bayonet locking.

isoliert, Ø 12 mm, Ø 16 mm mit Bajonettverriegelung.

Sinführung

und Ø 30 mm.

Les prises a encastrer peuvent être ropé-rèse par une abaju de couleur moritée errire le panneau et la bride. Les connec-tours avec fut a seriri sont ropérés par un cuban adnésir de couleur monté sur isolant.

Repérage couleurs

unipolaíres, isolés, Ø 12 mm,

verrouillage balonnette.

Connecteurs cylindriques, Ø 16 mm et Ø 30 mm. à

Multi-Contact

Les raccords et les prises à encastrer contact coding.

### plastique afors que les corps conducteurs sont des connecteurs embrochables unpolaires, de diamètre nominal Ø 12 mm, Ø 15 mm et Ø 30 mm, lls sont equipos des fameux contacts a lamelies MC\*. Les corps isolants sont en mattère niveau d'installations industrielles, d'equidivers. En particulier, on les retrouve au connecteurs (máles et femelles) sont équipés d'un système de verrouillage à Il s'agit de connecteurs servant notamment au raccordement d'apparentages sont en laiton (les fûts à sertir en Cu), avec une couche d'argent de 6 μm balonnette (voir ci-dessous). Les connecteurs Ø 16 mm peuvent être pements de lest et de contrôle, de aquipes d'un systeme de codage, génératrices auxiliaires. Tous les d épaisseur environ.

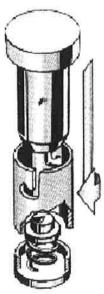
### Principe du verrouillage (Système -BV) ballonnette

Bayonet locking system (BV-System)

Bajonettverriegelung

Prinzip der

(BV-System)



## Steckvorgang:

Zum Stecken mussen sich die Markie-rungen (noter Punkt, Line oder weisses Dreieck) auf dem Stecker und der Buchse axal gegenüberstehen. Steckverbindung bis zum Anschlag zusammenstecken, dann mit axalem Druck freifer steckenund gleichzeitig um 90° nach links oder rechts drehen, bis die Verriegelung einrastet.

### Trentivorgang: ÜSen

die Steckverbindung zunächst axial tieferstecken und gleichzei-tig um 90° nach links oder rechts drehen, bis sich die Markierungen (roter Punkt, Linie oder weisses Dreieck) axial gegen Stecker und Buchse trennen, überstehen

Wahrend der Installation und/oder dem Stecken und Trennen muss der Anschluss stromlos sein! Der Schutz gegen elektrischen Schlag muss durch das Endprodukt gegeben sein.

triangle) on the plug and socket have to be lined up. Mater plug with socket to the stop then insert further with axial pressure and turn simultaneously through 90° to the right or left until the bayonet lock engages. markings (red point, line or white Plugging procedure:

## Unplugging procedure: Push plug in further and turn simultaneously through 90' to right or left until the markings (ed. point, line of winte trangle) are lined up. Pull plug out of socket.

During installation, connecting or dis-connecting, the terminal must not be connected underload! Protection against electric shock has to be provided in the end-use product.

Phase d'embrochage: Aligner les marquages (point rouge, ligne ou trangle blanc) rapportes sur la douille et la broche. Connecter les deux parties jusqu'en butée, puis pousser axialement tout en imprimant à l'une des deux parties un mouvernent de rotation relatif de 90° La connexion doit alors être vers lagauche ou la droite. Relacher, La connexion o

## Phase de débrochage:

tout en lui imprimant un mouvement de rotation de 90° vers la gauche ou la droite. de sorte à aligner les marquages (point rouge, ligne ou triangle blanc), apposés sur les deux parties sur un même axe. Retirer Pousser l'une des deux parties dans l'axe, la broche de la douille.

d'embrochage ou debrochage. l'élément à raccorder ne doit pas être sous charge!
La protection contre les chocs électriques doit être assurée par le produit final, à l'état monte. Pendant l'installation et les phases

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w

## Introduction Einführung

Baureihe mit einer ganzen Reihe von verriagelung, isoliert, vereinigen alle Vorzüge der bisherigen Standard verbinder Ø 16 mm mit Bajonett-Die neuen einpoligen Rundstack-Die neue Baureihe ... NS Extras und Verbessenungen:

The new series ... NS

The new single-pole round connectors, Ø 16 mm with beyonet locking and insulation, combine all features of the previous standard connectors with a whole series of extras and improvements:

Baruhrungsgeschusz (Pruffinger) m ungestecktern Zustand (IEC, Ditt EN 80629, VDE 0476-1)

plugged condition (REC, DIN EN 80629, VDE 0470-1) Protection au foucher (doigt d'épreuve) à l'état déconnecté (CEL DIN EN BOSZS, VDE BA70-1)

fouch pratected (test finger) in uni

La nouvelle série ... NS

Les nouveaux connecteurs unipolail'ancienne génération, de nombreures, isolés, Ø 16 mm à verrouillage ballonnette, intagrent, an complement des avantages offents par ses innovations:



Andalu eines Miscoychakers nur Steckrustandsanzeige modiich Can be equipped with a micro switch to show state of plugin compection. Possibilité de montage d'un micro contact indiquant l'état d'embrochage

Fut a santir num-plaçable (quand le chble est en dommagé par ex.)

Replaceable crimp sleeve (n.g. if conductor is defective)

Autovectopitalining Crimpenschluts (z.B. ten defrecter Leitung)



Zugentbayung in 3 verschiedenses Größsen Gable atrain relief in 3 different dimensions Rienstion du Cable en 3 dimensions differentes

Nouveau:

New Neu:

The new series .... NS fulfils and surpasses the safety Important note:

according to IEC 61984. With immediate effect, only this new series will therefore requirements for encapsula-ted plug connectors - protec-The existing ...N series can be easily converted to be tion against electric shock compatible and are then touch protected in the unmated condition. (See page 38). be supplied.

Baureihe angeboten und ge-liefert, Frühere ... N Baureihen

kónnen durch einfache

wird deshalb nur noch diese

Die neue Baureihe ...NS er-füllt und übertrifft die Sicherheitsanforderung für gekap-selte Stackvarbinder- Schutz gegen elektrischen Schlag, gemäss IEC 61984. Ab sofort

Wichtiger Hinweis:

gamme de produits. Avis important: (Voir page 38).

a enveloppe fermée selon CEI 61984. C'est pourquoi, des à présent, nous ne commercia-Les gammes précédentes ...N peuvent être transformées facilement et sont ensuite compatibles et protégées au toucher à l'état déconnecté. electriques pour connecteurs La nouvelle gamme ...NS répond aux contraintes de protection contre les chocs liserons plus que cette

**Multi-Contact** 

Choisir le connecteur selon

le câble utilisé

is to

Einfahrung	Introduction
Auswahl der	Choice of Plug connect
Steckverbinder aufgrund	according to cable use
der verwendeten Leitung	ı

Die Leitung muss beim Crimpanschluss zum Steckverbinder passen, das heisst der Cu-Einzelleiter sollen in der passenden Crimphülse sicher halten und die Isolation soll in der Kabelverschraubung dauerhalt fixiert sein.

Undern unterschiedlichen flexiblen Cu-Leutungstypen. (Klasses Eund 6 nach IEC 60228, DIN VDE 0295) die auf dem Markt sind gerecht zu werden, haben wir für die Ø 16 mm Baureine auch 2 verschiedene Steckverbindertypen.

entwickett.
Der Unterschled zwischen der Klasse 5
Der Unterschled zwischen der Resse 5
Der Klasse 6 leigt in der Flexbilltät.
Die Klasse 6 Leitungen haben eine hohere Flexbilität. bedingt durch den kleineren Oberschnitt der Einzellitzen.

In the case of crimp connection the lead must match the play connector, i.e. the individual Cu wire strands should be held firmly in the crimp sleeve and the insulation should be permanently fixed in the screwed gland. To meet the requirements of the different flexible Cu leads now on the market (class 5 and 6 according to IEC 60228) DIN VDE 0295, for the 16 mm series we have also developed two different types of plug connector. The difference between Class 5 and Class 6 lie in their flexibility, Class 6 leads have greater flexibility due to the smaller diameter of their individual strands.

Afin de permettre le mondage des differents types de Lable commercial: ses (Classes 5 et 6 selon CEI 60228, DIN VDE 0295), nous avons developpe pour la gamme 16mm types de connec-teurs. Le cable doit être adapte au connecteur. Cela signifie que l'âme du câble doit ètre adapté au fût à sertir et la rétention du câble sur isolant doit être assurée.

La souplesse difference des cables de classe 5 et de classe 6. Les cables de plasse 6. composés de brins de section plus faible, sont sensiblement plus souples.

ible Leiter, Klasse ible cable, class 5 ie souple, classe ie souple, classe	Flexible Letter, Klassa 5 nach IEC 60228, DIN VDE 0295, Iz B H Flexible chibe, GASS 5 Accord to IEC 60228, DIN VDE 0295. (e. Cabie souple, cussas 5 salon CEI 60228, DIN VDE0 256. (p.ex.	0295, (z B HO7RN-F) DE 0295, (e g H07RN-F) D 295, (p.ex. H07RN-F)	Flexible Leiter, Klass Flexible cable, class Cable souple, classe SSST	Freezible Lienk Kasser for LEC 60225 DIN VDE 20295 Fleesible cabler class 6 sector to EEC 60228. DIN VDE 0295 Cable souple. Classer 6 sector CEI 60228. DIN VDE 0295 SSECTI	DIN VDE 0295 28, DIN VDE 0295 DIN VDE 0295
esibilasini del Binaseorg bina de algine bo B. izam zinid seb izam B	Seluriquini) vəb (9 nəzənA severe ayease qura (9 asevir) a'yas 6 fu'il ub vusribiya (9	oelunfqmi.7 nab (9. nann) oerane genus na goberu O narerieur u füt a	SATHUSTING TO SO VOLESCORE DIRECTOR SUPPLY SOUTH STATEMENT OF ASSETTING SOUTH	Beilrigmin & der Crimpalise Oberen & Obern Oberles der Gründe der Gründen der	aekinfqrmn7) reb G neannt avæske grinns G-ebeerri งกาez d rút ub ในระจะรับการ G
mm	mm	ma	шш	mm	mm
0.41	14	10,0	0.31	14.5	=
0.51	16	12.0	0,31	17	13
0.51	18	13,5	0.31	20	15
0.51	19	15,0	0,31	22	17
0.51	22	17,0	0.31	25	19
0.51	24	19,0	0.41	27	21
0.51	58	22.0	0,41	30	24

Solite der Leitungstyp nicht den Klabsen 5 oder 6 zugedrüchtet werden Kohnen. mitsen de Masse der Crimphusen und kabelwerschraubungen, die bei allen Steckwerbindertypen angegeben sind, mit den Leitungstyaben angegeben sind, mit den Leitungstyaben angegeben sind.

werden. Fur Klasse 5 Leitungen: Siehe Seiten 14-15 und 18-19. Fur alle flexiblen Leitungen. Siehe Seiten 16-17 und 20-21.

Hinwelse zum Crimpen, siehe Seite 37,

If the type of cable cannot be assigned to class 5 or 0, the dimensions of the crimp sleeves and cable glands. Which are stated for all types of plug connectors, must be matched to the connectors, must be matched to the for cables class 5. See pages 1 4-15 and 18-19. For all flawhie cables: see pages 1 4-15 and 20-21.

Si le cáble ne peut pas être associé à la classe 5 ou 6, il conviendra de choisir des futs à sertir et des presse-étoupes adaptés aux cotes réelles du cáble en

question.
Pour cable de classe 5:
Voir pages 14-15 und 18-19.
Pour tous les cables souples:
Voir pages 16-17 und 20-21.

Informations sur le sertissage, voir page 37

Hints on crimping, see page 37.

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Umbaumassnahmen kompa-tibel gemacht werden und sind dann in ungsstecktem Zustand zusätzlich berüfrige-schützt, (siehe Seite 38).

Which connections are possible? Overview of models Welche Steckverbindungen sind möglich? Typenübersicht

Quelles sont les connexions possibles? Presentation des modèles

Ø 16 mm	KST16BV-NS/M	ISTGBV:NS	ID/S168V-NS-A
K81168V-NS/M	ф	ф	ф
(B16BV-NS-A	ф	ф	ф
ID/B16BV-NS-A	ф	ф	×

Ø 12 mm, Ø 30 mm	KSTBV/ Setter/DAge, 30.31	ISBV	WD/S8V
KBTBV/	ф	ф	ф
18BV	ф	ф	ф
MD/BBV	ф	ф	X

MD/8BV	ф	ф	×
IBBV	þ	ф	ф
KBTBV/	h	ф	ф
Ø 12 mm, Ø 30 mm	KSTBVI Setter/Degre, 3031	ISBV	MD/SBV



Multi-Contact	strer
	Prises à ence
	ceptacles

with bayonet locking and threaded stud Sockets ID/B16BV-NS-A Panel receptacles Buchsen ID/B16BV-NS-A mit Bajonettverriegelung und Gewindeanschluss

ID/B16BV-NS-A

1

Douilles ID/B168V-NS-A avec

verrouillage baïonnette et embout fileté

Schutzdeckei seihe Seite 35 Protestwe caver see page 35 Couvercie de protector volr pegn 35 Zubendr / Accessories / Accessores DE16N Ð

Microschater, withe Setu 33 Microsulteh wie page 33 Micro ruptour voe page 33 MS-B16BV-NS

Laboring Coloured reg Regue de covieur

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max 15

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Drilling plan Plan de perçage Bohrplan

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	20	10.5 95	10×5 95

PA	CuZn. (Ag)	MC-Kontaktismellen (Ag) MC-Multilami** (Ag) Contacts à ismelles (Ag)	mit Kabelschuh with cable lug avec cosse	in gestecktern Zustand: IP65 <sup>2)</sup> in mated condition:IP65 <sup>2)</sup> a Fetat connecte: IP65 <sup>2)</sup>	20000
Material Genause	Material Buchsenkörper	Kontaktprinzip	Leiteranschluss	Schutzart	Montageanleitung
Material of housing	Material of socket body	Contact principle	Cable connection	Degree of protection	
Matiere botter	Matiere corps de douille	Systeme de contact	Raccordement du câble	Degre de protection	

Farbmarkierung mit Farbring<sup>11</sup> Farben: 20-29\* Colour marking with coloured ring<sup>11</sup> Colours: 20-29\* Repérage avec bague de couleur<sup>11</sup> Couleurs: 20-29\*

Colour marking Repérage

ID/816BV-NS-A

14,00471

Bestell -Nr. Order No. No de Cde

Assembly instructions instructions

Gehause und Frontplatten housings and panels boltiers et panneaux

Flush mounting in A monter dars

Übersteckbarkeit Matching parts

Contre-pièces

siehe Seite 9 see page 9 voir page 9

sehe Seiten 40-41 see pages 40-41 voir pages 40-41

Technische Daten Technical data Informations techniques

5

1) La brigua de couleur est, à contrantder separement Typer. PR16, No de Cide 14.5041.\* framplaces "" par le code couleurs sountiet)
2) Sans micro-fupteur
2) Sans micro-fupteur

Please order coloured mig separately Type: FR16, Order No.: 14,5041-\* (add the desired colour code Instead of "-")
 Without microswitch

1) Ferbring brite separat bestellen.
Typ: FR16. Bestell-Nr.: 14.5041 \* (anstelle des. \*\*) bete den gewunschran Farbrode dess \*\* bete den gewunschran Farbrode densetzen)
2) Ohne Mikroschalter Aufbalu.

\*Farbcode
\*Colour code
\*Code couleurs 0 0

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Star Star

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grun green vert

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Panel receptacles Stecker ID/S16BV-NS mit Bajonettverriegelung und Gewindeanschluss Einbaudosen

ID/S16BV-NS

Plugs ID/S168V-NS with bayonet locking and threaded stud

Buchsen

## Zubehör / Accessories / Accessoires **DE16N**

**Broches ID/S16BV-NS avec** Prises & encastrer

Schuttdechel swhe Smin 15 Protechive chor sei pripr 35 Couvercie de profection von pagn 35 verrouillage baïonnette et embout fileté ø

MS-ID/S16BV-NS Mitrachalter sishe Sete 33 Microsupter, see page 33 Microsupters very page 33	

Tarbeng Coloured mg Begun do course

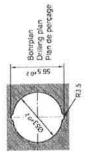
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Material Gehause/Steckerkörper Material of housing/plug body Matiere boltier/corps de broche	Ubersteckbarkeit siehe Seite 9 Matching parts see page 9 Contre pièces voir page 9
Cable connection with cable lug	

	0 100	Consuse and Emphalten	Frontplatten
_	THE OPPOSIT	General School	11011Charteri
-	Flush mounting in	housings and panels	nd panels
_	A monter dans	potners et panneaux	panneaux
1)			
1	1) Farbring bitte separal bestellen		1) Please orde
	Typ FR15 Bestell Nr : 14 5041 " (anstelle	" (Anstelle	Type: FR16
	des "" bitte den gewunschten Farboode	Farbcode	the desired
	amsetzen)		2) Without mi
R	2) Ohne Mikroschafter Aufbau		

Technische Dalen Technical data Informations techniques

Farbmarkierung Colour marking Repérage

Bestell -Nr. Order No. No. de Cde

## Multi-Contact

Douilles	Douilles IB16BV-NS-A avec verrouillage baïonnette et embout fileté
Sockets	Sockets IB16BV-NS-A with bayonet locking and threaded stud

Sockets

Buchsen IB16BV-NS-A mit Bajonettverriegelung und Gewindeanschluss

### IB16BV-NS-A

Zubehör / Accessories / Accessoires



DBT-IB16-NS Schutzhippen suthe Selici 34 Protective est, see page 34 Bruchen de protection veir page 34	MS-B16BV-NS Nikroschikor siche Safe 33 Nikroschikor sich page 33 Mikroschikor, voli page 33
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ype	IB16BV-NS-A	IS-A	Material Declarate Material housing Matthe botter
3estellNr. Order No. No. de Cde	14,2037.*1)	113	Material Buchsenkörper Material socket body Matière corps de douille
arbmarkierung	mit. Farbband	Farben: 20-29"	Kontaktprinzip
Colour marking	with coloured tape	Colours: 20-29"	Contact principle
Reperage	avec ruban adhésif	Couleurs: 20-29"	Systeme de contact
Technische Daten	siehe Seiten 40-41	40-41	Schutzart
Technical data	see pages 40-41	40-41	Degree of protection
Informations techniques	ques voir pages 40-41	40-41	Degre de protection
Ubersteckbarkeit	siehe Seite 9	ite 9	Montageanleitung Assembly instructions Instructions de montage
Matching parts	see page 9	je 9	
Contre-pièces	voir page 9	je 9	

in gestecktem Zustand: IP65<sup>23</sup> in mated conduon IP65<sup>23</sup> 8 Fétat connecte: IP65<sup>23</sup>

MA025

MC-Kontaktiamellen (Ag) MC-Multijam<sup>rw</sup> (Ag) Contacts a lamelles (Ag)

CuZn, (Ag)

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		FILES
<u></u>		8
eranschluss mit Kabelschuh oder Aufbau an Stromschienen, Kontaktblöcke oder isolierte Frontplatten		cordement d'un cable par cosse ou montage direct sur jeux de barres, blocs de contact ou panneaux isolants
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H.	N LK	un p
duss	le connection with cable lug or for screwing onto busbars, contact brocks or insulated panels	ent
nsch	משנים	шар
erai	le c	00

Anstelle des \*\*\* bitte den gewunschten Farboode ensetzen
 Ohne Makroschalter-Aufbau

1) Add the desked colour code instead of \*\*\* 2) Without the fitted microswitch

Remplacer \*\* per la code couleurs souhante.
 Sans micro-rupteur

chwarz rot

2

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grau grey gris

27 braun brun

26 violett violet

grûn green green vert

gelb yetlow

rot rot bed

21 Schwarz black nor

\*Farbcode grun-gelb green-yellow yertgaune

www.multi-contact com Election 23

Plugs IS16BV-NS with bayonet locking and threaded stud Bajonettverriegelung und Gewindeanschluss Stecker IS16BV-NS mit Stecker

verrouillage baïonnette et embout fileté **Broches IS16BV-NS avec** 

Broches

### IS16BV-NS



Schurzkepper neme Serter 34 Photocover cap, see page 34 Bouchen de potition en voer page 34 MS-IS16BV-NS Zubehör / Accessories / Accessoires DST16-NS

Cupplungen

Couplers Buchsen mit Bajonettverrie-gelung und Crimpanschluss für flexible Leitungen Klasse 51)

Sockets with bayonet locking for flexible cables, class 51) KBT16BV-NS/M...-..H and crimp sleeve HO7RN-F KBT16BV-NS/M...-...H

HO7RN-F

**Multi-Contact** 

ballonnette et fût à sertir pour cables souples de classe 51) Douilles avec verrouillage KBT16BV-NS/M...-..H HO7RN-F

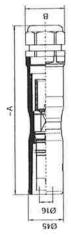
## KBT16BV-NS/M...-.-H



Microbana sehi Seta 23 Microsofth, ser pays 32 Microsofthus, ver pays 33

DBT-KBT16-NS	Schutzkapper, sarke Sesti 34 Protective cap, see page 34 Boucher on protection, ver page 34	

Zubenőr / Accessories / Accessoires



Type de doulle		KBT16BV-NS/M40H	KBT16BV-NS/M50H	KBT16BV-NS/M50L-240H
SUDISL	e E	51.5	61,6	9
Dime	A mm	218	230	234

Buchsentyp

Abrhessungen

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<u> </u>	
910	3
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Technische Daten	siehe Seiten 40-41	1 40-41	X X X
Technical data	see pages 40-41	40-41	
Informations techniques	iques voir pages 40-41	40-41	
Ubersteckbarkeit Matching parts Confre-pièces	Siehe Selte 9 see page 9 voir page 9	(e.9	P.G.A
Farbmarkierung	mit Farbband	Farben: 20-29"	Sec
Colour marking	with coloured tape	Colours: 20-29"	
Reperage	avec ruban de couleur	Couleurs: 20-29"	
Besonderes	auswechselbare Crimphülse <sup>a</sup>	Crimphülse <sup>21</sup>	2000
Special feature	replaceable crimp sleeve <sup>a</sup>	np sleeve <sup>23</sup>	
Particularite	Füt a sertir remplaçable <sup>a</sup>	nplaçable <sup>23</sup>	
Material Genause Material housing Matiere bolter	Ad		ASS

in gestecktem Zustand: IP652 in mated condition:IP652 à l'étal connecte: IP652

Farben: 20-29\* Colours: 20-29\* Couleurs: 20-29\*

mit Farbband with coloured tape avec ruban adhesif

14.2034-11

Bestell.-Nr. Order No. No. de Cde

IS16BV-NS

siehe Seite 40-41 see page 40.41 voir page 40-41 siehe Seite 9 see page 9

Technical data Informations techniques

lechnische Daten Farbmarkierung Colour marking Reperage

Ubersteckbarkeit Matching parts Contre-pièces

CuZn, (Ag)

Material Gehause
Material incusing
Material bother
Material Buchsenkörper
Material socket body
Materie corps de douille

d

MA025

Assembly instructions Instructions de montage Schutzart Degree of protection Degre de protection Montageanleitung

1) Nach IEG 60228. DIN VDE 0285, sieher Seite B.
2) Zum Ausbau der Cimphulsen ist ein Spezieller.
Werkzeug (WKZ1584/NS.A) notwerkelig, Seite Seite 32.

Remplacer \*\* par le code couleurs sochaité.
 Sans micro rupteur.

Add the desired colour code instead of "":
 Without the fitted microswitch

Anstelle den "" bitte den gewunschlen Farboode einselzen.
 Onne Mikroschalter-Außbau.

Leteranschluss mit Kabeischun oder Aufbau an Stromschienen, Kontaktblocke oder isolierte Frontplatten Cable connection with cable lug or for screwing onto busbars, contact blocks or insulated panels Raccordement d'un cable par cosse ou montage direct sur jeux de barres, blocs de contact ou panneaux isolants

50 mm<sup>2</sup> · 240 mm<sup>2</sup> MAD42 CuZn, (Ag) Crimpen Crimping Sertissage 15851 alerial Buchsenkörper aterial of socket body atiere corps de douille ale connection system scipe de raccordemen tructions de montage eiterquerschnitt sble cross section ection du conducteur intageanleitung sembly instructions gree of protection gre de protection schlussart utzart

1) According to IEC 60228, DN VDE 0739, wan page 8 1) Selon CEI 60228, DN VDE 0295, voir bage 8 2) Four femoning the criticy servers a special tool 2) Four le demonrage des tots a seath un out of the criticy servers a special fix 2) Four femonrage des tots a seath under out of the critics server and the construction of the critics and the critical and the critical and the critics and the critical and 3) In mated condition.

3) A l'état connecté,

Montagewerkzauge

Target of the color \*\*

28 weiss white blanc

grau grey grey

27 braun brown brun

26 violeti violet

					l
-	02	1.7	22	23	24
EDO:	arún aelb	schwarz	101	Dian	96
our code	green vellow	black	red	pine	yell
le couleurs	vert aune	noir	rouge	pleu	Tate!



Assembly tools, see page 32

X

ev.	23	24	25	26	27
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red	plue	yellow	green	violet	brown
ADE	pleu	Seume	Vert	Violet	prind

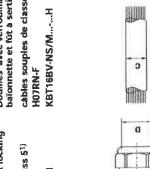
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218	tot	prese	delp
- *	ed G	plue	yeilow
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"Farbcode "Colour code g

KBT16BV-NS/M...-...H and crimp sleeve HO7RN-F Couplers gelung und Crimpanschluss für flexible Leitungen Klasse 51) **Buchsen mit Bajonettverrie-**KBT16BV-NS/M...-...H uegunidany HO7RN-F

Sockets with bayonet locking for flexible cables, class 51)

baïonnette et fût à sertir pour cables souples de classe 51) Douilles avec verrouillage



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SVØ

Buchsentyp Socket type Type de douile	BestellNr Order No No. de Cde	Lenterquirkschritt Conductor pross section Section du conductieur	O Bereich der Kabelverschraubung Ø range of cata gland Garmine de Ø du presse étoupa	Durcommover Crimphubsell Dismeter of crimp stenuell Dumeters ou for a serced	Iphulse3) sterve3
				Innen Inside Inférieur	Aussen outside exterieur
		c mm²	<b>o</b> ww	Emm	F mm
KBT16BV-NS/M40-50H	15.0600-*2	20	15-28	10	4
KBT16BV-NS/M40-70H	15.0601.*2)	70	15.28	12	16
KBT168V-NS/M40-95H	15.0602." 7)	96	15-28	13.5	18
KBT16BV-NS/M50-120H	15.0606-*2	120	22.35	15	6L
KBT168V-NS/M50-150H	15.0607.*2	150	22-35	71	22
KBT16BV-NS/M50-185H	15.0608-*2)	185	22.35	19	24
KRT16RV-NS/M501-240H	15.0610-*2	240	28-38	22	26

1) Nach IEC 6022B DIN VDE 025S, wahre Saile B
25 Ambood alle Father openies of anticode 20 24
analete das " bitte den qewurschinst Forcode
anderen sie and self and s

1) Accoung to IEC 6/0228, DNI VDE 0/295, see page 8
2) Coloused regis, all colours seconding to 10 character of 10 character o

1) Seion CE (69275 b) WV (DC 1925, over nage 8
2) Roben Mehreaf de couleur. Teutes les cooleurs
silonn code couleurs 2023 Remplaces "" par
le code codeurs sourvade " (or for partie des modélies
manufactures, mais peavant againment (or page)
manufactures, mais peavant againment (or page)
informations sur les extrasgies votro page 31

KBT16BV-NS/M...



Schulztappen, sethi Solie 34 Presettver cap, soo page 34 Bouzhon de protection veir page 34 DBT-KBT16-NS

Zubendr / Accessories / Accessoires

Les connecteurs sont définis selon les conservés réeles des algenfies que le Ø interieur du fuit à sent sera adapte à la section du cable et le presse-étoupe au Ø sur isolant du cable. Voir tableau, page 17.

Here the plug connectors can be crossen according to the effective dimensions of the leads.

In the internal Of of the crimp sleeve to match the conductor cross-section.

and the Q range of the cable gland to match the outside diameter of the leads. See table, page 17.

ausgesucht werden.
Das heisst der Inner-8 der Crmphüse
passend zum Leiterquerschnit und der
Ø-Bereich der Kabelverschnatung
passend zum Leitungs-Aussen-Ø.
Siehe Taloelle, Sokle 71.

Hier konnen die Steckverbinder nach den effektiven Massen der Leitungen

KBT168V-NS/M...

pour tous les câbles souples

KBT16BV-NS/M...

Douilles avec verrouillage batonnette et fot à sertir

Sockets with bayonet locking

Buchsen mit Bajonettverriegelung und Crimpanschluss für alle flexible Leitungen

(upplungen

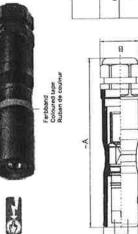
Raccords

Couplers

and crimp sleeve

for all flexible cables KBT16BV-NS/M...

Multi-Contact



Dime	Abmessungen Dimensions Dimensions	Socket type Type de douille
A mm	B mm	
218	51,5	KBI16BV.NS/M40
230	61,6	KBT16BV-NS/M50-
234	99	KBT16BV-NS/M50L-240

910

Technische Daten	see pages 40-41
Technical data	see pages 40-41
Informations techniques	ques voir pages 40-41
Ubersteckbarkeit	sene Seite 9
Matching parts	see page 9
Contre-pièces	voir page 9
Farbmarkierung	mit Farbband Farben: 20-29*
Colour marking	with coloured tape Colours: 20-29*
Repérage	avec ruban de couleur
Besonderes	auswechselbare Crimphülse <sup>2)</sup>
Special feature	replaceable crimp sleeve <sup>2)</sup>
Particularite	Füt a sertir remplacable <sup>2)</sup>
Material Gehause Material of housing Matière boitier	PA

CuZn. (Ag)	Crimpen Crimping Sertissage	50 mm² · 240 mm²	1P6533	MAD42
Material Buchsenkörper	Anschlussart	Leiterquerschnitt	Schutzart	Montageanleitung
Material of socket body	Cable connection system	Cable cross section	Degree of protection	Assembly instructions
Matiere corps de doulile	Principe de raccordement.	Section du conducteur	Degre de protection	Instructions de montage

I in mated condition. 1) Nach IEC 60229, DIN VDE 0295, siehe Selte B.
2) Zum Ausbau der Crimphisen ist ein soegeelles Verrzahig (WKZ18BU/NSA) norwendig, Sehe Selte 32

3) In gestocktem Zustand.

1) Selon CEI 60228. DIN VDE 0295, voir page 8
2) Pour le demontage des fürs le ventrum outlinspe-cal (WKZTEBVAS-A) ext. netenstain Voir page 32 3) A lieux connecte 1) According to IEC 60228, DIN VDE 0295, see page 8.
2) For removing the crimp sheeves a special tool
(WKZ168V-NS AI is:
Frequired, See page 32. Assembly tools, see page 32

Outil de montage voit page 32	
X	

20	21	22	23	24	52	26	2
drun delb		rot	plan	deip	grün	volett	Dran
nreph.veli	mv black	Ted Der	plue	vellow	green	violet	brown
vert iaun	101	roude	pleu	Janne	vert	VIOLEL	Dun

gelb yellow jaune www.multi-contact.com 23 blau blue 

• • • •

29 white blanc

grau grey grey

27 braun brown brun

26 violet violet

grun green vert

grün-gelb green-yellow vert-jaune

\*Code couleurs \*Colour code

\*Farbcode

0 0

133

Montagewerkzeuge stehe Seite 32

X

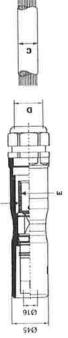
29 weiss white bianc 28 grau grey gris

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Sockets with bayonet locking and crimp sleeve for all flexible cables KBT16BV-NS/M... Couplers Buchsen mit Bajonettverrie-gelung und Crimpanschluss für alle flexible Leitungen KBT16BV-NS/M... Kupplungen

pour tous les câbles souples Douilles avec verrouillage baïonnette et fût à sertir KBT16BV-NS/M...





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		v	۵		
		min	ű.	LLL LLL	man
KBT18BV-NS/M40-50	15.0622-"2)	95	15-28	11	14.5
KRT16RV:NS/BA60-70	15.0823.*2)	7.0	15.28	13	13
KBT1EBV-NS/M40-BB	15.0624-2)	98	15-28	10.	20
KRT18RV-NS/JM40-120	15.0625-*2)	120	15.28	17	22
KRT168V-NS/M40-130	15.0426-7	150	15/28	19	25
KRTYKRV.NS/JUSG.05	15.0627.*23	88	22.35	15	70
KRT188V-NS/1460-120	15.0628-*2)	120	22-35	11	22
KBT1KBV.NS/IMS0-150	15.0629-*2	150	22-35	19	92
KRT1KBV-NS/NSS-18E	15.0630-12)	185	55-32	12	27
KRT168V-NS/JASO-240	15,0631-*2)	240	22.35	54	30
KBT168V-NS/MS0L-240	16,0632.*21	240	28-38	24	30

Parker has	(Admitted Admit	Charles on Katawarathakang	OCHPONICA IDDIO	O Companie 1 to Of compatence 1 to 6 to 6 settle?
	Section by conductor	Canting to 0 du previo ettupe	Meen Flexible Plettiffeur	Aunson / Outside / External
	Ü	Q	2	u.
	inm <sup>2</sup>	mm	mm	mm
KBT186V-NS/M40-60H 15.0800-*2)	20	15.28	10	14
	70	15.28	12	16
	95	15.28	13.5	18
-	120	15.28	15	19
	150	15.28	17	22
	382	22.35	13.5	18
	120	22.35	15	19
	150	22.35	17	22
	185	22.35	19	24
	240	22/35	22	56
_	240	28 38	22	1/2

Fur Leitungen mit anderen Querschnit-	ē
ten (z.B. AWG Grossen etc.) kann	A.A.
auforund der Crimphülsenmasse (E.F)	že
ein passender Typ ausgewählt werden.	티
A STATE OF THE PROPERTY OF THE PARTY OF THE	
THE MAN IS CLASSED BITCHES 6295, NIPPERSON IN	Ē

1. Next, CL 6.02.29 (IV. CR, CR). where 7-bets in 3. respect the sizes person statistics for another disc. " to the continuous loss despois ensuffer 3. Crimposus with featuration for adjugate flutural stream alone and as Lendonin business from series sizes 36. Aug. Another sufficiency with sufficiency and Sizes 36. Aug. Another sufficiency with sufficiency and Sizes 36. Aug. Another sufficiency with sufficiency and Sizes 36. Aug. Another sufficiency and Sizes 36. Aug. Sizes and Sizes a

1) According to RC 6027th, Day 1926 6255, see polyp. 8.
2) Control type, it accounts watering to inchred codes. 20.
2) Look the attent code, order visual of "".

3) Long section are controlled to the telestation societies for an exception of the telestation of the code of operating in relational parts, who page 35 with our controlled, see page 32.

www.multi-contact.com Dian Dive

22 red red

21 Schwarz black nor

\*Farbcode grun gelb
\*Colour code green yellow
\*Code couleurs

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1) Sear CE (6628) ON VOE 038A; vol popel il 2) Sear CE (6628) ON VOE 038A; vol popel il 2) Candery 7028 Remplem "The it controllers successively 3) Let 02.3 Sear bert parts deve moderns restrictores, man provide dell' grun green wert gelb yellow

\$ **...** 29 weiss white brown brown brun

## Multi-Contact

Raccords	Broches avec verrouillage baïonnette et fût a sertir pour	câbies souples de classe 51)	HO7RN-F	KST16BV-NS/MH
Couplers	Plugs with bayonet locking and crimp sleeve	for flexible cables, class 51)	HO7RN-F	KST16BV-NS/MH

Stecker mit Bajonettverrie-gelung und Crimpanschluss für

flexible Leitungen Klasse 5<sup>1)</sup>

KST16BV-NS/M...-..H

HO7RN-F

Kupplungen

Raccords

## Zubehör / Accessones / Accessores



の 一日 日本

(I)

KST16BV-NS/M...-..H

Schulzhappor sette Seith 34 Bleichse zig, sen pepp 34 Boucker de pretinction, voir 0901-34



5
Athena

Ferbband Coloured tape Ruban de couleur

V-

910

bEØ

	Abme Dime	Abmessungen Dimensions Dimensions	Steckertyp Plug type Type de broche
-	A mm	8 E	
	508	51.5	KST16BV-NS/M40H
+	722	61.6	KST16BV-NS/M50H
	225	99	KST16BV-NS/M50L-240

Technische Daten	sene Seten 40-41	n 40-41	Mater
Technical data	see pages 40-41	140-41	
Informations techniques	voir pages 40-41	140-41	
Upersteckbarkeit Matching parts Contre-pieces		ge 9 ge 9	Ansch Cable Princip
Farbmarkierung	mit Farbband Fa	Farben: 20-29*	Cable
Colour marking	with coloured tape Co	Colours: 20-29*	
Repérage	avec ruban de couleur Co	Couleurs: 20-29*	
Besonderes	auswechselbare Crimphulse <sup>2)</sup>	mphulse <sup>2)</sup>	Scrut
Special feature	replaceable crimp sleeve <sup>2)</sup>	s sleeve <sup>2)</sup>	Degre
Particularité	Fút a sertir remplacable <sup>2)</sup>	laçable <sup>2)</sup>	Degre
Material Genause Material housing Matiere boitier	Ve	tite	Monto Asser Instru

2) Рог гетпоу
3) In mated
4.3

Material Steckerkorper Material of plug body Matière corps de broche	Anschlussart Cable connection system Crimping Principe de raccordement Sertissage	Leterquerschnitt Cable cross section 50 mm² - 240 mm² Section du conducteur	Schutzart Degree of protection Degre de protection	Montageanleitung Assembly instructions Instructions de montage
Material S Material o	Anschlussart Cable conner Principe de n	Leiterquerschrift Cable cross secti Section du condu	Schutzari Degree o Degre de	Montage Assembl Instruction

er.	
value in IEC 50288, DIN VDE 0295, see page 8, emorand the crimp sheren a special trol (WKZ169NS, AL) is required. See page 32 and condition.	
7 2	
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08 5 g	
emoving the crimp  W  Med condition	
0 E 63	
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1) Selon CEI 60228, DIN VDE 0295, voir pagn 8
2) Paur le demonkage dins luis a sertir un budi 1905
CIAI (WYZTBEV-NS-A) est
necessale Voir page 32



Assembly tools, see page 32 N. C.



32	28 Weis
Outil de montage, voir page 32	graU
Dutil de mon	27 braun
X	26 Helioty
1 ]	525
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29 weiss white

graU gray

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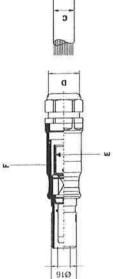
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	diar	Schwarz	TOL	plan
lour code green vellav	Woller	black	red	ania
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97	violet	viole	Viole
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24	qiao	Wellow	SAUDE
23	hlati	dille	Pierr
27	ĮO.	1	200
21	cefuer?	Mark	P. O. C.

Raccords Plugs with bayonet locking for flexible cables, class 51) KST16BV-NS/M....H and crimp sleeve HOZRN-F gelung und Crimpanschluss für Rexible Leitungen Klasse 51) Stecker mit Bajonettverrie-KST16BV-NS/M...-..H Kupplungen HO7RN-F





634



Associativy Sugitytin yon de tetoche	Bestell-Nr. Order No. No de Cde	Letterquerschnitt Conductor cross section Section du conducteur	2 Bereich der Kabelwerschraubung G-range of cable gland Gamme de 20 du presse-moupe	Durcrimesser Crim Diameter of crimp Dametre du füt à	steemall steemall
				Innen unsufe intereur	Austen
		c mm <sup>2</sup>	o ti	Emm	ugu ugu
KST16BV-NS/M40-50H 15.0611.*2	15.0611.*2	50	15-28	10	14

22-35 28-38 240 185 15.0619-7 15,0621-\*2 Nam IEC 60228 DIN VDE 0295, swha Swite 8
 Parbond, alle Farber gemäss Parbode\* 20.29, and elde des "bits den gewünschlen Ferbode einsetzen. KST16BV-NS/M50L-240H KST16BV-NS/M50-185H

1) Account on DE (CRSS), LINV VDC (D28), see page 8. 1
2) Coloured traps, all coloures recording to a colour code 10. 20, 40 do 10. 40 d

Crimbulsen sind Bestandtel der aufgefuhrten Stecker, konnen aber auch als Einzelfell bestellt werden, salen 36. Allg Hinwarse zum Crimpen, siehn Sete 37.

1) Sahon CEI 60228, DIN VDE 0295, von page 8
2) Rhahn anfherd for couleur, notes iles schelurs selon code couleurs. \*20.28 Remplacer "\* par 16 code couleurs. \*20.29 Remplacer "\* par 16 code couleurs. \*20.19 Remplacer \*20

Kupplungen

Stecker mit Bajonettverrie-gelung und Crimpanschluss für alle flexible Leitungen KST16BV-NS/M...

for all flexible cables and crimp sleeve

KST16BV-NS/M.

ausgasucht werden.
Das heisst der Innen-8 der Crimphülse
passend zum Leiterquerschnitt und der
R-Bereich der Kabelwerschraubung
passend zum Leitungs-Aussen-Ø.
Siehe Tabelle, Seite 21. Hier können die Steckverbinder nach den effektiven Massen der Leitungen

**Broches avec verrouillage** Plugs with bayonet locking

Multi-Contact

Les connecteurs sont définis selon les cotes réelles des Sables. Clads signifie que le Ø interieur du flu à Sertir sera adapte à la section du câble et le presse-ettoupe au Ø sur isolant du câble Voir l'ableau, page 21. KST16BV-NS/M...

pour tous les câbles souples

balonnette et fût a sertir

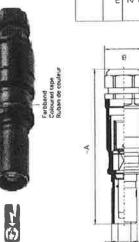
Here the plug connectors can be chosen according to the effective dimensions of the leads: the internal Ø of the crimp sleeve to match the conductor cross-section, and the Ø range of the cable gland to match the outside diameter of the lead. See table, page 21.

## Zubendr / Accessories / Accessories

KST16BV-NS/M.



Schutzkappen, sveha Smin, 34 Prosetive cáp, son page 34 Bouchen de protector, vivi page 34



Dimer Dimer	Abmessungen Dimensions Dimensions	Steckertyp Plug type Type de proche
A rhm	en En	
509	51,5	KST16BV-NS/M40
221	61,6	KST16BV-NS/M50
225	99	KST16BV-NS/M50L-240

910 VEØ

> 16 18 19 22 24 26

13,5 12

έ 17 13 22

22-35 15.28 15-28

22-35

150

15.0618-\*2

KST16BV-NS/M50-150H

KST16BV-NS/M50-120H

70 95

15.0613-\*2 15.0617."

15.0612-\*2

KST16BV-NS/M40-70H KST16BV-NS/M40-95H CuZn. (Ag)

Crimpen Crimping Sertissage

Material Steckerkorper	Anschlussart	Leiterquerschnitt	Schutzart	Montageanieitung
Material of plug body	Cable connection system	Cable cross section	Degree of protection	Assembly instructions
Matière corps de broche	Principe de raccordement	Section du conducteur	Degre de protection	instructions de montage
en 40-41	erte 9	Farbent 20-29"	s Crimphuise <sup>27</sup>	2
5 40-41	ge 9	Colours: 20-29"	mp sleeve <sup>28</sup>	
5 40-41	ge 9	Couleurs: 20-29"	mpiaçable <sup>28</sup>	
sehe Serten 40-41	sehe Seite 9	mit Farbband	auswechselbare Crimphulse <sup>21</sup>	PA
see pages 40-41	see page 9	with coloured tape	replaceable crimp sleeve <sup>21</sup>	
ques voir pages 40-41	voir page 9	avec ruban de couleur	Füt a sertir remplagable <sup>21</sup>	
Technische Daten	Ubersteckbarkeit	Farbmarkierung r	Besonderes	Material Gehause
Technical data	Matching parts	Colour marking v	Special feature	Material housing
Informations techniques	Contre-pieces	Repérage a	Particularite	Matière boltier

50 mm² - 240 mm²	(£89a)	MAD42
Cable cross section Section du conducteur	Schutzart Degree of protection Degre de protection	Montageanieitung Assembly instructions instructions de montage

Assembly tools, see page 32 3) In marked condition

(WKZ16BV-NS-A) Is required. See page 32.

1) Selon CEI 60228. DIN VDE 0295, war page 8
2) Pour le demontage des futs a santrun outil special cual (VMZ166V NS-A) est nicersonie Voir page 32. Outil de montage, voir page 32 3) A Fethr connecté 1) According to IEC 60228, DIN VDE 0295, see page 8. 2) For removing the critip sleaves a special tool

X

Stem gran

biau biue biue 21 Schwarz biack nor grun gelb green yellow vert jaune \*Colour code \*Code couleurs "Farbcode

6 0

26 violett volet grun green vert gelb yellow yatrne www.multi-contact.com

29 weiss white blanc

grey grey grey

27 braun brun

\*Colour code \*Code couleurs \*Farbcode ...

Montagewerkzeuge, siehe Seite 32

1) Nach IEC 60228 DIN VDE 0295. viene Seite B.
2) Zum Ausbau der Cimphulsen ist an spearielles.
Workzaug (WKZ1569 N S.A.) narwendig Seine Seite B.

In gestecktern Zustand

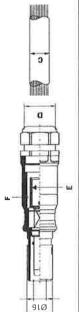
2 12 15 15 E Schwarz biack noir 20 grun gelb green yellow vertysune

gesb yellow Dieu Dieu Dieu

29 white branc grau grau 27 brown brown

Raccords Plugs with bayonet locking and crimp sleeve for all flexible cables KST16BV-NS/M... Couplers Stecker mit Bajonettverrie-gelung und Crimpanschluss für alle flexible Leitungen KST16BV-NS/M... uebunkddny





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Security	Bester At	Leconsectes	THE TRANSPORT LENGTH NAMES OF 17 TOT TRANSPORT CARS OF 17 TOUR CADIOS SOUTHWEST OF TRANSPORTER O	noice sonbies of the	s sonbes of these a
Type de broche	Drope No No de Cde	Section du consumer	Sympo of cubic gand Germen die 8 du presse etoupe	incord leads / Internal	Aussen / Duts-de / Extensus
		ú	Q	ш	Ę4.
		mm <sup>2</sup>	mm.	mm.	men
KST168V-NS/M40-50	15.0433-17)	50	15-28	11	14.5
KST1BBV-NS/M40-70	15,0634,*21	7.0	15.28	13	17
KST166V-NS/M40-88	18.0635-12	382	15.28	1.5	20
KST168V-NS/Me0-120	15.0434-*2!	120	15.28	17	22
K\$T188V-NS/M40-150	18,0437-52	150	15.28	19	25
KST188V-N\$/M60-B5	15.0638.*2	98	22,35	15	20
KST166V-NS/M60-120	15.0639."2	120	22.35	17	22
KST188V-NS/M50-150	15.0640-*2	150	22.35	19	52
KST188V-NS/M80-188	15.0641.*?)	185	22:35	12	22
KST148V-NS/M50-240	15,0642." 7	240	22.35	24	30
KST188V-NS/MBDL-240	15,0843,*21	240	28.38	54	PA.

Stockerty:	Boston Ne	Had held Seller	G Borney on Subneyndryshorg	O'Comphissell / O'Dre	O Competition 10 Or comp sidentify 0 to a sensell
The Driverse	Ne de Con	Socien its conductor	Camme de Clouperse eroupe	tenent lesson i interior.	Aussen (Chapde / Externul
		o mm²	o mm	E man	e umu
KST188V-NS/MAO-50H	15.0611,+2)	25	15.28	10	14
KST168V-NS/W40-70H	15,0612.*?}	Æ	15.28	12	16
KST168V-NS/M40-85H	15,0813-73	58	15.28	13,5	18
MST16BV-NS/M40-120H	15,0614.*2	120	15-28	15	19
KST18BV-NS/M40-150H	15,0415-12)	150	15.28	17	22
KST188V-NS/M50-95H	15.0816."2)	95	22.35	13.5	89 ←
KSTT68V-NS/M60-120H	16,0417-*2)	120	22.35	15	19
KST188V-NS/MS0-150H	15,0818-"2)	150	22:35	13	22
KST168V-NS/MS6-185H	16.0416-12]	185	22.35	18	24
KST168V-NS/M30-240H	15.0420-21	240	22-35	22	36
KST18BV-NS/MBOL-240H	16,0621.*2	240	28-38	22	56
Fur Lellungen mit anderen Querschnik- ten (1.8. AWG Grössen etc.) kann aufgrund der Crimphölsenmasse (E.F)	eren Querschn etc.) kann senmassa (E.F		For leads with other cross-sections (e.g. AWG sizes), a suitable type can be selected on the basis of the crimp sleeve	Pour des cables a (par ex. AWG etc un modèle adapt	Pour des cables avec d'autres sections par ex. AWG etc.), il conviendra de choisir un modale manaré à partir des cotes des

For leads with other cross-sections (e.g. AWG stres), a suitable type can be selected on the basis of the crimp sleeve dimensions (E.F.).	According to IEC 60228, DIN VDE 0295, whe plays 8     Obstanced trags, a blacker According in crease, confer-20     And the devined collact rode mirroral of "     I) Or my devenes we reclaimed in the ring purgs but can also be ordered required purgs. But can also be ordered requiredly as according to purgs 25     And the devined requiredly as according purst, seen purgs 35     And purgs 35
Fur Leitungen mit anderen Querschnik- ten (18 AWG Grössen etc.), kann aufgrund der Crimpholsenmasse (E.F) ein passender Typ ausgewählt werden.	1) MACH IEC 60228 DNN VOR 07895 wake Seer 8 2) and broad one before operated and operated and of the operated of the operated one opera

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ž	5	ĕ	9	2	m
й	문	ñ	Ė	9	è
₹	U	×	٥	ñ	ā
÷	2) Colcured tape, all colours accreding to coost code* 20		E		

Señor CELS022B UMI VDE 0295 voir pagn 8     Ruban inthosit de couline, Toutiès es couleurs seten code couleurs 20-29. Remptiece " par le come couleurs.	"LOLD'ARTO	3) Les futs a world rang partie des modoins menionning	mark proviers dysloment serve commender separement	yor page 36 Informanons sur le serbission, voir page 37
ccording to IEC 6022A, DIN VDE 0295, size pagin 8 bitalend tigne, all colours accepting in consultants 20- 99 and the desired colour code institute of ""	24mp stages are included in the felled purps, but can	this be ordered separatoly as individual parts, sen	sage 36 Hints on crimping, see page 37	

29 weiss white blanc	28 29 29 grau white grey blanc grey blanc
29 vveiss vvhite bianc	
	grau grey grey

26 violett, violet violet

25 grun green vert

gelb yeilow

22 rot red red

21 schwarz black noir

20 grün-gelb green-yellow vert-jaune

\*Farbcode \*Colour code \*Code couleurs

0 0

www.multi-contact.com 23 blau blue bleu

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4

Multi-Contact

Elipadoosaa	raitel receptacies	rises a encasues
Buchsen MD/BBV mit	Sockets MD/BBV	Douilles MD/BBV avec
Bajonettverriegelung und	with bayonet locking and	verrouillage balonnette et
Gewindeanschluss	threaded stud	embout fileté

Zubehor / Accessories / Accessoires

MD/B...BV

DE10-12N DE22-30/MD/B+S ķ

•	Page 15
D	Scruttdecsel, siens Seit Protective cover, see par Couvercle de protection, voe

Farbring<sup>1)</sup> Coloured ring<sup>1)</sup> Bague de couleur<sup>1)</sup>

Bohrplan Drilling plan Plan de perçage

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	(8)	

Type | ØM (mm)

43 19

Typ / Type / MD/8128V MD/8308V		7 60	N)	105	ager arrier contact		MC-Ker MC- Contac	100
		I	95	151	Material: Gehause/Kontaktträger Material: Housing/Contact carrier Matiere: Boltier/Support de contact	body douille	ij	
3		9	m	9	Gehause Housing Bottler/S	Material Buchsenkörper Material of socket body Matière corps de douille	Kontaktprinzip Contact principle Systeme de contact	Andrew or warmen
		ų.	45	124	Material: Material: Matiere:	Material Matière Matière	Kontaktprinzip Contact princip Système de co	The state of the same of the same of
	ensions (mm)	ш	M12	M36a3		6.29° 0.29° 20.29°		
	Abmessungan (mm) / Dimansions (mm) / Dimensions (mm)	O D	8	100	14,00311)	Farben: 20-29* Colours: 20-29* Couleurs: 20-29*	te 42-43 e 42-43 e 42-43	
	Dimension	C max	10	17	BestellNr. Order No. No. de Cda	J'I	siehe Seite 42-43 see page 42-43 voir page 42-43	ľ
	/ (шш) иебио	83	M42x1,5	MB0x2	BestellNr. Order No. No. de Cde	mit Farbring <sup>1)</sup> with coloured ring <sup>1)</sup> avec bague de couleur <sup>1)</sup>		
vo	Abmers	₹ 0)	12	30	BV BV	with cr	n s techniq	
9 (8)			BV	187	MD/B308V	Farbmarkierung Colour marking Reperage	Technische Daten Technical data Renseignements techniques	
סר	2	lybe adv	MD/812BV	MD/B308V	Type Type Type	Farbmarkii Colour ma Reperage	Techn Techn Rense	

18 55 15 55

140 275

AUPA	CuZn. (Ag)	MC-Kentaktlamellen (Ag) MC-Multilam <sup>14</sup> (Ag) Contacts à lamelles (Ag)	mit Kabelschuh with cable lug avec cosse
Materiai: Gehäuse/Kontaktiräger	Material Buchsenkörper	Kontaktprinzip	Leiferanschluss
Materiai: Housing/Contact carrior	Material of socket body	Contact principlo	Cable connection
Matiere: Boltier/Support de contact	Matière corps de douille	Système de contact	Raccordement du cáble

Gehäuse und Frontplatten housings and panels boitiers et panneaux

Embau in Flush mounting in A monter dans

siehe Seite 9 see page 9 voir page 9

Ubersteckbarkeit Matching parts Contre pièces

FR12 14.5021.* FR30 14.5051.* FR30 14.5051.* Mdd kith dhested colour ci	-	A CALL DE LA CALLED AND A CALLED AND				
FR12 14,5021.* FR30 14,5051.* Add the desired colour col	Type	Beetel Mr.	persent to	Type,	Order No.	Suitable for
FR30 14,5051.* add the desired colour col	FR12	14 5021 *	MD/B128V	FR12	14,5021.*	MD/8128V
anstrolle des *** bate den gewunschten	FR30	14.5051.*	MD/B30BV	FR30		MD/B30BV
	nstulle o	des " bate der	gewunschten	and bha	desired colour o	ode instead o

287	VBO	ad of "".	24 G
MD/B128V	MD/B30BV	code inste	23 Diau
14,5021.*	14,5051.*	add the desired colour code instead of ***	2 5
FR12	FR30	add she d	21 Schwarz
			20 200 - 0010

2	96	No. de Cao	convent pour le model
4	FR12	14,5021 *	WD/812BV
7	30	FR30 14,5051.*	MD/8308V
T HE	Digo	er ** par le c	remolecer "" par le code couleurs souheite

*Farbcode *Colour code *Code couleurs	20 grün-gelb green-yellow vert-aune	Schwarz black noir	red rouge	Diau Dieu Dieu	yellow mund
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25

Strang Green

www.multi-contact.com

28 grau grey gris 27 braun brown brun

26 VIOINT VIOINT

Plugs MD/S...BV with bayonet locking and threaded stud Stecker MD/S...BV mit Bajonettverriegelung und Gewindeanschluss Einbaudosen

Prises & encastrer

**Broches MD/S...BV avec** verrouillage baïonnette e embout fileté

Zubahor / Accessories / Accessoires

### MD/S...BV



DE10-12N	e Sette 35 e page 35 1, voir page 35
DE22/30/MD/B+S	Schutzdeckel, siehe Sette 35 Protective cover, see page 35 Couverale de protection, voir page 35

# I

	WO	
Bohrpian Driting plan Pian de perçage		

Ø	ØM (mm)	43	81	
)	yp / Type / Type (	MD/S12BV	MD/S30BV	
	<u>_</u>	Σ	Σ	

Iborstock			II .Nr	Roctoll .Nr		Tun
124	M36x3	100	11	MB0x2	30	MD/S308Y
45	M12	S	10	M42x1,5	12	MD/5128V
ů.	iù.	0.69	C max	B 63	OA	1ype
-	muskams (mm	ns (mm) / Din	/ Dimensio	Abmassungen (mm) / Dimensions (mm) / Dimensions (mm)	Abmes	1

14.00321)	Farben: 20-29*	siehe Seite 42-43	Genause and Frontplatten
	Colours: 20-29*	see page 42-43	housings and panels
	Couleurs: 20-29*	voir page 42-43	botters of pannoaux
BestellNr.	mit Farbring <sup>11</sup>		Genause und
Order No.	with coloured ring <sup>1)</sup>		housings d
No. de Cde	avec bague de couleur <sup>11</sup>		botters et
Type MD/S12BV Type MD/S30BV	Farbmarkierung n Colour marking v Reperage	Technische Daten Technical data Rensolgnements techniques	Einbau in Flush mounting in A monter dans

Ubersteckberkeit	siene Seite 9
Matching parts	see page 9
Contre pièces	voir page 9
Material: Gehause/Kontaktrager Material: Housing/Contact carrier Matiere: Boitier/Support de contact	AIIPA
Material Steckerkorper Material of plug body Matiere corps de broche	CuZn, (Ag)
Leiteranschluss	mit Kabelschuh
Cable connection	with cable lug
Raccordement du cable	avec cosse

Ubersteckbarkeit	siehe Seite 9
Matching parts	see page 9
Contre pièces	voir page 9
Material: Gehause/Kontakturager Material: Housing/Contact carrier Matiere: Boitier/Support de contact	AIIPA
Material Steckerkorper Material of plug body Matiere corps de broche	CuZn, (Ag)
Leiteranschluss	mit Kabelschuh
Cable connection	wich cable lug
Raccordement du câble	avec cosse

Sockets IB...BV with bayonet locking and threaded stud

Sockets

Buchsen

embout fileté

verrouillage baïonnette et

Douilles IB...BV avec

Schutzkappen fur IB128V

DBT12

Zubehör / Accessaries / Accessaires

Multi-Contact

### IB...BV



Profe Profe Bouc Rouc	DBT30 Schu
Selle 34 ctive cap for 1812 age 34 hon de protection 1812BV, voir pege	ixeppen fur iB30 Sete 34 curre cap for iB30 Age 34 Non de protection IB30BV, voir page

### O VØ 80 20

siehe Seite 42-43 Material Gehauser see page 42-43 Material of housing vor page 42-43 Matière botter	20.29*
chniques	mit Farbband with coloured tape
Technische Daten Technical data Renseignements te	Farbmarkierung Colour marking

S 2 2

140 284

55 105

± 56 29

PA

CuZn. (Ag)	MC-Kontaktlamellen (Ag) MC-Multilami** (Ag) Contacts à lamelles (Ag)	rontplatten
Material Buchsenkorper Material of socket body Materie corps de douille	Kontaktprinzip Contact principle Système de contact	A. Promosphioner Manualth Acts ander scalingto Frontibation
Farben, 20-29* Colours, 20-29* Couleurs, 20-29*	sighe Seite 9 see page 9 voir page 9	Chambert of
8.58	Set	

Leteranschluss mit Kabelschun oder Aufbau an Stromschlenen. Komtaktblocke oder isolierte Frontplatten Cabie connection with cable lug or for screwing onto busbars, contact blocks or insulated panels Raccordement de cable par cosse ou montage direct sur jeux de barres, blocs de contact ou panneaux isolants Ubersteckbarker Matching parts Contre pièces

-			
stellen.	passand tu	MD/B128V	MD/8308V
Farbring pilte separat besteller	Bestell -Nr.	14.5021	14.5051
1) Farbring b	Tyn.	FR12	FR30

mstelle des \*\*\* bitte den gewunschlen Farbcode einsetzen

, Ape.	Order No.	Suttable for
FR12	14.5021.*	MD/B128V
F R30	14.50511	MD/B30BV

yper.	No de Cds	convent pour in models.
FR12	14,5021.*	MD/8128V
-R30	FR30 14,5051.*	MD/B308V
molace	of "" there is to	"" ner le code couleurs souhaite.

1) Les hapars de course sont a commander séparém.

	*Farbcode grangelb schwarz rot rot "Colour code reserved black red	23 bleu blue	geib yellow	grun green	26 violett
--	--	--------------------	----------------	---------------	---------------

29 weiss white

grau gray gray

29 weigs white blanc

27 braun brun brun

26 violett violet

Strong grown green

get yellow jaun

23 blau blue bleu

2 to 15 galor

21 Schwarz biack nor

grangelb green-yellow vert-jaune

Farbcode
Colour code
Code couleurs

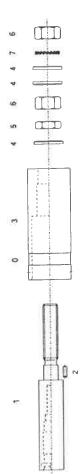
# 0 # 0

Douilles	
Sockets	
Buchsen	

# 18...BV Bestellangaben / Ordering information / Pour commander

9.	BestellNr.	Abmessu	ngen / Dimen	Abmessungen / Dimensions / Dimensions	risions			
Type	No. de Cde	GA (mm)	03 (mm)	@A (mm) @B (mm) @C (mm) E (mm)	£ (mm)		F (mm) G (mm)	K (mm)
IB12BV	14,2021-"1)	12	58	35	M12	49.5	90,5	140
B30BV	14.2041-*1)	30	90	69	M36x3	125	150	275
Farotand, Alle Fe (anstelle ons *** (side einsatzen)	1) Faround, Alle Farben gartass Farocode" 20.79, (arrstalle des "* okte den gewunschten Farbinde erretten)	irocode" 20-79. Inschlen Farb-	1) Coloured colour co colour co	<ol> <li>Calaurad tape. All colours according to colour code* 20-29. (add the desired colour code instead of **).</li> </ol>	according to the desired ).	)) Ru Seu (re	Ruban adhesif de couleur, toutas li Jeurs selon code couleurs 20.29, (remplacer "" par le code couleurs	) Ruban adhesif de couleur (toutes les couleurs selon code couleurs 20.28). (remplacers" par le code couleurs, souhaité).

# Einzelteile / Individual parts / Pièces détachées



Darie	Destell Nr Order No No de Cole	200	Barnerungen	Remacks	Remarques	Colours Couleurs
			Farbband	Coloured tape	Ruban adhésif de couleur	50.02
			Komakitouchse CuZn, verskbert mit Lemelle	Socker Cužn, Ag-plated with multitams	Doulle CuZn, argantee aquipée d'un contact à lamettes	
			Verdrehschurzbotzen, Sishi	Anti-twist om, skeel	Goupilite en acier	
			Isolergehause, PA. schwarz	Insulated body, PA. black	Bottler isolant en PA. noir	
U/M12 MUB,SD/M12	08 0307 08 0007	AUZ	Li-Schalber, CuZn, versibert Bkt Spanymutter, CuZn, versibert	Wesher, CuZn, Ag-plated Leck nist, CuZn, Ag-plated	Rondalle en latton, argentiée Contra-actor, en latton, argentié Consiste services en latton aroas	ě
MUG.BD/M12 F/M12	OB. 0107	LEII	5kt Anschlussmutter, CuZh, vers Facherscheibe	Commercial not, cut, it, agraemant Serrated lock washer	Rondelle eventall	
UM36x3	08 0314	٨	U-Schelbe, GuZn, varsibart	Washer, CuZn, Ag-plated	Rondelle CuZn, argentée	
MUO, SDVM36k3 MUO, BDVM36k3	08,0014	18308	Skt Anschlussmutter, CuZn, verskert Skt Anschlussmutter, CuZn, vers,	Lock nut, Cuth, Ag-parked Connector nut, Cuth, Ag-plated Connector nut, weather		¢.
	UM12 MUG.SDM17 MUG.SDM17 FM12 FM2 MUG.SDM3843 MUG.SDM3843	2 2	222	08 0300 08 0000 08 0000 08 0100 08 0100 08 0314 08 00014 08 00014	Farband   Farb	Farband   Caloured tape   Caloured tape   Caloured tape   Monatorine Cultured tape   Caloured tape   Monatorine Cultured tape   Caloured tap

Stecker ISBV mit bayonet locking and verrouililage balonnette et threaded stud threaded stud embout fileté par s'alla fileté embout fileté	Stecker	Plugs	Broches	
Subehor I Accessor  Barband Coloured Lape Ruban de Couleur  H  G  B  B  B  B  B  B  B  B  B  B  B  B	Stecker ISBV mit Bajonettverriegelung und Gewindeanschluss	Plugs ISBV with bayonet locking and threaded stud	Broches IS verrouillage embout file	BV avec e baïonnette et té
DST12  Farbband Coloured Lape Ruban de couleur  H G F  H G F			Zubenör / Acces	ssories / Accessoires
Farband Coloured tape Ruban de couleur Ruban de couleur Ruban de couleur	ISBV		DST12	Service/appen for 1512B siehe Snite 14 Ingestrion cap for 1512B sie page 14 Bouchen bis princition pour 1512BV van page
T VØ BØ OØ		Farrband Coloured tape	DST30	Schutzeopen für 15308 sahre Sate 34 Protective cap for 5308 sahr biggs 34 Bauchan de protection pour 15308V, voir perprocessor
VØ OB		Ruban de Couleur	<u>u</u>	
	ØØ.			3

Technische Daten Technical data Rensegnements techniques	siehe Seite 42-43 see page 42-43 schniques voir page 42-43	e 42-43 9 42-43 9 42-43	Material of housing Material of housing Mattere bottler	
Farbmarkierung Colour marking Repérage	영금등	Farben: 20-29* Colours; 20-29* Couleurs: 20-29*	Material Steckerkorper Material of plug body Matiere corps de broche	
Ubersteckbarkelt Matching parts Contre pièces	siehe Seite 9 see page 9 voir page 9	seite 9 age 9		1

CuZn, (Ag)

PA

Leteranschluss mit kabeischun oder Aufbau an Stromschienen, Kontaktblocke oder Isolierte Frontplatten Cable connection with cable lug or for screwing onto busbers, contact blocks or insulated panels. Raccordement de cable par cosse ou montage direct sur jeux de barres, blocs de contact ou panneaux isolants.

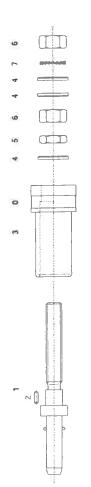
	0 0 2 0	"Farbcode "Colour code "Code couleurs	grun-gelb green-yellow	21 Schwarz black	22 rot red rouge	23 bleu blue	gelb yellow	25 grun green vert	26 violet violet	27 braun brown brun	grau grey grey	29 weiss white blanc
--	------------	---	---------------------------	------------------------	---------------------------	--------------------	----------------	-----------------------------	------------------------	------------------------------	----------------------	-------------------------------

2	white	biand
28	6.6	d
27	braun	pund
36	volett	Violot
25	gran	Specia
58	deb	ACIES OF
23	neng.	950
22	10.	199
7	SCHWARZ	Disck
20	dron gerb	green-yellow
	-Farbcode	apog inolog.
		7

Broches 15...BV Bestellangaben / Ordering information / Pour commander Plugs Stecker

Typ	Bestell -Nr	Abmessu	Abmessungen / Dimensions / Dimensions	ensions / D	imensions					
Type	No de Cde	@ A (mm)	(0 B (mm)	GC (mm)	@A (mm) @B (mm) @C (mm) @D (mm) E (mm) F (mm) G (mm) H (mm)	E (mm)	F (mm)	G (mm)	H (mm)	K (m
IS12BV	14.2022-*1)	12	21	28	35	M12	49.5	20.5	20	12(
IS30BV	14.2042.*1	30	46	58	69	M35x3	140	34	101	27
1) Farbband alie Falansialle des. *** cude ensetzen)	1) Farbland alle Farben germiss Farbcode" 20.29, lanstelle des. "" bite den gewunschten Farb- code ensetzen)	irbcode* 70-29, inschlen Farb-	1) Colour colour colour	Coloured Uspel, All colours ac colour code" 20-29, (add the colour code instead of "")	1) Coloured Lope, All colours according to colour code" 20-29, fadd the desired colour code instead of "1)	01 I to	1) Ruban ad leurs selo (remplace	Rupan adnéssi de couleur toutes les cou leurs selon code couleurs* 20.29 (rembaces**) par le code couleurs souhakte)	1) Ruban adhesif de couleur Foutes les cou leurs selon code couleurs, 20-29 (remplacet "- par le code couleurs, south	ou uhake)

# Einzelteile / Individual parts / Pièces détachées



50-29					नप्र क					
Ruban adhesif de couleur -	Broche avec embout flietà à lamettes CuZn, argentée	Goupille en acter	Bottier replant on PA. not	Rondella en latton, argentile	Contre ecrou en bacon, ergenter Ecrou de samage, en laiton, mge	Rondelle eventali	Rondelle CuZn, argentée	Contra Acrou CuZn, argenté	Ecrou de serrage, CuZh, argenté	Rondelle aventari
Coloured tape	Plug pin with timeded stud CuZn, Ag-plated	Anti-twist pin steal	Insulated body, PA. black	Wesher, CuZn, Ag-plated	Connector rut. CuZn. Ag-blated	Serrated lock washer	Washer, CuZn, Agiplated	Lock nut, CuZn. Ag-plated	Connector nut, CuZn, Ag-plared	Serrated lock washer
Farbland	Steckersült mit Gewindeanschluss Cuzh, versibert	Verdrehschutzbolzen Stanl	Isolergehause, PA, schwiez	U-Schelbe, CuZh, versibert	Bit Spenimutter, CuZn, versions Bit Amschiussmutter, CuZn, vers.	F acherscheibe	U-Scheibe, CuZn, varsilibert	6kt Spatintmutter, CuZn, versilbert	5kt Anschlussmutter, Cu2n, vers.	Facherschalbe
				٨	8215	į	,	190	es	0
				08.0307	7000.B0	08.0707	08 0314	08.0014	08 0114	08 0732
				UMITZ	MU0.5D/N12 MU0.8D/N12	FAM12	U/M35x3	MUO SDAMBEKT	MUD BD/M36x3	F/M36x3
	Coloured type Ruban adhesif de couleur -	Coloured tape Rubsan adhesif de couleur - Plag pan with transdad stud Buccha avec grittout fliere Cut'an Ag-blaned A lemesters Cut'an segentière	Coloured type Russiand stud Broche were embout file Plug pun with treasland stud Broche were embout filer Culfu, Agobared Almeites Culfu, ergentive Anti-twest pin steel Goupille en acter	Coloured type Rucha adhesit de couleur - Plug pin with transdad stud Boche avec embout fliets Culfu, Ag paked Anti-west pin sueal Gouplife en acter Insulad body, PA, no	Farberia  Sincherus (Caloured Lippe  Such was been continued State (Caloured Lippe)  Such was been continued State (Caloured Lippe)  Variethis Laboration State (Caloured Lippe)  Isolated such was been acted to the continued body PA, activities (Caloured Lippe)  Isolated such was continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued to the continued body PA, activities (Caloured PA)  Such was continued to the continued to	Farband   Caloured tripe   Rusan adhesit dis couldure	Fariband   Fariband   Caloured tripe   Rusan adhesit dis couldur - Caloured tripe   Rusan adhesit dis couldur - Caloured tripe   Rusan adhesit dis couldur - Caloured tripe   Buchin area embout files     Succineration of Caloured tripe   Sucine area     Succineration of Caloured tripe   Sucine area     Succineration of Caloured tripe   Sucine area     Succineration of Caloured tripe   Sucineration of Caloured tripe     Succineration of Caloured tripe   Succineration of Caloured tripe	Fariband   Fariband   Caloured tripe   Rusan adhesit dis couldurence   Caloured tripe   Rusan adhesit dis couldurence   Caloured tripe   Rusan adhesit dis couldurence   Caloured tripe   Sucrimense entroot like   Sucrimense entroot   Sucrimense entroot like   Sucrimense entroot   Sucrimense   Sucrimense entroot   Sucrimense   Sucrimense	Fariband   Fariband   Coloured Inpe   Rusan adhesit die couldur - Coloured Inpe   Rusan adhesit die couldur - Coloured Inpe   Rusan adhesit die couldur - Coloured Inpe   Buchin adhesit die couldur - Coloured Inpe   Buchin adhesit die couldur - Coloured Inpe   Coloured	Sectionarial Coloured type   Rusen adhesit desculdar.

1		
	Multi-Contac	ž.
		Records
		Couplers
		pplungen

Buchsen KBT...BV/... mit Bajonettverriegelung und Crimpanschluss

Sockets KBT...BV/... with bayonet locking and crimp sleeve

Douilles KBT...BV/... avec verrouillage baïonnette et fût à sertir

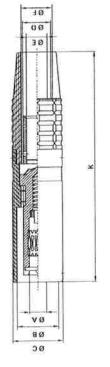
Zubehör / Accessories / Accessoires

KBT...BV/...

(mm) K 120 275



Farbband Coloured tape Ruban de couleur



fechnische Daten siehe Seite 42-43 fechnical data see page 42-43 Renseignements techniques voir page 42-43	Uberstreckbarkeit siehe Seite 9 Matching parts see page 9 Contre pièces voir page 9	Colour marking with coloured tape Colours: 20-29* Repérage avec ruban de couleur Couleurs: 20-29*	2 parties, a visser en 2 parties, a visser	Material Gehause Material housing PA
Technische Da Technical data Renseignemer	Ubersteckbarke Matching parts Contre pièces	Farbmarkie Colour ma Repérage	Gehause Housing Bottler	Material Gehar Material housin

Material Buchsenkorper Material of socket body Matière corps de douille	CuZn, (Ag)
Anschlussart Cable connection system Principe de raccordement	Crimpen Crimping Sertissage
Leiterquerschnitt Cable cross section Section du conducteur	50 mm² - 400 mm²
Kontaktprinzip Contact principle Système de contact	MC-Kontaktlamellen (Ag) MC-Multilam <sup>rw</sup> (Ag) Contact à lamelles (Ag)
Montageanleitung Assembly instructions instructions de Montage	MA018

		20	12	22	23	24	25	26
00	rathchoe	arin-nelb	SChwarz	9	pign	200	ON ON	400
000	*Colour code	Wollow Person	back	pou	pine	wellow	green	VID.
	"Code couleurs	wert lassner	no.	rouge	pleu	(Aune	wert	VOV

29 White White

grey grey grey

Drown brown brun

28

28 weiss white

grau grey gris

27 braun brown brun

26 Violett Violet Violet

green green vert

gelb yellow

Dlau blue blue

22 red ago

21 Schwarz black noir

20 grún gelb green-yellaw vert-jaune

\*Colour code

# **0** 

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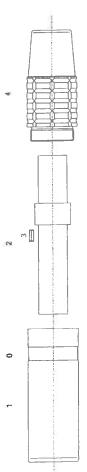
www.multi-contact.com

Couplers Kupplungen

## Bestellangaben / Ordering information / Pour commander KBT...BV/...

Type Type Type	Bestell-Nr. Order No. No. de Cde	Conductor Cu Conductor Cu Conducteur Cu		Abm	/ uagunssa	Dimension	Abmessungen / Dimensions / Dimensions	suc	
		mm	Ø A (mm)	Ø A (mm) Ø B (mm) Ø C (mm) Ø D (mm) Ø E (mm) Ø F (mm)	(mm) 00	(mm) 0 (0	Ø E (mm)	0 F (mm)	K (mm)
KBT12BV/50	15.0034.*1)	20	12	59	35	14.5	=	15,5	159
KBT12BV/70	15.0035-*1)	7.0	12	59	35	17	13	19	159
KBT12BV/95	15,0036-*1)	92	12	29	35	50	÷.	22	159
KBT308V/240	15,0054.*1)	240	30	9	69	30	24	35	261
KBT30BV/300	15.0055-*1)	300	30	90	69	32	92	38	261
KBT30BV/400 15.0056-*1)	15.0056-*1)	400	30	09	69	36	30	43	261
I) Farband alle Farben gemess Farbcode" 20-29, langelie des "" bitte den gewunschten Farb- code einsatzen)	Fintband wife Finten gemass Fintboode" 20-25 (instable des "* bitte den gewunschten Feitboode einsetzen)		Coloured tape, all colours ac colour code* 20-29, (add thi colour code instead of ""),	1) Coloured hape, all colours according to colour code? 20-29, ladd the desired colour code insised of "1).	ng 10 kred	1) Ruban b feurs sel (remplac	Ruban adhesif de couleur: touxes leurs selon code couleurs* 20 29 (remplacer ** par le code couleur	1) Ruban adhwiif de couleur: touxes les couleurs selon code couleurs* 20 29 (remplacer*** par le code couleurs soundeurs soundel)	u hartoj.

# Einzelteile / Individual parts / Pièces détachées



\$ 6 6 2	Testn Parts Pièces G	G mm	Gestel for Order No. No. de Cde	Demension	Reinwer	Remarques	Coleurs*
-				Faroband	Coloured type	Ruban adhesif de couleur	20.29
				Gehausevordentell, PA, schwitz	Front part of body, PA, black	Isolant event, PA, not	
				Kontektouchsen mit Lamallen	Contact socket with multifarms. Double equipped d'un contact à	Douille équipée d'un contact à	
				CuZn/Cu, varsibert	CuZn/Cu, Ag-plated	Iamelles, CuZn/Cu, argentée	
				Verdrehschurzbolzen, Stahl	Anti-twist pin, stael	Goupille and rotation en acier	
				Gehäusserückteli. abschraubber, PA, schwerz	Back and of body unscrawable, PA, black	Isolant arnera A devisser, PA, nor	





Assembly instructions MA018



21	22	23	24	25	56	27	97	Ğ
CHWARZ	101	pian	quab	drun	violett	braun	grau	Weiss
IBCk	red	plue	yellow	green	violet	Drown	grey	white
1000	POUGE	pien	SUNE	Yer	violet	punu	gris	planc

grun-gelb green-yillow vert.jalune

\*Farbcode \*Colour code \*Code couleurs



Multi-Contact

Broches KST...BV/... avec verrouillage baĭonnette et fût à sertir

Bajonettverriegelung und Crimpanschluss Stecker KST...BV/... mit

KST\_BV/...

Plugs KST...BV/... with bayonet locking and crimp sleeve

Zubenar / Accessories / Accessoires DST12

Schutzappen to: NST128VI... seha Sate 34. Prondlive cap for KST128VI... see been 14. 

Farbband Coloured tape Ruban de couleur

)	pour KST128VI voir page 34
DST30	Schutzkappen for KST308W., sanha Selte 34. Protective cap for KST308W. we page 14. Bouchon de protection pour KST308W., volt page 34

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CuZn. (Ag)	Crimping Crimping Sertissage	50 mm² - 400 mm²
Material Steckerkorper	Anschlussart	Leiterquerschnitt
Material of plug body	Cable connection system	Cable cross section
Matière corps de broche	Principe de raccordement	Section du conducteur

mit Farbband Farben; 20-29\* with coloured tape Colours; 20-29\* avec ruban de coulour Couleurs; 20-29\*

Farbmarkierung Colour marking Reperage

sighe Seite 42-43 see page 42-43 voir page 42-43

Technische Daten Technical data Renseignements techniques

siehe Seite 9 see page 9 vor page 9

Ubersteckbarkeit Matching parts Contre pièces

2-tellig, geschraubt 2 parts, screwed en 2 parties, à visser

Genause Housing Bottler

P.

Material Gehause Material housing Matière bottier

0 Montageanleitung Assembly instructions Instructions de Montage

MAG18

4	20	21	22	23	24	25	5.6	27
Leccoo	dlan nino	Schwarz	rot	plan	dian	drun	vlolett	braun
Colour code	Cream.vellow	Diack	92	piue	wellow	green	violet	Drown
"Code couleurs	Vert-Bune	NOIL	ronog	pien	(a)ne	vert	violet	brun

29 weiss white blanc

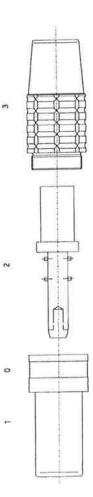
www.multi-contact.com

## Raccords Couplers Kupplungen

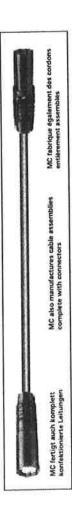
## Bestellangaben / Ordering information / Pour commander KST...BV/...

Type	Besten-Nr. Order No. No. de Cde	Conductor Cu Conductor Cu Conducteur Cu		Abm	Abmessungen / Dimensions / Dimensions	Dimensions	, / Dimension	Suc	
		, white	Q A (mm)	Ø B (mm)	Ø A (mm) Ø B (mm) Ø C (mm) Ø D (mm) Ø E (mm) Ø F (mm)	(mm) C Ø	Ø E (mm)	@ F (mm)	K (mm)
KST128V/50	15.0031.*1)	25	12	28	35	14,5	11	15,5	139
KST12BV/70	15.0032-*1)	70	12	28	35	17	13	19	139
KST12BV/95	15.0033-*1)	95	12	28	35	20	15	22	139
KST30BV/240	15.0051-*1)	240	30	59	69	30	24	32	242
KST30BV/300 15.0052.*1)	15.0052."	300	30	59	69	32	56	38	242
KST30BV/400	15.0053-*1)	400	30	59	69	36	30	43	242
1) Faroband, alle Farben gemass F. Mocorle * 20-29, (anstelle des *** bite den gewunschten Farb-code einsatzen)	Farbband, alle Farben gemass Fabrode* 20-25 (anstelle des *** bite den gewunschten Farb code anneatam)		<ol> <li>Coloured tape, all colours according to colour code? 20.29, (add the desired colour code instead of "").</li> </ol>	colours accord 9. (add the des ad of "").	ng to ired	Ruban at Increpted	Ruban agheolf do couleur: toutes mus velon code couleurs 20-29 immpisce " par in code couleur	1) Ruban adreoil de couleur: trunes les cou- leurs selos code couleurs 20-29 inemplace*** par la code couleurs souhad (i)	นระ กลศ์ ถ้า

# Einzelteile / Individual parts / Pièces détachées



Tean Parts	S	Beeral Nr. Order No.	Barriers, under	Remarks	Remarques	Colours
			Farboand	Coloured tape:	Ruben adhesif de couleur	20-29
			Gehausevordenteil, PA. schwarz	Front part of body, PA, black	Isolant avant, PA, now	
			Stackersoft mit Crimphulse CuZn/Cu, versibert	Plug pin with arimp sleave CuZn/Cu, Ag plated	Broche evec un füt a sertir en Cu2n/Cu, argentée	
			Genkusæruchteil, anschraubber, PA, schwarz	Back end of body, unscrewable, PA, black	Isolant arriere a dévissar, PA, noir	



S Montagenniestung WADTS

Assembly refruction Walfill

S restructions do montage MAD18

WKZ-16BV-NS-A

	(17)
weiss white blanc	
grau grey grey	
27 brown brown	
28 violet violet	
grun green vert	
yelow yelow	com
Diau Diau Diau	contact
22 H 25 G	www.mtult
21 Schwarz Stack nor	3

20 grün gelb green yellow vert joune

\*Farbcode \*Colour code \*Code couleurs

## Multi-Contact

behör	Accessories	Accessoires
ontagewerkzeuge	Assembly tools	Outil de montage

## Montagewerkzeuge

### Zum Anziehen der Kabelverschraubung der neuen Kupplungen KBT16BV... und MC-Gabelschlüssel

## Assembly tools

Clé à fourche MC

MC-Open-end spanner
Tool for tothermout the cable gland of the
Tool for tothermout the cable gland of the
Tool for tothermout the control of the
MC recomments this tool to prevent a
over-tignten of the thread with traditional
tools. Per Ype, two tools are necessary.

Destinee au serrage des presse-etoupes equipant les nouvaaux raccords KBT16BW... et KST16BW... MC recommande cet outil pour éviter d'endommager le filetage en cas d'utilisation d'outils traditionnels. Deux outils identiques sont necessaires pour chaque type.







## KBT16BV... M50 . . KBT16BV... /M50L... KST16BV... JM50... KST16BV.. /M50L Assembly instructions MA042

0

KBT15BV M40 ... KST16BV. M40.

GS38/46 GS55/60

passend zu Sutable for Convert pour les modèles

Bestell Nr Order No No. de Ode 15,0134 15.0135



## Montagnanfeitung MAD42

## Installation and removing tool WKZ-16BV-NS-A

Die Crimphuisen der Kupptungsteile KB1168V. und KST 168V. werden beim Monteren in den Metallieilen vernegelt. Zum Auswechsein der Crimphülsen Montage - und Demontagewerkzeug WKZ-16BV-NS-A

mussen die Metallteile aus den

verwendbar.

it is necessary to pull out the metal parts from insulations.
The Lool WKZ-16BV-NS-A is required for installation and removal, it is usable for all insulation sizes and for sockets KBT16BVL, and plugs KST16BVL, and plugs KST16BVL. The crimp sleeves of the coupler parts KBT16BV... will be locked into the metal parts during installation. To change the crimp sleeves Isolationen gedruckt werden. Das Verstagu WKZ-18B.V-S-A at sowohl für den Ausbau wie auch der Ernbau der Metaliteie notwerdig. Es ist für alle Isolationsgrössen und für Buchsen KBT16BV...

## Les fúts à serir des raccords KBT16BV... et KST16BV... et KST16BV... et KST16BV... et KST16BV... et KST16BV... et kst... et rouilles dans des pieces métalliques. Pour remplacer les fúts à serir, les pieces métalliques doivent être ex bieces métalliques doivent être ex bieces métalliques doivent être ex bieces métalliques. Il suflise avec des pièces métalliques. Il suflise avec douilles KBT16BV... et les broches KST16BV... et les broches Outil de montage et de démontage WKZ-16BV-NS-A



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passend zu Sutable for Convent pour les modèles	KBT16BV.JMKST168V,/M.
Bestell Nr Order No No de Coe	15,0136

Montageanleitung NAD43

Assembly Instructions MAD43



Accessoires Accessories Zubehör

### **Mikroschalter**

ein Wechselkontakt mit 3 Flachsteck-anschlüssen 2.8mm x 0.5mm und einer Schaltleistung von 6A. 250 VAC. Der Mikroschalter schaltet unmittelbar Mit Ausnahme der Kupplungen KBT16BV... und KST16BV... können die Steckzustandsanzeige ausgerüstet werden, Der Mikroschalter-Kontakt ist Steckverbinder der Baureihe ... NS zusatzlich mit einem Mikroschalter für bevor die Vernegelung einrästet und zeigt damit an, dass die Steckverbin-dung hergestellt ist.

## Microswitch

With the exception of couplers KBT16 BVN5X,... and BGNSX,... and Connections the series...,NS can be equipped with a microswitch to show the state of the plug-in connection. The microswitch is a changeover switch with 3 flat connecting babs 2.8mm x with 3 flat connecting babs 2.8mm x oil.5mm and switching capacity of 6A. ZSOVAC.

The microswitch switches immediately before the locking device engages, infidential grant the plug-connection is made.

### Micro-rupteur

A I exception des types KBT16BV... et KST16BV... et CST16BV... et Sonnecteurs des séries ... NS peuvent être équipés d'un micro-ripteur indiquent fétat de la connexion. Il s'apit d'un micro-rupteur inverseur 6A. 250 VAC... à trois contacts 2.8mm.

Le micro-rupteur doit s'enciencher avant même que le verrouillage ne soit réalisé. Il indiquera ainsi que le contact est établi

## Zubehör

## Accessories

Bouchons de protection

Multi-Contact

## Schutzkappen

Schutzkappen aus Kunststoff dienen als Staub- und Spritzwasserschutz für Kupplungen von Typ KBT...BV und KST...BV, Buchsen IB...BV und Stecker IS...BV,

Die Schutzkappen werden auf den abzudeckenden Steckvebinder gesteckt. Mit Hilfe einer Schnur können die Schutzkappen an der Isoherung der Steckverbinder befestigt werden.

A cord can be used to attach the cap the insulation of the connectors. The cap is simply slipped onto the connector.

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Type	Sestel Nr Order No No de Cde	passend zu suitable for convient pour
DBT-IB16-NS	15,5270	IB16BV-NS-

Serre Page Page 12



DBT-KBT16-NS

MA023 MA025

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ID/B16BV-NS-A IB16BV-NS-A

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MS-B168V-NS

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MS-B168V-NS

MAN: 11 MAN: 15 MAN: 15

Se te Page Page

passend zu suitable for convient pour modéle

Bestell .Nr. Order No No de Cde

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IS16BV-NS

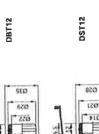
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KBT12BV IB12BV

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DST12

AS-ID/S168V.NS

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VS B16BV NS

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Schattschema Mikroschafter Wirng dagram of mcroswitch Schema de comexion du

Micro-rupteur

A SW VBB18/CI

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MS 8168V/NS

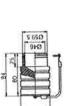
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KST12BV IS12BV

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DBT30

ID/S16BV/NS

VS:IS16BV/NS

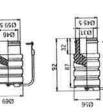
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KST30BV IS30BV

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DST30

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1) No. des Instructions de montage

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1) Nr der Montageanleitung

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IB16BV-NS A

www.multi-contact.com

IS16BV:NS

Accessoires Accessories Zubehär

Schutzdeckel DE...N

Sie dienen zum Abdecken der nicht ge-steckten Anschlussdesen und schulzen vor mechanischen Ernwirkungen. Schmutz und Spritzwasser. Der 1yp DE, Mis mit einem Vor-hangeschloss abschlinssbar (nicht von MC\* geleifen). Die Farbmarkeeung erfolgt mit Farbmarkeeungsscheiden (Farben 20.29, seha Farbcade unten). Schutzdeckel DE N und DE22/30MD/ 3+5 sind federnde Klappdeckel für inbaudosen ID/ .. und MD...

## Protective covers DE...N

Protective covers DE...N and DE22/30 ND/B4-5 are spring-loaded hinged covers for the panel receptacles ID/... and MD/... and MD/... They cover the open receptacles to keep out drift and splashing water. The model DE... N can be locked with a padlock frot available from MC?! Colour coding is effected with colour coding is effected with colour coding discs. (colours 20-29, see code below).

## Couvercles de protection DE...N

Les couvercles de protection DE....N et DE2230MD/B4.5 sont des couvercles a ressorts destines aux prises à encastrer ID... et MDL... Ils obturent les prises non accordes et les protegent dess inhumences meranques, de la poussière et des projections of asu. Le modèle DE...N peut être verrouille à l' aide d'un cadenas (non fourri par MC\*).

Le repérage couleur est réalisé par une pastille de couleur (couleurs 20-29, selon code couleurs ci-dessous).

14,5163-\*1 MD/B12BV, MD/S12BV

DE10-12N

210

Mutt. Contact

ID/B16BV-NS-A ID/S16BV-NS

14.5165-"1)

DE16N

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passend zu Sutable for Convient pour modele

Bestell, -Nr. Order No. No de Cde

2,2,2

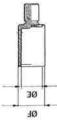
ा विकास्त्र स्वाहर

DE10-12N, DE16N

## Multi-Contact

Fots à sertir pour douilles et broches avec verrouillage baïonnette KBT16BV-NS..., KST16BV-NS..., pour cables souples de classes 5'' et 6') Accessoires Crimp sleeves for sockets and plugs with bayonet locking KRT16BV-NS..., KST16BV-NS... for flexible cable class 5" and class 6" 10. Accessories Stecker mit Bajonettverriegelung KBT16BV-NS..., KST16BV-NS... für flexible Leitungen Klasse 5<sup>11</sup> und Crimphülsen zu Buchsen und Klasse 61) Zubehör





Crimphülse Crimp sleeve Füt à sentir

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	CU-ETP		
Material:	Material	Matière:	
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CU-ET	
Material: Material: Matière:	
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13	52.5
Ŧ.	28.0

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für flexible Leitungen Klasse 6 <sup>1)</sup>		for flexible cable class § <sup>1)</sup>	pour cables	pour câbles souples de classe 6 <sup>1)</sup>
Type Type Type	Besteil Nr Order No No de Coe	Leterquerschnitt Conductor cross section Section du conducteur	innen Ø E Inside Ø E Ø intérieur E	Aussen Ø F Outside Ø F Ø exterieur F
		mm²	mm	шш
H50/16BV-NS	07.00432)	50	11	14,5
H70/16BV-NS	07.00442)	7.0	13	7.1
H95/168V-NS	07.00452)	20.00	35	02
H120/168V-NS	07.004027	120	1.7	22
H150/16BV-NS	07.00412)	150	19	25
H185/16BV-NS	07.00422	18.5	21	23
H240/168V-NS	07.00462)	240	24	30

1) Pastille de couleur couleur" (20.79). Rem-couleurs se un code couleur (20.79). Rem-placer "" par le code couleur souhaité

1) Coloured disc, calcul colour code" (20.29), add the desired colour code instead of """

1) Farbmarketrungsschebe Farben gerr Farbcode (20.29), anstelle des 11 bite den gewünschlen Farbcode einsetzen

Nonthywalerung MA036

Couvercle de protection DE22/30MD/8+S

Protective cover DE22/30MD/8+S

Schutzdeckel DE22/30MD/B+S

DE22/30MD/8+S

E.

Instructions de montage MAG36

0

Assembly instructions MA036

für flexible Leitungen Klasse 5 <sup>1)</sup>	(LS es:	for flexible cable class 5 <sup>1)</sup>	pour cables	pour câbles souples de classe 5
Type Type	Besteil Nr. Order No No de Cde	Letterquerschnitt Conductor cross section Section du conducteur	Innen Ø E InsidelØ E Ø interieur E	Aussen-Ø F Outside Ø F Ø exteneur F
		mm²	шш	ww.
HSO-MOTIEN-F/16BV-NS	12,50032)	20	10	14
H70-H07RN-F/18BV-NS	12,50042	70	2٢	16
H95-H07RN-F/168V-NS	12.50052)	50	13.5	18
H120-H07RN-F/16BV-NS	12,50067	120	15	19
H150-H07RN-F/16BV-NS	12.50072	150	17	22
H185-H07RN-F/168V-NS	12,50082)	185	19	24
HZ40-H07RN-F/16BV-NS	12.50092	240	22	26

1) nach IEC 60228, DIN VDE 0295, siehe Solke B
2) Zum Ausbru der Comphulsen ist ein spezieller.
Workraug (WKZ16BV/MSA) noswendig Siehe Stelle 32

1) Pastille de couleur, couleurs seion code couleur\* (20.29). Remi-placer \*\*\* par le code couleur souhaité.

1) Coloured diss: colour code\* (2029) add the desired colour code instead of \*\*\*

1) Farbmaikierungsscheibe Farben gem Farbcode\* (2029), anstelle ules \*\*\* bitte den gewunschten Farbcode ensetzen

Percages Ø 4,5 mm au niveau du panneau et fixation avec 2 vis M4 par l'arrière.

© 4.5 mm hole in panel, Fasten with 2 M4 screws from the rear side of the panel.

Bohrung Ø 4.5 mm in der Platte und Befestigung mit 2 Schrauben M4 von der Rückseite her

Montagehinweise

Assembly instructions

Instructions de montage

14.5057.\*1) MD/B30BV, MD/S30BV

DE22/30MD/B+S

passend zu Suitable for Convent pour modèle

Bestell.-Nr. Order No. No de Cde

y be

2 E D 4.5 mm

Bohrplan Oriling plan Plan de perçage

1) according to IEC 60228. DIN VDE 0295, see page 8.
2) For removing the curro bareans a special tool
(WKZ18BV.NS.A) is required.

1) Selon CE( 60228, DIN VDE 0295, voir pagin B.
2) Pour la demontage des tots a sentr un outil son-cial (WKZ) 169K/NS-A) est necessaden, Voir pagin 35

Assembly instructions MAD43

Instructions de montage MA043

Montageanlenung MAD43

26 violett violet violet green green ge:b yeilow

\*Farbcode \*Colour code \*Code couleurs

blue bleu tied age Schwarz black nort grun gelb green yellow vert, aune

35 29 white blanc S Proposition

27 Brown brown

Voiett Voiet

green green

2 4 4 5

22 to 15 gills

Schwarz black nor

20 gram gelb green yerlow vert gune

\*Code couleurs

0 0 0

·Farbcode

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36

27 braun brown brum

29 weiss white blanc

grau gray gray

www.multi-contact.com

### Hints on crimping with Technical information Hinweise zum Crimpen mit Technische Hinweise Crimphülsen

gelieferten Gesenke sind ausgelegt für das Crimpen flexibler Leiter der Klasse 6), Durch den vermehrten Einsatz von eine, für diese Leitungen abgesummte Baureihe mit angepasster Crimphüse wurde die bestehende Baureihe durch MC\* empfiehlt ELPRESS sechskant Crimpung, Die Abmessungen der Crimphülsen und die von ELPRESS Klasse 51) Leitungen mit geringerer Flexibilitat und somit geringerem Leiterdurchmesser (z.B., H07RN-F), erganzt, Die neuen Crimphülsen

ELPRESS, Les dimensions des füts a sertir et les matrices fournies par ELPRESS sont conques plant estitsas gedecables extra-souples, classe 6°°. Du fait de l'utilisation crossante de MC\* recommande le sertissage six pans ELPRESS. Les dimensions des fûts à

Informations sur le sertissage

Renseignements techniques

au moyen de fûts à sertir

MC\* recommends ELPRESS hexagonal

crimping sleeves

The dimensions of crimping sleeves supplied by ELPRESS are designed for crimping class 61 flexible conductors...

adaptes a ces cables, Les nouveaux futs

avec des füts à sertir directement

la gamme existante a ete complètée par une nouvelle gamme

donc de plus petil diamètre (p. ex. H07RN-F), la gamme existante a di

cables moins souples, classe 51)

ĕ

electríque et de tenue à l'arrachement, a sertir garantissent ainsi des liaisons parfailes en termes de résistance

range. The new crimping sleeves guarantee a perfect connection in terms

of both confact resistance and pull-out

resistance of crimping sleeve.

Crimping sleeve dimensions

crimping sleeve specially designed for these cables has been added to the

flexibility and therefore a smaller conductor diameter (e.g. H07RN-F), a new series of connectors with a

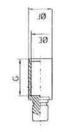
In response to the increased use of class 511 conductors with lower

Dimensions des fûts à sertir

## Crimphülsen-Abmessungen

Verbindungen bezuglich Ubergangswi-derstand und Ausreissfestigkeit,

garantieren somit einwandfreie



## X

# Messpunkte Measurerierk points Points de mesure

ungelyo Klinsse <sup>1)</sup>
25

Type Type Type	Bennik N Odder No No de Cde	Letterquerschnitt Conductor orons section Section du cibile	Cape type class?  Type de cable, classe?	30	50	Ŋ	Crimposcien Nr Crimp des No No, des matrices
H50/16BV/N5	07.0043	50 mm²	ъ	11	14.5	28	¥.
H70/16BV NS	07 0044	70 mm <sup>2</sup>	9	13	17	27	16
H95/16BV NS	07,0045	95 mm²	10	15	23	30	19
H120/16BV-NS	07 0045	120 mm?	9	1.7	22	30	22
H150/16BV-NS	07,0041	150 mm²	9	19	25	33	52
H185/16BV NS	07 0042	185 mm²	:40	7.1	23	38	23
H240/16BV-NS	07.0045	240 mm²	9	54	30	38	30
HSO HDIRN F/16BV NS	12,5003	50 mm²	un	10	7	28	14
H70:H07RN:F/T6BV NS	12,5004	70 mm <sup>2</sup>	1/3	12	16	28	118
H95-H07RN-F/16BV-NS	12,5005	95 mm <sup>2</sup>	s/T	13.5	18	30	18
H120 H07RN-F/16BV NS	12.5006	120 mm2	M)	45	10	J.D	19
H150 H07RN F/16BV-NS	12 5007	150 mm²	-2	17	23	30	22
H185 H07RN F/16BV-NS	12 S00A	185 mm²	LO	19	24	38	5.4
H240 H07RN-F/16BV-NS	12.5009	240 mm <sup>2</sup>	ın	22	92	36	92

### Crimphulse Oberprüfung der Crimp-Ergebnisse Annand der Verformung der Crimphulse lasst sich uberbprüfen, ob die Crimpung mit dem Werkzeug korrekt ausgeführt wurde, Dazu das Mass, X der Sechs-

Druckstempel erfolgt ist, (siehe Skizze Das gemessene Mass X sollte mit n Prufmass in der Tabelle übereinmit dem Messschieber überprü kant-Flachen, wo der Eindruck der fen.

Eine hydraulische Handpumpe kann von Multi-Contact leihweise, gegen eine geringe Gebühr, zur Verfügung gestellt Elpress hydraulische Crimpwerkzeuge Empfohlenes Crimpwerkzeug MC® empfiehlt für diese Baureihe mit passenden 6kt. Crimpbacken (Crimpbacken-Nr. siehe Tabelle)

1) rach IEC 60228, DIN VDF 0295, such auch Seite B

## Evaluation of the crimping results in can be determined from the deformation of the crimping sleeve whether the crimping has been crimped correctly or not. This is done by checking with a

Vérification des résultats de sertissa-

11,7 13,2 14,1 15,4 17,8

verifier si le sertissage a été correcte-ment effectué par l'outil. Pour ce faire, verifier au pied à coulisse la dimension X des surfaces hexagonales créées par le poinçon (voir dessin c-dessus). La dimension X mesuree doit coincider avec la cole de contrôle figurant dans le La déformation du fût à serur permet de caliper the dimension X of the hexagon should agree with the test dimension surfaces where the crimping die has above). The measured dimension X made an indentation (see drawing

### les outils de sertissage hydrauliques Elpress munis de matrices hexagonales Outil de sertissage recommandé MC® recommande pour cette gamme nant une somme modique, de vous préter une pompe à main hydraulique. reporter au tableau) Multi-Contact est en mesure, moyen-(pour le numêro de la matrice, se

Recommended crimping tool
For this series MC® recommends
Elpress hydraulic crimping tools with
appropriate hexagonal crimping dies
(see table for crimping die number).

stated in the table

1) salon CEI 60228, DIN VDE 0295, voir page B.

1) according to IEC 60228, DIN VDE 0295, see page 8.

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supply a hydraulic hand pump on loan.

For a small fee, Multi-Contact will

**Technische Hinweise** 

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Informations techniques

Conversion of 16BVN	plug connectors to NS
Umbau der 16BV Steckver-	binder, Baureihe N auf NS

Fechnical Information

The ... NS series is not plugtypes. IEC, EN 60529, DIN VDE 0470 und die Steckkompatibilität mit allen Die ... NS-Baureihe ist mit der ... N. Baureihe oder älteren nicht stecklierten ...N-Typen umgebaut wer kompatibel. Ohne grossen Auf-wand können die bereits instalden. Damit werden sie beruh-rungssicher nach den Normen ..NS-Typen ist gewährleistet.

## prug connectors to ... NS

Transformation des connec-

teurs 16BV...N en ...NS

converted. This gives them touch compatible with the ...N series or standards IEC, EN 60529, DIN VDE 0470 and ensures plug-compatibility with all ".NS types. already installed can easily be protection in accordance with ..N-type connectors that are

### tibilité avec la nouveile gamme ciennes générations de connecgamme ...N peuvent cependant eue transformés très simple-..NS ne sont pas systématiquement compatibles avec les an-Les connecteurs de la gamme teurs. Les connecteurs de la

ment. La protection au doigt d'épreuve selon CEI, EN 60529. DIN VDE 0470 ainsi que la compa-...NS seront ainsI garanties.

## Pièces et outillages nécessaires:

Parts and tools required:

Bedarf an Material und Werzeug

zum Umbau:

	Bezeichnung Description Description	Type Type	Bestell .Nr. Order No. No. de Cde	Passend zu Suitable for Convent pour les modèles
The second secon	Schutzbalzen Protection boit Doigt de protection	SB/IH16BV-NS 15.5287	15,5287	KB716BVN , IB16BVN ID/B16BV-N
	Schraubendreher Gr. 2 Screwdriver size 2 Tournevis Gr. 2	2		
	Loculte Nr 243 to	zur Schraubensicherung to secure the screw pour secureer a laison wissee	8	

Prutmans (X)
Control dimension (X)
Cota de controle (X)

11,7 13,2 15,4 16,3 20,3 20,5 23,4

Drucksternpel Indem Empreinte de sertissage

Umbau der Steckerseite KST16BV.N., ID/S16BV.N, IS16BV.N Schutzstopfen SST16BV-N mit Hilfe des Schraubendrehers Gr. 2 aus seiner Halterung entfernen.

Remove the protection plug SST16BV-N with help of the screwdriver. Conversion of plugs KST168V-N.,, 10/S168V-N, IS168V-N

Enlever le bouchon d'obturation SST16BV-N à l'aide d'un tournevis Gr. 2. KST16BV-N.,, ID/S16BV-N, IS16BV-N Transformation des broches



### KBT16BV-N..., ID/B16BV-N, IB16BV-N Umbau der Buchsenseite

Schutzbotzen am Gewinde mit Loctite 243 bestreichen und sorgfältig in die Buchse einführen und festschrauben, (Schraubendreher Gr.2). Es darf beim Einführen kein Loctite an die Kontaktflächen gelangen.

Enduire le filetage du dorgt de protecton avec de la Loctite 24.3. Iurodoure le doig de protection dans la douille sans toucher les surfaces de contact avec la Loctite. Le fixer en position avec le tournevis 65, 2.

KBT168V-N., ID/B168V-N, IB168V-N

KBT16BV-N..., ID/B16BV-N, IB16BV-N-N

Conversion of sockets

Transformation des douilles

Spread some Loctite 243 onto the thread of the protection both into the socket. Do not both the contact surface with Loctite. Screw in the protection bolt with the screwdriver size 2.

## Loctite 243

## SBUHTEBUNS

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38

Renseignements techniques Derating Diagram for PVC-insulated Cu-wires (70°C) according to DIN/VDE0298 part 4 Technical data Derating Diagramm für PVC-isolierte Cu-Leitungen (70°C) nach DIN/VDE0298 Teil 4 fechnische Daten

Utilisation of cables and cords in power installations. Part 4: Recommended current-certying capacity for sheathed and norsheathed cables for free in air in buildings and for flexible cables and cords. Verwendung von Kabeln und isosierten Leitungenfult Starkstommangen.
Teil 4: Empfohlende Werte fur die Stombelsstlaskeit von Kabeln und Lei-tungen fur Verlegung frei nicht in Ge-bauden und von flexiblen Leitungen.

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900

800

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Diagramme de derating pour cábles en Cu à isolation PVC (70°C) selon DIN/VDE0298 partie 4.

Utilisation de cablos et de cordons dans destinations est sixtiliation de pursante. Partie 4, Intensité de courant maximale admissible recommandee pour cables posses à demieure dans des batiments et pour rondons soupres.

Multi-Contact

Melulum Melulum Caractéristiques techniques Max. Anzugsdrehmonnent Max. Montgreng Lorque Coupe de son egge maxi Mechanische Daten Mechanical data Caractéristiques mécaniques Auszugskraft Withdrawał force Technical data S (M 16) S (M 16) S (M16) S (M16) บอกวอยนอก ชุษสิตหุกลล にほぼははははななななななななななななななななないは COLOURS 15.0633.\* 15.0634.\* 15.0635.\* 15.0636.\* 15.0637.\* 15.0629 1 15.0630 1 15.0631 1 15.0632 1 15.0612\*\*
15.0614\*\*
15.0614\*\*
15.0616\*\*
15.0618\*\*
15.0619\*\*
15.0619\*\*
15.0620\*\*
15.0620\*\* 15.0638 \* 15.0639\* 15.0640\* 15.0640\* 15.0641\* 15.0641\* 15.0643\* 15,0623 \* 15 0626 \* 14,0047 14,2037.\* 14,2034.\* 15,0600.\* 15,0601 \*\* 15,0602 \*\* 15,0603 \*\* 15.0605 \* 15.0606 \* 15.0607 \* 15,0625.\* 15 0628 \* Bostell Nr. Order No. No de Cde KST16BV.NS/M50-95H KST16BV.NS/M50-120H KST16BV.NS/M50-150H KST16BV.NS/M50-140H KST16BV.NS/M50-240H KST16BV.NS/M50L-240H KBT16BWASMAO70H
KBT16BWASMAO39SH
KBT16BWASMAO12DH
KBT16BWASMAO13CH
KBT16BWASMAO13CH
KBT16BWASMAO13CH
KBT16BWASMAO13CH
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 Chimpenschluss of a Chimpenschluss of the separat bestellen.
 Farbinge bitte separat bestellen.
 Farbiand, Alle Farban.
 gernass Farbooder. KBT16BUNSM5G-150 KBT16BUNSM5D-185 KBT16BUNSM5D-240 KBT16BUNSM5D-240 KST16BVNSM40-50H KST16BV.NSAMAD.50 KST16BV.NSAMAD.70 KST16BV.NSAMAD.95 KST16BV.NSAMAD.120 KST16BV:NS/M40.70H KST16BV:NS/M40.95H KST16BV:NS/M40-120H KST16BV:NS/M40-150H KST16BV:NS/M4D-150 KST16BV NS/M5D-120 KST16BV:NS/M50-150 KST168V-NS/MS0-95 KBT168V-NS/M40-50H Aligemeine Daten General data Données Générales ID/B16BV.NS.A ID/S16BV.NS IB16BV.NS.A IS16BV.NS **Technische Daten** odkj tkbe tkb 12 61 21 19:21 21 Serie

70 mm<sup>2</sup>

500

Betriebsstrom / Operating current / Intensité de service

9

400

95 mm<sup>2</sup> 50 mm<sup>2</sup>

 $150 \text{ mm}^2$ 120 mm<sup>2</sup>

300 mm<sup>2</sup> 240 mm<sup>2</sup> 185 mm<sup>2</sup>

500 mm<sup>2</sup> 400 mm<sup>2</sup> 0 0

5 = Scraw terminal
P = Criting connection
1) Please order colouned rings separately,
2) Colouned tape According
3) Colouned tape According

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8

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200

300

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Umgebungstemperatur / Ambient temperature / Température ambiante

node de S = Recordement à vaner

F to 1 avent

1) Les baques de couleur sont à commander

saberément

2) Rubar adressi (in couleur, selon le rodé di

couleurs \* 20/25).

grun green green vert gelb yellow jaune Diau Diau Diau Schwarz black noir gnün-gelb green-yellow wert, jaune Farbcode Colour code

29 weiss white

grey grey

27 brown brown

26 violett violet

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Technische

Caractéristiques techniques	
Technical data	Elektrische Daten
e Daten	

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		≪	>	G	5	κĀ	KA	kV	kWm
10	ID/816BV-NS-A	530	1000	52	7	10	55	£ .	8/3
11	ID/S168V-NS	530	1000	52	74	9	5.5	5.6	6/3
12	IB756VNS.A	530	0001	KC 7	14	0,0	25 4 25 4	8 4 4 4	E 1863
13	[5168V:N5	530	1000	5 5	- V	2 5	n ko	0 tg	
7170	KGT15BV-NS/M40-30H	250	1000	1 10		4.6	288	5.6	E/8
	KBT16BV-NS/M40 95H	300	1000	25	11	6.3	55	6.8	873
1.7	KBT16BV NS/M40 120H	340	1000	52	<b>z</b> :	œ .	45	ig i	E 500 2
	KBT168V-NS/M40-150H	400	0001	52	9 :	2.5	n .	D 10	2 0
200	KBT18BV NS/M50 95H	300	0001	2 2	- F	Ť. E	n with	9 9	3 53
ñ	KBT16BV NS/MS0 150H	400	1000	52	*	10	55	6.6	843
	KBT16BV-NS/MS0 185H	450	1000	25	14	DI.	55	9.9	B/3
ŗ	KBT168V:NS/MS0.240H	530	1000	25	14	10	55	d d	5/8
15/17	KBT16BV:NS/MS0L:240H	530	0001	25	14	10	25	9	873
17	KBT16BV NS/M40-S0	200	1000	\$ 22	eo a	P) II	ç 4	e u	6/3
	KBT16BV-NS/M40-70	250	1000	52 52		B 6	e r	Q 49	83
	KBT156V NS/MAD 95	340	1000	5 5	- 1	n ==	255	10	5
	KBT16BVINS/M40 150	400	1000	52	1	10	55	6.6	8/3
	KBT16BV NS/M50-95	300	1000	25	3.1	6.3	55	6.6	S
	KBT16BV-NS/M50-120	340	1000	52	14	EC	55	6.6	84/3
	KBI16BV-NS/MS0-150	400	1000	25	14	10	NJ (	io i	500
	KBT168V NS/MS0-185	450	0001	25	4 1	5 5	ND 4	D 40	5 6
	KBT16BV-NS/MS0-240	530	0001	52 %	9 7	2 =	55	6.5	663
19.21	KST16BV-NS/MAD-50H	2002	0001	25	5,B	T.E	ST.	6.6	8/3
7.0	KST16BV NS/MA0.70H	250	1000	52	H.,B	4.6	55	6.8	2
	KST158V-NS/M40-95H	300	1000	25	E	6.3	55	5.6	843
12	KS116BV NS/M40 120H	340	1000	25	14	פנ	15 C	up ii	6/3
	KST16BV-NS/M40-150H	400	0001	25	7	5.3	2 4	p sc	E/3
10 01	KST 168V NSIMSU 83H	340	1000	2 5	7	10	un 19	6.6	S
h	_	5 8	1000	25	14	01	5.5	9.9	873
	KST168V-NS/MS0-185H	450	1000	32	14	10	\$5	6.8	82
71		530	TDDO	52	14	01	5.5	10 t	8/3
19.21	_	530	1000	25	- n	0 %	6 6	0 10	873
2	CETTERN NSWARDS	200	1000	25	0. E	1 4	i siñ	6.6	5
	VCT TERVINGARAGIOS	000	COOCT	2 15	=	63	N,	9	8/3
	KST168V-NS/M40-120	340	0001	25	7	10	55	5.5	8/3
	KST16BV:NS/M40-150	400	1000	25	14	DL	22	6.6	683
	KST16BV-NS/M50-95	300	1000	\$2	11	6.3	156	eg e	873
	KST16BV NS/M50 120	340	1000	52	14	10	N I	ro e	50
	KST16BV-NS/M50-150	450	0001	25 25	4 7	2 0	22.53	9 19	973
	KST168W-NS/MS0 185	000	3 60	3 %	. 7	01	1/5	8 8	873
	KST168V NS/MS0.240	530	1000	25	17 1	2 2	55	19	6/3
	Deliver the second second	1							

grau grey grey
27 braun brown
26 Violett Violet
grun green
gelb yellow
23 blau blue
rot red

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21 Schwerz black norf

20 grún gelb green yellow vert jaune

Farbcode \*Colour code \*Code couleurs

• •

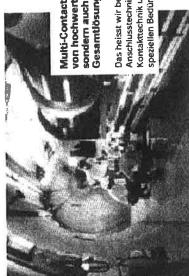
2) Voir page 45, renseignements de sécurité

2) See page 45, safety advises

2) Signa Sede 45. Sicherhaltshimweise

## Multi-Contact

			2	ופכונווכםו מפופ							
Mgel	Aligemeine Daten General data Données Générales			žžű	Mechanische Da Mechanical data Caractéristiques	Mechanische Daten Mechanical date Caractéristiques mécaniques	canique				
වේජ වෘම්	აძ.{ა გაქ.{ა ძ.{ა	Bes <i>tell</i> "Mr Order No No de Cde	Сапьслі г Сольслі г Евгрей	Anschuss Connection Raccordement	Soction au canducteur Conductor cross section Cu Leiterqueschnit Cu	Nenn Ø SufvBuchse Nominal des parlaccket Die, nominal broche/douille	Aużzyczkrałt Winterbrand (orce Porce d'exischon	Stęckkuelt Insertion force Force d'embrochage	Мах. Алгыдзаней топпел! Мах. Еділсейнд Тогаре Сацыз do serage тах:	Меўдяг Рюфэ	Lamekersyp Mulijam Spe de jemeke
					mm'	mm	z	Z	EN	Kg	
33	MD/B12BV	14 0031	٤	S (M12)	7.0	33	40	45	16	0,467	3
	MD/B30BV	14 0051	=	S (M36x3)	500	30	120	130	052	4,600	LAI
52	MD/S12BV	14.0032	=	5 (M12)	7.0	12	40	45	16	0,400	7"
	MD/S30BV	14,0052	F	S (M36x3)	m	30	25	130	250	4,5	= 3
24/25	IB12BV	14 2021	FCI	ŧΛ)	70	12	9	42	16	0,312	I.A.
	1830BV	14,2041.*	(2	ŧ۷	200	30	120	130	250	3,837	LAI
25/27	S12BV	14 2022.	23	S	10	12	40	45	16	0,217	
	15:30BV	14,2042.*	23	v	200	8	120	130	250	3,600	
28/29	KBT12BV/50	15,0034.*	N	۵	CS CS	12	40	45		0.301	Z
	KBT12BW73	15 0035 *	2	۵	70	13	90	45		0,302	L'Al
	KBT12BW85	15,0036-	5	۵	58	12	40	45		0,301	E.
	KBT308V/240	15.0054.7	(2)	С	240	30	120	130		1,5	L.A.
	KB130BW300	15 0055.*	(2	ը	300	30	120	130		1,5	LAI
	KBT308V/400	15 0056 "	(2)	D.	400	30	2	130		2,1	3
30/31	_	15,0031-7	R	۵	20	12	40	45		0,173	0
	_	15.0032	N	Δ	70	2١	09	45		17,10	
	KST12BV/95	15 0033 *	R	۵	98	12	40	45		0,170	•
	X5T308W/240	15 0051.*	12	e.	240	30	120	130		1,415	
	KST308V/300	15 0052.	23	D.	300	30	120	130		1,415	
	KS130BV/400	15,0053	[2]	۵	400	30	120	120		1415	
NO FR	5 = Schraubanschluss P = Chmbanhchluss 1) Farboring bette saparat bestellen 2) Farboring Lind Ann Terror		2= TS	Screw terminal     Crimp connection     Coloured the according shore body to coloured the according to colour code. 29, 29.	tion foured ring according 20.29.	S SAP RECEIVE		S - Raccordent P - Fut a serter 1) Les begues - Séparément 2) Ruban nethals	S. «Raccordement & visser p. « Fut & serier 1) Less begunss de couleur sont & commander separément. 2) Ruban nethessif de couleur, selon lei code de	iser ur sont å tom uleur, selon le	телдиг я соде да



Multi-Contact ist nicht nur Lieferant von hochwertigen Steckverbindern sondern auch Anbieter von Gesamtlösungen für Kontaktsysterne.

Das heisst wir beraten Sie in Sachen Anschlusstechnik, Isolations- und Kontakttechnik unter Berücksichtigung Ihrer speziellen Bedürfnisse.

		20	21	22	2	24	25	56
	"Farbcode	orin-delb	schwerz	Į.	Dian	deip	grün	violett
	"Colaur code	creen-vellow	black	red	plue	wellow	green	violet
	*Code conleurs	vertuaune	noır	rouge	pien	laune	vert	violet
				Ι.				
42			>	www.muft	ti-contact.con	COL		

29 weiss white bland

grau grey grey

27 braun brown brun

28 welss white blanc

alfyd alfyd	วงกรุก องกรุกระธ	Elektrische Daten Electrical data Caractéristiques i	Daten ta					
عروط ( الالال ( الالالال	บหากก อวิกฎหระย อวิกฎหระย		Caractéristiques electriques	202				
	Mated Ci	(รี อุลกษณะจะ ภดเลกส (รี ออิตริดง ชิวโรมี (รี ออิตริดง ชิวโรมี (รี อิตกางกรับรายการ	Konlaktwiderslande Contact resistance Resistance de contact	(utaveite de court cecu-t i s Sydat cercuit cereurt s Kursechiusseaum i s	2 & Criculeschinseshing Stort-circuit current 3 \$ Intensite the court carcuit 3 \$	בערסיה: בעושפ כעורפח? המחיבות לם ביפנס	Prum F shoè perumeyalung (S mm F shoè opulo Peal (S mm F shoè isser b normal	)soletionskodi dination Insulation coordination Coordination de l'isolement
		>	Gu	κÀ	4×	A.A	N/	kV/h
22 MD/B12BV		1000	40	7.5	5.5	25	6.6	8/3
MD/8308V	1000	1000	Ø.	39	58	150	9.9	873
23 MD/512BV	250	1000	40	7.5	5.5	52	9'9	8/3
MDISSOBV	1000	1000	6	39	29	150	6.6	E/B
24/25 IB12BV	250	1000	40	7.5	5.5	25	5.5	6/3
IB308V	1000	1000	σ.	39	29	150	5 6	873
26/27 IS12BV	250	1000	40	7.5	5.5	25	6.6	873
ISSUBV	1000	1000	.pn	38	29	150	9.9	6/3
28/29 KBT12BV/50	200	1000	07	5.8	3.3	25	5.6	8/3
KBT128V/70	250	1000	40	7.5	5.5	52	99	B/3
KBT128VRS	280	1000	40	7.5	5.5	25	5.6	8/3
KBT308V/240	530	1000	55	Ø	18	120	5 6	843
KBT308V/300	600	1000	ćπ	33	29	150	(D)	6/3
KB130,8V/4,00	750	1000	on:	38	5.8	150	86	873
30/31 KST12BV/50	200	1000	40	5.8	3.3	25	5.6	873
KST12BV/70	250	1000	40	7.5	5.5	25	9.9	8/3
KST12BV/95	280	1000	40	7.5	5.5	52	6,6	8/3
K\$T30BV/240	530	1000	ďì	53	55 25	120	6.6	8/3
KST30BV/300	600	1000 L	5	38	52	150	9.9	B/3
KST30BV/400	750	DOOT	Ø:	39	62	150	6.5	8/3

# Multi-Contact is not only a supplier of high-quality plug connectors, but also offers complete contact system solutions.

contact technology in accordance with your special needs. That means we advise you on connection, insulation and



Multi-Col	système système	contraintes	techniques contact.

Multi-Cor	connecte	offre égal	systèmes	Cela signifie	contraintes	techniques	contact	
						The state of the s		

Multi-Cont	connecteu offre égale	systèmes (	Cela signifie o	contraintes et	techniques de	contact.
					The state of the s	で

Multi-Contact est non se	connecteurs embrochab	offre également des solu	systèmes de connexion.	Cela signifie que nous sommes	contraintes et spécifications, de	techniques de raccordement d

e vous conseiller dans le choix des des techniques d'isolation et de s en mesure, à partir de vos

95.	21 Schwarz biack
	20 grun gelb green yellow
	*Farbcode
	***

arbcode 20 21 22 23 23 oldur code grian gelb schwarz rot blou ode couleurs wert, starre



2) Voir page 45 renseignements de sécurité

2) See page 45, safety advises

2) Signe Shite 45, Sicherhaltshinwerse

### les de haute qualité, mais sulement un fabricant de ntions complètes de

Kurzbezeichnung Symbole Symbole	Werkstoffbezeichnung Material description Désignation du matériau
PA	Polyamid Polyoxymethylen - Hamo
PA66	Polyamid 66 Polyamid 6
TPE	Thermoplasusches Elasto
Schmiermittel	Lubricant
MC <sup>4</sup> empfiehlt Schmlermittel von Kluber Lubrication, Munchen. Fett (allgemeine el	MC* recommends lubricants fr Lubrication in Munich.
Kontakte)" Kontasynth BA100 Spray (73.1051) Synthesin PDL 250/01(73.1050)	Grease (general elec. contacts) Kontasynth BA100 Spray (73.1 Synthesin PDL 250/01 (73.105

ubricant	MC* recommends tubneauts from Kluber universation in Munich.	Grease (general elec. contacts) Kontasynth BA100 Spray (73.1051)	Synthesin PDL 250/61 (73.1050)
Lub	MC	Gre	Ş

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44

43 29 white blanc

Start Start

23 braun brown brun

28 Vrolett Vrolet Vrolet

gron gronn green

geib yeilow jaune

## Multi-Contact

Technische Hinweise	Technical information	Informations techniques
Lamailentyp Eine technische Beschreibung von Einetrachen Kontakten mit Lamellen siehe Schrift: "Das MC" Kontaktlamellenprinzip".	Mutitiam type A technical description of electrical contacts with mutitiams, see publication: The MC*Mutitiam principle*	Type de lamelles Descripcion technique des con- tacts efectiques à lamilles, consultor la brochur Principe d'util- sation des contacts à lamelles MC**,
Auszugs- und Stecktraft Auggegeber Werte sind Kräfte nach 20. bis 30rauger Betatigung ber dunnern Schniermitteffin, im Neuzussand legen die Kräfte nöher.	Withdrawal and making forces The stated figures refer to forces after 20. 30 mating cycles with a thin film of lubricant present. Forces are greater in the new condition.	Efforts d'embrochage et de débrochage Los valours indiquées sont celles othernes agrès 20 à 30 cycles d'embrochage débrochage, les contacts étant legérement grassés. À l'état nout, les efforts sont plus importants.
Anzugsdrehmornente Die Orehmomente gelten fur saubere. Ieicht gefettete Bolzen, Muttern und Scheiben	<b>Tightening torques</b> The torque figures apply for clean, lightly lubricated boffs, nuts and washers	Couples de serrage Ces videurs sapiquont à des tiges filetes, écraus et rondelles propres, et légèrement graissés.
Bemesstangsstrom (IEC 61984) Von MC (estgelegter Strom, bee einer Umgebungstempetatu von 20°C. den der Steckverbinder dauerhaft (binne Untrer- trechung il krinen kann und der gleechzeitig durch samiliehe Kontakte fliesst, der an die grösstmoglichen festgelegten Leiter angeszhlossen sind und dabei die oberer Grenztempealur nicht überschritten wird.	Rated current (IEC 61984) Current value assigned by MC which the connector can carry continuously (without interruption) and simultaneously through all it, sorbacts winced with the largest specified conducto, at an ambient temperature of 20° C, without the upper limiting temperature being exceeded.	L'intensité assignée (CEI 61984) Valour du courant assigne par MC, que le comecteur peut supportre en continu (sans intensitéen peut supportre en continu (sans intensitéen) et sumulanement à l'asers (sus sas confactes ablès avec le conductour maxma specifié, a une température ambiente de 20° C, sans que la température ambiente de 20° C, sans que la température limite supérieure soit dépassée,
Bernessungsspannung (IEC 61984) Für Stockverbinder von MC firstgelegter Vert der Spannung, auf den Betrebs- und Lostsungskennwerte pezogen werden Lostsungskennwerte pezogen werden mehr als einen Wert der Bemessungs- spannung haben.	Rated voltage (IEC 61984) Value of votage assigned by MC to the commetor and for which operation and performance charactoristics are inflated. Note: A comector may have more than one voltage value.	La tension assignée (CEI 61984) Valeur de la trossion fixos par MC au connecteur, et à laquelle on se réfere bour le l'orictionnement et pour les caracteristiques fonctionnelles. Note: Un connecteur pour avoir plusieurs tensions assignees.
Kontaktwiderstand st den ande Beuhrungsstelle zweiler Kontaktibachen auftretende Widerstand Sein Wiert wird über den gemessenen Spannungsaltialt beim Bernessungsstrom berechnet.	Contact resistance is the resistance counted to resistance occuming at the contact point of two contact areas. Its value is calculated from the measured voltage drop at the rated current.	La résistance de contact cet la résistance du se cric a point de contact de doux suffaces. Sa valeur est calculec a parir de la chute de tension mesurée sous imensité assignée.
Prúfspannung ist die Spannung, der ein Steckwerbinder bei festgelegten Bedingungen ohne Durch- oder Überschlag standhalt.	Test voltage is the voltage withstood by a plug connector under predetermined test conditions, without breakdown or flashover.	La tension d'assai est la tension d'assai est la tension que supporte un connecteur dans des conditions prédéfinies sans que prenne naissance un arc électrique perforant ou de surface.
The state of the s	Current respond	Intensité de crête

according to IEC 60664-1, DIN VDE 0110-1.
The values in the tables indicate the rated surge voltage in kV and the degree of pollution.

gemäss IEC 60664-1, DIN VDE 0110-1 Die Werte in den Tabellen gebon die Bemossungs-Stossspannung in kV und den Verschmutzungsgrad an

La coordination de l'isolement d'après CEI 60664-1, DIN VDE 0110-1 Les vaiours indiquées dons les tableaux corre spondont à latension de crète assignee en NV

et au degné de pollution

Ddfinition selan DIN VDE 0102/1 90 (CE! 50909:1988)

As defined by DIN VDE 0102/1 90, (IEC 60909:1988).

Definition gcm. DIN VDE 0102/1 90 (IEC 60909:1988). Isolationskoordination

Stossstrom

Surge current

Insulation coordination

Intensité de crête

Kurzbezeichnung Symbole Symbole	Werkstoffbezeichnung Material description Designation du matériau	Temperatur 'C Temperature 'C Température 'C
PA	Polyamid	-40 + 80
POM	Polyoxymethylen - Hamopolymer	.40+100
PA66	Polyamid 66	-30,+115
PA6	Polyamid 6	-30, → 90
TPF	Thermoolastisches Elastomer	40,+100

	Lubrifiants
lubneants from Klüber	MC* recomm
L L	provenant de
c. contacts)	Munich, Grass
Spray (73,1051)	Kontasynth B

## MC® recommande l'utilisation des graisses provenant de la société Kilber Lubrication à Munch, Graisse (contacts courants). Kortusyntin RA-100 Spray (73.105.1). Synthesin PDL 250/01(73.1050).

## Technical information **Technische Hinweise**

### Steckzyklen

Die maximale Steckhaufigkeit der Standardsteckenderingungen beragt 1000 bis 2000 je nacht Einsatzbedinngungen. Voraussetzung ist ein dunner Schmiermittellim auf den Kontakten vor dem ersten Steckvorgang.

Anforderungen an die Oberflache, die Führung und die Schmierung und bedingen immer spezielle Abklarungen

### und Sonderausführungen. Crimpanschlüsse

für unsere Crimphulsen Sechskant-crimpung, Dörnkerbung ist möglich. Unsere Crimphulsen sind ausgelegt für hochflexible Cu-Leuler. Für andere Leuten. sind spezielte Crimphulsen erforderlich. siehe Seite 37), MC\* empfiehlt Elpress fur alle hochflexiblen Cu-Leiter, Bei den Kupplungen KBT./KST., der Baureinen NS ist der Crimpanschluss austausch-bar (z.B. bei Leitungsbruch etc.). ur die Leiteranschlüsse empfehlen wir

## Sicharheitshinweise

## Grundsatz für den Schutz gegen eintrischen Schlag [Er. DIN EN 61140 (VDE 0140 Teil 1) Pr. 41 Gefahrliche aktive Teile durfen nicht beruhtbar sein, und beruntbare leitfä-hige Peie Guffen nicht gefährlich aktiv-

- weder unter normalen Bedingungen (onne Fehler, bei bestimmungsgemaßer Verwendung),
- noch unter Bedingungen eines Einzelfehlers, z.B. fehlerhafte Basis-

Stewarther für Benessungsspir-Stewarthere für Benessungsspir-nungen von 50 V ber 1000 V und Be-messungsstrome bis 125 A je Kontak, und für die des entweder Weine Bauert-spezifikation (DS.- detail specification) glut, oder wern sich deren Bauert-spezifikation hinsichtlich der Scherheit auf die vorliegende Norm bazieht. Sicherheitsanforderungen und IEC 61984 "Steckverbinder

## Auszüge aus IEC 61984:Juni 2001 und Bemerkungen

### Kontakte sind beim Verbinden oder 1) Stackverbinder

nung stehen, bevor der Steckverbinder gesteckt oder herausgezogen wird. Mit einem Mikroschalter kann eine mechanische Verriegelung, kann verhindern, dass Kontakte unter Span-Trennen spannungsfrei und öhne Last/Strom, Eine elektrische oder Vernegelung erstellt werden.

Der Schutz wird vom Kunde durch das Enginodukts stehergestell, in das die Steckwebunder eingebalt werden. Oder es ineg eine Schehreitskien-spanning (SELV - safety extra low voltage) an: Schutz gegen elektrischen Schlag für ungekappselte Steckverbinder Der Schutz wird vom Kunde durch das

### Mating cycles

The maximum number of mating cycles of the standard plug-in connections is between 1000 and 5000, depending on duty conditions. Precondition is a thin film of lubricant on the contacts prior to nitial matino

Because higher cycle requirements calls for special surface treatment, guiding and lubrication measures, each case must be investigated to establish the

### Crimp connectors specifications.

a definir.

recommend hexagonal crimping for our crimping seeves. Donn crimping is possible. Our crimp seeves are designed for highly flexible Cu conductors. Special crimp seeves are required for other types of conductors. (see page 37). (see page 37). (see page 37). For conductor connections, we

flexible conductors.
The types KBT\_MST\_... of the series
TNS have a replaceable crimp sleeve
(e.g. if conductor is defective).

### Safety advises

## Fundamental rule of protection against electric shock (IEC, DIN EN 6114 (NDE 0140 part 1) Pt. 4 Hazardous-live-parts shall not be accessible and accessible conductive parts shall not be hazardous live: • either under normal conditions

- (operation in intended use
- and absence of a fault, or under single-fault conditions, e.g. failure of basic insulation.

## IEC 61984 Connectors - Safety

requirements and tests.
This international Standard applies to connectors with rated voltages above 50 V and up to 1000 V and rated currents up to 128 A per contact. (for which either no detail specification (DS) exists, or the DS calls up this standard for safety aspects.

### Extracts from IEC 61984;june 2001 and remarks

## 1) Connectors

Connectors should not be under voltage or under load/current when connection An electrical or mechanical interlock which prevents the contacts of a connector from becoming life before it is in proper engagement, or from being withdrawn while its contacts are life. An interlock can be obtained by micro is made Switch

### The protection against electric choc is provided by the customer by the enclosure of the equipment in which Protection against electric shock for unenclosed connectors. the connector is mounted

Or a safety extra low voltage (SELV) is applied.

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## Informations generales

Informations techniques

etre atteintes dans certaines conditions: etat de surface, guidage, graissage speciaux. Chaque cas implique une railisation particulière selon des criteres Cycle d'embrochage dabrochage Le nombre meximal de cycles d'une connexion standard est de 1000 à 5000 sous réserve de graisser légèrement les en fonction des conditions d'utilisation contacts avant le premier embrochage Des valeurs plus importantes peuvent

Pour le raccordement des conducteurs nous recommendors un seutissage à six pars de nos fits à settir un poinconnage etant également envisageable. Les fuls à seut ront concus pour des cables extra souples en curve. Des litrs à sent special un sont entre pour a conducteurs, four page 331, MC\* recommande le système. Élipress pour fous les Raccordements par fûts à sertir

### cables cuivre extra-souples. Les connec-teurs KBT... KST des senes ...NS sont équipes d'un füt à serlir amovible (quand le cable est endommage par exemple). Renseignements de sécurité

Regie fondamentale de protection contre les chocs électriques (EC, DIN EN 61140 (VDE, 0140 Teil 1) Pt. 4] Les parties actives dangereuses ne doivent pas devenir accessibles et les parties conductrices accessibles ne doivent pas devenir dangereuses.

• ni dans les conditions normales.

(fonctionnement en usage prévu et abdefaut, par example defaillance de sence de défaut.

teurs de tensions assignées comprises entre 50 et 1000 et de courants assignés jusqu à 128 par contact, pour leaqueis soit in rayste pas de spécifica-tions particuleres (5P), soit la SP fait appel aux aspects de sécurité CEI 61984 "Connecteurs -Prescriptions de sécurité et essais" Cette norme s'applique aux connecl'isolation principale

## Extraits de la norme CEI 61984;Juin 2001 et remarques

### 1) Connecteurs

Des disposités de verrouliage mèce-inque de décirque permatern d'évier que le comocteur ne soit insére au extrait sous tersion. Un verroullage peut être obtenu à l'aide d'un micro-rupteur.

### Protection contre les chocs électriques de connecteurs à enveloppe

La protection est assurée par le client au travers du produit final, dans lequel est monte le connecteur. Ou son utilisa-tion est limitée à la tres basse tension (SELV - safety extra low voltage).

## Multi-Contact

Informations techniques

Protection contre les chocs électri-

ques de connecteurs à enveloppe

## Technical information

## Protection against electric shock for enclosed connectors is required Mated condition; clearance and

Schutz gegen elektrischen Schlag für gekapselte Steckverbinder gestockter Zustand. Luft- und knech-strecken sind zwischen spannungs-führenden Teilen und dem IEC Prüf-

**Technische Hinweise** 

finger mit der Prufkraft von 20 N zu

Ungesteckter Zustand, Kontaktöff-nungen: Luft- und Knechstrecken

werden nicht betrachtet.

 Unmated condition, contact openings creepage distances are measured between live parts and the IEC probe with a test force of 20 N. clearance and creepage distances (lead-in) in the mating face

i état connecté: les distances dans i ain et les lignes de fuite doivent être mosurées entre les partes conductroes sere et dogs d'essai (El sous une force d'essai (El sous une force d'essai de 20N).
 i l'età (deconnecté: les distances a l'età (deconnecté: les distances).

dans l'air et les lignes de fuite ne sont das prises en comple.

## 2) Plug device

are not taken into account.

During connection or disconnection. Contracts are under vollage only. however, the contracts are not under load, they carry no current.

Plug devices stall have the stated researing earthly or stalled by or designed that it can only be inserted and withdrawn without load (current). This can be obtained by an interlock, such as a micro switch. A micro switch can be installed on the fixed part of the plug connector.

Steckvorichtungen müssen die angegebene Schalielstung beitzen oder
müssen so aufgebaut sein, dass sie nur
im bastreien Zustand (ohne Strom) zusammengesteckt und gebrennt werden
konnen. Dies kann mit einer Verriegelung, z. B. mit einem Mikroschalter.

Trennen nur spannungsführend: Kontakte sind aber nicht unter Last, sie

Tuhren keinen Strom

Steckvorrichung
 Kontakte sind beim Verbinden oder

ou deconnecte sans qu'il y ait passage de courant, (par l'intermédiaire par ex-emple d'un dispositif de verroullage tel un micro-rupteur, monte sur la partie fixe).

être conqus de sorte à n'être connecté pouvoir de coupure spécifié ou doivent

Les contacts sont lors de la connexion ou déconnexion uniquement sous tension; ils ne sont pas sous charge, il n y a pas passage de courant. Les dispositifs de connexion doivent avoir le

2) Dispositif de connexion

creepage distances must be measured between live parts and the Mated condition: clearance and

Mikroschalter angebaut werden.

Gestreckter Zustand: Luft, und Kriechstrecken sind zwischen spannungsführenden Tallen und dem IEC Pruf-

finger zu messen. Ungesteckter Zustang: Kontaktoff-

An den festen Steckverbinder kann ein

erreicht werden

(lead-in) clearance and creepage distances are measured between live parts and the mating face plane of the plug device. This does not apply to the male part of the connector. IEC test probe
 Unmated condition: contact openings

a l'état connecte: les disiances dans l'air et les lighes de fulle doivent être respectées entre les parties sous ensoine il e doigt d'épreuve CEI.
 a l'état déconnecte: les distances dans l'aire les lignes de fulle doivent ètre respectées entre les panies sous tension et le plan de la face.

## 3) Connector with breaking capacity (CBC)

Ausgenommen ist der mannliche Teil des Steckverbinders.

(CBC = connector with breat

nungen Luft- und Kriechstrecken sind zwischer spannungsführenden Teilen und der Steckgeschlisebene des Steckverbinders zu messen.

Contacts are under voltage and current (load) during connection and disconnection. MC blug devices are not assurable for connection of disconnection under load. No breaking capacity can be

CEBC = connector with breaking capacity, knowlaste sind before transmit status oder freinen spantungsfuhrend und Strom (Last) insast uber die Kontakte. M.C. Sterkvebinder sind nicht gesignet, unter Last gesteckt oder getremnt zu werden. Es kann keine Schattleistung spezifiziert werden.

connecteur specialement concu. dans une utilisation normale, pour être connecte ou déconnecte lorsqu'il est alimente ou sous charge. Les connec-teurs MC ne sont pas conçus à cet effet. Aucun pouvoir de coupure ne peut être spécifie.

## Cannecteur à pouvoir de coupure (CPC)

male du

d'accouplement. La partie mecteur en est exclus.

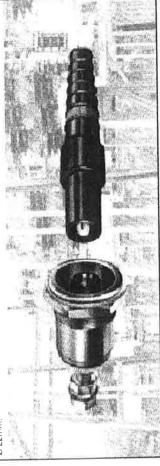
votre attention sur le catalogue Powering (Ex. Ho3): Connecteurs unipolaires Ø 10mm. Nous nous permettons d'attirer cylindrígues unipolaire Ø 14mm et Ø 22mm

See also our catalogue Powerfine (Ex. Ho3); round connectors single-pole Ø 10mm, Ø14 mm and Ø 22mm,

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Katalog Powerline (Ex. Ho3):

Rundsteckverbinder, einpolig, isoliert Ø 10mm, Ø 14mm und



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Appendice Appendix Alphabetisches Register Anhang

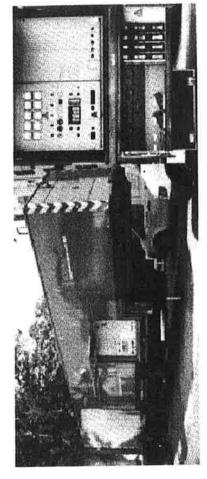
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Applikationsbeispiel Mobile Stromversorgung. (Polyma Energietechnik Dr. Appelhans GmbH, D-Kassel).

Application example
Mobile power Supply,
(Polyma Energietechnik
Dr. Appelhans GmbH, Germany).

Exemple d'application Generatre auxiliaire mobile, (Polyma Energletechnik Dr. Appeihans GmbH, Allemagne),

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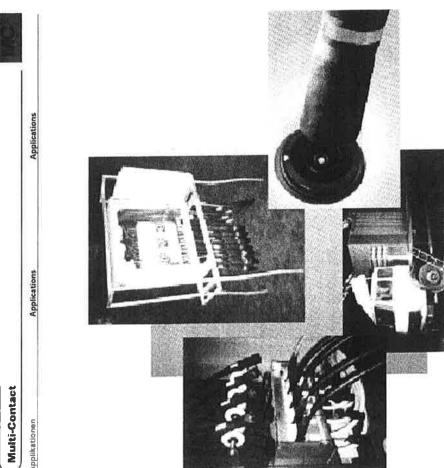
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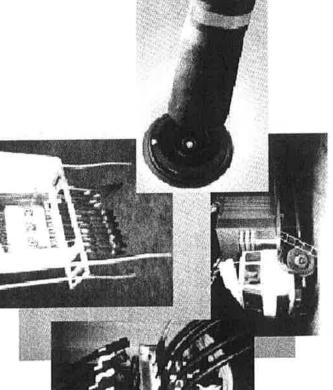
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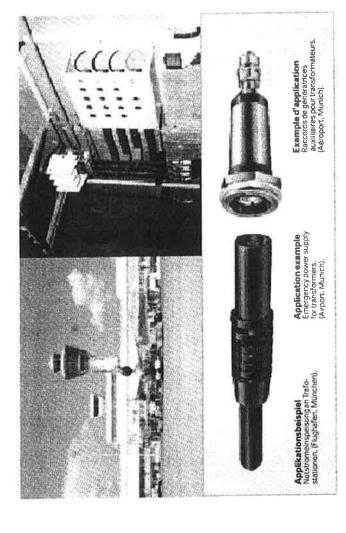




Applikationsbeispiel Mobile Netstrongruppe mit Verteilersystem. (ENEL Meiland, Italien)

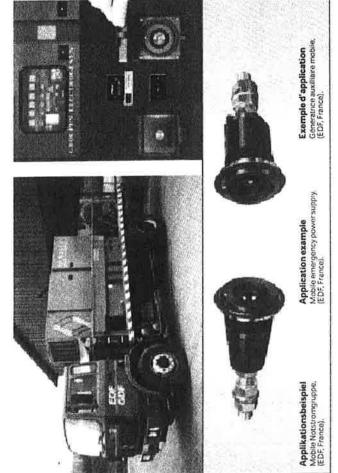
Application example Mobile power supply with distribution system. (ENEL, Milan, Italy)

Exemple d'application Generatice auxiliaire moble avec système de répartition, (ENEL, Milan, Italie)



Applikationen

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