V28/33D STC

Project Guide – Marine

Four-stroke diesel engine compliant with IMO Tier II

Revision..... **10.2026/10.1**

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Four-stroke diesel engine

V28/33D STC IMO Tier II Project Guide – Marine

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2026-10-29 - 10.1

Table of contents

1 Introduction 9

1.1 Medium-speed propulsion engine programme 9

1.2 Engine description IMO Tier II 9

1.3 Engine overview 18

1.4 Turbocharger overview 21

1.4.1 View of a TCA type turbocharger 21

1.4.2 Compensator between turbine outlet (engine) and exhaust gas pipe (plant) 22

1.4.3 No additional masses allowed 23

2 Engine and operation 25

2.1 Approved applications and destination/suitability of the engine 25

2.2 Engine design 26

2.2.1 Engine designations – Design parameters 26

2.2.2 Turbocharger assignments 27

2.2.3 Engine main dimensions, weights and views 28

2.2.4 Engine inclination 30

2.2.5 Engine equipment for various applications 31

2.3 Ratings (output) and speeds 34

2.3.1 General remark 34

2.3.2 Standard engine ratings 34

2.3.3 Power definition and load profile 35

2.3.4 Engine ratings (output) for different applications 37

2.3.5 Derating, definition of P Operating 37

2.3.6 Engine speeds and related main data 38

2.3.7 Speed adjusting range 39

2.4 Increased exhaust gas pressure due to exhaust gas after treatment installations 39

2.5 Starting 41

2.5.1 General remarks 41

2.5.2 Type of engine start 41

2.5.3 Requirements on engine and plant installation 42

2.5.4 Starting conditions 43

2.5.5 Start-up – Definitions and requirements 44

2.6 Low-load operation 45

2.6.1 Low-load operation V28/33D STC 45

2.7 Engine load reduction and engine stop 47

2.8 Engine load reduction as a protective safety measure 50

2.9 Engine operation under arctic conditions 52

2.10 Earthing measures of diesel engines 56

2.11 Propeller operation 58

2.11.1 STC operating range for mechanical propulsion 58

2.11.2 General requirements for the CPP propulsion control 59

2026-10-29 - 10.1

2.11.3 Load application for mechanical propulsion 62
2.12 Fuel oil, lube oil, starting air and control air consumption 65
2.12.1 Fuel oil consumption for emission standard: IMO Tier II 65
2.12.2 Lube oil consumption 69
2.12.3 Starting air and control air consumption 70
2.12.4 Recalculation of fuel consumption 71
2.12.4.1 Additions to fuel consumption 71
2.12.4.2 Recalculation of fuel consumption dependent on ambient conditions 71
2.12.5 Influence of engine aging on fuel consumption 73
2.13 Planning data 455 kW/cyl., CPP IMO Tier II 73
2.13.1 Nominal values for cooler specification – 455 kW/cyl., CPP 73
2.13.2 Flow scheme for cooler specification – 455 kW/cyl., CPP 75
2.13.3 Temperature basis, nominal air and exhaust gas data – 455 kW/cyl., CPP 76
2.13.4 Load specific values at ISO conditions – 455 kW/cyl., CPP 77
2.13.5 Load specific values at tropical conditions – 455 kW/cyl., CPP 78
2.14 Planning data 500 kW/cyl., CPP IMO Tier II 79
2.14.1 Nominal values for cooler specification – 500 kW/cyl., CPP 79
2.14.2 Flow scheme for cooler specification – 500 kW/cyl., CPP 80
2.14.3 Temperature basis, nominal air and exhaust gas data – 500 kW/cyl., CPP 81
2.14.4 Load specific values at ISO conditions – 500 kW/cyl., CPP 82
2.14.5 Load specific values at tropical conditions – 500 kW/cyl., CPP 83
2.15 Operating/service temperatures and pressures 84
2.16 Leakage rate 90
2.17 Filling volumes 91
2.18 Venting amount of crankcase and turbocharger 91
2.19 Exhaust gas emission 92
2.19.1 Maximum permissible NOx emission limit value IMO Tier II 92
2.19.2 Smoke emission index (FSN) 92
2.19.3 Exhaust gas – possible components and visibility 93
2.19.4 Emission-related installation instruction for engines 95
2.20 Noise 98
2.20.1 Airborne noise 98
2.20.2 Intake noise 98
2.20.3 Exhaust gas noise 99
2.20.4 Blow-off noise example 101
2.20.5 Noise and vibration – Impact on foundation 101
2.21 Vibration 104
2.21.1 Torsional vibrations 104
2.22 Requirements for power drive connection (static) 107
2.22.1 Limit values of masses to be coupled after the engine 107
2.22.2 10% PTO – Maximum torque and requirements screw connection 108
2.23 Requirements for power drive connection (dynamic) 108
2.23.1 Moments of inertia – Crankshaft, damper, flywheel 108
2.23.2 Balancing of masses – Firing order 110
2.23.3 Static torque fluctuation 111

2026-10-29 - 10.1

2.24 Power transmission 113
2.24.1 Flywheel arrangement 113
2.25 Foundation 114
2.25.1 General requirements for engine foundation 114
2.25.2 Resilient mounting position 115
2.25.3 Resilient seating 116

3 Data Logging Solutions 119
3.1 Data Logging - General Information 119
3.2 Data Logging Cabinet Plus (DLC+) 119
3.3 Data Logging - Additional Information 120

4 Engine automation 123
4.1 SaCoS 5000 system overview 123
4.1.1 Cybersecurity guidelines 124
4.1.1.1 Terms, abbreviations and definitions 124
4.1.1.2 System Overview 126
4.1.1.3 Physical security of SaCoS 127
4.1.1.4 Secure access and storage of SaCoS data 127
4.1.1.5 Secure use of the ExG-MM in the DLC+ 127
4.1.1.6 Securing Z1:Control(Customer) 127
4.1.1.7 Maintaining network segmentation 128
4.1.1.8 Preparation for security incidents 128
4.1.1.9 Safe disposal 128
4.1.1.10 User account management 128
4.1.1.11 Security Incident Report 129
4.1.2 Equipment on engine and off engine 129
4.2 Power supply and distribution 136
4.3 Operation 138
4.4 Functionality 139
4.5 Interfaces 141
4.6 Technical data 142
4.7 Installation requirements 143
4.8 Engine-located measuring and control devices 145

5 Specification for engine supplies 153
5.1 Specification of lubricating oil for operation with DMA, DFA 153
5.2 Diesel fuel (DMA, DFA) specification 154
5.3 Specification of engine coolant 160
5.4 Cooling water inspecting 163
5.5 Cooling water system cleaning 164
5.6 Specification of intake air (combustion air) 166
5.7 Specification of compressed air 167

6 Engine supply systems 169

2026-10-29 - 10.1

6.1 3D Engine Viewer – A support programme to configure the engine room 169
6.2 Basic principles for pipe selection 171
6.2.1 External pipe dimensioning 171
6.2.2 Engine pipe connections and dimensions 172
6.2.3 Specification of materials for piping 173
6.2.4 Installation of flexible pipe connections 175
6.2.5 Condensate amount in charge air pipes and air vessels 181
6.3 Lube oil system 183
6.3.1 Internal lube oil system 183
6.3.2 External lube oil system 189
6.3.3 Prelubrication/postlubrication 195
6.3.4 Lube oil filling and outlets 195
6.4 Crankcase vent 196
6.5 Water systems 198
6.5.1 Cooling water system description 198
6.5.2 Internal LT cooling water system 200
6.5.3 External LT cooling water system 202
6.5.4 Internal HT cooling water system 203
6.5.5 External HT cooling water system 203
6.5.6 Internal seawater system 204
6.5.7 External seawater system 204
6.5.8 External cooling water system diagram 205
6.5.9 External cooling water collecting and supply system 207
6.5.10 Miscellaneous items 207
6.5.11 Water pump performance 208
6.6 Fuel oil system 209
6.6.1 DMA supply system description 209
6.6.2 Internal fuel oil supply system 209
6.6.3 External fuel oil supply system 211
6.7 Compressed air system 215
6.7.1 Compressed air system description 215
6.7.2 Internal compressed air system 215
6.7.3 External compressed air system 217
6.7.4 External compressed air system – Dimensioning starting air receivers, compressors 219
6.8 Engine room ventilation and intake air 221
6.8.1 External general information 221
6.8.2 External air supply with or without arctic conditions 222
6.9 Exhaust gas system 227
6.9.1 External exhaust gas system – General information 227
6.9.2 External components and assemblies of the exhaust gas system 230

7 Engine room planning 231
7.1 Installation and arrangement 231
7.1.1 General details 231
7.1.2 Installation drawings 232
7.1.3 Removal dimensions 235

2026-10-29 - 10.1

7.1.4 3D Engine Viewer – A support programme to configure the engine room 241
7.1.5 Lifting device 243
7.1.6 Space requirement for maintenance 246
7.1.7 Major spare parts 246
7.1.8 Major spare parts – Main dimensions 249
7.1.9 Mechanical propulsion system arrangement 254
7.2 Exhaust gas ducting 255
7.2.1 Example: Ducting arrangement 255
7.2.2 Position of the outlet casing of the turbocharger 256

8 Annex 257
8.1 Safety instructions and necessary safety measures 257
8.1.1 General 257
8.1.2 Safety equipment and measures provided by plant-side 257
8.2 Programme for Factory Acceptance Test (FAT) 262
8.3 Engine running-in 267
8.4 Definitions 270
8.5 Abbreviations 275
8.6 Symbols 276
8.7 Preservation, packaging, storage 279
8.7.1 General 279
8.7.2 Storage location and duration 281
8.7.3 Follow-up preservation when preservation period is exceeded 281
8.7.4 Removal of corrosion protection 282
8.8 Engine colour 282

Index 283

2026-10-29 - 10.1

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2026-10-29 - 10.1

1 Introduction

1.1 Medium-speed propulsion engine programme

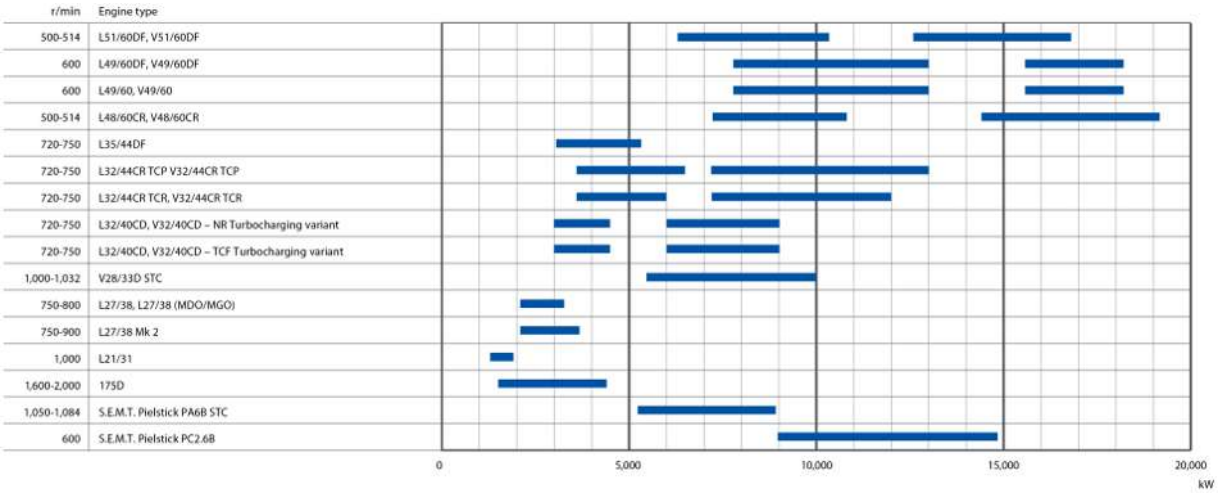


Figure 1: Everllence engine programme

1.2 Engine description IMO Tier II

Simplicity and functionality

The 280 mm-bore/330 mm-stroke V28/33D STC engine with its simple and functional design is known for:

- High reliability
- Low fuel consumption
- Low operating costs
- High operating efficiency at low and high powers
- Low acoustic and thermal signature characteristics
- Capable of extended operation at low loads without white smoke or maintenance impact
- Optimum power-to-weight and power-to-size ratios
- Ease of installation and maintenance

Fuel injection

An advanced microprocessor-managed, solenoid valve-controlled fuel injection system secures flexible and precise control of the injection quantity, rate and timing independent of engine speed.

With the advanced combustion chamber technology the specific fuel consumption is reduced to a competitive level. The large torque envelope of STC engines reduces fuel consumption by optimising the propeller efficiency.

2026-10-29 - 10.1

Operation with FAME - transesterified biofuel (optional)

In case of intended use of FAME fuels according to EN-14214 or ASTM D6751 and according to the additional requirements of Everllence (see paragraph FAME (fatty acid methyl ester) additive of 0.5 to 100% (DFA), Page 157 in section Diesel fuel (DMA, DFA) specification).

- Special considerations for fuel handling, storage and fuel preparation to be considered
- To be clarified, if special equipment on engine or within plant is needed
- Change of engine performance to be clarified

Contact Everllence if this option is needed.

Operation with synthetic fuels (optional)

Synthetic fuels such as HVO, BTL, CTL, GTL according to DIN EN 15940 differ in the procedure of production, but are identical in their fuel properties and need to comply to the requirements of Everllence (see paragraph "Synthetic fuels (DIN EN 15940)" in section Diesel fuel (DMA, DFA) specification).

In case of intended use of these synthetic diesel fuels:

- Special considerations for fuel handling, storage and fuel preparation have to be considered
- To be clarified, if special equipment on engine or within plant is needed
- Change of engine performance to be clarified

Due to the lower volumetric heat value than DMA in case of fixed engine setting a minor increase of the specific fuel consumption ($\Delta be_{42700,ISO}$ <+1,5%, and a slight decrease of NO_X-emissions is expected.

Contact Everllence if this option is needed.

Crankcase

Machined from a spheroidal graphite iron casting and featuring underslung main bearings which are retained by two vertical studs and two cross-bolts per side for overall engine stiffness. The main bearing caps are secured by hydraulically-tensioned studs to ensure maximum integrity of the crankshaft system.

Oil sump

There are two oil sump designs available, allowing different inclinations. Contact Everllence for detailed information.

Cylinder liners

Individual units machined from a centrifugal-spun grey iron casting and incorporating deep flanges that are cooled by a separate cast-aluminum water jacket enabling a dry crankcase. The liners are secured in position in the crankcase by the cylinder heads, and their running surfaces are plateau honed and finished to improve oil retention. A flame ring fitted at the top of the liner prevents the build-up of combustion residues (coke) on the piston crowns and minimises lubricating oil consumption.

2026-10-29 - 10.1

Crankshaft

A new strengthened design ensures reduced stresses and improved lubrication via optimized drillings. It is machined from a high tensile NiCrMo continuous grain-flow steel forging and fitted with two bolt-on balance weights per throw. A solid camshaft drive gear is bolted to a flange at the free end that also incorporates a taper to which the vibration damper is fitted.

Main power drive (100% PTO, optional)

As a standard the main power drive connection is placed at the coupling side. Optionally to provide better customer flexibility in engine arrangement, the main power drive is also available on free end side below turbochargers.

Power take off for auxiliaries (auxiliary PTO, optional)

If the main power drive connection is placed at the coupling side, optionally an auxiliary PTO at counter coupling side can be used, to drive for example, a fire fighting pump. This option is available for 12V, 16V, and 20V engine. Hereby the maximum available output of the engine has to be considered.

Main and connecting rod bearings

Generously dimensioned, precision made, extended life, easily replaceable, thin wall, steel-backed aluminum-tin shells.

Camshafts

Of modular design, comprising one cam element and one bearing journal per engine cylinder, assembled through side access doors and mounted on each side of the engine. Large cam base circles are employed together with large bearings to reduce operating stresses. Housed in the crankcase, the two hollow camshafts incorporate the oil supply gallery to the engine and bearings.

Engine driven pumps for easy installation

Lube oil pump, fuel oil supply pump, HT cooling water pump, LT cooling water pump and seawater pump are all as a standard installed and engine driven from the flywheel counter side of the engine to simplify the installation.

Pistons

A two-piece design with a lightweight body and alloy steel crown, and a three-ring pack comprising two chrome-ceramic compression rings and an oil control ring. The casehardened gudgeon pin is fully floating and retained by a circlip at each end. Lubricating oil is fed from the connecting rod through drillings in the gudgeon pin and piston to a cooling chamber in the piston crown. The oil is then discharged through drillings in the underside of the crown back to the sump.

Connecting rods

This straight cut design ensures high reliability, good engine balancing, and low vibrations. It is manufactured from a one-piece alloy steel forging, and the partially grooved lead bronze bearing shell is carried in straight cut big ends with each cap secured by four hydraulically-tensioned studs and nuts. The stepped small end features a steel-backed lead/bronze bush, and all bearing pressures are kept at a minimum.

2026-10-29 - 10.1

Cylinder heads

Machined from a spheroidal graphite iron casting with a thick combustion face incorporating coolant drillings. The two inlet and two exhaust valves, the latter with cooled seats, are arranged around the central fuel injector.

Twin inlet ports connect directly to the air manifold, while a single tandem exhaust port exits from the top face for ease of maintenance. Each pair of valves is operated via short push rods and conventional rocker arms from the camshaft via followers of the roller bucket tappet type mounted in a separate casing bolted to the crankcase.

Camshaft drive

Located at the free end of the engine and comprising a solid gear bolted to the crankshaft driving a compound idler gear for each cylinder bank, which in turn drive the two camshafts. All gear spindles are supported both sides of the gear by the crankcase.

Air manifolds

This single-element air manifold of symmetrical design is made of GGG40. It is mounted down the vee of the crankcase, and incorporating passages for the lubricating oil and water systems.

Intercooler

A cylindrical two-stage unit contained in a casing that includes part of the inlet ducting; the assembly is mounted directly on top of the air manifold.

Lube oil filter

Mounted at flywheel side of the engine including the lube oil filter and oil cooler.

Duplex filter system: Aluminum design with duplex paper oil filter cartridges allowing switch over during engine operation.

Also an automatic lube oil filter available: Cast iron design with integrated thermostat and a centrifugal oil separator.

2026-10-29 - 10.1

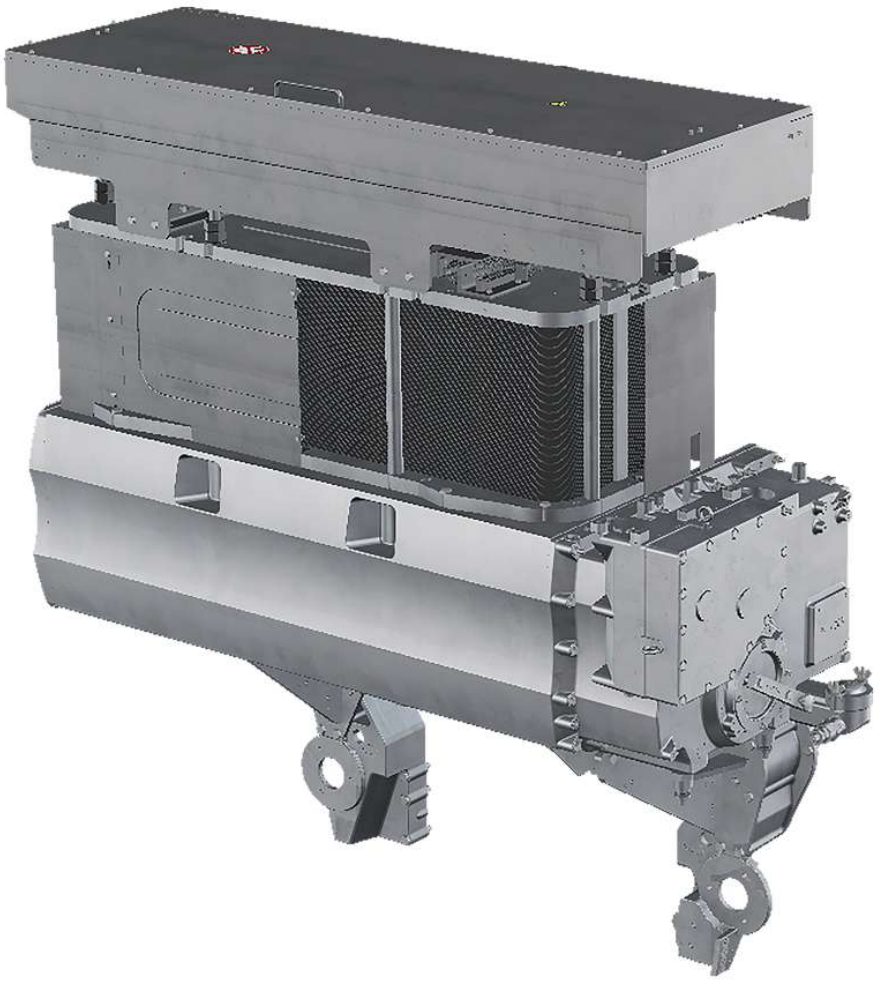


Figure 2: Oil cooler with mounted lube oil duplex filter

2026-10-29 - 10.1



Figure 3: Oil cooler with mounted lube oil automatic filter

Turbocharging

Twin axial-flow Everllence turbochargers are mounted on a cast iron bracket at the free end of the engine. Developed specifically for the V28/33D STC engine, the high efficiency and compact Everllence TCA33 turbocharger features angled turbine inlet casings designed to match the engine exhaust in terms of interfaces and gas flow optimization. Each turbocharger uses the same inlet casing, which is simply rephased to the opposite angle.

High efficiency at full and part loads from the turbocharging system yields a substantial charge air surplus and thorough combustion without residues. A requirement for the engine to fit compact machinery rooms resulted in a new turbine outlet casing design. Detailed analysis and design achieved very low pressure losses in the connection itself and in the downstream exhaust duct.

A single turbocharger frame size covers all cylinder configurations, making interfaces common across the engine range; and installation is standardised without compromising performance and efficiency.

2026-10-29 - 10.1



Figure 4: Generic illustration of a Everllence TCA turbocharger

Sequential turbocharging

The sequentially turbocharging (STC) offers optimised engine-turbocharger matching for high torque at low rpm with reduced fuel consumption, smoke and noise. The system incorporates two identical standard Everllence TCA33 turbochargers: One alone supplies sufficient charge air in low and medium speed running modes; the second unit cuts in to boost charging at higher speeds.

A digital control system is programmed to automatically switch off one turbocharger at low rpm, increasing the amount of air reaching the combustion chambers.

An extended torque envelope yielding economical operating modes and improved engine acceleration characteristics from STC versions are particularly valued for naval propulsion applications. High torque at low power is particularly useful when towing another vessel.

2026-10-29 - 10.1



Figure 5: V28/33D STC system

Extended low-load operation

With STC, the V28/33D STC engine has the capability to operate for extended periods at low-load conditions without visible smoke exhaust emissions or negatively affecting full load performance or maintenance demands.

Electronics – SaCoS 5000

The V28/33D STC is equipped with the classification society compliant safety and control system SaCoS 5000. SaCoS 5000 combines all functions of modern engine management into one complete system.

SaCoS 5000 offers:

- Integrated self-diagnosis functions
- Future prove design
- Digital ready
- Maximum reliability and availability
- Simple use and diagnosis
- Quick exchange of modules
- Crankcase monitoring system plus oil mist detection
  As a standard for all our four-stroke medium-speed engines manufactured in Augsburg, these engines will be equipped with a crankcase monitoring system (CCM = splash oil & main bearing temperature) plus OMD (oil mist detection). OMD and CCM are integral part of the Everllence´ safety philosophy and the combination of both will increase the possibility to early detect a possible engine failure and prevent subsequent component damage.
- Propulsion optimisation interface

2026-10-29 - 10.1

The propulsion optimisation interface serves with engine parameters and provides information about upcoming limitations at an early stage. This allows a smooth and look ahead control of the CPP propulsion system.

Cyber security

The marine certified safety and control system SaCoS 5000 is compliant to the IACS UR E27 requirements for cyber resilience on-board equipment, which will get mandatory for ships contracted for construction or after 1st July 2024. A confirmation of compliance will be given by the main classification societies, ensuring the utmost benefit for our customers.

NO_X emission - IMO 2008 versus IMO 2028[1)]

The V28/33D STC complies with IMO Tier II NO_X emission limits and in connection with an appropriate Everllence SCR exhaust gas aftertreatment system also with IMO Tier III NO_X limitations prescribed for ECA´s. Parent engines certified before January 1st 2028 and member engines of such groups built before January 1st 2030 have to be in line with IMO 2008 regulations. Engines that are certified or manufactured[1)] after these dates must comply with the requirements of the IMO NO_X Technical Code 2028. Among other changes, this updated regulation introduces more stringent limits on NO_X emissions compared to previous standards. As a result, engine setting is adapted accordingly.

[1)] Decisive is the issue date of the EIAPP certificate.

The V28/33D STC already complies with the new IMO 2028 regulations.

PrimeServ Assist - CEON (optional feature)

Everllence PrimeServ Assist is our solution to support our customers in monitoring and assessing the condition of their equipment. Equipment connected to our Everllence CEON cloud platform is monitored by Everllence's advanced analytics running in the Everllence CEON platform to detect degradations and optimisation potentials. Everllence experts analyse root causes and define mitigating actions based on this data.

Benefits:

- Availability: Ensuring 24/7 engine availability by monitoring operating values and pro-actively advising on operating tasks.
- Efficiency: Optimize equipment performance and reduce fuel consumption and emissions by detecting degradations of performance influencing parameters over time.
- Maintenance: Reduce maintenance cost by evaluating aging of individual components over time and pro-active advising counter measures.

2026-10-29 - 10.1

1.3 Engine overview



Figure 6: Engine overview, lube oil module with automatic filter, engine view on counter coupling side (CCS)

2026-10-29 - 10.1



Figure 7: Engine overview, lube oil module with automatic filter, engine view on coupling side (CS)

2026-10-29 - 10.1



Figure 8: Engine overview, lube oil module with duplex filter, engine view on counter coupling side (CCS)

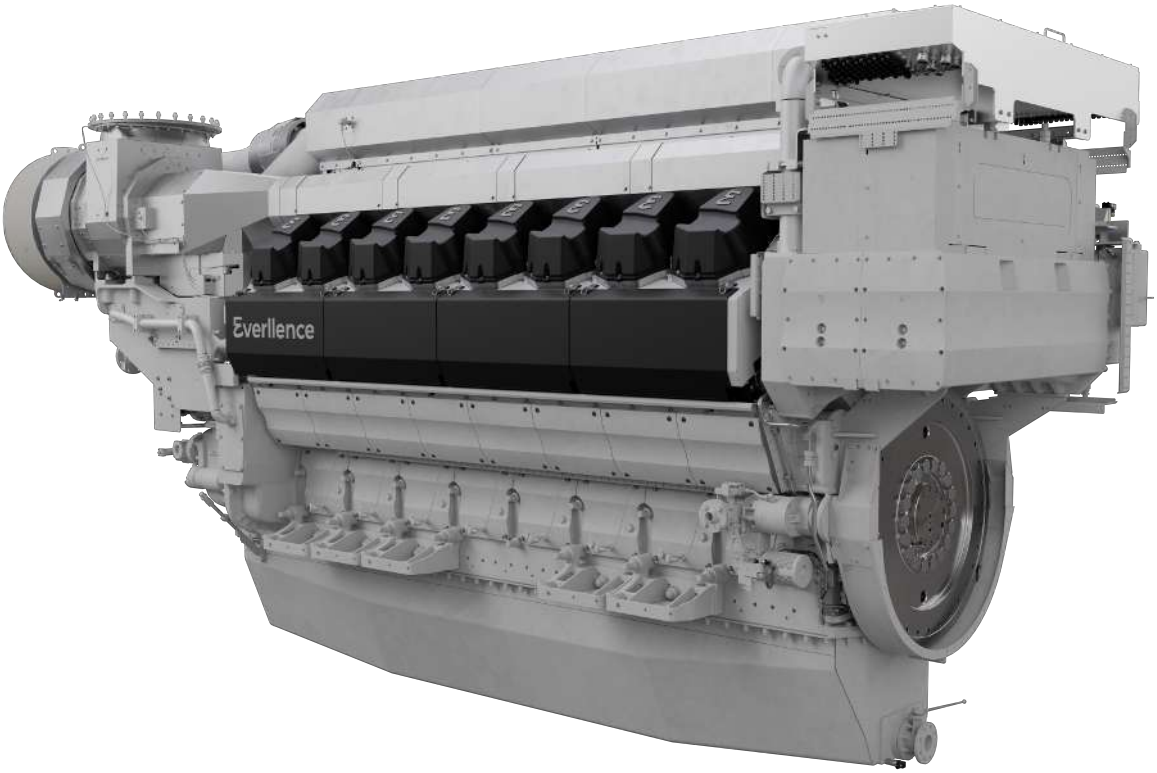
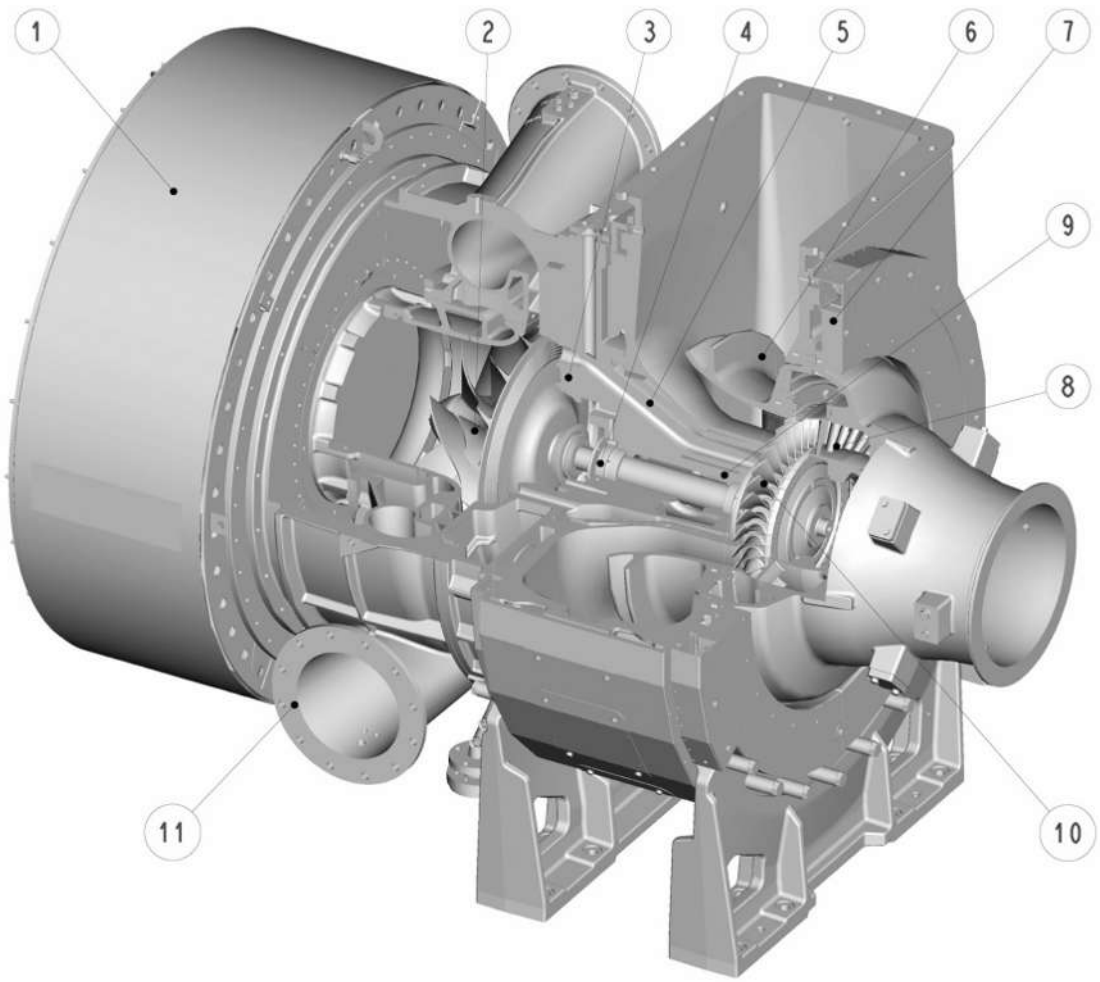


Figure 9: Engine overview, lube oil module with duplex filter, engine view on coupling side (CS)

2026-10-29 - 10.1

1.4 Turbocharger overview

1.4.1 View of a TCA type turbocharger



1 Silencer
2 Compressor wheel
3 Bearing casing
4 Thrust bearing
5 Integrated sealing air system
6 Exhaust diffuser
7 Burst-proof casing
8 Nozzle ring
9 Plain bearing
10 Turbine blades
11 Compressor casing

Figure 10: TCA type turbocharger

The following view indicates the modern design principle of the TCA series:

- Whispering silencer
- Easy-to-service, low-noise compressor wheel
- Optional water-cooled compressor wheel
- Uncooled bearing casing
- Easy access to thrust bearing
- Integrated sealing air, oil pipe, and venting systems

2026-10-29 - 10.1

1.4.2 Compensator between turbine outlet (engine) and exhaust gas pipe (plant)

All turbocharger casing flanges, with the exception of the turbine outlet, may only be subjected to loads generated by the gas forces, and not to additional external forces or torques.

This necessitates the use of compensators directly at the turbine outlet.

The compensators must be pre-loaded in such a manner that thermal expansion of the pipes and casings does not exert forces or torques in addition to those generated by the air and gas.

- Forces and torques according to API standard 617.
- Operating direction implemented according to Everllence standard.
- Minimising the load as far as possible.
- Characteristic values include gas forces, masses and compensator.

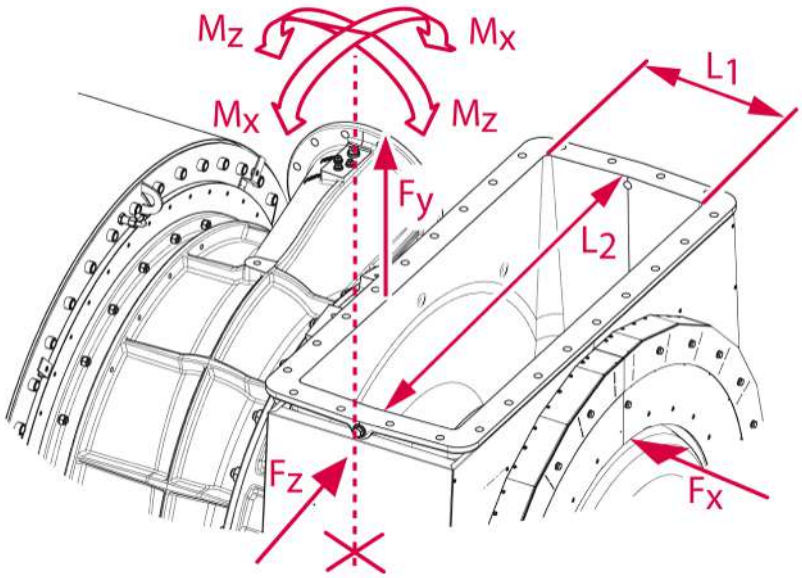


Figure 11: Maximum connection loads on gas outlet casing

Type	F_x [N]	F_y [N]	F_z [N]	M_x [Nm]	M_z [Nm]	L_1 [mm]	L_2 [mm]
TCA33	3,900	7,900	7,900	6,000	3,000	400	690
TCA44	4,200	8,500	8,500	6,400	3,200	340	949
TCA55	4,500	9,100	9,100	6,900	3,400	390	1,080
TCA66	4,900	9,900	9,900	7,500	3,700	463	1,283
TCA77	5,400	10,900	10,900	8,200	4,100	550	1,524
TCA88	5,900	12,000	12,000	9,100	4,500	653	1,810
TCA88-25	6,300	12,700	12,700	9,600	4,800	653	1,812

2026-10-29 - 10.1

Note:

- The layout of the compensator has to consider the possible movement of the engine according its foundation and engine mounting and the movement/extension of the exhaust gas pipe of the plant.
- Recommendations for the layout of the exhaust gas pipe in the section Exhaust gas system, Page 227 have to be considered.

1.4.3 No additional masses allowed

In general no masses are to be fixed to any part of the engine/turbocharger, as these have an impact to the general vibration behaviour of the engine.

Additional loads and changed vibration behaviour can endanger the operational safety of the engine.

Consequently, for any questions in this regard consult Everllence in advance.

2026-10-29 - 10.1

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2026-10-29 - 10.1

2 Engine and operation

2.1 Approved applications and destination/suitability of the engine

Approved applications

The V28/33D STC is designed as multi-purpose drive.

It has been approved by type approval as marine main engine.

As marine main engine[1)] it may be applied for mechanical propulsion drive[2)] for applications as:

- High-speed ferries
- Mega yachts
- Offshore patrol vessels
- Corvettes
- Frigates
- Amphibious ships
- Logistic ships
- Others – to fulfill all customers needs the project requirements have to be defined at an early stage

V28/33D STC to be applied for multi-engine plants only.

Note:
The engine is not designed for operation in hazardous areas. It has to be ensured by the ship's own systems, that the atmosphere of the engine room is monitored and in case of detecting a gas-containing atmosphere the engine will be stopped immediately.

[1)] In line with rules of classifications societies each engine whose driving force may be used for propulsion purpose is stated as main engine.

[2)] See section Engine ratings (output) for different applications, Page 37.

Offshore

For offshore applications it may be applied for mechanical drive for applications as:

- Platforms/offshore supply vessels
- Anchor handling tugs
- General all kinds of service & supply vessels
- Drilling ships

V28/33D STC to be applied for multi-engine plants only.

Due to the wide range of possible requirements such as flag state regulations, fire fighting items, redundancy, inclinations and dynamic positioning modes all project requirements need to be clarified at an early stage.

Note:
The engine is not designed for operation in hazardous areas. It has to be ensured by the ship's own systems, that the atmosphere of the engine room is monitored and in case of detecting a gas-containing atmosphere the engine will be stopped immediately.

2026-10-29 - 10.1

Destination/suitability of the engine

Note:
Regardless of their technical capabilities, engines of our design and the respective vessels in which they are installed must at all times be operated in line with the legal requirements, as applicable, including such requirements that may apply in the respective geographical areas in which such engines are actually being operated.

Operation of the engine outside the specified operated range, not in line with the media specifications or under specific emergency situations (e.g. suppressed load reduction or engine stop by active "Override", triggered firefighting system, crash of the vessel, fire or water ingress inside engine room) is declared as not intended use of the engine (for details see engine specific operating manuals). If an operation of the engine occurs outside of the scope of supply of the intended use a thorough check of the engine and its components needs to be performed by supervision of the Everllence service department. These events, the checks and measures need to be documented.

Electric and electronic components attached to the engine – Required engine room temperature

In general our engine components meet the high requirements of the marine classification societies.

Relevant design criteria for the engine room air temperature:

Minimum air temperature in the area of the engine and its components
Recommended: ≥ 5°C.

Maximum air temperature in the area of the engine and its components
≤ 45°C.

The electronic components are suitable for proper operation within an air temperature range from 5°C to 55°C.

For further information see also paragraph "Environmental conditions, Page 143" in section "Engine automation > Technical data".

Note:
Condensation of the air at engine components must be prevented.

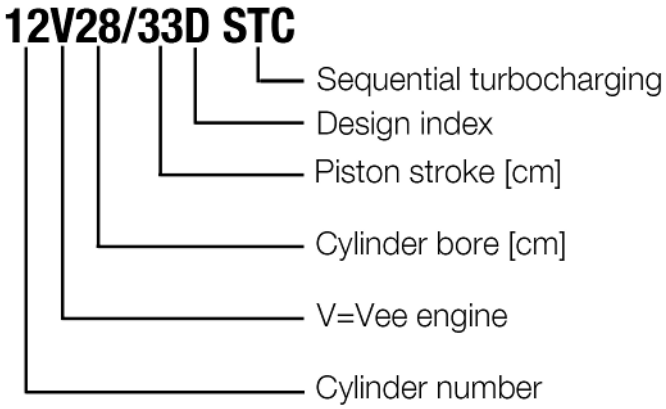
Note:
It can be assumed that the air temperature in the area of the engine and attached components will be 5–10 K above the ambient air temperature outside the engine room. If the temperature range is not observed, this can affect or reduce the lifetime of electrical/electronic components at the engine or the functional capability of engine components. Air temperatures at the engine > 55°C are not permissible.

2.2 Engine design

2.2.1 Engine designations – Design parameters

Example to declare engine designations

2026-10-29 - 10.1



Parameter	Value	Unit
Number of cylinders	12, 16, 20	-
Cylinder bore	280	mm
Piston stroke	330	
Displacement per cylinder	20.3	litre
Distance between cylinder centres, vee engine	460	mm
Vee engine, vee angle	52	°
Crankshaft diameter at journal, vee engine	300	mm
Crankshaft diameter at crank pin	240	

Table 1: Design parameters

2.2.2 Turbocharger assignments

No. of cylinders, config.	CPP
12V	TCA33-42
16V	TCA33-42
20V	TCA33-42

Table 2: Turbocharger assignments

Turbocharger assignments mentioned above are for guidance only and may vary due to project-specific reasons. Consider the relevant turbocharger Project Guides for additional information.

2026-10-29 - 10.1

2.2.3 Engine main dimensions, weights and views

V28/33D STC mechanical propulsion

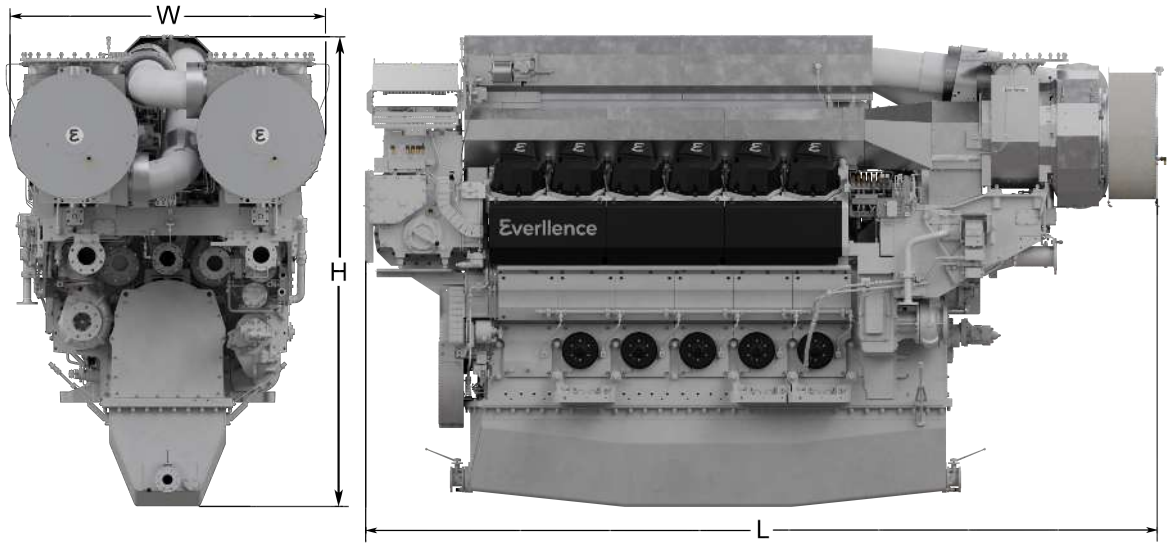


Figure 12: Main dimensions and weights – V28/33D STC mechanical propulsion (lube oil module with automatic filter)

No. of cylinders, config.	W	H (low oil sump)	H (deep oil sump)	L	Weight with flywheel[1)]
	mm				t
12V	2,473	3,417	3,682	6,217	36.1
16V				7,137	43.5
20V				8,057	51.0

[1)] Tolerance: 5%. Weight refer to engine with flywheel, TC silencer, attached pumps, oil filter and lube oil cooler (weight given without media filling of engine).

For Flywheel data, see section Flywheel arrangement, Page 113.

2026-10-29 - 10.1

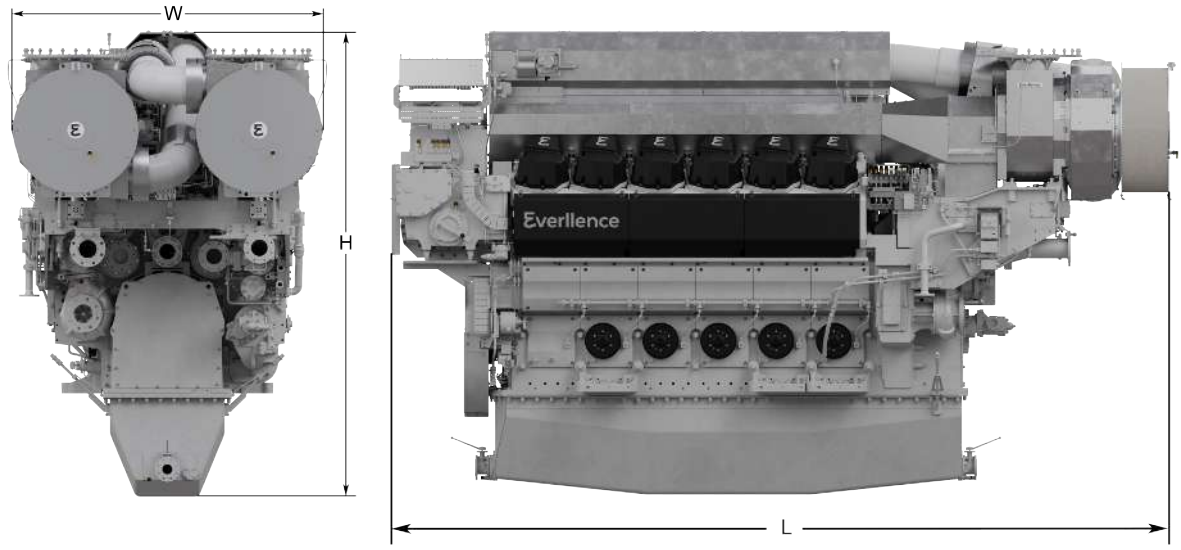


Figure 13: Main dimensions and weights – V28/33D STC mechanical propulsion (lube oil module with duplex filter)

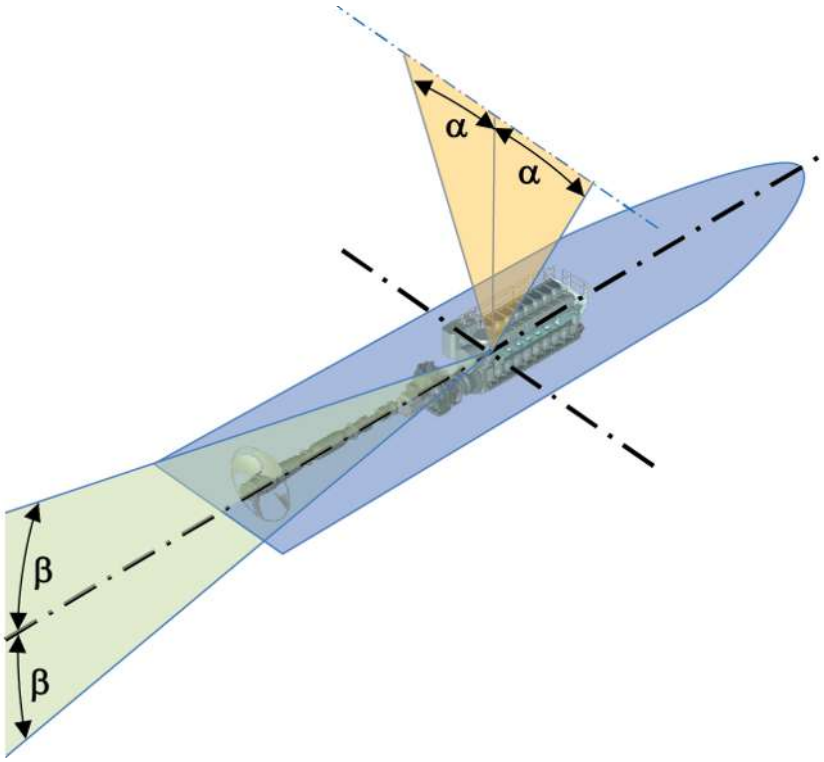
No. of cylinders, config.	W	H (low oil sump)	H (deep oil sump)	L	Weight with flywheel[1)]
	mm				t
12V	2,473	3,417	3,682	6,207	35.6
16V				7,127	43.0
20V				8,047	50.6

[1)] Tolerance: 5%. Weight refer to engine with flywheel, TC silencer, attached pumps, oil filter and lube oil cooler (weight given without media filling of engine).

For Flywheel data, see section Flywheel arrangement, Page 113.

2026-10-29 - 10.1

2.2.4 Engine inclination



α Athwartships β Fore and aft

Figure 14: Angle of inclination

Max. permissible angle of inclination [°][1) 2)]					
Application	**Athwartships α**		**Fore and aft β**		
	Heel to each side (static)	**Rolling to each side (dynamic)**	**Trim (static)[3)]**		**Pitching (dynamic)**
			L < 100 m	**L > 100 m**	
Main engines	15	22.5	5	500/L	7.5

[1)] Athwartships and fore and aft inclinations may occur simultaneously.

[2)] While engine may be installed 3° tilted as a maximum in vessels longitudinal direction.

[3)] Depending on length L of the ship.

Table 3: Inclinations

Note:
For higher requirements contact Everllence. Arrange engines always length-wise of the ship.

2026-10-29 - 10.1

2.2.5 Engine equipment for various applications

Device/measure, (figure pos.)	Mechanical propulsion
Cylinder pressure limitation by hot charge air blow-off (binary)	Order-related, required if the intake air < 0°C[1)]
Hot charge air by-pass (variable)	X
Exhaust flap STC and air flap STC	X
Turbocharger – Compressor cleaning device (wet)	X
Two-stage charge air cooler	X
Oil mist detector	X
Splash oil monitoring	X
Main bearing temperature monitoring	X
Starting system – Compressed air starter	X
Slow turn	X
Attached HT cooling water pump	X
Attached LT cooling water pump	X
Attached lube oil pump	X
Attached seawater pump	X
Attached fuel supply pump	X
Attached HT cooling water temperature control valve	X
Attached lube oil temperature control	X[2)]
Attached lube oil cooler	X
Attached lube oil pressure control valve	X[3)]
Oil sump	X (deep oil sump) O (low oil sump)
Power take off 100% on counter coupling side	O
Oil mist eliminator (not attached to the engine)	X
Attached lube oil duplex filter	X
Attached lube oil automatic filter	O (lube oil automatic filter plus lube oil centrifugal filter)

X = required, O = optional

[1)] Everllence recommends an engine room temperature of +5°C to avoid freezing wetness on intake air silencer filter mat and electronic equipment.

[2)] Lube oil inlet temperature control by wax thermostat (standard for engines with lube oil duplex filter). For engines with optional lube oil automatic filter: Lube oil outlet temperature control by wax thermostat.

[3)] Integrated in the attached lube oil pump.

Table 4: Engine equipment

2026-10-29 - 10.1

Engine equipment for various applications – General description

Cylinder pressure limitation by hot charge air blow-off (binary) (see figure Overview flaps, Page 32)

If engines are operated at full load at low air intake temperature, the high air density leads to the danger of excessive charge air pressure and, consequently, to excessive cylinder pressure. In order to avoid such conditions, part of the charge air is withdrawn upstream of the charge air cooler and blown off (hot charge air blow-off).

Note:
Hot air withdrawn before charge air cooler has to be blown outside the engine room where it can not harm persons and property or may be used e.g. for intake air preheating.

Hot charge air by-pass (variable) (see figure Overview flaps, Page 32)

A part of the hot charge air after compressor will be withdrawn into the exhaust gas pipe. The flap is closed in normal operation.
In some areas of the operating map of the engine, this charge air by-pass will be opened and the increased air flow at the turbine results in a higher charge air pressure of the compressor, which leads to an improved operational behavior of the engine.
In addition, this flap may be used to avoid surging of the turbocharger.

Exhaust flap STC and air flap STC (see figure Overview flaps, Page 32)

Allows to turn off the second turbocharger at lower loads.

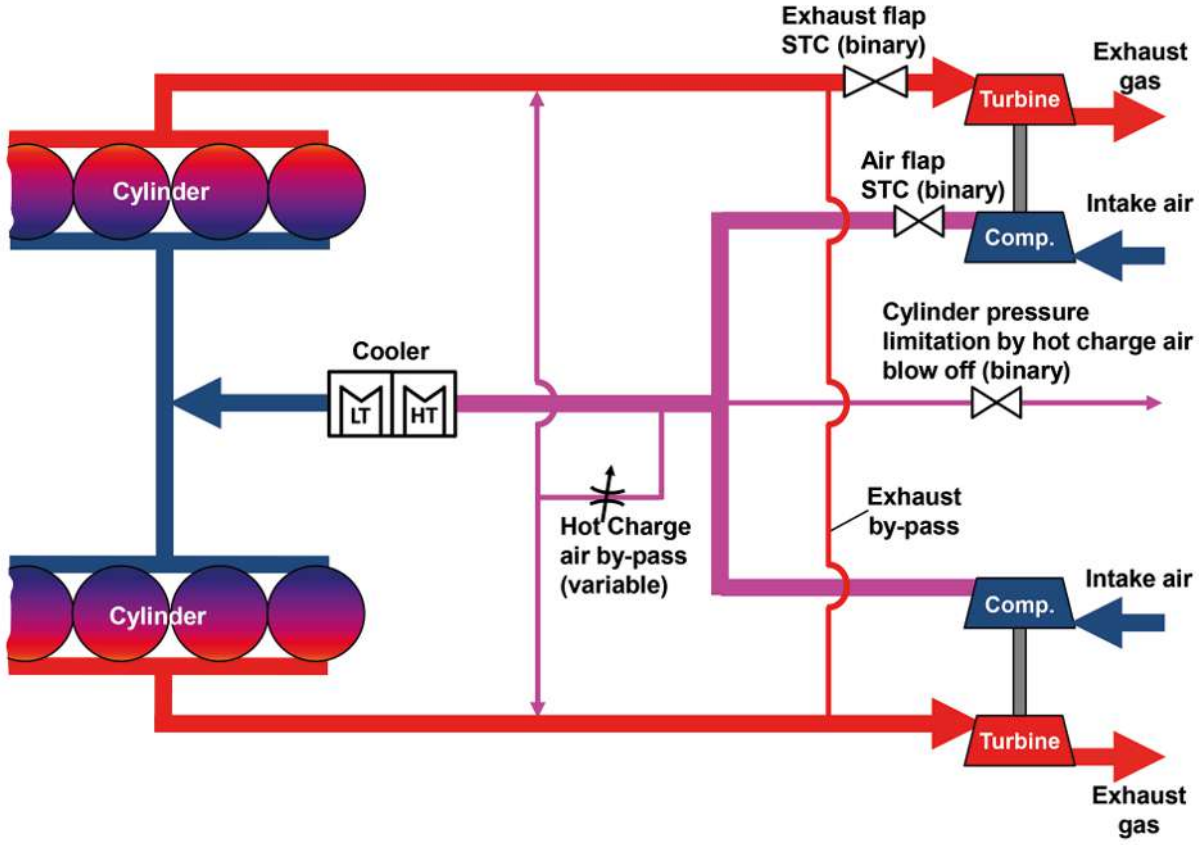


Figure 15: Overview flaps

2026-10-29 - 10.1

Turbocharger – Compressor cleaning device (wet)	Depending on the quality of the intake air, deposits may be formed on the blades of the compressor wheel and diffuser. This contamination reduces the efficiency of the compressor. Cleaning of the compressor is carried out with water during operation at full load with a special compressor cleaning device.
Two-stage charge air cooler	The two-stage charge air cooler consists of two stages which differ in the temperature level of the connected water circuits. The charge air is first cooled by the HT circuit (high temperature stage of the charge air cooler, engine) and then further cooled down by the LT circuit (low temperature stage of the charge air cooler, lube oil cooler).
Oil mist detector	Bearing damage, piston seizure and blow-by in combustion chamber leads to increased oil mist formation. As a part of the safety system the oil mist detector monitors the oil mist concentration in crankcase to indicate these failures at an early stage.
Splash oil monitoring	The splash oil monitoring system is a constituent part of the safety system. Sensors are used to monitor the temperature of each individual drive unit (or pair of drive at V engines) indirectly via splash oil.
Main bearing temperature monitoring	As an important part of the safety system the temperatures of the crankshaft main bearings are measured just underneath the bearing shells in the bearing caps. This is carried out using oil-tight resistance temperature sensors.
Starting system – Compressed air starter	The engine is equipped with compressed air starters, which are attached to the engine. On starting command they will turn the flywheel until a defined speed is reached.
Slow turn	Engines, which are equipped with slow turn, are automatically turned prior to engine start with the turning process being monitored by the engine control. If the engine does not reach the expected number of crankshaft revolutions (2.5 revolutions) within a specified period of time, or in case the slow turn time is shorter than the programmed minimum slow turn time, an error message is issued. This error message serves as an indication that there is liquid (oil, water, fuel) in the combustion chamber. If the slow turn manoeuvre is completed successfully, the engine is started automatically. Slow turn is always required for plants with power management system (PMS) demanding automatic engine start.
Attached HT cooling water temperature control valve	To facilitate the installation and media control the HT cooling water temperature control valve is installed at the engine and integrated in the media circuit already. The position of the valve is shown in figure Internal cooling water system (LT and HT) – Exemplary 12V28/33D STC, Page 201.
Attached lube oil temperature control	The lube oil temperature control valve regulates the inlet oil temperature of the engine.
Attached lube oil cooler	The lube oil cooler is designed according the heat data, flow rates and tolerances which are indicated in section Planning data, Page 73.
Attached lube oil pressure control valve	The lube oil pressure control valve regulates the inlet oil pressure of the engine.
Attached lube oil duplex filter	The lube oil filter is a duplex paper cartridge filter. It is a depth filter. The position is shown in figure Internal lube oil system – Exemplary for variant with lube oil duplex filter, Page 186.
Attached lube oil automatic filter	Optional a configuration with automatic filter and centrifuge is available. The attached lube oil automatic filter is equipped with an integrated second filtration stage. This second stage protects the engine from particles which may pass the first stage filter elements in case of any malfunction.

2026-10-29 - 10.1

2.3 Ratings (output) and speeds

2.3.1 General remark

The engine power which is stated on the type plate derives from the following sections and corresponds to $P_{Operating}$ as described in section Derating, definition of P Operating, Page 37.

2.3.2 Standard engine ratings

Engine V28/33D STC propulsion, 455 kW/cyl.

$P_{ISO, standard}$: ISO standard output (as specified in DIN ISO 3046-1)

455 kW/cyl., 1,000 rpm (ICN) [corresponds to 100% output]

No. of cyl., config.	Engine rating $P_{ISO, standard}$ [1) 2)]			
	455 kW/cyl., 1,000 rpm	Available turning direction	Minimum continuous rating up to a maximum of 12 hours[3)]	Minimum continuous rating up to a maximum of 48 hours[3)]
	kW	CW/CCW[4) 5)]	CPP at 400 rpm kW	CPP at 400 rpm kW
12V	5,460	Yes/Yes	165	325
16V	7,280	Yes/Yes	215	430
20V	9,100	Yes/Yes	270	540

[1)] $P_{ISO, standard}$ as specified in DIN ISO 3046-1, see paragraph Reference conditions for engine rating, Page 35, according ICN power definition.

[2)] Engine fuel: DMA according to ISO 8217, fulfilling the stated quality requirements. Contents of FAME or synthetic fuels are not considered for this reference, as they affect the volumetric heat value. In engine operation with FAME or synthetic fuels, the power output will be reduced due to the limitation of the injection quantity to the value of DMA.

[3)] See section Low-load operation V28/33D STC, Page 45.

[4)] For multi-engine arrangement only.

[5)] CW clockwise; CCW counter clockwise.

Table 5: Engine V28/33D STC propulsion, 455 kW/cyl.

2026-10-29 - 10.1

Engine V28/33D STC propulsion, "Navy" (ICFN), 500 kW/cyl.[1)]

$P_{ISO, standard}$: ISO standard output (as specified in DIN ISO 3046-1)

500 kW/cyl., 1,032 rpm (ICFN) [corresponds to 100% output]

No. of cyl., config.	Engine rating $P_{ISO, standard}$[2) 3)]				
	Fuel stop power ICFN[1)] 500 kW/cyl., 1,032 rpm	MCR 455 kW/cyl., 1,000 rpm	Available turning direction	Minimum continuous rating up to a maximum of 12 hours[4)]	Minimum continuous rating up to a maximum of 48 hours[4)]
	kW	kW	CW/CCW[5) 6)]	CPP at 400 rpm kW	CPP at 400 rpm kW
12V	6,000	5,460	Yes/Yes	165	325
16V	8,000	7,280	Yes/Yes	215	430
20V	10,000	9,100	Yes/Yes	270	540

[1)] Only available for special class rules or without class approval.

[2)] $P_{ISO, standard}$ as specified in DIN ISO 3046-1, see paragraph Reference conditions for engine rating, Page 35, according ICFN power definition for application with "Navy" load profile. (F = Fuel stop power, represents highest load also at FAT).

[3)] Engine fuel: DMA according to ISO 8217, fulfilling the stated quality requirements. Contents of FAME or synthetic fuels are not considered for this reference, as they affect the volumetric heat value. In engine operation with FAME or synthetic fuels, the power output will be reduced due to the limitation of the injection quantity to the value of DMA.

[4)] See section Low-load operation V28/33D STC, Page 45.

[5)] For multi-engine arrangement only.

[6)] CW clockwise; CCW counter clockwise.

Table 6: Engine V28/33D STC propulsion, "Navy" (ICFN), 500 kW/cyl.

Reference conditions for engine rating

According to ISO 15550; ISO 3046-1

Air temperature before turbocharger t_r	K/°C	298/25
Total atmospheric pressure p_r	kPa	100
Relative humidity Φ_r	%	30
Cooling water temperature inlet charge air cooler (LT stage)	K/°C	298/25

Table 7: Reference conditions for engine rating

2.3.3 Power definition and load profile

Ratings are given according to ISO 3046-1:2002.

According ISO 15550:2002, the power figures in the tables remain valid within a range of ± 3% up to tropical conditions at sea level, i.e.:

- Compressor inlet temperature 45°C.
- Compressor inlet pressure 1,000 mbar.
- Seawater temperature 32°C.

For all commercial medium speed propulsion engines the power is defined according ICN[1)] definition (ISO 3046-1:2002 : ISO standard power).

2026-10-29 - 10.1

For all navy medium speed propulsion applications the engine rated power is stated as ICFN (ISO standard Continuous Fuel stop Net power), derived from standard ISO 3046-1:2002. It means the engine is capable to deliver power continuously during a period of time corresponding to the application. The engine is operated at stated speed and reference ambient conditions as stated above, while the fuel amount is limited and the fuel stop power cannot be exceeded. The engine rated power is delivered between the maintenance intervals as defined. The ICFN engine power rating description corresponds to 100% engine power output and cannot be exceeded.

Exemplary load profile: V28/33D STC "Navy" (ICFN), 500 kW/cyl. = 100% engine output

Typical use: Fast yachts, frigates, corvettes, OPV.

The continuous operating time for loads > 455 kW/cyl. (DMA) ist limited to max. 1 hour. After an operation at higher loads, the load must be decreased to ≤ 455 kW/cyl. for at least 11 hours. Due to the limitation of the injection quantity to the value of DMA, the overload range is shifted to a lower power output when using FAME or synthetic fuels. An operating hours counter based on the injection quantity with a corresponding indication for overload operation is implemented in the engine control system. Please observe the engine control unit carefully. The proportion of higher loads in the load profile must not be exceeded.

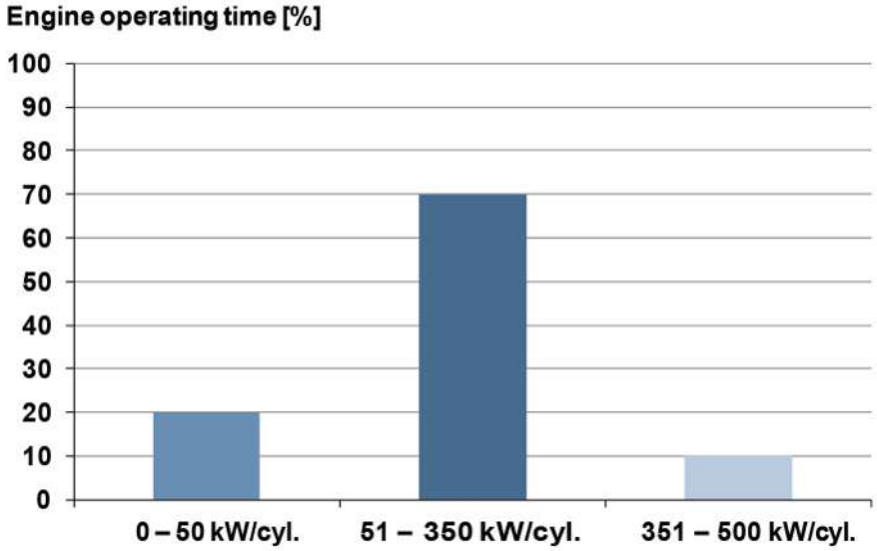


Figure 16: Exemplary load profile: V28/33D STC "Navy" (ICFN), 500 kW/cyl.

[1)] IC[F]N according to ISO 3046; I = Power to ISO 3046; C = Continuous power output; [F = Fuel stop power]; N = Net power

2026-10-29 - 10.1

2.3.4 Engine ratings (output) for different applications

$P_{Application}$, ISO: Available output under ISO conditions dependent on application

	$P_{Application}$ available output in percentage from ISO standard output	$P_{Application}$ available output	Max. fuel admission (blocking)	Max. permissible speed reduction at maximum torque[1)]	Tropic conditions ($t_r/t_{cr}/p_r$=100 kP_a)[2)]	Notes
Kind of application	**%**	**kW/cyl.**	**%**	**%**	**°C**	
Marine main engines						
Main drive with controllable pitch propeller	100	455 (ICN) 500 (ICFN)[3)]	100	-	45/38	[4)]

[1)] Maximum torque given by available output and nominal speed.

[2)] t_r = air temperature at compressor inlet of turbocharger; t_{cr} = cooling water temperature before charge air cooler; p_r = atmospheric pressure.

[3)] For engines with ICFN power definition ("Navy" load profile) as described in section Power definition and load profile, Page 35.

[4)] According to DIN ISO 3046-1 Everllence has specified a maximum continuous rating for marine engines listed in the column $P_{Application}$.

Table 8: Available outputs/related reference conditions

2.3.5 Derating, definition of P Operating

$P_{Operating}$: Available rating (output) under local conditions and dependent on application

Dependent on local conditions or special application demands a further load reduction of $P_{Application, ISO}$ might be required.

1. No derating

No derating necessary, provided that the conditions listed are met:

	No derating up to stated reference conditions (tropic), see 1.
Air temperature before turbocharger T_x	≤ 318 K (45°C)
Ambient pressure	≥ 100 kPa (1 bar)
Cooling water temperature inlet charge air cooler (LT stage)	≤ 311 K (38°C)
Intake air pressure before compressor	≥ –2 kPa[1)]
Exhaust gas back pressure after turbocharger	≤ 5 kPa[1)]
Relative humidity Φ_r	≤ 60%

2026-10-29 - 10.1

	No derating up to stated reference conditions (tropic), see 1.
[1] Below/above atmospheric pressure.	

Table 9: Derating – Limits of ambient conditions

2. Derating

Contact Everllence:

- If limits of ambient conditions mentioned in the upper table Derating – Limits of ambient conditions, Page 37 are exceeded. A special calculation is necessary.
- If higher requirements for the emission level exist. For the permissible requirements see section Exhaust gas emission, Page 92.
- If special requirements of the plant for heat recovery exist.
- If special requirements on media temperatures of the engine exist.
- If any requirements of Everllence mentioned in the Project Guide cannot be met.

2.3.6 Engine speeds and related main data

Engine V28/33D STC

Rated speed	rpm	1,000 (1,032)[1]
Permissible range of the speed		[2] [3]
Clutch[4]		
Minimum engine speed for activation (CPP)		400 [5]
Maximum engine speed for activation		1,000 [6]
Highest engine operating speed		1,000 (1,032)[1]
Alarm overspeed		1,070
Auto shutdown overspeed via control module/alarm		1,100

[1] For engines with ICFN power definition (Navy load profile) as described in section Power definition and load profile, Page 35.

[2] According, see section STC operating range for mechanical propulsion, Page 58.

[3] In rare occasions it might be necessary that certain engine speed intervals have to be barred for continuous operation. For applications using resilient mounted engines, the admissible engine speed range has to be confirmed (preferably at an early project phase) by a torsional vibration calculation, by a dimensioning of the resilient mounting, and, if necessary, by an engine operational vibration calculation.

[4] Engagement of clutch needs to be finished latest in 5 minutes, to minimize engine operation time without load at high speed.

[5] Dependent also on clutch in load.

[6] May possibly be restricted by manufacturer of clutch. Nominal speed for activation of clutch only allowed for necessity of switching a 2nd engine to an already driven shaft. After activation of clutch in accordance to Project Guide engine load to be increased instantly for a homogenous load distribution between these engines.

Table 10: Speeds

2026-10-29 - 10.1

2.3.7 Speed adjusting range

The following specification represents the standard settings. For special applications, deviating settings may be necessary.

	Drive	Speed droop	Maximum speed at full load	Maximum speed at idle running	Minimum speed
Electronic speed control	Parallel operation of 2 engines driving 1 shaft with/ without PTO (CPP):				
	Conventional	5%	100% (+0.5%)	105% (+0.5%)	40%
	or				
	master/slave operation	0%	100% (+0.5%)	100% +0.5%)	40%

Table 11: Electronic speed control

2.4 Increased exhaust gas pressure due to exhaust gas after treatment installations

Resulting installation demands

If the recommended exhaust gas back pressure as stated in section Operating/service temperatures and pressures, Page 84 cannot be met due to exhaust gas after treatment installations following limit values need to be considered.

Exhaust gas back pressure after turbocharger	
Operating pressure Δp_{exh}, maximum specified	0–50 mbar
Operating pressure Δp_{exh}, range with increase of fuel consumption or possible derating	50–80 mbar
Operating pressure Δp_{exh}, where agreement and feedback of Everllence is required	> 80 mbar

Table 12: Exhaust gas back pressure after turbocharger

Intake air pressure before turbocharger	
Operating pressure Δp_{intake}, standard	0 to –20 mbar
Operating pressure Δp_{intake}, range with increase of fuel consumption or possible derating	–20 to –40 mbar
Operating pressure Δp_{intake}, where agreement and feedback of Everllence is required	< –40 mbar

Table 13: Intake air pressure before turbocharger

Sum of the exhaust gas back pressure after turbocharger and the absolute value of the intake air pressure before turbocharger	
Operating pressure Δp_{exh} + Abs(Δp_{intake}), standard	0–70 mbar
Operating pressure Δp_{exh} + Abs(Δp_{intake}), range with increase of fuel consumption or possible derating	70–120 mbar
Operating pressure Δp_{exh} + Abs(Δp_{intake}), where agreement and feedback of Everllence is required	> 120 mbar

Table 14: Sum of the exhaust gas back pressure after turbocharger and the absolute value of the intake air pressure before turbocharger

2026-10-29 - 10.1

Maximum exhaust gas pressure drop – Layout

- Supplier of equipment in exhaust gas line have to ensure that pressure drop Δp_{exh} over entire exhaust gas piping incl. pipe work, scrubber, boiler, silencer, etc. must stay below stated standard operating pressure at all operating conditions.
- It is recommended to consider an additional 10 mbar for consideration of aging and possible fouling/staining of the components over lifetime.
- A proper dimensioning of the entire flow path including all installed components is advised or even the installation of an exhaust gas blower if necessary.
- At the same time the pressure drop Δp_{intake} in the intake air path must be kept below stated standard operating pressure at all operating conditions and including aging over lifetime.
- For significant overruns in pressure losses even a reduction in the rated power output may become necessary.
- On plant side it must be prepared, that pressure sensors directly after turbine outlet and directly before compressor inlet may be installed to verify above stated figures.

By-pass for emergency operation

- Evaluate if the chosen exhaust gas after treatment installation demands a by-pass for emergency operation.
- For scrubber application, a by-pass is recommended to ensure emergency operation in case that the exhaust gas cannot flow through the scrubber freely.
- The by-pass needs to be dimensioned for the same pressure drop as the main installation that is by-passed – otherwise the engine would operated on a differing operating point with negative influence on the performance, e.g. a lower value of the pressure drop may result in too high turbocharger speeds.

Single streaming per engine recommended/multi-streaming to be evaluated project-specific

- In general each engine must be equipped with a separate exhaust gas line as single streaming installation. This will prevent reciprocal influencing of the engine as e.g. exhaust gas backflow into an engine out of operation or within an engine running at very low load (negative pressure drop over the cylinder can cause exhaust gas back flow into intake manifold during valve overlap).
- In case a multi-streaming solution is realised (i.e. only one combined scrubber for multiple engines) this needs to be stated on early project stage. Hereby air/exhaust gas tight flaps need to be provided to safeguard engines out of operation. A specific layout of e.g. sealing air mass flow will be necessary and also a power management may become necessary in order to prevent operation of several engines at very high loads while others are running on extremely low load. A detailed analysis as HAZOP study and risk analysis by the yard becomes mandatory.

Engine to be protected from backflow of media out of exhaust gas after treatment installation

- A backflow of e.g. urea, scrubbing water, condensate or even rain from the exhaust gas after treatment installation towards the engine must be prevented under all operating conditions and circumstances, including engine or equipment shutdown and maintenance/repair work.

Turbine cleaning

2026-10-29 - 10.1

- Both wet and dry turbine cleaning must be possible without causing malfunctions or performance deterioration of the exhaust system incl. any installed components such as boiler, scrubber, silencer, etc.

White exhaust plume by water condensation

- When a wet scrubber is in operation, a visible exhaust plume has to be expected under certain conditions. This is not harmful for the environment. However, countermeasures like reheating and/or a demister should be considered to prevent condensed water droplets from leaving the funnel, which would increase visibility of the plume.
- The design of the exhaust system including exhaust gas after treatment installation has to make sure that the exhaust flow has sufficient velocity in order not to sink down directly onboard the vessel or near to the plant. At the same time the exhaust pressure drop must not exceed the limit value.

Vibrations

- There must be a sufficient decoupling of vibrations between engine and exhaust gas system incl. exhaust gas after treatment installation, e.g. by compensators.

2.5 Starting

2.5.1 General remarks

Engine and plant installation need to be in accordance to the below stated requirements and the required starting procedure.

Note:
Statements are relevant for non arctic conditions.
For arctic conditions consider relevant sections and clarify undefined details with Everllence.

2.5.2 Type of engine start

Normal start

The standard procedure of a monitored engine start in accordance to Everllence guidelines.

For details and requirements see section Starting conditions, Page 43.

Stand-by start

Shortened starting up procedure of a monitored engine start: Several preconditions and additional plant installations required.

This kind of engine start has to be triggered by an external signal: "Stand-by start required".

For details and requirements see section Starting conditions, Page 43.

Exceptional start (e.g. Black Start)

A monitored engine start (without monitoring of lube oil pressure) within one hour after stop of an engine that has been faultless in operation or of an engine in stand-by mode. This kind of engine start has to be triggered by an external signal “Black Start” and may only be used in exceptional cases. For details and requirements see section Starting conditions, Page 43

2026-10-29 - 10.1

Emergency start

Manual start of the engine at emergency start valve at the engine (if applied), without supervision by the SaCoS engine control. These engine starts will be applied only in emergency cases, in which the customer accepts, that the engine might be harmed.

2.5.3 Requirements on engine and plant installation

As stated in section Engine equipment for various applications, Page 31 the V28/33D STC in general is equipped with attached lubrication pump, HT- and LT cooling water pump, seawater pump and fuel oil supply pump.

Additional plant installation requirements

As a standard and for start-up in normal starting mode (preheated engine) following installations are required:

- Prelubrication pump (free-standing)
- Preheating HT cooling water system (40–68°C)
- Preheating lube oil system in case of stand-by operation and if minimum temperature +20°C of lube oil can not be kept (40–55°C), see accordingly section External lube oil system, Page 189

Additional plant installation requirements for "Stand-by Operation" capability

To enable in addition to the normal starting mode also an engine start from PMS (Power Management System) from stand-by mode with thereby shortened start-up time following installations are required:

- Prelubrication pump (free-standing) with low pressure before engine (0.3 bar < $p_{Oil\ before\ engine}$ < 0.6 bar)
- Preheating HT cooling water system (40–68°C)
- Preheating lube oil system (40–55°C), see accordingly section External lube oil system, Page 189
- Power management system with supervision of stand-by times engines

Additional plant installation requirements for "Blackout start" capability

As the V28/33D STC is equipped with all required attached pumps on plant side only following item needs to be considered:

- Regarding "Blackout start" fuel oil conditions, see table Fuel, Page 88.

2026-10-29 - 10.1

2.5.4 Starting conditions

Type of engine start:	Black Start	Stand-by start	Normal start
Explanation:	**After blackout**	**From stand-by mode**	**After stand-still**
Start-up time until load application:	**< 1 minute**	**< 1 minute**	**> 2 minutes**
General notes			
-	Engine start-up only within 1 h after stop of engine that has been faultless in operation or within 1 h after end of stand-by mode.	Maximum stand-by time 7 days[1]. Supervised by power management system plant. Stand-by mode is only possible after engine has been faultless in operation and has been faultless stopped.	Standard
Additional external signal:	Black Start	Stand-by request	-

[1] If an engine has been in total for 7 days in stand-by mode, no extension of stand-by mode is allowed. The engine needs to be started and operated faultless before the next stand-by mode can be applied.

Prior to next stand-by mode, engine needs to be operated at minimum 50% output for ≥ 30 min.

Table 15: Starting conditions – General notes

Type of engine start:	Blackout start	Stand-by start	Normal start
General engine status	No start-blocking active	Engine in proper condition No start-blocking active Note: Start-blocking of engine leads to withdraw of "stand-by mode".	Engine in proper condition No start-blocking active
Engine to be turned before start?	No	Yes[1]	Yes[2]
Engine to be pre-heated and prelubricated?	No[3]	Yes	Yes

[1] Engine has to be turned after 12 hours of standstill (shorter time intervals after alignment with Everllence possible).

[2] Automatic slow turn installed.

[3] Valid only, if mentioned above conditions (see table Starting conditions – General notes, Page 43) have been considered. Non-observance endangers the engine or its components.

Table 16: Starting conditions – Required engine conditions

Type of engine start:	Blackout start	Stand-by start	Normal start
Lube oil system			
Prelubrication period	No[1]	Permanent	Yes, previous to engine start

2026-10-29 - 10.1

Type of engine start:	Blackout start	Stand-by start	Normal start
Prelubrication pressure before engine	-	See section Operating/service temperatures and pressures, Page 84 limits according figure "Prelubrication/postlubrication lube oil pressure (duration > 10 min)"	See section Operating/service temperatures and pressures, Page 84 limits according figure "Prelubrication/postlubrication lube oil pressure (duration ≤ 10 min)"
HT cooling water			
HT cooling water to be preheated?	No[1)]	Yes	Yes
Fuel system			
For DMA operation	No special preparations required	External fuel system in operation or in operation with starting command to engine.	
[1)] Valid only, if mentioned above conditions (see table Starting conditions – General notes, Page 43) have been considered. Non-observance endangers the engine or its components.			

Table 17: Starting conditions – Required system conditions V28/33D STC

2.5.5 Start-up – Definitions and requirements

General remark

Prior to the start-up of the engine it must be ensured that the emergency stop of the engine is working properly. Additionally all required supply systems must be in operation or in stand-by operation.

Start-up – Cold engine

If an engine start has to be activated under cold engine conditions, following requirements have to be fullfilled as a minimum:

- Lube oil temperature +5°C, HT cooling water temperature ≥ 5°C.
- The engine is prelubricated. Due to the higher viscosity of the lube oil of a cold engine **the prelubrication phase needs to be increased**.

Before further use of the engine a warming-up phase is required to reach at least the level of the regular preheating temperatures (lube oil temperature > 20°C, cooling water temperature > 40°C).

Note:

- **It needs to be proven within plant layout, that lube oil circuit is capable to be operated at stated low lube oil temperature with accordingly high viscosity and high pressures.**
- **If engine cold start is frequently performed, wear could increase in a long-term perspective.**
- **“Start-Reliability” under stated cold start conditions is reduced and cannot be guaranteed, as the probability of a false start is increased.**
- **If applicable, warming-up phase can be shortened if engine is operated at lower speed.**

Start-up – Preheated engine (Normal start)

For the start-up of the engine it needs to be preheated:

- Lube oil temperature ≥ 20°C.
- HT cooling water temperature ≥ 40°C.

Start-up – Engine in stand-by mode (Stand-by start)

For engines in stand-by mode no start preparation is needed and accordingly the engine start will be done just after the start request (if preconditions are fulfilled).

Required conditions media system:

2026-10-29 - 10.1

- 0.3 bar < prelubrication pressure before engine < 0.6 bar.
- Lube oil temperature ≥ 40°C, see accordingly section Lube oil system, Page 183
- HT cooling water temperature ≥ 40°C.

Start-up (Exceptional start)

The engine start will be done just after the start request – but as previously stated without monitoring of lube oil pressure, and therefore this may only be used in exceptional cases.

2.6 Low-load operation

Definition

Basically, the following load conditions are distinguished:

Overload:	> 100% of the engine output (not admitted, see section Engine ratings (output) for different applications, Page 37)
Full load (MCR):	100% of the engine output
Part load:	< 100% of the engine output
Low load:	< 25% of the engine output
No load:	< 3% of the engine output, also named "idle"

Correlations

The best operating conditions for the engine prevail under even loading in the range of 60% to 90% of full load.

During idle or no-load operation, combustion in the combustion chamber is incomplete.

This may result in the forming of deposits in the combustion chamber, which will lead to increased soot emission and to increasing cylinder contamination.

There are no restrictions at loads > 15% of the full load, provided that the specified engine operating values are not exceeded.

2.6.1 Low-load operation V28/33D STC

Sequential Turbocharging (STC) allows to operate the engine for extended periods in low-load operation.

Figure Time limitation for low-load operation (navy and ferry application), Page 45 shows time-limited areas for low-load operation.

Range II: Operating range which is temporarily admissible e.g. during acceleration and manoeuvring.

After a phase of 12 respectively 48 hours in low-load operation, the load must be increased up to 70% of full load for 15 to 20 minutes.

2026-10-29 - 10.1

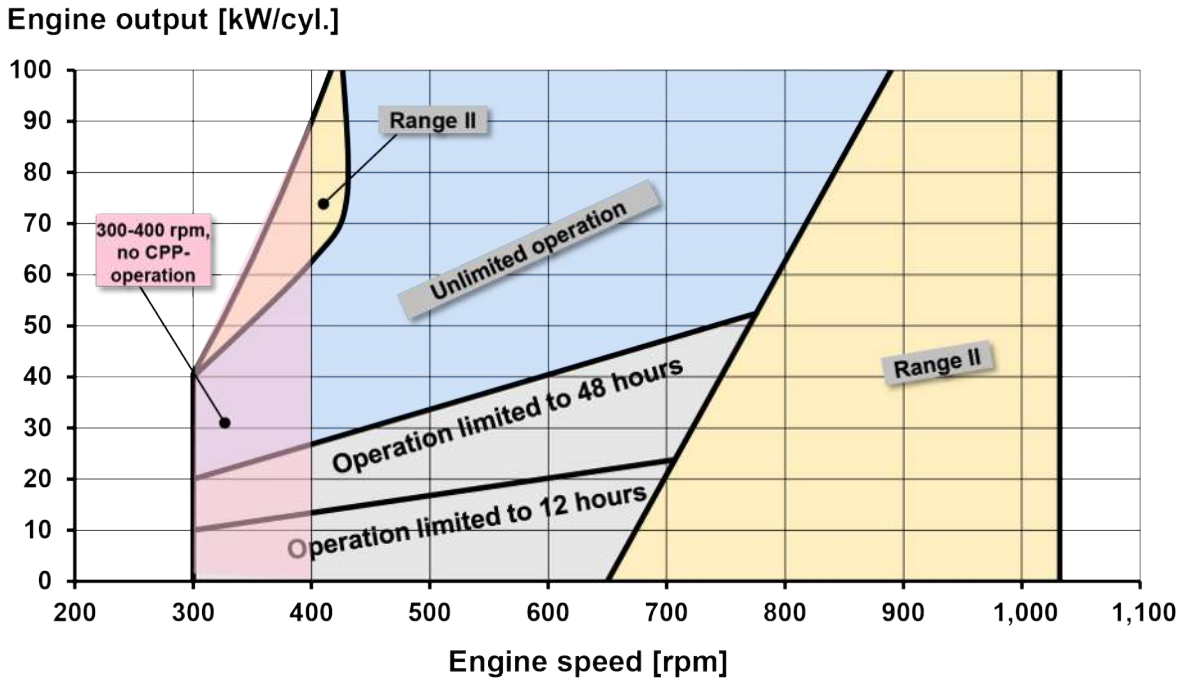


Figure 17: Time limitation for low-load operation (navy and ferry application)

2026-10-29 - 10.1

2.7 Engine load reduction and engine stop

Sudden load shedding

For the sudden load shedding from 100% to 0% engine load, several requirements of the classification societies regarding the dynamic and permanent change of engine speed have to be fulfilled.

In case of a sudden load shedding and related compressor surging, check the proper function of the turbocharger silencer filter mat.

Recommended load reduction/stopping the engine

Figure Engine ramping down, generally, Page 48 shows the shortest possible times for continuously ramping down the engine.

Even with the stated shortest possible times for continuously ramping down (Phase 1 and Phase 2) the requirements of ISO 8528-5 G2 will be fulfilled.

To limit the effort regarding regulating the media circuits and also to ensure an uniform heat dissipation it always should be aimed for longer ramping down times by taking into account the realistic requirements of the specific plant.

Before final engine stop, the engine has to be operated for a minimum of 1 minute in no-load operation.

Run-down cooling

In order to dissipate the residual engine heat, the system circuits should be kept in operation after final engine stop.

	Minimum operation time after final engine stop
Lube oil circuit	15 min.
HT circuit	15 min.
LT circuit[1)2)]	150 min

[1)] Also serves for compressor wheel cooling.

[2)] See accordingly for the layout of the LT cooling water pump section LT cooling water system, Page 200.

Table 18: System circuit operation time after engine stop

If for any reason the HT cooling water stand-by pump and/or the preheating unit is not in function, the engine has to be operated for 15 minutes at 0%-15% load before final stop, so that with the engine driven HT cooling water pump the heat will be dissipated.

If for any reason a LT cooling water stand-by pump is not in function, the engine has to be operated for 5 minutes at 0%-15% load before final stop, so hat with the engine driven LT cooling water pump the heat in the TC will be dissipated.

Note:
A lack of the run-down cooling endangers engine components and especially the turbocharger. For vessels with a risk of black-outs, therefore needs to consider:

2026-10-29 - 10.1

- Battery backup of SaCoS 5000 and relevant control systems for media systems.
- Air driven media pumps.
- Additional lube oil tank at sufficient height for post lubrication.

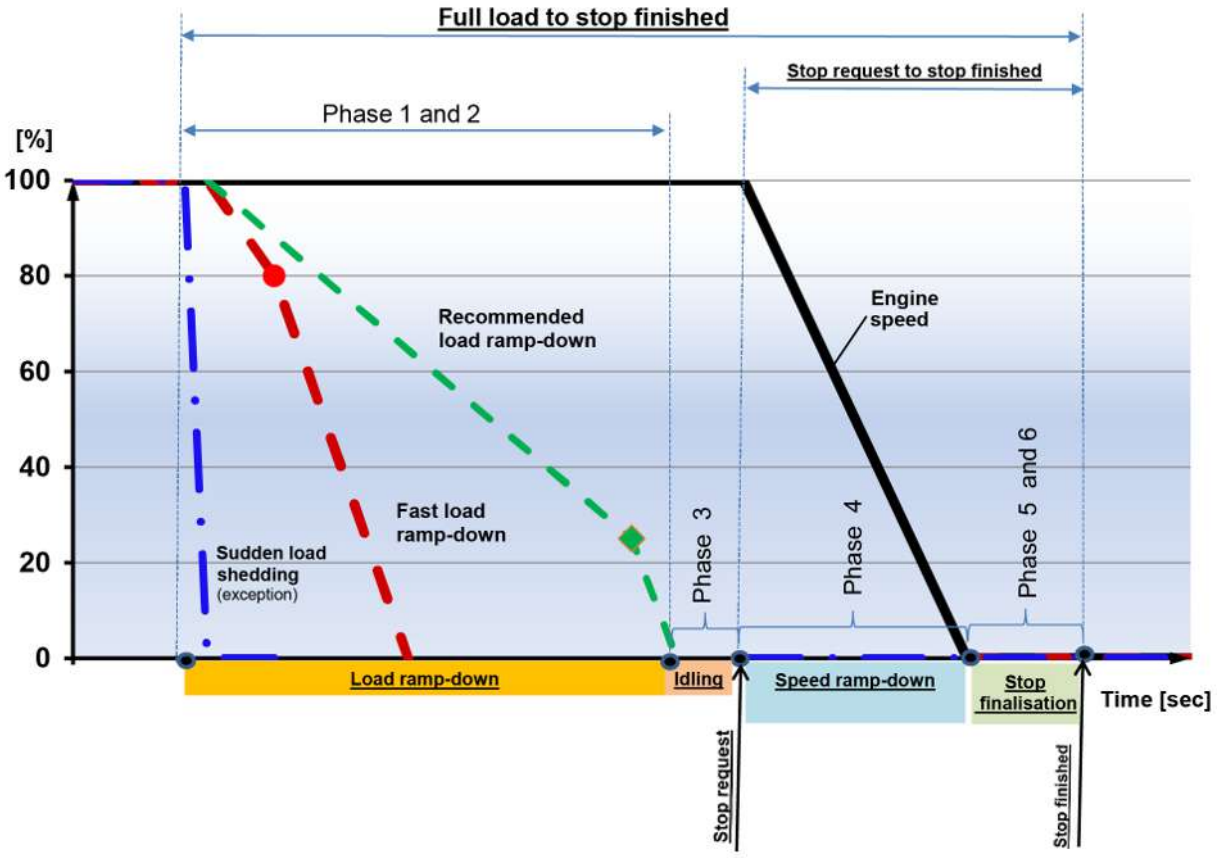


Figure 18: Engine ramping down, generally

Duration "Full load to stop finished"						
Phase	1	2	3	4	5 + 6	-
Designation	Load ramp-down	Load ramp-down	No-load operation	Speed ramp-down	5) SaCoS stop process finalization 6) Run down cooling and lubrication[1)]	Total duration ≥
Speed [%]	100	100	100	100-0	0	-
Fast stop						
Load [%]	100-80	80-0	0	0	0	-
Time [sec]	4	6	60	60	5) Active stand-by: 60 sec Otherwise: > 300 sec 6) 9,000 sec	5) 160 430 6) 9,130
Recommended stop						
Speed [%]	100	100	100	100-0	0	-
Load [%]	100-25	25-0	0	0	0	-

2026-10-29 - 10.1

Duration "Full load to stop finished"						
Time [sec]	115	5	10	60	5) In case of active stand-by 60 sec otherwise: > 300 sec 6) 9,000 sec	250 490 9,190
[1)] Run down cooling, for details see table System circuit operation time after engine stop, Page 47.						

2026-10-29 - 10.1

2.8 Engine load reduction as a protective safety measure

Requirements for the power management system/propeller control

In case of a load reduction request due to predefined abnormal engine parameter (e.g. high exhaust gas temperature, high turbine speed, high lube oil temperature) the power output (load) must be ramped down as fast as possible to ≤ 60% load.

Therefore the power management system/propeller control has to meet the following requirements:

- After a maximum of 5 seconds after occurrence of the load reduction signal, the engine load must be reduced by at least 5%.
- Then, within the next time period of maximum 30 sec an additional reduction of engine load by at least 35% needs to be applied.
- The “Prohibited range” shown in figure Engine load reduction as a protective safety measure, Page 50 has to be avoided.

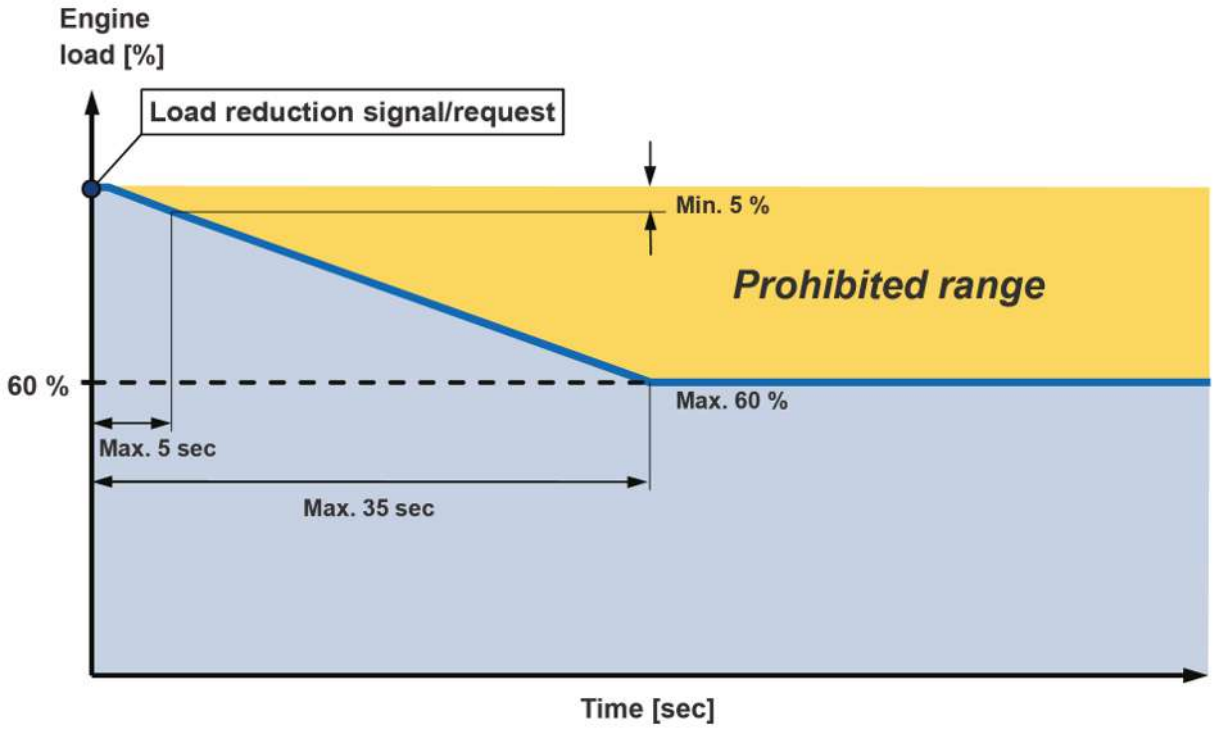


Figure 19: Engine load reduction as a protective safety measure

Run-down cooling

In order to dissipate the residual engine heat, the system circuits should be kept in operation after final engine stop.

	Minimum operation time after final engine stop
Lube oil circuit	15 min.
LT circuit[1)]	150 min.
HT circuit	15 min.

2026-10-29 - 10.1

	Minimum operation time after final engine stop
[1] Also serves for compressor wheel cooling.	

Table 19: System circuit operation time after engine stop

If for any reason the HT cooling water stand-by pump and/or the preheating unit is not in function, the engine has to be operated for 15 minutes at 0%-15% load before final stop, so that with the engine driven HT cooling water pump the heat will be dissipated.

If for any reason a LT cooling water stand-by pump is not in function, the engine has to be operated for 5 minutes at 0%-15% load before final stop, so hat with the engine driven LT cooling water pump the heat in the TC will be dissipated.

2026-10-29 - 10.1

2.9 Engine operation under arctic conditions

Arctic condition is defined as:

Air intake temperatures of the engine below 0°C.

If engines operate under arctic conditions (intermittently or permanently), the engine equipment and plant installation have to hold certain design features and meet special requirements. They depend on the possible minimum air intake temperature of the engine and the specification of the fuel used.

Minimum air intake temperature of the engine, t_x:

- Category 1
  0°C > t_x > −15°C
- Category 2
  −15°C ≥ t_x > −50°C

Special engine design requirements

Special engine equipment required for arctic conditions category 1 and category 2, see section Engine equipment for various applications, Page 31.

Engine equipment

SaCoS 5000

- SaCoS 5000 equipment is suitable to be stored at minimum ambient temperatures of −15°C.
- In case these conditions cannot be met, protective measures against climatic influences have to be taken for the following electronic components:
  - EDS Data box
  - TFT-touchscreen
  - Emergency switch module

  These components have to be stored at places, where the temperature is above −15°C.
- A minimum operating temperature of ≥ 0°C has to be ensured. The use of an optional electric heating is recommended.

See environmental conditions in section Technical data – Environmental conditions, Page 143.

Plant installation

Engine intake air conditioning

- Cooling down of engine room due to cold ambient air can be avoided by supplying the engine directly from outside with combustion air. For this the combustion air must be filtered (see quality requirements in section Specification of intake air (combustion air), Page 166). Moreover a droplet separator and air intake silencer become necessary, see section Intake air ducting in case of arctic conditions, Page 222. According to classification rules it may be required to install two air inlets from the exterior, one at starboard and one at portside.
- Cold intake air from outside is preheated in front of the cylinders in the charge air cooler. HT water serves as heat source. Depending on load and air temperature additional heat has then to be transferred to the HT circuit by a HT preheating module.

2026-10-29 - 10.1

- It is necessary to ensure that the charge air cooler cannot freeze when the engine is out of operation (and the cold air is at the air inlet side). HT cooling water preheating will prevent this. Additionally it is recommended to prepare the combustion air duct upstream of the engine for the installation of a blanking plate, necessary to be installed in case of malfunction on the HT cooling water preheating system.

Category 1

- Charge air blow-off is activated at high engine load with low combustion air temperature. With a blow-off air duct installed in the plant, it can be re-circulated in the combustion air duct upstream of the engine. Alternatively, only if blow-off air is deviated downstream of the charge air coolers and is cold (depending on engine type), blow-off air can be directly released in the engine room. Then a blow-off air silencer installed in the plant becomes necessary.
- Alternatively engine combustion air and engine room ventilation air can be supplied together in the engine room, if heated adequately and if accepted by the classification company.

Category 2

- Contact Everllence.

Piping for charge air blow-off

To ensure a correct operation of the charge air blow-off, the following need to be considered:

- Charge air blow-off flap installed at plant
- Diameter of piping > DN100
- Admissible pressure loss in piping between engine and flap: < 500 mbar
- Admissible pressure loss in piping after flap: < 1,000 mbar

Hereby as additional information, the expected charge air blow-off amount (per cylinder) and temperature is stated, dependent on the intake air temperature before compressor.

Charge air blow-off amount quantity										
Intake air temperature before compressor [°C]		**-55**	**-45**	**-35**	**-25**	**-20**	**-15**	**-10**	**-5**	**0**
12V										
Orifice installed at engine [mm]		Project-specific	45	38	29	23	17	11	6	0
Max. blow-off mass flow 12V (100% engine load) [kg/s]			1.50	1.10	0.67	0.47	0.28	0.13	0.03	0
Max. blow-off temperature [°C][1)]	Hot blow-off		125	140	155	163	171	178	185	191
16V										
Orifice installed at engine [mm]		Project-specific		45	35	30	22	15	7	0
Max. blow-off mass flow 16V (100% engine load) [kg/s]				1.49	0.98	0.72	0.45	0.45	0.06	0
Max. blow-off temperature [°C][1)]	Hot blow-off			142	157	164	172	180	187	188
20V										
Orifice installed at engine [mm]		Project-specific			46	40	34	25	13	0

2026-10-29 - 10.1

Charge air blow-off amount quantity										
Intake air temperature before compressor [°C]		**-55**	**-45**	**-35**	**-25**	**-20**	**-15**	**-10**	**-5**	**0**
Max. blow-off mass flow 20V (100% engine load) [kg/s]					1.57	1.20	0.90	0.55	0.18	0
Max. blow-off temperature [°C][1)]	Hot blow-off				159	169	176	184	192	193
Tolerances: ±5°C for temperature, ±4% for flow quantity. [1)] Temperatures specified for insulation design are max. blow-off temperature at 0°C intake air										

Table 20: Charge air blow-off amount quantity

Admissible pressure loss piping	Between engine and flap	< 500 mbar
	After flap	< 1,000 mbar

Instruction for minimum admissible fuel temperature

- In general the minimum viscosity before engine of 1.5 cSt must not be undershoot.
- The fuel specific characteristic values “pour point” and “cold filter plugging point” have to be observed to ensure pumpability respectively filterability of the fuel oil.
- Fuel temperatures of ≤ −10°C are to be avoided, due to temporarily embrittlement of seals used in the engines fuel oil system. As a result they may suffer a loss of function.

Minimum engine room temperature

- Ventilation of engine room.

  The air of the engine room ventilation must not be too cold (preheating is necessary) to avoid the freezing of the liquids in the engine room systems.
- Minimum power house/engine room temperature for design ≥ +0°C, recommended ≥ +5°C.

Coolant and lube oil systems

- Coolant and lube oil system have to be preheated for each individual engine, see section Starting conditions, Page 43.

  See also the specific information regarding special arrangements for arctic conditions, see section Lube oil system, Page 183 and Water systems, Page 198.
- Design requirements for the external preheater of HT cooling water systems according to stated preheater sizes, see figure Required preheater size to avoid heat extraction from HT system, Page 55.
- Maximum permissible antifreeze concentration (ethylene glycol) in the engine cooling water.

  An increasing proportion of antifreeze decreases the specific heat capacity of the engine cooling water, which worsens the heat dissipation from the engine and will lead to higher component temperatures.
- If antifreeze agents must be used, consult Everllence beforehand. Antifreeze agents reduce the capacity of the coolant to absorb heat. In some cases the cooling effect of the coolant may be insufficient.
- For information regarding engine cooling water see section Specification for engine supplies, Page 153.

Insulation

The design of the insulation of the piping systems and other plant parts (tanks, heat exchanger etc.) has to be modified and designed for the special requirements of arctic conditions.

2026-10-29 - 10.1

Heat tracing

To support the restart procedures in cold condition (e.g. after unmanned survival mode during winter), it is recommended to install a heat tracing system in the pipelines to the engine.

Note:
A preheating of the lube oil has to be ensured. If the plant is not equipped with a lube oil separator (e.g. plants only operating on DMA) alternative equipment for preheating of the lube oil must be provided.

For plants taken out of operation and cooled down below temperatures of +5°C additional special measures are needed – in this case contact Everllence.

Heat extraction HT system and preheater sizes

Start-up of an engine at arctic conditions (air intake temperatures of the engine below +0°C) has to be done with a preheated engine (normal start), see section Start-up and load application.

Engine operation under arctic conditions and at low load carries the risk of heat loss in the cooling water systems and resulting risk of engine operation problems or even damage.

Therefore three cases are given:

Case 1 Preheating of the intake air of the engine to a minimum of 10°C

Case 2 Installation of adequate HT preheater, that operates in parallel to engine operation to compensate HT energy losses

If operation within Range I is required,

a) the preheater size within the plant must be capable to compensate any heat losses within the cooling water system and to keep these on the required temperature level.

b) all preheaters need to be operated in parallel to engine operation until minimum engine load is reached.

2026-10-29 - 10.1

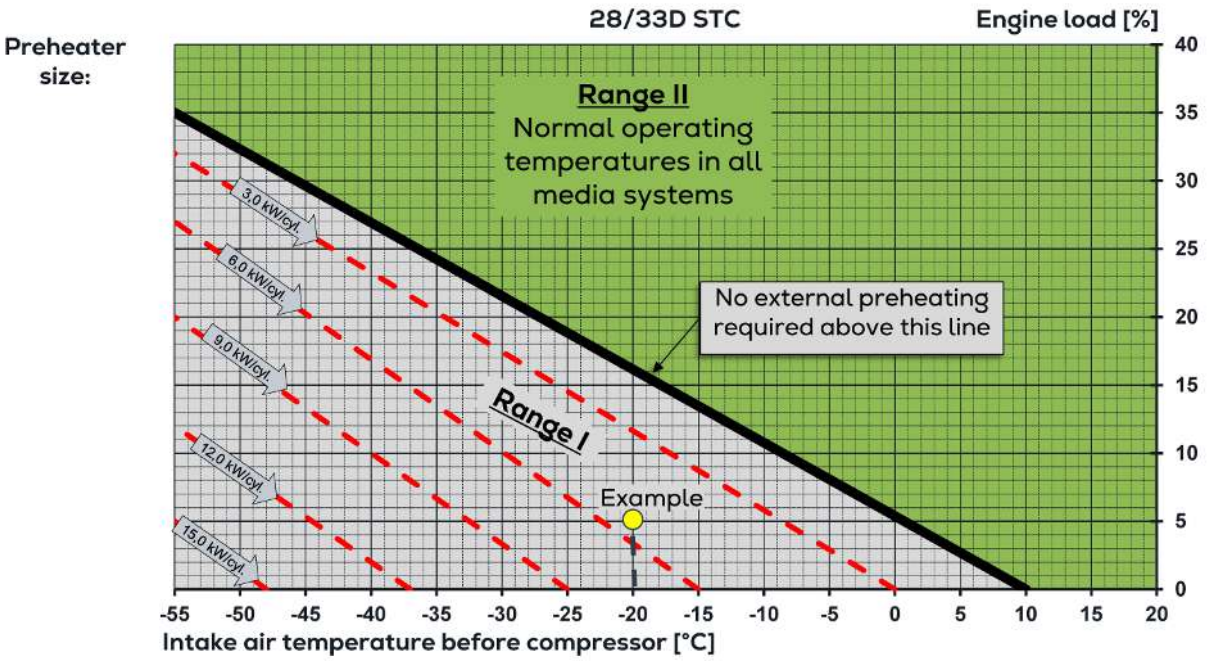


Figure 20: Required preheater size to avoid heat extraction from HT system

Example:

- Operation at 5% engine load and -20°C intake air temperature wanted.
- Preheating of intake air from -20°C up to minimum -0°C required.
- According diagram preheater size of 6 kW/cyl. required.
- Ensure that this preheater size is installed, otherwise this operation point is not permissible.

Case 3

Start up and fast passage through the area with HT energy loss.

In case operation within Range I is **not required** and the needed additional preheater capacity will not be applied, than following needs to be noticed:

- Start up and load up to a minimum of the stated engine load, where no external preheating is not longer required, must be done within ≤ 5 min.

  Within this 5 min the stored heat of the preheated media systems can overcome the possible heat loss, without the risk of operation problems of the engine.
- Operation in Range I must be avoided.
- For operation within Range I without the needed additional preheater capacity, no guarantee can be given for a stable, trouble free engine operation.

2.10 Earthing measures of diesel engines

General

The use of electrical equipment on diesel engines requires precautions to be taken for protection against shock current and for equipotential bonding. These measures not only serve as shock protection but also for functional protection of electric and electronic devices (EMC protection, device protection in case of welding, etc.).

2026-10-29 - 10.1

Earthing connections on the engine

Threaded bores M12, 17 mm deep, marked with the earthing symbol are provided in the engine foot on both ends of the engine.

It has to be ensured that earthing is carried out immediately after engine set-up. If this cannot be accomplished any other way, at least provisional earthing is to be effected right after engine set-up.

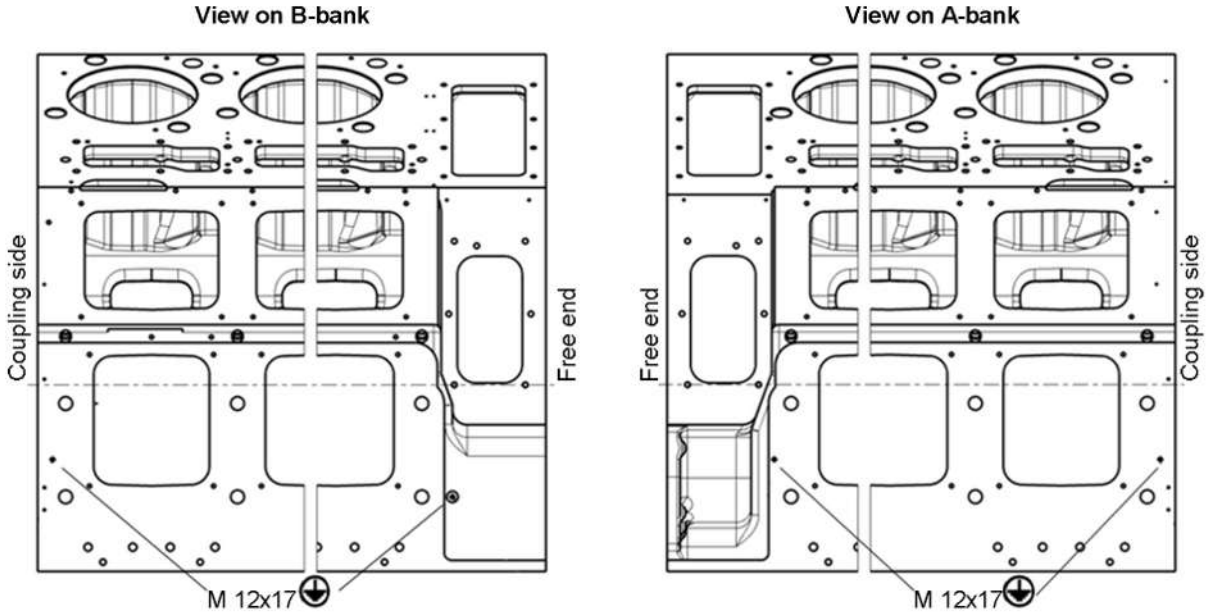


Figure 21: Earthing connection on engine

Earthing conductor

The nominal cross section of the earthing conductor (equipotential bonding conductor) has to be selected in accordance with DIN VDE 0100, part 540 (up to 1 kV) or DIN VDE 0141 (in excess of 1 kV).

Generally, the following applies:

The protective conductor to be assigned to the largest main conductor is to be taken as a basis for sizing the cross sections of the equipotential bonding conductors.

Earthing conductors have to be provided at two diagonally opposite points of engine.

Flexible conductors have to be used for the connection of resiliently mounted engines.

Execution of earthing

The earthing must be executed by the shipyard, since generally it is not scope of supply of Everllence.

Earthing strips are also not included in the Everllence scope of supply.

Additional information regarding the use of welding equipment

In order to prevent damage on electrical components, it is imperative to earth welding equipment close to the welding area, that is, the distance between the welding electrode and the earthing connection should not exceed 10 m.

2026-10-29 - 10.1

2.11 Propeller operation

2.11.1 STC operating range for mechanical propulsion

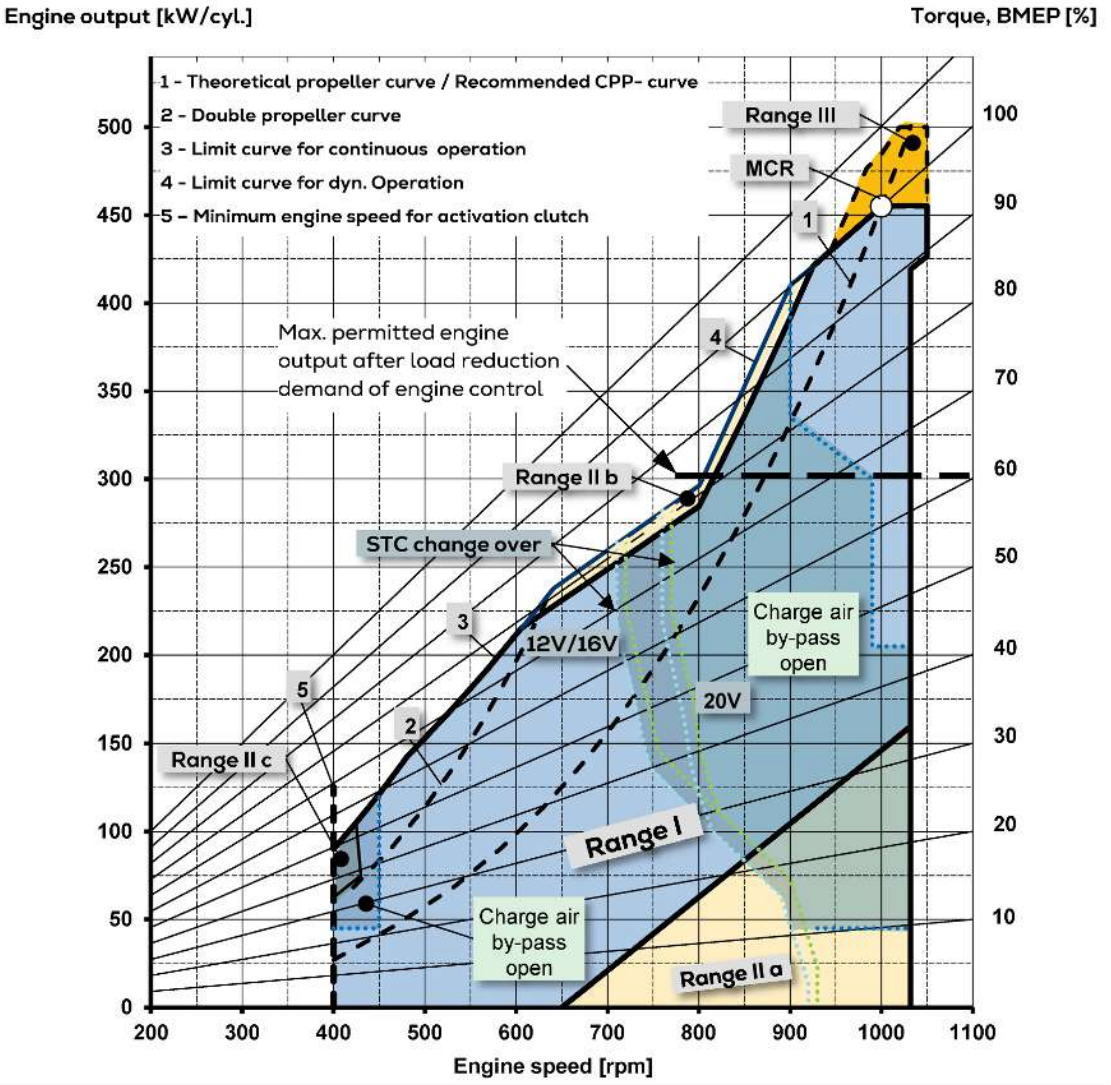


Figure 22: STC operating range for mechanical propulsion

Note:
In rare occasions it might be necessary that certain engine speed intervals have to be barred for continuous operation.
For applications using resilient mounted engines, the admissible engine speed range has to be confirmed (preferably at an early project phase) by a torsional vibration calculation, by a dimensioning of the resilient mounting, and, if necessary, by an engine operational vibration calculation.

MCR = Maximum continuous rating.

2026-10-29 - 10.1

Operating ranges

Range I: Operating range for continuous operation.

Note:

Operation at higher power or lower speed than limited by the "limit curve for continuous operation" is only permitted for less than 1 minute.

Range II: Operating range which is temporarily (less than 1 minute) admissible e.g. during acceleration and manoeuvring (II a, II b and II c).

Range III: For engines with ICFN power definition ("Navy" load profile) as described in section Power definition and load profile, Page 35.

Recommendation for manoeuvring

- For fast load response during manoeuvring we recommend to use left side of range I, before change from one TC to both TC (300 rpm up to max. 700 rpm)
- For CPP power trains with manoeuvring power requirements up to nominal power we recommend nominal speed operation

Determining the engine power

The energy demand or the energy losses from all aggregates additionally attached to engine have to be considered (e.g. shaft alternators, gearboxes).

After deduction of their energy demand from the engine power, the remaining engine power must be sufficient for the required propulsion power.

IMO certification for V28/33D STC engines with operating range for controllable pitch propeller (CPP)

Test cycle type E2 will be applied for the engine´s certification for compliance with the NO_x limits according to NO_x technical code.

STC

The V28/33D STC engine is equipped with a sequentially turbocharging (STC) using two turbochargers, one of them being switched off at lower engine loads.

Within figure STC operating range for mechanical propulsion, Page 58 the operating area with one turbocharger and with both turbochargers is stated.

The turbocharger arrangement is shown in figure Overview flaps, Page 32.

2.11.2 General requirements for the CPP propulsion control

Pitch control of the propeller plant

General

A distinction between constant-speed operation and combinator-curve operation has to be ensured.

Failure of propeller pitch control:

In order to avoid overloading of the engine upon failure of the propeller pitch control, the propeller pitch must be adjusted to a value, so that the resulting propeller-curve is covered by the allowed area for continuous operation within the operating diagram.

4–20 mA load indication from engine control

As a load indication a 4–20 mA signal from the engine control is supplied to the propeller control.

2026-10-29 - 10.1

Combinator-curve operation:

The 4–20 mA signal has to be used for the assignment of the propeller pitch to the respective engine speed. The operation curve of engine speed and propeller pitch (for power range, see section STC operating range for mechanical propulsion, Page 58) has to be observed also during acceleration/load increase and unloading.

Acceleration/load increase

The engine speed has to be increased prior to increasing the propeller pitch (see figure Example to illustrate the change from one load step to another, Page 61).

When increasing propeller pitch and engine speed synchronously, the speed has to be increased faster than the propeller pitch.

Automatic limitation of the rate of load increase must be implemented in the propulsion control.

Deceleration/unloading the engine

The engine speed has to be reduced later than the propeller pitch (see figure Example to illustrate the change from one load step to another, Page 61).

When decreasing propeller pitch and engine speed synchronously, the propeller pitch has to be decreased faster than the speed.

2026-10-29 - 10.1

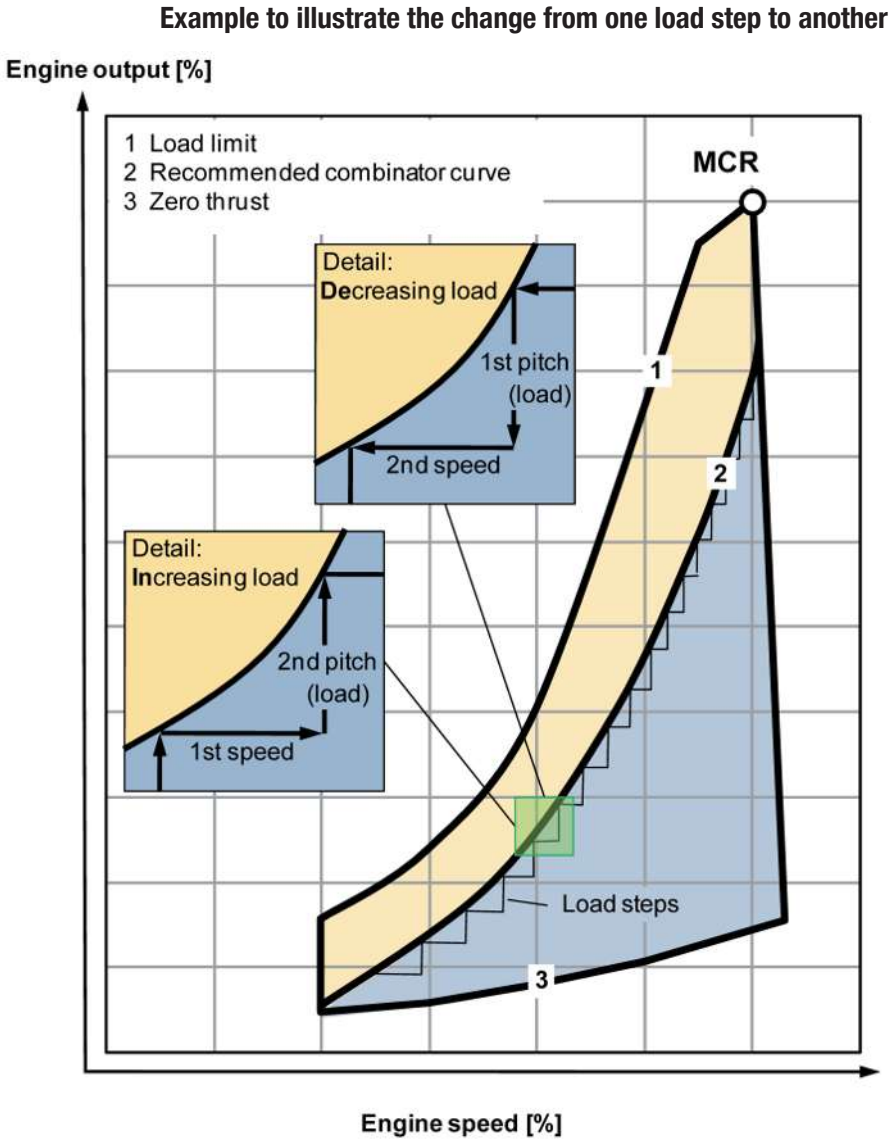


Figure 23: Example to illustrate the change from one load step to another

Windmilling protection

If a stopped engine (fuel admission at zero) is being turned by the propeller, this is called “windmilling”. The permissible period for windmilling is short, because windmilling can cause excessive wear of the engine bearings, due to poor lubrication at low propeller speed.

Single-screw ship

The propeller control has to ensure that the windmilling time is less than 40 sec.

Multiple-screw ship

The propeller control has to ensure that the windmilling time is less than 40 sec. In case of plants without shifting clutch, it has to be ensured that a stopped engine cannot be turned by the propeller.

For maintenance work a shaft interlock has to be provided for each propeller shaft.

2026-10-29 - 10.1

Binary signals from engine control

Overload contact

The overload contact will be activated when the engine's fuel admission reaches the maximum position. At this position, the control system has to stop the increase of the propeller pitch. If this signal remains longer than the predetermined time limit, the propeller pitch has to be decreased.

Contact "Operation close to the limit curve"

This contact is activated when the engine is operated close to a limit curve (torque limiter, charge air pressure limiter, etc.). When the contact is activated, the control system has to stop the increase of the propeller pitch. If this signal remains longer than the predetermined time limit, the propeller pitch has to be decreased.

Propeller pitch reduction contact

This contact is activated when disturbances in engine operation occur, for example too high exhaust gas mean-value deviation. When the contact is activated, the propeller control system has to reduce the propeller pitch to 60% of the rated engine output, without change in engine speed.

In section Engine load reduction as a protective safety measure the requirements for the response time are stated.

The power range (see section STC operating range for mechanical propulsion, Page 58) and the acceleration times (see section Load application for mechanical propulsion, Page 62 and figure Control lever setting and corresponding engine specific acceleration times (for guidance), Page 64 have to be observed.

In section Engine load reduction as a protective safety measure, Page 50 the requirements for the response time are stated.

2.11.3 Load application for mechanical propulsion

Acceleration times for controllable pitch propeller plants

General remark

Stated acceleration times in the following figure are valid for the engine itself. Depending on the project-specific propulsion train (moments of inertia, vibration calculation etc.) project-specific this may differ. Of course, the acceleration times are not valid for the ship itself, due to the fact, that the time constants for the dynamic behavior of the engine and the vessel may have a ratio of up to 1:100, or even higher (dependent on the type of vessel). The effect on the vessel must be calculated separately.

Propeller control

For remote controlled propeller drives for ships with unmanned or centrally monitored engine room operation in accordance to IACS “Requirements concerning MACHINERY INSTALLATIONS”, M43, a single control device for each independent propeller has to be provided, with automatic performance preventing overload and prolonged running in critical speed ranges of the propelling machinery. Operation of the engine according to the relevant and specific operating range (e.g. Operating range for controllable pitch propeller (CPP)) has to be ensured. In case of a manned engine room and manual operation of the propulsion drive, the engine room personnel are responsible for the soft loading sequence, before control is handed over to the bridge.

Load control programme

The lower time limits for normal and emergency manoeuvres are given in our diagrams for application and shedding of load. We strongly recommend that the limits for normal manoeuvring are observed during normal operation. An automatic change-over to a shortened load programme is required for emergency manoeuvres. The final design of the programme should be jointly determined by all the parties involved, considering the demands for manoeuvring and the actual service capacity.

2026-10-29 - 10.1

2026-10-29 - 10.1

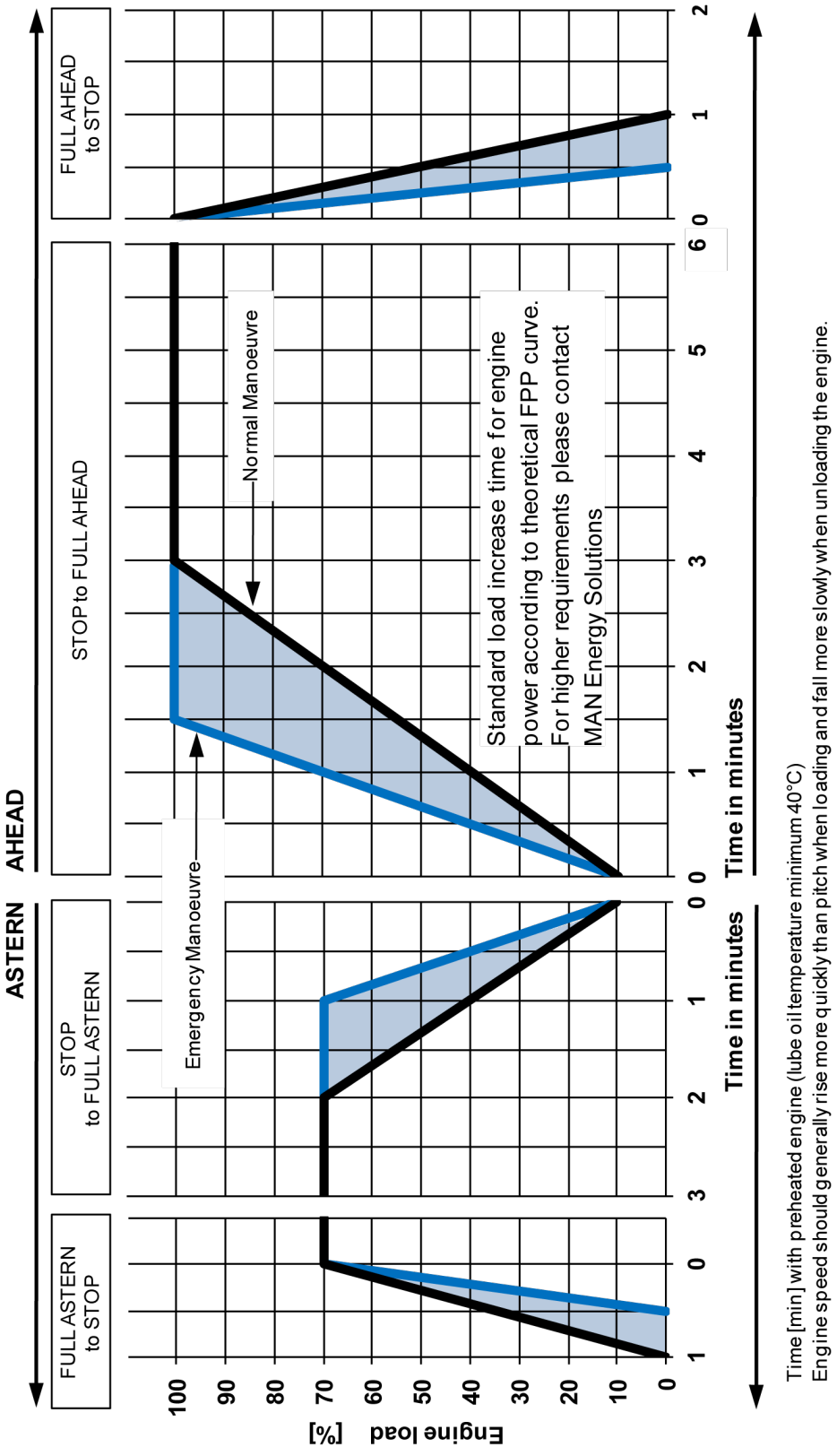


Figure 24: Control lever setting and corresponding engine specific acceleration times (for guidance)

2.12 Fuel oil, lube oil, starting air and control air consumption

2.12.1 Fuel oil consumption for emission standard: IMO Tier II

Note:

All below stated fuel consumption values are for engines equipped with duplex paper lube oil filter.

Engine V28/33D STC – Mechanical propulsion with controllable pitch propeller (CPP), 455 kW/cyl., (ICN), compliant with IMO NO_x Tech. Code 2028

455 kW/cyl., 1,000 rpm

% Output	Spec. fuel consumption [g/kWh] with DMA and with all attached pumps[1) 2) 3)]				
	100 [4)]	85	75	50	25
Speed (constant)	1,000 rpm				
12V28/33D STC	189	192.5	195	208	259
16V/20V28/33D STC	188	190.5	193	205	254
Speed (recommended CPP-curve)	1,000 rpm	947 rpm	909 rpm (IMO: 910 rpm)	794 rpm (IMO: 800 rpm)	630 rpm
12V28/33D STC	189	190.5	191	199	205
16V/20V28/33D STC	188	188.5	189	196	202

[1)] Tolerance +5%.

Note: The additions to fuel consumption must be considered before the tolerance for warranty is taken into account.

[2)] Based on reference conditions, see table Reference conditions for fuel consumption, Page 67.

[3)] Relevant for engine´s certification for compliance with the NO_x limits according E2 Test cycle.

[4)] Warranted fuel consumption at 100% MCR.

Table 21: Fuel consumption – Mechanical propulsion with controllable pitch propeller (CPP)[3)]

2026-10-29 - 10.1

Engine V28/33D STC – Mechanical propulsion with controllable pitch propeller (CPP), "Navy", 500 kW/cyl., (ICFN), compliant with IMO NO_x Tech. Code 2028

500 kW/cyl., 1,032 rpm (ICFN), constant speed, for test cycle E2

% Output	Spec. fuel consumption [g/kWh] with DMA and with all attached pumps[1) 2) 3)]				
	100	85	75	50	25
Output [kW/cyl.][4)]	500 [5)]	425	375	250	125
Speed [rpm]	1,032				
12V28/33D STC	194	199	198	207.5	206
16V/20V28/33D STC	192	197	196	204.5	206

[1)] Tolerance +5%.

Note: The additions to fuel consumption must be considered before the tolerance for warranty is taken into account.

[2)] Based on reference conditions, see table Reference conditions for fuel consumption, Page 67.

[3)] Relevant for engine´s certification for compliance with the NO_x limits according E2 Test cycle.

[4)] IMO relevant load points.

[5)] For engines with ICFN power definition (Navy load profile) as described in section Power definition and load profile, Page 35.

Table 22: Fuel consumption – Mechanical propulsion with controllable pitch propeller (CPP), load profile "Navy"[5)], constant speed

2026-10-29 - 10.1

500 kW/cyl., 1,032 rpm (ICFN), recommended CPP curve

% Output	Spec. fuel consumption [g/kWh] with DMA and with all attached pumps[1) 2) 3)]					
	100	91 [4)]	85	75	50	25
Output [kW/cyl.]	**500** [5)]	**455**	**425**	**375**	**250**	**125**
Speed [rpm]	**1,032**	**1,000**	**978**	**938 (IMO: 939)**	**819 (IMO: 826)**	**650**
12V28/33D STC	194	192	190.5	190.5	196	198.5
16V/20V28/33D STC	192	192	190.5	190.5	196	198.5

[1)] Tolerance +5%.

Note: The additions to fuel consumption must be considered before the tolerance for warranty is taken into account.

[2)] Based on reference conditions, see table Reference conditions for fuel consumption, Page 67.

[3)] Relevant for engine´s certification for compliance with the NO_x limits according E2 Test cycle.

[4)] Warranted fuel consumption at MCR, 455 kW/cyl. at 1,000 rpm.

[5)] For engines with ICFN power definition (Navy load profile) as described in section Power definition and load profile, Page 35.

Table 23: Fuel consumption – Mechanical propulsion with controllable pitch propeller (CPP), load profile "Navy"[5)], recommended CPP curve

Fuel oil consumption at idle running

Speed	Fuel consumption based on DMA (42,700 kJ/kg) [kg/h per cyl.]
1,000 rpm/1,032 rpm	10
400 rpm	2

Table 24: Fuel oil consumption at idle running

Reference conditions for fuel consumption

According to ISO 15550; ISO 3046-1

Air temperature before turbocharger t_r	K/°C	298/25
Total atmospheric pressure p_r	kPa	100
Relative humidity Φ_r	%	30
Exhaust gas back pressure after turbocharger[1)]	kPa	5
Engine type specific reference charge air temperature before cylinder t_{bar} [2)]	K/°C	313/40
Net calorific value NCV[3)]	kJ/kg	42,700

[1)] Measured at 100% load, accordingly lower for loads < 100%.

[2)] Specified reference charge air temperature corresponds to a mean value for all cylinder numbers that will be achieved with 25°C LT cooling water temperature before charge air cooler (according to ISO).

[3)] Stated figures for DMA, DMB or HFO valid for fuel type fulfilling the stated quality requirements and without contents of FAME or synthetic fuels, that may result in low volumetric heat values.

Table 25: Reference conditions for fuel consumption V28/33D STC

IMO Tier II requirements:

For detailed information see section Cooling water system, Page 198.

2026-10-29 - 10.1

IMO: International Maritime Organization

MARPOL 73/78; Revised Annex VI-2008, Regulation 13

Tier II: NO_x technical code on control of emission of nitrogen oxides from diesel engines.

2026-10-29 - 10.1

2.12.2 Lube oil consumption

455 kW/cyl. at 1,000 rpm or 500 kW/cyl. at 1,032 rpm

Specific lube oil consumption:

$$0.4\ \text{g/kWh}^{1)} \times \frac{100\%}{\text{load\%}} \times \frac{455\ \text{kW/cyl.}}{\text{nominal output per cyl.}}$$

Load%	Actual engine load	[%]
Nominal output per cyl.	Insert the nominal output per cyl.	[kW/cyl.]

[1)] The value stated above is without any losses due to cleaning of filter and centrifuge or lube oil charge replacement. Tolerance for warranty +20%.

Example:

For nominal output 455 kW/cyl. and 100% actual engine load: 0.40 g/kWh

For nominal output 500 kW/cyl. and 100% actual engine load: 0.36 g/kWh

2026-10-29 - 10.1

2.12.3 Starting air and control air consumption

Starting air consumption

No. of cylinders, config.		12V	16V	20V
Air consumption at minimum moment of inertia[1]				
Air consumption per start	Nm³ [2]	1.8	1.5	1.6
Air consumption per slow turn without subsequent start[3]	Nm³ [2]	1.8	1.5	1.6
Reference moment of inertia for stated air consumption figures	kgm²	311	364	421
Air consumption at high moment of inertia[1]				
Air consumption per start	Nm³ [2]	3.4	3.4	3.2
Air consumption per slow turn without subsequent start[3]	Nm³ [2]	3.4	3.4	3.2
Reference moment of inertia for stated air consumption figures	kgm²	2,300		
Starting system active in case of start[4]	sec	2		
Starting system active in case of slow turn without subsequent start[4]	sec	15		

[1] The air consumption per starting manoeuvre/slow turn of the unit increases in relation to its total moment of inertia. Linear interpolation must be carried out between the stated figures to gain the relevant air consumption figures for the unit within the plant based on its total moment of inertia at start. Consider also the "Required minimum total moments of inertia" as stated within table Moments of inertia/flywheel – Operation with variable speed, Page 108.

[2] Nm³ corresponds to one cubic metre of gas at 20°C and 100.0 kPa abs.

[3] Required for plants with power management system demanding automatic engine start. Slow turn only will be activated after a long period of engine standstill. This value states the air consumption for slow turn manoeuvre only, without the air consumption for the automatically activated engine start after the end of the slow turn manoeuvre.

[4] Stated time duration for activated starting system only relevant for layout of starting air system
For layout of the starting air system, note:

- Starting air pressure stated within section Operating/service temperatures and pressures, Page 84.
- Maximum velocity (m/s) see section External pipe dimensioning, Page 171.
- Consider multiple start of engines ant the temporal distribution of events (e.g. activation of jet assist), if needed.
- See section External compressed air system – Dimensioning starting air receivers, compressors, Page 219.

Table 26: Starting air consumption – V28/33D STC

Control air consumption

No. of cylinders, config.		12V	16V	20V
Control air consumption	[Nm³/h][1]	1.3		

[1] Nm³ corresponds to one cubic metre of gas at 20°C and 100.0 kPa abs.

Table 27: Control air consumption – V28/33D STC

2026-10-29 - 10.1

2.12.4 Recalculation of fuel consumption

2.12.4.1 Additions to fuel consumption

Additions to fuel consumption (g/kWh)	
For engines equipped with lube oil automatic filter instead of lube oil duplex paper filter	An addition of 0,31% to be calculated
For engines equipped with PTO	An addition of 0,5% to be calculated
For exhaust gas back pressure after turbocharger > 50 mbar	See table: Influence of exhaust gas back pressure on fuel consumption dependent on load
In case a charge air blow-off device is installed and activated	Consult Everllence

Table 28: Additions to fuel consumption

Output	Factor (f_{Pg})
≥ 75%	0.00014
< 75% and > 50%	Linear interpolation
≤ 50%	0

Table 29: Influence of exhaust gas back pressure on fuel consumption dependent on load

2.12.4.2 Recalculation of fuel consumption dependent on ambient conditions

In accordance to ISO standard ISO 3046-1 "*Reciprocating internal combustion engines – Performance, Part 1: Declarations of power, fuel and lube oil consumptions, and test methods – Additional requirements for engines for general use*"Everllence has specified the method for recalculation of fuel consumption for liquid fuel dependent on ambient conditions for single-stage turbocharged engines as follows:

$$\beta = 1 + 0.0006 \times (t_{ax}-t_{ar}) + 0.0004 \times (t_{bax}-t_{bar}) + 0.07 \times (p_{ar}-p_{ax}) + fp_g \times (p_{gx}-p_{gr})$$

The formula is valid within the following limits:	
Ambient air temperature	5°C-55°C
Charge air temperature before cylinder	25°C-75°C
Ambient air pressure	0.885 bar-1.030 bar
Exhaust gas back pressure	50 mbar-80 mbar

Table 30: Limit values for recalculation of liquid fuel consumption

$$b_x = b_r \times \beta \qquad b_r = \frac{b_x}{\beta}$$

β	Fuel consumption factor

t_{bar}	Engine type specific reference charge air temperature before cylinder see table Reference conditions for fuel consumption, Page 67
f_{Pg}	See table Influence of exhaust gas back pressure on fuel consumption dependent on load, Page 71.

	Unit	Reference	At test run or at site
Specific fuel consumption	[g/kWh]	b_r	b_x
Ambient air temperature	[°C]	t_{ar}	t_{ax}
Charge air temperature before cylinder	[°C]	t_{bar}	t_{bax}
Ambient air pressure	[bar]	p_{ar}	p_{ax}
Exhaust gas back pressure[1)]	[mbar]	p_{gr}	p_{gx}
[1)] Based on 100% output.			

Table 31: Recalculation of liquid fuel consumption – Units and references

Example (calculated for 75% output)

Reference values:

b_r = 200 g/kWh, t_{ar} = 25°C, t_{bar} = 40°C, p_{ar} = 1.0 bar, p_{gr} = 50 mbar

At site:

t_{ax} = 45°C, t_{bax} = 50°C, p_{ax} = 0.9 bar, p_{gx} = 70 mbar

ß = 1 + 0.0006 x (45-25) + 0.0004 x (50-40) + 0.07 x (1-0.9) + 0.00014 x (70-50) = 1.026

b_x = ß x b_r = 1.026 x 200 = 205.2 g/kWh

2026-10-29 - 10.1

2.12.5 Influence of engine aging on fuel consumption

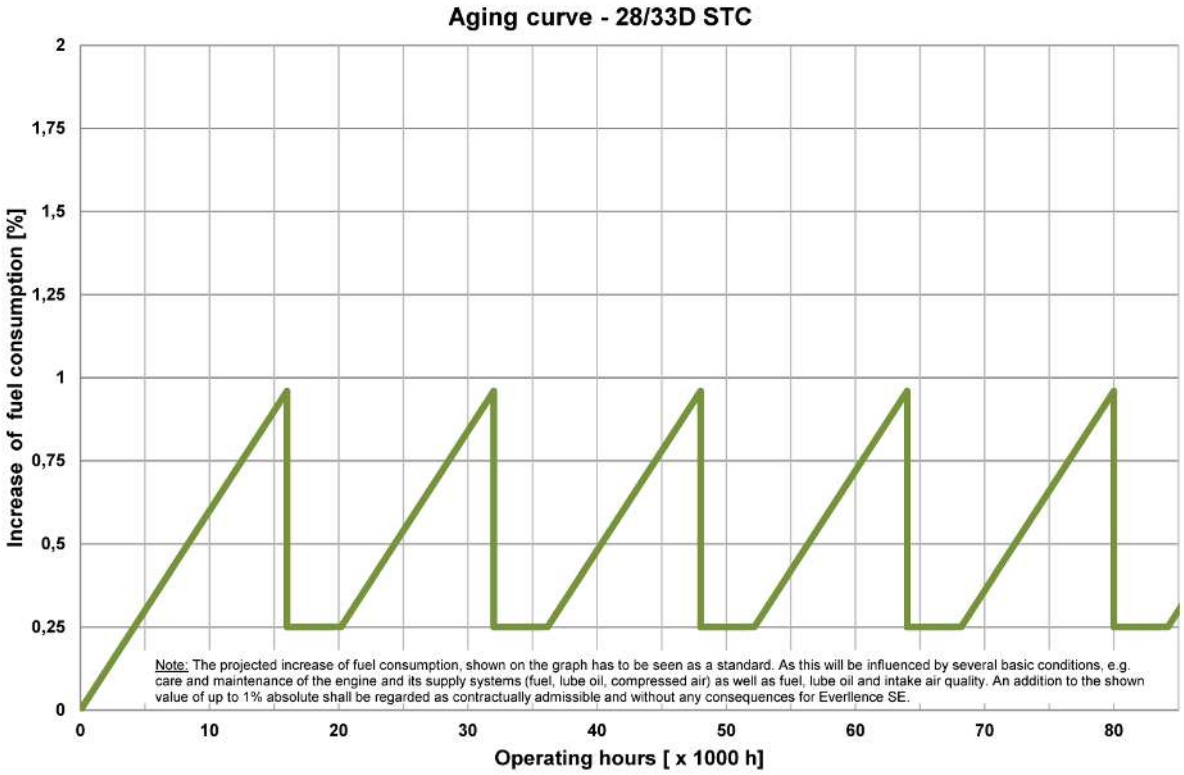


Figure 25: Influence of total engine running time and service intervals on fuel oil consumption

The fuel oil consumption will increase over the running time of the engine. Timely service can reduce or eliminate this increase. For dependencies see figure Influence of total engine running time and service intervals on fuel oil consumption, Page 73.

2.13 Planning data 455 kW/cyl., CPP IMO Tier II

2.13.1 Nominal values for cooler specification – 455 kW/cyl., CPP

455 kW/cyl.; 1,000 rpm, mechanical propulsion

Reference conditions: Tropics		
Air temperature	°C	45
Cooling water temp. before charge air cooler (LT stage)		38
Total atmospheric pressure	mbar	1,000
Relative humidity	%	60

Table 32: Reference conditions: Tropics

2026-10-29 - 10.1

No. of cylinders, config.		12V	16V	20V
Engine output	**kW**	**5,460**	**7,280**	**9,100**
Speed	rpm		1,000	
Heat to be dissipated[1]				
HT string: Charge air cooler (HT stage) Jacket cooling	kW	 1,237 915	 1,773 1,217	 2,259 1,509
LT string: Charge air cooler (LT stage) Lube oil cooler Turbocharger cooling		 968 892 20	 1,177 1,185 26	 1,494 1,475 33
Heat radiation (engine, based on engine room temp. 55°C)		117	155	194
Flow rates[2]				
HT circuit (1. engine/2. charge air cooler HT stage)	m^3/h	130 (130/65)	160 (160/75)	180 (180/75)
LT circuit (1. charge air cooler LT stage/2. lube oil cooler/3. compressor wheel casing cooling)		139 (54/135/4)	184 (108/180/4)	
Lube oil		108	134	160
Seawater		220	290	360
Pumps				
a) Attached pumps				
HT CW service pump at 4 bar, 1,000 rpm	m^3/h		190	
LT CW service pump at 4 bar, 1,000 rpm			190	
Lube oil service pump at 7.5 bar, 1,000 rpm		132	179	220
Fuel supply pump at 6.5 bar, 1,000 rpm			10.8	
Seawater pump at 3.5 bar, 1,000 rpm		300	380	460
b) Free-standing pumps[3]				
HT CW pump (preheating and post-cooling)	m^3/h	15	15	15
Prelubrication pump		16.5-19.5	20.5-24	24.5-28.5

[1] Tolerance: +8% for rating coolers and heat radiation, +6% for central (HT-, LT- and lube oil system), -12% for heat recovery from HT- or LT- or lube oil system.

[2] Basic values for layout of the coolers.

[3] Tolerance of the pump delivery capacities must be considered by the manufacturers.

Table 33: Nominal values for cooler specification – 455 kW/cyl.; 1,000 rpm

Note:
You will find further planning datas for the listed subjects in the corresponding sections.

- Minimal heating power required for preheating HT cooling water see paragraph MOD-004/HT cooling water preheating module, Page 203.

2026-10-29 - 10.1

2.13.2 Flow scheme for cooler specification – 455 kW/cyl., CPP

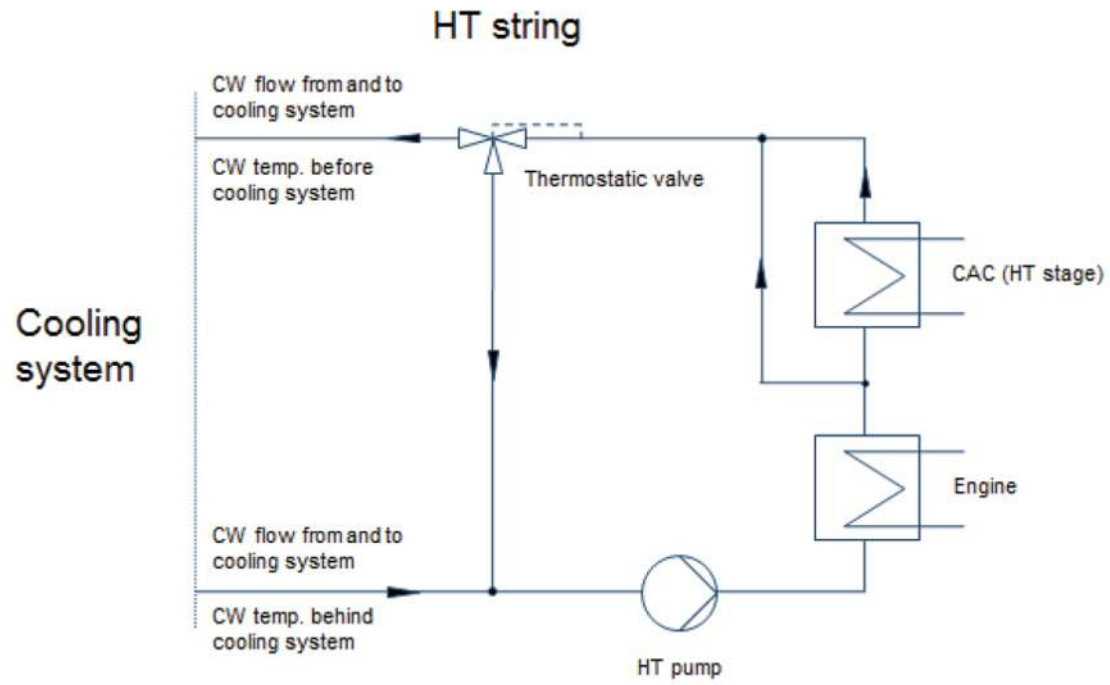


Figure 26: Flow scheme HT string

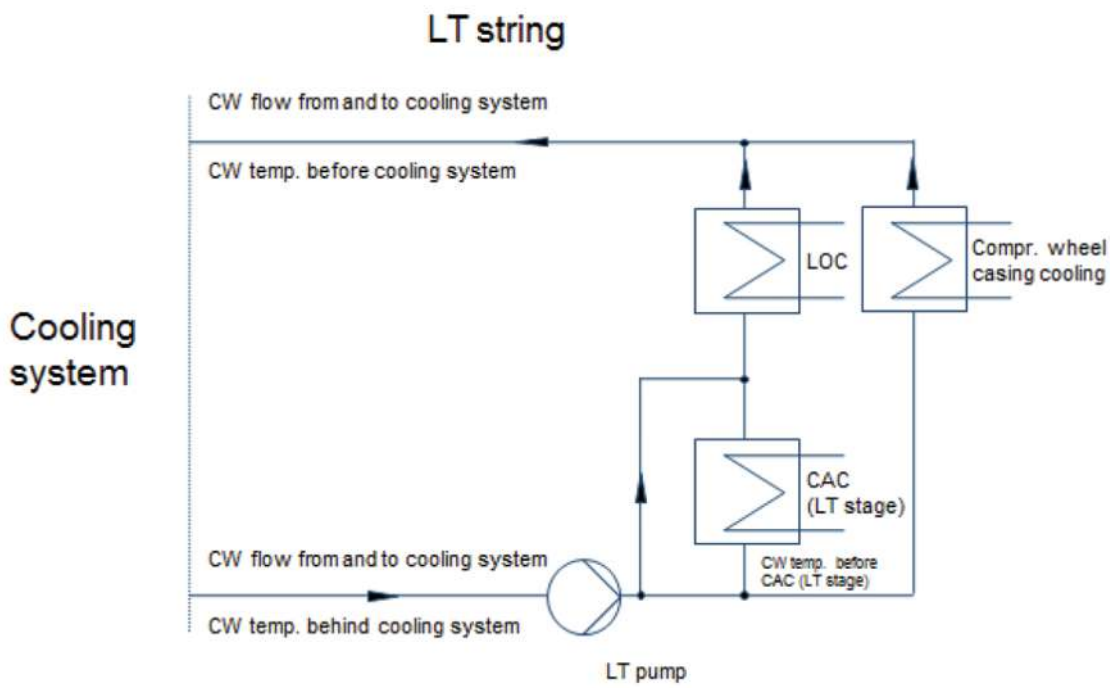


Figure 27: Flow scheme LT string

2026-10-29 - 10.1

2.13.3 Temperature basis, nominal air and exhaust gas data – 455 kW/cyl., CPP

455kW/cyl.; 1,000 rpm, mechanic propulsion

Reference conditions: Tropics		
Air temperature	°C	45
Cooling water temp. before charge air cooler (LT stage)		38
Total atmospheric pressure	mbar	1,000
Relative humidity	%	60

Table 34: Reference conditions: Tropics

No. of cylinders, config.		**12V**	**16V**	**20V**
Engine output	**kW**	**5,460**	**7,280**	**9,100**
Speed	rpm	1,000		
Temperature basis				
HT cooling water temperature before cooling system[1)]	°C	85		
LT cooling water air cooler inlet		38 (setpoint 32°C)[2)]		
Lube oil inlet engine		58[3)]		
Air data				
Temperature of charge air at charge air cooler outlet	°C	60.5	60.2	59.2
Air flow rate[4)]	m^3/h	32,859	43,812	54,768
	t/h	36	47.9	59.9
Charge air pressure (absolute)	bar abs	4.56	4.56	4.55
Air required to dissipate heat radiation (engine) (t_2 – t_1 = 10°C)	m^3/h	37,428	49,905	62,381
Exhaust gas data[5)]				
Volume flow (temperature turbocharger outlet)[6)]	m^3/h	68,806	91,695	114,497
Mass flow	t/h	37.1	49.4	61.8
Temperature at turbine outlet	°C	373	373	372
Heat content (190°C)	kW	2,049	2,728	3,397
Permissible exhaust gas back pressure	mbar	< 50		

[1)] HT cooling water flow first through water jacket and cylinder head, then through HT stage charge air cooler.

[2)] For design see figure External cooling water system diagram, Page 205.

[3)] 50°C with lube oil outlet temperature control (e.g. with attached lube oil automatic filter).

[4)] Under mentioned above reference conditions.

[5)] Tolerances: ±15°C for temperature at turbine outlet, ±4% for flow quantity.

[6)] Calculated based on stated temperature at turbine outlet and total atmospheric pressure according mentioned above reference conditions.

Table 35: Air and exhaust gas data – 455 kW/cyl.; 1,000 rpm

2026-10-29 - 10.1

2.13.4 Load specific values at ISO conditions – 455 kW/cyl., CPP

455 kW/cyl.; 1,000 rpm, mechanical propulsion

Reference conditions: ISO		
Air temperature	°C	25
Cooling water temp. before charge air cooler (LT stage)		25
Total atmospheric pressure	mbar	1,000
Relative humidity	%	30

Table 36: Reference conditions: ISO

Engine output	**%**	**100**	**85**	**75**	**50**	**25**
	kW/cyl.	**455**	**387**	**341**	**228**	**113**
Speed	rpm	1,000	947	910	800	630
Heat to be dissipated[1]						
Cooling water HT (jacket cooling + charge air cooler HT stage)[2]	kJ/kWh	1,192	1,211	1,171	1,070	1,722
Cooling water LT (charge air cooler LT stage, lube oil cooler, turbocharger cooling)[2]		1,041	1,067	1,064	1,168	1,439
Heat radiation		99	108	117	150	227
Air data						
Temperature of charge air: After compressor At charge air cooler outlet	°C	 217 40	 210 40	 194 40	 148 40	 139 40
Air flow rate	kg/kWh	6.91	7.15	7.23	7.89	9.4
Charge air pressure (absolute)	bar abs	4.55	4.09	3.69	2.57	2.38
Exhaust gas data[3]						
Mass flow	kg/kWh	7.11	7.35	7.43	8.1	9.61
Temperature at turbine outlet	°C	330	327	335	369	269
Heat content (190°C)	kJ/kWh	1,073	1,084	1,161	1,566	808
Permissible exhaust back pressure	mbar	< 50	-			

[1] Tolerance: +8% for rating coolers and heat radiation, +6% for central cooler (HT-, LT- and lube oil system), –12% for heat recovery from HT- or LT- or lube oil system (Tolerance refer to 100% engine output).

[2] The values of the particular numbers can differ depending on the charge air cooler specification.

[3] Tolerances: ±15°C for temperature at turbine outlet, ±4% for flow quantity (Tolerance refer to 100% engine output).

Table 37: Load specific values at ISO conditions – 455 kW/cyl.; 1,000 rpm

2026-10-29 - 10.1

2.13.5 Load specific values at tropical conditions – 455 kW/cyl., CPP

455 kW/cyl.; 1,000 rpm, mechanical propulsion

Reference conditions: Tropics		
Air temperature	°C	45
Cooling water temp. before charge air cooler (LT stage)		38
Total atmospheric pressure	mbar	1,000
Relative humidity	%	60

Table 38: Reference conditions: Tropics

Engine output	**%**	**100**	**85**	**75**	**50**	**25**
	kW/cyl.	**455**	**387**	**341**	**228**	**113**
Speed	rpm	1,000	947	910	800	630
Heat to be dissipated[1]						
Cooling water HT (jacket cooling + charge air cooler HT stage)[2]	kJ/kWh	1,491	1,500	1,450	1,332	2,071
Cooling water LT (charge air cooler LT stage, lube oil cooler, turbocharger cooling)[2]		1,188	1,241	1,256	1,373	1,768
Heat radiation		77	84	91	116	176
Air data						
Temperature of charge air: After compressor At charge air cooler outlet	°C	 248 59.2	 240 56.3	 222 53.7	 172 47.3	 161 43.4
Air flow rate	kg/kWh	6.59	6.82	6.89	7.53	8.97
Charge air pressure (absolute)	bar abs	4.54	4.06	3.64	2.5	2.3
Exhaust gas data[3]						
Mass flow	kg/kWh	6.79	7.02	7.1	7.74	9.18
Temperature at turbine outlet	°C	372	367	373	405	296
Heat content (190°C)	kJ/kWh	1,344	1,346	1,413	1,805	1,045
Permissible exhaust back pressure	mbar	< 50	-			

[1] Tolerance: +8% for rating coolers and heat radiation, +6% for central cooler (HT-, LT- and lube oil system), –12% for heat recovery from HT- or LT- or lube oil system (Tolerance refer to 100% engine output).

[2] The values of the particular numbers can differ depending on the charge air cooler specification.

[3] Tolerances: ±15°C for temperature at turbine outlet, ±4% for flow quantity (Tolerance refer to 100% engine output).

Table 39: Load specific values at tropical conditions – 455 kW/cyl.; 1,000 rpm

2026-10-29 - 10.1

2.14 Planning data 500 kW/cyl., CPP IMO Tier II

2.14.1 Nominal values for cooler specification – 500 kW/cyl., CPP

Load profile "Navy"

500 kW/cyl.; 1,032 rpm, (ICFN), mechanical propulsion

Reference conditions: Tropics		
Air temperature	°C	45
Cooling water temp. before charge air cooler (LT stage)		38
Total atmospheric pressure	mbar	1,000
Relative humidity	%	60

Table 40: Reference conditions: Tropics

No. of cylinders, config.		**12V**	**16V**	**20V**
Engine output	**kW**	**6,000**	**8,000**	**10,000**
Speed	rpm	1,032		
Heat to be dissipated[1)]				
HT string: Charge air cooler (HT stage) Jacket cooling	kW	 1,454 1,085	 2,087 1,443	 2,661 1,788
LT string: Charge air cooler (LT stage) Lube oil cooler		 1,088 946	 1,324 1,259	 1,679 1,567
Turbocharger cooling		22	29	36
Heat radiation (engine, based on engine room temp. 55°C)		120	160	200
Flow rates[2)]				
HT circuit (1. engine/2. charge air cooler HT stage)	m^3/h	134 (134/67)	165 (165/77)	186 (186/77)
LT circuit (1. charge air cooler LT stage/2. lube oil cooler/3. compressor wheel casing cooling)		143 (56/139/4)	190 (112/186/4)	
Lube oil		108	134	160
Seawater		227	300	370
Pumps				
a) Attached pumps				
HT CW service pump at 4 bar, 1,032 rpm	m^3/h	196		
LT CW service pump at 4 bar, 1,032 rpm		196		
Lube oil service pump at 7.5 bar, 1,000 rpm		132	179	220
Fuel supply pump at 6.5 bar		10.8 at 1,000 rpm 11.1 at 1,032 rpm		

2026-10-29 - 10.1

No. of cylinders, config.		12V	16V	20V
Engine output	**kW**	**6,000**	**8,000**	**10,000**
Seawater pump at 3.5 bar, 1,000 rpm		300	380	460
b) Free-standing pumps[3]				
HT CW pump (preheating and post-cooling)	m^3/h	15	15	15
Prelubrication pump		16.5-19.5	20.5-24	24.5-28.5
[1] Tolerance: +8% for rating coolers and heat radiation, +6% for central cooler (HT-, LT- and lube oil system), –12% for heat recovery from HT- or LT- or lube oil system.				
[2] Basic values for layout of the coolers.				
[3] Tolerance of the pump delivery capacities must be considered by the manufacturers.				

Table 41: Nominal values for cooler specification – 500 kW/cyl.; 1,032 rpm

Note:
You will find further planning datas for the listed subjects in the corresponding sections.

- Minimal heating power required for preheating HT cooling water see paragraph MOD-004/HT cooling water preheating module, Page 203.

2.14.2 Flow scheme for cooler specification – 500 kW/cyl., CPP

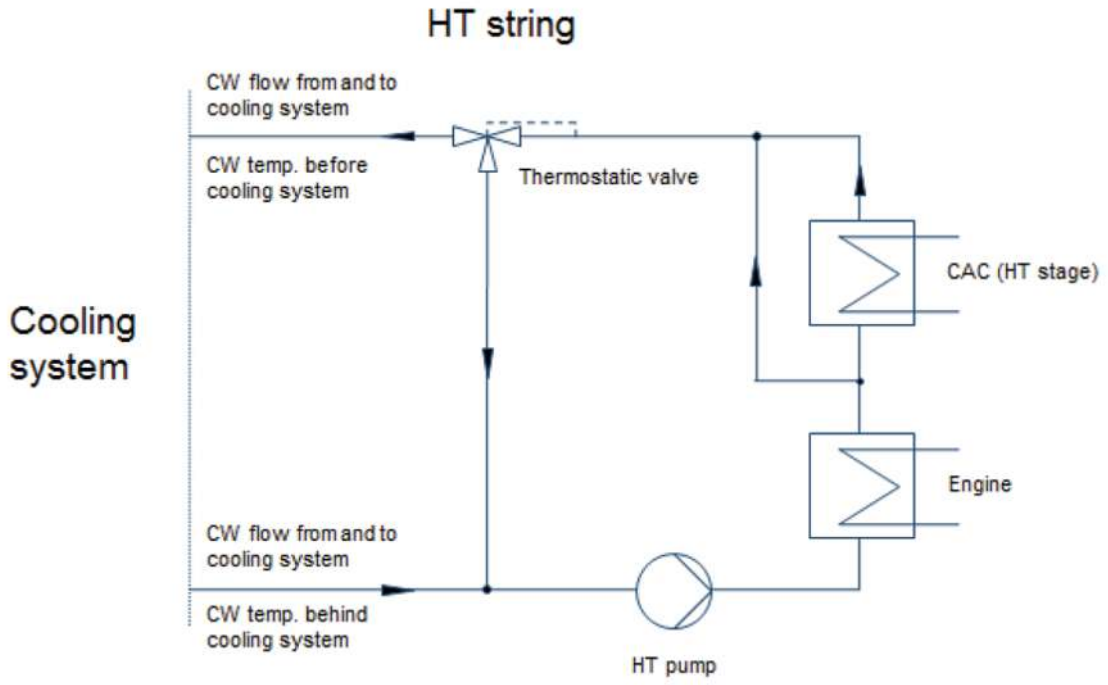


Figure 28: Flow scheme HT string

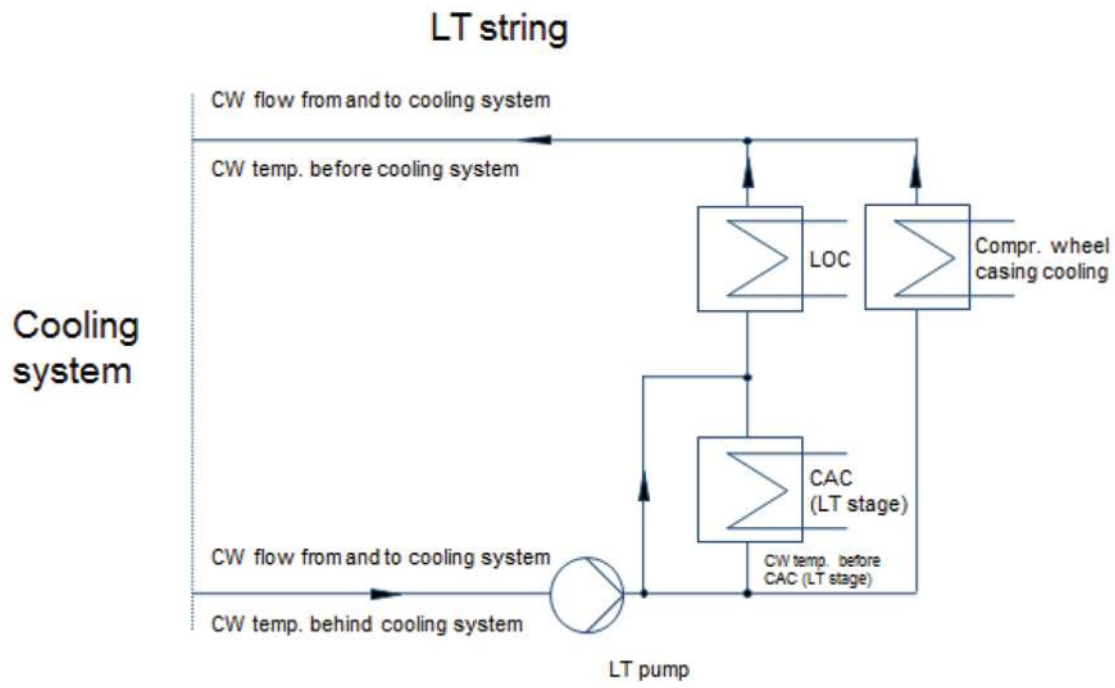


Figure 29: Flow scheme LT string

2.14.3 Temperature basis, nominal air and exhaust gas data – 500 kW/cyl., CPP

Load profile "Navy"

500 kW/cyl.; 1,032 rpm (ICFN), mechanic propulsion

Reference conditions: Tropics		
Air temperature	°C	45
Cooling water temp. before charge air cooler (LT stage)		38
Total atmospheric pressure	mbar	1,000
Relative humidity	%	60

Table 42: Reference conditions: Tropics

No. of cylinders, config.		**12V**	**16V**	**20V**
Engine output	**kW**	**6,000**	**8,000**	**10,000**
Speed	rpm	1,032		
Temperature basis				
HT cooling water temperature before cooling system[1)]	°C	85		
LT cooling water air cooler inlet		38 (setpoint 32°C)[2)]		
Lube oil inlet engine		58[3)]		
Air data				
Temperature of charge air at charge air cooler outlet	°C	62.5	62.2	61.1
Air flow rate[4)]	m^3/h	35,688	47,584	59,484

2026-10-29 - 10.1

No. of cylinders, config.		12V	16V	20V
Engine output	**kW**	**6,000**	**8,000**	**10,000**
	t/h	39.1	52.2	65.1
Charge air pressure (absolute)	bar abs	4.83	4.82	4.82
Air required to dissipate heat radiation (engine) (t_2 – t_1 = 10°C)	m^3/h	38,582	51,443	64,304
Exhaust gas data[5]				
Volume flow (temperature turbocharger outlet)[6]	m^3/h	77,970	103,886	129,710
Mass flow	t/h	40.3	53.7	67.2
Temperature at turbine outlet	°C	400	400	399
Heat content (190°C)	kW	2,572	3,422	4,262
Permissible exhaust gas back pressure	mbar	< 50		

[1] HT cooling water flow first through water jacket and cylinder head, then through HT stage charge air cooler.

[2] For design see figure External cooling water system diagram, Page 205.

[3] 50°C with lube oil outlet temperature control (e.g. with attached lube oil automatic filter).

[4] Under mentioned above reference conditions.

[5] Tolerances: ±15°C for temperature at turbine outlet, ±4% for flow quantity.

[6] Calculated based on stated temperature at turbine outlet and total atmospheric pressure according mentioned above reference conditions.

Table 43: Air and exhaust gas data – 500 kW/cyl.; 1,032 rpm

2.14.4 Load specific values at ISO conditions – 500 kW/cyl., CPP

Load profile "Navy"

500 kW/cyl.; 1,032 rpm (ICFN), mechanical propulsion

Reference conditions: ISO		
Air temperature	°C	25
Cooling water temp. before charge air cooler (LT stage)		25
Total atmospheric pressure	mbar	1,000
Relative humidity	%	30

Table 44: Reference conditions: ISO

Engine output	%	100	85	75	50	25
	kW/cyl.	500	425	375	250	125
Speed	rpm	1,032	978	939	826	650
Heat to be dissipated[1]						
Cooling water HT (jacket cooling + charge air cooler HT stage)[2]	kJ/kWh	1,282	1,213	1,220	1,110	1,747
Cooling water LT (carge air cooler LT stage, lube oil cooler, turbocharger cooling)[2]		1,058	1,061	1,077	1,164	1,410
Heat radiation		93	102	110	141	214

2026-10-29 - 10.1

Engine output	%	100	85	75	50	25
	kW/cyl.	500	425	375	250	125
Air data						
Temperature of charge air: After compressor At charge air cooler outlet	°C	 233 40	 215 40	 208 40	 158 40	 153 40
Air flow rate	kg/kWh	6.83	7.1	7.27	8.1	9.32
Charge air pressure (absolute)	bar abs	4.8	4.37	4.02	2.84	2.59
Exhaust gas data[3]						
Mass flow	kg/kWh	7.03	7.3	7.47	8.31	9.54
Temperature at turbine outlet	°C	354	334	329	345	255
Heat content (190°C)	kJ/kWh	1,248	1,134	1,118	1,386	659
Permissible exhaust back pressure	mbar	-	< 50	-		

[1] Tolerance: +8% for rating coolers and heat radiation, +6% for central cooler (HT-, LT- and lube oil system), -12% for heat recovery from HT- or LT- or lube oil system (Tolerance refer to 100% engine output).

[2] The values of the particular numbers can differ depending on the charge air cooler specification.

[3] Tolerances: ±15°C for temperature at turbine outlet, ±4% for flow quantity (Tolerance refer to 100% engine output).

Table 45: Load specific values at ISO conditions – 500 kW/cyl.; 1,032 rpm

2.14.5 Load specific values at tropical conditions – 500 kW/cyl., CPP

Load profile "Navy"

500 kW/cyl.; 1,032 rpm (ICFN), mechanical propulsion

Reference conditions: Tropics		
Air temperature	°C	45
Cooling water temp. before charge air cooler (LT stage)		38
Total atmospheric pressure	mbar	1,000
Relative humidity	%	60

Table 46: Reference conditions: Tropics

Engine output	%	100	85	75	50	25
	kW/cyl.	500	425	375	250	125
Speed	rpm	1,032	978	939	826	650
Heat to be dissipated[1]						
Cooling water HT (jacket cooling + charge air cooler HT stage)[2]	kJ/kWh	1,602	1,509	1,509	1,384	2,097
Cooling water LT (charge air cooler LT stage, lube oil cooler, turbocharger cooling)[2]		1,182	1,221	1,259	1,376	1,754
Heat radiation		72	80	86	109	167

2026-10-29 - 10.1

Engine output	%	100	85	75	50	25
	kW/cyl.	500	425	375	250	125
Air data						
Temperature of charge air: After compressor At charge air cooler outlet	°C	 266 61.1	 246 58	 238 55.7	 183 49	 176 44.2
Air flow rate	kg/kWh	6.51	6.77	6.93	7.73	8.89
Charge air pressure (absolute)	bar abs	4.82	4.35	3.99	2.78	2.51
Exhaust gas data[3]						
Mass flow	kg/kWh	6.72	6.97	7.14	7.94	9.11
Temperature at turbine outlet	°C	400	376	369	381	410
Heat content (190°C)	kJ/kWh	1,538	1,406	1,382	1,638	898
Permissible exhaust back pressure	mbar	< 50	-			

[1] Tolerance: +8% for rating coolers and heat radiation, +6% for central cooler (HT-, LT- and lube oil system), -12% for heat recovery from HT- or LT- or lube oil system (Tolerance refer to 100% engine output).

[2] The values of the particular cylinder numbers can differ depending on the cooler specification.

[3] Tolerances: ±15°C for temperature at turbine outlet, ±4% for flow quantity (Tolerance refer to 100% engine output).

Table 47: Load specific values at tropical conditions – 500 kW/cyl.; 1,032 rpm

2.15 Operating/service temperatures and pressures

Ambient air

	Min.	Max.
Ambient air temperature (outside vessel)	0°C[1]	45°C[2]

[1] Conditions below this temperature are defined as "arctic conditions" – see section Engine operation under arctic conditions, Page 52.

[2] In accordance with power definition. A reduction in power is required at higher temperatures.

Table 48: Ambient air

Engine room air

	Min.	Max.
Engine room air temperature	0°C recommended: 5°C[1]	55°C[2]

[1] Recommendation given to avoid any possibility for ice formation. In general it can be assumed that the air temperature in the area of the engine and attached components will be 5–10 K above the ambient air temperature outside the engine room.

[2] Air temperatures at the engine > 55°C are not permissible.

Table 49: Engine room air

2026-10-29 - 10.1

Intake air (conditions before compressor of turbocharger)

	Connection number internal media schemata "Charge air and exhaust gas diagram"	Min.	Max.
Intake air temperature compressor inlet	6101, 6102, TE6100	0°C[1]	45°C[2]
Intake air pressure compressor inlet	-	-20 mbar	-

[1] Conditions below this temperature are defined as "arctic conditions" – see section Engine operation under arctic conditions, Page 52. External intake air supply to be applied in this case.

[2] In accordance with power definition. A reduction in power is required at higher temperatures/lower pressures.

Table 50: Intake air (conditions before compressor of turbocharger)

Charge air (conditions within charge air pipe before cylinder)

	Connection number internal media schemata "Charge air and exhaust gas diagram"	Min.	Max.
Charge air temperature at charge air cooler inlet	TE6170	-	280°C
Charge air temperature at charge air cooler outlet / cylinder inlet[1]	TE6180	15°C	65°C
Lowest allowed charge air temperature cylinder inlet at engine start of a preheated engine			
DMA/HVO[2]	TE6180	0°C	-
Charge air pressure at charge air cooler inlet	PT6170	-	5 bar (absolute)
Charge air pressure at charge air cooler outlet / cylinder inlet[1]	PT6180	-	4.9 bar (absolute)

[1] Aim for a higher value in conditions of high air humidity (to reduce condensate amount).

[2] In case of falling below limit an engine start might not be possible or combustion anomalies might occur.

Table 51: Charge air (conditions within charge air pipe before cylinder)

HT cooling water – Engine

	Connection number internal media schemata "Cooling water system"	Min.	Max.
HT cooling water temperature engine inlet – Preheated before start	3121, TE3170	40°C	68°C
HT cooling water temperature at jacket cooling outlet[2]	TE3180	68°C	80°C[3]
HT cooling water temperature engine outlet[1]	3111, TE3190	79°C	95°C
HT cooling water pressure engine inlet, at nominal speed, nominal value 4 bar[4]	3121, PT3170	0.9 bar	5.5 bar
Pressure loss engine (total, for nominal flow rate)	-	-	1.35 bar

2026-10-29 - 10.1

	Connection number internal media schemata "Cooling water system"	Min.	Max.
Only for information:	-		
Pressure loss engine (without charge air cooler)		0.3 bar	0.5 bar
Pressure loss HT piping engine		0.2 bar	0.45 bar
Pressure loss charge air cooler (HT stage)		0.2 bar	0.4 bar
Pressure rise attached HT cooling water pump (attached as standard)	-	0.4 bar	5 bar

[1] Regulated temperature.

[2] SaCoS 5000 measuring point is jacket cooling outlet of the engine.

[3] Operation at alarm level.

[4] SaCoS 5000 measuring point is jacket cooling inlet.

Table 52: HT cooling water – Engine

HT cooling water – Plant

		Min.	Max.
Permitted pressure loss of external HT system (plant)	-	-	1.50 bar
Cooling water expansion tank			
Pre-pressure due to expansion tank at suction side of cooling water pump	-	0.45 bar	0.95 bar
Pressure loss from expansion tank to suction side of cooling water pump	-	-	0.1 bar

Table 53: HT cooling water – Plant

LT cooling water – Engine

	Connection number internal media schemata "Cooling water system"	Min.	Max.
LT cooling water temperature charge air cooler inlet (LT stage)	3221, TE4170	32°C[1]	38°C[2]
LT cooling water temperature charge air cooler outlet	TE4180	-	60°C
LT cooling water pressure charge air cooler inlet (LT stage), at nominal speed, nominal value 4 bar	3221, PT4170	0.8 bar	5.5 bar
Pressure loss charge air cooler (LT stage, for nominal flow rate)	-	-	0.6 bar
Pressure rise attached LT cooling water pump (attached as standard)	-	0.4 bar	4.6 bar

[1] Regulated temperature.

[2] In accordance with power definition. A reduction in power is required at higher temperatures/lower pressures.

Table 54: LT cooling water – Engine

2026-10-29 - 10.1

LT cooling water – Plant

	Connection number internal media schemata "Cooling water system"	Min.	Max.
Permitted pressure loss of external LT system (plant)	-	-	1.70 bar
Cooling water expansion tank			
Pre-pressure due to expansion tank at suction side of cooling water pump	-	0.45 bar	0.95 bar
Pressure loss from expansion tank to suction side of cooling water pump	-	-	0.1 bar

Table 55: LT cooling water – Plant

Seawater

		Min.	Max.
Seawater pressure seawater cooler inlet (if attached)	-	-	4 bar

Table 56: Seawater

Lube oil

	Connection number internal media schemata "Lubricating oil diagram"	Min.	Max.
Lube oil temperature engine inlet	2101, TE2170	50°C	68°C[1)]
Lube oil temperature engine inlet – Preheated before start[2)]	2101, TE2170	20°C	55°C[3)]
Lube oil temperature engine inlet – Preheated in case of stand-by operation[4)]	2101, TE2170	40°C	55°C[3)]
Lube oil pressure, at nominal speed (during engine operation)			
Lube oil pump outlet	-	-	8 bar
Engine inlet	2101, TE2170	2 bar[5)]	6 bar
Turbocharger inlet	PT2570	1.3 bar	2.2 bar
Prelubrication/postlubrication (duration ≤ 10 min) lube oil pressure			
Engine inlet	2101, PT2170	0.3 bar	5 bar
Turbocharger inlet	PT2570	0.2 bar	2.2 bar
Prelubrication/postlubrication (duration > 10 min) lube oil pressure			
Engine inlet	2101, PT2170	0.3 bar	0.6 bar
Turbocharger inlet	PT2570	0.2 bar	0.6 bar

2026-10-29 - 10.1

	Connection number internal media schemata "Lubricating oil diagram"	Min.	Max.
[1] Operation at alarm level. [2] Preheating required if minimum temperature +5°C of lube oil can not be kept. [3] If a higher temperature of the lube oil will be reached in the system, it is important at an engine start to reduce it as quickly as possible below alarm level to avoid a start failure. [4] See accordingly section External lube oil system, Page 189. [5] Operation at alarm level at a speed of < 600 rpm.			

Table 57: Lube oil

Fuel

	Connection number internal media schemata "Fuel system"	Min.	Max.
Fuel temperature engine inlet DMA according ISO 8217, DIN EN590 or equivalent fuel	5201, TE5070	-10°C[1]	45°C[2]
Fuel viscosity engine inlet DMA according ISO 8217, DIN EN590 or equivalent fuel	-	1.5 cSt	6 cSt
Fuel pressure before engine driven supply pump	-	-0.4 bar	0.5 bar[3]
Fuel pressure engine inlet	5201, PT5070	1.9 bar	7 bar
Fuel pressure engine inlet in case of black out (only for engine start idling)	5201, PT5070	0.2 bar	-
[1] Maximum viscosity not to be exceeded. “Pour point” and “Cold filter plugging point” have to be observed. [2] Not allowed to fall below minimum viscosity. [3] Pressure loss of piping included.			

Table 58: Fuel

Compressed air in the starting air system

	Connection number internal media schemata "Pressure air system"	Min.	Max.
Starting air pressure within vessel/pressure regulating valve inlet 12V	7101, PT7170	15 bar[1]	37 bar[2] [3]
Slow turn air pressure without subsequent start 12V	7171, PT7170	15 bar[1]	37 bar[2] [3]
Starting air pressure within vessel/pressure regulating valve inlet 16V	7101, PT7170	17 bar[1]	37 bar[2] [3]
Slow turn air pressure without subsequent start 16V	7171, PT7170	17 bar[1]	37 bar[2] [3]
Starting air pressure within vessel/pressure regulating valve inlet 20V	7101, PT7170	19 bar[1]	37 bar[2] [3]
Slow turn air pressure without subsequent start 20V	7171, PT7170	19 bar[1]	37 bar[2] [3]
Design pressure	-	-	PN40

2026-10-29 - 10.1

	Connection number internal media schemata "Pressure air system"	Min.	Max.
[1] After slow turn, the starting air pressure shall remain above the minimum starting pressure required for engine start. [2] Valid for attached PN40 air starter. For previous version of 30 bar air starter a pressure reducer 40/30 bar is necessary, that has to be installed 5 m before engine connection "starting motor" (7107). [3] For layout of the starting air system, note: ▪ Starting air consumption and start duration stated within section Starting air and control air consumption, Page 70. ▪ Maximum velocity (m/s) see section External pipe dimensioning, Page 171 - consider multiple start of engines, if needed.			

Table 59: Compressed air in the starting air system

Compressed air in the control air system

	Connection number internal media schemata "Pressure air system"	Min.	Max.
Control air pressure engine inlet Recommended	7102, PT7400 7102, PT7400	6.5 bar[1] 7 bar	9 bar -
[1] Operation at alarm level.			

Table 60: Compressed air in the control air system

Crankcase pressure (engine)

	Connection number internal media schemata "Lubrication oil diagram"	Min.	Max.
Pressure within crankcase	2841	-2.5 mbar	0 mbar

Table 61: Crankcase pressure (engine)

		Setting
Safety valve attached to the crankcase (opening pressure)	-	50-100 mbar

Table 62: Safety valve

Polar blow-off – Plant

		Min.	Max.
Permitted pressure loss of piping system for blow-off (plant)	-	-	50 mbar[1]
[1] 5% of air flow rate engine to be assumed for blow-off amount.			

Table 63: Charge air blow-off for ignition pressure limitation (plant)

Exhaust gas

	Connection number internal media schemata "Charge air and exhaust gas diagram"	Min.	Max.
Exhaust gas pressure turbine inlet	-	-	4 bar (absolute)
Exhaust gas temperature turbine inlet	TE6575	-	630°C

2026-10-29 - 10.1

	Connection number internal media schemata "Charge air and exhaust gas diagram"	Min.	Max.
Exhaust gas temperature turbine inlet at alarm level	TE6575	-	640°C
Exhaust gas temperature turbine outlet (normal operation under tropic conditions)	6511, 6512, TE6592	-	450°C
Exhaust gas temperature turbine outlet (emergency operation – STC function out of order at low load)	6511, 6512, TE6592	-	550°C
Minimum exhaust gas temperature after recooling due to exhaust gas heat utilisation	-	190°C[1)]	-
Exhaust gas back pressure after turbocharger (static)	6511, 6512	-	50 mbar[2)]

[1)] To avoid sulfur corrosion in the exhaust gas line (plant).

[2)] If this value is exceeded by the total exhaust gas back pressure of the designed exhaust gas line, sections Derating, definition of P_Operating, Page 37 and Increased exhaust gas pressure due to exhaust gas after treatment installations, Page 39 need to be considered.

Table 64: Exhaust gas

Note:
Operating pressures without further specification are below/above atmospheric pressure.

2.16 Leakage rate

Max. leak rate (clean fuel)	Burst leak rate in case of pipe break (for max. 1 min)
l/h per cyl.	l/min
DMA	
8	4

Table 65: Leakage rate

Note:

- The values given in this table are average values; there may be deviations in individual measurements, e.g. due to fuel temperature, fuel inlet pressure, wear condition of the high-pressure pump, etc.
- High flow rates of dirty leakage oil will only occur in case of a pipe break and should occur for short time only. An alarm will be activated (< 1 min) and the operator must take actions. Special considerations have to be taken for the layout of single engine plants. This leakage can be reused, if the entire fuel treatment of separation and filtration is done.
- The operating leakage (clean) consists out of the operating leakage amount of the high-pressure pumps, plus the operating leakage of the injector, which occur during normal operation due to their function. This leakage can be reused, if the entire fuel treatment of separation and filtration is done.
- All other leakage amounts (dirt fuel oil from filters or from engine drains) have to be discharged into the sludge tank.

2026-10-29 - 10.1

2.17 Filling volumes

Below stated LT and HT figures show the filling volumes within the engine. After engine stop, these volumes will drain from the engine and must be collected in a adequate tank.

Cooling water, fuel oil and oil volume of engine[1]					
No. of cylinders			**12**	**16**	**20**
On engine oil system with deep oil sump, 815 mm[3]	High oil level (eng. running)	litres	1,010	1,300	1,600
	Low oil level (eng. running)		845	1,093	1,352
On engine oil system with low oil sump, 550 mm[3]	High oil level (eng. running)		987	1,234	1,481
	Low oil level (eng. running)		822	1,027	1,233
On engine jacket (HT) water[2]			625	762	899
On engine (LT) water[2]			506	592	678

[1] The given values are for guidance only and may differ depending on the customer chosen engine specification.

[2] Be aware: This is just the amount inside the engine. By this amount the level in the service or expansion tank will be lowered when media systems are put in operation after first filling.

[3] Stated lube oil quantity represents the complete oil volume within the internal lube oil system and will be stored in the sump after engine stop.

Table 66: Cooling water, fuel oil and oil volume of engine

Below stated lube oil quantity represents the minimum oil volume required in the complete lubrication system to ensure continuous circulation through the engine.

Service tanks/expansion tanks	**Installation height**[1]	**Minimum effective capacity**		
	m	**m³**		
No. of cylinders		**12**	**16**	**20**
Expansion tank, cooling water HT circuit	4.5-9.5	0.15		
Expansion tank, cooling water LT circuit	4.5-9.5	0.15		
Fuel service tank	-4-6	according to classification rules		

[1] Installation height refers to tank bottom and crankshaft centre line.

Table 67: Service tanks/expansion tanks capacities

2.18 Venting amount of crankcase and turbocharger

A ventilation of the engine crankcase and the turbochargers is required, as described in section Crankcase vent, Page 196.

For the layout of the ventilation system guidance is provided below:

Due to normal blow-by of the piston ring package small amounts of combustion chamber gases get into the crankcase and carry along oil mist.

- The amount of crankcase blow-by air is approximately 0.1% of the engine´s air flow rate.

In addition, the sealing air of the turbocharger needs to be vented.

- The amount of turbocharger blow-by air is approximately:

2026-10-29 - 10.1

- For single-stage turbocharged engines 0.2% of the engine´s air flow rate. (Accordingly see Planning data, Page 73).
- For two-stage turbocharged engines 0.4% of the engine´s air flow rate. (Accordingly see Planning data, Page 73).

- The temperature of the crankcase and turbocharger blow-by air is approximately 15 K higher than the oil temperature at the engine´s oil inlet.
- The density of the crankcase and turbocharger blow-by air is 1.0 kg/m³ at the condition of approximately 70°C (343 K) and 1,013 mbar (assumption for calculation).

2.19 Exhaust gas emission

2.19.1 Maximum permissible NOx emission limit value IMO Tier II

IMO Tier II: Engine in standard version[1]

Rated speed	1,000 rpm	1,032 rpm
NO_X [1) 2) 3)] IMO cycle E2/E3	8.98 g/kWh[4)]	8.92 g/kWh[4)]
Note: The engine´s certification for compliance with the NO_X limits will be carried out during factory acceptance test according engine group concept.		
[1)] Cycle values, operation on DM grade fuel (marine distillate fuel: DMA) according ISO 8217, based on a LT charge air cooling water temperature of 32°C at 25°C reference seawater temperature. [2)] Calculated as NO_2. E2: Test cycle for "constant-speed main propulsion application" including electric propulsion and all controllable pitch propeller installations. E3: Test cycle for "propeller-law-operated main and propeller-law operated auxiliary engine" application. [3)] Based on a LT charge air cooling water temperature of 32°C at 25°C seawater temperature. [4)] Maximum permissible NO_X emissions for marine diesel engines according to IMO Tier II: $130 \le n \le 2000 \rightarrow 44 * n^{-0.23}$ g/kWh (n = rated engine speed in rpm).		

Table 68: Maximum permissible NO_X emission limit value

[1] Marine engines are guaranteed to meet the requirements of MARPOL Annex VI, regulations for the prevention of air pollution from ships, as amended.

2.19.2 Smoke emission index (FSN)

Smoke index FSN for engine loads ≥ 25% load well below limit of visibility (0.4 FSN).

Valid for:

- Distillate fuel according to ISO 8217 or RM-grade fuel, fulfilling the stated quality requirements.
- 50 mbar exhaust gas back pressure (at 100% output).

2026-10-29 - 10.1

Note:
An increased exhaust gas back pressure will also increase the FSN figure.
To be taken into account for ≥ 80 mbar exhaust gas back pressure.

2.19.3 Exhaust gas – possible components and visibility

The exhaust gas of reciprocating internal combustion engines is composed of numerous constituents. These are derived from either the combustion air and fuel and lube oil used, or they are reaction products, formed during the combustion process. Only some of these are to be considered as harmful substances.

The following listed exhaust gas components need to be seen as a general overview – the presence and amount of the singular component depends in large extends on the engine type, combustion process and fuel type.

Nitrogen N_2

Nitrogen (N_2) is with approximately 73–75 vol-% the main constituent of the exhaust gas.

Oxygen O_2

Approximately 21 vol-% of the ambient air is Oxygen (O_2).

Carbon dioxide CO_2

Carbon dioxide (CO_2) is a product of combustion.

Water vapour H_2O

The water in the exhaust comes from the combustion of the fuel and, to a lesser extent, from the moisture in the intake air. In diesel operation, the water vapour content is approximately 6 vol-%, in gas operation approximately 10 vol-%.

Inert gases Ar, Ne, He, etc.

Inert gases, such as Ar, Ne, He, etc., are constituents of the ambient air with a volume fraction of approximately 0.9 vol-%.

Sulphur oxides SO_x

Sulphur oxides (SO_x) are formed by the combustion of the sulphur contained in the fuel. The sulphur content in the fuel determines the SO_2 content in the exhaust gas.

Nitrogen oxides NO_x ($NO + NO_2$)

The high temperatures prevailing in the combustion chamber of an internal combustion engine cause the chemical reaction of nitrogen (contained in the combustion air as well as in some types of fuel) and oxygen (contained in the combustion air) to form nitrogen oxides (NO_x).

Carbon monoxide CO

Carbon monoxide (CO) is formed during incomplete combustion.

2026-10-29 - 10.1

Hydrocarbons HC

The hydrocarbons (HC) contained in the exhaust gas are composed of a multitude of various organic compounds as a result of incomplete combustion.

Particulate matter PM

Particulate matter (PM) consists of soot (elemental carbon) and ash.

Methanol CH_3OH

Methanol only occurs in methanol operation as result of incomplete combustion.

Formaldehyde CH_2O

Formaldehyde (CH_2O) is a gas known by its pungent smell. Its proportion in the exhaust gas depends on the fuel and the degree of combustion. If the proportion of formaldehyde (CH_2O) is high, it can be removed by an oxidation catalyst – this is only necessary for gas or methanol operation.

Nitrous oxide N_2O

Nitrous oxide (N_2O) is a gas that only might occur in relevant quantity in ammonia (NH_3) operation.

Visibility of the exhaust gas

The visibility of exhaust gas highly depends on ambient conditions and the observer's line of sight to the exhaust gas, background and the sun. The exhaust gas can either be seen or not depending on the ambient temperature, wind velocity, diameter and height of the chimney and the colouring of the background. It can be black, blue, brown, yellow or white depending on the components present in the exhaust gas. Black or gray exhaust gas is mainly due to the presence of carbon particles. A blue appearance is usually due to droplets resulting from the incomplete combustion of fuel or lubricating oil. A yellow or brown appearance can be caused by the presence of NO_2 in the exhaust gas. White exhaust gas may be caused by condensed water and/or liquid fuel.

2026-10-29 - 10.1

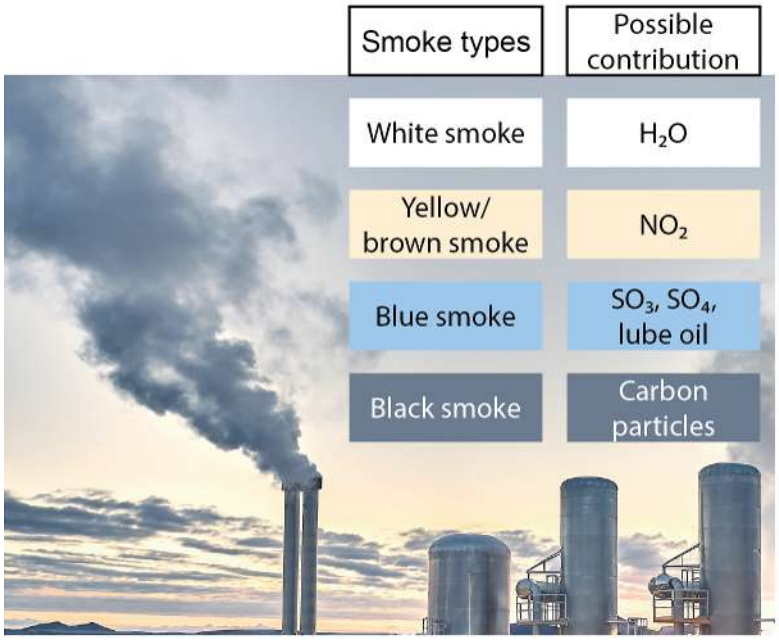


Figure 30: Possible components of the exhaust gas – Visibility

2.19.4 Emission-related installation instruction for engines

Position of the exhaust gas sampling points

The sampling position shall be fitted:

- At least 10 times the diameter of the exhaust pipe after the outlet of the engine, turbocharger or last after-treatment device
- In a straight pipe segment:
  - With an inlet path length before sampling position of at least 5 times the diameter of the exhaust pipe after last bending/obstruction/diameter deviation
  - With a path length after sampling position of at least 2 times the diameter of the exhaust pipe
- At least 5 times the diameter of the exhaust pipe before end of exhaust pipe
- Sufficiently close to the engine to ensure that the exhaust gas temperature at the sampling position will be minimum 180°C

If this is not attainable, a deviation of these requirements is acceptable if:

- justified by good engineering practice
- an incorrect measurement is not expected

2026-10-29 - 10.1

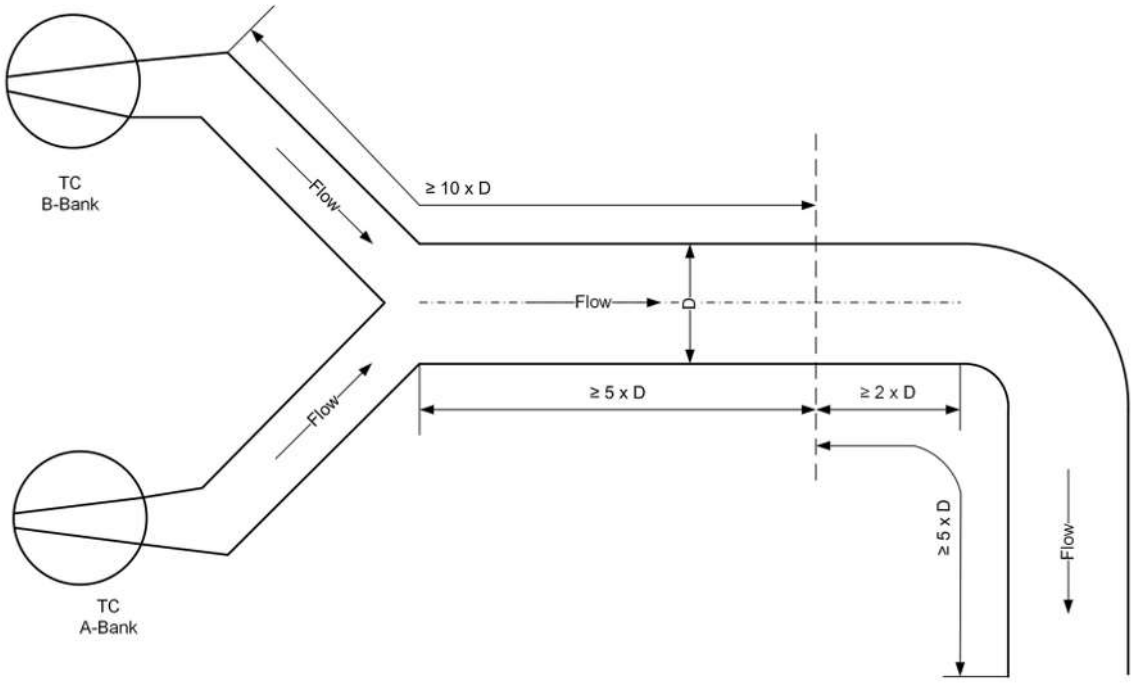


Figure 31: Position of sampling points (exemplary)

In the case an engine has distinct groups of manifolds, it is permissible to acquire a sample from each group individually and calculate an average exhaust emission. In this case, each sampling point must be designed as mentioned above.

The exhaust gas upstream the sampling point shall be free of any dilution from surrounding air or contamination from other exhaust gas systems.

Accessibility and working area at sampling point

The sampling point shall be accessible in a save way also during engine operation. In case the sampling point is covered by an insulation, the position shall be clearly visible marked on the insulation. The Insulation shall be designed in a way that it is easy to remove and to install again.

If necessary, a step has to be established.

There shall be enough space to place and operate the measurement equipment.

Requirements regarding the working area:

- Minimum space requirements: about 2-m width, 2-m depth, 2-m height
- Sufficient floor load capacity (at least 200 kg per m^2)
- Temperature at this working area should be within +5°C to + 40°C and well ventilated
- Not subjected to excessive vibrations
- If needed weather protection for personnel and equipment against sun, wind and rain

Depending on the measurement equipment it should be considered that during the measurements following items are available at the working area:

• Adequate lighting and ventilation

2026-10-29 - 10.1

- Power supply
- Pressurised air (instrument quality, oil free)
- Lifting devices for raising and lowering the equipment, if necessary

Exhaust pipe connection

- 1 piece of pipe thread inner diameter G 3” (use for particulate measurements)
- 2 pieces of pipe thread inner diameter G ½" (use for gaseous emission measurements or for smoke number measurement)

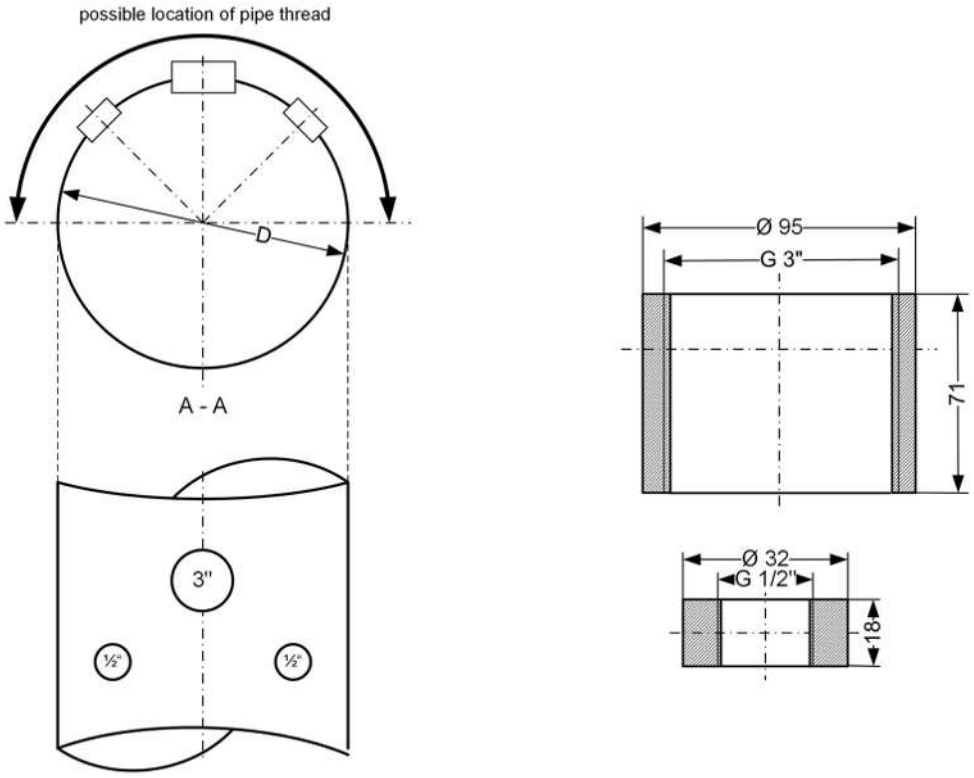


Figure 32: Sampling point, details

Installation of pipe thread G 3" and G ½”

To establish an airtight connection, the pipe threads shall be welded at the exhaust gas pipe. In case of a horizontal orientated exhaust gas pipe the position shall be in the upper half of the exhaust gas pipe in radial direction to the centre line and easy to access.

When the sampling points are not in use, a pipe plug shall close the pipe threads.

2026-10-29 - 10.1

2.20 Noise

2.20.1 Airborne noise

Sound pressure level Lp

Measurements

Approximately 20 measuring points at 1 metre distance from the engine surface are distributed evenly around the engine according to ISO 6798. The noise at the exhaust outlet is not included, but provided separately in the following sections.

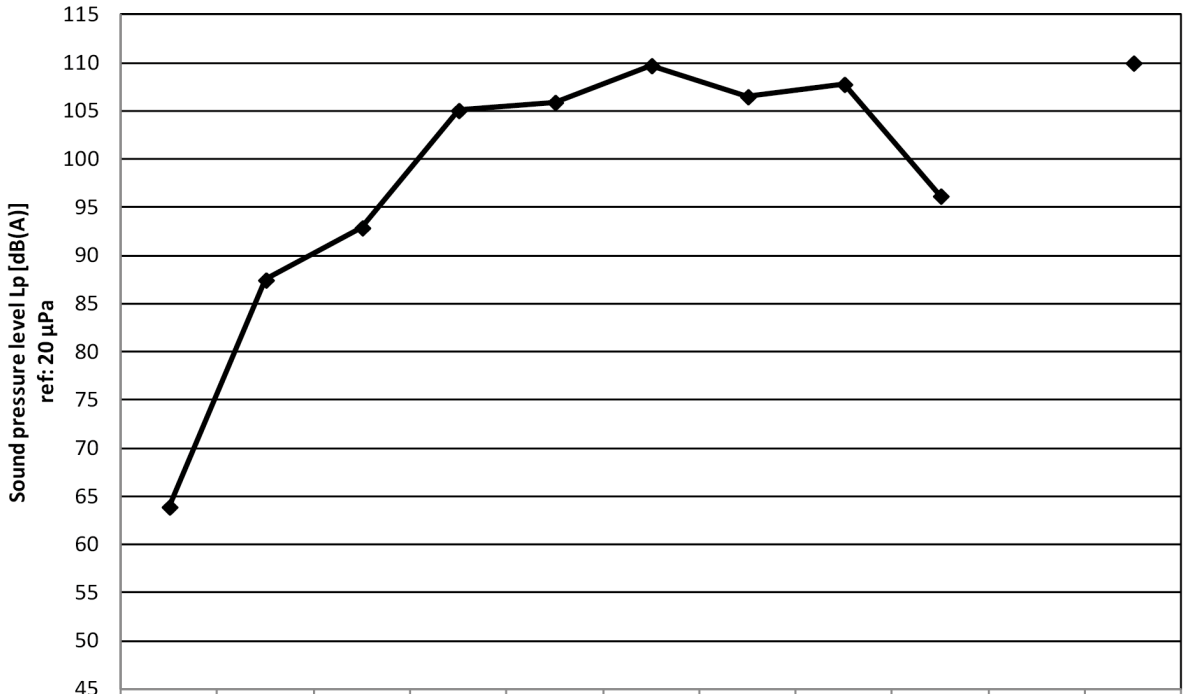
Octave level diagram

The expected sound pressure level Lp is approximately 110 dB(A) at 100% load.

The octave level diagram below represents an envelope of averaged measured spectra for comparable engines at the testbed and is a conservative spectrum consequently. No room correction is performed. The data will change depending on the acoustical properties of the environment.

Blow-off noise

Blow-off noise is not considered in the measurements, see below.



	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz		Sum
Lp	64	87	93	105	106	110	107	108	96		110

Figure 33: Airborne noise – Sound pressure level Lp – Octave level diagram

2.20.2 Intake noise

Sound power level Lw

2026-10-29 - 10.1

Measurements

The (unsilenced) intake air noise is determined based on measurements at the turbocharger test bed and on measurements in the intake duct of typical engines at the test bed.

Octave level diagram

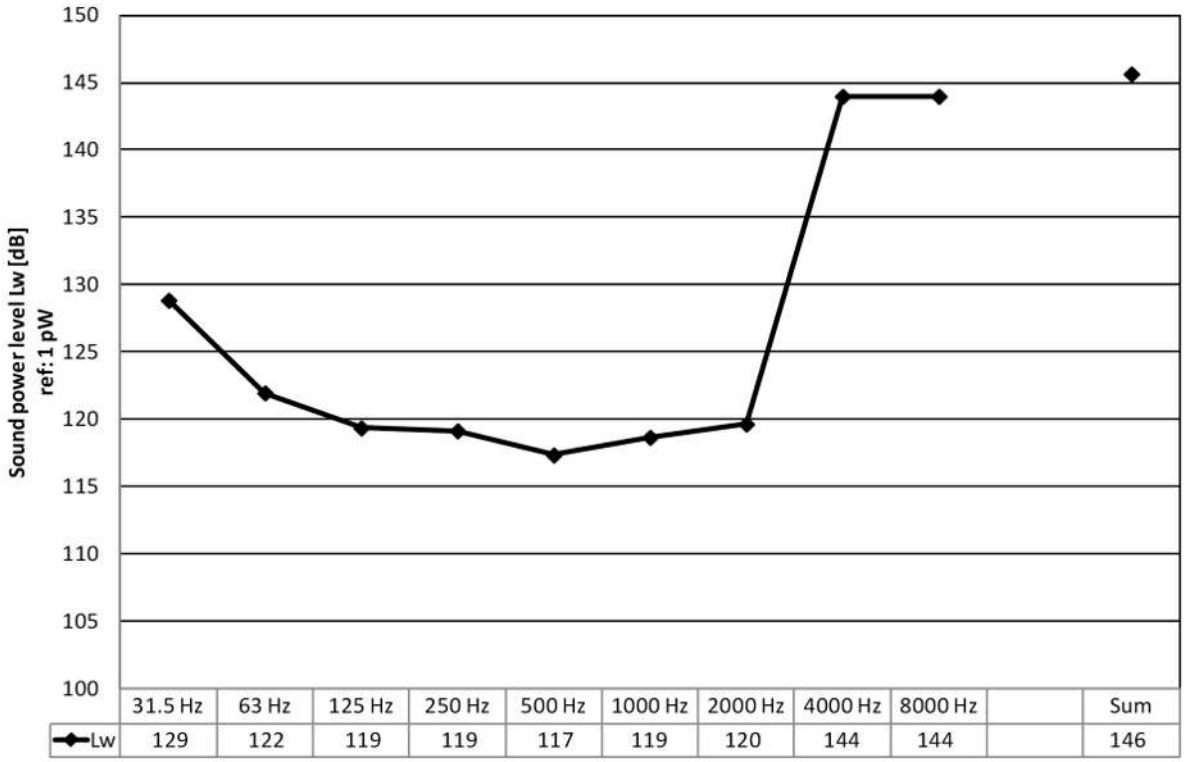
The expected sound power level Lw of the unsilenced intake noise in the intake duct is below 146 dB at 100% MCR.

The octave level diagram below represents an envelope of averaged measured spectra for comparable engines and is a conservative spectrum consequently. The data will change depending on the acoustical properties of the environment.

Charge air blow-off noise

Charge air blow-off noise is not considered in the measurements, see below.

These data are required and valid only for ducted air intake systems. The data are not valid if the standard air filter silencer is attached to the turbocharger.



	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz		Sum
Lw	129	122	119	119	117	119	120	144	144		146

Figure 34: Unsilenced intake noise – Sound power level Lw – Octave level diagram

2026-10-29 - 10.1

2.20.3 Exhaust gas noise

Measurements

The (unsilenced) exhaust gas noise is measured according to internal Everllence guidelines at several positions in the exhaust duct.

Octave level diagram

The sound power level Lw of the unsilenced exhaust gas noise in the exhaust pipe is shown at 100% MCR.

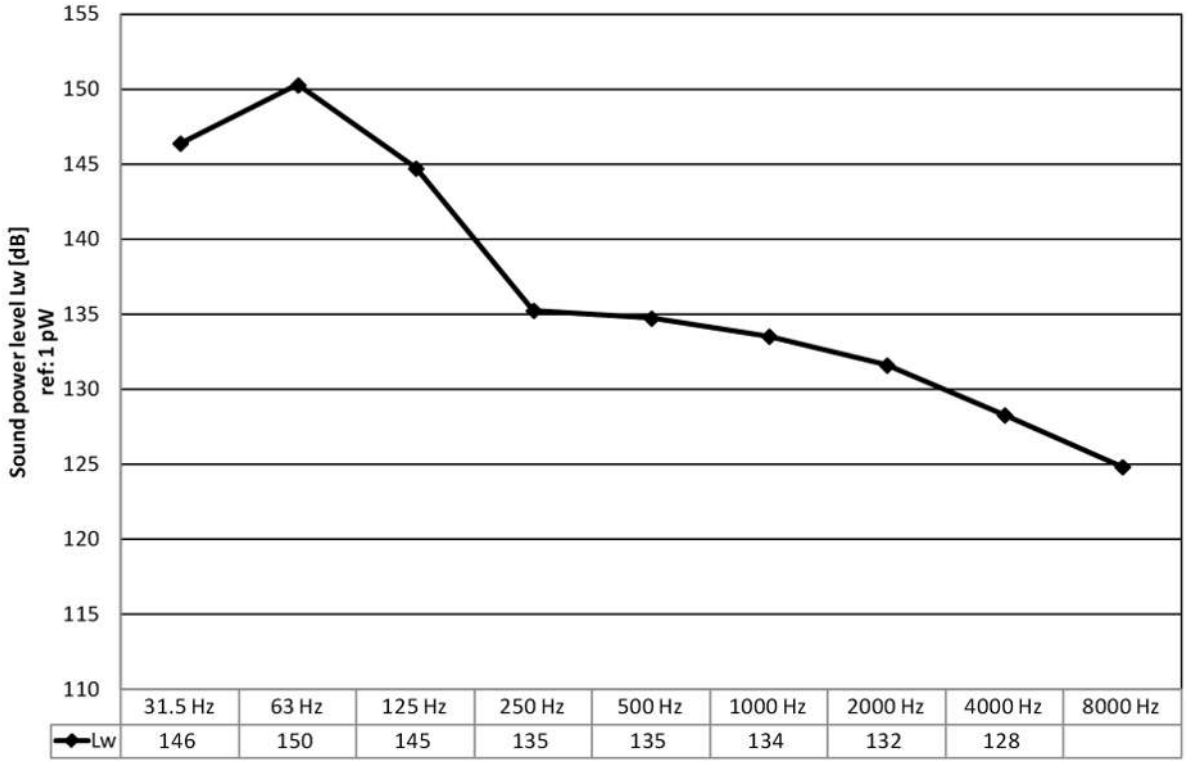
The octave level diagram below represents an envelope of averaged measured spectra for comparable engines and is a conservative spectrum consequently. The data will change depending on the acoustical properties of the environment.

Acoustic design

To ensure an appropriate acoustic design of the exhaust gas system, the yard, Everllence, supplier of silencer and where necessary acoustic consultant have to cooperate.

Blow-off noise

Blow-off noise is not considered in the measurements, see below.



	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz
Lw	146	150	145	135	135	134	132	128	

Figure 35: Unsilenced exhaust gas noise – Sound power level Lw – Octave level diagram

2026-10-29 - 10.1

2.20.4 Blow-off noise example

Sound power level Lw

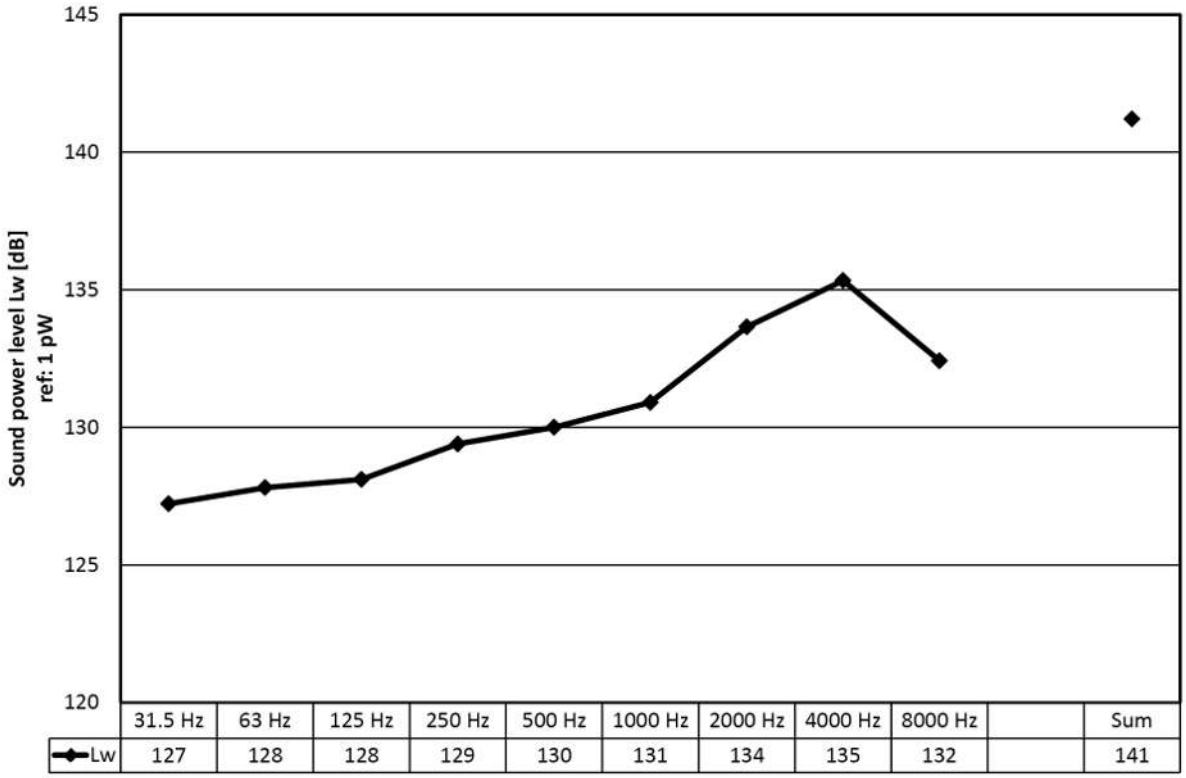
Measurements

The (unsilenced) charge air blow-off noise is measured according to DIN 45635, part 47 at the orifice of a duct.

Throttle body with bore size 135 mm

Expansion of charge air from 3.4 bar to ambient pressure at 42°C

Octave level diagram



	31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	8000 Hz		Sum
Lw	127	128	128	129	130	131	134	135	132		141

Figure 36: Unsilenced charge air blow-off noise – Sound power level Lw – Octave level diagram

2.20.5 Noise and vibration – Impact on foundation

Noise and vibration is emitted by the engine to the surrounding (see figure Noise and vibration – Impact on foundation, Page 102). The engine impact transferred through the engine mounting to the foundation is focused subsequently.

2026-10-29 - 10.1

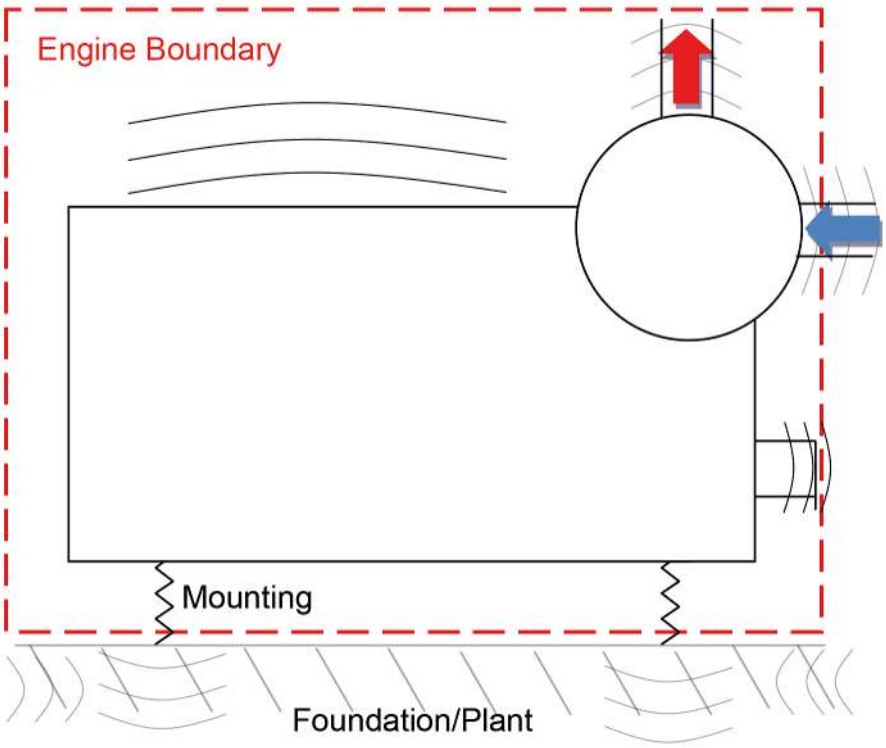


Figure 37: Noise and vibration – Impact on foundation

The foundation is excited to vibrations in a wide frequency range by the engine and by auxiliary equipment (from engine or plant). The engine is vibrating as a rigid body. Additionally, elastic engine vibrations are superimposed. Elastic vibrations are either of global (e.g. complete engine bending) or local (e.g. bending engine foot) character. If the higher frequency range is involved, the term "structure borne noise" is used instead of "vibrations".

Mechanical engine vibrations are mainly caused by mass forces of moved drive train components and by gas forces of the combustion process. For structure borne noise, further excitations are relevant as well, e.g. impacts from piston stroke and valve seating, impulsive gas force components, alternating gear train meshing forces and excitations from pumps.

For the analysis of the engine noise- and vibration-impact on the surrounding, the complete system with engine, engine mounting, foundation and plant has to be considered.

Engine related noise and vibration reduction measures cover e.g. counterbalance weights, balancing, crankshaft design with firing sequence, component design etc. The remaining, inevitable engine excitation is transmitted to the surrounding of the engine – but not completely in case of a resilient engine mounting, which is chosen according to the application-specific requirements. The resilient mounting isolates engine noise and vibration from its surrounding to a large extend. Hence, the transmitted forces are considerably reduced compared with a rigid mounting. Nevertheless, the engine itself is vibrating stronger in the low frequency range in general – especially when driving through mounting resonances.

In order to avoid resonances, it must be ensured that eigenfrequencies of foundation and coupled plant structures have a sufficient safety margin in relation to the engine excitations. Moreover, the foundation has to be designed as stiff as possible in all directions at the connections to the engine. Thus, the

2026-10-29 - 10.1

foundation mobility (measured according to ISO 7262) has to be as low as possible to ensure low structure borne noise levels. For low frequencies, the global connection of the foundation with the plant is focused for that matter. The dynamic vibration behaviour of the foundation is mostly essential for the mid frequency range. In the high frequency range, the foundation elasticity is mainly influenced by the local design at the engine mounts. E.g. for steel foundations, sufficient wall thicknesses and stiffening ribs at the connection positions shall be provided. The dimensioning of the engine foundation also has to be adjusted to other parts of the plant. For instance, it has to be avoided that engine vibrations are amplified by alternator foundation vibrations. Due to the scope of supply, the foundation design and its connection with the plant is mostly within the responsibility of the costumer. Therefore, the customer is responsible to involve Everllence for consultancy in case of system-related questions with interaction of engine, foundation and plant. The following information is available for Everllence customers, some on special request:

- Residual external forces and couples (Project Guide)

  Resulting from the summation of all mass forces from the moving drive train components. All engine components are considered rigidly in the calculation. The residual external forces and couples are only transferred completely to the foundation in case of a rigid mounting, see above.
- Static torque fluctuation (Project Guide)

  Static torque fluctuations result from the summation of gas and mass forces acting on the crank drive. All components are considered rigidly in the calculation. These couples are acting on the foundation dependent on the applied engine mounting, see above.
- Mounting forces (project-specific)

  The mounting dimensioning calculation is specific to a project and defines details of the engine mounting. Mounting forces acting on the foundation are part of the calculation results. Gas and mass forces are considered for the excitation. The engine is considered as one rigid body with elastic mounts. Thus, elastic engine vibrations are not implemented.
- Reference measurements for engine crankcase vibrations according to ISO 10816-6 (project-specific)
- Reference test bed measurements for structure borne noise (project-specific)

  Measuring points are positioned according to ISO 13332 on the engine feet above and below the mounting elements. Structure borne noise levels above elastic mounts mainly depend on the engine itself. Whereas structure borne noise levels below elastic mounts strongly depend on the foundation design. A direct transfer of the results from the test bed foundation to the plant foundation is not easily possible – even with the consideration of test bed mobilities. The results of test bed foundation mobility measurements according to ISO 7626 are available as a reference on request as well.
- Dynamic transfer stiffness properties of resilient mounts (supplier information, project-specific)

Beside the described interaction of engine, foundation and plant with transfer through the engine mounting to the foundation, additional transfer paths need to be considered. For instance with focus on the elastic coupling of the drive train, the exhaust pipe, other pipes and supports etc. Besides the engine, other sources of noise and vibration need to be considered as well (e.g. auxiliary equipment, propeller, thruster).

2026-10-29 - 10.1

2.21 Vibration

2.21.1 Torsional vibrations

Data required for torsional vibration calculation

Everllence calculates the torsional vibrations behaviour for each individual engine plant of their supply to determine the location and severity of resonance points. If necessary, appropriate measures will be taken to avoid excessive stresses due to torsional vibration. These investigations cover the ideal normal operation of the engine (all cylinders are firing equally) as well as the simulated emergency operation (misfiring of the cylinder exerting the greatest influence on vibrations, acting against compression). Besides the natural frequencies and the modes also the dynamic response will be calculated, normally under consideration of the 1st to 24th harmonic of the gas and mass forces of the engine.

Beyond that also further exciting sources such as propeller, pumps etc. can be considered if the respective manufacturer is able to make the corresponding data available to Everllence.

If necessary, a torsional vibration calculation will be worked out which can be submitted for approval to a classification society or a legal authority.

To carry out the torsional vibration calculation following particulars and/or documents are required.

General

- Type of propulsion (mechanical propulsion)
- Arrangement of the whole propulsion system including all engine-driven equipment
- Definition of the operating modes
- Maximum power consumption of the individual working machines

Engine

- Rated output, rated speed
- Kind of engine load (fixed pitch propeller, controllable pitch propeller, combinator curve, operation with reduced speed at excessive load)
- Kind of mounting of the engine (can influence the determination of the flexible coupling)

Flexible coupling

- Make, size and type
- Rated torque (Nm)
- Possible application factor
- Maximum speed (rpm)
- Permissible maximum torque for passing through resonance (Nm)
- Permissible shock torque for short-term loads (Nm)
- Permanently permissible alternating torque (Nm) including influencing factors (frequency, temperature, mean torque)

2026-10-29 - 10.1

- Permanently permissible power loss (W) including influencing factors (frequency, temperature)
- Dynamic torsional stiffness (Nm/rad) including influencing factors (load, frequency, temperature), if applicable
- Relative damping (ψ) including influencing factors (load, frequency, temperature), if applicable
- Moment of inertia (kgm^2) for all parts of the coupling
- Dynamic stiffness in radial, axial and angular direction
- Permissible relative motions in radial, axial and angular direction, permanent and maximum

Clutch coupling

- Make, size and type
- Rated torque (Nm)
- Permissible maximum torque (Nm)
- Permanently permissible alternating torque (Nm) including influencing factors (frequency, temperature, mean torque)
- Dynamic torsional stiffness (Nm/rad)
- Damping factor
- Moments of inertia for the operation conditions, clutched and declutched
- Course of torque versus time during clutching in
- Permissible slip time (s)
- Slip torque (Nm)
- Maximum permissible engagement speed (rpm)

Gearbox

- Make and type
- Torsional multi mass system including the moments of inertia and the torsional stiffness, preferably related to the individual speed; in case of related figures, specification of the relation speed is required
- Gear ratios (number of teeth, speeds)
- Possible operating conditions (different gear ratios, clutch couplings)
- Permissible alternating torques in the gear meshes

Shaft line

- Drawing including all information about length and diameter of the shaft sections as well as the material
- Alternatively torsional stiffness (Nm/rad)

Propeller

- Kind of propeller: controllable pitch propeller
- Moment of inertia in air (kgm^2)
- Moment of inertia in water (kgm^2); for controllable pitch propellers also in dependence on pitch; for twin-engine plants separately for single- and twin-engine operation
- Relation between load and pitch
- Number of blades
- Diameter (mm)

2026-10-29 - 10.1

- Possible torsional excitation in % of the rated torque for the 1st and the 2nd blade-pass frequency

Pump

- Kind of pump (e.g. dredging pump)
- Drawing of the pump shaft with all lengths and diameters
- Alternatively, torsional stiffness (Nm/rad)
- Moment of inertia in air (kgm^2)
- Moment of inertia in operation (kgm^2) under consideration of the conveyed medium
- Number of blades
- Possible torsional excitation in % of the rated torque for the 1^{st} and the 2^{nd} blade-pass frequency
- Power consumption curve

2026-10-29 - 10.1

2.22 Requirements for power drive connection (static)

2.22.1 Limit values of masses to be coupled after the engine

Evaluation of permissible theoretical bearing loads

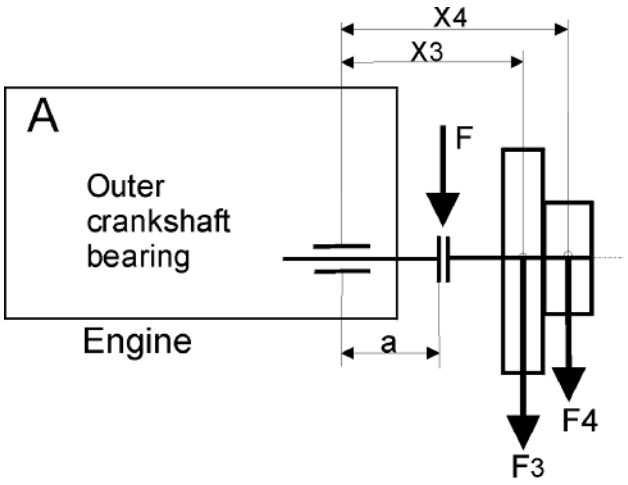


Figure 38: Case A: Overhung arrangement

$M_{max} = F * a = F_3 * x_3 + F_4 * x_4$

F_3	Flywheel weight
F_4	Coupling weight acting on the engine, including reset forces
a	Distance between end of coupling flange and centre of outer crankshaft bearing

1. Standard engine – Main power drive connection at coupling side

Engine	Distance a	$M_{max} = F * a$
	mm	kNm
V engine	300	8.2 [1]
[1] Inclusive of couples resulting from restoring forces of the coupling.		

Table 69: Example calculation – Coupling side

2. Optional – Main power drive connection at counter coupling side (100% PTO)

Engine	Distance a	$M_{max} = F * a$
	mm	kNm
V engine	592.6	23.2 [1]
[1] Inclusive of couples resulting from restoring forces of the coupling.		

Table 70: Example calculation – Counter coupling side

2026-10-29 - 10.1

3. Optional – Auxiliary PTO at counter coupling side (main power drive connection at coupling side)

Engine	Distance a	M_{max} = F * a
	mm	kNm
V engine	810.0	6.0 [1]
[1] Inclusive of couples resulting from restoring forces of the coupling.		

Table 71: Example calculation – For auxiliary PTO on counter coupling side

Note:
For main power drive connection related values see case 1.

Note:
Stated values only for orientation – need to be clarified project specific and may be limited due to the torsional vibration calculation or special service conditions.

Note:
Masses which are connected downstream of the engine in the case of an overhung or rigidly coupled, arrangement result in additional crankshaft bending stress, which is mirrored in a measured web deflection during engine installation.

Provided the limit values for the masses to be coupled downstream of the engine (permissible values for M_{max} and $F_{1\ max}$) are complied with, the permitted web deflections will not be exceeded during assembly.

Observing these values ensures a sufficiently long operating time before a realignment of the crankshaft has to be carried out.

2.22.2 10% PTO – Maximum torque and requirements screw connection

In case main power drive connection is at coupling side, on counter coupling side a PTO might be used if stated requirements are met.

Screw strength class	8.8	10.9	12.9
Number/standard	12 * DIN 931-M33		
Min. screw-in-depth	25 mm	28 mm	30 mm
Tightening torque	1,400 Nm	2,000 Nm	2,350 Nm
Max. torque at PTO	38 kNm	55 kNm	64 kNm

Note:
Stated values only for orientation – needs to be clarified project specific.

2.23 Requirements for power drive connection (dynamic)

2.23.1 Moments of inertia – Crankshaft, damper, flywheel

455 kW/cyl.; 1,000 rpm (ICN), 500 kW/cyl.; 1,032 rpm (ICFN)

Operation with variable speed

a_{mot} = 80%/sec

2026-10-29 - 10.1

Marine main engines				
No. of cylinders, config.	Engine			Required minimum total moment of inertia[1] $J_{Total\ min}$
	Maximum continuous rating	Moment of inertia crankshaft + damper J_1	Moment of inertia flywheel J_2	
	[kW]	[kgm²]	[kgm²]	[kgm²]
n = 1,000 rpm				
12V	5,460	221	89.5	622
16V	7,280	274	89.5	830
20V	9,100	328	93.0	1,037
n = 1,032 rpm				
12V	6,000	221	89.5	642
16V	8,000	274	89.5	856
20V	10,000	328	93.0	1,070

[1] Required minimum moment of inertia of engine, flywheel and arrangement after flywheel in total.

Table 72: Moments of inertia/flywheel – Operation with variable speed

For flywheels dimensions see section Flywheel arrangement, Page 113.

2026-10-29 - 10.1

2.23.2 Balancing of masses – Firing order

Certain cylinder numbers have unbalanced forces and couples due to crank diagram. These forces and couples cause dynamic effects on the foundation. Due to a balancing of masses the forces and couples are reduced. In the following tables the remaining forces and couples are displayed.

V engine

Rotating crank balance: 85%

No. of cylinders, config.	Residual external couples				
	M_{rot} (kNm)	$M_{osc\ 1st\ order}$ (kNm)		$M_{osc\ 2nd\ order}$ (kNm)	
	Engine speed 1,000 rpm				
Direction		vertical	horizontal	vertical	horizontal
12V	0	0		0	
16V					
20V					

Table 73: Residual external couples

The external mass forces are equal to zero.

M_{rot} is eliminated by means of balancing weights on resiliently mounted engines.

Firing order: Counted from coupling side

No. of cylinders, config.	Firing interval	Clockwise rotation (viewed from engine coupling side)
12V	68°; 52°	B1-A5-B5-A3-B3-A6-B6-A2-B2-A4-B4-A1
16V	38°; 52°	B1-A5-B5-A2-B2-A6-B6-A8-B8-A4-B4-A7-B7-A3-B3-A1
20V	20°; 52°	B1-A4-B4-A2-B2-A5-B5-A8-B8-A10-B10-A7-B7-A9-B9-A6-B6-A3-B3-A1

Table 74: Firing interval – Clockwise rotation

No. of cylinders, config.	Firing interval	Counterclockwise rotation (viewed from engine coupling side)
12V	68°; 52°	A1-B4-A4-B2-A2-B6-A6-B3-A3-B5-A5-B1
16V	38°; 52°	A1-B3-A3-B7-A7-B4-A4-B8-A8-B6-A6-B2-A2-B5-A5-B1
20V	20°; 52°	A1-B3-A3-B6-A6-B9-A9-B7-A7-B10-A10-B8-A8-B5-A5-B2-A2-B4-A4-B1

Table 75: Firing interval – Counter clockwise rotation

2026-10-29 - 10.1

2.23.3 Static torque fluctuation

General

The static torque fluctuation is the summation of the torques acting at all cranks around the crankshaft axis taking into account the correct phase-angles. These torques are created by the gas and mass forces acting at the crankpins, with the crank radius being used as the lever. An rigid crankshaft is assumed.

The values T_{max} and T_{min} listed in the following table(s) represent a measure for the reaction forces of the engine. The reaction forces generated by the torque fluctuation are dependent on speed and cylinder number and give a contribution to the excitations transmitted into the foundation see figure Static torque fluctuation, Page 111 and the table(s) in this section. According to different mountings these forces are reduced.

In order to avoid local vibration excitations in the vessel, it must be ensured that the natural frequencies of important part structures (e.g. panels, bulkheads, tank walls and decks, equipment and its foundation, pipe systems) have a sufficient safety margin (if possible ±30%) in relation to all engine excitation frequencies.

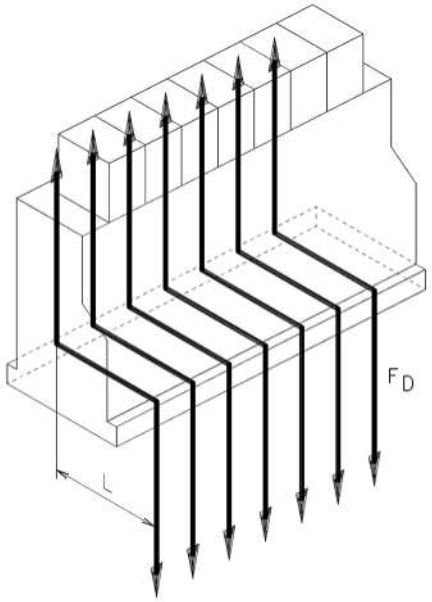


Figure 39: Static torque fluctuation

$$F_D \times L \times z = \frac{T_{max} - T_{min}}{2}$$

L Distance between foundation bolts

z Number of cylinders

2026-10-29 - 10.1

Static torque fluctuation and exciting frequencies

Example to declare abbreviations

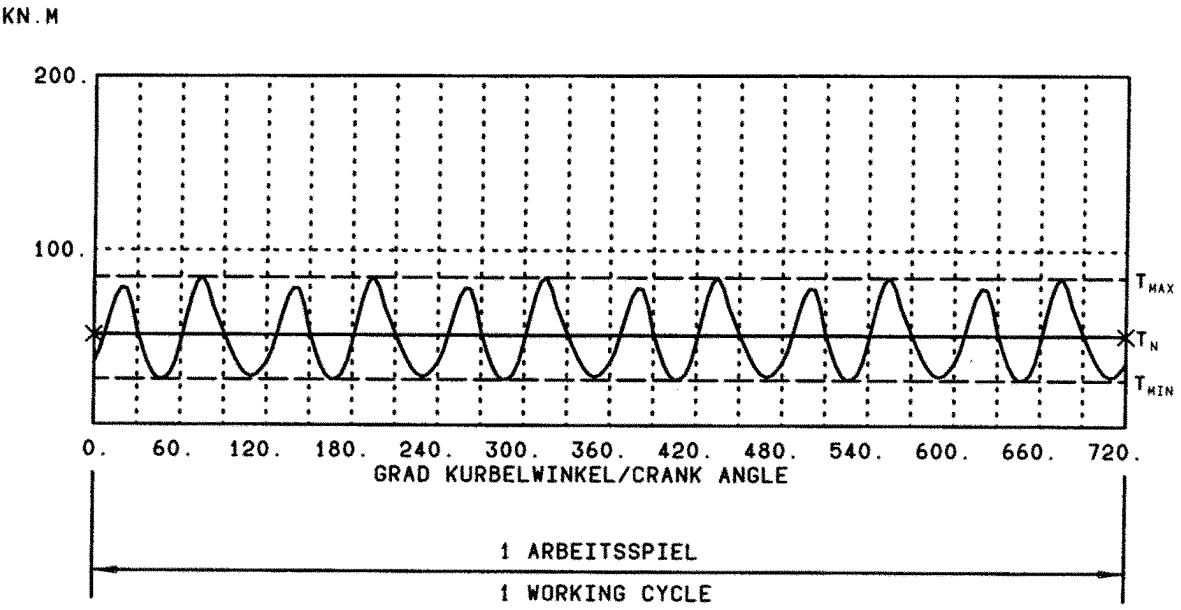


Figure 40: Example to declare abbreviations

No. of cylinders, config.	Output	Speed	T_n	T_{max}	T_{min}	Main exciting components		
						Order	Frequency[1)]	±T
	kW	rpm	kNm	kNm	kNm	rpm	Hz	kNm
12V	5,460	1,000	52.1	86.4	26.0	3.0	50	8.2
						6.0	100	22.9
16V	7,280		69.5	97.5	40.6	4.0	66.7	18.8
						8.0	133.3	10.2
20V	9,100		86.9	128.2	40.3	5.0	83.3	48.6
						10.0	166.7	0.8
12V	6,000	1,032	55.5	89.6	29.0	3.0	51.6	9.6
						6.0	103.2	24.0
16V	8,000		74.0	100.6	45.0	4.0	68.8	21.4
						8.0	137.6	8.7
20V	10,000		92.5	134.6	45.1	5.0	86.0	49.0
						10.0	172.0	0.6

[1)] Exciting frequency of the main harmonic components.

Table 76: Static torque fluctuation and exciting frequencies

2026-10-29 - 10.1

2.24 Power transmission

2.24.1 Flywheel arrangement

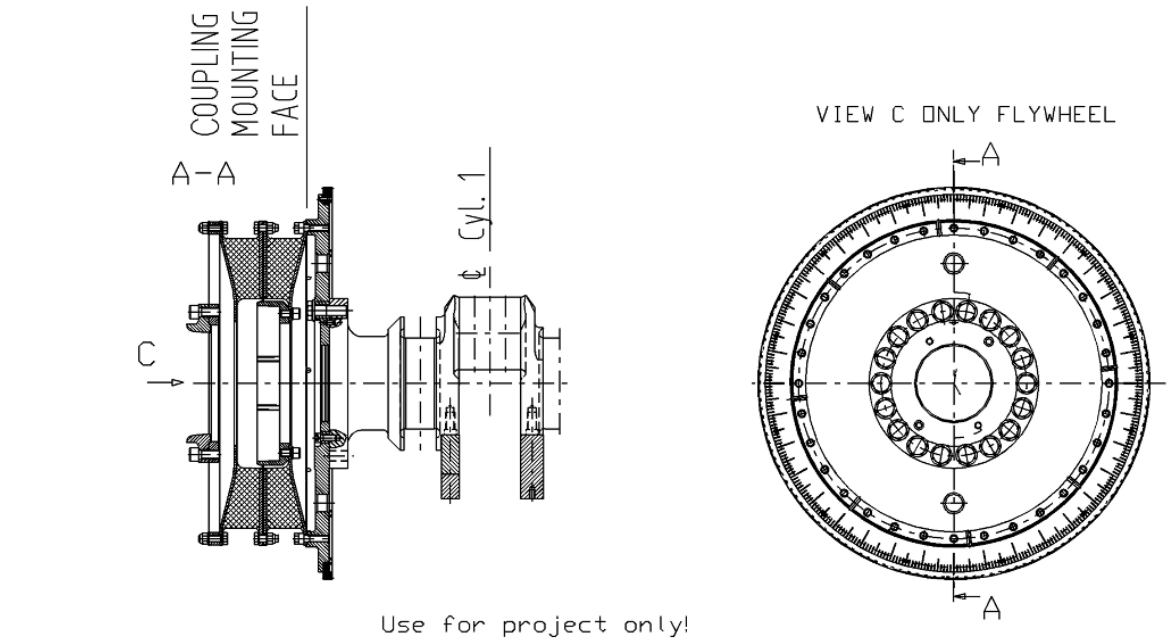


Figure 41: Example of flywheel arrangement with flexible coupling

Note:
The flexible coupling will be part of Everllence supply and thus we will produce a contract specific flywheel/coupling/driven machine arrangement drawing giving all necessary installation dimensions. Final dimensions of flywheel and

2026-10-29 - 10.1

flexible coupling will result from clarification of technical details of drive and from the result of the torsional vibration calculation. Flywheel diameter must not be changed.

2.25 Foundation

2.25.1 General requirements for engine foundation

Plate thicknesses

The stated material dimensions are recommendations, calculated for steel plates. Thicknesses smaller than these are not permissible. When using other materials (e.g. aluminium), a sufficient margin has to be added.

Top plates

Before or after having been welded in place, the bearing surfaces should be machined and freed from rolling scale. Surface finish corresponding to Ra 3.2 peak-to-valley roughness in the area of the chocks shall be accomplished.

The thickness given is the finished size after machining.

Downward inclination outwards, not exceeding 0.7%.

Prior to fitting the chocks, clean the bearing surfaces from dirt and rust that may have formed. After the drilling of the foundation bolt holes, spotface the lower contact face normal to the bolt hole.

Foundation girders

The distance of the inner girders must be observed. We recommend that the distance of the outer girders (only required for larger types) is observed as well.

The girders must be aligned exactly above and underneath the tank top.

Floor plates

No manholes are permitted in the floor plates in the area of the box-shaped foundation. Welding is to be carried out through the manholes in the outer girders.

Top plate supporting

Provide support in the area of the frames from the nearest girder below.

Dynamic foundation requirements

The eigenfrequencies of the foundation and the supporting structures, including GenSet weight (without engine) shall be higher than 20 Hz. Occasionally, even higher foundation eigenfrequencies are required. For further information refer to section Noise and vibration – Impact on foundation, Page 101.

Note:
The requirements of the respective classification society have to be considered in addition.

2026-10-29 - 10.1

2.25.2 Resilient mounting position

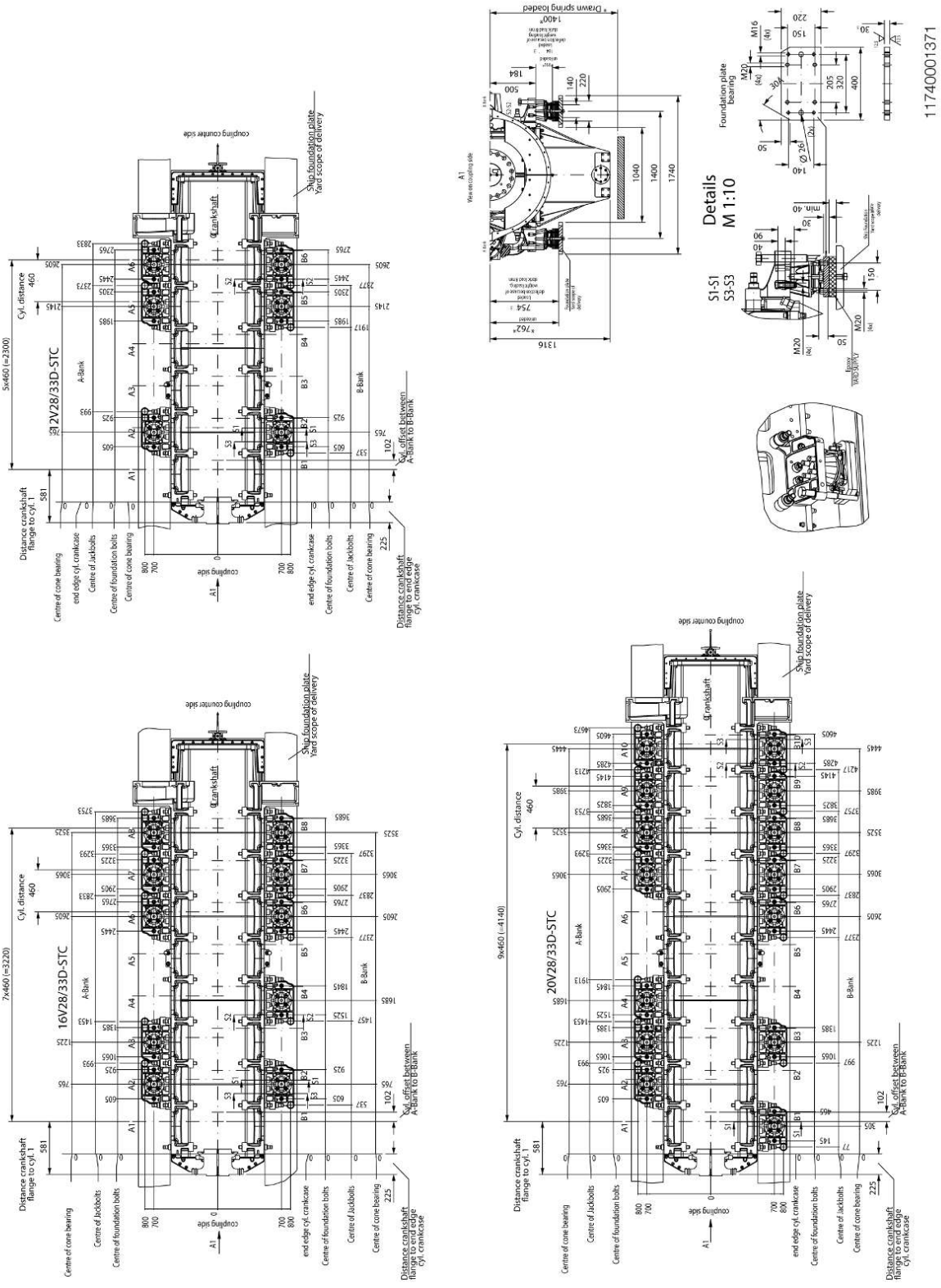


Figure 42: General arrangement

2.25.3 Resilient seating

General

The vibration of the engine causes dynamic effects on the foundation. These effects are attributed to the pulsating reaction forces due to the fluctuating torque. Additionally, in engines with certain cylinder numbers these effects are increased by unbalanced forces and couples brought about by rotating or reciprocating masses which – considering their vector sum – do not equate to zero.

The direct resilient support makes it possible to reduce the dynamic forces acting on the foundation, which are generated by every reciprocating engine and may – under adverse conditions – have harmful effects on the environment of the engine.

With respect to large engines (bore > 400 mm) Everllence offers two different versions of the resilient mounting (one using conical – the other inclined sandwich elements).

The inclined resilient mounting was developed especially for ships with high comfort demands, e.g. passenger ferries and cruise vessels. This mounting system is characterised by natural frequencies of the resiliently supported engine being lower than approximately 7 Hz. The resonances are located away from the excitation frequencies related to operation at nominal speed.

For average demands of comfort, e.g. for merchant ships, and for smaller engines (bore < 400 mm) mountings using conical mounts can be judged as being fully sufficient. Because of the stiffer design of the elements the natural frequencies of the system are significantly higher than in case of the inclined resilient mounting. The natural frequencies of engines mounted with this kind of mounts are lower than approximately 18 Hz. The vibration isolation is thus of lower quality. It is however, still considerably better than a rigid or semi resilient engine support.

The appropriate design of the resilient support will be selected in accordance with the demands of the customer, i.e. it will be adjusted to the special requirements of each plant.

In both versions the supporting elements will be connected directly to the engine feet by special brackets.

The number, rubber hardness and distribution of the supporting elements depend on:

- The weight of the engine
- The centre of gravity of the engine
- The desired natural frequencies

Where resilient mounting is applied, the following has to be taken into consideration when designing a propulsion plant:

- Resilient mountings always feature several resonances resulting from the natural mounting frequencies. In spite of the endeavour to keep resonances as far as possible from nominal speed the lower bound of the speed range free from resonances will rarely be lower than 70% of nominal speed for mountings using inclined mounts and rarely lower than 85% for mountings using conical mounts. It must be pointed out that these percentages are only guide values. The speed interval being free from resonances may be larger or smaller. These restrictions in speed will mostly require the deployment of a controllable pitch propeller.

2026-10-29 - 10.1

- Between the resiliently mounted engine and the rigidly mounted gearbox or alternator, a flexible coupling with minimum axial and radial elastic forces and large axial and radial displacement capacities should be provided.
- The media connections (compensators) to and from the engine must be highly flexible whereas the fixations of the compensators on the one hand with the engine and on the other hand with the environment must be realised as stiff as possible.
- For the inclined resilient support, provision for stopper elements has to be made because of the sea-state-related movement of the vessel. In the case of conical mounting, these stoppers are integrated in the element.
- In order to achieve a good vibration isolation, the lower brackets used to connect the supporting elements with the ship's foundation are to be fitted at sufficiently rigid points of the foundation. Influences of the foundation's stiffness on the natural frequencies of the resilient support of the engine will not be considered in the mounting design calculation.
- The yard must specify with which inclination related to the plane keel the engine will be installed in the ship. The inclination must be defined and communicated before entering the dimensioning process.

2026-10-29 - 10.1

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2026-10-29 - 10.1

3 Data Logging Solutions

3.1 Data Logging - General Information

Variants

Everllence offers two remote connectivity solutions (as Data Logging Cabinets):

- DLCB: Data Logging Cabinet Basic
- DLC+: Data Logging Cabinet Plus

DLC+ versus DLC Basic

DLC Basic

- Only usable in condition with non IACS UR-E27 requirements
- Log operational data and send it to CEON when connected online (read only)
- Solution enables Digital Service:
  - PrimeServ Assist

DLC+

- Solution classified according to IACS UR-E27 and IEC 62443-3-3 requirements
- Read and write access to operational data and parameters for SaCoS 5000 and SaCoSone modules
- Upgrade, update and advanced analytics capability (interactive remote access)
- Remote commissioning support
- Customer Reporting Tool (optional)
- Solution enables Digital Services:
  - PrimeServ Assist
  - PrimeServ Assist Stealth
  - Everllence Asset+

Localisation

The DLCB or DLC+ is part of the equipment off engine.

Connection

The DLCB or DLC+ component is an element of the SaCoS network architecture, implementing secure, encrypted communication channels for interconnection with Everllence digital services. This ensures authenticated data exchange and supports the delivery of digital remote services in compliance with network security standards.

3.2 Data Logging Cabinet Plus (DLC+)

Description

The Data Logging Cabinet Plus is used for maintaining SaCoS components (backup/restore), on-site data logging and diagnostic and to connect to Everllence Digital Services. Intelligent and for security hardened components are installed in the Data Logging Cabinet Plus.

The Data Logging Cabinet Plus enables through secure hardware and software the deployment locally or, on demand, over the air of the comprehensive Everllence Digital Services.
Everllence Digital Services include engine remote monitoring of operational data and diagnostics, troubleshooting and advice from Everllence engineers and also software and security updates in a safe manner.

2026-10-29 - 10.1

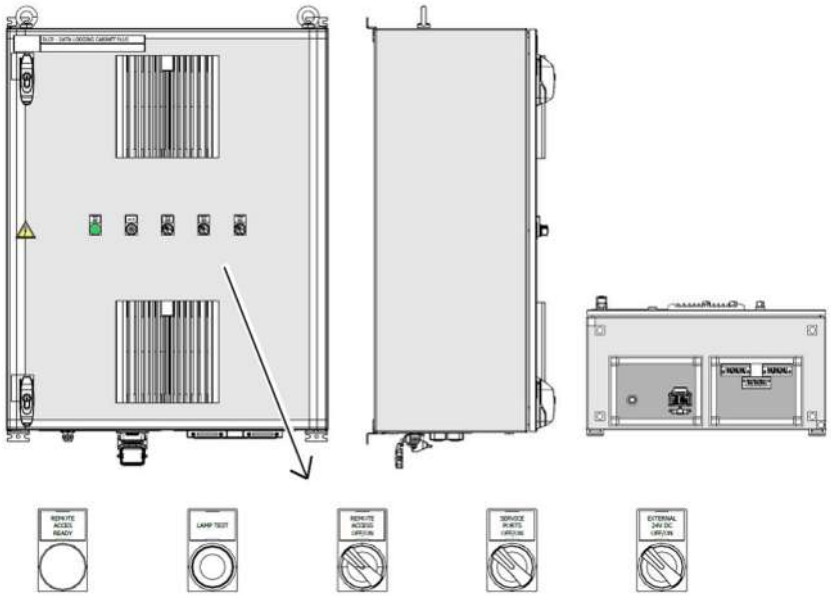


Figure 43: Data Logging Cabinet Plus (DLC+)

Power supply

The DLC+ can be connected either to 24V DC or to 230/115 VAC (50 / 60 Hz).

Dimensions and weights

Dimensions (H x W x D)	1000x800x400 mm
Weight	up to 100 kg, depending on configuration

Environmental conditions

- Ambient air temperature: +5 °C to +45 °C
- Relative humidity: < 96 %
- Vibrations: < 0.7 g

Design

- Cable entries: From below, through cabinet base
- Accessible by front door(s), doors with locks
- Opening angle: 90°
- Standard colour: Light grey (RAL7035)
- Ingress protection: IP54

Installation requirements

The cabinet is designed for installation in engine rooms or engine control rooms.

The cabinet must be installed at a location suitable for service inspection.

Do not install the cabinet close to heat-generating devices.

3.3 Data Logging - Additional Information

- For details on data logging, such as:
- Description of what data is logged
- Description of access rights
- Analysis of data
- Description of which tools are required
- Digital Services:
  - PrimeServ Assist

2026-10-29 - 10.1

- PrimeServ Assist Stealth
- Everllence Asset+

etc., contact Everllence

2026-10-29 - 10.1

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2026-10-29 - 10.1

4 Engine automation

4.1 SaCoS 5000 system overview

The engine is equipped with the latest generation of Everllence' engine control- and safety system SaCoS 5000 (Safety and Control System) for four-stroke diesel- and gas engines. The engine control- and safety system is responsible for complete engine operation, control, alarming and safety. All sensors and actuators are wired to the engine-attached units. The whole system design has a modular and flexible topology. The SaCoS 5000 design is based on highly reliable and approved components as well as modules specially designed for installation on 4-stroke medium speed engines. The used components are harmonised to an homogenous system. The system has already been tested and parameterised in the factory, the final parameterisation takes place at the customer. During engine installation, only the bus connections, the power supply and safety-related signal cables between the units/modules on engine and the cabinets are to be laid, as well as connections to external modules, electrical motors on the engine and parts on site.

The Control Modules and the Injection Module are integrated in the Control Unit (CU). The Display Module and Gateway Communication Module are integrated in the Interface Cabinet (IC), the cabinet has an ingress protection of IP65.

Abbreviation	Name	Function
DML	Display Module L	The 12.1"-touchscreen is used for operation of the engine and the visualisation of all operating values.
GCM	Gateway Communication Module	Provides the communication interface to an external system.
IM	Injection Module	Provides the complete fuel injection control functionality.
CM	Control Module	Offers a variety of different input/output functionalities to achieve basic control functionalities, e. g. as engine control.

Table 77: SaCoS 5000 module types

System bus

The system bus connects all the modules together and forms the basis of the data exchange between the SaCoS modules. Data communication is guaranteed at all times as the connection is made redundant. In this way, modules can access the redundant measured values from other modules if their own sensor should fail. I/O extensions are connected to modules via a non-redundant bus.

2026-10-29 - 10.1

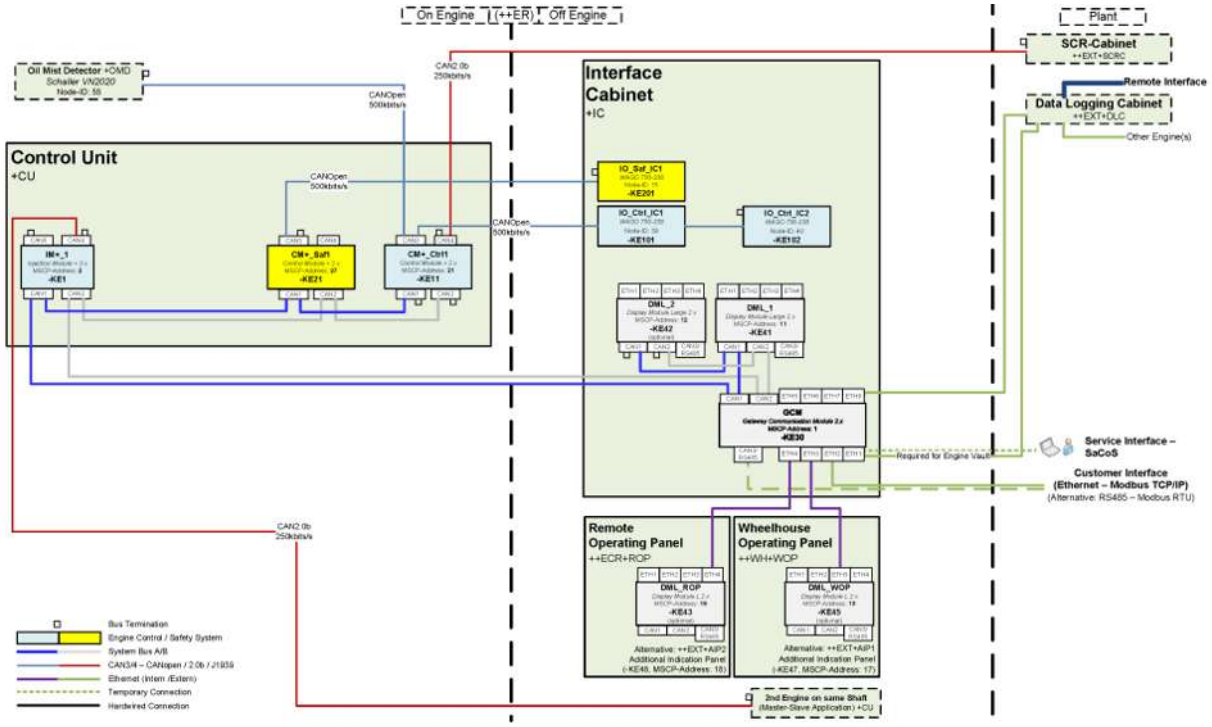


Figure 44: System bus

4.1.1 Cybersecurity guidelines

4.1.1.1 Terms, abbreviations and definitions

Term, abbreviation	Definition
CEON	Everllence service for recording engine data
Data	Data
DLC	Data logging cabinet (DLCB / DLC+)
DLC+	Data Logging Cabinet Plus (enable data logging functionality as well as additional services / remote support / update possibilities)
DLCB	Data Logging Cabinet Basic (enable data logging functionality)
DM	Display module
ER	Engine room
ECR	Engine control room
eToken	SaCoS 5000 security token SaCoSone security token (Thales Group eToken 5110+)
ExG-MM	Exchange Gateway Monitoring Module is an industrial PC used as a jump host / data logger / toolbox

2026-10-29 - 10.1

Term, abbreviation	Definition
ExG-EDM	Exchange Gateway EDM Module is an industrial PC used for Electronic Device Management for over-the-air updates
EXPERT	Everllence tool for SaCoS parameterisation
G(C)M	Gateway (Communication) Module
IAS	Integrated alarm system (see also “customer network”)
IC	Interface cabinet
LOP	Local operating panel
PMS	Power management system
RDP	Remote desktop protocol
ROC	Remote operation centre
ROP	Remote operating panel (see also WOP, wheel operating panel)
SaCoS	Safety and Control System
SCR	Selective catalytic reduction
SCR SL	SCR Single Line system (medium speed)
SCR ML	SCR Multi Line system (high speed / 175D)
SDI	SaCoSone device image
Toolbox	(Virtual) device for parameterisation and backup/restore of SaCoS
WBM	Web-based management

Table 78: Terms, abbreviations, and definitions

2026-10-29 - 10.1

4.1.1.2 System Overview

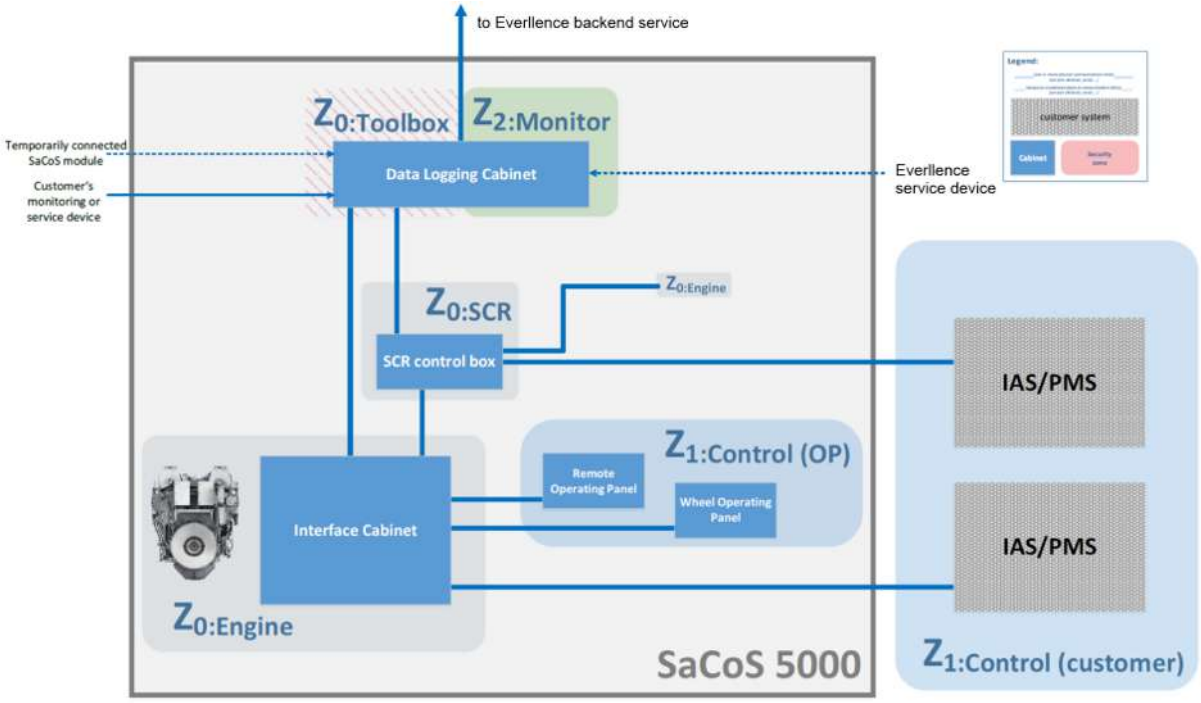


Figure 45: SaCoS 5000 with SCR and DLC: Zones and connections (simplified)

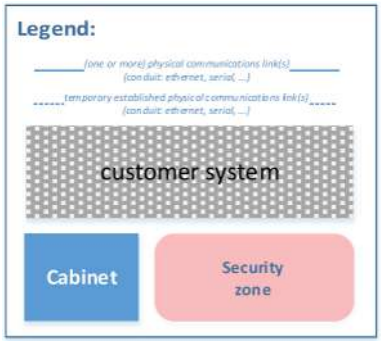


Figure 46: SaCoS 5000 with SCR and DLC: Zones and connections (simplified) – Legend

Fig. *SaCoS 5000 with SCR and DLC: Zones and connections (simplified)*: Shows a simplified overview of the SaCoS 5000 system (with SCR and DLC), and some of the relevant zones and connections.

Fig. *SaCoS 5000 with SCR and DLC: Zones and connections (simplified) – Legend*:
Shows the legend for the simplified overview of the SaCoS 5000 system (with SCR and DLC).

The system is divided into the following main security zones:

- $Z_{0:Engine}$: Devices in this zone implement the main functionality of the engine control system.
- $Z_{0:SCR}$: Devices in this zone implement the SCR functionality and enable local monitoring and control of the SCR system.

2026-10-29 - 10.1

- $Z_{1:Control\ (OP)}$: This zone contains the control panels (including, for example, the ROP and WOP) that enable local monitoring and control of the engine control system.
- $Z_{1:Control\ (customer)}$: This zone contains the ship's integrated alarm and/or power management system(s) (IAS/PMS).
- $Z_{2:Monitor}$: This zone (available only on systems with DLC) contains virtualized and physical devices that implement local/remote monitoring and logging of control system data. With DLC+, it is also possible to obtain limited, secure, and interactive access to the jump host (also called ExG-MM in SaCoS) and use the described functionality. For this, the user can connect to the system with their own device via the designated network port in the DLC+.
- $Z_{0:Toolbox}$: This zone (available only on systems with DLC+) contains virtualized and physical devices that enable local/remote system parameterization, including restoring system backups to SaCoS modules that are temporarily connected to the DLC+ for this purpose. To gain limited, secure, and interactive access to the jump host (ExG-MM) in the DLC+ and to use the described functionality, the user can connect to the system with their own device via the designated network port in the DLC+

The majority of the devices making up the control system are installed in locked control cabinets or units. These must be set up in restricted locations such as engine rooms (ER) and engine control rooms (ECR).

4.1.1.3 Physical security of SaCoS

Due to their design, some SaCoS devices and communication links must be physically protected against unauthorised access at all times (i.e., including during commissioning). Only authorised and authenticated personnel may have access to these devices and connections. Such access must be logged.

The security of these protections should be assessed by the customer, taking into account the system context, system purpose, system location, assumptions about current and future threats to the customer's business, and applicable regulations.

4.1.1.4 Secure access and storage of SaCoS data

It is necessary to keep the data created by or for SaCoS secure and protected against access by third parties.

4.1.1.5 Secure use of the ExG-MM in the DLC+

It is the customer’s responsibility to use the ExG-MM securely in accordance with the guidelines in the operating instructions.

4.1.1.6 Securing Z1:Control(Customer)

$Z_{1:Control(Customer)}$ must be a trusted network in the sense of IACS UR E27 (where applicable).

A compromised SaCoS can also pose a threat to customer networks and devices, and infect or compromise the customer systems within them. The operator/integrator can implement additional measures such as installing additional network security devices to protect against this threat.

2026-10-29 - 10.1

4.1.1.7 Maintaining network segmentation

Network segmentation is one of SaCoS's key protection measures. Therefore, the network structure set up by Everllence must not be changed.

Specifically, the following guidelines should be adhered to:

- Individual network segments must not be bridged (e.g. by connecting a device to several segments at the same time, connecting network switches from different segments to each other, or connecting devices from one segment to other segments).
- No additional devices may be connected to the SaCoS network segments.
- The physical switches on the DLC+ that enable and disable the remote network connection of Everllence service staff to the ExG-MM for remote maintenance (designation on the cabinet), as well as the ExG-MM network access to the GCM and DM (designation on the cabinet) for parameterisation, must normally be in the "disabled" position. Access should only be activated temporarily, only when required, only by authorised staff, and should be switched off again as soon as possible after completion of the work. Remote access (remote) to ExG-MM may only be enabled upon explicit and authenticated request from Everllence. Only those physical switches that are necessary for the functionality or activity actually required should be activated.

4.1.1.8 Preparation for security incidents

Residual risks may remain even if the present guidelines are followed. The customer should prepare for possible security incidents in order to be able to react to them quickly. This includes the creation of an *incident response plan*, which should address the following points, among others:

- Obtain spare parts to replace SaCoS modules that have failed or been compromised due to an attack.
- If changes are made to the system (e.g. parameterisation of the system), these changes should be saved accordingly.
- Report the security incident to Everllence via a secure channel and follow the instructions.
- Save all data relevant to the cause (may require assistance from the engine manufacturer's 1st level support). This includes, but is not limited to, the access logs and general audit logs generated by the customer, customer devices, and the plant.
- Analyse the data and take steps to address the vulnerability that led to the incident.

The customer is also instructed to monitor the system for indications of a possible security incident to the extent possible.

4.1.1.9 Safe disposal

The customer is responsible for the security of potentially sensitive data when disposing of the devices.

4.1.1.10 User account management

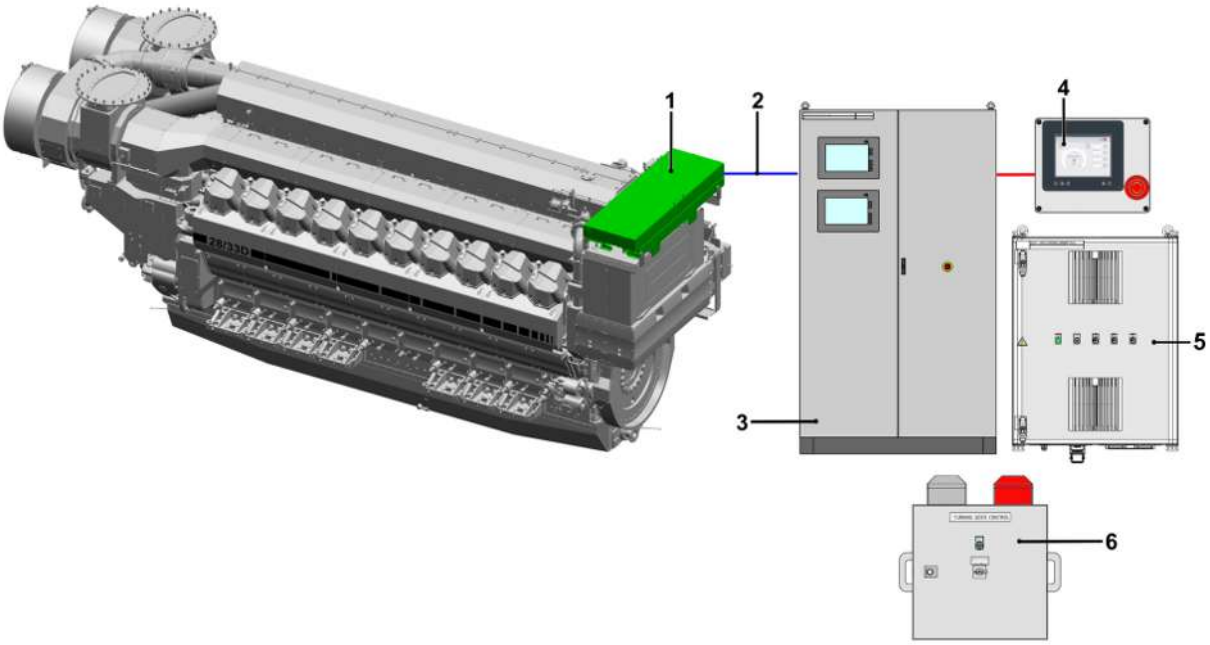
The operator and service personnel are responsible for managing the access data for SaCoS devices.

2026-10-29 - 10.1

4.1.1.11 Security Incident Report

The security incidents concerning SaCoS should be reported to Everllence PrimeServ.

4.1.2 Equipment on engine and off engine



1 Control Unit
2 System bus
3 Interface Cabinet with integrated Local Operating Panel
4 ROP/WOP, optional
5 Data Logging Cabinet (example view), for more information, see chapter Data Logging Solutions, Page 119
6 Turning Gear Cabinet
7 Power Supply Cabinet, optional (not shown)

Figure 47: System Overview

Control Unit

The Control Unit is mounted on the engine cushioned against vibration.

It includes two identical, highly integrated Control Modules: One for safety functions and the other for engine control and alarming. The modules work independently of each other and collect engine measuring data by means of separate sensors.

The Control Unit also includes a highly integrated Injection Module, which is responsible for speed control and rail injection.

2026-10-29 - 10.1

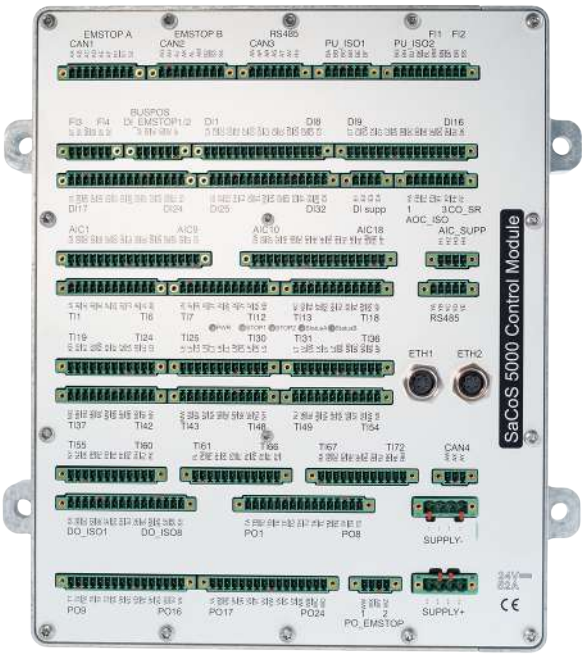


Figure 48: Control Module (example)

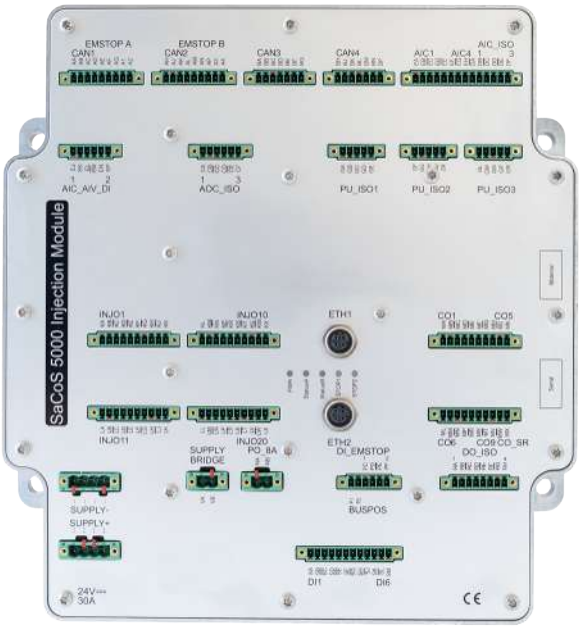


Figure 49: Injection Module (example)

Interface Cabinet

The Interface Cabinet is a floor-standing cabinet that optionally will be equipped with an air condition. The Interface Cabinet represents the communication interface between SaCoS 5000, the respective master system control and the engine room automation. For this purpose, the Interface Cabinet features a Gateway Communication Module with input and output channels as well as various interfaces like an interface to the Digital Services, Data Logging Cabinet and Remote Operating Panel.

2026-10-29 - 10.1

If necessary, the Interface Cabinet houses the power units of the loads attached to the engine (such as starters for pumps, etc., depending upon engine type).



Figure 50: Gateway Communication Module

The 400 V AC - if necessary - is fed into the Interface Cabinet and has to be provided for each Interface Cabinet separately by the customer.

The 230 V AC supply voltage for cabinet lighting/cabinet heating/cabinet ventilation and cabinet air conditioning is fed into the Interface Cabinet and has to be provided for each Interface Cabinet separately by the customer or the Power Supply Cabinet (optional).

The 24 V DC power supply is ensured via the customer or via the Power Supply Cabinet (optional).

2026-10-29 - 10.1

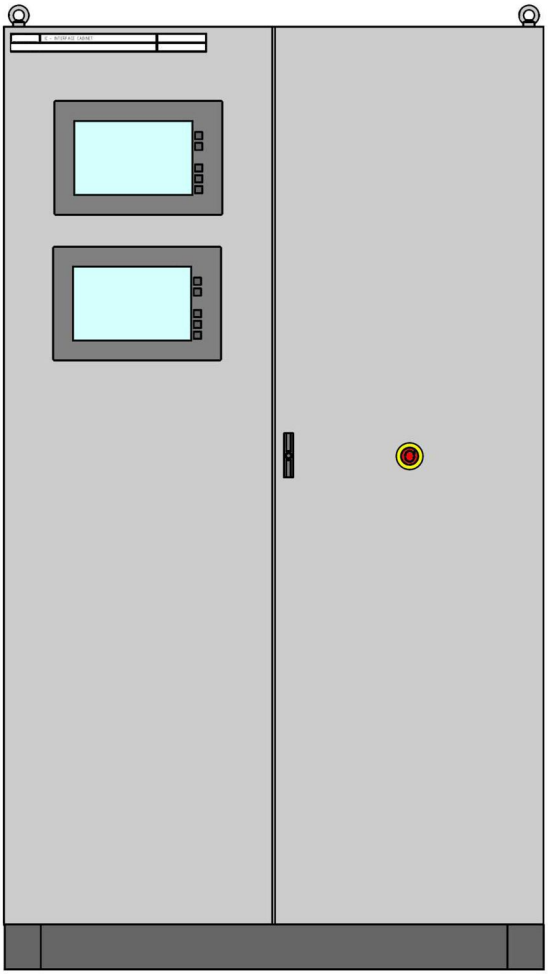


Figure 51: Interface Cabinet

The Interface Cabinet is equipped with a display module, optionally with two display modules. The display module enables complete control of the engine. The interface cabinet is fitted with an additional emergency stop button for manual emergency stops.

2026-10-29 - 10.1



Figure 52: Display Module

Remote Operating Panel/Wheelhouse Operating Panel (optional)

The Remote Operating Panel/Wheelhouse Operating Panel serves for engine operation from a control room. The Remote Operating Panel/Wheelhouse Operating Panel has the same functions as the Local Operating Panel.

The ROP/WOP is also equipped with an emergency stop button and a buzzer. In addition, the WOP is equipped with an override button.

From this operating device it is possible to transfer the engine operation functions to a superordinated automation system.

The panel can be delivered as loose supply for installation in the control room desk.

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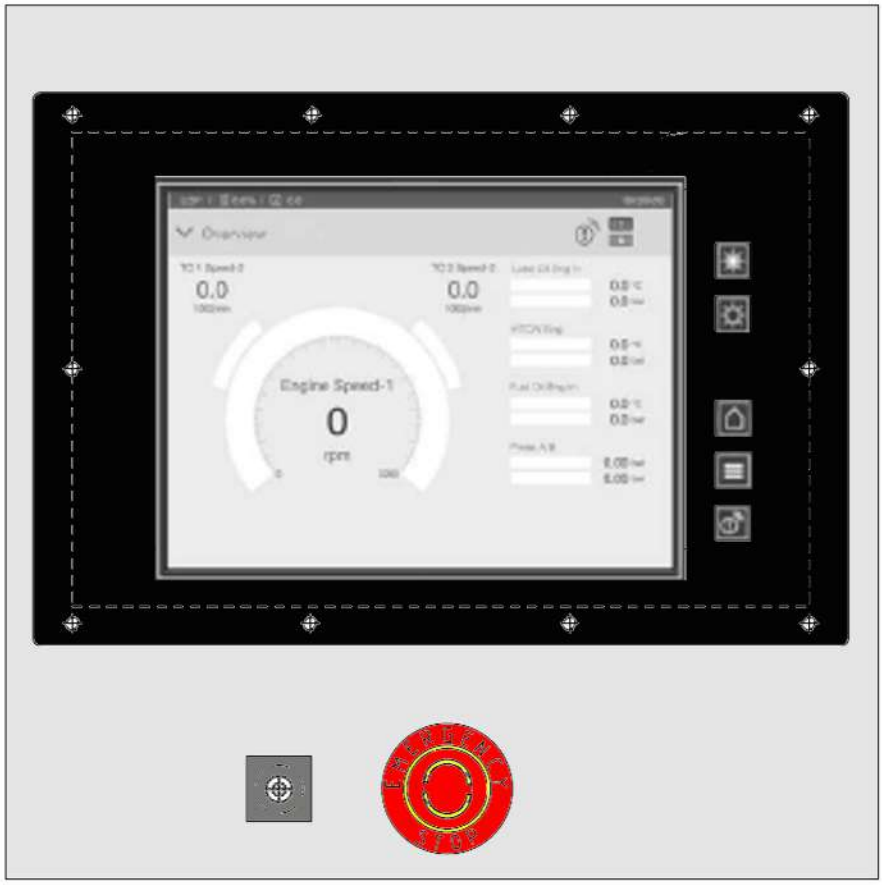


Figure 53: Remote Operating Panel

2026-10-29 - 10.1

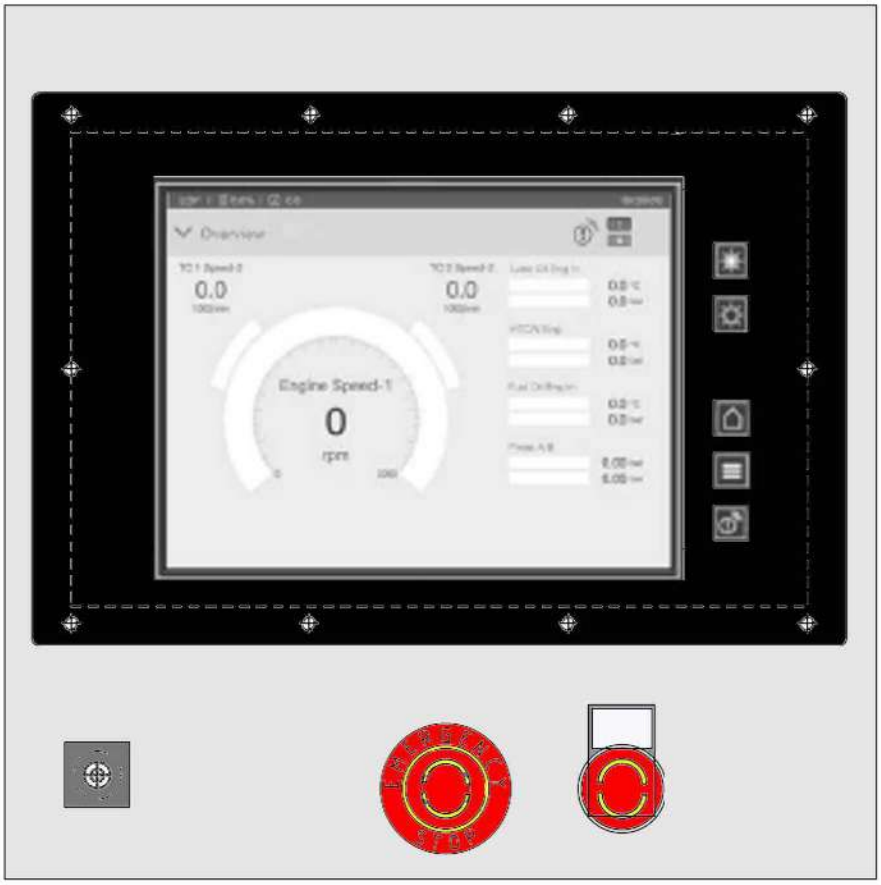


Figure 54: Wheelhouse Operating Panel

Turning Gear Control

The mobile Turning Gear Control contains the control system for turning operation.

The 230 VAC (optional 115 VAC) power supply is fed in via the Interface Cabinet.

The TGC is hard-wired to the Control and Injection Unit.

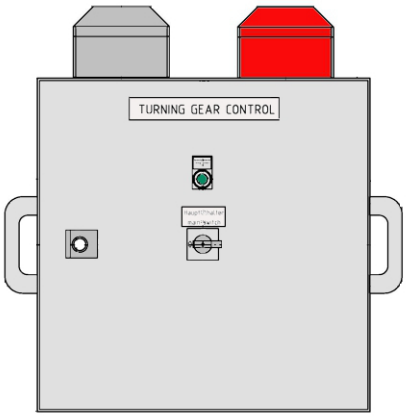


Figure 55: Turning Gear Control

Power Supply Cabinet (optional)

For the 24 V DC power supply Everllence offers a Power Supply Cabinet with uninterrupted power supply or without uninterrupted power supply.



Figure 56: Power Supply Cabinet

4.2 Power supply and distribution

The plant has to provide electric power for SaCoS 5000. An uninterrupted 24 V DC power supply is required for SaCoS 5000.

For marine main engines, a redundant power supply is required which must be provided by two individual supply networks:

- At least one of the power supplies must be uninterruptable (UPS).
- Both feeds must be decoupled from each other (e.g. with power diodes or MOSFETs) in the positive line so that they cannot interfere with each other.
- The minus conductors must be connected to each other to prevent voltage doubling in the event of a double earth fault (see DIN EN 50156-1).

2026-10-29 - 10.1

If the Power Supply Cabinet from Everllence is used, the Power Supply Cabinet will handle this requirements.

According to classification requirements it must be designed to guarantee the power supply to the connected systems for a sufficiently long period if both supply networks fail.

For the power supply Everllence offers a Power Supply Cabinet with uninterrupted power supply or without uninterrupted power supply.

If the Power Supply Cabinet is not used, the customer's infeed must take over the tasks of the Power Supply Cabinet. The following must also be noted:

- The back-up fuses specified in the circuit diagram must be provided for the SaCoS 5000 components (nominal current and tripping characteristics must be observed).
- The short-circuit breaking capacity of the back-up fuses must be sufficiently large.

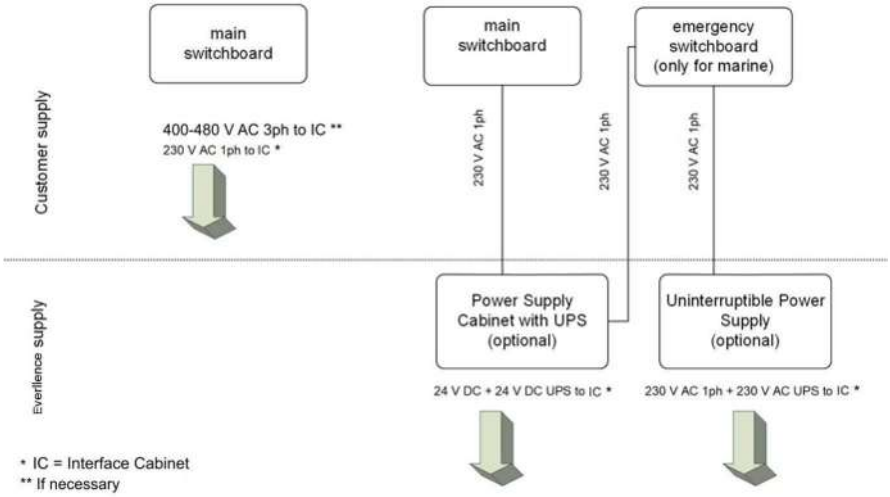


Figure 57: Supply diagram with Power Supply Cabinet and UPS

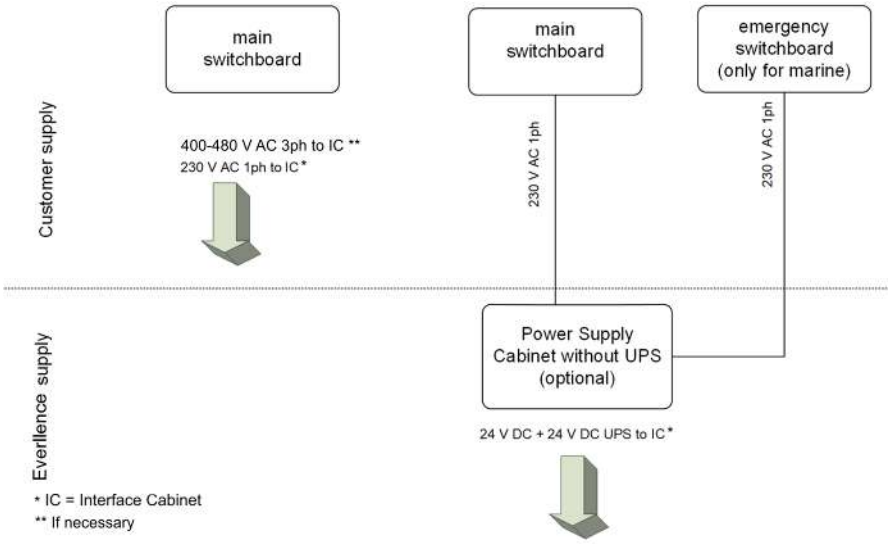


Figure 58: Supply diagram with Power Supply Cabinet

Required power supplies

Consumer	Voltage	Notes
Interface Cabinet	230 V 50/60 Hz	Light/socket, cooling device, heater
	24 V DC	All SaCoS components in the Interface Cabinet and on the engine
	400–480 V 50/60 Hz *	Power supply for consumers on engine

Table 79: Required power supplies

* If necessary.

For the Data Logging Cabinet, see chapter Data Logging Solutions, Page 119.

Galvanic isolation

A fault in an IT mains (see IEC 60364-1) affects the entire galvanic island formed by the IT network. If different engines are fed from galvanically connected power supplies, then a fault in one of the engines can also affect all other engines. It is therefore the subject of the system risk assessment to determine whether engines may be galvanically connected to each other. It is strongly recommended not to supply multiple engines from galvanically connected power supplies in order to limit the impact of errors and facilitate troubleshooting. For the same reason, the power supplies of the engines must be galvanically isolated from the power supplies for other parts of the system.

4.3 Operation

Control station changeover

The operation and control can be done from both operating panels. Selection and activation of the control stations is possible at the Local Operating Panel. On the displays, all the measuring points acquired by means of SaCoS 5000 can be shown in clearly arranged drawings and figures. It is not necessary to install additional speed indicators separately.

The operating rights can be handed over from the Remote Operating Panel to another Remote Operating Panel or to an external automatic system. Therefore a handshake is necessary.

For applications with Integrated Automation Systems (IAS) also the functionality of the Remote Operating Panel can be taken over by the IAS.

Operating modes

For alternator applications:

- Droop (5-percent speed increase between nominal load and no load)

For propulsion engines:

- Isochronous
- Master/Slave Operation for operation of two engines on one gear box

The operating mode is pre-selected via the SaCoS interface and has to be defined during the application period.

2026-10-29 - 10.1

Details regarding special operating modes on request.

Speed setting

The speed setting can be done either by means of binary contacts (e.g. for synchronisation) or by an active 4 – 20 mA analogue signal alternatively. The signal type for this is to be defined in the project planning period.

4.4 Functionality

Safety functions

The safety system monitors all operating data of the engine and initiates safety actions, e.g. load reduction request or engine shutdown, in case any limit values are exceeded.

Safety stop category	Properties	To external	
		Man Em Stop	
Manual Emergency Stop *ManEmStop*	• Source: Manually • Safety Chain: Hard- and Soft-wired • Processing: Redundant • Override-able: No • EmStop Actuators: all	SaCoS Safety Stop*	Overall Safety Stop*
Internal Automatic Emergency Stop *IntAutoEmStop*	• Source: Automatically • Safety Chain: Hardwired • Processing: Redundant • Override-able: No • EmStop Actuators: all		
Internal Automatic Shutdown *IntAutoSD*	• Source: Automatically • Safety Chain: Cloud-based • Processing: Single or redundant • Override-able: Yes • EmStop Actuators: Individually		
External Emergency Stop *ExtEmStop*	• Source: Unknown • Safety Chain: Hard- and Soft-wired • Override-able: No • Processing: Redundant • EmStop Actuators: all		
External Automatic Shutdown *ExtAutoSD*	• Source: Unknown • Safety Chain: Cloud-based • Override-able: Yes • Processing: Redundant • EmStop Actuators: Individually		

Figure 59: Safety Functions

Note:
The automatic emergency stop and automatic shutdown may have impact on the function of the plant. These effects can differ widely depending on the overall design of plant and must already be considered in an early phase of the project planning.

Note:
A manual emergency stop stops the engine, but does not affect the interface signals requesting the auxiliary units. During the integration, the respective integrator must determine how the system reacts.

Load reduction

The safety system supervises requests a load reduction to 60%.The load reduction has to be carried out by an external system (PMS, PCS, etc.). For safety reasons, SaCoS 5000 will not reduce the load by itself. The load reduction can be also requested via an external system.

2026-10-29 - 10.1

Override

With the Override switch on the bridge or in the engine control room, the safety system function can be restricted to the issuing of alarms and messages. With the Override active, the engine is not automatically shutdown by the safety system and neither a load reduction will occur.

Exceptions are:

- Manual emergency stop
- Internal automatic emergency stop
- External emergency stop

Further exceptions depend on the specifications of the respective classification society.

Alarm functions

The alarm functions supervise all necessary limit values and generate alarms to indicate discrepancies. The alarm functions are processed in an area completely independent of the safety system area in all redundant modules.

Self-monitoring

SaCoS 5000 carries out independent self-monitoring functions. Thus, for example the connected sensors are checked constantly for function and wire break. SaCoS 5000 reports all occurred malfunctions via alarm messages.

Speed control

The engine speed control is realised by software functions of the Injection Control Module. Engine speed and crankshaft turn angle indication is carried out by means of redundant pick ups at the camshaft.

Load limit curves

SaCoS 5000 features the following load limit curves:

- Start fuel limiter
- Maximum fuel limiter
- Charge air pressure dependent fuel limiter
- Torque limiter
- Rail pressure limiter
- Jump-rate limiter

Shutdown

The engine shutdown, initiated by safety functions and manual emergency stops, is carried out by redundant fast closing valves of the gas valve unit and independent interrupt of power supply of gas admission valves.

Note:
The engine shutdown may have impact on the function of the plant. These effects can be very diverse depending on the overall design of the plant and must already be considered in early phase of the project planning.

Overspeed protection

The engine speed is monitored independently from each other in the alarm system and safety system. In case engine overspeed is detected each system actuates the shutdown device via a separate hardware channel.

Control

SaCoS 5000 controls all engine-internal functions as well as external components in the plant.

2026-10-29 - 10.1

Start/stop sequence

SaCoS 5000 controls all steps of the start/stop sequence:

- Slow turn
- Start air/stop air pressure monitoring
- Requests of lube oil and cooling water pumps
- Monitoring of the prelubrication and post-cooling period
- Monitoring of the acceleration period

Control station switch-over

SaCoS 5000 controls the switch-over between the different operating panels and the switch-over to an external control system.

External functions

The scope of control functions depends on the plant configuration and must be coordinated during the project engineering phase. These control functions may cover:

- Electrical lube oil pump
- Electrical driven HT cooling water pump
- Electrical driven LT cooling water pump
- Nozzle cooling water module
- HT preheating unit
- Clutches

Media temperature control

Various media flows must be controlled to ensure trouble-free engine operation.

The temperature controllers are available as software functions. The temperature controllers are operated by the displays at the operating panels as far as it is necessary.

The cylinder cooling water (HT) temperature control is equipped with performance-related feed forward control, in order to guarantee the best control accuracy possible (refer also to section Cooling water systems, Page 198).

- The design of the lube oil temperature control depends on the engine type. It is designed either as a thermostatic valve (waxcartridge type) or as an electric driven control valve with electronic control similar to the HT temperature controller. Refer also to section External lube oil system, Page 189.

4.5 Interfaces

Data bus interface (machinery alarm system)

This interface serves for data exchange to the ship alarm system. The interface is actuated with MODBUS protocol and is available as:

- Ethernet interface (MODBUS over TCP (Transmission Control Protocol))

The status messages, alarms and safety actions, which are generated in the system, can be transferred to the ship alarm system. All measuring values acquired by SaCoS are available for transfer.

Power Management System

Hardwired interface, for remote start/stop, load setting, etc.

2026-10-29 - 10.1

Propulsion Optimization Interface

Standardised hardwired interface including all signals for control and safety actions between SaCoS 5000 and the propulsion control system.

This includes the following signals:

- Overload
- Operation close to the limit curve
- Propeller pitch reduction
- Engine speed
- Engine torque
- Distance to active limiter
- Derating factor (for DF engines)

This signals allow an optimized data exchange between engine and a smooth and look ahead control of the CCP propulsion system.

Clarify details at early stage of project.

Others

In addition, interfaces to auxiliary systems are available, such as:

- Nozzle cooling water module
- HT preheating unit
- Electric driven pump for lube oil
- Clutches
- Gearbox

4.6 Technical data

Cabinet

Design

- Floor-standing cabinets with plinth and fan/air condition
- Cable entries: From below, through cabinet base
- Accessible by front door(s), doors with locks
- Opening angle: 90°
- Standard colour: Light grey (RAL7035)
- Ingress protection: IP54

Dimensions and weights of cabinets

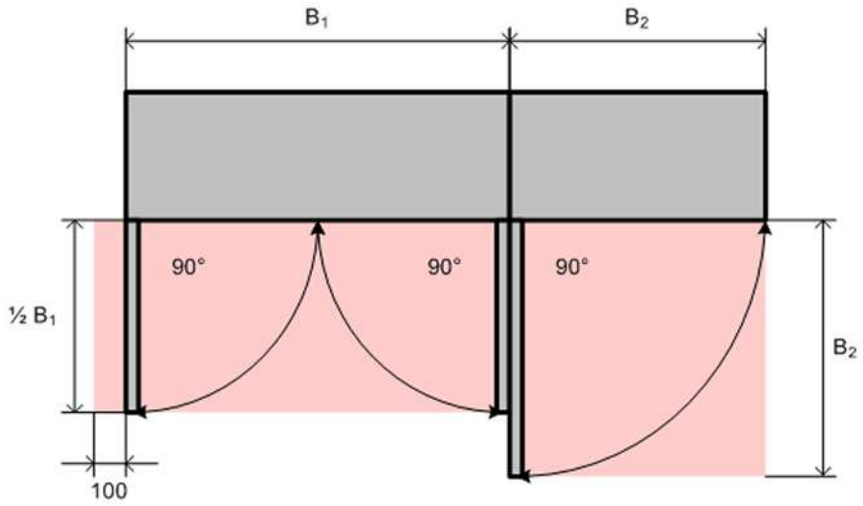
Cabinet	Dimensions (mm) including base			Approx. weight (kg)
	Width	Height	Depth	
Interface Cabinet, equipped with fan	1,200	2,100	400	300
Interface Cabinet, equipped with air condition	1,550	2,100	400	360
Power Supply Cabinet, equipped with fan	600	2,100	400	300
Power Supply Cabinet, equipped with air condition	950	2,100	400	360
Data Logging Cabinet	See chapter Data Logging Solutions, Page 119			

2026-10-29 - 10.1

Cabinet	Dimensions (mm) including base			Approx. weight (kg)
	Width	Height	Depth	
Turning Gear Cabinet	460	460	210	20
Remote Operating Panel	400	400	-	5
Wheelhouse Operating Panel	400	400	-	5

Table 80: Dimensions and weights of cabinets

Door opening area of cabinets



B_1 Width of cabinet 1 B_2 Width of cabinet 2

Figure 60: Exemplary arrangement of control cabinets with door opening areas (top view)

Environmental conditions

Components on engine and wall-mounted cabinets

- Ambient air temperature: +5 °C to +55 °C
  - Exception: an ambient air temperature of +5 °C to +45 °C applies to the SCR Cabinet, Gas Valve Unit Cabinet and Fuel Valve Train Cabinet
  - Exception: ambient air temperature Data Logging Cabinet, see chapter Data Logging Solutions, Page 119
- Relative humidity: < 96 %
- Vibrations: < 0.7 g

Floor-standing cabinets

- Ambient air temperature:
  - 0 °C to +45 °C: Floor-standing cabinets will be equipped with a fan
  - Over +45 °C: Floor-standing cabinets will be mandatory equipped with an air condition
- Relative humidity: < 96 %
- Vibrations: < 0.7 g

4.7 Installation requirements

Location

- The cabinets are designed for installation in engine rooms or engine control rooms.
- The cabinets must be installed at a location suitable for service inspection.
- Do not install the cabinets close to heat-generating devices.

2026-10-29 - 10.1

Wall-mounted cabinets and floor-standing cabinets

The cabinet must be installed at a location suitable for service inspection.

Do not install the cabinet close to heat-generating devices.

Floor-standing cabinets

In case of installation at walls, the distance between the floor-standing cabinet and the wall has to be at least 100 mm to allow air convection.

The foundation at the installation site must be solid enough to withstand the weight of the floor-standing cabinets.

All floor-standing cabinets have to be fixed to the floor. Also they have to be secured against tipping over (for example, by attaching the roof to the wall) with suitable mounting support, proven to withstand at minimum the maximum allowed inclination, see accordingly section Engine inclination.

Note:
If the restrictions for ambient temperature cannot be kept, the floor-standing cabinet must be ordered with an optional air condition system.

Ambient air conditions

For restrictions of ambient conditions, refer to the section Technical data, Page 142.

Cabling

The interconnection cables between the engine and the cabinets have to be installed according to the rules of electromagnetic compatibility. Control cables and power cables have to be routed in separate cable ducts.

Cabling

- The interconnection cables between the engine and cabinets have to be installed according to the rules of electromagnetic compatibility (for example, IEC 60446). Control cables and power cables have to be routed in separate cable ducts.
- The cables for the connection of sensors and actuators which are **not mounted on the engine** are not included in the scope of supply of Everllence. Shielded cables have to be used for the cabling of sensors. For electrical noise protection, an electric ground connection must be made from the cabinets to the ship's hull.
- All cabling between the cabinets and the controlled device is scope of customer supply.
- The cabinets are equipped with spring loaded terminal clamps. All wiring to external systems should be carried out without conductor sleeves.
- The redundant CAN cables are Everllence scope of supply.

Maximum cable lengths

Connection	Max. cable length
Cables between engine and Interface Cabinet	≤ 45 m
MODBUS cable between Interface Cabinet and superordinate automation system (only for Ethernet)	≤ 100 m
Cable between Interface Cabinet and Remote Operating Panel	≤ 100 m

Installation works

- During the installation period, the customer has to protect the cabinets against water, dust, and fire. It is not permissible to do any welding near the cabinets. The cabinets to be fixed to the floor by screws.
- If it is inevitable to do welding near the cabinets, the cabinets and panels have to be protected against heat, electric current, and electromagnetic influences. To guarantee protection against current, the cabling must be disconnected from the affected components.

2026-10-29 - 10.1

- The installation of other components inside the cabinets is only permissible after approval by the responsible project manager of Everllence.

Sensors

The sensor 1TE3165 “HTCW Temp After Mixing Point” (double PT1000) measures the HT-CW temperature after the mixing point.

The sensor 1TE4165 “LTCW Temp After Control Valve” (double PT000) measures the LT-CW temperature after the control valve.

The sensor 1TE6000 “Ambient Air Temp” (double PT1000) measures the temperature of the (outdoor) ambient air. The temperature of the ambient air will typically differ from that in the engine room.

Installation of sensor 1TE6000 „Ambient Air Temp”

The sensor may be installed in the ventilation duct of the fan blowing the (outdoor) ambient air into the engine room. Ensure to keep the sensor away from the influence of heat sources or radiation. The image below shows two options of installing the sensors correctly:

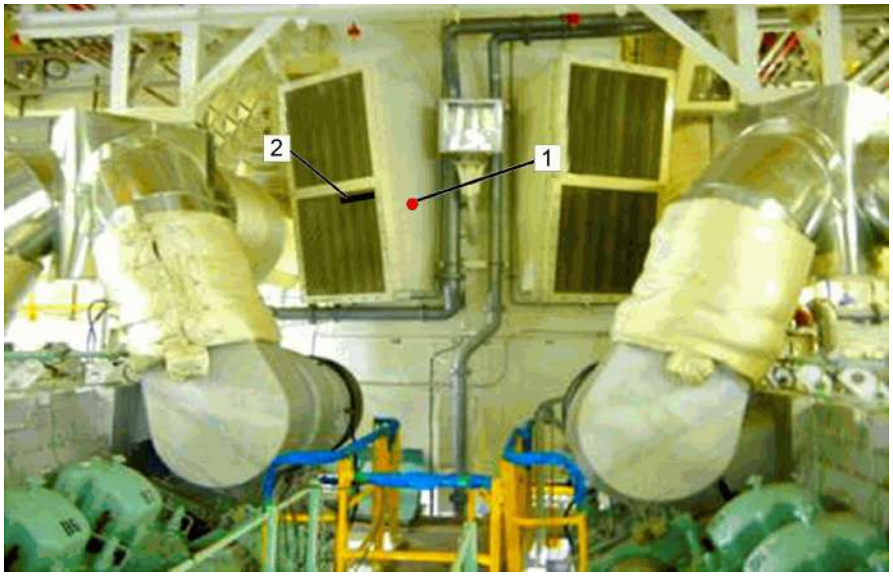


Figure 61: Possible locations for installing the sensor 1TE6000

1	Hole drilled into the duct of the engine room ventilation. Sensor measuring the temperature of the airstream.	2	Self-designed holder in front of the duct.

Note:
The sensor 1TE6100 “Intake Air Temp” is not suitable for this purpose.

4.8 Engine-located measuring and control devices

Exemplary list for project planning

No.	Measuring point	Description	Function	Measuring Range	Location	Connected to	Depending on option
Temperature control							

2026-10-29 - 10.1

No.	Measuring point	Description	Function	Measuring Range	Location	Connected to	Depending on option
1	1TE0003	temp sensor interface cabinet internal temp.	Indication	0-120 °C	Interface Cabinet	-	-
Speed pickups							
1	1SE1004A/B[1)]	speed pickup TC A/B speed-1	indication, supervision	0–30,000 rpm/ 0–1,000 Hz (16V) 0–40,000 rpm/ 0–1,333 Hz (20V)	turbocharger	Control Module/ Safety	-
2	2SE1004A/B[1)]	speed pickup TC A/B speed-2	indication, supervision	0–30,000 rpm/ 0–1,000 Hz (16V) 0–40,000 rpm/ 0–1,333 Hz (20V)	turbocharger	Control Module/ Safety	-
3	1SE1005	speed pickup engine speed-1	camshaft speed and position	0–1,200 rpm/ 0–2,000 Hz	camshaft drive wheel	Control Module/ Alarm	-
4	2SE1005	speed pickup engine speed-2	camshaft speed and position	0–1,200 rpm/ 0–2,000 Hz	camshaft drive wheel	Control Module/ Safety	-
Start and stop of engine							
1	1SSV1011	solenoid valve engine start valve	actuated during engine start and slowturn	-	engine	Control Module/ Alarm	-
Charge air bypass							
1	1XCV1030	control valve charge air engine bypass flap	blow by while part-load or low speed	-	engine	Control Module/ Alarm	charge air bypass
Charge air blow-off							
1	1XSV1031	solenoid valve charge air blow off flap	charge air blow off at low intake air temp	-	engine	Control Module/ Alarm	charge air blow off
Main bearings							

2026-10-29 - 10.1

No.	Measuring point	Description	Function	Measuring Range	Location	Connected to	Depending on option
1	1TE1064-x	double temp sensors main bearing 1 temp.-x	indication, alarm, engine protection	0–150 °C	engine	Control Modules	main bearing temp monitoring
2	xTE1064-x	double temp sensors main bearing x temp.-x	indication, alarm, engine protection	0–120 °C	engine	Control Modules	main bearing temp monitoring
3	xTE1066-x	double temp sensors engine PTO shaft bearing temp.-x	indication, alarm, engine protection	0–150 °C	engine	Control Modules	main bearing temp monitoring
Turning gear							
1	1GOS1070	limit switch turning gear engaged	indication and start blocking	-	engine	Control Module/ Alarm	-
2	1GOS1071	limit switch motor of turning gear engaged	indication and start blocking	-	engine	Control Module/ Alarm	-
Lube oil system							
1	1TE2160-x	double temp sensors lube oil temp. lube oil cooler inlet-x	indication	0–120 °C	engine	Control Modules	-
2	1PT2165	pressure transmitter lube oil pressure filter inlet	-	0–10 bar	engine	Control Module/ Alarm	-
3	1TE2170-x	double temp sensors lube oil temp engine inlet-x	alarm at high temp	0–120 °C	engine	Control Modules	-
4	1PT2170	pressure transmitter lube oil pressure engine inlet-1	alarm at low lube oil pressure	0–10 bar	engine	Control Module/ Alarm	-
5	2PT2170	pressure transmitter lube oil pressure engine inlet-2	auto shutdown at low pressure	0–10 bar	engine	Control Module/ Safety	-
6	1PT2570A/B[1)]	pressure transmitter lube oil pressure TC A/B inlet-1	alarm at low lube oil pressure	0–6 bar	engine	Control Module/ Alarm	-
7	2PT2570A/B[1)]	pressure transmitter lube oil pressure TC A/B inlet-2	auto shutdown at low lube oil pressure	0–6 bar	engine	Control Module/ Safety	-
8	1TE2580A/B[1)]-x	double temp sensors lube oil temp TC A/B outlet-x	alarm at high temp	0–120 °C	engine	Control Modules	-

2026-10-29 - 10.1

No.	Measuring point	Description	Function	Measuring Range	Location	Connected to	Depending on option
Crankcase pressure							
1	1PT2800	pressure transmitter crankcase pressure-1	input for alarm system	– 20-20 mbar	engine	Control Module/ Alarm	-
2	2PT2800	pressure transmitter crankcase pressure-2	input for safety system	– 20-20 mbar	engine	Control Module/ Safety	-
3	3PT2810	lube oil pressure oil pan	oil level monitoring	0-100 mbar	IC	ERA	-
4	5PT2810	lube oil pressure oil pan	oil level monitoring	0-100 mbar	IC	ERA	-
Splash oil							
1	xTE2880-x	double temp sensors splash oil temp compt. x(-x)	splash oil supervision	0–120 °C	engine	Control Modules	-
Gearbox							
1	2TE2970	temp sensor gear lube oil temp.	gearbox supervision	0-150 °C	gearbox	-	-
2	1PS2970	pressure switch gear lube oil press. low	gearbox supervision	-1-1 bar	gearbox	-	-
3	2PS2970	pressure switch gear lube oil press. low low	gearbox supervision	-1-1 bar	gearbox	-	-
4	3PS2970	pressure switch gear lube oil press. sufficient	gearbox supervision	-1-10 bar	gearbox	-	-
5	1SE2971	speed pickup gear pinion shaft speed-1	gearbox supervision	-	gearbox	-	-
6	2SE2971	speed pickup gear pinion shaft speed-2	gearbox supervision	-	gearbox	-	-
7	2TE2980	temp sensor gear thrust bearing temp.	gearbox supervision	0-150 °C	gearbox	-	-
Cooling water systems							
1	1TE3170-x	double temp sensors HTCW temp. cyl. cooling inlet-x	alarm, indication	0–120 °C	engine	Control Modules	-
2	1PT3170	pressure transmitter HTCW press. cyl. cooing inlet-1	alarm at low pressure	0–10 bar	engine	Control Module/ Alarm	-

2026-10-29 - 10.1

No.	Measuring point	Description	Function	Measuring Range	Location	Connected to	Depending on option
3	2PT3170	pressure transmitter HTCW press. cyl. cooing inlet-2	detection of low cooling water pressure	0–10 bar	engine	Control Module/ Alarm	-
4	1TE3180A/B[1)]-x	double temp sensors HTCW temp. cyl. cooing outlet row A/ B-x	-	0–120 °C	engine	Control Modules	-
5	1TE3190-x	double temp sensors HTCW temp. last charge air cooler outlet-x	-	0–120 °C	engine	Control Modules	-
6	1PT4120	pressure transmitter seawater pressure pump outlet	-	0–10 bar	engine	Control Module/ Alarm	-
7	1TE4170-x	double temp sensors LTCW temp. charge air cooler inlet-x	alarm, indication	0–120 °C	LT pipe charge air cooler inlet	Control Modules	-
8	1PT4170	pressure transmitter LTCW pressure charge air cooler inlet-1	alarm at low cooling water pressure	0–10 bar	engine	Control Module/ Alarm	-
9	2PT4170	pressure transmitter LTCW pressure charge air cooler inlet-2	alarm at low cooling water pressure	0–10 bar	engine	Control Unit	-
10	1TE4180-x	double temp sensors LTCW temp. charge air cooler outlet-x	-	0–120 °C	engine	Control Module/ Alarm	-
11	1TE4185-x	double temp sensors LTCW temp. lube oil cooler outlet-x	-	0–120 °C	engine	Control Module/ Alarm	-
Fuel system							
1	1TE5070-x	double temp sensors fuel oil temp engine inlet-x	alarm at high temp in MDO-mode and for EDS use	0–120 °C	engine	Control Modules	-
2	1PT5070	pressure transmitter fuel oil pressure engine inlet-1	remote indication and alarm	0–16 bar	engine	Control Module/ Alarm	-
3	2PT5070	pressure transmitter fuel oil pressure engine inlet-2	remote indication and alarm	0–16 bar	engine	Control Module/ Safety	-

2026-10-29 - 10.1

No.	Measuring point	Description	Function	Measuring Range	Location	Connected to	Depending on option
4	xFSV5078A/B[1)]	injection valve fuel oil injection cylinder A/B-x	fuel injection	-	engine	Injection Module 1/2	-
5	1LS5080	level switch fuel oil injector and pump leakage	alarm at high level	-	-	Control Module/ Alarm	-
Charge air system							
1	1TE6100A/B[1)]-x	double temp sensors intake air temp. row A/B-x	-	-50–80 °C	intake air duct after filter	Control Module/ Alarm	-
2	1TE6170A/B[1)]	double temp sensors charge air temp cooler A/B inlet	for EDS visualisation	0–300 °C	engine	Control Modules	-
3	1PT6170A/B[1)]	pressure transmitter charge air pressure cooler A/B-1	STC control	0–4 bar	engine	Control Modules	STC
4	2PT6170A/B[1)]	pressure transmitter charge air pressure cooler A/B-2	STC control	0–4 bar	engine	Control Modules	STC
5	1FSV6171A-x	solenoid valve charge air switch-over for STC	bistabile 5/2-way valve to cut off CA pipe of TC A for STC	-	engine	Control Module/ Alarm	STC
6	1TE6180-x	double temp sensors charge air temp engine inlet-x	alarm at high temp	0–120 °C	engine	Control Modules	-
7	1PT6180	pressure transmitter charge air pressure engine inlet-1	engine control	0–4 bar	engine	Control Module/ Alarm	-
8	2PT6180	pressure transmitter charge air pressure engine inlet-2	-	0–4 bar	engine	Control Module/ Safety	-
Exhaust gas system							
1	xTE6570A/B[1)]-x	double thermo-couples exhaust gas temp cylinders A/Bx outlet-x	indication, alarm, engine protection	0–800 °C	engine	Control Modules	-
2	1XCV6570	variable flap waste gate	-	-	-	-	-

2026-10-29 - 10.1

No.	Measuring point	Description	Function	Measuring Range	Location	Connected to	Depending on option
3	1FSV6571A-x	solenoid valve exhaust gas switch-over for STC	bistabile 5/2-way valve to cut off exhaust pipe of TC A for STC	-	engine	Control Module/ Alarm	STC
4	1TE6575A/B[1]-x	double thermo-couples exhaust gas temp TC A/B inlet-x	indication, alarm, engine protection	0–800 °C	engine	Control Modules	-
5	1TE6580A/B	double temp sensor exhaust gas temp TC A/B outlet	indication	-	turbocharger	Control Modules	-
Control air, start air, stop air							
1	1PT7170	pressure transmitter start air pressure-1	engine control, remote indication	0–40 bar	engine	Control Module/ Alarm	-
2	2PT7170	pressure transmitter start air pressure-2	engine control, remote indication	0–40 bar	engine	Control Module/ Safety	-
3	1PT7400	pressure transmitter control air pressure-1	remote indication	0–10 bar	engine	Control Module/ Alarm	-

[1] A-sensors: Installed on row A; B-sensors: Installed on row B.

Table 81: List of engine-located measuring and control devices

2026-10-29 - 10.1

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2026-10-29 - 10.1

5 Specification for engine supplies

5.1 Specification of lubricating oil for operation with DMA, DFA

General

The specific power achieved by modern diesel engines and the use of fuels that are increasingly reaching the very limits in terms of quality place higher requirements on the lube oil and necessitate careful selection of the lube oil.

Doped lube oils (HD oils) have a proven track record as lubricants for the drive, cylinder, turbocharger, and for cooling the piston. Doped lube oils contain additives that among other things ensure dirt absorption capability, engine cleaning, and neutralisation of acidic combustion products.

Only lube oils that have been approved by Everllence may be used.

Specifications

Neutralisation capacity

The neutralisation capacity (DIN ISO 3771) must be so high that the acidic products produced during combustion are neutralised. The reaction time of the additives must be matched to the process in the combustion chamber.

The base number (BN) should be at least 8.5 mg KOH/g with a fuel sulfur content of 0.2 % or less. At a fuel sulfur content between 0.2 and 1.5 %, the base number should be at least 12 mg KOH/g.

The oil must be a SAE40 monograde oil in terms of its viscosity.

Lubricating oil additives

It is not permissible to use any other additives in conjunction with the lubricating oil or to mix oils of different brands (oils from different manufacturers and different brands of the same manufacturer) since this can reduce the effectiveness of already existing additives, which have been carefully matched to one another and the base oil.

Military specification

The approved engine oils formally meet the requirements according to NATO O-278.

Other oils with approval according to NATO O-278 may only be used after prior approval from Everllence. A monthly oil analysis by Everllence PrimeServ is also required.

Selection of lubricating oils/ warranty

Most oil manufacturers are in close, permanent contact with engine manufacturers and can therefore specify which oil from their own product line is approved by the engine manufacturer for the specific application. Irrespective of this information, the lubricating oil manufacturers are liable for the quality and properties of their products. If you have any questions, we would be more than happy to provide you with additional information.

The list of the currently approved lubricating oils is available at Lubrication.

Oil during operation

The intervals between lubricating oil changes are determined by the ageing rate of the oil. The lubricating oil used must comply with the requirements stated in the table entitled Limit values for used engine oil.

Property	Unit	Limit value	Procedure
Viscosity at 40 °C	mm^2/s	100–190 (SAE 40) 80–190 (SAE 10W-40)	ISO 3104, ASTM D445, ASTM D 7042, DIN EN 16896

2026-10-29 - 10.1

Property	Unit	Limit value	Procedure
Viscosity at 100 °C		10.5–19.0 (SAE 40) 10.5–19.0 (SAE10W-40)	
Base number (BN)	%	At least 50 % of fresh oil - BN	ISO 3771
Flash point (PM)	°C	At least 170	ISO 2719
Water content	vol. %	Max. 0.20	DIN 51777, ASTM D6304
Soot content	% (m/m)	Max. 3.0	DIN 51452
Oxidation[1)]	A/cm	Max. 25	DIN 51453
Fuel dilution	% (m/m)	Max. 3.0	DIN 51454
Coolant additive	mg/kg	Free from	DIN 51399-1
TAN	mg KOH/g	+3.5 for fresh oil and BN > TAN	ASTM D664
Metal content (reference values) Iron, chrome, tin, copper, aluminium, lead	ppm	dependent on engine type and operating conditions max. 50 max. 10 max. 15 max. 20	ASTM D5185, DIN 51399-1
[1)] Only possible if there are no ester compounds and no ingress of biofuel.			

Table 82: Limit values for engine oil to be used

A monthly analysis of lube oil samples is mandatory for safe engine operation. We can analyse samples for customers in the Everllence PrimeServLab.

Note:
If operating fluids are improperly handled, this can pose a danger to health, safety and the environment. The relevant safety information by the supplier of operating fluids must be observed.

5.2 Diesel fuel (DMA, DFA) specification

General information

Diesel fuel is a middle distillate refined from crude oil. It is also referred to as: gas oil, marine gas oil (DMA), DFA, diesel oil. It should not contain any residue from crude oil refining.

Selection of suitable fuel

Unsuitable or adulterated fuel generally results in a shortening of the service life of engine parts/components, damage to these and to catastrophic engine failure. It is therefore important to select the fuel with care in terms of its suitability for the engine and the intended application. Through its combustion, the fuel influences the emissions behaviour of the engine.

Specifications and approvals (DMA)

The fuel quality varies regionally and depends on climatic conditions. All requirements from ISO 8217:2024 apply

The following values must be maintained at the engine inlet:

2026-10-29 - 10.1

Property	Unit		Limit value[1]	Standard[2]
Appearance	-	-	Clear, bright and free from visible contamination	visual
Kinematic viscosity at 40° C[3]	mm^2/s	Max. Min.	6.0 2.0	ISO 3104, ASTM D7042, ASTM D445, DIN EN 16896
Density at 15°C	kg/m^3	Max. Min.	890.0 820.0	ISO 3675, ISO 12185
Water content	% (m/m)	Max.	0.02	DIN 51777, DIN EN 12937, ASTM D6304
Cetane number		Min.	40	EN ISO 5165, IP541, EN 15195, EN 16715, EN 17155
Sulphur content[4]	% (m/m)	Max.	1.0	ISO 8754, ISO 14596, ASTM D4294, DIN 51400-10
Flashpoint[5]	°C	Min.	60.0	ISO 2719
Acid number	mg KOH/g	Max.	0.5	ASTM D664
Carbon residue[6]	% (m/m)	Max.	0.30	ISO 10370
Ash content	% (m/m)	Max.	0.010	ISO 6245
Lubricity (WSD)	µm	Max.	520	ISO 12156-1, ASTM D6079
Corrosion effect on copper	Class	Max.	1	EN ISO 2160
Hydrogen sulphide	mg/kg	Max.	2.0	IP 570
FAME[7]-content	% (V/V)	Max.	0.5	ASTM D7963, IP 579, DIN EN 14078
Oxidation stability	g/m^3	Max.	25	EN ISO 12205
Sediment content[8]	% (m/m)	Max.	0.01	ISO 10307-1
CFPP	°C		10°C below the lowest temperature in the fuel system	DIN EN 116, IP 309, IP 612
Pour Point[9] winter grade	°C	Max.	-6	ISO 3016
Pour Point[9] summer grade	°C	Max.	0	ISO 3016
Na, K, Ca, P, Cu, Zn, Si	mg/kg	Max.	free from	DIN EN 16476

Table 83: Requirements for diesel fuel (DMA)

Remarks:

[1] The fuel must be suitable for the intended application. It must not contain any substance in a concentration that causes additional air pollution, is harmful for personnel, jeopardises ship safety and/or has an adverse effect on machine performance. The fuel must be free from non-ferrous metals according to DIN EN 16476. The fuel must not contain any waste oil.

[2] Always refer to the currently applicable edition.

[3] Specific requirements of the injection system must be taken into account

2026-10-29 - 10.1

[4] Independent of the maximum permissible sulphur content, local laws and regulations must be adhered to

[5] Additional requirements (e.g. SOLAS) must be observed. Applicable laws must be adhered to.

[6] Determined at 10% distillation residue

[7] The FAME must either be in accordance with EN 14214 or with ASTM D6751 as well as with increased oxidation stability of at least 8 hours (EN 15751). For information on the use of fuels with more than 0.5% FAME see section Diesel fuel (DMA, DFA) specification, Page 157

[8] If the sample is not clear and bright, complete sedimentation through hot filtration and the determination of water content is required

[9] 10°C below the lowest temperature in the fuel system

The following fuels are approved for use if the fuel complies with table Requirements for diesel fuel (DMA), Page 155:

- Classes ISO F-DMA & DMZ according to ISO 8217:2024
- Diesel fuel as per EN 590:2022 with additional requirement regarding flashpoint > 60 °C in SOLAS regulated areas
- Diesel fuel no. 2-D as per ASTM D975-21 with additional requirement regarding flashpoint > 60 °C in SOLAS regulated areas

Fuels that do not comply with the above-mentioned standards must be queried with Everllence.

Viscosity

In order to ensure sufficient lubrication, a minimum level of viscosity must be ensured at the fuel pump. The permissible maximum temperature of the fuel required to maintain minimum viscosity upstream of the injection pump of 1.5 mm^2/s thus depends on the basic viscosity of the fuel. The fuel temperature must be set so that the viscosity does not fall below 1.5 mm^2/s. The temperature of the fuel upstream of the injection pump must under no circumstances be above 45°C, even if the basic viscosity of the fuel would ensure a viscosity of ≥ 1.5 mm^2/s at the injection pump at 45°C. The lubricity requirements of the fuel for the engine are always max. 520 µm WSD as per ISO 12156-1.

Military fuel specification

The fuels of type F-75 or F-76 as per NATO STANAG 1385 can be used if they fully comply with the standards or limit values listed in the table Requirements for diesel fuel (DMA), Page 155 pursuant to ISO 8217:2024 and the minimum permissible viscosity upstream of the injection pump with the corresponding temperature is adhered to.

Synthetic fuels (DIN EN 15940)

When using synthetic fuels according to DIN EN 15940 with a density of less than 820 kg/m^2 at 15 °C, prior consultation with Everllence is required.

Synthetic fuels such as HVO, BTL, CTL, GTL according to DIN EN 15940, can be produced from renewable electrical energy and CO_2 or from the same basic material such as FAME fuels (vegetable oil, cooking oil, animal fat) but in a completely different procedure. Synthetic fuels are produced by means of hydrogen treatment, with a fuel being generated which has a very similar chem-

2026-10-29 - 10.1

ical structure to high-performance diesel fuel and consists of paraffinic hydrocarbons. In contrast to fossil diesel fuel, synthetic fuel barely contains any aromatic components, which causes very good combustion properties.

Although the energy content (per mass unit) is higher in comparison with fossil diesel fuel, the volumetric energy content is lower due to the lower density (typically approx. 780 kg/m³ at 15°C). This may lead to deviations in the specified engine output, operating behaviour, load application and emissions as well as deviations in the specific fuel consumption.

The lubricity of synthetic fuels is relatively low. In order to meet fuel specifications (requirements on diesel fuel) and guarantee sufficient lubricity of the fuel, the fuel supplier needs to add a lubricity additive or FAME.

The lower flashpoint limit is too low at a minimum of 55°C. The additional requirement relating to flashpoint min. 60 °C in SOLAS regulated areas must be observed.

FAME (fatty acid methyl ester) additive of 0.5 to 100% (DFA)

The following values must be maintained at the engine inlet:

Property	Unit		Limit value[1)]	Standard[2)]
Appearance	-	-	Clear, bright and free from visible contamination	visually
Kinematic viscosity at 40° C[3)]	mm²/s	Max. Min.	6.0 2.0	ISO 3104, ASTM D7042, ASTM D445, DIN EN 16896
Density at 15°C	kg/m³	Max. Min.	890.0 820.0	ISO 3675, ISO 12185
Water content	% (m/m)	Max.	0.02	DIN 51777, DIN EN 12937, ASTM D6304
Cetane number		Min.	40	EN ISO 5165, IP541, EN 15195, EN 16715, EN 17155
Sulphur content[4)]	% (m/m)	Max.	1.0	ISO 8754, ISO 14596, ASTM D4294, DIN 51400-10
Flashpoint[5)]	°C	Min.	60.0	ISO 2719
Acid number	mg KOH/g	Max.	0.5	ASTM D664
Carbon residue[6)]	% (m/m)	Max.	0.30	ISO 10370
Ash content	% (m/m)	Max.	0.010	ISO 6245
Lubricity (WSD)	µm	Max.	520	ISO 12156-1, ASTM D6079
Corrosion effect on copper	Class	Max.	1	EN ISO 2160
Hydrogen sulphide	mg/kg	Max.	2.0	IP 570
FAME[7)]-content	% (V/V)	Min.	0.5	ASTM D7963, IP 579, DIN EN 14078
Oxidation stability	h	Min.	8	EN 15751
Sediment content[8)]	% (m/m)	Max.	0.01	ISO 10307-1

2026-10-29 - 10.1

Property	Unit		Limit value[1)]	Standard[2)]
CFPP	°C		10°C below the lowest temperature in the fuel system	DIN EN 116, IP 309, IP 612)
Pour Point[9)] winter grade	°C	Max.	-6	ISO 3016
Pour Point[9)] summer grade	°C	Max.	0	ISO 3016
Na, K, Ca, P, Cu, Zn, Si	mg/kg	Max.	free from	DIN EN 16476

Table 84: Requirements for diesel fuel (DFA)

Remarks:

[1)] The fuel must be suitable for the intended application. It must not contain any substance in a concentration that causes additional air pollution, is harmful for personnel, jeopardises ship safety and/or has an adverse effect on machine performance. The fuel must be free from non-ferrous metals according to DIN EN 16476. The fuel must not contain any waste oil.

[2)] Always refer to the currently applicable edition.

[3)] Specific requirements of the injection system must be taken into account

[4)] Independent of the maximum permissible sulphur content, local laws and regulations must be adhered to

[5)] Additional requirements (e.g. SOLAS) must be observed. Applicable laws must be adhered to.

[6)] Determined at 10% distillation residue

[7)] The FAME must either be in accordance with EN 14214 or with ASTM D6751 as well as with increased oxidation stability of at least 8 hours (EN 15751).

[8)] If the sample is not clear and bright, complete sedimentation through hot filtration and the determination of water content is required

[9)] 10°C below the lowest temperature in the fuel system

When using DFA (FAME according to EN 14214 or ASTM D6751* or their mixtures with DMA), prior consultation with Everllence is required. In addition, the following should be observed:

- Due to the typically lower calorific value or energy content of FAME fuels and their mixtures with DMA (DFA), it may result in deviations to the specified engine output, operating behaviour, load application, specific fuel consumption and emissions.
- The sealing materials used must be suitable for DFA. NBR seals are not suitable and must not be used.
- DFA tends to attract water. The risk of microbial growth is therefore increased. For this reason, the water content needs to be kept as low as possible. The maximum water content must not be exceeded. Everllence recommends draining water from the fuel tank every day.
- If there is a possibility of dead volume in the fuel system, it is strongly recommended to flush these areas regularly (weekly) to prevent bacterial growth (e.g., in the area of the fuel filters by briefly switching the filter chambers).
- Long standstill periods (e.g. emergency power units) must be avoided due to microbial growth. To prevent damage, it is recommendable to only operate applications with fuel which is free of FAME (DMA).

2026-10-29 - 10.1

- The fuel reacts to air and this may lead to microbial growth. Ensure that the atmospheric oxygen ventilation is kept to a minimum. A nitrogen buffer is ideally installed in the fuel tank.
- The entire fuel system must be purged with fuel which is free of FAME (DMA) prior to longer standstill periods.
- If DFA is to be used with other fuels and mixing cannot be avoided, contact your fuel supplier to ensure the compatibility of these fuels.
- It is recommended that wherever possible a heat tracing system is installed in the fuel supply system, in order to prevent deposits or blockage of the lines.
- As DFA have a higher evaporation temperature than standard DMA qualities, these are enriched in lubricating oil. Regular analysis of all the lubricating oil is highly recommended. The lubricating oil needs to be replaced if a FAME content of 12% is reached.
- DFA may cause a layer to form, such a phenomenon leads to increased consumption of lubricating oil. If such an increase in lubricating oil consumption values is detected, please contact your Everllence PrimeServ department.
- Fuels may cause harmful reactions with metals such as zinc or copper. We highly recommend getting in contact with your tank and heating oil system supplier.
- After switching to DFA, pay attention to the delta pressure indicators/ alarms of the filters, as the residues dissolved by DFA can clog the filters.
- In any case, it is the responsibility of the operating company to adhere to the legal requirements (e.g. SOLAS) and agree on these with the relevant authorities.

* as well as with increased oxidation stability of at least 8 hours (EN 15751)

Cold suitability

The cold suitability of the fuel is determined by the climatic requirements at the place of installation. It is the responsibility of the operating company to choose a fuel with sufficient cold suitability.

The cold suitability of a fuel may be determined and assessed using the following standards:

- Limit of filterability (CFPP) as per EN 116
- Pour point as per ISO 3016
- Cloud point as per EN 23015

To be able to draw a reliable conclusion, it is recommended to perform all three stated procedures.

Analyses

The examination of fuel samples is essential for safe engine operation. Examinations can be performed in the Everllence Laboratory PrimeServLab for our customers.

To guarantee the safety of the crew and to obtain a representative sample, sampling must take place in accordance with valid Everllence operating instructions.

2026-10-29 - 10.1

5.3 Specification of engine coolant

Preliminary remarks

The engine coolant is of the following composition: Water for heat removal and coolant additive for corrosion protection.

As is also the case with the fuel and lubricating oil, the engine coolant must be carefully selected, handled and checked. Otherwise, corrosion, erosion and cavitation may occur at the walls of the cooling system in contact with water, and deposits may form. Deposits obstruct the transfer of heat and can cause thermal overloading of the cooled parts. The plant must be treated with an anti-corrosion agent before bringing it into operation for the first time. The concentrations prescribed by the engine manufacturer must always be observed during subsequent operation. The above especially applies if a chemical additive is added.

Requirements

Limit values

The properties of the untreated coolant must comply with the following limit values:

Characteristic/property	Characteristics	Unit
Type of water	Distilled or fresh water, free from impurities.	–
Overall hardness	max. 10	dGH[1)]
pH value	6.5 – 8	–
Chloride ion content	max. 50	mg/l[2)]

Table 85: Characteristics of coolant that must be complied with

[1)] 1 dGH (German hardness) ≙ 10 mg CaO in 1 liter water ≙ 17.8 mg $CaCO_3$/l

≙ 0.357 mval/l ≙ 0.178 mmol/l

[2)] 1 mg/l ≙ 1 ppm

Testing equipment

The manufacturers of anticorrosive agents supply user-friendly testing equipment.

For information on monitoring cooling water see section 4.4 Cooling water inspecting.

Additional information

Distillate

If distilled water (from a fresh water generator, for example) or fully desalinated water (from ion exchange or reverse osmosis) is available, this should ideally be used as the engine coolant. These waters are free of lime and salts, which means that deposits that could interfere with the transfer of heat to the coolant, and therefore also reduce the cooling effect, cannot form. However, these waters are more corrosive than normal hard water as the thin film of lime scale that would otherwise provide temporary corrosion protection does not form on the walls. This is why distilled water must be handled particularly carefully and the concentration of the additive must be regularly checked.

Hardness

The total hardness of the water is the combined effect of the temporary and permanent hardness. The proportion of calcium and magnesium salts is of overriding importance. The temporary hardness is determined by the carbon-

2026-10-29 - 10.1

ate content of the calcium and magnesium salts. The permanent hardness is determined by the amount of remaining calcium and magnesium salts (sulphates). The temporary (carbonate) hardness is the critical factor that determines the extent of limescale deposit in the cooling system.

Water with a total hardness of > 10°dGH must be mixed with distilled water, or softened.

Damage to the coolant system

Corrosion

Corrosion is an electrochemical process that can widely be avoided by selecting the correct water quality and by carefully handling the water in the engine cooling system.

Flow cavitation

Flow cavitation can occur in areas in which high flow velocities and high turbulence is present. If the steam pressure is reached, steam bubbles form and subsequently collapse in high pressure zones which causes the destruction of materials in constricted areas.

Erosion

Erosion is a mechanical process accompanied by material abrasion and the destruction of protective films by solids that have been drawn in, particularly in areas with high flow velocities or strong turbulence.

Stress corrosion cracking

Stress corrosion cracking is a failure mechanism that occurs as a result of simultaneous dynamic and corrosive stress. This may lead to cracking and rapid crack propagation in water-cooled, mechanically-loaded components if the coolant has not been treated correctly.

Treatment of engine coolant

Formation of a protective film

The purpose of treating the engine coolant using anticorrosive agents is to produce a continuous protective film on the walls of cooling surfaces and therefore prevent the damage referred to above. In order for an anticorrosive agent to be 100 % effective, it is extremely important that untreated water satisfies the requirements in the paragraph Requirements, Page 160.

Protective films can be formed by treating the coolant with chemical slushing oil.

Treatment prior to initial commissioning of engine

Treatment with an anticorrosive agent should be carried out before the engine is brought into operation for the first time to prevent irreparable initial damage.

Note:

The engine must not be brought into operation without treating the cooling water first.

Additives for coolants

A list of currently approved coolant additives and their concentrations can be found under Lubrication .

Biocides

If you cannot avoid using a biocide because the coolant has been contaminated by bacteria, observe the following steps:

- You must ensure that the biocide to be used is suitable for the specific application
- The biocide must be compatible with the sealing materials used in the coolant system and must not react with these

2026-10-29 - 10.1

- The biocide and its decomposition products must not contain corrosion-promoting components. Biocides whose decomposition products contain chloride or sulphate ions are not permitted.
- Biocides that cause foaming of coolant are not permitted.
- Biocides should not be used continuously, but only as a spot treatment

Antifreeze agents

- If antifreeze agents must be used, consult Everllence beforehand. Anti-freeze agents reduce the capacity of the coolant to absorb heat. In some cases the cooling effect of the coolant may be insufficient.

Prerequisite for effective use of an anticorrosive agent

Clean cooling system

As contamination significantly reduces the effectiveness of the additive, the tanks, pipes, coolers and other parts outside the engine must be free of rust and other deposits before the engine is started up for the first time and after repairs of the pipe system.

The entire system must therefore be cleaned with the engine switched off using a suitable cleaning agent (see table Cleaning agents for removing oil sludge).

Loose solid matter in particular must be removed by flushing the system thoroughly as otherwise erosion may occur in locations where the flow velocity is high.

The cleaning agents must not corrode the seals and materials of the cooling system. In most cases, the supplier of the coolant additive will be able to carry out this work and, if this is not possible, will at least be able to provide suitable products to do this. If this work is carried out by the engine operator, he should use the services of a specialist supplier of cleaning agents. The cooling system must be flushed thoroughly after cleaning. Once this has been done, the engine coolant must be immediately treated with anticorrosive agent. Once the engine has been brought back into operation, the cleaned system must be checked for leaks.

Regular checks of the coolant condition and system

Treated coolant can become contaminated during operation and the additive can lose some of its effectiveness. It is therefore advisable to check the cooling system and the condition of the coolant regularly. To detect leaks in the lubricating oil system, regular checking of the water in the expansion tank is recommended. Signs of oil in the water include discoloration or a visible oil film on the surface of the water sample.

Check the additive concentration using the test kits provided by the additive manufacturer at least once per week. The results must be recorded.

Note:

The chemical additives must be added in the specified concentration. See paragraph Permitted coolant additives, Page 161.

Concentrations that are too low can lead to corrosion and must be avoided. Concentrations that are slightly higher do not cause damage. Concentrations that are more than double the recommended concentrations should be avoided.

2026-10-29 - 10.1

Every 2 to 6 months send a cooling water sample to an independent laboratory or to the engine manufacturer for integrated analysis.

If chemical additives or anti-freeze solutions are used, cooling water should be replaced after 3 years at the latest.

If there is a high concentration of solids (rust) in the system, the water must be completely replaced and entire system carefully cleaned.

Deposits in the cooling system may be caused by fluids that enter the coolant, by corrosion in the plant, and by limescale deposits if the water is very hard. If the concentration of chloride ions has increased, this generally indicates that seawater has entered the system. The maximum specified concentration of 50 mg chloride ions per kg must not be exceeded as otherwise the risk of corrosion is too high. If exhaust gas enters the coolant, this can lead to a sudden drop in the pH value or to an increase in the sulphate content.

Water losses must be compensated for by filling with untreated water that meets the quality requirements specified in the paragraph Requirements, Page 160. The concentration of anticorrosive agent must subsequently be checked and adjusted if necessary.

Subsequent checks of the coolant are especially required if the coolant had to be drained off in order to carry out repairs or maintenance.

Protective measures

Anticorrosive agents contain chemical compounds that can pose a risk to health or the environment if incorrectly used. Comply with the directions in the manufacturer's material safety data sheets.

Avoid prolonged direct contact with the skin. Wash hands thoroughly after use. If larger quantities spray and/or soak into clothing, remove and wash clothing before wearing it again.

If chemicals come into contact with eyes, rinse them immediately with plenty of water and seek medical advice.

Anticorrosive agents are generally harmful to the water cycle. Observe the relevant statutory requirements for disposal.

Approved coolant additives

A list of currently approved coolant additives and their concentrations can be found under Lubrication .

5.4 Cooling water inspecting

Summary

Acquire and check typical values of the operating media to prevent or limit damage.

The fresh water used to fill the cooling water circuits must satisfy the specifications. The cooling water in the system must be checked regularly in accordance with the maintenance schedule. The following work/steps is/are necessary:

Acquisition of typical values for the operating fluid, evaluation of the operating fluid and checking the concentration of the anticorrosive agent.

2026-10-29 - 10.1

Tools/equipment required

Devices for testing fresh water quality

The following can be used:

- The water test kit with all the necessary instruments and chemicals for determining water hardness, pH value and chloride content (available from Mar-Tec Marine, Hamburg).

Equipment for testing the concentration of additives

Testing equipment according to the recommendations of the supplier. The test kits from the provider normally also include testing equipment which can be used to determine the fresh water quality.

Testing the typical values of water

Short specification

Typical value/property	Water for filling and topping up (without additives)	Water in circulation (with additives)
Type of water	Fresh water, free of foreign matter	Treated coolant
Overall hardness	≤ 10 dGH[1)]	≤ 10 dGH[1)]
pH value	6.5 - 8 at 20 °C	≥ 7.5 at 20 °C
Chloride ion content	≤ 50 mg/l	≤ 50 mg/l[2)]

Table 86: Quality specifications for coolants (short version)

[1)] dGH German hardness

1 dGH = 10 mg/l CaO
= 17.8 mg/l $CaCO_3$
= 0.178 mmol/L

[2)] 1 mg/l = 1 ppm

If the testing kit provided by the additive supplier includes an option for determining the typical values of fresh water, it may be used.

Testing kit provided by the additive supplier

If the testing kit provided by the additive supplier includes an option for determining the typical values of fresh water, it may be used.

Testing the concentration of chemical additives

The concentration should be tested every week, and/or according to the maintenance schedule, using the testing instruments, reagents and instructions of the relevant supplier.

Chemical slushing oils can only provide effective protection if the right concentration is precisely maintained. This is why the concentrations recommended by Everllence (see section Specification of engine cooling water, Page 160 must be observed in all cases. These recommended concentrations may not be the same as those specified by the manufacturer.

Regular analysis of coolant is very important for safe engine operation. We can analyse fuel for customers at the Everllence PrimeServLab laboratory.

2026-10-29 - 10.1

5.5 Cooling water system cleaning

Summary

Remove contamination/residue from operating fluid systems, ensure/re-establish operating reliability.

Cooling water systems containing deposits or contamination prevent effective cooling of parts. Contamination and deposits must be regularly eliminated.

This comprises the following:

Cleaning the system and, if required, removal of limescale deposits, flushing the system.

Cleaning

The coolant system must be checked for contamination at regular intervals. Cleaning is required if the degree of contamination is high. This work should ideally be carried out by a specialist who can provide the right cleaning agents for the type of deposits and materials in the cooling circuit. The cleaning should only be carried out by the engine operator if this cannot be done by a specialist.

Oil sludge

Oil sludge caused by lubricating oil that has entered the cooling system, or a high concentration of corrosion inhibitors, can be removed by flushing with fresh water to which a small amount of detergent has been added. Table Detergents for removing oil sludge contains a list of suitable detergents in alphabetical order. Products from other manufacturers may be used provided their properties are comparable. The manufacturer's instructions for use must be strictly adhered to.

Manufacturer	Product
Drew	HDE - 777
Nalfleet	Maxi-Clean 2
Unitor	Seaclean, Seaclean Plus

Table 87: Cleaning agents for removing oil sludge

Limescale and rust deposits

Limescale and rust deposits can form if the water is particularly hard or if the concentration of the corrosion inhibitor used is too low. A thin layer of limescale does not need to be removed, as experience shows that it protects against corrosion. However, limescale deposits thicker than 0.5 mm impede heat transfer to such an extent that it leads to thermal overload of the components being cooled.

Rust that has been flushed out can have an abrasive effect (for example, on the seals of water pumps). Together with the components responsible for water hardness, they form what is known as iron sludge, which settles mainly in areas with low flow velocity.

Generally speaking, products designed to dissolve limescale are also suitable for removing rust. Table Cleaning agents for removing limescale and rust deposits contains a list of suitable cleaning agents in alphabetical order. Products from other manufacturers may be used, provided their properties are comparable. The manufacturer's instructions for use must be strictly adhered to. Before cleaning, check that the cleaning agent in question is suitable for the materials to be cleaned. The products listed in Table Cleaning agents for removing limescale and rust deposits are also suitable for stainless steel.

Manufacturer	Product
Nalfleet	Nalco 8344, 73190
Unitor	Metal Brite
Drew	Ferroclean

Table 88: Cleaning agents for removing lime scale and rust deposits

2026-10-29 - 10.1

The carbon dioxide bubbles released when the lime scale layer is dissolved can prevent the cleaning agent from reaching lime scale deposits. It is therefore absolutely necessary to circulate the water with the cleaning agent to flush away the gas bubbles and allow them to escape. The length of the cleaning process depends on the thickness and composition of the deposits.

Following cleaning

The cooling system must be flushed several times once it has been cleaned using cleaning agents. Replace the water during this process. If acids are used to carry out the cleaning, neutralise the cooling system afterwards with suitable chemicals then flush. The system can then be refilled with water that has been prepared accordingly.

Note:

Start the cleaning operation only when the engine has cooled down. Hot engine components must not come into contact with cold water. Open the venting pipes before refilling the cooling water system. Blocked venting pipes prevent air from escaping which can lead to thermal overloading of the engine.

When disposing of cleaning agents or acids, observe the applicable regulations.

Note:

The products to be used can endanger health and may be harmful to the environment. Follow the manufacturer's handling instructions without fail.

5.6 Specification of intake air (combustion air)

General

The quality and condition of intake air (combustion air) have a significant effect on the engine output, wear and emissions of the engine. In this regard, not only are the atmospheric conditions extremely important, but also contamination by solid and gaseous foreign matter.

Mineral dust in the intake air increases wear. Chemicals and gases promote corrosion.

This is why effective cleaning of intake air (combustion air) and regular maintenance of the air filter are required.

When designing the intake air system, the maximum permissible overall pressure drop (filter, silencer, pipe line) of 20 mbar must be taken into consideration.

Exhaust turbochargers for marine engines are equipped with silencers and air filters as a standard.

Requirements

Liquid fuel engines: As minimum, inlet air (combustion air) must be cleaned by an ISO Coarse 45% class filter as per DIN EN ISO 16890, if the combustion air is drawn in from inside (e.g. from the machine room/engine room). If the combustion air is drawn in from outside, in the environment with a risk of higher inlet air contamination (e.g. due to sand storms, due to loading and unloading grain cargo vessels or in the surroundings of cement plants), additional measures must be taken. This includes the use of pre-separators, pulse filter systems and a higher grade of filter efficiency class at least up to ISO ePM10 50% according to DIN EN ISO 16890.

2026-10-29 - 10.1

Gas engines and dual-fuel engines: As minimum, inlet air (combustion air) must be cleaned by an ISO COARSE 45% class filter as per DIN EN ISO 16890, if the combustion air is drawn in from inside (e.g. from machine room/ engine room). Gas engines or dual-fuel engines must be equipped with a dry filter. Oil bath filters are not permitted because they enrich the inlet air with oil mist. This is not permissible for gas operated engines because this may result in engine knocking. If the combustion air is drawn in from outside, in the environment with a risk of higher inlet air contamination (e.g. due to sand storms, due to loading and unloading grain cargo vessels or in the surroundings of cement plants) additional measures must be taken. This includes the use of pre-separators, pulse filter systems and a higher grade of filter efficiency class at least up to ISO ePM10 50% according to DIN EN ISO 16890.

In general, the following applies:

The inlet air path from air filter to engine shall be designed and implemented airtight so that no false air may be drawn in from the outdoor.

The concentration downstream of the air filter and/or upstream of the turbocharger inlet must not exceed the following limit values.

The air must not contain organic or inorganic silicon compounds.

Properties	Limit	Unit [1]
Dust (sand, cement, CaO, Al_2O_3 etc.)	max. 5	mg/Nm^3
Chlorine	max. 1.5	
Sulphur dioxide (SO_2)	max. 1.25	
Hydrogen sulphide (H_2S)	max. 5	
Salt (NaCl)	max. 1	
[1] One Nm^3 corresponds to one cubic meter of gas at 0 °C and 101.32 kPa.		

Table 89: Typical values for intake air (combustion air) that must be complied with

Note:

Intake air shall not contain any flammable gases. Make sure that the combustion air is not explosive and is not drawn in from the ATEX Zone.

5.7 Specification of compressed air

General

For compressed air quality observe the ISO 8573-1. Compressed air must be free of solid particles and oil (acc. to the specification).

Requirements

Compressed air quality of starting air system

The starting air must fulfil at least the following quality requirements according to ISO 8573-1.

Purity regarding solid particles	Quality class 6
Particle size > 40µm	max. concentration < 5 mg/m^3
Purity regarding moisture	Quality class 7

2026-10-29 - 10.1

Residual water content	< 0.5 g/m³
Purity regarding oil	Quality class X

Additional requirements are:

- The air must not contain organic or inorganic silicon compounds.
- The layout of the starting air system must ensure that no corrosion may occur.
- The starting air system and the starting air receiver must be equipped with condensate drain devices.
- By means of devices provided in the starting air system and via maintenance of the system components, it must be ensured that any hazardous formation of an explosive compressed air/lube oil mixture is prevented in a safe manner.

Compressed air quality in the control air system

Please note that control air will be used for the activation of some safety functions on the engine – therefore, the compressed air quality in this system is very important.

Control air must meet at least the following quality requirements according to ISO 8573-1.

- Purity regarding solid particles: Quality class 5
- Purity regarding moisture: Quality class 4
- Purity regarding oil: Quality class 3

For catalysts

The following specifications are valid unless otherwise defined by any other relevant sources:

Compressed air quality for soot blowing

Compressed air for soot blowing must meet at least the following quality requirements according to ISO 8573-1.

- Purity regarding solid particles: Quality class 3
- Purity regarding moisture: Quality class 4
- Purity regarding oil: Quality class 2

Compressed air quality for reducing agent atomisation

Compressed air for atomisation of the reducing agent must fulfil at least the following quality requirements according to ISO 8573-1.

- Purity regarding solid particles: Quality class 3
- Purity regarding moisture: Quality class 4
- Purity regarding oil: Quality class 2

Note:

To prevent clogging of catalyst and catalyst lifetime shortening, the compressed air specification must always be observed.

2026-10-29 - 10.1

6 Engine supply systems

6.1 3D Engine Viewer – A support programme to configure the engine room

Everllence offers a free-of-charge online programme for the configuration and provision of installation data required for installation examinations and engine room planning: The 3D Engine Viewer .

Easy-to-handle selection and navigation masks permit configuration of the required engine type, as necessary for virtual installation in your engine room.

In order to be able to use the 3D Engine Viewer, register on our website under:

Everllence Extranet

After successful registration, the 3D Engine Viewer are available under:

3D Engine Viewer

3D GenSet Viewer

by clicking onto the requested application.

In only three steps, you will obtain professional engine room data for your further planning:

- Selection

  Select the requested output, respectively the requested type.
- Configuration

  Drop-down menus permit individual design of your engine according to your requirements. Each of your configurations will be presented on the basis of isometric models.
- View

  The models of the 3D Engine Viewer include all essential geometric and planning-relevant attributes (e.g. connection points, interfering edges, exhaust gas outlets, etc.) required for the integration of the model into your project.

The configuration with the selected engines can now be easily downloaded.

For 2D representation as:

- .pdf
- .dwg
- .dxf

for 3D as:

- .dgn
- .stp
- .sat
- .igs
- 3D-dxf
- and many others

2026-10-29 - 10.1

On the following pages, you will find information on the four-stroke Diesel engine programme of Everllence SE. By means of the Engine Viewer, you can specifically select engine designs and download the technical data and 3-D-CAD models essential for engine room planning.

- By means of the combo box and the function "Search" choose the output in the table on the right.

or

- In case you already know the required engine type, a click on the engine type in the table on the bottom will take you to the data sheets of the desired engine.

All available engine types are listed in the table above. We are continuing our efforts to provide the data of our other medium-speed engines as well.

All data provided in this application is non-binding. This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.

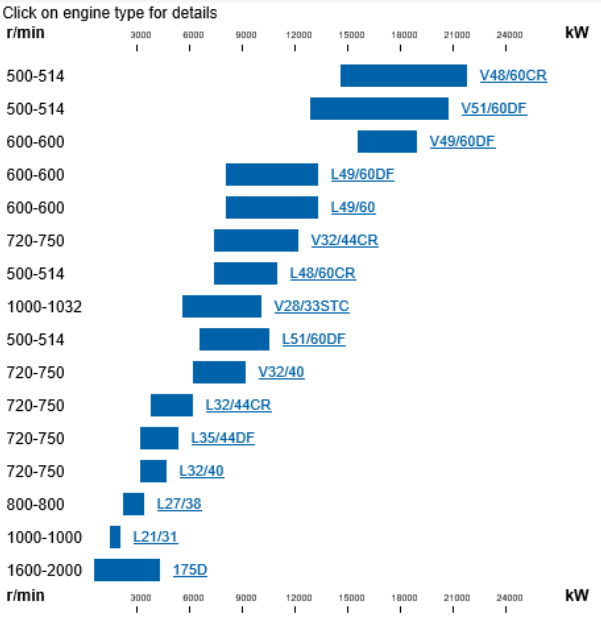


Figure 62: Selection of engine

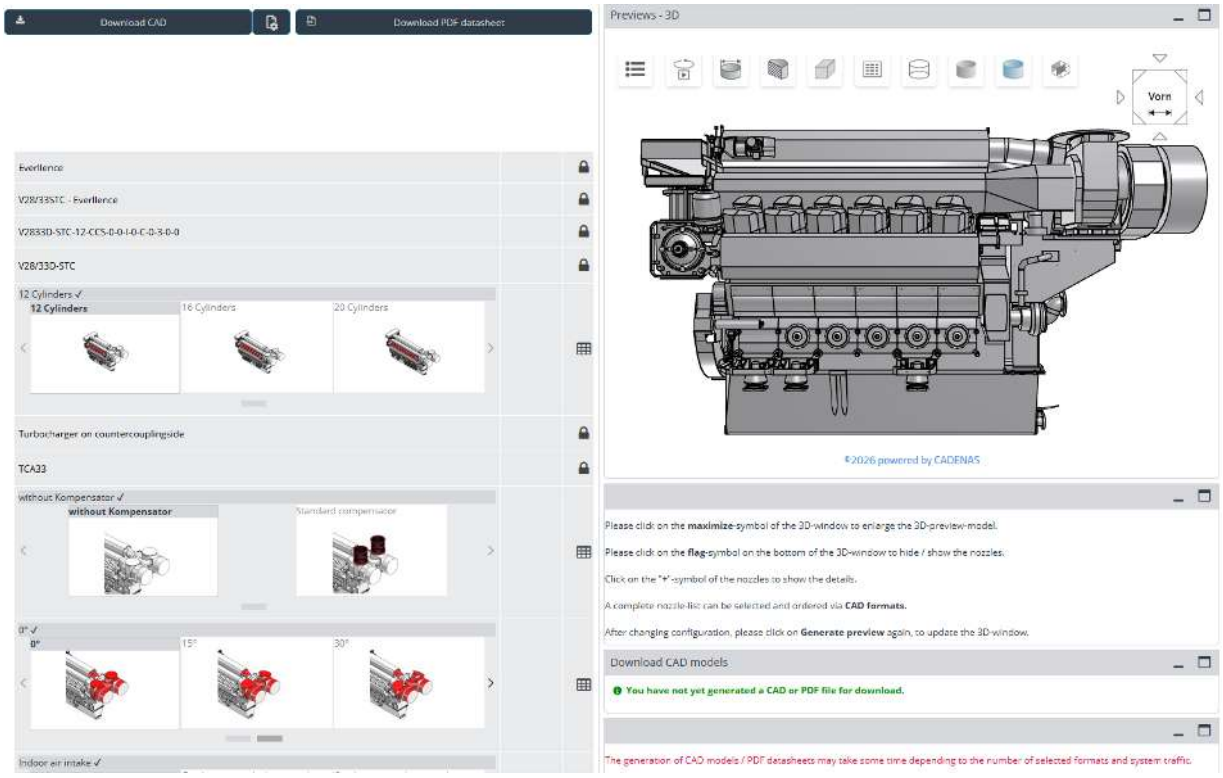


Figure 63: Preselected standard configuration

6.2 Basic principles for pipe selection

6.2.1 External pipe dimensioning

The external piping systems are to be dimensioned, designed, installed and connected to the engine by the shipyard. The pipe systems should to be designed in such a way that the pressure losses are kept within reasonable limits. To achieve this at justifiable cost, it is recommended to maintain the flow rates as indicated below. Nevertheless, depending on specific conditions of piping systems, it may be necessary in some cases to adopt even lower flow rates. Generally, it is not recommended to use higher flow rates.

For small pipes a low flow speed has to calculated, for bigger pipes (> DN 125) the higher values may be chosen.

	Recommended flow rates (m/s)	
	Suction side	Delivery side
Fresh water (cooling water)	1.0–2.0	1.5–3.0
Lube oil	0.5–1.0	1.5–2.5
Seawater	1.0–1.5	1.5–2.5
Diesel fuel	0.5–1.0	1.5–2.0
Compressed air for control air system	-	2–10
Compressed air for starting air system	-	25–30 [1]
Intake air	20–25	
Exhaust gas	40	

[1] During engine start higher velocities acceptable, depends on total pressure loss of supply system.

Table 90: Recommended flow rates

2026-10-29 - 10.1

6.2.2 Engine pipe connections and dimensions

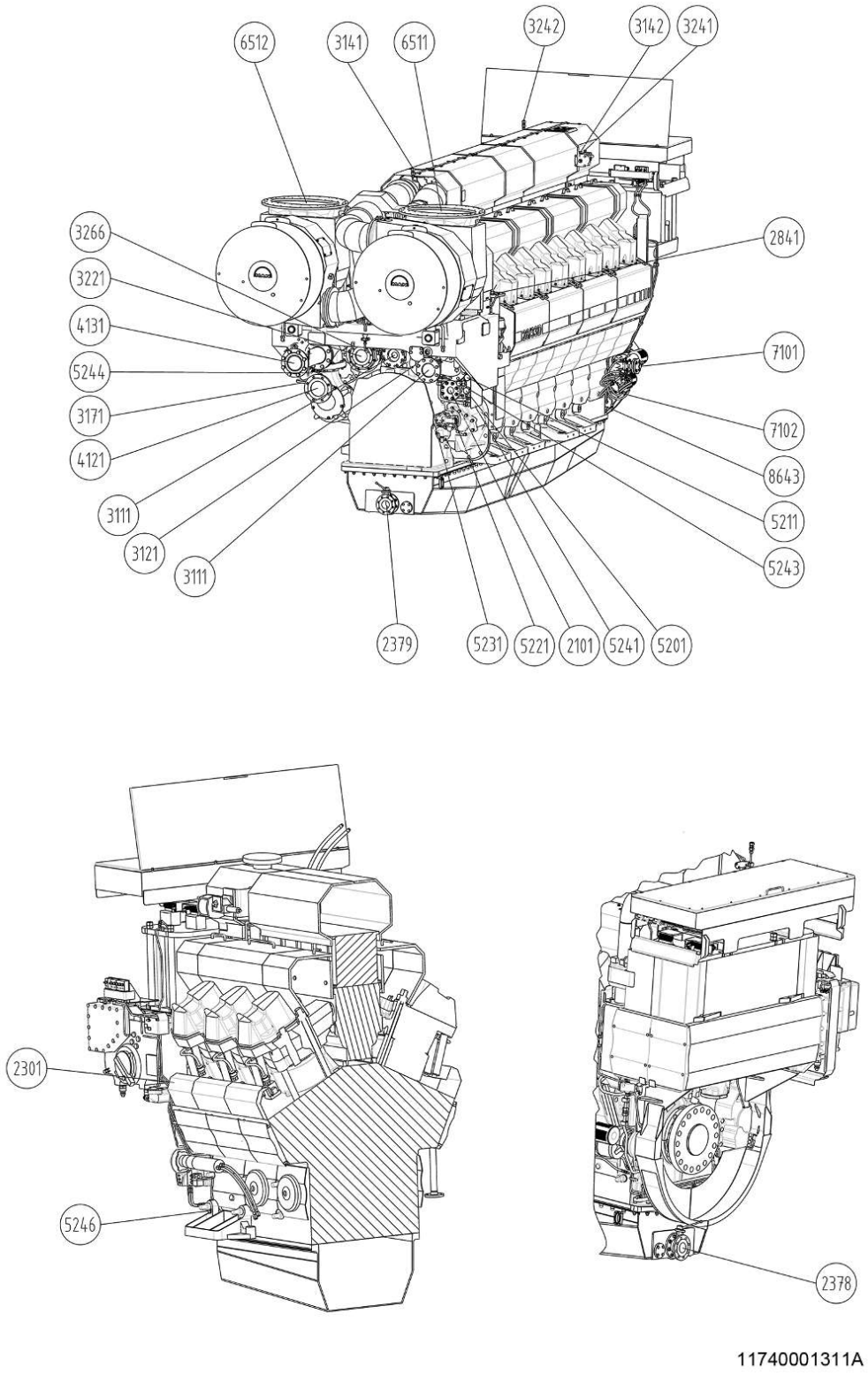


Figure 64: Engine pipe connections

Anschluss Nr. Connection-No.	Benennung des Rohranschlusses Description of pipe connection	Rohrabmessung Pipe dimension	Bezeichnung des Anschlusst. Code for connection part	Anschlussort Connection location	Flussrichtung Flow direction
2101	Schmieroel lubricating oil	StR 88,9x3,2	EN 1092-1/01 A/DN80/PN16/S235JRG2	Kupplungsgegenseite Coupling counterside	Eintritt Inlet
2301	Schmieroel Fuellleitung oil tank fill connection	Schlauch/hose EN 857 2SC 25	Schnellkupplung Quick coupling	Kupplungsseite Coupling side	Eintritt Inlet
2378	Aölauf aus der Ölwanne Drain from oil pan	StR 88,9x3,2	EN 1092-1/01 A/DN80/PN16/S235JRG2	Kupplungsseite Coupling side	Austritt Outlet
2379	Aölauf aus der Ölwanne Drain from oil pan	StR 88,9x3,2	EN 1092-1/01 A/DN80/PN16/S235JRG2	Kupplungsgegenseite Coupling counterside	Austritt Outlet
2841	Kurbelraumentlueftung crankcase venting	StR 88,9x3,2		Kupplungsgegenseite Coupling counterside	Austritt Outlet
3111	HT Kuehlwasser HT cooling water	StR 139,7x4,5	EN 1092-1/01 A/DN125/PN16/S235JRG2	Kupplungsgegenseite Coupling counterside	Austritt Outlet
3121	HT Kuehlwasser HT cooling water	StR 139,7x4,5	EN 1092-1/01 A/DN125/PN16/S235JRG2	Kupplungsgegenseite Coupling counterside	Eintritt Inlet
3141	Entlueftung HT Kuehlwasserleitung 1 air vent HT cooling water pipe 1	StR 16x2	ISO 8434-1 - S16 DIN 3861 - S16-St	Kupplungsgegenseite Coupling counterside	Austritt Outlet
3142	Entlueftung HT Kuehlwasserleitung 2 air vent HT cooling water pipe 2	StR 16x2	ISO 8434-1 - S16 DIN 3861 - S16-St	Kupplungsseite Coupling side	Austritt Outlet
3171	Kuehlwasservorwaermung cooling water preheat	StR 60,3x2,9	EN 1092-1/11 A/DN50/PN16/P265GH+N	Kupplungsgegenseite Coupling counterside	Austritt Outlet
3211	NT Kuehlwasser LT cooling water	StR 139,7x4,5	EN 1092-1/01 A/DN125/PN16/S235JRG2	Kupplungsgegenseite Coupling counterside	Austritt Outlet
3221	NT Kuehlwasser LT cooling water	StR 139,7x4,5	EN 1092-1/01 A/DN125/PN16/S235JRG2	Kupplungsgegenseite Coupling counterside	Eintritt Inlet
3241	Entlueftung NT Kuehlwasserleitung 1 air vent LT cooling water pipe 1	StR 16x2	ISO 8434-1 - S16 DIN 3861 - S16-St	Kupplungsseite Coupling side	Austritt Outlet
3242	Entlueftung NT Kuehlwasserleitung 2 air vent LT cooling water pipe 2	StR 16x2	ISO 8434-1 - S16 DIN 3861 - S16-St	Kupplungsseite Coupling side	Austritt Outlet
3266	NT Kuehlwasser Nachkuehlung LT cooling water post cooling	StR 22x2	ISO 8434-1 - L22	Kupplungsgegenseite Coupling counterside	Eintritt Inlet
4121	Seewasser Pumpe sea water pump	StR 168,3x4,5	EN 1092-1/01 A/DN150/PN16/CuSn7Zn2Pb3	Kupplungsgegenseite Coupling counterside	Eintritt Inlet
4131	Seewasser Pumpe sea water pump	DIN 86019-159x8 CuNi10Fe1,6Mn	EN 1092-1/01 A/DN150/PN16/CuNi10Fe1,6Mn	Kupplungsgegenseite Coupling counterside	Austritt Outlet
5201	Kraftstoff fuel	StR 38x3,5	ISO 8434-1 - S38 DIN 3861 - BS38-ST	Kupplungsgegenseite Coupling counterside	Eintritt Inlet
5211	Kraftstoff fuel	StR 38x3,5	ISO 8434-1 - S38 DIN 3861 - BS38-ST	Kupplungsgegenseite Coupling counterside	Austritt Outlet
5221	Kraftstoff Foerderpumpe fuel supply pump	StR 76,1x2,9		Kupplungsgegenseite Coupling counterside	Eintritt Inlet
5231	Kraftstoff Foerderpumpe fuel supply pump	StR 76,1x2,9		Kupplungsgegenseite Coupling counterside	Austritt Outlet
5241	Leckkraftstoffablauf leakage fuel drain	StR 10x1,5	ISO 8434-1 - S10 DIN 3861 - BS10-ST	Kupplungsgegenseite Coupling counterside	Austritt Outlet
5243	Kraftstoffleckageablauf 1 fuel oil leakage drain 1	StR 25x2	ISO 8434-1 - S25 DIN 3861 - BS25-ST	Kupplungsgegenseite Coupling counterside	Austritt Outlet
5244	Kraftstoffleckageablauf 2 fuel oil leakage drain 2	StR 20x2	ISO 8434-1 - S25 DIN 3861 - BS25-ST	Kupplungsgegenseite Coupling counterside	Austritt Outlet
5246	Kraftstoffleckageablauf 3 fuel oil leakage drain 3	StR 25x2	ISO 8434-1 - S25 DIN 3861 - BS25-ST	Kupplungsseite Coupling side	Austritt Outlet
6511	Abgasaustritt exhaust outlet	DN 700	DRW 11289840616	Kupplungsgegenseite Coupling counterside	Austritt Outlet
6512	Abgasaustritt exhaust outlet	DN 700	DRW 11289840616	Kupplungsgegenseite Coupling counterside	Austritt Outlet
7101	Anlassluft starting air	StR 48,3x2,6	EN 1092-1/11 B1/DN40/PN40/P245GH	Kupplungsseite Coupling side	Eintritt Inlet
7102	Steuerluft Eintritt control air inlet	StR 10x1,5	ISO 8434-1 - L10 DIN 3861 - BS10-St	Kupplungsseite Coupling side	Eintritt Inlet
8643	Kondenswasserablauf v. Ladeluftleitung condensed water drain f. air manifold	-	kein Anschluss / no connection	Kupplungsseite Coupling side	Austritt Outlet

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Figure 65: Legend to engine pipe connections

6.2.3 Specification of materials for piping

General

- The properties of the piping shall conform to international standards, e.g. DIN EN 10208, DIN EN 10216, DIN EN 10217 or DIN EN 10305, DIN EN 13480-3.
- For piping, carbon steel pipe should be used; stainless steel shall be used where necessary.
- Outer surface of carbon steel pipes needs to be primed and painted according to shipyard`s specification.

2026-10-29 - 10.1

- The pipes are to be sound, clean and free from all imperfections. The internal surfaces must be thoroughly cleaned and all scale, grit, dirt and sand used in casting or bending has to be removed. No sand is to be used as packing during bending operations.
- In case of pipes with forged bends, care must be taken to ensure that inner surfaces are smooth and that no stray weld metal remains after joining.
- Advices in Everllence work instruction 010.000.001-03. Pipelines cleaning, pickling and preservation. Carry out the pressure test for cleaning of steel pipes before fitting them together should be observed.
- Certain material combinations are sensitive to electro-chemical corrosion, therefore special attention must be paid to the arrangement within a pipe system including all connected components.
- All information given is to be regarded as indication only; the sole responsibility for the functionality and durability of the external piping system lies with the shipyard.

LT, HT cooling water pipes

Galvanised steel pipe must not be used for the piping of the system as all additives contained in the engine cooling water attack zinc. Moreover, there is the risk of the formation of local electrolytic element couples where the zinc layer has been worn off, and the risk of aeration corrosion where the zinc layer is not properly bonded to the substrate.

Proposed material (EN)

P235GH, E235, X5CrNiMoTi17-12-2

Fuel oil pipes, lube oil pipes

Galvanised steel pipe must not be used for the piping of the system as acid components of the fuel may attack zinc.

Proposed material (EN)

E235, P235GH, X6CrNiMoTi17-12-2

Urea pipes (for SCR only)

Galvanised steel pipe, brass and copper components must not be used for the piping of the system.

Proposed material (EN)

X6CrNiMoTi17-12-2

Compressed air pipes

Galvanised steel pipe must not be used for the piping of the system.

Proposed material (EN)

E235, P235GH, X6CrNiMoTi17-12-2

Seawater pipes

Material depending on required flow speed and mechanical stress.

Proposed material

CuNiFe, glass fiber reinforced plastic, rubber lined steel

2026-10-29 - 10.1

6.2.4 Installation of flexible pipe connections

Arrangement of hoses on engine

Flexible pipe connections are necessary to connect resiliently mounted engines with external piping systems. They are used to compensate the dynamic movements of the engine in relation to the external piping system.

The engine´s movement on its foundation is caused by the engine´s rotation and torque itself as well as by rolling and pitching of the ship. Based on roll angles of +/- 22.5° and pitching of +/- 7.5° (according to prescriptive rules of classification societies) the excursions at the exhaust gas outlet can be up to 5 mm in X-, 25 mm in Y- and 6 mm in Z-direction. As the exhaust gas outlet is at the highest point of the engine the excursions at lower positions are smaller respectively. In order to obtain exact data on excursions at certain points, a project-specific calculation of the elastic engine mount is required.

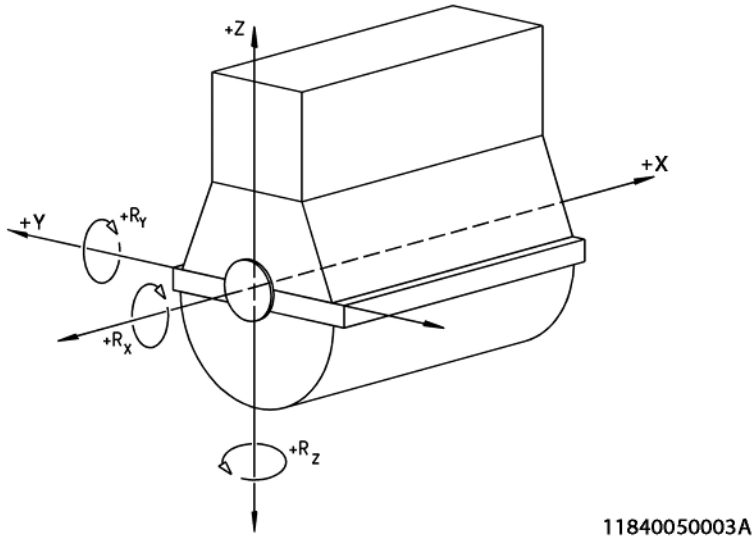


Figure 66: Coordinate system

Generally flexible pipes (rubber hoses with steel inlet, metal hoses, PTFE-corrugated hose-lines, rubber bellows with steel inlet, steel bellows, steel compensators) are nearly unable to compensate twisting movements. Therefore the installation direction of flexible pipes must be vertically (in Z-direction) if ever possible. Torsion on flexible pipe connections must be avoided. Flexible pipe connections which are installed in X-direction are particularly at risk. Therefore the installation of flexible pipe connections in this direction should be avoided. Where the installation of flexible pipe connections in X-direction is nevertheless unavoidable, the continuing pipeline on the plant side must be designed in such a way that the torsional forces can be safely absorbed. An installation in horizontal-lateral (Y-direction) is not recommended.

The media connections (compensators) to and from the engine must be highly flexible whereas the fixations of the compensators on the one hand with the engine and on the other hand with the environment must be realised as stiff as possible.

2026-10-29 - 10.1

Flange and screw connections

Flexible pipes delivered loose by Everllence are fitted with flange connections from DN32 upwards. Smaller sizes are fitted with screw connections. Each flexible pipe is delivered complete with counter flanges or, those smaller than DN32, with weld-on sockets.

Arrangement of the external piping system

Shipyard's pipe system must be exactly arranged so that the flanges or screw connections do fit without lateral or angular offset. Therefore it is recommended to adjust the final position of the pipe connections after engine alignment is completed.

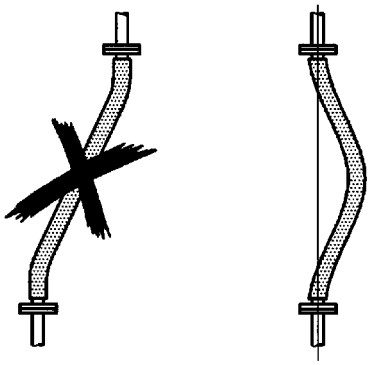


Figure 67: Arrangement of pipes in system

External piping system - Segmentation for maintenance access

The external piping system shall be designed and segmented in accordance with the media interface drawings, installation drawings, and the engine room arrangement.

Following requirements need to be considered:

- Easy access to engine areas that require regular inspection and maintenance.
- Segmentation of the external piping system into removable sections to allow access for maintenance activities. A complete drainage of the respective medium shall be possible prior to dismantling of any pipe section.

Installation of hoses

In the case of straight-line-vertical installation, a suitable distance between the hose connections has to be chosen, so that the hose is installed with a sag. To satisfy a correct sag in a straight-line-vertically installed hose, the distance between the hose connections (hose installed, engine stopped) has to be approximately 5% shorter than the same distance of the unconnected hose (without sag). Flexible hoses must not be installed with tensile stress, compression or torsional tension.

In case it is unavoidable (this is not recommended) to connect the hose in lateral-horizontal direction (Y-direction) the hose must preferably be installed with a 90° arc. The minimum bending radii, specified in provided drawings, are to be observed.

2026-10-29 - 10.1

Hoses must not be twisted during installation. Turnable lapped flanges on the hoses avoid this.

Where bolted connections are used, hold the hexagon on the hose with a wrench while fitting the nut.

All installation instructions of the hose manufacturer have to be complied with.

Depending on the required application rubber hoses with steel inlet, metal hoses or PTFE-corrugated hose lines are used.

Installation of steel compensators

Steel compensators are used for hot media, e.g. exhaust gas. They can compensate movements in line and transversal to their centre line, but they are absolutely unable to compensate twisting movements. Compensators are very stiff against torsion. For this reason all kind of steel compensators installed on resilient mounted engines are to be installed in vertical direction.

Note:
Exhaust gas compensators are also used to compensate for thermal expansion. Exhaust gas compensators are therefore required for all type of engine mountings, also for semi-resilient or rigid mounted engines. But in these cases the compensators can be shorter, as they are designed only to compensate the thermal expansions and vibrations, but not other dynamic engine movements.

Supports of pipes

Flexible pipes must be installed as close as possible to the engine connection.

On the shipside, directly after the flexible pipe, the pipe is to be fixed with a sturdy pipe anchor of higher than normal quality. This anchor must be capable to absorb the reaction forces of the flexible pipe, the hydraulic force of the fluid and the dynamic force.

Example of the axial force of a compensator to be absorbed by the pipe anchor:

- Hydraulic force
  = (cross section area of the compensator) x (pressure of the fluid inside)
- Reaction force
  = (spring rate of the compensator) x (displacement of the comp.)
- Axial force
  = (hydraulic force) + (reaction force)

Additionally a sufficient margin has to be included to account for pressure peaks and vibrations.

2026-10-29 - 10.1

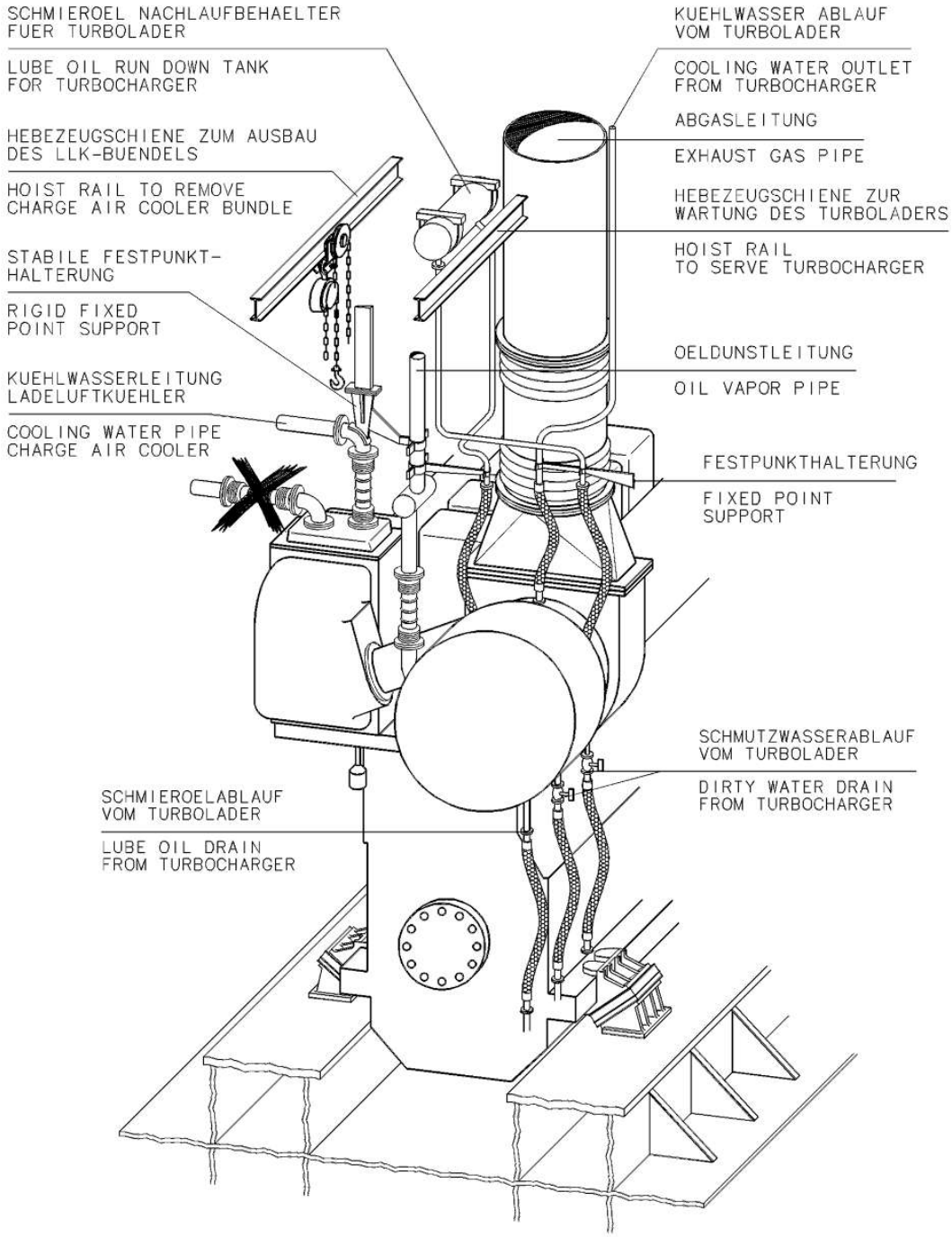


Figure 68: Installation of hoses

2026-10-29 - 10.1

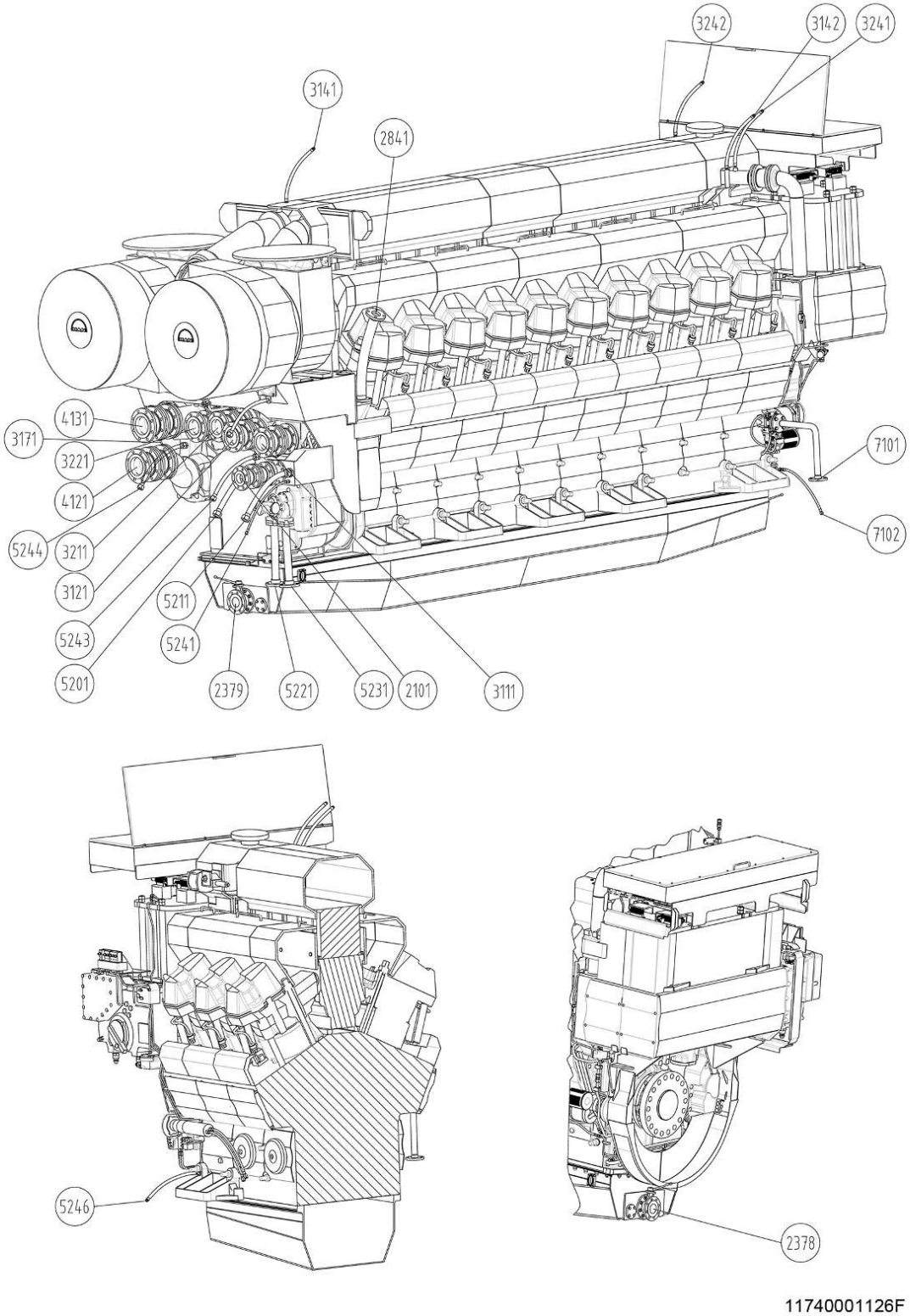


Figure 69: Example of installation of hoses

2026-10-29 - 10.1

Anschluss Nr. Connection-No.	Benennung des Rohranschlusses Description of pipe connection	Rohrabmessung Pipe dimension	Bezeichnung des Anschlusst. Code for connection part	Rohrverbindungen Pipe connection	Flussrichtung Flow direction
2101	Schmieroel lubricating oil	StR 88,9x3,2	EN 1092-1/01 A/DN80/PN16/S235JRG2	Doppelkompensator Double compensator	Eintritt Inlet
2378	Ablauf aus der ölwanne Drain from oil pan	StR 88,9x3,2	EN 1092-1/01 A/DN80/PN16/S235JRG2	Kompensator Compensator	Austritt Outlet
2379	Ablauf aus der ölwanne Drain from oil pan	StR 88,9x3,2	EN 1092-1/01 A/DN80/PN16/S235JRG2	Kompensator Compensator	Austritt Outlet
2841	Kurbelraumentlueftung crankcase venting	StR 88,9x3,2		Schlauch Hose-line	Austritt Outlet
3111	HT Kuehlwasser HT cooling water	StR 139,7x4,5	EN 1092-1/01 A/DN125/PN16/S235JRG2	Doppelkompensator Double compensator	Austritt Outlet
3121	HT Kuehlwasser HT cooling water	StR 139,7x4,5	EN 1092-1/01 A/DN125/PN16/S235JRG2	Doppelkompensator Double compensator	Eintritt Inlet
3141	Entlueftung HT Kuehlwasserleitung 1 air vent HT cooling water pipe 1	StR 16x2	ISO 8434-1 - S16 DIN 3861 - S16-St	Schlauch Hose-line	Austritt Outlet
3142	Entlueftung HT Kuehlwasserleitung 2 air vent HT cooling water pipe 2	StR 16x2	ISO 8434-1 - S16 DIN 3861 - S16-St	Schlauch Hose-line	Austritt Outlet
3171	Kuehlwasservorwaermung cooling water preheat	StR 60,3x2,9	EN 1092-1/11 A/DN50/PN16/P265GH+N	Schlauch Hose-line	Austritt Outlet
3211	LT Kuehlwasser LT cooling water	StR 139,7x4,5	EN 1092-1/01 A/DN125/PN16/S235JRG2	Doppelkompensator Double compensator	Austritt Outlet
3221	NT Kuehlwasser NT cooling water	StR 139,7x4,5	EN 1092-1/01 A/DN125/PN16/S235JRG2	Doppelkompensator Double compensator	Eintritt Inlet
3241	Entlueftung NT Kuehlwasserleitung 1 air vent LT cooling water pipe 1	StR 16x2	ISO 8434-1 - S16 DIN 3861 - S16-St	Schlauch Hose-line	Austritt Outlet
3242	Entlueftung NT Kuehlwasserleitung 2 air vent LT cooling water pipe 2	StR 16x2	ISO 8434-1 - S16 DIN 3861 - S16-St	Schlauch Hose-line	Austritt Outlet
4121	Seewasser Pumpe sea water pump	StR 168,3x4,5	EN 1092-1/01 A/DN150/PN16/CuSn7Zn2Pb3	Doppelkompensator Double compensator	Eintritt Inlet
4131	Seewasser Pumpe sea water pump	DIN 86019-159x8 CuNi10Fe1.6Mn	EN 1092-1/01 A/DN150/PN16/CuNi10Fe1.6Mn	Doppelkompensator Double compensator	Austritt Outlet
5201	Kraftstoff fuel	StR 38x3,5	ISO 8434-1 - S38 DIN 3861 - BS38-ST	Schlauch Hose-line	Eintritt Inlet
5211	Kraftstoff fuel	StR 38x3,5	ISO 8434-1 - S38 DIN 3861 - BS38-ST	Schlauch Hose-line	Austritt Outlet
5221	Kraftstoff Foerderpumpe fuel supply pump	StR 76,1x2,9		Schlauch Hose-line	Eintritt Inlet
5231	Kraftstoff Foerderpumpe fuel supply pump	StR 76,1x2,9		Schlauch Hose-line	Austritt Outlet
5241	Leckkraftstoffablauf leakage fuel drain	StR 10x1,5	ISO 8434-1 - S10 DIN 3861 - BS10-ST	Schlauch Hose-line	Austritt Outlet
5243	Kraftstoffleckageablauf 1 fuel oil leakage drain 1	StR 25x2	ISO 8434-1 - S25 DIN 3861 - BS25-ST	Schlauch Hose-line	Austritt Outlet
5244	Kraftstoffleckageablauf 2 fuel oil leakage drain 2	StR 20x2	ISO 8434-1 - S25 DIN 3861 - BS25-ST	Schlauch Hose-line	Austritt Outlet
5246	Kraftstoffleckageablauf 3 fuel oil leakage drain 3	StR 25x2	ISO 8434-1 - S25 DIN 3861 - BS25-ST	Schlauch Hose-line	Austritt Outlet
7101	Anlassluft starting air	StR 48,3x2,6	EN 1092-1/11 B1/DN40/PN40/P245GH	Schlauch Hose-line	Eintritt Inlet
7102	Steuerluft 1 control air 1	StR 10x1,5	ISO 8434-1 - L10 DIN 3861 - BS10-St	Schlauch Hose-line	Eintritt Inlet

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Figure 70: Legend to example of installation of hoses

2026-10-29 - 10.1

6.2.5 Condensate amount in charge air pipes and air vessels

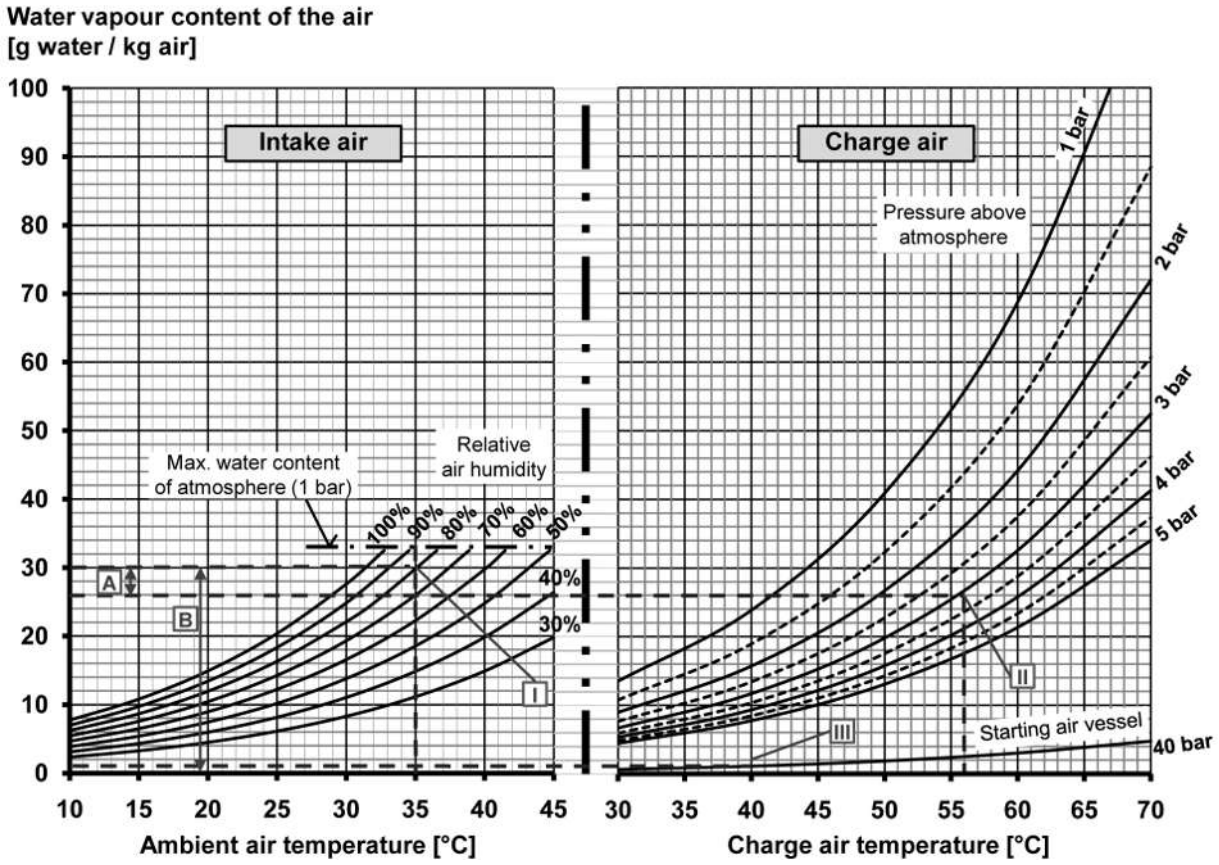


Figure 71: Diagram condensate amount

The amount of condensate precipitated from the air can be considerablly high, particularly in the tropics. It depends on the condition of the intake air (temperature, relative air humidity) in comparison to the charge air after charge air cooler (pressure, temperature).

It is important, that no condensed water of the intake air/charge air will be led to the compressor of the turbocharger, as this may cause damages.

In addition the condensed water quantity in the engine needs to be minimised. This is achieved by controlling the charge air temperature.

How to determine the amount of condensate:

First determine the point I of intersection in the left side of the diagram (intake air), see figure Diagram condensate amount, Page 181 between the corresponding relative air humidity curve and the ambient air temperature.

Secondly determine the point II of intersection in the right side of the diagram (charge air) between the corresponding charge air pressure curve and the charge air temperature. Note that charge air pressure as mentioned in section Planning data, Page 73 is shown as absolute pressure.

At both points of intersection read out the values [g water/kg air] on the vertically axis.

2026-10-29 - 10.1

The intake air water content I minus the charge air water content II is the condensate amount A which will precipitate. If the calculations result is negative no condensate will occur.

For an example see figure Diagram condensate amount, Page 181. Intake air water content 30 g/kg minus 26 g/kg = 4 g of water/kg of air will precipitate.

To calculate the condensate amount during filling of the starting air receiver just use the 40 bar curve (see figure Diagram condensate amount, Page 181) in a similar procedure.

Example how to determine the amount of water accumulating in the charge air pipe

Parameter	Unit	Value
Engine output (P)	kW	9,000
Specific air flow (le)	kg/kWh	6.9
Ambient air condition (I):		
Ambient air temperature	°C	35
Relative air humidity	%	80
Charge air condition (II):		
Charge air temperature after cooler[1)]	°C	56
Charge air pressure (over pressure)[1)]	bar	3.0
Solution according to above diagram		
Water content of air according to point of intersection (I)	kg of water/kg of air	0.030
Maximum water content of air according to point of intersection (II)	kg of water/kg of air	0.026
The difference between (I) and (II) is the condensed water amount (A) A = I – II = 0.030 – 0.026 = 0.004 kg of water/kg of air		
Total amount of condensate Q_A: Q_A = A x le x P Q_A = 0.004 x 6.9 x 9,000 = 248 kg/h		
[1)] In case of two-stage turbocharging choose the values of the high-pressure TC and cooler (second stage of turbocharging system) accordingly.		

Table 91: Example how to determine the amount of water accumulating in the charge air pipe

Example how to determine the condensate amount in the starting air receiver

Parameter	Unit	Value
Volumetric capacity of tank (V)	litre	1,500
	m^3	1.5
Temperature of air in starting air receiver (T)	°C	40
	K	313
Air pressure in starting air receiver ($p_{above\ atmosphere}$)	bar	40
Air pressure in starting air receiver ($p_{absolute}$)	bar abs	41
		41 x 10^5

2026-10-29 - 10.1

Parameter	Unit	Value
	$\frac{N}{m^2}$	
Gas constant for air (R)	$\frac{Nm}{kg \times K}$	287
Ambient air temperature	°C	35
Relative air humidity	%	80
Weight of air in the starting air receiver is calculated as follows: $m = \frac{p \times V}{R \times T} = \frac{41 \times 10^5 \times 1.5}{287 \times 313} = 68.5 \text{ kg}$		
Solution acc. to above diagram:		
Water content of air according to point of intersection (I)	kg of water/kg of air	0.030
Maximum water content of air according to point of intersection (III)	kg of water/kg of air	0.001
The difference between (I) and (III) is the condensed water amount (B) B = I – III B = 0.030 – 0.001 = 0.029 kg of water/kg of air		
Total amount of condensate in the vessel Q_B: Q_B = m x B Q_B = 68.5 x 0.029 = 1.99 kg		

Table 92: Example how to determine the condensate amount in the starting air receiver

6.3 Lube oil system

6.3.1 Internal lube oil system

To easen the installation of the V28/33D STC all core components of the lube oil system are already integrated in the engine design.

As a standard the engine is equipped with following attached equipment:

- Lube oil pump
- Oil sump for complete lube oil filling (2 different kinds available)
- Lube oil cooler
- Lube oil temperature control valve
- Lube oil duplex filter, optional: Alternatively lube oil automatic filter plus lube oil centrifugal filter

Not attached to the engine, but part of the delivery:

- Oil mist eliminator

Not included:

- Prelubrication pump (electric driven)
- Preheating unit

2026-10-29 - 10.1

P-001/Lube oil pump

The V28/33D STC engine is not used for single engine plants. Therefore an electrically driven stand-by lube oil pump with 100% delivery capacity is not required by classification rules. However, if for any other reason an electrically driven 100% stand-by lube oil pump becomes necessary, contact Everllence.

The lube oil service pump draws the lube oil through suction strainers in the engine sump. The engine driven attached lube oil service pump has an integral pressure relief valve to prevent overpressurisation of the system when the oil is more viscous during cold conditions.

A main lube oil pump as spare is required to be on board according to class society. For design data of these lube oil pumps see sections Planning data, Page 73, Operating/service temperatures and pressures, Page 84 and Filling volumes, Page 91.

Note:
Cold starting precautions:

If starting in cold conditions the service pump outlet pressure may exceed the maximum pressure of 8 bar (PT2170). Also, the differential pressure in the lube oil filter may exceed the maximum of 10 bar. Therefore, in cold conditions it is recommended that:

- Before starting the engine, lube oil is circulated by the prelubrication pump in order to absorb heat from the warm, upper part of the engine.
- After starting, the engine is allowed to idle; sensors PT2170 and filter differential pressure are monitored as speed is increased to ensure the maximum pressures are not exceeded.

HE-037/Engine attached lube oil cooler

Oil travels along a passage in the air manifold to the cooler and lube oil filter module mounted at the flywheel end of the engine above the flywheel itself. The cooler is of plate design and mounted horizontally flat on top of the filter module which also incorporates an integral oil thermostat valve.
The cooling medium passing the lube oil cooler is low temperature (LT) cooling water.

Between the main pump and the thermostat a supply is taken from the main feed line to a metal particle detector. This detector provides an additional high level of protection for the engine.

TCV-001/Lube oil temperature control valve

The thermostatic valve is a direct acting, pre-set wax element type, automatic temperature regulator fitted across the inlet and outlet of the cooler. As the oil warms the valve operates to divert more oil through the cooler to maintain it at the correct working temperature at engine inlet.

Filtration of lube oil

As standard the engine is equipped with a lube oil duplex filter. Optional a configuration with automatic filter and centrifuge is available.

FIL-002/Lube oil duplex filter

The duplex filter is equipped with filter elements of 25 µm absolute filter fineness. A changeover valve allows to change the elements in one filter chamber while the engine is running. See also figure External lube oil system diagram including lube oil module with duplex filter (standard), Page 192.

2026-10-29 - 10.1

FIL-001/Lube oil automatic filter (optional)

The back washing/flushing of the filter elements is arranged in a way that lube oil flow and pressure will not be affected. The flushing discharge is led to the oil sump. The automatic filter is equipped with an integrated second filtration stage (50 µm absolute filter mesh). This second stage protects the engine from particles which may pass the first stage filter elements (30 µm absolute filter mesh) in case of any malfunction. See also figure External lube oil system diagram including lube oil module with automatic filter (optional), Page 194.

CF-008/Lube oil centrifugal filter (optional)

The engine is equipped with a centrifugal by-pass filter in case an automatic filter is installed to get the contamination out of the system. This filter removes contaminants through centrifugal force. The sludge is collected in the filter fleece which must be cleaned/removed regularly. The cleaned oil returns into to lube oil pan.

Indication and alarm of filters

Lube oil module with duplex filter

The duplex oil filter is equipped with differential pressure transmitters on its inlet and outlet ports. The pressure at these points is transmitted to the control panel and the differential pressure between the two is derived in the control software. An alarm is triggered when the differential pressure reaches 1 bar (rising).

Lube oil module with automatic filter

The engine mounted automatic filter is equipped with differential pressure gauges, to protect the filter cartridges and to indicate clogging condition of the filter. A high differential pressure is indicated as an alarm. The centrifugal filter has to be cleaned in given intervals. There is no indication at the centrifuge.

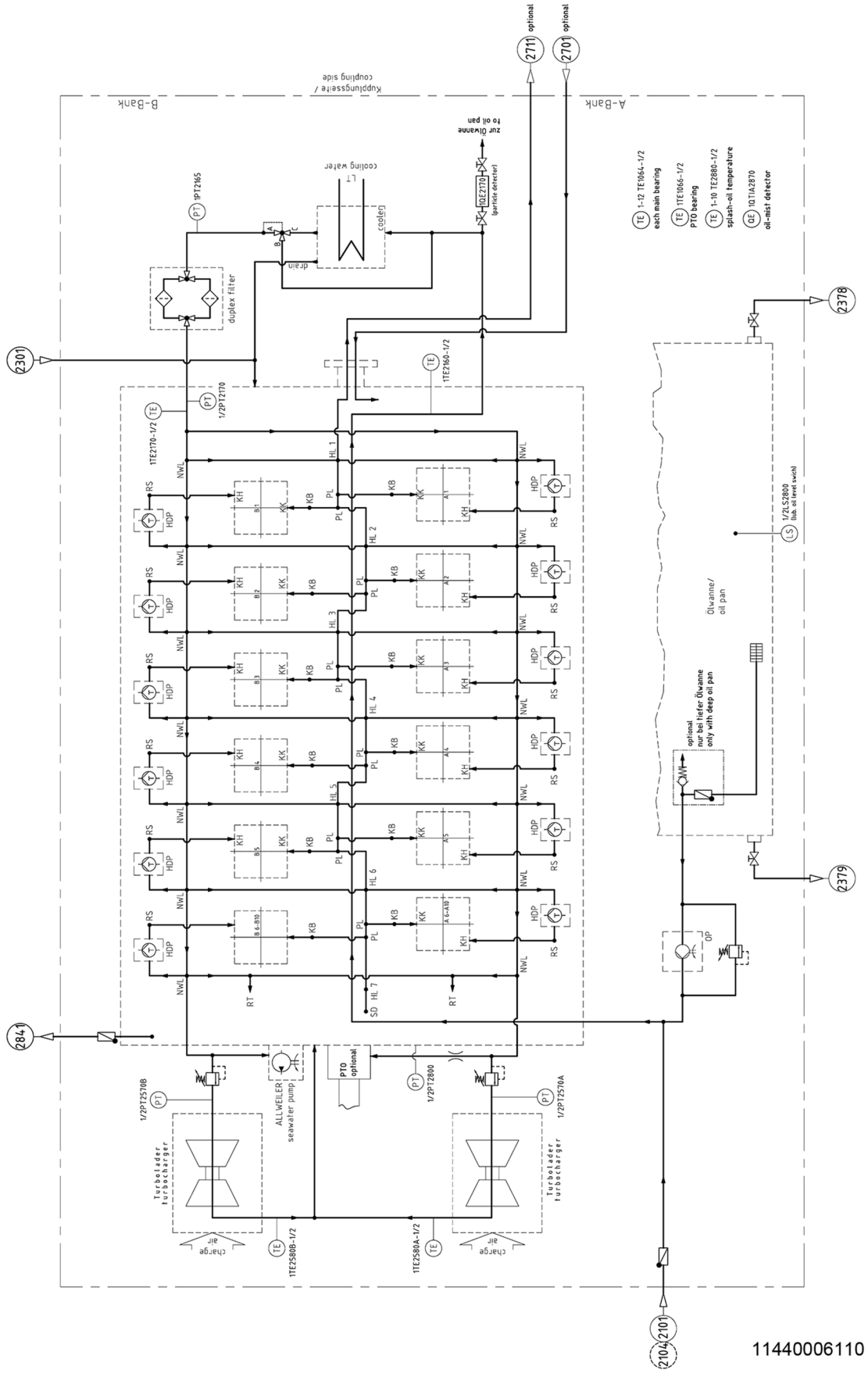
For details of the instrumentation, see section SaCoSone system overview.

PCV-007/Lube oil pressure relief valve

The pressure relief valve is integrated in the attached lube oil pump. By use of the pressure relief valve, a constant lube oil pressure at engine inlet is adjusted. The pressure relief valve is installed parallel to the attached lube oil pump. The return line of the valve is connected to the suction side of the pump.

2026-10-29 - 10.1

6.3 Lube oil system



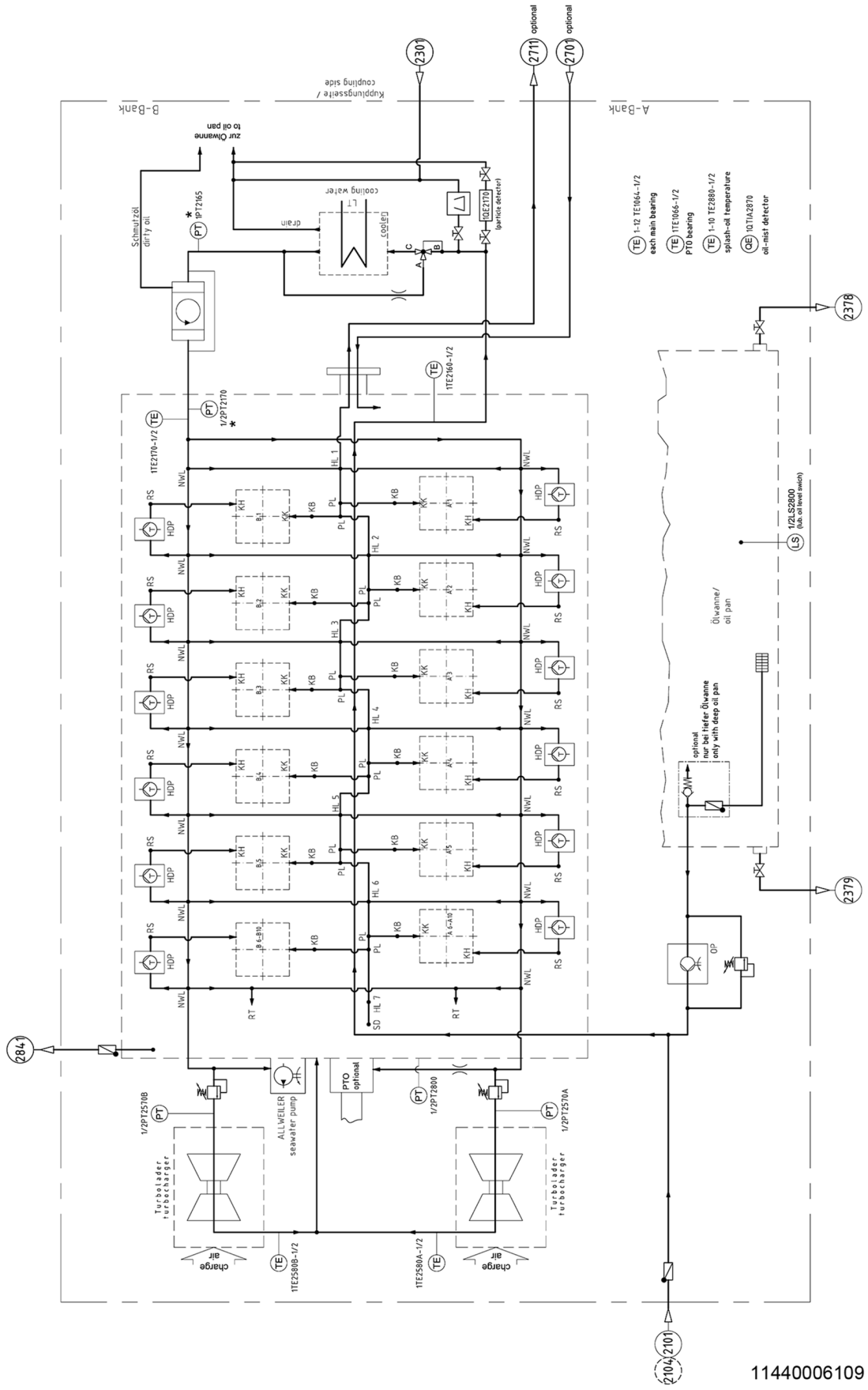
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	Meaning abbreviation		
HDP	High pressure fuel pump	NWL	Camshaft bearing
HL	Main bearing	PL	Con-rod bearing
KB	Piston pin	RS	Roller tappet
KH	Rocker lever lubrication	RT	Bearings gear drive
KK	Piston cooling	SD	Vibration damper
KW	Crankshaft	OP	Oil pump
NW	Camshaft		
	Connection numbers		
2101	Lube oil inlet to engine	2379	Lube oil connection of oil pan, coupling counter side (CCS)
2104	Lube oil inlet to engine for provisional lubrication	2701	Lube oil inlet from coupling to crankshaft (optional)
2301	Lube oil filling on engine	2711	Lube oil outlet from crankshaft to coupling (optional)
2378	Lube oil connection of oil pan, coupling side (CS)	2841	Venting of crankcase

Figure 72: Internal lube oil system – Exemplary for variant with lube oil duplex filter

2026-10-29 - 10.1

6.3 Lube oil system



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Meaning abbreviation			
HDP	High pressure fuel pump	NWL	Camshaft bearing
HL	Main bearing	PL	Con-rod bearing
KB	Piston pin	RS	Roller tappet
KH	Rocker lever lubrication	RT	Bearings gear drive
KK	Piston cooling	SD	Vibration damper
KW	Crankshaft	OP	Oil pump
NW	Camshaft		
Connection numbers			
2101	Lube oil inlet to engine	2379	Lube oil connection of oil pan, coupling counter side (CCS)
2104	Lube oil inlet to engine for provisional lubrication	2701	Lube oil inlet from coupling to crankshaft (optional)
2301	Lube oil filling on engine	2711	Lube oil outlet from crankshaft to coupling (optional)
2378	Lube oil connection of oil pan, coupling side (CS)	2841	Venting of crankcase

Figure 73: Internal lube oil system – Exemplary for variant with lube oil automatic filter

Note:
The drawings show the basic internal media flow of the engine in general.
Project-specific drawings thereof don´t exist.

6.3.2 External lube oil system

P-007/Prelubrication lube oil pump

The V28/33D STC engine is not used for single engine plants. Therefore an electrically driven stand-by lube oil pump with 100% delivery capacity is not required by classification rules. However, if for any other reason an electrically driven 100% stand-by lube oil pump becomes necessary, contact Everllence.

A prelubrication pump P-007 for pre- and postlubrication is necessary. The prelubrication pump draw oil through suction strainers in the engine sump. Dependent on the type of prelubrication pump, an orifice on the discharge side could be necessary to comply with the required differential pressure over the pump, given by the pump manufacturer.

The prelubrication pump is a positive displacement type fitted with a by-pass relief valve to protect the pump and system against overpressure. An interlock is fitted at the engine management (SaCoS) to prevent engine start if the prelubrication oil pressure is not detected or reached. The engine will be fully primed and available to start within 60 seconds of starting the prelubrication pump.

The prelubrication pump must be located as low as possible and close to the lube oil service tank to prevent cavitation. The pressure drop in the piping must not exceed the suction capability of the pump. With adequate diameter, straight lines and short length the pressure drop can be kept low.

For further information according this pump see section Planning data, Page 73 and paragraph Lube oil, Page 87.

After engine stop the postlubrication must be started and must persist accordingly to table System circuit operation time after engine stop, Page 47. This is required to cool down the bearings of the turbocharger and hot inner engine components.

2026-10-29 - 10.1

Note:
Cold starting precautions:
If starting in cold conditions the service pump outlet pressure may exceed the maximum pressure of 8 bar (PT2170). Also, the differential pressure in the lube oil filter may exceed the maximum of 10 bar. Therefore, in cold conditions it is recommended that:

- Before starting the engine, lube oil is circulated by the prelubrication pump in order to absorb heat from the warm, upper part of the engine.
- After starting, the engine is allowed to idle; sensors PT2170 and filter differential pressure are monitored as speed is increased to ensure the maximum pressures are not exceeded.

H-025/Lube oil preheater (optional)

For engine room temperatures below 5°C the HT cooling water preheater can be used to preheat the lube oil by circulating both media simultaneously through the engine. The prelubrication pump can be used for circulation of the lube oil through the engine. For temperatures significantly below 0°C a more powerful HT cooling water preheater must be provided and also the power of the electric motor and the suction ability of the prelubrication pump has to be adjusted to the highest possible lube oil viscosity. As alternative a separate lube oil preheating unit can be installed.

The same procedure can be used to keep the oil temperature above 40°C (start requirement) during stand-by operation of the engine.

A separate lube oil preheater or a HT cooling water preheater with higher capacity including a modified prelubrication pump can be supplied by Everllence. Contact Everllence for technical drawings of auxiliary equipment.

For low lube oil temperatures, heating up the lube oil can be achieved by circulating the lube oil via the pre-lubrication pump. For this purpose, oil pan connections 2378 (coupling side) and 2379 (coupling counter side) can be used to circulate the oil. Additional pipes and valves are required fromEverllence. Recommended design pressure for complete system installation is PN16.

FIL-004/Lube oil suction strainer

The lube oil suction strainer protects the lube oil pumps against larger dirt particles that may have accumulated in the tank. It is recommended to use a cone type strainer with a mesh size of 1.5 mm. Two manometers installed before and after the strainer indicate when manual cleaning of filter becomes necessary, which should preferably be done in port.

BL-007/Fan, crankcase venting

To ensure that a slight vacuum is maintained within the crankcase and to remove the potentially hazardous mix of oil mist and combustion gas a motor driven extractor fan is fitted. The majority of oil mist condenses into droplets in the venting pipe and runs back into the engine, thus the pipework to the fan unit has to have a continuous rise. To ensure prolonged maintenance free operation we recommend that this pipework is installed at a minimum angle of 25°. If this angle is not achievable for part or all of the installation, manual drain points are to be fitted in the pipework at positions where the oil might collect. The crankcase vacuum is regulated by an extraction fan placed within

2026-10-29 - 10.1

the engine venting pipe and regulated via a pressure transmitter placed on the crankcase. Distance between engine and venting fan shall be min. 7 metres and max. 10 metres.

Withdrawal points for oil sampling

A point for drawing lube oil samples is provided – the manual vent for the lube oil filter is used for this purpose. Looking on the flywheel, this vent is positioned on the right hand side of the oil filter casing, just above the manual sump filling point. There is enough room to enable a small sampling bottle to be positioned under the vent tap.

Piping system

As a minimum standard it is recommended to use pipes according to the pressure class PN 10. Lube oil prelubrication connections on the engine are PN 16.

MOD-064/Lube oil replenishing unit

This unit contains a lube oil suction strainer, see paragraph FIL-004/Lube oil suction strainer, Page 190, a lube oil transfer pump and a flexible hose. The lube oil transfer pump P-012 supplies fresh oil from the lube oil storage tank to the operating tank. Starting and stopping of the lube oil transfer pump should preferably be done automatically by float switches fitted in the tank.

Suction pipes

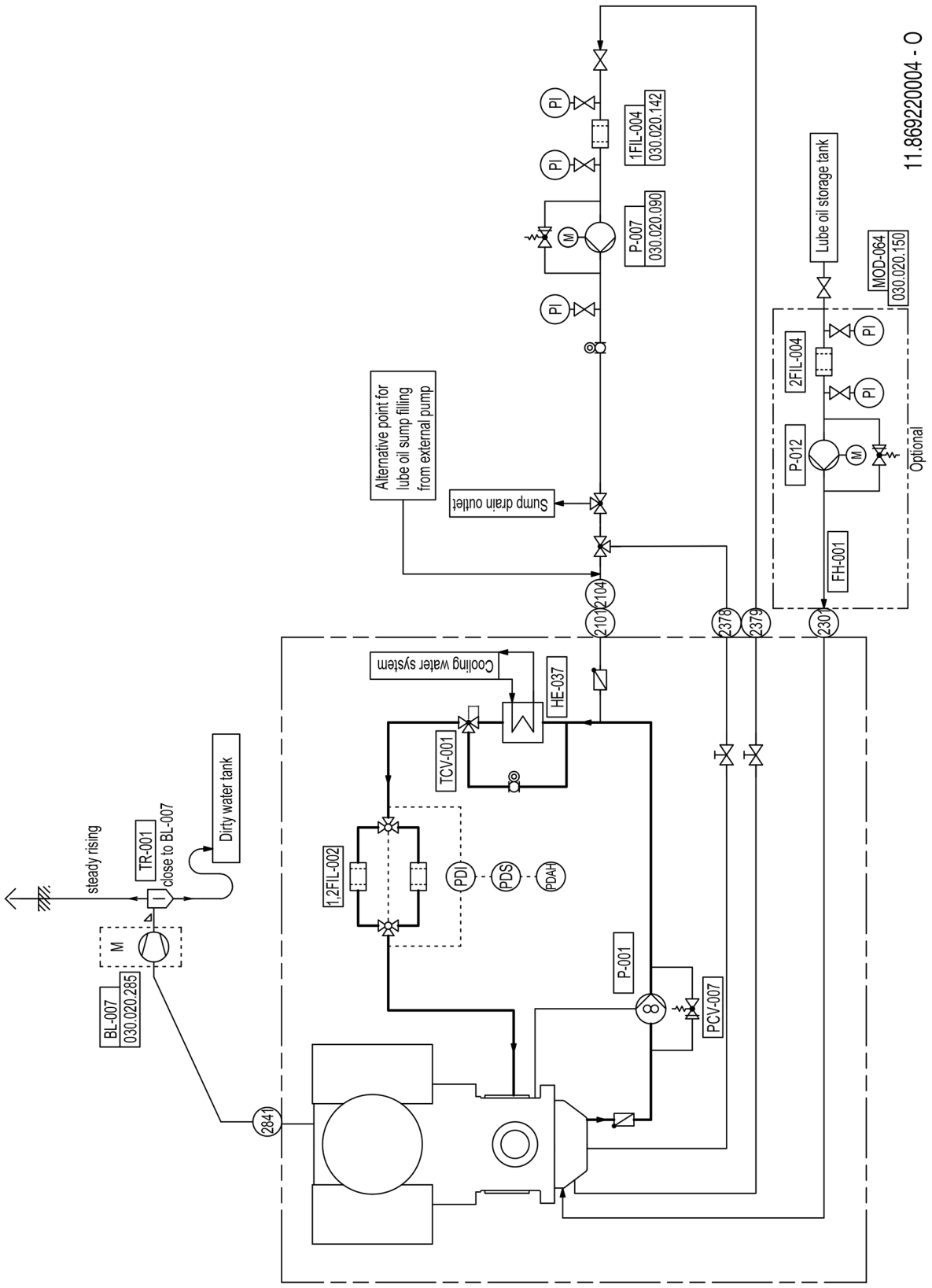
Suction pipes must be installed with a steady slope and dimensioned for the total resistance (incl. pressure drop for suction filter) not exceeding the pump suction head. Before engine starts, venting of suction line must be warranted. Therefore the design of the suction line must be executed accordingly.

Requirements before commissioning of engine

The flushing of the lube oil system in accordance to the Everllence specification (see the relevant working instructions) before commissioning of the engine demands that all installations within the system are in proper operation. Be aware that special installations for commissioning are required.

Contact Everllence or licensee if any uncertainties occur.

2026-10-29 - 10.1

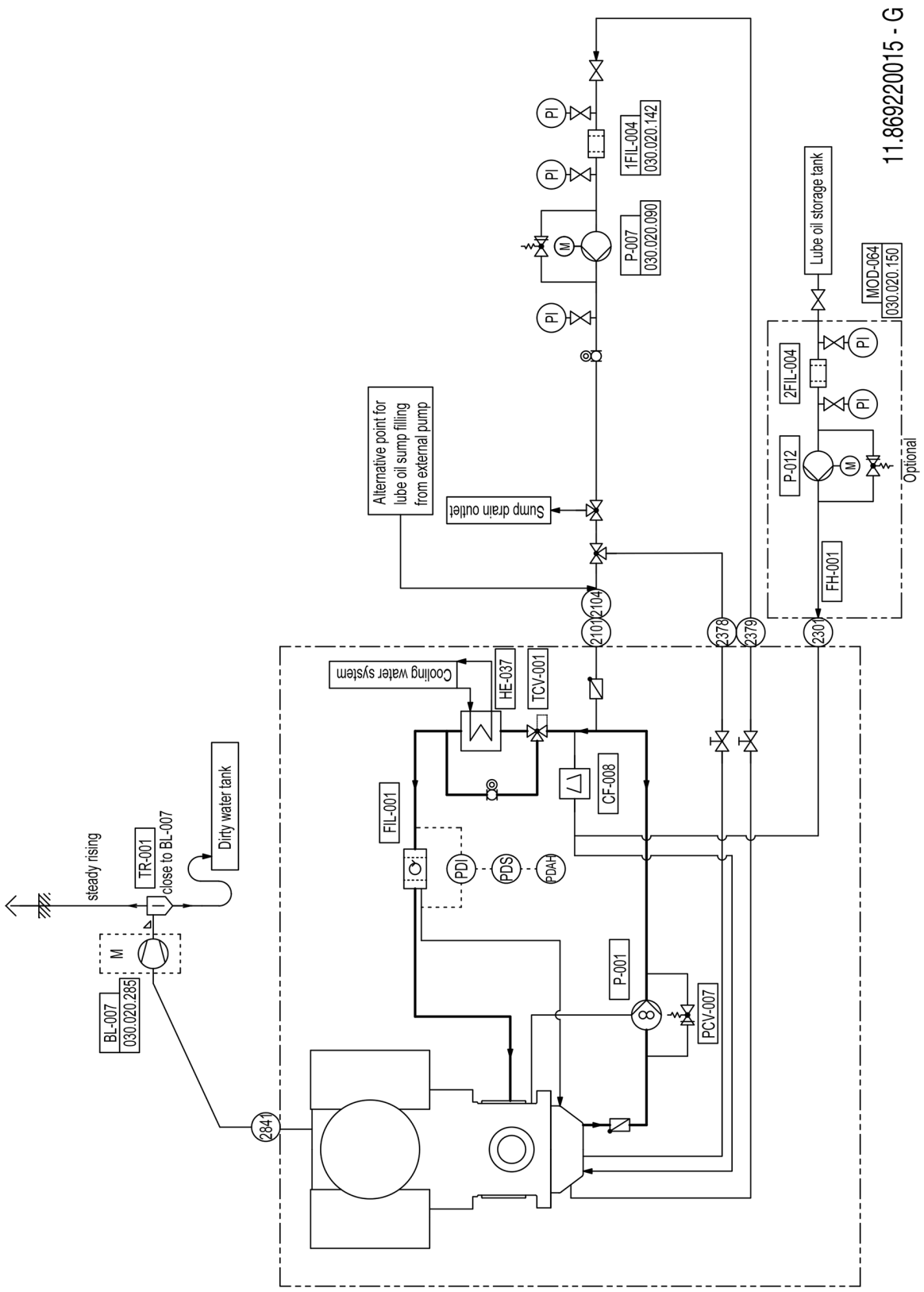


2026-10-29 - 10.1

	Components
FH-001	Flexible hose for lube oil replenishing unit
1,2FIL-002	Lube oil duplex filter
1,2FIL-004	Lube oil suction strainer
HE-037	Lube oil cooler main engine, attached
MOD-064	Lube oil replenishing unit (consists of P-012, 2FIL-004, FH-001)
P-001	Lube oil service pump, attached
	Major engine connections
2101	Lube oil inlet to engine
2104	Lube oil inlet for provisional lubrication
2301	Lube oil filling connection on base frame tank
P-007	Prelubrication pump
P-012	Lube oil transfer pump
PCV-007	Lube oil pressure relief valve
T-021	Sludge tank
TCV-001	Lube oil temperature control valve
TR-010	Oil mist eliminator with extraction fan
2378	Lube oil connection of oil pan, coupling side (CS)
2379	Lube oil connection of oil pan, coupling counter side (CCS)
2841	Venting of crankcase 1

Figure 74: External lube oil system diagram including lube oil module with duplex filter (standard)

2026-10-29 - 10.1


11.869220015 - G
Lube oil storage tank
MOD-064
030.020.150
1FIL-004
030.020.142
P-007
030.020.090
2FIL-004
P-012
Optional
FH-001
Alternative point for lube oil sump filling from external pump
Sump drain outlet
Cooling water system
HE-037
TCV-001
CF-008
FIL-001
PDI
PDS
PDAH
P-001
PCV-007
BL-007
030.020.285
TR-001
steady rising
close to BL-007
Dirty water tank
2101
2104
2378
2379
2301
2841

	Components
CF-008	Lube oil centrifugal filter
FH-001	Flexible hose for lube oil replenishing unit
FIL-001	Lube oil automatic filter
1,2FIL-004	Lube oil suction strainer
H-025	Lube oil preheater
HE-037	Lube oil cooler main engine, attached
MOD-064	Lube oil replenishing unit (consists of P-012, 2FIL-004, FH-001)
	Major engine connections
2101	Lube oil inlet to engine
2104	Lube oil inlet for provisional lubrication
2301	Lube oil filling connection on base frame tank
P-001	Lube oil service pump, attached
P-007	Prelubrication pump
P-012	Lube oil transfer pump
PCV-007	Lube oil pressure relief valve
BL-007	Fan, crankcase venting
TCV-001	Lube oil temperature control valve
TR-001	Condensate trap, lube oil systems
2378	Lube oil connection of oil pan, coupling side (CS)
2379	Lube oil connection of oil pan, coupling counter side (CCS)
2841	Venting of crankcase 1

Figure 75: External lube oil system diagram including lube oil module with automatic filter (optional)

6.3.3 Prelubrication/postlubrication

Prelubrication

The prelubrication pump must be switched on at least 5 minutes before engine start. The prelubrication pump serves to assist the engine attached main lube oil pump, until this can provide a sufficient flow rate.

For design data of the prelubrication pump see section Planning data, Page 73 and paragraph Lube oil, Page 87.

Postlubrication

The prelubrication pump is also to be used for postlubrication after the engine is turned off.

See table System circuit operation time after engine stop, Page 47 for the required operation time.

Postlubrication is effected for a period of 15 minutes.

A lack of the run-down cooling endangers engine components and especially the turbocharger.

6.3.4 Lube oil filling and outlets

Lube oil filling

The lube oil system can be manually filled from barrels and hand pump via the filling cap point (2361) situated on the oil filter housing on 'B' bank side, see section Definitions. Alternatively filling can be effected by transfer pump from an oil storage tank via the prelubricaton inlet pipe as indicated on the P&I diagram.

2026-10-29 - 10.1

Lube oil drain

Assuming a suitable drain or holding tank is installed, the lube oil system can be drained by the installation of lockable three-way valve as indicated on the diagram. Alternatively single valve configurations can be used if it is the shipyard preference. The prelubricaton pump, in manual control, can then be used to empty the system. As a warning, this pump has a high flow rate and will empty a typical oil system on a 12V28/33D STC in less than 3 minutes. Lube oil holding or drain tanks, transfer pumps and associated pipework are all shipyard supply.

6.4 Crankcase vent

Crankcase pressure arising from blow-by of combustion gases past the piston rings is relieved through the crankcase venting, connection 2841. This pressure, if unrelieved, could cause leakage of lubricating oil through the crankshaft oil seals and ultimately crankcase explosion if left unchecked.

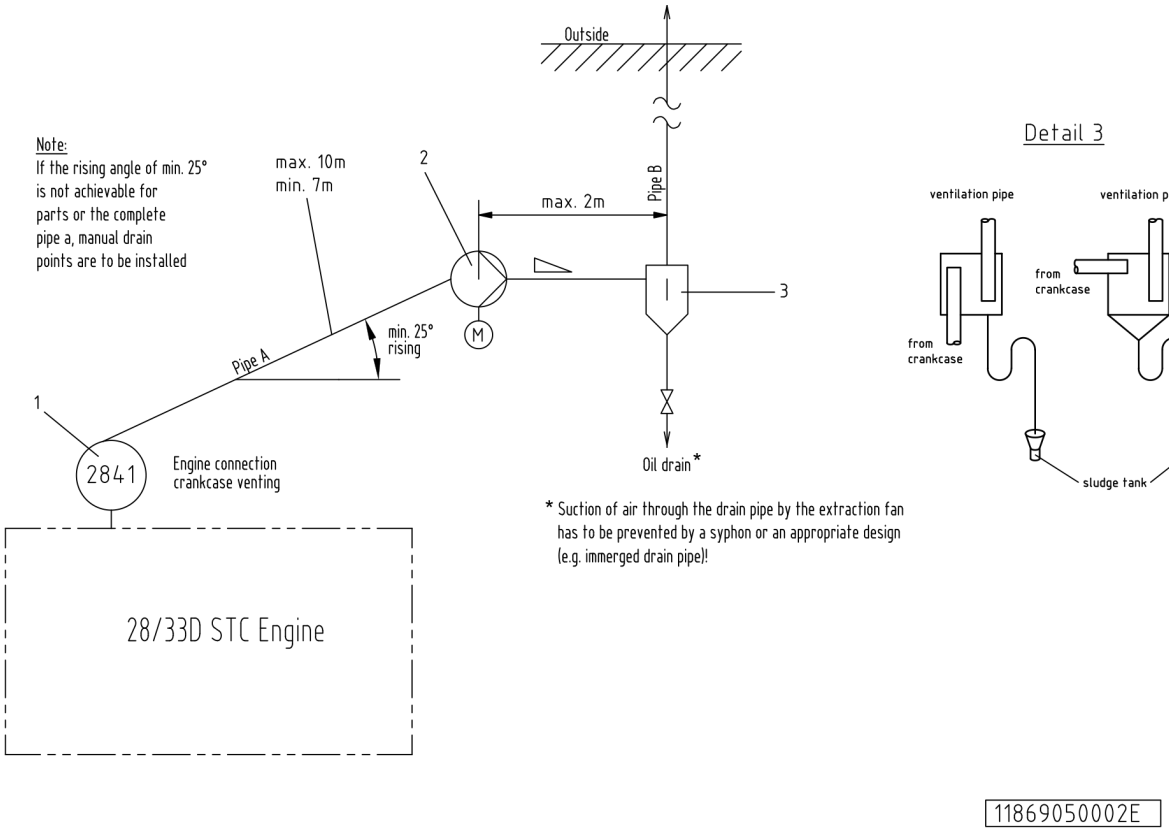
Under normal running conditions, the crankcase is filled with warm air laden with oil mist together with relatively small quantities of combustion gases that pass through the venting to the atmosphere.

In the event of a crankcase explosion, the sudden pressure rise is relieved through fast opening disc valves situated on the crankcase doors. The primary pressure wave is followed by a partial vacuum in the crankcase, which closes the valve and thus prevents the in-rush of a charge of air that could cause a secondary and more violent explosion.

Vent pipes

The vent pipe from the engine crankcase is to be arranged according to the following diagram. The required nominal diameter DN of the vent pipe is to be found in the legend following the diagram.

2026-10-29 - 10.1



1 Connecting crankcase vent
2 Condensate trap
3 Condensate trap

Figure 76: Crankcase vent

Pipe	Length	Engine	Diameter
A	7–10 m	12V	DN 65
		16V	DN 80
		20V	DN 100
B	See fan curve	12V	DN 100
		16V	
		20V	

2026-10-29 - 10.1

6.5 Water systems

6.5.1 Cooling water system description

Introduction

The following is a description of a V28/33D STC marine cooling system and it is designed to suit the majority of installations. However, should it be absolutely necessary, the cooling water system can be tailored to suit the requirements of individual vessels. In this case Everllence should be consulted.

For the design data of the system components shown in the diagram (figure External cooling water system diagram, Page 205), see section Planning data, Page 73.

The cooling water is to be conditioned using a corrosion inhibitor, see section Specification of engine coolant, Page 160.

LT = low temperature

HT = high temperature

Cooler dimensioning, general

For coolers operated by seawater (not treated water), lube oil or fuel oil on the primary side and treated freshwater on the secondary side, an additional safety margin of 10% related to the heat transfer coefficient is to be considered. If treated water is applied on both sides, Everllence does not insist on this margin.

- If antifreeze agents must be used, consult Everllence beforehand. Antifreeze agents reduce the thermal heat capacity of the coolant. This can lead in some cases to insufficient cooling effect.

The cooler piping arrangement should include venting and draining facilities for the cooler.

As demanded by modern marine installations, to ensure minimum weight and physical size is attained, the main plate cooler/s are designed with very small margins. In order to achieve maximum cooler efficiency it is important that the design water flow rates within the systems are correct. Also, design flow rates should not be exceeded by more than 15% to avoid cavitation within the engine and its systems. Therefore, facility for flow restriction, in the form of either adjustable valves or orifice plates and bosses for instrumentation should be installed in the off engine pipework where shown on the P&ID see figure External cooling water system diagram, Page 205.

Open/closed system

Open system

Characterised by "atmospheric pressure" in the expansion tank. Pre-pressure in the system, at the suction side of the cooling water pump is given by the geodetic height of the expansion tank (standard value 6–9 m above crankshaft of engine).

2026-10-29 - 10.1

Closed system

In a closed system, the expansion tank is pressurised and has no venting connection to open atmosphere. This system is recommended in case the engine will be operated at cooling water temperatures above 100°C or an open expansion tank may not be placed at the required geodetic height. Use air separators to ensure proper venting of the system.

Venting

Note:
Insufficient venting of the cooling water system prevents air from escaping which can lead to thermal overloading of the engine. Make sure that a minimum flow rate of 1% of the HT-cooling water flow given in section 2 is led from the engine HT-venting connection to the expansion tank at maximum engine speed.

The cooling water system needs to be vented at the highest point in the cooling system. Additional points with venting lines to be installed in the cooling system according to layout and necessity. In case engines may be operated on gas or low flashpoint fuels like methanol, all venting pipes have to be routed to open atmosphere.

If LT and HT string are separated, make sure that the venting lines are always routed only to the associated expansion tank. The venting pipe must be connected to the expansion tank below the minimum water level, this prevents oxydation of the cooling water caused by "splashing" from the venting pipe. We recommend to connect the venting pipes at the tank bottom. The expansion tank should be equipped with venting pipe and flange for filling of water and inhibitors.

In case a closed system with pressurised expansion tank is used, air separators have to be installed in the system.

Additional notes regarding venting pipe routing:

- The ventilation pipe should be continuously inclined (min. 5 degrees).
- At the interface to the system (engine connection terminal), the line must be continued directly with an elastic pipe connection (e.g. hose line).
- No additional masses such as shut-off valves, reducers, extensions, etc. may be attached to the engine-side connection terminal, since they represent an additional oscillating mass that can cause the line to break during operation.
- Venting pipes from several engine circuits may only be connected together if there are no longer any pressure differences between the individual pipes.
- It is to be avoided to merge venting pipes from low-temperature (LT) and high-temperature (HT) circuits, as a separate fault detection (e.g. lubricating oil or fuel in the cooling water) is no longer possible.
- No restrictions, no kinks in the ventilation pipes.
- Merging of ventilation pipes only permitted with appropriate cross-sectional enlargement.
- In case the engine HT cooling water may be cooled down in part load operation, a throttle valve has to be installed in the HT venting pipe to adjust the flow towards the expansion tank. The valve is recommended for plants with mixing systems, combustion air intake from outside the vessel, operation under arctic conditions or other special applications. In these cases, contact Everllence.

Draining

At the lowest point of the cooling system, a drain has to be provided. Additional points for draining to be provided in the cooling system according to layout and necessity, e.g. for components in the system that will be removed for maintenance.

2026-10-29 - 10.1

We recommend using lockable valves or locking caps for sample and draining points to avoid opening by mistake.

6.5.2 Internal LT cooling water system

As a standard the engine is equipped with following attached equipment:

- Two-stage charge air coolers (1,2 HE-008), relevant 2nd stage for LT cooling water
- Lube oil cooler (HE-037)
- LT cooling water pump (P-004)

1,2 HE-008/LT stage of two-stage charge air cooler

To cool down the charge air after compressor of the turbocharger the engine is equipped with a two-stage charge air cooler.

HE-037/Engine mounted lube oil cooler

To cool down the lube oil, the engine is equipped with a plate type heat exchanger.

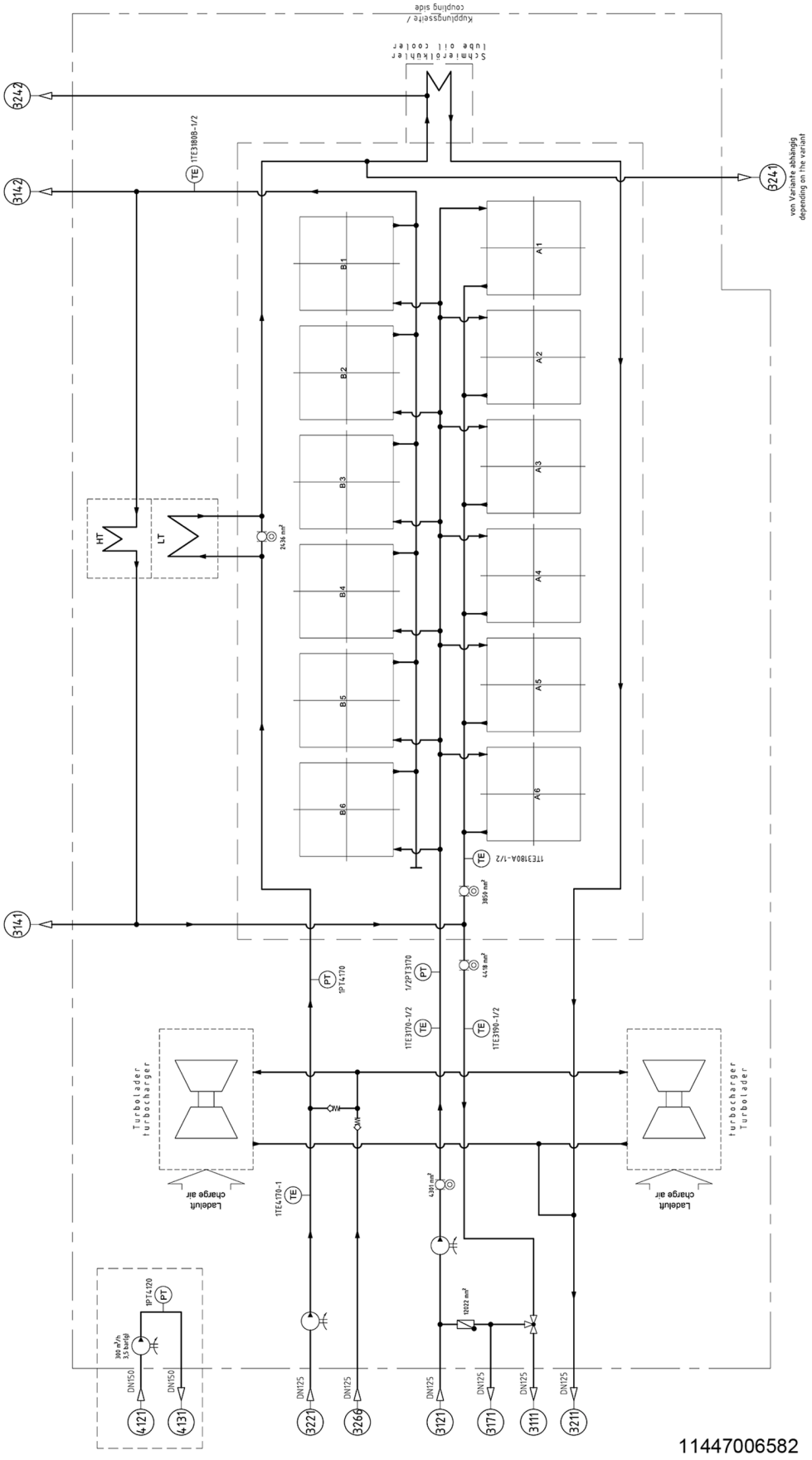
For the description see section Lube oil system, Page 183. For the heat data, flow rates and tolerances see section Planning data, Page 73. For the principal design criteria for coolers see paragraph Cooler dimensioning, general, Page 198.

P-004/LT cooling water pump

The LT cooling water pump is an engine driven centrifugal pump mounted about the center of the free end of the engine.

The engine driven LT pump circulates the water through the second stage of the charge air cooler and through the engine mounted lubricating oil plate cooler. The water then leaves the engine and is cooled by seawater in the main LT plate cooler. The pump inlet pipework should incorporate a connection to the header tank to ensure a positive pressure at the pump suction. For the LT water pump performance data see paragraph HT and LT fresh water pump, Page 208.

2026-10-29 - 10.1



2026-10-29 - 10.1

Major engine connections

3111	HT cooling water outlet from engine	3221	LT cooling water inlet to cooling water pump
3121	HT cooling water inlet to cooling water pump	3241	Venting of LT cooling water pipe 1
3141	Venting of HT cooling water pipe 1	3242	Venting of LT cooling water pipe 2
3142	Venting of HT cooling water pipe 2	3266	Cooling water inlet for compressor post cooling
3171	HT cooling water outlet to preheater	4121	Seawater inlet to seawater pump
3211	LT cooling water outlet from engine	4131	Seawater outlet from seawater pump

Figure 77: Internal cooling water system (LT and HT) – Exemplary 12V engine

Note:
The drawing shows the basic internal media flow of the engine in general.
Project-specific drawings thereof don't exist.

6.5.3 External LT cooling water system

TCV-016/LT cooling water temperature control valve

The cooling water temperature in the LT circuit is maintained by a three-way temperature control valve. For the standard configuration of the engine a wax type valve is used.

HE-024/Cooler for LT cooling water

The LT water is recooled by an external plate type heat exchanger. It is possible to either use a single LT cooling water cooler or a combined HT/LT cooling water cooler, see paragraph HE-036/Combined cooler for HT/LT cooling water, Page 204.

For heat data, flow rates and tolerances of the heat sources see section Planning data, Page 73. For the principal design criteria for coolers see paragraph Cooler dimensioning, general, Page 198.

P-092/LT cooling water circulation pump

The pump serves for cooling of the compressor wheel casing of the turbocharger after engine shutdown. It has to be operated during prelubrication and postlubrication and remain in operation accordingly to table System circuit operation time after engine stop, Page 47.

Everllence can supply a suitable pump.

1 FIL-021/Strainer for LT cooling water

In order to protect the engine and system components, several commissioning strainers are to be installed during the flushing process. We recommend a mesh size of 1–2 mm depending on the pipe diameter. To protect three-way valves and other sensitive components, we recommend to leave at least one strainer remaining in the piping of each system. Use stainless steel mesh material.

We recommend to install Y-type strainers with magnetic inserts. For further operation of the engine, we recommend to use a cartridge with mesh size of about 1 mm to catch particles. The strainers have to be installed in horizontal pipes or pipes with flow direction downwards.

HE-007/Fuel oil cooler

A fuel oil cooler is required to dissipate the heat of the fuel injection pumps during operation, see section Fuel oil system, Page 209 for further details. One cooler is required per engine. In case the fuel oil cooler is recooled by seawater, we recommend to use a double wall type cooler.

T-103/Cooling water expansion tank

The expansion tank compensates changes in system volume and losses due to leakages and temperature changes. It is to be arranged in such a way, that the tank bottom is situated above the highest point of the system at any ship inclination. The expansion pipe should empty into the suction pipe as close to the pump as possible. For the required volume of the tank and the recommended installation height see section Filling volumes, Page 91.

2026-10-29 - 10.1

The fresh water contained within the engine systems will require treatment with an approved corrosion inhibitor additive and depending on location of operation, anti-freeze agent (see section Specification of engine coolant, Page 160).

Venting pipes from engine connections must be led to the expansion tank separately.

Contact Everllence for details concerning auxiliary equipment.

6.5.4 Internal HT cooling water system

As a standard the engine is equipped with following attached equipment:

- Two-stage charge air coolers (1,2 HE-010), relevant 1st stage for HT cooling water
- HT cooling water temperature control valve (TCV-002)
- HT cooling water pump (P-002)

1,2 HE-010/HT stage of two-stage charge air cooler

To cool down the charge air after compressor of the turbocharger the engine is equipped with a two-stage charge air cooler.

TCV-002/HT cooling water temperature control valve

The cooling water temperature in the HT circuit is maintained by a three way temperature control valve. For the standard configuration of the engine, a wax type valve is used. The HT valve is attached to the engine.

P-002/HT cooling water pump

The HT cooling water pump is an engine driven centrifugal pump mounted at the free end of the engine. The HT cooling water pump circulates the water through the engine (jacket water) and through the first stage of the charge air cooler. The water then leaves the engine and is cooled by seawater in the main HT plate cooler.

The pump inlet pipework should incorporate a connection to the expansion tank to ensure a positive pressure at the pump suction side.

For details concerning the HT water pump performance data see paragraph HT and LT fresh water pump, Page 208.

Note:
See figure Internal cooling water system (LT and HT) – Exemplary 12V engine, Page 201.

6.5.5 External HT cooling water system

MOD-004/HT cooling water preheating module

The HT circuit also includes a jacket water heater and pump module comprising an in-line thermostatically controlled electrical heater and a centrifugal circulating pump. This unit is operated when the engine is not running and in stand-by mode to maintain the jacket water temperature above 60°C. The engine has to be preheated to reduce thermal expansion by quick load step up. A temperature above 60°C also prevents corrosion at the engine that may be caused by condensed water in humid air environments. Required heating power is at least 30 kW. For operation in cold conditions (arctic), a higher heating capacity is required. Consult Everllence for further information.

Avoid an installation of the preheater in parallel to the engine driven HT pump. In this case, the preheater may not be operated while the engine is running. Preheaters operated on steam or thermal oil may cause alarms since a post-cooling of the heat exchanger is not possible after engine start (preheater pump is blocked by counter pressure of the engine driven pump).

2026-10-29 - 10.1

HE-003/Cooler for HT cooling water

For heat data, flow rates and tolerances of the heat sources see section Planning data, Page 73. For the description of the principal design criteria for coolers see paragraph Cooler dimensioning, general, Page 198. It is possible to either use a single HT cooling water cooler or a combined HT/LT cooling water cooler, see paragraph HE-036/Combined cooler for HT/LT cooling water, Page 204.

HE-026/Fresh water generator

The freshwater generator must be switched off automatically when the cooling water temperature at the engine outlet drops below 75°C continuously.

This will prevent operation of the engine at too low temperatures. In case the HT temperature control valve attached to the engine is used, the valve will recirculate hot water and prevent the engine from cooling down.

T-103/Cooling water expansion tank

For information about the shared cooling water expansion tank see paragraph T-103/Cooling water expansion tank, Page 202.

2 FIL-021/Strainer for HT cooling water

In order to protect the engine and system components, several commissioning strainers are to be installed during the flushing process. We recommend a mesh size of 1–2 mm depending on the pipe diameter.The suction strainer protects the pump and system against larger dirt particles.

We recommend to install Y-type strainers with magnetic inserts. For further operation of the engine, we recommend to use a cartridge with mesh size of about 1 mm to catch particles. The strainers have to be installed in horizontal pipes or pipes with flow direction downwards.

6.5.6 Internal seawater system

P-093/Seawater pump

The seawater pump is an engine driven centrifugal pump mounted at the free end of the engine.

The seawater pump serves to draw seawater directly from the ship's seawater chest into the circuit, through a suction strainer and a recommended non-return foot valve (both client supply), delivering the water to the main engine combined cooler for HT/LT cooling water. After removing heat from these circuits, the water is piped to overboard discharge. In case the engine is placed above the seawater line, an electrically driven pump has to be used instead of the attached seawater pump. Contact Everllence in this case. In any case the required NPSH values of the pump have to be considered for the design of the seawater system.

6.5.7 External seawater system

HE-036/Combined cooler for HT/LT cooling water

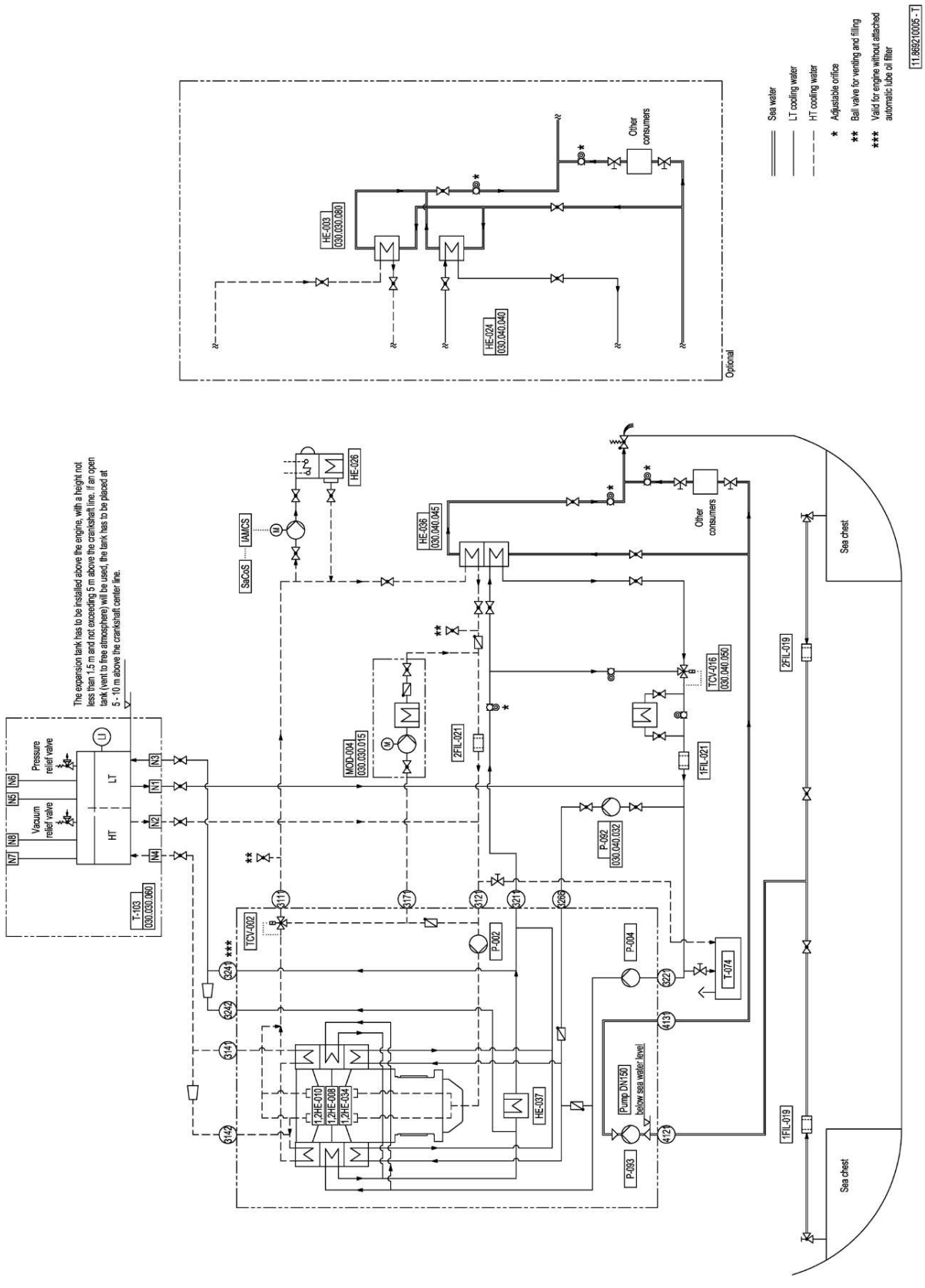
The combined cooler saves weight and installation space compared to solutions by two separate coolers. On the other hand the maintenance of the combined cooler is more time consuming since some pipe connections have to be dismounted to clean the plates.

FIL-019/Seawater inlet filter

The suction strainer protects the pump and system against larger dirt particles. For vessels with only one sea chest a reversible duplex filter is recommended. The mesh size should be in a range of 2–4 mm. For vessels operating predominantly in sandy waters, a mesh size of 0.3–0.5 mm is recommended.

2026-10-29 - 10.1

6.5.8 External cooling water system diagram



2026-10-29 - 10.1

Components

1,2FIL-019	Seawater filter
1,2FIL-021	Strainer for cooling water
HE-003	Cooler for HT cooling water
HE-007	Fuel oil cooler
1,2HE-008	Charge air cooler (stage 2)
1,2HE-010	Charge air cooler (stage 1)
HE-024	Cooler for LT cooling water
HE-026	Fresh water generator
1,2HE-034	Compressor wheel casing (water cooled)
HE-036	Combined cooler for HT/LT cooling water
HE-037	Lube oil cooler main engine, attached
MOD-004	HT cooling water preheating module
MOV-016	LT cooling water temperature control valve
P-002	HT cooling water service pump, attached
P-004	LT cooling water service pump, attached
P-092	LT cooling water circulation pump
P-093	Seawater service pump, attached
T-074	Fresh water collecting tank
T-103	HT/LT cooling water expansion tank
TCV-002	HT cooling water temperature control valve
TCV-016	LT cooling water temperature control valve

Major cooling water engine connections

3111	HT cooling water outlet from engine
3121	HT cooling water inlet to cooling water pump 1
3141	Venting of HT cooling water pipe 1
3142	Venting of HT cooling water pipe 2
3171	HT cooling water outlet to preheater
3211	LT cooling water outlet from engine 1
3221	LT cooling water inlet to cooling water pump
3241	Venting of LT cooling water pipe 1
3242	Venting of LT cooling water pipe 2
3266	LT cooling water inlet for compressor post cooling
4121	Seawater inlet to seawater pump
4131	Seawater outlet from seawater pump

HT/LT cooling water expansion tank connections

N1	To LT cooling water pump
N2	To HT cooling water pump
N3	From LT venting pipe
N4	From HT venting pipe
N5	Connection for manometer
N6	Connection for filling
N7	Spare connection
N8	Pressurised air connection/nitrogen flushing (optional)

Figure 78: External cooling water system diagram

2026-10-29 - 10.1

6.5.9 External cooling water collecting and supply system

T-074/Cooling water collecting tank (not indicated in the diagram)

The tank is to be dimensioned and arranged in such a way that the cooling water content of both the HT and LT water circuits can be drained into it for maintenance purposes.

This is necessary to meet the requirements with regard to environmental protection (water has been treated with chemicals) and corrosion inhibition (re-use of conditioned cooling water).

Volumes for the engine are listed in table Cooling water, fuel oil and oil volume of engine.

P-031/Cooling water filling pump

To refill the HT- and LT cooling water system after maintenance, we recommend to install a cooling water filling pump. The pump shall be installed below the cooling water collecting tank with pipe connections to the related systems.

6.5.10 Miscellaneous items

Piping

Coolant additives may attack a zinc layer. It is therefore imperative to avoid using galvanised steel pipes. Treatment of cooling water as specified by Everllence will safely protect the inner pipe walls against corrosion.

Moreover, there is the risk of the formation of local electrolytic element couples where the zinc layer has been worn off, and the risk of aeration corrosion where the zinc layer is not properly bonded to the substrate.

See the working instructions 6682 000.16-01E for cleaning of steel pipes before fitting.

Pipes shall be manufactured and assembled in a way that ensures a proper draining of all segments. Venting is to be provided at each high point of the pipe system and drain openings at each low point. Make sure to use lockable ball valves or locking caps to prevent hot water leaving the system in case the valves are opened by mistake.

Cooling water pipes are to be designed according to pressure values and flow rates stated in section Planning data, Page 73 and the following sections. Consider the maximal possible pressure level, that can be produced by the pumps (zero delivery head) integrated in the system and static pressure by expansion tanks or other equipment. The engine cooling water connections have to be designed according to PN10/PN16.

System instrumentation

For details of the instrumentation, see section SaCoSone system overview.

2026-10-29 - 10.1

6.5.11 Water pump performance

Engine driven water pumps

The engine driven pumps may be delivered with various impeller diameters to adapt the pump capacity to the needs of the plant. Normally HT- and LT-pump are delivered with the same capacity.

Seawater pump

The seawater pump attached to the engine is designed for a wide range of capacity. The standard volume flow required for the seawater cooler is given in section Planning data, Page 73. In case other consumers have to be supplied, the volume flow may be increased. In this case, the increased flow speed at the suction side of the pump can cause some underpressure upstream of the pump. Consider underpressure and increased NPSH value in the calculation of the system. For further information contact Everllence.

By use of orifices (yard supply) the delivery capacity of the seawater pump has to be adjusted in order to avoid pump cavitation. For further information contact Everllence.

HT and LT fresh water pump

Product range	Engine cooling
Branch suction flange	DN 125
Discharge flange	DN 125
Nominal speed	Variable rpm
Specific gravity	1.0
Performance curve based on water.	

2026-10-29 - 10.1

6.6 Fuel oil system

6.6.1 DMA supply system description

General

The V28/33D STC engine runs on distillate diesel fuel oil (light fuel oil) only.

The following is a description of a typical V28/33D STC fuel oil system and is designed to suit the majority of installations, refer to figure External DMA supply system diagram, Page 214. Tailored systems are possible for individual vessel requirements as well. To specify those contact Everllence for assistance.

6.6.2 Internal fuel oil supply system

P-028/Fuel oil supply pump, attached

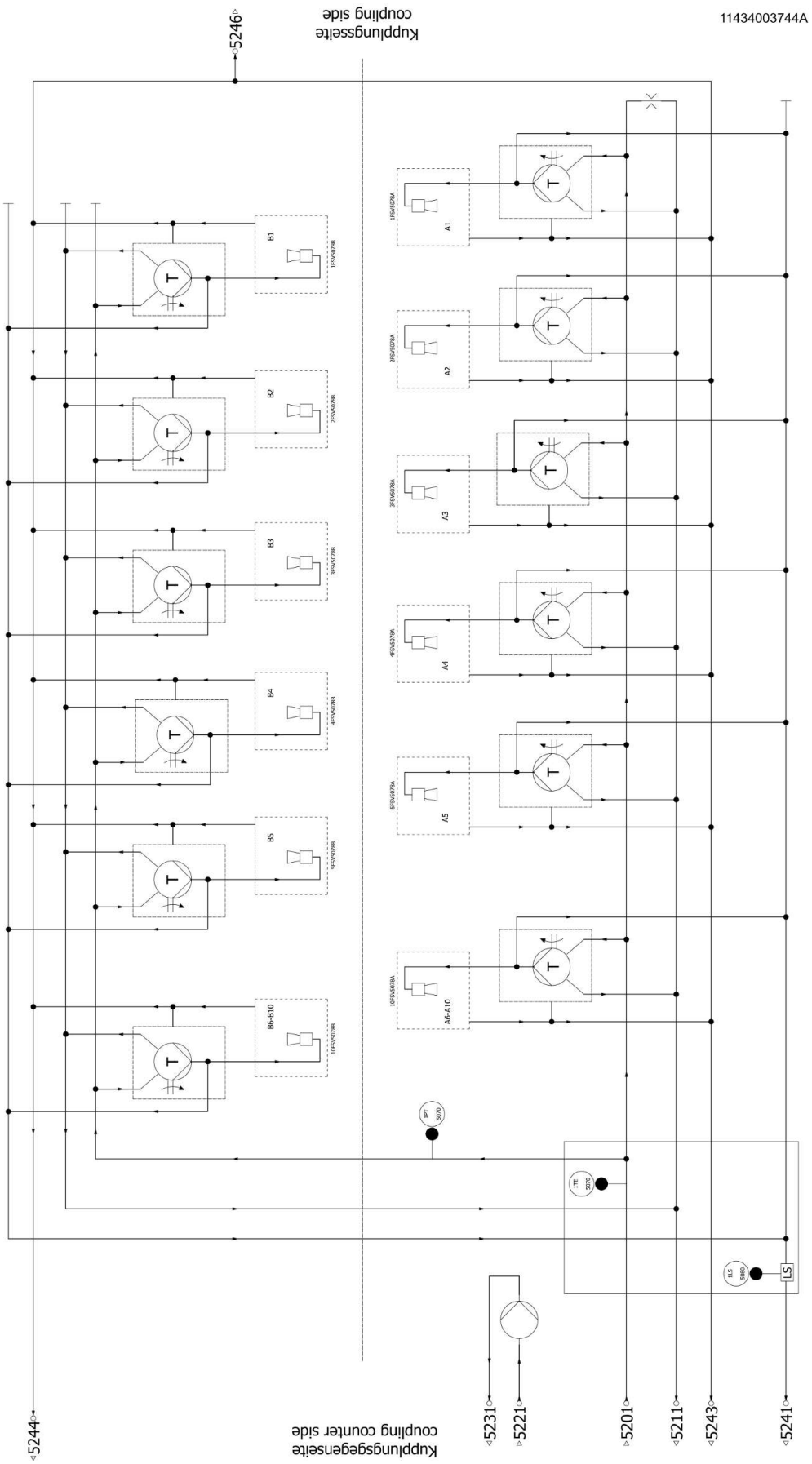
The diesel fuel oil supply pump is a positive displacement gear type pump. It is mounted and driven by the engine. The supply pump has an integrated pressure relief safety valve.

The day tank and mechanically driven pump arrangement ensures that the engine will remain running or available to start in "black ship" condition. This is assuming 24 V DC is available for the electronic fuel injection and control systems.

The pump increases fuel pressure up to 10 bar.

From the fuel oil pump discharge the fuel oil is piped to an off-engine duplex filter, see section External fuel oil supply system, Page 211.

2026-10-29 - 10.1


11434003744A
5246
Kupplungsseite
coupling side
B1
B2
B3
B4
B5
B6-B10
A1
A2
A3
A4
A5
A6-A10
LS
5244
Kupplungsgegenseite
coupling counter side
5231
5221
5201
5211
5243
5241

Major engine connections

5201	Fuel oil inlet to engine (main injection system)	5241	Fuel oil break leakage drain
5211	Fuel oil outlet from engine	5243	Fuel oil leakage drain (reusable from pumps and injectors) 1
5221	Fuel oil inlet to fuel oil supply pump	5244	Fuel oil leakage drain (reusable from pumps and injectors) 2
5231	Fuel oil outlet from fuel oil supply pump	5246	Fuel oil leakage drain (reusable from pumps and injectors) 3

Figure 79: Internal fuel system – Exemplary

Note:
The drawing shows the basic internal media flow of the engine in general.
Project-specific drawings thereof don´t exist.

6.6.3 External fuel oil supply system

The recommended design pressure for the complete system installation is PN16.

T-003/Diesel fuel oil service tank

Fuel oil is supplied into the circuit from a service or day tank. The tank is client supply so its dimensions can be customised to fit the vessel's specifications. It is normally a 'standard' header tank design, with float level control valve and fitted with vent and drain pipework. The base of the tank needs to be installed either max. 4 meters beneath or max. 6 meters above the engine crankshaft centreline (pressure loss of supply systems and piping not considered). This is to ensure the required pressure range at the inlet of the engine driven fuel oil pump (engine connection 5221), see table Fuel, Page 88.

P-006/Fuel oil hand pump

The fuel oil hand pump is required to fill up the system for commissioning, after maintenance of the fuel oil supply system and to improve the engine's starting behavior if the fuel oil tank is beneath crankshaft centerline. It is recommended to install the fuel oil hand pump in the supply line close to the tank. The fuel hand pump delivers fuel oil directly in front of the fuel oil supply pump P-028, see section Internal fuel oil supply system, Page 209.

Before engine start and engine operation, shut-off valves from and to pump must be closed and pump must be drained! Otherwise, air can enter the fuel oil suction line via the sealing of the pump.

STR-010/Suction strainer

To protect the engine driven fuel oil supply pump, an approximately 0.5 mm gauge (spherepassing mesh) strainer is to be installed at the suction side of the pump.

If a coalescer is installed, the suction strainer is not required.

TR-009/Coalescer

To fulfill the water content requirements in the fuel oil (see table Requirements for diesel fuel) a coalescer (water separator) should be installed. The coalescer element mesh width has 30 micron (nominal).

For safety reason the coalescer housing is equipped with a differential pressure transmitter. A certain differential pressure indicates a clogged coalescer element and triggers an alarm, the filter cartridge must be replaced. To allow the replacement of the filter during engine operation it must be switched over to a redundant coalescer element with a manual changeover valve. In the coalescer housing a water sensor is installed. The sensor triggers an alarm if a certain water level inside the coalescer is reached. Following the water has to be drained manually.

2026-10-29 - 10.1

FIL-013/Fuel oil duplex filter

The filter unit is a 5 micron (absolute) felt element depth type of duplex construction. It has a manual change over valve to allow filter cartridge change during engine operation to meet classification society requirements.

The flow through the fuel oil duplex filter is equal to the delivery of the engine driven fuel oil pump, see sections Nominal values for cooler specification – 455 kW/cyl., CPP, Page 73 and Nominal values for cooler specification – 500 kW/cyl., CPP, Page 79.

The fuel oil duplex filter is delivered with a differential pressure indicator.

The emptying port of each filter chamber is to be fitted with a valve and a pipe to the sludge tank. If the filter elements are removed for replacing, the filter chamber must be emptied. This prevents the dirt particles remaining in the filter casing from migrating to the clean oil side of the filter.

After changing the filter cartridge, the reconditioned filter chamber must be vented manually.

From the fuel oil duplex filter the fuel oil is piped back to the engine (connection 5201) and circulated around the engine manifold to the fuel oil injection pumps. Then it exits the engine (connection 5211) before being piped to main pump suction via the fuel oil cooler, and pressure control valve.

HE-007/Fuel oil cooler

The fuel oil cooler is required to cool down the fuel oil, which was heated up while circulating through the injection pumps. The cooler is normally connected to the LT cooling water system and should be dimensioned so that the DMA does not exceed a temperature of max. 45°C. Only for very light fuel oil types this temperature has to be even lower in order to preserve the minimum admissible fuel oil viscosity on engine inlet, see section Diesel fuel (DMA) specifications.

Engine type	Cooler capacity
V engine	3.0 kW/cyl.
The max. DMA throughput is approximately identical to the engine inlet fuel flow (= delivery quantity of the fuel oil supply pump).	

Table 93: Dimensioning of the fuel oil cooler

The recommended pressure class of the fuel oil cooler is PN16.

PCV-008/Fuel oil pressure retaining valve

In the fuel oil return loop a pressure control valve has to be installed, to ensure a certain fuel oil pressure at engine outlet, see section Operating/service temperatures and pressures, Page 84. It is to be adjusted so that the pressure before engine inlet can be maintained in the required range (see section Operating/service temperatures and pressures, Page 84).

MOD-011/Fuel oil leakage module

The high-pressure fuel oil lines are double skinned and under covers to protect against fuel oil spray in the unlikely event of failure. The outer skin of the line is connected to the alarm system; any fuel oil entering the outer sheath drains to the on-engine leakage tank, below the crankshaft centreline, in which a rise in level will trigger the alarm. The drain connection (connection 5241) should be piped back to the clean leakage fuel oil tank (T-071).

The operating fuel leakage is continuous and depending on engine load (see section Leakage rate, Page 90).

It exits the engine (connection 5243, 5244 and 5246) under gravity, there should be no back pressure imposed on this flow as this will lead to contamination of the engine lube oil with fuel oil. The leak off fuel oil will therefore require collection in a tank and pumping back to bulk tanks should they be sited above the engine.

2026-10-29 - 10.1

The function of the fuel oil leakage module is to collect the fuel oil leakage of the diesel engine and to pump the fuel oil back to the fuel storage tank. The module is in operation, when the engine is also in operation. The start and stop of the pump is controlled by a level switch. In case of pump failure there is a second pump installed on the module as stand-by pump.

The leakage fuel flows pressureless (by gravity only) from the engine into this tank, therefore the module has to be installed below the engine connections.

Note that sheath drains (connection 5241) and leak off (connection 5243, 5244 and 5246) should not be connected together and run separately to the collection tank. This prevents backfilling of the sheath drain pipe thus causing false sheath drain alarms.

T-071/Clean leakage fuel oil tank

The clean leakage fuel oil tank is part of the leak-oil module, see paragraph MOD-011/Fuel oil leakage module, Page 212.

FQ-003/Fuel oil flowmeter

The upstream flow rate of the engine should be displayed in the ship automation system. The flowmeter requires a by-pass to ensure a continuous fuel oil flow in case of maintenance or malfunction.

A coriolis type flowmeter is recommended for fuel oil flow measuring. The by-pass of the coriolis type flowmeter needs a shut-off valve.

If a positive displacement type flowmeter is used the by-pass needs to be equipped with a spring loaded overflow valve which opens automatically in case of blocking.

The pressure resistance of the fuel oil flowmeter should be as low as possible and considered during the system design stage.

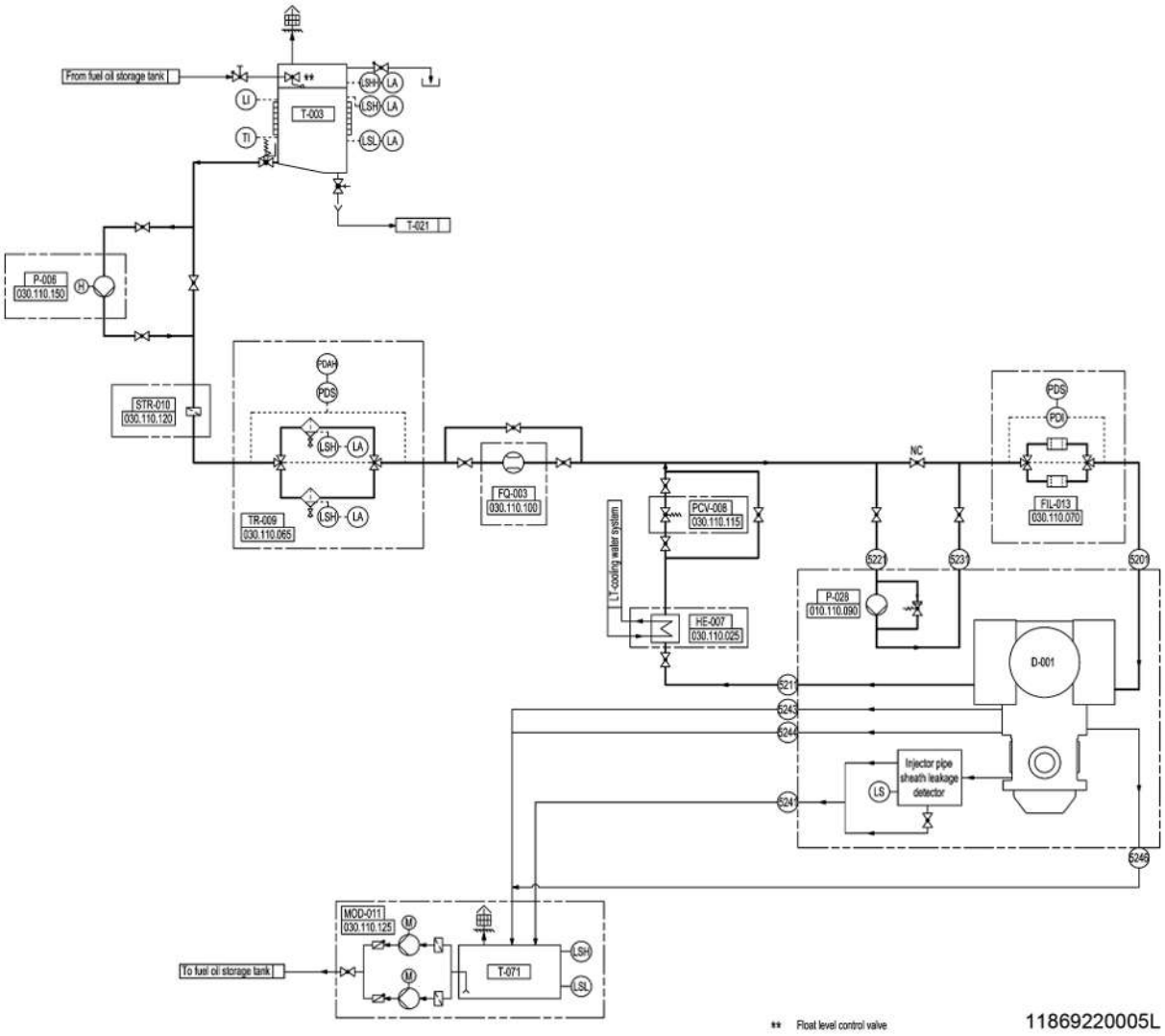
Instrumentation

For details of the instrumentation, see section SaCoSone system overview.

Contact Everllence for technical drawings of auxiliary equipment.

2026-10-29 - 10.1

External fuel oil supply system diagram



Components

D-001	Diesel engine
FIL-013	Fuel oil duplex filter
FQ-003	Fuel oil flowmeter
HE-007	Fuel oil cooler
MOD-011	Fuel oil leakage module
P-006	Fuel oil hand pump
P-028	Fuel oil supply pump, attached
PCV-008	Fuel oil pressure retaining valve
STR-010	Fuel oil suction strainer
T-003	Diesel fuel oil service tank
T-021	Sludge tank
T-071	Clean leakage fuel oil tank
TR-009	Coalescer (water trap)

Major cooling water engine connections

5201	Fuel oil inlet to engine
5211	Fuel oil outlet from engine
5221	Fuel oil inlet to fuel oil supply pump
5231	Fuel oil outlet from fuel oil supply pump
5241	Fuel oil break leakage drain 1
5243	Fuel oil leakage drain (reusable from pumps and injectors) 1
5244	Fuel oil leakage drain (reusable from pumps and injectors) 2
5246	Fuel oil leakage drain (reusable from pumps and injectors) 3

Figure 80: External DMA supply system diagram

2026-10-29 - 10.1

6.7 Compressed air system

6.7.1 Compressed air system description

The compressed air supply to the engine plant requires starting air receivers and starting air compressors of a capacity and air delivery rating which will meet the requirements of the relevant classification society.

Piping

The main starting pipe, which is connected to both air receivers, leads to the engine attached air starter (engine connection 7101).

The 7 bar pressure line (7102) with separate connections to both air receivers 40 bar supply the engine via pressure reducing unit (MOD-100) with control air.

A line branches from the aforementioned control air pipe to supply other air-consuming engine accessories (e.g. fuel oil automatic filter) with compressed air.

The pipes to be connected by the shipyard have to be supported immediately behind their connection to the engine. Further supports are required at sufficiently short distance.

Flexible connections for starting air (steel tube type) have to be installed with elastic fixation. The elastic mounting is intended to prevent the hose from oscillating. For detail information refer to planning and final documentation and manufacturer manual.

Galvanised steel pipes must not be used for the piping of the system.

Compressed air, at 37 bar for the starting system is supplied from the air receivers/compressors, directly to the engine mounted main air starting motor, engine connection "starting motor" (7101), via an approved flexible connection.

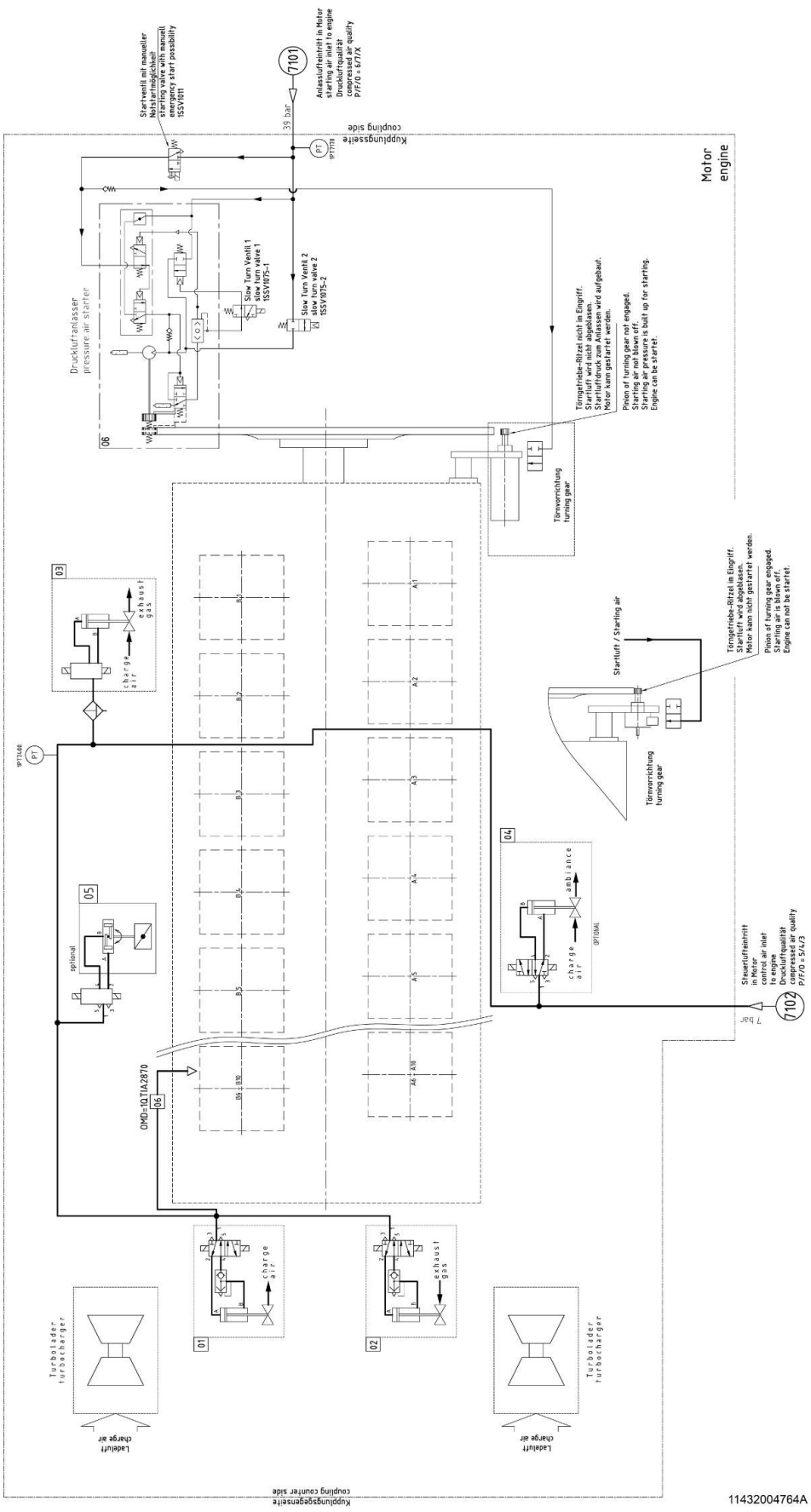
If supplied by Everllence, additional connections on the air receivers are provided for air requirements of the ship, for example the horn. The pipes to be connected by the shipyard have to be supported immediately behind their connection to the engine. Further supports are required at sufficiently short distance.

6.7.2 Internal compressed air system

See overleaf

2026-10-29 - 10.1

6.7 Compressed air system



Components

01	STC regulating valve, B-bank (charge air pipe)	05	Waste gate (optional)
02	STC regulating valve, B-bank (exhaust gas pipe)	06	Oil mist detector
03	Charge air by-pass	PT	Pressure transmitter
04	Charge air blow-off valve (optional)		

Connection numbers

7101	Starting air inlet to engine	7102	Control air inlet to engine 1

Figure 81: Internal compressed air system – Exemplary

Note:
The drawing shows the basic internal media flow of the engine in general. Project-specific drawings thereof don´t exist.

6.7.3 External compressed air system

1 C-001, 2 C-001/Air compressor

These are multi-stage compressor sets with safety valves, cooler for compressed air and condensate traps.

The operational compressor is switched on by the pressure control at low pressure then switched off when maximum service pressure is attained.

For the V28/33D STC engine an air receiver pressure of 37 bar is required to reduce the physical size of the receiver to a minimum.

The service compressor is electrically driven; the auxiliary compressor may also be driven by a diesel engine. The capacity of both compressors should be identical.

The total capacity of the air compressors has to be capable to charge the air receivers from the atmospheric pressure to full working pressure within one hour.

Piping

The piping should be as straight and unrestrictive as possible. Pipe diameter DN80 (2 starters).

1 T-007, 2 T-007/Starting air receivers

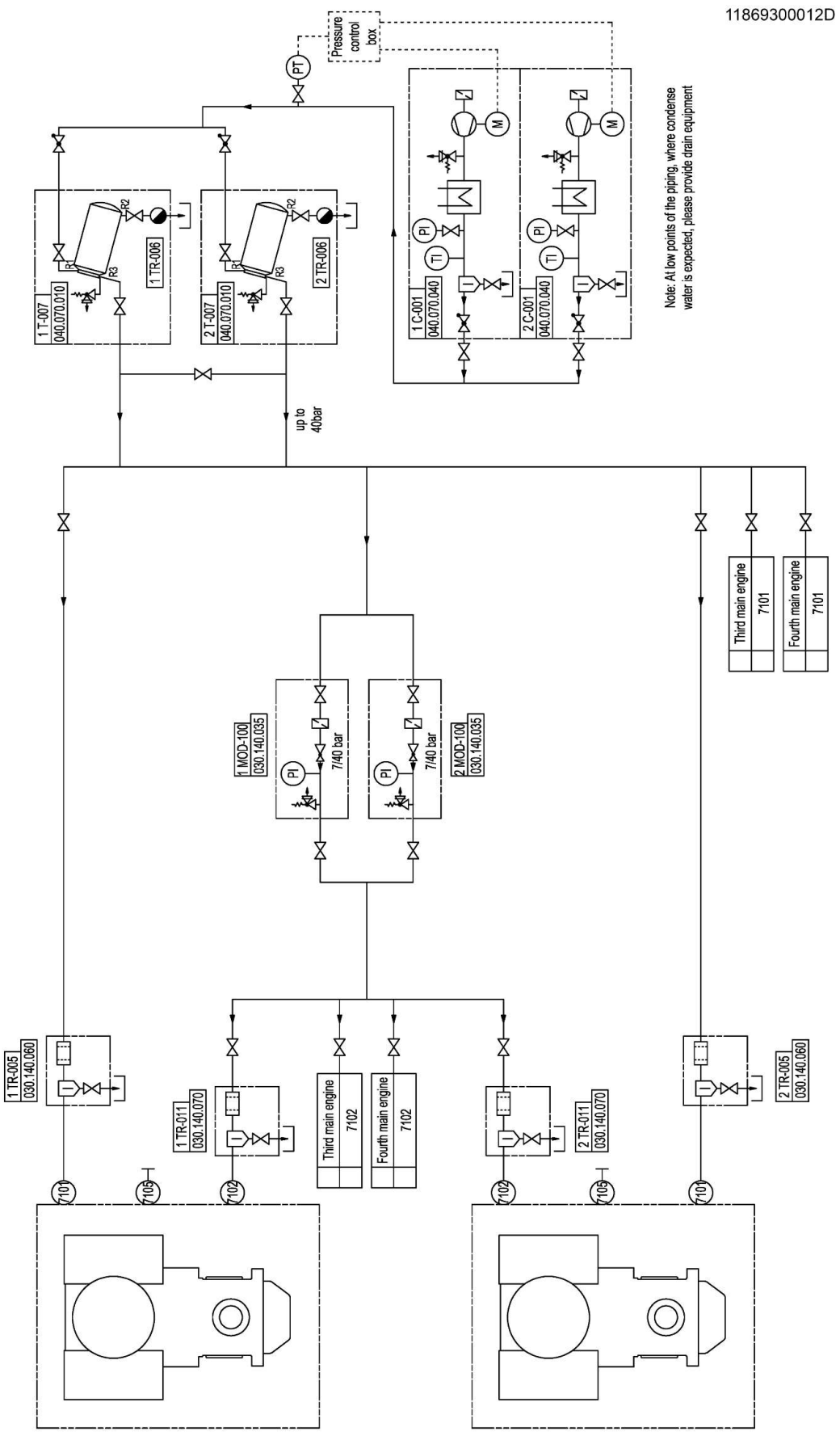
The installation situation of the air receivers must ensure a good drainage of condensed water. Air receiver must be installed with a downward slope sufficiently to ensure a good drainage of accumulated condensate water.

The installation also has to ensure that during emergency discharging of the safety valve no persons can be compromised.

It is not permissible to weld supports (or other) on the air receivers. The original design must not be altered. Air receivers are to be bedded and fixed by use of external supporting structures.

The standard design pressure of the starting air receivers is 40 bar.

2026-10-29 - 10.1


11869300012D
Pressure control box
PT
1 T-007 040.070.010
2 T-007 040.070.010
1 TR-006
2 TR-006
R2
R3
1 C-001 040.070.040
2 C-001 040.070.040
PI
TI
M
Note: At low points of the piping, where condense water is expected, please provide drain equipment
up to 40bar
1 MOD-100 030.140.035
2 MOD-100 030.140.035
7/40 bar
Third main engine 7101
Fourth main engine 7101
1 TR-005 030.140.060
2 TR-005 030.140.060
1 TR-011 030.140.070
2 TR-011 030.140.070
Third main engine 7102
Fourth main engine 7102
7101
7105
7102

	Components		
1,2 C-001	Air compressor	1,2 TR-006	Automatic condensate trap
1,2 MOD-100	Compressed air pressure reducing unit	1,2 TR-011	Water separator with filter
1,2 T-007	Starting air receiver	1,2 TR-005	Water separator for air starter
	Connection numbers		
7101	Starting inlet to engine	R1	Air inlet
7102	Control air inlet 1	R2	Condensate drain
7105	Control air inlet 2 to emergency shut-off unit (optional)	R3	Air outlet

Figure 82: External starting air system diagram

6.7.4 External compressed air system – Dimensioning starting air receivers, compressors

Starting air receivers

The starting air supply is to be split up into not less than two starting air receivers of nominally the same size, which can be used independently of each another.

The capacity of the air receivers have to be designed so that at least six engine starts without replenishment are possible.

The exact number of required starts depends on the arrangement of the propulsion system and on the special requirements of the classification society.

Compressors

According to most classification societies, two or more air compressors must be provided. At least one of the air compressors must be driven independently of the main engine and must supply at least 50% of the required total capacity.

The total capacity of the air compressors has to be capable to charge the receivers from the atmospheric pressure to full pressure of 37 bar within one hour.

The compressor capacities are calculated as follows:

$$P = \frac{V \times 40}{1000}$$

P [m^3/h]	Total volumetric capacity of the compressors
V [litres]	Total volume of the starting air receivers at 37 bar service pressure

As a rule, compressors of identical ratings should be provided. An emergency compressor, if provided, is to be disregarded in this respect.

Diesel-mechanical main engine

In case of mechanical-propulsion drive without shifting clutch but with shaft driven alternator, consult Everllence.

Calculation formula for starting air receivers see below:

$$V = \frac{V_{st} \times f_{Drive} \times (z_{st} + z_{safe})}{(p_{max} - p_{min})}$$

2026-10-29 - 10.1

V [litre]	Required receiver capacity
V_{st} [litre]	Air consumption per nominal start
f_{Drive}	Factor for drive type (1.0 = diesel-mechanic, 1.5 = alternator drive)
z_{st}	Number of starts required by the classification society
z_{Safe}	Number of starts as safety margin
p_{max} [bar]	Maximum starting air pressure
p_{min} [bar]	Minimum starting air pressure

Other consumers (e.g. auxiliary engines, ship air etc.) are not accounted for in the above formula. If these are connected to the starting air receiver, the capacity of the receiver must be increased accordingly, or an additional separate air receiver has to be installed.

Contact Everllence for technical drawings of auxiliary equipment.

System instrumentation

For details of the instrumentation, see section SaCoSone system overview.

2026-10-29 - 10.1

6.8 Engine room ventilation and intake air

6.8.1 External general information

Engine room ventilation system

Its purpose is:

- Supplying the engines and auxiliary boilers with combustion air.
- Carrying off the radiant heat from all installed engines and auxiliaries.

Intake air engine

The intake air of the engine must be free from spray water, snow, dust and oil mist.

This is achieved by:

- Louvres, protected against the head wind, with baffles in the back and optimally dimensioned suction space so as to reduce the air flow velocity to 1–1.5 m/s.
- Self-cleaning air filter in the suction space (required for dust-laden air, e.g. cement, ore or grain carrier).
- Sufficient space between the intake point and the openings of exhaust air ducts from the engine and separator room as well as vent pipes from lube oil and fuel oil tanks and the air intake louvres (the influence of winds must be taken into consideration).
- Positioning of engine room doors on the ship's deck so that no oil-laden air and warm engine room air will be drawn in when the doors are open.
- Arranging the separator station at a sufficiently large distance from the turbochargers.

As a standard, the engines are equipped with turbochargers with air intake silencers and the intake air is normally drawn in from the engine room.

In tropical service a sufficient volume of air must be supplied to the turbocharger(s) at outside air temperature. For this purpose there must be an air duct installed for each turbocharger, with the outlet of the duct facing the respective intake air silencer, separated from the latter by a space of approximately 1.5 m (see figure Example: Exhaust gas ducting arrangement, Page 255). No water of condensation from the air duct must be permissible to be drawn in by the turbocharger. The air stream must not be directed onto the exhaust manifold.

If the ship operates at arctic conditions, an air preheater must be applied to maintain the engine room temperature above 5°C. In order to reduce power for air preheating, the engines can be supplied by a separate system directly from outside, see section Intake air ducting in case of arctic conditions, Page 222.

Air fans are to be designed so as to maintain a positive air pressure of 50 Pa (5 mm WC) in the engine room.

2026-10-29 - 10.1

Radiant heat

The heat radiated from the main and auxiliary engines, from the exhaust manifolds, waste heat boilers, silencers, alternators, compressors, electrical equipment, steam and condensate pipes, heated tanks and other auxiliaries is absorbed by the engine room air.

The amount of air V required to carry off this radiant heat can be calculated as follows:

$$V = \frac{Q}{\Delta t \times cp \times \rho t}$$

V [m^3/h]	Air required
Q [kJ/h]	Heat to be dissipated
Δt [°C]	Air temperature rise in engine room (10–12.5)
cp [kJ/kg*k]	Specific heat capacity of air (1.01)
ρt [kg/m^3]	Air density at 35°C (1.15)

Ventilator capacity

The capacity of the air ventilators (without separator room) must be large enough to cover at least the sum of the following tasks:

- The combustion air requirements of all consumers.
- The air required for carrying off the radiant heat.

A rule-of-thumb applicable to plants operating on residual fuel is 20-24 m^3/kWh.

Moreover it is recommended to apply variable ventilator speed to regulate the air flow. This prevents excessive energy consumption and cooling down of engines in stand-by.

Maximum engine room temperature

The engine room ventilation must ensure a maximum engine room temperature, with following boundary conditions:

- Maximum air temperature in the area of the engine and its components ≤ 45°C.
- Maximum air temperature at least 5 K below the flash point of any liquids, that is present within the engine room.

6.8.2 External air supply with or without arctic conditions

General recommendations for external intake air system of vessels

The design of the intake air system ducting is crucial for reliable operation of the engine. The following points need to be considered:

(1) Every single engine must be provided with a dedicated intake air system. It is not allowed to combine air intake systems of different engines.

(2) According to classification rules, it may be required for arctic operation to install two air inlets from the exterior, one at starboard and one at portside.

(3) It must be prevented that exhaust gas and oil dust is sucked into the intake air duct as fast filter blocking might occur.

2026-10-29 - 10.1

(4) In case of arctic operation, suitable corrosion and low temperature resistant materials should be applied. Stainless steel S316 L might be suitable. For non-arctic operation, a steel duct with C5-M-coating acc. DIN EN ISO 12944 might be sufficient.

(5) Inside the duct, there must not be any parts (e.g. bolts, nuts, stiffening, etc.) that could fall off and move towards the engine. Installations, that are absolutely necessary (e.g. light behind filter wall) must be specially secured (self-locking nuts, screwed covers instead of clamped covers etc.).

(6) Due to the air flow, load changes and other external forces, (especially during ice breaking, if applicable) the intake air pipe is subject to heavy vibrations. Additionally engine and propeller exciting frequencies have to be taken into account. This has to be considered within the overall layout and the intake air duct needs to be reinforced sufficiently.

(7) Thermal expansion has to be considered for the layout and foundation of the duct (e.g. flexible mounting, additional compensators).

(8) Suitable drainage arrangements to remove any water from the intake air ducting should be provided. Backflow of air through drains has to be avoided (e.g. by syphons) and regularly checked for proper functioning. Adequate heating is required to prevent icing of drains.

(9) The air duct and its components need to be insulated properly. Especially a vapor barrier has to be applied to prevent atmospheric moisture freezing in the insulation material.

(10) An (automatic) shut-off flap should be installed to prevent a chimney effect and cooling down of engine during stand-still (maintenance or stand-by of engine). This flap is to be monitored and engine start should only be allowed in fully-open position. As an alternative, the intake system can be closed by a roller shutter or tarpaulin in front of the filter.

(11) The overall pressure drop of the intake air system ducting and its components is to be limited to 20 mbar. Moreover the differential pressure of the intake air filter must be monitored to fulfill this requirement. For additional safety, other components as the droplet separator and the weather hood can be monitored by differential pressure devices.
During commissioning and maintenance work, checking of the air intake system back pressure by means of a temporarily connected measuring device may become necessary. For this purpose, a measuring socket is to be provided approximately 1–2 metres before the turbocharger, in a straight length of pipe at an easily accessible position. Standard pressure measuring devices usually require a measuring socket size of 1/2".

(12) The turbocharger as a flow machine requires a uniform inflow. Therefore, the ducting must enable an air flow without disturbances or constrictions. To prevent non-uniform compressor inlet flow conditions, the duct design should consider the following:

- Avoid or minimise the number of elbows.
- Avoid multiple/repetitive deflections with a flow turn angle > 45°.
- Avoid combinations of flow turns in multiple planes.
- For engines with two turbochargers it must be ensured, that both turbochargers have identical conditions for the air supply, otherwise this would result in decreasing the surge stability.

(13) To prevent stalling, any intake air flow that exhibits a swirl counterrotating against the compressor wheel rotation must be avoided.

2026-10-29 - 10.1

(14) It is recommended to verify the layout of the intake air piping by CFD calculations up to the entry of the compressor of the turbocharger.

(15) The maximum specified air flow speed of 20-25 m/s should not be exceeded at any location of the pipe.

(16) A silencer is recommended to reduce the noise emissions from engine inlet and charge air blow-off. Sound power levels can be found in the relevant section of the Project Guide. Care must be taken, that no insulation material can escape from the silencer, which can fuse into glass spheres in the combustion chamber.

Components of intake air ducting

The whole system and its components must be designed suitably robust to withstand pressure peaks occurring from turbocharger surge. This will not happen during normal operation, but it could occur at fast load changes of the engine. This can happen 2–3 times consecutively, until the turbocharger comes back to its normal working range.

The table below shows values at engine inlet connection with a suitable intake air ducting. An unfavorable intake air duct design can also lead to higher values.

Type	Variation	Frequency	Comment
Pressure oscillation	± 40 mbar, 5–10 Hz	Permanent	Normal operation/constant load
Peak pressure (shock wave)	± 300 mbar	Sporadically	Engine emergency stop/turbocharger surge

The ambient air, which is led to engine by the intake air duct, needs to be conditioned by several components as shown in figure External intake air supply system, Page 226. It needs to be cleaned according to the requirements in section Specification of intake air (combustion air), Page 166. This could be done by the following components:

- Section for cleaning of intake air (1–4)

  A weather hood (1) in combination with a snow trap (2) removes coarse dirt, snow and rain. A heated droplet separator (3) subsequently separates remaining water droplets or snow from the air. An appropriate filter cleans the intake air from particles. (4). A metal grid (e.g. 10x10 mm) after filter wall at intake air room is necessary to avoid filter elements or lost parts getting into air intake system. As a minimum, inlet air must be cleaned by an ISO coarse 45% class filter as per DIN EN ISO 16890. If there is a risk of high inlet air contamination, filter efficiency should be at least ISO ePM10 50% according to DIN EN ISO 16890. See figure External intake air supply system, Page 226.
- Combustion air silencer (5)

  Noise emissions of engine inlet and charge air blow-off can be reduced by a silencer in the intake air duct. It is recommended to apply a mesh (5a) at the outlet of the silencer to protect the turbocharger against any loose parts (e.g. insulation material of silencer, rust etc.) from the intake air duct. This mesh is to be applied even if the silencer will not be supplied. A drain close to the turbocharger is required to separate condensate water. See section Noise, Page 98.
- Overpressure flap (6) (optional)

2026-10-29 - 10.1

Depending on the system volume and chosen components, it might be necessary to install an overpressure flap between silencer and engine. Peak pressure pulses (e.g. during emergency stop) are conducted into the engine room via this flap, preventing possible damage to the filter and silencer.

- Shut-off flap/blind plate (7)

  It is recommended to install a shut-off flap to prevent cooling down of the engine during longer standstills under arctic conditions. This flap should be monitored by the engine automation system to prevent engine starting with a closed flap.
  As an alternative, the intake system can be closed by a roller shutter or tarpaulin in front of the filter.

- Compensator (8) and transition piece (9)

  A steel compensator (rubber might also be considered) has to be installed directly vertically upstream of the 90° transition piece behind the turbocharger. A rigid support must be provided as close as possible upstream of the compensator. It has to be noted, that this compensator is solely foreseen to compensate engine-borne movements. Additional compensators might be necessary to cope for thermal expansion.

- Strainer for commissioning phase (9a)

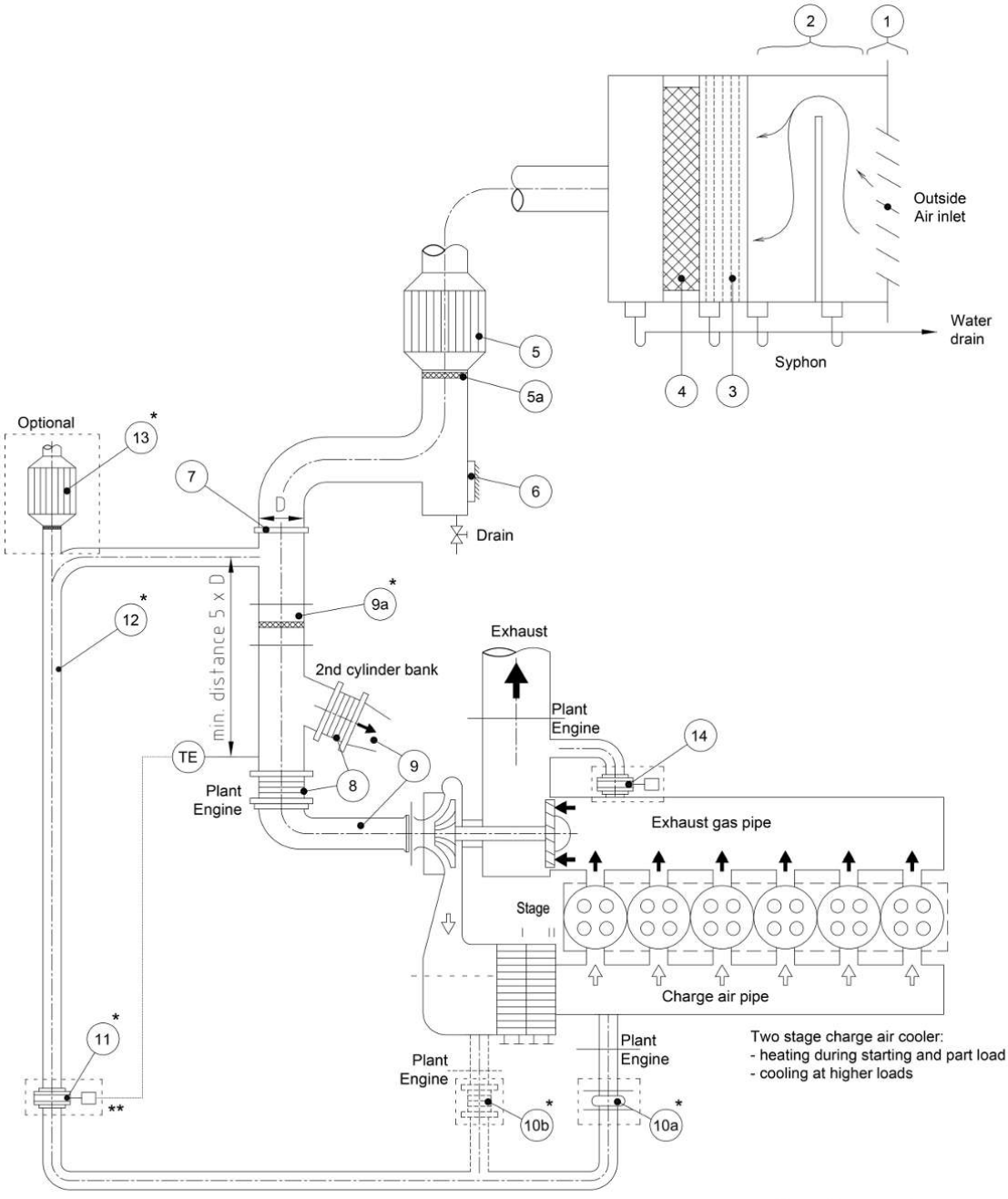
  To prevent residues from installation phase entering the engine during commissioning, a strainer or protective mesh must be installed as close as possible to the turbocharger. After the running-in is finished, the strainer must be removed and exchanged by an intermediate pipe. Final performance measurement and engine setting shall be done without an intake air strainer.

- Charge air blow-off or recirculation

  For arctic conditions, an increased firing pressure, which is caused by higher density of cold air, is prevented by an additional valve, which blows off charge air (11). A compensator (10) connects the engine with the charge air blow-off piping. The blown-off air is taken after (cold blow-off) the charge air cooler or before the charge air cooler (hot blow-off) and is circulated (12) back in the intake air duct or blown out via an additional silencer. A homogenous temperature profile and a correct measurement of intake air temperature in front of compressor has to be achieved. For this a minimum distance of five times the diameter of the intake air duct between inlet of blown-off air and the measuring point must be kept.

Within section Engine operation under arctic conditions, Page 52 additional information is given and boundary conditions for the layout of the piping are stated.

2026-10-29 - 10.1



* Depending on engine type
(not needed for 175D)
either cold or hot blow off.
Depending on application it
can be located in plant.

** Depending on engine type
flap with add-on orifice.

1173500107G

1 Weather hood
2 Snow trap
3 Heated droplet separator
4 Air intake filter 030.120.010
5 Combustion air silencer 030.130.040
5a Protective mesh
6 Overpressure flap (optional)
7 Blind plate/shut-off flap (for maintenance case)
8 Metal bellow expansion joint combustion air (rubber might be considered)
9 Transition piece
9a Intermediate pipe with strainer for running-in phase (to be removed afterwards) 030.120.190
10a Rubber bellow expansion joint – Cold blow-off
10b Metal bellow expansion joint – Hot blow-off
11 Charge air blow-off valve
12 Charge air blow-off pipe
13 Charge air blow-off silencer
14 Waste gate (if required for relevant engine type)

Figure 83: External intake air supply system

6.9 Exhaust gas system

6.9.1 External exhaust gas system – General information

Layout

The flow resistance in the exhaust system has a very large influence on the fuel consumption and the thermal load of the engine. The values given in this document are based on an exhaust gas system which flow resistance does not exceed 50 mbar. If the flow resistance of the exhaust gas system is higher than 50 mbar, contact Everllence for project-specific engine data.

The pipe diameter selection depends on the engine output, the exhaust gas volume and the system back pressure, including silencer and SCR (if fitted). The back pressure also being dependent on the length and arrangement of the piping as well as the number of bends. Sharp bends result in very high flow resistance and should therefore be avoided. If necessary, pipe bends must be provided with guide vanes.

It is recommended not to exceed a maximum exhaust gas velocity of approximately 40 m/s, at stack outlet 35 m/s.

Installation

When installing the exhaust system, the following points must be observed:

- The exhaust pipes of two or more engines must not be joined.
- The V28/33D STC has two turbochargers. To avoid interaction of the exhaust gas flows, the exhaust pipe of at least one turbocharger (preferably from Bank A) must have a length of minimum five times of its diameter before beeing joined.
- Because of the high temperatures involved, the exhaust pipes must be able to expand. The expansion joints to be provided for this purpose are to be mounted between fixed-point pipe supports installed in suitable positions. One compensator is required just after the outlet casing of the turbocharger (see section Position of the outlet casing of the turbocharger, Page 256) in order to prevent the transmission of forces to the turbocharger itself. These forces include those resulting from the weight, thermal expansion or lateral displacement of the exhaust piping. For this compensator/expansion joint one sturdy fixed-point support must be provided.
- The exhaust piping should be elastically hung or supported by means of dampers in order to prevent the transmission of sound to other parts of the vessel.

2026-10-29 - 10.1

- The exhaust piping is to be provided with water drains, which are to be regularly checked to drain any condensation water or possible leak water from exhaust gas boilers if fitted.
- During commissioning and maintenance work, checking of the exhaust gas system back pressure by means of a temporarily connected measuring device may become necessary. For this purpose, two measuring sockets need to be provided approximately 1 to 2 metres after the exhaust gas outlet of the turbocharger, in a straight length of pipe at an easily accessed position. Standard pressure measuring devices usually require a measuring socket size of 1/2". This measuring socket is to be provided to ensure back pressure can be measured without any damage to the exhaust gas pipe insulation.

Exhaust piping insulation

The exhaust gas pipe system has to be insulated to reduce the maximum surface temperature to the level required by both the classification society and SOLAS and to avoid temperatures below the dew point. Therefore the complete exhaust gas system (from outlet of turbocharger, silencer, boiler to outlet stack) should be sufficiently insulated. Also, to avoid temperatures below the dew point, resulting in excessive water formation within the pipe, the exhaust gas piping to the outside, including boiler, if fitted and silencer, should be insulated thus avoiding intensified corrosion and soot deposits on the interior surface of the exhaust gas pipe. When fast engine load changes occur, these deposits might flake off and be entrained by exhaust in the form of soot flakes. The flange connection on the turbocharger outlet, as well as the adjacent round flanges of the adaptor or transition piece, must also be covered with insulating collars, for reasons of safety. Insulation and covering of the compensator must not restrict its freedom of movement. The relevant provisions concerning accident prevention and those of the classification societies and SOLAS requirements must be observed.

Exhaust silencer – Mode of operation

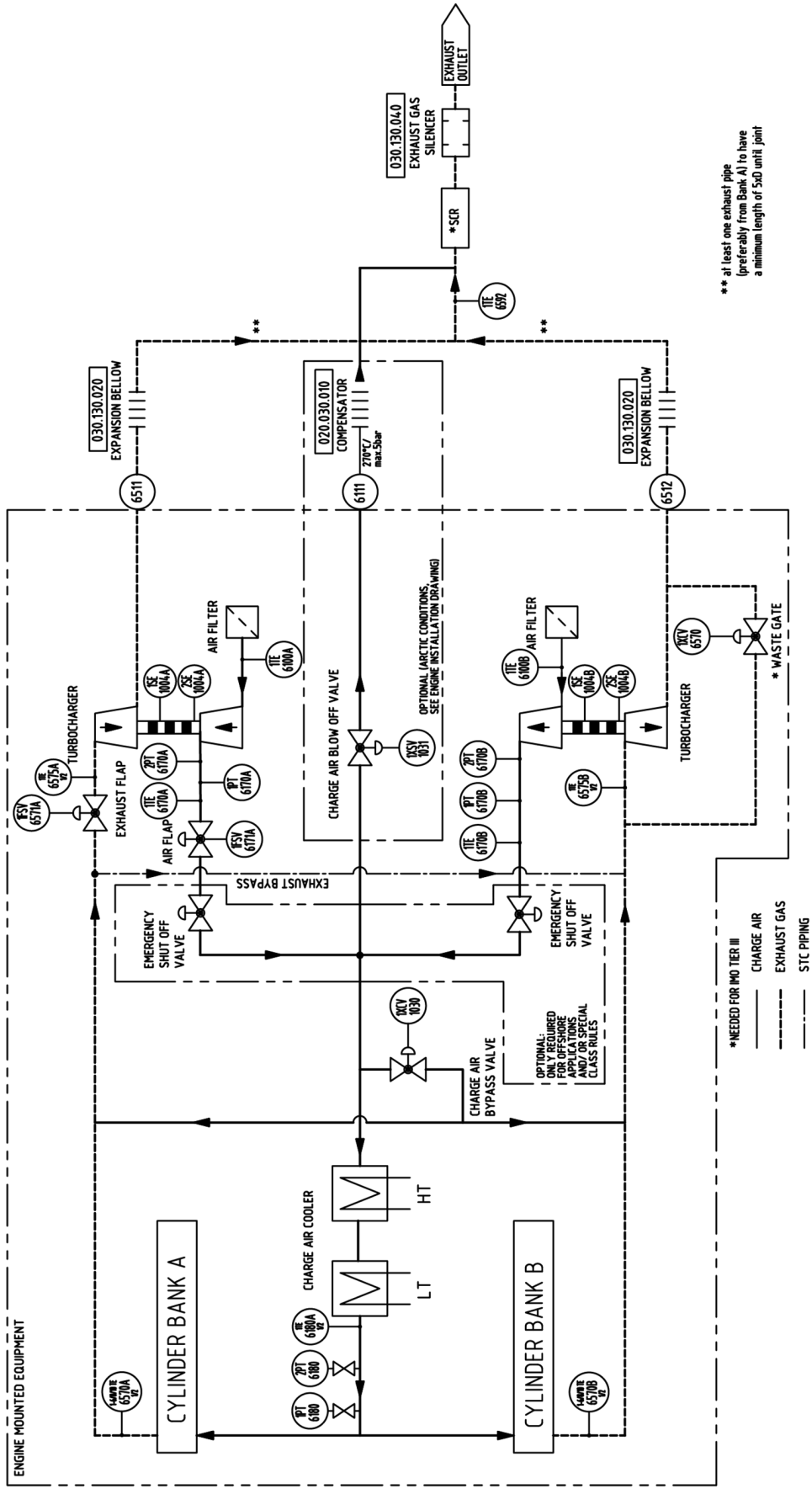
The silencer, normally of client supply, usually operates on the absorption principle, this design being very effective throughout a wide frequency band. The flow path, running through the silencer in a straight line, ensures optimum noise reduction with minimum flow resistance and therefore low back pressure.

Silencer installation

If possible, the silencer should be installed towards the end of the exhaust line; the exact position can be adapted to the space available (from vertical to horizontal). If the silencer has a spark arrester, it must be ensured that the cleaning ports are easily accessible.

Contact Everllence for technical drawings of auxiliary equipment.

2026-10-29 - 10.1



11869310004F

6111 OPTIONAL: Charge air blow off
6511 Outlet exhaust gas
6512 Outlet exhaust gas

Figure 84: Exhaust gas and charge air system diagram with STC

6.9.2 External components and assemblies of the exhaust gas system

Exhaust gas silencer and exhaust gas boiler

Mode of operation

The silencer operates on the absorption and resonance principle so it is effective in a wide frequency band. The flow path, which runs through the silencer in a straight line, ensures optimum noise reduction with minimum flow resistance.

A spark arrestor should be provided in the exhaust gas system (e.g. integrated in the silencer).

Note:
Spark arrestors are mandatory for certain ship types.

Installation

If possible, the silencer should be installed towards the end of the exhaust line.

A vertical installation situation is to be preferred in order to avoid formations of gas fuel pockets in the silencer. The cleaning ports of the spark arrestor are to be easily accessible.

Note:
Water entry into the silencer and/or boiler must be avoided, as this can cause damages of the components (e.g. forming of deposits) in the duct.

Exhaust gas boiler

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

Insulation

The exhaust gas system (from outlet of turbocharger, silencer, catalyst, boiler to the outlet stack) is to be insulated to reduce the external surface temperature and airborne noise to the required level.

The relevant provisions concerning accident prevention and those of the classification societies must be observed.

The insulation is also required to avoid temperatures below the dew point on the interior side. In case of insufficient insulation intensified corrosion and soot deposits on the interior surface are the consequence. During fast load changes, such deposits might flake off and be entrained by exhaust in the form of soot flakes.

Insulation and covering of the compensator must not restrict its free movement.

2026-10-29 - 10.1

7 Engine room planning

7.1 Installation and arrangement

7.1.1 General details

Apart from a functional arrangement of the components, the shipyard is to provide for an engine room layout ensuring good accessibility of the components for servicing.

The cleaning of the cooler tube bundle, the emptying of filter chambers and subsequent cleaning of the strainer elements, and the emptying and cleaning of tanks must be possible without any problem whenever required.

All of the openings for cleaning on the entire unit, including those of the exhaust silencers, must be accessible.

There should be sufficient free space for temporary storage of pistons, camshafts, turbocharger etc. dismounted from the engine. Additional space is required for the maintenance personnel. The panels on the engine sides for inspection of the bearings and removal of components must be accessible without taking up floor plates or disconnecting supply lines and piping. Free space for installation of a torsional vibration meter should be provided at the crankshaft end.

A very important point is that there should be enough room for storing and handling vital spare parts so that replacements can be made without loss of time.

In planning marine installations with two or more engines driving one propeller shaft through a multi-engine transmission gear, provision must be made for a minimum clearance between the engines because the crankcase panels of each engine must be accessible. Moreover, there must be free space on both sides of each engine for removing pistons or cylinder liners.

Note:
Everllence delivered scope of supply is to be arranged and fixed by proven technical experiences as per state of the art. Therefore the technical requirements have to be taken in consideration as described in the following documents subsequential:

- Order related engineering documents.
- Installation documents of our sub-suppliers for vendor specified equipment.
- Operating manuals for diesel engines and auxiliaries.
- Project Guides of Everllence.

Any deviations from the principles specified in the aforementioned documents require a previous approval by Everllence.

Arrangements for fixation and/or supporting of plant related equipment deviating from the scope of supply delivered by Everllence, not described in the aforementioned documents and not agreed with us are not permissible.

For damages due to such arrangements we will not take over any responsibility nor give any warranty.

2026-10-29 - 10.1

7.1.2 Installation drawings

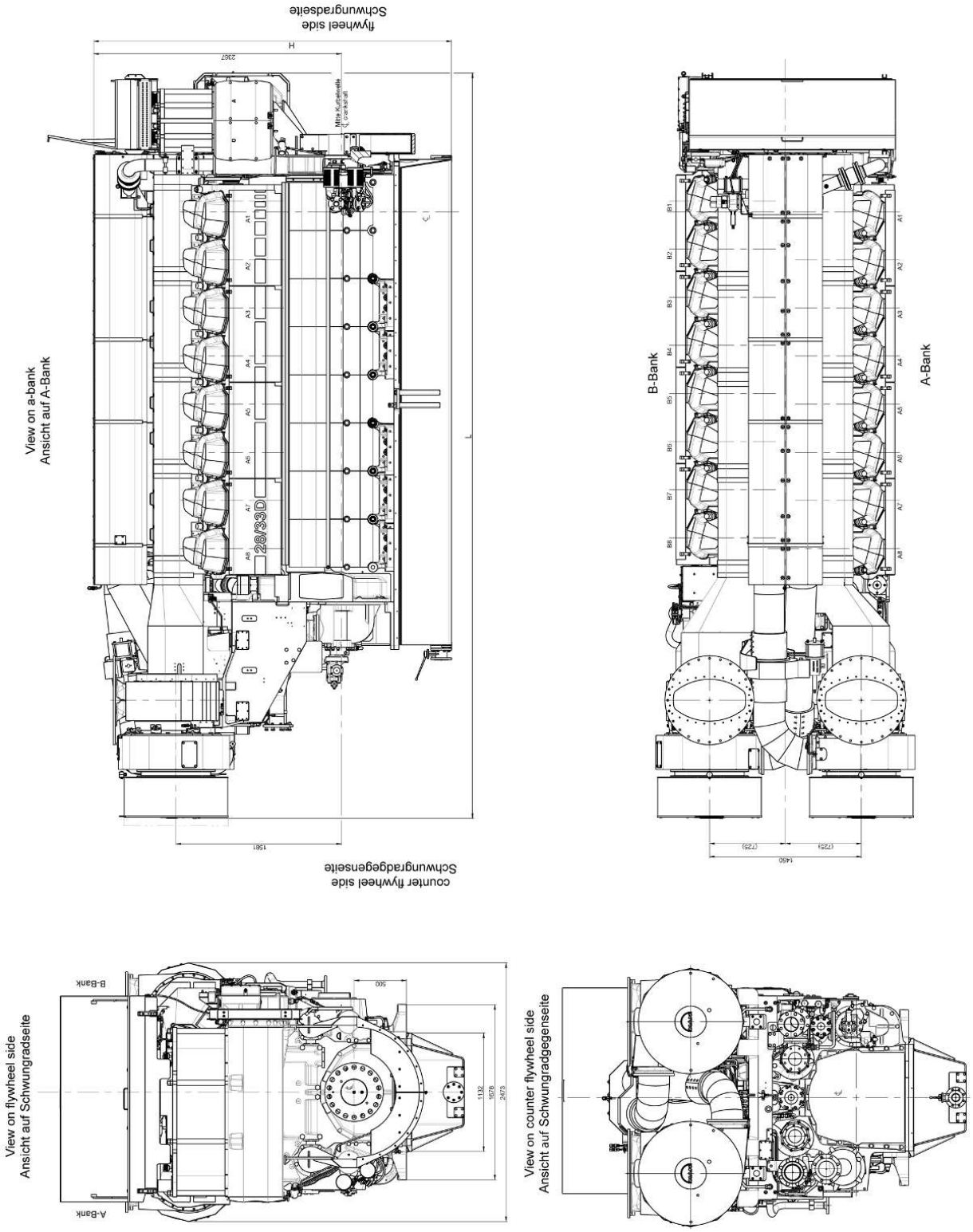


Figure 85: Installation drawing 16V engine with duplex filter (standard) and low oil sump

No. of cylinders, config.	H (low oil sump)	L
	mm	
12V	3,419	6,217
16V		7,137
20V		8,057
The dimensions are given for guidance only. The figures show a possible design of the engine. The equipment can be combined differently.		

2026-10-29 - 10.1

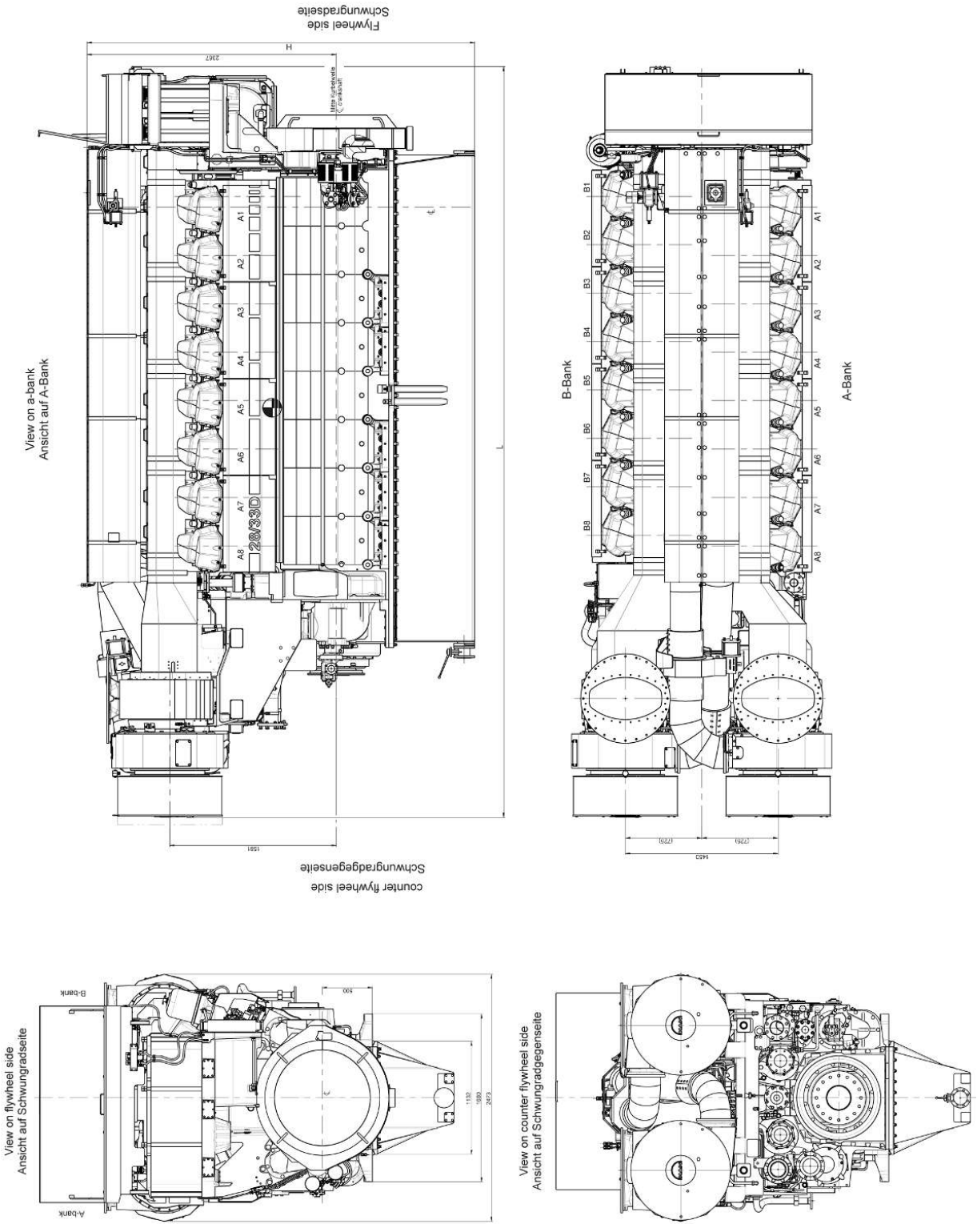


Figure 86: Installation drawing 16V engine with automatic filter (optional), deep oil sump and PTO 100%

2026-10-29 - 10.1

No. of cylinders, config.	H (deep oil sump)	L
	mm	
12V	3,683	6,217
16V		7,137
20V		8,057
The dimensions are given for guidance only. The figures show a possible design of the engine. The equipment can be combined differently.		

7.1.3 Removal dimensions

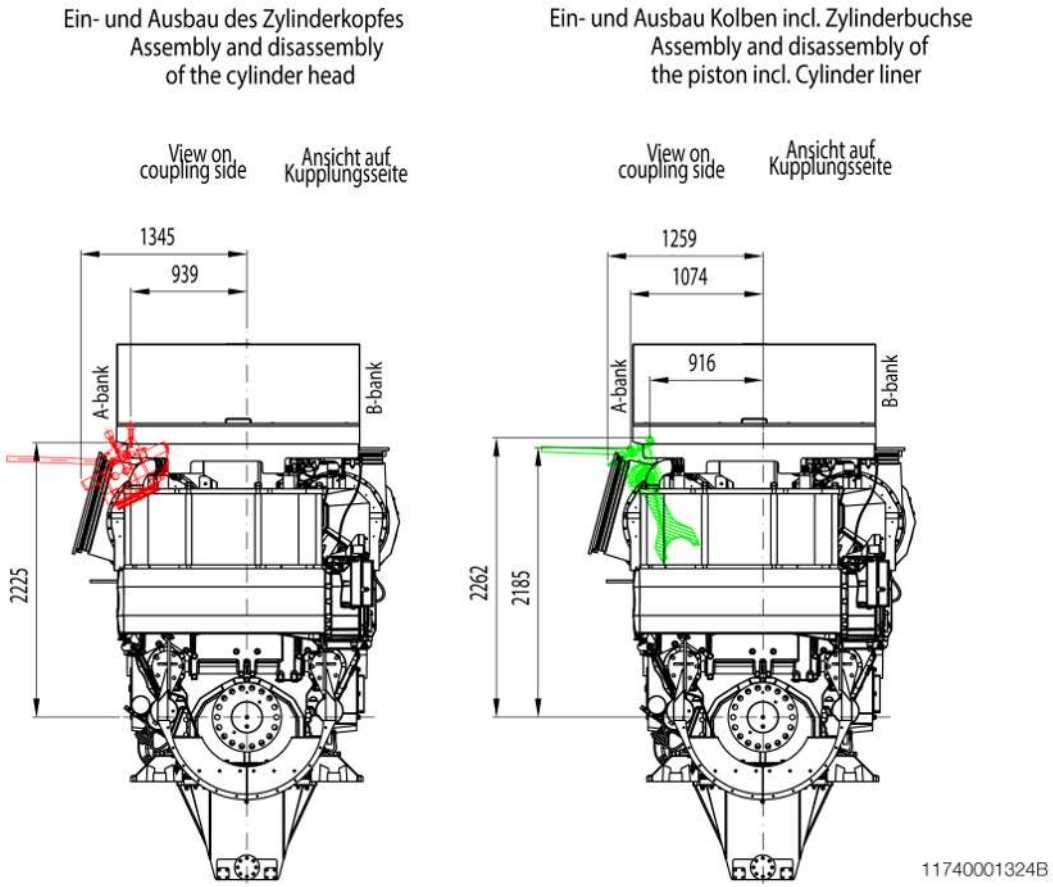


Figure 87: Removal dimensions of cylinder head and piston including cylinder liner

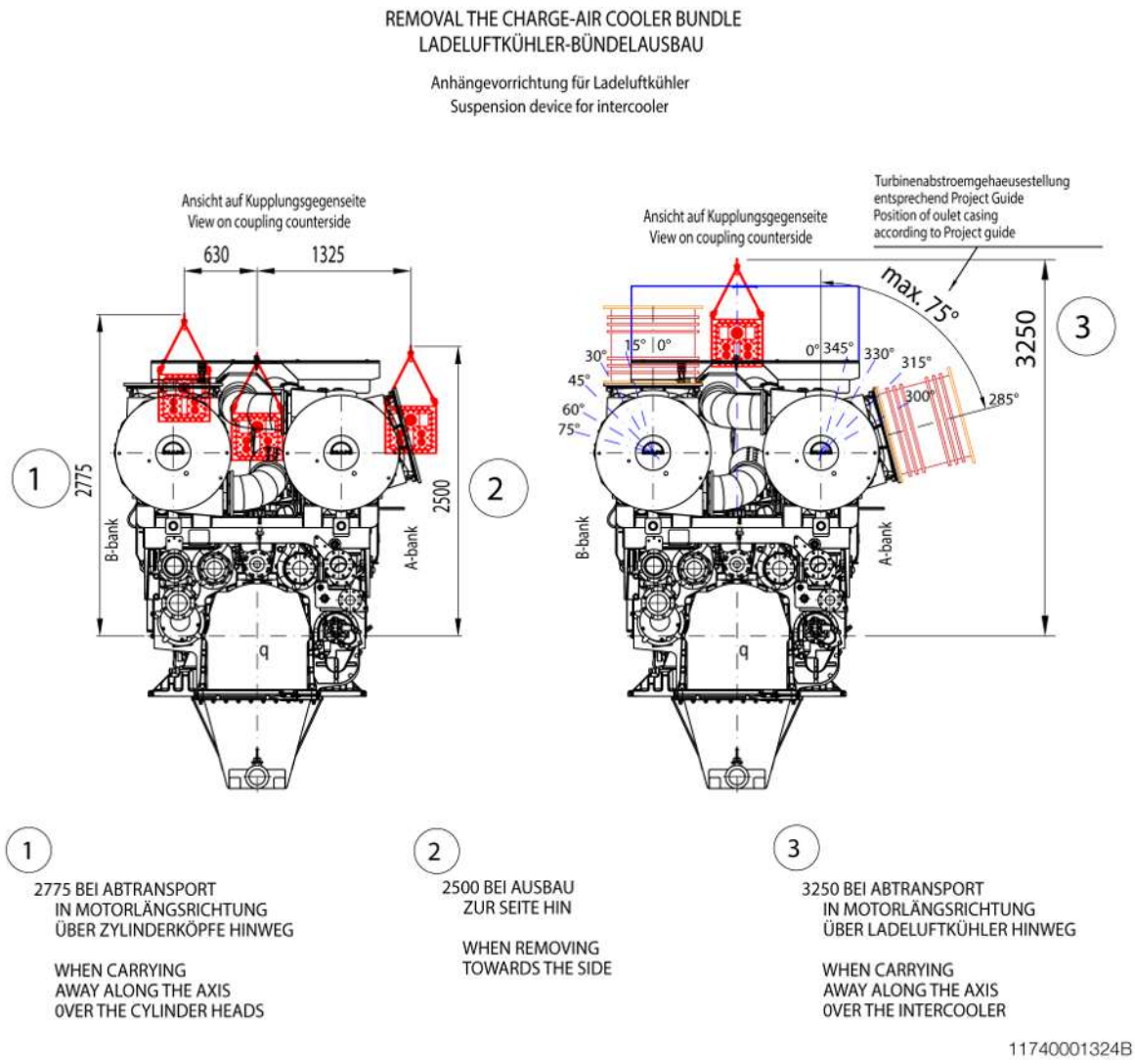


Figure 88: Removal dimensions of charge air cooler bundle

1	When carrying away along the axis over the cylinder heads
2	When removing towards the side
3	When carrying away along the axis over the intercooler
Capacity of suspension device for intercooler: 825 kg	

2026-10-29 - 10.1

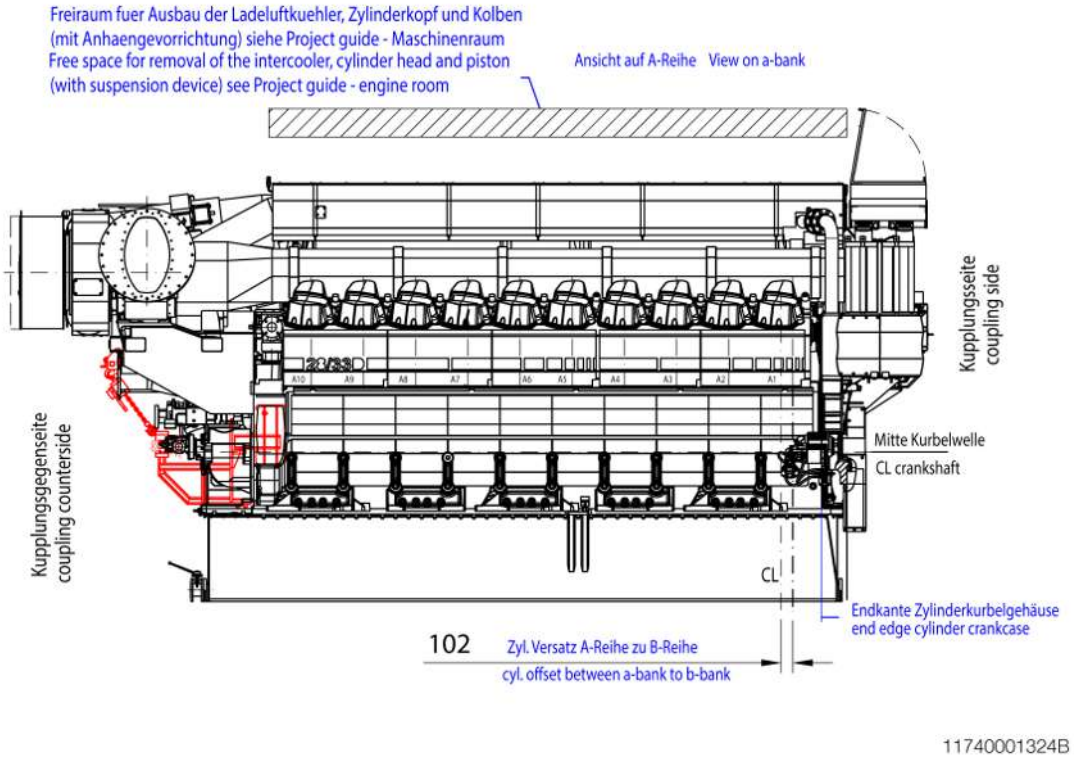


Figure 89: Removal dimensions of lube oil pump and fuel pump

2026-10-29 - 10.1

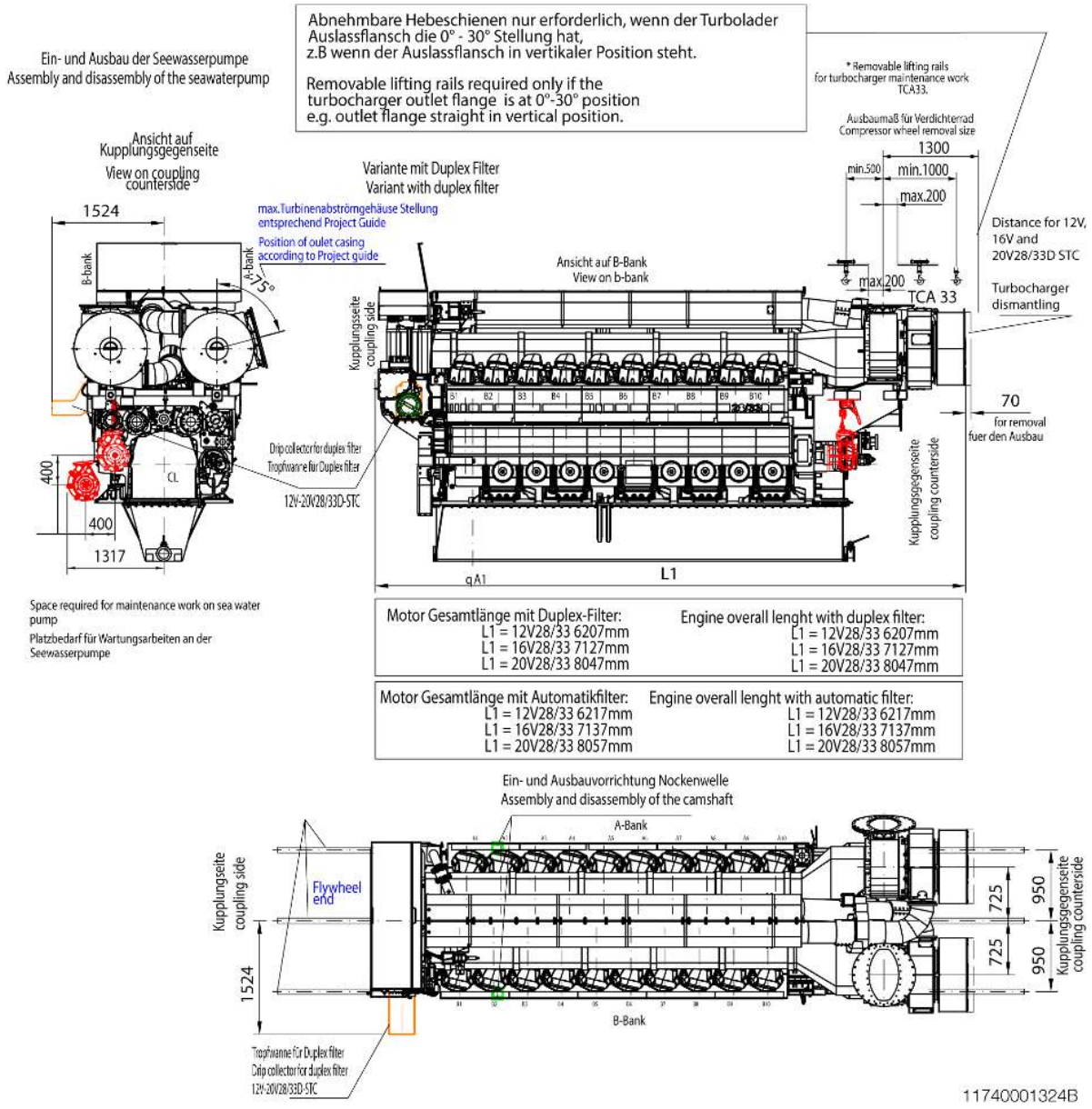


Figure 90: Removal dimensions of lube oil duplex filter, lube oil automatic filter, centrifuge, turbocharger, compressor wheel and seawater pump

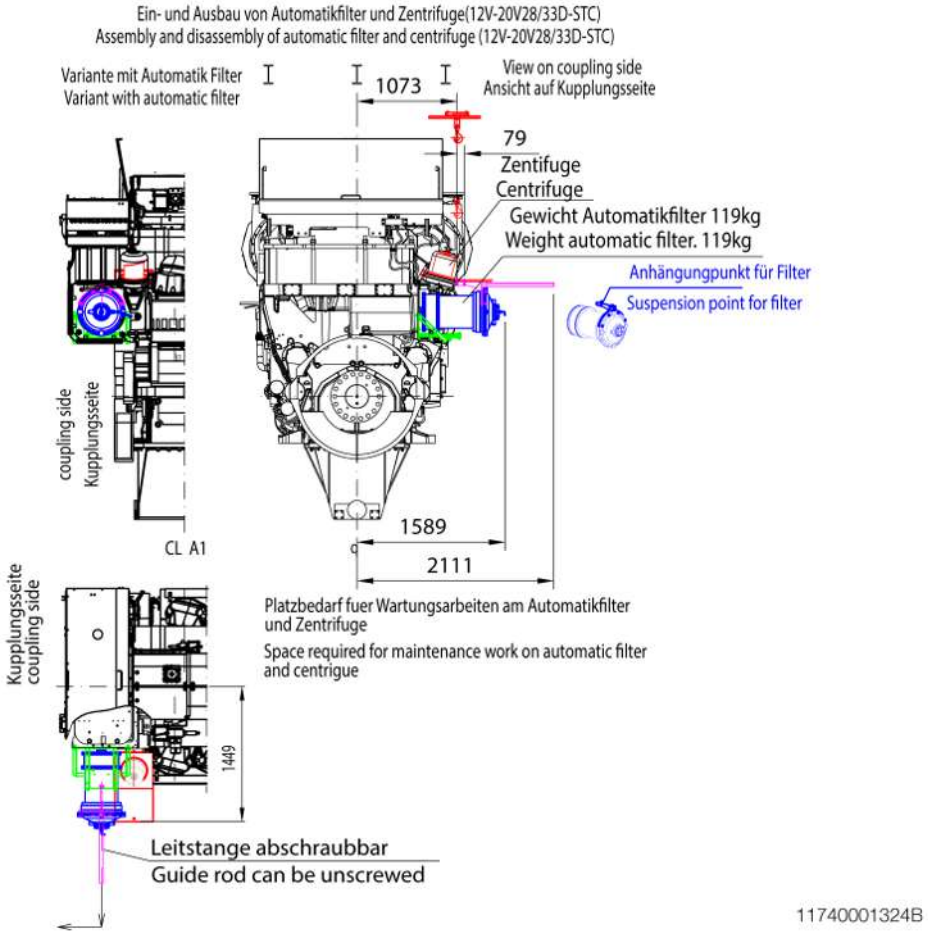


Figure 91: Removal dimensions of seawater pump, lube oil automatic filter, centrifuge, camshaft and turbocharger

2026-10-29 - 10.1

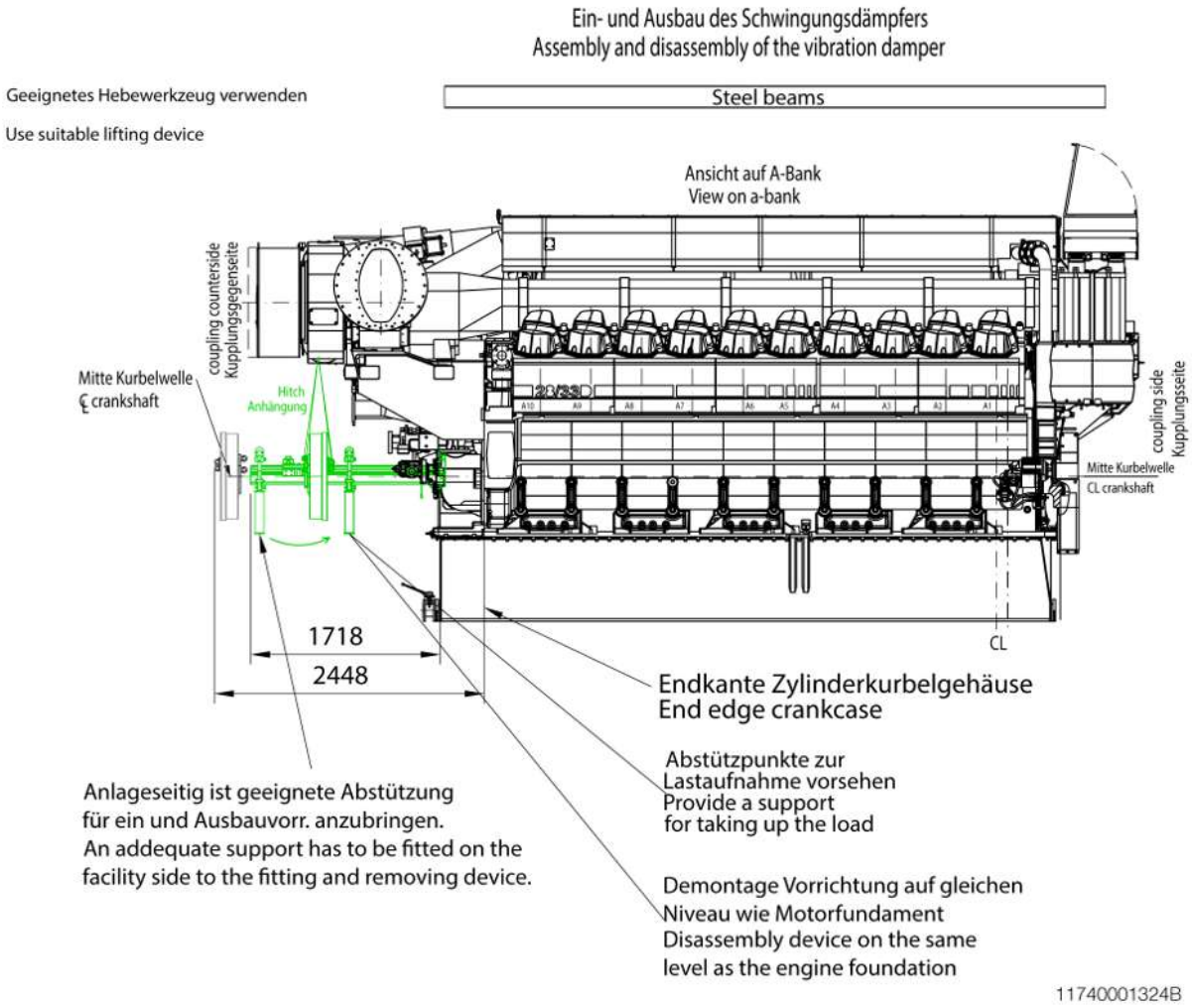


Figure 92: Removal dimensions of vibration damper

2026-10-29 - 10.1

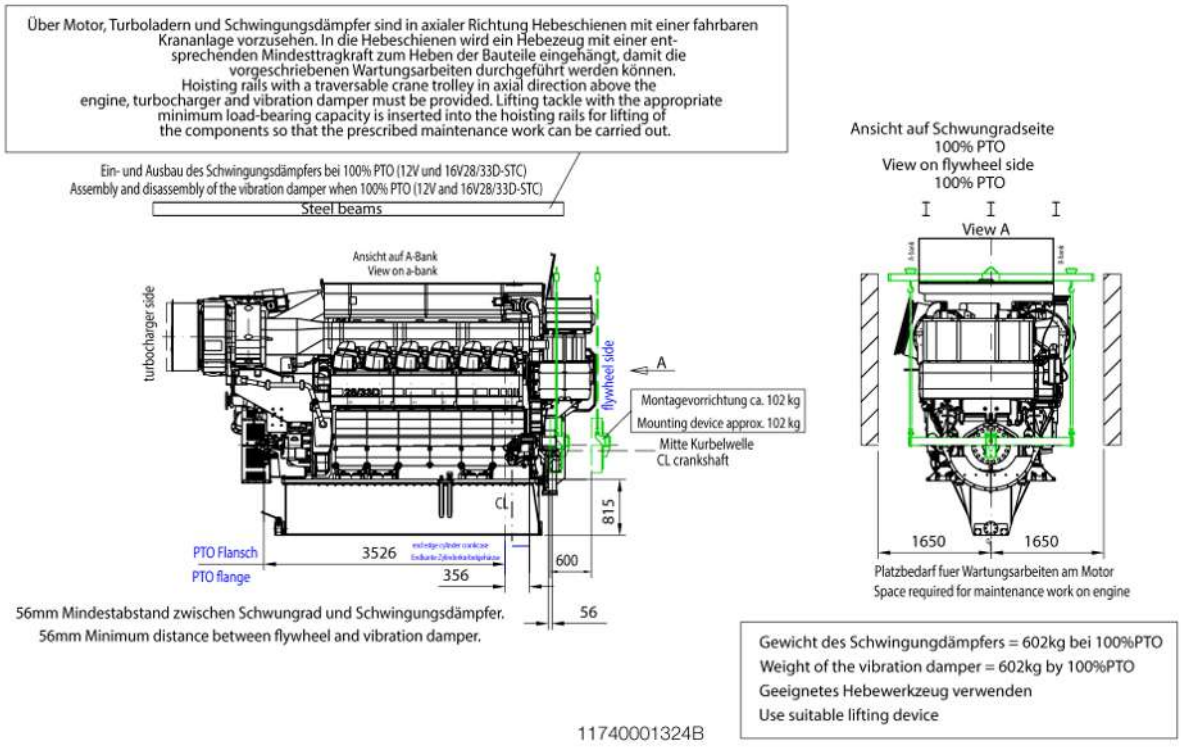


Figure 93: Removal dimensions of vibration damper PTO 100%

7.1.4 3D Engine Viewer – A support programme to configure the engine room

Everllence offers a free-of-charge online programme for the configuration and provision of installation data required for installation examinations and engine room planning: The 3D Engine Viewer .

Easy-to-handle selection and navigation masks permit configuration of the required engine type, as necessary for virtual installation in your engine room.

In order to be able to use the 3D Engine Viewer, register on our website under:

Everllence Extranet

After successful registration, the 3D Engine Viewer are available under:

3D Engine Viewer

3D GenSet Viewer

by clicking onto the requested application.

In only three steps, you will obtain professional engine room data for your further planning:

- Selection

  Select the requested output, respectively the requested type.
- Configuration

  Drop-down menus permit individual design of your engine according to your requirements. Each of your configurations will be presented on the basis of isometric models.
- View

2026-10-29 - 10.1

The models of the 3D Engine Viewer include all essential geometric and planning-relevant attributes (e.g. connection points, interfering edges, exhaust gas outlets, etc.) required for the integration of the model into your project.

The configuration with the selected engines can now be easily downloaded.

For 2D representation as:

- .pdf
- .dwg
- .dxf

for 3D as:

- .dgn
- .stp
- .sat
- .igs
- 3D-dxf
- and many others

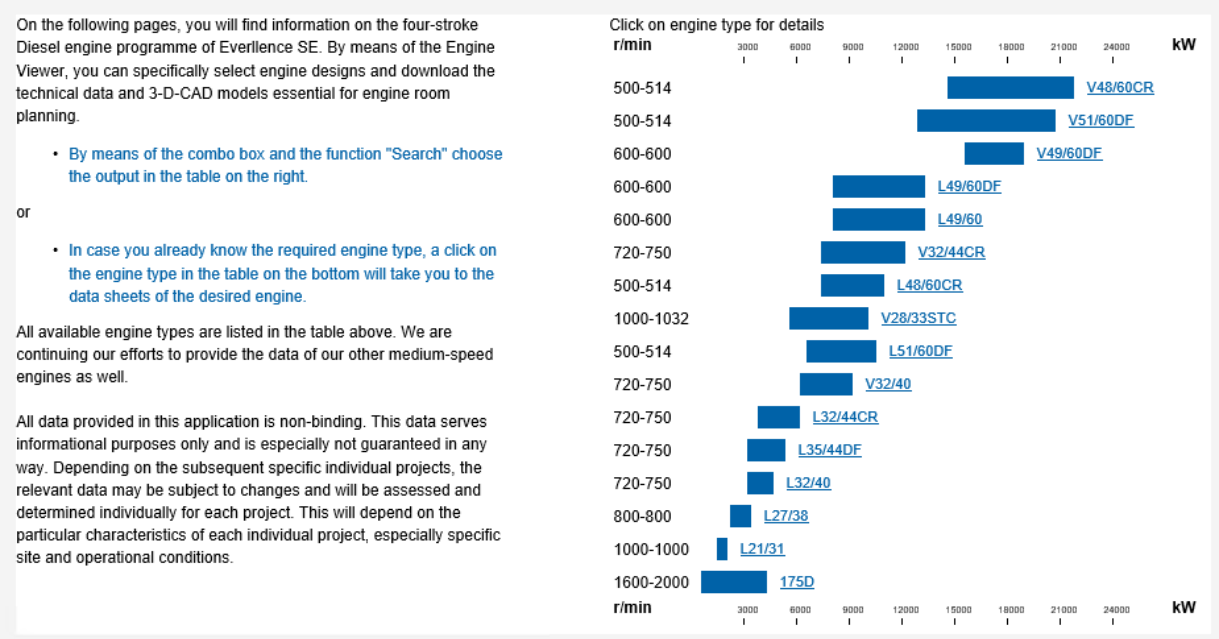


Figure 94: Selection of engine

2026-10-29 - 10.1

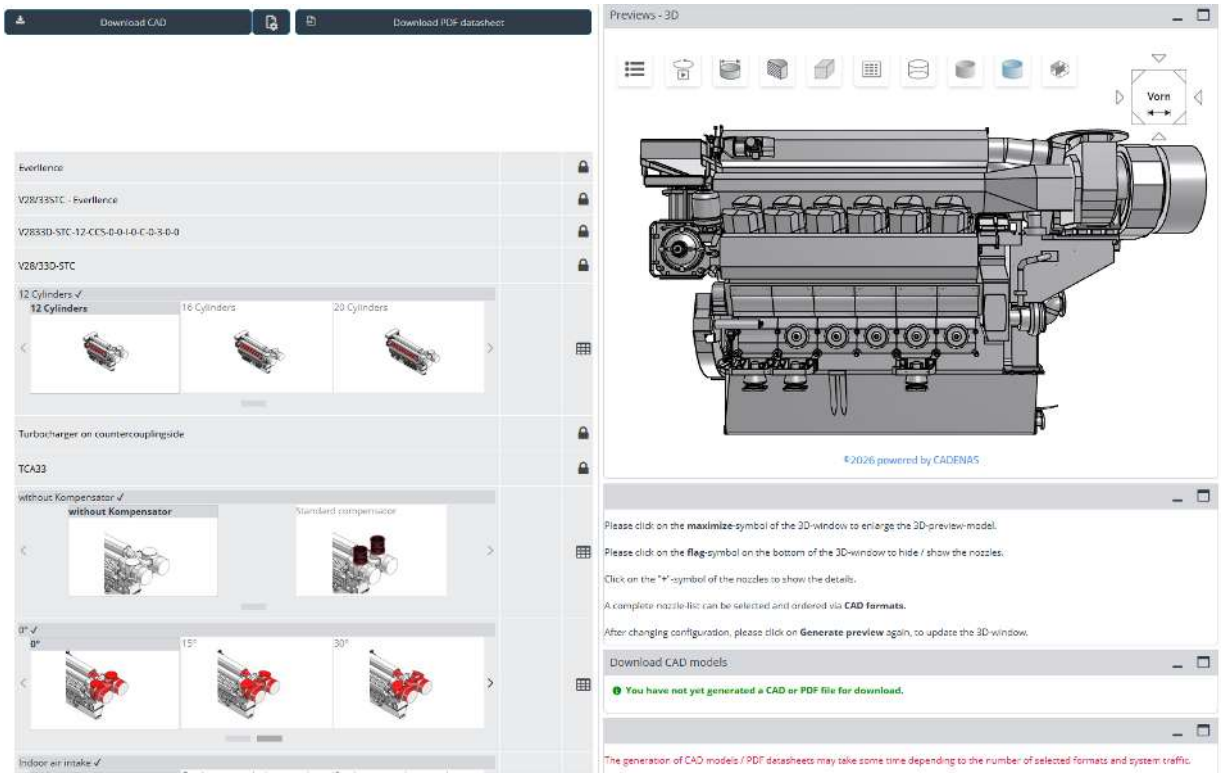


Figure 95: Preselected standard configuration

7.1.5 Lifting device

Lifting gear with varying lifting capacities are to be provided for servicing and repair work on the engine, turbocharger and charge air cooler.

Engine

Component weights

For servicing the engine an overhead traveling crane is required. The lifting capacity shall be sufficient to handle the heaviest component that has to be lifted during servicing of the engine and should foresee extra capacity e.g. to overcome the break loose torque while lifting cylinder heads. The overhead traveling crane can be chosen with the aid of the following table:

Components	Unit	Approximate weights
Cylinder head complete	kg	282
Piston with piston pin, connecting rod (for piston removal) and cylinder liner		320
Charge air cooler		789
Lube oil cooler		1,142

Table 94: Component weights

Crane arrangement

The rails for the crane are to be arranged in such a way, that the crane can cover the whole engine +1,000 mm at both sides. Three rails are required, each one over the cylinders and one over the centre line of the engine.

The hook position must reach along the engine axis, past the centreline of the first and the last cylinder, so that valves can be dismantled and installed without pulling at an angle.

Similarly, the crane must be able to reach the tie rod at the ends of the engine. In cramped conditions, eyelets must be welded under the deck above, to accommodate a lifting pulley.

The required crane capacity is to be determined by the crane supplier.

Crane design

It is necessary that:

- There is an arresting device for securing the crane while hoisting if operating in heavy seas
- There is a two-stage lifting speed

  Precision hoisting approximately = 0.5 m/min

  Normal hoisting approximately = 2 – 4 m/min

Places of storage

In planning the arrangement of the crane, a storage space must be provided in the engine room for the dismantled engine components which can be reached by the crane. It should be capable of holding two rocker arm casings, two cylinder covers and two pistons. If the cleaning and service work is to be carried out here, additional space for cleaning troughs and work surfaces should be planned.

Transport to the workshop

Grinding of valve cones and valve seats is carried out in the workshop or in a neighbouring room.

Transport rails and appropriate lifting tackle are to be provided for the further transport of the complete cylinder cover from the storage space to the workshop. For the necessary deck openings, see following figures and tables.

Turbocharger

Section Turbocharger assignments, Page 27 shows which turbocharger type should be used for which engine variant.

Turbocharger dimensions

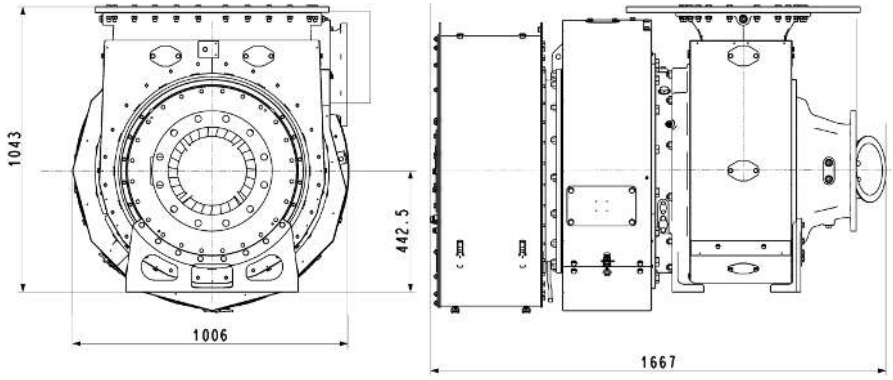


Figure 96: Exemplary illustration of TCA33

Hoisting rail

A hoisting rail with a mobile trolley is to be provided over the centre of the turbocharger running parallel to its axis, into which a lifting tackle is suspended with the relevant lifting power for lifting the parts, which are mentioned in the table(s) below, to carry out the operations according to the maintenance schedule.

Turbocharger		TCA33
Compressor casing	kg	328
Turbine inlet casing axial		68

2026-10-29 - 10.1

Turbocharger		TCA33
Silencer		264
Turbine rotor		54
Turbocharger		1,481
Space for removal of silencer	mm	156

Table 95: Hoisting rail of the axial turbocharger

Withdrawal space dimensions

The withdrawal space shown in section Removal dimensions, Page 235 and in the table(s) in paragraph Hoisting rail is required for separating the silencer from the turbocharger. The silencer must be shifted axially by this distance before it can be moved laterally.

Minimum distance required for dismantling clearance for the filter silencer is 70 mm, however 500 mm is recommended.

Make sure that the silencer can be removed either downwards or upwards or laterally and set aside, to make the turbocharger accessible for further servicing. Pipes must not be laid in these free spaces.

Fan shafts

The engine combustion air is to be supplied towards the intake silencer in a duct ending at a point 1.5 m away from the silencer inlet. If this duct impedes the maintenance operations, for instance the removal of the silencer, the end section of the duct must be removable. Suitable suspension lugs are to be provided on the deck and duct.

Gallery

If possible the ship deck should reach up to both sides of the turbocharger (clearance 50 mm) to obtain easy access for the maintenance personnel. Where deck levels are unfavourable, suspended galleries are to be provided.

Charge air cooler

One unit is installed on the 12V engine and two units are installed on the 16V and 20V engines.

No. of cylinders, config.	Weight (per unit)	Length (L)	Width (B)	Height (H)
	kg	mm	mm	mm
12V	710	2,338	445	410
16V	420	1,303	445	410
20V	600	1,763	445	410

Table 96: Weights and dimensions of charge air cooler bundle

For further information contact Everllence.

2026-10-29 - 10.1

7.1.6 Space requirement for maintenance

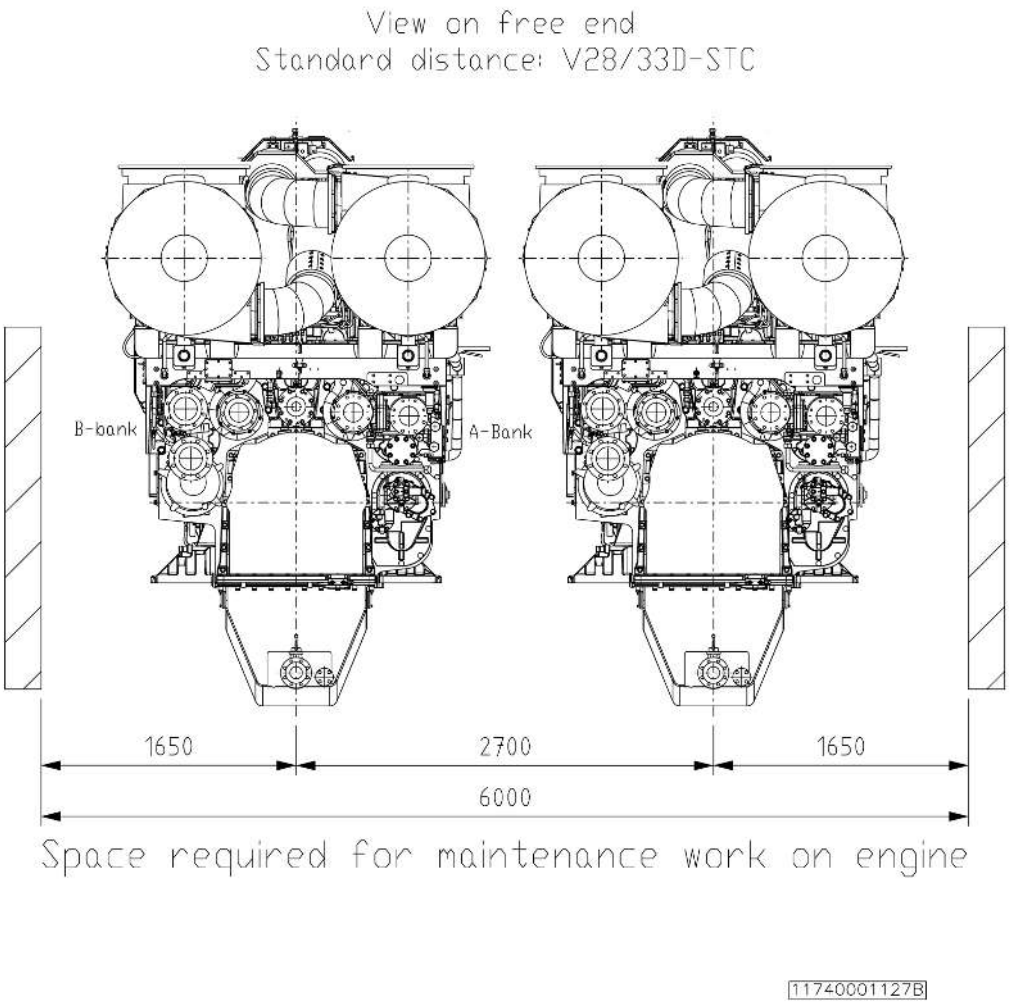


Figure 97: Space requirement for maintenance

7.1.7 Major spare parts

In accordance with the rules of the classification society "DNV GL" we only supply those spare parts specified in the following list which refer to original equipment supplied by us. Spare parts for monitoring and remote control equipment are included in the relevant items of the scope of supply.

Note:
Navigation range A = unrestricted range.

Scope of supply for 1 ship

	Quantity	Description
Crankshaft bearing	1	Crankshaft bearing shells, 2-part of each kind, tie-rods and cross pin with nuts
	1	Thrust bearing ring (two part) for 1 locating bearing

2026-10-29 - 10.1

	Quantity	Description
Connecting rod and main piston	1	Upper and lower connecting rod bearing shell, with bolts (and nuts where provided)
	1	Piston pin bush
	1	Piston pin
	2	Lock ring for piston pin
	1	Main piston with piston rings, piston pin, connecting rod, bearing shells, bolts and nuts, ready for fitting
	1	Compression and oil scraper rings for 1 main piston
Cylinder liner and cylinder head	1	Cylinder liner with seals, ready for fitting
	1	Cylinder head with valves and seals
	2	Bolts with nuts, for fixing one cylinder head
Valves in cylinder head	2	Inlet valve with valve guide and valve seat ring
	2	Exhaust valve with valve guide and valve seat ring
	12/16/20	Fuel injection valve (for 1 engine 12V/16V/20V) with injection pipes
Miscellaneous	1	Air start motor
	1	Seals for cylinder liner, support ring[1)], cooling water overflow, valves in cylinder head[1)], between cylinder head and charge-air pipe, between cylinder head and exhaust gas pipe, to push rod jacketing[1)] and to valve protection cap[1)] sufficient for 1 cylinder
	1	Expansion joint for exhaust gas pipe on the engine

[1)] where provided.

Note:
Subject to modification. Consumed spare parts should be replaced immediately.

Table 97: Scope of supply

For weight of turbocharger and turbocharger components see table Hoisting rail of the axial turbocharger, Page 244.

Maintenance items

Major spare parts	Weight [kg]
Air by-pass valve	2
Camshaft journals	35
Camshaft gears	65
Camshaft gears – Intermediate	80
Camshaft segment	50
Charge air cooler 12V	754
Charge air cooler 16V	870 (2 x 435)
Charge air cooler 20V	1,220 (2 x 610)
Connecting rod – Complete with bush, bearing and bolts	91

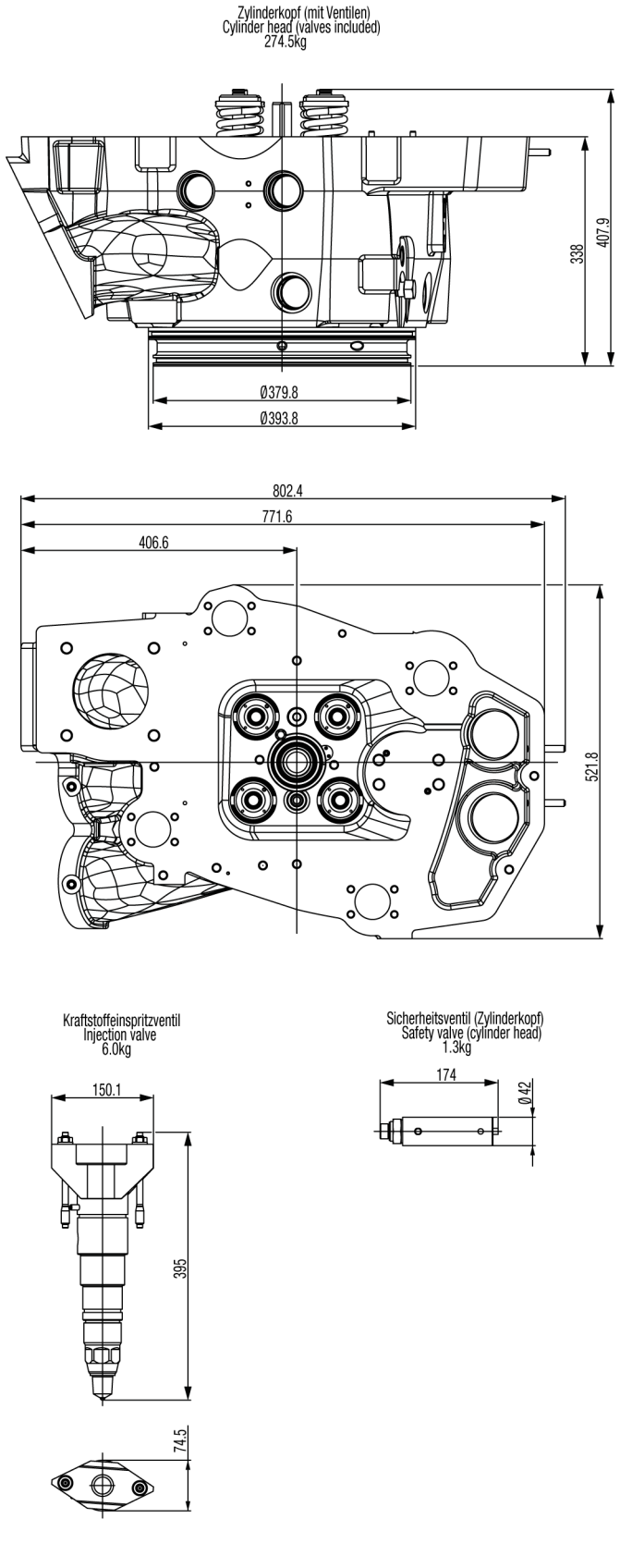
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Major spare parts	Weight [kg]
Crankshaft gear	32
Cylinder head covers (main)	7
Cylinder head with valves (less covers and valve gear)	275
Cylinder liner without cutting ring	133
Explosion relief valve and door	12
Fuel filter element (off engine)	8
Fuel injection pump	9
Fuel injector	6.5
Fuel circulating pump	12
Main bearing (lower + upper)	3
Main bearing caps	72
Oil filter element	8
Lube oil pump with attached fuel pump	285
Piston with piston pin	70
Compressed air starter motor	30
Tappet housing assembly	55
Turbocharger	1,430
Vibration damper 12V, 16V	579
Vibration damper 20V	595
Water pump – High temperature	90
Water pump – Jacket water	90
Water pump – Seawater	250
All weights quoted are for guidance only.	

Table 98: Maintenance items

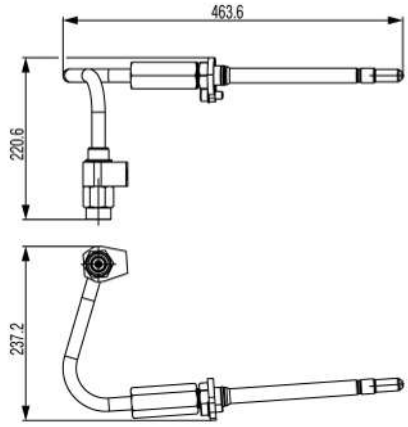
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7.1.8 Major spare parts – Main dimensions

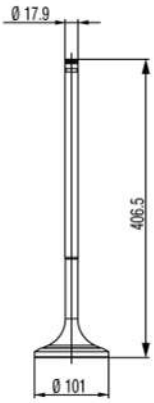


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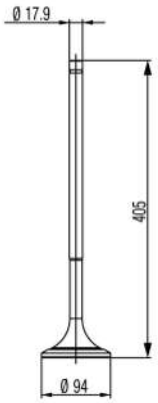
Kraftstoffeinspritzleitung
Fuel injection pipe
4.5kg



Einlassventilkegel
Inlet valve cone
1.8kg

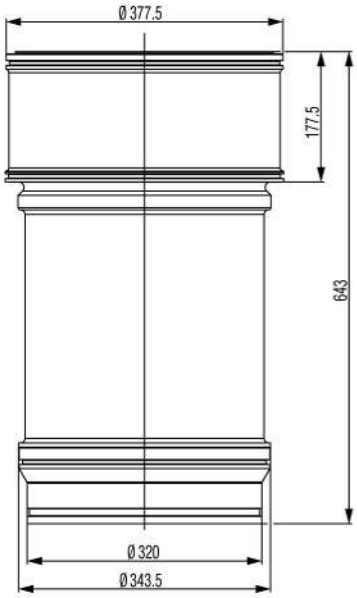


Auslassventilkegel
Outlet valve cone
1.6kg

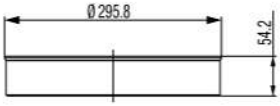


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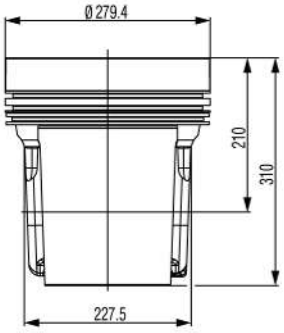
Zylinderbuchse
Cylinder liner
132.4kg



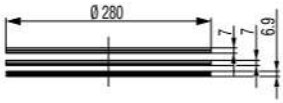
Flammring
Flame ring
2.1kg



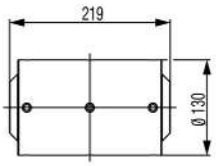
Kolben
Piston
49.9kg



Kolbenringe (Paket)
Piston rings (pakage)
0.9kg



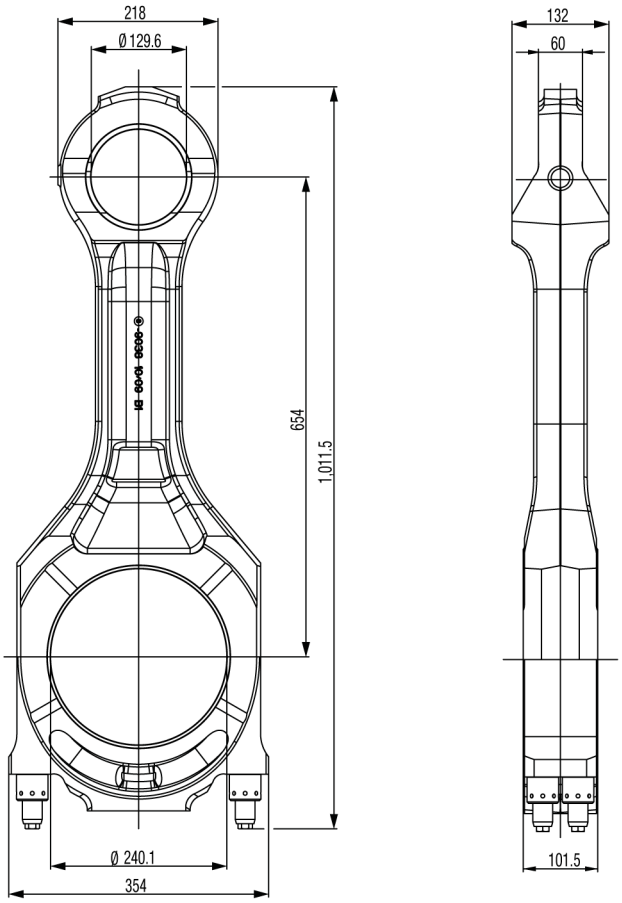
Kolbenbolzen
Piston Pin
19.7kg



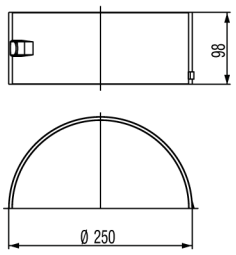
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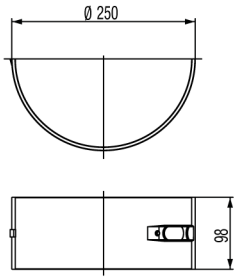
Pleuel (komplett)
Connecting rod (complete)
90.6kg



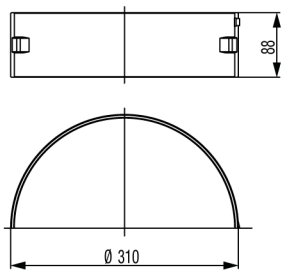
Obere Pleuellagerschale
Upper connecting rod bearing shell
1.5kg



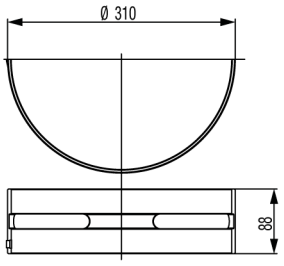
Untere Grundlagerschale
Lower main bearing shell
1.4kg



Obere Grundlagerschale
Upper main bearing shell
1.5kg

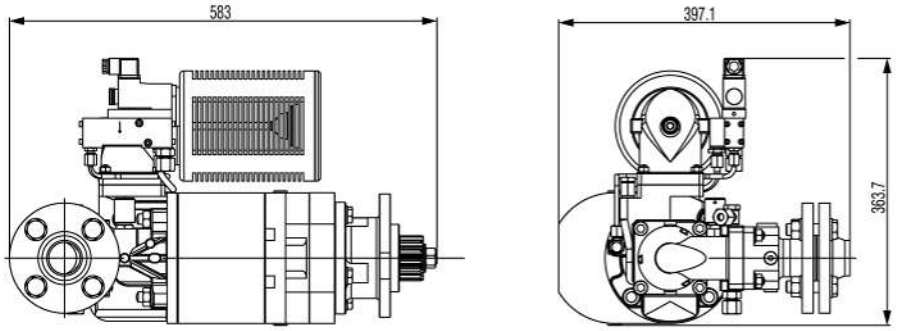


Untere Grundlagerschale
Lower main bearing shell
1.4kg

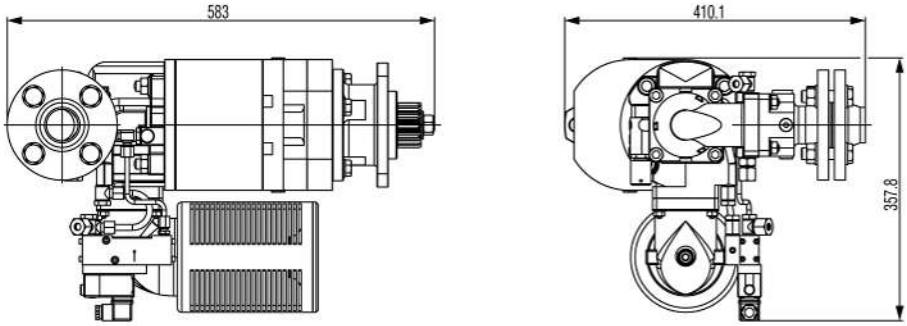


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Druckluftanlasserfür Motorrechtslauf
Compressed air starter for engine clockwise rotation
39.5kg

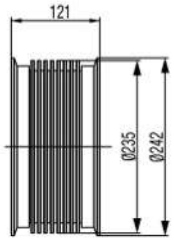


Druckluftanlasserfür Motorlinkslauf
Compressed air starter for engine counter clockwise rotation
39.5kg

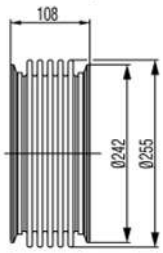


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Abgaskompensator (Zwischen Leitungsteilstücken)
Exhaust gas expansion joint (between pipes)
5.0kg

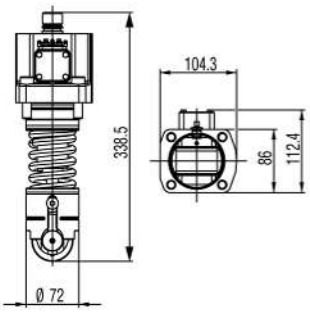


Abgaskompensator (für STC-Leitung)
Exhaust gas expansion joint (in STC-pipe)
4.3kg

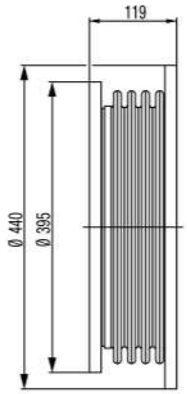


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Hochdruckpumpe
High pressure pump
9.2kg

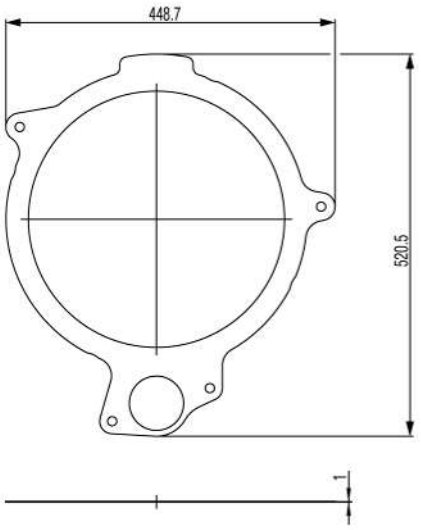


Abgaskompensator (vor Turbolader)
Exhaust gas expansion joint (before turbo charger)
31.8kg

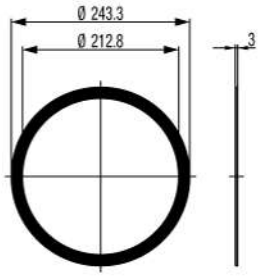


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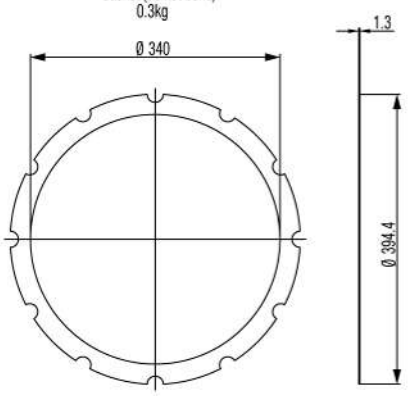
Dichtung für Wasserleitmantel (nicht knicken)
Gasket for water leading jaket (do not bend)
0.4kg



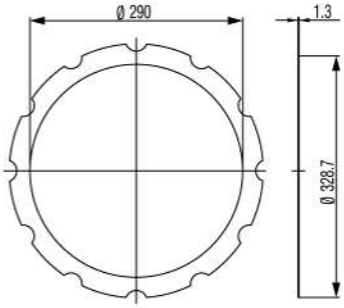
Dichtung (nicht knicken)
Gasket (do not bend)
0.1kg



Dichtung (nicht knicken)
Gasket (do not bend)
0.3kg



Dichtung (nicht knicken)
Gasket (do not bend)
0.3kg



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7.1.9 Mechanical propulsion system arrangement

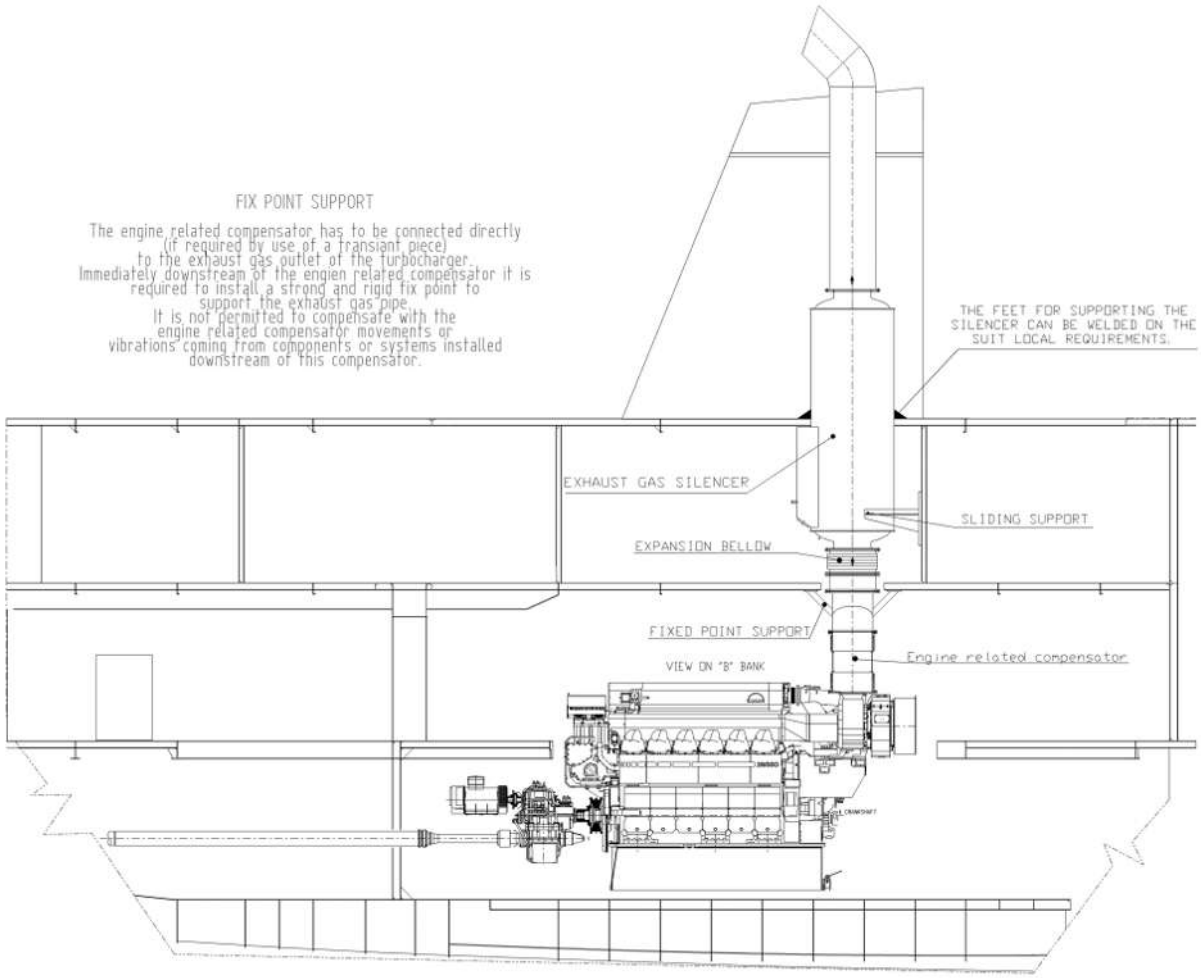


Figure 98: Example: Mechanical propulsion system arrangement – Exhaust gas section

Fix point support

The engine related compensator has to be connected directly to the exhaust gas outlet of the turbocharger (installation of compensator vertically or max. 45° position after turbocharger).

In case that the compensator cannot be directly connected to the exhaust gas outlet of the turbocharger, contact Everllence.

Immediately downstream of the engine related compensator it is required to install a strong and rigid fix point to support the exhaust gas pipe.

It is not permitted to compensate with the engine related compensator movements or vibrations coming from components or systems installed downstream of this compensator.

2026-10-29 - 10.1

7.2 Exhaust gas ducting

7.2.1 Example: Ducting arrangement

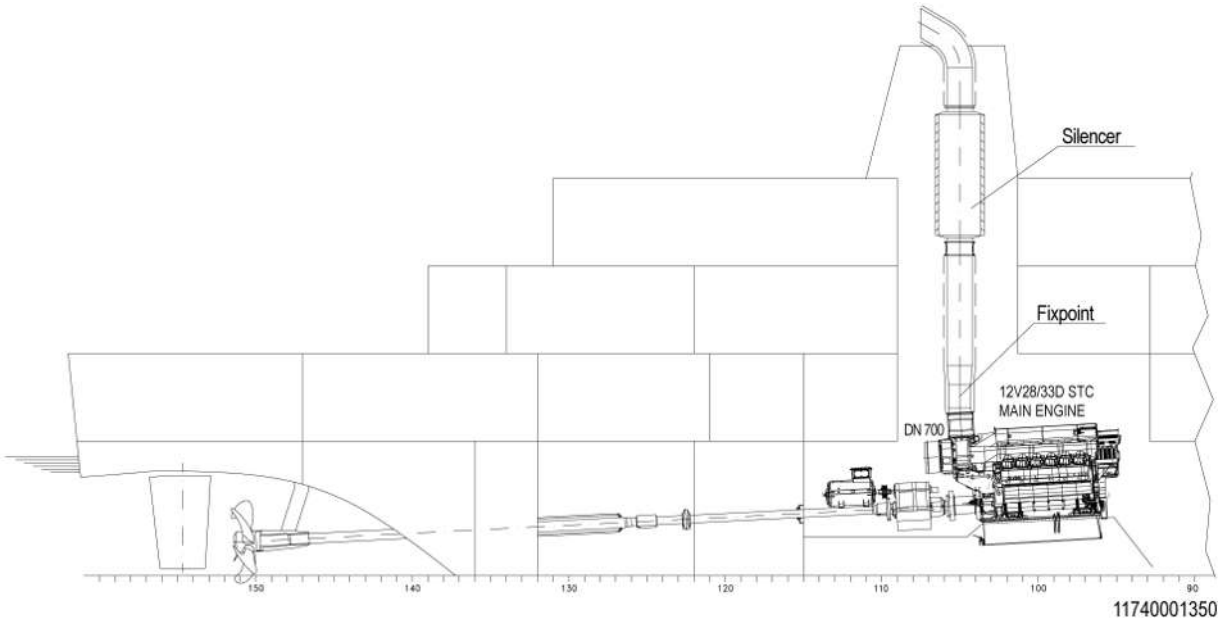


Figure 99: Example: Exhaust gas ducting arrangement

Fix point support

The engine related compensator has to be connected directly to the exhaust gas outlet of the turbocharger (installation of compensator vertically or max. 45° position after turbocharger). In case that the compensator cannot be directly connected to the exhaust gas outlet of the turbocharger, contact Everllence. Immediately downstream of the engine related compensator, it is required to install a strong and rigid fix point to support the exhaust gas pipe. It is not permitted to compensate with the engine related compensator movements or vibrations coming from components or systems installed downstream of this compensator.

2026-10-29 - 10.1

7.2.2 Position of the outlet casing of the turbocharger

Resiliently mounted engine

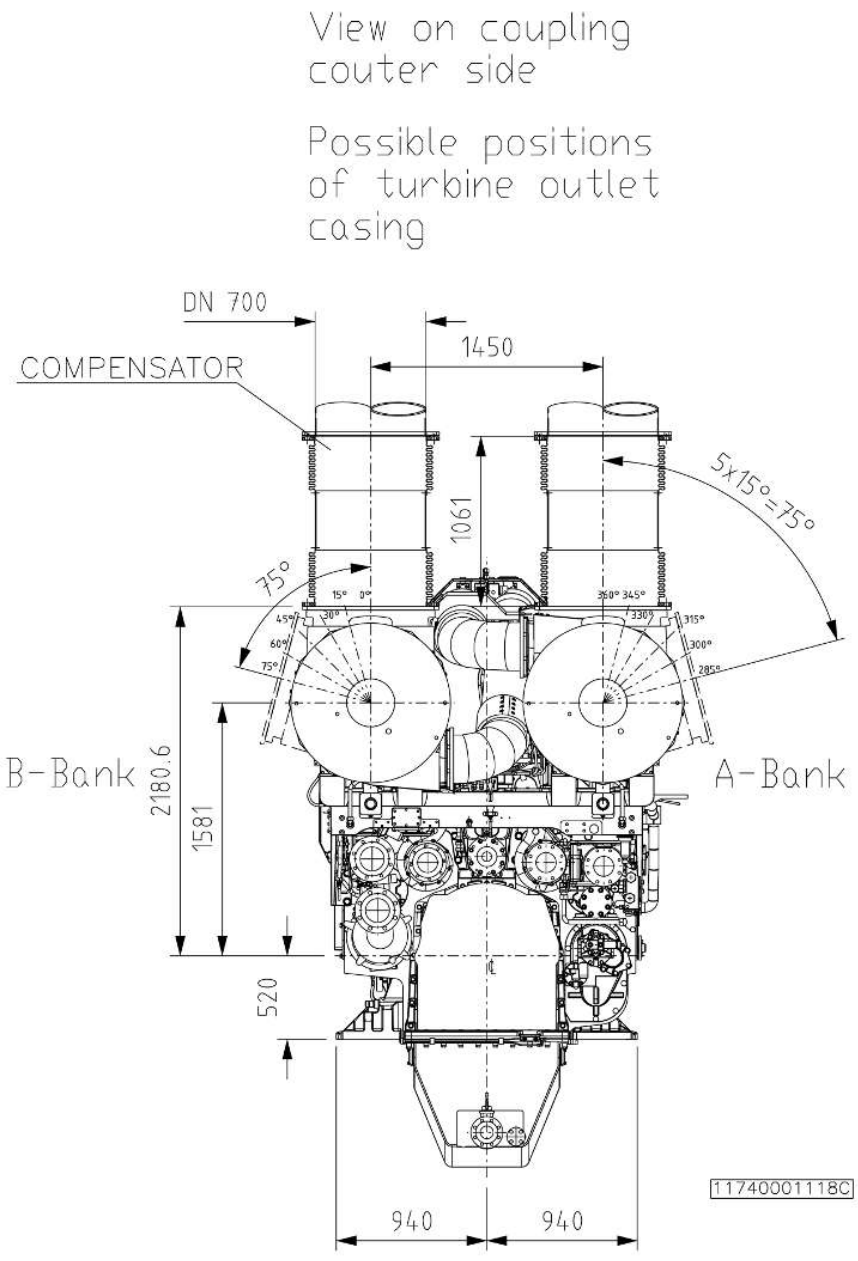


Figure 100: Possible positions of the outlet casing of the turbocharger – View on counter coupling side

Note:
[1] In case of attached wastegate (valid for all Tier III applications) the position of the outlet casing of the turbocharger on B-Bank needs to be "0°".

2026-10-29 - 10.1

8 Annex

8.1 Safety instructions and necessary safety measures

The following list of basic safety instructions, in combination with further engine documentation like user manual and working instructions, should ensure a safe handling of the engine. Due to variations between specific plants, this list does not claim to be complete and may vary with regard to project-specific requirements.

8.1.1 General

There are risks at the interfaces of the engine, which have to be eliminated or minimised in the context of integrating the engine into the plant system. Responsible for this is the legal person which is responsible for the integration of the engine.

Following prerequisites need to be fulfilled:

- Layout, calculation, design and execution of the plant have to be state of the art.
- All relevant classification rules, regulations and laws are considered, evaluated and are included in the system planning.
- The project-specific requirements of Everllence regarding the engine and its connection to the plant are implemented.
- In principle, the more stringent requirements of a specific document is applied if its relevance is given for the plant.

8.1.2 Safety equipment and measures provided by plant-side

- Proper execution of the work

  Generally, it is necessary to ensure that all work is properly done according to the task trained and qualified personnel.

  All tools and equipment must be provided to ensure adequate accesible and safe execution of works in all life cycles of the plant.

  Special attention must be paid to the execution of the electrical equipment. By selection of suitable specialised companies and personnel, it has to be ensured that a faulty feeding of media, electric voltage and electric currents will be avoided.
- Fire protection

  A fire protection concept for the plant needs to be executed. All from safety considerations resulting necessary measures must be implemented. The specific remaining risks, e.g. the escape of flammable media from leaking connections, must be considered.

  Generally, any ignition sources, such as smoking or open fire in the maintenance and protection area of the engine is prohibited.

  Smoke detection systems and fire alarm systems have to be installed and in operation.
- Electrical safety

  Standards and legislations for electrical safety have to be followed. Suitable measures must be taken to avoid electrical short circuit, lethal electric shocks and plant specific topics as static charging of the piping through the media flow itself.

2026-10-29 - 10.1

- Noise and vibration protection

  The noise emission of the engine must be considered early in the planning and design phase. A soundproofing or noise encapsulation could be necessary. The foundation must be suitable to withstand the engine vibration and torque fluctuations. The engine vibration may also have an impact on installations in the surrounding of the engine, as galleries for maintenance next to the engine. Vibrations act on the human body and may dependent on strength, frequency and duration harm health.

- Thermal hazards

  In workspaces and traffic areas hot surfaces must be isolated or covered, so that the surface temperatures comply with the limits by standards or legislations.

- Composition of the ground

  The ground, workspace, transport/traffic routes and storage areas have to be designed according to the physical and chemical characteristics of the excipients and supplies used in the plant.

  Safe work for maintenance and operational staff must always be possible.

- Adequate lighting

  Light sources for an adequate and sufficient lighting must be provided by plant-side. The current guidelines should be followed (100 Lux is recommended, see also DIN EN 1679-1).

- Working platforms/scaffolds

  For work on the engine working platforms/scaffolds must be provided and further safety precautions must be taken into consideration. Among other things, it must be possible to work secured by safety belts. Corresponding lifting points/devices have to be provided.

- Setting up storage areas

  Throughout the plant, suitable storage areas have to be determined for stabling of components and tools.

  It is important to ensure stability, carrying capacity and accessibility. The quality structure of the ground has to be considered (slip resistance, resistance against residual liquids of the stored components, consideration of the transport and traffic routes).

- Engine room ventilation

  An effective ventilation system has to be provided in the engine room to avoid endangering by contact or by inhalation of fluids, gases, vapours and dusts which could have harmful, toxic, corrosive and/or acid effects.

  The engine room ventilation must ensure a maximum engine room temperature, with following boundary conditions:

  – Maximum air temperature in the area of the engine and its components ≤ 45°C.

  – Maximum air temperature at least 5 K below the flash point of any liquids, that is present within the engine room.

- Venting of crankcase and turbocharger

  With crankcase ventilation the gases/vapours originating from crankcase and turbocharger are not ignitable. For multi-engine plants, each engine has to be ventilated separately. The engine ventilation of different engines must not be connected.

  In case of an installed suction system, it has to be ensured that it will not be stopped until at least 20 minutes after engine shutdown.

- Intake air filtering

2026-10-29 - 10.1

In case air intake is realised through piping and not by means of the turbocharger´s intake silencer, appropriate measures for air filtering must be provided. It must be ensured that particles exceeding 5 µm will be restrained by an air filtration system.

- Quality of the intake air

  It has to be ensured that combustible media will not be sucked in by the engine.

  Intake air quality according to the section Specification of intake air (combustion air), Page 166 has to be guaranteed.

- Emergency stop system

  The emergency stop system requires special care during planning, realisation, commissioning and testing at site to avoid dangerous operating conditions. The assessment of the effects on other system components caused by an emergency stop of the engine must be carried out by plant-side.

- Fail-safe 24 V power supply

  Because engine control, alarm system and safety system are connected to a 24 V power supply this part of the plant has to be designed fail-safe to ensure a regular engine operation.

- Hazards by rotating parts/shafts

  Contact with rotating parts must be excluded by plant-side (e.g. free shaft end, flywheel, coupling).

- Safeguarding of the surrounding area of the flywheel

  The entire area of the flywheel has to be safeguarded by plant-side.

  Special care must be taken, inter alia, to prevent from: Ejection of parts, contact with moving machine parts and falling into the flywheel area.

- Securing of the engine´s turning gear

  The turning gear has to be equipped with an optical and acoustic warning device. When the turning gear is first activated, there has to be a certain delay between the emission of the warning device's signals and the start of the turning gear. The gear wheel of the turning gear has to be covered. The turning gear should be equipped with a remote control, allowing optimal positioning of the operator, overlooking the entire hazard area (a cable of approximately 20 m length is recommended). Unintentional engagement or start of the turning gear must be prevented reliably.

  It has to be prescribed in the form of a working instruction that:

  – The turning gear has to be operated by at least two persons.
  – The work area must be secured against unauthorised entry.
  – Only trained personnel is permissible to operate the turning gear.

- Securing of the starting air pipe

  To secure against unintentional restarting of the engine during maintenance work, a disconnection and depressurisation of the engine´s starting air system must be possible. A lockable starting air stop valve must be provided in the starting air pipe to the engine.

- Securing of the turbocharger rotor

  To secure against unintentional turning of the turbocharger rotor while maintenance work, it must be possible to prevent draught in the exhaust gas duct and, if necessary, to secure the rotor against rotation.

- Consideration of the blow-off zone of the crankcase cover´s relief valves

2026-10-29 - 10.1

During crankcase explosions, the resulting hot gases will be blown out of the crankcase through the relief valves. This must be considered in the overall planning.

- Installation of flexible connections

  For installation of flexible connections follow strictly the information given in the planning and final documentation and the manufacturer manual.

  Flexible connections may be sensitive to corrosive media. For cleaning only adequate cleaning agents must be used (see manufacturer manual). Substances containing chlorine or other halogens are generally not permissible.

  Flexible connections have to be checked regularly and replaced after any damage or lifetime given in manufacturer manual.

- Connection of exhaust port of the turbocharger to the exhaust gas system of the plant

  The connection between the exhaust port of the turbocharger and the exhaust gas system of the plant has to be executed gas tight and must be equipped with a fire proof insulation.

  The surface temperature of the fire insulation must not exceed 220°C.

  In workspaces and traffic areas, a suitable contact protection has to be provided whose surface temperature must not exceed 60°C.

  The connection has to be equipped with compensators for longitudinal expansion and axis displacement in consideration of the occurring vibrations (the flange of the turbocharger reaches temperatures of up to 450°C).

- Media systems

  The stated media system pressures must be complied. It must be possible to close off each plant-side media system from the engine and to depressurise these closed off pipings at the engine. Safety devices in case of system over pressure must be provided.

- Drainable supplies and excipients

  Supply system and excipient system must be drainable and must be secured against unintentional recommissioning (EN 1037). Sufficient ventilation at the filling, emptying and ventilation points must be ensured. The residual quantities which must be emptied have to be collected and disposed of properly.

- Spray guard has to be ensured for liquids possibly leaking from the flanges of the plant´s piping system. The emerging media must be drained off and collected safely.

- Charge air blow-off (if applied)

  The piping must be executed by plant-side and must be suitably isolated. In workspaces and traffic areas, a suitable contact protection has to be provided whose surface temperature must not exceed 60°C.

  The compressed air is blown-off either outside the vessel or into the engine room. In both cases, installing a silencer after blow-off valve is recommended. If the blow-off valve is located upstream of the charge air cooler, air temperature can rise up to 200°C. It is recommended to blow-off hot air outside the plant.

- Signs

  – Following figure shows exemplarily the risks in the area of a combustion engine. This may vary slightly for the specific engine.

    This warning sign has to be mounted clearly visibly at the engine as well as at all entrances to the engine room.

2026-10-29 - 10.1



Figure 101: Warning sign E11.48991-1108

– Prohibited area signs.

  Depending on the application, it is possible that specific operating ranges of the engine must be prohibited.

  In these cases, the signs will be delivered together with the engine, which have to be mounted clearly visibly on places at the engine which allow intervention of the engine operation.

- Optical and acoustic warning device

  Communication in the engine room may be impaired by noise. Acoustic warning signals might not be heard. Therefore it is necessary to check where at the plant optical warning signals (e.g. flash lamp) should be provided.

  In any case, optical and acoustic warning devices are necessary while using the turning gear and while starting/stopping the engine.

2026-10-29 - 10.1

8.2 Programme for Factory Acceptance Test (FAT)

Table of Contents

1 Purpose 2
2 Scope 2
3 Terms and definitions 2
4 Engine testing 3
4.1 Pre-tests (internal tests) 3
5 References 5
6 Appendices 5

Figure 102: Programme for Factory Acceptance Test (FAT) – Part 1

2026-10-29 - 10.1

Change history

Edition	Department	Author	Changes
1	MWAA5	Andreas Müller	New document, replacing document Q10.09053-0016

Review history

Edition	Department	Review by	Review issues
1	MWAA5	Sascha Stoll	

Approval history

Edition	Department	Approver
1	MWAA	Sonja Adorf

Former Number

Q10.09053-0016

1 Purpose

This quality guideline specifies engine tests and checks at Factory Acceptance Test (FAT) for power applications. The following tests are to be done at a standard FAT.

2 Scope

This instruction is valid for all employees of companies mentioned below, and is binding for all employees, which are affected by this instruction within the scope of their duties. The respective manager has to ensure that the employees know and observe this instruction.

It is valid for Power application of Medium speed engines and engines up to 1050rpm nominal speed.

Valid for the following company(ies): Everllence SE

Valid for the following organizational unit(s): PL Engines

Valid for the following location(s): Augsburg; Aurangabad; Frederikshavn; Saint-Nazaire

Valid for the following department(s): FR-EET; PEAA5; PEFS; RM-IN-PET

3 Terms and definitions

Term	Definition
FAT	Factory Acceptance Test

Figure 103: Programme for Factory Acceptance Test (FAT) – Part 2

2026-10-29 - 10.1

4 Engine testing

The complete test of a medium speed engine on a test bed requires several days. Therefore, the test is separated into two periods, the pre-test and the demonstration test at FAT. The pre-test is an internal test and could be carried out before FAT. The demonstration test is to verify the engine quality and observance of contractually agreed terms and conditions in presence of the customer. For each engine, an engine specific procedure for the demonstration test has to be generated based on the tests and checks of point 4.2 of this instruction and contractual agreements with the customer. Under the following points the standard scope of pre-test and demonstration test is specified.

4.1 Pre-tests (internal tests)

Limits and requirements for each test can be found in project guides and internal specifications of the engine manufacturer. The following points represent the minimum of tests to be conducted to ensure the functionality and performance of the engine.

a. Thermographic scan needs to be carried out (for leakage detection)
b. Start tests and calculation of start air consumption in gas and diesel operation.
c. Performance Check: The engine performance is to be tested at the load points listed in table 1. Further information can be found under point 4.3 of this instruction. Performance readings must be stated in the FAT protocol.
d. Governor test (load drop): Sudden load drop from full load to zero load. Results must be stated in the FAT protocol.
e. Switch from liquid to gas operation and back (only for Dual fuel engine)
f. Check of attached engine flaps and valves (blow off, blow by, waste gate, jet assist).

g. Visual check for leakages on fuel oil, lube oil and water systems of the engine (check of connecting flanges, screw connections and inspection drillings).

h. Surge test of turbocharger on new engine configurations during the turbocharger-matching process. Results not to be stated in the FAT protocol.
i. Optional inspections (by indication of abnormalities).

4.2 Demonstration tests

The demonstration test is a final quality approval of the engine before its delivery in presence of the customer. The demonstration test has to be done according to the engine-specific test procedure (demonstration test), confirmed by the customer. The scope of the FAT-procedure (demonstration test) is based on the following standards:

a. Performance Check: The engine performance has to be tested on the load points listed in table 1. Further information can be found under point 4.3 of this instruction.

b. Visual check of crank case, camshaft, rollers and gear drive after engine stop.

Figure 104: Programme for Factory Acceptance Test (FAT) – Part 3

2026-10-29 - 10.1

c. Optional tests and inspections only by contractual agreement with customer or by indication of irregularities.

4.3 Engine performance check

The engine performance check has to be done on all load points listed in table 1. The performance parameters to be measured are specified in ISO 15550. The measurement data have to be within the specification limits of the engine manufacturer. A guaranteed fuel consumption as well as emission compliance can only be checked at site (if not especially defined for FAT). All measurement readings have to be conducted according to the specified instructions of the engine manufacturer. Engines for Generator applications are to be tested on constant speed curve. Engines for pump or compressor applications are to be tested on the characteristic speed curve.

Table 1: Engine Performance check

Engine load	Running time
Diesel operation:	
100%[1)]	M
110%*	M
Contractual load point[2)]	M
75%*	M
50%*	M
25%*	M
Gas operation:	
100%[1)]	M
110%*	M
Contractual load point[2)]	M
75%*	M
50%*	M

[1)] Two readings have to be taken at an interval of 30 min, on Dual fuel engines only one reading in Diesel and one in Gas operation
[2)] Guarantee load point if different from 100%, 75%, 50% or 25% load
* Can be done prior to FAT / Measurement results have to be stated in FAT protocol
M = Measurement at steady-state condition

Figure 105: Programme for Factory Acceptance Test (FAT) – Part 4

4.4 FAT - protocol

All operations, events, findings, measures and agreements have to be documented in one engine specific FAT protocol of Everllence. The final FAT-protocol has to be reviewed and to be handed out to the customer. The FAT protocol contains the following information:

- Cover sheet
- List of contents
- Signature sheet with representatives
- Operating record for all engine operation points
- Fuel oil analysis
- Check of crank web deflection
- Line records for governor test or load jump tests
- Check of safety functions of engine
- Visual inspection sheet with conducted checks and documentation of engine conditions
- Additional remarks
- Software versions of engine control and safety system and emission relevant identification number
- Information about engine equipment
- Calibration certificates

5 References

Further applicable documents always refer to the current version unless not stated otherwise.

- ISO 15550 Internal combustion engines – Determination and method for the measurement of engine power – general requirements and ISO 3046
- ISO 10816-6 - Mechanical vibration
- Workcard for rigging up, connecting, commissioning, performing the test run and performing the customer acceptance test for a combustion engine on the test bed
- W0221EN Sampling of fuel oil
- I0158EN - Guideline for conducting a measurement at the test beds
- I0248EN - Fuel oil consumption measurement of 4 – Stroke Engines on Test bed

6 Appendices

Appendix [No]

Figure 106: Programme for Factory Acceptance Test (FAT) – Part 5

2026-10-29 - 10.1

8.3 Engine running-in

Prerequisites

Engines require a running-in period in case one of the following conditions applies:

- When put into operation on site, if
  - after test run the pistons or bearings were dismantled for inspection or
  - the engine was partially or fully dismantled for transport.
- After fitting new drive train components, such as cylinder liners, pistons, piston rings, crankshaft bearings, big-end bearings and piston pin bearings.
- After the fitting of used bearing shells.
- After long-term low-load operation, see section Low-load operation, Page 45.

Supplementary information

Operating Instructions

During the running-in procedure the unevenness of the piston-ring surfaces and cylinder contact surfaces is removed. The running-in period is completed once the first piston ring perfectly seals the combustion chamber. i.e. the first piston ring should show an evenly worn contact surface. If the engine is subjected to higher loads, prior to having been running-in, then the hot exhaust gases will pass between the piston rings and the contact surfaces of the cylinder. The oil film will be destroyed in such locations. The result is material damage (e.g. burn marks) on the contact surface of the piston rings and the cylinder liner. Later, this may result in increased engine wear and high lube oil consumption.

The time until the running-in procedure is completed is determined by the properties and quality of the surfaces of the cylinder liner, the quality of the fuel and lube oil, as well as by the load of the engine and speed. The running-in periods indicated in following figures may therefore only be regarded as approximate values.

Operating media

Liquid fuel engines

The running-in period may be carried out preferably using DMA.

The fuel used must meet the quality standards see section Specification for engine supplies, Page 153 and the design of the fuel system.

Dual fuel engines

Dual fuel engines are run in using liquid fuel mode with the fuel intended as the pilot fuel.

Gas fuel engines

For the running-in of gas four-stroke engines it is best to use the gas which is to be used later in operation.

Lube oil

The running-in lube oil must match the quality standards, with regard to the fuel quality.

Engine running-in

Cylinder lubrication (optional)

The cylinder lubrication must be switched to "Running In" mode during completion of the running-in procedure. This is done at the control cabinet or at the control panel (under "Manual Operation"). This ensures that the cylinder lubrication is already activated over the whole load range when the engine

2026-10-29 - 10.1

starts. The running-in process of the piston rings and pistons benefits from the increased supply of oil. Cylinder lubrication must be returned to "Normal Mode" once the running-in period has been completed.

Checks

Inspections of the bearing temperature and crankcase must be conducted during the running-in period:

- The first inspection must take place after 10 minutes of operation at minimum speed.
- An inspection must take place after operation at full load respectively after operational output level has been reached.

The bearing temperatures (camshaft bearings, big-end and main bearings) must be determined in comparison with adjoining bearings. For this purpose an electrical sensor thermometer may be used as a measuring device.

At 85% load and at 100% load with nominal speed, the operating data (ignition pressures, exhaust gas temperatures, charge air pressures, etc.) must be measured and compared with the acceptance report.

Standard running-in programme

Dependent on the application the running-in programme can be derived from the figures in paragraph Diagram(s) of standard running-in, Page 268. During the entire running-in period, the engine output has to be within the marked output range. Critical speed ranges are thus avoided.

Running-in during commissioning on site

Most four-stroke engines are subjected to a test run at the manufacturer´s premises. As such, the engine has usually been run in. Nonetheless, after installation in the final location, another running-in period is required if the pistons or bearings were disassembled for inspection after the test run, or if the engine was partially or fully disassembled for transport.

Running-in after fitting new drive train components

If during revision work the cylinder liners, pistons, or piston rings are replaced, a new running-in period is required. A running-in period is also required if the piston rings are replaced in only one piston. The running-in period must be conducted according to following figures or according to the associated explanations.

The cylinder liner may be re-honed according to working instructions 050.05, if it is not replaced. A transportable honing machine may be requested from one of our service and support locations.

Running-in after refitting used or new bearing shells (crankshaft, connecting rod and piston pin bearings)

When used bearing shells are reused, or when new bearing shells are installed, these bearings have to be run in. The running-in period should be 3 to 5 hours under progressive loads, applied in stages. The instructions in the preceding text segments, particularly the ones regarding the "Inspections", and following figures must be observed.

Idling or no-load operation at higher speeds for long periods should be avoided if at all possible.

Diagram of standard running-in

2026-10-29 - 10.1

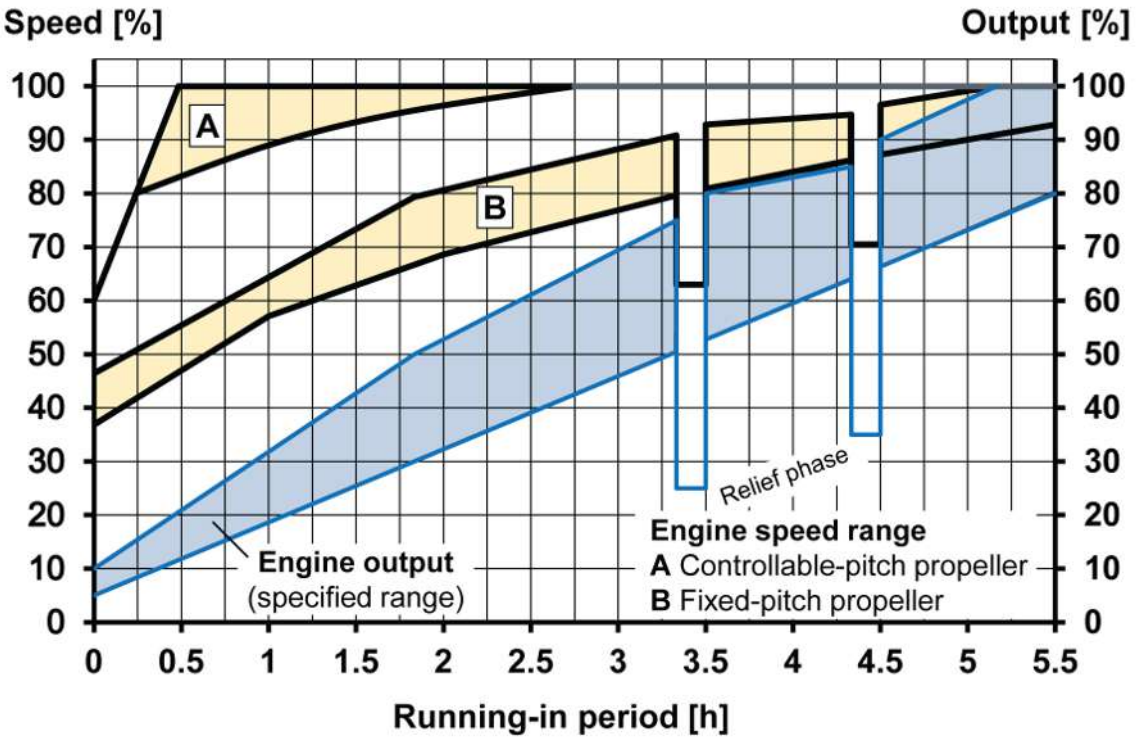


Figure 107: Standard running-in programme for marine engines (variable speed)

2026-10-29 - 10.1

8.4 Definitions

Auxiliary GenSet/auxiliary generator operation

A generator is driven by the engine, hereby the engine is operated at constant speed. The generator supplies the electrical power not for the main drive, but for supply systems of the vessel.

Load profile with focus between 40% and 80% load.

Engine´s certification for compliance with the NO_x limits according D2 Test cycle. See within section Engine ratings (output) for different applications, Page 37 if the engine is released for this kind of application and the corresponding available output $P_{Application}$.

Blackout

The classification societies define blackout on board ships as a loss of the main source of electrical power resulting in the main and auxiliary machinery to be out of operation and at the same time all necessary alternative energies (e.g. start air, battery electricity) for starting the engines are available.

Dead ship condition

The classification societies define dead ship condition as follows:

- The main propulsion plant, boilers and auxiliary machinery are not in operation due to the loss of the main source of electrical power.
- In restoring propulsion, the stored energy for starting the propulsion plant, the main source of electrical power and other essential auxiliary machinery is assumed not to be available.
- It is assumed that means are available to start the emergency generators at all times. These are used to restore the propulsion.

Designation of engine sides

- Coupling side, CS

  The coupling side is the main engine output side and is the side to which the propeller, the alternator or other working machine is coupled.
- Free engine end/counter coupling side, CCS

  The free engine end is the front face of the engine opposite the coupling side.

Designation of cylinders

The cylinders are numbered in sequence, from the coupling side, 1, 2, 3 etc. In V engines, looking on the coupling side, the left hand bank of cylinders is designated A, and the right hand bank is designated B. Accordingly, the cylinders are referred to as A1-A2-A3 or B1-B2-B3, etc.

2026-10-29 - 10.1

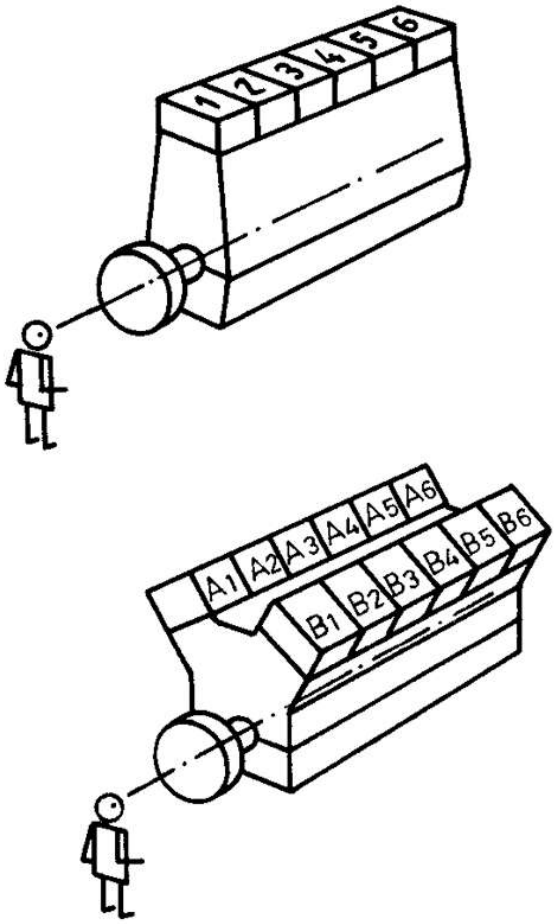


Figure 108: Designation of cylinders

Direction of rotation

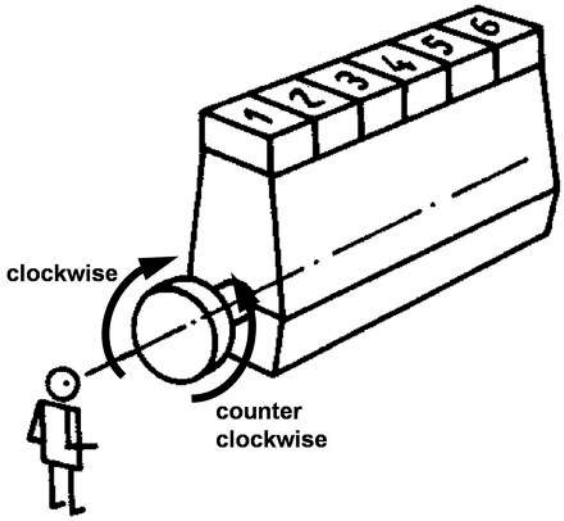


Figure 109: Designation: Direction of rotation seen from flywheel end

2026-10-29 - 10.1

Electric propulsion

The generator being driven by the engine supplies electrical power to drive an electric motor. The power of the electric motor is used to drive a controllable pitch or fixed pitch propeller, pods, thrusters, etc.

Load profile with focus between 80% and 95% load.

Engine´s certification for compliance with the NO_x limits according E2 Test cycle. See within section Engine ratings (output) for different applications, Page 37 if the engine is released for this kind of application and the corresponding available output $P_{Application}$.

GenSet

The term "GenSet" is used, if engine and electrical alternator are mounted together on a common base frame and form a single piece of equipment.

Gross calorific value (GCV)

This value supposes that the water of combustion is entirely condensed and that the heat contained in the water vapor is recovered.

Idling operation

Idling/Idling operation refers to operation:

- Before the engine is coupled to the propulsion system or to the mechanical dredge pump
- Of the GenSet with open Genoswitch

A distinction is made between:

- Idling at minimum speed and
- Idling at rated speed

Mechanical propulsion with controllable pitch propeller (CPP)

A propeller with adjustable blades is driven by the engine.

The CPP´s pitch can be adjusted to absorb all the power that the engine is capable of producing at nearly any rotational speed.

Load profile with focus between 80% and 95% load.

Engine´s certification for compliance with the NO_x limits according E2 Test cycle. See within section Engine ratings (output) for different applications, Page 37 if the engine is released for this kind of application and the corresponding available output $P_{Application}$.

Multi-engine propulsion plant

In a multi-engine propulsion plant at least two or more engines are available for propulsion.

Net calorific value (NCV)

This value supposes that the products of combustion contain the water vapor and that the heat in the water vapor is not recovered.

2026-10-29 - 10.1

No-load operation

As soon as the engine has been coupled, or a GenSet with closed Geno switch has been connected to electrical grid and no load has yet been delivered, this is named as no-load operation.

Offshore application

Offshore construction and offshore drilling place high requirements regarding the engine´s acceleration and load application behaviour. Higher requirements exist also regarding the permissible engine´s inclination.

Due to the wide range of possible requirements such as flag state regulations, fire fighting items, redundancy, inclinations and dynamic positioning modes all project requirements need to be clarified at an early stage.

Output

- ISO standard output (as specified in DIN ISO 3046-1)

  Maximum continuous rating of the engine at nominal speed under ISO conditions, provided that maintenance is carried out as specified.
- Operating-standard-output (as specified in DIN ISO 3046-1)

  Maximum continuous rating of the engine at nominal speed taking in account the kind of application and the local ambient conditions, provided that maintenance is carried out as specified. For marine applications this is stated on the type plate of the engine.
- Fuel stop power (as specified in DIN ISO 3046-1)

  Fuel stop power defines the maximum rating of the engine theoretical possible, if the maximum possible fuel amount is used (blocking limit).

2026-10-29 - 10.1

- Rated power (in accordance to rules of DNV)

  Maximum possible continuous power at rated speed and at defined ambient conditions, provided that maintenances carried out as specified.
- Output explanation

  Power of the engine at distinct speed and distinct torque.
- 100% output

  100% output is equal to the rated power only at rated speed. 100% output of the engine can be reached at lower speed also if the torque is increased.
- Nominal output

  = rated power.
- MCR

  Maximum continuous rating.
- ECR

  Economic continuous rating = output of the engine with the lowest fuel consumption.

Overload power (at FAT or SAT/sea trial)

Only if required by rules of classification societies, it is admitted to operate the engine at 110% of rated power for a maximum of 1 h in total as part of the FAT or SAT/sea trial and in addition a maximum of 1 h in total as part of the comissioning of the plant. Engine operation has to be done under supervision of trained Everllence personal.

Single-engine propulsion plant

In a single-engine propulsion plant only one single-engine is available for propulsion.

Suction dredger application (mechanical drive of pumps)

For direct drive of a suction dredger pump by the engine via gear box the engine speed is directly influenced by the load on the suction pump.

The power demand of the dredge pump needs to be adapted to the operating range of the engine, particularly while start-up operation. Load profile with focus between 80% and 100% load.

Engine´s certification for compliance with the NO_x limits according C1 Test cycle. See within section Engine ratings (output) for different applications, Page 37 if the engine is released for this kind of application and the corresponding available output $P_{Application}$.

Weight definitions for SCR

- Handling weight (reactor only):

  This is the "net weight" of the reactor without catalysts, relevant for transport, logistics, etc.
- Operational weight (with catalysts):

  That's the weight of the reactor in operation, that is equipped with a layer of catalyst and the second layer empty – as reserve.
- Maximum weight structurally:

  This is relevant for the static planning purposes maximum weight, that is equipped with two layers catalysts.

2026-10-29 - 10.1

8.5 Abbreviations

Abbreviation	Explanation
BN	Base number
CBM	Condition based maintenance
CCM	Crankcase monitoring system
CCS	Counter coupling side
CS	Coupling side
DLC	Data Logging Cabinet
DMA	Gas oil
DMB	Diesel oil
ECR	Economic continuous rating
EDS	Engine diagnostics system
GCV	Gross calorific value
GVU	Gas Valve Unit
HFO	Residual fuel
HT CW	High temperature cooling water
LT CW	Low temperature cooling water
MCR	Maximum continuous rating
MN	Methane number
NCV	Net calorific value
OMD	Oil mist detection
SaCoS	Safety and control system
SAT	Site acceptance test
SECA	Sulphur emission control area
SP	Sealed plunger
STC	Sequential turbocharging
TAN	Total acid number
TBO	Time between overhaul
TC	Turbocharger
TC	Temperature controller
ULSHFO	Ultra low sulphur residual fuel

2026-10-29 - 10.1

8.6 Symbols

Note:
The symbols shown should only be seen as examples and can differ from the symbols in the diagrams.

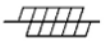
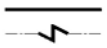
DESIGNATION	SYMBOL	CODE	DESIGNATION	SYMBOL	CODE
MAIN CIRCUIT (FLOW DIRECTION SHOWN)			FLEXIBLE PIPE CONNECTION		EH
SECONDARY CIRCUIT			EXPANSION BELLOWS (STEEL)		EB
CONTROL AIR PIPE, PULSE LINE, ELECTRICAL LINE			2/2 (TWO-PORT, TWO-POSITION) DIRECTIONAL CONTROL SOLENOID-OPERATED VALVE		
CAPILLARY TUBE (WITH THERMOSTATIC REGULATORS)			3/2 (THREE-PORT, TWO-POSITION) DIRECTIONAL CONTROL VALVE		
LAGGED PIPE			GENERAL SHUT-OFF VALVE		V
STEAM HEATED PIPE (HEAVY FUEL OIL OPERATION, MAIN CIRCUIT)			GATE VALVE		GV
ELECTRICALLY HEATED PIPE (HEAVY FUEL OIL OPERATION, MAIN CIRCUIT)			STRAIGHT-WAY VALVE		V

Figure 110: Symbols used in functional and pipeline diagrams 1

2026-10-29 - 10.1

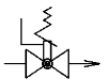
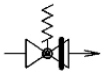
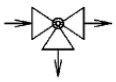
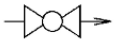
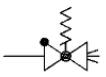
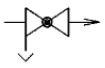
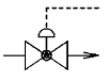
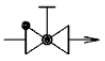
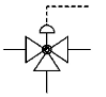
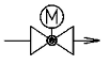
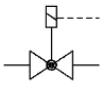
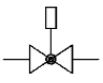
DESIGNATION	SYMBOL	CODE	DESIGNATION	SYMBOL	CODE
ANGLE VALVE		V	GENERAL SHUT-OFF VALVE, MOTOR DRIVEN		MOV
VALVE WITH MINIMUM FLOW		V	QUICK ACTING SHUT-OFF VALVE		V
GENERAL THREE-WAY VALVE		CK	SAFETY VALVE (STRAIGHT WAY)		PSV
THREE-WAY VALVE		V	SAFETY VALVE (ANGLE)		PSV
COCK		CK	BACK PRESSURE VALVE (STRAIGHT WAY)		BPV
SHUT-OFF VALVE WITH VENTILATION		V	BACK PRESSURE VALVE (ANGLE)		BPV
NON-RETURN VALVE		NRV	DIAPHRAGM VALVE (PNEUMATICALLY-OPERATED)		DV
NON-RETURN VALVE (CAN BE SHUT OFF)		NRV	DIAPHRAGM SHUTTLE VALVE		DV
ANGLE NON-RETURN VALVE		NRV	MOTORISED VALVE		MOV
SOLENOID-OPERATED VALVE		SOV	GENERAL THREE-WAY VALVE, MOTOR DRIVEN		MOV
SOLENOID-OPERATED VALVE (AUTOMATIC VENT)		SOV	MOTORISED SHUTTLE VALVE		MOV
GENERAL SHUT-OFF VALVE, GENERAL DRIVE		V	GENERAL SHUT-OFF VALVE WITH TRANSATORY MOTON VALVE		V

Figure 111: Symbols used in functional and pipeline diagrams 2

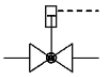
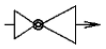
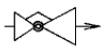
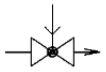
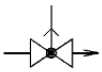
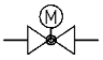
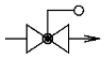
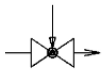
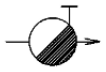
DESIGNATION	SYMBOL	CODE	DESIGNATION	SYMBOL	CODE
PISTON-OPERATED VALVE		POV	PRESSURE REDUCING VALVE		PCV
SHUTTLE VALVE WITH DRIVE PISTON		POV	PRESSURE CONTROL VALVE		PCV
SELF-CLOSING VALVE (STRAIGHT WAY)		QV	TEMPERATURE REGULATOR (SELF-ACTUATING DISTRIBUTION VALVE)		TCV
SELF-CLOSING VALVE (ANGLE)		QV	TEMPERATURE REGULATOR (SELF-ACTUIATING MIXING VALVE)		TCV
AUTOMATIC OPENING VALVE		V	TEMPERATURE CONTROL VALVE, ELECTRICALLY CONTROLLED		TCV
FLOAT VALVE		LOV	VANE HAND PUMP		P
SPRING-LOADED ADJUSTABLE PRESSURE LIMITING VALVE		PCV	WATER TRAP		TR
SAFETY VALVE		PSV	OIL TRAP		TR
FLOW-CONTROL VALVE, ADJUSTABLE			CONDENSATE TRAP, CAN BE SHUT OFF		TR
NON-RETURN VALVE, UNIDIRECTIONAL FLOW			ACCUMULATOR, GAS CYLINDER		
NON-RETURN VALVE WITH SPRING, NORMALLY CLOSED			OILER		
PILOTED NON-RETURN VALVE WITH SPRING, FLOW IN BOTH DIRECTIONS POSSIBLE DUE TO CONTROL PRESSURE			HEATING COIL (STEAM OR WATER)		H

Figure 112: Symbols used in functional and pipeline diagrams 3

2026-10-29 - 10.1

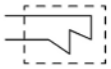
DESIGNATION	SYMBOL	CODE	DESIGNATION	SYMBOL	CODE
PLUG-IN HEATER (STEAM OR WATER)		H	SUCTION STRAINER		STR
PLUG-IN HEATER (ELECTRIC)		H	SUCTION BELL		SB
BACKFLOW PREVENTER (DISCOTYP)		NRV	FLAME TRAP		GS
NON-RETURN FLAP		NRF	VENT		
STRAINER		STR	VENT WITH FLAME TRAP		
FUNNEL (OPEN)		FU	VENT, OUTBOARD ABOVE DECK		
FUNNEL (CLOSED)		FU	VENT CAP		
OVERFLOW CHECK TANK, DISCHARGE FUNNEL		FU	Withdrawal point for fuel oil sample		

Figure 113: Symbols used in functional and pipeline diagrams 4

8.7 Preservation, packaging, storage

8.7.1 General

Introduction

Engines are internally and externally treated with preservation agent before delivery. The type of preservation and packaging must be adjusted to:

- Means of transport
- Type and period of storage

Improper storage may cause severe damage to the product.

Packaging and preservation of engine

The type of packaging depends on:

- The requirements imposed with transport and storage period
- Climatic and environmental effects
- Which preservative agents are used

2026-10-29 - 10.1

As standard, the preservation and packaging of an engine is designed for a storage period of 12 month and for sea transport.

Note:
The packaging must be protected against damage. It must only be removed when:

- A follow-up preservation is required
- The packaged material is to be used
- Shortly before operating the engine

The condition of the packaging must be checked regularly and repaired in case of damage. Especially a VCI packaging can only provide a proper corrosion protection if it is intact and completely closed.

In addition, the engine interiors are protected by vapour phase corrosion protection. Inner compartments must not be opened while transportation and storage. Otherwise, a re-preservation of the opened compartment will be required. The inner corrosion protection can remain inside the engine.

If bare metal surfaces get exposed for example, by disassembly of the coupling device, the unprotected metal must be treated with agent "f" according to the list of recommended anti-corrosion agents (Corrosion protection).

This especially applies to the tie rod where the lifting device has been mounted.

In case of an installed intake air filter there is a steel plate cover or similar around the filter fleece, which has to be used during transportation and storage.

Note:
During storage and in case of a follow-up preservation the crankshaft must not be turned. If the crankshaft is turned, usually for the first time after preservation this will be done during commissioning, the preservation is partially removed. If the engine is to be stored again for a period thereafter, then adequate re-preservation is required.

Preservation and packaging of loose equipment

Unless stated otherwise in the customer specification, the preservation and packaging of loose equipment and engine parts which are dismantled for transport, must be carried out such that:

- The preservation and packaging of loose equipment and engine parts will not be damaged during transport
- The corrosion protection remains fully intact for at least 12 months when stored in a roofed dry room

Transport

Transport and packaging of the engine, loose equipment and engine parts must be coordinated.

After transportation, any damage to the corrosion protection and packaging must be rectified, and/or Everllence must be notified immediately.

2026-10-29 - 10.1

8.7.2 Storage location and duration

Storage location

Storage location of engine

As standard, the engine is packaged and preserved for outdoor storage.

The storage location must meet the following requirements:

- Engine is stored on firm and dry ground.
- Packaging material does not absorb any moisture from the ground.
- Engine is accessible for visual checks.

Storage location of loose equipment

Loose equipment must always be stored in a roofed dry room.

The storage location must meet the following requirements:

- Parts are protected against environmental effects and the elements.
- The room must be well ventilated.
- Parts are stored on firm and dry ground.
- Packaging material does not absorb any moisture from the ground.
- Parts cannot be damaged.
- Parts are accessible for visual inspection.
- An allocation of loose equipment to the order or requisition must be possible at all times.

Note:
Packaging made of or including VCI paper or VCI film must not be opened or must be closed immediately after opening.

Storage conditions

In general the following requirements must be met:

- Minimum ambient temperature: –10°C
- Maximum ambient temperature: +60°C
- Relative humidity: < 60%

In case these conditions cannot be met, contact Everllence for clarification.

Storage period

The permissible storage period of 12 months must not be exceeded.

Before the maximum storage period is reached:

- Check the condition of the stored engine and loose equipment.
- Renew the preservation or install the engine or components at their intended location.

8.7.3 Follow-up preservation when preservation period is exceeded

A follow-up preservation must be performed before the maximum storage period has elapsed, i.e. generally after 12 months.

Request assistance by authorised personnel of Everllence.

2026-10-29 - 10.1

8.7.4 Removal of corrosion protection

Packaging, corrosion protection and silica gel must only be removed from the engine immediately before commissioning the engine in its installation location.

Remove outer protective layers, any foreign body from engine or component (VCI packs, blanking covers, etc.), check engine and components for damage and corrosion, perform corrective measures, if required.

The preservation agents sprayed inside the engine do not require any special attention. They will be washed off by engine oil during subsequent engine operation.

Contact Everllence if you have any questions.

8.8 Engine colour

Engine standard colour according RAL colour table is RAL 7040 Window grey. Other colours on request.

2026-10-29 - 10.1

Index

A

Abbreviations 275
Acceleration times 63
Additions to fuel consumption 71
Aging (Increase of S.F.C.) 73
Air
  Flow rates 73, 79
  Starting air consumption 65, 70
  Temperature 73, 79
Air receivers
  Capacities 219
Air vessels
  Capacities 182
  Condensate amount 181
Airborne noise 98
Ambient conditions causes derating 38
Angle of inclination 30
Approved applications 25
Arctic conditions 52
Arrangement
  Flywheel 113
Attached pumps
  Capacities 73, 79
Auxiliary generator operation
  Definiton 270
Auxiliary GenSet operation
  Definition 270
Available outputs
  Related reference conditions 37, 38

B

Bearing, permissible loads 107
Blackout
  Definition 270
Blackout start 42
By-pass 31, 32

C

Capacities
  Attached pumps 73, 79
  Pumps 73, 79
CEON 17
Charge air
  Blow-off 31
  Blow-off device 32
  Blow-off noise 101
  By-pass 32
  By-pass device 32
Charge air cooler
  Condensate amount 181
  Flow rates 73, 79
  Heat to be dissipated 73, 79
Colour of the engine 282
Combustion air
  Flow rate 73, 79
  Specification 153
Components
  Exhaust gas system 230
Composition of exhaust gas 93
Compressed air
  Specification 153
Compressed air system 215, 217
Condensate amount
  Air vessels 181
  Charge air cooler 181
Consumption
  Control air 70
  Fuel 65
  Fuel oil 65
  Lube oil 69
Control air
  Consumption 65, 70
Controllable pitch propeller
  Definition 272
  Operating range 58
Cooler
  Flow rates 73, 79
  Heat radiation 73, 79
  Heat to be dissipated 73, 79
  Specification, nominal values 73, 79
  Temperature 73, 79
Cooler dimensioning, general 198

2026-10-29 - 10.1

Cooling water
Inspecting 153
Specification 153
Specification for cleaning 153
System description 198
System diagram 198
Temperature control 33
Crankcase vent 196
Crankshaft
Moments of inertia 109
Cyber security 17
Cylinder
Designation 270
Cylinder liner, removal of 235

D

Damper
Moments of inertia 109
Dead ship condition
Definition 270
Required starting conditions 43, 44
Definition of engine rating 35
Definitions
Engine start 41
Derating
As a function of water temperature 38
Due to ambient conditions 38
Due to special conditions or demands 38
Design parameters 27
Diagram
Lube oil system 193
Diagram condensate amount 181
Diesel fuel see Fuel oil 68
DLC
Data Logging Cabinet 275
DMA (fuel oil)
Specification 153
DMA see Fuel oil 68
DMA supply system for diesel engines 209
DMB see Fuel oil 68

E

Earthing
Bearing insulation 56
Measures 56
Welding 57
ECR
Definition 274
Electric propulsion
Definition 272
Emissions
EPA standard 92
Exhaust gas – IMO standard 92
Static torque fluctuation 111
Torsional vibrations 104
Engine
3D Engine viewer 169, 241
Colour 282
Definition of engine rating 35
Description 9
Designation 27, 270
Equipment for various applications 32
Inclinations 30
Main dimensions 28
Operation under arctic conditions 52
Outputs 34
Overview 18
Programme 9
Ratings 34
Ratings for different applications 37
Room layout 231
Running-in 267
Single-engine propulsion plant (Definition) 274
Speeds 34
Speeds, Related main data 38
Weights 28
Engine automation
Interfaces 141
Operation 138
Supply and distribution 136
Technical data 142
Engine pipe connections and dimensions 171

Index

2026-10-29 - 10.1

Engine ratings
Power, outputs, speeds 34
Suction dredger 274
Equipment for various applications 31
Exhaust gas
Back pressure 38
Composition 93
Ducting 255
Emission 92
Flow rates 73, 79
Noise 99
Pressure 38
Smoke emission index 92
System description 227
Temperature 73, 79
Exhaust gas pressure
Due to after treatment 39
Exhaust gas system
Assemblies 230
Components 230
External cooling water system diagram 206
External HT cooling water system 204
External LT cooling water system 202
External seawater system 204

F

Factory Acceptance Test (FAT) 262
Filling volumes 91
Firing order 110
Flexible pipe connections
Installation 169, 175
Flow rates
Air 73, 79
Cooler 73, 79
Exhaust gas 73, 79
Lube oil 73, 79
Water 73, 79
Flow resistances 91
Flywheel
Arrangement 113
Moments of inertia 109
Follow-up preservation 281
Foundation
General requirements 114
Resilient seating 116
Four stroke diesel engine programme for marine 9
Fuel
Consumption 65, 71
Dependent on ambient conditions 71
Diagram of DMA supply system 214
DMA supply 209, 214
Recalculation of consumption 71
Stop power, definition 273
Fuel oil
Consumption 65
Specification for gas oil (DMA) 153

G

Gas oil
Specification 153
General requirements
Fixed pitch propulsion control 59
Propeller pitch control 59
General requirements for pitch control 59
GenSet
Definition 272
Grid parallel operation
Definition 273
Gross calorific value (GCV)
Definition 272

H

Heat radiation 73, 79
Heat to be dissipated 73, 79
Heavy fuel oil see Fuel oil 68
HFO see Fuel oil 68
HT-switching 45

I

Idle speed 38
IMO Marpol Regulation 68, 92
IMO Tier II
Definition 67
Exhaust gas emission 92

2026-10-29 - 10.1

Impact on foundation
Noise and vibration 101
Inclinations 30
Installation
Flexible pipe connections 169, 175
Installation drawings 232
Intake air (combustion air)
Specification 166
Intake noise 99
Internal HT cooling water system 203
Internal LT cooling water system 200
Internal seawater system
Seawater pump 204
ISO
Reference conditions 35
Standard output 37, 273

L

Layout of pipes 169, 171
Leakage rate 90
Lifting device 243
Load
Low-load operation 45
Reduction 47
Load application
Change of load steps 61
Cold engine (only emergency case) 43
Electric propulsion plants 43
Preheated engine 63
Start-up time 44
Load reduction
As a protective safety measure 50
Recommended 48
Stopping the engine 48
Sudden load shedding 47
Low-load operation 45
LT-switching 45
Lube oil
Automatc filter 33
Consumption 69
Cooler 33
Duplex filter 33
Flow rates 73, 79
Outlets 195
Pressure control valve 33
Specification (DMA) 153
System description 183
System diagram 183, 193
Temperature 73, 79
Temperature control 33

M

Main dimensions 28
Marine diesel oil see Fuel oil 68
Marine gas oil
Specification 153
MARPOL Regulation 65, 68, 92
Materials
Piping 173
MCR
Definition 274
Measuring and control devices
Engine-located 145
Mechanical propulsion
System arrangement 254
Mechanical propulsion with CPP
Definition 272
Moments of inertia 109
Mounting points 115
Multi-engine propulsion plant
Definition 272

N

Net calorific value (NCV)
Definition 272
Noise
Airborne 98
Charge air blow-off 101
Exhaust gas 99
Intake 99
Noise and vibration
Impact on foundation 101

2026-10-29 - 10.1

Nominal output
Definition 274
NOx
IMO Tier II 92

O

Offshore application
Definition 25, 273
Oil mist detector 31, 33
Operating
Pressures 85
Standard-output (definition) 273
Temperatures 85
Operating range
CPP 58
Operating/service temperatures and pressures 84
Operation
Acceleration times 63
Load reduction 47
Low load 45
Running-in of engine 267
Output
Available outputs, related reference conditions 37, 38
Definition 273
Engine ratings, power, speeds 34
ISO Standard 37

P

Packaging 279
Part-load operation 45
Pipe dimensioning
Layout of pipes 172
Piping
Materials 173
Pitch control
General requirements 59
Planning data
Flow rates of cooler 73, 79
Heat to be dissipated 73, 79
Temperature 73, 79
Position of the outlet casing of the turbocharger 256
Postlubrication 195
Power
Engine ratings, outputs, speeds 34
Power drive connection 107, 109
Preheating
At starting 42
Prelubrication 195
Preservation 279
PrimeServ Assist 17
Propeller
General requirements for pitch control 59
Operating range CPP 58
Pumps
Capacities 73, 79

R

Rated power
Definition 274
Ratings (output) for different applications, engine 37
Reduction of load 47
Reference conditions (ISO) 35
Removal
Cylinder liner 235
Piston 235
Removal of corrosion protection 282
Room layout 231
Running-in 267

S

Safety
Instructions 257
Measures 257
Service tanks capacities 91
Slow turn 33, 43, 44
Smoke emission index 92
Space requirement for maintenance 246
Spare parts 247

2026-10-29 - 10.1

Specification
Cleaning agents for cooling water 153
Combustion air 153
Compressed air 153
Cooling water inspecting 153
Cooling water system cleaning 153
Engine cooling water 153
Fuel (Gas oil, Marine gas oil) 153
Intake air (combustion air) 166
Lube oil (DMA) 153
Specification for intake air (combustion air) 166
Speed
Adjusting range 39
Droop 39
Engine ratings 38
Engine ratings, power, outputs 34
Idling 39
Main data 38
Mimimum engine speed 39
Speeds
Clutch activation 38
Idling 38
Mimimum engine speed 38
Splash oil monitoring 31, 33
Stand-by operation capability 42
Starting 42
Starting air
/control air consumption 70
Consumption 65, 70
receivers, compressors 219
System description 215
Starting air receivers, compressors 219
Starting air system 215
Start-up time 44
Static torque fluctuation 111
Stopping the engine 48
Storage 279
Storage location and duration 281
Suction dredger application
Definition 274
Sudden load shedding 47
Supply system
DMA 214
Switching: HT 45
Switching: LT 45
Symbols
For drawings 276
System bus 123
System description
Lube oil 183

T

Table of ratings 34
Temperature
Air 73, 79
Cooling water 73, 79
Exhaust gas 73, 79
Lube oil 73, 79
Temperature control
Media 141
Time limitation for low-load operation 45
Torsional vibration 104
Turbocharger assignments 27
Two-stage charge air cooler 31, 33
Type of engine start 41

U

Unloading the engine 47, 50

V

Venting
Crankcase, turbocharger 91
Vibration, torsional 104

W

Water
Flow rates 73, 79
Specification for engine cooling water 153
Water pump performance 208
Water systems
Cooling water collecting and supply system 207
Engine cooling 198
Miscellaneous items 207

Index

2026-10-29 - 10.1

Weights
Engine 28
Lifting device 243
Welding
Earthing 57
Windmilling protection 61
Works test 262

2026-10-29 - 10.1